CW 11W 2·13OA
~~SSB~~ 6W 1·8OA

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80mA - tx, rx, fan no linear
110 mA linear to 300mA bias
70mA - rx only
730
~~8~~mA tx, rx only
130mA + linear bias @ Ø
~~Cut~~ Dun.
2·43A - tx, rx, lin, fan.

Linear Amplifier

Introduction

This kit can be added to increase the output of many Somerset Range transmitters having nominal 1.5 Watt output stages – thus far including the Dundon, Butleigh, Fivehead, and Triton. Because it was originally suggested by Andy Howgate, G7WHM, to whom I am much indebted, the kit is also known as the Howler! It uses two IRF510 MOSFETs in a push-pull arrangement to provide a nominal output of 10 Watts on a 13.8 volt supply. It is connected inside the normal transmitter signal path so it does not include any output RF filtering or TR switching since it uses those of the driving rig. The 50 x 80 mm double sided PCB should be mounted immediately behind the output stage of the driving transmitter with good ground bonding between the two PCBs. The heatsinks are generous to cater for extended CW or SSB operation. It is intended for use on the HF bands, 20m downwards.

Technical Outline

The RF amplifier consists of a single push-pull stage. The circuit is given in Fig. 1.

Supplies The amplifier can use a supply between 9 and 22 volts but I suggest you use it initially on a nominal 12 volt supply to assess dissipation etc.

Amplifier The actual maximum output power is highly dependant on the actual supply voltage. The push pull arrangement helps reduce unwanted harmonics. A small forward bias set by RT1 provides a standing current in the MOSFETs during transmission leading to better linearity. The bias is removed during reception to conserve power for /P operation and to keep the heatsinks cooler. The bias supply is provided by a zener diode fed from the rig's normal high voltage supply; if available, the supply to the zener would normally only be on during transmission. Alternatively the main supply can be used at the point VT with the actual bias being removed (during reception) by grounding the zener output at point 6. (The design includes a optional switch stage TR1 which can be used for this bias control, or to apply a short in the receiver's antenna RF path to prevent any chance of RF feedback in the transmitter.) The high input capacitance of the two 510 gates requires a step down RF input transformer to drive the high capacitance of the MOSFET gates and their low value matching resistors – it is these arrangements which determine the upper useable frequency limit of about 20 MHz. An input drive of about 1 Watt should produce full output but this does decline as the upper frequency limit is reached. (Operation on higher frequencies can only be achieved by increasing the step-down turns ratio with lower matching resistors, leading to lower overall gain and higher drive requirements.) The output RF transformer steps up for matching a 50R load or low pass filter. Both transformers are wound on ferrite toroidal cores. A small amount of negative feedback is included through R8/9 to improve stability and the two gate 'stoppers' R10/11 prevent oscillation in the VHF range!

General Construction Advice

Follow the normal advice given in your Somerset Range rig instructions. The PCB for this kit must be mounted very close to the driving circuits with good RF bonding of the ground planes. Normally the linear will be mounted immediately behind the driving rig. The input and output RF signals are best made by direct unscreened wires laid close to the PCB.

Building the amplifier

The parts layout is given in Fig 2. First check the heatsinks fit into their mounting holes but do NOT solder them in place yet. If necessary, ease the holes with a rat-tail file. Note the desired very close physical relationship between C6 and L2. You may find it best to turn C6 on its side after fitting but do check that the hot lead does not short to the ground plane! Fit the supply parts:-

RT1	10K Preset		C8	10 nF disc	(E)
C1	10 nF disc - 103	(E)	R2	1K BN BK RD	
C4	10 nF disc	(E)	D1	6v2 Zener	
C5	10 nF disc	(E)	L3	10 uH choke - 0080	
C6	10 nF disc	(E)	C7	10 uF 35v electro	

Connect your nominal 12 volt supply to 0 volts and the positive to point V and to the bias positive input VT – check the polarity and switch on; measure the DC voltage on the point 6, it should be 6 volts. Switch off.

If you need the extra 'control' stage TR1 for your application (see later about connection to different rigs), fit this now:-

R1	1M BN BK GN	(E)	TR1	BS170	

This can be tested by temporally connecting point X to point 6. Switch on and the voltage on point 6 should still match its name. Temporally connecting point Z to V or VT should make the voltage on 6 go to zero. Switch off and remove the link between X and 6.

