Atlas 210X/215X Transceivers Engineering Supplement

Includes the LE Model

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TABLE OF CONTENTS

I. OVERVIEW

A new ham radio company, called Atlas Radio, was created in 1974. Their first product was the Atlas 180 - an all solid state mobile HF SSB transceiver. Almost all HF transceivers at that time had vacuum tubes for the transmitter final amplifier. The 180 progressed to the 210/215 models, the 210X/215X models, the 350XL model, and finally the 210X/215X LE models. The amateur radio community owes a deep debt of gratitude to Herb Johnson for enabling the average ham to have access to factory made SSB transceivers at very low costs. This document applies to the 210X/215X and 210X LE models, but the same principals can be applied to the entire transceiver series.

Please note that this document is a work in progress and will probably never be totally finished. It is hoped that this document will provide sufficient information to the user community such that one does not have to reinvent the wheel in trying to discover the background/history on the various operating and maintenance quirks for these radios.

These radios had some problems even when brand new, and have developed additional problems as they have aged over the past 40+ years. Most of these problems can be resolved if one has a good working knowledge of the radio and has the patience to search out solutions.

In the 70s, most SSB transceivers had minor and major compromises in a number of areas. The Atlas series of radios was no exception. Resolving the areas of compromise could have been costly, delayed production, and maybe would not have been appreciated by most hams. You will probably come across areas of the radio where you will be asking yourself "why did they do it that way". In some cases, changing the design in one area creates problems in other areas. Please keep in mind that computer aided design and high performance spectrum analyzers/tracking generators were not available in the 70s.

A. Audience

This document is written for amateur radio operators that want to better understand the operation of the Atlas radios, repair problems as they occur, and improve the operation of the radio by implementing engineering changes that improve upon the original design. Most of the repairs/changes are easy to make, if one has the patience and tenacity to keep going, even when things are initially not working quite right. Experimenting with these radios offers a rare opportunity for putting a large amount of theoretical knowledge into practice, at a low cost for parts. Unlike modern solid state transceivers, one can be reasonably assured that an expensive part, such as a microprocessor, is not going to be blown out by shorting out a wire/terminal point while doing testing.

Most of the recommended changes can be implemented very quickly and with a minimum amount of technical skill – i.e. replacing capacitors, resistors, etc. A couple of the improvements require some moderate technical skills and also require several hours to complete – i.e. installation of digital frequency display or DDS VFO.

B. Objectives

This document was written with the following objectives:

Provide a consolidated source of technical information associated with the Atlas radios
Generate feedback from users for additional information that can be documented
Restore the transceiver so that it operates at the original factory specifications
Install modifications that correct original factory design deficiencies
Install modifications that improve upon the original factory design
Increase the life of the radios by having a single source of information for repairs

C. Restoration versus Modification

This presented information should not be considered a restoration document, but there are some pieces that deal with that area. If you complete the modifications described in this document, then the resulting radio will be considerably different from a factory built unit.

Most of the described changes can be restored to the original factory configuration. The outside visual appearance of the radio will remain the same – there are no new controls added to the front panel, except for the DDS VFO mod.

The authors have tested the modifications in this document on several different 210X and LE models. Kevin was the true engineer for most of the changes. He would pose the problem, offer up several solutions, and Clint would test and document the results. The sampling quantity has been small and the testing time has only been a couple of years. You may find that a particular modification does not work well in your radio. That could be due to slight differences in circuit boards, other problems in other boards, and/or Kevin and Clint may have overlooked something in their testing. Please share your experiences with the team. We may need to do additional testing.

For any modifications, it is recommended that you only complete a small subset and then test for several days/weeks before making additional changes.

Example: Replace all of the electrolytic capacitors on the PC-300 board, test for several days, and then move on to the next board.

One of the wonderful things about the Atlas radios is that most of the modifications are not very expensive and it is relatively easy to return the radio to the previous condition if a particular modification does not work out.

D. Recommendations

Some of the modifications in this document only affect a specific area of the receiver or the transmitter. There are some changes that affect both areas. Common areas for both the transmitter and receiver include:

Low pass filters
Relays
Voltage regulator
VFO
Carrier Oscillator
1st and 2nd mixers
1st and 2nd IF amplifiers
FET oscillator switches
Crystal Filter
Meter

Each reader will have their own specific reasons for using this document. The following plan of attack is recommended:

1. Repair the radio such that it is fully operational. This would include areas such as:

   Low receiver sensitivity on all bands or some bands
   Low or no transmitter power out on all bands or some bands
   No S-Meter operation or pegged S-Meter
   Distorted receive/transmit audio
   Broken VFO dial cord and/or broken plastic frequency drum
   Excessive frequency drift

2. Install modifications that correct original factory design issues. This would include areas such as:

   IF Trap and Image filter coils and capacitors
   Stable TX carrier balance adjustments
   S-Meter calibration

AGC time constants
Receiver audio band pass

3. Install modifications that improve upon the original factory design. This would include areas such as:

   Improved receiver sensitivity
   Improved receiver overload performance
   Less loss through filters and impedance matching networks
   S-meter and VFO drum backlighting
   Improved receiver/transmitter stability
   Reduced transmitter spurious signals
   Less ripple in receiver IF pass band
   Improved receiver audio band pass
   VFO frequency stability (Cumbria X-Lock)
   BHI DSP
   Receiver band pass filter board

E. Dirty Switch Contacts

One of the most common problems with the 210X/215X radio is dirty contacts on the band-switch wafers, the antenna relay, and the DC Switching relay. De-Oxit will need to be applied to the switch contacts and the relay contacts will need to be burnished.

Here is a recommended process for determining if the bandswitch contacts have a high resistance (this process does not include the TX band pass filter contacts).

1. Connect ohm-meter test leads between the antenna jack and ground and measure the resistance on each band. It should be less than 2 ohms. This check measures the continuity between low pass filter switch contacts, the low pass filter coils, the antenna relay RX contacts, the input switch contacts for the RX band-pass filter, and the interconnecting wiring. There should be a direct short to ground since the electrical path will pass through the RX input band pass filter coils to ground.

   On one test radio, the receiver sensitivity was sometimes poor on the 20M and 15M bands. Moving the band switch between bands would usually help. The measured resistance on 20M was 70 ohms and on 15M, it was 50 ohms. After application of De-Oxit to the Low Pass filter switch contacts, the inconsistent readings were greatly improved. All bands now had 10 ohms resistance to ground. After the RX antenna relay contacts were burnished, the resistance dropped down to 1.5 ohms.

2. Remove the PC-100/PC-120 board. Connect ohm-meter test leads between pin 1 on the PC-100/PC-120 edge card connector and ground. The reading should be less than 2 ohms.

   This check measures the continuity between output of the RX band pass filters, the IF Trap/Image filters, and the interconnect wring. There should be a direct short to ground since the electrical path will pass through the RX band pass filter output filter coils to ground.

3. **Clean Antenna Relay Contacts**

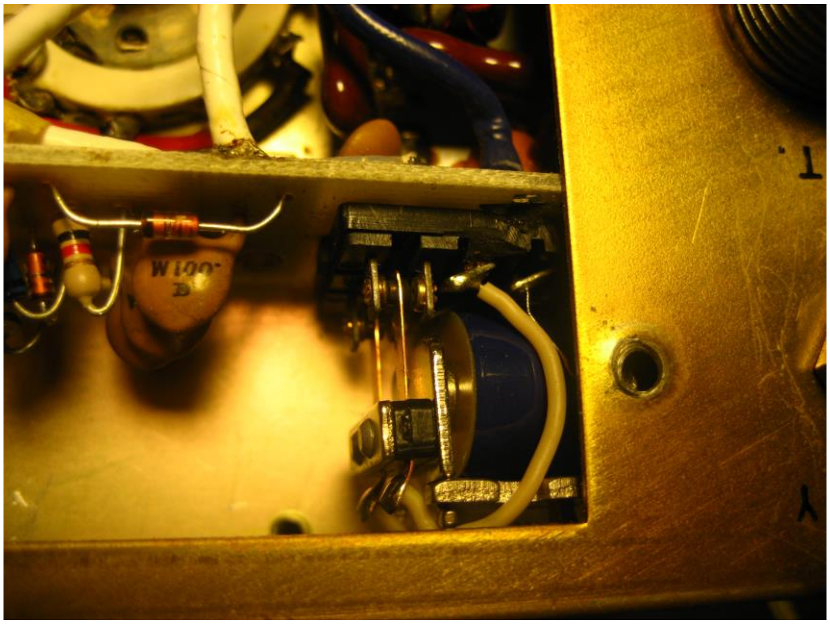
   The antenna relay is located on the PC-1100C board. The following steps need to be followed in order to remove the plastic cover on the relay:

   Remove two screws on the sides of the PA module and swing open the module
   Remove the four screws holding the low pass filter cover to the back of the chassis
   Remove the two screws holding the PC-1100C board to the back of the chassis
   On the low pass filter switch wafer, at the switch tabs, unsolder the input and output wires going to the PC-1100C board

Remove the top cover to the ALC/100 KHz Calibrator adjustments
Slide the PC-1100C board slightly to the left side of the radio so that the top of the Antenna Relay is fully exposed in the opening on the top of the chassis
Use a small flat blade screwdriver to carefully disengage the visible Antenna Relay cover tab (tab is located at bottom of relay)
Slide the cover off the Antenna Relay – through the opening in the top of the chassis
Burnish the RX and TX relay contacts
Install a spike diode on the circuit board pads for the antenna relay coil
Install the Antenna Relay cover
Reassemble the boards and covers

Note: For replacement purposes, the part number on the Antenna Relay was:
Sigma 77R2-12DC

Antenna Relay with plastic cover removed

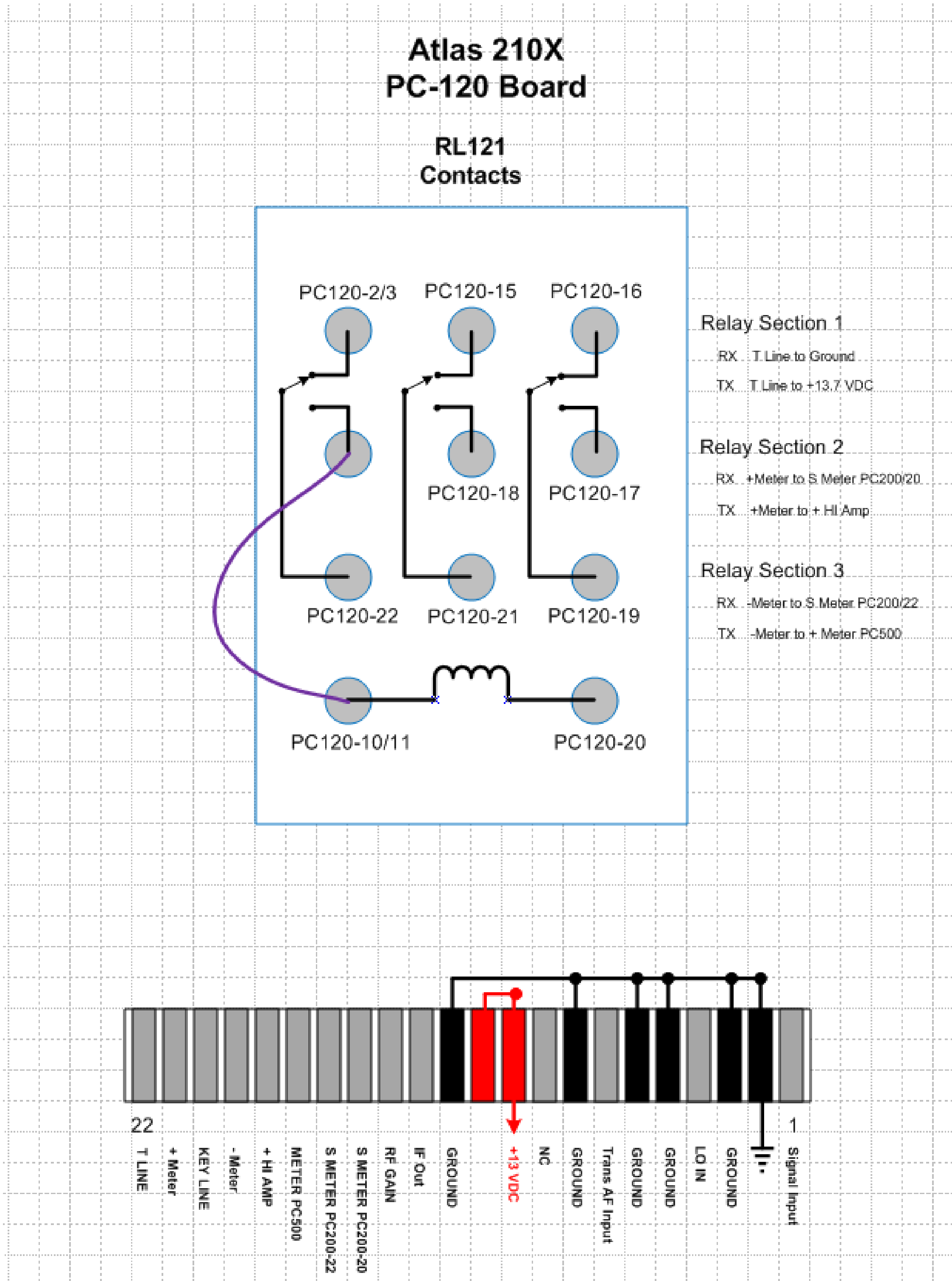


4. Clean DC Switching Relay Contacts

The DC Switching Relay is located on the PC-100/PC-120 board,

It is very easy to remove the plastic cover on the DC Switching relay. The PC-100/PC-120 board should be removed from the radio before attempting to remove the cover. Once the cover is removed, burnish all relay contacts. A few ohms of resistance on the TX meter contacts can cause the meter to be totally inoperative in the TX mode (meter would be showing TX current).

The following diagram can be helpful in trouble-shooting the switch contacts of this relay:



5. Clean Switch Contacts

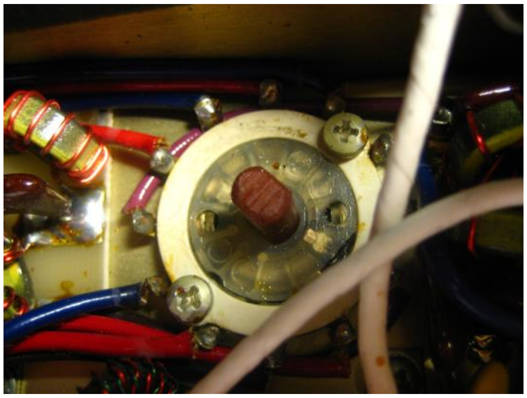
This process applies to the band-switch contacts, but can also be applied to other switches.

Very small drops of De-Oxit should be applied to the switch contacts on each of the 5 wafers. There are two wafers in the VFO compartment, one behind the VFO compartment for the TX band pass filters, one in front of the rear wall of the chassis for the RX band-pass filters, and one in the PA compartment for the TX/RX low pass filters.

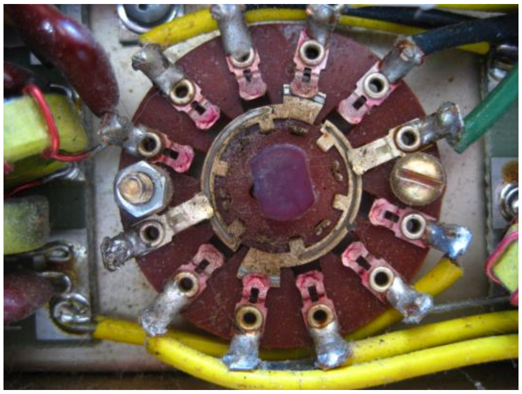
You will find two different types of switch wafers on the band-switch assembly. Most radios used phenolic wafer switches.
210X LEs used wafers that appeared to be ceramic (they are white in color), but are actually some type of hard plastic that will not melt. Some LE radios used a combination of phenolic and hard plastic wafers on the switch assembly.

It is relatively easy to apply drops of De-Oxit to the phenolic wafers since all of the contacts are exposed. On the white wafers, there are some small round holes in the clear plastic sealing cover. You can apply De-Oxit in the holes as you rotate the switch. You should be able to clean all contacts.

LE Low Pass Filter White Wafer Switch Contacts



210X Low Pass Filter Phenolic Switch Contacts



II. Atlas Factory Changes

The Atlas 210X/215X LE models were introduced in June of 1979. There were supposed to be only 1000 LE units produced. By October of 1979, Atlas Radio had gone out of business for the first time.

A. Differences between 210X and 210X LE Models

Per the Atlas marketing literature, the LE model offered these additional features over the standard 210X model:

Receiver Incremental Tuning (RIT)
CW coverage of 10 meters (translated – coverage of 10 meter CW band)
Power increased to 250 watts (translated – power input increased to 250 watts)
Special front panel with commemorative gold name plate

A 210X LE user manual was never produced – Atlas provided the existing manual for a 210X model. Atlas did produce a two page 210X LE addendum that included a schematic diagram of the new RIT control and the Dial Set control.

LE Changes

The following changes do not seem to appear on all LE models. Keep in mind that the production run was only about five months long.

Two braided, insulated straps between the ground foil on the PC-900 board and the back corner of the VFO chassis. This is to improve grounding on the PC-900. It was not really successful, as the single-sided filter board had major ground impedance issues.

Top and bottom covers are black vinyl over steel, and black vinyl on the inside, as opposed to being bare metal

VFO bottom cover is painted vinyl black (or green) as opposed to being bare metal
The bottom VFO cover has six screws holes, but on the LE, the chassis hole next to the front panel is not drilled on some units
VFO tuning dial cord is red in color instead of black
Paper speaker cone color is a very light gray as opposed to black

The LE front panel does not have a meter zero hole

Some electrolytic capacitors on the PC-300 board have a silver insulated sleeve around the aluminum can as opposed to being blue or black in color

VFO plastic frequency drum is from a RX110 receiver

Internal speaker is wired so that it is active all the time, even when an external speaker is plugged into the rear panel speaker jack

Different routing scheme was used for some of the wiring on the bottom of the chassis

ALC control knob is slightly thicker

Lots of solder flux residue on the PC-500 printed circuit board and the chassis ground connections

Receiver IF transformer cans were not fully seated before being soldered to the circuit board

RF gain control is only effective for the last 90 degrees of CW rotation, as opposed to the normal 270 degrees

Plastic VFO window mounting changed to two screws at bottom of window as opposed to screws on either side of the window

Dimmer switch for dial lights has been removed

AGC delay time constant has been increased

The Atlas Tech Bulletin AGC mod appears to be fully implemented in the AGC circuit of PC-300. The delay capacitor was increased from 15 uf to 47 uf. This results in an AGC delay of about 5 seconds as opposed to 1 second with a 15 uf capacitor.

The LE model has a slightly different color scheme on the front panel, there is a different scheme of the white accent lines, and the front panel is anodized on the front and back sides.

B. Alignment Addendum

The alignment information provided by Atlas often did not cover later models (210X/215X and the LE models) and/or was missing for all models.

C. User Manual & Diagrams

Atlas did not create a user manual for the 210X LE model. They continued to provide the standard 210X manual. They did provide a single sheet that described the changes made in the LE and provided a schematic of the RIT control circuitry.

III. Test Equipment

Various pieces of test equipment will be needed for trouble-shooting and upgrading the 210X/215X radios. Here are some recommendations for needed equipment:

A. Audio Generator

B. Soldering Station

Quality temperature controlled soldering station

C. Oscilloscope

50 to 100 MHz dual trace oscilloscope with a low capacitance probe (<10 pf)

The oscilloscope is needed for measuring high signal levels that have little harmonic content

D. Spectrum Analyzer

The spectrum analyzer is needed for measuring low level signals that may or may not have significant harmonic content. The 10X scope probe can also be used as a probe for the spectrum analyzer if sufficient attenuation is placed at the input to the analyzer so that it will not be overloaded.

In using a typical scope probe, you will probably find that it will detune some receiver and transmitter circuits due to the capacitance of the probe. In some cases, you may want to use both probes on a dual trace scope so that your test points can have constant loading.

Example:

The scope can be used to measure the insertion loss of the TX Low Pass Filter. One probe is attached to the output of the PC-500 board. The second probe is attached to the antenna jack. Both test points have the same load from the probes, so your readings should be relative accurate. You can quickly subtract the difference between the two traces, apply log to the base 10, multiply by 20 and you have the DB difference – i.e. insertion loss of the Low Pass Filter.

E. Signal Generator

Needs to generate a clean sine wave down to a -120 dbm level

F. RF Power Meter

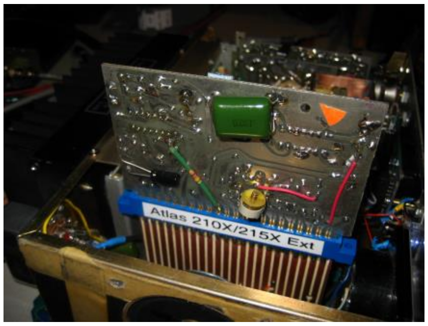
G. Frequency Counter

H. Extender Boards

A straight extender board (for PC-100, PC-120, PC-200, and PC-300 boards) makes it much easier to do trouble-shooting. A right angle extender board is needed for providing access to the PC-900 board. It can also be used to provide access to the older PC-900 boards that had the capacitor adjustments on the backside of the board.

Extender boards are available from:
John Nery – WA1ESO
3 Springer Ave.
Tiverton, RI 02878
WA1ESO@JUNO.COM

Keep in mind that the extender board for the PC-200/300 socket in a LE model needs to be longer than a board for the 210X model. This is because of interference created by the LE's dial set pot.



I. Oscillator Interconnect Cable

On the right rear chassis panel, there is a socket labeled "EXT OSC". The socket is a standard 9 pin tube socket. Normally, there are jumpers connected between pins 2 to 3 and 5 to 6.
If the jumper is removed between pins 2 to 3, then an external VFO signal can be fed into pin 2 and 4 (ground). An external oscillator cable can be fabricated using a 9 pin tube extender plug, some coax cable and a RF connector (BNC, SMA, etc.). The 9 pin tube extender can be obtained from Chinese eBay sources (do a search on 9 pin tube socket adapter). He is a picture of a fabricated oscillator cable:

'

Pin 2 is still available on the top side of the socket plug for attaching an oscilloscope or frequency counter.

J. DC Power Supply

Just about any low current power supply can be used for testing the receiver in the radio. It just needs to be stable, have low RF noise, and have minimum AC ripple.

Power supply requirements for testing the transmitter are more stringent. In order to accurately assess TX power output capability, the power supply should provide 13.6 volts to the back of the radio on the banana plugs/jacks. Lower voltages can be used, but one will have to extrapolate the transmitted power to account for the lower voltage.

You may have a good power supply that shows 13.8 VDC at the output terminals, but the voltage at the radio could be low as 13.1 VDC.

The large voltage drop is directly related to the high current requirements - >15 amps on 80M to 15M. This high current creates voltage drops in places that you might not be aware. A 0.05 ohm resistance point (wire, Power Pole connectors, etc.) would have a 0.85 volt drop to the radio when a current draw of 17 amps is present.

In order to do any type of testing on the transceiver, one is going to need a DC power connector to plug into the back panel of the radio. Positive power is carried on two banana jacks and the ground connection is carried on a banana plug.

Power Supply Voltage Drop
An Astron SS25M puts out 13.81 volts under no load. With a 17.5 amp load, the voltage drops to 13.74 VDC. That is 0.5% regulation.

Best Case DC Power Feed
8" of #10 gauge wire directly from power supply set screw terminals to banana jacks/plug on the back of the radio. Voltage drops to 13.65 volts (power out was 112 watts on 80M and 69 watts on 10M). That equates to a 0.09 volt drop on the power cable.

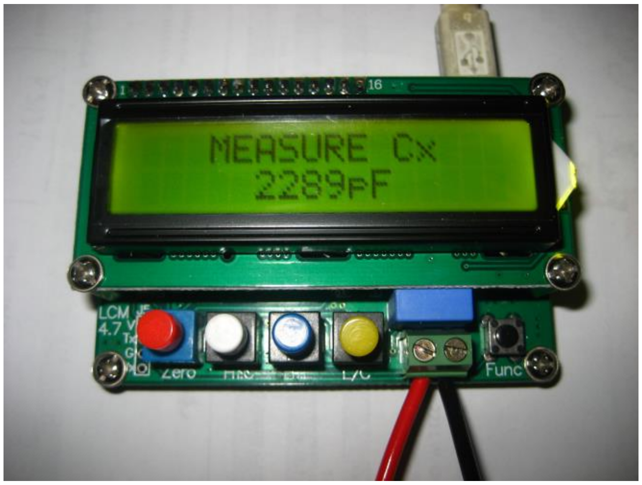
Test Shop DC Power Feed with Shop Pigtail and Power Pole Distribution Panel
18" of #10 gauge pigtail to Power Pole distribution panel. 36" of #10 gauge automotive zip cable to banana plugs/jacks to the radio.

Voltage drops to 13.11 volts at the back of the radio with a 17.5 amp load (100 watts out on 80M and 65 watts on 10M). Keep in mind that the radio only draws 9 amps on 10M. Most of the voltage drop was coming from the Power Pole distribution panel.

Final Solution for High Current Testing
36" of #10 gauge automotive zip cable to 8" of #10 gauge pigtail connected directly to the output of the power supply. There are Power Pole connectors between the 36" and 8" cables. The Power Pole distribution panel is bypassed. The supply voltage drops to 13.54 VDC at the back of the radio with 17.5 amps load (110 watts out on 80M and 70 watts out on 10M).

K. LC Meter
One of the most useful pieces of test equipment is one of the Chinese Inductance/Capacitance meters available on eBay for about $30. Typical model numbers are the LC100 and the LC200. The LC100 is open board construction with brass standoffs on the bottom circuit board. It gets its power from a USB connector.

Here is a picture of a typical LC100 unit:



L. Pulse Noise Generator

To test the noise blanker in the receiver, one needs a way to simulate the ignition noise from an automobile. Two different generators are described, depending upon the availability of parts from your junk box. The design for the first unit came from the Swan MX-100 user manual. The second unit was engineered from a Chinese NE555 oscillator module.

1. Swan Unit

The following circuit description appeared in the Swan 100MX manual.

The noise blanker circuit utilized in the 210X/215X, like all effective noise blankers, is designed to detect the presence of impulse noise able a certain threshold, and to mute, or blank, the output of the receiver for the duration of the pulse. There is no circuit or scheme that can eliminate static or background hiss types of noise.
Since operation of the blanker circuit depends upon the presence of this high level impulse type of noise, it is difficult, if not impossible, to service the circuit unless a source of such impulses is available. Efforts to service it using the commonly available test equipment lineup are ineffective, and may well lead to mis-adjustment. Most often, this section of the receiver is never checked out, but merely accepted on faith.

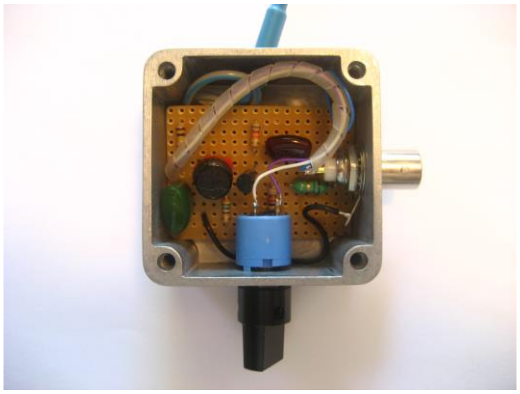
It follows then, that a simple, inexpensive instrument that generates this type of signal could be most useful in the service shop, yet commercial instruments are prohibitively expensive. For that reason the circuit of such an instrument in included here, so that it may be built up locally and added to the shop equipment inventory for such service.

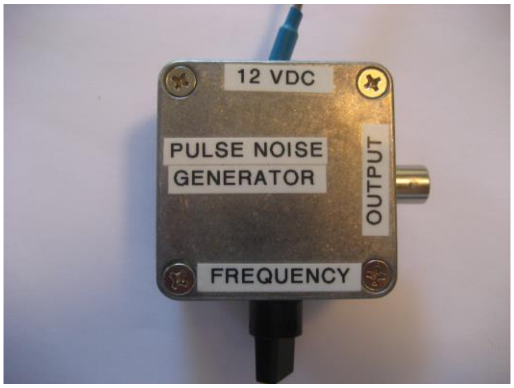
Referring to the following diagram, we see that the 2N1671 is a uni-junction transistor, connected in an oscillator circuit. The 0.22 uf capacitor is charged through the 100K and 1M ohm resistors, with the latter made adjustable to control the charging rate. When the charge reaches a certain level, the UJT fires, discharging the capacitor, and generating a sharp pulse of current through the 56 ohm resistor. This in turn fires the 2N5060, delivering a relatively large current pulse through the inductor. This pulse is used to simulate the impulse noise. Level is adjusted by the 100 ohm potentiometer. Power is can be two 9 volt batteries in series, although a suitable DC power supply delivering approximately 12 - 18 volts at a few mill amperes would also be suitable.

Using the design from the Swan manual, a simplified circuit was built leaving out a power switch and level adjust pot. The frequency adjust pot can vary the pulses from about 2/sec to 20+/sec.

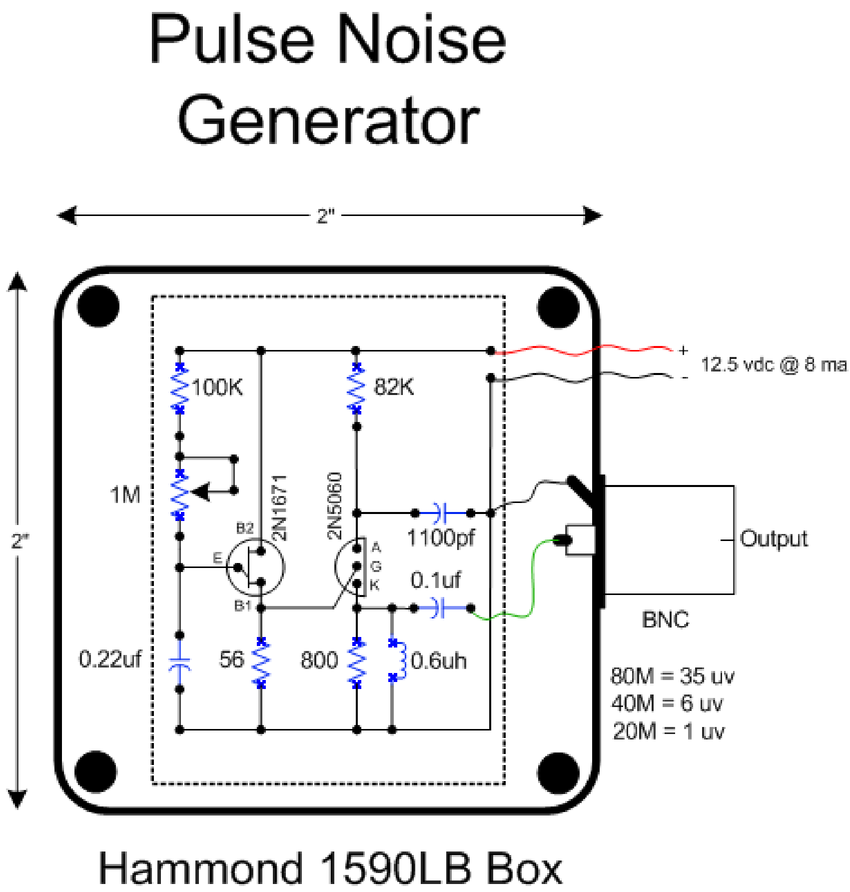
Please note that the signal strength of the pulses into the receiver from the pulse generator will not be as high as one might expect. The receiver band pass filters provide quite a bit of attenuation to the pulses. However, you should still be able to see a S9+ reading on 80M and 40M. If the noise threshold pot on the PC-120 board is adjusted for no pulse noise on the 40M band, then there will still be low level pulses on the 80M band. Further adjustment of the noise threshold pot can reduce the 80M noise pulses. However, this will probably result in worse 3rd order IMD distortion products when strong SSB signals are present.

Here are pictures of the pulse noise generator mounted inside a Hammond case.

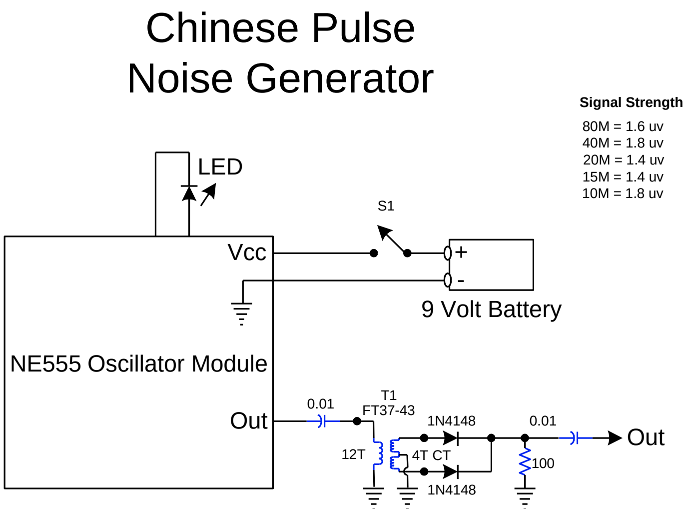




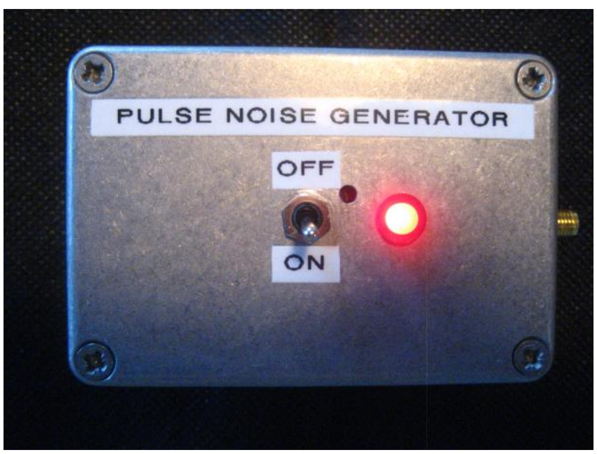
Here is a schematic of the pulse noise generator.

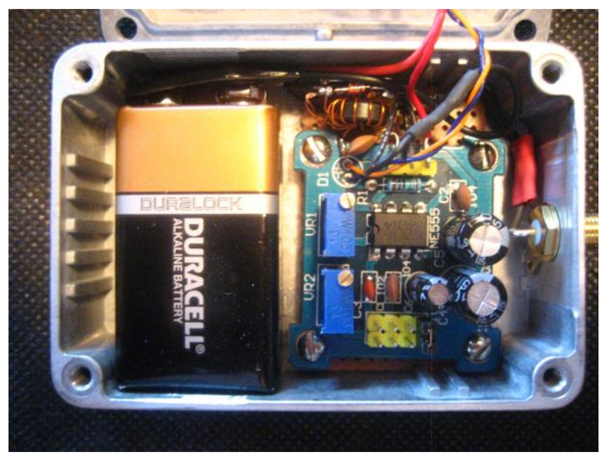


1. **Chinese NE555 module**
   Inexpensive NE555 oscillator modules are available on eBay. With a couple of additional parts, ignition noise can be easily simulated. The output circuit was modeled after a design from VE7CA. This particular design puts out pulses across the 80M to the 10M bands, but the signal strength for 80M to 20M is less than the Swan MX-100 design.



Here are some pictures of the completed unit:





IV. Modification Overview

Most of the component parts of the radio are very rugged and are not easily damaged from a physical standpoint. It is easy to poke a hole through the paper cone of the internal speaker. It is recommended that you tape a piece of thin cardboard over the front of the speaker cone before starting any work on the radio.

A. Function Switch

In order to trouble-shoot the radio, one needs to understand how the function switch operates. This switch has five positions:

OFF

The radio is inoperative in this position, but the PA module still has DC power applied via P2 (+13 High Amps.)

Notes: +13 volts is applied to the “+13 RED” line in all switch positions except OFF.

CAL
The crystal calibrator is enabled by applying +13 volts to the "IN" terminal on the calibrator module. The receive modules are energized by applying +13 volts to the "+13 RED" line.

The transmitter can be activated by pressing the push-to-talk switch on a microphone. This places a ground on the "KEY LINE".

REC
The receive modules are energized by applying +13 volts to the "+13 RED" line. The transmitter can be activated by pressing the push-to-talk switch on a microphone. This places a ground on the "KEY LINE".

TRANS
The receiver is placed in the standby mode (no audio from the speaker). The transmitter is keyed by placing a ground on the "KEY LINE". SSB RF out is produced if one speaks into the microphone.

CW
The receiver is placed in the standby mode (no audio from the speaker). The transmitter is keyed by placing a ground on the "KEY LINE". A ground is also placed on the "CW GND" line. +13 Volts is placed on the +CW line. This unbalances the TX balanced modulator. RF is produced from the RF antenna jack if the CW key is closed (or CW plug is removed from J7) and the Mic Gain control is advanced in the clockwise direction.

On pin 11 of the PC-200 board, the DC voltage varies from 0.0 volts to a maximum of 1.44 volts, when adjusting the Mic Gain pot from minimum to the maximum clockwise position.

On pin 16 of the PC-200 board, the DC voltage varies from 5.6 volts to 1.44 volts, when adjusting the Mic Gain pot from minimum to the maximum clockwise position.

The voltage difference between pin 16 and pin 11 varies from 5.6 volts to 0.0 volts, when adjusting the Mic Gain pot from minimum to the maximum clockwise position. The actual carrier unbalance is the result of a DC voltage being applied to one side of the TX balanced modulator bridge diodes (comes from pin 7 of PC-120). The voltage on pin 7 varies between 0.0 volts to 0.34 volts, with the Mic Gain pot in the full clockwise position.

B. Component Parts

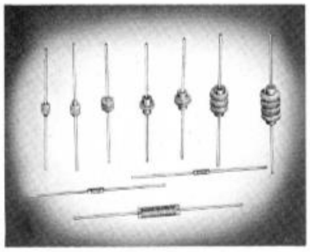
1. Parts Availability

Most of the parts used in the Atlas series of radios are still available on the ham forum swap boards, eBay, and parts vendors. The RF Parts Company has the best stock of parts specifically related to the Atlas 210X/215X.

https://www.rfparts.com/catalogsearch/result/?q=atlas

In many cases, some of today's available parts offer better performance than the parts that were installed back in the 70s. Some of the ICs and transistors used in the radio are no longer manufactured, but are still available from various vendors.

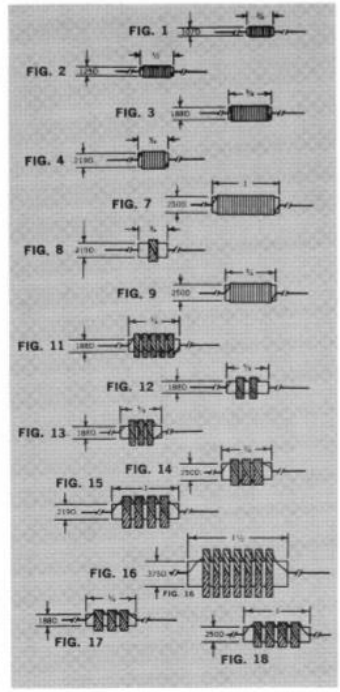
A number of RF chokes (using Pie construction) were used on the Atlas boards. In many cases, Pie construction was not the best design, but was the only available part for the required inductances. Here is a page from a 1972 James Millen catalog showing the available Pie RF chokes:



34300 SERIES INDUCTORS

Part	Inductance Microhenries	Self Resonant Freq. Mc.	Fig. No.
34300-0.15	0.15 ± 10%	645 MC.	1
34300-0.22	0.22 ± 10%	510	1
34300-0.33	0.33 ± 10%	445	1
34300-0.47	0.47 ± 10%	375	2
34300-0.5	0.5 ± 10%	350	2
34300-0.68	0.68 ± 10%	300	2
34300-0.82	0.82 ± 10%	265	2
34300-1	1 ± 10%	175	4
34300-1.1	1.1 ± 10%	210	4
34300-1.2	1.2 ± 10%	210	3
34300-1.5	1.5 ± 5%	190	3
34300-1.8	1.8 ± 5%	171	3
34300-2.2	2.2 ± 5%	160	3
34300-2.5	2.5 ± 5%	140	3
34300-2.7	2.7 ± 5%	142	3
34300-3	3 ± 5%	132	3
34300-3.3	3.3 ± 5%	120	3
34300-3.9	3.9 ± 5%	118	3
34300-4.7	4.7 ± 5%	105	3
34300-5	5 ± 5%	85	3
34300-5.6	5.6 ± 5%	98	3
34300-6.2	6.2 ± 5%	90	7
34300-6.8	6.8 ± 5%	90	3
34300-8.2	8.2 ± 5%	81	3
34300-10	10 ± 5%	65	7

Catalog Number	Inductance Microhenries	Self Resonant Freq. Mc.	Fig. No.
34300-12	12 ± 5%	65	3
34300-15	15 ± 5%	22	8
34300-18	18 ± 5%	22	8
34300-20	20 ± 5%	27	8
34300-22	22 ± 5%	46	9
34300-24	24 ± 5%	24	8
34300-25	25 ± 5%	26	8
34300-27	27 ± 5%	23	8
34300-30	30 ± 5%	15	8
34300-33	33 ± 5%	36	9
34300-36	36 ± 5%	35	9
34300-39	39 ± 5%	18	8
34300-47	47 ± 5%	18	8
34300-50	50 ± 5%	18	8
34300-56	56 ± 5%	28	9
34300-68	68 ± 5%	26	9
34300-75	75 ± 5%	12	8
34300-100	100 ± 5%	13	8
34300-120	120 ± 5%	12	8
34300-150	150 ± 5%	11	8
34300-180	180 ± 5%	9.8	8
34300-200	200 ± 5%	7.5	8
34300-220	220 ± 5%	12	11
34300-250	250 ± 5%	6.8	8
34300-270	270 ± 5%	11.9	11
34300-300	300 ± 5%	6	8
34300-330	330 ± 5%	8.5	17
34300-350	350 ± 5%	8	12
34300-470	470 ± 5%	7.6	13
34300-500	500 ± 5%	7.5	13
34300-750	750 ± 5%	5.8	14
34300-820	820 ± 5%	5.7	13
34300-1000	1000 ± 5%	4	12
34300-1200	1200 ± 5%	4.8	15
34300-1800	1800 ± 5%	2.6	16
34300-2200	2200 ± 5%	2.8	18
34300-2500	2500 ± 5%	2.7	18
34300-10000	10000 ± 5%	1.5	18



The Pie constructed RF chokes are easily damaged if anything scrapes against the outer coils – often breaking a wire in the outer coil. The broken wire can usually be repaired by carefully removing one turn of wire and resoldering to the wire lead of the choke.

The following boards used Pie constructed chokes:

PC-100	L204-200 uh		
PC-120	L127-200 uh	L128-5mh	L129-200 uh
PC-200	L204-200 uh		
PC-300	L301-33 uh (solenoid single layer construction)		

Modern ferrite cores can probably be used to make new chokes. About six turns of wire on a BN73-2402 core will give 200 uh of inductance. More turns can be added to get to 5 mh.

2. Capacitors - Replacement

There are several different types of capacitors used in the Atlas radios. Due to the age of the units (40+ years), various problems can develop in these parts. Typical capacitor types include silver mica, electrolytic, tantalum, paper, Mylar/poly, and ceramic disc.

Problems with old capacitors include:
Shorted, open, microphonic, and/or leaky (high ESR)
Low capacitance (for electrolytic and tantalums)
Lower than stated capacitance at RF frequencies
Low Q at RF frequencies

Shorted capacitors are the easiest problem to find. These capacitors usually cause the radio to draw high current and/or the radio does not work.

One of the low cost overseas capacitor testers can be used to check for capacitors that are open and/or have low capacitance. An ohmmeter can be used to find shorted capacitors. An ESR meter is needed to find capacitors that have high ESRs.

Capacitor ESR
http://en.wikipedia.org/wiki/Equivalent_series_resistance

The recommendation is to replace all electrolytic capacitors in the radio. There are a large number of these capacitors on the PC-300 board and a lesser number on the PC-120, PC-200, and PC-500 boards. There are also a couple of large DC filtering capacitors on the main chassis.

You will notice the newer type electrolytic capacitors are physically smaller than the original units that were used in the 1970s. Thus, larger capacity capacitors could go back in the same physical space on the radio. Replacing an older capacitor with a higher capacity unit is not always a good idea.

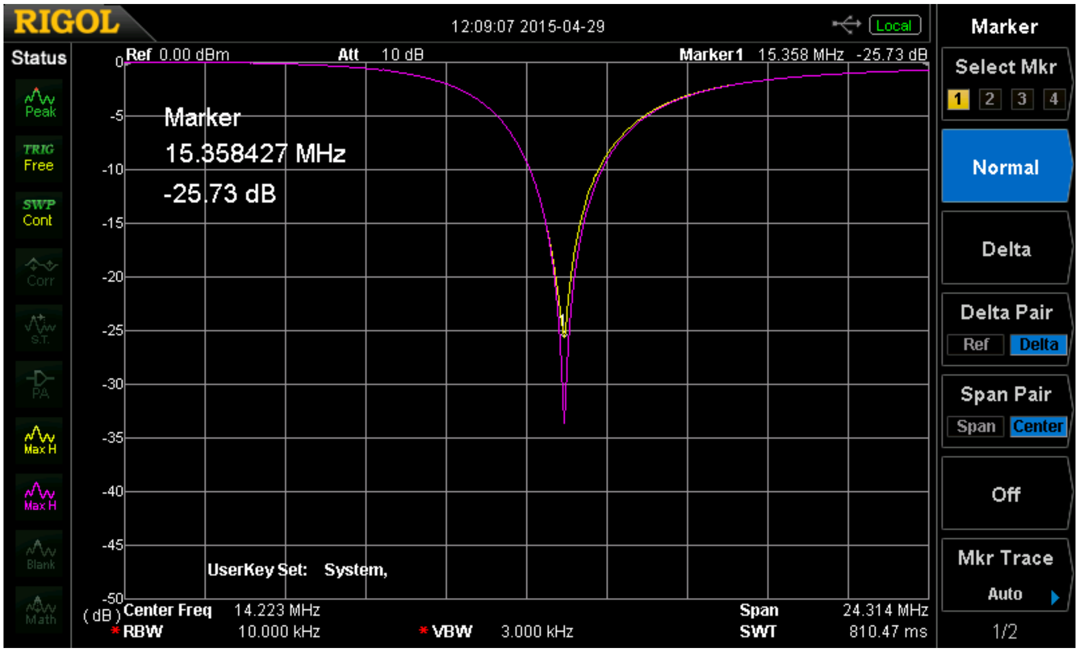
Some of the electrolytic capacitors are used for decoupling – mainly on DC power supply lines. Installing larger capacitors in these areas is usually OK. However, some of the capacitors are used for timing circuits and/or shaping audio band pass. Using a larger value capacitor in those areas could degrade the performance of the radio.

It would also be good to replace all tantalum capacitors, but they are more expensive than the electrolytic units. These capacitors tend to be stable for capacitance values and ESR, but can short out. On the PC-200 board, there are two 0.1 uf 50 volt ceramic disc capacitors that are very large in size. Small 0.1 uf 50 volt monolithic capacitors are nice replacements.

X5F ceramic disc capacitors were used in a number of the radio's RF circuits. The X5F dielectric is very unstable with temperature changes, the capacitance gradually decreases over time, and the ESR is poor. Capacitors having low capacitance and/or low Q at RF frequencies are difficult to find unless one runs some frequency sweeps of the associated filters. These types of capacitors should never have been used in RF circuits. Kevin calls these type of capacitors "molded mud".

The X5F capacitors can have a very high insertion loss at RF. Changing to a silver mica capacitor can greatly improve the frequency response of band pass and notch/trap filters. Please see the section on the PC-120 board for data on Q changes when going from a X5F capacitor to a high quality ceramic or silver mica unit.

Here is a spectrum analyzer sweep that shows the difference between a 240 pf X5F capacitor and a 220 pf silver mica capacitor when used in a simple parallel trap circuit. The trace for the 220 pf silver mica capacitor is shown in purple.



Polyester film capacitors present similar problems. A typical example is the 2200 pf capacitor used in the receiver and transmitter IF Traps and the 80M receiver band pass filter. Forty years later, these capacitors can show varying amounts of capacitance at RF frequencies. These capacitors had a very low Q, even when new.

Green mylar capacitors were used in the audio circuits. Some of the small green Mylar capacitors are labeled 0.002 uf, but they test out to be 0.0015 uf. This issue will be discussed in detail in the section dealing with IF Traps/Image Filters.

3. Coil Forms in Traps/Filters

The paper coil forms used for the IF Traps and Image Filters tend to get loose from the coil turns. This can result in the entire coil form turning when you try to adjust the tuning slug. An application of Super Glue or Q Dope between the coil form and the coil turns will secure the wiring to the coil form.

4. Variable Resistors

Almost all of the potentiometers used in the radio are the miniature exposed carbon track type. This includes the carrier balance pot, the PA bias adjust pot, the S-Meter adjust pots, and the TX BP filter equalizing pots.

It is sometimes difficult to get the proper adjustment when a very small change of the pot's wiper arm causes a large change in the adjustment reading. Replacing these pots with modern units can make adjustments much easier and more stable over the long term. In most cases, the modern pots have mounting wires that mate up with the existing solder hole traces on the circuit board.

C. Transmitter Power Testing

One of the most common problems with the Atlas series of transceivers is low or no transmitter power output. This particular problem is one of the more difficult issues to trouble-shoot. Best case, you may have a bad resistor, capacitor, or dirty switch contact.

Worst case, you may need to replace the two PA final transistors at a cost of $40 to $100 for a matched pair. Fixing the problem is usually pretty easy – finding the problem can be very difficult.

The secret to finding the problem is being able to isolate the problem to a specific area of the radio. Initially, you would want to isolate the problem to the PC-500 board or stages earlier than the PC-500 board.

A simple, low cost modification, can make that isolation process easier. There is a small RG-174 type of coax cable going between the band switch output of the PC-900 board to the input of the PC-500 assembly. The cable is about 15 inches long.

The existing coax cable is replaced with a cable that has mating MCX connectors in about the middle of the cable run. By pulling the mating connectors apart, one can measure the RF output power from the band pass filters and can also inject a signal generator signal into the PC-500 assembly.

Two adapter test cables are needed - a BNC male to MCX male and a BNC male to MCX female. Quality cables are available on eBay for less than $10. The output power from the band pass filter is about 0.1 mw. It takes about one hour to make this modification. Here are the steps for replacing the coax cable.

Remove the PC-100/120 board
Remove two screws and mounting spacer from the band pass board

Document the position of the wires between the band switch and the PC-900 board. There should be a different color pair going to each band. In my unit, the following colors were used:

80M Black
40M Red
20M Yellow
15M Green
10M White

Unsolder all 10 wires from the PC-900 board and remove the band pass board.

Unsolder the existing white coax cable on both ends. Pull the band switch end of the cable through the feed through hole to the bottom part of the chassis.

This would be a good point to apply DeOxit to the switch contacts of the mode switch and band switch.

Attach your new cable assembly to the end of the cable that was attached to the band switch. Use the existing coax cable as a pull string to pull the new cable into place
Place a plastic sleeve around the mating MCX connectors so that the connector bodies will not touch the chassis.

Strip back the new coax cable and solder both ends to the original connection points.
Replace the two 0.0022 uf capacitors (C918 and C919) with quality 0.0022 uf ceramic disc units. My two units measured about 2100 pf, but they usually read much lower at RF frequencies. You want as much Q as possible for the IF Trap so that you can get the best possible notch of the IF.

If you suspect that C902 and C903 are no longer at 1800 pf, then they should be replaced with quality ceramic disc units. My particular units were X5F which is not good for RF frequencies.

Insure that the coil forms on the two IF Traps are securely glued to the coils so that the coil forms do not move when turning the tuning slugs.

Move the PC-900 board into place and solder the 10 wires to the board in this order: 80M, 40M, 20M, 10M, and 15M.

Install the mounting spacer and install the two mounting screws on the PC-900 board. Install the PC-100/120 board.

Align the 20M, 15M, and 10M bands on the board for maximum power out. Adjust the two IF Traps for minimum IF signal on the 80M and 40M bands.

1. **PC-900 RF Power Out**
With the MCX cable installation previously discussed, one can easily measure the RF power out of the PC-900 board. The male and female MCX connectors need to be separated and a low level power meter, with 50 ohm load, is attached to the end of the cable that goes to the band switch.

   Here are some typical readings that you might see. The mode should be in CW, with the Mic Gain turned for max signal on each band. The equalizing pots were set for minimum loss. Additional output can be obtained on some bands by adjusting the filter tuning caps. For these readings, the caps were not adjusted.

BAND	Drive to PC-500 - Equalize Pots Set For Max Power Single Tone/Two Tone	Drive to PC-500 Start of Compression – Two Tone	Drive to PC-500 - Equalize Pots Optimized	Antenna power out – max/opt	3rd Order IMD drive/PA	5th Order IMD - driver
80M	0.055/0.048 mw	0.230 mw	0.025 mw	119/90 watts	-35/-28 db	-55 db
40M	0.051/0.045 mw	0.021 mw	0.025 mw	121/90 watts	-33/-28 db	-53 db
20M	0.028/0.025 mw	0.011 mw	0.020 mw	82/82 watts	-30/-26 db	-50 db
15M	0.047/0.043 mw	0.023 mw	0.031 mw	109/90 watts	-25/-30 db	-55 db
10M	0.028/0.024 mw	0.012 mw	0.022 mw	70/70 watts	-26/-26 db	-56 db

   Please refer to the Appendix, section M - Signal Measurements to see the spectrum analyzer sweep of the IMD products.

2. **PC-500 RF Power Out With Maximum Drive Signal**
With the MCX cable installation previously discussed, one can easily measure the RF power out of the PC-500 board.

   The male and female MCX connectors need to be separated and a signal generator connected to the cable that goes to the PC-500 assembly. A wattmeter, with 50 ohm load, is attached to the antenna jack. Here are some typical readings that you might see.

