SWR Reflectometer, Slotted Line for the VHF Powermatch System

Here are two further accessories for the VHF Powermatch measuring system presented in February. One is an SWR reflectometer, the other a slotted line. Both are easy to build, and each can be of great value in checking and optimising aerial-feedline matching.

When a transmission line is used to connect a radio transmitter to an aerial, the largest proportion of RF power from the transmitter is fed to the aerial when the effective loading resistance of the aerial is arranged to match the so-called "characteristic impedance" of the line. Similarly, when a transmission line is used to connect an aerial to a receiver or receiving converter, the received signals will be fed most efficiently between aerial and receiver when both the aerial and the receiver input circuitry are matched to the line impedance.

Accurate impedance matching of transmitting aerials, receiving aerials and receiver input circuits to the transmission line is therefore quite important. This is no less true for the radio amateur than for the professional broadcaster operating at high power levels with sophisticated equipment. Faced with the limitations of a relatively modest aerial system and a relatively low level of transmitter power, the amateur must generally ensure that he is making the best possible use of his facilities.

Generally speaking, there are two practical approaches which may be followed in checking impedance matching. One approach is to connect the device to be checked to the feedline, and feed RF power along the line to it from a low power transmitter or similar source. The degree of matching can then be gauged by measuring the extent to which power is reflected back down the line. The less power reflected, the more accurate is the impedance match.

This method is quite direct, although it is usually only suitable for checking aerial matching. At the power levels involved most receiver input circuits suffer severe overload, and even if damage does not occur the input resistance may differ quite markedly from the normal value. The results may therefore be quite misleading.

The alternative approach is to actually measure the loading impedance of the device concerned, and compare it with the nominal characteristic impedance of the feedline cable. While perhaps less direct than the first approach, this method has the advantage that in the event of a mismatch, it indicates the direction in which the device impedance must be changed to improve the situation.

Neither approach offers inherently greater accuracy, nor does either offer clear advantages in terms of convenience. In fact there are times when each is preferable, either because it allows a deeper analysis of the situation, or because it allows a more rapid check on the value of modifications.

For this reason, the Powermatch system has been designed to include accessory units for both types of measurement. Two different accessories have in fact been designed to make measurements using the "reflected power" approach, and these will be described in the present article. A following article will describe a further accessory designed to make measurements using the "impedance" approach.

Why two different accessories designed for the "reflected power" approach? Again, the reason is that two different measurement methods are available, and each has advantages.

One accessory is an **SWR reflectometer** or dual directional coupler, also known as a "monimatch" or "SWR bridge". This type of device functions by directly sensing the relative proportions of RF power flowing in each direction along the feedline. The basic theory of operation was described by the author in the article "A Fresh Look at the SWR Reflectometer", in last month's issue.

The other accessory is a **slotted line**, which allows monitoring of the variations in electric field intensity associated with the "standing wave" pattern which is set up along the feedline as the result of interference between the forward and reflected power components.

Of the two types of device, the reflectometer is the more practical at lower frequencies. The slotted line must be at least a half-wavelength long, and preferably one wavelength, in order to be able to properly sample the standing wave pattern. This makes it rather unwieldy at 144MHz and lower frequencies. On the other hand it is difficult to construct a reflectometer to perform reliably at 1296MHz and higher, yet at these frequencies the slotted line becomes compact, convenient and reliable.

Each type of instrument therefore has its own sphere of usefulness, and if the amateur operates on bands covering a wide range of frequencies, the construction of both can be easily justified. This also has the advantage that the two may be used to cross-check results at those frequencies in the middle of the VHF-UHF spectrum where both are capable of reliable operation.

Like most SWR reflectometers which have been described, the unit presented here is based on the configuration shown in figure 1. It consists of three short sections of transmission line, arranged in such a way that the outside sections are lightly coupled to the centre section. It is the latter section which is inserted into the feedline connecting transmitter and aerial, while the outside sections are used to monitor the "forward" and "reflected" power flow.

As normally described, reflectometers of this type generally consist of an assembly of metal rods or wires, mounted inside a length of large-diameter tube. For the average radio amateur, this type of construction can pose problems.

For example he may well find it quite difficult to obtain short lengths of rod or tube of the required diameters, in a suitable metal. Metal suppliers are generally loath to supply

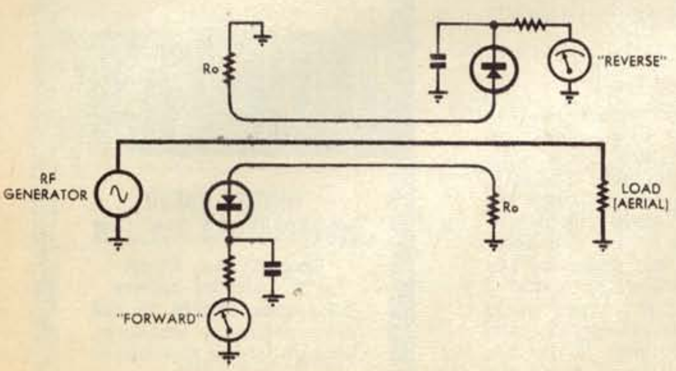


Figure 1: The basic configuration used for the SWR reflectometer accessory.

