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EMC-Related Functional Safety (An Update)

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EMC-Related Functional Safety
An Update

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Summary

There are huge loopholes in safety and EMC regulations and standards, at least in the commercial, automotive, healthcare and industrial industries.

Where errors or malfunctions in electronics due to electromagnetic interference could possibly have safety implications, the resulting hazards and risks can fall right through these loopholes, leaving users at risk from unsafe products or systems, and suppliers at financial risk from liability lawsuits and product recalls.

This issue is known as EMC-Related Functional Safety.

Because the electronic marketplace is very cost-sensitive and because there are EMC-related functional safety loopholes in the regulations and standards, a business situation similar to that which caused mad cow disease in Europe already exists.

A freely downloadable guide [1] from the IEE describes solutions to this problem. It is strongly recommended that everyone involved in electronics or safety reads at least the first few pages of this guide.

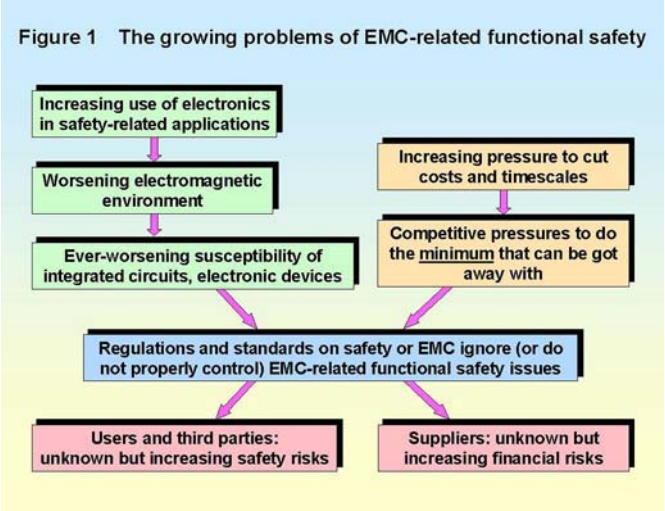
Introduction

Most safety regulations and standards address *intrinsic* safety – the possibility that injury or damage could occur due to electric shock, fire, mechanical instability, sharp edges, etc.. Here we are concerned with *functional* safety – where the hazards and risks depend upon the correct *operation* of devices, equipment, or systems.

Electronic technology is increasingly used where its accuracy or reliability is important for functional safety. This is mainly due to the useful amounts of processing power now becoming available in low-cost digital devices. The accuracy and reliability of such safety-related electronics is a functional safety issue. But all electronic technology is inherently prone to suffering from inaccuracy, errors in operation, or even damage when exposed to electromagnetic (EM) disturbances.

Most of the laws, regulations, and standards on safety or EMC do not take full account of this modern development. The result is that users and third parties are being exposed to increased risks of safety hazards, and suppliers are exposed to higher risks of product liability claims, as shown by Figure 1.

Figure 1 The growing problems of EMC-related functional safety



The electromagnetic environment is becoming more 'polluted', due to increased use of electronic technologies, especially wireless communications and power conversion. Consequently, the EM disturbances that electronics can be expected to be exposed to are getting steadily worse.

The integrated circuits (ICs) used to construct electronic products and systems are becoming more vulnerable to interference and damage from EM disturbances as their feature size decreases and operating voltages fall. Smaller feature size and lower voltages means electronic signals are 'weaker' and so are more easily corrupted by a given EM disturbance. Smaller feature size also means that actual semiconductor damage is more likely from a given EM disturbance.

Software employs electronic signals and ICs, of course, and when they suffer from interference or damage the software can suffer from errors or malfunctions, causing the equipment it is controlling to suffer errors or malfunctions.

Regulations on product safety are becoming commonplace in many countries around the world, as are regulations on product electromagnetic compatibility (EMC). But except for the European Union (EU) they do not cover EM immunity. In fact, there is very strong opposition in almost all countries except the EU for any legislation on immunity. Manufacturers in these countries argue forcibly that immunity is a reliability issue, so should be left to consumer choice.

But present-day safety regulations and safety standards relevant to electronics provide very poor control of functional safety. EMC regulations and standards are also inadequate when it comes to functional safety. Consequently the reliability and EM immunity needs of electronics when used in safety-related applications is not adequately controlled by *any* regulations or standards.

These loopholes, due to the issues described above and in Figure 1, are increasing the risks of safety hazards for users of almost any kind of equipment or vehicles, and to third parties such as the public at large. Consequently, some suppliers are increasingly exposed to huge product liability risks.

