KENWOOD TS-940 PAGE

One of the greatest transceivers ever produced.

This page provides:

- Some information not available anywhere else which should be useful to any TS-940 owner,
- Information at single web site, easy to follow, [no other site provides this about the 940]
- Information remaining available so more TS-940s will be repaired + functional, (and probably improved),

Version 2: 4 April 2005, Version 3: 25 April 2005, Version 4: 27 May 2005, Version 5: 31 May 2005, Version 6: 10 June 2005: Version 7: 16 June 2005: Version 8: 25 July 2005, Version 9: 30 July 2005. Version 10: 4 August 2005, Version 11: 13 Sep 2005, Version 12: 18 October 2005, Version 13: 23 October 2005, Version 14: 22 March 2006, Version 15: 8 April 2006, Version 16: 27 May 2006, Version 17: 12 July 2006 Version 18: 22 Aug 2006, Version 19: 23 Sep 2006, Version 20: 5 October 2006, Version 21: 7 Jan 2007, Version 22: 17 Jan 2007, Version 23: 5 Oct 2007, Version 24: 19 April 2008, Version 25: 27 July 08, Version 26: 20 Sept 08, Version 27: 26 Sep 09, Version 28: 13 Feb 10, Version 29: 28 Jan 15

Latest addition: more comprehensive analysis and better much power circuit diagrams by:
150128...NC6PT...Paul Trehewey. DETAILED POWER SUPPLY ANALYSIS.htm

http://homepages.ihug.co.nz/cgi-bin/

The intention is to acknowledge the person who discovered the information

When information is already well documented and reliably maintained on another site then a hyperlink is made to that site to avoid yet another slightly different version.

I will publish all email feedback of new information at the end of the page, so that whatever is discovered by others can be shared by all. Please email to jaking@es.co.nz

Yours sincerely
Jeff King ZL4AI / DU7 http://www.jking.netau.net/ZL4AI.htm

See also TS-950sdx page which hold valuable information: http://www.jking.netau.net/TS950sdx/TS-950sdx.htm

TS-590S: the future !!!
Jan 2014 a TS-590S arrived at ZL4AI: Since then the TS-940 have been turned on only few times.... The TS-590 is an outstanding radio, has a receiver much easier to listen than the 940 or 950 SDX, with the close in performance at 1 KHz more than 20dB better than the TS-940 with a LT1028 modification.... wow!!!
Kenwood are complimented in having maintained / sustained world market leader position 30 years later still providing the best state of the art transceiver [with every fault of the TS-940 eliminated], at a very competitive low price.

INDEX

TO ACCESS THE SECTIONS BELOW CLICK HERE ------>: TS-940_02_part2.htm

PROMOTIONAL BROCHURE

TRIO

TS-940S

HF TRANSCEIVER

TS-940S

HF TRANSCEIVER

The TS-940S is a competition class HF transceiver having every conceivable feature, and is designed for SSB, CW, AM, FM and FSK modes of operation on all 160 through 10 metre Amateur bands, including the new WARC bands. It incorporates an outstanding 150 kHz to 30 MHz general coverage receiver having a superior dynamic range (102 dB typical on 20 meters, 50 kHz spacing, 500 Hz CW bandwidth).

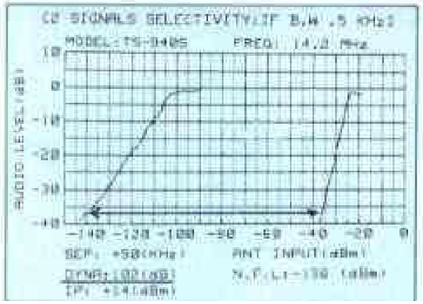
Engineered with the serious DX'er/contest operator in mind, the TS-940S features a wide range of innovative interference rejection circuits, including SSB IF slope tuning, CW VBT (Variable bandwidth tuning), IF notch filter, AF tune circuit, Narrow/Wide filter selection, CW variable pitch control, dual-mode noise blanker, and RIT plus XIT. The use of a new microprocessor with advanced digital technology controlled operating features, plus two VFO's, 40 memory channels, programmable memory and band scans, a large fluorescent tube digital display with analogue-type sub-scale for frequency indication, and a new dot-matrix LCD sub-display for showing graphic characteristics and messages, all serve to provide maximum flexibility and ease of operation. In addition, a CW full break-in circuit, switchable to semi break-in, a built-in automatic antenna tuner, a solid-state final amplifier that is powered from a higher voltage source, a speech processor, all-mode squelch, and a host of other convenience features all add up to even greater versatility of use in fast-paced DX operations. With its power supply and antenna tuner built-in, and with its new whisper-quiet cooling system, the TS-940S is a complete, all-in-one type transceiver that brings tomorrow's sophistication to today's serious enthusiast. The unit may be ordered with the antenna tuner installed or available as an option.

FEATURES

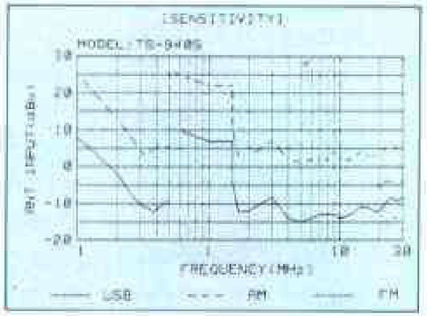
OUTSTANDING RECEIVER PERFORMANCE AND SENSITIVITY SPECIFICATIONS

Superior Dynamic Range Receiver Front End.

The TS-940S RF circuits have been specifically designed to provide the lowest noise floor level coupled with a superior dynamic range. Use of 2SK125 junction-type FET's wired in a cascode amplifier circuit, followed by two 2SK125's each in the first balanced mixer and in the push-pull gate grounded buffer amplifier, and working into a 2nd balanced mixer circuit, results in outstanding two-signal characteristics accompanied by a substantially improved noise floor level. The IM (intermodulation) dynamic range characteristic for the TS-940S receiver section is typically 102 dB (20 metres, 50 kHz spacing, 500 Hz CW bandwidth), with an overall intercept point of +14 dBm, noise floor level of −138 dBm and the blocking dynamic range at a point 200 kHz to either side of the centre frequency of the IF filter is −139 dB (typical).



conceived and engineered digital PLL circuit provides superior frequency accuracy and stability since only the standard frequency crystal oscillator determines those parameters. Selection of a specific Amateur band may be speedily and efficiently accomplished by the touch of the appropriate band access key (10 keys provided), or through use of the UP/DOWN 1 MHz step band switches, allowing easy access to all frequencies in the 150 kHz to 30 MHz range. Each of the two digital VFO's is continuously tunable from band to band across the full range of the transceiver.



All-Mode Operation.

Modes of operation include USB, LSB, CW, AM, FM, and FSK. Mode selection is quickly effected through use of the proper front panel mode key. An adjacent LED confirms the selection. When a key is depressed, the first letter of the mode selected is announced in Morse code through the internal speaker, e.g., "L" for LSB, "F" for FM, etc. When FSK is selected, the Morse code letter "R" (for RTTY) is heard.

Superb Interference Reduction.

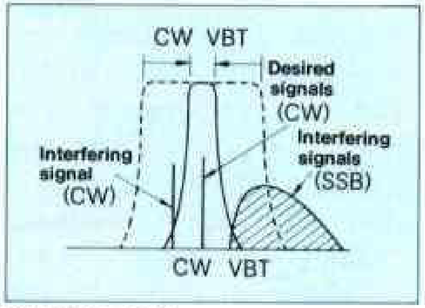
The TS-940S incorporates a number of special interference control circuits perfected by TRIO and described in the following paragraphs that give the operator maximum capability to minimize the effect of interference of all kinds.

(1.) SSB IF Slope Tuning.

This feature operates in the LSB and USB modes. Front panel controls are provided to allow independent adjustment of either the low frequency or high frequency slopes of the IF passband. These HIGH CUT and LOW CUT controls permit the operator to

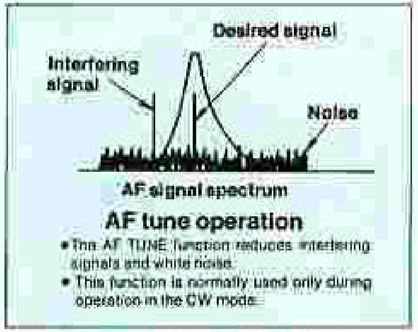
(2.) CW VBT (Variable Bandwidth Tuning.)

When all optional filters are installed, CW VBT operates in the CW, FSK and AM modes. When none of the optional filters are installed, CW VBT operates in the CW and FSK modes with the filter switch positioned at WIDE, and in the AM mode with the filter switch positioned at NARROW. In the CW mode of operation, the CW VBT and pitch control circuits are automatically enabled. The VBT control allows the passband width to be continuously varied within the range of the control without affecting the centre frequency. Graphic illustration of these adjustments is accomplished on the LCD sub-display panel.



(3.) IF Notch Filter.

A tunable notch filter is located between the 4th receive mixer and the 100 kHz IF amplifier. The use of L-C-R components in a bridged-T filter circuit at the 100 kHz IF frequency results in deep, sharp notch characteristics that provide attenuation in the order of 40 dB to the interfering signal. As shown in the figure below, only the interfering signal is reduced while the desired signal remains unaffected. The resonant frequency of the filter is shifted by varying the voltage applied to the cathode of a vari-cap diode. The filter operates in all modes (except FM mode).



(5.) Narrow/Wide Filter Selection.

A front panel "NAR/WIDE" switch allows narrow/wide IF filter selection as required, based on interference conditions. The use of an 8.83 MHz 2nd IF, followed by a 455 kHz 3rd IF promotes excellent selectivity, with maximum potential for the use of various filter combinations to further enhance that important performance characteristic. The TS-940S comes with 2.7 kHz SSB filters (both 8.83 MHz and 455 kHz IF), and a 6 kHz AM filter (455 kHz IF), built-in. A selection of easily installed plug-in optional filters is available for the operator who requires maximum selectivity control.

W/N switch	WIDE		NARROW	
Mode	2nd IF filter	3rd IF filter	2nd IF filter	3rd IF filter
SSB	2.7 kHz*0	2.7 kHz*0	2.7 kHz*0	2.7 kHz*1
CW.FSK	2.7 kHz	2.7 kHz	0.5 kHz*2	0.5 kHz*3 or 0.25 kHz*4
AM	6 kHz*1	6 kHz	2.7 kHz	2.7 kHz
FM	Wide band	12 kHz	Wide band	12 kHz

*0: 2.7 kHz+2.7 kHz=2.4 kHz (Total selectivity)
*1: option YK-88A-1 installed
*2: option YK-88C-1 installed
*3: option YK-455C-1 installed
*4: option YK-455CN-1 installed

Built-in CW Variable Pitch Circuit.

The CW pitch control shifts the 4th IF passband in the demodulator circuit while, at the same time, raising or lowering the pitch of the audible beat frequency. This is very useful in avoiding interference or for changing the pitch tone to a frequency that is easier to copy, without moving the signal out

Built-in RIT/XIT.

The front panel "RIT" (Receiver Incremental Tuning)/"XIT" (Transmitter Incremental Tuning) control shifts the receive or transmit frequency in 10 Hz steps across a range of ±9.99 kHz, using an optical encoder, to tune stations that are slightly off frequency, and without affecting the VFO transmit/receive frequency. RIT/XIT frequency shifts (0.0~±9.99 kHz) are displayed in the main display area. A "CLEAR" switch resets the RIT/XIT frequency to zero. The "RIT/XIT" control may be used in any mode of operation.

All-Mode Squelch Circuit.

The squelch circuit is effective in suppressing background noise in all operating modes.

RF Attenuator.

The meticulously engineered receiver section front end includes a 4-step, 0, 10, 20, or 30 dB RF attenuator, for optimum rejection of intermodulation distortion.

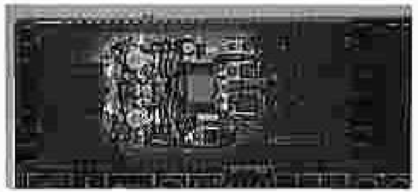
Switchable AGC Circuit (OFF/FAST/SLOW).

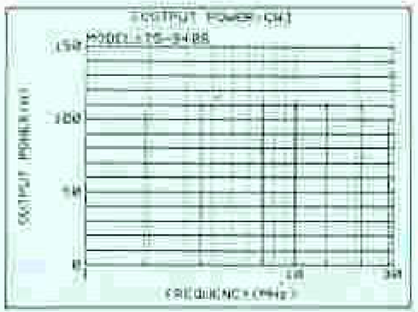
The automatic gain control (AGC) is activated by a 3-position (OFF/FAST/SLOW) switch, to provide optimum receiver operation in all modes, and under all signal strength conditions.

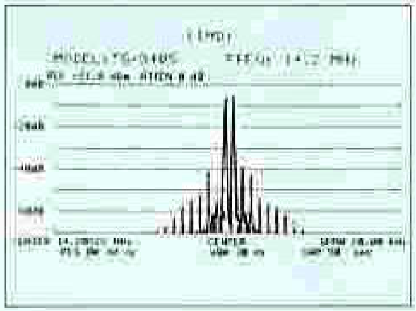
AUTOMATIC ANTENNA TUNER PLUS LOW DISTORTION, HIGH RELIABILITY TRANSMISSION

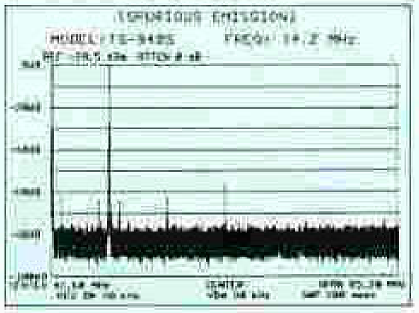
Automatic Antenna Tuner (160-10 metres) Built-In.

The TS-940S is available with a completely automatic antenna tuner covering all Amateur bands from 160 through 10 metres built-in, or may be ordered without the tuner installed. An AT-940 antenna tuner is available for future installation in transceivers initially ordered without the tuner. With the "AUTO/THRU" switch in the "AUTO" position, depressing the "AT.T" key sets up the automatic tune condition, which lasts for approximately 3 seconds. The LCD sub-display reads "ANTENNA TUNER AUTO-TUNE READY." Keying the transmitter while this message is being displayed initiates automatic tuning at the 50 watt RF output level, using high speed motors to reduce the tuning time. During the tuning



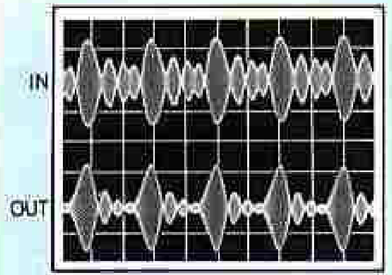






Built-in Speech Processor.

The TS-940S employs speech processing circuitry based on RF clipping techniques. A marked improvement in the intelligibility threshold is attainable, depending on the positions of separate front panel "IN" and "OUT" controls. A higher average "talkpower" plus improved intelligibility makes for outstanding DX performance.



(Approx. 10 dB compression)

RF Output Power Control.

Using a front panel control, the RF output power may be continuously varied from 10 watts to the maximum power, in any mode of operation.

OPERATING FREQUENCY CONTROL USING NEW MICROPROCESSOR PLUS DIGITAL TECHNOLOGY.

The use of a new microprocessor plus advanced digital technology to control the various tuning functions, including the 2 digital VFO's, the 40 channels of memory, band scan and memory scan, etc., assures maximum flexibility and ease of operation under the most difficult operating conditions.

10 Hz Step Dual Digital VFO's with Optical Encoder.

Special tuning logic, working in conjunction with the basic 10 Hz step, high stability digital VFO design, provides a variable speed tuning characteristic that is directly related to the speed of tuning knob rotation. A large, die-cast tuning knob with moulded rubber cover, rotated at normal tuning speeds, results in a frequency shift in 10 Hz increments, or 10 kHz per tuning knob revolution. Rotation of the tuning control at

40 Memory Channels.

For operating purposes, the 40 memory channels are divided into 4 groups of 10 channels each. Both mode and frequency data are stored, making all operations simple and convenient. The operator may select any 1 of the 4 memory groups for operations, using the 4 position memory bank switch located on the top panel. Depressing the "VFO/M" switch on the front panel permits selection of the memory channel, using the 10 band keys. The "M▶VFO" switch is used to transfer memory data (frequency and mode) to the active VFO. Memory information is backed-up by an internal lithium battery. (Est. 5 yr. life.)

Built-in Scan Functions.

Memory scan is initiated by depressing the "MS" switch. Memories in which no data is stored are skipped. Programmable band scan is initiated by depressing the "PG.S" switch, and scans in 10 Hz (100 Hz in AM, FM modes) steps from the lowest frequency within the frequency limits specified in memory channels "9" and "0". A "HOLD" switch is provided to interrupt the scanning process during memory and program scan operations. When the "HOLD" switch has been depressed during program scan, the VFO operating frequency may be adjusted within the frequency limits established in memory channels "9" and "0".

Rapid Band Selection.

A specific Amateur band may be quickly selected by depressing the appropriate front panel band key. One MHz step "UP" and "DOWN" switches on the front panel allow rapid selection of shortwave broadcast frequencies. An "F.LOCK" switch prevents accidental loss of the selected frequency.

Direct keyboard entry of frequency

The dual function band selection keyboard is also used for direct entry of any frequency within the operating range of the TS-940S. Touching the ENT button transfers the TS-940S into direct entry mode. Any frequency can then be keyed into the main display, and a second touch of the ENT button, transfers this frequency into the operating VFO. The main tuning knob can then tune up or down from the entered frequency if required.

MULTI-FUNCTION

memory "ON", memory channel number, "F.LOCK", and RIT/XIT "ON". The use of the fluorescent tube display makes reading easy, and minimizes eye fatigue. A "DIM" switch has been provided to allow dimming of the display and the meter illumination, if desired.

LCD Dot-matrix Sub-display.

The sub-display is capable of displaying a maximum of 16 digits and 2 lines of data. Frequency, graphic characteristics, messages, and clock time are the 4 different kinds of information that can be displayed.

■ **Frequency.**
The upper line shows frequency and mode of VFO "B" when VFO "A" is indicated on the main display. The lower line indicates memory group (1−4), memory channel (CH-1, 2, 3, ... 0), plus frequency and mode during VFO operations.

■ **Graphic Characteristics.**
Graphically indicates the effect on bandwidth when "SSB SLOPE TUNE" or "CW VBT" controls are operated.

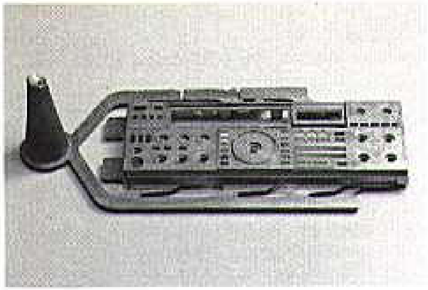
■ **Messages.**
Displays messages relating to operation of the Automatic Antenna Tuner, as follows:

1. "ANTENNA TUNER AUTO TUNE READY" when "AT.T" switch is depressed.
2. "ANTENNA TUNER TUNING" when transmitter is keyed within 3 seconds after pressing "AT.T" switch.
3. "TUNING FINISHED TX-READY" when automatic antenna tuner has finished tuning.

■ **Clock.**
Indicates the current time, or the preset timer time. The clock has a built-in battery back up. (Est. 3yr. life)

MECHANICAL DESIGN AND CONSTRUCTION TYPICAL OF COMPETITION-CLASS EQUIPMENT.

The clean, sharp, lines and functional stability so characteristic of die-cast construction are quickly recognized in the



Efficent Cooling System Allows 100% Transmit Duty Cycle.

The 100 W final amplifier stage is mounted directly on its die-cast aluminum heat sink and by using a ducted air-flow cooling system, provides maximum thermal conduction efficiency. The high efficiency of the cooling system permits continuous transmission at full power for periods of approximately one hour without thermal shut-down.
The power supply unit has its own independent cooling system and fan, also incorporating the ducted air-flow concept.

A VARIETY OF EXTRA, EASY-TO-OPERATE FUNCTIONS.

Built-in AC Power Supply and Speaker.

The TS-940S is a self-contained HF station, including a built-in power supply, and a rugged, top-mounted, high quality, 10 cm (4 inch) speaker. The power supply circuit provides ample capacity by use of a special, compact, laminated core transformer, assuring maximum stability of operation of the final transistor circuits. The correct AC circuit polarity is achieved through use of the 3-wire connector and cable assembly supplied with the unit.

Clock/Timer Function.

In addition to a 24-hour clock function, a single event timer is provided for scheduled un-attended recording of a specified transmission. Clock/Timer program data may be displayed on the LCD sub-display at the operator's option.

Transmission Monitor Circuit.

A built-in transmit monitor circuit operating in the SSB, FM, and FSK modes may be operator activated by depressing the front panel "MONI" switch. This circuit monitors the product detector signal from the output of the IF section during transmission, allowing the operator to check his audio quality, and the effectiveness of the speech processor.

High Stability RTTY Transmit Circuit.

The stability of RTTY transmissions is greatly improved through design that obtains the FSK signal information from the reference oscillator. The FSK shift width is 170 Hz.

Voice Synthesiser Unit (Optional).

An optional VS-1 "Voice Synthesiser Unit", which announces the operating frequency on demand by depression of the front panel "VOICE" key, is available. Installation within the cabinet is simple and easy.

Optional SO-1 TCXO "Temperature Compensated Crystal Oscillator".

An optional, high-stability TCXO, model SO-1, may be installed in place of the reference oscillator. This unit operates at a frequency of 20 MHz and has a thermal stability of $\pm 5 \times 10^{-7}$.

ADDITIONAL FEATURES, PLUS ACCESSORY TERMINALS.

Dimmer Switch

A front panel "DIM" switch permits selection of either normal or reduced intensity on the digital display and SWR/POWER meter.

100 kHz Marker.

A 100 kHz marker signal, controlled by a switch located under the sliding panel on top of the unit, is available for use in calibrating the fundamental oscillator against received standards such as WWV or MSF.

VOX Circuit.

The VOX gain, VOX delay, and Anti-VOX controls are located beneath the sliding panel on the top of the cabinet.

Meter Functions.

"COMP" (Compression), "ALC" (Automatic Level Control), "POWER" (RF Output Power), "SWR" (Standing-wave Ratio), "IC" (Final Amplifier Collector Current), and "VC" (Final Amplifier Collector Voltage.) S units and dB on receive.

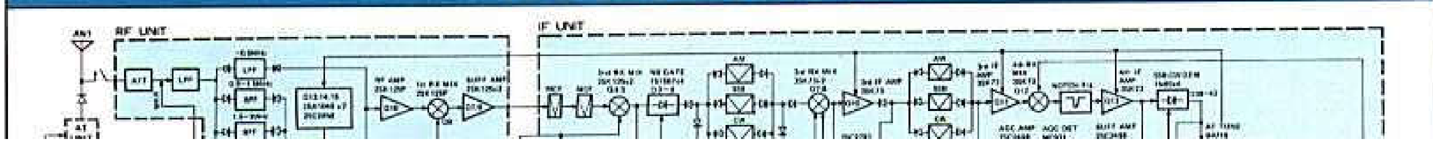
LED Indicators for Miscellaneous Functions.

"ON AIR", "AT", "TUNE", "SPLIT", "NOTCH", "NAR".

Input/Output Terminals

RX antenna terminal and switch, transverter terminal, IF OUT 1 (For PAN-DISPLAY) and IF OUT 2 (Oscilloscope Modulation Monitor) terminals, phone patch IN/OUT terminals, accessory terminals 1 and 2, remote control terminal.

TS-940S BLOCK DIAGRAM



CW break-in selector
During CW operation, selects either full break-in at FULL, or semi break-in at SEMI.

MONI (MONITOR)

ATT (RF attenuator)
(0, −10, −20, −30 dB)

PROC (processor) switch

DIM

SUB DISPLAY
Frequency/Graphic characteristics
Messages/Clock

MAIN DISPLAY
Frequency/VFO A, B
MCH (Memory Channel)/RIT, XIT

MEMORY function
Used to select memory scan, program scan VFO or memory operation.

BAND/KEY
- Selects Amateur bands

Ten keys: Used for direct frequency entry.

CLOCK/GRAPH
SCROLL • Recall frequencies in the memories.
SET • Used to set the "?" mark on the time display for setting time adjustment.
• Used when erasing time-controlled set time.

NOTCH -⊖- SQL controls

PITCH -⊖- AF TUNE controls

AF -⊖- RF controls

RIT/XIT control
Shifts the receive/transmit frequency in 10 Hz steps within a range of ±9.99 kHz when the RIT/XIT mode has been selected.

STAND-BY

NB 1/NB 2 switches

NAR/WIDE
Selects narrow or wide IF bandwidth.

AUTO/THRU
AUTO: Antenna tuner is ON.
THRU: Antenna tuner is OFF.

NB LEVEL control
Controls noise blanker operating level.

MODE switches
The first letter of the mode (FSK mode: "R") is announced in International Morse Code.

MIC (microphone gain) -⊖- PWR (RF power) controls
- Controls microphone amplifier gain for SSB operation.
- Controls the transmit power in SSB, CW and FM modes.

PROCESSOR-IN -⊖- PROCESSOR-OUT controls
Controls compression level, speech processor output level.

AT. T switch
Used when operating the transceiver in conjunction with the antenna tuner, when fitted.

CW VBT control
Continuously adjusts the IF filter bandwidth to eliminate interference from adjacent stations.

SSB SLOPE TUNE control
This permits independent variation of the high and low frequency slopes of the IF passband. High and low audio frequencies may be simultaneously cut.

UP/DOWN
Shifts 1 MHz up/down.

FUNCTION switches
- T-FSET switch

Depress this switch to "SPOT", or momentarily interchange reception frequency with transmission frequency. Frequency "SPOTTING" is possible only in receive and is ineffective during transmission.

- A/B — Selects VFO A or VFO B.
- SPLIT — For split frequency operations A-R, B-T or B-R, A-T.
- A=B — During VFO operation, press this switch to equalize the frequency and mode of the idle VFO to that of the active VFO.
- F. LOCK — Press this switch to lock the VFO and BAND switches.
- VOICE — Announces the frequency when an optional VS-1 is installed inside the cabinet.

PHONE PATCH jacks

ANTENNA ...

RTTY KEY jack
For FSK operation

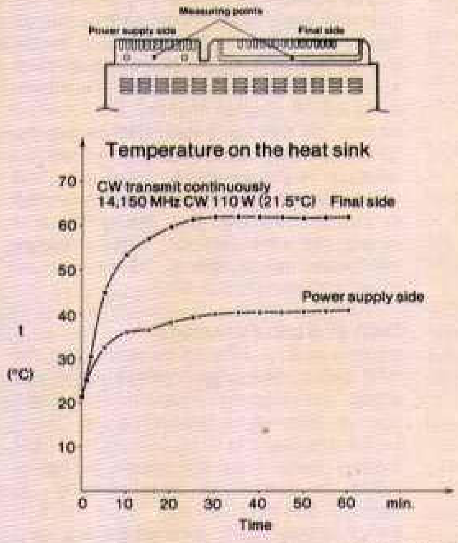
Cooling fan (final section)
Electronically controlled automatic cooling fan for the final amplifier section.

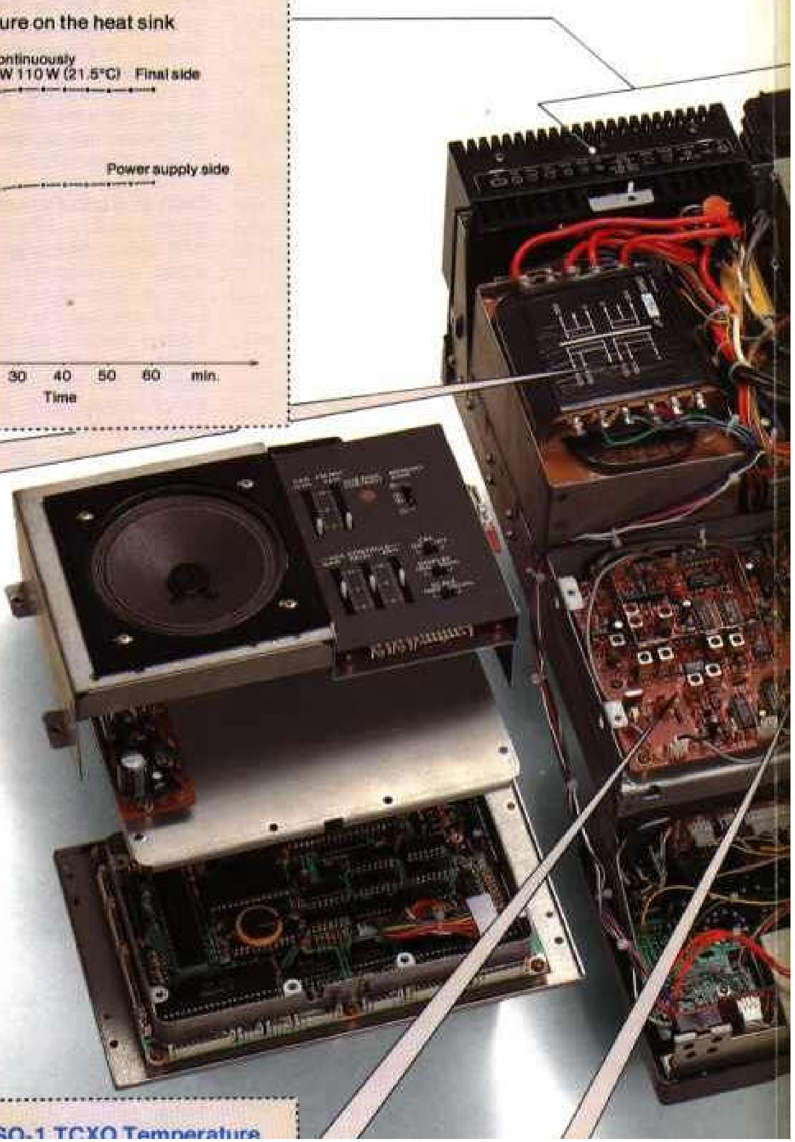
Cooling fan (power supply)
Electronically controlled automatic cooling fan for ...

Highly Efficient, Ducted Air-Flow, Cooling System

A new air distribution system allows operation on a 100% transmit duty cycle basis for periods of approximately one hour.

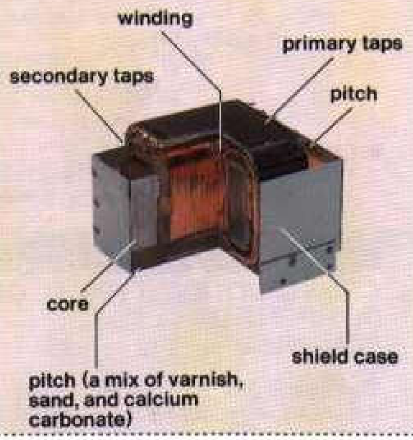
The heat sink cooling fins are designed to be an integral part of the ducted air-flow system, which is constructed in such a manner as to assure a continual flow of air across the front and rear surfaces of the heat sink, as well as over the fins themselves. Ports of varying sizes have been strategically located throughout the air-flow system to prevent dead-air pockets. Cooling air is drawn through the cabinet area by a quiet, two-speed fan that then directs its discharge air-flow into the ducting at a point immediately adjacent to the final amplifier transistors, assuring maximum heat transfer from these important components. Fan operation is controlled through use of automatic switching initiated by a detecting thermistor that senses final amplifier temperature.





Laminated Core Transformer

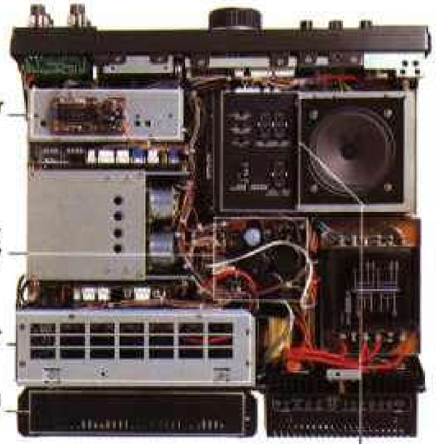
The power transformer is high performance, shielded, and potted to protect the windings and connections from vibration and impact damage.

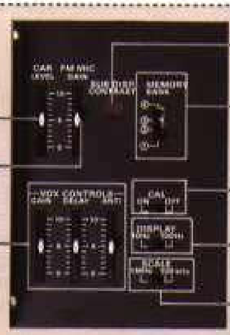


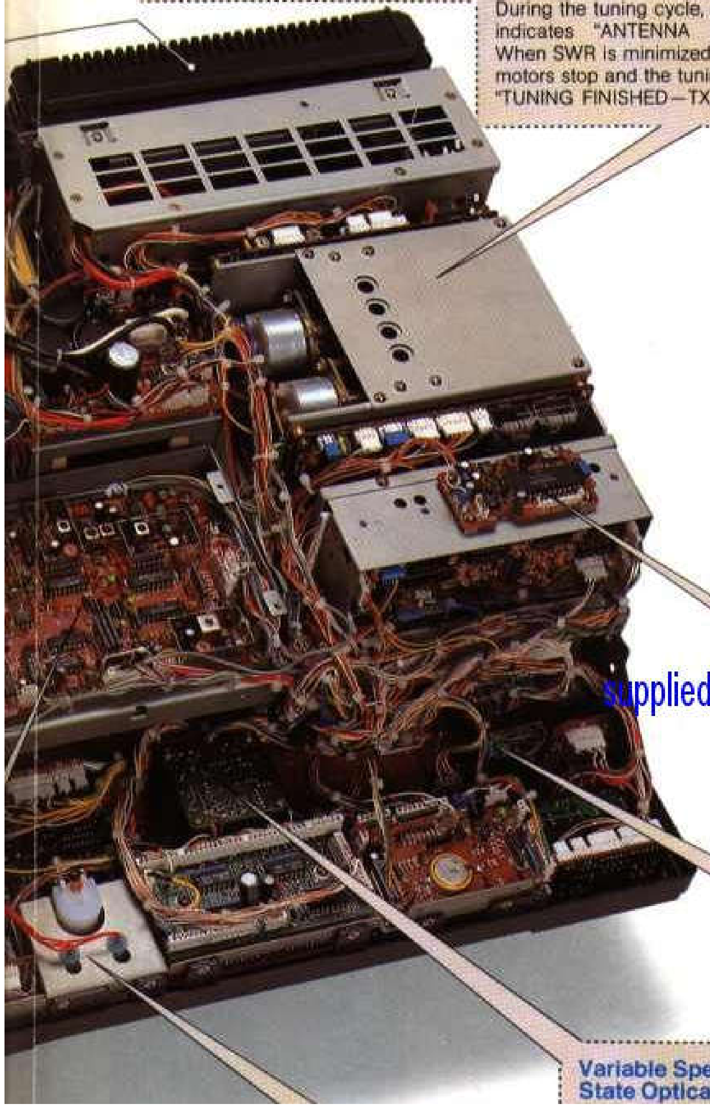
Optional SO-1 TCXO Temperature

Automatic Antenna Tuner

Forward and reflected power are detected by a directional coupler. Signals proportional to the antenna line voltage and current are processed for phase comparison. These signals are used to control servo motors which turn the two antenna tuner capacitors for minimum SWR. (The two variable capacitors are controlled independently.) During the tuning cycle, an LCD sub-display indicates "ANTENNA TUNER TUNING." When SWR is minimized (1.2 : 1 or less), the motors stop and the tuning display indicates "TUNING FINISHED—TX READY."







Voice Synthesizer Unit (option)

The optional VS-1 voice synthesizer is easily installed inside the cabinet, and announces the main display frequency on demand.

RIT/XIT Encoder Mechanism.

The RIT/XIT control employs a moulded optical encoder disk having fifty slits located along its outer circumference, providing a total of 2 kHz frequency shift in 10 Hz steps.

Variable Speed Tuning With Solid State Optical Encoder

TS-940S OPTIONAL ACCESSORIES

SP-940

External Speaker

The SP-940 is a high class external speaker designed to match the TS-940S in size, colour and appearance. The SP-940 uses a panel made of reinforced ABS plastic and an expanded metal speaker grill to improve tone quality. It is a low-distortion speaker with selectable frequency response for high intelligibility in any mode. The frequency response is determined by the built-in audio filters, which are effective in improving signal-to-noise-ratio under certain interference conditions, or when receiving weak signals. On the front panel is a headphone connector, for listening to audio output passed through the filters. Also on the front panel is a switch for selecting either of two audio inputs to the SP-940.

SPECIFICATIONS

•Speaker Diameter: 100 mm (4 inch) •Input Power (max.): 1.5 W (3.0 W) •Impedance: 8 Ω •Frequency Response: 100 Hz～5 kHz •Filter Cut-off Frequency: LOW 430 Hz (−3 dB)/ HIGH1 1 kHz (−3 dB)/HIGH2 2.5 kHz (−3 dB)/ HIGH1 + HIGH2 730 Hz (−3 dB) •Filter Attenuation: −6 dB/OCT •Dimensions: 180 (7.01) W ×140 (5.51) H×290 (11.4) D mm (inch), (Projections not included) •Weight: 2 kg (4.41 lbs) approx.

AT-940

Automatic Antenna Tuner

The AT-940 is an optional automatic antenna tuner that can be installed in the TS-940S.

FEATURES

- Full coverage of 160 through 10 meters, including the new WARC bands.
- Automatic motor speed control. The motor automatically stops when the SWR drops to its minimum value (1.2:1 or less).
- The AUTO-THRU circuit is disabled during transmission to protect the final transistors in case the AUTO-THRU switch is accidentally operated.
- The "tune" condition for automatic antenna tuning remains unchanged during transmission when the "AT.T" switch is depressed.

SPECIFICATIONS

•Frequency Range: All Amateur bands from 1.8 to 29.7 MHz •Input Impedance: 50 Ω unbalanced •Output Impedance: 20～150 Ω unbalanced •Insertion Loss: Less than 0.8 dB •Through Power: 150 W •Maximum Tuning Time: Less than 15 seconds.

SM-220

Station Monitor

Based on a wide-frequency-range oscilloscope (up to 10 MHz), the SM-220 station monitor features, in combination with a built-in two-tone generator, a wide variety of waveform-observing capabilities. When the BS-8 is installed in the SM-220 and connected to the transceiver, signal conditions in the vicinity of the receive frequency can be viewed over a ±20 kHz or ±100 kHz range. The SM-220 provides efficient station operation as it monitors transmitted waveforms, and it also serves as a high-sensitivity, wide-frequency range oscilloscope for various adjustments and experiments.

SPECIFICATIONS

(Transmit Signal Monitor Terminal) •Frequency range: 1.8～150 MHz •Maximum power: 1 KW (1.8～54 MHz), 50 W (150 MHz) •SWR: 1.2:1 or less •Deflection sensitivity: Better than 1 div. at 2 W input •Attenuator: 6 steps **(Trapezoid waveform observation)** •Frequency range: 1.8～30 MHz •Maximum power at DRIVE TERMINAL: 2～100 W •SWR: 1.2:1 or

DC～250 kHz or over (EXT GAIN at MAX); DC～40 kHz (EXT GAIN at 1/2) •Input resistance/capacitance: 1 MΩ (±20%)/35 PF or less (SYNC switch at INT) •Attenuator: Fully variable to 0 •Max. input voltage: 100 Vp-p **(Sweep circuit)** •Sweep frequency: 10 Hz～100 kHz (4 ranges, with fine adjustment) •Sweep linearity: Better than 5% •Sync system: Synchronized sweep, internal negative sync and external sync •Sync amplitude: Internal: Better than 1 div. on CRT, External: Better than 2 Vp-p **(Vertical amplifier)** •Deflection sensitivity: Better than 20 mV/div. •Frequency response: 2 Hz～10 MHz (−3 dB) •Input resistance/ capacitance: 1 MΩ / 40 PF •Overshoot: Less than 5% •Attenuator: 1, 1/10, 1/100 and GND/MONITOR (Error between steps: 5% max.) •Max. input voltage: 300 V (DC+AC peak) or 600 Vp-p •Power supply: 120/220/240 V AC±10%, 50/60 Hz 20 W •Dimensions: 215 (8.6) W×153 (6.1) H×335 (13.4) D mm (inch) •Weight: 5 kg (11 lbs.)

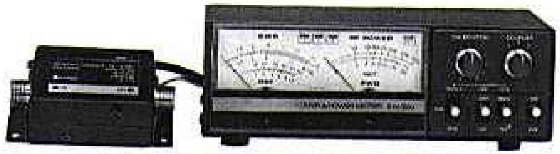
SW-200A, 2000

SWR/POWER Meter (supplied with a coupler)

SW-200A supplied with SWC-1
SW-2000 supplied with SWC-3
Selectable Peak-reading/RMS, SWR/POWER meters for base station use.

SPECIFICATIONS

•Impedance: 50~52 Ω •Frequency range: 1.8~150 MHz (SW-200A) 1.8~54 MHz (SW-2000) •Power measuring range: 0~20/200 W (SW-200A) 0~200/2000 W (SW-2000) •Accuracy: Less than ±10% of full scale •Sensitivity: Less than 20 W •Power supply: 12 VDC 100 mA •Dimensions: 193 (7.6) W × 62 (2.4) H × 79 (3.1) D mm (inch) •Weight: 0.7 kg (1.5 lbs.) approx.



YK-88A-1

6 kHz AM Filter for 8.83 MHz IF

•Centre Frequency: 8830.0 kHz •Selectivity: 6 kHz (−6 dB), 11 kHz (−60 dB)
•Guaranteed Attenuation: More than 80 dB

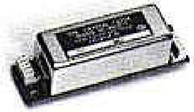
YK-88C-1

500 Hz CW Filter for 8.83 MHz IF

•Centre Frequency: 8830.0 kHz •Selectivity: 500 Hz (−6 dB), 1.5 kHz (−60 dB)
•Guaranteed Attenuation: More than 80 dB

YG-455C-1

500 Hz CW Filter for 455 kHz IF



•Centre Frequency: 455.0 kHz •Selectivity: 500 Hz (−6 dB), 820 Hz (−60 dB)
•Guaranteed Attenuation: More than 80 dB

YG-455CN-1

250 Hz CW Narrow Filter for 455 kHz IF for 455 kHz IF

•Centre Frequency: 455.0 kHz •Selectivity: 250 Hz (−6 dB), 480 Hz (−60 dB)
•Guaranteed Attenuation: More than 80 dB

SO-1

Superior Stability TCXO (Temperature compensated crystal oscillator)

(Requires modifications)
•Frequency Oscillator: 20 MHz •Frequency Stability: $\pm 5 \times 10^{-7}$ (−10°C~+50°C) •Frequency Correct Range: Better than ±60 Hz

VS-1

Voice Synthesiser unit

MC-42S (500 Ω)

UP/DOWN Hand Microphone (8 pin)

The MC-42S is a handy dynamic microphone with PTT switch and UP/DOWN switches.

MC-60A (50 k Ω/500 Ω)

Deluxe Desk-Top Microphone with built-in Preamplifier (8 pin)

The zinc die-cast base provides high stability, and the MC-60A is completed with PTT and LOCK switches, UP/DOWN switches, an impedance selector switch and a built-in pre-amplifier.

MC-85 (700 Ω)

Multi-function Desk-Top Microphone with built-in Audio Level Compensation (8 pin)

The MC-85 is an unidirectional high-class electret condenser microphone provided with an output select switch, audio level compensation circuit, low cut filter, level meter, PTT and LOCK switch.

MC-80 (700 Ω)

Desk-Top Microphone with built-in Preamplifier (8 pin)

The MC-80 is an omnidirectional electret condenser microphone provided with UP/DOWN switch, volume adjustment for output level, PTT and LOCK switch, and built-in pre-amplifier.

TS-940S SPECIFICATIONS

[GENERAL]

Transmitter
Frequency Range ..... 160-m band 1.8~2.0 MHz
80-m band 3.5~4.0 MHz
40-m band 7.0~7.3 MHz
30-m band 10.1~10.15 MHz
20-m band 14.0~14.35 MHz
17-m band 18.068~18.168 MHz
15-m band 21.0~21.45 MHz
12-m band 24.89~24.99 MHz
10-m band 28.0~29.7 MHz

Receiver Frequency Range .... 150 kHz~30 MHz
Mode.................. A3J (USB, LSB), A1 (CW) F1 (FSK), F3 (FM), A3 (AM)
Frequency Stability ... $\pm 10 \times 10^{-6}$ (-10°C~$+50$°C)
Frequency Accuracy .. $\pm 10 \times 10^{-6}$ (at normal temperatures)
Antenna Impedance... 50 Ω (20~150 Ω with the AT-940 antenna tuner installed, transmission only)
Power Requirements .. 120/220/240 VAC, 50/60 Hz
Power Consumption .. Max. transmit 510 W
Receive (no signal) 80 W
Dimensions .... 401 (15.79) W × 141 (5.55) H × 350 (13.78) D mm (inch) (Projections not included)
Weight .... 18.5 kg (40.78 lbs.) approx.
20 kg (44.09 lbs.) approx. (with antenna tuner)

[Transmitter]

Final Power Input ..... SSB/CW/FSK/FM=250 W PEP
AM=140 W
Modulation............ SSB=Balanced Modulation
FM=Reactance Modulation
AM=Low Level Modulation
FM Maximum Frequency Deviation ±5 kHz

[Receiver]

Circuitry .... SSB/CW/AM/FSK: Quadruple conversion system
FM: Triple conversion system
Intermediate frequency .... 1st IF 45.05 MHz
2nd IF 8.83 MHz
3rd IF 455 kHz
4th IF 100 kHz

Sensitivity............ at 10 dB (S/N) (0 dBμ=1 μV)

Mode \ Frequency	150~500 kHz	500 kHz~1.8 MHz	1.8~30 MHz
SSB, CW, FSK	Less than 1 μV	Less than 4 μV	Less than 0.2 μV
AM	Less than 10 μV	Less than 32 μV	Less than 2 μV
FM (SINAD 12 dB)	—	—	Less than 0.5 μV

Squelch Sensitivity ... Less than -10 dBμ (0.32 μV)
Image Ratio .... More than 80 dB (1.8~30 MHz)
IF Rejection .... More than 70 dB (1.8~30 MHz)
Selectivity............ SSB, CW, AM (Narrow), FSK
2.4 kHz (-6 dB)
3.6 kHz (-60 dB)
AM (Wide)
6 kHz (-6 dB)
15 kHz (-50 dB)
FM
12 kHz (-6 dB)
22 kHz (-60 dB)
Variable Frequency Range .... SSB slope tuning

ALWAYS READ THIS SITE TO SEE THE UPDATES PLANNED TO BE PUBLISHED

From: "Vaso Nastasic" <vaso.yt5t@gmail.com>
To: <kenwood@mailman.qth.net>
Sent: Thursday, January 04, 2007 9:09 PM
Subject: [Kenwood] TS940S CW heterodyne tone

Hello from this part of world and HNY 2007! I have problem with ……
Anyone can help?
73s de Vaso YT1XX / YT6XX.

Hi Vaso,

did you find the home page of Jeff King ZL4AI,
http://homepages.ihug.co.nz/~jaking/TS-940_02.htm
Regards, Nermin S58DX

On Behalf Of Lynn Baustian
Sent: Friday, 5 January 2007 2:02 p.m.
To: kenwood@mailman.qth.net; 4i2benhad@comcast.net
Subject: [Kenwood] TS-940S

Does anyone happen to have all the info on Jeff Kings sight saved to a .pdf
It could be invaluable should his sight go down for any reason.
73.....Lynn WA7ADY
==

From: jaking [mailto:jaking@es.co.nz]
Sent: Saturday, 6 January 2007 10:48 a.m.
To: 'kenwood-bounces@mailman.qth.net'
Cc: 'Lynn Baustian'
Subject: RE: [Kenwood] TS-940S Page and updates

PDF of TS-940 page, or TS-950sdx page. If you really need this, print to a printer or a pdf writer and just print off your own version, Or just save the site as an html. Ihug is very reliable and this site is unlikely to go down. If that happened I would shift it to another ISP.

Taking a copy in any form is not recommended. because I update the TS-940 page regularly. I record my notes of working on the 940 on the site page. After that it takes about 5 minutes to post a new page. That way the site progressively becomes better.

The reason copies are not so good is they will not include improved / revised information. It is better to have just one authenticated source of information. For example I used to get lots of questions about how to follow circuit diagrams. Since I posted my ideas on how to read, all those questions seem to have stopped. If you have an old copy of the site you will not have that information. Ironically the reason I first published the site was I had collected the information and published it because I could see it would be helpful to others. Now I have to defend the advantages of keeping the information in just one place.

In the next years or longer as time permits I intend doing on both a late and an early 940

1. phase noise tests,
2. receiver tests, such as MDS [minimum discernable signal], IMD3 etc, because no source of this important information exists for modified or later 940s, [ZL4AI measured on his 20 mil unit MDS CW = -144 dBm, MDS SSB -139 dBm]
3. band filter adjustments / alignment
4. FET 2SK125 reversal with before and after laboratory MDS tests, to establish what the change in receive signal level is. Plus I intend telephoning Kenwood USA Amateur radio technical support on 001-310-639-4200, option 5, option 2, option 1, to find out what the real truth of Kenwoods official position on FET reversal is? I find it difficult to understand why reversing a single FET should overload or make the receiver unstable? I anticipate the measured change in MDS due to reversal will be only a couple of dBs.
5. possibly replacing 2SK125s with J310s to discover if later (year 2005 made) (of higher quality manufacturing standard) pre-amp FETs reduce the noise,
6. try installing better and additional shielding around the entire pre-amp sections to block out and reduce noise,
7. replacing band filter diode switches with relays to see if MDS and other receiver qualities improve,
8. Figure out the switching in and out of filters in SSB mode, so I can develop a rewiring of jumpers which allow switching in the empty CW filter bays while in SSB mode. Then try INRAD, and / or Kenwood AM 6K wide or other filters as additional or alternative switch ins, to enable filtering capability similar to the TS-950 and TS-850. [Measure receiver tests, for various combinations.]
9. publish audio spectrum graphical outputs of the 940 performance. [Possibly try replacing audio components such as capacitors to give a more hi-fi higher quality audio].
10. publish files of 940 performance with and without DSP filtering. Experience so far is 940 plus DSP is an exceptional improvement]
11. -evaluate and publish information on how to link 2 940s together so as to have and simultaneously use, a second 940 as a dual receiver,
12. Information about replacing bulbs with LEDs [published version 23]
13. Details on 28 volt crowbar circuit to protect the radio against power supply failure, [base data was published in Version 20]
14. An adjustable resistor for activating temperature of the power supply fan,
15. More experience on removing the very hot power diodes off the AVR board onto the heatsink
16. publish details of all the changes Kenwood made to the 940 between 1985 and November 1986. There are many more changes to the 940 than those on the published services bulletins.
17. publish info about filter input of SM-220 to remove ghost signals from 1 MHZ generated by the 940. [Published version 24]

All that information, should be of real interest to any 940 owner. For that reasons I suggest you keep reading the site.

[If anyone has done or undertakes any of the above earlier please send your results for publication. There are definitely more mods that can be undertaken to improve the 940.]

Jeff King ZL4AI

HUGE ADVANTAGE IS YOU CAN STILL SERVICE THE 940

Remember the only reason most 940 owners ever sell, is their radio has now developed faults, and they cannot bear the large cost of getting another person to repair the radio. So sadly they replace it with a radio that is working, for economic reasons. Most say if it had not developed faults I will still be using it because its performance is as good as all the latest models.

INRAD will soon release the 940 roofing filter [930 roofing filter came out recently].
http://www.qth.com/inrad/
For crowded bands, the roofing filter should provide the 940 receiver enhanced performance equivalent to the best current receivers.

Almost all radios after 1991 have been made using surface mount technology. The components are very small and difficult to work on.
For many amateurs servicing these radios is difficult, and requires soldering equipment with good temperature control, very fine tips and electrostatic safe.

The TS-940, (and others of the very early 1990s like the Icom 765, and Yaesu FT-1000D)
can still be serviced, and most parts are still readily available at local stores.

You can use standard off the shelf equivalent capacitors, resistors, ICs and often equivalent replacement transistors. The cost of these parts is low and they are readily easily available.

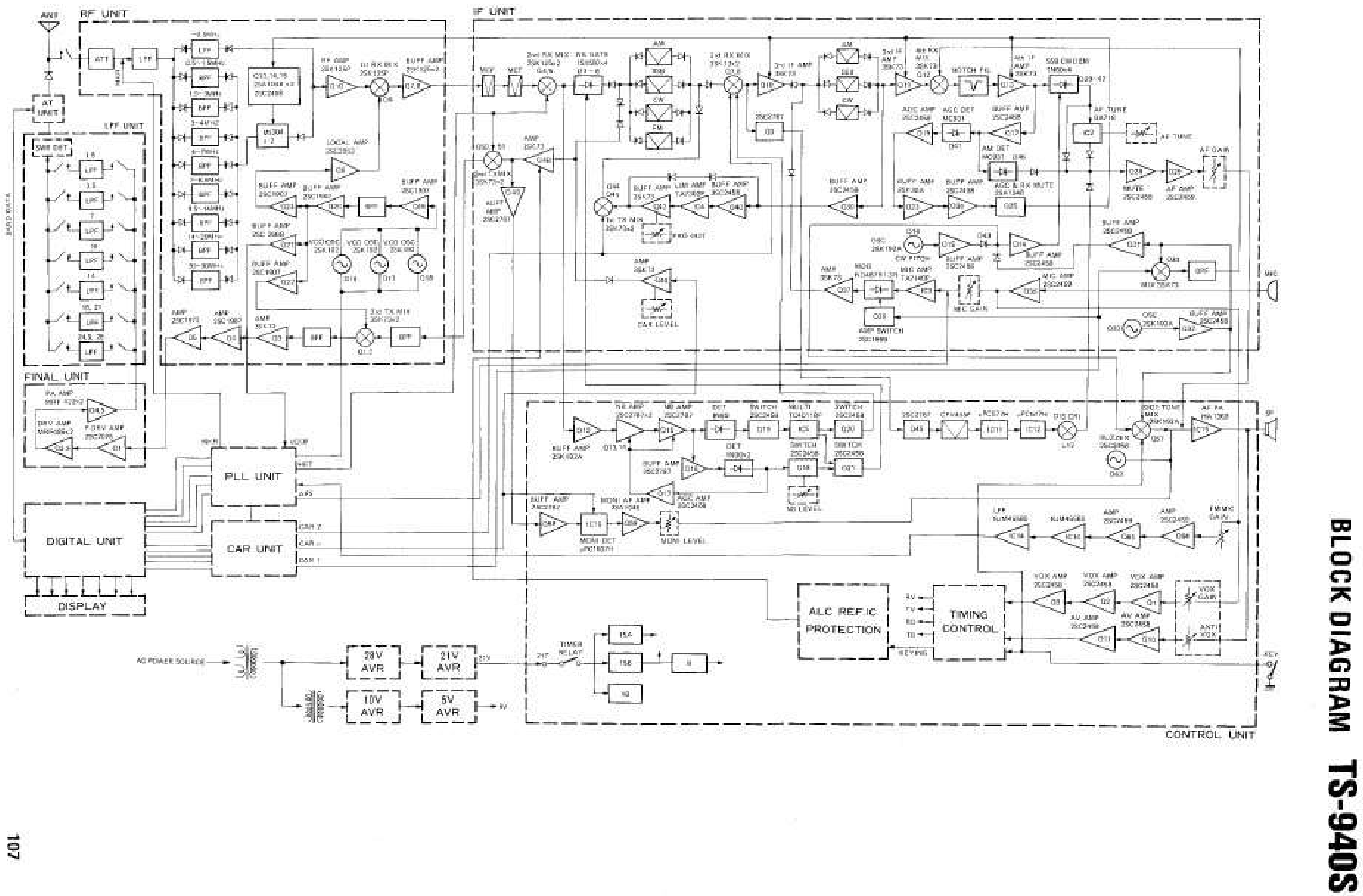
The only parts hard to get are ICs specially programmed by Kenwood [Only a few of these in the 940]
You can buy second hand TS-940 boards on EBay and elsewhere at very reasonable prices. With second hand boards and parts you can still obtain every component. Don’t sell your 940… Repair it.

If you like kit sets, you could say the 940 is like one large kit set, preassembled.

KEY TO SERVICING IS: HOW TO READ THE SERVICE MANUAL

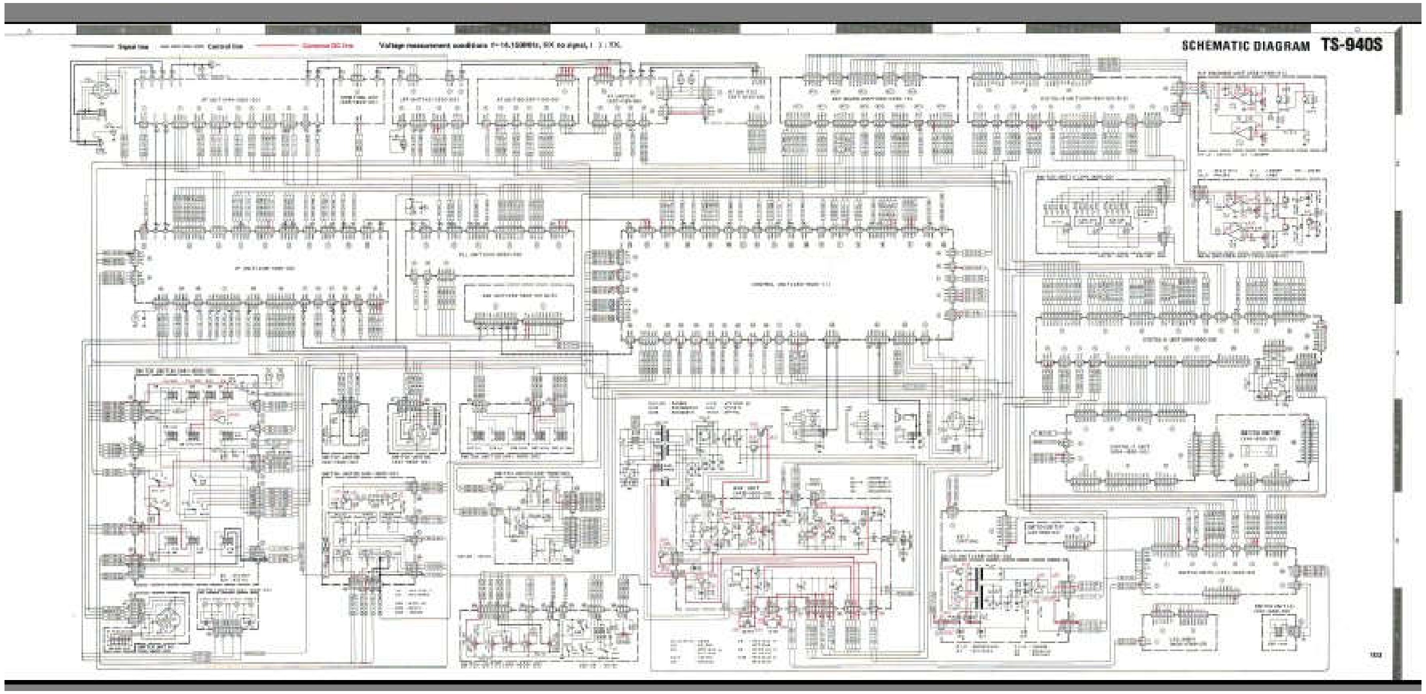
This section is first because it is key to working on the Ts-940. It is not explained in the service manual.
Once you understand this you can easily understand the TS-940.
First step is download the manual from www.mods.dk.com, or other sites.

On page 107 find the BLOCK DIGRAM. This is probably the most useful diagram in the book because it illustrates conceptually how the radio works. It should have been at the very front of the manual. From this you can easily follow through where major signals and functions travel.

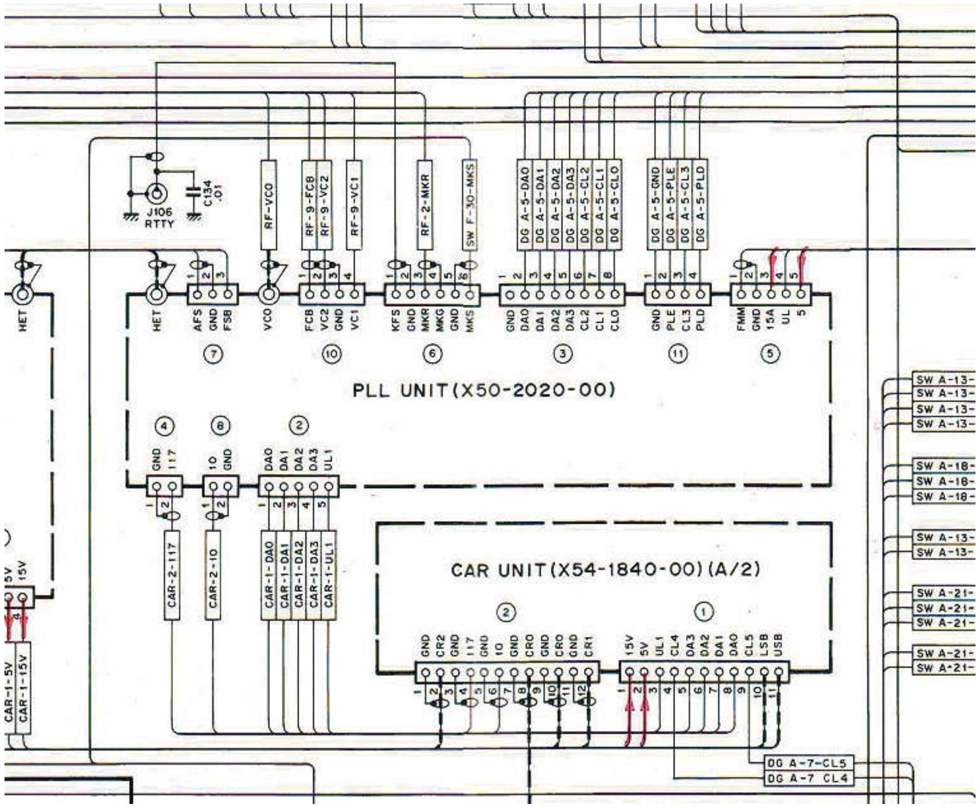


Then go to page 12 Receiver and page 17 transmitter and read through how the receiver / transmitter functions while following through the block diagram. This will give very good idea of how the radio works.

Then on page 103 find the overall schematic of the 940. This lays outs out all the major boards. There is a coding system, to trace between boards.



Now zoom into part of that schematic and look at example connectors:



Best illustrated by worked example.
On The PLL board X50-2020-00 find Connector Plug 2.
It has five wires:

Two example traces are shown below;

Wire 1-DA0 shown with a destination tag "CAR-1-DA0", whose destination is Carrier Board (X54-1840-00)(A/2) Connector Plug 1 –DA0 Wire 8,
Wire 2-DA1
Wire 3-DA2
Wire 4-DA3
Wire 5-UL1 shown with a destination tag "CAR-1-UL1", whose destination is Carrier Board (X54-1840-00)(A/2) Connector Plug 1 –UL1 Wire 4,

As you can see if you trace along all grouped wires through on the diagram, the grouped wire line leads from one board to another.

Using this system you can trace from any part of the 940 to any other part.

On each schematic or board layout diagram all you have to do is find the Connector Plug Number. Then you can easily trace through the board.

Page 83 to 89 of the service manual shows every Connector Plug on every board is listed out with description of its function. This helps identify what the wire function is doing.

Page 80 and 81 shows the physical location of most boards inside the radio.

WARNING: Please NOTE: There is no colour coding for wires listed in the service manual. IT IS VERY SAFE PRACTICE BEFORE TAKING A BOARD OUT TO DRAW A DIAGRAM OF THE BOARD SHOWING EVERY CONNECTOR PLUG AND THE COLOUR OF EEVRY WIRE. ONLY DOING THIS WILL GUARANTEE YOU PLUG THE WIRS BACK IN CORRECTLY. FOR THE IF BOARD AND CONTROL BOARD THERE ARE MULTIPLE WAYS TO PLUG IN WIRES, AND YOU COULD SERIOUSLY DAMAGE YOUR 940 IF YOU DONOTT DARW OUT WIRING COLOUR CODE PLUG IN DIAGRAMS.

Using the above decoding method solved the following problems.

From: W5EJ
Sent: Friday, 18 August 2006 7:45 p.m.
To: jaking@es.co.nz
Subject: RE: Need help on 940 Wires

Jeff, after seeing your documentation on the 940 I thought I'd send you a note and see if you could help me out.

I picked up a used 940 and appears whoever had it before me had replaced several connectors inside the unit with direct solder connections. (yes a mess).

Question. On the Speaker/internal switch unit (left front top with cover top off) there are 3 connectors that plug into the right side of the unit. One has three wires, red orange and black. All three of mine are disconnected and I cannot tell which connector terminal on the PCB to re-solder them too. (your wires would be in a connector)

I don't have another unit to reference and cannot find any pictures. do you have any pictures or 940's with the tops off could you let me know in what order front to rear the three wires are in your connector? (Of the three connectors on the right side facing the unit this is the connector towards the rear of the unit and only connector on that board with just three wires) Crazy question I know. …….

Any thoughts or help or pictures would be greatly appreciated.

thanks 73 - John (W5EJ)

From: jaking [mailto:jaking@es.co.nz]
Sent: Monday, 21 August 2006 8:59 a.m.
To: 'jwill@verizon.net'
Subject: RE: Need help on 940 Wires

John,

I don't have a TS-940 apart right now. But it is easy enough to figure out. Down load a service manual from www.mods.dk

Then on page 103 overall schematic, find those connections.
You may have to look at board layout middle of p 102 to identify the connector number and wire letter. Looks like connectors 48 29 and 30. You will see the letters for each number there.

Then find the same places on the schematic p 103.

Follow the wires through on the schematic to see which board and connector they end on another board.

Find that other connector inside the radio, and get the colour of the wire from where it connects to the other board.

Then use a multi meter to verify you have the same wire at both ends. You would be best to un-plug the other end connector, before measuring continuity, because that way you are 100% you are only measuring on that wire only.

Then you can reconnect.

There is no color coding in the manual so this is the only way to decode the wire colours.

