IN COMPLIANCE Magazine
January 2010

EMC TEST SITE QUALIFICATIONS

Site Voltage Standing Wave Ratio versus Time Domain Reflectometry

by Michael J. Windler, Underwriters Laboratories Inc. and Zhong Chen, ETS-Lindgren

INTRODUCTION

Everyone in the EMC business is familiar with the traditional Normalized Site Attenuation test (NSA). However, in February of 2007 CISPR 16-1-4 was published complete with the new Site Voltage Standing Wave Ratio (SVSWR) test. At the time, the American National Standards Institute (ANSI) Accredited Standards Committee (ASC) C63® had developed a draft proposal for C63.4 (Draft 1 - May 20, 2005) called the Time Domain Reflectivity (TDR) measurement. The critical question addressed by this article is which method – SVSWR or TDR - more accurately provides an assessment of the test site. Given the investments companies make in test sites for EMC compatibility, this is key assessment question.

BACKGROUND

Conceptually, the SVSWR method is quite straightforward and easily understood. As with any VSWR measurement the objective is to measure the maximum and minimum values of a standing wave as illustrated in Figure 1. The ratio of these values is the VSWR. The most common application of the VSWR measurement is in evaluating transmission lines. If there is an impedance mismatch at the end of a transmission line between the impedances of the transmission line and the load (for example), there will be a boundary condition that results in a reflected wave. The reflected wave will, at various locations on the transmission line, be constructively or destructively interacting with the continuous wave from the source. The resulting construct (direct and reflected wave combination) is a standing wave. A simple example of this is found in the conducted power test required for appliances in CISPR 14-1. In this test a transducer (power clamp) is moved along an extended power cord of the product in an effort to measure the maximum voltage on the power cord over the frequency range of interest. The same event is realized on an imperfect test site. The transmission line is the path from the equipment under test to the receiving antenna. Reflected waves are created from other objects in the test environment. Those objects could range from chamber walls to buildings and cars (at open area test sites). Just as in the case of a transmission line, a standing wave is created. The test set up for the site VSWR or SVSWR test is shown in Figure 2.

UNDER SAMPLING

The physical dimensions of the standing wave are a critical factor in accurately measuring a standing wave. The objective, again, is to find the maximum and minimum value. The SVSWR test in CISPR 16-1-4 proposes to measure the standing wave on a test site by moving a transmitting antenna along a straight line in the chamber and measuring the received voltage with the emissions antenna in the normal location used for product testing. Just as in a conducted power test or similar VSWR measurement, a continuous movement of the transducer, or in the case of SVSWR the

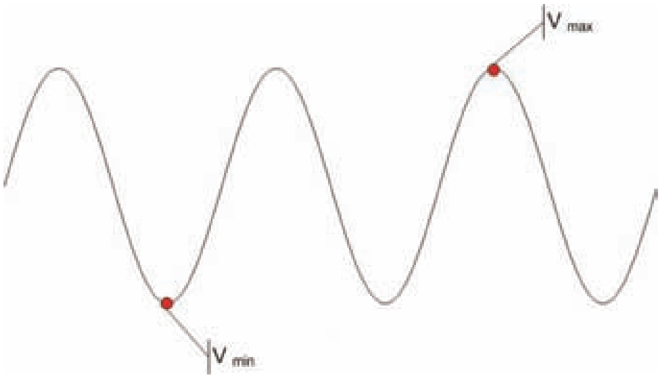


Figure 1: VSWR Measurement Values

transmitting antenna, is needed to ensure the capture of the maxima and minima of the standing wave. This could be done at each frequency but only at considerable expense and time. Consequently, the CISPR working group decided to compromise and measure only six physical positions for each of the volumetric locations (see Figure 3). The only other option for reducing the test time was to reduce the frequency resolution of the measurement (e.g. measure fewer frequencies but at each frequency measure more positions). The problem with that option is that many objects that reflect can have narrow spectral characteristics. In other words, some materials can be significantly reflective for a narrow frequency range. Consequently, the working group decided to apply a maximum 50 MHz step size to the test resulting in a minimum of 340 frequencies from 1-18 GHz but with only six positions as shown in Figure 3.

The sampling of a standing wave at only a discrete number of positions may plausibly provide sufficient accuracy to compute an approximate SVSWR depending on the size of the steps. However, another compromise was to have the same prescribed positions for every frequency so that the test would save time by moving the antenna and sweeping frequency. The chosen positions are 0, +2, +10, +18, +30, +40 cm. Try to imagine a sign wave superimposed on a ruler with six marks on it. Now imagine compressing the sign wave into shorter and shorter wavelengths. Figure 4 illustrates this thought experiment. There will be frequencies where the chosen locations will never come close to the true maxima or minima of the sign wave. This is a compromise that will result in a compliance bias, e.g. a result that is always lower than the true SVSWR. This bias is an **error term** and should not be confused with a measurement uncertainty contribution.

