Part D: Packaging of Electronic Equipments

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21. Components of Electronic Systems

21.1 Introduction

Electronic packaging is the art and science of connecting circuitry to perform some desired function in some applications. Packaging also provides ease of handling and protection for assembly operations. We will devote this partition for engineering technologies include mechanical, thermal, materials, and components for electronic systems.
In mechanical design concerns the supports, frames, etc. to withstand the mechanical stresses due to vibration, shocks, etc to which the electronic package may be subjected.
While the thermal design to ensure that the electronic systems are amply cooled and would not over heat to a point where they become unable to function properly.

21.2 Components for Electronic Systems and its Cooling Solution

21.2.1 Electronic Components for Airplanes, Missiles, Satellites, and Spacecraft

Electronic boxes used in airplanes, missiles, satellites, and spacecraft often have odd shapes that permit them to make maximum use volume available as shown in Figure 21.1. An odd-shaped box may require more time to design, because it is usually more difficult to provide the circuit cards with an efficient heat flow path, regardless of the cooling method used.

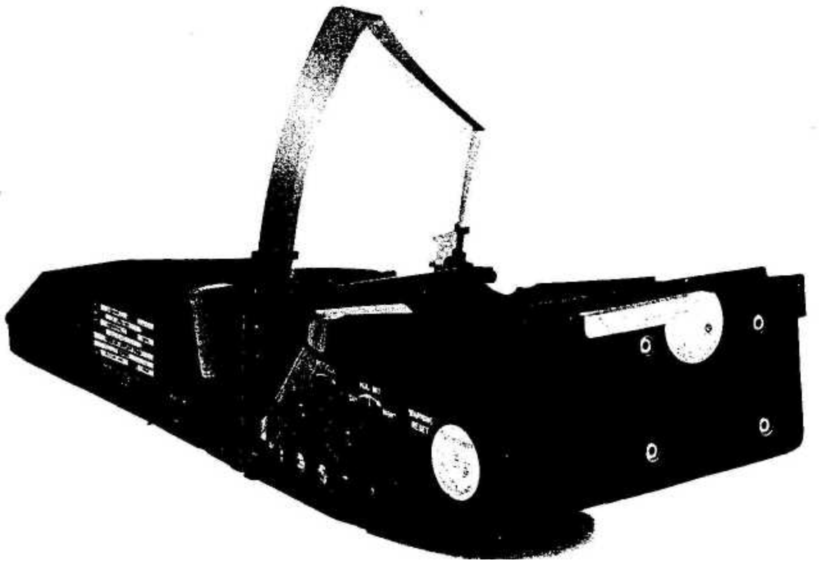

Figure 21.1 Ahead-up-display (HUD) electronic box for fighter air craft

Many of the electronic boxes are cooled by forced convection with bleed air from the jet engine compressor section. Since this air is at a high and pressure, it is throttled (passed through the cooling turbine), cooled, and dried with a water separator before it is used.

Sometimes the conditioned cooling air is not completely dry because of excessive moisture in the air from humidity or rainstorm so that small drops of water will often be carried into the electronics section together with the cooling air. If this water accumulates on PCBs or their plug-in connectors, electrical problems may develop. Therefore, many specifications do not permit external cooling air to come into direct contact with electronic components or circuits. Air-cooled heat exchangers, commonly called air-cooled plates, which are being used more in airplanes, provide conditioned air for cooling the electronics. Theses heat exchangers are usually dip-brazed when many thin (0.006 to 0.008 in) aluminum plate fins are used. Pin fin aluminum castings are becoming very popular because of their low cost but performing extremely poorly in pressure drop and weight.

Electronic systems for missiles have two cooling conditions to consider, captive and free flight.

If the missiles flight duration is relatively short, the electronics can be precooled during captive phase so that the system can function with no additional cooling during the flight phase. The electronic support structure would act as the heat sink.

