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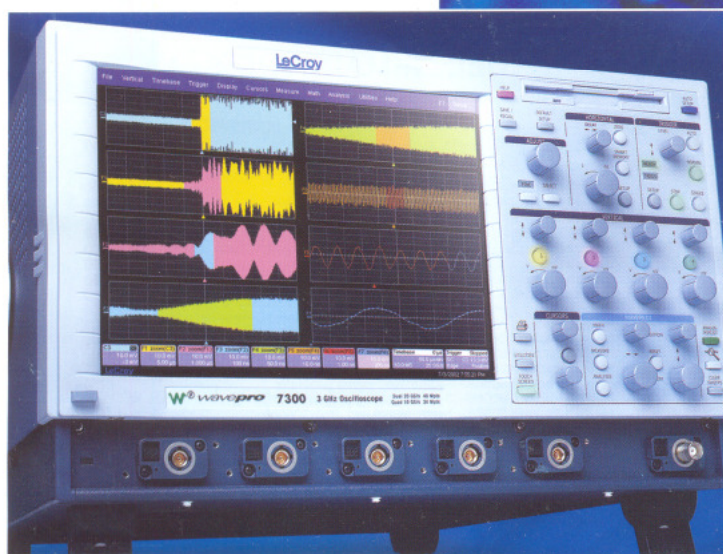
ELECTRONICS WORLD

MARCH 2003 £3.25



EMC - A fatally flawed discipline?

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EMC

A Fatally Flawed Discipline?

His attendance at an IEE Open Discussion Forum on the teaching of electromagnetics in undergraduate courses on 12th December last year encouraged him to confront the EMC incubus. Ivor Catt explains.

I have been very concerned about the EMC community since 1964, when I first ran into it in Los Angeles whilst designing a power supply for a torpedo-proof line printer for the US Navy in Data Products Corporation.

I became extremely concerned when in Europe it became a criminal offence to fail to take a piece of equipment through their ridiculous EMC tests. Of all the subcultures in electronic engineering, EMC is the worst.

There is a strong rumour that during the Falklands War, the British warship HMS Sheffield had to switch off its radar looking for incoming missiles in order to resume radio communication. This is why it did not see incoming Exocet missiles, and you know the rest. How was it that after decades of pouring money into the EMC community, this could happen? Do the EMC community agree that they should shoulder the blame? Of course not. This is because that community has gone into limbo, sucking in money but evading the real problems, like watching for missiles while you talk to HQ.

While visiting the EMC magicians in the Ford Motor Company, I found that it was illegal to have a car radio that inadvertently affected an overtaking car's electronically controlled brakes. However, the EMC community is totally indifferent if, whilst switching on your car's starter motor, you cause a passing motorist's brakes to lock suddenly.

My experience in England started with NWS3, a British copy of US test specs. It is fatally flawed at the fundamental theoretical level. These flaws remained during further decades because of the lack of grasp of the fundamentals of electromagnetism by the whole EMC community.

Los Angeles

I first came across the EMC community as a design engineer for the Data Products Corporation based in Los Angeles, in 1964¹. My family, our furniture and I were shipped to Los Angeles by the Ampex Corporation and I was fired seven months later and hired on the following Monday by the Ampex spinoff company Data Products Corporation down the road for 50% more salary.

At Data Products, I was put to design a power supply for a torpedo-proof line printer for use on board ship in the US Navy². (As luck would have it, the evening lecturer at the 12th December meeting shipped over by the IEE from the USA came from the US Navy EMC community.) We had to meet EMC requirements, so we hired an EMC magician for six months from the company whose name I remember as Geniston. He came and sat in our offices. Immediately I went to him and asked him about the EMC criteria he relied on. He would not give me any technical information. He said that I should just carry on designing and building the prototype as before. After it was completed he would add a few grilles and things.

