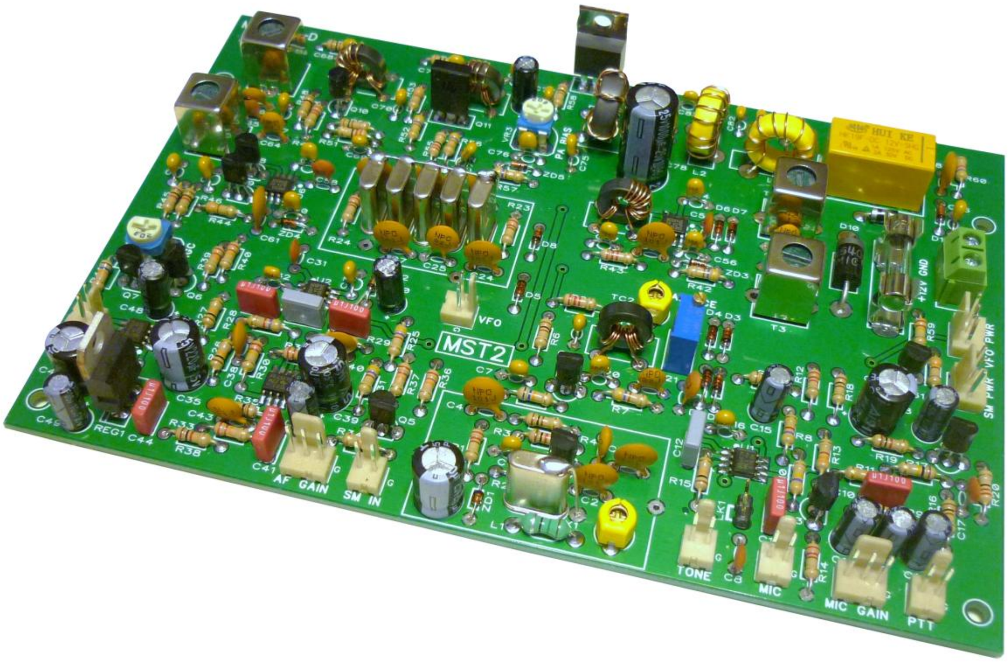
MST2

SSB TRANSCEIVER BOARD

20M



CONSTRUCTION MANUAL

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1 INTRODUCTION

The MST2 (Minimalist Sideband Transceiver series 2) mono-band SSB transceiver board follows the minimalist design approach of the original MST transceiver board, but adds a number of new features and performance enhancements.

With the addition of a VFO, an enclosure and a hand full of parts you have a complete and working SSB transceiver.

For best results mate the MST2 with the DDS VFO for drift free operation and the LED S meter for accurate receive 'S' units and transmit power display.

Full kits of parts for the MST2 transceiver board, the DDS VFO and LED S meter are available from www.ozQRP.com.

MST2 Features:

1. Sensitive Superhet receiver using a 5 pole 10MHz crystal filter.
2. 5W PEP minimum power output using a rugged power MOSFET output stage.
3. TDA7052A speaker amplifier incorporating an AGC circuit to even out received audio level.
4. Onboard fuse and diode protection to guard against power supply over current and reverse polarity.
5. Carrier oscillator can be 'pulled' to provide either USB or LSB operation.
6. Tone generator provides a constant audio tone to assist with alignment, checking SWR and adjusting antenna couplers.
7. Microphone amplifier accepts standard low impedance dynamic or Electret microphone with selectable on-board bias resistor.
8. Connectors for optional LED S meter or a simple front panel LED transmit power and modulation indicator.
9. AF and microphone gain controls.
10. Plenty of audio output to drive a loudspeaker.
11. Unwanted sideband suppression typically 40dB.
12. All spurious transmit outputs below -50dBc.
13. Receive current drain (including DDS VFO) approximately 135mA with no signal.
14. Transmit current approximately 950mA at 5W output.
15. High quality double sided PCB with groundplane, solder mask and silk screen.
16. Simple and easy to build.
17. No complicated coil winding required. Uses inexpensive commercial coil assemblies for tuned circuits.
18. Easy to adjust and set up with minimal tools required.

2 Block Diagram

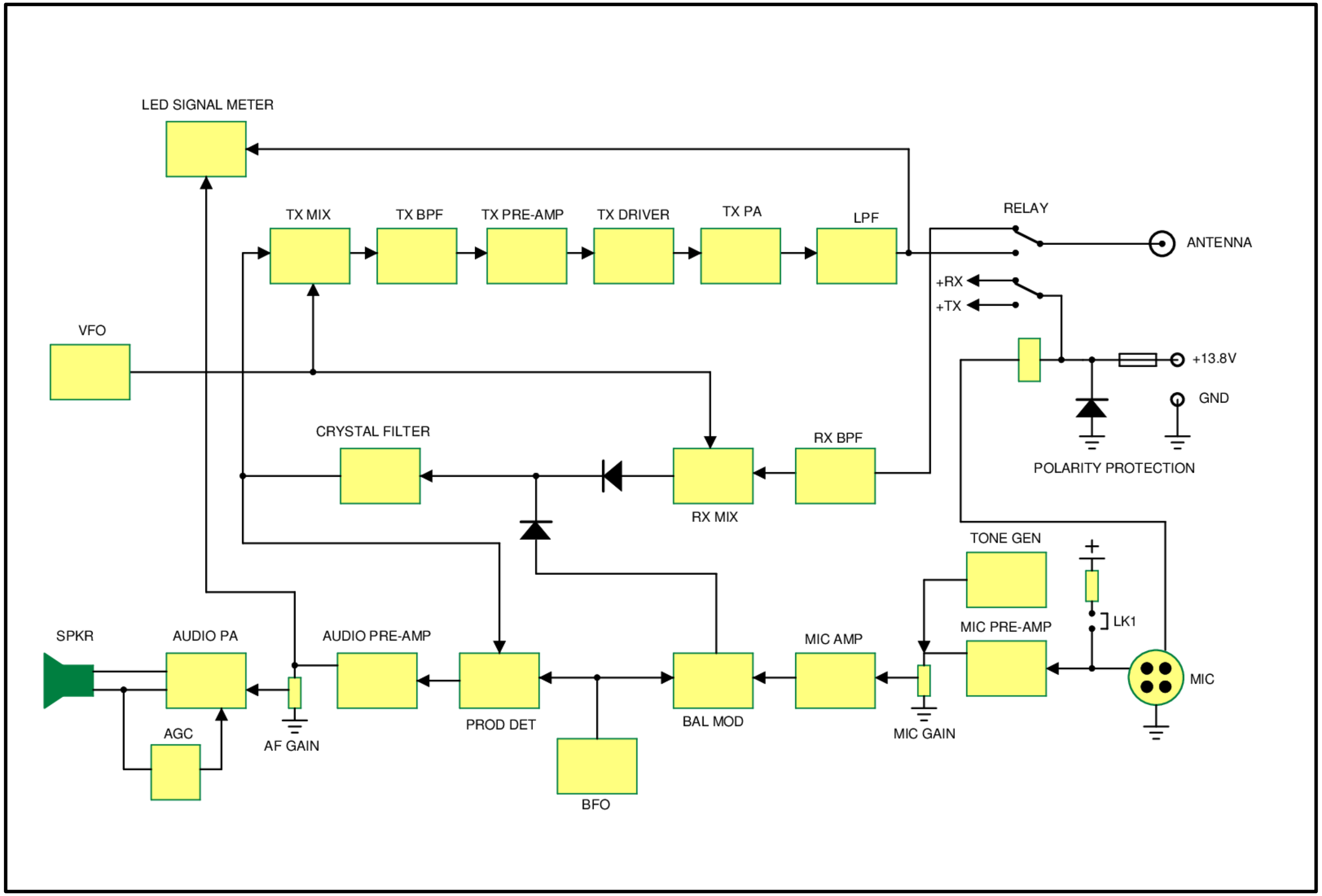


Figure 1 MST2 Block diagram

3 CIRCUIT DESCRIPTION

3.1 CARRIER OSCILLATOR

Transistor Q1 is configured as a Colpitts oscillator and acts as the 10MHz carrier oscillator in transmit and beat frequency oscillator (BFO) in receive. The frequency of crystal X1 is pulled slightly below the lower crystal frequency response by trimmer capacitor TC1 and inductor L1. This results in USB being generated. The power supply to the oscillator is regulated with a 9.1V Zener diode ZD1.

The oscillator feeds buffer stage Q2 to provide a low impedance drive for the balanced modulator. A lower level output of around 500mV pk-pk is obtained at the junction of Q1 emitter resistors to feed the receive product detector.

3.2 SSB GENERATOR

Transistor Q3 is the microphone pre-amplifier with a 20K ohm input impedance and gain of around 10. C8 is included to prevent RF feeding into the amplifier. The output of Q3 is fed to the Mic gain control via C13.

If an Electret microphone is used, R8 provides a DC bias current and is enabled by shorting LK1. If a dynamic microphone is used LK1 is left open. Transistor Q4 is the second microphone amplifier and has a gain of about 10. It is biased for higher current and has a low value collector resistor to enable it to drive the balanced modulator. R16 and C17 form a low pass filter to keep RF out of the amplifier.

The balanced modulator is a diode switching type and doubly balanced. When the carrier signal is positive diodes D1 and D4 conduct and when it is negative diodes D2 and D3 conduct. The result is that no RF is present at the output transformer T1. If an audio signal is injected into the bridge the balance is upset and a double sideband suppressed carrier signal is produced at the output of T1. Note that capacitor C21 holds the junction of D1 and D2 at ground for RF.

Due to variations in component parameters the balance is not exact and so trimcap TC2 and trimpot VR1 are adjusted to bring the modulator into balance. In practice up to 50dB of carrier suppression can be achieved.

Diode D5 is used as an RF switch. With no DC current flowing through the diode it is high impedance to RF. In TX mode around 6mA of DC current flows through D5 and it becomes a low impedance path for RF. This feeds the output of the balanced modulator into the crystal filter. In receive D8 performs a similar function.

A 555 timer (U1) is configured for astable operation with a frequency around 1KHz. A triangle waveform is available at the junction of the timing components C12 and R15. This is filtered by R11 and C10 to provide an approximate sine wave for transmission. This is coupled to the top of the Mic gain control via R9 and C9. U1 is not oscillating until pin1 is taken to ground by closing the Tone switch. The level of tone and hence the transmitter output can be varied by adjusting the Mic gain control. The tone generator serves as a handy tool during alignment and when checking SWR and adjusting antenna couplers.

3.3 CRYSTAL FILTER

The crystal filter is a 10MHz 5 pole ladder type using closely matched crystals on the same frequency. Capacitors C24 to C29 are selected to provide an approximate 2.7KHz bandwidth. Resistors R23 and R24 terminate the crystal filter in the correct resistance to give low ripple in the pass band.

3.4 TRANSMIT MIXER

The transmit mixer is based around U6 a SA612 balanced mixer. The 10MHz LSB signal from the crystal filter is fed single ended into pin1 while the other input on pin 2 is grounded to RF by C59. The VFO signal of around 300mV pk-pk is fed into pin 6. Transistors Q8 and Q9 act as emitter follower buffers providing a balanced low impedance feed for the transmit band pass filter. The transmit band pass filter is comprised of T5, T6 and associated capacitors and tuned to the sum of the VFO and carrier frequencies. The transformers used here are actually 10.7MHz IF transformers with the integral 47pF capacitor removed. A smaller external capacitor is used instead to increase the resonate frequency to match the 14MHz transmit frequency.

The output of the transmit band pass filter is link coupled to the pre-driver built around transistor Q10 which has both series and shunt feedback. The collector load is a broadband transformer (T7) with a 10 to 3 turn ratio. R50 determines the DC collector current, while R51 and C69 set the AC gain.

3.5 POWER AMPLIFIER

Transmit signal from the pre-driver is applied to the driver stage built around transistor Q11. A BD139 works well here when biased with about 60mA of collector current. The design is well proven using both shunt and series feedback to provide low input and output impedance and good stable gain on the low HF bands.

The power amplifier (Q12) is an IRF510 MOSFET and has been used in many designs. It is a good candidate for the HF bands and provides up to 5 Watts PEP of power from a 13.8 V drain supply. The output from the driver is applied across resistor R58 and becomes the AC drive component for Q12 gate. Zener diode ZD5 and trimpot VR3 provides a stable and variable DC gate voltage to place Q12 just into conduction for linear service. There is a short ramp up of the gate voltage when switching to TX mode as capacitor C74 charges and is included to provide a smooth gate voltage transition.

The drain load for Q12 is a broadband bi-filar wound transformer (T9) and was found to provide maximum output into a 50 ohm load. The waveform from Q12 can be high in harmonics and so a 5 pole low pass filter is included to reduce the level of harmonic and other spurious energy to an acceptable level.

As a visual indication of power output and modulation, the transmit signal is sampled by capacitor C85 and ground referenced by R60. The signal is rectified by D11 and filtered by C86. This drives transistor buffer Q13 to drive an external LED S meter or a front panel LED via current limiting resistor R61.

3.6 POWER SUPPLY AND RX/TX SWITCHING

When the PTT is operated the TX/RX relay is energized and the transmit signal is passed to the antenna. When the PTT is not operated the relay switches the antenna through to the receive circuits. The relay also switches power to the TX and RX sections as required. The power supply is also made available on separate connectors for the external VFO and LED S meter.

Diode D10 and a 2A fuse provide both over current and reverse polarity protection. If the supply is connected in reverse D10 will conduct and the fuse will blow. If however, the supply is not capable of supplying much more than 2A, the fuse may not blow, but the supply will be limited to a safe voltage and no damage should occur.

3.7 RECEIVE MIXER

Signals from the antenna are applied to a bandpass filter formed with two transformers T2, T3 and capacitors C50, C51 and C52. The antenna is link coupled to T2 while the output is fed from a tap on the tuned primary winding of T3 to for improved impedance matching.

The mixer U5 is another SA612. The input is protected with a pair of back to back diodes and fed single ended into pin 1. Pin 2 is grounded to RF by C54. Zener diode ZD3 provides a stabilized 6.8 volt supply. VFO signal is injected into pin 6 at about 300mV pk-pk. The balanced output which contains the difference signal of 10MHz is fed to broadband transformer T4. The output of T4 is passed to the crystal filter when DC current flows through R43 and into D8.

