"CE Certification" is a fallacy

— and —

Low-cost compliance with the EMC Directive

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Way back in the mid-1990s, the IEE ran a series of very successful seminars all over the UK, on the subject of low-cost EMC compliance with the new EMC Directive (and its corresponding UK EMC Regulations).

But any effect they had at the time appears to have been diluted by the intervening 20 years, so that I and other independent consultants are constantly being asked to help manufacturers obtain what they call "CE Certification" for compliance with the EMC and other EU Directives.

"CE Certification" is a fallacy

Let's make one thing perfectly clear right from the start:

There is no such thing as "CE Certification"!

Neither the words, nor the concept of "CE Certification" have ever appeared anywhere in any EU Directives. It is a meaningless phrase.

The reason why "CE Certification" is meaningless, is that EU Directives require *every individual item* that they cover, to comply. Having a test laboratory test one or two examples of a product cannot ensure that all of the products that roll off a production line over months or years are also compliant, which is what is required by the Directives.

> In the rest of this article we'll focus on the EMC Directive, 2004/108/EC [1] (which will be replaced by 2014-30-EC [2] on the 20th April 2016, with no consequences for this article). Apart from a few exceptions for especially dangerous products, the issues discussed here are relevant for most other EU Directives, for example the Low Voltage Equipment (Safety) Directive 2006/95/EC [3], usually called the LVD.

A test lab cannot provide "CE Certification" because – over time – products in serial manufacture experience the range of normal component tolerances; out-of-range component tolerances; variations in processes and assembly; replacement of obsolete components; modifications to reduce costs or fix errors in the original design (e.g. "bug fixes"); improvements and additions to features and functionality, etc., etc., etc.

And we must not forget the continual shrinking of the internal dimensions of the silicon chips used in electronics according to Moore's Law [4], which always affects their EMC performance (usually making it worse). New "die-shrunk" silicon chips are slipped into the semiconductor supply chain about every two years, on average, without anyone knowing (unless they take special steps to find out).

All of these issues can affect a product's performance on certain EMC tests, so the EMC Directive requires manufacturers to employ Quality Control (QC) methods to ensure that every single, *individual* product that rolls off their lines complies with the EMC Directive.

> (OK, the actual requirement is more like: *most* of our products must comply with *most* of the EMC Directive's requirements, but that discussion is outside the scope of this article. (That's a clever way for me to avoid having to admit that – like most people – I don't really understand it! It seems to depend on legal issues that can only be decided in a Court of Law, which is a place we never want to find ourselves anyway, so I suggest we default to having our QC system ensure that all serially-manufactured products comply with all the requirements of the EMC Directive all of the time.))

Because the actual compliance of products in serial manufacture requires appropriate QC of EMC in design, purchasing, assembly, test, and sometimes even in packaging (e.g. to prevent the salty air that can be experienced during containerised shipping from corroding EMC gaskets), only manufacturers are permitted by the EMC Directive to decide when they have sufficient confidence to affix the CE mark to their products.

And only a manufacturer's responsible person (usually the Technical/Engineering Director) can sign an EU Declaration of Conformity to the EMC Directive.

In the UK, our use of the English language is so very sloppy and imprecise that we often confuse Declarations of EMC Conformity with Certificates of EMC Conformity. So *declaring* conformity is often mistakenly called *certifying* conformity.

In official documents, the process by which a manufacturer (*not* a test lab) declares a product to be compliant with an EU Directive is called Self-Declaration, which we in the UK often call Self-Certification instead because of our sloppy use of language. (I understand that mistaking "declaration" with "certification" would be incomprehensible in Germany, because the words for "declare" and "certify" in German have clearly different meanings.)

During past decades, independent EMC test laboratories have indulged in a great deal of advertising, accidentally encouraging many manufacturers to believe that what is necessary for CE marking according to the EMC Directive is to have a "full-compliance test certificate" from a 3rd-party test lab to tests that are accredited by a National Accreditation Body (e.g. UKAS in the UK, NAVLAP or A2LA in the USA, etc.).

For the most part, this false impression is created implicitly, but I have had occasion to complain to labs whose advertisements included explicitly false statements about who declares whether a product is EMC compliant.

The situation is further confused by test labs offering "compliance marks" for Europe – purely voluntary proprietary marks that – like the concept of "CE Certification" – exist nowhere in the EU Directives.

The overall result is that – in the English-speaking world – we often seem to confuse Certificates of EMC Testing (such as are issued by test laboratories) with "Certifying" EMC Conformity, and end up using actual gibberish phrases like "CE Certification" or "CE Certified".

In Compliance magazine's May 2013 edition [5] included an excellent article by Ozgur Ozturk: "Heading for the EU? Get Your Compliance Passport Ready" [6].

