# Cumbria Designs

## T-2 SSB IF Sub-System

# User Manual




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# 1. Introduction

Thank you for purchasing the Cumbria Designs T2 SSB IF sub-system. We hope that you enjoy constructing this kit and find many uses for this versatile design. This manual describes the assembly and operation of the T2. Even if you are a seasoned constructor, we respectfully ask that you first read this manual and familiarise yourself with the instructions and kit contents before commencing soldering. If assembled carefully, this unit will provide many years of reliable service.

*The Cumbria Designs Team*

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# 2. Preparation

### *2.1. Unpacking*

The T-2 kit is a complicated project which comprises over 270 parts. To reduce the risk of error or mislaid parts we suggest the following method of working;

- Keep all parts in a large clean container, preferably a tin with a lid.
- When unpacking the anti static bags check very carefully to ensure that no parts are trapped in the corners of the bags.
- Resistors and diodes are generally supplied in bands. Cut the component from the band only when you are ready to fit it to the board.
- Loose pins are provided for the header connector shells. During transit some of these may become lodged in the connectors. Check and if necessary remove carefully.
- Choose a well lit work area with a light neutral covering (e.g. white paper) to help you spot dropped parts.
- Don't attempt to solder too many parts at once, similarly limit your time spent soldering to a comfortable periods (of say an hour), taking breaks in between.

### *2.2. Tools*

We recommend that the following tools are used during assembly and testing;

25W fine tipped soldering

60/40 Rosin cored solder

5" or smaller diagonal side cutters

Small pointed nosed pliers

Solder sucker (just in case!)

Multimeter

Magnifier

# 3. Assembly

The production of a successful finished working kit is dependent upon care during component handling, placement and good soldering! Don't be tempted to rush the construction, a wrongly placed component can provide hours of frustrating fault finding. Also, as this kit uses a double sided Printed Circuit Board (PCB) with through plating, removal of a wrongly soldered part can be difficult. Follow the assembly instructions carefully to avoid mistakes.

### 3.1 *Component Identification*

All parts carry a coded identity to describe their values. It is important to be able to recognise these during assembly. Capacitors have their value printed numerically, e.g. 104 = 100nF,


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103 = 10nF etc. Resistors have their values represented by coloured bands – the latter is a frequent source of confusion!

To simplify component identification, the parts list carries the identities of each component as it appears on the device. For resistors the colour coding is given. This should be referred to during assembly to ensure the right parts are placed in their respective positions on the PCB.

### 3.2 *Component Leads*

Many of the passive components will require their leads to be formed to align with the holes on the PCB. This mainly applies to the axial parts such as resistors and diodes. Forming component leads is easily done with a pair of pointed nose pliers and using the hole spacing on the PCB as a measure. Alternatively, small formers made from scrap off cuts of Vero board etc make ideal templates that produce consistent results. Some parts, such as the variable resistors, have preformed leads designed for machine assembly. These will require straightening to align with the board layout. Again, a pair of pointed nose pliers should be used to carefully flatten the factory performing to produce straight leads.

### 3.3 *Soldering*

Before applying solder, **check carefully that the component you have placed is in the right position!** The T-2 uses a through plated double sided printed circuit board (PCB). Whilst some of the pads are very small, the area presented by the through plating is more than adequate to allow good solder flow to form mechanically strong, good electrical joints. These can be difficult to undo, please double check!

The majority of problems are likely to be caused by soldering faults. These can sometimes be difficult to find. Here are some basic golden rules that will help you to avoid poor solder joints;

- **Clean Iron**

Make sure your soldering iron tip is in good condition and tinned. A small moistened pad for cleaning tips, regularly used to wipe off excess solder and flux, will ensure that your iron performs well. Remember to tin the iron immediately after each wipe.

- **Clean Leads and Pads**

All of the component leads and PCB pads in this kit are pre-tinned and should not need cleaning before soldering. Please ensure that parts are handled so as to avoid contamination with grease or fingerprints.

- **Soldering**

This is the bit that can trip up even experienced constructors. For the solder to fuse with the surfaces to be joined it is necessary for them to be hot – but not so hot as to damage the parts! It's a simple as ***1-2-3***;

1. *Place the tip of the iron against the joint, hold it there briefly to bring the metal surfaces up to temperature.*
2. *Apply the solder allowing it to flow smoothly onto the surfaces.*
3. *Remove the iron and inspect the new joint.*

The finished joint should have a smooth shiny coating of solder. If the joint is dull grey or has formed a spherical "blob", apply the iron to the joint, remove the old solder with a solder sucker and re-solder. Mistakes do happen! Should you inadvertently solder a part in the wrong position, we recommend that you **DO NOT** attempt to remove it intact. To prevent damage to the PCB through excessive heating and mechanical strain, the wrongly placed part should be cut off the board


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leaving it's leads/pins exposed. These can then be removed individually and the PCB pads de-soldered and prepared for the replacement part.

# 4 Circuit Description

## 4.1 *General*

The Cumbria Designs T2 is designed to serve as the core of a single conversion SSB transceiver for operation from a few kHz to 400MHz. A simplified block diagram of the T1 is shown in **Fig1**. The signal path uses bilateral circuitry allowing several of the main circuit elements to be used during both transmit and receive. The RF port is common to transmit and receive signals. A two stage hybrid cascode IF amplifier provide the IF gain which is controlled by a full wave audio derived AGC system. Control functions are included to disable AGC and apply manual IF gain control. A CMOS bi-lateral switch performs the product detector/modulator and audio path switching functions. Low noise operational amplifiers are used in the AF stages, the AF power amplifier output is in the order of 500mW. Two carrier oscillators provide Upper Sideband (USB) and Lower Sideband (LSB) operation. The PCB carries all DC switching circuitry for controlling signal flow during transmit and receive operation.

A detailed stage description follows. Please refer to the circuit diagram given at the rear of this manual.

**Mixer** A TUF-3 mixer forms the front end. Rather unconventionally, the IF port of theTUF-3 is used as the RF input/output port. This allows operation down to a few 10s of kHz for experimentation at VLF. The penalty for this increased flexibility is a slight in distortion products – but so slight as to not be noticeable except with measurement equipment.