Some missiles, such as the Cruise missiles, have a very long free flight phase, so that the cooling system must be capable of cooling the electronics for several hours. If ram air is used at speed near Mach 1, the ram temperature rise of the cooling air may exceed 100 ^{o}F. Since Cruise missiles fly at low altitudes, where the surrounding ambient air temperatures can be as high as100 ^{o}F, the cooling air temperature could reach values of 200 ^{o}F (93 ^{o}C) even before the cooling process begins. Since the maximum desirable component mounting surface temperature is about 212 ^{o}F(100 ^{o}C), the out- side air cannot be used directly for cooling.

Electronic systems for satellite and spacecraft generally rely upon radiation to deep space for all their cooling. Deep space has a temperature of absolute zero, -460 ^{o}F (-273 ^{o}C). This low temperature can provide excellent cooling.

Special surfaces finishes and treatments may be required for satellite and spacecraft to prevent them from absorbing large quantities of heat from the sun. This heat may be direct solar radiation plus solar radiation reflected from the various planets and their moons.

Natural convection cannot be used to transfer heat in satellite and spacecraft electronics. Natural convection requires field to permit the heated air to rise, because of its reduced density. In satellite and spacecraft, the effects of gravity are neutralized by velocity and the continuous free-fall characteristics of the flight path. Therefore, only radiation, conduction, and forced convection (in sealed boxes) should be considered for cooling electronic systems in space.

21.2.2 Electronic Components for Ships and Submarines

Large cabinets, consoles, or enclosures are normally used to support the electronic equipments used on ships and submarines as shown in Figure 21.2. These cabinets are usually heavy and rugged, to provide protection for the electronics during storms and rough seas. Some cabinets may dissipate more than 2 kilowatts of heat. The electronic components are often mounted on panels and sliding drawer. Panels are used to support displays, and drawers are used to support the heavy power supply units.

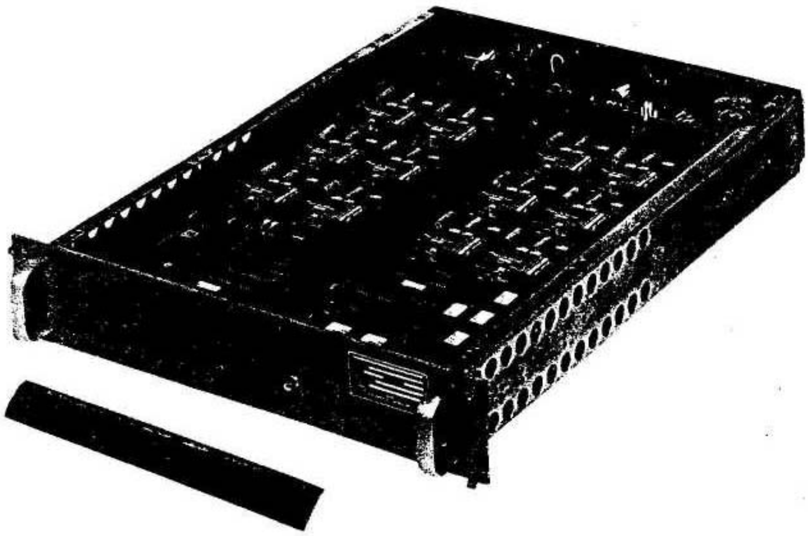

Figure 21.2 Plug-in drawer type of chassis for use in a cabinet

Water is usually available on ships and submarines, so that it is natural to utilize it for cooling. Water-cooled heat exchangers are often used, with external fins to permit cooling with forced air. Fans are used to force the air through heat exchanger fins to cool the air, which is then circulated through the consoles. This type of forced convection cooling can be used with both closed-loop and open-loop systems.

With closed-loop system, a cooling air supply plenum and a return plenum may be established within the sidewalls of the consoles. The sidewalls are often several inches deep, with ribs to provide rigidity from high shock loads, so that they can easily carry the cooling air to and from the electronic equipment. For an open-loop system the air entering the consoles would be forced through the Water-cooled heat exchangers, which is usually at the base of the console. The conditioned air would be circulated through the electronic equipments and then exhausted at the top of the console.

When the heat loads are not too high, natural convection techniques can often be used to cool the electronic equipments. This works well on tall cabinets, which can use chimney effects to force the air through the system without the use of fans. Air enters the bottom of the cabinet, where it first picks up heat from the electronic equipments. The warmer air has a reduced density, so that it starts to rise through the chassis, picking up more heat as it rises. The air finally exits at the top of the cabinet.

