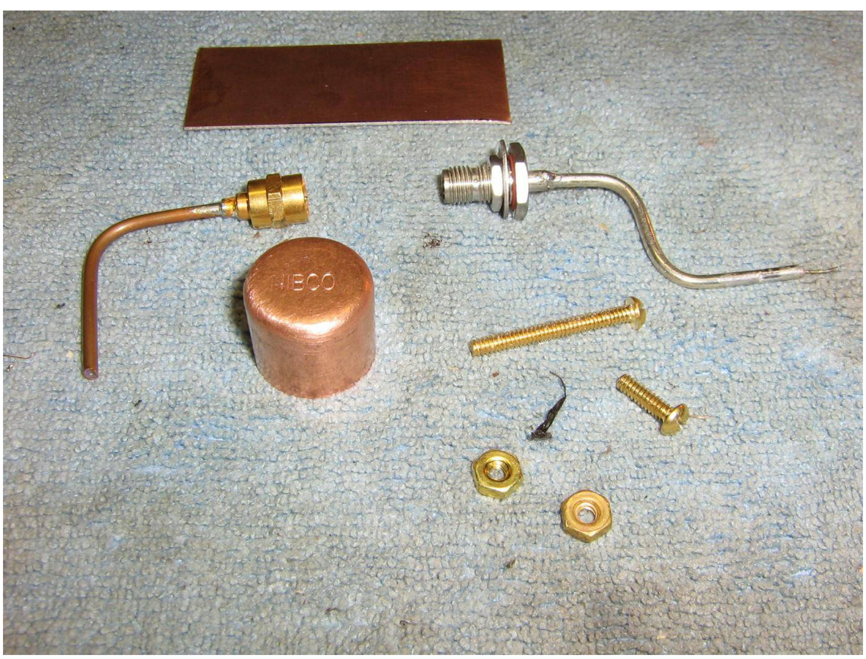
Copper Pipe End Cap 10 GHz Bandpass Filters

Overview

The ARRL *UHF/Microwave Projects Manual − Volume 1* has a really nice article from Kent Britain (WA5VJB) on constructing microwave bandpass filters using only copper pipe end caps, brass hardware, and some scrap pieces of UT−141 or UT−085 semi−rigid coax. And like most things from the ARRL, it's missing a few bits of important information and better documentation. A copy of Kent Britain's original paper from the 1988 "Proceedings of Microwave Update" will be at the end of this article. Be sure to read that paper first to get an idea on what you should expect.

This project will cover the very simple construction of a bandpass filter centered at 10.5 GHz. All you'll need is a 1/2−inch copper pipe end cap, a scrap piece of double−sided PC board, some #6−32 brass hardware (screws and nuts), some solder flux, and two pieces of scrap UT−085 semi−rigid coax with SMA connectors already installed. The most difficult item to track down will be the UT−085 semi−rigid coax. You'll have to roam your local hamfest for old commercial microwave gear to take apart and scrouge for the semi−rigid coax jumpers. I found some old Sinclair 800 MHz mobile duplexers which had really nice panel−mount SMA connectors already installed on UT−085 semi−rigid coax.