3.8 PRODUCT DETECTOR

The 10MHz SSB intermediate frequency (IF) signal from the crystal filter is applied to the product detector U2. The product detector is formed with another SA612 and mixes the IF signal with the 10MHz BFO signal to produce an audio output. The BFO is adjusted slightly below the crystal filter response so that Upper Side Band signals are detected correctly.

A balanced input audio amplifier is formed with one half of a NE5532dual low noise op-amp (U3a). A reference supply for the non-inverting input is obtained from R26, R27 and C35. The high frequency response of U3a is limited by C34, C38 and C40, while capacitors C36 and C37 reduce the low frequency response.

The output of U3a is fed via a 1uF coupling capacitor to the AF gain potentiometer. The audio signal is also made available via R34 on a separate connector for a LED S meter to display receive signal strength. Transistor Q5 is turned on in TX mode and shorts the audio signal input to the LED S meter to ground. This stops switching transients from being displayed.

As the receiver gain is fixed between the antenna and the AF gain control, the audio level across the AF gain control is directly proportional to the receive signal strength. The LED S meter measures this audio level and accurately displays the receive signal strength on an LED bar graph.

3.9 Audio Power Amplifier

Audio fed from the wiper of the AF gain control is amplified by the other half of the dual op-amp (U3b) which is configured for a gain of 5. The amplified signal is then applied to the audio power amplifier (U4) to drive a loudspeaker. This is a TDA7052A device with a Bridge-Tied Load (BTL) output. This configuration has a number of advantages for operation at low supply voltages, and also allows the speaker to be directly connected to the chip without the need for a large coupling capacitor.

⚠ **Both speaker wires are connected directly to the IC. Connecting a speaker wire or external load to ground may damage the IC.**

3.10 Audio AGC

The main reason for choosing the TDA7052A is the ability to alter the gain over a very large range by varying the DC voltage at pin 4. If pin 4 is left floating an internal source provides about 1.1V resulting in a maximum gain of +30dB. As pin 4 is pulled low the gain decreases, and if pulled all the way to ground the device is effectively shut off. By varying the amount of current pulled from pin 4 the gain can be continuously varied. This feature is used here to provide an Automatic Gain Control (AGC) circuit to even out receive audio and limit blasts from the speaker on very strong signals.

The power supply for U4 is set to +8V by a 7808 regulator. This is done for two reasons. Firstly the TDA7502A can become unstable at high supply voltages, but more importantly to fix the voltage at the output pins under no signal conditions. With no signal this voltage is half the supply voltage (+4V), but when audio is fed to the speaker the voltage at pin 5 will swing above and below the 4V quiescent point. The base of transistor Q7 is DC connected to pin 5 by a resistor and a trimpot. The trimpot (VR2) is adjusted so that transistor Q7 is just below conduction when there is no audio. When a signal is received the positive audio peaks at pin 5 will start to turn on Q7 and cause some current to be pulled from pin 4 and lower the gain. When the audio decreases, Q7 will begin to turn off which raises the voltage on pin 4, and increases the gain. This action continually attempts to adjust the audio level and provide AGC action. Capacitor C48 stores the charge in between positive cycles to avoid Q7 turning off during negative peaks and causing distortion. For such a simple circuit the dynamics are very good and make a great addition to the receiver.

In TX mode transistor Q6 is turned on hard and pulls pin 4 immediately to ground. This shuts off U4 and prevents any spurious audio from the transmit circuits being heard in the speaker. When returning to RX mode C48 charges slowly and provides a smooth click-less transition.

