Amateur and Short Wave Radio Electronics Experimenter's Web Site

Voltage Probe Antenna Experiments

Introduction

Some experiments with active or voltage probe antennas (VPA) were performed and are presented. The reason for these experiments was simple. Occasionally it is nice to take a small receiver on holidays to a friend's place and not have to put up a big wire antenna.

Looking on the world wide web, there are a number of web sites which provide information and/or schematics for active antennas. Most of these sites diagram, write about or sell the broadband variety.

Some of these antennas are subject to significant second and third order intermodulation products caused by non-linearity in the VPA stages producing unwanted signals from the sum and difference of mixed strong radio broadcast stations. Intermodulation distortion may appear as a wall of noise, spurious signals or even as several stations overlapping in some band areas. Intermodulation distortion from a VPA can reduce weak signal reception and often completely overloads the receiver.

VPAs are also subject to atmospheric noises and interference from electrical and electronic devices such as televisions, appliances and computers. Our washing machine all but blocks any band on my general coverage receiver when any active antenna is used.

The simple designs that follow are not antennas for critical, high performance, high dynamic range receivers. However, with filtering, they can sometimes provide surprisingly decent performance for casual receiving on a popcorn or better quality superhet.

An electrically short whip has a high input reactance with a very low radiation resistance, when connected to a piece of 50 ohm coax essentially causes a short-circuit and essentially no current presented to the receiver input.

A simple solution is to connect the whip antenna directly to a JFET with a high input impedance and a low output impedance or matching network for the 50 ohm coax cable.

Although other topologies were tried (Figure 1), a JFET source follower coupled to a common gate amplifier was settled upon. The source follower has an output approximately 90% of the input signal voltage. The output can be easily filtered, amplified and matched to a receiver's input impedance.

Experiments with broadband, 40 and 80 meter band versions follow. A design goal was 9 volt battery power and low current drain.

There are 3 QRPHB web pages for this topic.

This page which covers the broadband versions and project conclusion, a tuned Q2 input/output VPA page and a supplemental web page for the tuned Q2 input/output 40 M band version.

[Tuned Q2 Input/Output Web Page]
[Tuned Q2 Input/Output Supplemental Web Page]

Broadband Voltage Probe Antennas

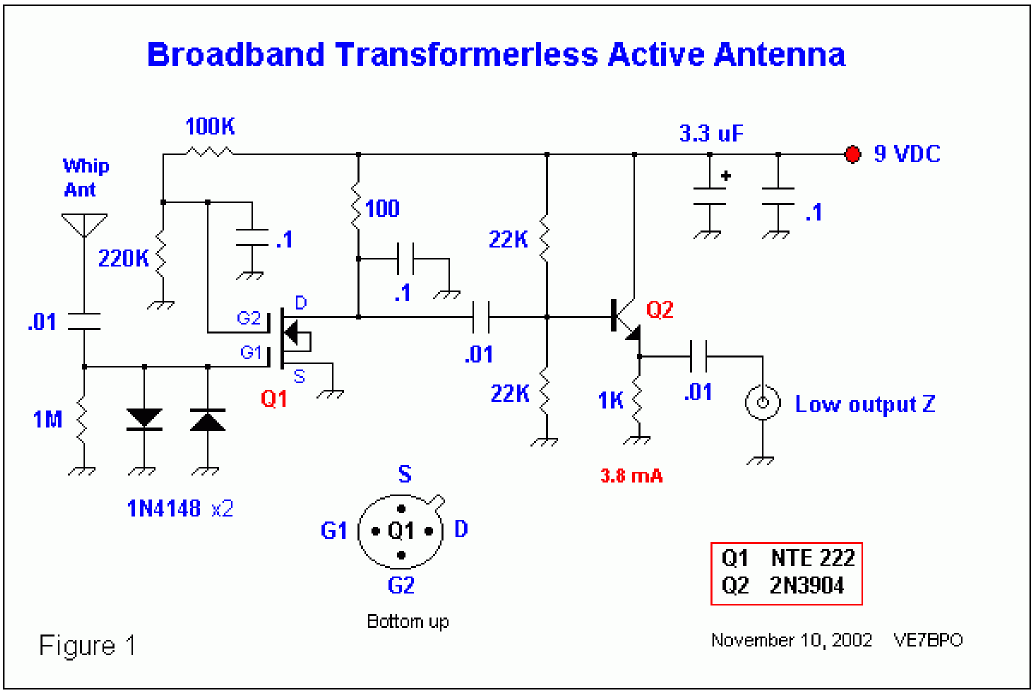
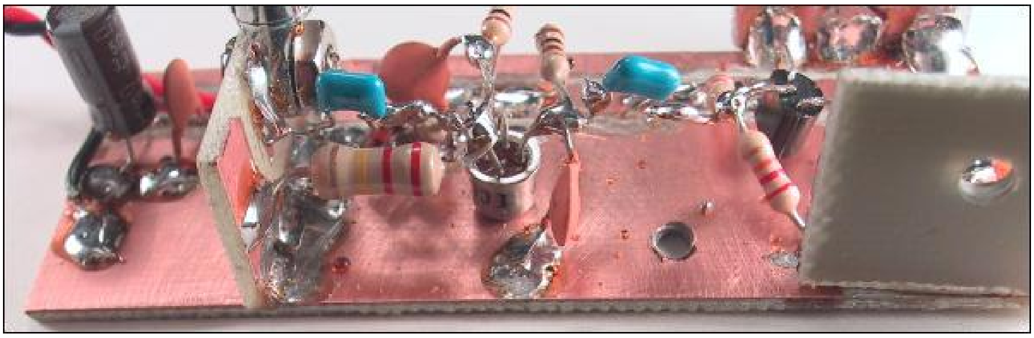


