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EMI Stories 856 - 890

Helping you solve your EMC problems

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New EMI stories – numbers 856 – 890

Created January 2017 - December 2018. More will be added later.

Numbers 1-855 were originally published as Banana Skins in The EMC Journal, www.theemcjournal.com

Some of these stories are extracted from official documents and reports,
some are personal anecdotes, and some come from research.

Some of these EMI stories had harmless or amusing outcomes,
some lost companies large amounts of time / money, even causing bankruptcy,
and some caused (or could easily have caused) injuries and deaths.

My experience is that these stories only represent the very tip of a large iceberg, with unguessable costs for manufacturers and society as a whole. As electronic devices and technologies continue to advance; more (and more complex) software and wireless communications are used; as electronic systems are increasingly integrated into systems-of-systems which no person can understand fully, and even into systems-of-systems-of-systems (including the "Internet of Things", IoT, and autonomous vehicles): the only thing of which we can be certain is that EMI problems will occur more frequently and have larger impacts on cost and safety.

I hope these stories help identify possible EMI problems in advance, so that they are dealt with as part of the normal design/development procedure and don't create the embarrassment and costs of trying to correct poor EMC design after products have been shipped or systems installed.

If you have any suitable stories or know of any relevant research or reports, please tell me about them so they can be included (anonymously, if preferred) in this list.

Compiled by Keith Armstrong , keith.armstrong@cherryclough.com

856) EMI could affect bird migrations

The internal magnetic compasses of migratory birds can be disrupted by weak, man-made electromagnetic interference, according to a new study. The unexpected effect was seen in European robins, which were unable to orient themselves in the presence of broadband, radio-frequency noise believed to be caused by AM radio and electronic signals.

Given previous theories that robins might be affected by radio-frequency magnetic fields, the European researchers experimented with reducing local electromagnetic noise by screening the bird's huts with electrified and grounded aluminium plates. This shielding reduced the interference by two orders of magnitude, while leaving the static geomagnetic field unaffected, and this restored the bird's ability to orient themselves. (Nature 10.1038/nature13290)

(Kindly sent in by Richard Marshall, who spotted "Noise could set European robin adrift", in "Frontiers", Physics World, June 2014, page 4, www.physicsworld.com.)

857) Increasing need for reliable industrial comm's to have RFI/EMI protection

The increasing need for reliable communications in factories and plants means that more and more industrial electronic equipment may require built-in radio frequency interference (RFI) immunity. At the same time, this equipment's susceptibility to the electromagnetic interference (EMI) effects of inductive load switching relays and noise induced by heavy operating equipment must be considered.

It is, however, possible that you will not know you need RFI/EMI protection until somebody keys up a radio transmitter near your device or mounts it in a noisy electrical environment and the output readings become erroneous.

(Taken from "Making the right choice", by Amplicon, in Instrumentation magazine, March 2015, pp 17-18, www.connectingindustry.com/instrumentation.)

858) Lightning strikes cause downtime for petroleum refinery

Control Engineering Europe looks at the journey taken by Tüpras Kirikkale petroleum refinery to ensure its plant is better protected from downtime due to lightning stikes in the future.

Tüpras Kirikkale petroleum refinery was established in 1986. One of the plants within the refinery contains a diesel desulpherisation (DHP) and continuous catalyst regeneration (CCR) unit.

Since commissioning, in 2007, this plant has suffered a series of electrical trips, caused by lighting strikes in the area.

To help overcome the problem the company asked experts from Yokogawa Italy to help to identify the root cause of the plant shutdowns. Following a site survey in 2013, Yokogawa collected information and measurement data to prepare a report for the company.

The report concluded that the safety system had performed a safety action because the same event had occurred in in many areas of the plant – this consisted of an overvoltage on an input or output channel coming from external devices or cabling, due to lightning strikes.

Analysis of the data did not identify whether the channel overvoltage was caused by equipment installed internally in the system or by marshalling cabinets. This kind of overvoltage is considered to be a major failure of the safety input/output loop, causing the system to drive the plant in a safe conditon (shutdown on emergency).

(Taken from "Eliminating downtime caused by lightning strikes", in Control Engineering Europe, 17 February 2015,www.controlengeurope.com/article/90631/Eliminating-downtime-caused-by-lightning-strikes.aspx.)

859) Industrial control panels more susceptible to Power Quality issues

In view of the progress of electronic development of PLCs, sensors, and the like, the electronic components (that are used to assemble industrial control panels – Editor) become more sensitive to voltage dips and interruptions.

(Taken from "Electronic circuit breakers protect 24V dc circuits in industrial control panels", by Cristoph Wesner, Dipl.-Ing. (FH), in Control Engineering Europe, April 25, page 18, www.controleng.com/single-article/electronic-circuit-breakers-protect-24-v-dc-circuits-in-industrial-control-panels/77bcbeb9e83743ad6564dd6bab86e814.html.)

860) Nearly all PhotoVoltaic inverters assessed were EMC non-compliant

- The majority of EUT - 32 (58 %) - were of EU / EFTA origin.
- Approximately a third (33 %) of the EUT met the disturbance emissions compliance tests.
- Approximately a third (38 %) of the EUT met the administrative requirements (as assessed).
- All but one assessed EUT (54) were CE marked (2 were incorrectly formatted).
- A quarter (25%) of DoC was not provided, and 75 % of the DoC provided were correct.
- Nearly all (91 %) of the EUT were assessed as overall non-compliant.
- Study of emissions below 150 kHz (optional): approximately a third of the EUT (38%) were found compliant to EN 55011 Table 8 limits at mains terminals in the frequency range 9 kHz-150 kHz.
- Study of DC side (optional): approximately a half of the EUT (43%) were found compliant to EN 61000-6-3 emission requirements to the DC power port.
- From the results obtained of the solar panel inverters under test, the majority did not meet the harmonised standards that would provide a presumption of conformity with the EMCD.
- The EUT represented a large sample of the products available on the market and it is clear that much remains to be done by manufacturers in terms of compliance.

(Taken from page 12 of "Conclusions, EMC Administrative Co-operation Working Group, Report on the 6th EMC Market Surveillance Campaign 2014, SOLAR PANEL INVERTERS (Grid-connected PV inverters and optimisers intended to be used by consumers). This document may be downloaded from the "Member's Area" at www.emctla.com, or else Google "6th EMC Market Surveillance Campaign 2014")

861) Variability of ESD test results

The immunity to ESD of present-day electronic components and devices has further decreased due to the high sensitivity of ICs.

Electronic devices can be exposed to electrostatic discharge (ESD). The discharge process generates rapid electric and magnetic processes that can impair the function of the electronic devices. Devices are tested for their immunity to ESD using special ESD generators and test setups (EN 61000-4-2).

The effort and expense for developers to achieve ESD immunity in compliance with EN 61000-4-2 has steadily risen over recent years. The causes for this increased effort and expense are firstly the technology-related increase in sensitivity of ICs. Secondly, position changes, tilting and turning of the ESD gun yields different measurement results during ESD testing. That means even device or component tests performed with the same ESD gun will not be identical. Thirdly, it has been discovered that different types of ESD generators ("ESD guns") create different scattering in the test results. Device tests performed with different ESD generators are therefore also not always comparable.

A MORE DETAILED DESCRIPTION OF THE PROBLEM

IC sensitivity to interference is increasing. One reason for this increased sensitivity is that the structural width of ICs is shrinking. ASICs and microcontrollers are currently approaching 10 nm. Shrinking structural geometries allows higher switch speeds of the transistor cells while also reducing supply voltage. This necessarily increases IC sensitivity to interference. Increased switch speed in ICs gives rise to a greater possibility of interference from shorter disturbance pulses (less than or equal to 1 ns). Several years ago, these relatively short disturbance pulses were not an issue; they were not "seen" by the ICs.

CHANGES IN THE LENGTH OF ESD GUNS (ESD GENERATORS)

The ESD generator is typically in the shape of a gun with a metal tip. When testing "contact discharge", this metal tip is touched onto metallic parts of the test setup in order to trigger the test pulse. The current pulse introduced is relevant to the interference. It is defined in the standard EN 61004-2. Its curve shape parameters should define the interference effect during the test procedure.

In practice, the ESD gun does not necessarily obey the curve shape parameters. Interference phenomena occur that are difficult to explain. For example, certain EUT may only experience interference when the right side of the gun is facing it, while all other sides cause no interference. This would be explained by fields emanating from the gun housing that act on the EUT.

ESD guns cause rapid transient electric and magnetic fields. These fields emanate from the housing of the ESD gun and can act on the EUT during testing. The ICs of the electronic circuit will therefore react with failures according to their sensitivity. The sensitivity of ICs depends on the manufacturer and technology. The faster an IC is, the shorter disturbance pulses it can see and convert into errors. As the speed of an IC increases, so does its sensitivity to pulsed fields.

The internal structural components of ESD guns create these fields. Electric fields are generated by the switching of the high voltage switch. Magnetic fields are generated by the resulting recharge currents. (Figure 1a and Figure 1b)

The electric pulse fields couple capacitively from the gun into signal lines, test points, pads, IC pins and internally into the IC. The coupling capacity is in the fF range. Determinative of the gun's interference effect is the field strength E as well as its change over time dE/dt.

The magnetic field induces voltage in conductor loops in the electronics. These loops can exist as conductive traces on the component or inside the IC. Determinative of the interference effect is flux φ or $d\varphi/dt$.

ESD guns contain all kinds of internal conductor systems, switches and components that can generate E or H fields. The high voltage switch of the ESD gun can switch in the range of 100 ps. The tester can hold the gun tip to the EUT at different distances and orientations. The gun housing can in some cases rest against the EUT. The gun is deliberately turned and tilted. This brings different field generating parts of the gun closer to the electronics.

It is known from practice that ESD guns have different interfering effects depending on their type and position.