How large is the error term? If we think of the example illustrated in Figure 4 it is clear the wavelength is 2 centimeters. That would be a 15 GHz sign wave. At that frequency, there would be no measured standing wave because the wavelength is 2 cm and the other locations are even multiples of 2 (10, 18, 30 and 40 cm)! Of course, the same issue occurs at 7.5 GHz. At virtually every frequency the sampling results in measuring neither the maximum nor the minimum.

TEST TIME

A laboratory must measure four locations as shown in Figure 3 in two polarities and at least two heights in accordance with CISPR 16-1-4. The measurement range is 1-18 GHz. Until recently, the only antennas available that met the pattern requirements were available in 1-6 GHz and 6-18 GHz models. The consequence is that the test time is shown in Equation 1:

$$Time = t_{set\ up} + [(t_{move\ antenna} + t_{sweep}) \times n_{positions} \times n_{locations} \times n_{heights} \times n_{antennas} \times n_{polarities}] + (n_{antennas} \times t_{switch\ antennas})) + (n_{heights} \times t_{change\ heights}) + (n_{polarities} \times t_{change\ polarities}) \quad (1)$$

Where: t_x = time to perform function x, n_y = number of times activity Y must be performed.

Equation 1: Estimate test time for SVSWR

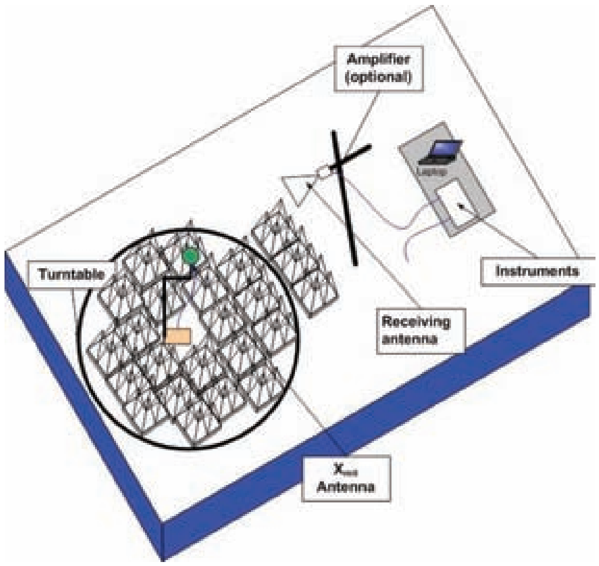


Figure 2: SVSWR Test Set Up

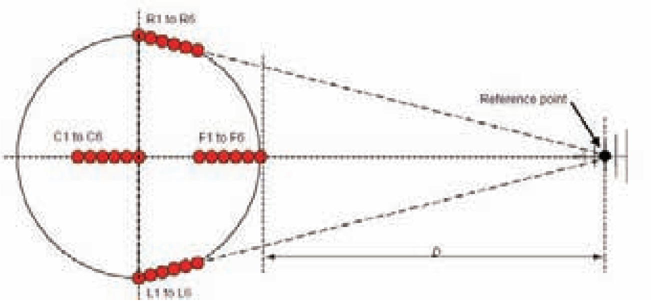


Figure 3: SVSWR Measurement Locations and Positions

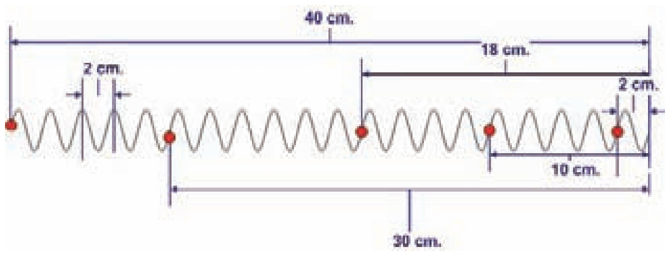


Figure 4: SVSWR Measurement Locations vs. Wavelength

The result of this combination of positions, locations, polarities, heights and antennas results in a rather lengthy test. This time represents an opportunity cost to the laboratory. The opportunity cost is the revenue that could otherwise have been realized in lieu of conducting this lengthy test. As an example, a typical test time for this test is at least three test shifts. If a lab were to charge $2,000 USD for a shift, this test represents an annual opportunity cost, assuming the site is checked annually as recommended, of at least $6,000-$12,000 USD. This does not include the initial costs of the special antennas ($14,000 USD).

