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EMC AWARE

EMC and Compliance International Conference - May 2024

BANANA SKINS 941-950

Real-life short stories about electromagnetic interference

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EXCLUSIVE INTERVIEWS

Editor's interview with Mariyah, a recent electronics graduate. She tells us about her findings and how she plans to use her skills.

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EMC AND COMPLIANCE INTERNATIONAL 2024

22-23 May, 2024
9:00 AM

Newbury Racecourse,
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Join us at EMC&CI 2024, the premier event for engineers seeking to enhance their EMC and compliance knowledge for practical product and system design. Explore training sessions, gain insights from industry experts, and connect with your peers.

The show offers many different ways to learn and expand your knowledge through its world-leading training and conference sessions.

Events Schedule

Date	Day 1 (22/05/2024)		Day 2 (23/05/2024)	
Time	Training	Conference	Training	Conference
9:00 -9:30	The Physical Basis of SI, PI and EMC *Andy Degraeve*	Military/Electric Aircraft *Gavin Barber, QinetiQ*	Essential EMC Design Techniques for PCB Layout *Rod Macpherson*	System & Installation *Prof. Ian Macdiarmid*
9:30 - 10:00				
10:00 - 10:30				
10:30 - 11:00	Demo & Hands-on	Coffee/Tea Break in Exhibiton Area	Demo & Hands-on	Coffee/Tea Break in Exhibiton Area
11:00 - 11:30	Essential EMC Design of Switching Power Converters *Keith Armstrong*	Design for EMC *James Pawson, Unit 3 Compliance*	Essential Circuit Design for EMC *Keith Armstrong*	Practical Compliance *Wil Corker, BP Pulse*
11:30 - 12:00				
12:00 - 12:30				
12: 30 - 13:00	Lunch Break		Lunch Break	
13:00 - 13:45	KeyNote Speaker - Schaffner		KeyNote Speaker - James Pawson, Unit 3 Compliance	
13:45 - 14:00	Break		Break	
14:00 - 14:30	Radiated emissions (RE) bench top characterization, troubleshooting and mitigation *Kenneth Wyatt*	Simulation *Tamara Monti, Dassault Systems*	Radiated immunity and ESD bench top characterization, troubleshooting and mitigation *Kenneth Wyatt*	Electrification *Oskari Leppaaho, Danfoss*
14:30 - 15:00				
15:00 - 15:30				
15:30 - 16:00	Discussions – Min Zhang	Coffee/Tea Break in Exhibiton Area	Discussions – Min Zhang	Coffee/Tea Break in Exhibiton Area
16:00 - 16:30	Social Events with complimentary drinks and snacks		Panel Discussion & EMC Question Time with free drinks and snacks	
16:30 - 17:00	IEEE Talk - Charging applications and EMC, BP			
17:00 - 18:00				

Event Highlights:

- **Exhibition (Ground Floor):** Explore the FREE exhibition featuring around 50 companies. Experts will offer guidance on new EMC directives, components, test techniques, equipment, and the latest EMC modelling software. The exhibition includes organised demonstrations and daily keynote presentations.
- **Training Sessions:** Engage in a full program of EMC training courses conducted by renowned industry professionals, including Kenneth Wyatt and Keith Armstrong. Gain insights into various EMC-related topics through specialised training sessions.
- **Conference Sessions:** Delve into six sessions covering a broad spectrum of EMC applications, from design and simulation to military, railway applications, and more. Each topic features three industry experts, totalling 18 expert speakers sharing invaluable insights and experiences.
- **Social Networking:** Enjoy social networking opportunities with engineers and experts from diverse industries daily after 16:00. This provides a unique chance to exchange ideas and insights across various fields. On the afternoon of the 22nd, BP representatives will organise an IEEE talk, offering valuable insights and industry perspectives.

Engagement Details:

For registration or further information, visit **www.emcandci.com**

Join us for an enlightening experience at EMC and Compliance International on the **22nd and 23rd of May, 2024**, at the Dubai Duty-Free Grandstand, Newbury Racecourse.

For inquiries or partnership opportunities, please contact **info@emcandci.com**

EMC & COMPLIANCE INTERNATIONAL

Issue 6 | January 2024

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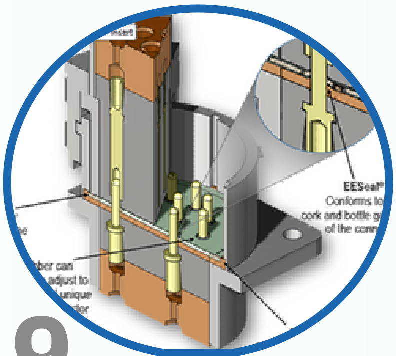

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AN EMC PERSPECTIVE:
HEAR IT FROM THE BEST IN EMC

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EMC Expert

Chris Nicholas
EMC Design Specialist
Cherry Clough Consultants Ltd

Praveen Rao
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C-PRAV Group

Andy Degraeve
EMC Design Specialist
Cherry Clough Consultants Ltd

Julia Moses
Internal Applications Engineer
Wurth Electronics Australia

Melbourne

5TH February 2024 | 9:30am - 4:30 pm
Box Hill Golf Club
202 Station St, Box Hill South VIC 3128

Sydney

7TH February 2024 | 9:30am - 4:30 pm
The Epping Club
45-47 Rawson St, Epping NSW 2121

Brisbane

8TH February 2024 | 9:30am - 4:30 pm
Indooroopilly Golf Club:
Meiers Road Indooroopilly Brisbane Queensland 4068

Adelaide

9TH February 2024 | 9:30am - 4:30 pm
Mount Osmond Golf Club
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MESSAGE FROM THE EDITOR

Dear Readers,

With the New year just over, we hope that you have decided on your resolutions and are working towards them. It is quite tempting to begin thinking about what we can cause to happen this coming year.

So far, I have noted that a few long-served EMC Consultants and practitioners have decided to retire and sell up their business. Some of these are family owned but as there is no family continuance, it either folds up or is bought out and consolidated into a bigger enterprise.

Either way it means that a particular aspect of the EMC practising knowledge base is reduced and that may make it just that bit more difficult for the rest of us still active. It challenges us to provide the design, test and diagnostic services that customers want. Some companies may also decide to set up their own services for EMC and try to fill the vacancy left.

For those companies that have bought an existing business, it should be straightforward enough to amalgamate and extend the business the scope to include more clients. For a new entity coming on the scene, it can be costly to enter in the industry due to the specific skills required to operate a new test service and laboratory.

The key point in all this economic movement is that the technical knowledge density now becomes more concentrated in fewer people. This then results in a bottle neck effect at the design and test stages of electronic products. The pool of knowledge is reduced. Knowledge of mitigating the EMC issues arising, becomes scarce and difficult to apply.

For those of you in the fortunate position of approaching retirement, do consider how you have significant knowledge still with you. What is your direction now? You certainly will enjoy the time off at your own discretion with no programme manger or systems engineer trying to direct your energies. What happens say a year later when boredom kicks in?

What about you previous business owners who are now enjoying the rewards of your years of labour with your life partner? Perhaps you will yearn to have an involvement in some light activity in a year or two.

Please do let us know how your plans are working out for you.

Do let me know your views at ***editor.EMCawaremag@gmail.com***.

All the best for 2024.

Chris Nicholas

Chris Nicholas
Editor

STANDARDS AWARENESS 2

by J. M. Woodgate B.Sc.(Eng.) C.Eng. MIET SMIEEE FAES FInstSCE
Date: 23/11/05

It's not as simple as that

Last time, only IEC and CISPR standards were mentioned, for simplicity at the introductory stage, but there are others, many others.

ITU

The International Telecommunications Union is an organ of the United Nations, although it was founded in 1865. It deals with both telephony/telegraphy and radio communication, including broadcasting. It is divided into three sectors, ITU-T, ITU-R and ITU-D. For more information, go to: https://www.itu.int/en/Pages/default.aspx

ITU-T produces reports and standards, while ITU-R used to produce reports and 'recommendations', but many of the latter have become de facto standards; one of the first was selectivity requirements for FM broadcast receivers, which is EMC by another name.

ETSI

The European Telecommunication Standards Institute was set up to interface with the European Commission on telecommunications issues, but it now operates world-wide. It produces standards In the EN 30000 series and reports in the EN 10000 series. The standards include Product Family and Product standards intended to show prima facie compliance with the Radio Equipment Directive.

CENELEC

As well as adopting IEC/CISPR standards, unchanged or modified, CENELEC also produces its own standards in the EN 50000 series and formerly in the EN 55100 series, the latter being concerned with EMC, but these standards have been withdrawn.

ISO and CEN

The International Organization for Standardization (ISO) and CEN, the parallel European SDO (Standards Development Organization) are mainly concerned with non-electrical issues, but do have some electrotechnical standards in the automotive field, notably ISO 11452, presumably because the industry wants to deal with only one SDO, on both mechanical and electrical issues.

Military standards

Naturally, military bodies need to have their own EMC standards, generally with lower emission limits and higher immunity test levels.The United States has the MIL-STD series, which are widely respected outside the US, and NATO also has its own set. In Britain, the Defence Standards series applies; see https://www.gov.uk/guidance/uk-defence-standardization

EMC testing

Apart from very costly electronic test gear, EMC testing also requires land for an open-air test site, screened rooms, electrical anechoic rooms, and antennas and masts.

Note: Radio has antennas, insects have antennae.

Only very large companies can afford to have their own comprehensive EMC test facility, but some ‘pre-compliance testing’ can be affordable for smaller companies, and can be economically attractive. It also eases the essential involvement of EMC at the design stage, not waiting to consider it until after the design is ‘finished’. It isn’t finished if it doesn’t meet the EMC requirements.

This means that most EMC testing is carried out by EMC test houses. Like everything else, test houses vary in competence, diligence, client relations and affordability. Competence and diligence are monitored by national assessment bodies, UKAS in Britain (https://www.ukas.com/), but things can change between assessments. Client relations are very important, and there are two main aspects:

- Formality: some houses minimise informal interaction, which can hamper the essential development of trust between test house and client, while a few others may go too far the other way and allow test technicians to be distracted by clients’ staff.
- Troubleshooting: houses vary in how far they will go to help with remedial actions (I.e. technical changes) in the event of a product not passing a test.

At present, most companies have already selected a test house (or maybe more than one if their product range is diverse). New companies doubtless have recruited EMC experts who already have experience of test house selection. It’s far more difficult these days for ‘two guys in a garage’ with little experience to set up a new company, because of the costs of EMC and safety testing, and product liability insurance.

Note: It’s far easier to meet EMC emission requirements with analogue equipment designs, but meeting immunity requirements can be rather more difficult. However, there are very effective techniques that improve immunity.

Selecting the standards

For an existing product, and for most natural developments, the selection has, of course, already been done, unless someone moves the goalposts, which is not unknown. Usually, the impetus for that comes from regulatory authorities, like the European Commission or the Federal Communications Commission (FCC) in the USA. For example, the predecessor of the (European) Radio Equipment Directive, the Radio and Telecommunications Terminal Equipment (RTTE) Directive, caused the introduction ‘at a stroke’, of a large number of EMC emission and immunity standards that had no real predecessors.

For entirely novel products, it is necessary to examine the EMC standards applicable in the market or markets to be served, under established headings:

- Radiated emissions (electric and magnetic), usually above 9 kHz; the top limit is 400 GHz at present for IEC and CISPR standards, but that may change. A gap below 30 MHz is under study to be filled, but consistent measurements in this range are very difficult.
- Conducted emissions, below and above 9 kHz; the EMC issues and the measurement techniques are very different on each side of the dividing line, because there is no civilian radio communication below 9 kHz.
- Immunity to continuous radiated energy
- Immunity to continuous conducted energy
- Immunity to impulsive energy (such as electrostatic discharge and transients on the public electricity supply).

Good guidance on the requirements can often be obtained from the applicable Generic standards, but it would be unwise to rely entirely on them: a novel product might not have special emission requirements (but, for example, solar photo-voltaic installations did), but special attention to immunity issues is often required. There are many excellent technical books on EMC and how to tame it, as can be found by a Web search.

EMC assessment

Regulatory requirements often include one for an assessment document, which must be kept updated with all changes to the product that might (not 'will') affect its conformity to the applicable standards. It is often necessary, also, to record any decisions about a need (or not) for re-testing as a consequence of a change. See, for example, Clause 3 of Annex II of the EMC Directive (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0030)

Confidence

EMC testing can be very costly, so it is important to be as confident as possible that the sample product to be tested will pass (or very nearly pass). First, make sure that not only are the correct standards applied, but the correct editions, with amendments. The situation is very complicated in Europe at present, because of the legal issue mentioned in Part 1 of this article. This has delayed the acceptability notification of new and amended EMC standards in the Official Journal, which permits them to show evidence of compliance with the EMC Directive. However, older editions, which have appeared in the Journal, no longer represent the 'state of the art', so can be challenged under EU law as no longer being acceptable. The European Commission has created this paradox. Your test house will have a view on how to resolve this, usually by applying the notified version and the latest version. This can work as long as they are not absolutely contradictory on an important requirement. For example, a more stringent requirement in a later edition is not absolutely contradictory, because meeting that requirement satisfies both versions of the standard.

Things to come

My next article will take a look at recent and forthcoming changes to key standards that are applicable to most products.

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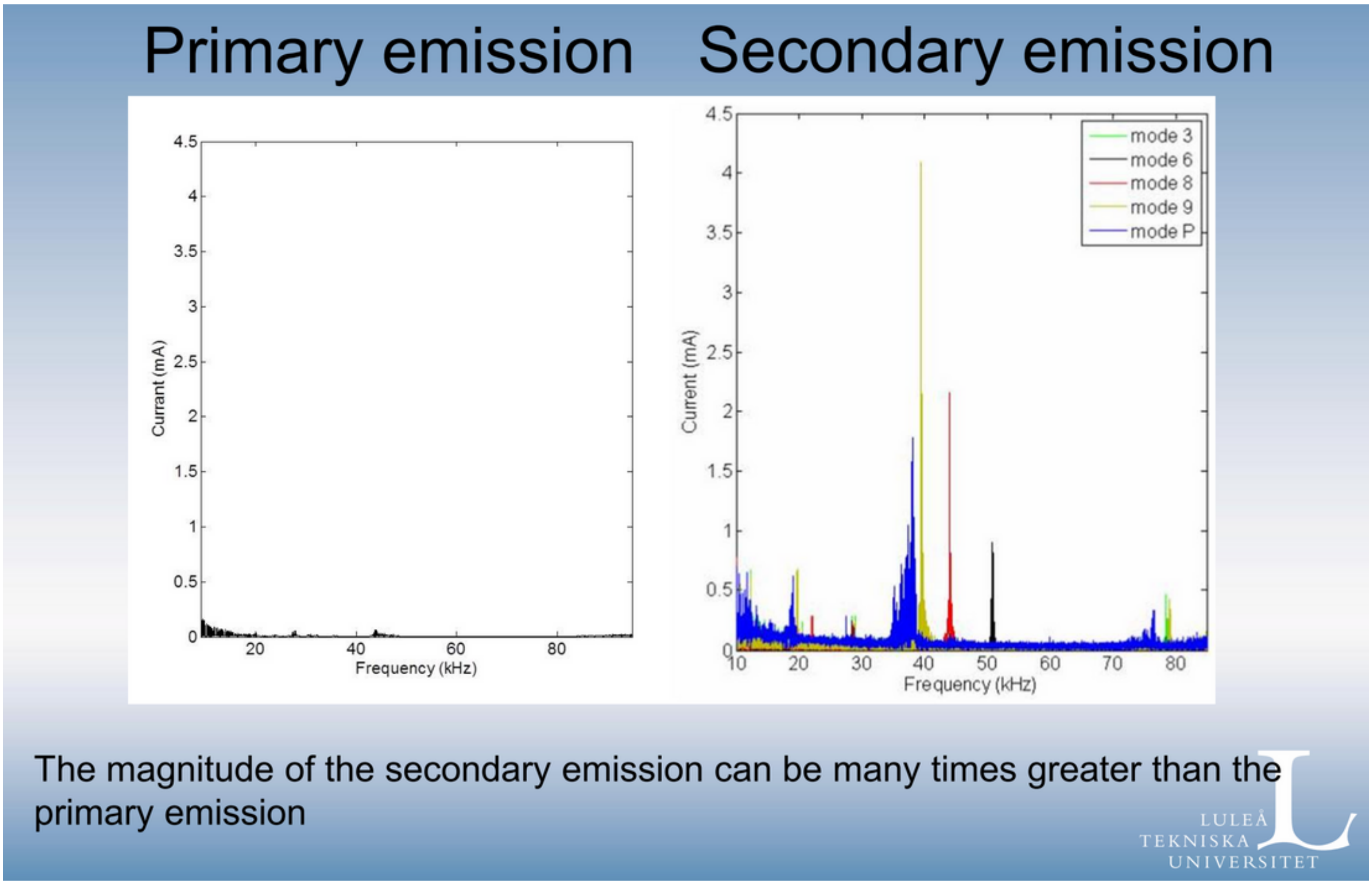
Compiled by: Keith Armstrong, www.cherryclough.com

941) Interference from 'Supraharmonics'

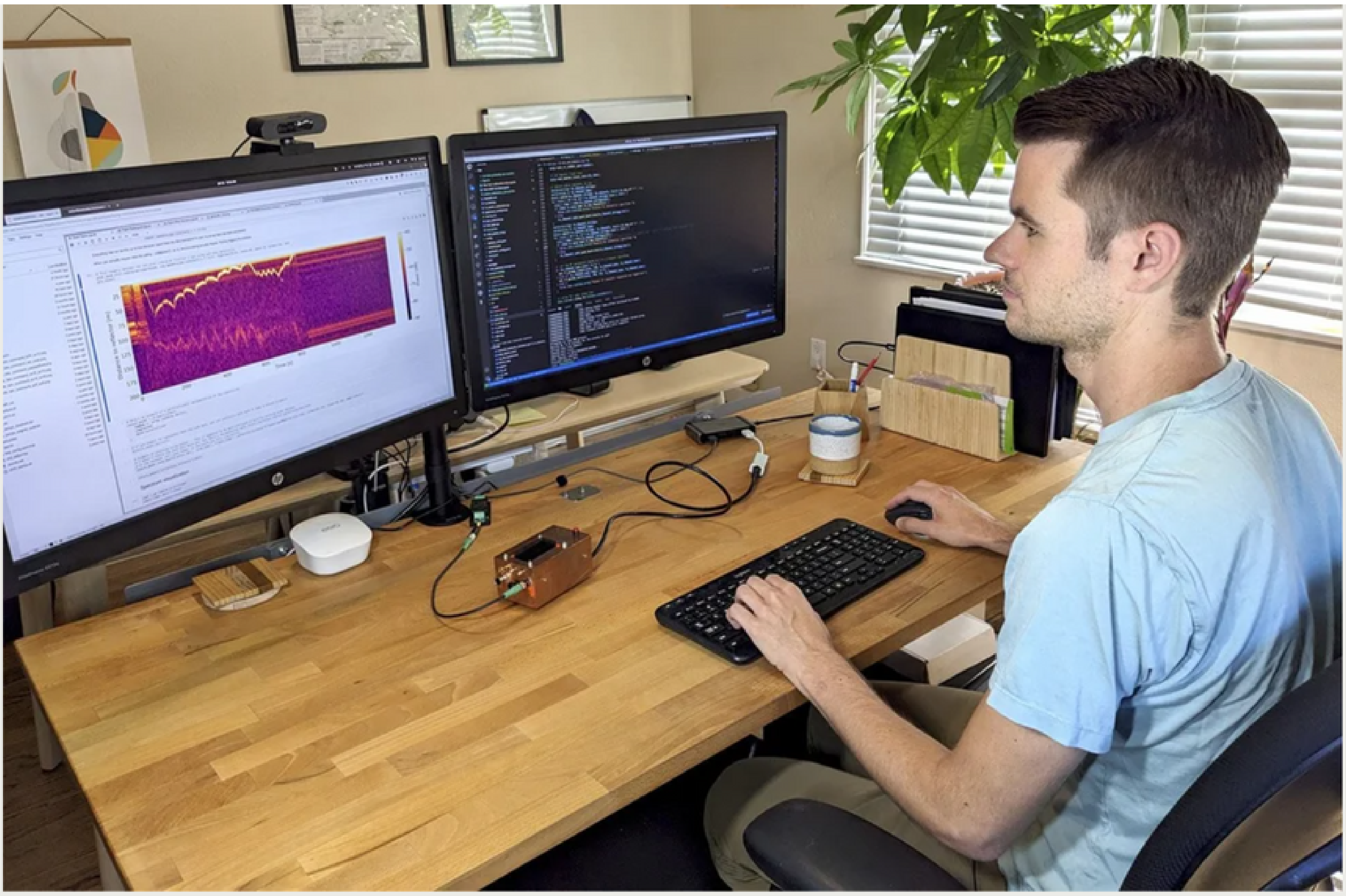


These are just examples and not all cases are reported

- Reduced quality of the output of a copy machine due to frequencies in the lower kHz range
- Interference with light dimmers, medical equipment, electricity meters, and earth leakage current breakers
- An 8-kHz voltage, due to a CNC mill, resulted in a range of complaints: malfunction of a fully automated coffeemaker; a hair dryer randomly turning on an off; malfunctions of the control of the CNC drive itself.
- Unwanted tripping of earth leakage current breakers in Japan
- Audible noise coming from a television
- Failure of varistors due to repetitive activation by recurrent oscillations in voltage
- Voltage distortion around 12 kHz was shown to cause mechanical oscillations and audible noise
- Clocks running too fast

(Taken from: Slide 36 of "Supraharmonics, a new field within power quality" by Sarah Rönnberg, presented at the Annual General meeting of the IEEE Chapter of Power & Energy Society and Power Electronics, 2019-03-04, http://r8.ieee.org/sweden/wp-content/uploads/sites/130/2019/02/IEEE_KTH_SR_20190304.pdf.
Also see: S. Rönnberg et al. "On waveform distortion in the frequency range of 2 kHz–150 kHz—Review and research challenges" Electric Power System Research 150 (2017): 1-10, https://www.sciencedirect.com/science/article/abs/pii/S0378779617301864.)

942) Fighting noisy signals in an ice-penetrating radar flown on a UAV



Thomas Teisberg reviews some of the data recorded by Peregrine. The small box on his desk with wires

I thought we were ready. But when we took our UAV out to a field near our lab, we discovered that we could not get a GPS fix on the drone when the radar system was active.

After some initial confusion, we discovered the source of the interference: our system's USB 3.0 interface.

To solve this problem, I designed a plastic box to enclose the Raspberry Pi and the SDR, 3D-printed it, and wrapped it in a thin layer of copper tape. That shielded the troublesome USB circuitry enough to keep it from interfering with the rest of our system.

Finally, we were able to fly our tiny radar drone over a dry lakebed on the Stanford campus. Although our system cannot image through dirt, we were able to get a strong reflection off the surface, and at that point we knew we had a working prototype.

We carried out our first real-world tests six months later, on Iceland's Vatnajökull ice cap, thanks to the help and generosity of local collaborators at the University of Iceland and a grant from NASA.

