An SWR Meter for the Blind – and everyone else!

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Introduction

This article describes an SWR meter which measures SWR from 160 to 6 metres at power levels from 10 to 100 watts.

It is based around the "Stockton Bridge" which is a beautifully simple circuit completely lacking in any of the usual tweaks and fiddles which occur when setting up competing bridge circuits. This bridge was developed by Warren Breun of the Collins Radio company in the 1960s and came about as result of his general investigation into RF measurement bridges. Many of these circuits were patented and it is only in about the last twenty years or so that this bridge has become general public knowledge.

Like all SWR measuring circuits, it outputs two dc voltages which represent forward and reflected power in the system being monitored.

The development of this project commenced when a blind friend asked whether I could modify one of my two previously published antenna analyser designs to speak. I thought about this for some time and came to the conclusion that such an instrument would be useless for tuning antennas. There are designs around which output SWR data in Morse Code or speech but imagine trying to use such an instrument to tune a sharply

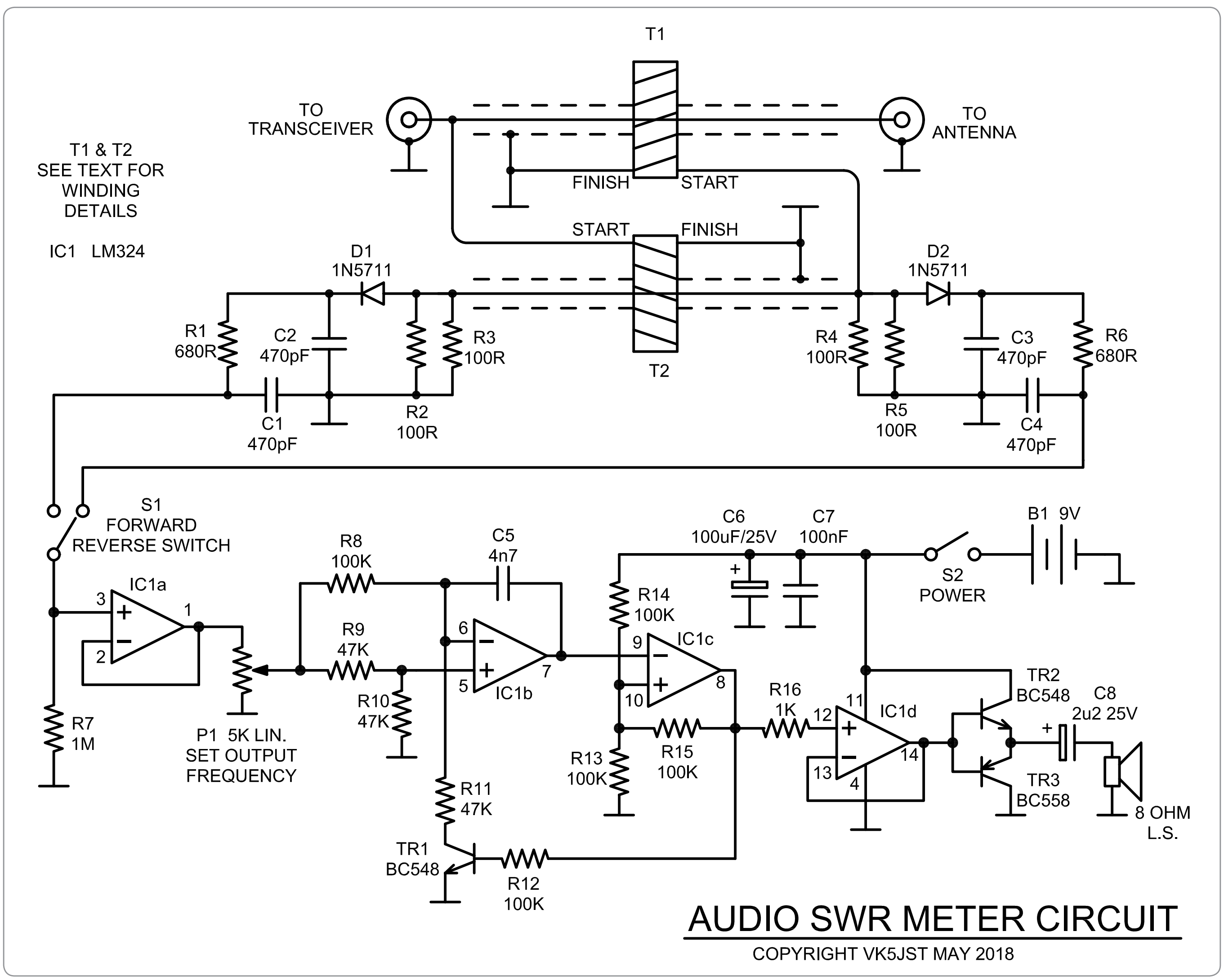

Figure 1: The circuit diagram of the project.

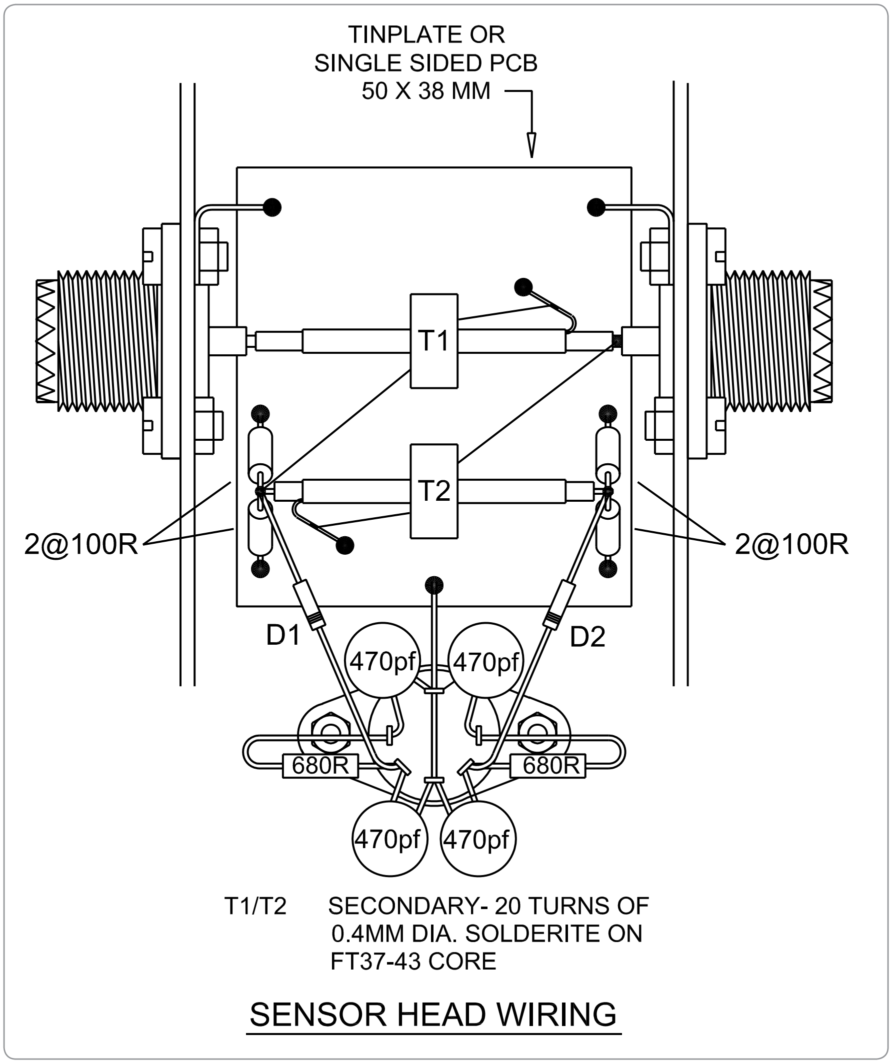

Figure 2: Component overlay for the sensor head.

resonant antenna system containing say a Z match or a magnetic loop while the instrument babbles away. Confusion can be the only result as the time taken to announce SWR is too long to let the user know exactly where they are sitting on the sharply varying SWR curve.