Transportation industries (road, rail, air, marine) have traditionally treated EMC as a safety-related issue, often out of fear of liability claims rather than the need to comply with specific regulations. But even in these industries, the rapidly increasing number of safety-related functions which depend on the correct operation of electronics has led some safety experts to question whether the approach being taken to EMC-related safety issues is adequate.

The IEE's Guide

The Institution of Electrical Engineers (IEE), based at Savoy Place, London, Great Britain has

been concerned with EMC-related functional safety issues for many years [2], [3], and in 1998 they established a working group (WG) to develop some professional guidance on this issue. This WG produced *"IEE Guidance Document on EMC and Functional Safety*" [1], published by the IEE in September 2000, believed to be the first such guide ever published by a professional institution.

EMC and safety experts from a wide range of industries, along with representatives of the UK's Health and Safety Executive (HSE), were represented on the WG. Care was taken in the composition and management of the WG to ensure that the Guide it produced was relevant to real engineering, safety, and financial issues.

- This IEE Guide is freely available from: http://www.iee.org/Policy/Areas/Emc/index.cfm or from http://www.iee.org.uk/PAB/EMC/core.htm in either Word or PDF formats.

A paper on this IEE guide was presented at the IEEE EMC Symposium in Montreal, August 2001 [4].

Because the Guide is aimed at engineers and their managers involved in design or manufacturing, the main argument it gives for following its recommendations is financial, rather than ethical. Although the senior professional institutions (such as the IEE and IEEE) require members to behave according to an ethical code of conduct, and although ethical behaviour is also expected by the courts in most countries, it seems that in the business world financial arguments are the most persuasive.

The financial argument can be simply summed up as 'a stitch in time saves nine'. The money saved on a large number of projects by cutting corners on EMC-related safety can easily be lost by just one safety incident. It is even possible for the entire reputation and goodwill of a company, built up over decades, to be lost overnight as a result of a single incident. Because EMC-related functional safety falls through loopholes in regulations and standards, even companies which are very diligent in meeting all the regulations and standards may be unwittingly running much greater financial risks than they realize.

The Guide has a '*Core*' section which starts with a one-page executive summary, and then introduces and describes the relevant issues and how they can be best dealt with. The Core also includes brief descriptions of some safety incidents where a lack of adequate EMC was *officially proven* to be the cause. Due to the statistical nature of EM disturbances and the general ignorance of EMC matters, it is thought likely that a very much larger number of 'no fault found' safety incidents were actually caused by inadequate EMC.

Briefly, the IEE Guide recommends fully-answering the following questions:

- What EM threats could the equipment be foreseeably exposed to?
- What could foreseeably happen as a result of these EM threats?
- How might the equipment's EM emissions foreseeably affect other equipment?
- What could be the reasonably foreseeable functional safety implications of the above?
- What actions are needed to achieve acceptable safety hazards and risks?
- What verification and documentation is required to show that adequate safety has been achieved?

As you can see, the recommendations in the IEE Guide are hardly earth-shattering, and are a

common-sense good engineering approach to helping make a product safe by considering its relationship with its electromagnetic environment.

Since the engineering issues involved are so obvious and so basic (especially in hindsight), people who are not involved with engineering on a day-to-day basis (such as lawyers, judges, and juries) – and who aren't familiar with the cost and time pressures suffered by those working in engineering industries – might find it hard to understand why the techniques described in this Guide are not already being followed as a matter of course.

It is strongly recommended that everyone involved (even peripherally) with electronics or safety, whether as a designer or a manager, reads at least the first few pages of the 'Core' of this IEE Guide, to at least see whether it is relevant to their activities. They should also bring it to the attention of anyone to whom it may be relevant.

The IEE Guide also includes a number of '*Industry Annexes*', each showing how a particular industry has addressed (or should address) EMC-related functional safety, each written by experts from the industry concerned.

A Aerospace
B Building services and electricity distribution
C Healthcare (especially the EU's Medical Devices Directive)
D Marine transport
E Offshore oil and gas
F Rail transport
G Road transport (especially the Automotive EMC Directive)
H Software
J Heavy Industry (projects where design/construction is done by subcontractors)

The annex on Software and EMC-related safety is especially important because more and more safety-related functions are controlled by programmable electronics.

Annex J contains some very useful procedures for any project which involves subcontractors, and helps avoid the usual problems of apportioning the responsibility.