We did as he suggested, and on completion we sent it for EMC

testing to a test company - Geniston. We were correct to choose Geniston, because this ensured that it would pass. I was mystified by all of this until I heard rumours that Navy Admirals had large holdings of stock in Geniston. Then it all made sense.

The EMC regulations prescribed that electric power drawn by the line printer must not vary at a greater rate than 3Hz. This meant that if the line printer suddenly had to print a whole row of 200 'A's:

AAAAAAAAAAAAAAAAAAAAAAAAAAAA

(requiring 720 amps) the amount of power demanded down the mains cable from somewhere else on the ship must not increase in a detectable way, at a greater rate than that indicated by the figure of 3Hz. This was because in principle the EMC test magicians would put a current probe around one of the wires, live or neutral, bringing in power. The idea was obviously that there might be a Russian spy with a current probe on the US Navy ship, and he might be able to detect whether the line printer was printing information. We all know that increased communication would indicate that the US was about to attack his brother on a nearby Russian ship. The machine sounded like a machine gun, but obviously all Russian spies were deaf, or at least all those who served in the US Navy, so the audio pandemonium was not a matter of concern for our freedom-loving democracy.

My solution to the "problem" was to take in constant power and build a shunt regulating power supply instead of the normal series regulating power supply. That is, whenever the line printer was not printing at maximum rate, I would divert all the unused power into an electric fire. This design was much admired for its novelty, and the prototype worked fine. It was appreciated most on cold mornings.

Our line printer was the most advanced and sophisticated. Each of the 120 hammers had a row of one inch square coils attached to them through which a 6 amp current would be delivered for 2msec. Thus, printing a row of 'A's meant a 6 amp sudden pulse (perhaps with a rise time of one microsecond) flowing in each of the 120 coils for 2 milliseconds. The number of turns in each coil is now unknown (although my notes do indicate 3mH), but my records tell me the rest. The DC resistance of the coil was 10 ohms, which indicates that the number of turns was large, as it would be. When EMC testing, Geniston would bring up the most sensitive antenna to two feet from the end of this gigantic electromagnet, to try to detect electromagnetic (but to ignore sonic) activity. Their resident magician would then propose blocking metal grilles and the like to blind the antenna, but on no account would he get inside our line printer and discuss our circuits and layout, with a view to causing mutual cancellation of magnetic fields. It appears that this madness continues to this day, and EMC magicians continue to stay outside each of the possibly incompatible boxes, brewing up their million pound Faraday cage test rooms and billions of nonsensical mathematical equations.

An example of some Faraday cage nonsense is when (more recently) I was an electronic engineer at GEC Chaucer House,

Portsmouth, but not at the time an EMC magician. The bright young thing designated Portsmouth Tigerfish Torpedo EMC guru talked about buying a screen room (Faraday Cage). He said it should be 100dB. It was interesting that the naïve, long term defence electronics designer sitting behind me argued with him that surely 60dB would suffice. I told him that this was ridiculous. The bright young thing's future career path required that he buy the £100,000 100dB cage. What the job needed had nothing to do with it.

Back at the line printer, the 720 amps into the hammer actuators was delivered by a gigantic resident 60v electrolytic in the line printer. At that time, electrolytics exploded at -60 degrees F. Naval

requirements were that on board items must survive down to -65 degrees F. Obviously, the US navy operated in very cold waters. It was frustrating to know that the USAF only required that their equipment survive down to -50 degrees F. This problem (how to print the message that the sea was frozen solid) was not solved by the time I was fired.

More costs

EMC was not the only ruse to increase costs in the defence of freedom and democracy. The printer had to survive 200g. This test involved strapping the equipment to a 4,000 pound anvil, and then

The fatal flaws

How do I get to Killarney? – I wouldn't start from here.

