In Practice

Up the Coax… and Over the Top

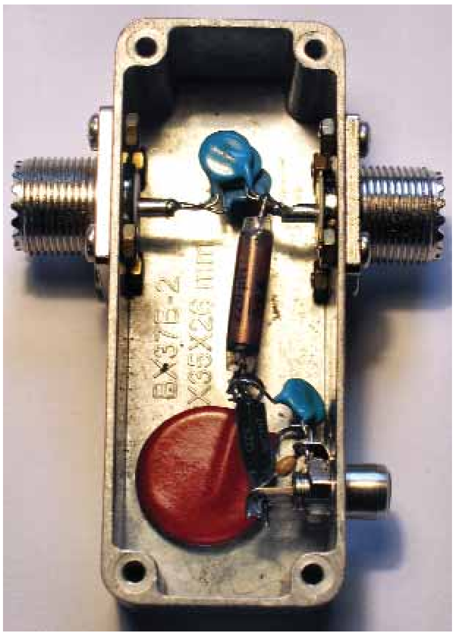

PHOTO 1: The DC injector/extractor shown in Figure 1.

Q: What is the best cable to run 12V DC power to my remote HF antenna switch?

A: The best cable may be your existing coax! It is quite easy to send DC power up the coax along with the RF, a well known technique for masthead preamplifiers but not so common at HF. The obvious advantage of sending DC up the coax is that that cable's already there and is probably well rated to carry the current. If you are using low-loss cable such as RG213, the centre conductor will be much larger than anything you'd normally consider as a control cable. Together with the braided outer shield (the return path) this will ensure a small DC voltage drop. The same can apply for thinner cable like RG76, provided you're only using a relatively short length. So, wherever a long run of control cable would be needed alongside an existing coax cable, 'DC up the coax' can be a very attractive option.

A single coax cable obviously can't perform as many remote switching functions as a multi-core control cable could… or can it? A future column will show how one coax cable can easily control up to four remote switching functions using no complex electronics, just a few diodes and capacitors. With a bit more electronics at both ends, you can make that single coax cable do some very fancy tricks. The common factor in all these schemes is some way to inject DC onto the centre conductor in the shack, and to extract it for use at the remote end.

DC INJECTOR/EXTRACTOR. As **Figure 1** shows, the circuit of this three-port device could hardly be simpler and all the components are readily available **[1]**. **Figure 1a** is the basic circuit. The two coaxial RF ports are connected together by C1, but only one of the RF ports has a DC connection via RFC1. C1 prevents DC from escaping towards the left, while RFC1 and the bypass capacitor, C2, prevent RF from escaping through the DC port. **Figure 1b** shows a few optional refinements. RFC2 and C2 provide some additional decoupling on the DC port and the voltage dependent resistor, VDR1, protects the DC circuits against any unexpected surges. **Photo 1** shows this circuit built into a small diecast box, with a pair of SO239 sockets for the RF ports and a phono socket for the DC.

You can throw this circuit together using almost any RF choke and capacitors and it will pretty much work. The real challenge is to make it work well. You want to see no noticeable increase in VSWR when the unit is inserted in-line and, when high RF power is applied, you don't want to see smoke! You also want this device to function across the entire HF range – and preferably beyond. So even this simplest of circuits can benefit from *well* chosen components. I'll show you how to make those choices.

The key components are RFC1 and C1. RFC1 is connected in parallel with the 50Ω feedline; to avoid upsetting the VSWR, the inductive reactance of this choke must be several times higher than 50Ω. The standard formula ($X_L = 2\pi fL$) immediately tells us that 1.8MHz will be the worst case, because the lowest reactance will be at the lowest frequency. However, a few quick calculations show that even on Top Band, a few hundred microhenries will provide plenty of reactance. At higher frequencies, the effect on VSWR should become progressively smaller, provided that the choke has no unwanted self-resonances **[2]**. Quite separately from having enough reactance, the choke must also have very low losses on *all* of its operating frequencies. You discover this very quickly when operating at higher power. If the choke absorbs even a few percent of the power that's passing between the two RF ports, it will burn up most impressively! Fortunately, there is a 'best buy' for RFC1. The 220µH choke shown in the lead photo is one of a range of ferrite-cored chokes manufactured by Epcos (Siemens) and this particular value offers a 'sweet spot' combination of sufficient inductance, very low losses, freedom from unwanted resonances and a DC current rating of 0.5A, which is sufficient for most remote switching applications. It is also readily available from a number of component suppliers **[1]**. The low losses are demonstrated by passing 1kW of RF continuously through the completed DC injector and checking for temperature rise. On any amateur band from 1.8MHz to 50MHz and beyond, this particular choke doesn't even get warm.

