# A Simple Harmonic Mixer/Antenna Feed for 47 and 76 GHz Experiments

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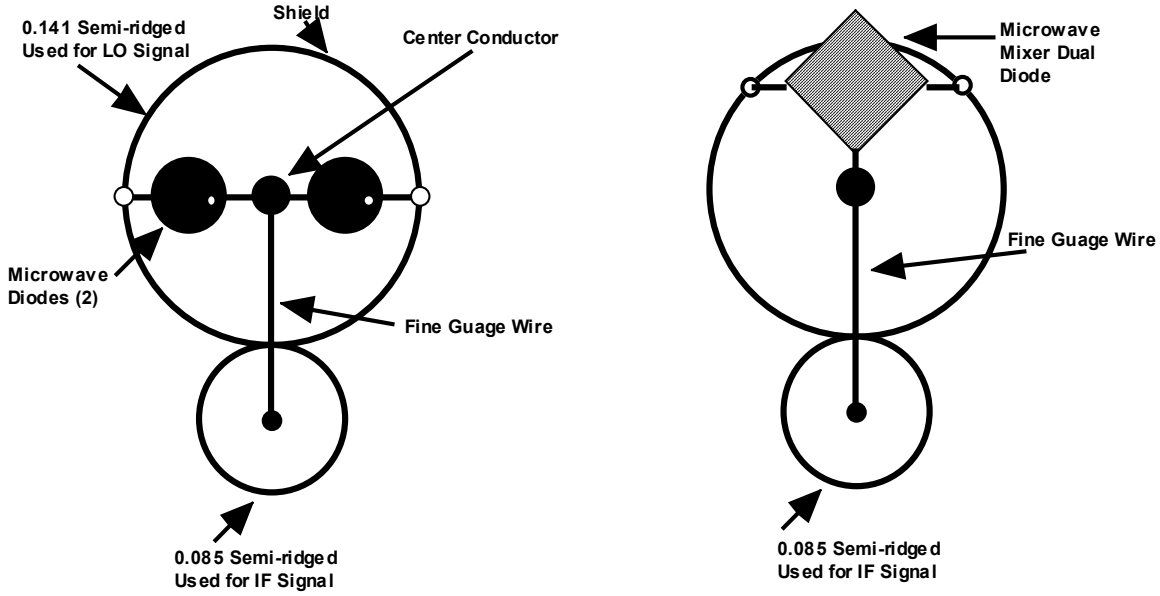
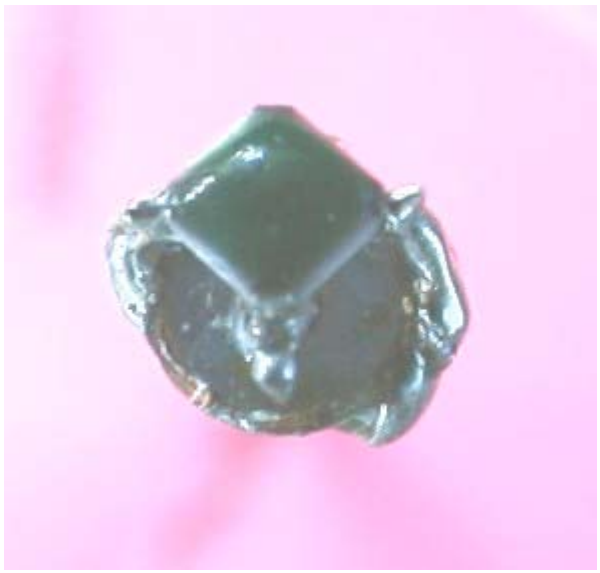
Just in the last year, members of the SDMG have started experimenting at 47 and 76 GHz. The issues for those bands seemed to be providing a clean LO signal and coming up with a harmonic mixer and antenna with feed. We were fortunate to purchase a quantity of two models surplus Verticom synthesizers which cover about 9-10.7 GHz and 12.6-13.3 Gz with very low phase noise and are locked to an external 5 or 10 MHz reference. These units have provided considerable flexibility while getting our feet wet on these bands.

With the LO source issue resolved , I decided to look for approaches to build harmonic mixers from materials available to our group in quantity. At the time, I had not yet been fortunate enough to put my hands on DB6NT harmonic mixer boards or one of the Phillips or other modules appearing on the Amateur scene. Even with one of these mixers, I'd have needed to come up with a suitable dish and feed. Falling back to using Qualcomm surplus as usual, I came up with this simple and crude way of getting on the 47 and 76 GHz bands. This approach is really intended as a means to get started easily as it does have a number of potential drawbacks. It's simple , does work ,and I hope to have several SDMG members operational for at least the basic 1 km contacts during the 2003 10 GHz & Up contest.