(Taken from "EMC Properties of ESD Generators", by Gunter Langer, in the In Compliance 2014 Annual Guide, pp 172-176, www.incompliancemag.com.)

862) Not all RJ45 cables and connectors have equal noise immunity

Not all cables with RJ-45 connectors meet the same specification. The table below compares cabling schemes, and reveals that the IMI connector achieves the highest noise immunity. Industrial cables with RJ-45 cables may be OK for machines, but commercial off-the shelf RJ-45 cables should not be considered for a machine to be reliable.

	Cable radiation noise immunity		Noise Immunity Conclusion
IMI STP 50m	*+1800 V*	*-1800 V*	*Best*
RJ-45 STP Industrial Grade 50m	*+1400 V*	*-1400 V*	*Good*
RJ-45 STP COTS 50m	*+200 V*	*-100 V*	*Very Poor*
RJ-45 UTP COTS 50m	+100 V	-100 V	Very Poor

Noise immunity comparison of various Ethernet cables with various connectors.

(Taken from "Symptoms of unreliable machine control systems", by Derek Lee, in the Industrial Ethernet book, October 2014, www.iebmedia.com/index.php?id=10429&parentid=63&themeid=255&hft=84&showdetail=true&bb=1)

863) RFI prevents smoke detectors from alarming

Two separate operating units of the United Technologies Corporation of Hartford, CT have recalled a combined total of over 140,000 smoke detectors manufactured in China.

According to a press release issued by the U.S. Consumer Product Safety Commission (CPSC), radio frequency interference (RFI) can cause the smoke detectors to fail to alert consumers of a fire. There have been no reports of incidents or injuries related to the smoke detectors, but the company has issued the product recall to prevent the risk of future incidents.

The recall involves Edwards-branded and Interlogix-branded units that have been hardwired into security systems. They were sold through alarm system, security system and electrical equipment contractors, dealers and installers for use in fire alarm systems installed in commercial buildings, hotels, apartments, schools, dormitories and homes from March 2013 through February 2014.

(Taken from*"Recalled Smoke Detectors Fail to Alert", in the "News" section, on page 10 of In Compliance magazine, October 2014, http://www.incompliancemag.com/DigEd/icm1410/. For the original CPSC recall notice, visit www.cpsc.gov/en/Recalls/2014/ESL-Interlogix-Hard-Wired-Smoke-Alarms-Recalled/.*

The Editor comments – US magazines are always keen to mention when products recalled for safety reasons were not made in the USA. However, in this case it is likely that the RFI problem was caused by inadequate design (in a country that is not mentioned) or inadequate assembly. From time to time it is noticed that offshore electronic assemblers sometimes omit what they think are non-essential components, such as EMI filters, to save cost. Whether the design or the assembly was at fault, it is the responsibility of the company that markets the products under their own brand names to apply adequate Quality Control to ensure their customers are safe enough. And in this case, that company is not based in China.)

UNITED STATES CONSUMER PRODUCT SAFETY COMMISSION

864) Ravens overcame headset EMI issues in Miami

The Ravens were unable to communicate to quarterback Joe Flacco's helmet Sunday.

Joe Flacco got in an extra workout running back-and-forth to the sidelines between plays Sunday afternoon. The Ravens quarterback had to consistently jog over to the sidelines to get the play calls from Offensive Coordinator Gary Kubiak because of communication issues from the sideline to the transmitter in his helmet.

All quarterbacks wear a helmet with a radio signal transmitter inside to allow them to hear play calls from the sideline or the coach's box. But that line of communication was halted because of interference with the frequency.

"It was crackling the whole time," Head Coach John Harbaugh said. "We couldn't get our plays in and we couldn't hear from the press box. Finally we had Gary on a wire in the second half, which made his communication better, but it was really no better back to Joe."

To offset the communication barrier, Flacco had to run over to the sidelines to talk with Kubiak or the Ravens would send in the play call by changing personnel on the field.

"We were old-schooling it," Harbaugh said. "We were running plays out there and shuttling plays with players back and forth. It was a challenge."

The exact cause of the issue was unknown, but Harbaugh said it's been a common problem during Baltimore's recent trips to Miami.

"We always have trouble in Miami for some reason," Harbaugh said. "We always have trouble down there with interference, radio stations and whatever is going on down there. Hopefully that will get fixed someday, but it's been going on for years there. It must not be something that can be dealt with."

(Posted Dec 8, 2014 by Garrett Downing,Staff Writer for BaltimoreRavens.com: www.baltimoreravens.com/news/article-1/Ravens-Overcame-Headset-Issues-In-Miami/fbae31a0-f448-43de-8b5e-27e4d395683f#commentSystem. Also posted on 12/17/2014 as: www.interferencetechnology.com/radio-interference-causes-headset-issues-during-football-sunday)

865) EMI is a major issue for broadcast radio and TV

The 66th IEEE Broadcast Technology Society Fall Symposium got underway Wednesday in Hartford, Conn., with the group's President Bill Hayes welcoming some 190 attendees, which included 40 students and their professors from Quinnipiac University and the University of Hartford.

Increasing RF noise pollution is a concern to almost everyone now, and the symposium program reflected this with presentations on manmade noise from Wisconsin Public Radio's Director of Engineering and Operations Steve Johnston, and Tom King, president of Kintronic Labs.

Johnston described measurements of indoor and outdoor RF noise levels and how such interference is creating problems that are not just limited to the AM broadcast band.

"The growing level of noise is hurting otherwise receivable AM, FM and TV signals," said Johnston. "Streaming is not really the solution, as this is not always available in rural areas."

King provided an update about efforts by a number of groups to help curb interference, noting that more and more spectrum is being impacted due to the increasingly higher operating frequencies used in switching power supplies. He concluded by stating that "the FCC needs to take action to remediate this noise floor situation."

ARRL PAYS A VISIT

Tom Gallagher, CEO at the American Radio Relay League, journeyed from the amateur radio support organization's base of operations in nearby Newington, Conn., to deliver a luncheon address about the ARRL's history, services and ongoing projects, which include efforts to help clean up the RF interference problem.

Manmade radio frequency noise remained a topic as afternoon sessions got under way, with the first presentation from Ed Hare, ARRL's test lab manager, who described ongoing efforts to help identify and remediate noise problems. He noted that powerline companies are big offenders and aren't always cooperative when confronted with evidence of the problems their distribution systems cause.

David Layer, senior director of advanced engineering at the NAB, followed Hare with a presentation on "noise" of a slightly different nature — co-channel interference to experimental all-digital AM broadcasting operations.

*(From "*2016 IEEE Broadcast Symposium Curtain Rises in Hartford*" by James E. O'Neal, www.radioworld.com/article/2016-ieee-broadcast-symposium-curtain-rises-in-hartford/279816#sthash.8xGGbwmr.dpuf on 10.12.2016.)*

866) EM noise evaluation of 3rd-party DC-DC converters

More of my clients are starting to use small third-party DC-DC converters to provide the multitude of voltages required for today's processor and DDR RAM ICs. While these are convenient to drop onto a circuit board, they can be quite a source of radiated and conducted emissions – especially those that switch in the MHz range.

I recently published an article on how these converter circuits can generate harmonic noise all the way up to 1 GHz, and above, severely compromising RF receiver sensitivity in the wireless telephone bands [1]. Kevin Slattery and Harry Skinner called this "Platform Interference", in their book, Platform Interference in Wireless Systems – Models, Measurements, and Mitigation [2].

One example of this type of "drop-in" DC-DC converter is manufactured by Murata and we'll use their model UWE-24/3-Q12, which is an "Eighth Brick" power supply that can take 9 to 36V and convert it to 24V at 3A (Figure 1). My client was using three of these converters on a product and was measuring a high level of radiated emissions, as well as observing broadband noise throughout his system all the way through 150 MHz.

If you read the manufacturer's specification sheets, you'll generally find that to "pass EMI" will require "additional filtering", and this converter is no different. In this case, the additional filtering required to meet EMI limits was not described. I decided to bring one of these back to the lab and try some experiments to attempt to quiet the EMI.

To do this required some instrumentation. I used a Siglent Technologies SPD3303C three output power supply, a Tekbox Technologies TBOH01 5uH LISN, A Tekbox Self-Powered Active Load, and a Siglent Technologies SSA3032X spectrum analyzer. All this gear is available from the U.S. distributor, Saelig Electronics [3]. The active load was really handy, because I could dial in the exact load current I wanted…in this case 0.5 amps, to avoid cooling issues. I connected a couple of Fluke DMMs to

monitor the output voltage and current (Figure 2). The spectrum analyzer picked off the conducted emissions via the LISN.

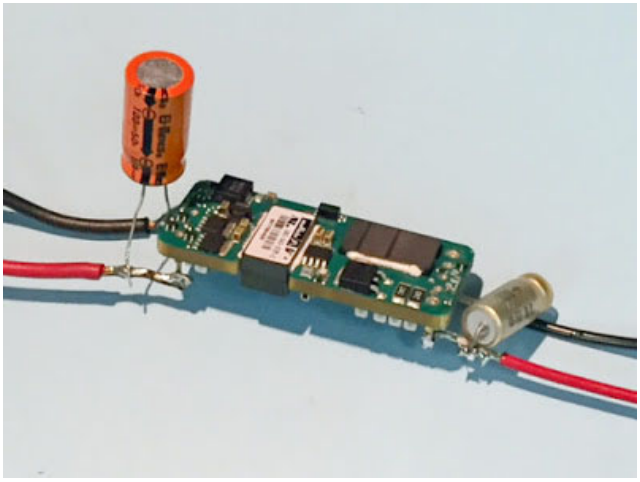

Figure 1 – The Murata UWE-24/3-Q12 DC-DC converter.

The manufacturer recommends specific capacitors on the input and output, and I've tack-soldered these on as shown.