   The mode should be in CW, with the signal generator output turned for max signal on each band, at the amplifier's compression point.

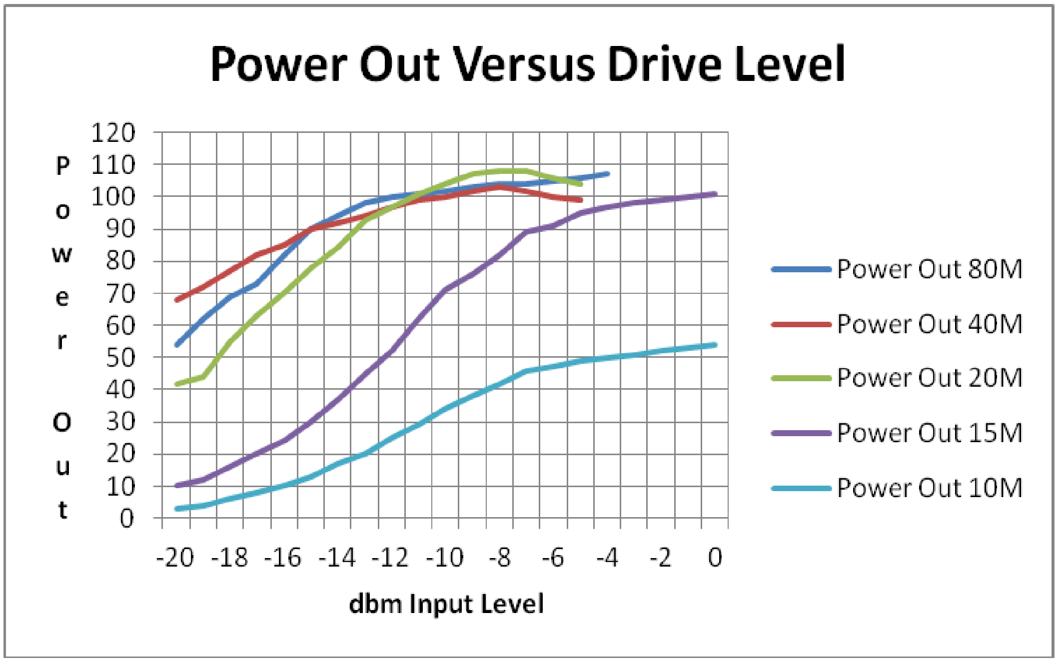
BAND	Drive to PC-500 Equalize Minimum	Power Out at Antenna Jack
80M	-14 dbm	110 watts
40M	-13 dbm	110 watts
20M	-17 dbm	90 watts
15M	-5 dbm	105 watts
10M	-6 dbm	68 watts

3. **PC-500 RF Power Out With Varying Input Signal Levels**
With the MCX cable installation previously discussed, one can easily measure the RF power out of the PC-500 board while varying the signal level into the PC500 assembly.

The male and female MCX connectors need to be separated and a signal generator connected to the cable that goes to the PC-500 assembly.

A wattmeter, with 50 ohm load, is attached to the antenna jack. Here are some typical readings that you might see. The mode should be in CW, with the signal generator set for varying levels from -20 dbm to 0 dbm.

CAUTION: Make sure that the 210X band position always matches up with the signal generator output frequency band. Otherwise, you may blow out the final PA transistors at high power levels.



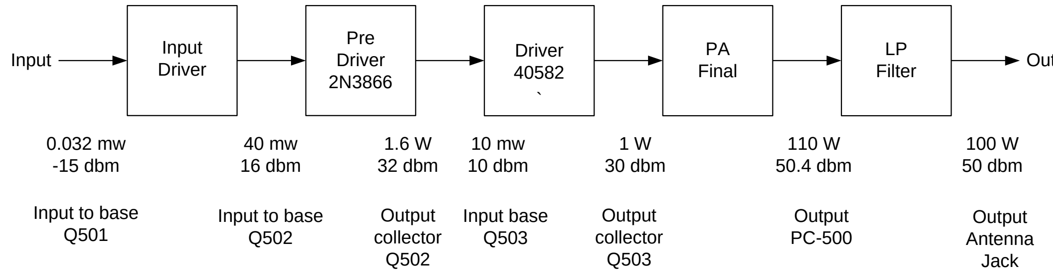
4. **PC-500 Stage Gain**

A spectrum analyzer or high frequency oscilloscope can be used to make RF output power measurements.
You would want to make these measurements on an operating Atlas radio. In trouble-shooting a problem radio, you would use the same test equipment setup. You are looking for relative changes within the amplifier chain as opposed to absolute values.

Please note that the process that you use can de-tune some of the circuits in the amplifier (you may notice that output power goes down). That is OK.
Here are some relative stage gain checks on a standard 210X PC-500 board that were made with a 100 MHz oscilloscope and a 10X probe.

The tests were run at a 10 watt power output and then extrapolated up to 100 watts. Try to minimize the amount of time that you run the PA at full power output in order to reduce heating of components and damage to the PA transistors.

PC-500 Gain
210X – 20M



Please note that the power levels shown are calculated values, assuming a 50 ohm impedance at each measurement point. These figures were confirmed with a spectrum analyzer, but the spectrum analyzer is also using a 50 ohm impedance.

The voltage levels are more accurate for doing trouble-shooting, since they can be easily measured with an oscilloscope, except for the Input Driver area.

5. Power Output Trouble-shooting Example

Here is an example of an actual trouble-shooting scenario that happened to one of our 210X units. The transmitter power output on each band had been previously measured on the radio.

In the process of testing, the band switch of the radio was on 40M, but the signal generator was tuned to a frequency in the 80M band. Full RF drive from the signal generator was applied to the radio. The power out was quite high and went to zero after about 2 seconds.

Verification checks were made on all bands – there was no power out and the amp meter continued to read about 1 amp of current. The MCX connector junction was separated and power out of the PC-900 board was measured on all bands. The readings were the same as previously recorded.

A signal generator was then attached to the input of the PC-500 board. There was no power at the antenna jack. I then started testing the various stages in the PC-500, comparing the readings with those previously recorded. The signal levels looked normal up to the base of the final PA transistors. There was an extremely low signal on one base and no signal on the other base. There was a slight difference in the bias voltage on each base. One was normal at about .65 volts and the other one was about .575 volts. Normally, the bias voltage should read the same on both bases.

It was suspected that at least one of the PA transistors was bad.
The PA transistors were the original CD2545 units. Both transistors were replaced with a matched set of SD1405 units. The replacement process took about one hour. There was no heat sink compound on the bottom of the transistors. After removing the transistors, it was discovered that there was a base to emitter short on the transistor that had shown zero input signal on the base (one with low base voltage).

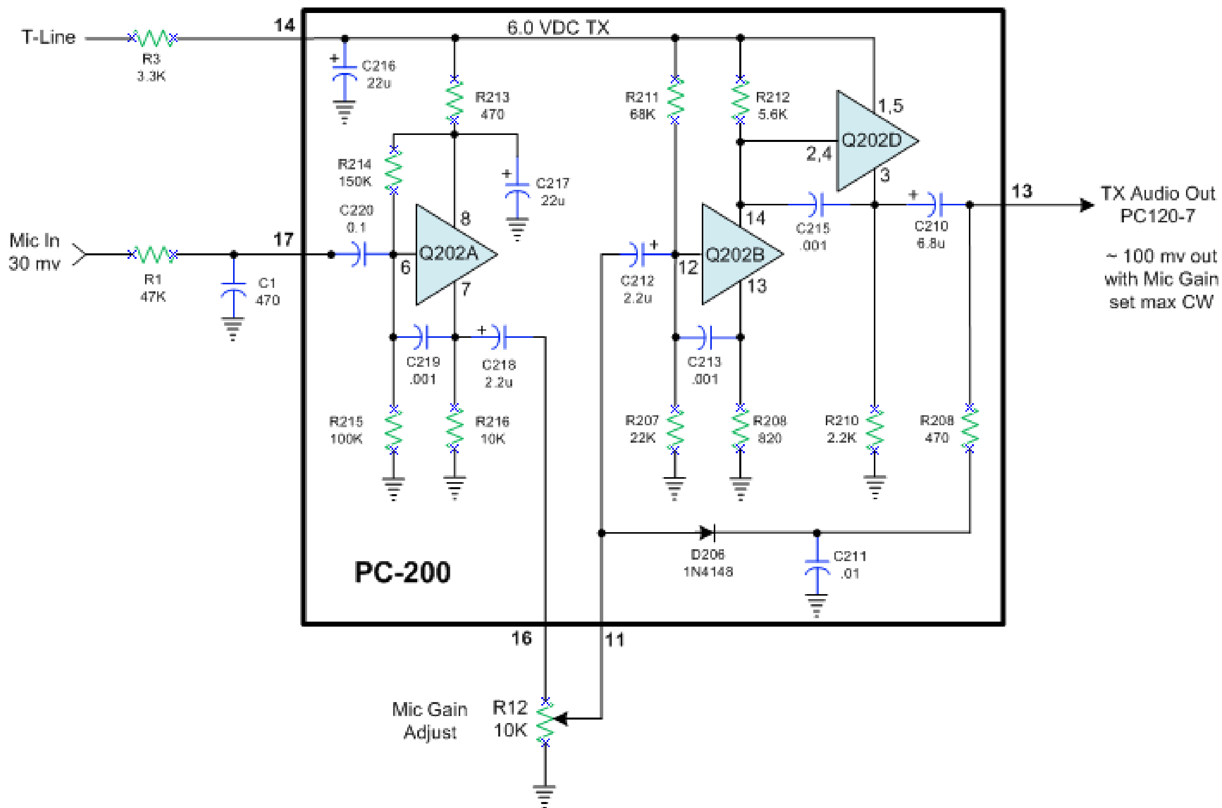
After completing the transistor replacement, the unit was fired up and checked for power output.
There was close to normal output on each of the bands, so that confirms that at least one of the PA transistors was bad. See the PC-500 section for details on using the replacement SD1405 transistors.

D. Transmitter Audio Testing

An often reported problem with the 210X/215X transmitter is low or no TX audio. Here is a redrawn schematic of the mic gain circuit on the PC-200 card.

With a test input audio signal of 30 mv, then the audio out on pin 13 of the PC-200 board should be about 100 mv with the Mic Gain set to the maximum clockwise position. If should take less than 30 mv on pin 13 to drive the transmitter to full power output.

Tranmitter Mic Audio



V. Summary of Replaced/Modified Parts

In addition to replacing bad parts, the following parts were replaced on the 210X boards and the chassis in order to improve performance:

NOTE: If you feel that an IC is bad, cut the body of the IC away from the leads. This will make it easy to remove the soldered-in leads and should eliminate problem with damage to the circuit board foil traces.

A. Chassis

R5 – added 5k ohm resistor in parallel with R5 – increases range of control of RF Gain pot
Speaker – replaced with high output unit
VFO Tuning Knob –replaced with weighted tuning knob
Meter lamps – replaced with white high intensity LEDs
SO-239 antenna connector – replaced with Teflon connector
C7 – replaced with 2200 uf electrolytic
Replaced low power voltage regulator with LDO unit
Applied DeOxit D100L to all switch contacts
Replaced rubber feet on bottom of enclosure panel
Added spike protection diode across antenna relay coil

B. PC-120D

R135 – replaced 500 ohm single turn pot with 500 ohm multi-turn pot
R134 – checked to make sure that 68 ohm resistor was installed
R136 – checked to make sure that 68 ohm resistor was installed
R131 – replaced 2.5K ohm single turn pot with quality 2K ohm single turn pot
C130 – replaced with new 47 uf unit
Dxxx - added spike protection diode across relay coil

C129
schematic shows 150 pf capacitor – installed unit shows 100 pf
Measured 93 pf with LC meter
120 pf silver mica measured 125 pf with LC meter

C131
schematic shows 150 pf capacitor – installed unit shows 180 pf X5F
Measured 184 pf with LC meter
180 pf silver mica cap measured 184 pf on LC meter

C134
0.001 uf X5F capacitor – measured 976 pf with LC meter
1000 pf silver mica measured 1032 pf

C136
Schematic shows 240 pf - capacitor installed unit shows 200 pf X5F
200 pf X5F capacitor – measured 192 pf with LC meter
Measured 176 pf in RF Trap on SA at 16.96 MHz
-26 db null at 16.96 MHz
200 pf silver mica measured 200 pf on LC meter
-33 db null at 16.96 MHz

C137
0.001 uf X5F capacitor – measured 1013 pf with LC meter
Measured 910 pf in RF Trap on SA at 7.14 MHz
-11 db null at 7.46 MHz trap
1000 pf silver mica measured 993 pf on LC meter
-23 db null at 7.14 MHz trap

C141
360 pf X5F capacitor – measured 300 pf with LC meter
Measured 300 pf in RF trap on SA
330 pf silver mica cap had about 3 db better notch on a test trap SA at 12 MHz

C142 – replaced with new 47 uf unit
C143 – replace with a unit that is physically smaller in size
Note: Installing silver mica capacitors for C129, C131, C134, C136, C137, and C141 usually improves the receiver sensitivity by several db.

PC-200D
C205 – replaced 130 pf X5F capacitor with 130 pf silver mica
C221 – replaced 2200 pf capacitor with quality 2300 pf ceramic disc unit
L205 – insure that there are 7 turns of wire on the coil with either a short or long tuning slug
Q201 – installed 8 pin dip socket
Q202 – installed 14 pin dip socket
L128 – in case you need to replace this inductor, the value is about 4.5 mh

Replaced discrete mixer parts with MCL TUF-1 packaged mixer
Added 1N4148 diodes across pins 4 & 6 on Q201 (diode bands reversed)

C. PC-300D

C317 – replaced 0.1 uf ceramic disc with 1 uf tantalum
C320 – replaced 250 uf electrolytic with 470 uf electrolytic
C221 – replaced with high quality 2300 pf ceramic disc
C322 – replaced 0.47 uf tubular capacitor with 0.47 uf 100 volt green Mylar
R309 – replaced 2.5K single turn pot with 5K multi-turn pot
Q301 – installed 14 pin dip socket

D. PC-400C

Q403 – replaced MPS6514 transistor with a 2N2222 unit

E. PC-600

Installed low pass filter on output of carrier oscillator board

F. PC-900

C913 – replaced with high quality 2300 pf ceramic disc
C919 – replaced with high quality 2300 pf ceramic disk
L916 – insure that there are 7 turns of wire on the coil with either a short or long tuning slug
L918 – insure that there are 7 turns of wire on the coil with either a short or long tuning slug

G. PC-1200

Replace all 2200 pf capacitors with quality 2300 pf monolithic ceramic units
Insure that there are 7 turns of wire on the coils using either short or long tuning slugs
Adjust 20M Image Trap to bottom of frequency range if a station does not need to be nulled out
Adjust 10M Image Trap to bottom of frequency range if a station does not need to be nulled out

VI. Modifications – Chassis Components

A. Back Lighting

The 210/215 transceiver series used small incandescence bulbs (grain of wheat) to provide backlighting for the front panel meter and the VFO frequency dial (two bulbs). These lamps receive power from the 13 volt DC power rail and they will eventually fail.

Replacement lamps are hard to find. A better replacement is to use high intensity white LEDs. Each lamp will require a current limiting resistor to drop the voltage to the LED to about 2 to 3 volts DC. With a current draw of 10 ma, the LEDs are very bright.

For the meter, two T1 LEDS, one on either side of the meter works well. A typical part number would be MCDL-3004UWC (Jameco 217525). For the VFO frequency dial, two T-1 3/4 LEDs should fit the existing lamp mounting holes. A typical part number would be LWK333 (Jameco 334502).

Here is a picture of the meter with the high intensity white LEDs installed on either side of the meter.

The following link provides good details on how to prepare the LEDs for installation in the radio:

http://www.kwarc.org/Tedds%20Tech%20Corner/kenwood%20ts440%20bulb%20replacement.pdf

B. Crystal Filter

1. Replacement

One of the most critical parts in the radio is the crystal filter.
Crystal Filter Design
http://f6aoj.ao-journal.com/cariboost_files/ladder_fileter_n6nwp.pdf

The filter was manufactured by Network Sciences of Phoenix, Arizona. Network Sciences also made filters for other radios such the Drake SSB transceivers. The early Atlas radios used a 5520 Khz filter and later radios used a 5645 Khz filter. Normally, the specified frequency for a crystal filter is the center frequency of the filter. Atlas did not follow this standard. Thus, a 5645 filter had a center frequency of about 5646.600 Khz.

The crystal filters used in Drake TR-7 transceivers looked identical to the later Atlas filters. They both had 5.645 – x/8 on the top label of the filter. The standard Drake filter had a bandwidth of 2.3 Khz. The center frequency of the Drake filter was 5645 Khz, thus the Drake filter cannot be used in an Atlas radio.

If a filter needs to be replaced, there are two available options:
Obtain a filter from another radio that has the same IF frequency
Purchase a filter from Sherwood Engineering.
http://www.sherweng.com/filters.htm

The Sherwood filter is an 8 pole direct replacement for the Atlas unit, has a bandwidth of 2.2 KHz versus the 2.7 KHz of the original equipment filter, and costs $55.

2. Impedance Matching

The Atlas 210X schematic chassis diagram shows a 1000 ohm resistor to ground on the output pin of the crystal filter. The output pin also feeds a 0.01 uf capacitor that goes to pin 3 on the PC-200 board. On one of the newer 210Xs, a different matching setup was used. The resistor was replaced with a 9 mm OD toroid core with 15 bifilar turns of wire. The transformer inductance measures 14.3 uh. It appears that the core is type 61 material.

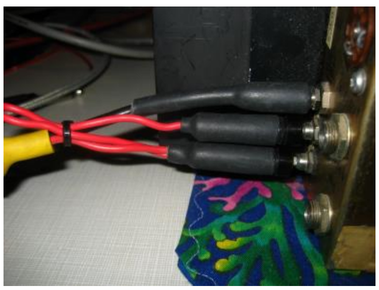
The two common points of the coils go the crystal filter output pin. One end the coil is grounded and the other end coil goes to the 0.01 uf capacitor. The coil and capacitor are enclosed in black heat shrink tubing.

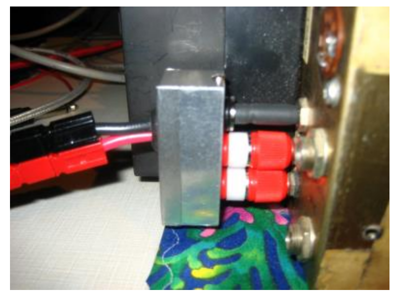
Audio output frequency response curves were plotted for the standard filter termination and the one with the toroid coil. It appears that the toroid termination has more pass band ripple and slightly less insertion loss than the resistor termination.

C. DC Power Connector

Original equipment Atlas power connectors are very hard to find, but one can easily make one. For any connector contained in a box, it is important to make sure that the side next to the PA heat sink does not interfere with the cover screw on the heat sink. This can be done by extending the lengths of the banana jacks/plugs or by making the box very narrow.

1. Simple power adapter with no box enclosure (left picture)
2. Enclosure milled out of a solid block of aluminum bar (middle picture)
3. Enclosure made out of aluminum channel with cover plate (right picture)
   This is my favorite, since I can easily get inside the enclosure where the soldered connections are located.





D. Main Tuning Knob

A larger main tuning knob, with additional weight can make frequency changes much smoother. A stock tuning knob weighs about 1.2 oz versus the 5+ oz of a larger upgraded knob. The larger tuning knob is the Collin's KWM-380 knob. The knob has a built-in finger dimple that allows one to quickly scan from one end of the band to the other. This knob is available from Surplus Sales of Nebraska for about $14 plus shipping.

http://www.surplussales.com/Collins/CollKWM380-3.html

A KWM-380 main tuning knob may not work good for mobile installations. Depending upon the mounting angle of the radio, this larger main tuning knob may obstruct the view for the bottom portion of the frequency dial.

For the upgrade, you will need some #9 lead shot and quick setting resin. The lead shot is available on eBay. There are several available sources for the resin:

Hobby Lobby
Easy Cast 33008 - sets in about 12 hours and has a two year shelf life

Walmart or Autozone
Bondo Fiberglass Repair Kit #420 - Sets in about 90 minutes
Hardener evaporates in about 4 months after the tube is opened
Resin goes bad after about two years after the tube is opened

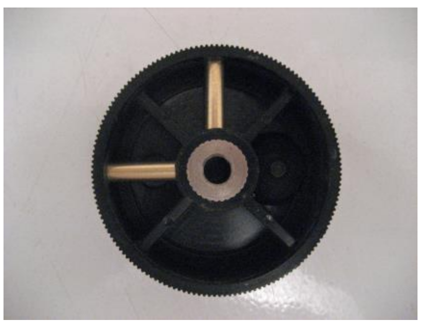
The later Atlas stock knob and the LE knob can be upgraded with more weight, but the knob must be separated from the aluminum skirt in order to gain access to the open chambers on the knob. The volume of the open space on the stock knob is less than the Collins knob, so the knob will weigh less than the Collins knob, once it is filled with lead shot.

This knob is easier to upgrade because you do not have to worry about resin running into the hub set screw opening. The weight of the knob goes from 25 grams to 75 grams.

For the KWM-380 knob, you have to make sure that you completely seal the set screw opening in the hub of the knob and also the small hole in the outer rim of the knob. The resin can easily flow through very small openings. I recommend that you watch the setting process and quickly remove any resin that may be getting into the wrong areas of the knob.

Here is a view of the KWM-380 knob ready to be filled with lead shot and resin. The brass tubes are used to seal out the resin from the setscrew holes in the hub and the outer skirt of the knob.

Here is a view of the knob with the resin installed.



Here is a view of the knob installed on the VFO tuning shaft.

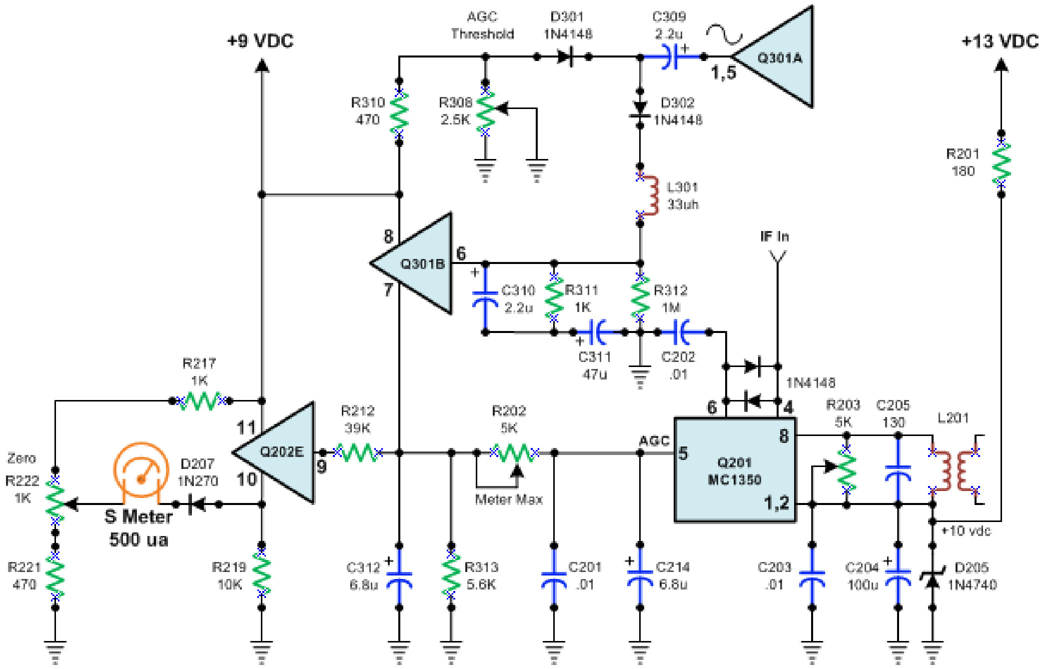
E. S-Meter & AGC

1. Background

The 210X/215X S-Meter provides a visual interface of received signal strength and also provides a valuable tool for trouble-shooting receiver problems. Typical problems in this area include no S meter readings on any signal or meter readings appear to be inaccurate.

The CA3086 IC on the PC200 board is often the root source of the problems. The relay located on the PC-120 board can also have dirty contacts.

Here is a schematic that shows the S-Meter and AGC loop on the PC-200 and PC-300 boards:



Notes:
A jumper is installed across R220 and D207 on the PC-200D schematic.

R202 is a fixed 2.2K ohm resistor on a factory board.

R203 is a fixed 3.9K ohm resistor on a factory board.

This schematic shows the actual installed parts on a PC-200D & PC-300D board, as opposed to what an Atlas schematic may show.

1N4148 diodes added across the input to Q201

Mis-adjustment of the S Meter zero pot (R222) and/or the AGC Threshold pot (R309) can cause the S Meter readings to be inaccurate. The calibration spec for the 210X/215Xs was S9 = 30 uv (~-77 dbm). In 1981, the industry started migrating to the new standard of S9 = 50 uv (-73 dbm).

Latest S-Meter standards for HF SSB receivers
http://en.wikipedia.org/wiki/S_meter

It is recommended one adjust the S meter for the industry standard of S9 = 50 uv.

On the later 210X radios, an additional pot adjustment has been added to the PC-300 board. On the later version boards, pot R309 at 2.5k ohms has replaced fixed resistor R309.
This part of the circuit is very similar to the PC-320 board in a 350XL. In the 350XL, they call the pot adjustment the "AGC Threshold Adjust". It is recommended that R222 and R309 be changed to multi-turn pots. It is very easy to bump the setting on R309, resulting in a big change in the S-meter reading.

There have been a number of complaints about the inaccuracy of the S-Meter readings on 210X/215X radios. If you compare the readings with other radios, you will find that they all have about the same readings and same inaccuracies.

This article provides details on real world testing of S-Meters on various ham radio transceivers
http://www.seed-solutions.com/gregordy/Amateur%20Radio/Experimentation/SMeterBlues.htm#

Ideally, you want 6 db between each S units and 10 db between units greater than S9.

The PC-200C boards match up with the schematics shown in the 210X user manual (1977 version) – in the areas of R220 and D207. On the PC-200D models, R220 and D207 were removed. Per Atlas service bulletin info, a 1N34A diode was put back in their place with the band of the diode facing Pin 20 on the board. In practice, the diode is a 1N270 unit.

2. **Trouble-Shooting**

The front panel meter is used for the S-Meter on receive and transmitter current in the transmit mode. The basic meter movement is 500 ua. 100 mv across the meter will cause a full scale deflection. One can test the accuracy with the following steps:

Remove positive and negative leads from the meter and connect a 5K resistor to the positive lead. Apply 2.5 volts DC between the negative terminal on the meter and the loose end of the resistor. The meter should read full scale. For a full scale reading, the voltage potential across the meter contacts is about 100 mv.

In the transmit mode, the meter negative lead is switched to R516 (560 ohms) by RL121. The positive lead of the meter is switched to Hi-Amps (+13 VDC) by RL121. The meter measures the DC voltage across L505 and is current limited by R516. The meter reading at full scale can be adjusted by changing the value of R516.

If the transmit current on the meter is low, the meter reading can be raised by decreasing the value of R516. If the transmit current on the meter is high, the meter reading can be lowered by increasing the value of R516.

3. **S-Meter Zero**

Prior to making any S-meter electronic adjustments, the meter's mechanical zero should be set. As a minimum, this will require removal of the 210X label on the front panel. This will usually require the heating of the label with a hair dryer while using a utility knife blade to slightly pry the label off the front panel.

Once the label is removed, then the meter zero adjust hole will be visible on a 210X model. For a 210X LE model, there is no hole in the panel, so you will have to remove the two screws holding the meter to the front panel and remove the meter. A small flat bladed screwdriver can be used to set the zero. Depending upon the condition of the label adhesive, you may be able to reattach the label to the front panel without any additional glue.

4. **S-Meter Calibration Mod**

The following modification will increase the levels between major divisions above S9, to about 10db/div. On some PC-200 boards, there may be a couple of large (0.5" across) 0.1 uf ceramic disc capacitors. These capacitors should be replaced with 0.1 uf 50 volt monolithic capacitors. This frees up circuit board space for other mods.

Remove the R202 2.2K ohm AGC resistor. Replace with a 5K ohm pot. There is space on the board to drill 3 small holes for the pots mounting wires, if the TUF-1 mixer mod has been completed. On a stock board, the pot can be located on the foil side of the board and glued to the foil.

With no signal into the radio, adjust pot R222 for a zero level on the S-Meter. Inject a 50 uv signal into the antenna jack and adjust pot R309 for a S9 level on the S-Meter.

The two pots interact with each other, so you may need to go back and forth several times until you can get the correct levels for signal and no signal.

A slight adjustment on R309 results in a large change in the gain. Input a -23 dbm signal into the radio. Adjust your new AGC pot for a reading of S9+50 db on the S-meter. You will need to go back and adjust the R222 and R309 pots again since there is interaction with the new AGC pot.

Various diode combinations were evaluated for D207. I tried a 1N270, a 1N4148, a 1N5711, a 1N4148 in series with a 1N270, etc. The results were about the same with each configuration.

The following table shows the signal levels for S-Meter reading on various boards and calibration levels. Please note that the AGC Resistor Mod provides about 10db/major unit for readings above S9. The S Meter was calibrated for S9 = -73 dbm and S9 +50db = -23 dbm, for R202 Mod. With the AGC resistor mod, the accuracy of the S Meter improves in the range of S9 to S9+50 db and the accuracy decreases in the range of S3 to S8.

S-UNIT	Std 210X PC-200D – 1N270 diode	Std 210X PC-200D – R202 Mod	Std 210X PC-200D – R202 Mod & no diode	Std 210X LE PC-200D – R202 Mod	Industry Standard S Meter Readings
S0	-112 dbm	-106 dbm	-109 dbm	-111dbm	**-127 dbm**
S1	-106 dbm	-100 dbm	-102 dbm	-102 dbm	**-121 dbm**
S2	-103 dbm	-97 dbm	-100 dbm	-100 dbm	**-115 dbm**
S3	-102 dbm	-96 dbm	-98 dbm	-99 dbm	**-109 dbm**
S4	-100 dbm	-94 dbm	-96 dbm	-97 dbm	**-103 dbm**
S5	-97 dbm	-92 dbm	-94 dbm	-95 dbm	**-97 dbm**
S6	-93 dbm	-90 dbm	-91 dbm	-92 dbm	**-91 dbm**
S7	-88 dbm	-86 dbm	-87 dbm	-88 dbm	**-85 dbm**
S8	-82 dbm	-80 dbm	-81 dbm	-82 dbm	**-79 dbm**
S9	-73 dbm	-73 dbm	-73 dbm	-73 dbm	**-73 dbm**
S9 + 10 db	-63 dbm	-58 dbm	-60 dbm	-61 dbm	**-63 dbm**
S9 + 20 db	-57 dbm	-48 dbm	-49 dbm	-52 dbm	**-53 dbm**
S9 + 30 db	-49 dbm	-38 dbm	-40 dbm	-43 dbm	**-43 dbm**
S9 + 40 db	-43 dbm	-31 dbm	-32 dbm	-36 dbm	**-33 dbm**
S9 + 50 db	-37 dbm	-23 dbm	-23 dbm	-23 dbm	**-23 dbm**

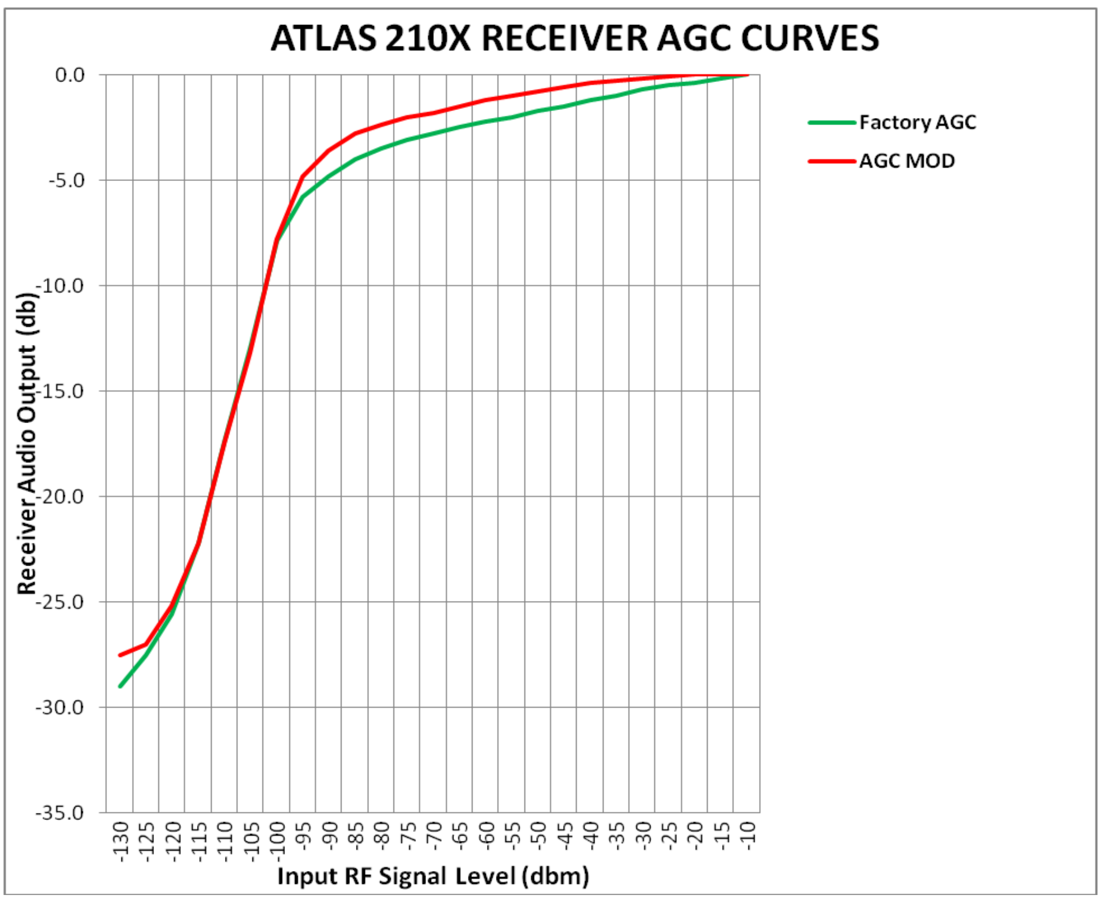
5. **AGC Gain Curves**

Here are typical AGC voltages for two 210X radios. The BHI DSP module on the LE radio was installed but turned off. The S Meter was adjusted for S9 = -73 dbm and S9 +50 = -23 dbm.

Factory AGC / **AGC Mod**

Signal Level in dbm	Pin 19 AGC in vdc	Relative Audio Output	S Meter Reading	Signal Level in dbm	Pin 19 AGC in vdc	Relative Audio Output
-112	4.53	0 db	S0	-111	4.11	0 db
-106	4.60	4.5	S1	-102	4.19	3.5
-103	4.68	7.5	S2	-100	4.26	5.5
-102	4.72	8.5	S3	-99	4.36	7.0
-100	4.80	10.0	S4	-97	4.41	8.0
-97	4.88	11.5	S5	-95	4.50	9.0
-93	4.95	12.5	S6	-92	4.59	10.0
-88	5.02	13.5	S7	-88	4.65	11.5
-82	5.08	14.5	S8	-82	4.73	12.0
-73	5.16	15.0	S9	-73	4.79	12.5
-63	5.22	15.8	S9 +10	-61	4.87	13.0
-57	5.26	16.0	S9 +20	-52	4.91	13.5
-49	5.31	16.5	S9 +30	-43	4.97	14.0
-43	5.35	17.0	S9 +40	-36	5.00	14.2
-37	5.39	17.2	S9 +50	-23	5.03	14.4

Here is a plot of the AGC curves for a standard radio and one that has the AGC mod installed.



The AGC design of the Elecraft K2 transceiver is very similar to the 210X design. The AGC curves for the K2 can be found at:

http://www.cliftonlaboratories.com/receiver_agc_curves.htm

Signal Level Versus Audio Out

This chart shows the audio output level change from a no-signal condition up to -20 dbm input on the antenna. A modified 210X LE radio was compared with an Argonaut 539.

20M
Pre-amp turned off in Argonaut
BHI module turned off in 210X

Input Signal	210X LE Audio Out	210X LE S Meter Reading	Argonaut 539 Audio Out	Argonaut 539 S Meter Reading
-130 dbm	0 db	S0	0 db	S1
-120	3	S0	2.5	S2
-110	10	S1	9.5	S4
-100	18	S5	19	S5
-90	20	S7	21.25	S7
-80	21.5	S8.5	21.5	S8
-70	22	S9 +5	21.5	S10
-60	22.4	S9 +15	21.5	S30
-50	22.75	S9 +25	21.5	S30
-40	23	S9 +40	21.5	S30
-30	23.25	S9 +45	21.5	S30
-20*	23.5	S9 +50	21.5	S30
-10*	23.5	S9 +50	21.5	S30
0 dbm*	23.5	S9 +50	21.5	S30

* 210X goes into oscillation

F. Speaker

The internal speaker is rugged and the condition tends to not have deteriorated physically over the last 40+ years. The paper cones are usually in good shape and the voice coil stays sealed to the cone and metal frame. Electrically, typical problems include:

Distortion at high audio drive levels
Ringing as a result of internal resonances at a couple of audio frequencies
Ringing as a result of resonances with the radio chassis
Too many holes punched in the paper cone resulting in degraded frequency response

The speaker specs appear to be:
Part Number: 3C3CS 3C2473
4 ohms
will handle a couple of watts of audio power
3" outside frame to outside frame
1 ¼" deep
2 3/8" mounting hole to mounting hole
3 3/8" diagonal distance mounting hole to mounting hole

There are a number of 4 ohm speakers that are close in dimensions, but have a large ferrite core magnet that sticks out too far at the rear of the speaker, resulting in the magnet either hitting the PC-300 board or the variable cap on the foil side of the PC-300 board. One suitable replacement is available from Jameco for $2.95.

Jameco Part Number: 99996
Manufacturer Part Number: TQ-966F-R

This speaker is rated at 4 ohms, 4 watts, and 95 dBA. The speaker appears to be of good quality since there is a complete set of specs (including frequency response graph) provided on the Jameco site.
http://www.jameco.com/Jameco/Products/ProdDS/99996.pdf

This speaker is a good fit for the existing mounting holes in the chassis. One just needs to elongate the existing mounting holes with a small round file so that the holes will line up with the holes in the chassis.

It appears that this speaker does not quite have the same bass as the original speaker, but the audio punch appears to be better. The high sensitivity of the speaker allows one to get a very loud output at low audio gain control settings.

Driving the LM380 audio amp at lower levels means that the distortion contribution from the amp will be less.

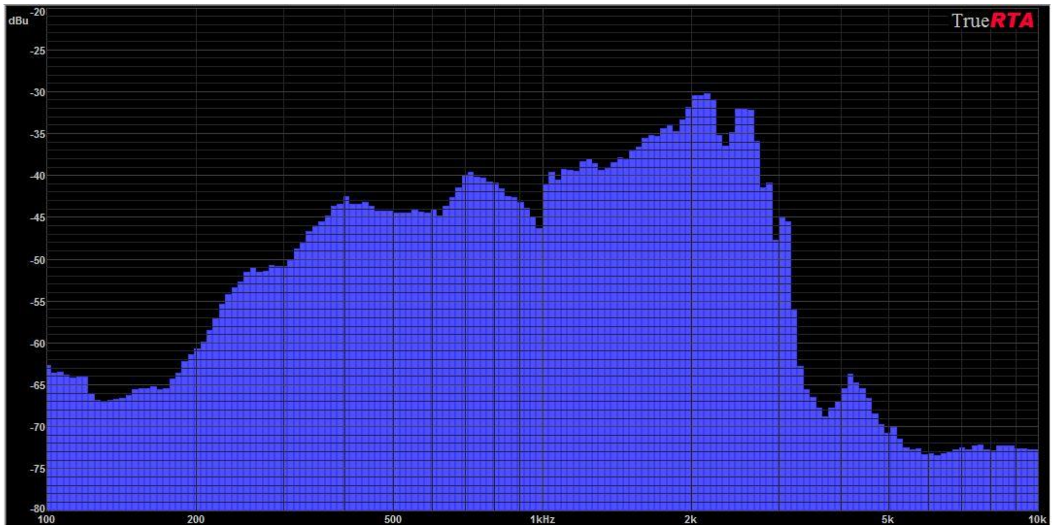
You may find some small tears/hole in the paper cone. A good repair solution is to use Permatex Black Silicone Adhesive Sealant. The result repair looks very similar to the original equipment sealant that was used for the voice coil attachment to the speak cone.

An exact physical replacement is available from Surplus Sales of Nebraska.
http://www.surplussales.com/Collins/CollKWM380-8.html

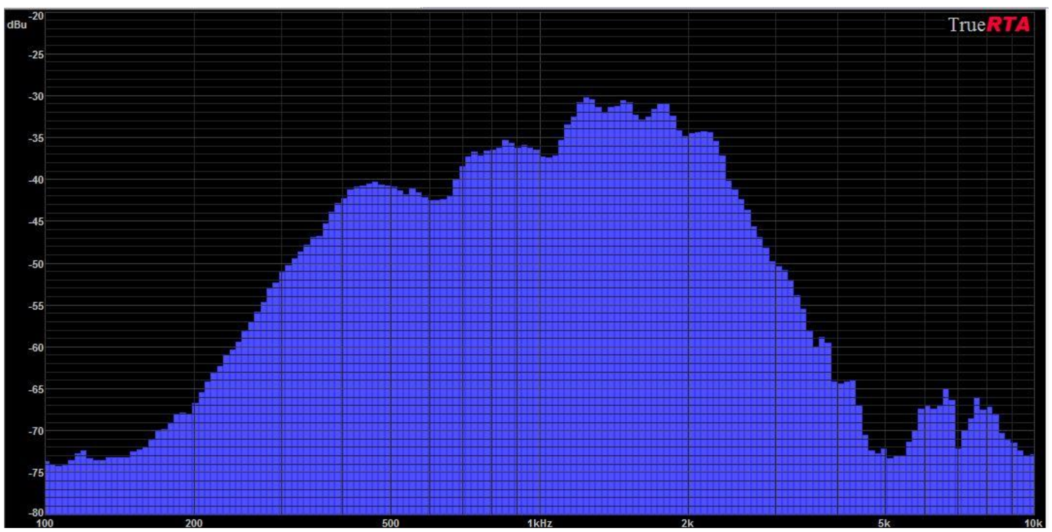
This speaker has large magnet so it provides more audio out. The back of the magnet will hit the circuit board side variable capacitor on the PC-200 board, but that does not seem to cause any issues. Here is a picture of the stock Atlas speaker and the KWM380 unit. The speaker on the right is the KWM380 unit.

The KWM380 speaker sounds the best of four different speakers that were evaluated. Here is the spectrum analyzer response curves using a Telex boom mic feeding into the spectrum analyzer.

Atlas 210X stock speaker

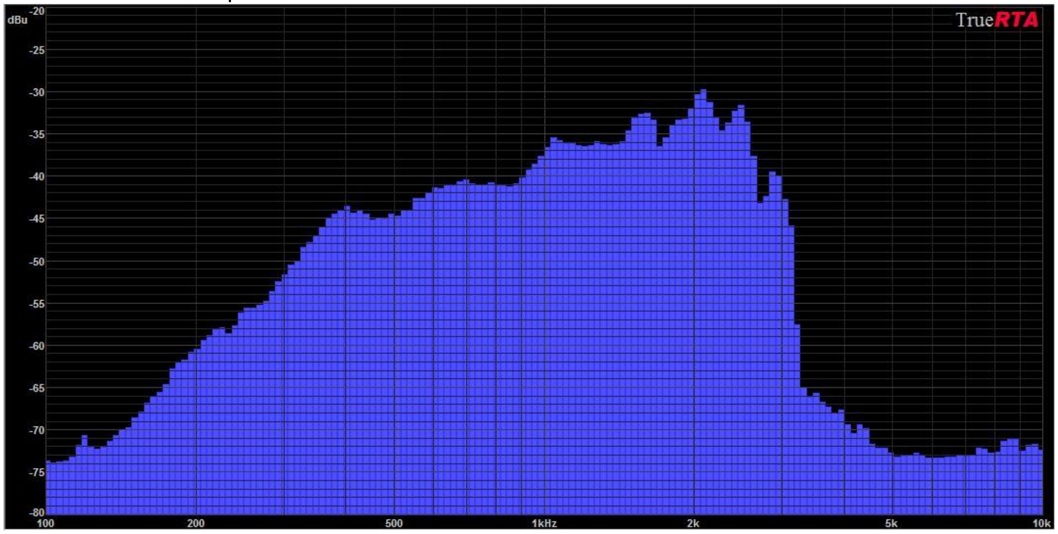


Jameco Speaker

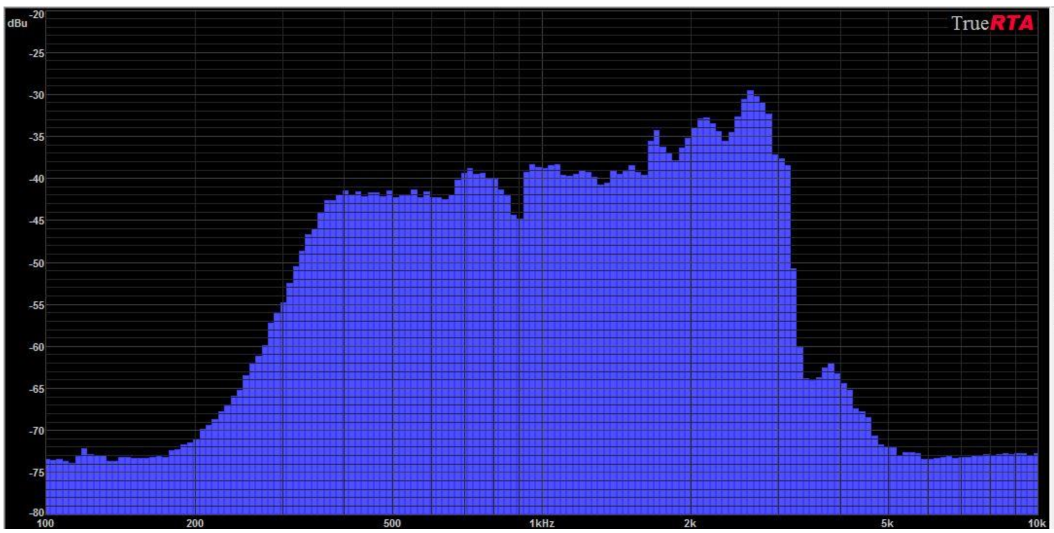


RC

A 40-5000 External Speaker



KWM380 Speaker



G. VFO Dial Cord

The VFO dial cord on the Atlas radios seems to be very durable. Here are the specs for the dial cord:

16.5" total length, including the loops on the end
0.015" diameter - 14 turns on a cylinder measured 7/32"
one turn around the tuning knob shaft (two turns will also work)
multi fine strand nylon

To replace the cord, you need to remove the bottom cover of the VFO and remove the two screws that hold the dial light assembly. It takes about 15 minutes to replace the cord, once the cord is cut to the proper length and the ends are secured with the proper fisherman knots. Be sure to clean the brass shaft area on the tuning shaft where the dial cord loops are attached.

A dental pick with a right angle end makes the work easier in getting the loops of the dial cord around the dial cord shaft attached to the front panel. One loop around the shaft should be sufficient. If your finished cord assembly is slightly too long, then two loops will work. There is not enough room on the shaft to put more than two loops.

H. VFO Tuning Drive

A common complaint on the Atlas radios is in the area of the VFO tuning knob. The knob is attached to a 5:1 reduction mechanism that attaches to the dial cord. Often the tuning is not very smooth and/or the knob has a springy feel (knob jumps back up to ¾ KHz after releasing it).

The problem is in the drive reduction. Remove the tuning knob and turn the VFO shaft with your fingers. You will feel any roughness as you turn the shaft if the internal drive mechanism is bad. The drive mechanism does not use a traditional sealed ball bearing. There are three balls that ride within the bearing race and three holes in the hollow shaft.

The positioning of the shaft in relation to the 3 balls is very critical. From my perspective, there is nothing that can be repaired on the vernier and the problem is not related to having dried out grease in the bearing.

I. VFO Frequency Dial Drum

The frequency dial drum is made out of polystyrene plastic – which can easily crack. The hub on the dial was all plastic on the early versions of the radios and was replaced with a brass insert in later versions. Forty years later, almost all radios will have some type of damage to the dial drum in two areas – hub cracking and main body cracking. If not caught early, chunks of plastic will fall out of the hub. Any pressure across the top of the drum will usually produce cracks across the drum.

The stress cracks will not cause any problems if they do not extend all the way across the top of the drum. The fix is to drill a 1/16" to 1/8" hole at the end of each crack. This will keep the crack from growing longer.

The repair to the plastic hub is more involved. Some type of collar needs to be installed around the outside of the hub and glued into place. The collar will contain any chunks of plastic that are trying to fall out. The collar should be glued around the hub and to the top of the drum. This usually provides enough strength to stabilize the hub and makes it secure on the VFO tuning shaft.

With a metal lathe, an aluminum collar can be quickly machined. If you have one of the solid plastic hubs, then it is best to tap a screw hole in the collar and use that hole to secure the set screw. For additional strength, a flat washer can be glued to the top of the frequency drum above the center hub.

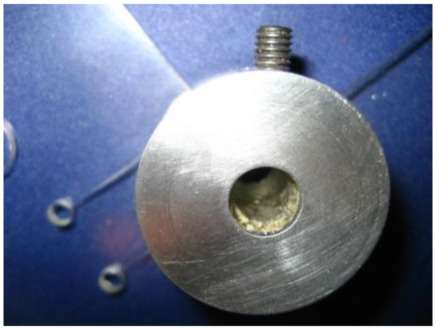
The washer needs to be perfectly flat and have sufficient surface area so that the glue can provide a good bond between the washer and the top of the drum. For the aluminum collar, I use Gorilla Glue. It will expand to fill any open areas where small pieces of plastic may be missing.

Any excess glue can be removed with a utility knife after the glue has set up. Gorilla Super Glue is used to glue the flat washer to the top of the drum. Worst case, you can fill any voids with fiberglass resin once the collar has been installed.

View of aluminum collar around the plastic hub with Atlas brass insert.

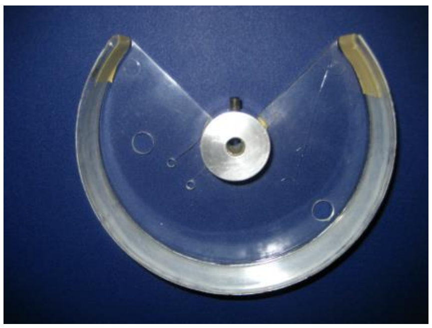
Repaired hub showing flat washer that was installed. This particular drum has no cracks.

Bottom side of repaired hub



View of repaired hub that has stress cracks

View of repaired hub with repaired stress cracks.



An alternate solution is to use a short piece of ¾" ID copper plumbing pipe, ½" high. I hole needs to be drilled into the side of the pipe to allow access to the set screw. The copper piece should be attached to the plastic hub with Gorilla Glue.

Here is a picture of the copper piece glued to the VFO dial hub:

J. Voltage Regulator

A simple 3 terminal voltage regulator is used to provide a constant voltage to critical sections of the 210X radio. These sections include:

RF Gain control (via 470 ohm resistor R7)
VFO (PC-400)
PC-200 (pin 21)
PC-300 (pin 19)
PC-600
Accessory Socket (pin 5 and pin 6 if jumper wire is connected)

The 78L06AC regulator is shown on most of the various 210X versions.
http://pdf1.alldatasheet.net/datasheet-pdf/view/161949/ETC1/78L06AC.html

This regulator puts out 6 VDC when pin 2 is grounded. In the 210X radios, pin 2 is raised above ground level using a combination of resistors and diodes. The current rating of the 78L06AC is 100 ma and the load from the radio is slightly less than 100 ma. This regulator is mounted on a small terminal strip on the top side of the chassis between the PC-200 and PC-300 boards.

On the chassis wiring diagram for radios with a 5520 KHz IF, an 8.5 regulated voltage is shown. On the chassis wiring diagram for radios with a 5645 KHz IF (diagram dated 1-26-77), a 10.0 regulated voltage is shown. The design in the LE units appears to have a regulated value of 9.6 volts. Actual regulated voltages in the radios can vary.

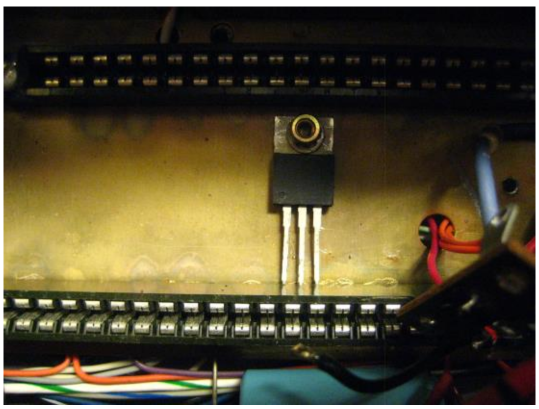
The following steps will replace the existing voltage regulator with a low drop out voltage unit – LM2940-9. This regulator has 9 volts regulated output and comes in a TO-220 package.
The mounting tab of the regulator is attached to pin 2 of the regulator (ground pin). Pin 3 is the output pin from the regulator.
http://www.ti.com/lit/ds/symlink/lm2940-n.pdf

1. Remove boards PC-200 and PC-300 from the radio.
   Remove the 4 pin terminal strip that has an attached 3 pin voltage regulator.
2. Remove voltage regulator, any capacitors on the input/output pins, any resistors, and any diodes.
3. Remove screw holding the 4 pin terminal strip next to the chassis. This screw attaches to a metal standoff stud on the bottom of the radio.