Fit the remaining passive parts:-

R3	100K BN BK YL		R4	47R YL VIO BK	
D2	1N4148		R5	47R	
C2	10 nF disc		R6	47R	
C3	10 nF disc		R7	47R	
R8	1K		R10	10R BN BK BK	
R9	1K		R11	10R	

With the supply to both V and VT, arrange to measure the DC voltage on the junctions of R4/5/6/7. Switch on, the voltage should be adjustable by RT1 to between 0 and 6 volts. Switch off, set RT1 fully anti-clockwise and fit the amplifier MOSFETs.

First assemble the IRF510 TR2 to its heatsink thus; put a 6 BA bolt up through the hole of the heatsink from the narrow side, then put on the insulating washer, then the device, then the small bush and finally the nut. Do the nut up very loosely and 'shuffle' them around (especially the washer) until the bush fits easily through the device hole AND THE washer into the heatsink body; then do the nut up to just grip the parts in place but still not fully tight. Use your multi-meter to check that the device tab is insulated from the heatsink lugs. (If it is connected, release the nut and check the washer has not been pressed inadvertently into the heatsink.) Bend the outer leads of the MOSFET forward a little so that they match the hole pattern in the PCB and offer up to the PCB. First insert all three device leads into the PCB, and then fit the heatsink lugs into the PCB; now carefully turn the whole assembly over so that the top of the heatsink can rest on the bench with the bottom of the PCB uppermost. Use a 25 W iron to solder the heatsink lugs to the PCB while gently pressing the PCB down against the heatsink. Then solder the source lead direct to the topside of the PCB, as shown on the parts layout. Do not also solder the source lead on the underside - then it can be removed more easily if necessary! Finally solder the gate and drain leads on the underside. Now tighten the nut properly – but not excessively! Repeat for TR3.

Now wind the input transformer L1 as shown in Fig. 3. This is a 10:5+5 turn step down transformer wound with 22 gauge enamelled wire on the smaller violet toroid. Each time a wire passes through the central hole of the toroid, it counts as one turn. Start with the centre-tapped secondary. Cut off about 400 mm of the wire and bend it back double in the middle to form the centre tap. Compress the two wires at the bend to form a point. Use a 25 Watt iron to burn off the enamel on the tip and to tin it. (Do not breath the fumes.) Then insert each free end into opposite sides of the core and align the tip so it is pointing away from the centre of the core. Since the ends have each gone through the centre of the core, you have applied one turn of each half of the secondary. Pull the ends tight so that the tip projects about 10 mm from the outside of the core. With each end, put on another 4 turns to make a full 5 + 5 centre tapped winding. The turns should be tight and not spread around the core but with just enough gaps between them to allow the primary wires to sit tightly around the core between the secondary turns you have just applied. Trim the free ends to about 30mm and let them emerge radially from the centre in the plane of the core. Mark them in some manner to distinguish them from the primary wires – double the ends back maybe. Cut off about 400 mm for the primary and slide the core to the middle of it. Place the wire immediately behind the secondary centre tap and then wind on one turn each side of the centre tap tip which is already sticking out. Pull them tight. This wire passes through the centre of the toroid three times so counts as 3 turns. Then put on 4 more turns with one end and 3 with the other end making a total of 10 primary turns. These turns should be interleaved with the existing secondary wires and drawn tight. Let the free ends project radially from the centre in the plane of the core and shorten to about 30 mm. Burn the enamel insulation of all four ends and mount the assembly on the PCB by first installing the centre tap point into the larger hole provided for it. Check that you have properly identified the two secondary outside wires and insert them into the two holes either side of the centre tap; then place the two primary leads into the pair of holes beside the right side of the core (from on top). Solder all leads below the PCB to the tracks and the earthy primary lead to the ground plane. Tidy the wires so they radiate from the core central plane as much as possible.

