Use 75 ohm CATV Hardline in a 50 ohm System

Get the benefits of low loss transmission lines by using 75 ohm hardline at VHF. The proposed transformer is inexpensive and 60 % shorter than a conventional quarter wavelength transformer.

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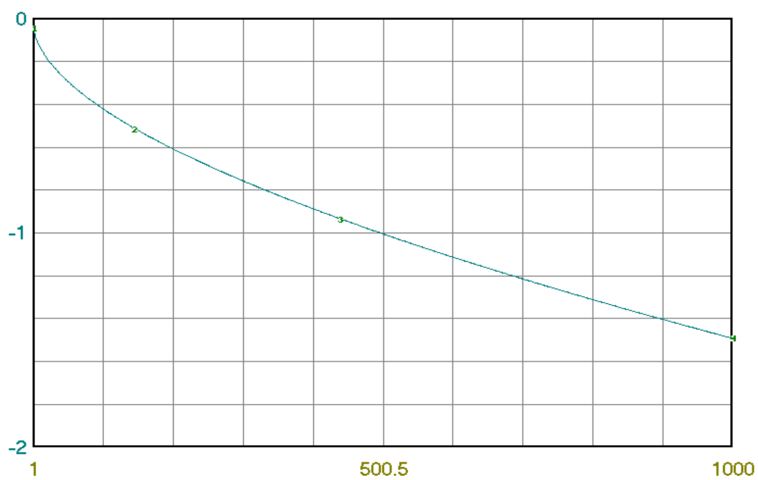
Introduction

Surplus 75 ohm hardline is often available at bargain prices from cable TV operators. These provide lower losses than their 50 ohm counterparts and this article shows how to make simple wide band transmission line transformers for use in the 2 meter band. As shown in figure 1, the losses are about 0.5 dB/100 ft at 146 MHz and 0.95 dB/100 ft at 440 MHz, for the CommScope hardline model P3 - 840.



Typical matched loss vs frequency of CommScope P3 - 840   75 ohm hardline

Figure 1

The impedance transformation is achieved with an L - C network, where the L is made up of the hardline inner conductor and the C is a discrete capacitor, located at the end of the line dielectric. **Note that this L-C network allows ~ 60% reduction in the length of the transformer, compared to a quarter wavelength line.

Some general notes:

Note that in a 50 ohm system, the SWR varies from a maximum of 2.25 for a quarter wavelength to 1.0 for a half wavelength. On HF it's probably simpler to use multiples of a half wavelength to reduce the SWR. For instance, a 176 deg. line at 3.5 MHz yields low swr on 80-75m, 40m, 20m and 15m HF hambands, assuming that the load is 50 ohms across all these bands. A custom length may also be chosen to optimize swr on selected bands.
The other option on HF is to use a tuner. Even a 5:1 SWR will not cause much loss SWR losses since the line matched loss is less than 0.3 dB/100 ft at HF.
On VHF/UHF, while a tuner could be used, it is not common. Setting a multiple of a half wavelength is difficult since connector length must be taken into account.

Construction details

As shown in figure 2, the foam insulation is removed, leaving the center conductor exposed.
An N connector is soldered at the end. A capacitor is added close to the foam. It is made from a ½ inch copper pipe cap. Teflon tape is wound over the cap to provide mechanical stability and the required capacitance.