And so this design came about. The user is provided with instantaneous feedback on the SWR by coupling the dc outputs of a Stockton Bridge to an audio VCO to produce audible tones. At 100 watts, the dc output of the bridge representing forward power is around 2.0 volts and this can be used to set the output of a VCO to say 400 Hz.

When the SWR of the system being measured is infinity, both dc outputs of the bridge will be 2.0 volts dc. As the SWR of the system falls, so too does the dc output representing reflected power, which finally reaches zero when the SWR is 1.00. At this point the VCO output frequency will also be zero.

So in summary, at an infinite SWR, the VCO output is 400 Hz, and at an SWR of 1.00, the VCO output is zero. But how can we calibrate this sliding frequency scale?

In a standard SWR meter which displays SWR on a moving coil meter, full scale, which is set by the user during calibration, represents an infinite SWR. An SWR of 3.0 appears at half scale, while an SWR of 1.5 appears at around 25% of full scale. An SWR of 1.2 appears at approximately 12% of full scale. These three different SWR readings occur as the dc voltage applied to the meter circuit (representing reflected power) progressively halves. If we apply these same changes in reflected voltage to a VCO, an SWR of 3.00 will generate 200 Hz, an SWR of 1.5 causes a 100 Hz output, and an SWR of 1.2 gives a frequency of around 50 Hz. These are musical octave steps and it does not take much training to recognize such steps. Of course 5 Hz (a few clicks a second) represents an SWR so close to 1.00 as to not be funny. And the frequency representing an infinite SWR does not have to be 400 Hz. The user can set this to whatever is convenient.

So there it is – a meter with a calibrated musical scale which instantaneously represents SWR which can be used with very little training.

General

The instrument is deliberately constructed in two halves, with the Stockton Bridge measurement head being the first half. Note that this head is a universal element which allows remote monitoring of an antenna system at considerable distances.

Coupled with a standard analogue meter, it can be used to form a standard SWR meter. Teamed up with a micro-processor and LCD, it can form an SWR and Power meter. Another application when used with a microprocessor is to generate automatic ATU designs for either standard wire antennas or magnetic loops. And finally when used with an audio VCO, we have the current design.

The second part of the instrument is the VCO unit and to save precious magazine space, only the component overlay for the VCO printed circuit is given. No details for the VCO box are published as the wiring of this section is completely non critical.