(Taken from page 8 of: "Studying Climate Change with an Ice Radar Drone – This budget system probes beneath the ice to discover its secrets", by Thomas Teisberg, 5th August 2023, in https://spectrum.ieee.org/drone-ice-radar.)

943) Increasing levels of RF noise in the environment

1) The local authority for a radio amateur colleague in Cheltenham had wonderful new LED street lighting installed a couple of months ago. Now he cannot use HF bands at all (when the lights are on).

2) My sister has a neat (and very expensive) battery powered salt and pepper mill set that always switches their DAB radio off when they are used.

3) Just for interest, the ambient noise level at my house now across the spectrum 1.5MHz-12MHz averages out at -52dbm since the roll out of VDSL. Prior to this I had a noise level of -105dbm as you can see a significant increase. This has basically made the HF spectrum unusable in my urban environment.

OFCOM will not do anything as they do not consider it to be 'harmful interference'

(Taken from discussions amongst EMCIA members in June 2016. The EMCIA is the EMC Industry Association, based in the UK, www.emcia.org.)

944) Excessive magnetic field emissions at 30-40kHz from 'e-mobility' chargers

Table 2

Reference levels for electric, magnetic and electromagnetic fields (0 Hz to 300 GHz, unperturbed rms values)

Frequency range	E-field strength (V/m)	H-field strength (A/m)	B-field (μT)	Equivalent plane wave power density S_{eq} (W/m²)
0-1 Hz	—	$3,2 \times 10^4$	4×10^4	—
1-8 Hz	10 000	$3,2 \times 10^4/f^2$	$4 \times 10^4/f^2$	—
8-25 Hz	10 000	4 000/f	5 000/f	—
0,025-0,8 kHz	250/f	4/f	5/f	—
0,8-3 kHz	250/f	5	6,25	—
3-150 kHz	87	5	6,25	—
0,15-1 MHz	87	0,73/f	0,92/f	—
1-10 MHz	$87/f^{1/2}$	0,73/f	0,92/f	—
10-400 MHz	28	0,073	0,092	2
400-2 000 MHz	$1,375\ f^{1/2}$	$0,0037\ f^{1/2}$	$0,0046\ f^{1/2}$	f/200
2-300 GHz	61	0,16	0,20	10

At the IEC MT15 meeting in Waldkirch Germany, 23 Sep 2014, Dipl.-Ing Werner Grommes of the IFA said that ‘e-mobility’ chargers (charging electric vehicles from coils in the road as they drive over them) use 30-40 kHz at 2mT, and he measured 170μT at 3 metres distance!

Note that the European Council Recommendation 1999/519/EC limits human exposure in this frequency range to 6.25μT, and gets its legal force via the ‘Low Voltage Directive’, 2014/35/EU.

(IFA = Institute for Occupational Safety and Health of the German Social Accident Insurance. The figure is taken from “COUNCIL RECOMMENDATION of 12 July 1999, on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz), 1999/519/EC”, available free from: https://op.europa.eu/en/publication-detail/-/publication/9509b04f-1df0-4221-bfa2-c7af77975556/language-en.)

945) EMI mitigation techniques cannot be regarded as fixed and/or universal

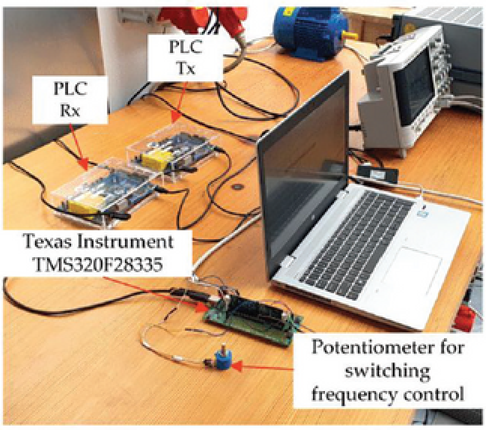
The potential interference of electric and electronic equipment with communication systems has been one of the main EMC concerns, starting from the earliest studies [1], which deals on radio communications in general, and [2], which deals with car receivers.

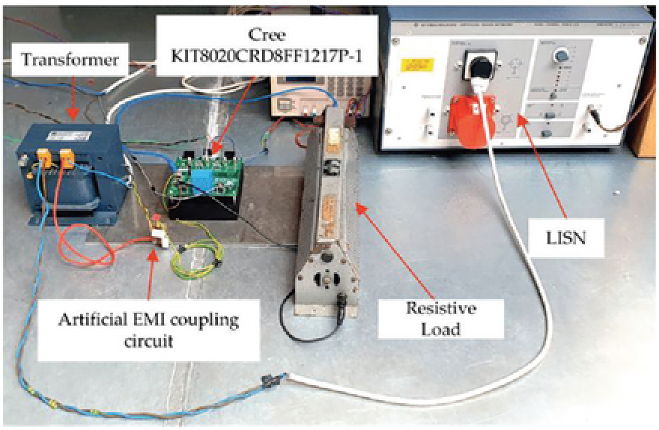
While the goal – i.e., avoiding interference – is always the same through the years, the players, i.e. the sources of interference and the potential victims, are continuously changing. This gives rise to new scenarios and EMC challenges, so that EMC requirements and electromagnetic interference (EMI) mitigation techniques cannot be regarded as fixed and/or universal, but need to be considered in a continuously evolving perspective.

[1] J. G. Allen, "Radio Interference," in Proceedings of the Institute of Radio Engi¬neers, vol. 17, no. 5, pp. 882-891, May 1929

[2] L. F. Curtis, "Electrical Interference in Motor Car Receivers," in Proceedings of the Institute of Radio Engineers, vol. 20, no. 4, pp. 674-688, Apr. 1932

(Taken from: “Interference of Periodic and Spread-Spectrum-Modulated Waveforms with Analog and Digital Communications”, by Paolo S. Crovetti and Francesco Musolino, in “Technical Theme Topics” (Associate Editor Flavia Grassi) in the 2022 IEEE Electromagnetic Compatibility Magazine, Vol.11, Qu.2, https://ieeexplore.ieee.org/document/9873819.)





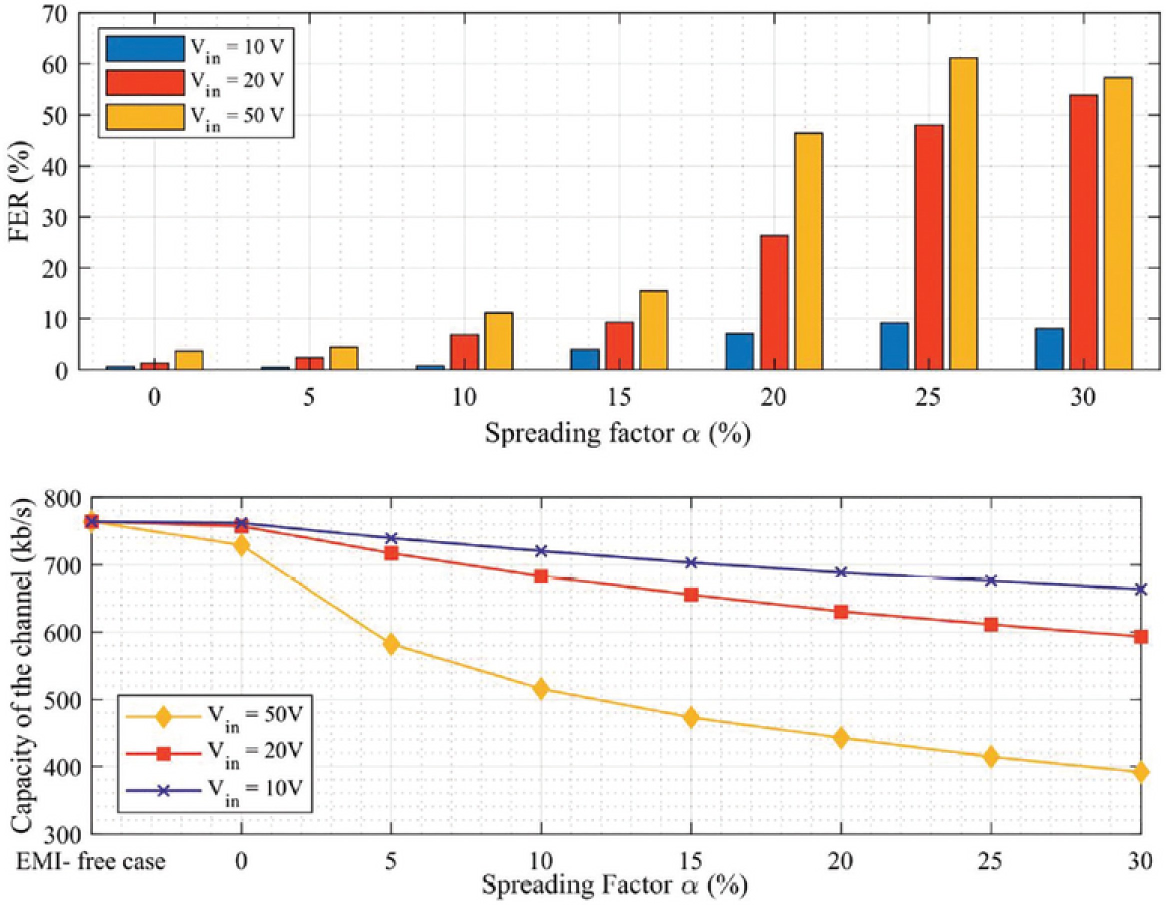


Fig. 11 Application scenario: G3 Power Line Communication (PLC) system [28]. The G3 PLC systems features advanced forward error correction (FEC) coding. A detrimental effect of SS modulation is observed as in Fig. 10.

946) Army investigates development of EMP grenades for disabling IEDs

The U.S. Army is investigating the possibility of creating electromagnetic pulse grenades to disable the radio transmitters on improvised explosive devices.

According to its latest series of research contracts with small businesses, the Army wants to design "high power microwave grenades" to "generate an electromagnetic pulse that could be used to defeat the electronics used to activate [homemade bombs]." Troops currently rely on explosive ordnance demolition specialists, bomb-disposing robots and vehicle-mounted, signal-jamming equipment to disable IEDs; the use of EMP grenades could allow an individual soldier to remove an IED while minimizing loss of life.

The Army is requiring companies participating in the project to design their prototypes similar to the size of "hand or robot delivered munitions, 40mm grenades, rocket propelled grenades (RPGs) and Stinger, Hydra and Javelin missiles." The companies are allowed to design either an explosive or non-explosive design.

A Marine lobs a grenade during a September 2007 exercise in Iraq. PHOTO: U.S. MARINE CORPS

Electromagnetic pulse grenades are a favorite of sci-fi storytellers and videogame designers, a la Halo and Call of Duty. The Army evidently doesn't want to be left out: It's seeking a real-life version that can blast electromagnetic signals and fry insurgent bombs.

To be specific, the Army wants "High Power Microwave (HPM) grenades" to "generate an electromagnetic pulse that could be used to defeat the electronics used to activate [homemade bombs] or that could be used to attack blasting caps," according to its latest round of research contracts with small businesses. In theory, the electrical components on improvised explosive devices, like radio transmitters, could be overwhelmed by surging electromagnetic radiation emitted by such a weapon.

If the Army can actually develop this kind of Halo weapon, it'll take a step toward making each of its soldiers a kind of one-man bomb squad.

While the improvised bomb is the primary weapon used against U.S. troops fighting overseas, not every soldier or marine can destroy a bomb like he or she can shoot an insurgent. To defuse bombs, troops rely on explosive ordnance demolition specialists, bomb-disposing robots and vehicle-mounted jammers. The Pentagon has also desperately struggled to stay a step ahead of the bombs' technical adaptations. But if the Army has working EMP grenades, any soldier could conceivably lob one into a room, around a corner or into a ditch to fry an awaiting booby-trap's circuits. As the Army puts it, it could mean "defeating IEDs by the individual soldier, while minimizing the collateral damage to humans." Easier said than done.

For instance: An EMP grenade has to be small and lightweight enough to carry. The Army is requiring companies participating in the project to design their prototypes to fit the size of "hand or robot delivered munitions, 40 mm grenades, Rocket Propelled Grenades (RPGs), and Stinger, Hydra, and Javelin missiles." The next step is figuring out a working design itself.

The first thing to know is that an EMP grenade could be either explosive or non-explosive, with trade-offs for each. According to the 2011 textbook Explosive Pulse Power by Army engineer Larry Altgilbers, who is overseeing the project, a non-explosive device could use "pulse compression," or blasting brief but fierce electrical pulses while compressing the electrical current and voltage, thereby making the pulses stronger. As the device continues to blast out signals, the pulses then gradually decrease in duration. For a bomb circuit without protection diodes, such a burst of energy could theoretically fry its circuits or cause it to detonate.

Unfortunately, non-explosive systems "tend to be massive, large in size and fairly expensive," Altglibers wrote. But explosive systems are smaller, lighter and can generate a lot more electrical power. The Army solicitation refers to potentially using "energy stored in ferromagnetic, ferroelectric or superconducting materials." Possibly, these various magnets and superconductors could trap an electrical field inside a grenade, and when exploding, the grenade could compress the field. That would cause rapid changes in the field's structure, boosting its power and thus generating — and releasing — tremendous amounts of electromagnetic energy.

A downside to that, though, is superconducting materials have to stay cool. It's also likely to be a one-shot weapon as explosive pulse devices "generally destroy themselves and, quite usually, the load they are driving," according to Altgilbers. But if it's a grenade, then that might be no loss.

Less certain is how such a device would be used neuter a bomb detonated with minimal electrical parts, like the Taliban bombs that detonate when someone compresses a wooden pressure plate; whether it would inadvertently fry U.S. troops' own electronic circuits; or how difficult (or expensive) it'll be to develop an EMP grenade. One Israeli company has developed a much more conventional IED-jamming "grenade," but it uses tiny antennas to scram bomb signals instead of exploding out EMP waves. Perhaps if all else fails, the Army could consider it. If not, it might play another round of Halo in order to brainstorm.

(Taken from: www.interferencetechnology.com/army-investigates-development-of-emp-grenades-for-disabling-ieds/, 11/26/2012. For more information, visit Wired, http://www.wired.com/dangerroom/2012/11/emp-grenades/.)

947) Backup System to GPS Developed

(May 17, 2016) With the recent disruption of GPS service by North Korea still in mind, the Army News Service reports the Defense Advanced Research Projects Agency (DARPA) is working now to develop a backup system to be used by service members in the event that access to GPS is denied to them by adversaries.

A new project, the "Spatial, Temporal and Orientation Information in Contested Environments", or STOIC, is meant to provide position navigation and timing in situations where GPS is denied to U.S. forces.

The STOIC project makes use of VLF signals already being generated by the Navy for use in communicating with submarines. The VLF stations are located around the globe in fixed locations. In part, STOIC uses those signals to triangulate a user's position on the globe, in much the same way a GPS receiver is used.

The project team is planning to demonstrate real-time positioning with their system by fiscal year 2018 or 2019. There will also be an at-sea demo this summer.

(Taken from: Backup System to GPS Developed, 06/01/2016, www.interferencetechnology.com/backup-system-gps-developed/?utm_source=itnewsletter&utm_medium=email&utm_campaign=20160602.
Also see: https://www.darpa.mil/program/spatial-temporal-and-orientation-information-in-contested-environments and https://www.nytimes.com/2016/04/02/world/asia/north-korea-jams-gps-signals.html)

948) Jodrell Bank radio telescope at risk of EMI

(May 17, 2016) Britain's most famous observatory, Jodrell Bank, is currently at risk from a proposed housing estate two miles from the site. Observatory experts claim appliances, lighting, and other electronic products, will play havoc with their instruments.

As a radio telescope, it is highly susceptible to levels of interference produced by electrical appliances – indeed the observatory was set up in rural Cheshire by scientists from Manchester University because the city's trams proved too disruptive.

Jodrell Bank director Prof. Simon Garrington said in a submission to the council, "Interference is correlated with human activity, whether due to intentional transmissions or unintentional leakage from a wide range of electrical and electronic devices. The proposed development itself is likely to generate interference which exceeds the internationally agreed threshold for what constitutes “detrimental interference” to radio astronomy observations.”

According to BBC.com, appliances with electric motors such as lawn mowers, hedge trimmers, power tools, and washing machines are regarded as particularly problematic, while tiny amounts of radiation from microwave ovens can also drown out the scientists’ observations.

Associate director Prof. Tim O’Brien said, “The electrical and electronic devices in houses can produce radio waves that basically mask our view of the distant universe. This is one of the world’s most powerful and sensitive telescopes and these sort of signals are basically wiping out the data that we’re picking up. It’s already difficult for us, this is only going to make things worse.”

Jodrell Bank has already had to stop searching for new pulsars due to the existing level of interference, which it says has been proven to come from nearby houses, rather than cities such as Manchester.

(Taken from: www.interferencetechnology.com/britains-famous-observatory-risk/?utm_source=itnewsletter&uutm_campaign=20160602, to read more: www.bbc.co.uk/news/uk-england-manchester-3630812.)

949) Radio Astronomers hate robot lawnmowers

IRobot Corp., maker of the Roomba vacuum, is hoping to find another consumer hit with robots that can mow your lawn. But those plans are causing some friction with astronomers who are mapping the galactic regions that produce new stars.

Scientists from the National Radio Astronomy Observatory have formally objected to iRobot's early plans for a lawn-mowing bot, telling the Federal Communications Commission that a radio-frequency fence meant to keep the product from wandering away would interfere with their sensitive equipment.

The company needs FCC permission to market its lawnmower robot because it plans to use radio transmitters mounted on two-foot spikes to define the boundary of an owner's lawn, sending signals that would halt the mower before it starts motoring down the street. There are other robotic lawn mowers in the world, but they typically use hard-wired fences to keep their bots in place.

Officials from the federally funded observatory said one way to solve the problem could be by forcing iRobot to remotely disable any lawn mower bots if they're too close to an installation of radio telescopes.

Credit: NRAO/AUI/NSF

In its official response, Bedford-based iRobot said that while it "respects the work of the radio astronomy community," the remote location of the radio telescope facilities and the low-power signals that are proposed for iRobot's radio-fence system mean "there is an exceedingly low practical risk" of any interference with the work of mapping the heavens.

That's where things get a little snarky. In response to iRobot, Harvey S. Liszt, an astronomer and spectrum manager with the National Radio Astronomy Observatory, implied that iRobot's claims about the need for its autonomous mechanoid landscapers were both wildly overblown and utterly trivial:

"iRobot cited multiple statistics of grim accidents and spilt gasoline to assert the public benefit of approving its wireless robotic lawn mowers. However, there is already a competitive market for robotic lawn mowers using wire loops, which has somehow failed to stanch the stream of ghastly accidents and spilt gasoline that iRobot associates with the mundane practice of lawn-mowing. Robotic lawn devices are expensive, typically several thousand dollars, and meant for situations where mowing is performed far more frequently than in the typical front yard."

It's too early to tell who will win this particular fight, which was previously noted by Bloomberg News. But iRobot's proposed lawnmower bots are a long way from hitting the market. The company's plans to enter the lawn-care field were teased earlier this year — right after a lackluster company earnings report dinged iRobot's shares on Wall Street. In its initial FCC paperwork, the company acknowledges the lawn mower is still "in the early design phase."

IRobot has pushed into several other robotics categories in the dozen years since it debuted the Roomba, its original disc-shaped robotic vacuum. But most consumers would probably be hard-pressed to name iRobot's bots for cleaning gutters and pools or mopping household floors — iRobot says that Roomba remains the company's biggest seller.

(Taken from: "Heavens! iRobot's tangling with astronomers. Plans for lawn bot called a potential problem for mapping stars" by Curt Woodward of Globe Staff, April 7, 2015, kindly sent in by Ian Forse who saw it in the Boston Globe in April 2015, see https://www.bostonglobe.com/business/2015/04/06/heavens-irobot-tangling-with-astronomers/bq6nRH5EvXvnTDfxxvYNKO/story.html.)

950) Cuba Jamming Ham Radio? Listen For Yourself

Back in July, ham-radio operators in Florida began noticing interference swamping many of the amateur broadcasting bands. After coordination with operators in South America and Europe, the source of the interfering signals—which sound like "the unfortunate offspring of a frog and a Dalek"—was quickly identified as Cuba.

At the time, Cubans were protesting in large numbers in response to the government's handling of the pandemic and other economic woes, and many theorized that the government had cracked down on amateur radio bands as part of a wider response.

A modern home amateur ham radio station. Equipment includes a solid-state radio transceiver and a desktop computer interfaced to work with the radio. PHILIP DUFF/ALAMY

The jamming seems to have subsided since (you can check for yourself by following the instructions in the original story, see below) but for several days this past summer, it caused a lot of confusion and anxiety in the ham-radio community.

(Taken from: "Ham Radio Jamming, Wireless Industry Battlegrounds, and IoT in Space, IEEE Spectrum's biggest telecom headlines of 2021" by Michael Koziol 29 Dec 2021, https://spectrum.ieee.org/top-telecom-posts-2021.

Original story: "Cuba Jamming Ham Radio? Listen For Yourself A public SDR network triangulates the island as the source of mystery signals" by Stephen Cass, 21 July 2021, https://spectrum.ieee.org/cuba-jamming-ham-radio-listen-for-yourself.)

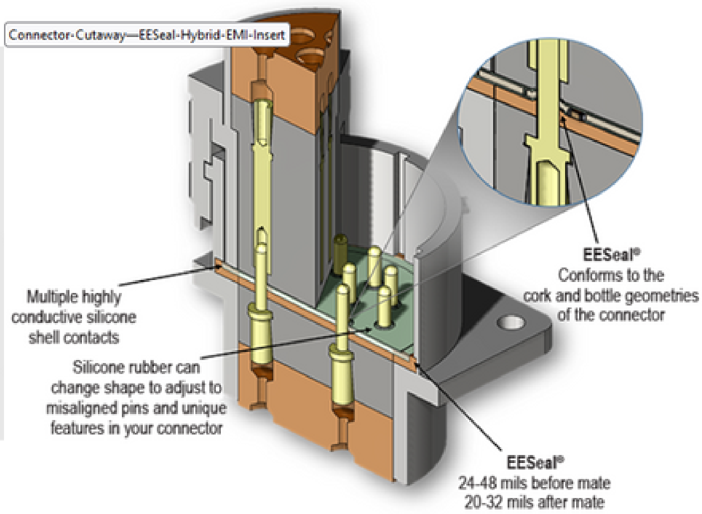
CONNECTOR FILTER INSERT FROM QUELL

Following Scott Lindberg's presentation of the EESeal filter insert at the EDS Coventry in Oct 2023, we took a look at how these work.

Some of you may have experienced electromagnetic noise propagating through connectors and wondered how to filter it out. As coupled energy can be induced into any line, and emissions are measured from every line, electromagnetic energy includes that which is generated inside the equipment as well as energy induced from outside to inside. This induced energy may occur in voltage spikes, current surges or as a continuous signal coupled onto the power or signal lines. Each wire connected to the equipment must be filtered, shielded or perhaps both. It is even possible that transient protection may also be required. Filtered connector solutions may be large and heavy incurring a possible weight penalty. Their expense and long lead times can also affect production schedules and cost. The location of the filter components would need to be as close to the point of entry/exit as possible in order to be spectrally effective. If these components are mounted too far away, it is possible that the energy induced into the lines outside the equipment could cross couple into sensitive electronics before reaching the filtering components.