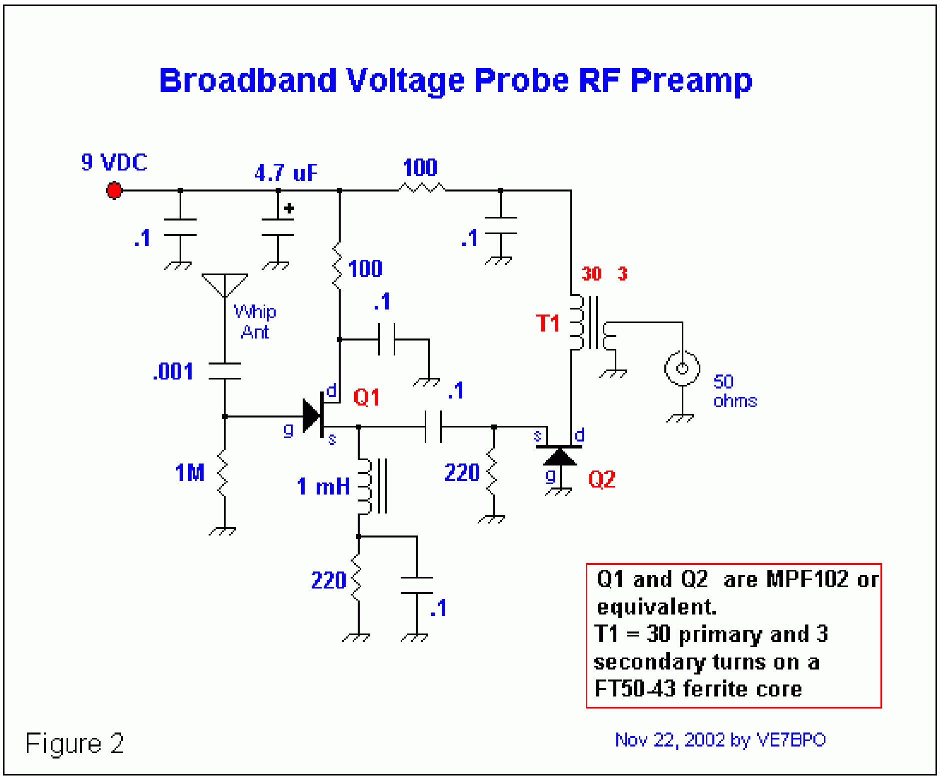
Figure 1

Figure 1 and Picture 1 shows the respective schematic and outcome for the first broadband version I constructed. This is similar to a version sold as a kit, except for the Q2 stage, which was added to decrease the output impedance to preserve the function of my receiver double tuned filter stage.



This VPA has a low parts count, no transformers and a low noise figure. However, after walking across some carpet and touching the telescopic antenna, a static discharge toasted the dual-gate MOSFET. Hence the back-to-back diodes added to the first gate. I went to our local electronics store to purchase another and did not as the price was $17.32 each!

The quintessential popcorn JFET, the MPF102 is $0.25 Canadian from Digi-Key when purchased in lots of 100, so I decided to use this part exclusively for the rest of the VPA experiments on this topic.



Next came the VPA shown in Figure 2. This stage has about 10-12 dB of gain and works reasonably well on my MF, HF receiver. Needless to say, the receiver tends to roar with intermodulation products and environmental electrical noise.

This low parts count, simple VPA is okay for trivial use, but all of the spurious noise quickly becomes tiresome when trying to seriously tune the bands and copy stations.

Above: The Figure 2 prototype VPA in a die-cast Hammond case. Antenna element is a 3 foot telescopic whip.