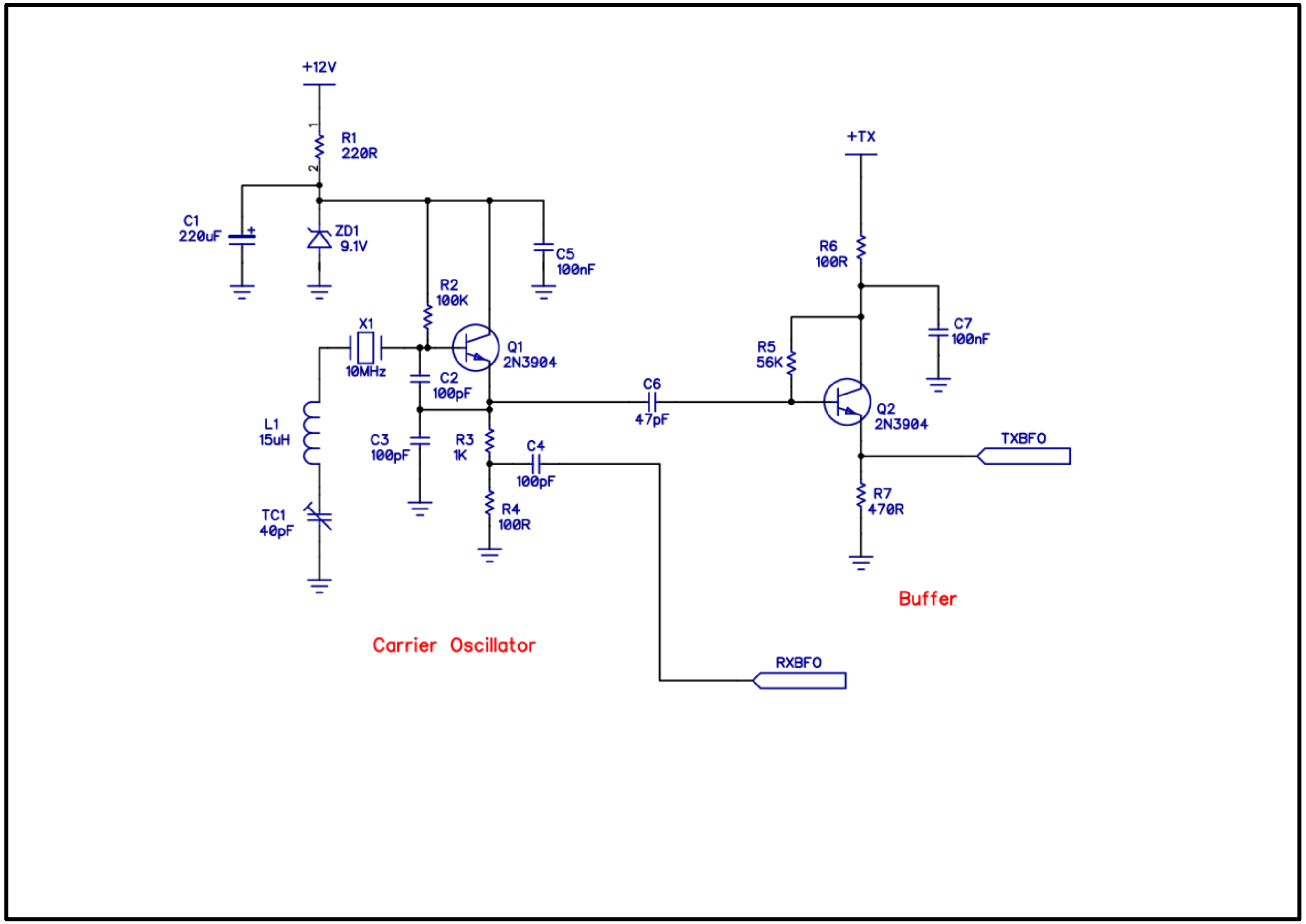


Figure 2 Carrier oscillator

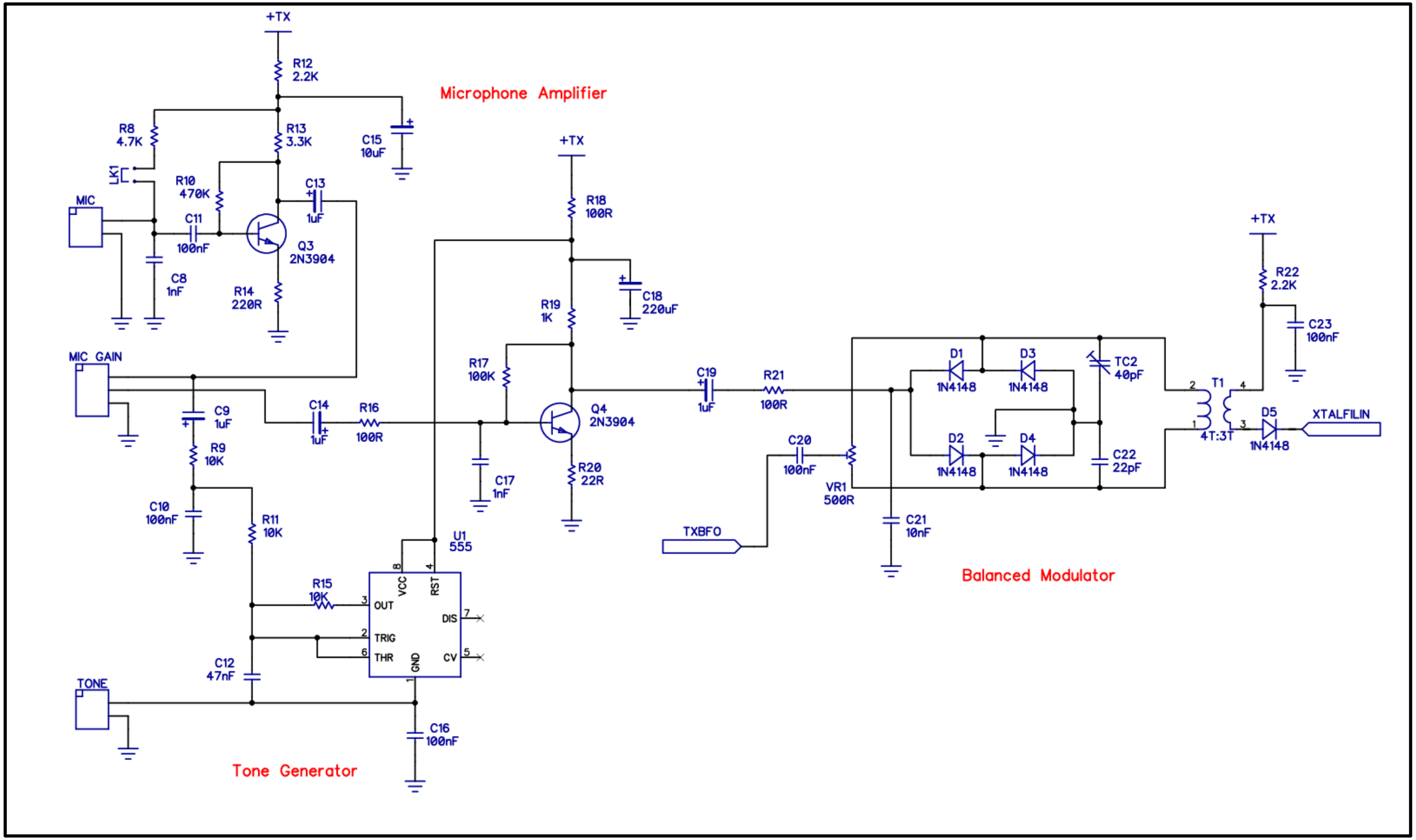


Figure 3 Balanced Modulator

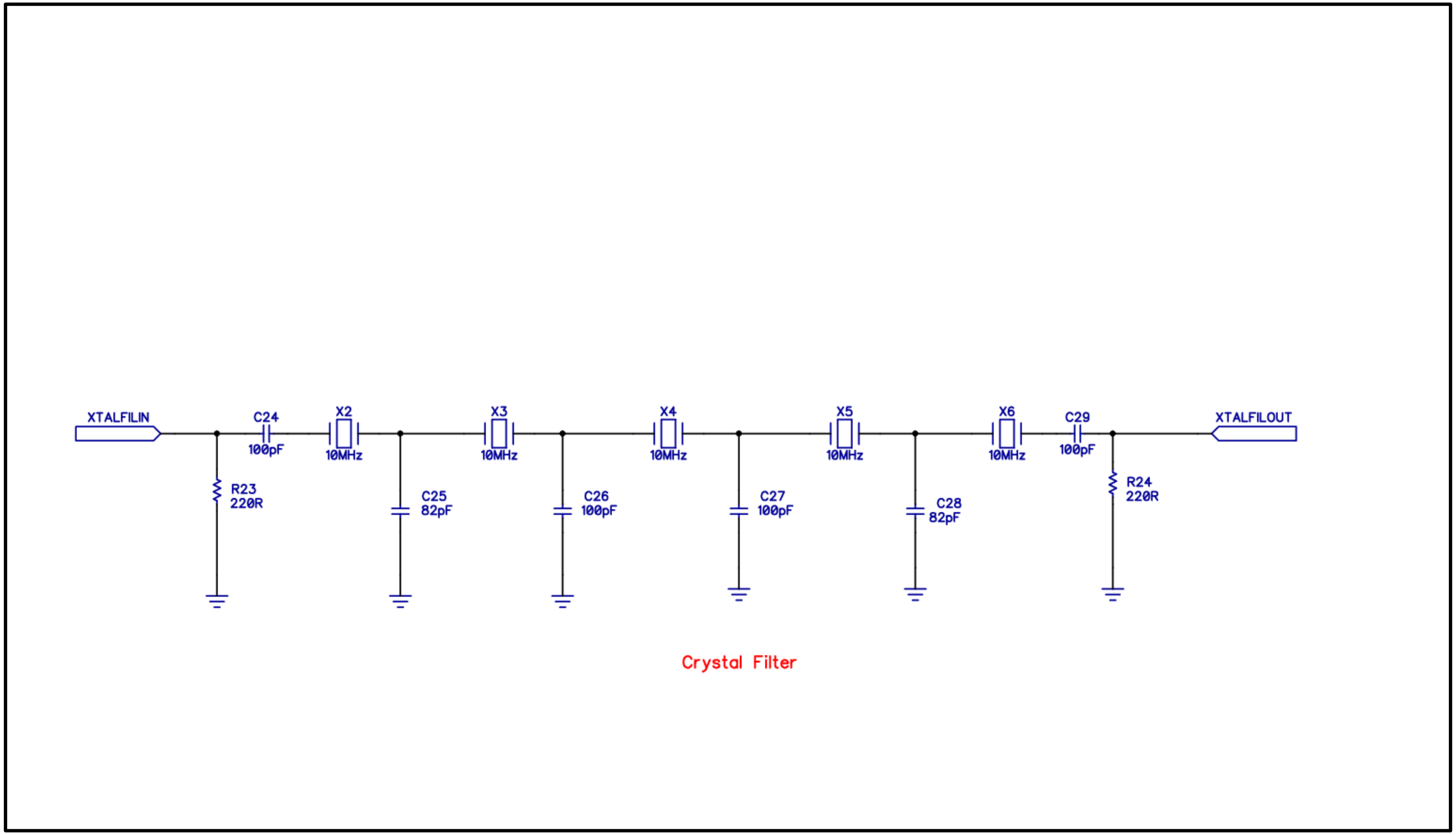


Figure 4 Crystal Filter

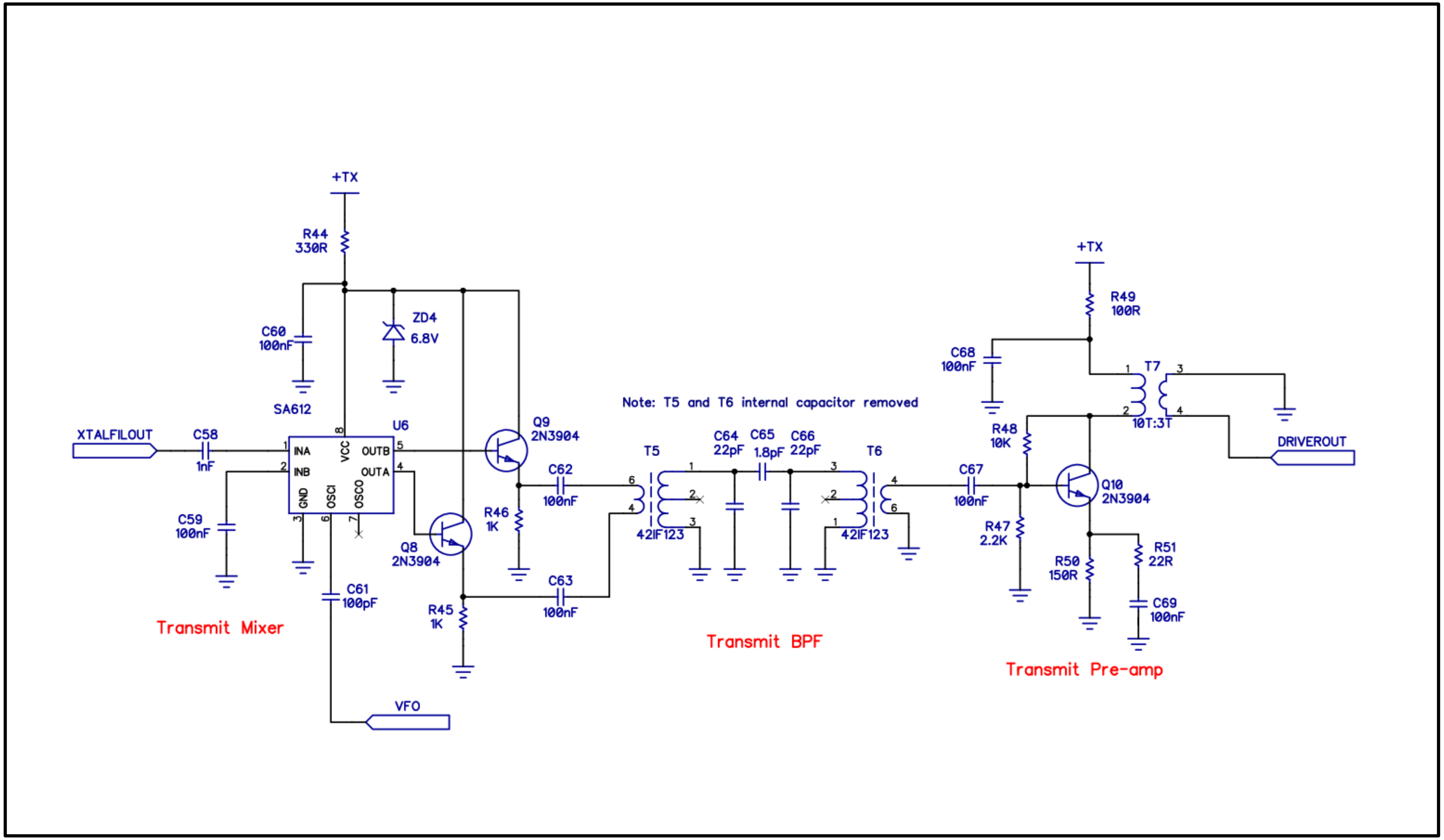


Figure 5 Transmit mixer

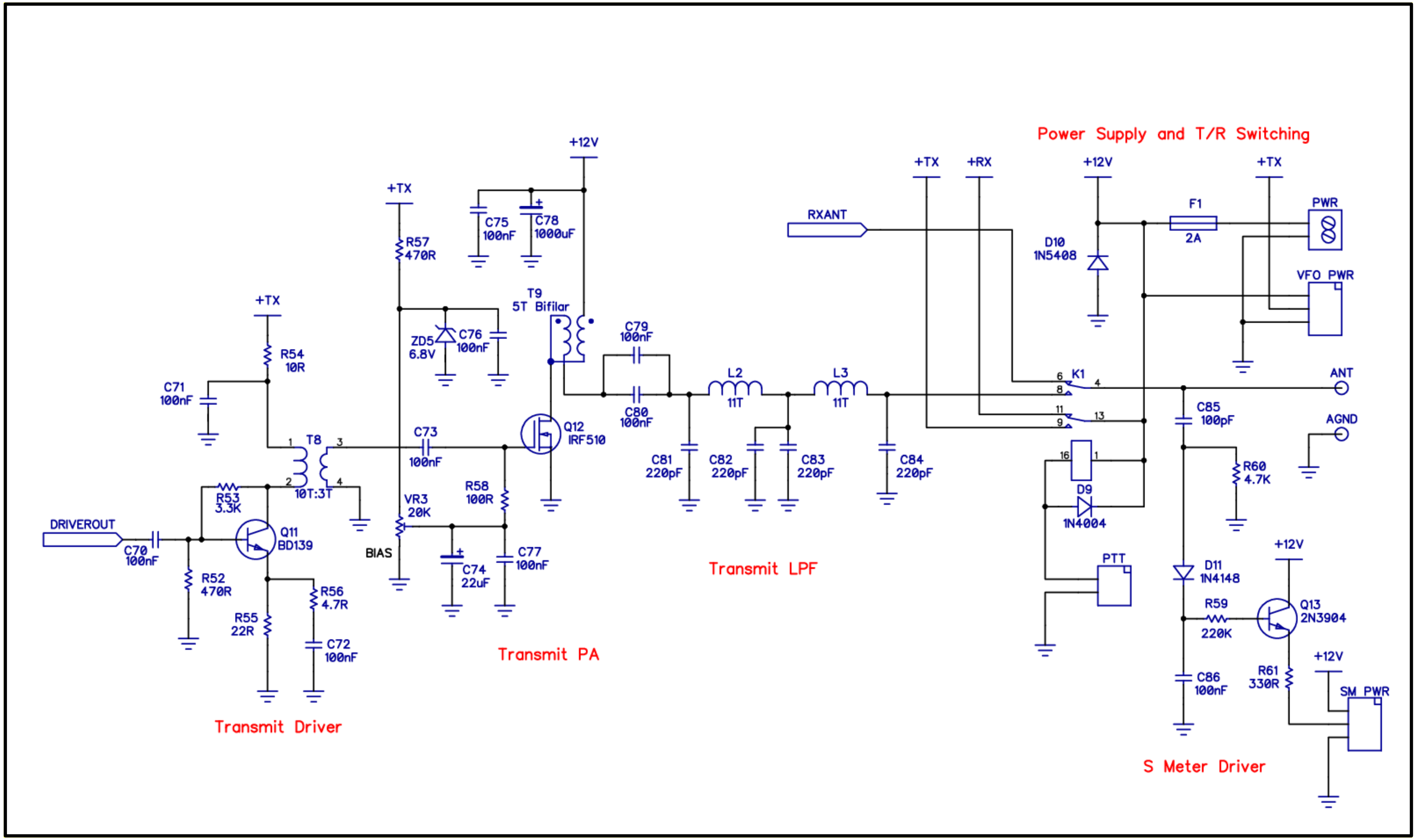


Figure 6 Power amplifier and RX/TX switching

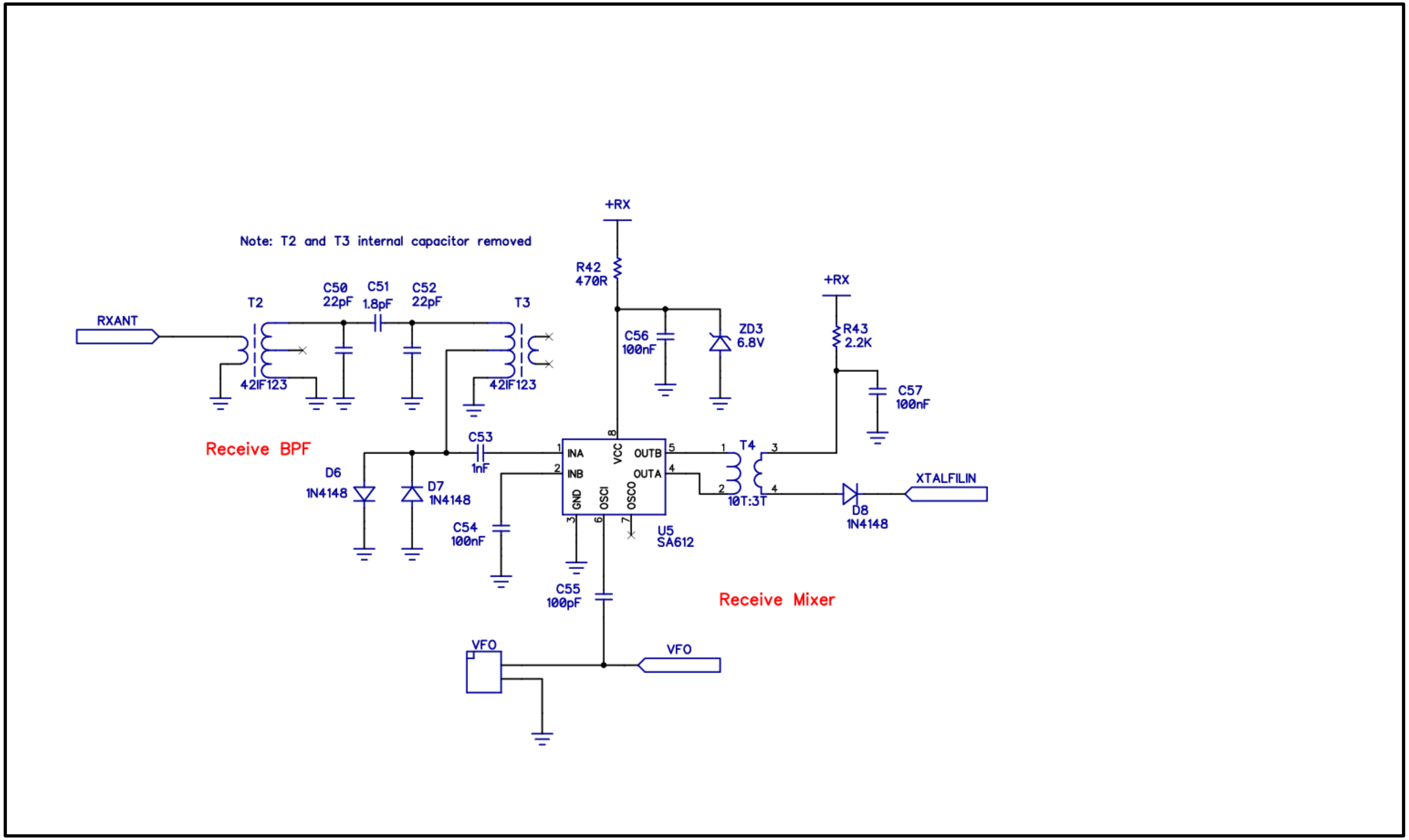


Figure 7 Receive mixer

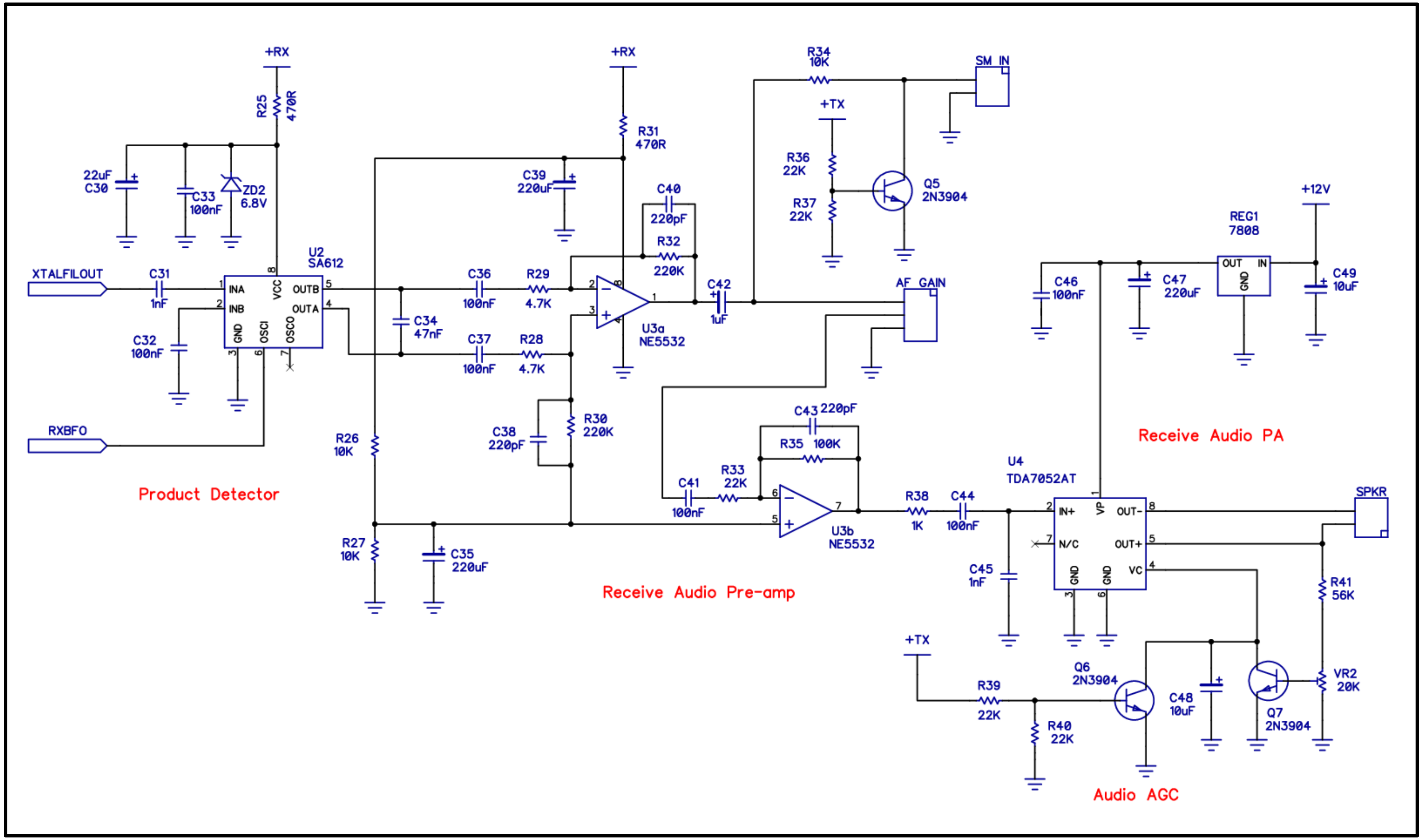


Figure 8 Receive audio

4 Kit Supplied Parts

QTY	Value	Designator
		Capacitors
2	1.8pF ceramic disc NPO	C51, C65
5	22pF ceramic disc NPO	C22, C50, C52, C64, C66
1	47pF ceramic disc NPO	C6
2	82pF ceramic disc NPO	C25, C28
10	100pF ceramic disc NPO	C2, C3, C4, C24, C26, C27, C29, C55, C61, C85
3	220pF ceramic disc	C38, C40, C43
4	220pF 100V C0G ceramic MLCC	C81, C82, C83, C84
6	1nF ceramic disc	C8, C17, C31, C45, C53, C58
1	10nF ceramic disc	C21
2	47nF polyester MKT	C12, C34
6	100nF polyester MKT	C10, C11, C36, C37, C41, C44
28	100nF ceramic MLCC	C5, C7, C16, C20, C23, C32, C33, C46, C54, C56, C57, C59, C60, C62, C63, C67, C68, C69, C70, C71, C72, C73, C75, C76, C77, C79, C80, C86
5	1uF 50V RB electrolytic	C9, C13, C14, C19, C42
3	10uF 25V RB electrolytic	C15, C48, C49
2	22uF 25V RB electrolytic	C30, C74
5	220uF 25V RB electrolytic	C1, C18, C35, C39, C47
1	1000uF 25V RB electrolytic	C78
2	40pF trim capacitor	TC1, TC2
		Resistors
1	4.7Ω 1/4W 5%	R56
1	10Ω 1/4W 5%	R54
3	22Ω 1/4W 5%	R20, R51, R55
7	100Ω 1/4W 5%	R4, R6, R16, R18, R21, R49, R58
1	150Ω 1/4W 5%	R50
4	220Ω 1/4W 5%	R1, R14, R23, R24
2	330Ω 1/4W 5%	R44, R61
6	470Ω 1/4W 5%	R7, R25, R31, R42, R52, R57
5	1K 1/4W 5%	R3, R19, R38, R45, R46
4	2.2K 1/4W 5%	R12, R22, R43, R47
2	3.3K 1/4W 5%	R13, R53
4	4.7K 1/4W 5%	R8, R28, R29, R60
7	10K 1/4W 5%	R9, R11, R15, R26, R27, R34, R48
5	22K 1/4W 5%	R33, R36, R37, R39, R40
2	56K 1/4W 5%	R5, R41
3	100K 1/4W 5%	R2, R17, R35
3	220K 1/4W 5%	R30, R32, R59
1	470K 1/4W 5%	R10
1	500Ω vertical multi-turn trimpot	VR1
2	20K horizontal trimpot	VR2, VR3

QTY	Value	Designator
Semiconductors		
9	1N4148 signal diode	D1, D2, D3, D4, D5, D6, D7, D8, D11
1	1N4004 1A power diode	D9
1	1N5408 3A power diode	D10
1	9.1V 500mW Zener	ZD1
4	6.8V 500mW Zener	ZD2, ZD3, ZD4, ZD5
11	2N3904 NPN transistor	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q13
1	BD139 NPN transistor	Q11
1	IRF510 power MOSFET	Q12
1	7808 +8V 1A regulator	REG1
1	NE555 timer SMD	U1
3	SA612 RF mixer SMD	U2, U5, U6
1	NE5532 dual op-amp SMD	U3
1	TDA7052A audio power amp SMD	U4
Coils		
1	15uH RF choke	L1
4	IF transformer 42IF123	T2, T3, T5, T6
1	FT37-43 4T:3T	T1
3	FT37-43 10T:3T	T4, T7, T8
1	FT50-43 5T bifilar	T9
2	T50-6 11T	L2, L3
1	2M 0.4mm enamelled wire	-
Hardware		
1	12V DPDT DIP relay	K1
2	M205 PCB fuse clip	F1
1	M205 2A fuse	F1
1	2 way screw terminal block	PWR
6	2 pin 2.54mm pitch header	MIC, TONE, SM IN, SPKR, VFO, PTT
4	3 pin 2.54mm pitch header	MIC GAIN, AF GAIN, VFO PWR, SM PWR
Crystals		
6	10MHz crystal	X1, X2, X3, X4, X5, X6

5 Individual Parts List

Designator	Value	Type	Designator	Value	Type
C1	220uF	25V RB electrolytic	C44	100nF	polyester MKT
C2	100pF	ceramic disc NPO	C45	1nF	ceramic disc
C3	100pF	ceramic disc NPO	C46	100nF	ceramic MLCC
C4	100pF	ceramic disc NPO	C47	220uF	25V RB electrolytic
C5	100nF	ceramic MLCC	C48	10uF	25V RB electrolytic
C6	47pF	ceramic disc NPO	C49	10uF	25V RB electrolytic
C7	100nF	ceramic MLCC	C50	22pF	ceramic disc NPO
C8	1nF	ceramic disc	C51	1.8pF	ceramic disc NPO
C9	1uF	50V RB electrolytic	C52	22pF	ceramic disc NPO
C10	100nF	polyester MKT	C53	1nF	ceramic disc
C11	100nF	polyester MKT	C54	100nF	ceramic MLCC
C12	47nF	polyester MKT	C55	100pF	ceramic disc NPO
C13	1uF	50V RB electrolytic	C56	100nF	ceramic MLCC
C14	1uF	50V RB electrolytic	C57	100nF	ceramic MLCC
C15	10uF	25V RB electrolytic	C58	1nF	ceramic disc
C16	100nF	ceramic MLCC	C59	100nF	ceramic MLCC
C17	1nF	ceramic disc	C60	100nF	ceramic MLCC
C18	220uF	25V RB electrolytic	C61	100pF	ceramic disc NPO
C19	1uF	50V RB electrolytic	C62	100nF	ceramic MLCC
C20	100nF	ceramic MLCC	C63	100nF	ceramic MLCC
C21	10nF	ceramic disc	C64	22pF	ceramic disc NPO
C22	22pF	ceramic disc NPO	C65	1.8pF	ceramic disc NPO
C23	100nF	ceramic MLCC	C66	22pF	ceramic disc NPO