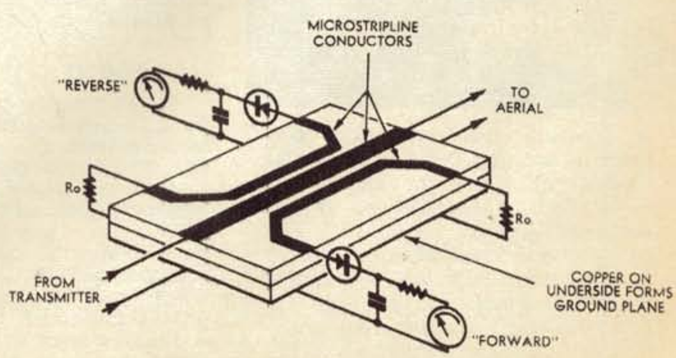
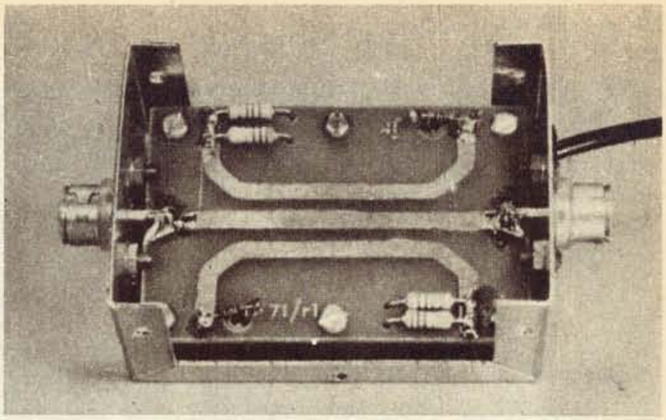


Figure 2: The device uses microstriplines, formed using two printed wiring boards.

by JAMIESON ROWE



The inside of the reflectometer, showing the microstripline conductors, terminating resistors and diodes. The unit shown is the 75 ohm version.

short lengths, because of the trouble involved. This means that the required materials must be either salvaged from the proverbial "junk-box", or obtained from a scrap metal dealer. In either case it may be necessary to adapt or modify the design to suit the material available.

During assembly, there is the further problem of ensuring that the various lines are spaced evenly and accurately both between each other and with respect to the outer shield tube. Even when great care has been taken, the characteristic impedance of the coupled side lines may still differ significantly from the design figure, and the two may not have sufficiently equal coupling to the centre line. This generally makes it at least desirable for the amateur to test both the terminations and the coupling factors of both lines, before the unit can be put into use.

In an effort to solve these problems, the author has based the present design not on a critical assembly of rods, wires and tubes, but rather on a small printed wiring board. Or to be more accurate, it consists of two small wiring boards which are bolted together.

The three sections of transmission line are not in the form of conventional co-axial lines, but instead are in the form of sections of **microstripline.** For those who have not met it before, microstripline is a type of transmission line consisting of a single conductor strip spaced evenly from a conducting sheet or "ground plane".

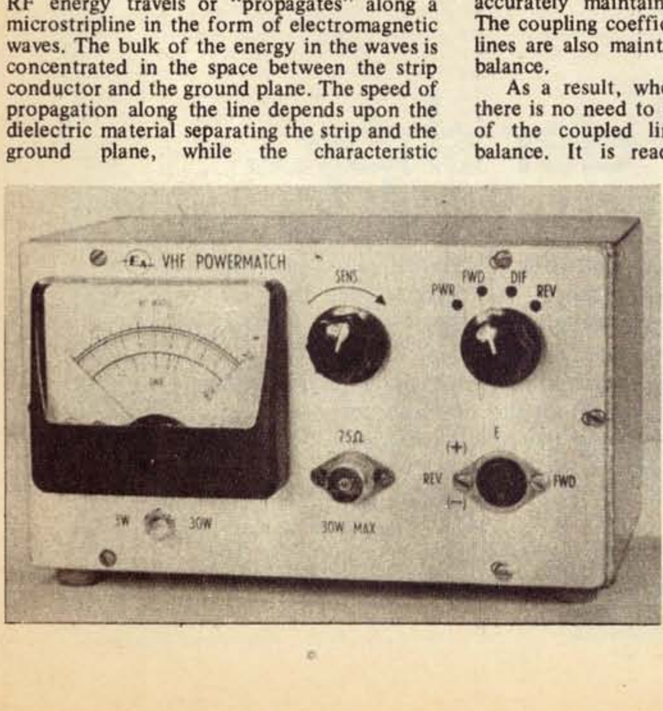
As with other types of transmission line, RF energy travels or "propagates" along a microstripline in the form of electromagnetic waves. The bulk of the energy in the waves is concentrated in the space between the strip conductor and the ground plane. The speed of propagation along the line depends upon the dielectric material separating the strip and the ground plane, while the characteristic impedance of the line is a function of the strip width, the separation between the strip and the ground plane, and the dielectric.

Figure 2 shows the basic arrangement of the new printed board SWR reflectometer which has been designed using the microstripline approach. It may be seen that all three sections of line forming the directional couplers of the device are in the form of microstriplines. The strip conductors of the lines are etched on one side of the board assembly, with dimensions and spacing to provide the appropriate characteristic impedances and coupling coefficients, while the largely unetched copper laminate on the other side of the board assembly forms a common ground plane.

