AN RF AMMETER

James Brett G0TFP says that by looking back to the time when 'Aerial current' was used as the indicator for antenna system efficiency, instead of an s.w.r. meter, you could improve your station.

There was a time, before coaxial cable feeder was generally used in Radio Amateur stations, when output power and general antenna system efficiency were gauged by the amount of r.f. current flowing in the antenna circuitry.

In the early days of radio 'aerial current' was an important measurement to be observed. Just look at Second World War military equipment, the ammeter used for this purpose was often an hot wire type, with the antenna system current flowing through a short section of thin wire within the ammeter.

Mechanical Instrument

Such a mechanical instrument as the hot wire ammeter, shown in **Fig. 1** and hot wire thermocouple ammeters are not now generally available. The design presented here, is based on the technique of a current transformer, feeding a moving coil meter, calibrated to read root mean square (r.m.s.)* current, via a rectifier.

(* *The r.m.s. value of a sinewave is the mathematical derivation of the effective d.c. voltage that produces the same power in the load as a sinewave with a known peak voltage.* **Editor**)

The heat generated by the actual current flowing, caused the length of the wire to extend slightly. This slight extension was magnified via a pointer, and used on a scale, as an indication of the r.f. current passing into the feeder system and so to the antenna.

Consider what this current flow can show. In tuning up and loading antennas, it follows that the more current flowing into it the better. More current means a stronger magnetic field and hence potentially more signal radiated.

The r.f. ammeter can also be used for transmitter power output measurements. Working in to a matched dummy load or tuned and correctly matched antenna, which can be also considered as a pure resistance, measurement of the current will indicate the power.

For example with a 50Ω load and a with a measured current of 0.5A flowing, power (given by $I^2 R$) is 12.5W. Interestingly a current of 1A flowing in a 50Ω load, represents a power 50W.

With the lower h.f. bands and antennas that were often random length, measurement of current in the antenna was the easiest solution to maximising output. Using the r.f. current ammeter this approach can be repeated and other experiments with long wire antennas made.

Circuit Diagram

The circuit diagram of my current meter, is shown in **Fig. 2**. One big advantage of this approach is its tolerance to overload. The old hot wire instruments were very easily burnt out and even a moderate overload would alter the characteristic of the hot wire making it very inaccurate.

The design uses a current transformer with a ratio of 50:1. So, for a current of 1A flowing in the primary circuit, the secondary current will be 20mA. The secondary r.f. current is rectified by the diode bridge, D1-D4, and used to drive the shunted moving coil meter M1.

The peak value of a sinewave is 1.414 times (√2) its r.m.s. value (either current or voltage). But in a meter the value indicated in not the r.m.s. but the value of the mean voltage (or current). Like all moving coil meters, the displayed value of the rectified a.c. is the mean value of the a.c. voltage's peak level. And so, this must be taken

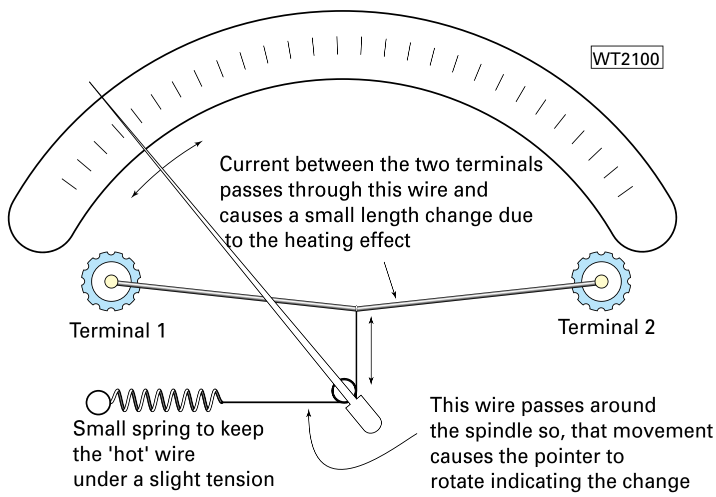


Fig. 1: A skeleton view of a hot wire current meter, an instrument that reads a.c. (r.m.s.) or d.c. current with the same scale. See text for more details.