C24	100pF	ceramic disc NPO	C67	100nF	ceramic MLCC
C25	82pF	ceramic disc NPO	C68	100nF	ceramic MLCC
C26	100pF	ceramic disc NPO	C69	100nF	ceramic MLCC
C27	100pF	ceramic disc NPO	C70	100nF	ceramic MLCC
C28	82pF	ceramic disc NPO	C71	100nF	ceramic MLCC
C29	100pF	ceramic disc NPO	C72	100nF	ceramic MLCC
C30	22uF	25V RB electrolytic	C73	100nF	ceramic MLCC
C31	1nF	ceramic disc	C74	22uF	25V RB electrolytic
C32	100nF	ceramic MLCC	C75	100nF	ceramic MLCC
C33	100nF	ceramic MLCC	C76	100nF	ceramic MLCC
C34	47nF	polyester MKT	C77	100nF	ceramic MLCC
C35	220uF	25V RB electrolytic	C78	1000uF	25V RB electrolytic
C36	100nF	polyester MKT	C79	100nF	ceramic MLCC
C37	100nF	polyester MKT	C80	100nF	ceramic MLCC
C38	220pF	ceramic disc	C81	220pF	100V C0G ceramic MLCC
C39	220uF	25V RB electrolytic	C82	220pF	100V C0G ceramic MLCC
C40	220pF	ceramic disc	C83	220pF	100V C0G ceramic MLCC
C41	100nF	polyester MKT	C84	220pF	100V C0G ceramic MLCC
C42	1uF	50V RB electrolytic	C85	100pF	ceramic disc NPO
C43	220pF	ceramic disc	C86	100nF	ceramic MLCC

Designator	Value	Type	Designator	Value	Type
D1	1N4148	Signal diode	R15	10K	1/4W 5%
D2	1N4148	Signal diode	R16	100Ω	1/4W 5%
D3	1N4148	Signal diode	R17	100K	1/4W 5%
D4	1N4148	Signal diode	R18	100Ω	1/4W 5%
D5	1N4148	Signal diode	R19	1K	1/4W 5%
D6	1N4148	Signal diode	R20	22 Ω	1/4W 5%
D7	1N4148	Signal diode	R21	100Ω	1/4W 5%
D8	1N4148	Signal diode	R22	2.2K	1/4W 5%
D9	1N4004	1A power diode	R23	220Ω	1/4W 5%
D10	1N5408	3A power diode	R24	220Ω	1/4W 5%
D11	1N4148	Signal diode	R25	470Ω	1/4W 5%
			R26	10K	1/4W 5%
F1	2A	M205 Fuse + PCB clips	R27	10K	1/4W 5%
			R28	4.7K	1/4W 5%
K1	DPDT	PCB mount DIP relay	R29	4.7K	1/4W 5%
L1	15uH	RF choke	R30	220K	1/4W 5%
L2	11T	T50-6 toroid	R31	470Ω	1/4W 5%
L3	11T	T50-6 toroid	R32	220K	1/4W 5%
			R33	22K	1/4W 5%
Q1	2N3904	NPN transistor	R34	10K	1/4W 5%
Q2	2N3904	NPN transistor	R35	100K	1/4W 5%
Q3	2N3904	NPN transistor	R36	22K	1/4W 5%
Q4	2N3904	NPN transistor	R37	22K	1/4W 5%
Q5	2N3904	NPN transistor	R38	1K	1/4W 5%
Q6	2N3904	NPN transistor	R39	22K	1/4W 5%
Q7	2N3904	NPN transistor	R40	22K	1/4W 5%
Q8	2N3904	NPN transistor	R41	56K	1/4W 5%
Q9	2N3904	NPN transistor	R42	470Ω	1/4W 5%
Q10	2N3904	NPN transistor	R43	2.2K	1/4W 5%
Q11	BD139	NPN transistor	R44	330Ω	1/4W 5%
Q12	IRF510	Power MOSFET	R45	1K	1/4W 5%
Q13	2N3904	NPN transistor	R46	1K	1/4W 5%
			R47	2.2K	1/4W 5%
R1	220Ω	1/4W 5%	R48	10K	1/4W 5%
R2	100K	1/4W 5%	R49	100Ω	1/4W 5%
R3	1K	1/4W 5%	R50	150Ω	1/4W 5%
R4	100Ω	1/4W 5%	R51	22Ω	1/4W 5%
R5	56K	1/4W 5%	R52	470Ω	1/4W 5%
R6	100Ω	1/4W 5%	R53	3.3K	1/4W 5%
R7	470Ω	1/4W 5%	R54	10Ω	1/4W 5%
R8	4.7K	1/4W 5%	R55	22Ω	1/4W 5%
R9	10K	1/4W 5%	R56	4.7Ω	1/4W 5%
R10	470K	1/4W 5%	R57	470Ω	1/4W 5%
R11	10K	1/4W 5%	R58	100Ω	1/4W 5%
R12	2.2K	1/4W 5%	R59	220K	1/4W 5%
R13	3.3K	1/4W 5%	R60	4.7K	1/4W 5%
R14	220Ω	1/4W 5%	R61	330Ω	1/4W 5%

Designator	Value	Type	Designator	Value	Type
REG1	7808	+8V regulator TO-220	X1	10MHz	Crystal
			X2	10MHz	Crystal
SK1	MIC	2 pin polarised header	X3	10MHz	Crystal
SK2	MIC GAIN	3 pin polarised header	X4	10MHz	Crystal
SK3	TONE	2 pin polarised header	X5	10MHz	Crystal
SK4	SM IN	2 pin polarised header	X6	10MHz	Crystal
SK5	AF GAIN	3 pin polarised header			
SK6	SPKR	2 pin polarised header	ZD1	9.1V	500mW Zener diode
SK7	VFO	2 pin polarised header	ZD2	6.8V	500mW Zener diode
SK8	PTT	2 pin polarised header	ZD3	6.8V	500mW Zener diode
SK9	VFO PWR	3 pin polarised header	ZD4	6.8V	500mW Zener diode
SK10	SM PWR	3 pin polarised header	ZD5	6.8V	500mW Zener diode
T1	4T:3T	FT37-43 ferrite			
T2	42IF123	10.7MHz IF transformer			
T3	42IF123	10.7MHz IF transformer			
T4	10T:3T	FT37-43 ferrite			
T5	42IF123	10.7MHz IF transformer			
T6	42IF123	10.7MHz IF transformer			
T7	10T:3T	FT37-43 ferrite			
T8	10T:3T	FT37-43 ferrite			
T9	5T Bifilar	FT50-43 ferrite			
TB1	PWR	2 way terminal block			
TC1	40pF	Trimmer cap			
TC2	40pF	Trimmer cap			
U1	NE555	Timer			
U2	SA612	RF mixer			
U3	NE5532	Dual low noise op-amp			
U4	TDA7052A	BTL power audio amp			
U5	SA612	RF mixer			
U6	SA612	RF mixer			
VR1	500 Ω	Multi-turn trimpot			
VR2	20K	Horizontal trimpot			
VR3	20K	Horizontal trimpot			

6 Off Board Parts

The following is a suggested list of parts to install the MST2 transceiver board in an enclosure along with the DDS VFO and LED S meter. These parts are not included in the kits.

