The following is an extract from our "Global certifications for makers & hardware startups" eBook. So there are references and links to other sections of the book that only exist in the full version. Grab a copy here if you need it.

Unintentional Radiator Testing Process (FCC)

I'm going to describe the full testing process to you as if you've never been through it before. This includes products subject to the verification and DoC authorization procedures that I discussed in the section above. Usually this applies to devices which either don't incorporate a wireless transmitter OR devices that incorporate a pre-certified wireless module (and you adhere to all of the guidelines within the existing modular certification grant so that you don't invalidate the certification).

Step by Step

1. Contact 3 labs and discuss the project

It's important to get a dialogue going with a lab so that they can get a feel for your project. They may give you advice on the required software/hardware configuration, auxiliary equipment, cabling and a host of other information.

2. Get quotes from 3 labs

The labs will also need to discuss the function of your product, the target geographic markets and the ports that your product has (e.g. power port, USB port etc...). Using this information, they will determine which tests are necessary and will create a quote.

It's important to note that you may get differences in test schedules between labs that lead to wildly different quotes. One lab may have incorrectly stated that a particular test is mandatory, while another lab may have inadvertently missed including a mandatory test on the list. If you see a discrepancy between quotes, talk with the labs about why they included/left off a particular test and determine who was correct. This is why it's important to get 3 quotes.

3. Select lab based on criteria talking about in 'selecting a test lab' section

Consider not only the quotes, but also the criteria I outlined in the 'selecting a test lab' section. If your product fails a test, the upfront cost of a test schedule may pale into comparison compared to hiring a consultant and re-test fees. It's worth thinking about this eventuality carefully and consider what a test lab can bring to the table.

4. Send in a prototype or pre-production unit for pre-scan (optional)

Many hardware manufacturers choose to have what's called a 'pre-scan' of their product by the 3rd party test lab. They do this with a prototype version of their product rather than pre-production unit so they can get a grasp of the potential scope of issues that the product may face at the lab. It's essentially

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an exercise in risk reduction. That way, if they run in to issues during a pre-scan, any required changes can be rolled in to a later version of hardware that was already scheduled.

Many companies just pre-scan radiated and conducted emissions, but you can also request a pre-scan of any other aspects of your device that you suspect may be an issue during final certification testing. For example, if your device is destined for Europe where immunity testing is needed, and you're concerned that ESD testing may affect the operation of your product, you could request an ESD pre-scan. The lab may be able to advise you on the potential risk areas for your product.

Labs generally do pre-scans in 4 hour blocks, so it's up to you what you have done in that time.

5. When product is fully functional + mechanically sound, send unit in for finals testing.

For what's normally referred to as "finals" testing, you should have your product fully functional and in the correct enclosure. The enclosure can have an effect on the emissions from your device, so it's important that you provide the lab with an enclosure of the same material type that you're going to be selling. Small variations to non-conductive enclosures are probably ok, but a change from conductive to non-conductive or vice versa would be very risky and would likely invalidate any testing that is undertaken on your product.

Additionally, your product should always be operating in 'worst case' mode, which means all functions of your product are operational and running at 100%. This may mean that your motors are running, LCD display is being updated constantly and DDR memory is running continuously. Manufacturers often create a special purpose test software/firmware version to exercise the full functionality of their product during testing. The risk of not doing this is that the test lab may not measure worst case emissions and your product could be found to be non-compliant in the field.

6. If your product fails, troubleshoot and fix issues

Approximately 50% of products fail EMC first time according to Intertek Labs, one of the larger lab groups in the world. If your product fails, you can either try to fix it during the test schedule or take it back to your office. Depending on the nature of the failure, you may get (extremely) lucky and manage to fix it within the allotted time, or more likely, you'll need to investigate the failure back at your office. It's beyond the scope of this eBook to get into EMC troubleshooting techniques; there are plenty of textbooks on that subject.

Let's assume that you've fixed the issue. Depending on which test your product failed and the scope of the modifications to the product, you may have to:

(a) Re-test only the test(s) that failed
(b) Re-test all of the tests

The deciding factor is usually whether you perceive that the changes you made could negatively affect the results of the previously successful tests. There is a discussion on this topic on the section below.