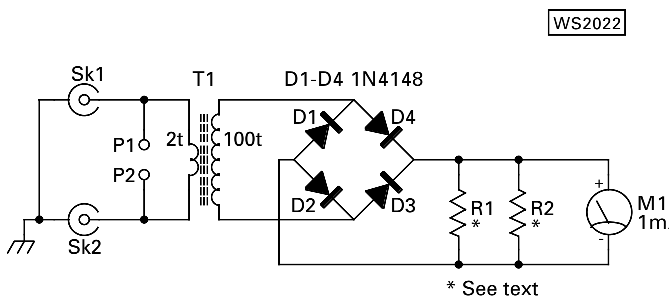


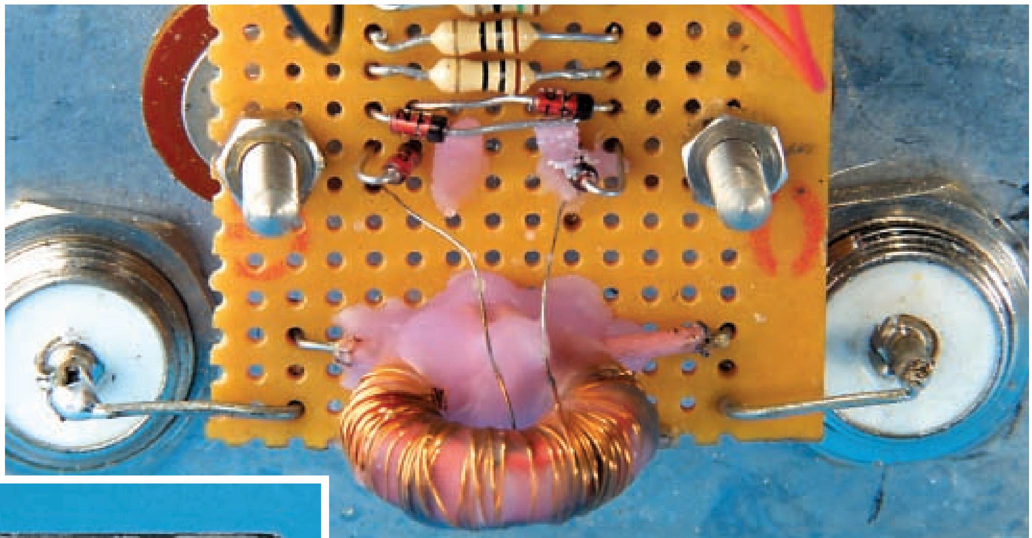
Fig. 2: The circuit diagram of G0TFP's r.f. current meter. See text for more detail.

into when calibrating the meter.

Mean Value

The mean value of a sinewave is 0.636 times the peak level. Hence the meter will not indicate the r.m.s. value, but the lower, mean value. Let's assume we wish to measure a primary current of 1A r.m.s.. The 20mA r.m.s. in the secondary must be shunted to display the mean value of this value at full scale. We must bypass some of the secondary current with low value resistors, shown as R1 and R2 in the circuit diagram of Fig. 2.

The peak value of a 20mA current is 28.28mA so, the meter must be shunted to show a full scale reading with the mean of this current. To calculate the mean value of



● Fig. 3: All components are mounted on a small piece of Perf-board mounted between the two coaxial sockets.

● Fig. 4: A close up of the simple layout of the current sensing transformer, rectifiers, and loading resistors.

28.28, multiply it by the mean conversion ratio of 0.636. So, 0.636¥28.28 = 17.98mA or more practically 18mA full scale, corresponding to a primary current of 1A r.m.s..

If you know the internal resistance of the milliammeter, then it's quite easy to calculate the actual value of the shunt. But I've found that the best way to make up the shunt is by trial and error using several low value resistors connected in parallel. In my prototype, this worked out as a shunting resistance made from one 15Ω and two 10Ω resistors in parallel, giving 3.75Ω in parallel with the 1mA meter.

Construction Simple

Construction of the current meter is simple, as shown in the photographs. Just remember to keep leads short and layout as compact as practically possible, **Fig. 3**. The toroidal current transformer is wound as a single layer with 100 turns of 0.2mm (36s.w.g.) enamelled wire and two turns of 1 x 0.24 plastic covered hook up wire.

I find that a convenient way to wind 100 turns on the toroid is to take a little over two metres of the enamelled wire and thread one end on to a darning needle. Pass half the wire through the toroid, held in a bulldog clip, and restrain the wire.

Use the needle to feed the wire through the middle of the toroid, as you wind 50 turns evenly over the free half of the toroid. Next rotate the toroid, so that the wound half is held in the bulldog clip, then again using the needle, thread the remaining half length of wire through the toroid to wind a further 50 turns.

You should now have a single winding with 100 turns evenly wound on the toroid. A small dab of glue at each end will hold this winding in place. Then wind the primary two turns onto the toroid, leaving the ends free.

Circuit Board

My circuit board is assembled and can be positioned so that direct connection to the terminals can be made, **Fig. 4**. This will also support the circuit board. Cut unwanted tracks and ensure that the terminal nuts are not making any unwanted short circuits. The toroid is supported by the primary winding and held in place by dropping melted candle wax on to the toroid and circuit board.

After checking that all is well the ammeter is ready to use. The prototype was checked using a transmitter and dummy load. Calculation of power from current measurements showed good correlation with the selected power levels from the transmitter.

Now you can begin testing out all your antenna systems, and you have a reading of the real power passing up into the antenna system. You never know - you might dispense with the s.w.r. meter all together! PW

COMPONENT LIST

To make the r.f. ammeter, you will need the following items:
A 1mA moving coil meter, four diodes (typically IN4148 or IN914), one T68-2 toroid (Micrometals), several low value resistors for shunt (see text), two panel sockets, two terminals, a die cast box (depth to suit meter) and finally, a small piece of Veroboard or Perfboard.