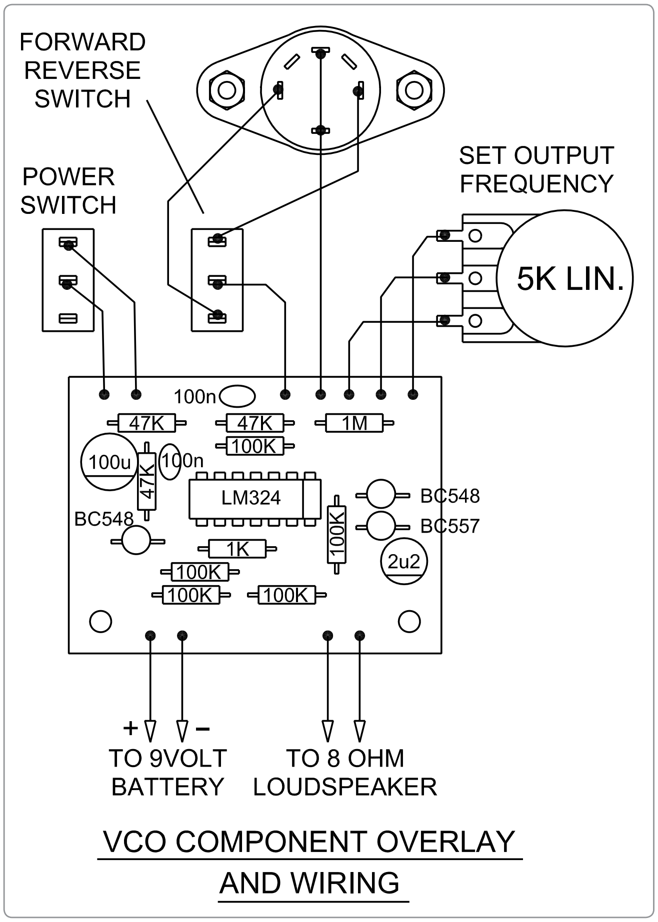

Figure 3: Component overlay/wiring for the VCO unit.

Circuit operation

The only part of the circuit worth describing is the VCO unit. First, note the input switching that allows the VCO circuit to be driven by either of the two detector head dc outputs which represent forward and reflected power. IC1a acts as a buffer amplifier (gain of 1) to provide the measuring head detectors with a very high impedance load. The input to the VCO circuit from IC1a can be adjusted by the user with P1 to give a suitable output frequency to represent forward power. IC1b and IC1c form the VCO, giving a square wave output at pin 8 of the LM324, which in turn is buffered by IC1d. High current loudspeaker drive is provided by TR1 and TR2 which provide a high amplitude square wave at their emitters. To maximize battery life and make very low frequencies easily audible, this square wave is differentiated by using a very small value of coupling capacitor to the loudspeaker (2.2 uF). The loudspeaker is consequently driven with a series of very narrow spikes and the result of this bit of unusual practice is to limit total circuit current to around 1.5 mA at low frequencies (a few Hz) and about 15 mA max at around 400 Hz. The total maximum power input to the circuitry at high frequencies is thus limited to just 135 milliwatts (9 volts x 15 mA) but the audio output is more than adequate.

Construction

First, mark out and drill all holes in the boxes. Pilot drill all holes first, using a drill of around 1.5 mm diameter. A small diameter flexible drill like this will self-centralize in the marking out pricking in the plastic if a long length of drill is left protruding from the chuck. Then drill all holes to size to suit your components. Using an ordinary metal drill to drill plastic is exceedingly dangerous because the high positive rake angles used on the cutting edges will cause the drill to dig in and grab, wrenching the box from your hands or the holding fixture, probably damaging both you and the box. To safely drill plastic with standard drills, reduce the rake angle to zero using your bench grinder and drill slowly.

When all case work is complete, assemble the measurement head first. First, cut two pieces of RG178 coaxial cable to a length of 40 mm (this type of coax. prevents shorts during soldering because the Teflon inner will not melt). Remove 14 mm of the outer covering at one end and twist all the exposed shield wires together to form a 14 mm long pigtail. Next push the inner back through the shield to give equal lengths of inner protruding at each end of the cable, and then strip about 3 mm of insulation from both ends of the inner. Tin the pigtail and both ends of the inner.

Next, wind 20 turns of 0.4 mm diameter wire on to two FT37-43 toroids (from TTS Systems or Minikits), carefully winding both in exactly the same direction and noting start and finish of each winding. Then assemble the coaxial cables and toroids to form two identical assemblies with the toroids in the centre of each length of coaxial cable. Solder the winding finish on each toroid to the 14 mm long cable pigtail on each assembly.

Twist the ends of two sets of 100 ohm resistors together to form two “A” shaped structures, cutting the resistor leads at the bottom of the “A” to around 5 mm long. Solder each of these structures on to opposite edges of the printed circuit board or tin plate baseplate (38 x 50mm); 2 mm in from each side and about 20 mm up from the bottom end of the baseplate. Mount one of the cable/toroid assemblies on the top of these two resistor supports as shown in the assembly drawing, and solder the coax pig tail to the copper surface of the PCB. Insert this assembly into the box.