EMC will never escape from its origins – the stamping ground of ex RAF radio operators and the like. Later recruits are probably engineers who failed to cut the mustard as designers, or who were in any case in the surreal world of "defence" electronics. When a GEC or RCA product or similar failed to work properly, management would call in RFI "experts", who would do tests and write awesome reports (later on copied out from the Don White manual). Like Don White, they drew on the theory and practice in AM and then FM radio developed during the first half of the 20th century when the number of transmitters increased and they began to interfere with each other. To understand the EMC magicians of 50 years later, it is useful to see them as dinosaurs stuck in the age of radio and radio interference, decades before the arrival of digital systems.

In the IEE discussion on the teaching of electromagnetics on 12th December 2002, all the thirty attendees sounded technically naïve when they began to talk about personal computers. However, they demonstrate fatal flaws in their attitude, which would remain a problem even if digital systems did not exist.

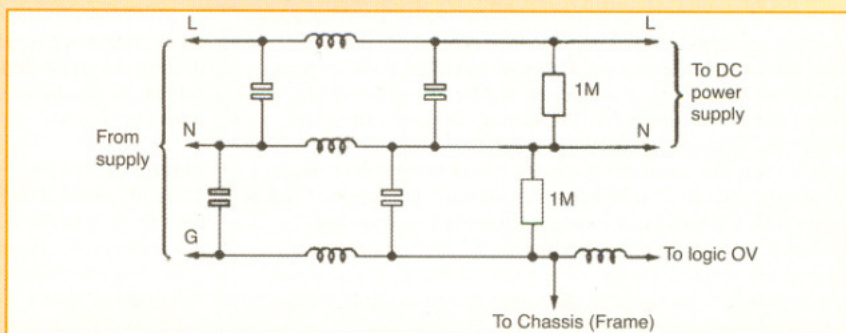
The EMC specifications discuss conducted interference and radiated interference. Thus, the whole EMC community is committed to the idea that interference is of two types; conducted interference which travels down one wire and radiated interference which travels down no wires. This immediately confronts Kirchhoff's Laws, which insist that conducted interference travels down two wires; the signal wire and the return wire. This brings us to the second, strange weakness in the whole EMC game. They assume that two interfering units will both be electrically connected to "ground", which in their test rigs is a large plate of copper. As I moved further into high speed logic, my approach was to electrically float units in order to reduce mutual interference. Put crudely, when the length of the module is less than the wavelength of concern, grounding helps, but if it is longer, grounding hinders. (This was echoed when

the discussion on the 12th dwelt on new problems arising at above 1GHz – wavelength one foot.) Thus, the very process of coming within the EMC specifications bans a potent way of minimising electromagnetic interference! In my case, I went so far as to design a revolutionary mains filter which, although safe and within British safety regulations for being DC earthed, floated at high frequency. The simple stratagem was to insert a choke in the earth line which had a DC resistance of less than half an ohm, and similar impedance at 50Hz. The mains filter was an open circuit between earth and the unit at anything much above 50Hz⁴. The filter came to market at about that time. The ideas built into that filter are crucial for limiting interference, but cannot be communicated to the EMC community or their testing standards, since both exist within a cloud of bizarre mathematics and prejudice, and would probably not understand my idea. They limit themselves to a low frequency worldview where tying something to ground reduces interference and radiation. The worst comes by attaching two already interconnected units to ground, which increases the pickup of interference, even at lower frequencies, by creating a square loop antenna.

Another fundamental flaw is the assumption that if the emission from one unit is less than the susceptibility of another unit at every frequency, taken one at a time, then there will remain immunity when a number of frequencies are emitted from one and received by the other at the same time. This assumption is implicit in the fact that EMC wallahs sweep through frequencies

one at a time. This is true if a radio transmitter and a receiver tuned to another frequency are involved. However, if the susceptible unit contains digital electronics, it is not true. Here we see confirmation of the EMC community's ignorance of digital electronics, which means their ignorance of more than 95% of all of today's electronic equipment.