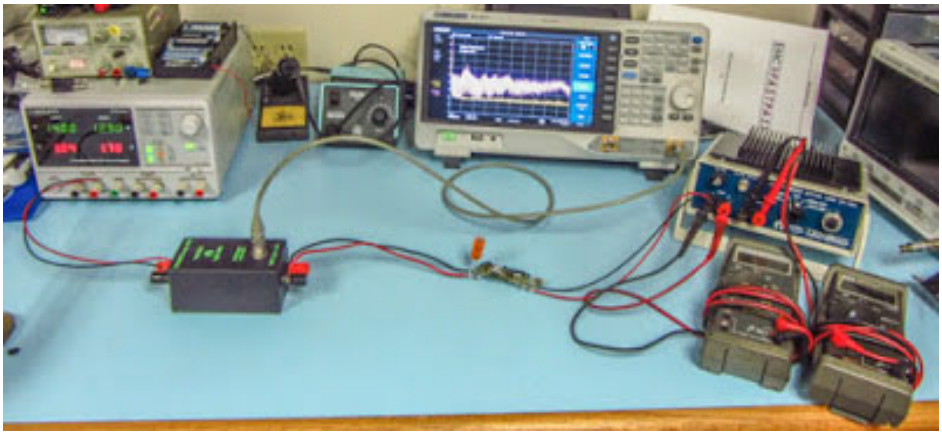

Figure 2 – The test setup for evaluating the conducted emissions from the Murata DC-DC converter.

After trying some inductors and common-mode chokes I had on hand, I determined that simply placing a 100µH inductor in series with the input terminal was enough to quiet the emissions rather drastically (Figure 3).

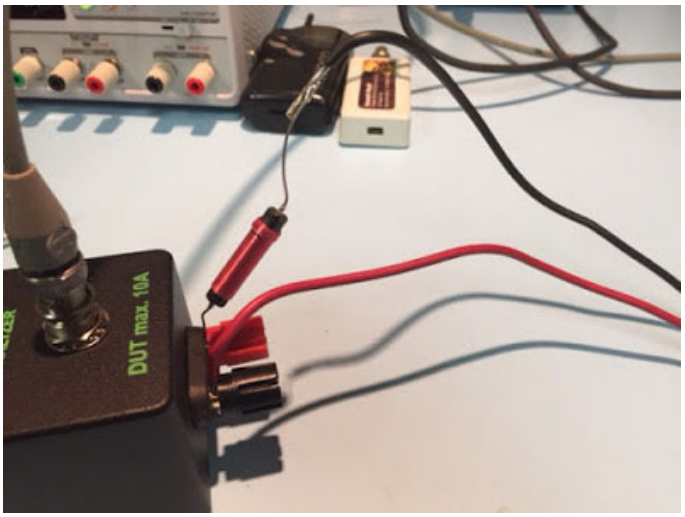

Figure 3 – A 100 µH inductor was all that was required to dramatically reduce the conducted emissions.

Figure 4 shows the result. The yellow trace was the ambient (baseline) signal level. The red trace was unfiltered (no inductor) and the blue trace was with the inductor added in series with the input voltage to the converter.

The addition of a single inductor nearly reduced the conducted emissions down to the noise floor of the measurement.

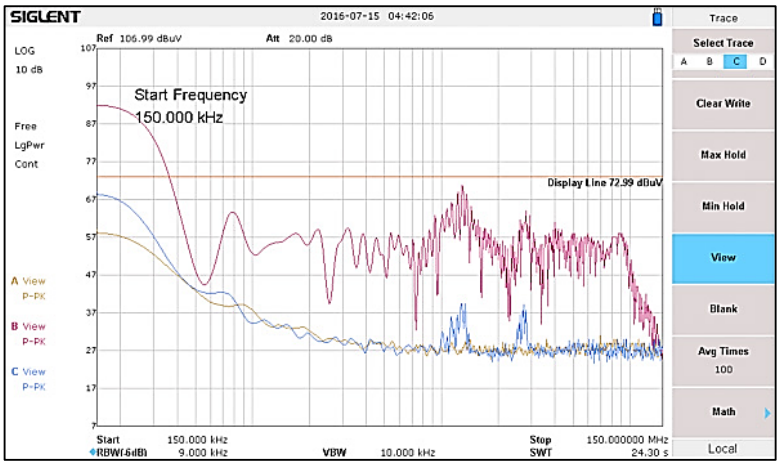

Figure 4 – The results with the 100 uH inductor installed (blue trace) over 150 kHz to 150 MHz. The red trace is the unfiltered noise and the yellow trace was the ambient baseline noise. The display line is the approximate emissions limit.

Conclusions:

Many EMI tests may be conducted right at the bench top. Evaluating various vendor products, such as DC-DC power supply converters, is always wise, prior to committing to a PC board design.

It's also wise to verify EMI performance as well as reading the "fine print" within the product specification sheet. Very often, claimed EMI performance will require additional components.

References:

[1] Wyatt, Platform Interference, http://www.edn.com/electronics-blogs/the-emc-blog/4441086/Platform-interference

[2] Slattery and Skinner, Platform Interference in Wireless Systems – Models, Measurements, and Mitigation,www.amazon.com/Platform-Interference-Wireless-Systems-measurement/dp/0323281451/ref=sr_1_2?ie=UTF8&qid=1450492921&sr=8-2&keywords=Platform+interference

[3] Saelig Electronics, www.saelig.com

*(From the article "*DC-DC Converter Noise Evaluation*" by Kenneth Wyatt, of Wyatt Technical Services LLC, published in Interference Technology Magazine's EMC ZONE on August 31, 2016, www.emc-zone.com/2016/08/dc-dc-converter-noise-evaluation.html. EMC ZONE is an avenue for discussion on the current issues affecting today's engineers working in the EMC industry. Ken is an excellent EMC engineer with huge experience, and these days specialises in showing the rest of us how to avoid/solve EMC problems quickly and easily on our own test benches using low-cost test equipment.)*

867) Illegal and dangerous installation of ferrite beads on US power distribution poles

The chief engineer at our local power cooperative called me yesterday. He asked if I could come to their local office around 9:00AM this morning. He promised me it would be interesting and well worth my time.

We drove toward the other side of XXXXX County and he asked how "plugged in" I am with the local radio community. I told him that I am a loner by nature and while I had been in a local ham club twenty years ago, these days I only participate in the severe weather nets. I mentioned I that there are about 20 hams and SWL within a 30 mile radius of my home that are what I consider serious HF operators.

He laughed as we pulled next to a substation and he led me over to a power pole and asked if I had ever seen anything like the "thing" he pointed to. I said "No, but I bet it is a string of ferrite beads in a PVC shell." He grunted, walked back to his truck and brought out a work light (a torch for those on the other side of the big pond) with a magnet on the bottom. He placed the magnet against the plastic shell and surprise surprise, it stayed in place.

We walked back to this truck and I asked if I could use his laptop with a "cell phone" modem to do some digging. He moved it over, it is on a very nice mount that I hope to copy for my radio desk, and I

quickly found the clowns selling the “thing”, a company called XXXXXX, and downloaded the information on it. I explained its intended purpose and noted that there is a MW station and the Non Directional Beacon for the XXXX airport within a mile or so of where we were, so it may well be solving someone's receive intermodulation problems, but that it defeated the ground wire’s function to allow fast transients to pass through the wire to the "ground'.

Power poles are buried on average 6 feet deep and have a spiral of copper wire at the bottom that runs up the side of the pole to provide a lighting "protection". It works better than I would have thought, but is less than ideal. He mentioned that some of his customers demand much better grounding at the step-down transformer to their service drops.

The chief engineer loved this quote from the “thing’s” downloaded information; "*Once you have determined which poles are causing problems, you develop a plan of action. The first thing to do is to contact the power company to explain what the problem is. They will not allow you to cut the pole ground wires to solve your problem, but if you can guarantee continuity of the ground wires with the same gauge and type of wire, they usually allow you to fix your problem*". His response was "Bull Shit! We never allow anyone to tamper with protective grounds."

It is a felony in this State to "mess" with the power distribution system; and cable and telephone are also protected. As we walked the road we found 5 more poles with these 'things' on them. He radioed back to Dispatch to send a couple of work crews to restore the grounds to the correct state. I asked if he wanted me to see if I could find out who placed them there, and he told me no. The devices would be turned over to their legal counsel and if they found out who installed them, they would be forced to press charges. He told me he didn't enjoy the thought of some poor clown getting a 5 to 10 year jail sentence for something so insanely stupid. At my suggestion he had the staff back at Dispatch make a bunch of laminated warning signs to inform "whoever" where his devices had gone, that he had violated the law and if he really wanted to face prosection, to drop by the power cooperative and talk it over.

XXXXX's web page does not give a price, but given the rest of the snake oil they are selling, I suspect the guy spent a bundle on these “things”. I do not know how many were found and replaced. At this point I am just shaking my head in disbelief over the insanity out there. The sad part is that the Chief Engineer told me if the guy had contacted them, they have several tricks they can use to reduce the problem he was trying to correct, and it would have been done at the power cooperative's expense.

On the way back to the office I asked him about the effectiveness of their decentralized grounding system and he told me that it works better then most non-power engineers would believe. Even direct strikes generally only trip a few transformer breakers or blow a few fuses. About 1 in 500 strikes causes a transformer failure. He admitted it might be higher because a transformer might be damaged and start to arc inside and run that way for days or months before it fails.

He told me they have contracted with a company to provide them with near real time data on strike locations, along with the polarity and an estimate of the intensity. He admitted that given the nature of a lighting bolt, the actual ground strike point may be several hundred to thousand feet in error. They are starting to log strike locations and look for delayed failure patterns. He said that in the event of a direct hit, the ferrite beads in the “things” we had found on the poles would explode and so could present a safety hazard, but the risk to the system came from nearly invisible streamers that never complete the connection with a cloud, so the grounding system is used a lot more than one would think.