Ozgur's article detailed how manufacturers can best utilise 3rd-party EMC test laboratories to comply with the EMC Directive.

> (It is a common mistake in the USA to believe that (what they often call) "Fortress Europe" requires a comprehensive set of certificates of passing accredited tests to achieve "CE Certification" (gibberish, see earlier).
> Apparently what happened is that in the early 1990s at least one UK company made a large effort to sell their EMC services in the USA, by pandering to their fears of "Fortress Europe" by falsely representing the EMC Directive as being much more demanding than it really is.
> I remember meeting people at IEEE EMC Symposia in the USA who described test plans for EMC Directive compliance that cost $40k per product, when I would have expected to spend no more than £4k if using 3rd-party test laboratories (and could do it for much less using the methods described below).
> In fact, the EU's single market is the exact opposite of a "fortress" – it need not present any significant barriers of cost or delay to most products from anyone, anywhere.)

But Ozgur's excellent article did not go into much detail about what manufacturers can do to comply, when supplying electrical/electronic products in the EU if —

a) Their products can't pass all the relevant harmonised EMC standards that have been officially notified as providing a presumption of conformity to the EMC Directive; or,

b) Their products can't actually be tested to all of the relevant harmonised EMC standards; or,

c) They can't afford to test to all of the relevant harmonised EMC standards; or,

d) They would prefer to save time and/or money by not relying solely on 3rd-party test laboratories.

I have written this section of this article to focus on these issues – which I summarised in the title as "low-cost compliance" when the scope is actually much broader, as a) – d) above shows.

As I mentioned earlier, EMC test laboratories advertise their testing services a great deal, so it is hardly surprising that many manufacturers get the impression that it is necessary for CE marking to have 3rd-party EMC test reports for their products.

But it is very important to understand that ***the EMC Directive contains no legal requirements for performing <u>any</u> EMC tests*.**

This was also true of the original EMC Directive, 89/336/EEC, when it came into force in 1996, and it will also be true for compliance with the future EMC Directive, 2014-30-EC [2] when it comes into force on the 20th of April 2016.

A manufacturer of a product that is within the scope of the EMC Directive (and intended to be supplied in the EU) is legally required to create a EMC Technical Documentation File (TDF) which describes the product and why the manufacturer reckons it is compliant.

When the TDF is complete, the manufacturer may then create an EU EMC Declaration of Conformity (DoC) for their product; and only when this is complete and signed may they "affix the CE Marking" to the product.

If the product is too small for the legal minimum 5mm height of the CE Marking, it must instead be affixed to its packaging and documentation.

Any DoC must be immediately available to any EU EMC Directive enforcement official who asks for it, and for that reason many manufacturers include them with their products" enclosed documentation (e.g. the User Instructions). However, officials are only empowered to ask to see TDFs if they are investigating a complaint of non-compliance.

A manufacturer can choose one of two different ways of declaring conformity to the EMC Directive in a DoC: the 'Standards Route", which relies entirely on the relevant harmonised test standards, or the "EMC Assessment Route", which uses just a few or none of the relevant harmonised test standards.

These "Routes" are explained in more detail later on, but the important point here is that whichever of them is followed, listing any test standard in a DoC is actually a legal statement by a manufacturer that: "***<u>if</u> my product was tested to this standard, it would <u>probably</u> pass***".

How a manufacturer obtains sufficient confidence to make this legal declaration ***is entirely up to that manufacturer,*** and should be documented (amongst other things) in the TDF.

Obtaining sufficient confidence to make such a declaration does not require any test certificates or reports, and this is what makes it possible for many manufacturers of electronic products around the world, including some of the very largest companies, to save time and money by testing in their own EMC labs, or using other methods of ensuring EMC compliance (see later).

I often meet entrepreneurs who tell me they can't afford to comply with the EMC Directive and are worried that they will have to go out of business, or at least not grow their sales as much as they would have liked to.

They have fallen for the false impression that test certificates are required, when in fact it is actually very easy for individual entrepreneurs, who might be working out of their garages (like Mr Hewlett and Mr Packard did when they first started [7]) to sell their products totally legally throughout the EU without the high costs associated with EMC testing to standards.

OK, I think the above has dealt with the first part of the title – that phrases like "CE Certification" or "CE Certified" are totally meaningless. Now onto the second part of the title – how to comply with the EMC Directive without spending more than is necessary.

The EMC Directive

The EMC Directive [1] applies to both "apparatus" and "fixed installations" – but beware: it attaches special legal meanings for both of these otherwise commonplace terms. It is a common mistake to think that, for example, the EMC Directive's requirements for "fixed installations" apply to any installation that is fixed in one place.