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7. Once you've passed, test lab will generate test reports.

The test lab generally takes 5-10 days to generate a test report. For "verification" and "DoC" authorization routes, no further action is required other than marking your products and packaging correctly. You can go ahead and start marketing and selling your product. For "certification" authorization routes, your test report must be submitted along with a full application (see appendix A for typical documents required) to a special test lab called a "TCB" (Telecommunications Certification Body). The TCB then reviews the test report and application package. Assuming all is in order, they will issue the certification within 2-5 days. I cover the certification route in detail in the next section.

8. Assuming there are no other approvals required, now you're at liberty to affix FCC/CE labels and sell/import your product.

9. FCC Form 740

If your product is being manufactured outside of the US, you may need to fill out Form 740 for the FCC. This will be checked at customs and your shipment may bounce back or be held if the document is not present.

What Hardware and Software Configuration do you Need to Provide?

One of the most common delays to certification is when a manufacturer doesn't provide all of the required hardware, software, firmware, auxiliary equipment or cabling to the 3rd party lab. If you want things to go smoothly and avoid delays to the start of testing, you should make sure that you have everything in order.

Here's a non exhaustive list of items you will need to provide:

Hardware

1. At least 1 device for testing purposes. 2 or 3 devices would be better in case one malfunctions or is damaged during susceptibility testing.

2. Any auxiliary equipment required to exercise the full functionality of your product. This may include a laptop or power supply etc. Note that if all ports (e.g. USB, Ethernet etc.) can be fully functional in normal usage, then they should also all be enabled and functional during testing.

3. Real or dummy loads. If your equipment provides drive signals to other equipment, provide either a typical real load or a dummy load to simulate a real load.

Software

1. Test mode software/firmware that exercises all of the internal and external interfaces to the maximum extent that would be possible in normal usage.

2. For immunity testing, (for Europe and other international product standards) a method to monitor the performance of your product. This may be an on screen display of measurements or a program running on a separate machine that verifies your equipment is operating as it should.

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3. To make the test schedule go smoothly, it's advised that your equipment boots up as quickly as possible. It's often the case that the lab will want to switch your equipment off and on to check whether an emissions is being generated by your product (especially when being tested at an OATS). If the equipment boot up time is in the order of minutes or requires lots of human input to get it into the correct mode, the testing can take much longer.

Cabling

1. For emissions testing, all I/O ports should be loaded with a cable. For FCC testing, the minimum cable length is 1 meter. For other standards, the rules can vary. Contact your test lab for confirmation of required cable lengths for your product.

2. Shielded/suppressed cabling. As a precaution, I would also recommend giving the lab shielded versions of your cables and/or cables with ferrite noise suppressors. If your product fails testing with unshielded cables, but passes with shielded/suppress cables, then you can most likely still be able to sell your product if you ship it with shielded cables.

Timescales

Testing for a simple verification or DoC authorizations can take as little as one day. Once the test lab informs you that the device passed, then you can go ahead immediately and start marketing and selling it. The test lab will follow up in a few days with your completed test report which you must archive in case authorities request to see it.