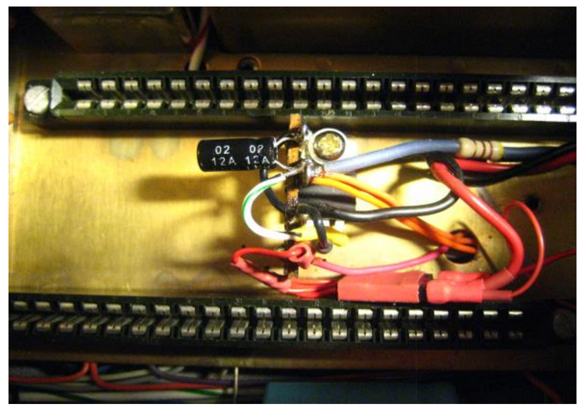
4. Attach LM-2940T regulator to the chassis, using a small brass standoff spacer (0.2" high). The regulator should be flat against the chassis. No insulator is needed between the metal tab of the regulator and the chassis since the tab is at ground potential.
5. Screw down 4 pin terminal strip to the top of the brass spacer.
6. Wire 3 pin regulator to the terminal strip
    a. Pin 1 of the regulator should go to the 13 VDC input pin on the terminal strip
    b. Pin 2 of the regulator should go to the ground pin on the terminal strip
    c. Pin 3 of the regulator should go to the output pin of the terminal strip.
7. Attach a 22 uf electrolytic capacitor between the output pin of the regulator and ground.
8. Power up radio and confirm that you see 9 VDC on the output of the regulator.
9. Install the PC-200 and PC-300 boards.
10. Adjust S-meter for a reading of S9 with a 50 uv signal into the receiver's antenna jack

Keep in mind that the regulated output voltage affects the control range of the RF Gain control. As the regulated output voltage is decreased, then the span of the RF Gain Control becomes less and less. The range can be widened by increasing the value of R5 (4.7 k resistor). The goal is to have a control range of about 2.70 VDC (RF Gain control at minimum) to 8.3 VDC (RF Gain control at maximum).

Picture of LM-2940-9T regulator secured to the chassis with a brass standoff.



Picture of completed LM-2940-9T installation:



VII. <u>Modifications – Minor</u>

A. PC-120 Board

1st IF Amp & 1st Mixer

This board contains the first mixer (balanced modulator in TX), 1st IF amplifier, the noise blanker, and the 2nd IF amplifier.

There are at least two different board versions. The first version used a pot on the front panel for the noise blanker adjustment. The pot would vary the DC voltage on pin 5 of the MC1350, which varied the gain. With max DC voltage on pin 5, the gain of the IC was almost zero and the noise blanker was disabled.

The later version board (issued sometime in 1977) replaced the front panel pot with a toggle switch. When the switch was open, the noise blanker was enabled. In the open position, there was no DC voltage on pin 5 of the MC1350 IC, so the gain of the chip was max. With the switch closed, a high DC voltage was applied to pin 5, so the gain of the IC was zero and the noise blanker was disabled.

The PC-120 board plays a major role in the performance of the transceiver's receiver. The sensitivity of the receiver, IMD overload, and RF Gain control are all affected by this board. The board also has the balanced modulator for the transmitter. Strong RF signals into the antenna jack easily overload the receiver.

Problem areas include poor termination of the LO input to the blanaced mixer, poor termination on the IF output of the mixer, overload of the 1st and 2nd IF ampliers, and poor matching to the input of the crystal filter.

Improving the linearity of the 1st and 2nd IF amplifers would greatly improve the handling of strong signals. On a factory board, the emitter current on the 1st IF amplier is about 3 ma and the emitter current on the 2nd IF amplifer is about 10 ma.

Please note that the overall IF gain on the PC-120 board is about 10 db greater than the gain on a PC-100 board. On a PC-120 board, the audio baseband noise will increase about 5 db greater than the noise from a PC-100 board.

1. **Summary of possible changes/mod:**

Highly Recommended
replace three electrolytic capacitors (very old and suspect)

Insure that C136 and C137 are high quality ceramic disk capacitors (improves Q of circuit)

Replace D127 to D130 with HP 1N5711 hot carrier diodes (improves RX sensitivity and carrier balance)

Align all three IF transformers for best RX SN

Changed Parts on PC-120 Board
There is some variation of parts between Atlas units of the same series. For the transmitter carrier balance, the standard config seems to be a 500 ohm carrier balance pot with two 68 ohm resistors in parallel with both legs of the pot. Later LE models used a 500 ohm pot with no 68 ohm resistors. Some radios have 100 or 250 ohm pots.

For maximum sensitivity, the best combination is a 500 ohm pot with the two 68 ohm resistors. Not having the two 68 ohm resistors installed on the board degrades the receiver sensitivity by about 5 dbm. It appears that these resististors were never installed at the factory on the 210X LE models – the solder pads have never had any resistors installed. Replacing the 500 ohm pot (R135) with a multi-turn unit makes carrier balance adjustments much easier. It will also make the final adjustment more stable.

OPTIONAL
Remove existing mixer components and install a MCL TUF-1 mixer, ADE-1 or equivalent. This change provides improves mixer balance and LO rejection. It also eliminates the need to manually null the TX carrier.

Replace one large 0.1uf ceramic disc capacitor with a 0.1 uf monolithic units. This capacitor is about ¾” in diameter

2. **RF Gain Control**
The RF Gain control varies the DC voltage going to base of Q125 (1st IF amp) on the PC-120 board, which varies the gain of Q125.
The total variation of gain reduction with this control is in the range of 60 db, depending upon the radio and the mods that have been made to the receiver. The change in the audio output signal is in the range of 30 to 40 db – i.e. the actual gain reduction seen on the audio output is less than 60 db because of the AGC action applied to the 2nd IF Amplifier (MC1350).

It has been found that with the RF Gain control fully counter-clockwise, the gain reduction is sometimes not enough for strong signals.

Adding a 5K ohm resistor in parallel with R5 lowers the voltage on Pin 14 of PC-120 such that a full 40 db of gain reduction can be achieved on the audio output.

210X with 8.0 vdc voltage regulator

RF Gain Position	Pin 14 PC-120	GAIN (R5=4.7k)	GAIN (R5=2.4k)	Pin 14 PC-120
MAX	7.50	0 db	0 db	7.50
3 o'clock	3.80	-3 db	-5 db	3.37
12 o'clock	2.10	-30 db	-32 db	1.61
9 o'clock	1.90	-30 db	-33 db	1.33
MIN	1.80	-30 db	-33 db	1.20

210X LE with 9.0 vdc voltage regulator

RF Gain Position	Pin 14 PC-120	GAIN (R5=4.7k)	GAIN (R5=2.4k)	Pin 14 PC-120
MAX	8.30	0 db	0 db	8.26
3 o'clock	3.80	-3 db	-2 db	3.53
12 o'clock	2.34	-30 db	-31 db	1.74
9 o'clock	2.20	-30 db	-39 db	1.55
MIN	2.10	-30 db	-41 db	1.44

The actual gain change to the 1st IF Amplifier is about 60 db with the R5=2.4k.

3. Carrier Balance

The mixer on the PC-120 board is used as a balanced modulator in the transmit mode. R135 and C138 are adjusted for null of the carrier. The Atlas spec is a maximum of 0.2 VAC RF for carrier at the antenna jack. That equates to 0.8 mw of power. For 100 watts out, that puts the carrier null at 51 db and the Atlas spec is 50 db.

On most oscilloscopes, a 0.2 VAC signal is going to pretty fuzzy even when the band in on 80M. An alternative method is to use a digital wattmeter that measures very low power levels (-50 dbm) via a 40 db coupler in line with the antenna jack going to a 50 ohm dummy load.

The adjustments for the best carrier null on one sideband will probably not be the best adjustments for the opposite sideband. For most users, performing the carrier null in the "NORM" position will be OK since that gives the best LSB null on 80M and 40M and the best USB null on 20M to 10M. Prior to making any carrier null adjustments, the transmitter filter rollout should be adjusted per the Atlas doc, for both sidebands. The crystal filter contributes to the depth of the carrier null.

With careful adjustments of the carrier balance controls and matched 1N5711 diodes in the mixer, you should be able to get the carrier balance null to somewhere in the 55 to 60 db range. With a measured carrier balance of 55 db in the NORM position, the balance was 30 db worse in the OPP position. If you adjust the null for equal values on the NORM and OPP positions, then the carrier balance will be about 40 db.

4. TX IF Gain Control

On later versions of the PC-120 board, there is an IF gain pot labeled R151. It is located in the emitter circuit of Q125 (1st IF Amp).

The actual circuit configuration on late model boards does not match the schematic in the back of the 210X user manual. The Atlas 350XL transceiver uses a similar gain adjustment scheme (page 18 of the user manual).

In the PC-120 board installation document, Atlas provided the following information for adjusting the pot.

"Transmitter Drive: A trim pot, R131, located towards the back of the transceiver in the middle of the P.C. board has been factory set, and should not require further adjustment. However, if indications are that more or less gain is required, it can be moved by using a small screwdriver blade, pushing the knurled edge of the trim pot."

This pot controls the IF gain when in the transmit mode only. The pot is blocked from being active in receive by diodes D125 and D126. There is several db of gain change in the receive mode from one end of the pot adjustment to the other end. In the in receive mode, the 1st IF Amp has about 36 db of gain and the 2nd IF Amp has about 12 db of gain. In the TX mode, the pot can vary the gain about 25 db. Maximum gain occurs when the pot is set at minimum resistance. If the gain is set too high, then Q125 will break into oscillation in the transmit mode.

From the Atlas 350XL User Manual:
"Tune transceiver to 1.8 Mhz. With Dummy Load and Wattmeter connected, set I.F. Gain trim pot to full CCW position. Switch transceiver to CW transmit mode and rotate gain control trim pot in a clockwise direction until a slight decrease in power is noted (2 – 3 watts)."

The 350XL adjustment procedure is recommended, with one caveat. After making the adjustment, check the transmitter's IMD products and further reduce the gain as needed to insure low levels of 3rd and 5th order IMD products. Typical 3rd order IMD products will be about -25 db (-31 db is using the ARRL measurement method).

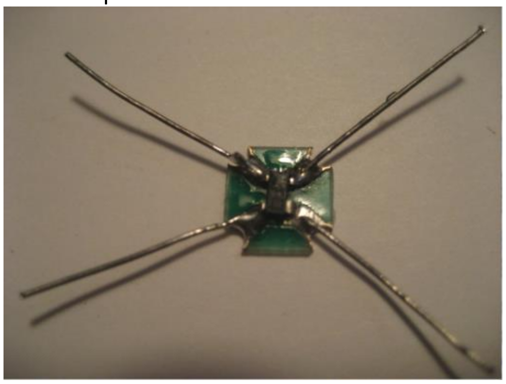
5. HP HSMS-2829 First Mixer

The four 1N4149 first mixer diodes can sometimes be replaced to improve receiver sensiitivty and transmitter carrier balance. The replacement 1N5711 diodes have to be manually matched which can be very labor intensive.

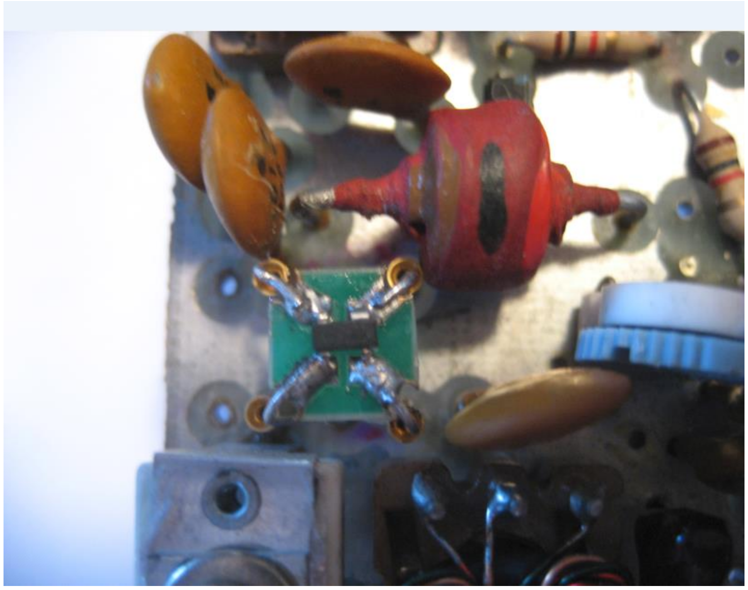
A better replacement is the HP HSMS-2829 quad diode array. These arrays are available on eBay for less than $1.00. To make the replacement easy, a SOT converter board from Mini-Kits can be used.

http://www.minikits.com.au/EME180-PCB?search=eme180

Here is a picture of a HSMS-2829 mounted on the circuit board:



If you install four machine socket pins, then the HSMS-2829 can be mounted in the pins so that no soldering is required.



6. In-Depth Engineering & Testing

Kevin has completed extensive performance testing in these areas. He has posted quite a few articles on the forum dealing with the original design of the radio and recommended solutions to the problems that he discovered.

Benchmarking a standard system
Model: Atlas 210X LE
S/N A1268LE, fitted with a PC120B RF PCB.
Equipment used: Elecraft XG3 with switchable and fixed 10 and 20 dB 50 ohm attenuators
Audio Level meter leader LMV181A AC Mill voltmeter
GW Instek GDS 1072A-U Oscilloscope (70 MHz Bandwidth)
DC Power 12v battery SLA type.

Some initial tests are being done to provide benchmarks. An Elecraft XG3 signal generator was programmed for frequencies in the middle of the bands. The Elecraft XG3 is fitted in a die cast box, and an adjustable 0 to 10 dB attenuator is also fitted inside the box. Connections on the outside of the box are N-type, and tests are done with a LMR240 1.2m cable (LMR cable is double screened) For these tests the box lid was open.

On initial tests, it was found that the audio preamp IC CA3086 was faulty. The first transistor in the array had an open circuit B-E junction. Note the CA3086, and CA3046 are compatible, with the CA3046 being a premium device.

Measurements: S/N at -107 dbm Test 1

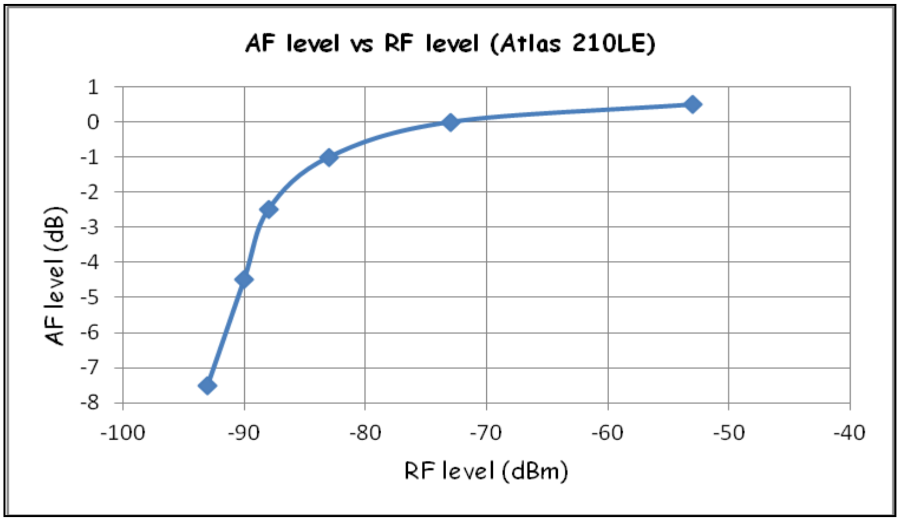
The Leader LMV181A is an average responding AC mill voltmeter, and this type of meter is commonly used.
There are some errors with using average responding meters, and ideally a true RMS meter would provide more accurate results, however it is less commonly available to the home experimenter.

The S/N is calculated from 10 log $_{10}$(10^ ((S+N)/N)/10)-1 MDS is the input level -107 dbm minus the S/N. At a large (S+N)/N, the difference between (S+N)/N and S/N is quite small, however at low (S+N)/N, then the error can be quite large, which can be seen in the table below.

Table 1			
Band	(S+N)/N	S/N	MDS
80M	13.5 db	13.3 db	-120.3 dbm
40M	11.5 db	11.2 db	-118.2 dbm
20M	7.5 db	6.6 db	-113.6 dbm
15M	2.0 db	-2.3 db	-104.7 dbm
10M	3.5 db	0.9 db	-107.9 dbm

AGC Threshold Test 1

The signal is set to the most sensitive band, which is this case is 80M. The XG3 is set to 50uV and the output level noted. The level of the XG3, and attenuators is adjusted until the level falls 3 dB. Measurements will also initially be made at RF intermediate levels to look at the slope (change in AF level vs. RF level). Some AGC systems are very flat, while others like the Elecraft K2 has a noticeable slope.



The AGC threshold (-3dB) appears to be around -89 dbm which is quite high. The level is about 8 uv. The level quoted by the manufacturer is 5 uv or -93 dbm, so this is about 4 dB different.
Although I have made changes to the demodulator circuit (discrete diode mixer), this isn't expected to change the threshold)

The AGC range for the MC1350 IF amp IC is about 65 dB, so with a -89 threshold, then the AGC would run out of range around -34 dbm or 4.5 mV. This typically would result in AF level increase with additional distortion.

Another issue I noticed is that the volume control does not reduce the signal at high levels... I suspect an AGC problem?

Local Oscillator level Test 1

This level is measured with the PC120 fitted to the radio, with a 10:1 CRO probe fitted to the LO pin entering the PCB. The level is measuring using the Oscope. Antenna port of transceiver is terminated with a 50 ohm load.

Table 2					
Band	LO Volts (p-p)	V RMS	Power mW	Pwr dbm (1)	Pwr dbm (50 ohms)
80m	2.70	0.95	9.5	+9.7	+6.5
40m	2.40	0.85	8.5	+9.3	+5.6
20m	2.75	0.97	9.7	+9.9	+6.7
15m	2.16	0.76	7.6	+8.8	+4.6
10m	1.72	0.6	6	+7.8	+2.5

Notes:
There is considerable harmonic content starting at 12 to 15 db down, depending on which band, due to non-linearities in the LO chain. This may cause problems on RX with reception of spurious signals and also on TX with the generation of spurious signals.

Normally, the level of the 2nd harmonic signals/products in balanced mixers is very low, due to the balanced operation of the mixer, however these 2nd harmonics are being generate before they enter the mixer.

Note 1
Voltage was measured on the PC120, before the 47 ohm resistor. The mixer and its 47 ohm resistor looks ideally like~ 100 ohms, so the calculation for power and power dbm (1) is done for a 100 ohm load not 50 ohms. The RF voltage measured will have some error due to the effect of the harmonics only being 12 to 15 dB down.
The last column is calculated from V RMS/2 and assuming a 50 ohm load. One can see a drop in LO level at the higher frequencies which can lead to marginal performance with the mixer using 1N4148 diodes. Which leads me to the next experiment...? Changing the diodes to 1N5711

Changing the mixer diodes
The 1N5711 diodes are commonly available both off EBay and other sources, such as Digikey, Element 14, etc. The threshold of Schottky diodes is lower, and should offer superior performance over the 1N4149 diode.

Table 3				
Band	(S+N)/N	S/N	MDS	MDS vs. Table 1
80M	13.5 db	+13.3 dbm	-120.3 dbm	0 db
40M	12.0 db	+11.7 dbm	-118.7 dbm	+0.5 db
20M	8.0 db	+ 7.3 dbm	-114.3 dbm	+0.7 db
15M	4.5 db	+ 2.6 dbm	-109.6 dbm	+4.9 db
10M	6.0 db	+ 4.7 dbm	-111.7 dbm	+3.9 db

We will see... I will repeat sensitivity and AGC threshold tests, and possibly LO levels, as at higher frequencies, the impact of the Schottky diodes may result in increased loading.

S/N at -107 dbm Test 2
The image below shows the 4 diodes before replacement (to right of image). The 47 ohm on pin 4 of the connector is the LO input.

The results show that at lower frequencies, the effect of the new diodes is virtually nil (zero), however as the frequencies increase the improvement is more noticeable as can be seen on the 15m band.

It is suspected that the 1N5711 diodes, with their lower threshold and reduced capacitance, provide improvement.

Although the results on 10m are a positive it is possible that the low oscillator level compromises the performance a little. The major deterioration in high frequency performance is due to losses in the RX BPF filters (see next page).

A quick AGC test was done at 80m, but no level change was seen, as was expected. However the AGC threshold on the higher bands would be reduced, by the improvement in MDS (or effective gain increase). The LO level was rechecked but difference was only fraction of a dB.

Losses in Rx BPF/LPF/Notch circuits

There appears to be reduced sensitivity of the mixer on 15 and 10m, with the BPF/LPF/Notch losses normalized to 2dB. These extra losses are of the order of 4 to 5 dB... Is this due to LO level or the configuration of the mixer? The MDS on 80 and 40m equates to a noise figure of ~20 dB or ~ 0.7 uv for 10 dB S/N.

Table 4		
Band	Loss	MDS all bands with @ 2 dB BPF loss
80m	2.0 dB	-120.3 dbm
40m	3.5 dB	-120.2 dbm
20m	7.0 dB	-119.3 dbm
15m	8.5 dB	-116.1 dbm
10m	7.3 dB	-117.0 dbm

Below are some (S+N)/N tests by Clint - W7KEC on his collection of Atlas 210X's

Band	Newer LE with TUF-1 mixer	Older LE with TUF-1 mixer	Older LE with HP 1N5711 diodes	210X with HP 1N5711 diodes	210X with TUF-1 mixer
80M	14.0 db	12.5 db	14.0 db	16.5 db	16.0 db
40M	15.0 db	11.5 db	13.0 db	17.0 db	16.5 db
20M	17.5 db	14.0 db	13.5 db	14.5 db	14.5 db
15M	17.5 db	13.5 db	14.0 db	17.0 db	16.0 db
10M	14.0 db	13.0 db	13.0 db	17.5 db	14.5 db
AGC Threshold	-69 dbm	-73 dbm	-69 dbm	-88 dbm	-83 dbm

Notes:
1. Input was -107 dbm from HP8640B signal generator
2. Output was calibrated with Boonton 4220 power meter
3. Heath IM-104 solid state voltmeter was used for audio measurements
4. IF/Image traps were bypassed for newer LE TUF-1 measurements
5. HP 1N5711 diodes were matched for forward current
6. For each measurement, RX BP filters were optimized, along with RX IF coils
7. Standard PC-120 board has two 68 ohm resistors across carrier balance pot

The test results from my own 210X, with modified mixer setup using 1N5711's in conventional mixer configuration.

Table 5	-107 dbm			
Band	(S+N)/N	MDS	BPF/LPF/Notch Loss	MDS using 2 db loss
80m	20.5 dB	-127.5 dbm	-2	-127.5 dbm
40m	20.0 dB	-127.0 dbm	-2	-127.0 dbm
20m	18.5 dB	-125.5 dbm	-3.3	-126.8 dbm
15m	11.5 dB	-118.5 dbm	-10	-126.5 dbm
10m	12.0 dB	-119.0 dbm	-7	-124.5 dbm

Interesting - my own Atlas 210X has an edge on sensitivity on 80 thru 20m bands. This has a high gain IF preamp configuration as well as numerous other modifications. Rx Noise figure about 13 dB on 80 and 40m. Note other tests indicate some of these measurements were in AGC and also the 20-10m BPFs need tuning.

What to do on the LE... I will try optimizing (tuning) the filters for 20, 15 and 10M. The 80 and 40m filters are not tunable.

S/N at -107 dbm Test 3

Table 6	-107 dbm				
Band	S+N/N	S/N	MDS	MDS vs. Table 1	MDS vs. Table 3
80m	13.5 dB	13.3 dB	-120.3 dbm	0.0 dB	0.0 dB
40m	12.0 dB	11.7 dB	-118.7 dbm	0.5 dB	0.0 dB
20m	10.5 dB	10.1dB	-117.1 dbm	+3.5 dB	+2.8 dB
15m	10.0 dB	9.5 dB	-116.5 dbm	+11.8 dB	+6.9 dB
10m	11.0 dB	10.6 dB	-117.6 dbm	+9.7 dB	+6.9 dB

I put a 50 ohm load on the antenna port, and turned the calibrator on and adjusted for maximum S-meter signal on 20, 15 and 10m. A few dB was gained on 20, but 15 and 10M showed large improvements either due to aging, or changes due to diode replacement.

There is approximately 3.5 dB difference between MDS now between bands, of which increased losses in the BPF/LPF notches are responsible at the higher frequencies.

Clint W7KEC mentioned that the preset resistor across the output of the mixer is 500 ohms and should be fitted with 68 ohms across each end to ground. I also noticed the capacitors used to resonate the first tuned circuit after the mixer (seen at the top of image between green topped coil and blue trimmer, are of the lossy type, so they will be replaced as well.

S/N @ -107 dbm Test 4

Reducing balance resistor across mixer output, I placed 2x 68 ohm resistors from the common of the blue 500 ohm preset, (see the top of the picture) to ground.

Table 7	-107 dbm			
Band	(S+N)/N	S/N	MDS	MDS vs. Table 6
80m	17.2 dB	17.1 dB	-124.1 dbm	+3.8 dB
40m	16.2 dB	16.1 dB	-123.1 dbm	+4.4 dB
20m	15.5 dB	15.4 dB	-122.4 dbm	+5.3 dB
15m	15.2 dB	15.1 dB	-122.1 dbm	+5.6 dB
10m	15.5 dB	15.4 dB	-122.4 dbm	+4.8 dB

The improvement is an average of ~ 4.8 dB, so very worthwhile and about 2 dB differences in S/N between bands. Loss was due to a large component of the mixer output, being dissipated in the 500 ohm resistor. There is still a portion of the mixer output being dissipated in the resistor network, so another 1 dB or so could be gained in a different configuration.

Later I will adjust the carrier balance resistor for best 5.645 MHz carrier null on both USB and LSB TX, normally a compromise.

<u>Replacing the capacitors in the LC circuit after the mixer.</u>

The Q of the capacitors across the inductor L124 is low because of the material used. I have located some silver mica capacitors which have superior Q, which should reduce the loss of the tuned circuit. On the LE PC120 board, it was a 200pf and a 1000pF, which Q around 100 and 18 respectively when measured at 300 kHz.

This was tried but the sensitivity improvement was less than 1 dB, probably due to the low Q inductor that resonates the capacitors. The circuit needed to be retuned as the original capacitors were at their extremes of their 10% tolerance.

The S/N gap is narrowing...I will try another modification, which should reduce losses between the crystal filter and the MC1350. The matching is currently done by a resistor in parallel with the MC1350 input, so most of the power is absorbed by the termination. Removing the resistor and matching with a transformer should improve gain significantly.

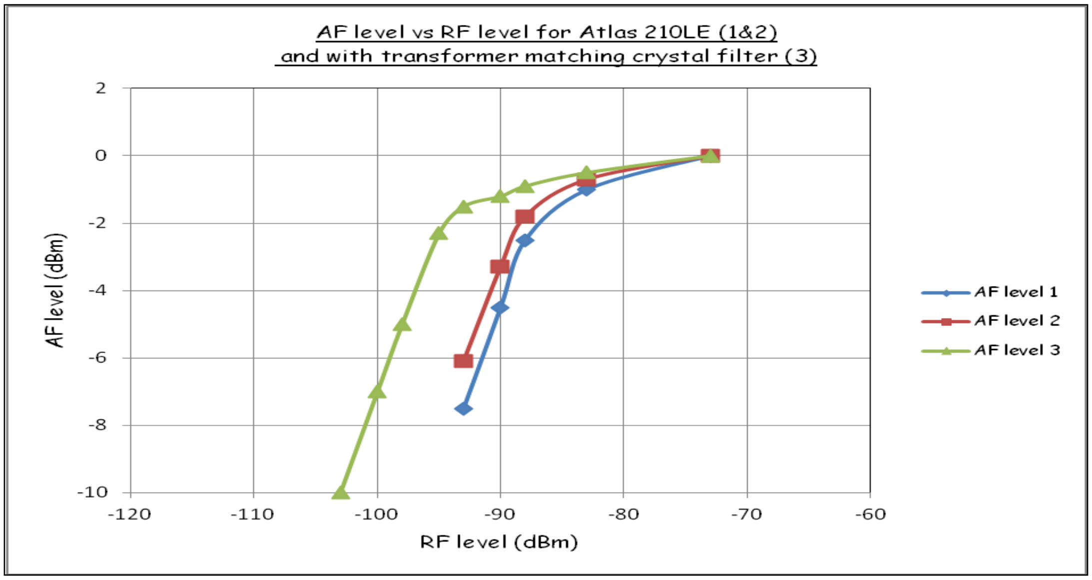
This should reduce the AGC threshold by perhaps up to 7 dB (!), however the improvement in MDS may be marginal, as the gain preceding this stage, should override most of the losses.

There was still a slight improvement in sensitivity of between 1.5 and 2 dB, due to the frontend noise exceeding the IF noise by another 7 dB.

Table 8	-107 dbm				
Band	(S+N)/N	S/N	MDS	MDS vs. Table 7	MDS vs. Table 1
80m	19.0 dB	18.9 dB	-125.9 dbm	+1.8 dB	+5.6 dB
40m	18.0 dB	17.9 dB	-124.9 dbm	+1.8 dB	+6.7 dB
20m	17.2 dB	17.1 dB	-124.1 dbm	+1.7 dB	+10.5 dB
15m	16.8 dB	16.7 dB	-123.7 dbm	+1.6 dB	+19.0 dB
10m	17.2 dB	17.1 dB	-124.1 dbm	+1.7 dB	+16.2 dB

The AGC threshold has dropped by about 7 db as well, so this was a worthwhile move. When a signal is tuned across the pass band, the S-meter moves up and down, indicating some filter ripple. I will do some spectral analysis using a PC audio spectrum analyzer software. I will compare the ripple on my Atlas 210X and this 210 LE.

The AF level 2 AGC plot was done, just before this transformer modification.



B. PC-200 Board
Mic Amp, S-Meter Amp, 2nd IF Amp, & 2nd Mixer

1. Differences between PC200C and PC200D Boards

Note: Some PC200 boards labeled with the "D" option are still using the "C" design.

The following changes were made to the PC200D board:

C214 added from pin 5 of Q201 to ground – 6.8 uf
R211 changed from 27K to 68K
R207 changed from 5.6K to 22K

R208 changed from 68 ohm to 520 ohms
Schematic shows that R208 is grounded
schematic shows that R209 & C214 removed
the real change is that R208 has changed in value and R209 and C214 are still installed

schematic shows R220 and D207 removed with jumper installed across each part location
the real change is that R220 and D207 is removed
jumper is installed across R220
IN270 diode is installed in place of D207

schematic shows R221 removed and a jumper connected across the part location
for the real change, R221 is still installed

2. Receive Sensitivity Measurements

For receiver sensitivity testing, you want the 2nd IF amplifier (MC-1350) to be running at full gain. The gain of this IF amplifier is controlled by the AGC voltage on pin 19 of the PC-200 board.

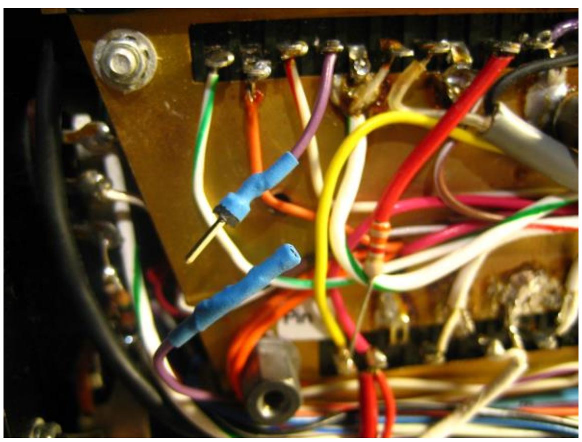
This AGC voltage is derived from the audio signal on the PC-300 board, converted to a DC voltage and fed to the PC-200 board. According to the Motorola spec sheet, the AGC gain range on a MC-1350 is 60 db.

If the idle signal (no RF signal into the radio) AGC voltage is too high, then the measured receiver sensitivity will be less than the actual value. This problem is not usually observed on stock 210X radios, but could be seen on radios that have been modified. The best way to make sensitivity measurements is to completely disable the AGC.

In order to determine if the AGC voltage is reducing your measured receiver sensitivity, then the following tests should be performed.

Disconnect the wire going to pin 19 of the PC-200 board
Measure the receiver's 10 db S/N sensitivity and note the signal generator level – call this M1
Connect the wire to pin 19
Measure the receiver's 10 db S/N sensitivity and note the signal generator level – call this M2
Note the difference between M1 and M2. If there is no difference, then the AGC voltage is not reducing your measured value for receiver sensitivity.
A quick way to disable the receiver's AGC is to install a quick disconnect connector on the wire that goes to pin 19.

Here is picture with the AGC disabled, using the quick disconnect connector:

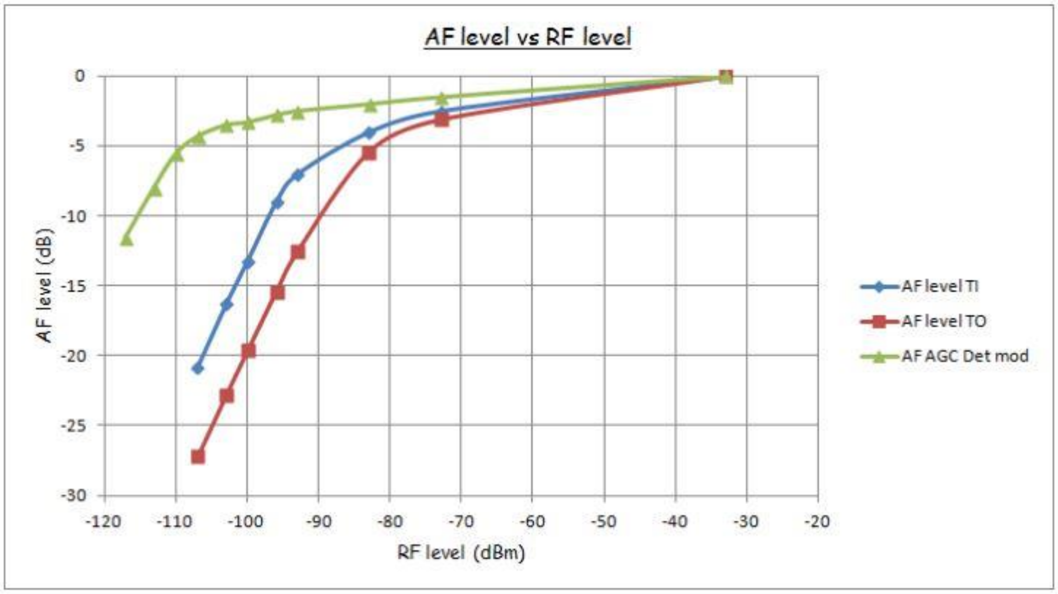


3. AGC – Improved Attack/Release Times

The following changes were recommended by Atlas in a Tech Bulletin and the changes were incorporated on the 210X LE radios. This modification significantly increases the AGC delay times.
This modification is discussed on this link:
http://atlas.wireless.org.uk/mods.htm

On the PC200 card, remove R218 (3k9) and replace with 100R in series with a 1N4148 diode with the cathode (stripe) end towards the edge-connector. Also remove C201 (15uF). Add a 9V Zener across C206, stripe to +.

On PC300 card, change C320 to 47uF (from 15uF), change R315 to 1k5 (from 1k) and change R314 to 1k (from 3k3). Add a 5v1 Zener across R312, stripe to the chip.



4. Summary of possible changes/mod:

Highly Recommended

replace all electrolytic capacitors (very old and suspect)
replace any tantalum capacitors that are suspect of being bad
Check to make sure that L205 has 8 turns of wire on the coil form.

Glue L205 windings to the paper coil form so that the form does not slide out of the windings. The bottom on the coil form needs to be at least 5/32" from the edge of the card.

Replace C221 0.0022uf Mylar capacitor with a high quality 0.0022uf ceramic disc capacitor. This will allow the TX IF Trap to be tuned to 5.645 MHz
Tune IF Trap for null when in TX

Replace R222 with a better quality 1K single turn pot where the adjustment cannot be bumped with your fingers. A multi-turn pot can be used if you can easily get to the adjustment from the top of the radio.

Tune IF transformer L201 for max power out when in TX mode.
Align the S-Meter

OPTIONAL

Remove existing mixer components and install a MCL TUF-1. This change provides improved mixer balance and LO rejection. The change is also needed if a DDS VFO board is installed.

Replace two large 0.1uf ceramic disc capacitors with 0.1 uf monolithic units. These two capacitors stick out like sore thumbs because of their size. Replacing them with smaller capacitors frees up physical space on the ground plane side of the board for additional parts that might be added.

Remove R202. Install a 5K ohm single turn pot in place of R202. This will allow you to get closer to 10db/major division between S9 and S9+50.

Insure that R220 and D207 have been removed. A 1N270 diode should go from Pin 20 on the edge card to pin 10 on Q202.

R219 should remain from Pin 10 to ground. This is the latest AGC change from Atlas on the PC-200D boards and increases the db change between the minor S units (S1 to S9).

Remove Q202 and install low profile IC socket. At some point, you will probably blow out Q202. Having it socketed makes replacement of the IC very easy.

Install audio output transformer between pin 3 of PC-200 and pin 20 of PC-300. This provides an additional 7 dB gain, due to improved impedance matching. There is room on the PC-200 board to mount the transformer or it can be mounted on the chassis.

5. **IF Amplifier**

The IF amplifier IC on the PC-200 board is a MC1350. The operation of this amplifier has a major contribution to the overall performance of the receiver. Here is a link to a data sheet for the IC:

http://rfkits.com/parts/MC1350.pdf

Kits and Parts has a test IF amplifier kit using the 1350, at a very reasonable price. You can use this amplifier for testing various circuit changes that you might want to incorporate into the 210X design. The kit comes with a machined pin socket for the IC. This allows you to easily remove the MC1350 device and insert a MC1349 IC that has about 20 db more gain.

If you install a 5k ohm multi-turn pot to replace 2.2K resistor (R202), then you can vary the gain of the MC1350 amplifier by changing the DC voltage going to pin 5 of the IC. The normal AGC control voltage range is 5 to 7 volts, with a supply voltage of 12 volts and a 5.1K resistor for R202. The actual voltage downstream of R202 would vary between 4.49 to 5.98 volts, based upon AGC supply currents of 0.0001 and 0.0002 ma respectively.

In the 210X, the supply voltage is 10.0 volts, thus the AGC voltage control range on pin 5 would be 4.17 to 5.83 volts. The actual range downstream of R202 would be 3.96 to 5.41 volts.

It is also recommended that you wind the 6 turns of green wire on T1 first. You can then adjust the number of turns of the red wire (input to amp) to match the impedance of your drive signal. You can get up to 5 turns of red wire, with the 6 turns of green wire installed.

Here are details on the test kit:
http://www.kitsandparts.com/mc1349ifamp.php

On later versions of the 210X and 210X LE radios, R203 (3.9 k ohms) was replaced with a single turn 2.5 k ohms pot soldered to the foil side of the circuit board. I have not found any schematics that shows this pot.

Varying the pot from maximum resistance to somewhere close to 0 ohms decreases the gain of the circuit by about 13 db. This was determined by connecting a RMS AC voltmeter across the speaker terminals and measuring the noise level as the pot is varied. The receiver sensitivity did not change as the pot's resistance was varied, but the calibration of the S Meter did change. Atlas did not provide a procedure for adjusting this pot and it is recommended that the pot be positioned for maximum resistance.

C. PC-300 Board
Receiver Audio & Oscillator Switch

1. **Improved Receiver Bass Audio Response**

The following changes are recommended in order to improve the audio bass response of the receiver.

Please note that the changes will slightly degrade the receiver S+N/N sensitivity since there will be more noise power in the audio pass band. On one 210X, I saw the 10 db S+N/N go from 0.40 uv to 0.43 uv after the changes were made.

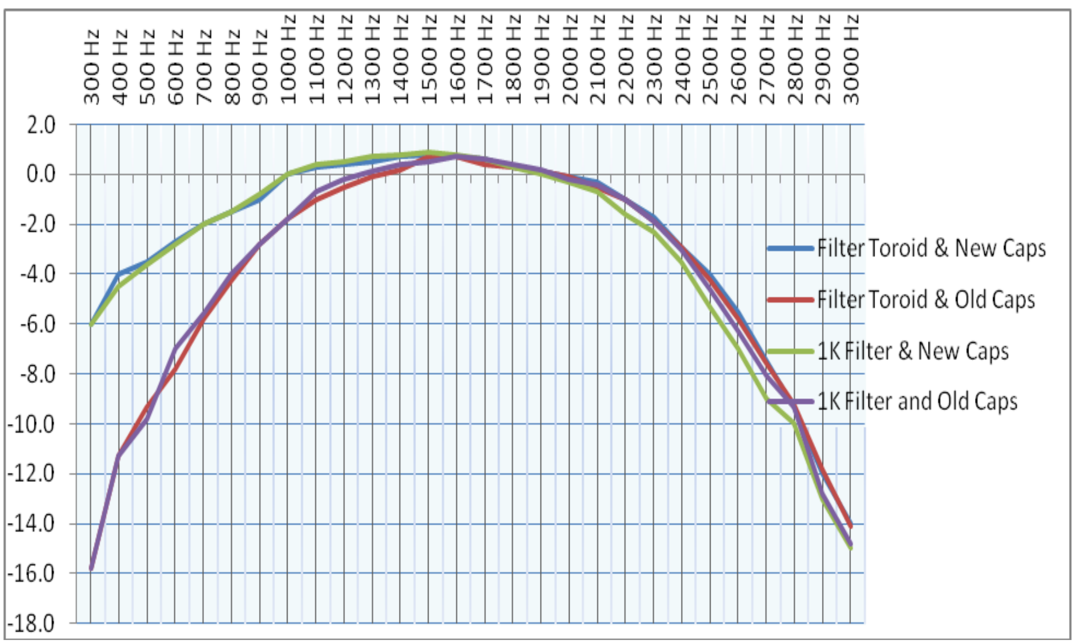
C302
Manual shows a 0.1 uf capacitor on PC-300C board.
Manual shows a 0.02 uf capacitor for PC-300D board.
Replace with a 1 to 2.2 uf capacitor.

C303 on PC-300C Board
C316 on PC-300D Board
Manual shows a 0.22 uf capacitor and a 0.2 uf large green Mylar is installed. Replace with a 1 to 2.2 uf capacitor.

C317 on PC-300C Board
C311 on PC-300D Board
Manual shows a 0.1 uf capacitor. Replace with a 1 to 2.2 uf capacitor.

C320 on PC-300C Board
C315 on PC-300D Board
The manual shows a 250 uf capacitor and a 250 uf capacitor is installed. Replace with a 470 uf capacitor. A modern 470 uf capacitor is physically smaller than the old 250 uf unit.

Here are some test results for before and after for the three capacitor changes. A swept RF frequency was applied to the radio and the speaker audio was measured in db.



D. PC-400C Board

The VFO design in the Atlas radios offered simplicity and low cost, at the expense of frequency instability, high level harmonics, spurious signals, and a course frequency display. Different versions of the Atlas radios have different designs for the VFO, with different transistors and parts.

Other than the transistor differences, some versions coupled the output signal from the emitter of the oscillator and 2nd transistor amplifier. The other version coupled the output signal from the collector of the oscillator and the 2nd transistor amplifier.

There appears to be at least four different versions of the VFO.

Version 1: Early versions prior to June 1975
2N706, 2N3819, and 2N706 for Q401, Q402, and Q403

Version 2: Referenced in Atlas Service Bulletin and Atlas User Manual
Schematic is in the User Manual (5520 KHz IF version)
2N706, MPS6514, and 2N3866 for Q401, Q402, and Q403

Version 3: Schematic is in the User Manual (5645 KHz IF version)
2N4416, 2N4416, and MPS6514 for Q401, Q402, and Q403
The 2N4416 is a JFet transistor.

Version 4: Not documented
Appears to have been used in the later 210X and 210X LE models
2N5486, 2N5486, and MPS6514 for Q401, Q402, and Q403
The 2N5486 is a JFet transistor

It is assumed that the intended changes were to increase the VFO injection level to the receiver first mixer in order to improve receiver sensitivity on 15M and 10M. The unintended changes appear to be increases in spurious signals in the output.

The VFO signal from the 2nd transistor amplifier appears to be distorted – with clipping and distortion products on the lower half of the sine wave.

On a 210X with the latest VFO version, the sine wave is very pure on the output of the oscillator transistor and becomes distorted in the amplifier chain.

Here is the measured outputs on the oscillator:

80M 2.4 V pp 11.5 dbm
40M 2.3 V pp 11.2 dbm
20M 2.35 V pp 11.4 dbm
15M 2.1 V pp 10.4 dbm
10M 1.7 V pp 8.6 dbm

According to an Atlas factory service bulletin, the minimum required VFO injection level is 0.4 v RMS (+5 dbm).

It appears that Q403 is being over-driven, resulting in a distorted sine wave on the output. Changing Q403 to a 2N2222 transistor results in several db of additional headroom and the output signal is no longer distorted. The actual load on the VFO output by the FET switches is about 150 ohms. This was determined by measuring the VFO signal on Pin 4 of the rear accessory socket.

The jumper wire between pins 3 and 4 was then removed and a resistor was placed to ground and pin 4. A 150 ohm resistor resulted in the same signal level as when the VFO was connected to the FET switch (jumper between pin 3 and 4 installed).

BAND	Center Frequency	Signal Generator Output on Pin 2 of ACC socket	2^{nd} Harmonic	3^{rd} Harmonic	210X VFO 2^{nd} Harmonic	210X VFO 3^{rd} Harmonic
80M	9.395 MHz	4.0	-48 dbm	-35 dbm	-26 dbm	-25 dbm
40M	12.795 MHz	4.0	-48 dbm	-34 dbm	-25 dbm	-22 dbm
20M	8.505 MHz	4.0	-48 dbm	-33 dbm	-30 dbm	-30 dbm
15M	15.580 MHz	4.0	-48 dbm	-30 dbm	-31 dbm	-25 dbm
10M	22.855 MHz	4.0	-43 dbm	-30 dbm	-25 dbm	-22 dbm

BAND	Center Frequency	Output Factory Stock pp volts	2^{nd} Harmonic Factory Stock	3^{rd} Harmonic Factory Stock	Output 2N2222 Q403	2^{nd} Harmonic	3^{rd} Harmonic
80M	9.395 MHz	5.6	-21 dbm	-18 dbm	5.8	-26 dbm	-25 dbm
40M	12.795 MHz	5.0	-23 dbm	-21 dbm	5.8	-25 dbm	-22 dbm
20M	8.505 MHz	5.9	-22 dbm	-16 dbm	5.8	-30 dbm	-30 dbm
15M	15.580 MHz	4.5	-23 dbm	-21 dbm	5.6	-31 dbm	-25 dbm
10M	22.855 MHz	3.8	-22 dbm	-13 dbm	5.3	-25 dbm	-22 dbm
BAND	**Center Frequency**	**Output Factory Stock pp volts**	**2^{nd} Harmonic Factory Stock**	**3^{rd} Harmonic Factory Stock**	**Output 2N3866 Q403**	**2^{nd} Harmonic**	**3^{rd} Harmonic**
80M	9.395 MHz	5.6	-21 dbm	-18 dbm	4.9	-26 dbm	-25 dbm
40M	12.795 MHz	5.0	-23 dbm	-21 dbm	4.8	-25 dbm	-22 dbm
20M	8.505 MHz	5.9	-22 dbm	-16 dbm	4.9	-35 dbm	-37 dbm
15M	15.580 MHz	4.5	-23 dbm	-21 dbm	4.8	-32 dbm	-35 dbm
10M	22.855 MHz	3.8	-22 dbm	-13 dbm	4.5	-25 dbm	-35 dbm

E. PC-500 Board

Pre-Amp, Driver, & Power Amp

These circuits have used the same basic design from the initial 210/215 radios to the final 210X/215X LE radios produced in 1979. Different versions of transistors have been used for the PA driver and the final PA transistors. As noted previously, a schematic of the LE PA circuit was never made available, but the 210X schematic can be used for trouble-shooting LE issues.

When making any transmitter power output measurements and adjustments, be sure to carefully note the DC voltage at the input to the radio. Less voltage means less power out.

Note: If R522 (SWR Protect) on the PC-500 board is not adjusted properly, you could see substantial lower output power levels in your testing.

Here are the Atlas published specs for the 210X radio:

Supply Voltage	Minimum Spec.	10 Meter Minimum
13.6 volts	80 watts	50 watts
13.0	73	45
12.5	67	42
12.0	62	39
11.5	57	35

1. **Similar PA Designs**

A number of manufacturers have used a push-pull RF amplifier design very similar to what was used in the Atlas transceivers. These designs can be used for situations where you need to install new PA transistors in an Atlas 210X model.

Here is some comparison data on the designs:

RADIO	***PA***	***Base to Ground***	***Collector To Base Feedback***	***Collector To Ground***	***RF Input Cap***	***Driver Xformer Cap***	***Driver Resistor***	***Output Xformer Cap***	***Antenna Out Cap***
210X	CD2545	4.7 ohms	none	330 pf	None	None	none	none	100 pf
210X LE	MRF454	10 ohms	none	330 pf	None	820 pf	none	none	100 pf
400X	SD1405	10 ohms	0.1 uf + 34 ohms	none	100 pf	620 pf	10 ohms	1300 pf	none
Kachina	SD1405	10 ohms	0.1 uf + 34 ohms	none	100 pf	620 pf	10 ohms	1300 pf	none
AN EB63	MRF454	10 ohms	none	330 pf	18 pf	1100 pf	none	910 pf	24 pf
TT 535	SD1405	none	0.01 uf + 47 ohms	none	220 pf	2300 pf	54 ohms	1640 pf	none
RM HLA150	SD1446	10 ohms	0.047 uf + 68 ohms	220 pf	150 pf	940 pf	none	1300 pf	47 pf

Notes:
Most of the designs use either 3 or 4 turns on the driver transformer and the output transformer.

2. **Bias Regulator**

The bias regulator on the PC-500 board provides base current for the final output transistors. The output transistors need to operate in class AB (as opposed to class A or class B).

Per the Atlas alignment instructions, class AB is established by adjusting the TX current, in the TX idle mode, somewhere between 0.25 to 0.5 amps of current, using the front panel meter.

The PA transistors need to be in full conductance for all of the RF cycle when RF drive is applied. As the transmitter power increases, the amount of base current increases.

Too little base current results in the PA transistors being cut-off during a portion of the RF cycle. This results in degraded 3rd order and 5th order IMD products. If the base current is too high, then the PA transistors will run hotter when in the transmit mode. There are a large number of radios that use PA designs that are similar to the 210X. The recommended amount of base current in the idle mode varies between 200 ma, up to 1000 ma.

The actual amount of required base current can be calculated based upon the amount of collector current during max power output and the Hfe of the transistors. With a collector current of 15 amps, and a Hfe of 20, then the base current would be about 750 ma. This means that the bias voltage regulator needs to maintain base current up the 750 ma area.

The nominal base voltage to the PA transistors is about 0.65 volts. If the base voltage starts to decrease, as RF power is increased, then the PA transistors may not stay in class AB.

The bias regulator in the 210X is actually quite good, considering the simplicity of the circuit. Here are some test readings for various bias regulator designs:

All tests were made with a supply voltage of 13.6 volts.

Bias Load	210X	EB63 Amp	Diode + Resistor	LM723
Idle	300 ma @0.69 v	130 ma @ 0.65 v	70 ma @0.65 v	33 ma @0.65 v
20 ohm load	328 ma @0.69 v	153 ma @0.61 v	80 ma @0.55 v	33 ma @0.65 v
10 ohm load	363 ma @0.69 v	162 ma @0.54 v	90 ma @0.45 v	65 ma @0.65 v
5 ohm load	419 ma @0.67 v	176 ma @0.44 v	100 ma @0.35 v	130 ma @0.65 v
2.5 ohm load	533 ma @0.64 v	174 ma @0.29 v	111 ma @ 0.23 v	260 ma @0.65 v
1.5 ohm load	644 ma @0.58 v	156 ma @0.18 v	118 ma @0.16 v	427 ma @0.64 v
1.0 ohm load	786 ma @ 0.55 v	Not measured	Not measured	640 ma @ 0.64 v

The bias circuit used in the Kachina KC103 transceiver appears to be an improvement over the 210X unit. A 78L08 regulator was used to drive the base of the pass transistor.

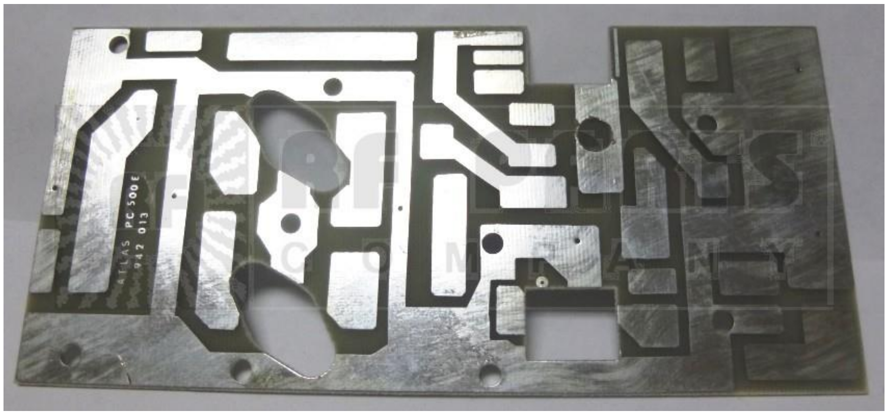
3. PC-500 RF Transistors

Repair of the PC-500 board is probably one of the most technically challenging areas of the radio. Repairs vary from replacing shorted capacitors, open resistors, and open RF chokes, up to having to replace the final driver transistor or the final PA transistors. The original 40582 driver transistor is no longer available and I have not seen any details of providing a replacement TO-220 transistor that would work.