**Bi-Lateral Amplifer** Two J310 JFETs introduce about 15dB of post mixer gain with a low noise figure. The direction of amplification is selected by switching the +12v supply between either stage. PIN diodes D3 and D4, isolate the unused amplifier. The impedance matching into the amplifier is performed by transformers T1 and T2 which transform the 1K input impedance seen from either amplifier port into 50 Ohms for the mixer and 180 Ohms for by the filter.

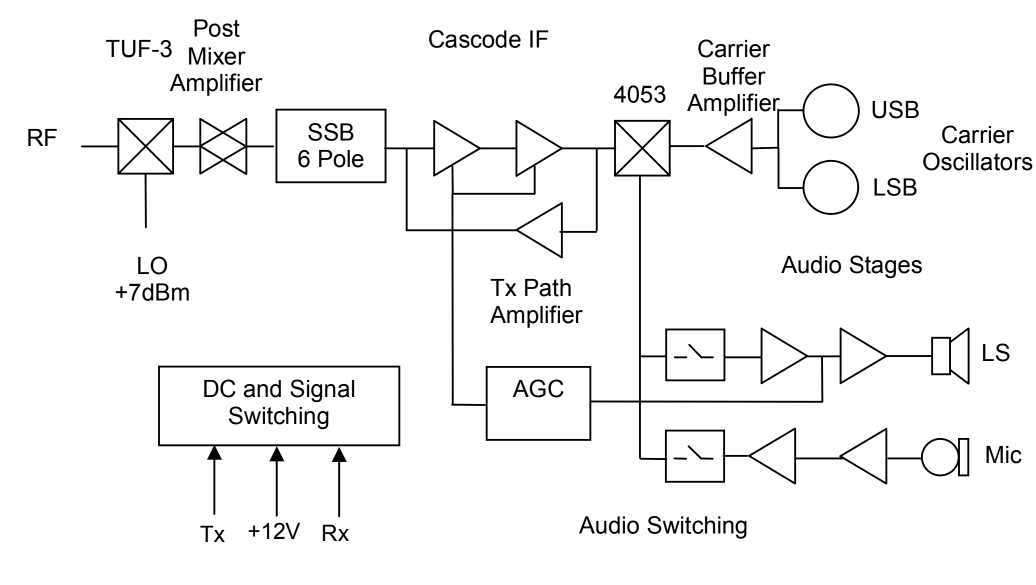


**Fig. 1** T-2 block diagram


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**SSB Filter** A Minimum Loss six crystal 11.059HMz Cohn SSB filter provides excellent selectivity and stop band attenuation. The filter bandwidth is approximately 2.3kHz. All crystals have been matched in frequency to ensure reproducibility. The two carrier crystals are marked with indelible ink. These must not be used in the filter.

If you wish to adjust the filter bandwidth, increasing the terminating impedance and reducing the capacitor values will increase bandwidth, the converse will reduce bandwidth.

Other types of ladder filter such as the Butterworth or Chebychev may also be used with the existing crystals by using different capacitor values and terminating impedances. We recommend that you breadboard your filter off the main PCB before installing the final parts values.

Due to the slight asymmetry of the SSB ladder filter, the USB/LSB passbands may sound slightly different. This has little or no impact upon performance. An alternative to selecting sideband by carrier oscillator is to shift the Local Oscillator (LO) frequency. With modern DDS devices this is trivial. If this approach is to be used we recommend operating the IF in LSB mode to take advantage of the better opposite sideband suppression offered by the asymmetry.

If desired the filter parts may be completely omitted from the PCB and a commercial crystal lattice filter installed. If you decide to use a different filter to that included with this kit, ensure that you adjust T3 and T4 to provide the correct terminating impedance.

**IF Amplifier** A two stage “hybrid” cascode amplifier provides the IF gain. In the hybrid configuration, a JFET and a bipolar transistor are used to form a cascode pair. All of the benefits of the cascode are retained (high gain, stability and low noise), but with a bipolar transistor as the gain control element the biasing conditions offer the additional advantage of a much larger gain control range. A further advantage of this configuration is that gain control and stage gain are preserved at much lower supply voltages than with the dual FET cascode.

The common reference for the IF stages is lifted a couple of volts above ground by an LED. This allows the AGC voltage to go negative with respect to the IF stages increasing AGC range and ultimate attenuation. The Led provides a useful diagnostic indication of amplifier current.

The IF amplifier gain is around +45dB with an AGC range in excess of 100dB. IF muting on transmit is provided by FET Q14 which grounds the AGC line.

**Product Detector/Modulator** The product detector/modulator employs a single switch of a 4053 CMOS bi-lateral switch in conjunction with T4 to form a single balanced mixer. Fixed mid rail DC bias is applied to the transformer side and an adjustable bias for balancing the mixer to the audio side. The bias voltage is adjusted to null the current flowing through the switches which in turn produces a carrier null. During receive operation the mixer demodulates the IF output to audio and during transmit modulates the microphone audio into a Double Sideband Suppressed Carrier (DSBSC) signal. The DSBSC signal is fed to the SSB filter by the IF bypass amplifier where the unwanted sideband is filtered out to produce an SSB signal at the IF frequency. The mixer requires single phase, square wave carrier signal to drive the switching action. This is generated by the carrier oscillator section.

The two other switches of the 4053 are used to select the transmit and receive audio signal paths to and from the product detector/modulator.


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**Carrier Oscillator** Dual JFET Colpitts oscillators generate the carrier signals for LSB and USB operation. A bipolar buffer stage amplifies the carrier signal to a level suitable for driving the 4053 mixer. Two identical crystals are used for LSB and USB operation. An inductor (L2) in series with the crystal of the USB oscillator (X8) allows it to be pulled down in frequency on the lower side of the filter response for USB operation.

Carrier oscillator selection is made by switching the +8v regulated supply to either oscillator.

**Receive Audio Stages** A low noise pre-amplifier and a power amplifier, make up the receiver audio chain. Both of these stages are permanently powered. Most of the AF gain is provided by the AF pre-amplifier, an NE5534 op amp. To reduce speaker noise during transmit, the output of the pre-amplifier is muted by a FET switch (Q8). A resistor and capacitor in the gate circuit delay the turn off time of the FET switch slightly preventing loud clicks or thumps on Tx-Rx operation. This simple circuit produces a nice, soft change over action.