Pictures & Construction Notes

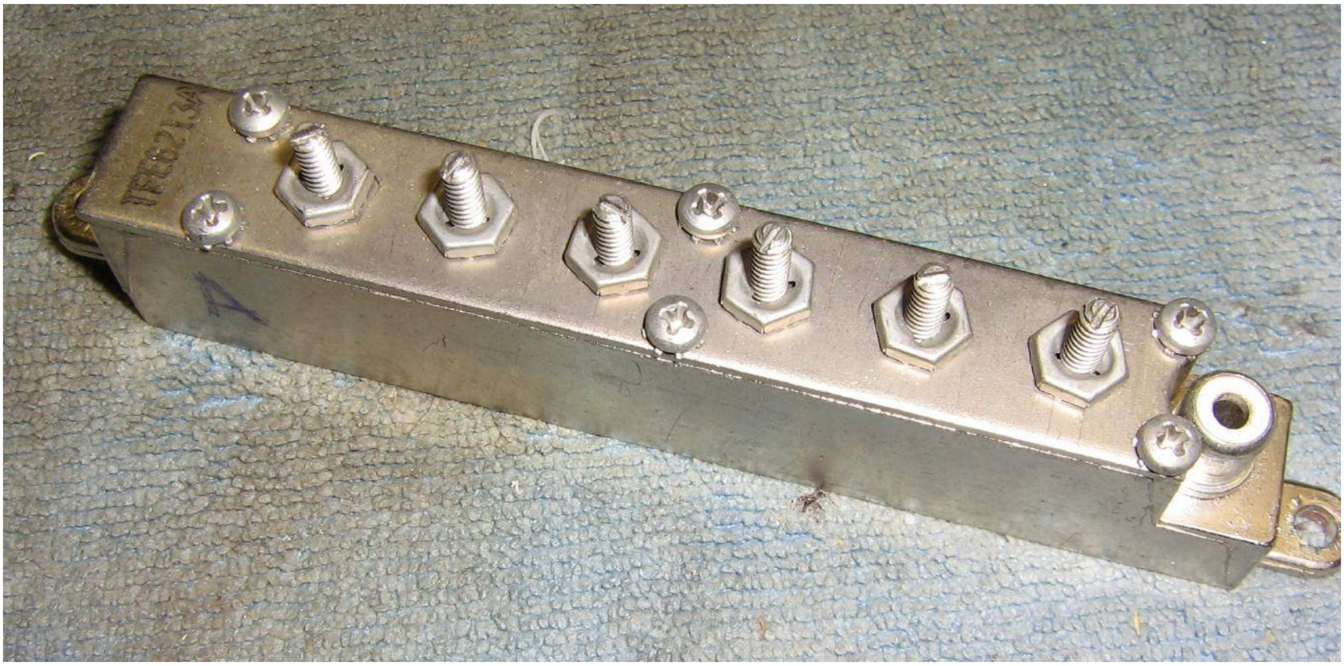


All the parts you'll need to construct a 10.5 GHz bandpass filter. That's it!

On top is a scrap piece of double−sided PC board material. Below that are two salvaged pieces of UT−085 semi−rigid coax with SMA connectors installed.

Below them, on the left, is a NIBCO 1/2−inch copper pipe end cap (CP−617). Finally, some #6−32 brass screws (1−inch long) and nuts.

You may wish to start with a 1−inch long #6−32 brass screw and trim it down, if necessary.



A good source of (optional) silver−plated #6−32 hardware is from old Motorola UHF (Micor?) radios from the 1970s and 1980s. I believe this filter was used for some type of post−mixer filtering.

The silver−plating helps to lower the insertion loss of the bandpass filter and will increase the filter's "Q." This means the bandpass will have much steeper out−of−band rejection skirts.

Using a #36 drill bit, drill a hole in the center of the end cap.

Run a #6−32 stainless−steel screw (or tap) through the hole to create some threads.

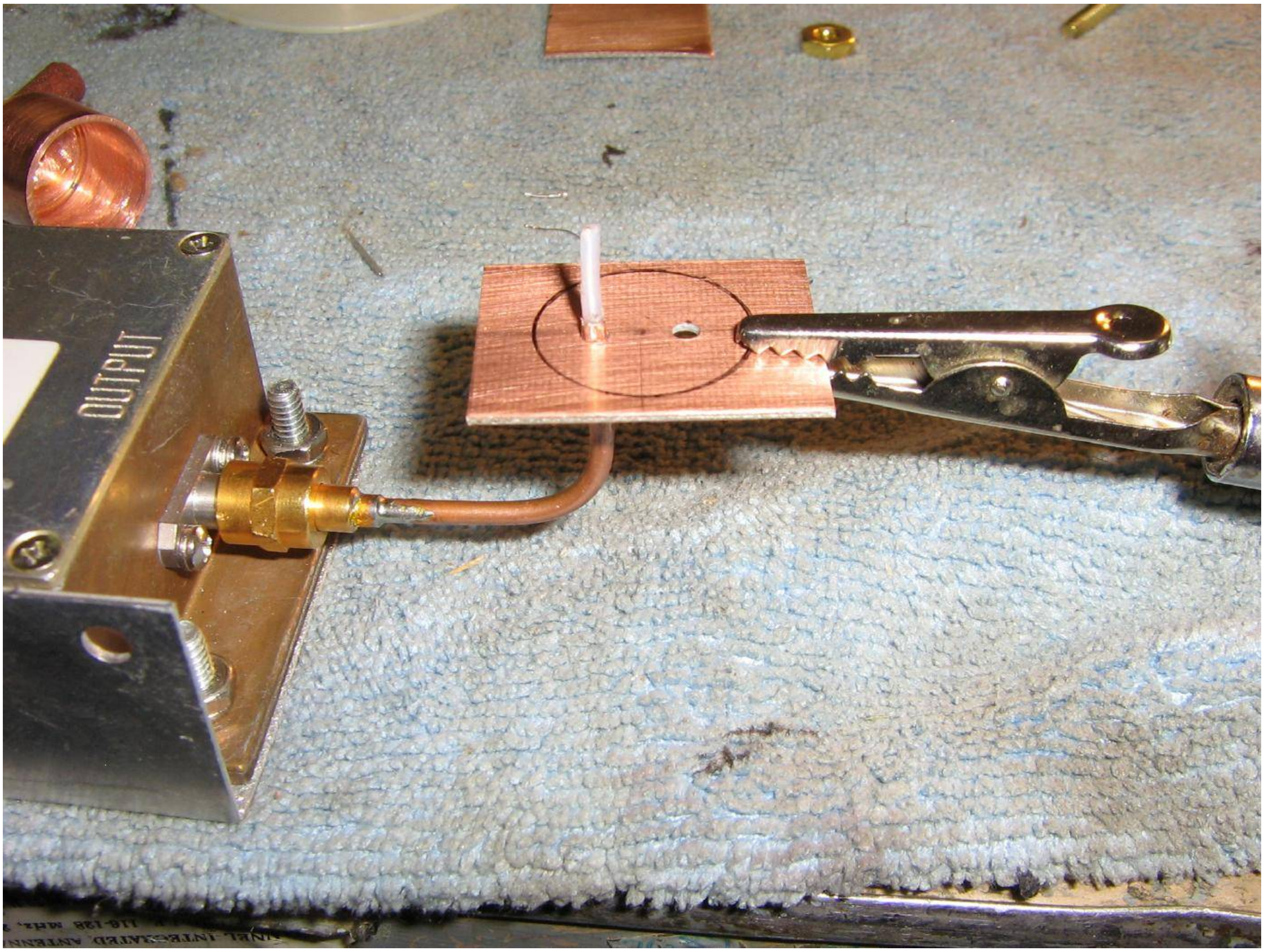
Keep using the #6−32 stainless−steel screw to hold a brass #6−32 nut to the top of the end cap. Apply a bit of solder flux and solder the brass nut to the top of the end cap. Using a heat gun will be much easier than using a torch for this.

