David / The whole "document" may be of interest.

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Regards, Richard

Meter Kit

Introduction

This kit is an optional extra which provides the facilities of a receiver S meter and audio derived AGC, together with a transmitter matching bridge and output indicator. When the S meter circuits are used to feed back the input audio to the rig, there is also an increase in audio voltage gain of x20 but subject to the AGC action. The resistive matching bridge is brought into action by a TUNE relay and provides an indication of reflected voltage from your Antenna Matching Unit. Transmission through this section without the Tune relay on gives an output voltage/power indication.

The kit has been designed primarily for the Bristol TCVR but can be used with any of the Somerset Range of receivers or transmitters, or most other rigs needing such facilities. It is supplied as a 50 x 80 mm single sided PCB which can be cut in two to divide the receive and transmit sections if required. A horizontal style 100 micro-amp edge meter is included for mounting in your rig front panel. For the Bristol, the TUNE relay is controlled by the rig's TUNE switch however other rigs may need a Tune toggle switch. The kit requires a nominal 12 volt supply of a few milli-amps on receive but higher when the Tune relay is on.

Technical Description

The block diagram is given in Fig. 1 and the complete circuit in Fig. 3. Apart from both outputs driving the meter, the receive and transmit sections are separate enabling the PCB to be cut in two if required.

Supply aspects: The kit needs a nominal 12 volt supply. It does not have reverse polarity protection hence it should be finally connected to some section of the associated rig which is already protected. D5 is used to generate a local nominal 6 volt bias supply and reference.

Receive section: The S meter and AGC aspects use a single control loop where the receiver's audio, taken from just *before* the manual audio gain control, is amplified in two stages (IC1B and TR2) to bring it up to a suitable level to operate a detector (D3/4) whose output DC voltage controls an attenuator (R2/TR1) in the audio input. The audio output from IC1B is returned to the rig's manual gain control. Both the audio stages have a nominal voltage gain of 20, so that on weak signals insuffucient to activate the AGC, this kit provides an additional audio voltage gain of times 20. The attenuator formed by R2 and the BS170 MOSFET TR1, just begins to reduce the signal when the DC control voltage on the gate of TR1 starts to turn it on. This happens when the gate voltage rises above about 2 volts causing the audio voltage driving the detector to stabilise at near 2 volts p-p. This implies that the audio voltage fed back to the rig from the output of IC1B also stabilises at 2 volts divided by the gain of TR2 (x20) or 100 milli-volts p-p. This output level will occur for an input of 100 mV divided by the gain of IC1B (x20), implying that AGC action will commence on audio input signals of 5 milli-volts p-p upwards. This analysis assumes perfect diodes so in practice the signals will be a little larger at the onset of AGC. The audio bandwidths are set for 300 Hz to 3 KHz with C2 feeding a 4K7 AFG pot. The diodes D1 and 2 provide a clipping action against extreme noise spikes which might otherwise desensitize the AGC. IC1B is arranged as a conventional op-amp gain stage whose gain is defined by R5 divided by R4. Similarly, the gain of TR2 is R7 divided by R8.

The gate turn characteristics of the BS170 used for TR1 are pretty abrupt so that only very small control voltage changes are involved for a wide AGC range. Hence the need for a DC amplifier (IC1A) to raise these to the nominal 10 volts FSD for the meter implied by its scaling resistor R14. RT2 sets the DC gain of IC1A (roughly times 20) to achieve full scale deflection on your S9 plus plus signal! RT1 is used to adjust the DC offset or zero signal input reading of the meter. The output of the TL072 used for IC1 cannot go below about 0.9 volt so there is often a small residual meter reading - adding a second diode in series with D6 will reduce this if required. During transmission, the rig's muting circuits should prevent any audio coming the meter kit hence this kits AGC control voltage will decay to near zero so that it does not interfere with the DC output voltage from the transmit section applied through D8.