By adopting the microstripline approach for the new reflectometer, two important advantages have been gained over more conventional designs. The first is that construction of the unit has been very much simplified. There are no rods, wires of tubes of critical dimensions to be obtained or fabricated, and no tricky assembly jobs involving accurate spacing of parts. Only a straightforward printed wiring board assembly, on which a handful of minor components are mounted before housing in a standard small aluminium utility box.

The second advantage is no less important. Because of the stable and predictable conductor dimensions and spacing provided by the wiring board pattern, the characteristic impedances of the main and coupled lines are accurately maintained at the design values. The coupling coefficients for the two coupled lines are also maintained quite accurately in balance.

As a result, when the unit is completed there is no need to check either the matching of the coupled line terminations, or the balance. It is ready for use immediately following assembly. Any residual errors due to within-tolerance component variations should be negligibly small for most practical purposes.



The basic Powermatch unit, which was described in the February issue. Together with its accessories, it forms a versatile VHF measuring system.

The wiring boards used in the device should be made from epoxy fibreglass laminate rather than from the less costly bakelised paper laminate. The reason for this is that epoxy fibreglass has lower losses and is more stable and predictable as a dielectric material. The material used for the prototype unit was "Epocor" laminate, marketed by Standard Telephone and Cables Pty Ltd. It is single-sided board, 1/16in thick with a "1 oz" copper laminate, coded type EPO/1/16/S/1.

As the microstriplines of the reflectometer have been designed using the parameters of this material specified by the manufacturer, it is strongly suggested that readers use the same material. The use of material having characteristics different from EPOCOR might well degrade the performance of the reflectometer to a significant degree.

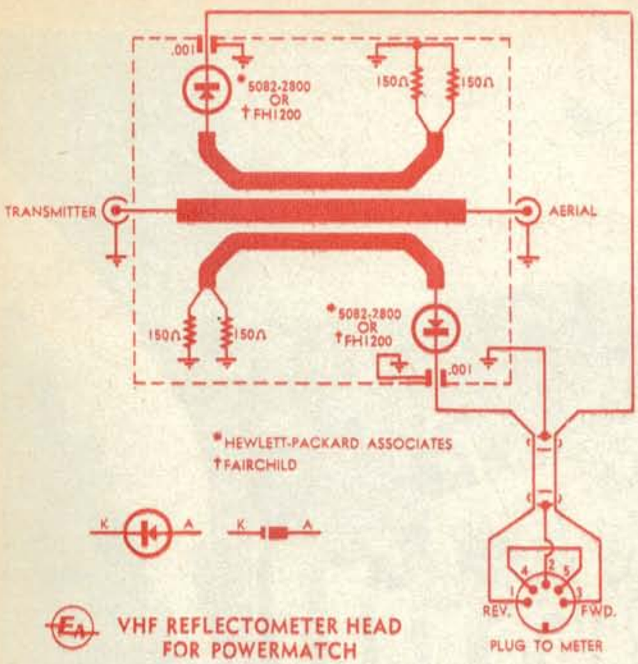
Two single-sided boards are used, each measuring 3in x 2in. One board provides the microstrip conductors, and the other the ground plane. The two are clamped together with both laminate surfaces facing outwards, using six small 1/8in Whitworth screws and matching nuts.

The reason for using two single-sided boards screwed together, rather than one double-sided board, is that this enables standard 1/16in board to be used to obtain a microstripline dielectric of 1/8in. The double thickness is required in order to obtain the correct microstripline characteristic impedances, while using copper conductor strips of practical width.

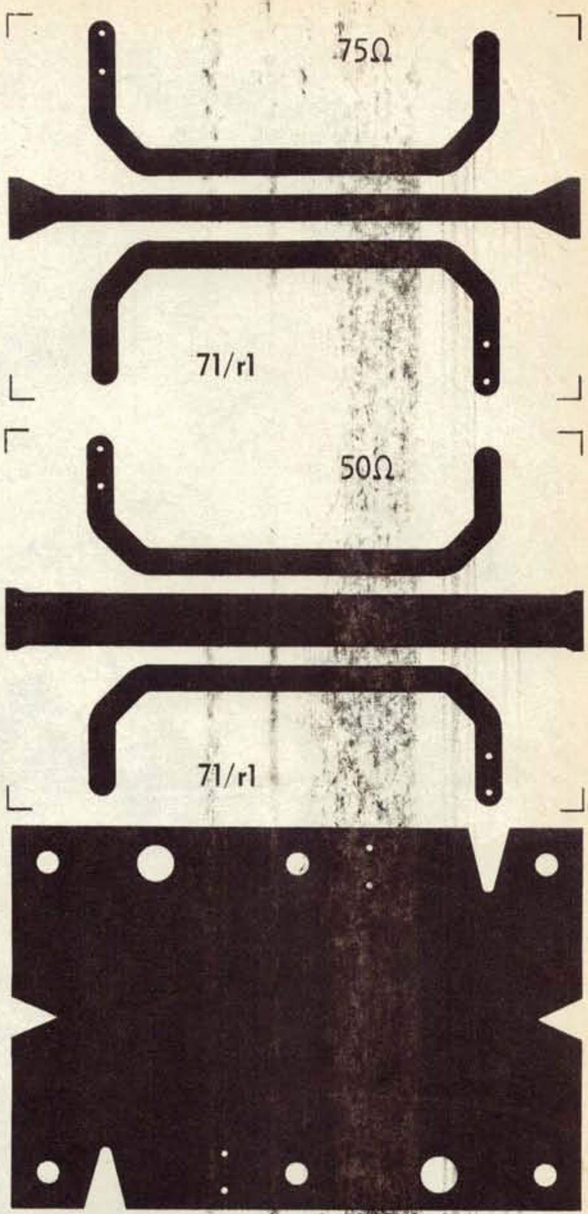
Two alternative patterns have been produced for the upper or "conductor" board, the two differing in terms of the width of the conductor strip for the centre or "primary" line. The width of this conductor on one pattern corresponds to a nominal characteristic impedance of 75 ohms, and on the other pattern to an impedance of 50 ohms. It is thus possible to build the reflectometer to suit either a 75 ohm or a 50 ohm co-axial system as desired, simply by using the appropriate top board.

