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DEPARTMENTS

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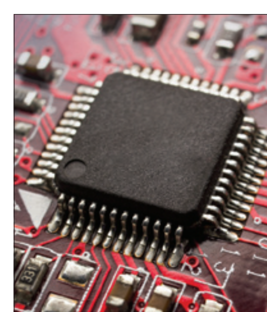


News in Compliance

FCC News

Verizon to Pay $7.4 Million for Violations of Consumer Privacy Rights

Telecommunications giant Verizon has agreed to a $7.4 million settlement with the U.S. Federal Communications Commission (FCC) in connection with the company's use of personal consumer information for marketing purposes.

The Federal Communications Act requires phone companies to protect the privacy of consumer information, and limits the use of that information for marketing purposes without the consent of the consumer. Companies such as Verizon often use an opt-in or opt-out process in their email marketing efforts to verify consumer consent, and must notify the FCC of any problems with its verification system within five business days.

According to the FCC's Enforcement Bureau, Verizon failed to generate the required opt-out notices in mailings to approximately two million consumers beginning in 2006. The failure was reportedly not detected until September 2012, but Verizon failed to notify the FCC until early 2013, more than four months after discovering the problem.

In addition to making a payment of $7.4 million (according to the FCC, the largest payment ever for settling a case involving the privacy of telephone customers' personal information), Verizon will also be required to adopt a stringent program to protect customer privacy and to monitor the effectiveness of that program.

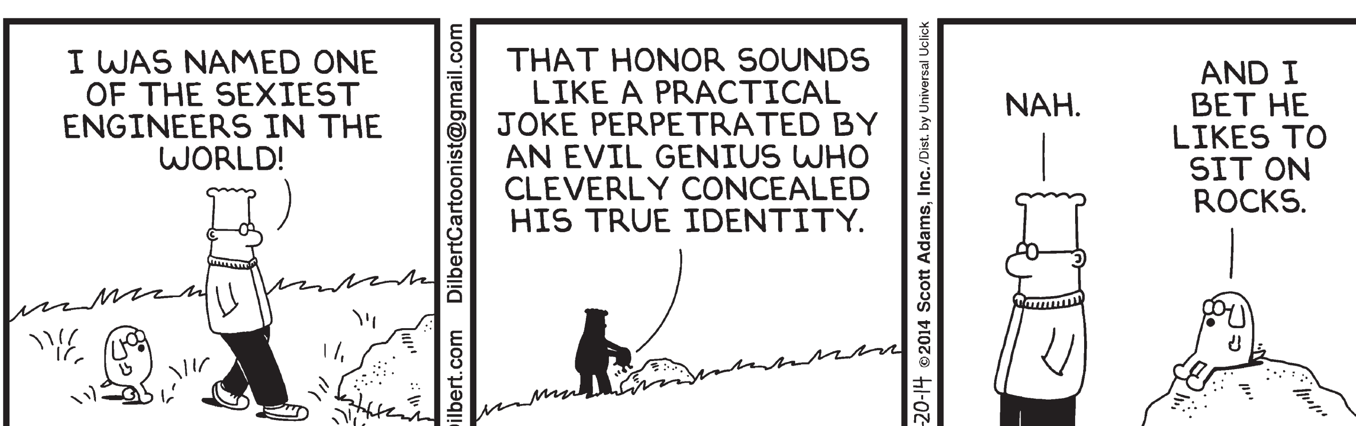
The complete text of the Commission's Consent Decree in connection with Verizon is available at incompliancemag.com/news/1411_1.

FCC Proposes $500k Fine Phone Card Privacy Violations

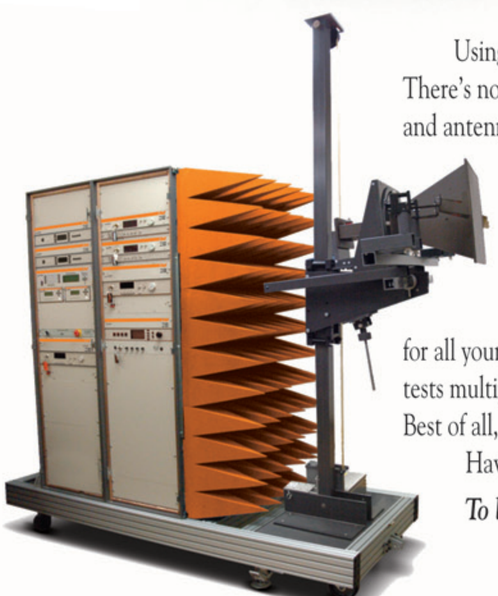
In a separate case, the U.S. Federal Communications Commission (FCC) has proposed a monetary forfeiture of $493,327 against a Pennsylvania-based company for numerous violations of the Federal Communications Act, including failing to protect the privacy of consumers.

In a Notice of Apparent Liability for Forfeiture issued in September 2014, the FCC charged PTT Phone Cards, Inc. of Philadelphia with failure to comply with "virtually all" of it regulatory obligations over a three year period, including failure to protect private consumer information and failure to contribute to the Telecommunications Relay Service (TRS) Fund, intended to help people with hearing and speech disabilities place phone calls.

According to the FCC, PTT provided prepaid calling card services under the trade name *Star Pinless* between 2010 and 2014 without ever receiving permission from the Commission to provide international telecommunications services, nor without certifying that it had taken the necessary steps



System Components From Multiple Sources Can Be A Real Horror



Using products from different sources isn't just scary, it's expensive, risky and time consuming. There's no guarantee that components from different vendors, especially the RF/microwave amplifiers and antennas, will work together and provide the performance or field level that you require.

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News in Compliance

FCC News

to protect the private information of consumers using its prepaid cards. PTT also reportedly failed to file annual reports with the Commission that would support the determination of payments due to the TRS Fund as well as other regulatory payments.

The complete text of the FCC's Notice of Apparent Liability in connection with PTT is available at incompliancemag.com/news/1411_2.

Canadian National Railway to Pay $5.25 Million for FCC Licensing Violations

Canadian National Railway Company has agreed to a $5.25 million civil penalty to settle charges by the U.S. Federal Communications Commission (FCC) that the company failed obtain approval for the acquisition and operations of hundreds of wireless radio facilities in the U.S.

Canadian National Railway is a Montreal-based corporation that offers freight warehousing and distribution services throughout Canada as well as parts of the U.S. The company reportedly came into possession of FCC-authorized wireless radio services as a result of a series of rail service acquisitions in 1995. (Devices employing wireless radio transmissions are frequently used in the industry to ensure the safe operation of trains.)

However, a 2012 internal audit by the company determined that Canadian National had engaged in unauthorized transactions related to its wireless radio services since their acquisition. In addition, the audit determined that the company and its predecessor companies had constructed, relocated, modified or operated several hundred wireless facilities without FCC authorization as far back as 1990. A subsequent investigation by the FCC's Enforcement Bureau further documented hundreds of unlicensed wireless operations by the company.

According to the FCC, "the scope and duration of these unauthorized operations is unprecedented in the history of the Commission," thereby justifying what the Commission says is the largest civil penalty related to unauthorized radio operations and transfers of control.

The complete text of the Commission's Order in connection with Canadian National Railway is available at incompliancemag.com/news/1411_3.

European Union News

EU Commission Updates Standards List for R&TTE Directive

The Commission of the European Union (EU) has published an updated list of standards that can be used to demonstrate compliance with the essential requirements of Directive 1999/5/EC, covering radio equipment and telecommunications terminal equipment (R&TTE).

According to the Directive, 'radio equipment' is defined as any product capable of communication via emission and/or reception of radio waves. 'Telecommunications terminal equipment' is any device intended to be connected directly or indirectly to the public telecommunications network. The scope of the Directive also includes certain medical devices and active implantable medical devices.

The extensive list of Cenelec and ETSI standards was published in September 2014 in the *Official Journal of the European Union*, and replaces all previously published standards lists for the Directive. The revised list of standards can be viewed at incompliancemag.com/news/1411_4.

The R&TTE Directive will soon be replaced with the EU's new Radio Equipment Directive (2014/53/EU), with new requirements scheduled to come into full effect in June 2016. The completed text of the Radio Equipment Directive is available at incompliancemag.com/news/1411_5.

ARRL News

ARRL Says That Grow Light Ballasts Are Causing Interference

The ARRL, the national association for Amateur Radio, has lodged a formal compliant with the U.S. Federal Communications Commission (FCC), contending that ballasts used in certain models of grow lights are creating interference with amateur radio operations.

According to an article from the ARRL website published earlier this year, numerous amateur radio operators notified the ARRL of radio signal interference in the medium to high frequency bands between 1.8 MHz and 30 MHz, attributable to nearby grow lights and other RF lighting devices. Subsequent conducted emissions testing performed by the ARRL on specific ballast models showed emissions in the HF band that significantly exceeded FCC rules.

According to the ARRL, “the level of conducted emissions from (the tested) device is so high that…one RF ballast operated in a residential environment would create preclusive interference to Amateur Radio HF communications throughout entire neighborhoods.”

A copy of the ARRL’s testing report was sent to the FCC as part of its compliant, along with a request by ARRL’s General Counsel for immediate action by the Commission.

The complete text of the ARRL press release about the interference from grow lights is available at incompliancemag.com/news/1411_6.

(Thanks to *In Compliance* reader Wes Plouff for bringing this issue to our attention!)

News in Compliance

Product Recall News

Humidifiers Sold Through QVC Recalled

Great Innovations LLC of Miramar, FL has announced the recall of about 70,000 humidifiers sold exclusively through the QVC shopping channel and at QVC.com.

According to the company, water can enter the base of its Ultrasonic Clean Mist humidifiers, causing the circuit board to short circuit and overheat, and posting a fire hazard. Great Innovations has received 100 reports of humidifiers overheating, resulting in smoke and burning odors. However, there have been no reports of injuries or property damage.

The recalled humidifiers were sold through QVC television broadcasts in January 2014, and online at QVC.com from December 2013 to February 2014 for about $55.

Additional details about this recall are available at incompliancemag.com/news/1411_7.

Fire/Smoke Alarm Recalls

Siemens of Buffalo, IL is recalling about 9000 audible fire alarm bases manufactured in China by a Siemens affiliate and used with alarm systems sold under the Siemens, Desigo, Cerbenus and Faraday brand names.

Siemens says that the recalled alarm bases can fail to sound an alarm in the event of a fire, posting a risk of personal injury to consumers and property damage. The company has not received any reports of incidents or injuries related to the recall alarm bases, which were included with alarm systems sold through Siemens sales offices and authorized distributors and installers throughout the U.S. from February 2013 through June 2014.

Additional information about this recall is available at incompliancemag.com/news/1411_8.

In a separate recall, Walter Kidde Portable Equipment, Inc. of Mebane, NC has recalled about 1.2 million Kidde-brand hard-wired smoke and combination smoke/carbon monoxide alarms. Manufactured in Hong Kong, the recalled alarms could fail to alert consumers of a fire or a CO incident following a power outage.

The company says that it has not received any reports of incidents or injuries related to the recalled alarms, which were sold through big box retailers, electrical distributors

You Can't Make This Stuff Up

2014 Ig Nobel Prizes Announced

The 24th 1st Annual (not a typo!) Ig Nobel Prize ceremony was held in September 2014 at Harvard University's Sanders Theatre. Not to be confused with the Nobel Prizes scheduled to be announced in October in Stockholm, Sweden, the Ig Nobel Prizes are intended to "honor achievements that first make people laugh and then make them think."

This year's Ig Nobel Prize award winners this year included:

- For physics, Japanese researchers who determined the frictional coefficient between a shoe and a banana peel, and the banana peel and the floor;
- For neuroscience, scientists from China and Canada who studied the effect on the brains of people who see the face of Jesus Christ in a piece of toasted bread;
- For psychology, Australian, British and U.S. researchers for amassing evidence that people who routinely stay up late are more self-admiring and more manipulative than those who wake up early;
- And, for public health, researchers in Japan, the U.S., India and the Czech Republic for investigating whether owning a cat is mentally hazardous for humans.

Additional details of this year's winners are available at the website of Improbable Research (the humorous folks behind the Ig Nobel Prizes) at incompliancemag.com/news/1411_12.

Product Recall News

and online from January 2014 through July 2014 for between $30 and $50.

More information about this recall is available at incompliancemag.com/news/1411_9.

HP Recalls 6 Million Notebook Power Cords

Hewlett-Packard of Palo Alto. CA has issued a voluntary recall for nearly 6 million AC power cords manufactured in China and distributed for use with HP-and Compaq-brand notebook computers.

According to the company, the power cords can overheat, posing a potential fire and burn hazard to consumers. HP says that it has received 29 separate reports of power cords overheating and melting or charring, resulting in two claims of minor burns and 13 claims of minor property damage.

The recalled power cords were distributed with HP- and Compaq-brand notebook computers, as well as with mini notebook computers and accessories. These products were sold worldwide at computer and electronics stores and authorized dealers, as well as online at hp.com, from September 2010 through June 2012 for between $500 and $1500, depending on the product.

Additional information about this recall is available at incompliancemag.com/news/1411_10.

Playtex Issues Voluntary Recall of Breast Pump Power Adapters

Playtex Manufacturing, Inc has announced an expansion of its earlier voluntary nationwide recall of certain AC/DC power adaptors used with the company's Playtex-brand electric breast pump.

According to the company, the casing of certain production runs of the adaptors may come loose or separate, posting a risk of electric shock to consumers. Although the company has not received any reports of consumer injuries, it has expanded the recall "out of an abundance of caution."

The recall adaptors were manufactured from November 2012 through July 2013, and were distributed with the Playtex Nurser Deluxe Double Electric Breast Pump. The breast pumps were sold at specialty and online retailers nationwide.

Further details about this recall are available at incompliancemag.com/news/1411_11.

REALITY Engineering

Follow Your Nose

BY MIKE VIOLETTE

Olfactory nerves lie at the top of your nasal passages and their associated axons wind their way through holes in your skull to a spot just below the cerebellum. The business-end of these cells are covered with a thin layer of mucus and are exposed to volatile and non-volatile odors in the environment.

Through a complex chemical binding of odorants with proteins in the proto-boogers, olfaction signals are transported via tuned receptors and travel to the most inner mass of your brain, where they are decoded. By an involuntary response, whether smelling trouble—or romance—your head pivots upward to gather more of what's in the air: danger, delight, disgust or, sometimes, disappointment.

Amazingly keen, the whole smell system—when it's working correctly—can sense and discriminate concentrations of substances down to a few parts per million in an air awash with complex organic and inorganic molecules. A single smell can affect the smeller's response, associating scents with causes and events. (For the engineers of the unwashed variety that I have met on occasion, their own, er, natural miasma, may interfere with this function. It's no wonder we are a dateless bunch.)

Having a keen sense of smell is only the physical manifestation of connecting-the-dots, so to say, in the world of real engineering. In the non-physical sense we learn to discern what we're measuring, examining or observing can pass the *Sniff Test*.

A great deal of attention has been and is paid to the human sense of smell, one of the first senses to imprint on us from birth, and most strongly connected with our earliest memories. A defenseless infant quickly learns its mother's scent. The study of smell can be traced to the first century BC: Lucretius posited that different smells had atoms with different sizes and shapes. Naturally, the notion of atom was not our modern-but-evolving quantum mechanical view, but the idea is not too far off from what we understand about the nature of proteins binding on sense receptors. Remarkably and uniquely, the olfactory system relies on stem cell turnover.[1]

Smells and their association that embed in the permanent parking lot of the brain, now electro-chemical in nature, must first pass through the hippocampus to be stored in long-term memory. (We examined learning and memory mechanisms in *Training the Engineering Brain* in January 2013 of this periodical.[2])

Other senses—sight, sound, taste (largely driven by olfaction) and touch—contribute their own piece and an emotional coupling reinforces the link from an odorant to a place in time and space. The smell of cut grass, the whiff of a campfire, the aroma of cinnamon, a waft from a dank basement—all can trigger memory sensations in humans. For me, walking through old wooden houses and smelling the fermented air and resinous framing triggers memories of explorations of my aunt's mysterious attic, crammed with family relics and piles of long-forgotten toys, dusty discarded clothes and leaning stacks of hardback books. A walk on a rainy steaming late summer day in any given city can trigger Taipei: a little sweet, a little sweaty.

We can associate strong memories with complex odors; the powers of discrimination are wondrous. According to the Fifth Sense "Humans possess around 12 million

REALITY Engineering

Most of our community probably recall their first whiff of that distinctive electrical smell when the POP! of an over-stressed tantalum capacitor or the CRACK! of an overheated FET erupted an acrid smoke.

olfactory receptor cells that can detect approximately 10,000 odours"—nothing to sniff at—allowing us to sort oregano and oranges. Flavor experts (those with intrinsically more sensitive and discerning palates) craft custom drinks and tasty custom beverages. (http://flavorman.com/about-us/)

Lest our human hubris make us feel superior in the animal kingdom, however, consider canines' capabilities. Some breeds have up to 300 million receptors and can detect 40,000 different odors![3] The long nose—packed with olfactory receptors—knows. The only being that I know that has a more sensitive nose than a bloodhound is my wife, who can detect the smell of a smoke I had stubbed out two hours before. I wander in the room, and with just one whiff: "Did you have a cigarette???"

A NOSE FOR DATA

Most of our community probably recall their first whiff of that distinctive *electrical smell* when the POP! of an over-stressed tantalum capacitor or the CRACK! of an overheated FET erupted an acrid smoke. (My first experience of a self-inflicted electrical smell occurred at the tender age of eight: I tried to pry a stuck electrical plug out of an AC outlet with a quarter. Impressive were the two gouged molten edges along the serrated edge of the coin, O2 turning into a trace amount of O3) The Washington DC Metro elicits a memory of this: the energized third rail (at ~400V) is prone to occasional arcing and sparking as well.

After doing this compliance stuff for a while, one develops a sense of smell of another variety.

Having a *nose for data* is an acquired skill and we rely on the sniff test as part of a data-collecting activity. This acuity is garnered after hours of staring at the spectrum analyzer screen and plots of time and frequency domain data.

In reviewing measurement results, the question becomes: Does it pass the sniff test?

This skill also accrues to a savvy designer—practiced in reading schema, learning what works (and what doesn't), who can assess the probable outcome after a quick glance at a product or project and can tell when something *doesn't smell right.*

Although we are born with the capability to process chemicals in the olfactory, we must develop a sense of smell. Problems may arise when that sense is overwhelmed, ignored or starts to fail. It can sometimes be fatal.

A WHIFF OF DANGER

Air France flight 447 pancaked into the Atlantic Ocean on June 1, 2009 shortly after 2 a.m. UTC. Two hundred and twenty eight passengers and crew perished instantly (it is presumed, given the plane's vertical speed). Upon impact, the aircraft was performing perfectly (at least according to its design). The last set of data indicated that the plane "was flying due west with its nose 16 degrees up and its wings nearly level; thoroughly stalled, it was progressing at merely 107 knots, but its descent rate, despite full thrust, of 11,000 feet per minute. The impact was shattering."[4]

The plane, a nearly-new wide-bodied Airbus A330 with advanced avionics alarms, autopilot and every imaginable system designed to avoid human error, sank into deep water in the Intertropical Convergence Zone. Some wreckage and bodies were found quickly. After nearly a two-year search, the aircraft's flight data recorders were found in 13,000 feet of water (remarkable). Hours of inquiry and analysis of voice cockpit recordings and aircraft sensor data painted a picture of the last moments of the doomed plane and conclusions about the cause of the crash.

