Construction project:

RF detector probe for our Bench Amp

This simple and effective RF probe may be built from a handful of common components. It becomes a sensitive AM signal tracer when coupled to last month's Bench Amp or an audio amplifier.

by ROB EVANS

The simple RF detector probe has quite a pedigree. Its line extends back to the early days of radio, when it was one of the few essential pieces of test gear. When coupled to a small audio amplifier, the inexpensive probe was ideal for troubleshooting AM radio receivers without the luxury (or cost!) of an oscilloscope.

In these days of widely available and reasonably priced oscilloscopes (CROs), we tend to dive for the CRO probe to test any circuit. When tracing through an AM radio for example, the CRO will show us the presence of a signal and its relative amplitude, without significantly loading the circuit.

However, our old friend the RF probe has the advantage of allowing us to actually *hear* the signal as it progresses through the stages. This gives us an immediate indication of the quality and gain of each section, without analysing waveforms. Very 'real time' indeed!

Also, it's unlikely that everyone who troubleshoots or experiments with radio has an oscilloscope, leaving them with little means of tracing through a circuit. In this case, the RF probe is just the shot as a portable, low cost signal tracing tool.

Probing the circuit

The original and most basic form of the RF probe is simply a series connected signal diode, followed by a capacitor across the output. The diode rectifies (or detects) the incoming signal which is then filtered by the capacitor, leaving a voltage that is proportional to the input signal level. Therefore, the envelope of an amplitude modulated (AM) signal may be detected by this circuit, whilst removing the original carrier frequency.

Due to its moderate input impedance, such a simple design tends to load the circuit under test possibly causing it to detune, or stop altogether. Also, the forward voltage drop of the diode means that signal levels of less than this voltage will not be detected.

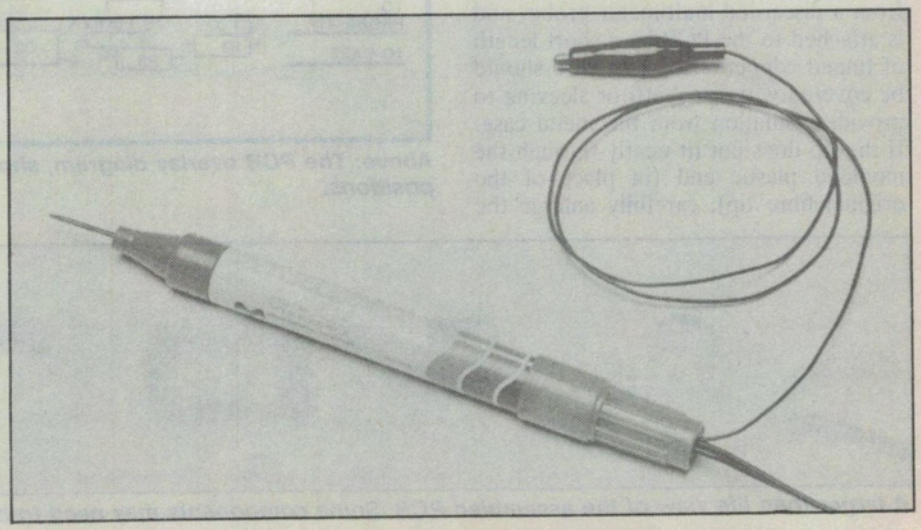
The simplest solution to these problems is to amplify and buffer the RF signal, before it is applied to the detector stage. The circuit now requires a DC power source, but is able to detect quite low signal levels.

Perhaps the most convenient device for this purpose is the common Field Effect Transistor (FET), which offers a high input impedance and moderate gain at radio frequencies. The FET (Q1) in our circuit is arranged as a common source amplifier, with a gain of about 5 (up to 10MHz), and an input impedance of 1.5M ohms as set by R2.

The input signal to this stage is coupled from the probe tip via C1, while the FET is self-biased by R3 and the source bypassed by C2. The 10M ohm resistor R1 provides a DC path for C1; this minimises discharge transients when tracing through a circuit. The amplified RF signal appears across the drain load R4, where it is coupled to the detector stage via C3.

As a further refinement on the basic design, a second diode has been added to the detector stage to form a diode pump style detector. This will provide still more output from the probe, by its voltage doubling action.

Finally, the carrier frequency (remaining RF) is removed by the filtering action of C4, and the resulting audio frequencies (AF) developed across R5. The AF may then be monitored by a suitable amplifier/speaker combination, such as the EA Bench Amp as



RF Probe

described in the April 88 issue of *Electronics Australia*.