The enclosure listed is the type used in the prototype, however any suitable plastic or metal type with the approximate dimensions can be used. When choosing consider the following:

- Metallic rear panel to act as a heatsink for the transmit PA.
- Placement of mounting screws to match the PCB mounting holes.
- Height of the enclosure to allow clearance for the DDS VFO PCB and LCD.
- Sufficient space at the front of the enclosure to mount the DDS VFO and LED S meter.

QTY	Item	Comment
	Basic Transceiver	
1	Plastic instrument enclosure. 200mm x 155mm x 65mm with aluminium panels.	www.altronics.com.au H0480F or equivalent.
1	Red binding post	POS power supply.
1	Black binding post	NEG Power supply.
1	SO239 panel mount socket	Antenna socket.
3	Knobs	Nominally 20mm diameter.
1	SPST toggle switch	Tone control switch.
2	10K log pot 16mm	AF gain and Mic gain.
1	5mm amber LED and bezel	If the LED S meter is not installed.
1	Microphone socket	To suit microphone. Must have a separate PTT line.
1	Front panel label	If required.
1	Loudspeaker 8 or 16 ohm 67mm square or equivalent	Minimum recommended size.
4	4g x 6mm self-tapping screws	PCB mounting into plastic posts.
1	3mm x 10mm screw and nut	To mount TX PA.
1	TO-220 insulating washer and bush	To mount TX PA.
6	2 pin 2.54mm pitch header plugs + pins	Optional.
4	3 pin 2.54mm pitch header plug + pins	Optional.
	DDS VFO	
4	10mm long x 3mm threaded spacer	4 single 22mm spacers as alternative
4	12mm long x 3mm threaded spacer	
4	6mm long x 3mm round head screw	PCB to spacer
4	16mm long x 3mm countersunk head screw	Front panel to spacer
	LED S meter	
1	Aluminium bracket	See LED S meter construction manual
2	10mm long x 3mm countersunk screws + nuts	Bracket to front panel
2	10mm long x 3mm round screws + nuts	Bracket to PCB
2	3mm or 4mm long unthreaded nylon spacer	PCB mount
1	2 pin 2.54mm pitch header plugs + pins	Optional.
1	3 pin 2.54mm pitch header plug + pins	Optional.
	Misc	
	hook-up wire, shielded audio cable	

7 CONSTRUCTION

7.1 GENERAL

The MST2 is built on a high quality fiberglass PCB. The PCB is doubled sided with the majority of the tracks on the bottom side with the top side forming a ground plane.

To assist construction the component overlay is screen printed on the top side and a solder mask is included to help guard against solder bridges.

The ground plane is substantial and can sink quite a bit of heat from low wattage soldering irons so ensure you use a good quality iron that can sustain the power required. You may find that sometimes solder doesn't appear to flow through to the top side. This is not necessarily a problem because the plated through holes make a connection to the top side automatically.

Another point to consider is that plated through holes consume more solder than non-plated holes and makes it more difficult to remove components. So check the value and orientation of components before soldering!

There isn't a 'best' scheme for loading the components. If desired you can build sections at a time and test them out, but it is not really necessary and in any case some sections rely on others before they will operate. The suggested procedure is to load the smaller components and those closest to the PCB first and then work upwards.

7.2 Construction Steps

It's advisable to print out the parts list and tick off the components as they are installed. The PCB has a silkscreen component overlay with components designators, but you might like to print Figure 9 as an additional reference when installing the components.

Step 1: PCB

Remove the PCB from its bag.

> ⚠ **The PCB comes shipped in a static shielded bag to protect against static damage. While the ICs are not particularly sensitive to static damage it is still good practice to take the usual precautions against static discharge during construction.**

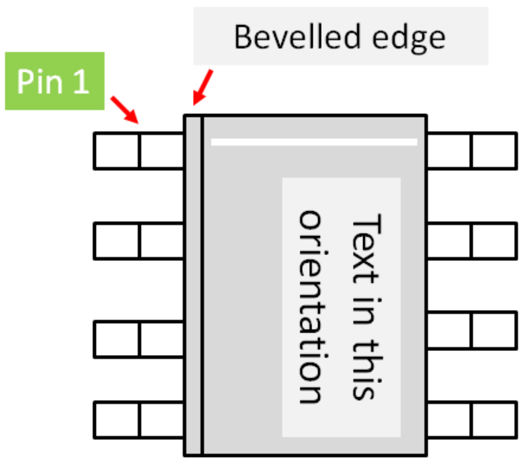
It is normal practice to install the ICs last, but it is almost impossible to solder them with the larger and nearby components in place and so they are installed first.

All the ICs are 8 pin SOIC types with 1.27mm pitch pins and are quite a bit smaller than conventional DIP through-hole ICs they are by no means difficult to work with.

The diagram below shows how to identify the SMD IC pins.

The ICs will have one or more of the following identifiers to locate pin 1:

- A dot above pin 1
- A beveled edge down one side starting at pin 1 and ending at pin 4.
- A line across the top from pin 1 to pin 8.



Step 2: Resistors

The resistors are all 5% ¼ watt types with easy to read colour bands.

⚠ **If in any doubt about reading resistor values measure them with a multimeter first.**

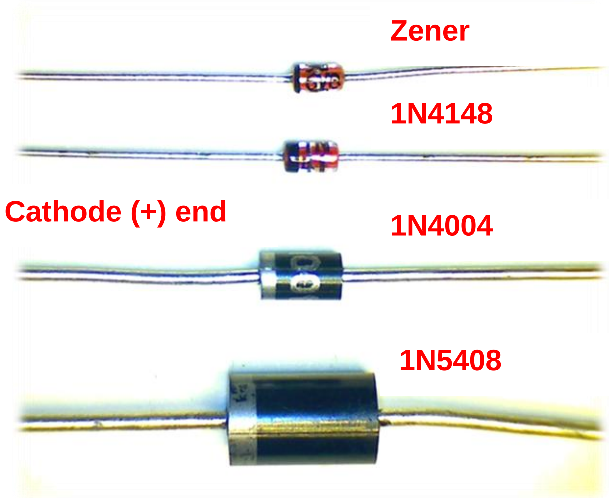
Pass the pigtails through from the top and bend out slightly underneath to hold them in place. Turn the PCB over and press down slightly to press them against the surface and solder. Cut off the excess pigtail with side cutters.

It is easier and less confusing to install a group with the same value rather than to cover a section of the PCB with mixed values. You will also find it more convenient to install 5 or 6 resistors at a time rather than inserting them all before soldering as the pigtails will more than likely get in the way.

Step 3: Diodes

Note the positive or Cathode end before installation. The small Zener diodes look like signal diodes so make sure you don't get them mixed up. You may need a magnifier to identify them correctly. Form the leads before inserting to reduce stress on the body when pulling through the PCB.

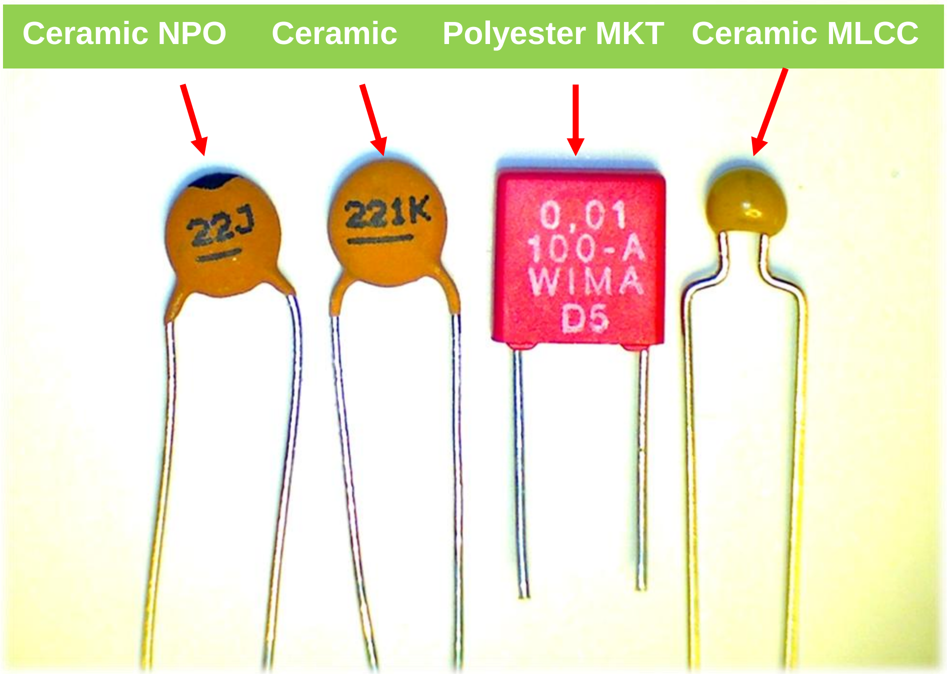
The diodes are identified with a band printed on the case at the Cathode (+) end.



Step 4: Non-polarized capacitors

Note the various types. Ceramic disc NPO, standard ceramic disc, polyester MKT and ceramic multi-layer chip capacitors (MLCC). These are all non-polarized and can go in either way.

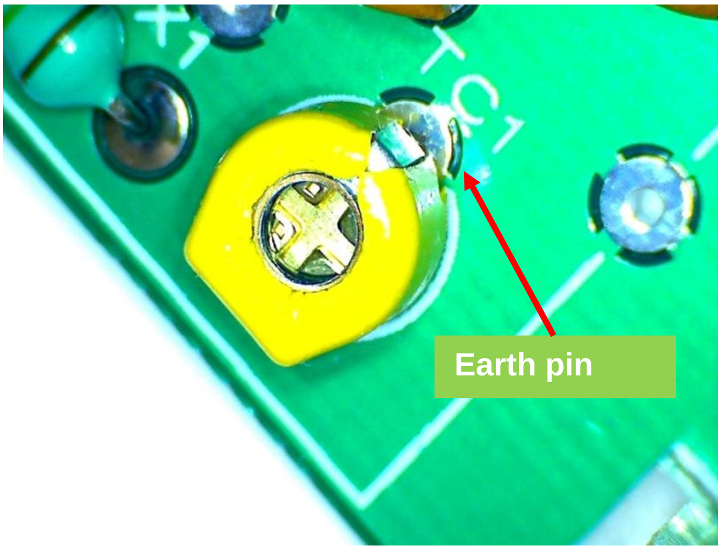
There are 28 x 100nf (0.1uF) MLCC and as they are quite small install these first. Follow this with the low pass filter capacitors, then the disc ceramics and finally the MKT.



Step 5: Trimmer capacitors

The type of trimmer capacitor supplied is quite small and has one lead electrically connected to the screwdriver adjustment slot. Use a multimeter to determine this pin and solder to the hole in the PCB connected to the ground plane. If you find the leads too wide for the PCB holes, simply trim them down with sidecutters before inserting.

The earth pin of the trimmer capacitor is highlighted in the picture opposite.

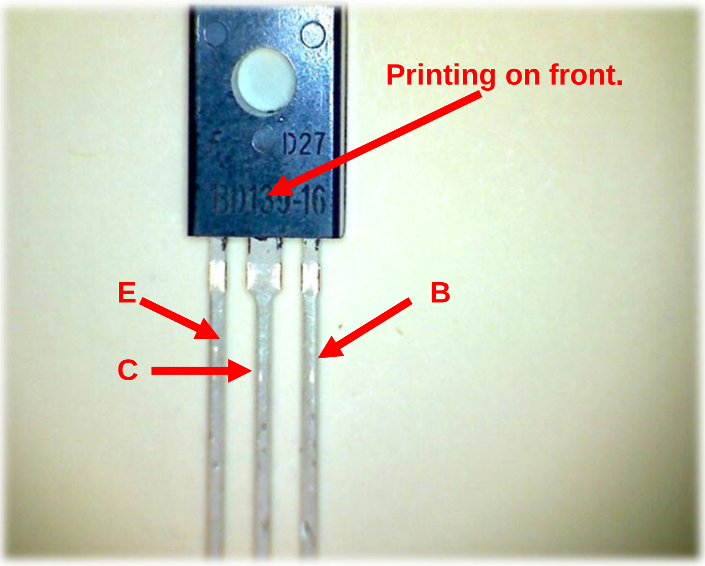


Step 6: Trimpots

Note that the carrier balance trimpot is a multi-turn vertical mount while the bias and AGC trimpots are horizontal mount types.

Step 7: Transistors

The 2N3904 transistors are orientated to match the screen silk component overlay. The BD139 pins are shown below:



⚠ Leave the IRF510 power MOSFET and the 7808 voltage regulator installation till later.

Step 8: Electrolytic capacitors

These are polarized and it is very important that they go in the correct way. Electrolytic capacitors have a line down the side of the case indicating the negative lead and the positive lead is generally the longer lead. The PCB component overlay has a '+' mark to indicate the hole for the positive lead.

Step 9: Connectors

The MST2 board utilizes polarized pin headers for some external connections. These are equivalent to the MOLEX 'KK' range. If preferred the wires may be soldered directly to the PCB, but the connectors make for a professional looking build, plus allow easy disconnection and testing if required. The connectors have a vertical polarizing piece and the connectors are installed with this piece towards the centre of the PCB.

The power connector is a 2 way screw terminal block and the terminal openings face towards the edge of the PCB.

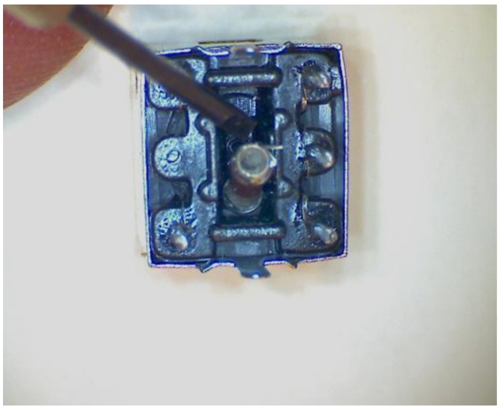
The fuse holder clips have a small tab located on side of the upper parts contacts that are intended to locate the fuse within the holder. Ensure the clips are installed so these tabs are on the outer ends of the holder.

Step 10: IF transformers

The four IF transformers can only go in one way and are simply fitted into the holes in the PCB and soldered. They do however require the internal capacitor to be removed so that the primary winding can be resonated on 20M with an external capacitor.