I was rather surprised to find out that cold weather is much rougher on transformers and substations then hot weather and the first real cold snap will reveal a lot of transformers that are failing, but either no one has complained about the arc, or the arc isn't producing much RFI.

He told me it was funny that he has seen transformers with major insulation failure that were dissipating several kW in heat from the internal arc(s) that were as RF quiet as a good transformer, and that he has seen those with only a few hundred mA leakage that are RFI nightmares.

Being in the RFI business, or perhaps I should say the "fighting RFI business", I thought you might enjoy this odd anecdote. And you think we resort to extreme measures to reduce the local RFI…. At least life is interesting!

(From a private discussion with the Editor in December 2009. Because of the legal implications, all the locations and names have been redacted.)

868) Radio Interference Caused by 1967 Solar Storm Nearly Started Nuclear War

(August 9, 2016) Business Insider reported that a colossal solar burst caused radio interference in 1967 that almost started a nuclear war.

The "Great [Solar] Storm" of May 1967 caused widespread radio communications blackouts, and was seen as potential jamming from Soviet Russia. The Air Weather Service (AWS) — a relatively new branch of the Air Force — had warned military leadership about the possibility of a solar storm, but US commanders believed the Soviet forces were jamming NORADsystems designed to detect threatening planes and missiles and radio jamming, at the time, was interpreted as an act of war.

As the Strategic Air Command (SAC) warmed up the engines of bombers and taxied toward the runway, the decision to go airborne may have been kicked all the way up to the highest levels of government, possibly involving President Lyndon B. Johnson.

"Just in time, military space weather forecasters conveyed information about the solar storm's potential to disrupt radar and radio communications," according to a press release from the American Geophysical Union. "The planes remained on the ground and the U.S. avoided a potential nuclear weapon exchange with the Soviet Union."

*(From a report with the same title published in Interference Technology magazine on 31st August 2016: www.interferencetechnology.com/radio-interference-caused-1967-solar-storm-nearly-started-nuclear-war/?utm_source=itnewsletter&utm_medium=email&utm_campaign=20160901. For the original Business Insider article "*A giant solar storm nearly triggered a nuclear war in 1967*" visit http://uk.businessinsider.com/cold-war-geomagnetic-storm-radio-disruption-2016-8?r=US&IR=T.*

869) Conducted EMI can cause misreading of electronic electricity meters.

Conducted electromagnetic interference can cause misreading of static electronic energy meters. This was already observed in the past, but only for cases with lower energy reading. In one actual case the cause of this misreading is the interfering currents caused by active infeed converters for renewable energy. In this paper it is shown that also higher readings are possible.

Electromagnetic interference tests have been introduced so that static meters will be immune against this type of interference. The static energy meters are used for billings and if a customer files a complaint the meter can be calibrated. However, this is done using ideal sinusoidal voltages and currents, while in our current living environment the currents deviate substantially due to the non-linear loads of modern equipment.

Controlled experiments performed on static energy meters confirm that they can present still faulty, and substantially higher, readings. The main cause of interference appears to be the current sensor.

Meters with a Rogowski coil current sensor showed a positive deviation of 276%, or an increased reading of 376%, using a controlled power supply with undistorted voltage and defined impedance, compared to the reading of a conventional electromechanical meter based on the Ferraris principle. Meters with a Hall sensor showed a deviation of registered energy of -46%, or a decrease in energy reading to 54%.

Using the mains supply in the laboratory, from 9 static meters 5 showed positive deviations of up to 582%, which is a higher energy reading of 682%, and 2 showed deviations of around -30%, equivalent to a reading of 68%.

(The Conclusions of the paper "Static Energy Meter Errors Caused by Conducted Electromagnetic Interference", by Frank Leferink, Cees Keyer, and Anton Melentjev, in the 2016 IEEE Electromagnetic Compatibility Magazine – Volume 5 – Quarter 4, pages 49-55, http://ieeexplore.ieee.org/xpl/tocresult.jsp?isnumber=7866217. Kindly sent in by John Woodgate.)

870) Filament light bulbs have three ways of emitting EM noise

…….a short note summarising the findings of 1953 Wireless World correspondence on lamps as sources of interference with television. The main point put on record was that gas-filled lamps may interfere when they are so near the end of their life that a microscopic break occurs in the filament, across which an arc is produced, but vacuum lamps can radiate interference throughout their life. No explanation was offered of how vacuum lamps managed to perform this remarkable but objectionable feat, so I have looked into the matter to see if it could be explained.

(Taken from "Vacuum Lamp Interference" by "Cathode Ray", in Wireless World, May 1954, pages 245-248, available from the truly remarkable website http://www.americanradiohistory.com, more specifically from http://www.americanradiohistory.com/Archive-Wireless-World/50s/Wireless-World-

1954-05.pdf. Cathode Ray goes on to describe Barkhausen-Kurz oscillations, and how they can occur in vacuum lamps.)

(John Woodgate writes (Feb 2017): I am astonished (;-) that the committee, and indeed the lighting industry, is not aware that (until yesterday, strange coincidence!), this effect was described on my web site. See the attached file *(the Wireless World article above – Ed.)*, and note the date of original publication, May 1954. Note for enchantingly young people: "Cathode Ray" was Marcus G Scroggie, a most trustworthy engineer and very well-known tutor.)

(See also EMI Story number 159, which describes how roughly 1% of "coiled coil" gas-filled filament light bulbs are significant sources of emissions at VHF due to "monode" oscillation. This brings the total number of ways in which filament lamps can emit significant EM disturbances to three, hence the title of this item.)

871) Avionics interference from PEDs (Passenger Electronic Devices)

ACN: 1242472 (7 of 50), Synopsis: B737 Captain reported possible interference from cell phones in the cabin that could account for the electronic anomalies they were experiencing during the flight.

ACN: 1219051 (9 of 50), Synopsis: B767 flight crew reported deviating from ILS course and altitude on approach to SPIM because of an autopilot error, possibly caused by passenger cell phone use.

ACN: 1159513 (10 of 50), Synopsis: Air Carrier Captain experiences localizer oscillations during approach in VMC that he suspects may have been caused by an electronic device.

ACN: 1128249 (11 of 50), Synopsis: CRJ-200 Captain experiences interference in his Bose X headset possibly caused by a cell phone.

ACN: 950259 (13 of 50), Synopsis: CRJ200 First Officer reports compass system malfunctions during initial climb. When passengers are asked to verify that all electronic devices are turned off the compass system returns to normal.

ACN: 754696 (21 of 50), Synopsis: IN AN APPARENT PED INTERFERENCE EVENT, A PAX'S PORTABLE GARMIN GPS MODEL NUVI 660 ALLEGEDLY INTEFERED WITH A B737 CLASSIC'S (NO GLASS) DME NAVIGATION UPDATE FUNCTION.

ACN: 702630 (29 of 50), Synopsis: CAPT OF AN A320 RPTS VHF INTERFERENCE ON ZOB ARTCC FREQ FROM A CELL PHONE ABOARD HIS PLANE.

ACN: 681689 (31 of 50), Synopsis: A B757-200'S L FUEL GAUGE BLANKED AFTER TKOF AND BECAME OPERABLE PRIOR TO LNDG. CREW SUSPECTS POSSIBLE PED INTERFERENCE.

ACN: 673795 (32 of 50), Synopsis: B737-800 FLT CREW EXPERIENCED SEVERAL TCAS RA'S ALLEGEDLY GENERATED BY A WI-FI ENABLED LAPTOP COMPUTER.

ACN: 661013 (33 of 50), Synopsis: FLT CREW OF CRJ-700 RPTS THAT AURAL INTERFERENCE IN VHF COMS CEASED WHEN PAX WERE ASKED TO ENSURE ALL FORMS OF 2-WAY COMS WERE TURNED OFF.

ACN: 609264 (42 of 50), Synopsis: B737-300 CREW HAD ERRATIC LOC SIGNALS ON ILS RWY 13 AND RWY 7 AT JAX. A PAX WAS USING A 'PALM PILOT' AT THE TIME.

ACN: 600964 (45 of 50), Synopsis: FLT CREW OF MD80 EXPERIENCE MISALIGNED HEADING INFO ON FMS DISPLAY. SUSPECT PAX OPERATED ELECTRONIC DEVICES.

(Taken from the NASA ASRS Database Report Set: "Passenger Electronic Devices"; Description: A sampling of reports referencing passenger electronic devices incidents"; Update Number: 27.0; Date of Update: January 29, 2016. NASA Ames Research Center, Moffett Field, CA 94035-1000, USA. NASA ASRS reports on PEDs (Passenger Electronic Devices) are available from: https://asrs.arc.nasa.gov/docs/rpsts/ped.pdf, but they are updated regularly so this URL does not return the January 29, 2016, report from which the above were taken. It is interesting to note that in this ASRS Report there were many reports of batteries or electronic devices overheating, leaking toxic fumes, melting, etc. far more than I remember from the earlier ASRS PED reports that featured in EMI Stories numbers 187, 188, 189, 467, 468, 487, 488 and 564. I don't know where the superseded ASRS PED Reports are archived, or even if they are archived at all, but I have copies of all the ones that have been referenced in earlier EMI Stories if anyone needs them - Editor.)

872) Routers closer than 2 metres can interfere with LG 27-inch "Ultrafine 5K" display

Two years ago (www.edn.com/electronics-blogs/brians-brain/4438488/USB3-interferes-with-Wi-Fi-capabilities), I told you about ASUS' RT-N65 "N750" router family, whose 2.4 GHz Wi-Fi facilities were degraded to the point of unusability whenever a USB3 interface mass storage device was connected to it. Disconnecting the USB3 peripheral, or reconfiguring the router to run the USB interface at slower USB2 speeds, restored normal Wi-Fi functionality. The likely root problem, quoting from my earlier coverage, is "a lack of shielding around the router's wireless subsystem, thereby opening the door to destructive RF interference from the USB3 subsystem (which is also shield-less) and devices connected to it." And yes, an example of that particular router is still sitting in my teardown-candidate stack; stay tuned for the chance to peruse the shielding shortcomings for yourself, courtesy of my camera!

