Comb Generator As a Reference Source
AN-104 CG

What is a Comb Generator?

We start with the discussion of what is a comb generator. It is an electronic device that produces a very fast (impulse-like) pulse repeatedly. An impulse by definition, however, has an infinitely high amplitude and infinitesimal duration, which translates into frequency domain as a broadband signal covering the entire spectrum. Of course, this definition is only for theoretical discussion, and cannot be produced in practice. A comb generator is an implementation of this idea. It generates a very short, fast pulse with a sharp rise time and a sharp fall time. The rise time and the fall time are extremely small, but are non-zero. The pulse is continuously repeated as frequency *(F)*, translating into a series of frequencies, which are multiples (or harmonics) of *F*, in the frequency domain. The signal extends out into the spectrum, depending on the waveform characteristics. The sharper the rise and fall time, the greater the frequency range over which the output is useful. When viewed on a spectral analyzer display with a wide frequency span, the output resembles a comb; hence the name, "Comb Generator".

Use of a Comb Generator:

A comb generator is often used when a reliable reference signal source is needed. It is quite versatile, in that it is an ideal solution for use, whether your application requires multiple simultaneous frequencies, or a single discrete frequency. A typical RF signal generator is bulky, requires AC power, and takes time to set up and configure it for the desired frequency and amplitude, and must then be retuned for each individual frequency needed. A comb generator, in contrast, is small, quick and versatile. It is light and portable, powered by an internal battery, generates multiple frequencies simultaneously, and has only two modes of operation; on and off. So, when wide band performance is to be tested or studied, comb generators are preferred.

EMI/EMC Test Site Validation:

The Comb Generator has a special application as a reference source in emissions testing for various EMC requirements. As in all RF testing, it is difficult to judge the validity of a reading. Consider, for example, the set up for the radiated emissions measured from a device under test at a random frequency. On a carefully calibrated open field test site (OATS) or anechoic chamber, with the antenna at a 3-meter (or 10-meter) test distance, with cables and connectors connecting the antenna, preamplifier and the receiver, it is difficult or impossible to tell if the data collected is right or not. Well, most engineers assume the data is correct, until they find something inconsistent. Only then the question arises whether something has gone wrong with the Equipment Under Test (EUT) or the test setup/equipment. Many things can go wrong with the test setup/equipment. It could be a damaged antenna, a broken cable, a loose connector pin, a blown preamplifier, measurement receiver, or a test site related problem. If such problem is discovered before the data is taken, it is a problem, but still better than not knowing about it until after the results are completed and published!

Just imagine how damaging, expensive and disastrous it would be to not discover that something was damaged in your test equipment for a month. A comb generator is used as a reference signal source prior to commencing the each emissions test. The test engineer takes a few readings across the spectrum and compares to the data taken before. If the data compares well, it is a reasonable reassurance that all test equipment and accessories used are in proper working order. The readings taken can be as few as five or six for manual test, or as much as a complete scan of all frequencies for an automated test in an anechoic chamber. The characteristics considered desirable for a reference emission source are described below.

Radiated Reference Source:

The radiated reference source should be simple, like any comb generator, so that it is turned on by just a flip of the switch and is ready for use. But there are other desirable qualities required. These are discussed here.

1. **Radiation Pattern:** A radiated reference source should generate a consistent radiation pattern. Therefore, it should include a reliable antenna and a reference ground plane, and no other part of the equipment should affect the radiation pattern. So there should be no cables or other flexible conductive parts affecting its radiated signal. Ideally its pattern should be omnidirectional. All models manufactured by Com-Power Corporation (except one) are omnidirectional with circular chassis, which also aids in maintaining a circular pattern.
2. **Battery Power:** Internal batteries power the comb generators. This eliminates the need for an external power connection during the use. The comb generator should not be used as a radiated reference source while charging, as it could affect the readings depending upon the position of the power cable.
3. **Temperature Stability:** The output of the comb generator should be stable with respect to temperature and time. The internal circuits are designed with this consideration in mind. The frequency of the comb generator output is fairly stable, however, better stability options are available.
4. **Output Power level**: There are opposing arguments regarding the output levels desired from the comb generators. One important consideration would be to keep them close to the specification emission limits. The emission levels permitted for the unintentional radiators by the regulation are quite low. Some design engineers may think that these levels are unnecessarily strict. Another consideration would be to make them high so that the levels are easily visible whether you place the comb

generator at 3-meter distance or 10-meter distance. On the other hand, there is a concern that the high level of comb generator may saturate the measurement system, by saturating the preamplifier or the spectrum analyzer input. This is especially true for the comb generator because, several peaks at various frequencies combine the energy to make the pulse amplitude high. So generally, the Com-Power comb generator models are designed to maintain the outputs close to (within about 10 dB of) the specification limit for the usable frequency range.

5. **Limiting Energy:** At times, it is desirable to get high signal level at a given frequency, but not have excessive energy within a frequency band. This can be somewhat controlled by using an appropriate step size if possible. In other words, if your frequencies are spaced farther apart, the energy within a particular frequency range would be lower due to fewer frequencies being present. In this case, you would use a larger frequency step size. (Example: a 20 MHz Comb Generator will have harmonics present every 20 MHz, or a 20 MHz step size, whereas a 1 GHz Comb Generator will have a 1 GHz step.
6. **Applicable Frequency Range:** Ideally a user would like to get a wideband source, to cover many applications and test ranges. This is a rather challenging task, but some comb generators are designed to give the widest frequency range possible. However, this may conflict with other requirements, such as bandwidth, output level, output flatness, as well as low battery consumption. So, compromising on some of these requirements, different comb generators are designed to cover varying frequency ranges.

