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LOW-COST HARMONIC COMB GENERATOR

Harmonic comb generators are designed to produce fixed harmonics over a wide range of frequencies. Generally, the harmonics are fairly stable in frequency and with temperature, therefore, they may be used as standards for verifying radiated emissions measurement systems in anechoic chambers or on open area test sites (OATS). There are many other uses for these

Fig. 1 - AET model USB-S-10 comb generator

generators as I have discussed in an article in the January 1991 issue of RF Design Magazine and now in my various EMC seminars. In this article, I'd like to introduce a low-cost USB-powered comb generator recently available from Applied Electromagnetic Technology (AET) for approximately $300. More information may be found on their Web site: www.appliedemtech.com. These generators are available in various fundamental comb frequencies from 1.8 MHz up to 200 MHz and useful harmonic frequencies into the GHz. The company also makes spherical models specifically for verification of chambers and OATS ranges. I ordered their 10 MHz model, which produces harmonics from 10 to over 1000 MHz and use it for a variety of purposes; from test range measurement and validation to shielding effectiveness measurement (you'll have to attend one of my seminars!) to various demos during the seminars.

The basic circuit starts off with a crystal oscillator, which feeds a driver and then is capacitively coupled to several microwave gain blocks. The resulting signal is comprised or positive and negative impulses with very fast rise times. Because the rise times are in the picosecond range, these impulses create a wide range of harmonics. The 10 MHz model produces useful harmonics out beyond 1000 MHz.

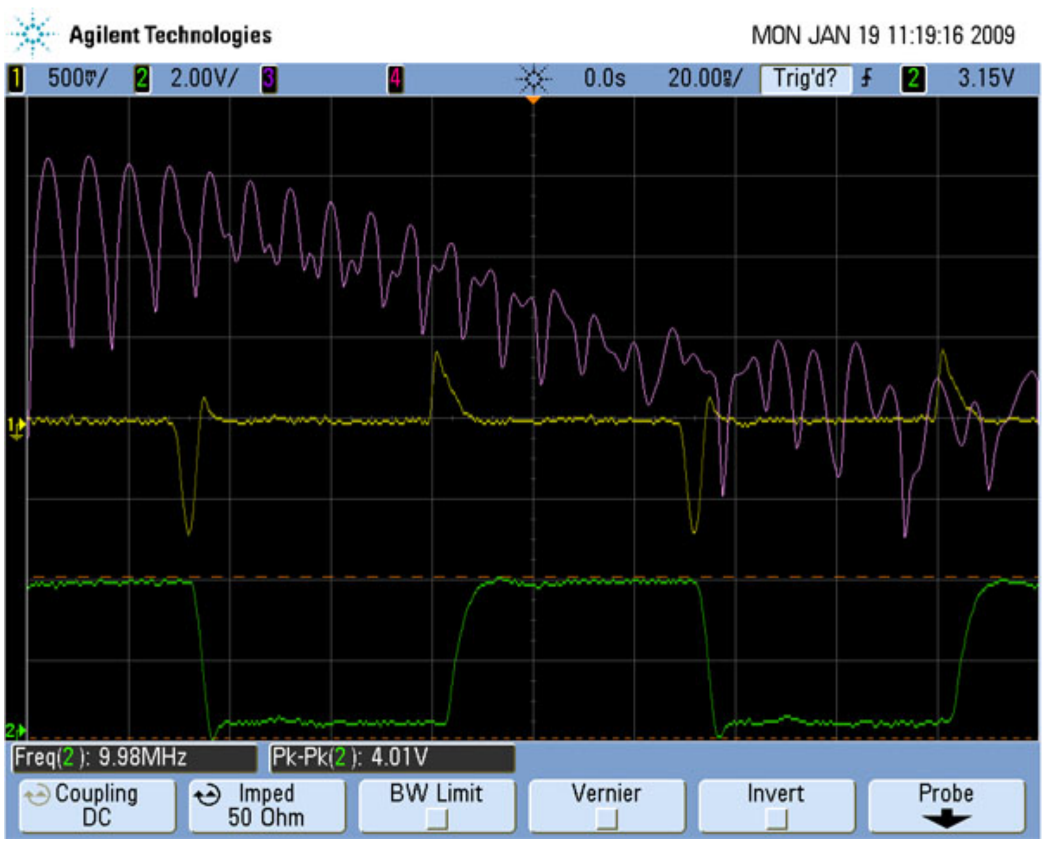

Fig. 2 - Measured signals from comb generator. Violet - harmonic output (10 MHz spacings), Yellow - comb generator output: 0.7 to 1.4 V spikes, Green - crystal oscillator output (10 MHz).

