How to get EMC matters into Good Order with your Clone Micro Computer

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Abstract: Electromagnetic interference and disturbance, with regard to electronic equipment, have been under scrutiny for the last few years. Information material regarding EMC has been distributed in many different ways and the field's testing services have also been extended. Considering all these opportunities for gaining information and obtaining testing services, it has therefore been very surprising to learn how common it is to find microcomputers on the market which have serious defects regarding EMC aspects. It is also, a fact that interference problems can be detected and corrected with some planning and very little trouble.

Last year, the Finnish EMC market surveillance authority prepared a study of 24 different makes of microcomputer and only in two cases did the interference level remain beneath maximum level EU norms. In seven cases, excesses were so great that sales bans had to be issued on the products. As is customary in these cases in Finland, all the incurred costs of banning were consequently carried by the manufacturers. This fact goes someway towards underlining the message that manufacturers are totally responsible for the planning for and insulation of EMC releases. This paper hopes to give a basic format as to how EMC matters should be handled with regard to microcomputers and how related problems can be avoided.

Introduction

Electromagnetic compatibility means the ability of a device, unit of equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. The EMC directive has been mandatory since 1st January 1996 and it requires that the national authorities of every Member State of the European Union must monitor their market. The supervision of electrical equipment in Finland is based on rules provided for by the Electrical Safety Act. This means that the manufacturer is responsible for the conformity of the product, while the relevant authority, using available market surveillance means, attends to the safety and conformity of products manufactured for sale. Surveillance of most of electrical equipment in Finland is the responsibility of The Safety Technology Authority of Finland (TUKES). The Authority for radiotransmitters and equipment intended to be connected to the public telecommunications network is The Telecommunications Administration Centre (TAC).

In Finland the market surveillance authority continuously selects various pieces of electrical equipment for testing. According to the Electrical Safety Act, The Safety Technology Authority is entitled to receive a necessary number of product samples for testing purposes. The Finnish Authority, in fact, makes random purchases at current retailer prices. In cases when they are proved to be in non-conformity with the regulations repayment for the purchase and the cost of testing is demanded.

The Safety Technology Authority of Finland uses competent testing laboratories for the testing, and takes the necessary action depending on the defects which have been discovered. Among the most severe sanctions is a withdrawal from the market and even from consumers or a destruction order for the entire product lot. Furthermore, a ban on sales of any defective product may become effective immediately - even prior to testing. Should tests reveal any defects calling for the limitation of a product's free movement, testing costs can be charged to the company which is responsible for putting the product on the Finnish market.

The technology of PCs is burgeoning and the life time of new manufacturing series is only a few months. A whole set of EMC tests for every new PC system is time demanding and expensive. For that reason the computer industry has understood the EMC directive so that assembling only CE marked plug-in cards, power supplies and other components the whole system meets essential protection requirements of the EMC directive. In the directive there is no mention of that matter. The former guidelines of the EMC directive said that CE+CE=CE but new guidelines on the application of the EMC directive [1] abolish this procedure at the product level such as inside the central unit of computer (CPU).

What is the interference caused by PCs?

Fax machine reception problems, cordless telephone background noise, TV picture and sound disturbance - these are the most common interference sources that our Authority is faced with and which have been proved to be caused by microcomputers.

These electromagnetic interferences occur when two pieces of electrical equipment are used simultaneously and one or both

of them issues disturbance signals. In the worst cases, one problem piece of equipment may course even a dangerous situation in which the delicate electronics of equipment are damaged or the equipment produces a dangerous misfunction. For example, this is the reason that use of portable microcomputers is forbidden during the take off and landing of aircraft.

What is the EMC directive?

The main purpose of EU directives is to make possible and simple the free movement of goods within the European market area. Directives are European regulations which each EU country is bound to accept into their own laws.

Responsibilities

It is said in [2] that the manufacturer is any natural or legal person who is responsible for designing and manufacturing a product with a view to placing it on the Community market under his or her own name. The responsibilities of the manufacturer apply also to any natural or legal person who assembles, packs, processes , or labels ready-made products with a view to their being placed on the community market under his or her own name. Further, the responsibility of the manufacturer is placed on any person who changes the intended use of a product in such a way that different essential requirements will became applicable, or substantially modifies or re-builds a product.. The responsibility of the manufacturer does not depend on or end with the fact that he or she uses CE-marked components for making his or her own product.