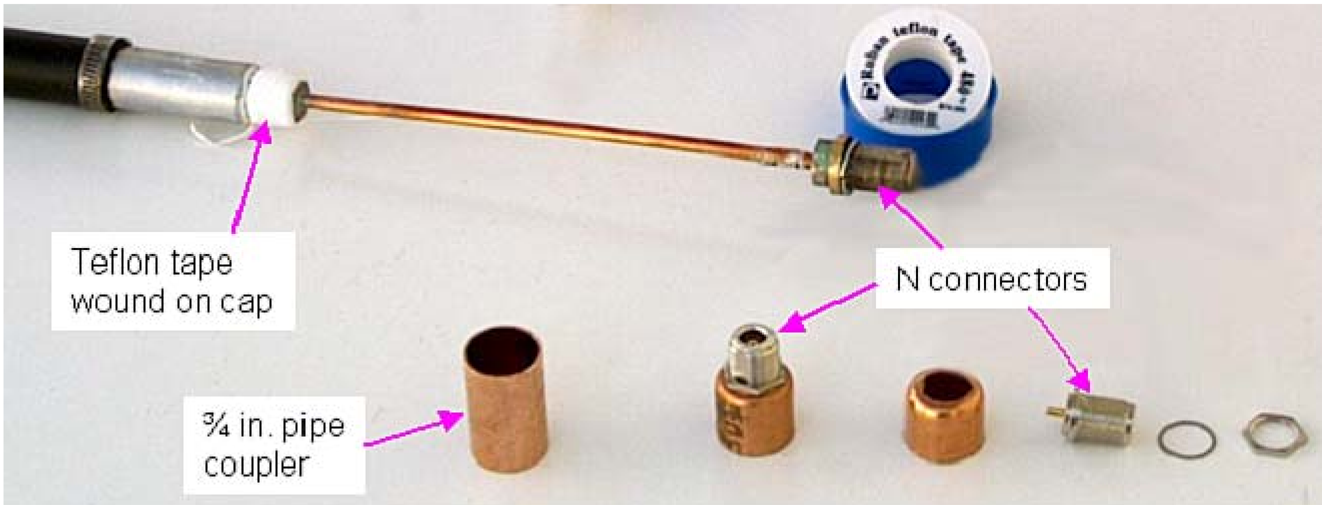


Figure 2. View of the impedance matching transformer with the outer tube removed.

The completed transformer is shown in figure 3.

Figure 3. The completed transformer. (the N connector nut is not screwed in)

The N connector of figure 3 at the right will probably need to be modified, since it is difficult to find these with an internal shoulder.

I started with an N Female / Female Bulkhead Adapter - UG-30D/U or equivalent like this one. Part #….. Generally available on Ebay.
Its left side was cut just before the shoulder.

Figure 4. Unmodified N to N feedthru.

The modified connector with the remaining shoulder. This shoulder rests against the interior of the pipe cap. Take care to not damage the center pin when cutting.

Figure 5. After modifications.