This mistake is one of the reasons why the Amended UK Wiring Regulations got it so wrong, which I discussed in the previous Edition of this Journal [8].

Figure 1 shows that apparatus is treated very differently from fixed installations.

"Apparatus" is any electrical/electronic item that could cause or suffer EMI, and which is "made available for an end-user in the EU" for the first time (see later). It is important to remember that, as I said above, the EMC Directive applies to every individual item (e.g. individual serial numbers) – Chapter 2.2 in [9] and Chapters 1.2 and 3.2.2 in [10] provide much more detail on this.

The EMC Directive also has a special category of apparatus "…intended for incorporation into a given fixed installation, and not otherwise commercially available" (which most of us would call "custom", "bespoke", or "one-off" equipment). This can avoid having to be CE marked for EMC, and can even fail any/all EMC tests, although it would then have to comply with other EMC activities specified in the EMC Directive.

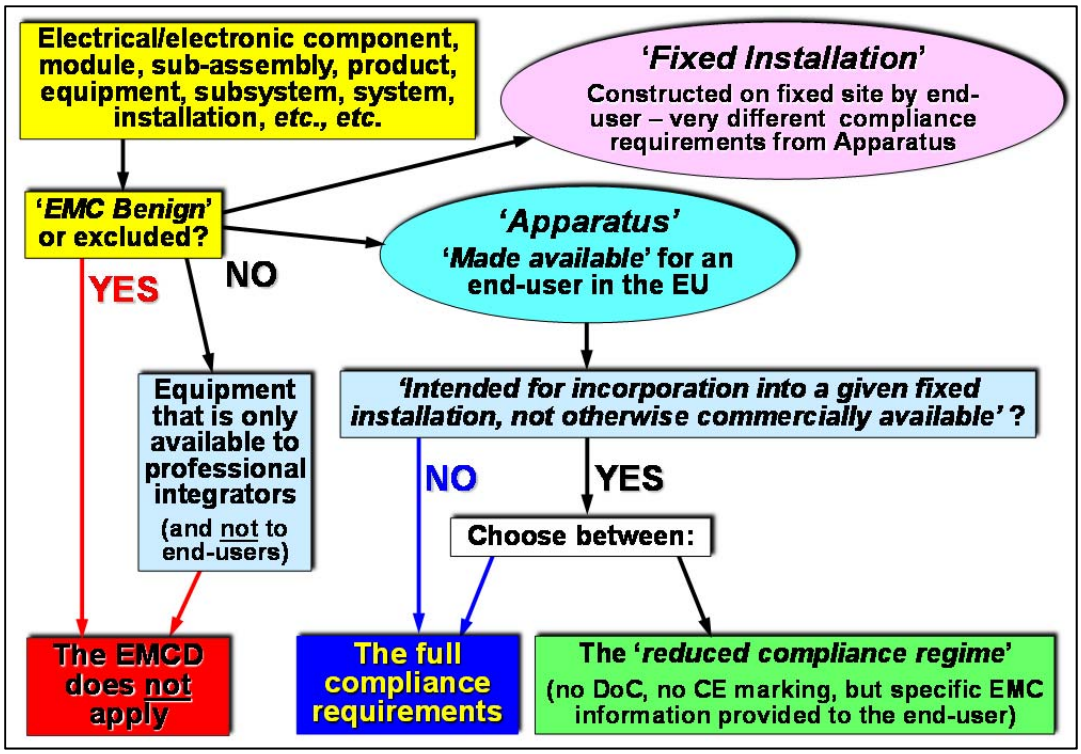

Figure 1: Applying the EMC Directive

"EMC Benign" equipment is excluded from the EMC Directive's scope, and the official guide [10] contains a list of what is currently considered EMC Benign. As a general rule, this exception cannot be used for anything that contains any semiconductors (rectifiers, transistors, ICs, etc.) or thermionic valves, or makes any sparks (even at electromechanical contacts).

It is worth bearing in mind that EMC Benign items can still be important for EMC compliance when used in a system or installation. For example, cables are EMC Benign but whether a shielded cable has its shield terminated properly inside both of its moulded connectors is very important indeed for the EMC of the equipment it is used to interconnect.

Products and equipment that are only made available for the exclusive use of professional integrators in the construction of their own products, and are not "made available" for end-users (even by distribution) are also excluded from the scope of the EMC Directive.

This is true no matter how large and complex they are – for example suppliers of containerised Internet server-farms, RAID arrays, complete control systems for electricity generating plant, high-power inverters for large photovoltaic arrays, etc. – should not declare their products to be compliant with the EMC Directive *unless* they supply them direct to their end-users under their own name, and are paid directly by their end-users.