Product Liability and the IEE's Guide

Product liability regulations generally require that products be as safe as the state of the art permitted, at least at the time they were manufactured. Most safety and liability regulations also generally require that safe design should consider reasonably foreseeable situations, including faults and misuse.

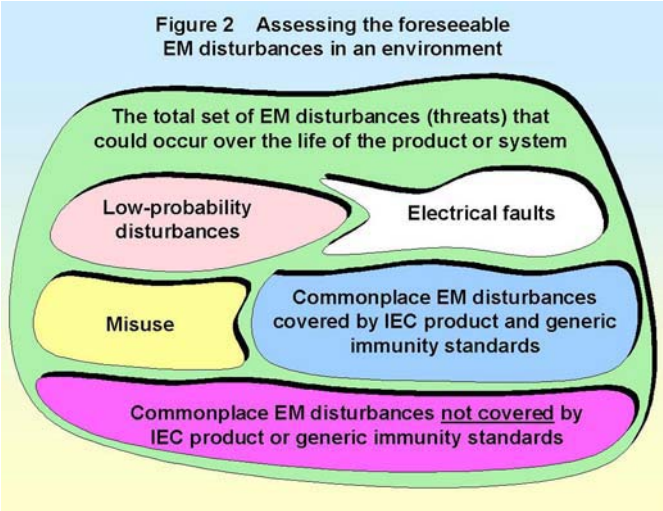
There seems to be rather limited awareness of the EU's Product Liability Directive (85/374/EEC), and its more recent modification by the General Product Safety Directive (92/59/EEC) – possibly because compliance does not require company directors to sign a declaration of conformity. This is unfortunate, because the potential financial liabilities that suppliers are exposed to by these directives could be very much larger than under 'CE marking' safety directives.

The '*state of the art*' legal defense required by product liability regulations (at least, in the EU) is understood to be a lot more difficult to achieve than the '*due diligence*' defense required by 'CE marking' directives.

Because the IEE's Guide is publicly available (and free), and because it has been widely publicized, manufacturers (or other supplier) who ignore its recommendations, or who fail to follow them correctly could be at significant financial risk, whichever kind of legal defense is required.

Competency: EMC-related functional safety falls through more loopholes

In commercial and industrial manufacturing companies and test laboratories across the world, EMC engineers are concerned with meeting EMC regulations and standards so that products can be sold in various countries. Very few EMC engineers ever consider going further (or are allowed to go further) than the minimum requirements of the necessary regulations or standards, which often don't include immunity. Also, commercial and industrial EMC standards (at least) only consider typical operating environments and don't take account of reasonably foreseeable fault or misuse situations. Even the very latest immunity standards being adopted by the EMCD are inadequate for dealing with safety, as Figure 2 shows. As a result, most EMC engineers are unfamiliar with important functional safety concepts.



On the other hand, safety engineers in companies and test laboratories generally don't understand EMC (often derided as 'black magic') and are pretty hazy about functional safety, because most of the safety regulations and standards they are involved with never mention either issue.

Both types of engineers are usually incapable of predicting what types of EM disturbances a product might reasonably foreseeably be exposed to; what the peak magnitude and statistical variance of these disturbances could be, or how the product's electronic hardware and software might reasonably foreseeably go wrong when exposed to such disturbances.

Consequently, few of the EMC or the safety engineers working for commercial and industrial manufacturers or their test laboratories are likely to have the competency to deal with EMC-related functional safety issues without further education or experience.

Installation, maintenance, service and repair personnel are often overlooked. They are not usually EMC and functional safety experts, and may not see the importance of closing a cabinet door fully, replacing all the fixing screws in a panel (with the correct torque), terminating a cable shield in the required manner, or reading, understanding, and following a manufacturer's manuals in full.

So as well as the loopholes in the regulations and standards (described earlier) EMC-related functional safety also suffers from loopholes in personnel *competency. Problems* even for the traditionally safety-conscious industries.

But what about the transport (road, rail, air, marine), nuclear, medical and other industries, where EMC-related functional safety has long been taken into account? Surely they are dealing with it correctly? Sadly, not all of them are. Even in some of these industries there are shortcomings, especially due to the explosive increase in cellphone and walkie-talkie use.

Although cellphones radiate only up to 2 watts, and walkie-talkies up to 10 watts, because they are hand-portable they can be held so close to electronic devices that the immunity threats from their radio-frequency fields are very severe.