The flight took off and progressed normally for four hours with manageable weather along the flight path. The crew, with nearly twenty thousands of hours of flight time between them, apparently over-corrected when the pitot tubes—the forward portion of the pitot-static system that provide relative airspeed indication to the cockpit—froze over during a passage through an interlude of icing at 35,000 feet. With the erroneous airspeed inputs to the flight computers, the flight control system switched to alternate law 2, a mode that, among other things, disengaged the auto-pilot. Under control of the Pilot-Flying, the plane climbed to its maximum altitude of 38,000 feet and stalled. At some moments during the crisis in the cockpit, the nose of the aircraft was pitched up to forty degrees, an amazing attitude and well above the stall-angle.

What happened between the time of the initial airspeed errors and impact with the Atlantic is a fascinating, if tragic, read. It took just four minutes for Flight 447 to pass from straight and level flight to plummet seven miles into the water. The crux of the issue appears that the pilots swirled around in a spiral of confusion in the four minutes between the first erroneous inputs and the airplane's final moment. Errors in airspeed reporting overwhelmed the otherwise very experienced pilots.

Modern aircraft fly themselves after initial climb-out to near-final approach, but fewer and fewer pilots spend much time at the controls, apparently, and "It seems we are locked into a spiral in which poor human performance begets automation, which worsens human performance which begets increasing automation." It also seems that the increasing reliance on automation makes us lose our sense of smell.

It was not just the incorrect readings, however, that doomed Air France 447. Examination and inquiry pointed to several modes of fatal failure in "one of the most foolproof airplanes ever built." According to some analysis, some of the blame pointed to the lack of following protocol by the crew and a hierarchical culture that stifled critical communications. Part of the blame was assigned to faults in the human-machine interface and some, perhaps, due to the crew relying on instruments and not on their noses.

This is indicated in the lab, too, where automated measuring equipment decouple the engineer from the physical quantity: Press Button, Get Result. One should always ask: Does what I'm looking at *smell right*? If not, have another look, run another test, check the cable, the calibration, the settings. Sometimes, losing your sense of smell, or ignoring it, can lead to big problems.

THE END, BY THE NOSE

Recent research connects our sense of smell to our own mortality.

This is indicated by findings from the University of Chicago, which conducted a study of the *smelling capability* of 3000 middle-aged and older subjects. They were asked to assess and discern the differences between various odors.[5] The researchers "hypothesized that olfactory dysfunction could be an early integrative indicator of impending death."

Basically, the study found that deterioration in the olfactory was a strong predictor of mortality in the next five years.

A physical sniff test, using real smells, can be administered to see if one's olfactory is functioning correctly. This study gave a smell test (and yes, there are standard smell test kits) to the study's participants. This test consisted of administering a set of smells to the subjects asking two basic questions: 1) can you smell it? 2) what does it smell like?

Subjects with low smell recognition/ability are deemed *anosmic*. *Hyposmia* is normal to above-average smell capability. After bench-lining the participants, the researchers followed up five years after the study to determine the fate of those who were attached to all of those noses.

After adjusting the data for age and gender, it was found that anosmia accounted for a higher indicator of mortality within five years than heart disease, stroke, diabetes, heart attack and cancer. The loss of sense of smell was the highest predictor (not necessarily the cause) of all major diseases! The researchers' conclusion points out that "believe olfaction is the canary in the coal mine of human health, not that its decline directly causes death." If you find yourself running around asking "what's that smell?" you may just have a nice long life.

OOH THAT SMELL

It is important to develop a keen sense of smell: it first aids us in survival and it can steer us away from problems. But it may be fatal if it fails you or you fail it. By any measure, it is often best to follow your nose.

ENDNOTES

1. "Olfactory Dysfunction Predicts 5-Year Mortality in Older Adults": http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0107541
2. http://www.incompliancemag.com/DigEd/inc1301
3. http://www.fifthsense.org.uk/what_is_smell/how_smell_works/
4. "The Human Factor." William Langewiesche. *Vanity Fair.* October 2014.
5. c.f. 1

(the author)

MIKE VIOLETTE

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TECHNICALLY Speaking

The Hi-pot Test

Product Safety Newsletter - May/June 1989

BY RICHARD NUTE

The hi-pot test is another safety subject of which few of us feel comfortable that we are in control. What is the purpose of the hi-pot test, and what hazard does it address or obviate?

First, each of the standards seems to have its own unique voltage which differs from all the other standards. As if this was not enough, it often seems that each of the various test houses has its own unique voltage regardless of the standards. What voltage should we use?

And, why is the voltage so high compared to the working voltage?

Next, we are often given our choice of waveform, either ac or dc. More recently, a third waveform, the 1.2 x 50 µsec impulse, is appearing in some standards. What waveform should we use?

Then, we must select the duration or time of the test. The conventional time is one minute. Some standards allow a shorter time, but a higher voltage. What duration should we use?

For the impulse test, duration is measured in number of impulses applied to the equipment under test. One standard is proposing three positive impulses and three negative impulses, with no more than one second between applications.)

Some standards specify different voltages and times depending on whether the test is a type test or a routine test. (A type test is the test done during the safety engineering investigation of the product, and the routine test is the test done on the production line.) Why do the voltages and times depend on whether the test is an engineering evaluation test or a production-line test?

Some standards specify a maximum rate of rise of the test voltage. Why?

Another concern that is not usually addressed, and often does not appear in hi-pot tester specs is output current. How much current does the hi-pot tester need to put out?

Finally, how do you know when you have a hi-pot test failure? And, what should you do when you have a hi-pot test failure? What does the failure mean, and what should you do about it?

Have you ever had your friendly certification house inspector (field representative) ask you to prove that your hi-potter can detect a failure? How do you know your hi-potter will truly trip when it detects a legitimate failure?

Often, there is concern that the hi-pot test will damage sensitive semiconductors or other components in the equipment under test. Is this true, and what can you do to prevent damaging your newly built expensive product?

Exactly what is a hi-pot test?

In its simplest form, the hi-pot test applies a relatively high voltage between two conductors which are separated by insulation. The insulation is supposed to withstand this voltage without breaking down. If it withstands the voltage without breaking down, the insulation is said to have adequate or acceptable electric strength (or dielectric strength).

In practice, the hi-pot test applies a voltage between two sets of conductors, the primary circuit and the grounding circuit, which are separated by various insulations.

The hi-pot test is also often applied between the primary circuit and low-voltage secondary circuits. But, since low-voltage secondary circuits are usually grounded, the primary-to-ground test also tests the primary-to-secondary insulations, and only one test need be performed.

(In some cases, it is necessary to disconnect the secondary from ground, and perform a primary-to-secondary hi-pot at a higher voltage, and with the equipment under test ground open.)

Thus, the hi-pot test is a test of the insulation surrounding the primary circuits. The insulation surrounding the primary circuits is essential to providing protection against electric shock from the primary circuits. Therefore, the successful hi-pot test is one measure of the adequacy of one of the equipment's mechanisms providing protection against electric shock.

Some of my colleagues will claim that the insulation surrounding the primary circuits also provides protection against electrically-caused fire from the primary circuits. Therefore, the successful hi-pot test is also one measure of the adequacy of one of the equipment's mechanisms providing protection against electrically-caused fire. (I have yet to sort out this issue to my personal satisfaction; I cannot argue against it, so I include it as if it were a legitimate issue. Perhaps my readers would offer their views on the relationship of electric strength of insulation to electrically-caused fires.)

There are two purposes for the hi-pot test. The purpose of a type test is quite different from the purpose of the routine test.

The purpose of the type test is to determine that the design engineer covered all his bases. In order to pass

TECHNICALLY Speaking

When I do a hi-pot type test, I not only determine that the unit passes the specified voltage, I also increase the voltage beyond that value until I get a breakdown. Then, I band-aid that point so it won't break down.

the hi-pot test, the design engineer must make sure that the distance between the primary circuit and the ground circuit at every point meets the spacing requirements in the standard. In addition, he must make sure that the various solid insulations that are interposed between the primary circuits and the ground circuit are thick enough so that they have more than enough electric strength to withstand the test voltage. He must do the same for the spacings and solid insulations between the primary circuits and the low-voltage secondary circuits, and, indeed, all of the insulation surrounding the primary circuits. (Note that spacings are a form of insulation.) If the design engineer does all these, the unit will pass the hi-pot test first time through and without any difficulty.

When I do a hi-pot type test, I not only determine that the unit passes the specified voltage, I also increase the voltage beyond that value until I get a breakdown. Then, I band-aid that point so it won't break down and continue increasing the voltage until I get the next breakdown. I continue this process until I get up to two or three times the required hi-pot test voltage. I like to know what are the weakest links in the insulation system so that if I should have a breakdown in my routine testing, I have a leg up on what might be breaking down and why. The results of such testing may identify some production-dependent processes that may cause the withstand voltage to decrease.

The purpose of the routine test is to determine that the production folks covered all their bases. In order to pass the hi-pot test, the production folks must make sure that they made it like the design engineer designed it. Unless the type test was marginal, the routine test, in the end, finds gross defects in the manufacturing process. It is really difficult to set up a hi-pot test to find marginal defects in the manufacturing process; if you did so, production folks would be continually testing and tweaking to get each unit to pass, and the process could be out of control insofar as assuring that any particular unit would retain its withstand capability for any length of time. So, for all practical purposes, the routine test is to find gross defects. (Some standards recognize this fact by allowing a lower hi-pot voltage for routine tests than that required for the type tests; since we are looking for gross defects, a few hundred volts difference out of a thousand or more is insignificant. Later, we'll discuss why a lower voltage is desirable for routine tests.)

How do you find where the breakdown is occurring?

Most of the time, this is obvious: you can see the arc. But, sometimes you can hear it, but you can't see it. And, sometimes, it only trips the hi-pot tester, and you can't see or hear it. Ultimately, you have to see the arc to know where the breakdown is occuring. What do you do to find the breakdown?

The trick is to narrow down the components or pieces until you are able to isolate the insulation or air-gap that is breaking. One method is to remove components from the assembly, one at a time, each time re-testing the assembly to see if the breakdown is still in the assembly or went with the component. I set the trip point on the hi-pot tester to minimum so as to limit the damage and establish repeatability. I also adjust the voltage manually to creep up on the breakdown.

Besides setting the hi-pot to its most sensitive trip, I sometimes add a 10 k to 100 k resistor in series with the output so as to limit the current and therefore the power. This, too, limits the damage done by the hi-potter to the insulation, but still allows you to see what is happening and repeat the test over and over again. This only works if the current is in the tens of microamperes during the hi-pot test; otherwise, there is too much voltage drop across the resistor, and you may not get enough voltage to see the breakdown.

Later, we'll discuss why there may be high current during the hi-pot test, and what you can do to reduce the current during troubleshooting.

Still another technique of finding the breakdown is to use an ultrasonic translator. If your company is lucky enough to own one of these, I advise you to latch onto it. (Hardly anyone else in your company will have any use for it; you should get it before it is discarded!) The ultrasonic translator is an ultrasonic microphone with a heterodyne circuit which translates the ultrasonic frequencies to the sonic frequencies. Insulation breakdown is preceded by partial discharge which

> I like to know what are the weakest links in the insulation system so that if I should have a breakdown in my routine testing, I have a leg up on what might be breaking down and why.

produces lots of ultrasonic noise. The ultrasonic translator allows you to hear the partial discharge long before it results in a breakdown. The microphone can be fitted with a flexible tube which can be used to search small areas for sounds of breakdown.

What should be the value of test voltage, and where does the value come from?

Simply, the electric strength of the insulation must be greater than the applied or working voltage. But, how much greater?

Answer: Any value greater than zero.

Why, then, do we test 120-volt circuits at anywhere from 900 volts to 4000 volts?

Answer: Mains or primary circuits normally have transient overvoltages on them; the electric strength of mains or primary circuits must be greater than the greatest transient overvoltage that might occur on the building power wiring. Otherwise, the insulation may fail when a transient occurs.

So, the hi-pot test voltage must be greater than the greatest transient overvoltage that can occur.

What is the greatest value of transient overvoltage?

The answer to this question is sort of like: Which came first, the chicken or the egg? The failure of insulation under transient overvoltage conditions limits the value of the transient overvoltage! So, if we have a low value of electric strength, then we will have corresponding low value of transient overvoltage. And, if we have a high value of electric strength, we will have the natural values of transient overvoltages. These natural values arise from switching inductive loads on and off the system, where the back-EMF goes into the power line. The natural values are related to the value of the inductance, the current through the inductance, and the aggregate load impedance at the point the transient is generated.

However, when the insulation fails, we either have a hazardous condition, or the circuit breaker pops open. So, we don't want a low value of electric strength.

Again, what voltage is appropriate?

Answer: In the old days, the traditional value for the hi-pot test was 900 volts. Gradually, this increased to 1000 volts. And then, the familiar formula, 2V + 1000, gave us 1250 volts for a 125-volt rating.

There are many papers published on studies of overvoltages in household and commercial power distribution circuits. One of the most recent is Transients on the Mains in a Residential Environment, by Ronald B. Standler in IEEE Transactions on Electromagnetic Compatibility, May 1989.

These studies boil down to identifying the maximum transient overvoltage as 1500 volts peak, and a duration less than ten microseconds. (The new impulse test was formulated from these studies to more closely test insulations under actual conditions of use.)

In practice, if you follow the spacings specified in the various standards, and if you choose UL or CSA certified solid insulating materials, you end up with spacings with electric strength in the order of 5000 volts rms, and solid insulation worth about 5000 volts rms.

Almost any solid insulation is worth 3000 volts rms; one wag once said that two layers of Mr. Whipple's squeezingly soft Charmin will pass 3000 volts!

It turns out that the standards for component insulations such as wire and transformer papers require electric strengths in the order of 5000 volts rms.

So, there is lots of margin built into almost every primary circuit insulating system. The actual breakdown potentials should be three or four times the worst-case peak transient voltage, 1500. This agrees with my personal experience.

Once again, what voltage is appropriate? Since the spacings and solid insulations should have several times higher dielectric strengths than those specified for the hi-pot test, the actual voltage or its waveform is not critical, and should only show up gross design or manufacturing errors.

A 1000-volt rms hi-pot very nearly covers the worst-case overvoltage (1000 volts rms = 1414 volts peak). 1000 volts rms and 1414 volts peak are

TECHNICALLY Speaking

the withstand voltages; the breakdown voltage should be considerably more than the withstand voltage. So, 1000 volts rms or 1500 volts peak or dc or impulse should be adequate to test whether the insulation has any gross errors. Furthermore, when the test voltage is low compared to the breakdown voltage of any part of the system, the waveform and duration of test are insignificant.

These preceding rules-of-thumb do not apply when the dielectric breakdown voltage of any component of the system is less than twice the hi-pot test voltage. As the hi-pot voltage approaches the breakdown voltage, we see the inception of partial discharge in the solid insulation. Experts report that this inception of partial discharge is also the first step in the catastrophic dielectric breakdown of solid insulation. Therefore, for routine hi-pot testing, it is imperative that the test voltage be less than the partial discharge inception voltage—unless the waveform is the impulse, and the number of impulses is limited.

Fortunately, with primary insulations we commonly use, and with the relatively low hi-pot voltages, we are usually well below the partial discharge inception voltage. However, this is a good reason to use the least practicable voltage for the routine hi-pot test.

Partial discharge is not only a function of voltage, but also a function of the time the voltage is applied. Therefore, it is prudent to use the least time practicable for the routine hi-pot test.

What current does the hi-pot tester need to supply?

The answer depends on whether the hi-pot tester is dc, ac, or impulse.

As a general rule, during the hi-pot test, the equipment under test appears to be a resistor and capacitor in parallel connected between the primary circuits and the ground circuit. The current required from the hi-pot tester depends on the values of the resistor and capacitor. The hi-pot tester must have enough current to develop the required voltage across the resistor-capacitor load.

The resistor is the insulation resistance and is of the order of 100 megohms or more. The capacitance is the natural capacitance that exists when two conductors are separated by an insulator and, for primary-to-ground, is typically in the range of 0.001 uF to 0.0025 uF depending on primary circuit complexity and excluding any line filter. With a line filter, the capacitance may be as high as 0.02 uF.

Thus, the hi-pot tester must be capable of at least:

$$\text{I1} = \frac{E1}{R(insulaion)} + \frac{E1}{X(capacitance)}$$

where

I1 is the required hi-pot tester output current,

*E*1 is the hi-pot tester output voltage,

R (insulation) is the insulation resistance, and

X (capacitance) is the capacitive reactance.

For example, if your product had an insulation resistance of 100 megohms, a capacitance of 0.0025 uF, and hi-pot test voltage 1500 volts rms, the required hi-pot tester output current would be:

$$\text{I1} = \frac{1500}{100\ Megohms} + \frac{1500}{X(0.0025\mu F, 60\ Hz)}$$

$$\text{I1} = 0.015 + 1.5$$

$$\text{I1} = 1.515 \text{ milliamperes}$$

The same product with a line filter would require about ten times the natural current, or about 15 milliamperes at 1500 volts. When I'm evaluating a design, I often disconnect the line filter line-to-ground capacitors as they usually are not the culprits I'm looking for. After I remove these caps, I'm testing insulation, and I can better assess what is happening.

Here's another way of calculating how much current the hi-pot tester must supply. If you examine the circuits for the hi-pot test and for the neutral-open, power on leakage current test, you will find that they are identical. The required current for the hi-pot tester is proportional to the equipment leakage current, and can be predicted from the following information:

$$\text{I1} = \frac{E1}{E2} \times \text{I2}$$

where

I1 is the required hi-pot tester output current,

*E*1 is the hi-pot tester output voltage,

*E*2 is the line voltage at which leakage current was measured, and

I2 is the maximum measured leakage current.

For example, if your product was rated 120 volts, leakage current 0.5 mA maximum, and hi-pot test voltage 1500 volts, the required hi-pot tester output current would be:

$$\text{I1} = \frac{1500}{120} \times 0.5$$

$$\text{I1} = 6.25 \text{ milliamperes}$$

If you're using a dc hi-pot tester, you need to be concerned with the rate-of-rise of voltage. You must charge the capacitance that is in the circuit, and it takes current to do that. The charging current is given by the relationship:

$$\text{I (charging)} = \frac{dV}{dt}$$

Rearranging terms, if we know the value of capacitance, C, and the maximum hi-pot tester output current, we can calculate the maximum rate-of-rise of voltage.

$$\frac{dV}{dt} = \frac{\text{I(charging)}}{\text{C}}$$

If your dc hi-pot tester puts out 0.5 microamperes as mine does, and the capacitance of your product is 0.0025 uF, then the maximum rate-of-rise is:

$$\frac{dV}{dt} = \frac{0.5\ \mu\text{A}}{0.0025\ \mu\text{F}}$$

$$\frac{dV}{dt} = 200\ \text{volts/second}$$

If your test voltage is 1500, then you must take at least 7.5 seconds to raise the voltage from 0 to 1500. If you do it faster, either the hi-pot tester will trip, or the voltage won't go to 1500.

There is no corresponding limitation for an ac hi-pot tester.

Now the $64 question: At what current do you set the hi-pot tester trip for routine tests? Or, what current constitutes a failure?

We've already answered these questions. The trip current must be set above the current to develop the required voltage across the resistor-capacitor load. Since we are only looking for gross manufacturing defects, the actual value of the trip is not significant. It probably should be set for about 25% more current than that necessary for the resistor-capacitor load. Typical manufacturing defects are pinched wires and bent-over components. These kinds of defects result in really high current when breakdown occurs, so the trip current usually is not critical. It should be as low as practicable, but we're not making a precision measurement.

The hi-pot test is neither sophisticated nor precise. The trick to making it work for you is to understand what it tests, and how the hi-pot tester works.