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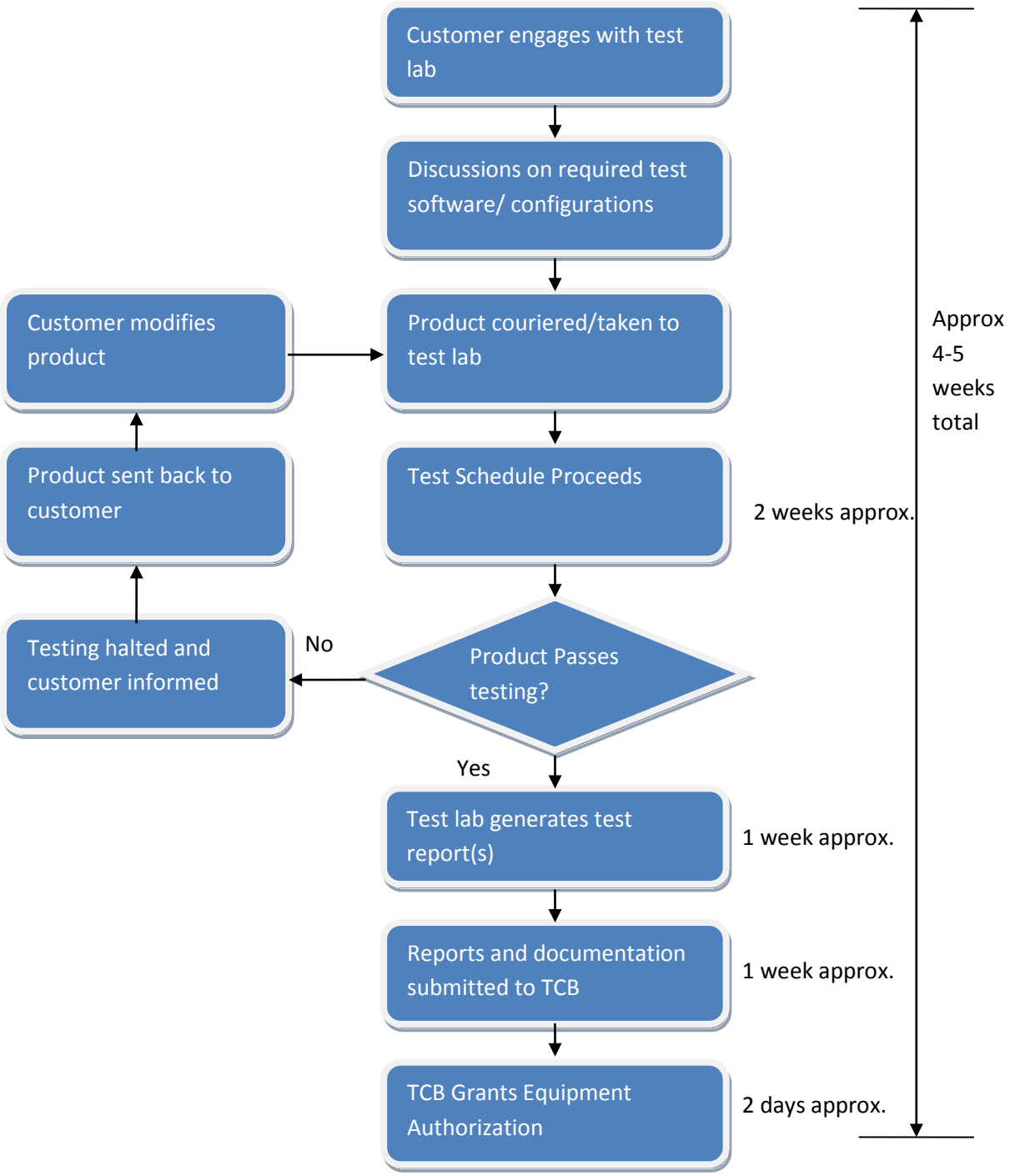
Intentional Radiator (Wireless) Certification Process (FCC)

Overview

Here we'll concentrate on the certification authorization route. Note that transmitters subject only to verification, follow the same procedure as defined in the unintentional radiator process described above instead.



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Step by Step

The procedure is almost exactly the same as the procedure described for unintentional radiators above. The main difference is that the test reports need to be submitted along with supporting documentation to a TCB. The documentation is described in Appendix A of this eBook. You also need an FRN number from the FCC so that they have you in their system.

What Hardware and Software Configuration do you Need to Provide?

You can add several days delay if your product is not properly configured for testing. It's crucial to get your hardware and software/firmware package correct, especially for wireless devices.

Hardware

1. A fully functional production or near-production unit with all necessary ancillary hardware to operate the unit to the full extent of its capabilities.

2. Testing or modifying units for testing purposes can occasionally be destructive to the equipment under test, so two units are recommended.

3. If possible, one unit should be modified with an SMA connector so that conducted RF measurements can be made.

Software/Firmware

1. Software control, or means to program the transmitter frequencies among all available channels. At a minimum, the test lab will need the ability to individually select the highest, middle and lowest channels within the band.

2. A unit that is capable of selecting between all modulation modes and data rates.

3. If the unit is only intermittently transmitting, provide a means to enable transmission 100% of the time.

4. If the unit transmits several different packet sizes, provide a means to select between the smallest, medium and largest packet sizes.

