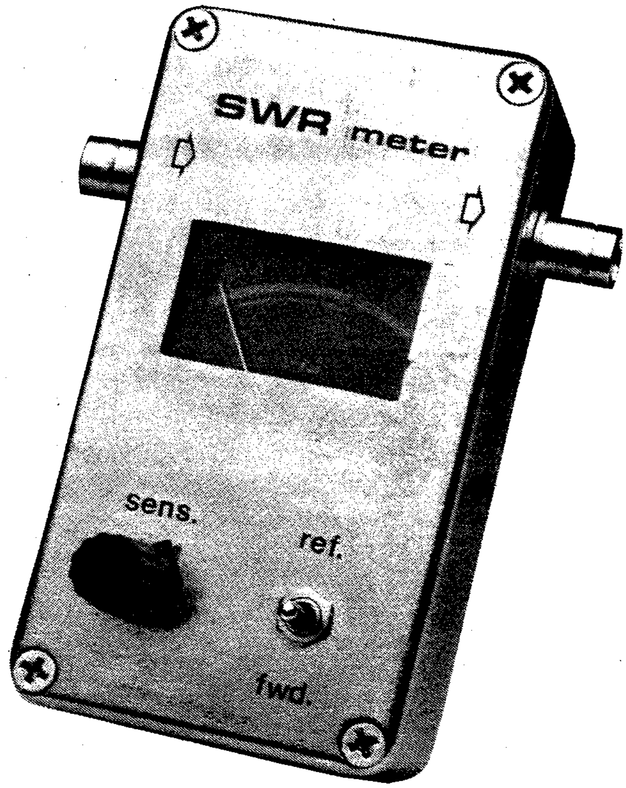
SWR METER FOR 1.5 – 70 MHz



Waste not, want not! Radio amateurs are a breed of electronics enthusiasts who like to see every milliwatt of their precious RF power arriving where it belongs: at the antenna terminals. However, budgets being what they are (RF plugs and low-loss coax cable are pretty expensive...), impedance mismatches occur readily between the transmitter and the aerial, causing power reflection. The low-cost instrument described here will tell hams operating in the 160 m through 4 m bands the ratio of the forward to the reflected RF power.

J. Bareford

A standing-wave ratio (SWR) meter is an indispensable RF power monitoring instrument found in almost any radio amateur's shack. It is often connected permanently between the transmitter/receiver rig and the coax cable to the antenna. During transmissions, it provides a relative indication of the transmitted power, as well as an indication of the ration of the forward RF power (i.e., the power fed to the antenna) to the reflected RF power (i.e., the power reflected into the transmitter owing to a mismatch at some point in the transmission line).

Since most radio amateurs have several transmitters and antenna systems, it is good operating practice to check the antenna match at a low power level, before starting a transmission. In this way, hams protect their precious RF amplifiers from going up into smoke owing to a gross mismatch, a faulty coax relay, or a totally absent antenna connection. During the transmission, hams have one eye on the tuning scale, and the other on the needle of the moving-coil meter in the SWR instrument. Just for reassurance? No, a must to ensure the best possible signal at the receiving station.

Standing-wave ratio

The ratio of the forward RF power to the reflected RF power is called the standing-wave ratio, or SWR. Since, in the actual SWR meter, we are working with one, definitely established, transmission line impedance, the term 'power' may be replaced by 'voltage'. Thus, in a transmission line system where a mismatch exists, we have a forward voltage, U_F, and a reflected voltage, U_R. This allows the SWR to be determined from

$$SWR = \frac{U_F + U_R}{U_F - U_R}$$

From this, it is seen that an SWR of 1 corresponds to optimum matching of the transmitter to the coax and antenna system. That is not to say that there are no losses: it only means that the transmitter output is matched to the load impedance formed by the transmission line, which includes the aerial, i.e., the load at the far end of the cable. In fact, the effect of an improperly matched antenna becomes smaller as the attenuation on the cable rises. This is because both the forward and the reflected power are subject to the same attenuation. A good discussion of the relative importance of the SWR is found in Ref. 1. Incidentally, long runs of lossy coax cable often form the perfect dummy load: any length of (matched) coax cable that introduces an attenuation of more than, say, 20 dB at the test frequency, will reflect so little power that it looks like a perfect resistance to the transmitter (keep an eye on the dissipation, though!).

