# E Field Probe

# Active Antenna

# Technical Manual

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Acknowledgements

This kit was originally designed and sold by the late Dave Powis G4HUP and sold under the HupRF name. The rights to this kit were purchased by UKRAA in 2018 and this manual has been updated to reflect this change. No significant changes to the technical content of Dave Powis's original documentation have been made.

This manual should be read in conjunction with the "E-field Probe Testing and Mounting" document available from the UKRAA Website. This describes Dave Powis' original testing of the device and recommendations for mounting the finished antenna.

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# E Field Probe Active Antenna Manual

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## Scope of Document

This manual provides information on the assembly, testing and installation of the E Field Probe Active Antenna, EFP. The unit is supplied either as an SMD level component and PCB only kit, or as a completed SMD sub-assembly (assembly kit). An optional connector kit containing all the BNC connectors is also available.

The SMD kit is designed as an entry-level SMD project.

## E Field Probe Active Antenna Description

There are two parts to the circuit, supplied as a single, but separable, PCB. The antenna part is a small PCB containing the buffer amplifier stages, input protection circuit and power separation filter. This section of the system is called the Probe. The second, larger, part is the power separation filter for the receiver end of the installation – this is referred to as the Bias Tee.

The Probe gets its operating current via the coaxial cable that connects it to the Bias Tee. The Bias Tee allows a DC supply to be provided for the Probe over the same coax, without applying any DC voltage to the receiver input.

Assembly instructions for the SMD kit version of the E Field Probe Antenna are given in Appendix 1, at the end of this Manual. These should be followed, including the testing sections, before attempting to install the probe and connect it to a receiver.

Fig 1 shows the circuit schematic of the Probe and Bias Tee.

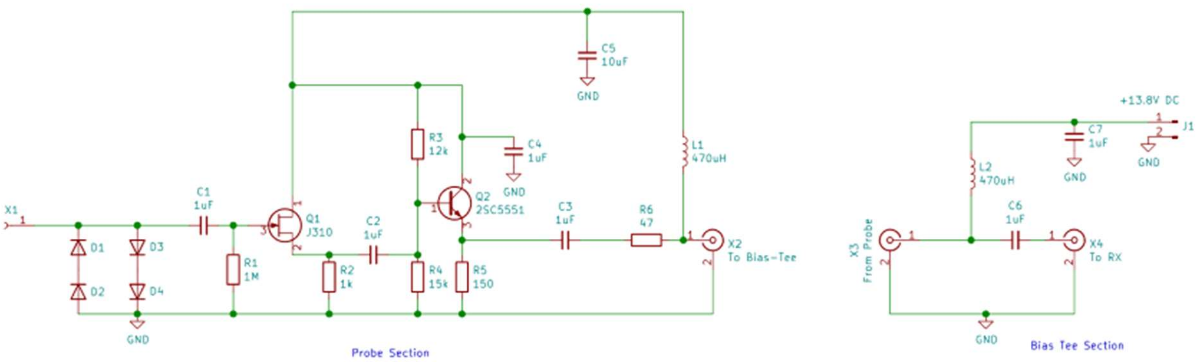
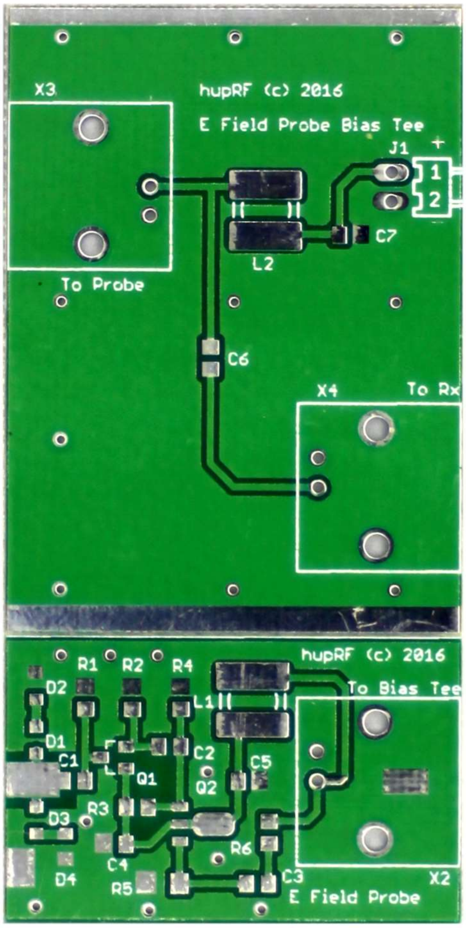