The coupled secondary lines on both board patterns have a width corresponding to a characteristic impedance of 75 ohms. Thus the terminating resistors are the same on both the 75 ohm and 50 ohm versions of the device, consisting of two 150 ohm ½watt composition resistors in parallel for each line load.

The board patterns for the unit are being supplied to those manufacturers who make a practice of supplying boards for "E-A" projects. Thus readers should be able to obtain ready-made boards for the project in the near future.



The circuit for the SWR reflectometer, which is the same for both the 75 ohm and 50 ohm versions.



The printed board patterns for the reflectometer, shown here actual size to permit tracing if desired. At right is the lower board, while above it are the alternative upper boards.

The nominal dielectric constant for the EPOCOR material used for the boards is 4.4, which gives the microstriplines a velocity factor of 0.47. The coupled line lengths on both the 75 ohm and 50 ohm top boards is 4.5cm, which when the velocity factor is taken into account corresponds to a free space length of 9.45cm. This amounts to only 0.138 of a wavelength at 435MHz, becoming a quarter wavelength only when the frequency is raised to 770MHz.

Theory thus suggests that the performance of the new reflectometer should be maintained to well beyond the 420-450MHz amateur band. The author is happy to report that practical tests have supported this prediction quite well. Without adjusting the prototype device after assembly, it produced SWR readings of less than 1.05:1 at frequencies in all VHF amateur bands up to 435MHz, when monitoring power flow to the dummy load of the VHF Powermatch. Such low readings tend to vindicate the designs of both the reflectometer itself and the dummy load.

The detector diodes used in the device should be of the hot-carrier or Schottky-barrier type if the performance is to be maintained to beyond 450MHz. The diodes used in the prototype were Hewlett-Packard devices, type 5082-2800, which although quite low in cost are capable of excellent performance well into the GHz region. These are the same as used in the power rectifier of the VHF Powermatch, and in the RF voltmeter probe.

As noted in the earlier article, the 5082-2800 may be purchased in small quantities by mail from Hewlett-Packard Australia Pty Ltd. In NSW the address is 61 Alexander Street, Crows Next, 2065, while in Victoria the address is 22-26 Weir Street, Glen Iris 3147.

Alternative hot carrier diodes may be used, such as the Fairchild type FH1200. This has a lower breakdown voltage than the 5082-2800, only 25V compared with 70V. However this should present no problems because the power levels present in the secondary lines of the reflectometer will normally be quite low.

But note that the lower breakdown voltage of the FH1200 makes it quite unsuitable for use in the power rectifier of the basic VHF Powermatch, or in the RF voltmeter probe.

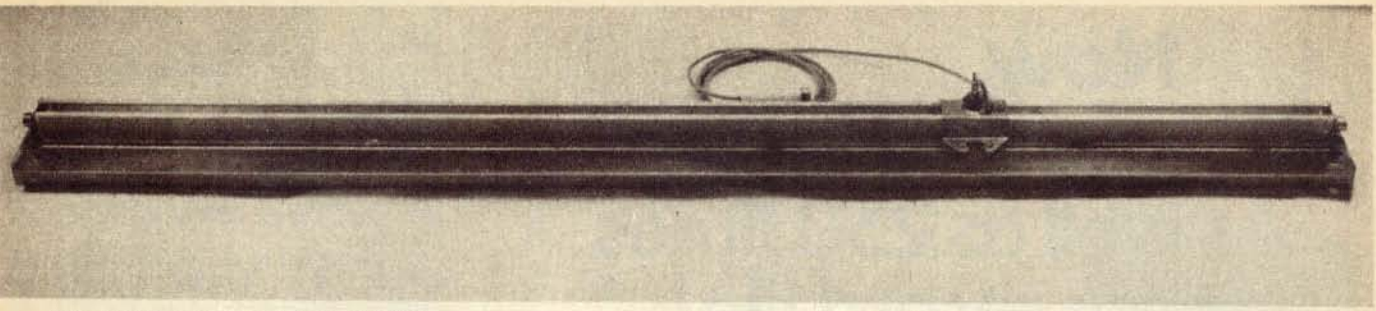
The detector diodes and the terminating resistors are mounted directly on the printed board assembly. The "live" ends of the terminating resistors are soldered directly to the ends of the secondary lines, while the "earthy" ends pass through holes in both boards and solder to the ground plane. The anodes of the diodes are soldered directly to the appropriate ends of the secondary lines, while their cathode leads are soldered to the lugs of .001uF feedthrough capacitors used to provide low-inductance detector reservoirs. The "earth" rings of the feedthroughs are soldered to the ground plane copper of the lower board, and the lower lugs are used for the output lead connections.