5. If your transmitter is also subjected to immunity test requirements (Europe and other international wireless standards) then provide a means to detect whether the wireless link remains operational. In some cases you may also need to provide a means to monitor the BER (bit error rate) of your communications link.

Timescales

A typical test schedule for a wireless transmitter should only take between 3 and 7 working days. As you can see from the overview diagram though, the additional time for other items can easily add up. Budgeting 4-6 weeks for a wireless certification would be about average. However, the main threats to schedule come from a few sources:

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1. **Test Failure**

If your device fails testing, the time it takes to debug, re-manufacture (in some cases) and to re-test the product can easily be in the order of weeks. You really want to make sure that your equipment passes first time. EMC FastPass provides online training for wireless pre-compliance testing so that you can make sure you've nailed the design before sending it for certification.

2. **Submission Package**

If your submission package isn't perfect, it will be bounced back from the TCB. By perfect I mean you need to make sure that absolutely every document you provide is consistent and the forms are filled out correctly. Very common errors include model numbers and FCC ID numbers being inconsistent between labelling and other documentation. Other common issues include missing documentation and blurry photographs of the circuit board(s). I can't stress enough that you cannot half ass this submission package. The more care you take to create the package, the smoother the certification will go.

It isn't uncommon for submission packages to be bounced back from the TCB two or three times before it is accepted. This can easily add a couple of weeks to the total certification time. You should also be aware that TCBs often have a maximum number of submission package reviews before they start charging for extra reviews.

3. **Test Lab Lead Time**

Busy test labs can have a lead time of 4 weeks or more. If you need to use a particular test lab, it's best to book as far in advance as you can.

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EMC/RF Certification Process for Other Regions

Canada

The procedures for entering the Canadian market are almost identical to the US. There are a few subtle differences that your test lab will inform you about, but for most companies, the guidance given above will also gain you entry into the Canadian market.

One key thing to ensure is that the test lab you select is registered with Industry Canada as well as the FCC. Otherwise your test reports may not be acceptable for importing products into Canada.

Europe

Many test labs will be able to undertake EMC, RF and safety testing for Europe at the same time as your FCC test schedule. Confirm this beforehand though, as some test labs do not have the test equipment available to undertake some aspects of European testing such as immunity testing.

Overview

For the purposes of showing you a step by step procedure on how to show compliance with the European rules, I'm going to focus on the conformity assessment procedure that uses EMC harmonized standards. For the EMC directive, this is only one of 3 potential assessment procedures as you can see from the diagram below. The harmonized standards method is the one that is most widely used, so I'll focus on that. If you are interested in the other methods, see section 3.2 of the general guide for the EMC directive for further information.