The use of cellphones is banned on commercial air flights, and have been implicated in at least one air crash [5]. But banning the use of cellphones cannot guarantee that cellphones will *not* be used – in fact it is reasonably foreseeable that people will forget about the ban, or decide to flout it. So banning cellphone use cannot be considered an adequate measure, on its own, in response to the threat to functional safety from cellphone use. Although aircraft EMC standards are getting tougher, most of the commercial aircraft now flying use electronics that have never been tested for their response to the threats that cellphones create in their passenger cabins or baggage holds.

A similar situation arises in medical institutions. Some now have public notices banning the use of cellphones, but this ban is known to be commonly flouted (even, according to personal communications, by doctors and surgeons). It is also known that life-critical medical equipment can be susceptible to cellphone radiation, and even more so to the private mobile radio system walkie-talkies in use at some sites [6].

The automobile industry also has a problem with cellphones. Most auto manufacturers warn drivers (in the manuals provided with each new car) not to use hand-held cellphones in their vehicles, even though they know that drivers and their passengers will do just that. Even the stringent EMC tests applied to road vehicles don't generally take full account of the reasonably foreseeable possibilities of interference from hand-held cellphones.

Analyzing EU Directives for EMC-related functional safety

The EU's safety directives are arguably the most comprehensive set of product safety legislation in the world, at the present time, so it is interesting to see how they deal with EMC-related functional safety.
Most EU safety directives do not mention functional safety at all, much less EMC-related functional safety, and can only be considered to address these issue because they contain catch-all clauses that require products to be 'safe' and all environmental conditions to be taken into account.

The Low Voltage Directive and some EU Directives that *do* mention EMC, are assessed below. The conclusion must be reached that they do not adequately deal with EMC-related functional safety, in the common-sense manner recommended by the IEE's Guide. This justifies the earlier assertion that the real engineering and financial necessity to address EMC-related functional safety could easily be overlooked due to loopholes in safety and EMC regulations.

The Low Voltage Directive (LVD)

Although the LVD (73/23/EEC, modified by 93/68/EEC) is generally reckoned to cover functional safety, there are no words in its text that specifically mention it – never mind EMC-related functional safety.

Paragraph 3B in LVD Annex 1 states that: "*…electrical equipment shall be resistant to non-mechanical influences in expected environmental conditions, in such a way that persons, domestic animals, and property are not endangered.*" This could be taken to mean that EMC-related functional safety must be considered, but the situation is complicated by the EC's July 1997 Guidelines on the LVD. In its Scope section, under the heading "Which safety aspects are covered by the Directive?, it says (paragraph 11): "*It should be noted that electromagnetic compatibility (emission and immunity) aspects are excluded from the scope of this directive and are separately regulated under Directive 89/336/EEC.*" This seems to suggest that all EMC issues can be ignored, because they are covered by the EMCD, but it is shown below that the EMCD

does not cover safety issues at all.

Although it is possible to find some LVD Notified Bodies and other LVD experts who will say that functional safety issues, including EMC-related ones, are covered by the LVD, as far as I know no published article, paper, or textbook about designing products to meet the LVD has ever mentioned this issue. Since no supplier to the EU has to involve any LVD Notified Body, or third-party expert, or test laboratory when declaring conformity to the LVD, from this assessment it seems very unlikely that suppliers would conclude that the LVD included any requirement to consider EMC-related functional safety.

The EMC Directive (EMCD)

The EU's EMCD (89/336/EEC) includes immunity requirements, and many engineers and their managers appear to assume that meeting the EMCD means that they have done all they need to on EMC.

But the EMCD is solely concerned with preventing technical barriers to trade in the EU single market and cannot properly deal with EMC-related functional safety issues [7]. The EMCD only considers normal operational and typical EMC environments, whilst safety compliance must consider all reasonably foreseeable events and situations, including operational overload and environmental extremes, equipment faults, human error and misuse (see figure 2).

This issue has only recently become widely publicly acknowledged by the European Commission, and then only because of the work being done by the 'SLIM' team towards the 2nd edition EMCD. The decision of the team was that EMC-related safety issues should be dealt with by safety directives and their standards, not by the EMCD or its harmonized standards [8].

At the time of writing it is unclear whether the relevant IEC (and other) safety standards committees have begun to seriously consider including EMC-related safety issues in their standards, but even if they have it will still take at least a couple of years before suitably modified standards are published.