How do you know your hi-pot tester is working? How do you know it will trip when it tests a bad unit?

Most hi-pot testers have a voltmeter on the output which is good enough to indicate the presence of voltage.

But, how do you know the trip circuit is working? We apply the voltage to a resistor which can be switched into the circuit after the hi-pot tester reaches its output voltage. Just a simple box with a resistor and a switch will suffice. What value resistor? If you know the output current at which you set the trip point, you can calculate the value of resistor which should trip the tester. We check our testers at the beginning of each shift.

What about damaging semiconductors and other components with the hi-pot test?

Semiconductors are damaged by either excessive voltage or excessive current. When the hi-pot test is successful, there is no current (except as described earlier). So, there should be no semiconductor damage when the test is successful. But, when an insulation fails, we have current from a high-voltage source which, depending on the current path, will indeed damage the semiconductors. The answer is to make sure your product has a good primary-to-ground insulation system, and you won't have any failures.

There are reports that line filter capacitors can be damaged by the high test voltage. These fellas are supposed to be designed for such application and, if they are of good quality, should easily withstand the test voltage without any untoward effects.

The hi-pot test is neither sophisticated nor precise. The trick to making it work for you is to understand what it tests, and how the hi-pot tester works. I hope my comments have helped you better understand both of these.

(the author)

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is a product safety consultant engaged in safety design, safety manufacturing, safety certification, safety standards, and forensic investigations. Mr. Nute holds a B.S. in Physical Science from California State Polytechnic University in San Luis Obispo, California. He studied in the MBA curriculum at University of Oregon. He is a former Certified Fire and Explosions Investigator.

Mr. Nute is a Life Senior Member of the IEEE, a charter member of the Product Safety Engineering Society (PSES), and a Director of the IEEE PSES Board of Directors. He was technical program chairman of the first 5 PSES annual Symposia and has been a technical presenter at every Symposium. Mr. Nute's goal as an IEEE PSES Director is to change the product safety environment from being standards-driven to being engineering-driven; to enable the engineering community to design and manufacture a safe product without having to use a product safety standard; to establish safety engineering as a required course within the electrical engineering curricula.

Voltage and Field Strength

Part 2: Conductors

BY NIELS JONASSEN, sponsored by the ESD Association

Screening noncontacting meters will often reduce the field distortion caused by the presence of meters.

INTRODUCTION

Associate Professor Neils Jonassen authored a bi-monthly static column that appeared in *Compliance Engineering Magazine*. The series explored charging, ionization, explosions, and other ESD related topics. The ESD Association, working with *In Compliance Magazine* is re-publishing this series as the articles offer timeless insight into the field of electrostatics.

Professor Jonassen was a member of the ESD Association from 1983-2006. He received the ESD Association *Outstanding Contribution Award* in 1989 and authored technical papers, books and technical reports. He is remembered for his contributions to the understanding of Electrostatic control, and in his memory we reprise "Mr. Static".

~ The ESD Association

Anyone who has worked with static or dynamic electricity is familiar with the concept of voltage. After all, Ohm's law states that $V = R \cdot I$, voltage (difference) equals resistance times current. But this well-known relationship does not say anything about voltage; rather, it defines resistance, and it cannot be applied to ESD problems because there is no current. Then there is the definition of the voltage difference between points A and B as the work done per unit charge when a charge is brought from A to B. But here there is a metrological problem because there is no way to measure the work that is done on a charge. So, we have to go back to the basics and realize that voltage is not a fundamental quantity, but rather a property of an electric field.

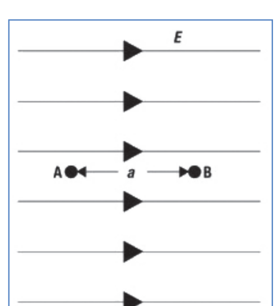


Figure 1: A homogeneous field with field strength E.

Figure 1 shows a section of a homogeneous field with field strength E, where the voltage difference between points A and B is defined by

$$V(A) - V(B) = E \cdot a \qquad (1)$$

However, in most cases, fields are not homogeneous. Figure 2 shows the field from a positively charged insulator with a grounded conductor placed in front of the insulator. In this case, the voltage difference between A and B is defined by

$$V(A) - V(B) = \int_A^B E \cdot da \qquad (2)$$

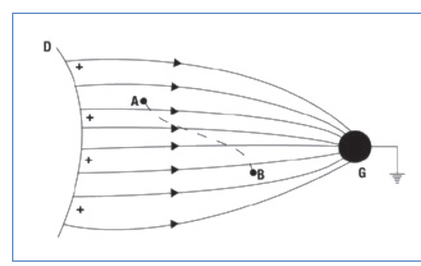


Figure 2: The field between a positively charged insulator and a grounded conductor.

Equations 1 and 2 only define voltage differences. The voltage of a point P in a field is defined as the integral of the field from P to infinity or to any grounded object, that is,

$$V(\mathrm{P}) = \int_{\mathrm{P}}^{\infty \text{ or ground}} E \cdot da \qquad (3)$$

VOLTAGE OF A CONDUCTOR

Figure 3 shows an insulated conductor A with a charge q. The charge will automatically distribute itself on the surface of the conductor in such a

The voltage of an insulated conductor may be measured directly by connecting the conductor to an electrometer or static voltmeter.

way that (a) the field in the interior of the conductor is zero, (b) the field is perpendicular to the surface, and (c) the integral of the field strength from any point P in or on the conductor to a ground point G is constant:

$$V_{P_1} = \int_P^G E \cdot da \quad (4)$$

V is the voltage or potential of the conductor. The voltage V and the charge q are proportional, and this is usually written as

$$q = C \cdot V \quad (5)$$

C is the capacitance of the insulated conductor and is determined by the size and shape of the conductor and its placement relative to other conductors and ground.

The charged system stores an electrostatic energy given by

$$W = \frac{1}{2} C \cdot V^2 \quad (6)$$

which can be dissipated in a single discharge or current pulse.

MEASUREMENT OF CONDUCTOR VOLTAGE

Direct-Contact Voltmeters

The voltage of an insulated conductor may be measured directly by connecting the conductor to an electrometer or static voltmeter (see Figure 4). The voltmeter measures the common voltage of the conductor and the voltmeter. If the capacitance C of the conductor is much larger than the capacitance C_i of the voltmeter, the voltage read on the voltmeter is, with good approximation, equal to the voltage of the conductor without the meter being attached.

However, the measuring range of most static voltmeters is in the order of tens or, at best, hundreds of volts. On the other hand, static voltages will often be in the kilovolt range.

This problem can be circumvented by the use of a capacitive voltage divider. In Figure 5, a capacitor with capacitance C_y is inserted in the connection between the conductor and the static voltmeter.

If the voltage read on the voltmeter is V_i, then the voltage V of the conductor is given by

$$V = \frac{C_y + C_i}{C_y} \cdot V_i \quad (7)$$

As an example, let us assume that the maximum voltage to be read on the meter is $V_{i,\,max} = 10$ V, $C_i = 10$ nF = 10^{-8} F, and $C_y = 10$ pF = 10^{-11} F, then Equation 7 will give a maximum voltage of

$$V_{max} = \frac{10^{-11} + 10^{-8}}{10^{-11}} \cdot 10 \cong 10\ \text{kV} \quad (8)$$

The necessary high capacitance in this application of the meter is usually obtained by running the meter in the charge-measuring mode. It appears that using a capacitive voltage divider expanded the measuring range of the voltmeter by a factor of 1000.

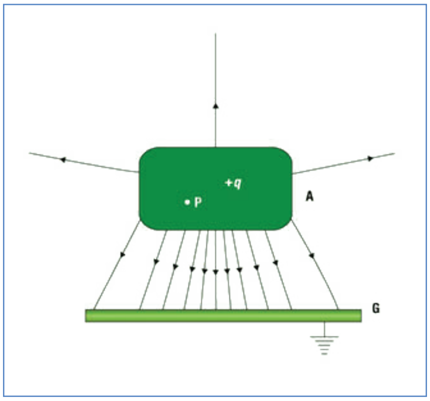


Figure 3: An insulated conductor A with a charge *q*, placed over a ground.

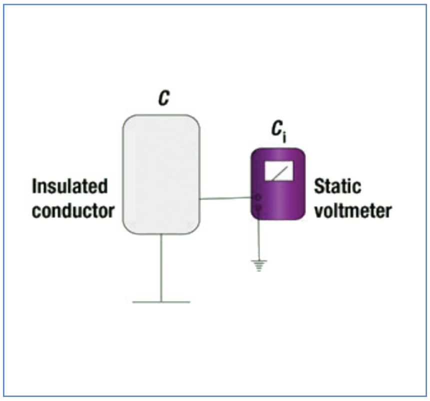


Figure 4: The direct measurement of voltage.

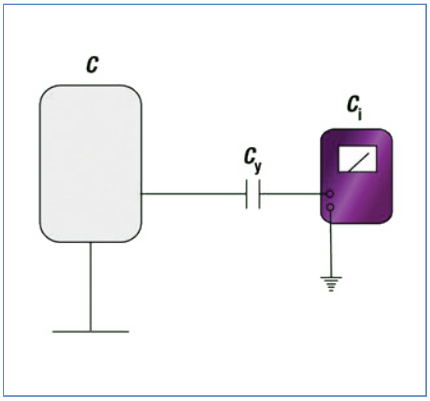


Figure 5: A capacitive voltage divider.

Noncontacting voltmeters may have greater sensitivity (but not necessarily greater accuracy) than do field meters.

Noncontacting Measurements

Electrostatic noncontacting measurements are always based on the effects of the fields of charges, whether they are located on conductors or insulators. There are basically two types of instruments: field meters, which measure the charge induced on a probe and convert it to the field strength in front of the probe, and noncontacting voltmeters, which raise the voltage of the probe until the field in front of the probe is zero. The noncontacting voltmeter then takes this voltage as the voltage of the object that it is pointing toward.

Noncontacting voltmeters may have greater sensitivity (but not necessarily greater accuracy) than do field meters. However, both types of instruments may distort the original field considerably unless the meters are suitable screened.

Figure 6 shows a charged insulated conductor. In the figure, the noncontacting voltmeter reads the voltage V of the conductor and estimates the mean field strength $E = V/d$ between the conductor and the meter, whereas the field meter reads the field strength E in front of the meter and estimates the voltage $V = E \cdot d$ of the conductor. However, it should be emphasized that the quantities read and calculated refer to the conditions that exist when the instruments are in place.

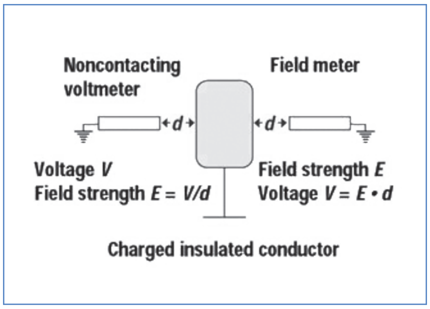


Figure 6: Noncontacting measurements.

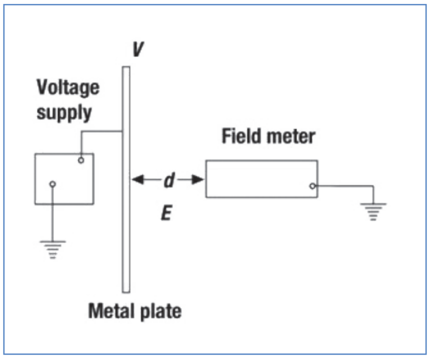


Figure 7: An unscreened field meter.

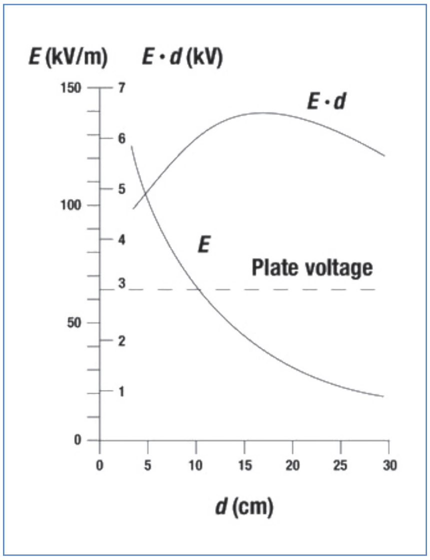


Figure 8: Measurement results from an unscreened field meter.

CONDUCTOR AT FIXED VOLTAGE

The experiment shown in Figure 7 was conducted to investigate the influence of the meters on the field from and the voltage of the charged conductor. A 35 · 35-cm metal plate was connected to a voltage supply kept at a constant voltage of 3 kV. A field meter was placed perpendicular to the plate, pointing at the center of the plate, and the field strength E was measured as a function of the distance d between the plate and the field meter. For each distance d, the product $E \cdot d$ was calculated.

The results of the measurements are shown in Figure 8. It appears that the field strength E decreased with increasing distance d, as expected. However, if the voltage V of the plate is calculated from Equation 1 as $V = E \cdot d$, the result would be a very poor approximation of the true value (3 kV) of the plate voltage.

The reason for this is that Equation 1 assumes the field to be homogeneous, as shown in Figure 1. But the setup in Figure 7 resembles much more closely the situation in Figure 2 because the housing of the field meter (or for that matter, the housing of a noncontacting voltmeter) is essentially at ground potential. The field strength read on the field meter (or compensated for in a noncontacting voltmeter) is therefore higher than the mean field strength between the meter and the target, and the $E \cdot d$ approximation of the voltage will therefore be too high. Figure 8 shows that in the range of distances from 4 to 30 cm, the estimated voltage $E \cdot d$ varies between 4.5 and 6.2 kV, rather than the true value of 3 kV.

However, both types of instruments may distort the original field considerably unless the meters are suitable screened.

The problem of the instruments distorting the field can be corrected partly by surrounding the meter with a grounded screen placed parallel to the face of the target, as shown in Figure 9. The experimental setup had a 25 · 25-cm screen and a 35 · 35-cm metal plate as the target.

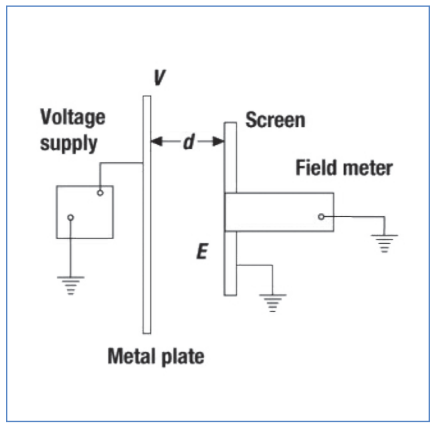


Figure 9: A screened field meter.

Figure 10 shows the field strength *E* and the apparent voltage *E* · *d* as a function of the distance *d*. The results demonstrate that, with the screen attached, the voltage *V* of the metal plate is adequately determined by the product *E* · *d* out to a distance of approximately 15 cm between the plate and the field meter. In this range, the field is homogeneous and inversely proportional to the distance to the field meter, that is, the E-field curve is a hyperbola. At larger distances, the field again becomes inhomogeneous, and at this range, the field meter underestimates the voltage.

The distance to which the voltage can be determined with reasonable

The previous cases do not represent the ordinary, everyday situation in which a conductor has been charged and the voltage is measured by pointing a meter at the conductor.

accuracy also depends on the target size. If the measurements in Figure 10 were repeated with a 15 · 15-cm plate, the readings would yield reliable results only out to a distance of approximately 6–7 cm.

CONDUCTOR WITH CONSTANT CHARGE

In the previously discussed cases, the target conductor was locked to a voltage supply. The voltage of the conductor would therefore be kept constant, independent of field meter placement. The charge, on the other hand, might vary with the intercapacitance of the conductor and the field meter, that is, with the distance *d*.

The previous cases do not represent the ordinary, everyday situation in which a conductor has been charged and the voltage is measured by pointing a meter at the conductor. In this more common case, the charge stays constant while the voltage may change because of the coupling with the meter capacitance. Figure 11 shows an experimental setup for investigating this situation. In the experiment, a 35 · 35-cm metal plate was charged to an initial voltage of 3 kV (in the absence of the field meter), and then the connection to the voltage supply was broken. Next, the field meter was placed at various distances *d* from the metal plate, and the field strength *E* was measured.

Figure 12 shows the product $E \cdot d$ (the apparent voltage) as a function of *d* for plate capacitances C ≅ 20 pF (the plate alone) and C ≅ 220 pF (the plate and an additional external capacitor).

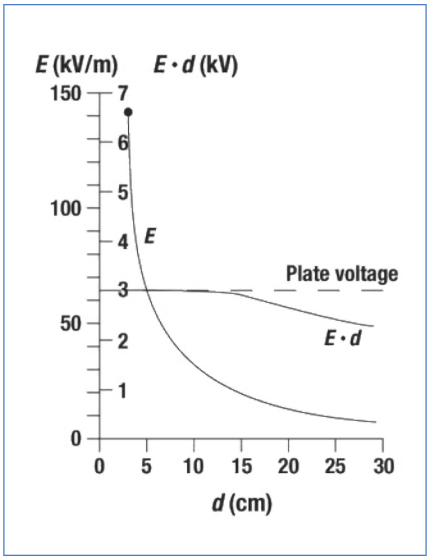


Figure 10: Measurement results from a screened field meter.

The greater plate capacitance of 220 pF provided a curve that is very similar to the one plotted in Figure 10, where the metal plate was locked at 3 kV. This means that the presence of the field meter does not significantly change the total capacitance and, hence, the plate voltage for a given distance. The lesser plate capacitance of 20 pF resulted in a calculated voltage that is lower at all distances than that found with the plate of greater capacitance. This is due to the added value of the meter capacitance. At the very short measuring distance, the presence of the meter increases the original value of the capacitance from 20 to about 45 pF, resulting in the voltage dropping from 3 to about 1.3 kV.

The measurements reported in Figure 12 were repeated with an unshielded field meter. The general trend was the same as demonstrated in Figure 8. At all distances (and with both capacitances tested), the unshielded field meters overestimated the true values of the plate voltage by up to 100%.

STATIC LOCATORS

Probably the most common way to do a fast static survey is to point a handheld meter at the suspicious item and pronounce a voltage. Often, this is the only measurement done. And very often, this is not enough.

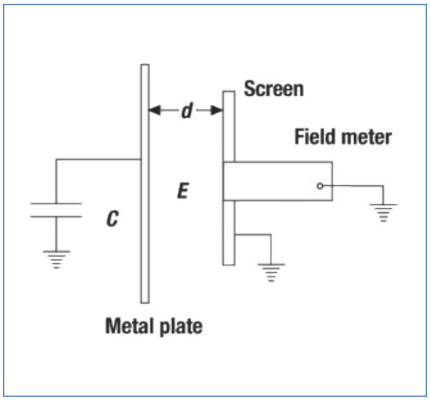


Figure 11: Measuring a conductor with constant charge.

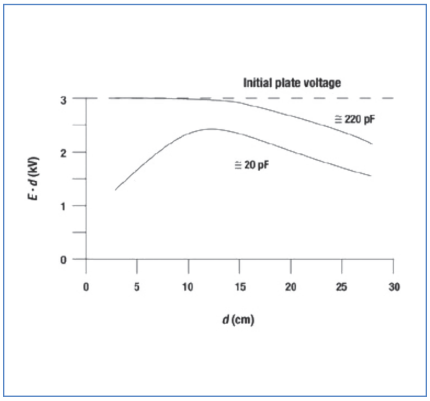


Figure 12: Measurement results from an unshielded field meter

It has been demonstrated that the instruments used will often distort the fields and hence change the properties to be measured.