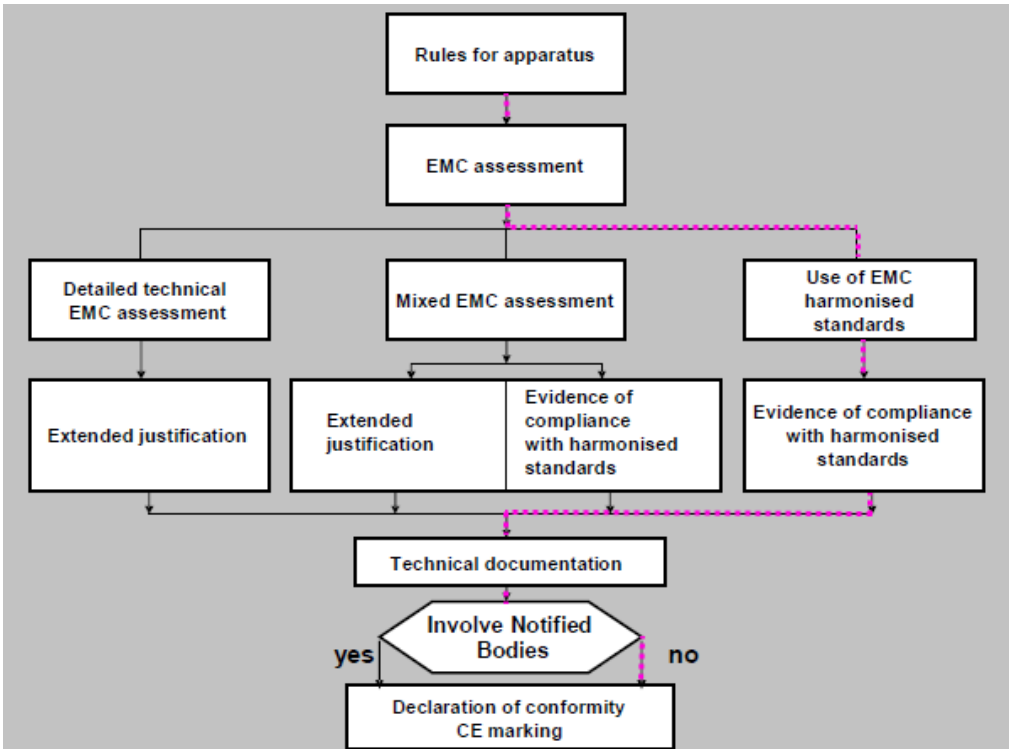

Figure 1 - CE Mark Conformity Assessment Routes

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Step by Step

1. Identify the harmonized standards that apply to your product

Harmonized standards sit below the directives to allow manufacturers to claim compliance with the directives. The standards are the documents that contain definitions of test requirements that will be applied to your product. You can follow the section on how to work out standards that apply to you or go find out at the EMC standards finder tool from EMC FastPass. Usually, several standards are required to cover all of the requirements of the EMC directive. These may include: high frequency emissions, low frequency emissions and immunity to EMC phenomena.

The correct application of the relevant harmonized standards is equivalent to the carrying out of a detailed technical EMC assessment.

3. Evidence of compliance with harmonised standards

The evidence of compliance with the harmonized standards usually takes the form of test reports from a 3rd party test lab. If you have your own in house lab, then the evidence may come from that. You can even do some tests yourself and outsource some to a 3rd party lab.

Your product needs to be tested in a worst case scenario. This usually means that the highest level of functionality is tested (applies if you have a family of derivate products with lower functionality).

4. Technical documentation

It is your responsibility as manufacturer to collate the technical documentation and keep it in a file for at least 10 years. The documentation should contain:

- An identification of the product
- A general description of the product (e.g. a manual)
- Evidence of compliance (e.g. a dated list of the harmonized standards applied and the results obtained)

6. DoC and CE Marking

Now you need to declare that your product complies with all of the requirements of the relevant directives. You do this by creating a DoC (Declaration of Conformity). It is issued by you, the manufacturer, and nobody else. You can find a template of a DoC here (page 3). You also need to physically apply the CE Mark to your product and packaging. The WEEE logo may also be required (see earlier section).

The DoC needs to travel with your product when you import it. The package may be blocked at customs without one.

That's it!

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Note that the process above covers only the EMC directive. For other applicable directives such as for wireless devices (R&TTE directive) and safety (Low Voltage Directive), the process is usually much the same. Get confirmation from an accredited lab on the exact process for your particular product.

For further detailed instructions, refer to the general guide.

Other Regions

For other regions I haven't mentioned, sometimes it can be as simple as asking your test lab to perform any additional testing at the same time. There may be slightly different limits to emissions or immunity requirements, but these can usually be rolled in to your existing test schedule as long as the requirements are discussed up front.

RF (wireless) requirements and certifications tend to vary more than EMC between regions because frequency band allocation can differ significantly between regions. If your wireless device will be sold around the world, it's definitely worth your time to contact a test lab early in your development cycle to ensure that your chosen wireless solution is capable of meeting the requirements of every region that you intend to sell into. They may give you advice on the available unlicensed frequency bands, and maximum radiated and conducted output power that you can legally use.

Some regions are tougher to access than North America and Europe. For example, in some regions, you may need to hire a local representative to import and take responsibility for the compliance of your product. In others, such as China (in some instances), you may need to use an approved test lab within their borders. They may also mandate an annual inspection of your production facilities to ensure ongoing compliance.

When you enter multiple markets, it is really best to approach a test lab familiar with many international approvals. Another potential source of assistance for entering specific markets is a "type approval specialist". Just search Google for that term along with the name of the region in question and some help should pop up.

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