144MHz Anglian 3 L Transverter Assembly Manual

G4DDK Document V0.9

The accompanying Technical Description introduces the design of the Anglian 3 L transverter. Anglian 3L was described in DUBUS 3/17 and in the Proceedings of the Central States VHF Society 2017.

This document details the recommended method of construction to go along with those two articles. If you have either of these articles then the Anglian 3L technical description PDF can be read instead.

You don't have to built the Anglian 3L this way, but it is tried and proven and a kit of parts are available to save you from having to buy more SMD parts than you really need.

If you buy a kit and lose or damage components I can supply replacements. It is all too easy to 'ping' a small SMD part onto the shack carpet and lose it forever. However, I am not able to supply ad hoc parts to those who choose to buy just the PCB.

This kit is not recommended for inexperienced SMD constructors. Many very small parts are used in its construction.

Let the building begin

The kit builder should ensure that they have a static-free place in which to work. Antistatic matting and wrist straps should always be used when working with small parts (and large ones too!).

A suitable insulated or grounded, temperature controlled, soldering iron should be used.

Small, stainless steel, tweezers are a must.

The order of work in building the kit is:

1. Assemble the SMD board. Do not fit the tuneable coils or crystal at this stage.
2. If the Anglian board is to be mounted into other than the recommended tinplate box, use the bare board as a drilling template.
3. Mark the position for the PCB inside the tinplate box
4. Mark the position for the connectors and feed-through capacitor holes in the box.
5. Drill and clear the holes
6. Seam solder the assembled PCB into the box
7. Solder the 6 tuneable coils and the crystal onto the PCB
8. Solder the SMA connector spills to the PCB RF and IF tracks
9. Wire the feed-through capacitors to the correct PCB pads using thin wire. Do not bend the feed-through capacitor leads
10. Solder the supply diode between the appropriate feed-through capacitor and PCB pad

11. Stick the copper heat-sink to the PCB, as indicated later. This may need to be carefully repositioned as the recommended position blocks one of the mounting holes.
12. Clean up any excess flux around the seam soldering, connectors and feed-through capacitors.

Each of these steps is described in the following section.

Inspect the PCB

Use a magnifying glass to inspect the PCB for damage. If you spot any problems it will be necessary to return the board for replacement. Boards that have been soldered into the box and then reported as damaged will be considered on a case by case basis for obvious reasons!

Assembling the SMD board

Start by identifying all of the parts and ticking them off on the Anglian 3 L component list.

You will need a small pointed, temperature controlled, soldering iron suitable for SMD work. You will also require small diameter wire SOLDER of 0.25-0.3mm diameter. I prefer leaded solder.

Start by soldering all of the SMD resistors and capacitors to the board according to the component position overlay. Note the polarity of C29 and C64 tantalum capacitors. I recommend a small blob of solder on ONE of each of the many component pads (do the whole board at the same time). A searchable PDF is available on request to ad finding the location of each component on the overlay. Highly recommended!

You will need to decide if you need IC3 or not. It can be soldered in anyway, but resistor R29 should NOT be used if the amplifier IS required. Instead, that resistor should be used as R31. Note, this is a 0Ω bridge. If the TX IF amplifier is NOT required, use R29 to bridge the amplifier and ensure R31 is NOT used. Clear? If not, re-read that last section!

Solder the remaining semiconductors to the PCB, observing correct orientation of the transistors, diodes, MOSFETs and the MMIC amplifiers. In particular the PSA3-5043 orientation can be confusing. The PCB is correct. Make sure you considering the device could be 90° out of position if you believe I've got it wrong!

Solder the SMD inductors to the PCB. These can be tricky as the connections are underneath the inductor in order to keep them clear of the PCB and improve their Q. Heat applied to the exposed part of the pad will result in the inductor dropping down onto the pad as the solder blob melts. Once in position, apply solder and the iron tip to the other pad to ensure a clean joint. It is recommended that you check each and every inductor is properly soldered to their respective pads using an multimeter on its Ohms range.

Be careful handling the inductors. They are fragile and relatively expensive parts.

Solder the mixer, MX1 (observing the index dot position), TX gain pot (R24) and trimmers C5 and C10 onto the PCB.

The SMD board is now complete.

If the board is to be mounted in OTHER THAN the tinplate box then the tuneable inductors and the crystal can now be soldered on the 'top' of the board. Note that this is actually designated the bottom of the board by the CAD programme.

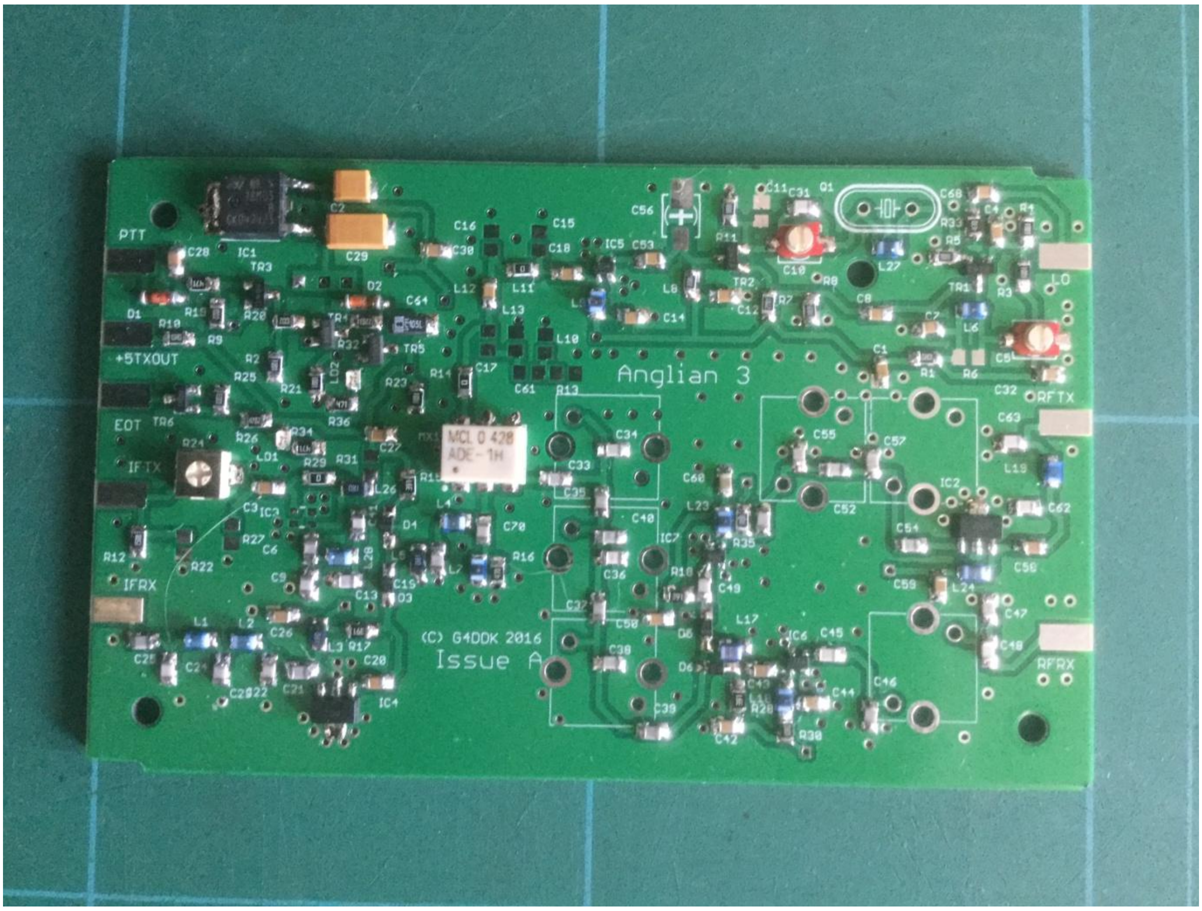


Photo 1A Assembled Anglian 3L PCB. Only the SMD parts on the top of the board have been placed. The board is now ready to be seam soldered into the box.

