EMC DIRECTIVE

From 1 January 1996, home-made equipment must take into account emc Directive 89/336/eec (emc = ElectroMagnetic Compatibility). Basically, the directive states that no equipment may cause, or be susceptible to, external interference. Here, interference means many phenomena, such as electromagnetic fields, static discharge, mains pollution in the widest sense of the word.

### Legislation

Home-made equipment may be taken into use only when it is certain that it complies with the directive. In the United Kingdom, the dti (Department of Trade and Industry) will, in general, only take action against offenders when a complaint has been made. If the equipment appears not to comply with the directive, the constructor may be sued for damages.

### ce label

Home constructors need not affix a ce label to their equipment.

### Elektor Electronics and the Directive

The publishers of Elektor Electronics intend that designs published in the magazine comply with the directive. Where necessary, additional guidelines will be given in the article. However, the publishers are neither obliged to do so, nor can they be held liable for any consequences if the constructed design does not comply with the directive. This column gives a number of measures that can be taken to ensure that EE-designed equipment complies with the directive. However, these are needed only in some designs. Other measures, particularly in case of audio equipment, are not new and have been applied for some time.

### Why emc?

The important long-term benefit for the user is that all electrical and electronic equipment in a domestic, business and industrial environment can work harmoniously together.

### Radiation

The best known form of emc is radiation that is emitted spuriously by an apparatus, either through its case or its cabling. Apart from limiting such radiation, the directive also requires that the apparatus does not impart spurious energy to the mains—not even in the low-frequency range.

*Ferrite through-filters as illustrated are used for feeding cables through a panel.*

### Immunity

The requirements regarding immunity of an equipment to emc are new. Within certain limits of ambient interference, the apparatus must be able to continue working faultlessly. The requirements are fairly extensive and extend to a wide range of possible sources of interference.

### Computers

Computers form the prime group for application of the directive. They, and microprocessors, are notorious sources of interfering radiation. Moreover, owing to the way in which their internal instructions are carried out sequentially, they are also very sensitive to interference. The notorious crash is but one manifestation of this.

### Enclosures

A home-made computer system can comply with the emc directive only if it is housed in a metal enclosure. A minimum requirement is that the underside and rear of the enclosure is an l-shaped frame. All cabling must converge on this area or be filtered. If there are connectors on the front panel, a u-shaped metal frame should be used.

Even better results are obtained if a 20 mm wide, 1 mm thick copper strip is fixed along the whole width of the rear wall with screws at 50 mm intervals. The strip should have solder tags at regular distances for use as earthing points.

A closed case is, of course, better than an l-shaped or u-shaped frame. It is important that all its seams are immune to radiation ingress.

### Power supplies

In any mains power supply, account should be taken of incoming and outgoing interference. It is good practice to use a standard mains filter whose metal case is in direct contact electrical contact with the enclosure or metal frame. Such a filter is not easily built at home. It is advisable to buy one with integral mains entry, fuse holder and on/off switch. This also benefits electrical safety in general. Make sure that the primary of the filter is terminated into its characteristic impedance—normally a series network of a 50 Ω, 1 W resistor and a 10 nF, 250 V capacitor.

Mains transformers must be provided with rc-networks at the primary and secondary side. Bridge rectifiers must be filtered by rc-networks. The peak charging current into the reservoir capacitor must be limited by the internal resistance of the transformer or by additional series resistors. It is advisable to use a 250 V, 2 W varistor between the live and neutral mains lines. At the secondary side, it is sometimes necessary to use a transient suppressor, preferably following the reservoir capacitor.

If the supply is used with digital systems, a common-mode inductor in the secondary a.c. lines may prove beneficial for limiting radiation. For audio applications, an earth screen between primary and secondary is advisable. This screen must be linked via a short wire with the earthing strip.

The supply must be able to cope with a mains failure lasting four periods and with mains supply variations of +10% and –20%.

Peripheral equipment and earthing

All cables to and from peripheral apparatus, such as measurement sensors, control relays, must be fed through the metal wall of the enclosure or frame. The earth lines of such cables must be connected directly to the earthing strip at the inside of the enclosure or frame via a wire not longer than 50 mm. When plugs are used, the cable earth, if any, must be connected to the earth pin or the metal surround of the connector.