An LM380-8 is used as the audio power amplifier.

**AGC System** A full wave audio derived AGC system controls the IF gain. The AGC circuit uses an NE5532 dual op amp to amplify the audio from the AF pre-amplifier and produce two anti-phase outputs to drive the AGC detector. The detector comprises of two transistors that are alternately switched on, on each half cycle of audio to discharge the AGC timing capacitor. The attack time is set by series resistor R59, decay time by R55 the supply resistor to the timing capacitor C60. A 2N7000 (Q16) in the collector circuit of the AGC detector allows the detector to be isolated from the AGC circuit, disabling the AGC action.

There are two adjustments for the AGC system, AGC gain set by VR5, AGC bias by VR3.

The output from the AGC detector is buffered by Q15 an emitter follower, from which the AGC line is taken to drive the IF stages and S-Meter circuit.

The AGC action is very good and with the careful adjustment provides a good clean action with no clicks or popping.

On transmit the AGC line is grounded by a 2N7000 (Q14) controlled by the Tx supply line. This mutes the IF stages preventing them from interfering with the transmit path operation.

**Microphone Amplifier** A simple non inverting amplifier, similar in design to the receiver AF preamplifier, is used to amplify the audio from the microphone input to drive the modulator. A fairly large output swing of several volts is required to produce an RF output from the modulator that is high compared to the residual carrier.

**Transmit Path IF Switch** A 2N3906 (Q1) and two PIN diodes form the IF bypass route for the transmit signal from the modulator. On receive the PIN diodes isolate the transmit signal path from the IF amplifier. On transmit the IF amplifier is muted and Q1 is powered causing the PIN diodes conduct to provide a signal path in the transmit direction.

**Power Sequencing** A simple circuit using two 2N7000 FETs (Q2, Q3) ensures that during Tx-Rx change over, the unused supply rail is quickly discharged to allow a clean transition. The unit requires the supplies; +12v permanent, +12v Rx and +12v Tx. The Tx and Rx lines should be taken from a “break before make” relay to ensure that both lines are not simultaneously active.


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# 5 Assembly

The order of assembly is not particularly critical, even though this is a relatively complicated circuit it is easier to test it in its complete state rather than to attempt to carry our individual stage testing as construction progresses. The key to success is simply to ensure that the right component is placed in each position.

***Please check very carefully the value and orientation of each part before soldering*. In the words of the carpenter, "Measure twice, cut once!"**

The following recommended assembly sequence is based upon part profile above the PCB and will allow parts to be held in place whilst the board turned over for soldering. All components except ceramic capacitors Ca and Cb, are mounted on the top (silk screen) side of the board. You are strongly advised to check off each part number in the instructions as it is installed to keep a track of progress. Trim off excess leads after soldering.

**PRECAUTIONS**

Static sensitive components. Discharge yourself to ground before handling. Avoid wearing static generating clothing (e.g. wool, man made fibres etc) during assembly.

! Critical step during installation such as orientation. Read associated note.

## 5.1 *IC Sockets*

! Ensure correct orientation! Match index cut out on socket to board printing. Tip; solder one corner pin only then check positioning before continuing.

| | | |
|---|---|---|
| 4 | DIL Socket 8 way | IC1, IC2, IC4, IC6 |
| 1 | DIL Socket 16 way | IC3 |

## 5.2 *Resistors*

All resistors are mounted horizontally. Bend leads sharply to 90 degrees at each end of the body and insert into board. Press resistor body firmly against PCB and bend leads apart slightly on underside of PCB to hold resistor in place.

| | | | |
|---|---|---|---|
| 2 | 2R7 | Red, Mauve, Black, Gold, (Brown) | R23, R32 |
| 2 | 10R | Brown, Black, Black, (Brown) | R3, R4 |
| 12 | 100R | Brown, Black, Black, Black, (Brown) | R1, R2, R16, R18, R19, R21, R22, R26, R30, R40, R49, R54 |
| 5 | 220R | Red, Red, Black, Black, (Brown) | R5, R6, R7, R46, R47 |
| 3 | 470R | Yellow, Mauve, Black, Black, (Brown) | R42, R48, R50 |
| 16 | 1K | Brown, Black, Black, Brown, (Brown) | R8, R9, R11, R13, R20, R25, R27, R34, R36, R39, R41, R56, R59, R63, R64, R65 |
| 4 | 2K2 | Red, Red, Black, Brown, (Brown) | R12, R24, R44, R58 |
| 7 | 4K7 | Yellow, Mauve, Black, Brown, (Brown) | R10, R28, R29, R52, R53, R67, R68 |
| 10 | 10K | Brown, Black, Black, Red, (Brown) | R14, R15, R17, R31, R33, R35, R57, R60, R61, R66 |
| 5 | 100K | Brown, Black, Black, Orange, (Brown) | R38, R43, R45, R51, R62 |
| 2 | 150K | Brown, Green, Black, Orange, (Brown) | R37, R55 |


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### 5.3 *Inductors*

Inductor L1 is mounted horizontally, as with the resistors. Inductor L2 is mounted vertically by bending one lead over in line with the inductor body and inserting into PCB as shown on the silk screen overlay.

| | | | |
|---|---|---|---|
| 1 | 47uH | Yellow, Mauve , Black | L1 |
| 1 | 15uH | Brown, Green, Black | L2 |

### 5.4 *Diodes & LED*

Polarity conscious parts. The cathode is marked by a band on the diode body. Ensure orientation matches the PCB silk screen. All diodes are mounted horizontally. Bend leads at 90 degrees and insert into PCB, hold diode body flush against PCB and bend underside leads apart slight to hold the diode in place.

| | | | |
|---|---|---|---|
| 4 | BAV21 | SILICON DIODE (Red Glass Body) | D5, D6, D7, D8 |
| 4 | 5082-3081 | PIN DIODE (Black or Clear body) | D1, D2, D3, D4 |
| 1 | LED | Bias LED Long Lead (Anode) facing IC2 | LED |

### 5.5 *Crystal Filter*

This improved version of the Cohn filter requires series end capacitors to be installed between the filter and the matching transformers. Two tracks between T3 and X1, and X6 and T4 are cut and bridged by 68pF ceramic capacitors Ca and Cb. Cut the tracks before assembling the filter, see **Fig.2** below. **Do not fit Ca, Cb at this stage!**