The Automotive EMC directive

The Auto EMC Directive 95/54/EC (and the technically similar Directive for 2 and 3 wheeled vehicles: 97/24/EC) *does* attempt to address EMC as a functional safety issue. It is discussed in Annex G to the IEE's Guide, which concludes that it is inadequate because:

- It does not fully cover the fitting of after-market equipment, including mobile transmitters.
- Its tests are limited in their application, and are not very thorough.
- Radiated immunity tests are only carried out at a steady state speed. The Directive does not test for dynamic situations such as changing gear, unlocking the vehicle or reading an ignition key transponder to allow the vehicle to start.
- It does not include transient emissions or immunity requirements and so does not adequately cover after-market products and their potential to interfere with OEM systems (or to be interfered with by them).
- It does not require electro-static discharge (ESD) tests.

Although the Auto EMC Directive can be criticized for its limited test regime, it does require the relevant Vehicle Approval Authority to see evidence of compliance of any system that affects the direct control of the vehicle if the defined tests do not do this. But what about facilities such as memory controlled seats and mirrors? These are not considered to be related to the direct control of the vehicle and so may legally escape immunity testing.

Consider a married couple where he is 6 feet 6 inches tall and weighs 240 pounds, and she is just 5 feet tall and weighs 100 pounds. If he is driving and the seat erroneously resets to her setting (maybe because he held his cellphone too close to the seat's ECU) the steering wheel may become jammed against his body, preventing steering, and his legs may become jammed under the dashboard and unable to control the pedals. If she is driving and the seat alters to his setting, she may be unable to reach either the steering wheel or the pedals whilst sitting on the seat.

Loss of control due to malfunction of a memory controlled seat is clearly quite a plausible (i.e. reasonably foreseeable) situation, and could be very dangerous to the driver, any passengers, and other road users, even though the electronic systems involved are not at all concerned with the 'direct control of the vehicle'.

It is fair to say that the EMC and safety testing done by many well-established auto manufacturers far exceeds the requirements of the Auto EMC Directive, because of their concerns over product liability. But even their tests don't cover after-market accessories, and of course some manufacturers will only aim to meet the minimum legal requirements for vehicle certification. A recent study [9] showed a wide variation in interpretation of 95/54/EC amongst manufacturers and vehicle certification authorities across the EU, especially for items such as electrically-controlled seats and mirrors.

The Machinery Safety Directive (MSD)

The Machinery Safety Directive (98/37/EC) has a few clauses that relate to EMC and functional safety. Annex 1 paragraph 1.2.1 states: "*Control systems must… ...withstand the rigours of normal use and external factors…*" External factors could be interpreted as meaning reasonably foreseeable electromagnetic disturbances, although this is not mentioned in [10].

Annex 1 para 1.2.6 states: "*The interruption, re-establishment after an interruption or fluctuation in whatever manner of the power supply to the machinery must not lead to a dangerous situation.*" Reference 10 says that this can mean any possible noise or fluctuation in the power supply, but then goes on to state that the EMC Directive 89/336/EEC "*…deals with all electromagnetic phenomena likely to cause operating problems in a device, an appliance or a system.*" Since we now know (see above) that the EMCD is officially considered inadequate to deal with safety-related issues, the effect of this paragraph is diminished considerably.

Annex 1, para 1.5.11 states: "*Machinery must be so designed and constructed that external radiation does not interfere with its operation.*" The commentary on this in [10] seems to be quite robust, requiring the manufacturer to take account of the foreseeable environment conditions at the intended location for the machine. Unfortunately this paragraph limits itself to radiated disturbances, and does not apply the same robust requirements to power, signal or control cables.

Annex 1 paragraph 1.7.4 lists the instructions that must accompany a machine. These do not include any requirement to specify the electromagnetic environment or the disturbances the machine is designed to withstand (e.g. how close operators are allowed to bring their walkie-talkies or cellphones). They also do not suggest including installation and commissioning instructions which would help ensure that the EM performance designed-in by the manufacturer was achieved in practice.

Many machinery manufacturers use low-cost computers, PLCs, and instrumentation products to control functionality, without appearing to consider the consequences for functional safety if those devices should ever suffer from interference. For sales in the EU, many of them also seem to believe that if they make sure that each electronic part they purchase bears the CE mark, then that is all they need to do for EMC or LVD compliance – an approach that is well known to be inadequate in most cases.

Some machinery manufacturers, and most of the MSD Notified Bodies, take a much more robust approach to EMC-related functional safety. But of course there is no legal obligation to involve a Notified Body or any third-party when declaring machines compliant to the MSD.

So the conclusion must be that the MSD goes some way towards following the IEE's Guide but nevertheless is inadequate. Unfortunately, it appears that many machinery manufacturers don't even take EMC-related functional safety as far as the MSD requires.