Next, insert the DIN socket into its hole in the case end, allowing it to rotate and then add the two 680 ohm resistors, four 470 pf capacitors and the flying ground lead **before** you screw the socket into final position.

Now add the two type N or SO239 sockets to the case sides, using 3 mm screws, spring washers, nuts, and two 3 mm bore solder tags. Note the position of these solder tags on the assembly drawing. Each socket has one solder tag on a bottom screw, providing connection from the

Photo of the rear of the finished units.

Driving the Beast

Connect the sense head into your system between your transceiver and ATU. Set the VCO to sense forward power and switch everything on. To avoid audio feedback which will generate some very odd noises, use an UNMODULATED carrier (CW, RTTY, or AM with zero mic. gain) and set the audio output frequency of the unit to something which suits you. Switch to sense reverse power and adjust your ATU to produce the lowest frequency possible (a few Hz hopefully). You are now tuned up!

socket to the baseplate and hence a continuous connection between the sockets. Keep the solder tags flat while mounting the sockets.

Bend the two solder tags around as shown and solder them to the base plate to keep it in position. Solder the flying earth lead from the DIN socket to the base plate. Add the second cable and toroid assembly, soldering each end of the coax inner to the central pins of the N /SO239 sockets and also soldering the coaxial pigtail to the base plate. Add the two diodes and connect the toroid winding starts as shown in the assembly diagram.

Make up the 3-wire connecting cable between the two boxes to the length you want and you now have a good SWR meter. Congratulations. You can now annoy yourself and the neighbours with high frequency whistles and obscene low frequency noises.

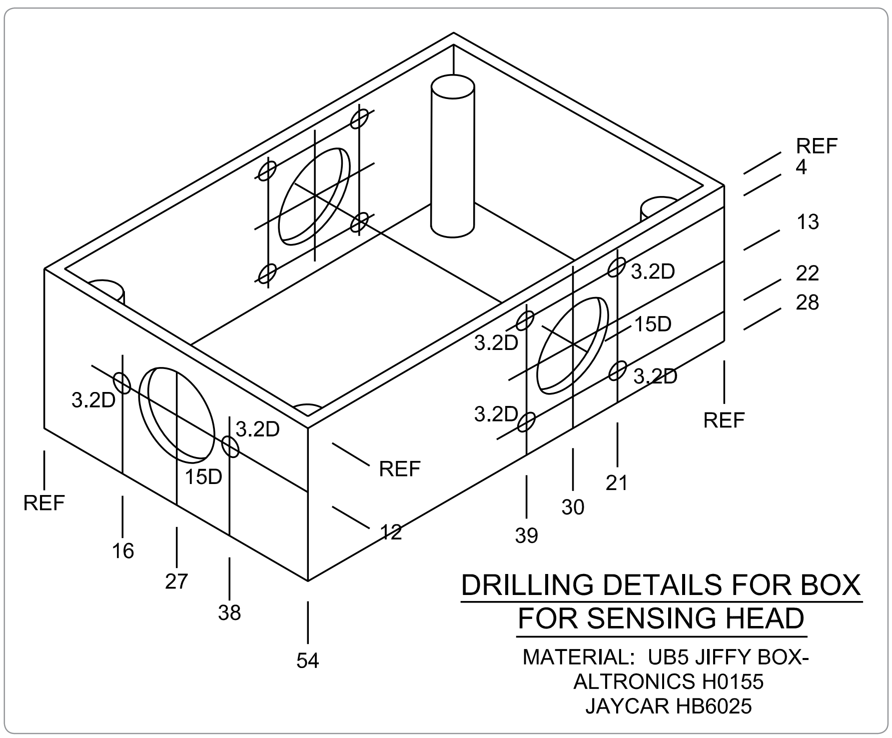

Figure 5: Sensor head box details.

Finally

PCBs are available from the author for $3.00 plus postage.
For quantities of over 10 for club projects we can negotiate.