Be sure the parts are clean and well fluxed before soldering, or the solder will not flow properly.

Clean up the copper pipe end cap and nut from any excess solder using a piece of emory cloth.

Use a Dremel tool with a drywall bit to grind away *just* the copper jacket of the UT−085 semi−rigid coax, leaving the Teflon dielectric exposed.

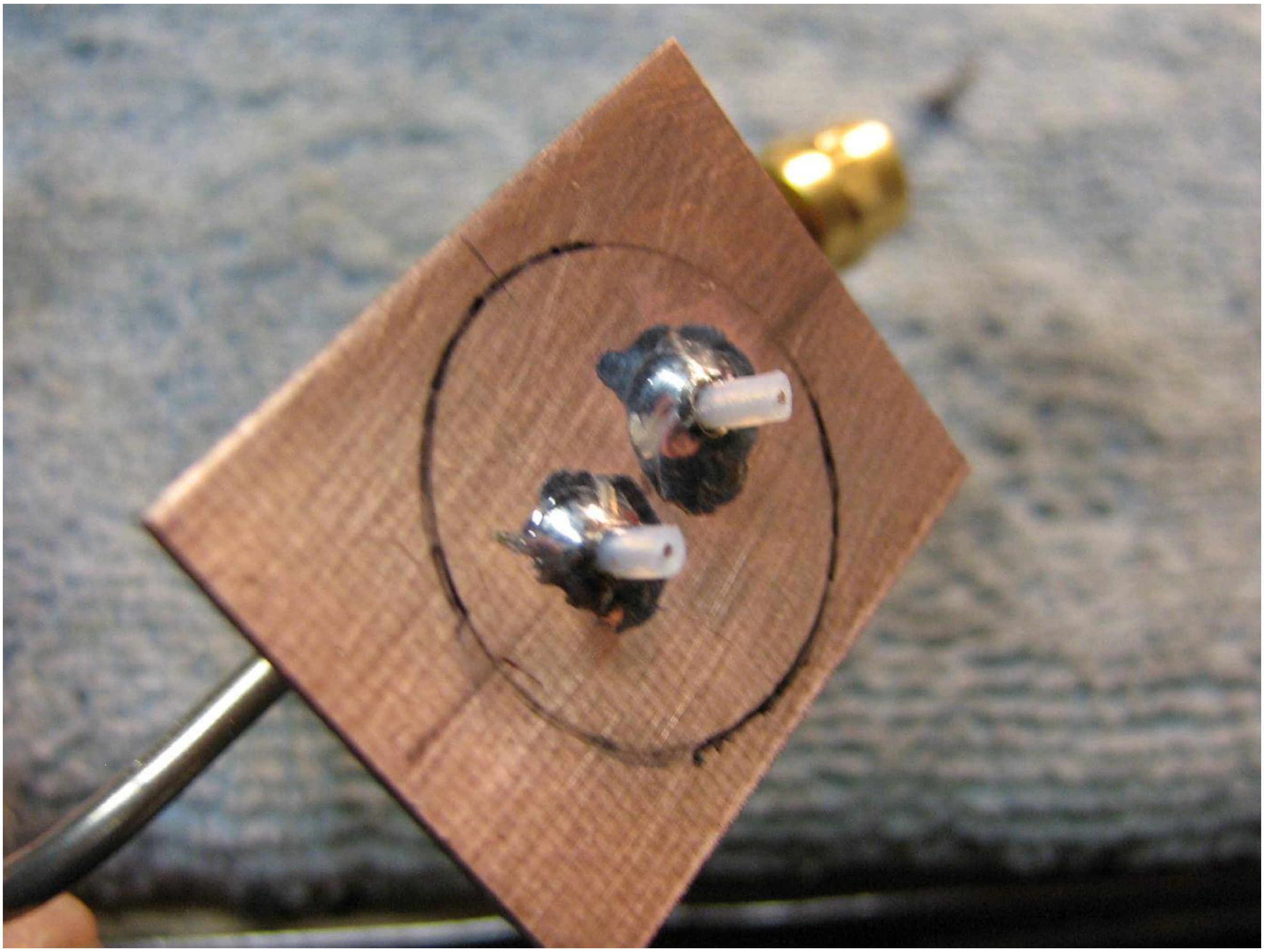
I wasn't sure how to properly do this, but this method seemed to work out very well. For now, you'll want to scrap away around 3/8−inch or so.