Since the probe is connected to an amplifier via the audio cable, it may be remotely powered by a second wire from the amplifiers power supply. This avoids the size and reliability compromises of battery power.

As a further bonus, since all of the electronics are mounted in the probe itself, the circuit under test can only 'see' as far as the probe input. This eliminates the capacitive effects of long test leads when the detector circuitry is inside the amplifier. In fact, the described probe can have quite a long interconnecting lead without any ill effects.

The hardware

As well as electronic performance, there are physical considerations for a truly useful RF probe. It must easily fit the hand, and be able to probe (hence the name!) between the components of a radio circuit. In fact, the ideal shape is somewhat like a pen.

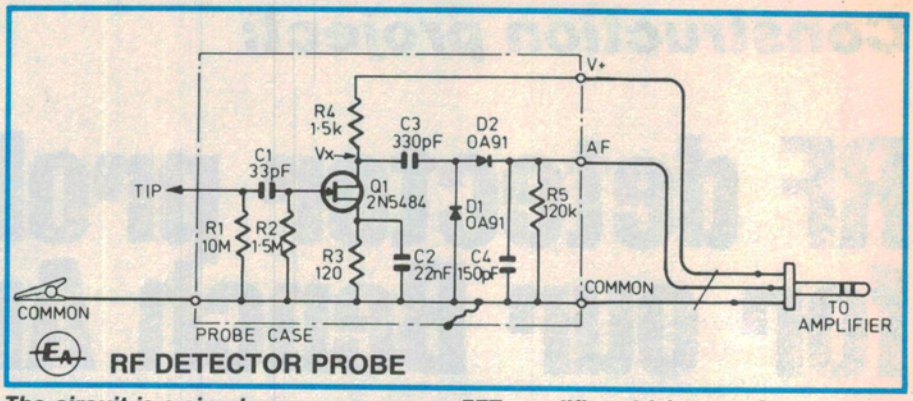
The case of a readily available fibre-tipped marker pen was too tempting to resist. Not only is its size and tapered point suitable, but the aluminium body may be a convenient RF shield. Naturally, a small amount of drilling and filtering is necessary.

Construction

All of the components are mounted on a small printed circuit board (PCB) coded 88pr5, and measuring 80 x 12mm. This is a snug fit inside a standard marker pen body.

Begin construction by mounting the components on the PCB, while referring to the component overlay diagram. Pay particular attention to the orientation of the FET and signal diodes.

The metal probe tip was salvaged from a discarded multimeter probe, and is attached to the PCB by a short length of tinned copper wire. This wire should be covered with spaghetti or sleeving to provide insulation from the metal case. If the tip does not fit neatly through the moulded plastic end (in place of the original fibre tip), carefully enlarge the hole with a drill bit.



The circuit is a simple common source FET amplifier, driving a voltage doubling detector.

A short length of hookup wire should be connected to the 'case earth' position on the PCB, and about 10mm of the insulation stripped from its end. This exposed wire is wound into the aluminium case thread, and held in place when the plastic end is screwed on, during final assembly.

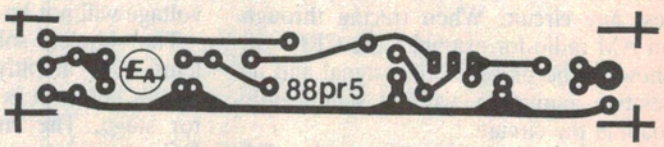
Next, a few simple modifications on the pen body are necessary. The enclosed end of the aluminium case should be opened to allow installation of the PCB. This may be done by drilling holes of ever increasing size, or alternatively cutting off the end carefully with a small metal saw.

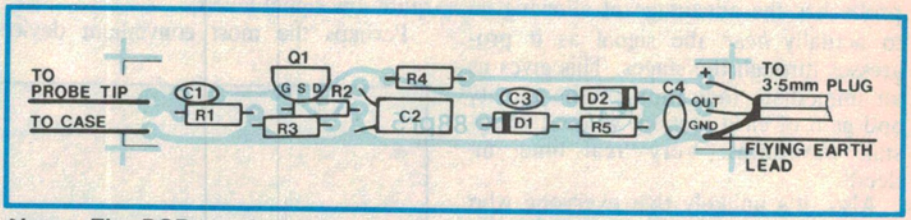
The original pen cap will become the rear cover of the probe, and must have a hole drilled in its centre as a cable exit point. The twin-core shielded cable and a length of hookup wire should be passed through this hole, and attached to the PCB as shown in the component overlay.