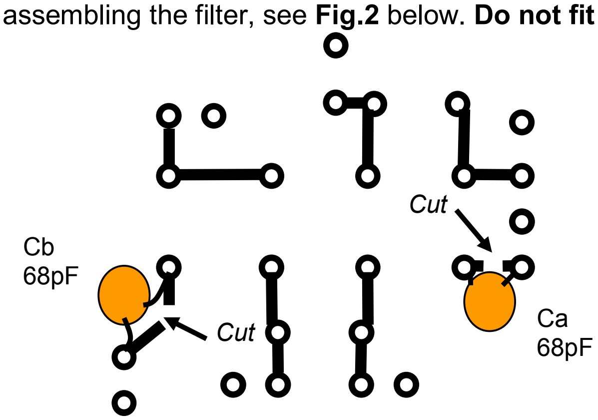


**Fig. 2** Track cuts and Ca, Cb positions.

### 5.6 *Crystal Filter*

Heat sensitive parts. When soldering do not apply excessive heat. 8 crystals are supplied with the kit for the filter and USB/LSB carrier oscillators. The two carrier oscillator crystals are marked with indelible ink, install these first in positions X7 and X8 of the carrier oscillator circuit (order unimportant). The 6 remaining crystals have been matched in frequency for use in the Cohn filter. Install these in positions X1 to X6 of the filter section (order unimportant).

### 5.7 *Ceramic Capacitors*

Insert leads into PCB such that the capacitor body is flush with the board surface. Bend the leads outwards slightly to hold the capacitor in place during soldering.

| | | | |
|---|---|---|---|
| 1 | 22pF | CERAMIC | C52 |
| 5 | 68pF | CERAMIC | C16, C17, C18, C19, C20 |
| 4 | 100pF | CERAMIC | C37, C42, C46, C56 |
| 1 | 1n5 | CERAMIC | C47 |
| 29 | 10nF | CERAMIC | C1, C2, C4, C5, C6, C7, C9, C12, C13, C14, C15, C23, C24, C27, C29, C31, C32, C33, C34, C35, C36, C40, C41, C44, C45, C49, C50, C59, C62 |



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### 5.8 *Ceramic Dipped Capacitors*

These 2.54mm pitch capacitors have a yellow resin coating and are marked “100n”.

| | | | |
|---|---|---|---|
| 5 | 100nF | CERAMIC DIPPED | C28, C39, C48, C64, C65 |

### 5.9 *Polystyrene Capacitor*

Insert into PCB and bend leads outwards slightly to hold in place whilst soldering.

| | | | |
|---|---|---|---|
| 1 | 0.47uF | POLY | C21 |

### 5.10 *Voltage Regulators*

Polarity conscious parts. Two three terminal TO92 style regulators are used to supply the analogue switch and biasing voltage to the audio stages. These are very similar in appearance to the transistors, please take care not to mix them up!

| | | | |
|---|---|---|---|
| 1 | 78L05 | +5V REGULATOR | IC5 |
| 1 | 78L08 | +8V REGULATOR | IC7 |

### 5.11 *Transistors*

Polarity conscious parts. Static sensitive parts. Discharge yourself before handling. Insert transistors so as to leave about 3mm of lead between the body and the board. Solder centre lead, check position and solder outside leads.

| | | | |
|---|---|---|---|
| 5 | 2N3904 | TRANSISTOR NPN | Q6, Q7, Q12, Q17, Q18 |
| 2 | 2N3906 | TRANSISTOR PNP | Q1, Q15 |
| 6 | J310 | JFET | Q4, Q5, Q9, Q10, Q11, Q13 |
| 5 | 2N7000 | POWER MOSFET | Q2, Q3, Q8, Q14, Q16 |

### 5.12 *Variable Resistors*

Straighten the pre-formed pins by gently compressing each pin with pointed nose pliers to remove the corrugations. Align with holes and rake pins if necessary to allow body to clear adjacent parts. Solder one pin, check and adjust alignment if necessary and solder remaining two pins. **Note;** VR4 and VR6 are a close fit. Rake pins to allow both pots to sit horizontally.

| | | | |
|---|---|---|---|
| 4 | 10K | CERMET | VR1, VR3, VR5, VR6 |
| 2 | 100K | CERMET | VR2, VR4 |

### 5.13 *Variable Capacitors*

| | | | |
|---|---|---|---|
| 2 | 65pF | TRIMCAP | VC1, VC2 |

### 5.14 *Electrolytic Capacitors*

Polarity conscious Parts. The short lead marked ‘–‘, goes to ground.

| | | | |
|---|---|---|---|
| 8 | 10uF | ELECTROLYTIC | C8, C10, C11, C43, C51, C55, C60, C61 |
| 8 | 100uF | ELECTROLYTIC | C3, C22, C25, C26, C30, C54, C57, C58 |

### 5.15 *Connectors*

**a) Headers.** Recommended Header Connector orientation is as marked on the PCB with rear locking tab facing into the centre of the board.

| | | |
|---|---|---|
| 4 | Header 2 way | AGC, LS, MIC, S-MTR |
| 3 | Header 3 way | AF_GAIN, IF_GAIN, MODE |
| 1 | Header 4 way | PWR |

**b) SMB Sockets.** Insert socket into PCB and solder centre pin to secure. Check connector sits square, adjust if necessary and solder remaining pins.

| | | |
|---|---|---|
| 2 | SMB Socket | LO, RF |


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### 5.16 *DIL Integrated circuits*

Static sensitive parts. Discharge yourself to ground before handling. Orientation critical. Form IC pins correct alignment before insertion into sockets by placing the device on its side on a flat firm surface, and gently rotate the body downwards against its pins.

| | | | |
|---|---|---|---|
| 2 | NE5534N | OP AMP | IC1, IC2 |
| 1 | LM380N-8 | AF POWR AMP | IC4 |
| 1 | NE5532N | DUAL OP AMP | IC6 |
| 1 | 74HC4053 | ANALOGUE SWITCH | IC3 |

### 5.17 *Packaged Mixer*

Static sensitive part. Discharge yourself to ground before handling. Fit TUF-3 Mixer in positions M1 taking care to observe marked orientation.

