RADCOM TECHNICAL FEATURE

Power Splitter For 70cms

by Peter H Saul, G8EUX.

THIS NOTE DESCRIBES a simple, accurate power splitter for the 70cm uplink to Oscar 13. The invention was to derive a design which could be made in an afternoon, with hand tools and no specialist equipment. The prototype was built in exactly this way, using scrap copper water pipe, at a total cost of one pound from the local tip. Other components needed are connectors and some solder.

The conventional power splitter shown in the *RSGB VHF/UHF Manual* uses two quarter wave sections, each of 72Ω, to achieve a match of the 50Ω source to the two 50Ω antennas. This is a simple design, but results in a fairly large assembly. The dimensions do not suit standard sizes of copper, and would need to be cut to dimension fairly accurately.

Looking at the dimensions of standard copper water pipes as potential coaxial structures, there are several useful combinations. The dimensions of the pipes are shown diagrammatically in **Fig 1**. From the standard texts:

Coaxial Line impedance (circular conductors) =138 x log D/d

Where D and d are the outer inside diameter (I/D) and inner outside diameter (O/D) respectively. The available impedances are therefore 33.0Ω, 17.2Ω and 10.0Ω. More could be achieved with combinations including microbore tape.

The match from 50Ω to 25Ω, ie two 50Ω antennas in parallel, requires a single quarter wave section of 35.3Ω. This can be fairly accurately approximated by a 15mm outside diameter (O/D) conductor in a 26mm inside diameter (I/D) outer, ie a 15mm pipe inside a 28mm (O/D) pipe.

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The actual impedance is 33.0Ω, so the output impedance is theoretically:-

(33 x 33)/50 = 21.8

ie Close to the target of 25Ω.

Since the pipes were surplus in origin, they were first thoroughly cleaned using steel wool. In particular, the inside of the 28mm pipe was cleaned by many passes through with the steel wool; even new pipe should be cleaned and deburred.

Pipe cutting was by hacksaw, with filing to final size and squareness, although a pipecutter would have given a better finish. The only critical dimension is the inner conductor length, at 172.2mm nominal. It is possible to get this within 0.5mm with care. The outer was cut about 15mm longer.

Scrap copper pipe was opened up and flattened to make an end cap and a connecting fillet from the input connector to the coaxial line. A large pair of tinsnips were used for this cutting out, since they do a neat job much faster than the saw.

The connecting fillet was soldered in place in the inner pipe first. As a compromise, soft (ordinary cored electrical) solder was used. A lot of heat was required. It was found that the hot air gun (Black and Decker 1600 watt) which was used for pre-heating was capable of reaching soldering temperatures, so this was the technique used. The metal was heated for a minute or so, then the solder was flowed on. Plumbers solder might have been even better, but would needed flux; this was not been tried.

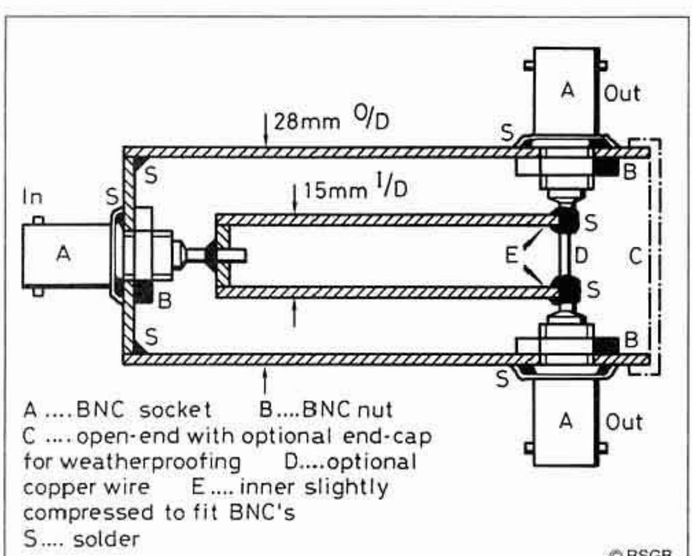

Fig 1: The power splitter is constructed from standard sizes of copper pipe.

The connector was mounted through an appropriate hole in the bottom plate. Screw mounting BNC connectors were used for convenience of assembly, especially in the dual ported end of the assembly. **Fig 2** shows the arrangement. The connector was soldered to the fillet. The outer pipe was prepared by attaching the two output connectors. The bottom plate was then soldered to the outer pipe. Since this involved much heat, it would have been better to silver solder the inner connections, but this was not available. Instead, the joints were inspected visually and with anohmmeter to check for continuity.