In recent days, I've encountered a similar situation, albeit somewhat in reverse. Apple's been whittling down its product plethora lately, not only turning its back on its longstanding networking equipment presence but also dropping its line of branded displays. Back in June of last year, the company discontinued its last LCD, a Thunderbolt-interface model; a couple of months later, Apple formalized a reference-sell relationship with LG Electronics. Only one problem, though; LG's 27" "UltraFine 5K" display (www.apple.com/shop/product/HKN62LL/A/lg-ultrafine-5k-display) tends to misbehave when in close proximity to a router. According to 9to5Mac's testing, the LCD begins to flicker when a router is approximately 2 meters (6.5 feet) away; any closer than that and the display will eventually go completely dark. The destructive interaction between router and display can in some cases be so severe as to lock up a connected computer, necessitating a restart even if the router is moved away again.

LG's Ultrafine 5K display, from www.apple.com/shop/product/HKN62LL/A/lg-ultrafine-5k-display

(Taken from http://www.edn.com/electronics-blogs/brians-brain/4458576/Electronics-interference--LG-displays-and-routers, by Brian Dipert on June 26, 2017 in the "EDN Network" www.edn.com. Kindly sent in by Ronny Deseine of Barco NV, Belgium, on 10 July 2017. Also see: https://tech.slashdot.org/story/17/01/30/2241256/lgs-ultrafine-5k-display-becomes-useless-when-its-within-two-meters-of-a-router, and https://9to5mac.com/2017/01/30/lg-ultrafine-5k-display-router-disconnecting/)

An LG spokesperson confirmed with Ars that the 5K UltraFine monitor isn't adequately shielded from EM radiation, and that displays manufactured after February 2017 "will be fitted with enhanced shielding." Furthermore, existing displays can be retrofitted with extra shielding—if you own the 5K UltraFine, and you're having issues, you should "contact your nearest customer service centre for prompt service." Curiously, the spokesperson said that the Wi-Fi router interference problem only

occurs when the router is behind the display within a distance of 0.6m (2ft). LG didn't comment on the other issues that customers are reportedly experiencing. Apple still hasn't responded to our request for comment.

(Taken from "New 5K monitor sold by Apple apparently lacks EM shielding, has other issues" by Sebastian Anthony (UK) 1/31/2017, 2:04 PM, Updated, February 3: Downloaded 5 Feb 2017, https://arstechnica.com/gadgets/2017/01/apple-lg-5k-display-issues/.)

873) HDMI Cables and EMI

As more consumer and commercial products are introduced with High-Definition Multimedia Interface (HDMI) cable connections, the resulting EMI issues related to HDMI cable emissions have continued to be problematic for product designers and EMC engineers. It is very common to have one, or more, added HDMI cables cause a product to fail the radiated emissions (RE) test.

The reason EMI has reared up is that many brands of HDMI cables have poor cable shield bonds to the connector back shell. Unfortunately, it's not possible to simply purchase well-known cable brands and be assured of passing RE.

It's not uncommon for the shield to be tied to the connector back shell with a one-inch, or longer, pigtail connection. The problem has been with the original HDMI standard, developed by the HDMI Forum Technical Working Group. Unfortunately, the standard never completely addressed the best way to terminate the cable shield – that is, what we call in the business, a "360-degree" bond, where the shield is bonded in multiple places (ideally, all around the back shell) directly to the connector back shell (ground).

At high frequencies, pigtails can become highly inductive. For example, a one-inch pigtail (about 20 nH of inductance) can appear as a12-Ohm impedance. As the frequency increases, the impedance also increases. As the impedance increases, the cable shield essentially becomes "disconnected" from the connector ground and the result is cable emissions.

This issue has been dogging EMC engineers and compliance test labs for years. In 2008, Dana Bergey and Nathan Altland, both of FCI, authored a paper at DesignCON, entitled "EMI Shielding of Cable Assemblies", where they tested a number of cables for their EMI emissions properties when driven by a swept RF source. The cables were tested for emissions in a conventional mode-stirred chamber.

Looking at just the HDMI results, eight cables were tested and two of them had emissions some 20 dB higher than the other six. Dissecting these cables, it quickly became apparent as to the reason – and that was the pigtail issue as noted above. See Figure 1.

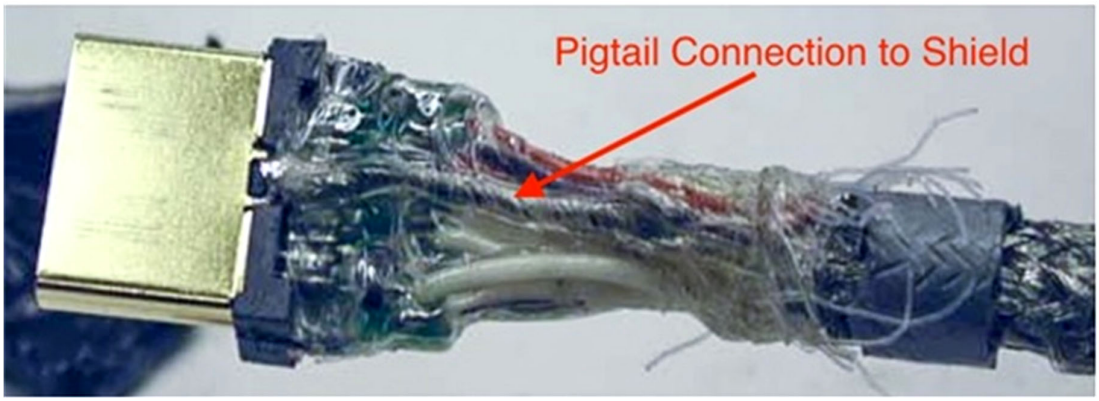

Figure 1 – A poorly terminated HDMI cable shield using a long pigtail connection.
Image, courtesy Dana Bergey and Nathan Altland.

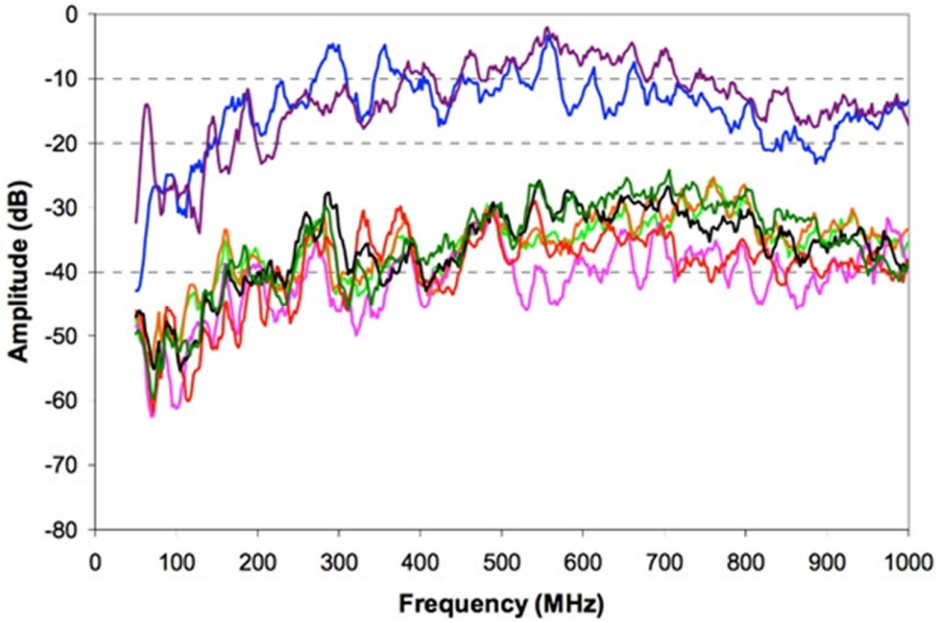

Figure 2 – The resulting radiated emissions from a sample of eight HDMI cables. Two of the samples exhibited EMI 20 dB higher than the average. Image, courtesy Dana Bergey and Nathan Altland.

I recently contacted Brad Bramy, HDMI Licensing Administrator, to determine whether the working group was aware of the issue and whether the current standards development would be resolving this through a more rigorous EMI-worthy assembly procedure. He passed my questions on to the working group. Here was the official reply:

1. What exactly does the current HDMI specification say about this ground connection?

• The HDMI 1.4b specification governs current cable specifications, which were developed by the HDMI Founders. The Forum is not authorized to comment on the HDMI 1.4b specification or its content. HDMI LA works directly with the Founders and will be the best resource for you to get these questions answered.

2. Does the newer version 2.1 spec address this better?

• HDMI 2.1 does introduce a new cable with improved overall performance (The current working marketing name is the 48G HDMI Cable). However, since the specification remains under final development, the Forum cannot yet comment on specific details.

3. Is the working group aware of this problem and are there any plans to remedy this issue?

• The HDMI Forum Technical Working Group is aware of concerns about the current cable specifications. However, since the specification remains under final development, the Forum cannot yet comment on specific details.

While I'm encouraged that the working group is aware of the concern, time will tell whether future releases of the standard will address this issue. Let's hope so! In the meantime, you'll need to secure a range of high-quality HDMI cables and try them one at a time to find the best one to use for EMI testing – not an ideal solution.

References:

1. Bergey and Altland, EMI Shielding of Cable Assemblies, DesignCON 2008, http://www.magazines007.com/pdf/DC08_Dana_Bergey.pdf.

2. HDMI Forum Technical Working Group, http://www.hdmi.org.

(Taken from Kenneth Wyatt's Blog at Interference Technology magazine, "HDMI Cables and EMI", July 3, 2017, Cable & Connectors, Featured, https://interferencetechnology.com/hdmi-cables-emi/)

874) Error in EMC test standard causes non-compliant equipment to be placed on the market

We were recently presented with an electromechanical device powered by 230V 50Hz, to be tested against the requirements of IEC/EN 60947-4-1. In that standard there is a referenced clause (7.3.2.1 of EN 60947-1) that states that if the product does not incorporate any so called 'electronic circuits' then testing is not required, see Figure 1.