Note the empty component locations as a result of the redesign!

Seam soldering the assembled PCB into the box.

Marking the box

Carefully examine photo 1. The box has two overlapping edges. The PCB has two corresponding cut outs that clear these overlapping edges. This shows which way up the PCB should be mounted into the box

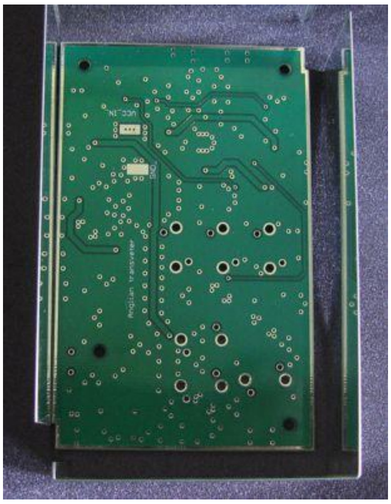


Photo 1. note the cut outs at the top right and lower left of the PCB. These should correspond with the overlapping edges of the tinplate box. Note that an unpopulated Anglian1 PCB is shown in this photo.

Mark on the insides of the box, above the PCB, the word **'UP'** with a marker pen so that these cannot be confused in the next step.

With the two sides as shown in photo 2, using a Vernier, mark a line all the way around the inside of the box sides. The line should be 22mm below the rim of the box **UP** side.

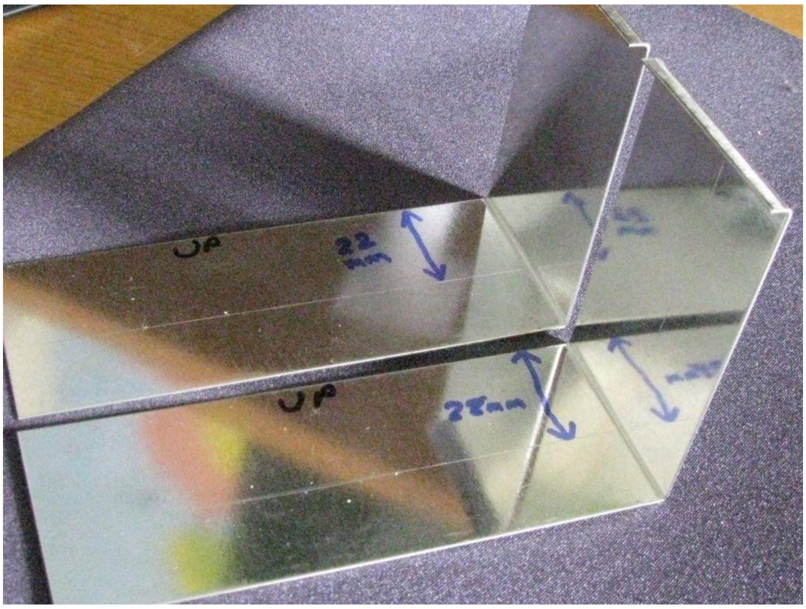


photo 2 inside box sides and ends marked identically, 22mm below the rim of the box. This will be the line to which the PCB will be seam-soldered into the box, after the holes are drilled.

Hold the **IF input** end of the PCB up to one end wall and mark the location of the IF control connector pads and RF connector pads onto the box, using a scriber. The control connector marks should be 24.3mm below the same rim as the 22mm lines. This is the centre line of the SMA spill. These are most easily marked by resetting the Vernier to 24.3mm and marking a second line inside the END WALL ONLY. NOT on the sides!

A third line should now be marked AT THE IF END ONLY. This should be 30mm below the top rim. This line marks where the position for the 3mm holes for the feed-through capacitors should be located.

This is shown in photo 3.

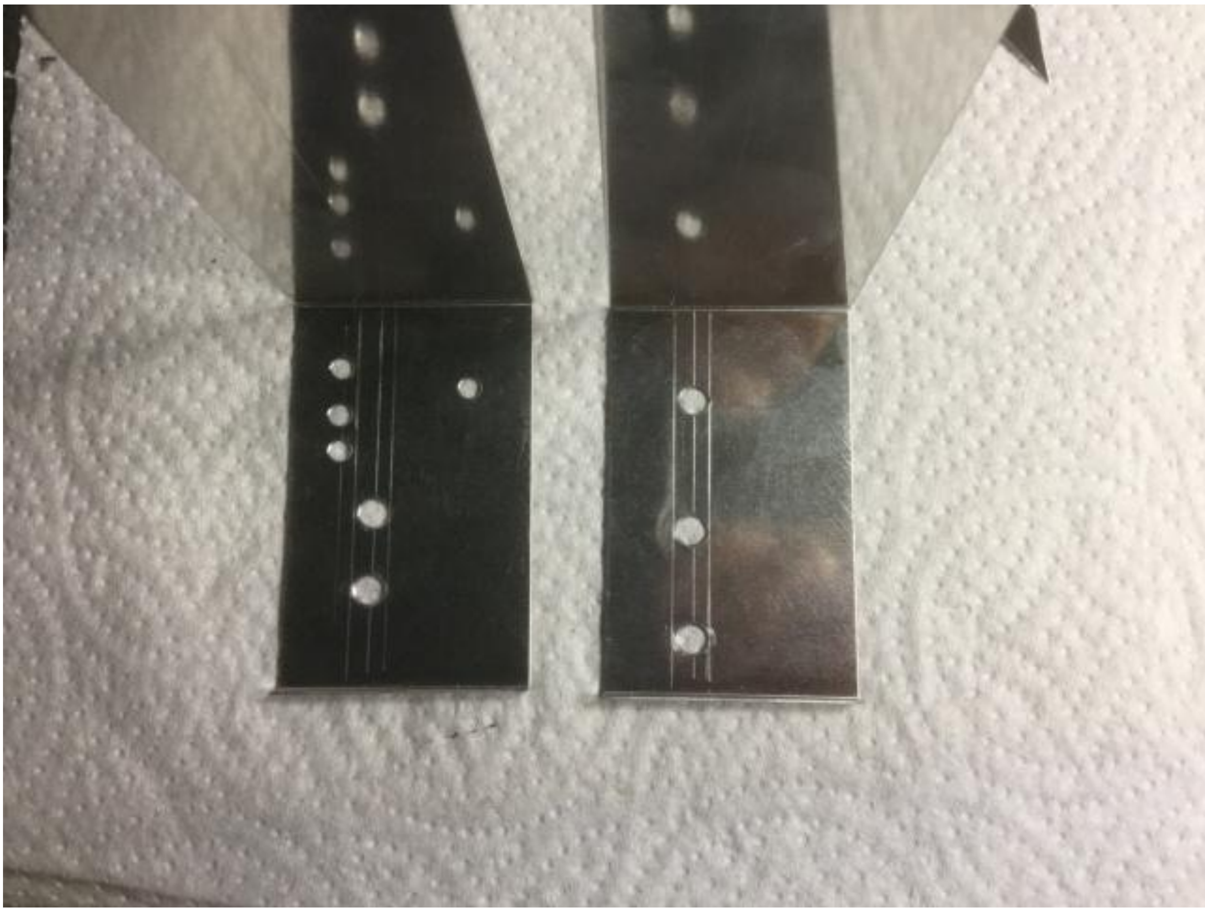


photo 3 the end walls of the box are marked with a third line 30mm below the rim of the box. Mark the positions of the feed-through capacitor mounting holes directly above the PCB. The single marking, close to the rim of the box, is for the power feed-through capacitor. It is not necessary to scribe a line for this hole as there is only one hole to be drilled. Also note that whereas the control feed-through capacitors are located BELOW the component side of the PCB, the power feed-through is located ABOVE the PCB.