Repeat in a similar manner for the output transformer L2 as shown in Fig. 4. This is a 4+4:10 turn step up transformer wound with 22 gauge-enamelled wire on the larger violet toroid. Start with the centre tapped primary this time. This needs about 300 mm, make the centre tap point and put on 4 turns each side of the central point. Space them out a little and keep them tight as before. Make sure you can identify them! The secondary needs about 400 mm and is started by placing the first turn immediately behind the centre tap. Because the secondary turns has 10 turns which is more than for the whole primary, there will be a few turns at both outside ends of the secondary which will not have adjacent primary ones. Burn the enamel insulation of all four ends and mount the assembly on the PCB by first installing the centre tap point into the larger hole provided for it. Take care with C6 to ensure that it is not shorting to the ground plane! Check that you have properly identified the two primary outside wires and insert them into the two holes either side of the centre tap; then place the two secondary leads into the pair of holes beside the left side of the core (from on top). Solder all leads below the PCB to the tracks and the earthy secondary lead to the ground plane. Tidy the wires so they radiate from the core central plane as much as possible.

The PCB is now fully loaded and ready for connection to the driving rig.

Installation with the transmitter

This should only be done after the driving rig has been commissioned and is working properly. The Linear has to be installed very close to the transmitter's output stage and low pass filters. The bonding between the ground planes of these different RF sections has also to be very good. Normally the Linear will be fitted immediately behind the transmitter. The two PCBs can be rigidly attached to each other with the two supplied small PCB joining strips, these are soldered vertically across the ends of the joint between the PCBs, direct to both ground planes. In addition, the PCBs should be joined by at least three stout linking wires between the ground planes at about 25 mm intervals between the PCB mounting strips.

There are at least four other electrical connections. The RF is taken from the driving rig after the output stage coupling capacitor but before the low pass filter. It is returned to input to the rig's low pass filter. Some rigs (Fivehead etc) have pads specifically for these connections with a short track between them, which has to be cut when the Linear is added. Other earlier designs may not have these extra pads so it maybe easiest to remove the existing TX output coupling capacitor (usually 100 or 220 nF) and use its holes for these connections NOT forgetting that this capacitor will need to be installed elsewhere at the input to the Linear.

So make the following connections:-

RF input from after the rig output stage capacitor to the point labelled RF IN.

RF output from the point labelled RF OUT back to the input to the rig's low pass filter

Main supply link the V point to the main incoming positive supply of the rig

The bias supply, input to the point VT, should come from a point in the rig which goes to supply voltage during transmission and which can supply a few milliAmps. The relatively high impedance signals, such as the TR electronic switch control signals, should not be used directly. If there is no suitable source then the point VT should be connected to the main V supply and the bias controlled by TR1. This requires point X to be linked to point 6; with a suitable control signal to point X. This has to be low (below about 1.5 volts) during transmission so that TR1 is turned off allowing the bias preset to be active. During reception this control signal must be above 2.5 volts but can be up to full supply voltage. The high value of R1 means that it will not interfere with most existing PTT switch or key circuits.

Suggestions for specific rigs are:-

Fivehead This has a suitable source labelled VT (used to drive the TR relays) for direct connection to the Linear's point VT without needing TR1.

Dundon This needs TR1. The point X is connected to the Dundon point N.

Butleigh This has a suitable source labelled VT (used for driving the relay) for direct connection to the Linear's point VT without needing TR1.

Setting up the Linear

First check that RT1 is fully anti-clockwise. If the driving rig is a phone rig, or a CW rig with some form of RF drive control, set this back to near zero. Connect your dummy load and power output indicator as you did for setting up the base rig. Arrange to measure the supply current to the rig and linear. Switch on and go to transmit; note the current and then carefully increase RT1 until the supply current has risen by about 300 mA (being 150 in each IRF510). Now make the driving rig produce RF, either with its Tune facilities or by whistling etc. Carefully adjust its RF drive control to just below the point where the RF output from the Linear ceases to increase. It should produce full output easily from a 1.5 Watt driving rig and often will need a lower setting for the drive control than that which gave full output without the linear. If the driving rig is a CW one without any form of RF drive control (like the Dundon), then it should be possible to reduce the Linear's standing current (RT1) without reducing the Linear's RF output.