A1 For the purpose of this standard, the phrase "electronic circuit" excludes circuits in which all components are passive (including diodes, resistors, varistors, capacitors, surge suppressors, inductors). A1

7.3.3 Emission

7.3.3.1 Equipment not incorporating electronic circuits

A2 The requirements for electromagnetic emissions for equipment not incorporating electronic circuits are deemed to be satisfied, and no verification is necessary. A2

Figure 1 Extracts of relevant text from Subclause 7.3 in IEC/EN 60947-1

We almost called off testing on the basis that the device only apparently contained only a bridge rectifier and solenoid (which seemed to conform to the list of passive components further defined in the parent standard EN 60947-1), but as the customer had been specifically asked to get the testing done for their client we progressed anyway.

We were then surprised to be presented with this (see Figure 2) for conducted emissions:

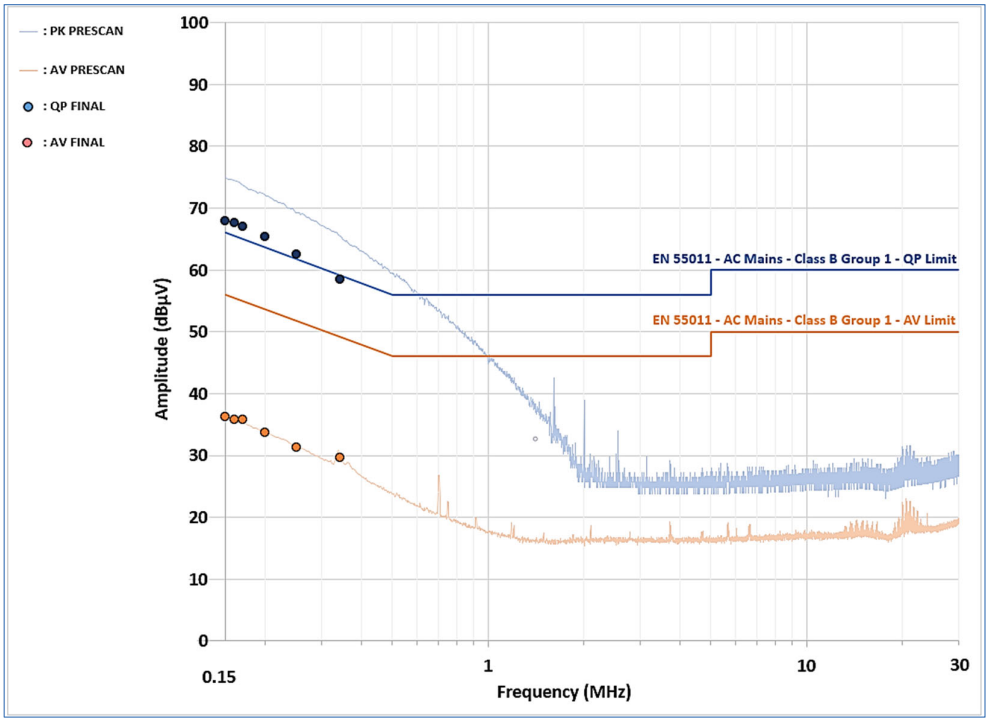

Figure 2 Conducted emissions plots, blue = QP, brown = AV

We set up the spectrum analyser in zero span in conjunction with an oscilloscope (with a shared trigger) and confirmed that the emission occurred at zero crossing, see Figure 3.

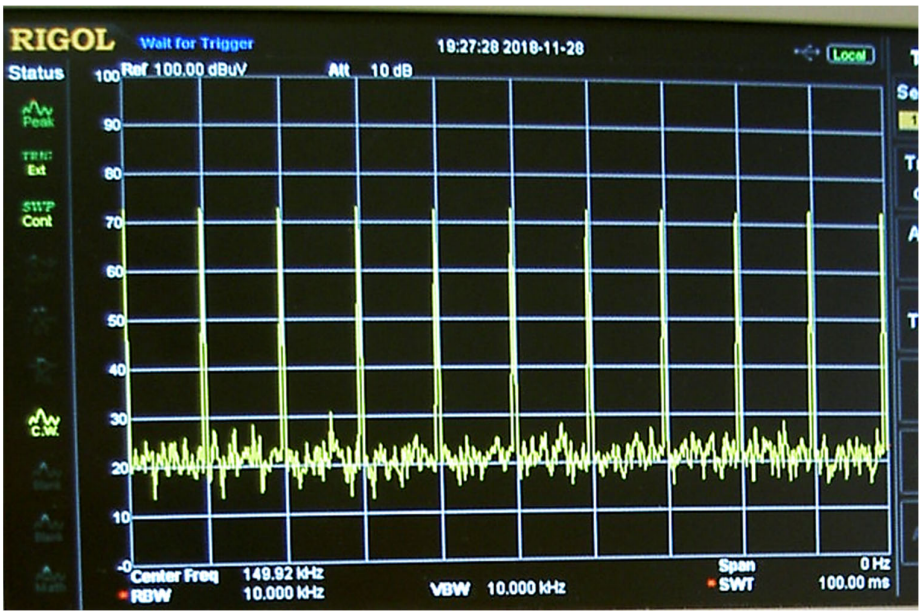

Figure 2

All this from a bridge rectifier?

Subsequent investigations revealed that there are two contributors to rectifier noise, but we usually never see them because they are swamped by the noise emissions from switching power converters, and the mains filters required to make them EMC compliant reduce the rectifier noise to below the noise floor. Of course, the product was an entirely passive device except for its bridge rectifier, and had no mains filter.

The two noise sources in silicon PN junction rectifiers are:

i) The deadband in diode conduction caused by their silicon's 0.7V band-gap voltage

ii) The 'reverse recovery time' of the rectifier's PN-junctions' minority carriers (usually called 'holes'), which even in reasonably fast 1A silicon rectifiers causes them to continue to conduct for several hundred nanoseconds, perhaps even for as long as 1.8 microseconds, *after their voltage has reversed*.
However, due to the slow rate of change of the 50Hz mains waveform this is not a significant source of noise for off-line rectifiers, although it usually is a big problem for the fast-switching rectifiers required in switching power converters.

We wonder how many similarly non-compliant items of equipment have been placed on the market, but never tested for EMC as a result of the passive components/ 'electronic circuit' clause referenced above?

We have amended our internal procedures for this product class to include a precautionary conducted emissions measurement for all samples submitted for assessment against this standard. We also intend to raise it with our trade association to find out what similar experiences other labs have had, and whether there may be grounds to re-assess this entry to the standard.

(Kindly sent in by Product Approvals Ltd, Telford, www.productapprovals.co.uk/ on 28 November 2018. The Editor adds: I have seen the noise from a bridge rectifier alone, in a 4kW linear power supply, exceed the QP limit all the way up to 4MHz.)

875) DAB radio interfered with by LED lighting

Just FYI: I was called and interviewed by the Belgian radio on the question why the DAB+ radio of one of their listeners always stopped working when he switched on his new LED lights.

(Kindly sent in by Prof. Davy Pissoort, Assistant Professor, Mechatronics Group, KU Leuven, Belgium, on 12 December 2017, https://iiw.kuleuven.be/brugge/m-group.)

876) FCC Ends Heater Interference to Aircraft Radio on Coast

The Proceedings of the IEEE – June 1967 had a special issue on Radio Measurement Methods and Standards. An article of particular interest was "Electromagnetic Compatibility Measurements" by R. M. Showers and O. M. Salati.

Public Notice G 1844, under the above title, is as follows: "The FCC has eliminated a serious source of interference to aircraft radio transmission in the Los Angeles and San Francisco areas. The interference, caused by industrial heaters, resulted in severe difficulties for commercial and private aircraft and was a matter of serious concern to the FAA.

FCC engineers, called in to locate and eliminate the source of the interference, set up a series of spotting flights. Using direction finding equipment, they were able to spot 16 heaters, 12 of which were causing interference in flight communications. Contacts with the firms using the heaters resulted in action being taken to eliminate the interference.

Industrial heaters are electronic devices in manufacturing operations requiring very rapid drying. The firms using the heaters causing the interference were manufacturers of such diverse products as plywood, plastics, rubber mats, handbags and eyeglass cases.

The interference can generally be eliminated by shielding the heater equipment properly."

(This is an extract from: "50-25-10 Years Ago: A Review of EMC Society Newsletters", by Daniel D. Hoolihan, Associate Editor, in: 2017 IEEE Electromagnetic Compatibility Magazine – Volume 6 – Quarter 4, on page 41. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8272278.)

877) Even NASA get it wrong!

NASA's human-shaped 'robonaught', deployed on the ISS, suffered a series of problems and eventually stopped working. The problem was eventually traced to a missing 'ground wire', see: https://spectrum.ieee.org/automaton/robotics/space-robots/robonaut-has-been-broken-for-years-and-now-nasa-is-bringing-it-home#.Wt7aqYdu3W0.mailto (the missing ground wire is only mentioned near the end).

(Kindly sent in by Paul Ruzic from Australia, on 1 May 2018.)

878) First admission that EMI could cause autonomous cars to crash

The promise of self-driving cars is speeding ever closer to fruition, but as evidenced last week, automakers and tech companies still have quite a bit of work to do to ensure that these cars are actually safe for the road. Mobileye, one of the major firms manufacturing the driver-assistance systems responsible for getting cars to drive themselves, recently announced debuted a new fleet of prototype vehicles that would be able to make their way through cities and across streets without using lasers or radars — an impressive feat.

