5.6 Recommendations for Thermal Management of Electronic Systems

The overall strategy with the thermal management of electronic systems should be to aim first for a sealed enclosure because we also need to keep shock protection, protection against ingress of foreign bodies or water, and electromagnetic compatibility in mind. If a sealed enclosure is impossible due to the large quantity of heat to be dissipated (see Table 5.11), ventilation from outside as free convection should be implemented by means of an open (perforated) enclosure. If this measure does not achieve the desired cooling, forced convection with fans or other functional elements should be deployed as a last resort.

Arrangement of heat sources in the system

The closer the heat source is to the top panel of an electronic system, the higher its temperature and the temperature of the top panel; however, the interior of the unit is then mostly cooler. Considering two identical heat dissipating enclosure areas, the maximum overtemperatures of the heat sources are lower for sealed enclosures with low overall height than those with a larger overall height.

Arrangement of printed circuit boards in an enclosure

Printed circuit boards are typically arranged in horizontal or vertical stacks. Boards should be arranged horizontally in small, compact systems for best thermal results, if the enclosure height/width ratio is less than 0.6. In all other scenarios, printed circuit boards should be installed vertically: There is better convection and temperatures are more evenly balanced. A clearance >30 mm is required between double-sided assembled printed circuit boards (single-sided boards ≥ 20 mm) so that unobstructed natural convection can more easily form; only 10–20 mm clearance is needed for forced convection.

Flow channels in the system

Vertical flow channels should be created if possible to facilitate the rising warm air. Head losses caused by flow resistances should be minimized. Channel constrictions and changes in the flow direction should be avoided.

Sealed enclosures

In sealed systems, heat is best removed from the heat sources to the enclosure by thermal conduction and by convection and radiation from the enclosure surface to ambient. Heat fluxes of up to 100 W/m^2 (i.e., 1 W per 10 cm$\times$ 10 cm enclosure surface area) can be dissipated through a sealed, bare metallic enclosure (mostly convection) for a temperature differential of 20 K, and up to 200 W/m^2 through painted surfaces (convection and radiation, all these values are approximations). Up to 180 W/m^2 could be dissipated through a 3-mm plastic enclosure with the same temperature differential.

Open enclosures

Airstream cross sections and panel cut-outs should be sufficiently large. Intake and exhaust vents should be located at the bottom and top of the enclosure. The reduction in the effective pressure at the intake and/or exhaust vents in the side panels should be compensated by larger panel cut-outs. The effective overall cross section of the airstream should be maximized. You should avoid inlet and exhaust vents of different sizes. Perforations should not exceed 25% of the enclosure surface (12.5% bottom and 12.5% top), as there are no additional benefits to be gained with larger openings. The enclosure base needs to be high enough off the floor (>30 mm) to ensure that the air can flow unrestricted into the enclosure through the air inlets in the enclosure bottom panel. It should be impossible to block the air vents in the top panel by placing objects on them.

Fans

When selecting a fan at the design stage, the required volumetric flow rate can often be estimated using only Eqs. (5.38a) and (5.38b); applications at high altitudes should consider the lower air mass delivered by the fan. The engineer typically has to resort to estimates and tests, such as measuring the static pressure at various flow rates, to obtain the required static pressure. The system should be designed so that more, or more powerful, fans can be used if required.