POSITIONING UNCERTAINTY

Each measurement of the SVSWR method requires the positioning of the transmitting antenna to the positions specified (0, 2, 10, 18, 30, 40 cm). Since the computations are corrected for distance, the repeatability and reproducibility of the positioning directly impacts the measurement uncertainty. The question then becomes, how repeatable and reproducible is the positioning of the antennas in increments as small as 2 cm? A recent gage study conducted at UL has demonstrated this contribution to be approximately 2.5 mm or about 15% of the 18 GHz wavelength. The magnitude of this contributor will depend on frequency and the amplitude of the standing wave (an unknown).

A second factor related to positioning is angle versus the antenna pattern. The antenna pattern requirements in CISPR 16-4-1 has variability of roughly +/-2 or 3 dB in H-plane and even wider in E-plane. If you pick two antennas with different patterns but both meet the pattern requirements, you can have very different results. In addition to this antenna to antenna variability (a reproducibility problem), the antennas used to transmit do not have perfectly symmetric patterns (e.g. patterns vary with small increments in angle) as shown in the standard. As a consequence, any change in alignment of the transmitting antenna to the receiving antenna results in a changed received voltage (a repeatability problem). Figure 5 illustrates the actual pattern changes of a SVSWR antenna with small increments in the angle. These true pattern characteristics result in significant angular positioning variability.

The changes in antenna gain as a function of relatively small angular rotations causes as much as 1 dB of variability in the example shown.

TIME DOMAIN METHOD TO OBTAIN SVSWR

The SVSWR method in CISPR 16-1-4 is based on moving antennas spatially to vary the phase relationship between the direct wave and reflected waves from chamber imperfections. As discussed previously, when the waves add constructively, there is a peak response (E_{max}) between the two antennas and when the waves add destructively, there is a minimum response (E_{min}). The transmission can be expressed as

$$E = E_D + \sum_i^N E_R(i) \qquad (2)$$

where E is the received field strength.

E_D is the direct path signal, N is total number of reflections from the site (this could include single or multiple reflections from the chamber walls or open area site imperfections). $E_R(i)$ is the I^{th} reflected signal. For ease of the derivation, let us assume there is only one reflected signal (this will not lose the generality). The site VSWR (or the relative ripple size) of the site can be expressed as

$$S = \frac{Emax}{Emin} = \frac{E_D + E_R}{E_D - E_R} = \frac{1 + E_R/E_D}{1 - E_R/E_D} \qquad (3)$$

By solving Equation 3, we obtain the ratio of the reflected signal to the direct signal

$$E_{relative} = E_R/E_D = \frac{1-S}{1+S} \qquad (4)$$

As can be seen from Equation 4, the two terms, i.e. the reflected to direct signal ratio ($E_{relative}$) and the site VSWR (S) describe the same physical quantity – a measure of the level of reflections in the site. By measuring the site VSWR (as is the case in CISPR 16-1-4), we can determine how large the reflected waves are relative to the direct wave. In an ideal situation there is no reflections, resulting in $E_{relative} = 0$, and $S = 1$.

As previously discussed, to detect the ratio between the reflected and the direct signal, in the site VSWR method in CISPR 16-1-4, we change the separation distance so the phase relationship between the direct path and reflected signals can be varied. Subsequently, we derive the SVSWR from these scalar responses. It turns out that we can acquire the same SVSWR using vector (voltage and phase) measurements without the need to physically move the antennas. This can be done with the aid of a modern vector network analyzer (VNA) and time domain transformations. Notice that Equations 2 to 4

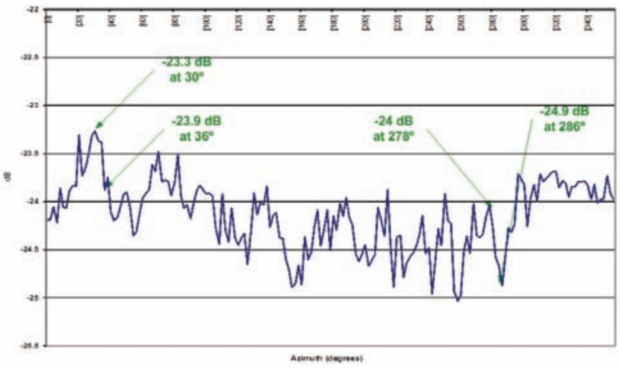


Figure 5: SVSWR Antenna Pattern

hold true in either frequency domain or time domain. In time domain, however, we can distinguish the reflected signals from the direct signal because the point in time at which they arrive at the receive antenna is different. This can be viewed as a pulse sent out from the transmit antenna. In time domain, the direct wave will arrive at the receive antenna first, and the reflected wave will arrive later. By applying time gating (a time filter), the effect of the direct signal can be separated from the reflected ones.