When the resistors and diodes are soldered into position on the board assembly, their pigtails should be kept as short as possible in order to minimise lead inductance and stray capacitance. As the short leads will tend to increase the risk of component damage by over-heating during the soldering, it would also be wise to use a pair of long-nose pliers or a surgical "mosquito" clamp as a heatsink.

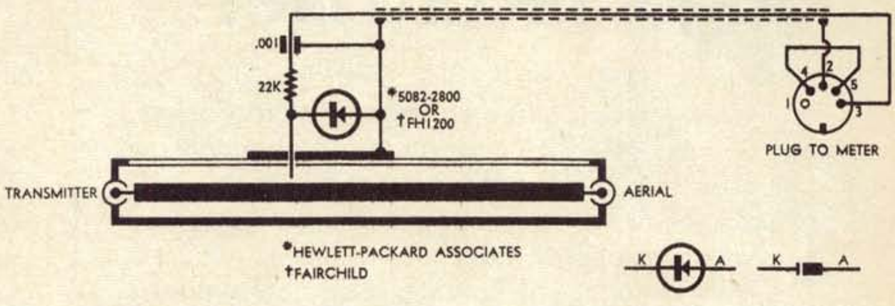
The completed board assembly of the reflectometer is mounted inside a small aluminium utility case measuring 3¼in x 2¼in x 1½in. RF input and output co-axial connectors are mounted centrally on the ends of the case, as may be seen from the photograph. The twin shielded output cable carrying the DC detector signals to the main Powermatch unit leaves one end of the case via a small grommetted hole, being terminated at the far end with a 5-pin DIN plug.

The co-axial connectors used on the prototype unit are the well-known Beeling-Lee type, which offer quite good performance at relatively low cost. They have a nominal impedance of 72 ohms, but for amateur purposes may be used quite satisfactorily with both 75 ohm and 50 ohm systems.

Inside the case the board assembly is supported by four solder lugs which are clamped under the co-axial connector mounting nuts. The narrow ends of the lugs are first soldered to the ground plane copper



Above is the completed slotted line, which is 42 inches long. At right is the schematic diagram. Note the use of a hot-carrier diode.



VHF SLOTTED LINE (ACCESSORY FOR POWERMATCH)

of the lower board, and then bent at right angles in such a way that when the board assembly is lowered into the case, the holes in the lugs align with the connector mounting screws when the top surface of the board assembly is just touching the underside of the centre spigots of the connectors. Screws are then passed through the connectors, case ends and lugs, and nuts dropped down in the 1/8in spaces between the board assembly and the case ends to complete assembly. Finally the connector centre spigots are soldered to the ends of the centre microstripline conductor.

Just before the board assembly is mounted in the case in this manner, the shielded detector output cable should be fed through the grommet in the case end and the leads soldered to the feed-through lugs on the lower side of the board assembly. The cable braid is also soldered to the ground plane copper, to complete the meter return circuit.

When the unit is completed, it may be used immediately. As noted earlier, the printed board microstripline construction obviates the need for the line matching adjustments and balance checks required with more conventional designs. It is simply a matter of connecting the unit between the main transmission feeder and the aerial, using a short jumper cable, and plugging the detector output cable into the VHF Powermatch unit.

Readings of "forward" and "reflected" power flow in the line may be read simply by turning the Powermatch function switch to the appropriate positions. The usual procedure is to turn the sensitivity pot of the Powermatch to the minimum (fully anti-clockwise) position, and switch to the "forward" position. The RF power is then fed into the line, and the sensitivity pot advanced until the meter gives a full-scale reading. Switching to the "reverse" position then allows the reflected power flow to be read off directly in terms of SWR.

The coupling coefficients of the reflectometer have been designed so that full-scale readings should be obtainable in the "forward" position even with very modest power levels. On the 52-54MHz band, where sensitivity is lowest, no difficulty should be experienced in obtaining full-scale deflection unless the power level available is below 3 or 4 watts. On the higher bands the coupling coefficients are greater, so that even less power is required.

In addition to the switch positions allowing forward and reflected power measurement, the Powermatch also provides a position for indication of the difference between the two components. This position is useful when making adjustments to an aerial or matching system, because it allows changes to be observed without the need for repeated switching back and forth between the forward and reverse positions. Any improvement in matching is immediately indicated by an increase in the difference meter reading.

This completes the description of the new SWR reflectometer. The slotted line accessory will now be described.