Such equipment will almost certainly have to be CE marked for compliance with an EU safety directive, such as the LVD [3], Machinery Directive [11], etc. This is one reason why we should never assume EMC compliance when purchasing a CE-marked 3rd-party product for incorporation into a different product, or into a system or installation.

I have seen many large projects suffer greatly from major contractors making two big errors regarding EMC:

i. Mistakenly assuming that every item of equipment that carries a CE marking must perforce comply with the EMC Directive. This article describes three ways in which this assumption can be wrong, all of which are shown in Figure 1:
    a. When the equipment is "EMC Benign"
    b. When the equipment is only supplied to professional integrators, whether it is manufactured in volume or custom-designed (e.g. as a subcontract)
    c. When the equipment is custom-made for a particular end-user's "Fixed Installation"

ii. Mistakenly assuming that an EMC compliant final system merely needs EMC compliance for its constituent parts (often called the "CE + CE = CE approach", discussed later).

Radio amateur equipment that is not commercially available; aeronautical equipment covered by Regulation 1592/2002, and equipment covered by the R&TTE Directive (1999/5/EC) is also exempt from the EMC Directive.

The new Radio Equipment Directive, or RED, 2014/53/EU will replace the R&TTE Directive from June 12, 2016, at which time some of the equipment that used to be covered by R&TTE will instead come under the new EMC Directive [2] and the LVD [3]. Also, equipment currently covered by the EMC Directive which uses electromagnetic fields for communications of any kind, at any frequency, will then be covered by the RED instead.

Equipment that has EMC aspects addressed in specific product Directives (e.g. medical devices, automotive, etc.) is only exempt from the EMC Directive to the extent covered by those other Directives. Unfortunately, this is widely misunderstood to mean they are totally exempt from the EMC Directive.

Apparatus that must comply with the EMC Directive when made available for an end-user in the EU may be advertised or exhibited before it is EMC compliant – as long as it is clearly marked as being: a) non-compliant with the EMC Directive, and b) not (yet) being available for 'supply" in the EU.

EMC Conformity of Apparatus

The EMC Directive requires all "apparatus" to:

i. Comply with the "Protection Requirements"
ii. Undergo a "conformity assessment" procedure
iii. Have a TDF prepared and readily available for inspection by enforcement officials
iv. Be supplied with specified User Information
v. Have a signed EC DoC
vi. Carry the "CE marking"

Items i - v in the above list must be complete before the CE marking is applied (item vi).

All of the items i - vi must be complete before the apparatus is "made available" for the first time to an end-user in the EU (see 2.2 in [9]).

It is important to note that being made available to an end-user for the first time in the EU, does not only mean new products. Used or second-hand products that are brought into the EU are also "made available for the first time in the EU", and so have to comply with the EMC Directive no matter how old or how large they are.

The Protection Requirements

The Protection Requirements (Clause 1 of Annex I in [1]) state the essential legal requirements for compliance with the EMC Directive, using simple terminology in the hope (probably a vain one) that this will make it difficult for lawyers to interpret them in ways other than what was intended:

> "Equipment shall be so designed and manufactured, having regard to the state of the art, as to ensure that:
>
> (a) the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment or other equipment cannot operate as intended;
>
> (b) it has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use."

Who would ever want their products not to comply with these Protection Requirements?

The costs of dealing with the resulting complaints (and the loss of possible future sales) would eat into the financial bottom line, making a manufacturer less profitable.

So even if there was no EMC Directive, the Protection Requirements above should still be applied to help reduce financial risks.

Conformity Assessment in General

Conformity Assessment is specified in Annex II of [1], and requires an "EMC Assessment" that results in a TDF that demonstrates how it is that a product can claim compliance with the Protection Requirements, taking into account <u>all</u> possible operational modes and <u>all</u> possible intended use configurations.

As I said earlier, there are two "routes to conformity" with the EMC Directive:

i. The 'Standards Route", which uses harmonised EMC test standards – see 3.2.2 in [10]

ii. The "EMC Assessment Route", which can use any EMC test standards, or none – see 3.2.3 in [10]

Conformity Assessment by Using Harmonised Standards

When following this 'Standards Route", the product's DoC must list all of the relevant harmonised EMC test standards that apply to it, which can be found in the official listing website at [12].

This route to EMC conformity requires that all these harmonised standards are "correctly applied" – *but what does "correctly applied" actually mean?*

One way is to have a 3rd-party test lab perform all of the tests exactly as described in the relevant standards, with the EMC test reports forming the bulk of the TDF. If the test lab is accredited by a national accreditation body to perform a particular test, there is more confidence that the test will be done correctly. Unfortunately my experience (and that of many others) is that not all national accreditation bodies are equal.