Trim the PC board material to a usable size.

Layout the diameter of the end cap and drill two 3/32−inch holes 5/16−inch apart in the relative center of the end cap.

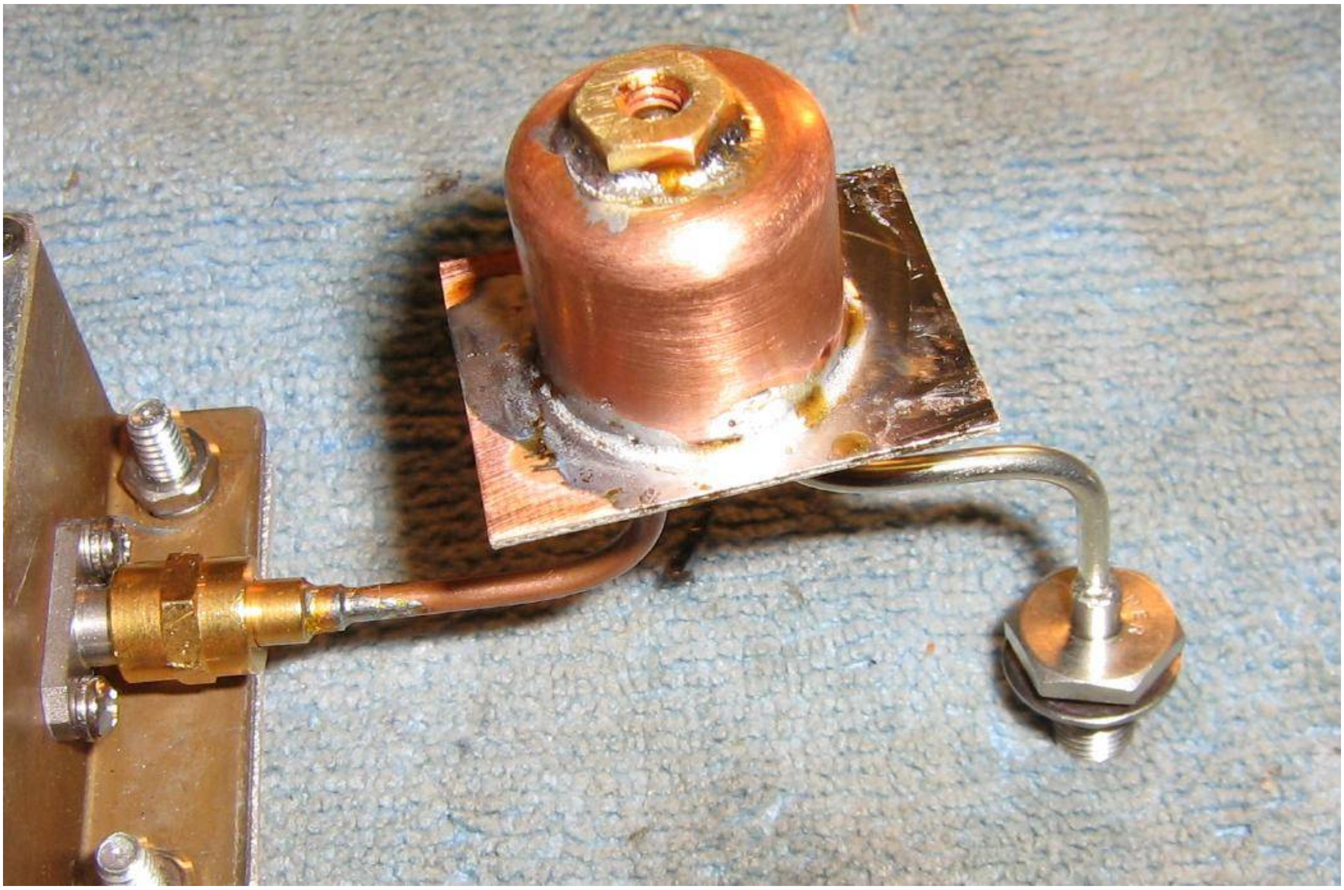
Take you time and try to keep the holes inline and centered.