Typical, tolerable, SWR values resulting from small mismatches are in the range from 1.5 to 2.0. Most radio amateurs would agree that an SWR greater than 2 is a definite cause for investigating the mismatch, as then more than 11% of the transmitted power is 'wasted' by reflection. The cause of the mismatch may be found in an incorrectly tuned RF amplifier, a piece of coax with the wrong impedance (the notorious 50/75-Ω prob-

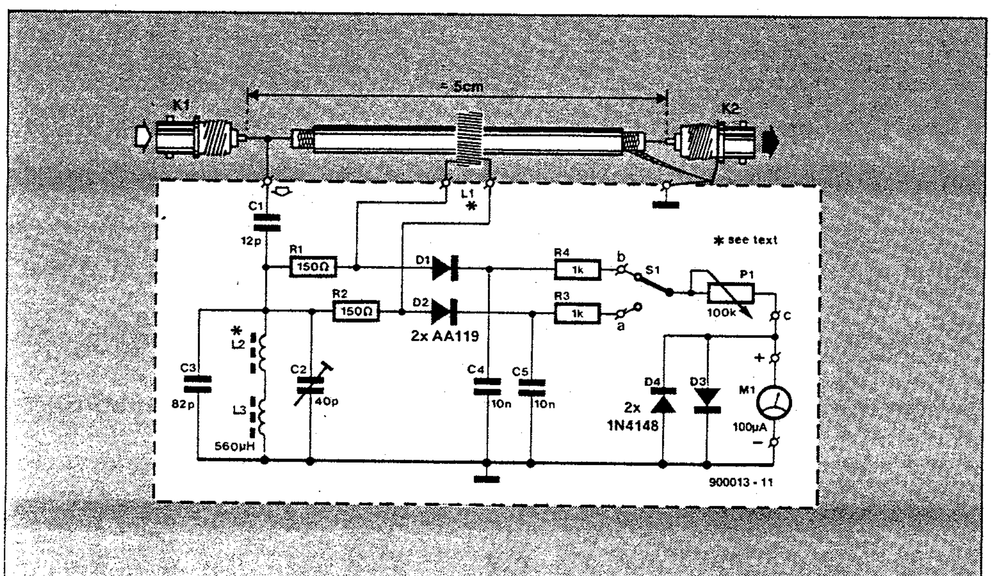


Fig. 1. **Circuit diagram of the SWR meter. The RF energy produced by the transmitter is coupled capacitively via C1, and inductively via L1 to establish the ratio of the forward to the reflected power.**

lem), birds on your aerial, a frozen-over aerial, the hectic of a contest, water in your coax cable, or a couple of faulty RF connectors somewhere on your attic or on the roof. Whatever the cause, make sure you eleminate it before starting to transmit, since many RF amplifiers, particularly those used for SSB (single-sideband) and other linear modes, do not like output mismatches, and produce an excessively wide output spectrum, causing splatter in the band and annoyance to your fellow hams in the neighbourhood.

The circuit

The circuit diagram of the present SWR meter is conventional, see Fig. 1. The forward and reflected powers induce RF voltages in a toroid inductor, L1, which is positioned around a short length of coax cable. Note that the cable is grounded at one side of the instrument only (a coax cable grounded at both ends does not radiate).

The RF voltage supplied by the transmitter is capacitively coupled via C1 to serve as a kind of reference against which the forward and reverse powers are measured. The coupling capacitor is connected to a tuned circuit, L2-L3-C3-C2, that serves to balance the measurement circuit at higher frequencies (in the 6 m band and possibly the 4 m band also).

The forward and reflected voltages are rectified by two diodes, D1 and D2, to establish the relative powers and thus the SWR. The AA119s used are low-capacitance point-contact germanium diodes with a low threshold voltage of about 0.2 V. A toggle switch, S1, allows the user to select a (relative) forward power indication, or reflected power relative to forward power.