That's all! There are no filters to adjust since all the suitable driving rig's have fixed low pass filters which are also correct for the Linear. Similarly, the TR control uses that of the driving rig. The Linear can take up to 22 volts and will then produce about 15 Watts on 20m but check the driving rig can also take the higher voltage! I hope you enjoy it and as ever, I am delighted to have any comments. Tim Walford G3PCJ Nov 17 2002 & Nov 18 2003

Parts list for Lin-amp

Resistors			Capacitors		
2	10R	R10,11	7	10 nF disc - 103	C1,2,3,4,5,6,8
4	47R	R4,5,6,7	1	10 uF 35v electro	C7
3	1K	R2,8,9			
1	100K	R3			
1	1M	R1	Semiconductors – in anti-static bag		
			1	1N4148	D2
1	10K Preset	RT1	1	6v2 Zener – bent leads	D1
			1	BS170	TR1
Inductors			2	IRF510	TR2, 3
1	10 uH choke - 0080	L3	2	6BA nut, bolt, bush & washers	
1	Small VI toroid	L1			
1	Large VI toroid	L2	Miscellaneous		
1.5 m	24 gauge enam wire	For L1/2	4	Rubber feet	
			2	Large upright heatsinks	
			2	PCB joining strips	
TRN Walford G3PCJ		8/11/02	1	DS Lin-amp PCB	Is 2

