Regular Feature

in practice

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DIY DESOLDERING BRAID

FOR REPAIRING PC boards, there is often no substitute for desoldering braid. Here's a way to make your own.

DESOLDERING BRAID is often better than a solder pump for cleaning-up tracks and holes before inserting new components. In particular, it has the almost magical property of clearing out plated-through holes by capillary attraction, leaving a clean, tinned pad ready to re-solder (never try to clear out a plated-through hole with a drill!). The August 1997 'In Practice' showed how to use desoldering braid, which is impregnated with flux so that the surplus solder easily tins the braid and is sucked away. However, desoldering braid is quite expensive and the flux tends to 'go off' if it's kept for some time. Here's a cheaper and better alternative: use plain copper braid, salvaged from scraps of coax, and add your own flux when you're ready to use it. Just give the braid a swipe with an Electrolube flux pen, or use one of the much cheaper sources of liquid flux that were mentioned in the October 1999 'In Practice'.

INVERTED-U ANTENNA

*IF I USE a half-wave 'Inverted U' antenna (**Fig 1**) what is the effect of grounding or ungrounding the far end?*

THE EFFECT IS to transform the same wire into a different antenna. To see why and how, we'll use the rules for drawing current and voltage distributions on a piece of wire ('In Practice', September/October 1998). This simple pencil-and-paper method used to be in all the antenna handbooks, and is in danger of becoming lost in the computer age, but it gives you the fundamental understanding that is always essential to ensure that computer models have been applied correctly.

Let's take the ungrounded case first (**Fig 1(a)**). The place to start is at the open-circuited end, remote from the feedpoint, because we know that here the current is close to zero - the wire has ended. The equation derived from Ohm's Law, R = V/I, says this must be a point of high impedance. A quarter-wave back from the open end, a current minimum becomes a current maximum, a voltage maximum becomes a voltage minimum, and high impedance becomes low; this is at the mid-point of the horizontal section. A further quarter-wave back, at the feedpoint, voltage and current have swapped over again, so we're back to high impedance. The main radiation will be from the current maximum on the horizontal leg, and the pattern is very similar to that of a low horizontal dipole. The small amounts of current in the two vertical legs flow in opposite directions (Fig 1(a)) and will substantially cancel. However, because there is some physical separation between the two legs, there will be a small amount of vertically-polarised radiation from the antenna, almost bi-directional from left to right.

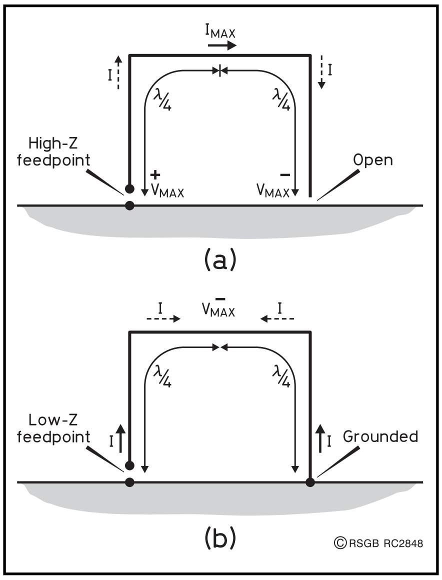

Fig 1: Half-wave inverted-U antenna has two completely different modes of radiation, depending whether the far end is (a) ungrounded, or (b) grounded to make a 'half loop'.

The same length of wire behaves completely differently when the far end is grounded (**Fig (1b)**). This configuration is often called a 'half-loop' and was popularised by Jack Belrose, VE2CV [1, 2]. You can think of this antenna as the top half of a full-wave loop, with the lower half supplied by ground reflection. To analyse the voltage and current distributions, once again we start at the far end. This time it is grounded, so we have a voltage minimum and a current maximum. A quarter-wave back, at the mid-point of the horizontal section, we now have a voltage maximum and a current minimum. At the feedpoint, we're back to low voltage and high current, so the feed impedance is low. Comparing Figs 1(a) and 1(b), by grounding the far end we have forced the voltage and current to distribute itself along the wire in a totally different way. Notice the current reversal at the top centre, which happens each time the wire passes through a voltage maximum. This means that the currents in the two vertical legs are now both flowing in the same direction, and will reinforce. Although the pattern is slightly bi-directional in and out of the page, for practical purposes it is almost omni-directional. However, the small currents in the horizontal section are almost exactly equal and opposite, so the horizontally-polarised radiation from this antenna is very weak.