Construction

The layout of the double-sided printed circuit board is shown in Fig. 2. Be sure to avoid overheating the trimmer, C2, while soldering its terminals. As shown in the photograph in Fig. 3, the two BNC sockets are connected by a short length of thin 50-Ω coaxial cable, of which the screening braid is connected to the socket and the board **at the antenna side only**. In the prototype, the coax cable was a 40-mm long piece of RG174U, which has an outside diameter of about 3 mm.

The winding data of the two inductors in the instrument, L1 and L2, are as follows:

Pick-up inductor L1:
Wind 30 turns of 0.2-mm dia (SWG36; AWG34) enamelled copper wire on a FT 37-43 ferrite ring core from Amidon Associates Inc. An alternative core is the FB 43-2401. Distribute the wire evenly on the core. Carefully remove the enamel coating at the ends. Put the coax cable through the hole in the core, and solder the wire ends of the inductor to the holes marked 'L1' on the PCB. Connect the coax cable to the BNC sockets as indicated above.

Choke L2:
This is made from 6 turns of 0.2 mm dia. (SWG36; AWG34) enamelled copper wire through a 3-mm long ferrite bead. After winding the inductor, carefully remove the enamel coating at the ends, and solder the device in place.

The completed printed circuit board fits in an Eddystone or Hammond diecast enclosure of about 11×6×3 cm. The size of the rectangular clearance in the lid of the enclosure depends on the meter you use. The lid is drilled to accept the threaded shafts of the sensitivity control potentiometer and the forward/reflected power switch. The connec-

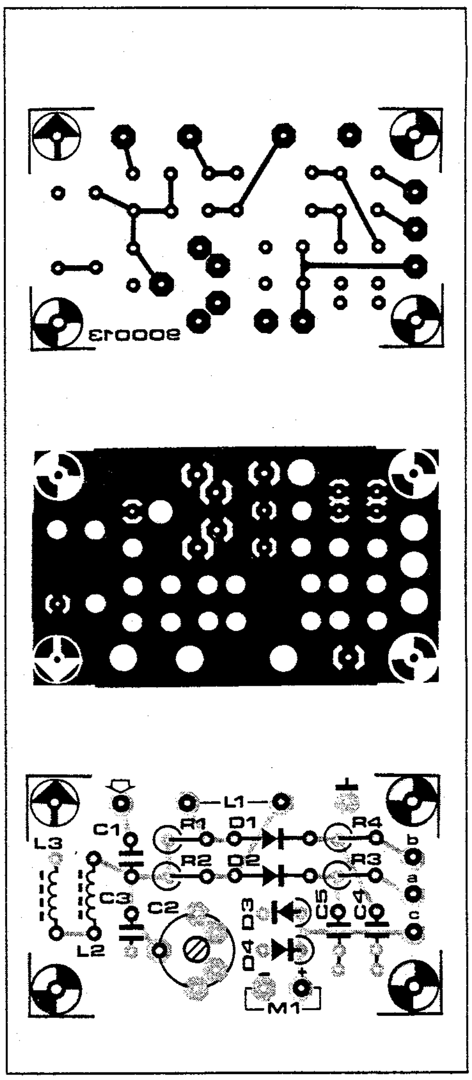


Fig. 2. Double-sided, not through-plated, printed circuit board for the SWR meter.

COMPONENTS LIST

Resistors:

2	150Ω	R1;R2
2	1kΩ	R3;R4
1	100kΩ linear potentiometer	P1

Capacitors:

1	12pF	C1
1	40pF trimmer	C1
1	82pF	C3
2	10nF	C4;C5

Semiconductors:

2	AA119	D1;D2
2	1N4148	D3;D4

Inductors (see text):

1	FT37-43 (Amidon)	L1
1	3-mm ferrite bead	L2
1	560µH	L3

enamelled copper wire 0.2 mm dia.