The actual measurements are performed in frequency domain with a VNA. The results are then transformed to time domain using inverse Fourier transform. In time domain, time gating is applied to parse the direct and reflected signals. Figure 6 shows an example of the time domain response between two antennas (by using inverse Fourier transform from frequency domain measurements). Figure 7 shows the same time domain response with the direct signal gated out. The time domain data (after the parsing) are finally converted back to frequency domain using Fourier transform. For example, when the data in Figure 7 is transformed back to frequency domain, it represents E_R versus frequency. In the end, we obtain the same $E_{relative}$ as the CISPR spatial varying method, but by going through a different route. Although the inverse Fourier transform (or the subsequent Fourier transform) sounds like a daunting task, it is actually a **built-in function** in a modern VNA. It takes no more than the pushing of a few buttons.

NEXT STEPS: IMPROVING THE TIME DOMAIN SVSWR METHOD FURTHER

We have established that the SVSWR by spatial movement and SVSWR by time domain produce equivalent data. Empirical measurements can validate this point. Questions that still linger are: whether this is the most representative data for Equipment Under Test (EUT), and what uncertainties we can achieve due to antenna selections? Referring to Equation 2, all reflections are modified by the antenna pattern before being summed. For simplicity, let us consider a test chamber where multi-reflections are negligible. We then have seven terms in the transmission path, namely the direct signal, and reflections from four walls, the ceiling and the floor. In CISPR 16-1-4, there are very specific requirements on the transmitting antenna pattern. For practical reasons, these requirements are by no means restrictive. For example, assume the back wall reflection is the dominant imperfection, and the front to back ratio of the antenna is 6 dB (within CISPR 16 specification). For a site with a measured SVSWR=2 (6 dB) using a perfect isotropic antenna, E_R/E_D is 1/3. If we use an antenna with a front-to-back ratio of 6 dB, the measured SVSWR becomes

$$S = \frac{Emax}{Emin} = \frac{1+0.5E_{R\_backwall}\ /E_D}{1-0.5E_R\_backwall\ /E_D} = \frac{1+0.5*1/3}{1-0.5*1/3} = 1.4 \qquad (5)$$

The antenna with a front-to-back ratio of 6 dB underestimates the SVSWR by 20*log (2.0/1.4) = 2.9 dB. The above example is obviously overly-simplified. When considering all other reflections of the chamber, and all variations of the antenna patterns, the potential uncertainty is even larger. In the other polarization (in E-plane), it is not possible to have a physical isotropic antenna. It is an even greater challenge to define a strict antenna pattern, which all real physical antennas must meet.

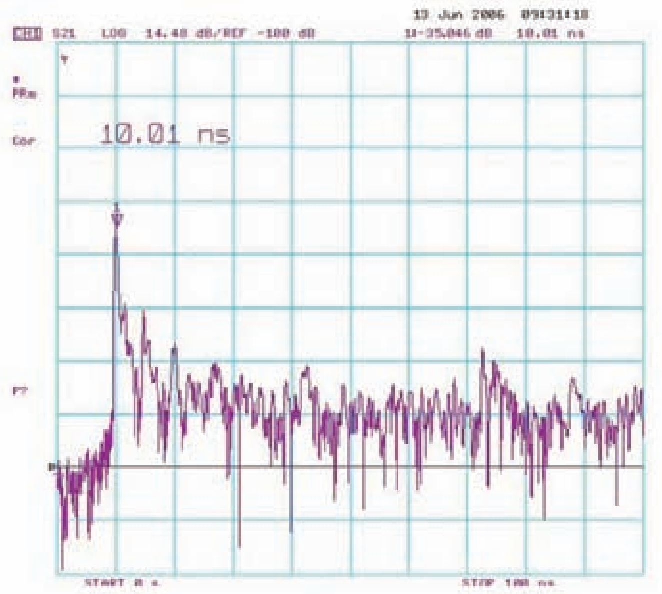


Figure 6: Time domain response (from inverse Fourier Transform of the VNA data) between two bore sighted antennas. Marker 1 shows the direct signal which occurs at 10 ns x (3 x 10^8 m/s) = 3 m from the transmit antenna.

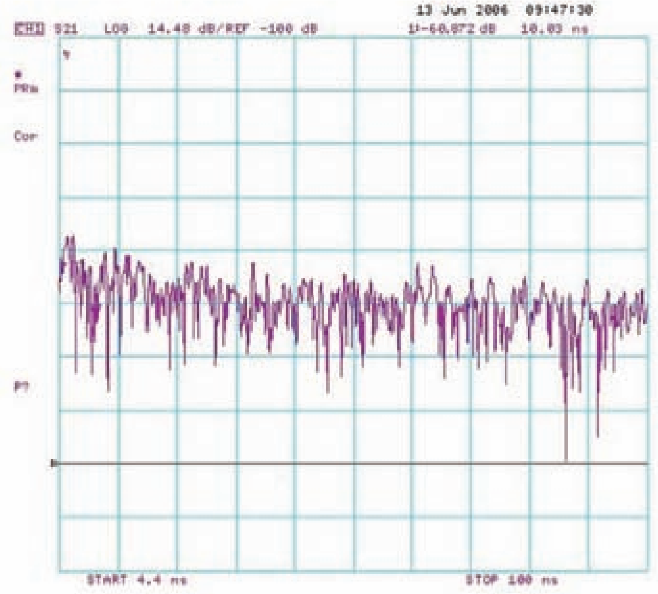


Figure 7: Time domain response with the direct signal gated out – leaving only late arrival (reflected) signals.