The coupling capacitor C1 is connected in series with the 50Ω system impedance, so good VSWR performance requires its capacitive reactance to be *small* compared with 50Ω. The reactance formula ($X_C = 1/2\pi fC$) once again tells us that 1.8MHz is the worst case, but here we notice that a first-guess value of 10nF (0.01µF) will have a reactance of about 9Ω which really isn't low enough. For that and another reason I am using three 10nF capacitors in parallel. The combined reactance of 3Ω creates a small residual VSWR on Top Band but C1 quickly becomes 'transparent' at higher frequencies. The capacitor of choice is a 10nF 1kV disc ceramic by Murata [1]; this range of capacitors has no published RF voltage or current ratings, but the 1kV DC rating helps to ensure good performance under stress. Using three capacitors in parallel means that each capacitor carries only one-third of the total RF current, and RF voltage is not an issue here. Once again, practical experience is the final proof and these capacitors remain completely cool in the 1kW RF test.

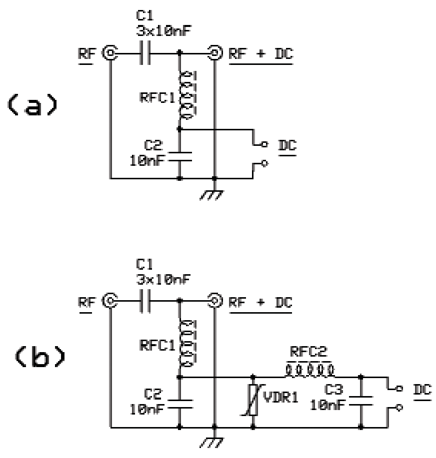

FIGURE 1: DC injector/extractor. (a) Basic circuit, (b) With optional extras [1].

PHOTO 2: 80m dipole over the top of a small HF beam.

PHOTO 3: Close-up of the rotating dipole centre (balun box to the rear).

I can recommend only those specific components for RFC1 and C1 – many other types may work, but you'd have to find them for yourself. However, none of the other components in Figure 1 has to operate at such high levels of RF voltage and current, so there you have a wider range of choice. C2 is under no particular stress and I only specified the same Murata component because these have become my standard 10nF capacitors for transmitting applications. In Figure 1b, RFC2 and C3 provide extra RF filtering at the DC port. RFC2 could be any RF choke of about the same inductance and DC rating as RFC1 (so if there's nothing in the spares drawer, buy two of the same type). C3 can be almost any 10nF ceramic capacitor. Finally, VDR1 can be any low-voltage VDR (varistor); I used a V24ZA50P because it gives reasonable protection against surges on nominal 12V DC circuits, so there are usually a few in the spares drawer [1].

MECHANICAL CONSTRUCTION. For high power operation you definitely need a shielding box to keep RF currents in their proper place – inside the coax. A small diecast box is very good for this application and by being totally enclosed it helps to keep the VSWR acceptably low on all bands up to 50MHz. A construction tip: the patterns of holes for the two SO239 sockets were marked out using a paper template as described in August and December 2007. The drawing was made using the PC board layout program ExpressPCB [1] and the five-hole pattern was copied at the correct spacing to print a template to mark out both sockets at the same time. Then the template was taped into place and the drilling marks centre-punched through the paper. It isn't precision engineering, but far better than trying to measure and mark directly onto the box.