Unfortunately, at a press event in Jerusalem meant to show off the capabilities of this new autonomous system, a test car drove straight through a red light. Needless to say, this wasn't the outcome Mobileye was hoping for.

Luckily, no one was hurt in the incident, and this was the only hiccup in the test run. Still, it was clearly a rather alarming mistake to make. Camera footage shows that a Mobileye safety driver was inside the vehicle monitoring its actions, but for some reason, allowed the car to continue through the stoplight without taking action.

According to the company's chief executive officer, Amnon Shashua, the reason behind the mistake was electromagnetic interference. As Bloomberg reported, "wireless transmitters on cameras used by the television crew created electromagnetic interference, which disrupted signals from a transponder on the traffic light." Consequently, even though the car's camera realized that the light was red, the car itself ignored this information and continued to drive as per signals sent from the transponder. Shashua says that this issue has since been addressed.

"It was a very unique situation," he said. "We'd never anticipated something like this." Shashua added that Mobileye is also making tweaks to the hardware meant to protect the car's computers from electromagnetic interference with hopes of ensuring that similar incidents do not occur in the future.

Alas, this is by no means the first time that a self-driving car has run into this sort of issue. Uber had a similar problem in 2016, when a driverless car was caught running a red light. And just two months ago, a YouTube video seemed to show a Waymo car going through a red light after initially stopping and trying to make a left turn.

In any case, these issues will clearly have to be sorted out before autonomous cars are trusted to transport human passengers.

(Taken from: 'Mobileye tries to show off self-driving car, runs a red light instead' by Lulu Chang@luchanglu, in Digital Trends on-line magazine, www.digitaltrends.com/cars/mobileye-red-light/ and sent in by Professor Davy Pissoort of the M-Group (Mechatronics Group) at KU Leuven, Bruges, Belgium, https://iiw.kuleuven.be/brugge/m-group on 28 March 2018.)

879) RFID can interfere with non-implantable medical devices

Background: The use of radiofrequency identification (RFID) in healthcare is increasing and concerns for electromagnetic compatibility (EMC) pose one of the biggest obstacles for widespread adoption. Numerous studies have documented that RFID can interfere with medical devices. The majority of past studies have concentrated on implantable medical devices such as implantable pacemakers and implantable cardioverter defibrillators (ICDs). This study examined EMC between RFID systems and non-implantable medical devices.

Methods: Medical devices were exposed to 19 different RFID readers and one RFID active tag. The RFID systems used covered 5 different frequency bands: 125–134 kHz (low frequency (LF)); 13.56 MHz (high frequency (HF)); 433 MHz; 915 MHz (ultra high frequency (UHF])) and 2.4 GHz. We tested three syringe pumps, three infusion pumps, four automatic external defibrillators (AEDs), and one ventilator. The testing procedure is modified from American National Standards Institute (ANSI) C63.18, Recommended Practice for an On-Site, Ad Hoc Test Method for Estimating Radiated Electromagnetic Immunity of Medical Devices to Specific Radio-Frequency Transmitters.

Results: For syringe pumps, we observed electromagnetic interference (EMI) during 13 of 60 experiments (22%) at a maximum distance of 59 cm. For infusion pumps, we observed EMI during 10 of 60 experiments (17%) at a maximum distance of 136 cm. For AEDs, we observed EMI during 18 of 75 experiments (24%) at a maximum distance of 51 cm. The majority of the EMI observed was classified as probably clinically significant or left the device inoperable. No EMI was observed for all medical devices tested during exposure to 433 MHz (two readers, one active tag) or 2.4 GHz RFID (two readers).

Conclusion: Testing confirms that RFID has the ability to interfere with critical medical equipment. Hospital staff should be aware of the potential for medical device EMI caused by RFID systems and should be encouraged to perform on-site RF immunity tests prior to RFID system deployment or prior to placing new medical devices in an RFID environment. The methods presented in this paper are time-consuming and burdensome and suggest the need for standard test methods for assessing the immunity of medical devices to RFID systems.

(Extracted from 'Adhoc electromagnetic compatibility testing of non-implantable medical devices and radio frequency identification', a paper by Seth J Seidman and Joshua W Guag, in BioMedical Engineering OnLine 2013, http://www.biomedical-engineering-online.com/content/12/1/71, which was kindly sent to the Editor by Jeff Silberberg of the US Food & Drug Administration (FDA) in June 2018.)

880) LED lighting on ships can interfere with marine VHF communications

During periodical inspections of GMDSS equipment and AIS performed by the National Frequencies Agency on board ships, crews and shipowners reported problems regarding reception on VHF frequencies (radiotelephone / DSC and AIS) when navigation lights are switched on or during the use of other system of lighting (i.e. searchlights).

Occurrence of these problems coincides with the replacement of classical lighting by LED lamps. Many internet yachtsmen forums also describe similar problems.

(From the Editor, who came upon this in the ITU liaison report 5B/TEMP/220, "EMI standards for LED lighting" dated 13 June 2018. Visit http://f6hcc.free.fr/lampesled_fichiers/led_vhf_marine.pdf dated 4 March 2015 and in French, for the official report referenced in this ITU liaison report.)

881) Superconducting quantum interference device (SQUID) suffer EMI from an overhead light

Our original system for detecting the magnetic nanoparticles was based on a superconducting quantum interference device (SQUID) sensor that operated in liquid nitrogen, and although we managed to cope with supplying liquid nitrogen to the operating theatres during the clinical trials, it was a hell of a nuisance. There were issues even with small things like taking nitrogen up and down in a lift – people get quite exercised about the possibility of spillages in small spaces.

Also, SQUIDs are very sensitive to radio frequency fields, and under certain circumstances they will become completely non-operative if there's a sufficient level of background interference, however good your screening is – and we spent a long time trying to produce good screening.

On one occasion, the SQUID simply failed to tune in the operating theatre, and it was only after the operation was over (all the trials were done using both the radioactive technique and our magnetic technique) that we worked out that the radiofrequency interference was coming from one of the overhead lights. If I'd known that and I'd been able to turn off that one set of lights, we'd have been able to continue, but that lack of robustness in a system you're hoping to market everywhere is just not going to be acceptable.

Then there's the fact that not many companies make SQUIDs that work at liquid-nitrogen temperatures – and of course, the low-temperature ones, which require liquid helium, were completely out of the question.

Eventually, I managed to work out a way of doing our measurements with room-temperature electronics by pushing up the frequency to increase the level of sensitivity, using really low-noise amplifiers and developing our correlation techniques a bit more.

(Kindly sent in by Richard Marshall, who saw it in the article "Tracing the spread of cancer" in the 2018 Physics World Focus on Biomedical Physics, at https://physicsworld.com/a/tracing-the-spread-of-cancer.)

882) Cellphone voice recognition system spoofed by 500mW IEMI attack around 230MHz

In this study, we presented a new technique for remote and silent voice command injection in a specific model of smartphones based on conducted propagation and back-door coupling phenomena. This technique is complementary to the existing one based on radiated propagation and front-door coupling and allows compromising different targets, from a longer range and with less emitted power.

By characterizing different configurations of the propagation path, it was shown that a proper voice command injection is achievable with a reduced effect of the elements on the propagation path. Finally, this study highlights a potential attack vector on VCIs, demonstrating that a stealth unauthorized exploitation of this UI is possible, attracting the attention of both vendors and users on its criticality and emphasizing the need to secure it and to use it wisely.

More EMC/EMI analysis is required in order to have a better understanding of the power network random configurations on the efficiency of the attack scenario. Moreover, as proposed in this study, the experimental set-up can be used to characterize other devices in order to check the exploitability of this attack path against other Smartphones.

(Taken from the paper: "System Design & Assessment Note SDAN 48, April 2018, Remote and Silent Voice Command Injection on a Smartphone through Conducted IEMI – Threats of Smart IEMI for Information Security" by José Lopes Esteves and Chaouki Kasmi of the Wireless Security Lab, French Network and Information Security Agency – ANSSI, which is available from: http://ece-research.unm.edu/summa/notes/SDAN/SDAN0048.pdf.

They found that the conducted noise coupling from the mains side of the charger to the microphone signal was almost 0dB around 230MHz! Making it easy to put RF on the mains or the USB power modulated with voice commands that the cellphone assumes were actually spoken. It only required 500mW of RF power to spoof a voice recognition system.)

883) New Hitachi 'Azuma' trains cause EMI to older signals and points in the north of England

New trains planned for the East Coast mainline do not work properly with track-side equipment, it has emerged.

The Azuma trains cause electromagnetic interference to older signals and points in the north of England. This means the electro-diesel trains can only run on diesel, travelling much more slowly than their promised speed.

Network Rail said it was working with Japanese train manufacturer Hitachi to fix the problem but it was too early to identify a solution. "We are committed to delivering improved passenger services and are working on a long-term solution," a spokesperson said. "In the meantime, the new trains continue to be tested on the East Coast mainline."

The problem affects equipment that registers passing trains and instructs signals and points accordingly. The older system used on the line north of York does not work with the new trains when they operate on electric power.

Former Labour transport secretary Lord Adonis said he had ordered the new trains 10 years ago. "They had 10 years to get these signalling issues right," he added. "They'll be much more expensive to operate, they'll be slower, they'll have less capacity and hundreds of millions of pounds of public money has been wasted again. "This should be sorted out and it's [transport secretary] Chris Grayling's responsibility."

Mr Grayling admitted there were "teething problems in the same way we had teething problems on the Great Western line". He said: "We have started to move towards greater integration between track and trains. The new franchises involve much closer working between Network Rail - the track operator - and the train companies. "The North needs and deserves better railways. It's getting new trains, it's getting investment, it doesn't happen overnight."