### 5.18 *Transformers*

Wind the four transformers (T1 –T4) onto FT34-43 cores as described below. Trim the ends to fit the board. Before insertion, scrape the enamel away from the ends and tin with a hot iron. Holding the iron on the exposed copper and applying solder will remove more enamel and tin the wire at the same time. Primary and secondary windings go in direction of receive signal flow, left to right. See circuit diagram.

**Transformers T2 to T4**

| Transformer | Primary | Secondary | Orientation |
|---|---|---|---|
| T2 | 4 turns | 18 turns | Primary facing M1 |
| T3 | 16 turns | 7 turns | Primary facing Q5 |
| T4 | 5 turns | 17 turns | Primary facing X6 |

Be sure to fit transformers with windings orientated correctly!

**Ca and Cb.** Once T2 and T3 have been installed, solder 68pF ceramics Ca and Cb as shown in **Fig.2**.

**Transformer T1**

Transformer T1 is the most complicated to wind. This carries the IF output winding (20 turns), the modulator/demodulator winding (6 turns bifilar) and the transmit path link winding (2 turns). The recommended assembly order is as follows;

**IF Output Winding**

Take 30cm of enamelled copper wire and wind 20 turns onto an FT37-43 toroid. Space the turns evenly around the toroid. Trim the ends and tin.

**Bifilar Winding**

a.) Take 20cm of enamelled copper wire and fold in half.
b.) Grip the open end of the in a small vice or similar to anchor it and the folded end in the chuck of a small hand drill.
c.) Apply gentle tension and keeping the bundle taut turn the hand drill to twist the bundle to around 5 twists per cm. Remove from the drill and vice.
d.) Wind the twisted bundle over the IF output winding to give 6 turns.
e.) Trim each end of the bundle, cutting off the fold, to form two separate conductors. Leave at least 1.5cm free. Tin the ends.
f.) Using a meter in resistance or continuity mode, identify the start and finish of each conductor and combine as shown.


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g.) Insert the transformer winding ends into the PCB, taking great care to ensure that all windings are matched to the correct pads, tension gently to hold the core in place and solder.

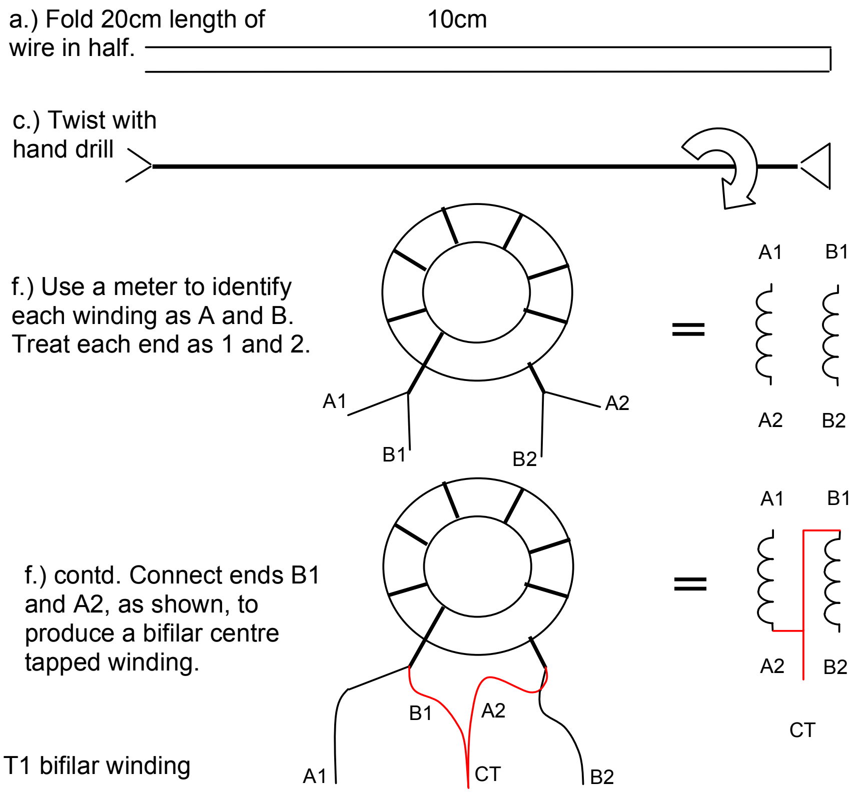


**Fig. 3** T1 bifilar winding detail

## Mounting T1

Insert the leads into the T1 PCB pads as shown. The orientation of the IF output and bifilar A1/B2 ends is not important. Be sure to make the centre tap (CT) using B1 and A2, ensure that the centre tap pair is inserted into the CT pad shown below.

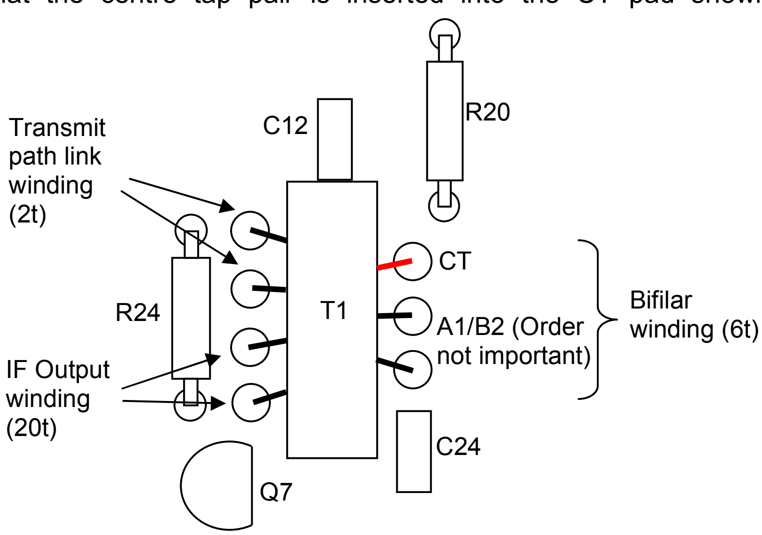


**Fig. 4** Transformer T1 placement

## Transmit Path Link Winding


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This is best installed once the T1 has been mounted onto the PCB. Fit the two turn transmit path winding using 10cm of wire to form a double turn on the lower part of the toroid near to the Transmit Path Link Winding pads. Trim the ends of the winding, leaving enough wire to pass through the pads, clean the ends tin and solder in place.