Finally, the inner was soldered to the output connectors in the end of the outer pipe. This required some squeezing of the inner pipe to make a good mechanical fit. The connectors centre pins were fitted into triangular grooves in the end of the inner pipe to ensure that it was not increased in length. The

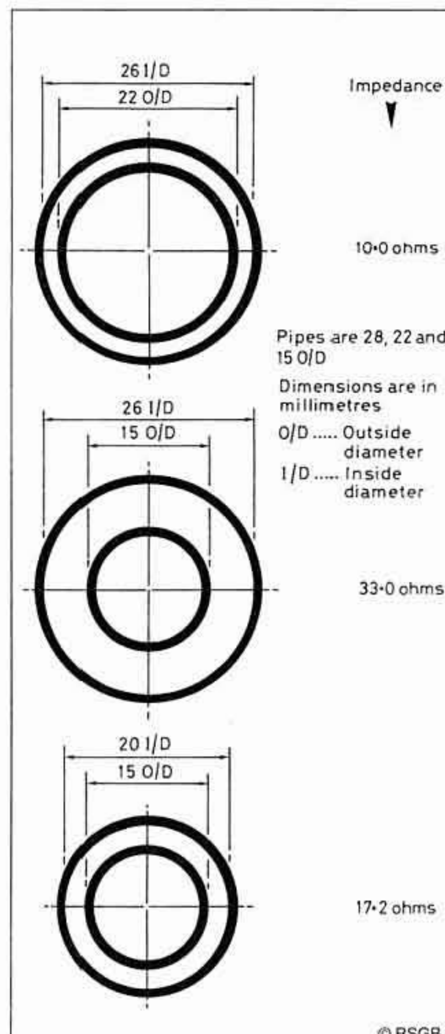

Fig 2: Variations of matching impedance.

really critical dimension was the length of the pipe at the 33Ω impedance, so the small fillet length, which was approximately 50Ω anyway, was ignored. No end cap was used on the prototype, but this could be easily provided if desired.

Finally, the assembly was cleaned again, and surplus solder filed off.

An on-air test was carried out as soon as the assembly was sufficiently cool! VSWR minimum was at 435.0MHz, suggesting a small lengthening of the line, but very close to theory. The power returned by the whole assembly, including antennas, was less than 0.5W for 10W forward, over the central part of the band from 432MHz to 438MHz. When two 50Ω loads were fitted, reflected power remained constant at 0.4W over the whole band.

SATELLITE CONNECTIONS

Satellites normally operate with circular polarisation, ie a mix of horizontal and vertical, with appropriate phasing. Although it is perfectly possible to operate through satellites with only horizontally (or only vertically) polarised signals, better results are usually obtained using circular polarisation. This is achieved by using two ('crossed') antennas, with an equal power split between them, and a 90° phase shift in one feed.

My feature 'Antenna Feeder Cable Measurements', *Oscar News* Issue 92, Dec 1991, pp 12,13, indicated how antenna feeder cables can be matched and fed appropriately. Most satellites also spin about their axis at a rate of a few Hz. This imposes an apparent amplitude modulation on the signal known as 'spin modulation'; it can make the signals very difficult to read at times. Although not a complete cure, the use of circular polarisation on transmit and receive does go some way to reducing this effect by removing the gain variation due to antenna orientation.

Operationally, the improvement of the circular polarisation over horizontal or vertical was noticeable, both in reduction of spin modulation on the return signal from the satellite, and in apparent signal strength.

In terrestrial contacts, simple equal cable length phasing of antennas would be adequate in most cases; the power splitter enables two antennas to be connected very simply into the transceiver. A useful alternative for those who want to mix terrestrial and satellite contacts is to leave the satellite connections in place. On UHF, over long paths especially, some polarisation twist is almost inevitable, so the apparent loss of 3dB in feeding the additional antenna of the unused polarisation is less of a disadvantage than simple theory indicates.

Bench measurement showed that the insertion loss, to each output port, with both ports terminated correctly, was 3.35dB at the band centre, against a theoretical zero loss of 3.01dB. The excess loss of only 0.34dB was considered to be very satisfactory, especially as it includes connector losses. There was only a very small increase at the band edges.

After completing and using the unit for some weeks, the possibility of computer modelling came to mind. The author has a demonstration version of the CAD program SPICE on the shack computer. This can model lossless transmission lines, in addition to many other facilities. The result of a simple insertion loss calculation is shown in **Fig 3**. This indicates a minimum insertion loss to either output port of 3.01dB. The figure measured, 3.34dB includes connector losses and copper losses. More interesting is the apparent bandwidth. VSWR cannot be easily predicted, but the diagram indicates that acceptable performance is available from 420MHz to 450MHz, with only slight degradation outside this range. This agrees with the measurements over the actual band, which showed very little variation between the band edges. For reference, the conventional 2x72Ω splitter was also modelled (**Fig 4**). This showed a similar in-band loss, the theoretical 3.01dB, but sharper band edges, ie the design is more critical. Intuitively, this is correct, since two tuned circuits are involved instead of just one.