IEC equipment safety and EMC standards, and EMC-related functional safety

This section assesses how well the IEC standards for EMC and for safety address the issue of EMC-related functional safety. Three types of equipment are considered: information technology; measurement and control; and machinery.

The information technology and measurement and control standards don't include any functional safety requirements at all – in fact they don't even use the phrase 'functional safety' in their texts. The machinery safety standard takes a stab at EMC-related functional safety, but falls well short of even the barest adequate requirements as set out in the IEE's Guide.

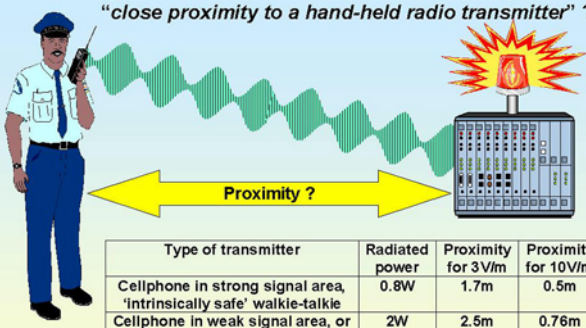
This standards assessment shows that the earlier assertion is correct – EMC-related functional safety can easily be overlooked or ignored due to loopholes in the safety and EMC standards. This assessment also shows that all ordinary electronic equipment (sub-assemblies, modules, products, systems, etc.) should be considered unsuitable for use in any application where its reliability or functional performance could possibly have any consequences for safety. (In fact, I would like to see all electronic equipment sold with a clearly-visible life support policy statement similar to that found on the first page of almost all semiconductor databooks.)

Information technology equipment standards

IEC 60950:1999 [11] does not mention anything to do with functional safety, or the possible consequences of EM disturbances for safety.

The EMC immunity standard, CISPR 24:1997 [12] states in it's Scope section that "*Safety considerations are not covered in this publication*." It also includes the same warning about its requirements being inadequate in special cases "*...for example where a hand-held transmitter is used in proximity…."* – which does not seem like a special case these days, where everyone carries a cellphone and private mobile radio handsets and vehicle mobiles are also very widespread. Apart from the fact that it does not say what it means by '*proximity*' (see Figure 3) it fails to mention foreseeable situations such as proximity to much more powerful vehicle-mounted radio transmitters, or base-stations for a private mobile radio or cellphone system.

Figure 3 What do immunity standards really mean by "*close proximity to a hand-held radio transmitter*" ?



Type of transmitter	Radiated power	Proximity for 3V/m	Proximity for 10V/m
Cellphone in strong signal area, 'intrinsically safe' walkie-talkie	0.8W	1.7m	0.5m
Cellphone in weak signal area, or standby mode	2W	2.5m	0.76m
Typical walkie-talkie handset	4W	3.7m	1.1m
Some emergency services or CB radio handsets	10W	6m	1.8m
Typical vehicle-mobile transmitter or fixed base-station	100W	18m	5.5m
Multiply distances by $\sqrt{2}$ for one constructive reflection from a metal surface, by $\sqrt{3}$ for two reflections, etc.			

A very few computers, PLCs, and instrumentation are designed for use in safety-related systems, and some now even meet the new voluntary functional safety standard IEC 61508 [13]. Such products are usually more expensive than ordinary ones so there is a natural reluctance to use them.

Measurement and control equipment standards

The safety standard, IEC 61010-1:2001 [14] includes immunity to transient overvoltages, but only in as much as they might cause damage to insulation. EMC requirements are excluded from its scope by its clause 1.2.2.

The EMC standard, IEC 61326-1:1998 [15] is much better than most EMC standards, in that it requires the manufacturer to perform an assessment of the electromagnetic environments his product might be used in, and structure the EMC tests applied to the product so that it is compatible with those environments. Unfortunately, it does not go so far as to address safety issues – Note 1 of its General section states: "*Higher immunity levels than those specified may be necessary for particular applications (for example, when reliable operation of the equipment is essential for safety)*."

Standards for the electrical equipment of machines

The safety standard IEC 60204-1:1997 [16] is a rare example of a safety standard that *does* make an effort to cover EMC-related functional safety.

Section 4.4.2 states: "…the equipment shall have an adequate level of immunity to electromagnetic disturbances so that it can operate correctly in its intended environment.". A 'strong' interpretation of this could be that equipment must remain safe despite reasonably foreseeable electromagnetic disturbances, including those caused by electrical faults or misuse.

