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Will 4% Steps Find Radiated Susceptibilities?

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The American National Standards Committee on EMC - C63®

Exporting Radio Equipment to Saudi Arabia: A Look at the Law

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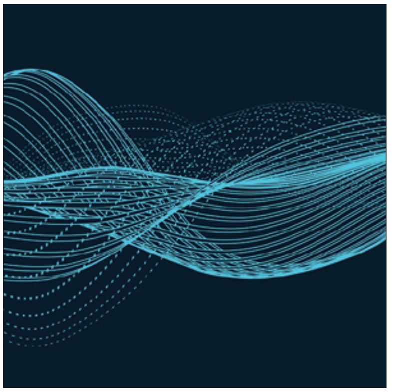


FCC Launches Emergency Broadband Benefit

The U.S. Federal Communications Commission (FCC) has announced the launch of a program to fund consumer discounts on broadband services and equipment.

According to an Order issued by the FCC, the Emergency Broadband Benefit Program will offer consumers discounts of up to $50 per month on their broadband services, as well as a one-time $100 discount on the purchase of a laptop, desktop, or tablet computer from participating providers. The discounts are available until the $3.2 billion in federal funding has been exhausted, or six months after the U.S. Department of Health and Human Services (HHS) has declared an end to the COVID-19 pandemic.

Households can qualify for the discounts available under the Program through their use of existing assistance programs, such as SNAP, Medicaid, or Lifeline, or if a child in the household relies on a reduced-price school meals program. The discounts are also available to low-income households who suffered a large loss of income since February 29, 2020 due to job loss or furlough during the pandemic.

FDA Releases 510(k) Third-Party Performance Metrics

The U.S. Food and Drug Administration (FDA) has published its most recent data on the performance of accredited third parties conducting primary reviews of medical devices under the Agency's 510(k) process.

The FDA's "Third Party Review Organization Performance Report" summarizes the activity of third parties accredited by the FDA's Accredited Persons Program who completed at least five 510(k) submissions in each federal fiscal year between October 1, 2017, and March 31, 2018.

Created under the scope of the FDA Modernization Act of 1997, the FDA's Accredited Persons Program is intended to improve the efficiency and timeliness of medical device 510(k) reviews and help speed market access for medical devices.

During the 30-month evaluation period, the FDA accepted 282 submissions from four different accredited third parties, with 244 (86%) ultimately receiving final decisions from the FDA and with 22 decisions pending by the conclusion of the evaluation period. An additional 16 submissions to the FDA were withdrawn by the device manufacturer for unspecified reasons.

For those submissions receiving a final FDA decision, the average FDA review time for third-party submission was 32 calendar days or less, with an average of just 26 days in FY 2020. Average review times in the lowest 25th percentile of submissions was as low as 22 calendar days, while the maximum review time reached as long as 108 days.

Interestingly, the data suggests that the average review times for FDA decisions regarding third-party submissions may have benefited significantly from the extensive review conducted by third parties prior to their filing a 510(k) submission with the Agency. The average total time for third-party reviews conducted prior to an FDA 510(k) filling during the period ranged from 127 to 154 calendar days, with average review times in the lowest 25th percentile of between 49 and 66 days. However, the maximum total review time was as long as 836 days for submission data collected during FY 2020.

EU Proposes Rules on the Use of AI

The Commission of the European Union (EU) has released a comprehensive proposal for a regulation governing the use of artificial intelligence (AI)

The EU Commission's proposal to provide harmonized rules on the use of AI provides a legal framework that would both serve to promote the use of AI in future technologies while also addressing the risks associated with its use. The proposed regulation, which complements the EU's General Data Protection Regulation (Regulation (EU) 2016/679) and its Law Enforcement Directive (Directive (EU) 2016/680), consists of three "core components," as follows:

- Provide for a technology-neutral definition of AI systems that is future-proof, to the extent that it can cover techniques and approaches that are not known or developed.
- Avoid regulatory overreach by focusing on "high-risk" AI use cases, based on their intended purpose, the severity of potential harm, and the probability of its occurrence.
- Ensure that high-risk AI systems follow a set of specifically designed requirements, including: 1) the use of high-quality datasets; 2) establishing appropriate documentation to enhance traceability; 3) sharing of adequate information with the user; 4) the design and implementation of appropriate human oversight measures, and; 5) achieving the highest standards of robustness, safety, cybersecurity, and accuracy.

The proposal is the product of a multi-year effort by the Commission and other stakeholders to develop regulations and guidelines applicable to current and future uses of AI technology in the EU.

FCC Issues Forfeiture Orders for Unlicensed Equipment

The U.S. Federal Communications Commission (FCC) has levied penalties against two Colorado-based companies for providing unlicensed GPS services and for altering equipment to operate outside of authorized spectrum bands.

The Forfeiture Orders levy fines of $207,290 against IOU Acquisitions and $327,290 against Air-Tel LLC for offering wireless broadband-based GPS services that rely on satellite communications and wireless broadband. The companies were also found to have altered the settings of wireless equipment to operate the equipment outside of the frequency bands for which they were authorized.

The Forfeiture Orders followed an investigation by an FCC field agent at the companies' joint facility in Denver, and the issuance of a Notice of Apparent Liability for Forfeiture in 2018.

FCC Registration Number Required for Amateur Examination Applicants

First-time applicants for the amateur radio examination will soon be required to register with the U.S. Federal Communications Commission before taking the exam.

According to an article posted on the website of the ARRL, the national association for amateur radio, recent changes to the FCC's licensing system will mandate that examination applicants obtain an FCC Registration Number (FRN) in advance of their examination date. Examination applicants are required to provide their FRN on the Form 605 license application submitted to volunteer examiners.

The FCC has reportedly provided an instructional video that provides step-by-step instructions on how applicants can obtain an FRN through the FCC's Commission Registration System (CORES).

The video is available at https://www.fcc.gov/rofrn.

FDA Warns of Potential Effects of Magnets in Cell Phones and Smart Watches

The U.S. Food and Drug Administration (FDA) is advising consumers with embedded pacemakers and other implanted medical devices to take precautions when using consumer electronics with integrated magnets.

In an updated advisory posted to its website, the FDA quotes recent studies that have shown the consumer electronics with high field strength magnets, such as some cell phone and smartwatch models, may cause certain implantable medical devices to accidentally switch into "magnet mode." Magnet mode is a medical device safety feature that is typically activated during certain medical procedures and temporarily suspends normal device operations.

The FDA advises consumers with implantable medical devices to keep all consumer electronics at least six inches away from the implantable device. The agency also recommends that consumers not carry their electronic devices in a pocket over the medical device, and to use their home monitoring system (if available) to check the operational status of their medical device.

The EU's MDR is Now in Effect

The European Union's (EU's) new regulation for medical devices sold or imported into the EU are now fully applicable to all devices.

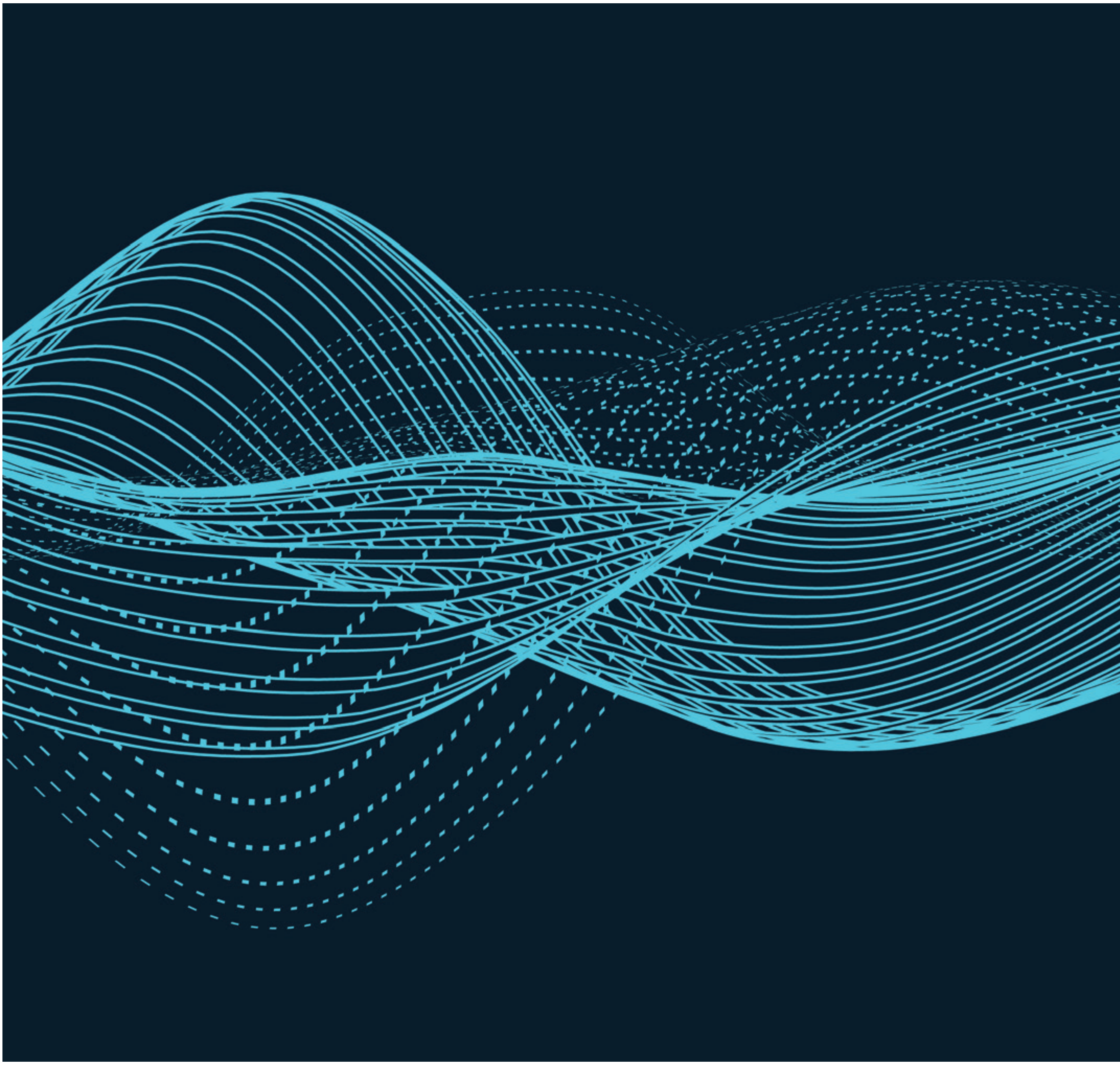
All new and existing medical devices must now conform with the requirements detailed in the EU's Medical Device Regulation (2017/745, also known as the MDR).

Published in the *Official Journal of the European Union* in 2017, the MDR replaces the EU's Medical Device Directive (93/42/EEC) and the Active Implantable Medical Devices Directive (90/385/EEC). The MDR originally provided medical device manufacturers three years to ensure that existing medical devices were compliant with the requirements under the new regulation. The EU Commission extended that period one additional year in April 2020, due to the impact of the COVID-19 pandemic on healthcare institutions, medical device developers, and regulatory authorities.

The MDR's companion regulation on in vitro diagnostic medical devices (2017/746, known as the IVDR) provided in-vitro medical device manufacturers with a five-year transition period and is fully applicable to all in vitro devices as of May 2022.

The full application of the MDR and IVDR represents the culmination of a nearly 10-year process that began in 2012 when the European Commission first published initial proposals for the new regulations.

WILL 4% STEPS FIND RADIATED SUSCEPTIBILITIES?



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By David Arnett and Edward Blankenship

Editor's Note: *The paper on which this article is based was originally presented at the 2020 IEEE International Symposium on Electromagnetic Compatibility & Signal/Power Integrity (EMC, SI & PI), where it received recognition as the Best Symposium Paper. It is reprinted here with the gracious permission of the IEEE. Copyright 2021 IEEE.*

INTRODUCTION

CISPR Publication 24 [1] allows the use of 1% or 4% frequency steps when testing a product for immunity to both radiated RF disturbances and conducted RF disturbances in the frequency range from 150 kHz to 1 GHz. When testing using 4% steps, the disturbance voltage level is doubled. This is a 6 dB increase. CISPR Publication 35 [2] has carried forward the same testing option. CISPR 35 currently includes spot frequency tests above 1 GHz rather than swept frequency tests. However, other standards such as the ETSI EN 301 489-1 [3] implement swept frequency testing above 1 GHz. A swept frequency test from 1 GHz to 6 GHz is under consideration for inclusion in a future edition of CISPR 35.

During a February 2018 meeting of CISPR/I Maintenance Team 8 (MT8), a discussion about the necessity of 4% steps for certain products led to the question of whether it is valid to allow 4% testing at twice the disturbance level. Some of the experts expressed concern that this is a relaxation in the standard since susceptibilities could be missed using the wider step size.

The work described in this paper was carried forward in response to that good question. Much of the material from the section of this paper on "Observed Contours Below 1 GHz" was presented during the October 2018 MT8 meeting. The MT8 experts asked for the data to be made more visible to peers, both as a formal CISPR/I working document and for broad review in a technical forum like an IEEE EMC Society conference or publication. They also asked for further work looking to see whether the patterns observed below 1 GHz also applied above 1 GHz should swept testing be implemented in a future edition of CISPR 35 or other CISPR standards.

This paper presents a portion of what was presented to MT8 on the contours or shapes of radiated susceptibilities between 80 MHz and 1 GHz. This paper also presents new data on the shape of susceptibilities above 1 GHz. While the 4% frequency step option is allowed for both radiated and conducted immunity testing, this paper looks only at radiated immunity using data taken at the HP Vancouver EMC Engineering Lab, where both authors worked at the time.

SUSCEPTIBILITY CONTOURS

In many EMC test labs, a radiated immunity test is performed at the regulatory limit, and it either passes or fails. In the HP Vancouver lab, testing is typically performed at twice the required field strength using 1% frequency steps to demonstrate design margin. The lab's common process when a susceptibility is found is to characterize the range and depth of the weakness.

The regular 1% step process tells us the lower end of the failure range. The operator will select a frequency many steps higher in frequency until he or she finds a frequency where the EUT again would pass at the doubled field strength. Then the disturbance frequency is lowered in 1% steps until the highest susceptible frequency is identified. To gain more data about the susceptibility contour, the same process might be run with the disturbance level lowered to the required field strength. For further insight, at several frequencies within the susceptible range a step attenuator in the

RF signal path would be used to significantly lower the disturbance field strength. Then the field is raised in 1 dB steps to find the susceptible field strength at that frequency. This kind of investigation is repeated at several frequencies within the susceptible range.

The result is a susceptibility contour: a set of data showing the shape of the field strengths at which a product will pass or fail at multiple frequencies. Figure 1 is an example of such a contour. The horizontal axis counts 1% frequency steps making it a logarithmic axis for frequency, while the vertical axis is field strength in linear units. The blue dots represent the field strength data at each frequency step tested within the susceptible range. It is plotted at the highest level where the EUT 'passed' by showing Criterion A performance. The superimposed brown curve and the number 4598 will be explained later in this paper.

Since these anomalies can occur anywhere in the tested frequency range, the left-most data point is not the 80 MHz frequency where the test starts. Rather, it is a frequency step just below the lower edge of the susceptible range. This makes the contour easier to see. Outside the susceptible range, the blue dots will be at 6 V/m, since that is the highest field strength tested. The actual susceptible level may be higher.

This measurement process takes effort. It is a useful way to compare the susceptibilities across multiple test samples to understand manufacturing variability. This data also allows designers to understand more clearly how a proposed remedy is affecting the underlying issue in frequency and depth. It provides a richer view of what is happening in the EUT than merely a binary pass or fail result.

CHARACTERIZING THE CONTOURS

When the question was asked at that MT8 meeting in early 2018, we realized we had a unique library of information on our data drives that could add to the shared understanding of the way real electronic devices are susceptible to RF disturbances. Our answer could have been simple: in all the historic test data we reviewed, every test sample that failed the 3 V/m test also failed the 6 V/m test on at least four consecutive 1% steps. Thus, any EUT that passed the 4% test would also have passed the 1% test. Furthermore, in our data sets are many test samples that would have failed the 4% test but passed the 1% test. This data says the 4% test is not a relaxation. It is a more stringent test.

That would have been the simple conclusion. But we wanted to probe deeper.

The better question is about the shape of these susceptibility contours. Do they tend to be narrowband or broadband? That's the key physics question for whether 4% steps are valid. If we think about this in RF Engineering terms, we consider the underlying resonance of an unintended bandpass filter and ask: Is the susceptibility coupled through structures and circuits with high-Q or low-Q resonances?

Our simple model for that question is to apply a 3-point parabolic fit to the data. We start with the equation

$$v = af^2 + bf + c \qquad (1)$$

where v is the highest disturbance level for a passing result at frequency step f, with **a**, **b,** and **c** being constants derived from the test data. Note that f is treated as a unitless step number, not a direct frequency in Hz units, because we are interested in the shape of a susceptibility with reference to ratio step spacing.

If we pick a set of three radiated immunity data points $\{(F_1\ V_1), (F_2\ V_2), (F_3\ V_3)\}$ we can compute the

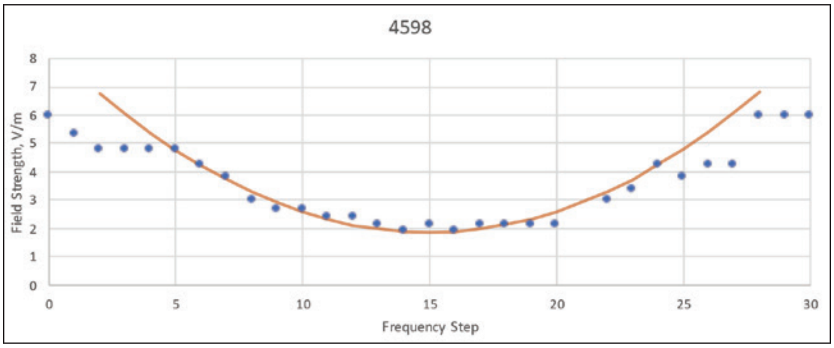
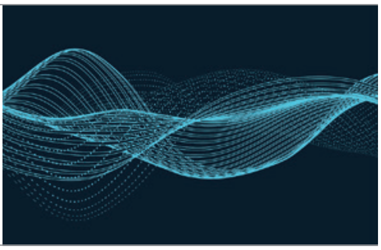


Figure 1: Sample susceptibility contour

The shape of any parabola is determined by the parameters a, b, and c for that parabola. Parameter a sets the width of the parabola, while b and c together shift the parabola up, down, left, and right.



parameters **a**, **b**, and **c** as follows. It is helpful to first calculate an intermediate constant **k**.

$$k = (F_1 - F_3)/(F_2 - F_3) \tag{2}$$

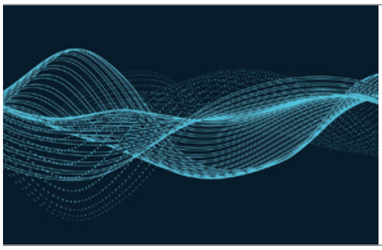
$$a = [V_1 - kV_2 + (k\text{-}1)V_3]/[F_1^{\,2} + (k\text{-}1)F_3^{\,2}] \tag{3}$$

$$b = [V_2 - V_3 - a(F_2^{\,2} - F_3^{\,2})]/(F_2 - F_3) \tag{4}$$

$$c = V_1 - aF_1^{\,2} - bF_1 \tag{5}$$

The brown parabola shown in Figure 1 was calculated by selecting three data points, applying (2) through (5) to calculate the critical parameters of a parabola passing through those points and then plotting the resulting parabola using (1). The same process was applied to each data set reported in this paper.