Turn the PCB around and mark the positions of the two RF connectors and single LO connector on the ***other*** inside box end wall. The centre line of these connectors (assuming you use the supplied SMA connectors) is also 24.3mm below the **'UP'** rim of the box. There are no feed-through capacitors at this end of the box.

Hold the end wall of the box against a piece of wood as support and gently centre punch the positions of the holes ready for the next stage.

Drilling the holes

The five SMA connectors require 4mm diameter holes. The four feed-through capacitors require 3mm holes. These are best drilled with a bench drill press with the end walls supported by the piece of wood. If the drill does not clear the upright wall of the box, gently bend the wall away from the drill. It will bend back when you've completed drilling.

If necessary, clean up the holes with a countersink bit.

Seam soldering

Offer up the populated PCB to the side of the box with the holes for the IF and feed-through capacitors. Seam solder into place.

Carefully slide the second box side into place in the lid.

Check everything is a good fit and all corners are square.

Tack solder the two flange box corners as shown in photo 4

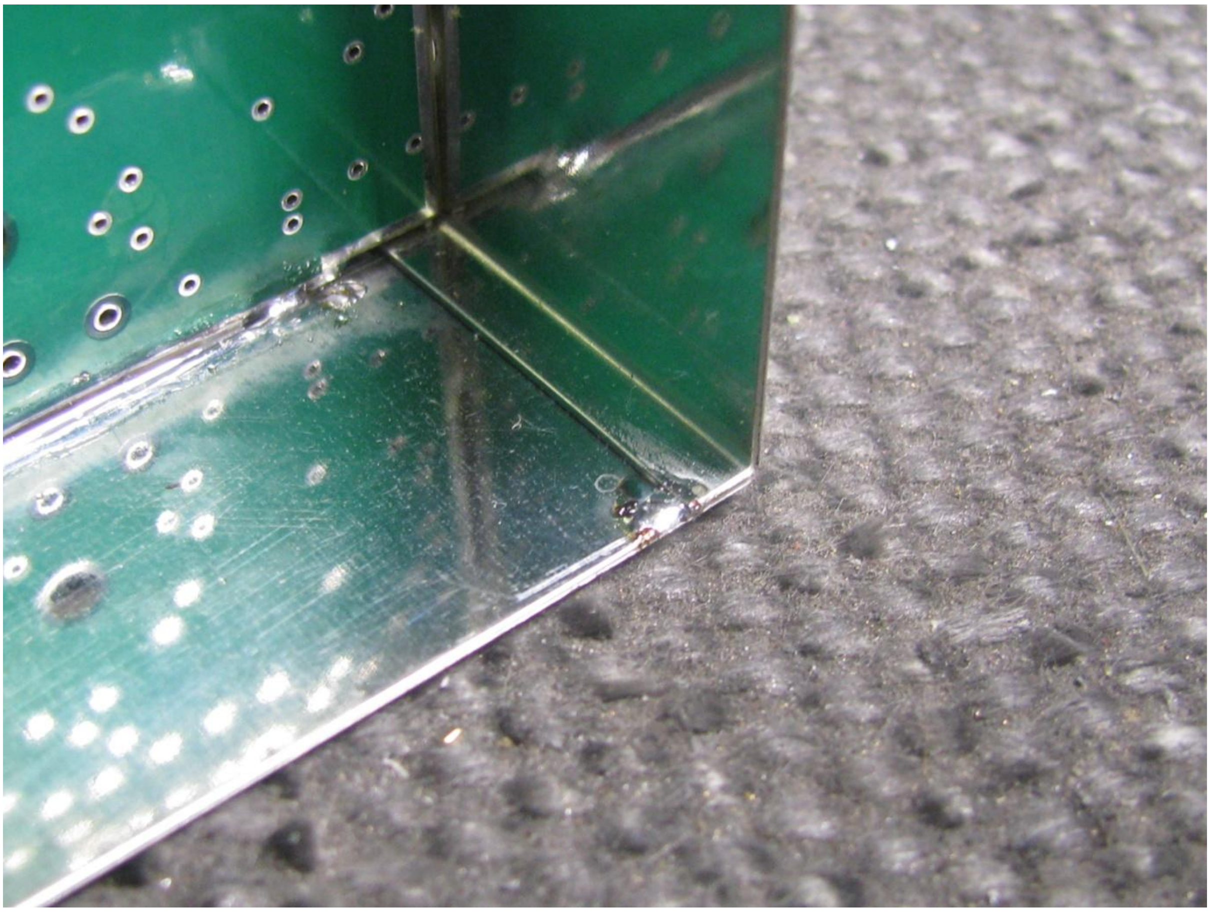


Photo 4 PCB offered up to end wall of box prior to soldering.

Remove the lid, carefully check that the PCB (tuneable inductor side) is level with the '22mm' lines inside the second box side. Seam solder the PCB to the second box side.

The solder border running around the PCB should be level with the line marked at 22mm below the rim. Tack solder the PCB in two places initially (to the inside of the box). This will allow you to move the PCB if it is not straight. A Weller 45-50W temperature controlled iron is ideal for seam soldering the PCB and box.

Once you are happy it is level you can complete the seam soldering on both the box end wall and the box side.

Now place the PCB and box side into the lid of the box. DO NOT SOLDER TO THE LID!