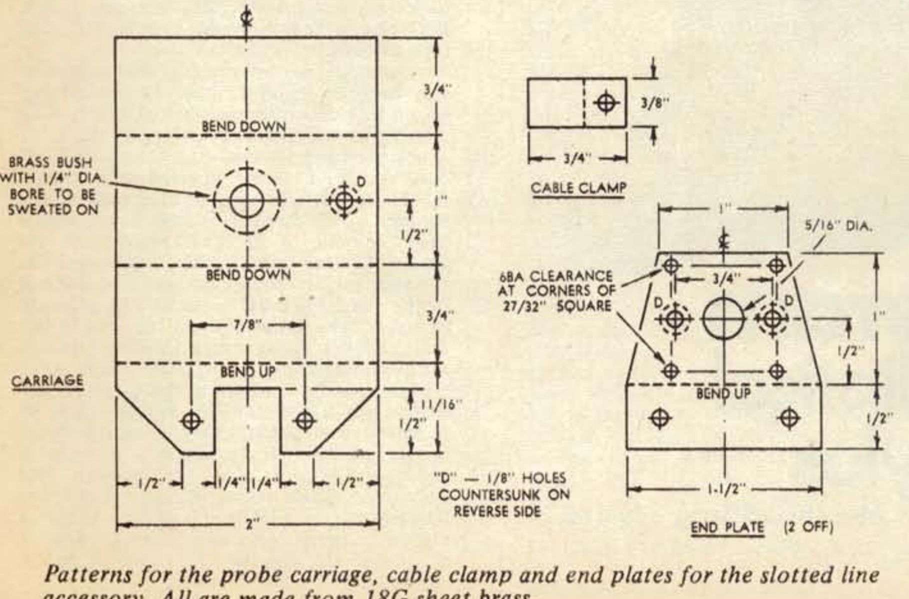
Although probably less familiar to the average radio amateur than the SWR reflectometer, the slotted line is basically a very simply and straightforward device. It consists essentially of nothing more than a section of co-axial transmission line provided with a longitudinal (lengthwise) slot in the outer conductor. The purpose of the slot is to allow a small detector probe to be inserted for sampling the internal electromagnetic field at any position in the line section.

The probe may be arranged to sample either the magnetic component of the electromagnetic field, or the electric component.

If there is a mismatched load connected to the feeder line into which the slotted line section is inserted, both "forward" and "reflected" power components will be flowing in the line. Interference between the two power components will cause a standing wave pattern to be set up along the line. The standing wave pattern will consist of regular variations in field strength along the line, the pattern of variation being quite steady and fixed in position.

The difference in field intensity between the maxima or "peaks" and the minima or "troughs" of the standing wave pattern depends, as one might expect, on the relative magnitude of the reflected power component compared with the forward component. The smaller the reflected component as a proportion of the forward component, the less pronounced the standing wave pattern and the difference between peaks and troughs. Conversely the larger the reflected component as a proportion of the forward component, the more pronounced the standing wave pattern and the difference between the peaks and troughs.

The difference between the peaks and troughs is thus a good indicator of the ratio between the forward and reflected power



Patterns for the probe carriage, cable clamp and end plates for the slotted line accessory. All are made from 18G sheet brass.

flow, and hence also of the matching of the line load. In fact the ratio of the field intensities at the peaks and troughs is nothing more nor less than the **standing wave ratio,** or SWR.

The slotted line is ideally suited for measuring SWR, as it allows direct location and measurement of the standing wave peaks and troughs. The probe is simply moved along the line to find and measure an adjacent peak and trough, and the ratio of the two readings calculated.

A second but no less valuable use for the slotted line is as a wavemeter. Its use for this purpose depends upon the fact that the peaks (and the troughs) of the standing wave pattern are always spaced by an exact half-wavelength. The wavelength of the RF energy flowing through the slotted line may thus be found quite simply by measuring the distance between two successive peaks (or troughs), and multiplying by two. (This assumes that the slotted line uses an air dielectric, which is normally the case. If not, the velocity factor would have to be taken into account.)

PARTS LIST

SWR REFLECTOMETER

1 Utility case, 3¼in x 2¼in x 1½in.
2 Epoxy fibreglass printed boards, 71/rl (50 or 75 ohms as desired) together with ground plane board.
2 Hot carrier diodes, Hewlett-Packard type 5082-2800 or Fairchild type FH1200.
4 150 ohm ½ watt composition resistors.
2 .001uF feedthrough capacitors.
2 Co-axial sockets.
Length of 2-core shielded cable, 5-pin DIN plug, nuts and bolts, screws, ¼in grommet, solder, etc.

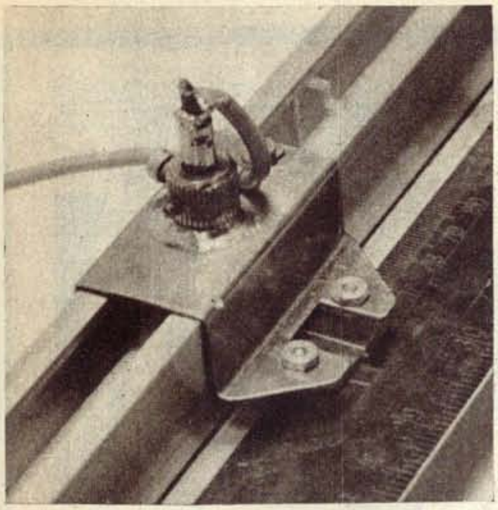
SLOTTED LINE

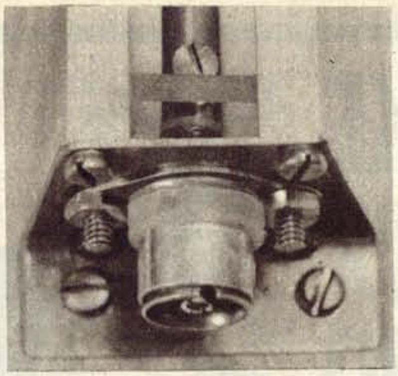
1 40in length of aluminium extrusion, Comalco type E-865.
1 39¼in length of ¼in diameter rod, aluminium or brass.
1 Hot carrier diode, Hewlett-Packard type 5082-2800 or Fairchild FH1200.
1 22K ½ watt composition resistor.
1 .001uF feedthrough capacitor.
2 Co-axial sockets.
Length of shielded cable, 5-pin DIN plug, scrap brass for end plates and probe carriage, wood for base, metre rule, screws, etc.