The shape of any parabola is determined by the parameters **a**, **b**, and **c** for that parabola. Parameter **a** sets the width of the parabola, while **b** and **c** together shift the parabola up, down, left, and right. It is the



If a class of products consistently shows values of a smaller than 0.75, then the 4% step option is valid for those products and is at least as rigorous as the 1% step option.

parameter **a** that will help us understand how narrow or broad is the susceptibility response of an EUT. If **a** is large, then the parabola is narrow. This means that the EUT circuits or structures that participate in the susceptibility are highly resonant, and the 4% step size may miss some susceptibility that the 1% step size would find. If **a** is small, the parabola is wide. This tells us that the EUT is not strongly resonant and the 4% method will work just fine.

Figure 2 shows the theoretical limiting case. In this situation, the susceptibility is just wide enough to touch two adjacent 4% steps at the 6 V/m level, and deep enough to touch the 3 V/m level. Make the parabola any wider, and the 4% case would always catch the susceptibility even when the 3 V/m test does not. Make it any narrower, and the EUT might fail at 3 V/m but pass at 6 V/m. In this Figure, **a** has the value 0.75.

If a class of products consistently shows values of **a** smaller than 0.75, then the 4% step option is valid for those products and is at least as rigorous as the 1% step option.

OBSERVED CONTOURS BELOW 1 GHZ

The data in Table 1 are from a variety of products tested in two randomly selected date ranges: November 2001 to June 2002, and June 2009 through August 2010. We will not indicate whether the samples were early prototypes or near-production units, nor will we identify the EUT other than by the internal project number. The table also indicates the number of frequency steps where anomalies were observed, the approximate center frequency of the susceptible range, and the depth of the susceptibility below the 6 V/m target level.

These EUTs are from a variety of office products including printers and scanners for home and small office use or for commercial use. No product was tested within the receive band of an intentional radio

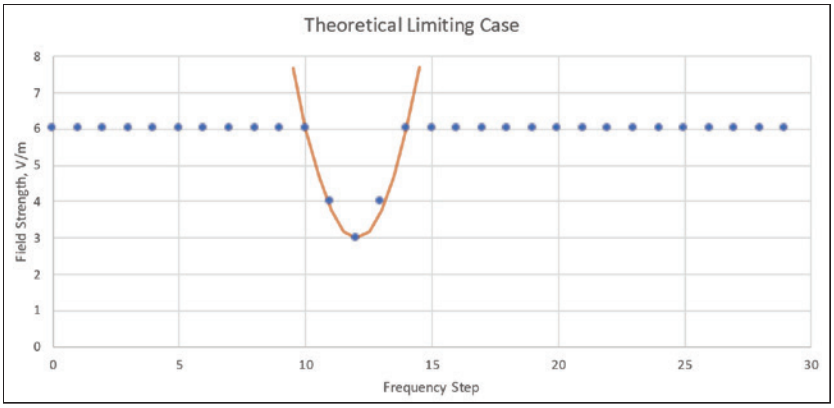


Figure 2: Theoretical limit case for 4% step size validity

Project	a value	Center Freq.	Width	Depth
4598	0.029	152.7 MHz	27 steps	10 dB
5432	0.075	193.4 MHz	23 steps	9 dB
5381	0.040	139.3 MHz	23 steps	12 dB
5498	0.169	82.9 MHz	8 steps	8 dB
5811	0.195	179.2 MHz	5 steps	3 dB
5825	0.033	187.3 MHz	19 steps	8 dB
30004	0.040	271.8 MHz	18 steps	10 dB
30100	0.677	390.3 MHz	17 steps	4 dB
30204	0.060	94.8 MHz	9 steps	2 dB

Table 1: Summary of results below 1 GHz

receiver, since radio receivers are designed to respond to RF signals within their tuned frequency bands. No product model is presented twice, but the most complete contour is shown for each product model tested within those date ranges where a radiated susceptibility was observed. A few susceptibility contours are included as Figures 3 through 5. The internal project number is indicated at the top of each graph and in the caption, for correlation with the Table 1 entries. The brown curve in each Figure is the parabola passing through three data points and its width corresponds to the **a** value shown in Table 1.

In all but one of these cases, the **a** value is much lower than 0.75. The one outlier is project 30100 where the **a** value listed in Table 1 is 0.677, just below 0.75. That test showed a rippling susceptibility curve that doesn't match a parabola well. This **a** value is based on the brown curve in Figure 4 which traces just one of the ripples. An equally valid interpretation of that susceptibility contour is the green parabola in Figure 4, which leads to an **a** value of 0.040. Parabolic curve matching is useful, even if it is not perfect.

ASSEMBLING A BENCHTOP SETUP FOR EXPERIMENTING ABOVE 1 GHZ

The data in Table 1 are from regular product testing. This lab has no history of test projects that failed radiated immunity testing above 1 GHz. To investigate this part of the spectrum, we set up a special test environment to explore the frequency range 1 GHz to 2 GHz at much higher field levels.

We assembled a benchtop system that could be used in place of the full chamber configuration. This was done so that we could experiment in a way that would not tie up the main test facility. Between experiment sessions, the benchtop assembly could be rolled into storage in under 5 minutes. We were aiming our experiments toward small, inexpensive EUTs since products might be damaged or destroyed by disturbances at approximately 20 times the usual field levels. We were hopeful that we could quickly and inexpensively

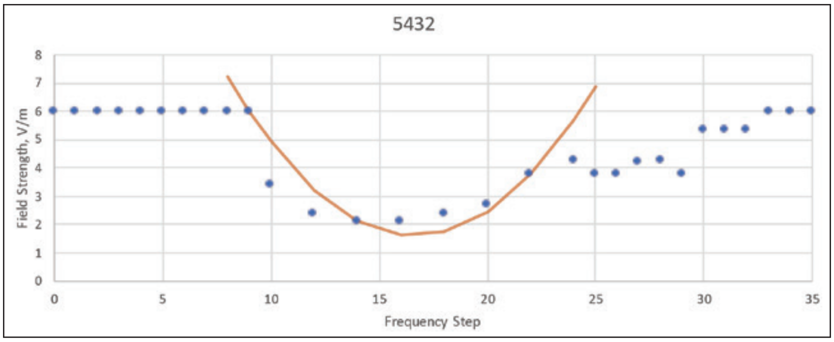


Figure 3: Susceptibility contour and parabolic curve fit from project 5432

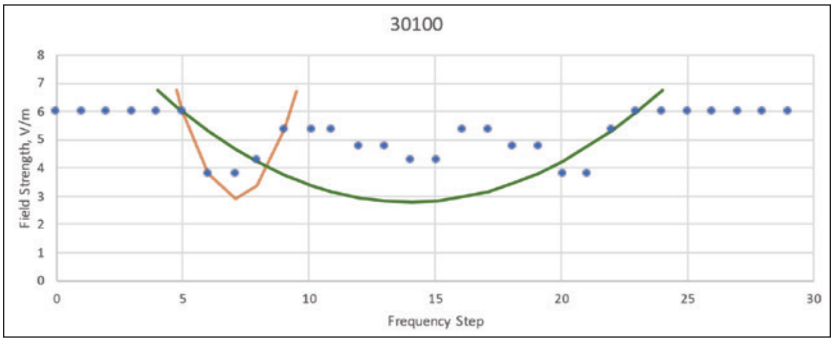


Figure 4: Susceptibility contour and parabolic curve fit from project 30100

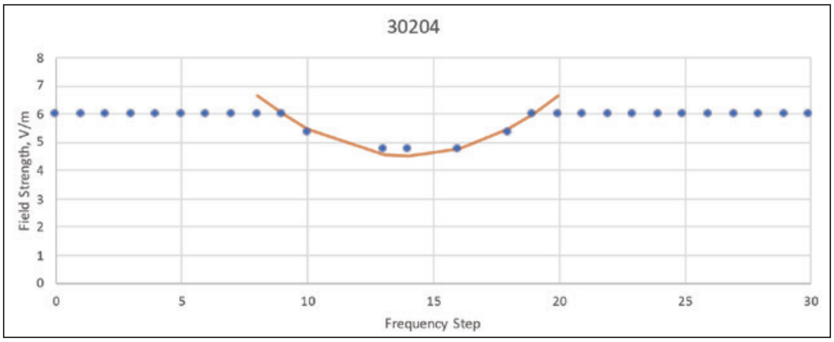


Figure 5: Susceptibility contour and parabolic curve fit from project 30204

identify samples that had anomalies we could study. Our benchtop system includes an HP83623B Swept Signal Generator that allowed precise control of frequency, amplitude, sweep time, and modulation. This allowed us to explore devices quickly and then further investigate using precise, small steps to develop susceptibility contours for the ones that showed non-destructive anomalies. These small steps are much smaller than the 1% or 4% steps discussed so far. The steps used are over-sampling compared to a test performed according to the test standards already mentioned.

Our intent was to find interesting cases, hoping that we could understand the width of the susceptibilities and project or scale our results to the 3 V/m and 6 V/m test modes. This seems easier than having to find real products that are sensitive to fields below 6 V/m. As the data in section VI will show, we saw anomalous details that would have been missed, hidden, or otherwise obscured in standard testing.

Figure 6 shows some of the test hardware used to explore the susceptibility contours of two samples at these higher frequencies. A carrier at a maximum level of -25 dBm was 80% AM-modulated and fed into the amplifier. The amplifier output was sent into a small TEM cell, an FCC-TEM-JM2. The second coaxial port on the cell was loaded with an RF attenuator, and the attenuated signal was sent to a spectrum analyzer for additional monitoring. This allowed us to drive the test fields well above the CISPR 24 or CISR 35 disturbance levels and find some anomalous behaviors. The testing was performed manually, with the frequency stepped in 1 MHz increments, not 1% increments. However, analysis to find **a** was done based on the fractional 1%-step value calculated for each test frequency.

The IEC 61000-4-3 [4] test method describes the field strength based on the carrier level before modulation is added. Our estimate was that a -25 dBm unmodulated carrier from the signal generator produced an unmodulated field within the TEM around 117 V/m. With the effect of modulation added, we estimate that the same drive strength yields a peak field strength above 200 V/m. Those are the levels of disturbance field we used in hopes of finding susceptibilities to study in this frequency range.

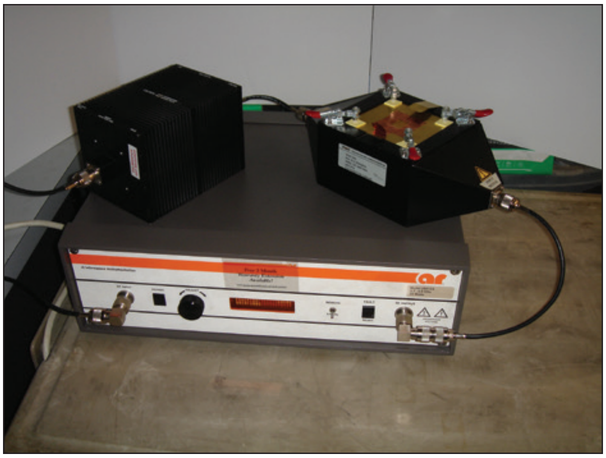


Figure 6: Test equipment used for evaluations above 1 GHz

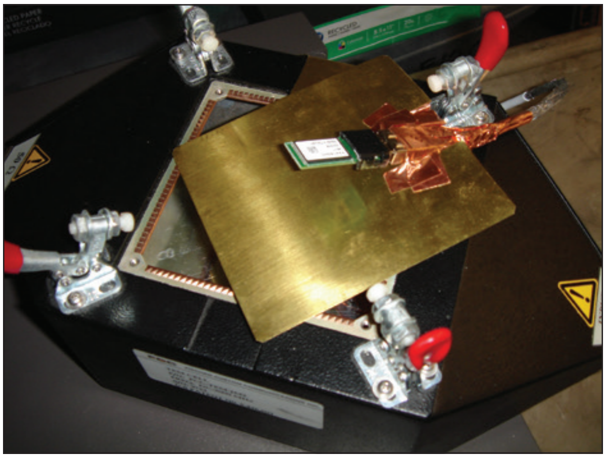


Figure 7: USB memory drive inserted through the metal plate

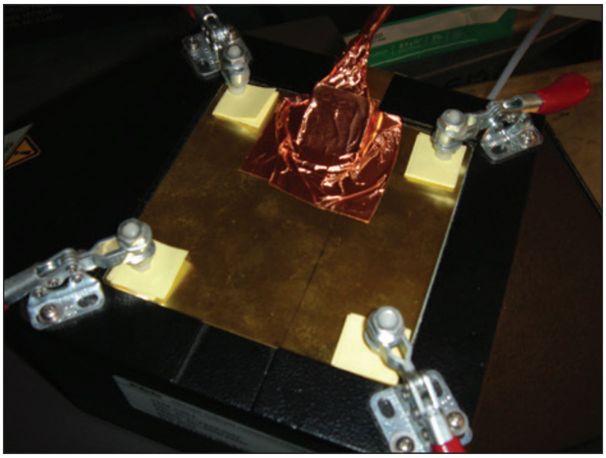


Figure 8: TEM cell closed with the USB cable merging

The TEM we have is designed for testing integrated circuits. The top surface is a square metal plate that can be removed to place a sample inside. The plate can also be replaced with a custom fixture that accommodates the test sample. The device is 34 cm long, and its manufacturer states it can accept an EUT up to 6 cm x 6 cm x 1 cm.

We used two samples in this study. The first was a 16 GByte USB memory drive shown in Figure 7. Part of the plastic housing was removed. In this case, we used a top plate with a hole through which we ran the USB cable. The cable shield was bonded to the metal plate with foil tape which also sealed the TEM. The plate was then inverted as shown in Figure 8, so that the drive was inside the sealed TEM and only the USB cable emerged. The cable was connected to a computer. The drive was exercised with repeated read-write-verify cycles.

The second sample was a small mobile flip phone as pictured in Figure 9. It was small enough to fit entirely within the TEM with no attached cables. It was exercised by repeatedly playing music files stored in internal memory. We listened for the music to stop playing in response to the disturbance field.

This test method does not give us calibrated field values, and it isn't a standard test environment. These test samples may be large enough to distort the fields in this small TEM. Our goal was to excite a susceptibility then to measure the shape of the contour across a range of frequencies to see the degree of resonance involved. That only required relative measurements, which are still feasible in a nonstandard uncalibrated overloaded fixture. Relative measurements only require that the test system be linear with applied power and across a narrow range of frequencies. We believe this benchtop system remained linear over the frequency and amplitude ranges used.

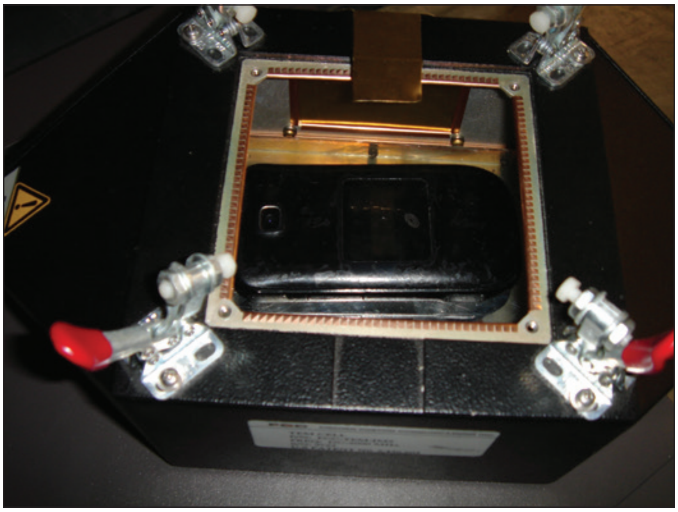


Figure 9: Flip phone placed in the TEM cell

OBSERVED CONTOURS ABOVE 1 GHZ

This experiment found one set of anomalies for each test sample. The susceptibility contours are shown in Figures 10 and 11. The data is characterized in Table 2. No test samples were damaged by the strong field levels used in these experiments.

In Figures 10 and 11, the frequency axis is a linear axis with data points separated by 1 MHz. The USB memory drive had a contour that is reasonably modeled with a parabola. The mobile phone demonstrated a very erratic contour that does not seem to match any simple function. It showed anomalies with applied fields in the vicinity of 20 to 60 V/m. Both of the **a** values observed are well above the reference of 0.75, indicating that a 4% step size for these test items in this frequency range could miss an anomaly.

To calculate the parabolas in Figures 10 and 11 and the data in Table 2 consistent with the earlier sections, the amplitude data had to be translated to a 6-unit linear scale, and the frequency data converted to 1% step values.

