PCB design and mains voltage

safety and reliability

Designing printed-circuit boards that may be safely connected to the mains supply need not give rise to unnecessary worries. A condition is, however, that the correct rules are adhered to.

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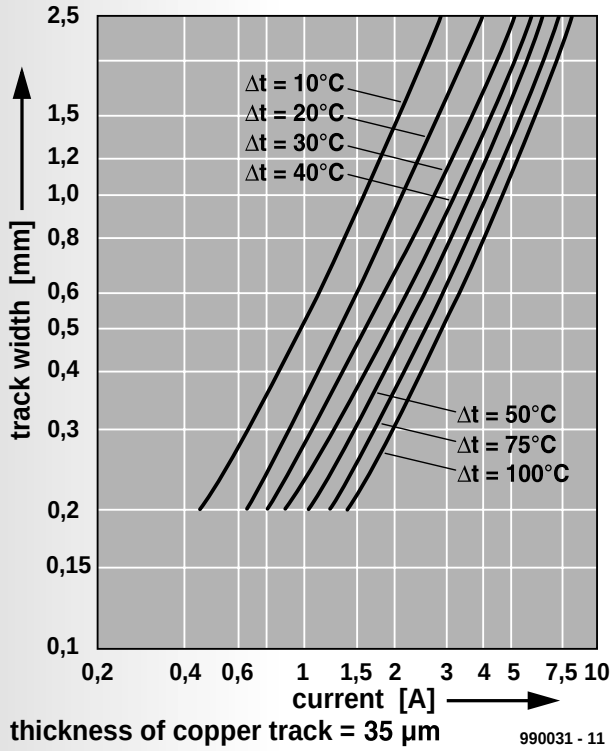

Figure 1. Rise in temperature of a 35 µm thick copper track as a function of the track width and the current level.

When a printed-circuit board is to be linked to the mains supply, so that certain copper tracks carry the mains voltage, a potentially dangerous situation arises if a wrong layout is chosen. Provided that the right rules are obeyed, anyone can design and make a PCB that may be safely connected to the mains supply.

There are two matters that need careful observation: the potential between two adjacent copper tracks, and the current flowing through a track.

Fortunately, the possible uses and applications of board material have been well recorded, so that all relevant data can be found rapidly from a couple of characteristic curves. **Figure 1** shows the rise in temperature of a copper track as a function of the track width and the level of the current flowing through the track. The curves are based on a printed-circuit board with copper tracks 35 µm thick, which is the standard thickness in the case of normal board material.

The temperature rise shown by the curves occurs in an ideal situation in which the board can readily radiate the heat. If ventilation is poor, perhaps because the board is used in an tightly enclosed space, the temperature may rise to a much greater extent. Although standard board material can withstand an appreciable rise in temperature (from ambient), it is sensible to keep it within reasonable limits: 30–40 °C.

WATCH OUT: HIGH VOLTAGE

The distance between adjacent tracks is an important parameter when high voltages will occur on the board. The characteristics in **Figure 2** show the minimum distance for a number of potential differences. The value derived from these curves is the minimum distance anywhere on the board between two adjacent tracks. See also **Figure 3**. At this distance, there is no risk of flashover. Since during the etching of the board tiny irregularities (jagged edges) almost inevitably arise, and later dust particles may settle between the tracks, a good safety margin must be provided.

The curves in Figure 2 show two situations of use of the board: indoor (dashed lines) and out of doors (solid lines). In both cases, it is assumed that the board is used at an altitude not