These handheld meters are known as, and often even called, static locators. And that is exactly what they are—instruments to locate a static electric field. As long as that is the only thing they are being used for, everything is fine. But often, their use is being extrapolated into the absurd.

Figure 7 is an illustration of the typical use of a field meter as a static locator. The meter ranges may be in volts, but the meter is not a voltmeter. It does not react to a voltage, but rather to an electric field. Often, it is a regular field meter, for instance, a field mill, or it may essentially just contain an operational amplifier that reacts to the charge induced on a sensor plate at the front of the meter housing.

The meter also has a stipulated measuring distance. In the case shown, it is *d*. This means that the meter was calibrated by placing it at a distance *d* from, and parallel to, a metal plate, which was then raised to a range of voltages, and a corresponding scale was drawn.

So the question is this, after the calibration, what can the meter be used for? The answer is very simple: The meter can be used to measure the electric field at a distance d from a metal plate with the same dimensions and the same capacitance as the one used for factory calibration. For conductors, the value obtained is approximately equivalent to surface voltage. At any other distance or when measuring insulators, the measurement is not calibrated and the instrument has merely located an electric field.

The problem is that manufacturers seem very reluctant to mention this, or to just describe what the calibration conditions were and what happens if the instrument is used under other, and maybe even more-everyday, conditions. It is very rare, if it ever happens at all, for the dimensions of the calibration plate, not to mention its capacitance, to be given in the manual. Nor is there any warning that if the meter were to be pointed toward an insulator, the reading in volts would never refer to the insulator as a whole. As was mentioned in Part I of this article, an insulator does not have a voltage. If the user is lucky, a kind of surface voltage may be found.[1]

It is something of a puzzle why static locators are always calibrated in volts. After all, they are just ordinary field meters pretending to be voltmeters, without really being so. All they can do is measure the voltage of a certain metal plate at a certain distance. If these meters were calibrated in units of field strength, that is, $V \cdot m^{-1}$, they could be used much better to evaluate the static conditions of insulators as well as conductors.

But could the explanation simply be that most people understand voltage better than they do field strength? No, that does not seem possible. Just look at Equations 1, 2, and 3 of this article. A voltage is always defined by a field strength (and a distance), so if someone does not understand one, that person would not understand the other.

CONCLUSION

This article has analyzed the problems connected with measuring the voltage of a charged insulated conductor. The emphasis was placed on noncontacting measurements, that is, measurements based on the effect of the field from the charge. It has been demonstrated that the instruments used will often distort the fields and hence change the properties to be measured. It was also shown that, by screening the meters, it is often possible to reduce the field distortions considerably.

REFERENCE

1. Niels Jonassen, "Surface Voltage and Field Strength: Part I, Insulators" in Mr. Static, *Compliance Engineering* 18, no. 7 (2001): 26–33 and *In Compliance Magazine*, October 2014.

(the author)

NIELS JONASSEN, MSC, DSC, worked for 40 years at the Technical University of Denmark, where he conducted classes in electromagnetism, static and atmospheric electricity, airborne radioactivity, and indoor climate. After retiring, he divided his time among the laboratory, his home, and Thailand, writing on static electricity topics and pursuing cooking classes. Mr. Jonassen passed away in 2006.

EMC Education

The View from the Chalkboard

BY MARK STEFFKA

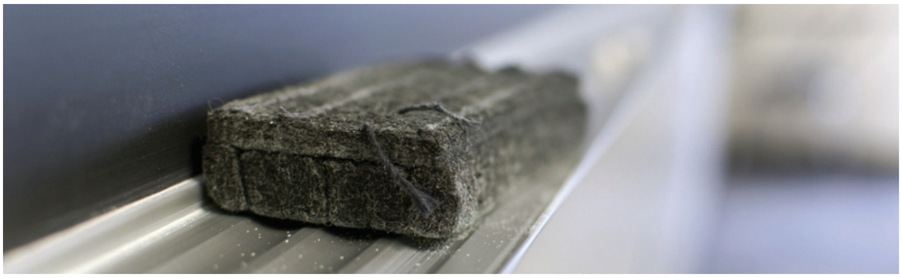
Hello everyone, by the time you read this – the Fall 2014 semester at most academic institutions will be well underway and I thought this would be a good time report on of some of the printed books (yes – PRINTED) on EMC (and/or related to EMC topics) that are used in academic settings for EMC education.

The intention of this month's *View from the Chalkboard* is to highlight some of the books that have been found to be useful in the teaching of EMC, to help you identify suitable EMC resources for your classes (and even if you are not teaching formal EMC courses, it is hope that this will highlight books that you may find useful in your work in everyday work EMC).

It is hoped that the information here will provide you with insight as you either plan your upcoming curriculum or want to build up your own personal library of reference material.

Recently, as Chair of the IEEE Electromagnetic Compatibility Society (EMCS) Education and Student Activities Committee (ESAC) (http://www.ewh.ieee.org/soc/emcs/committees/esac_main.html), I had an opportunity to discuss this topic with my colleagues who are members of ESAC and they wanted to share with you their observations and thoughts about the resources they use. In addition to my comments in this article, others who provided input for are: Professor Arturo Mediano, of Spain, Mr. Matthew Juszczyk of Cedar Rapids, Iowa. While Professor Mediano and I are providing an EMC instructor perspective, Mr. Juszczyk brings an interesting approach and insight as a student who had a formal course in EMC at Kettering University (in Flint, Michigan).

With that introduction – let's see what books are used in EMC education.



PROFESSOR ARTURO MEDIANO

I have a nice course on EMC for electronic engineers in my University. I teach the fundamentals especially from the designer point of view, we solve examples in class, we have two visits to EMC labs external to the University and finally the students take a product and a full analysis of EMC is done on it.

You know we have many EMI/EMC books. Really we spent a lot of time with application notes, datasheets, etc, so I have selected two books for the course (as a reference), not to follow exactly day by day. They are:

1. Henry W. Ott, *Electromagnetic Compatibility Engineering*; Ed. John Wiley & Sons; 2009; ISBN-13: 978-0470189306

Do you think this first book could be neglected in any EMC course? This is the best book I know for any engineer interested in EMI/EMC fundamentals. The structure is excellent and any subject is clearly explained.

2. Tim Williams; *EMC for Product Designers*; Ed. Newnes; 2006; ISBN-13: 978-0750681704

EMC Education

This book is nice for me because the EMC fundamentals (regulations and tests) are explained in a very understandable style followed by a good EMI approach for designers. I feel this an excellent complement to Henry Ott's book.

Arturo Mediano received both his M.Sc. (90) and Ph. D. (97) in Electrical Engineering from the University of Zaragoza, Spain where he has held a teaching professorship in EMI/EMC/RF since 1992. He is author/co-author for many publications and patents and a frequent speaker in the most important symposiums and conferences related to RF/EMC. Arturo is Senior Member of the IEEE, member of the EMC Society (ESAC Committee), and member (Chair since 2013) of the MTT-17 (HF/VHF/UHF technology) Technical Committee of the Microwave Theory and Techniques Society.

MR. MATTHEW JUSZCZYK

Kenneth Kaiser's *Electromagnetic Compatibility Handbook*; CRC Press, First edition 2004, ISBN: 978-0849320873, contains over 2500 pages of detailed content covering a vast array of EMC concepts. The book is written in a non-traditional fashion where each section poses a question to the reader and cites original sources to demonstrate the answer. This approach amounts to a highly practical reference guide for EMC engineers that is strongly tied to academic concepts. Kaiser has gone at length to develop numerous reference tables showing both the simplest and most complicated of derivations for unique situations. For example, there are sixty-one derivations for the characteristic impedance of varying transmission line cross-sections. All modeling in the book was written using Mathcad and each of the scripts is available for free on the textbook's website. While perhaps not the most traditional choice for an undergraduate electromagnetic fields course, this textbook can serve as a fine addition to augment a senior or graduate level EMC course.

Matt Juszczyk is a Principal EMC Engineer at Rockwell Collins in Cedar Rapids. He earned his BSEE at Kettering University in 2007 and his MSEE from Iowa State University in 2012. He is an adjunct instructor at a local college, and he primarily teaches in the mathematics department.

MARK'S PICKS

Finally, my selection of books on EMC: I teach two courses on EMC, an undergraduate course typically in the Fall semesters, and a graduate level course in the Winter semesters. Due to the nature of each course (the undgraduate course has students that will be receiving their engineering degree soon, and the graduate course students are more deeply involved in advance studies), I use two different books for each course.

For the undergraduate course, I use Henry Ott's *Electromagnetic Compatibility Engineering* book (as referenced by Professor Mediano). The book is exceptionally well suited to prepare the students in the fundamentals of EMC, and through the topics covered at end of chapter problems the students can relate their experiences in real world work or previous classroom topics to look at those from an EMC standpoint.

For the graduate course, I use Dr. Clayton Paul's book *Introduction to Electromagnetic Compatibility*, ISBN 978-0471755005, John Wiley and Sons, 2006, since the students in the graduate program are well versed in advanced mathematics and physics that Dr. Paul references to explain EMC. Since many of the students are also working full-time engineers, the combination of their day to day experiences and the content of the book explaining EMC as applied to product engineering works well to develop their insight into challenges they face as engineers.

So, I hope this has helped you as you plan your EMC courses, or are looking for resources that have been found to be useful to understand EMC. If you have experiences with other books and publications, I am sure readers of this column would be interested in knowing your thoughts!

(the authors)

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Mr. Steffka is the author and/or co-author of numerous technical papers and publications on EMC presented at various Institute of Electrical and Electronics Engineers (IEEE) and Society of Automotive Engineers (SAE) conferences. He has also written about and has been an invited conference speaker on topics related to effective methods in university engineering education. He is an IEEE member, has served as a technical session chair for SAE and IEEE conferences and has served as an IEEE EMC Society Distinguished Lecturer. He holds a radio communications license issued by the United States' Federal Communication Commission (FCC) and holds the call sign WW8MS. He may be reached at msteffka@umich.edu.

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Cellular Medical

A case study of international wireless certification processes

BY MICHAEL CASSIDY

Medical device manufacturers are well aware of the benefits cellular technology can bring to their products. A cellular link, for example, can send patient data off-site to enable remote monitoring. Although cellular technology adds exciting new possibilities for healthcare, it also adds regulatory burdens. Despite these obstacles, the benefits of cellular technology outweigh the brief pain of certifying a wireless product, even in the most onerous countries.

Let's explore the example of an imaginary medical manufacturer. A fictitious company, Saturn Medical, has decided to integrate a cellular modem in its product so it can monitor a patient's vitals remotely. Saturn, a US company, wants to sell their product internationally. They would like to enter several countries immediately. What are the next steps?

Saturn must first outline the wireless certification requirements and processes in these countries. This sounds obvious but because requirements vary the earlier Saturn understands what is required the less likely it is to run into trouble. Also, understanding the requirements may determine if the manufacturer decides to add the cellular modem. Often, a manufacturer considers adding wireless in dozens of countries but ultimately proceeds with only a few. A look at each country's cellular certification requirements offers a window into how product approvals vary around the world. Although these countries may seem like a random selection, they represent many others with similar processes.

INDONESIA

Cellular certification in Indonesia requires the smooth navigation of a complex bureaucracy. SDPPI, or the directorate general of posts and telecommunications, oversees the certification process for wireless devices[1]. Saturn must certify its end unit with SDPPI. It cannot certify only the modem. Indonesia also requires testing in country. Therefore, Saturn will have to send two full units of the medical device to the Indonesia.

1 http://www.postel.go.id

Saturn must configure the two samples in accordance with Indonesian standards and testing procedures. This is the case for any wireless transmitter used in a medical device. Indonesia standards are generally not published in English but can, of course, be translated as needed. It is beyond the scope of this article to get into details of Indonesia cellular testing. It is important to note, however, that pre-testing in the U.S., to the applicable standard, is crucial. Any testing failure in Indonesia will cause significant delays. Shipping alone can take over a week and samples often must be cleared from customs. Saturn's engineers should be prepared to speak directly with Indonesian test engineers in case the local lab has any questions on the test procedure or the modem itself. SDPPI will also likely ask for the IMEI (international mobile station equipment identity) number for the cellular modem during the certification process. They could also have questions about the SIM card, connectivity, or numerous other issues.

Many of the officials at SDPPI do not speak English and the approval process can appear murky to novice applicants. SDPPI does, however, have a long-standing system in place for cellular certifications and they are well organized. Still, it is important to have a bilingual partner in Indonesia in order to determine the status of the application. The language barrier alone can be a show-stopper. Saturn's partner should be familiar with the certification process so as not to constantly barrage SDPPI with questions. They should have a realistic timeframe for how long each step takes and know that SDPPI does not always alert the applicant the second there is a delay. One must follow the procedure carefully and determine any obstacles without becoming an annoyance to the regulators.

UNITED ARAB EMIRATES (UAE)

If Saturn Medical decides to sell its wireless medical device in UAE, it can prepare for a stress free type approval process. Despite its relatively small size, UAE is a major market for U.S. exporters. The Telecommunications Regulatory Agency (TRA) oversees spectrum affairs and type approvals for wireless devices. The certification process is clearly outlined in published TRA documents, in English, and the regulators often respond quickly to questions. Many TRA officials speak and write quite well in English. UAE will accept test reports to European standards. They have, however, recently begun to require a sample for in-country inspection. That is not a typo; in international approvals we should distinguish in-country sample inspections from in-country testing. The TRA typically completes a visual inspection only and Saturn can avoid the hassle of configuring its sample to unique country configurations. Still, the question arises if the manufacturer must send a complete 'end-unit' or just the modem itself. For UAE type approval, Saturn can send a sample of the modem only. The applicant can expect to complete the certification process in about two weeks from the time the sample arrives and the TRA receives all documents.

First time applicants must also complete a one-time 'brand registration' with the TRA. In our hypothetical situation, Saturn has never approved a wireless device in UAE. Therefore, Saturn will need to register its brand with UAE. In many cases, the brand is simply the company name but there are always exceptions and Saturn should know in advance which brand name it would like to operate under in UAE. All of this, of course, assumes Saturn is registering the modem in its own name. We will address this in the concluding section. The brand registration process takes about a week and requires minimal effort from the applicant.

PARAGUAY

Wireless Approvals in Paraguay are administered by CONATEL, Comision Nacional de Telecomunicaciones[2]. The regulatory approval process is straightforward and although it takes several weeks to complete, requires minimal effort for the applicant.

Saturn must have an in-country representative in Paraguay. This is not unique; for the registration of cellular modems, many countries require that a foreign applicant has a local office or affiliated partner. This can be an international office, supplier, or even a third party set up to provide the local representative service. For Paraguay, Saturn will need to provide a power of attorney letter to its local representative. This letter must be notarized by the nearest Paraguay consul in the U.S. If, however, Saturn decides to use a third party approval service, that provider will likely already have a registered in-country representative. Saturn may be able to avoid the hassle of sending documents to the Paraguayan consulate. Paraguay has recently begun to tighten these requirements and further steps may be necessary for authorization.

2 http://www.conatel.gov.py

Paraguay does not mandate testing in-country and will instead accept international test reports. This is also not unique; while some countries, like Indonesia, require local testing, many others, if not the majority, will allow FCC or European (R&TTE) reports as part of the application package. In this case, Saturn can submit FCC or R&TTE reports for the modem to Paraguay. The test reports often come from the modem manufacturer. It is important that Saturn check with the manufacturer of their modem to see what testing has already been done. Ideally, the modem will have already undergone FCC, European and possibly testing for other countries. The application for Paraguay typically takes 8 to 10 weeks to complete. Once Saturn submits the application, they need only to follow up on occasion and wait for it to go through CONATEL's queue.

INDIA

Saturn can likely avoid wireless registration in India altogether for their cellular modem. The service provider of, for example, a 2G/3G modem, may already have the necessary registrations in place and further approval would not be necessary. For a non-cellular short range device (SRD), the registration process in India is generally quite simple. The manufacturer can submit test reports to European standards to the Wireless Planning Coordination (WPC) wing of the Department of Telecommunications. A local representative is required for the submission process and the review usually takes four weeks to complete before the authority issues type approval. Although Saturn may not have to complete this for their cellular modem, it helps to understand the processes in place and the relevant authority in a given country. Further, if Saturn decides to add other wireless transmitters in the future, they will already understand what regulatory hurdles to meet.

COLOMBIA

As long as the cellular modem does not transmit voice, it is exempt from certification with the Comision de Regulacion de Telecomunicaciones (CRT). Bluetooth, 802.11 and RFID are also exempt from certification assuming they are operating in accordance with Colombian frequency allocations. Saturn may want a voluntary letter of exemption from the CRT confirming the device is exempt. This could be for Saturn's internal due diligence or to prove to a customer the device is acceptable for use in Colombia. The CRT is usually quick to respond and issue a letter of exemption. They do not charge for this service. It is helpful to send them a few documents for review, including the product specifications, and the FCC/TCB Grant. Saturn does not want to burden the CRT with too many documents as this may slow the review process.

KOREA

Wireless certification for South Korea can be intense and time consuming compared with many other countries. Yet, Saturn should not let this stop it from entering a major international market. Korean approval is achievable. The cellular modem will require MSIP, ministry of science, ICT and future, certification[3].

Korean approval for a cell modem is a multi-faceted project. Saturn will need two samples for testing to Korean standards. One sample should be configured for conducted testing and one for radiated. It may be possible for Saturn to avoid sending complete medical units. Testing can be performed on the wireless card if it has the right casing. If not, EMC (Electromagnetic compatibility) testing will need to be performed on the end-unit because without the casing electrostatic discharge could damage the wireless card. In addition to EMC, Korea will also test for RF emissions and product safety. Saturn will need to provide detailed documents on the modems like block diagrams and schematics. Occasionally, a cellular manufacturer will be hesitant or even refuse to share these types of materials with the medical manufacturer integrating its modem. Saturn must confirm that the modem manufacturer will be willing to share these items before starting the Korean approval process.

If Saturn is using a modem with multiple interfaces, it is important to note that Korea has restricted GSM[4]. Saturn should check for similar restrictions in other countries, which may emerge in coming years. Korea also requires a local representative and the user manual for the product must be in Korean. If Saturn properly configures samples, and works with a competent partner in Korea, they can approve their modem in as fast as four weeks. The process, however, often takes longer—especially if questions or failures arise during testing. Although it can be completed faster than Paraguay, it requires more hours of effort from the applicant.

Although these countries look like a random selection, they illustrate several themes one can find around the world. This article deals with a hypothetical situation of a medical manufacturer incorporating a new modem. It assumes the modem manufacturer did not have type approval in any of the aforementioned countries. A manufacturer should always attempt to leverage existing approvals, where possible, from their supplier. When the modem manufacturer does not have any approval in a country that requires end unit approval for any wireless product, even medical, the manufacturer most often must obtain approval on its own.

For medical devices, the 'end unit' is often expensive and the manufacturer cannot always be certain it will be returned. Therefore, one must determine if the modem alone is sufficient for in-country testing or in-country inspection. Cost is also a major consideration. If a medical manufacturer is looking to use a third party to help with its wireless registrations, it should contact more than one provider to compare quotes, response time and quality of service.

A medical manufacturer must also confirm that the vendor of its modem is responsive and helpful. The required documents vary across countries. The applicant may need to submit sensitive information such as Schematics or Bill of Material (BOM). Even basic items such as test reports can be hard to obtain if the modem manufacturer is unresponsive. Therefore, one should speak with the modem manufacturer or meet in person to determine they will be an engaged partner during the certification process.