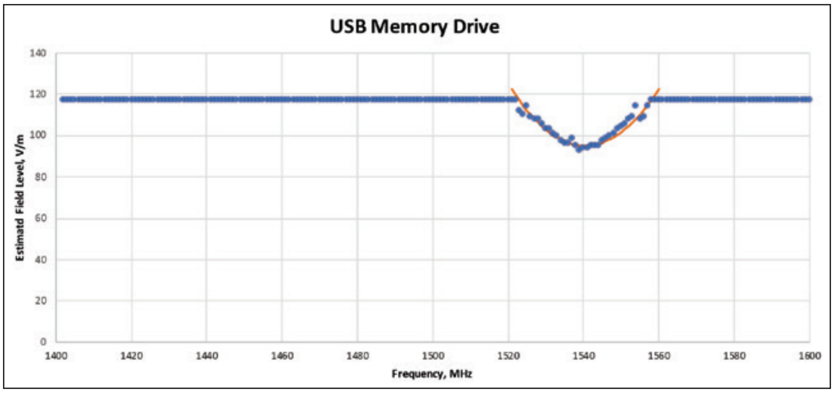


Figure 10: USB drive susceptibility contour and parabolic curve fit

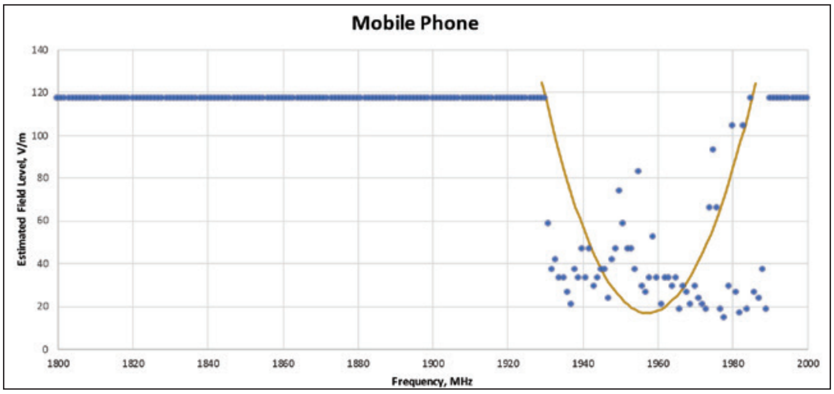


Figure 11: Mobile phone susceptibility contour and parabolic curve fit

Sample	a value	Center Freq.	Width	Depth
USB drive	0.87	1541 MHz	2.22 steps	2 dB
Phone	2.57	1958 MHz	3.03 steps	18 dB

Table 2: Summary of results above 1 GHz

The frequency was converted to step values assuming the starting test frequency is 1000 MHz. During 1% steps the frequency increases by repeated factors of 1.01. A linear frequency G, in MHz, is converted to a numeric step value, F, using (6).

$$F = (\log_{10}G - \log_{10}1000)/\log_{10}1.01 \quad (6)$$

The signal amplitudes H, originally in dBm, were converted to linear voltage values, V, using (7).

$$V = 10^{(H + 40.56)/20} \quad (7)$$

A factor of 40.56 dB in (7) controls the scaling. With this conversion factor, -25 dBm maps to 6 linear voltage units and -31 dBm maps to 3 linear voltage units. A similar equation with a different scaling factor leads to the estimated actual field strength of 117 V/m.

DISCUSSION OF RESULTS

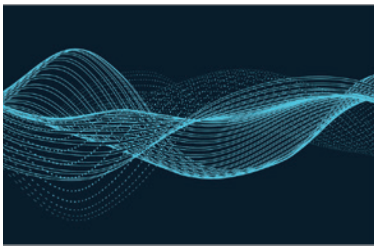
The data in the lower frequency range supports the full validity of 4% step testing at twice the disturbance level. The second data set in the higher frequency range does not.

We should acknowledge some of the weaknesses of our data. This data set is somewhat limited by the kinds of anomalies that have been observed in our lab. We have not seen radiated immunity failures centered at frequencies above 400 MHz. We have simulated some anomalies above 1 GHz, but these are at field levels well above the standard test levels for these multimedia devices. At these disturbance levels, different effects could be at play from what is excited by fields at the typical CISPR 35 test level of 3 V/m.

This data leaves us unable to state anything reliable about what a typical susceptibility contour would look like in the range from 400 MHz to 1 GHz.

We add, for discussion, Figures 12 and 13 on page 20 to simulate 1% step test results. These two plots are drawn from the same basic data shown in Figures 10 and 11 with the following modifications. First, the vertical axis data is scaled for presentation against a 6-voltage-unit maximum test level implying a 'limit' of 3 voltage units. Second, the horizontal scale is now step numbers. This axis counts 1% steps starting at 1 GHz, which is numbered step zero when using (6). Finally, all the data points that lie between the 1% step frequencies were omitted. Since each parabola was calculated based on the full data set, it may no longer pass through three visible data points.

A few observations come from this revised analysis of the data. The first is that the mobile phone has a lot of fine detail in its susceptibility curve that is lost in even a 1% step test. Compare Figure 11 to Figure 13. Selecting only the 1% step data, we see some odd and erratic steps, very much like we saw in some of the data below 1 GHz reported in section IV. This causes us to wonder what fine detail might have been available from the test samples shown in Figures 3 and 4 had those tests used a smaller step size.



It would be rash to suppose that all susceptibilities have the same kinds of underlying failure mechanisms, so we do not suggest that the parabola comes from a physics-based model.

Second, we realize that statistics are fickle on small sample sizes. Most radiated immunity tests are done with a sample size of one. The memory drive and mobile phone had narrow susceptibilities, with **a** values greater than 0.75. We have shown that a 4% step test *might* have missed a susceptibility that appears over such a narrow frequency range. That does not necessarily mean the 4% step test is a relaxed standard or that a narrowband weakness *will* be missed. The memory drive would have failed the 6-unit 4% test at the twelfth frequency (step 44) but passed the 3-unit 1% test with no anomalies. The phone would have failed the 3-unit 1% test at three frequencies, steps 67, 68, and 69. As luck would have it, the 4% test would have found the susceptibility at step 68. For these two samples, the 4% frequency step test at twice the test level would have detected more EUT weaknesses than the 1% step test. Yet with a slight frequency shift, there is a fair chance that the deep mobile phone weakness could have been entirely missed using the 4% step method.

Finally, we will note that the parabolic fit was not selected due to any specific analysis of why radiofrequency immunity failures occur. It would be rash to suppose that all susceptibilities have the same kinds of underlying failure mechanisms, so we do not suggest that the parabola comes from a physics-based model. The parabola is simply a gauge we selected because it is based on easily solvable math, and it seems to match some of the data well enough to provide a useful way to think about these disparate data sets. We shouldn't assume that the selection of 1% frequency steps was based on some prior rigorous analysis of RF test failure mechanisms, either. Engineering is often an intersection of math, physics, and practicality.

AREAS FOR FURTHER STUDY

There seems to be little public information about the typical susceptibility profiles for electronic equipment. This kind of data may be held privately and kept confidential for fear that it might be misunderstood as a product or brand weakness. If others have examined

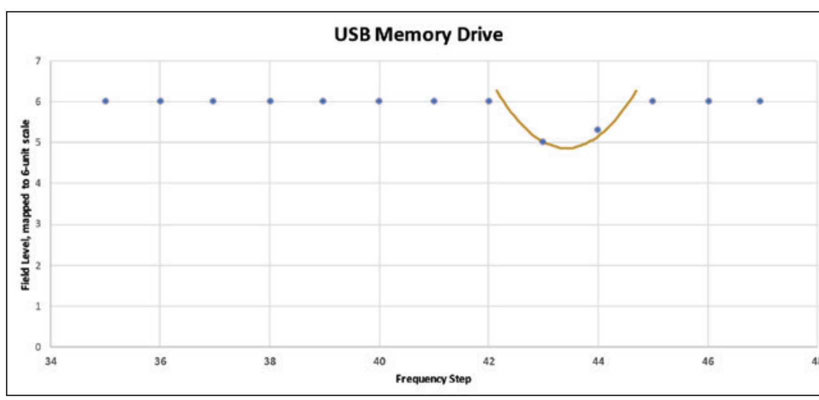


Figure 12: USB drive susceptibility data scaled and reduced to 1% steps

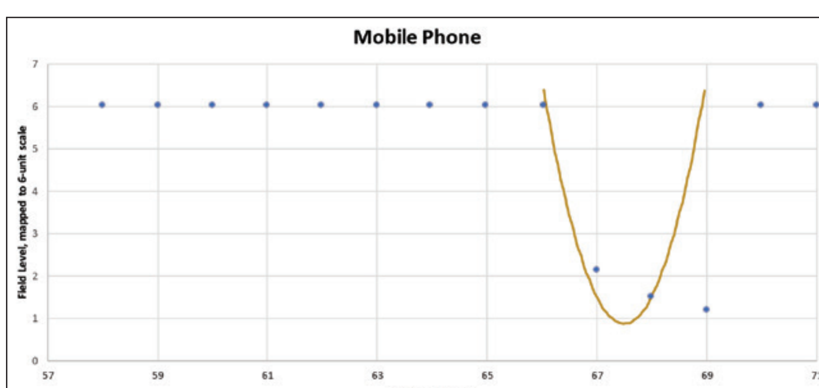
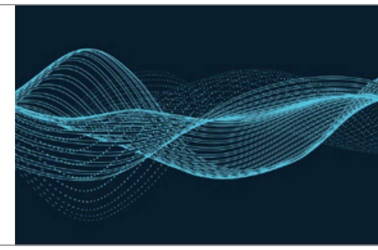


Figure 13: Mobile phone susceptibility data scales and reduced to 1% steps

CISPR 24 and CISPR 35 allow two methods of swept frequency immunity testing: 1% frequency steps at the specified disturbance level, and 4% steps at twice that disturbance level.



the width and depth of product susceptibilities, we encourage publication of those data so that the standards development organizations can optimize the test processes to match actual types of issues and threats faced by electronic products.

The authors of this paper particularly welcome further data covering additional product families and additional frequency bands. We hope that colleagues who see immunity issues at these higher frequencies and at standard test levels will spend the additional few hours required to measure the breadth and depth of the issues. While one sample might not make a good conference paper, we would be happy to help several individuals with one sample each combine their efforts into a joint paper.

This paper has focused on radiated immunity testing, and the same questions exist regarding conducted susceptibility from 150 kHz to 80 MHz. We are unable to report on the shape of conducted immunity profiles because we have rarely seen issues in that test. We simply do not have contour data sets from that frequency range. If other labs see conducted susceptibilities, we hope they will explore and report on the contours of those susceptibilities using methods like those we have described.

Absent data that characterizes swept immunity issues, we are all left to theorize about how well the 4% step processes – or even a 1% step process – will find typical product weaknesses.

If the absence of good data at higher frequencies is because products rarely have susceptibilities at higher frequencies, that would also be important to know. A lot of time and money is spent each year doing radiated immunity testing from 1 to 6 GHz. If there are no anomalies being found, then our profession may wish to reconsider the practical value of that testing on products that are not safety-critical or mission-critical.

This data suggests a general pattern that 4% steps are fine below 400 MHz but perhaps not above 1 GHz. We welcome researchers to share data on anomalies in the intervening range to help our profession understand where between 400 MHz and 1 GHz that changes, and perhaps help explain why.

CONCLUSION

CISPR 24 and CISPR 35 allow two methods of swept frequency immunity testing: 1% frequency steps at the specified disturbance level, and 4% steps at twice that disturbance level. The data presented here suggests that testing with the 4% step method will reliably find radiated susceptibilities in multimedia equipment at frequencies below 400 MHz but may not always find those that exist above 1 GHz. The authors can draw no conclusions regarding the effectiveness of the 4% step method in the frequency range from 400 MHz to 1 GHz due to a lack of product issues observed in this frequency range.

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EMC Antenna Calibration: Importance of Specifying What You Actually Need

EMC antenna calibration is often over-specified resulting in customers paying more, and waiting longer, for a calibration service than actually needed. Doug Kramer explains how to maximize your EMC calibration experience, now and in the future.

Why are EMC antenna calibration services over-specified?

Often we are asked to provide a calibration in vague terms, such as “per CISPR 16” or “the same as last time”. This results in customers over-specifying calibration services rather than purchasing what they actually need. EMC testing provides a wide variety of different requirements and test methods. Calibration is the process used to provide the traceability of the measurement to the International System of Units (SI). Depending on the product testing method and standards writing body, the three most commonly referenced documents for antenna calibration are CISPR 16-1-6, ANSI C63.5, and SAE ARP 958. Many customers only require a portion of the services that can be offered per these standards. It’s important when requesting a calibration service to understand how to specify these services as needed.

What do you recommend people do BEFORE they request an EMC antenna calibration service?

They should understand that different applications result in different calibration methods. For example, military (MIL-STD), automotive, and aerospace applications currently tend to reference the SAE standard. For industrial consumer products, such as radio devices, ISM, ITE, and/or multi-media equipment, these applications reference the CISPR and ANSI C63 standards. Keep in mind that the ANSI C63 and CISPR standards also specify the Standard Site Method (SSM) which requires an acceptable calibration site. We are happy to educate our customers so they can confidently specify the calibration method for their measurement application to ensure they get the calibration service they actually need. Additionally, they should consider tracking the three most common standards noted above as these documents are continually updated and revised.

How does a well-specified request for calibration services benefit industry?

Knowing exactly what the customer needs for their calibration service allows calibration labs to provide for a competitive quote and allocation of the appropriate resources necessary to perform a quality calibration. This expedites the calibration service time so the antenna is returned to the customer quicker. Less down-time benefits commercial labs who charge for test lab time; for design engineers, less down-time means more time for product R&D. A detailed calibration service request also avoids potential “surprises” when the antenna is received at the lab or returned to the customer, which can result in further delays. We recommend spending a little more time upfront on your calibration service specification. As a result, you’ll have less down-time and save money. This efficiency benefits industry in the long run.

To learn more about EMC antenna calibration, view the webinar by ANSI C63.5 and CISPR 16-1-6 experts at http://www.ets-lindgren.com/services/education-training.

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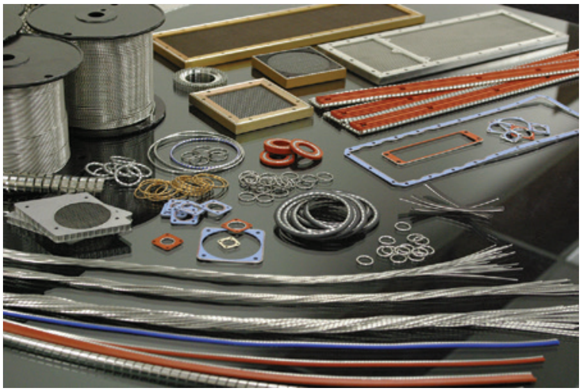

Spira Manufacturing Corporation is at the forefront of EMI gasket innovation, design, and customer service. With over 40 years as experts in the field and using our uniquely patented spiral EMI gasket, we offer customers a range of EMI gaskets, shielded honeycomb filters, and other products.

Spira's patented EMI and environmental shielding gaskets offer excellent solutions for both cost-sensitive and high-performance applications. The company was founded over 40 years ago by one of the leading EMI design engineers in the industry, who recognized a need that wasn't being fulfilled. The spiral EMI gasket was created and patented, along with a host of other EMI shielding products. The unique spiral design offers extremely low compression set, long life and high shielding. Spira's products are of the highest quality and reliability, built to meet your requirements for the life of a system. Spira also manufactures EMI gaskets designed for cost-sensitive commercial applications.

Spira's commitment to quality is demonstrated through our ISO-9001 and AS9100 certifications. Our products also meet requirements including REACH, ITAR, RoHS, DFAR, FCC, EC, HIRF, TEMPEST and others. Spira specializes in meeting customers' unique shielding needs. All products are available in custom configurations.

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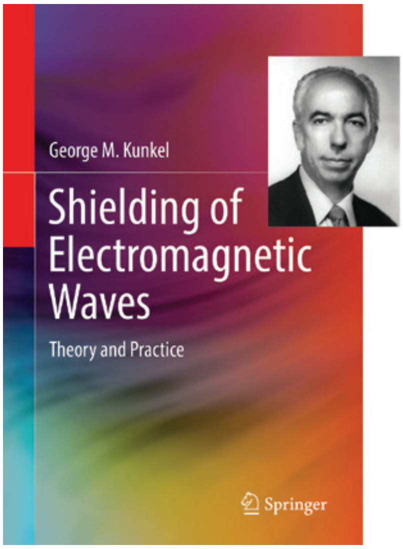
- Emphasizes the use of transfer impedance to explain the penetration of an electromagnetic wave through an EMI gasketed seam
- The definition of an electromagnetic wave and how it is generated is included
- Chapters in the book are included that reinforce the presented theory



Components:

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Shielding Materials

EMI / RFI Shielding Materials

Shielded Air Filters

Shielded Connectors

Shielding Gaskets

SPIRA

TROUBLESHOOTING EMC PROBLEMS LIKE AN MD

First-Hand Lessons From Three Medical Professionals

Daryl Gerke, PE, has been a successful consulting engineer for 40 years. Co-founder of Kimmel Gerke Associates, Daryl specializes in EMI/EMC design, troubleshooting, and training. He has co-authored three books and over 200 articles on EMI/EMC and has trained over 12,000 students on EMI/EMC design and troubleshooting through his seminars. Daryl can be reached at dgerke@emiguru.com.

By Daryl Gerke, PE

Ever ponder how a physician troubleshoots medical issues in their patients? Neither did I until a consulting client pointed out I was following a medical methodology known as "differential diagnosis."

Intrigued by the comment, which led me to further investigate how doctors work to fix patients, just like we work to fix EMC problems.

But first, a little background…

Early in my EMC consulting career, a client asked me to explain each step as we worked to improve ESD immunity on an existing product. In addition to solving the problem, he wanted to better understand my thinking process. Fair enough, I thought.

At one point, I laid out a "fault tree" of possibilities, along with prescribing a short course of action. As it was getting complicated, I apologized for any confusion. The conversation went something like this:

"Not a problem," my client said, "you are doing differential diagnosis."

"Stop," I said. "What did you just say? And where did you hear that?" Joking, I added, "I'm a consultant — we make our living with buzz words like that."

Laughing, he responded, "It is a medical term. My brother-in-law is a physician, and we often discuss troubleshooting methods."

This began my fascination with how doctors troubleshoot problems. In this article, I'll share three concepts — differential diagnosis (DD), gross & microscopic diagnosis, and the ninety percent rule. All were the results of conversations with medical doctors over the years, in reverse chronological order.

DIFFERENTIAL DIAGNOSIS

A few weeks after my initial introduction to this concept, I struck up a conversion with a seatmate on a cross-country flight. Upon learning he was a doctor with the Mayo Clinic, I asked about DD and was treated to a most interesting lecture. After all, he was a teaching doctor and I was a very willing student. Those of us who teach love these situations.

He began by explaining the father of DD was Arthur Conan Doyle (the creator of Sherlock Holmes). Doyle was an MD who also wrote short stories. He had an idea for a detective based on a favorite medical professor who taught clinical diagnosis. As we all know, the rest is history. It also explains the presence of Holmes's medical sidekick, Dr. Watson.

The objective is "rule things in/rule things out" by creating two lists - high probability and low probability. The goal is to quickly narrow down a large list of potential causes to a smaller list, maybe even one likely root cause.

For example, if a patient presents with a red rash, there may be a hundred or more possibilities. Maybe it is the measles, or maybe it is bubonic plague. The first step is looking at vitals (temperature, blood pressure, etc.), which helps quickly eliminate possibilities.

The next step is the physical examination, along with detailed questions. Sometimes an immediate diagnosis can be made — other times additional tests may be necessary.

At that point, the prescription can follow — but not before. As the Mayo doctor on my flight emphasized to me, "prescription without diagnosis is malpractice." As an aside, how many of us have performed EMI tests or thrown solutions at the problem without thinking it through? Think like a doctor instead.

Years ago, I learned a simple framework for attacking problems with the acronym ACT (aware, critique, try.) The last step in the framework is very important to avoid "paralysis by analysis."

If there are multiple possibilities, address the likely simple ones first (Occam's razor.) The doctor shared another medical saying: "If you hear the sound of hoofbeats, don't assume zebras." It is probably a horse (unless you are in Africa). As technical people, we all like to sink our teeth into a juicy problem, but most problems are simple.