For example ON PAGE 103 YOU WILL FIND 48 LG appears to connect to Switch L-49-LG

Or 28 CV1 connects to IF board 14-CV1

So find IF board 14-CV1, on the IF board and you will get the colour of that wire there. Un plug IF board 14-CV1, and use the meter to verify you have the same wire.

This decoding systems works right through all 940 connections.

Let me know how you get on.
73s
Jeff ZL4AI

From: W5EJ
Sent: Sunday, 20 August 2006 6:41 p.m.
To: jaking@es.co.nz
Subject: Re: RE: Need help on 940 Wires

Took your advise and downloaded the manual, had the unit fixed in 30 minutes. Thanks for the help - John

HOW TO FIND FAULTS AND FIX THE RADIO

I was initially lost about what and how to look for faults. Developed the following methodology. (All suggestions about repair methodology are welcome)

Step 1 is to download a service manual
www.mods.dk

Step 2: Read how radio works.
Read though the receiver and transmitter written explanations, and then follow those paths through on the circuit diagrams.
Easiest way to follow through is photocopy circuit pages and get a highlighter and highlight those paths on the circuits.
Only then you get feeling for where you look to find a particular fault.

Step 3:
Find the region of the radio responsible for the function causing your fault,
And locate that on the main wiring diagrams and detailed wiring diagrams.
Then progressively check every connection and component.
That is slow and tedious.
Write down every check you made.
By a process of logical and elimination you will find the fault.
It may take days or weeks, but if you are methodical you will find the fault.

Step 4:
In suspect region:

- Do go over and tighten all connectors. These white plugs have metal female clamps which get stretched open after many insertions. For each pin you need to take each connector out of the plastic sleeve and clamp it more closed with small pliers. [Female outers are only designed for so many insertions. After that they just become loose]

- Re-solder regions of boards where suspect components are located.

I would guess this would fix 80% of ts-940 faults, because the connectors and solder joints are the weak point of 940s

Step 6:
Using a digital volt meter continuity checker, verify all suspect connections are connected both inside and across boards.
(You can make your own RF volt meter for a couple of dollars by following articles in the ARRL Hand book.)

Step 7:
If you can locate replacement board for the suspect region and try that that will get fault absolutely defined to that board.
The fastest way and possibly cheapest way to fix is probably by elimination

All boards on the 940 are plug and play. When you put in replacement boards there are service adjustments to make afterwards , before seriously using the radio. But if the board is defective you can replace it and the radio should spring back to life.

For example your can buy a PLL and / or Digital A Board on EBay for between $50 and $100 each.

If you have problem in these regions I would suggest you buy, plug and play to eliminate if it is any of these boards.

You can always sell the boards you don't need again afterwards.

You can also probably sell your defective board as well for the parts on it. [Those parts are valuable to others]

Max cost is one board, plus postage plus eBay fees.
A lot cheaper than sending the radio away, and waiting and waiting.

Step 8:
To find the fault, with radio running
- Mechanical connection fault find by tapping components with plastic non conducting object.

- Fault that occurs as radio heats up. Use Freeze spray to cool suspect regions. If fault reappears when cooled you have found the region.
- Use a hair dryer to heat up regions to see if you can make a fault appear or dis-appear,
- Use shields make of cardboard around suspect commonest to try and isolate the cooling or heating to just one of two suspect components,
- Use digital volt meter to verify correct voltages shown on circuit diagrams,
- -Use oscilloscope to verify correct patterns as shown on circuit diagrams

Step 9:
Progressively replace components in suspect regions. Except for programmed ICs, You can use alternative parts,
From
www.Mouser.com

Find parts description on parts list in service manual,
Or more detail at
www.kenwoodparats.com

If you are methodical,
make written notes of everything you do,
re-think about what functions you have verified are working,
re-read the service manual, re-checking your understanding,
you will fix the 940.

This maybe safer than the risk of damage during shipping.

RECEIVER PERFORMANCE IMPROVEMENTS.

R1. KENWOOD PRODUCED 3 SERVICES BULLETINS which do considerably improve the receiver.

AGC circuit improvement

http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=2d13f766bec08d9297b46280e3758b9b95e42da53ae01ebf6db6adb98b2ed832baa0aa033a297d15598713460b315fbb

http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=d02a8b1ae4c8a39115ff83f169f65a1895e42da53ae01ebf6db6adb98b2ed832baa0aa033a297d15598713460b315fbb

TS-940S Signal To Noise Ratio Improvement With Noise Blanker
http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=09b9d746891ed0281dcc8482861e53da08bf66aab282a3fe0ec52cce1a1412bab3177362513310ffd26e29ff6af16615

TS-940S VCO/Carrier To Noise Ratio Improvements
http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=57aa76a9447b3b37e1e9f60965f865a395e42da53ae01ebf6db6adb98b2ed832baa0aa033a297d15598713460b315fbb

http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=2e0ca5ad0e0e9060f7f850fe27f80b1a95e42da53ae01ebf6db6adb98b2ed832baa0aa033a297d15598713460b315fbb

http://www.kenwood.net/indexKenwood.cfm?do=DownloadFile&Document=55221dd570b7e465e5087cf67f5e71fa95e42da53ae01ebf6db6adb98b2ed832baa0aa033a297d15598713460b315fbb

KENWOOD TS-940S RECIPROCAL MIXING NOISE
In early March I [Rich Maher] talked to someone at International Radio regarding the reciprocal mixing noise problem with the Kenwood TS-940S. I had been in the process of installing the fix described in your newsletter (late 1986 issue) and found that it had already been installed on my TS-940S (S/N 7100269). The factory installation had one problem, the resistors used for R120/R129 were color coded for 900 ohm (close enough to the 1K in the newsletter), but in actuality measured 465 ohms. Apparently, Kenwood had gotten a bad batch of resistors from some supplier and had not discovered the problem.

At the time you indicated that was the first report you had received of the resistor value problem and recommended that I contact Kenwood. I called them and was told that they had not heard of the problem before. They also stated that a new fix for the reciprocal mixing noise problem had been developed and was described in a Service Bulletin dated March 2, l987. I requested a copy of the bulletin and have attached a copy of it to this letter for your information. (See Issue No. 76, Pg. 30 and 31 for Kenwood Service Bulletin No. 917 and schematics pertaining to this subject.)

Since receiving the bulletin from Kenwood, I have installed it on my TS-940S and found it to make a very significant improvement in weak signal handling in the presence of nearby strong signals. I would recommend highly that anyone experiencing reciprocal mixing problems install the new fix. It should be noted that some of the newer TS-940S have the fix installed. I was preparing to install the fix on a friends's TS-940 which had a serial number 100 lower than my own and found that the fix had been factory installed. Apparently, more than one manufacturing site is used and serial numbers are given to each in blocks. Consequently, it is possible for higher serial numbers to be produced at one location without the fix, while another site any have cut in the fix but is using numbers from a lower block.

The quickest way to verify whether the fix has been installed is to check R120 and R129 on the PLL Unit (X50-2020-00). If these two resistors are 3.3 ohms in value [*Editor correction Service Bulleting 917 says 3.3 Kilo-Ohms*], the fix is already installed. Do not depend on the on the absence of C176, C180 or C181 as an indication, as earlier attempts (factory or field) to correct the mixing noise problem may have removed these same capacitors. The instructions in the bulletin state that when making the modifications to the RF Unit (X44- 1660-00), it is easiest to move C132/C133 to the foil side of the board. As the component side of the section of the RF Unit containing these two capacitors has been filled with wax, it is definitely not easier. The factory installation of the fix left C132/C133 on the component side and installed the R154/C193 and R155/C194 series RC networks on the foil side. This is definitely easier. As a side note, the installation of the fix took me about 2 hours. Both the PLL Unit and RF Unit modifications must be completed before the transceiver is usable. If you install just the PLL Unit modifications and then try the receiver, CW signals will should like raw AC. Also, to make life simple, do not remove each of the boards above the PLL Unit individually. The easy way to gain access to the PLL Unit is to remove the top two screws (one on each side) holding the front panel and loosen the bottom tow screws. This allows the front panel to be tilted forward. The speaker assembly and all the boards above the PLL unit may then be removed as a unit by removing only 4 screws and tilting this unit towards the front of the TS-940S. No cables need be removed from the boards above the PLL Unit.

I hope the above information is helpful to you in dealing with the reciprocal mixing noise problem. (Thanks, Rich Maher, WZ4Z, 1117 NW 7th St., Boynton Beach, FL 33435)

RECEIVER 2. FIELD EFFECT TRANSISTORS AROUND THE WRONG WAY.

In September 2004 PY1NR announced he had discovered:

- on RF board Preamp Q10 and
- on the IF board 2nd balanced mixer Q4,

had been drawn on the circuit boards and mounted in the reverse orientation to that shown in the Kenwood Circuit Diagram.

See PY1NR web site www.guisard.com
and
http://www.eham.net/articles/9261

Initially ZL4AI found it hard to understand this website and actually what PY1NR had discovered. Starting with the circuit board layouts I tried to draw out the circuit: What I found was that apparently the FETS were mounted with the drain where the source was supposed to be and vice-versa.

As FETs normally allow current flow until the gate has a potential, I wonder if this really makes that much difference.

PY1NR suggest that reversing these transistors will provide 10 dB of gain. But this claim does not appear be based on before and after measurement. It would be useful to have some feedback on whether others have had much improvement by reversing the FETS.

Garey Barrell provides Kenwood's advice

```
========================================================== ============================
From: kenwood-bounces@mailman.qth.net [mailto:kenwood-bounces@mailman.qth.net] On Behalf Of Garey Barrell
Sent: Wednesday, 9 March 20055:53 a.m.
To: Kenwood@mailman.qth.net
Subject: Re: [Kenwood] RE:TS-940 What is the correct FET direction?
Jeff -
OK.....  Just in from Kenwood...
+++++++++++++++++++++++++++++++++++++++++++++++++++++
Dear Kenwood Customer:
This information pertains to the TS-940S component location.
The circuit designer said the installation of Q10 in the actual TS-940S transceiver is correct.
The PCB view in the Service Manual is correct too. The schematic is the only section that is in error. The schematic indicates the drain of one FET connected
to the source of the second FET. The correct installation is to have the source of one FET connected to the source of the second FET.
In addition, testing at Kenwood Communications in Long Beach, CA showed poor results. Sensitivity can become unstable. The most important point about the Q10
pair is that both FET's must be replaced at the same time (like a matched pair). Replacing only one FET at a time can affect sensitivity.
If you need further assistance, please e-mail us again.
Sincerely,
Kenwood Amateur Radio Customer Support
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
73, Garey - K4OAH
Atlanta
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From: Garey Barrell [k4oah@mindspring.com]
Sent: Friday, 11 March 2005 7:26 a.m.
To: jaking@es.co.nz
Subject: Re: [Kenwood] RE:TS-940 What is the correct FET direction?

Jeff -

OK. I just had a discussion via phone with the Amateur service department at Kenwood.

The Q4 situation is not quite as clear. The schematic appears to be correct, (sources tied together or push-pull,) and the board layout drawing appears to be incorrect. According to a tech in Japan, the FET's in the actual unit are correct. They have not found any instance where they were reversed in the actual radio or any 'in-house' docs that could have resulted in such an error. *I guess someone is going to have to open one up and look at the traces! Looking at the board traces in the component layout, it certainly appears that one FET has the Source and Drain connections reversed if the FETs are installed in the orientation shown. Perhaps the board traces were changed? [ZL4AI editor comment: Boards made exactly as shown in the Service Manual]*

The guys at Kenwood, both in LA and Japan, are pretty frustrated with the whole mess! They tried to duplicate the Q10 situation, and found that performance was degraded considerably when the PY1 "correction" was made. They also mentioned that replacing one of the pair was not recommended. The original circuit used a matched pair and they recommended replacing them only with a matched pair. They were unable to describe the "matching" process, but we surmised they selected for Idss, and possibly transconductance.

The big question is, these transceivers have been working and meeting specs for 15+ years, so who cares!? :-)

73, Garey - K4OAH

Atlanta
==

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-----Original Message-----
From: Traian Belinas [mailto:traian@deck.ro]
Sent: Tuesday, 5 April 2005 9:34 p.m.
To: jaking@es.co.nz
Subject: Re: Ts-940 All problems SOLVED .. Possibly for you too!

Hi Jeff,

The website is and will be great.
Will look carefully at.

I have two things to say.
First is that the second mixer Q4 JFET is indeed wrong mounted.
Here are attached pictures, you can use them on the website.
The PCB traces are symmetrical, the mixer should be balanced, and as the two
FETs are identical type, the way that they are mounted is obviously wrong.
As I said, I have reversed the Q4 and the improvement exist, but it is not
so great as other had reported (the sensitivity goes improved by 2 to 3 dB)
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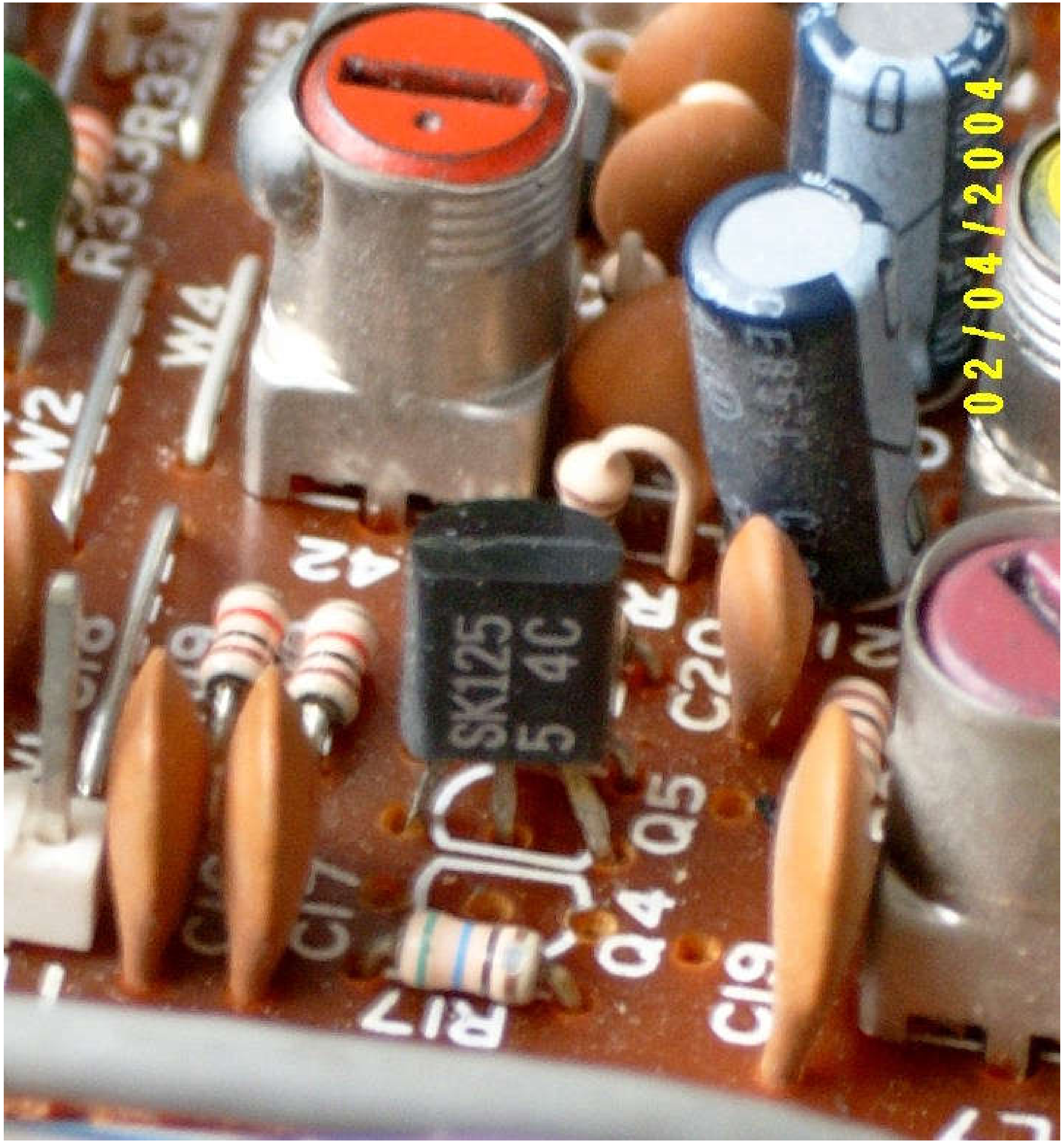
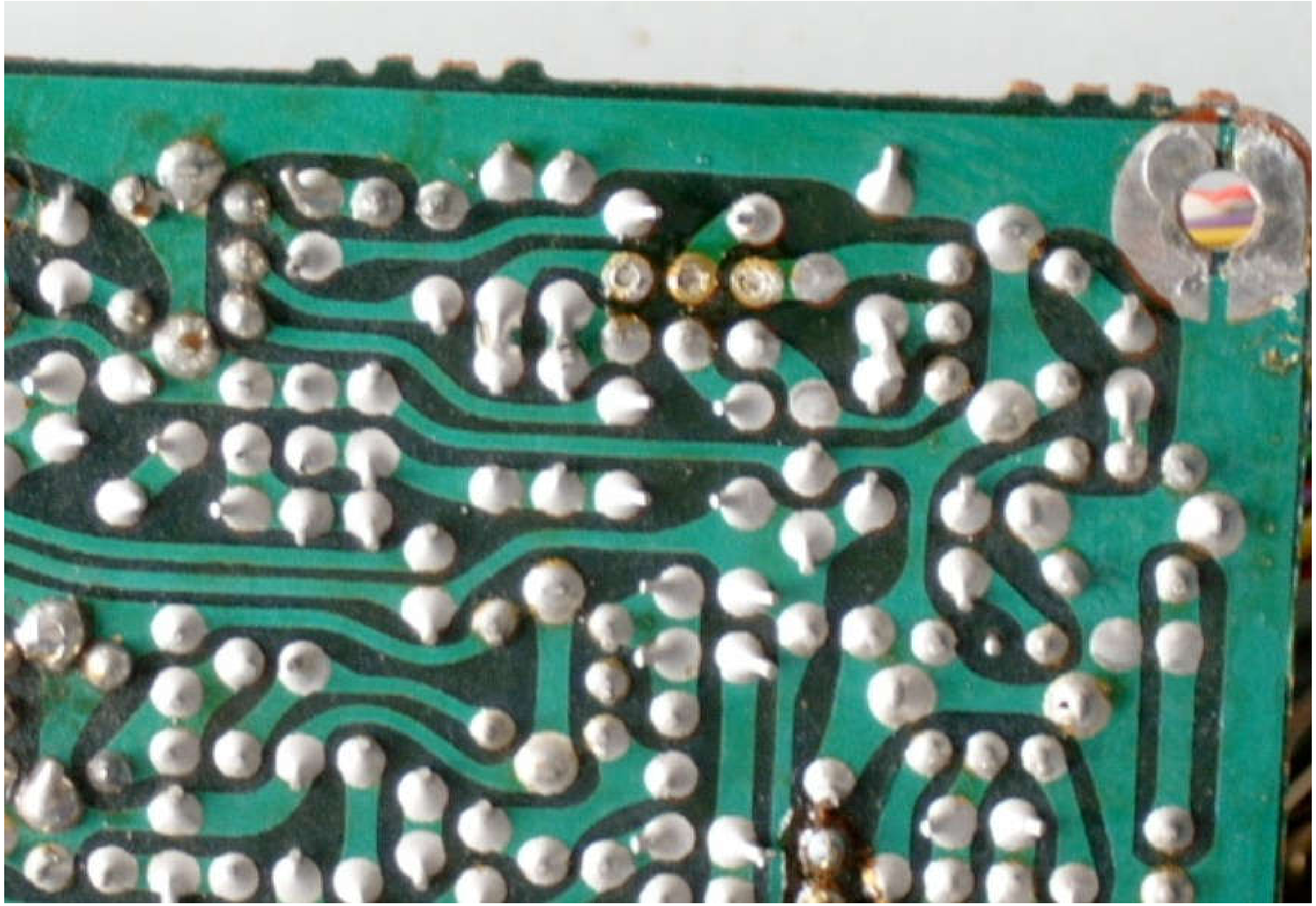
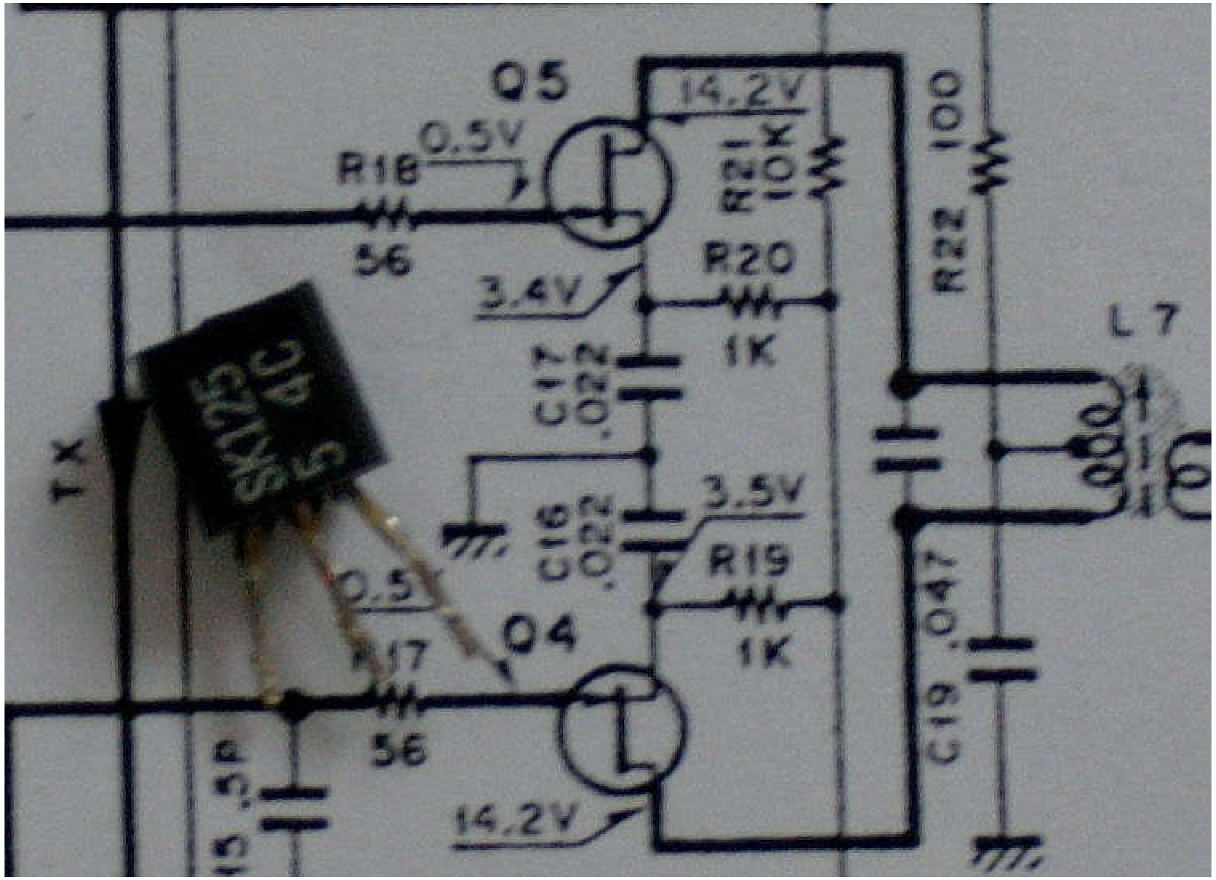

02/04/2004
SK125
5 4C
Q5
Q4
C17
C19
R17
W4
W2





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After reading Kenwood's Garey's and Traian's advice, I turned around only Q4 on the IF board.
The result was a quieter receiver. I do not believe that there was any significant gain increase in the receiver.
I would appreciate (and will post on this page) emails describing others experience regarding this change.

From Kenwood.net on 25/4/05

Hi Dale

I also became interested in the RX mod you mention. Before opening my 940, I decided to first check whether drain and source of the 2SK125 are symmetrical or not. This was easy for me because I own a "dead" 940 RF board as a source of parts for future repair of my rig.

I collected one of the 2SK125s from this board and built a source-grounded test configuration with a 5K resistor connecting drain to +8V. Then, I fed a sawtooth test signal (about -6 to -1V) via 10K into the gate. U(drain) was recorded against U(gate) on a DSO (Tek 468). Thereafter, I repeated the measurement with drain and source exchanged.

I obtained the characteristical FET response curves and these were exactly (!) identical in both configurations. This did not change when the test frequency was increased to 10 MHz. It seems, therefore, that the 2SK125 is symmetrical.

As a consequence, i decided not to correct the layout error in my 940.

Like others, I also believe that there is not much to improve. My 940 has an RX sensitivity of about 0.15 µV (10 dB S/N) on all bands (well, I must say it was worse until I re-aligned the entire RX). The IP3 is +18 dBm (I once replaced the band switching diodes by PIN diodes).

Like others, I often had connector problems after working in the 940 - another reason only to go into this rig when necessary.

Best 73,
Thomas (DF5KF)

THEN TRAIAN PROVIDES MORE OVERVIEW

-----Original Message-----
From: Traian Belinas [mailto:traian@deck.ro]
Sent: Friday, 29 April 2005 2:05 a.m.
To: jaking@es.co.nz
Subject: Re: FW: ts-940

Regarding the TS940 2SK125 preamp, yes the FETs have this interesting
feature: for low signal/low freq and/or low DC, they are symmetric. This is why they are used as passive variable low resistance/attenuator/switching for low signal with rather good results. The things are changing at HF/VHF amplifiers where the interelectrode capacitances became important (do you remember about neutralising a FET preamp?), and these are not quite symmetrical, as the devices are manufactured so that the drain to gate capacitance to be as low as possible for obtaining lower out to in feedback when used for common source applications... So, even if symmetrical, why to use it as for having the greatest unwanted out ot in capacitance/feedback? The gain obtained by inverting the D/S for the TS940 Q10 may be still not high (I don't intend to do it because of the reason explained before), but the engineering feel tell us that something is not ok there... And regarding the second mixer, there it is obvious that it is not ok, even if it works... An counterexample is also the TS950 (both SD and SDX) which use the same Rx preamp as the TS940 with 2SK125 and 2SK520 (they are all FET cascade preamps) but for the 950 it is actually build as shown in the diagram, no drain/source inverting there (maybe the same for their second mixer), so which of them is the best regarding this, the 940 or the 950?!

Please let me know if any other new info about the 940/950.

Tnx,
73,
Traian

PY1NR provides feedback and re-endorses previous statements on turning the FETs around
PY1NRFeedback

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] On Behalf Of John Rotondi

Sent: Friday, 17 March 2006 10:51 p.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] FET Reversal Fix Notes

Dear Fellow TS-940 users-

Just a quick post to let others know this information, which you can use as you see fit:

I have now fixed 2 TS-940SATs according to the findings of PY1NR who first detailed the reversal of 2 FETs in the TS-940, based on factory mistakes in the PCB silk-screening. After doing my own radio, I absolutely found a significant increase in received signal levels, with no audible increase in noise floor. I wondered why other users were not rushing to do the fix- and then saw several posts denying the validity of the fix. However, since I did not effectively document this in a scientific manner, I could not effectively offer valid 'proof' of the results.

When I mentioned this to one of my RACES group leaders- who also owns a TS-940- he decided that we would to do the 'fix' to his unit- but this time, we would document the results using a repeatable local test signal. The documented results: after each FET was reversed, we found a 1 S-unit improvement in received signal level using our local test signal in the 20 meter band, for a total of 2 S-units receive gain improvement.

Now, there is much conjecture regarding the dB value of S-units, and other TS-940 users may know what these 2 S-units on the TS-940 meter mean in terms of dB. Generally, from my research, each S-unit may represent 5 or 6 dB of signal, which means the fix has increased receive gain 10 to 12 db. Certainly nothing to sneeze at: being able to give one of the finest receivers made the full scope of RF gain that it was originally intended to have
- at no cost, and without negative repercussions? As the bands wane on the downside of the sunspot cycle, and running only a vertical 10 feet off the ground, I am finding I can use all the noise-free gain available to hear DX!

At any rate, this was my experience, which I humbly offer to the TS-940 user community.

Wishing you all good DX!
73,
John, WA2OOB
Ventura, CA

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On Mar 19, 2006, at 1:53 AM, Jeff King wrote:


John,
found your report very very interesting.
Despite all the controversy, some of which I have reported on
TS-940_02.htm

I would appreciate if you could you please confirm you turned one FET around, ran signal test, identified improvement 1 S unit and then Turned other FET
around and ran signal test, identified improvement 1 S unit?

You know it would be helpful if Kenwood would actually confirm their view of whether the FET in correct position results in too much gain.

hope to work you one day! and
73s
Yours sincerely
Jeff King zl4ai
```

From: John Rotondi, WA2OOB [mailto:wa2oob@earthlink.net]
Sent: Sunday, 19 March 2006 11:56 p.m.
To: jaking@es.co.nz
Subject: Re: [ts-940] FET Reversal Fix Notes

Hello Jeff!

Very nice to hear from you! Thank you for your interest in my posting on this topic.

I have seen your excellent website- thank you for providing such valuable information to the user community. I am still reading through all the information regarding PIN diodes, and may mod my radio in that area as well.

Just a bit on my background: I am a professional sound engineer, and have been designing/building/maintaining/operating professional music recording and TV/Film post production facilities for many years. When I first did the FET fix to my TS-940, the results were obvious to my ears. In doing the second radio with my friend, we systematically followed these steps to document the results relative to an external repeatable test signal, independent of band conditions, QSB, etc.:

1) Set up the signal source: my MFJ-259 antenna analyzer with whip antenna, to generate a signal near 14.200 MHz.
2) Set up the TS-940 with a small whip antenna on the work table, about 4 feet from the test source.
Note that the MFJ-259 RF test signal is fixed in level, so this would not be a variable in these tests.
3) Tuned the TS-940 to this test signal, peaking the carrier reception in USB mode, and recording the maximum S-meter reading.
Note that I moved the radio around a bit to ensure that the reading was stable and repeatable, and not sensitive to relative position.
4) Shut off the test source so as not to deplete the battery while working on the radio.
5) Reversed the first of the FETs, reinstalled it's PC board, installed the whip antenna, and positioned the radio as for the original measurement.
6) Powered up the test source, and tuned the TS-940 to it as before.
There was a full 1 S-unit increase in received signal level.
7) Shut off the test source.
8) Reversed the second of the FETs, reinstalled it's PC board, installed the whip antenna, and positioned the radio as for the original measurement.
9) Powered up the test source, and tuned the TS-940 to it as before.
There was now another full 1 S-unit increase in received signal level over the previous measurement, giving 2 full S-units total over the original base reading.

While this is probably not as sophisticated as if we would have used a Communications Monitor (IFR, Marconi, etc.) or other test system directly coupled to the receiver, with stepped calibrated attenuators, and RF voltmeters coupled to the IF of the TS-940, we felt that it would be a fast way to have valid empirical data to verify that we had created an improvement, rather than a disability, for the TS-940. BTW, post fix listening on air clearly showed the significant gain improvement.

In listening today on 10 meters on my own TS-940, I know that this additional gain has brought signals to the readable level that would otherwise have not been readable. I have also done extensive listening tests with extremely strong local broadcast signals to determine if this fix has compromised rejection of extraordinarily strong out-of-band signals, or has resulted in compromised receive RF or audio intermod or other non-linearities resulting from component saturation, imbalance, or interstage distortion- but have heard no such issues. I will mention that my recently purchased IC-706 MK II (for mobile use), of more recent design and with some DSP, totally folds up from same broadcast interference that has no effect on the 940!
The 940 receive audio quality remains exemplary. I have been pleased with the results of the fix, and feel it was worth the effort to realize the full potential of the original design intent.

I can only think that some amateurs did not have the same results because perhaps the FETs were not closely enough matched to begin with, or they had other problems, such as bad solder joints as often found in these units?

I hope this information is helpful to you! And yes- it would be nice if Kenwood would enlighten us on these issues- but as the radio is not a current product, and did quite well even with this 'defect', they have little motivation to do so.

I will look forward to a QSO with you on HF!
73,
John , WA2OOB

Editors Note:
John has undertaken some very useful measurements and it is very useful to have some measurements.
Measurement outcomes could be more factual if a change in signal to noise ratio was measured by laboratory methods described by the ARRL. For example MDS.
http://p1k.arrl.org/~ehare/aria/ARIA_MANUAL_TESTING.pdf
http://www.arrl.org/~ehare/testproc/testproc.pdf
If someone could do an MDS noise floor test before and after the FET swap, it would be more complete evidence of the assumed improvement.

Garey Barrell sensibly advises:
Even a good test, i.e., s+n / n measurements before and after, or _accurate_ noise figure measurements really wouldn't impress me that much, since a receiver meeting the Kenwood specs would be limited by external noise regardless!

I suspect Garey is correct about the noise floor: This is a less than 0.2 microvolt receiver: Maybe turning the FETS around produces more noise, [which of course lifts the S meter] but does it produce any more signal or better signal to noise ratio?
If first before an FET swap the S meter was calibrated against a signal generator, then signal strength against independent signal source measured, then an MDS measured, then after the FET swap the s meter was again re-calibrated, then a reading of the independent signal sourceand separately MDS again would show that it was just not an increase in noise.
I wish Kenwood would behave like a responsible manufacturer and explain the technical reasons they do not recommend turning the FETs around.

Have a look at the following links which show how measuring receiver improvement is a difficult undertaking. Even definition of what you are measuring requires some considerable reading and comprehension.

http://www.sherweng.com/table.html

http://www.rac.ca/opsinfo/smeters.htm

http://www.seed-solutions.com/gregordy/Amateur%20Radio/Experimentation/SMeterBlues.htm

http://www.w8ji.com/receivers.htm

From: Bruce Bennett [mailto:maritimus49@yahoo.com]
Sent: Monday, 21 September 2009 12:49 p.m.
To: jaking@es.co.nz
Subject: Kenwood TS-940S questions

Hi Bruce
Answers are in text below.

Hello Mr. King -
I was hoping to get some advice from you concerning the 940. I am about to buy a 940SAT from a ham here in Indiana.
…… I am really looking forward to this as I have read for years about the great receiver and superb audio quality for both ham use and SWLing, which will be a big part of my use of the rig.
I am aware of the FET problem and I wanted to ask you about your opinions about my rig. The serial number is 8,2xx,xxx and I was wondering what you think about whether I should make an effort to change the installation of the two FETs.

I do not think not will make much difference. Cliff of Aavid the well know Kenwood repair expert only found 2 db. He is the only person I know who has used calibrated spectrum analyser to make the measurement. If you look at the function of an FET it is and on off valve like a water tap. It should function much the same no matter which way round it is.
I will soon do some tests now that I have a calibrated signal generator and spectrum analyser to prove what the real difference is.

I am confused about the potential effectiveness of this procedure. I saw something you wrote several years ago in which it appeared that there was little difference in gain after the leads were changed. However, there was also a test engineer who achieved about 5-6 db increase in gain with each FET making an impressive 2 S unit increase in gain.

6dB = 1 S Unit

In this time of poor propagation I imagine that could make a significant difference in being able to copy weak signals, DX or otherwise.

Yes but if you buy or make an outboard before radio pre-amp you could add 20 dB difference much more easily. Good pre-amps are not that expensive.

I would very much appreciate your comments about this. I should tell you that I was close to buying an Icom 746Pro for about the same amount that I paid for the 940. However, I really like the pre-DSP design of the Kenwood and the way that it operates, the smooth tuning and that wonderful audio. One owner said that the way it sounded for AM shortwave listening was wonderful.

You can add DSP at the outlet end and it helps alot.

That decided it for me. Frankly, I also like the "bigness" of it. It is very enjoyable to sit down to a large rig that looks like it is ready for serious operating.

73,
Bruce Bennett K6RQR/9
Bloomington, Indiana

p.s. If there is anything else that you think I should be aware of concerning the operation of my 940 I would be glad to hear it.

If I find anything else I will publish it when found.

I did a calibrated minimum discernable signal test on my 20 Million 940 last year.
ON 20 meters
SSB it measured 134 dB
CW with AF tune, peaked, measured 142 dB

My 20 mil 940 has no extra CW filters.

ARRL test on a 5 mill with CW filters engaged gave only 138 dB

Much is made of ARRL tests, but unfortunately they do not specify which filters or mode was engaged for the test. This makes a huge difference to the result. The ARRL TS-950 and TS-950SDX tests were done different filter combinations. Hence they are incomparable. Yet many Ham buyers (like I once) did place far too much weight on that one test result when making their decision.

If you look at Sherwood Engineering's site you will see variability between various similar models. I suggest you do a MDS to verify your radio is operating to spec.

Then if there is a problem you can work your way through the receiver flow path to identify where performance drops off. All you need to the test is a signal generator, a step attenuator and an AC volt meter cable of resolving at 2 KHz or less. Be aware that most cheap volt meters will only measure AC to 400 HZ and hance cannot be used.

The suspicion without any measured evidence I hold is that those capacitors are 20 years old now and some may have deteriorated, and replacement may on some radios improve receiver performance by returning it to specification.

Hope this helps
Yours sincerely
Jeff King

RECEIVER 3. THERE IS NO AGC TIMING CORRECTION

Short (Simple) Version of What you need to verify on your TS-940 is the next 5 lines

Leave R 149 and R 150 in their original positions.

With the radio upside down and the front facing you,
R149 is on the right of the pair and should be 150K or 68K.
R150 is on the left of the pair and should be 2.2 meg.

If you want to upgrade (the way Kenwood changed the Service Manual), change R149 to 150K.

Thanks to Dennis WB8WTU who suggested a short Version of what to verify.

Now
If you are interested in the history of this Verification read the rest of this Section 3,
If you are NOT interested in the history of this Verification go to Section 4.

===

This R149, R150 issue was first discovered in about 1986, and is mentioned in International Radios Bulletins

STOP: This modification was suggested following Kenwood Japan's advice, that
"The I.F circuit diagram was correct and the I.F. board was labelled incorrectly."
Communications_1_2_with_Kenwood_Japan

Kenwood Japan have now changed their mind and confirmed
"The I.F circuit diagram is incorrect.
Communication 3 with Kenwood Japan

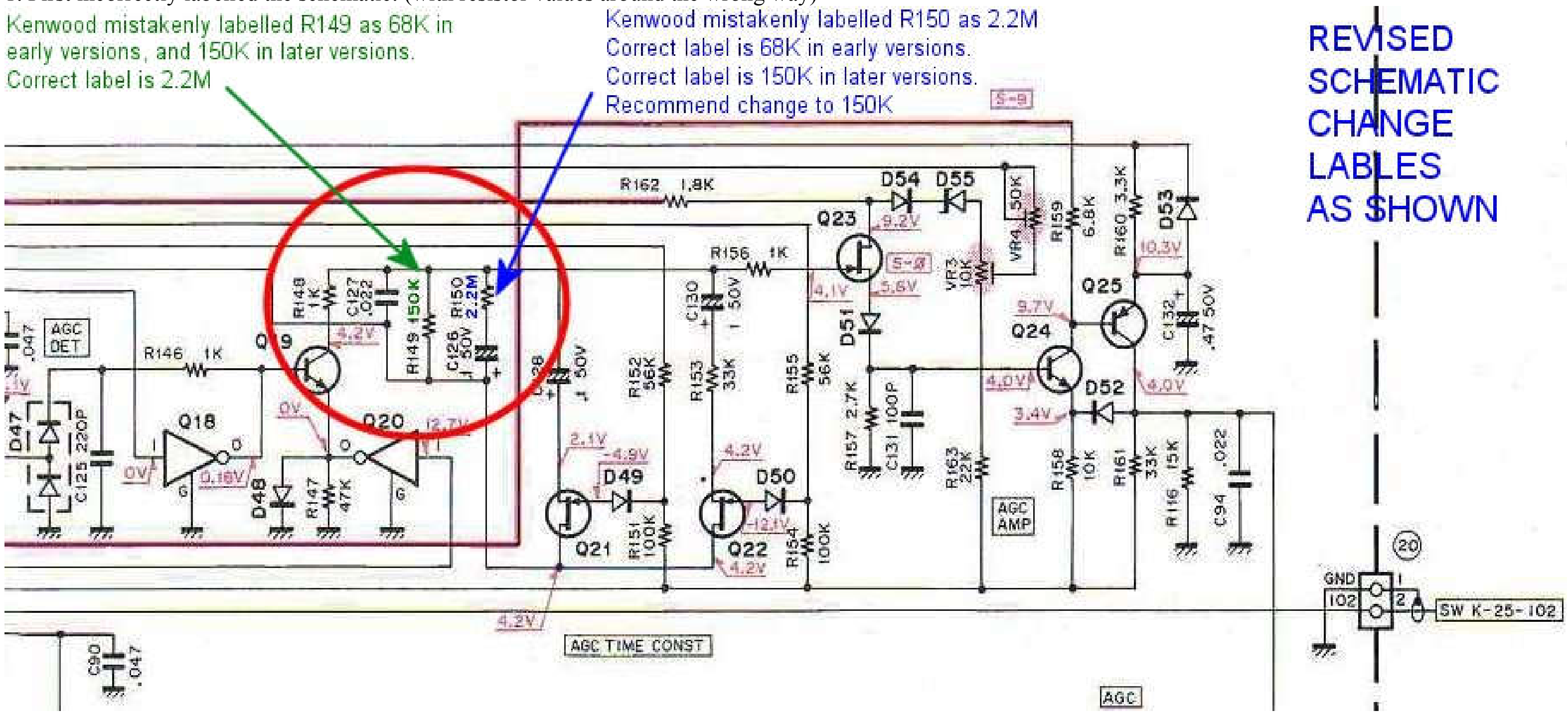
Swapping R149 and R150 probably increases sensitivity to similar degree as achieved by just turning the AGC off

Please review KI4NR's email below advising the (Kenwood intended) correct construction was electrical layout of the AGC identical to the TS-930.
KI4NR_email
KI4NR advises the rising S meter caused is leaking in C128 and C130. On the Editors radio C128 has been replaced and does not fix the rising S meter.
When time permits C130 [and / or other AGC capacitors] will be replaced and when replacement has been shown to remove the rising S meter this web page will be updated to confirm that. At that time this section of the web page will be restructured to separate communications about IF circuit diagram from the rising S meter problem.

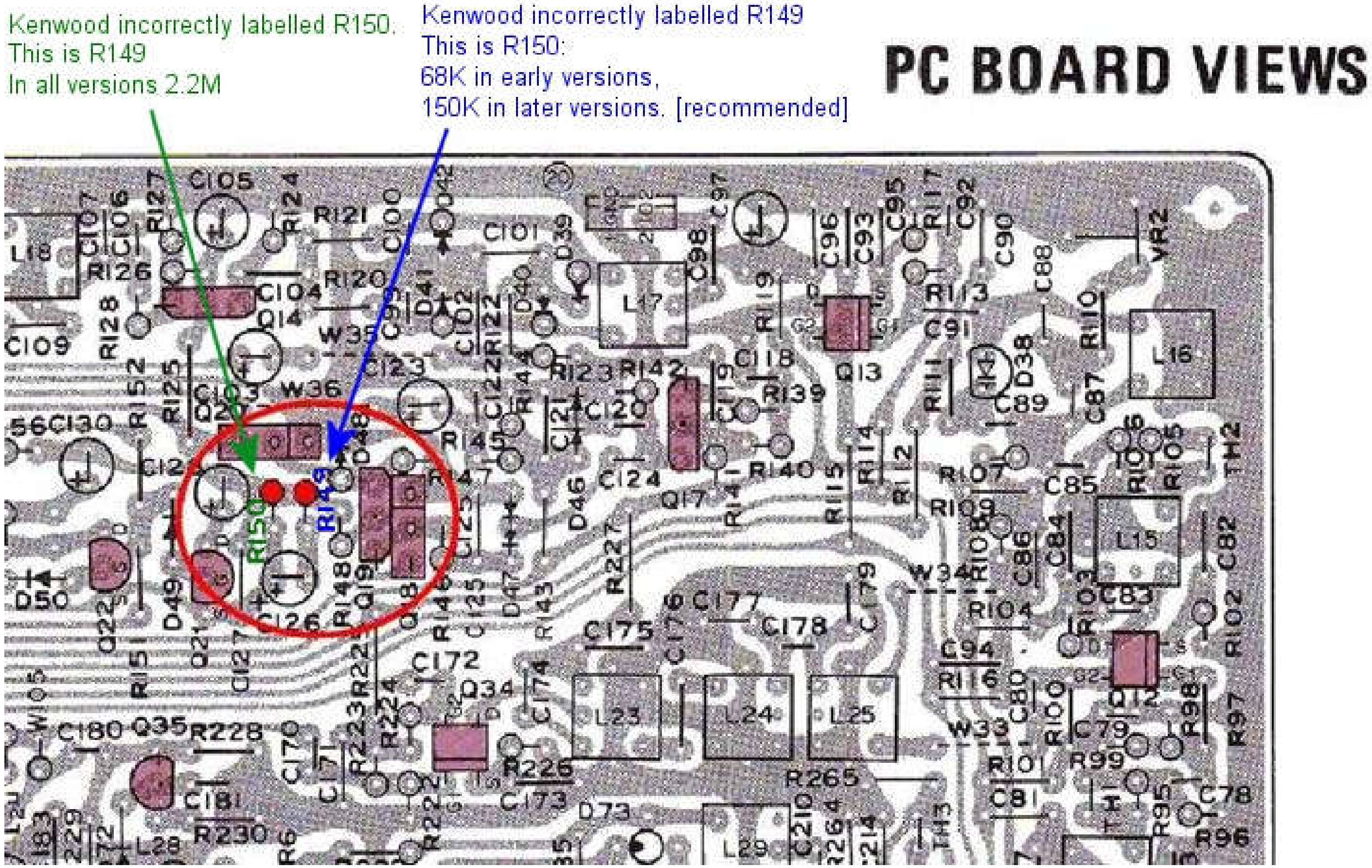
SUMMARY OF R149 AND R150 MIS-LABELLING

Kenwood appears to have done the following: **Please note there are 2 mistakes.**

1. First incorrectly labelled the schematic: (with resistor values around the wrong way)



2. Then incorrectly labelled the PC board [to correct the mistakes on the schematic] so correct resister values put in circuit.
(For example the position of R150 was labelled as R149 on the PC Board, which resulted in a 150K resistor being put at the R150 position.)



Areas in grey below should be disregarded.

Significantly improves the AGC timing function: After modification:
- You hear weak signals a lot better.
- S meter with AGC SLOW ON becomes quite responsive and lively in the region of S1 to S4 signals.
--Before S meter did not move much in S1 to S4 region.
--Before it would take a strong signal to lift the meter suddenly to S4.

I always wondered why the TS-940 behaved differently to other transceivers [TS-930S, TS950SDX] which react much faster over S1 to S4.

Mike KC8ZNW on 25/4/05 describes this same behaviour to the Kenwood.net.

Hello everyone I have a question about the movement of my 940's meter. It seems that it barely moves on some signals which are perfectly readable, other sigs give me 8 or 9 and I have even heard an occasional 10DB+ movement. My TS830S will give me a 2 or 3 s-unit increase when I switch the antenna to it for the same signal.
Is this an effect of the sensitivity of the receive section? Or do I have a malfunction? In addition my VFO exhibits the occasional hiccup on the last 2 digits on small movements of the knob. I understand this may be caused by solder joints.
TIA, Mike KC8ZNW

Executive Summary of AGC Mod

Its easy to modify a TS-940S to hear better (or as well as) a TS-950SDX.
When fixed, TS-940 really pulls out those very weak signals.
Simply swapping 2 resistors around, will enable this rig to hear as Kenwood designed and intended in Kenwood's original circuit diagram.

The error is on the IF board:
Kenwood printed labels for R149 and R150 around the wrong way!!!
As assembled by the factory, (the outcome is) in the main signal path, a 2,200 Kilo-Ohm resistor ends up where a 150 Kilo-Ohm Resistor should be.
Being 14 times larger the 2,200 Kilo-Ohm resistor (incorrectly) significantly degrades the signal.
Swap the resistors around and the receiver hearing improves significantly!!!

Kenwood have confirmed the resistors are in the wrong place. Their emails are below:
Probably "these resistors in the wrong place" occurs in every TS-940S produced.

Independent Feedback on how Receiver Improves

1.
From: Ed [mailto:ca.urso2@verizon.net]
Sent: Monday, 23 May 2005 7:18 a.m.
To: jaking@es.co.nz
Subject: TS-940S

Also, your AGC Timing Correction was applied on my rig (SN 806XXXX) and worked great! Sure enough, resistors R149 (68K on my equip) and R150 2.2Meg had been incorrectly installed by the Mfr. The board markings for those resistors were wrong.

73,
Ed Alves KD6EU
USA

Full email at: FeedbacK_3

2.
From: el34guy@aol.com [mailto:el34guy@aol.com]
Sent: Thursday, 23 June 2005 4:46 p.m.
To: jaking@es.co.nz
Subject: agc modification
Hi Jeff,
I was looking through the 940 page and found my feedback to you(regarding the AGC modification with resistors 149 and 150) under the alc setting portion. Im sure I mislabeled my original email to you on this(think *I wrote alc*). I am having some luck with changing out the 2.2 meg for a 1 meg resistor. Im thinking maybe a little lower value might be worthwhile to test also, like a 6-800k ohm value.
I know I received another email from you on this but I just wanted to let you know it looked like my feedback was in the wrong spot on your page.

-----Original Message-----
From: el34guy@aol.com [mailto:el34guy@aol.com]
Sent: Sunday, 12 June 2005 9:43 p.m.
To: jaking@es.co.nz
Subject: Re: alc mod
Jeff
I thought that mod might be a little better than it was for the alc. It made my radio appear as if it was in fast agc mode all the time. There wasnt a lot of smoothness in the ssb signal that Im used to. Like I said, maybe something like a 1.1 meg is worth considering in there. There isnt much room to solder at all in there. Geez, its tight.
73
Mark

[Editors Note: ZL4AI questions the validity of these observations but has included them to keep feedback information unbiased. Varying the resistors from Kenwoods values was never recommended or intended. With resistors changed around on the Editors 940 AGC slow is still very much slower than AGC fast.]

3.
-----Original Message-----
From: Michael Feryok II [mailto:mikeferyok@yahoo.com]
Sent: Saturday, 9 July 2005 9:57 a.m.
To: jaking@es.co.nz
Subject: AGC Mod

Hey Jeff,
Thanks so much for your TS940 page it helped a co-worker and I today to swap the R149-150 resistors for the AGC mod. Very apparent improvement in noise level and gain. I can hear stations that are buried into the noise floor now. Mike, KC8ZNW

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** mikeferyok
Sent: Saturday, 9 July 2005 9:53 a.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] AGC mod works great!!

My friend and I did the R149-R150 swap and it improved the gain and

noise level. Adjusted the VR3 for a proper zero on the meter and
worked LZ1YE and YV5YMA right after on 17 meters!
Very low noise compared to before the swap. I highly recommend it.
Thanks to everyone here, and Jeff ZL4AI, Mike KC8ZNW
I'm still debating the transistor gain swap.....????

4.
From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** Dale
Sent: Tuesday, 12 July 2005 5:37 a.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] Re: AGC mod works great!!

Hello Mike, I'm having both mods done to my 940 now and I hope the out come is like yours. I'll post after I get my 940 back and let everyone know how it goes. I have a very late model serial number which is 20700050 and it still had both mistakes in it, so I hope this will improve on the already great recieve on the 940. 73 and enjoy your improved TS-940S. Dale, KD5UVV

--- In ts-940@yahoogroups.com, "mikeferyok" <mikeferyok@y...> wrote:
> My friend and I did the R149-R150 swap and it improved the gain and
> noise level. Adjusted the VR3 for a proper zero on the meter and
> worked LZ1YE and YV5YMA right after on 17 meters!
> Very low noise compared to before the swap. I highly recommend it.
> Thanks to everyone here, and Jeff ZL4AI, Mike KC8ZNW
> I'm still debating the transistor gain swap.....????

5.
-----Original Message-----
From: Articles@eham.net [mailto:Articles@eham.net]
Sent: Sunday, 24 July 2005 3:52 p.m.
To: jaking@es.co.nz
Subject: [Articles] Improve TS-940 Receiver for Weak Signals

Posted By KB9IV
Well I finally got around to the AGC mod. What a fantastic difference.........it also improves CW to my ears. In addition the AGC mod also seems to improve useable weak sensitivity and decreases distortion.
Forget the "FET reverse" project. NO difference here, it's not worth the risk and time.
Best 73,
Bill KB9IV

-----Original Message-----
From: Bill & Becky [mailto:wmarvin@hickorytech.net]
Sent: Sunday, 24 July 2005 4:00 p.m.
To: jaking@es.co.nz
Subject: 940 AGC Change

Hello Jeff,

Thank you for the info on the "AGC" correction. What a fantastic difference here!!
Makes a good 940 a great 940........I can now hear much better not. I found the FET reversal change useless...........not worth the bother.

Have a Great Day!!

73
Bill KB9IV ....Minnesota

6.
http://www.eham.net/articles/11090

7.
-----Original Message-----
From: John [mailto:hydroaction@cfl.rr.com]
Sent: Friday, 29 July 2005 4:03 a.m.
To: jaking@es.co.nz
Subject: Your 940 observations

Jeff

I appreciate your efforts on the 940. I have to say the AGC deal is not quite right. I have work on more 940 that I can remember. I have known for years the silk screening of the numbers on the circuit board is wrong. but the resistor placement on the board is correct. also the service manual is wrong on the schematic. The 2.2 Meg ohm resistor is in parallel with C-127 .....the 68K or 150K resistor is in series with C-126 which give you the base line time constant when AGC switch is in the fast postion. This is the CORRECT arrangement. Also if you look at the TS -930 that has the identical AGC circuit this is how it is on that radio too. The reason why you get the AGC rise when the radio has been sitting is the Capacitors are leaky and by swapping the resistors around helps correct that problem. I have had 940's have the rising S meter problem and changing and the caps C128, C130 in the AGC fixed it. This circuit is a Hi impedance type with FET very sensitive and crazy things happen. I have check many, many 940 I have repaired new and old serial numbers and have not found one yet that had the resistors in wrong. Look at the TS-930 schematic to see what I am taking about.

73 John KI4NR

Editors note:
On the TS-930 signal board the equivalent AGC resistors to R150 and R149 are:
R730 2.2M
and
R710 68K

-----Original Message-----
From: LPC Wireless, KI4NR [mailto:lpcwireless@cfl.rr.com]
Sent: Friday, 29 July 2005 5:39 a.m.
To: jaking@es.co.nz
Subject: More Info ... Your 940 observations

Jeff

I forget to add something. When you swap the resistors around. you are putting the 2.2 Meg ohm in series with C-126. this effectively removes the Base line time constant to all AGC positions on the switch including AM even thou the switch does not function there. That why people say the meter is more jumpy. plus the 150 K or 68 K bias the gate of Q23 more heavy and allows the receiver to stay more sensitive to low level signals. if you look at the TS-930 schematic this is the correct circuit in every way and the way Kenwood intended it to work and how the 940 is

One other thing .....on all the older 940 4, 5 and early 6 mil serial number ...the IF board is different. The gain distribution in not the same. All the 940 ... late 6 and newer had better IF boards. They have more gain TX & RX the radio are hotter sensitivity wise, better AGC compression. I use a 5 mil TS 940 with a later model 8 Mil IF board in it ....much , much better !!

Also Kenwood put an S meter slam mod in those boards. all the older 940 when you shut the radio off, pin the S meter over. The newer boards are fix for that.

8.
From: Jeff King [mailto:jaking@es.co.nz]
Sent: Monday, 1 August 2005 8:01 a.m.
To: 'css@kenwood.co.jp'
Cc: 'lpcwireless@cfl.rr.com'
Subject: RE RE: Is your advice Correct about TS-940 R149 and R 150: being in wrong places???

Dear Mr T.Soranaka

Thank you so much for your 2 emails sent in March 2005 [attached as below].
COMMUNICATIONS_WITH_KENWOOD_JAPAN About R149 & R150
From your advice I understood:

“The I.F circuit diagram is correct about positions of R150 and R 149 and the I.F. board is labelled incorrectly.”

Because your advice was valuable I recorded this to a small web page:
TS-940_02.htm
This has been seen by some TS-940 enthusiasts. It enables one to adjust a TS-940 to operate as (you advised) Kenwood designers really intended.

A very experienced Kenwood repair expert from the USA very strongly suggests your advice may not be correct. The reasons he states sound correct and are very convincing: Those reasons are summarised below.

With the greatest of respect to Kenwood Corporation and yourself I ask please:
Could you please review your advice and advise again if R150 and R149 on the IF Board should be swapped around to make the TS-940 to operate as Kenwood designers really intended?

==
30 July 2005:
Abbreviated summary of key points in Emails from KI4NR Kenwood Repair Expert in USA

When R149 and R150 are swapped around the AGC does not function as Kenwood intended.

- The service manual is wrong on the schematic.
- The silk screening of numbers on the circuit board are reversed to the schematic and wrong in relation to the schematic (only).
- But the resulting resistor placement on the board is correct.

I believe the silk screening on the 940 IF board is correct and the IF schematic is wrong.

The 2.2 Meg ohm resistor is in parallel with C-127 .....the 68K or 150K resistor is in series with C-126 which gives the base line time constant when AGC switch is in the fast position. This is the CORRECT arrangement.

The 2.2 meg ohm resistors in both the TS-930 and TS-940 sets up the bias to the FET from the 3.2 volt AGC reference voltage. The 68k or 150k in series with the Cap set up the base time constant. The other FET switch in for slow AGC on SSB and Fixed AGC on AM.

Also if you look at the TS-930 (both schematic and signal board) that has the almost identical AGC circuit.
(R730 2.2M and R710 68K, are the equivalent resistors on the TS-930.) The TS-930 is the correct circuit in every way and the way Kenwood intended "the AGC of the TS-940" to work.

When you swap R149 and R150 around. you are putting the 2.2 Meg ohm in series with C-126.
This effectively removes the Base line time constant to all AGC positions on the switch including AM even thou the switch does not function there. That is why people say the meter is more jumpy. Plus the 150K or 68K bias the gate of Q23 more heavy and allows the receiver to stay more sensitive to low level signals.

73 John KI4NR

LPC Wireless
lpcwireless@cfl.rr.com
Phone: 386-774-9921

==

Mr T.Soranaka I look forward to receiving your advice.

Yours sincerely
Jeff King

9.
-----Original Message-----
From: Customer Service Section [mailto:css@kenwood.co.jp]
Sent: Tuesday, 2 August 2005 6:01 p.m.
To: jaking@es.co.nz
Subject: Re: RE RE: Is your advice Correct about TS-940 R149 and R 150: being in wrong places???

Dear Mr.King,

Please accept my apologies for having supplied incorrect information.
A very experienced Kenwood repair expert from the USA is right.
The service manual is wrong on the schematic.

Yours sincerely,

T.Soranaka
++++++++++++++++++++++++++++
Customer Support Center
Kenwood Corporation
(Japan)
URL: http://www.kenwood.com/
Email: css@kenwood.co.jp
++++++++++++++++++++++++++++

10.
From: John Brush [mailto:brushj@comcast.net]
Sent: Monday, 12 September 2005 2:29 p.m.
To: jaking@es.co.nz
Subject: TS-940S R149/R150 More Info

Jeff,

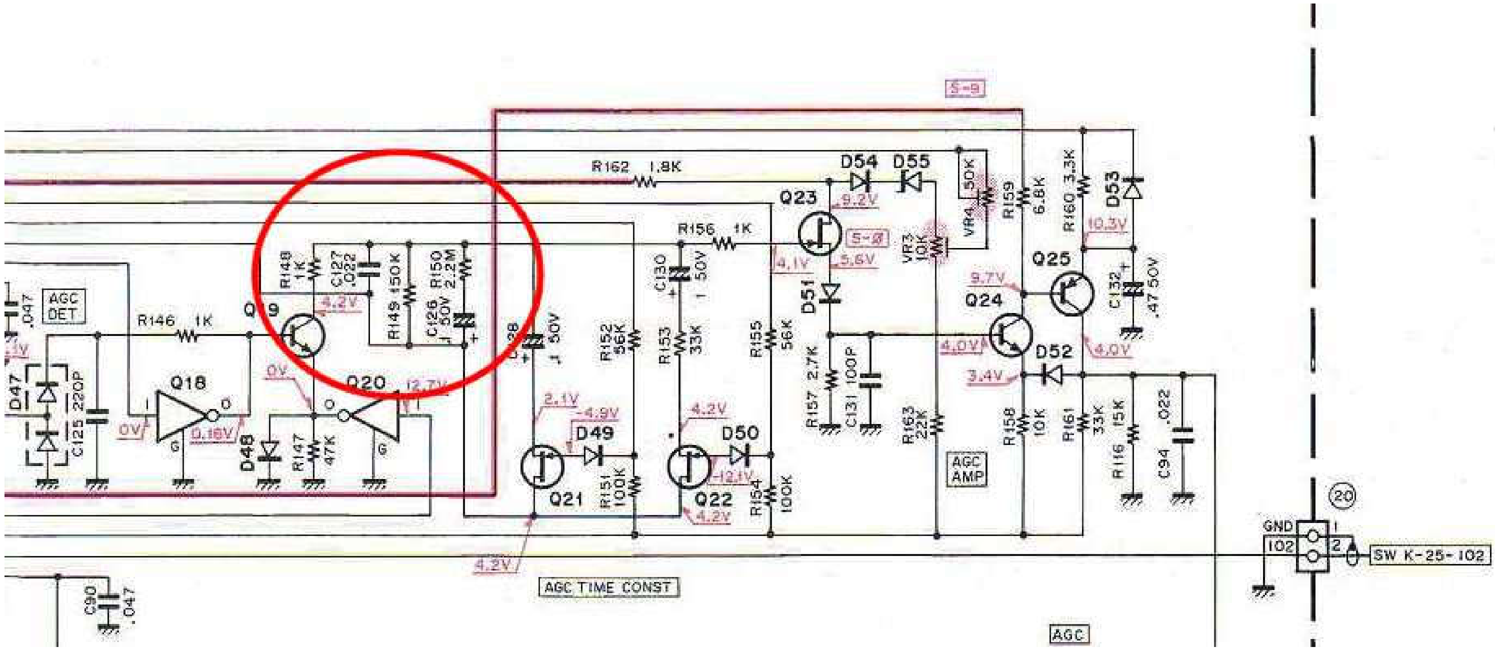
I absolutely agree with the comments made by John KI4NR. A rising S-meter reading is due to a leaking capacitor, and not the incorrect placement of R149/R150. In my case, I did the resistor swap and noticed that the S-meter's response was the same for both the AGC's Fast and Slow positions – not good. After undoing the resistor swap, I now had the rising S-meter problem (a problem I didn't have before the modification). In my case, the problem was resolved by replacing C126, the capacitor that is in series with R150 (2.2M) as shown on the schematic. Per John's advice, I also plan on replacing C128 and C130.

I must have one of those old IF boards, because my S-meter pegs when I turn the radio off.

73, John (WA3CAS)

THE PRODUCTION MISTAKE DESCRIBED:

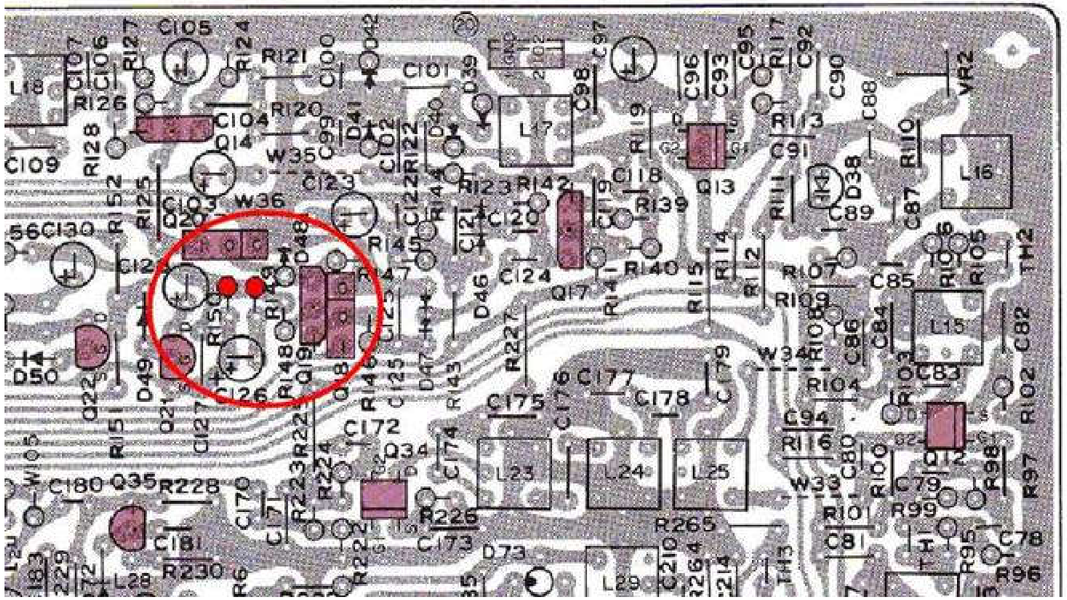
Below is Page 92 of the Revised Service Manual
Observe that:
- **-R 149 and R 150 are mounted between almost the same connections. I.e. between the junction of C127- R148 - C128 - C130 - R156 to-> C126 - Q21 - Q22**
- **-The difference being that "additional C 126" is between R150 and C126 - Q21 - Q22**



Below is page 93 of the Revised Service Manual

You will notice that R 149 is connected between C126 and the junction of C126 - Q21 - Q22. That is R149 has been mounted where R 150 should be.

PC BOARD VIEWS



Does putting the 2.2M ohm resistor where the 150 ohm Resistor should be make a difference. **Yes! You bet.** Change the 150 ohm back to the direct circuit and the AGC responds very quickly. [similar to the AGC in a TS-930]. AGC could not respond quickly before because it had to wait until C126 charged up.
This is in the heart of the AGC timing section.
Probably all TS-940s have R149 and R150 in the wrong place.
==

TO CHANGE THE RESISTORS

Change around is easy.
You will need to take the IF Board out.