Fig 1 Schematic Circuit of E Field Probe and Bias Tee

Starting from the input of the Probe, D1-4 provide protection against large signals, which can easily be generated if you are close to a local Medium Wave transmitter or similar emitter within the frequency range of the device. They are arranged as two pairs, providing clipping at approx. 1.4V peak RF input. Q1 forms a high impedance source follower stage, to avoid loading the antenna probe, and feeds a lower impedance output signal into Q2, which is a high IMD emitter follower, matching down to 50Ω for the output to the receiver. L1 and C5 form the power separation filter function in the probe.




The Bias Tee is a replication of the power separation filter already seen in the Probe, with an extra DC blocking capacitor, C6, to prevent any DC at the receiver input.

The PCB is shown in Fig 2, and is mostly self explanatory, with reference to Fig 1There is a score line across the PCB between the Probe and Bias Tee sections – once assembly is complete, then the two should separated by carefully bending the board over the edge of a bench or table. Assembly kit versions will be supplied with the two board sections still joined.

Fig 2 – EFP PCB complete view

## Power Supply

The Probe require a direct current supply between 12V and 15V. This gives the user several options for powering the device. UKRAA supply a suitable 15V DC power supply which is available from our website.

Alternatively a nominal 12V (or 13.8V) DC power supply or a battery can be used.

## Probe Assembly Instructions

There is minimal work to do on the Probe. A right angle PCB Mounting BNC socket must be soldered in position X2, and a wire probe or a plate probe must be connected to the input. See later in this Manual for a discussion on wire and plate probes.

The Probe will need to be mounted in a housing of your choice – a small plastic enclosure is recommended. At one end of the housing you need to drill a single 12mm diameter hole to mount the BNC socket in – this will support the probe inside the box, so no further fixings are required. At the other end of the box, if you are using a wire probe, then a V notch will be needed in the centre of the join between lid and box to allow the probe wire through. Depending on the box and plate size, you may be able to accommodate the two within a single box. The wire can be sealed with silicone sealant once the box is finally assembled.

Alternatively, a vertical rod can be used as the probe, and if threaded this can be secured to the top surface of the box, and a wire used to link it to the input connection of the PCB. This may be more suitable for permanent installations.

## Bias Tee Assembly Instructions

Two right angle PCB mounting BNC connectors must be soldered into positions X3 and X4 on this board, and a 2 way right angle 0.1" Molex type plug goes into position J1. Note that these all mount on the topside of the PCB.

The Bias Tee assembly may need to be mounted in an enclosure although this will depend on your overall installation. If you are using an enclosure you will also need to prepare the case. A suitable enclosure can be purchased from Evatron (https://evatron.com/product-category/aluminium-enclosures/aluminium-enclosures-re-series/) although other suitable enclosures are available to suit the builder's preferences. The following notes refer to working with the Evatron enclosure.

A drilling template is given in Fig 3 – note that the positions of the BNC connectors are identical on the front and back of the box, but the power connector hole is only required on one side. The power connection drilling needs to be adjusted to suit your own choice of connector.

Check that the Bias Tee board slides smoothly into the case slots – if necessary, use a file to decrease the width of the PCB slightly.

Fit one of the end panels, slide the PCB into the box and fasten the BNC securing nut on the outside of the fitted end panel. Now fit the other end panel and secure with the 4 remaining screws and the BNC nut. Make sure that you have the PCB in the case the right way round!