The quandary related to pattern variations can be solved by rotating the transmitting antenna. In this scheme, we do not need an antenna with a broad beam – a familiar double ridged waveguide antenna commonly used in this frequency range will work fine. It is still preferred to have a large front to back ratio (which can be easily improved by placing a small piece of absorber behind the antenna). The implementation is the same as discussed earlier for the time domain method, except that we also rotate the transmitting antenna by 360° and perform a maximum hold. Instead of trying to illuminate all walls at the same time, this scheme does it one at a time. This method may yield results that are slightly different from ATTEMPTING to broadcast to all walls at the same time. It can be argued that it is a better metric of a site performance, as a real EUT is likely to have a narrow beam rather than looking like a specifically crafted antenna. In addition to avoiding the messy situation due to the antenna patterns, we can pinpoint where an imperfection occurs in a chamber or an OATS. The location can be identified from the rotation angle, and time needed for the signal to travel (thus the distance to where the reflection occurs).

CONCLUSION

The benefits of the time domain method are numerous. It avoids the pitfall of the under-sampling issue discussed earlier. The method does not depend on physically moving the antennas to a few discrete locations, and the SVSWR from time domain represents the true value of the site. Also, in the CISPR method, to normalize the influence due to the path length, the exact distance between the antennas must be known. Any uncertainties due to the distance translate into uncertainties of the SVSWR (considering the small increments needed, it is even more challenging). In time domain, there are no distance normalization uncertainties. In addition, perhaps the most attractive feature for an end user is that time domain SVSWR is much less time consuming. The test time is reduced almost six fold (see Equation 1).

One might be tempted to argue that in the CISPR method, because the antennas are moved, the reflection points move on the chamber walls, and more areas of the imperfections are covered. This is a red herring. The purpose of moving the receive antenna is to vary the phase relations only. The total distance varied is 40 cm. It translates to 20 cm (7.9”) coverage on the wall due to geometry translations (if the transmission path is parallel to the chamber wall). For the theory to work out, we in fact need to assume the reflection properties of the absorbers are uniform along the whole 20 cm. To cover more areas, one needs to move the antennas much more drastically, as is done in CISPR 16-1-4 (the front, center, left and right locations). ■

MORE INFO

The term free-space implies that there is no electromagnetic interaction between the test environment and the antenna. Use of the time domain to separate spacial effects allows for determination of the environment or the antenna without influences of the other. A recent paper on this topic was presented, and selected as best symposium paper, at the 2007 IEEE International Symposium on EMC. The paper [1], titled “Free Space Antenna Factors through the use of Time-Domain Signal Processing” by Dennis Camell, Robert Johnk, David Novotny and Chriss Grosvenor of the National Institute of Standards and Technology (NIST), describes a process to determine free space antenna factors using the standard site method (SSM) without the accompanying facility effects. Time domain gating routines, usually built into a vector network analyzer (VNA), can be used to remove the reflected signals of the facility thus providing a free-space environment for the antenna. This process provides excellent results above 1 GHz and good results for some cases below. This method allows for improved accuracy in the determination of free-space antenna factors. Finally, this method fits well with current EMC standards methods.

ANSI ASC C63®, a US national standards committee on EMC, has working groups that are leading efforts to include time domain measurement methodology in EMC standards. This includes both the antenna area with the revision of the ANSI C63.5 standard and in site acceptability with a new standard, C63.25. These working groups are always looking for new members to help in this work.

Visit www.c63.org or contact Don Heirman at d.heirman@ieee.org for more information. Better yet, attend the next series of ANSI C63 meetings which will be held in New Brunswick, NJ at IEEE Headquarters the week of April 19, 2010. Contact the Subcommittee 1 Secretary, Janet O’Neil, for meeting information at j.n.oneil@ieee.org.

1. Free-Space Antenna Factors through the Use of Time-Domain Signal Processing, Camell, D., Johnk, R.T., Novotny, D., Grosvenor, C., 2007 IEEE International Symposium on EMC, July 9-13, 2007, pp 1-5.