CONCLUSIONS

This article has described a prototype assembly, which is now in constant use. The only improvement required was the soldering of the BNC connectors to the outer tube, to avoid twisting the centre conductor when removing the unit. N-type connectors were considered, but the BNCs work well at this frequency and are very convenient in the assembly. Most cables for this frequency are better suited to N types, so adaptors are used at the outputs. The input has a short length of RG58 from the linear.

The antennas are separately fed, so that all polarisations are available by arrangement of connections. A switch would increase losses. Of course, a simpler arrangement would be to use a single feed, with the power splitter at the mast-head; it is amply rugged enough for outside use, and with an end cap could be made watertight.

The dimensions of the pipes are such that no narrow gaps are involved, so no arcing should be expected. Operation at close to 100W input has been proved, and no problems are expected at full legal power.

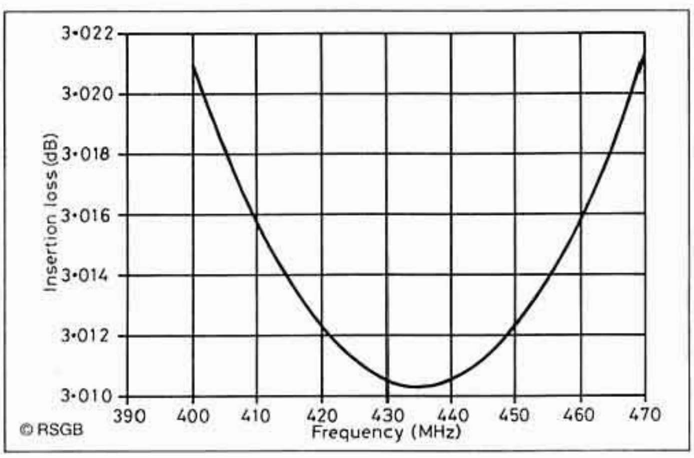

Fig 3: Results of a computer model using the SPICE program (2 x 50Ω version).

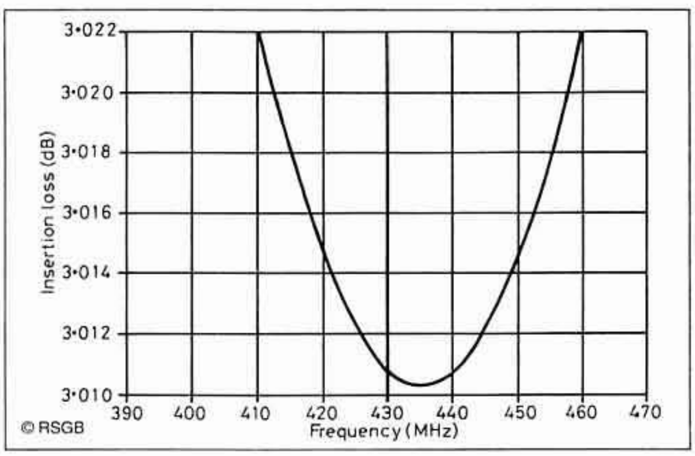

Fig 4: The conventional version (2 x 72Ω) shows similar bandwidth.

TECHNICAL UPDATE

A PROPOSED CODE OF PRACTICE FOR AMATEUR OPTICAL COMMUNICATIONS

AN UPDATED VERSION (v2.1) of the BASIC computer program published in the January 1993 issue of *RadCom* has been supplied by the author, B.Chambers, G8AGN. This includes suggestions from G4XVJ and others, who have shown interest in this fascinating mode of communications. The following lines should be amended or, if they do not already exist, inserted into the program:

```
240  CLS: INPUT' Enter laser output power in mW ';
     Po
285  IF yn$ <>'Y' AND yn$ <> 'y' THEN GOTO 340
290  INPUT 'Enter expander magnification factor
     (>1) ';emf
365  IF yn$ <> 'Y' AND yn$ <>'y' GOTO 450
370  INPUT 'Enter collecting lens diam in mm ';od
460  IF yn$ <>'Y' AND yn$ <>'y' THEN
     r = (SQR(4 * Po/(PI * 18 * t^(-.25))) - a) / phi
     ELSE r = (SQR(4 * Po * k / (PI * 18 *t^(-.25))) -
     a) / phi
465  END IF
470  ir = INT(r + .5)
```

All other lines in the program remain unchanged. Note that many forms of BASIC use double quotes rather than the single ones shown in the original listing and amendments.

SIMPLE 160M PHONE TRANSCEIVER

COMPONENT LAYOUT DIAGRAMS for this project (Jan & Feb 1993 *RadCom*) are being supplied with the pair of PCB's. In addition the component overlay is marked on the board to simplify construction. Available from Badger Boards (Tel 021 353-9326).