On rare occasions, however, it well may be a zebra. He pointed out the Mayo Clinic often deals with "zebras." There may be 100 possibilities, of which 99 have been ruled out by previous doctors, making it simple to identify the zebra. This is why it is important to ask what has already been done to address the problem.

For many non-EMI engineers, all EMI problems seem like zebras, rarely seen but still common for those of us in the EMI trenches.

So what steps should we follow? Years ago, I learned a simple framework for attacking problems with the acronym ACT (aware, critique, try.) The last step in the framework is very important to avoid "paralysis by analysis" — eventually one must try something, but best to have a logical approach. Or at least a plausible hypothesis.

Aware—First, gather information. Begin with four key questions:

1. What are the symptoms? (Equipment issues.) Focus "inside the equipment." Think like a doctor, and ask where does it hurt? When did you first notice the pain? What else is wrong?
2. What are the likely causes? (Environmental issues.) Focus "outside the equipment." Three likely suspects for upsets/failures are ESD (electrostatic discharge,) RFI (radio frequency interference), and power disturbances.
3. What are the constraints? (Systems issues.) Focus on the "cost of failure" not the "cost of components." Once you find a solution, you can then optimize for cost. Determine constraints like no mods to circuit boards, etc. And watch out for "wishful thinking."
4. How will you know when it is fixed? (Success issues.) Establish a goal and a method to validate it. For chronic problems, this might include no field failures for six months, etc. But do have a measurable objective.

Critique—Next, sort and prioritize the information

This is where you apply differential diagnosis. The goals are to rule out the least likely scenarios and determine the most likely. It is all about probabilities and priorities. Don't discard the low probabilities - you may need them later. Remember the "zebras" — occasionally you will find one. But don't chase them first, no matter how interesting.

Try—The last step

Start with the highest probability, as that has the best chance of success. If that does not work, move on to the next item on your list. Remember, "if at first you don't succeed, try again…" Solving EMI problems is often a process of elimination.

However, if something is very simple, go ahead and try that first. I learned this the hard way chasing a problem for several days, only to discover moving a simple ground connection solved it. A bit embarrassing but my client was still happy to have the problem solved.

A bonus to the above. Assuming a one percent probability of success, that still means that one time in a hundred you will succeed. When that happens, everyone will think you are a genius. So be sure to pick the low-hanging fruit first.

Two caveats as you try. First, start with an open mind — don't fight last year's battle. Second, don't be too "scientific" and try only one thing at a time. Rather, stack the fixes up.

Two caveats as you try. First, start with an open mind — don't fight last year's battle. Second, don't be too "scientific" and try only one thing at a time. Rather, stack the fixes up. EMI problems are often like a leaky boat — if you have multiple holes in the boat and only patch one at a time, you will never succeed.

Finally, don't be afraid to change directions. I've solved more than one problem by just starting over, asking "what if up was down." These are often the most interesting problems when solved, as one is left musing "who would have thought…" And those cases make for great EMI war stories to share later.

GROSS AND MICROSCOPIC DIAGNOSIS

I learned this troubleshooting technique from a pathologist years prior to EMC consulting. Moonlighting at the time, I was engaged to help automate a hospital pathology lab. It was one of the more interesting consulting projects in my career. Not for the squeamish, though — my pathologist had buckets of preserved human hearts on a bookshelf. And we think EMC engineers are weird?

Most of us assume pathologists spend their time in ghoulish activities like autopsies, but they also serve as quality controls on hospital procedures like surgery. For example, if a surgeon removes an appendix (or anything else), the tissue is not just thrown away. Rather, it is sent to the pathology lab for a two-step procedure. Even a small hospital may run several thousand samples per month. Thus, the need to automate the process.

The first step is the gross diagnosis, that is, a quick visual inspection. "Yes," the pathologist says, "this looks like a diseased appendix." But then it is tagged and may be preserved and sliced and diced for further investigation.

The second step is the microscopic diagnosis, occurring sometime later. Typically examined under a microscope, this may be done by the same pathologist or another — it doesn't matter. If the microscopic diagnosis does not match the gross diagnosis, no harm/no foul. It just means we now have more detailed information.

I find this useful when dealing with EMI problems, particularly when people are in a panic and want a quick answer. I'm often able to give the gross diagnosis, but I remind them that this may change upon additional information or test data.

Explaining this helps manage expectations, and also gives me permission to change my own mind. No, it is not flip/flopping — it just means we now have a better handle of the problem. If pressed, I often share the pathologist story to explain my change in EMI diagnosis.

THE NINETY PERCENT RULE

I learned this troubleshooting technique as a young EMC engineer. We drank a lot of coffee in the EMC lab (too much really) and I ended up with an occasional irregular heartbeat. In my mid-20s, this was a bit scary and sent me to my doctor.

After a few quick questions, including my coffee consumption, I was advised to cut back on the caffeine. Pretty simple, right? Except it did not resolve the problem. So back to the doctor I went.

He next prescribed some kind of pill, and it worked and after a few months was no longer needed. But being the curious engineer, I asked why the initial diagnosis did not work, and also what the next step was if the pill did not work.

My doctor knew I was an engineer, so he asked with a grin, “Does everything you do work the first time?” Well, no.

He then shared his “Ninety Percent” rule. First, go with the diagnosis/treatment that works 90% of the time. If that fails, go with the next 9%, and so on. Or as we say in the engineering world, first try Plan A, then Plan B, etc. Always good to have those alternate plans in reserve.

So Plan B worked for me, but I asked about Plan C? My doctor replied, “Well we could get out the scalpel.” At that time, I decided Plan C was not in my future.

FINAL THOUGHTS

One more medical story that goes back almost a century. A great uncle of mine was a doctor from around 1900 to 1950. I barely remember him, but his wife (also his nurse) once showed me the little black bag he used on house calls.

An engineering student at the time, I was intrigued with the simple tools of his trade — a stethoscope, a simple surgical kit, and some pretty basic drugs. Yet he was able to troubleshoot medical problems with these tools, along with using the gray matter between his ears. As EMC engineers we can do the same.

I hope these anecdotes and examples help clarify your thinking on troubleshooting, as they have for me. Troubleshoot like a doctor indeed!

THE AMERICAN NATIONAL STANDARDS COMMITTEE ON EMC - C63®

An Update on Recent Standards Development Activities

Daniel D. Hoolihan is the founder and principal of Hoolihan EMC Consulting. He serves as chair of the C63-Committee on EMC. He is also a past-president of the IEEE's EMC Society and the current Chair of the History Committee of the Society's Board of Directors. Hoolihan is also an assessor for the NIST NVLAP EMC and Telecom Laboratory Accreditation program. He can be reached at danhoolihanemc@aol.com.

By Daniel D. Hoolihan

During the COVID-19 pandemic, the C63 Committee, which has always been closely associated with the American National Standards Institute (ANSI), has continued to meet by using modern video-conferencing capabilities. The last face-to-face meeting of the full C63 Committee was in November of 2019 in Santa Rosa, California when eight Subcommittees, the C63 Steering Committee, and the C63 Main Committee all met in a series of week-long meetings. Since then, there have been four meetings of the C63 Steering Committee and each of our eight Subcommittees have met approximately every quarter. Each of the Committee's Working Groups (WG) is responsible for one C63 standard, and the WGs have continued to meet remotely on an as-needed basis to continue work on their respective standards.

This article outlines the activities of the C63 Committee in 2020 and 2021. It describes the EMC standards that have been approved recently as American National Standards and outlines the EMC standards that are actively being worked on as American National Standards.

DETAILS

The November 2019 meeting of the Main Committee was held at the Keysight Technologies campus in Santa Rosa. The week-long meeting was well-attended and the meeting facilities were excellent. Progress was reported by the Chairs of each Subcommittee and each WG on a number of C63 standards.

Anticipating a "normal" year for 2020, the C63 Committee and its Subcommittees (as well as some of its WGs) were scheduled to meet for a week in early May 2020. The rise of the COVID-19 threat in the first quarter of 2020 soon destroyed the 2020 face-to-face meeting plan and the backup plan became having the Subcommittees meet remotely during the second quarter of 2020. This was successfully executed, and progress continued on developing new C63 standards and revising current C63 standards. Of course, it helped that the WGs doing the development work on the standards continued to meet as they often had, that is, remotely via teleconferencing capabilities.

The C63 Steering Committee took over a majority of the Main Committee's administrative activities by meeting quarterly via teleconferencing and then submitting Motions to members of the Main Committee for any important issues requiring the majority approval of the forty-plus members of the Main Committee. This included the approval of several standards and the annual approval of the Scope, Duties (the standards they are responsible for), and Membership of each Subcommittee.

The scenario of meetings performed by the Subcommittees in the second quarter of 2020 was re-used for the third and fourth quarters of 2020 as well as the first quarter of 2021. It is also planned to use the Subcommittee quarterly-meeting approach for the second and third quarters of 2021.

It is anticipated that the Main Committee, the Steering Committee, and the eight Subcommittees of C63 will meet face-to-face this coming November at the IEEE Operations Center in Piscataway, New Jersey. This plan assumes progress continues on suppressing the COVID-19 virus and the opening of the IEEE Operations Center.

MAIN COMMITTEE MEMBERS

The present C63 roster consists of the following Organizational Members:

- American Association of Laboratory Accreditation (A2LA)
- American Council of Independent Laboratories (ACIL)

- American Radio Relay League (ARRL)
- ANSI-National Accreditation Board (ANAB)
- Apple, Inc.
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- Keystone Compliance
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- Society of Automotive Engineers (SAE)
- TCB Council
- TUV Rheinland of North America
- TUV SUD of America
- UL LLC
- U.S. Department of Defense - Joint Spectrum Center
- U.S. Department of Navy – NAVWAR

Individual members of the Committee include:

- Steve Berger
- David Case
- Werner Schaefer
- Dave Zimmerman
- Dan Sigouin
- John Lichtig
- Mits Samoto
- Dan Hoolihan

MAIN COMMITTEE OFFICERS

The officers of the C63-Committee include:

- Chair–Dan Hoolihan
- Vice-Chair–Dan Sigouin
- Secretaries–Jerry Ramie and Allen Crumm
- Treasurer–Mike Windler

The Secretariat of the C63 Committee is the IEEE Standards Association represented by Jennifer Santulli. The Secretariat handles the editing and publishing of the C63 standards as well as assisting the committee in meeting the ANSI guidelines and regulations on publicly announcing the development of our Committee's American National Standards.

SUBCOMMITTEES

There are eight Subcommittees within the C63 Committee, as follows:

- SC-1—EMC Techniques, Zhong Chen, Chair: Standards include C63.2, C63.4, C63.5, C63.7, C63.23, C63.25.1, C63.25.2, and C63.25.3
- SC-2—E3 Terminology Definitions and Best Practices, Marcus Shellman, Chair: Standards include C63.14 and C63.28
- SC-3—International Standardization, Ross Carlton, Chair: Standards include C63.12
- SC-4—Wireless and ISM Equipment, Bob DeLisi, Chair: Standards include C63.10, C63.26, C63.29, C63.30, and C63.31
- SC-5—Immunity Testing and Measurements, Ed Hare, Chair: Standards include C63.9, C63.15, C63.16, and C63.24
- SC-6—Lab Accreditation/Conformity Assessment, Randy Long, Chair: Standards include C63.34
- SC-7—Spectrum Etiquette, Jason Coder, Chair: Standards include C63.17 and C63.27
- SC-8—Medical Devices EMC Test Methods, Stephen Berger, Chair: Standards include C63.18, C63.19, and C63.33

WORKING GROUPS

Each active standard (standards being developed or revised) has a WG associated with it. Each WG has a Chair that schedules meetings of the WG and reports to the respective Subcommittee Chair.

RECENT STANDARDS PUBLISHED BY THE C63 COMMITTEE

C63.10 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

This standard is the second edition of C63.10. It was published on 29 January 2021. The first edition was published in 2013 and this is a technical revision of that standard. The revised standard is 270 pages long. The C63 Committee has petitioned the U.S. Federal Communications Commission (FCC) to adopt this revised standard and incorporate it into the FCC Rules as it did for the First Edition. The Chairman of the WG that developed the standard was Jason Nixon. The Abstract of C63.10 is

> *The procedures for testing the compliance of a wide variety of unlicensed wireless transmitters (also called intentional radiators and license-exempt transmitters) including, but not limited to, remote control and security unlicensed wireless devices, frequency hopping and direct sequence spread spectrum devices, anti-pilferage devices, cordless telephones, medical unlicensed wireless devices, Unlicensed National Information Infrastructure (U-NII) devices, intrusion detectors, unlicensed wireless devices operating on frequencies below 30 MHz, automatic vehicle identification systems, and other unlicensed wireless devices authorized by a radio regulatory authority are covered in this standard. Excluded by this standard are test procedures for unlicensed wireless devices already covered in other published standards (e.g., Unlicensed Personal Communication Services (UPCS) devices).*

C63.30 – American National Standard for Methods of Measurement of Radio-frequency Emissions from Wireless Power Transfer Equipment

This is a new standard for the C63 Committee. It was published on 19 March 2021. The Chairman of the

In the May 4, 2021 issue of the *Federal Register*, the FCC published a Final Rule on Standards for Hearing Aid-Compatible Handsets.

WG that handled the standard is Travis Thul. The standard is 268 pages long. The Abstract of C63.30 is:

> *U.S. consensus standard methods, instrumentation, and facilities for measurement of radio-frequency (RF) emissions and signals emitted from wireless power transfer equipment in the frequency range from 9 kHz to 40 GHz are specified. This standard does not include generic nor product-specific emission limits. Where possible, the specifications herein are harmonized with other national and international standards used for similar purposes.*

C63.24 – American National Standard – Recommended Practice for In Situ RF Immunity Evaluation of Electronic Devices and Systems

This is a new standard for the C63 Committee. It was published on 24 March 2021. At the time of publication, David Schaefer was the Acting WG Chair. (Don Heirman, who served as the WG Chair during most of the standard's development, passed away in October 2020). The standard is 28 pages long. The abstract of C63.24 is:

> *This document provides recommended test methods for assuring the radio frequency (RF) immunity of electronic devices and systems that might experience susceptibility from general-use transceivers or the RF ambient.*

C63.17 – Methods of Measurement of the Electromagnetic and Operational Compatibility of Unlicensed Personal Communication Services (UPCS) Devices

This standard was Reaffirmed in 2020 and it is active through 2022. The WG Chair of the Reaffirmation was Stephen Berger. The Scope of C63.17 is:

Reaffirmation of ANSI C63.17 – 2013. Specific test procedures are established for verifying the compliance of unlicensed personal communications services (UPCS) devices with applicable regulatory requirements regarding radio-frequency (RF) emission levels and spectrum access procedures.

C63.23 – Standard Guide for Electromagnetic Compatibility – Computations and Treatment of Measurement Uncertainty

This Standard Guide was reaffirmed on August 20, 2020. The WG Chair on the Reaffirmation was Bob DeLisi. The Abstract of C63.23 is:

> *This application Guide provides methods for determining the uncertainty of measurement for Electromagnetic Interference (EMI) measurement results. This Guide provides information on the application of Type A statistical evaluations. For Type B applications, this guide also provides information on where to obtain specified published information that can lead to an evaluation of uncertainty. The current document provides information on the range 150 kHz to 30 MHz for conducted emissions on main lines and 30 MHz to 18,000 MHz for radiated emission measurements.*

C63.19 – American National Standard Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids

The 2019 version of this standard was a revision of ANSI C63.19-2011 which was approved on August 19, 2019. The Chair of the WG that revised the 2011 standard was H. Stephen Berger. The Abstract of C63.19 is:

> *Uniform Methods of measurement for compatibility between hearing aids and wireless communication devices are set forth in the standard.*

In the May 4, 2021 issue of the *Federal Register*, the FCC published a Final Rule on Standards for Hearing Aid-Compatible Handsets. The summary stated:

> *In this document, the FCC incorporates by reference into its wireless hearing aid compatibility rules ANSI C63.19-2019 (2019 ANSI standard) and ANSI/TIA-5050-2018 (Volume Control standard). These standards will be used to evaluate the hearing aid compatibility of wireless handsets."*

The Incorporation by Reference of certain standards into the Commission's wireless hearing aid compatibility rules is approved by the Director of the Federal Register.

The effective date of the new Rules was June 3, 2021. The Incorporation by Reference of certain standards into the Commission's wireless hearing aid compatibility rules is approved by the Director of the *Federal Register* as of June 3, 2021. The Incorporation by reference of ANSI C63.19-2007 and ANSI C63.19-2011 were approved by the Director of the *Federal Register* as of June 6, 2008 and August 16, 2012, respectively.