Another fundamental flaw in the EMC wallah's thinking and therefore testing standards is their resort to averages. In the lectures last December, I heard that their aim was to estimate the peak emission of unwanted interference on the basis of measured emission. The implicit assumption was that any system, including digital, needed minimal average interference. They just do not know that if a digital system loses just one bit, the result should be assumed to be catastrophic. They cannot get away from their world, where a bit of interference of a voice over the radio is O.K. so long as it does not happen too often. The truth is that peak emission should be calculated, not measured with test equipment. Similarly, the susceptibility to interference should be calculated, not measured. This is the fundamental flaw in the approach of the whole EMC community, to test instead of doing what they have to do in order to be relevant. To be relevant, they must get involved in the design process; or else leave the whole problem to the existing design engineers. When a customer buys some equipment, he or his advisers should consult the design details, not the test results from an EMC test.



hitting the anvil with a 3,000 pound hammer which had been raised through one foot and then left to swing at the anvil like a pendulum. Presumably nervous designers would pray for a fly, or better still a wasp, to intervene. Interestingly, all the seamen aboard would have had their legs broken, but the printer would continue to print a message ("Torpedo attack" for example). The demonstration film, where I saw a nice piece of electronic equipment turn into an array of projectiles, was taken seriously by the freedom-loving Americans watching with me. They objected to my laughter, although I was only fired much later.

We have to realise that had the resident Geniston EMC magician ventured inside our equipment, or even entered into technical discussions with me, he would probably have been betrayed as part of "rent-a-crowd", similarly to the way Weinstock would rent a crowd of milkmen and the like for a weapons project to keep his roster of "electronic engineers" up to the two thirds contractual minimum. This minimum roster saved the government funded project from cancellation. In any case, at 100% of cost plus 14%, the more milkmen he hired as engineers, the more would be the GEC profits. Professor "stinking fish" Brown played his part in this when he betrayed the IEE, who were trying to establish a way to distinguish between an EE and a milkman. In both cases, the Official Secrets Act or the like would provide ample cover. Even at this late stage, this article is probably undermining the UK's defences, which are based on bluff and scam³, the EMC community fits well into such a scene.

The EMC requirements meant that the little three foot long line printer turned into something looking very much like a tank, as can be seen in the Data Products equipment brochures of the time. Since the antenna used by EMC magicians to detect emitted noise was brought up to a standard distance from the edge of the device under test, one obvious recourse was to make the device bigger and so push the EMC detecting antenna away from the workings inside.

Stingray

Whenever a major scandal hit GEC, Weinstock would rename it Marconi, or vice versa. MPs were too dim to realise that all the weapons scandals involved the single company. In this article, GEC stands for GEC or Marconi.

The Stingray project was special. GEC operated a number of "defence" weapon "design" scams, and Stingray was by far the most surreal³.

Davidson, Walton and Catt had made major breakthroughs in electromagnetic theory. We needed to find out how much of our breakthroughs were known in all the electromagnetism subcultures. Two of us were employed at GEC Borehamwood (Herts, UK) at the time, so Malcolm Davidson went upstairs to the microwave design department. He came back down to report that they were only plumbers. They knew nothing, and merely played with equations and connected together tubes to pipe around only one mode.

Later, the question arose as to whether the EMC community already knew any of our advances. So I stopped teaching remedial English and got a job as the top EMC magician on the Stingray torpedo project in Stanmore, Middlesex. As a magician myself, I would be able to find out what they knew. (For instance, I would be better placed to force them to tell me what their jargon meant.) I had to avoid the EMC experts in GEC Portsmouth, GEC Rochester, etc., until I had rumbled what some of their main buzz-words (e.g. lisen) meant and found out what books they relied on. After a few days I found out that their bible was the £400 Don White manual. However, no other EMC experts would lend me their copy, or let me see it. After about ten days, however, I met a man who sold EMC devices imported from Los Angeles to our weapons industry. He volunteered to lend me the EMC bible, which was one of his products, for two or three weeks. When I asked him why, he said that he had mixed loyalty. On the one hand he was happy to take a 10p capacitor manufactured in Los Angeles, renamed an EMC capacitor, sold to him for £2 for him to mark up to £5 and then sell to GEC. On the other hand, he was also a taxpayer, and was appalled by the drain on the taxpayer. (At the time, "defence" took 6% of GDP.