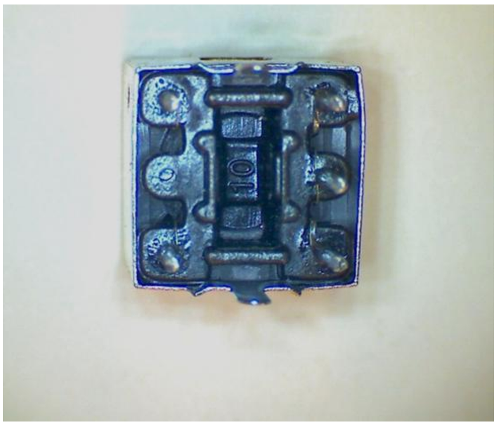
This picture shows the IF transformer from underneath. Notice the tubular resonating capacitor located in the recess at the bottom of the former.

Using a small tool such as a jeweler's screwdriver or scriber lever up one end of the capacitor. Grab the capacitor with long nose pliers and pull out completely. The connecting wires are very fine and will break off easily.



You may need to cut off any excess wire and ensure there are no fragments remaining in the recess.

This photo shows the capacitor completely removed.



Step 11: Relay

The relay can only go in one way, so simply insert into the board and solder.

Step 12: Coils

Choke

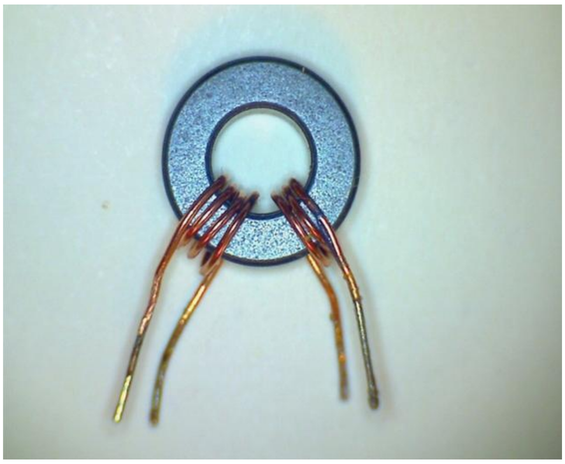
Install the RF choke in the same manner as the resistors.

Transformer T1

Take two 80mm lengths of 0.4mm enamelled copper wire.
Wind 4 turns for the primary (bal mod) and 3 turns for the secondary (xtal filter) on a **FT37-43** ferrite toroid.

Scrape the enamel off the ends of the wires and tin with solder before installing in the PCB.

The winding direction is not important.



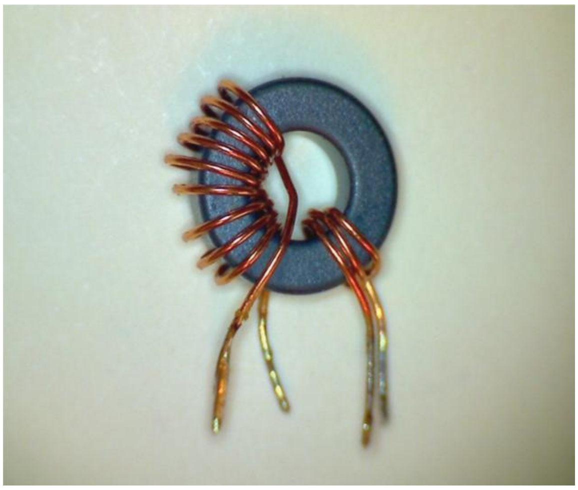
Transformers T4, T7 and T8

Take an 80mm length of 0.4mm enamelled copper wire and wind the 3 turn secondary on a **FT37-43** ferrite toroid.

Take a 150mm length of 0.4mm enamelled copper wire and wind the 10 turn primary.

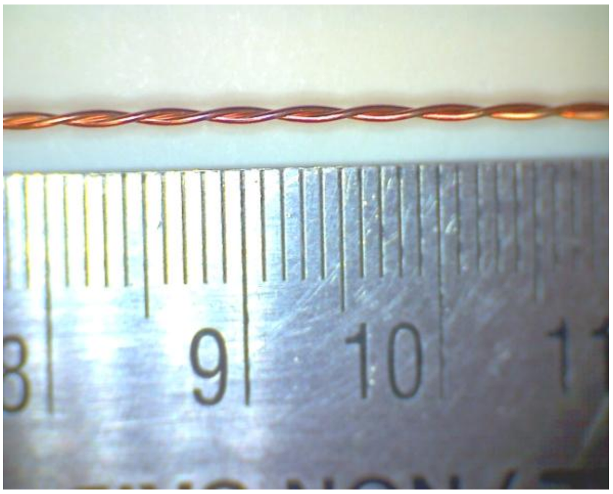
Scrape the enamel off the ends of the wires and tin with solder before installing in the PCB.

The winding direction is not important.



Bifilar transformer T9

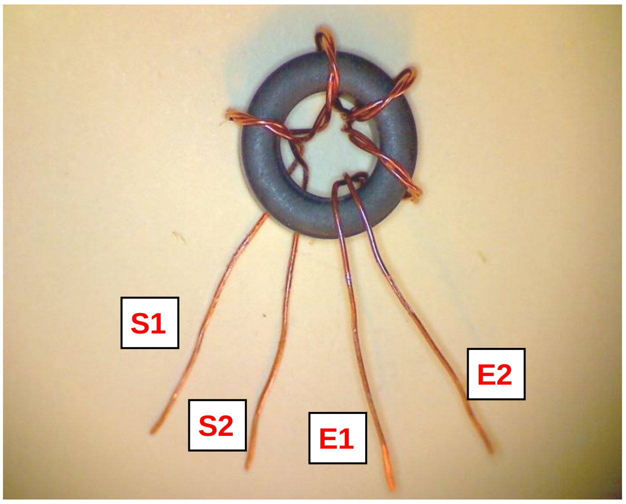
Take a 500mm length of 0.4mm enameled wire and fold in half. The wires need to be twisted together. Following is a suggested method:
Clamp one end of the doubled wires in a vice. Make a loop at the other end and place on a hook shaped bit in a battery drill. While keeping the wires taut, run the drill on slow speed until there are about 3 twists per cm.



Carefully wind 5 turns on a **FT50-43** ferrite toroid trying to avoid scraping the enamel on the sharp edges of the toroid.

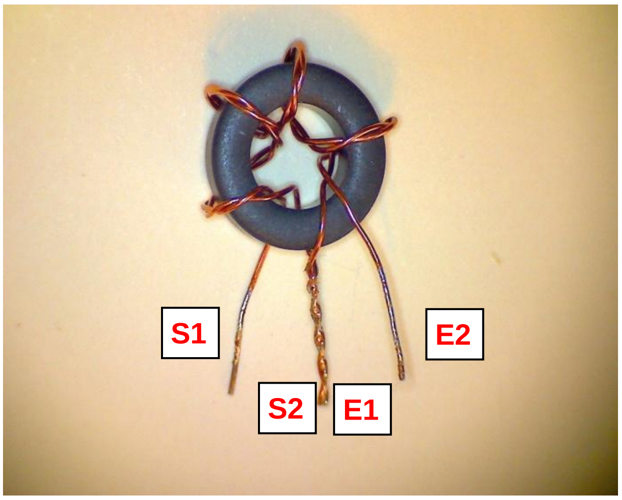
Scrape some enamel off the ends and use a multimeter to find the start (S) and end (E) of each winding.

Also check that there are no shorts between the two windings.



Take the end of the first winding and the start of the second winding and twist together to form the centre tap.
Trim the leads with side-cutters and tin with solder before installing. Push the wires through the holes in the PCB and sit the toroid so that it rests against the surface of the board.

Ensure the two-wire centre tap goes to the middle hole of the T9 component overlay closest to Q12.

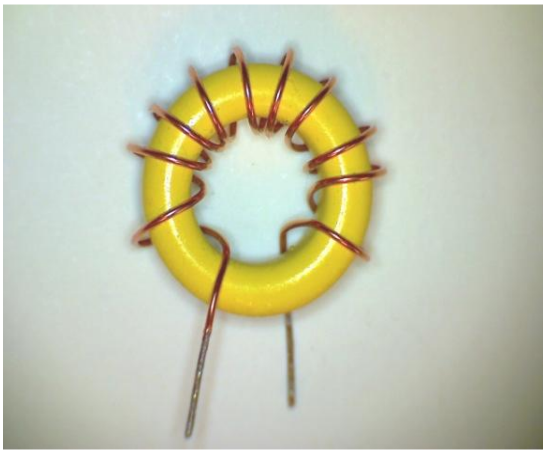


Low Pass Filter Coils L2 and L3

Take a 250mm length of 0.4mm enamelled copper wire and wind on **11** turns on a T50-6 toroid. Spread the turns to cover about 80% of the toroid circumference.

Note the direction of winding as this makes for a neater alignment on the PCB.

Scrape the enamel off the ends of the wires and tin with solder before installing in the PCB.



Step 13: Crystals

The crystals have been closely matched in frequency, so they can go in any position. The PCB has a solder mask which should insulate the crystal metal cases from the PCB tracks, but to be sure mount them about 0.5mm off the PCB. Once the crystals for the filter are installed solder a wire across the top of the metal cases and down to a spare pad in the PCB groundplane set aside for this purpose. The carrier oscillator crystal also has a PCB ground connection hole adjacent to the crystal.

Step 14: Antenna wires

The antenna wires are difficult to solder to the pads once the PCB is installed in the case so solder short lengths to the ANT and GND pads now.

Step 15: Power MOSFET and regulator

The reason these are left to last is simply because they sit high and near the edges and may get damaged as the PCB is turned over and back as other components are being installed.

The 7808 voltage regulator is installed with the metal tab facing capacitor C47.

Mount the IRF510 MOSFET with the metal tab facing towards the edge of the PCB and with about 5mm of lead length between the PCB and body.

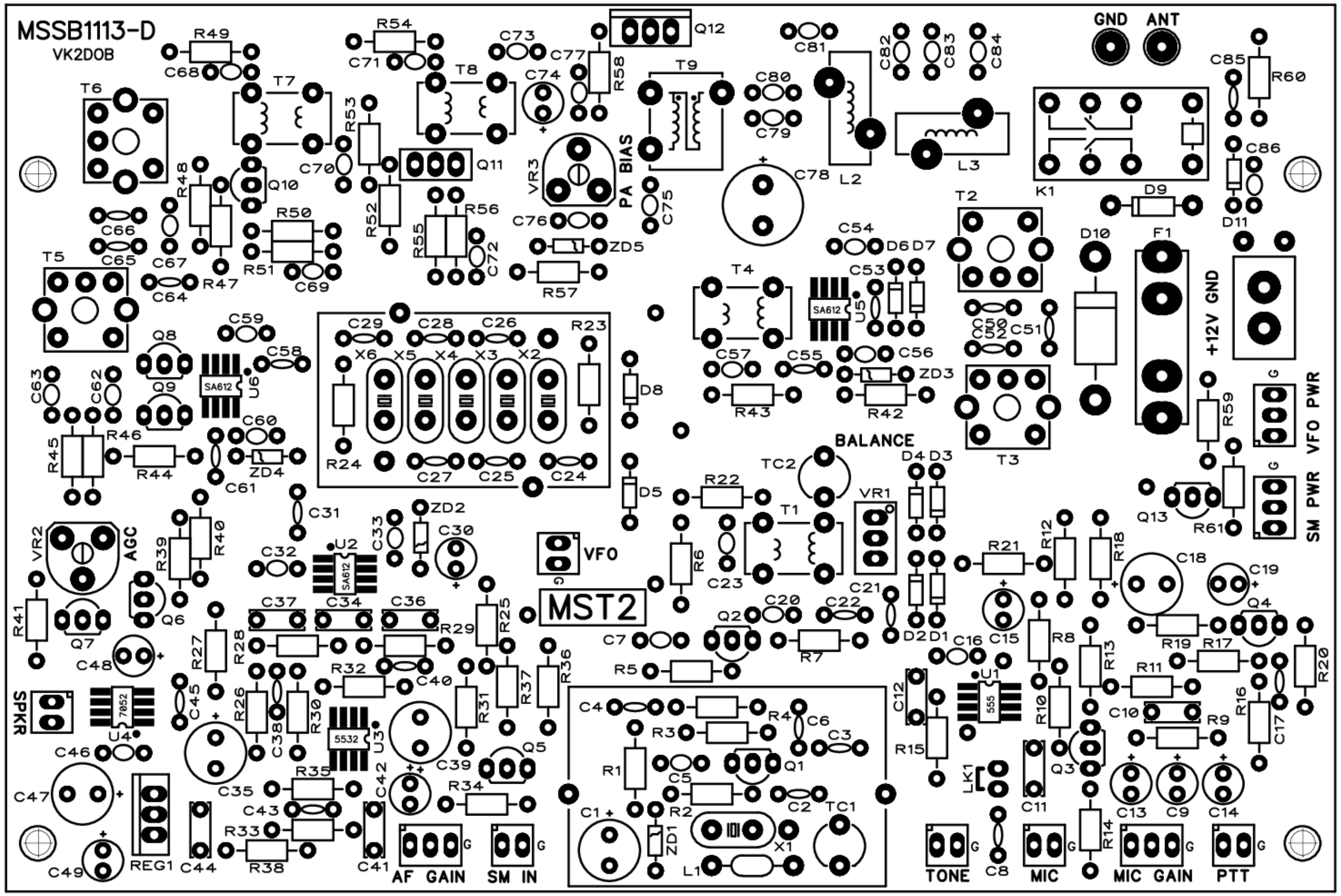


Figure 9 Component overlay

8 ENCLOSURE

Now that your MST2 board is completed you'll want to put it in an enclosure and try it out. The PCB was designed to fit inside a plastic instrument enclosure 200mm wide by 155mm deep by 65mm high. A suitable type is catalogue number H0480F available from www.altronics.com.au. It can be purchased with aluminium panels or you can easily make them yourself from 1.5 or 2mm thick aluminium sheet. The PCB mounting holes match plastic pillars on the bottom of the enclosure and it will be necessary to remove unwanted pillars using either a large pair of sidecutters or carefully with a large drill.

Of course any other enclosure that accommodates the PCB will be suitable, although if using the companion DDS VFO and LED S meter it will need to have similar minimum dimensions.

Before installing the board in the enclosure, carefully look for errors, such as components in the wrong way and solder bridges between tracks. The risk of solder bridges is greatly reduced due to the solder mask, but check anyway. A few moments spent here is cheap insurance against big problems later on.

One of the more common problems is poor solder joints with enamel covered wire. Some types when soldered will melt the enamel but most will not, so it is important to scrape the enamel off the ends of the wires with sandpaper or a sharp knife before soldering.