3rd-party testing has been very well described in [6], so I won't go into it here.

Some manufacturers (and not only the larger ones) have their own full-compliance EMC test labs, and some of them even have some/all of their tests accredited. These labs are generally best used just as if they were 3rd-party labs, as described in [6].

(In-house test labs located in the same building as the design teams can pay back their original investment much more quickly than the usual business case predicts – I have seen one such lab pay back in just 4 months!)

As much as 3rd-party test labs would like us to believe that the only way to "correctly apply" a harmonised standard is to test a product exactly according to that standard, in a lab accredited to perform that test, this is <u>not</u> the only option when following the Standards Route.

The "correct application" of a harmonised standard, actually means that a manufacturer has done enough homework to have sufficient confidence that *<u>if</u> the product was fully tested in an EMC laboratory that was accredited to test to that standard – it would <u>probably</u> pass*.

Let's be perfectly clear on this: "correct application" does <u>not</u> mean that the product has actually been tested to that standard, only that – <u>if</u> it was tested at some future time – it would probably pass.

The EMC Directive leaves manufacturers totally free to decide on the amount and quality of EMC testing they do themselves, or have done for them, to have sufficient confidence to sign their DoC when using the Standards Route.

(It is important to understand that there are no absolute guarantees in the world of EMC – even with fully-accredited 3rd-party testing, a product that passes in one test lab can fail when tested in another lab, even though nothing has changed in the product and the exact same cables are used with it. Some manufacturers take advantage of this by always using test labs that are more likely to give them a pass result!)

Here are four examples of when laboratory testing might not be required to "correctly apply" a harmonised radiated emissions standard such as EN 55022:

i. When the product emits a certain amount of RF power spread in a particular way over a particular frequency spectrum, and calculations/simulations show that if this emitted power was measured according to the relevant EMC test standard, it would be almost certain to pass (even when taking measurement uncertainty into account). For examples of this approach, see [13] [14] and [15].

ii. When the product is housed in a well-shielded and well-filtered enclosure that has been proven by shielding effectiveness testing and/or simulation to provide more than sufficient RF attenuation to ensure that if its emitted RF power was measured according to the relevant EMC test standard, it is certain to pass (even when taking measurement uncertainty into account).

Many manufacturers purchase well-shielded/filtered overall enclosures, then ruin them with modifications, completely wasting their high cost, see Chapter 5 of [16]. So an expert assessment and/or close-field probing (see vi below) is usually required to have sufficient confidence in the final assembly.

iii. When a product fails in a test lab and a simple modification applied by hand makes it pass, then applying the same modification to production units can provide sufficient confidence that if a new production sample with the modification was retested, it would now pass.

In this context, 'the same modification" means physically and dimensionally the same – for example an additional shield bond made with a screw-fixing is not the same for EMC as an additional bond made in a different place, or made in the same place with a braid strap or piece of green/yellow wire instead of a screw.

iv. When a product has passed an equivalent or tougher radiated emissions test and has not been changed (either in its hardware, software, or components).
A typical example is a product that has passed MIL STD 461 radiated emissions tests which set lower emissions limits than the relevant harmonised test standard, see [17].

v. When appropriate calculations or computer simulations [18] have been applied, which have been proven (i.e. validated) in the past to result in passes on full-compliance EMC tests, see [13], [14] [15] and [18].

This method should only be relied upon when the exact same electronic technologies and construction are used in the new product as the calculations or simulations have been validated for.

vi. When close-field probing and similar tests have been applied, proven in the past (i.e. validated) to result in passes on full-compliance EMC tests, for example by "golden product" testing, see [19], [20] and [21].

vii. "Pre-compliance" testing, proven in the past (i.e. validated) to result in passes on full-compliance EMC tests, for example by "golden product" testing, see [19] and [21].

Pre-compliance tests modify the full-compliance test methods for speed, for example if a product's emissions are under the limit line when measured with the Peak detector, it is bound to measure even less when measured with the Quasi-Peak, RMS, or Average detectors – so those time consuming tests (which are required for full-compliance testing) are not done. And a typical way of speeding up an RF immunity test is to double the frequency step size whilst also doubling the test level.

Cost can also be saved because the test laboratory does not have to create a test certificate, or even a test report. The test engineer copies the emissions plots at the time to the manufacturer's engineer(s) attending the tests, who also make their own notes, take photographs, etc., and create their own in-house test report.

There are many test labs specifically set up to provide pre-compliance testing, who do not bother with the cost of maintaining accreditation for any tests. Their lower overheads often make them less costly than a "full compliance" test lab, and it is not unusual for their test engineers to be helpful when tests are failed.