Transmit section: This section serves as matching bridge and output indicator. A resistive matching bridge is used to measure when the load presented by your matching unit is 50 Ohms resistive. The bridge is brought into action when S1, or your rig's Tune switch, turns on the relay RL1 to bring the resistors R16 to 21 into circuit. When the relay is *not* on, the meter indicates the output RF voltage (or 'forward' reading) but because the bridge will have just been used to set the load to the standard 50 Ohms, the meter can also be calibrated in power (with a square law scale). With the relay on, for the 'reflected' meter reading, the bridge works by D9 comparing the RF voltage across R20/21 with that across the line to the antenna matching unit obtained via C11; if the load is 50 Ohms resistive, then the voltage difference across the bridge will be zero because all four bridge 'resistors' are equal at 50R - hence no meter reading. For other antenna line load impedances, the bridge is unbalanced and there will be a reading. RT3 is used to adjust the meter reading to full scale for rig full output into an external 50 Ohm dummy load. With the bridge in circuit, the maximum meter reading will always be near half the full RF ouput voltage, and only one quarter of the tranmitter power is radiated. Since the technique is to adjust the AMU for minimum meter reading, the maximum half scale reading is of no consequence. (Avoiding this quirk would complicate things appreciably!) Given that R16 to 21 are 1 Watt resistors, the bridge can handle up to 20 Watt transmitters for short periods with care! With the bridge in circuit, the load presented to the transmitter is between 33R and 100R no matter what is, or is not, connected to the bridge output - hence there will always be a safe load on the transmitter while tuning up the AMU.

Building the Meter Kit

Since you are likely to already have a Somerset Range rig, the general advice on construction matters need not be repeated. This PCB is single sided so all components are soldered on the non-component side only. Before starting assembly decide how you will mount the kit and carefully drill any mounting holes if required. There are suitable spaces in the four corners. In addition you can cut the PCB into two lengthwise sections along the unconnected central 'cutting line', this may allow you to mount the two sections nearer to the associated aspects of the rig. If you do cut it in two, trim back the ends of the cut track linking the points D, and the other track linking the V+ points, so that they won't short to any metalwork or ground planes. Alternatively, you can mount the PCB by soldering the ground track (or sections of it), which runs around the outside of the PCB, to the main ground plane of the rig - possibly using some small PCB offcuts as braces. If the available space is limited and it has to be mounted ontop of the rig PCB, make sure that all presets on both the rig and this kit can be accessed. For an 'open' style Bristol, the kit can be secured to the top of the heatsink, using an insulating spacer between heatsink and PCB, by a self tapping screw carefully positioned on the centre line near C11. Lead lengths are not critical but keep them as short as is reasonably convenient.

Cut a mounting hole in your control panel for the front part of the meter. It is fitted from behind the panel and can be secured either by the supplied clamps or by a wire loop soldered tightly over each side lug to the copper backside of a PCB front panel.

The parts layout is given in Fig. 2 - this has been drawn as though the two sections were separated for clarity only. Remember that if you are in any doubt about the correct holes for a part, that you should check that it links to other parts as shown on the circuit diagram in Fig. 3. Start assembly with the presets and supply aspects:-

RT1	10K preset		R11	4K7	
RT2	100K preset		R12	4K7	
RT3	10K preset		C5	10 uF 35v electro	
R6	220R		C9	10 uF 35v electro	
R10	1M		D5	6v2 Zener	

Arrange for a nominal 12 volt supply to be connected positive to the V+ pad on the Receive PCB section and negative to the 0 volt track around the outside or the E point. Check the polarity before turning on. Measure the DC voltage at the point labeled 6 with respect to 0 volts - it should be near 6.2 volts. Switch off and fit the parts associated with the audio amp:-

R1	4K7		C2	220 nF Polyester	
R2	100K		C3	470 pF disc	marked 471
R3	1M		C4	220 nF Polyester	
R4	4K7		D1	1N4148	
R5	100K		D2	1N4148	
C1	220 nF Polyester		IC1	TL072	