Main assembly

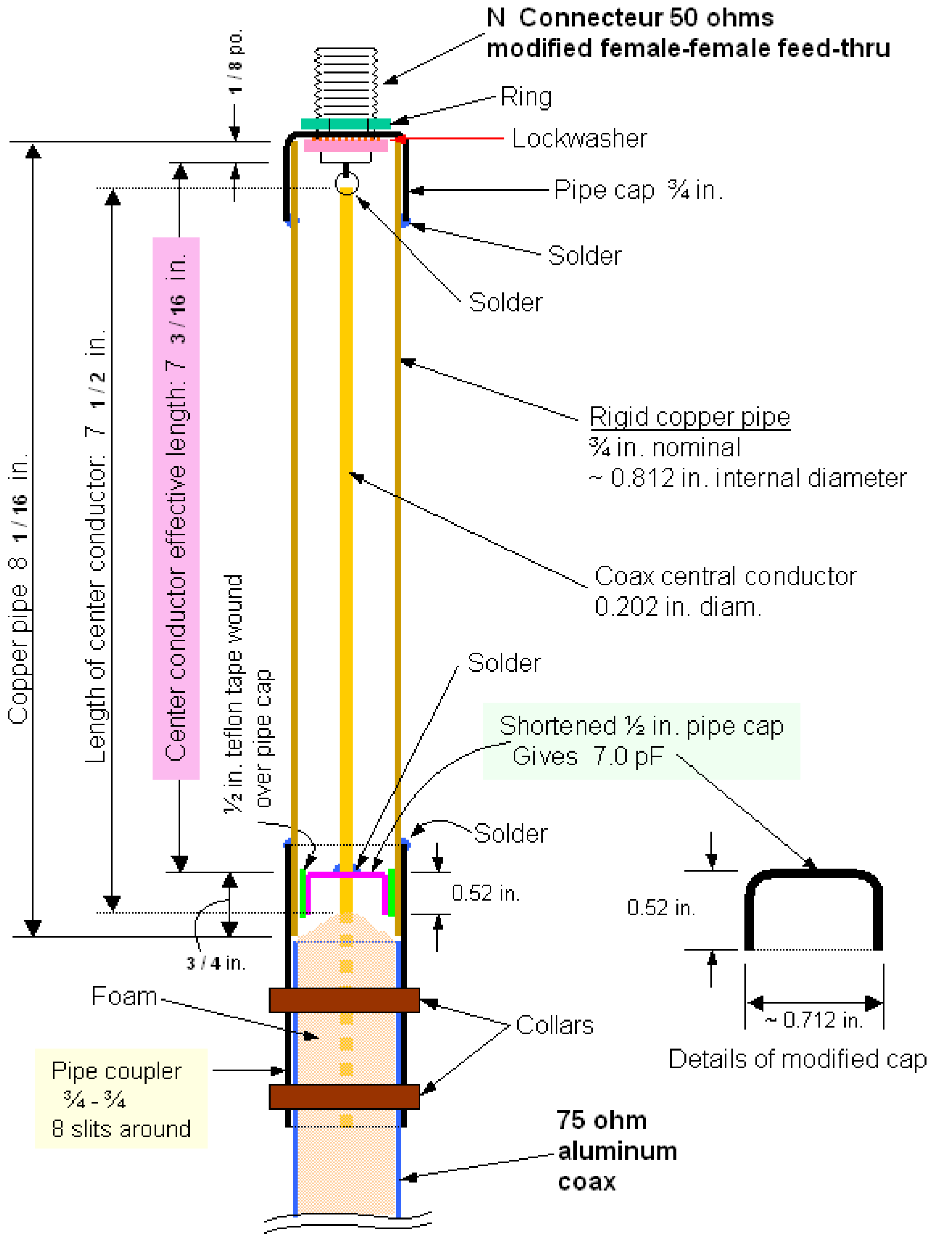


Figure 6. Transformer assembly.

The added air line is made of a length of ¾ in. rigid copper pipe.
Note that the N connector is screwed on the ¾ in. pipe cap.
The effective center conductor length is 7 3/16 inch as show in bold lettering.
The capacitor is made of a ½ in. pipe cap which is cut to a 0.52 in. length to provide the 7.0 pF required capacitance, for the CommScope P3 – 840 cable.

Solder the ½ in. pipe cap and the N connector on the bare center conductor as shown in Figure 6. Add just enough Teflon tape around the cap so that it fits easily inside the ¾ in. rigid copper pipe.

The tube assembly may now be built as per figure 7.
Solder the cap and the pipe coupler.
Cut 8 slots in the pipe coupler and file the inside along the cuts to eliminate surplus copper burrs.

Slip the tube assembly over the aluminum hardline and the N connector. Use stainless steel collars to press the pipe coupler firmly against the hardline. Vaseline gel may be used to seal the aluminum to copper interface to prevent corrosion.

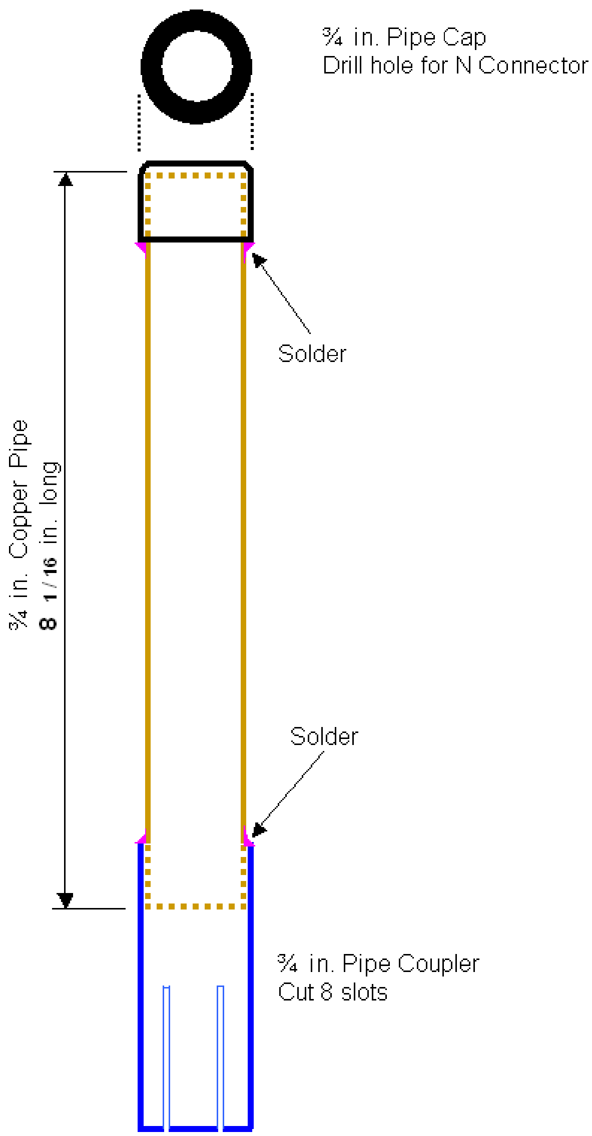


Figure 7
Tube assembly

The air line inner diameter (d) is 0.202 in. and the inside diameter of the copper tube (D) is 0.812 in. This gives a diameter ratio of 4.02. As shown in figure 8, a capacitance of 7.0 pF and a length of 7.2 in. (7 3/16 in.) is required for the center conductor. Figure 8 gives the required capacitance values and the center conductor lengths for a range of D/d ratio's, for use in the 2 meter band.