It is stated in [1] that a PC composed of a CE marked CPU, keyboard, printer and monitor, not intended to be placed together on the market as one single functional unit, does not need additional CE marking or Declaration of Conformity. However, if the units are put together by the same person and placed on the market as a single functional unit, the system manufacturer must provide the system with an EC Declaration of Conformity, and the instructions must refer to the system as a total unit. A computer CPU, composed of a power supply, CD-ROM, mother board and disk drive supplied in an enclosure is regarded as an apparatus and therefore subject to the EMC Directive. So, the clone micro assembler is always a manufacturer with a manufacturer's full responsibilities.

There is no common playing field for PC integrators in Europe. PC builders have two ways to show compliance with the EMC Directive: 1) Self certify to harmonised standards. 2) Construct a Technical Construction File (TCF) which must contain a report or certificate from a third part (Competent Body). PC integrators doing things the "right" way were paying the commercial price for doing so and they cannot compete on price nor have the latest development incorporated, because the EMC compliance loop takes time.

Special EMC features for PCs

The limits of electromagnetic interference (EMI) for personal computers are given in standard CISPR 22 [3] or its corresponding European standard EN 55022 [4].

The effect of the EMC test load

A PC enclosure normally contains a switch mode power supply system and a filter which is designed for reducing the low and middle frequency range EMI emissions caused by the power supply. In [4] it is not said, what kind of load the power supply must have during EMC tests. Plug-in cards have direct function and they can be separately placed on the market, so, they must be CE-marked. A plug-in card, which causes high frequency range EMI, can be tested inside a PC enclosure, which has much better high frequency filtering capacity than another EMC emission tests fulfilled enclosure. For this reason, when choosing an enclosure and plug-in cards, it is very important to check what kind of test arrangements were in place when they were EMC tested.

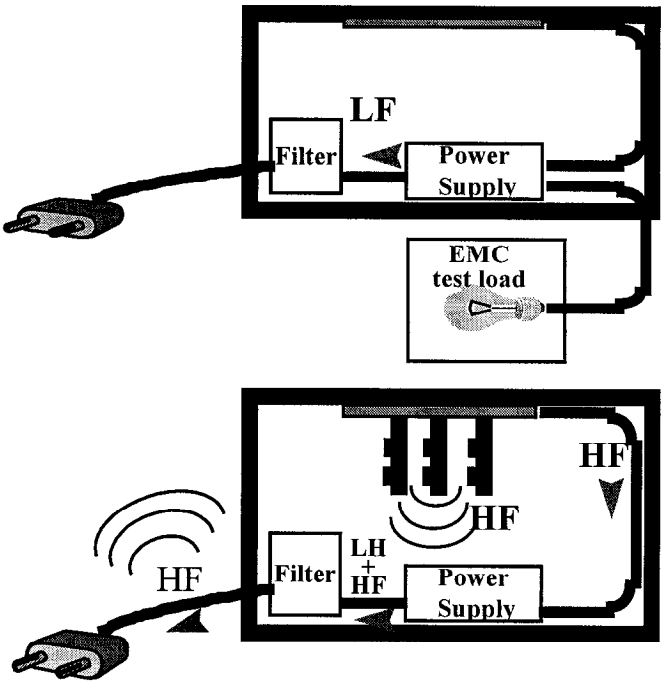

Figure 1. The effect of EMC test load

Software EMI reduction

There are many possibilities as to how to reduce the EMI emissions of PCs. For example, [5] shows a Spread Spectrum Clocking (SSC) technique which spreads EMI energy over a wider frequency range. Instead of maintaining a constant frequency, SSC modulates the clock frequency/period along a

predetermined path. That can reduce emissions from critical frequencies of more than 8 dB [5].

The opinion of market surveillance authorities regarding that kind of software based EMI emission reduction is not clear, because the user can very easily turn off the modulation.

FCC open-enclosure regulations

As the speed of PCs continue to increase, it is becoming more difficult to design a shielding structure (enclosure) to contain high-frequency EMI radiation. To facilitate PC system integration, The Federal Communication Commission (FCC) imposed an open-enclosure requirement on board products. The open-enclosure regulation, 6 dB above close-enclosure spec line, requires that the top and at least two side panels be removed during the open-enclosure compliant test. This measurement procedure eliminates emission difference due to enclosure containment, and emphasizes the need for minimizing emission at radiation sources, including high-speed processors and motherboards. Even with the 6 dB spec relaxation, it is generally more difficult to meet the open-enclosure requirement. Therefore, further EMI suppression techniques are needed to comply with FCC regulation. [5]

The effect of a thin enclosure

Fig. 2, 3 and 4 show radiated EMI emissions from a PC CPU with closed, thin and open enclosures [6].The spectrum in Fig. 2-4 is measured from 10 meters distance using a peak value detector. The greatest interference frequencies were measured using a quasi peak detector, as well.