Temporally connect the audio output from the point O to a suitable audio amplifier (Hi-Fi etc.) or the hot side of the rig's audio gain control (after removing the feed from the RX's earlier stages). Don't forget to also make a ground or 0 volt connection to the point E. Switch on and measure the DC voltage on the output pin 7 of the op-amp IC1B or the top of R5. It should be the same as the '6' volts measured on point 6 above. Now do the 'hum screwdriver finger' test! Wind the rigs audio gain control up and put your screwdriver, with finger on it, to the meter kit input point I - there should be some sort of rough noise or hum! Switch off and fit the second audio amp associated with TR2:-

R7	4K7		C6	10 uF 35v electro	
R8	220R		C8	220 nF Polyester	
R9	4K7		TR2	BS170	

Alter the Meter kit end of the temporary audio input to the rig from point O to the junction of D3/D4/C8 on the track side. Switch on and measure the DC voltage on the TR2 drain end of C8 - it should be about 4 volts below the supply voltage at around 9 to 10 volts for a 13.8 volt supply. Then repeat the hum finger test on the input point I - take care as the sound should be louder! Switch off and fit the AGC detector and attenuator parts:-

C7	10 uF 35v electro		D4	1N4148	
D3	1N4148		TR1	BS170	

Now reconnect the audio input to the rig (or Hi-Fi) to the Meter kit's proper output at point O. Switch on and try repeating the finger hum test but also vary your 'input signal' by adjusting finger pressure on the screwdriver. Since this is not too scientific, you might prefer to use an audio signal generator if available. Despite altering the input level, the audio output in the LS should now be almost constant (providing the input is more than about 10 milli-volts p-p). Don't worry too much if this test is inconclusive! Switch off and add the S meter parts:-

R13	220R		D6	1N4148	
R14	100K				

If you have cut the PCB in two, temporally connect the two points marked D. Connect your meter positive to the point M and the meter negative to any E point or the 0 volt track. Set both RT1 and RT2 to approximately mid position. Switch on and adjust RT1 so that the meter just begins to move off its least negative reading. Note that since the output of the TL072 op-amp cannot go below about 1 volt there may always be a small residual reading of the meter. (If this is seriously annoying try adding a second 1N4148 in series with D6!) You can now experiment with your input signal and see if the meter moves up. RT2 will alter the high end scale readings - both presets are set properly after connection to the rig.

Proceed to the transmitter section TUNE relay:-

RL1	12v DPCO relay		D7	1N4148	

Assuming you have the nominal 12 volt supply still connected, switch on and check the relay clicks on when you ground the point marked TU. (Remember to link the two V+ pads if you have cut the PCB in two.) Now fit all the remaining matching bridge parts:-

R15	4K7		R21	100R 1W	
R16	100R 1W		C10	10 ,uF 35v electro	
R17	100R 1W		C11	220 nF Polyester	
R18	100R 1W		D8	1N4148	
R19	100R 1W		D9	1N4148	
R20	100R 1W				

It is not quite so easy to test this section. If you have a suitable source of several volts of RF, such as another HF CW QRP rig, you can connect the ANT and E terminals across a dummy load connected to the TX output. (Without other connections to this kit, the input impedance of the RF voltmeter section is several K so it can be connected directly across a 50R load.) With the other rig producing RF, the meter should read positively with the deflection dependent on RT3. The Tune relay should NOT be on for this test. It is now best to fit the PCBs properly to the rig, so remove all temporary connections.

Connection to the rig

Bearing in mind where you will eventually mount the PCB(s), cut suitable length wires and make the following connections. Do not yet mount the Meter kit PCB(s) as this is likely to deny underside access. Mount the meter, and TUNE switch S1, if the rig does not have one.

0 volts, link point E to any convenient nearby rig groundplane - this is a safety feature. If the PCB has been cut, this should be short and thick.

Supply, connect the point V+ to a suitable source in the main rig, maybe on the front panel.

Audio input, alter the rig wire currently feeding pre-amplifier audio to the rig's audio gain control - re-connect it to the Meter kit input point I. Use a longer wire if necessary. In the Bristol this wire comes from point F at grid F3.

Audio output, connect the Meter kit output point O to the clockwise (now unconnected) end of the rig's audio gain control.