Make up a power lead to suit your own connector requirements ensuring that the positive side of the supply goes to JP1 pin 1!

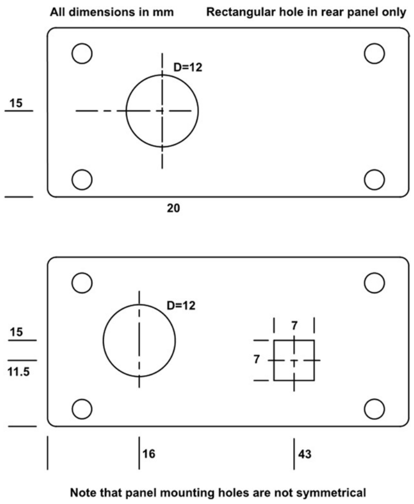



Fig 3. Drilling template for the EFP Bias Tee housing panels

## Antenna Probes – Plate or Wire?

It's really down to your preference. If you use a plate, connected to the input, then it will need to be supported, but it may be possible to include the plate within the same housing as the Probe PCB, which makes weather proofing easier. The plate does not need to be very large, perhaps 50mm x 40mm, for example.

If you decide to use a wire probe, then experiment has shown that a length of between 40 and 50cm gives very good results. You can use a shorter wire, but signal levels will be lower.

## EFP Probe Mounting and Connection

An E field Probe effectively measures the difference in potential between ground and its probe. Thus there are two important considerations in mounting it:

1. Its needs height – the higher above ground, the greater the available signal in microvolts (μV).
2. The support must be insulating – wood or fibreglass, etc. If you use a metal pole, you are effectively causing a temporary raising of the ground in the vicinity of the Probe antenna, so you lose the advantage of any height!

Testing carried out with the probe mounted approx. 3.5m above ground, on a fibreglass mast gave very good results from around 20kHz to 30MHz. Fig 4 shows the arrangement, with the Probe box held to the mast using cable ties.

Grounding of the probe is a very important consideration. To achieve good performance, the braid of the coax from the probe MUST be grounded at the base of the supporting mast. This is shown in Fig 5. Relying on grounding through the Bias Tee and Rx will give a considerable reduction in performance. Also, the braid must not be connected to ground at the Probe itself – this would have same result as consideration 2 above.

Fig 4 – Probe mounting on temporary fibreglass mast

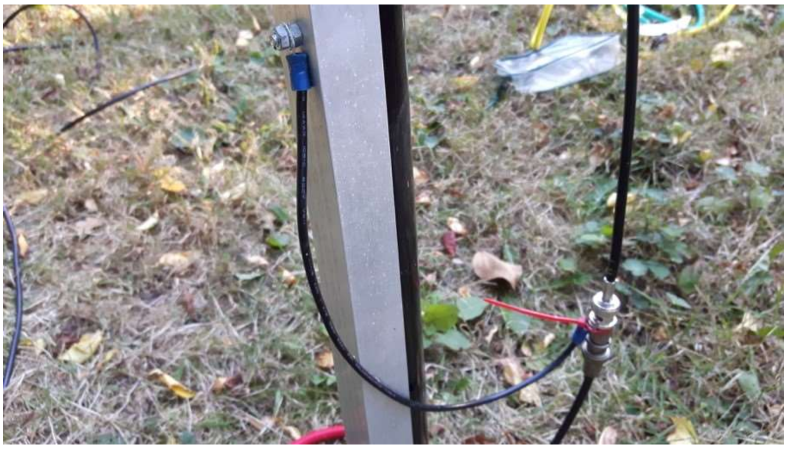


Fig 5 – Grounding of Coax Braid at base of support

The best way to achieve this is to use two lengths of coax to connect the Probe to the Bias Tee. One of these lengths should be the same as the height of the support, and the other long enough to reach to the Bias Tee and Rx. Connect the two together using BNC barrel connector, and use a small jubilee clip to hold the grounding wire in place. For a permanent installation, this can be weatherproofed using self-amalgamating tape and an outer PVC tape layer.