Comparing these Figures, it can be seen that the radiated emissions from the PC CPU with a thin enclosure is distinctly more than from the one with closed enclosure. In the worst case, the difference is 13 dB at a frequency of 832.9 MHz. The half of the wave length which corresponds to that frequency, is 18 cm.

EMC market surveillance tests for PCs in Finland

The Safety Technology Authority of Finland observed through the EMC market surveillance project that most of the micro computers on the market did not fulfil the EMC requirements for radiated EMI emissions. In the project, 24 micros were tested. Half of them were lent to The Safety Technology Authority and the other 12 PCs were Authority purchased.

The Experimental Setup

The test was performed according to the test specification EN 55022:1994 by using an accredited test method. This study concentrated on the radiated emission phenomenon. A preliminary test was performed in an absorber-lined shielded

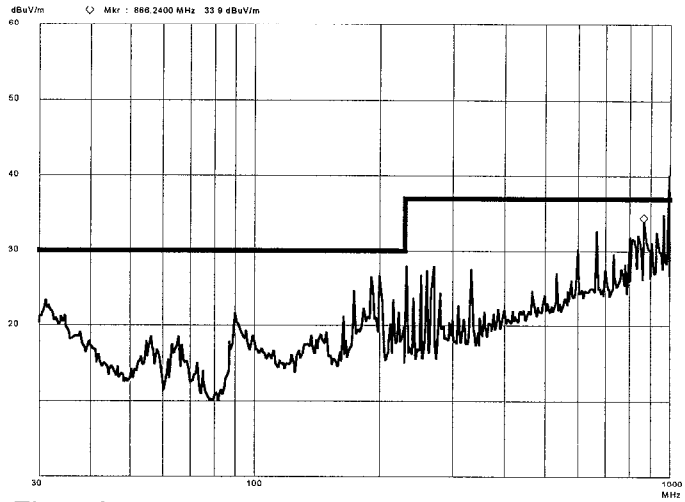

Figure 2. Radiated emissions from PC CPU with a closed enclosure. [6]

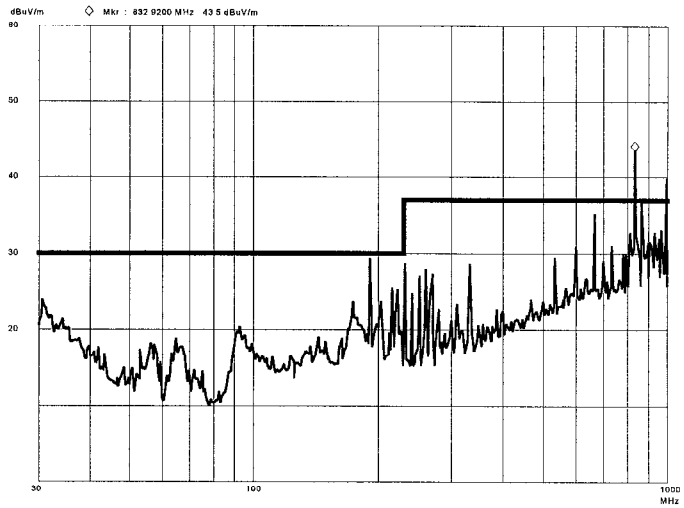

Figure 3. Radiated emissions from PC CPU with a thin enclosure. [6]

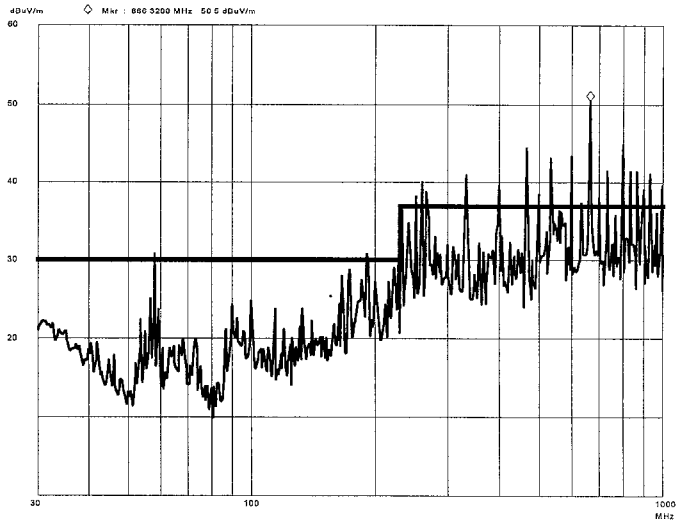

Figure 4. Radiated emissions from PC CPU with an open enclosure [6]