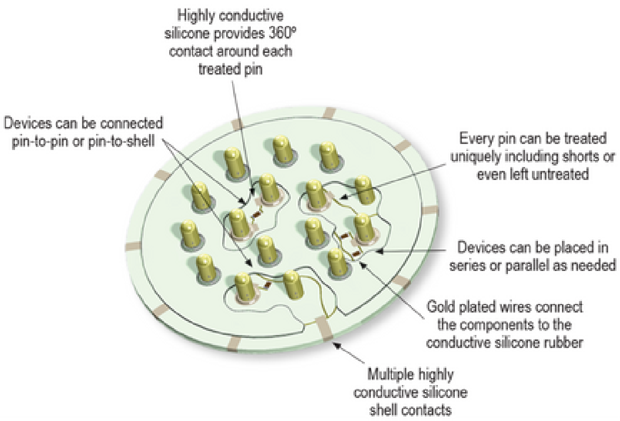
The approach Quell Corporation has taken is to mount very small capacitors onto a flexible dielectric insert called an EESeal. This silicone rubber insert is then fitted over each pin in the connector. It makes electrical contact forming a capacitive filter for each pin on the connector. There is no redesign of the connector needed!

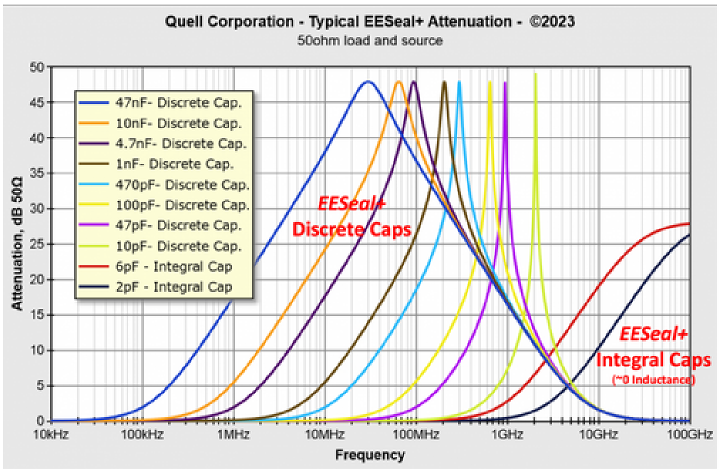
Quell provides these solutions for circular connectors, rectangular connectors and more. Some examples of the range are shown below left.



A side-on view provides an indication of how this is achieved. See image above right.

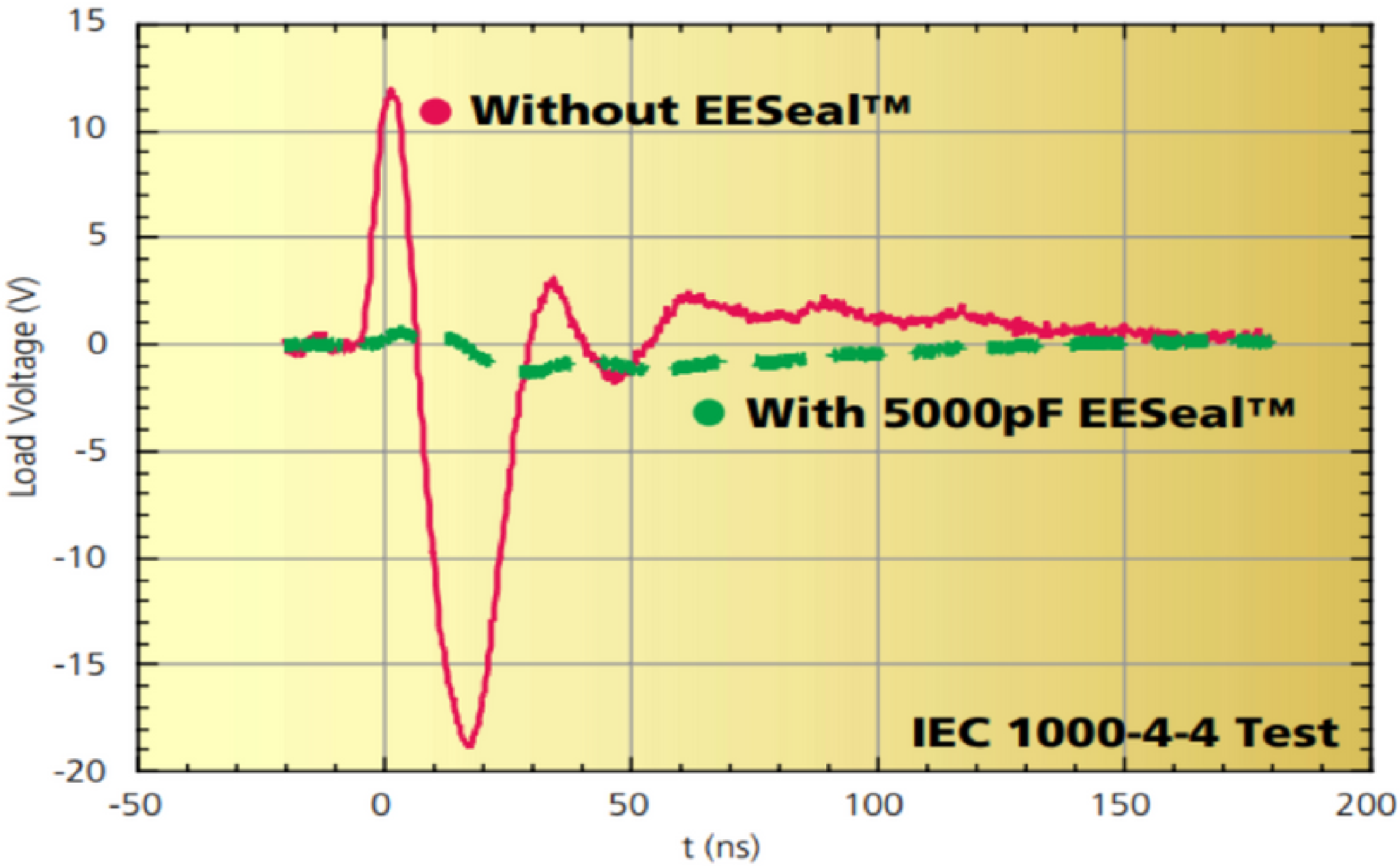
When put together in a connector this is what it looks like. See image below left.





Some of the performance capabilities with the EESeal are shown above right for a wide range of capacitance.

Adding an EESeal to your existing connector can have dramatic results. The figure below shows the performance change to a unit undergoing the IEC-61000-4-4 fast transient /burst immunity test after adding a 5000pF capacitor to each pin.



For further details about Quell and and EESeal sample availability, please contact Andy Brayford, Quell European Sales & Distribution Manager; email Andy@Quell.US
https://eeseal.com/

Using Close-field Probes to Reduce Design Risks Early in a Project -PART2-

First published in the EMC Journal, Issue 114, October 2014
Modified – with thanks to Tom Sato for his perceptive comments – on 15 Oct 2014

Keith Armstrong, www.cherryclough.com

Available on-line from: https://www.emcstandards.co.uk/close-field-probing-part-two

Contents

7 Introduction to Part 2

This is the second part of a short series of articles about using close-field probing techniques to deal with EMC issues during design and other project stages, in order to:

- save time and money
- reduce project/financial risks
- help ensure that if we take products to a 'proper' EMC test lab for compliance testing (which is not a legal requirement for CE marking) they will pass on the first test.

It is often the case that, by the time the prototype electronic PCBs and software is ready for its first functional tests, the mechanical design (and the materials it uses) and the cable harness design are considered to be finished, and it is not unusual for production tooling and jigs to have already been made.

Some of us may have also worked for manufacturers who would commence volume-manufacture of enclosures and/or cable harnesses before it had been possible to operate and test any electronics!

Inevitably, Murphy's Law applies, so that even if the functional testing does not reveal any problems with the mechanical and cable harness design, the EMC testing does – with the result that long delays and large costs are incurred while they are redesigned to be able to comply with EMC standards, regulations and/or Directive.

[13] and [14] show us that time to market has, since 2000 (if not before), been the most important issue for the financial success of new electronic products, at least in the consumer markets, with their BOM (Bill Of Materials) cost considered to be of less importance (but see [15]).

But many manufacturers still leave any/all EMC testing to (very expensive) test laboratories, testing in accordance with published EMC standards, when their new product is otherwise ready for market and its glossy brochures have been printed, marketing/sales programmes are under way, and booths booked for up-coming exhibitions!

These articles describe a number of close-field probing techniques that can be used to assess the electromagnetic (EM) characteristics of materials, mechanical enclosures and cabling, long before any prototype electronic printed circuit boards (PCBs) have been designed or constructed, never mind any prototype software/firmware written to run on them.

Part 1 of this series [12] briefly described close-field EMC probing (often called near-field probing); its limitations and benefits, and showed how to make some simple but very effective probes from commonly- available low-cost materials and components.

[12] also described, with photographs, the following three close-field probing techniques:

- The 2-probe method of finding flaws in shielding
- The 1-probe 'reflectometer' method of finding flaws in shielding
- The 2-probe 'internal illumination' method

This article describes:

- the 2-probe method for discovering the EM characteristics of materials, and of holes, gaps, and joints in them

The next article(s) will cover the following close-field probing techniques:

- The 2-loop-probe method of finding resonances in cables
- The 2-clamp-probe method of finding resonances in cables
- The 1-clamp-probe 'reflectometer' method of finding resonances in cables
- The 1-clamp-probe 'reflectometer' for finding flaws in cable screen terminations and connectors

All of these close-field probe techniques can be used very early in a project:

All of these close-field probe techniques can be used very early in a project:

- before any electronics or software/firmware are available
- using test equipment that costs just a little over £1,000
- by mechanical design engineers who have no special EMC knowledge or training
- without requiring a special location (such as a shielded room or anechoic chamber), i.e. in a normal office, design laboratory, workshop or (even in a manufacturing plant, so can be used for QA in serial manufacture)

8 The 2-probe method for discovering the EM characteristics of materials, and of holes, gaps, and joints in them

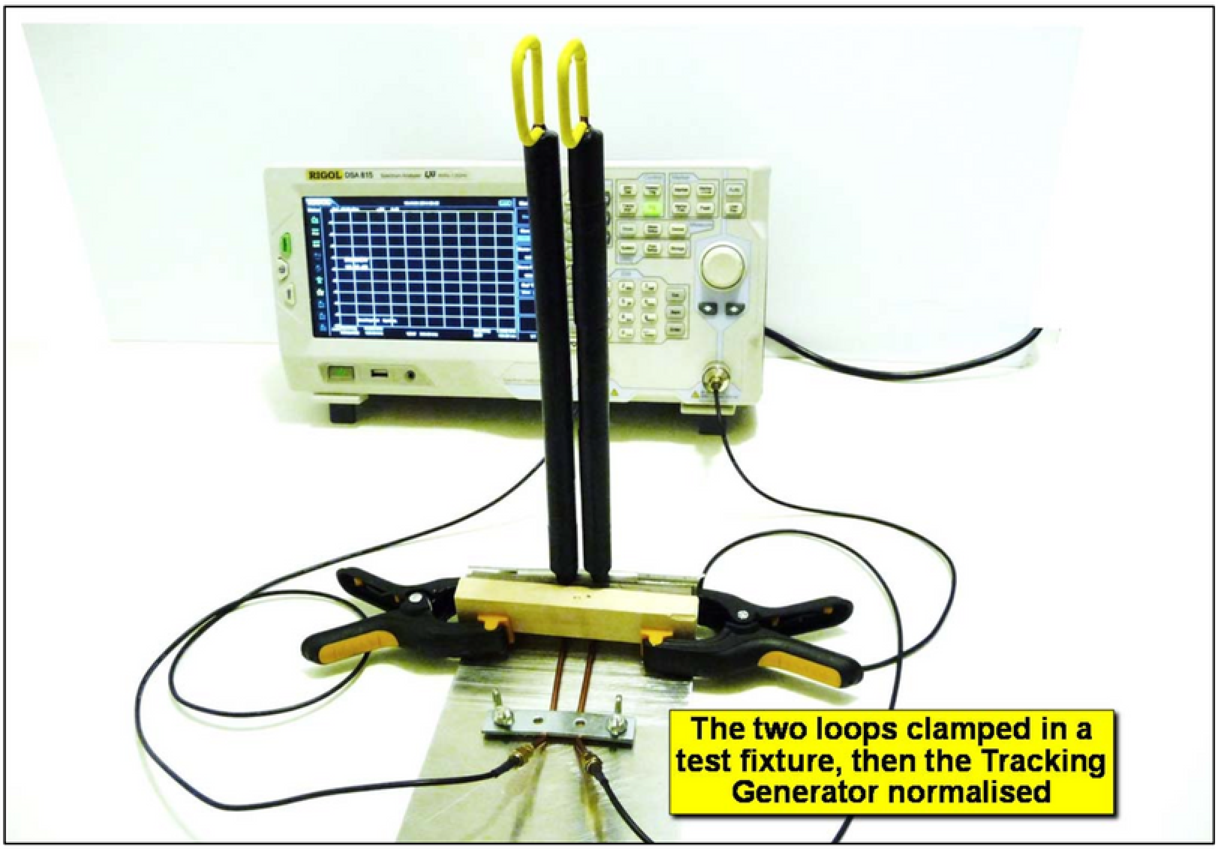


Figure 41 The two ferrite-handled loops clamped in a test fixture

Figure 41 shows a bent piece of aluminium that I call my 'Test Fixture' – which was originally a piece of scrap I had been saving for years in case I found a use for it – supporting two identical close-field probes with ferrite 'handles'.

The purpose of the test fixture is to reliably hold the two probes spaced just a little apart, so that sheets of materials to be tested can be placed between them without disturbing the positions of the probes.

These two probes are identical to those I described making in Figures 12 and 13 of [12] – except that their microwave semi-rigid conductors are extended by about 150mm beyond their ferrite 'handles' and bent to help provide mechanical stability when clamped in the test fixture.

Material samples tend to come in a wide variety of shapes and sizes, and I found that having long ferrite tubes on the 'handles', on these otherwise very simple close-field probes, was very important indeed. Without the ferrite handles, the shape and size of the test sample affected the measurements, making it very difficult to compare one sample with another. But with the ferrite handles – as long as there was sufficient material outside the area enclosed by the (yellow insulated) loops – sample shapes and sizes had no effect.

In addition, I found that it was necessary to make reliable low-resistance metal-to-metal connections between the surfaces of the probes' microwave semi-rigid conductors and the metal structure of the test fixture. Because the aluminium piece I was using was rather old, its surface had become very oxidised and difficult to make electrical contact with – so I abraded it down to shiny metal using emery cloth over the areas that would come into contact with the probes.

I suspect that differential-mode to common-mode conversion in the SMA coaxial cables I was using to connect the probes to the spectrum analyser was responsible for the need to electrically bond the screens of the two probes to test fixture. I wonder if this electrical bonding would not be so important if I used high-spec low-loss double-screened coaxial cables.

A proper test fixture would have the aluminium cleaned back to shiny metal and then its surface treated with a reliably-conductive non-oxidising process such as alochrome (using trivalent chromium, please!), aludine, or Iridite. Aluminium can also be tin-plated, which would have better galvanic compatibility with the copper semi-rigid cable screens, or of course the test fixture could be made of mild steel with zinc or tin plating, or stainless steel.

As it is, whenever I come to use the plain aluminium test fixture shown in Figure 41, I must remember to first of all 'clean' the areas in contact with the copper of the probes, using an abrasive of some sort to remove the oxidised film that will have built up since I last used it.

Figure 41 shows that one of the clamped loops is connected to the RF tracking generator output of the Rigol DSA815 spectrum analyser I was using (9kHz to 1.5GHz, with Tracking Generator option costs a little over £1000, see [12]). The other loop is connected to the spectrum analyser's RF input.

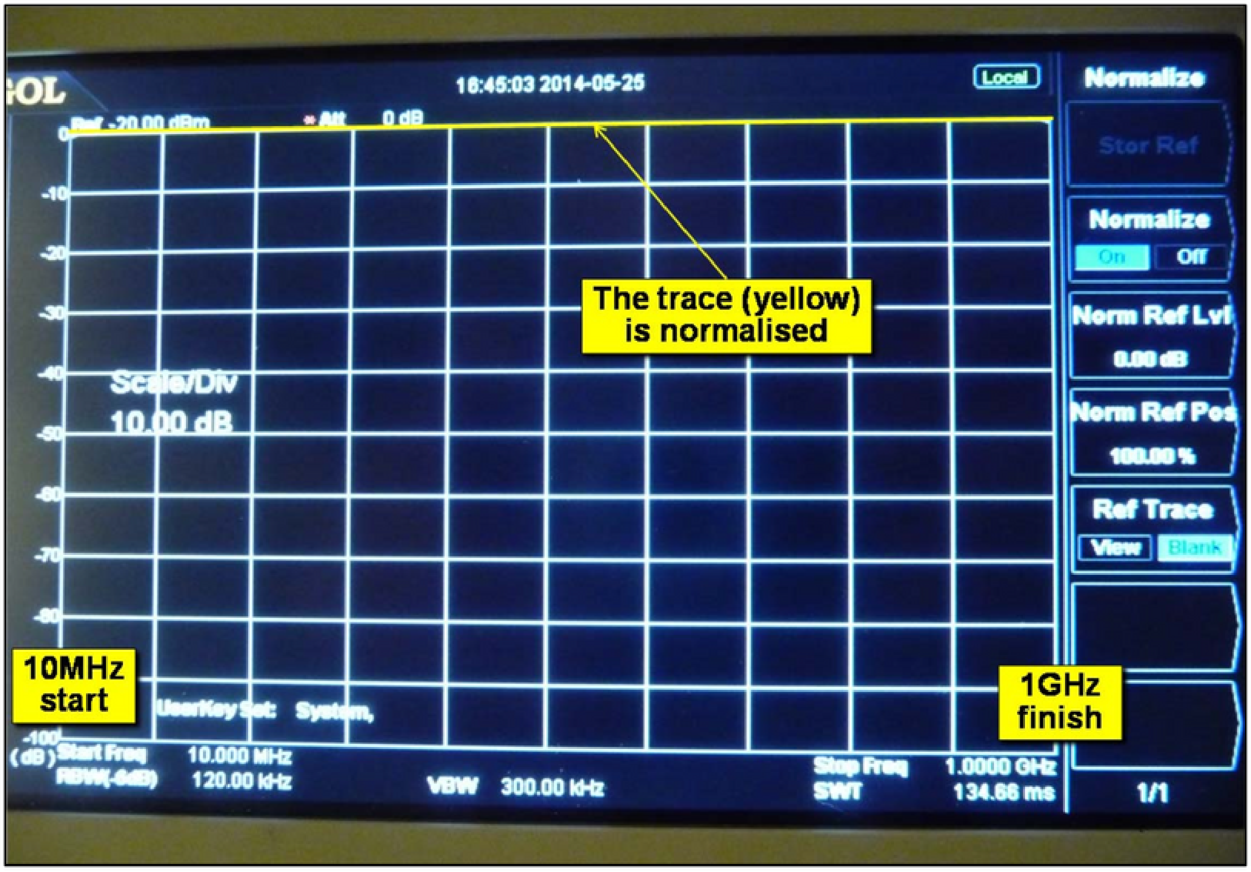


Figure 42 The two ferrite-handled loops are normalised

The tracking generator is 'normalised' – compensating for the frequency-dependent attenuation of the coupling between the two probes and resets the amplitude scale so that the result is a straight line at the 0dB line at the top of the display, as shown in Figure 42.

Without the digital processing functions in modern spectrum analysers, normalisation of a test set-up like this would be a very tedious process of recording the attenuation values for a number of frequencies and using them as correction factors for subsequent measurements of materials at the same frequencies.

These days, as we were using a spectrum analyser that lacked the necessary digital processing functions, we would use a spreadsheet to apply these correction factors. But long, long ago, deep in the mists of time, we used pen and paper, and the measurements I am about to describe in the remainder of this article would have taken very many hours to do, probably more than two full days, instead of the 30 minutes they actually took me.

(This alone creates an excellent business case for replacing an old analyser with a tracking generator but without an automatic normalising function, with a new analyser that has normalisation. The time saved by using the new analyser when doing the sort of close-field probe tests described in these articles, many of which require normalisation, will pay back the cost of the new analyser within a few days. Or within a couple of weeks, if we purchase a costly Agilent (now Keysight Technologies) or Rohde & Schwarz model.)

When normalised, the amplitude display is scaled in dB, simply a ratio, and not dBm, dBV, dBµV, dBµA, dBpT, dBµA/m, dBµV/m or any of the other amplitude scales we use in our EMC work. We use this to display the attenuation-versus-frequency – otherwise known as the Shielding Effectiveness (SE) – achieved by the materials and constructions we place between the two probes.

The Rigol display also tells us that the Reference Level (the 0dB line) is at -20dBm. Because I had set the tracking generator's output level to +10dBm, this tells us that the dynamic range of the spectrum analyser has been reduced by 30dB in order to draw a nice straight line along the top of the screen when it normalises the coupling between the two probes in Figure 41.

As we will soon see, this reduced dynamic range limits the maximum SE that can be measured by this low- cost spectrum analyser.

Figure 43 A 0.35mm thick copper sheet, the first material tested

The first material whose shielding effectiveness we test should be something with very good SE over the frequency range we are scanning (10MHz to 1GHz for the tests shown here) to check that our 2-probe test set-up is working as well as it can, and has no problems.

Figure 43 shows the shiny, clean, new copper sheet that I use for this, which is 0.35mm thick and 300mm square.

(Copper is not as good at shielding when its surface is dull and oxidised, or not smooth for any reason. This is why, when we use copper or brass for shielding, we always plate it with tin.)