Miscellaneous:

1	miniature SPDT switch	S1
1	100µA moving-coil meter	M1
2	BNC socket	K1;K2
1	diecast enclosure, e.g., Hammond type 1590B	

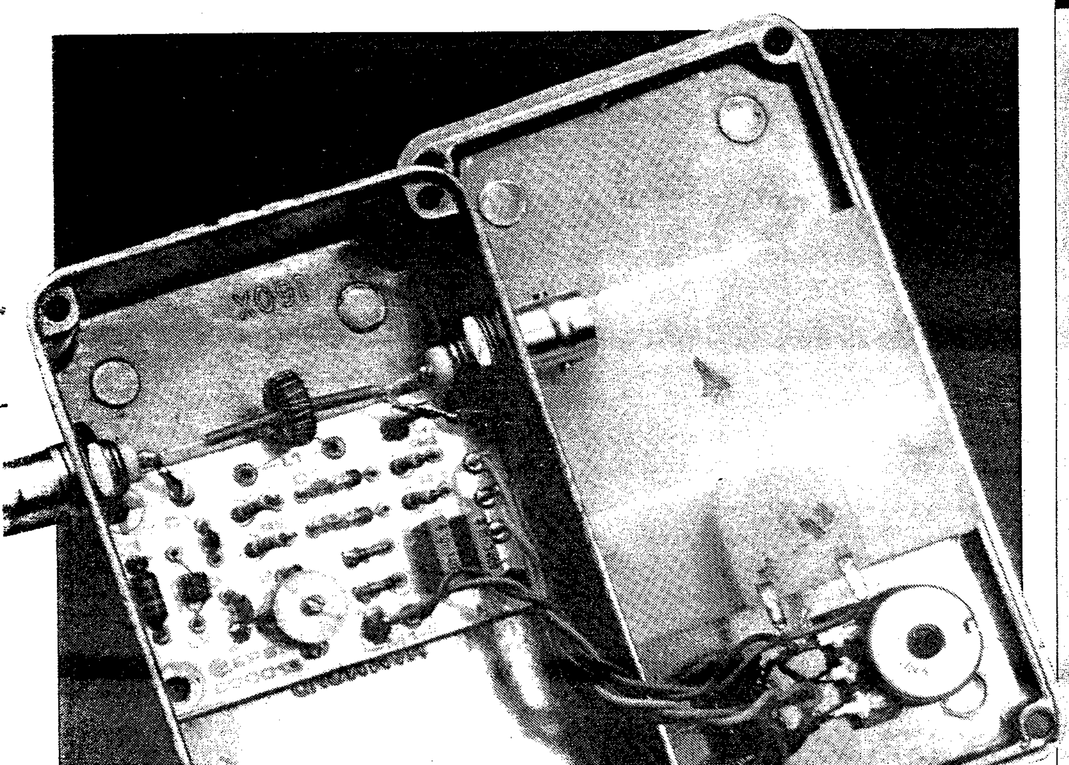


Fig. 3. A look inside the prototype. Note that the toroid core, L1, is fitted around the 3-mm dia. coax cable connected between the input and output BNC sockets.

tions between the board and the external components are shown in Fig. 4.

Test and practical use

Connect the completed SWR meter between a short-wave transmitter and a load you know to be non-reflective, e.g., a dummy load of the appropriate impedance and power rating. Transmit at a continuous output power. If the indications of forward and reflected power appear to be reversed, swap the terminals of L1, or change the lettering of the switch on the instrument.

If you work in the short-wave bands only, there is probably no need to adjust the balance trimmer, C2. If you do work at 50 MHz or 72 MHz (UK only), connect a dummy load to the output of the SWR meter, and adjust the trimmer for minimum reflected power indication while transmitting at a relatively low power.

Use the SWR meter as follows after making any change to your rig or antenna system: transmit at a continuous level, select forward power, and adjust the sensitivity control, P1, for full meter deflection. Next, switch to reflected power. The higher the indication, the worse your antenna match. ■

Reference:

1. "Losses encountered when interconnecting cables having the incorrect impedance". by Dr. P. Brumm, DL7HG. *VHF Communications* issue 3/1974.