The LE model used a different driver design and there appears to be two different versions. Early versions used the MRF-497 and later versions used the MRF-476. Different circuit board layouts were used for each transistor model.

Both of these driver transistors are still available on secondary markets. The 2SC2166 is supposed to be direct replacement for the MRF-497. The 2SC2075 is supposed to be a direct replacement for the MRF-476.

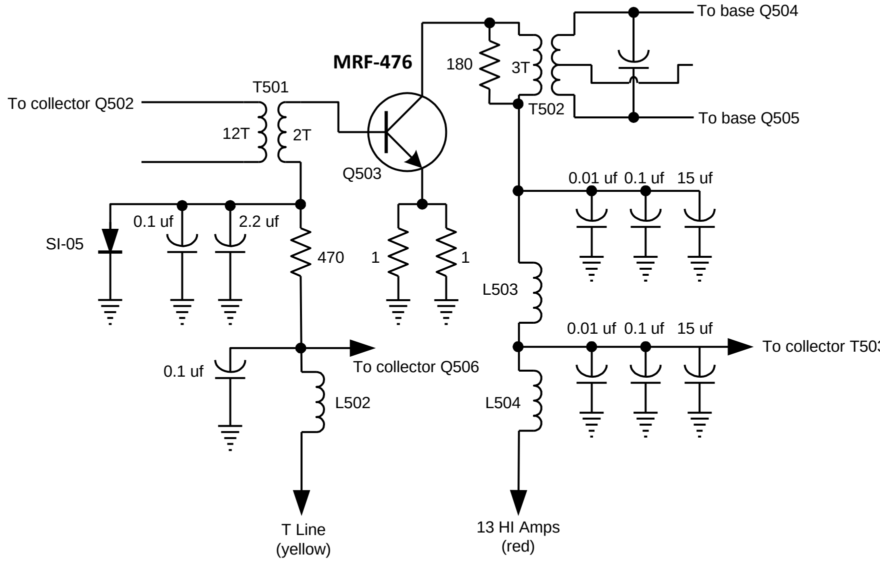
Here is the layout for the latest LE board (PC-500E):



This circuit board is available from:
http://www.rfparts.com/pc500e.html

This is the latest PC-500 board that was produced and used the MRF-476 for the driver transistor. The circuit for this board is almost identical to a standard 210X radio that used the 40582 transistor.

Atlas continued the design with a fixed bias adjustment for the driver transistor. This bias voltage is created by the 0.6 volt drop across the SI-05 diode on the base of the transistor. This resulting bias voltage is supposed to produce about 30 ma of drive current.
Here is the schematic for the LE driver:



The original final PA transistors were the CD2545. This transistor is no longer available. The common recommended replacement is the MRF-454. This transistor is available on the secondary markets for about $90 for a matched pair. The new HF SuperPacker Pro 100W V2 amp from Virgil K5OOF uses this transistor. A replacement for the MRF-454 is the SD1405.

A matched pair of this model can be obtained on eBay for less than $50. Regardless of the model of transistor used, the two transistors need to be matched for idle current draw since there is a single bias adjustment.

Here are links to the SD1405 and MRF454s:

http://www.st.com/web/en/resource/technical/document/datasheet/CD00000613.pdf
https://www.macomtech.com/datasheets/MRF454.pdf

The Motorola RF Power amplifier described in Engineering Bulletin EB63 is almost identical to the final power amplifier used in the Atlas 210X radio and even more so with the 210X LE model.

http://www.communication-concepts.com/index.php/amplifiers/eb27a/eb63a.html

The Ten-Tec Delta 535 used the SD1405s in the PA. On page 4-12, you will find the schematic of the PA.

http://www.tentec.com/content/downloads/manuals/Argonaut%20II%20535%20Delta%20II%2053 6%20Manual.pdf

The 454s were used in the 210X LE model. There have been a number of postings about installing MRF-454 transistors and power output issues. I started comparing the 210X PA circuitry with the Motorola EB63 power amplifier design. Here is what the Atlas LE addendum stated:

"The Limited Edition model is now rated at 250 watts P.E.P. input and CW input on 160, 80, 40, 30 and 15 meters. 10 meters is rated at 150 watts P.E.P. input and CW input. This power increase over the standard 210X/215X has been accomplished by changing the final amplifier circuit design."

An inspection of the PA-500 circuit board reveals the following differences from a standard 210X radio:

Q503 (40582) replaced with a MRF-476 transistor (TO-220 case). There are some minor changes in the parts surrounding the MRF-476.

There are 3 coil turns on the primary transformer going to the collector of the MRF-476. The standard 210X has 4 turns. There is a silver mica capacitor across the secondary of the transformer on a LE model. There is no capacitor on a standard 210X.

The LE design incorporates negative feedback between the collector and base of each PA transistor. This consisted of a 1 watt 100 ohm resistor in series with a 0.1 uf 100 volt capacitor.

Different PA output transistors
There are 3 turns of wire on the 210X and the LE output transformers. On the driver transformer, the 210X has 4 turns of wire on the primary and the LE has 3 turns. The Motorola EB63 type designs using the MRF-454s have 3 turns on the driver transformer and 4 turns on the output transformer.

It appears that Atlas used different core materials on the output transformer on the LE model. On the LE output transformer, there are two separate cores for each half of the transformer. The cores were made up of two single cores – 19 mm and 6 mm. On a standard 210X, there are two separate cores – 12.5 mm and 12.5 mm. I put a two turn loop of wire on the transformers and measured the inductance:

LE: 3.62 uh output transformer and 1.6 uh input transformer
210X: 2.28 uh output transformer and 1.6 uh input transformer

As previously referenced, I had the unplanned opportunity to replace a bad set of CD2545 transistors with a pair of SD1405s. Initially, the power out was lower than the original values on most bands.

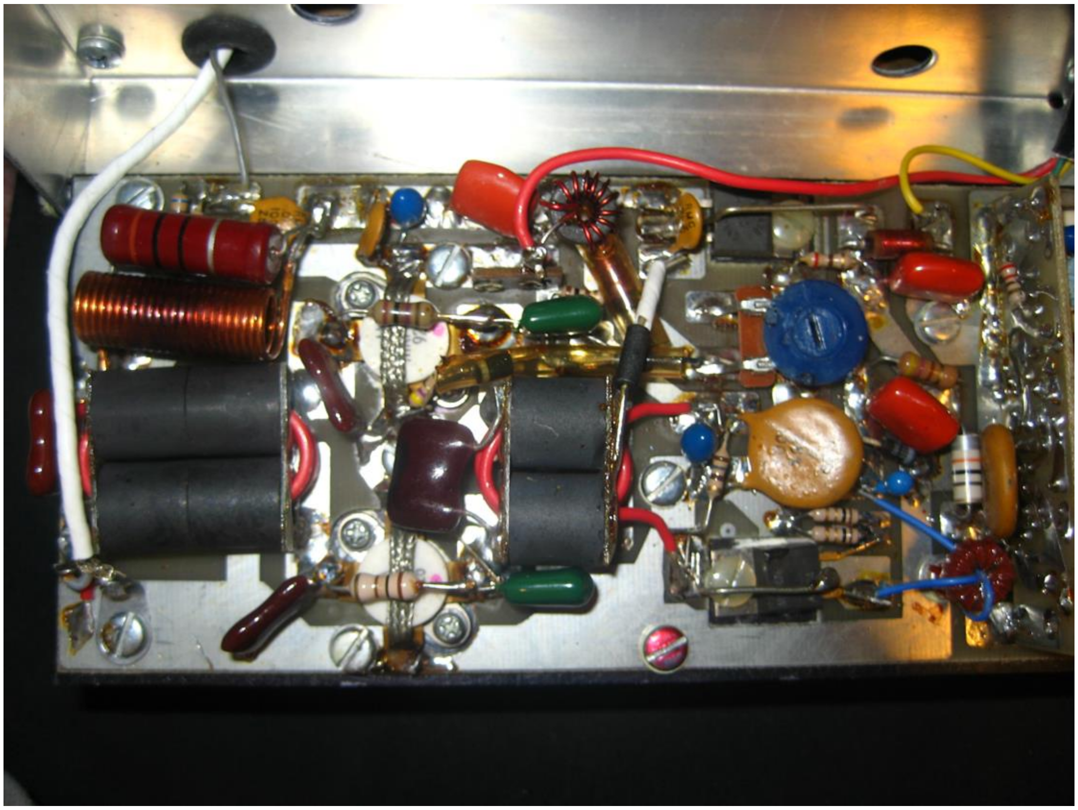
Here are the changes that were needed to restore normal power:

Installed 4 turns of #16 gauge Teflon silver plated wire on the output transformer (about 16” long).
The OD of the wire’s insulation jacket cannot exceed 0.092” in order to get 4 turns on the core
The OD of the original Atlas #16 gauge wire is 0.070”
Installed 3 turns of #16 gauge Teflon silver plated wire on the driver transformer – about 9” long
Installed a 820 pf silver mica capacitor on the output of the driver transformer
Installed a 220 pf silver mica capacitor in parallel with C505 (the original SM cap was 120 pf)
Increased PA bias current to 500 ma
Changed the base to ground resistors on the SD1405s from the original 4.7 ohms to 10 ohms
Added RF grounds across the top of the PA transistors. The LE model uses a flattened coax braid shield to go from one ground pin of the PA transistor to the other ground pin.

With these changes, I was able to get back to 100+ watts out on 80M to 15M and 65 watts on 10M, at a supply voltage of 13.4 VDC. At a supply of 13.8 VDC, the output would approach a LE output. It was also observed that the signal was cleaner on the 15M and 10M bands, when viewed with an oscilloscope at the output of the PC-500 board.

The following changes, as referenced in the EB63 doc, need to be tested out:

Increase value of capacitor on secondary of driver transformer from 810 pf to 1100 pf
Add 910 pf silver mica capacitor to primary winding of output transformer
Here is a picture of a 210X LE PA module:



4. **PC-500 Testing Checkpoints**
A common reported problem with the Atlas transceivers is lower than expected power output, especially on 10 meters. There are a number of other transceivers that use almost identical PA designs as the 210X, yet they have a spec of 100 watts out 80 through 10 meters.

The Communication Concepts EB63 amplifier was assembled with the K5OOR 100 watt low pass filter. SD1405 transistors were used in place of the MRF454 units. This config allowed an apples-to-apples comparison between the EB63 and my 210X with SD1405 transistors. The EB63 amp met published specs – 140 watts out on 80 through 15 meters and +100 watts out on 10 meters. At 100 watts out, the EB63 amp had a 3rd order IMD of -25 db, which is about the same as the 210X.

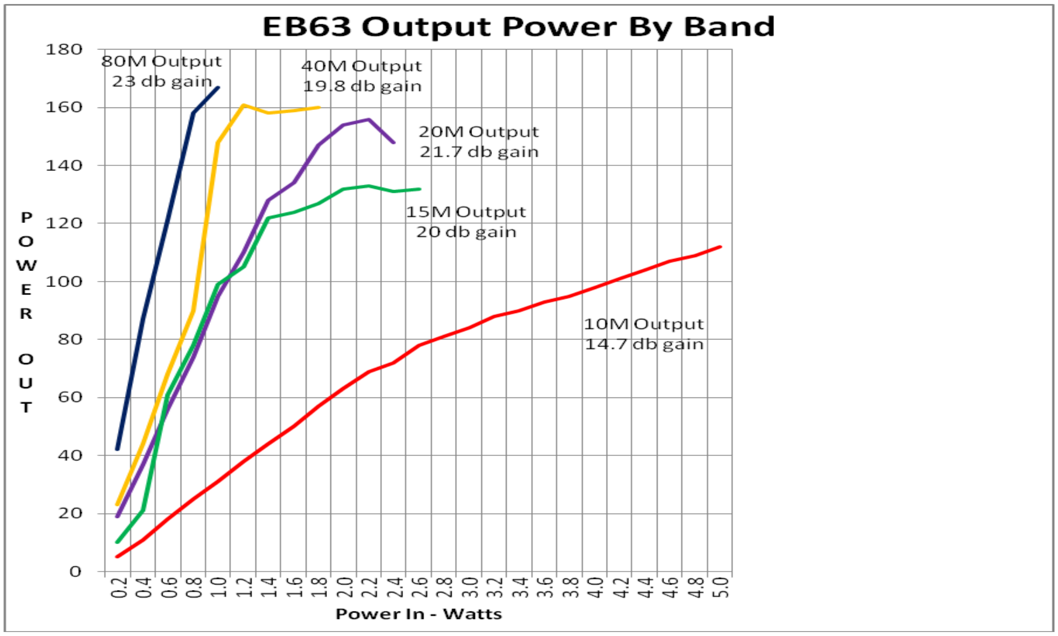
Here are possible areas that need further investigation to determine why the 210X is limited on the power out, when compared with an EB63 amp.

Bias voltage on 210X drops off at higher drive levels. Varying the bias voltage on the EB63 amp changed the power output gain between 16 db to 20 db.

210X does not provide enough RF drive level to the PA transistors.

The PA output transformers could have different specs between the two amps, even though they appear to be identical physically and have the same number of secondary turns.

The insertion loss on the 210X 10 meter low pass filter may be higher than the EB63. Here is a chart that shows the RF output from an EB63 amplifier. The 210X radio should be able to provide the same amount of output, if the same drive level is applied on each band:



Here is 20M IMD test data for the EB63 amplifier:

Flex 1500 Power Out	Flex 1500 3rd Order IMD	EB63 Power Out	EB63 3rd Order IMD
100 mw	-42 db	12 watts	-32 db
200 mw	-42 db	23 watts	-34 db
400 mw	-42 db	45 watts	-34 db
800 mw	-42 db	93 watts	-30 db
900 mw	-42 db	126 watts	-26 db
1000 mw	-42 db	152 watts	-26 db

The 3rd order IMD products on a 210X at 100 watts out is about -25 db. Please keep in mind that the driver signal to the 210X final PA contributes to this -25 db signal. Here is an example calculation to show why that is true:

Assume that the driver signal to the final PA transistors is 1 watt and has a 3rd order IMD of -30 db. That would put the IMD signal at 1 mw. After coming out the amp (with 20 db of gain), this signal becomes 100 mw. Assume that the final PA puts out 100 watts with 1 watt of drive and that the 3rd order IMD is -30 db with a perfect driving signal. That would put the IMD signal at 100 mw. So the final IMD signal out of the 210X amp will be 200 mw or -27 db.

F. PC-600 Board
Carrier Oscillator

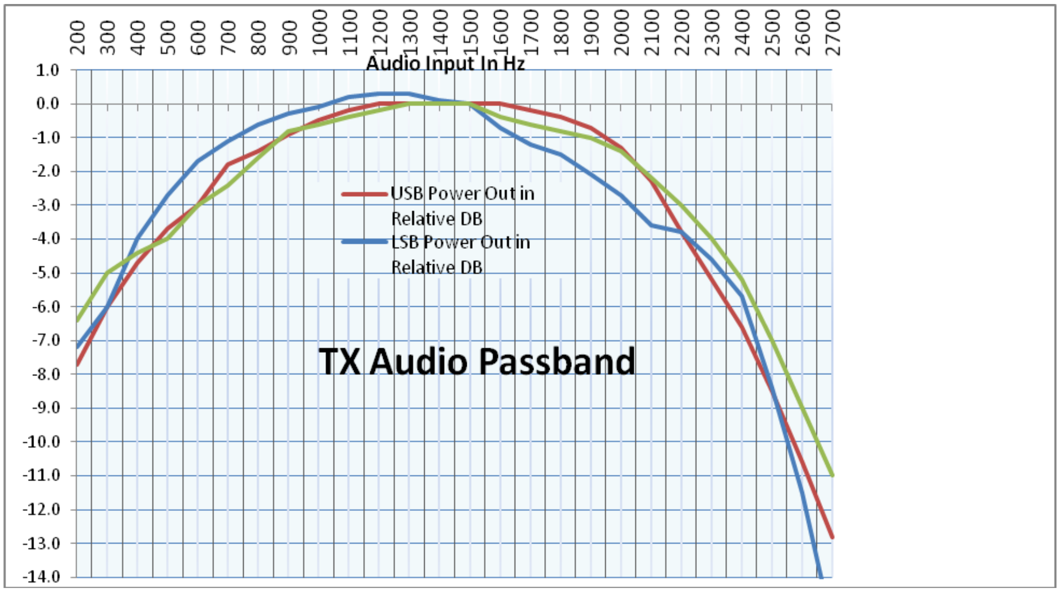
There are three alignment points for the carrier oscillator – CW, USB, and LSB. On a 5645 Khz IF radio, the carrier frequencies could be tuned as follows:

NOR: 5644.700 Khz to 5645.200 Khz (standard setting = 5645.000 Khz)
OPP: 5648.200 Khz to 5649.300 Khz (standard setting = 5648.300 Khz)
The set point is to get a reference power level with a 1500 Hz audio signal to the mic jack and then adjust for a 6 db power decrease at 300 Hz.

Please keep in mind that this adjustment will affect the transmitter audio pass band and also the receiver audio pass band.

The original specs for the 210X showed an IF pass band of 2.7 KHz at the -6 db reference points. We have not been able to obtain that response in the testing that we have done on various radios.

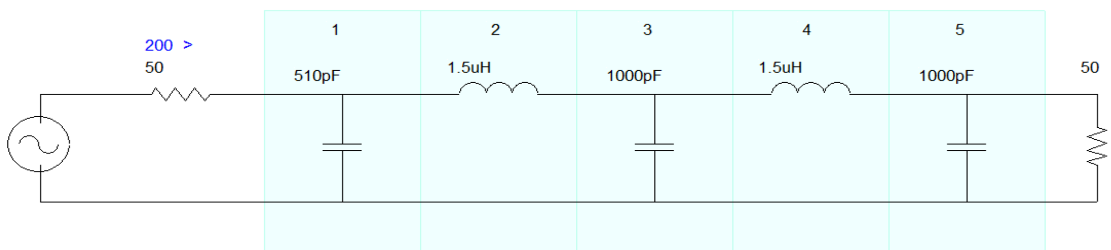
The bandwidth shown in this graph is pretty typical of what we see for receive and transmit – about 2.0 to 2.3 KHz.



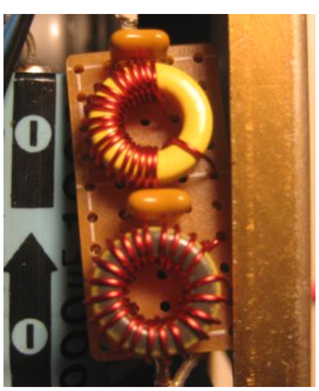
The output signal from the carrier oscillator board has high signal levels for the 2nd (-28 dbm), 3rd (-18 dbm), and 4th (-42 dbm) harmonics. On 10 meters, there is a very strong spur at 28.226 MHz. This is a result of the 3rd harmonic mixing with the VFO signal to create the strong spur.

3 x 5645 = 16935 22581 – 16935 = 5646 KHz

Installing a simple pi low pass filter in the output coax lead of the carrier oscillator will reduce the signal level of the harmonics. The 510 pf capacitor is the existing C613 on the carrier oscillator board.



Here are pictures of the low pass filter board:



G. PC-810 Board

Receiver Input Tuning

The PC-810 board contains the receiver band pass filters. It appears that no changes have been made to this board during the lifespan of the 210, including 210X LE model. Higher than normal insertion losses between the antenna jack and pin 1 on the PC-120 board results in reduced receiver sensitivity. Insertion loss checks can be made with a signal generator and spectrum analyzer. A high signal level will be needed in order to see a usable signal on the spectrum analyzer. A typical signal injection level would be about -20 dbm to -10 dbm. Insure that you do not have signal leakage past components. This can be done by dropping the signal level in 10 db increments and checking that the measured reading also drops by 10 db.

The measurement checkpoints would be at the antenna jack SO-239 pin and pin 1 on the PC-120 board. There are no active components between these two checkpoints, so the high signal level should not create any signal compression issues.

Here are some typical losses on a 210X radio:

BAND	Frequency Range	LOW BAND	MID BAND	HIGH BAND
80M	3.5 – 4.0 MHz	-1.6 db	+1.0 db	-1.6 db
40M	7.0 – 7.350 MHz	+1.4 db	+1.0 db	0.0 db
20M	14.0 – 14.350 MHz	-6.0 db	-4.0 db	-5.4 db
15M	21.0 – 21.450 MHz	-1.4 db	-1.0 db	-2.1 db
10M	28.0 – 29.0 MHz	-3.4 db	-1.0 db	-3.4 db

NOTES:

The mid-band readings for 80M & 40M are probably the results of impedance mismatches

The 20M reading appears to be typical for Atlas radios & is probably due to the band pass filter design.

If you see normal insertion losses on each of the bands, then you know that these components are all working good. A separate set of checks were made on a RX band pass board that was removed from a 210X radio. A tracking generator was used for the tests.

The output of each filter was terminated with a 10 db pad and a 50 ohm load. The tuning slugs on each band (20M, 15M, and 10M) was then adjusted for minimum loss.

The 210X was designed for operation outside of the amateur radio bands. Thus, the receiver band pass filters were wide-banded. Consolidating info from several different Atlas documents, the receiver would operate in the following frequency bands:

4 3000 – 5300 KHz
7 5900 – 10,000 KHz
14 13,800 – 14,900 KHz
21 20,600 – 21,600 KHz
28 27,500 – 30,000 KHz

If you have a 210X LE radio, then all of the TX/RX IF Trap/Image filter coils will need to be reworked because of incorrect factory assembly (coils would not tune to correct frequencies).

With a little more work, one can build out a new RX band pass board so that the PC-1200 board can be completely eliminated.

The overall receiver 10 db S+N/N depends upon these factors:

Antenna Relay on PC-1100 board

PC-1010 Low Pass Filter

PC-1010 Low Pass Filter switch contacts

Receiver band pass filter switch contacts
PC-810 Receiver Band Pass Filters
PC-1200 Image Traps for 80M, 40M, and 10M
PC-1200 IF Traps for 20M (two traps)
Conversion loss of first mixer
VFO signal level into first mixer
Gain of first IF amplifier

The following data shows the impact of not having enough VFO injection into the mixer:

The following test process was used:
Inject a low level signal (1 uv or less) into antenna jack and note the S+N/N on your AC voltmeter.
I used a an Elecraft XG2 signal generator set for 20M and 1 uv signal out

Use a stable signal source with a variable level output for the VFO signal source.
I used my HP 8647A for my initial signal tests and then used the DDS VFO
Remove the jumper between pin 2 and pin 3 on the accessory jack of the 210X
Connect the VFO signal source to pin 2 of the accessory jack
Set the VFO signal source to +13 dbm
Record the S+N/N levels while reducing the VFO signal in 1 db increments

Here is what I measured on my 210X radio:

VFO Signal Level	S+N/N ADE-1 Mixer – HP 8647A VFO	S+N/N Std PC120 Mixer with 5711 diodes – HP 8647A VFO	S+N/N ADE-1 Mixer – DDS VFO	S+N/N Std PC120 Mixer with 5711 diodes – DDS VFO
+10 dbm	12.0 db	10.0 db		10.0 db
+9 dbm	12.0 db	10.0 db		10.0 db
+8 dbm	12.0 db	10.0 db	12.0 db	10.0 db
+7 dbm	12.0 db	9.5 db	12.0 db	10.0 db
+6 dbm	12.0 db	9.5 db	12.0 db	10.0 db
+5 dbm	12.0 db	9.5 db	12.0 db	10.0 db
+4 dbm	12.0 db	9.5 db	12.0 db	9.5 db
+3 dbm	12.0 db	9.0 db	12.0 db	9.0 db
+2 dbm	12.0 db	8.0 db	11.5 db	7.5 db
+1 dbm	11.0 db	5.5 db	10.5 db	5.5 db
0.0 dbm	10.5 db	5.5 db	9.5 db	4.0 db
-1.0 dbm	10.0 db	4.0 db	8.5 db	2.0 db
-2.0 dbm	8.0 db	3.0 db	6.0 db	1.0 db
-3.0 dbm	7.0 db	2.0 db	4.0 db	0.5 db
-4.0 dbm	4.5 db	1.0 db	3.0 db	0 db

The TUF-1 and ADE-1 mixers have a saturation level of about +1.0 dbm. The 1N5711 mixer has a saturation level of about +4.0 dbm. Once the saturation level is reached for a given mixer, then any increase in signal level from the VFO source will not increase the level at the LO pin on the mixer.

H. PC-900 Board

Transmitter Input Tuning

This board has the transmitter band pass filters – one filter for each band. There are also two IF Traps on this board – one for 40M and one for 80M. Any unusual losses in these filters can have a dramatic effect on the transmitter RF output power at the antenna jack.

For example, one extra db of loss can reduce the output power by 20 watts, assuming a nominal power output of 100 watts.

On later versions of this board, equalizing pots have been installed on the 80M – 15M bands. These pots replace the fixed resistors shown on the schematics. The 80M and 40M pots are 50 ohms and the 20M and 15M pots are 500 ohms.

Atlas did not provide any documentation as to how these pots should be adjusted. On the later radios, it was easy to get more than 100 watts of output power on 80M through 15M. Unfortunately, running at these higher power levels usually produces severe IMD products. It is recommended that the equalizing pots be adjusted for a max output power of about 90 watts on each of the four lower bands. You do not have to worry about 10M since a normal output power on this band was 50 to 70 watts.

I. PC-1010 Board

Low Pass Filters

This board has the low pass filters – one for each band. The 80M to 15M filters are on one board and the 10M filter is on a separate board. Two separate boards were needed because of the physical location of the band switch wafer. The output of this board connects directly to the antenna jack via the antenna relay on the SWR board. Thus, the board is in the output of the PC-500 board in transmit and is the input to the PC-120 board in receive.

The filters are conventional design with silver mica capacitors and toroid coils. All ferrite cores are 0.5" OD, yellow for 10M to 20M, and red for 40M and 80M. The board should be relatively problem free – i.e. the insertion loss for each band should be about the same as the values when the radios were manufactured.

The values of the silver mica capacitors and toroid coils installed on the boards may not match with what you see on the schematic. Example: The schematic shows the two 15M coils to be 0.32 uh. On my test unit, one coil was 0.32 uh and the other one was 0.48 uh (same as the 20M coil). This combination actually improved the 2nd harmonic attenuation, compared with an Elsie plot using the schematic values.

210 Low Pass Filter

210X LE Low Pass Filter

The main purpose of the low pass filters is to reduce the 2nd and 3rd harmonic signals to values specified by the FCC and to reduce the level of any spurious signals that might have a frequency greater than the 2nd harmonic frequency of the operating band. A secondary benefit is reducing receiver signal overload from received signals that are at, or greater, than the 2nd harmonic of the operating band.

Here is the FCC Part 97 requirement for RF emissions:

For transmitters installed after January 1, 2003, the mean power of any spurious emission from a station transmitter or external RF power amplifier transmitting on a frequency below 30 MHz must be at least 43 dB below the mean power of the fundamental emission.

For transmitters installed on or before January 1, 2003, the mean power of any spurious emission from a station transmitter or external RF power amplifier transmitting on a frequency below 30 MHz must not exceed 50 mW and must be at least 40 dB below the mean power of the fundamental emission.

For a transmitter of mean power less than 5 W installed on or before January 1, 2003, the attenuation must be at least 30 dB. A transmitter built before April 15, 1977, or first marketed before January 1, 1978, is exempt from this requirement.

Since the Atlas 210X was first marketed prior to January 1, 1978, then it would appear that there are no emission requirements to be met. However, good engineering practices would dictate that all spurious emissions should be down at least 40 db.

It is possible to have good suppression of spurious signals and still have higher than normal insertion losses in the low pass filters. High losses will result in reduced power output and lower receiver sensitivity.

Measuring the actual insertion loss on each band, with the filters installed in the radio, can be difficult. Kevin has detailed modeling graphs on the Atlas210x-215x Yahoo forum that shows the predicted losses (using Elsie app) on each filter. The document can be found on the forum under:
Files\Information from ZL1UJG\Filters\LPF Plots.zip

If you find that your transmitter power out is down on one band from factory specs, and/or your receiver sensitivity is reduced on the same band, then you could have a problem with a low pass filter or the attendant interface wiring, band switch contacts, etc. There is no easy way to accurately measure the insertion loss of a filter. The loading of the probe will shift the actual signal level that you are measuring.

You can get some relative readings with a scope or spectrum analyzer, but they usually will not be accurate. However, relative readings are all that you need to find a bad filter.
For accurate readings, you need a signal generator and a spectrum analyzer. The low pass filters will need to be measured with the radio powered down.

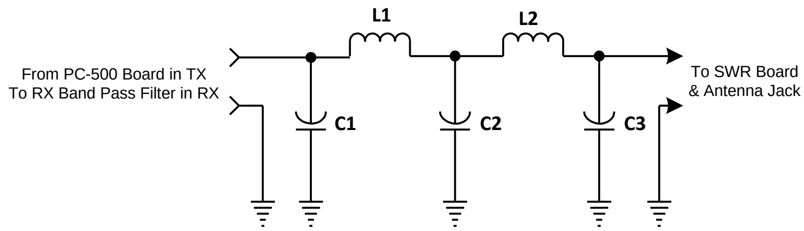
You will need to get to the low pass filter boards and the band switch contacts. You can do this by removing the PC-500 assembly and most of the wires going to it. Once you can see the band switch, then you will need to unsolder the wire going from the output switch contact and solder in a short RG-174 pigtail with either a BNC or SO-239 connector attached.

You then will need to feed a signal generator signal into the antenna jack and measure the output level at the end of the pigtail. Your measurement device – i.e. spectrum analyzer, should present a 50 ohm load to the output of the filter. The signal flow path will match a received signal coming into the radio, going through the low pass filter. You are breaking the connection between the output of the low pass filter and the receive band pass filter.

Alternate Measuring Process:
In the receive mode, you can measure the insertion loss by removing the brown lead on the band switch that comes from the SWR board. A signal generator is connected to this removed lead and a spectrum analyzer is connected to the antenna jack.

This testing method is not a true simulation of the radio. In normal operation, the downstream receive band pass filters would interact with the low pass filter to change the actual insertion loss.

Atlas 210X Low Pass Filter



Here is the Atlas design for the low pass filter and the capacitor and inductor values for each band:

BAND	L1 & L2	C1	C2	C3	Filter Loss	2nd Harmonic @ PC-500	2nd Harmonic @ Antenna Jack	Elsie Loss	Elsie 2nd Harmonic
80M	1.8 uh	820 pf	1300 pf	820 pf	0.1 db	-31 db	-48 db	0.35 db	-16 db
40M	0.95 uh	430 pf	680 pf	430 pf	0.2 db	-36 db	-54 db	0.24 db	-17 db
20M	0.48 uh	180 uf	330 pf	220 pf	0.2 db	-36 db	-50 db	0.14 db	-15 db
15M	0.32 uh	68 pf	270 pf	180 pf	0.4 db	-28 db	-55 db	0.29 db	-17 db
10M	0.24 uh	100 pf	180 pf	100 pf	0.6 db	-33 db	-50 db	0.10 db	-16 db

Note: The 2nd harmonic levels are relative to the fundamental frequency being tested.
On the test 210X, the L1 inductor for 15M was 0.48 uh.
The 2nd harmonic levels are on a radio with the SD1405 modifications

Here are the return loss measurements for the filters:

BAND	Return Loss	Best Return Loss
80M	27 db	27 db @ 3.8 MHz
40M	32 db	56 db @ 7.0 MHz
20M	20 db	26 db @ 15.5 MHz
15M	12 db	19 db @ 19.2 MHz
10M	10 db	22 db @ 38.1 MHz

The following chart shows the Elsie optimized values for each band, with a target of 20 db down for the 2nd harmonic signal and 2% step size:

BAND	L1 & L2	C1	C2	C3	Elsie Loss	Elsie 2nd Harmonic
80M	3.37/3.76 uh	135 pf	1026 pf	390 pf	0.88 db	-22 db
40M	1.36/1.54 uh	101 pf	590 pf	403 pf	0.24 db	-21 db
20M	.653/.675 uh	133 pf	332 pf	180 pf	0.14 db	-21 db
15M	.389/.394 uh	116 pf	246 pf	127 pf	0.10 db	-21 db
10M	.264 uh	104 pf	202 pf	101 pf	0.10 db	-21 db

This chart shows the Elsie optimized values for each band, using commonly available silver mica capacitors:

BAND	L1 & L2	C1	C2	C3	Elsie Loss	Elsie 2nd Harmonic
80M	3.37/3.76 uh	130 pf	1000 pf	390 pf	0.75 db	-21 db
40M	1.36/1.54 uh	100 pf	620 pf	390 pf	0.24 db	-21 db
20M	.653/.675 uh	130 pf	330 pf	180 pf	0.14 db	-20 db
15M	.389/.394 uh	110 pf	240 pf	130 pf	0.1 db	-20 db
10M	.264 uh	100 pf	200 pf	100 pf	0.1 db	-20 db

For comparison purposes, the K5OOR 100 watt low pass filter board was evaluated. This board has a similar design to the filters used in the 210X radio.

Here are the test results from that board:

BAND	Insertion Loss	2nd Harmonic	3rd Harmonic
80M	-0.2 db	-34 db	-55 db
40M	-0.2 db	-45 db	-55 db
20M	-0.4 db	-35 db	-58 db
15M	-0.4 db	-52 db	-45 db
10M	-0.6 db	-50 db	-45 db

J. PC-1200 Board
Receiver Trap and Filter Board
Includes info on Transmitter IF Traps

A number of undesirable RF signals can be present in the transmitter and receiver sections of the transceiver. This includes internally generated signals and signals that come in via the antenna. The PC-1200 board has the IF Traps and Image Filters to reduce the level of these undesirable signals. There are IF Traps and Image Filters in the receiver and IF Traps in the transmitter.

The traps/filters consist of simple parallel LC circuits placed in series with the signal path and function as a notch filter. All of the traps are tunable with tuning slugs in a small tubular coil. The IF traps and Image Filters are tuned to single frequency, so the bandwidth needs to be as narrow as possible.

VIII. Modifications – Major

The modifications described in this section provide major improvements in the performance of the radio. They are also significantly more costly and complex than the modifications described in the previous "Minor" section.

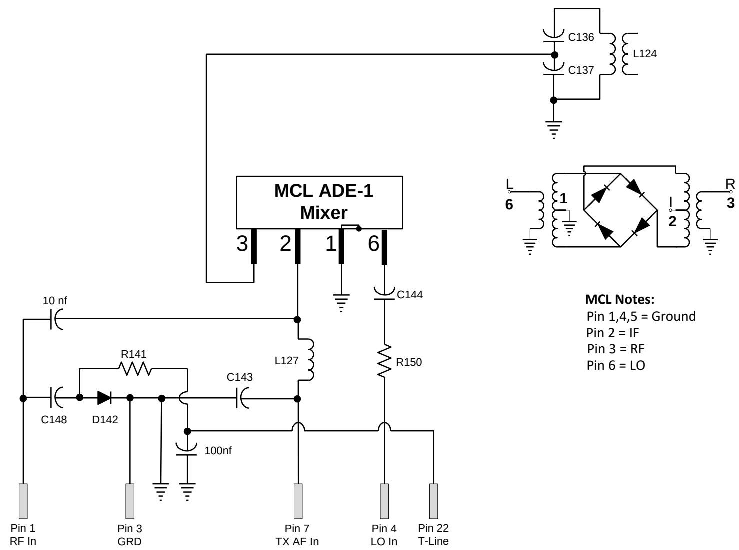
A. ADE-1 Mixer/Balanced Modulator

There are a number of different Mini Circuit double balanced mixers that can be installed in the radio to replace the existing mixer components on the PC-100/PC-120 boards. The recommended model is the MCL Lab ADE-1 mixer. This mixer is similar to the one used in the Ten-Tec Argonaut VI 539 transceiver. Using the ADE-1 mixer allows good integration of a DDS VFO. For any mixer changes, please keep in mind that the VFO and Carrier Oscillator injection levels need to remain matched – about +10 dbm.
The ADE-1 mixer is available directly from Mini Circuits Lab for less than $3 plus shipping charges. This mixer should provide better receiver sensitivity, better isolation between ports, and eliminates the carrier balance controls on the PC-120 board.

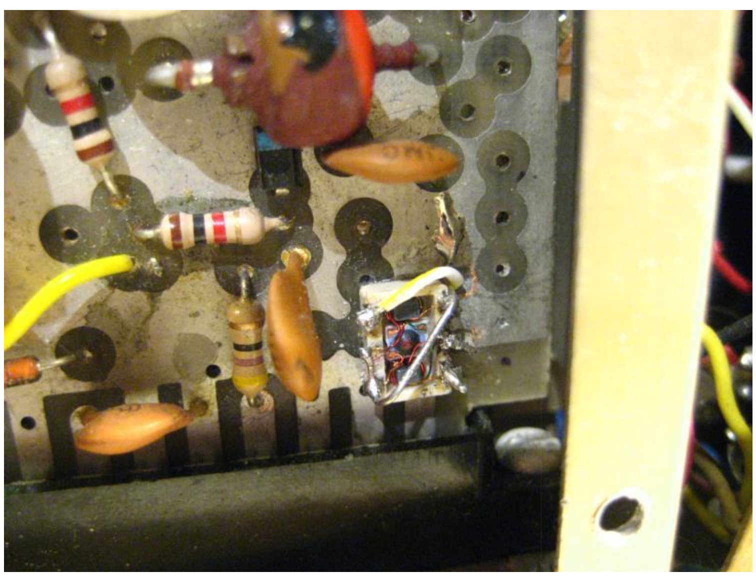
Here are the steps for the mixer replacement:
Remove L125 & L126
Remove D127 to D130
Remove C138, C146 & C147
Remove R134, R135, & R136
Drill four 0.0256" holes on the lower right corner next to pin 1 of PC120 board.
The hole for pin 3 of the mixer should go through the board's ground trace.
Pins 1, 2, & 4 should go though areas with no foil on the trace side of the board.
On the ground plane side of the board, remove foil around holes 1, 2, & 4.

Install the mixer on the component side of the board, with pin 3 next to the bottom right of the board.
Solder a small bare wire to pins 1, 4, and 5 on the mixer
Solder a small bare wire from pin 1 to the ground foil of topside of the board
Solder a short insulated jumper wire from mixer pin 6 to foil pad going to C144
Install a short jumper wire from mixer pin 2 to foil pad with L127 attached.
Solder 0.01 uf ceramic disk capacitor from the mixer pin 2 to pin 1 of the circuit board.
Install RG174 coax cable from pin 3 of the mixer to the circuit pad with C136 and C137 attached
Here is how the mixer circuit will look after the upgrade.

PC-120 ADE-1 Mixer Mods



Here is a picture of a PC-120 board with the factory mixer components removed and a MCL ADE-1 mixer installed.



B. Tee Bridge Diplexer

The IMD performance of the receiver can be greatly improved by properly terminating the front end mixer with a 50 ohm impedance. The front end mixer needs to see a 50 ohm impedance at the IF frequency and also at all other frequencies.

This section provides information on the concept of using diplexers and some actual implementations used by other hams. Additional IF gain after the first mixer is not needed or desired. Please note that any gain provided by a post mixer amplifier does little to improve the sensitivity of the receiver.

Generally, the only tuning required for a post mixer amplifier is to insure that the device draws sufficient current to obtain the best possible IMD performance.

The following link provides general discussion information on diplexers:
http://www.qrp.pops.net/dip2.asp

A 2N5109 post mixer amplifier has been used in a number of receiver designs (Elecraft K2) that use a passive double balanced mixer. This type of amplifier provides a large amount of gain and is not recommended for the Atlas receiver.

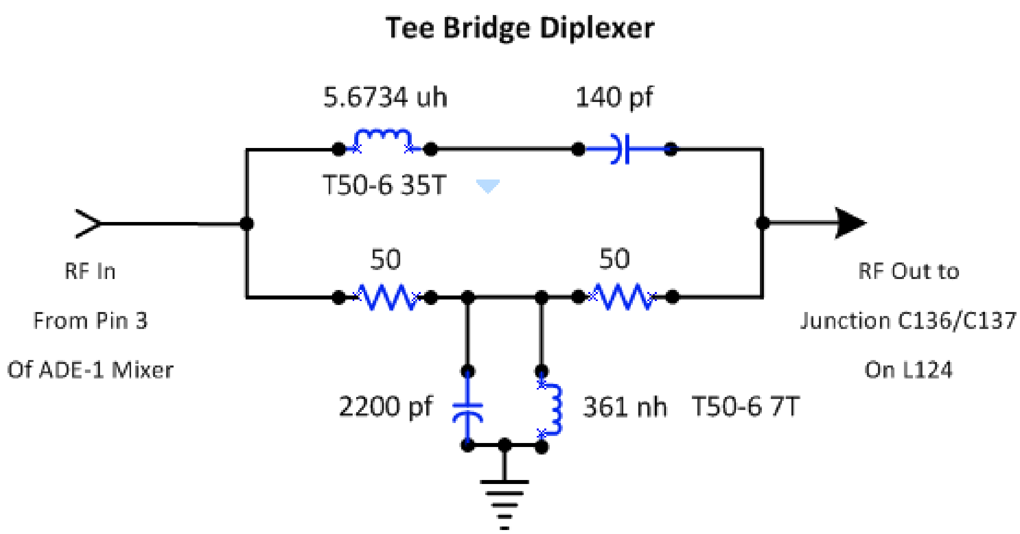
The following link provides information on this type of amplifier that also performs the function of a diplexer:
http://www.qsl.net/wn5y/spostmixamp.htm

Post mixer-amplifier for the 210X using a JFET310
http://pa0fri.home.xs4all.nl/Mods/Atlas215%20post%20mixer%20amp/Atlas215x%20post%20mixer%20amp.htm

I tried this amplifier and the results were not good. The receiver sensitivity decreased up to 5 db on some bands and some spurs saw a significant increase in level.

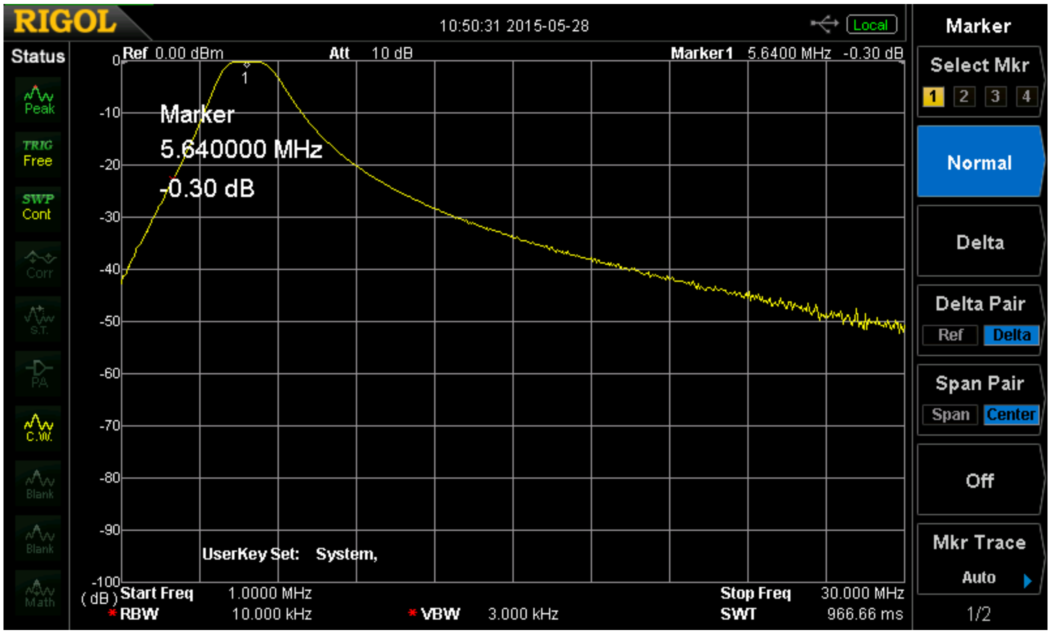
A Tee Bridge Diplexer design was implemented. The parts values were determined from the following calculator:

http://www.changpuak.ch/electronics/calc_16a.php



Using a Q value of 3.9, then standard silver mica capacitors could be used. Each section was assembled, swept with a spectrum analyzer, and then tuned for minimum insertion loss at 5645 KHz. The two sections were then combined and swept again.

Here is the sweep results:



Once the circuit is installed on the PC-120 board, then there should be minimum insertion loss for 5645 KHz and a high level of insertion loss for all other frequencies. The diplexer parts were installed on the PC-120 board, using blank circuit traces that were freed up when the factory balanced mixer was installed.

Here is a picture of the installed parts (the MCL ADE-1 mixer is in the upper right portion of the circuit board:

The diplexer decreased the receiver sensitivity up to 0.5 db on some bands and the number of spurs were greatly reduced.

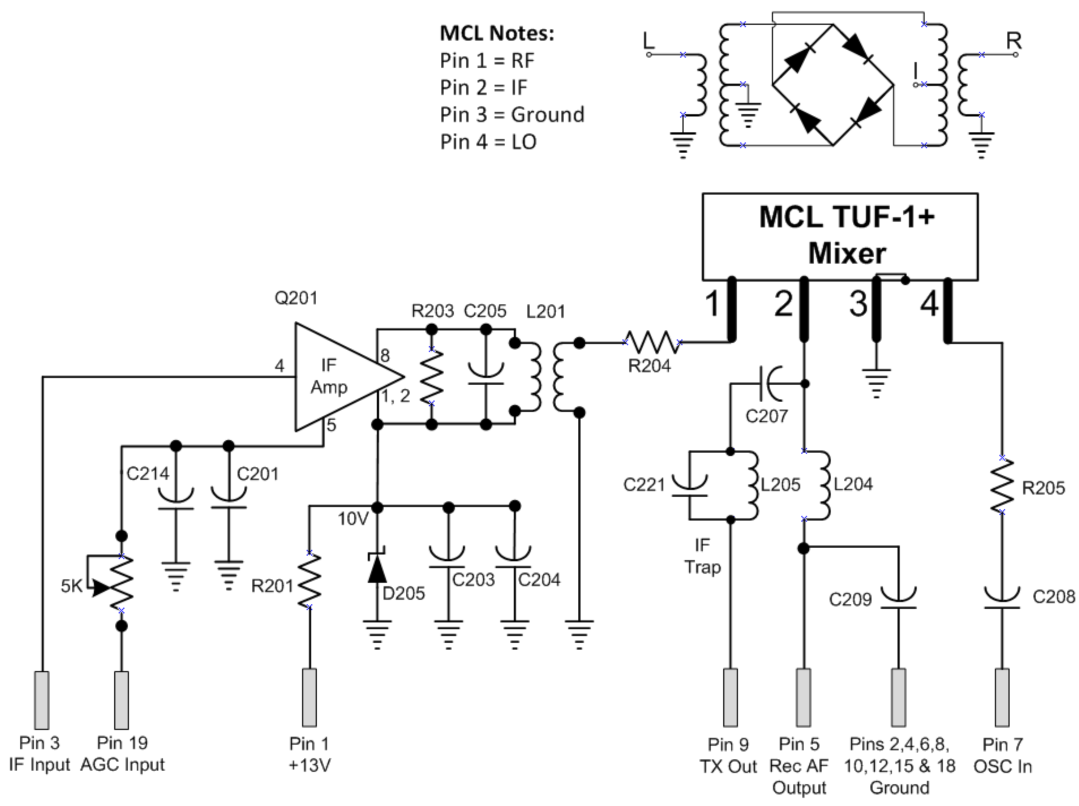
C. TUF-1 Product Detector/Mixer

A MCL TUF-1 mixer can be used to replaced the existing mixer components on the PC-200 board. The TUF-1 mixer is available directly from Mini Circuits Lab for less than $10 plus shipping charges.

Here are the steps for the mixer replacement:

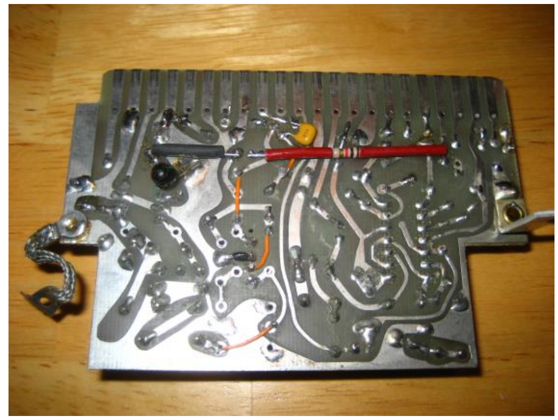
Remove L202 & L203 (toroid coils)
Remove D201 to D204 (mixer diodes_
Remove C206
Refer to the upgraded PC-200 board for the following changes.
Drill two 0.0256” holes on the upper middle of the PC-200 board for pins 2 and 3 of the mixer.
Pin 1 will use an existing pad that went to L202. It will need to be elongated for the 0.1” pin spacing of the mixer pins. On the ground plane side of the board, remove copper around pin 2.
Pin 4 will use an existing pad from C206.
Install the mixer so that pin 1 is at the top of the board and pin 4 is next to the center of the board.
Solder pins 1 and 4 to the solder pads. Run a short jumper from pin 3 to the ground foil about 0.2” away.
Solder a short jumper from pin 1 to the free end of R204.
Solder a short jumper to pin 2 and the free end of C207.
Solder a short jumper from the other side of C207 to the junction of L205 and C221.
Solder a short jumper from pin 4 to the end of the circuit trace going to R205
Cut off excess lengths on the mixer pins
You will need to retune L201 for max power out on 40M after the upgrade is complete.

Here is how the mixer circuit will look after the upgrade.



Top side of PC-200 board with TUF-1 Mixer installed. Note space that was freed up by removing the original mixer toroid coils and diodes. The blue and yellow pots have been added per previous discussion.

Bottom side of PC-200 board with the TUF-1 jumpers installed. Note orange 2200 pf capacitor installed at bottom of the board to replace the original green Mylar capacitor.



D. IF Trap/Image Filters

A number of undesirable RF signals can be present in the transmitter and receiver sections of the transceiver. This includes internally generated signals and signals that come in via the antenna. IF Traps and Image Filters are used to reduce the signal level of these undesirable signals. There are IF Traps and Image Filters in the receiver and IF Traps in the transmitter.

Computer aided design was not available when the radios were designed in the mid 70s. Through use of computer design, the existing LC circuits can be improved.

The traps/filters consist of simple parallel LC circuits placed in series with the signal path and function as a notch filter. All of the traps are tunable with tuning slugs in a small tubular coil. The IF traps and Image Filters are tuned to single frequency, so the bandwidth needs to be as narrow as possible.

Atlas used at least two different types of capacitors in their IF Traps. It appears that both of them were polyester film construction as opposed to my previous comments about them being mylar/paper

One capacitor was yellow in color and had a part number of "EWF2222". Here is info on this cap:

EWF CAPACITORS POLYESTER WRAP EPOXY END FILLED

Mallory type EWF capacitors have high insulation resistance, good moisture resistance, excellent electrical parameters, low dissipation factor, miniature case sizes and economical prices.

The physical and electrical characteristics of the EWF make it an ideal capacitor for coupling and by-pass applications in color or black and white TV, radio, hi-fi and instrumentation. Its tubular configuration adapts to printed circuit wiring or point to point soldering for normal by-pass coupling.

Type EWF capacitors are made from the finest polyester film available. The outer case is polyester wrapped and end sealed in epoxy resin. The axial centered leads are copper wire with double tinning. **Tolerance: ± 10%.** EWF capacitors are available from Mallory distributors in quantities from one to full production levels. Operating Temp.: −55°C to +85°C (to +125°C with proper voltage derating). **For detailed information see Mallory Bulletin EWF form 9-645. For pricing refer to price sheet No. 332. Replaces WMF, B1500.**

The other type was orange in color and had this part number: M235 M192P.

click picture to enlarge

Part Number:
M192P22392
Manufacturer:
MALLORY
Item ID: 2020027757

MALLORY M192P22392 SPEC

- capacitance: 0.022 uf
- voltage: 200 v
- tolerance: 10%
- temperature: 85
- lead type: axial
- package: BULK
- item per pack: 1

DESCRIPTION

M192P22392 is a miniature, sleeved polyester film / foil capacitor. M192P Pacer series. M192P22392 has axial leads, non-inductively wound with extended foil construction. Moisture resistant. Epoxy sealed sides and encased in polyolefin sleeve.

M192P22392 is commonly used in power supplies, instrumentation, communication equipment and many general purpose applications. Made in USA.

Here is a link to this capacitor:

https://www.tedss.com/DataSheets/2020/2020023959.pdf

These capacitors were never designed for RF and are often referred to as “molded mud”.

Here is a definition for molded mud:
Molded mud is any capacitor, used at RF, that is not NPO, or has temperature specs – i.e. N750, N330, etc. so that their properties as RF filters are questionable.

Lots of capacitors used for bypassing and coupling are not NPO type but their performance in that situation doesn’t affect the capacitor. They have poor temperature stability and Q. When new (40 years ago), these capacitors varied in frequency from 2200 pf at 100 Khz to less than 2200 pf at higher frequencies. As the capacitors age, the capacitance can decrease even more at higher frequencies. Consequently, the actual capacitance of the units may not be 2200 pf at the IF Trap frequency.

Replacing the 2200 pf capacitor with a monolithic ceramic disc units will increase the depth of the IF Trap notches about 5 db.

There is also an IF Trap filter on the PC-200 board, and two IF Trap filters (one for 80M and one for 40M) on the PC-900 board

The filter coils in the latest versions of the 210X LE has a lower wiring turn count for the receiver IF Traps and Image Filters, compared with earlier 210X versions. It is not known why the lower count was used. These lower turn count coils cannot be tuned to the factory design frequencies. In some LE radios, the length of the tuning slug was changed from 8 mm to 9.7 mm.

This longer length helped in reaching the design frequencies, but still was not sufficient. As an example, an IF Trap with a 6 turn coil and short tuning slug could not be tuned any lower than 5.9 MHz.
With the longer slug, the coil could be tuned to 5.7 MHz. None of the Image Filter coils could be tuned to the correct design frequencies with either a short or long tuning slug.