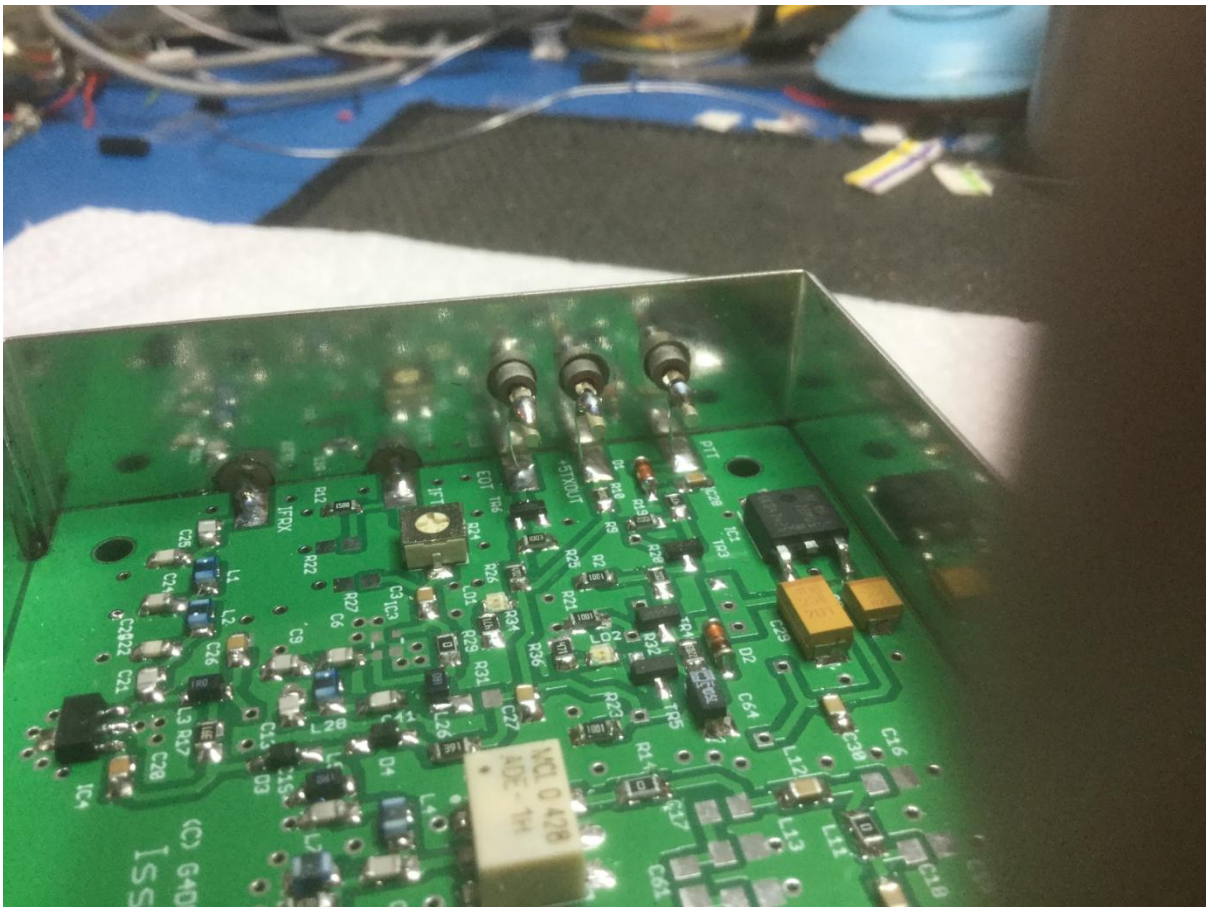


Photo 5 PCB seam soldered into the box. Component side shonw, the seam soldering is on the OTHER SIDE.

Check that the box top and bottom both fit correctly.

Soldering the connectors

Prepare the SMA connectors by cutting off the PTFE insulation from the rear of the connector. A Stanley knife is ideal for this. photo 6

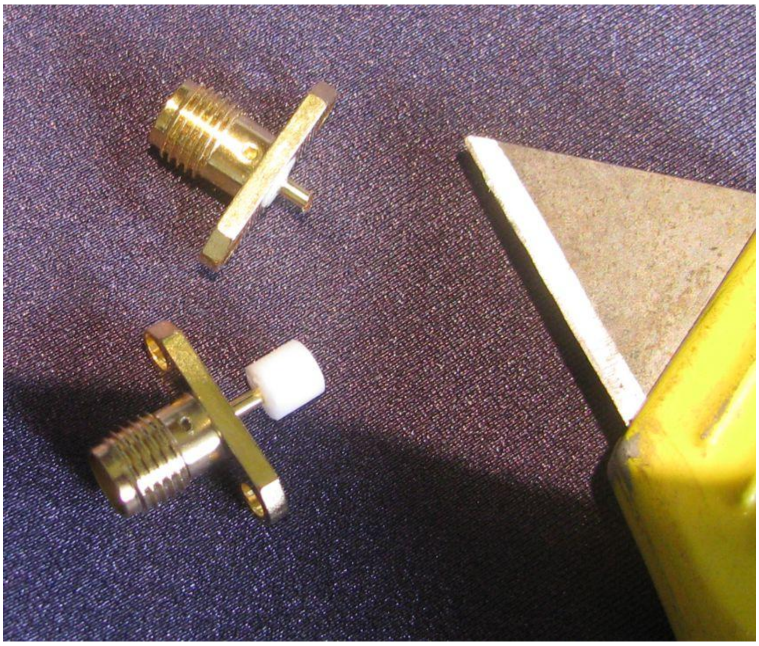
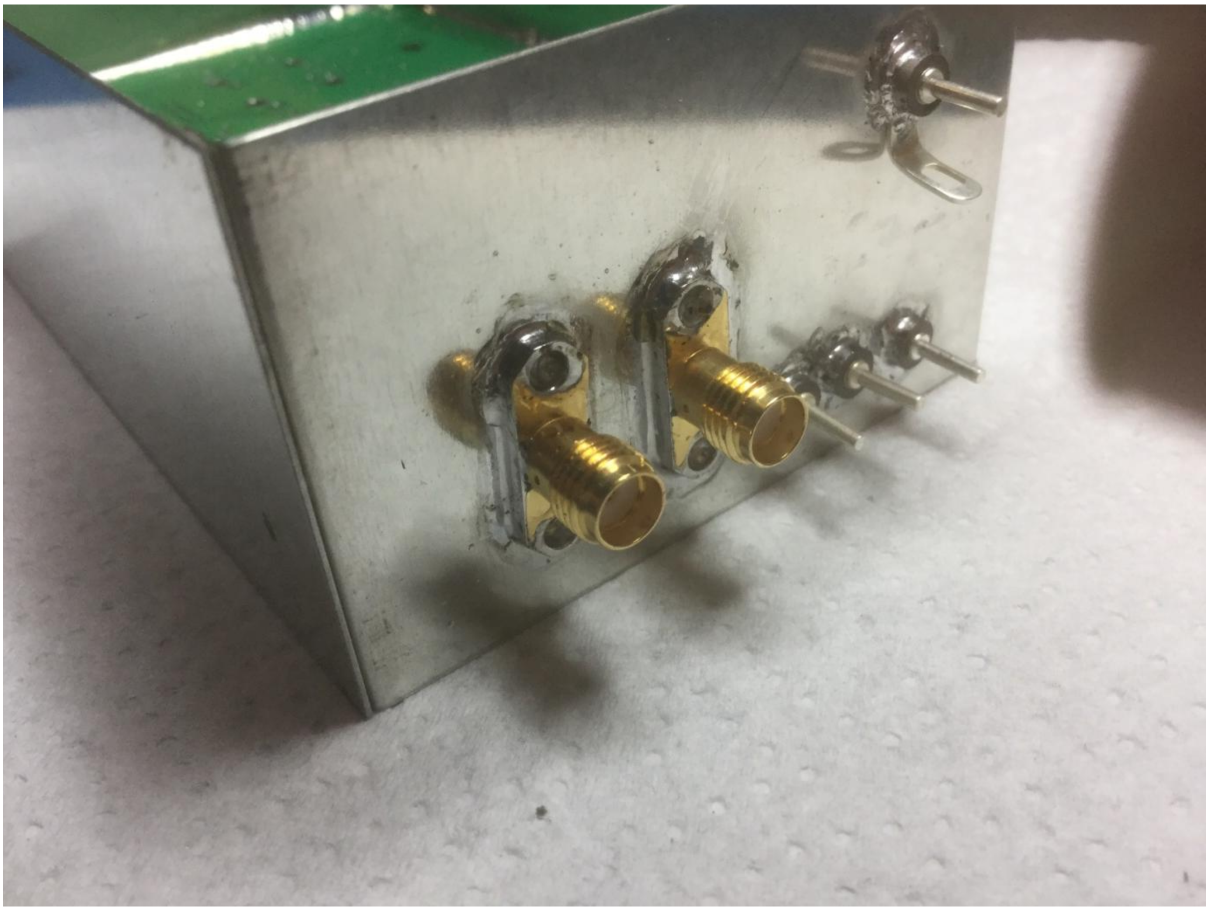


Photo 6 preparing the connectors

When all five connectors have been prepared they can be soldered to the outside of the box. The IF connections and the control feed-through end is shown in photo 7. Note that the flux has not yet been removed from the soldered connector flanges.