When using the comb generator as a standard source for use in verifying radiated emissions measurement systems, the generator will require an omni-directional antenna. These can be easily made from a set of telescoping antennas. The antenna shown below was given to me , so I don't know the manufacturer, however, it appears to yield a good omni-directional radiation pattern, as you will see later.

The Fig. 3 below shows the comb generator and monopole (ground plane) antenna sitting on my workbench with the nearby spectrum analyzer picking up the harmonics. Later, we'll take all this into the 3m fully anechoic chamber to record the actual harmonics on professional measurement equipment.

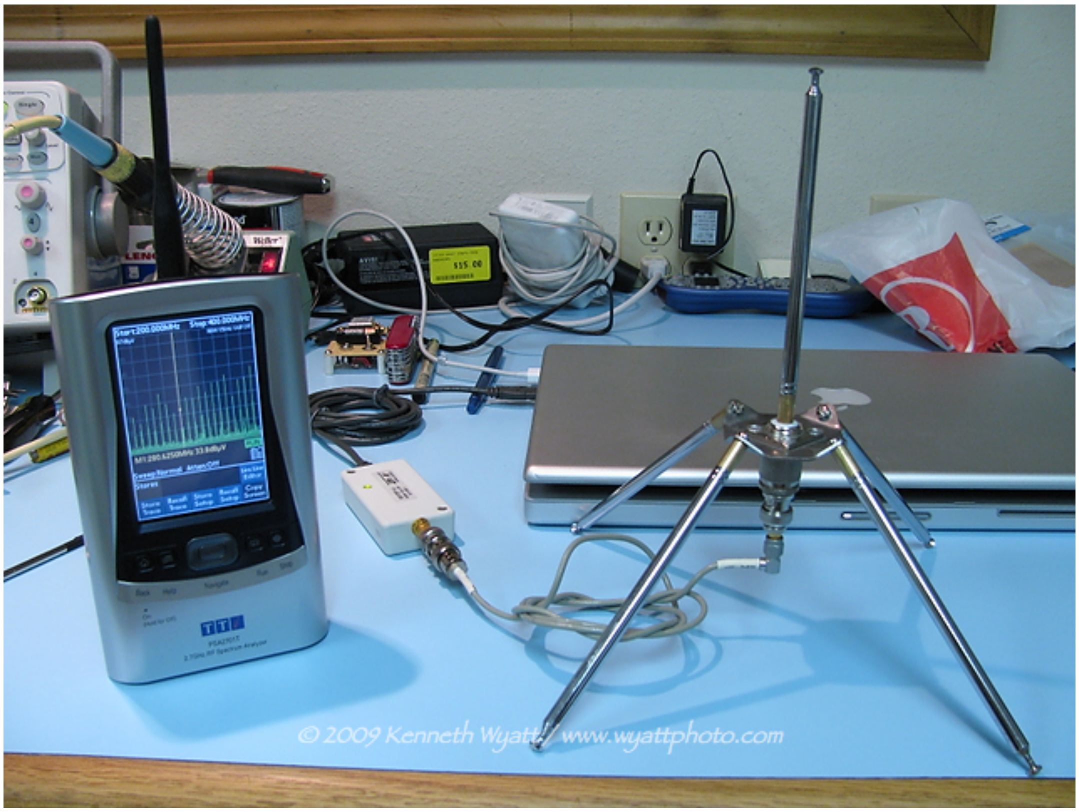

Fig. 3 - Reference antenna used for comb generator testing in the 3m chamber. I'm not sure of the source for this antenna, as it was given to me as a retirement gift by another ham/employee. The elements are telescoping, but I used it in the collapsed state.

I purchased a small switch-mode USB power supply from Radio Shack (as of a few days ago, now officially referred to as "The Shack"). The generator is connected to the antenna with a short piece of coaxial cable. In the chamber, we'll use several ferrite chokes spaced evenly along the coax and power supply cable to reduce any effect of cable radiation by common-mode currents.