Michael J. Windler is the General Manager responsible for the operation of the EMC and NEBS laboratories of Underwriters Laboratories Inc. in North America. Mike has a BSEE from the University of Wisconsin - Madison, and an MBA from Northwestern University. Mike is also a licensed Professional Engineer in the states of Wisconsin and Texas. He has been a member of the IEEE for 24 years and is a member of the American National Standards Institute Accredited Standards Committee C63®. In addition, Mike is the immediate past Chair of ANSI ASC C63® Sub-committee 1 on measurement techniques and methods, chairman of the Finance Committee and a member of Sub-committee 6 on laboratory accreditation. Mike is the chairman of working group 1-13.2 on requirements for sites operating above 1 GHz and has been one of the principle researchers in this area. He was also a principle researcher in the development of correction factors for biconical dipole antennas. Mike has published numerous technical articles on EMC measurement issues and given presentations on EMC related issues at the IEEE EMC Symposiums. He may be reached at michael.j.windler@us.ul.com or (847) 664-3409.

Zhong Chen is a senior principal design engineer at ETS-Lindgren. He has more than 15 years of experience in RF testing, and EMC antenna and field probe design and measurements. He is an active member of ANSI ASC C63® committee and its working groups responsible for antenna calibration and test site validation. He is chairman of IEEE 1309 committee for developing calibration standards for field probes. Zhong Chen received his M.S.E.E. degree in electromagnetics from the Ohio State University at Columbus. He may be reached at zhong.chen@ets-lindgren.com or (512) 531-6400.

Photo used with permission of ETS-Lindgren

A fully anechoic chamber features absorber treatment on all four walls, floor and ceiling of the chamber. Time Domain Reflectivity (TDR) measurements not only can provide an accurate assessment of a test site such as this, but can also provide additional information such as where the largest contributors to deviations from an ideal site come from.

The Application of Time Domain Measurements at Northwest EMC

Greg Kiemel, Northwest EMC, Inc.

Several years ago, we decided to purchase a 20 GHz Vector Network Analyzer (VNA) to improve the quality of our calibrations and to perform site validation measurements. Previously, we had been using a 500 MHz VNA to calibrate LISNs, CDNs, and current probes; but we only had a basic understanding of network analysis. We didn't really grasp the benefits of time-domain reflectometry (TDR) that are available in modern VNAs.

It wasn't until we witnessed a TDR demonstration by Mike Windler of UL, that we began to understand the possibilities. Mike performed site validation above 1 GHz using a proposed revision of ANSI C63.4 (circa April 2005) in one of our 10m chambers. The benefits were immediately obvious: the TDR method was much faster than the Site Voltage Standing Wave Ratio (SVSWR) method, it was much less labor intensive, and troubleshooting with the TDR method was far superior. In fact, it appeared to be the only way to identify the source of non-compliance.

Despite the many benefits of using the TDR method for site validation, as an accredited test laboratory we are compelled to also perform site validation measurements using the CISPR 16-1-4 SVSWR method. The SVSWR method is also cited in the latest edition of CISPR 22 and the EuroNorm version (EN55022) will be a requirement in Europe and Japan next year (note at the time of this writing there may be some delay). We decided to conduct a study where both methods were used on a variety of test sites (10m, 5m, and 3m chambers, and a 10m OATS). Our hope was to correlate the results, so we would use the TDR method to not only troubleshoot problems with our test sites, but also confirm their continued compliance.

The study was conclusive in many aspects:

- Both TDR and SVSWR methods correlate extremely well in determining compliance
- Our test facilities which were measured with the SVSWR and the TDR techniques passed the respective site validation requirements. This was considered very useful in accepting the TDR technique as well as the SVSWR technique.
- RF absorber type, the coverage area of the absorber, and the chamber volume are all factors in meeting site validation requirements
- The SVSWR method is more labor intensive and utilizes more of the existing lab equipment
- The TDR method is an excellent tool in identifying the source of non-compliance and is much faster

So in addition to using our VNA to perform equipment calibrations, it is used on an on-going basis to improve the performance of our test sites. The TDR function is terrific in identifying the exact fault location in cables and fixtures. It is also the best tool to measure absorber performance.

We also make the VNA available to our clients as a product development tool. It is extremely well suited to evaluate antenna matching networks as well as antenna performance. As a result, we've been able to grow our business while lowering our cost for calibrations and site verifications.

Greg Kiemel is the Director of Engineering at Northwest EMC, Inc. He has 23 years experience in the EMC field. Mr. Kiemel is a NARTE-certified EMC and ESD engineer, as well as a Senior Member of the IEEE. He is active in the ANSI ASC C63® and TCBC committees. Mr. Kiemel recently completed his tenure as a Distinguished Lecturer for the IEEE EMC Society. Prior to his fifteen years with Northwest EMC, he worked as the lead regulatory engineer in the personal computer division at Epson Portland, Inc. and as an EMC engineer at Tektronix, Inc. He earned his BS in Engineering from Weber State University. Mr. Kiemel may be reached via email at gkiemel@mwemc.com or phone at 888-364-2378.