Medical manufacturers are often used to complicated regulations and bureaucratic procedures. Now, they have to deal with wireless registrations. Many who have gone through the medical regulatory process, however, insist that wireless registrations are easier and more straightforward. Of course, it will depend on the product and country. But, for the most part, if you can conquer a medical registration you can conquer wireless. IN

(the author)

MICHAEL CASSIDY is the founder of MC Global Access LLC (MCGA). He lives in Menlo Park, California. Prior to forming MCGA, he was the operations manager for TUV Rheinland's international approvals group. Michael also worked as project manager with Intertek's global market access program. He has worked with a variety of clients and obtained product certifications in over 100 countries.

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3 http://english.msip.go.kr/index.do

4 http://www.globaltelecomsbusiness.com/article/2940473/Goodbye-to-2G-services-says-Koreas-KT.html


SPACE
ALT
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The FCC TCB Program: A Government and Industry Cooperative

"Great discoveries and improvements invariably involve the cooperation of many minds. I may be given credit for having blazed the trail, but when I look at the subsequent developments I feel the credit is due to others rather than to myself." – Alexander Graham Bell

BY MARK MAYNARD

As a compliance engineer it is easy to develop a "victim" mentality after working with a multitude of government agencies and bureaucracies, having to adjust and adapt to whatever regulatory roadblocks are set up in your path. It can seem as though some of the rules and compliance criteria are arbitrary and random, and I have wished on more than one occasion that I was able to talk and work directly with the agencies, and be able to better understand and influence the requirements and processes.

I was finally granted that wish when I became involved with the United States (US) Federal Communications Commission (FCC) Telecommunications Certification Bodies (TCB) program. My initial exposure to this government and private industry initiative was a decade ago, while I was working at an ITE manufacturer, and more recently I've observed it from a different perspective while working at a third-party compliance test lab that is an authorized TCB. TCBs are private industry independent organizations, which have been authorized under this FCC program to issue grants to electronic product manufacturers for the certification of specific types of telecommunications equipment covered under the program scope.

Please note that this article is intended as an overview of the TCB program based on my work experiences, and I am not speaking in any official capacity for the FCC, the National Institute of Standards and Technology (NIST), the Telecommunications Certification Body Council (TCBC), or any other agency. The opinions and views provided are my own, and you should utilize the FCC, NIST, TCBC and other official resources provided at the end of this article for the program details, requirements, and publications before applying for product approvals.

So let's start with some background on how this program came to be.

CREATING A GOVERNMENT-INDUSTRY PARTNERSHIP

Prior to the TCB program, certification for telecommunication equipment required a grant of authorization issued directly from the FCC. These "new equipment authorizations" were legal documents, which were issued based on exhibits demonstrating compliance to the FCC rules and regulations, such as test reports from the FCC lab, or a FCC authorized test lab. The FCC grant certificate has several purposes:

to define the device operating modes, features, and ratings; the allowed uses and environments for the device, and to show that the product was properly tested according to the applicable FCC rules and regulations, including worst cases configurations, so that it can be sold and placed on the US market.

With momentum from a wider effort in the United States to reduce the size of government agencies by turning more regulatory activities over to private enterprises, the legislative framework for the TCB was established at the end of 1998, when the FCC GEN Docket Report and Order No. 98-68 was adopted. For the FCC, this was seen as a method to reduce the number of applications filed directly with them, reducing their workload, so they could focus on enforcement activities. The program also allowed TCBs outside of the US to participate, by establishing procedures for government-to-government Mutual Recognition Agreements (MRA); for example, the MRA between the US and the European Union (EU) governments allows accredited US TCBs to certify radio and telecom products for the EU markets, and reciprocally allows accredited EU TCBs to certify radio and telecom products for the US market. Another driver for this program was industry, who had encountered occasional bottlenecks at the FCC in obtaining certification, especially prior to seasonal selling periods such as the Christmas holidays, and wanted faster options for US certification and regional labs outside of Washington D.C, which would match the US efforts with foreign MRA partners to expand the certification options.

The criteria for TCB accreditation and designation was further defined in FCC Public Notice DA 99-1640 issued on August 17, 1999. The program officially started on June 2, 2000, with the publication of FCC Public Notice DA 00-1223, which listed the 13 initial designated TCBs, along with their specific scope of accreditation for licensed radio service equipment, unlicensed radio frequency devices, and telephone terminal equipment. Another major revision for TCB rules for designation and requirements was published in ET Docket No. 03-201 (FCC 04-165), which was officially adopted on July 8, 2004.

BECOMING A TCB

To become an accredited Telecommunications Certification Body, an independent third-party lab must be accredited to ISO/IEC 17065 (2012), titled *Conformity assessment-Requirements for bodies certifying products, processes and services,* ISO/IEC Standard 17025 (2005), titled *General requirements for the competence of testing and calibration laboratories,* and also incorporate the applicable FCC rules and regulations. In the US the TCB accreditation process is managed by NIST, which has qualified two US accreditation bodies as being in compliance with the standard ISO/IEC 17011 (2004), *Conformity assessment - General Requirements for Accreditation bodies accrediting conformity assessment bodies,* and therefore authorized to accredit TCBs: the American National Standards Institute (ANSI) and the American Association for Laboratory Accreditation (A2LA).

TCB Scope A - Unlicensed Radio Frequency Devices	
A1	Low power transmitters operating on frequencies below 1 GHz (with the exception of spread spectrum devices). emergency alert systems, unintentional radiators (e.g., personal computers and associated peripherals and TV Interface Devices) and consumer ISM devices subject to certification (e.g., microwave ovens, RF lighting and other consumer ISM devices)
A2	Low power transmitters operating on frequencies about 1 GHz, with the exception of spread spectrum devices
A3	Unlicensed Personal Communication Service (PCS) Devices
A4	Unlicensed National Information Infrastructure (UNI) devices and low power transmitters using spread spectrum techniques
TCB Scope B - Licensed Radio Service Equipment	
B1	Commercial Mobile Services in 47 CFR Parts 20, 22 (cellular), 24, 25, and 27
B2	General Mobile Radio Services in 47 CFR Parts 22 (non-cellular), 73, 74, 90, 95, and 97
B3	Maritime and Aviation Radio Services in 47 CFR Parts 80 and 87
B4	Microwave Radio Services in 47 CFR Parts 27, 74, and 101
TCB Scope C - Telephone Terminal Equipment	
C1	Telephone terminal equipment in 47 CFR Part 68

Table 1: List of TCB Scope of Accreditation Categories

The FCC Office of Engineering and Technology (OET) has oversight authority for the TCB accrediting process, and will coordinate frequently with ANSI and A2LA to confirm and verify that the veracity of their programs meets acceptable standards for performance. The FCC has a very strong vested interest in keeping this program performing effectively, and will perform frequent assessments to check for any issues or to find areas for improvement in the authorized program accreditation bodies.

In turn, ANSI and A2LA will accredit qualifying US TCBs that meet the requirements of both the TCB certification program requirements, which are defined and set by NIST, and the ISO/IEC 17065 (2012) standard. Also, as mentioned, foreign certification bodies (non-US) can become a recognized TCB for issuing FCC grant certificates if a government-to-government MRA is in effect between the US and the foreign country. However it will be up to the designated accrediting authority in the foreign country to assess the TCB and evaluate it to determine the competency of the organization, and this accrediting authority must meet the criteria found in the standard ISO/IEC 17011 (2004).

The TCBs will select the specific products they choose to certify, which will define the scope of their TCB accreditation. There are three scopes covering unlicensed radio service equipment (Scope A), unlicensed radio frequency devices (Scope B), and telephone terminal equipment (Scope C). Scopes A and B each have four sub-categories, which can be seen in Table 1. The TCB may be accredited for all scopes and sub-categories, or a limited set, depending on their preferences and capabilities, so prospective customers should always verify that their equipment type falls under one of the accredited scope for the specific TCB.

However wide or narrow the scope of the TCB accreditation, each TCB is required to have the essential competency to perform the mandated set of tests for each scope and sub-category of scope selected. This will be verified during the ISO/IEC 17025 (2005) accreditation process.

WHAT DOES A TCB DO?

So if you are a product manufacturer seeking FCC certification for a device that falls under the scope of the TCB program, you probably are interested in finding out more about the process and requirements. It is important to find a TCB that you are comfortable working with, as there will be a need for frequent interactions and exchanges of information throughout the process, especially if this is your first experience with certifying a product.

The TCB is responsible for testing, evaluating, and reviewing the product, to verify that it meets all of the applicable FCC rules and regulations. To do this, the manufacturer needs to provide fully functioning device samples, technical documentation, and operating instructions that will enable to fully investigate the operating abilities and parameters, so that they can render a valid and fair decision on the conformity of the product.

As mentioned, the compliance testing has to be performed in a test lab facility that has been accredited as meeting the requirements of ISO/IEC 17025. The test data and results are incorporated into an evaluation test report, which plays a big part in the review process. The decision to certify the product will be based on the examination of the test report, to verify compliance with the FCC requirements for the specific product type, along with the review of any other relevant supporting documentation. If the device is then deemed to be in compliance, then the test lab can render their decision to certify. If it is not found to be in compliance, then the test lab should review the results and shortcomings with the client, so any necessary product changes can be made and incorporated before retesting the product.

If the ISO/IEC 17025-accredited test lab facility is also a TCB accredited to ISO/IEC 17065 (2012), then there must be separation of responsibilities at the TCB between those that are performing the evaluation of a device, and those that are making the decision to certify the device. This is to ensure an autonomous review process takes place to impartially review the findings, so a correct ruling can be made based on the findings. The ISO/IEC 17065 standard requires that the individuals that perform the TCB evaluation functions, such as type-testing, report generation, and assessing the supporting documentation to verify compliance with the applicable FCC rules and regulations, must not be the same individuals that perform the TCB certification functions of reviewing all of the provided information and documentation, and then making the decision to certify the product.

A TCB is required to be impartial, meaning that they are responsible for making sure that any other activities it is involved in with other related groups or organizations does not impact or influence the fairness, neutrality, or confidentiality concerning their ruling on certification for the product. In addition, the TCB is not allowed to give guidance or provide consulting services to the client concerning techniques for resolving the issues which prevent the specific certification that is being sought.

While the FCC allows for a wide range of different types of devices to be certified under the TCB program, it still requires certain specific functions to be performed solely by the FCC, which it does not allow TCBs to perform. As defined in the Title 47 of the Code of Federal Regulations (CFR), TCBs are not allowed to grant waivers to FCC rules, nor certify devices that don't have applicable FCC rules, or take action on any rules that are not clear. Also, TCBs can not authorize the transfer of control for a grant, and are not allowed to interpret any FCC rules or regulations.

Previously there was a "TCB Exclusion List," which specifically detailed types of products that TCBs were not allowed to certify. However, this has changed under a FCC procedure known as Permit-but-Ask. The intent of this option is to allow the TCBs to expand the types of devices for which they can issue grants, while allowing the FCC to have oversight for new technology devices that do not have specific FCC guidance available, or for cases where the client is planning to demonstrate compliance by using some alternative to the published procedures or guidelines.

RESOURCES FOR USING THE FCC TCB PROGRAM

If you are a manufacturer wanting to obtain FCC certification for equipment that falls under the scope of the TCB program, my strongest advice is for you to first learn all you can about the program requirements, and to learn from the experience of others who have already been through this process. There are two great resources available to you on the Internet, the first is on the FCC website, and the other is for a TCB industry organization called the Telecommunications Certification Body Council (TCBC). Let's start with the FCC.

THE FCC KNOWLEDGE DATABASE

The FCC rules and regulations are famous for being complex and sometimes ambiguous, and it is hard to find all of the specific information and details that will help to ensure the compliance of your product. To help this situation, the FCC created the Knowledge Database (KDB) system (**apps.fcc.gov/oetcf/kdb/index.cfm**), which is a part of the FCC website, in order to provide additional guidance and assistance to manufacturers, TCBs, test labs, and other interested stakeholders.

KDB publications are created by FCC staff members, and are intended to provide clearer guidance and explanations on specific topics, outside of the FCC rules and regulations. While the KDB is intended to assist the public in following FCC requirements, the KDB publications do not constitute FCC rules; the guidance is not binding on the FCC, and it will not prevent them from making a conflicting or different ruling on any issue that comes to them for resolution.

You can search for whatever topic you are interested in, with the available keyword search engine, or use the more advanced search options. Currently there are about 200 active KDB publications available, with popular topics such as the Permit-but-Ask procedure, DFS/UNII requirements, and test procedures. One warning; there doesn't seem to be a logical order for the numbering system for the KDB publications and revision levels, so make sure you verify that you are utilizing the most current version, as updates can be frequent for certain categories. Most KDB documents have a 6-digit code, and if you know the code you can search for it by just using the code. Also know that you will usually have to reference several KDB publications to find all of the information or guidance you are seeking; it is not common to find everything in one document.

You may notice that there are two areas in the KDB, one is public and accessible by anyone on the Internet, but the other is restricted to TCBs only. The KDBs available on the public site usually give FCC guidance or interpretation of the rules for a general category or technology, and do not cover specific applications or devices, because of rules on confidentiality.

THE TELECOMMUNICATIONS CERTIFICATION BODY COUNCIL

The TCBC is a not-for-profit industry consortium of TCBs, the FCC and other government regulators, accrediting bodies, test laboratories, equipment manufacturers, product developers, consultants, and other interested stakeholders. The purpose of the TCB Council, as stated on their website, is to "provide a forum for periodic dialogue between the FCC and the TCB's and to facilitate on-going activities geared toward the improvement of TCB technical and administrative performance."

The TCBC has a website (www.tcbcouncil.org) containing general information on the organization and benefits of joining. The members of this organization have a wealth of experience in all aspects of the TCB program, and members also have access to monthly conference calls with the FCC, training materials, and discounted registrations for the twice-yearly training workshops on the latest compliance requirements featuring presenters from the FCC, Industry Canada, the European Union, and other international government regulators, in addition to the TCBs.

Anyone that is interested can become a member of the TCB Council. Membership is extended to a company, and any employees of the member company can receive TCBC membership benefits without any additional cost. Any FCC designated TCB can join as a full TCB council member, and any other company of individual can join as an associate member.

My hope is you now have enough background for an understanding of the TCB program and requirements to get started on the certification process. You will still have a lot more to learn, but with the provided Internet resources you have connections to the sources that can help you to obtain FCC approvals for your products.

INTERNET RESOURCES

FCC Telecommunications Certification Bodies (TCB) System
http://apps.fcc.gov/tcb/index.html

FCC Knowledge Database (KDB) System
http://apps.fcc.gov/oetcf/kdb/)

National Institute of Standards and Technology (NIST) EMC and Telecommunications Mutual Recognition Agreements (MRA)
http://gsi.nist.gov/global/index.cfm/L1-4/L2-16

American National Standards Institute (ANSI) Accreditation Services
http://www.ansica.org/wwwversion2/outside/PROgeneral.asp?menuID=1

American Association for Laboratory Accreditation (A2LA)
http://www.a2la.org

International Electrotechnical Commission (IEC)
http://www.iec.ch/

International Standards Organization (ISO)
http://www.iso.org

ANSI Document Store (ISO/IEC documents are available at the ANSI website) **http://webstore.ansi.org/ansidocstore/default.asp**

The Telecommunications Certification Body Council (TCBC)
http://www.tcbcouncil.org

(the author)

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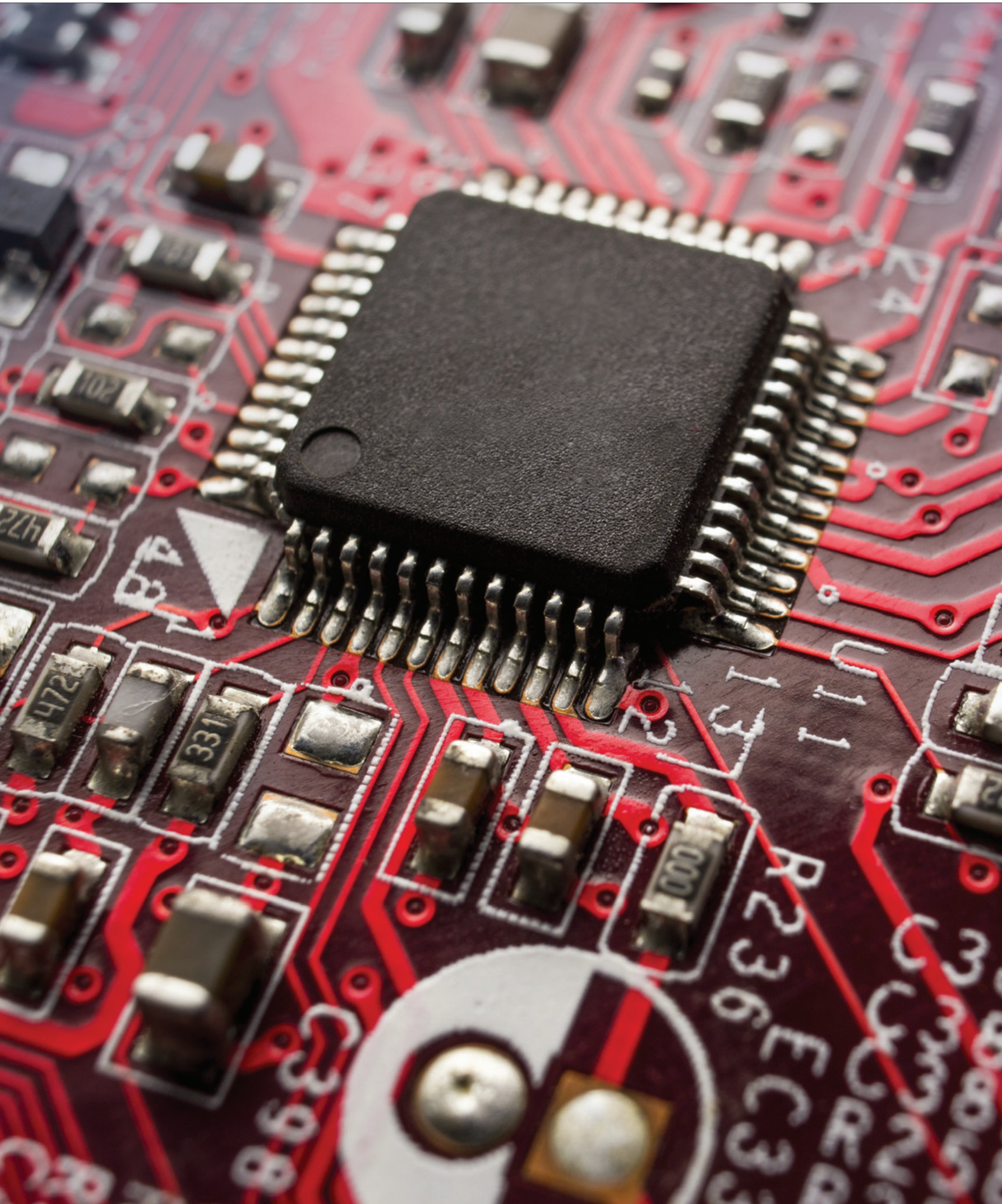
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Pulse Immunity of Microprocessors/Microcontrollers

BY LARS GLAESSER

Comparatively simple measures can be taken to enhance EMC if a circuit is to be used in a well-known environment. But this becomes more difficult if the module is to be used as universally as possible in different applications. Disturbance fields may cause problems, particularly with high integration levels.

The aim of the current test procedure is to develop a temperature monitoring system controlled by a microcontroller which can be used in greenhouses, for example.

The module will be offered without a package and should be a genuine all-round device. A number of potential circuit environments thus have to be taken into account:

- Is the printed circuit board housed in a metal or plastic package?
- Is the circuit ground well connected to the package in the metal version?
- Is the circuit operated in the vicinity of other metal conductors such as a top-hat rail, 230 V mains lead, etc.?