VPA With A High Pass Filter After The Q1 Stage

Mixing of broadcast signals can occur in either the Q1 or Q2 stages or both. Inserting a high pass filter after Q1 will attenuate strong broadcast stations and hopefully reduce the intermodulation products resulting from mixing in the Q2 amplifier stage below the cutoff frequency. However, if mixing occurs in the Q1 FET above the cutoff frequency, the mixed products can scream right through the high pass filter.

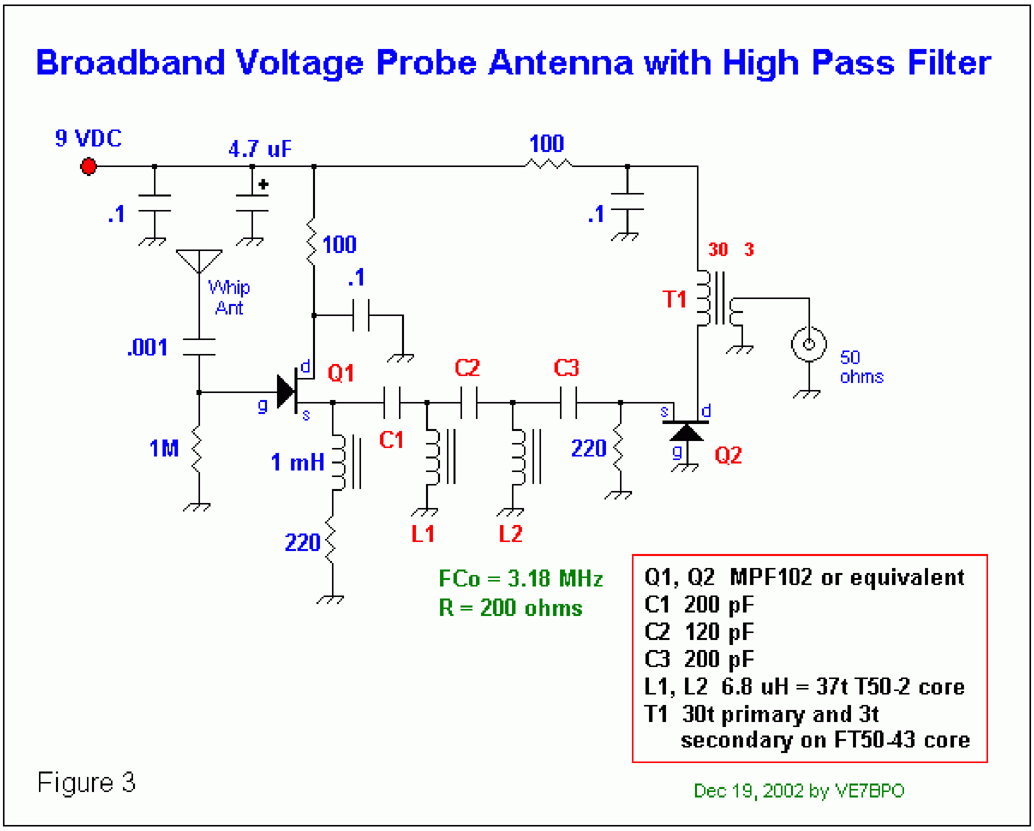


Figure 3

There is a 25 kilowatt A.M. broadcast station at 1.150 MHz nearby which plagues me and essentially makes copying on the 160 meter band difficult from overload when using a broadband VPA. To that end, I decided to design a high-pass filter with a cutoff below the 80 meter band that uses standard value capacitors. The input/output impedance was 200 ohms.

I sent the filter design to Wes Hayward for his opinion and he found it wanting. Much to my delight, Wes designed one with a respectable response, which is shown in the Figure 4 SPICE plot.

Figure 3 shows Wes' filter. As an experiment, I tuned my general coverage receiver at 1.150 MHz in the A.M. mode. I set the Figure 3 VPA up so I could switch the high pass filter in and out of the signal path. With no filter, the S-Meter read 60 dB over S9. With the filter switched in, the meter dropped to around S8.

This crude experiment suggests that the filter works pretty much as SPICE said it would. Wes also suggested dropping the 0.1 uF bypass capacitor on the Q1 source lead as it is not required. Thanks Wes!