21.2.3 Electronic Components for Communication Systems and Ground Support Systems

Both communication systems and ground support systems must capable of continuous operation for extended periods of time at hot desert areas, arctic area, and in rain, sleet, and snow. Large systems have their electronics completely enclosed within shelter that similar to small barns and can hold several people for along periods of time. While small systems usually enclosed in transit cases and may be carried on the back seat of vehicle for rapid mobility.

The communication shelters are used all over the world by military personnel and by commercial television networks to transmit and receive all forms of data.

The shelters are usually lined from wall to wall with large electronic control consoles that can easily dissipate many kilowatts of heat. Such shelters are insulated to protect them from both heat and cold. In hot climates the shelters are often equipped with exhaust fans to flush out hot air that has been trapped. This is important because the electronic consoles within the shelters use the local ambient air for cooling. This is done using forced or natural convection, depending on the power dissipation and the location of the console. If the internal ambient temperatures within the shelter become too hot, refrigeration units may be provided, with auxiliary power units, to keep the shelters cool.

Ground support systems usually used to perform functional checks of the electronic equipment such as airplanes, missiles, ships, submarines, trains, trucks, and automobiles to ensure that they are operating properly

Ground support equipments are also used to supply auxiliary power or auxiliary cooling for electronic equipment.

21.2.4 Personal Computers, Microcomputers, and Microprocessors

The computer industry has been changing very rapidly. Since the first chip were introduced in about 1962 which made from semiconductor silicon and contained only about 15 to 20 diodes, transistors, and resistors on a substrate that measured about 0.15 by 0.2 in. Component densities have since increased sharply, so that the same size chip can now incorporate several million components, and the costs have dropped just as fast.

Personal computers have found exciting new applications in many areas. Their small size, flexibility, reduced costs, and improved memory storage have permitted more small business to make use of them.

Microcomputers are even smaller than personal computers. A typical personal computer will occupy one drawer of a filing cabinet. While microcomputer will fit on one plug –in PCB a bout 5 x 7 in. Microcomputers are not as fast as personal computers and are generally used where flexibility, size, and cost are more important than speed.

Both personal computers and microcomputers requires some type of central processing unit(CPU) to control input an out put, to perform mathematical operations, to decode, and move information in and out the memory. This CPU, which would normally require the mounting surface area of one plug-in PCB, can now be placed on a single small chip. This chip is called microprocessors, and it is the most expensive part of the microcomputer.

Microprocessors are available in rectangular cases about 2.5 x 0.75 x 0.2 in with about 40 external wires, which perform all of the CPU functions. Microprocessors must be used with memory systems, which can also be expensive.

21.3 Surface Mount Technology (SMT)

SMT allows production of more reliable assemblies with higher I/O, increased board density, and reduced weight, volume, and cost. The weight of printed board assemblies (PBAs) using SMT is reduced because surface mount components (SMCs) can weigh up to 10 times less than their conventional counterparts and occupy about one-half to one-third the space on the printed board (PB) surface. SMT also provides improved shock and vibration resistance due to the lower mass of components.

The smaller size of SMCs and the option of mounting them on either or both sides of the PB can reduce board cost by four times. A cost savings of 30% or better can also be realized through a reduction in material and labor costs associated with automated assembly.

21.3.1 SMT Process Flow

Surface mount components are placed directly on the substrate surface. To create a metal-lurgical connection between the SMC and the substrate, solder paste is first deposited on the component lands. The SMCs are then mounted on the lands using a suitable placement method. The printed wiring boards (PWBs) plus SMCs are then reflow soldered, forming a surface mount PWA.