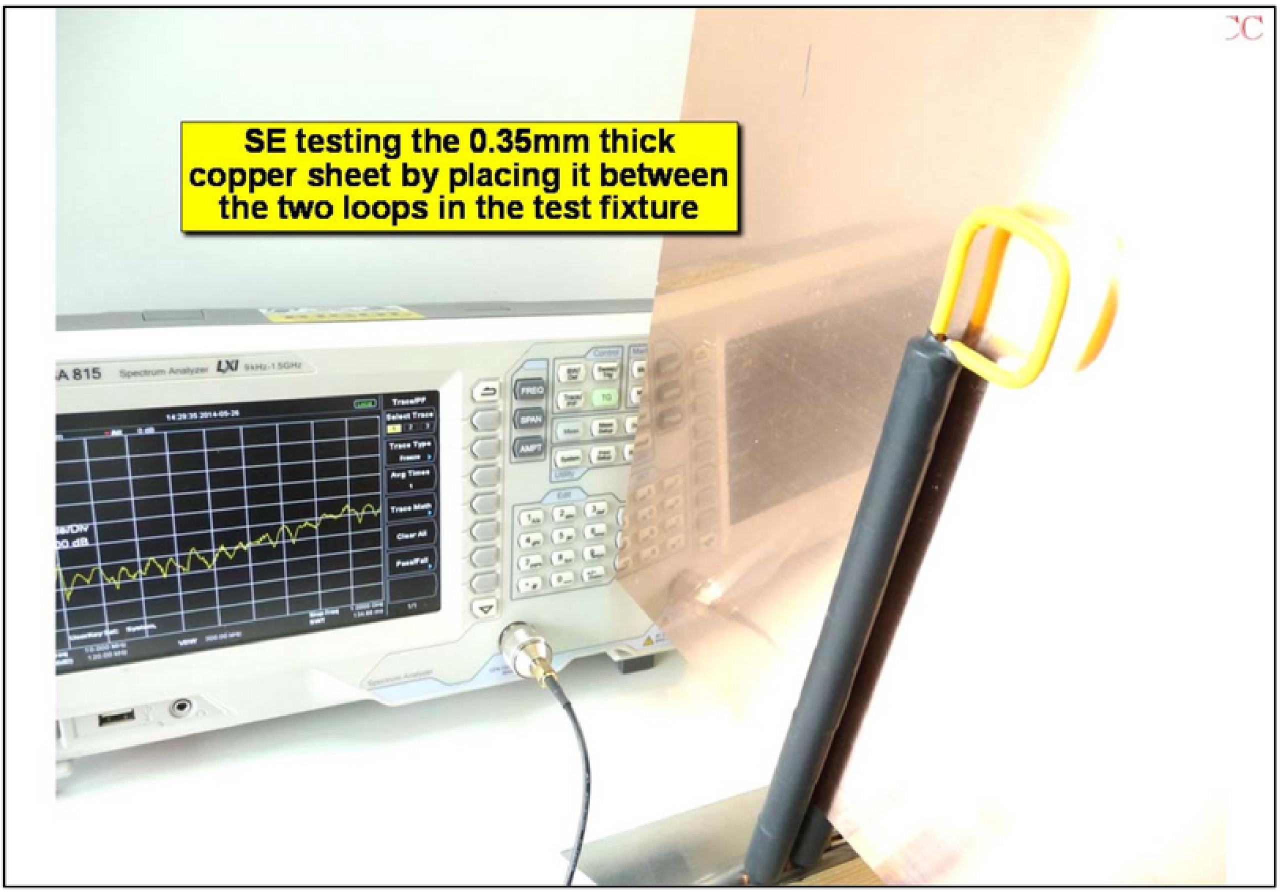


Figure 44 The copper sheet inserted in the 2-probe test set-up

Figure 44 shows the copper sheet carefully slid between the two probes without disturbing them, and the resulting spectrum analyser display – which is repeated in Figure 45 below.

For a stable and repeatable test of a material, the parallel pair of probe loops seems to need to be at least two loop dimensions away from the sides of the sample. This is easy to check by watching the analyser display and seeing when it stops recording lower values.

This is, admittedly, a rather crude test fixture that needs a steady hand to position the copper sheet between the probes without altering their positions. There are many other ways of constructing the test fixture that would hold the probes more firmly and so be easier to use, and really I wish I had thought this issue through before I made the fixture shown in Figure 41!

If we suspect that we have knocked a probe out of position, we withdraw the sheet and check to see if the measurement is once again aligned with the 0dB line at the top of the display, exactly as it was when normalised – as shown in Figure 42.

If the display is not exactly correct, we press the button on the spectrum analyser and renormalize it – which takes about 3 seconds. If the display is a long way from being correct, we reposition the probes to get it as close as we can and then press the 'normalise' button. (If we were doing this by hand, we would have to record a new set of correction factors and enter them in our spreadsheet.)

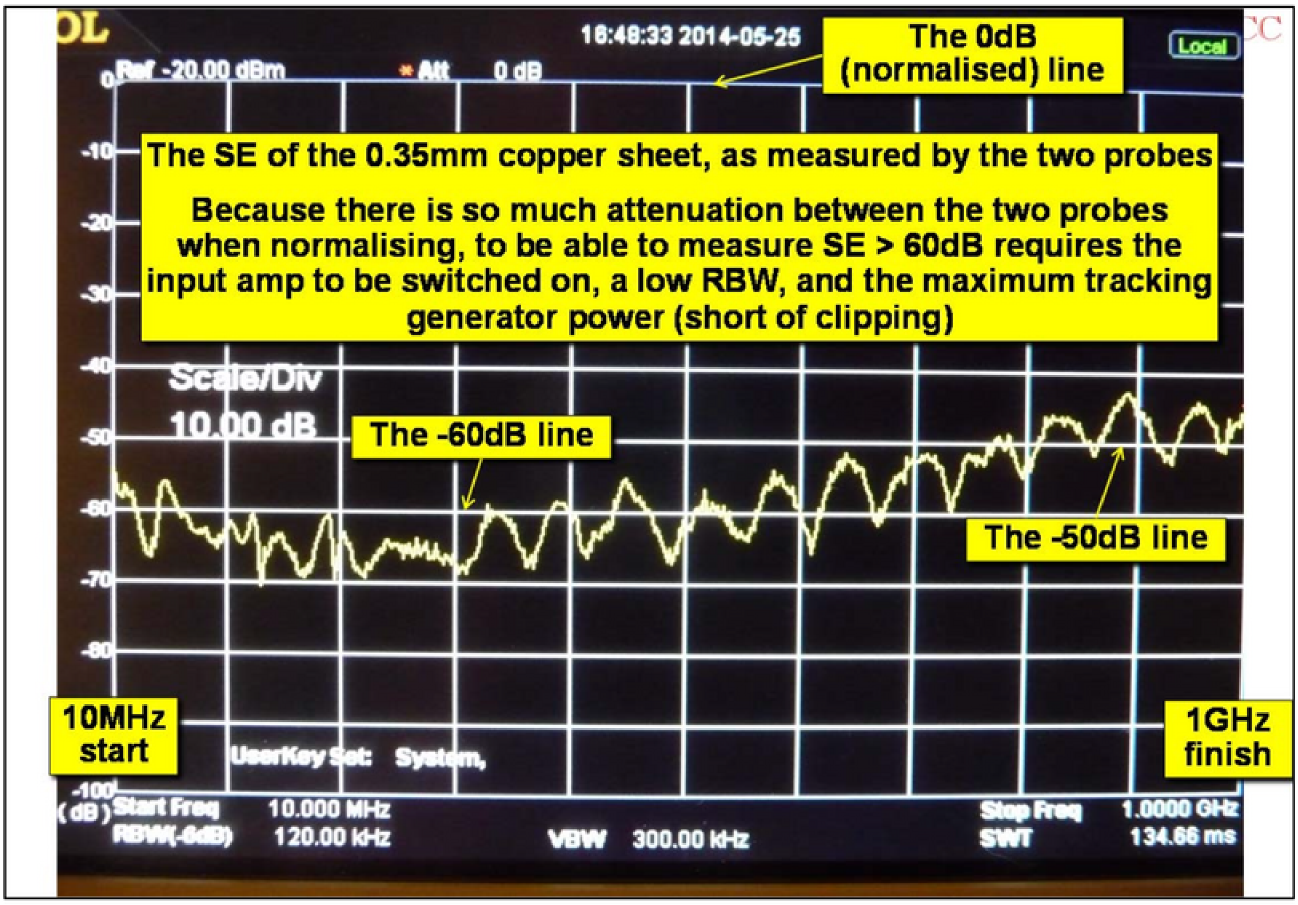


Figure 45 The analyser's display with the copper sheet in the 2-probe test set-up

Figure 45 shows that the copper sheet achieved about -60dB of attenuation at 10MHz, falling to around - 65dB over the range 100MHz to 300MHz, then rising to around -47dB at 1GHz.

Another way to report this, would be to say that the copper sheet achieved about 60dB of SE at 10MHz, rising to around 65dB over the range 100MHz to 300MHz, then falling to around 47dB of SE at 1GHz.

It would have been interesting to actually switch off the tracking generator (TG) and see how close the measurement was to the noise floor of the instrument, compared with the attenuation achieved by the copper sheet. If nothing else, it might point to cable and connector coupling between the TG output and receive input, or even crosstalk between them inside the instrument.These SE figures are much less than would be achieved by 0.35mm thick copper when tested to an official SE test standard, and they tell us the limitations of our test method. If we want to use this type of test to determine whether a material will give us better SE results than these, we need to make some improvements!

One way of improving the maximum SE that can be measured is to reduce the resolution bandwidth (RBW) of the spectrum analyser and hence reduce its noise floor. The results shown here are with 120kHz RBW, and we would expect the noise floor to reduce by 10dB for every ten-fold reduction in RBW. For example, to measure SE to 85dB from 100MHz – 300MHz, we would set the RBW to 1kHz – about one hundredth of the current setting of 120kHz.

(120kHz is a RBW setting used by CISPR EMC test standards which are meaningless for this sort of measurement. I now wish that I had set the RBW to 100kHz instead, to make this point.)

Unfortunately, the analyser's sweep time is automatically related to its RBW, and reducing the RBW from 120kHz to 1kHz would multiply the sweep time by 100. Instead of taking a couple of seconds, it would take nearly three minutes to cover the range 10MHz to 1GHz – not very appropriate when we are holding a sample in place by hand!

The short answer, is that if we want to measure substantially better SE than is shown in Figure 45, to be able to quickly compare hand-held samples of materials, we will need to use a spectrum analyser with a substantially lower noise floor, which will also cost substantially more than this very low-cost DSA815.

The ripple in the measurement is almost certainly caused by the mismatch between the impedance of the probe (a shorted turn) and the 50 impedance of the analyser's input and output, the flexible connecting cables, the connectors, and the semi-rigid conductors used to make them with. We should be able to reduce the height of these ripples by fitting 6dB (or more) through-line attenuators at the connections to one or both probes. Each would reduce the maximum SE that could be measured by 6dB (or more), but this may not matter if the dynamic range was still sufficient for our purposes.

However, many consumer/commercial/industrial applications do not need SEs better than those shown in Figure 45 – which will become evident below.

8.1 Assessing the effects on SE of holes, gaps and jointing methods

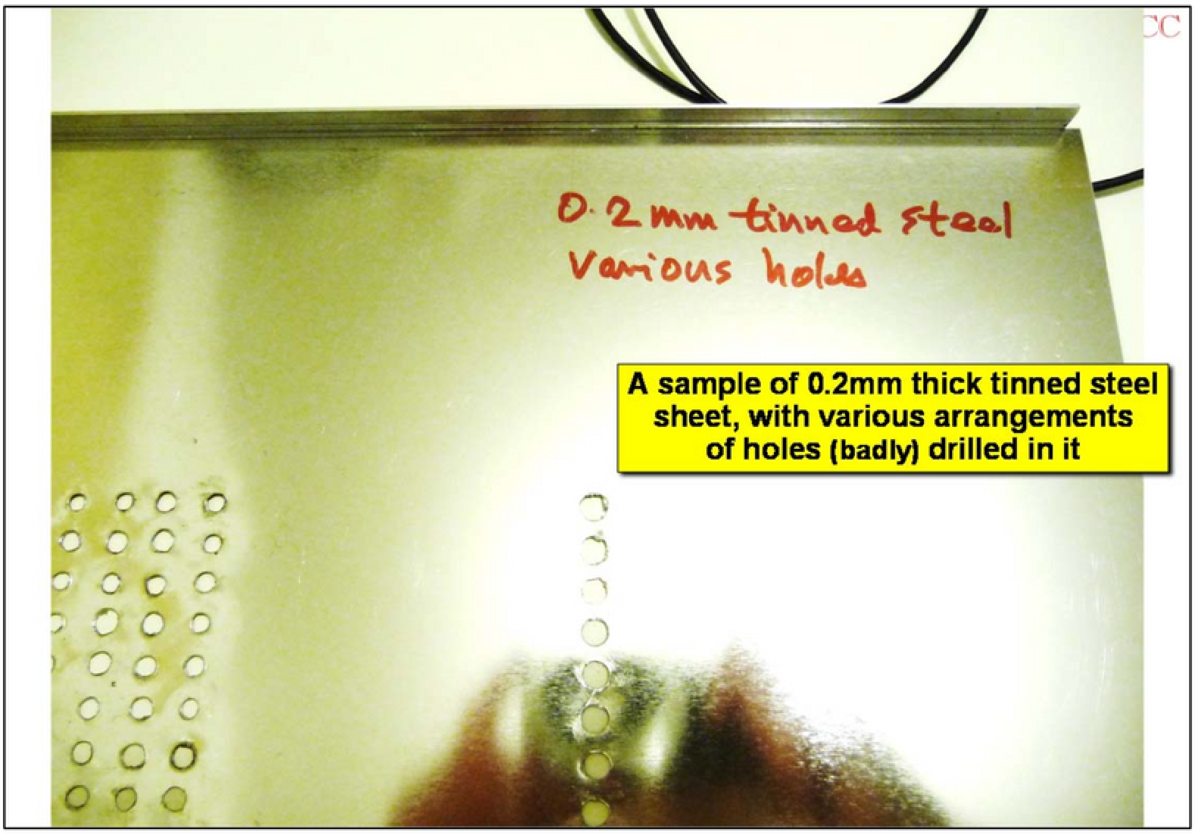


Figure 46 A sample of tin-plated steel with various arrangements of holes in it

Figure 46 is of one of a number of examples I created for demonstrating the effectiveness of this 2-probe technique for assessing the SE of holes, gaps and jointing methods. All are made from 0.2mm thick tinned sheet steel, and this one has various arrangements of drilled (rather crudely, it must be said) holes in it.

Figure 47 shows the 2-probe set-up of Figure 41 being used to test the SE of a hole-free area of the tinned steel sheet shown in Figure 46. The method used for this test (and for all the others in this article) is exactly the same as was used for the 0.35mm thick copper sheet in Figures 44 and 45 and their associated text, above.

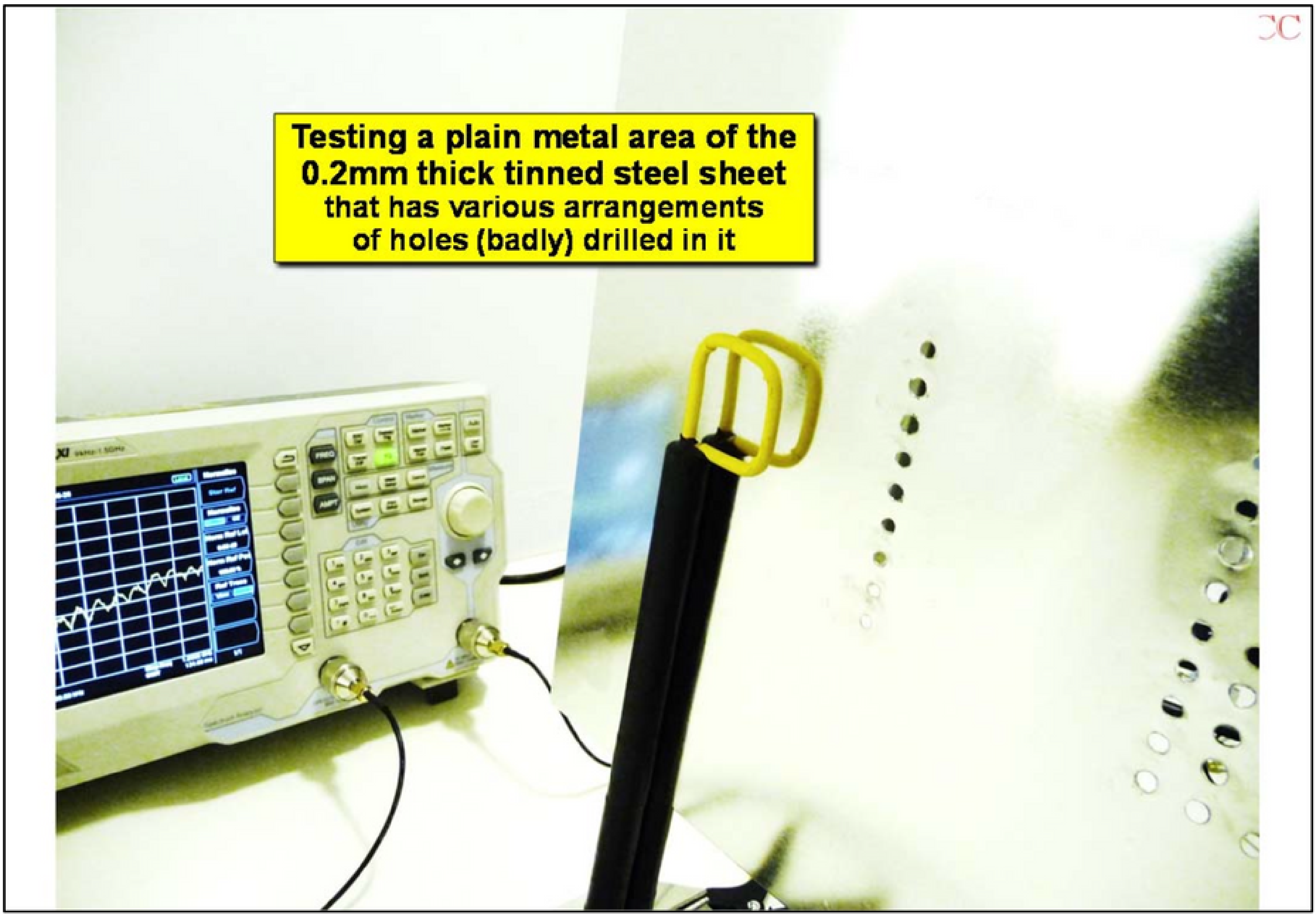


Figure 47 The tin-plated steel sheet inserted in the 2-probe test set-up

Before every test the 2-probe setup is normalised, and the sample is inserted between the probes without disturbing their positions. The sample is positioned so that the edges of the sample are further from the probes than twice the probes' dimensions, and the SE is read directly off the spectrum analyser's display, which can be seen in Figure 47 and is shown in full in Figure 48.

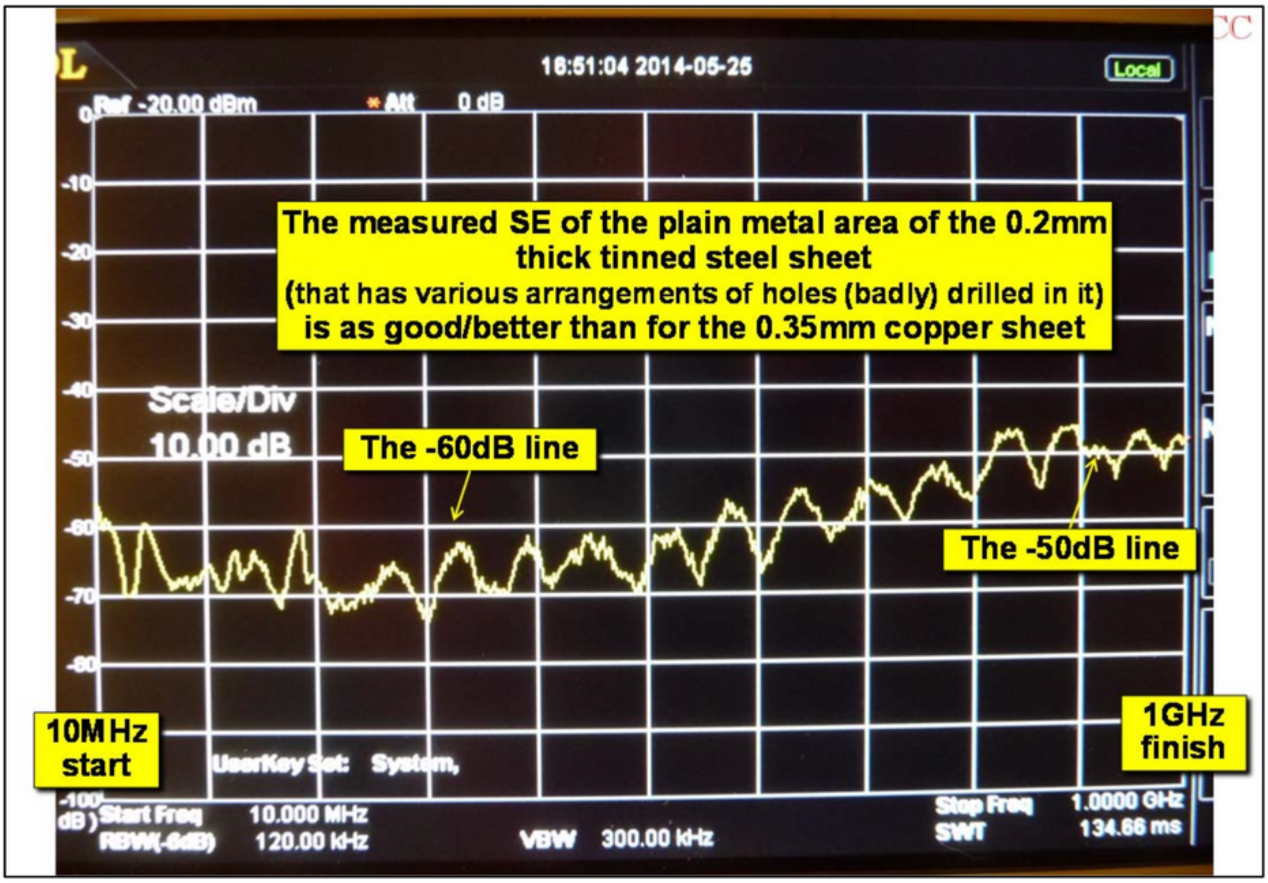


Figure 48 The analyser's display with the tinned steel sheet in the 2-probe test set-up

Figure 48 shows that, if anything, the plain area of the 0.2mm tinned steel sheet has slightly better SE from 10MHz-1GHz than the 0.35mm thick copper sheet.

Figure 49 shows the sample shown in Figure 46 moved to place the probes at the centre of a row of 4mm diameter holes on 10mm spacing, and Figure 50 shows the resulting analyser display.