C63.18 – Standard Recommended Practice for an On-Site, Ad hoc Test Method for Estimating Electromagnetic Immunity of Medical Devices to Radiated Radio-Frequency (RF) Emissions from RF Transmitters

This Recommended Practice was Reaffirmed in August of 2019. It is a Reaffirmation of ANSI C63.19 – 2014 (which was a Revision of ANSI C63.18-1997). The Chair of the Working

C63.2 – 2016 - American National Standard for Specifications of Electromagnetic Interference and Field Strength Measuring Instrumentation in the Frequency Range 9 kHz to 40 GHz
C63.4 – 2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
C63.5 – 2017 - American National Standard for Electromagnetic Compatibility— Radiated Emission Measurements in Electromagnetic Interference (EMI) Control—Calibration and Qualification of Antennas (9 kHz to 40 GHz)
C63.7 – 2015 - American National Standard Guide for Construction of Test Sites for Performing Radiated Emission Measurements
C63.9 – 2014 - American National Standard for RF Immunity of Audio Office Equipment to General Use Transmitting Devices with Transmitter Power Levels up to 8 Watts
C63.10 - 2020 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
C63.12 – 2015 - American National Standard Recommended Practice for Electromagnetic Compatibility Limits and Test Levels
C63.14 – 2014 - American National Standard Dictionary of Electromagnetic Compatibility (EMC) including Electromagnetic Environmental Effects (E3)
C63.15 – 2017 - American National Standard Recommended Practice for the Immunity Measurement of Electrical and Electronic Equipment
C63.16 – 2016 - American National Standard Guide for Electrostatic Discharge Test Methodologies and Acceptance Criteria for Electronic Equipment
C63.17 - 2013 (Reaffirmed 2020) - American National Standard Methods of Measurement of the Electromagnetic and Operational Compatibility of Unlicensed Personal Communications Services (UPCS) Devices
C63,18 – 2014 (Reaffirmed 2019) – Recommended Practice for an On-Site, Ad hoc Test Method for Estimating Electromagnetic Immunity of Medical Devices to Radiated Radio-Frequency (RF) Emissions from RF Transmitters
C63.19 – 2019 - American National Standard Methods of Measurement of Compatibility Between Wireless Communications Devices and Hearing Aids
C63.23 – 2013 (Reaffirmed 2020) - American National Standard Guide for Electromagnetic Compatibility—Computations and Treatment of Measurement Uncertainty C63.24 – 2021 - American National Standard— Recommended Practice for In Situ RF Immunity Evaluation of Electronic Devices and Systems
C63.25.1 – 2019 - C63.25.1 - American National Standard for Validation Methods for Radiated Emission Test Sites - 1 GHz to 18 GHz
C63.25.2 – 2021 (anticipated) – American National Standard for Validation Methods for Radiated Emission Test Sites, 30 MHz to 1 GHz
C63.26 – 2015 - American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
C63.27 – 2017 - American National Standard for Evaluation of Wireless Coexistence
C63.28 - Under Development - American National Standard Guide for Best Practice Applications of the ASC C63® Standards for Electromagnetic Compatibility (EMC)
C63.29 – Under Development – American National Standard of Procedures for Compliance Testing of Lighting Products
C63.30 – 2021 - American National Standard for Methods of Measurement of Radio-frequency Emissions from Wireless Power Transfer Equipment
C63.31 – Under Development – ISM Equipment
C63.32 – Reserved for future use
C63.33 – Under Development – Immunity to EAS Systems
C63.34 – Under Development – American National Standard Guide for Calibration of EMC Test Equipment
C63.35 – Reserved for future use

Table 1: List of Current C63 American National Standards

Group that reaffirmed the Recommended Practice was H. Stephen Berger. The Abstract of C63.18 is:

> *This Recommended Practice is a guide to evaluating the electromagnetic immunity of medical devices to radiated radio-frequency (RF) emissions from common RF transmitters (e. g., two-way radios; walkie-talkies; mobile phones; wireless-enabled tablets, e-readers, laptop computers, and similar devices; radio-frequency identification (RFID) readers; networked mp3 players; two-way pagers; and wireless personal digital assistants (PDAs). This protocol does not provide a comprehensive test or offer any guarantee, but it is a basic evaluation that can help identify medical devices that might be particularly vulnerable to interference from common RF transmitters. The ad hoc test protocol can be used to evaluate existing or newly purchased medical devices or can be implemented for the purpose of pre-purchase evaluation. This recommended practice applies to medical devices used in health-care facilities, but it can also be adapted to medical devices in home healthcare or mobile health-care settings. It does not apply to implantable medical devices (e. g., pacemakers and defibrillators), transport environments, such as ambulances and helicopters, or RF transmitters rated at more than 9 Watts of output power. Testing with transmitters greater than 8 Watts in health-care facilities is not recommended because of possible adverse effects on critical-care medical devices that are in use in nearby areas of the facility. Finally, this recommended practice does not address in-band RF interference where the fundamental frequency of an RF transmitter overlaps with frequencies used by a hospital wireless network or monitoring or used by other medical device wireless links.*

COMPLETE LIST OF STANDARDS FROM THE C63 COMMITTEE

A complete list of active C63 standards is given in Table 1.

AVAILABILITY OF STANDARDS

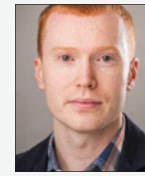
ANSI C63 publications are available from the Institute of Electrical and Electronics Engineers (https://standards/ieee.org) and the American National Standards Institute (https://www.ansi.org).

EXPORTING RADIO EQUIPMENT TO SAUDI ARABIA: A LOOK AT THE LAW

An Overview of the Legal Framework and the Obligations Applicable to Equipment Manufacturers and Importers

With a gross domestic product of 793 billion (USD) in 2019,[1] the economy of Saudi Arabia is among the wealthiest in the world. Indeed, it is one of the world's top 20 economies with Saudi Arabia a G20 member country. A high-income nation, Saudi Arabia also has a large and fast-growing population – over 34 million and rising in 2019[2] – with approximately 39% under the age of 25.[3] The latter is noteworthy with regard to Saudi Arabia's emergence as an increasingly favored export destination for North American, European, and Asian manufacturers of consumer electronics and information communications technology (ICT). In particular, Saudi Arabia's young consumer market has been identified as including some of the world's most prominent early adopters of new technologies.[4]

Dr. Alex Martin is Principal Regulatory Consultant at RINA. He provides advice and compliance support on various regulations affecting electro-technical products, from EMCD, LVD, and RED through environmental laws like RoHS, REACH, and WEEE. Dr. Martin can be reached at alex.martin@rina.org.



By Alex Martin

Combine this with new consumer electronics and ICT products that usually incorporate wireless functionality as a standard feature, and an understanding of Saudi radio equipment regulation becomes imperative for ensuring market access. This article discusses the national legislation in place, including, as relevant, its references to international and European product standards.

OVERVIEW

Saudi Arabia has a well-developed legal framework when it comes to the design, supply, and use of radio equipment. At the most fundamental level, any device with a radio transmitter is a potential regulatory target. This includes mobile handsets, wireless LAN (WLAN) equipment such as Wi-Fi, Bluetooth, and Zigbee devices, and a wide range of other products incorporating some kind of radio frequency transmitter.

Within the legal framework, there is an overarching Telecommunications Act, an Ordinance that created the Saudi Communications and Information Technology Commission (CITC), and assorted telecommunications bylaws. As the national regulator, CITC has responsibilities that encompass drafting, publishing, and enforcing laws and national guidelines. This article provides some detailed discussion of a few of these laws and one set of guidelines, namely:

- The Importation and Licensing of Telecommunications and IT Equipment Regulations;
- The WLAN/Wi-Fi Usage Regulations;
- Certain Technical Specifications, of a general nature; and
- The Guidelines for Human Exposure to RF Electromagnetic Fields.

THE IMPORTATION AND LICENSING OF TELECOMMUNICATIONS AND IT EQUIPMENT REGULATIONS

These Regulations state that, together with relevant CITC Technical Specifications, they:

> *…shall be considered obligatory to any party that intends any action related to manufacturing, importation, distribution or sales of telecommunications and IT equipment in the kingdom [of Saudi Arabia].*

Hence, the Regulations are notable with respect to the potential export, installation, and/or use of various consumer electronics and ICT products in Saudi Arabia.

Equipment Licensing/Approval

Under the Regulations, licensing is defined as "the verification of the conformity of telecommunications and IT equipment to the Technical Specifications issued by the CITC," while this can also be extended to "meeting any other requirements determined by the Commission" (e.g., obtaining a service providing license or radio license). The Regulations detail the conditions that must be fulfilled for equipment to be considered licensed for use. The conditions are as follows:

- The equipment is approved by CITC or conforms to the Technical Specifications issued by CITC;
- The user of the equipment fulfills all relevant additional requirements (if there are any), such as holding a service providing license and/or the radio licenses for the use of frequencies;
- The equipment's specifications or characteristics go unaltered by the user;
- The equipment is imported in accordance with the conditions and procedures established in the Regulations; and
- All the usage regulations and conditions issued by CITC and published on its website are complied with.

As worded, the first of these conditions might suggest that manufacturers or importers of some types of telecommunications and IT equipment are able to self-certify their products, in much the same way that internal production control (Module A) exists as a conformity assessment procedure under the European Union's (EU's) Radio Equipment Directive.[5] In practice, however, equipment approval (type approval) is a necessary first step when supplying into Saudi Arabia. The Regulations explain that this entails:

- Registering on the ICT Equipment Licensing Portal.[6]
- Making an application for approval, specifically by providing the following documentation as supporting evidence:

  a. Detailed technical information, including a manufacturer's datasheet, equipment description, the equipment's "functioning mechanism and accessories," intended equipment applications, data related to interface characteristics and interoperability with public networks, and photographs of the equipment;

  b. A Declaration of Conformity from the manufacturer that the equipment conforms to CITC Technical Specifications (the applicant must retain the original copy of the Declaration and submit it to CITC upon request);

  c. Test reports from ILAC-accredited laboratories[7] outlining the details of the tests conducted on the equipment pending approval, and their results. Reports are to include the names of the laboratories that conducted the tests, their addresses, and the date(s) of the tests.
- A successful approval and issue of a Certificate of Conformity is subject to meeting any technical or administrative requirements that are raised by CITC prior to the equipment being imported and/or used in Saudi Arabia. The most common appears to be that the equipment is supplied/used unaltered, meaning that its design and construction remain consistent with the detailed technical information for which the approval was granted.
- Adhering to the certification period: certification is valid for a total of two years, after which re-certification will be required. An equipment-specific time duration will be stated on the Certificate of Conformity.
- Meeting any other conditions that might apply, such as prompt payment of any applicable approval fees.

Anecdotal information suggests that approval leading to the issue of a Certificate of Conformity takes one to two weeks in total.

Equipment Importation/Customs Clearance

There are specific procedures and conditions that apply. These are detailed in Sections 6 and 7 of the Importation and Licensing of Telecommunications and IT Equipment Regulations. The following provides a summary:

- Any party wishing to import and market telecommunications and IT equipment in Saudi Arabia must be a Saudi company or establishment with a valid commercial registration, which, significantly, includes the activities of importing wireless and wired telecommunications and IT equipment, its marketing, installation, and maintenance.
- Importers must conform to the terms stipulated in Council of Ministers Decree No. 100, Reference 08/08/1415H, concerning undertaking importation and maintenance of wireless and wired communications equipment and their components.
- Importers must be located in Saudi Arabia.
- Importers must be able to demonstrate compliance of imported equipment with all relevant CITC Technical Specifications.
- Importers must inform CITC about any alterations they may want to make to approved equipment before the importation in order to obtain CITC approval.

There is customs clearance permission as well, but within the Regulations, this seems to be specific to certain, restricted items of telecommunications and IT equipment. Please consult the Regulations for further information.

THE WLAN/WI-FI USAGE REGULATIONS

These are notable as they set certain rules for devices that make use of WLAN/Wi-Fi. In the first instance, the Regulations define WLAN/WiFi as:

> *Communication networks used to provide wireless services in a limited area. Such networks are built in*

accordance with the international standards, such as IEEE 802.11/HIPERLAN, and provide the user with the ability to move within a limited area.

The rules for "operating and using networks" are then as follows:

1. *All devices which are used in these networks must comply with the Technical Specifications, areas of coverage, and frequencies approved by the CITC (see below table). It is not permitted to make any modifications in the Technical Specifications without prior written approval from CITC.*
2. *All devices which are used must comply with the safety specifications, electromagnetic compatibility, and any other CITC related specifications.*
3. *To provide to the CITC, when requested, all required documents to prove the compliance of the devices with the technical standard specifications and any other related documents and proofs.*
4. *To ensure that the operation of the devices and the appropriate places for the installation, especially in terms of improving the level of network security, will prevent any possible hacking or misuse.*
5. *The operator of these networks for outdoor usage must coordinate with concerned authorities to obtain any required licenses for the implementation of the network.*
6. *Internet service must be provided only through an internet service provider licensed by the CITC.*
7. *Internet service providers are responsible for registering users' data and all other technical requirements.*
8. *Services provided through these networks are considered secondary services; thus, they are not protected against any possible interference, and must not, at any time or anywhere, cause any harmful interference to the primary services. CITC shall not*

> *be held liable for any damages following use of these networks.*
>
> 9. *The usage of these networks is subject to all CITC regulations, the anti-crime law, and all other related regulations.*

Table 1 is also contained within the Regulations. It is a reference table that details standards, areas of coverage, and CITC approved frequencies.

TECHNICAL SPECIFICATIONS

CITC has adopted nearly 100 Technical Specifications, which are equipment-specific laws. All the Technical Specifications appear to be structured in the same way, which includes defining a scope of application before going on to specify proof of compliance and technical requirements (typically conformance to one or more EN standards). The following summarizes three Technical Specifications of general application/note: GEN001, IT001, and RI054.

GEN001: General Requirements Technical Specification

This is a key document since it:

> *…defines the minimum requirements which must be met by all Radio & Telecommunications Terminal Equipment, such as transmitting equipment and equipment/devices connected to or constituting local periphery or telecommunication networks, which is intended to be used and sold in the Kingdom of Saudi Arabia. These requirements must be applied in addition to any product specific requirements that may exist.*

Proof of Compliance

Equipment compliance with the requirements of GEN001 is to be demonstrated by:

> *…producing a suitable "notified body statement" or similar type examination certificate or test report(s) obtained from a laboratory (or group of laboratories) that has been accredited by a body that is a member of the ILAC Mutual Recognition Arrangement.*

Technical Requirements

It is stated that:

> *Testing should be carried out to ensure compliance with the applicable specifications from those listed in the Technical Specification and with other requirements where such are established in separate product-specific Radio Interface specifications. If European norms are used as the basis for providing proof of compliance, the issue or version of the specification(s) used, should have been published in the Official Journal of the European Community (OJEC). Also, the specification(s) should be recognized as providing "presumption of conformity" under the European Radio Equipment Directive at the time the approval is sought. If internationally recognized equivalent standards are applied, the latest published version of the standard should be used.*

Standard	Area of Coverage	DFS	TPC	RPSDL-PSD	Maximum EIRP	Frequency MHz	Allowable frequencies in use within Saudi Arabia
EN 300 328	Indoor and outdoor	N/A	N/A	10 mW/MHz in any 1 MHz band	100 mW	2400 - 2483.5	
EN 301 893 & ITU-R M1652	Indoor	N/A	N/A	10 mW/MHz in any 1 MHz band	200 mW	5150 - 5250	
EN 301 893 & ITU-R M1652	Indoor	Required	Required	10 mW/MHz in any 1 MHz band	200 mW	5250 - 5350	
EN 301 893 & ITU-R M1652 & IEEE802.11a	Indoor and outdoor	Required	Required	50 mW/MHz in any 1 MHz band	1W	5470 - 5825	

Table 1: CITC approved frequencies, as matched to relevant standards and areas of coverage

Where the norm listed below had become updated or superseded by a different norm in the meantime, the most up to date relevant version/norm shall be deemed applicable for the purpose of compliance verification.

A number of standards are then listed, which are reproduced in Table 2.

Topic	Standard	Title
Electrical safety	EN 62368-1 or IEC 62368-1	Audio/video, information and communication technology equipment – Part 1: Safety requirements.
Radio and Specific Absorption Rate (SAR)	EN 50360	Product standard to demonstrate the compliance of mobile phones with the basic restrictions related to human exposure to electromagnetic fields (300 MHz - 3 GHz).
	EN 50364 Ed.2	Limitation of human exposure to electromagnetic fields from devices operating in the frequency range 0 Hz to 300 GHz, used in Electronic Article Surveillance (EAS), Radio Frequency Identification (RFID) and similar applications.
	EN 62479:2010	Assessment of the compliance of low power electronic and electrical equipment with the basic restrictions related to human exposure to electromagnetic fields (10 MHz to 300 GHz).
	EN 50385	Product standard to demonstrate the compliance of radio base stations and fixed terminal stations for wireless telecommunication systems with the basic restrictions or the reference levels related to human exposure to radio frequency electromagnetic fields (110 MHz - 40 GHz) – General public.
	EN 62311:2008	Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz - 300 GHz).
EMC	EN 55032	Electromagnetic compatibility of multimedia equipment – Emission requirements.
	EN 55035	Electromagnetic compatibility of multimedia equipment – Immunity requirements.
	EN 301 489	Electromagnetic Compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services.
	EN 61000-3-2 or IEC 61000-3-2	Part 3-2: Limits – Limits for harmonic current emissions (equipment input current up to and including 16 A per phase).
	EN 61000-3-3 or IEC 61000-3-3	Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection.
	EN 61000-3-11 or IEC 61000-3-11	Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current <= 75 A and subject to conditional connection.
	EN 61000-6-1 or IEC 61000-6-1	Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments.
	EN 61000-6-2 or IEC 61000-6-2	Part 6-2: Generic standards – Immunity for industrial environments.
	EN 61000-6-3 or IEC 61000-6-3	Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments.
	EN 61000-6-4 or IEC 61000-6-4	Part 6-4: Generic standards – Emission standard for industrial environments if no issue or revision number is quoted along with the title of a Technical Specification, the latest published version should be used.
Optical & Laser	EN 60825 or IEC 60825	Safety of laser products.

Table 2: Standards cited as “applicable specifications” in GEN001

IT001: IT Equipment Technical Specification

This Technical Specification applies to equipment including, but not limited to, standalone PCs, external hard disks, USB digital cameras, and peripherals (e.g., printers, scanners, monitors). According to IT001, if more than one interface type is offered by a piece of IT equipment, each interface must meet the applicable specifications.

Regarding proof of compliance, IT001 recommends that "test reports are obtained from a laboratory that has been accredited by a body that is a member of the ILAC Mutual Recognition Arrangement" while IT001's "applicable specifications" include the following:

- EN 55022 / CISPR 22 *Information technology equipment — Radio disturbance characteristics — Limits and methods of measurement.*
- EN 55024 / CISPR 24 *Information technology equipment — Immunity characteristics— Limits and methods of measurement.*
- EN 61000-3-2 / IEC 61000-3-2 *Electromagnetic compatibility (EMC) — Part 3-2: Limits — Limits for harmonic current emissions (equipment input current ≤ 16 A per phase).*
- EN 61000-3-3 / IEC 61000-3-3 *Electromagnetic compatibility (EMC) — Part 3-3: Limits — Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection.*
- EN 61000-3-11 / IEC 61000-3-11 *Electromagnetic compatibility (EMC) — Part 3-11: Limits — Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems — Equipment with rated current ≤ 75 A and subject to conditional connection.*

In addition, IT001 stipulates that all in-scope IT equipment must comply with GEN001 requirements (see above), be safe, and not adversely affect other electrical equipment.

RI054: Non-Specific Short-Range Devices, etc. Technical Specification

This Technical Specification could be relevant to various WiFi-enabled consumer electronics and ICT products, depending on their frequency of operation. The Technical Specification's reference table in this regard is shown in Table 3.

RI054 then advises that testing is to be performed against any of the following standards, as applicable: EN 300 220-2, EN 300 330-2, EN 300 440-2, EN 301 489-1, and EN 301 489-3.

Much like IT001, RI054 also stipulates that all in-scope equipment must comply with GEN001 requirements (see above), be safe, and not adversely affect other electrical equipment.