But the use of the words '*operate*' and '*intended environment*' corresponds exactly with wording used by the EMCD. Also, section 4.4.2 goes on to refer to the generic standards EN 50081 and EN 50082 as well as to product standards harmonized under the EMCD (despite the fact that these all *specifically exclude* their use for safety purposes). This makes a 'weak' interpretation possible – that compliance with the EMCD is sufficient for functional safety (whereas the earlier assessment of the EMCD shows that it is not). Some manufacturers, when faced with alternative interpretations such as this, will take the easiest route – claiming that to do otherwise might put them at a competitive disadvantage.

Annex 18 to IEC 60204-1:1997 describes the technical documentation to be provided with the electrical equipment of a machine, and although it requires the physical environment to be

specified, it does not suggest specifying the intended electromagnetic environment. There is clearly little point in designing a machine to be safe in a specific electromagnetic environment, if the user is not provided with a specification for that environment (e.g. how close operators are allowed to bring their walkie-talkies or cellphones).

The most up-to-date EMC immunity standard for industrial apparatus, IEC 61000-6-2:1999 [17], states in Note 1 to its Scope that "*Safety considerations are not covered by this standard.*". It goes on to warn in Note 2 that its immunity requirements may be inadequate in special cases, for example: *"….where a hand-held transmitter is used in close proximity to an apparatus*." Apart from the fact that it does not say what it means by '*close proximity*' (see Figure 3) it fails to mention foreseeable situations such as proximity to much more powerful vehicle-mounted radio transmitters or base-stations for a private mobile radio or cellphone system.

IEC/TS 61000-1-2 : 2001 on EMC and Functional Safety

IEC 61508 [13] requires EMC to be taken into account, but is not very explicit on how this should be done. IEC/TS 61000-1-2 [18] has been written to support [13] in this area.

This new IEC Technical Specification specifically addresses the issue of EMC-related functional safety. Its requirements are very similar to the IEE's Guide – it goes into more detail in some areas but does not cover as broad a range of issues.

As a Technical Specification it can be used in contracts but it is not a full standard. In a few years it is likely to become a full IEC standard, at which time it may be adopted by Cenelec as an EN standard. Once it is an EN standard it might then be harmonized under a number of safety directives (e.g. the Machinery directive), alternatively it may be used as a basis for developing product family standards (e.g. under the LVD). The earliest date when it could possibly become a mandatory harmonized standard for apparatus supplied in the EU is probably around 2006.

Although – like [13] – IEC/TS 61000-1-2 represents an aspect of the 'state of the art' in safety and therefore should be employed to help ensure compliance with safety and Product Liability directives, commercial pressures may cause many manufacturers to ignore it until the relevant standards become mandatory under EU directives.

But ignoring EMC-related safety issues until the relevant standards become mandatory will continue to expose customers to avoidable safety hazards, and will continue to expose manufacturers to liability claims, non-compliance with EU directives, and loss of reputation.

Developments

At the time of writing (November 2002) IEC 61508 has been adopted by the EC as EN 61508 and is undergoing its first revision. It is hoped that it will contain more explicit guidance on EMC-related safety issues, especially for software.

In a year or two IEC/TS 61000-1-2 will be reviewed to see if experience with using it, or increases in knowledge, make any changes necessary as it progresses towards being a full IEC standard and possible adoption as a harmonized EN and notification under one or more EU safety directives.

Working Group C of the EMC Test Labs Association [19] has been working on a Technical Guidance Note (TGN) on the EMC requirements for machinery safety as required by the Machinery Directive (98/37/EC), and also on a TGN on the EMC requirements for the safety of electrical equipment as required by the Low Voltage Directive (72/23/EEC amended by 98/36/EEC). These two TGNs are based on the IEE's Guide on EMC and Functional Safety and recommend the application of IEC/TS 61000-1-2, and they will soon be issued on the TGN page of the EMCTLA's website http://www.emctla.co.uk/.

Conclusion – act now to prevent the electronic equivalent of 'mad cow disease'

Many suppliers feel that cost and timescale pressures are increasing, not least because of the pressure towards 'globalization'. As a direct result, many suppliers have a policy of only meeting the minimum requirements of safety and EMC standards, because the added cost of going further would (they believe) put them at a competitive disadvantage.

I have shown that EMC-related functional safety is a real safety issue of rapidly increasing importance, and that by the time the regulations and mandatory standards evolve to deal with this issue correctly the world will already be full of electronic equipment inadequately designed for the EM environment they find themselves subjected to. It will probably be too late and too expensive to recall or modify it all, so we will all just have to put up with the resulting increases in financial losses, injuries and deaths.