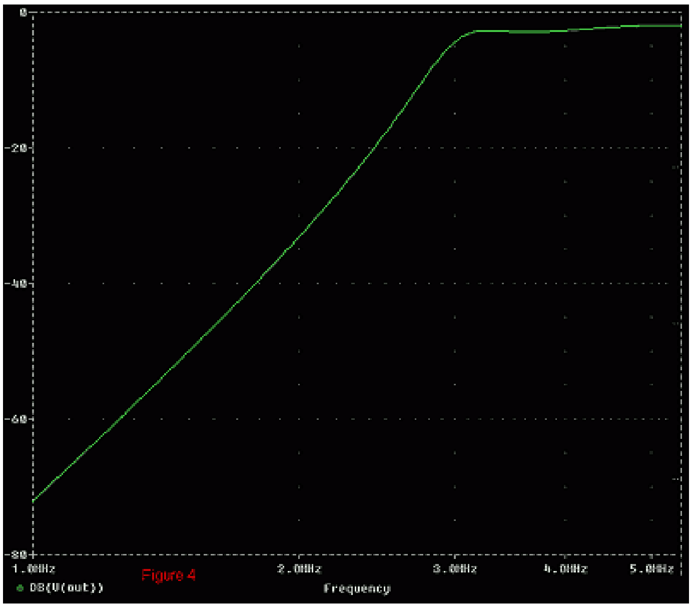


Figure 4

VPA High Pass/Low Pass Filter after Q1 Stage

I wanted a VPA that would cover the 80, 40 and 30 meter bands, which are the only bands I monitor while working in the evening.

Choosing a 3.18 MHz cutoff frequency, rather than one just below the 160M band, was intentional to provide some serious attenuation to signals from the A.M. broadcast band. For interest sake, a low pass filter was added at the output with a cutoff frequency of 10.4 MHz. This half-wave filter was pulled from the ARRL Handbook.

This project was built and includes Figure 5 and the 3 photos that follow. The second photograph details how the antenna connection was passed through the die cast lid, allowing access to the battery.

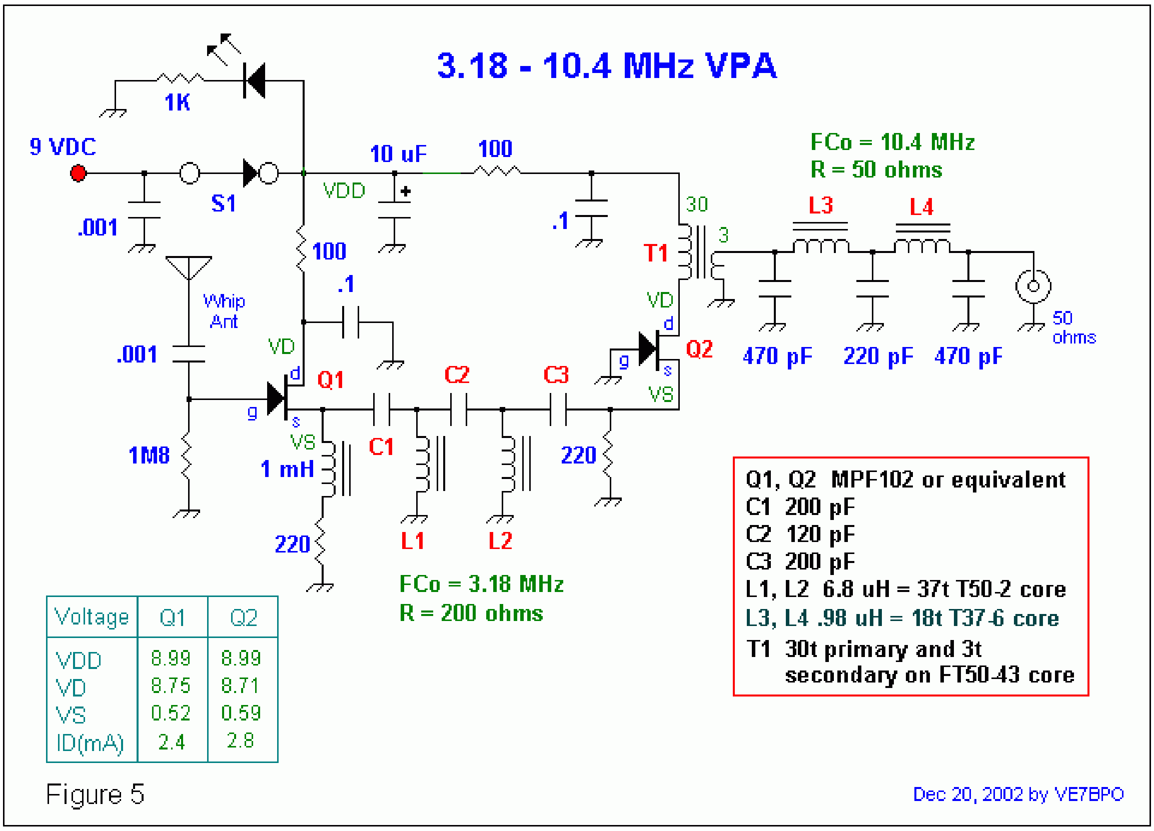
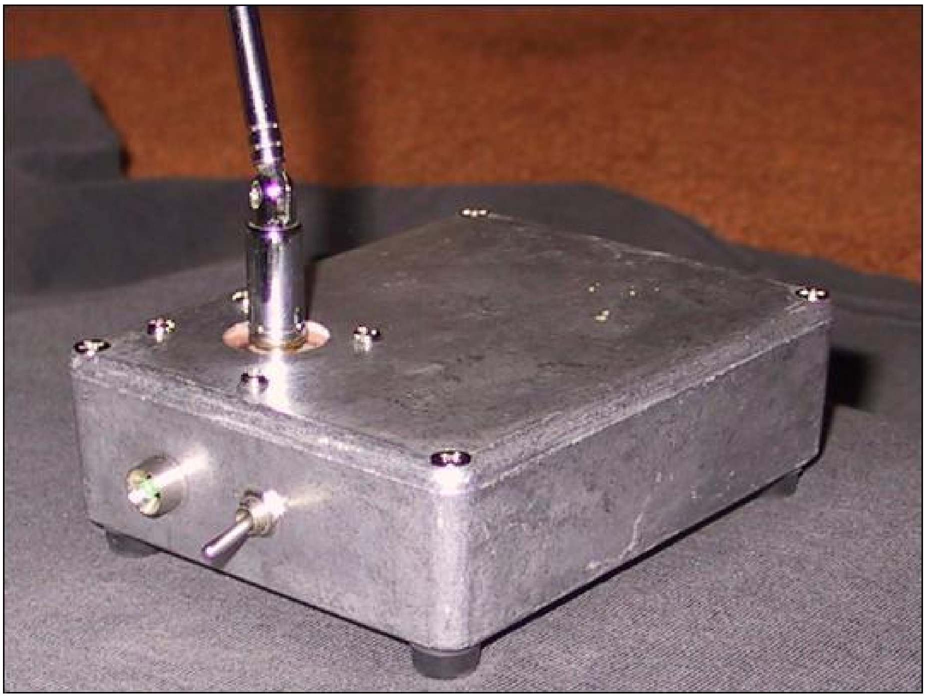