Frequency Band	Maximum Output Power or Magnetic Field	ETSI Standard
6765 - 6795 kHz	42 dBμA/m @10m	EN 300 330
13.553 - 13.567 MHz	42 dBμA/m @10m	EN 300 330
26.957 - 27.283 MHz	42 dBμA/m @10m 10 mW e.r.p.	EN 300 330 EN 300 220
40.660 - 40.700 MHz	10 mW e.r.p.	EN 300 220
433.050 - 434.790 MHz	10 mW e.r.p.	EN 300 220
433.050 - 434.790 MHz	1 mW e.r.p. 13 dBm/10 kHz	EN 300 220
434.040 - 434.790 MHz	10 mW e.r.p.	EN 300 220
863.000 - 870.000 MHz	≤25 mW e.r.p.	EN 300 220
(Subbands for Alarms excluded)	≤25 mW e.r.p.	EN 300 220
	≤25 mW e.r.p.	EN 300 220
868.000 - 868.600 MHz	≤25 mW e.r.p.	EN 300 220
868.700 - 869.200 MHz	≤25 mW e.r.p.	EN 300 220
869.400 - 869.650 MHz	≤500 mW e.r.p.	EN 300 220
869.700 - 870.000 MHz	≤25 mW e.r.p.	EN 300 220
870-876 MHz	≤25 mW e.r.p.	EN 300 220
915-921 MHz	≤25 mW e.r.p.	EN 300 220
2400 - 2483.5 MHz	10 mW e.i.r.p.	EN 300 440
5725 - 5875 MHz	25 mW e.i.r.p.	EN 300 440
24.00 - 25 GHz	100 mW e.i.r.p.	EN 300 440
122 - 123 GHz	100 mW e.i.r.p.	EN 300 440

Table 3: Frequency of operation reference table detailed within RI054

GUIDELINES FOR HUMAN EXPOSURE TO RF ELECTROMAGNETIC FIELDS

While guidelines in name, these are enforceable under Saudi law by CITC. They are therefore no less significant than Technical Specifications when it comes to identifying and adhering to relevant regulations in Saudi Arabia.

Published in November 2009, the *National Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields* are, at 76 pages, comprehensive, while for the most part drawing directly upon the restrictions and reference levels recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

In general terms, the National Guidelines establish technical regulatory practices for limiting human exposure to radiofrequency (RF) electromagnetic fields (EMF) to protect against known adverse health effects from installations or devices emitting RF fields. More specifically, the National Guidelines set minimum requirements for the protection of the public and workers from health risks arising, or likely to arise, from their exposure to RF in the frequency range 3 kHz to 300 GHz. While some applications are excluded from the scope of the National Guidelines, these are limited in number and include, for example, use of RF by the military, RF exposure from radars, and RF exposure from industrial uses of RF for heating, drying, or welding.

The National Guidelines begin by classifying exposure limits before specifying basic restrictions and reference levels, and then covering the compliance of, respectively, mobile/portable radio devices and fixed RF sources.

The basic restrictions include those of a general nature (e.g., to prevent electric shock or burns) as well as specific restrictions relating to current density induced in the head and torso of the body from RF exposure; whole-body average specific absorption rate; localized specific absorption rate; specific absorption in the head for pulsed RF exposures; and power flux density that is incident at the surface of the body.

Please note that restrictions are considered in relation to both public and occupational exposures. As defined by the National Guidelines:

> *…the occupational limits apply to the exposure of designated RF trained workers who have been formally identified as such under a workplace RF safety program and are generally exposed under known conditions.*

With respect to in-scope products, it would appear that it is for whatever business that ultimately makes use of it in Saudi Arabia (which may not be the product manufacturer) to judge whether an RF safety program is necessary. A key determinant seems to be whether RF exposure above Saudi's public limits is certain, likely, unlikely, or not possible.

CONCLUSION

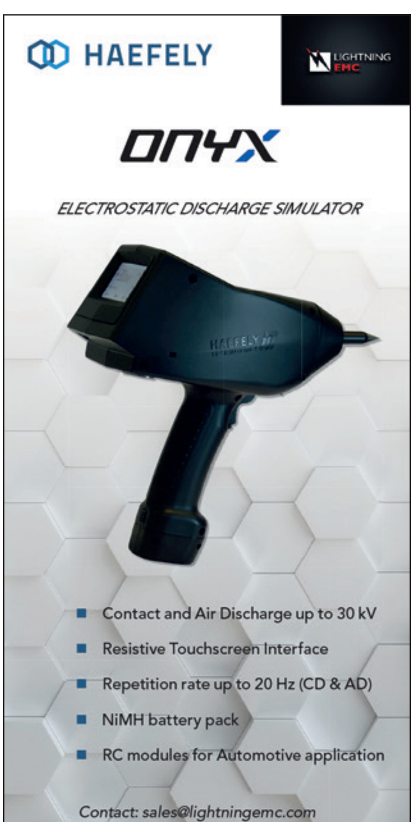
There is much to consider and address before placing radio equipment on the Saudi market for the first time. This article has presented an overview of the relevant Saudi legal framework, touching upon matters including customs clearance, equipment conformance with standards, and proof of compliance. The article additionally identified CITC as the national regulator, with whom the author would encourage readers to engage should they find themselves unclear on any aspect of the legislation, including the scope of equipment-specific laws like IT001 and RI054.

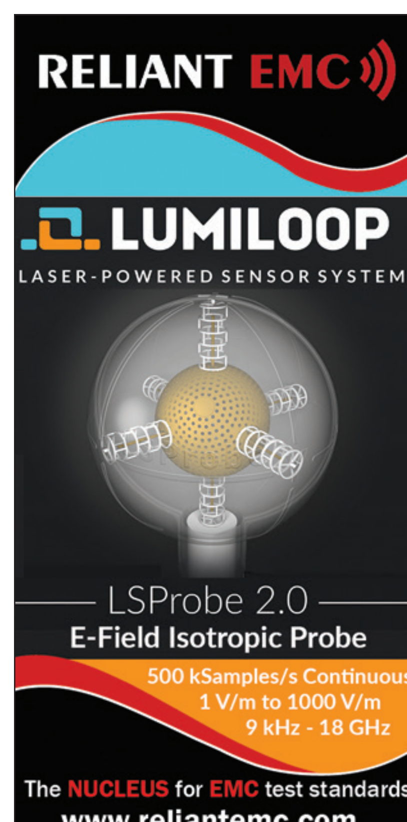
Readers can contact CITC via its website, with the English language version of it accessible at https://www.citc.gov.sa/en.

ENDNOTES

1. See https://data.worldbank.org/country/SA
2. See https://data.worldbank.org/country/SA
3. See https://www.great.gov.uk/markets/saudi-arabia
4. See https://www.great.gov.uk/markets/saudi-arabia
5. Directive 2014/53/EU.
6. See https://ers.citc.gov.sa/english/pages/home.aspx
7. ILAC is the international organization for accreditation bodies. For further information see: https://ilac.org/about-ilac
8. Tables 2-7 of the National Guidelines give information on frequency ranges and target values in each instance and should be consulted for more information.

PRODUCT Showcase





EVALUATION OF EMC EMISSIONS AND GROUND TECHNIQUES ON 1- AND 2-LAYER PCBs WITH POWER CONVERTERS

Part 3: DC/DC Converter – Baseline EMC Emissions Evaluation

By Bogdan Adamczyk, Scott Mee, and Nick Koeller

This is the third article in a series of articles devoted to the design, test, and EMC emissions evaluation of 1- and 2-layer PCBs that contain AC/DC and/or DC/DC converters, and employ different ground techniques [1, 2]. In this article, we evaluate the performance of the baseline DC/DC converter (e.g., use only IC vendor recommended components and no additional EMC countermeasures). Specifically, we present the test results from the radiated and conducted emissions tests performed according to the CISPR 25 Class 5.

Like so many industries at this time, while working on the DC/DC converter we were faced with a semiconductor shortage issue in our design with the main controller integrated circuit. This forced us to redesign the converter using a different DC/DC IC that is widely available in quantities. After selecting a new integrated circuit, a new design was created and appropriate components were chosen. Then the PCB layout was updated and a 'quick turn' PCB fabrication was ordered and received. The schematic, PCB layout, and a photograph of the assembly are shown below for the new design which was tested and results are discussed in this article.

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1. INTRODUCTION

In the first article in the series, [1], we presented the schematic for the overall system shown in Figure 1.

The second article, [2], focused on the details of the DC/DC converter design.

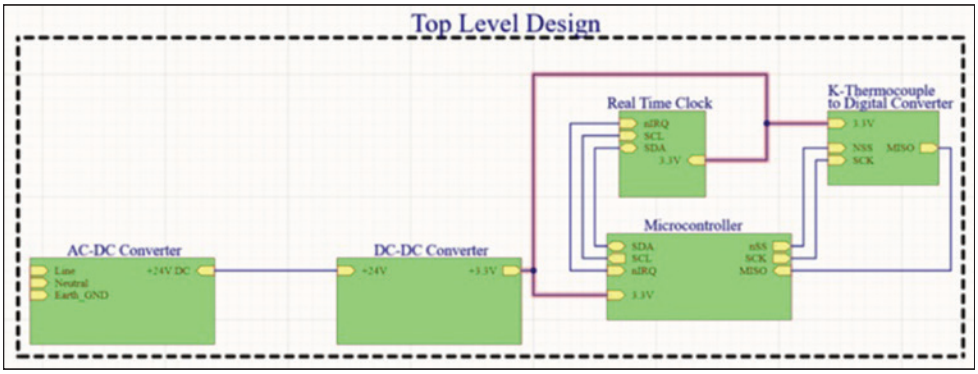

Figure 1: Top-level schematic

Due to the aforementioned semiconductor shortage, a new design was created using the same process and is shown in Figure 2.

The layout of the DC-DC converter is shown in Figure 3.

The baseline converter is shown in Figure 4.

This article is organized as follows. Section 2 presents the radiated emissions test results. In Section 3, the conducted emissions (voltage method) results are shown. The current method, conducted emission results are included in Section 4. Section 5 addresses the content of the next article.

2. CISPR 25 RADIATED EMISSIONS TEST RESULTS

The DC-DC switcher was tested according to CISPR 25 4th Edition, Class 5. The radiated emissions test setup is shown in Figure 5.

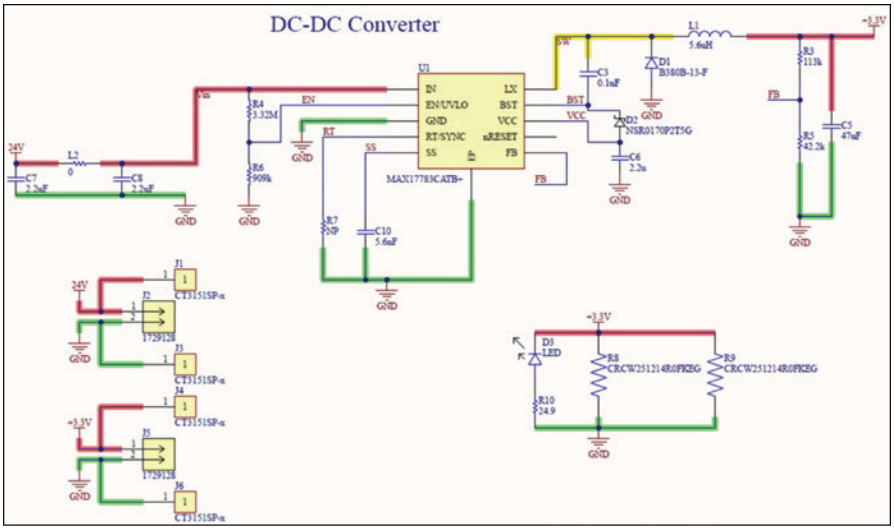

Figure 2: DC-DC converter baseline schematic

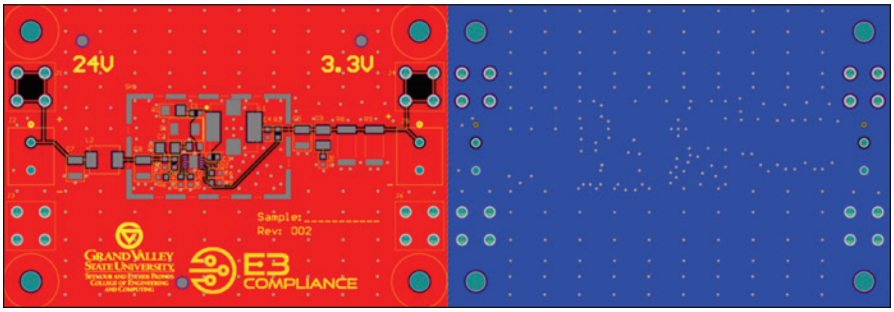

Figure 3: DC-DC Converter layout (Top Layer in Red, Bottom Layer in Blue)

Figure 4: DC-DC converter assembly

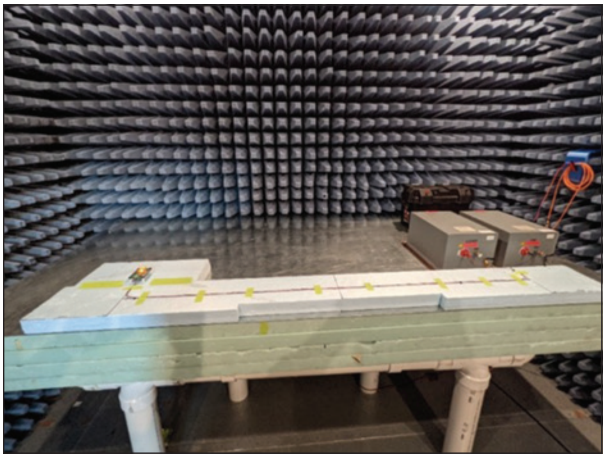

Figure 5: Radiated emissions test setup

A legend for the radiated emissions plot is shown in Figure 6.

Figure 7 shows the radiated emissions measurements results in the frequency range of 150 kHz - 1GHz. These measurements were made using a monopole antenna from 150 kHz - 30 MHz, a biconical antenna from 30 MHz - 300 MHz, and a log-periodic antenna from 300 MHz - 1GHz.

The monopole range (150 kHz - 30 MHz) shows a failure of the Quasi-Peak and Average limits at 978 kHz and 1469 kHz. The emissions in this region are all narrowband, and spaced by ~487 kHz. This suggests that these emissions are all harmonics of the 487 kHz switching frequency of the power supply.

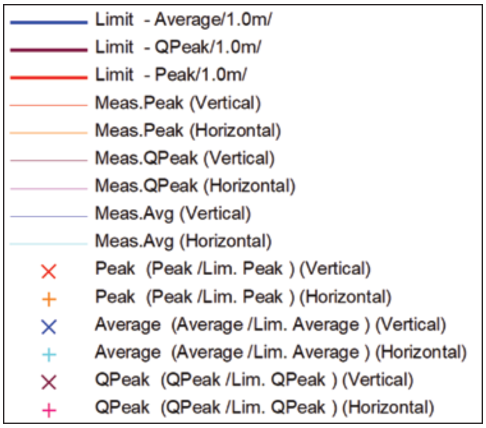

Figure 6: Radiated emissions legend

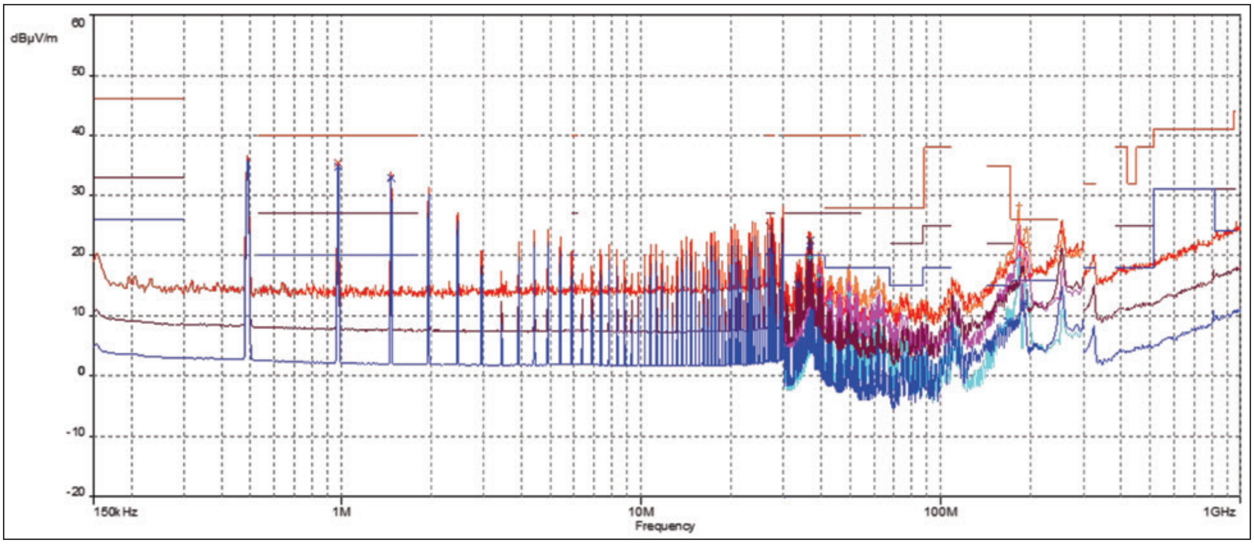

Figure 7: Radiated emission results in the frequency range 150kHz – 1GHz

The biconical range (30 MHz - 300 MHz) shows failures of the average limit at 36.75 MHz and 182.46 MHz, and failure of the peak limit at 182.46 MHz. By measuring the distance between the different peaks that are present in this range shows that these failures are also due to the buck converter, but because of the broadband nature of this noise this would indicate these emissions are likely due to ringing on the switching signal.

3. CISPR 25 CONDUCTED EMISSIONS (VOLTAGE METHOD) TEST RESULTS

Figure 8 shows the voltage method conducted emissions test setup.

Figure 8: Conducted emission test setup (voltage method)

A legend for the conducted emissions plots is shown in Figure 9 on page 54.

The test results on the battery line, in the frequency range of 150 kHz - 108 MHz, are shown in Figure 10 on page 54.

The conducted emissions plot of the Battery line, like the Monopole region of the RE test data, shows significant emissions at the switching frequency of the Buck regulator and the harmonics of this frequency. This measurement was taken with a 9 kHz resolution bandwidth from 150 kHz - 30 MHz and a 120 kHz resolution bandwidth from 30 MHz - 108 MHz. This shows the failure of all three limits at 978 kHz, and 1.4685 MHz. This also shows failures of the average and quasi-peak limits from ~25 MHz - ~100 MHz.

The test results on the ground line, in the frequency range of 150 kHz - 108 MHz, are shown in Figure 11 on page 54.

From this measurement of emissions from the GND line, it is seen that there is a similar amount of emissions coming from the Battery line and the GND line for this DUT. This measurement was taken with a 9 kHz resolution bandwidth from 150 kHz - 30 MHz and a 120 kHz resolution bandwidth from 30 MHz - 108 MHz. Like the Battery line measurements this shows failures of all three limits at 978 kHz, and 1.4685 MHz, and multiple failures of the average and quasi-peak limits from ~25 MHz - ~100 MHz.

4. CISPR 25 CONDUCTED EMISSIONS (CURRENT METHOD) TEST RESULTS

Figure 12 shows the current method conducted emissions test setup.

The test results, at 50 mm, in the frequency range of 150 kHz - 245 MHz are shown in Figure 13 on page 56. The measurement from 150 kHz - 30 MHz was taken with a 9 kHz resolution bandwidth, and the measurement from 30 MHz - 245 MHz was taken with a 120 kHz resolution bandwidth.