8.1 REAR PANEL

The rear panel only contains the SO239 antenna socket and two binding post to connect the power supply. As the rear panel layout is straightforward no layout drawing is supplied, however remember to locate the antenna socket near the PCB ANT and GND pins so the wires are kept short.

8.2 FRONT PANEL

The front panel is designed to accommodate the DDS VFO and LED S meter. It requires a number of holes and cut-outs to be made as shown in Figure 10. The microphone hole is dimensioned to fit a standard 4 pin connector however this may need changing to match your own.

⚠ **If the LED S meter is not installed you will need to drill a clearance hole for the TX PWR LED bezel instead of the cutout for the LED bar display.**

There are two options for the DDS VFO mounting holes. Make them countersink to have a flush surface and no holes in the label, or if you are happy to have screw heads showing on the front leave them straight drilled.

8.3 MOUNTING THE PCB

Temporarily put the rear panel in place and sit the PCB on the mounting pillars. If needed bend the leads of Q12 slightly so that the metal tab is resting parallel against the rear panel. Use a sharp pencil or scriber and run around the inside of the hole in the tab to mark the position for the mounting hole on the rear panel. Remove the rear panel and drill a 3mm hole ensuring that you remove all burrs.

Screw the PCB to the mounting pillars using small self-tapping screws. Slide an insulating washer between the rear panel and Q12 tab. Insert a plastic bush into Q12 tab then pass a 3mm screw from the rear through the bush and screw on a nut and tighten.

⚠ **Check with a multimeter that there is no electrical connection between the rear panel and Q12 tab.**

8.4 FRONT PANEL LABEL

A front panel label will add a professional look to the completed transceiver. You can design one yourself using a graphic design software package or you can simply download a completed sample from www.ozQRP.com. If you plan to design your own then use the dimensions shown in Figure 10 as a guide. Once you have either your own file or the downloaded file follow the procedure below to produce the label:

1. Print the file using a colour inkjet printer onto an A4 sheet of high quality photo paper.
2. Using a sharp hobby knife and steel rule as a guide cut out the inside area of the DDS VFO LCD window and the LED S meter window.
3. Laminate the whole sheet using an A4 laminator. If you don't have your own then this can be done quite cheaply at large stationary stores. The exciting thing about this is that the cutouts convert into transparent windows.
4. Using the hobby knife cutout the other holes in the label.
5. Cut around the border of the label so that it is the same size as the front panel.
6. Place the label on the front panel and install the pots, switch, microphone socket and LED bezel if required. You can use some spray adhesive to secure the label to the front panel if it tends to lift off, although if using the recommended case it will stay in place once the enclosure is assembled.

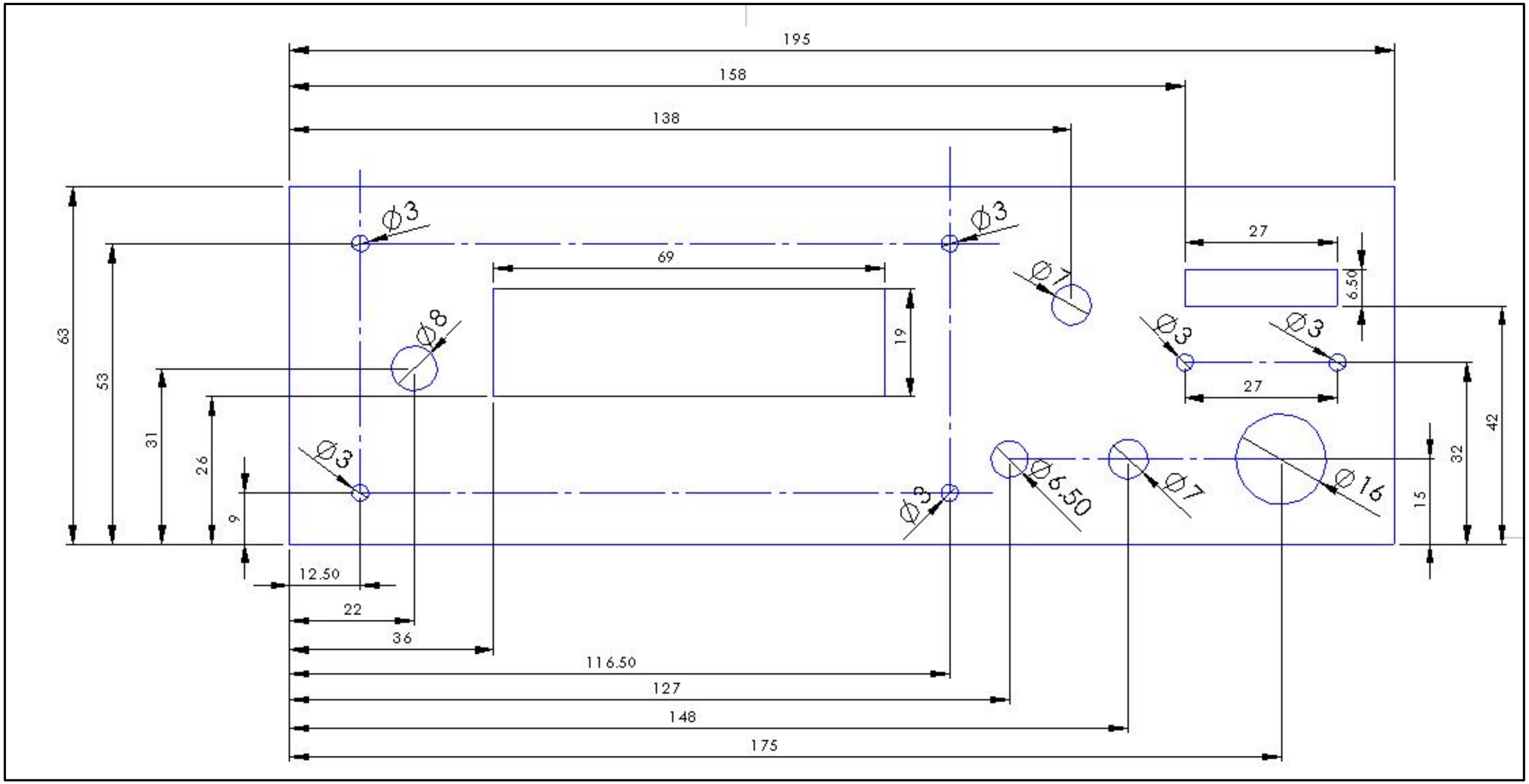


Figure 10 Front panel drilling guide

8.5 Fitting the DDS VFO

The DDS VFO is simply screwed to the inside of the front panel. The DDS VFO PCB is set back from the panel using threaded spacers to allow room for the LCD. Using the specified LCD the distance will be 22mm and is made up of a 10mm spacer and 12mm spacer. Alternatively a long spacer cut down to 22mm can used.

A countersink screw is used on the front panel to provide a flush surface for the front panel label to sit. If preferred round head screws can be used which means that holes need to be made in the label and also the heads will be visible from the front.

If an alternate LCD is used that does not incorporate a backlight it will not be as high and so the length of the screws and spacers need to be reduced accordingly.

The general mounting arrangement is shown in Figure 11.

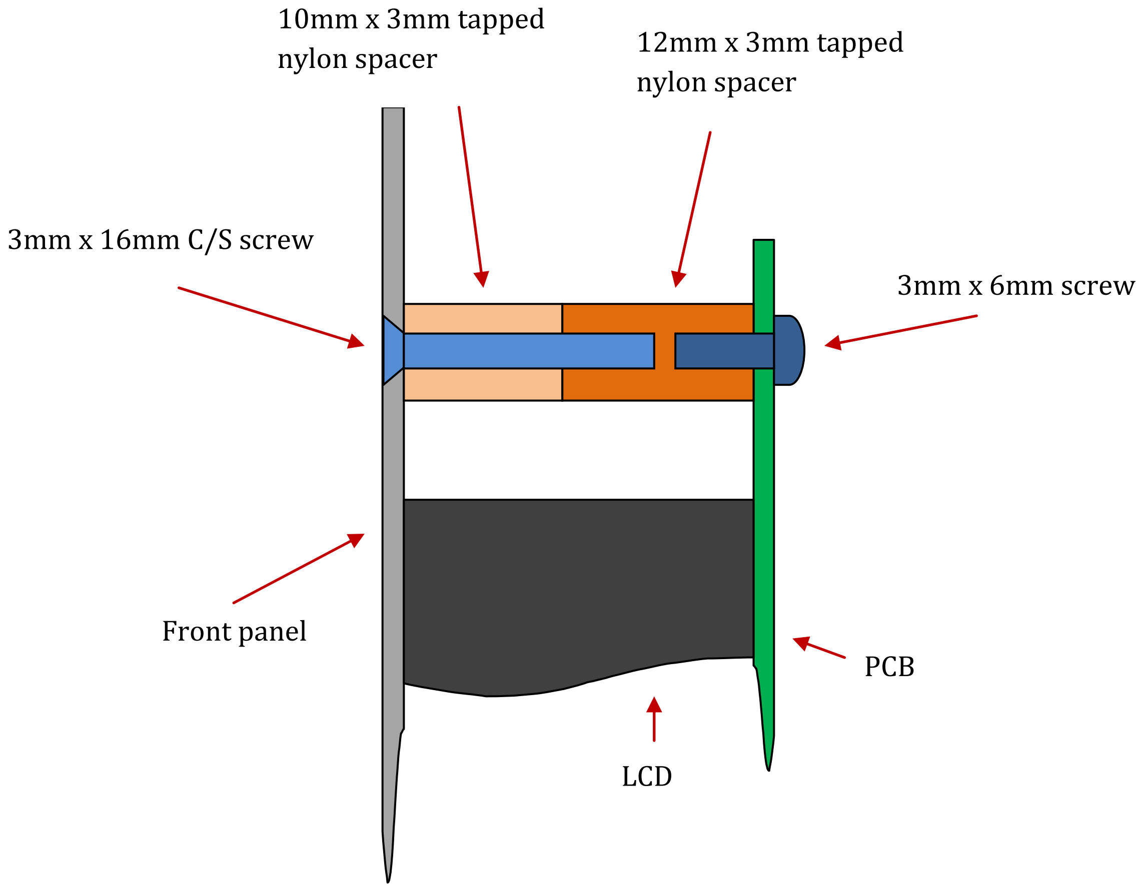


Figure 11 DDS VFO front panel mounting

9 WIRING UP

The wiring diagram is shown in Figure 12. Connections using with light duty hookup wire employ different colours for easy identification and parallel wires are twisted together. The connections to the AF gain control, MIC gain control and the LED S meter input should be in light duty shielded audio cable. The VFO cable can also be made from shielded audio cable as the length is quite short.

Most PCB connections utilize 2.54mm (0.1") pitch polarized headers and mating plugs. These are inexpensive, give a professional looking appearance and allow easy disconnection and removal of the PCB if required. The plugs are comprised of a plastic housing and crimp contacts which slide into the housing and click in place. If you don't have a suitable crimper it is best to squeeze the contact wings around the wire with long nose pliers to hold in place and then solder. Be careful not to use too much heat and solder as it will make it difficult to insert the contact into the housing.

The power supply connection uses a screw terminal block because of the higher currents involved.

The antenna connection uses short wires soldered between the antenna socket and PCB pins to give a low resistance connection. You will also need to install a solder tag for the earth wire under the closest antenna socket screw.

The loudspeaker is mounted on the underside of the enclosure lid and held in place with 3mm countersunk screws and nuts. A series of holes needs to be drilled in the lid to act as a speaker grill.

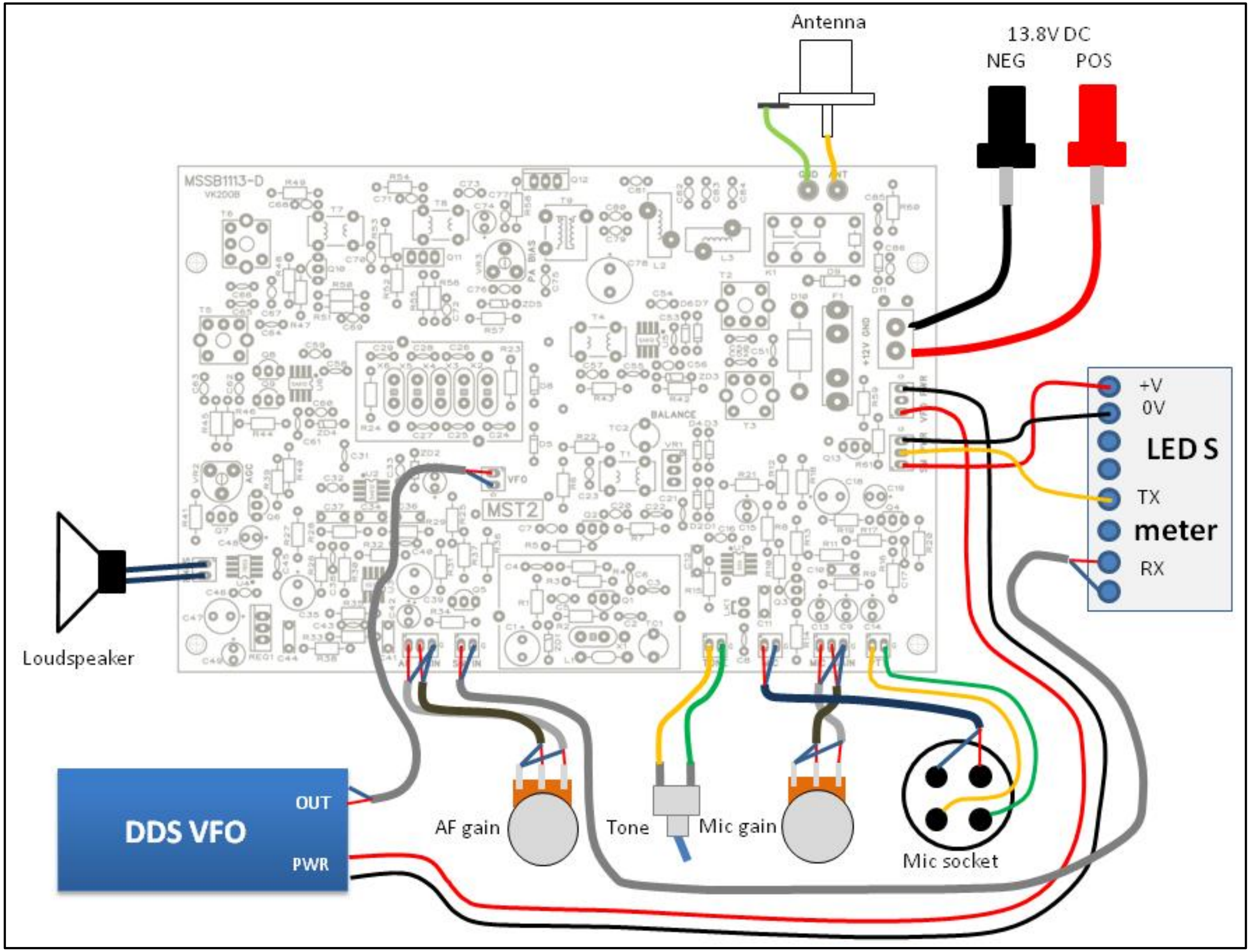


Figure 12 Wiring diagram

10 TESTING AND ALIGNMENT

10.1 GENERAL

A suggested list of basic tools and accessories to undertake testing is shown below.