The paper coil forms used for the IF Traps and Image Filters tend to get loose from the coil wire. This can result in the entire coil form turning when you try to adjust the tuning slug. An application of Super Glue, Q Dope, etc. between the coil form and the coil wire will secure the wiring to the coil form. Metal objects in close vicinity of the coils decreases the inductance of the coil and thus increases the frequency of the notch.

1. **General Observations**

   Over the period of manufacture from 1975 to 1979, the design of the traps and filters changed several times. The changes were mostly in the number of turns of wire used on the inductors. There appears to be at least four different versions of the wiring turns used for the transmitter and receiver IF traps. Depending upon the manufacture date of your transceiver, you may find the following inductors for these traps:

   16 turns with 820 pF capacitor (about 35 dB notch for TX filter)
   7 turns with .002 uf capacitor (from an old 210 with old style TX band pass board)
   7 turns with 2200 pF capacitor (about 10 dB notch for TX filter)
   5 turns with 2200 pF capacitor (about 10 dB notch for TX filter)

   For a given resonant frequency, changing the values of the inductor and capacitor changes the depth of the null and the bandwidth of the filter. Lower values for the capacitor provides deeper nulls. If the null is too deep on the IF Traps, then there can be a couple of dB insertion loss at 4000 KHz and 7000 KHz. This will reduce your transmitter output power on 80M and 40M and can reduce receiver sensitivity. If the null is too deep on the 20M Image Filter, there can be a couple of db insertion loss in the 20M receiver band.

   Please see the Appendix for details on the factory IF Traps/Image Filters and the improvements that can be made.

2. **PC-1200 Board**

   This board is used in the receiver and there are four LC combinations on the board. Two are IF Traps and two are image filters. The IF Traps and Image Filters are downstream from the PC-810 receiver band pass filters. Please note that there is a second 20M Image Filter located below the band switch wafer and attached to small terminal strip on the chassis. This filter is upstream of the PC-810 board.

Here is a factory IF Trap/Image Filter board from a 210X radio:

The bottom coil next to the band-switch is a 20M Image filter. From left to right on the main board is an 80M IF Trap, a 40M IF trap, a 20M Image Filter, and a 10M Image Filter. The two yellow axial capacitors are 2200 pf mylar/paper units. These capacitors can also be orange mylar units similar to what is shown in this picture:

The Atlas User Manual is slightly misleading on the labeling of the PC-1200 schematic. It shows image filters of 11.8 MHz and 17.8 MHz In reality, the filters are tunable around the frequencies of 11.8 and 17.8 MHz, depending upon the frequency of the interfering signal.

The latest PC-1200 board for the 210X radio has the following traps/filters:

Receiver:

80M IF Trap
L1202 and C1201 (5645 KHz)

40M IF Trap
L1203 and C1202 (5645 KHz)

****

20M Image Filter
L1204 and C1203
Tunable range of 11065 KHz to 12065 KHz
Filter for 2nd harmonic of VFO mixing with interfering signal to produce 5645 KHz IF

20M Image Filter on main chassis
L1201 and C1210
tunable range of 11065 KHz to 12065 KHz
Filter for 2nd harmonic of VFO mixing with interfering signal to produce 5645 KHz IF

The two 20M Image Filters are in series with the 20M RX band pass filter. The purpose of these filters is to attenuate broadcast signals in the 25M band (11 to 12 MHz). The value of these filters is questionable and Atlas actually recommended removing them in one of their 1977 Service Bulletins.

Please keep in mind that the filters were originally installed because of the strong second harmonic signal from the VFO. On 20M, the VFO 2nd harmonic signal is only down about 10 db from the fundamental.
With a good DDS VFO, the 2nd harmonic would be down at least 40 db from the fundamental, so 11 MHz AM broadcast signals would create even less of problem.

Example calculation:

Receiver is tuned to 14.2275 MHz
VFO is tuned to 8.5825 MHz
2nd harmonic from VFO is 17.165 MHz
Interfering broadcast signal would need to be on 11.520 MHz

Signals in the 11 MHz broadcast band need to be about -48 dbm for a 10 db S+N/N reading. Each 20M Image Filter has about 7 db of attenuation (even though bench testing shows quite a bit bigger null). The 20M RX band pass filter adds about 16 to 25 db of attenuation. The remainder of the attenuation comes from the cancelling effect of the balanced mixer.

In the early Arizona morning summer hours, very strong (S9+ on a FT-857D radio) AM broadcast signals were heard on the following frequencies (in MHz):

Frequencies that could show up in the 14.000 to 14.350 MHz band

11.520	11.565	11.610	11.620	11.635	11.640	11.665	11.680	11.687 (RTTY)
11.709	11.735	11.740	11.760					

Frequencies that could show up in the 14.350 to 14.500 MHz band

11.775	11.785	11.795	11.800	11.815	11.825	11.860	11.865
11.915	11.935	11.985	12.010	12.050	12.065		

An outside antenna was connected to the 210X radio. I tuned across the 14.000 to 14.500 MHz band. I used two different setting for the two Image Filters – one setting was at 11.065 MHz and the other setting was at 12.065 MHz.
I could not hear any AM broadcast signals.
****

10M Image Filter
L1210 and C1211
tunable range of 16710 KHz to 18410 KHz
Filter for primary image mixing with interfering signal to produce 5645 KHz IF

The 20M Image Filter discussion could also be applied to the 10M Image Filter. This filter was included in the radio to reduce interference from the 16M broadcast band (17.0 to 18.0 MHz). The actual broadcast portion of this frequency range is 17.48 to 17.90 MHz. The probability of receiving interference in this band is less than the 25M broadcast band, especially in the tuning range of 28.0 to 28.5 MHz (16.71 to 17.21 MHz).

Example calculation:
Receiver is tuned to 28.500 MHz
VFO is tuned to 22.855 MHz
Receiver primary image frequency is 17.210 MHz

Signals in the 16M broadcast band need to be about -77 dbm for a 10 db S+N/N reading, with no Image Filter. This level becomes -43 dbm with the Image Filter.

The strength of the primary image frequency in the radio is reduced by the 10M RX band pass filter and the 10M Image Filter. Using a DDS VFO would not reduce the strength of the primary image frequency in the radio.

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If the 20M and 10M Image Filters are not needed to reduce a interfering broadcast band signal, then they should be tuned to the bottom of their design frequency range. This will reduce the amount of receiver insertion loss for the 20M and 10M band.

3. **Transmitter IF Traps**

There are three each IF Traps used in the transmitter. There are two traps on the TX band pass filter board. There is also a trap located on the PC-200 board.

All bands	IF Trap on PC-200 board	L205 and C221 (5645 kHz)
80M	IF Trap on PC-900 board	L913 and C918 (5645 kHz)
40M	IF Trap on PC-900 board	L914 and C919 (5645 kHz)

4. **Examples of Bad Traps/Filters**

The following two examples show how the performance of the radio can be degraded by not having the correct IF Traps and Image Filters.

Example 1:

On one LE radio, the transmitter power output was good on all bands except 40M. On that band, the output was only 50 watts compared with 100 watts on the other bands. It was found that the IF Trap on the PC-200 board was off frequency.

The trap could be nulled at the IF, but the null also reduced the output on the 40M band by a couple of dB. It was found that the best null was around 6000 kHz. The 2200 pF capacitor was no longer at the correct value, even though it measured correctly on a capacitance meter. Keep in mind the earlier statement that some capacitors are not designed for use at RF frequencies. The actual value of the capacitor was about 1500 pF when used at 5000 KHz. The fix was to install a new 2300 pF ceramic disc capacitor. This allowed the proper null at the IF and also did not have any insertion loss at 7000 KHz.

Example 2:

On one 210X LE radio, none of the IF Traps and Image Filters could be tuned to the correct design frequency. All of the coils had 5 turns of wire with the short tuning slugs. The long tuning slugs were installed in the coils. The receiver IF Traps could almost be tuned to 5645 KHz.

A shorter tuning slug was used in the LE coils, thus raising the minimum possible frequency of the coil. No one at the factory caught this problem because it is suspected that the coils were never tuned at the factory.

There are several ways to fix this problem:
Rewind the coils to 7 turns of wire
Increase the value of the capacitors
Install a longer tuning slug (more inductance)
Install a second tuning slug (more inductance).

The 2200 pf orange/yellow capacitors were replaced with 2300 pf monolithic ceramic units. The 80M and 40M IF Trap coils were replaced with ferrite cores (T37-2 with 7 turns of wire). These two IF Traps were tuned to 5645 KHz by adjusting the spacing between the turns of wire. Final tuning was completed after the board was installed back into the radio. The five turn 20M and 10M Image Filter coils were replaced with 7 turn coils and short tuning slugs. The coil wire was Q-Doped. The 20M and 10M Image Filter capacitors were replaced with silver mica units.

5. Trap/Filter Tuning Ranges

Here is the tuning range for the IF Trap and Image Filters:

FILTER	Coil Turns	Coil Slug	L in uH	C in pf	Tunable Range MHz	Filter Freq MHz
IF Trap	5	short	0.16 - 0.32	2300	5.9 – 8.2	5.645
IF Trap	5	long	0.16 - 0.34	2300	5.7 – 8.2	5.645
IF Trap	**7**	**short**	**0.26 - 0.50**	**2300**	**4.8 – 6.5**	**5.645**
IF Trap	7	long	0.26 - 0.53	2300	4.5 – 6.5	5.645
Image Filter	5	short	0.16 - 0.32	470	13.0 – 18.3	11.07 – 11.77
Image Filter	5	long	0.16 - 0.34	470	12.6 – 18.3	11.07 – 11.77
Image Filter	**7**	**short**	**0.26 - 0.50**	**470**	**10.4 – 14.4**	**11.07 – 11.77**
Image Filter	7	long	0.26 - 0.57	470	9.7 – 14.4	11.07 – 11.77
Image Filter	5	short	0.16 – 0.32	200	19.9 – 28.1	16.71 – 17.71
Image Filter	5	long	0.16 – 0.34	200	19.3 – 28.1	16.71 – 17.71
Image Filter	**7**	**short**	**0.26 - 0.50**	**200**	**15.9 – 22.1**	**16.71 – 17.71**
Image Filter	7	long	0.26 – 0.57	200	14.9 – 22.1	16.71 – 17.71

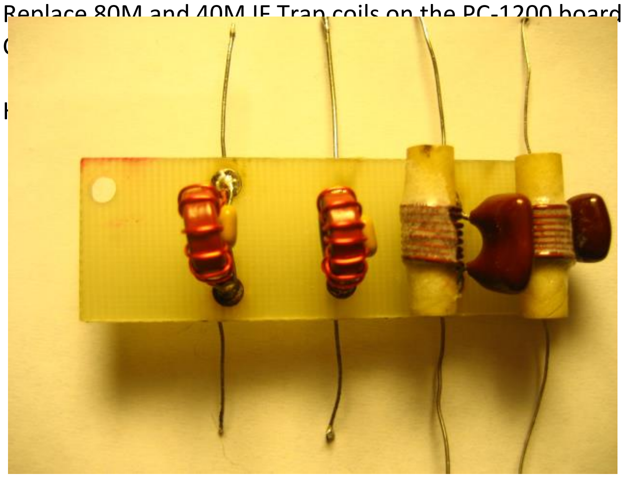
Notes:
Data in blue text is the recommended configuration.

The actual notch for the 80M and 40M IF Filters is about -15 db due to self coupling between the two coils mounted adjacent to each other on the trap filter board. The actual loss was measured with the filter board removed from the radio. Replacing the coils with toroid units will eliminate the self coupling and will also improve the notch.

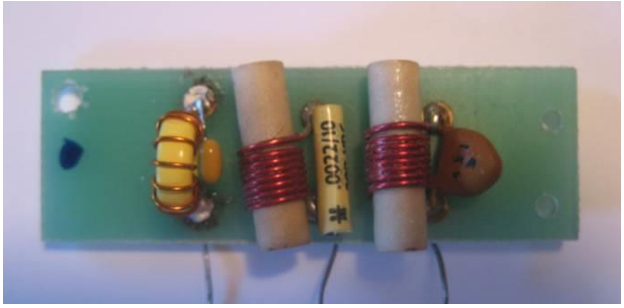
6. Modification Overview

The following changes are recommended for the IF Traps and Image Filters;

Replace all 2200 pf orange or yellow polyester film capacitors with high quality ceramic disc or SM units
Replace 80M and 40M IF Trap coils on the PC-1200 board with toroid units



This is a reworked filter board from an early 210 radio. The middle IF trap is factory installed with the 2200 pf polyester film capacitor and the tunable coil.



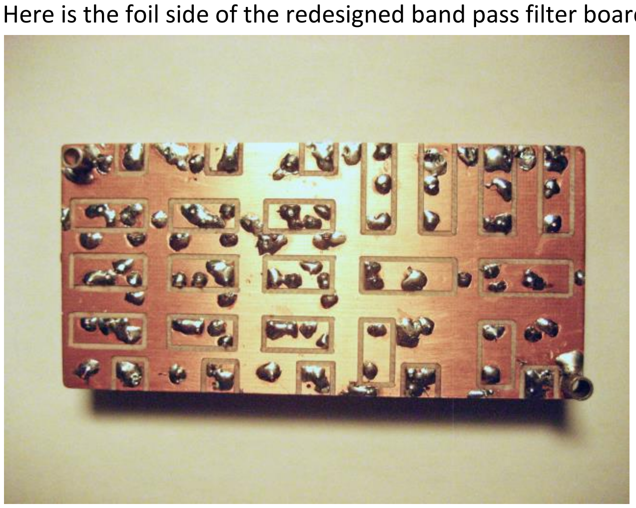
E. Receiver Band Pass Filters

As previously mentioned, the receiver will benefit from a custom band pass filter board. The board was designed using the Elsie LC Filter application.

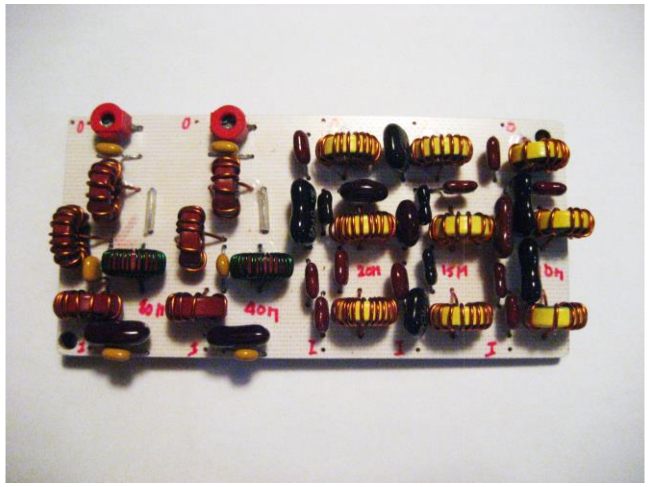
1. Goals:
   a. Bessel, Chebyshev, or Cauer filters are acceptable
   b. Combine all band pass filters, IF Traps, and Image Filters on a single board
   c. Size of new circuit board would be 1.7” x 3.6” (same size as factory board)
   d. New board would use two existing mounting holes
   e. No impedance matching transformers needed on input or output of each band filter
   f. All toroids would be wound on T37-x cores
   g. Maximum turn count on a T37-2 core to be 42 turns (7 uh) with #28 gauge wire
   h. Maximum of four toroids on each band
   i. Primary image frequency on each band to be attenuated at least 40 db
   j. IF frequency on each band to be attenuated at least 40 db
   k. Filters could be tuned with board removed from the radio
   l. Insertion loss on each band should not exceed 1.0 db
   m. 80 & 40 meter filters to have at least 40 db attenuation in the broadcast band (540 to 1600 kHz)
   n. All capacitors to use commonly available silver mica values
   o. Available ceramic disc monolithic values of (in pf) 1000, 1500, and 2300
   p. Coverage of frequencies outside the ham bands was OK, but was not mandatory

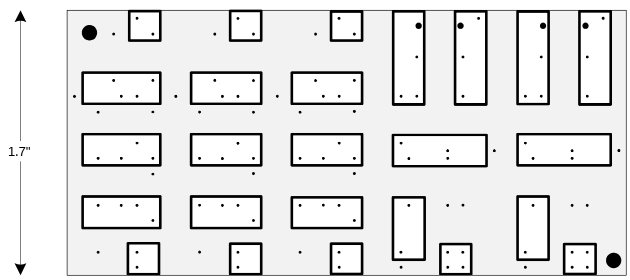
2. Boards:

   Here is the foil side of the redesigned band pass filter board:

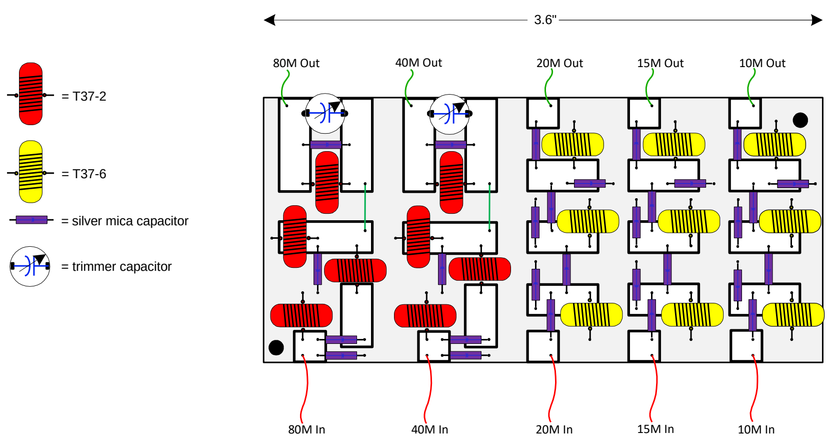


Here is the component side of the redesigned band pass filter board:





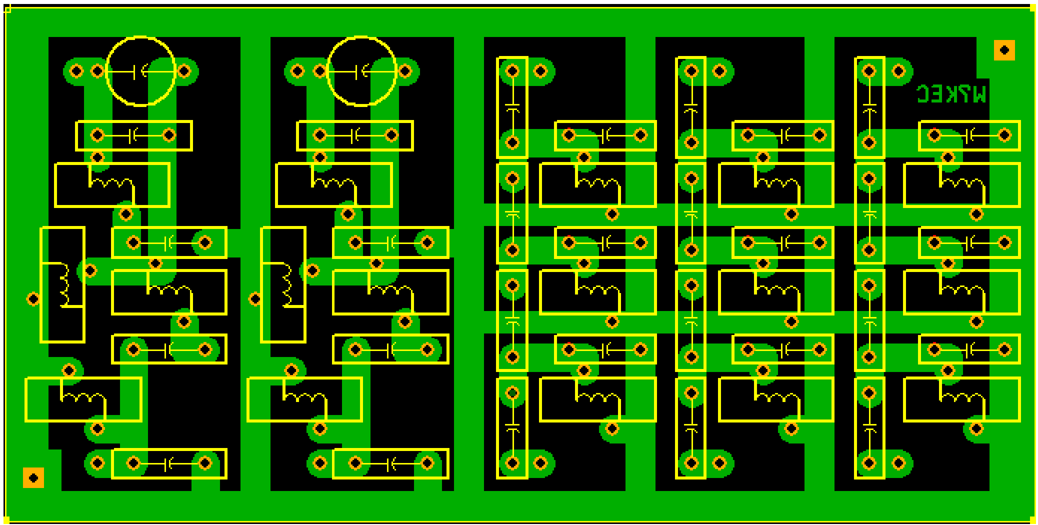
Foil Side Of Board



Component Side Of Board

Here is the same board designed with the ExpressPCB Classic app:

Top side of board with silkscreen shown for parts



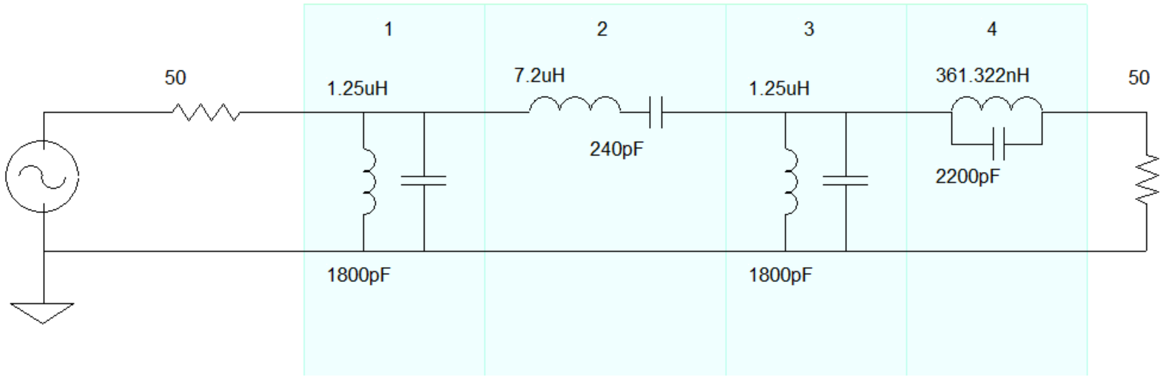
Here are the signal level measurement results from three different radios:

210X Standard with factory band pass filter board and IF Trap/Image Filter board.
210X LE with factory band pass filter board and IF Trap/Image Filter board.
210X LE with custom band pass filter board. The IF Trap/Image Filter board has been removed.

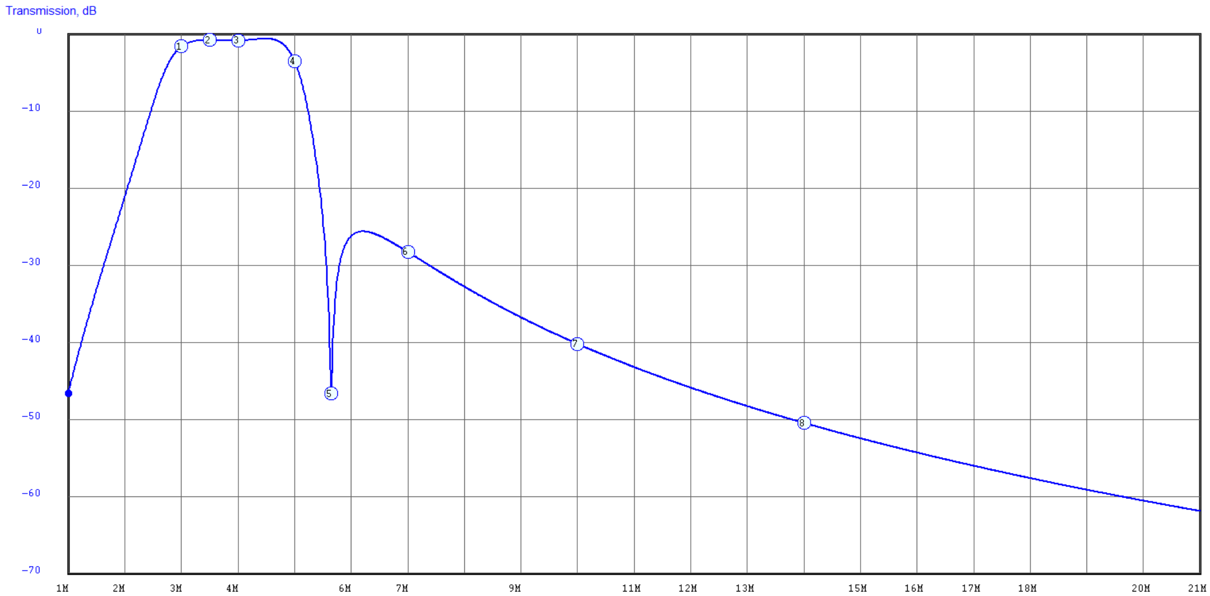
TEST FREQUENCY	ATLAS 210X DIGITAL DISPLAY					ATLAS 210X LE FACTORY RX BAND PASS FILTERS					ATLAS 210X LE CUSTOM RX BAND PASS FILTERS					COMMENTS
	80M	40M	20M	15M	10M	80M	40M	20M	15M	10M	80M	40M	20M	15M	10M	
1875 khz	-59					-59					-58					2nd harmonic + VFO on 80M
2960 khz			-62					-88					-52			primary image on 20M
3625 khz		-58					-57					-58				2nd harmonic + VFO on 40M
3750 khz	**-114**					**-112**					**-114**					80M sensitivity 10 db S+N/N
5000 khz	NA	NA	NA	NA	NA	S9	S8	S5	S4	S5	S8	S0	0	0	0	antenna connected - WWV
5645 khz	-82	-85	-42	-62	-51	-84	-70	-44	-57	-54	-42	-44	-23	-27	-32	IF Traps on 80M and 40M only
7250 khz		**-115**					**-114**					**-115**				40M sensitivity 10 db S+N/N
9960 khz				-65					-84					-60		primary image on 15M
10000 khz	NA	NA	NA	NA	NA	S0	S9+10	S8	S0	S7	0	S8	0	0	0	antenna connected - WWV
11565 khz			-45					-61					-28			2X VFO image on 20M
13145 khz	-33					-32					-21					2X VFO image on 80M
14250 khz			**-112**					**-113**					**-113**			20M Sensitivity 10 db S+N/N
15000 khz	NA	NA	NA	NA	NA	S7	S6	S9+20	S8	S8	0	0	S7	0	0	antenna connected - WWV
15040 khz	-64					-74					-59					primary image on 80M
17210 khz					-55					-77					-61	primary image on 10M
18540 khz		-62					-56					-52				primary image on 40M
20145 khz		-56					-36					-41				2X VFO image on 40M
20170 khz			-63					-46					-76			3X VFO image on 20M
21250 khz				**-114**					**-112**					**-113**		15M sensitivity 10 db S+N/N
22540 khz	-44					-61					-55					3X VFO image on 80M
25565 khz				-83					-58					-54		2X VFO image on 15M
28500 khz					**-114**					**-110**					**-114**	10M sensitivity 10 db S+N/N
33040 khz		-39					-58					-52				3X VFO image on 40M
40065 khz					-74					-58					-64	2X VFO image on 10M
41170 khz				-46					-52					-47		3X VFO Image on 15M
62920 khz					-57					-50					-58	3X VFO image on 10M

Here are details on the filters used on the custom band pass filter board.

80M
Schematic of factory 80M receiver band pass circuit with IF Trap filter:



Elsie model of factory 80M receiver band pass circuit with IF Trap filter:

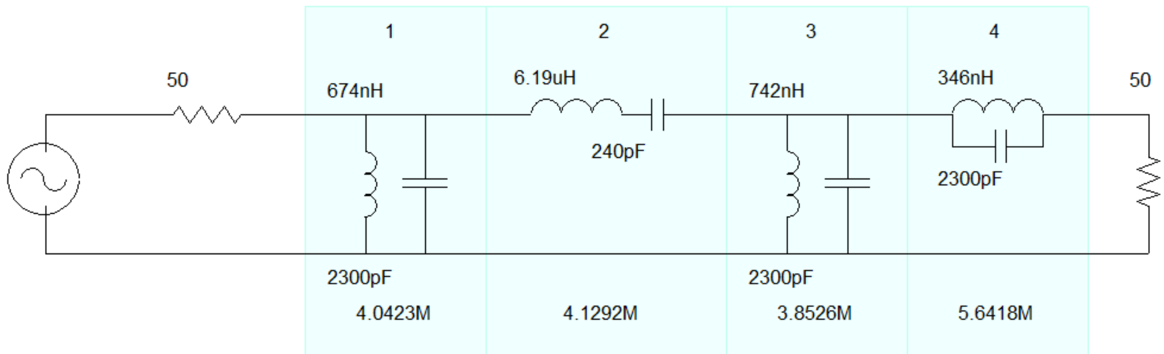


NEW 80M FILTER DESIGN:
Cauer
Not suitable – one of the toroids needed to be 31.5 uh and the input/out filter caps needed to be about 4400 pf each.

Chebyshev
Not suitable – rejected at 1.5 MHz was only 28 db

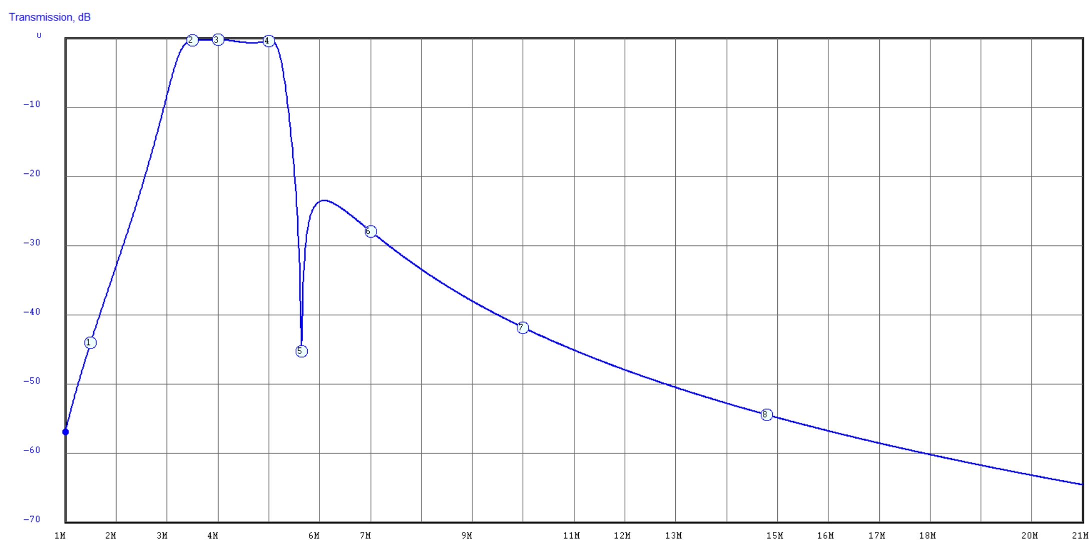
Butterworth – best solution
3300 pf capacitors on input/output filter have the best stop band attenuation (5 db improvement) but silver mica capacitors are very large in physical size

Here is a schematic of the resultant filter:



674 nh	= T37-2 with 12 turns of #24 wire
6.19 uh	= T37-2 with 40 turns of #28 wire
742 nh	= T37-2 with 13 turns of #24 wire
346 nh	= T37-2 with 8 turns of #24 wire

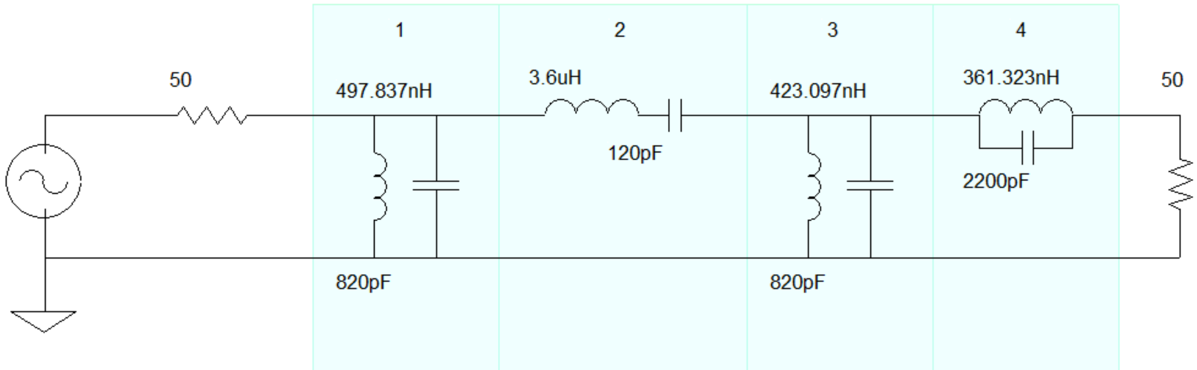
Here is the resulting Elsie model:



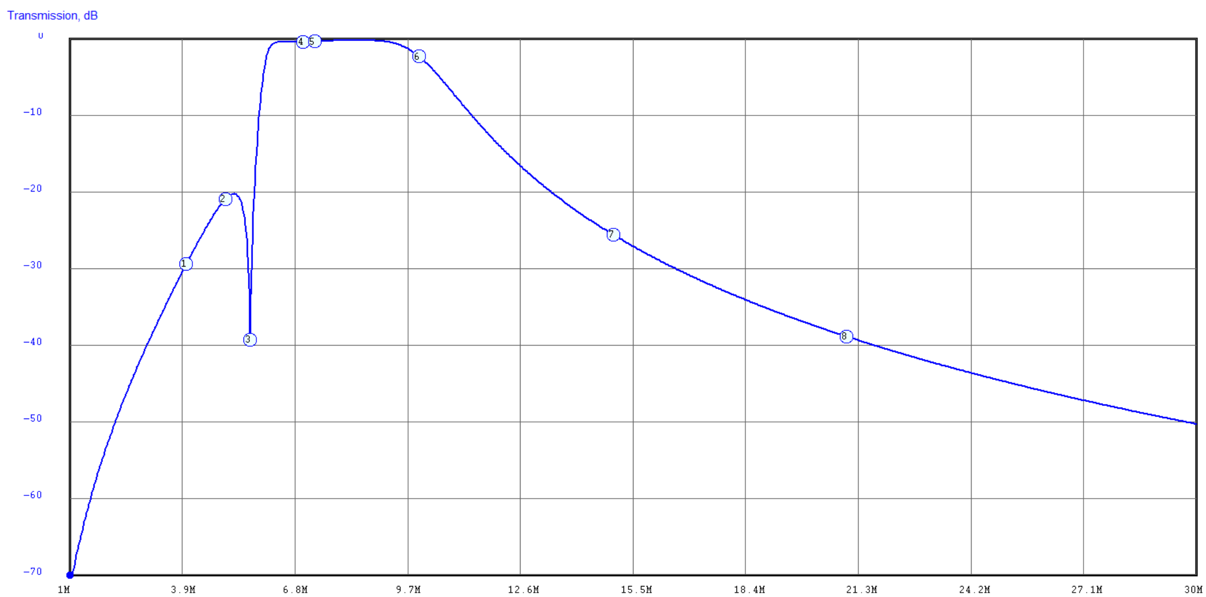
	Freq.:	Trans.:	Angle:	Return:	Delay:	VSWR:	Zmag.:	Zangle:	Real:	Imag.:
1	1.5M	−43.997	−113.78	−0.03827	51.55n	453.88	7.5145	89.141	0.11265	7.5136
2	3.5M	−0.31538	67.968	−23.399	536.2n	1.145	54.995	5.5027	54.741	5.2736
3	4M	−0.22998	−8.766	−26.605	383.9n	1.0981	54.895	−0.32167	54.894	−0.30818
4	5M	−0.40968	−154.78	−20.662	629n	1.2043	42.298	−4.6149	42.161	−3.4033
5	5.645M	−45.256	144.64	−0.10557	−11.44u	164.56	36.87	−89.271	0.46904	−36.867
6	7M	−27.875	149.63	−0.02131	59.89n	815.3	16.292	−89.761	0.06784	−16.292
7	10M	−41.816	120.18	−0.00331	12.8n	>1000	8.4944	−89.934	0.00981	−8.4944
8	14.79M	−54.43	107.89	−0.00118	4.051n	>1000	5.1055	−89.962	0.00343	−5.1055

40M

Schematic of factory 40M receiver band pass circuit with IF Trap filter:



Elsie model of factory 40M receiver band pass circuit with IF Trap filter:



NEW 40M FILTER DESIGN:

Cauer

not suitable – one of the toroids needed to be 9.6 uh and the input/out filter caps needed to be about 3500 pf each.

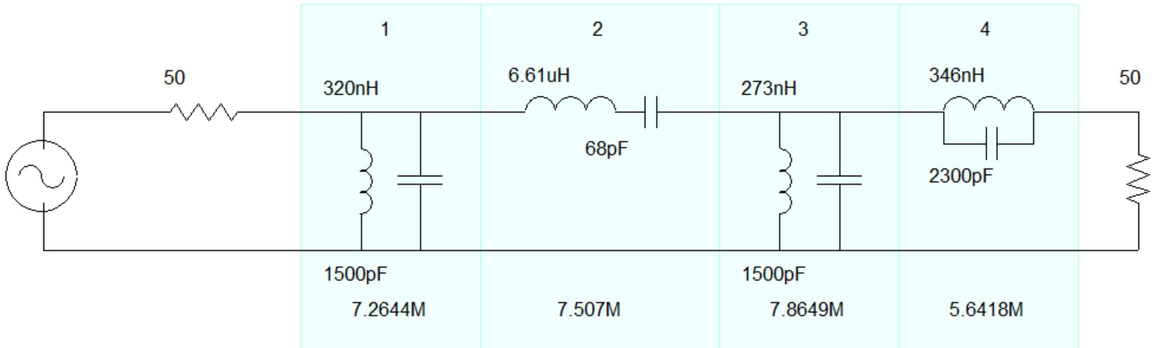
Chebyshev

Not suitable – one of the toroids needed to be 17.5 uh

Butterworth – best solution

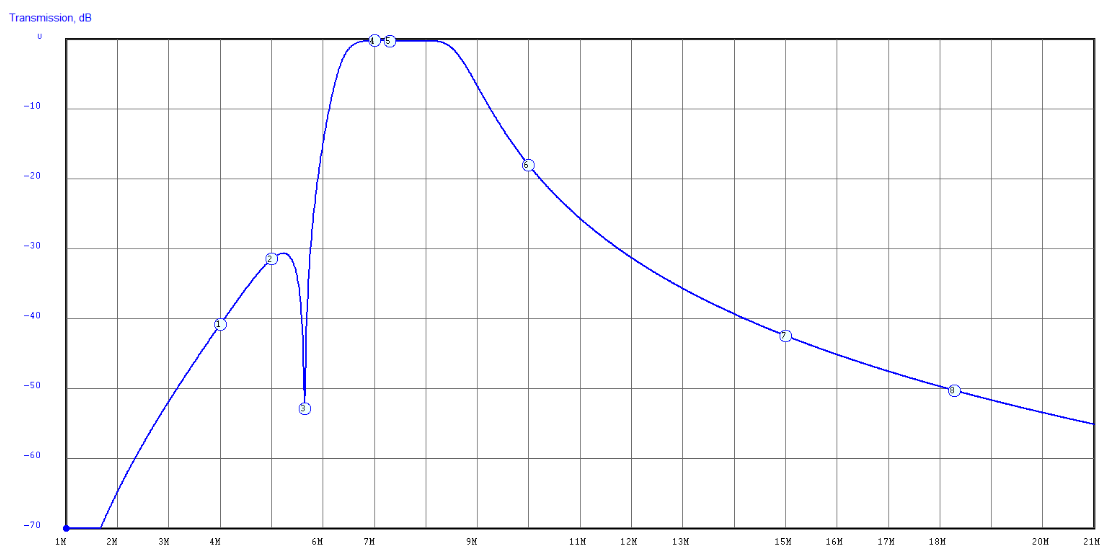
2300 pf capacitors on input/output filter have the best stop band attenuation, but the 1500 pf capacitors provided the flattest pass band.

Here is a schematic of the resultant filter:



20 nh = T37-2 with 8 turns of #24 wire
6.61 uh = T37-2 with 42 turns of #28 wire
273 nh = T37-2 with 7 turns of #24 wire
346 nh = T37-2 with 8 turns of #24 wire

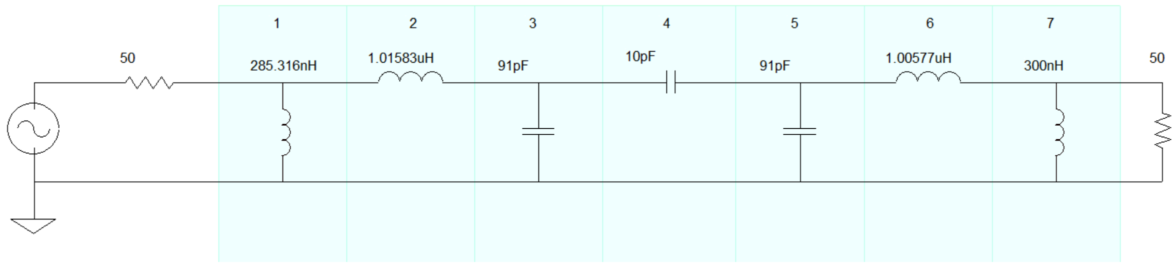
Here is the resulting Elsie model:



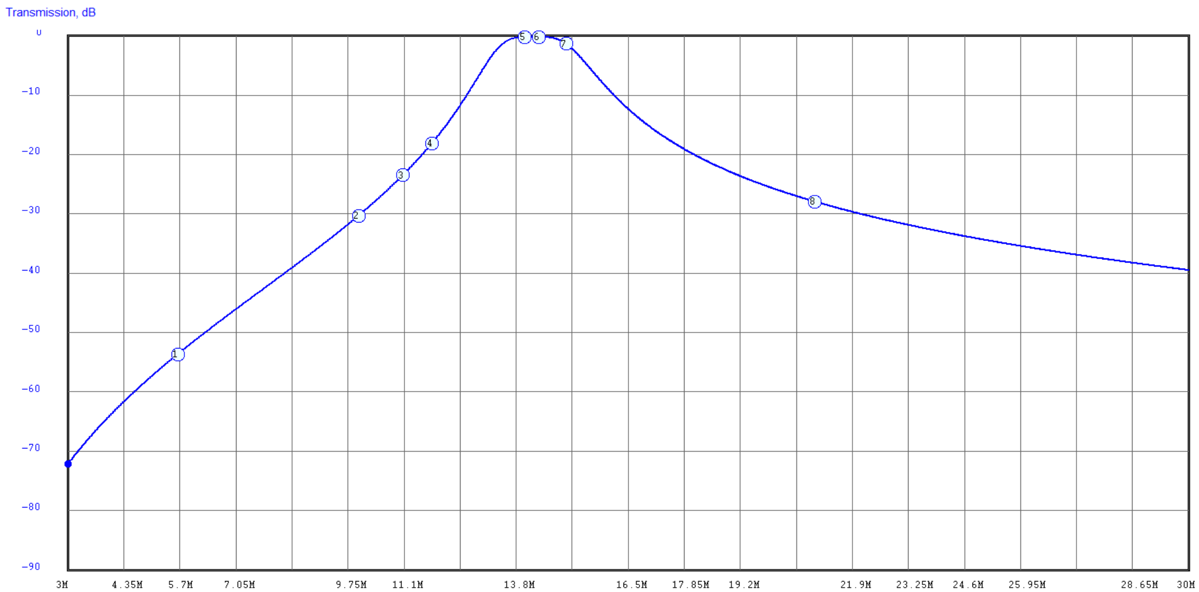
	Freq.:	Trans.:	Angle:	Return:	Delay:	VSWR:	Zmag.:	Zangle:	Real:	Imag.:
1	4M	-40.78	-132.5	-0.02858	60.18n	607.76	11.876	89.581	0.08691	11.876
2	5M	-31.453	-165.77	-0.05582	140.3n	311.23	20.696	89.479	0.18818	20.696
3	5.645M	-52.863	-110.23	-0.10475	-11.47u	165.85	34.89	89.264	0.44826	34.887
4	7M	-0.23258	75.543	-27.259	371.8n	1.0906	54.128	-2.01	54.095	-1.8985
5	7.3M	-0.24099	38.626	-19.969	320.1n	1.2231	58.114	-7.624	57.601	-7.7101
6	10M	-17.987	159.41	-0.10294	69.85n	168.75	26.088	-89.172	0.37694	-26.086
7	15M	-42.431	117.97	-0.00372	8.269n	>1000	9.4313	-89.933	0.01108	-9.4313
8	18.29M	-50.271	110.92	-0.00196	4.318n	>1000	6.9645	-89.953	0.00576	-6.9645

20M

Schematic of factory 20M receiver band pass circuit with no Image filters:



Elsie model of factory 20M receiver band pass circuit with no Image filter:



NEW 20M FILTER DESIGN:

Cauer –solution looked good on paper

Prototype did not work – XL too low on input and out coils

Chebyshev

Not suitable – would require two toroids at 32 uh

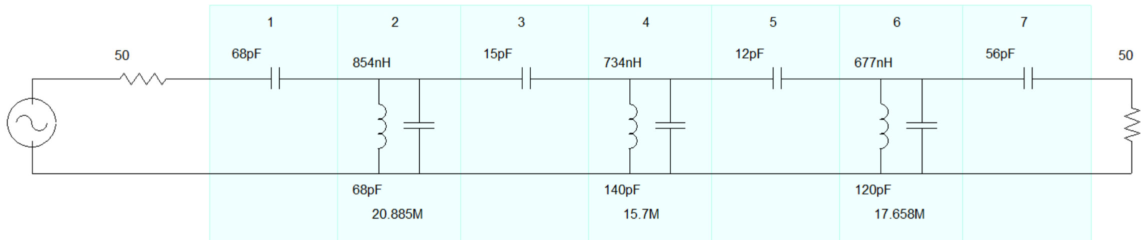
Would require one capacitor to be 8700 pf

Butterworth

Not suitable - Would require two toroids at 19 uh and one at 8 uh

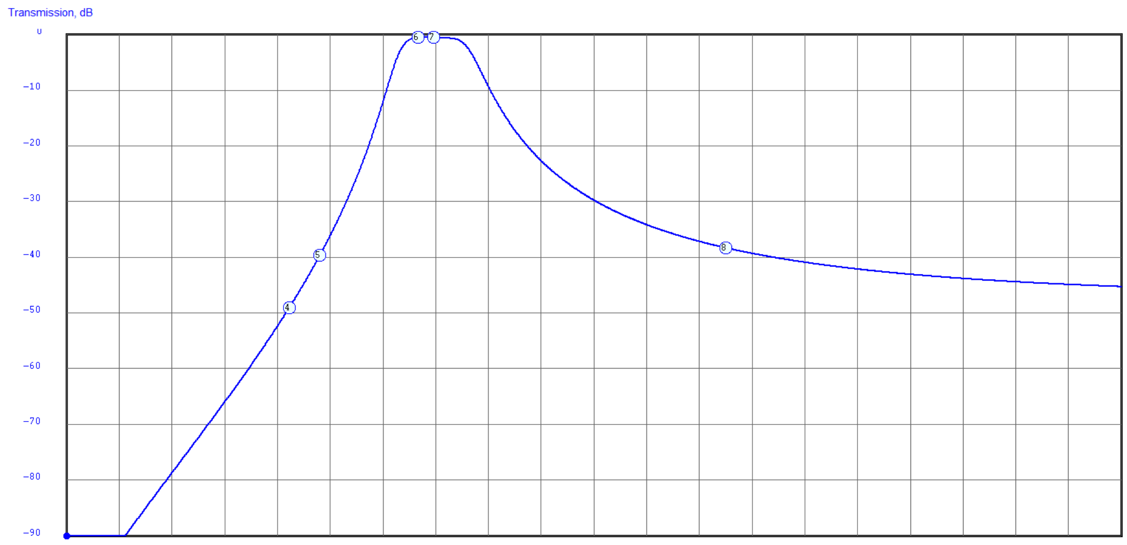
Would require two capacitors at 6 pf

Top coupled with capacitive impedance divider on input/output – best solution



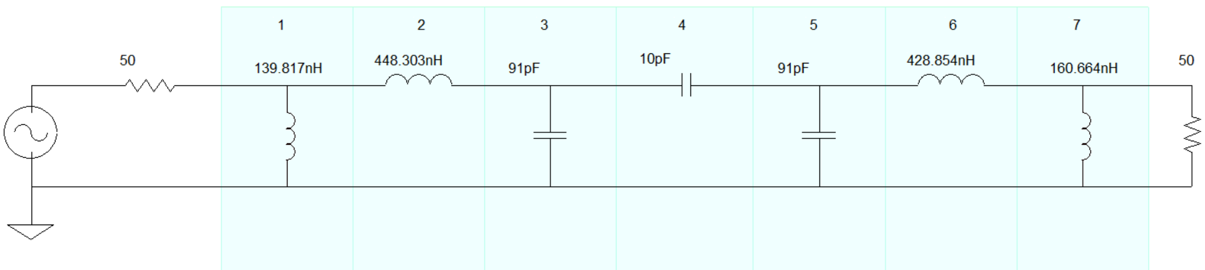
854 nh = T37-6 with 15 turns of #24 wire
734 nh = T37-6 with 14 turns of #24 wire
677 nh = T37-6 with 14 turns of #24 wire

Here is the resulting Elsie model:

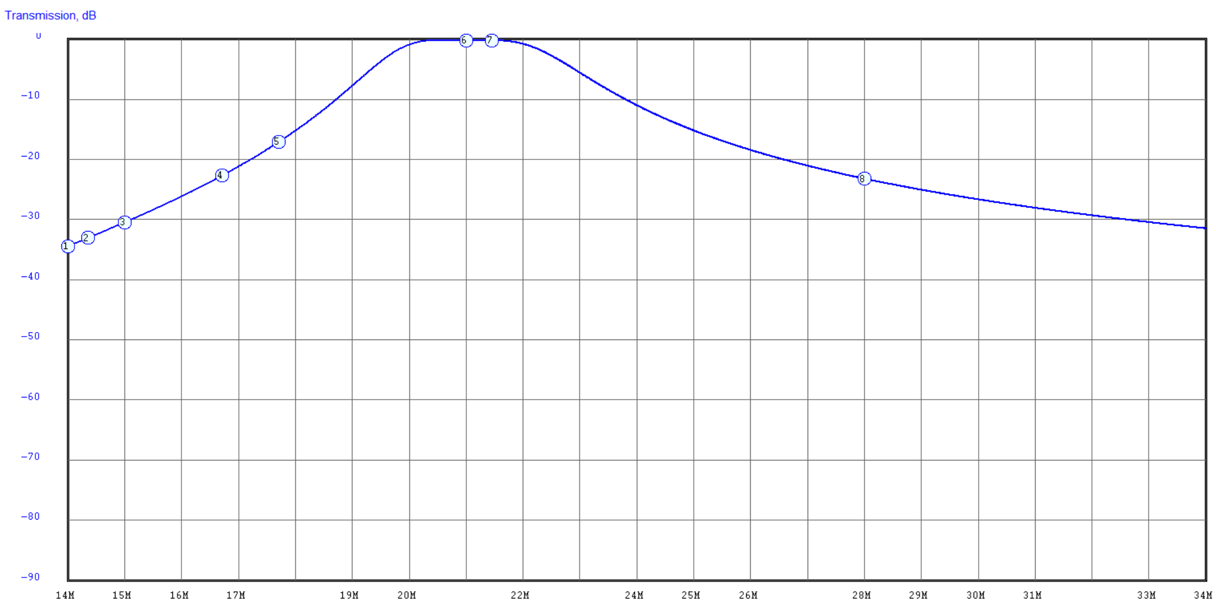


	Freq.: Mousedown for data	Trans.:	Angle:	Return:	Delay:	VSWR:	Zmag.:	Zangle:	Real:	Imag.:
1	3M	<-120	-98.621	-0.00082	-----	>1000	763.66	-89.959	0.54973	-763.66
2	5M	-117.75	-102.97	-0.00182	-----	>1000	439.25	-89.946	0.41031	-439.25
3	5.645M	-109.36	-104.61	-0.0023	-----	>1000	381.35	-89.941	0.39167	-381.35
4	11.065M	-49.033	-130.05	-0.02565	28.41n	677.17	120.07	-89.762	0.49965	-120.07
5	11.765M	-39.602	-139.04	-0.04491	44.77n	386.79	93.666	-89.643	0.58292	-93.664
6	14M	-0.51154	15.975	-19.013	472.7n	1.2523	58.496	9.161	57.75	9.3131
7	14.35M	-0.5135	-37.832	-15.701	396.4n	1.3925	65.622	10.631	64.496	12.106
8	21M	-38.305	76.687	-0.01154	9.362n	>1000	687.09	-89.474	6.3066	-687.06

15M
Schematic of factory 15M receiver band pass circuit:



Elsie model of factory 15M receiver band pass circuit:

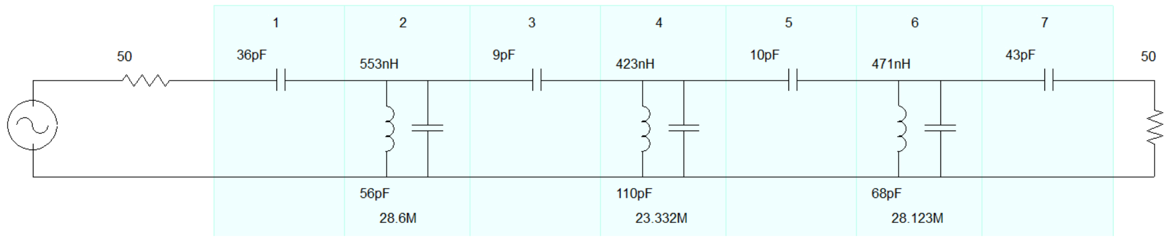


NEW 15M FILTER DESIGN:
Cauer –best solution on paper – did not use because of problems with similar 20M filter

Chebyshev
Not suitable – would require one toroid at 9.6 uh and one capacitor at 5.6 pf

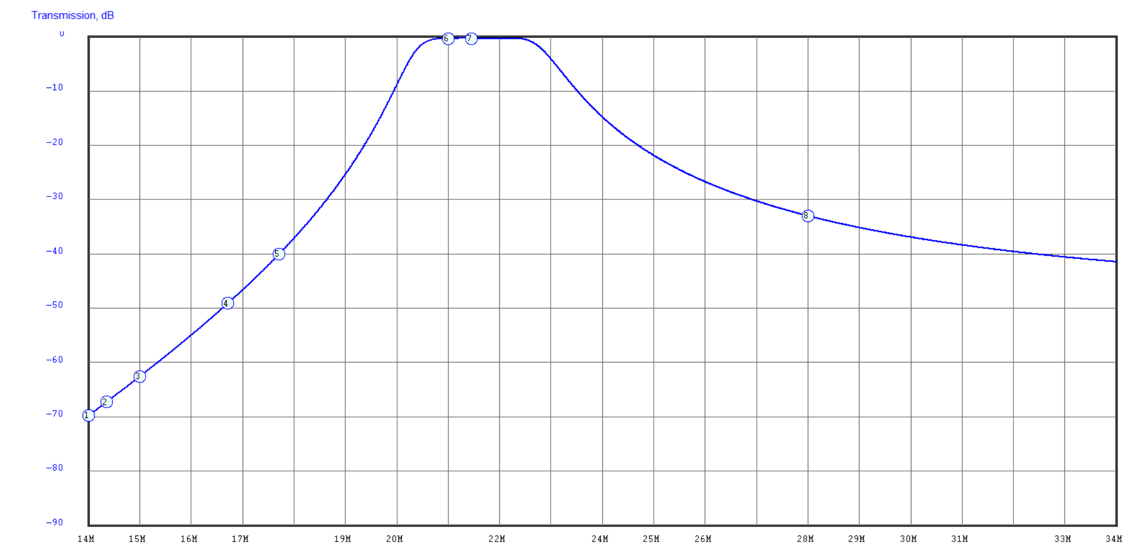
Butterworth
Not suitable - Would require two toroids at 8 uh and one at 35 uh
Would require two caps at 7000 pf and one at 1.5 pf