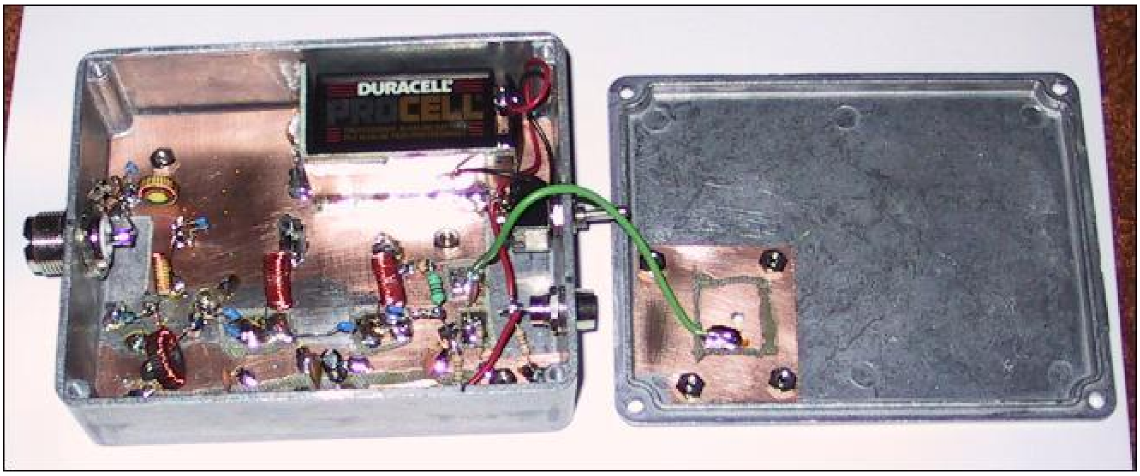
Figure 5

The battery holder was fabricated by soldering single-sided PC board material to the main copper board. A 14 gauge wire was used to connect the 4 foot moveablewhip to the Q1 gate.

Note a small "island pad" was cut in the main copper board which connects to the Q1 gate through a 0.001 uF capacitor. This pad prevents the wire from damaging the cap in case it gets pulled on when the top cover is off.

The slack antenna connection wire is directed over the battery compartment, just before the lid is screwed on, to keep it out of the Q1-Q2 signal path.





Tuned Input VPA

Placing a tank under the whip antenna is probably the best method of reducing intermodulation distortion in a VPA, however there are caveats tothis approach.

First, some technical info on whip antennas is needed.