Finally, the flying ground lead may be terminated by a crocodile clip, and the twin shielded lead connected to a stereo 3.5mm plug. This plug mates to a 3.5mm socket mounted in the amplifier, which accepts the audio and also provides a DC supply for the probe.

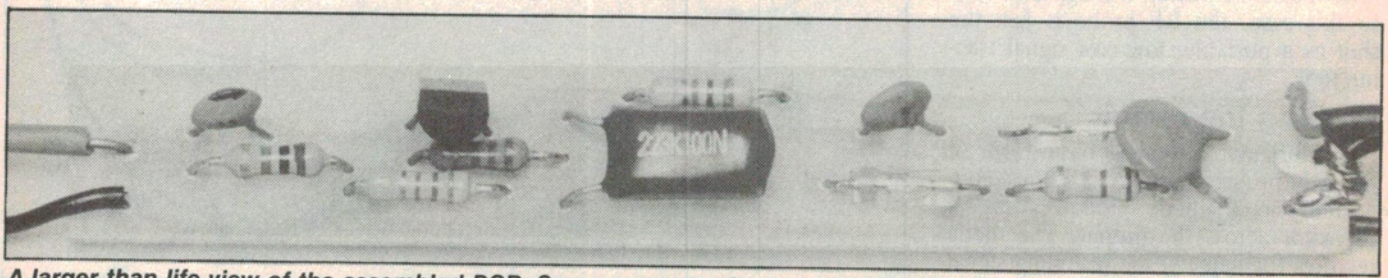
The complete PCB may now be slid into the pen body, and the plastic tip screwed on with the case ground connection. A knot should be tied in the cable to prevent undue stress on its PCB terminations. Also, a small amount of packing may be required when fitting the end cap to firmly secure the PCB/tip assembly inside the case.

Right: The PCB may be built from this full size artwork.

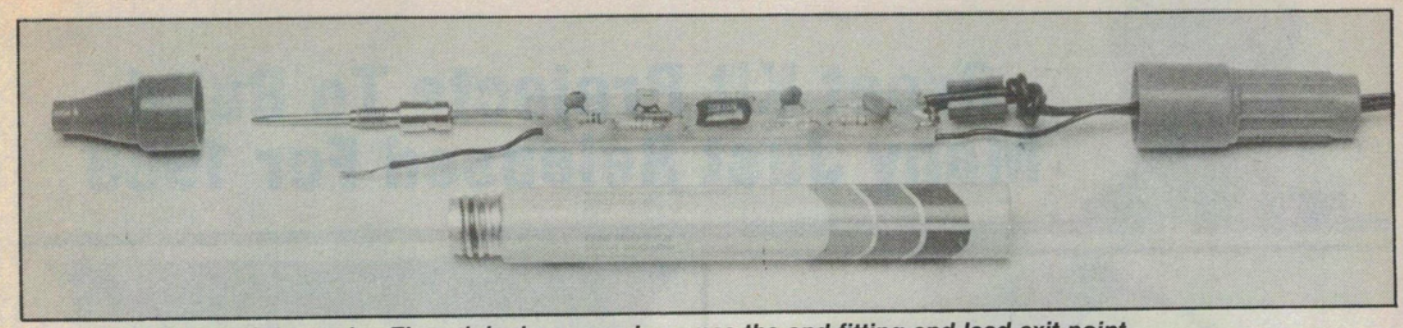




Above: The PCB overlay diagram, showing the component and wiring positions.



A larger than life view of the assembled PCB. Some components may need to be bent over to clear the pen body.



An exploded view of the probe. The original pen cap becomes the end fitting and lead exit point.

The amplifier

A suitable amplifier for the probe signal should have a reasonably high input impedance and sensitivity. The EA Bench Amp easily satisfies these requirements with figures of 1M ohm and 10mV respectively.

There is provision on the Bench Amp PCB for extra power supply decoupling components, which were labelled 'R' and 'C'. With values of 680 ohm and 100uF (25VW) installed respectively, the prototype provided a low ripple supply of about 14 volts for the RF probe. The supply voltage required by the probe is not critical in level, however the ripple content should be as low as possible.