The difficult part is removing and putting all the connectors off / on the board.
Before starting, draw a diagram of the board showing each connector and position and colour of its wires.
That makes it certain you put the right connectors back in the right places.
If you don't draw a diagram you will not know where all the connectors go back. Some two pin connectors could easily go in more than one place. That's could be disastrous
These colours are not shown in the service manual.

I suggest you put in new resistors, because with longer leads they will slightly easy to hold in place while soldering.

THE INITIAL PROBLEM SYMPTOMS:

ZL4AI discovered this while searching for the a fault described below
AGC:
Only happens in SSB:
If TS-940 left not running for a couple of days, when you turn it on, with the AGC turned off or set in fast position, then the meter needle goes to up 25db + 9 (approx). The signal is diminished like RF gain turned up. Over the next 25 minutes the meter needle slowly moves it way back to S0.
SSB in normal position, and TS-940 turned on this does not happen.
Needle is initially at s0.
During the first 25 minutes if you switch between off - fast - normal then the needle goes back to zero in less time ... say 20 minutes.
If TS-940 left for a couple of months, and then turned on same behaviour but worse.
Meter needle goes full scale right in all positions (off - fast - normal)
It takes longer say 40 minutes for the needle to move to the s0. then ts-940 functions as described above.
===

After R149 and R150 changed back to positions Kenwood intended in the circuit diagram, the result was:
-The fault of the rising S meter when cold disappeared.
- S meter dropped back to S1 on both AGC OFF and AGC SLOW, with no antenna signal. Needed to adjust VR3 to bring the S Meter to S0.

ACKNOWLEDGEMENTS TO PERSONS WHO HELPED SOLVE THIS

T.Soranaka Kenwood Japan was most helpful. You will see in the emails below Kenwood have readily confirmed that these components are around the wrong way. Then in a third communication (above) confirmed they are correctly installed.

Traian Belinas

traian@deck.ro
who diagnosed the problem and really understands these circuits. Traian appears to have amazing skill and after reading the symptoms pointed me to look at R149. From there it became obvious the circuit was not assembled according to the circuit diagram.

Garey Barrell
'k4oah@mindspring.com'
Who provide some very useful advice on functions of components and explanations how to read the circuit diagrams.
==

A CAUTION:

Not all IF boards are identical.
I installed another IF board installed as per factory spec with R149 and R 150 in their other components position in my TS-940. It did not have the rising S meter problem. But it was not sensitive to weak signals
==

COMMUNICATIONS WITH KENWOOD JAPAN BELOW:

-----Original Message-----
From: Customer Service Section [mailto:css@kenwood.co.jp]
Sent: Tuesday, 15 March 20057:11 p.m.
To: jaking@es.co.nz
Subject: Re: Question about TS-940 R149 and R 150: Appear to be in wrong places!
Dear Customer,
Thank you for your reply. I suppose that currently R149 and R150 are mounted correctly as the screen printing lettering R149 and R150 are reversed. Please confirm actual resistors comparing the circuit diagram. The circuit diagram is correct.
Yours sincerely,
T.Soranaka
++++++++++++++++++++++++++++
CustomerSupportCenter
Kenwood Corporation
(Japan)
URL: http://www.kenwood.com/
Email: css@kenwood.co.jp
++++++++++++++++++++++++++++

----- Original Message -----
From: Jeff King

To: 'Customer Service Section'
Cc: k4oah@mindspring.com ; traian@deck.ro ; Bill Bailey ; Ken McVie
Sent: Tuesday, March 15, 20051:53 PM
Subject: RE: Question about TS-940 R149 and R 150: Appear to be in wrong places!
Dear T.Soranaka
Thank you for your advice.
Could you please advise if it would be advisable to swap R149 with R 150 and vice versa, so the TS-940 functions in accordance with the circuit diagram?
Yours sincerely
Jeff King
-----Original Message-----
From: Customer Service Section [mailto:css@kenwood.co.jp]
Sent: Monday, 14 March 200510:29 p.m.
To: jaking@es.co.nz
Cc: kcc-amateur@kenwoodusa.com; sabura.tech@kenwood.com.au
Subject: Re: Question about TS-940 R149 and R 150: Appear to be in wrong places!
Dear Customer,
We are sorry for inconvnience. I have checked with our communication department as to R149 and R150. Unfortunately reference number of R149 and R150 on the borad are reversed. R150 and R149 are 2.2M and 68K or 150K respectively as shown in the Service Manual.
Yours sincerely,
T.Soranaka
+++++++++++++++++++++++++++
CustomerSupportCenter
Kenwood Corporation
(Japan)
URL: http://www.kenwood.com/
Email: css@kenwood.co.jp
+++++++++++++++++++++++++++

----- Original Message -----
From: Jeff King
To: css@kenwood.co.jp ; kcc-amateur@kenwoodusa.com ; sabura.tech@kenwood.com.au
Cc: k4oah@mindspring.com ; traian@deck.ro ; Bill Bailey ; Ken McVie
Sent: Saturday, March 12, 20056:41 AM
Subject: Question about TS-940 R149 and R 150: Appear to be in wrong places!
Dear Kenwood Customers Services,
I have found that when emailing Kenwood USA about a Kenwood USA product I got redirected to contact a Kenwood representative close to my home location. I am not sure who is best to send this to. So I am sending it onto to all Kenwood contacts.
Thank you for your recent replies.
While trying to find a fault in my TS-940 I have been going over the IF board. It appears to me when the board was made it was marked with the screen printing lettering of R149 being where R150 should be and vice versa. I have followed the board traces both in the Service Manual and on the back of a board, and these resistors both seem to be in the wrong place.
This means:
Specified in First Service Manual:
R149 68K
R150 2.2M
Specified in Revised Service Manual:
R149 150K

```
R150K 2.2M
Resistors as actually installed on my board if you follow the logic of the circuit diagram.
R149 2.2M
R150 150K
I have two IF boards here and they both have the resistors installed as required by the screen printing and hence on both boards both resistors are reversed.
Possibly this is the case for every TS-940 ever made.
I cannot understand how the circuits would function as the designer intended, as the installed resistors are very different to those shown on the schematic
diagrams. Could you please advise if my observation is correct, and after later when Kenwood has investigated if it would be advisable to swap  R149 with R
150 and vice versa?
At this time could you please just confirm that the question will be investigated?
I look forward to your reply.
Yours sincerely
Jeff King ZL4AI
```

RECEIVER 4. PIN DIODE IMPROVEMENTS

This improvement is not fully documented yet. Please send in information.

4.1: Background on how Pin Diodes were discovered to improve radios.

[TenTec] Pin Diodes / Paragon
Chester Alderman chestert@pressroom.com
Wed, 17 Sep 1997 17:14:45 -0400

TenTec builds a great amateur radio and obviously to give you a 'million dollar radio' that cost the user five bucks, economics really does have to enter the picture. PIN diodes have been around for many years, however they wer

Dont quote me on this because I've been out of microwave design for too long. A regular diode is a piece of silicon (or germanium) that has a junction. One side of the junction is doped, during mfg process, to have an excess of e

What all of this means is that PIN diodes are relatively expensive. A regular PN junction diode (typically a 1N4148 for instance) may cost 5 cent apiece,
however a 'cheap' true PIN diode will cost between one and three dollars apiece; and thats why you do not see them in very many amateur radios.
ECONOMICS. (I'm not sure why it took that much verbage to explain, but it did.)

Corsair II's used a regular silicon switching diode, 1N4148 to switch the filters. The Omni 6 does use PIN diodes, but probably because of the above
mentioned economics, TenTec uses diodes that 'will do the job' verses expensive PIN diodes.

I read Rhode's article on PIN diodes and decided I could improve the IM performance of my Omni 6 (it didn't need it!!), so I bought the expensive Hewlett-Packard PIN diodes that Rhode stated were the best, and installed them in my Omni 6. Over the past five years using my Omni, chasing DX and participating in some serious DX contest, I have yet failed to see where these expensive HP PIN diodes made any substantial improvement.

TenTec runs about 10ma of current through their production PIN diodes, in order to gain the full IM advantage of the HP PIN diodes, you must run 80ma through the HP PIN diodes!

So the bottom line is if you replace the PIN or silicon diodes in a rig, you will see (hear) practically no improvement, UNLESS you redesign the circuitry to utilize the diodes operating at their optimum design specifications. Probably if you find the filter switching diodes in your rig are running 'hot' to your touch, it probably means that someone has taken the time to change the current running through the switching diodes to really improve the IMD.

```
At 01:32 PM 9/17/97 -0400, you wrote:

>H. M. 'Puck' Motley W4PM wrote:
>> I have the feeling that the pin diodes in question are a modification
>> suggested in an article by Ulrich Rhode (not sure of the spelling of his
>> name) a few years back concerning 2nd order IMD in modern rigs. One of
>> the rigs mentioned was the Paragon.  The article stated that by replacing
>> the common switching diodes used to switch the receiver front end band
>> pass filters with a certain type of pin diode, 2nd order IMD could be
>> improved. Maybe some of our more technically oriented folks remember this
>> article and can comment in greater detail. This is all I remember so if
>> you have additional questions don't ask me!
>Thanks, Puck. I was certain it was something Rohde said, just wasn't
>quite sure when or what the exact reason was. I just spoke to Ten Tec
>about this, and they actually said they had tested different types of
>diodes to switch the Paragon's receiver filters, and settled on regular
>switching diodes because there wasn't much difference with other types.
>So, I guess replacing the receiver filter switching diodes with PIN or
>other (hot carrier, etc.) types is probably a mod that some users have
>done themselves. At least I know for sure it's not a factory
>modification.

>Is there anyone out there who knows this for sure? Has anyone done the
>aforementioned mod? I know one fellow recently mentioned in a message
>that a rig he had for sale had the mod. Now I'll go search for the Rohde
>article. 8^)

>73, KE3KR
```

4.2 RadCom Technical Topics explains what Pin Diodes were supposed to achieve.

TECHNICAL TOPICS April 1995
RF SWITCHING I TUNING DIODES

TT FEBRUARY 1993 REPORTED briefly an important article by Dr Ulrich Noble, KA2WEU/DJ2LR, which was published simultaneously in English and German QST and *CQ-DL* November 1992) on "Recent advances in shortwave receiver design". He subsequently published a series of three articles (QST May, June and July 1994)on Key components of modem receiver design, and a recent follow-up Key components of modern receiver design: a second look" (QST, December 1994). In these articles he stressed that for receivers intended to have a very wide dynamic range, the intermodulation distortion that arises from the use of unsuitable RF switching and tuning diodes imposes an important limitation. He has recommended the use (or substitution) of such special-purpose RF diodes as the Hewlett-Packard HP5082-3081 PIN diodes.

Dr Rohde's articles encouraged Tom Thomson, WOIVJ, to investigate how bad in practice are the more distortion-prone switching diodes and how good are those designed for low distortion ('Exploring intermodulation distortion in RF switching and tuning diodes', QST, December 1994). He carried out laboratory tests on four types of diodes: The IN4153 generic PN switching diode: the Motorola MPN 3700 PIN diode intended for RF switching; the BAT-17 Siemens PIN switching diode; and the low-cost 1N4007 which is a generic 1 kV-PIV rectifier diode with a PIN structure but not intended for RF switching

He has tabulated results in terms of diode switch insertion loss (dB) at 1O MHz with 0, 5, 10 and 20mA bias currents; and similarly the second- and third-order intercept points (IP2, 1P3 and dBm). He draws the following conclusions: "RF-specified PIN diodes are the devices of choice for low-distortion switching at HF and above, for band pass filter selection and C switching in a narrow-band pre-selector. Although the presence of a PIN structure in the 1 N4007 makes it seem attractive as a low-cost alternative to RF-specified PIN diodes, its insertion-loss performance When unbiased and reverse-biased - and its IMD performance when unbiased - is demonstratively interior to RF-specified PIN diodes.

He adds: 'The manually switched and tuned front-end filters of the 1960s and 1970s had much to offer in terms of second-order IMD, but we need not retrogress to those techniques to achieve improved 1P2 and 1P3 performance today. More attention paid to front-end filtering in general can produce the improvement we need."

Dr Rohde in commenting on W0IVJ's finding, notes that many amateurs had reported difficulty in obtaining HP5062-3081 diodes. He recognises that even with the Motorola MPN3700 with a US price Of less than £11 replacing all 20-plus filter-switching diodes can be expensive. Nevertheless he recommends changing all the diodes between the antenna and the first mixer, which includes the diodes on both sides of the band pass filters of a transceiver but not the transmit/ receive switching diodes which typically are already high-quality PIN types. He also adds some notes on Japanese switching diodes which might be used to replace the 'bad' diodes seen in the past".

Pat Hawker's Technical Topics

PAT HAWKER, G3VA
London 37/SE22 8SS

RF SWITCHING DIODES CONTROVERSY

AN APRIL *TT* item ('RF Switching and Tuning Diodes', p63) drew attention to the series of QST articles by Dr Ulrich Rohde, KA2WEU/DJ2LR - recognised world-wide as a leading professional expert in HF receiver design - supplemented in a separate *QST* article by measurements made by Tom Thomson, WOIWJ. These highlighted the shortcomings of some general purpose PN and PIN diodes used for RF switching in some popular amateur HF transceivers. Dr Rohde pointed out that the second order IMD performance could be improved in such cases by substitution of PIN diodes specifically designed for RF purposes, and in particular recommended the Hewlett Packard HP5082-3081.

In part three of his article (*QST*, July 1994) Dr Rohde gave results of measurements made on unmodified and modified transceivers - an ICOM IC-765, a Yaesu FT890 and a Kenwood TS-50. These measurements suggested significant improvements in second and third order IMD performance. He also evaluated the second-order IMD performance of several other transceivers including Collins KWM-390, TS950SDX, Ten-Tec OMNI VI (second order intercept +43dBm) and FT-1000. But he did not appear to specify which, if any, of this second group would or would not benefit from diode replacement. As a result of his findings, ARRL decided that they would include second-order IMD measurements in future *QST* Equipment Reviews.

This is highlighted in a letter from Dave Farn, G4HRY, who reported the unfortunate experience of G4KPT who replaced all 40 switching diodes in his Omni VI only to find that sensitivity had suffered. As a result, G4HRY has now replaced the original diodes and believes that "the validity of the original articles is brought into doubt". G4HRY, however, was not able to check on second-order IMD performance before or after modification.

While I am sure that Dr Rohde could provide a convincing reply to his criticisms, G4HRY does make some comments that deserve to be aired. He writes:

"G4KPT read the *QST* articles and as the

Freq	BA482	HP3081	BAT85	1N4148	BA439	IN4007
1.8MHz	-0.6	-0.9				
3.5MHz	-0.4	-0.75				
7MHz	-0.2	-0.7	-0.6	-0.7	-0.55	-0.5
10MHz	-0.3	-0.8				
14MHz	-0.2	-0.9				
18MHz	-0.3	-0.8				
21MHz	-0.3	-0.9				
24.5MHz	-0.3	-0.9				
28MHz	-0.3	-0.98	-0.6	-0.7	-0.55	-0.5

Table 1: G4HRY's measurements of diode loss (dB) in 50Ω transmission path with 10mA forward bias.

"After completing the modification he noticed that the receiver seemed a little deaf and the S-meter could no longer be calibrated. Thinking he had introduced a fault, he brought the set to me for a second opinion. Tests showed the sensitivity was at least 5dB worse than another OMNI VI. I could not find a hard fault with the rig and decided that, as it had worked well before modification, it was probably something to do with the new diodes. To prove this I built the small jig shown in **Fig 1**. This enabled diode through-loss to be measured in a 50Ω system which can be equated to diode RF resistance. The jig was used to measure the BA482 types and then the HP PIN diodes. Out of interest, I took a quick look at a variety of other general purpose diodes and this indicated that in respect of through-loss, the original diodes selected by Ten-Tec were a good choice: see **Table 1**.

"The receive RF path of the OMNI VI includes 5 diodes before the 1st RF amplifier. The first two isolate the transmitter from the

ascribed to the switching diodes. My existing test equipment introduces more 2nd order products than the diodes. Better isolation is required between the test oscillators and the hybrid combiner and I hope to follow this up soon.

"As a result of this exercise, I came to the following conclusions:

(1) Owners should consider carefully before attacking expensive transceivers. Only consider making modification if technically competent and equipped to measure the results. The actual circuit configuration should be considered to judge the likely effects of a modification. It may prove to induce high losses and will almost certainly effect filter termination impedance's required realignment. Some modern filters have fixed values and therefore performance on receive and transmit could be compromised.

"(2) The validity of the original articles is brought into doubt. If the author did not consider the effect of an extra 4dB of loss inserted before the first mixer, the resulting improvement in intermod performance credited to the use of PIN diodes may be a false assumption. Building a 4dB input attenuator is much cheaper than changing all those diodes!

"(3) Considering specifically the OMNI VI, rather than changing diodes, performance would probably be enhanced by implementing better matching of the 1st mixer. The IF port has no diplexer and the buffer amplifier has only a 20dB return loss at 9MHz. The LO port is fed directly from the LO power amplifier without any attempt at matching. Better filtering at the RF signal input would reduce 2nd order effects."

G4HRY is particularly concerned by the unquestioning faith often put in published articles, including *QST* and *RadCom*. He urges others to follow his own philosophy and become professional sceptics!

In his three-part article, Dr Rohde noted that second-order IMD products change 2dB for every decibel of input-signal change, and appear at frequencies that result from the

Diode	Bias conditions per diode

simple addition and subtraction of input-signal frequencies. His introductory notes on switching diodes were as follows:

"The receiver sections of amateur MF/HF transceivers generally use diode-switched front-end filtering. The switching diodes used have low junction capacitance and can typically handle medium DC levels (10 to 100mA). These characteristics are important because we want these diodes to contribute minimal loss when turned on and leak very little RF when turned off.

"The two-tone, third-order MD dynamic-range testing routinely done to amateur transceivers seems to point up no weakness in these switching diodes. In real life, however, a huge number of signals simultaneously appear at a transceiver's antenna connector. Periodically, their voltages all sum in phase producing, for short durations, enough voltage to change the bias of the diode at the input of the filter in use. This causes intermodulation distortion - generally ,second-order IMD. This is ironic for two reasons: First, this diode-generated IMD generates exactly the interference the filters switched by the diodes are supposed to prevent! Second, amateur radio equipment reviews have long let second-order front-end IMD go unmeasured because we have long assumed that our radios front-end filtering reduces this IMD to a non problem. Later, I will present measurement results that prove that second-order IMD is a very real problem today. (The test jig used by WOIVJ is shown in **Fig 2** with some of the results in **Table 2** - *G3VA*).

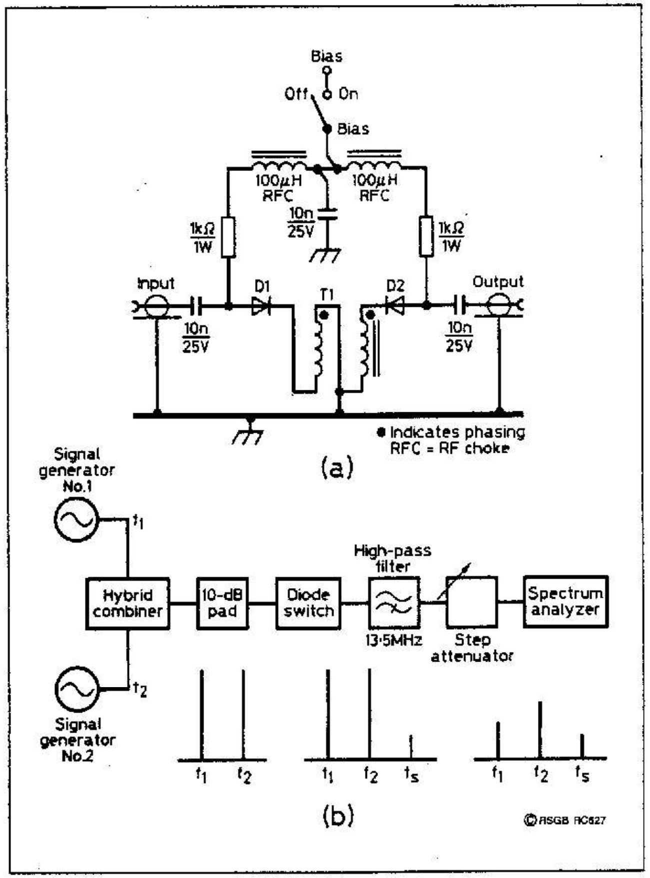


Fig 2: (a) The diode switch used by WOIVJ for his tests. D1 and D2, the diodes under test, included PN and PIN (power-rectifier and RF-specified) types. Capacitors are disc or monolithic ceramics. T1 consists of 11 bifiliar turns of Nr28 enamelled wire on an FT-37-43 ferrite toroidal form; the inductance of each winding is about 50uH. (b) Set up for measuring the diode switch's second - and third-order intercept points.

"The best way to avoid switching-diode IMD is to switch the filters with relays instead of diodes, and military and commercial gear generally take this approach. Relays are costly, however. A less expensive work-around that is acceptably good for amateur if anyone can suggest modest-priced diodes that are better than the 1N4148 and will stand up in service? Meanwhile, I am unable to detect any difference between a new FT757 and one that has had 1N4148s fitted".

My own feeling is that the experiences of both G4HRY and G3LLL highlight an increasingly serious problem involving modern technology. Without the most advanced (and expensive) laboratory test equipment, it is extremely difficult to evaluate fully the performance of equipment. With equipment which is new, or has been in service for some months, it is hard to assess how important these laboratory measurements are likely to prove in normal operational use on the amateur bands. In the case of HF receivers/transceivers, the 'old technology' of variable-capacitor tuned RF filtering with mechanical wavechange switching did have significant advantages over current broadband 'low-pass' or even sub-octave bandpass filtering. However, the 'old technology' was not without its own problems and costs.

DIODE TYPE	FREQUENCY 1.815MHz (dBm)	(dB)	FREQUENCY 7.015MHz (dBm)	(dB)	FREQUENCY 28.015MHz (dBm)	(dB)
BYD11M (@6 & 10mA)	38.0	1.16	45.0	1.23	35.5	1.93
IN4007 (@6 & 10mA)	38.0	0.25	42.0	0.97	37.0	2.0
HP3081 (@6mA)	38.0	3.82	37.0	3.9	36.0	3.36
HP3081 (@10mA)	35.5	2.68	41.0	2.5	35.5	2.84
BA482 (@14mA)	25.0	0.51	38.0	0.81	38.0	2.32
BA482 (@6mA)	18.5	3.49	23.5	0.71	36.0	2.0
IN4148 (@6mA)	21.2	6.61	19.0	7.47	17.3	5.63
IN4148 (@10mA)	12.5	3.61	15.0	4.1	16.5	2.84

Table 1: Third order Intercept (dBm) and Test circuit insertion loss (dB)

DIODE TYPE	FREQUENCY 1.815MHz	FREQUENCY 7.015MHz	FREQUENCY 28.015MHz
BYD11m	73.9	53.9	50.0
1N4007	63.0	43.9	35.3
HP3081 @6mA	80.0	63.5	57.0
HP3081 @10mA	81.9	63.9	56.8
BA482 @14mA	80.0	65.0	57.0
BA482 @6mA	84.0	61.8	52.4

Table 2. Test circuit off isolation (dB).

ANOTHER LOOK AT RF SWITCHING DIODES

DAVE FAR, G4HRY, in 'RF Switching Diodes Controversy' (*TT*, July 1995, pp67-78) questioned the wisdom of wholesale substitution of HP 5082-3081 RF PIN diodes for the switching diodes fitted in the front-ends of typical modern HF transceivers. This item interested a number of readers concerned with the development of high-performance receivers including Colin Horrabin, G3SBI.

that an important factor with some diodes is the sensitivity of insertion loss to forward current. The HP 3081 diode, severely criticised by G4HYR, shows a marked reduction of loss and hence improved performance as the forward current is increased from 6 to 10mA. As noted by G4HRY the Siemens BA482 (as used in the Ten Tec Omni) shows the lowest insertion loss (this would seem also to confirm G4HRY's view that it is inadvisable to replace BA482 diodes with HP3081 diodes - *G3VA*).

"Clearly anyone contemplating changing the RF switching diodes used in his transceiver must first estimate or measure the 'on' current used in the particular model concerned.

"All the measurements shown in Tables 1 and 2 were made in 50Ω systems. Some transceivers use 200Ω design impedances so that the insertion loss of the switching diode is of less consequence, but in this case the signal voltages are higher so that the IP3 intercept point may be lower.

"We could not achieve the sort of third order intercept figures reported by W0IVJ but it became clear that the IP3 performance of diodes is very much affected by the frequency. One is tempted to suggest that the designer of the 1N4007 diode must have been a radio amateur since its best performance seems to be around 7MHz where we measured an IP3 of +50dB. In fact, it is surprising how well the 1N4007 performs.

TECHNICAL TOPICS

"The 1N4007 performance encouraged us to obtain some BYD11M diodes from RS Components (29p each). These are rated as 1000V PIV, 0.5A rectifier diodes and are the same physical size as normal signal diodes. Performance as switching diodes was good: relatively low insertion loss, good IP3 intercept point, and good degree of 'off-isolation' at 50MHz, even with a fairly low 'on' current: see **Fig 4 (a)** and **(b)**.

"It should be appreciated that a very high degree of 'off-isolation' between different bandpass filters is less important in up-conversion receivers (50dB is probably adequate) since the image frequency will be in the VHF region and will be largely taken out by low-pass filters before the mixer. However, in the case of a receiver with a 9MHz IF and a 5MHz local oscillator, the image will fall in the 3.5 and 14MHz bands. In this case, isolation between the filters should be greater than 90dB so that two diode switches in series with a shunt diode would be needed to achieve this degree of isolation. It would be better to use double-pole relays, one bandpass filter to ground. It may then be necessary to use the technique of 'DC-wetting' ie arranging to pass a few mA of direct current through the relay contacts, to improve long-term contact reliability."

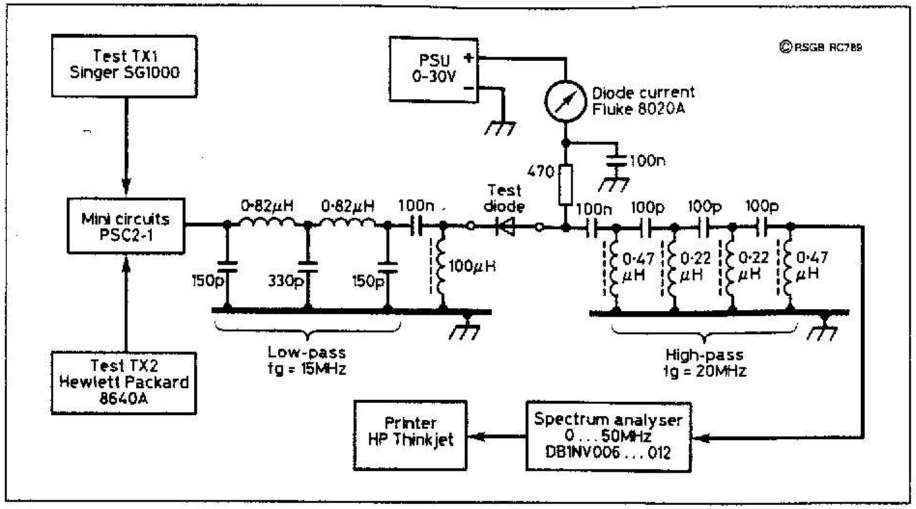


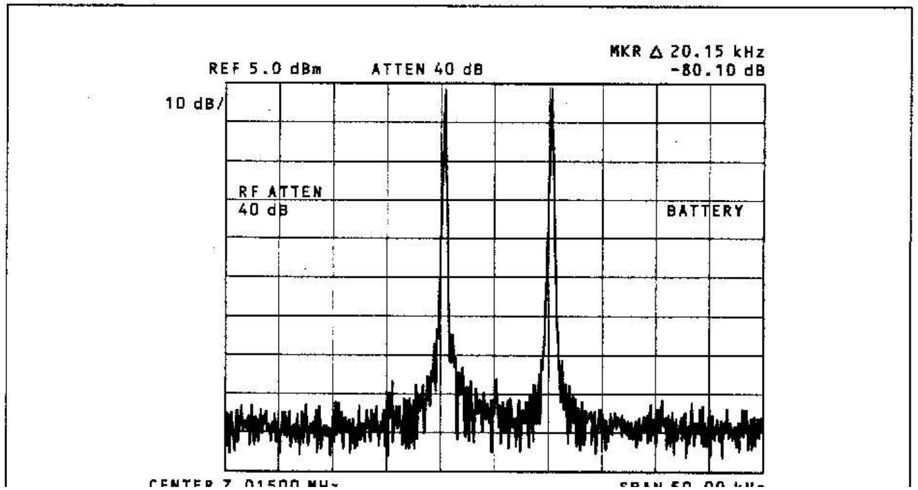
Fig 5: Test rig used by DB1NV for the measurement of intermodulation characteristics of switching diodes.

B J Mitchell, G3HJK, commenting on the strictures by G3LLL on the long-term reliability problems of RF switching by relays (*TT*, September, p68) also draws attention to the better reliability that can be achieved by DC-wetting, a long-established Post Office dodge, both in minimising oxidation and in reducing migration of contact material. This can be achieved with the aid of suitable blocking capacitors and resistors to feed DC across the contacts without changing the biasing of the active devices. G3HJK uses this technique with his FT102 and, despite being a pipe smoker, has not had to replace any of the six RF switching relays over years of use.

Another source of information on the 'Intermodulation properties of switching diodes' is an article which appeared in *VHF Communications* (Vol 26, Spring, 1/1994, pp12-18). Dr Ing Jochen Jirmann, DB1NV, used the measuring rig shown in **Fig 5** to measure intermodulation characteristics of a selection of switching diodes most of which have not been investigated by either W0IVJ or by G3SBI etc at SERC. DB1NV measured both IP2 and IP3. For the IP2 data he used test frequencies of 12 and 15MHz measuring IP2 at 27MHz while varying the diode DC from 2mA to 20mA: **Fig 6(a).** For IP3 he used test frequencies of 6 and 15.5MHz with the IM product evaluated at 25MHz with diode currents of 2mA and 5mA only: **Fig 6 (b).**

The conclusions drawn by DB1NV tend to differ in some respects from those of G3SBI. He wrote:

- Good repeatable intermodulation figures



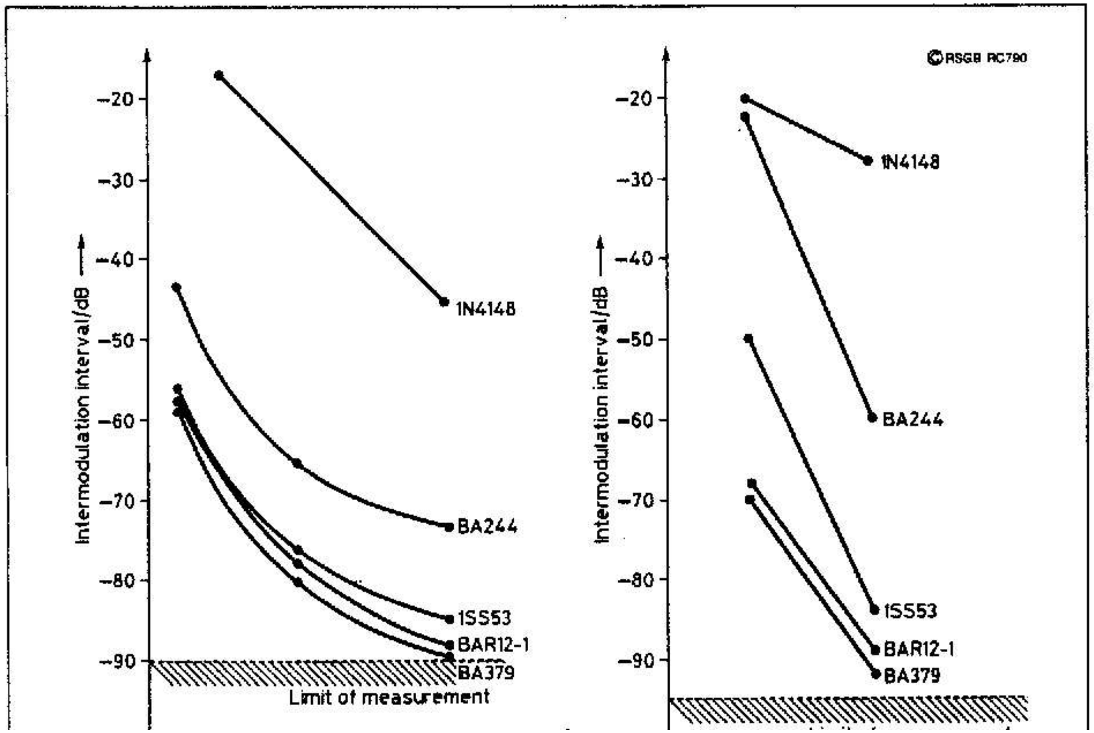
DB1NV also investigated the IM products resulting from saturated ferromagnetic cores, as used in both the aperiodic case (RF chokes) and for tuned (resonant) circuits. He found, for example, that Amidon ring cores of various sizes and intended for HF applications were practically free from intermodulation effects under normal conditions. He did, however, provide some design tips "some of which are not new, but which have probably fallen into oblivion in Japan". He wrote:

(1) Input filters effectively resistant to IM can be produced only using sufficiently large iron powder ring cores as inductances. They offer the best compromise between the space requirement and the level controllability.

(2) In compact rigs, rod core chokes, such as the Siemens MCC, can be considered as alternatives.

(3) Chokes in the filter structure, eg on the operating voltage feed, are largely non-critical provided they do not resonate.

DB1NV recalled the band-pass filters using ring core coils that were publicised many years ago by VE3TP. He commented: "These were not exactly cheap to construct but . . . solved every receiver IM problem so far . . . (proving) that it is possible to produce receiver input components which can meet today's requirements in relation to sensitivity and high-level signal strength." Dr Rohde's reply to G4HRY's criticisms will be published next month.



TECHNICAL TOPICS December1995
SWITCHING DIODES: DJ2LR/KA2WEUs REPLY

THE ITEM 'RF Switching Diodes Controversy 'TT, July 1995, included G4HRY's criticism of the advice given by Dr Ulrich Roinde, DJ2LR/KA2WIEU/4, in his excellent articles in OST that the second order IMD performance of several popular amateur HF transceivers could be improved by judicious substitution of PIN diodes, such as the Hewlett Packard HP5082-3081 , specifically intended as RF switching diodes. I pointed out that the criticisms were based solely on RF losses and that G4HRY had not made any IMD measurements. I added that I was sure that Dr Rohde could provide a convincing reply. However, in view of his experiences with GKPT's Omnii VI 1 felt it would be right to include G4HRY's view that it was unwise to put unquestioning faith in published articles including even those in OST and *RadCom*.

The detailed measurements provided by G3SBI (TT, November) and those published by DB1 NV in *VHF Communications* showed clearly that there is a wide difference between different diodes used for RF switching both in insertion loss and in IMD performance and that IMD is significantly affected both by the forward current through the diode and by frequency.

As a result of an unfortunate delay, the November item was written before I received a fax sent by Dr Rohde on July 18th. This, in a slightly abridged form, reads: I feel really concerned and sorry about G4KPT and the results of his experiments. As a matter of record, I would like to point out that intentionally
1 had not changed any of the diodes myself. but had the authorised service departments of AES, Milwaukee replace the diodes in the Yaesu FT890; ICOM changed the diodes in two IC765s; and Kenwood made the same changes in a TS50. The itemised ICOM repair bill shows 0.12uV for 12dB SINAD, I also had the other companies involved validate that following the diode changes, the receivers were within specifications.

'This validates my statement that this was a repeatable effort and the changes were not done at the expense of performance in any respect. It is also a matter of record that the HP5082-3081 diodes were used in the production of the Collins KWM380, one of which I still own and whose noise figure is on target with 0.3uV without a pre-amplifier and whose 2nd order IMD is superior to other diode applications. This should remove any doubts as to the correctness of my OST article.

1 have had no experience in modifying an Omni VI nor did I do any measurements or modifications with it. The ARRL edited in the Omni VI because it is a popular US-made transceiver and there had been some discussion as to whether or not the European version had different diodes or relays. Before fingers are pointed at specific diodes, I would like to examine the circuit diagram because there can be no need to change all 40 diodes. As an experiment, 1 may want to supply one set of more modem diodes.

"Everyone who has contacted me as the result of the OST articles had been advised not to use the HP 3081 (for reasons of cost and availability) but rather to use a Siemens BAR17 diode or M1204 diode, which is available through ICOM dealers/repair centres. Those diodes are much less expensive and more readily available.

"To the best of my knowledge, the companies who changed the diodes in the equipments involved did not change the diode bias. It is questionable why any one should wish to change diodes in the IF section; similarly diodes in the transmit / receive switches should not be touched.

"Finally, there is no question that relays provide the best of all worlds as far as IMD characteristics are concerned, but not necessarily the best solution in terms of space and costs. 1 have just tested a soon-to-be-re leased transceiver which uses PIN-type di odes and exhibits superb IMD characteristic while maintaining a good noise figure.

"As to multi-tone functionality, once 2n and 3rd order IMD tests have been done, on can predict the higher-order IMD effects, especially since they are based on diode characteristics and this type of test is a legitimate test to evaluate receivers.

"Hopefully, your readers will not deduct from this experiment that QST or other reputable magazines publish articles which are technically incorrect."

In a subsequent letter, dated September 19, 1995, Dr Rohde confirms that he has run into a lot of people who have modified their RF switching diodes and have been extremely happy with the results. Further, after refining his test set-up he finds the improvement is now slightly more dramatic than outlined in his QST article.

In regard to Dr Rohde's endorsement of the technical accuracy of articles, I would enter a caveat. While most writers strive lo complete accuracy. the mechanics an Murphy's Law of publication make it difficult to avoid some errors, particularly in column produced to a tight deadline. Many years ago I stressed that I regard Technical Topics as forum for new ideas, not all of which are likely to prove repeatable or even strictly accurate No guarantees can be given on experimental ideas still under development! I welcome comments from sceptical readers or those spotting printing errors etc. Fortunately, there is good evidence that the vast majority of 7T items do work as intended, and often provide useful additions to amateur lore!
==

Intermodulation properties of switching diodes, by Dr. Ing. Jochen Jirmann, DB1NV

ZL4AI was contacted by a neighbouring ham, (known for many years). Peter Johnson ZL4LV. peter.Johnson@Paradise.Net.Nz
Peter designed and developed from scratch in the early 1970s an HF transceiver. (Actually it is still under development and may soon have BA479s installed.) The local Branch of the New Zealand Amateur Radio Transmitters Association under Peter's guidance sold this as a kitset. Peters design was the first use of diodes for band switching. Peter published this technique in English Radio magazines the early 1970s and thereafter the first commercial transceivers appeared with diodes switching bands. As the inventor of the concept Peter has collected articles on diode switches, and provided the following.

Dr. Ing. Jochen Jirmann, DB 1 NV

Intermodulation Properties of Switching Diodes

Some attempts to improve the intermodulation properties of short-wave receivers were described in (1). It was demonstrated there that the main reason for the moderate intermodulation properties of many short-wave receivers should be looked for in the use of unsuitable switching diodes for the switching of the input band pass filters. Following numerous enquiries, the intermodulation behaviour of commercially available high-frequency switching diodes was measured in a second investigation. The results were obtained using resources which were still almost on an amateur level, and should thus not be put down to the "dB scales". The comparison between the various diode types is actually more important than the absolute values.

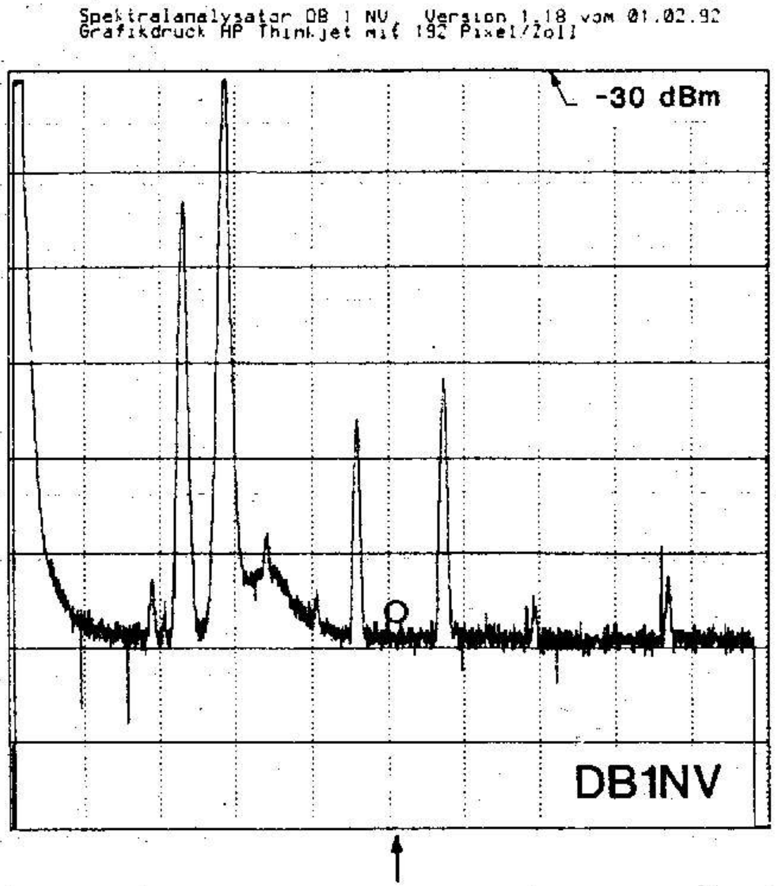


Fig.2:
Measurement Curve without Diode (IM2 measurement).
Circle shows location of Intermodulation Product
SA: centre 25 MHz; 5 MHz/div

1. THE MEASURING RIG

The previous experiments, using an IC765 from OM Hercher, DL8MX, had demonstrated that the critical level above which audible intermodulations arise should be sought at an aerial voltage of about 100mV. This correspo-

frequencies, and the frequency diagram was drawn up in such a way that harmonics from the test transmitter can be separated from the IM products sought. With some filters, a measurement dynamic range could be usable at about 90dB. The measuring rig is sketched in Fig.1.

Two test transmitters act as signal sources, a Singer SG 1000 and a

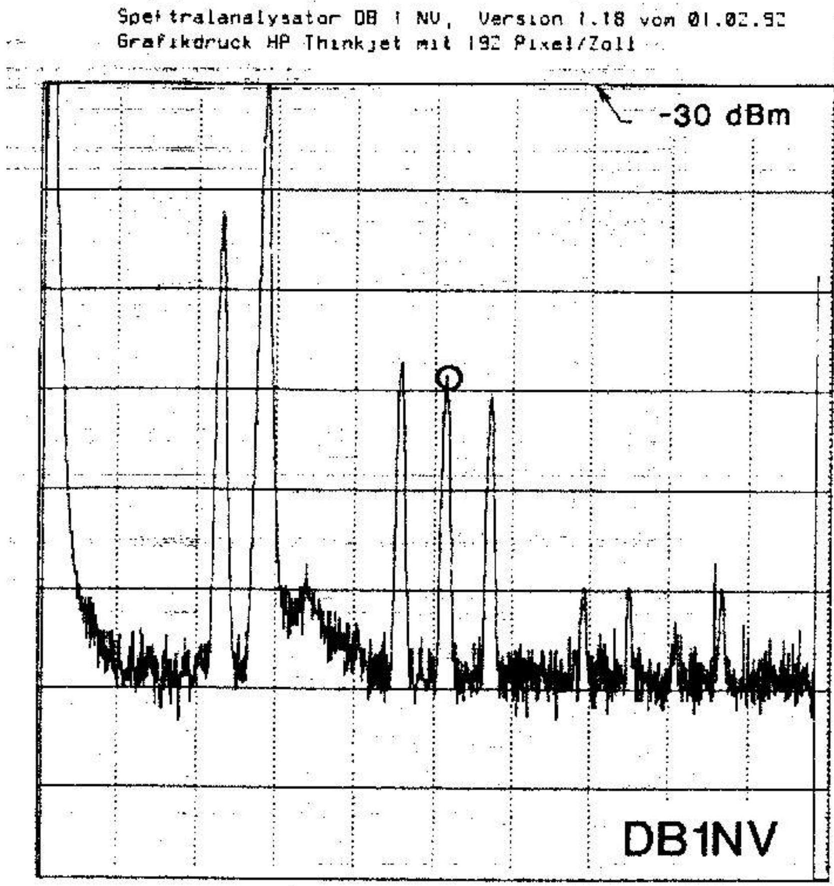


Fig.3: Measurement Curve: IM2 Spectrum of a BA379 with 2mA Diode Current

lowed by the test diode, which is biased with adjustable DC. A high-pass with a limiting frequency of 20 MHz relieves the spectrum analyser (home-made by the author) of the strong carrier wave signals from the test transmitter. The analyser was set to an average frequency of app. 25 MHz and to 5 MHz/div.

For the measurement of total fre-

To measure third-order intermodulation, the test transmitters were set to 15.5 Hz and 6 MHz and the mixed product was measured at 25 MHz.

To check the measuring rig, the diode was short-circuited. Fig.2 shows the analyser screen print-out. The two test transmitter signals can be recognised (here 12 MHz and 15 MHz), together with their harmonics at 24, 30, 36 and

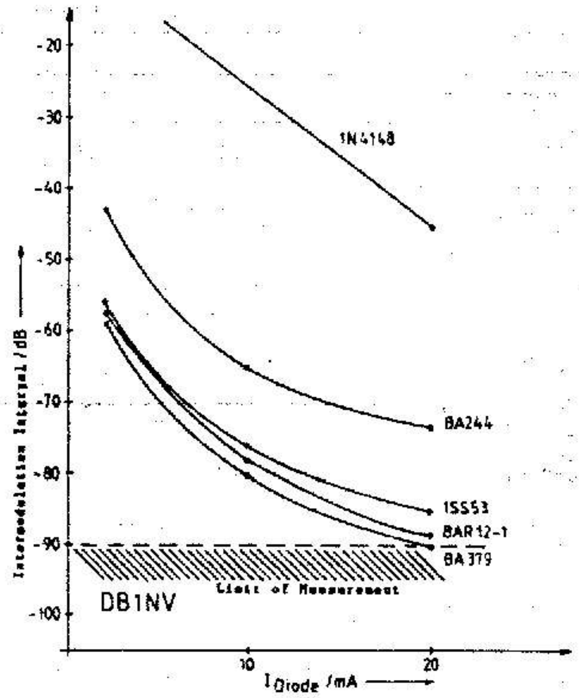


Fig.4: Second-order Intermodulation Products plotted against Diode Current

2. SECOND-ORDER INTERMODULATION

In this range, measuring frequencies of 12 and 15 MHz were used. The diode DC was varied from 2mA to 20mA. various diodes are plotted against the diode DC in Fig.4. As can be seen, the first round in the IM contest goes to the BA379 from Siemens, followed by the BAR12-1 and the 1SS53. The good cut-off results from the 1SS53 universal diode are surprising. But since the diodes removed from the IC765 carried no type description, it might perhaps be conceivable that ICOM had secretly used improved diodes here. It isn't clear from the parts list. It can clearly be seen how important a sufficiently high level of DC through the diodes is, since at current levels below 10mA the intermodulation products increase greatly.

3. THIRD-ORDER INTERMODULATION

In this measurement range, the test transmitters were tuned to 6 and 15.5 MHz and the IM product was evaluated at 25 MHz. The diode DC was altered here at only two values, 2mA and 5mA, and the same diodes were used as in Section 2. Fig.5 shows the inherent interference spectrum for the measuring rig, Fig.6 the IM spectrum for a

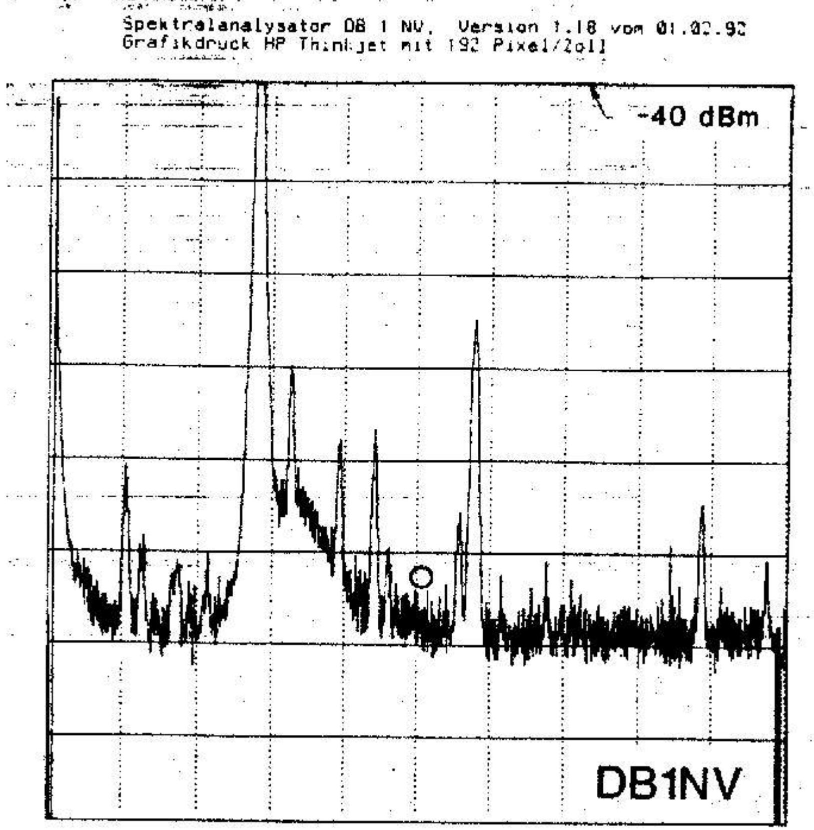


Fig.5: Measurement Curve without Diode (IM3 measurement). Circle shows location of Intermodulation Product

4. SUMMARY OF RESULTS SO FAR

The measurement results listed essentially show four things:

- Good, repeatable intermodulation intervals can be obtained only through the use of "correct" PIN diodes, but they have their price. Miniature (different production lines, different production methods).
- The relatively good cut-off results obtained in practise from the apparatus fitted with tuner switching diodes is not consistent with the poor measurement results from the BA244.
- The existing apparatus should also be improved or re-constructed in order to check whether sufficient

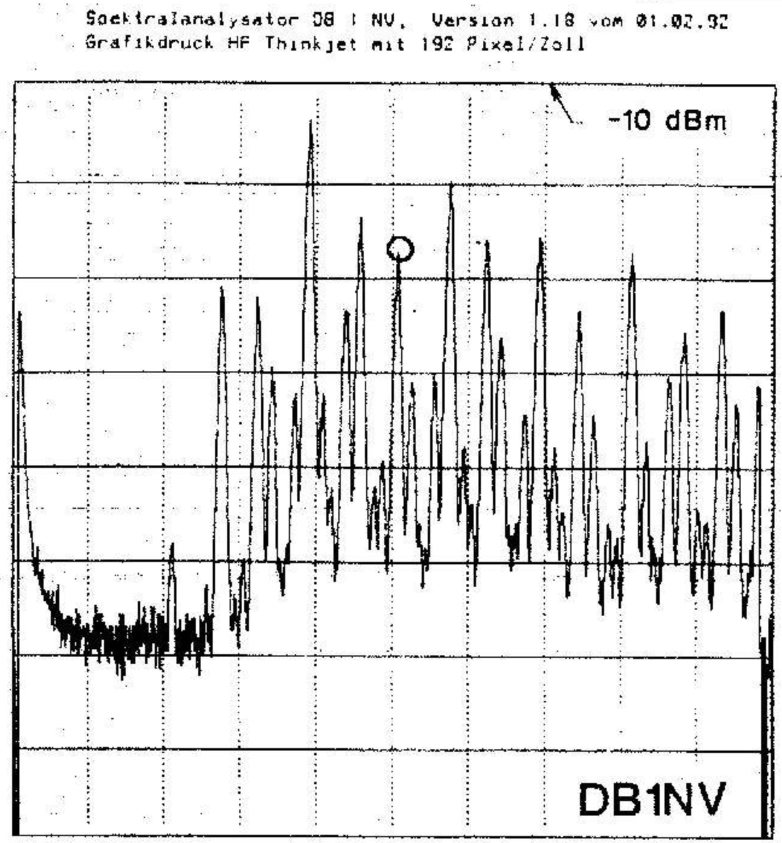


Fig.6: Measurement Curve: IM3 Spectrum of a 1N4148 with 5mA Diode Current

But since over-modulated coils with ferromagnetic cores can also generate intermodulation effects, the same measuring rig was used to classify inductive components.

5. INTERMODULATIONS IN INDUCTANCES

– With a choke effect, intermodulation products above -110dBm were not detected either for rod core micro-chokes from the Siemens MCC range or for Neosid and TOKO ready-made coils selected at random. Only the "VK200" six-bore core choke from Valvo or Philips Components, a favourite with VHF Communications readers, yielded an IM level of between 85 and 95dBm, depending on the ferrite material. A

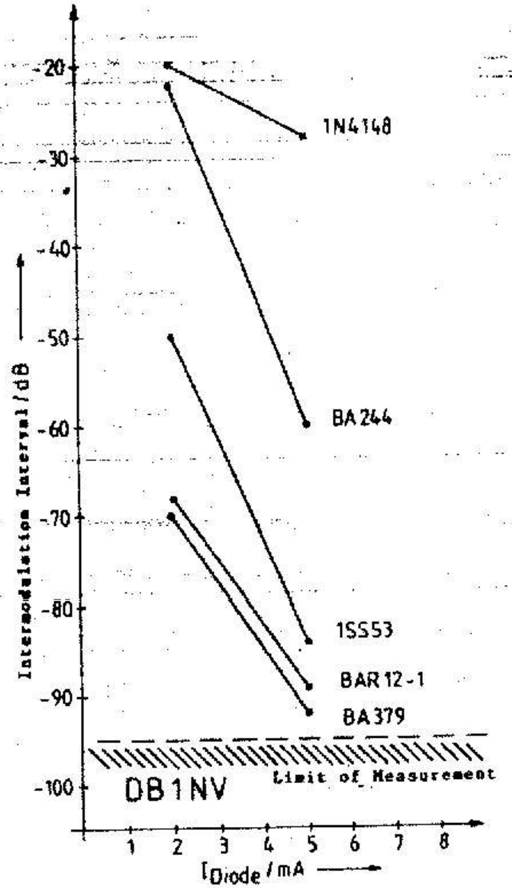


Fig.7: Third-order Intermodulation Products plotted against 2mA and 5mA Diode Currents

Amidon ring cores, suitable for short-wave use and of various sizes, were practically free from intermodulation.

The following design tips can thus be derived, some of which are in any case

2. In compact rigs, rod core chokes, such as the Siemens MCC, can be considered as alternatives.

3. Chokes in the filter structure, e.g. on the operating voltage feed, are largely uncritical, as long as they do not resonate.

In this connection, we might recall the band-pass filters with ring core coils publicised many years ago by VE3TP, which were not exactly cheap to construct, but on the other hand have solved every receiver IM problem so far. This statement shows that, in spite of statements to the contrary from the industry and from a few, probably unqualified, "specialists", it is possible to produce receiver input components which can meet today's requirements in relation to sensitivity and high-level signal strength. Since in our hobby we don't need to worry about tenths of a penny, like industrial manufacturers, we can obtain results which are some orders of magnitude better for a slightly increased cost!

The author hopes that this account of his measurements will start people thinking about experiments of their own, and would be pleased to receive reports of their experiences.

FOR THE SUBSEQUENT SECTIONS CLICK HERE: TS-940_02_part2.htm

TS-940S
TS-940SAT
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TS-940
ts940
ts940 battery
ts950 sd
ts940 cold solder
ts950sd fan
ts950 serial numbers
TS-940S HF Transceiver
Feb 1986
kenwood serial number
LO Local (TS-940 : Remote control of SLOPE, TUNE, VBT)
1.8khz ssb filter ts850s
Resistors in wrong place in the Kenwood Ts-940
950SDX + diode mod
rtty key input ts570
buy mI204 pin diode
ten tec omni vi transverters
difference between ts930 and ts940
TS-830 drift
DJ2LR
ts-930s unlocking
GU74 hybrid
TS-940
gu74 plate voltage
TS50 data operation rtty interface schematics
how to replace s-meter lamps in the Kenwood ts-940
ts50 psk interface schematics
ts850 color schematics
kenwood 940
ts850 repair rx attenuation
kenwood amateur ts-940 antenna tuner repairs
ts870 number serial
kenwood amplifier heats up and blows fuse
ts930s no display no receive
kenwood ts 940
ts940
kenwood ts 940s late serial number
ts940
kenwood ts-930 display vfo
ts940 lithium battery
kenwood ts-940 tuning upgrade
TS940 VCO Loop

kenwood ts940
ts940s problem solved
ts870 number serial
how to replace s-meter lamps in the Kenwood ts-940

Back to Part 1 of TS-940 page: Click here

4.4 Experience from Persons who modified the TS-940

First from www.contesting.com

TopBand: : [WSVHF] TS-940 Specs
km1h @ juno.com mailto:km1h@juno.com
Thu, 05 Mar 1998 10:30:41 EST

```
To all those on Topband who asked...here is the results of the TS-940 tests.

73  Carl   KM1H

--------- Begin forwarded message ----------
From: km1h@juno.com (km1h @ juno.com)
To: wsvhf@qth.net
Subject: [WSVHF] TS-940 Specs
Date: Tue, 09 Sep 1997 22:35:15 EDT
Message-ID: <19970909.214104.9687.15.km1h@juno.com>

As an addition to the Sherwood receiver info,  here are some specs on a TS-940.

All tests were run on 28MHz during the past few days on a customers unit.

TS -940 late serial #  with factory phase noise updates:
MDS SSB  -135 dBm
MDS CW cascaded 500Hz filters   -137 dBm
Sensitivity 10dB S+N/N   .12uv
Phase Noise    -131dBc   at 10 KHz
Filter rejection CW  >90 dB
2 tone dynamic range Wide  95 dB @ 20 KHz
2 tone dynamic range Narrow ( CW Filters)  77 dB @ 2 KHz
3rd Order IP  +1dBm at  20 KHz
Wide Band transmitted noise  -75 dB below full carrier


The same TS-940 but with PIN diode mods to RF and IF boards:
MDS SSB  -137dBm
MDS CW   -142 dBm
Sensitivity  ~ .1uv
Phase noise  -131 dBc  @  10 KHz
Filter rejection ( CW )  >90 dB
2 tone Dynamic Range Wide  102 dB @ 20 KHz
2 tone Dynamic range Narrow  ( CW Filters)   83 dB @ 2 KHz
3rd Order IP   +5 dBM @ 20 KHz
Wide band transmitted noise  -90 dB below full carrier

A few notes and comments:

Although the PIN diode improvement is evident in the numbers the audible difference is much greater.
First of all the receiver is noticeably quieter. The IMD performance shows an "apparent" improvement of
about 10-12 dB under crowded band conditions. This follows along with conversations I had with Dr. Ulrich
Rhode several years ago when I first started using PIN diodes. The cumulative effect of multiple strong signals degraded IMD performance in a stock receiver a lot more
The receiver is a pleasure to use in lowband pileups now.
```

The improvement in wideband TX noise is due to, I believe, the use of PIN's in those paths that were common to TX and RX on the IF board. The stock diodes either generated noise or allowed RX path noise into the TX path. The same appears to hold true in the opposite scenario. This TX noise is something I was recently made aware of by a local on 6M and bears closer examination and possible additional improvements. The noise does not change dB levels when going from full power to the 20-30mw from the transverter port so it can not be blamed on thermal noise in the subsequent linear amp stages.

Magazine reviews of the TS-940 were of early production. Kenwood at first refused to admit to phase noise problems. They then went thru two different mods before they were satisfied. The improvement between early and late models is about 15 dB.
Serial numbers in the mid 8 Million group and up had factory mods.
Kenwood Service Bulletin 917 may be retrofitted to the earlier radios. It is a fairly simple mod.

Other KW radios such as the TS-850 and TS-930 could also benefit from PIN mods. They both have transverter ports and are quite reasonably priced on the used market.

I cant speak for other brands but a quick review of a few Service Manuals shows an awful lot of commonality across all brands with respect to diode switching schemes.

73....Carl KM1H
----- Submissions: wsvhf@qth.net Subscription/removal:
wsvhf-request@qth.net
--------- End forwarded message ----------
===

-----Original Message-----
From: thomas hohlfeld [mailto:thomas_hohlfeld@hotmail.com]
Sent: Wednesday, 27 April 2005 10:42 a.m.
To: jaking@es.co.nz
Subject: RE: ts-940

Hi Jeff,
thank you for your reply and congrats for the informative web site. I read about the PIN diode mod in a web message.
I replaced diodes D9 through D20 of the RF board by the PIN types BA479. I did not replace D3-D8 because these switch a frequency too low for the BA478 to be an effective PIN. I checked the BA478 and found them to be good at frequencies above 2 to 3 MHz. The BA479 have been offered in different versions and it is important to use those which are designed for HF (not VHF). Certainly, other PIN diodes may also be useful. The IMD of my 940 improved by about 5 dBm after this mod.

For re-alignment of the receiver, I mainly followed the instructions of the service manual for the RF and IF amplifier stages (I did not align oscillator and PLL circuits). I have a sweep generator (Rohde & Schwarz SWOB 5 equipped with log amplifier), which was very helpful to optimise the bandpass filters on the RF board.

I established RX sensitivity with a HP8640B RF generator together with a home made audio voltage detector to determine an audio increase by 10 dB. I have two of the HP8640B, so that I am able to determine receiver IMD. The HP8640B are quite famous, since they produce a very clean RF signal and are sold at a reasonable price.

By the way, I own two TS940 and use one of them for experimental modifications which are more ´critical´, so that I would not really recommend others to reproduce them. If you are interested anyway, I will report on that later. It’s past midnight now.

73 for today,
Thomas

>From: "Jeff King" <jaking@es.co.nz>
>Reply-To: <jaking@es.co.nz>
>To: <thomas_hohlfeld@hotmail.com>
>Subject: RE: [ts-940] Re: Why don't more people use this group?
>Date: Mon, 25 Apr 2005 09:09:42 +1200
>
>Thomas
>
>I found your review of the FETS most interesting.
>My reason for writing is to ask you to tell me more about the pin diode modifications you have undertaken.
>Where are these diodes and what do you do to replace them?
>What else did you do to realign receive?
>How did you establish the 0.15 uV sensitivity.?
>
>Yours sincerely
>Jeff King ZL4AI
==

>From: "Jeff King" <jaking@es.co.nz>
>Reply-To: <jaking@es.co.nz>
>To: <jaking@es.co.nz>
>Subject: RE: ts-940
>Date: Fri, 29 Apr 2005 17:05:30 +1200
>
>Hi Tom,
>
>Thanks this information is very interesting.
>I really appreciate your advice on aligning the 940 very helpful information.
>
>I also read [below] about pin diodes being changed in the IF board RX / TX circuits. Have you tried changing any of those?
>
>Is the Temic's- Vishay (former Telefunken) BA479 (G or S suffix) a suitable diode? Spec sheet attached.
>
>Yours sincerely
>Jeff King ZL4AI
>
>

-----Original Message-----
From: thomas hohlfeld [mailto:thomas_hohlfeld@hotmail.com]
Sent: Monday, 2 May 2005 9:23 a.m.
To: jaking@es.co.nz
Subject: RE: ts-940

Hi Jeff,
Thank you for the comments on the pin diodes. Yes, I used the BA479G. These were quite inexpensive and it was easy to obtain them when I did this mod two years ago. Today, I checked for a source in the internet and found a German distributor who may still have the BA479G. Check at http://www.schuricht.de/w3a/default.asp (a button at the lower left will switch language into English). They do not look too expensive (0.31 Euro when 50

are ordered).I checked the BA479G with an RF generator and scope and found it to be good at 7 MHz and higher. I am not sure if it is very effective at 3.5. Nevertheless, I decided to replace D7 through D20 on the RF board. I think I also exchanged D21 (don't know any more, but makes sense). I did not change D23 and D26 in the preamplifier because these probably are already pin diodes and their exchange might impair the AGC characteristics. There are some switching diodes also in the IF section of the 940, but I did not replace these, because XF-1 already cuts the bandwidth at the front of the IF amplifier and there may not be too much intermodulation behind. May be I will do this later when I have to take out the IF board for some other reason.

I told in my last mail that I did other mods in my 940s. It may take quite long to describe them all, so for the first time here is a short list:

(1) I exchanged the PLL amplifier IC (IC18, PLL board) into a pair of extremely low noise OPamps, which lowered phase noise. However, this required to tackle some problems with PLL instability.

(2) I have the optional 250 Hz CW filter for the 455 kHz IF. When working PSK in SSB mode, I missed the possibility to activate this filter. I found out how to modify the 940 to allow for activation of the CW filter in SSB, including the control LED at the narrow CW filter switch.

(3) When I bought my first 940, it came without the AT unit. So I built one with an automatic antenna tuning board (kit) and built an interface which nicely communicated with the antenna tuning control circuit of the 940. Later, I got the original AT-940.

(4) Follow hyperlink
VOLTAGE_REGULATOR_HEAT_UP_AND_BFO_SHIFT

(5) I equipped my 940s with the piexx boards which allows to control the 940 via the serial interface of a PC.

Best 73s for today, Jeff

Thomas, DF5KF
==

The following 2 emails have had some irrelevant content edited out.

>From: "Jeff King" <jaking@es.co.nz>
>Reply-To: <jaking@es.co.nz>
>To: "'thomas hohlfeld'" <thomas_hohlfeld@hotmail.com>
>Subject: RE: ts-940
>Date: Fri, 27 May 2005 19:35:16 +1200
>
>Hi Thomas,
>
>Thanks for your email which I am still thinking about, a lot.
>
>Anyway I have been trying to get BA479G diodes from
>a supplier.
>
>The supplier advises they have the BA479 but cannot tell if it is a G or S.
>I have asked them to put a resistance meter on it and await those
>results. [They replied they could not help.]