Basically, all non-screened signal lines must be provided with a filter consisting of not less than a 30 mm ferrite bead around the cable or bunch of wires. This bead may be outside the enclosure (for instance, around the pc-to-monitor cable).

Leads that may have a resistance of 150 Ω must be provided with a 150 Ω series resistor at the inside of the connector shell. If technically feasible, there should also be a capacitor from this point to earth. Commercial feed-through t-filters or π-filters may, of course, be used. In all other cases, screened cable must be used for connections within the enclosure. Symmetrical lines must consist of twisted screened cable and be earthed at both ends.

The earth plane of printed-circuit boards must be linked as firmly as feasible with the earthing strip, for instance, via a flexible flat metal strip or flatcable.

### Electrostatic discharge (esd)

All parts of an equipment that can be touched from outside must preferably be made from insulating, antistatic material. All parts that can be touched and enter the enclosure, such as potentiometer and switch spindles, must be earthed securely. All inputs and outputs whose wires or connector pins can be touched must be provided with an earth shield, for instance, an earthed metal surround via which any electrostatic discharge are diverted. This is most conveniently done by the use of connectors with sunken pins, such as found in sub-d connectors, and a metal case.

### Audio equipment

Immunity to radiation is the most important requirement of audio equipment. It is advisable to use screened cables throughout. This is not always possible in case of loudspeaker cables and these must, therefore, be filtered. For this purpose, there are special high-current t-filters or π-filters that do not affect bass reproduction. Such a filter must be fitted in each loudspeaker lead and mounted in the wall of a metal screening box placed around the loudspeaker connections.

### Low-frequency magnetic fields

Screened cables in the enclosure do not provide screening against the low-frequency (< a few kHz) radiation of the mains transformer. Therefore, these cables must run as close as possible to the walls of the enclosure. Moreover, their braid should be linked at one end to the earthing strip. In extreme cases, the power supply should be fitted in a self-contained steel enclosure. Special transformers with a shading ring that reduce the stray field can lower the hum even further.

### High-frequency fields

High-frequency fields must not be allowed to penetrate the metal enclosure. All external audio cables must be screened and the screening must be terminated outside the enclosure. This again necessitates the use of all-metal connectors. All cable braids must be linked to the earthing strip inside the enclosure.

Owing to the skin effect, it is important to choose an enclosure with a wall thickness ≥2 mm to ensure that internal and external fields are kept separate. Any holes must be either small (<20 mm) or be covered with a metal mesh.

### Heat sinks

Heat sinks should preferably be inside the enclosure and be earthed at several points. Non-earthed heat sinks in switch-mode power supplies often create problems. If possible, place an earth screen between transistor and heat sink. Ventilation holes must be covered with metal mesh unless they are smaller than 20 mm. Ventilators should be fitted inside the case.

*Standard mains filters built into a mains entry together with an on/off switch. The metal shell must be in firm contact with the enclosure.*

### Cables

Cables often function as transmit/receive aerials. This applies equally well to screened cables. The braid of a coaxial cable must be terminated into a suitable connector such that it makes contact along the whole circumference. The braid may be used as the return path to obtain r.f. magnetic screening. For a.f. magnetic screening it is better to use twisted-pair screened cables. In a ribbon (flat) cable, each signal wire should be flanked, if at all possible, by earthed wires. The cable should be screened along one surface or, preferably, all around. Cables that carry signals ≥10 kHz that are not filtered in the enclosure, must be provided with a ferrite bead functioning as a common-mode inductance.

### Printed-circuit boards

Elektor Electronics printed-circuit boards are provided with coppered fixing holes that are connected to the earth of the circuit. This arrangement, in conjunction with metal spacers, ensures good contact between the board and the circuit earth. Where this is important, boards have a special earth plane that can be connected, where feasible, to the earthing strip via a flatcable. These boards normally have no other earthing points and their fixing holes are, therefore, not coppered.

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*T-filters and π-filters ensure that interference cannot em te from, or enter, the equipment via signal lines. They are available in various current ratings and for various frequency ranges.*