Although I have described this circuit mainly as the 'DC injector' that resides in the shack, you will need something very similar as a 'DC extractor' at the remote end of the coax. The circuit diagram is exactly the same as Figure 1 (or maybe its mirror image). However, it isn't always necessary to build two mechanically identical units, For example, if you want to convert an existing remote switchbox, you can often cut a track on the PC board to insert the 3x10nF disc ceramics in the RF pathway behind the input socket and then solder RFC1 directly onto the rear of the socket. The other end of RFC1 is connected to C2, which in turn is soldered to a convenient spot on the PC ground plane – and there's your DC, extracted from the coax and delivered inside the switchbox. Exactly the same can be done for receiver preamplifiers, both at VHF/UHF and for LF receiving antennas such as Beverages and small loops that may also need a remote preamp.

OVER THE TOP

Q: Someone told me you'd made a swivel mounting to run an 80m inverted V over the top of your rotary beam?

A: Yes, although it certainly isn't an original idea. Most users of telescopic masts and towers suspend their HF wire dipoles from a point below the rotator cage, leaving the beam free to rotate above. That wouldn't work for me because the tower has to spend most of the winter nested down, and although the beam can still rotate, dipoles suspended below the rotator would be lying in the tree-tops… not good. Mounting a dipole on a mast extension above the beam is a much better solution, provided the inverted-V angle can be made shallow enough to clear the beam as it rotates underneath. Another strong reason for mounting low-band dipoles above the beam is the extra height above ground, which makes them more effective – undoubtedly for DX, and often for more local QSOs as well.

The problem with this 'over the top' approach (**Photo 2**) is that the centre of the dipole must be able to pivot on the top of the mast, so that the mast and beams can rotate beneath it. The solution was inspired by the Top Band dipole at the super-station of Jan Fisher, G0IVZ [3]. On top of his heavy duty four-section Versatower that already carries two stacked HF beams, Jan added a 30ft rotating mast extension that lifts the centre of the Top Band dipole to about 100ft – gloriously 'over the top' in every way! My setup is a mere half-scale model. The rotating mast for the HF beam is made from scaffold tubing, extended by a 1.5in fibreglass pole (an aluminium pole of that diameter probably couldn't handle the bending forces). The top of the extension pole is filled by a close-fitting hardwood plug, drilled 8mm through the centre and secured with epoxy.

G0IVZ's bright idea was to use a ready-made centre insulator that was originally designed for mounting a tubular dipole on the boom of a Yagi. The plastic moulding is strong enough to support a much longer wire dipole, simply tied on through the fixing holes as shown in **Photo 3**. Jan used the built-in terminal box to connect the dipole to the coax feedline, while I connected the two wire ends to the terminals on the balun box. The main mounting hole of the centre insulator is drilled 8mm for an M8x100mm stainless steel screw which is the pivot pin for the whole assembly. In my version, the balun bracket is fixed to the bottom of the insulator with a nut, so those two parts rotate together. A large washer is added to spread the down-thrust, and the free end of the screw simply drops into the hole in the wooden plug. A later addition was the piece of white PVC waste pipe, taped to the bracket to prevent the bottom edge scratching the fibreglass. Below this fitting there has to be a rotation loop in the coax (Photo 2) and of course there's the usual loop around the rotator itself.

It simply works – nothing more to add about the mechanicals, except that the fibreglass tube and centre insulator both came from Moonraker and the stainless steel hardware from Screwfix [1]. Obviously there is some interaction with the HF beam, but it isn't seriously greater than the interaction with a dipole immediately below the beam (which most people readily accept). At the present stage of the sunspot cycle, that's a small price to pay for a *much* better signal on the lower bands.

NOTES AND REFERENCES

[1] For web links and a list of parts, see www.tinyurl.com/inpractice

[2] The traditional 2.5mH HF choke has far more inductance than needed and the very high capacitance between turns will almost guarantee some unwanted resonances. See the March 2007 and July 2007 columns for more information.

[3] Photos of G0IVZ's antennas can be found on GM3WOJ's excellent website about Versatowers – just follow the links as usual [1].