However there is no standard definition of "pre-compliance testing" so it can vary from an otherwise full compliance test that allows modification to the product during the test, right through to test methods whose only link with the full test method is that it measures the same electromagnetic phenomenon, somehow. [19] and [21] describes a wide range of alternative pre-compliance methods for the most common EMC tests.

viii. "In-house" testing. All of the various kinds of testing mentioned earlier can be carried out on a manufacturer's own premises – from close-field probing and other bench-tests, through pre-compliance to full-compliance testing. Some manufacturers even have their in-house test equipment and procedures accredited by a National Accreditation Body.

Where their National Accreditation Body does not enjoy a World-Class reputation (as UKAS does), or where the products are destined for a particular national market, manufacturers may even obtain accreditation for their laboratory testing from other National Accreditation Bodies than their own country's.

ix. "In-situ" or "On-site" testing. Very few EMC test standards allow full-compliance testing outside of a controlled electromagnetic environment (e.g. a shielded room or Open Area Test Site), but some products and many systems or installations are too large for this – or only come together on the customer's site and so can only be tested there.

For this reason, many test lab offer on-site ("in-situ") EMC testing that is considered to be as equivalent to laboratory EMC testing as practical. Guidelines on such testing have been published by the EMC Test Labs Association (www.emctla.com) in their series of Technical Guidance Notes, [22].

Even where a product or system could have been tested in a test laboratory, such on-site ("in-situ") EMC testing could be used to provide sufficient confidence that it would pass the relevant tests in a laboratory.

x. For a system integrator, using 3rd-party modules and equipment chosen from a list of Approved Components, then designing, assembling and installing the resulting system following well-proven good EMC practices appropriate to each situation, can provide a "QA-controlled, validated process" that ensures that EMC tests would be passed – if they were performed.

I first wrote about this approach, which I called "the Procedural TCF" approach, in the EMC Journal in February 1998 [23], and it still valid today – except that under 2004/108/EC there is now no requirement to have them assessed by a Competent Body. 2004/108/EC replaced Competent Bodies with Notified Bodies, who can be asked to assess a TDF but are not legally required to.

Companies using this approach often test one example of a system or installation each year as a way of proving that their EMC process still provides fully-compliant results (rather than testing every one they make, which can be unaffordable for manufacturers of one-off products or systems).

xi. Some manufacturers have large ranges of modules and other items that can be mixed and matched to provide a huge range of possible products, and might rarely construct a particular "build standard" more than once.

Analysis of their ranges (for example by using any of the methods listed above) can identify worst-cases for individual EMC tests, and if products are constructed to realise these worst-cases, and they pass their tests, sufficient confidence can be achieved that all possible build-states would also pass all relevant EMC tests, see 3.2.1 in [10] for more information on this.

An example of this is the typical modern motor vehicle, which has such a wide range of electronic options that it would be economically impossible to perform EMC tests on every possible build state.

xii. Some EMC tests can be guaranteed to be passed by design. For example, a laptop computer with its battery-backup is guaranteed by design to pass all the mains power dips, dropouts and short interruption tests in IEC/EN 61000-4-11 (as long as the battery has been maintained in reasonable health, of course, which reminds us that some good EMC design techniques require maintenance if they are to last long enough).

A product powered solely by primary batteries (or rechargeable batteries that cannot be recharged in the product), or by local energy-harvesting (such as a photovoltaic panel, wind turbine, etc.) and has no mains power supply, is guaranteed by design to pass all of the EMC tests that would apply to its mains cord – if it had one.

xiii. Using well-proven good EMC design methods, see [24], [25], [26], [27], [28], [29] and [30] for modules and products; [16], [31], [32] and [33] for systems and installations. Good EMC design often requires some aspects to be calculated or simulated (see v. above); and unforeseen problems can usually be quickly detected by close-field probing (see vi. above), ideally very early in a project when modifications cost less.

Good EMC design methods must be applied from the very beginning of a project, so may not be totally effective when applied to a new product, system or installation that modifies an existing ("legacy") product.

They may be used retrospectively to modify equipment that fail EMC tests, so they comply with the lowest overall cost of manufacture, see [34], although this may require significant redesign (e.g. of PCB design) so could cause unacceptable delays.

Correctly applying well-proven good EMC design methods from the start of an entirely new product design project is now well proven to achieve the best functionality, the shortest time-to-market, and the lowest overall cost of manufacture. This is because all electrical signals and power are electromagnetic phenomena, so using good electromagnetic design techniques automatically takes care of all signal integrity (SI) and power integrity (PI) issues as well as EMC.