The conducted emissions measurement at 50 mm, shows significant broadband emissions from 25 MHz - 100 MHz, and at ~180 MHz.

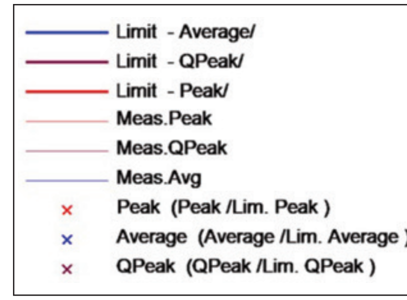

Figure 9: Conducted emission results legend

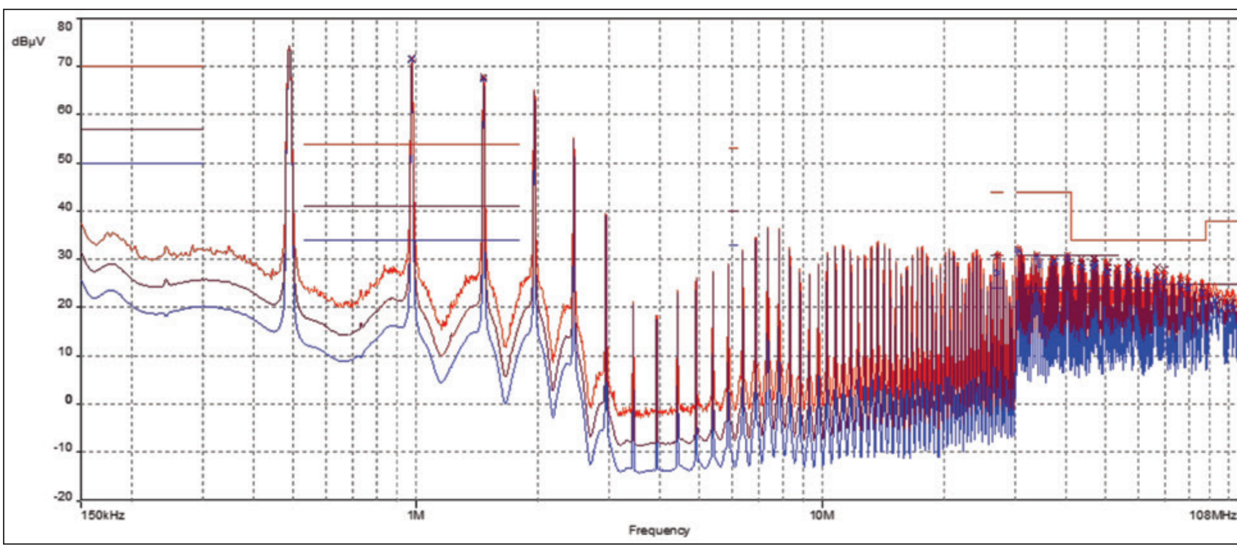

Figure 10: Conducted emission test results – BAT line – 150 kHz – 108 MHz

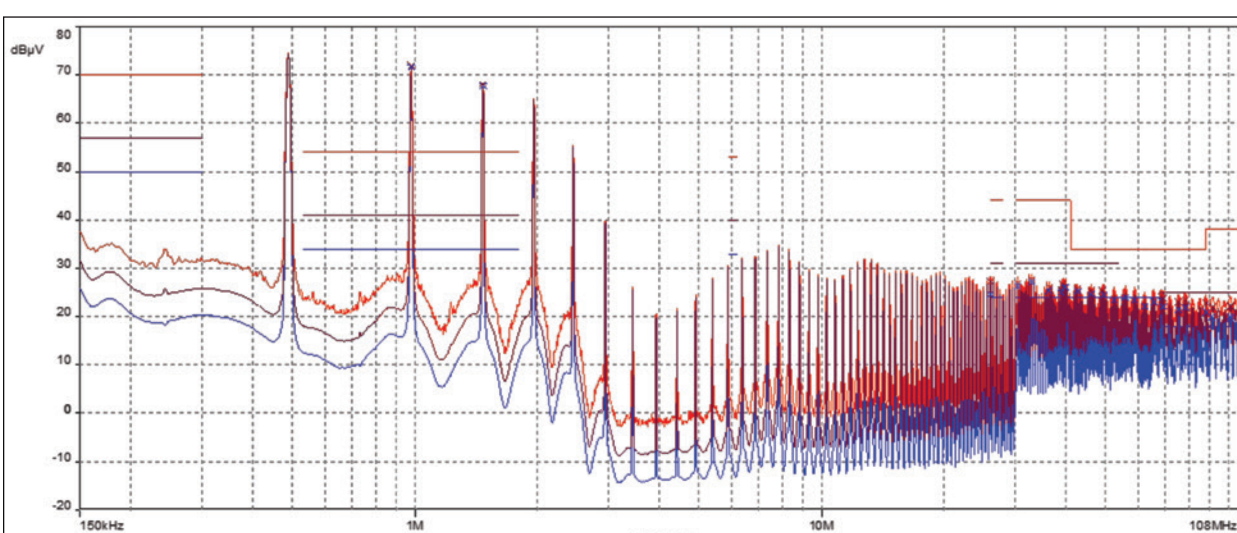

Figure 11: Conducted emission test results – GND line – 150 kHz – 108 MHz

These emissions are likely due to ringing in the switching waveform.

The test results, at 750 mm, in the frequency range of 150 kHz - 245 MHz are shown in Figure 14 on page 56. The measurement from 150 kHz - 30 MHz was taken with a 9 kHz resolution bandwidth, and the measurement from 30 MHz - 245 MHz was taken with a 120 kHz resolution bandwidth.

Like the 50 mm measurements, this measurement taken at 750 mm, shows significant broadband emissions from 25 MHz - 100 MHz, and at ~180 MHz. These emissions are likely due to ringing in the switching waveform.

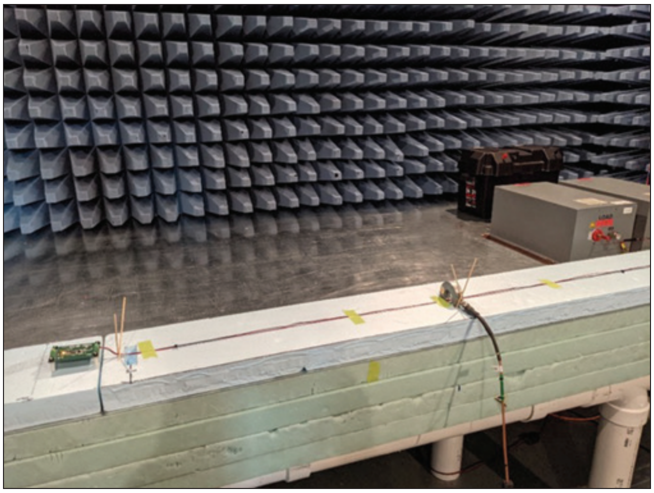

Figure 12: Conducted emission test setup (current method)

5. FUTURE WORK

The next article will be devoted to the evaluation of EMC countermeasures to address the radiated and conducted emissions non-conformities. The article will address each test result and the impact of the optional EMC components.

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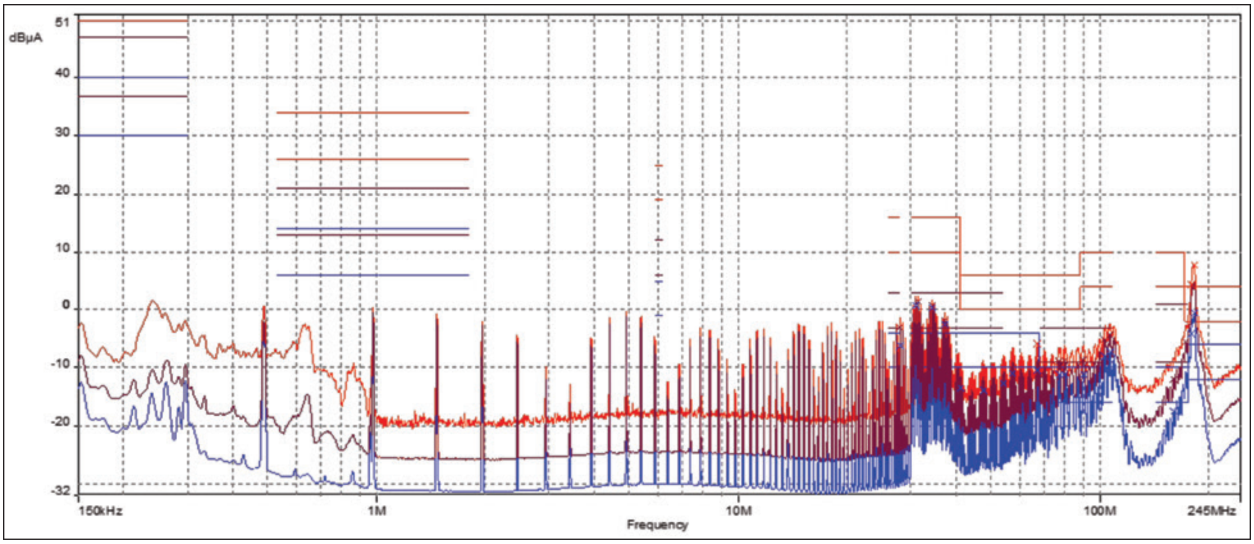

Figure 13: Conducted emission test results at 50 mm

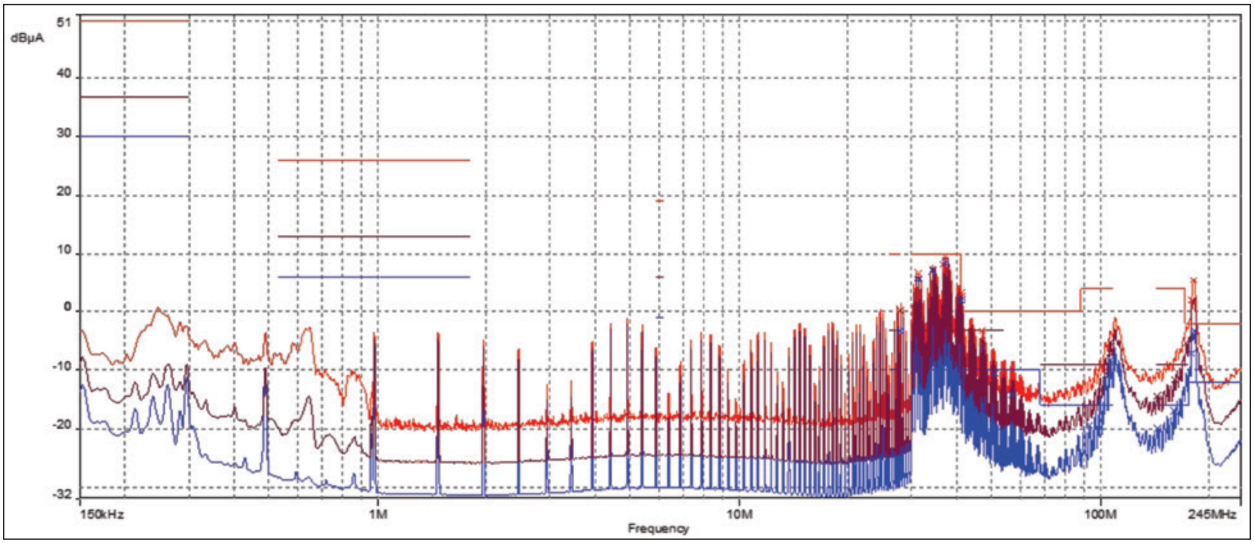

Figure 14: Conducted emission test results at 750 mm

NEXT TO FinFET, HOW WILL ESD SUFFER?

By Shih-Hung Chen for EOS/ESD Association, Inc.

Roughly a decade ago, starting at 22nm technology nodes, the transistor architecture changed from planar to FinFET [1-3]. Bulk FinFET (FF) which is a multi-gate transistor built on Si substrate has been the mainstream in the state-of-the-art logic CMOS technologies for many mobile SoC applications [1-3]. Fortunately, ESD reliability has not been an obstacle in the FinFET era from 22nm to 5nm technology nodes. Nowadays, with the increased requirements of high-performance computing applications, logic CMOS technologies need further evolutions. Several new transistor architectures have been proposed to achieve more powerful computing capability. In this article, we will look at the impacts of these transistor architectures on ESD reliability.

Shih-Hung Chen received a Ph.D. degree from the Institute of Electronics, National Chiao Tung University, in 2009. Since 2019, he has been ESD team lead and principal member of technical staff (PMTS) at IMEC. He authored or co-authored more than 100 conference and journal publications.

Founded in 1982, EOS/ESD Association, Inc. is a not for profit, professional organization, dedicated to education and furthering the technology Electrostatic Discharge (ESD) control and prevention. EOS/ESD Association, Inc. sponsors educational programs, develops ESD control and measurement standards, holds international technical symposiums, workshops, tutorials, and foster the exchange of technical information among its members and others.

NEW GAA TRANSISTOR ARCHITECTURE

Next to bulk FinFET technologies beyond 5nm nodes, bulk gate-all-around (GAA) technology has been proposed as a promising candidate because of improved channel electrostatic and leakage control [4-8]. The vertically stacked horizontal nanosheets (NS) can further maximize the driving current per layout footprint [8-11]. Compared with nanowires (NW), the NS can provide more driving capability per layout footprint due to the larger effective channel width (W_{eff}) [10, 11], as shown in Figure 1.

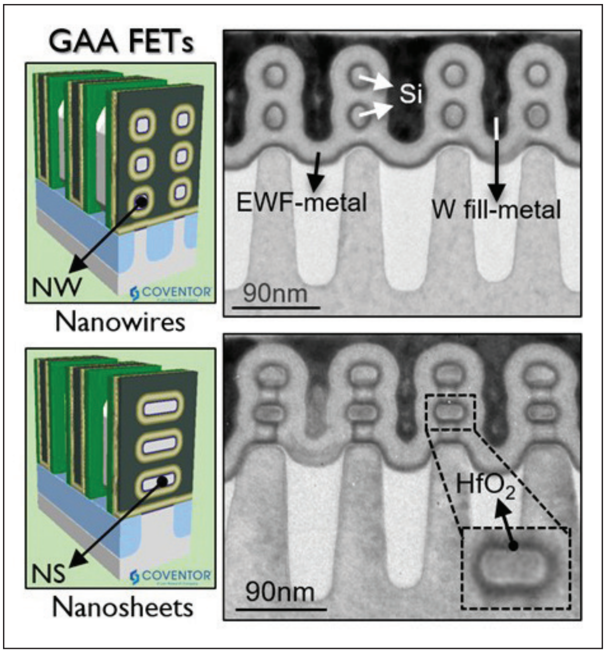

Figure 1: 3D schematic images of Gate-all-around (GAA) FETs with two different vertically stacked horizontal nano-architectures: one is the nanowire (NWs) and the other is the nanosheet (NS). Corresponding TEM cross-section views of these different two vertically stacked horizontal GAA NW and GAA NS are shown. Effective work function (EWF) and Tungsten (W) gate metals are also shown [7, 9, 11].

In addition to the new GAA transistor architecture, the integration of a Source/Drain (S/D) dual epitaxy process with strain engineering [3, 12-15] has been proposed to continuously enable better, faster, and more compact devices [13]. For example, in p-type MOSFETs, the Si S/D epitaxy structure is replaced by a SiGe S/D epitaxy structure [13-15] for providing the channel strain engineering. These examples of architecture and material options can bring critical challenges of ESD reliability.

One measure of ESD performance in these new device structures is to characterize diodes as a way of assessing their impact. Prior research has shown the investigations of ESD diodes in SOI and bulk FinFET technologies [16, 17]. ESD diodes in bulk Si GAA vertically-stacked horizontal nanowires (NW) technology have been also reported [18]. In addition, the impact of the material options with SiGe S/D epitaxy on the bulk FF ESD diode performance has also been shown [15, 19]. In this article, the influence of the SiGe epitaxy stressor on bulk GAA NS ESD diodes will be disclosed.

IMPACTS OF NS AND SIGE EPITAXY ON ESD DIODE PERFORMANCE

Although the NS diodes have enlarged fin dimensions, they did not show any significant advantage on 100ns TLP *IV* characteristics, as shown in Figure 2 [20]. The wider fin structure in the GAA NS technology can prevent the current crowding inside the fin which should be beneficial to the *It2* enhancement. However, the *It2* results are relatively similar in these three different advanced CMOS technologies. Moreover, the NS ESD diode even has a higher *Ron*, compared to the NW ESD diode. The reason can be related to the differences in S/D epitaxy process options. This is not only due to the fin-to-wire or wire-to-sheet architecture differences, but also the S/D (or anode/cathode) epitaxy differences. It is important to note that the S/D (or anode/cathode) regions will still retain a “fin-shape” structure in GAA technology nodes.

One outcome in the architecture change from FF to GAA NW, due to a different fin height (H_{fin}) in these two technologies, is that the ESD diodes have different thermal behaviors. A taller fin structure usually has a large epitaxial volume on the anode and cathode regions [18]. This improves the thermal dissipation and results in less self-heating and lower *Ron* under 100ns TLP stress. However, this taller fin architecture with a reduced fin pitch can result in a smaller contact area at the S/D regions due to the S/D epitaxy growth and the middle-of-line (MOL) process modules, which can impact ESD diode failure levels, as illustrated in Figure 3. With a H_{fin} of 50nm and a fin pitch (P_{fin}) of 45nm, the S/D epitaxy growth between any two fins results in their adjacent epitaxy regions merging. This allows an increased area of the contact scheme in MOL local interconnect (LI)

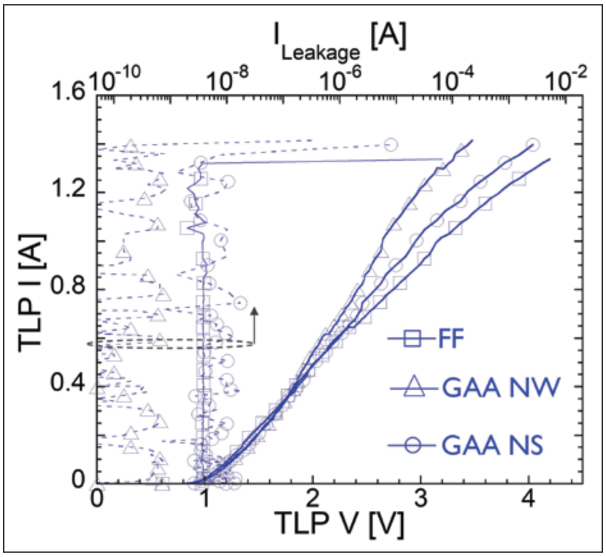

Figure 2: Measured TLP IV curves of the ESD diodes in three different technologies. They are bulk FF, bulk GAA NWs, and bulk GAA NS, respectively. The ESD diodes have exactly the same layout parameters [20].