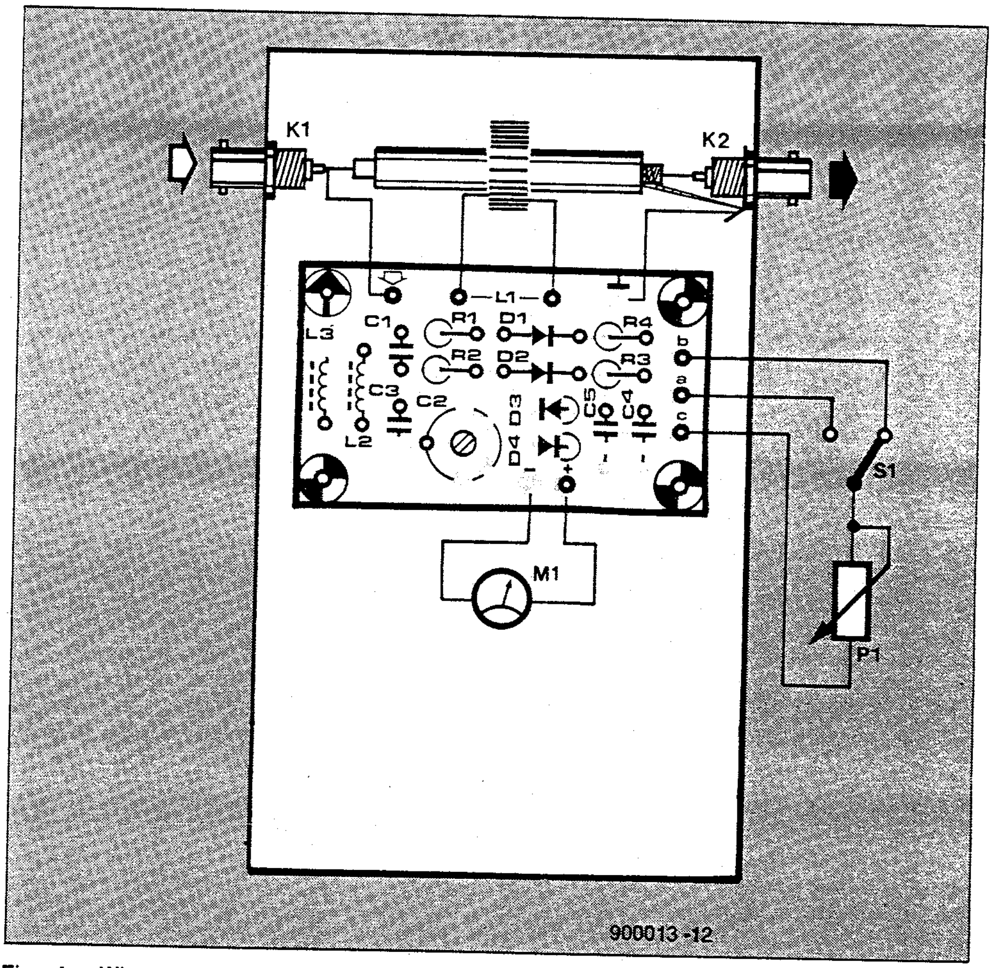
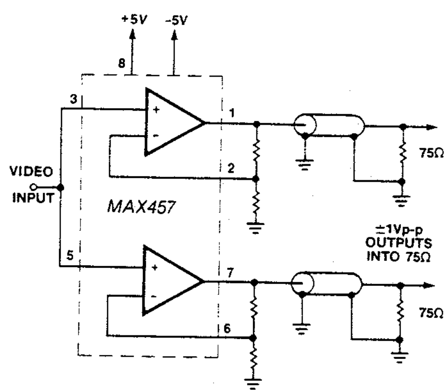


Fig. 4. Where to connect the external components.

DUAL 70 MHz CMOS VIDEO AMPLIFIER



Maxim Integrated Products introduces the MAX457, a monolithic IC comprising two 70 MHz CMOS video amplifiers which can drive 75 Ω loads. These amplifiers operate from ±5 V supplies, and together consume only 350 mW. The only necessary external components are two resistors for gain setting, and two decoupling capacitors.

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