>
>Attached you will find the datasheet. As you can see on the second
>and third lines on the first page
>Reverse impedances are:
>G: 5 k Ohms
>S: 9 K Ohms
>
>It appears to me that the S might be better, or no worse than the G.
>
>Do you think S would be suitable to use without further testing.
>My worry is installing an S and finding it does not work well.
>
>I have an interesting article from Radcoms Pat Hawker on Pin Diode
>replacements in July 1995. If you would like this I will send that when
>I have it scanned. This article explains that the BA482 replaced in the
>Omni VI with the HP 5032-3081 resulted in impaired performance because
>the HP put through 0.5 dB less signal.
>
>
>Your sincerely
>Jeff King

-----Original Message-----
From: thomas hohlfeld [mailto:thomas_hohlfeld@hotmail.com]
Sent: Tuesday, 31 May 2005 9:15 a.m.
To: jaking@es.co.nz
Subject: BA479 etc.

Hi Jeff,
Thank you for your mail and your thoughts on the PIN diode mod. Yes, you are perfectly right in that this mod will probably be a tradeoff between linearity and a slight loss of sensitivity. I would be very interested to read Hawker´s article you mention.

Your mail also made me re-think about this mod. The G version of the BA479 has been suggested to be better for short wave purposes, but it is true that there is not much evidence in the datasheet. My guess is that the BA479 should simply be measured in a test setup, and this is what I started yesterday.

I set up a simple circuit with two RF generators (300 mV out) fed into a hybrid combiner, the output of the combiner going into one end of the diode under test. The other end of the diode was coupled via a step attenuator into a spectrum analyser (my shack is a museum of old instruments, hi). I fed a forward current of about 10mA through the diode, uncoupled from RF of course. The generators were adjusted between 2 and 15 MHz, always 500 kHz apart (two tone signal).

I hadn’t much time and did only some very short measurements. Anyway, the results were interesting. Here they are:

1. A conventional all-purpose diode (1N4148) produced a horrible spectrum of intermodulation products. In addition, the insertion loss was high (up to 10

dB).

2. Next, I inserted one of the original diodes which I replaced in my TS-940 (of course I did not through them away). The difference was impressing. At 10 MHz and above, these diodes produced very little intermodulation distortion with very low insertion loss (1 dB or so). Below 10 MHz, the intermodulation became worse and was poor at 3.5 and below. Interestingly, insertion loss moderately increased below 7 MHz (reaching 3 dB at 3.5).

3. I also tried a BA479G which I left from another project. These produced very low intermodulation signals, even below 2 MHz (which surprised me). At 10 MHz and above, the BA479´s have a slightly higher insertion loss than the original Kenwood diode (1-2 dB worse). Below 10MHz the BA479 showed less (!) insertion loss and were clearly superior with respect to intermodulation.

To summarize, the BA479G is better than the original TS-940 diode only at frequencies lower than 10 MHz. As you will imagine, I am thinking about returning to the original diodes at 10 MHz and above. It may take a couple of weeks until I will have time.

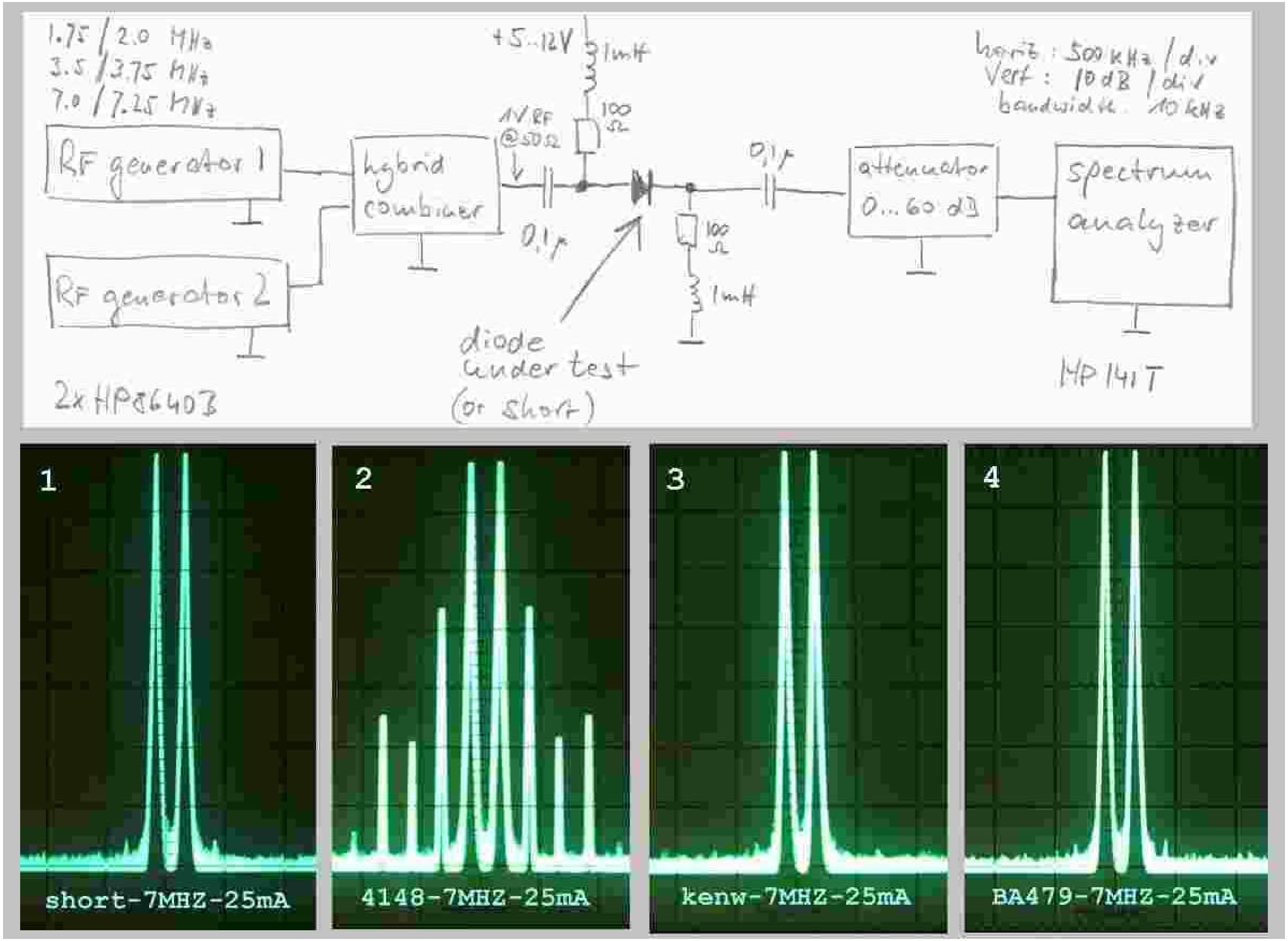
I can also take some digital photographs of the intermodulation spectra and mail them to you, if you are interested (may take 2-3 weeks). Let me know if your e-mail server has limitations in file size.

Best regards for today and vy 73,
Thomas,
DF5KF

-----Original Message-----
From: thomas hohlfeld [mailto:thomas_hohlfeld@hotmail.com]
Sent: Friday, 10 June 2005 8:56 a.m.
To: jaking@es.co.nz
Subject: RE: BA479 etc.

Hi Jeff,
thank you very much for including these excellent articles on the web page.
It’s so useful that I’ll print it out.

Now, here is part #1 of my measurements on the RF properties of the 940 Front end diodes. To start, I concentrated on the diodes in front of the filters (diodes # 3, 5, 7 ... 19), which see the whole RF spectrum from by the antenna. The forward current of these diodes is 25 mA in my 940, which appears quite a lot, but probably was chosen because the diodes need to be very linear here.
The attached file (25mA-all.jpg) shows the schematic test setup on top. I already described it in my previous mail, but this time I measured at a ´realistic´ diode current of 25 mA. The two RF generators were set close to 7, 3.5 and 1.75 MHz, always 250 kHz apart. The spectra (figs 1-12) show the two carriers at the center. All additional peaks are 3rd and higher order products, indicating the non-linearity of the diodes. To get an ´ideal´ reference, I also measured with the diode replaced by a wire bridge (figs 1, 4 and 8). Here, the low remaining 3rd order signals (less than -60dB) reflect some non-linearity of my test setup (my homemade hybrid combiner may not be perfect).
As I already noticed in my earlier mail, a general purpose diode (1N4148) produced a horrible spectrum of side products at all three bands (figs 2, 6, 10). The original Kenwood diode (1S2588) was very good at 7 MHz (and at higher QRG´s, not shown), but worse at 3.5 and quite poor at 1.75 MHz (figs 3, 7, 11). In contrast, the BA479G was very good and provided the least side products (figs 4,8,12). If you look closer at the distance of the carriers from the top graticule (sorry, background is quite dark), you will notice that the carrier attenuation of the BA479 is low at all bands and not much different from the original Kenwood diode.



1.75 / 2.0 MHz
3.5 / 3.75 MHz
7.0 / 7.25 MHz
RF generator 1
RF generator 2
2x HP8640B
hybrid combiner
1V RF @50Ω
0,1µ
+5..12V
1mH
100 Ω
diode under test (or short)
0,1µ
100 Ω
1mH
attenuator 0...60 dB
spectrum analyzer
HP 141T
horiz: 500 kHz / div
Vert: 10 dB / div
bandwidth 10 kHz
1
short-7MHZ-25mA
2
4148-7MHZ-25mA
3
kenw-7MHZ-25mA
4
BA479-7MHZ-25mA

Part #2 of my measurements will follow, where I studied the diodes behind the input filters (D4,6,8...20 and D21) which are run at a lower forward current. The measurements are already finished but the figures need to be arranged.

Good luck for today!
Thomas
DF5KF

-----Original Message-----
From: thomas hohlfeld [mailto:thomas_hohlfeld@hotmail.com]
Sent: Monday, 13 June 2005 4:31 a.m.
To: jaking@es.co.nz
Cc: hohlfeld@uni-duesseldorf.de
Subject: TS-940S - pin diode part#2 and some other considerations

Hi Jeff,
here comes part #2 of the pin diode measurements, which concentrates on the diodes between the bandpass and the preamplifier of the TS-940.

First a short comment on the 940´s front-end: when the RF has passed the RX bandpass, three diodes follow before the signal reaches the preamplifier Q10. Of these, two are switching diodes (one of D6,8 ... D20, D21), while one (D26) is a pin diode. Only the two switching diodes are candidates for replacement. For test purposes, I assumed that D26 is fully open and D23 closed (AGC at highest sensitivity). In this case, we deal with two switching diodes in series. They are also in series with respect to their forward current, which is determined by R31. I measured 17 mA in my TS-940. The impedance, which these diodes see, is also important. I estimate it about 50 Ohm, because the bandpass filters of the TS-940 are constructed symmetrically.

Therefore, my test setup was similar as before with the following changes: (1) I tested two diodes in series, (2) I used a forward current of 17mA and (3) I also measured at 10.1 MHz. Because the 1N4148 was so poor in part#1, I did not consider it further. The attached jpg file again contains a plot of the test setup.

Here are the results (see attached jpg file): At 10.1 MHz (figs 1-3), the original Kenwood switching diode (1S2588) is as good as the pin diode BA479. The same also applies to higher frequencies, which I do not show here. The insertion loss of the two BA479 in series is slightly higher than that of two Kenwood diodes, but is still less than -1 dB (more on this below). At 7 MHz (figs 4-6), the 3rd order products are clearly increased by the Kenwood diodes (fig 5) in comparison with the reference (diodes shorted, fig 4). The BA479 (fig 6) is clearly better than the Kenwood diode, although a minimal increase is also seen compared with the reference. At 3.5 MHz the Kenwood diodes generate a lot of intermodulation products (fig 8) and the BA479 (fig 9) is obviously superior. The same is true for the 1.75 MHz band (figs 10-12). In summary, the BA479 is better than the original Kenwood switching diode at 7MHz and the lower bands at a forward current of 17mA. There is no relevant difference at 10 MHz and higher.

It would also be interesting to know how the diodes behave at frequencies below 1.75 MHz. Unfortunately, my combiner is not appropriate for a lower QRG. But I compared the generation of harmonics by the Kenwood diode and the BA479 at lower frequencies and found the BA479 still to be better than the Kenwood diode even at frequencies down to 100KHz.

The above measurements also show that the BA479 has a slightly higher insertion loss than the Kenwood diode. This is a well known disadvantage of pin diodes (also adressed in the excellent articles on your web page). In the case of the BA479, however, the effect is less than –1dB and therefore probably negligable in the 50 Ohm system of the TS-940. To confirm this, I also used a dB meter to determine the insertion loss of two Kenwood diodes in series compared with two BA479 in series. At 17 mA diode current, two Kenwood diodes produce a loss of -0.2dB at 1.75 and -0.1 dB at 3.5 though 28 MHz. Two BA479 in series cause a loss of –0.8 dB at 1.75 and 3.5MHz and -0.7dB at 7 through 28MHz. So there is a clear difference, but probably without much importance.

What are the consequences? As long as a broadband antenna feeds the TS-940, the front-end before the bandpass (diodes D3, D5... D19) will probably be improved by changing into suitable pin diodes, such as the BA479. Those who use the TS-940 only with a beam antenna (e.g. 20-10m), which is unlikely to deliver large signals at 80 and 160m, will probably not have much benefit. The two switching diodes between the bandpass filters and the preamplifier may also be replaced by pin diodes at the lower bands (D6, D8 ... D14 and D21). I would not recommend to exchange D16, D18 and D20, because the original diodes are already excellent at the higher bands and the pin diodes would add nothing else than a (minimal) increase of insertion loss.

In addition to the front-end diodes, there are also numerous switching diodes in the IF unit. Particularly those before the 8MHz crystal filters may be considered for replacement by pin diodes. I can imagine that this will improve narrow-band intermodulation. I’d be curious if anybody else has experience with this. If not, I may check out this point in future.

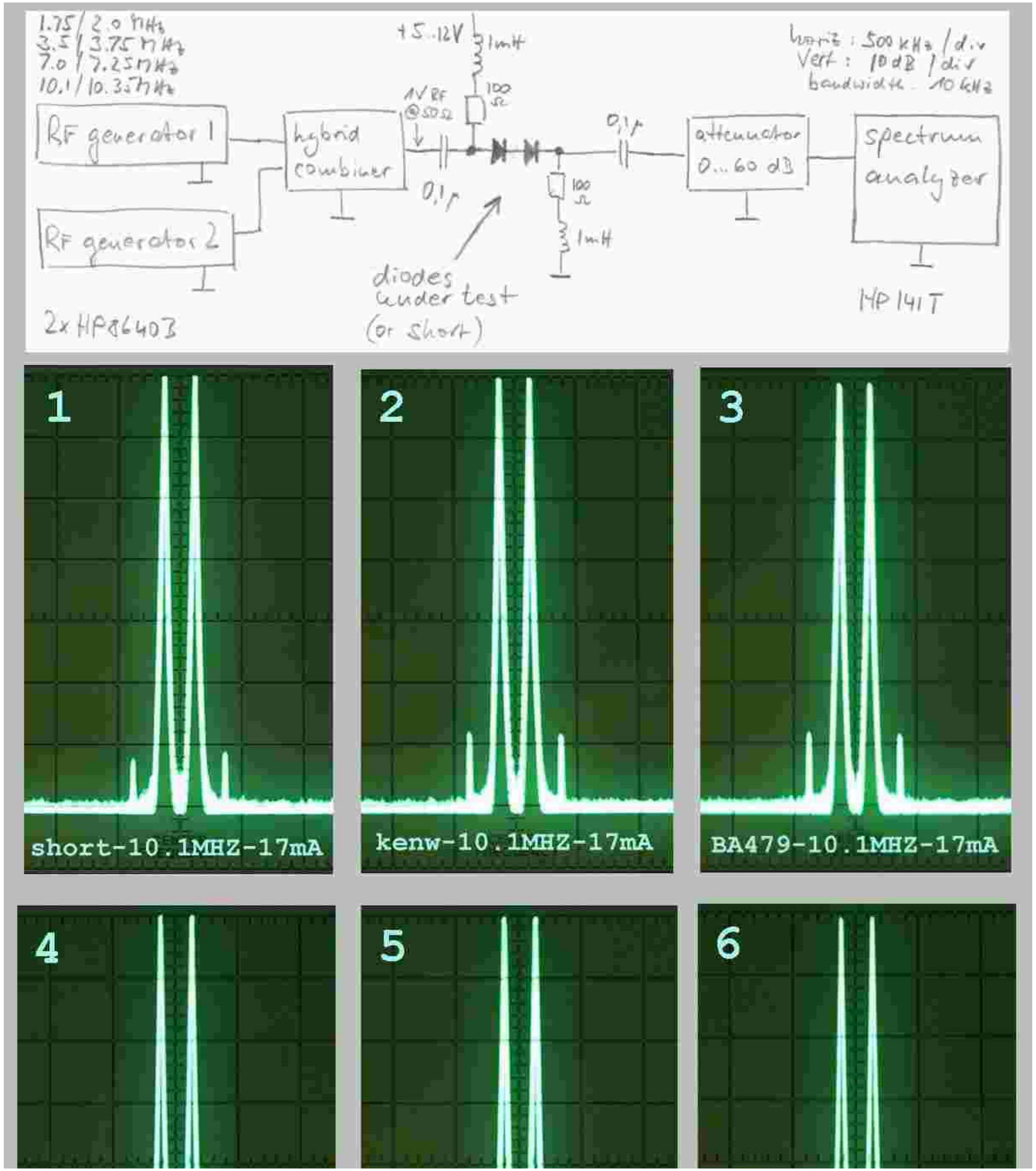
Your last mail says you ordered 40 BA479 diodes, so it seems you found a source. I for myself also ordered 50 BA479 from Schuricht, here in Germany. It’s good to have some on stock for future projects and people say these parts are likely to be replaced by SMD types in future. If you still need BA479, let me know and I will try to help. By the way, there are probably excellent alternatives. The TS-940 uses in its front-end an attenuation pad which is part of the AGC (D23 and 26, MI204). I tested these and found they are even a little better than the BA479. The problem with these is that they are hard to obtain.

Thank you for mailing the discussion on the reversed Q10/Q4 problem. Although I was unable to find a difference in my test setup (as I reported earlier), it is certainly possible that there is an asymmetry of the internal capacitances that did not become apparent in my measurements. I think I should try out this mod and do some measurements, but it may take a little until I’ll have time. It would also be interesting to see how the increase in sensitivity, if it really occurs, will change the receiver's dynamic range.

Finally, my congratulations for your exciting web page! You did a very good job in digging out all the fascinating information about and around the TS-940. It's a pleasure to contribute.

Best regards,

Thomas
(DF5KF)


1.75 / 2.0 MHz
3.5 / 3.75 MHz
7.0 / 7.25 MHz
10.1 / 10.35 MHz
+5..12V
1mH
100 Ω
1V RF @50Ω
0,1µ
RF generator 1
RF generator 2
hybrid combiner
0,1µ
diodes under test (or short)
100 Ω
1mH
attenuator 0...60 dB
spectrum analyzer
horiz: 500 kHz / div
Vert: 10 dB / div
bandwidth 10 kHz
2x HP8640B
HP 141T
1
short-10.1MHZ-17mA
2
kenw-10.1MHZ-17mA
3
BA479-10.1MHZ-17mA
4
5
6

4.5 : Pin Diode Modification for TS-440

A similar sort of mod for the TS-440 maybe found at:
http://www.mods.dk/view.php?ArticleId=1709
===

4.6: So summary of Pin Diode Modification

Until further research verifies otherwise, only replace (odd numbered) diodes that carry less than 10 MHz. [Above 10MHz BA479 has more attenuation than the Kenwood 1s2588, so leave the original 1s2588 in place.] It maybe better to hold off any replacement until research is completed.

-----Original Message-----
From: Jeff King [mailto:jaking@es.co.nz]
Sent: Monday, 13 June 2005 9:53 p.m.
To: 'thomas hohlfeld'
Subject: RE: TS-940S - pin diode part#2 and some other considerations

Hi Thomas,

Thanks for this.
Just to verify I understand you correctly.

At 17 ma you advise
===
The above measurements also show that the BA479 has a slightly higher insertion loss than the Kenwood diode. This is a well known disadvantage of pin diodes (also addressed in the excellent articles on your web page). In the case of the BA479, however, the effect is less than -1dB and therefore probably negligible in the 50 Ohm system of the TS-940. To confirm this, I also used a dB meter to determine the insertion loss of two Kenwood diodes in series compared with two BA479 in series. At 17 mA diode current, two Kenwood diodes produce a loss of -0.2dB at 1.75 and -0.1 dB at 3.5 though 28 MHz. Two BA479 in series cause a loss of -0.8 dB at 1.75 and 3.5MHz and -0.7dB at 7 through 28MHz.
===

so Jeff King concludes that
Two BA479s at 17 ma show
-0.6 dB more insertion loss at 1.75 MHz
-0.7 dB more insertion loss at 3.5 MHz

-0.6 dB more insertion loss at 4 MHz through to 28 MHz

This means the BA479 will reduce the signal and therefore will not improve the receiver performance. In Jeff's opinion this is considerable increase in loss of receiver performance, and not really viable to use a BA479 as a replacement.

Transmitter performance between 1.5 and 7 MHz will improve because of the much better BA479 IMD performance you describe.

On 31-5-2005 Thomas advised at 25 ma
==
3. I also tried a BA479G which I left from another project. ……… At
10 MHz and above, the BA479´s have a slightly higher insertion loss than the
original Kenwood diode (1-2 dB worse). Below 10MHz the BA479 showed less (!)
insertion loss and were clearly superior with respect to intermodulation.
==

This means the only diodes that should be replaced are
D13, D11, D9, D7. in operating at 1.5 MHz to 8.5 MHz and 25 ma

D5 and D3 operate at less then 1.5 MHz, and the performance of the BA479 is unknown in that region.

I wonder if you could document the actual insertion loss of a BA479 performance at 25 ma between 1.75 MHz AND 10.0 MHz?

I look forward to your reply.
Yours sincerely
Jeff King

Diodes on RF board	Original Kenwood Diode	Original Spec	Operating Frequency MHz	Replacement	Replacement Spec
D3	1s2588 [(L30) DIODE TW-4000A, $3.15]		~0.5	Don't replace until testing verifies suitability	
D4	1s2588		~0.5	Don't replace BA479 -0.3 dB loss is too great	
D5	1s2588		0.5-1.5	Don't replace until testing verifies suitability	
D6	1s2588		0.5-1.5	Don't replace BA479 -0.3 dB loss is too great	
D8	1s2588		1.5 -> 3.0	Don't replace BA479 -0.3 dB loss is too great	
D10	1s2588		3 - 4	Don't replace BA479 -0.35 dB loss is too great	
D12	1s2588		4 - 7	Don't replace BA479 -0.3 dB loss is too great	
D14	1s2588		7 - 8.5	Don't replace BA479 -0.3 dB loss is too great	
D7	1s2588		1.5 -> 3.0	PIN type BA479	SI-D 30V 50mA 100MHz
D9	1s2588		3 - 4	PIN type BA479	SI-D 30V 50mA 100MHz
D11	1s2588		4 - 7	PIN type BA479	SI-D 30V 50mA 100MHz
D13	1s2588		7 - 8.5	PIN type BA479	SI-D 30V 50mA 100MHz
D16, 15	1s2588		8.5 - 14	don't replace BA479 has 1 - 2 dB higher insertion loss than 1s2588 > 10MHz	
D18, 17	1s2588		14 - 20	don't replace BA479 has 1 - 2 dB higher insertion loss than 1s2588> 10MHz	
D20, D19	1s2588		2 -- 30	don't replace BA479 has 1 - 2 dB higher insertion loss than 1s2588> 10MHz	

D21	1s2588		2 -- 30	don't replace BA479 has 1 - 2 dB higher insertion loss than 1s2588> 10MHz	
D26	MI204	Pin Diode	2 -- 30	don't replace BA479 has 1 - 2 dB higher insertion loss than 1s2588> 10MHz	

Whether you install many pin diodes depends on how crowded the bands are at your location.
More information below explains this:

-----Original Message-----
From: thomas hohlfeld [mailto:thomas_hohlfeld@hotmail.com]
Sent: Tuesday, 21 June 2005 9:16 a.m.
To: jaking@es.co.nz
Subject: RE:

Hi Jeff,
yes, I think that 0.3-0.4 dB is almost nothing. Remember that one S unit makes 6 dB (20-fold more!). The additional loss caused by the pin diodes therefore is a very small fraction of an S unit. A few meters of RG58 antenna cable with conventional plugs cause more attenuation than these pin diodes.

By the way, I also measured the attenuation between the TS-940 antenna plug and the preamplifier input. All frontend switching diodes plus the relay contacts plus the bandpass filters (14 MHz) have an attenuation of 2 dB. The same measurement with my Icom IC751 was 5 to 6 dB. This shows that the TS940 is indeed an excellent construction.

Based on the results of my pin diode measurements I have now replaced most of the switching diodes with BA479G. The only exception are D20, D18, D16 and D14 which I did not change. With this change (plus turning around Q10), the RX sensitivity (MDS) is -135 dBm, an excellent result fully competitive with the top Rigs marketed today.

Best regards,
Thomas

From: Traian Belinas [mailto:traian.belinas@deck.ro]

Sent: Monday, 20 June 2005 10:29 p.m.
To: jaking@es.co.nz
Subject: Re: pin diode, reversed FET
Hello Jeff,
0,35 dB is an INSIGNIFICANT amount of loss, it is even dificult to detect a such low difference....
The positive aspect of the reduced IMD (especially the second order IMD reduction) is by far more important than the little loss.
My only doubt in such case is the parts and labour cost, and if the mod is really needed for you there.
If you consider it as being needed (if you have unwanted strong signals at your QTH, and please consider the broadcast bands also), **then go for this mod with confidence.**
Thomas is right, the lower bands are really crowded here, especially during the evening. You are a lucky OM being there in ZL...
After 22.00 local time, the 80m band is full here, I can hear even the italian and DL stations making local QSO's with other I and DL stations there respectively and having some big signals, as not to mention the russians which are everywhere and really strong, like locals, and S9 + 30 to 40 dB signals are usual. The thousands of GU43, GU74 and GS35 power tubes are really put to work out there, hi.
In my case, the added city QRN is also high, the normal noise is to +20 dB, so I use the attenuator for to get the noise lower, at a reasonable level as it have no sense seeing the S meter to S9 + 20

only because of the noise and so to loose a big part of available Rx dynamic range. The PIN mods are usefull here in Eu.
73,
Traian, YO9FZS
All the Best,
Traian

From: Traian Belinas [mailto:traian.belinas@deck.ro]
Sent: Wednesday, 22 June 2005 10:26 p.m.
To: jaking@es.co.nz
Subject: Re: pin diode, reversed FET

Jeff King wrote:
Traian,
Hi thanks for this. It did really help my understanding.
In New Zealand we have max of 4,500 hams.
The bands are not crowded
http://kb9amg.slyip.com/markd/KB9AMG/top_dx_spots/by_callsign/zl.html
This is the strongest ZL stations.
So on 80 meters at night I can tune whole band and only hear about 2 or more other stations.
My 80 antenna, you have seen diagram is only about 13.5 off ground so it does not work well.
Usually I hear Australian stations and occasionally some USA.
Yes when propagation is there I hear those strong Russians here too.
Now back to Pin diodes.
My simple understanding of how the pin diode works is that the clean pin diode prevents other unwanted multiple frequencies up and down the band. This would seem to be an advantage during transmitting because it prevents unwanted additional off frequency splatter signals on the band.

Until I read your email yesterday, I did not comprehend to the fact that of course this works in reverse for receive!!! It the existing diodes generate those off frequency signals then of course the a nearby signal will be picked up off frequency in reverse the same way and that off frequency signal will be heard as interference on top the signal you want to hear. Hence Pin Diodes significantly improve the selectivity of the receiver. Traian please confirm this understanding is correct.

Not quite so.
The PINs will have big advantage for Rx only.
The problem with the normal junction diodes is that when they conduct (when the filter is switched in line), the far out of band signals may cause 2nd order IMD and the close or in band signals may cause 3rd order IMD. Note that the in band mean inside the BPF which may have many MHz bandwidth...
Actually the diode act like a mixer (such simple one diode mixers are used, especially at SHF)! You may see how it hapen if consider the unwanted signals which will be mixed by the diode...
For example, when receiving the 14 MHz band here in EU, if big signals exist in the 41m broadcast band, they may cause second order IMD (a 7110 and 7150 kHz BC stations may produce a ghost signal at 14250 kHz as second order IMD; the same will hapen for different bands/frequencies...). Also, when receiving the 40 m ham band, two signals on the 41m BC band may cause 3rd order IMD apearing as ghost unreadable or carrier signals on the 40m amateur band. These are only particular examples, as when the propagation is good, many hundreds of signals arrive simultaneously at the RX diode bandpass filters input which may cause a lot of trouble, especially the stronger ones, the band may seem noisy or ghost or unreadable signals may appear.
The advantage of the PINs is that they act (theoretically) as controlled resistor, they can rectify and mix only for the signals at frequency lower than the one corresponding to its carrier lifetime and their switching characteristics regarding the produced IMD are much better than for the normal diodes.
You may understand now why PINs having large carrier lifetime specification as the BA479 are better for HF than the ones having very small carrier lifetime: they may maintain the same good IMD behaviour at lower frequencies; and the bigest problem is at the lower bands, as Thomas measurements confirm, it is just a practical confirmation of the theory...
Regarding the TX, the signals switched during Tx are few, they are the mixing products from the Tx mixer and IMD is not a problem, as all are originating from the same signal, so a PIN will not make large improvement for Tx. Actually, the Tx IMD are generated by the final amplifier...
Jeff, please note that the proffesional Rx, if not using relays for the BPF switching then they are using good PIN diodes.
So, using PINs instead of the existing diodes is a good thing, especially if the above mentioned problems seemed to occur (so include the presence of the strong signals of the broadcast bands!).

But if big signals are not present, if have a good quiet location like yours, and when considering the cost and the effort involved, it may not worth doing it. It is only a decision of each of us, depending also on the local Rx conditions...
This is what I intended to let you know before.
The mod shall be more usefull for me here, but I am not decided because I will have to sell all the radios some day, so no reason for spending $ and effort for such mod, and I consider also that some buyers don't like buying the modified radios...

Now I must admit I am not sure if I Need these pin diodes. Now propagation is not good I am only really listening on 20 at about 3 UTC. According to Thomas [if one want to avoid losses] I probably should only be interested in changing the diodes below 10 MHz, so this is really only going to improve 40m and 80m
Yes, this is done on some Rx, as the Icom R9000, where the Rx BPF are splitted in two banks (LF+MH and HF) switched by good PINs.
the other diodes are normal.
[The TS950 SDX Rx BPFs are also separated in two banks by a HPF filter which attenuate the LF/MF signals when using the higher bands, for avoiding the 2nd order IMD caused by the LF/MF broadcast signals. This is the only difference between the TS950SD and TS950SDX regarding the RF board/front end , and some amateurs that are not aware of this are still speaking of the "big difference" between the two radios !!!]

Now I'm convinced not to do the PIN diode mod. I think you are right I do not need it here, where there is little interference.
===
I look forward to your reply.
Yours sincerely
Jeff King

RECEIVER 5: S METER SLAM AND IMPROVED PERFORMANCE

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** Martin Sole
Sent: Tuesday, 11 July 2006 2:31 p.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] S meter slam mod

I saw a note here the other day/week about the S meter pinning over on power down and an unpublished fix.
I have a radio here that is doing just that, what was the fix? Cannot see it anywhere in the various references checked so far.
Thanks
Martin HS0ZED

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** Jeff King
Sent: Wednesday, 12 July 2006 9:53 a.m.
To: ts-940@yahoogroups.com; kenwood@mailman.qth.net
Subject: RE: [ts-940] Re: S meter slam mod: A Fix does exist but is not documented out in the public forum.
Garey, Not all 940s make an S meter slam on shutdown. On
http://TS-940/TS-940_02.htm#KINR_email

KI4NR [a Kenwood repair expert] explains,

One other thing .....on all the older 940 4, 5 and early 6 mil serial number ...the IF board is different. The gain distribution in not the same. All the 940 ... late 6 and newer had better IF boards. They have more gain TX & RX the radio are hotter sensitivity wise, better AGC compression. I use a 5 mil TS

940 with a later model 8 Mil IF board in it ....much , much better !!
Also Kenwood put an S meter slam mod in those boards. all the older 940 when you shut the radio off, pin the S meter over. The newer boards are fix for that.
If someone can get hold of a later than late 6 mil board, that person will find that extra capacitors / diodes / transistors have been patched onto the rear of the board. There may also have been changes on the on-board components.
If someone could fully document all the changes on the late 6 mill or later board then we would all know what to do to improve the receive. Kenwood must have made a factory modification which has not been publicly released. Once the late 6 mill plus board has been documented, one would have to identify the changes that were due to already published service bulletins. The remaining changes are the secret to improving the receiver the way Kenwood did. If someone could access the unpublished Kenwood Service Bulletins for these changes then that would be the ultimate information for any 940 owner.
Yours sincerely
Jeff King ZL4AI,

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** Garey Barrell
Sent: Wednesday, 12 July 2006 3:31 p.m.
To: ts-940@yahoogroups.com
Subject: Re: [ts-940] Re: S meter slam mod: A Fix does exist but is not documented out in the public forum.

Hi Jeff -

Well, mine is not only a "mid 7 mil" unit, it's even been to KI4NR for a complete workover, and it still pegs the S-Meter at turn-off.! Always has.
Typical Kenwood, nothin's ever easy. (Or documented!) :-)

Good to hear from you!
73, Garey - K4OAH
Atlanta

Drake 2-B, 4-B & C-Line Service Data
<http://www.k4oah.com>

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** DavidGriffin
Sent: Thursday, 13 July 2006 12:08 a.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] Re: S meter slam mod: A Fix does exist but is not documented out in

Mine does not.
Dave

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From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** Martin Sole
Sent: Thursday, 13 July 2006 1:22 a.m.
To: ts-940@yahoogroups.com
Subject: Re: [ts-940] Re: S meter slam mod: A Fix does exist but is not documented out in

Sooo... the question has to be, what's your serial number, the radio's I
mean. Starting to look like a cutoff in the 7 mil region.

73
Martin, HS0ZED

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** Martin Sole
Sent: Thursday, 13 July 2006 2:52 a.m.
To: ts-940@yahoogroups.com
Subject: Re: [ts-940] Re: S meter slam mod: A Fix does exist...

A quick check now I have the 9 mil radio fixed, at least as far as getting the power supply going anyway, shows no tendency to pin the meter needle on power down in the way my 7 mil radio does. All this one does is drop to zero immediately followed by a slight blip to about S6.

Now to investigate the difference.
73
Martin HS0ZED

Editor Comment: It looks like Martin is going to investigate and solve the mystery of the S Meter Slam / Receive performance improvement. Here is a question asked 2 days earlier:

Jeff King wrote:
Hi Martin,
Thanks for your communication.
…..

Re The S meter slam. If you find the solution to that I would be eager to know. As KI4NR advised Kenwood fixed that from 7 mil or 8 mil on, but Kenwood never published the fix. I emailed Kenwood Australia about this but they refused to give the information. Whatever Kenwood did to the 8 mil board improved reception and finding that out would be so useful.
Yours sincerely
Jeff King ZL4AI

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] On Behalf Of Martin Sole
Sent: Friday, 14 July 2006 1:22 a.m.
To: ts-940@yahoogroups.com
Subject: Re: [ts-940] Re: S meter slam mod: A Fix does exist...

For those who may have an interest I believe I have identified the cause of and solution for the S meter end stop slam on power down.
Resources were a 7 mil radio with the 'problem' and a 9 mil radio without.

Observation shows a couple of differences in this area, an additional 100u capacitor under the board and a diode in place of a jumper.
Reference TS940 service manual revised edition 1987-3 pages 92 and 93 on page 92 IC1 is located in area H,2. and on the board layout, page 93 at E,2.

On the 7 mil radio IC1 is fed with 15 volts through R206 and R178. On the 9 mil radio a diode is located between R206 and R178 in the position of J5 on the board layout. Additionally a 100u capacitor is fitted between the junction of this new diode (cathode) and R178 (+ve side) and ground (-ve side).

Overall this gives an increase in the time taken for the supply to IC1 to fall. Increased from approx 300mS to approx 800mS.
I used an ordinary 1N914 type diode and a 100uF 25 volt electrolytic.

73,
Martin, HS0ZED

Jeff King wrote:
Martin,
Thank you so much for investigating and evaluating the effect of the new components which eliminate S meter power off slam. That is very useful

information which many 940 owners will value. I really appreciate your efforts.

Two questions:
1.
On the 9 mill IF board did you identify any other component changes that will effect (make improvement to) the receiver?

2.
Any particular reason you used a 1n914 as opposed to the more commonly available 1n4148?
[With your permission All you findings will be placed on the TS940 page.]
Yours sincerely
Jeff ZL4AI?

-----Original Message-----
From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] On Behalf Of Martin Sole
Sent: Saturday, 15 July 2006 3:53 p.m.
To: ts-940@yahoogroups.com
Subject: Re: [ts-940] Re: S meter slam mod: A Fix NOW exists... are there any 9 MILL IF changes that IMPROVE THE RECEIVER?

Hi Jeff,

So far I have not dug any deeper into the various board differences. I did note a couple of resistors and capacitors under the board of the 9 mil unit that do not appear to be on the 7 mil board.
A couple of things that I have noted is that the 9 mil radio sounds quieter, equally as sensitive but less background noise. It could be alignment, not sure yet. I do know that the noise blanker in the 7 mil radio is vastly better than the 9 mil radio but I put this down to my own alignment. On many of the 940's and 930's that I have seen over the years most have their noise blanker incorrectly set up such that they are usually only partly effective.
Actually I do not know exactly what the diode was that I used for the meter mod, only that it was a small silicon signal diode, could well have been a 1N4148.
Like Garey, K4OAH, I'm not all that sure that the slam is a big problem. Most older radios, Collins, Drake to name but two generally pin their S meters at switch on and also when muted by a connected transmitter, Have never heard of a lot of meter failures. Either way I think it is better engineering to avoid such where possible.

By all means add whatever you want from this to your most useful resource.
73,
Martin HS0ZED

dean hunsinger wrote:
I have a 9 mil s/n radio and at shut down the meter does not hit the > other end just a slight rebound from off position.Is there a freq that this group uses?

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] On Behalf Of Martin Sole
Sent: Sunday, 16 July 2006 2:20 p.m.
To: ts-940@yahoogroups.com
Subject: Re: [ts-940] shutdown

Hi Dean,
That sounds about right from what others have said and what I found. Seems to be somewhere in the 7 or 8 mil range that the change got implemented.
73,
Martin HS0ZED

RECEIVER 6: PHASE NOISE

The Phase Noise improvements are probably the most significant improvements possible to the 940.
These will upgrade a 1984 design to a 2008 design.

What follows in this section is:

1. Observation of the Phase Noise problem by Thomas Hohlfeld DF5KF in 2005
2. Extensive History of the Phase Noise Issues upto about June 1987
3. Data Sheet for Problem BA718 OpAmp
4. What is Phase Noise and how to measure it by John Grebenkemper, KI6WX
5. Phase Noise measurements on Elecraft K2 by John Grebenkemper, KI6WX
6. Significant Phase noise improvements developed by Thomas Hohlfeld DF5KF
7. Information on Ultra Low Noise OpAmps available in 2008
8. Further assessment and Phase noise improvement evaluations planned by Jeff King ZL4AI

6.1 Observation of the Phase Noise problem by Thomas Hohlfeld DF5KF in 2005

From: hohlfeld_thomas [mailto:thomas_hohlfeld@hotmail.com]
Sent: Sunday, 3 April 2005 10:08 p.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] VCO phase noise

Hello to everybody

A couple of years ago I came across some test reports on the 940, which claimed that the phase noise of VCO3 is rather poor. I measured it and, indeed, is was worse than reported for other rigs of the time. A comparison with an IC-751 (my former rig) indeed favoured the ICOM. Thereafter, I added the PLL modification recommended by Kenwood, which improved phase noise by 5-10 dB. Still, the ICOM is better. Any suggestions about further mods to improve the PLL circuit (PLL3)?
For example, I can imagine that replacing IC18 on PLL unit by a modern low noise op amp will improve phase noise.

When measuring the phase noise of my 940, I noticed weak unwanted signals about +/- 20 kHz apart from the main signal. Indeed, the rig receives weak spurious signals about 20 kHz apart from an S9+40 carrier from a high quality RF generator (HP8694B). The spurious signals (not the main signal) are slightly shifted when the digital display is dimmed. I checked another TS-940 with a similar result. My conclusion is that the DC-DC unit (which oscillates at about 20 kHz) somehow interacts with the VCO. Attempts to improve uncoupling the DC-DC unit from the power supply did not help. Did anybody else observe this and, perhaps, could find a solution?

Certainly, the phase noise and weak spurious signals are minor problems. The 940 remains an excellent rig I. But why not thinking about making a good thing better?

Any suggestions are appreciated.
73 de Thomas, DF5KF

6.2 Extensive History of the Phase Noise Issues upto about June 1987

John Delevore in Edition 1 of Low band DXing speaks specifically about his frustration with phase noise in both the 930 and 940.

Link below is 13 pages of very important observations and dissatisfaction with phase noise in the 940 , when first released.

TS-940_InterNational_Radio_users_Supplement_Addendum1Mar1988.tif

Suggest reading these 13 pages carefully.

Key Points are:

- Kenwood mod 911 (which ZL4AI has never seen) quoted as AR-81-031, 18 Aug 1986 reduces phase noise by 2 to 3 db
- Kenwood mod 917, 2 March 1987, reduced phase noise further to 8 dBc / HZ
- Lowe Modifications by Technical Director John Wilson reduced phase noise further to 13 dBc / HZ. Lowe Modifications are introduction of simple loop filters shown at the bottom of page 11. These can be added to the coax connectors as the VC1 and VC2 lines enter the RF Unit.

Points of interest is:
1.
Lowe did the modifications to transceiver 7060088: manufactured in June 1987.

Lowe was UK Kenwood (Trio) agent so would have had in June 1987 Kenwoods latest modification versions including 917.
Why did John Wilson do his tests against a transceiver fitted with only mod 911?

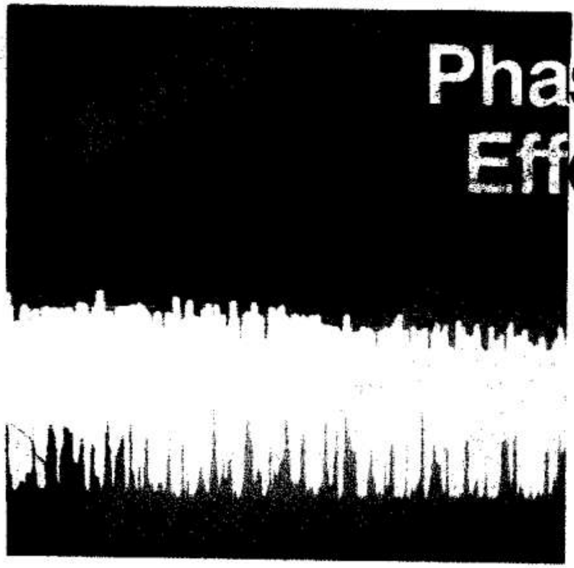
2.
Kenwoods mod 917 is similar to Lowe's Mod. It is adjusting the filtering of signals in and out of IC18 which is dual OpAmp.
It appears this OpAmp is very noisy.

6.3 Data Sheet for Problem BA718 OpAmp

BA718.pdf

Please note there is no data at all on this sheet about this OpAmp being low noise.
One could conclude this means the OpAmp is noisy.

6.4 What is Phase Noise and how to measure it by John Grebenkemper, KI6WX



Phase Noise and its Effects on Amateur Communications

Part 1: A mystery to many amateurs, phase noise is nonetheless an important performance parameter of our gear. This month, we look into its causes and effects.

By John Grebenkemper, KI6WX
Tandem Computers, Inc
10501 North Tantau Ave
Cupertino, CA 95014

It's a Saturday evening and you're listening on 80 meters, tuning for a response to your just-completed CQ. You hear a weak station calling, and just as you are about to copy the last part of the call sign, the signal is masked by a loud, raspy CQ. The station answering you is totally masked by this hissy signal. This noise is clobbering the whole band! You recognize the call sign of the interfering station—it's George, the new Novice just a few blocks away. After you tune up the band to confirm that he is really operating in the Novice subband, you're tempted to give him a call and tell him what a lousy radio he purchased, but good sense and curiosity prompt you to try to figure out the cause of the interference.

You doubt your receiver is the problem, because it has excellent dynamic range, and turning on its RF attenuator doesn't eliminate that awful rasping. Therefore, it must be George's transmitter. Maybe his transmitter has a parasitic oscillation, but you've never heard a signal so thoroughly wipe out an *entire* band.

or high-Q LC tuned circuits as resonant elements. More recently, *phase-locked loops* (PLLs) have been used in radios with synthesized local oscillators. There is no theoretical reason that prevents a phase-locked oscillator from having better phase-noise characteristics than a free-running oscillator using an LC tuned circuit.

An ideal oscillator would generate a sine wave at a given frequency with no deviation in amplitude or phase over time. If we looked at this signal with an ideal spectrum analyzer, we would see all of the energy concentrated at the fundamental frequency

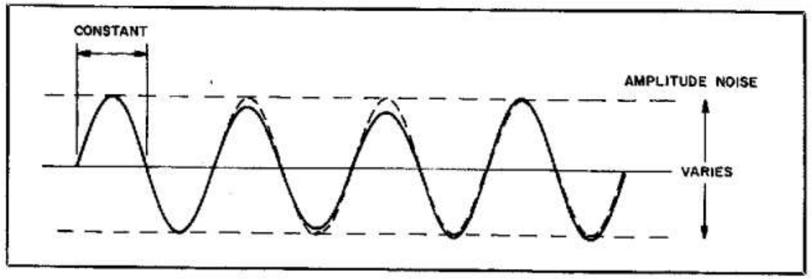


Fig 1—Oscillator amplitude noise effects as viewed on an oscilloscope. The broken line shows the output of an ideal oscillator; the solid line shows the output waveform of an oscillator with a large amount of amplitude noise.

and none at any other frequency. If ideal oscillators existed, problems with phase noise wouldn't exist.

Oscillator signals vary in both amplitude and phase as a function of time. These variations are referred to as *amplitude noise* and *phase noise*. Amplitude noise is an undesired variation in the *amplitude* of an oscillator signal. If we use an oscilloscope to look at oscillator output, we can see that the amplitude peaks of the sine wave vary with time (Fig 1).

Phase noise is an undesired variation in the phase of the signal. In this case, an oscilloscope shows that the time between zero crossings of the signal varies over time when compared to the zero crossings of an ideal sine wave. An exaggerated example of phase noise is shown in Fig 2.

Several factors combine to make amplitude noise much less important than phase noise. The first is that most oscillators tend to produce less amplitude noise than phase noise. This occurs because the active devices in most oscillators are operated in a gain-saturated condition. Gain saturation occurs when increasing the input to a device or stage results in no further increase in output. If a device or stage is sufficiently gain saturated, small changes in the amplitude of the input signal (amplitude noise, in other words) produce no change in the output level.

Amplitude noise is secondary in importance to phase noise for another reason. Most modern ham rigs use mixers in their signal-generation schemes. Because mixers are usually operated with their local-oscillator input ports gain saturated, any amplitude noise on the input signal generally does not appear on the mixer output.

Specifying Phase Noise Levels

There are many ways to display oscillator phase noise. The most common presentation is called single-sideband (SSB) phase noise. This is simply a display of the phase-noise characteristics on one side of the carrier. The SSB phase-noise presentation has probably achieved its widespread use because SSB phase noise is easy to measure and interpret for the average person who is familiar with RF measurement techniques. The display of SSB phase noise is exactly what you would see if the oscil-

A Sample Phase-Noise Scenario

Phase-noise levels are specified in decibels relative to the carrier level, at a particular offset frequency *in a 1-Hz bandwidth*, or dBc/Hz. But this doesn't tell us how much interference is caused by a particular phase-noise level at a given offset frequency, because we don't use 1-Hz receiving bandwidths. If you know your receiver's IF bandwidth, the received carrier power of the phase-noisy signal, the phase-noise level and the frequency offset, you can easily calculate the received power of the phase noise. Then you can calculate how strong a desired signal must be to be copiable through the phase-noise interference.

Let's assume that somehow we know the phase noise on a transmitted signal is −110 dBc/Hz at 4 kHz (where our receiver is tuned) from the carrier. Let's also assume that our receiving bandwidth is 500. This means that there is *500 times* as much phase-noise power getting through our receiver as there would be at a receiving bandwidth of 1 Hz. A power ratio of 500, expressed in dB, is 27. Because our receiver bandwidth is wider than 1 Hz, the phase-noise hiss we hear is not 110 dB below the carrier: it's 27 dB greater in our 500-Hz bandwidth. That's −83 dBc/500 Hz.

If the carrier of the phase-noisy signal produces 5000 microvolts at the receiver antenna terminals, the phase noise in our 500-Hz receiving bandwidth is 83 dB below 5000 microvolts.† This is equivalent to 0.35 microvolt at the receiver's antenna terminals.

This is more than enough signal strength to degrade the sensitivity of a good HF receiver. In fact, a desired signal of reasonable strength could easily be masked by this much phase noise. The sensitivity of a typical receiver is about −137 dBm for a 500-Hz receiving bandwidth. Such a receiver can detect a signal as weak as 0.03 microvolt. In our sample case, the phase noise hits 0.35 microvolt at the receiver input—21 dB greater than the weakest signal our receiver can hear. The phase-noisy incoming signal has degraded our receiver's sensitivity by 21 dB! *—David Newkirk, AK7M, Assistant Technical Editor, QST*

†How true to life is the strength of the interfering signal in this example? On a receiver S meter calibrated for S9 = 50 μV (a common standard), 5000 μV is 40 dB over S9, assuming that the meter calibration is accurate. Signals of this strength are commonplace at many locations.

difference between the measurement and oscillator frequencies, and is usually referred to as the *offset frequency*. Offset frequency is measured in Hz, and it is usually plotted on a logarithmic scale. An offset of 1 kHz means that we are measuring the phase noise 1 kHz from the carrier; an offset of 10 kHz is 10 kHz from the carrier, and so on. A 10-kHz offset from a 10-MHz carrier means that we are making measurements at 9.99 MHz or 10.01 MHz.

Two typical phase-noise measurements are shown in Fig 3. At an offset frequency of 0 Hz, the SSB phase noise is always 0 dBc/Hz, because we are measuring the carrier power, which is the reference for these measurements. At any other offset, the SSB phase noise is always a negative dB value.

Phase noise in a communications system can be divided into two different regions.

Glossary of Terms

Amplitude noise—Undesired variations in the amplitude of an oscillator or synthesizer signal.

Blocking—The region in which a receiver limits the output resulting from a desired signal because of an undesired signal on a different frequency.

Gain saturation—The point at which an increase in input to a device or circuit results in no increase in output.

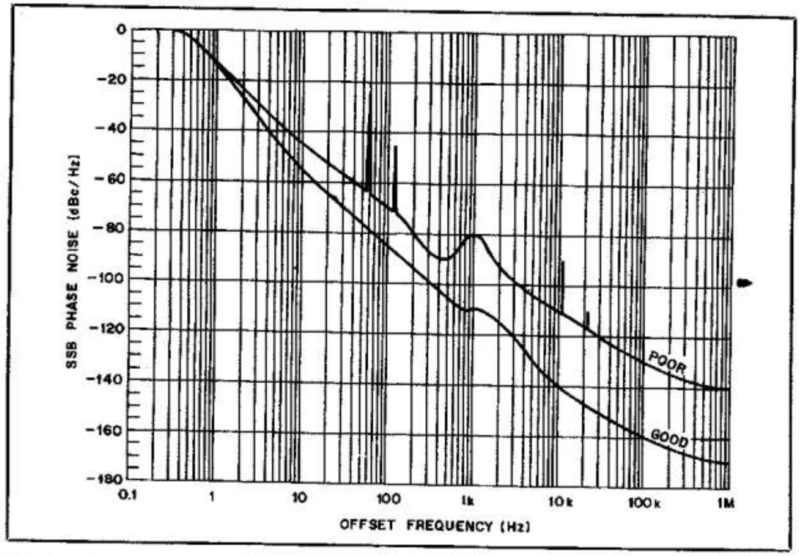


Fig 3—Phase-noise characteristics of two synthesized oscillators. The lower curve represents the output of a well-designed synthesized oscillator. The upper curve represents that of a poorly designed synthesized oscillator. Note the broad peak at 1 kHz, and the spikes visible near 60 and 120 Hz, and 11 and 22 kHz. (See text.)

The example used in Fig 3 shows the phase noise for two different synthesized oscillators. The phase-noise plot labeled "good" is the phase noise from an excellent synthesized local oscillator. These phase-noise characteristics are considered "state of the art" for oscillators used in HF receivers. The phase noise from this oscillator rapidly decreases with increasing offset frequency, reaching −160 dBc/Hz at an offset frequency of 100 kHz. The slight flattening of the phase-noise plot near 1 kHz results from the natural frequency of the PLL. (See the glossary.) (It is normal for a synthesized oscillator to show flattening or a few dB of peaking of the phase noise at the natural frequency of the PLL.) This oscillator would present only minor phase-noise problems in amateur applications.

The phase-noise plot labeled "poor" is typical of what one would expect from an inferior synthesized oscillator. The characteristics of such an oscillator include strong spurious signals, an underdamped PLL, and a high phase-noise floor. (See the glossary.) Large spurious signals are shown at harmonics of 60 Hz and 11 kHz. These signals result from frequency modulation

phase noise of an oscillator compromise the performance of a transmitter (and/or receiver).

Effects of Oscillator Phase Noise

In order to understand the effects of phase noise, we have to keep some basic principles in mind. The term *communications system* used throughout this article refers to the receiver, the transmitter to which the receiver is tuned, and other nearby transmitters. The term *system* is used to convey that phase-noise effects can result from *both the receiver and transmitters,* not just the affected receiver.

Principle 1: Whenever a carrier is passed through a mixer, the phase noise of the oscillator driving that mixer is *added* to the carrier. This means that the oscillator SSB phase-noise power at a given offset frequency is added to the phase noise already present on the carrier at the same offset frequency. For instance, suppose we pass an ideal carrier (one with no phase noise) through two mixers, each driven by an oscillator with an SSB phase noise of −130 dBc/Hz at a 10-kHz offset. After passing the carrier through the first mixer,

system. This principle holds for both transmitters and receivers.

Principle 2: *Phase noise on a transmitted signal causes effects identical to phase noise generated in a receiver.* (Of course, transmitter-generated phase noise can affect many users of the radio spectrum, while receiver-generated phase noise only affects the person using that receiver!)

Principle 3: Passing an oscillator signal through a filter *reduces* the phase noise in accordance with the filter bandwidth and attenuation characteristics. For instance, passing a carrier through a filter (centered on the carrier frequency) with a bandwidth of 20 kHz reduces the phase noise for offset frequencies greater than 10 kHz. As a result of this, transmitters and receivers have an *apparent phase noise* that is usually less than the sum of their local oscillator phase-noise levels. The *apparent* phase noise is what limits the *system* performance.

Phase noise on a transmitted signal causes effects identical to phase noise generated in a receiver.

This effect must be applied with a good understanding of exactly what the filtering does. For instance, in receivers, filtering *before* a mixer determines the apparent phase noise; in transmitters, filtering *after* a mixer determines apparent phase noise. The improvement in the apparent phase-noise floor achievable with filtering depends on the power level of the signal being filtered. A normal filter at room temperature generates thermal-noise power of about −170 dBm/Hz. A −10-dBm signal passed through this filter can achieve a noise floor no lower than −160 dBc/Hz.

Close-In versus Far-Out Phase Noise

The close-in and far-out phase-noise components act on a communications systems in different ways. Close-in phase noise limits the performance of the system even when there is plenty of signal present. With an AM or FM signal, the close-in

Amplifier Noise: The Hiss that Confuses the Phase-Noise Issue

Plus or minus perhaps 100 Hz to 100 kHz from the transmitted carrier of a synthesized, broadbanded rig, phase noise is usually the major hiss producer.[1] Farther out from the carrier, however—half the band away, perhaps—transmitted amplifier noise from the same broadbanded rig may be busting up weak-signal QSOs for hams across town. What's going on? Isn't all transmitted broadband hiss caused by phase noise?

Phase-noisy oscillators usually manifest themselves as broadband hiss when

(1) Our receiver has a phase-noisy oscillator, and we tune it to a frequency adjacent to a very strong signal emitted by a phase-quiet transmitter; or

(2) Our receiver has a phase-quiet oscillator, and we tune it to a frequency adjacent to a very strong signal emitted by a phase-noisy transmitter; or

(3) Our receiver has a phase-noisy oscillator, and we tune it to a frequency adjacent to a very strong signal emitted by a phase-noisy transmitter.

We can infer from these points that if we install phase-quiet oscillators in transmitter and receiver, we ought to be able to tune our receiver to a frequency closely adjacent to a very strong signal from the transmitter without encountering anything like phase-noise hiss. Yet, after an exhaustive phase-noise cleanup at transmitting and receiving sites, we test our communication system only to discover that the transmitter still emits broadband hiss! The culprit is transmitted *amplifier noise.*

Just about every modern transmitter or transceiver consists of a high-gain, linear amplifier strip that amplifies the low-level output of oscillators, mixers and phase-locked loops to hundreds of watts or a few kilowatts. Because amplifier circuitry is not perfectly quiet, the output of the transmitter contains noise (hiss) in addition to the amplified signal. Transmitted along with the desired signal, this hiss can degrade the noise floor of nearby receivers—just as transmitted phase noise can.

Where does amplifier noise come from? *Thermal noise,* for one thing. Electronic components operated at temperatures greater than absolute zero generate random electrical noise. This noise is broadband in nature. Greatly amplified in an audio amplifier—or greatly amplified in a radio transmitter, transmitted as broadband radio noise, received and converted to audio—it sounds like hiss. Random variations in electron flow within active amplifier components (transistors and vacuum tubes) are another source of amplifier noise. Transmitted as broadband radio noise, received and converted to audio, it also sounds like hiss.[2]

How strong will transmitted amplifier noise be on the receiving end? As is the case with phase noise, its severity depends on path loss and antenna gain. The nearer the noisy station, the stronger the noise will be—if your receiver doesn't overload first.

How wide will transmitted amplifier noise be? That depends on the characteristics of tuned circuits and other filters in the transmitter's signal path. If the rig needs no retuning for full power output across an entire amateur band, the power bandwidth of its transmitted amplifier noise may be correspondingly wide. By comparison, the strength of transmitted phase noise generally varies greatly within a relatively small band around the carrier, generally decreasing in amplitude with distance from the carrier.[3]

As we become more aware of the importance of phase-quiet oscillator design, we need to keep transmitted amplifier noise in mind as well. In the laboratory, amplifier noise can interfere with phase-noise measurements, just as a preamplifier can modify the results of receiver measurements. In practice, one ham's transmitted amplifier noise can raise the noise floor for ham neighbors even if all the rigs in the neighborhood have phase-quiet oscillators. Because of this, knocking phase noise back to the Vacuum-tube Age won't be the end of the transmitted-hiss battle. We need quieter broadband transmitter amplifiers, too.—*David Newkirk, AK7M, Assistant Technical Editor,* QST

Notes

[1]As encountered on the air, the practical effects of phase-noisy oscillators often appear to be limited to this range. In fact—and this is very important to keep in mind in the testing laboratory and as equipment is designed—there is no theoretical limit to the bandwidth of phase noise.

[2]Strictly speaking, only the second of these occurs as a result of amplification. Combining thermal noise under the term amplifier noise is acceptable for the purposes of our discussion because their on-the-air effects are identical.

[3]The output spectrum of a phase-noisy rig often contains abrupt peaks and dips within this general amplitude decrease, depending on the design and characteristics of its signal-generation scheme. The amplitude of amplifier noise is usually not as variable with frequency.

Table 1
Typical Maximum Tolerable Phase-Noise Levels

	14 MHz	*144 MHz*
EIRP	+50 dBm	+50 dBm
Loss from transmitter to receiver (distance = 1 mile)	60 dB	80 dB
Signal power at receiving antenna (0-dBi gain receiving antenna)	−10 dBm	−30 dBm
Noise power at receiving antenna (background noise)	−150 dBm/Hz	−172 dBm/Hz
Equivalent SSB phase noise	−140 dBc/Hz	−142 dBc/Hz

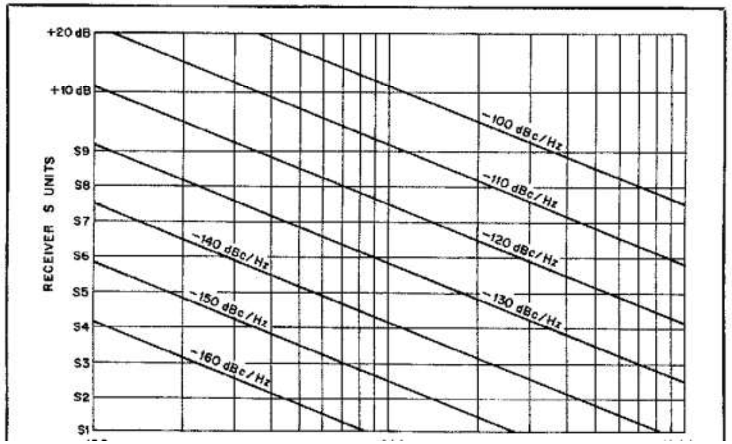
This table shows maximum phase-noise levels tolerable in a communications system before dynamic range is significantly degraded. In both cases, EIRP is 100 W; separation between transmitting and receiving antennas is 1 mile; the receiving antenna is omnidirectional and has 0 dBi gain; and the receiver is sensitive enough to detect the noise.

At 14 MHz, path loss and received noise power allow the receiver to detect any phase noise stronger than −140 dBc/Hz. At 144 MHz, background noise is lower and path loss is higher, resulting in a tolerable equivalent phase-noise level of −142 dBc/Hz at this frequency. See text for additional information.

produces only a few microwatts in a typical amateur receiving bandwidth. As low as this may seem, however, it can be quite a problem for nearby receivers when you consider that a typical HF receiver is capable of detecting signals of less than 10^{-15} watts!

Far-out phase noise in a receiver oscillator is less destructive, because it affects only the receiver in which it is generated. The net effect, however, is the same: Any signal that reaches a mixer in the receiver is modulated by the phase noise in the local oscillator driving that mixer. As such, the signal appears to have at least as much phase noise as the local oscillator. Thus, sufficiently strong signals *off* the receiving frequency can degrade receiver sensitivity by raising the noise floor *at* the receiving frequency. Receiver dynamic range is reduced as the noise floor rises.

As an example, suppose that a transmitter has a power output of 1 kW and an SSB phase noise of −100 dBc/Hz at a given offset frequency. At that offset frequency, the transmitter radiates noise at a level of −40 dBm/Hz. In a 2-kHz bandwidth, this is equivalent to a noise level of −7 dBm, or 200 μW. This is sufficient power to cause significant interference to local receivers. *The effect on a receiver is the same as if the transmitter had low phase noise and the receiver had an SSB phase noise of −100 dBc/Hz.* Fortunately, the oscillators in most amateur equipment don't have this much SSB phase noise at offset frequencies greater than a few kilohertz.



The effect of phase noise on an amateur communications system can be calculated with reasonable accuracy if a few simple assumptions are made. From the calculated effects, we can calculate the oscillator performance necessary to meet our requirements. The assumptions are:

1) The transmitter is located 1 mile from the receiver.

2) The EIRP (effective isotropic radiated power) of the transmitter is 100 W (+50 dBm).

3) The loss from the transmit antenna to the receive antenna is the same as in free space. (This isn't strictly true for signals propagated above ground, but it gives an approximation of the expected signal attenuation. The actual attenuation is almost impossible to calculate because of the effects of the local terrain.)

4) The receive antenna gain is 0 dBi in all directions.

5) Our goal is phase-noise level that does not significantly degrade the performance of the communications system. That is, the received noise resulting from oscillator phase noise should be equal to or less than the background noise normally picked up by an antenna on a given amateur band. (Background noise is composed of radio emissions from our galaxy, as well as man-made noise and atmospheric noise, and varies with frequency.)

Table 1 shows the results of these calculations. The table shows values for both 14 MHz (representative of the HF bands) and 144 MHz (representative of the VHF bands). As can be seen from these calculations, the phase noise must be less than −140 dBc/Hz if there is to be no noticeable interference. A higher EIRP or less transmitter-to-receiver antenna separation would require even better phase-noise performance to guarantee no significant interference. The graph of Fig 4 shows phase-noise interference generated at 14 MHz as a function of transmitter-to-receiver antenna separation, and the apparent SSB phase noise of the system. The interference level is plotted in S units, assuming S9 is equal to 50 μV and each S unit is 6 dB. As can be seen from the graph, an SSB phase noise of −120 dBc/Hz at a distance of 500 feet produces nearly an S9 signal. This graph may be applied to local situations to estimate the interference potential that could result from oscillator phase noise.

Phase Noise Levels in Amateur Equipment

Equipment cost limits the extent to which

curves represent tools for comparison of phase-noise performance in amateur equipment. I derived them to give an overall idea of the phase-noise performance of amateur equipment.

These recommendations are shown by four curves: "excellent," "good," "fair" and "poor." When the phase-noise characteristics of a radio are known, they can be compared to the curves in Fig 5. The worst curve that a radio's phase-noise characteristics pass through should be considered the performance of that radio. The "excellent" curve represents close to "state of the art" performance for HF and VHF synthesized oscillators. For amateur equipment, this curve is approached by free-running LC and crystal oscillators, and the very best transceivers.

The "good" curve represents what is achieved by most well-designed amateur equipment. It doesn't cost a great deal more to design a radio that meets this curve (as opposed to the "poor" or "fair" curves). A radio with phase-noise performance that only meets the "fair" curve hasn't been designed with much regard for minimizing phase noise. The "poor" curve represents a design that is *so* poor that a transmitter with this performance shouldn't be used on the amateur bands because of the great amount of interference it can generate.