Meter, connect the meter negative terminal to a nearby 0v point or ground plane. Connect the Meter kit output point M to the meter's positive terminal.

Control, connect the Meter kit point TU to the rig's Tune switch. (This can be directly in parallel with any other lower voltage rig control signal provided that signal has an isolating diode in series as for the TU point in the Bristol.) If a new TUNE switch S1 is being fitted, connect its other contact to 0 volts.

RF signals - if this kit is being used within a rig you might wish to permanently connect it in the RF route between the rig's antenna connector and the internal circuits such as the TR relay - if so cut this track near the antenna connector. If you are using low pass RF filters, it should be connected between them and your AMU. The RF connections between rig and Meter kit are best made with miniature 50R coax earthed nearby at both ends. Connect the rig or low pass filter output to the Meter kit point TX and connect the output connector (leading to your AMU) to the Meter kit point ANT.

If the Meter kit PCB has been cut in two, link the two V+ pads, and then also separately link the two meter drive points marked D.

It is important that the rig's muting circuits should act on the circuits *before* this kit, in order to prevent any transmitted audio (or TR transients) from desensitizing this kit's AGC immediately prior to reverting to reception. The Bristol has suitable arrangements but do check this aspect for other rigs. If in any doubt, consult me. If the muting circuit applies either an electronic or relay short across the AFG pot slider, it can usually be changed to the AFG input and hence across the input to this kit.

Adjustment of the Meter kit's presets

Receive section The settings for RT1 and RT2 only affect the S meter functions so, having connected it as above, the rig should function normally but now with AGC action so that suddenly tuning onto a strong signal does not knock you out of your chair! There is nothing to adjust for the audio or AGC aspects. With RT2 at about mid position and no antenna input signal, adjust RT1 so that the meter is just about to move off its lowest reading. Now tune onto what you consider to be a typical S9 signal and adjust RT2 so the needle is on about calibration point 8. Remember that very few S meters give dependable quantitative information on the input signal strength; they are often non-linear with readings that vary from band to band for the same RF input signal level. However they are useful for

comparative measurements done close together in time. I suggest you set it up for your favourite band. There is some interaction between the settings of RT1 and RT2 so do experiment well before making any marks on the meter. If you have a signal generator with a good attenuator, set it to produce 50 micro-volts RMS across a 50R load (-73 dBm) which is the usual definition of an S9 signal. Experiment with RT2 to find the best meter position for the S9 point with various input signals and bands. Then mark this S9 position; each 6 dB change in input level usually corresponds to one S point.

If you wish to use only the S meter aspect, and not have the AGC action on the rig's audio, then only connect the rig's audio (from the clockwise tag of the AFG control) to the input point I. Remove R1 as this will be in parallel with the AFG pot. Leave the Meter kit output point O unconnected. You may find it harder to find a good compromise point for the best S9 indication. 18/4/

Transmitter section Firstly connect your dummy load to the ANT terminals, and then with the Tune relay off, go to CW transmit on your favourite band. The meter should read positively allowing you to adjust RT3 for full scale deflection. Key up and turn on the Tune relay, if the rig is not already producing RF, press the key - there should be no deflection of the meter because its reading the correct zero reflected voltage for this properly matched 50R load. (Note! The lowest meter reading will always be that set by RT1. Also see the earlier note about adding a diode in series with D6 to reduce this further.) If you now disconnect the dummy load and then produce RF with the Tune relay on (so that there is a safe but not ideal load on the TX!), the meter will read around the theoretical half scale - often a little higher as the TX load impedance is actually nearer 100R. Alternatively, shorting the ANT output will give a 33R load and just below half scale reading. With a real AMU/antenna connected, with Tune on, you adjust the AMU controls for least meter reading so the maximum half scale reading is of no real consequence!

With the matching bridge out of circuit, the meter indicates RF voltage (linearly) on the TX feed line when transmitting, but since you have just adjusted the AMU to present a 50 Ohm load to the matching bridge and rig, the meter can also indicate RF power output but this will be with a square law scale.