Top coupled with capacitive impedance divider on input/output – best solution



553 nh = T37-6 with 13 turns of #24 wire
423 nh = T37-6 with 11 turns of #24 wire
471 nh = T37-6 with 12 turns of #24 wire

Here is the resulting Elsie model:

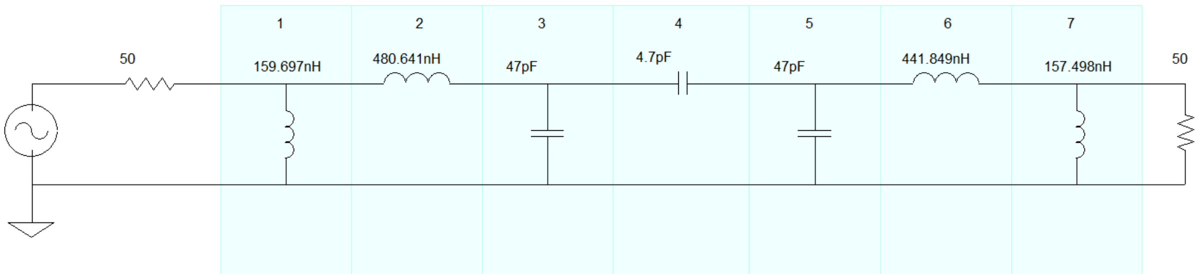


Mousedown for data

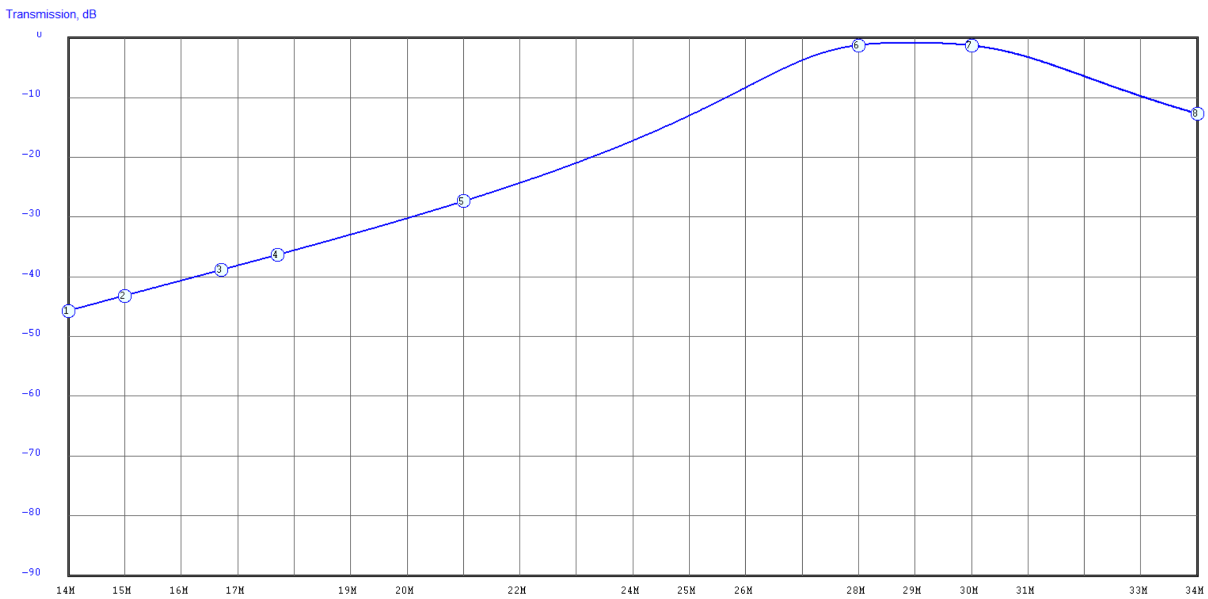
	Freq.:	Trans.:	Angle:	Return:	Delay:	VSWR:	Zmag.:	Zangle:	Real:	Imag.:
1	14M	−69.706	−115.8	−0.00489	8.629n	>1000	248.21	−89.917	0.36112	−248.21
2	14.35M	−67.209	−116.92	−0.00541	9.231n	>1000	237.41	−89.911	0.36687	−237.41
3	15M	−62.485	−119.24	−0.00662	10.63n	>1000	217.84	−89.9	0.3808	−217.84
4	16.71M	−49.071	−127.6	−0.0127	17.61n	>1000	167.46	−89.847	0.44659	−167.46
5	17.71M	−39.984	−135.48	−0.02147	27.28n	809.11	136.87	−89.78	0.52485	−136.87
6	21M	−0.3344	19.835	−27.276	310.8n	1.0905	49.56	−4.9297	49.376	−4.2588
7	21.45M	−0.31665	−26.453	−21.455	268.8n	1.1848	58.405	3.8707	58.272	3.9426
8	28M	−32.986	84.958	−0.01334	10.64n	>1000	1.3k	−88.855	25.982	−1.299k

10M

Schematic of factory 10M receiver band pass circuit with no Image filter:



Elsie model of factory 10M receiver band pass circuit with no Image filter:



NEW 10M FILTER DESIGN:

Cauer –best solution on paper – did not use because of problems with similar 20M filter

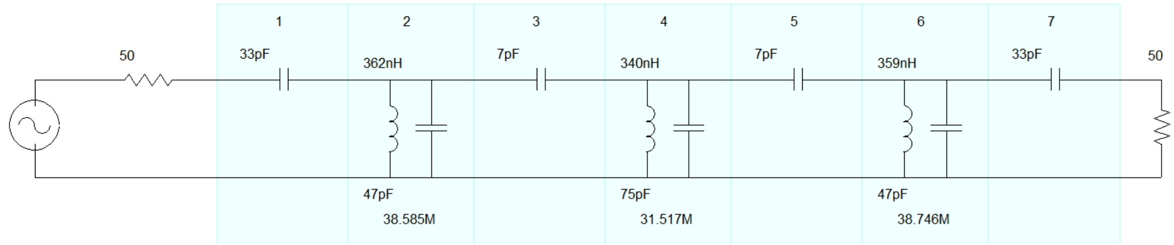
Chebyshev

Not suitable – would require one toroid at 7.7 uh and one capacitor at 4 pf

Butterworth

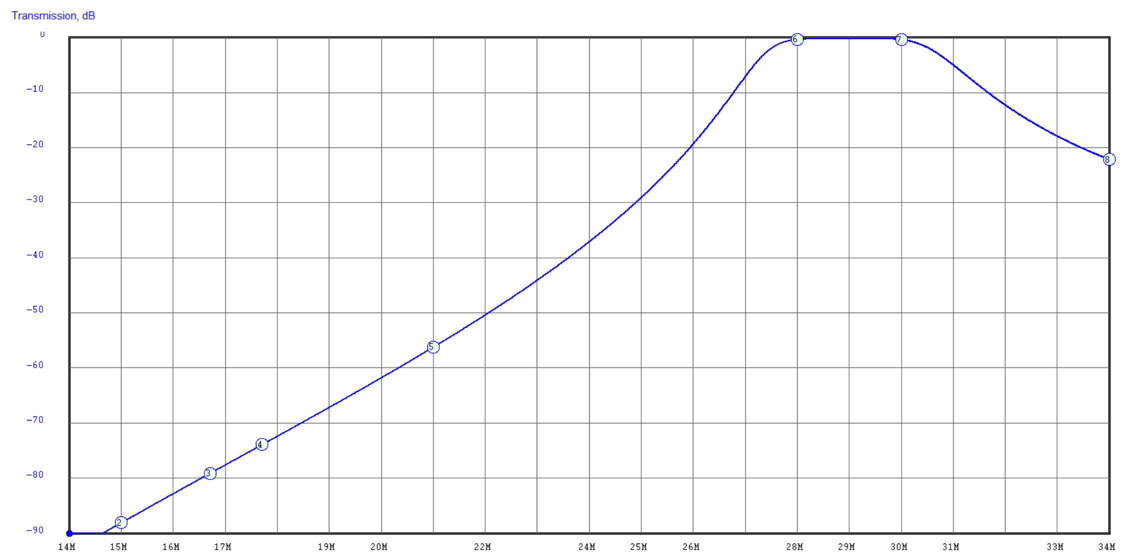
Not suitable – would require one toroid at 16 uh and one capacitor at 2 pf

Top coupled with capacitive impedance divider on input/output – best solution



362 nh	= T37-6 with 10 turns of #24 wire
340 nh	= T37-6 with 10 turns of #24 wire
359 nh	= T37-6 with 10 turns of #24 wire

Here is the resulting Elsie model:



	Freq.:	Trans.:	Angle:	Return:	Delay:	VSWR:	Zmag.:	Zangle:	Real:	Imag.:
	Mousedown for data									
1	14M	−93.42	−109.09	−0.00238	4.618n	>1000	306.95	−89.951	0.2649	−306.95
2	15M	−88.019	−110.81	−0.00278	4.963n	>1000	280.21	−89.947	0.25939	−280.21
3	16.71M	−79.036	−114.1	−0.00369	5.766n	>1000	240.11	−89.939	0.25585	−240.11
4	17.71M	−73.839	−116.29	−0.00443	6.42n	>1000	219.08	−89.933	0.2573	−219.08
5	21M	−56.172	−125.98	−0.00915	10.68n	>1000	156.82	−89.896	0.28528	−156.82
6	28M	−0.39286	36.553	−17.029	257.2n	1.3277	44.855	14.804	43.366	11.461
7	30M	−0.42789	−111.01	−14.293	216.6n	1.478	36.769	13.483	35.756	8.5731
8	34M	−22.163	105.48	−0.0555	24.04n	313.02	397.34	88.522	10.247	397.21

F. DSP Module

A BHI NEDSP1061-KBD module can be installed to reduce receiver noise. The module incorporates DSP technology to provide up to 35 db of noise cancellation. The module is controlled by a single toggle switch with audio beep feedback for determining DSP mode.

1. Module installation

These instructions cover the installation of the DSP module in a 210X LE unit that has a digital Si570 VFO. Installation of the Si570 VFO frees up the space in the VFO compartment for additional accessory modules. If the original factory VFO is still installed, then the module will need to be installed somewhere on the top side of the 210X chassis.

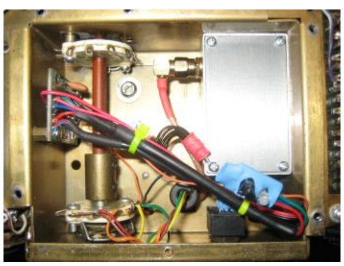
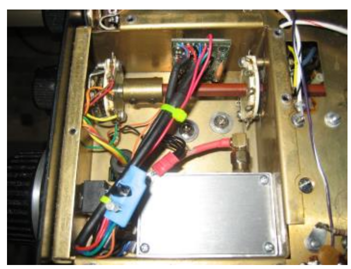
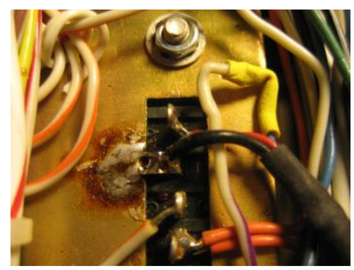
The module is mounted to the side wall of the VFO compartment using an existing hole. A brass standoff is mounted in the hole with a lock washer and nut. A second brass standoff is mounted on the DSP module and is used as a spacer. Fiber washers should be installed between the brass standoffs and the DSP module circuit board.

The end of the DSP module's audio interface cable is soldered in at Pin 22 of the PC-300 edge card connector. A jumper should be placed across C302 on the PC-300 board, per the general installation instructions provided in the BHI documentation.

Heat shrink tubing should be placed over the keyboard module to keep the circuit board from shorting out to the chassis. The DDS VFO front panel control switches are used to control the operation of the DSP module.

Prior to installing the module, measure the audio output noise of the receiver with no signal and the audio gain set out the 12 o'clock position.

Once the BHI module is installed, you can compare the new audio output readings and determine if you need to make a gain adjustment on the module.

2. Setup

The BHI setup procedure provided in the installation manual should be followed. The Input and Output pots are set to maximum from the factory. The input level control will need to be backed off ¼ of a turn to keep from overloading the DSP module.

One should listen to strong SSB signals for audio clipping, while viewing the overload LED indicator on the DSP module. You should not be able to hear any clipping/distortion and the LED overload indicator should just barely light on strong signal peaks. You will notice that the audio level gain control on the 210X will have to be turned up slightly in order to get the same level audio output as a non-DSP radio.

3. Operation

For these instructions, it is assumed that the Si570 VFO has been installed with the new front panel controls.

SAVE/DSP RIT toggle switch

replaces the Dial Set pot
center off – up momentary – down ON

Up momentary performs two different functions, depending upon position of the AUX control
If the AUX switch is in the DSP position, then the toggle switch is held in the up position to enable/disable the DSP module and also change the modes when the DSP mode is enabled – audio feedback beeps from the DSP module tells you the mode of the DSP module.

AUX Switch

replaces the RIT control
rotary switch with six positions
DSP Position – in this position, the SAVE/DSP toggle switch becomes the DSP mode switch

4. Noise Reduction

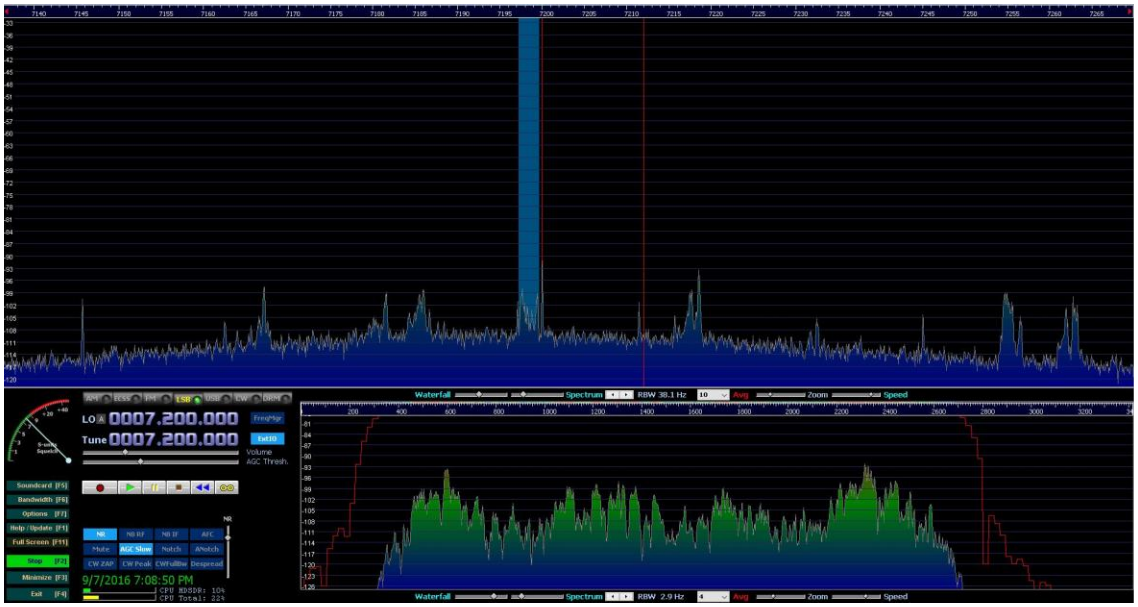
Here is the amount of noise reduction that was achieved for the various mode settings:
The noise was measured with a RMS voltmeter connected across the speaker on 40M.

1 beep	9 db
2 beeps	10 db
3 beeps	12 db
4 beeps	13 db
5 beeps	14 db
6 beeps	15 db
7 beeps	18 db
8 beeps	20 db

G. Panadapter

A full screen panadapter display is probably one of the most useful accessories that one can add to the Atlas radios. This particular installation uses a PAT board from G4HUP and a SDRdisplay receiver. The implementation is very easy.

Here is a typical display from the 40M band when there was not a lot of signal activity.



IX. Appendix

A. Information Links

The following links provide a wealth of information concerning design, operation, and testing of DDS VFOs:

1. 50 ohm Pi attenuator pad calculator
   http://www.random-science-tools.com/electronics/PI_attenuator.html

2. Mini Circuits Lab TUF-1 mixer
   http://www.minicircuits.com/pdfs/TUF-1+.pdf

3. Mini Circuits Lab ADE-1 mixer
   http://www.minicircuits.com/pdfs/ADE-1.pdf

4. Mini Circuits Lab SRA-1 mixer
   http://www.minicircuits.com/pdfs/SRA-1+.pdf

5. Discussion of spurs from a AD9951
   http://martein.home.xs4all.nl/pa3ake/hmode/hmode_intro.html

6. References to a number of different articles dealing with receiver band pass filters
   http://w4kaz.com/qth/?p=210

7. Performance tests for various diode types in a double balanced mixer.
   http://users.tpg.com.au/nfieraru/Electronics/DoubleBalancedMixers.htm

8. Phase noise in oscillators
   http://www.qsl.net/va3iul/Phase%20noise%20in%20Oscillators.pdf

9. Source of 210X/215X hard to find parts
   https://www.rfparts.com/catalogsearch/result/?q=atlas

10. Receiver IMD Testing
    http://www.sm5bsz.com/dynrange/qex/digital-imd.pdf
    http://www.ab4oj.com/test/ar7030comments.html
    http://www.robkalmeijer.nl/techniek/electronica/radiotechniek/hambladen/qex/2001/05_06/page45/index.html

B. HF Frequency Assignments (1 to 30 MHz)

In order to determine what frequencies might cause interference in the radio, one can do manual calculations. Here is a link that automatically computes the frequencies based upon your IF frequency, IF bandwidth, and LO injection:

http://leleivre.com/rf_mixerspur.html

The frequencies in the 1 to 30 MHz band are used for a number of purposes. The following link provides details on these frequency bands:

http://www.dxing.com/tuning.htm

Signals in the following frequency bands could cause interference in the 210X receiver if the signals are strong enough to get past the low pass, band pass, IF, and Image filters:

2498 to 2850 kHz:
Maritime stations are found here, as well as standard time and frequency stations WWV and WWVH on 2500 kHz.

2850 to 3150 kHz:
This band is used mainly by aeronautical stations in USB. Several stations broadcasting aeronautical weather bulletins, and you can also hear traffic between airports and airplanes aloft.

5450 to 5730 kHz:
This is another band for aeronautical communications in USB.

9500 to 9900 kHz:
This is the 31-meter international broadcasting band, and is packed with stations from around the world.

9900 to 9995 kHz:
Several international broadcasters use this range along with fixed stations using FSK modes.

9995 to 10005 kHz:
This is set aside for standard time and frequency stations, like WWV and WWVH on 10000 kHz.

10005 to 10100 kHz:
This range is used for aeronautical communications.

10100 to 10150 kHz:
This is the 30-meter ham radio band. Because it is so narrow, operation here is restricted to CW and RTTY.

10150 to 11175 kHz:
This segment is used by fixed stations. In addition to various FSK and digital modes, you may hear several international broadcast stations being relayed in SSB. These "feeder" stations are used to send programming to relay sites not served by satellite downlinks.

11175 to 11400 kHz:
This range is used for aeronautical communications in USB.

11400 to 11650 kHz:
This segment is mainly used by fixed stations in FSK and digital modes, but some international broadcasters also operate here.

11650 to 11975 kHz:
This is the 25-meter international broadcasting band. You can usually hear several stations here no matter what time of day you listen.

12330 to 13200 kHz:
This is a busy maritime communications band during the day and evening hours, with traffic in USB and various FSK modes.

13200 to 13360 kHz:
Aeronautical communications in USB are heard here during the day and evening.

13360 to 13600 kHz:
This range is used by fixed stations, mainly in FSK and digital modes.

13600 to 13800 kHz:
This is the 22-meter international broadcasting band, with best reception generally during the daytime and early evening.

14350 to 14990 kHz:
This segment is used by fixed stations, primarily in FSK and digital modes. Canadian standard time station CHU is also found here, on 14670 kHz.

14990 to 15010 kHz:
This sliver is reserved for standard time and frequency stations, with the best heard being WWV and WWVH on 15000 kHz.

15010 to 15100 kHz:
This range is for aeronautical communications in USB, although a few international broadcasters do show up here.

15100 to 15600 kHz:
This is the 19-meter international broadcasting band, and it is usually packed with signals during the daytime and early evening.

16460 to 17360 kHz:
This range is shared between maritime and fixed stations using USB, FSK modes, and digital modes.

17360 to 17550 kHz:
The range is shared by aeronautical and fixed stations using USB, FSK modes, and digital modes.

17550 to 17900 kHz:
This is the 16-meter international broadcasting band, and best reception is usually during the daylight hours.

17900 to 18030 kHz:
This band is used for aeronautical communications in USB.

18030 to 18068 kHz:
This range is used by fixed stations, mainly in FSK and digital modes.

18068 to 18168 kHz:
This is the 17-meter ham radio band, where CW, RTTY, and USB are used.

18168 to 19990 kHz:
This large band is used by fixed stations, with a few maritime stations also found here. Most traffic is in FSK and digital modes. An interesting frequency is 19954 kHz, used for decades as a beacon frequency by Soviet/Russian manned spacecraft. Reception in this range will usually be limited to daylight hours.

19990 to 20010 kHz:
This segment is reserved for standard time and frequency stations, like WWV on 20000 kHz.

20010 to 21000 kHz:
This range is mainly used by fixed stations and a few aeronautical stations. Most traffic is in FSK and digital modes as well as USB.

21450 to 21850 kHz:
This is the 13-meter international broadcasting band, with best reception during the daytime.

21850 to 22000 kHz:
This band is shared by fixed and aeronautical stations in FSK and digital modes as well as USB.

22000 to 22855 kHz:
This range is reserved for maritime communications in USB and FSK modes.

22855 to 23200 kHz:
This band is used by fixed stations, mainly in FSK and digital modes.

23200 to 23350 kHz:
Aeronautical communications in USB are found here.

25010 to 25550 kHz:
This band is used by fixed, mobile, and maritime stations, many of them low powered units in trucks, taxicabs, small boats, etc. USB and AM are mainly used, along with FM having 5 kHz deviation.

25550 to 25670 kHz: This region is reserved for radio astronomy and is usually free of stations.

25670 to 26100 kHz:
This is the 11-meter international broadcasting band. However, only Radio France International has any broadcasts scheduled here at this time. Reception is usually possible only in daytime during years of high sunspot activity.

C. Possible Interfering Signals

The following table shows frequency bands listed under Appendix Item G, that might cause interference in an Atlas radio.

Frequency Range	80M	40M	20M	15M	10M	Comments
2498 to 2850 kHz			X			Primary image
2850 to 3150 kHz			X			Primary image
5450 to 5730 kHz (5645 KHz IF)	X	X	X	X	X	All bands
9500 to 9900 kHz				X		Primary image
9900 to 9995 kHz				X		Primary image
9995 to 10005 kHz				X		Primary image
10005 to 10100 kHz				X		Primary image
10100 to 10150 kHz				X		Primary image
10150 to 11175 kHz			X	X		Primary image
11175 to 11400 kHz			X			2x VFO image
11400 to 11650 kHz			X			2x VFO image
11650 to 11975 kHz			X			2x VFO image
12330 to 13200 kHz	X					2x VFO image
13200 to 13360 kHz	X					2x VFO image
13360 to 13600 kHz	X					2x VFO image
13600 to 13800 kHz	X					2x VFO image
14350 to 14990 kHz	X					Primary image
14990 to 15010 kHz	X					Primary image
15010 to 15100 kHz	X					Primary image
15100 to 15600 kHz	X					Primary image
16460 to 17360 kHz					X	Primary image
17360 to 17550 kHz					X	Primary image
17550 to 17900 kHz					X	Primary image
17900 to 18030 kHz					X	Primary image
18030 to 18068 kHz					X	Primary image
18068 to 18168 kHz					X	Primary image
18168 to 19990 kHz		X			X	Primary image, 2x, 3x
19990 to 20010 kHz		X				2x VFO image, 3x
20010 to 21000 kHz		X				2x VFO image, 3x
21450 to 21850 kHz	X					3x VFO image
21850 to 22000 kHz	X					3x VFO image
22000 to 22855 kHz	X					3x VFO image
22855 to 23200 kHz	X					3x VFO image
23200 to 23350 kHz	X					3x VFO image
25010 to 25550 kHz				X		2x VFO image
25550 to 25670 kHz				X		2x VFO image
25670 to 26100 kHz				X		2x VFO image

D. Technical Resources

The following links provide a wealth of information concerning design, operation, and testing of HF SSB transceivers:

Mods For Atlas Radios
http://atlas.wireless.org.uk/mods.htm
Drake TR7 PA design considerations very similar to 210X design
http://www.wb4hfn.com/DRAKE/DrakeManuals/PDFDOCS/TR7-Circuit-Diagrams.pdf

Receiver Measurements – How To Evaluate Receivers
http://www.hb9gr.ch/dokumente/Receiver%20Measurements.pdf

Crystal Filter Design
https://www.arrl.org/files/file/QEX_Next_Issue/Nov-Dec_2009/QEX_Nov-Dec_09_Feature.pdf
http://www.w0qe.com/Projects/crystal_bandpass_filters.html

A high-dynamic-range MF/HF receiver front end
http://www.robkalmeijer.nl/techniek/electronica/radiotechniek/hambladen/qst/1993/02/page23/

Testing diode mixers
http://users.tpg.com.au/nfieraru/Electronics/DoubleBalancedMixers.htm

Present-day receivers – some problems and cures
http://www.sherweng.com/documents/Present-dayReceivers-sm.pdf
Sherwood Engineering receiver test results
http://www.sherweng.com/table.html

AGC Curves, including Elecraft K2 – which uses a similar receiver design as the 210X
http://www.cliftonlaboratories.com/receiver_agc_curves.htm

Software tone generators – can be used for performing two tone IMD tests on transmitter
http://ko4bb.com/ToneGenerator/ToneGeneratorReleaseNotes.php
http://download.cnet.com/Dual-Function-Generator/3000-2169_4-75717132.html
Transmitter IMD testing
http://www.elecraft.com/manual/2T-Gen_Manual_Rev_B.pdf
http://www.w8ji.com/transmitter_splatter.htm
http://www.cliftonlaboratories.com/imd_measurements.htm
http://preciserf.com/wp-content/uploads/2012/03/Appnote-3-Spectrum-analyzer-test2.pdf
http://preciserf.com/wp-content/uploads/2012/03/Appnote-2-Two-Tone-Tests2.pdf

This document has more content than the one found on the Yahoo forum:
http://translate.google.com/translate?hl=en&sl=nl&u=http://pa0fri.home.xs4all.nl/Mods/Atlas215/atlas215.htm&prev=/search%3Fq%3Dsd1405%2Bhf%2Bamplifier%26start%3D50%26client%3Dsafari%26sa%3DN%26hl%3Den%26biw%3D1024%26bih%3D672

IMD Tests on HLA-150 amp that has similar design to Atlas 210X
http://www.w8ji.com/rm_hla-150_test.htm

Bias designs for RF Power Amplifiers
http://www.qsl.net/va3iul/Bias/Bias_Circuits_for_RF_Devices.pdf

Heat sink design for RF Power Amplifiers
http://sound.westhost.com/heatsinks.htm

Schematics for the Ten-Tec Argonaut VI 539 transceiver:
http://www.tentec.com/pages/Transceiver-Downloads.html

Technical discuss on various capacitor types:
http://www.radio-electronics.com/info/data/capacitor/capacitor_types.php

E. Receiver 3rd Order IMD Testing

One of the original Atlas transceiver claim-to-fame features was its ability to hear weak signals with nearby signals that were very strong. Forty years later, the 210X/215X radios still have better overload specs than many of the modern day transceivers. This was the result of having no RF amplifier ahead of the first mixer and having a passive double balanced mixer.

If you go to the Sherwood Engineering web site, you can see how the Atlas receivers compare with other models in the areas of Dynamic Range Wide Spaced.

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

The dynamic range data can be converted to 3rd Order IMD values with the following formula:
IP3 = (3 x IFDR)/2 + (noise floor)

Here is an example using the data for the 210X radio.
IP3 = (3 x 80)/2 + (-120)
IP3 = 120 - 120
IP3 = 0 dbm
Using the above formula, here are some 3rd Order IMD specs for some of the popular transceivers, normalized for a MDS of -120 dbm. The data in parenthesis is the raw data, using the measured MDS listed on the Sherwood web site.

+39.5 dbm (+39.5)	Kenwood TS-990S
+38 dbm (+40)	Flexradio Systems 6700
+37.5 dbm (+37.5)	Yaesu FT-950
+37.5 dbm (+34.5)	Elecraft KX3
+37.5 dbm (+30.5)	Icom IC-7700
+36 dbm (+33)	Yaesu FTdx-5000D
+36 dbm (+29)	Kenwood TS-590SG
+36 dbm (+26)	Elecraft K3 (old version)
+33 dbm (+18)	Icom IC-7410
+33 dbm (+31)	Yaesu FTdx-1200
+28.5 dbm (+16.5)	Icom 756 Pro-III
+28.5 dbm (+14.5)	Drake TR-7
+27 dbm (+21.5)	Elecraft K3 (new version)
+27 dbm (+18)	Elecraft K2 (very similar RX front end design to the 210X with PC-100 board)
+22.5 dbm (+17.5)	Ten-Tec Argonaut 539
+21 dbm (+14)	Collins KWM-380
+19.5 dbm (+15.5)	Ten-Tec Eagle 599
+15 dbm (+12)	Flex 3000
+12 dbm (+16)	Flex 1500
+ 7.5 dbm (-13.5)	Collins 75S3C
+ 1.5 dbm (- 9.5)	Atlas 350XL (same basic front-end as the 210X)
0 dbm (0)	Atlas 210X with PC-120 board – measured by Clint
- 1.5 dbm (- 4.5)	Heath SB-104
- 6 dbm (-6)	Atlas 210X with PC-120 board
- 9 dbm (-13)	Drake TR-4C
-14 dbm (-14)	Atlas 210X – measured by Kevin

Please note that Wide Spaced figures d0 not tell the entire story. One also needs to look ats the Narrow Spaced figures.

Low cost test equipment is readily available to perform 3rd order IMD testing on the radios. HP 8640 and Marconi 2018 signal generators are available for reasonable prices on eBay for about $300. Both of these signal generators have very low close in phase noise.

Here is a link to an article that provides info on building two crystal controlled oscillators.

http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=6&ved=0CC0QFjAFahUKEwiC1uDm5tPIAhWGKYgKHUn7AH0&url=http%3A%2F%2Fwww.cqham.ru%2Fforum%2Fattachment.php%3Fattachmentid%3D33030%26d...%2520&usg=AFQjCNE9w5ihVotlm_Sd3D_Urup5dhgNaA&sig2=SC9A79I_iojWEvMqrxTztw

Si570 oscillators could also be used. Here is a couple of sources for these oscillators:

http://ac0c.com/main/page_homebrew_2xsi570_rf_gen.html
http://www.qsl.net/k5bcq/Kits/Kits.html
http://sdr-kits.net/#Pricing

Jack from Clifton Laboraories has confirmed that the SI-570 oscillator has about the same amount of phase noise as the HP-8640.

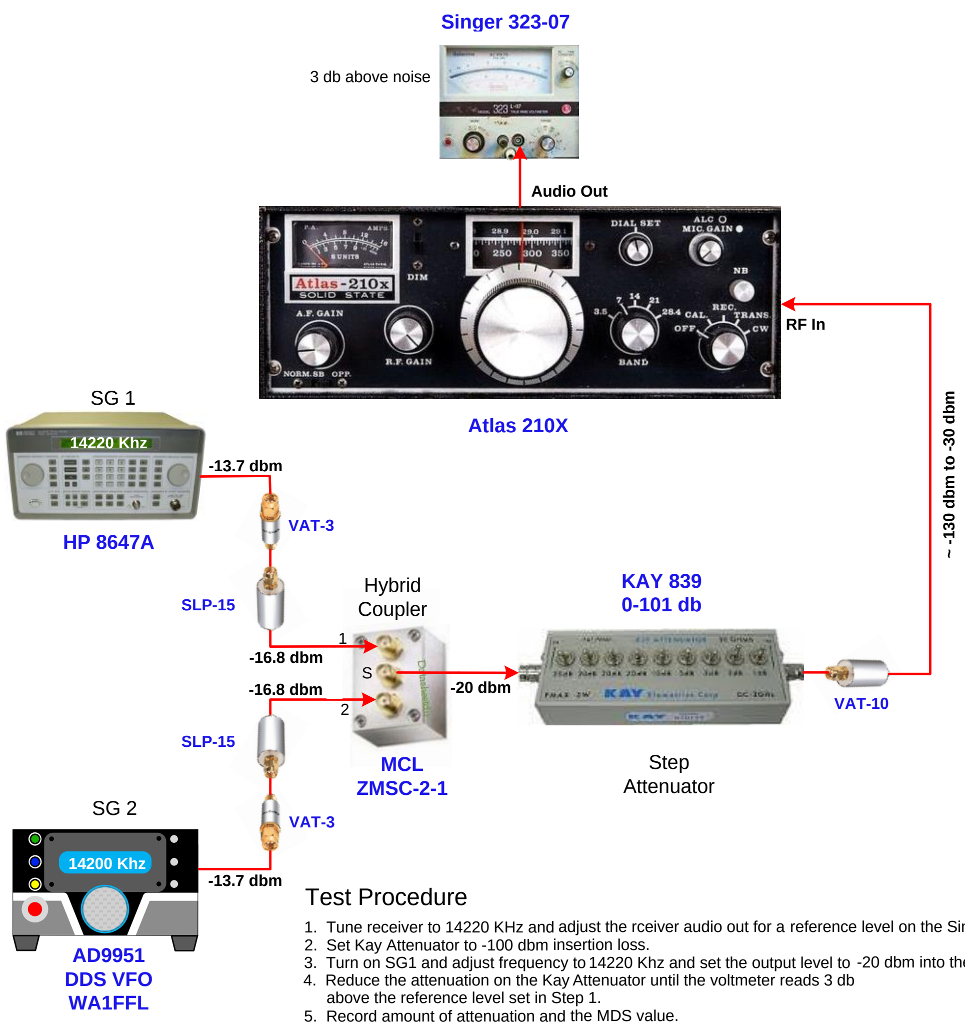
http://www.cliftonlaboratories.com/si570_kit_from_k5bcq.htm
An excellent AD9951 oscillator kit is available from this source:
http://www.wa1ffl.com/

The measured 3^{rd} order IMD spec for a receiver can be no better than the spec for the first mixer. For a receiver with an MCL ADE-1 mixer, that spec would be +15 dbm. The more gain stages in a receiver, the higher the probability of reduced 3^{rd} Order IMD measurements.

The noise blanker on a PC-120 board, has a very large effect on the measured 3^{rd} order IMD. In some cases, measured IMD is reduced as much as 40 db when the noise blanker is enabled. This happens even when the noise blanker thresh-hold pot is correctly adjusted.

Here is an example of a test configuration that could be used:

Receiver 3rd Order IMD Testing



Test Procedure

1. Tune receiver to 14220 KHz and adjust the rceiver audio out for a reference level on the Singer voltmeter.
2. Set Kay Attenuator to -100 dbm insertion loss.
3. Turn on SG1 and adjust frequency to 14220 Khz and set the output level to -20 dbm into the Kay attenuator.
4. Reduce the attenuation on the Kay Attenuator until the voltmeter reads 3 db above the reference level set in Step 1.
5. Record amount of attenuation and the MDS value.
6. For an Atlas 210X LE, that value will be about – 120 dbm.
7. Turn on SG2 and set frequency to14200 Khz and the output level to - 20 dbm into the Kay attenuator.
8. Tune the receiver to 14180 KHz or 14240 Khz.
9. Reduce the attenuation on the Kay Attenuator until you reach the MDS level on the voltmeter.
10. Record amount of attenuation on the Kay Attenuator.
11. Subtract the attenuator setting in Step 10 from the setting in Step 5.
    This is your 3rd Order IMD Dynamic Range.
12. Multiply the Dynamic Range value by 1.5 and add the MDS value from Step 5.
13. Typical 210X LE value would be: 1.5 x 80 -120 = 0 dbm
14. Typical 210X with PC-100 board would be: 1.5 x 90 -120 = + 15 dbm

F. Undocumented Factory Changes

The following factory changes were made to the 210X/LE series of radios, but the changes were never documented by the factory:

The IF of the radio was moved from 5520 KHz to 5645 KHz
No updated user manual was produced for the 210X LE model
No schematic was produced for the PA-500 module used in the 210X LE model
No details were provided on how the 210X LE model achieved higher TX power output
Two types of PA-500 boards used on the LE model (different foil pattern in area of driver transistor)
Type 1: MRF-476 driver, 3 turns on output driver transformer, and MRF-454 PA transistors
Type 2: MRF-497 driver, 2 turns on output driver transformer, and CD-3435 PA transistors
C515 is 180 pf versus 100 pf on a standard 210X model
IF Trap and Image filters on the 210X LE models were 6 turns of wire as opposed to 8 turns
3.9k ohm resistor replaced with a 2.5k ohm pot on the PC-200 board
No details on how to adjust the 2.5k ohm pot on the PC-200 board
The two 68 ohm resistors were removed from across the carrier balance pot on the PC-120 board
Some 210X radios had a push/pull On-Off switch installed on the Mic Gain pot
Change from open contact phenolic wafers to enclosed hard plastic wafers on the band-switch
Several different regulated voltages on different models (8.5 vdc, 9.5 vdc, 10 vdc, etc.)
Chassis edge card connectors changed to a single row of 22 pins as opposed to a dual row of 22 pins

G. Unresolved Design & Engineering Issues

There are a number of areas in the radios that do not appear to operate correctly and/or a better design seemed to be available when the radios were produced. The easy answer is related to cost. Produce a radio with a low manufacturing cost so that a reasonable profit could be made. We will continue to research these areas for solutions.

These items include:

Crystal Filter bandwidth measures about 2.3 KHz at the -6 db points, versus the advertised 2.7 bandwidth
Low Q capacitors were used in a number of RF circuits, when higher quality capacitors were available
Discrete component mixers were used when packaged MCL mixers were available in 1974 at low prices
The output of the receiver mixer was not adequately terminated at 50 ohms
The radios were never submitted to QST for lab testing
The receiver audio circuits appear to be low frequency crippled due to low values of coupling capacitors
On the PC-120 boards, different designs were used on the 1st and 2nd IF amplifier circuits
Double sided PCB was not used on the TX BPF resulting in instability and spur generation

H. History of Atlas Radio

Here are links related to the various models of radios produced by Atlas Radio:

One of the first magazine article reviews of the Atlas radio.
http://www.radiomanual.info/schemi/Surplus_Radioamateur/Atlas_210_215_review_1975.pdf

This link has 8 different ads for the 210X LE radio.
https://archive.org/stream/73-magazine-1979-06/06_June_1979#page/n29/mode/2up

Press release for the 310 radio:
www.atlas.wireless.org.uk/310.htm

Links for the 410X radio:
www.atlas.wireless.org.uk/pictures2.htm

http://www.atlas.wireless.org.uk/400.pdf

The following information was compiled from Google searches, the Yahoo Group Atlas forums, and from individuals that had knowledge in this area.
Herb Johnson, W6QKI, was the founder of Swan Electronics in 1961, manufacturing the first generation of highly successful single band SSB/CW Transceivers for the amateur radio market. The single band models evolved into tri-band units and then into full five band units. Swan's success in the early 60s paved the way for National to release their NCX-3 tri-band transceiver and Drake – their TR-3 five band transceiver.

In 1967, Herb merged Swan with Cubic Corp. of San Diego, and continued managing the Swan subsidiary until 1973. The Swan line of equipment was mostly tube type design, and through the years more than 80,000 Swan Transceivers were sold.

A high percentage of them are still on the air, putting out strong, good quality signals. (The name "Swan" was chosen in memory of Herb's dad, whose name in the old country, Sweden, was Sven, but was Americanized to Swan when he came to the U.S.A.)

In 1974, Herb started his second company and named it Atlas Radio (after the 1924 vintage diesel engine in the 1924 motor vessel, "Westward", owned and skippered by his friend, Don Gumpertz, K6OF). Atlas introduced the first successful all solid state transceiver.
In this design, Herb had valuable assistance from Les Earnshaw, founder of Southcom International. The original model 180 covered the 160, 80, 40, and 20 meters.

In 1975, the 210 and 215 models evolved, followed in 1976 with improved 210X and 215X models. (The 210 series covered the bands from 80 through 10 meters, while the 215 covered 160 through 15 meters). The 210X/215X LE models were released in early 1979.
There were over 19,000 of the various models sold. They were developed under the "KISS" principle ("Keep-It-Simple-Stupid"), and the design set new standards for high performance and reliability, as well as being practically bullet proof. The majority of these early Atlas radios are still in service.
A typical eBay price for a fully working model is $200 to $400. The price seems to be going back up, compared with pricing from 10 years ago.

Herb Johnson, W6QKI died February 1. 2000. Johnson, who lived in Cardiff, California, was 79 and had been in ill health for several years. Information from Gary Smith - VE4YH (who is the proprietor of the VE4YH Virtual Swan Museum, http://www.pcs.mb.ca/~standard/). Swan Electronics, then Swan Engineering, began during the winter of 1960-1961 as a one-man operation with Johnson, then W7GRA, building the first 10 Swan SSB rigs in a garage in Benson, Arizona.

In the early days of this Yahoo group, there was an ex-Atlas employee who would from time to time take pity on us and explain why these things were so.

Such as the lack of a workshop manual (apparently they intended to write one but just never got around to doing it, too busy building radios) and the variations between radios of the same model which were not covered in the circuit diagrams (modifying the radios as they were going down the production line seems to have been a regular thing at Atlas) Herb apparently pushed this aspect of the Atlas production as a plus, listening to his customers suggestions.

Apparently Atlas had the FCC on their backs on a regular basis as the output spectrum of some units was not all that wonderful; the ex employee advised me not to put my 210x on a spectrum analyzer as I might be shocked by the results, or might not be, as the output spectrum of each transceiver rolling down the production line varied considerably.

In 1995, a revived Atlas Radio promised to produce a new-generation Atlas 400X and even collected deposits and full payments for radios – which it ultimately failed to deliver or which failed to meet expectations. Johnson conceded in 1996 that he had “wandered into a mire of technical problems" in trying to design a new Atlas HF rig.

He said he personally lost thousands of dollars on the revived Atlas Radio venture and estimated that as many as 250 hams had made deposits, while only a few ever saw their money again. Many hams complained to the ARRL, and a few sought legal actions against Atlas Radio.

Other hams who invested in Atlas Radio also were left in the cold. In 1995, a company called O.M. Radio struck a deal to take over Atlas Radio's assets and manage the company.
O.M. Radio also operated an Atlas Radio repair service and even promised to make good on delivering the new transceiver, but nothing ever came of the effort.

An old Swan employee said that Herb Johnson had some great plans for some great new rigs, but became too sick to see the development through, and then the people that ran the company for him while he was dying messed up the finances beyond repair. He feels that if Herb's health would have been better at the time, we would have seen some radios that even outclass the 350-XL!

350XL Radio Info
Around 1977, Herb and the engineers (Bob Ruby and Fenner Hudson, both silent keys) came up with the 350XL to better compete with Kenwood and Yaesu, who were chipping away at Atlas sales.

The 350XL was a magnificent radio but it spent a long time in development and was costly to produce so not many were made and in the long run didn't really catch on.

Mike Williamson – KA5DVR, has serial number 2863 CA of the 350XL Mark II series. Per the user manual, Atlas started with SN 1950 CA for the first Mark II radio. Mike suspects that 200 to 400 of the Mark II units were made, so there could have been up to 1200 total units sold from the entire series.
Herb personally tweaked every 350XL that went out the door and Herb indicated that he lost money on every unit that was sold. It is reported that Herb made the statement “When it is working, the 350XL is a dream machine, when it’s not, it’s just a pile of junk”.

210X LE Info
This model was released around June 1979 and was probably the last fully functional transceiver that Atlas produced. Three months later, the Atlas Radio Company went out of business. I suspect that the competition was too much for the company to overcome. There were any number of solid state transceivers on the market at that time, including units for mobile operation.

Competition included the:
Icom IC-701
Kenwood TS-120S and TS-180S
Swan 100MX and Astro 150
Tec-Tec Omni 545
Yaesu FT-101ZD and FT-7B

310 Radio Info
There was a press release in 1993 for this model and it appears that no units were ever produced.

"The Swan transceivers were what I like to think of as my first generation of SSB HF Transceivers," says Herb. "They were then followed by my second generation, the Atlas transceivers of the 70's."

"And, so here we are, back again, this time with the third generation, the brand new Atlas 310. I'm sure you'll find the 310 to be as innovative and exciting as the 210 was 18 years ago, with many additional features to make it the radio of the 90's.

The general design philosophy is the same 'KISS' principle, but without compromise in any area. In state-of-the-art technology, performance, and reliability, the 310 takes a back seat to no one."

400X Radio Info (from a ham that received one):
The 400X was released in 1994 and about 5 or 6 of them were sold. Some hams paid for the radios up front and received a refund when the radio could not be delivered.

One ham never received a working radio, but did receive two units that did not work and a console power supply. Both of these radios were missing the PA module.
Here is some info from another ham that purchased this model:
The 400X did arrive. It appears to be in pristine condition. Doesn't look like a coax has ever been plugged in. It has a few wires hanging that need homes.
It is a very curious mix of old Swan with the Jones plugs on the back. It seems to have a modified 210X LE P.A. in it with the negative rc feedback networks on both P.A. transistors.

They appear to be the 80W MRF454 size. The front panel controls are very smooth with a high class quality feel to them. There is a conflict with the chassis and the top mounted speaker, (which has a Mylar speaker cone instead of paper). So the lid won't go on. This is a very small problem to fix.

The boards have a distinctive Astro 103 look to them, but the components are laid out flat to the boards and perpendicular to each other in a real neat layout. The construction is way better than I thought it would be. It will take some time to power it up, as I want to make sure all is good to do so. The IF crystal filter is discrete and not like the packages from Network sciences.

It has a 2.7, a 1.8 and a 0.6 kHz setting on the front panel switch for the IF filters. Some parts of the wiring do look as if home made. There is a 210X looking dial drum, metal this time, but it harkens back to the 210X with the black string. The front panel silk screening is very good quality and the powder coated covers are nice. It has the Swan 100MX/Astro line feet on the bottom cover. The top and bottom cover are the same, so both have a speaker grill pattern, but only the bottom have holes for the feet.

Jack Brewer appears to have the only 400X that is working. Research is in progress to find out who was working in the 400X shop. It appears that one of Herb's sons was working with him.

Last Days (from an ex-Atlas employee):
In March 1976, I was fortunate enough to land a job managing the stockroom at Atlas Radio, Inc. in Oceanside, California. Prior to this, I was working for minimum wage in the mailroom of a non-profit organization and working nights and weekends at Mel's Bubblebath Carwash.

A friend of mine had previously held the Atlas Radio stockroom job and, having decided that he and his wife were moving to Oregon, got me an interview with his boss Les Johnson, who was the Atlas Production Manager and son of Atlas Radio owner Herb Johnson.

W6QKI (now silent key), Les, and I talked for a while and I guess he figured I was, at least, halfway intelligent and he hired me on the spot. The next day I quit the carwash and gave my notice at the non-profit organization.

I was very elated about all this for two reasons: 1) The wages offered by Les exceeded the total of my previous day and night/weekends jobs combined, and: 2) I had been interested in amateur radio since 1965 when I became an avid SWL after my Dad built a Knight Kit 'Star Roamer' regenerative shortwave receiver. I listened to lots of hams (mostly AM in those days) and dreamed of someday earning my ham ticket but for various reasons I was never quite able to get to it.

Atlas Radio, Inc. was loaded with enthusiastic Hams.

The Engineers, most of the Technicians and nearly all of management was Hams. After a few weeks there, I found myself with an Elmer, an old time Ham whose name was Tom Marshall (can't remember his call sign). Tom was in his late sixties at the time and mentioned that he had helped set up a few of FDR's 'Fireside Chats' back in the late 1930's while he lived in Maryland.

Tom would send me practice code during our lunch breaks and after a couple months I got my code speed up to around 15 words a minute. Tom worked 40m CW exclusively and he was good!

While I would painstakingly write down every letter when copying CW, Tom never wrote down anything. He just listened and heard entire sentences and paragraphs and worked CW at around 40 words per minute. Meanwhile I was studying up on radio theory and FCC rules and regulations.
The big day came and I drove down to the San Diego FCC Field Office, took my written and code tests for a General Class license and passed, first try.

Back at work, Les had heard about my newly earned Ham ticket and took it upon himself to set me up with an Atlas 210X which Clint Call (W6OFT, now silent key) kept as a loaner in customer service. Then Les had me pick out a multiband vertical antenna which purchasing ordered for me. The idea being that I would pay back the company later when I had some extra cash. Later came around after the next payday and I approached Les with partial payment in hand and he said with a smile, "Forget about it".

My antenna arrived after a few days which I set up on the roof of my small rental bungalow. Right away I turned into a DX hound and would stay up late at night tuning around the 20 meter band. I had QSO's with Hams around the world and I was in Ham Heaven.

After a year in the stock room, Les called me into his office and told me that they liked my attitude and work habits and that they wanted to move me up. I was offered a job as a parts buyer or a technician. I asked Les. 'which one makes more money?' Technician was Les's answer.
The next day Burr Chamblis, the Test Department Supervisor, sat me on a test bench between two old timers (two hams in their 50's - I was 25) who taught me electronics and troubleshooting.

I began testing modules and then assembled radios. Turns out I had an easy grasp of this and after another year I was doing the final check out, troubleshooting and burn-in of the completed 180's, 210X, and 215X's.

A year later, I was the go-to guy and was fixing all the problems the other techs were having a tough time with. The components were always very hearty and reliable so 95% of the problems were assembler errors which were pretty easy to find.

By today's complex standards, an Atlas 210X is super simple, straight forward and EASY to trouble shoot! By early 1979, I was running the final checkout tests and burn-in bench and having fun doing it.

Things started to go downhill when AR introduced the 350XL which was a bugger to develop and test. And then there was the ill fated 110X which was the entry level modular system which almost no one bought. There were still hundreds of these on the shelves in Sept. 79 when AR went bust.

There were not many 350XL's made and sold, maybe a thousand. They're rare. I found one the other day at a garage sale which prompted me to discover this web site.

I worked at Atlas Radio Inc. from March 1976 until September 1979 when the doors were closed. Besides family members, Herb Johnson and sons Les and Eric, I and two other guys was the last people to get laid off.

It was a sad day for me because Atlas was a great place to work. It was loaded with a lot of very nice people, not least among them, the Johnson's who helped me launch my career in HF radio electronics manufacturing.

I. Background of Authors

KEVIN MURPHY – ZL1UJG

Kevin is 55 and developed an interest in radio from his late father, who was a short wave listener for many decades. Upon leaving school, he spent some time (~ 1.5 years) in the Radio Section at the local Naval dockyard, which was a short walk from where he lived in Auckland NZ.

The family moved to the UK during the mid 1970's and after a short time, was employed at one of the RACAL Radio companies in Reading, Berkshire.

He was employed for almost 10 years repairing and calibrating test equipment, involved with the design and manufacture of their radios. He interacted with the design engineers and developed an interest in radio performance. He got his first Amateur license in 1977 under the call G8NXT.

Upon returning to NZ in 1986, he started working on radio repair (down to component level) for the NZ Post Office, which then changed its name to Telecom. The repair of their Telecom systems then centralized in Hamilton. Since 1989 he has been working as a radio technician in the same facility, which has become privately owned. (http://www.looptechnologies.com/)

Kevin has an interest in radio performance with a moderately equipped home workshop, and some modern tools, (such as the SignalHound Spectrum Analyzer, and VNWA2.6), and other surplus test equipment.

CLINT CHRON – W7KEC

Clint is 67 and retired from Charles Schwab as a HP server hardware engineer. He operates a small consulting company (www.telechronconsulting.com) to help pay for his hobby. Clint's family moved from Texas to Alaska in the mid 50s and AT&T telephone calls were about $20 for a 5 minute call. His grandfather in Texas told him that he would buy him a ham radio setup if he would get his ham license so that someone in his small Texas town could run phone patches to him.

Clint got his Novice license in 1960 with a call sign of WL7DQP. His grandfather bought him a Heath DX100 transmitter (assembled) and a Hallicrafters SX96 receiver. Clint had to buy the antenna – a Hygain AVQ-14 vertical. Shortly thereafter, Clint's family moved back to Texas and Clint became KN5HGF. He later upgraded to a Conditional license. He saved his earnings as a "bag-boy" at a local grocery store and was able to purchase one of the first Drake TR-3 SSB transceivers in 1963.

Clint joined the US Navy during the Viet Nam war and was trained primarily as a submarine nuclear reactor operator, with a secondary skill as a radar technician. He also worked as a sonar technician on a submarine tender. Clint ran a number of phone patches from the Navy MARS stations of K6NCG at Treasure Island and KH6SP at Pearl Harbor.

Upon leaving the Navy in the early 70s, Clint worked in various jobs as a land mobile radio technician. Everything that he did in the land mobile area was directly transferable to the ham radio area. He was always experimenting with new ham radio circuits.

Clint's passion in ham radio is building, testing, and experimenting. Not much time for operating. His current operating goal is to get some type of 10M – 40M antenna installed in the attic at his house (HOA restrictions). He has to keep his Cushcraft vertical folded over when not using it.