The close-in phase-noise characteristics shown in the curves of Fig 5 are relatively easy for most oscillators to achieve. The

Phase-Noise Photographs from the ARRL Lab

The photographs in this section show phase-noise characteristics of several common amateur transmitters. These photos were taken in the ARRL laboratory using procedures developed by Laboratory Engineer Zack Lau, KH6CP. The technique involves mixing the RF output of a Hewlett-Packard 8640B signal generator with the attenuated output of the transmitter under test. (Details of the test setup will be given in Part 2 of this article.)

The scale on the spectrum analyzer on which these photos were taken is calibrated so the base line in the photographs represents −140 dBc/Hz. Vertical divisions are 10 dB, and horizontal divisions are 2 kHz. The horizontal scale covers offset frequencies from 2 kHz to 20 kHz. *Phase-noise levels can be read in dBc/Hz directly from the photographs.* The photos presented here were chosen because they are representative of the equipment available on the amateur market, although *these photos do not necessarily reflect the phase-noise characteristics of all units of a particular model.* Photo A, which shows the phase-noise characteristics of the HP 8640B RF signal generator, serves two purposes: It shows excellent phase-noise characteristics, and it shows the measurement limits of the ARRL test setup. (We hope to have much greater measurement capability in the near future, but this system allows measurement of all but the most phase-quiet signals.)—*Rus Healy, NJ2L, Assistant Technical Editor,* QST

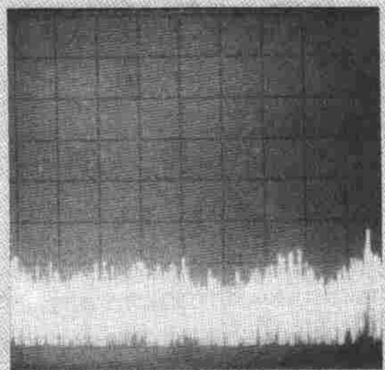


Photo B—ICOM IC-751A (serial number 01043) phase-noise characteristics. Measurement frequency: 14 MHz, power output: 102 W.

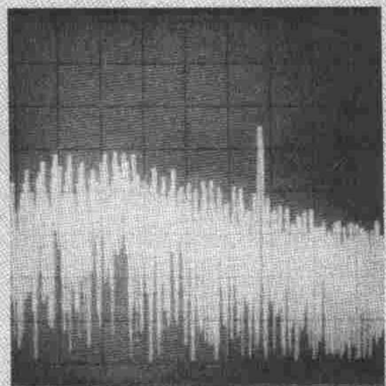
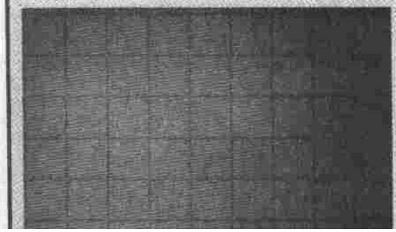
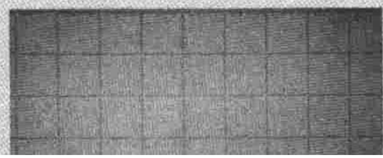


Photo D—Yaesu FT-767GX (serial number 6J030740) phase-noise characteristics. Measurement frequency: 14 MHz, power output: 95 W.





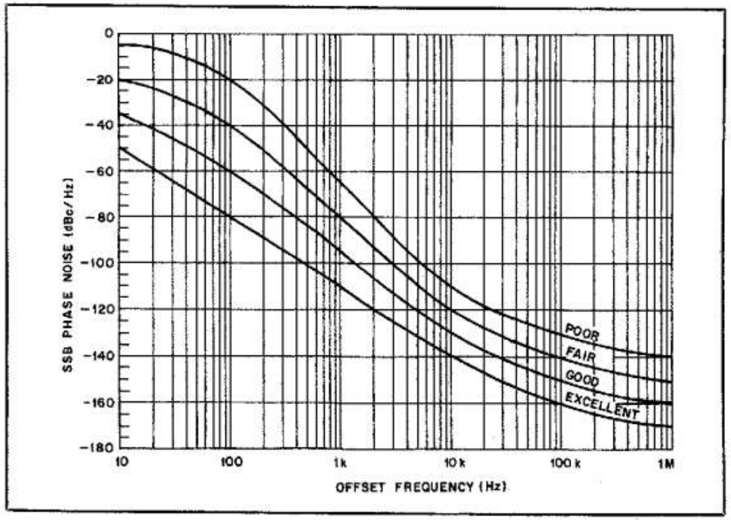


Fig 5—Phase-noise performance levels for amateur equipment. The curves from top to bottom represent poor, fair, good and excellent phase-noise performance. (See text.)

Table 2
Incidental Frequency Modulation

Curve	*IFM*
Excellent	0.4 Hz
Good	2.5 Hz
Fair	20 Hz
Poor	160 Hz

Incidental frequency modulation (IFM) resulting from the phase-noise levels shown in Fig 5. The IFM was calculated for the frequency range from 10 Hz to 10 kHz.

close-in regions of the curves were derived mainly from the effects of IFM on the limiting FM SNR. Table 2 lists the close-in phase-noise IFM integrated from 10 Hz to 10 kHz for each of these curves. (Even a radio generating the IFM level corresponding to phase noise matching the "poor" curve provides adequate voice communications capability.)

Measuring Phase Noise

Equipment capable of measuring low levels of far-out phase noise is quite expensive. It is not unusual for commercial enterprises to invest $100,000 in good phase-noise measurement equipment. Inexpensive techniques are, however, available for measuring the apparent phase noise of communications receivers and transmitters. In Part 2 of this article, I'll mit and receive, overall phase-noise performance can be evaluated by measuring either transmitted or received phase noise—Ed.] The equipment necessary to measure *receiver* phase noise can be built by enterprising amateurs for well under $100.

APPENDIX

Manipulating Units of Measurement

Several of the units of measurement used in this article may be unfamiliar to many amateurs. Manipulation of some of these units is covered here.

Oscillator phase noise is converted to a power level per Hz [Pn(f)] by adding the SSB phase noise [L(f)] to the carrier power [Pc]. This is done by the equation

$$Pn(f)\ \{dBm/Hz\} = Pc\ \{dBm\} + L(f)\ \{dBc/Hz\}$$

where the units are shown in braces.

Power level per Hz [Pn(f)] is converted to a power level [P] in a given bandwidth [Δf] by

$$P\ \{dBm\} = Pn\ \{dBm/Hz\} + 10 \log (\Delta f\ \{Hz\})$$

where the units are shown in braces. This equation assumes that the power level per Hz is constant across the bandwidth.

Incidental Frequency Modulation

The incidental frequency modulation (IFM) resulting from the phase noise on an oscillator can be found by

$$IFM = \sqrt{2 \int_{f_a}^{f_b} f^2\, L(f)\, df}$$

noise ratio in dB can then be defined (using IFM) as

$$SNR_{limit} = 20 \log \left(\frac{FM_{dev}}{IFM} \right)$$

where FM_{dev} is the RMS deviation of the FM signal. This equation yields only an approximation because it doesn't take into account the effects of preemphasis or deemphasis in the FM system, nor the spectral distribution of the modulating signal. (This equation generally yields results that are within a few dB of the actual numbers we would find if we took the trouble to include the other effects.)

The limiting SNR effects on a VHF amateur communications system can be found as shown in the following example. Let's assume the apparent phase noise in a communications system is −40 dBc/Hz at a 100-Hz offset frequency, and decreases to −74 dBc/Hz at a 5-kHz offset frequency. The resulting IFM is 100 Hz. This is not very good performance for synthesized oscillators, even at VHF. If we now assume that the RMS deviation of the FM signal is 5 kHz, the maximum SNR that can be achieved in this system is 34 dB, which is more than adequate for voice communications.

Phase Noise and its Effects on Amateur Communications

Part 2: Last month, we looked into the causes and effects of phase noise in amateur gear. This month, we'll delve into measurement of phase noise, both at home and in the lab.

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In part 1 of this article, I discussed the causes and effects of phase noise in amateur communications systems.[1] This month, procedures used for measuring both receiver and transmitter phase noise will be discussed.

Measuring Receiver Phase Noise

A block diagram of my receiver phase-noise measurement setup is shown in Fig 6. The test setup consists of an oscillator, a step attenuator and an ac voltmeter. The output of the oscillator is fed through the attenuator to the receiver's RF input. The ac voltmeter is connected to the audio output of the receiver. The receiver is operated in SSB or CW mode with the AGC disabled.

The oscillator and step attenuator must be carefully constructed (well shielded, minimum necessary lead lengths, and so on) for proper operation of this test setup.[2] The oscillator provides the reference signal for measuring phase noise. The phase noise of the oscillator must be less than that of the receiver if we are to measure receiver phase noise accurately. The oscillator should have a power output of at least +10 dBm (10 mW) into 50 Ω. Less power than this may limit the accuracy of the measurement setup at low phase-noise levels. The oscillator should be constructed in a metal box and powered by an internal 9-V battery to minimize unwanted signal leakage.

The step attenuator must have a maximum attenuation of at least 140 dB. Preferably, it should be adjustable in 1-dB steps. It is difficult to design a single attenuator circuit that provides this much

A design for a suitable step attenuator is given in *The ARRL Handbook*.[3] Each of the fixed attenuators can be constructed in a shielded enclosure using standard pi or T resistor configurations to achieve the desired attenuation.[4] Use BNC connectors on the oscillator and step attenuator; they have better shielding properties than UHF connectors. Commercial step attenuators and in-line coaxial attenuators are sometimes available on the surplus market. If you choose to build attenuators, use 5% (or better) precision resistors. The accuracy of the phase-noise measurements depends to a great extent on the accuracy of the attenuators.

The ac voltmeter is used to measure the audio output level from the receiver. The voltmeter should measure true RMS voltage, but commonly available peak-reading ac voltmeters are adequate for this application.

Phase-noise measurements are done on the band for which the oscillator is built. Measurements should be made in each amateur band, since phase-noise levels of many receivers vary from one amateur band to another. Briefly, the measurement procedure is as follows: A reference audio output level is established by tuning the receiver to the oscillator frequency and measuring the audio output voltage. The receiver is then tuned above (or below) the oscillator frequency in increments of the desired offset frequency. The attenuation is then decreased until the noise voltage at the audio output is the same as the reference level. The difference in the two attenuator settings is then corrected for the receiver bandwidth to give the SSB phase noise at that offset frequency. The process is then repeated for several different offset frequencies. Now we'll go through the measurement procedure step by step.

Step-By-Step Measurement Procedure

1) Connect the test equipment as shown in Fig 6. Set the step attenuator to its maximum attenuation. Switch the oscillator out of the line. Set the receiver for SSB or CW reception with the AGC disabled. Preamplifiers or input attenuators in the receiver should be disabled, if possible. Use the narrowest IF bandwidth available in the receiver. Set the RF and AF gain controls to maximum, unless this causes the audio amplifier to overload from receiver noise. In case of audio-amplifier overload, reduce the audio gain until there is a minimum of 10 dB of headroom in the audio amplifier. This can be done by decreasing the AF gain (while monitoring audio output voltage) by 10 dB after all signs of gain compression disappear. In other words, decrease the AF gain to 10 dB below the point at which the audio output voltage begins to vary linearly with adjustment of the AF gain control.

2) Determine the 6-dB bandwidth of the receiver. An easy way to do this is to enable the oscillator, tune the oscillator signal through the receiver passband and note the

frequencies at which the audio voltage is 6 dB below the peak response. The difference between the upper and lower frequencies is the receiver's bandwidth. Alternatively, the published 6-dB bandwidth for the receiver can be used. The bandwidth measurement doesn't have to be very accurate—a 25% error in the bandwidth factor affects the phase-noise measurement by only 1 dB. Record the receiver bandwidth (Δf).

3) Switch the oscillator into the line. Center the oscillator signal in the receiver passband. Switch the oscillator out of the line and measure and record the audio output voltage. Switch the oscillator into the line again and adjust the step attenuator until the audio voltage increases by 41% (3 dB) from the no-signal value. The signal is now at the receiver's MDS (minimum discernible signal) level. This setting is a compromise: A higher setting allows more precise measurement of the audio output voltage; a lower setting decreases the possibility of overloading the receiver front end. Record the frequency to which the receiver is tuned (fo), the setting of the step attenuator (A_0), and the audio output voltage (V_0).

4) Measure the phase noise by first tuning the receiver to the desired offset frequency, given by fo + f, where f is the offset frequency. Then, adjust the attenuator until the audio output voltage is as close as possible to (V_0). Record the total attenuation (A_1) and the audio voltage (V_1). The SSB phase noise at this offset frequency is found by

$$L(f) = A_1 - A_0 - 10 \log (\Delta f) \quad \text{(Eq 1)}$$

where L(f) = SSB phase noise in dBc/Hz.

5) Determine if the receiver is overloaded at this offset frequency as follows: Decrease the attenuation by 3 dB. Note the audio voltage at the new attenuator setting (V_2). The audio output voltage of the receiver should increase by approximately 22% (1.7 dB) from V_1. If it increases by less than 18% (1.4 dB), it is likely that some stage in the receiver is overloaded, and the SSB phase-noise measurement is inaccurate. If the overload is in the audio stages, it can be eliminated by decreasing the audio gain and repeating the measurements. If the overloading is occurring in the RF or IF stages, the receiver's blocking dynamic range has been exceeded. The overload may be eliminated by reducing the

Table 3

SSB Phase Noise of ICOM IC-745 Receiver Section

Oscillator output power = −3 dBm (0.5 mW)
Receiver bandwidth (Δf) = 1.8 kHz
Audio noise voltage = 0.070 V
Audio reference voltage (V_0) = 0.105 V
Reference attenuation (A_0) = 121 dB

Offset Frequency (kHz)	*Attenuation (A_1) (dB)*	*Audio V_1 (volts)*	*Audio V_2 (volts)*	*Ratio V_2/V_1*	*SSB Phase Noise (dBc/Hz)*
4	35	0.102	0.122	1.20	−119
5	32	0.104	0.120	1.15	−122*
6	30	0.104	0.118	1.13	−124*
8	27	0.100	0.116	1.16	−127*
10	25	0.106	0.122	1.15	−129*
15	21	0.100	0.116	1.16	−133*
20	17	0.102	0.120	1.18	−137
25	14	0.102	0.122	1.20	−140
30	13	0.102	0.122	1.20	−141
40	10	0.104	0.124	1.19	−144
50	8	0.102	0.122	1.20	−146
60	6	0.104	0.124	1.19	−148
80	4	0.102	0.126	1.24	−150
100	3	0.102	0.126	1.24	−151
150	3	0.102	0.124	1.22	−151
200	0	0.104			−154
250	0	0.100			−154
300	0	0.098			< −154
400	0	0.096			< −154
500	0	0.096			< −154
600	0	0.097			< −154
800	0	0.096			< −154
1000	0	0.096			< −154

Asterisks indicate measurements possibly affected by receiver overload (see text).

looked. This is tedious at the greater offset frequencies. Generally, a coarser sampling is adequate to plot the phase-noise curve, as long as you check the intermediate offset frequencies to make sure that no discrete signals are present. The measurements can start at offset frequencies as close as a few times the receiver's bandwidth, if the receiver has good IF filters. You can determine if the offset is too small by disconnecting the audio voltmeter from the receiver and listening to the audio. If you can hear the carrier signal at all, the offset is too small. All that should be present is noise, if the measurement is to be accurate. Increase the offset until no trace of carrier remains in the audio to be sure.

The measurement technique outlined in the steps above is quite accurate. SSB major advantages is that it measures the *apparent* phase noise of the receiver. Apparent phase noise includes the effects of filters; it is the phase noise that actually limits a receiver's dynamic range.

One disadvantage of this measurement technique is that it doesn't allow *direct* measurement of the phase noise of an oscillator. Therefore, it can't be used to directly measure the phase noise of a transmitter. This limitation can be overcome by using a receiver with known phase-noise characteristics to measure the phase noise of a transmitter. The transmitter is substituted for the oscillator in the test setup, and its output is attenuated to the power level of the oscillator. As long as the transmitter phase noise is greater than that of the receiver, measurements of the transmitter's phase noise will be accurate.

Transmitter Phase-Noise Measurement in the ARRL Lab

Last month, the technique used in the ARRL lab to measure transmitter phase noise was introduced briefly. The system essentially consists of a direct-conversion receiver with very good phase-noise characteristics. As shown in Fig A, we use an attenuator after the transmitter, a Mini-Circuits ZAY-1 mixer, a Hewlett-Packard 8640B signal generator, a band-pass filter and an audio-frequency spectrum analyzer (HP 8556A/8552B) to make the measurements.

The transmitter signal is mixed with the output of the signal generator, and signals produced in the mixing process that are not required for the measurement process are filtered out. The spectrum analyzer then displays the transmitted phase-noise spectrum. The 100 mW output of the HP 8640B is barely enough to drive the mixer—the setup would work better with 200 or even 400 mW of drive. To test the phase noise of an HP 8640B, we use a second '8640B as a reference source. It is quite important to be sure that the phase noise of the reference source is lower than that of the signal under test, because we are really measuring the combined phase-noise output of the signal generator and the transmitter. It would be quite embarrassing to publish phase-noise plots of the reference generator instead of the transmitter under test! The HP 8640B has much cleaner spectral output than most transmitters.

As in the sidebar, "Phase-Noise Photographs from the ARRL Lab," in part 1 of this article, phase-noise photographs for several popular amateur transceivers are shown. All photographs were taken directly from the spectrum-analyzer display, using the test setup shown in Fig A. These photos do not necessarily reflect the phase-noise characteristics of all units of a particular model.

The log reference level (the top horizontal line on the scale in the photos) represents −60 dBc/Hz. It is common in industry to use a 0-dBc log reference, but such a reference level would not allow measurement of phase-noise levels below −80 dBc/Hz. The actual measurement bandwidth used on the spectrum analyzer is 100 Hz, but the reference is scaled for a 1-Hz bandwidth. This allows phase-noise levels to be read directly from the display in dBc/Hz. Because each vertical division represents 10 dB, the photos show the noise level between −60 dBc and −140 dBc. The horizontal scale is 2 kHz per division. The offsets shown in the photos are 2 through 20 kHz.

What do the Phase-Noise Pictures Mean?

Although they are useful for comparing different radios, Figs B-E can also be used to calculate the amount of interference you may receive from a nearby transmitter with known phase-noise characteristics. An approximation is given by

Interfering signal level =
$$NL + 10 \times \log BW \qquad \text{(Eq A)}$$
where

Interfering signal level is in dBc
NL is the noise level on the receiving frequency
BW is receiver IF bandwidth in Hz

For instance, if the noise level is −90 dBc and you are using a 2.5-kHz SSB filter, the interfering signal will be −56 dBc. In other words, if the transmitted signal is 20 dB over S9, and each S unit is 6 dB, the interfering signal will be as strong as an S3 signal.

The measurements made in the ARRL lab apply only to transmitted signals. Because we do not have computer-controlled instrumentation, it is not practical to make the large number of measurements necessary to evaluate receiver phase noise more precisely than author Grebenkemper's setup allows. It is reasonable to assume that the phase-noise characteristics of most transceivers are similar on transmit and receive, because the same oscillators are generally used in the local-oscillator (LO) chain.

In some cases, the receiver may have better phase-noise characteris-

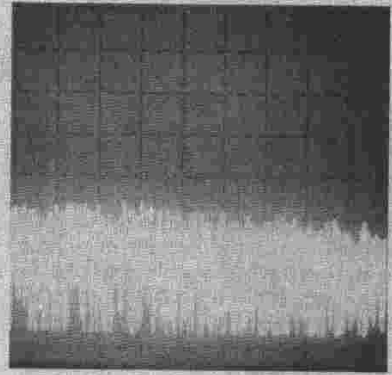


Fig B—Kenwood TS-940S (serial number 7050361) phase-noise characteristics. Measurement frequency: 3.5 MHz, power output: 127 W.

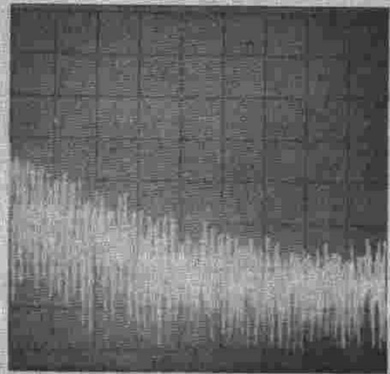


Fig C—ICOM IC-745 (serial number 03101) phase-noise characteristics. Measurement frequency: 3.5 MHz, power output: 100 W.

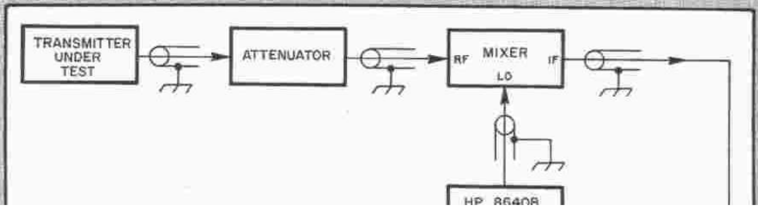


Fig D—Kenwood TS-440S (serial number 7051669) phase-noise characteristics. Measurement frequency: 3.5 MHz, power output: 104 W.

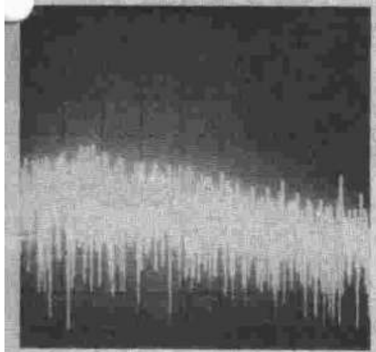


Fig E—Ten Tec Corsair II (serial number 58001721) phase-noise characteristics. Measurement frequency: 14 MHz, power output: 103 W.

removes all but a small slice of spectrum for further signal processing. If the desired filtered signal is a product of mixing an incoming signal with a noisy oscillator, signals far away from the desired one can end up in this slice. Once this slice of spectrum is obtained, however, unwanted signals cannot be reintroduced, no matter how noisy the oscillators used in further signal processing. As a result, some oscillators in receivers don't affect phase noise.

The difference between this situation and that in transmitters is that crystal filters are seldom used for reduction of phase noise in transmit-

their relationships to phase-noise levels in my IC-745 over this range of offset frequencies. The data obtained from the ratio of V_2 to V_1 indicates that the receiver was probably overloaded at offset frequencies from 5 kHz to 15 kHz. This measurement was limited to an SSB phase-noise floor of −154 dBc/Hz because of the low power-output level of the oscillator. Fig 7 is based on the far-out phase noise data obtained from Table 3, as well as the close-in phase noise measured using laboratory test equipment and the same IC-745. The data obtained using the method described earlier and that obtained from the laboratory test equipment closely track each other. The phase-noise performance of this transceiver generally exceeds that indicated by the "good" curve in Fig 5 of part 1 of this article.

Conclusion

Close-in phase noise generally has little effect on the performance of amateur communications systems. However, far-out phase noise *can* significantly reduce the dynamic range of a receiver. Far-out phase-noise performance has effects just as critical as blocking dynamic range and two-tone dynamic range performance of receivers. Ideally, these measurements should be made for a range of offset frequencies. Far-out phase noise in receivers

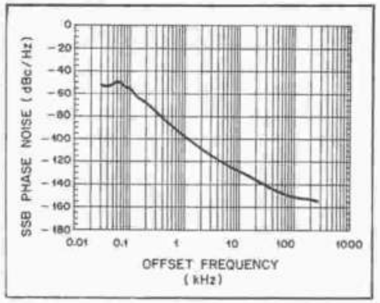


Fig 7—Measured SSB phase noise of an ICOM IC-745 transceiver (serial number 01528).

can be measured with relatively inexpensive test equipment, as long as care is taken to perform the measurements properly.

Notes

[1]Part 1 appeared in Mar 1988 *QST*, p 14-20.

[2]A simple oscillator circuit suitable for use in this application appears in W. Hayward and D. DeMaw, *Solid State Design for the Radio Amateur*, 2nd printing (Newington: ARRL, 1986), p 126, Fig 26.

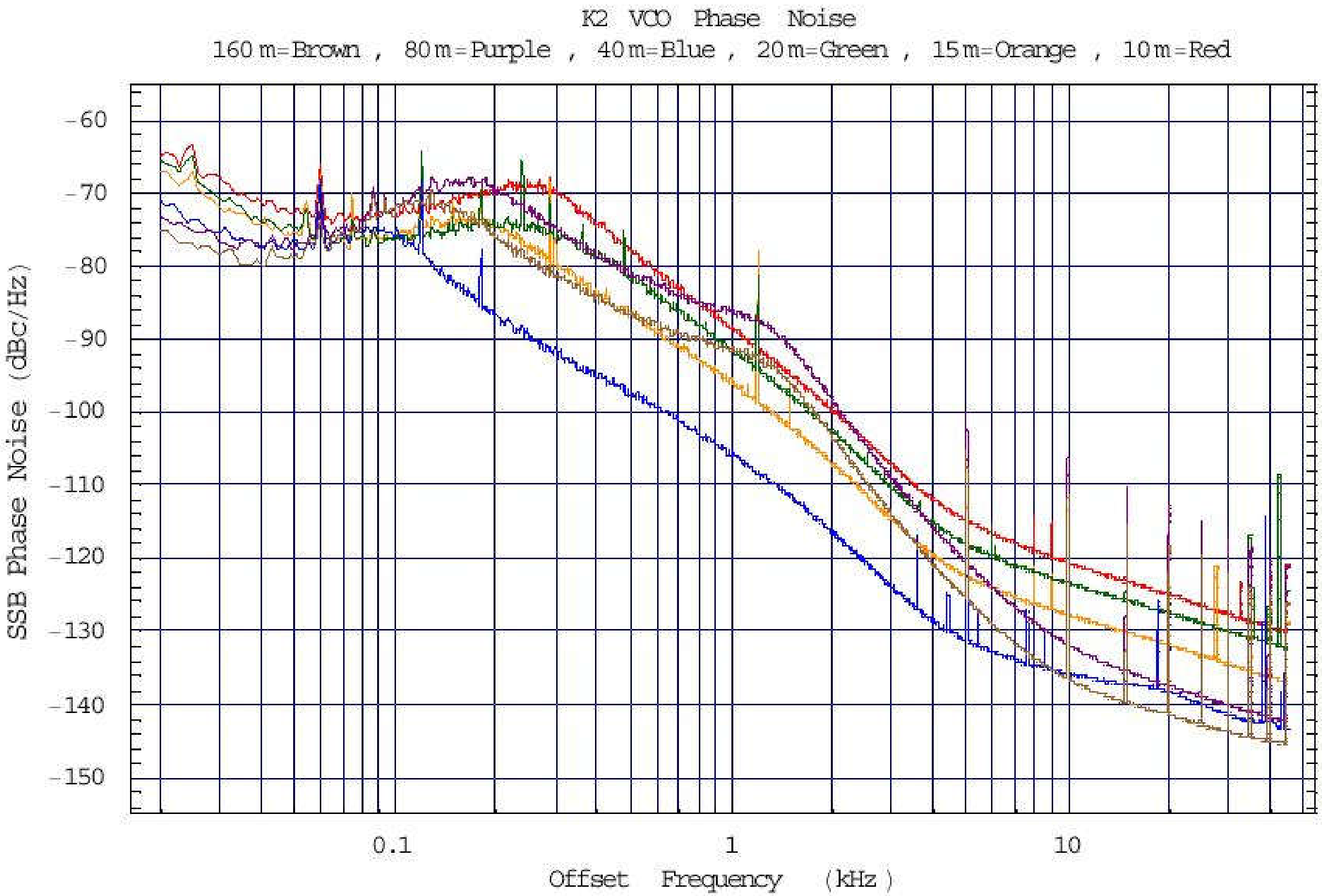
[3]M. Wilson, Ed., *The ARRL Handbook*, 1988 edition (Newington: ARRL, 1987), p 25-43.

[4]Component values and construction information for fixed attenuators are given in *The ARRL Handbook*, 1988 edition, p 25-44.

6.5 Phase Noise measurements on Elecraft K2 by John Grebenkemper, KI6WX

Well worth reading:
http://home.pacbell.net/johngreb/k2phasenoise.pdf

John shows that phase noise varies per band. So you really need to measure phase noise across all major bands 160, 80, 40, 20, 15, 10 to characterize a receiver performance.



6.6 Significant Phase noise improvements developed by Thomas Hohlfeld DF5KF

http://www.darc.de/g35/df5kf.htm

Thomas has probably done more than any amateur to improve the 940. His work is truly impressive.
This modification is probably the single largest improvement to the 940 receiver in its history

Phase noise of the TS-940

Thomas Hohlfeld, DF5KF

The relatively mediocre phase noise of Kenwoods TS-9 0 is largely produced by the PLL loop of the main VCO. Kenwood developed a modification and published a service bulletin for improvement. Read here how much this modification helps and what else can be done.

I own a TS-940 for several years and I am still happy with it. Its general performance is competitive with many contemporary high performance radios. Nevertheless, the TS-940 isn’t free of problems. One is the excess noise generated in the RX when there are strong out-of-passband carriers close to the tune frequency. This is caused by noise surrounding the receiver’s local oscillators and, hence, is produce within the receiver. This ´phase noise´ is mixed with receive signals and appears as a noise sideband of the receive carrier. It may not be evident when performing a QSO under standard conditions, but can be disturbing when weak signals are to be detected with strong signals nearby. Local oscillator phase noise has been designated as a main limiting factor of modern
receiver performance [1, 2]. A good discussion of oscillator phase noise and its consequences on system performance is given in [3]. I studied the problem more closely in my TS-9 0 and evaluated some possible cures.

1. Measurement setup for phase noise determination

The measurement setup was simple: I connected my HP8640B RF generator to the TS-940 antenna input. The HP8640B is known for its clean signal, with phase noise below that of most commercial receivers (<140 dBc/Hz [4]).

The TS-940 was switched to CW mode, RF attenuator off, AGC off an RF gain set to maximum. Band width was set to maximum (2, kHz) and the RX tune to 14.100 MHz. The TS-940 audio output was fed into a true RMS voltmeter. A -125 dBm signal from the RF generator produced a defined audio output, which was 10 B above background noise (= audio out with RF generator replace by 50 Ohm termination).

Then, the RF generator was set to 14.200 MHz (+100 kHz carrier offset) an the generator output increased until the audio noise reached the same audio output as the -125 dBm in-passband signal. The measurements were repeated with stepwise reducing the carrier offset. Lower carrier offsets required lower generator outputs to produce the same audio output.

Phase noise was calculated as follows:

Phase noise [dBc/Hz] = -125 dBm (reference) – dBm RF generator output – 33.8 (*)
(*) correction for 1 Hz bandwidth

2. Improvement of phase noise by Kenwood´s recommended modification

The results of all measurements are depicted in figure 1. The grey line represents the phase noise I obtained before any modifications. The phase noise dropped from about -100 dBm/Hz at 4 kHz offset in a log/linear fashion down to -142 dm/Hz with carrier offsets increasing to 50 kHz. There was no relevant change at higher offsets up to 100 kHz.

Next, I installed the Kenwood modification as described in Service Bulletin #917. As shown by the blue line in figure 1, this reduced phase noise by 5 to more than 10 dB, an encouraging result. Kenwood´s re-design of the PLL apparently moves the loop filter behind IC18 (BA718), which allows for a better suppression of the noise produced by this OpAmp. As a consequence, one would expect less voltage noise FM modulating the VCO varactor diodes. I could not find a detailed datasheet of the BA718, but I assume it is not a particularly low noise OpAmp.

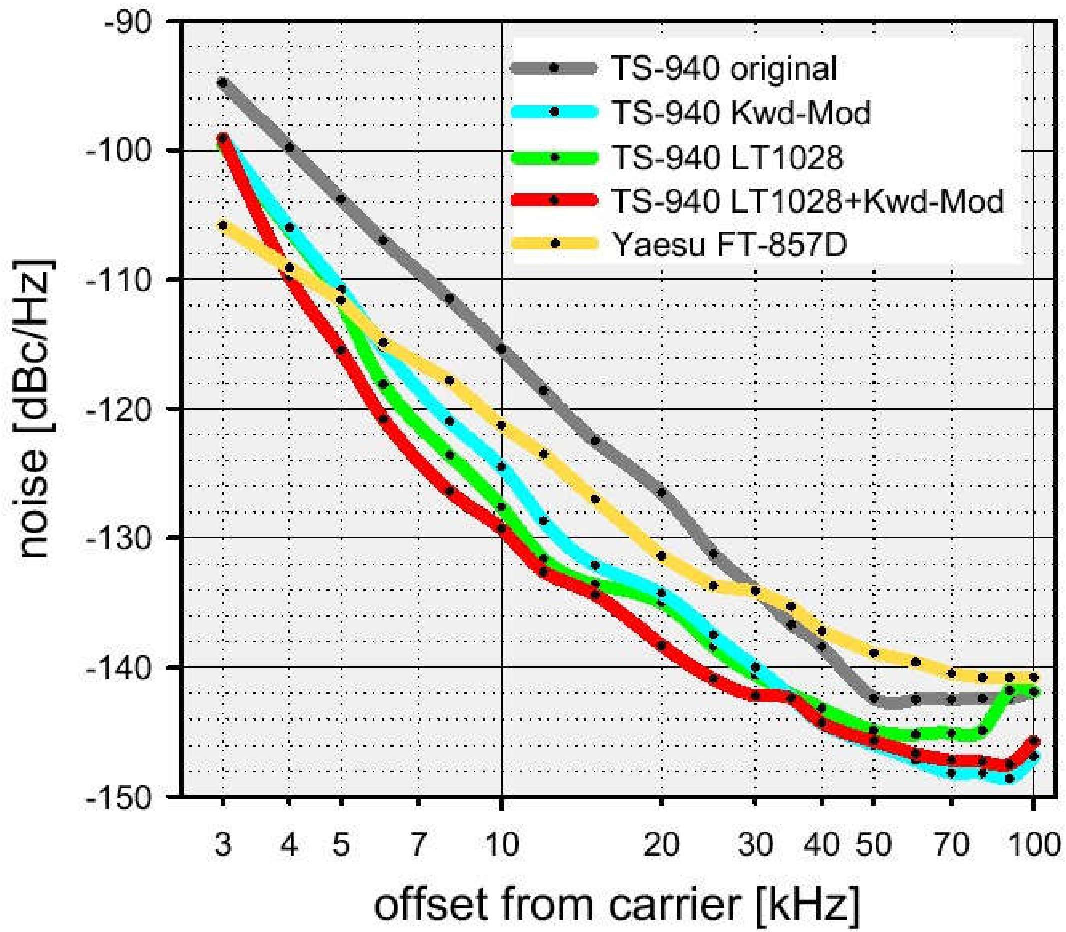
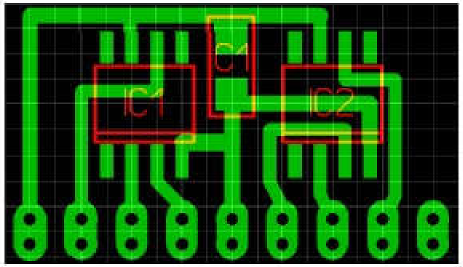


Figure 1: *Phase noise versus carrier offset from the tuned frequency (14.1 MHz). The actually measured offset points are marked by black dots. These were later connected by the coloured lines.*
All measurements have been performed on the same PLL board and the same rig, using the same measurement setup, but were performed on different days. Offsets <3 Hz could not be measured with the available setup.

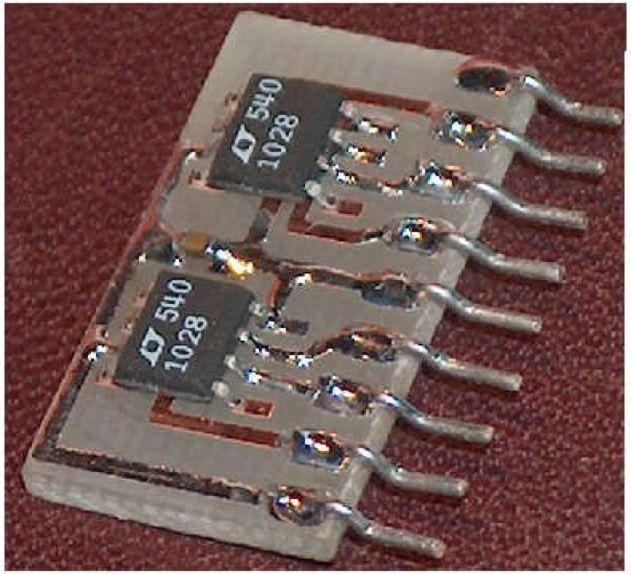
3. Replacement of IC18 by an ultra-low noise OpAmp

Noise in PLL systems can be generate by many causes. One is the loop amplifier stage itself. A good discussion of the origin of PLL noise is given in the ARRL Han book [2]. During the past years, ultra low noise OpAmps have become available, which might be more appropriate for a good
PLL design than the BA718. Therefore, I constructed a small replacement board which contains two LT1028 OpAmps, each in an 8-lead SMD (SOIC) package. The LT1028 is a little more expensive than conventional OpAmps, but still affordable. Figure 2 shows the layout of the PCB, the complete board and part of the TS-9 0 PLL unit after replacement of IC18.

A



B



C

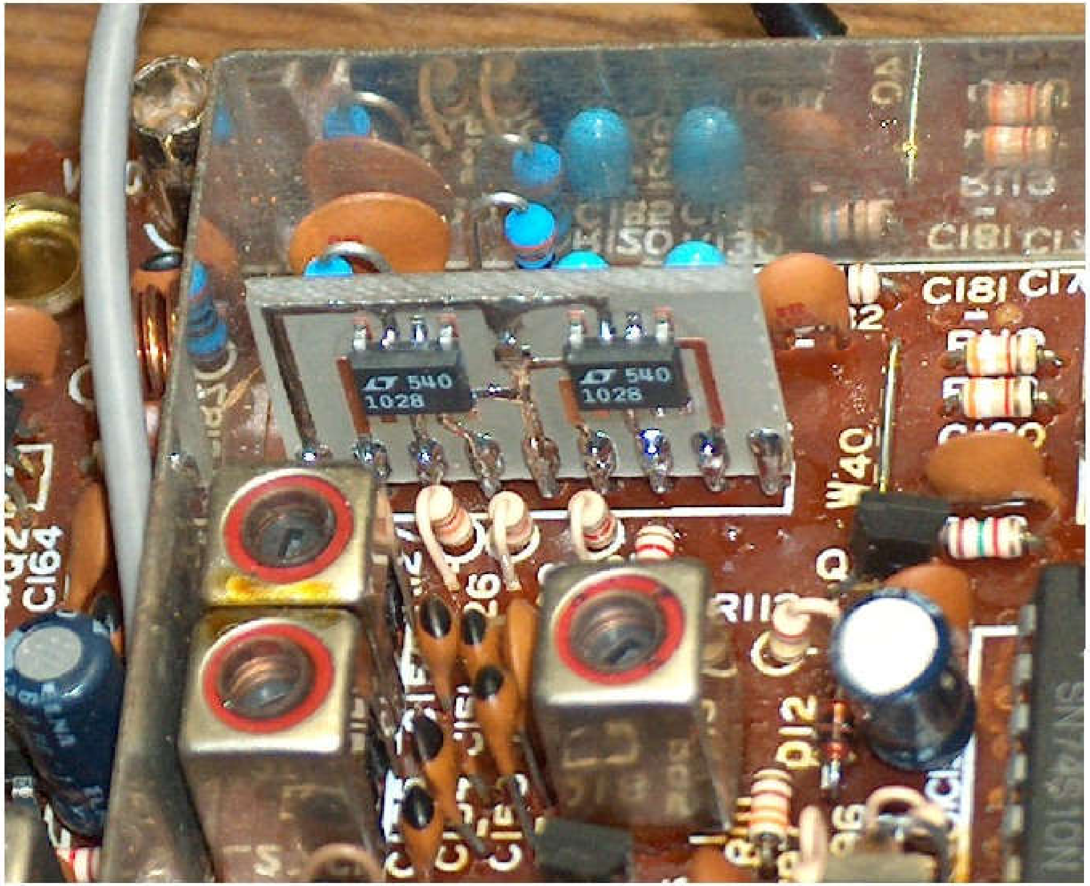


Figure 2:
A: PCB layout of the loop amplified board, matching the pins of the dual OpAmp BA718.
A capacitor (C1, 100 nF) was included across the voltage supply.
B: the finished unit before soldering into the PLL board.
C: PLL board after installation of the new board replacing IC18.

The evaluation of the LT1028 modification started with the original PLL board, without the Kenwood modification. The results are given in figure 1 (green line). At lower frequency offsets (5 to 20 kHz), the LT1028 modification appears to produce less phase noise while at higher offsets (>50 kHz) the Kenwood modification appeared to be slightly better. Both modifications in place (figure 1, red line) produce a limited further improvement above the single mods.

After these modifications, some weak spurs became detectable during the measurements which I not recognize before, because they were covered by phase noise. As to my knowledge, this is quite normal for conventional PLL designs. (By the way: the origin of one spur, which appears when a strong carrier is about 20 kHz off-passband , is interesting: this one results from coupling of the 20 kHz magnetic field from T1 on the DC-DC-unit over a long distance into the chokes L65, L69 and L72 on the RF board , causing a slight 20 kHz modulation of the VCOs.)

4. Comparison with other rigs

I was curious how the modified TS-940 compared with other rigs. Since I don't own one of the contemporary top performance (and top expensive) rigs, I use an FT-857, which I recently bought.
It is technically similar to the FT-897. As figure 1 (yellow line) shows, the FT-857 is superior to the original TS-940, but the TS-940 modifications reduce its phase noise clearly below that of the 857 (exception: 3 kHz).

The phase noise levels of the OMNI VI+ an K2 transceivers for a 10 kHz spacing are -123 and -126 dBc, respectively [1,]. Although comparisons with performance data given in the literature are limited (different measurement techniques etc.), a comparison with figure 1 suggests that the
TS-940, with the above modifications, is still very competitive.

In summary, the phase noise of the TS-9 0 can be substantially improve . The modification described in Service Bulletin #917 is highly effective. It can be even improved by replacing IC18 by an ultra low noise OpAmp, such as the LT1028.

73 e Thomas,
DF5KF

5. References

[1] Raczek T: The DX Prowess of HF receivers. QEX Sept/Oct, 1-5 (2002)

[2] The ARRL handbook for radio communications. ARRL headquarters, Newington,
84th ed., 10.1 ff. (2007)

[3] website: http://rfdesign.com/vlf_to_uhf/time_an _frequency/radio_impact_ultralow_phase/

[4] web document: http://home.pacbell.net/johngreb/k2phasenoise.p f

6.7 Information on Ultra Low Noise OpAmps available in 2008

The LT1028
Described as
LT1028 - Ultra Low Noise Precision High Speed Op Amps
looks very low noise when compared to other OpAmps:
http://www.linear.com/pc/productDetail.jsp?navId=H0,C1,C1154,C1009,C1026,P1234

Compare these very low voltage noise figures to other conventionl OpAmps

Voltage Noise

- 1.1 nV/rt Hz Max. at 1kHz
- 0.85 nV/rt Hz Typ. at 1kHz
- 1.0 nV/ rtHz Typ. at 10Hz
- $35nV_{P-P}$ Typ., 0.1Hz to 10Hz

Gain-Bandwidth Product

- LT1028: 50MHz Min.
- LT1128: 13MHz Min.

Another possible replacement is desribed as
LT1037 - Low Noise, High Speed Precision Operational Amplifiers

- Guaranteed 4.5 nV/Root-Hz 10Hz noise
- Guaranteed 3.8 nV/Root-Hz 1kHz noise
- 0.1Hz to 10Hz noise, 60nVP-P, Typical
- Guaranteed 7 Million Min Voltage Gain, RL = 2k
- Guaranteed 3 Million Min Voltage Gain, RL = 600 Ohm

http://www.linear.com/pc/productDetail.jsp?navId=H0,C1,C1154,C1009,C1026,P1213#applicationsSection

ZL4AI had earlier communications with DF5KF and suggested to DF5KF the LT1028, because of its ultra low noise figures, maybe a better choice than the LT1037 that was available in Germany.
With the passage of time it appears DF5KF agrees.

The following design notes seem to provide really god information on OpAmp Selection.
http://www.linear.com/pc/downloadDocument.do?navId=H0,C1,C1154,C1009,C1026,P1234,D4193

http://www.linear.com/pc/downloadDocument.do?navId=H0,C1,C1154,C1009,C1026,P1234,D4187

http://www.linear.com/pc/downloadDocument.do?navId=H0,C1,C1154,C1009,C1026,P1234,D4187

ZL4AI is still to review these notes to decide which is the best OpAmp and
the values of surrounding isolating resistors and capacitors that should be supplied to minimize noise from the OpAmp.
At this stage ZL4AI is still to measure the frequency the OpAmp operates at. This will be major factor in amp selection.
Probably the LT1028 is the must suitable OpAmp.

LT1028/LT1128

Ultralow Noise Precision High Speed Op Amps

FEATURES

- Voltage Noise
  - 1.1nV/√Hz Max at 1kHz
  - 0.85nV/√Hz Typ at 1kHz
  - 1.0nV/√Hz Typ at 10Hz
  - 35nV$_{P-P}$ Typ, 0.1Hz to 10Hz
- Voltage and Current Noise 100% Tested
- Gain-Bandwidth Product
  - LT1028: 50MHz Min
  - LT1128: 13MHz Min
- Slew Rate
  - LT1028: 11V/µs Min
  - LT1128: 5V/µs Min
- Offset Voltage: 40µV Max
- Drift with Temperature: 0.8µV/°C Max
- Voltage Gain: 7 Million Min
- Available in 8-Pin SO Package

APPLICATIONS

- Low Noise Frequency Synthesizers
- High Quality Audio
- Infrared Detectors
- Accelerometer and Gyro Amplifiers
- 350Ω Bridge Signal Conditioning
- Magnetic Search Coil Amplifiers
- Hydrophone Amplfiers

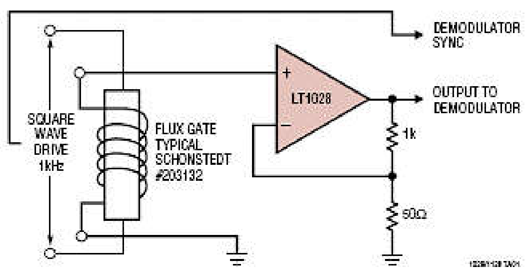
DESCRIPTION

The LT®1028(gain of –1 stable)/LT1128(gain of +1 stable) achieve a new standard of excellence in noise performance with 0.85nV/√Hz 1kHz noise, 1.0nV/√Hz 10Hz noise. This ultralow noise is combined with excellent high speed specifications (gain-bandwidth product is 75MHz for LT1028, 20MHz for LT1128), distortion-free output, and true precision parameters (0.1µV/°C drift, 10µV offset voltage, 30 million voltage gain). Although the LT1028/LT1128 input stage operates at nearly 1mA of collector current to achieve low voltage noise, input bias current is only 25nA.

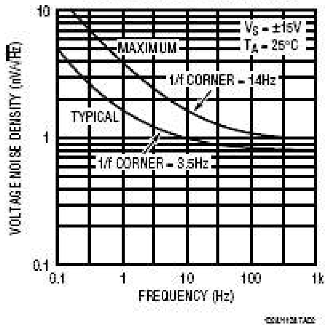
The LT1028/LT1128's voltage noise is less than the noise of a 50Ω resistor. Therefore, even in very low source impedance transducer or audio amplifier applications, the LT1028/LT1128's contribution to total system noise will be negligible.

TYPICAL APPLICATION

Flux Gate Amplifier



Voltage Noise vs Frequency



6.8 Further assessment and Phase noise improvement evaluations planned by Jeff King ZL4AI

Well DF5KF's work has got ZL4AI excited at the improvements that can be achieved.

ZL4Ai intends to:

- measure phase noise across all major bands (before changing the OpAmp) to draw comparison graphs
- against the K2,
- against the earlier work by John Wilson, and
- against the data collected by DF5KF and,
- against the ICOM 745 data by KI6WX

Install dual LT1028 or alternative low noise amps if they appears a better match to required operating circumstances

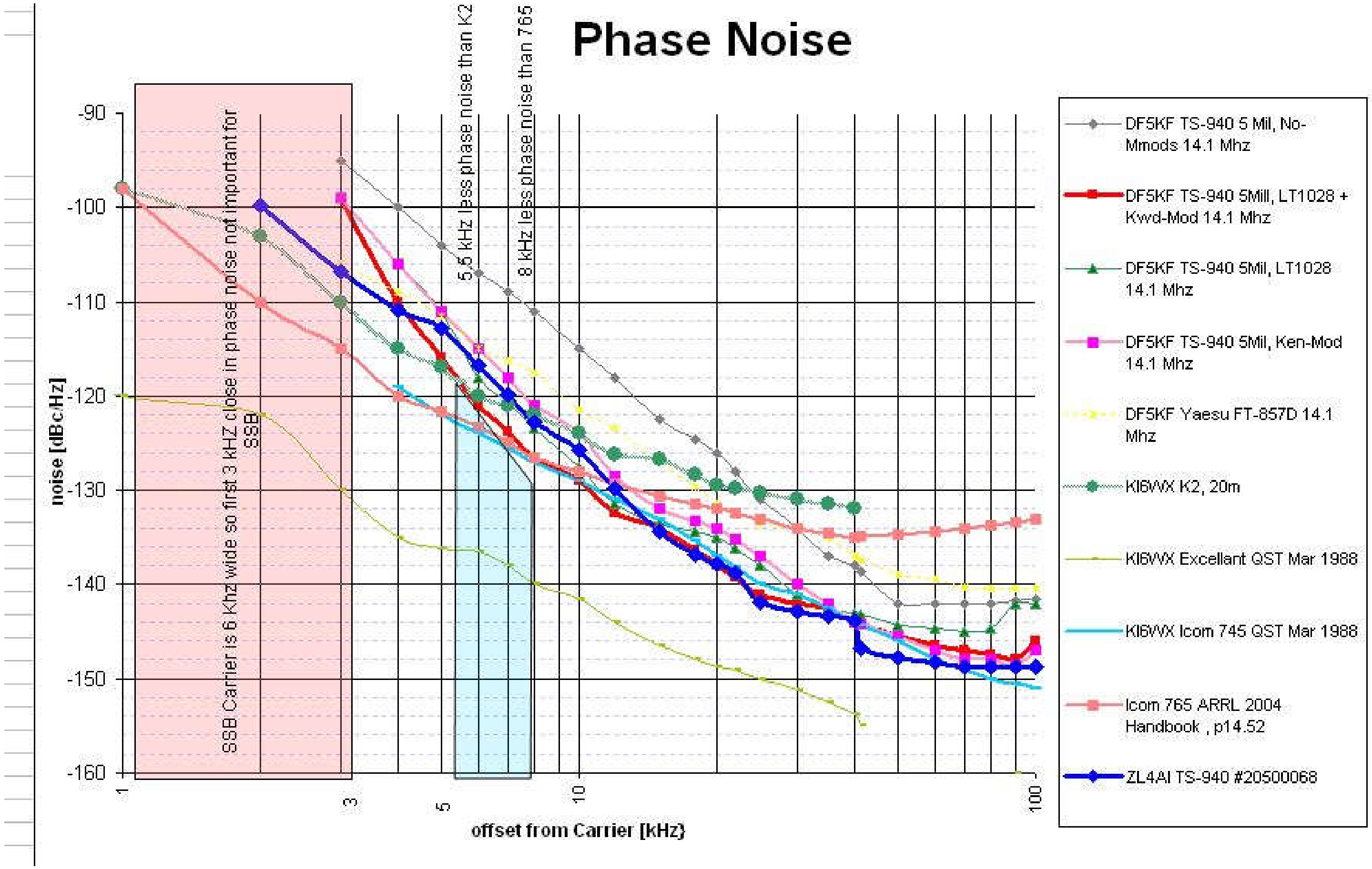
Investigate the simple loop filters used by John Wilson. It appears that by careful matching of the OpAmp input / output filtering that even lower phase noise performance maybe possible. DF5KF does not seemed to yet have investigated the this further filtering potential improvement.

6.9 First plots of phase noise comparisons below show some very exciting results:

1. The TS-940 5 Mil, DF5KF mod at 14 MHz has better phase noise than the K2, beyond 5.5 kHz offset from the carrier,

,

2. Icom 745 and 765 appear to have 4 to 5 dB less phase noise than the K2 or DF5KF 5 Mil 940 at 5.5 kHz offset: We do not know which bands 745 or 765 phase noise measurements were taken on. We know K2 Phase noise plots (above) vary significantly band to band. So the difference shown, may not be correct as these 745 or 765 phase noise plots maybe for band other than 14.1 to 14.2 Mhz.
    - If Icom 765 data is on 14 MHz, then the DF5KF 5 Mil 940 has less phase noise than the 765 from 8 kHz offset from the carrier.
3. ZL4AI 20 Mil 940, (Manufactured May 1992):
    - Measured with HP 8640B generator and HP 400FL AC Voltmeter using KI6WX method. [Note: VERY important to use an AC voltmeter that reads AC to at least 1 KHz, and preferably 2 Khz. Most cheap Multi meters do not read AC voltage and are not suitable because the CW tone on a 940 is approximately 700 Hz to 1 KHz]
    - has less phase noise than DF5KF 5 Mil 940 Kenwood Modified, so later modifications undertaken at factory decreased phase noise more than just the Service Bulletin Modification: This is why very late serial numbers perform better,
    - Between carrier offsets 3 KHz and 8 KHz 20 Mil 940 only has 3 dBc to 0 more phase noise than a K2,
    - Between carrier offsets 3 KHz and 12 KHz 20 Mil 940 only has 8 dBc to 0 more phase noise than a IC-765,
    - When ZL4AI adds the LT1028 to 20 Mil 940 it looks possible the 20 Mil 940 may have less close in phase noise than the K2 as follows:
        - § 3 kHz off set 2 dBc less,
        - § 4 KHz off set and 5 KHz off set same as K2,



6.10 Real Experience of the Ultra Low Noise LT1028 significant receiver performance improvement

Jan 2102 ZL4AI got around to installing a pair of LT1028s. Mounted on a perf board with small wires from the ICs to the solder in wire. Does not look neat like the board by Thomas. Took abaout 2.5 hours to install and commission.

How does it perform. **Outstanding.** I would say this improves the SSB listening pleasure by 20%. 20% of what you may ask! Well I do not have any technical justification but the 940 is really much much much better to listen to. [It is worth pointing out what I anticipated this mod would do is reduce splatter from nearby QSOs becoming a drone noise interfering with reception. This may have improved, but noticeably. Probably will have to undertake the phase noise tests again to detect the difference. What did change that was not expected was general listening to the receiver became better. I did not expect this to change. So it was an unexpected pleasant outcome. I have owned and used the 940 for 10 years so did not really expect that such a change could be achieved.] Wish I had done this 3 years ago. For the effort put in this single modification improves your 940 more than any other modification that could be undertaken. Try it out and tell me what you think!!!

Below are others experiences.

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** sv9dru
Sent: Wednesday, 8 June 2011 10:12 a.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] Phase noise PLL improvement

Just wanted to convey my experience with the DF5KF PLL mod.

It does provide a very significant improvement in the Rx performance and it is a worth while task.
In my case, after having all the other Rx mods (including changing the 2 FET orientation in the RF and IF boards and the Kenwood PLL improvement mod), I ordered 3 pairs of LT1028 ICs from ebay (Taiwan) and installed 2 of them as suggested by Thomas in his excellent article.
That turned a nice and quiet TS-940 into a FANTASTIC 940 Rx.....!!! Significantly better and more pleasant than my TR7.

Good job my friend DF5KF !
73s,
Marinos, sv9dru / ki4gin

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** sv9dru
Sent: Wednesday, 8 June 2011 8:31 p.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] Re: Phase noise PLL improvement (construction details)

For anyone interested I have some more details of the project done without having to use a specialized PC board or having access to surface mount soldering equipment:

I actually ended up using a general purpose perforated board for the mod. Got the lt1028 chips as seen at the following link: http://cgi.ebay.com/2pcs-LT1028-SOIC-DIP-adapter-/220724201398?pt=LH_DefaultDomain_0&hash=item33643007b6

As you can see they are already mounted on small DIP adapter boards. If you leave them on these boards you have at least 2 advantages over the option of desoldering them and resoldering on a small custom made board:

1) You do not need any specialized (hot air) equipment for the task and you do not risk damaging the chips in the process.
2) these small boards can be mounted exactly on a general purpose perforated board and you can work their interconnections from both sides of the composite board.

Detailed instructions: First I desoldered and removed the 4 pins from each side of the lt1028 little boards in order to be able to mount them flat on the respective insulated surface of the general purpose board. I then used short component leads to interconnect the IC boards to the underlying one.
The combination (3) boards will fit in the space left after IC18 is removed. I did have to sandpaper the sides of the Lt1028 boards to make them fit within the 9 hole required size of the general purpose board, and also carefully adjusted the height of the composite board to make it slightly shorter than the metal shield present around the area of IC18. You only need to install 8 small leads for mounting the new IC on the board, as the lead #9 is neither soldered nor used.

I ended up using a small conventional 100n cap mounted on the front (same as the chips themselves) surface from:

http://cgi.ebay.com/C8-AVX-100nF-MONOLITHIC-CERAMIC-CAPACITORS-100-PCS-/360344126576?pt=LH_DefaultDomain_0&hash=item53e62f0470

The cap and its interconnections were on the front while the other interconnections were done with small caliper insulated wire on the back surface of the structure.

I do regret not having taking any photos of my project before installing it in its place !! I was so anxious to see if the whole thing would work, and since everything worked A-ok from the first powering op of the radio, could not find the courage of disassembling the rig one more time just to take pictures of it..

I am sure that one can construct the little PC as described in the original article and if using the proper tools (hot air soldering paste etc) the whole project would be a breeze, but if one is willing to invest some more time doing it as described above, would be rewarded with a very nice looking and performing structure...IC18

No matter what construction technique you use, the result will ABSOLUTELY BE WORTH YOUR EFFORT!!

73s,
Marinos, sv9dru / ki4gin

From: jaking@es.co.nz
To: sv9dru@hotmail.com
CC: thomas_hohlfeld@hotmail.com
Subject: Phase noise PLL improvement some ideas for even more improvement.
Date: Thu, 9 Jun 2011 22:45:41 +1200

Hi Marinos,

I am really so fascinated with your posting. I suggested the LT1028 to Thomas who originally was proposing using an LT1028.
I have brought all the parts about 2 years ago but have not found time yet to do the mod yet so its great to hear how well it works.
You will see I analysed its potential on the TS-940 page.

When I read Thomas's application idea I have wondered if he matched the gain of the LT1028 with the original OPamp BA718.
I know on quick read the LT1028 had greater gain that the original op amp.

What I have been thinking about doing is measuring the frequency the op amp worked through, and comparing the gain of the LT 1028 with original Opamp BA718.
I do have the data sheet for the original BA718 opamp showing the gain if your interested. Anyway if the LT1028 was much greater gain and this was proven by taking measurements I was thinking of putting in an attenuator of resistors to reduce the LT1028 gain the same as the original op amp. I suspect this will reduce the phase noise even further, and will make the receiver even better.

As you will see on TS-940 page it is close to a K2 or an ICOM 765 low phase noise, and reducing that gain may make it equal the K2.

I am really interested in any developments you make. I am also sure Thomas will be really interested too!

Yours sincerely

Jeff King ZL4AI
in Dunedin New Zealand.

From: Marinos Markomanolakis M.D. [mailto:sv9dru@hotmail.com]
Sent: Thursday, 9 June 2011 11:14 p.m.
To: jaking@es.co.nz
Subject: RE: Phase noise PLL improvement some ideas for even more improvement.

Hi Jeff,
I am glad to see the results of the modification and grateful that technically inclined guys like you and Thomas are able to suggest these rather delicate mods to improve the already excellent TS-940.
I have made 3 K2s (sold them all eventually) so I would have to say that the TS-940 has nothing to worry about when compared to the K2. If anything, at least subjectively, it has a better SSB performance after the kenwood PLL mod alone, and suspect it is much better with the lt1028.

Since currently I do not have a K2 for side by side tests, can not comment any further though.

As for any additional improvement with attenuating the lt1028 to match the BA718, I would be very interested to know myself about it, but since I am lacking either the theoretical knowledge or the specialized equipment necessary for measuring the results, would have to wait for input from you guys ......

At any rate, if you have the small PC board for mounting the 2 lt1028 ICs, it should be a very straight forward job to do the mod yourself. I am sure you will not regret it!

73,
Marinos, sv9dru / ki4gin

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** hohlfeld_thomas
Sent: Friday, 10 June 2011 8:44 a.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] Re: Phase noise PLL improvement

Hello Marinos,
I am really happy to see you were successful with this PLL mod. You did a great job by realizing the mod with the general purpose perf board.
This modification started with a very inspiring communication with Jeff, ZL4AI, who proposed different Opamp types and kindly provided the datasheets. We discussed several Opamps and I ended up with the LT1028, because I discovered some on a used board in my junkbox. First I examined and compared the audio noise of the LT1028 and the original BA718 on my lab bench because I did not have a good datasheet of the BA718. As expected, the LT1028 was far better. So I decided to try the replacement and, as you experienced, there was a remarkable improvement of phase noise. If I remember correctly, I also experimented with the addition of very weak negative feedback (many MegOhms from Opamp output to inv input) to compensate for the somewhat higher internal forward gain of the LT1028. I did not notice a difference and removed this feedback. My interpretation is that the capacitive/resistive feedback of the circuit is more important for the amplifier characteristics than the Opamp intrinsic gain.

Thank you very much again for your kind feedback,

73s,
Thomas, DF5KF

From: Hugh Coleman [mailto:ae5vb@yahoo.com]
Sent: Tuesday, 19 July 2011 10:02 p.m.
To: jaking
Subject: pll boards

Hi yes I am using the same one that Thomas did he even sent me his template and permission to use. Just let me know how many you want and where to ship. You can use my paypal account at hu_man@suddenlink.net. the boards are $10 and what ever the shipping is. I can use USPS priority shipping for $5 if you want a good quality shipping or regular post if not.

Here is the link to the mod.

http://www.jking.netau.net/TS-940/TS-940_02_part2_1.htm#_Toc205437785

The parts from digikey are about $20 just two op amps and a chip.

I have the parts here:

http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=490-1524-6-ND

http://search.digikey.com/scripts/DkSearch/dksus.dll?Detail&name=LT1028CS8%23PBF-ND

Thanks,
Hugh

==

[For the record ZL4AI spent hours trying the Lowe [by John Wilson] Modification on top of Kenwood Service Bulleting 917 modifications.

TS-940_InterNational_Radio_users_Supplement_Addendum1Mar1988.tif

I did not install the 2.2K resistor because the Kenwood 3.3K replacement was already sufficient. The result was very disappointing resulting in more distorted sound for me, and I ended up removing the Lowe Modifications, except for replacement on the PLL board C184 C185 C186 C187 with 4.7UF 35V tantalums, which did improve the stepping of the VFO tuning on 10 KHz steps. Maybe the Lowe Mod does not work as well as the Kenwood 917 mod. Others have reported the Lowe mod is better than the Kenwood 917 mod, so maybe I did not put iit in correctly. Next required step is to speak to John Wilson because I'm sure he knows what he is doing and did have really good success with this mod.]

7.0 SM-220 mods to remove Ghost Signals generated by the 940

THE KENWOOD TS-940 AND THE SM220

This is a translation of an article Andy, ON5DO, sent to me for publication in Kenwood Newsletter.
If you have any questions on this article, please don't hesitate to contact me. (Thanks, Andre Peeters, 7803 E. Oak Shore, Scottsdale, AZ 85258)
"After selling my TS-940, I bought a TS-940 which has the standard output for connecting the SM220 monitorscope. After hooking up the SM220, I listened on 14 Mc and watched on the monitorscope. There were many signals which could be heard, but surprisingly enough more could be seen!!
During the morning, when there was no propagation on 20 meters, I could still see signals, which were not heard!! Definitely something was wrong. If we take a close look at the SM220, which was designed for the TS-830, we see that the input frequency of the receiver is 8.830MHz and that the IF is 455kHz. As in any superheterodyne circuit, there is an image frequency on 8.830 - 2 X 0.455 = 7.920MHz. When I measured the image suppression, I only found a 7 dB attenuation. This was not a problem with the TS-830 because of the input selectivity of the receiver. The story is different for the TS-940, where the input selectivity is determined by the octave filters, and there is almost no attenuation for signals between 14 and 20 MHz.
When we tune in on 14.200MHz with the TS-940, then the SM220 actually sees an image frequency which is 14.200 + 0.910 = 15.110MHz. Now the 15MHz is a broadcast band with usually S9+ signals. These are the phantom signals we see on the SM220. The only attenuation for this 15MHz signals to the SM220 are provided by the 45MHz coils L44, L45 and L46 on the RF board and the 2 coils L1 and L2 on the IF board. The total attenuation

for this 7.920MHz image frequency in the TS-940 is approximately 21 dB and the extra 7 dB of the SM220 results in a total of approximately 28 dB, which is absolutely insufficient. There is a simple solution to cure this problem. By adding a band rejection filter for 7.920MHz in series with the input of the SM220, the problem can be solved. The image rejection of the SM220 will be, after modification, around 47 dB, so that the total rejection is 47 + 21 = 68 dB.

This filter is a simple parallel LC which acts as a band reject type. The capacitor is 330 pF and the inductor is made of 13 turns 0.3mm diameter wire on an adjustable core, having a diameter of 5.5mm. This will resonate on 8MHz, with the core almost turned in the half of the coil.