Remember that when you are adjusting the matching controls, it may not be possible to get the reflected meter reading right down to zero owing to unwanted harmonics which are reflected by a resonant AMU and the antenna. The dummy load connected directly on the bridge output can absorb all the harmonics, because it is not frequency conscious, so the meter will read 'zero'. Fitting a suitable low pass filter (see the Somerset Range catalogue!) between rig and matching bridge will remove the harmonics and should enable a 1:1 match for dummy load or AMU plus antenna.

If you find that your rig does not produce enough RF output for full scale with RT3 fully clockwise, it is best to reduce R15 - try 1K for a 1 Watt rig but it will waste proportionately more power. The 4K7 value for R15 is suited to a 5 Watt TX output and least wasted power!

That's all there is to do! Enjoy using it!

Tim Walford G3PCJ August 5th 2000

Parts List for the Meter kit

Resistors			Capacitors		
6	100R 1 Watt - Brown	R16 to R21	1	470 pF - 471	C3
3	220R	R6, 8, 13	5	220 nF Polyester	C1, 2, 4, 8, 11
7	4K7	R1, 4, 7, 9, 11, 12, 15	5	10 uF 35v electro	C5, 6, 7, 9, 10
3	100K	R2, 5, 14			
2	1M	R3, 10	Semiconductors		
			8	1N4148	D1,2,3,4,6,7,8,9
2	10K Preset	RT1, 3	1	6v2 Zener	D5
1	100K Preset	RT2	2	BS170	TR1, 2
			1	TL072	IC1
Miscellaneous					
1	Small DPCO 12v relay	RL1			
1	100 uA edge meter	M1			
1	Single sided PCB	Issue 1			
1	SPCO toggle	S1 - For rigs without a Tune switch			
	TRN Walford G3PCJ	Aug 4th 2000			