I find the easiest way to do this is to tack solder the spill of the connector, through the 4mm hole in the box end, to the pad on the PCB. Try to get the two hole connector flange vertical and the flange tight against the box and then tack the spill again. You can then **gently** rotate the connector to bring it vertical. Make sure that the spill does not rotate and damage the PCB pad.

Repeat for the remaining four connectors.

Soldering the feed-through capacitors

Carefully slip one of the feed -through capacitors through the hole in one of the 3mm solder tags. Push the feed-through capacitor through the power connection 3mm hole in the box end. Bend the solder tag away from the box. Solder into place.

Repeat for the remaining feed-through capacitors. You shouldn't need solder tags on these feed-through capacitors. See photo 7

Soldering the coils and crystal

Five of the 6 Coilcraft coils are mounted with screening cans, but the receiver input coil (L20) does NOT have a screening can. This increases the coil Q and reduce input circuit losses.

Note which end of the coils should go to ground. The top of the coil winding should be at the ground end. Failure to connect this way round may result in excess loss in the tuned circuits due to stray capacitance. Photos 8 and 9 show the correct orientation for these coils. Note that the coils have one corner larger than the others. This is the 'hot' end of the coils that goes to the 'top' of the tunes circuits that make up the filter. L20 orientation is with the bulge towards the PSA4-5043. This is shown in
fig 1

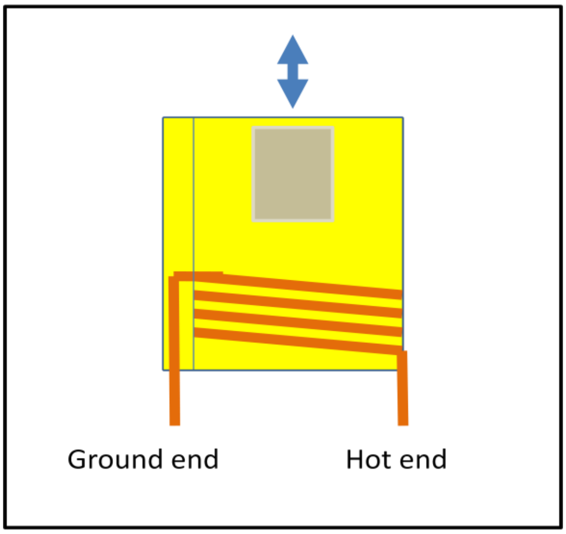


Fig1 Tuneable coil connections

To be sure of the correct orientation, remove the screening cans from these five coils and check that the 'top' of the coil goes to the ground connection pads. After soldering the coils into place solder the screening cans back in place. The coil is easily removed from the screening can by gripping BOTH pins with a small pair of long nose pliers and gently pulling the coil out of the can if you want to check their pin orientation.

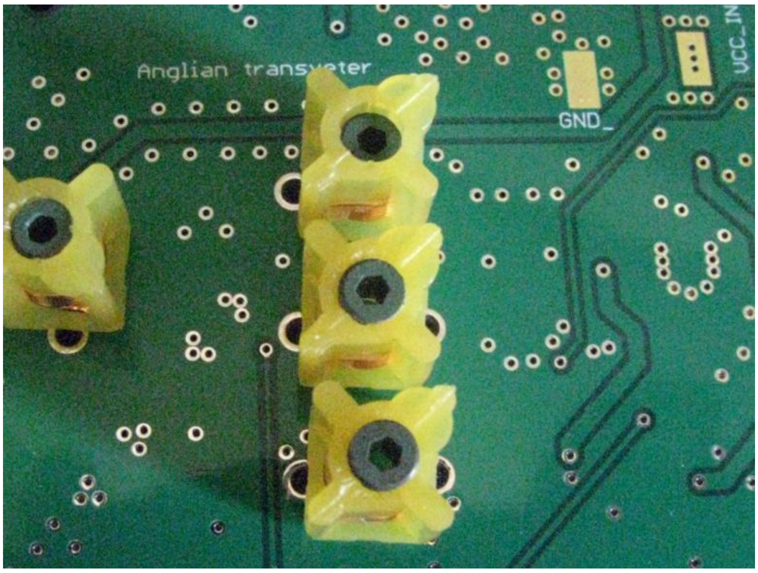


Photo 8 Three pole filter coil orientation. Note the 'bulging' fourth corner.

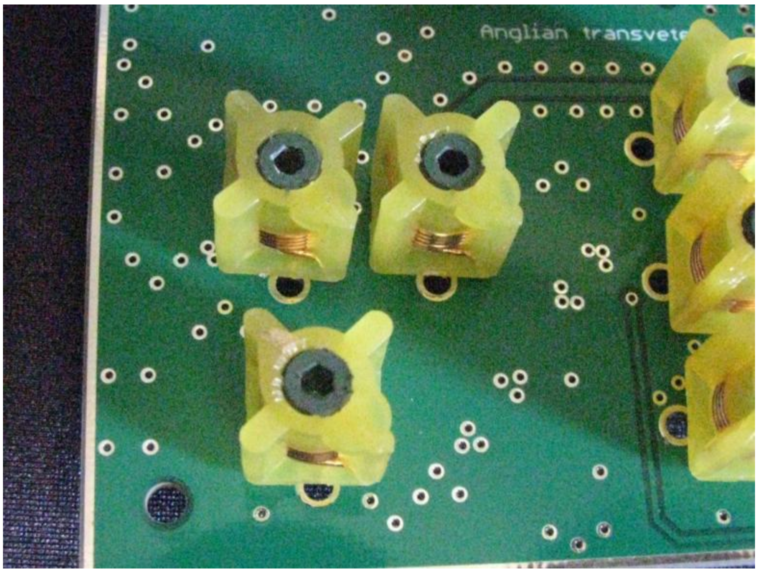


Photo 9 two pole and input filter coil orientation.