MOUNTING AND ADJUSTMENTS:

1. Remove the top and bottom cover of the SM220.
2. Disconnect the inner conductor of the cinch plug of the IF input on the back side.
3. Solder band reject filter to cinch plug and to the inner conductor of the coax.
4. Inject with an RF generator a signal of 7.920MHz on the IF input. Adjust the vertical gain to maximum and adjust the output voltage of the signal generator.
5. A vertical sweep will result on the screen. Adjust the core of the inductor to a minimum amplitude on the screen.
6. Readjust the signal generator to 8.830MHz and decrease the output signal. Adjust T208 with an insulated trimming key for maximum amplitude on the screen. (T208 is located left and under BS8 and can be reached through an opening in the side panel.)
7. Repeat Steps 5 and 6.
8. Mount top and bottom cover of the SM220 again and connect to the TS-940.

The built-in convertor (converts 45MHz to 8.830MHz) for the SM220 on the IF board and Q1 and Q2 in the TS-940, are connected in parallel with the 45MHz Xtal filter. The Xtal filter also acts as a bandreject filter. This filter introduces an attenuation of 14 dB at 8kHz lower and 6 dB at 5.5kHz higher than the center frequency. This is perceivable when, without any antenna connected to the TS-940, and by using the internal marker, one tunes around the 14MHz band. This problem can be corrected by connecting the convertor at another node, but this is not very easy to implement on the IF board.

SENSITIVITY

A signal of 2 microvolts on 14.200MHz at the antenna input of the TS-940, and the vertical gain of the SM220 turned to maximum, will result in a vertical sweep deflection of 4 divisions. A signal of 3000 microvolts on 15.110MHz, and the TS-940 tuned in on 14.200MHz results in the same sweep amplitude. This is a 63.5 dB attenuation. (Thanks, Andy, ON5DO, translated by Andre Peeters, ON7PG)

8.0 INRAD ROOFING FILTER

http://www.inrad.net/home.php?cat=6

Inrad are providing filters for experimenters who want to create their own modifications. For more information on this topic, please see our document entitled VHF Filters for Experimenters. The table below lists the first IF for many of the better radios.

Reference	Frequency MHz	Radio	Main Rx	Sub Rx
#912	69.4500	FT-2000		X
#908	48.6400	FT-1000D		X

#916	73.6200	FT-1000D	X	
#907	47.2100	FT-1000MP, MkV		X
#914	70.4550	FT-1000MP, MkV	X	
#904	45.7050	FT-847	X	
#910	68.9850	FT-920	X	
#906	47.0550	FT-980	X	
#909	64.4550	IC-746, IC-756PRO I, II, III	X	
#911	69.0115	IC-756, 765, 775	X	
#913	70.4515	IC-761	X	
#905	46.5115	IC-781	X	
#902	45.0000	Orion, Orion II		X
#915	73.0500	TS-450, 690, 850, 870, 950SDX	X	
#901	44.9300	TS-930	X	
#903	**45.0500**	**TS-940**	**X**	
#900	40.0550	TS-950SDX		X

Adding this narrow roofing filter is a really outstanding improvement to the receiver. Inrad's statement about the filter is not correct and bizarre because the filter offers a huge improvement to the receiver by narrowing the first IF from 15 KHz down to 5 KHz. For crowded bands, the roofing filter provides the 940 receiver enhanced performance equivalent to the best current receivers. *[The best way to install the filter is by cutting tracing traces on the IF board and mounting the filter on a board with relays so it can be switched in when needed instead the existing 15 KHz roofing filter. A section describing this is still to be written up for this page]*

Thomas Hohlfeld provides an outstanding explanation of the installataion of this filter and its benefits.
Thomas_Hohlfeld_DF5KFT_Roofing_Filter.pdf

PLL BOARD PROBLEMS

PLL BOARD 0: Reconnect Connectors

[Kenwood] 940S Question -Solved
RMead100@aol.com mailto:RMead100@aol.com
Fri, 7 Jun 2002

At the suggestion of one of the list members, I lugged the xcvr off its self and removed the cases and re-seated all of the connectors on the boards which I had moved. PLL and one underneath. Also, I re-seated the connectors on the Digital A board above the PLL.

The "missing bands" are now working fine.

I think the connectors on the Digital A board are vulnerable to improper seating, and being propeRLY PULLED LOOse, ESPECIALLY when that board is lifted and tilted aside to get to the PLL board. There is one very long connector on the front left of that board which seem to work itself loose at one side and needs to be looked at.
Thanks to all
Randy K8BUX

ZL4AI: Notes: Re seat is the wrong description. Each and every time you pull those connectors off & on the spring clamp inside opens up a little. Eventually the connector fails to connect to the pin, the circuit is lost and you get a PLL failing to lock. You have to remove each connector from the shell using a sharp tool, and then using small pliers close the spring clamp back together. This is the only way to make the connectors connect again. It takes quite some time to get to the connectors in the inside edges of the PLL board. This re-clamping connectors has fixed the PLL failing to lock for me anumber of times.

PLL BOARD 1: Remove the Black Foam from Behind the Board

From: "kt4xw" <kt4xw@...>
Date: Sun Jul 25, 2004 9:41 am
Subject: Re: TS-940 Very low output. update kt4xw

Hello,
This morning I had a chance to look at the rig again, and found out some things that were interesting. The power adjust control on the front panel, along with the carrier control in cw all seem to work. The output power goes up and down with adjustment. With the power out adjustment VR2 all the way up, the SSB power jumped to 100w, but I still only had 3w or so CW. The IC meter showed 4 amps with no output on SSB, so I check the current with a ohm meter and verified it was around 1.2a. A adjustment of the IC0 control fixed that. With 100w out on SSB, the IC meter read over 16a. The ohm meter read 8.5a to 9a Adjument of the IC meter adjust pot fixed that. Then, on a fishing expedition, I look at the micro processor board, and fixed several fish eyed solder joints, no help, but made me feel better. Then, under the Het. Osc. on the PLL unit there was a piece of black conductive foam that had deteriorated. Also, it had a green/white residue covering it. I cleaned all of it, and removed the rest of the foam. It helped alot. I had to readjust VR2 back down to 110w or so, and the CW output jumped up to 15-18w. But still, that is it on CW.

Thanks for all of your help!
Keith Spainhour, KT4XW

PLL BOARD 2: Remove the Wax from the VCOs

From: Garey Barrell <k4oah@...>
Date: Thu Oct 9, 2003 1:49 pm
Subject: Re: [ts-940] Welcome k4oah

Fred -
This is an indication that one or more of the PLL's are unlocked. It will only get worse!
The two VCO's under the speaker (two layers down, of course!) are "potted" with a sort of beeswax. Over time this wax becomes contaminated and the VCO's become unreliable.

I fixed mine by using a heat gun (judiciously) to melt the wax out of these two compartments. Standing the transceiver on end, tipping it toward me and putting a piece of cardboard under the shield can to catch the wax as it drips out. Some will run out 'under' the shield, but it can be picked off with a Q-tip stick or other.

The alignment was not changed in either circuit, but it wouldn't hurt to check the adjustments in those two areas after the "meltdown". They are simple peaking adjustments.

Solder troubles are more common in the TS-440 and TS-930, but could be a problem in the 940 as well. My AVR board had a LOT of solder problems, but I have not reworked VCO areas.

73, Garey - K4OAH
Atlanta

PLL BOARD 3: Replace all Electrolytic capacitors.

ZL4AI found that most of the electrolytic capacitors were much lower values than their specification. Especially test C71, C172, C143, C97, C93, which I found to be close to only 50% of rated capacitance. With a 28 year old radio these capacitors will have deteriorated. It is best and easiest to just replace all the electrolytic capacitors. Takes about 1 hour to replace all and costs about $10

PLL BOARD 4: Tune through all Frequencies in USB mode 30 Hz to 30 MHz to verify PLL Board is working correctly.

In summary: a fault on the PLL board can show up and did show up in ZL4AI's 940 as internally generated signals which showed up as S Meter readings when no antenna was connected. This existed for 9 years but ZL4AI never realised the PLL board had a fault. ZL4AI just presumed the receiver had the occasional birdie which produced an S meter reading. When the PLL board was exchanged with an error free board there were the occasional whilst birdies as you tuned through in side band mode, but no birdie ever produced a an S meter reading. If your 940 dos have internally generated S meter readings then something is wrong on your PLL board.

ZL4AI found that when a PLL board had a fault which showed up first as an background humming noise through the tuning range of VCO #3, the following symptoms were present:

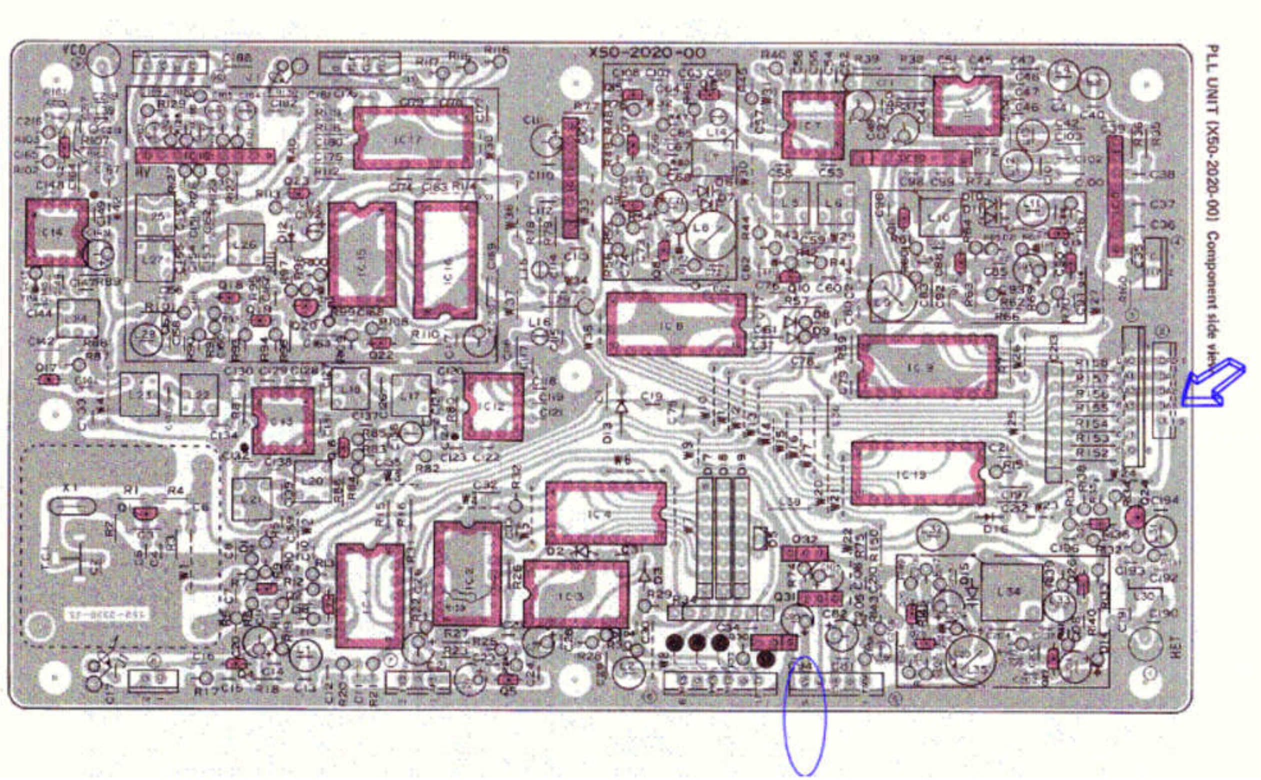
- Adjusting PLL voltages and VCO voltages enabled the PLLs to lock and the normal display returned,
- Voltage on VCO #3 could not be set below 12.4 volts regardless of where L71 was set,
- The humming noise was
  - § Intense and loud on the entire 28.01 to 28.99 MHz range
  - § vaguely present in background noise on VCO #2 from 19.499.99 MHz down to 9.50 MHz,
- At many odd frequencies for a spot when tuning 30 Hz to 30.0 MHz a birdie would should which resulted in an S meter reading of S3 to S7. This birdie would only occur over say 1.5 KHz but was all generated internally from the defective PLL board.
- When the board was replaced with a fully functional PLL board, throughout the entire tuning range there were birdies, but none of these caused the S Meter to lift off S0.

PLL BOARD 5: Identify which PLL is not locked

From: "k8aicurt" <k8ai@...>
Date: Tue Nov 30, 2004 1:57 pm
Subject: Re: PLL unlock k8aicurt

Well, I finally got it working. There is a line on the PLL board that goes to the control unit that's labeled "UL". This line goes low if one of the individual PLL IC's is in unlock from both the PLL board and the carrier board. If you have dots on the display, first disconnect connector #2 on the PLL board and check the voltage at connector #5 pin ~~5~~ 4. If the voltage is "high" (~4.6V) then the unlock is on the carrier board. If the voltage is still low (~0V) then replace the #2 connector and then check the voltage on the individual IC's.

Check the voltage on IC8 pin 2, IC9 pin 2, IC19 pin 2 and IC17 pin 7. The one(s) that has(have) a low voltage on them are the PLL's out-of-lock. Troubleshoot that PLL circuit.
Curt, K8AI



From Jim/G3KAF:

TS940 'DOT' PROBLEM

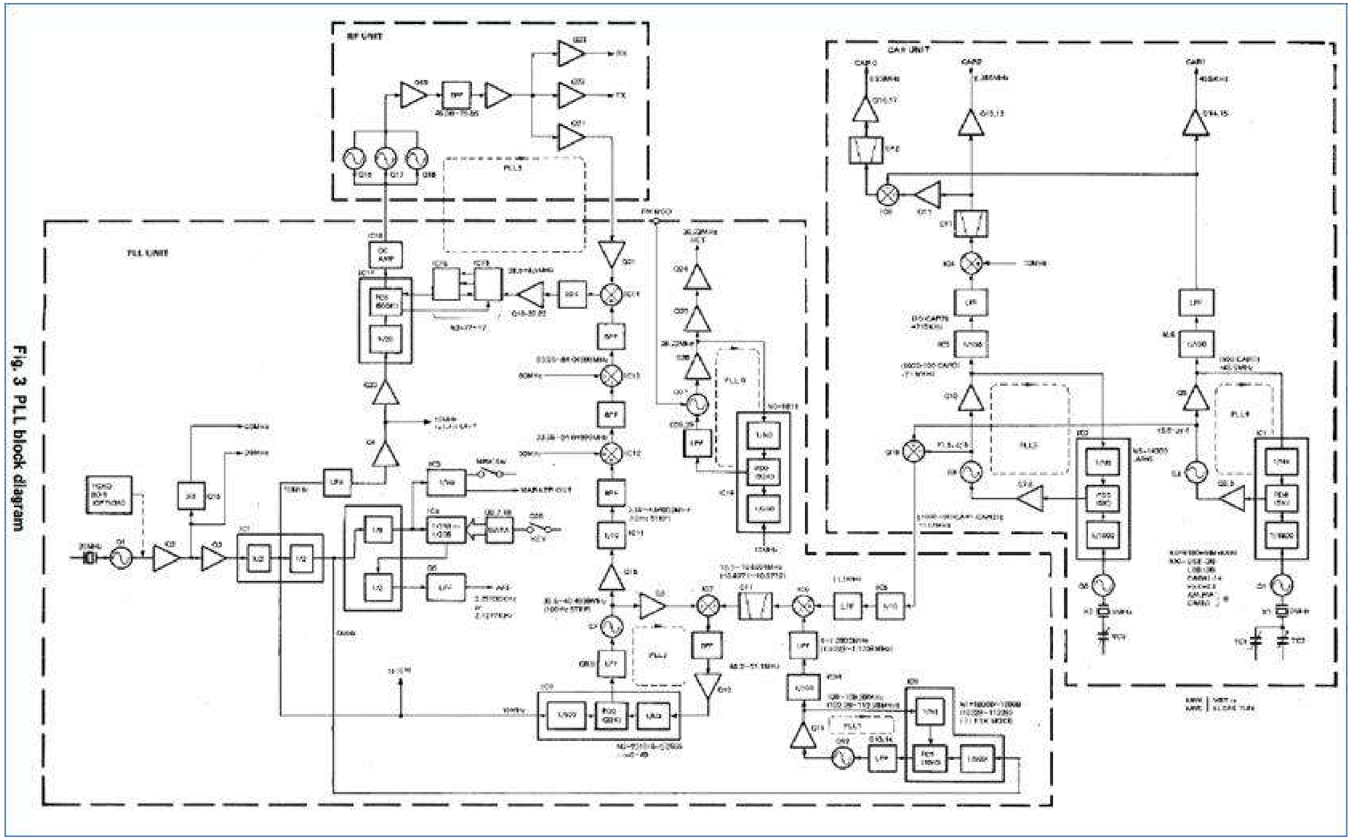
ZL4AI: Notes: It is very easy to carefully follow the procedure below and identify exactly which PLL is unlocked and which component is not operating.
Then you can easily solder joints around the components which fixes most unlocks. Components do not fail that often, so start with soldering all the joints. Once you identify which PLL use the Figure 3 below listing of components in that PLL, print out a copy of the circuit board from the Workshop manual, and use a highlighter to highlight all the components in the defective PLL. Then solder all the leads on these components.

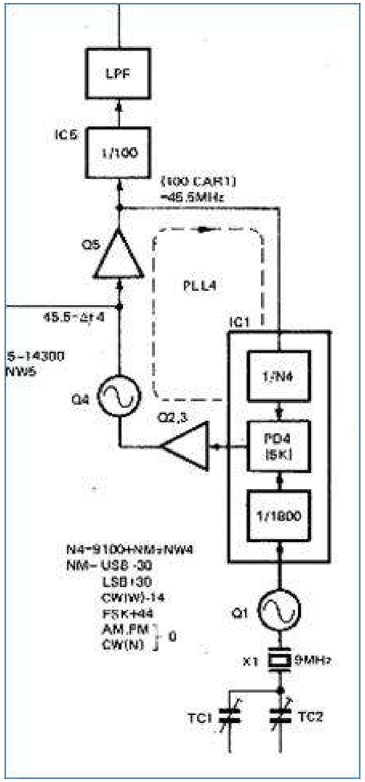
The TS940S along with other Kenwood transceivers are prone to a common fault - that of displaying a row of dots instead of a frequency readout. This is caused by one or more of the Phase Lock Loops (PLL) going out of lock.

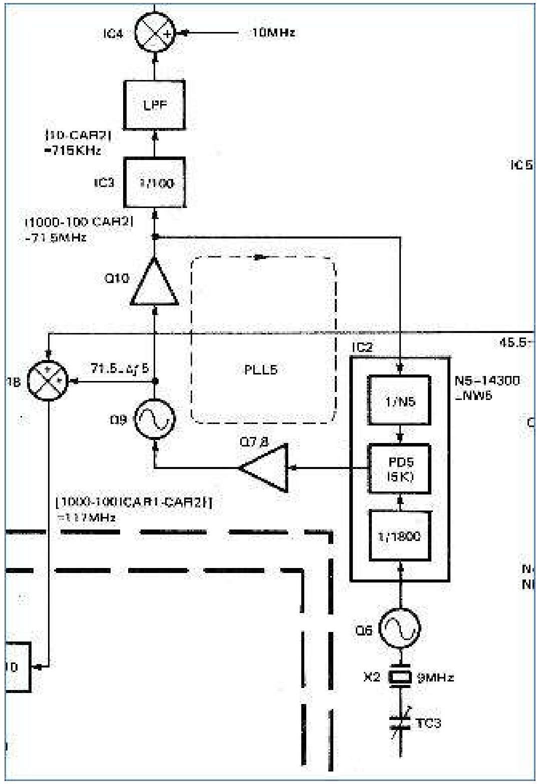
A number of suggestions have been put forward to cure the fault. The most common two being to remove all the wax from parts of the PLL board by heat or other methods and the other is to resolder all the joints on the underside of the board. Either method may cure the problem but (unless great care is taken) they could induce additional faults thereby adding to the problem and obscuring the original fault. An alternative method would be to narrow down the fault to a particular part of the board or boards as suggested below.

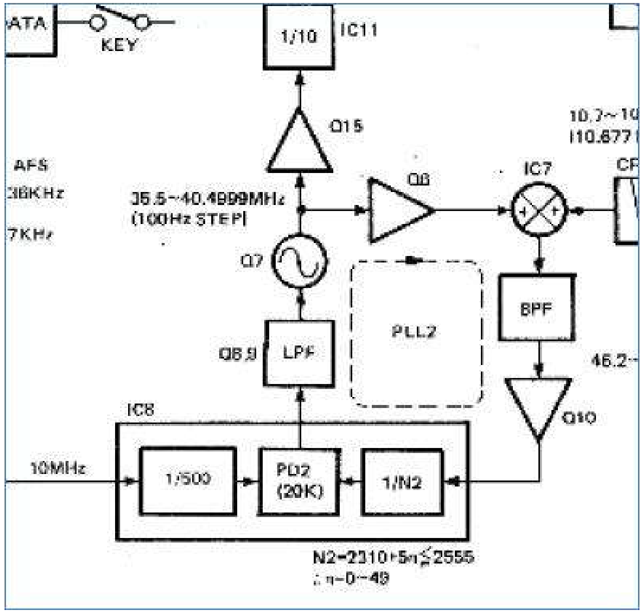
In the case of the TS940 there are a total of 6 phase lock loops, any one of which could be out of lock and cause the 'DOT' problem. Only 4 are on the PLL board - the other 2 are on the CAR board. At this point I suggest you click here and download the relevant pages of the TS940 service manual (4.7MB) which is in PDF format.

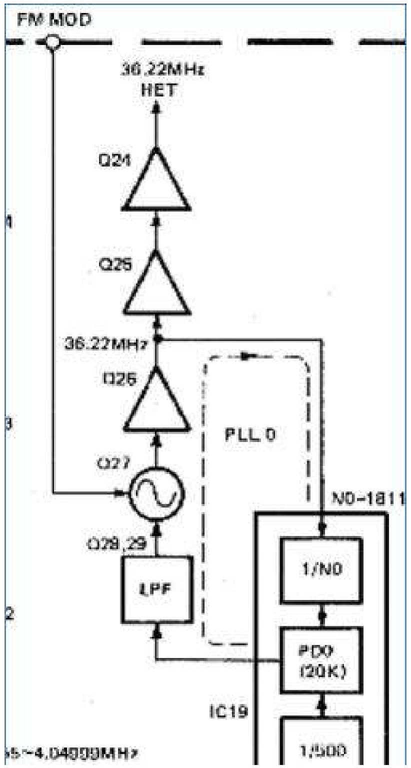
ZL4AI: On Figure 3 page 6 identify the 6 PLL circuits; This diagram shows all the components in the PLL.

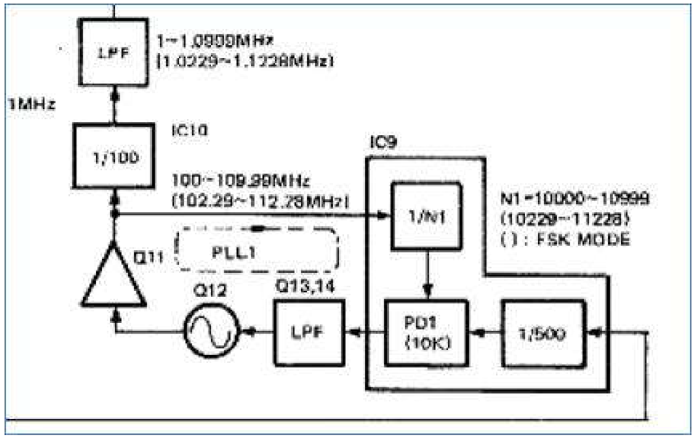



LPF
IC6
1/100
(100 CAR1)
=45.5MHz
Q5
PLL4
IC1
1/N4
Q4
Q2,3
PD4
(5K)
1/1800
Q1
X1
9MHz
TC1
TC2


IC4
10MHz
LPF
IC3
1/100
(1000-100 CAR2)
Q10
PLL5
IC2
1/N5
Q9
Q7,8
PD5
(5K)
1/1800
Q6
X2
9MHz
TC3


KEY
1/10
IC11
Q15
Q8
IC7
35.5~40.4999MHz
(100Hz STEP)
Q7
PLL2
BPF
LPF
Q10
IC8
10MHz
1/500
PD2
(20K)
1/N2
N2=2310+5n≦2555


FM MOD
36.22MHz
HET
Q24
Q25
36.22MHz
Q26
PLL 0
Q27
LPF
1/N0
PD0
(20K)
IC19
1/500


LPF
1~1.0999MHz
(1.0229~1.1228MHz)
1MHz
IC10
1/100
100~109.99MHz
(102.29~112.28MHz)
IC9
1/N1
N1=10000~10999
(10229~11228)
( ) : FSK MODE
Q11
PLL1
Q12
Q13,14
LPF
PD1
(10K)
1/500


RF UNIT
Q23
RX

Note for PLL3 is on both the PLL board and the RF Board.

Before making any tests on either board it is best to check that the supply voltages are correct. On the PLL board connector 5 pin 5 should be +5V and pin 3, +15V.

Each individual phase lock loop produces a permanent voltage of around +4.75V if it is in lock and just above 0V if it is out of lock. The signals from all 6 are gated together using diodes such that any one PLL producing a 0 voltage will 'override' the other signals and produce 0 volts at the final output designated UL.

First we need to decide whether the fault is in the PLL board or the CAR board. With the rig powered up, connect a voltmeter (I use an oscilloscope) to pin 4 on connector 5 of the PLL board (be careful, pin 5 has +5V on it and pin 3 has 15V as previously mentioned). This is the final lock/unlock signal from all 6 phase lock loops. As we are out of lock, this voltage should read around 0 volts or a little above. Now unplug connector 2. If the voltage on pin 4 of connector 5 is still around 0 volts then the fault is on the PLL board. If the voltage is now around 5 volts then the fault is on the CAR board.

For arguments sake let's assume the fault is on the PLL board (the most likely scenario) then we may now proceed to narrow down the fault to 1 of the 4 phase lock loops.

We can leave connector 2 unplugged at this stage. Check the output of each phase lock loop as follows. With the rig powered up, check the voltage on IC8 pin 2, IC9 pin 2, IC19 pin 2 and IC17 pin 7 (yes pin 7). Whichever output is giving a low voltage of around 0V is the loop which is out of lock.

circuit diagram page 96 shows:

	Output of each PD Location shown as connected to in PLL diagrams

1.8V on : IC8 pin 2 as 180 mV p to p [ZL4AI measures this as 4.6V when locked. probably the 4.6V label on pin 1to ground should be on pin 2 and probably theses labels should be written on pin 3]	*PD LPF Q8/Q9*
4.9V on : IC9 pin 2	*PD LPF Q13/Q14*
4.7V on : IC19 pin 2	*PD LPF Q28/Q29*
5.1V on : IC17 pin 7 shown as connected to IC8 pin 2, IC9 pin2, IC19 pin 2 & CAR-1-UL1	
AND BELOW ON CARRIER BOARD	
4.9V on : IC1 pin 2	*PD TO Q2/Q3*
4.9V on : IC2 pin 2	*PD TO Q7/Q8*

Say for example we find that all levels are showing +4.5V except for the output of IC17 pin 7 which is showing around 0V. By looking at the circuit diagram it becomes obvious that we need to fault find around the components associated with IC15, IC16 IC17, Q22, and Q23. We have the option here of taking the board out and resoldering all the joints and components associated with those semiconductors or we can narrow it down further by checking the voltage levels and comparing them to those shown on the circuit diagram. The choice is yours.

If you have an oscilloscope available you can in addition check the RF signal on the base and emitter of Q22 and it's subsequent input to pin 9 in IC15. Check the output signal on pin 8 of IC15 and it's subsequent input to pin 1 on IC16.Check the output on pin 7 of IC16 and it's subsequent arrival at pin 8 on IC17. Check also the RF input signal on the base of Q23 and it's output which goes to pin 1 on IC17.

With the voltage readings and/or oscilloscope measurements it should be possible to narrow the fault down to a single component. Before changing it though, I would suggest that you resolder the component as most faults appear to be due to bad soldering on the board rather than to a component failure.

Good Luck............Jim G3KAF

PLL Board 6: PLL Board and RF Board and PLL out of lock

```
kc0bi <kc0bi@yahoo.com> wrote:
Hello everyone.  I am troubleshooting a TS-940S and it has at least two problems - I tackled the easy one first
- it had a bad optical encoder and I replaced it with a known good pull from a TS-430S.

This unit definitely has PLL problems - the exact frequency that it fails changes with heat but the general problem is this:  Above  10 MHz it works correctly
in USB and LSB - below 10  MHz it works  only in USB.  There is an area between approximately 9 MHz and 10 MHz where it is probably unlocked but the frequency
display still works - and that point changes with heat. Below 9 MHz it gives the "all-dots" display indicating PLL unlock (but seems to still work in USB). I
am using the built-in 100 kHz calibrator as a signal.  After a period of time the nice sounding sine wave becomes a very "ratty" sounding tone.  This is true
regardless of which sideband and at any frequency I've tried.  Does anyone have an idea of where to start looking? One of the PLL's must be losing lock.
Thanks in advance and 73,
 Harold W0HJW (formerly KC0BI)
```

From: [mailto:TS930S@yahoogroups.com] **On Behalf Of** Bill K0ZL
Sent: Wednesday, 19 October 2005 11:47 p.m.
To: TS930S@yahoogroups.com
Subject: Re: [TS930S] TS-940S Phase-Lock-Loop Problems?

Drop your RF unit down (rig up on it's left side) and resolder all around the VCO area, which is about the front 2-3" of the board. Also resolder around the RF RX preamp and first mixer area (that is on the same unit, the narrower shielded area, about mid-way back.

Be patient, you have about a two hour job there. Use bright light and drugstore reading glasses to make sure you get them all and watch for bridges as you solder. Much easier to find and clean them "as you go" rather than discover them later.

Next, get the PLL unit out, scrape the adhesive pad from under the VCO nearest the front right cornner of the board (as the rig is facing you), and Resolder that area about 1 sq inch.

Next, do the PLL/VCO service note [Editors Comment this is Service Bulletin 900], which should be in the files section of the group. Requires an RF probe for your DVM.

73, Bill K0ZL

PLL Board 7: PLL Board and setting voltages: Comprehensively updated in 2012

ZL4AI: in year 2013. Much easier to use an oscilloscope.. Much easier that trying to make an RF probe. With an oscilloscope you can get a picture of how clan or distorted the signal your era measuring is.

From: Alan & Susie Carlton [mailto:carlton2@flash.net]
Sent: Saturday, 22 April 2006 4:09 a.m.
To: jaking@es.co.nz
Subject: TS-940 PLL Problem

Jeff, I found your web page interesting and have tried some of the mods. I am having problem with the PLL unlocking and got in contact with Cliff Holland, Kenwood's Service guy in Irving Texas, and he had me melt the bee's wax from the cans and re-solder the whole PLL Board, and re-align it.

The problem that frustrates me is he claims KENWOOD SERVICE MANUAL IS APPARENTLY NOT TRANSLATED INTO ENGLISH CORRECTLY for a proper alignment procedure, e.g., Page 67 call out the test equipment needed, and page 68 & 69) of the manual clearly calls for RF Voltage measurements with an RF Probe, due to the PLL voltage being @100+MHz, but Cliff says to use a DMM in DC measurement. What does not make sense is (following the schematic) we are adjusting slugs in coils or transformers and these are tuned circuits, which should be an AC/RF voltage……… However, with my fluke RF Probe I can not get more than a volt on TP calling for 8 volts.

Apparently, when the PLL is aligned properly (He says) it will stay locked when the Bee's Wax is poured back in the metal cans.

I have already tried the mod about PLL Unlocking adjusting L-22, L-23, & L24, It all went fine as they said to peak each of these. L-24 even gave the greatest change just as they said, but it did not help the unlock situation. One thing that bothers me is the mod said the voltage will be about 250mV; well, I started with 300mV on a Fluke RF probe, and they peaked to 700mV…… Nothing seems to do what they say it will do.

Any advise would be most appreciated,

Alan, N5GKY

From: Jeff King [mailto:jaking@es.co.nz]
Sent: Saturday, 22 April 2006 8:04 p.m.
To: 'Alan & Susie Carlton'
Subject: RE: TS-940 PLL Problem

Alan,
Thanks for your interesting email. What you state sounds very similar to my experiences.

I am just an amateur who wanted to fix his own radio. That's why I started collecting the information on the page. I am sure Cliff knows a lot. His advice often appears remarkable, because of his long experience. When I communicated with Cliff a couple of times by email I found Cliff's answers were quite short. …. But I did really appreciate that he replied…… I suspect Cliff is aware of some service information others have not seen.

I am sure Cliff is correct about the poor translation of the Japanese. I find the workshop manual very difficult to understand in places. See my comments about important information Kenwood missed out regarding S meter settings. Cliff holds knowledge there about Japanese DB scales that others were not aware of.

- On my radio, I have not been able to set PLL frequencies, so I just left them until I gathered some more knowledge of what to do:
So I really appreciate your email, because what you find may also help me.

Referring to Items numbers listed in the service manual

Item 2 PLL1: bottom of page 67,
Could not measure any RF voltage reading, and at TP1 frequency jumped all over the place. I was confused by this and just left it.
Test data said it should be 8 volts and 3.5 – 4.5 volts, but then
the circuit diagrams shows 80 mV p-p
I concluded there was something wrong with the information in the manual.

-Item 3: PLL2 TP3: mine measured 47.699 MHz to 47.700 MHz, with RF voltage = 0.128 and DC 10.3 volts.
So I left that too, because the readings I got did not make sense, compared with the manuals values.

As well for both the above, how do you set the frequency at the frequencies the manual calls for???????????????????/
This seemed to be critical instruction that was missed out of the manual???????????????????????/

Item 4: PLL-IF TP5: With the radio set at 14.200 MHz last time I first measured 24.5 MHz and RF V at 0.411v. Way too high.
Then I followed Service Bulletin 900, which supersedes the manual. It told the critical information to adjust the frequency to just below 1.8 MHZ. I then adjusted L22, L 23, and L24 to give me a

peak of 264mV. SB 900 said it should be 250 mV.
I looked through my notes and when previously setting this I ended up peaking it at 698 mV. I suspect but I am not sure, that I did not read the instruction to set the dial frequency to 1.700 MHz.

My RF probe is home made following ARRL Handbook.

I agree with you, in theory voltages should be measured with an RF probe.
Maybe Cliff is right about using a DVM and reading DC?????? Cliff may well have seen service advice on how to correctly set these voltages.
It would be very useful if you could get Cliff to tell us how one sets up these PLL voltages.

Maybe there is frequency setting like 1.799 MHz (SB-900) we are supposed to put the radio at before setting these voltages.

I would be most grateful if you would advise whatever you discover.

Yours sincerely
Jeff King ZL4AI

Yahoo! Groups Links

jeff_king169 wrote:
> I cannot understand the instructions in the service manual. Can anyone help, who has successfully setup the PLL-1?
> Page 68 of the manual Control adjustment 2 states:
>
> Item PLL-1 100-110 MHz
> Measurement Test equipment: RF V.M, FREQ.C
>
> Measurement Unit: PLL
> Measurement Terminal TP1
>
> Adjustment Unit: PLL
> Adjustment Part L10
>
> Adjustment Method: ADJ to 8V at 110MHz
>
> Specification / Remarks: 100 Mhz: 3.5-4.5 V
>
> All thats sounds ok, but here is what I measured Frequency jumped all over the place 0.067 Mhz to 0.432 Mhz.
> Couldnt get any RF voltage reading, with my home made Rf probe and Digital volt meter.
> The circuit diagram shows 80 mV P-P at this point!
>
> Can anyone tell me what L10 adjusts to? Are you adjusting the counter to read 110MHz or the voltage to read 8 volts?
> Does this specification setting mean ideally it should show exactly 8 volts when you adjust the frequency to 110 MHz?

> What does the specification mean?
> The voltage could be as low as 100 mHz or the voltage as low as 3.5 to 4.5 V?
> Or do you change something else on the radio to check the voltage at 100 MHz as 3.5 to 4.5 volts?
> If so what do you change?
>
> Does any one know how to make this adjustment correctly
>
> It seems to me there is something missing from the instruction here.
>
> For example when you set the PLL-IF at 100 to 170 mV you have to carry out an extra step, which is to set the band to 1.797 MHz. If you dont
> set the band to 1.797 mHz the voltage reads 411 mV. I found the instruction to set the band to 1.797 Mhz in Service Bulletin 900. That
> information IS NOT IN THE SERVICE MANUAL. Without knowing this band setting instruction you cannot set achieve the lower voltage.
>
> Is there similar CRITICAL instruction information missing from the settings for PLL-1?
>
> Any advice from anyone who knows how to make this setting would be
> really appreciated
>
> Yours sincerely Jeff King ZL4AI

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** Martin Sole
Sent: Thursday, 14 September 2006 1:23 p.m.
To: ts-940@yahoogroups.com
Subject: Re: [ts-940] How do you Set PLL-1 ? Advice from someone who has successfully set please

Hi Jeff,

Just a few thoughts. PLL1 is responsible for the 100Hz steps. It does this by tuning in 10kHz steps which get divided by 100 at the output, IC10. So I guess then that every 10kHz of real tuning should cause PLL1 to go from 100MHz to 110MHz if we ignore the 109.99 rollover.

The front panel encoder steps in 10Hz or 1/10 of the IC10 output (100Hz) so for every 10Hz step the vco of PLL1 should move by 10kHz. This should start at some frequency xx.xx0.00 and finish at some frequency xx.xx9.99.

If the loop is in lock then the frequency should be stable at whatever the dividers state it should be and adjustment of the inductor, L10, should cause the tune voltage to vary such that it adjusts the capacitance in the tuned circuit in order to maintain the same frequency.

What they want you to do is have a tune voltage of 8 volts when the vco is at 110MHz and a tune voltage between 3.5 to 4.5 volts at 100MHz. If the tune volts at 100MHz is more than say 4.5 volts then by the time the vco tries to get to 110MHz there is not enough voltage available from the tune line supply. Same if you have the volts set too low at 110MHz then when you tune the radio such as to cause the vco to want to go to 100MHz the tune line cannot go low enough to pull it there. There also needs to be a margin such that any drift, which causes the tune line volts to vary so as to keep everything on frequency, can be accommodated from the available supply range.

As I look at Fig 3 I see that PLL1 moves in 10kHz steps, gets divided by 100 so gives 100Hz steps at its output. This is mixed and fed as another frequency, but variable in the same 100Hz steps, to mix with the output of PLL2. This causes PLL2 to move in similar 100Hz steps which then get divided by 10 to give us our 10Hz steps.

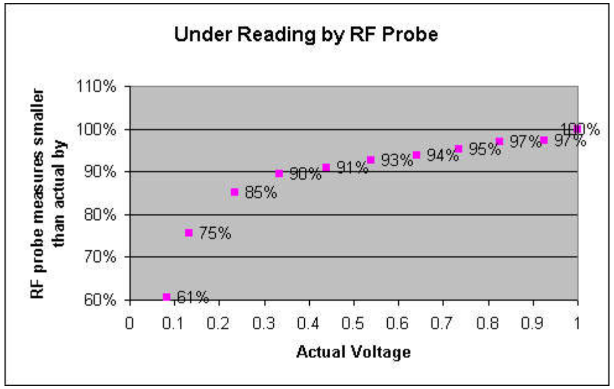
Of course you do need to have the correct divider data for IC9 coming from digital A else all bets are off !

73
Martin, HS0ZED

p.s. It's a bit early and the coffee has hardly had time yet so might be
a bit out here and there.

Editors note: The above procedure for setting frequencies to get the correct voltages is explained much more fully in the ts-930 service manual. Obtain a copy of the TS-930 service manual and read it.
As well, discovered home made RF probe at 200 to 300 mV probably only reads about 85% to 90% of actual voltage,
So the actual figures will be as much as 15% larger than those recorded above.

See **RF_probe.htm**



29 Jan 2013. More Comprehensive PLL set up instructions are now available at:
12113. TS-940 PLL1 & PLL2 Adustment Procedures v04.htm

CONTROL BOARD

VOLTAGE REGULATOR HEATS UP AND CAUSES A SHIFT IN BFO ON IF BOARD

-----Original Message-----

From: thomas hohlfeld [mailto:thomas_hohlfeld@hotmail.com]
Sent: Monday, 2 May 2005 9:23 a.m.
To: jaking@es.co.nz
Subject: RE: ts-940

(4) One of the voltage regulators on the control board warms up the bottom of the 940, which causes a small but detectable shift of the BFO on the IF board. I removed this regulator from the control board and mounted it on the big aluminium heat sink at the rear side of the TRX.

Best 73s for today, Jeff
Thomas, DF5KF

>From: "Jeff King" <jaking@es.co.nz>
>Reply-To: <jaking@es.co.nz>
>To: "'thomas hohlfeld'" <thomas_hohlfeld@hotmail.com>
>Subject: RE: ts-940
>Date: Fri, 27 May 2005 19:35:16 +1200

Your mod (4) is also very helpful for me. I have heard about a TS-940 that is supposed to have this problem of frequency drift after operating for 30 minutes. It apparently shifts frequency slightly then jumps back. Just sometimes: comes and goes. Sounds like you have solved the problem. Wow thanks. Can you please tell me which regulator was it that you shifted to the heat sink?

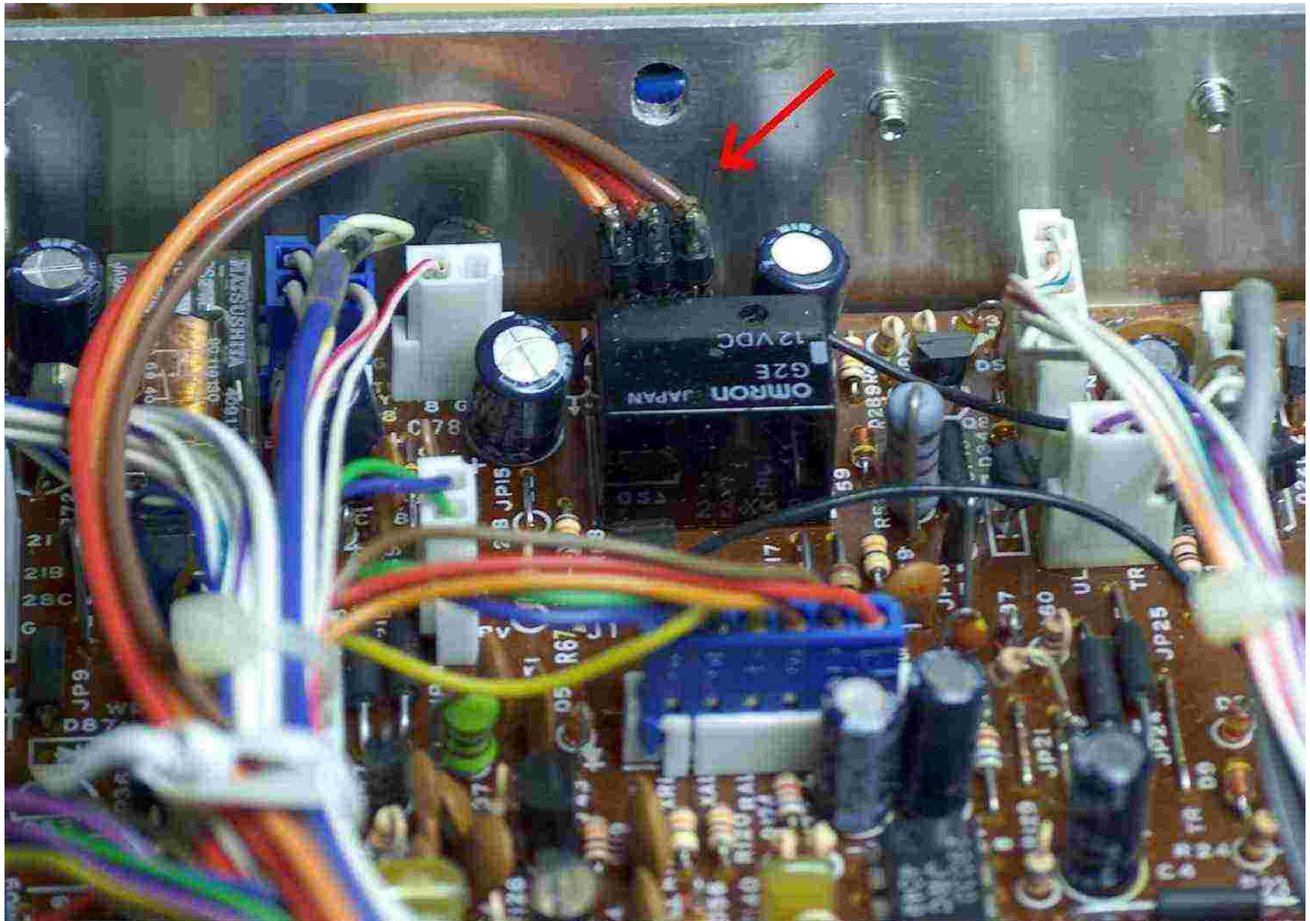
>Your sincerely
>Jeff King

-----Original Message-----
From: thomas hohlfeld [mailto:thomas_hohlfeld@hotmail.com]
Sent: Tuesday, 31 May 2005 9:15 a.m.
To: jaking@es.co.nz
Subject: BA479 etc.

You also asked for the IC that warms up (my mod 4). I believe it was either IC7 or IC6 on the control board, but I am not entirely sure. Next time I open my 940 I will see and let you know. Warming up of the IC caused a slow shift of the 100 kHz BFO (L19). Indeed, L19 was quite sensitive to changes in temperature in my 940. Perhaps you should verify with a counter that the jumps in frequency you mention are really caused by this BFO.
Best regards for today and vy 73,
Thomas,
DF5KF

-----Original Message-----
From: thomas hohlfeld [mailto:thomas_hohlfeld@hotmail.com]
Sent: Friday, 10 June 2005 8:56 a.m.
To: jaking@es.co.nz
Subject: RE: BA479 etc.

As my TS940 is open now, I had a look which of the voltage regulator IC I had moved back to the heat sink. It is IC7 on the control board, next to relay RL2. I include an additional jpg file which shows (upper figure) the place on the control board where I replaced IC7 by a connector with the three cables leaving (arrow). The lower figure shows the voltage regulator at its new place (arrow). The heat sink needed to be unscrewed in order to drill a hole for mounting IC7. I mounted IC7 isolated from ground. If you decide to do this mod, be very (!) careful not to make any mistakes. The primary 22V line may cause severe damage when connected to the 15V regulator output.



Good luck for today!
Thomas
DF5KF

See also COOL AVR COMPONENTS BY REMOUNTING ON HEAT SINK
Below:

AVR BOARD & POWER SUPPLY

FAN AND TEMPERATURES

eHam.net Forum : Elmers : Kenwood TS 940s Forum

Kenwood TS 940s Reply
Anonymous post on February 19, 2001
Can someone help? My fan in back of my TS940s has developed annoying rattling sound, nothing appears to be loose. Is there any quick fix to this problem? Thank you

by AL7BB on February 19, 2001
This fan has sealed "permanently lubricated" bearings, if it is like the one on my TS-940.
With this type of motor, I have had some results in lubricating motors like this by taking a straight pin and pricking a small hole in the cover over the bearings, and injecting a light oil through the hole.
This will possibly extend the life for a short period, but in my experience, it is time for a new set of bearings, or in this case, a new fan motor.
Bill, AL7BB

by WG7X on February 21, 2001
My TS-940S and two of those owned by fellow hams have developed the noisy fan. Like another poster, I oiled my motor, and that helped for a little while. Eventually, the motor failed and had to be replaced.

You should also be aware that there are two of these fans. Number one, and usually the one that fails, is the one on the back of the transformer. Number two is the fan on the finals. This fan can be seen inside the rig. Look down through the slots on the top cabinet in the right hand side in front of the finals. This fan probably would be a bear to change. Thankfully, the other fan seems to fail more often. These fans go for about $32(US). I bought two just in case.

Sometimes I also use an auxiliary fan over the transformer. Of course, this introduces a little extra fan noise into the shack. I might eventually replace the back fan with a full time muffin fan on the back transformer. I tried that while waiting for the replacement fans to arrive. A six-inch fan does a great job of cooling the power supply. In fact, it does a BETTER job of cooling the rig. I know this because I used a Fluke DVM with a temp. probe to measure the temp of the cooling fins. With the stock fan, the thermistor kicks in at about 45 deg C. With the muffin fan I was able to keep the temp at about 20 deg C.
Gary WG7X

by AL7B on March 22, 2001
I replaced my fan about 8 years ago with one used for cooling a 486 computer chip. I was too cheap to pay Kenwood $35 for a new motor. After tweaking the brushes a few times I gave up.
I did have to pack foam around the opening to force the air through the fan, but it has worked fine over the years.
Something to think about anyway and hope this helps.
Dick
Anchorage, AK

COOL AVR COMPONENTS BY REMOUNTING ON HEAT SINK

```
From: Victor Zelenin <vic_kz@mail.ru>
To: jaking@es.co.nz
Date: Tue, 27 Sep 2005 17:09:12 +0400
Subject: TS940 Mods

Dear Jeff,
Thank You for the nice page about Kenwood TS940S.
I have a small question to Thomas DK5KF and to Jeff as experts.
I am waiting replay from both of you.

DK5KF wrote the mod N4  Voltage regulator heats up and causes a shift  in  BFO on IF Board".

In my TS940 there is the shift in BFO due the warm up. The shift is about 150 Hz per first 30 min of operation.
Thomas advice to be careful with the IC7 voltage regulator on the Control Unit.


From my assumption it is god to reduce the voltage drop on IC-s on the Control Unit via AVR Unit thru reduction the signal 21T from 23.2V (see service manual
page 103) to 21 V.
May be the name of the signal has a sense? To drop the voltage we shall use D14 with 22 V or a bit less.

U (i/o) IC7 = 23.2-15=8.2 V
21-15= 6V
6:8.2 *100 =73%
So we would have a 27% reduction the dissipated power from all the 3 voltage regulators in Control Unit.



Additional advantage of my suggestion is:  the Q6 will not blow  when AC 220 Volt is low. It is happened in winter time in Russian country side due electrical
heating of houses.

When AC =190V, the voltage drop on Q103 too low, it current amplification is low (beta is function from emitter-collector voltage), due that Q6 is trying to
give more drive to Q103 till Q6 had burn with D14. I have changed two times Q6 with D14 by the conditions.

Best regards Jeff and Thomas
Victor UA2FP
Kalinigrad, 27 September 2005
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-----Original Message-----
From: thomas hohlfeld [mailto:thomas_hohlfeld@hotmail.com]
Sent: Sunday, 16 October 2005 9:44 a.m.
To: vic_kz@mail.ru
Cc: jaking@es.co.nz
Subject: RE: Fw: TS940 Mods

Hi Victor, hi Jeff
sorry for the late reply. I had to visit a couple of conferences during the last days.

Victor's suggestion to reduce the 21T Voltage from 23 to 21 Volts, bringing down the heat production of IC7, makes perfect sense to me. Let us know whether
this will help to reduce the BFO shift of your rig during warm-up.
It is interesting that the service manual says that D14 is either an MTZ 22 or an MTZ 24 type (legend below the AVR schematic, page 103). It seems therefore
that Kenwood has also tried different diodes here. One of my 940 rigs is presently open, so I did a few measurements. The voltage across D14 is  22.7 V.  At
Pin 21T of the AVR unit I have 21.2 V. It appears thus that my TS-940 has the MTZ 22 diode.
It may be interesting to you that, despite the lower 21T voltage,  I had to replace Q6 a couple of years ago.  I chose a standard NPN type in a TO-220 case.
This one gets only a bit more than handwarm and there were no problems any more.


In addition to Q6, other parts on the AVR board also become quite hot, for example C12 after a couple of hours. I found that diodes D10-D13 are the reason.
They dissipate a lot of heat to the board (which turned dark below the diodes) and to other parts, such as C12. I removed these diodes from the AVR board,
connected an appropriate bridge rectifier with sufficiently long wiring and mounted this rectifier on the black heat sink. D1 and D2 ran also hot and were
moved to the heatsink as well. This has helped, C12 remains cool now.

Best regards and 73s for today,

Thomas
(DF5KF)
```

Power Supply HEAT SINK RUNS TOO HOT

quickfaststang <scott.vitiello@verizon.net> wrote:
I just bought a ts-940 off of ebay. Had it on for about 3 hours just receiving and i noticed the unit was getting pretty hot,
i also noticed the fan or fan's are not working, Now i believe they are tempature controlled,
So my question's are: Do these radio's normally get real hot, before
the fan kicks on ? Also, I am sure this is a common problem, So What
usually is the cause of this, Is it the motor probabally burned out
or the thermistor etc. ?
Also, I believe there are 2 fans one in the tranformer area and one
in the final section, I dont believe any of them are working, but my
main concern would be the tranformer fan first !

read
120205. Power Supply 04.htm

VERIFY THERMISTOR 101 IS ATTACHED AND FUNCTIONING

ZL4AI 940 had a very hot TS-940 power supply.
On removing the power supply heat sink the thermistor 101 actually fell out of its housing metal housing. It had become unglued. It had been sitting in the correct position but probably was not making adequate contact thermal heat transfer. Hence not turning on the cooling fan.
To verify the thermistor changed resistance I connected a ohm meter and heated the thermistor with soldering iron. It went from approx 16,700 ohms at 12 degrees C to 220 ohms at say 400 degrees C. I have no idea if these are correct resistance values but they give an indication of what happened.
If anyone has the temperature table for Thermistor 101, please send to jaking@es.co.nz.

On page 8 of the promotional brochure above, its shows that the heat sink should run at or below 40 degrees Celsius.

REPLACE Q101 AND Q 102: THE MOST DANGEROUS DEFECT OF THE 940

After these fail, they release 36.1 volts down the 28 volt supply lines, and 23.9 volts down the 21 volt supply line.

Q101 and Q102 can fail at any time.
36.2 volts can destroy the final amplifier transistors: MRF422 [Vceo 40V and MRF485 [has Vceo 35 volts]
DO NOT TRANSMIT IF YOU SUSPECT THAT YOU HAVE A PROBLEM. DO NOT USE THE METER ON THE 940 TO CHECK 28.5 VOLTS, BECAUSE THIS WOULD MEAN TRANSMITTING.
TAKE THE TOP COVER OFF THE RADIO AND CHECK THE VOLTAGE AT CONNECTOR 28A ON THE AVR BOARD
28A SHOULD READ 28V TO 29V

IF 28A READS 36.2 THEN 36.2 IS BEING APPLIED TO YOUR FINAL AMP TRANSISTORS. [ZL4AI measured 36.2 volts when one of his Q101/102 failed]
THEY MAY NOT YET HAVE FAILED.

TRANSMITTING MAY PUSH THEM OVER THE LIMIT AND MAY WELL DESTROY YOUR FINAL AMP TRANSISTORS COSTING US$310 to replace.

==
ZL4AI found after replacing the original power supply transistors 2n5885 (60 volt version)
with the 2n5886 (80 volt version), the heat sink temperature seemed to decrease.

Original 2N5885 is by Motorola [60V, 25A]
http://www.datasheetarchive.com/search.php?q=2N5885

Replacement could be any brand of 2n5886, [80V, 25A]
http://www.datasheetarchive.com/search.php?q=2N5886
Motorola and ON semiconductor are recommended brands

A possible ever stronger replacement is the NPN 100V 30A, NTE181

http://www.nteinc.com/specs/100to199/pdf/nte180.pdf
ZL4AI has not used the NTE181 yet but intends to review the NTE181. NTE181
Veb is down to 4V compared with 5V on the 2N588X:
Hfe min is 25 compared with 20 on the 2N588X
If these changes are critical needs to be verified before the NT181 can be used.
The up rated stronger transistor maybe a safety advantage.

From: G3JVC

Power supply regulator failure in a TS930s, or TS940s (usually one will go short circuit) will cause the 28 volt supply to the PA board to rise to 40 volts, if over voltage protection has not been fitted to the power supply output, serious damage to the PA board transistors will be certain, before the PSU internal fuse blows!

A better, cheaper, direct TO3 replacement for the 2N5885 is the MJ15003, (RS Components 296-267) this is a 140 volt working transistor, rated at 250 watts, and more than able to cope with the power supply demands of the TS930s and TS940s circuitry.
73, John. G3JVC.

SAFETY PROCEDURES WHEN Q101 AND Q 102 HAVE FAILED:

If 28A reads > 29 volts:

From: Traian Belinas [mailto:traian.belinas@deck.ro]
Sent: Wednesday, 7 February 2007 5:14 a.m.
To: jaking@es.co.nz
Subject: TS940 problem!!!
Importance: High

Yes, the Q101/102 may have been gone, indeed...
It is a known problem!
Also, they may be ok and other to be the problem: check the Q101, Q102, Q1, Q2, R1, D3, Q3, Q104 and the soldering under the board.
For my previous TS940, the Q101/102 were ok, the problem was their Q1 driver transistor, and the finals and drivers were ok!

For further investigation:
- disconnect the 28V line from the AVR to the Final Unit (the FB connection, I think) for avoiding further damage to the Final Unit;
- disconnect the connector 3 and so avoiding powering the rest of the radio from the bad 28V line (don't forget to check the Q103 first).
- make checking on AVR without power (the above transistors, diodes, R)
- replace the defective parts;
- replace the F1 fuse with a low value one (1 amp is ok) or with a low value fusible R (10-20 ohm 1/2W is ok); place a light load to the 28V line (500 ohm is ok)
- apply power and check the 28A line voltage

- from now on you may work on AVR unit with power on for checking, but take care anyway;

Editor note: At this point the AVR is in test mode loaded against a 500 ohm dummy load.

Take a deep breath, relax for a while, and then go on for it!
Don't forget to reconnect the connectors and replace the F1. back to original.

MOTOR BEARINGS GUMMED UP: TEMPORARY FIX

-----Original Message-----
From: kenwood-bounces@mailman.qth.net [mailto:kenwood-bounces@mailman.qth.net] On Behalf Of Garey Barrell
Sent: Friday, 28 October 2005 4:48 a.m.
To: Bill Stewart
Cc: kenwood@mailman.qth.net
Subject: Re: [Kenwood] TS-940S Cooling Fan Problem

Bill Stewart wrote:

>I have a TS-940S, s/n 6040XXX, which has a sluggish cooling fan (on left, facing front, behind the power trans.). Sometimes it will not start. I have shot WD-40 in it and tried to get oil to go down the shaft but sometimes it still won't start and if it does start, it turns slowly & erratically. I measured the voltage to be around 18VDC with the fan disconnected and connected, a fluctuating .5 to 1.5VDC with the erratic rotation.
>Questions: 1. Is this no-load to load voltage drop normal?
> 2. Does the voltage and fan speed increase with temp. rise?
> 3. If the above is a problem, are there any mods. to replace this fan or maybe make the fan run all the time?
>The fan runs ok if it gets beyond the low start-up point (on a seperate DC supply).
>Any comments will be appreciated, thanks...Bill K4JYS

Bill -

The problem is that the motor is drawing too much current at start-up. The supply voltage is applied through a series resistor and the excess current drawn because of the gummed up bearings is high enough to drop the supply voltage too low to start. The correct fix is to replace the motor. East Coast Parts has them but they are expensive, ~$30. You might be able to find a hobby motor that will fit, if you look long enough.

A "temporary" fix is to put an 18V Zener diode across the motor dropping resistor so that if the voltage drop across the resistor is more than 18V, the Zener conducts, supplying enough voltage to start the motor. Once the motor starts, the voltage across the resistor drops below 18V and the Zener is out of the circuit. BUT this is only a temporary fix! If the motor freezes up, the 940 WILL overheat significantly.

73, Garey K4OAH

Chicago

-----Original Message-----
From: kenwood-bounces@mailman.qth.net [mailto:kenwood-bounces@mailman.qth.net] On Behalf Of Garey Barrell
Sent: Monday, 31 October 2005 4:10 a.m.
To: Bill Stewart
Cc: Kenwood@mailman.qth.net
Subject: Re: [Kenwood] TS-940S Cooling Fan Problem

Walt -

I have been through this several times. The problem is gummy or worn bearings in the fan motor. The "locked rotor" current is too high, dropping the supply voltage (supplied through an 18k, 1W resistor) too low to start the motor. The fan will start sometimes if you spin the blade to get it started. The fan will start and run fine if the supply is stiff enough. All Bill has to do is measure the voltage across the 18k resistor and he will see about 22V. The transistor will be saturated, and about a volt across the motor winding. An 18V Zener across the resistor will allow the motor to start, and once it starts the voltage across the resistor will drop to about 12V, and about 9-10V across the motor. But once the motor stops altogether, which it will, the transceiver WILL overheat, damaging AVR board parts first, and if you're unlucky, the PS pass transistor will short putting 40V across the final and driver transistors. The fan motor will sound cheap then...

73, Garey - K4OAH
Chicago

VK5KYO includes Larger Computer Fan and relocated Rectifiers.

```
-----Original Message-----
From: Joan de vk5kyo [mailto:vk5kyo@adam.com.au]
Sent: Friday, 22 September 2006 10:12 a.m.
To: jaking@es.co.nz
Subject: TS940 Modifications

Hi Jeff

You may be interested in the mods I completed to my 940.
Since you run such a good site for this radio, I'll be quite happy if
you want to share it with others.
```

Joan made these significant changes:
This looks a very good improvement but has not been verified yet.
If you ask Joan for clarification,
Please send on all feedback so the revised versions can be updated here.

VK5KYO_power_supply.htm

28 Volt Crowbar safety circuit for the TS-940

crowbar.htm

TS-940 Power Supply Improvement in 2012: Read this page first

120205. Power Supply 04.htm

Back to Part 1 of TS-940 page: Click here

ts940 battery
ts950 sd
ts940 cold solder
ts950sd fan
ts950 serial numbers
ts940
TS-940S HF Transceiver
Feb 1986
kenwood serial number
LO Local (TS-940 : Remote control of SLOPE, TUNE, VBT)
1.8khz ssb filter ts850s
Resistors in wrong place in the Kenwood Ts-940
950SDX + diode mod
rtty key input ts570
buy mI204 pin diode
ten tec omni vi transverters
difference between ts930 and ts940
TS-830 drift
DJ2LR
ts-930s unlocking
GU74 hybrid
TS-940
gu74 plate voltage
TS50 data operation rtty interface schematics
how to replace s-meter lamps in the Kenwood ts-940

ts50 psk interface schematics
ts850 color schematics
kenwood 940
ts850 repair rx attenuation
kenwood amateur ts-940 antenna tuner repairs
ts870 number serial
kenwood amplifier heats up and blows fuse
ts930s no display no receive
kenwood ts 940
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kenwood ts 940s late serial number
ts940
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ts940 lithium battery
kenwood ts-940 tuning upgrade
TS940 VCO Loop
kenwood ts940
ts940s problem solved
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ts-930
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ts-930sat
TS-930
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TS-930sat
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TS-930S
TS-930SAT
TS-950
TS-950S
TS-950sdx
TS-950SDX

Back to Part 1 of TS-940 page: Click here

FEEDBACK FROM READERS

RF BOARD 1: Board Runs very Hot

[Kenwood] ts940s - PCB burning
Clif mailto:clif@avvid.com
Tue, 4 Mar 2003 20:06:53 -0600

That is the way they run, very hot. Reflow the solder on them with good
solder and don't worry about it.

Clif Holland, KA5IPF
AVVid
Authorized Kenwood and Icom Service
www.avvid.com

----- Original Message -----
From: "PY2NFE" <py2nfe@uol.com.br>
To: "Kenwood" <kenwood@mailman.qth.net>
Sent: Tuesday, March 04, 2003 7:52 PM
Subject: [Kenwood] ts940s - PCB burning

Hi Gang:
I need a help A TS940S is with a part from the printed plate of circuit - RF unit - blackened, but barely in the region of the transistors Q6, Q7 and Q8 (armored rectangular area). Already verify everybody the tensions and RF levels and is everything OK, but the transistors are heating more than the normal one, causing problems in the solder. Soon after it link the radio the transistors (and all the region in return) already are with temperature above of the normal one Someone has some idea?

73
Ronaldo Brisolla - PY2NFE
py2nfe@uol.com.br

FINAL POWER AMPLIFIER

from
http://www.k8gu.com/repair/ts930s/pa.html

Editor note: Although about a TS-930 amplifier, this information maybe useful for repair of the TS-940 final amplifier.

repair notes
Power Amplifier

When I purchased my first TS-930S, it had a number of "improvements" that the owner had added. One of his selling points was that he'd pushed the power output to 150W because the "28-volt transistors could handle it." [I bought the radio because it had three Inrad and one Kenwood filters plus the PIEXX board and the service manual, figuring that for $650 I could remove the PIEXX board and the filters even if the radio was junk.] Although I removed almost all of the other modifications, I naively failed to spend 30 seconds to reduce the output power. It wasn't until my PA failed that I learned how fragile the PA in the '930 really was.

When the 28.5-volt power supply fails, it is invariably related the failure of the MRF-485 driver transistors. However, if you have low or no output and a good 28.5-volt power supply, check the mechanical and electrical integrity of the coaxial cables that connect the signal unit to the PA. I got an outstanding deal on a "low output" '930 on eBay only to find it had dirty contacts on the input connector for the PA. Unfortunately, this is rarely the case. Further, the MRF-485 Kenwood used in the TS-930S and TS-940S is a low-hFE grade of the part that often difficult and expensive to obtain. Higher gain parts are readily available although still somewhat more expensive than the NTE-listed substitute, the NTE236.

W6NL claims that he made a successful substitution of the NTE236 for the MRF-485 as well. However, ON7WP/AA9HX makes a rather scathing assessment of the choice suggesting a much cheaper FET. Although I agree that the MRF-485 [and the NTE236] is being pushed very hard, his sounds like a convoluted solution which I believe is neither justified nor necessary. He offers no indication of whether he checked the hFE of the NTE236's he burnt-up before trying the FET. This is a subtle, yet crucial, consideration because I believe that high gain in the driver stage leads to instability, inciting both the power supply and driver failure. Of a handful of NTE236 parts that I ordered from Jameco Electronics, all but one were clustered around a DC hFE value of approximately 80, which is substantially higher than the YELLOW and ORANGE coded MRF-485's [specified by Kenwood] corresponding to a maximum hFE of 52. The remaining part measured at 52, suggesting that Leeson may have been fortunate to have used a lower-gain pair.