In many ways Fig 1(b) is like two short verticals, so naturally you can expect performance to be highly dependent on the ground beneath. VE2CV describes a number of different grounding arrangements for the two ends, including buried radials, elevated radials and a distributed 'ring' system using all the concreted posts for his metal boundary fence [2]. He writes mainly about triangular loops which can use a single support, eg a 20m tower makes a good support for a 3.5MHz half-loop, but the principle can also be scaled down for 7MHz. Although the effects of voltage and current distributions on triangular loops are more difficult to visualise than on the inverted-U configuration of Fig 1, in fact the same principles apply. For a sloping wire, you simply divide the currents into the separate vertical and horizontal components (see below). **Figs 2(a)** and **2(b)** show the same two feed and grounding options as Figs 1(a) and 1(b) with the same total length of wire, a half-wave-length.

Fig 2(c) shows the detail of how the current is divided (resolved) into its horizontal and vertical components. The current arrow is drawn parallel to the physical wire. The length of the arrow (a vector) is proportional to the current. Then the horizontal and vertical components are the projected lengths from the tip of the main current vector on to the horizontal and vertical axes.

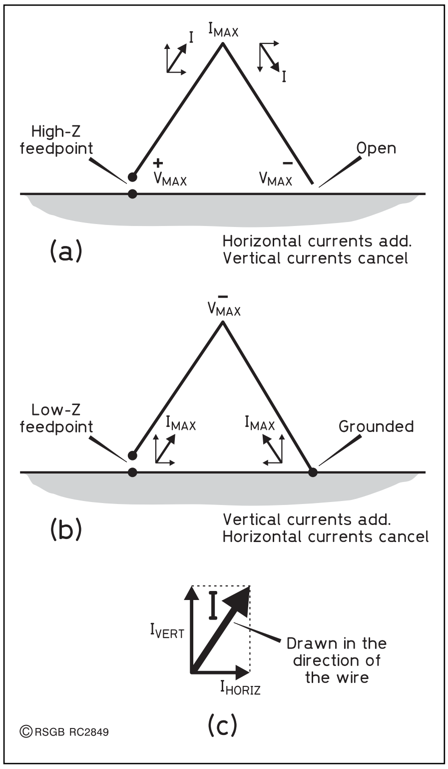

Fig 2: Half-wave inverted-V antenna. (a) and (b) are equivalent to Fig 1(a) and Fig 1(b). (c) shows how the current in a sloping wire is resolved into horizontal and vertical components.

In Fig 2(a) the horizontal components at the sides of the apex add together, while the vertical components tend to cancel. In Fig 2(b) it's the horizontal components that cancel while the vertical components add. Comparing Fig 1(a) against Fig 2(a), and Fig 1(b) against Fig 2(b), you can see there is relatively little difference between an inverted-U configuration and an inverted-V. To find any detailed differences between the radiation patterns, you would need to use an antenna modelling program, but there will be no surprises if you have already used the simple pencil-and-paper method described here.

REFERENCES

1. 'The Half-Delta Loop' by J S Belrose, VE2CV, *Ham Radio Magazine*, May 1982.

2. 'Loops for 80-meter DX' by J S Belrose, VE2CV, *QEX*, August 1997.

Reference 1 is out of print, but reference 2 is available on an ARRL CD-ROM.

RF GROUNDING ON PC BOARDS

WHAT'S THE difference between plated-though holes and solid copper for making grounds to the top surface of a double-sided PC board?