Moving Forward in ANSI ASC C63® and IEC/CISPR with Time Domain Measurements

Don Heirman, Don HEIRMAN Consultants

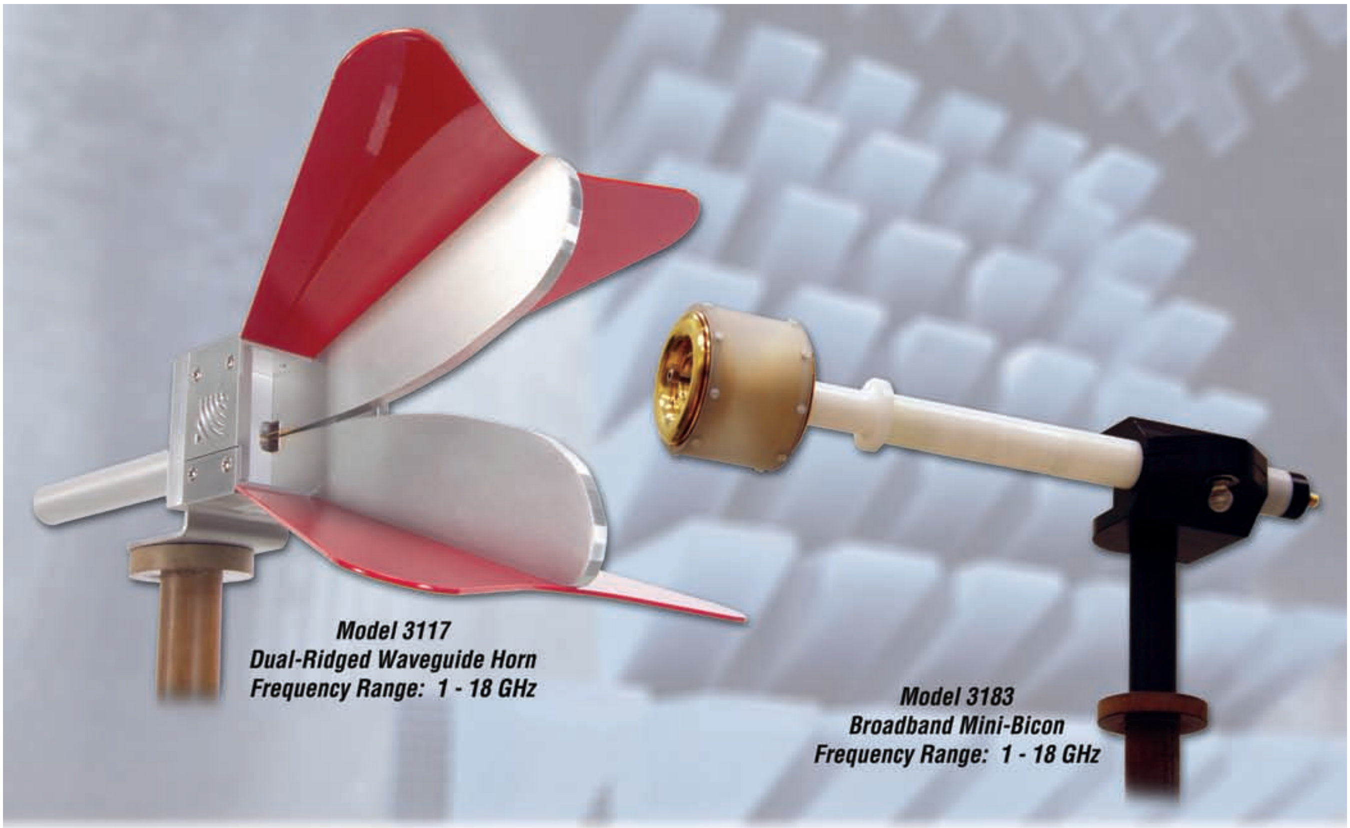
The 2003 and 2009 editions of ANSI C63.4 have recently been recognized by the FCC in a Public Notice issued in November for compliance measurements for product certification. In the 2009 edition, there are two methods for site validation above 1 GHz. One is to have absorber laid down in a particular pattern between the place where the EUT is placed and the measurement antenna location. The absorbers have to have a specific performance identified in the 2009 edition. The second method in making site validation measurements is to use the method in IEC/CISPR in their publication 16-1-4. This is referred to as the site VSWR method (S-VSWR). This is based on a series of measurements at the extremes of the EUT volume occupied on the test site using a specified transmit and receiving antennas aimed at each other and test equipment owned by every test laboratory. This work was based on years of effort that included practical experimentation by several test labs. Presently test site validation is performed using this technique internationally.