The module has to be protected against all possible interference mechanisms since its future environment is unknown.

Disturbances may enter the module via conductors and/or fields.

We will initially consider conducted interference: disturbances may enter the module via the power supply socket (a switched-mode power supply unit, for example) or the peripherals' interface (a temperature probe, for example). The magnetic fields caused by disturbance currents flowing through the board may induce voltages in the conductor loops. Two problems have to be taken into account with regard to safeguarding the module's functionality: the induced voltage may either be treated as a logic signal by the integrated circuit's input or it drives a disturbance current, which causes problems in other parts of the integrated circuit.

All conductor runs have been relocated in the printed circuit board's intermediate layers to prevent this. Critical signal pins of the controller such as the reset pin and the sockets which connect the printed circuit board to the outside are fitted with filter elements.

The same correlations apply to disturbances which enter the module via fields. Magnetic field vortexes may penetrate the circuit and induce a voltage in the conductor loops, which in turn drives a disturbance current through the module and causes the aforementioned problems.

Interferences are also caused by electric coupling. Electric fields capacitively couple into the circuit board's line networks or even components. The resulting displacement current may cause a voltage drop at a resistor

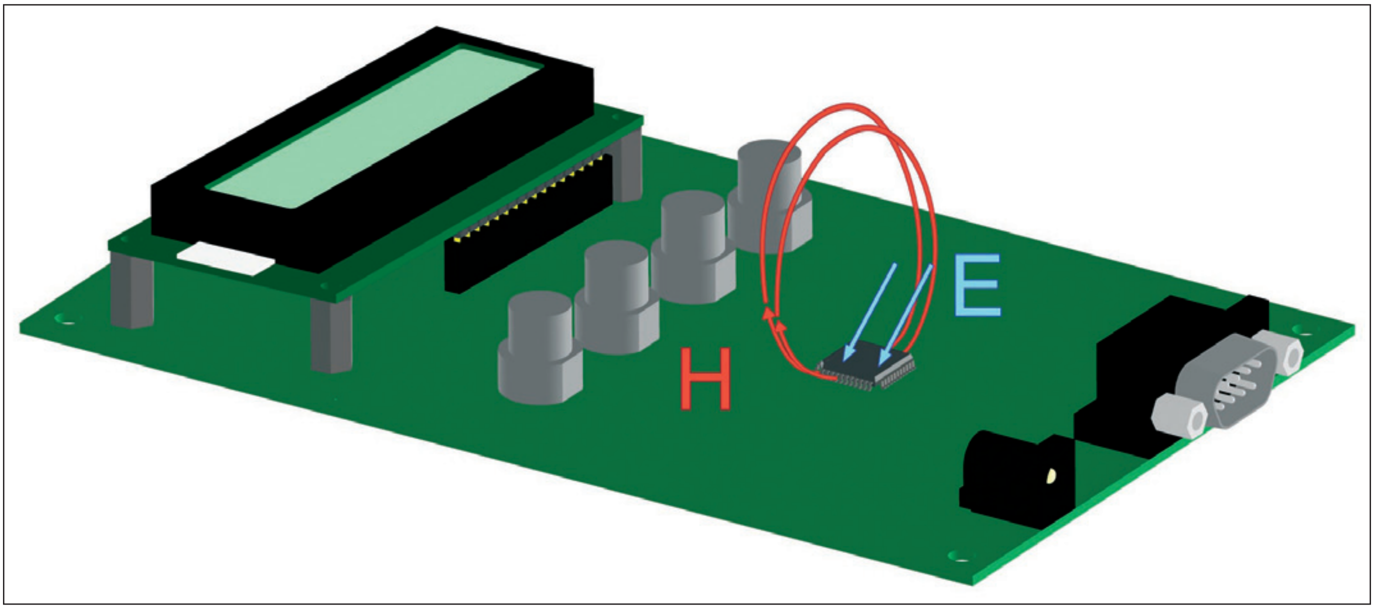


Figure 1: H-field and E-field coupling mechanisms

(against Vss or Vdd), which in turn is recognized as a logic signal, or induce voltages in other parts of the circuit.

The bottom of the printed circuit board that is only populated on one side is provided with a continuous GND layer as a counter-measure. The top is also GND-flooded to minimize the disturbing influence of magnetic fields.

Both capacitive and magnetic coupling also have to be considered on the integrated circuit level.

H-field coupling causes a magnetic field vortex to penetrate the IC. A disturbance voltage is induced in the IC's current loops. The induced voltage may interfere with signals or the supply voltage in the IC and cause faults or drive a disturbance current through the conductor loop and thus interfere with the integrated circuit.

During E-field coupling, a voltage which is present between the IC and field source generates an electric field depending on the respective IC-to-field source distance. The electric field lines end on the IC's metal parts (pad of the IC pin, bond wire, die). They conduct a displacement current into this surface (Figure 1).

Since the integrated circuit's EMC itself cannot be influenced, a controller has to be found with the highest possible immunity for the application. A number of integrated circuits with a comparative range of functional features are potential candidates for this application. The manufacturers'

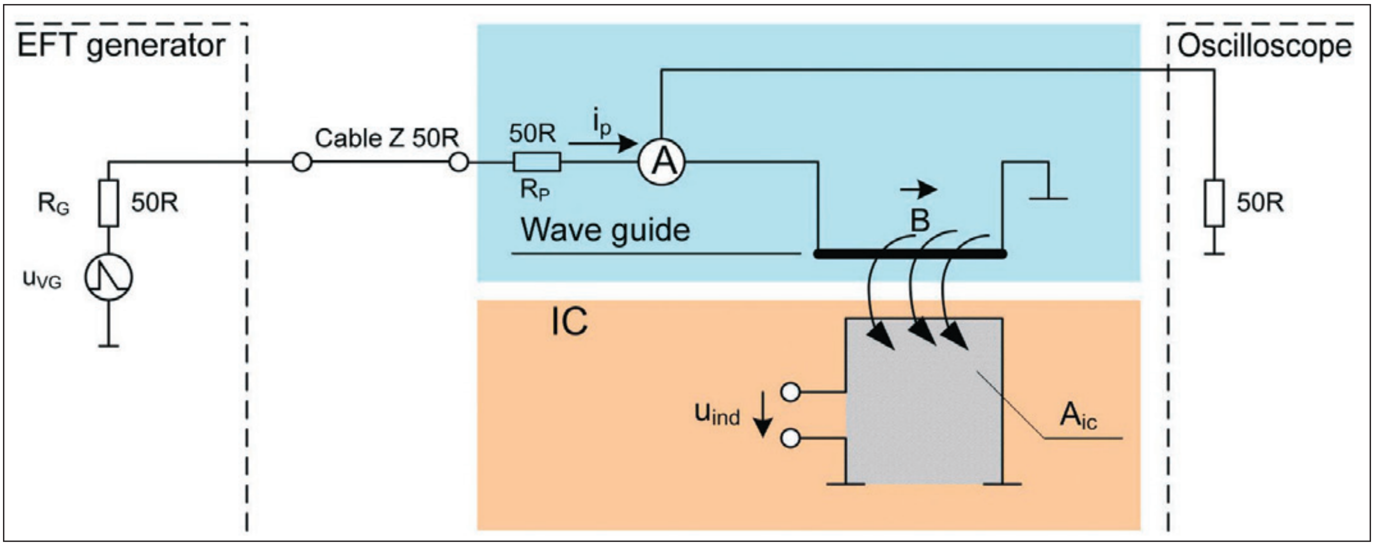


Figure 2: H-field coupling

Either one or both coupling mechanisms (H-field/E-field) can cause faults depending on the IC's design. An objective immunity evaluation thus has to subject the integrated circuits to disturbances via both coupling mechanisms.

data sheets, however, do not reveal the respective immunity parameters. A new criterion has thus to be found to evaluate the immunity with E and H field coupling.

The aim is to evaluate/compare the potential integrated circuits in terms of their immunity to disturbances coupled in via fields.

Either one or both coupling mechanisms (H-field/E-field) can cause faults depending on the IC's design. An objective immunity evaluation thus has to subject the integrated circuits to disturbances via both coupling mechanisms.

The chosen approach is shown in the Figures 3 and 4.

Separate coupling circuits were designed for both coupling mechanisms. An EFT/burst generator (burst generator according to IEC 61000-4-4) was used as a disturbance source. This generator was connected to the coupling waveguide via a 50 Ω high voltage cable for H-field coupling. The wave guide had a 50 Ω input to ensure that the burst reaches the device under test without distortion. An additional measuring shunt monitored the generated disturbance pulses.

The wave guide was arranged above the devices under test at the defined angle and distance. This guaranteed that all ICs were subjected to a comparable disturbance field with an identical EFT/burst generator setting.

The pulse shape generated by the waveguide (measured via the shunt) is shown in Figure 3.

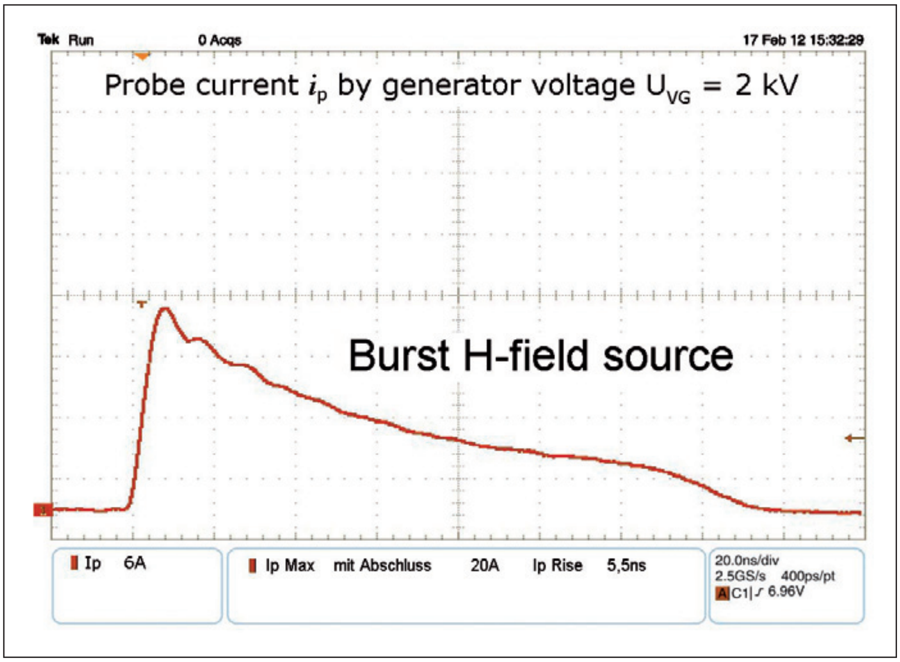


Figure 3: Pulse shape generated by the waveguide of the H-field source P1202-4

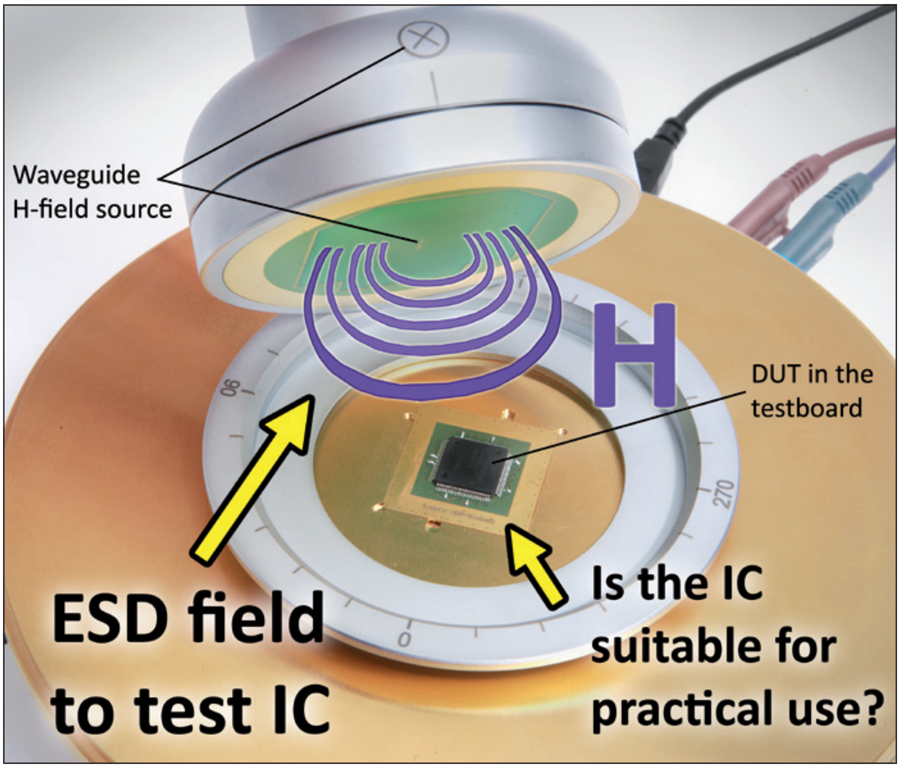


Figure 4: Burst H-field source

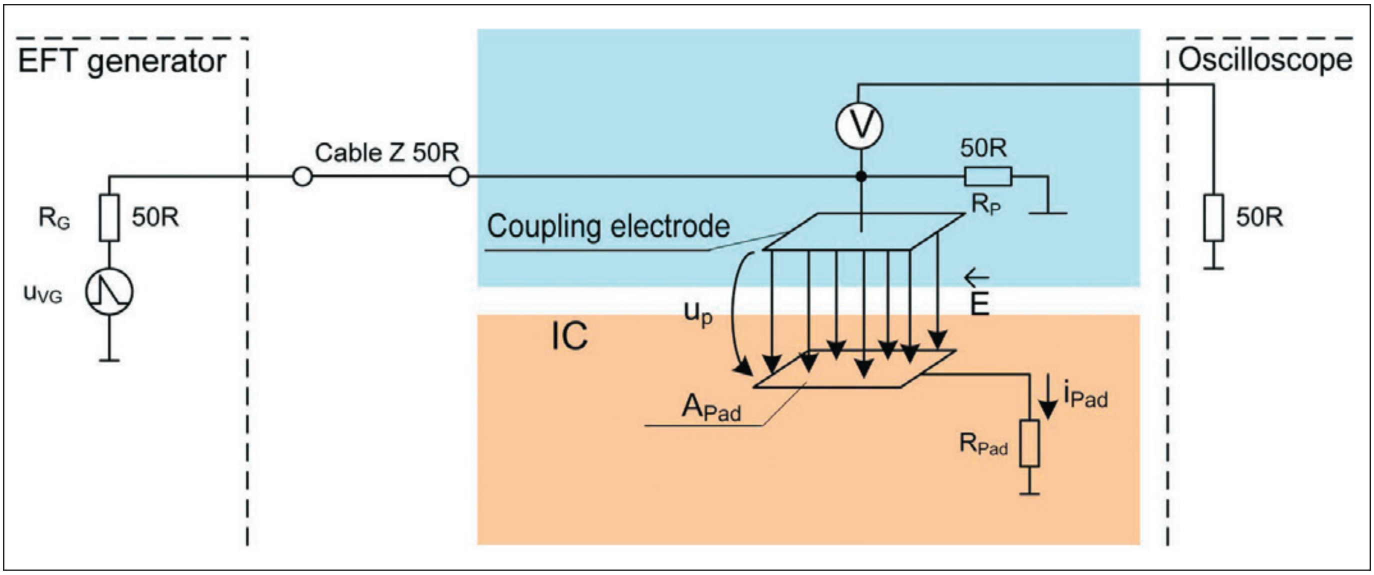


Figure 5: E-field coupling

Apart from the generator setting, the magnetic field's angle also had to be taken into account since it is related to the waveguide's orientation and has a direct influence on the interference effect achieved.

A similar set-up was chosen for E-field coupling (Figure 5).

The EFT/burst generator was connected to a coupling electrode instead of a waveguide. This electrode was arranged at a defined distance above the device under test. The voltage between the coupling electrode and the device under test generated an electric field proportional to the burst voltage amplitude.

The devices under test could thus be subjected separately to E-field and/or H-field disturbances.

The subsequent measurement was expected to show that the individual integrated circuits fail completely or cause faults at different EFT/burst generator voltages, coupling mechanisms (E-field/H-field) and field angles. Or in other words: the integrated circuits' immunity to E/H-field disturbances differed from manufacturer to manufacturer and the measured results let the engineer choose a suitable IC for the described application.

80C51 microcontrollers from three manufacturers were examined as potential candidates for the application in the course of the measurements described below.

The integrated circuits were not tested in the application but on customised test adapters to create reproducible conditions and prevent parasitic effects by other parts of the circuit.

The following parameters applied for the measurement:

- Identical package pin-out (VQFP44)

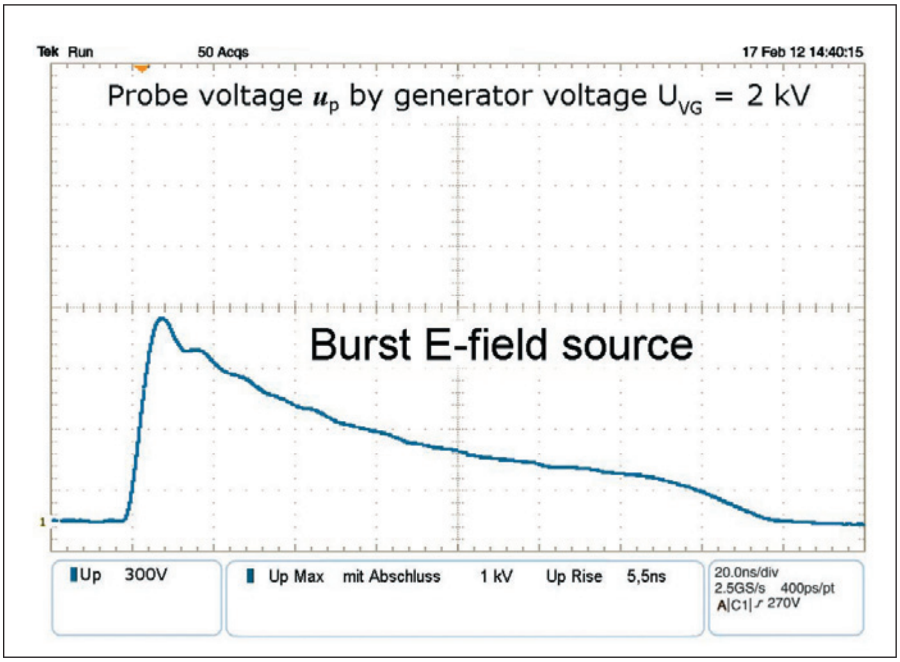


Figure 6: Burst E-field source

- Comparable functionality – all three are 8051-compatible
- Identical test adapter (packaged with the same filter elements)
- Identical test program and/or firmware

PREPARATION

The integrated circuit was tested during operation. The test program was selected so that each component in the integrated circuit (timer/UART/watchdog, etc.) was used and the corresponding test signals on the pins provided information about their functionality.

A pin was continually toggled (heartbeat signal) and a static signal sent to the outside in the present example. An oscilloscope was sufficient to monitor this test set-up. In addition, the outputs were connected to LEDs to receive visual feedback about the operating state of the device under test. The individual operating states of the IC were controlled by a PC via a test adapter-to-PC connection.

The test program ran in the following way: LED_01 (heartbeat) flashed slowly while LED_02 came on permanently during the start of the IC. Depending on its firmware, the IC changed over to another operating mode which caused LED_01 (heartbeat) to flash faster and switched LED_02 off should a crash and subsequent reset occur. Irregularities of the heartbeat signal indicated an internal program sequence problem.