Conducted Reference Sources:

The conducted reference source should also be simple to use, like the radiated comb generator. Also, some features desired, such as temperature stability, output power level and wide frequency range, are similar. Other desirable qualities are discussed below.

1. **Ease of Connection:** The conducted reference source should plug into the power source just like the EUT and couple the generator output directly into the LISN. It should provide a switch so that the noise source can be turned on and off.
2. **Battery Power:** This requirement is debatable, because a reference source connects to a power source and could take power from this source, so it can be designed so that battery is optional for function. Com-power comb generators are made with batteries designed in.

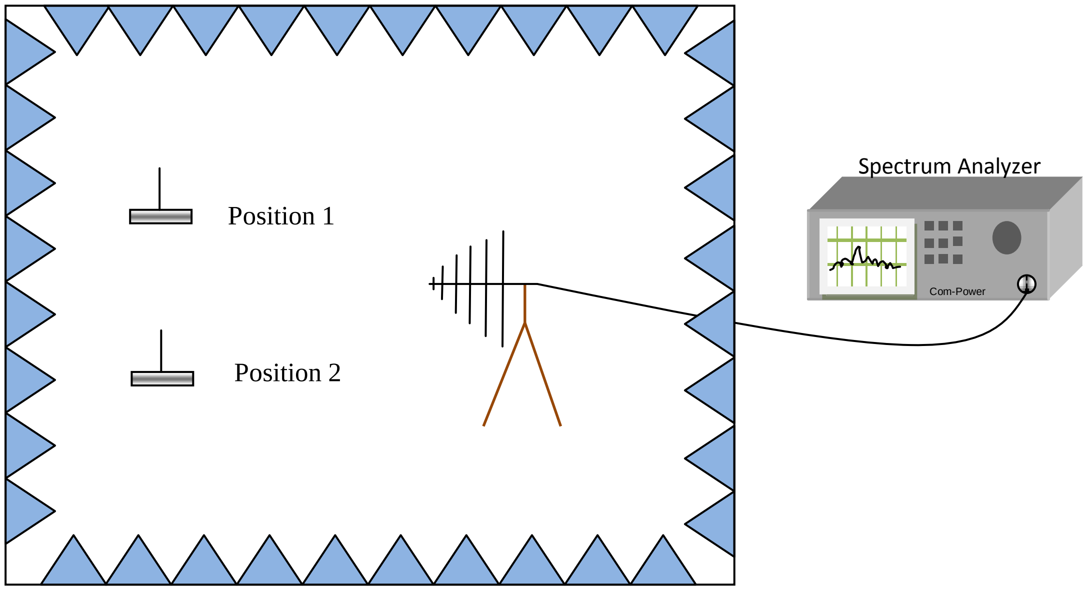
Comparing OATS and Anechoic Chambers

Open Area Test Sites (OATS) and fully and semi-anechoic chambers are used for radiated emission tests. OATS is the classic and traditionally preferred test site. It is required to be in a relatively "quiet" RF location with low ambient noise levels. Such locations are in canyons and away from areas where electronic design and manufacturing companies are located. Therefore, a less ideal, more expensive, yet convenient alternative of anechoic chambers has been accepted. There is no standard design or method of construction of an anechoic chamber. In the early days of their use, the final test had to be verified on OATS. Now, the criteria are that it meets the same normalized site attenuation requirements as the OATS, but with multiple locations of the transmitting antenna within the test volume of the turntable.

It is not uncommon to get different data for the same device tested in different test chambers. A typical EUT is too complex and can it self change in form (interconnecting cables, positions of peripheral devices, cables, operating mode or software). So use of a radiated reference source is extremely useful in verifying the measurement setup/equipment.

A Special Test for Anechoic Chamber: The anechoic chamber offers a specific advantage over the OATS, in that it removes the ambient noise. However, the same chamber walls that prevent the RF from entering the chamber cause another problem. They reflect the RF originating inside the chamber, which makes the measurements inaccurate. Of course, the anechoic material is supposed to absorb the reflections, but the absorption is never perfect. So, partial reflections do remain, making the anechoic chamber an imperfect site.

Often, it is desirable to know or to measure the extent of the imperfection. A radiated reference source (comb generator) can help this evaluation. After taking emission readings at a given position of the reference source, move it some distance (30 or 50 cm) to a side, but keeping the distance to the receiving antenna unchanged as shown in Figure 1 below. Change the receiving antenna direction if necessary to point to the new radiated reference source position. (Or move the receiving antenna so that the relative position of the antenna is the same as before). A perfect anechoic chamber would make no difference in the reading. The reading, if changed, reveals an imperfection in the chamber, and the extent of the change would be an indication of the quality of the chamber and/or the absorbing material.



Conclusion

The comb generators made to simulate the radiated and conducted reference sources make valuable tools in an EMC or EMI lab helping the test engineer to verify the reliability of the his test equipment on a daily basis. This is the best way to discover a potential problem before it is too late.

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June 20, 2010