Solder the two pieces of UT−085 semi−rigid coax into the holes you drilled and then trim the two Teflon−coated "probes" so they are only 5/32−inch above the PC board. Use as little solder as possible to hold the probes. Solder is quite lossy at 10 GHz.

The height of the probes determines the filter's overall bandwidth, with 5/32−inch giving around 100 MHz bandwidth at 10.5 GHz. The filter's bandwidth and insertion loss are both dependant on the length of these probes. The shorter the probes, the narrower the bandwidth will be, but the insertion loss will increase.

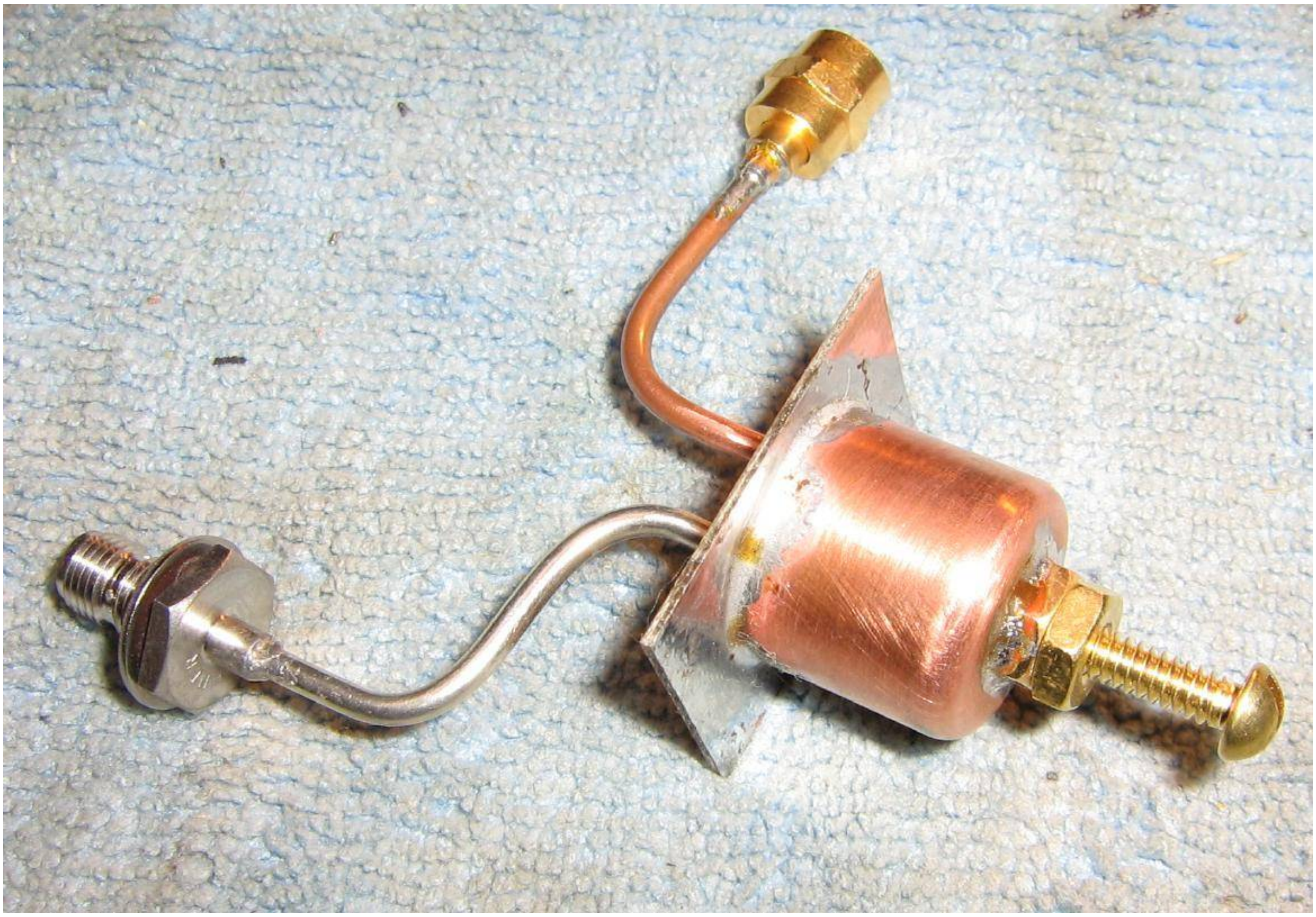
You may have to fiddle a bit with the coax to keep them perpendicular while soldering.