In ASC C63®, work has been proceeding in another method that has much promise as indicated in this article. This is part of the work that will lead to the publication C63.25. It has been shown that using this time domain approach will add value in that it not only will determine if a site meets validation requirement but also locate areas in the test site where the site may need to be improved or rid itself of a reflective source to meet the site validation requirement using this technique. To facilitate this test, a vector network analyzer is needed which may not be available to a test lab but can be rented for the purpose. Experimentation with this technique has been ongoing with test labs showing its usefulness. Preliminary results that both the S-VSWR and time domain techniques have given similar site validation results, i.e. sites meet the acceptance criteria for both validation techniques. This is quite helpful as the test lab does not want to perform two validation techniques to show site acceptance. Once there is experience with the time domain technique, it should be considered for introduction into C63.4 or referenced as one of the options for site validation above 1 GHz.

CISPR has been introduced to time domain concept in the past. The work on the S-VSWR received the immediate attention and hence was published. ASC C63® is encouraged to suggest time domain site validation techniques to CISPR as a US contribution. The best time for this is once C63.25 is published; it is always preferable to base inputs to CISPR on published standards that are used by industry. This will show the usefulness and practical application for test labs. Such usefulness is also a goal of CISPR as it provides basic standards covering measurement methods and instrumentation (including test sites). Hence, the users of C63.25 when it is published will be encouraged to bring the matter to the attention of members of the technical advisory committee of the US National Committee of the IEC/CISPR. All inputs to the CISPR must come from a member of the working group for in this case, CISPR Subcommittee A Working Group 1. While this concept has been discussed, it is time again to revisit it with the CISPR working group by tabling a document for consideration at the WG's next meeting in Seattle in October 2010.

This then leads to a call for help in working with the new technique and the drafting of C63.25 as well as introducing it into the CISPR working group noted above. Please contact Don Heirman at d.heirman@att.net if there are questions on your willingness to work this exciting project(s).

Donald Heirman is president of Don HEIRMAN Consultants, training, standards, and educational electromagnetic compatibility (EMC) consultation corporation. Previously he was with Bell Laboratories for over 30 years in many EMC roles including Manager of Lucent Technologies (Bell Labs) Global Product Compliance Laboratory, which he founded, and where he was in charge of the Corporation's major EMC and regulatory test facility and its participation in ANSI accredited standards and international EMC standardization committees. He chairs, or is a principal technical contributor to, US and international EMC standards organizations including ANSI ASC C63® (chairman) and the International Electrotechnical Commission's (IEC) Special International Committee on Radio Interference (CISPR) where in October 2007 he was named the chair of CISPR moving from his previous role as its subcommittee A chairman responsible for CISPR Publication 16 on basic EMC measurement methods, test instrumentation requirements and statistical methods. He is a member of the IEC's Advisory Committee on EMC (ACEC) and the Technical Management Committee of the US National Committee of the IEC. In November 2008 he was presented with the prestigious IEC Lord Kelvin award at the IEC General Meeting in Sao Paulo, Brazil. He is a life Fellow of the IEEE and a life member of the IEEE EMC Society (EMCS) and member of its Board of Directors, chair of its technical committee on EMC measurements, past EMCS president and vice president for standards, and past chair of its standards development committee. He also is past president of the IEEE Standards Association and past member of the IEEE Board of Directors.



Model 3117
Dual-Ridged Waveguide Horn
Frequency Range: 1 - 18 GHz

Model 3183
Broadband Mini-Bicon
Frequency Range: 1 - 18 GHz

CISPR 16-1-4 Chamber Characterization:

The Antennas You Need Are Here!

Smart Choices

The new CISPR 16-1-4 standard requires chambers to be characterized above 1 GHz. ETS-Lindgren has a pair of broadband antennas that make the task easier. Both antennas have an operating frequency range of 1-18 GHz, so you don't have to stop for band breaks.

Detecting signals of interest with our new mini-bicon is also simplified. With maximum power input levels of 50W at 1 GHz to 25W at 18 GHz, it can generate signals with higher amplitudes that won't get confused with noise floor clutter.

Complete Systems

We make a lot of great antennas, but ETS-Lindgren is also the world's largest manufacturer of EMC components and test systems. So if you don't already have one, we can provide a chamber, or a complete turnkey system, or anything in between. (If you do have a chamber, but it's non-CISPR compliant, we can help with that too.)

Information for the antennas featured here is available at www.ets-lindgren.com/3117 and www.ets-lindgren.com/3183.

Enabling Your Success™

ETS·LINDGREN™
An ESCO Technologies Company

www.ets-lindgren.com

Phone +1.512.531.6400 ● info@ets-lindgren.com
Offices in the US, Finland, UK, France, India, Singapore, Japan, China, Taiwan

© 2009 ETS-Lindgren