A short whip antenna presents a highly reactive (capacitive) impedance. A six foot whip at 3.6 MHz has a parallel equivalent impedance of 15 pF capacitance and a 40.5 megohm resistance according to some calculations performed this winter by Wes Hayward. The calculations they were performed with an antenna modelling and analysis program called EZNEC by Roy Lewallen, W7EL. Information regarding this program may be found at **www.EZNEC.com**.

Adding some loss, for example 10 Ohms, the parallel equivalent is then 833K in parallel with the 15 pF of capacitance. If the loss is higher at 100 Ohms, the parallel equivalent is then 85K in parallel with 15 pF.

Using a Boonton Type 250 RX Bridge, Wes tried to actually measure the 6 foot whip at 3.6 MHz. This was a difficult endeavor for the highest R to chose from was 100K. There is about a quarter of an inch on the scale between 100K and "infinity" parallel resistance on the instrument.

"I tuned things for a balance and read a parallel C of right close to 17 pF along with a parallel R somewhere between the 100K and the infinity mark. As I pushed the whip in, making it shorter, everything tuned in the right direction. However, never got any good R numbers from it. But all of the measurements, such as they are, were right in line with the calculations." (Private email Dec 21, 2002, Wes Hayward, W7ZOI).

A graph depicting the reactance of somewhat longer whips versus frequency is shown in Figure 7.

For designing a tank to place under a whip, keep in mind that an electrically short whip will have around 10 to 15 pF of capacitance. As long as you chose your L and C below the place where the whip is a quarter wavelength, whatever L and C that will achieve resonance will work.

In addition, throughout these VPA experiments a gate resistor of 1 to 1.8 megohms was used and it seems that this value is not super critical. You should probably not use less than 1 megohm unless you really know what you are doing.

Whip length and diameter critically affects the tuning of the tank circuit the antenna element is attached to. I also found that the proximity of the whip to my body, hand/body movement and even touching a knob to make an adjustment on my scope, which was connected to the Q2 output, affected the tuning of the VPA. A whip antenna is most certainly a reactive device!

An electrically short antenna also has limited bandwidth and tunes sharply. As a result of this phenomena, my feeling is that a front panel method of tuning is probably required for optimal performance. In certain locations (such as a tent), you will be unable to fully extend the telescopic whip or nearby objects and/or people may affect the tuning, necessitating adjustment.

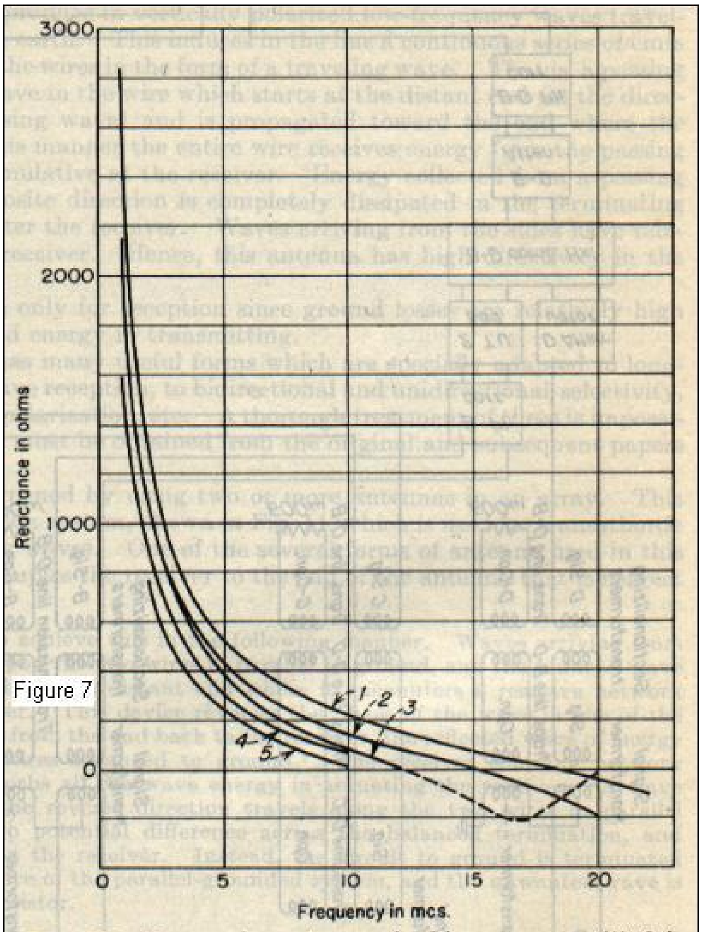


FIG. 10b. Measured reactance of whip antennas: (1) 8-ft single rod; (2) 12-ft single rod; (3) 16-ft single rod; (4) 12-ft V aerial, 60 deg on common base insulator; (5) 16-ft V aerial, 60 deg on common base insulator.