It took me a day or two to find out that Don White and his EMC

cardinals were technically ignorant. I wrote a document blowing the gaff on Don White, which I withheld. At that stage, I knew that the EMC community knew no electromagnetic theory, much as we had found for the plumbers called "microwave engineers". However, by now I preferred to sit in GEC at £11 per hour rather than sit at home for £0 per hour. I was justified, because the same British government was funding research into my inventions at Middlesex Polytechnic, Brunel University and RSRE Malvern. I was on the research management committees. Everyone else on these committees was so jealous of the fact that my inventions, not theirs, were being funded, that they were determined that anyone else on these projects would be salaried, but not me, the inventor. This was thus a double double-cross. I would sit at my GEC Stingray desk working on the Catt Spiral projects, which paperwork looked more or less the same as Stingray paperwork. I would be paid to do nothing on Stingray, and be paid nothing to work for the same government on Catt Spiral projects. An interesting moral dilemma occurred when I skipped out of "work" on Stingray to attend (unsalaried) a management conference on one of my government-funded projects at Brunel or Middlesex. Should I claim pay for those hours away from my desk at Stanmore?

To keep my £11 per hour going, I had to keep away from other EMC magicians on Stingray. However, after two or three weeks the Portsmouth EMC magician could no longer be held off by my excuses. So two days before his proposed visit, I sent him my report rubbishing his Don White bible. Realising the danger to himself, he cancelled, and I never saw him. In the "defence" industry, reality threatens everyone.

By then I knew that EMC magicians were ex-RAF airborne radio operators or the like, good sound troopers who knew little electromagnetic theory. The £400 Don White manual gave them project plans which they could copy into their own reports for the MoD. They could also copy technical sections into their reports. All this copying was the reason why nobody except EMC magicians must ever see the Don White bible.

While Principal Lecturer in West Herts College, I found out that it was an offence to have no functioning earth leakage detector in the fuse box for power entering a room occupied by students. However, the indispensable mains filters on each machine in my room full of computers put too much electric current into the earth line. I set out to find out who generated the regulation. After some months, I homed in on an engineer hiding in the back of the IEE. I told him that that was fine; students' lives had to be protected. All it meant was that throughout England, computer training would have to be done without using computers. I would make sure that everyone knew his involvement in making it illegal to use computers when teaching computers, and so saving students' lives. He then replied that the standard was only advisory. Given minimal support, I could do the same with these ridiculous EMC standards, which at present have criminal sanctions against those who breach them. Under pressure, no technocrat will accept accountability for their enforcement.

In the past, EMC, spawned in "defence", would only boost the parasitic activity called "defence", and help to waste a fraction of the GDP. However, the recent move, where it becomes a criminal offence for commercial industry to avoid their ridiculous, expensive standards and tests, makes them a more serious threat to us all. I need assistance to winkle out the technocrats responsible for the present standards, to require them to defend the test standards, and to be accountable for them. Such people probably do not exist. If they do, we must begin to destroy the credibility of such individuals and in the end make these ridiculous standards unviable in a criminal court, because a jury will refuse to convict. ■

References:

- 1 See my book "The Catt Concept" pub. Hart-Davis 1972 for insight into my time in the US.
- 2 I discuss it in my book "Computer Worship" pub. Pitman 1973
- 3 See <http://www.electromagnetism.demon.co.uk/gamoe.htm> for more information.
- 4 This is discussed in my out of print book "Digital Hardware Design", pub. Macmillan 1979, p83.