Next is the hardest part...

Center the copper pipe end cap on the layout marks you made on the PC board. Apply a bit of solder flux to the end cap and the PC board material then, using a *very hot* soldering iron, quickly solder the end cap to the PC board. Be sure the solder flows all around the end cap.

Lap the opening of the end cap with some emory cloth so it sits level on the PC board.



Overall view of the finished copper pipe end cap bandpass filter.

Add the brass #6−32 tuning screw and another nut to "lock" the tuning screw in place.

Testing and tuning the finished bandpass filter. The filter's insertion will be around 1 to 2 dB, depending on the cavity's "Q" and coupling probe lengths.

You'll need to slowly turn the brass #6−32 tuning screw *into* the end cap to lower the filter's bandpass frequency.

On this filter, the brass #6−32 tuning screw is about 7 millimeters into the end cap for a final bandpass frequency centered on 10.5 GHz.

Original Bandpass Filter Paper by Kent Britain, WA5VJB

CHEAP MICROWAVE FILTERS

From: Kent Britain - WA5VJB

These filters are for our 3, 5 and 10 GHz ham bands. The design is based on the filters used in the DJ6EP 5760 MHz transverter.

When I first saw these filters used in the DJ6EP transverter I thought; Wow, how neat and simple! But Roman's design used Teflon P.C. board and small pins through 50 Ohm stripline for coupling. The next trick was to find a simple way of putting them together with commonly available materials. I ended up using 1/2", 3/4" and 1" copper plumbing end caps sweat soldered onto common P.C. board.

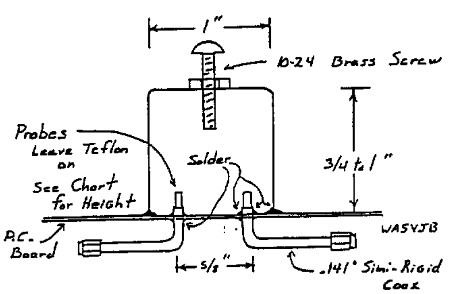
First, I've built a bunch of these filters, and they all worked. Next, I built several with intentional errors, lots of sloppy solder, misaligned probes, unequal probes, off center tuning screws, etc. Loss went up a bit on a few of them, but they all WORKED! These guys are very forgiving!

The length of the probe determines the coupling and therefore the Q of the filter. Keep the probes as short as you can, consistent with how much loss you can stand in your system. I did build some multi-stage versions to get a tighter bandwidth. But it really wasn't worth the effort, just use shorter probes.

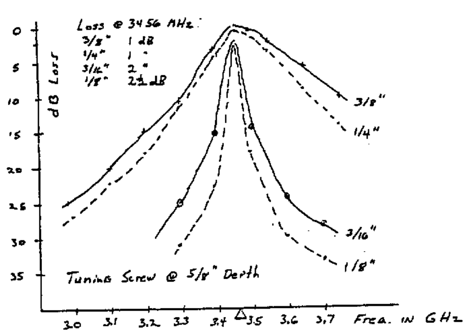
You can drill and tap the hole for the tuning screw, but I found it much easier to drill a slightly undersized hole and just force a steel screw (same thread size) through. The locking nut is tightened down after you have everything tuned.