Fig. 4 - Comb generator and antenna installed into a 3m chamber. The comb generator and it's USB power supply were buried under the carbon-loaded foam block. Several ferrite chokes were installed at intervals along the power and coax cables. One of these chokes can be seen at the base of the antenna.

Once the comb generator was installed into the turntable, the generator was turned on and the amplitude versus frequency was measured. Because the turntable was rotated continuously during this measurement, we were also able to capture amplitude versus azimuth as shown in Fig. 5.

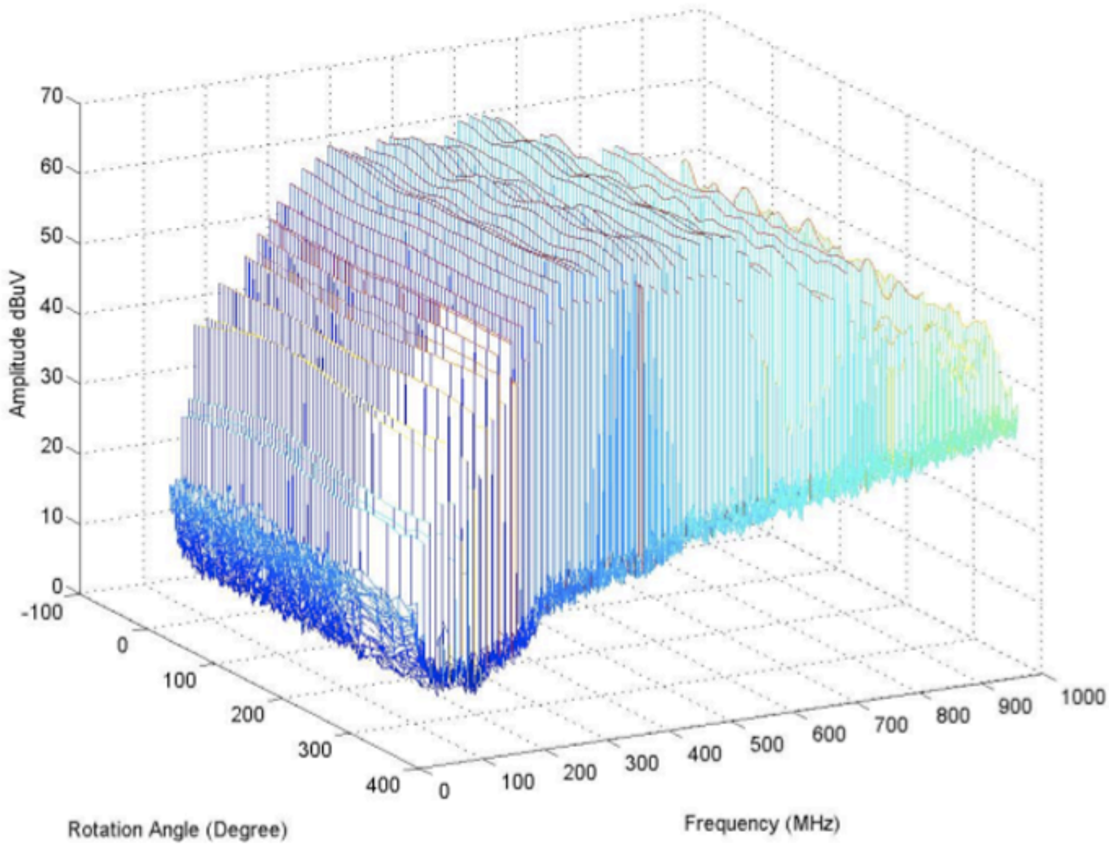

Fig. 5 - 3D plot of frequency, amplitude and azimuth (rotation) from zero to 360 degrees. This plot shows the amplitude versus frequency of the system. The amplitude falls off at the low end due to inefficiencies in the antenna.

The maximum point around 450 MHz indicates the resonant point of the antenna. The response falls off at the high frequency end due to both inefficiencies in the antenna and the fact the output of the comb generator is gradually falling off.

Note the amplitude versus azimuth is fairly constant at the low frequency end, gradually getting worse at the high frequencies, probably due to reflections in the system and chamber.

Acknowledgment: I'd like to thank Kuifeng Hu, Agilent Technologies, for his assistance making this measurement.