room and the final test at an open area test site or in the screened half anechoic chamber of Emcec Ltd. In both the test sites, the final measurements were made in the same way. During the final test the distance from the EUT to the measuring antenna was 10 meters. For the duration of the final test the EUT was placed on a non-conductive table 80 cm high standing on a turntable as shown in Fig. 5. The excess length of the cables of the EUT were made into bundles of 30-40 cm length. In order to discover maximum levels of disturbance radiation the angle of the turntable, the height of the measuring antenna and the lay-out of the EUT cables were varied during the test. The test was performed separately with the measuring antenna in both horizontal and vertical polarization.

The peripheral devices were the main unit, monitor, mouse, keyboard and two speakers. The EUT was in normal operating mode during the measurement. When performing the test the microcomputer was continuously printing two rows of letter H on the display of the monitor and also storing a file from the disk drive A to the hard disk drive C and vice versa. The measurement antenna received the electromagnetic interference (EMI) that the EUT radiated. The receiving antenna was connected to the measuring receiver by an RF-antenna cable. The measuring receiver directly showed the field strength that the EUT radiated.

The measuring frequency was from 30-1000 MHz and the distance from the EUT to the receiving antenna was 10 meters. According to the standard EN 55022, the greatest acceptable field strength in the frequencies 30-230 MHz is 30 dBμV/m and in the frequencies 230-1000 MHz it is 37 dBμV/m.

During the measurement, the EUT was rotated through 360^0 using the turntable to find the maximum emission direction. The receiving antenna was scanned at a height of 1 to 4 meters and varied in horizontal and vertical polarization so as to find the maximum emission level at each test frequency.

Results

The results of radiated EMI tests are shown in Table 1. As can be seen, only two PCs fulfilled norms the first time. Three PCs could be readjusted with small corrections. In seven cases excesses were so high that sales bans had to be issued. The sales ban decision was affected by the extend of excess radiation, the amount, and the wave-length the system was using when the disturbances became apparent.

Many PC integrators rely on their component suppliers to provide the necessary expertise and documentation to show compliance with the EMC Directive. This in itself causes problems, as there is as yet no consistent approach to using component data to demonstrate compliance on a completed PC. According to the measurements of this study, a PC which consists of CE marked components and equipment, can radiate excessive interference. The results indicated that the emission magnitude of most of the PC systems studied exceeded set limits. In addition, the results indicated that the equation CE+CE=CE is not true. The results support the EMC directive guidelines according to which the CE+CE=CE approach is not possible at the product level.

According to results, the bus speed of the motherboard is a more significant cause of emissions interference than the clock speed of the processor.

The root of the problem in clone micros

Many companies whose business it is to assemble clone micros are under the false illusion that their products comply with all the demands of the EU when all the components used are marked with the CE label. This is just not the case. The CE label itself is not enough to make the component compatible with the demands of technical requirements. Putting the label itself on a component does not make it acceptable, even if the component producer mistakenly believes it does.

The manufacturer who purchases components from external sources has a responsibility to check their quality and demand complete documentation relating to the components he uses. Even if the CE label is correctly marked on components, it does not guarantee that a central unit assembled from such components automaticly fulfils all requirements. A clone micro assemble company is also a manufacturer who has full responsibility for the quality of his products and for seeing that all the requirements demanded by the CE directive have been observed.

How can root problems be corrected?

Radio interference should always be tested for whenever parts of casing, power supply or motherboard combinations are changed. Simple processor changing does not normally demand new testing unless the motherboard has been altered in some way. The new resonances of busses and processor should, however, in these cases be carefully monitored.

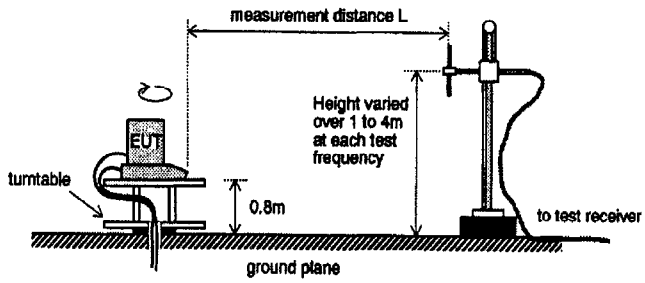

Figure 5. The setup for the radiated emission test.