The new trains are being assembled at Hitachi's plant in Newton Aycliffe in County Durham. At expected speed they would reduce the journey time from Edinburgh to London by 22 minutes to four hours, the company said. Network Rail said they were still due to be rolled out by the end of the year. It added: "Electromagnetic emissions from the train are interfering with existing safety critical systems - a fact confirmed by the independent report. "It is Hitachi's responsibility to demonstrate that the IEP trains can run safely on the East Coast mainline, and we believe that this issue can only be fixed on the train."

itachi said: "There are a number of 30-year old signalling systems on the East Coast mainline which require modifying to operate with modern electric trains - which has been confirmed by an independent report. Network Rail is planning to carry out this modification work before the Azuma trains enter into passenger service. This is the same issue encountered 15 years ago when the Pendolino was introduced on the West Coast mainline. Whilst testing started over 12 months ago, this issue has been identified by Network Rail only recently during multi-train testing. Hitachi is working hard to support Network Rail to overcome this interface issue".

(Kindly sent in on 10 September 2018 by Dr Antony Anderson, an independent consultant based in the north of England, who saw it on the BBC News, https://www.bbc.co.uk/news/uk-england-tyne-45435683.)

884) A new equipment caused half the other equipment in a factory to malfunction

I once had to deal with a new machining centre in a factory, that put 15Vp-p on the mains at 20kHz when it was operated, causing more than half of the other equipment in the factory to malfunction.

20kHz was the 5th harmonic of the machining centre's 55kW 4kHz variable-speed motor drive (VSD), but the fundamental and harmonics below the 5th were not a problem, even though they probably had higher levels of energy in them.

This pointed to a resonance in the interaction of the filter with its complex source impedance, causing a significant gain (rather than attenuation) at or near 20kHz.

The solution turned out to be quite quick and easy. The 55kW motor drive was a Siemens type, but the manufacturer of the machining centre had chosen to use a cheaper mains filter than the one Siemens recommended for use with their drive.

The cheaper mains filter had allowed the machining centre to pass emissions tests above 150kHz, but the manufacturer had only thought about passing the tests – not about the fact that the VSD's rather high-power noise emissions at its switching frequency of 4kHz and its harmonics – 8kHz, 12kHz, 16kHz, 20kHz, etc. – might cause EMI problems in real-life at frequencies below 150kHz.

Retrofitting the filter that Siemens recommended for their motor drive reduced the 20kHz noise to below 1.5 Vp-p, didn't cause any other noises to become significant, and immediately solved the problem throughout the factory.

(Provided by Keith Armstrong, November 2018. He also notes: "All filters are specified by testing with 50Ω resistive source impedances for both differential-mode (DM, which the filter industry calls 'symmetrical') and common-mode (CM, which the filter industry calls 'asymmetrical'). In real life, of course, neither the DM or CM source impedances are likely to even be close to 50Ω, and even then are very much more likely to be capacitive or inductive depending on the frequency, than resistive. So it is not that unusual for a mains filter in real life to amplify certain frequencies instead of attenuating them, because of its 'mis-matched' source impedances. The very real possibility of similar real-life problems with their risks of claims under contract penalty clauses or high warranty costs is obscured by the fact that EMC test methods used on finished products or equipment use LISNs or AMNs that create the unrealistic 50Ω resistive source impedances for both DM and CM.")

885) The lack of IC ESD sensitivity data has reached a critical stage

With the downward trend in IC ESD thresholds as discussed, it is essential to know, prior to initial production, when component sensitivities fall outside the scope of the document. The absence of device ESD sensitivity data in the public domain has reached a critical stage and will only worsen with technology trends towards the expanding use of extreme ESD sensitivities.

Therefore, it is strongly recommended that manufacturing quality executives require notification of any such devices to avoid a production crisis such as the case study described above.

Likewise, it is strongly recommended that IC suppliers make the data readily available either in publicly available data sheets utilizing the standard practice being developed by EOS/ESD Association, Inc. or in other documentation in the case of custom devices.

(The conclusions of Ted Dangelmayer, writing on behalf of the EOS/ESD Association, Inc., in "Absence of IC ESD Sensitivity Data Has Reached a Critical Stage", in In Compliance magazine, October 2018 edition, visit: https://incompliancemag.com/article/absence-of-ic-esd-sensitivity-data-has-reached-a-critical-stage/)

886) Always avoid using 1kHz clock frequencies!

A company just couldn't get their device through the immunity test. I very quickly discovered that it was because their main clock frequency was 1kHz, identical to the sine-wave modulation used in the tests.

(Kindly sent in by Prof. Davy Pissoort, Assistant Professor, Mechatronics Group, KU Leuven, Belgium, on 20 Nov 2018, https://iiw.kuleuven.be/brugge/m-group.)

887) Your Tesla can go from zero to 60mph in 2.5s, but can't get AM radio

Electric-powered motors interfere with AM reception, prompting some car makers to drop the dashboard option; 'I was so mad I told them to take the car back'.

The problem, experts said, is that electric-vehicle motors generate electromagnetic frequencies on the same wavelength as AM radio signals. That creates the buzzing and signal fading from electromagnetic interference.

"You get two signals that literally collide into each other and cancel each other out before the antenna even receives the signal," said Brian McKay, head of engine innovation and technology at the North American operations of Continental AG. As EV motors grow more powerful, so does AM static.

(Taken from the Wall Street Journal, 11 September 2018, visit https://www.wsj.com/articles/your-tesla-can-go-zero-to-60-in-2-5-seconds-but-cant-get-am-radio-1541523098 for the full article.)

888) Emissions between 2kHz and 150kHz can cause overheating and audible noises

Abstract: Due to the increasing use of modern technologies (e.g. PWM inverters in PV installations, equipment with active power factor correction circuits, PLC, …) the emission levels in the frequency range between 2 kHz and 150 kHz are rising continuously. In the recent time the number of reported disturbances (e.g. malfunctions of coffee machines, audible noise of electronic ballasts) caused by this emission is growing. Beside these obvious interferences the question arises, if electronic mass-market equipment is affected by this higher frequency (HF) emission as well.

Especially in shunt elements with low impedance at higher frequencies, like DC-link capacitors in rectifier circuits, larger high frequency currents can occur, which may result in additional thermal stress and lifetime reduction.

Based on a laboratory setup the paper analyses the impact of HF components in the supply voltage on the operating temperature within different lamps with electronic ballast. Using a laboratory setup the frequency-dependent input behaviour of different electronic equipment was measured up to 50 kHz. For selected lamps detailed temperature studies were carried out.

Conclusions: The paper demonstrates that HF voltages can have a significant impact on the thermal stress and subsequently the life time of electronic equipment, which contains rectifiers with electrolytic capacitors as DC link. Especially the equipment without active cooling has shown a significant impact of the HF voltages on operating temperatures.

Therefore the discussion about immunity and emission levels should not only consider obvious malfunctions but also take the possible long-term effects as described in the paper into account. Besides the additional heating, especially audible noise was observed for a lot of the analysed equipment. This can occur already at HF voltage levels of about 1%.

From the viewpoint of additional thermal stress and disturbing audible noise the compatibility levels in the frequency range up to 20 kHz should be considerably low. Anyway, it should be lower than those levels that already cause obvious equipment malfunctions. Moreover, it is suggested to introduce a limit for the whole frequency band (similar to THD) too.

Currently the measurements are extended to other equipment (e.g. PC power supplies) and to test voltage waveforms containing more than one HF component. Long-term experiments for an assessment of possible lifetime reductions are planned.

(Taken from "Impact of Higher Frequency Emissions above 2kHz on Electronic Mass-Market Equipment", by Jan Meyer, Stephan Haehle and Peter Schegner of the Technische Universitaet Dresden, Germany, CIRED 22nd International Conference on Electricity Distribution Stockholm, 10-13 June 2013, Session 2 Paper No 0999, available from https://ieeexplore.ieee.org/document/6683630.)

889) Photovoltaic active infeed power converters can interfere with power line communications

Field measurements, laboratory tests and simulation have shown that some inverters dedicated to photovoltaic energy production do interfere with power line communication systems.

A method was presented to assessing interferences in the CENELEC A band with the help of frequency scans of equivalent circuits modelling LV grid components, active infeed converters and loads. The proposed method was evaluated on the basis of simulations and measurements realised on a simple laboratory setup.

The results revealed that EMC-filters for PV inverters can play an important role on signal attenuation, if resonances are located close to the frequency used by the PLC system.

(Taken from "Electromagnetic Interferences in Smart Grid Applications: A Case Study With PLC Smart Meters and PV Energy Generation", by Dominique Roggo, Rodolfo Horta, Lino Capponi, Loïc Eggenschwiler, Fabrice Decovert, Cédric Pellodi and Franz Buholzer, presented at the 24th International Conference on Electricity Distribution Glasgow, 12-15 June 2017, CIRED 2017, paper 1285, which is available from https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8315836.)

890) FAA restrictions for use of electronic devices aboard aircraft, October 2017

7.2.2 Aircraft Not Designed and Certified PED Tolerant. An operator may choose to conduct a safety risk assessment following the process in RTCA DO-363 if it 1) does not have a designed and certified PED-tolerant aircraft, and 2) chooses not to test its aircraft fleet types according to RTCA DO-307A or obtain supporting documentation from an aircraft manufacturer. The operator's assessment must evaluate the avionics configuration of its fleet and failure modes of communication, navigation, surveillance, and other electronic systems with respect to electromagnetic interference. This assessment ultimately outlines mitigations and controls the operator needs to adopt to expand PED use into various phases of flight.

7.2.3 Aircraft Not Demonstrated PED Tolerant. If the operator has not demonstrated PED tolerance for their aircraft, they may allow PED operation during cruise flight. If interference to aircraft systems from PEDs is experienced during cruise flight, the devices causing interference should be isolated, and applicable conditions recorded. The device responsible for the interference should be turned off.

(Taken from: "Use of Portable Electronic Devices Aboard Aircraft", U.S. Department of Transportation, Federal Aviation Administration Advisory Circular, 10/27/17, AC No: 91.21-1D, available from: https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91.21-1D.pdf.)