Knowing the wavelength, the frequency may easily be found. Probably the easiest way is to divide the wavelength in metres into 300, which gives the frequency in Megahertz.

To be used in this way the slotted line does not have to be inserted into a main feeder line. It can be used in a very similar manner to the familiar "Lecher line", with a small amount of energy coupled into the device by means of a coupling loop. The coupling loop is simply connected to one end of the slotted line by means of a short length of cable. The other end of the unit is left unterminated, giving a high SWR and thus an easily measured pattern of peaks and troughs.

For use in measuring both SWR and wavelength the slotted line should ideally be at least one wavelength long, to ensure that it will be possible for the detector to locate a minimum of two peaks or troughs. This makes the device rather impractical at lower frequencies. At 52MHz the device should be at least 6 metres long, while even at 144MHz it should ideally be 2 metres long — approximately 6 feet 7 inches!





At left is a close-up of the slotted line carriage, while above is a view of one end.

As even a 2 metre long line would probably present problems of storage and use for most radio amateurs, the unit shown in the photographs has been kept to a length of 40 inches. This limits its primary use to frequencies above 300MHz. However it can be used to measure both SWR and wavelength on the 144MHz band, providing short spacing cables are inserted into the main feedline to "shift" the standing wave pattern along until a peak and a trough are available in the slotted section. The SWR may then be measured as before, although the distance between the peak and the trough will have to be multiplied by four in order to obtain the wavelength.

In view of this ability to use the shorter line to make useful measurements even on the 144MHz band, it would seem unnecessary to consider a longer unit. However if the reader to desires, there is no reason why he should not build a longer unit based on the same design.

The construction of the slotted line shown is based on a length of aluminium extrusion. The extrusion has a square cross-section, and is rather like a square tube except that one side is not completed. On the fourth side are two stub walls, separated by a gap of ½in. Although this gap is rather wider than one would ideally like for the slot of a slotted line, tests have shown that very little energy is radiated. The extrusion thus provides a convenient and labour-saving way of providing the outer conductor of the unit.

The extrusion measures one inch square (outside), with walls approximately 1/8in thick. It is a stock extrusion from the range manufactured by Comalco Industries Pty Ltd, being coded type E-865. The 40-inch length used may be obtained readily from Comalco distributors in the various states, whose addresses may be obtained from Comalco sales offices.

The centre conductor of the line is formed from a 39¾in length of ¼in diameter round rod. This may be brass or copper, although in the prototype unit aluminium was again used. This is again a standard aluminium extrusion, and would be available from the same suppliers.

With an outer conductor having four complete sides and internal dimensions of ¾in x ¾in, the ¼in diameter inner conductor would give the slotted line section a characteristic impedance of approximately 69 ohms. The reduction in capacitance produced by the fairly wide slot increases this figure to about 72 ohms, so that the unit should be ideally suited for 72-75 ohm co-ax systems.

Actually, because of the relatively short length involved, the unit should also be satisfactory in 50 ohm systems. However if a lot of work in 50 ohm systems is anticipated at UHF and microwaves, where the small impedance discontinuity might become significant, it would be wise to use a centre conductor with a suitably larger diameter. For a nominal characteristic impedance of 50 ohms the centre rod should ideally have a diameter of 11/32in, but the more readily available 3/8in size rod should be quite satisfactory.

Screwed to the ends of the main extrusion are small L-shaped brackets which mount the input and output co-ax connectors and also serve as mounting feet for the line. In the prototype the brackets are made from 18 gauge sheet brass, but aluminium would also be suitable.

The ends of the centre conductor rod are drilled axially so that they slip over the centre spigots of the co-ax connectors. Holes are then drilled and tapped for 6BA setscrews to ensure a good contact to each connector spigot.

The co-ax connectors are screwed to the end plates via countersunk head 1/8in screws, which are arranged so that the heads are flush with the inside surface of the brackets. Each bracket is in turn screwed firmly to the ends of the extrusion by means of four 6BA screws which mate with holes tapped in the extrusion ends.

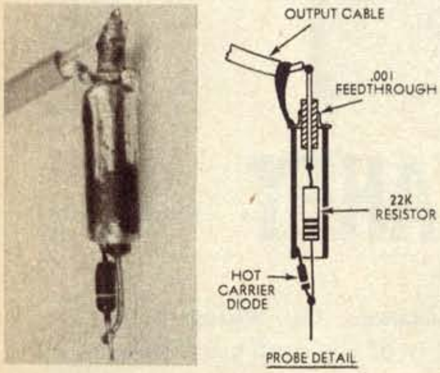
Additional support for the centre conductor rod inside the line is provided by four spacers fashioned from 1/8in acrylic sheet ("Perspex" or similar). These are simply squares of acrytic approximately ¾in by ¾in, with a ¼in hole drilled centrally to clear the conductor rod. Two of the spacers are positioned near the ends of the unit, to relieve strain on the co-ax connectors, while the other two are spaced at approximately 13 inches from the ends. The latter spacers have small slots filed centrally in their upper side, to clear the sliding test probe.