The overall approach for the harmonic mixer is to use a pair of microwave diodes connected in ant-parallel fashion from the center conductor to shield of a piece of 0.141 semi-ridged coax. A piece of 0.085 coax is placed in parallel with the 0.141 and attached at several points with solder between the two shields. A short piece of very fine wire (single strand from a zip cord) is used as a microwave choke to connect the center conductors of the two coaxes together. The figures and pictures below show how the harmonic mixers are constructed. That dual diode mixer picture does not include the IF coax.




**Sketch of Harmonic Mixers for 47 & 76 GHz Using Two Individual Diodes or One Dual-Diode Package**



The LO signal at +20 dBm is applied to the 0.141 coax and the 0.085 serves to connect the IF which is about 145 MHz ( IF should function up in to several GHz). The coaxes are bent to act as a feed for a flashlight reflector as in the figure below.

The original bulb filament was only about 3/8" from the rear of the reflector so the coax with diodes needs to be located in about the same position. The nice optical reflection of the diodes from the metalized surface shows about where the feed needs to be located to illuminate the reflector. So far I have tested four different reflectors and all function well enough to get started. Three reflectors are from flashlights and the fourth is an old flash bulb holder from a camera which Chuck (WB6IGP) found at the swap meet for a couple of bucks. By sliding in & out the feed, some of the antennas will provide a nice, single main lobe while others (such as the flash bulb reflector) seem to have very serious side lobes. They all have 20- 30 dB gain which is enough to get started.

Two types of surplus Qualcomm diodes have been used with very similar performance. I started off using the two individual, tiny, black diodes from a 14.5 GHz mixer assembly as is used for the noise source project. I then tried the green dual mixer diode package which is used on the "Gold Boards". The two outer leads connect to the shield and the center lead connects to the center of the coax. The leads should be kept as short as possible to minimize radiation at the LO frequency. The concept used to mount the feed on to the dish is shown in the figure below. The dishes are so light that they can be supported by the coax.

Two approaches for providing the sub-harmonic LO drive have been used so far. In the simplest and most efficient case, the mixer is driven directly from the output of the synthesizer at 9.41 GHz (X5 = 47.05 GHz) and the other system at 9.439 GHz (X5 = 47.195 GHz) and operated in full duplex similar to a Gunnplexer with 145 MHz IF. This mode is only good for NBFM or CW. The other approach uses the same LO frequency and a 145 MHz IF signal at +10 dBm is applied to the mixer for Tx mode. This of coarse is good for any mode of operation but has considerably less conversion efficiency.

We currently have two stations (WB6IGP and N6IZW) equipped with P-Com Tx modules outputting about 23.5 Ghz at +20 dBm. Using one of these to drive the harmonic mixer provides about a 20 dB improvement in signal strength over the 9.41 GHz approach. The total improvement for a system using two of the P-com units is then about 40 dB

The received signal level at 47 GHz for two 9.41 GHz synthesizers feeding harmonic multipliers with reflectors is about – 80 dBm at 10 feet. The received signal for two units using P-Com drivers at 23.5 GHz is about –40 dBm at 10 feet. Based on these figures, it does not appear two 9.4 Ghz units can make the 1km distance required for the 10 GHz & Up contest. It does appear that one 23.5 GHz P-com driven unit should be able to work a 9.41 GHz unit easily at 1 km and two P-com driven units should be capable of working better than 10 miles. These assumptions make no allowances for moisture absorbtion. No measurements have been made at 76 GHz to this point other than to note that good quality cw signals can be copied from across the room using two Verticom synthesizers directly driving the harmonic mixer/feed assemblies.

The configuration used to provide 23.5 Ghz from the P-Com Tx modules consists of a Verticom synthesizer providing an LO in the 10.43 GHz range which is doubled in the P-Com module to 20.86 GHz. A QC synthesizer at 2640 MHz is used to supply a signal for the Tx IF port mixing up to about 23.5 GHz. The low-side P-Com modifications are shown on the SDMG site as noted below.

The diodes can be obtained from either Chuck Houghton, WB6IGP (clhough@pacbell.net) or Kerry Banke, N6IZW (kbanke@qualcomm.com)

Visit the SDMG projects web page (http://www.ham-radio.com/sbms/sd/projindx.htm) for updates on this project and other microwave construction projects.