### 5.19 *Connector Assemblies*

Connector shells and pins are supplied to allow connection of power, audio and controls to the T-1. The use of good quality, colour coded, heat resistant, multi stranded wire is recommended. To avoid accidents, a colour code convention should be chosen to represent function, e.g. Red +ve supply, Black ground, striped colours controls etc. Each connector assembly comprise of two component parts; the shell and the pins. To terminate a conductor first strip back about 2mm of insulation and tin the exposed wire. Place the tinned end of the wire into a pin such that the tinned wire sits inside the inner pair of tabs and the insulation sits within the outer tabs. With small pointed nose pliers carefully compress the outer tabs onto the insulation to hold the wire.

Repeat this with the inner tabs to grip the exposed conductor. Very carefully solder the exposed conductor in place taking care not to allow solder to flow onto the locking tab. Finally, insert the pin into the shell with the small locking tab orientated to the face of the shell with the small cut outs. Push home until the locking tab snaps into the cut out. Should you need to remove a pin, gently press the locking tab in with a small screwdriver or the end of some pointed nose pliers. The pin will be released and can be pulled out of the shell.

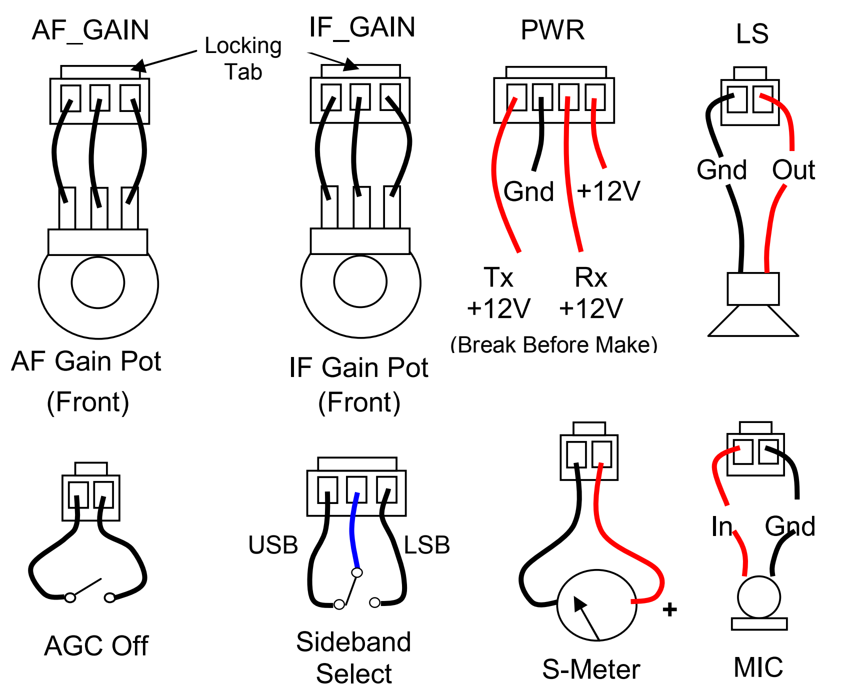


**Fig. 5** Connector Wiring

Assembly complete, well done! Now carefully check your work for dry joints and bridges before moving on to testing.



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# 6 TESTING

The testing sequence assumes that the filter and carrier crystals have been have been installed. A log 10K AF gain pot, speaker, microphone and sideband select switch will be required for basic testing. A linear 10K IF gain pot and S-Meter (100uA - 200uA) will allow full testing and set up.

## 6.1 *DC Tests*

Before connecting the T-2 to your power supply for the first time, carry out these simple checks – just to be safe!

- With a meter set to resistance or continuity check the PWR supply connector on the main PCB for shorts or very low resistance. Check each supply input against ground.

- Check the polarity of your supply and ensure that the PWR plug is wired correctly

## 6.2 *Receive Set Up*

With a switch or wire link connected to the MODE plug select LSB operation. Apply +12V to +12V and RX inputs of the PWR connector and check that the current is in the region of 200mA. Disable the AGC input by shorting pins 1 and 2 of the AGC_OFF input. Advance the AF gain until a faint hiss is heard. With no IF Gain pot attached, adjust the AGC bias pot VR3 for maximum IF noise, this will be at an AGC voltage of about 8V. If no noise is heard, check that the carrier oscillator is functioning and that the right DC conditions have been applied to the USB/LSB control input.

Select USB operation on the MODE connector. Connect a +7dBm local oscillator source set to the desired receive frequency +/- IF frequency to the LO port. (e.g. for 14.250MHz LO = 14.250 -11.059 = 3.191MHz or 14.250 + 11.059 = 25.309MHz with inverted sideband operation) Connect an antenna or signal source and adjust the carrier oscillator by listening to the unwanted sideband suppression level. Change over sideband oscillators and adjust USB carrier for good suppression and a similar passband sound to that of LSB operation.

Enable the AGC by removing the short on the AGC_OFF control and set AGC gain by adjusting VR5. Note that too much gain will cause the AGC to “overshoot” indicated by a characteristic “pumping” of audio level. A smooth AGC operation across a wide range of receive signal levels should be obtained.

## 6.3 *SSB Transmit Set Up*

Reconfigure the supply inputs for transmit operation. With a receiver <u>loosely</u> coupled to the RF port of the T-2 it should now be possible to detect the carrier output. Adjust VR1 (carrier balance) for minimum signal. Note that in close proximity with unscreened connections the receiver will also detect a directly radiated carrier from the oscillator circuit making a true assessment of suppression impossible. Adjust coupling to minimise this.

Connect a low impedance microphone to the MIC connector and adjust VR2 the microphone gain, for a clean SSB signal. An oscilloscope (of suitable bandwidth) connected to the RF port should show a peak to peak output of approximately 150mV across 50 Ohms.