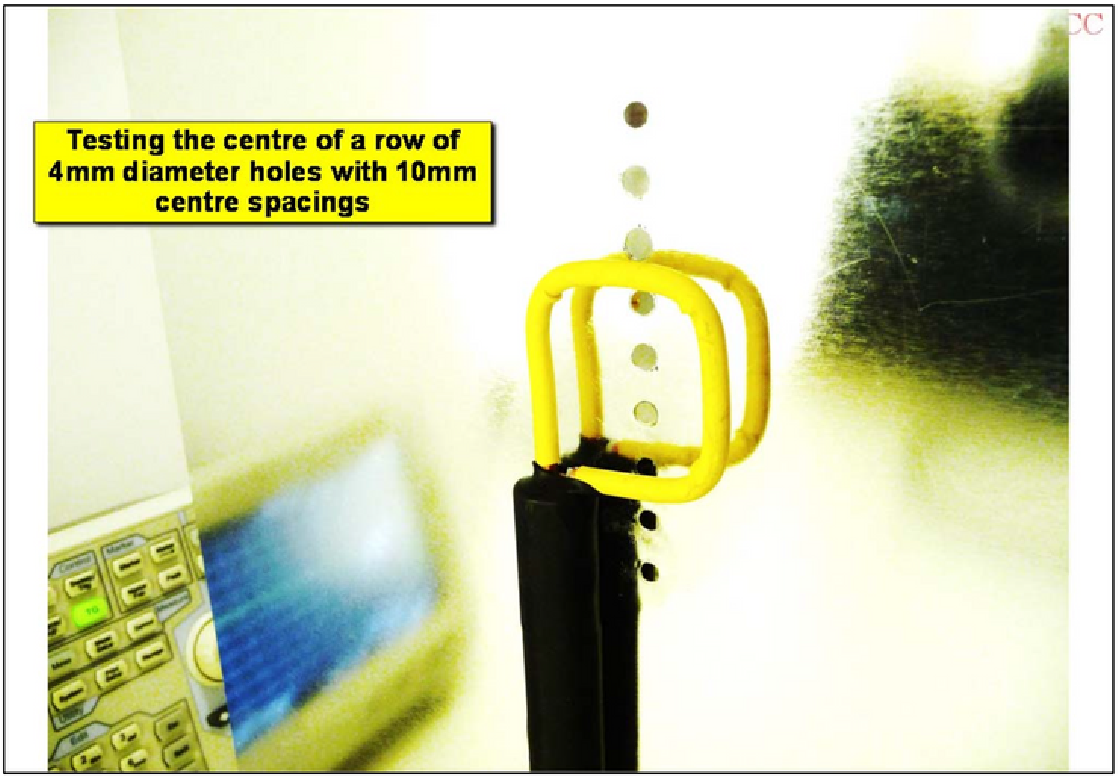


Figure 49 Measuring a line of 4mm holes on 10mm spacing in the 0.2mm tin-plated steel

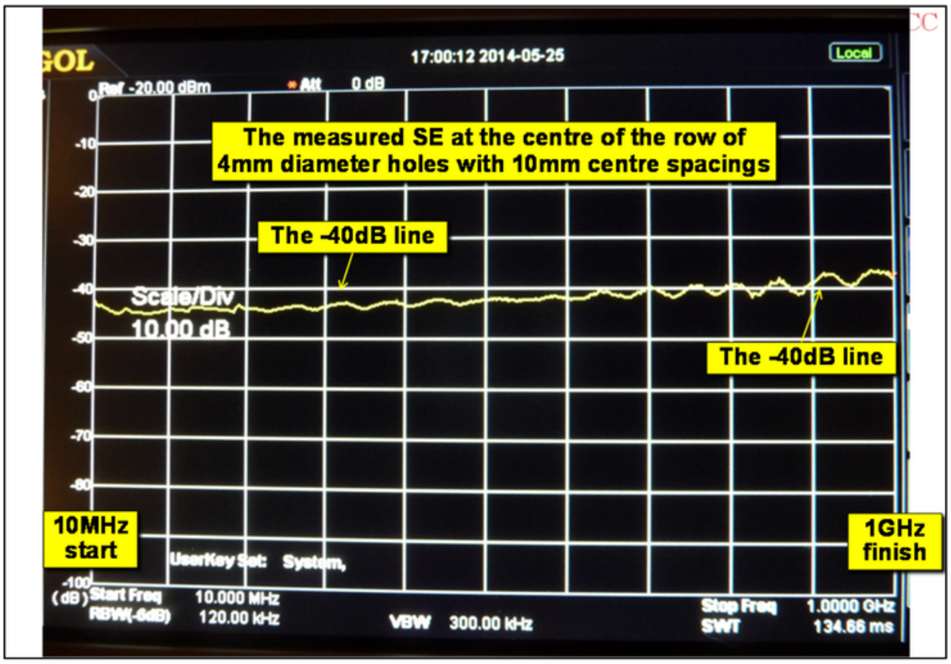


Figure 50 The analyser's display when measuring the line of 4mm holes on 10mm spacing

Figure 50 shows that the row of 4mm diameter holes on 10mm spacing has reduced the SE measured in Figure 48 by about 20dB below 300MHz and by about 10dB at 1GHz.

So, although this test set-up is not capable of measuring very high values of SE, it is more than adequate for detecting the degradation in SE caused by a few small ventilation (for e.g.) holes.

Figures 51 and 52 show that an array of 5mm diameter ventilation holes on 10mm spacings reduces the SE by a further 10dB below 300MHz and by about 5dB at 1GHz when compared with the line of 4mm holes in Figures 49 and 50. Compared with the results for the plain tinned-steel sheet shown by Figures 47 and 48, these figures show that the array of 5mm holes on 10mm spacings reduces the SE by about 30dB between 100MHz and 300MHz and by about 15dB at 1GHz.

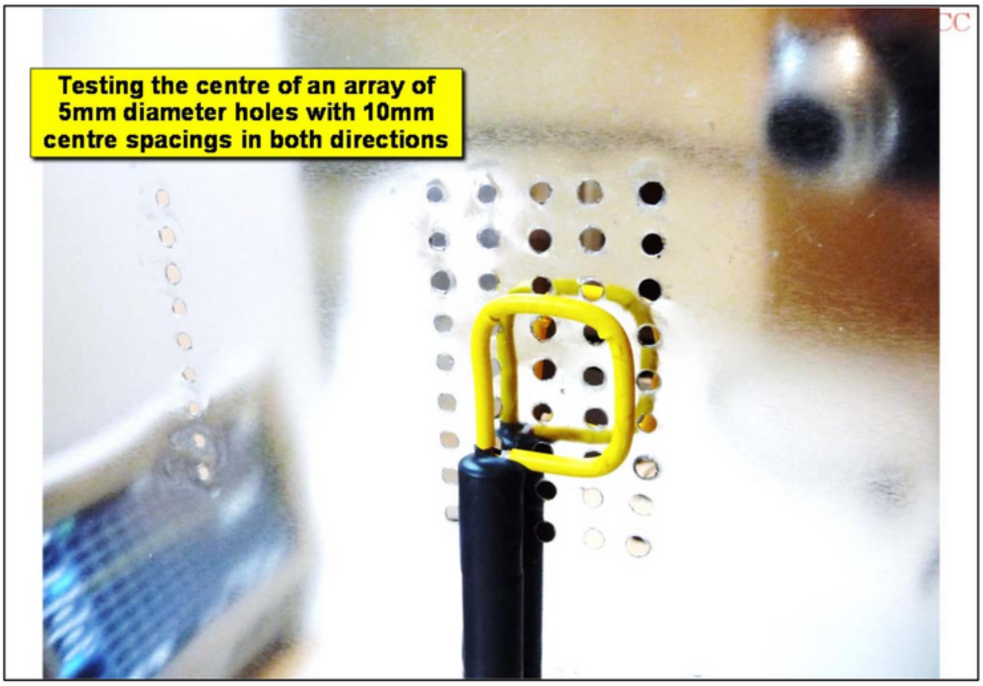


Figure 51 Measuring an array of 5mm holes on 10mm spacing in the 0.2mm tin-plated steel

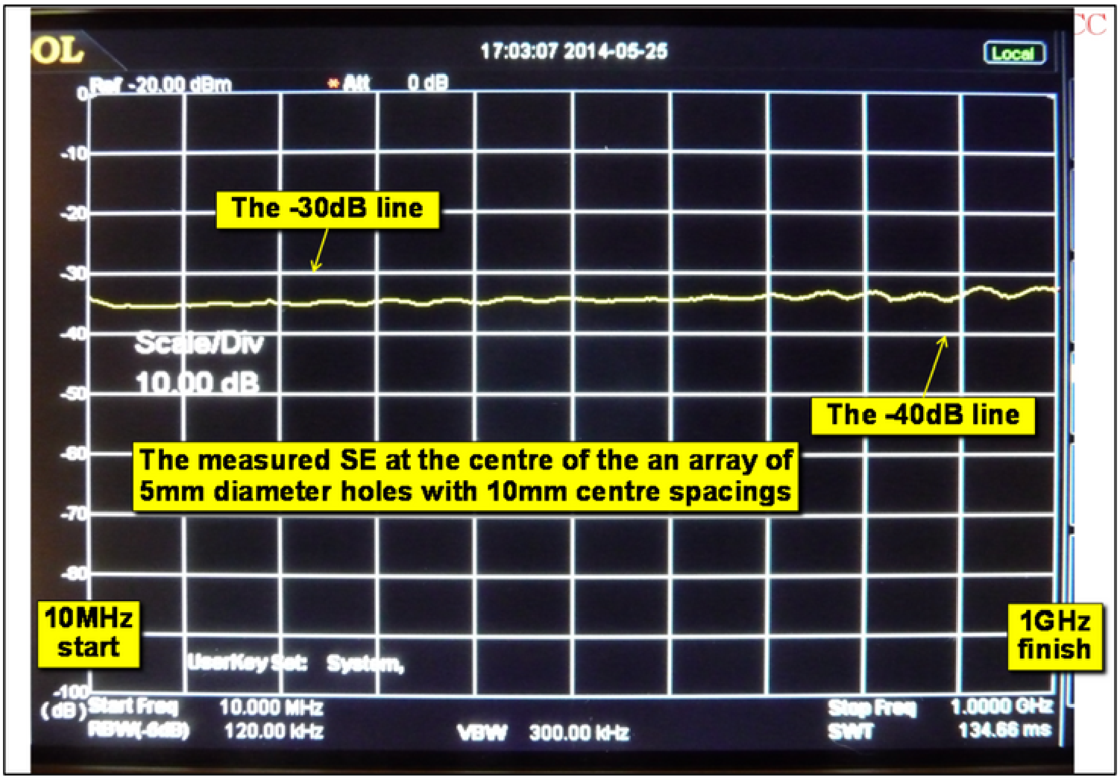


Figure 52 The analyser's display when measuring the array of 5mm holes on 10mm spacing

Figures 53 and 54 show that a line of 6mm diameter ventilation holes with 10mm spacing reduces the SE by more than the line of 4mm holes in Figure 50, but not by quite as much as the array of 5mm holes in Figure 52.

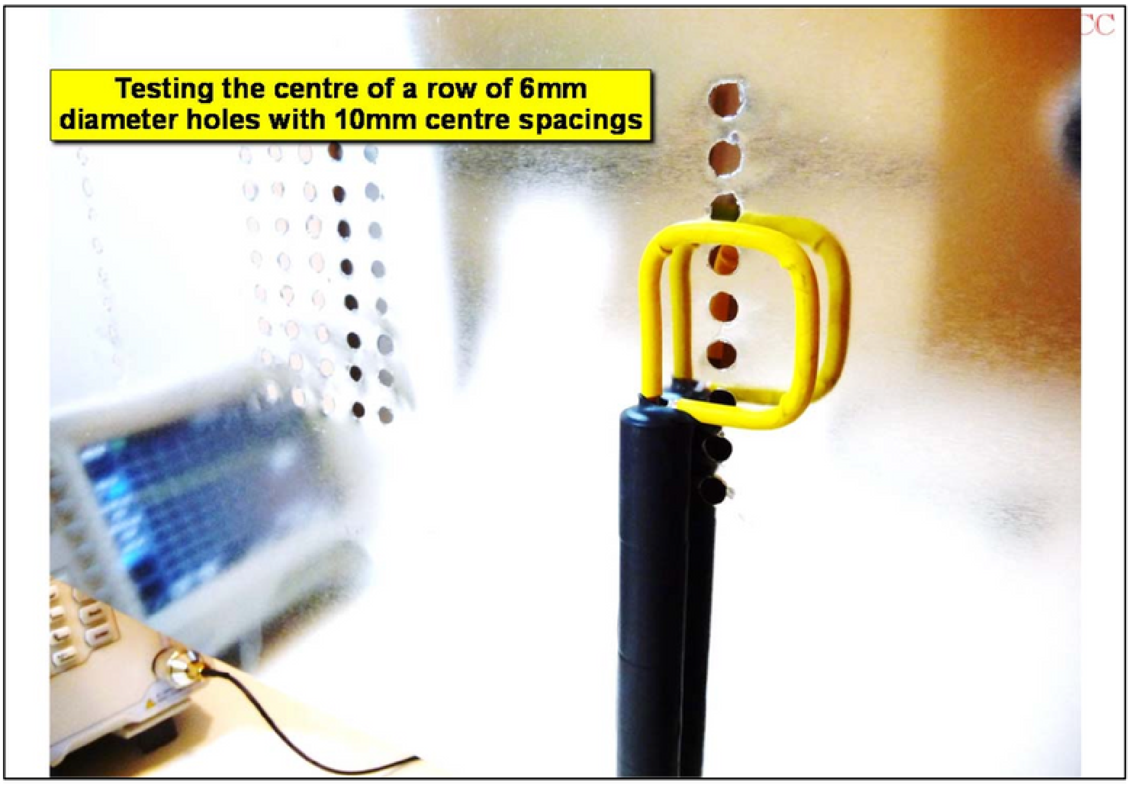


Figure 53 Measuring a line of 6mm holes on 10mm spacing in the 0.2mm tin-plated steel

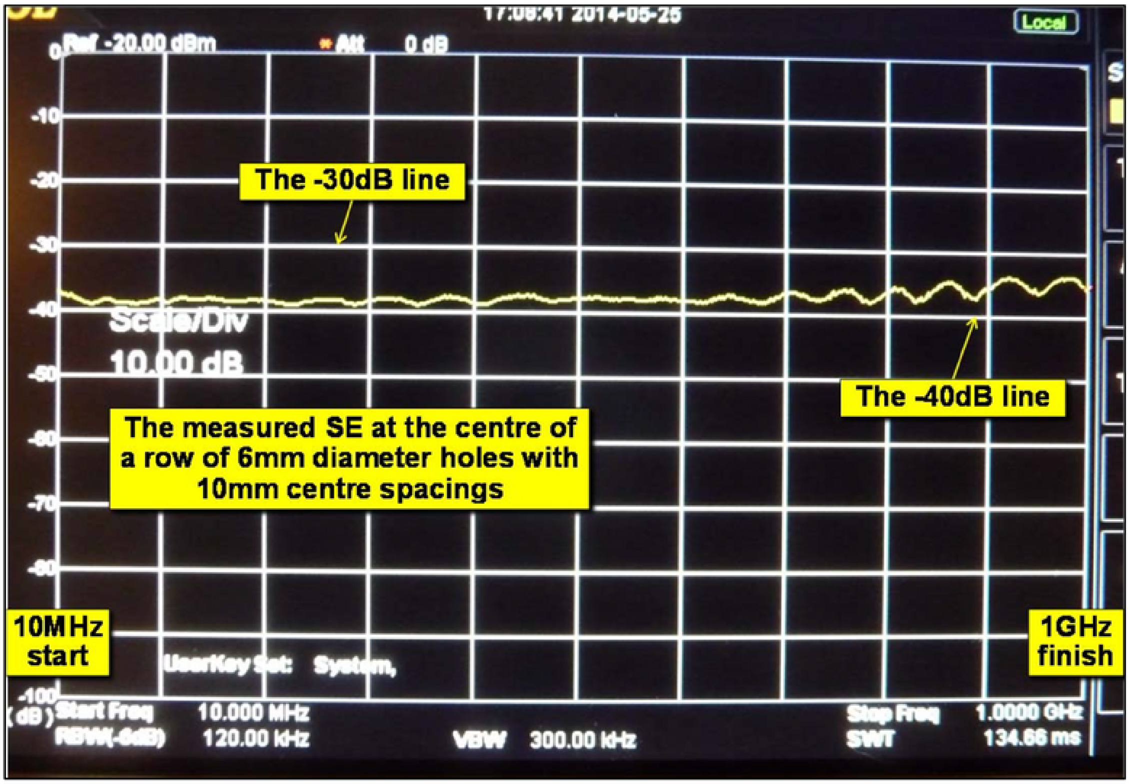


Figure 54 The analyser's display when measuring the line of 6mm holes on 10mm spacing

Figure 55 introduces the next test in my demonstration: two sheets of the same 0.2mm tin-plated steel that has been used in Figures 47-54 above have been placed with their edges abutting each other, and electrically bonded together with solder blobs on a 68mm spacing all along their common seam.

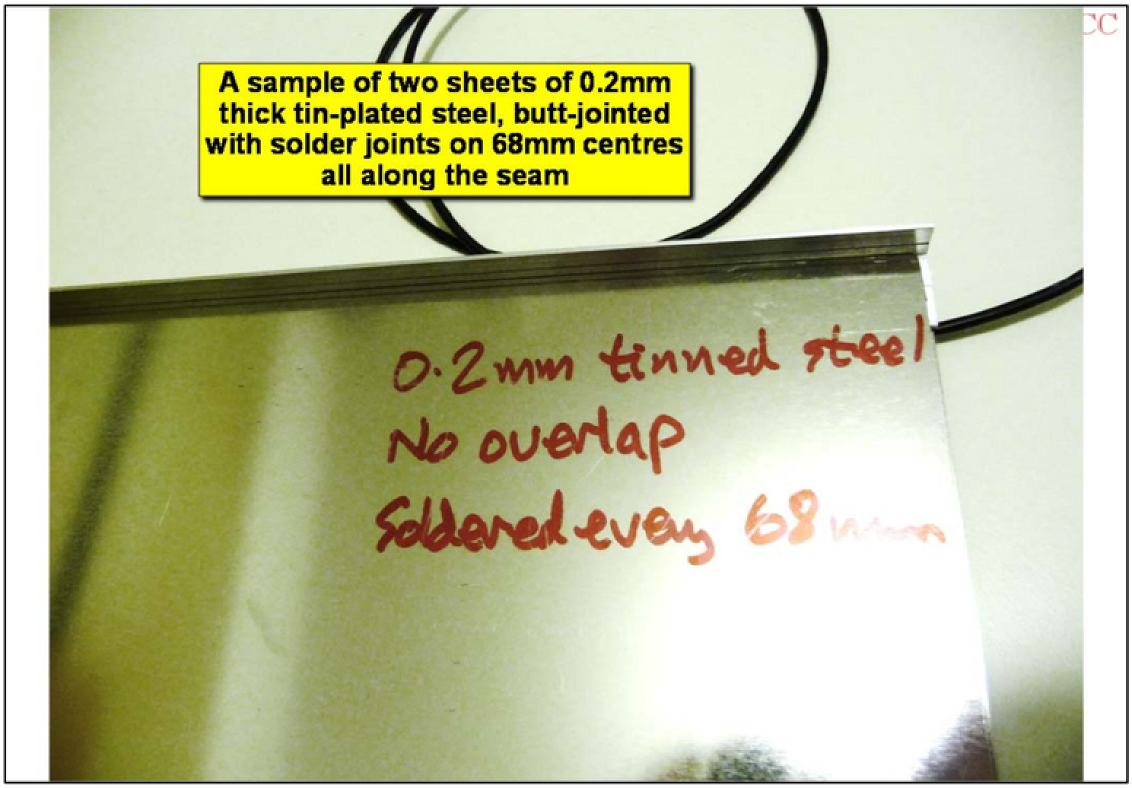


Figure 55 The butt-jointed tin-plated steel sheet to be tested

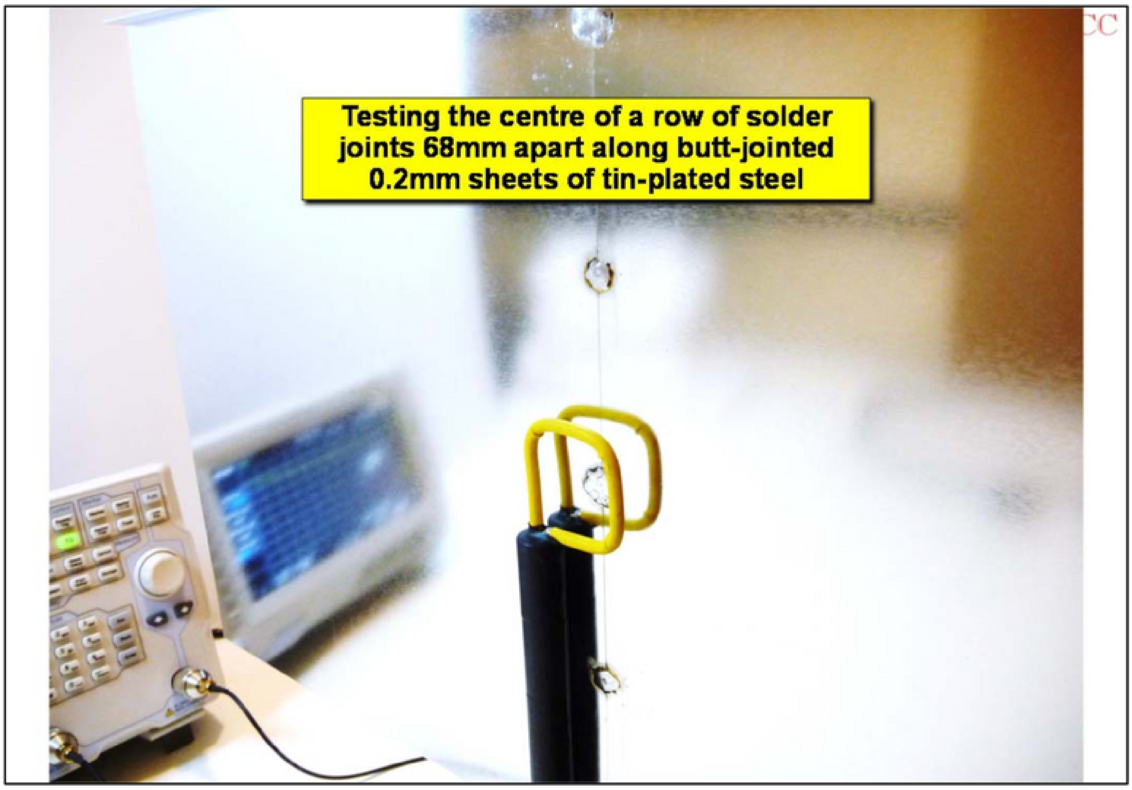


Figure 56 Measuring the butt-jointed 0.2mm tin-plated steel

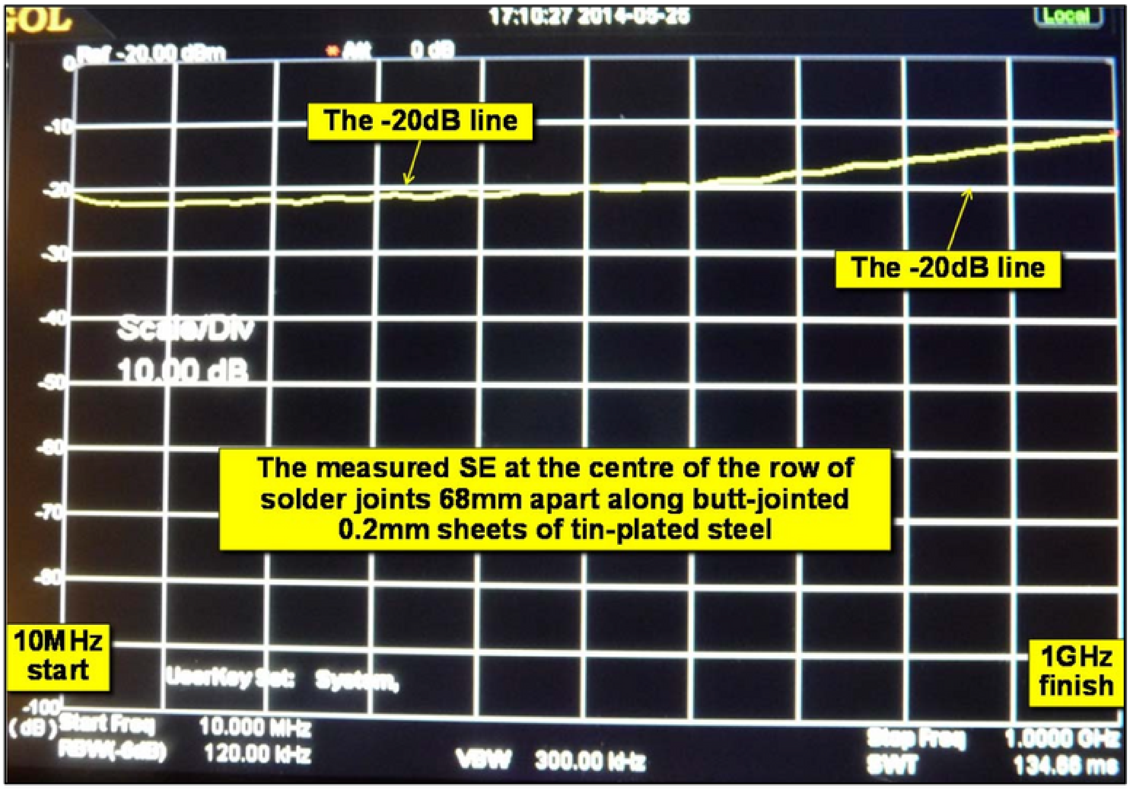


Figure 57 The analyser's display when measuring the butt-jointed 0.2mm tin-plated steel

Figure 56 shows the actual test – with a central solder joint along the seam positioned in the centre of the loop probe pair – whilst Figure 57 shows the analyser's screen in full. The SE has reduced considerably from the values achieved by the plain metal sheet (see Figure 48) in this test set-up, and is now only 20dB at 10MHz (down from 60dB), 22dB from 100MHz to 300MHz (down from 70dB) and 12dB at 1GHz (down from 50dB).