Solder the crystal through the holes on the PCB. The crystal case should not be pushed down onto the PCB in order to reduce heat conduction to the crystal can and aid thermal stability. This is shown in Fig 2

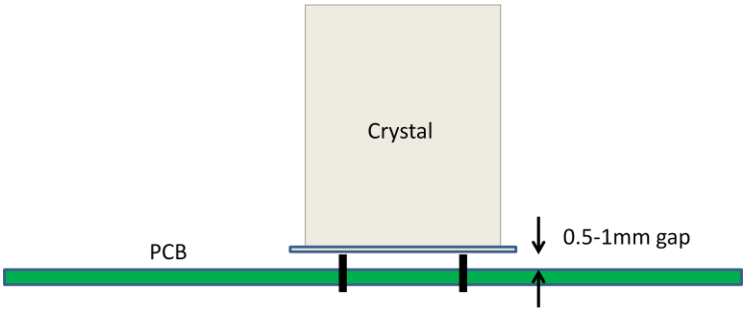


Fig 2 soldering the crystal to the PCB pads

Connecting the pads

On the bottom side of the PCB connect the 1N5401 (or similar 3A silicon diode) to the power feed-through capacitor and the power supply input pad. In this case the cathode or banded end of the diode should connect to the Vcc pad on the top of the PCB as shown in photo 10. Note that you should carefully dress the diode leads to allow the diode to fit between the power feed-through capacitor and the Vcc pad.

Peel the backing from the underside of the small copper heat-sink and stick the heat-sink ON THE CRYSTAL SIDE of the PCB (designated bottom on this PCB) immediately over the voltage regulator. This is the on the opposite side of the board to the regulator! Be careful not to short the copper onto the adjacent power input pad. The heat-sink should be pushed firmly up against the inside of the box.

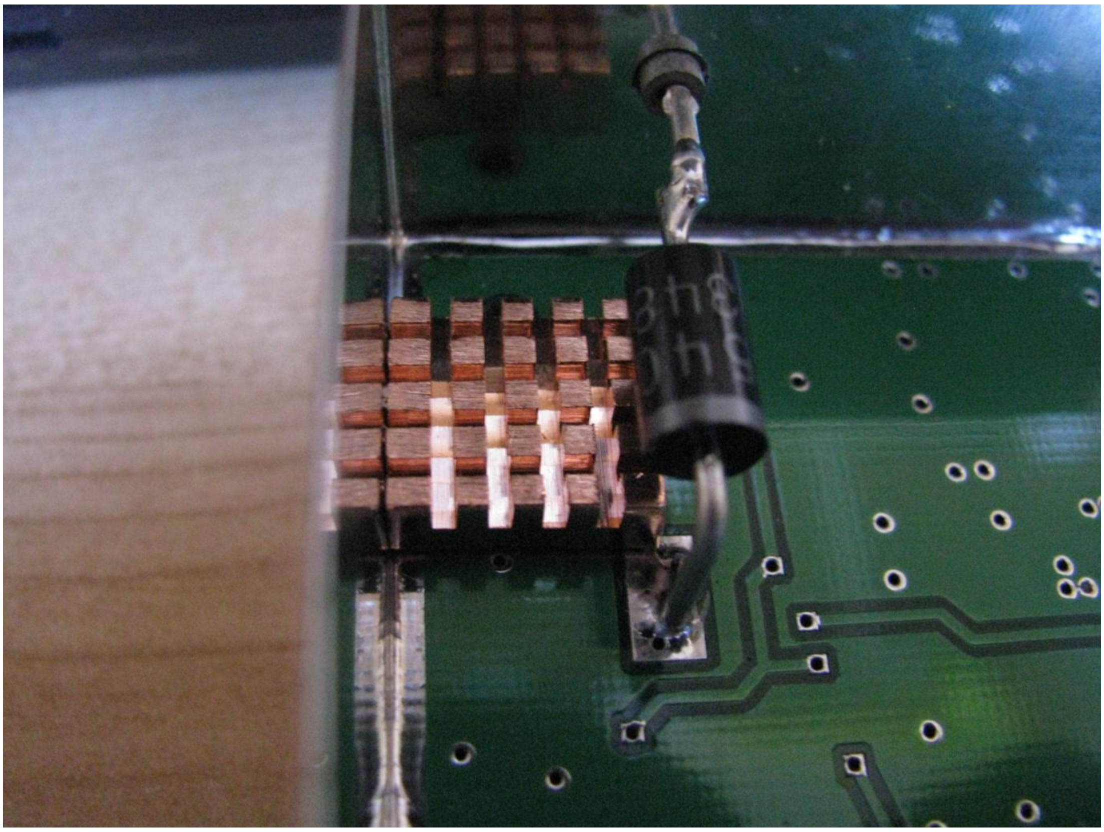


Photo 10 shows the 1N5401 diode connected from the power feed-through capacitor to the Vcc pad and the heat-sink.

Connect the other feed-through capacitors to the adjacent pads (EOT, TX 5V and PTT) on the PCB with suitable, short lengths of wire.

Test and Alignment

Refer to the schematic circuit diagram.

Connect a 50Ω termination to the receiver (144MHz) input and IF (28MHz) output. You will get more noise with the input terminated in 50Ω than with the input open circuit.

Connect +12v to the power input feed-through capacitor. The supply should be set to current limit at around 0.5A if possible.

Check that the current taken is about 250mA. If significantly more or less you probably have a fault and this must be fixed before proceeding.

Check that there is +5V present at the junction of R1 and C1.

Check that you have +5V at the junction of R30 and C42.

The green RX LED, LD1, should be illuminated

Ground the PTT feed-through

LD1 should extinguish immediately and then after a few tens of ms the TX LED, LD2, should illuminate.

Check that there is +5V at the junction of L19 and C54. The total current taken will briefly dip before the TX LED illuminates and its value will depend on whether you have strapped IC3 into circuit, or bypassed it.

Remove the PTT ground.

Switch the power off.

The 0Ω bridge, R14, will need to be temporarily removed in order to allow the local oscillator power to be measured. This resistor, or a short wire link, must be in place after the measurement in order for the transverter to work.

Ideally a spectrum analyser set to 116MHz centre frequency with 10MHz span and +30dBm amplitude should be used. However it is possible to do the alignment with a power meter and frequency counter or accurate frequency readout receiver.

Switch the power back on.

Adjust C5 trimmer until you see a strong signal at 116MHz. This should be +20 to +21dBm.

Now adjust C10 to bring accurately onto frequency. It may be necessary to go back and forth, re-adjusting C5 and C10, as there is some interaction between these two trimmers. Set the frequency as accurately as you can to 116.000.000MHz. An error of 100Hz maximum should be allowed.

Switch the power off

Remove the spectrum analyser connection.

Replace R14 or wire link.

Connect a 28MHz receiver to the 28MHz IF output in place of the 50Ω termination.

Tune to 29MHz.

Switch the power back on.

The noise in the receiver should increase. It may still be slightly low level at this stage.

Using the **correct** core trimming tool, set the cores of L14, L15 and L16 to one turn below the top of the screening can. In practice the cores will be VERY close to the correct setting already.

The noise should increase slightly. Adjust the core of L15 (middle coil) in by about a turn. The noise should increase noticeably. *In practice it has been found that the cores of L14, L15 and L16 are supplied already quite close to optimum and only L15 might need any adjustment. However, do not rely on this being the case!*

Readjust L14 and L16 to increase the noise. Re-adjust L15 if necessary.

By careful setting of the cores of these three inductors it should be possible to equalise the noise across the whole of 28 to 30MHz on the receiver.

Note that there is NO SCREENING CAN ON L20. This gives the maximum Q for this coil and hence lowest loss (best noise figure).

With the HF receiver tuned to 28.5MHz, adjust the core of L20 to maximise the noise at this frequency. If you have a noise figure meter it should be possible to adjust the noise figure to around 1.6 - 1.7dB at 144.3MHz with slightly higher noise figure at 28 and 30MHz. It may not be very different!