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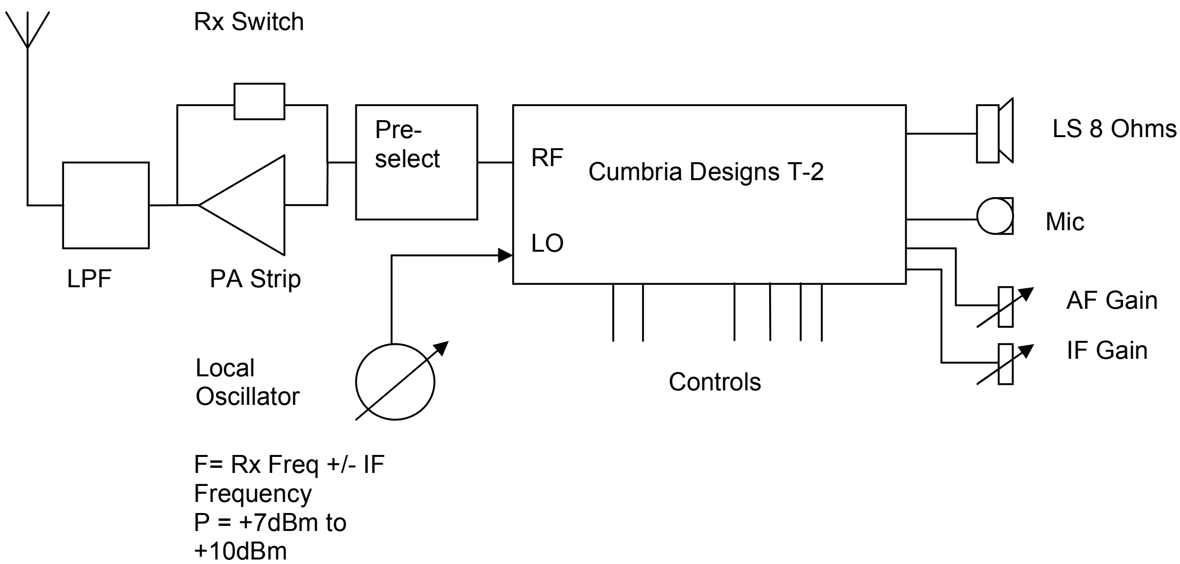
Now revisit the carrier oscillator tuning. As a rough guide, aim to have the carrier oscillators sitting around -20dB down the filter skirt. There will be some asymmetry due to the ladder filter. By re-adjusting the carrier oscillator frequencies, trimming the carrier balance and setting the microphone gain correctly, good suppression will be achieved together with a good audio passband. The T2 is now ready for use.

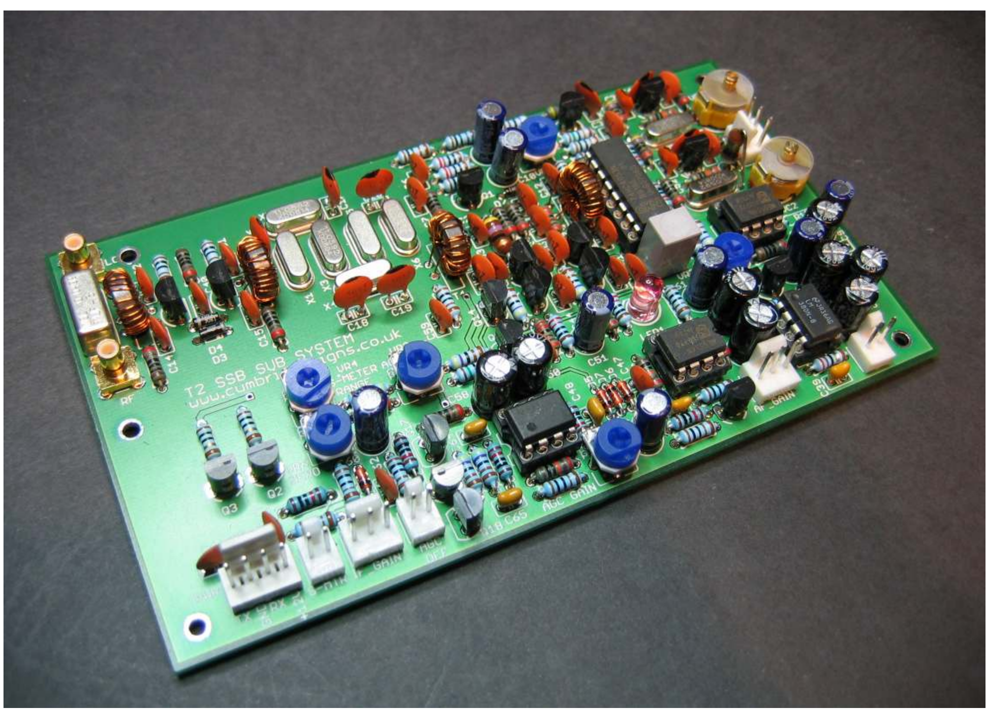
### 6.4 *Need Help?*

Hit a problem that you can't resolve? Don't worry, we're here to help. Contact us by letter or email at support@cumbriadesigns.co.uk for support.