But never mind the degradation in SE values, the absolute value of the SE that is achieved is simply not very good at all, with this metal jointing method.

It is true that this jointing method is not sturdy, and is so impractical that it would never be used, but it is quite common to see people connecting metal parts of enclosure shields together with short wires or braid straps, and assuming that because they are all 'earthed' or 'grounded' together they must provide good RF shielding.

This simple test method, which is easy to set up using low-cost equipment, and is very quick to do, shows that even if the lengths of the connecting wires or straps was under 1mm, the SE would be poor. And of course it is fairly obvious that using longer wires or straps would not improve the SE.

So here is an example of how the risks of making bad mechanical design decisions for EMC can easily and quickly be identified very early in a project by people with little/no EMC expertise, at their normal workbenches.

Clearly, butt-jointing metal shielding is not very effective. If the soldered joints were spaced only half as far apart (34mm), I would expect the SE to improve by about 6dB across the measured frequency range – still not very good.

Another common metal jointing technique is to overlap two pieces of sheet metal by enough to fix them together mechanically, for example by using self-tapping screws, pop-rivets, nuts and bolts, or spot- welding, and this is tested by the next sample, shown in Figure 58.

Figure 58 introduces this sample as having two sheets of the same 0.2mm tin-plated steel that was used above, placed with their common edges overlapping by 5mm, and (as before) electrically bonded together with solder blobs on a 68mm spacing all along this seam.

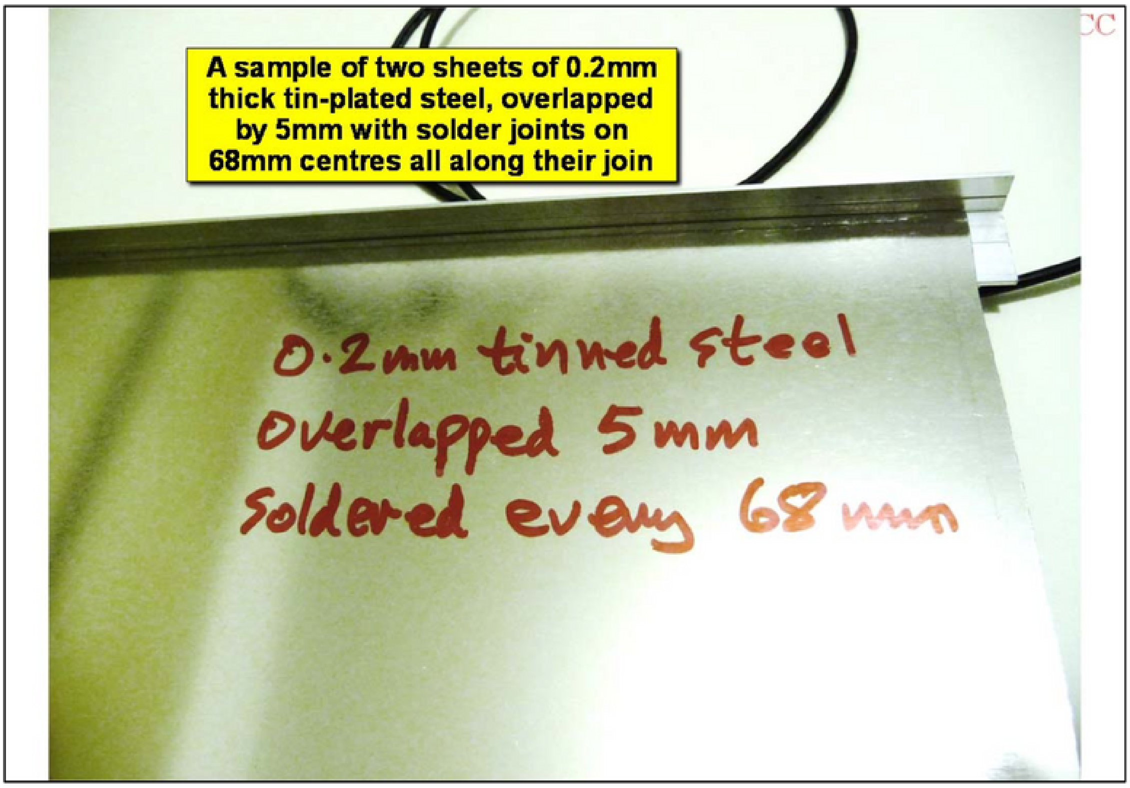


Figure 58 The 5mm overlapped tin-plated steel sheet to be tested

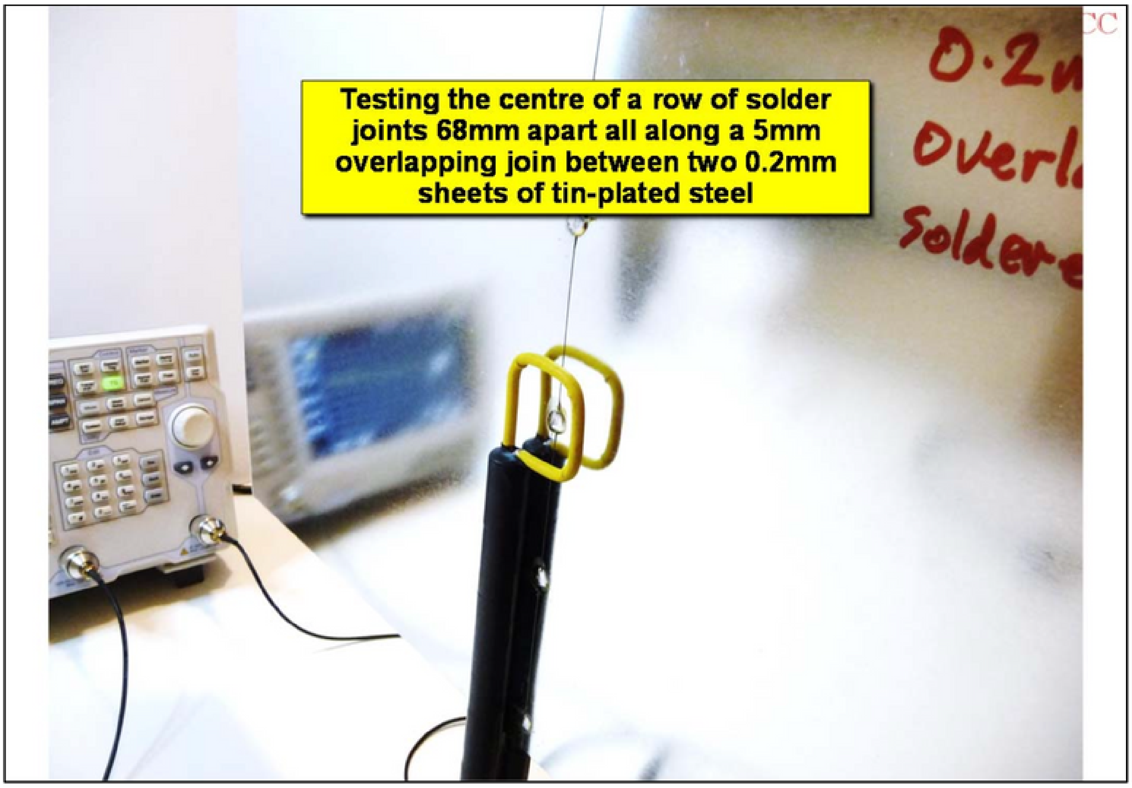


Figure 59 Measuring the 5mm-overlapped 0.2mm tin-plated steel

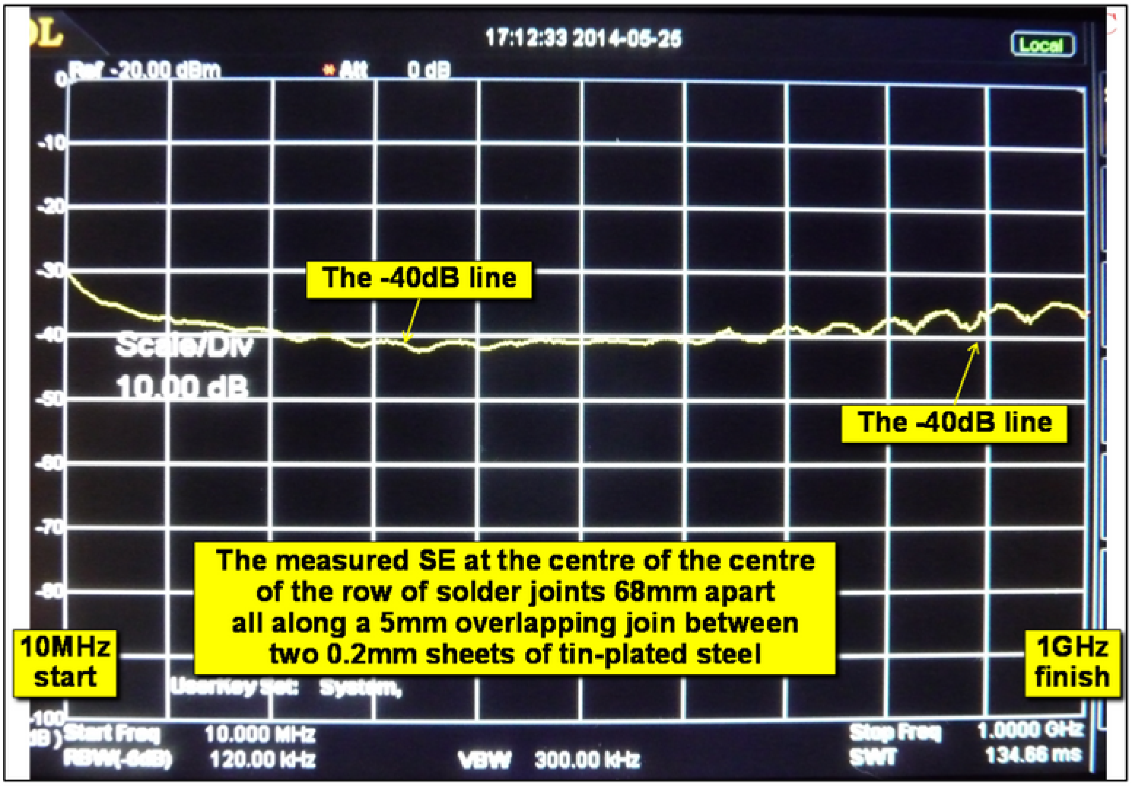


Figure 60 The analyser's display when measuring the 5mm-overlapped 0.2mm tin-plated steel

Figure 59 shows the actual test – with a central solder joint along the seam positioned in the centre of the loop probe pair – and Figure 60 shows the analyser's screen in full.

Compared with the butt-jointed sheets shown above, the SE has improved by a useful amount, up by 10dB to 30dB at 10MHz, and up by 20dB between about 200MHz and 1GHz, with about 35dB at 1GHz.

Once again, I would expect that halving the spacings between the electrical bonds (solder blobs in this case) would improve the SE by 6dB across the measured range.

Figure 61 shows another sample in this series, which is the same as the last one but has increased the overlapping from 5mm to 55mm. As for the previous two samples, the sheets are electrically bonded together with solder blobs on a 68mm spacing all along this seam.

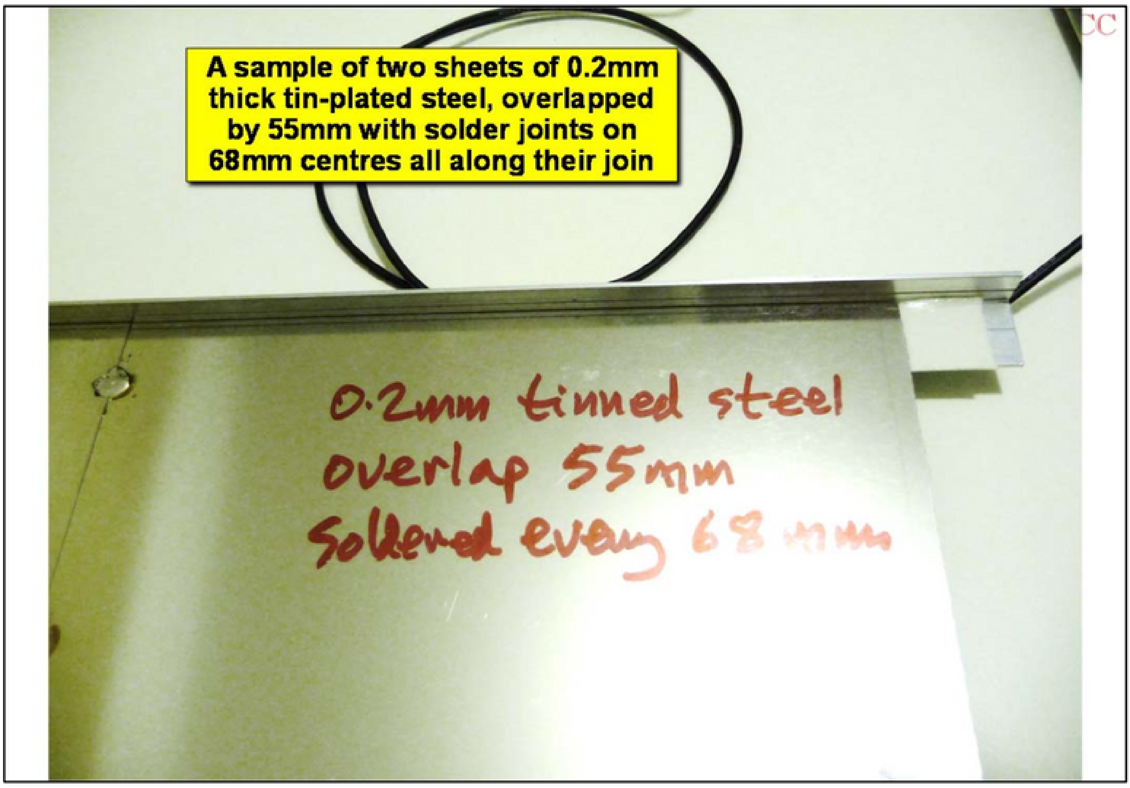


Figure 61 The 55mm overlapped tin-plated steel sheet to be tested

Figure 62 Measuring the 55mm overlapped 0.2mm tin-plated steel

Figure 62 shows the actual test – with a central solder joint along the seam positioned in the centre of the loop probe pair – and Figure 63 shows the analyser's screen in full.

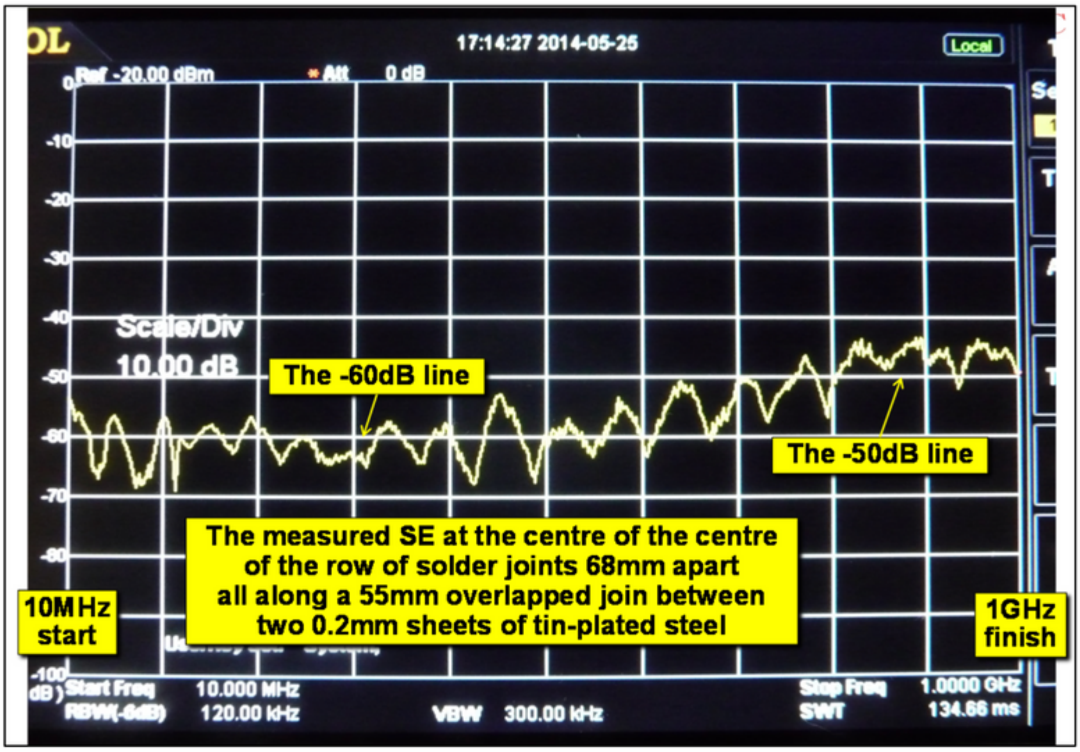


Figure 63 **The analyser's display when measuring the 55mm overlapped 0.2mm tin-plated steel**

The increase in SE by increasing the overlap from 5m to 55mm varies from 30 dB to 20dB.

Sheet steel is essentially free, whereas metal fixings are not. The costs of metal fixings are much more than the cost of the parts, and includes the labour-costs of assembling them, the QA costs of inspecting their correct assembly, and the warranty costs associated with their omission or failure (for example because they were not tightened to the correct torque when assembled, and so over time have worked loose and become ineffective electrical bonds, reducing SE and allowing interference to occur when it should not have).

A common method for improving the SE at metal sheet joints with small overlaps is to fit their overlapped seams with costly conductive gaskets. Compressing these gaskets requires careful attention to the strength of the metal structures to be jointed and the number of fixings, for the gaskets to work effectively and not be a waste of money.

However, this simple test has demonstrated that simply by overlapping sheet metal by enough (essentially, by at least the same distance as the spacing between the electrical bonds) can make very significant improvements in SE for essentially no cost.

I often want to use the technique of increasing metal overlap when I am trying to fix a product that is failing its EMC tests due to inadequate SE of its enclosure, but it is not at all easy to do in general, so I end up adding more fixings, conductive gaskets, etc., – all of which add to the overall cost of manufacture and increase the costs of QA and the likelihood of warranty claims (because there are more things to go wrong!).

In my training courses I am always encouraging designers to use techniques such as increased metal overlapping at the joints and seams in shielded enclosures, because it is a powerful shielding technique that is essentially free – providing it is designed-in from the start.

Now, with this simple, quick, low-cost test technique, mechanical designers can evaluate the EM characteristics of various designs of assemblies and construction methods before they ever even open their CAD software and start to create the design.

8.2 Assessing shielding materials

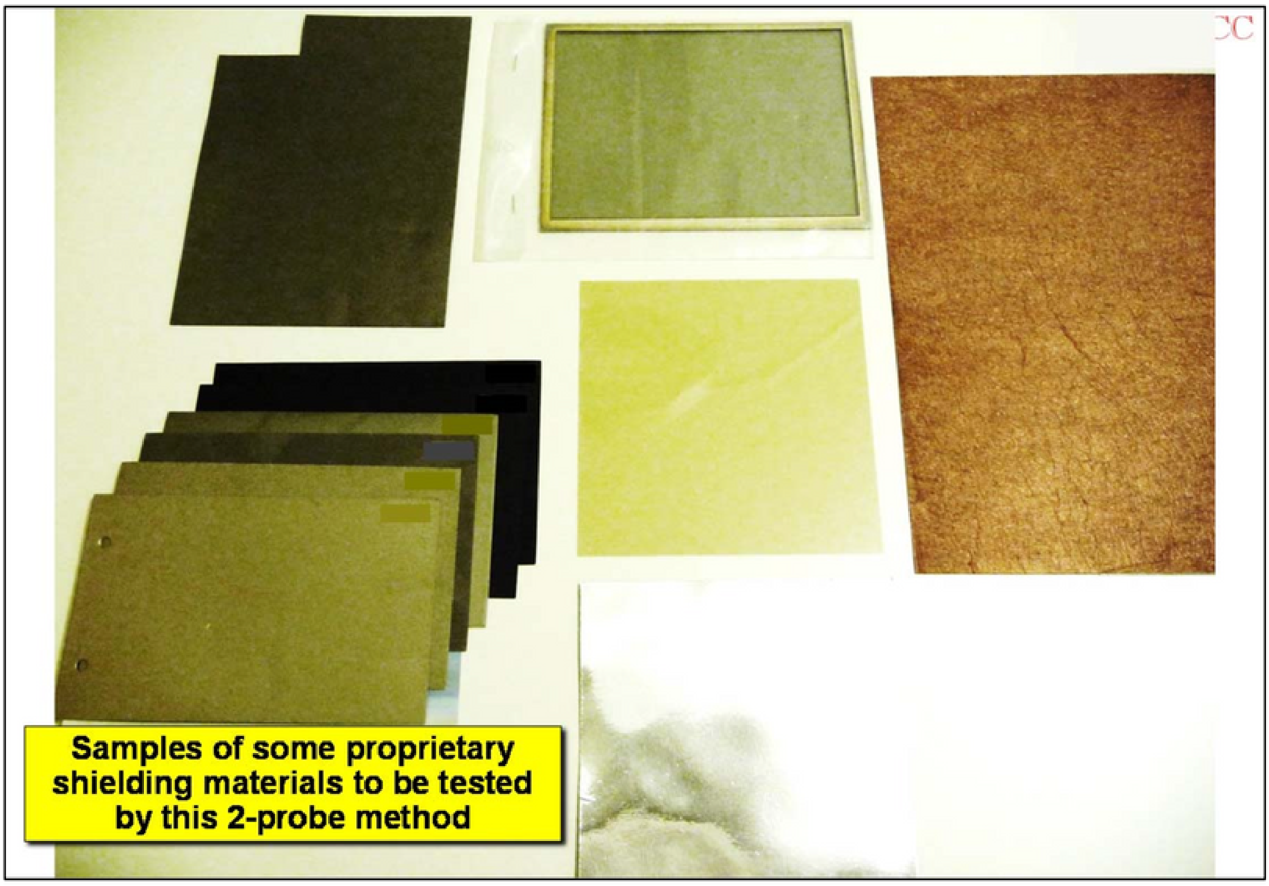


Figure 64 A range of proprietary shielding materials to be evaluated

Figures 44 and 47 show that 0.35mm copper and 0.2mm tin-plated steel are, when free from holes, gaps and joints, at the limit of the SE that can be measured by this low-cost and quick 2-probe method.