Table 1. Tested PCs and summary of results

Manu-facturer	Clock frequency of prosessor	Test date	Biggest excess, (Quasi-peak)	Frequency of biggest excess MHz	Number of excesses
1	180	15.4.1998	-	-	-
2	200	6.4.1998	5,2 dB	199,97	1
3	200	22.12.1997	31,4 dB	200,45	at least 37
4	200	23.12.1997	15,5 dB	668,24	at least 22
5	200	23.12.1997	5,4 dB	134,01	8
6	200	23.12.1997	6,2 dB	264,06	20
7	200	16.4.1998	20,0 dB	150,37	at least 21
8	233	23.12.1997	8,2 dB	699,86	12
8	233	17.7.1998	-	-	-
9	233	23.12.1997	3,9 dB	167,86	2
10	233	16.4.1998	7,9 dB	467,78	3
11	233	22.9.1998	24,2	233,93	at least 24
12	266	20.11.1998	8,48	41,1	7
13	266	22.12.1997	4,8 dB	466,58	3
14	266	22.12.1997	9,7 dB	466,57	5
14	266	10.3.1998	-	-	-
15	266	22.12.1997	13,0 dB	668,14	18
16	266	23.12.1997	9,9 dB	186,67	7
17	266	13.3.1998	-	-	-
18	266	30.4.1998	2,3 dB	668,30	3
19	266	20.11.1998	8,48 dB	41,10	7
20	300	9.4.1999	2,8 dB	62,90	3
21	333	17.4.1998	6,9 dB	668,21	4
21	333	25.6.1998	-	-	-
22	333	31.3.1999	11,7 dB	666,2	6
23	350	10.3.1999	6,9 dB	698	8
24	350	7.10.1998	12,53 dB	501,24	at least 31
4	400	5.6.1998	-	-	-
16	400	27.8.1998	-	-	-
18	450	17.9.1998	-	-	-

Other components used in assembling a micro computer should always be covered by the component manufacturer's test documentation which should contain information concerning tests made under authentic conditions, and what, in fact, the actual conditions were. The situation today is that North American component manufacturers seem to be ahead of others in this respect because their Authority (the FCC) requires that all tests concerning clone components be run with the micro casing unassembled.

Planning to make things easier

First, we need to make a risk analysis of all the product families, in which, for example, are listed all EMC critical components, showing levels of emissions and degrees of immunity. The results of the tests of all the EMC critical components plus other relative documentation would be collected together. In those cases where the EMC critical component information is incomplete the component would be replaced by another which had fully acceptable information.

The fulfillment of immunity requirements can be realized by way of the module principle (CE+CE=CE). This assumes that all components carry sufficient documentation on immunity properties and that assembly of components is in full compliance with the component manufacturer's instructions.

If the power supply manufacturer has provided all the proper documentation concerning tests of low frequency

disturbances, harmonics and flicker, this should be sufficient and no test for the total computer need be run.

Following this, it is then possible to build up the most EMC critical combination thanks to the very detailed risk analysis information. The conducted and radiated RF disturbances for that combination should then be tested. If findings are found to remain below standard criteria, all other combinations as well can be CE labelled and a Declaration of Conformity document can be issued.

These proposed steps are only the minimum requirements which should be undertaken and in no way a guarantee that all assembled equipment follows standard regulations. The manufacturer always, in the final analysis, is fully responsible for his product and the components therein.

Conclusions

According to the EMC guidelines only the "worst case" should be shown to be compliant and the other variants of that apparatus are included in it in EMC terms. Because almost each PC configuration is unique and PC integrators have little technical knowledge of the EMC characteristics of the components that they use to construct their product, it is difficult to define the "worst case". PC builders do not have the necessary equipment nor knowledge to carry out EMC testing themselves and the costs of testing individual products would be excessive.

One possible solution could be Root Sum Square (RSS) TCF for system integrators [7]. RSS is the standard technique for summing uncorrelated noises and combining RSS with EMC expertise allows system integrators' TCFs to be entirely based on component data [7].

In the future, in my opinion, the best solution is to adopt the FCC open-enclosure requirements into European standards.

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