The corresponding impedance Zo of the air line is computed from:

$$Zo = 138 * \log\left(\frac{D}{d}\right)$$

Here Zo = 83.38 ohms.

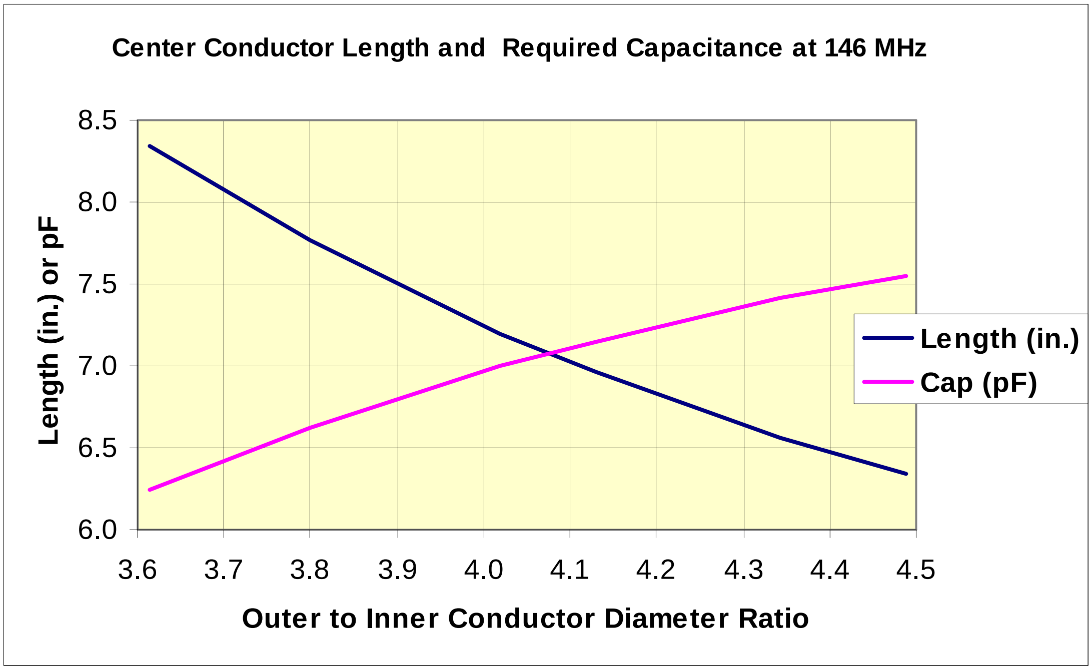


Figure 8 Length of center conductor and capacitor value versus diameter ratio.

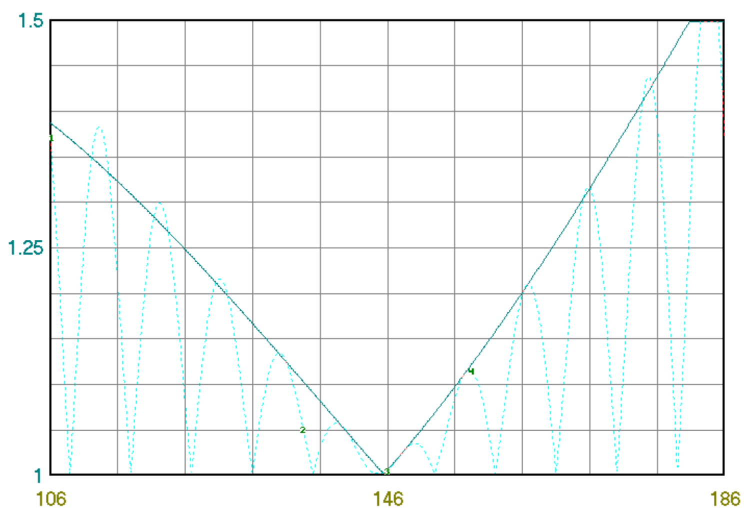


Figure 9

Simulated SWR vs frequency at the 50 ohm port

Figure 9 shows the simulated SWR vs frequency at the 50 ohm port, for two transformers connected back to back , with a short 75 ohm line (solid curve, 1/8 wavelength) and a long line (dotted curve, 10 wavelengths). Markers 2 and 4 are at 136 and 156 MHz respectively.