It is of course possible to mix and match the above approaches, using one or several in combination to obtain sufficient confidence for one of the EMC test standards listed on a DoC; and a different approach (or combination) for another test standard.

Where no test standards are listed for a particular EMC issue on a DoC (using the "EMC Assessment" route), the above approaches can also be used individually or in some combination to demonstrate that the Protection Requirements will be complied with.

Manufacturers using alternative techniques such as the above should of course thoroughly document what they do in the product's TDF, and are usually recommended by EMC consultants like me to have at least one product tested for full-compliance using accredited test methods (where practical) at least once every year, as a check on their EMC compliance processes.

If any non-compliance is found, the alternative techniques that were used are modified accordingly, so that they ensure compliance once again.

In fact, to help ensure QC of EMC in serial manufacture despite all the issues I listed earlier, many larger companies test at least one example of each product they manufacture at least once per year – even when they have not changed its design, replaced any components or fixed any software "bugs".

If a manufacturer has his own test laboratory, and if it is accredited for all of the applicable tests (or they have good reasons for knowing their tests are as good as if they were accredited by a 3rd-party), they have no need to spend money on 3rd-party testing.

Chapter 3.2.2 of [10] provides very good guidance on the Standards Route, and states that where a product follows this route there is no legal requirement in the EMC Directive to perform the EMC Assessment process outlined below.

Unfortunately, even when full testing is done in a lab that is accredited for that test, and passed, it might not ensure compliance with the Protection Requirements in real-life operation, which is, of course, what really matters for compliance with the EMC Directive – and also (more importantly) for financial success.

This is because no harmonised test standards cover all of the EM disturbances that could occur in real life. Also, it is because the tests have been specifically developed to ensure repeatability in testing, which can often mean they are simply not representative of real-life EM disturbances.

Also – given the inevitably slow pace of international standardisation – all published standards are behind the times. For example: none of the harmonised immunity standards cover the very close proximity of cellphones, e-book readers, Wi-Fi transmitters, RFID transmitters (including active RFID tags), etc., even though such proximity is now a normal "…*electromagnetic disturbance to be expected in its intended use*…".

Immunity to the *near-fields* (see [35]) that can be created by portable RF transmitters in very close proximity is arguably now a necessity for legal compliance with the Protection Requirements, even though not tested by any harmonised standards.

Many manufacturers regard EMC compliance as a regulatory issue that they don't want to spend any more money and time on than they have to, but this is missing the whole point. Think for a minute about what I said earlier in the section on Protection Requirements – if products don't comply they are less likely to be financially successful. If they have big problems with EMC in real life, they could even do irreparable damage to a manufacturer's brand image and future profitability. Some companies have even been bankrupted by real-life EMC problems.

The real reason we need to achieve EMC compliance, is to have products that work well enough in real life and don't upset customers. Achieving this is important to help control financial risks, and so what if we have to produce a few pages of legal documentation for EU sales, when it merely covers EMC work we have already done?

And if method xiii above (i.e. using well-proven good EMC design methods) is applied correctly, the very real financial risk benefits of EMC compliance will almost certainly be achieved more quickly, with less investment and greater profitability than if EMC was ignored.

(Looked at from this perspective, we can see that the manufacturers who ignore good EMC design and sell non-compliant products in the EU, thinking they are being clever by relying on the low level of market surveillance on EMC compliance, may not actually be maximising their profits as much as they could.)

For these reasons, when following the Standards Route, in addition to "correctly applying" all relevant harmonised standards, I always recommend performing a full EMC Assessment as below, then doing *whatever else it takes* to ensure conformity to the Protection Requirements. This can sometimes be as quick and easy as a check for emissions or immunity using a close-field probe [19], [20].

Note: When following the Standards Route, the DoC should <u>not</u> state that the listed harmonised standards have been tested and/or passed. Generally, it is much better for the DoC to say something like: 'the following standards have been applied", which means: if/when you test this product to any of the standards listed here, they will probably pass.

Conformity Assessment by *Not Using* Harmonised Standards

This is the other "route to EMC conformity" permitted by the EMC Directive – the "EMC Assessment Route".

When following the EMC Assessment Route, a manufacturer declares the EMC conformity of his apparatus directly to the EMC Directive's Protection Requirements, using just some of the relevant harmonised standards, or just some parts of some harmonised standards, or even ignoring all harmonised standards completely.

The EMC Assessment Route must follow a specified technical methodology to ensure that the Protection Requirements are met.