However, we can't always use such metals (e.g. when we want to shield visual display screens), and also are often exhorted by advertisers to purchase more costly shielding materials, often claimed to have wonderful performance.

Usually, we do not discover whether these materials live up to the promises of their sales brochures until we are in an EMC test lab doing testing, whether pre-compliance (costly and time-consuming) or full- compliance (very costly and very time-consuming).

However, using the 2-probe set-up which is the subject of this article, we can very quickly determine whether these materials are any good for our purposes, or not.

I must point out that this 2-probe test set-up measures the SE of materials by exposing them to ‘near-field’ magnetic fields, which may not always be appropriate where shielding is required.

(For an explanation of near- and far-fields, see Chapter 2.4 of [16]. And for a discussion of shielding techniques, see its Chapter 6.)

In general (but not always!) the close-field magnetic-field measurements described here give worse SE results than the same material would achieve when exposed to far-field electromagnetic fields (sometimes called plane waves), or when exposed to ‘near-field’ electric fields.

It should be possible to make a low-cost close-field electric field probe version of this 2-probe test, probably using a pair of coaxial probes so as to only excite the tested material over a small area so as not to suffer from the ‘edge effects’ of different shapes and sizes of samples.

However, to measure the SE of materials to 60dB or above at frequencies up to 1GHz or above when exposed to far-field plane waves, requires a whole different level of effort and cost. This requires a shielded chamber – either anechoic or stirred-mode – with the material to be tested clamped over a hole in one of its walls with a good electrical bond to the metal wall of the chamber all around the perimeter of the sample of material. This is not an easy or quick test to set up, and it is not low-cost either (unless you already own the shielded chamber).

Ideally, it uses two shielded rooms – each one either anechoic or stirred-mode – with a common metal wall with the material sample clamped and electrically bonded all around a hole in their common wall.

In the following, the figures show both the test of the material and the spectrum analyser’s display of SE over the same frequency range as before: 10MHz to 1GHz, with the test set-up having been normalised before each test.

I have not included figures showing the SE display alone, in order not to overburden the printers of the EMC Journal, and so I hope that the yellow SE plots on the display are visible when printed.

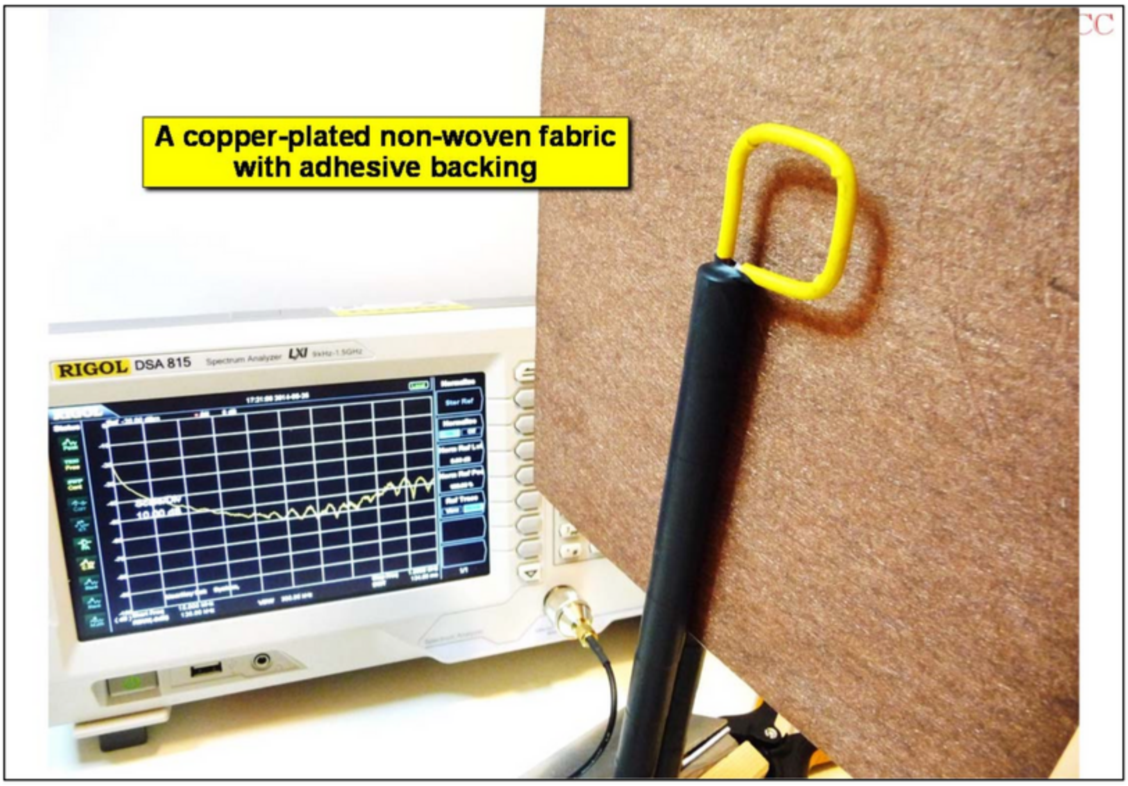


Figure 65 A copper-plated non-woven fabric with adhesive backing

Figure 65 shows a copper-plated non-woven fabric, which only achieves an SE of 20dB at 10MHz, increasing to about 55dB over the range 400MHz to 800MHz, and falling off slightly to 50dB at 1GHz. Not bad at all, above 300MHz on this test.

Figure 66 shows a thin aluminium-coated PVC sheet, which was surprisingly good on this test: 60dB of SE at 10MHz reducing to about 50dB at 100MHz then staying at this level all the way to 1GHz. Not bad at all, and much better SE than I had expected below 200MHz!

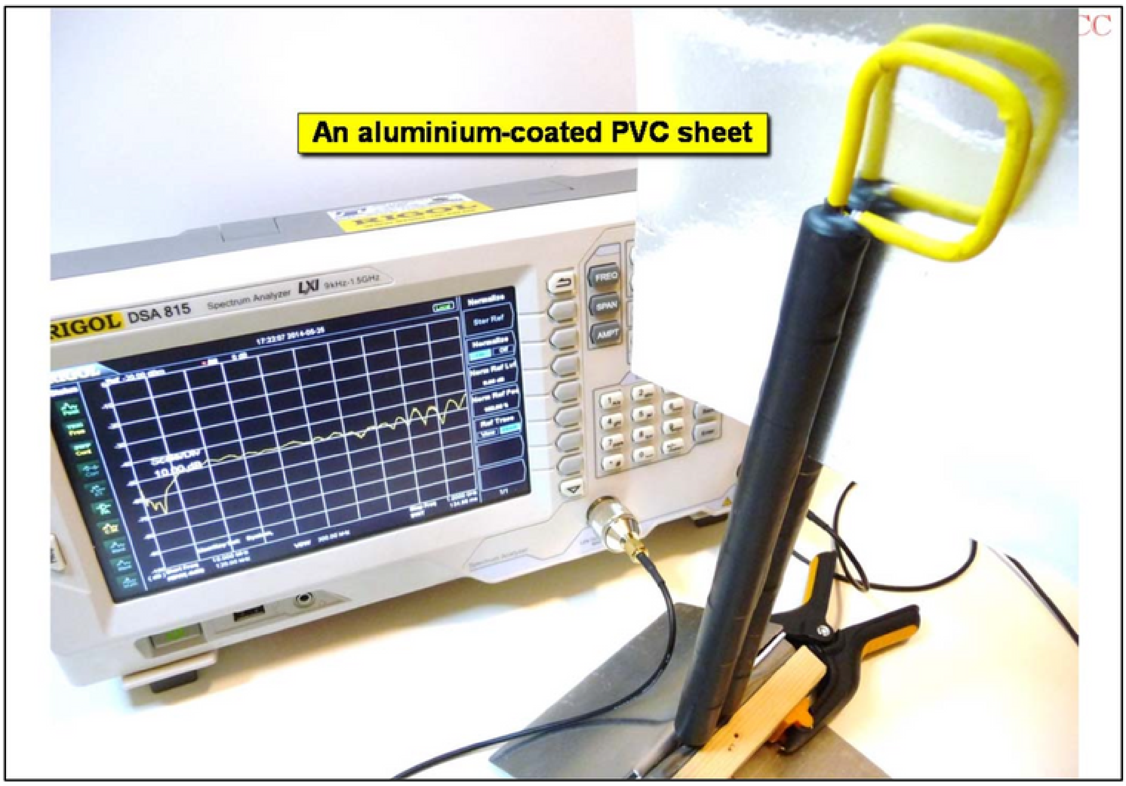


Figure 66 An aluminium-coated PVC sheet

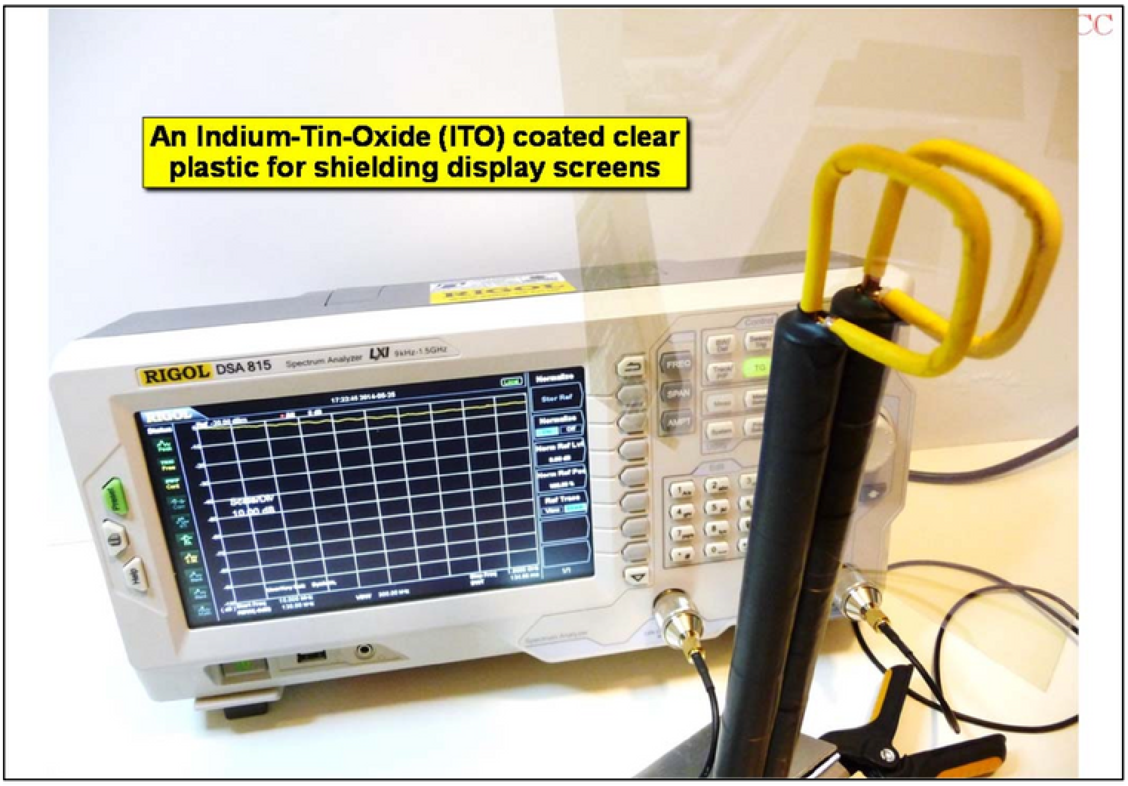


Figure 67 An Indium-Tin-Oxide (ITO) coated clear plastic for shielding visual displays

Figure 67 shows an ITO coated clear plastic sheet, intended for shielding visual display screens. It is hard to see any SE at all from this material, which gradually increases from 0dB at 10MHz to 5dB at 1GHz.

This shows us that it will provide virtually no shielding at all for near-field magnetic fields, but it will probably be a lot better for close-field electric fields over this frequency range, and for plane waves above, perhaps, about 200MHz (this is a guess based on some experience of these types of materials).

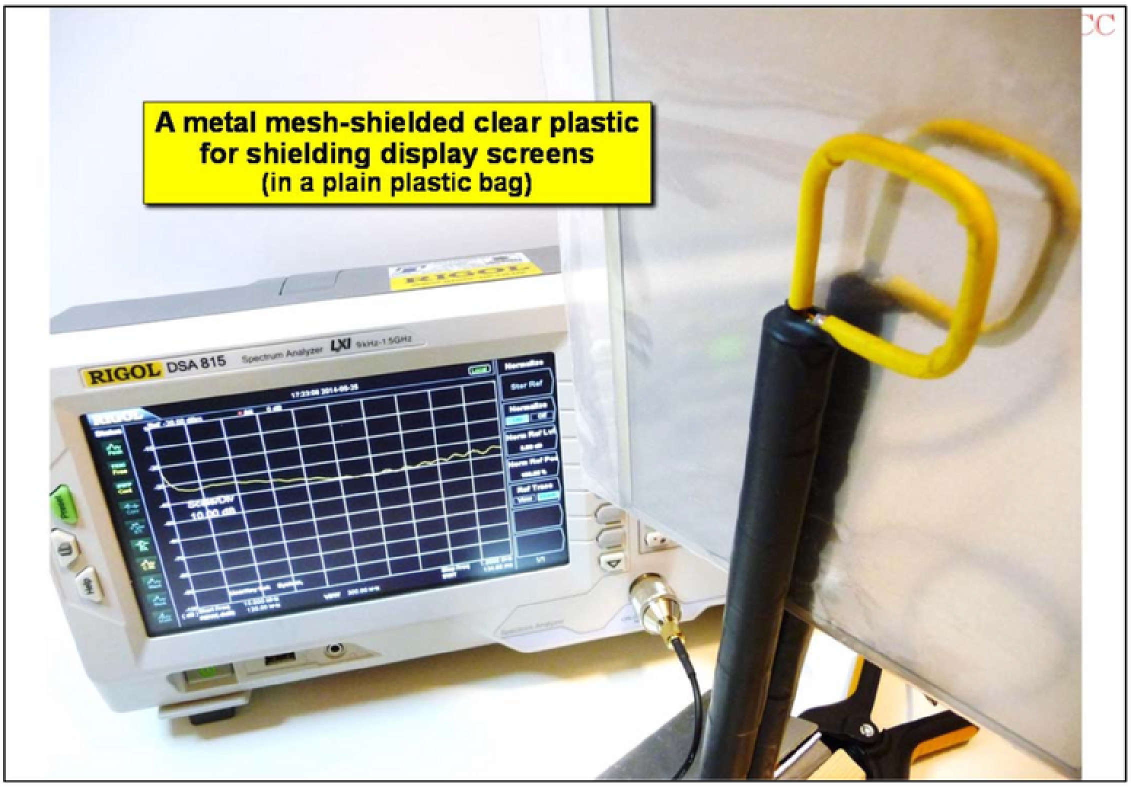


Figure 68 A metal mesh-shielded clear plastic for shielding visual displays (in a plain plastic bag)

Figure 68 shows a metal mesh-shielded clear plastic sheet, also intended for shielding visual displays. This sample has 20dB of SE at 10MHz, increasing quickly to about 33dB at about 50MHz, then increasing more slowly to 40dB at 500MHz. Its SE then remains around 40dB up to about 700MHz after which it degrades slowly to around 36dB at 1GHz.

This is clearly a much better material for shielding displays than the ITO-plated plastic sheet in Figure 67, at least as far as close-field magnetic fields are concerned. I would expect it to be at least as much better than the ITO sheet for close-field electric fields and plane waves as well.

Figure 69 shows a ferrite-loaded synthetic rubber 'EMI Suppressor' material, which provided me with another surprise result – unfortunately, it was an unpleasant one.

This was a fairly expensive sample (£20 for a piece 100mm by 150m) of ferrite-loaded synthetic rubber about 1.5mm thick, and on this close-field magnetic field test I expected it to have a lot better SE than 8dB at 10MHz falling slowly as frequency increased to about 1dB at 1GHz.

No wonder I never had any luck with using it as a suppressor when trying to fix products that were failing their EMC tests in test laboratories. I want my £20 back!

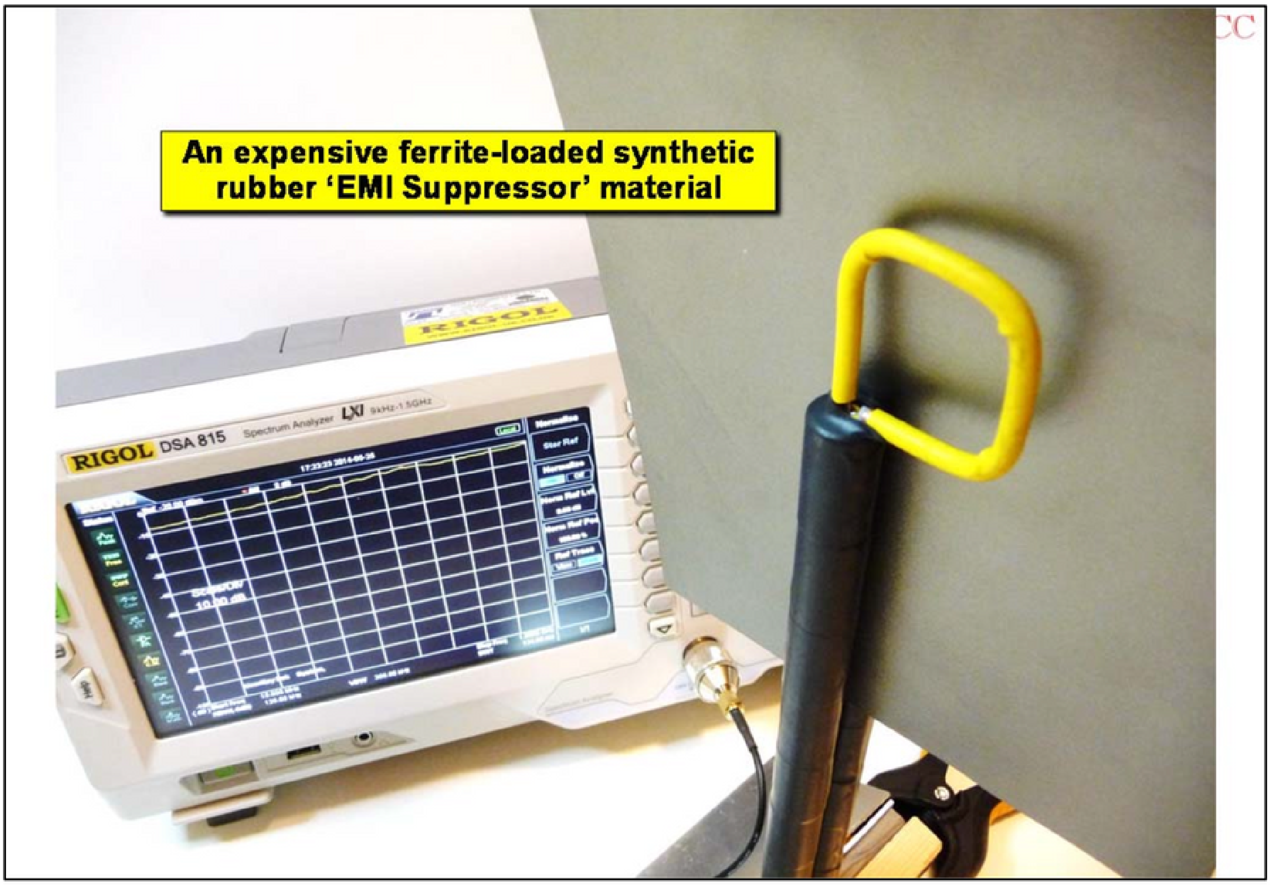


Figure 69 An expensive ferrite-loaded synthetic rubber 'EMI Suppressor' material

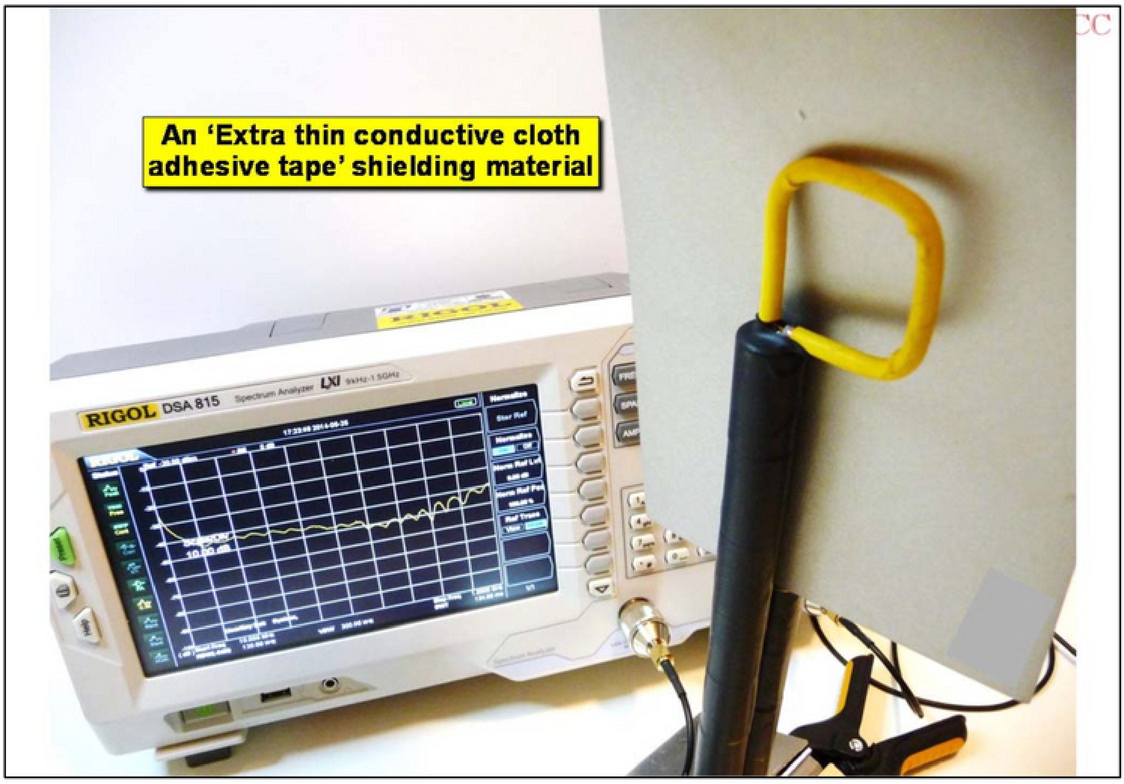


Figure 70 An 'Extra thin conductive cloth adhesive tape' shielding material

Figure 70 shows a sample of an 'Extra thin conductive cloth adhesive tape' shielding material, which gave me yet another surprise!