That is the receive converter aligned.

Switch off the Anglian power.

Connect the spectrum analyser, set to 144MHz centre frequency, 200MHz span, +30dBm reference level, to the RF (144MHz) output socket. Do not connect any 28MHz input signal at this stage.

Switch the power on.

IC3 not used

Connect a ground to the PTT feed-through capacitor.

The spectrum analyser should show no output. There might be a very small, residual, 116MHz output if you check that frequency.

Adjust the TX gain potentiometer, R24, fully anticlockwise to give maximum attenuation.

Connect a 0dBm 29.00MHz input source to the 28MHz IF input. There might be a slight 144MHz output due to IF signal leakage across the attenuator.

Slowly turn the TX gain control 1/4 turn and as you do so the 144MHz output should increase, slightly. Adjust the cores of L21 and L22 to peak the output. The initial starting positions for the cores should be with the cores just level with the top of the screening cans. The cores will need to be wound in, not out. There will be a broad, but distinct, peak.

Once the output is peaked, continue to adjust the TX gain pot up to a maximum of about +21dBm output. The output increase should be steady without any sign of jumps in level. Widening the spectrum analyser span to cover to 1GHz (starting at ~10MHz) should reveal just the 144MHz output plus the second and third harmonic at over 45dB below the 144MHz output, at maximum output.

IF IC3 used
Repeat as above but instead of 0dBm IF input, set the IF signal source to -18dBm.

Remove the PTT ground

Check that the local oscillator is accurately on 116.000.000MHz by monitoring with an accurately controlled time-base (clock) frequency counter.

Switch off the power.

The transverter is now aligned. It is possible to go back over the these adjustments (what radio amateur wouldn't!) to improve performance slightly. If you don't have access to a spectrum analyser it is HIGHLY recommended that you do find access to one as it would be irresponsible to assume everything is working as it should without properly checking it on the appropriate test equipment. Analysers are often available for this purpose at the regular UK Microwave Round Table events.

Interfacing the Anglian transverter to the HF transceiver

Drive level
Ideally the Anglian transverter mixer should be driven with a 28MHz level of 0dBm. Full transverter output will be achieved at this level. For those rigs with lower output levels, such as the ICOM range, The additional IF transmit amplifier, IC3, can be used as previously described in the technical description. Back off the output to a maximum output of +20dBm

Single coax IF
It is possible to simply combine the two IF ports on the Anglian transverter using a 3dB splitter/combiner, such as one of those from MCL, to bring the two ports to a single HF radio IF port like the ICOM PRO range. This has been done quite successfully with an ICOM 756 Pro 3 and I can personally confirm that it works well and the power output can still be adjusted using the Pro 3 power control.

It should also be possible to re-combine the 28MHz IF input and output from an Elecraft K3 with similar splitter/combiners so that the Anglian can be located remotely from the K3, with just a single coax connection

Higher power rigs
In the case of HF radios such as the IC7300, with no low level transverter output, it will be necessary to use an external power attenuator to dissipate some of the higher power output . I use a 25W,

20dB attenuator with my IC7300, with the IC7300 output turned down to 10W. This has two advantages. If the power accidently gets turned up to full then the power attenuator will ensure that no more than 1W is applied to the transverter. The power attenuator will not burn out immediately, so you will have won some time to realise something is not right and turn the power down. Transverters are, generally, more tolerant to overdrive damage survival than modern RF MOS power amplifiers. Power attenuators are cheaper than a new transverter. Suitable 10m band power attenuators are simple and cheap to build.

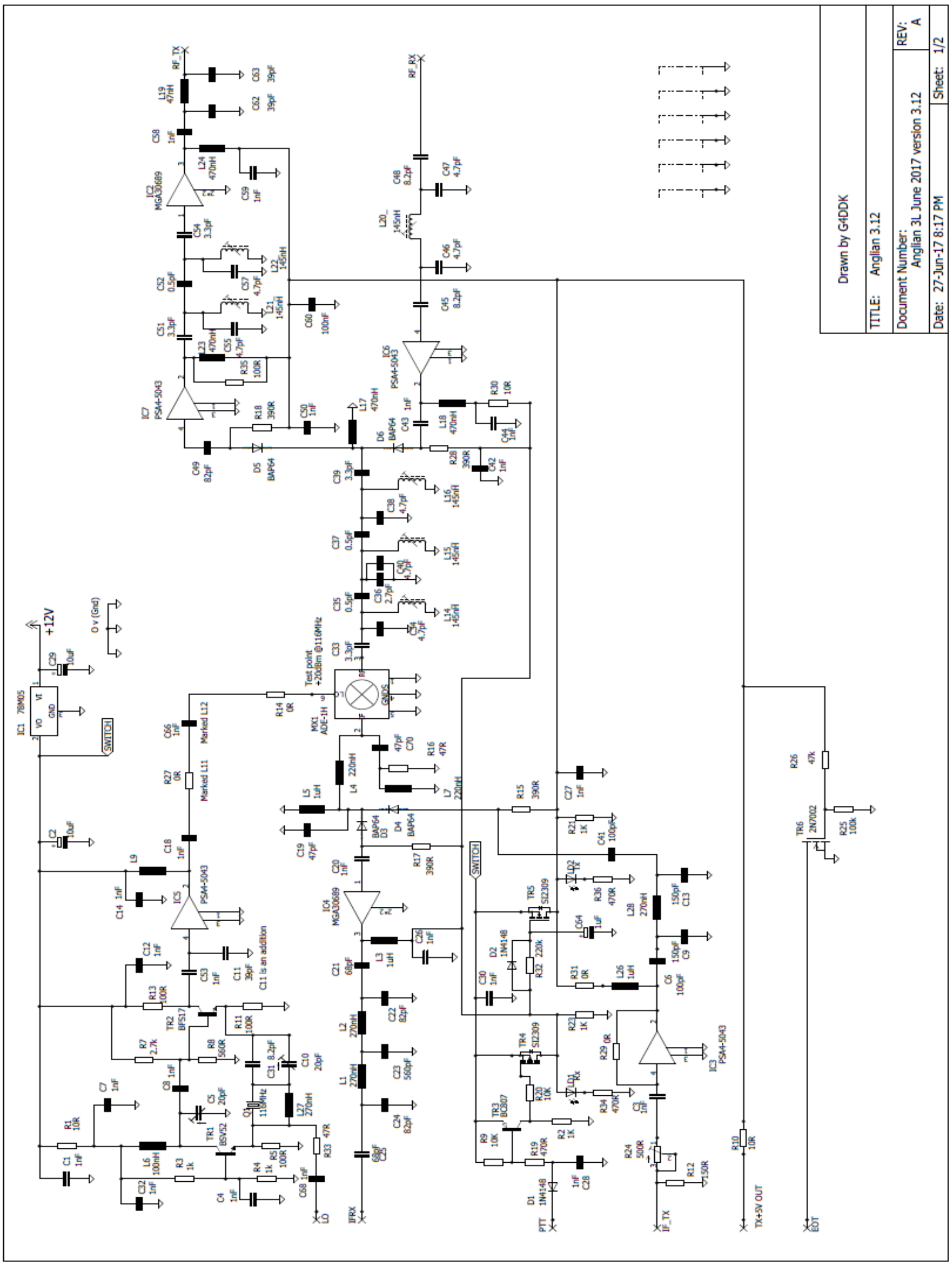
Secondly, the 20dB provides a good way to lose some of that unnecessary gain ahead of the HF rig. You may not want the HF rig's 20dB preamp on normally, but now it will come into its own in overcoming the loss of the attenuator.