- Digital multimeter.
- 50 ohm dummy load capable of dissipating at least 5 Watts.
- QRP wattmeter or oscilloscope.
- Power supply capable of 13.8V DC regulated at more than 1 Amp.
- Small adjustment screwdriver.
- An audio signal generator.
- An RF signal generator.
- A frequency counter.

⚠ **A VFO is required for testing and operation and it is assumed during the rest of this section that the MST2 board is being used with the DDS VFO which is already configured and fully operational.**

⚠ **Figure 13 lists typical voltages at various points around the board and can be used to verify operation.**

10.2 POWER ON

- Temporarily remove the power connector for the VFO so that the MST2 board current can be measured alone.
- Using a small screwdriver:
    - Rotate the bias trimpot VR3 fully counter-clockwise so that the gate bias voltage is zero volts.
    - Set carrier balance trimpot VR1 to halfway by counting turns. You should hear a slight click as you reach either end.
    - Rotate the AGC trimpot VR2 fully counter-clockwise.
- Connect a 50 Ohm dummy load to the antenna socket.
- Connect the power supply to the board terminals.
- If your power supply does not include a current meter, connect a multimeter in series with the power supply positive lead and set to measure current.
- Turn on the power supply and note the supply current. It should be around 80mA. If it's far from this turn off immediately and look for problems.
- The relay should be de-energized and the board in RX mode. To verify that there are no obvious problems do a quick probe around the board with a multimeter and check the DC receive voltages as shown in Figure 13.
- Plug in the VFO power connector. Check the power supply current. If using the DDS VFO it should rise to around 135mA. Again, anything far from this needs investigating.

10.3 Receive

- Set the VFO to a frequency in the middle of the band you will be using.
- Turn the AF gain control to halfway. You should hear some low level hiss come from the speaker indicating that the audio stages are working.
- Connect a frequency counter at the emitter of transistor Q2. Adjust trimmer capacitor TC1 until the frequency is 9.996MHz. This is the carrier (BFO) frequency and is placed on the lower skirt of the crystal filter for Upper Sideband operation.
- Remove the dummy load and apply a moderate RF signal to the antenna connector and tune the VFO until a clear tone is heard in the speaker. Carefully adjust the slugs in coils T2 and T3 for maximum volume. As you approach maximum you will need to turn the AF gain down and probably the RF signal level as well to avoid overload. You can experiment with the position of the two slugs to obtain a specific bandwidth, but in general, peaking at the middle of the band will be satisfactory.
- If fitted, set up the LED S meter display as per the instructions in the LED S meter construction manual.

10.4 Transmit

- Remove the RF signal source and reconnect the dummy load. It will be an advantage to have either a QRP power meter or oscilloscope to obtain an indication of power output.
- Turn the Mic gain control fully counter-clockwise.
- Briefly switch to TX mode by shorting the PTT contacts. Check the power supply current. This is the base transmit current and should be about 220mA. Anything far from this indicates a problem and should be investigated.
- Operate the PTT and using a screwdriver slowly rotate the bias trimpot clockwise. The power supply current should rise gradually and smoothly. Keep increasing until the power supply current is about 400mA. The increase over the base current is mainly due to the output MOSFET starting to conduct and move into linear operation, but some will be because we have not balanced the carrier yet and there is some power output.

⚠ **The final bias current is set in a later step. Ensure now that the current is not too high or the output MOSFET will get very hot.**

- Adjust carrier balance controls TC2 and VR1 for minimum power output. The null is quite sharp, and there is some interaction between the controls, so you will need to go back and forwards to obtain maximum balance.
- With the carrier balanced rotate the bias trimpot fully counter-clockwise to turn off the MOSFET. **Note the quiescent transmit current again.**
- Slowly rotate the bias trimpot clockwise until the power supply current is 150mA higher than the base transmit current. The output stage bias current is now set.
- If you still notice some power output readjust the carrier balance controls for minimum.

- Apply an audio signal generator to the Mic socket set to 1KHz at around 50mV. Operate the PTT and slowly increase the Mic gain while monitoring the power output. When some power (about 1 Watt) is indicated carefully adjust the slugs in coils T5 and T6 for maximum output. You may need to readjust the Mic gain to get a suitable power output to monitor the peak. Once the coils are peaked operate the Mic gain up and down while monitoring the power output. The power output should change smoothly up and down and you should be able to easily achieve 5 Watts output.
- Refer to the LED S meter Construction manual and verify operation. If you are not using the LED S meter, check that the RF power LED illuminates and changes intensity with varying power output.
- If you intend to use an Electret microphone place a short across LK1. This can be a soldered link or you can install a 2 pin header and a removable shunt. Leave LK1 open for dynamic microphones.
- Plug in a microphone and check there is RF output when you speak and the relay operates when the PTT is pressed. You will now be able to monitor yourself with a receiver placed nearby and determine the correct Mic gain setting.

10.5 Tone Generator

- Rotate the Mic gain control fully counter-clockwise. Close the Tone generator switch.
- Operate the PTT and check there is no RF output.
- Slowly rotate the Mic gain control clockwise and note the power output increase. You should be able to go between 0 and about 5W output.

Location	V DC Receive	V DC Transmit
U1 pin 8	0V	13V
U1 pin 1	0V	12.8V Note 4
U2 pin 8	6.8V Note 1	0V
U3 pin 8	10.8V	0V
U3 pin 1	5.25V	0V
U3 pin 7	5.25V	0V
U4 pin 1	8V	8V
U4 pin 5	3.9V	3.9V
U4 pin 4	1.1V Note 7	0V
U6 pin 8	0V	6.8V Note 1
U5 pin 8	6.8V Note 1	0V
Q1 collector Note 1	8.9V	8.9V
Q1 emitter Note 2	3.9V	3.7V
Q2 emitter	0V	5.3V Note 3
Q3 collector	0V	5.4V
Q3 emitter	0V	0.35V
Q4 collector	0V	5.2V
Q4 emitter	0V	0.17V
Q8 emitter	0V	4.9V
Q10 emitter	0V	1.5V
Q11 emitter	0V	0.9V
Q12 gate	0V	4V Note 5
Q13 emitter	0V	7.5V Note 6

Notes:

1. Zener tolerance +- 5%.
2. DC measurement affected by RF. Approx. 5V without crystal.
3. DC measurement affected by RF. Approx. 7V without crystal.
4. 0V when Tone switch closed.
5. No RF drive.
6. 5W output
7. No receive signal

Readings taken with a digital multimeter.
Power supply voltage set at 13.8V DC.

Figure 13 Typical circuit voltages.

10.6 Audio AGC adjustment

The audio AGC is easy to set up and the procedure outlined below has been refined after many hours of on-air listening.

- Set the AF gain control to about half way
- Inject an S9 RF signal into the antenna connector.
- Slowly rotate the AGC trimpot (VR2) clockwise until you can just notice a lowering of the audio level. This sets the point where AGC starts to operate.
- Increase the RF signal level and check that the rate of increase of the audio level is much less than the RF input level change.

⚠ **The AF gain control is located before the audio AGC circuit and so adjusting the AF control for signals above S9 may not have the expected outcome. This is because the AGC circuit is attempting to adjust the audio and keep it constant. For signals below S9 the AF gain control works in the expected manner.**

If the audio AGC is not required simply rotate VR2 fully counter-clockwise.

10.7 Carrier Frequency Adjustment

For proper SSB operation it is important to align the carrier frequency with the frequency response of the crystal filter.

Shown in Figure 14 are three possible conditions that can be found in practice. The DSB signal produced by the balanced modulator contains both LSB and USB sidebands. These extend equally outward from the carrier. The carrier oscillator is shown as a dotted line but it is suppressed in the modulator. Also shown is the crystal filter frequency response.

⚠ **While the examples shown are for transmission, the same concept applies to reception.**

The suggested carrier frequency for USB operation is 9.996MHz which places it on the lower skirt of the crystal filter frequency response. This is shown in the top diagram in Figure 14.

Due to small variations in individual crystal filters the carrier frequency may need changing slightly to match the filter. The middle and bottom diagrams in Figure 14 show the two scenarios where the carrier frequency and the crystal filter response are misaligned.

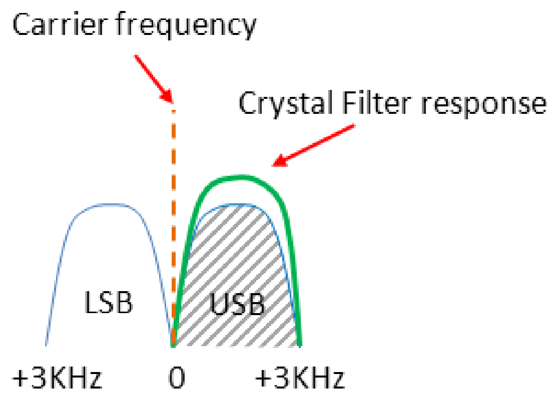
There are a number of ways to correct this but without instruments the easiest is to listen to a good strength station of known quality while gently adjusting trimmer capacitor TC1. Adjust until the received audio sounds natural and the balance of high and low audio frequencies appears correct.

⚠ **Note that you will need to adjust the VFO frequency to retune the received signal while making adjustments because the received signal will have moved off frequency by an amount equal to the change in the carrier frequency.**

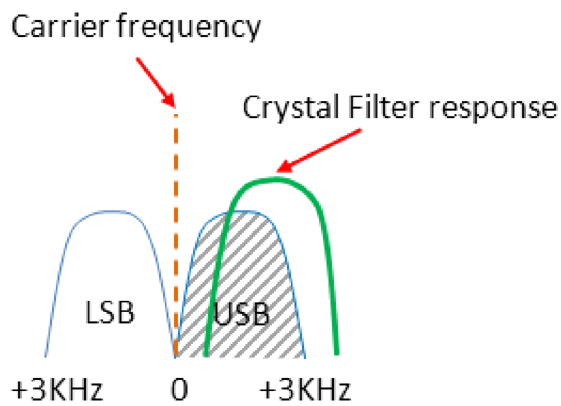
Alternatively you can adjust the carrier frequency while transmitting into a dummy load and monitoring yourself on a nearby receiver. While speaking adjust TC1 until you sound 'normal'. You can also switch between sidebands on the receiver to hear the reduction in the opposite sideband.

⚠ **If you move the carrier frequency and using the companion DDS VFO you will need to measure the carrier frequency and re-program the IF frequency configuration item to ensure the display reads accurately. See the DDS VFO construction manual for details.**

This diagram shows the carrier frequency correctly aligned with the crystal filter passband. The whole of the USB is passed but the LSB is filtered out.



In this diagram the carrier frequency is shifted low in comparison to the crystal filter. This results in the low frequency components of the USB being filtered out. This would make the signal sound thin and lack body.



In this diagram the carrier frequency is shifted high in comparison to the crystal filter. This results in the high frequency components of the USB being filtered out. This would make the signal sound muffled and have too much bass.
Note also that some of the LSB signal is passed by the filter.

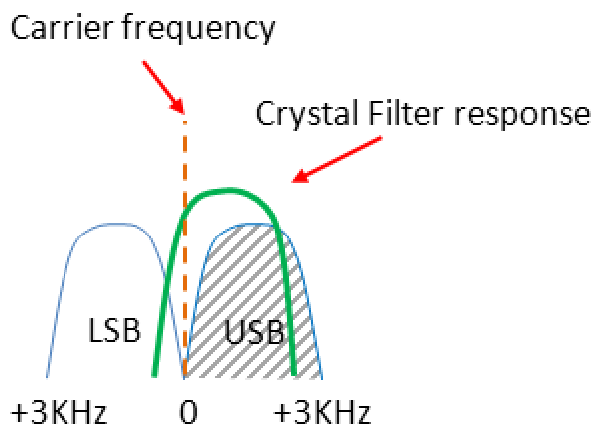


Figure 14 Carrier frequency and crystal filter relationship

11 Operation

Operating the MST2 is very easy as there are no complicated controls and software menus to navigate. It's simply a matter of connecting a power supply, microphone and antenna and talking. Operation of the DDS VFO is covered in the DDS VFO construction manual, and the LED S meter in the LED S meter construction manual.

In RX mode apart from the VFO there is only the AF gain control to adjust. The MST2 does incorporate a form of automatic gain control (AGC) where the audio level to the speaker is limited for input signals above about S9 level. This is performed in the audio power amplifier which is after the AF gain control. Advancing the AF gain control will not seem to act in the normal way for large signals, as the AGC circuit will attempt to keep the speaker level constant. For signals less than S9 the AF gain control will act in the normal way as the AGC circuit has not been activated.

To transmit press the PTT button on your microphone and talk. The LEDs on the LED S meter will illuminate giving an indication of the power output.

If the LED S meter is not installed the front panel RF LED indicator will illuminate on voice peaks. It can also be used as a rough guide to power output as the current through the LED, and therefore its brightness, is dependent on the peak RF output. If the LED is illuminated at a constant level when talking, it indicates that you are driving the transmitter too hard and causing clipping of the RF signal.

⚠ **Overdriving will create distortion and excessive harmonic generation and must be avoided.**

To check your signal either connect the MST2 to a dummy load and monitor yourself with headphones on a nearby receiver, or have a friend that lives close by listen to your signal. The idea is to increase the Mic gain progressively while the receiver sweeps across your transmission looking for distortion and unwanted spurious byproducts. Set the Mic gain control just below the point where these are noticeable.

Congratulations your new SSB QRP transceiver is ready to put on the air.

Have fun!