So the conditions for an electronic equivalent to mad cow disease are complete – compliance with minimum legal safety regulations and standards (rather than the state of the art), plus intense pressure to drive down costs. This is exactly what gave rise to 'mad cow disease' (BSE) and its human equivalent Variant CJD (vCJD) in Europe, which have cost Europe (and the UK in particular) many hundreds of millions of pounds to deal with.

Unless suppliers apply the state of the art in safety, which now includes the requirements of IEE's Guide [1] and IEC/TS 61000-1-2:2001 [18], many people could suffer financial loss, injury, or death, and many suppliers could suffer expensive liability lawsuits and product recalls.

Let us hope that the IEE's Guide on EMC and Functional Safety is adopted quickly and widely enough to avoid similar predictions for the injuries, deaths and financial losses which could arise because – in a very cost-conscious business where rapid advances are being made in technology – important EMC-related functional safety issues are inadequately covered by the mandatory minimum legal product regulations and their associated standards.

References

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[2] '*Dangers of Interference – EMC and safety*', Simon Brown , IEE Review, July 1994.

[3] '*EMC Management for Hazardous Installations (Workshop)*', IEE 10th International Conference on Electromagnetic Compatibility, University of Warwick, 1-3 September 1997.

[4] '*New guidance on EMC-related functional safety*', Keith Armstrong, 2001 IEEE EMC International Symposium, August 13-17 2001 (session D3-P3, 15th August).

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[8] '*Report of the SLIM III team on the electromagnetic compatibility directive (89/336/EEC as amended), Final version, Brussels 24th September 1998'*, especially paragraphs 12-14 and recommendations R5 and R7, all on page 8. SLIM III documents and drafts of the 2nd edition EMCD may be obtained from: http://europa.eu.int/comm/enterprise/electr_equipment/emc/slim/review.htm

[9] '*Study on the application of Directive 95/54/EC relative to the EMC of road vehicles. For the European Commissions DG III*' I E Noble, D Flintoff and L M McCormack, York EMC Services Ltd, available in PDF format from http://www.yorkemc.co.uk/Research/index.htm

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http://europa.eu.int/comm/enterprise/mechan_equipment/machinery/guide/content.htm
[11] IEC 60950:1999 '*Safety of Information Technology Equipment*'. This is harmonized in the EU under the Low Voltage Equipment (Safety) Directive (LVD) as EN 60950:2000.
[12] CISPR 24:1997 '*Information Technology Equipment – Immunity Characteristics – Limits and methods of measurement*'. As EN 55024:1998 this becomes mandatory for all equipment within its scope supplied in the EU from 1st July 2001.
[13] IEC *61508 'Functional safety of electrical/electronic/programmable electronic safety-related systems*' (in seven parts). This is a voluntary standard which (it is understood) might not be adopted by the EU as an EN, or become a harmonized standard under any directives. However, it will influence some product standards which could become EN's and might become harmonized. It is now being used by the UK's Health and Safety Executive as an example of good safety engineering practice.
[14] IEC 61010-1:2001 "*Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*". Harmonized in the EU under the LVD as EN 61010-1:2001.
[15] IEC 61326-1 + A1:1998 "*Electrical Equipment for measurement, control, and laboratory use – EMC requirements*". As EN 61326-1 this standard becomes mandatory for all equipment within its scope supplied in the EU from 1st July 2001.
[16] IEC 60204-1:1997 "*Safety of machinery – Electrical equipment of machines –Part 1: General requirements*". Harmonized in the EU under both the LVD and MSD as EN 60204-1:1998 and required for all new equipment in its scope from the 1st July 2000, and for all equipment in its scope from 1st July 2001.
[17] IEC 61000-6-2:1999 "*Electromagnetic Compatibility (EMC) – Part 6.2: Generic standards – Immunity for industrial environments*". As EN 61000-6-2:1999 this becomes mandatory for all equipment within its scope supplied in the EU from 1st April 2002, replacing any use of EN 50082-2:1995.
[18] IEC/TS 61000-1-2:2001 "*Electromagnetic Compatibility (EMC) – Part1-2: General – Methodology for the achievement of the functional safety of electrical and electronic equipment with regard to electromagnetic phenomena*".
[19] EMC Test Labs Association (EMCTLA), http://www.emctla.org contact Dave Imeson (Secretary) dimeson@iee.org. The EMCTLA is an international association of test laboratories, and has been publishing their helpful technical guidance notes (TGNs) for many years.

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