Front panel tuning will also allow signal peaking when moving up and down in frequency. I know it is possible to design tanks that would cover 2 or more bands, however, I built 2 single band versions for the 80 and 40 meter HAM bands. These experimental designs were built on a crude copper platform with a mounted rotatable 4 foot whip antenna. This type of construction is not recommended for actual use, but is good for experimenting and left me realizing why shielding is so critical.

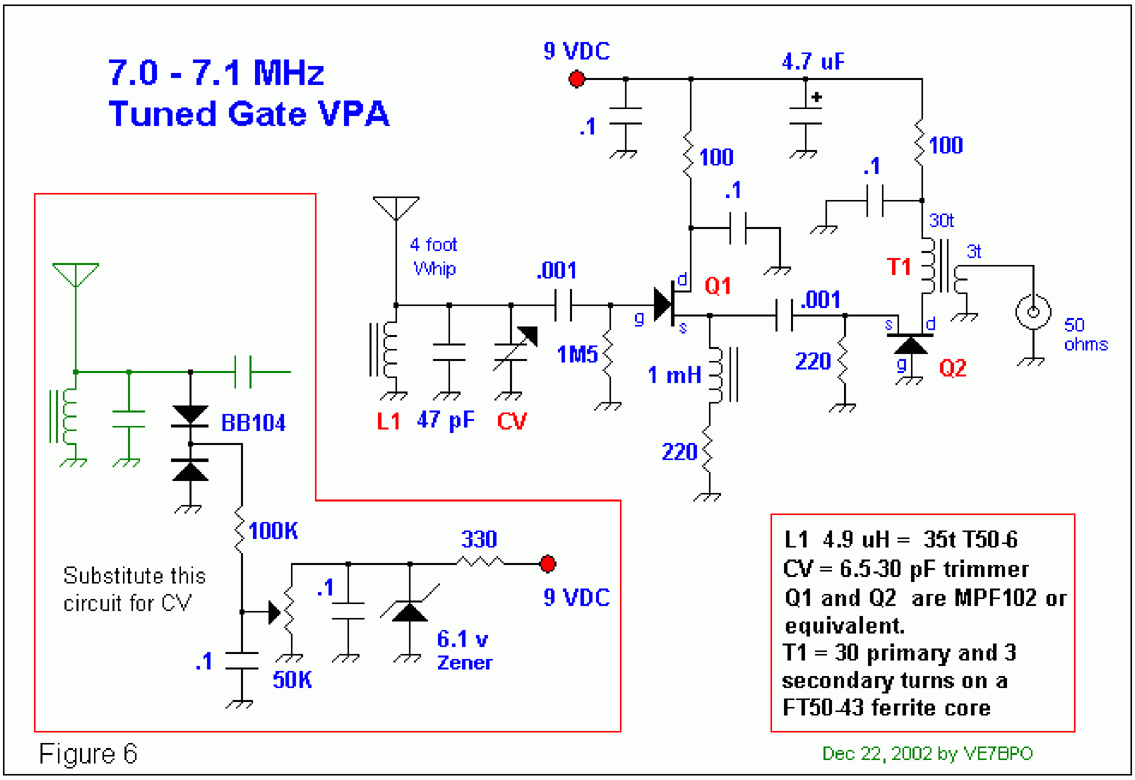


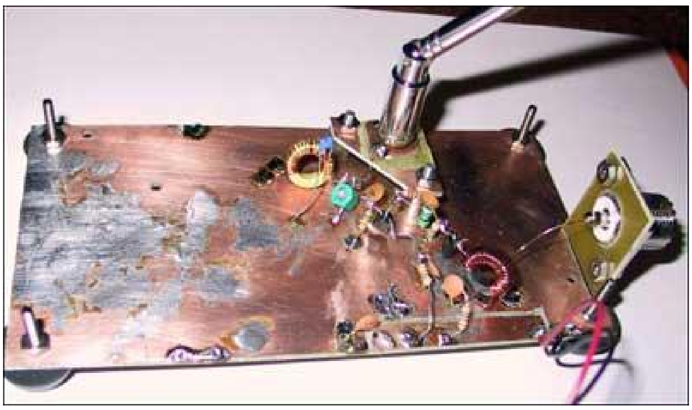
Figure 6

Figure 6 shows the end schematic for the 40 M version, which uses a parallel tuned resonant circuit under the whip. I did not have any air variable capacitors and only had one varistor (a BB104 VE7GC gave me) in my parts stock.

A variable trimmer cap was first used so I could experimentally determine how much C would be required to resonate the chosen inductor. A VVC tuning circuit was later added in place of the trimmer cap CV to permit more practical tuning and is shown in the Figure 6 inset.