Another addition to the amplifier is the 3.5mm input/power socket. This may be installed in a convenient position, and the signal input terminal (say, the tip connection) bridged to the amplifier's standard input. Naturally, the socket should be grounded, and the filtered DC supply connected to say the sleeve connection.

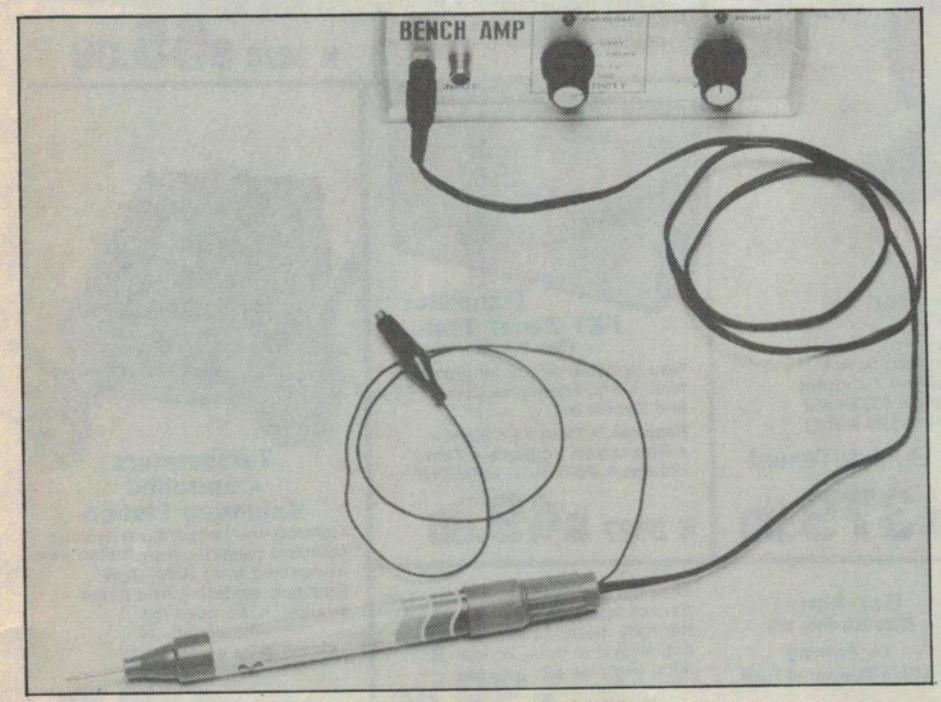
If an amplifier other than the Bench Amp is used, a similiar supply decoupling filter will be required. The same values for 'R' and 'C' should be fine, although the supply may need to be bypassed in the probe itself (try a 22nF metallised polyester).

Testing and probing

A couple of voltage checks can be made on the probe before installing the unit in its case. The DC supply should be between about 10 and 15 volts, and the FET's drain voltage (Vx) between about 1/3 and 2/3 of this value. This type of range is likely due to the wide spread of FET parameters. In extreme cases, the value of R3 may need to be altered to obtain a reasonable level of Vx.

The easiest way to complete the checks on the RF probe, is to trace through the circuit of an AM radio. The probe should be fully installed in its case, and the flying earth lead clipped to a convenient point on the radio's ground. Start tracing at the radio's own detector circuitry and then try a few points in the IF stages.

Finally, the amplifier input could be automatically switched between the two inputs (normal or probe), by using a switched 3.5mm socket. However, switched stereo 3.5mm sockets are quite difficult to obtain. So unless a different (and bulkier) style of socket is used, don't forget to unplug the RF probe when using the amplifier's standard input for normal audio signals.



Parts List

1 fibre tipped marker pen (cleaned and gutted!)
1 PCB, code 88pr5, 80 x 12mm
1 3.5mm stereo plug
1 crocodile clip
1 metal probe tip

Semiconductors

1 2N5484 FET
2 0A91 germanium signal diodes

Resistors (all 0.25W, 5%)
1 x 120Ω, 1 x 1.5k, 1 x 120k, 1 x 1.5M, 1 x 10M

Capacitors

1 33pF ceramic
1 150pF ceramic
1 330pF ceramic
1 22nF metallised polyester

Miscellaneous

Twin-core shielded cable, hookup wire, tinned copper wire, plastic sleeving.

Additional parts for Bench Amp

1 x 680Ω resistor, 1 x 100uF (25VW) PCB mount electrolytic capacitor, 1 x 3.5mm stereo socket.