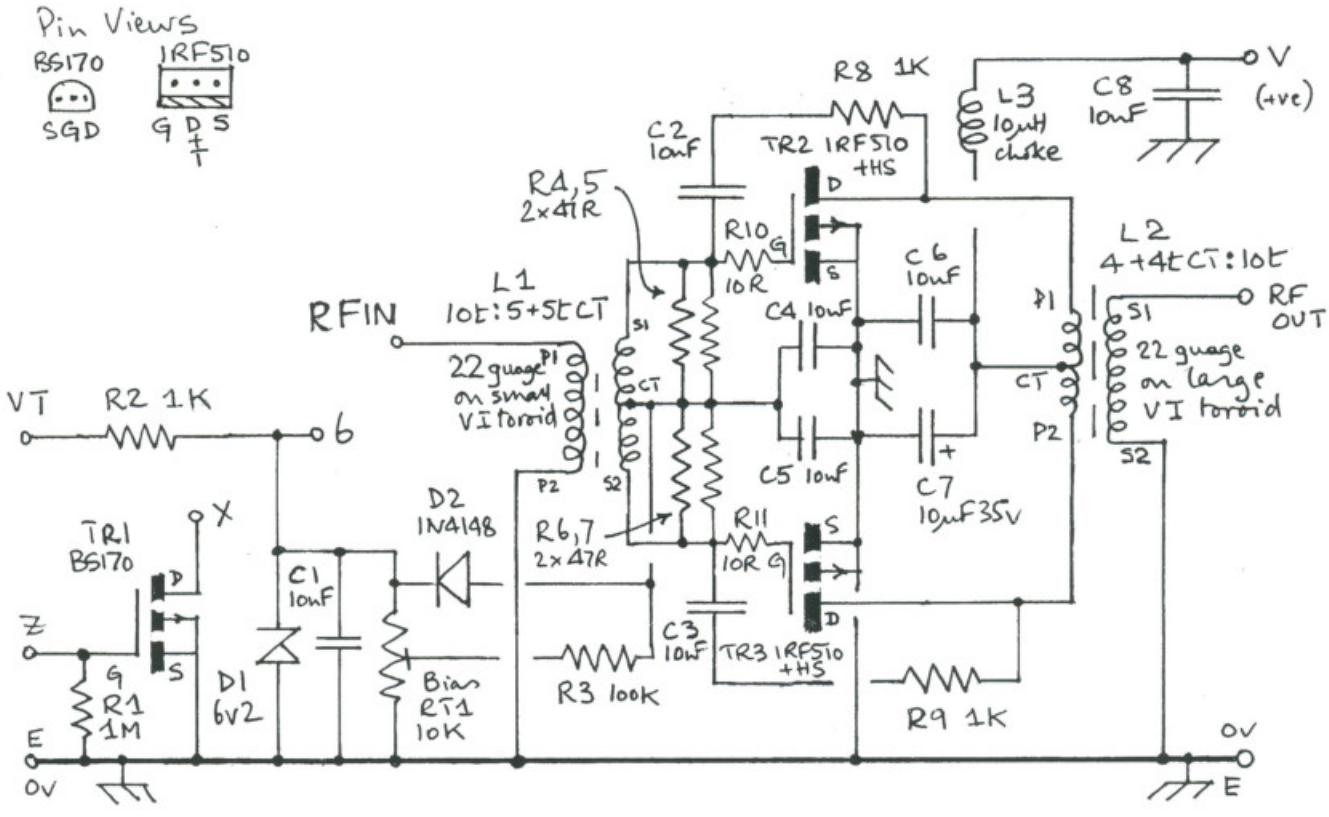


FIG 1: CIRCUIT OF LIN-AMP

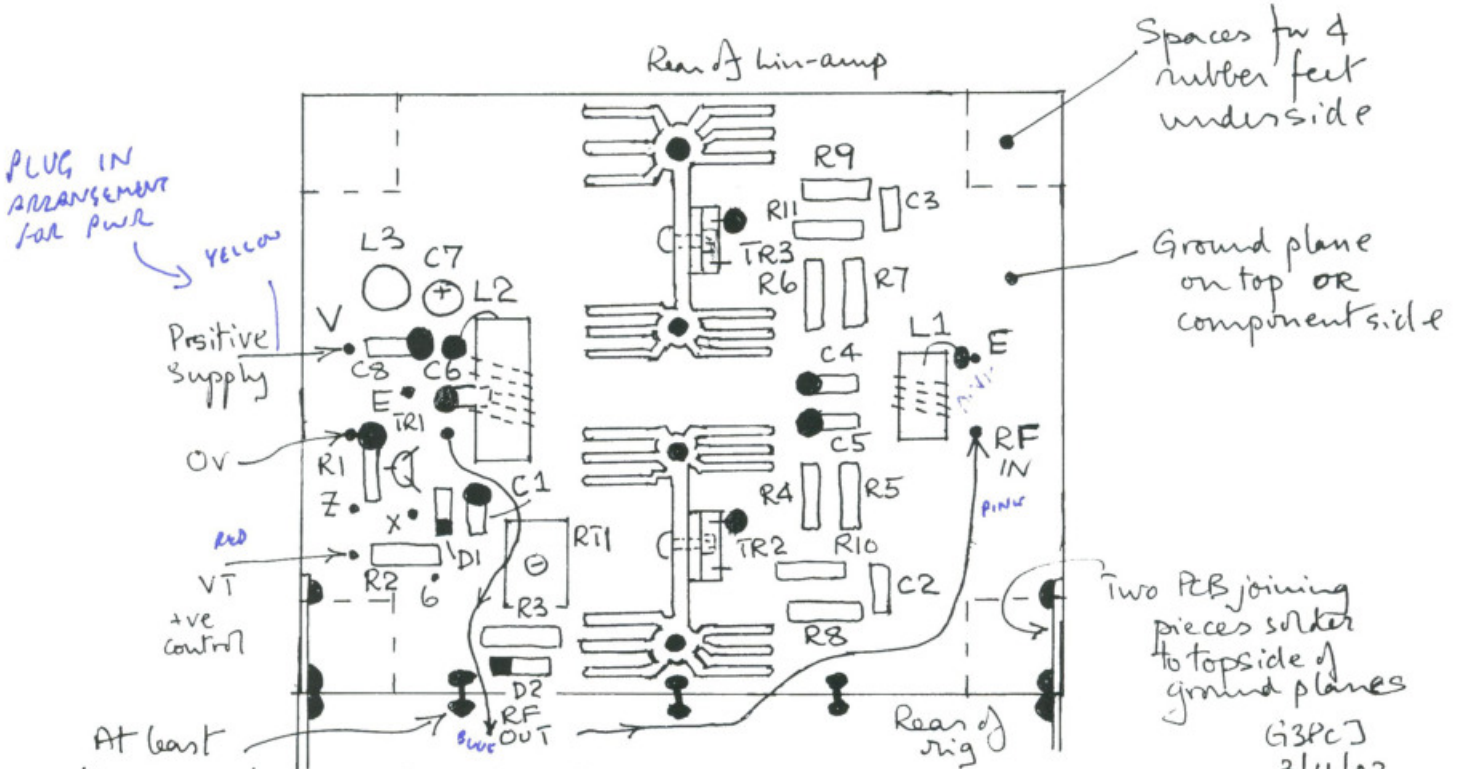
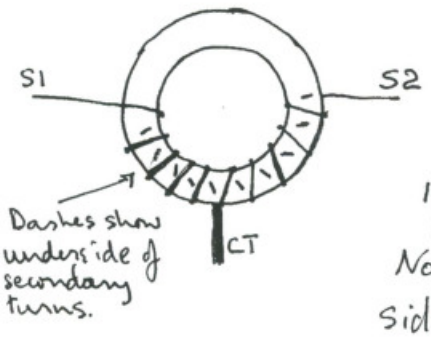