The simulated insertion loss is below 0.02 dB for the two transformers, assuming a Q of 400 for each capacitor and 0.472 dB/100 feet conductor loss for the two transmission line transformers.

Appendix: Impedance Conversion

On the Smith Chart of figure 10, the 50 Ω load is at point 1. The series transmission line (0.088 λ) having its Zo = 83.38 Ω reflects an impedance of 60.6 + j 29 Ω (point 2). Then a shunt cap of 7 pF converts the impedance to 75 + j 0 Ω (point 3).

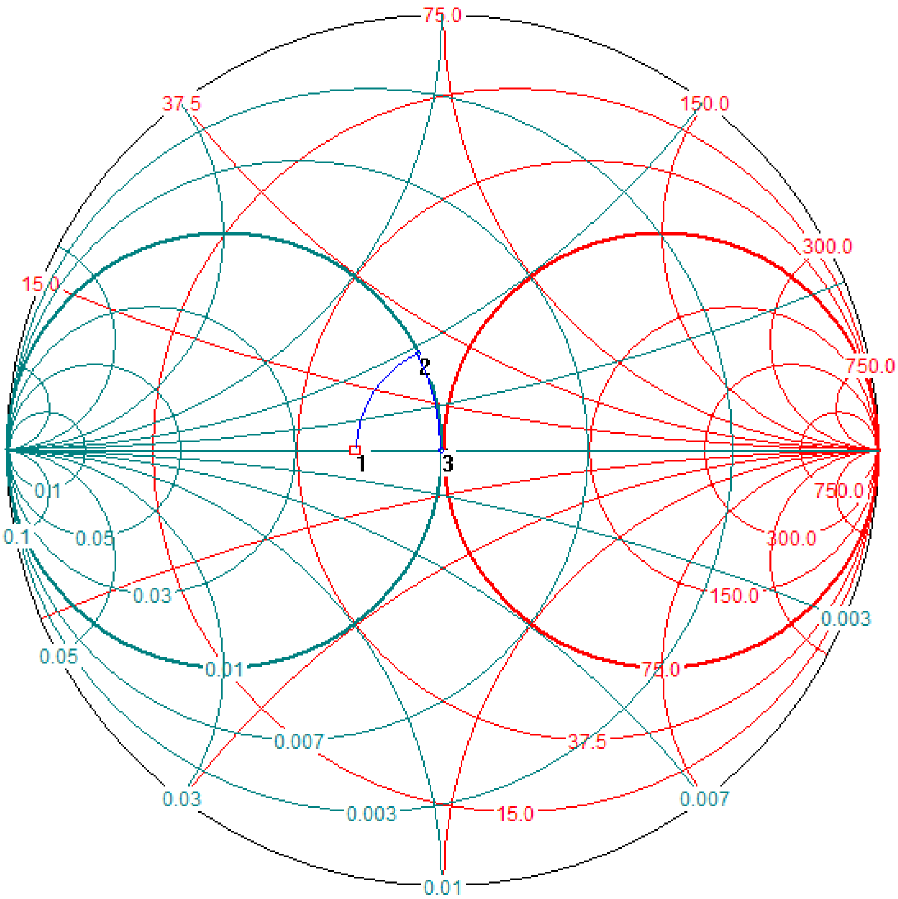


Figure 10
Impedance transformations from 50 to 75 Ω

Note: Red lines are Impedance circles and green lines are admittance circles.

Conclusion

The proposed transformer is inexpensive and 60 % shorter than a conventional quarter wave transformer. It will handle just about as much power that the hardline can take. The same idea could be used to build UHF transformers, with suitable transformer length and capacitor adjustment. In general, using a 75 ohm hardline in a 50 – 50 ohm system will generate an SWR that varies from 1:1 when the line length is half wave multiple, up to 1:2.25 when the line length is an odd quarter wave multiple.

Reference:

CommScope cable catalog: available from the author.

Many thanks to Jean-Nicol VE2BPD for his assistance in building the transformers.

The Smith chart of fig. 10 was generated using the **Smith V2.0** software from:
http://fritz.dellsperger.net/