The test probe itself is quite simple, consisting basically of a standard shunt diode detector. The only difference from a conventional circuit is that here the input coupling "capacitor" is formed by the stray capacitance between the probe and the centre conductor of the slotted line.

The diode used in the probe should ideally be a hot-carrier type, particularly if the unit is to be used at high UHF and microwave frequencies. Either the Hewlett-Packard 5082-2800 or the Fairchild FH1200 would be suitable, as the peak inverse voltage will be quite low. However if the unit is only likely to be used on the lower VHF bands, a germanium device such as the OA90 could be used.

The probe is mounted on a simple sliding carriage bent up from a scrap of sheet brass. The carriage slips neatly over the line extrusion, and allows the probe to be moved smoothly up and down the line. The front of the carriage has a bent up lip which is provided with a small acrylic cursor to allow distance measurements using a metre rule or yardstick.

To allow convenient adjustment of the penetration of the probe into the line, the active probe components are mounted on a short length of ¼in diameter brass tubing. This is clamped by setscrews in a small bushing which is soldered to the top of the carriage. In the prototype unit the tubing for the probe was salvaged from the sleeve of an old telephone jack plug, while the carriage bush was from an old-style instrument knob.



A photograph and diagram showing the construction of the slotted line probe assembly.

The construction of the basic probe unit may be seen from the photographs. It is assembled as follows. First one pigtail of the 22K series resistor is cut to about 3/8in long, and soldered to one centre lug of the .001uF feedthrough. The outer flange of the feedthrough is then soldered to one end of the ¼in support tube, with the resistor inside the tube. A small slot is then cut or filed in the opposite end of the tube, and after cutting the anode lead of the diode to about ¼in long, this lead is soldered into the slot in such a way that the excess solder may be filed away to restore the tube to its former diameter. A pair of pliers or a "mosquito" clamp should be used to prevent overheating of the diode during the soldering operation.

The free pigtail of the 22K resistor is bent over to contact the cathode lead of the diode at a point some 3/16in from the diode body. The two are then soldered together, again using a heatsink to prevent damage to the diode. Finally the surplus resistor pigtail is removed, and the diode pigtail cut short at about 5/16in from the diode body.

The shielded cable which connects the output of the detector probe to the Powermatch metering circuit is attached to the probe after assembly. The inner conductor is soldered to the feedthrough capacitor lug, while the braid is soldered to the top of the brass tube. When the probe is mounted on the sliding carriage the cable is anchored to the carriage by a small C-clamp fashioned from a scrap of brass sheet.

The position of the probe in the carriage bushing is used to adjust the coupling. The idea is to use the minimum coupling which will give satisfactory readings on the Powermatch meter, as a large amount of coupling will cause the probe to disturb the line conditions.

The wiring of the 5-DIN plug used to connect the slotted line to the Powermatch has been arranged so that the output of the probe detector is read with the switch in the "forward" position. The sensitivity control is connected in circuit, to allow the meter to be set to full-scale on a "peak". The magnitude of a trough may then be read directly from the linear 0-10 meter scale as a fraction of the peak amplitude.

Note that in construction and assembly of the slotted line, care should be taken to ensure that the centre conductor of the line is straight and supported centrally in the main extrusion. If there are bumps or bends in the rod, these will result in changes to the probe coupling along the line, and thus mask the variations associated with the standing wave pattern.

Both the SWR reflectometer and slotted line accessories just described enable the forward and reflected power flow components in an RF feeder line to be resolved. Because of this they are both very useful for rapid evaluation of the matching of aerials and other loads. However in the event of a mismatch they do not provide sufficient information regarding the exact nature of the load impedance to enable the amateur to decide easily the most effective way in which he can remedy matters.

To obtain sufficient information for this to be done it is necessary to use an instrument such as an RF impedance bridge, and the next Powermatch accessory to be described is an instrument of this type. Although simply constructed, it is capable of accurate measurements from HF right through to the 432MHz band.

REFERENCES

FISHER, R.E., and TURRIN, R.H., "UHF Directional Couplers", in **QST**, Vol 54, No 9, September 1970.

GRIVET, P., **The Physics of Transmission Lines at High and Very High Frequencies**, Vol 1, 1970. Academic Press Inc, London.

JESSOP, G.R., **VHF-UHF Manual**, 1969. The Radio Society of Great Britain, London.

NAPOLI, L.S., and HUGHES, J.J., "Characteristics of Coupled Microstrip Lines", in **RCA Review**, Vol 31, No 3, September 1970.

ROWE, J., "A Fresh Look at the SWR Reflectometer", in **Electronics Australia**, Vol 32, No 12, March 1971.

TILTON, E.P., **The Radio Amateur's VHF Manual**, 1965. The American Radio Relay League, Newington, Connecticut. ■