3456 MHz FILTER

The 3456 version is based on a 1" copper plumbing end cap. The hollow filter resonates between 6 and 7 GHz. The tuning screw pulls the filter down to 3.4 GHz at a depth of about 5/8".



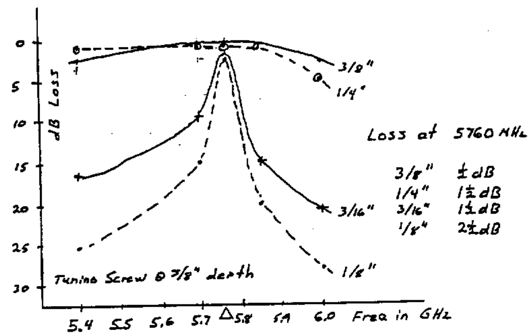
These plots were made using my HP-616A Signal Generator and HP-415B indicator, and they give a pretty good idea of the shape of these filters. In a 3456 MHz station using a 144 MHz I.F., a filter using 3/16" probes would give 25 dB rejection of the L.O. and better than 30 dB rejection of the image with 2 dB of loss.



5760 MHz 1" FILTER

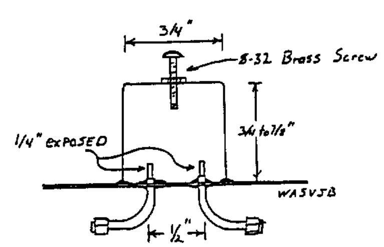
The 1" filters will also tune 5760 MHz with the tuning screw set at about 3/8" into the cavity. The plots below were made using my HP-614A signal generator driving a passive tripler and bandpass filter into a HP-415B indicator. Again, a pretty good idea of the charactistics of these filters emerge.

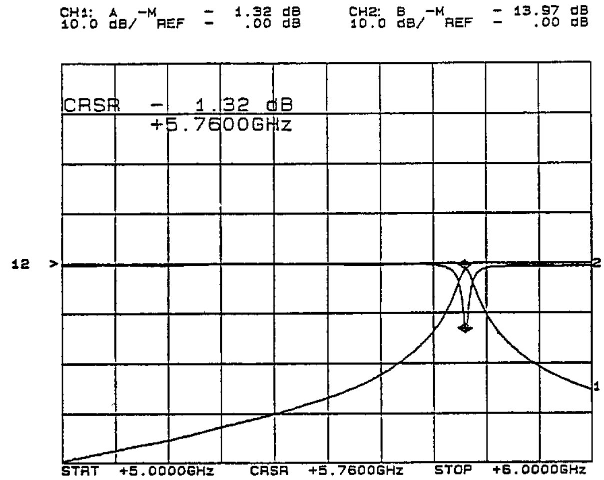
With a 1/8" long probe, a 5760 MHz transverter would see about 20 dB rejection of the L.O. and almost 30 dB rejection of the image when using 144 MHz I.F.'s.



5760 MHz 3/4" FILTER

This was one o the filters I was fortunate to get plotted on some really fancy equipment. I didn't get an opportunity to build a family of these filters before the proceedings deadline, but my first try seems to have done pretty well. Again, a 5760 MHz transverter using a 144 MHz I.F. would have about 20 dB rejection of the L.O. and almost 30 dB image rejection with less insertion loss than the 1" filter.