FIG 2: PARTS LAYOUT OF LIN-AMP

- TOP VIEW OF COMPONENT SIDE (Heatsinks Not to scale!)
- LARGE BLACK BLOBS ● ARE TOPSIDE SOLDER POINTS

To increase inductance of L1 increase all turns by 50%
— done with no Brain effect 25/7/10

Small Violet toroid with 22 guage enamelled wire



10t: 5+5tCT
Enlarged!
Not to scale!
Side views.

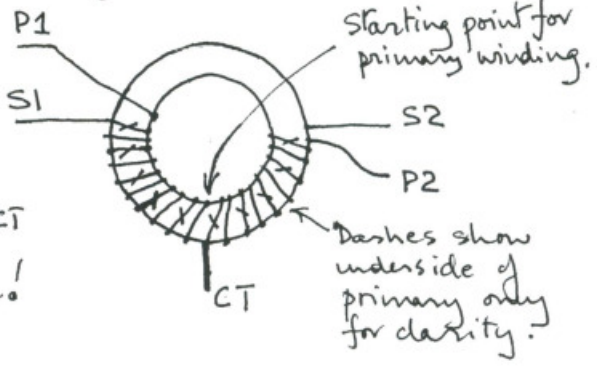
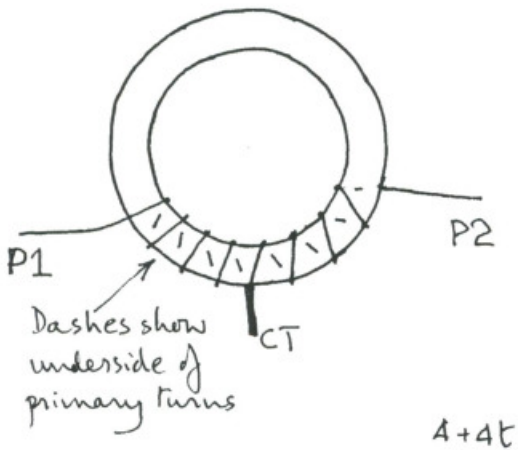


FIG 3A – L1 Secondary only

FIG 3B – L1 With Primary added

Large Violet toroid with 22 guage enamelled wire.



4+4tCT: 10t
Enlarged!
Not to scale!
Side views

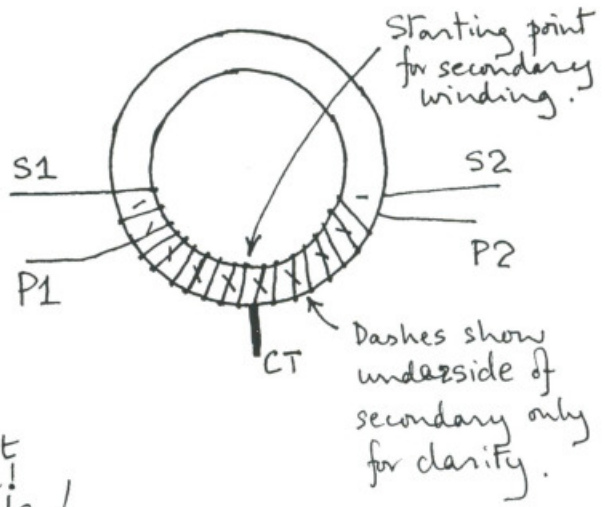


FIG 4A – L2 Primary only

FIG 4B – L2 with Secondary added

G3PCJ 17/11/02