## Typical T-2 Application




## The Assembled T-2

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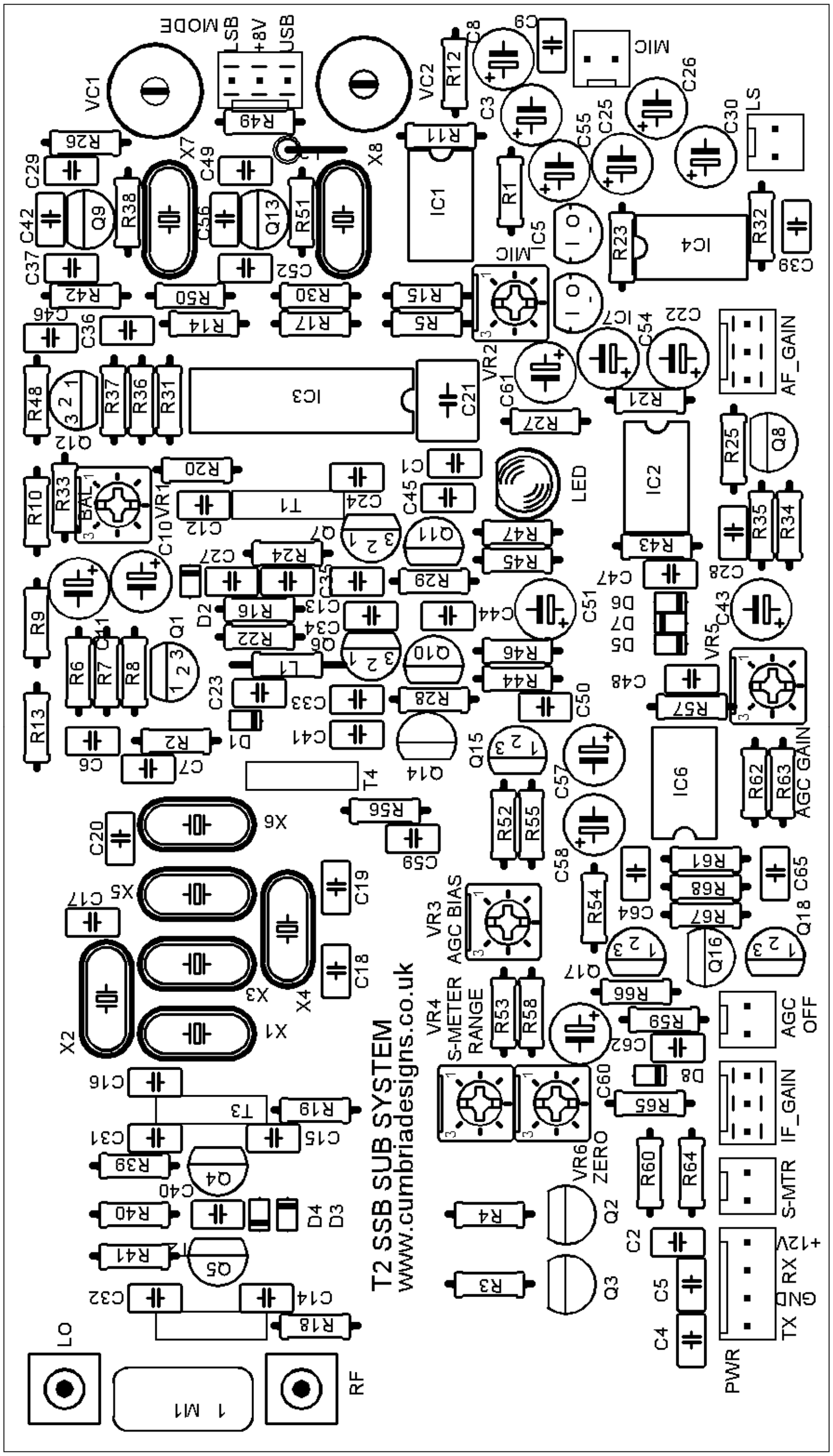
## Appendix A T-2 Component Overlay





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## Appendix B T-1 PCB VERSION 1.0 PARTS LIST

**Resistors**

| | |
|---|---|
| 2R7 | R23, R32 |
| 10R | R3, R4 |
| 100R | R1, R2, R16, R18, R19, R21, R22, R26, R30, R40, R49, R54 |
| 220R | R5, R6, R7, R46, R47 |
| 470R | R42, R48, R50 |
| 1K | R8, R9, R11, R13, R20, R25, R27, R34, R36, R39, R41, R56, R63, R64, R65, R59 |
| 2K2 | R12, R24, R44, R58 |
| 4K7 | R10, R28, R29, R52, R53, R68, R67 |
| 10K | R14, R15, R17, R31, R33, R35, R57, R60, R61, R66 |
| 100K | R38, R43, R45, R51, R62 |
| 150K | R37, R55 |

**Trimpots**

| | |
|---|---|
| 10K | VR1, VR3, VR5, VR6 |
| 100K | VR2, VR4 |

**Capacitors**

| | |
|---|---|
| 22pF | C52 |
| 68pF | C16, C17, C18, C19, C20, Ca*, Cb* |
| 100pF | C37, C42, C46, C56 |
| 1n5 | C47 |
| 10nF | C1, C2, C4, C5, C6, C7, C9, C12, C13, C14, C15, C23, C24, C27, C29, C31, C32, C33, C34, C35, C36, C40, C41, C44, C45, C49, C50, C59, C62 |
| 100nF (Dipped) | C28, C39, C48, C64, C65 |
| 0.47uF | C21 |
| 10uF | C8, C10, C11, C43, C51, C55, C60, C61 |
| 100uF | C3, C22, C25, C26, C30, C54, C57, C58 |

* Filter series capacitors mounted underneath PCB

**Trimmers**

| | |
|---|---|
| 65pF | VC1, VC2 |

**Inductors**

| | |
|---|---|
| 47uH | L1 |
| 15uH | L2 |

**Semiconductors**

| | |
|---|---|
| 2N3906 | Q1, Q15 |
| 2N3904 | Q6, Q7, Q12, Q17, Q18 |
| 2N7000 | Q2, Q3, Q8, Q14, Q16 |
| J310 | Q4, Q5, Q9, Q10, Q11, Q13 |
| 78L05 | IC5 |
| 78L08 | IC7 |
| 5082-3081 | D1, D2, D3, D4 |
| BAV21 | D5, D6, D7, D8 |
| LED5MM | LED1 |
| 74HC4053 | IC3 |
| LM380N-8 | IC4 |
| NE5532N | IC6 |
| NE5534N | IC1, IC2 |

**Mixer**

| | |
|---|---|
| TUF-3 | M1 |

**Connectors**

| | |
|---|---|
| SMB Sockets | LO, RF |
| Header 2 way | JP2, JP4, JP6, JP8 |
| Header 3 way | JP3, JP5, JP7 |
| Header 4 way | JP1 |
| Crimp Pins | (21) |

**Toroid Cores**

| | |
|---|---|
| T37_43 | T1, T2, T3, T4 |

**Crystals**

| | |
|---|---|
| 11.0592MHz | X1, X2, X3, X4, X5, X6, X7, X8 |

**Misc**

| | |
|---|---|
| Copper Wire | 1m |
| T2 PCB | |

### Additional Parts Required for operation

| | | |
|---|---|---|
| **AF Gain** | 10K Log | With switch for transceiver power on/off |
| **IF Gain** | 10K Lin | With optional switch for AGC on/off |
| **Speaker** | 8 Ohm 2W | |
| **Microphone** | Low Impedance dynamic. | |


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