Increasing the zener diode voltage, above the 6.3 volts shown, may allow the circuit to tune higher in frequency. However, I did not have any in stock.

I have no data on the BB104. Peaking was easily performed with the 50K potentiometer even when the antenna was shortened to 2 feet in length. The variable plus fixed 47 pF capacitance values, needed to tune the 4 foot whip tank circuit, were found experimentally and will likely vary somewhat in your own designs.



Adding a tuned circuit to the whip increases the parts count and complexity of the VPA. However, putting a bandpass response before the Q1 stage is probably a good way to go if you are getting IMD from mixing within the Q1 stage. VPAs without tuning on the antenna element are more convenient and easier to build and use.

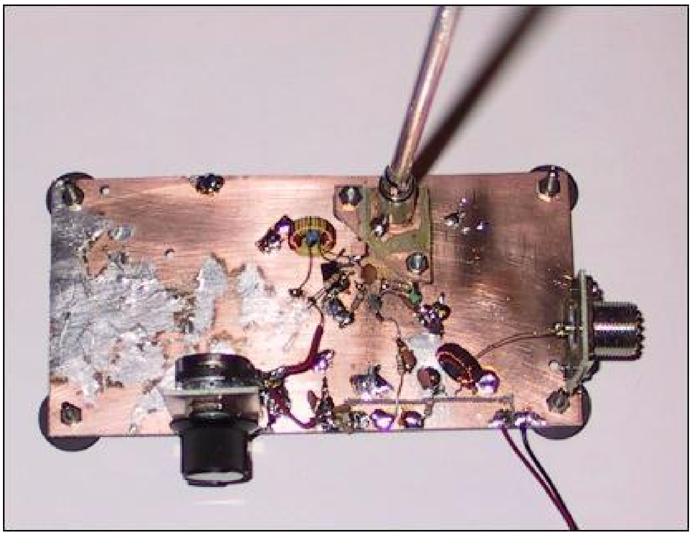
The experimental board has a (green) 6.5-30 pF variable cap for tuning in this experimental project.

A potentiometer, voltage regulation circuit and VVC diode are added for tuning the VPA. It worked reasonably well. The pot was mounted on a small scrap of copper board which was soldered to the main board. Richard Fisher, K16SN built a version of this stage for **WorldRadio Magazine.** WorldRadio is an excellent periodical covering a wide variety of topics for the radio frequency enthusiast. They have a web site at [WorldRadio Online].

Richard kindly scanned his article and there are 2 jpeg files to download if you wish to see them. Many thanks to K16SN and the great people of WorldRadio magazine for permission to post these files.

Download Part 1

Download Part 2



Remote Location

To reduce environmental noise, some radio buffs mount their VPAs outside and run 50 ohm coax into the house. The operating voltage is fed via the coax and the basic circuit is altered to block the DC from the output and provide line RF filtering. My friend has a kit-built VPA that he eventually mounted in a PVC pipe outside. It is now a lot quieter than when it was in the house.

Tidbits

VPAs should be enclosed in a metal box. Even then, hand capacitance may affect the circuit. Moveable whips are more convenient in tight locations. Angling the whip allows full extension of the telescopic segments in restricted locations and allows different polarization to be tried.

An angled or 6 foot whip tends to be top heavy and may topple your VPA over. I found that heavy project cases with wide feet-spacing are required for moveable or greater than 4 foot long whips.

Radio Shack is a good source for telescopic whip antennas. The shorter the whip the lower the gain of a given VPA. This permits a crude form of gain regulation by extending or lowering the whip. Do not do this for Figure 6.

Clipping a piece of wire to the top of the whip and then extending it outward increased the gain in all but the Figure 6 versions.

My favorite VPA on this page is the version shown in Figure 3. Tuning of the antenna element (as in Figure 6) could be added to any of the other VPA schematics shown on this web site.

Tuned Q2 Input/Output VPA Web Page

Tuned Q2 Input/Output Supplemental Web Page

Project Conclusion

VPAs are no panacea. I would rather listen on my long dipole with balanced feedline and an antenna tuner anytime. The problem being is such gear is not very portable.

A lot of knowledge was gained performing these experiments. No doubt there are errors lurking and ideas that beg for improvement. Any comments, criticisms and contributions are welcomed.

My sincere thanks to Wes Hayward, W7ZOI for his tidbits of elmering which kept me going. Thanks also to VE7TW for the test equipment and David White, WN5Y for his editting and web authoring assistance. W7ZOI and WN5Y both have fabulous web sites which are listed in the links section.

Above. A trio of VPAs built and kept during the experiments on this topic

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