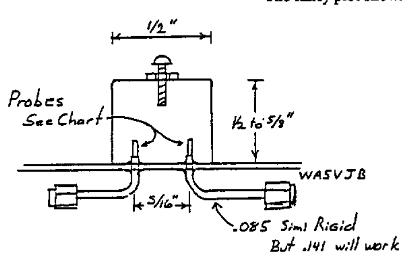


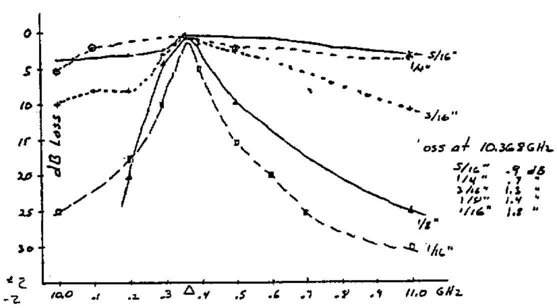


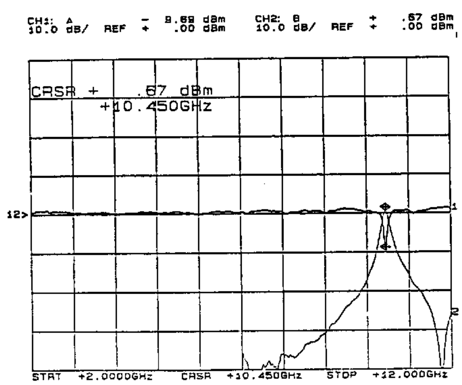
10 GHz FILTER

When I first started building these probe coupled filters, they were used at 10.368 GHz. If you can dig up some .085" semi-rigid coax, it's much easier to use than the larger .141", but both sizes work. The filter resonates somewhere between 11.5 and 12 GHz, so while digging through the bins at your hardware store, look for the longer end caps. The longer ones will have slightly lower loss, but it's not worth driving around town. I did try replacing the brass tuning screw with a steel screw on the 1/8" filter, loss went up from 1.3 to 2.0 dB.

The fancy plot shows a filter from 2 to 12 GHz.







SCANDINAVIAN VHF-UHF-SHF MEETING 1989

DAVUS and **EDR Horsens division**, hereby have the pleasure of inviting all VHF-UHF-SHF amateurs to participate in the:

SCANDINAVIAN VHF-UHF-SHF MEETING 1989

The meeting will take place in the weekend 9 - 10 - 11 of June and will be located somewhere in the lake district of Silkborg, Denmark.

The programme of the meeting will, besides the social aspects, contain:

Lectures on: EMC, microwave antennas, computer simulation of 144 MHz Yagi-antenna gain and hopefully many more interesting topics.

Measurements of: Antenna (432 MHz and up), Preamplifiers (noisefigure / gain) and general TX / RX measurements.

If you wish to give a lecture on a topic related to VHF-UHF-SHF in connection with the meeting, please contact:

DAVUS
Soren Petersen, OZ1FTU
Krumstien 10 A
DK-2730 Herlev
DENMARK

A provisional programme and final invitation will be sent out in March '89.

Look forward seeing you all!

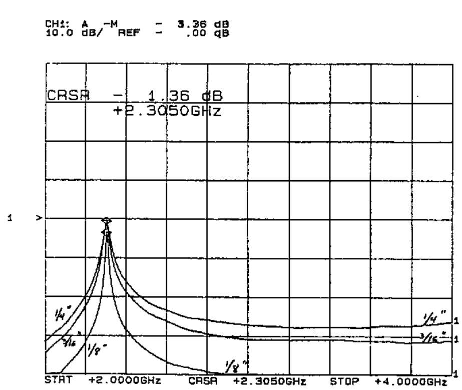
vy 73 de DAVUS, EDR Horsens.

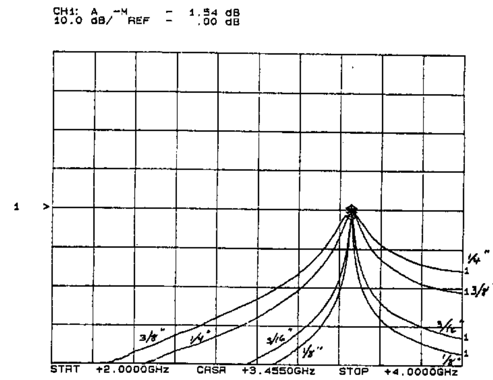
CHEAP FILTER UPDATE

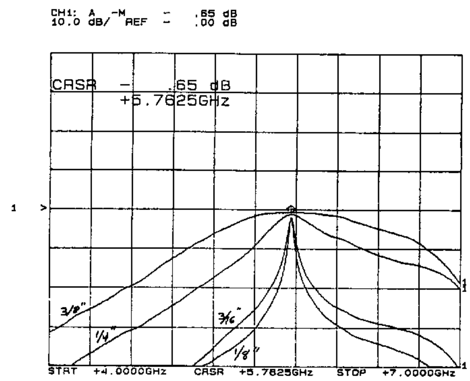
By: Kent Britain - WA5VJB

Since my **Cheap Microwave Filter** article was written, I've had a chance (thanks to WB5LUA) to try out the filters on some real nice equipment It was really interesting to watch a felt pen trace out curves I had spent hours plotting a point at a time on 30 year old stuff.

1 Inch Filter: I quickly noticed how close to 2304 MHz the filter was tuning. With a slightly longer tuning screw protuding about 7/8" into the cavity, they hit 2304 MHz. First class plots are provided for 2.3, 3.4, and 5.7 GHz.







1/2 Inch Filter: Again I noticed how far down in frequency the filter tuned. A slightly longer screw protuding about 1/2" into the filter resonated on 5760 MHz. I don't have a family of bandpass plots a 5.7 GHz, but the Q's were very high and the skirts quite steep.