The subsequent figures show the measurement set-up used for the test procedure (Figures 7 and 8).

It comprised the following components:

- EFT/burst generator with a maximum generator voltage of 4.4 kV
- Base plate for the test adapter with an integrated IC-to-PC interface
- Device under test in the test adapter
- H-field source/E-field source with a 3 mm spacer
- Oscilloscope and oscilloscope adapter
- Power supply for the PC interface and IC

The IC was connected to the PC interface via the test adapter. This allowed the engineer to monitor and control the IC.

The measurement set-up shown in the figure also included an oscilloscope adapter which made it easier to connect the oscilloscope's scanning heads and did not affect the measurements.

A controlled switched-mode power supply unit with an internal current limiting function supplied the measurement set-up with power and was intended to protect the IC from destruction in the event of a malfunction.

The field sources were connected to the EFT/burst generator. The 50 Ohm measurement output of the field source was connected to the oscilloscope to monitor the injected pulses.

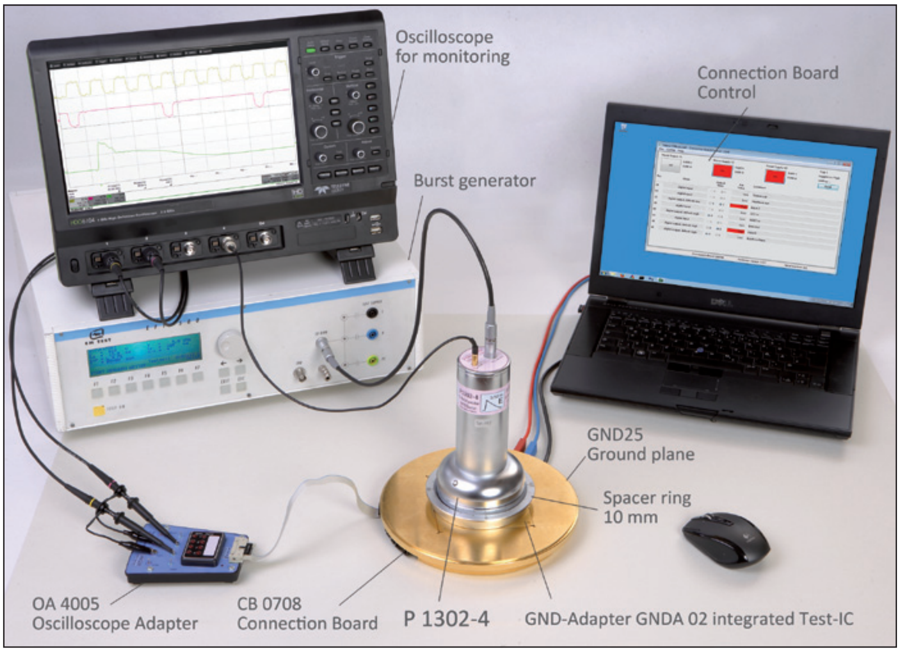


Figure 7: Measurement set-up with the DUT in the test adapter

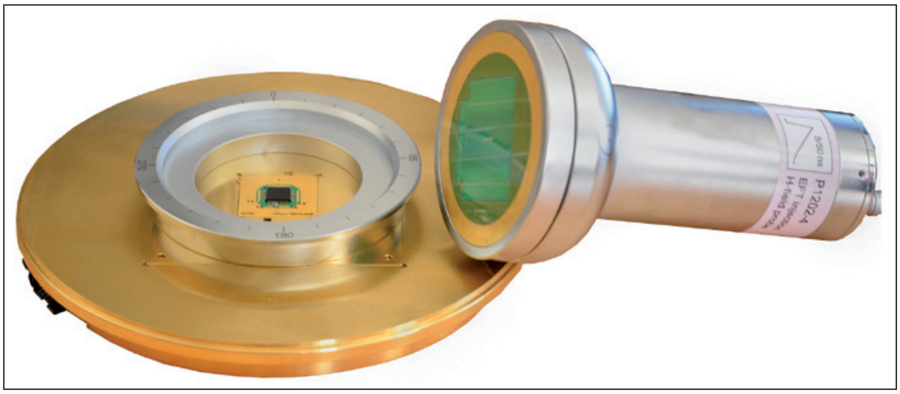


Figure 8 :Device under test and waveguide P1202-4

The integrated circuits' different immunity levels become visible straight away. None of the tested integrated circuits was susceptible to E-field.

The measurement procedure was as follows: first of all, the IC's program was started. Its proper functioning was monitored by the oscilloscope. The field source was placed over the centre of the integrated circuit, starting with the H-field source.

It was important to adjust the field source relative to the device under test when this was subjected to an H-field. This ensured that the results are comparable since the interference effect depends on the field angle. The field angle did not have to be adjusted if an E-field was coupled in.

Field coupling was started at the EFT/burst generator's lowest amplitude value and a positive polarity. The severity was then gradually increased up to a maximum generator voltage of 4.4 kV or until a fault occurred. The polarity was then switched over and the measurement repeated. Several measurements had to be taken at different field angles under the influence of H-field. The integrated circuits were subjected to the disturbance for one minute in each of the test runs.

Tables 1 and 2 summarize the results and show at which voltage amplitude, polarity and field angle a reset occurred for the different IC's.

Only three field angles were chosen for an initial test of the ICs under the influence of a magnetic field. A second test run with a finer resolution can be carried out to pinpoint any functional faults that occur.

The integrated circuits' different immunity levels become visible straight away. None of the tested integrated circuits was susceptible to E-field.

A crash could only be invoked in the 80C51 IC from Manufacturer 2 at 4

Manufacturer	Polarity	Generator voltage at the moment the circuit failed		
		Angle 0°	Angle 90°	Angle 180°
Manufacturer 1	positive	2,040 V	No failure	No failure
	negative	No failure	No failure	2000 V
Manufacturer 2	positive	4,000 V	No failure	No failure
	negative	No failure	No failure	4000 V
Manufacturer 3	positive	3,600 V	No failure	800 V
	negative	800 V	No failure	3,300 V

Table 1: Immunity level determined during H-field coupling

Manufacturer	Polarity	Generator voltage at the moment the circuit failed
Manufacturer 1	positive	No failure
	negative	
Manufacturer 2	positive	
	negative	
Manufacturer 3	positive	
	negative	

Table 2: Immunity level determined during E-field coupling

The measurements at a field angle of 180° provided the same results as the measurements at a field angle of 0° with the opposite generator polarity.

kV while the IC from Manufacturer 3 carried out a reset at a value as low as 1 kV when subjected to magnetic field. Since all of the test conditions (test set-up, interconnection, test program, etc.) were identical, the differences must be inherent to the integrated circuits themselves.

The measurements at a field angle of 180° provided the same results as the measurements at a field angle of 0° with the opposite generator polarity.

The deviations which occurred and are clearly visible in the table can be explained by variations within the generator. These can be verified on the basis of the pulse shape generated at the oscilloscope's measurement output.

None of the integrated circuits could be influenced at a field angle of 90°.

The heartbeat signal was not influenced during any of the measurements, i.e. the IC's were functional until the reset. In view of these findings it seems reasonable to assume that the integrated circuits' power supply was disturbed.

Figure 9 shows the top view of a device under test with a spacer. The spacer has a degree scale where the position of the waveguide (H-field) and thus the field angle can be read.

The Vcc and Vss pins are on opposite sides of the IC package in the present example. A maximum voltage is induced in this loop at a field angle of 0° and/or 180°, leading to an IC power supply failure and thus a reset. Since no other faults occurred and none of the integrated circuits was susceptible to E-field, the generator voltage at which the ICs failed when subjected to H-field was used as a comparison criterion. As a result, the 80C51 from Manufacturer 2 was chosen for the application since it has the highest immunity level of the ICs measured. After this EMC assessment the engineers can proceed to the development of the modular electronic switchgear. IN

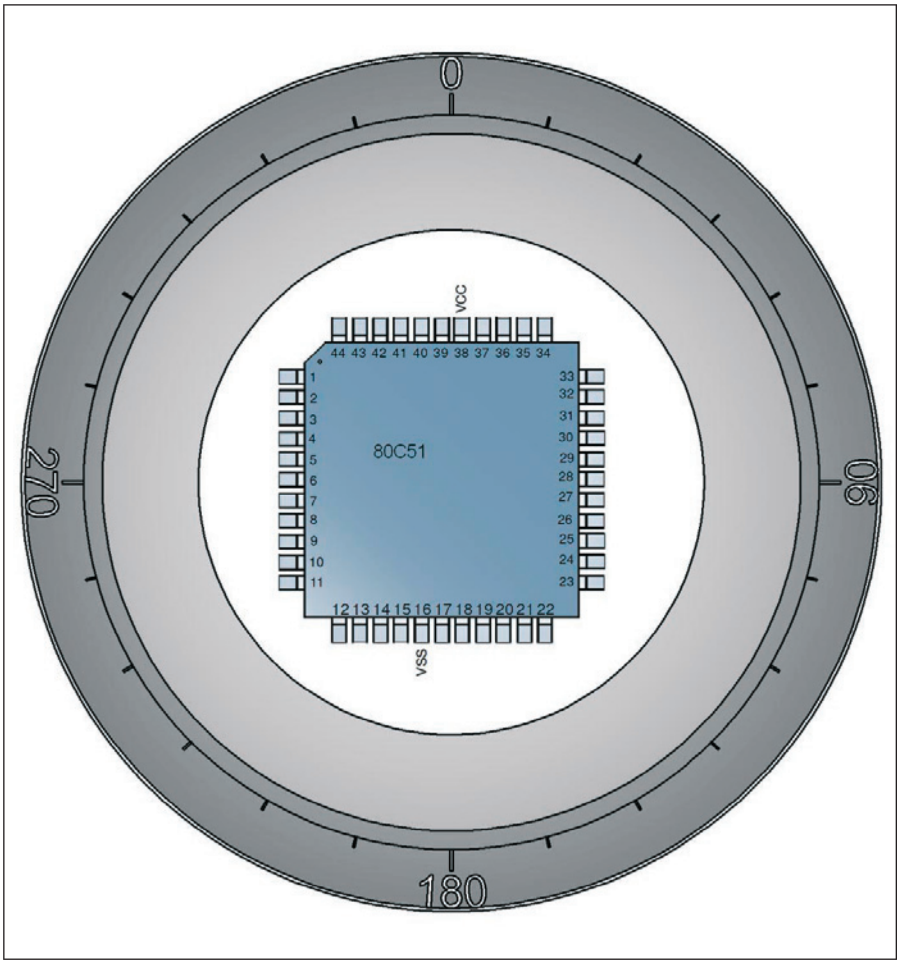


Figure 9: Position of the 80C51 supply pins relative to the field angle

(the author)

LARS GLAESSER

Dipl.-Ing. Lars Glaesser studied electrical engineering at Technische Universität Dresden. He has been employed by Langer EMV-Technik GmbH since 2010. In addition to product development of precompliance measurement instruments, he deals with EMC immunity tests on IC level.

Fundamentals of Electrostatic Discharge

Part Six: ESD Standards

BY THE ESD ASSOCIATION

The electronics industry is continually shifting. Device circuitry density and technology is more complex. Electronics manufacturing is more heavily reliant on out-sourcing. The ESD industry seems to have jumped into this swirling eddy headfirst. ESD control programs have mushroomed. Black has been replaced by green, blue and gold. Shielding bags dominate the warehouse. Ionizers exist alongside wrist straps and ground cords. An early history of "smoke and mirrors," magic and lofty claims of performance is rapidly being relegated to the past.

Today, more than ever, meeting the complex challenge of reducing ESD losses requires more than reliance on faith alone. Users require a way to legitimately evaluate and compare competing brands and types of products and ESD protection strategies. They need objective confirmation that their ESD control program provides effective solutions to their unique ESD problems. Contract manufacturers and OEM's require mutually agreed-upon ESD control programs that reduce duplication of process controls.

That's where standards come into play. They provide information in developing programs that effectively address ESD process control. They help define the sensitivity of the products manufactured and used. They help define the performance requirements for various ESD control materials, instruments, and tools. Standards are playing an ever-increasing role in reducing marketplace confusion in the manufacture, evaluation, and selection of ESD control products and programs.

THE WHO AND WHY OF STANDARDS

Who uses ESD standards? Manufacturers and users of ESD sensitive devices and products, manufacturers and distributors of ESD control products, certification registrars, and third party testers of ESD control products.

Why use ESD standards? They help assure consistency of ESD sensitive products and consistency of ESD control products and services. They provide a means of objective evaluation and comparison among competitive ESD control products. They help reduce conflicts between users and suppliers of ESD control products. They help in developing, implementing, auditing, and certifying ESD control programs. And, they help reduce confusion in the marketplace.

In the United States, the use of standards is voluntary, although their use can be written into contracts or purchasing agreements between buyer and seller. In most of the rest of the world, the use of standards, where they exist, is compulsory.

KEY STANDARDS AND ORGANIZATIONS

Just twenty-five years ago, there were relatively few reliable ESD standards and few ESD standards development organizations. Today's ESD standards landscape is not only witnessing an increase in the number of standards, but also increasing cooperation among the organizations that develop them.

Today's standards fall into three main groups. First, there are those that provide ESD program guidance or requirements. These include documents such as *ANSI ESD S20.20 – Standard for the Development of an ESD Control Program, IEC 61340-5-1 – Protection of electronic devices from electrostatic phenomena – General requirements, ANSI/ESD S8.1 – Symbols-ESD Awareness,* or *ANSI/ESD TR20.20 – ESD Handbook.*

A second group covers requirements for specific products or procedures such as packaging requirements and grounding. Typical standards in this group are *ANSI/ESD S6.1 –Grounding* and *ANSI/ESD S541 –Packaging Materials for ESD Sensitive Items*.

A third group of documents covers the standardized test methods used to evaluate products and materials. Historically, the electronics industry relied heavily on test methods established for other industries or even for other materials (e. g., *ASTM-257 – DC Resistance or Conductance of Insulating Materials*). Today, however, specific test method standards focus on ESD in the electronics environment, largely as a result of the ESD Association's activity. These include standards such as *ANSI/ESDA-JEDEC JS-001– Device Testing, Human Body Model* and *ANSI/ESD STM7.1: Floor Materials – Resistive Characterization of Materials*.

WHO DEVELOPS STANDARDS?

Standards development and usage is a cooperative effort among all organizations and individuals affected by standards. There are several key ESD standards development organizations.

Military Standards

Traditionally, the U.S. military spearheaded the development of specific standards and specifications with regard to ESD control in the U.S. Today, however, U.S. military agencies are relying on commercially developed standards rather than developing standards themselves. For example, the ESD Association completed the assignment from the Department of Defense

(DoD) to convert MIL-STD-1686 into a commercial standard called ANSI/ESD S20.20 which was adopted by the DoD July, 7, 2000.

ESD Association

The ESD Association has been a focal point for the development of ESD standards in recent years. An ANSI-accredited standards development organization, the Association is charged with the development of ESD standards and test methods. The Association also represents the US on the International Electrotechnical Commission (IEC) Technical Committee 101-Electrostatics.

The ESD Association has currently 32 standards documents available and 30 Technical Reports. These voluntary standards cover the areas of material requirements, electrostatic sensitivity, and test methodology for evaluating ESD control materials and products. In addition to standards documents, the Association also has published a number of informational advisories. Advisory documents may be changed to other document types in the future.

ESD Association Standards Classifications and Definitions

There are four types of ESD Association standards documents with specific clarity of definition. The four document categories are consistent with other standards development organizations. These four categories are defined below.

Standard: A precise statement of a set of requirements to be satisfied by a material, product, system or process that also specifies the procedures for determining whether each of the requirements is satisfied.

Standard Test Method: A definitive procedure for the identification, measurement and evaluation of one or more qualities, characteristics or properties of a material, product, system or process that yields a reproducible test result.

Standard Practice: A procedure for performing one or more operations or functions that may or may not yield a test result. Note: If a test result is obtained, it may not be reproducible between labs.

Technical Report: A collection of technical data or test results published as an informational reference on a specific material, product, system, or process.

As new documents are approved and issued, they will be designated into one of these four categories. Existing documents have been reviewed and have been reclassified as appropriate. Several Advisory Documents still exist and may be migrated to either Technical Reports or Standard Practices in the future.

International Standards

The international community, led by the European-based International Electrotechnical Commission (IEC), also develops and publishes standards. IEC Technical Committee 101 has released a series of documents under the heading IEC 61340. The documents contain general information regarding electrostatics, standard test methods, general practices and an ESD Control Program Development Standard IEC 61340-5-1 that is technically equivalent to ANSI/ESD S20.20. A Facility Certification Program is also available. Global companies can seek to become certified to both ANSI/ESD S20.20 and to IEC 61340-5-1 if they so choose. Japan also has released its proposed version of a national electrostatic Standard, which also shares many aspects of the European and U.S. documents.

Organizational Cooperation

Perhaps one of the more intriguing changes in ESD standards has been the organizational cooperation developing between various groups. One cooperative effort was between the ESD Association and the U.S. Department of Defense, which resulted in the Association preparing ANSI/ESD S20.20 as a successor to MIL-STD-1686. A second cooperative effort occurred between the ESD Association and JEDEC, which started with an MOU and resulted in the development of 2 documents: a joint Human Body Model document was published in 2010; a joint Charged Device Model document will be published in 2014.

Internationally, European standards development organizations and the ESD Association have developed working relationships that result in an expanded review of proposed documents, greater input, and closer harmonization of standards that impact the international electronics community.

For users of ESD standards, this increased cooperation will have a significant impact. First, we should see standards that are technically improved due to broader input. Second, we should see fewer conflicts between different standards. Finally, we should see less duplication of effort.

SUMMARY

For the electronics community, the rapid propagation of ESD standards and continuing change in the standards environment mean greater availability of the technical references that will help improve ESD control programs. There will be recommendations to help set up effective programs. There will be test methods and specifications to help users of ESD control materials evaluate and select ESD control products that are applicable to their specific needs. And there will be guidelines for suppliers of ESD control products and materials to help them develop products that meet the real needs of their customers.

Standards will continue to fuel change in the international ESD community. IN

Principal ESD Standards

U.S. Military/Department of Defense

MIL-STD-1686: Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
This military standard establishes requirements for ESD Control Programs. It applies to U.S. military agencies, contractors, subcontractors, suppliers and vendors. It requires the establishment, implementation and documentation of ESD control programs for static sensitive devices, but does NOT mandate or preclude the use of any specific ESD control materials, products, or procedures. It is being updated and converted to a commercial standard by the ESD Association. Although DOD has accepted the new ANSI/ESD S20.20 document as a successor, it has not yet taken action to cancel STD-1686

MIL-HBDK-263: Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
This document provides guidance, but NOT mandatory requirements, for the establishment and implementation of an electrostatic discharge control program in accordance with the requirements of MIL-STD-1686.

MIL-PRF 87893 — Workstation, Electrostatic Discharge (ESD) Control
This document defines the requirements for ESD protective workstations.

MIL-PRF-81705—Barrier Materials, Flexible, Electrostatic Protective, Heat Sealable
This documents defines requirements for ESD protective flexible packaging materials.

MIL-STD-129—Marking for Shipment and Storage
Covers procedures for marketing and labeling ESD sensitive items.