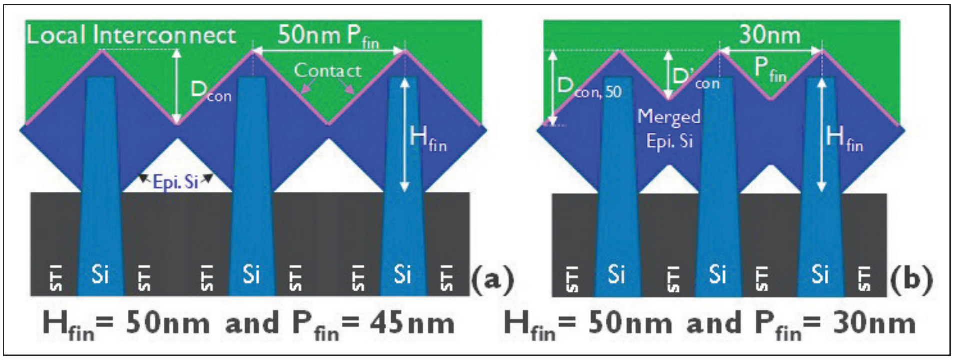

Figure 3: Schematic cross-sectional views at the S/D (or anode/cathode) regions with a fixed H_{fin} of 50nm but two different fin pitches (P_{fin}) of (a) 45nm and (b) 30nm. (b) Due to a further merged epitaxy structure, the contact depth (D_{con}) is reduced to a shallower contact depth (D'_{con}) between two fins in the ESD diode with the P_{fin} of 30nm [18].

processes, as shown in Figure 3a. The contact scheme depth (D_{con}) is defined by the top of a Silicon (Si) epitaxy structure and the bottom of a LI recess ending depth in ILD0 layer. With a reduced P_{fin} of 30nm, the Si epitaxy structure between two fins will be merged, resulting in a reduced contact depth (D'_{con}), as shown in Figure 3b. Taller fins with a further reduced P_{fin} will have more merged epitaxy volume. The contact scheme along the fin length has been shown to impact It2 [17]. The reduced D_{con} can be expected to bring a negative impact on ESD diode performance, increasing its thermal heating under ESD and hence lower failure current. Fortunately, the original fin pitch in sub-5nm GAA NS technology can be relaxed from the industrial 7nm/5nm FF technologies [10]. Therefore, the impact of S/D material options on ESD diode performance can be more critical in GAA NS technologies.

Different from the GAA NW diodes with their HDD-implanted Si epitaxy in both anode and cathode regions, the GAA NS diodes have the in-situ Boron doped SiGe (SiGe:B) epitaxy anode with a thin Si:B liner and the in-situ Phosphorus doped Si (Si:P) epitaxy cathode. The in-situ Boron doped Si (Si:B) liner is used to prevent the S/D SiGe:B epitaxy structures from being accidentally attacked by the SiGe etchant during the SiGe sacrificial layers etching process (which is needed for releasing the stacked NS structures). This Si:B liner further brings an additional benefit to ESD diodes, as presented in [15, 19, 20]. However, this Si:B liner might be removed in future GAA NS technologies with inner spacer process options. Moreover, the SiGe epitaxy anode of the GAA NS ESD diode can degrade the local thermal dissipation, which can deteriorate the ESD diode performance, for example resulting in its increased *Ron*, as shown in Figure 2. The S/D process options in next-generation transistors become more crucial to ESD diode performance in future technology nodes.

UPCOMING ESD CHALLENGES IN DTCO AND EVEN STCO SCALING ERA

Recently, an improved GAA transistor implementing a fork-shaped architecture has been proposed to further reduce the spacing between the p-type and n-type MOSFETs in a standard cell design, as shown in Figure 4 [21, 22]. Thanks to this minimized n-to-p spacing, the novel fork-sheet (FS) device architecture can offer superior area and performance scalability over the NS architecture [21]. In addition to the promising GAA FS technology, the complementary FET (CFET) which consists of "folding" the n-type MOSFET on top of the p-type MOSFET can provide a high level of scalability by fully eliminating the n-to-p separation bottleneck, as presented in Figure 4. It can reduce the standard cell active area footprint by ~50%. More design-technology co-optimization (DTCO) scaling options, such as buried power rail (BPR) and back-side power delivery network (BS-PDN), have been also proposed as scaling boosters in future logic CMOS technologies [21]. However, ESD reliability has not yet been evaluated, and building efficient ESD protection devices may be challenging for these DCTO scaling options.

Finally, the concept of system-technology-co-optimization (STCO) has been proposed. It can further enhance not only the (sub-)system functional performance but also can increase the diversities of functionality by hetero-system 3D integrations. However, due to the placement of these novel ESD protection strategies in these architectures, the present

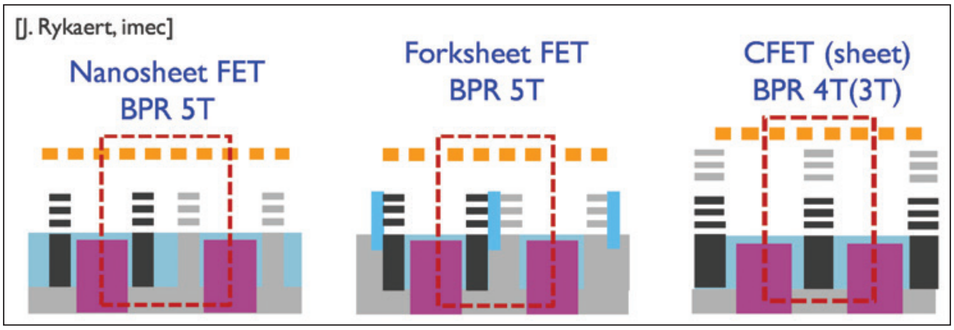

Figure 4: Design-technology co-optimization (DTCO) scaling options with various transistor architectures are proposed to obtain the full benefits of transistor scaling at the cell level [21].

methodologies described in ESDA component-level testing standards do not describe a process to verify ESD requirements for interconnects in the STCO scaling era of nano-scale die-to-die, die-to-wafer, or wafer-to-wafer 3D stacking options. The EOS/ESD Association Standards Working Groups have been well aware and are working with the industry to better describe the upcoming requirements and techniques of ESD verification for the STCO scaling option with its 3D multi-chip stacking technologies.

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342 Spectrum reallocation to reduce interference with emergency services radiocomms

26 January 2005: Philadelphia FOP Wants Radios Replaced; failures characterized as possible life-or-death issue. In a follow-up to a story reported earlier on Interference Technology's website, major news outlets in the Philadelphia metropolitan area report that the head of the city's Fraternal Order of Police (FOP) has called on city officials to replace the two-and-a-half-year-old Motorola police radio system because of repeated communications failures. A report from an independent consulting firm hired by the city cited possible interference from wireless telecoms Nextel Communications and Cingular Wireless. City officials expressed reluctance to scrap the $52 million dollar system and expressed hope that the FCC's proposed spectrum-swap for Nextel would help alleviate the problem. Meanwhile, FOP officials warned that their next press conference could bring very tragic and sobering news if the problems go uncorrected.

11 February 2005: Nextel, FCC Agree to Spectrum Swap to Solve Long-Standing Interference Issues. In an historic agreement, Nextel Communications will receive a new swath of spectrum from the FCC in exchange for ceding its former spectrum in the 800-MHz band. Nextel will also pay to reconfigure the airwaves it currently occupies. Presumably, this pact will put an end to the complaints from numerous public safety agencies that Nextel's signals interfere with and sometimes drown out vital police and fire radio communications. The agreement was announced by FCC Chairman Michael Powell and Nextel President Tim Donohue. Powell hailed the solution to a problem that he termed, "difficult, complex, and challenging." Donohue characterized the resolution as, "simply the right thing to do for first responders, homeland security, and for Nextel."

Specifically, Nextel will move its remaining spectrum in the 800-MHz band, bundle it together, and move it further away from the airwaves used for public safety broadcasts. The public safety broadcasters will be located next to each other within the band. Nextel will also receive new spectrum in the 1.9-GHz band, where other major wireless telecoms are located. The new spectrum is valued at $4.8 billion, which Nextel must pay the FCC; but the telecom will receive a $2 billion credit for the spectrum it is returning. Nextel will also receive a credit for the relocation costs it incurs; these costs have been estimated at $1.3 billion. The transition is to begin immediately and should be completed in about three years. For the official announcement, go to http://www.fcc.gov.

(From Interference Technology E-News, 26 January 2005 and 11 February 2005. For the background to this issue see Banana Skin No. 281.)

343 'Broadband over power line' (PLC) will interfere with radio astronomy

Sharing studies between the radio astronomy telescopes and the power line communication systems in the HF region. Summary: Radio Astronomy has frequency allocations in 13.36-13.41 MHz and 25.55-25.67 MHz on a primary basis worldwide. These bands are extensively used by radio astronomers to observe electromagnetic waves emitted by the Sun, the Jupiter and other large, gaseous planets in the solar system. The powers from a single Power Line Communication (PLC) system in the above radio astronomy bands are -33 dBW and -29.2 dBW respectively and therefore the PLC systems seem to be a harmful interference source for the radio astronomical observation in the HF band.

It is necessary to keep an adequate separation distance to avoid harmful interference to the radio astronomy telescope, and we calculated the separation distance based on the free-propagation method. We obtained a value of 424 km. If the PLC system is widely deployed, it is sure that the interference level increase greatly and the separation distance will become much larger. Thus it was recognized that it is quite difficult to share frequencies with the PLC systems and radio astronomy telescopes, at least, in Japan, and that a new technology to dramatically reduce leaked emissions from the power lines are crucial for the PLC systems to coexist with other radiocommunications services. Authors: by M.Ohishi, J.Nakajima and M.Tokumaru

(The above was extracted from: http://www.arrl.org, June 2003. Concerned radio astronomers should also see Banana Skin No. 272.)

344 Interference from lighting is an ever-increasing threat

Standard CISPR15 (EN 55015) is a special product family standard for electrical lighting and similar equipment that has served the market well for many years, but in recent times the incidence of interference from lighting has increased [1]. This has coincided with technological developments in the lighting industry [2]. With the increasing pressure for more energy efficient lighting [3] and because of requirements for more energy labeling of household lamps [4], there will be an increase in the use of technologically advanced lighting. This is the reason, why CISPR15 has been seen to be insufficient and it is under revision.

Unlike the generic standards and most other product family standards, CISPR15:2000 contains no requirements for radiated emissions from 30MHz to 1GHz. Also in Finland, it has been found that some lighting appliances are causing harmful interference to radio communications on the VHF band. Therefore these lamps and luminaires are not in compliance with the EMC Directive (EMCD), although they might fulfil the requirements of CISPR15.

Energy saving lamps (ESLs) are typical sources of interference to TV VHF broadcast receivers and also to private radiotelephone networks on the VHF band [2], [1]. Finnish EMC market surveillance authorities, the Safety Technology Authority (TUKES) and the Finish Communications Regulatory Authority (FICORA) have received several interference complaints concerning ESL bulbs. In 2003, FICORA solved ten interference cases caused by ESLs. It is likely that these kinds of interference cases will increase in future. Fig. 1 shows the measurement results from an ESL that was intended to be used in a new conference hall in Tampere, Finland. These kinds of lamps were installed throughout the building. Radiated interference from these lamps was so high that it was not possible to use VHF radiotelephones inside. All ESLs were then replaced. The bandwidth of the interference was about 50MHz (-30 dBc points) and the interference occurred on the frequency band 159 – 209 MHz. In Finland, this band is sued by many different radio services including emergency services (police, fire brigade, ambulance services, etc.).

TUKES has also received other complaints concerning interference cases caused by ESLs. Typical equipment being disturbed has been, for example, the remote control of TVs or narrow band in-house telecommunication networks using domestic 50Hz/230V electricity mains wiring. The disturbances between TVs and their remote control equipment was mostly caused on the infrared band, for which there are no requirements at all. In local telecommunication cases, conducted EMI from ESLs made it unable to use domestic electricity wiring as media for signal transmission. Also, other fluorescent lamps have caused both kinds of disturbance.

Finnish market surveillance test results with regard to ESLs have been a little better than those from Germany. According to Finnish tests, 43% of ESLs do not fulfil the standard. In Germany, 48% has failed. In ten cases, emissions from ESLs were so high that TUKES was obliged to restrict the distribution of the lamps (sales bans). Surprisingly, defects were found to be equally distributed between inexpensive and expensive ELS models.

Also in the USA, surprisingly high conducted emissions from some ESLs have been measured in the band 450kHz to 2MHz. The need for measuring was prompted by problems with AM radio reception while ESLs were in operation, and levels approaching 100dBμV occurred at the low end of the MF band. At 1.7MHz, the levels were more reasonable, but were still in the region of 70dBμV. The majority were reported as very high-order harmonics of the supply frequency, which suggest that the rectifier should have had shunt capacitors and/or soft recovery diodes. If these emission levels are common, where does that leave the troublesome subject of power line communication? It seems to both provide a case for relaxed limits and an indication that communication may be compromised by the very emissions that support that case! [6]

As serious problem seems to be that the ESLS originating from the Far East do not have uniform quality and quality can vary a lot between production runs. The high number of lamp and luminaire manufacturers in the Far East leads to competition between factories. There is a ready buyers market and factories are prepared to do nearly anything in order to keep their clients satisfied. It became apparent from project interviews that the importer himself could mar the quality of products e.g. through over negotiating the price down too much.

An open European market makes the importation business easy. It also tempts unskilled businessmen with dreams of big profits, and they usually make so-called 'one-off' business deals. They import a few containers of products from the Far East, distribute them quickly on the market, and then disappear. Such kinds of business change the price structure of the market, which impedes the operations of those importers who take care of their reputations by being responsible businesspersons.

The most troublesome interference case in Finland concerning metal halide lamps (MHLs), occurred in relation to a public swimming pool. The rated life time of the type of MHLs used was 10,000 hours usage, but after 2,000 hours, the sparking interferences of the lamp's electrodes during normal operation caused serious interference to TV receivers in a neighboring house.

When the lamps were exchanged for new ones, the event repeated itself after about 2,000 hours. One regrettable detail was that the pool had to be once again emptied before it was possible to change the lamps.

In Finland, there has been one very serious interference case caused by a single rechargeable torch model. After about half a year's use the regulatory circuit together with the battery began to oscillate causing serious interference to one TV channel. Before identification of this problem source, many interference cases were noted all around Finland. In fact, this could be considered to be more of a battery-charger problem than a lighting interference one.

The four halogen sets we tested in 2002, fulfilled all the other testing, but they had enormous difficulties with mains harmonic currents. According to measurements made by the Swedish Authority, halogen lighting sets powered by an 'electronic transformer' might cause radiated interferences. Also, [2] supports Swedish views. It seems that almost all plasma lights do not fulfil the requirements for conducted emissions. However, they have not yet caused serious EMC problems in Finland.

(Extracts from "Lighting Interferences – An Ever Increasing Threat!" *by Jyri Rjamäki, IEEE 2005 International EMC Symposium, Chicago, Aug 8-12, ISBN: 0-78-03-9380-5, pp 7-12. For more instances of interference from lamps and luminaires, see Banana Skins 19, 40, 58, 102, 158, 159, 171, 198, 218, 271 and 322.)*

345 Rice cooker interferes with pacemaker, plus other examples of interference

This is an excerpt from a monthly newsletter that sends out interesting news items. I don't believe this is an April Fools' item, but then who knows? A Japanese woman's automatic rice cooker changed the settings on her pacemaker. Doctors doing a routine check up were baffled to find that the hi-tech pumping device they had implanted in the woman, 60, had been remotely adjusted. They contacted the manufacturer, who visited her home and found that a rogue rice cooker had somehow beamed signals to the device.

[Source: A&A Economic Digest - April 2003 Edition, 1 April 2003] [Quite plausible, in light of previous reported cases of electromagnetic interference on pacemakers]

From ACM Software Engineering Notes back issues:

- Arthritis-therapy microwaves set pacemaker to 214, killed patient (S 5 1)
- Retail-store anti-theft device reset pacemaker, man died (S 10 2, 11 1)
- Pacemaker locked up when being adjusted by doctor (S 11 1)
- Electrocauterizer disrupts pacemaker (S 20 1:20)

And from RISKS:

- Stores' shoplifting gates can set off pacemakers, defibrillator (RISKS-20.05)
- Heart pacemaker and implantable cardioverter defibrillator recalls and alerts involve 520,000 devices (S 26 6:8, RISKS-21.60)

(Sent in by Simon Brown, who saw it on the RISKS-LIST: Risks-Forum Digest Friday 4 April 2003 Volume 22 : Issue 67, FORUM ON RISKS TO THE PUBLIC IN COMPUTERS AND RELATED SYSTEMS (comp.risks), ACM Committee on Computers and Public Policy, Peter G. Neumann, moderator. Archived at http://catless.ncl.ac.uk/Risks/22.67.html.)

346 Lightning strikes are a major cause of insurance claims in the U.K.

It is true that you are unlikely to be struck by lightning in the UK. But it may come as a surprise to know that around one-third of all insurance payments made by UK household insurers are compensation for damage caused by lightning strikes. Most of the damage is not caused by the direct strikes, but by the effects of more distant strikes. These produce voltage surges, most often on the mains electricity supplies, but also sometimes in telephone lines and other long cables.

(Taken from "When Lightning Strikes" *by Jim O'Connor in Electrical Engineering magazine September 2005, page 27, http://www.connectingindustry.com.)*

The regular "Banana Skins" column was published in the EMC Journal, starting in January 1998. Alan E. Hutley, a prominent member of the electronics community, distinguished publisher of the EMC Journal, founder of the EMCIA EMC Industry Association and the EMCUK Exhibition & Conference, has graciously given his permission for In Compliance to republish this reader-favorite column. The Banana Skin columns were compiled by Keith Armstrong, of Cherry Clough Consultants Ltd, from items he found in various publications, and anecdotes and links sent in by the many fans of the column. All of the EMC Journal columns are available at: https://www.emcstandards.co.uk/emi-stories, indexed both by application and type of EM disturbance, and new ones have recently begun being added. Keith has also given his permission for these stories to be shared through In Compliance as a service to the worldwide EMC community. We are proud to carry on the tradition of sharing Banana Skins for the purpose of promoting education for EMI/EMC engineers.

Advertiser Index

Upcoming Events

July 20-23
2021 ESD Workshop

July 27-August 13
2021 Joint IEEE International Symposium on Electromagnetic Compatibility, Signal & Power Integrity, and EMC Europe (EMC+SIPI 2021)

July 28
The Battery Show - Digital Express

August 16-18
DesignCon 2021

August 16-19
Military Standard 810 (MIL-STD 810) Testing Open Course

August 23-26
Military Standard 810 (MIL-STD 810) Testing Open Course

Due to COVID-19 concerns, events may be postponed. Please check the event website for current information.