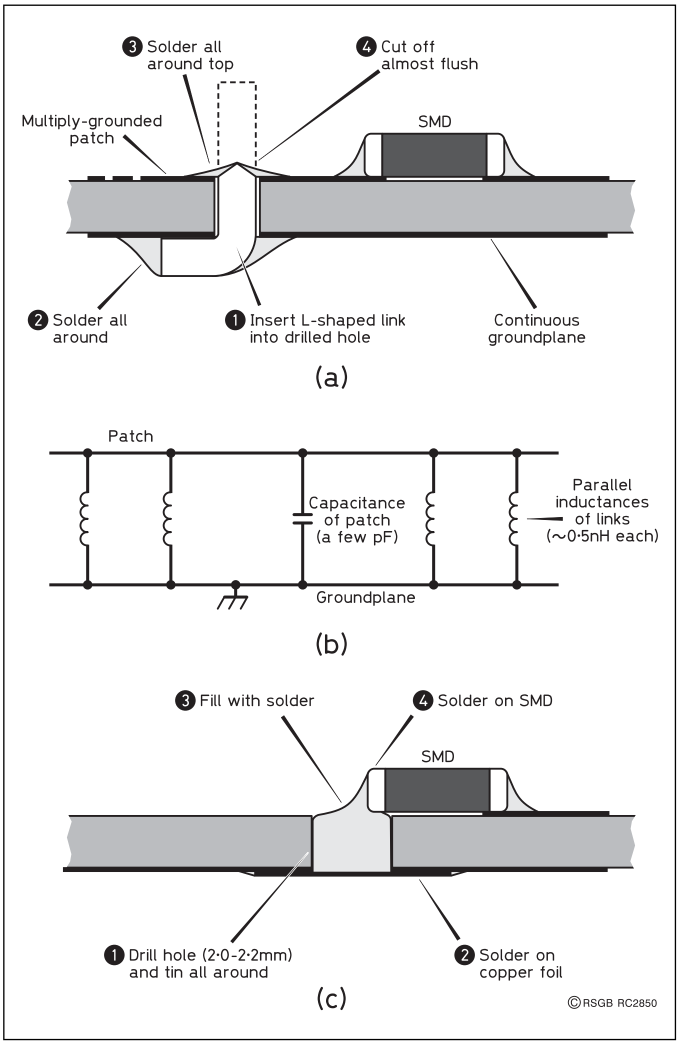

Fig 3: (a) Making 'dip-links' out of solid wire. (b) Equivalent circuit of several dip-links in parallel. (c) Alternative by S53MV.

IN A WORD, none. The RF current flows on the outside of a conductor owing to the skin effect, but it doesn't flow through holes ('In Practice', April 1995). We're talking here about VHF/UHF/microwave printed-circuit boards for microstrip and/or surface-mounted devices. In this type of construction, the main RF groundplane is the underside of the board, but there will be several locations on the component side that need to be RF-grounded. The 'cold' ends of SMD bypass capacitors are typical examples. The usual technique is to make a patch on the component side and link it through to the groundplane in several places to create a low-impedance ground. In production boards, the links would be plated-through holes (PTH), but for prototyping or amateur construction it is more normal to use 'dip-links' made of solid wire (**Fig 3(a)**).

The performance is almost identical, because the inside of the PTH doesn't count in RF terms. Therefore it is not necessary to use hollow rivets or any other attempt to simulate a true PTH. Such rivets are available, but are mostly intended either for repair of PTH boards or when making an exact mock-up of a future production version. For amateur boards you can use 1.5-2mm tinned copper wire for the links. Instead of a straight wire, it's easier to bend the wire sharply into an L-shape which is soldered to the groundplane first (Fig 3(a)). Then you can solder the top side more easily without the bottom side becoming unsoldered too. Finally, cut off the wire almost flush with the top side, but be sure to keep a continuous solder joint all the way around.

Fig 3(b) shows the equivalent circuit for multiple grounding of a patch on the upper surface of the board. Each link or PTH has a very small self-inductance in parallel with the self-capacitance of the patch. At low frequencies, the combined impedance will be dominated by the multiple low inductances in parallel, and this gives the good RF ground you were hoping for. However, there will also be a higher frequency at which the combination will be parallel-resonant and totally ineffective. The capacitance of the patch will be a few picofarads, and the inductance of each link will be about half a nanohenry. This puts the parallel-resonant frequency of a multiply-grounded patch somewhere in the region of 5GHz. Hopefully this frequency will be much higher than any frequency at which you need to establish a good RF ground - but that is far from guaranteed if you're designing a VHF/UHF amplifier using a microwave GaAsFET which will try to oscillate at all frequencies from LF to light! Fortunately, other RF grounding methods become available at frequencies of several gigahertz, such as broadband quarter-wave resonators (those little quarter-circles that you see on microwave PC boards).

Fig 3(c) shows a simple alternative grounding method favoured by S53MV. A 2.0-2.5mm hole is drilled through the PC board, and the groundplane underneath is replaced by soldering on a piece of copper foil. Then the hole is simply filled with solder, and the SMD component is soldered directly to it. This creates a conducting 'post' of relatively large diameter which provides a very effective RF ground - it has much lower inductance than anything you could reasonably achieve with foil or by bending component leads sharply downwards. It doesn't look pretty, and it doesn't fit in with modern automated assembly techniques (which is why you don't see it on commercial boards), but like many so-called 'ugly' construction techniques its RF performance is excellent.

Most amateur VHF/UHF/microwave construction requires a mixture of grounding techniques for optimum performance. Typically the board is soldered into a metal box, and any areas of foil on the component side that have one edge soldered direct to the box walls can be regarded as a good RF ground. Out in the middle of the board, you might use multiple links to 'nail down' the edges of large grounded areas. Then for the grounding individual components you can use either smaller patches with multiple grounding, or the S53MV technique. On the other hand, if the designer of a modern project has specified a particular method of grounding for active devices, go with that - the ground lead inductances may well have been included in the circuit modelling, and changing the method of grounding could in some cases make performance worse. ♦

If you have new questions, or any comments to add to this month's column, I'd be very pleased to hear from you by mail or E-mail. But please remember that I can only answer questions through this column, so they need to be on topics of general interest.