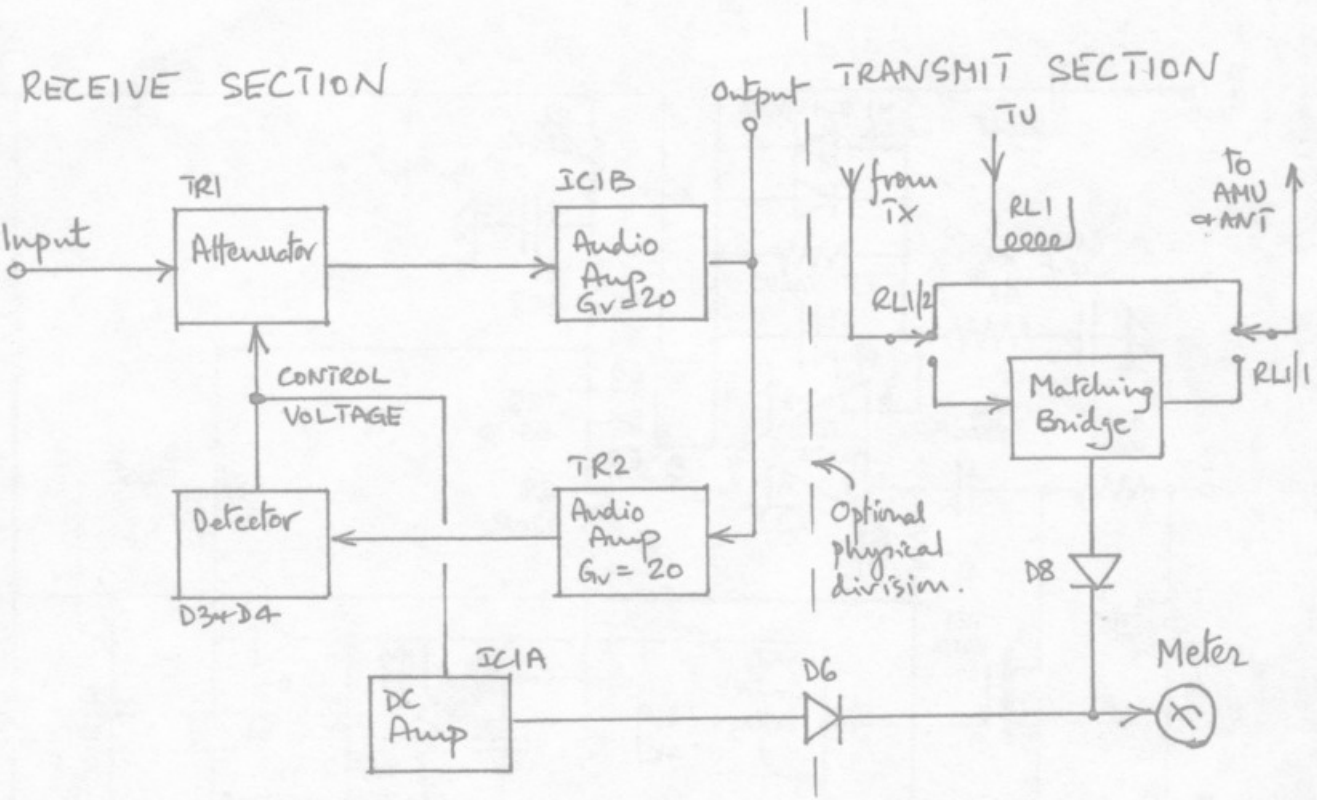


FIG 1: BLOCK DIAGRAM OF METER KIT

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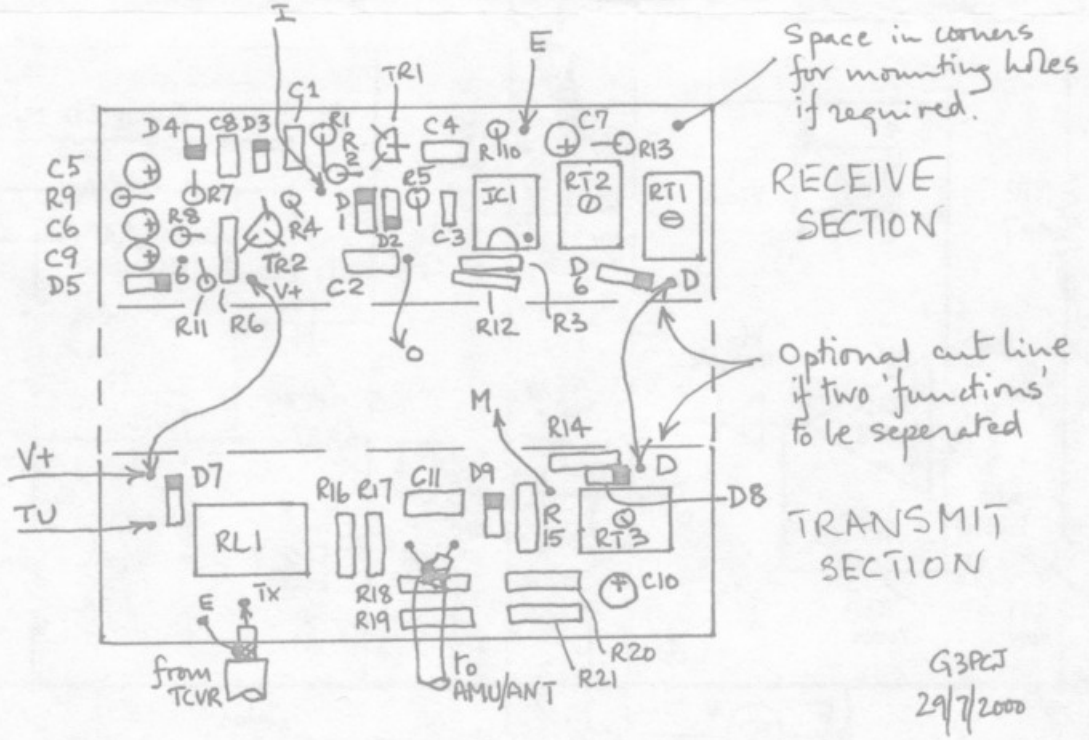