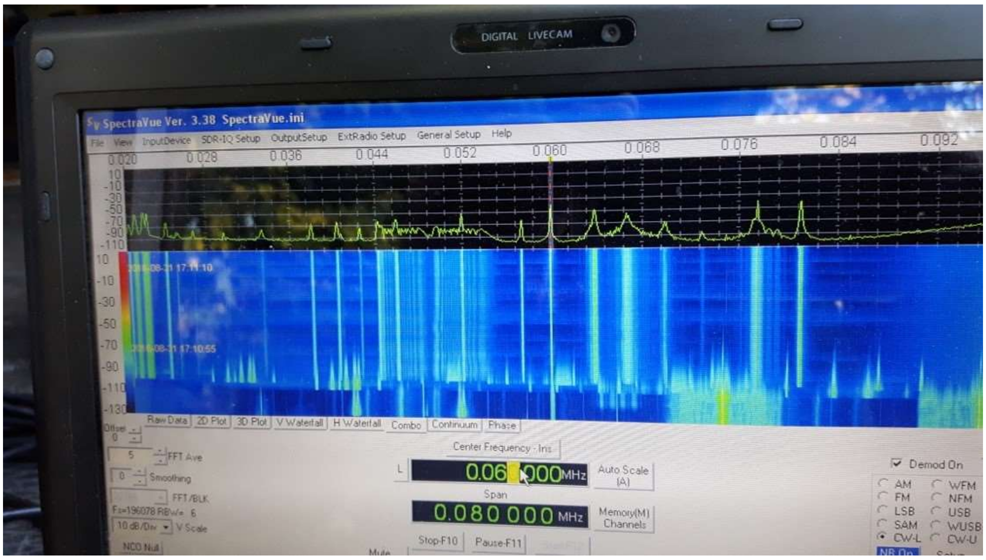



Fig 6 – Example of a Received Spectrum from 20kHz to 100kHz

# Appendix 1 – SMD Kit Assembly Instructions

## Introduction

These notes are to assist in the assembly and initial use of the E Field Probe Active Antenna. The schematic diagram of the board is shown below in Fig A1. A full page schematic is included at the end of this document for reference.

There are two separate parts to the circuit – the probe itself and the bias tee to provide power to the remote probe and separate out the RF signals to pass to the receiver. These are supplied as a single PCB, with a score line, so that the two parts may be easily separated. For assembly you may either leave it as a single board and break it later, or separate the two sections first.

The layout of the two boards is shown below in Fig A2. Note that although connectors are shown on the circuit and layout diagrams, these are not supplied as part of the basic kit. An optional connector kit containing all the BNC connectors is also available

## Assembly – Bias Tee Board

Since there are not many components on this board, you may feel more comfortable building this part first – there is lots of space between the parts!

For all the SMD parts, the same technique for mounting can be used – apply a small amount of solder to just one of the pads, hold the component in place with tweezers, and then re-heat the solder. Allow to cool, then solder the other end of the component to the pad. The same technique works for the transistors too – solder one leg in place, then work your way round the remaining connections.

When you come to the inductor, which is best fitted as the last SMD item, you need to create a pool of molten solder on one of the pads. Keeping the solder molten, place the inductor on it, making sure that you have it the right way round – it is easy to get them 90°out (and if you do that, the circuit won't work). The notches on the top side of the inductors should be as shown in Fig A4.

A little time spent to ensure the inductor is the right way round is worthwhile, as they are very difficult to remove! Once one side is secure, solder the other side, using plenty of solder and heat to allow it to flow under the inductor.