This small sample of material feels so light and insubstantial that it was hard for me to imagine it would show hardly any SE on this close-field magnetic field test, but in fact it achieved about 25dB at 10MHz, improving rapidly to 45dB at 100MHz.

Its SE remained around 45dB up to about 400MHz after which it improved to 50dB from 600MHz to 800MHz and then fell back a little to 40dB at 1GHz. Surprisingly good.

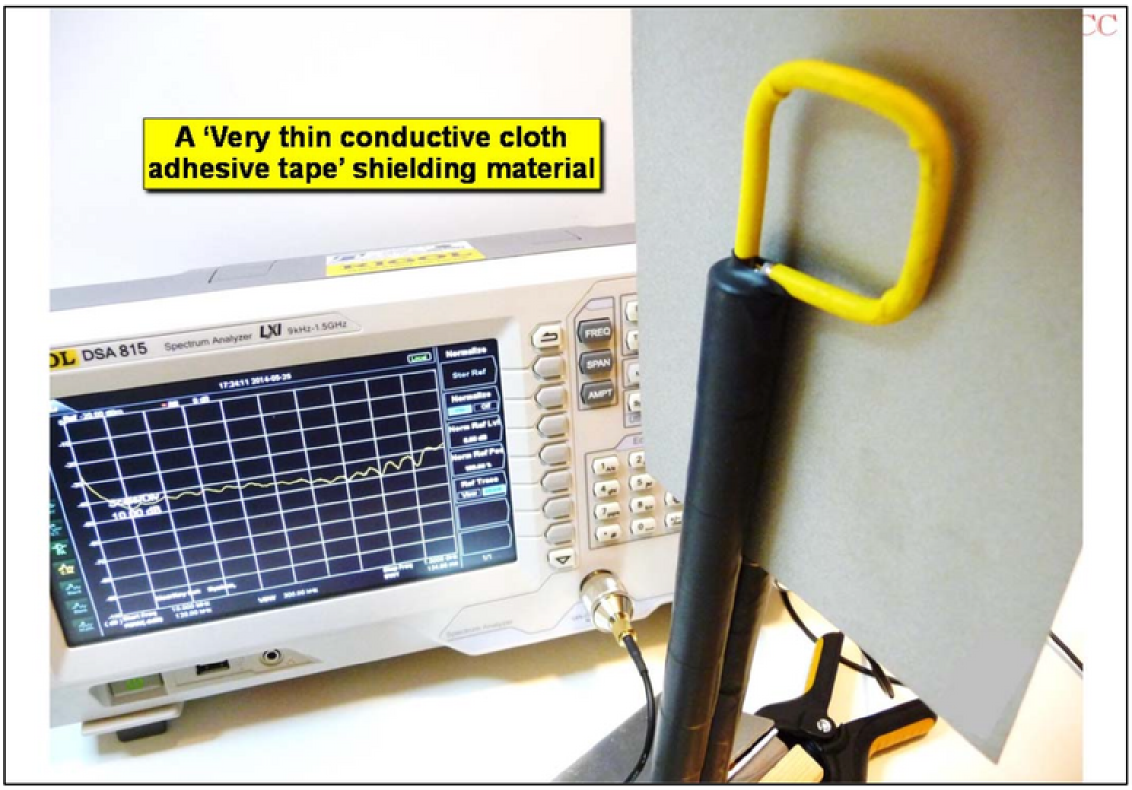


Figure 71 A 'Very thin conductive cloth adhesive tape' shielding material

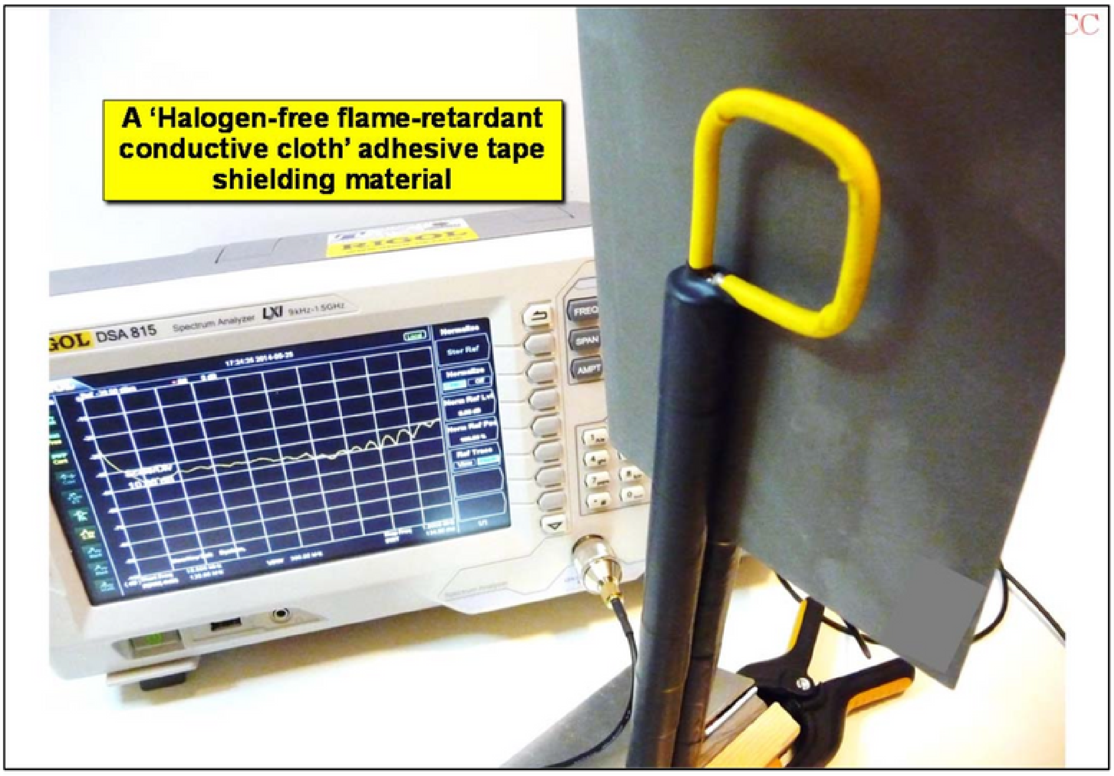


Figure 72 A 'Halogen-free flame-retardant conductive cloth' adhesive tape shielding material

Figure 72 shows a 'Halogen-free flame-retardant conductive cloth' adhesive tape shielding material, which was in turn only a little more substantial than the samples shown in Figures 70 and 71, and which gave an SE result similar to theirs on this test.

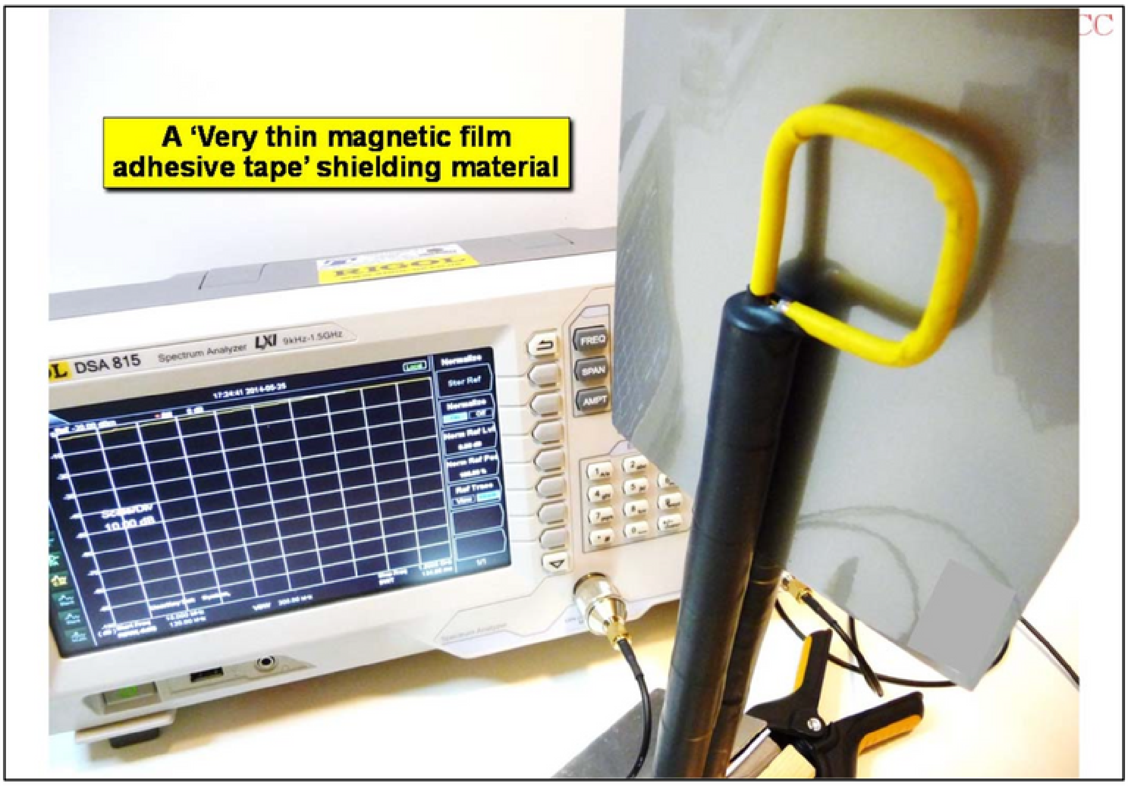


Figure 73 A 'Very thin magnetic film adhesive tape' shielding material

Figure 73 shows a sample of 'Very thin magnetic film adhesive tape' shielding material. As for the sample in Figure 69, I expected it to have good SE on this close-field magnetic field SE test, but – also as for the sample in Figure 69 – I was disappointed: it measured about 3dB at 10MHz falling to 0dB above 800MHz.

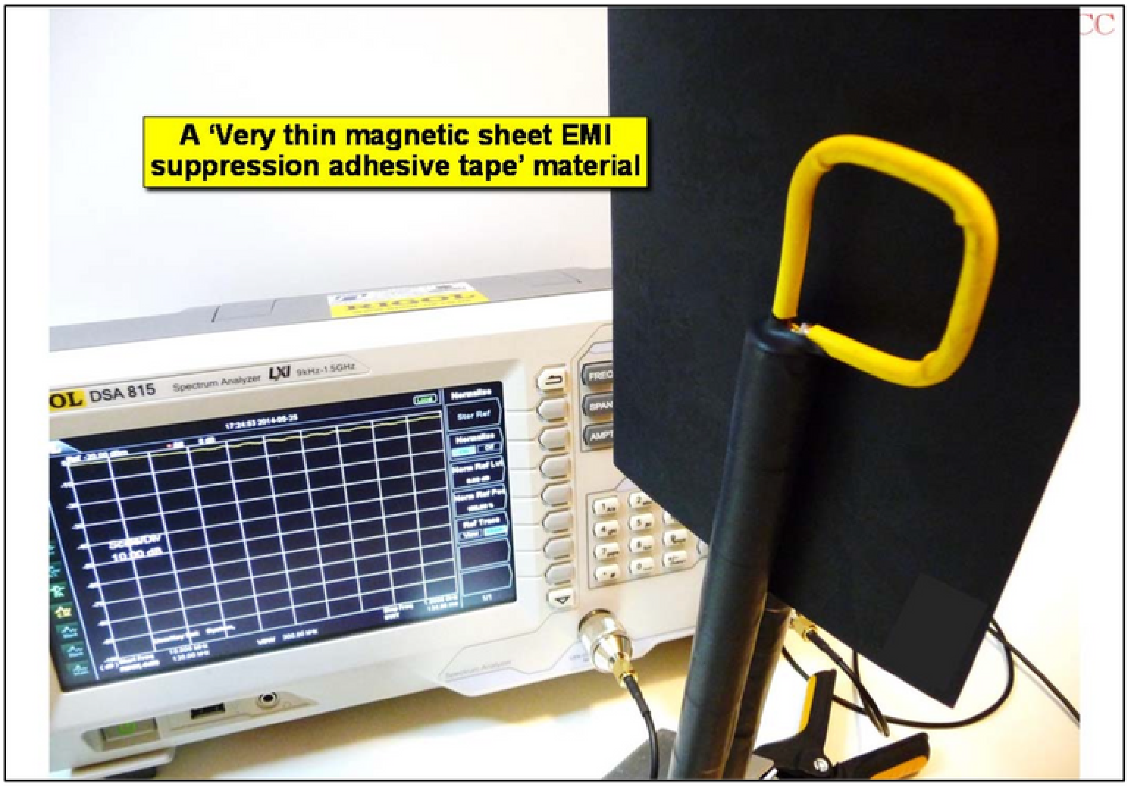


Figure 74 A 'Very thin magnetic sheet EMI suppression adhesive tape' material

Figure 74 shows a sample of a 'Very thin magnetic sheet EMI suppression adhesive tape' similar to that tested in Figure 73. Just as for the samples in Figures 69 and 73, this measured very poorly: 1dB at 10MHz improving (if that is the word) to about 3dB at 400MHz and then falling back to about 2dB by 1GHz.

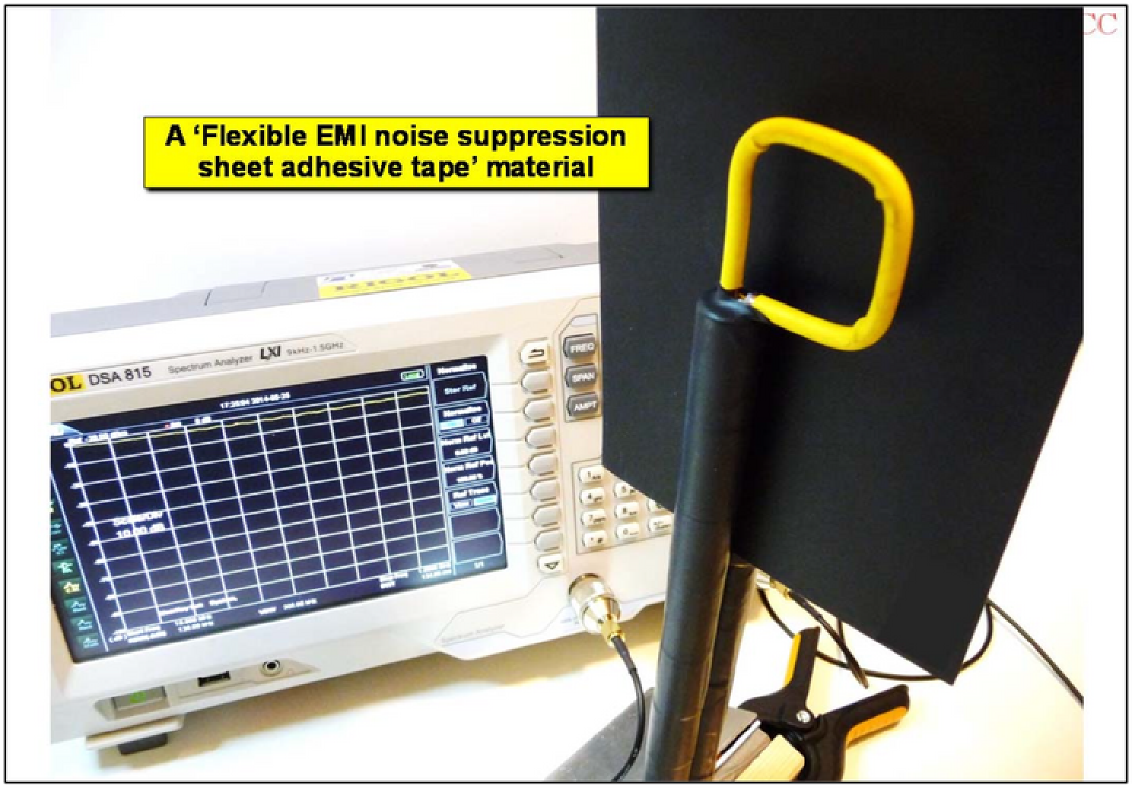


Figure 75 A 'Flexible EMI noise suppression sheet adhesive tape' material

Figure 75 shows a sample of a ‘Flexible EMI noise suppression sheet adhesive tape’ material, which gave SE performance on this test that was much the same as for the materials in Figures 69, 73 and 74.

The results of the tests shown in Figures 69, 73 and 74 were rather disappointing. It is difficult to see what these materials are intended to do – given that they claim to be magnetic absorbers and this is a magnetic field test.

Perhaps these materials are intended for shielding at much higher frequencies than 1GHz? I have seen data on special materials that ‘tune’ their characteristics to provide good absorption over certain bands of radar and other microwave frequencies, and are effectively useless outside those bands. But the websites for the manufacturers of the samples in Figures 69, 73 and 74 make no mention of such exotic shielding properties.

Well, that’s it for this quick, easy, low-cost 2-probe shielding effectiveness test technique for reducing project and financial risks. The next article(s) in this series will cover the following close-field probing techniques:

- The 2-loop-probe method of finding resonances in cables
- The 2-clamp-probe method of finding resonances in cables
- The 1-clamp-probe ‘reflectometer’ method of finding resonances in cables
- The 1-clamp-probe ‘reflectometer’ for finding flaws in cable screen terminations and connectors

I hope that by the time I come to write the next article(s) I have managed to figure out how to get the 1- clamp-probe ‘reflectometer’ method for finding flaws in cable screen terminations and connectors working properly. I had it working in my own workshop, but when I tried to demonstrate it to 50 engineers in Belgium earlier this year, I couldn’t get it to work. Most embarrassing!

Shielded cables with over-moulded connectors often cause problems because their shields are not correctly terminated inside their moulded connectors. The only way of checking them is to X-Ray them, usually from two different angles, or else cut the plastic over-moulding away with a sharp knife – taking care not to remove parts of fingers, or even whole fingers, in the process.

So I hope I can get this method to work well, because it would be a lot less costly and much more flexible and convenient than X-Raying connectors; and a lot less destructive (and dangerous) than cutting the over- moulding off with a knife.

9 References for Part 2

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Telonic Instruments Introduces SIGLENT's Flagship SDS7000A Series Oscilloscope to the UK.

SIGLENT has introduced a new range of high-performance oscilloscopes to the UK with the help of Telonic Instruments Ltd. The SDS7000A oscilloscope range has been developed for dynamic markets, such as telecommunications, wireless technologies and high-speed digital technology.

The SDS7000A is just such an oscilloscope range, offering 12-bit vertical resolution that not only enables the precise imaging of high-frequency signals, but also offers fine differentiation in vertical detection.

Sampling & Memory

The SDS7000A meets new and emerging test requirements, with four analogue channels and 16 digital channels, with bandwidths of 3GHz and 4GHz. Maximum sampling rate is 20GSa/s which allows for the capture of fast signal transitions with high fidelity. Each sample utilises the 12-bit ADC to limit the quantisation error. This allows engineers to observe the waveform details clearly and to measure accurately.

Standard acquisition memory depth is 500 Mpts/channel which can be upgraded to 1 Gpts/channel. The long storage depth enables signal sequences for up to 50 milliseconds at maximum sampling rate to be captured without any gaps.

The SDS7000A also has a low noise floor, as low as 220µVrms at 4GHz.The waveform capture rate can go up to 1 million wfm/s, which speeds up when capturing abnormal events.

X86 Processor

The SDS7000A is equipped with an upgraded processor to enhance performance. The X86 processor greatly improves the response speed, measurement, operation and analysis speed of the oscilloscope. Its use has also created more opportunities for future expansion of analysis functions.

Eye/Jitter Analysis

The SDS7000A series supports automatic parameter measurements for jitter and eye characterisation. Eye diagrams characterise high-speed communication signals and system quality can be evaluated by observing the influence of inter-symbol crosstalk, noise, and bandwidth. Jitter analysis characterises the statistical distribution of small timing changes in a system and is often used to debug digital communication systems and high-speed signal transmission.

The SDS7000A also benefits from easy setup and automatic measurements to speed debugging and simplify design testing, for a distinct time-to-market advantage.

Protocol Compliance Analysis

To identify and resolve critical signal and transmission issues quickly, SIGLENT provides embedded compliance test solutions. These evaluate systems against communications standards including USB 2.0, 100base-TX, 1000base-T, 100base-T1 and 1000base-T1. Users can configure the test items and the software controls the oscilloscope to automatically complete the test and provide signal test results (Pass/Fail) after comparison with the reference standards.

SAP5000D Active Differential Probe

The SAP5000D is SIGLENT's highest performing active differential probe kit providing up to 5 GHz of bandwidth and low noise for detailed signal analysis. Its high input resistance and low input capacitance ensure that the load introduced by the measurement system is minimised. SAP5000D active probe unitises the SAPBus interface, making it suitable for oscilloscopes including SIGLENT's SDS5000X, SDS6000A and SDS7000A series. These probes do not need an additional external power supply and are automatically recognized by the oscilloscope.

For ease of use, the SDS700A has a 15.6-inch, high-definition touch screen, which allows various signals to be analysed simultaneously, improving efficiency and contributing to a reduced development cycle. In addition, search and navigate, and history tools, make analysis of the entire stored trace an easy operation.

Based in Wokingham, Berks, Telonic has been supporting the electronics, automotive, aerospace, education, manufacturing, research and development sectors with sales, service, calibration and hire in the UK for over 50 years.

Editor's Interview

In this issue we have been talking to Mariyah, a recent electronics graduate. Here she tells us what she has found out and how she is intending to use her skills.

How did you get into EMC design of electronics products?

I graduated from university with a BSc in Electrical and Electronic Engineering in 2021. I started working as a Junior Electronics Engineer at Aeristech. Coming out of university you're not aware of EMC as not enough content is taught or maybe even nothing at all. I was only made aware of EMC during my time at Aeristech, as my mentor described how EMC can be a cause of products failing.
I attended an EMC training workshop led by Keith Armstrong back in May 2023, where I was able to learn more about what EMC is and how to overcome it. Initially you might think EMC is only related to noise getting into and out of units, but it is much larger than that.
I learnt how to minimize the risks early on from the design stage, learnt how simulating it could be a way to prevent EMC, testing products to see if they're compliant and how to minimize EMC if the products do fail.
Of course, the main thing I learnt was to start thinking about EMC in the initial design phase of your products so that when it does come to testing it, it is operating as intended. This is also to prevent any changes that could happen later down the line which could lead to delays in project timelines.

What did you get out of this experience?

You come to appreciate how big the topic is but what I realized is the big age gap between those who are aware of EMC and the younger generation. However, it was good to meet like-minded people as they were helpful in passing on years of experience on how to tackle issues you might face and gain an understanding of any questions you may have.

How did you see yourself progressing in EMC?

In the coming future, I hope that with my current job at Warwick Acoustics, I will be able to gain practical experience in EMC to apply everything I have learnt. I would like to develop my own tools to do some product testing in house, before going on to the EMC test chambers.

Thank you very much Mariyah. We hope that as one of the new generation of EMC Aware engineers you will be able to build up even more EMC skills and use them advantageously.