FIG 2: PARTS LAYOUT OF METER KIT

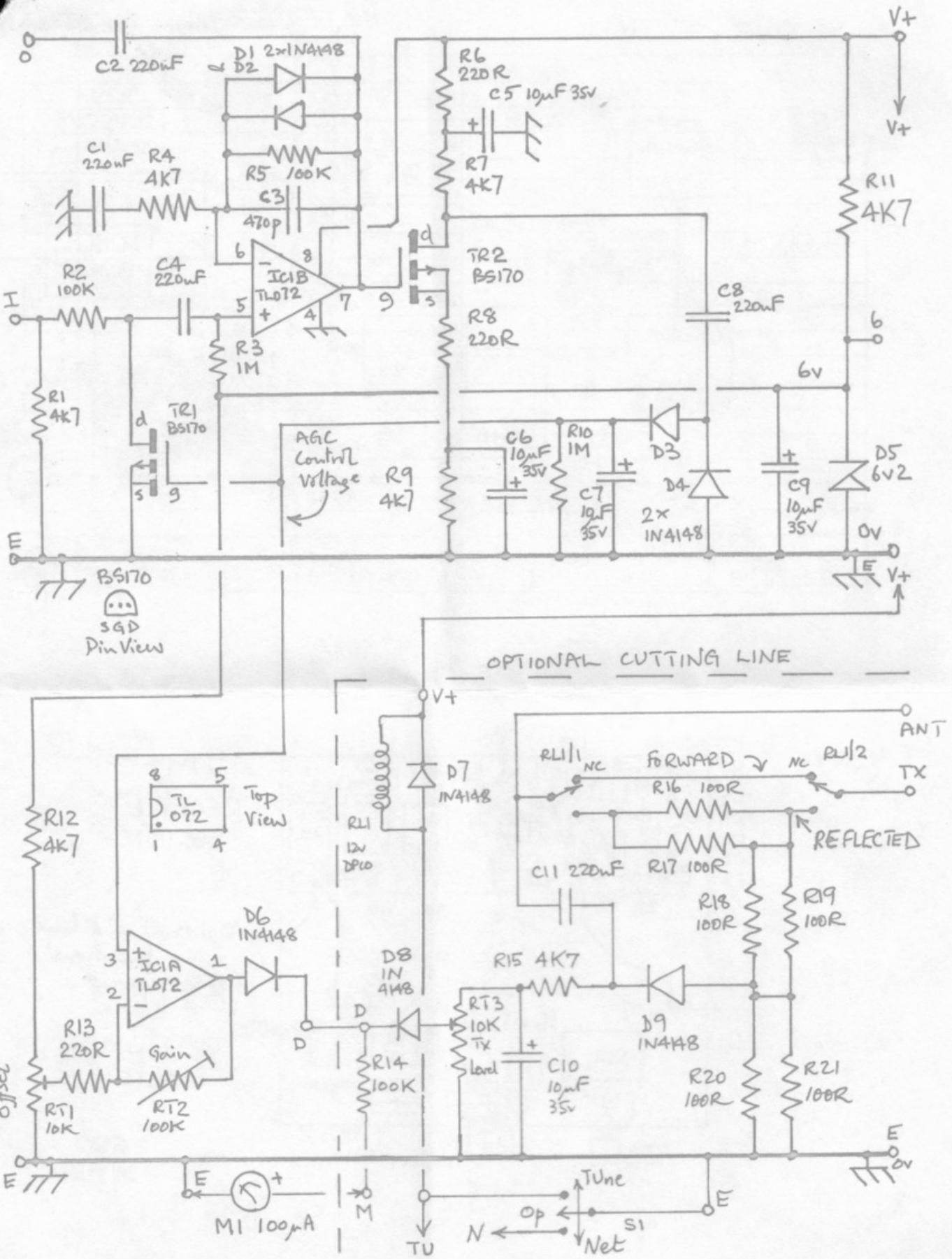


FIG3: CIRCUIT OF METER KIT

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