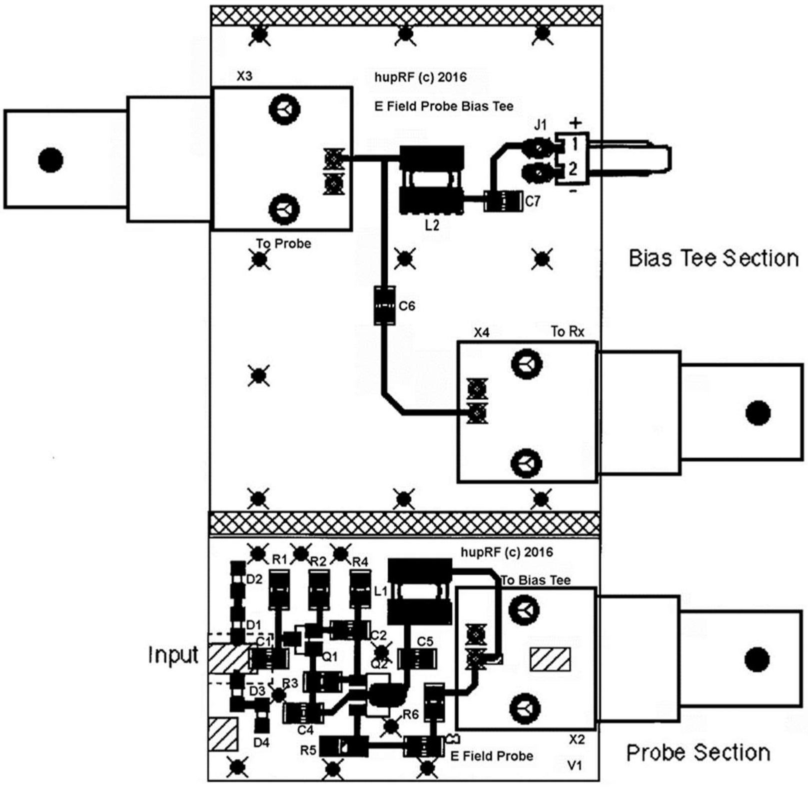



Fig A2 – E Field Probe Board Layout

## Assembly – Probe Board

The diodes are for input protection of the FET in the case of large local RF signals. As shown in the Schematic Diagram, they are arranged as two series pairs connected 'back to back' – this means that they will clip signals greater than about 1.4V peak. On the PCB the four diodes are in line. It does not matter which way round the diodes are, so long as they are all the same way round. Each diode has a white band towards one end – this marks the cathode. Fig A3 shows a fully assembled set of boards before the Probe and Bias Tee are separated.

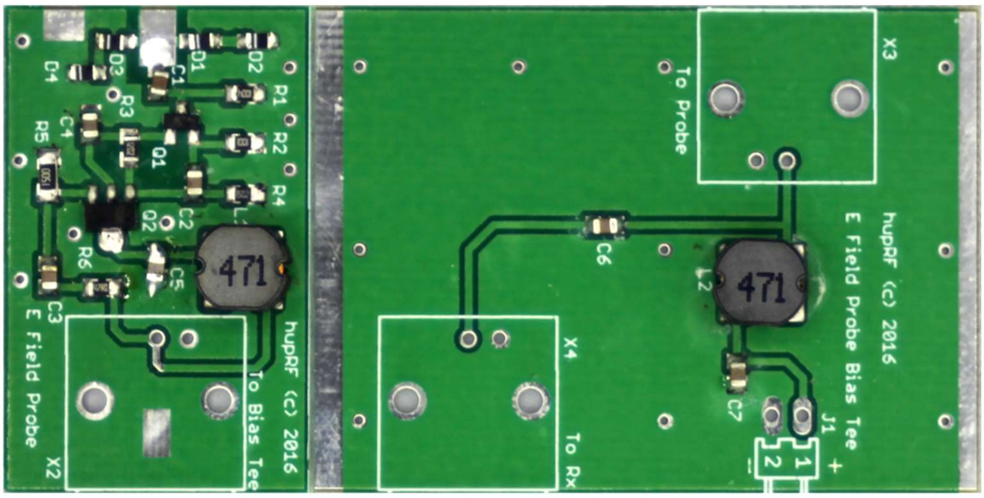



Fig A3 – Completed PCB assembly prior to separation

## Testing

Once assembly of both parts is completed, some simple DC tests can be carried out.

1 Using a multi-meter on the low Ω ranges, measure between J1 pin 1 and X3 centre conductor on the Bias Tee board – you should get a very low reading (almost 0 Ω, confirming that the inductor is soldered both sides.