Clint has a moderate setup of test equipment – most of it old, but still very usable - HP 8647A signal generator, Rigol DSA 815 spectrum analyzer, Boonton 4220 power meter, and various power supplies, frequency counters, oscopes, etc. He also has a machine shop with a Taig lathe and a Harbor Freight mill, so it is easy to fabricate mechanical parts for his ham radio projects.

J. MMIC Wide Band Amplifiers

For some testing/engineering scenarios, one needs a simple wide band amplifier with input and output impedances of 50 ohms. Mini Circuits has a number of MMICs that provide excellent amps. This includes the GALI-6, GALI-74, GALI-84, ERA-5 etc. These chips can be obtained from Mini Circuits as evaluation samples. A minimum number of parts are needed for a complete amplifier.

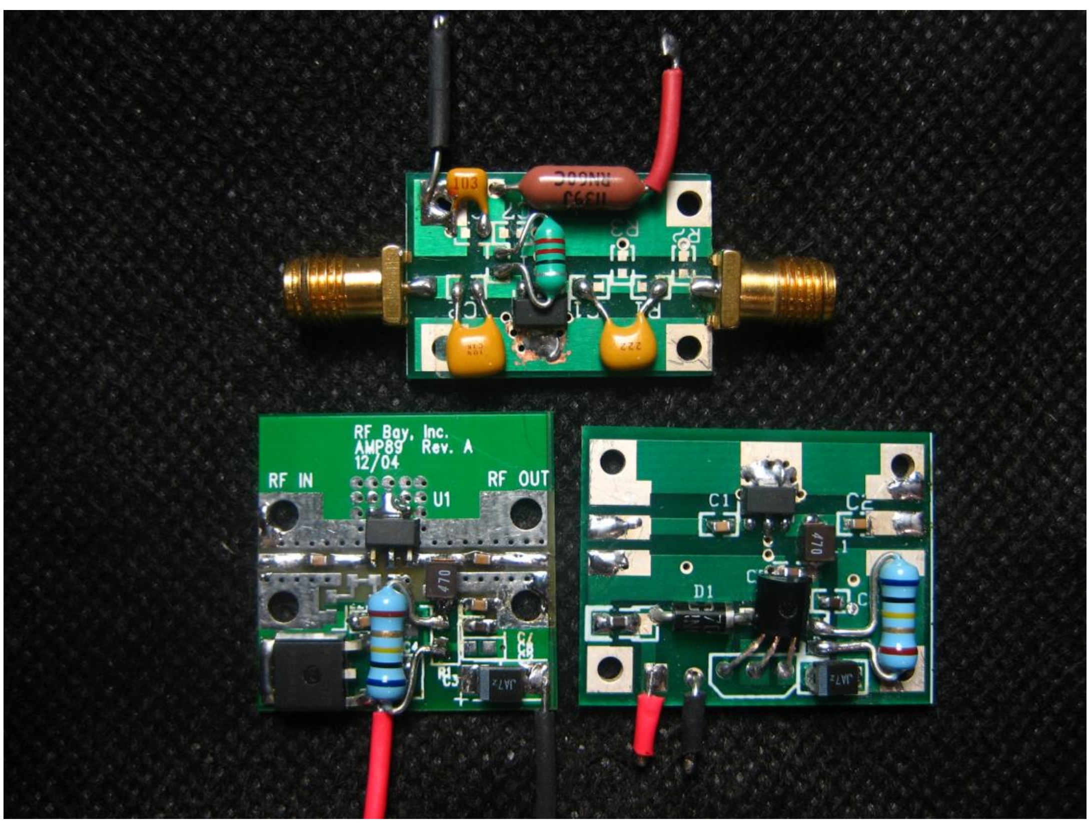
Links for the some of the more popular MMIC chips:

http://www.minicircuits.com/pdfs/GALI-6+.pdf
http://www.minicircuits.com/pdfs/GALI-74+.pdf
http://www.minicircuits.com/pdfs/GALI-84+.pdf
http://www.minicircuits.com/pdfs/MAR-1+.pdf
http://www.minicircuits.com/pdfs/MAR-6SM+.pdf
http://www.minicircuits.com/pdfs/ERA-5+.pdf

Circuit boards can be obtained from eBay and these sources:
Chuckwa3iac (eBay seller)
http://www.w1ghz.org/
http://stores.ebay.com/RF-Basic-Store/MMIC-and-RF-Amplifier-/_i.html?_fsub=2
http://www.ebay.com/sch/rfextra/m.html?item=400080328667&ssPageName=STRK%3AMEBIDX%3AIT&rt=nc&_trksid=p2047675.l2562

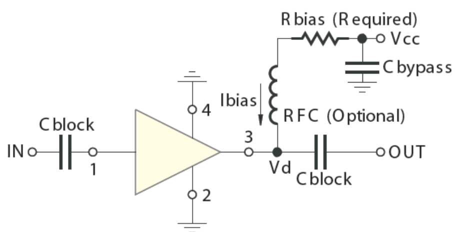
The ERA-5 kit, available from eBay seller chuckwa3iac, uses SMTs parts for the inductors and capacitors and the provided values that work very good for a for a 1 to 50 MHz amplifier. For any of the MCL MMIC amps, the inductive reactance of RFC plus the Rbias resistor should equal approximately 500 ohms.

Here are some amps that use discrete and SMP parts:



The boards are about 1" wide. A ½ watt current limiting resistor was needed in order to handle the MMIC chips that requi

Recommended Application Circuit



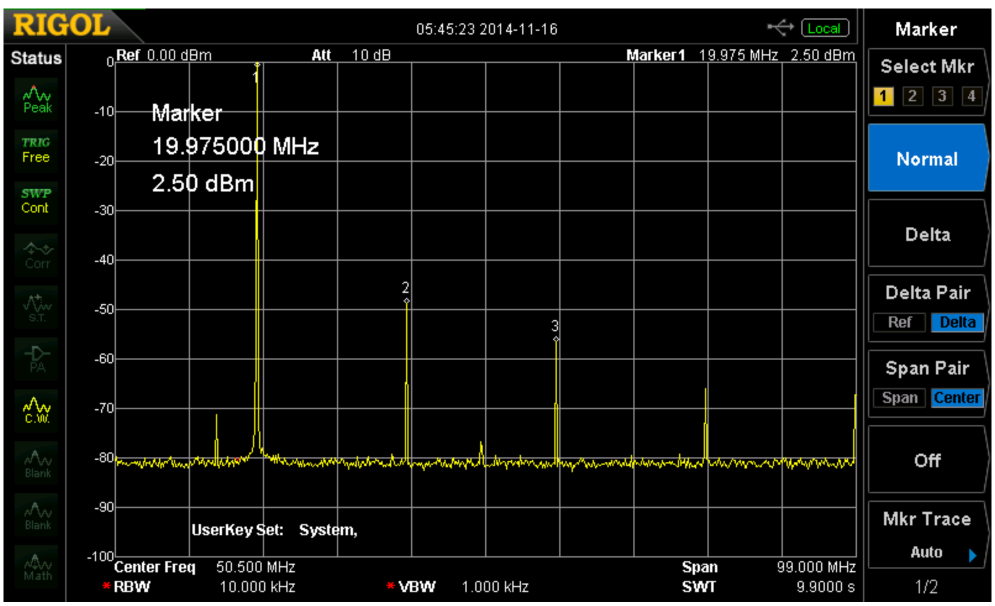
Test Board includes case, connectors, and components (in bold) soldered to PCB

R BIAS	
Vcc	"1%" Res. Values (ohms) for Optimum Biasing
7	30.1
8	43.2
9	56.2
10	69.8
11	84.5
12	97.6
13	113
14	127
15	140
16	154
17	169
18	182
19	196
20	210

The GALI-6 amplifier is optimized at 70 ma current, has about 12.8 gain, and has an extremely flat response from 1 to 100 MHz. With a GALI-84 MMIC, the gain is about 23 db.

Here is the harmonic response with the amplifier being driven with a 20 MHz signal at 0 dbm.

d



At a drive level of -10 dbm, the 2nd harmonic drops to a level of -58 dbm below the fundamental.

Here is a partial listing of suitable Mini Circuit MMIC amplifier chips:

CHIP	GAIN	Current Draw	1 db comp.	IP3 Output in db	Noise Figure in db
GALI-6	12 db	70 ma @ 5.0 vdc	18.2	35.5	4.5
GALI-74	25 db	80 ma @ 4.8 vdc	19.2	38.0	2.7
GALI-84	25 db	100 ma @ 5.8 vdc	21.9	37.6	4.2
MAR-1	18 db	17 ma @ 5.0 vdc	2.5	14.0	3.3
MAR-6SM	22 db	16 ma @ 3.5 vdc	3.7	18.1	2.3
ERA-5	20 db	65 ma @ 4.9 vdc	18.4	33.0	3.5

The chips with the high IP3 Outputs make good amplifiers in areas that have a high output signal such as the VFO, Carrier Oscillator, etc. The chips with the low current draw and Noise Figure make good amplifiers in the receiver front end circuits. The following chart shows the differences in harmonic distortion for various mmic amps at different drive levels:

AMP	GAIN	INPUT	OUTPUT	2nd HARMONIC	3rd HARMONIC	COMMENTS
NA	NA	+10 dbm	+10 dbm	-63 dbm	NA	Signal generator into SCFL23
						then into Spectrum Analyzer
GALI-6	12 db	-2.2 dbm	+10 dbm	-35 dbm	-50 dbm	
		-7.2 dbm	+5 dbm	-45 dbm	-64 dbm	
		-12.2 dbm	0 dbm	-55 dbm	NA	
		-17.0 dbm	- 5 dbm	-64 dbm	NA	
GALI-74	24 db	-14.5 dbm	+10 dbm	-31 dbm	-48 dbm	
		-19.4 dbm	+ 5 dbm	-41 dbm	-63 dbm	
		-24.4 dbm	0 dbm	-51 dbm	NA	
		-29.4 dbm	- 5 dbm	-62 dbm	NA	
GALI-84	25 db	-15 dbm	+10 dbm	-31 dbm	-50 dbm	
		-20 dbm	+ 5 dbm	-42 dbm	-64 dbm	
		-25 dbm	0 dbm	-51 dbm	NA	
		-29.9 dbm	- 5 dbm	-60 dbm	NA	
ERA-5	20 db	-10 dbm	+10 dbm	-28 dbm	-41 dbm	
		-15 dbm	+5 dbm	-38 dbm	-61 dbm	
		-20 dbm	0 dbm	-51 dbm	NA	
		-25 dbm	- 5 dbm	-60 dbm	NA	
LT1227	VAR	NA	+10 dbm	-26 dbm	-32 dbm	DDS VFO for signal generator
10 vdc		NA	+5 dbm	-37 dbm	-46 dbm	fed directly into SA
		NA	0 dbm	-48 dbm	-60 dbm	
		NA	-5 dbm	-58 dbm	-67 dbm	
AD8007	VAR	NA	+10 dbm	-28 dbm	-57 dbm	
10 vdc		NA	+5 dbm	-39 dbm	-66 dbm	
		NA	0 dbm	-49 dbm	NA	
		NA	-5 dbm	-58 dbm	NA	
AD8007	VAR	NA	+10 dbm	-48 dbm	-80 dbm	DDS VFO for signal generator
10 vdc		NA	+5 dbm	-57 dbm	NA	fed into MCL SCLF23 then SA
		NA	0 dbm	-68 dbm	NA	
AD8007	VAR	NA	+10 dbm	-45 dbm	-70 dbm	DDS VFO for signal generator
9 vdc		NA	+5 dbm	-57 dbm	NA	Fed into MCL SCLF23 then SA
		NA	0 dbm	-68 dbm	NA	
AD8007	VAR	NA	+10 dbm	-53 dbm	-63 dbm	DDS VFO for signal generator
GALI-6		NA	+5 dbm	-63 dbm	-78 dbm	fed into GALI-6 then into SCLF23
SCLF23		NA	0 dbm	-68 dbm	NA	Low Pass Filter, then SA

Setup: 15 MHz test frequency
10 db internal attenuation on spectrum analyzer
20 db external attenuation to spectrum analyzer

The best configuration for the DDS VFO is the VFO feeding a GALI-6 amp and then feeding a SCLF23 low pass filter. The 2nd best configuration is the VFO feeding a SLF21.4 low pass filter and 3 db attenuator.

K. Receiver Spurs

The number of spurs and the signal level of the spurs depend upon the receiver design, the quality of the parts, and the physical layout of the parts. In Atlas radios, the receiver spurs are mainly the result of the mixing of the carrier oscillator with the VFO signal (both primary and harmonic signals). As previously noted, the harmonic output from the carrier oscillator and VFO is very high.

The recommended method for checking for receiver spurs is to terminate the antenna jack with a 50 ohm dummy load. A RMS AC voltmeter should be connected across the receiver's speaker terminals.

For each band, the baseband noise level should be recorded. The VFO should be slowly tuned across each band and the frequency and relative noise level of each spur should be noted. Ten-Tec's spec for the Argonaut VI receiver says that there will no more than five birdies with amplitudes greater that -100 dbm.

The following spurs are found on a standard 210X LE radio with a 5645 KHz IF.

BAND	RX 10 db S+N/N	SPUR	SPUR	SPUR	SPUR	SPUR	SPUR
80M	-113 dbm	3763 @+5					
40M	-114 dbm						
20M	-110 dbm	14113 @+12	14222 @+7				
15M	-113 dbm	21450 @+10					
10M	-103 dbm	28266 @+22					

NOTES:

The spur at 14113 KHz is internally generated from the 3rd harmonic output of the carrier oscillator mixing with the 3rd harmonic frm the VFO signal.

The spur at 28226 KHz is internally generated by the 3rd harmonic output of the carrier oscillator mixing with the VFO signal.

Spurs on an Argonaut 539 – 10 Hz Frequency Increment with pre-amp turned off
Spurs less than +3 dbm are not recorded

BAND	RX 10 db S+N/N	SPUR	SPUR	SPUR	SPUR	SPUR	SPUR
80M	-110 dbm	3545 @+4	3553 @+5	3569 @+3	**3637 @+17**	3617 @+5	3697 @+3
80M	100 dbm=+20	3760 @+4	3781 @+3	3791 @+4			
80M	--125 dbm=+1						
40M	-112 dbm	7009 @+6	7019 @+7	7048 @+5	7196 @+6	7222 @+4	7231 @+3
40M	-100 dbm=+21	**7238 @+12**	7247 @+5	7263 @+9	**7269 @+10**		
40M	-125 dbm=+1						
20M	-111 dbm	14026 @+7	14061 @+4	14074 @+4	14135 @+5	14155 @+3	14158 @+7
20M	-100 dbm=+19	14181 @+3	14276 @+4	14288 @+9	14322 @+5		
20M	-126 dbm=+1						
15M	-111 dbm	21076 @+6	21147 @+5	21193 @+4	21252 @+5	21255 @+4	21310 @+10
15M	-100 dbm=+21						
15M	-125 dbm=+1						
10M	-110 dbm	28006 @+5	**28020 @+10**	28056 @+4	**28093 @+10**	28098 @+5	28162 @+8
10M	-100 dbm=+21	28228 @+5	28271 @+8	28333 @+5	28383 @+4	28393 @+6	28463 @+8
10M	-125 dbm=+1	**28520 @+14**	28605 @+3	28682 @+9	28728 @+4	28863 @+5	28877 @+6
10M		28897 @+3	28899 @+8	28949 @+3	28959 @+5		

NOTES:

210X LE Spurs
Spurs with Tee Bridge Diplexer installed – 10 Hz Frequency Increment
External VFO with MCL SLP21.4 low pass filter followed by a 3 db pad in output
Spurs less than +3 dbm are not recorded

BAND	RX 10 db S+N/N	SPUR	SPUR	SPUR	SPUR	SPUR	SPUR
80M	-114 dbm	3743 @+8	3775 @+4	3789 @+3	3791 @+8	**3960 @+22**	
80M	-100 dbm=+22						
80M	-129 dbm=+1						
80M	LO = 7.5 dbm						
40M	-114 dbm	7046 @+5	7061 @+4	7250 @+3			
40M	-100 dbm=+23						
40M	-129 dbm=+1						
40M	LO = 7.5 dbm						
20M	-111 dbm	**14112 @+15**	14126 @+4	**14187 @+15**	**14223 @+19**	14276 @+8	
20M	-100 dbm=+21						
20M	-125 dbm=+1						
20M	LO = 7.0 dbm						
15M	-111 dbm	21006 @+6	21020 @+7	21052 @+6	21054 @+4	21075 @+6	21091 @+4
15M	-100 dbm=+20	**21099 @+10**	21105 @+4	**21107 @+12**	21126 @+5	21131 @+3	**21133 @+10**
15M	-126 dbm=+1	21144 @+5	21207 @+3	21208 @+6	21219 @+3	**21229 @+14**	**21236 @+15**
15M	LO = 7.2 dbm	21241 @+5	21249 @+8	21251 @+9	21253 @+7	21278 @+7	21278 @+5
15M		21281 @+7	21293 @+3	**21296 @+14**	21355 @+4	21366 @+7	21370 @+4
15M		**21373 @+13**	21386 @+9	21389 @+4	**21421 @+15**	21425 @+5	21433 @+8
15M		21434 @+6	**21436 @+11**	21437 @+4	21438 @+7	21440 @+6	21444 @+6
10M	-110 dbm	28023 @+7	**28044 @+12**	28091 @+6	28125 @+8	28154 @+3	28170 @+4
10M	-100 dbm=+20	28181 @+3	28181 @+6	28182 @+7	28210 @+6	**28224 @+20**	**28229 @+19**
10M	-125 dbm=+1	28277 @+4	28289 @+4	28294 @+7	28342 @+9	28376 @+6	28394@+7
10M	LO = 7.5 dbm	28436 @+4	28459 @+3	28461 @+7	28471 @+9	28473 @+6	**28496 @+10**
10M		28518 @+6	28541 @+4	28545 @+4	28552 @+4	28557 @+4	28602 @+4
10M		28626 @+3	28657 @+5	**28677 @+10**	28690 @+8	28740 @+6	28810 @+7
10M		28832 @+4	28834 @+9	28835 @+7	28836 @+4	28893 @+6	**28917 @+10**
10M		28931 @+5					

NOTES:
The spur at 28224 and 28229 KHz is internally generated by the 3rd harmonic output of the carrier oscillator mixing with the VFO signal.

L. Signal Measurements

The testing/measurement results in this section should help in trouble-shooting system problems and in optimizing the 210X/215X radios for best performance.

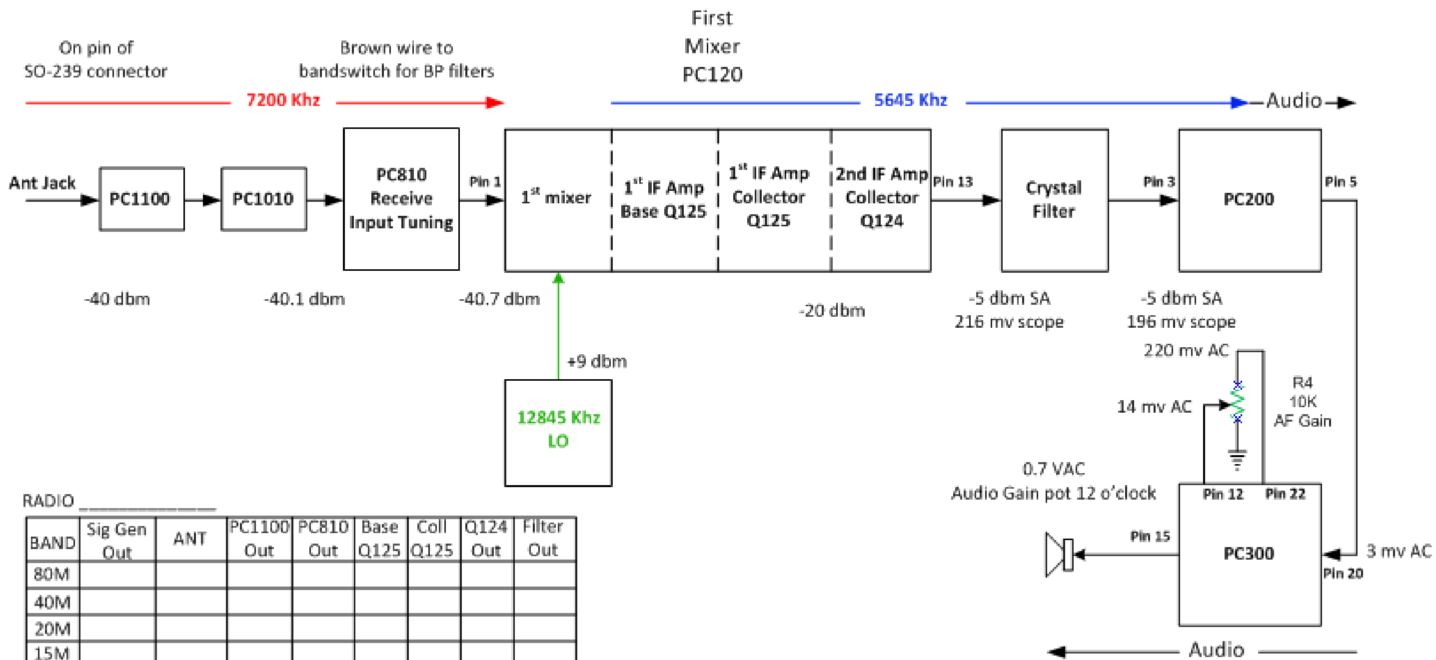
1. Receiver Gain Distribution

The following diagram shows the overall receiver gain distribution from the input of the antenna jack to the output of the audio amplifier. These measurements were made on a 210X radio that had a HP diode array in the first mixer, as opposed to the factory 1N4148 diodes. A factory first mixer will have an additional 2 to 3 db conversion loss. The measurements were made on the 20M band. On most 210X radios, this band usually has the most front end loss as a result of the two image filters in series with the receiver band pass filter.

Updated: 09-02-2018

ATLAS 210X LE
Mods
RECEIVER GAIN

-110 dbm = 0.20 vac = 120 db gain
-73 dbm = 0.50 vac = 91 db gain
-40 dbm = 0.70 vac = 60 db gain
-30 dbm = 0.70 vac = 51 db gain



RADIO ______________

BAND	Sig Gen Out	ANT	PC1100 Out	PC810 Out	Base Q125	Coll Q125	Q124 Out	Filter Out
80M								
40M								
20M								
15M								
10M								

NOTES

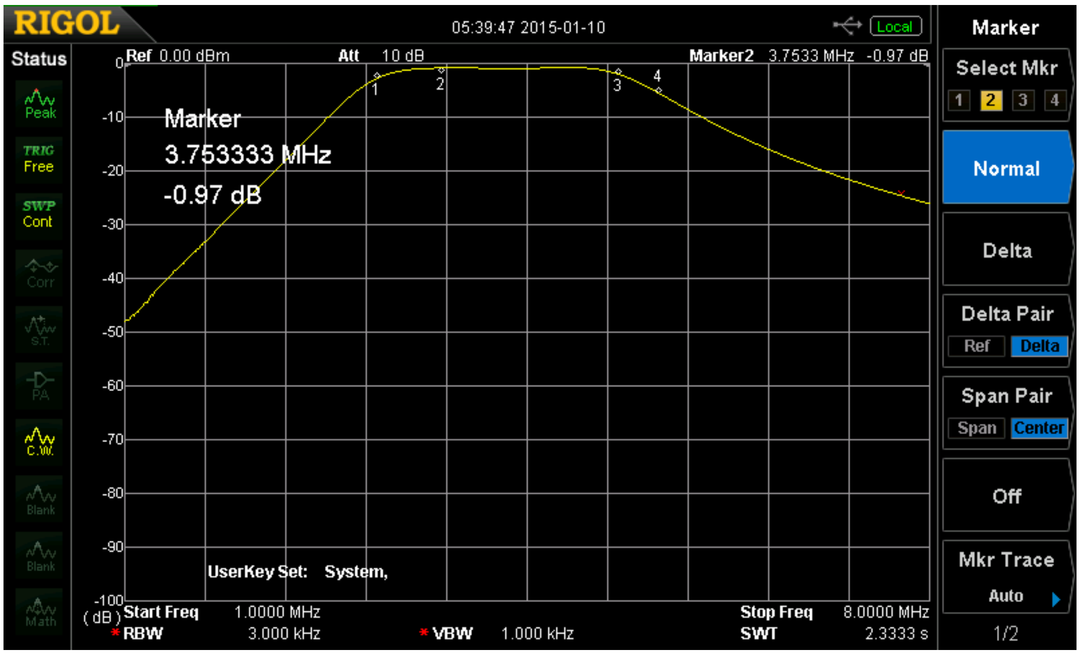
-73 dbm = 50 uv = S9 on meter
1st mixer = ADE-1
Readings taken on 40M band
-115 dbm = 10 db S/N

2. **Receiver Band Pass Filters**

The following snapshots show the response curves of the receiver band pass filters that are ahead of the receiver mixer. These measurements were made with the PC-810C board removed from the radio. A 3 db pad was inserted on the input and output of the filters. Coax cables, terminated with SMA connectors were soldered to each filter section. Markers 1, 2, and 3 shows the band pass points for each amateur band. Marker 4 shows the 5645 KHz IF signal. Snapshots are also shown for a new RX Band Pass board that will fit in place of the existing PC-810 board.

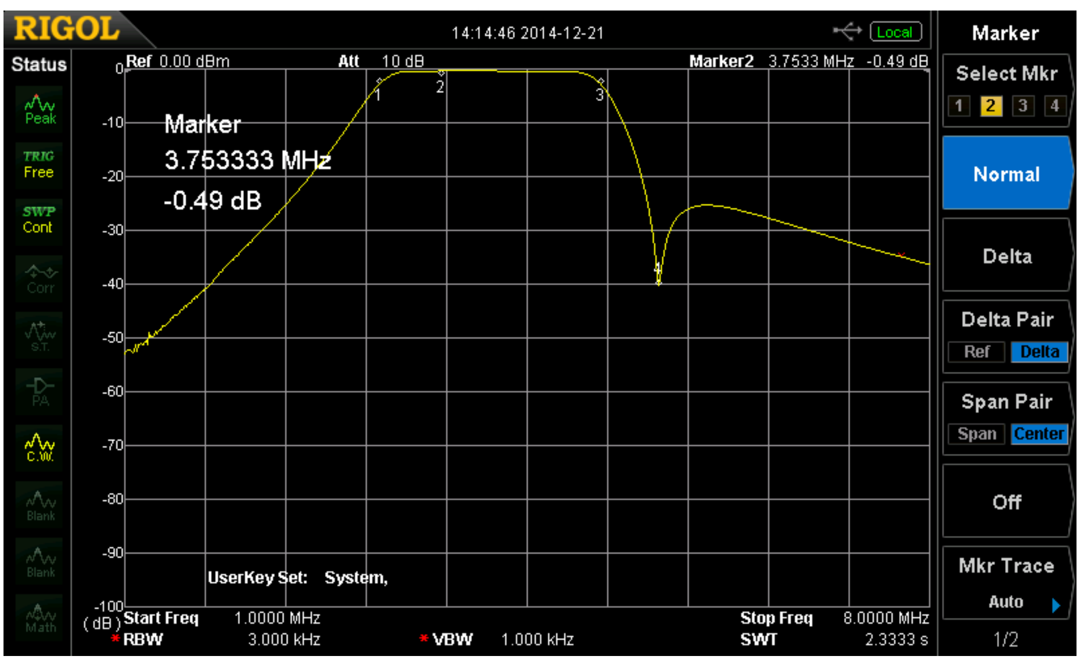
This board provides better performance than the factory board and allows removal of the PC-1200 IF Trap/Image Filter board.

80M – Factory Filter

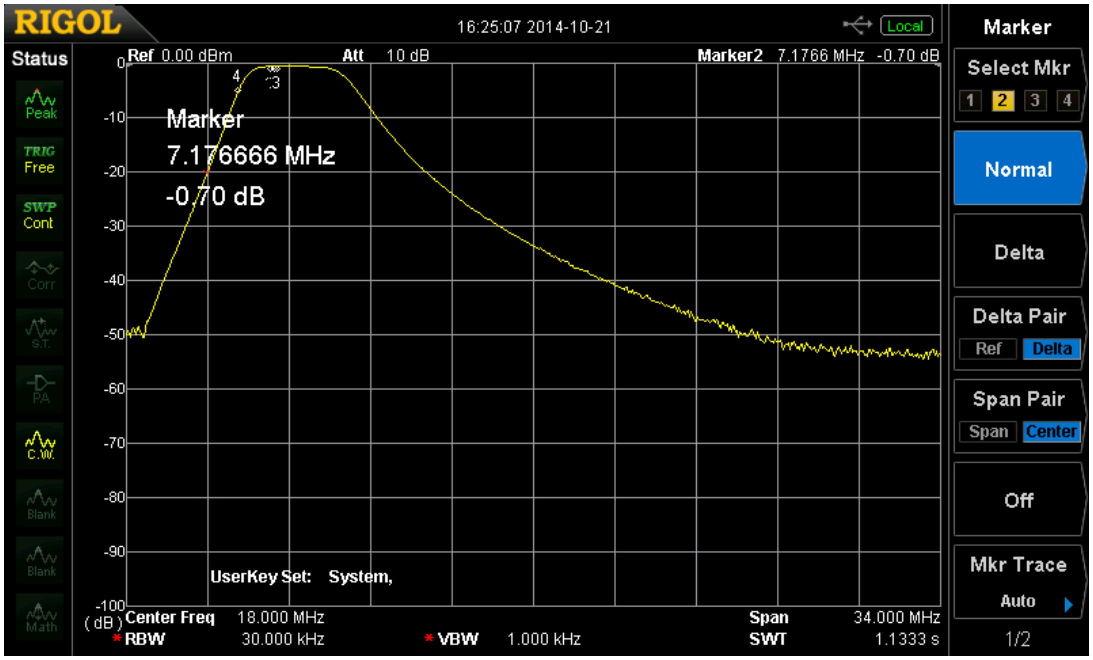


80M – New Band Pass Board

Please note that the new filter board includes the IF Trap filter.

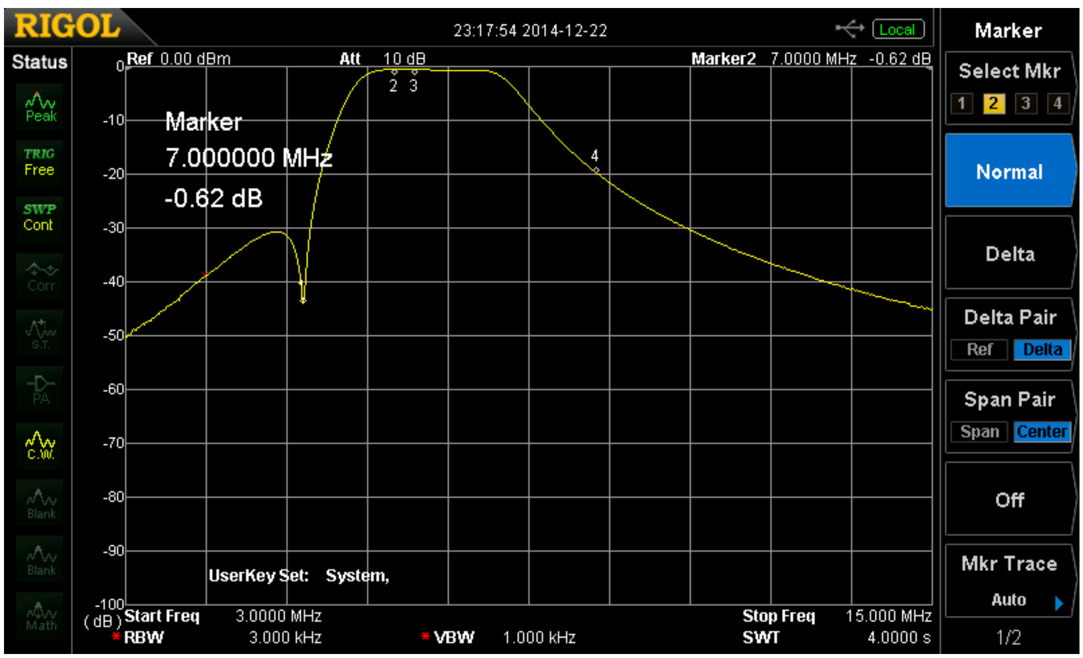


40M – Factory Filter

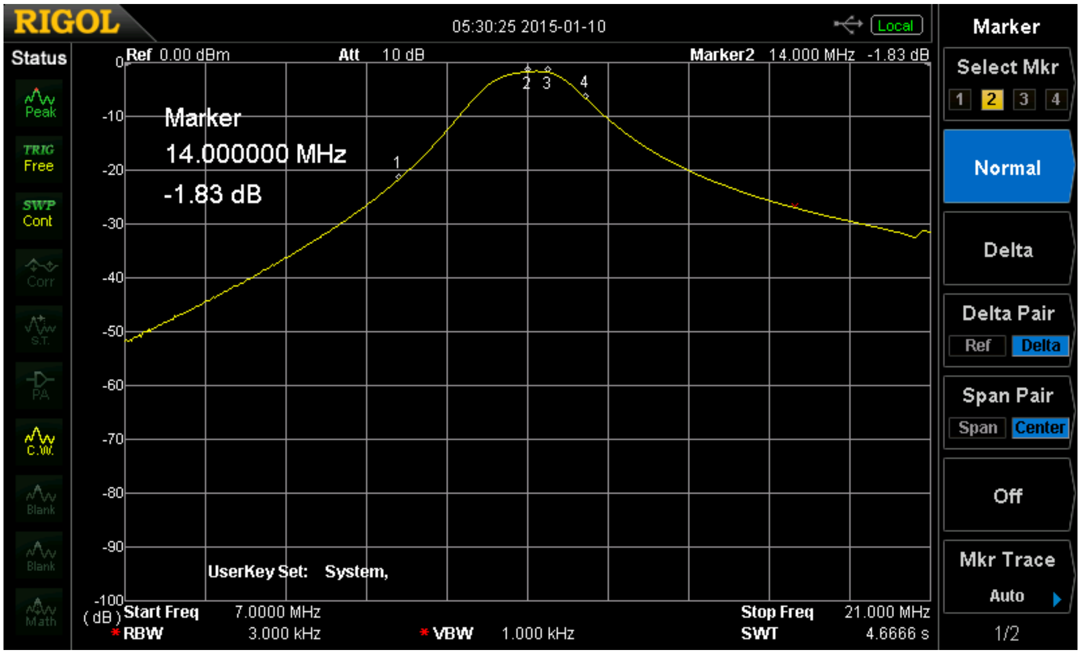


40M – New Band Pass Board

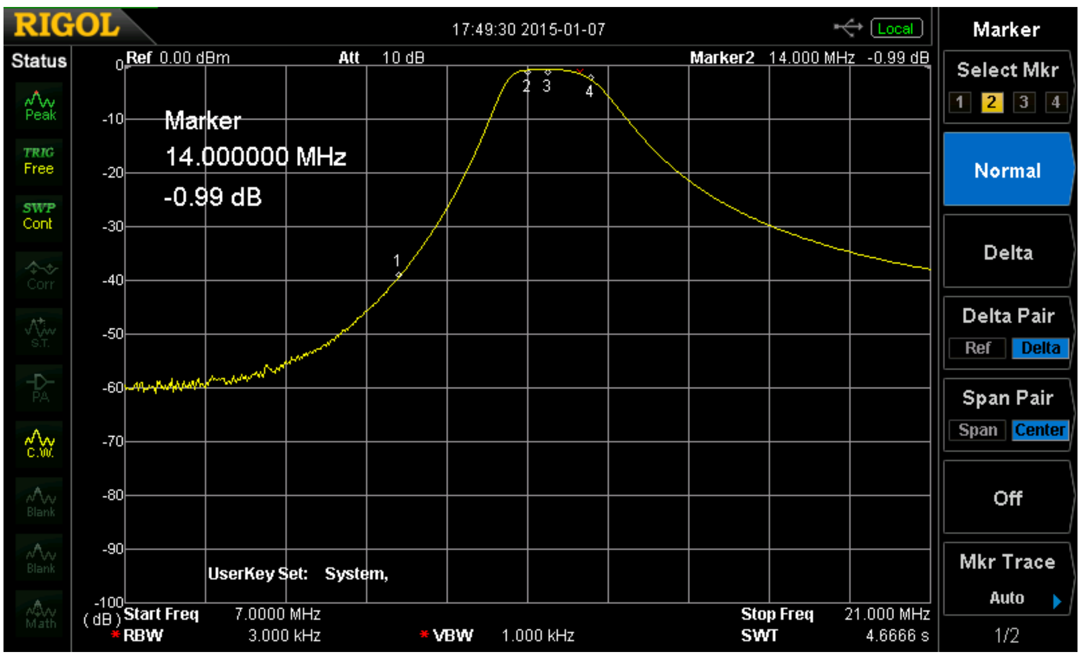
Please note that the new filter board includes the IF Trap filter.



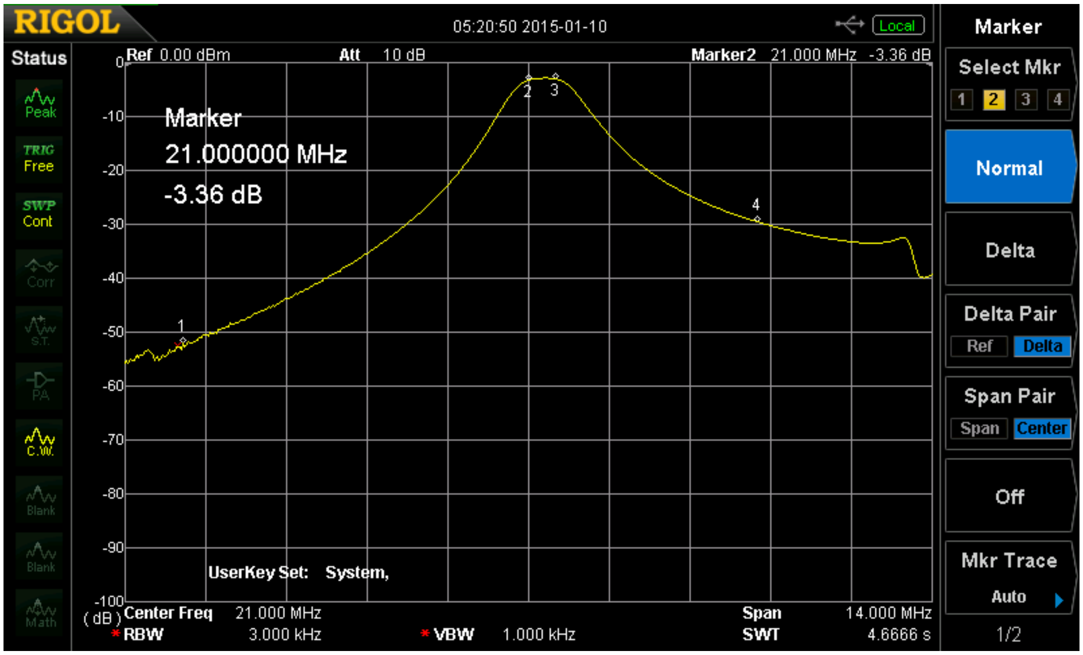
20M –Factory Filter



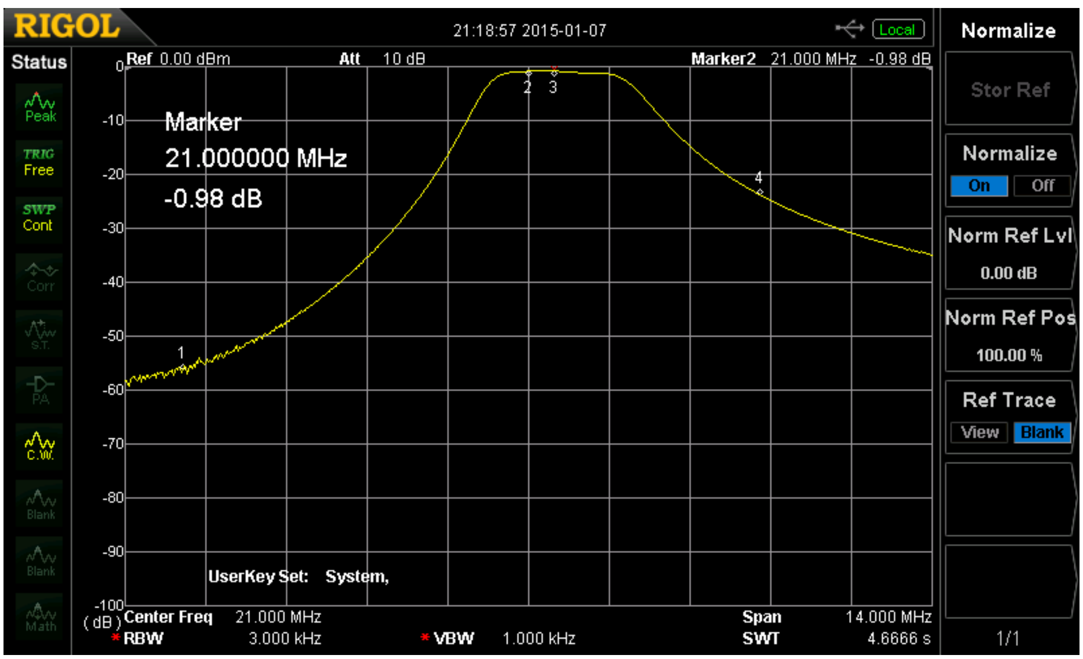
20M – New Band Pass Board



15M – Factory Filter

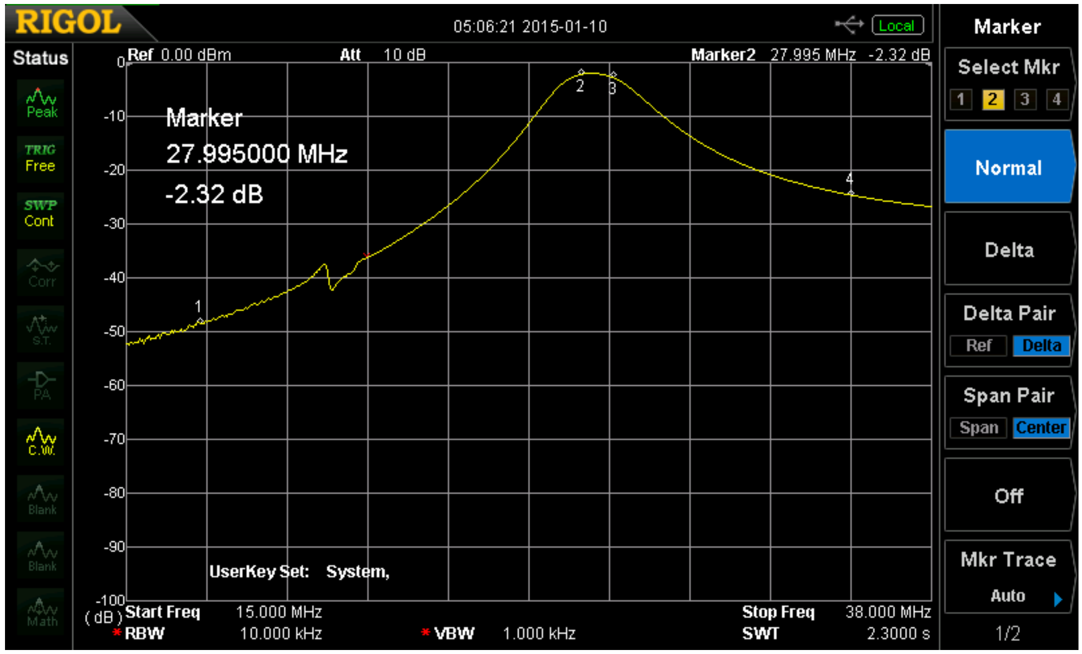


15M – New Band Pass Board

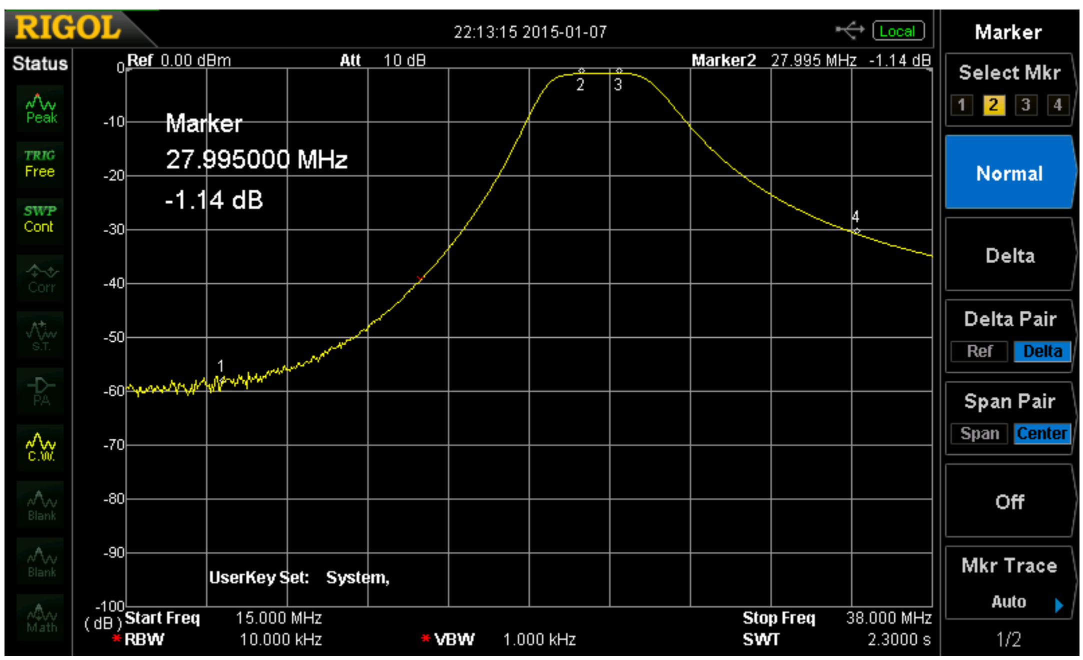


10M – Factory Filter

Normally, in an operational radio, the two tuning slugs in the band pass filter coil end up being on the far end of coil form. For the board out of box testing, the two slugs had to be positioned near the center of the coil form.



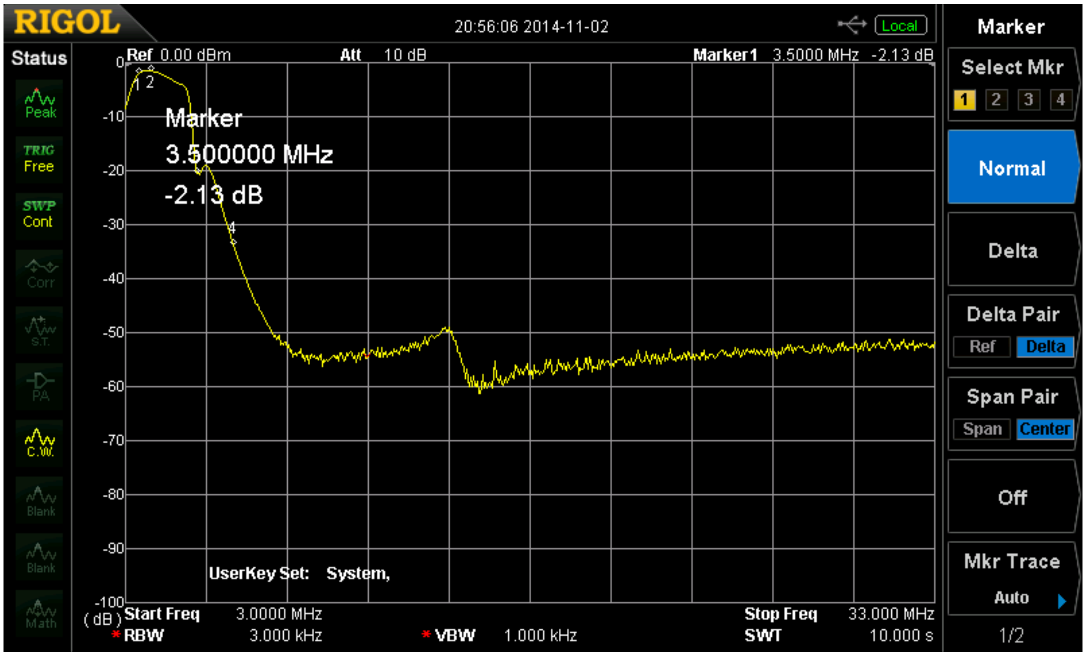
10M – New Band Pass Board



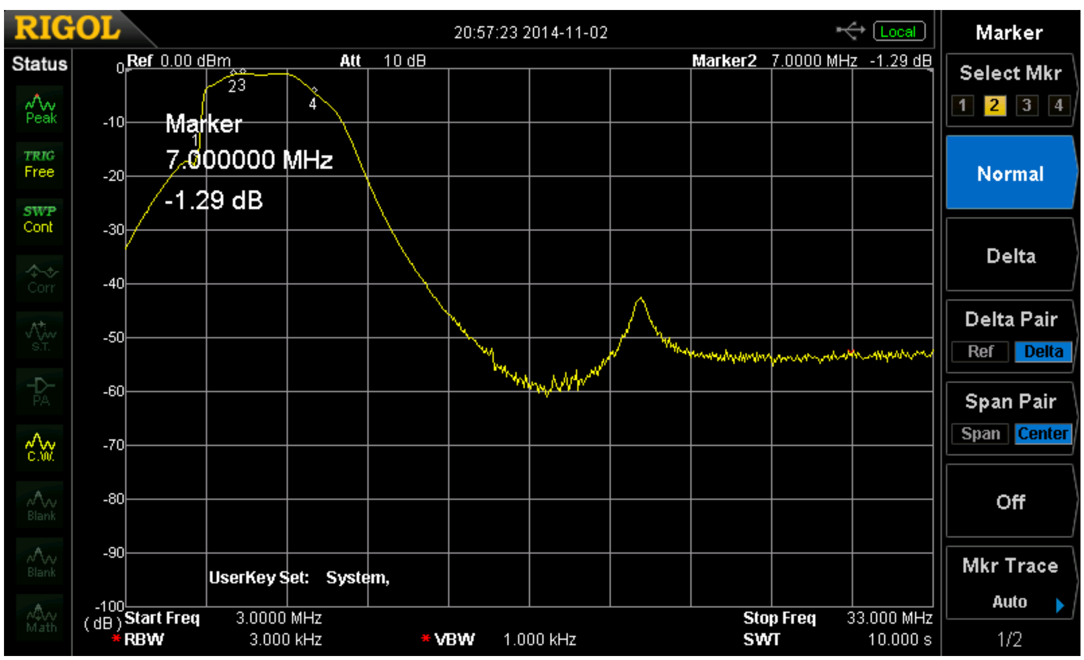
a. **Receiver Front End Filters**

The following snapshots show the response curves of the factory receiver front end filters. The front end filters include the low pass filter, the receiver band pass filters, the IF Trap filters, and the Image filters.