KB2LJJ/CT1APV offers some help in his rather complete discussion of mods for the TS-940S, which contains a similar, if not identical, PA to the '930. Apparently a design change to the bias network in the '940 production run allowed the radio to use the higher gain drivers. This change involves increasing the value of resistors in the part of the bias circuit where diodes are thermally-bonded to one of the drivers and the PA heat sink to mitigate thermal run-away. According to this suggestion, I increased the value of R16 to 2.2k Ohms.

After installing the new drivers, replaced the regulator transistor Q6. The bias on the emitters of Q2 and Q3 remained near 0.1 volts. Eventually, I tracked this down to zener diode D5, which I replaced with an NTE5078A. In the process, I also replaced Q9 with an NTE377, which turned-out to be unnecessary. But, I include it for completeness.

According to W6NL and the service manual, I reset the bias on the drivers to 60 mA. I conservatively chose to shoot for the low end of the bias tolerance suggested by the service manual to avoid provoking unnecessary instability. At the suggestion of KB2LJJ, I let the radio transmit in USB mode with no audio input for well over an hour, monitoring the bias current through L7 carefully for changes. I then reset the CW carrier and TUNE carrier to 110 W and 55 W, respectively. Finally, I listened to myself on a second receiver as I sent some CW at 35 wpm into a dummy load. Sounds good. I was able to test the radio in the January 2006 North American QSO Party CW contest for about 8 hours, where it was subjected to high duty-cycle CQing and high SWR on 160 meters. The radio has continued to perform well [as of February 15, 2006] under occaisional contesting and casual operating.
Parts and Suppliers

A list of all the parts I replaced in the PA are in the table below. I purchased my parts from Mouser Electronics and Jameco Electronics. Both of these companies carry nearly the complete NTE line, although Jameco tends to be slightly cheaper. Many larger cities have a local electronics emporium [not the one with the Answers, although they probably can order them] or two that carries NTE/ECG replacement semiconductors or even original replacements. This repair should cost around $35 dollars as I described. You may also elect to obtain original parts at higher cost from RF Parts or East Coast Transistor.

id	part	replacement

Q2,Q3	MRF-485LB	NTE236
Q6	2SC496(Y)	NTE295
D5	BZ-192	NTE5078A
R16	1.2 k-ohm	2.2 k-ohm

Good luck. I appreciate your feedback, particularly from readers who have actually attempted or completed this repair, either on their own or using my comments.

Update [18 June 2006]: the NTE236 has been discontinued. You may be able to find vendors who still have it; but, prospects are not good.

TS-930 (and TS-940…) Power amplifier repair

(or how to replace bipolars by FET's…)

Revision 2 by Pedro M.J. Wyns ON7WP-AA9HX dd. 20031228

Introduction:
Kenwood made a big mistake by putting two MRF485 transistors rated 25 V DC Vce max in the driver stage of these great rigs running on 28 V. It is still a mystery for me how it ever worked but there is a huge collection of broken TS-930 and TS-940 around this globe waiting for repair. Usually the 28 Volt regulator transistors fail due to heat (use 240 Volts setting instead of 220 V) and these broken series regulators put 36 Volts on the final module. Boom!!!! The powerstage MRF422 survives, as well as the predriver, but the MRF485 goes into smoke after milliseconds with a short circuit between C and B.

Start by replacing the two shorted regulator transistors 2N5885 *[.... Editor Note: some un-needed text removed here from original]*

Check for 28 Volts.

Don't try to find spare MRF485 transistors. They are no longer made and the ones you can still find at an indecent price are NOT SUITABLE due to a far too high HFE causing instability and oscillation. The otherwise excellent article by W6NL Dave Leeson suggests using the NTE236 but this 'ersatz' one is also having the same low Vce of 25 V DC. Unless you want start by blowing up three pairs of these 15 $ transistors like I did, you better believe me, this is a bad replacement part….

Halleluia….There is a far better AND CHEAPER solution, putting in FET's instead… I started on my broken rig number one (I collect them J …) by using IRF730's. IRF710 would be a better choice but no longer available in Europe after Radio Shack closed down. After replacing some other parts I got 100 watts out on all bands from 160-30 meter, but only 50 watts on 20 and QRPp on 10 meter… although better than no output…but not a perfect solution. Boah…

One day (a sleepless night and one bottle of 1998 French wine) later…however, broken rig number two (J …) was modified using the even cheaper but well available P4NA80 by ST. The lower gate capacity of this 0.25 $ device gave 100 watts on all bands except 80 watts on 10 meter YES !!! (oops, bottle again empty….)

The mod:
start by rotating both bias pots fully CCW. Replace zener D5 by a 1k load resistor. Replace R13 3.9k by a 1k resistor. Take out the (burned?) R9 and R10 both 22r. Take out the ferrite bridge between these two resistors and mount a 8.2 V 400 mW zener between a ground hole from one of both now missing resistors (anode) and the other hole from the now missing bridge (cathode). This zener replaces the original series of D2 and D3 no longer used. Fets don't require diode heat sensors. Remove both MRF485's and put the rig back on. Check if you can adjust the driver bias voltage somewhere between 2 and 6 volts approx. If not the Q6 2SC496 is gone (not in my case but could be…) Turn back the bias pot CCW. Now take a quick nip of the freshly opened bottle Bordeaux 1998…

Perhaps you don't believe me but all feed-through platings ARE BAD !!! Kenwood really messed up things those days… Cure: put a 0.3 mm silver wire through all of them, especially at the two groundings at the former MRF485 emitter place and at the base and collector of the MRF422's. Put the P4NA80's in the place of the MRF485's after bending the gates completely upward and cutting off the middle pin (drain). Solder source to the groundlug (with the wire in it). Solder one end of a 10 ohm resistor in each base connection (both sides of the PCB) of the former MRF485. (all resistors ¼ W) The other end is going to the 'flying' gate of the P4NA80 preventing oscillation. That's it… Put an Ammeter in the power amp red wire supply. Initial current during TX with NO DRIVE is 220 mA. Increase the bias of the FET predriver to 100 ma = 320 mA total consumption by adjusting the bias pot VR2 (about 3,7 V gate voltage). Adjust the final bias to 500 mA = 820 mA total consumption by pot VR1.

Finish by readjusting the IF/RF unit VR8 to 110 watts max after setting the current limiter VR10 to 11 amps while slightly overdriving the amp. Close the rig and empty the bottle Bordeaux.

Who ever said technical articles have to be boring, hips….

If this article was valuable to you please write me a short mail to keep me motivated posting these kind of repair tips.

73's from 'Radio Guru Number One' in Europe…

Pedro M.J. Wyns ON7WP-AA9HX
on7wp@pandora.be
Moutstraat 7
B-2220 Hallaar
Belgium, Europe, World, Milkyway…

More from John E.Cleeve, G3JVC.

It is true, that Motorola USA has ceased production, of the MRF485, and MRF422, so you cannot buy these transistors "off the shelf" from your local electronics outlet, but as I say, they are still available as spare parts for the TS930s and TS940s, from Kenwood Japan.

MRF485 and MRF 422 transistors I have received are marked "Motorola Japan", and any Kenwood dealer, or, authorised Kenwood spares agent, will be able to obtain the driver and PA transistors for clients, via the Kenwood "spares" organisation, and that includes private individuals. 73, John. G3JVC.

Alternative replacement for MRF485

how ZL3BG replaced MRF485 with
2SC2078 + 12 volt regulator or
2SC1969 + 12 volt regulator
See:
crowbar.htm

DIGITAL A BOARD AND IF 10B

Martin Sole http://www.qsl.net/hs0zed/brochure940.html pulled both EPROM's from his TS-940S and saved the code in Intel hex format. This is for TS-940S firmware version JA4 (That's what it says on the chip)

http://www.qsl.net/hs0zed/TS940.HEX
TS940.HEX

http://www.qsl.net/hs0zed/IF10B.HEX
IF10B.HEX

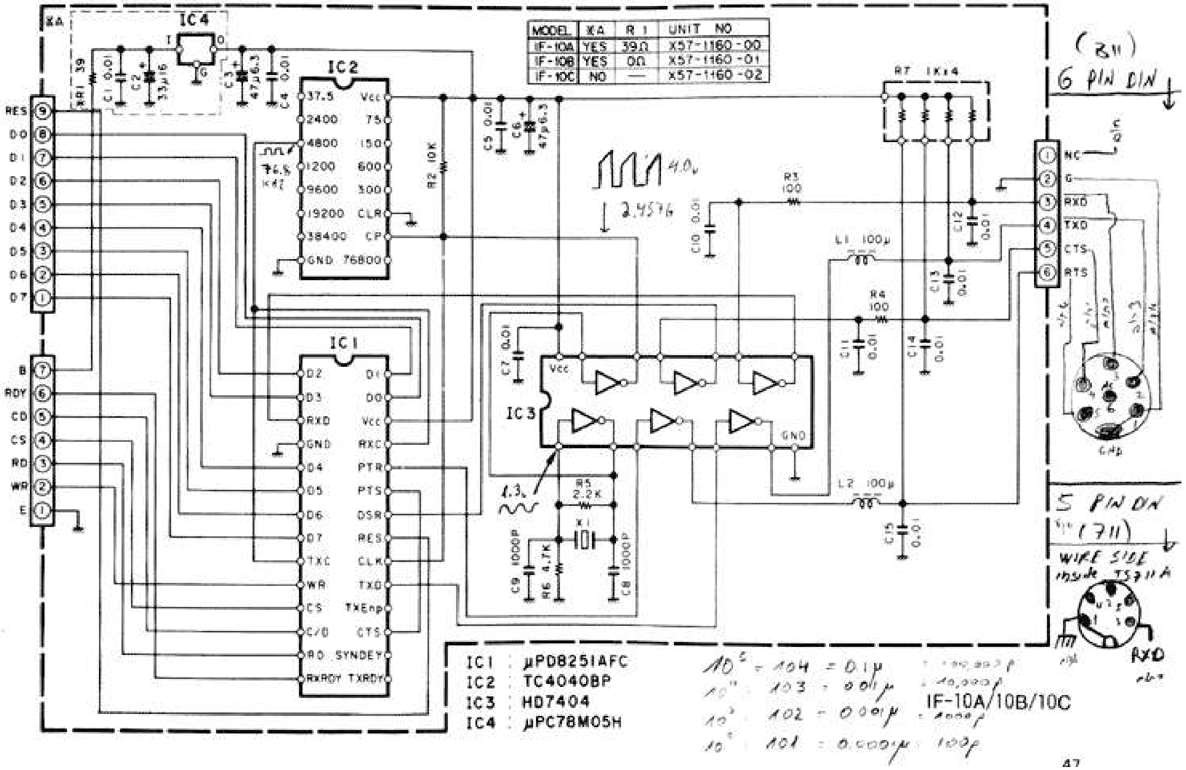
The instruction manual for the IF10_ABC holds a lot of useful information: Circuit diagrams installation instructions, and how to computer interface:
if-10abc.pdf

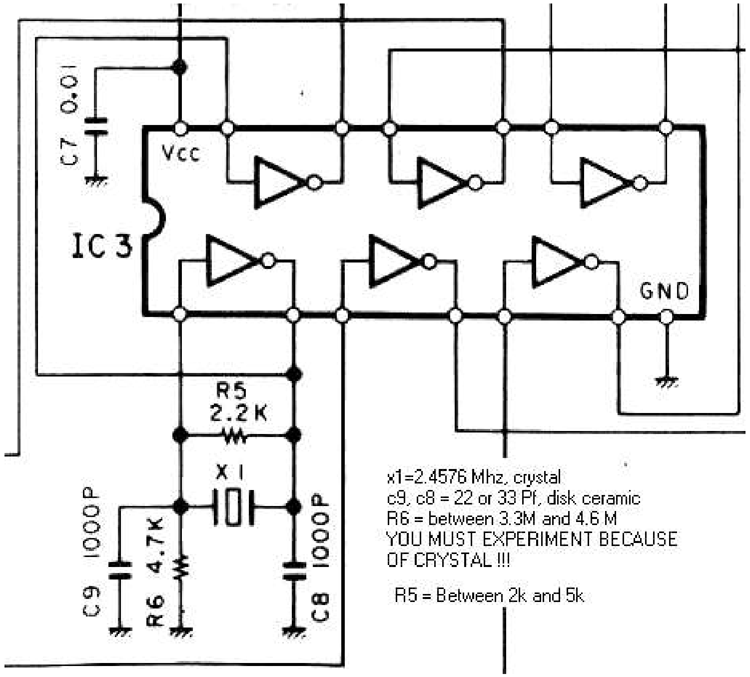
The following came from: Mods.DK Article Id 3352.htm

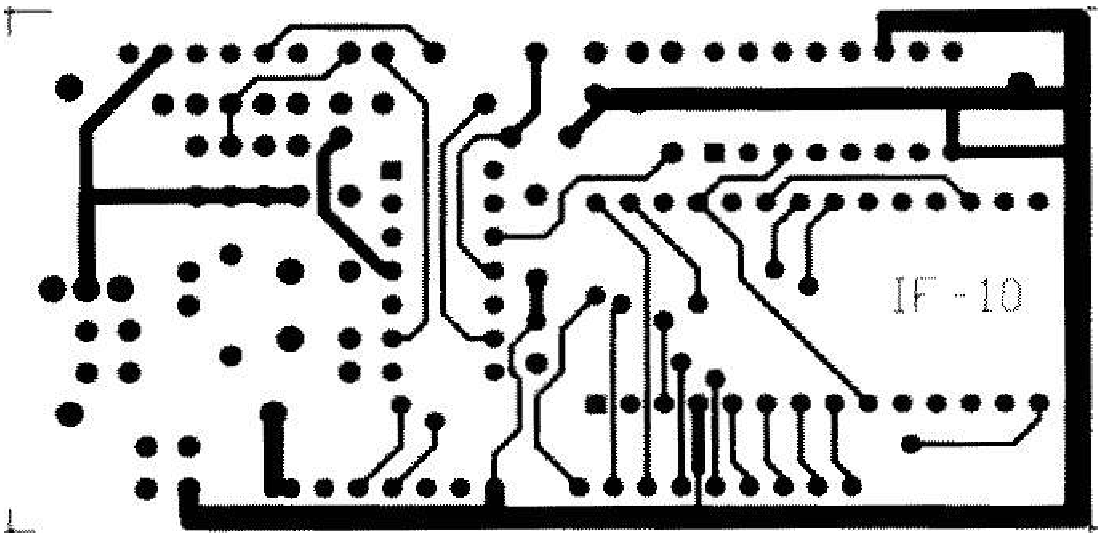
The TS-940s inside serial interface is not available now so here is a solution.

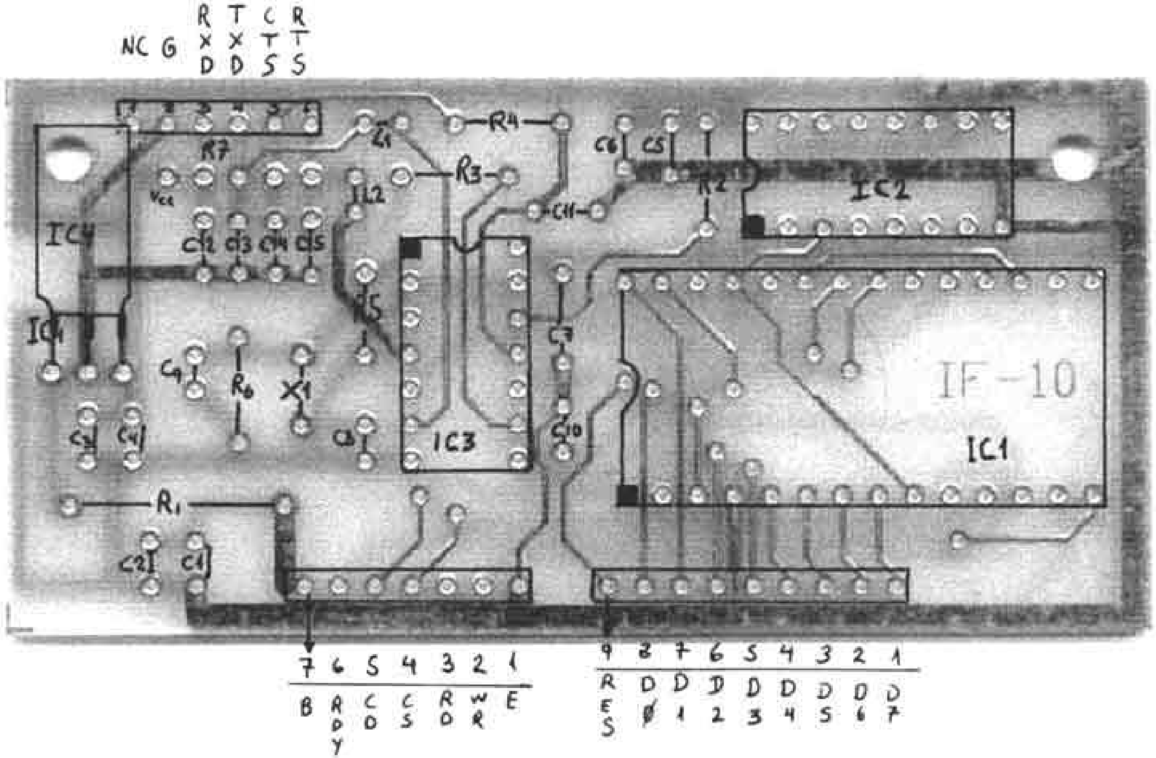
5. SCHEMATIC DIAGRAM

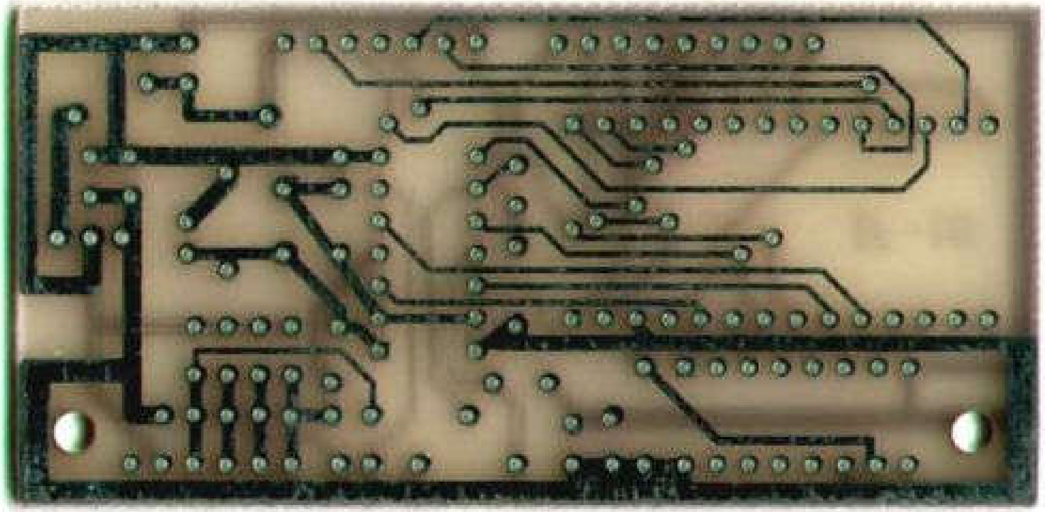
(X57-1160-00,01,02)

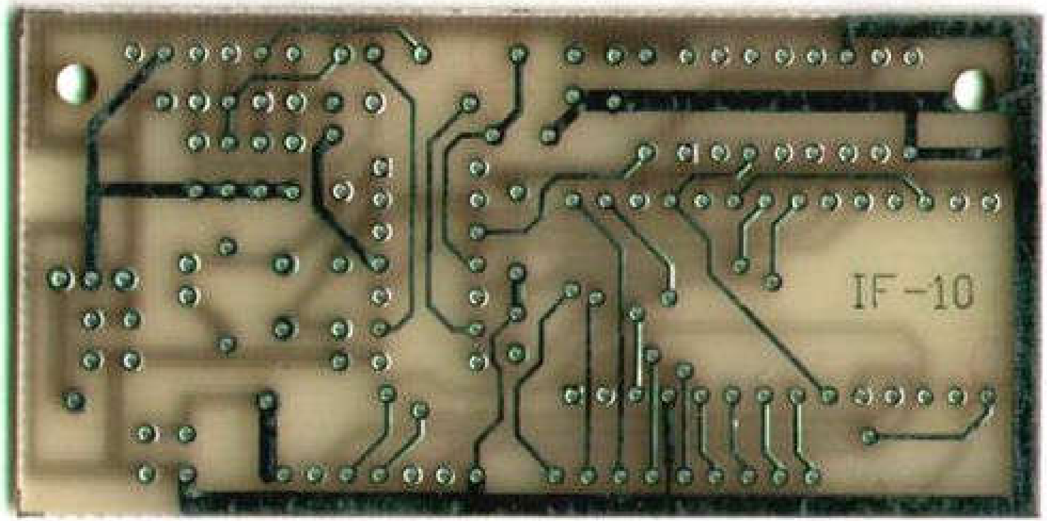


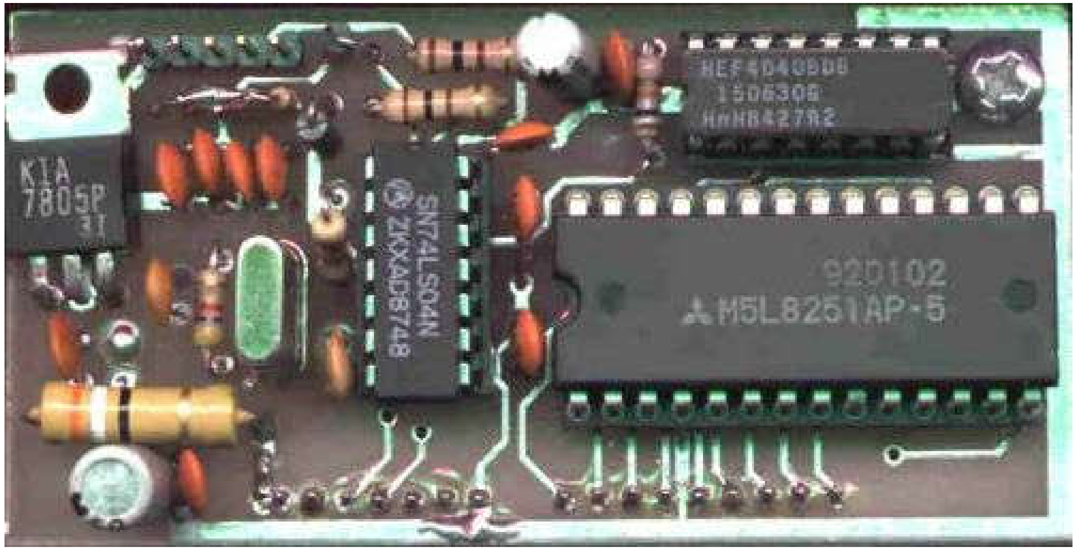

C7 0.01
Vcc
IC3
GND
R5
2.2K
X1
1000P
C9
R6 4.7K
C8 1000P
x1=2.4576 Mhz, crystal
c9, c8 = 22 or 33 Pf, disk ceramic
R6 = between 3.3M and 4.6 M
YOU MUST EXPERIMENT BECAUSE
OF CRYSTAL !!!
R5 = Between 2k and 5k


IF-10


NC G RXD TXD CTS RTS
R7
R4
R3
R2
R1
R6
C6 C5
C11
C12 C13 C14 C15
C9 C3 C4 C2 C1 C8 C7 C10
X1
IC4
IC1
IC2
IC3
IC1
IF-10
7 6 5 4 3 2 1
B RDY CD CS RD WR E
9 8 7 6 5 4 3 2 1
RES DØ D1 D2 D3 D4 D5 D6 D7




IF-10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HMH8427R2
KIA
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92D102
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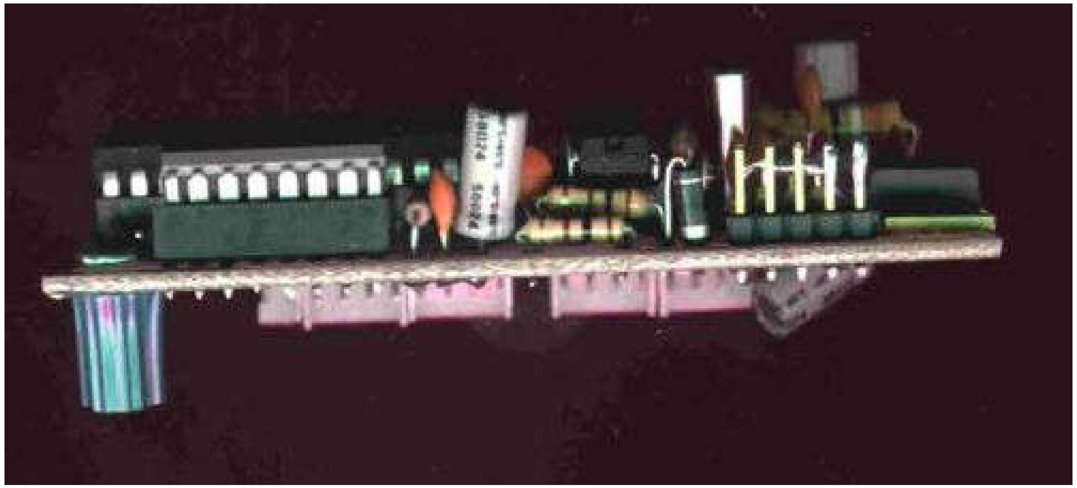


MAIN DISPLAY

Repairing old fluorescent displays (to brighten up dim digits)

From: kenwood-bounces@mailman.qth.net [mailto:kenwood- bounces@mailman.qth.net] On Behalf Of Philip, KO6BB
Sent: Wednesday, 9 August 2006 9:23 a.m.
To: Kenwood List
Subject: [Kenwood] Perking up old fluorescent displays

Hi All,
Here is a little trick that users of older radios having fluorescent displays (Kenwood, JRC etc.) might be interested in.

Having just completed the 10Hz digit mod to my Kenwood 430 I was left staring at a display that had some digits that were dimmer than others. This set apparently hadn't been used for a LONG TIME as it had a number of problems when it arrived (worst was the bad solder connections on Voltage Regulator). Anyway, the display looked "funky". JRC Radios typically suffer from this malady even more than the Kenwood radios do. Unused digits/segments gradually turn dim, and may be most apparent on the Tens of MHz digit if the owner is primarily a low band operator!

I've seen this on other radios in the past, so I did the usual "trick" that I do in such cases. I tuned the radio to 28.88888 MHz and left it turned on continuously. After being on for about 24 hours the display is brighter and COMPLETELY EVEN in brightness across all digits. I will leave it on for at least another day just to be sure.

Results? The display now looks very nice indeed.

73 de Phil, KO6BB

HOW IT WORKS

AM MODE: HOW TO VERIFY ITS SWITCHED IN

From: Traian Belinas [mailto:traian@deck.ro] the CAR acts for AM and CW only.

For the AM and CW, the balanced modulator is unbalanced also by CAR pot voltage by D89. for the AM and CW it is adjusted by CAR pot, it is not a fixed value voltage.
D97 is an OR gate which supply the unbalancing voltage for CW or AM modes only (the CAR acts for these modes only), switched by the mode voltages at the Q410 and Q408 outs, so by F and D CWG and AMG bias voltages respectively (connector 12, contact 6 and 4). So you may check for the AMG voltage and switching Q408.
When AM mode, Q408 shall supply the TV voltage (from connector 13) to the right side diode of the D97 then to the CAR potentiometer (CV1, CV2 at connector 14), then by D89 to the balanced modulator and so unbalancing it and so introducing the AM carrier for the TX path.
So, check if the Q408 output is switching from near zero to near TV value when changing modes from SSB to Am and follow that voltage trough that path down to the balanced modulator.

D78 and D79 have to be directly biased, i.e. current shall flow through them when AM. This mean they shall have 0,65 aprox voltage drop, anode to cathode. The current shall flow from the +15V line by the R277/R278 voltage divider to R276 - D78 - D79 - R300 chain to GND.

You shall check the voltage at the R277/R278, and all of the R276 D78 D79 R300 parts and the respective trace.

FM MODE: SETTING FM CARRIER

From: Traian Belinas [mailto:traian@deck.ro]

Regarding the FM power, did you tried adjusting the VR9 on the IF board, and checking the bias to the balanced modulator D73?
VR9 settle the FM carrier (ie FM output power), as it is adjusting the DC bias/unbalance to the D73 balanced diode ring modulator for FM.

Some of the TS940 VRs are very very touchy.
The power setting VR on the Control board and VR9 FM car are some of these. I am sure you have observed that others have this behaviour.

I have found the 940 as being the most "unstable" radio from all of I had, as the adjustments are very touchy and also need readjustment sometime or from time to time if you want constant trx parameters .

CW FILTERS

```
--- In ts-940@yahoogroups.com, "Stjepan Nikolic" <snikolic@...> wrote:

Hi all,
Just a quick question. Which CW filter would you recommend:
YK-88C-1 or YG-455C-1.
The price is very similar but I'm not sure about Performances on 40mtrs band where the noise is stronger than, for example, on 15mtrs band.
Thanks
73's  Stjepan VK3TSN
```

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] On Behalf Of John Rotondi
Sent: Friday, 17 March 2006 10:07 p.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] Re: YK-88C-1 or YG-455C-1

Hello Stjepan,

First, please note that the performance of these filters will not be evidenced by different performance on different bands, since these are 'I.F.' (Intermediate Frequency) Crystal Filters. I.F. Stages are used to provide fixed selectivity across wide frequency ranges while rejecting image frequencies. These are selectivity filters- not 'noise filters'- they will not lessen noise within their passband- but by having a reduced passband (over the SSB
2.4KHz passband let's say), they will pass less noise then the wider passband, so the signal-to-noise ratio within the passband will be greater. Please read the ARRL Handbook sections on Receivers for more information about I.F. stages.

The TS-940 has 4 Intermediate Frequency stages, with the capability of inserting filters into both the 8.83MHz, and the 455Khz I.F. Both the filters you ask about provide the same 500Hz bandpass characteristic, and should provide similar results when compared against each other. The YK-88C-1 is used in the 8.83MHz I.F., and the YG-455C-1 in the 455KHz I.F. You can use either one, or both at once to provide a cascade effect in terms of narrowing the response in the upper I.F. prior to the secondary filter, making the rejection of out-of-passband signals even more pronounced- especially helpful if they are strong signals. You gain selectivity, and rejection of out-of-passband signals. The in-band noise should not be affected (lessened) by having 2 filters in cascade.

Note there is also a YG-455CN-1 250Hz narrow CW filter available for the TS-940, although this may be at greater expense. If noise is the problem, the narrower filter will have a better signal-to-noise ratio by 3dB over the 500Hz filter, assuming the same insertion loss.

I am using the YG-455C-1 by itself with excellent results, especially when used in conjunction with the CW VBT control and Notch Filter (this helps to notch out noise as well as nearby signals)- but I am not heavily working CW, nor do I have excessive noise. If you are heavily into CW, and especially CW contesting, then using both filters, or, better yet, using the YG-455CN-1 250Hz Narrow CW Filter in the 455KHz I.F. would likely provide the
optimum performance.

If noise is your main issue, it might be worth it for you to start with the narrow YG-455CN-1 CW filter- that might be all you'll need. If not, you can always add a second filter in the 8.83MHz I.F.

BTW, use of the RF Attenuator, or backing off on the RF gain control, and using the AGC in 'Fast' mode while in CW, will help lessen noise, if that is the main issue.

The TS-940 is a great radio! Have fun!

I hope this information is helpful.

73 es gd dx

John, WA2OOB

Service Manual & Serial Numbers

----- Original Message -----
From: "Brian P. Mileshosky" <n5zgt@swcp.com>
To: <kenwood@mailman.qth.net>
Sent: Friday, July 12, 2002 1:11 PM

Subject: [Kenwood] TS-940S Service Manual & Serial Numbers

Hello Everyone,
I have a gentleman who has an original "Revised Edition" Kenwood TS-940S service manual. However, I do not know what serial numbers it is good for. My TS-940S serial number is 6030606.
Can anyone please comment on if the revised edition is the correct manual to have, given my serial number?
Thanks and 73,
Brian, N5ZGT

Clif" <clif@avvid.com
Fri, 12 Jul 2002 14:03:51 -0500

Which revision???
Original Manual, Copyright 1985-2
Revised Manual, Copyright 1985-2/1985-9/1986-2
Revised Manual, Copyright 1985-2/85-9/87-3/87-4/87-10/88-4/88-11/89-08/90-3

That is from 3 different manuals, looks like a sackful of revisions are out there.
Clif Holland, KA5IPF

Editors note:
Be careful: Digital A Board is double sided: You **NEED** to be able see colour pictures of the board.
Without colour pictures it is impossible to be able to understand the traces and to work on the board.
Colour pictures of other boards help a lot too.

Revisions identified with Part numbers:

Copyright / Revision	Part Number	Source:
1985-2	B51-2058-00	
1985-2/1985-9/1986-2	B51-2058-10	
1985-2/1985-9/1987-3/1987-4/1987-10		
1985-2/85-9/87-3/87-4/87-10/88-4/88-11/89-08	B51-2058-10	sales@w7fg.com
1985-2/85-9/87-3/87-4/87-10/88-4/88-11/89-08/90-3		

SERVICE MANUALS:
These can be found from time to time on the internet. If you need a service manual, we offer it on a comprehensive CD-ROM, which contains in PDF format, a complete set of TS-940 documents.

- 13 Service Bulletins (above)

-TS-940S Revised Service Manual, 62 pages,

-SO1 service adjustment instructions,

-SP-940 Service Manual,

-VS1 (Voice Synthesiser Unit) Service Manual,

-TS-940S operators manual, 108 pages
-TS-940S Technical Supplement, 48 pages,
- TS-940S promotional brochure 9in full colour),
- IF10B Instruction Manual [internal kit for computer interface control]
- IF232 Instruction Manual [external control unit for computer interface control]
-PC1A Phone Patch Operator Manual and wiring Diagram,
-YK-88CN manual,
-SWR 2000 Service Manual,
-HS5 Operators manual [headphones]
- SM220 Service Manual, 29 pages [Station Monitor]
-TL 922 Service Manual [1,500 watt linear amplifier]
- TS570 Control Program, fully operational,
-MC-43 operators manual,
-MC-60 operators manual,
-MC-85 operators manual,
-MC-90 operators manual,
- Kenwood miscellaneous connectors schedule,
- All files on this website

If you require the CD cost is $US11.00 plus postage [$US 3.00 to USA, other places will be advised by email].
Payment can be received by Paypal. Please jaking@es.co.nz to request delivery.

Identifying When Radio Manufactured

ZL4AI advice based as much as possible on analysis of facts gathered:

930s		reviewed by QST in	Sep 1983
940s serial number	5110330	reviewed by QST in	Feb 1986.
950s serial number	1010616	reviewed by QST in	Jan 1991.
950SDX serial number	31200011	reviewed by QST in	Dec 1992.

Owners Manual:
940 First Issue has part number
85902 PRINTED IN JAPAN B50-8001-30 K W M X T (T)
Most likely means the 940 was released in Sep 1985

Service Bulletins:
940 First Bulletin #896 issued 14 Sep 1985
940 Last Bulletin #988 issued 16 Jan 1992

Service Manual
940 1st issue has code 85-2
940 2nd issue has code 85-2
940 Last issue has code 96-11

The first issue may mean the 940 was first circulated by Feb 1985, and the author suspects this was a Japanese Domestic model
Kenwood re-issued service support information until November 1996 which means support for the 940 went on much later than end of production.

From: *ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com]* ***On Behalf Of*** *Charlie Wirth*
Sent: *Friday, 12 February 2010 10:42 a.m.*
To: *ts-940@yahoogroups.com*
Subject: *RE: [ts-940] 940 Serial Numbers*
….
I also read somewhere that the serial numbers started with 5xx for the first production run
and then went to 6xx, 7xx, 8xx, 9xx, 0xx, 1xx and finally 2xx.

ZL4AI has personal experience of three 940s
5xx, 7xx, and a 2xx

ZL4AI owns
20500068 which came with hand written records showing
It was purchased on 8 Oct 1990 at the Ham Radio Outlet in San Diego
Inside I see ICs on the control board marked with date codes
8943 to 9025
There were at least there IC with the 9025 date code
9025 is 25th week of 1990, which is 25 June 1990 so these ICs were made about 25 June 1990.
It would seem relatively likely this 940 was made in June 1990 and was number 68 made that month.

Most importantly it proves 940s with a 20 serial number were not made in 1992 and were made in 1990.
It also suggests the 0xx, 1xx and finally 2xx series may have all been made in 1990.

From: ts-940@yahoogroups.com [mailto:ts-940@yahoogroups.com] **On Behalf Of** Dale
Sent: Saturday, 24 November 2007 5:33 p.m.
To: ts-940@yahoogroups.com
Subject: [ts-940] Re: VERY LATE TS-940Sat, 20 mil serial number available.

Hello Kevin, I have a 20 mil serial numbered TS-940SAT also it's # 20700050 but it's not for sale just thought I mention it. Great radio

73, Dale KD5UVV

20700050 is the highest serial number for a 940 ZL4AI has ever seen reference to.

From that it can be concluded the 940 was made as late as July 1990.

At this stage it is concluded the 940 was
Manufactured in some form from approx Feb 1985 to at least July 1990.
Released in the United States from Sep 1985.

Production of the 940 probably stopped in late 1990, because the 950s was released in Jan 1991.
But this is not absolutely certain because ZL4AI has heard that 940s were sold in parallel with the 950 for period.

What is also bizarre is that the alleged *X-2 year coding system* does not seem to work for 940, because
5xx series 940s were not made in 1983, because the 940 was not released until 1985.

ZL4AI does not know the exact dates, of 940 manufacture and would appreciate being emailed this information.

A well talked about scheme for the 950SDX is below:
ZL4AI found this system did not work for his TS-940 which was manufactured in 1987 and began with 7
[You will notice this X-2 number year system would identify
950SDX serial number 31200011 reviewed by QST in Dec 1992.
as a radio made in Dec 1991, when the 950SDX had not been released.]

It seems that somewhere between 1985 and 1990 Kenwood may have changed the year coding system for the 940.

A good idea is to
Take covers off and look at the IC chips.
Use the date scheme code below [W9IXX email], to confirm when the parts were made.

[Kenwood] TS-950sdx serial number
Bill Martin k4sgf@k4sgf.net
Sun, 27 Jan 2002 20:22:07 -0500

```
Mine is 01100190 so guess that makes it November of 98 - right?
Bill K4SGF

----- Original Message -----
From: NR1DX
To: k.d.wilson@ntlworld.com ; KENWOOD
Sent: Sunday, January 27, 2002 3:01 PM
Subject: Re: [Kenwood] TS-950sdx serial number

Kenwood serial number decoder
XYYZZZZZ
```

```
X-2 = last digit of the year
YY = Production Month
ZZZZZ = sequence in production for that month

So Kenny yours would have been the 7th unit to be produced in April of 1998 (the 950SDX wasn't in production in 1988). I'm told that this applies to all Kenwood radios
Dave
Nr1DX


At 07:02 PM 1/27/02 +0000, k.d.wilson wrote:
```
Hi Gang, The serial number of my TS-950sdx is 00400007, can anyone please tell me what year this is?.
>73 de Kenny M1HAM / M5RIG

[Kenwood] Fwd: RE: Feedback from Kenwood.net re:serial numbers
Phil Florig W9IXX@arrl.net
Tue, 09 Mar 2004 17:40:59 -0500

Hi all,
I received the following e-mail reference my inquiry on serial numbers for some of my Kenwood units. This information seems to correlate with the information on the date codes of some of the components. As you know there are usually Date codes on components. The common way is to give a 2digit year and 2digit week.
EX: 9340 is 1993 and the 40th week
8837 is 1988 and the 37th week
As shown below my TS850s ser#60200208 is mfg in 1994. This is right as the component date codes are 9340, 9409, 9350, 9410, and etc. As shown below my TS940s ser#9100162 is mfg in 1988. This is right as the component date codes are 8817, 8825, 8837, and etc. Bottom line is to check as many parts in the rig as you can to see the general date span. I know that some parts may be older stock and some may have been replaced but the majority of the date codes should be within a year. This will hold true for most medium to high production runs. Hope this helps in some way. Tnx agn guys for all of your inputs on this reflector and thank you Kenwood for answering my e-mail request so fast.
We do appreciate it.

73 Phil W9IXX

>Dear Kenwood Customer:
>
>
>There is no sequence with our serial numbers. TS-850S s/n 60200208 1994 TS-940S s/n 9100162 1988
>If you need further assistance, please e-mail us again.
>Sincerely,
>Kenwood Amateur Radio Customer Support
>
>
>-----Original Message-----
>From: Philip Florig [mailto:null@kenwood.net]
>Sent: Saturday, March 06, 2004 9:22 AM
>To: KCC-Amateur
>Subject: Feedback from Kenwood.net
>
>Hi,

>The question has come up as to the meaning of the serial numbers used. Can you explain the serial number system to me please. I have 2-TS830,1-TS850, & 1-TS940. Serial numbers are TS850 60200208 and TS940 is 9100162. Would like to know date of mfg and any other information.
>Thank you in advance.
>Regards,
>Phil Florig
>
>Contact Information:
>Email address: w9ixx@arrl.net
>Call Sign: W9IXX

BULBS

Sub display bulb:

Editor ZL4AI: 2 Feb 2007:

In my 20 mill 940, both bulbs blew at once
In service manual on page 35 for the LCD, the lamp circuit is shown. The bulbs are specified as 9V at 60 mA = (0.54W)
Editor measured bulbs at 3 mm dia x 7 mm long.
The mounting hole in the LCD board is 4 mm dia: The hole has plastic bezel around it inside so it cannot be made larger.
Conclusion you will have to use bulbs 3 mm dia or smaller.

Editor measured at his LCD supply volts available at 7.74, (compared with 8 on circuit diagram.)

LEDs? will these work? Advantage: Will increase life to 80,000 hours and reduce power consumption.
Guess will have to experiment to find out what LED works?

Information cross correlating MCD with luminance of a 540 mill watt bulb.

http://led.linear1.org/how-do-i-convert-between-candelas-and-lumens/
How do I convert between candelas and lumens?
You can't directly convert since they measure different things. The most useful explanation I've found is that lumens measure light output at the source, while candelas measure the light that falls on a surface. As the area of the surface increases, the number of candelas will decrease even as the number of lumens remains constant. So, they measure different things, and there's no direct conversion. Update: I didn't find that answer very satisfying either, so I worked out the conversion details and made a conversion calculator for you to use.

Light bulbs and LEDs sold for illumination tend to carry ratings in lumens. Indicator LEDs tend to be rated in candelas.

You can also use this table to get an approximate conversion from candelas to lumens. Find your LED beam width in degrees, and divide the candelas number in your specs by the cd/lm factor listed for that beam angle to get lumens.

beam angle	cd/lm
5	167.22
10	41.82
15	18.60
20	10.48
25	6.71
30	4.67
35	3.44
40	2.64
45	2.09

http://www.onlineconversion.com/forum/forum_1108372773.htm
Re: Lumens / Watts
by Chris Ward on 12/13/05 at 14:17:17

Lumens and Watts are just photometric and radiometric terms for the same thing: optical power or flux. The only difference is that photometry (luminous power) takes into account human perception and accounts for the sensitivity of the eye to different colours. This can make it difficult to convert between the two unless you know the spectra of the bulb.

By definition, at the peak sensitivity of the eye (green 555nm) 1 Watt equals 680 lumens.

It would make the most sense to talk about lumens with a flashligh, because what you really care about is the perceived "brightness", not the true optical power.

Chris

This information can be referenced on pg. 27 of "Optoelectronics", Prentice Hall 1983

so 1 lumen = 1/680 watts

So putting it all together.

Choices

Supplier	Dia	Colour	MCD (milli Candela)	Beam Angle	candella / lumen conversion	lumen to mWatt = 1.0/0.68	mWatt	Cost $NZ	V operating Vo	Current draw I in mA	Resistor Ohms based on R = V [7.74-Vo] / I	Best match resistor
DSE	3	green	5.6			1.47		0.45	2.2	20	277	270
Jaycar	3	Green diffused	6	40	2.64	1.47	3.3	0.25	2.1	30	188	180
DSE	3	green	45					1.70	2.2	20	277	270

Jaycar	3	Green clear	500	70	880.28	1.47	0.8	1.15	2.1	30	188	180
Jaycar	3	White clear	1,000	20	10.48	1.47	140	2.35	3.5	30	141	150
DSE	3	White clear	1,500					4.35	3.5	30	141	150
Jaycar	**3**	**White clear**	**3,500**	**20**	**10.48**	**1.47**	**491**	**3.75**	**3.5**	**30**	**141**	**150**
Jaycar	3	Green clear	6,000	15	18.6	1.47	474	5.25	3.5	30	141	150

I chose to use the Jaycar 3,500.
What the calculations above illustrate is that the more focus of a narrow beam LED puts out more light in a very small region.
LEDS seem to put out similar light levels, but high powered units intensely focus light into narrow beam.
In our LCD display what we want is diffused light across a wide area. We definitely don want to stare at intense light.
So I filed the lens off the front of the LED and filed all around to make the surface rough. This somewhat increased the diffused light

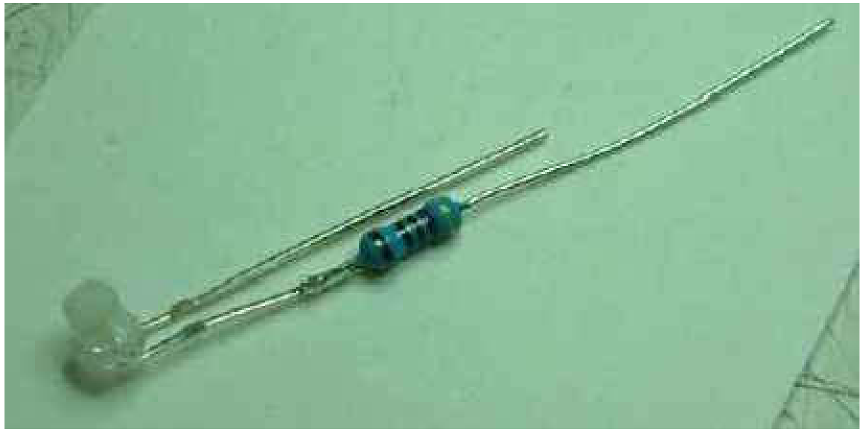
None of the LEDs will produce 540 m Watts.
The purpose of the resistor is to limit the current draw in the LED to a conservative safe value of 30 m Amps
If I push the current up by 540/491 to 33 m Amps then this can be achieved by a 120 ohm dropping resistor.

Jaycar	**3**	**White clear**	**3,500**	**20**	**10.48**	**1.47**	**491**	**3.75**	**3.5**	**30**	**128**	**120**

How does it look?
Brighter than the original incandescent bulbs, and more blue in colour.
I will try this for a while. If the blue is too irritating, I will change to the green LEDS with 6,000 mcd.

Power savings: each LED consumes about 130 mWatt, so savings are: 2 x 560 – 2 x 130 = 840 mWatt. This should take a small lad off the AVR board.

Preparing the LED to give diffuse light. Please note that LEDs have a lens at the front. This gives a bright beam of light.
To make his light diffuse:
File it off flat. Use a flat file. and some 220 grit sand paper to roughen the outside.
Do not file off too much, other wise you will expose the anode and cathode connections. Leave these covered by 1 mm of plastic.



The following 5 mm LEDs cannot be used on the LCD, but the date maybe useful when I convert the S meter to LEDs.

Supplier	Dia	Colour	MCD (milli Candela)	Beam Angle	candella / lumen conversion	lumen to mWatt = 1.0/0.68	mWatt	Cost $NZ	V operating Vo	Current draw I in mA	Resistor Ohms based on R = V [7.74-Vo] / I	Best match resistor
Jaycar	5	Green diffused	10					0.30	2.1	30	188	180
DSE	5	green	140					1.70	2.2	20	277	270
DSE	5	green	8.7					0.45	2.2	30	185	180
Jaycar	5	Green clear	3000					1.80	3.5	30	141	150
Jaycar	5	Green clear	6,500					3.75	3.5	30	141	150
DSE	5	green	10,000					10.00	3.5	30	141	150
Jaycar	5	Green clear	10,000					7.25	3.5	30	141	150

S Meter Display Bulbs

Ham To Ham #13 - October 1996
73's Ham To Ham column
c/o Dave Miller, NZ9E
7462 Lawler Avenue
Niles, IL 60714-3108

Lighten up

From George Vaughn WA4VWR comes this tip:

"I've found a local source for the bulbs that illuminate the Kenwood TS-940's sub- display. When one of them went bad in my TS-940S, I removed both and measured the voltage applied to and the current drawn by the single working bulb...12 volts at 75 milliamperes *[Editor note: Kenwood spec is 9V 60 mA, and supply is 8v]* . A trip to the local Radio Shack (reg. trade mark) store resulted in my discovering standard RS replacement bulbs of the exact size and shape (RS Cat. #272-1092), but the RS bulbs draw 15mA less, or 60mA - and they lack the little green "bootie" that the original Kenwood bulbs have. The green "bootie" can be carefully removed from the old bulb, provided it hasn't been "cooked" into place too badly, and with the aid of a touch of clear silicone grease, can be installed on the RS replacement bulb quite easily.

The 15 milliamp difference in current (and light output) is about the same as if one were to put a 47 ohm, 1/2 watt "bulb-life-extender-resistor" in series with the Kenwood bulb, so to me it's perfectly acceptable. The biggest difference is in the price...$1.49 for two of the RS bulbs vs. $4.19 each ($8.38 total) plus $6.00 shipping, for the Kenwood replacements. That's $7.19 per bulb from Kenwood...75 cents per bulb from Radio Shack. Guess which ones I'm using in the future.

What about the TS-940S's 'S-meter' bulbs...does Radio Shack carry a replacement for them? Yes, but this time the difference is more pronounced. The bulbs in the S-meter are 12V at 75mA;

……..

Moderator's note: We've all noticed how difficult it's become to change the pilot lamps inside of most of today's radios? In the old days - when radios and lamps both were a lot bigger - changing a pilot lamp was a pretty straight-foreword, easily accomplished job . The lamps were always mounted in sockets, and usually just a twist of the wrist popped it right out, ready to receive a new one. Not so today...most are now on small wires, soldered in-place and buried deep within the wiring of it's front panel. It usually requires some internal "surgery", so many hams either don't bother changing them at all when they burn out, or they leave the job for when the set has to be disassembled for some other troubleshooting reason. George has offered some well-thought-out advise in his tips from above; here's some more for you to consider.

What follows won't make the task of bulb changing any easier, but it just might double or triple the time between pilot lamp failures. When a lamp does burn out, many probably think first of going back to the manufacturer for a replacement. There's nothing wrong with that idea, especially if it's a very specialized type of bulb. But as George pointed out, it's probably the most expensive and time consuming route to take, especially when there may be a much more cost effective approach. Since Radio Shack stores stock a number of small low voltage lamps, many of which will either fit directly or can be adapted to fit, a bit of "ham innovation" is sometimes needed, as displayed in George's piece.

Take a look into what Radio Shack calls their 12V micro-lamp, Cat. #272-1092. It may well work as a replacement bulb for LCD displays and other situations where a very small size lamp is in order. Hobby stores also carry what they call "grain-of-wheat" lamps, which are very similar, but be sure to ask about their voltage and current ratings. By the way, using a lamp rated at a higher voltage is fine, as long as it will provide enough brightness once it's installed; in fact, it will last a lot longer than one rated at the nominal voltage. Additionally, if you lower the voltage to a 12V lamp, even by just a couple of volts, you'll increase it's life dramatically. I've seen test curves that prove that the life expectancy of a lamp zooms upward as the voltage across it goes down, and vice versa of course. Putting a resistor in series with each lamp that you replace, will often give you two to three times the life expectency from a given bulb, everything else being equal.

There are three things to consider before doing this: 1) what value resistor will be needed, 2) what its wattage rating should be and 3) how much loss of light is acceptable? Lowering the voltage to the lamp will decrease its brightness - and shift its color toward the red region - so you'll have to visually judge whether you can accept both of these consequences.

You can install the lamp, clip-leading a resistor in series with it, then looking at the meter or display under normal room lighting, to see if it's okay for you own particular situation. To arrive at the right resistor values, simply use Ohm's Law, plugging in the correct numbers for your own transceiver's lamp supply:
Voltage drop desired divided by the lamp's rated current equals the resistance needed.
and
Voltage drop desired times the lamp's rated current equals the resistor's wattage.
By way of an example, let's take the Radio Shack #272-1092 lamp that I mentioned before, which has a current rating of 60 mA or .06 Amp. Let's say we'd like to drop the 12 volts feeding the lamp down to 10 volts, or a 2 volt total drop. We plug in the numbers:
2 (volts) divided by .06 (amp) equals 33 ohms
and
2 (volts) times .06 (amp) equals .12 watt
Now we know that we'll need a 33 ohm, 1/4 to 1/2 watt resistor in series with each lamp in order to drop the 12 volt lamp supply down to 10 volts. A 1/2 watt resistor will provide a 4 times safety margin for heat dissipation (dissipation ratings for resistors generally assume their full lead length, in free air, so it's safest to over-rate them by 2 to 4 times for shorter lead lengths and operation within confined enclosures).
By the way, try to avoid using bulbs intended for flashlight service...they're often high brightness, low life expectancy...since flashlights are usually on intermittently. There are charts available showing life expectancy at rated voltages for various lamp type numbers. The lamp's manufacturer can provide this information and it's also sometimes included in the more complete electronic supply house catalogs. It's surprising how much different lamps do vary in their average life expectations.
Dave, NZ9E

From: TS930S@yahoogroups.com [mailto:TS930S@yahoogroups.com] **On Behalf Of** Garey Barrell
Sent: Tuesday, 16 May 2006 6:30 a.m.
To: TS930S@yahoogroups.com
Subject: Re: [TS930S] TS-940S Sub-Display lamp burnt.
Two "grain of wheat" bulbs, one at either end, with green silicone rubber "socks" over them. Replace both while you're in there! They are ~~10V~~ *[Editor note 9V 60 mA]* bulbs, so the more easily found 12V versions are a little dim. The "correct" bulbs are available from East Coast at:
<http://www.kenwoodparts.com/>
The easiest way is probably to tilt the front panel down, although I think I was able to do it without. Remove top and bottom covers. The front panel tilts easily, you remove the flat-head screws near the top on either side, then _loosen_ the two round head screws near the bottom. The front panel will then tilt down 90 degrees, but you don't need to go nearly that far. There are two screws that go through the board with the clock battery on it that hold the whole "sandwich" together and to the front panel. The bulbs actually mount through the LCD board and the leads solder to two pads on either side of the hole. When reassembling, watch carefully that you don't pinch any wires.
73, Garey - K4OAH
Atlanta

From: TS930S@yahoogroups.com [mailto:TS930S@yahoogroups.com] **On Behalf Of** ve3fh
Sent: Wednesday, 17 May 2006 5:23 a.m.
To: TS930S@yahoogroups.com
Subject: [TS930S] Re: TS-940S Sub-Display lamp burnt.
Thanks Garey, that is a very good explanation. Do you happen to know the Radio Shack part number for these lamps or perhaps an equivalent GE p/n? The Kenwood p/n is B30-0835-08, from East Coast these are $4.19 and from Burghardt $5.18 but I would like to find an alternative source.
73,
Julio VE3FH

From: TS930S@yahoogroups.com [mailto:TS930S@yahoogroups.com] **On Behalf Of** Garey Barrell
Sent: Wednesday, 17 May 2006 7:19 a.m.
To: TS930S@yahoogroups.com
Subject: Re: [TS930S] Re: TS-940S Sub-Display lamp burnt.

Julio -
The ~~10V~~ *[Editor note 9V 60 mA]* lamps are pretty tough to find outside of OEMs. They are expensive, but on the "bright" side, they last 12-15 years! You _can_ use the fairly common 12V bulbs, but you end up with a dark area in the middle of the display.
You could try places like "Bulb Direct" or other on line bulb suppliers, or if you have a model railroad shop locally. The green color is from a silicone "boot" that is removable to transfer to the new bulbs.
73, Garey - K4OAH
Atlanta

CONNECTOR PROBLEMS

The following is the most sensible write up I have ever read about connector problems It is from the site below which contains other information and is well worth reading.

http://www.qsl.net/n5iw/ts940.html

Next I detached and then re-attached each of the connectors mounted to the transceiver printed circuit boards. Systematically I went over each of the boards carefully; unplugging the connector, inspecting and then reconnecting each one. This process went routinely until I got to the main control board. On this board the fourth connector checked pulled completely out of the board (the male portion of the connector completely separated from the board) leaving two very clean holes in the board. I make a note of the faulty connector and continued checking plug connections. The very next plug checked also pulled out of the board. My inspection of the rest of the connectors did not yield any more problems quite so obvious.

I removed the board, inspecting the faulty connection points, and re-soldered the plug bodies back into the board. ….
Before removing the connectors I sketched a simple schematic and labeled it and the plug connectors. This enabled the return of the connectors into the original configuration without doing a lot of schematic wire tracing. I removed all remaining old solder from the original plug bodies and solder connections, then re-inserted the male plug bodies into the pcb board. I re-soldered these parts back into the boards and while the board was accessible to the solder iron; I used a jeweler's loupe and carefully inspected the solder points all over the board. I pay special attention to the plug body pins for the numerous connectors on the board. This process pays off big results! I find at least 8 other connectors on this same board that are obvious cold solder connections (the pins were

obviously "floating" in the old solder, and moved visibly when touched). This discovery was very encouraging; an obvious root cause of some of the intermittent issues this rig has had in the past. I suspect that the loose plugs and many of the cold solder joints were actually caused by the WIGGLE and Plug/Unplug technique so heavily endorsed in earlier internet comments and reports. The first time it probably had good results; over time this technique actually increased the amount of transceiver issues.

I reheated the solder on the connector pads that are bad, discovering that the old solder would not stick to the plug body pins. I used a solder vacuum and solder wick to carefully remove the old solder from each of the old pins that I know and even suspect are bad. This process is repeated for any solder point that is suspect on the rest of the components on the board. As you can imagine; this process takes some time. When I completed the control board, it was re-installed into the rig, and the transistor heat sinks and disconnected plug bodies were re-installed.

After completing the process noted above; I repeated the process for each of the other remaining boards on the rig. There are 5 other main pcb boards on the rig, not counting the little specialized boards located on the back of the main panel. I went through each pcb with the same process; finding and correcting more bad or suspect solder connections. In summary total; I corrected 2 completely disconnected plug bodies, 12-14 visually obvious cold-solder connections and another 30 or so suspected bad connections on various plugs and components.

BATTERIES: [INTERNAL]

There are two

Behind switch Unit L (X412-1600-00)

On Digital A Board: (X54-1830-00)

Typical symptoms for the Switch Unit battery failing are:

From: TS930S@yahoogroups.com [mailto:TS930S@yahoogroups.com] **On Behalf Of** Jim Bazsika
Sent: Tuesday, 21 March 2006 11:44 a.m.
To: TS930S@yahoogroups.com
Subject: [TS930S] 940 clock display stopped working

Good day all,
I recently got hold of a Kenwood 940. . . . I have only been using it a couple of weeks and the other day the green display that shows the clock and split freq's (which was working fine up until then) had some '0's in the display, as well as some '/' symbols when I turned it on. I shut it off and put it back on, and the display has been blank ever since.

Any ideas as to what the problem may be?? Could it be the clock battery? I don't know when, or if, the radio last had it's batteries changed, but I wouldn't think a clock battery would go so fast. I don't know. Any thoughts, ideas or suggestions would be very much appreciated. Thanks!
JIM
ZL4JB

BATTERY REPLACEMENT

From: Jeff King [mailto:jaking@es.co.nz]
Sent: Wednesday, 22 March 2006 5:16 a.m.
To: 'Jim Bazsika'
Subject: RE: [TS930S] 940 clock display stopped working
Jim,

Definitely the battery behind the LCD has lost voltage. Almost exactly same happened to my 940.

What I found was voltage on this battery had dropped to 1.7 V, Should be 3.0 V. found if I left the 940, 24 hours the battery recovered up to 1.8V and the sub display worked, for about 20 minutes, and then became scrambled letters again.

Anyway what to do to fix.
The TS-940 has internal batteries which are similar to a CR2430. 3V lithium at 285 mAh.
Have a look at this page which explains battery replacement in an 850.
http://n6tr.jzap.com/850BAT.html

Genuine Kenwood batteries
W09-0359-05 TS-940S LITHIUM BATTERY
have metal tabs and leg pin wires on them and are soldered to the boards.

You don't need to use genuine batteries.

The table below shows many of the 3 volt dc coin type batteries you can use!!

Model Number	Capacity (mAh)	Dimensions (mm)					Weight (g)
		A	B	C	D	E	
CR 2016 RH	75	20.0	20.2	15.2	3.95	7.95	2.0
CR 2025 RH	148	20.0	20.2	15.2	4.85	8.85	2.8
CR 2032 RH	200	20.0	20.2	15.2	5.45	9.45	3.3
CR 2032 RH1	200	20.0	20.2	17.8	5.45	9.45	3.3
CR 2325 RH	190	23.0	23.2	17.8	4.85	8.85	3.3
CR 2430 RH	285	24.5	24.7	17.8	5.45	9.45	4.4
CR 2430 RH1	285	24.5	24.7	20.4	5.45	9.45	4.4
CR 2450 NRH	540	24.5	24.7	17.8	7.35	11.35	5.9
CR 2450 NRH1	540	24.5	24.7	20.4	7.35	11.35	5.9
CR 2477 NRH	950	24.5	24.7	17.8	10.05	14.08	8.4

You can buy a CR2430 at Dick Smith or Radcliff. If you want battery with legs which is easily soldered then go to Radcliff behind the Railway Station. It will take you a week to get. Maybe longer because they are unhelpful with finding small parts. But they definitely can obtain special batteries.

Any way I brought a CR2430 and soldered wires onto it. Wasn't easy to solder.

Then at Dick smith I brought two push on plugs, with legs that can be soldered directly into a board similar to those used in later model Kenwoods.
http://dse.resultspage.com/search.php?sessionid=44202d9e016908da273fc0a87f9906b7&site=&w=p2731

Cut one leg off the plug and solder it into the hole that was left when you unsoldered the old battery.

To get at the battery remove the top side screws on the front, loosen bottom screws and tip the front face forward.

Then un plug, take out screws and remove Switch Unit L.

Unsolder the battery wires, and soldered in the new plugs.

Reassemble.

Find a small enclose to hold the battery, so if it leaks the enclose contains the leaking fluid.
Attach this container by Velcro to a convenient point inside the radio.

This way next time I replace a battery it will be just a plug in without having to take the 940 apart so much.

Next time I will look at using AAA size 3V lithium in a battery holder. With the potential long life from newer AAA lithium battery may never have to replace them again.

Yours sincerely
Jeff King
ZL4AI / DU7

INFORMATION NOT ANNOUNCED by KENWOOD:

While working on IF Boards the following parts were found to be missing:
Any information as to why Kenwood removed these parts would be appreciated. If box below empty means existence of component not yet searched for.

	First Edition Service Manual	Revised Edition Service Manual	Serial number 6,02x,xxx USA model	Serial number 6030687 USA model	Serial number 7,xxx,xxx USA model	Serial number 9,xxx,xxx USA model	Comment
IF BOARD C129	Exists	Removed	Removed	Removed	Exists	Removed	
IF BOARD R152	Exists	Exists	Removed	Removed	Exists	Removed	Reason removed unknown. Any information would be appreciated.
IF BOARD R118 as 4.7K between Q13 and L17 to C96	Exists	Removed				Removed	
IF BOARD C8	Exists	Exists	Removed	Exists	Removed	Removed	Reason removed unknown. Any information would be appreciated.
IF BOARD C9	Exists	Exists	Removed	Exists	Removed	Removed	Reason removed unknown. Any information would be appreciated.
IF BOARD C10	Exists	Exists	Removed	Exists	Removed	Removed	Reason removed unknown. Any information would be appreciated.
IF BOARD R220	Replaced with wire 105	Replaced with wire 105				Replaced with wire 105	Reason removed unknown. Any information would be appreciated.

KENWOOD RELEASED INFORMATION:

KENWOOD AMATEUR SERVICE BULLETINS
Available at: http://www.kenwood.net/indexKenwood.cfm?do=SupportFileCategory&FileCatID=1

ASB0896.jpg TS-940S LCD Clock Display Erratic Operation 81.38 KB
ASB0900.JPG TS-940S PLL Unlock 54.42 KB
ASB0907A.JPG TS-940S Antenna Tuner Relay Damage/Modification 69.35 KB
ASB0907B.JPG TS-940S Antenna Tuner Relay Damage/Modification 29.92 KB
ASB0908.JPG TS-940S PLL Unlock Due To Low Levels 91.39 KB
ASB0909.JPG TS-940S AVR Unit Capacitor Change/Failure 104.22 KB
ASB0910A.JPG TS-940S AGC Circuit Improvements 61.02 KB
ASB0910B.JPG TS-940S AGC Circuit Improvements 60.39 KB
ASB0912A.JPG TS-940S Transmitter Hum In SSB 71.53 KB
ASB0912B.JPG TS-940S Transmitter Hum In SSB 41.30 KB
ASB0913.JPG TS-940S Signal To Noise Ratio Improvement With NB 60.94 KB
ASB0917A.JPG TS-940S VCO/Carrier To Noise Ratio Improvements 89.43 KB
ASB0917B.JPG TS-940S VCO/Carrier To Noise Ratio Improvements 59.09 KB
ASB0917C.JPG TS-940S VCO/Carrier To Noise Ratio Improvements 36.90 KB
ASB0918A.JPG TS-940S Squelch Switching Noise S/N 711XXXX 85.04 KB
ASB0918.JPG TS-940S Squelch Switching Noise S/N 711XXXX 53.83 KB
ASB0918B.JPG TS-940S Squelch Switching Noise S/N 711XXXX 65.29 KB
ASB0921A.JPG TS-940S SSB Talk Power Improvements S/N 601XXX - 708XXX 84.05 KB
ASB0921B.JPG TS-940S SSB Talk Power Improvements S/N 601XXX - 708XXX 51.11 KB
ASB0951A.JPG TS-940S Erratic Display (Remove The ROM Socket) 84.33 KB
ASB0951B.JPG TS-940S Erratic Display (Remove The ROM Socket) 49.49 KB
ASB0988A.JPG TS-940S MFR-485 Driver Transistor Changes (Blue Dot) 79.27 KB
ASB0988B.JPG TS-940S MFR-485 Driver Transistor Changes (Blue Dot) 29.54 KB

ZL4AI found that some of the diagrams Kenwood put on the web cannot be read. Legible versions can be obtained by emailing Kenwood. It helps to point out there is considerable Health and Safety issue / liability fro Kenwood if an Amateur using information makes a mistake because the information Kenwood provided could not be correctly interpreted.