Document History

Date	**issue**	**changes**
8/8/2017	**Draft 0.9**	**Initial draft**

Appendix 1

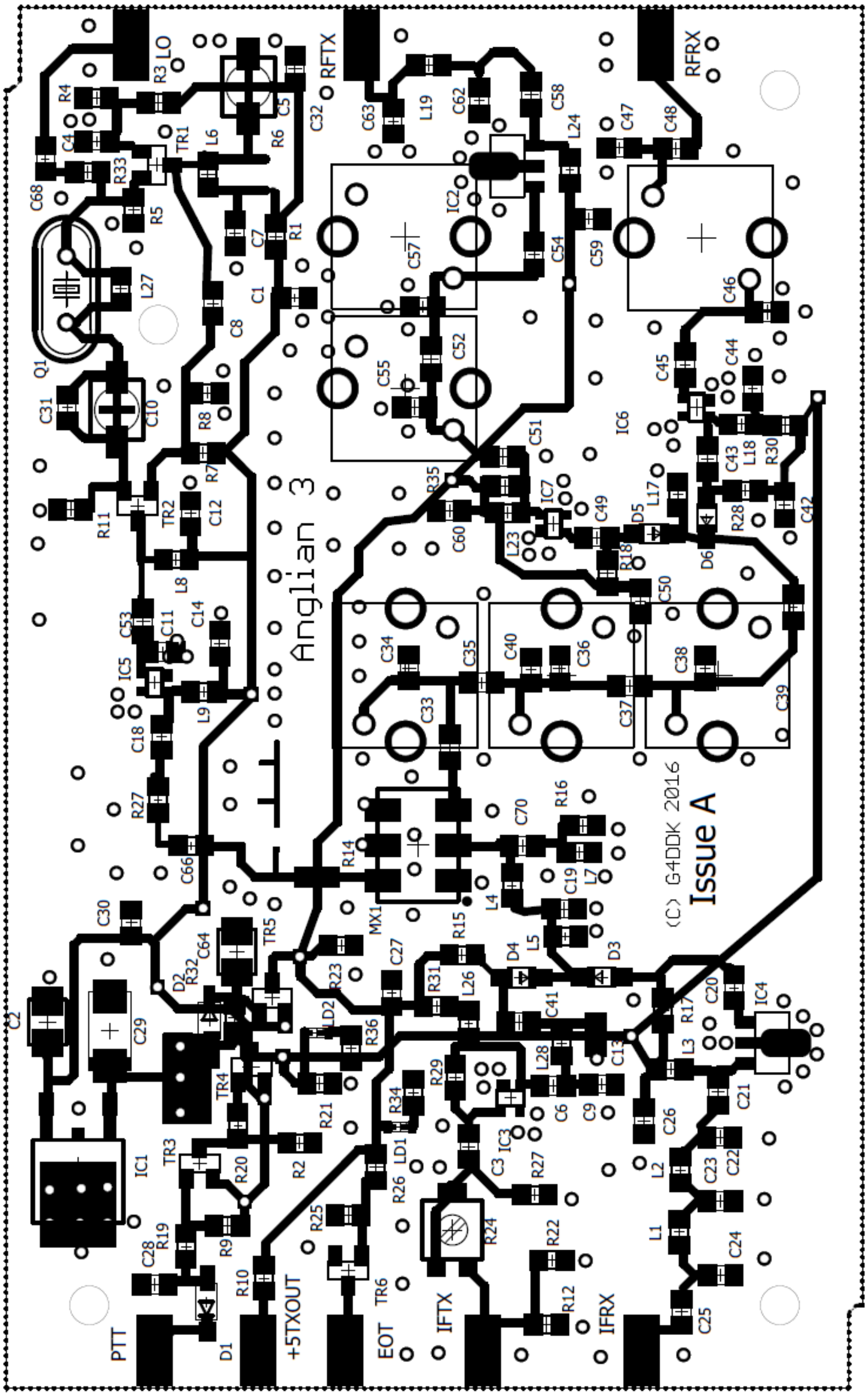
Circuit schematic diagram of the Anglian 3 L. A higher definition schematic appears as a PDF on a separate web page.



Appendix2

Anglian 3 component overlay

A searchable PDF overlay is available on request for those building a kit.



Appendix 3

Anglian 3 component list

Qty	Value	Package	Parts
3	0.5pF	C0805	C35, C37, C52
3	0R	R0805	R14, R29, R31
4	100R	R0805	R5,R11,R35,R13
1	100k	R0805	R25
1	100nF	C0805	C60
1	100nH	L0805	L6
2	100pF	C0805	C6, C41
2	10K	R0805	R9, R20
3	10R	R0805	R1, R10, R30
2	10uF	SMC_B/C	C29,C2
1	116MHz	HC49U-V	Q1
6	145nH	COILCRAFT	L14, L15, L16, L20, L21, L22
3	15pF	C0805	C15, C17, C61
2	150pF	C0805	C9, C13
1	150R	R0805	R12
1	180nH	L0805	L8
2	1N4148	SOD123	D1, D2
5	1k	R0805	R2 R3, R4, R21, R23
23	1nF	C0805	C1, C3, C4, C7, C8, C12, C14, C18, C20, C26, C27, C28, C30, C32, C42, C43, C44, C50, C58, C59, C66, C68
1	1uF	SMC_A/B/C	C64
3	1uH	L0805	L3, L5, L26
1	2.7pF	C0805	C36
2	20pF	CTRIM3018	C5, C10,
1	220k	R0805	R32
2	220nH	L0805	L4, L7
2	2.7K	R0805	R7
4	270nH	L0805	L1, L2, L28, L27
4	3.3pF	C0805	C33, C39, C51, C54
4	390R	R0805	R15, R17, R18, R28
3	39pF	C0805	C11, C62, C63
7	4.7pF	C0805	C34, C38, C40, C46, C47, C55, C57
3	470R	R0805	R19, R34, R36
5	470nH	L0805	L9, L17, L18, L23, L24
2	47R	R0805	R13, R33
1	47k	R0805	R26
1	47nH	L0805	L19
2	47pF	C0805	C19, C70
1	500R	3314G/J	R24
1	560R	R0805	R6
1	560pF	C0805	C23
2	68pF	C0805	C21, C25,
1	78M05	TO252	IC1
3	8.2pF	C0805	C31, C45, C48

3	82pF	C0805	C22, C24, C49	
1	ADE-1H	CD636	MX1	
4	BAP64	SOD323	D3, D4, D5, D6	
1	BFS17	SOT23	TR2	
1	BSV52	SOT23	TR1	
2	MGA30689	SOT89	IC2, IC4	
2	Green	LZ1-00WW03	LD1, LD2	
2	Si2309	SOT23	TR4, TR5	
4	PSA4-5043	SOT343R	IC3, IC5, IC6, IC7	
1	BC807	SOT23	TR3	
1	2N7002	SOT23	TR6	
1	Box	Tinplate		100x64x40mm
4	F/T	1000pF feed-through capacitors		Tusonix 20A
5	SMA	2 hole connectors	SMA female	
1	HS1	Copper heat-sink 10mm x 10mm		
1	1N5401	3A diode	D7	