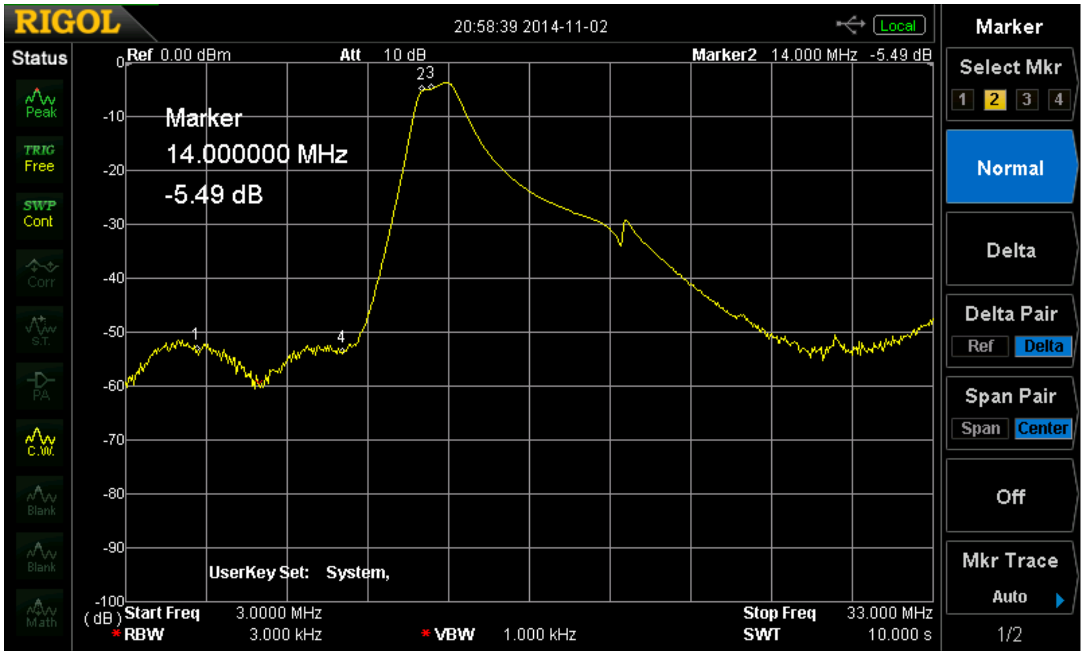
80M – Marker 4 is 5645 KHz



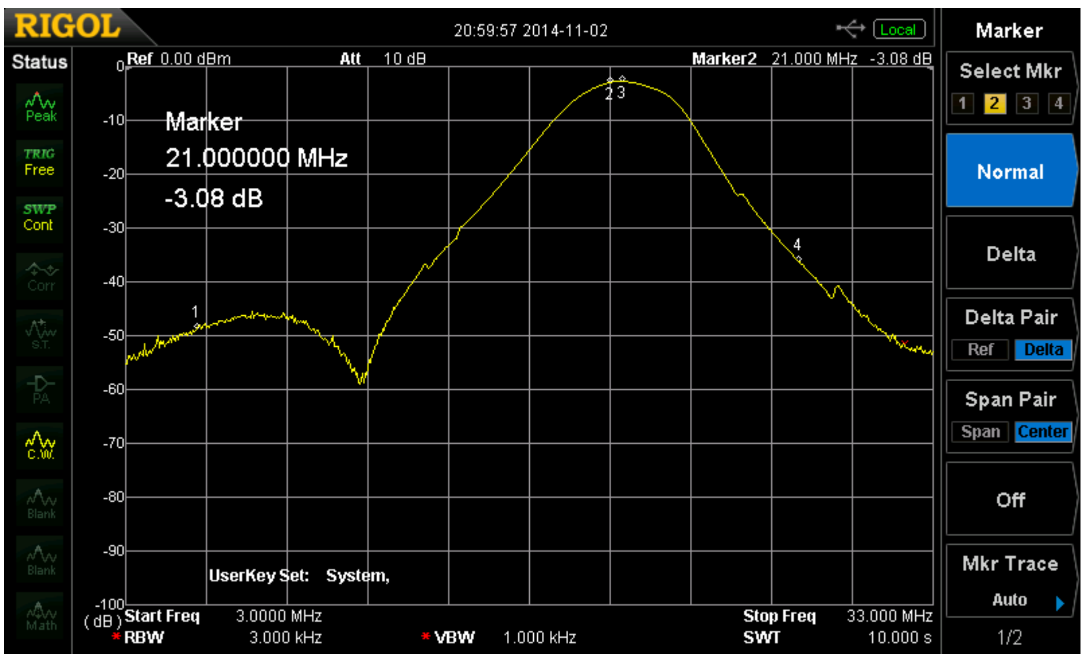
40M – Marker 1 is 5645 KHz



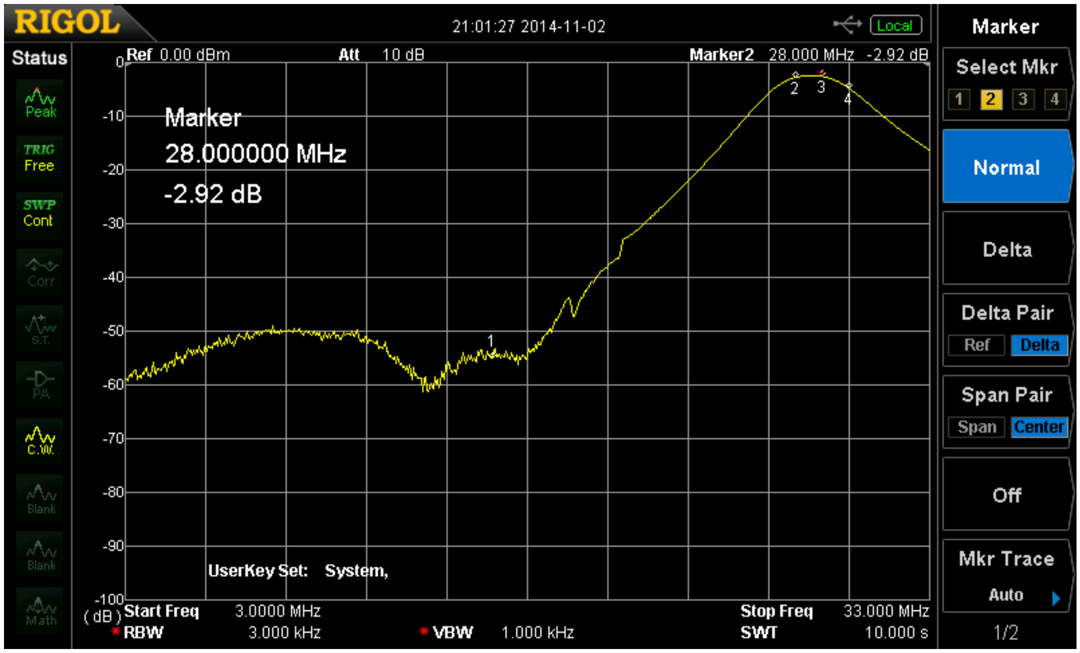
20M – Marker 4 is 11065 KHz



15M



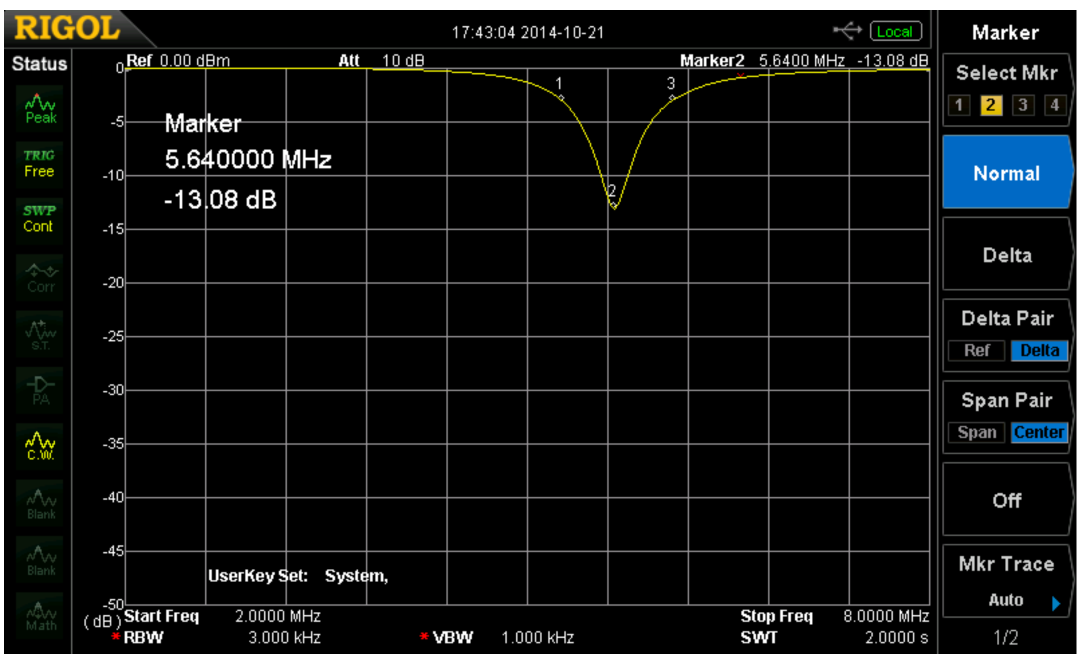
10M – Marker 1 is 16710 KHz



b. IF Trap & Image Filters

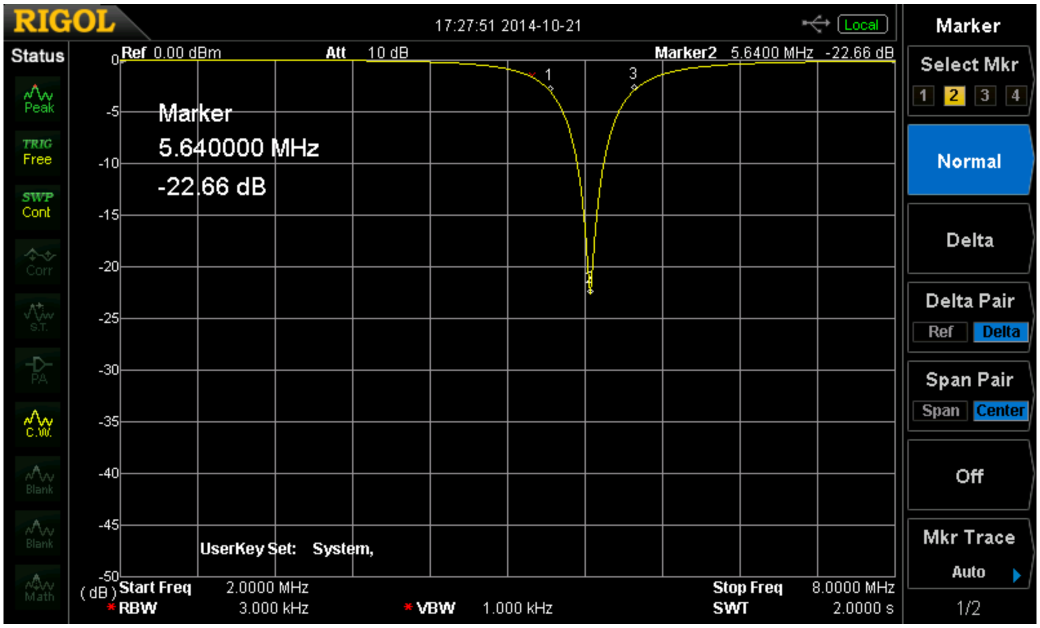
There are eight IF Trap/Image filters used in the later 210X and LE models – 5 in the receiver, 2 in the transmitter, and a common IF Trap filter for the receiver and transmitter. These traps are tunable via a tuning slug in each coil. The response of the receiver traps on the PC1200 board was measured with the filter board removed from the radio. Three db pads were inserted on the input and output of the trap.

Factory 5645 KHz IF Trap with correct coil turns



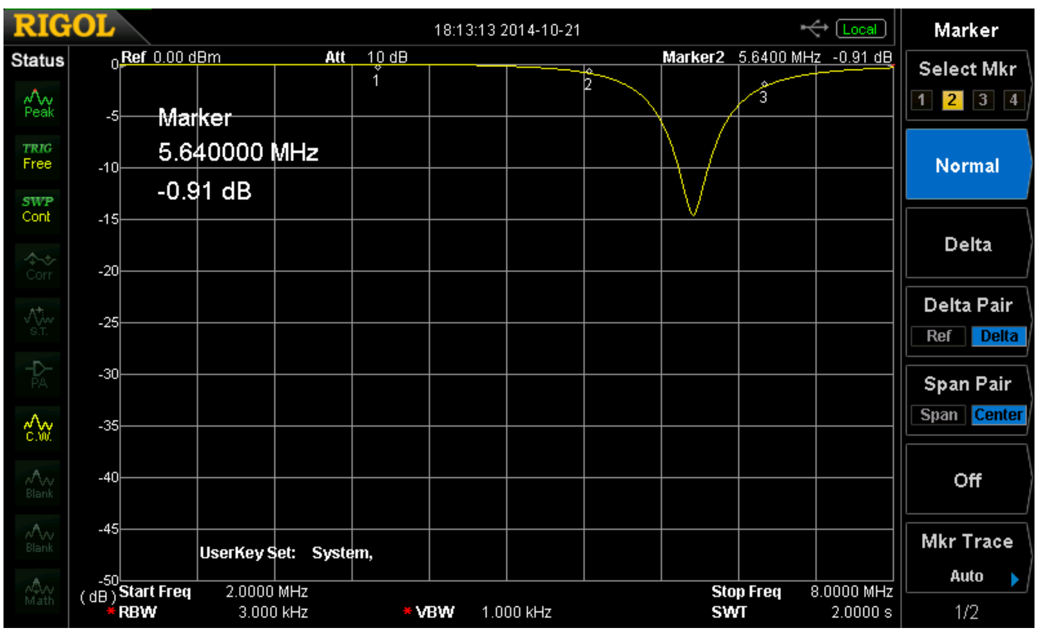
5645 IF Trap Filter with T37-2 core and 2300 pf ceramic capacitor

The ceramic capacitor adds 3 db of additional notch and the toroid core adds another 3 db of notch.

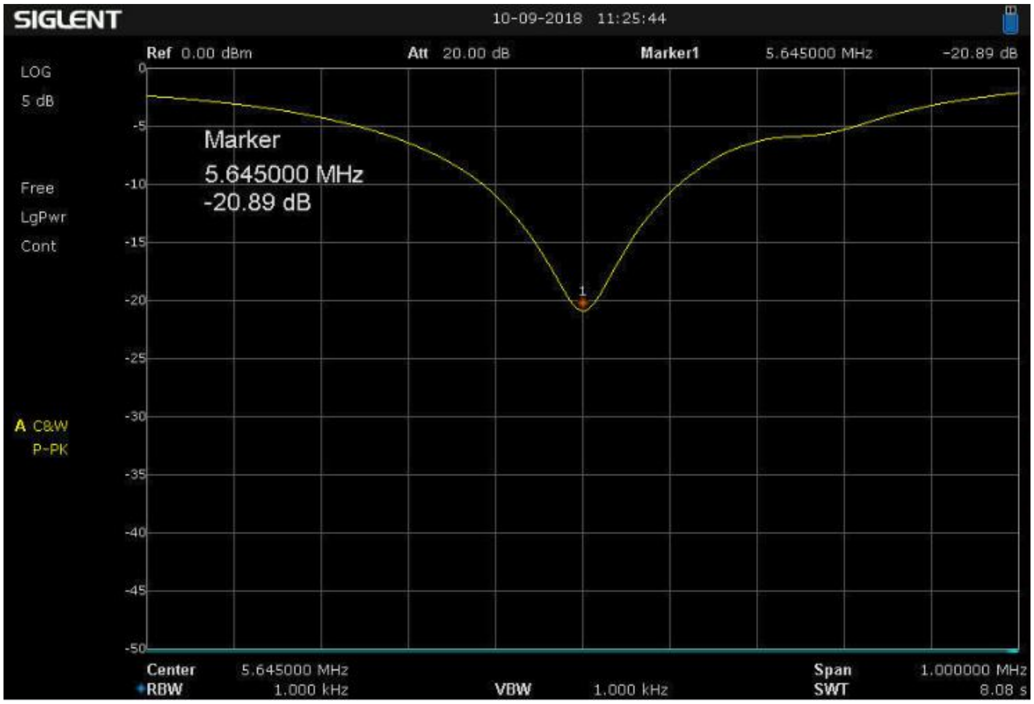


5645 IF Trap Filter from a 210X LE Radio with incorrect coil turns

This trap was tuned to the lowest frequency – i.e. tuning slug positioned for maximum inductance. The trap was still a long way from being resonant at 5645 KHz. This trap creates about 2 db of receiver degradation at 7.000 MHz on the 40M band.

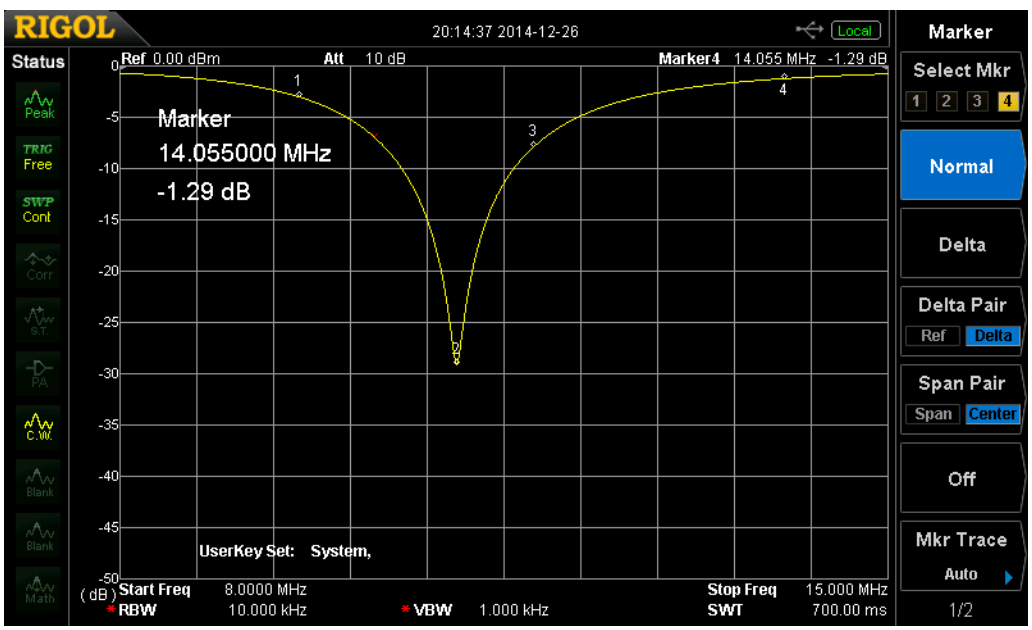


Here is a sweep snapshot of a LE IF Trap filter with the factory 5 wire turn coil, a 2300 pf ceramic disc capacitor, and a second tuning slug.

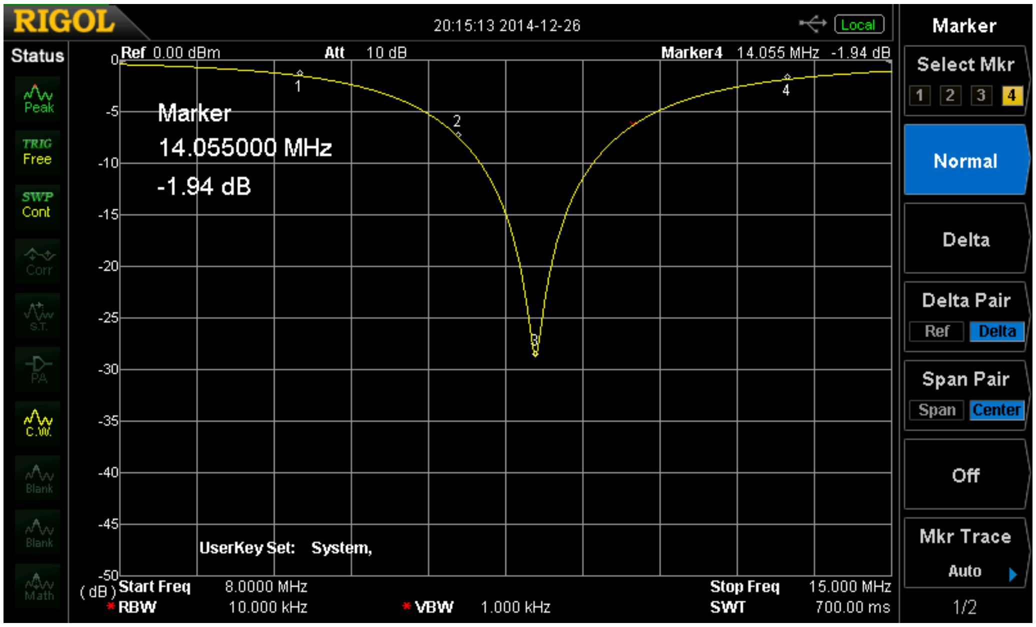


20M Image Filter with correct coil turns

This filter is used to filter out strong shortwave broadcast signals that would mix with the VFO 2nd harmonic when on the 20M band. It can only be used to filter a single signal. There are two filters in the radio. This picture shows the response for a single filter. The tuning slug was set for 11065 KHz. Notice the impact on the insertion loss at 14 MHz.

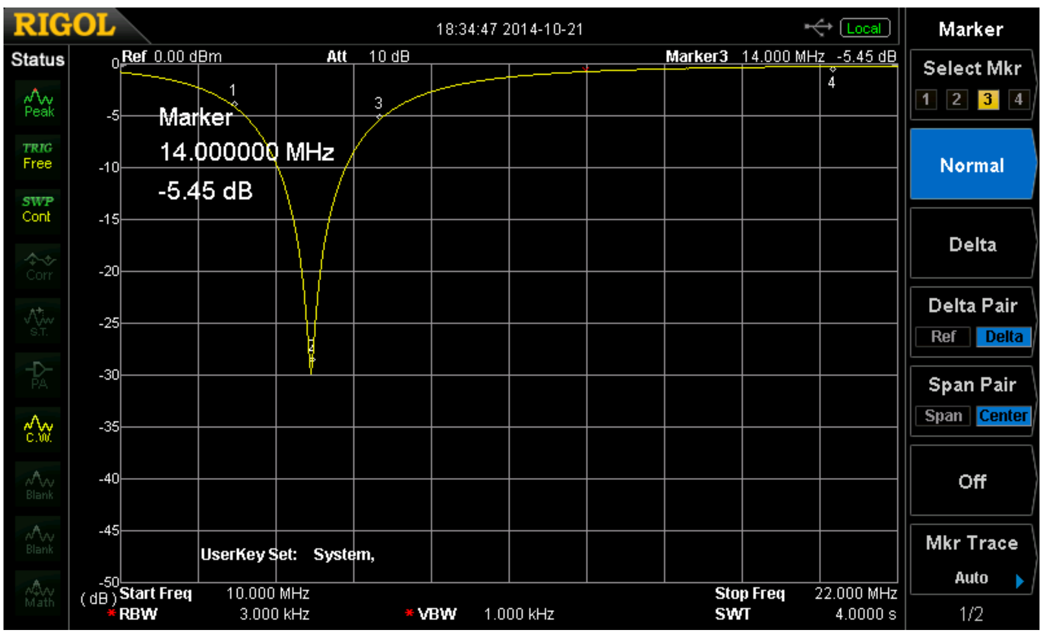


This is the same filter with the tuning slug set for 11765 KHz. Notice the impact on the insertion loss at 14 MHz.

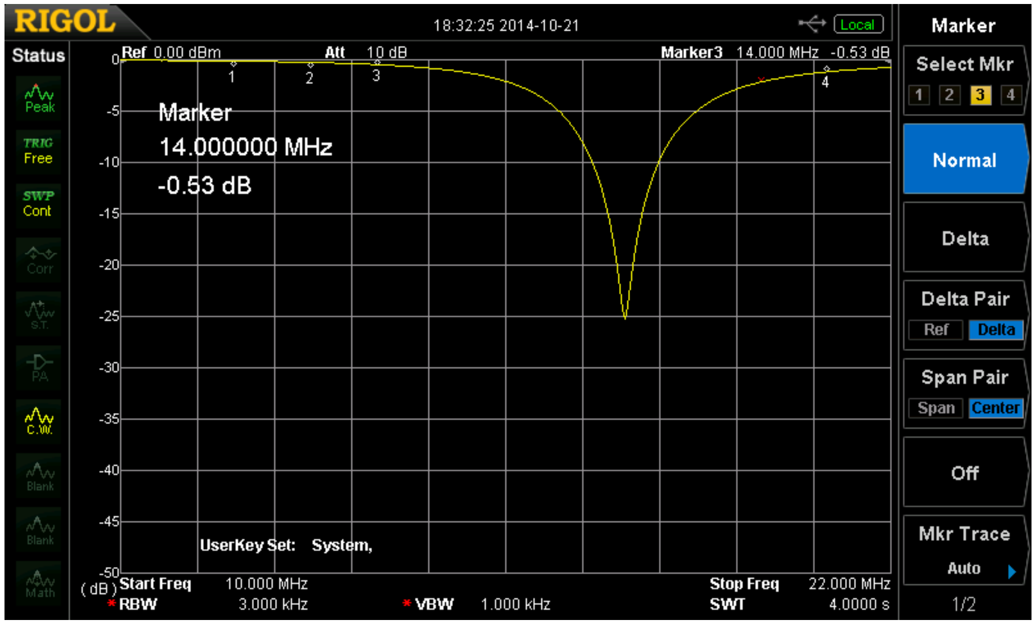


20M LE Image Filter with incorrect coil turns

The tuning slug was set for maximum inductance. The tuning range of the filter should be 11065 KHz to 12065 KHz. The actual range is 13 to 18 MHz. There is several db of degradation at the bottom of the 20M band.

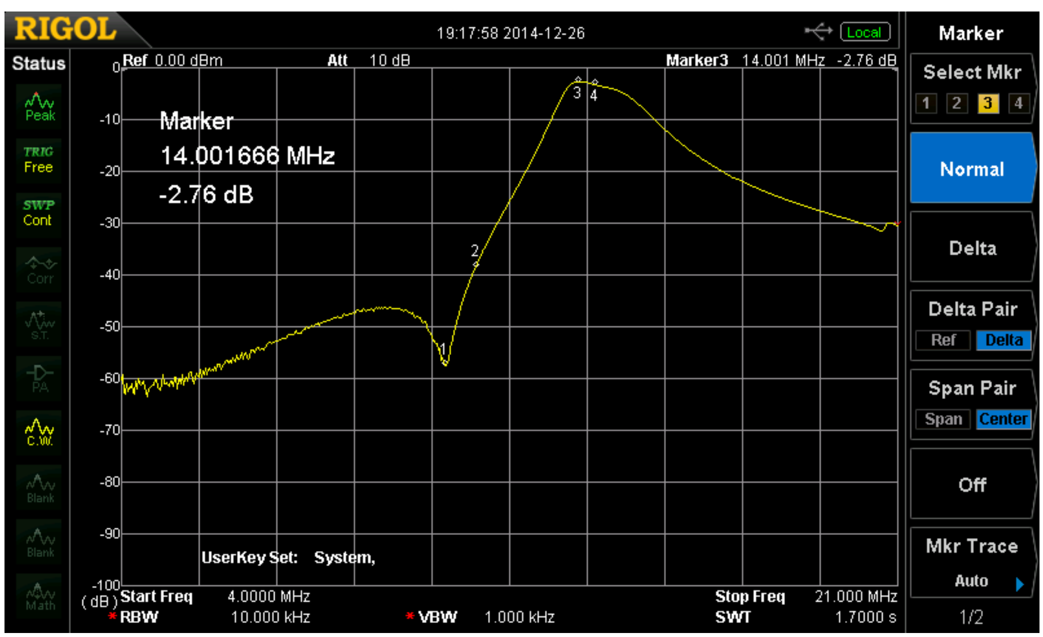


The tuning slug was set for minimum inductance. There is about 0.5 db of degradation at the top of the 20M band.



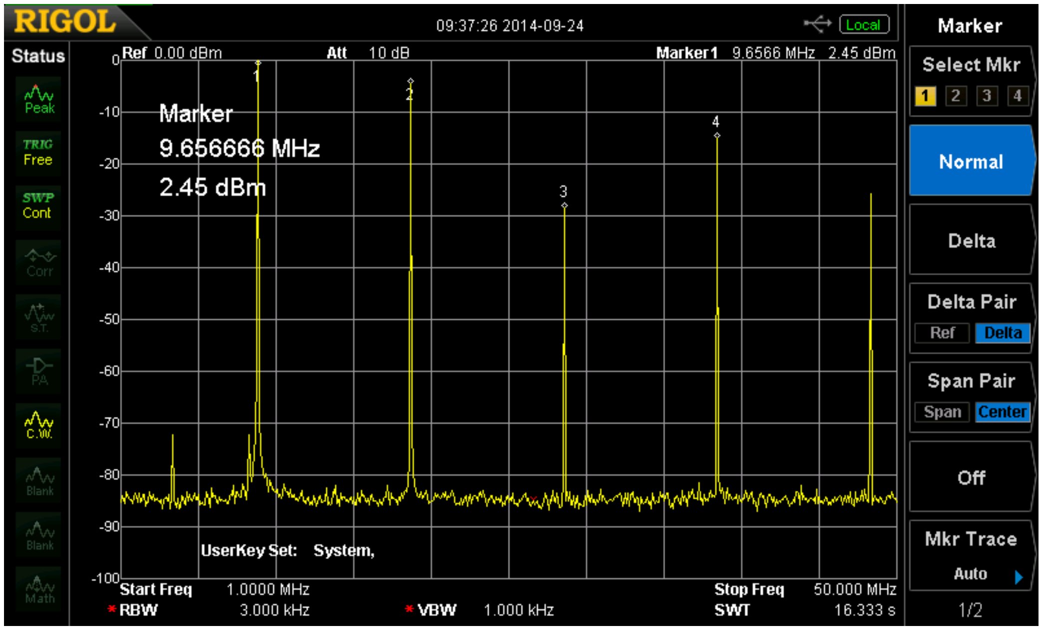
20M Image Filter with Band Pass Filter

This is factory 210X 20M band pass filter with a single image filter. The measurement was made with the filters removed from the radio. This snapshot shows with a standard 210X factory radio always has reduced RX sensitivity on 20M, when compared with the other bands. Adding the second image filter will increase the insertion loss at 14 MHz another 2 db.



c. VFO Output

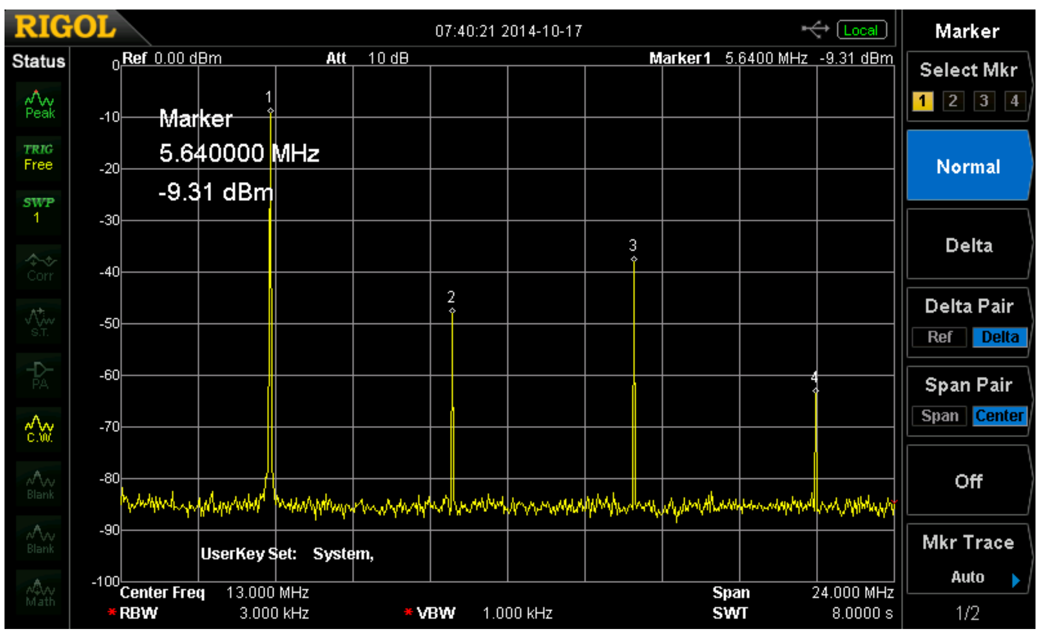
Jumper removed on the rear accessory socket and VFO output fed through a 6 db pad into the spectrum analyzer.



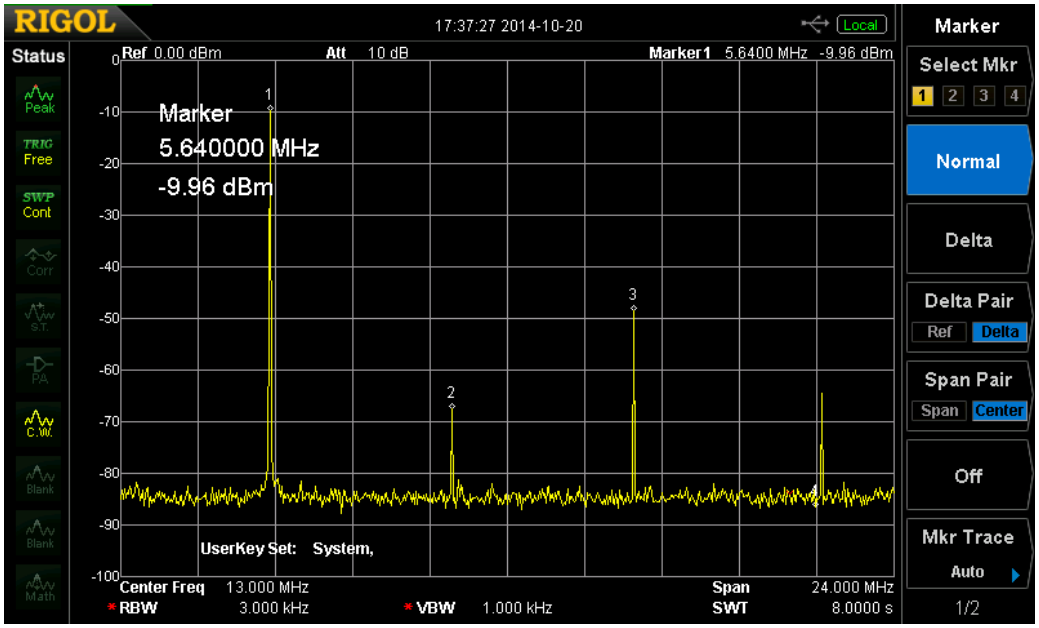
d. Carrier Oscillator

Carrier Oscillator Output Signal – Factory Design

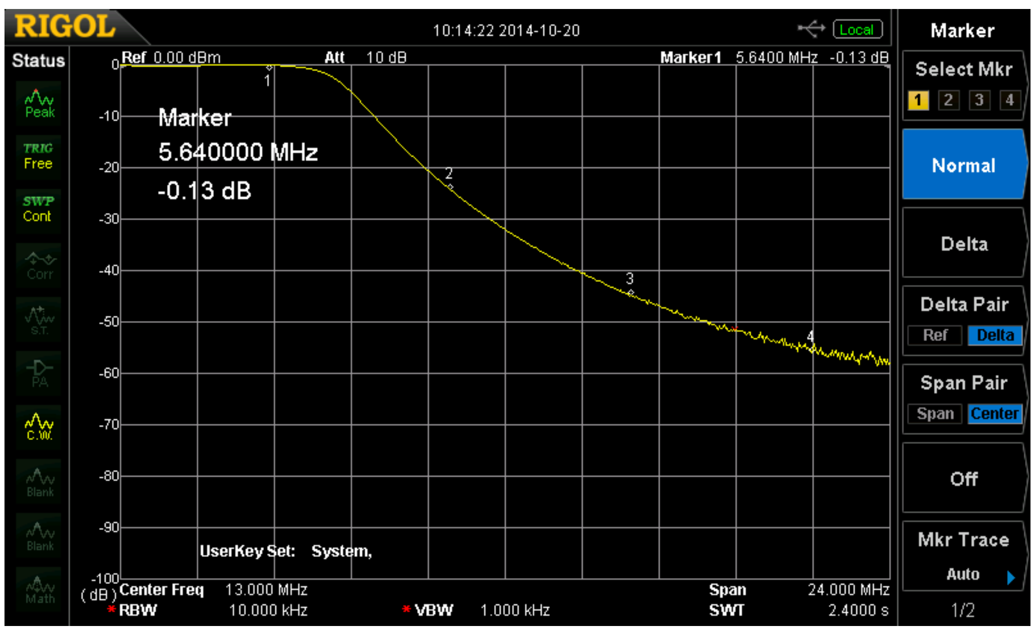
Here is a spectrum analyzer screen snapshot from the output of the carrier oscillator using a 20 db probe:



Here is a spectrum analyzer screen snapshot from the output of the carrier oscillator with a pi low pass filter added in the output. A 20 db probe was used on the input to the spectrum analyzer:



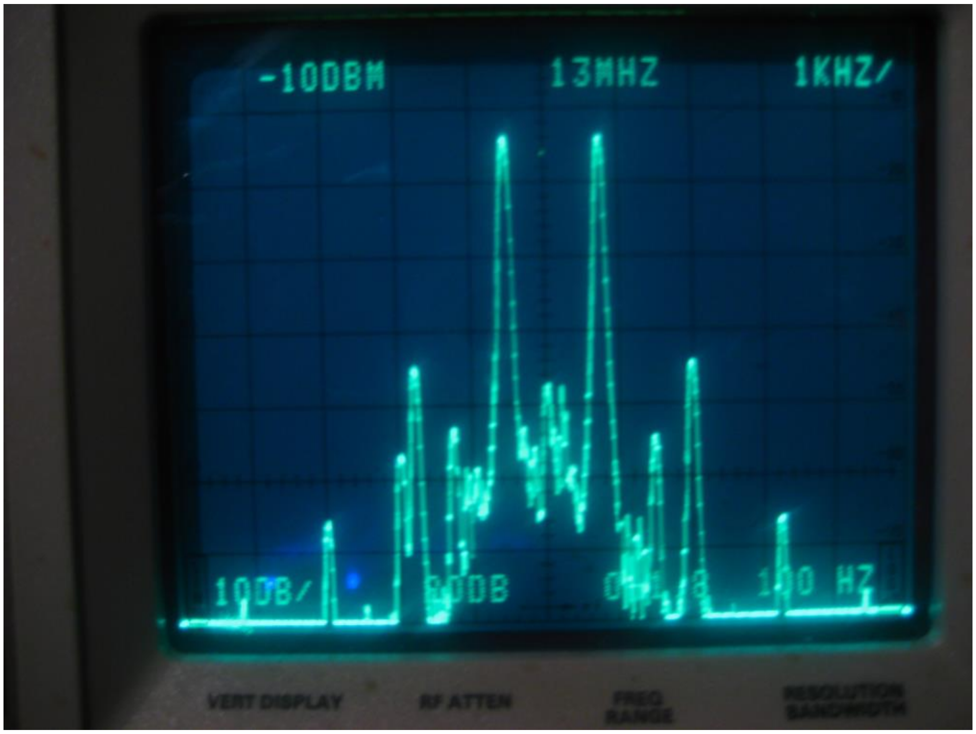
Here is the output of the carrier oscillator with the low pass filter installed:



e. Transmitter Measurements

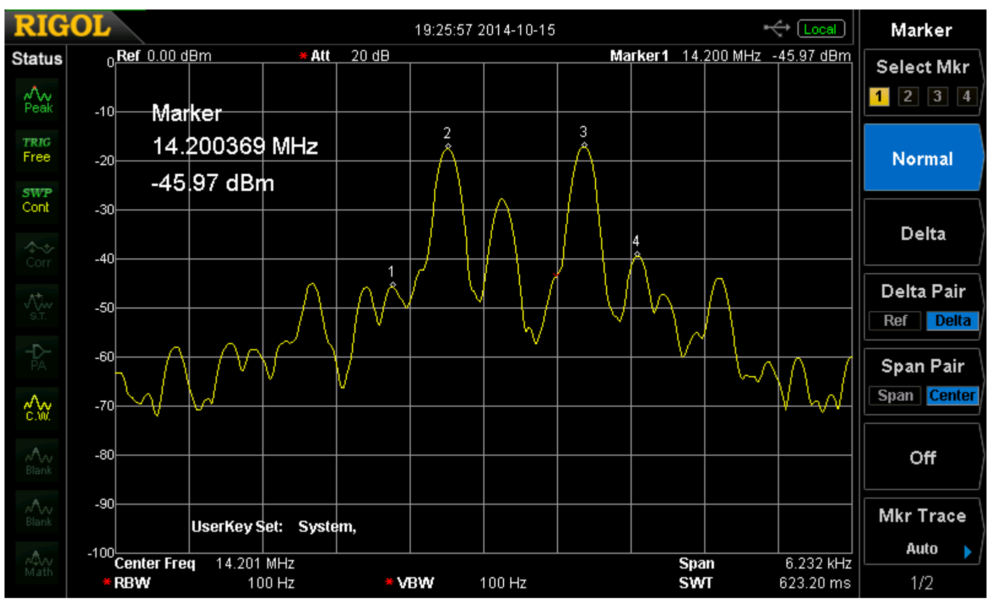
1. IMD at Output of Transmitter Band Pass Filter

Here is a picture of the band with the worst IMD results (20M). The IMD results will be worse when measured at the antenna jack as a result of the additional IMD contribution from the PC-500 board.



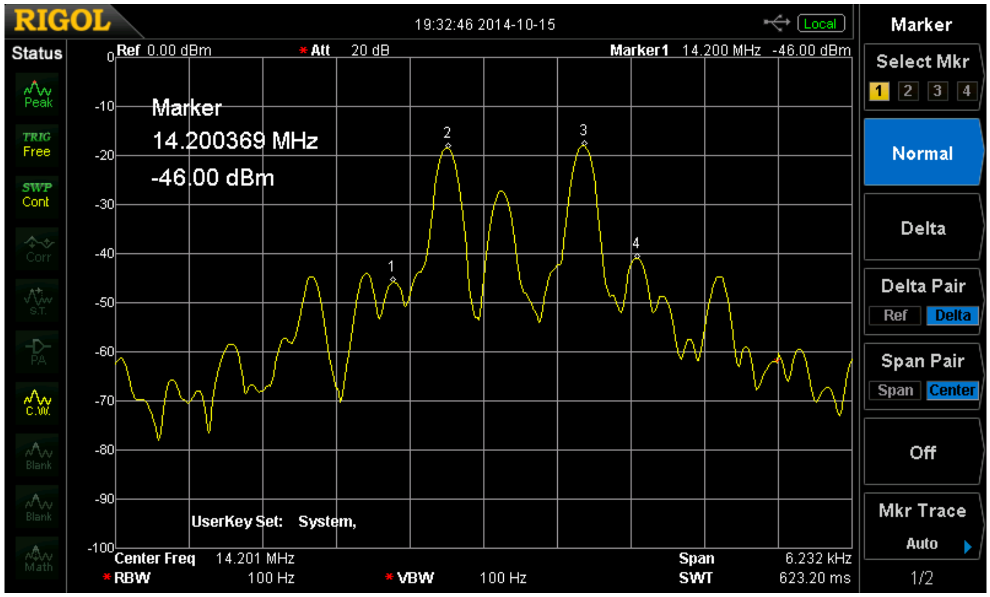
2. IMD at Output of Transmitter – Factory Mixer on PC-120 Board

Two tone test using 700 and 1900 Hz tones. Power output of single tone set to 40 watts.



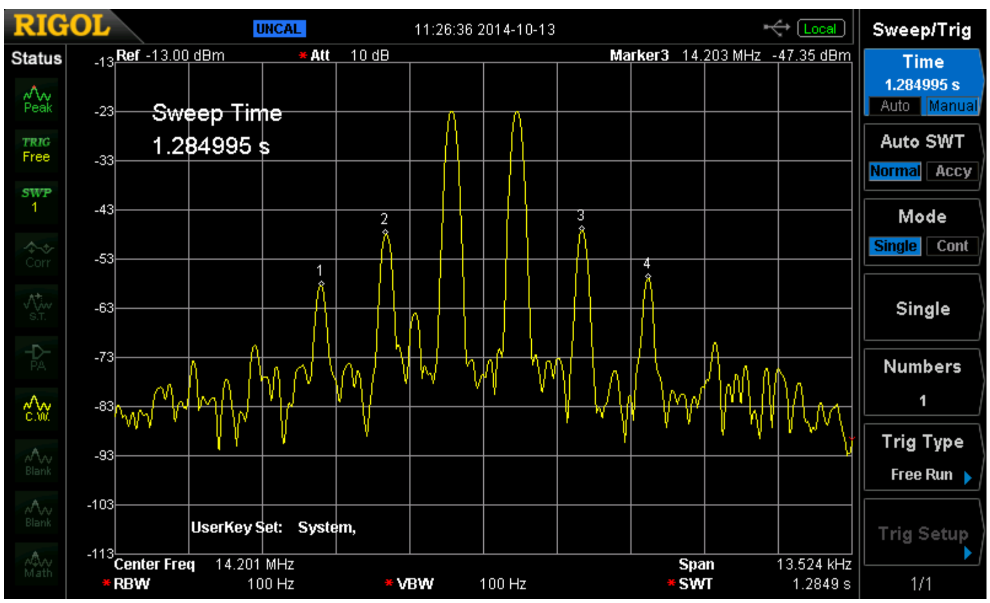
3. IMD at Output of Transmitter – ADE-1 Mixer on PC-120 Board

Two tone test using 700 and 1900 Hz tones. Power output of single tone set to 40 watts.



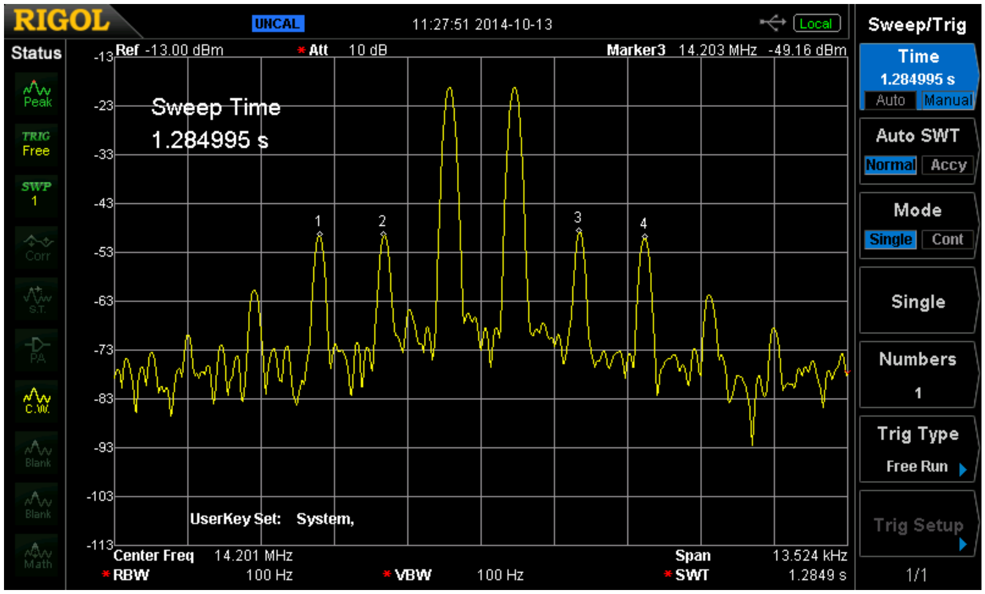
4. IMD at Output of Flex 3000 Transmitter – 2 watts out

Two tone test using 700 and 1900 Hz tones.



5. **IMD at Output of Flex 3000 Transmitter – 50 watts out**

Two tone test using 700 and 1900 Hz tones.

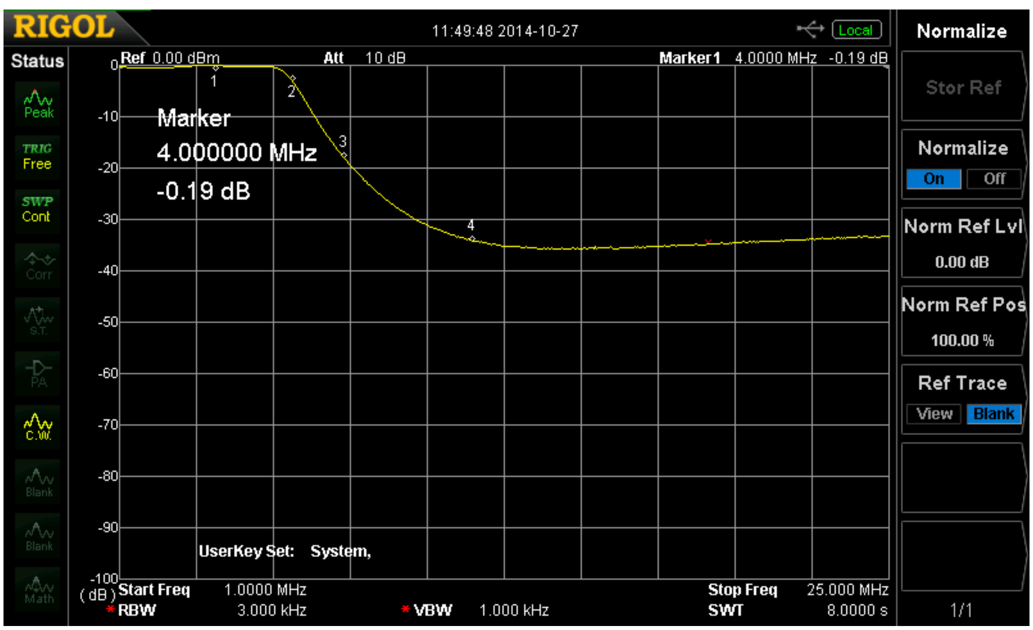


f. **Low Pass Filters**

The low pass filters are inserted into the receive path, after the antenna jack and are inserted into the transmit path before the antenna jack. Marker 2 on each sweep is the -3 db roll off point of the filter. Markers 3 and 4 of each sweep are the 2nd and 3rd harmonic frequencies of the primary frequency.

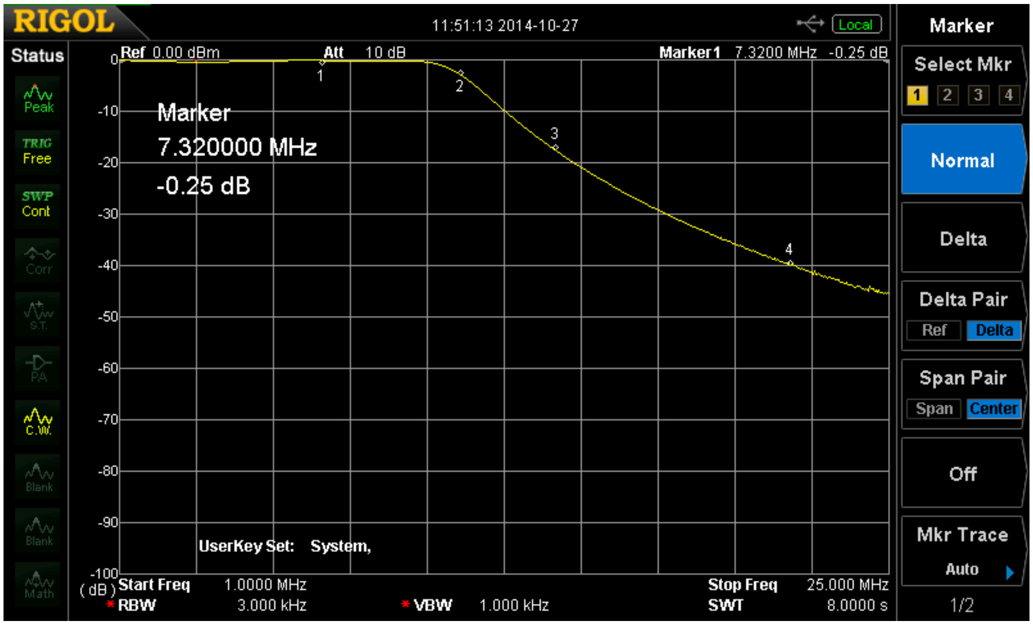
80M

- 3 db roll off point: 6.415 MHz



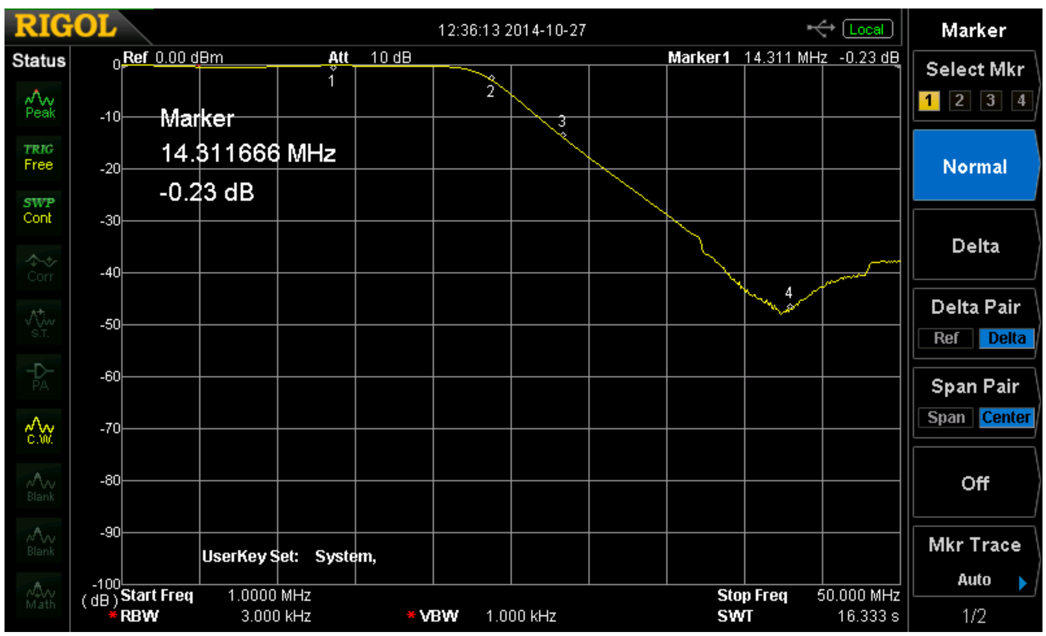
40M

- 3 db roll off point: 11.67 MHz



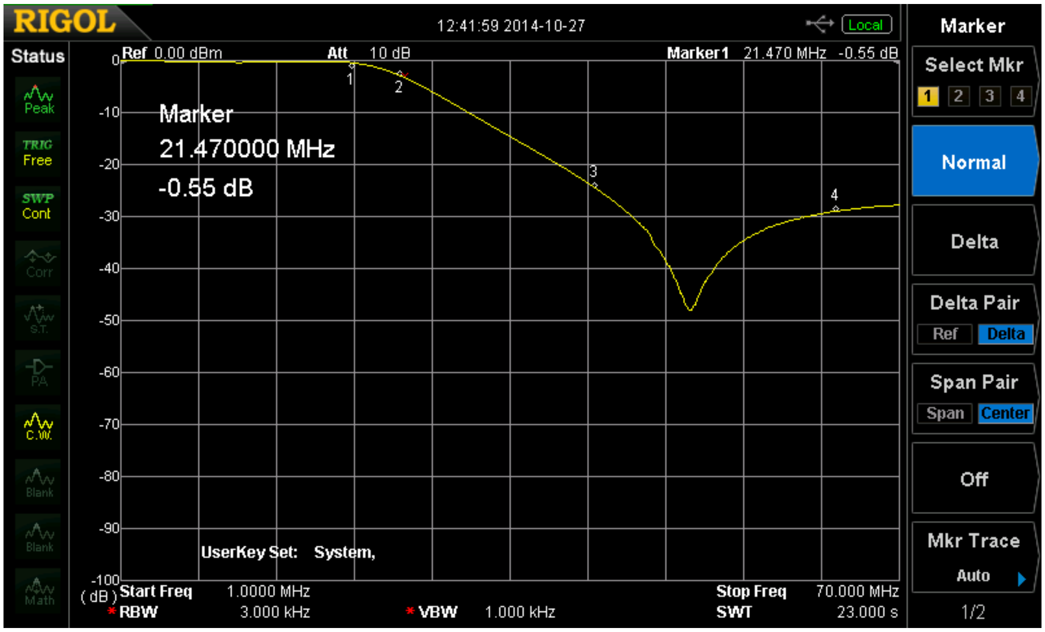
20M

- 3 db roll off point: 24.28 MHz



15M

- 3 db roll off point: 25.73 MHz



10M

- 3 db roll off point: 48.02 MHz