S METER ALIGNMENT LEVELS

Copied from “W6NL Mods for the TS-930.PDF”

Clif Holland of Avvid, a respected repairer of Kenwood radios, emailed me to note that
the Japanese specification for the standard signal generator used in alignment is different from the US signal generator calibration.
The 930 service manual refers to signal levels in dBuV, so I had assumed 0dBuV was 1 uV and 40dBuV was 100uV.

But not so. Clif is right and I'm off by 6 dB. I checked it out, and although I see no mention of the issue in the TS-930 or TS-950 manuals, I found a table in the TS-850 service manual, pg. 96, that confirms this. It has two columns:

Japanese "SG"	*American "SG"*
-6dB	*0.25 uV*
+0dB	*0.5 uV*
+6dB	*1 uV*
+12dB	*2 uV*
+24dB	*8 uV*
+30dB	*15.8 uV*
+40dB	*50 uV*
+50dB	*158 uV*
+60dB	*500 uV*
+80dB	*5 mV*

Apparently the JA generator defines output in terms of open circuit voltage rather than voltage into a matched load. This 6 dB difference affects the alignment of the RF PIN attenuator start point as well as the S-meter settings for S1 and S9. Since the manual specs are ±4 dB anyway the difference will be mighty small except for a more active S-meter.

S meters revised from here on at version 25

ZL4AI adds:
from page 78 / 79 of the TS-930 service manual, confirms the above:
Japanese SG ***0dB = American 0.5 uV***

from page 51 of TS-940 Operating Manual
If a standard signal generator (SSG) is available, adjust VR-4 so the S meter indicates"S-9", at 14.175MHz for a 40 dB (50uV) signal

from page 69 of the TS-930 service manual
SSG output: at 14.175MHz 100dB /u: = S meter reading S9+60dB +- 6dB

100 dB/u S-meter maximum calibration information seems to be unclearly laid out in the TS 940 service manual, but is inferred in the accompanying notes in the TS 940 service manual. It looks like Kenwood's made a typo and missed it out.

from page 101 of the TS-850 service manual, (are different values to those used on the TS-930 and TS-940
Standard Signal Generator 14.100 MHz, AGC OFF
S0: Output set VR12 to 0.1 V +- 0.01V
AGC ON
S1: Output + 6dBµ   Tolerance within +- 3 dB
S9: Output + 32dBµ   Tolerance within + 4 dB, -8 dB

TS-950SDX values not included because S9 meter readings not stated.

The TS-940 Service Manual below on pages 72-73 is not very easy to understand:

							output.	
6. S meter	BAND : 14.175MHz SSG : 0dB	SSG AF V.M SP SCOPE			IF	VR3	ADJ meter needle for mechanical φ point.	
					RF	VR1	Set the VR1 to CCW.	

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TS-940S

ADJUSTMENT

Item	Condition	Measurement			Adjustment			Specification/Remarks
		Test equipment	Unit	Terminal	Unit	Part	Method	
6. S meter	SSG : 8dB AGC : FAST				IF	VR1	ADJ to S1	S1 : 8dB +6dB −4dB
	SSG : 40dB					VR4	ADJ to S9	S9 : 40dB±6dB
							Repeat ADJ S1 and S9.	S9 + 60dB : 100dB±10dB

ZL4AI prepared extended service instructions below:

Item	Condition	Measurement			Adjustment			Specification / Remarks	American Signal Generator RMS volts	dBm referenced to 1 milli Watt
		Test equipment	Unit	Terminal	Unit	Part	Method			
6.1 S meter	BAND: 14.175MHz SSG output : 14.175 MHz 0dB	SSG AF V.M SP SCOPE			IF	VR3	Adjust meter needle for mechanical f		0.5 µV	-113 dBm
					~~RF~~ IF	VR1	Set the VR1 to CCW			
6.2 S meter	SSG output: 8dB AGC: FAST				IF	VR1	ADJ to S1	S1: 8dB + 6dB - 4dB	1.26 µV *> IARU usual 0.19 µV for S1*	-105 dBm *16 dBm > IARU usual -121 dBm for S1, = 2.7 S units*

6.3	SSG output: 40dB				IF	VR4	ADJ to S9	S9: 40dB + 6dB - 6dB	50 µV	-73 dBm
6.4	SSG output: 100dB						Verify full scale	S9+60dB: 100dB + 10dB - 10dB	50,000 µV 50 mV	-13 dBm
6.5							Repeat ADJ S1 and S9			

Red are items Kenwood missed out

S meter Information

IARU Region 1 Technical Recommendation R.1 BRIGHTON 1981, TORREMOLINOS 1990
Page 1 of 1

STANDARDISATION OF S-METER READINGS

1. One S-unit corresponds to a signal level difference of 6 dB,

2. On the bands below 30 MHz a meter deviation of S-9 corresponds to an available power of -73 dBm from a continuous wave signal generator connected to the receiver input terminals,

3. On the bands above 144 MHz this available power shall be -93 dBm,

4. The metering system shall be based on quasi-peak detection with an attack time of 10 msec ± 2 msec and a decay time constant of at least 500 msec.

Rob Sherwood NC0B, http://www.sherweng.com/
who seems to lead thinking about receiver design performance measurement quotes:

Assume S9 = 50 µV which is –73 dBm

The -73 dBm power level calculates out that 50 µV is an RMS value. {Not peak to peak}
This enables preparing:

S-METER TABLE

S Meter reading	Power (dBm) *	Voltage at receiver input	

		(RMS micro volts, µV, and millivolts mV)	
S9 + 60 dB	-13	50.06 mV	
S9 + 50 dB	-23	15.83 mV	
S9 + 40 dB	-33	5.01 mV	
S9 + 30 dB	-43	1.58 mV	
S9 + 20 dB	- 53	500 µV	
S9 + 6 dB	- 67	100 µV	
S9	- 73	50 µV	
S8	- 79	25 µV	
S7	- 85	12.5 µV	
S6	- 91	6.2 µV	
S5	- 97	3.1 µV	
S4	-103	1.6 µV	
S3	-109	0.77 µV	
S2	-115	0.39 µV	
S1	-121	0.19 µV	*Kenwood 940 uses 1.26 uV, = -105 dBm*

(* dBm is power expressed as decibels relative to one milli watt)

To Calculate between µV and –dBm see ARRL Handbook 2004, page 30.14 which explains all the calculations, and formulas.

==

dBm values quite interesting to compare with other expert observations, that is S Meters are not linear:

To: <amps@contesting.com>
Subject: [AMPS] s meter calibration
From: w7iuv@nis4u.com (Larry Molitor)
Date: Tue, 13 Jun 2000 22:57:40 +0100

At 07:45 AM 6/13/00 +0100, Ian White, G3SEK wrote:
>According to the lab reviews in the magazines, most modern receivers seem to be calibrated so that **the difference between S9 and S9+20 is pretty close to 20dB**. **Below S9, the scale looks linear** but the dB per S- point is not1 It typically takes many more dB to get from S2 to S3 than it does to get from S8 to S0 - often less than 3dB per S-point at the top end.
>It doesn't have to be that way - there are engineering solutions that could easily deliver the full IARU specification - but when everybody on HF is "five nine" anyway, who cares any more?
>
>73 from Ian G3SEK

Ian and all,
As has been said before, the manufacturers correctly assume that the majority of buyers are technical idiots. Have a S-meter that has 1 dB per S-unit and about 5 uV for S 9 is a good marketing thing. Besides it's a lot cheaper to build. I would hope that anyone who actually cares about such things would take the time to "calibrate" the meter on their store-bought radio. Since I do this with all my radios, I would not care to pay extra for a manufacture to make a feeble attempt at a real meter.

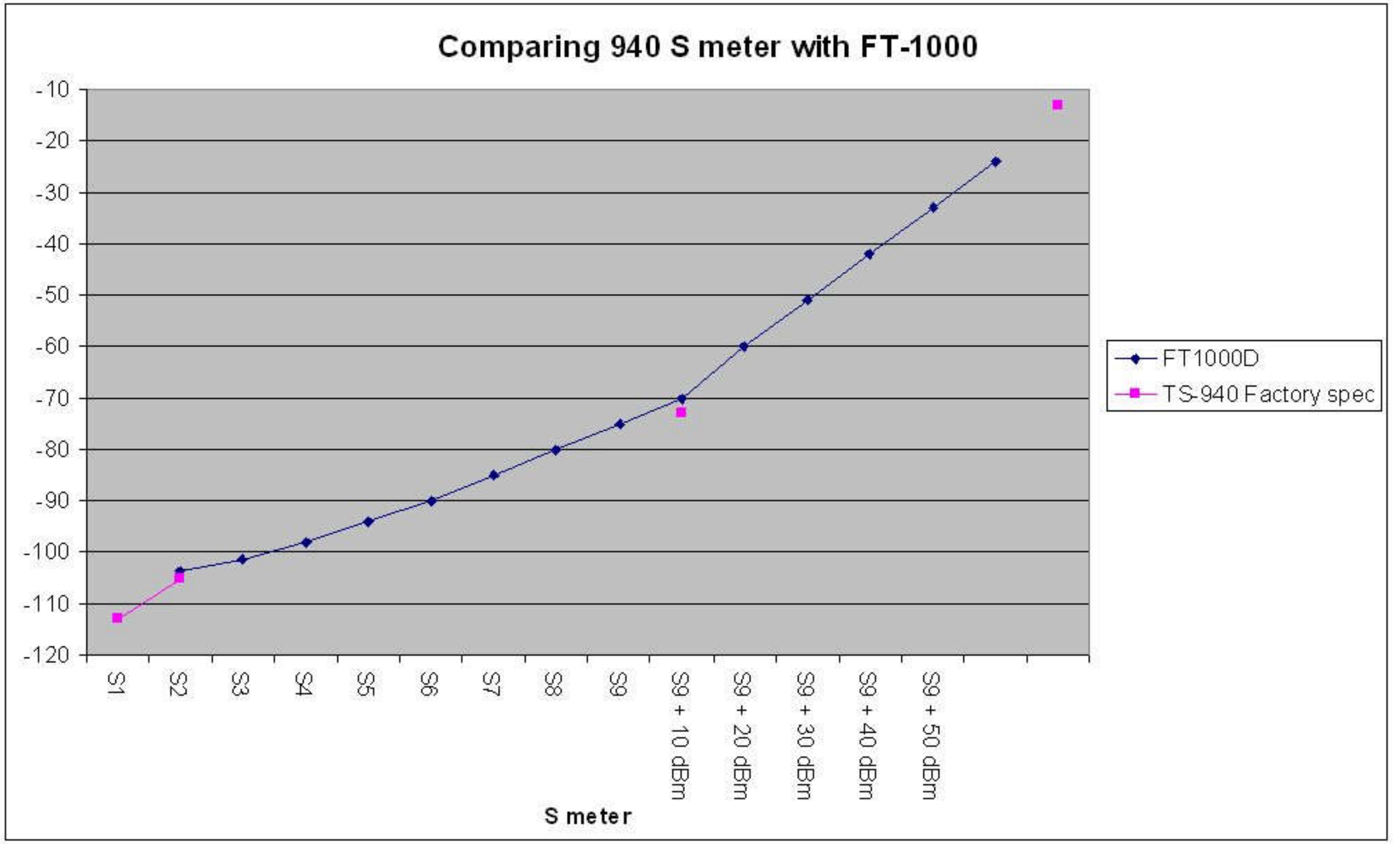
Using a HP8648C generator (at 14.1 MHz) this last time, I produced the following chart for my **FT1000D**:

S1 = -103.5 dBm
S2 = -101.5 dBm
S3 = -98 dBm
S4 = -94 dBm
S5 = -90 dBm
S6 = -85 dBm
S7 = -80 dBm
S8 = -75 dBm
S9 = -70 dBm
+10 = -60 dBm
+20 = -51 dBm
+30 = -42 dBm
+40 = -33 dBm
+50 = -24 dBm

As you can see, it's kinda poor at the bottom end, but quickly stabilizes at about 5 dB per S-unit. With S-9 being within 3 dB of 50 microvolts and 5 dB per S-unit, this particular FT1000D has the best S-meter out of the 10 or so radios I've checked.

With a chart like this handy, it gives you a real good idea just how good the other guys antenna is or how much gain his amp really has. While the guy on the other end is usually an idiot and won't believe what you tell him, at least you will know for sure.

Since it's so easy to do this, I'm surprised there aren't more folks with handy little charts for their radios. I know, not everyone has a room full of good test equipment. But I bet most people on this list know someone who does or has access to it one way or another. Give it a whirl, you might be amazed!
73,
Larry - W7IUV



Kenwood failed to observe the same standard

TS-870
From Item 10, page 95 of TS-870 Service Manual, year 1995
Standard Signal Generator 14.101 MHz,

S0: Output -110 dBm
S1: Output -107 dBm
S9: Output -81 dBm
S9 + 60dB Full Scale (lights up all) Output -23 dBm

TS-2000 or TS-480, changed to:
From Item 21 TS-2000 Service Manual, year 2000
From Item 10, page 64 of TS-480 SAT / HX Service Manual, year 2003
Standard Signal Generator 14.201 MHz,

S1 Output -107 dBm (1µv)
S9 Output -81 dBm (19.9µv)
S9 + 60dB Full Scale (lights up all) Output -21 dBm (19.9mv)

PARTS

(800) 637-0388 www.kenwoodparts.com
East Coast Transistor has an online data base with part numbers: Very helpful in identifying the correct part. They also supply some parts not listed on the database.

From: wa1hmw@comcast.net [mailto:wa1hmw@comcast.net]
Sent: Wednesday, 20 September 2006 6:10 p.m.
Cc: Jeff King
Thomas & Jeff : I found a Website where they sell the digital board for my TS 940 S also their prices for IC's much lower than anywhere else. For instance East Coast Parts Kenwood Approved dealer) sells an IC for $7.50 at part store its $2.50 Site is
http://www.partstore.com
Regards Bill Cridland WA1HMW

Editors Note: For a 930 Digital A Board CPU parts store.com charges $65 compared with East Coast charging $95.
Looks like a 30% saving

LINKS TO USEFUL SITES

Kenwood_Japan
Kenwood Corporation
Kenwood Electronics Australia Pty Ltd
Kenwood Electronics Europe UK

K0BX Kenwood Interface HomePage
850 Repair Page

K0BX Kenwood Interface HomePage
Piexx Company - Home
International Radio Service Division
http://home.fuse.net/jg/Chips/TS940Chip.html
QSL.Net Index
Yahoo! Groups : TS-940
Yahoo! Groups : Kenwood TS-950SDX
AAvid
The Defpom Kenwood Radio Modifications Page
KENWOOD MODIFICATIONS - LINKS - XE1BEF PAGE
K0CKD's Topband/Kenwood Resources & More!
The Kenwood Archives
http://www.eham.net/reviews/detail/239
http://efjdevices.net/Problems.html
Martin Sole www.qsl.net/hs0zed This is actually the First TS-940 page, and holds quality information.
K4NR repairs http://www.qsl.net/ki4nr/index.htm
Geihl Chip http://home.fuse.net/jg/index.html

HELP WANTED

More information on the Pin Diode Improvements would be appreciated

PERFORMANCE COMPARISONS

A lot of reviews found at
http://www.eham.net/reviews/detail/239

Product Review

Conducted By Bruce O. Williams, WA6IVC
Assistant Technical Editor

Trio-Kenwood Communications TS-940S HF Transceiver

What a radio! This feature-packed box is Kenwood's newest state-of-the-art transceiver and their showpiece. Here, in one package, you will find a high-performance, general-coverage receiver; a 250-W input, solid-state, broadband transmitter; a sturdy power supply; lots of "bells and whistles" and even an optional all-band, automatic antenna-matching network.

There is more to say about the TS-940S than available space will allow. For that reason, this review will highlight some of the unique features of this radio and compare it to the TS-930S (see January 1984 *QST*).

Frequency Control

Like the '930, the '940 employs a push-button band switch. There is a button for each ham band from 160 to 10 meters, including the WARC bands. A pair of buttons, located immediately below these, allow UP/DOWN tuning in 1-MHz frequency steps. The 10 band switches in the '940 serve a second purpose. They can also be used to enter a frequency directly into the selected VFO. This is a handy feature indeed.

The A/B push button is used to select between the two VFOs that control the frequency synthesizer. The SPLIT push button allows split operation. The T-F SET button allows selection of transmit frequency during split operation. The A=B switch brings the unused VFO to the frequency in use. Rotating the weighted VFO knob at normal tuning speeds shifts the frequency in 10-Hz steps, or 10 kHz per VFO knob revolution. Turning the knob faster (over 5.5 to 6 rev/s), increases the frequency step rate proportionally.

If you like memories, you'll love the '940. Here you will find four switch-selected banks of 10 memories each. That's right—40 of your favorite frequencies ready for rapid recall. (A big increase over the 8 memories—16 if you make a modification—of the '930.) The bank switch is located inside a door in the top cover, so you'll want to organize memory contents into the four banks in a logical manner, like favorite nets in one bank, short-wave and standard BC stations in another, and so forth.

Each memory location contains both a frequency and a mode. This is possible because the mode is selected electronically by means of push buttons located to the left of the VFO knob. An annunciator indicates the mode

Trio-Kenwood TS-940S Transceiver, Serial No. 51110330

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Transmitter frequency range: 160 m, 1.8-2.0 MHz; 80 m, 3.5-4.0 MHz; 40 m, 7.0-7.3 MHz; 30 m, 10.1-10.15 MHz; 17 m, 18.068-18.168 MHz; 15 m, 21.0-21.45 MHz; 12 m, 24.89-24.99 MHz; 10 m, 28.0-29.7 MHz.	As specified.
Receiver frequency range: 150 kHz-30.0 MHz.	As specified.
Modes of operation: A3J (USB, LSB) A1 (CW), F1 (FSK), A3 (AM), F3 (FM).	As specified.
Frequency display: Large fluorescent-tube digital main display and LCD dot-matrix 16-digit sub-display.	As specified.
Frequency resolution: 10 Hz	As specified.
Frequency stability: 10 PPM	Not measured.
Transmitter:	*Transmitter Dynamic Testing*
Power input: 250-W PEP (160-10 m bands, SSB, CW, FSK, FM); 140-W (AM).	Power output (CW): 160 m, 118 W; 80 m, 120 W; 40 m, 120 W; 30 m, 116 W; 20 m, 120 W; 17 m, 118 W; 15 m, 117 W; 12 m, 115 W; 10 m, 118 W.
Spurious signal and harmonic suppression: −40 dB or less (in CW).	−54 dB. See Fig 1.
Third-order intermodulation distortion: −37 dB or less (single-tone input).	−37 dB. See Fig 2.
CW keying waveform: Not specified.	See Fig 3.
Receiver:	*Receiver Dynamic Testing*
Receiver sensitivity: 10-dB S/N −14 dBμ (0.2 μV) or less in SSB, CW and FSK; 10-dB S/N 6 dBμ (2 μV) AM; 12 dB signal + noise + distortion/signal + noise, −6 dBμ (0.5 μV) or less in FM.	Minimum discernible signal (noise floor) (dBm): *80 m* −140; *20 m* −139
Receiver dynamic range: Not specified.	Blocking dynamic range (dB): *80 m* 141; *20 m* 138
	Two-tone third order intermodulation

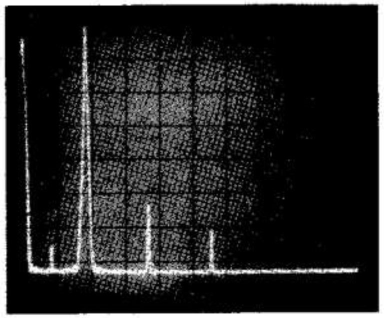


Fig 1—Worst-case spectral display of the TS-940S operating on the 160-m band. Vertical divisions are each 10 dB; horizontal divisions are each 1 MHz. Output power is approximately 100 W at a frequency of 1.85 MHz. All spurious emissions are at least 54 dB below peak fundamental output. The TS-940S complies with current FCC specifications for spectral purity.

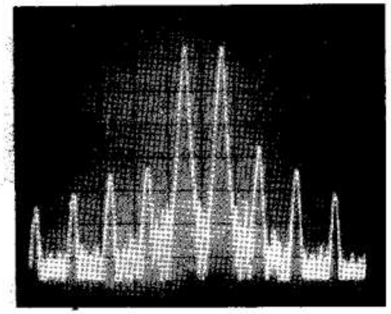


Fig 2—Spectral display of the TS-940S output during transmitter two-tone intermodulation distortion (IMD) test. Third-order products are 37 dB below PEP, and fifth-order products are 43 dB down. Vertical divisions are each 10 dB; horizontal divisions are each 1 kHz. The TS-940S was being operated at rated input power on the 20-m band.

CLEAR switch returns the offset to zero.

A unique green multipurpose subdisplay located to the right of the main display shows a clock, a graphical representation of the receiver bandpass characteristics, or frequencies contained in the VFOs or the selected memory bank. The clock function in the '940 includes a timer that can be used to turn the transceiver on and off at predetermined times.

Kenwood has even thought of the vision-impaired ham. An optional voice-synthesizer unit can be mounted inside the cabinet. The synthesizer announces the main display frequency ... mixer. The receiver lives up to Kenwood's fine reputation for producing high-dynamic-range receivers.

As with the '930, two noise blankers are included. The first, with a threshold control, is effective against pulse-type noise. The second is for pulses of a longer duration, such as those annoying woodpecker (over-the-horizon radar) pulses. Both blankers work effectively, but blankers can degrade receiver performance under high-level signal conditions. Judicious use of the NB LEVEL and RF ATTenuator controls will get rid of the noise while keeping overload problems to a minimum.

Several optional filters are available for the '940. There is a 6-kHz (AM) second IF filter, and 500-Hz, CW filters for the second and third IFs, and a 250-Hz filter for the third IF. The CW VBT control is a continuously variable bandwidth tuning control that may be used to tighten up CW selectivity. Used with the wide (SSB) filters, the VBT varies the bandwidth from 2.7 kHz down to 600 Hz. With either or both 500-Hz CW filters installed, the VBT range is 500 to 150 Hz. VBT is especially handy for those times when the narrow filter is too much and the wide filter is not enough. In fact, the casual CW operator may never need the selectivity afforded by the optional CW filters.

In addition to IF filtering, the '940 incorporates an effective audio filter. The AF TUNE circuit controls a peak-type audio filter with an 800-Hz center frequency, adjustable ± 400 Hz. This filter is useful for reducing unwanted signals and noise.

Perhaps the most important feature for the CW operator is the PITCH control. The normal CW offset is 800 Hz. For those operators who prefer to listen to a different note, the PITCH control simultaneously shifts the IF passband, the received beat frequency *and* the sidetone pitch.

For the SSB operator, the SSB SLOPE TUNE controls (HIGH CUT and LOW CUT) allow independent adjustment of the high and/or low frequency slopes of the IF passband. These controls help cut interference from stations higher or lower in frequency. In addition, the NOTCH filter (also useful on CW) helps cut carriers or SSB QRM.

Transmitter

Kenwood chose a pair of rugged Motorola MRF-422 transistors, each capable of dissipating 290 W, for the final amplifiers. The finals operate at 28-V dc, and the net result is a clean, cool-running transmitter. Output power is at least 100 W on all bands. The transmitter is broadbanded, and no tuning is required. Internal protection circuitry reduces transmitter output if the load SWR is greater than about 2:1. Two quiet cooling fans, one for the final amplifier heat sink and one for the power supply,

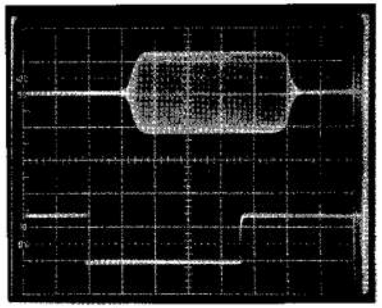


Fig 3—CW keying waveform of the TS-940S. The lower trace is the actual key closure; the upper trace is the RF envelope. Each horizontal division is 5 ms.

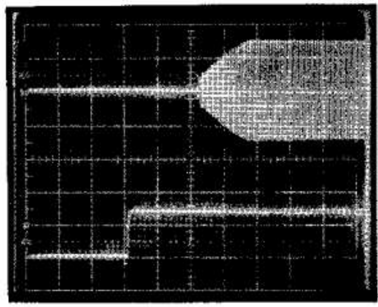


Fig 4—Receiver recovery (turnaround) time. The lower trace shows the key opening; the upper trace shows receiver audio output. Horizontal divisions are each 10 ms. There is an approximate 20-ms delay before receiver recovery.

Full-break-in CW, that is real QSK, is another feature of the '940. Proper sequencing is assured by CMOS logic circuitry, and reed relays provide nearly silent operation. Receiver AGC action is smooth with no annoying pops or thumps.

The built-in speech processor gives punch to the transmitted voice signal. I particularly appreciate the facilities for properly adjusting the processor. Use headphones and operate the MONI switch so that you can hear the audio signal as it will be transmitted. With the METER switch in the COMP position, adjust the PROCESSOR IN control for about midscale deflection as you speak into the microphone. Next, place the switch in the ALC position and adjust the PROCESSOR OUT control for mid-scale deflection as before.

Operation

The manual covers what you need to know in plain, easy-to-understand language, and it is profusely illustrated. It is very well done, and especially useful for the beginner. The only shortcoming I found is a lack of connection details for the ACC1 jack.

In normal operation, I found the XIT to be particularly useful and easier to use than operating split with two VFOs. Variable-speed tuning makes rapid QSYs within a band faster. These and many other features make this a significant improvement over the '930. As in the '930, synthesizer switching transients can be heard when tuning the band at a moderate-to-fast rate. These "pops" are particularly annoying when tuning across a nearly dead band.

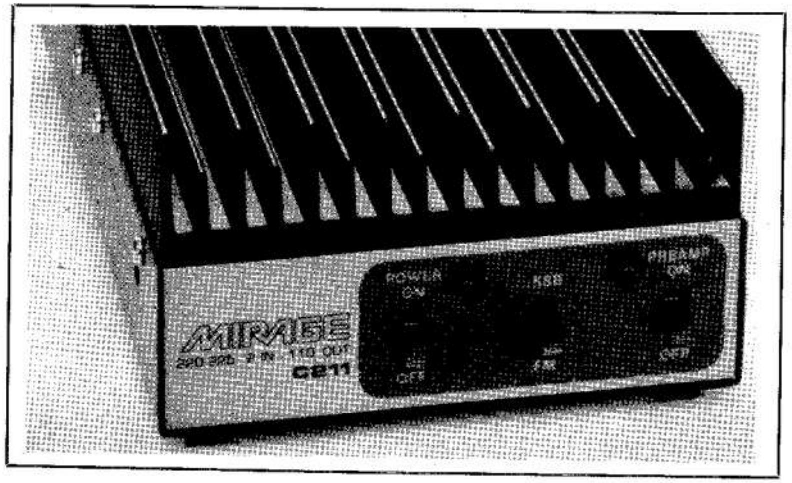
In my opinion, Kenwood has come up with another winner in the '940. If you are thinking about buying a state-of-the-art transceiver, you should check this one out. Manufacturer: Trio-Kenwood Communications, 1111 West Walnut St, Compton, CA 90220. Price class: TS-940S with AT-940 antenna tuner, $2000; YK-88A-1 6-kHz AM filter, $60; YK-88C-1 500-Hz filter for 8.8-kHz IF, $70; YG-455-1 500-Hz CW filter for 455-kHz IF, $100; YG-455CN-1 250-Hz CW filter for 455-kHz IF, $120; VS-1 voice-synthesizer unit, $40. —Chuck Hutchinson, K8CH

MIRAGE COMMUNICATIONS C211 220-MHz AMPLIFIER

With all the concern these days about the Amateur Radio Service keeping the allocation at 220 MHz, it's only right that we get on the band and use it. From an operator's viewpoint, it's a great band—the DX-communications possibilities are approximately the same as on 2 meters, and in many areas, the repeater segment is much less crowded. Several persistent amateurs have earned WAS and VUCC on the band. Commercial equipment for 220 MHz is not nearly as plentiful as for other bands because the market is much smaller; only North American amateurs are blessed with an allocation here. The lack of commercial equipment, especially for SSB and CW, is part of our 220-MHz population problem.

Enter Mirage Communications, a major manufacturer of VHF and UHF accessory equipment. Mirage markets several power amplifiers that are of interest to amateurs active on 220 MHz; the newest is the C211. This amplifier features 110-W output for just over 1-W drive and a preamp for the receiver. TR switching with a variable delay for SSB is standard. Like most other Mirage power amplifiers, the C211 may be used with the optional remote-control head (model RC-1), which duplicates the front-panel controls.

Circuit Highlights



Mirage Communications C211 220-MHz Amplifier, Serial No. 018-384

Manufacturer's Claimed Specifications	*Measured in ARRL Lab*
Frequency coverage: 220 to 225 MHz.	As specified.
Modes of operation: FM, SSB and CW.	As specified.
Power output: 110 W or more for 2-W input. Input power 0.2 to 4 W.	94 W for 0.8-W drive; 110 W for 1.2-W drive.
Spurious signal and harmonic suppression: Not specified.	See Fig 5.
Receive preamplifier: 10-dB gain with 2.5-dB (± 0.5 dB) noise figure.	9-dB gain. NF not measured.
Power requirements: 13.6-V dc at 18-20 A, nominal.	13.6-V dc at 19.5 A at 110-W output.
Size (height, width, depth): 3 × 5.5 × 12 in.	
Weight: 5 lb.	

output, a phono jack for TR control, a six-pin Molex connector for the RC-1 and two heavy wires for dc power. A 35-A fuse is provided in the dc power line. The cover must be removed to replace this fuse.

The C211 is always biased for linear operation, even when the front-panel switch is set for FM. The only difference between the SSB and FM mode settings is the TR relay drop-out time delay. The relay drops out instantly in FM, but drop-out time may be set for anywhere between a few milliseconds and about 1.5 seconds for VOX SSB operation. This delay adjustment is made through a hole in the left side of the cover, behind the front panel.

Two stages of power amplification are used to get from the 2-W level up to the 110-W output. The first stage uses an MRF240A, while the second stage uses a pair of SRF2838 transistors. The preamp uses a U309 FET. All components are mounted on a PC board that is bolted to the hefty heat sink that forms the top of the amplifier. A built-in thermostat

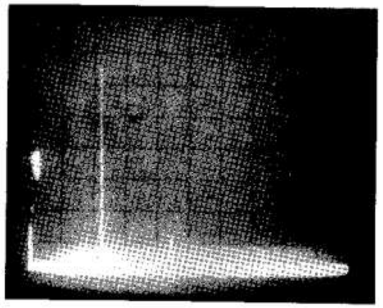


Fig 5—Worst-case spectral display of the Mirage C211 amplifier. Vertical divisions are each 10 dB; horizontal divisions are each 100 MHz. Output power is approximately 110 W at 220 MHz. The fundamental (pip at the left of the photo) has been reduced in amplitude approximately 14 dB by means of a notch filter to prevent spectrum-analyzer overload. All harmonics and spurious emissions are at least 68 dB below peak fundamental output. The

TopBand: Comparison of TS940 to newer receivers
MEL CRICHTON_MELVIN_J@LILLY.COM
Tue, 15 Apr 1997 12:35:24 +0000 (GMT)
April 14, 1997
A number of weeks ago I asked the TOPBAND reflector about their experiences with newer receivers, and promised to summarize your comments and my tests for the group.
I'm slow in getting this out because I lost some mail messages (including my own) but here's what I pieced together:
****Comparison of Kenwood TS-940 to other Receivers****
(This test is aimed at CW reception)
MY ORIGINAL QUESTION (my own comparisons are at the end of the message):
As a died in the wool TS940 user, I've been believing that the 940's receiver was as good as I could find for 160 and 80 meter DX CW, short of some of the older rigs (like the Drake and Collins stuff). Even though copy is rough here in the "black hole" of DX, I have been able to work a number of countries on these bands with just 100 watts. Line noise at my place is MAJOR!
Then I visited N9QCT to see his new TS-570 on a trap vertical. What I hear on the 570 amazes me. It's early evening, when all I hear at home on 160 M is static. And his 570 is dragging in European signals above the background noise. When he kicks in noise reduction (NOT the noise blanker) the CW sounds like it's a code practice tape! On 160! Not only that, but at the 50 hz filter bandwidth (actually about 80-90hz) there was practically no ringing. I plan to borrow his rig and try it at my place with better RX antennas and the heavy line noise, just to get an apples/apples comparison.
So the question to recent buyers of new rigs is: Compared to your experience with older "top-end" receivers (like the 940 WAS ten years ago) how do the new receivers stack up? I know that audio DSP will overload without a mechanical filter as well, and I saw it on Eric's 570 (he has a 500 Hz filter on order). But what about fully loaded TS570, TS870, FT1000MP, Omni VI, etc?
What differences do YOU notice?

AND THE SNIPPED REPLIES:
(R4C about same as TS940, per AA1K)
I'm a 940 user too, in a high noise urban area (1000 feet from Amtrak line and major power transmission line, etc.) but have an array of Beverages that help overcome the noise. I've not had anything newer here to compare with, do have an R4C with Sherwood mods and find it about neck-and-neck with the 940.
Also use a DSp 59+.
73/Jon AA1K
==
(Fixing the 940, from KM1H)
T'aint nothing wrong with the TS-940 that a little work won't cure Mel. Depending upon the serial number (8 Million a rough cut-off) there are many to some mods that really help. Private E-Mail me for specifics. (KJ9C NOTE: MY 940 IS ONE OF THE NEWER ONES, SO THAT AIN'T THE PROBLEM)
Also by changing about 45 diodes over to PIN's there is a dramatic performance improvement in RX performance. I also use cascaded IRCI filters for both CW and SSB...the Kenwoods have poor skirt rejection.
I have 4 940's here that are used fm HF thru microwaves as platforms for transverters. I quickly sold a FT1000D as not worth the money that 2 well modified 940's could perform at.

I had a TS870 here on loan...it has a great RX but very prone to overload on 40 thru 160.
GL and 73 Carl KM1H 261 DXCC on 160; 309 on 80

(Comments from George Guerin..K8GG)

1. My experience with the TS-940 is it does not hear as well as the TS-930 or TS-950SDX. Also there is generally a spike on the leading edge of the first CW character sent which risks grid damage to tubes like the 8877, 8874, 3CX800A7, etc.

2. Your description of the TS-570 sounds very good. Maybe they will make a TS-970 soon??

3. I hear there are problems with the TS-870, because there are no filters at all, except digital in the last IF. This creates birdies in the pass band, since it is at something like 14 or 17 Khz, and a signal 28 or 34 Khz away can leak through. I hear one W6 added filters and cleaned the birdies, but Kenwood will not do this on production units, so we will have to wait for a TS-871 or 880?

4. I have used the FT1000MP and it does a pretty good job, but I haven't put it side by side with other radios. Setting the two DSP controls on the concentric rotary switches is a bit tricky. The dual receive and or split is very good and easy. A friend in Chicago says it hears better on CW than the FT1000D and the TS950SDX. On phone I like the TS950SDX best, but that is not true 160 operation.

5. I would like to try the IC-775. More money, but the automatic carrier null is very fine. On CW, I would like to try one on 160 for a while myself, and see about the noise removal system.

6. I understand TenTec has a Omni 6+ just out with dsp. I have no way of trying it and the TenTec "chemistry" and my body chemistry do not get along, so I will never buy one. I do have friends on 160 with Omni 5 and Omni 6 radios doing well. They do have good beverages. One has a directional vertical array!! I do have a TenTec tuner I like a lot. There is no chemistry problem without electronics inside the box! HI !

George Guerin

[NE3H compares the 940 to the Omni VI (not the VI+)]

On the OMNI .. no question, best receiver that I've ever heard. Yes, I think the FULL DSP receivers may be more sensitive ... or have lower noise floor .. but none of the HAM gear that I am aware of ..
I cannot hear the diff between my old 940 and the OMNI .. if normal ambient noise, most people cannot hear the diff. The outstanding characteristic.. and the second reason I got TWO OMNIs .. is that you can have an S9 + 20 signal next door to one in the mud .. and it does not make a difference. I have a neighbor .. a mile away .. who runs a kW on RTTY .. (as do I) and we can op within a Khz or two without disturbing each other.
Fact is, if you have lots of line noise .. I don't think you'll notice the diff in rcvr sensitivity. The noise blanker on the OMNI is about as effective as any .. but I don't think it is better than the 940 re noise blanking. But Yes .. the front end does not 'Block' in the presence of a loud signal next door ...
The second reason that I went for the OMNI is that it's signal on CW / QSK (at high speed) is distinctly better that anything else .. save the Icom 781 that I've heard anywhere else.
The fact that you can cascade filters on the NEW OMNI PLUS really makes me twitch .. I've already signed up to do the full upgrade to my radios. I have a 500hz RTTY filter in the 9mhz path .. after the mod .. I'll be able to have a choice of the RTTY filter or the CW filter .. I think that is a real advantage ..
Of course, stacking of filters is pretty nice on the FT1000 stuff too ..
The OMNI operation is pretty intuitive too .. it has less bells and whistles .. but I can't think of any I miss (from the old 940s).
Remember that 98% of my operation is CW and RTTY.
de joe

(comments from K3SME)

Were you able to borrow the rig and try it at your QTH? I have found that 160M performance is very QTH specific. I have borrowed "goodies" like DSPs which knocked noise down ALOT at my buddy's QTH but didn't do much for my noise here as an example. One of the locals here in Maryland picked up a 570 about 2 months ago and after a week said it was pretty good but he HAD to get the optional filter to make it decent on low band CW for receive. Have you had other comments? The few guys I know with OMNI V and VI praise them highly for low phase noise and tremendous RX capabilities. I am using a TS830S. It replaced a Drake 4 line. Tough to keep up with technology and I refuse to pay for a 100 memory tranceiver when I don't need all those bells and whistles.
73, Sid.

(K8GG asks about the 570, comments on TS950)
Have you read the review by Doug DeMaw, W1FB in the March 1997 issue of CQ Magazine? It reads well but raises the questions I have written here below:
1. I wonder if the only way to get a beverage hooked up is to change antenna selections on the front panel?
2. I also wonder if there are plug in slots for more than one extra filter? I don't need a 1.8 Khz SSB filter with slope tuning, but I would like to have both the 500 and 270 Hz filters in the 8.8 MHz IF.
That is one complaint about the TS950SDX: There is room for both the 500 and 250 Hz IF filters in the 455 Khz IF, but only one CW filter in the 8.8 IF, and it is more important to have selectivity in the first possible stage (2nd IF) rather than in the next stage (3rd IF).
Obviously, it does not have the DSP available in the TS570!
I may send Doug an SASE and note and see what happens. He now lives maybe 175 miles NNW of me.

73 GL George K8GG

(Another comment from K8GG George Guerin)
As I saw the TS-870 show at the W9DXCC a couple of years ago, there are NO IF filters. That model uses digital filtering at about 17 Khz to shape the passband. Problem is the images 34 khz away!
There is no plan to put in filters, although a couple of California hams have done it. (WONDER WHO?) With out a 2.7 Khz filter at the 8.8 or 455 IF, it has troubles from what I know.
Kenwood is NOT planning to make filters optional. I do understand using the SSB filter and digitally making the CW filter in the 4th IF works fine.
On the TS-570: Is there an accessory socket like the TS-940 and TS-930 that has the ability to pull out and put back in the RX antenna line? (SEE ANSWER BELOW)
That is my fear! The Icom radios like the '740, '751A, '765 and '775 all have a coax jumper for the RX antenna line. The '728 and '726 do not!! I complained to the Icom rep's at Dayton.
The TS-950SDX has a jumper like most of the Icom radios.
There is a guy in Ft. Wayne who makes FEP's - front end protectors. If you can figure a way to bring out the RX antenna line, it is a neat way to make sure the RX input is grounded on transmit. It is written up, but not in enough detail, in one of the recent CQ Mag's as well. That might help, but toggling the front end on each "over" is a true
pain!!
Have fun, 73 George
===
MY OWN TESTS, Side by side with TS-940... KJ9C
>From what I saw of my friend's 570, and from his comments, the CQ article is on the money
To switch antennas one must MANUALLY hit the ANT switch... so that's one hit for transmit, one to receive when using a beverage... I have not yet looked for a transverter input on his rig, as that is how my TS-940's external RX antennas are wired,... when I get the rig at my place I will check for features... but I know there is NO dedicated RX antenna input... this would keep me from buying a 570, but I guess I could build an external TR switch like we built back in 1968 for club's S-Line.
There is room for only ONE filter... so decide whether it's SSB or CW, 500 or 270... that's a big drawback but would not keep me from buying a 570, as I would likely go for the single 270 for IF protection... but one in each IF would be nice... I guess the TS870 has room for NO IF filters
Written later:
I borrowed the 570 for a few hours and installed it with antenna switching next to the TS940 at my NOISY QTH (line noise on some antennas as high as 20 dB over S9). In every case the 570's noise REDUCTION unit did a better job of reducing noise and bringing up weak signals (most tests on 160 and 80 meters where my noise is worst). The noise blanker also worked, but the digital reduction was better. On the contrary, the noise blanker on the 940 seems to be a little better than the 570's. However, as you know, strong signals tend to swamp receivers with noise blankers ON. The 570 noise REDUCTION beat the DSP59+ NR feature.
The 570 was tested without an IF filter installed, and it did exhibit some overload from adjacent signals... since then, Eric has installed a 500 Hz IF filter and reports that adjacent signal swamping is negligible, and he can crank the DSP down to 100 Hz without ringing.

The DSP is the selling point of this receiver... better signal to noise than the 940 (with STRONG noise) and therefore can dig out the weaker ones. However, in the absence of strong line noise (say S3 or lower) the TS940 with outboard DSP seems to work pretty well. See below.

The CW autotune works with relatively weak signals, but not down in the mud. This makes tuning with tight bandpass a lot easier.

Very little SSB testing, but the heterodyne filter works as good (or better) than the one on the 59+ DSP. Did not have multiple heterodynes to see how it works, but would guess OK.
Forgot to check for transverter input!!! Dope! Suppose that auxiliary receive antenna is possible somehow.
COMPARISON OF TS940 TO YAESU 1000MP:
I borrowed K9IG's 1000MP for similar testing. I felt like I should sign away rights to my firstborn grandchild if I damaged it, so better believe I was REAL careful with it and read the manual first!! But Greg seemed unconcerned that I was driving away with HIS 2500 dollar radio in my truck.

I set up similar to the TS570 test, and as luck would have it the power company chose to temporarily fix the line noise (after five months!!!) that day. With all the mechanical and DSP features kicked in (including a DSP59+ on the 940), the TS940 and the FT1000MP performed about the same on 160 through the other bands (CW only tests). Some of the controls WERE tricky, and the preset filters on the 1000MP took some getting used to. There must be about two million bells and whistles on the 1000MP, and my fat fingers found a few by accident. It is an impressive rig... but without line noise, not enough to make me dump the old 940. Without the noise reduction, the 940 is OK.

One thing I noted... small point... S meter readings were comparable for both rigs at low signals and noise levels... but S meter readings were higher on the 940 for stronger signals... of course, that does not mean much, as an S meter ain't that accurate... just needed more attenuation with 940.

I packed up the 1000MP and got it ready to take back to Greg (about 8 miles from me)... then Indianapolis Power and Light came through just in time!!! Line noise returned, but only at S9 levels. I quickly patched the 1000MP back into the setup and compared reception. In this case (with strong line noise), the 1000MP was better at pulling weaker signals up out of the crud. Even with noise blanker on, the 940 lost some of its ears. Noise blankers on both rigs eliminated the noise HEARD, but the 1000MP was better at finding signals and bringing them up than the 940 with DSP59+ was.
4/15: Bill Tippett reports that his 1000MP is extremely clean (no intermod products observed) compared to the TS930 he retired.

COMPARISON WITH OMNI VI+
I wanted to test an Omni VI+, but none to be borrowed locally, so I asked NE3H for his opinion (see above). In the meantime, power company has repaired a number of defective lightning arresters, a bad transformer, and God knows what else to the point where my line noise is now S3 or less most of the time..so the 940 gets a reprieve. I fact, even though it's almost too late in the season, am working DX on 160 most evenings now when I could not hear it in winter!!! With a little luck I might hit 50 countries for the 96-97 season.
I wish I could find the mail messages I sent to George because there was more specific info in them... but this report is the bottom line. From my own observation, the 1000MP and the TS570 outperform the TS940 receiver with high line noise levels. Mechanical filters are needed on both rigs. But with little line noise the 940 is still pretty dang good.
Thanks to K9IG (formerly KO9Y) and N9QCT for the loan of their rigs.

Mel KJ9C
--
FAQ on WWW: http://www.contesting.com/topband.html

-----Original Message-----
From: kenwood-bounces@mailman.qth.net [mailto:kenwood-bounces@mailman.qth.net] On Behalf Of Mike McCarthy, W1NR
Sent: Wednesday, 13 July 2005 1:13 a.m.
To: Philip Neidlinger; kenwood@mailman.qth.net
Subject: Re: [Kenwood] "New" TS-940S

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----- Original Message -----
From: "Philip Neidlinger" <PNeidlinger@dwginc.com>
To: <kenwood@mailman.qth.net>
Sent: Tuesday, July 12, 2005 8:45 AM
Subject: [Kenwood] "New" TS-940S

>Yes I know the 850 is probably a better rig, but I like to have an analogue meter on my radios.

No it's not!  The quad conversion of the 940 blows the doors off the 850.
I've used them side by side.

Mike, W1NR
```

http://www.k6sgh.com/shack.html

UPDATE: (8/17/03) After two months of using the Orion (and one repair trip back to TenTec), I have sent the Orion back to the good people at TenTec for a refund. It is a long story why I sent it back, but the short of it is that the Orion just did not meet my expectations. It has a lot of good features, but it just isn't what I was expecting. I found the SSB receive to be muddy and difficult to copy even if the signal was strong. Maybe it's just my ears, but I found my Kenwood 940 to be a better radio. The Orion is a *very noisy radio*, at least mine was, and the dsp really did not do much to make weak signals more understandable. After 6 weeks of only using the Orion, I finally hooked up the Kenwood on an A/B switch. I spent several hours looking for only weak, at the noise level, signals. Hands down the Kenwood ran rings around the Orion for weak signals. Signal levels were about the same on both radios, but how the audio sounded is the key. On the Orion, weak signals were muddy and difficult to understand. The Kenwood brought out those same signals and made them easily copyable. If you cannot understand what someone is saying, you cannot communicate.

That being said, I will also commend Jack Burchfield and the other people at TenTec who listened to me and really tried to help me. TenTec is an excellent company and their people are dedicated to their customers.
So what did I do? I went out and bought a Yaesu FT-1000D. What they say is true. It is the king of radios. There is a lot to be said about good old fashioned stacked crystal filtering. Nice rounded smooth audio is what my ears want to hear.
So, for now, that's the story from the shack.

MODIFICATIONS

POWER SUPPLY IMPROVEMENTS

-----Original Message-----
From: John [mailto:hydroaction@cfl.rr.com]
Sent: Sunday, 10 April 2005 3:06 a.m.

To: jaking@es.co.nz
Subject: Re: Advice on what to do upgrade TS-940 PowerSupply

First thing

Replace all the Zener diodes on the AVR board with 1 watt Units. Same voltage values. you will have to open the hole up slightly to allow for larger leads on new parts

D-3
D-4
D-8
D-9
D-14

D-1, 2 ,10-13 are all ok ... just leave them. They are 2.5amp at 100Vpiv

Q-1 and Q-2 , Q-6 are fine. Just replace them with same.

replace C-3 ,C-4,C-6 with 2200UF 50volts , replace C-13 too.

Put a 47 ohm 1/2 watt resistor in series with the collector of Q-6 to limit inrush current on turn on.

Replace the pass transistor Q101, Q102 with 2N5886 ......if these short it puts 42 volts on final unit
and burns out the expensive driver transistor in about 30 seconds

Resolder the complete board & deflux it too.
===

Observations by ZL4AI

Original Diode Specifications:
ZL4AI thinks the file below gives MTZ diode operating values.
MTZ specs MTZJ_LESHAN.pdf

Possible Replacement Diode Specifications:
1n_Formosa.pdf
1n_General.pdf
1N_JDG.pdf
1N_Leshan.pdf
1N_Rectron.pdf
1n47__Vishy.pdf
1n4728A to 1n4753A Hitachi.pdf

bzx85C__Fairchild.pdf

	Original	Original 1	Original 1	Measured in service at:	Replacement 1	Replacement 2	Measurements taken on replacement
D1, D2, D10 to D 13					1N5404 [400V 3A]	1N5408 [1000V 3A]	
D4	500 mW				1N4742 1W 12V	BZX85C12 1.3W	
D8	500 mW				1N4746 1W 18V	BZX85C18 1.3W 18V	
D14	500 mW	MTZ22JD 19.72v to 20.72v	MTZ24JA 22.05v to 23.18v	ZL4AI measured for diode 'marked 22D', 22.8v DF5KF measured 22.7v	Hitachi 1N4748 1W 22v +- 5% 21v – 23v Leshan 1N4747 20v +- 5% 19v – 21v	Fairchild BZX85C22 1.3W, 22V	ZL4AI put in 1N4748-209 and measured at pin 5-21T on AVR 20.7v see AVR_D14_replace_voltage

D9 is difficult to find a replacement match for
Kenwood Original is MtZ 9.1 JA which has voltages between 8.29 -> 8.73 median = 8.53V
Kenwood alternative part is MtZ 8.2 JC which has voltages between 8.03 -> 8.45 median = 8.24V

Possible replacements
1N4738 8.2 V +- 0.5V
1N4739 9.1V +- 0.5V

Installed and measured I found
1N4738 output 7.27V at AVR terminal 9 pin 8 ie. 0.63 Volts too low
1N4739 output 8.31V at AVR terminal 6 pin 1 ie. 0.31 Volts too high

D9 only supplies the liquid crystal display and the remote control IC in Digital A, it is very unlikely to have 0.5 watt drawn from it. Very few 940s have the remote control chip installed. My conclusion was it was best to leave in the original diode putting out 8.0 volts.

From Eham
RE: Kenwood ts 940s avr board Reply
by N0XWR on February 28, 2006
you won't find an AVR board for sale new. you should endeavor to fix the one you have. first, check regulator Q103. it is in the rear left corner of the rig as the rig faces you. it is on the heatsink for the power supply. there are three regulators side by side. it is the one on the far left. no matter whether you replace it or it is good, it is imperative that you cut the connector off of the three wire harness that plugs on to regulator Q103 and solder directly to it. this harness comes from plug-in #2 on the AVR. over time the connector overheats and fails and cannot carry the 20-30 volts to and from that regulator. i have seen the problem many, many times. when the connection to that regulator fails, it takes out Q6 on the AVR board, so check it next. clif at AAvid, now retired helped me get through the problem. also check D3, D9 and D14 which are zener diodes on the AVR board. they can be checked right on the board with a multimeter. the board can be removed easily. as you unplug the wiring harness use a sharpie and number each connector so that you can reinstall it easily. make a diagram, too. use small long nose forceps to unplug the connectors to the AVR board. Incidentally, Q103 is part #NTE377 available at mouser. Q6 is part #NTE382 also available at mouser. i have the part numbers for the zeners if you need them. 73s Jerry N0XWR

ALC DELAY TIME:

This mod to your TS-940 will change the ALC delay time from approximately 1 sec to 0.022 second. This means that the ALC will no longer impose its own time characteristics on your audio response; the ALC will now follow your own sylabbic rate amd emphasis. Usually the average power output will increase which will drive a linear amp harder.......(at least those meters will swing higher!).

The TS-940 has a 10uF cap (C31) and 100k resistor (R104) which make up the time constant for the ALC. This tends to reduce the output power for the duration of the ALC time constant (or till the circuit charges up again). Then it starts all over again on the next word.

This procedure allows modification to the Control PCB (X53- 1420- 11) in the TS-940 WITHOUT having to remove the PCB. Remove the bottom cover and locate the Control PCB. Locate R137 and R104. These are located in the upper right hand corner as the rig faces you upside-down (near VR3). A
Service Manual would be very helpful for locating parts!!! using a knife edge or similar, carefully scrape off the insulation from the top of the two resistors. Tack solder an 1/8 watt 2.2k ohm resistor from the top of one to the top of the other. Put the cover on and it's finished.

TS-940 AVERAGE OUTPUT POWER SSB

On the air conversations concerning a kenwood newsletter mod to change ALC delay time called for putting a 2.2k ohm across the top of r137 and r104 on the control p.c.b , along with a .47 mfd cap between pin 1 and pin 2 of connector 8 on the control board. The mod is excellent except .47 mfd is far too much. instead use a .005 to .01 mfd to keep from over driving. electrolytic not necessary, but if used, make sure nagative goes to shield wire pin..

USE OF TS940S FSK RECEIVE FOR HF PACKET

TS940S owners may wish to use FSK mode for HF packet. FSK cannot be used for Packet transmit because the shift is 170Hz, and Packet requires 200Hz shift. This necessitates using LSB with AFSK. I'm not aware of any way to adjust the shift, and 170Hz is required for FSK on AMTOR and RTTY. It would still be nice to use FSK for receive, the primary advantage being the availability of CW filters which are inaccessible in LSB mode. By using the SPLIT capability you can use LSB for transmit and FSK for receive. Tune in signals with VFO-A on LSB. Then press A=B, switch to VFO-B, enable FSK, enable RIT and tune the offset to exactly -2.3KHz. Then enable SPLIT. When listening to signals,
depression of T-F-SET will allow you to listen alternately with each VFO; the signal tones should be identical. If they are not, adjust the RIT on VFO-B (FSK mode) until they are. Optional CW filters are switched in by selecting the NAR ("narrow") filters with the NAR/WIDE switch (LED indicates NAR).

I have found that this arrangement works quite well, and enhances the readability of received packets, especially under heavy QRM and fading. It is easier to adjust the CW filters (NAR/WIDE and VBT in WIDE mode) than the SSB Slope Tune controls.
I would like to hear from other TS940S users who have tried this technique or others that enhance HF Packet operation. Send replies to WA1FMM @ W8AKF.
73...Dan / WA1FMM / Thousand Oaks, CA.

INQUIRY REGARDING USE OF ADDITIONAL RECVR.

I would be most interested in getting Information on how to use an additional receiver at the same time as the TS-940S is in operation (receiving, of course). (ED Note: We covered adding another receiver to 930, Issue 59, Page 54.) The User's Manual covers use of an additional receiver in lieu of the receiver of the 940 receiver section. I am the owner of a 75A4 which I've modified and updated over the 30 years I've had the receiver, and I find no other receiver comparable to it in many most significant ways. So I would very much like to know how to connect the 75A4 into the TS-940S for use simultaneously with the receive section of the latter. If this subject has already been covered in a previous newsletter, please tell me how to get a copy. (ED Note: Nothing published on this in back issues.) I'm confused as to whether I need to cut diode
130 and 135 on digital Unit B in order for the Xcvr to operate over the same frequency range as the receiver. Somewhere I noted that only diode 130 need be cut. (ED Note: Kenwood Newsletter No. 54 clearly states: D135 is for MARS frequency only. D130 is for Gen.Cover- age Transmit.)

GEIHL CHIP

a chip available from Giehl electronics in Cincinnati that will slow the tuning rate to 2 khz per revolution on the main dial of a kenwood ts-940
http://home.fuse.net/jg/index.html
http://home.fuse.net/jg/Chips/TS940Chip.html

RE-PROGRAMMING THE CONTROL SYSTEM ON THE DIGITAL A BOARD

FEEDBACK FROM READERS

```
-----Original Message-----
From: DGB [mailto:dwibos@netnet.net]
Sent: Tuesday, 5 April 2005 6:46 p.m.
To: jaking@es.co.nz
Subject: Re: [Kenwood] TS-940 Full description of AGC timing improvement which significantly improves receiver performance


>
Excellent job on your efforts/compilations Jeff.

73 Dwight W9YQ
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-----Original Message-----
From: Curtis Benjamin [mailto:benjamic@michigan.gov]
Sent: Wednesday, 11 May 2005 1:39 a.m.
To: jaking@es.co.nz
Subject: Thanks

Jeff, thanks for setting up the TS-940 page. I hope it "takes off" and becomes "the" spot for '940 info.

Curt
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-----Original Message-----
From: Ed [mailto:ca.urso2@verizon.net]
Sent: Monday, 23 May 2005 7:18 a.m.
To: jaking@es.co.nz
Subject: TS-940S Reciprocal Mix.Noise Mod - Correction

Jeff:

Congrats on your fine TS-940 Web Page. Keep up the good work!
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I wish to point out a text error in the letter  from Rich, WZ4Z, regarding
resistors R120 and R129 in the PLL Unit  which should be corrected to
3.3KOhms each, NOT 3.3 Ohms as stated. This refers to a Kenwood fix given in
their Bulletin 917 dated 3/2/87.

Also, your  AGC Timing Correction was applied on my rig (SN 806XXXX) and
worked great! Sure enough, resistors R149  (68K on my equip) and R150 2.2Meg
had been incorrectly installed by the Mfr.  The board markings for those
resistors were wrong.

I am also following with great interest  the developments regarding  FETs
reversals noted by PY1NR.

73,
Ed Alves KD6EU
USA
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-----Original Message-----
From: EL34GUY@aol.com [mailto:EL34GUY@aol.com]
Sent: Thursday, 2 June 2005 3:37 p.m.
To: jaking@es.co.nz
Subject: ts-940 stuff

Hi Jeff,

Im getting my first 940 hopefully sometime next week. Ive been reading your website and it has some very helpful comments and recommendations. How hard was it to make the resistor mods you describe on the IF board? Also, I found an SO-1 for mine, how difficult are they to put it? Have you done any pin diode modifications? Thanks for the great website, 73

Mark
W0NCL

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-----Original Message-----
From: Traian Belinas [mailto:traian.belinas@deck.ro]
Sent: Monday, 13 June 2005 5:05 p.m.
To: jaking@es.co.nz
Cc: eduardo@guisard.com; 'thomas hohlfeld'
Subject: Re: TS-940S - Some few considerations

Hi all,

Jeff, thank you for keeping me informed about the TS940 work and about your website, and please continue doing it...
Please also pass any usefull info to me also, I am interrested about.

Using switches for comparison of the normal/reverse FET state may be not feasible, even in the case of using shielded cables.
The added hardware (switches and cables) will unbalance the mixer in the case of Q4 or may cause other Rx problems in the case of Q10, so the comparison may not be made this way or can be irrelevant.
A better aproach shall be using hole contact pins for the FETs and reversing them one or another position for comparison.
Don't let the contact pins there, don't forget removing them as the Q10 runs at high drain current, and so it runs normally very hot and its cooling is made mostly by the terminals conduction and by the PCB traces path....

Tnx & GL,
73,
Traian Belinas, YO9FZS

-----Original Message-----
From: Jeff King [mailto:jaking@es.co.nz]
Sent: Sunday, 12 June 2005 5:34 p.m.
To: 'eduardo@guisard.com'
Cc: Traian Belinas; 'thomas hohlfeld'
Subject: RE: TS-940S - Some few considerations

Hello Eduardo,

Thanks for the email. As you will see last year on your comments page I was very inspired by your discovery.
I was like many 940 owners very excited.
After doing the research, on my web page I was disappointed to find that turning q10 allegedly made the front end unstable.
So for that reason I have not done that.
Have you any more information on turning q10 around?

I have turned q4 around on my radio.

In the end I am drawn between two view points

- 2SK125 FETs function the same in both directions as Thomas has measured, so turning then\m around makes no difference [the scientific view to which I subscribe]
- 2SK125s make a lot of difference turned around, which makes the radio overload with the resulting gain.

Here is suggestion that you could carry out to prove your point, and publish further.

If you connect the D + S leads of the 2SK125 to a shielded lead and a switch so that the switch in one position is the normal factory setting, and in the other position it is the PY1NR setting then you could swap the positions while listening to the radio and verify just how effective the reversal is. You could report it by S point variation on switching.
If you could prove the point more, all hams would be very appreciative, of your good work.

This could be done for both Q10 and Q4 … 2 different switches. These could be mounted on the right side of the top hatch, and act as more adjustment controls for the 940.

I thought about doing this for R149 and R 150, but decided it was not necessary. Now with R149 and (150 swapped, I have to turn on 10dB or 20dB attenuation to diminish a strong signal.

Re solder joints and connectors. I already have a section about this on the web page. It needs more work and more information on soldering especially. You of course are correct about that but it is a separate matter to reversing the FETs.
There is another possibility. I actually fund on my PLL board a missing trace!!!! Wow. This meant the oscillator never worked on my radio. I'm sure some other 9404s also have this problem.

Yours sincerely
Jeff King zl4ai

-----Original Message-----

From: Eduardo Guisard [mailto:eduardo@guisard.com]
Sent: Sunday, 12 June 2005 9:28 a.m.
To: jaking@es.co.nz
Subject: TS-940S - Some few considerations

Hello Jeff,
PY1NR asked me to also say that he modified 2 (two) TS-940S, from 2 different originations. The same improvements of gain and AGC were found. He cannot precisely measure the gain improvement due to poor instrumentation.

He also wants to emphasize that is very important to fix all contact fails (very common in many TS-940S). The contact fails could "mask" the improvements that the modification may occur.

There's another Brazilian ham that did the mod and found no difference the first time. But later on he found a defect on the VR2 trimpot. After this correction he got 6 dB more at 1,8 Mhz and 12 dB at 28 Mhz. It's also very important to fix all eventual defects before the make the mods described by PY1NR.

Thanks and regards
EG - PY1BR

-----Original Message-----
From: Eduardo Guisard [mailto:eduardo@guisard.com]
Sent: Saturday, 11 June 2005 10:51 a.m.
To: jaking@es.co.nz
Subject: TS-940S

Hello Jeff,
I read the comments about the FIELD EFFECT TRANSISTORS AROUND THE WRONG WAY.
I am PY1BR and together with PY1NR, we include all details about this MOD in my website www.guisard.com. The error was found by PY1NR.
We know that in some cases the differences in the Rx performance or gain may not be important if you correct the FET position on the PCB.

Please, let everybody know through your homepage about all comments we received from many Hams in http://www.guisard.com/Index_reviews.htm.
There are many people around the world that agree with improvements after the FET's correction.
Thanks and regards
EG - PY1BR

-----Original Message-----
From: Martin Sole [mailto:msole@loxinfo.co.th]
Sent: Tuesday, 4 July 2006 12:54 p.m.
To: jaking@es.co.nz
Subject: TS940 page

Hello Jeff,

Just writing to say that I have found your 940 page most useful in repairing a couple of units here. One which suffered a terrible overvoltage surge and another with strange digital B unit problems. Your pages are invaluable as a source of information and links to other information.

In viewing your page I couldn't help but notice the 940 brochure is for a Trio unit, the same as I have on my website at www.qsl.net/hs0zed. I was also interested to note that it has the original Lowe Electronics UK stamp on it, the same as mine and even the same scuff marks and folds. Seems rather likely that it might have come to you by way of my site, have a look and see what you think. *[Editors Note: I confess I copied Martin's brochure, and he is ok with* *the copy.]*

I also have on my site the code for the TS940 and the computer interface EPROM's should anybody ever need this to either replace or reproduce them, I don't believe this information is available elsewhere. You can also find the documentation for the IF-232C and the somewhat rarer IF-10B together with all of the various programming data. *[Editors Note: Now in the links section: It is the original TS-940 page]*

In repairing the 940 that suffered a nasty overvoltage I found that in addition tho the usual zener and driver transistor failures that the zener, D1, on the PA board had also failed short circuit. I still have a problem with the LCD display on this rig which I am working on now. It seems to have the top row illuminated but all segment dots are on, never seen this one before.
Keep up the good work,

73
Martin, HS0ZED, G4UQF

From: Edwin Bruijns [mailto:eb2@quicknet.nl]
Sent: Tuesday, 11 July 2006 8:54 a.m.
To: jaking@es.co.nz
Subject: ts940s

Dear Jeff,

My name is Edwin Bruijns, PA7EW from the Netherlands.
I recently bought an old TS940s, and via Internet I found your TS940 site with info about mods etc. First I would like to compliment you with this nice initiative and the info about the TS940 . I changed the two fets and found a small improvement in receive (on the ears). Now I followed the discussion about the two resistors R149 en R150. But it is not so easy to find a good conclusion. Am I right when the info from KI4NR (John) concluded that we better not swap te resistors (in other words, the actual placement of the resistors in de print is correct). And what is your conclusion about this advise. I thougt, better ask then try with some error-risk on other parts of my beloved TRX.
I hope you can give me some advise,
Thanks and 73's to you and your family.
from Edwin the PA7EW
QTH : Hoorn 35 km north of Amsterdam.

From: Gerwitz, Jim-P06288 [mailto:Jim.Gerwitz@gdc4s.com]
Sent: Monday, 21 August 2006 10:26 a.m.
To: jaking@es.co.nz
Subject: RE: TS-940 CD

Thanks Jeff…! Have a great day! Your web site is great!
Jim
AC7FN

Back to Part 1 of TS-940 page: Click here

ts940 battery
ts950 sd
ts940 cold solder
ts950sd fan
ts950 serial numbers
ts940
TS-940S HF Transceiver
Feb 1986
kenwood serial number
LO Local (TS-940 : Remote control of SLOPE, TUNE, VBT)
1.8khz ssb filter ts850s
Resistors in wrong place in the Kenwood Ts-940
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rtty key input ts570
buy mI204 pin diode
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kenwood ts 940
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TS940 VCO Loop
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TS-950S
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TS-950SDX