According to 3.2.3 in [10], the EMC Assessment Route is usually more appropriate than the Standards Route in the following situations:

- Where the Protection Requirements are not entirely covered by the application of the harmonised standards that are relevant for the product
- The apparatus uses technologies incompatible with, or not yet taken into account by, any harmonised standards
- The manufacturer uses test facilities not yet covered by harmonised standards
- The manufacturer prefers to apply other standards or specifications (even in-house specifications) that are not harmonised under the EMC Directive
- The apparatus is physically too large to be tested in the facility specified by a relevant harmonised standard, or where "in-situ" testing is necessary (e.g. for systems or installations that are first assembled on the end-user's site) and is not adequately covered by a harmonised standard

Of course, a manufacturer may choose to follow the EMC Assessment Route simply to save time and money – which is often the case for start-up companies who cannot afford the cost of laboratory testing.

This alternative conformity route is essentially the old 'technical Construction File" (TCF) route under the first EMC Directive (89/336/EEC) – but with the significant difference that now there is no legal requirement for any TDFs to be assessed by a 3rd-party (see Notified Bodies, later).

Non-harmonised methods of demonstrating conformity with the Protection Requirements, that may be able to be used, either singly or in suitable combinations, as part of an EMC Assessment Route include (but are not limited to) the list of alternative techniques i – xiii in the previous section,

The EMC Assessment Route's technical methodology includes (but is not limited to)—

a. Assessing the EM environment(s) normally expected at the user(s) location(s), taking into account (see [36]):
    - The likely proximity to sensitive equipment that the product's emissions could interfere with;
    - The likely EM threats that could interfere with the product, plus the degradation of functional performance that the user will accept when it is interfered with.

b. Create the EMC specifications for the product.
    To help make life easier, these often use modified versions of harmonised standards, basic IEC test methods (see [6]), other EMC standards (automotive, military, aerospace, etc.),

and/or guidance for systems and installations such as [16] [31] [32] or some of the many references they contain.

c. Verify and/or validate the product's design against the EMC specifications.
As before, the relevant verification and validation techniques include – but are not limited to – EMC testing (see the list i – xiii above).

d. Assess the actual EMC characteristics of the product over the entire frequency range (not just the limited range covered by the test standards). For example by using close-field probing to discover the highest frequency at which the product's emissions can be detected.

CE + CE Does Not Equal CE

Constructing systems only from items that are CE-marked, and *mistakenly* assuming that *this alone* takes care of the EMC compliance of the overall system or installation, is often called 'the CE + CE = CE approach." Which simply doesn't work!

This incorrect approach is very widely used by system integrators, installers, and major contractors. However, it is easy to show that, technically and/or legally, this approach should never be relied upon, and Chapter 1.2.2 in the official guide [10] contains a specific warning against using it. More detailed information on this is given in Chapter 1.5 of [16], Chapter 2.3.4 of [31] and Chapter 2.3.3 of [32].

Note that the "CE + CE = CE approach" is also incorrect technically and/or legally for most, if not all other EU Directives, including [3] and [11].

Conclusions and More Information

I could write a great deal more about cost-effective EMC compliance, but I've covered the main issues within the scope of my title, and wandered around a bit into some related issues as well, so I should stop soon.

Some parts of this article appeared previously in a different format, in [38].

To find out more about related issues, here are some excellent sources of free information —

- Employing Notified Bodies – see Chapter 6 of [10], [6] and [37]
- Creating and maintaining the TDF (Technical Documentation File) – see Chapter 3.3 of [10], [6] and [37]
- The EU EMC DoC (Declaration of Conformity) – see Chapter 3.3 of [10], [6] and [37]
- Correctly affixing the CE Marking – see Chapter 3.4 of [10] and [37]
- The EMC information legally required to be provided with each apparatus – see Chapter 3.4.4 of [10] and [37]
- Maintaining EMC compliance in serial or batch manufacture – see [37]
- Maintaining EMC compliance when the harmonised standards change – see Chapter 3.2.2 of [10], [6] and [37]
- EMC compliance of custom-designed "apparatus intended for incorporation into a given fixed installation, and not otherwise commercially available" – see Chapter 2.5 of [31]
- EMC compliance of "Fixed Installations" – see [31]

- Market Surveillance of EMC compliance by EU Member States – see Chapter 7 of [9]
- Compliance of used or second-hand apparatus – see Chapters 2.1, 2.4, 3.1 and 4.5.1.6 of [9]

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Conformity magazine has closed down, and (very unfortunately) its archives are no longer available on-line. However, the author will be pleased to email anyone a copy of the revised version as published in 2009.

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The above URLs are correct at the time of writing. However webmasters regularly change their websites with no thought for the links they are breaking and the valuable connections they are losing. I am told this is because they have no experience or understanding of the professional engineering world, in which information more than 6 months old can still be useful.

If you find a link to the above references is broken, a good search engine primed with the title and/or author and/or publication and/or date should find the document.