SOURCES OF STANDARDS

ESD Association, 7900 Turin Road, Building 3, Rome, NY 13440. Phone: 315-339-6937. Fax: 315-339-6793. **http://www.ESDA.org**

IHS Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112. Phone: 800-854-7179. Fax: 303-397-2740. **http://global.ihs.com**

International Electrotechnical Commission, 3, rue de Varembe, Case postale 131, 1211 Geneva 20, Switzerland. Fax: 41-22-919-0300. **http://www.iec.ch**

Military Standards, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120. **https://assist.dla.mil**

JEDEC Solid State Technology Association, 3103 North 10th Street, Suite 240-S, Arlington, VA 22201-2107. **http://www.jedec.org**

ESD Association

Standards Documents

ANSI/ESD S1.1: Evaluation, Acceptance, and Functional Testing of Wrist Straps
A successor to EOS/ESD S1.0, this document establishes test methods for evaluating the electrical and mechanical characteristics of wrist straps. It includes improved test methods and performance limits for evaluation, acceptance, and functional testing of wrist straps.

ANSI/ESD STM2.1: Resistance Test Method for Electrostatic Discharge Protective Garments
This Standard Test Method provides test methods for measuring the electrical resistance of garments used to control electrostatic discharge. It covers test methods for measuring sleeve-to-sleeve and point-to-point resistance.

ANSI/ESD STM3.1: Ionization
Test methods and procedures for evaluating and selecting air ionization equipment and systems are covered in this standard. The document establishes measurement techniques to determine offset voltage ion balance and discharge neutralization time for ionizers.

ANSI/ESD SP3.3: Periodic Verification of Air Ionizers
This Standard Practice provides test procedures for periodic verification of the performance of air ionization equipment and systems (ionizers).

ANSI/ESD SP3.4 Periodic Verification of Air Ionizer Performance Using a Small Test Fixture
This standard practice provides a test fixture example and procedures for performance verification of air ionization used in confined spaces where it may not be possible to use the test fixtures defined in ANSI/ESD STM3.1 or ANSI/ESD SP3.3.

ANSI/ESD S4.1: Worksurfaces – Resistance Measurements
This Standard establishes test methods for measuring the electrical resistance of worksurface materials used at workstations for protection of ESD susceptible items. It includes methods for evaluating and selecting materials, and testing new worksurface installations and previously installed worksurfaces.

ANSI/ESD STM4.2: Worksurfaces – Charge Dissipation Characteristics
This Standard Test Method provides a test method to measure the electrostatic charge dissipation characteristics of worksurfaces used for ESD control. The procedure is designed for use in a laboratory environment for

qualification, evaluation or acceptance of worksurfaces.

ESDA-JEDEC JS-001: Electrostatic Discharge Sensitivity Testing – Human Body Model
This Standard Test Method updates and revises an existing Standard. It establishes a procedure for testing, evaluating and classifying the ESD sensitivity of components to the defined Human Body Model (HBM).

ANSI/ESD STM5.2: Electrostatic Discharge Sensitivity Testing Machine Model
This Standard establishes a test procedure for evaluating the ESD sensitivity of components to a defined Machine Model (MM). The component damage caused by the Machine Model is often similar to that caused by the Human Body Model, but it occurs at a significantly lower voltage.

ANSI/ESD STM5.3.1: Electrostatic Discharge Sensitivity Testing – Charged Device Model – Non-Socketed Model
This Standard Test Method establishes a test method for evaluating the ESD sensitivity of active and passive components to a defined Charged Device Model (CDM).

ANSI/ESD SP5.3.2: Electrostatic Discharge Sensitivity Testing – Socketed Device Method (SDM) – Component Level.
This standard practice provides a test method generating a Socketed Device Model (SDM) test on a component integrated circuit (IC) device.

ANSI/ESD STM5.5.1: Electrostatic Discharge Sensitivity Testing – Transmission Line Pulse (TLP) – Component Level.
This document pertains to Transmission Line Pulse (TLP) testing techniques of semiconductor components. The purpose of this document is to establish a methodology for both testing and reporting information associated with TLP testing.

ANSI/ESD SP5.5.2: Electrostatic Discharge Sensitivity Testing – Very Fast Transmission Line Pulse (VF-TLP) – Component Level
This document pertains to Very Fast Transmission Line Pulse (VF-TLP) testing techniques of semiconductor components. It establishes guidelines and standard practices presently used by development, research, and reliability engineers in both universities and industry for VF-TLP testing. This document explains a methodology for both testing and reporting information associated with VF-TLP testing.

ANSI/ESD SP5.6: Electrostatic Discharge Sensitivity Testing – Human Metal Model (HMM) – Component Level
Establishes the procedure for testing, evaluating, and classifying the ESD sensitivity of components to the defined HMM.

ANSI/ESD S6.1: Grounding
This Standard recommends the parameters, procedures, and types of materials needed to establish an ESD grounding system for the protection of electronic hardware from ESD damage. This system is used for personnel grounding devices, worksurfaces, chairs, carts, floors, and other related equipment.

ANSI ESD STM7.1: Floor Materials – Resistive Characterization of Materials
Measurement of the electrical resistance of various floor materials such as floor coverings, mats, and floor finishes is covered in this document. It provides test methods for qualifying floor materials before installation or application and for evaluating and monitoring materials after installation or application.

ANSI ESD S8.1: ESD Awareness Symbols
Three types of ESD awareness symbols are established by this document. The first one is to be used on a device or assembly to indicate that it is susceptible to electrostatic charge. The second is to be used on items and materials intended to provide electrostatic protection. The third symbol indicates the common point ground

ANSI/ESD S9.1: Resistive Characterization of Footwear
This Standard defines a test method for measuring the electrical resistance of shoes used for ESD control in the electronics environment.

ESD SP9.2: Footwear – Foot Grounders Resistive Characterization
This standard practice was developed to provide test methods for evaluating foot grounders and foot grounder systems used to electrically bond or ground personnel as part of an ESD Control Program. Static Control Shoes are tested using ANSI/ESD STM9.1.

ANSI/ESD SP10.1: Automated Handling Equipment
This Standard Practice provides procedures for evaluating the electrostatic environment associated with automated handling equipment.

ANSI ESD STM11.11: Surface Resistance Measurement of Static Dissipative Planar Materials
This Standard Test Method defines a direct current test method for measuring electrical resistance. The Standard is designed specifically for static dissipative planar materials used in packaging of ESD sensitive devices and components.

ANSI/ESD STM11.12: Volume Resistance Measurement of Static Dissipative Planar Materials
This Standard Test Method provides test methods for measuring the volume resistance of static dissipative planar materials used in the packaging of ESD sensitive devices and components.

ANSI/ESD STM11.13: Two-Point Resistance Measurement
This Standard Test Method provides a test method to measure the resistance between two points on an items surface.

ANSI ESD STM11.31: Evaluating the Performance of Electrostatic Discharge Shielding Bags
This Standard provides a method for testing and determining the shielding capabilities of electrostatic shielding bags.

ANSI/ESD S11.4: Static Control Bags
This standard establishes performance limits for bags that are intended to protect electronic parts and products from damage due to static electricity and moisture during common electronic manufacturing industry transport and storage applications.

ANSI/ESD STM12.1: Seating-Resistive Characterization
This Standard provides test methods for measuring the electrical resistance of seating used to control ESD. The test methods can be used for qualification testing as well as for evaluating and monitoring seating after installation. It covers all types of seating, including chairs and stools.

ANSI/ESD STM13.1: Electrical Soldering/Desoldering Hand Tools
This Standard Test Method provides electric soldering/desoldering hand tool test methods for measuring the electrical leakage and tip to ground reference point resistance and provides parameters for EOS safe soldering operation.

ANSI/ESD SP15.1: Standard Practice for In-Use Testing of Gloves and Finger Cots
This document provides test procedures for measuring the intrinsic electrical resistance of gloves and finger cots as well as their electrical resistance together with personnel as a system.

ANSI ESD S20.20: Standard for the Development of an ESD Control Program
This Standard provides administrative, technical requirements and guidance for establishing, implementing and maintaining an ESD Control Program.

ANSI/ESD STM97.1: Floor Materials and Footwear – Resistance in Combination with a Person.
This Standard Test Method provides for measuring the electrical resistance of floor materials, footwear and personnel together, as a system.

ANSI/ESD STM97.2: Floor Materials and Footwear Voltage Measurement in Combination with a Person
This Standard Test Method provides for measuring the electrostatic voltage on a person in combination with floor materials and footwear, as a system.

ANSI/ESD S541: Packaging Materials for ESD Sensitive Items
This standard describes the packaging material properties needed to protect electrostatic discharge (ESD) sensitive electronic items, and references the testing methods for evaluating packaging and packaging materials for those properties. Where possible, performance limits are provided. Guidance for selecting the types of packaging with protective properties appropriate for specific applications is provided. Other considerations for protective packaging are also provided.

Advisory Documents and Technical Reports

Advisory Documents and Technical Reports are not Standards, but provide general information for the industry or additional information to aid in better understanding of Association Standards.

ESD ADV1.0: Glossary of Terms
Definitions and explanations of various terms used in Association Standards and documents are covered in this Advisory. It also includes other terms commonly used in the ESD industry.

ESD ADV3.2: Selection and Acceptance of Air Ionizers
This Advisory document provides end users with guidelines for creating a performance specification for selecting air ionization systems. It reviews four types of air ionizers and discusses applications, test method references, and general design, performance and safety requirements.

ESD ADV11.2: Triboelectric Charge Accumulation Testing
The complex phenomenon of triboelectric charging is discussed in this Advisory. It covers the theory and effects of tribocharging. It reviews procedures and problems associated with various test methods that are often used to evaluate triboelectrification characteristics. The test methods reviewed indicate gross levels of charge and polarity, but are not necessarily repeatable in real world situations.

ESD TR5.4-04-13 Transient Latch-up Testing
This document defines transient latch-up (TLU) as a state in which a low-impedance path, resulting from a transient overstress that triggers a parasitic thyristor structure or bipolar structure or combinations of both, persists at least temporarily after removal or cessation of the triggering condition. The rise time of the transient overstress causing TLU is shorter than five μs. TLU as defined in this document does not cover changes of functional states, even if those changes would result in a low-impedance path and increased power supply consumption.

ESD TR53: Compliance Verification of ESD Protective Equipment and Materials.
This technical report describes the test procedures and test equipment that can be used to periodically verify the performance of ESD protective equipment and materials.

ESD TR20.20: ESD Handbook
ESD handbook provides detailed guidance for implementing an ESD control program in accordance with ANSI/ESD S20.20.

BUSINESS News

REACH-Compliant Inrush Current Limiters and NTC Thermistors

As part of Ametherm's commitment to the environment, the company announced that its entire lineup of inrush current limiters and NTC thermistors conforms to the requirements of the European Union's Registration, Evaluation, Authorisation, and Restriction of Chemicals (REACH) regulation. As a REACH-compliant manufacturer, Ametherm's products contain none of the chemicals on the Candidate List of 155 Substances of Very High Concern (SVHC), which was last updated on June 16, 2014, by the European Chemical Agency (ECHA). For more information or to request a sample, visit www.ametherm.com.

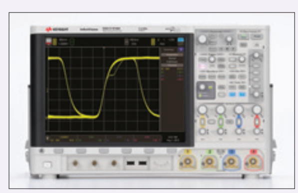
New Temperature/Humidity Stability Test Chambers

CSZ Testing is expanding its capabilities in their Ohio Test Laboratory. Now equipped with a state-of-the-art Altitude Environmental Test chamber, CSZ's Test Lab is now able to perform Altitude Testing combined with Temperature and Humidity. The 32 cu. ft. chamber is capable of simulating Altitude environments of -5,000 to +100,000 feet, temperatures of -65C to +190C and a humidity range of 10% to 95% RH. For more information about CSZ's altitude testing services, visit www.csztesting.com.

Desco Introduces New ESD Workstation Covers

Desco ESD Workstation Covers are designed to cover ESD sensitive products on a workstation. The covers protect products from ESD, dust, and other contaminants. They can be grounded with an available ground cord. Surface resistance of the covers is 1 x 10^5 < 1 x 10^7 ohms RTT to attenuate electrostatic fields and electrostatic discharges (ESD). Covers come in 4 standard sizes. Custom sizes are available or sublimate customer artwork can be added to meet your company's needs. For more information, visit www.desco.com.

Oscilloscopes Donated to Three University Engineering Programs



Keysight Technologies, Inc. announced it has donated an MSOX4154A oscilloscope to each of the universities supporting the company's student internship program. The universities include: University of Colorado Boulder – Boulder, Colorado, Rensselaer Polytechnic Institute – Troy, New York, and Rochester Institute of Technology – Rochester, New York. Art Lizotte, Keysight sales development manager states, "our donation of an oscilloscope is a small recognition of the excellent work done by the students and the tremendous dedication the universities have in preparing the next-generation of engineers." For more information about Keysight's education programs, visit www.keysight.com.

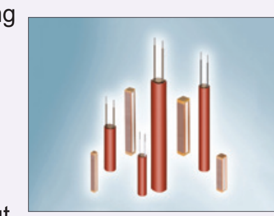
Reliant EMC Authorized Distributor of FRANKONIA Anechoic Chambers & RF-Shielded Rooms and EMC Test Equipment

Reliant EMC is now an authorized distributor of FRANKONIA Anechoic Chambers & RF-Shielded Rooms for North American and EMC Test Equipment and Anechoic Chambers & RF-Shielded Rooms to Central and South America. For more information about the FRANKONIA product line, visit www.reliantemc.com.

USB Mini Spectrum Analyzers

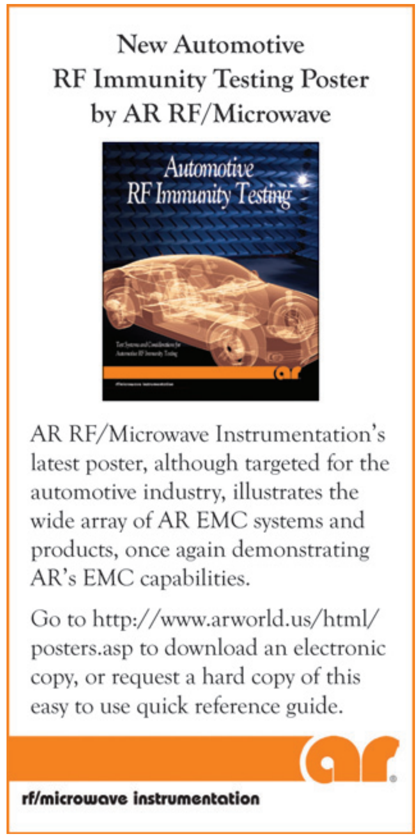
Saelig Company, Inc. announced the availability of the TSA Range of Spectrum Analyzers - economical USB-stick-sized miniature RF tools with large instrument performance. These PC-connected devices can perform most of the basic tests of much more expensive bench-top spectrum analyzers. Though tiny, the TSA Range of Spectrum Analyzers covers a wide measurement range in three models: TSA4G1 (1MHz - 4.15GHz), TSA6G1 (1MHz - 6.15GHz), and TSA8G1 (1MHz - 8.15GHz). For detailed specifications, visit www.saelig.com.

New EPCOS Piezo Actuators from TDK Raise the Bar on Performance



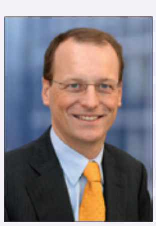
TDK Corporation announced the third generation of EPCOS piezo actuators with copper internal electrodes, which offer both improved performance and higher cost-effectiveness. These innovative actuators are characterized by outstanding stability and reliability. They can operate a billion switching cycles without failures at 170 degrees C. Silver-palladium actuators already exhibit significant failure rates under these extreme conditions. The new copper piezo actuators set a new standard for operating life. For more information, visit www.epcos.com.

PRODUCT Showcase



Business News

Dr.-Ing Michael Fübi Appointed New CEO of TÜV Rheinland



The Supervisory Board of TÜV Rheinland AG, a leading global provider of independent testing, inspection, and certification services, has appointed Dr.-Ing Michael Fübi as the new Chairman of the Executive Board. Dr.-Ing Fübi, 47, will assume his new position on January 1, 2015. Since 2012, Dr.-Ing Fübi has served as Chief Executive Officer for Germany-based RWE Technology, the RWE Group's arm responsible for project development and power plant construction. Dr.-Ing Fübi began his career at RWE Technology in 2002, where his various roles included management of climate protection at RWE Power for a four-year period. To learn more about TÜV Rheinland, visit www.tuv.com/us.

500 V High-Voltage MOSFETs Built on E Series Super Junction Technology

Vishay Intertechnology, Inc. announced the first MOSFETs in a new 500 V family that features the same benefits of low conduction and switching losses as the company's 600 V and 650 V E Series devices.

The low on-resistance and gate charge of the new devices will play a key role in saving energy in high-power, high-performance consumer products, lighting applications, and ATX/silver box PC switch mode power supplies (SMPS). The new MOSFETs provide ultra-low gate charge of 57 nC and low gate charge times on-resistance, a key figure of merit (FOM) for MOSFETs used in power conversion applications. For more information, visit www.vishay.com.

(Authors)

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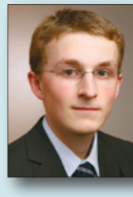

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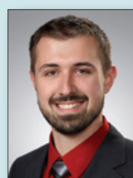

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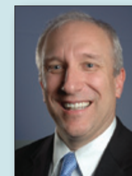


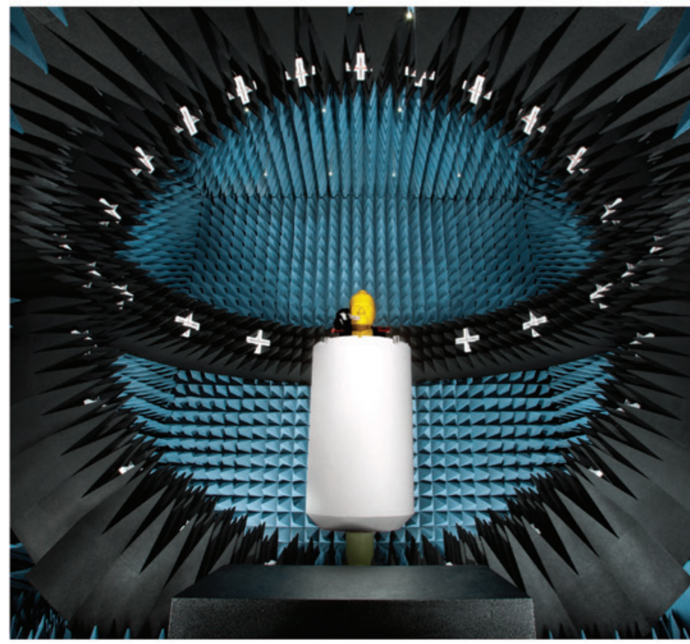
MIKE VIOLETTE
is President of Washington Labs and Director of American Certification Body. For more information, visit page 15.

We wish to thank our community of knowledgeable authors, indeed, experts in their field - who come together to bring you each issue of *In Compliance*. Their contributions of informative articles continue to move technology forward.

(Advertisers)

Reverb or Anechoic: What's the Best Solution for Wireless Over-The-Air Test?

AMS-7000 Reverb Test System



AMS-8923 Anechoic Test System ***(shown with MIMO option)***

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Reverb chambers are a good choice for pre-compliance wireless OTA measurements for a simple performance indicator. However, they don't provide directional information for generating pattern data needed make antenna performance evaluations.

Anechoic chambers on the other hand, provide vector information as a function of the test device's antenna orientation. This gives you directional information for full compliance with CTIA OTA measurements, as well as delay and fading profiles that represent real-world environments.

ETS-Lindgren is the only wireless OTA test systems supplier that offers both technologies – reverb and anechoic – as a ready-to-test, full turnkey solution. And both reverb and anechoic systems use EMQuest™ antenna measurement software, for easier operability and data comparisons between systems.

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