2 Now measure between X3 centre and X4 centre on the Bias Tee board. Here you should not see a DC connection at all, so the meter (if a digital one) should read 1.

3 If either of these readings are not correct, then you need to find and solve the problem before moving on.

4 A similar check needs to be done on the Probe PCB. Here measure between X2 centre and the tab of Q2. You should get the same result as you did in Step 1, above. If not, seek out the problem and correct it.

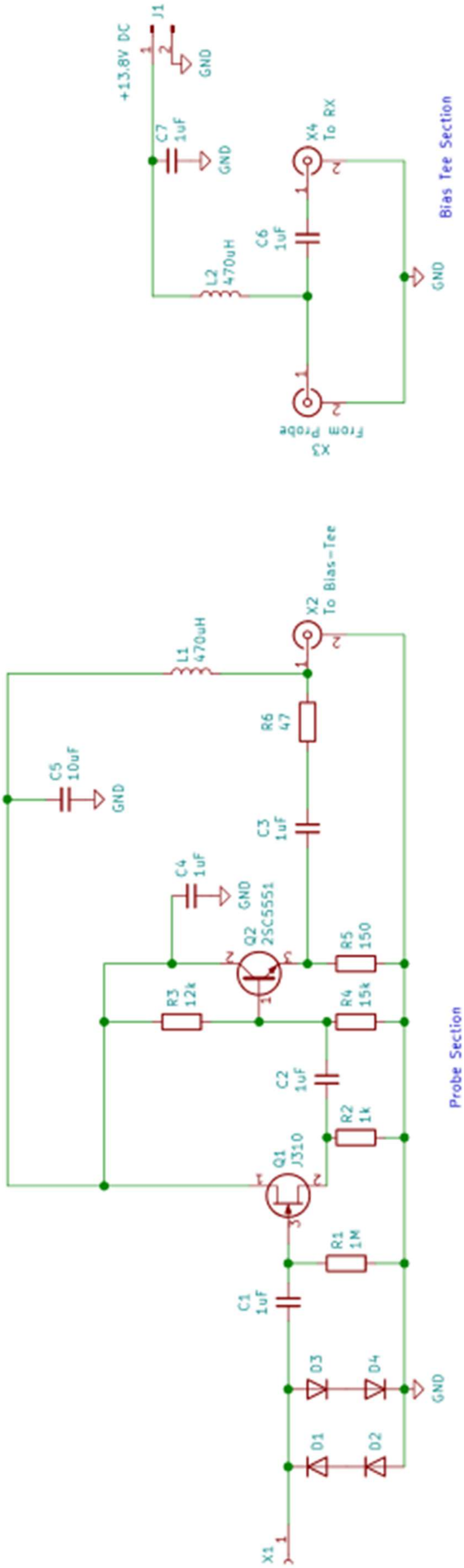
5 Do not connect the Bias Tee to the Probe board at this stage. Connect a power supply to the power connector, with the positive connection to pin 1 and 0V to pin 2. Set the Multi-meter to the 20V range, and measure between the centre of X3 and ground – you should read the full DC voltage.

6 As above, if you do not get the correct result, resolve the problem at this stage.

7 Once all is working, connect X2 of the Probe board to X3 of the Bias Tee board and apply power. Using the multi-meter, measure the voltage across R5 – it should be between 5 and 6V, indicating that Q2 is drawing the right amount of current.

8 At this point you can separate the two PCB’s along the score line by bending it over a sharp edge.


J1
+13.8V DC
GND
C7
1uF
X4
To RX
Bias Tee Section
C6
1uF
L2
470uH
X3
From Probe
X2
To Bias-Tee
L1
470uH
R6
47
C5
10uF
C3
1uF
C4
1uF
Q2
2SC5551
R5
150
R3
12k
R4
15k
Probe Section
C2
1uF
R2
1k
Q1
J310
R1
1M
C1
1uF
D3
D4
D1
D2
X1