By K.S.M. Walraven

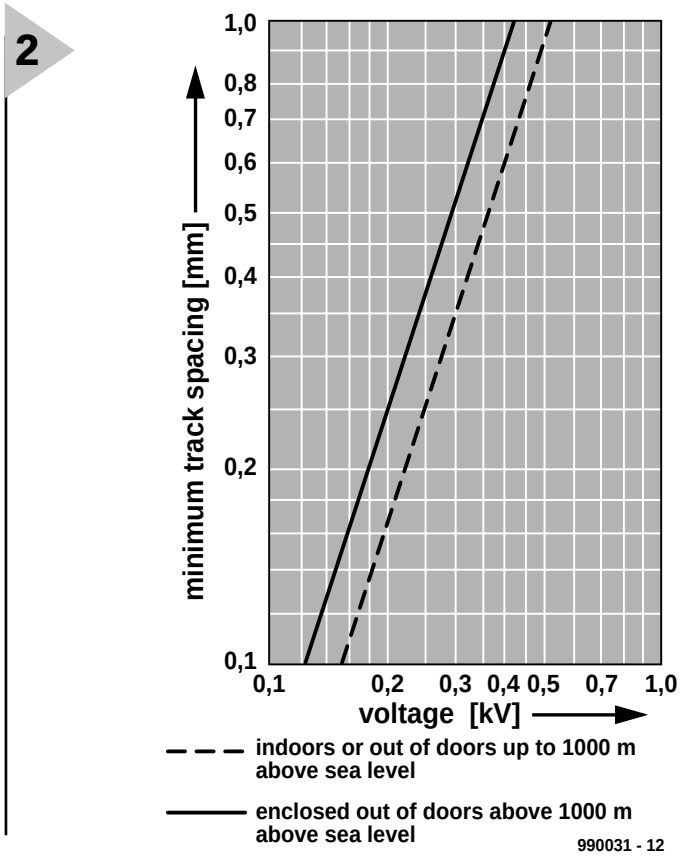

Figure 2. Minimum track spacing as a function of the applied voltage. Note the difference between indoor and outdoor use – see text.

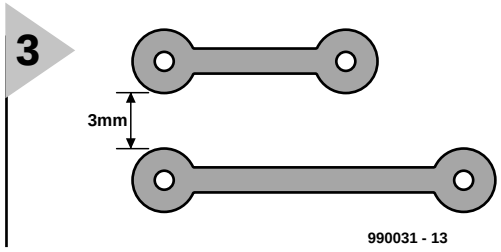

Figure 3. The safe track spacing is the smallest spacing between adjacent tracks anywhere on the board.

exceeding 1000 metres above sea level.

There are furthermore various legal requirements for boards that are to be connected to the mains supply. These include the stipulation that the minimum distance between mains-carrying copper tracks must be at least 3 mm, which is appreciable more than indicated by Figure 2. If the equipment in which the board is used is double-insulated (that is, it is not connected to the supply protective mains earth – which is not advisable in the case of home constructed equipment), the distance between mains-carrying tracks must be not less than 6 mm. This distance is also obligatory between the mains-carrying section and the low-voltage section of the board. Note, by the way, that if a Class II insulated transformer

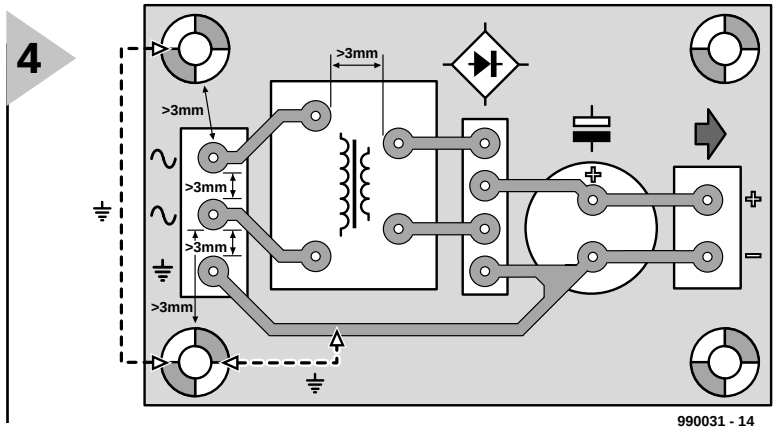

Figure 4. In apparatus with a supply protective earth (which should be the case with virtually all home built equipment) the minimum track spacing is (legally) 3 mm.

is used in a Class I equipment, this does not confer Class II status on the equipment. Also, if an electrically conductive enclosure is used to isolate and protect a hazardous supply voltage from user access, it must be protectively earthed, irrespective of whether the transformer is Class I or Class II.

Figures 4 and **5** give the main points which the designer of the board must observe and adhere to.

The material used does, of course, influence the properties of the board, but fibre-reinforced epoxy is a good practical starting point.

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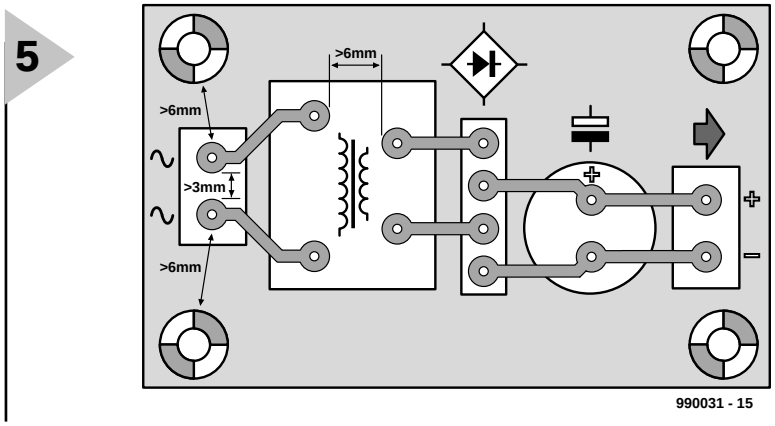

Figure 5. In apparatus without a supply protective earth (rare in electronic equipment – mainly applicable to power tools and some proprietary domestic electrical goods) the minimum track spacing must be (legally) 6 mm.