The PWAs are then cleaned and tested. In a nutshell, these are the major steps for producing surface mount PWAs:

- Solder paste application on the lands of a suitable substrate (e.g., a PWB)
- Adhesive deposition {not always required)
- Component preparation (if required)
- Component placement
- Soldering
- Cleaning
- Inspection
- Clean prior to conformal coat (if required)
- Conformal coat (if required).
- Test

21.3.2 Surface Mount Classification

There are two widely used classification schemes for surface mount PWAs. These assemblies are often simply called surface mount assemblies (SMAs). The first classification is the most classification follows IPC-CM-770, Component Mounting Guidelines for Printed Boards. This classification utilizes two categories: assembly types and assembly classes. According to this classification, there are two assembly types:

1. Type 1 assembly: The components only on its top side.
2. Type 2 assembly: The components on both its top side and its bottom side.

According to the IPC classification, there are three assembly classes:

1. Class A assembly is entirely through hole technology (THT). A Type 1 Class A assembly as shown in Figure 21.3.
2. Class B assembly is entirely surface mount technology (SMT).
3. Class C assembly is a combined THT and SMT assembly (mixed technology).

Based on the IPC classification, the types of SMT assemblies are:

- Type 1B (single-sided pure SMT assembly). As shown in Figure 21.4.
- Type 2B (double-sided pure SMT assembly-no adhesive). As shown in Figure 21.5.
- Type 2B (double-sided pure SMT assembly-adhesive). As shown in Figure 21.5.
- Type 1C (single-sided with a mixture of THCs and SMCs). As shown in Figure 21.6.
- Type 2C (S) (simple) (double-sided with THCs only on top; small, discrete SMCs on the bottom). As shown in Figure 21.7.
- Type 2C (C) (complex) (double-sided with large SMCs and THCs on the top; small, discrete SMCs on the bottom) As shown in Figure 21.8
- Type 2C (VC) (very complex) (double-sided with large SMCs and THCs on the top; large and small SMCs on the bottom) As shown in Figure 21.9

The second classification for surface mount PWAs is the oldest classification based on the soldering technology employed.

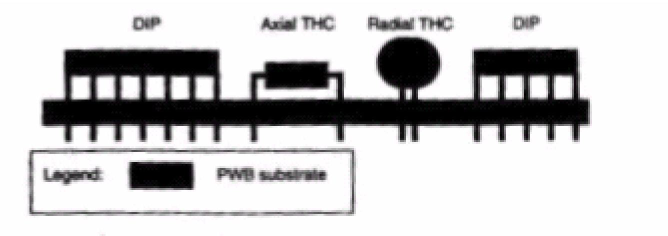

Figure 21.3 Type 1A assembly (all through hole)

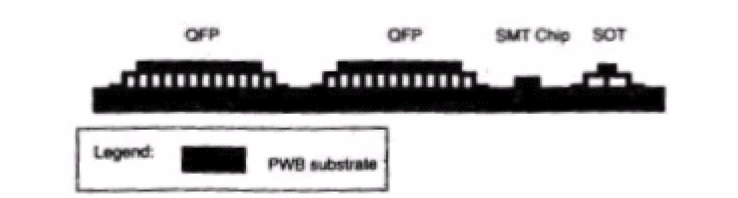

Figure 21.4 Type 1B assembly (single-sided pure SMT)

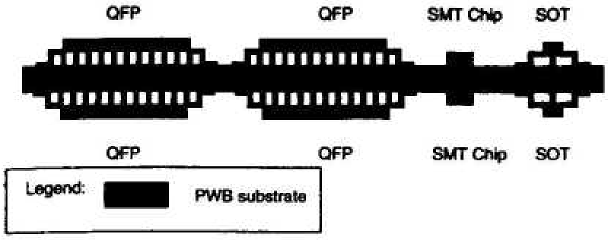

Figure 21.5 Type 2B assembly (double-sided pure SMT)

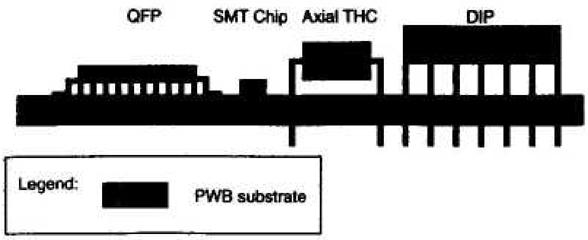

Figure 21.6 Type 1C assembly (single- sided mixed technology SMT)

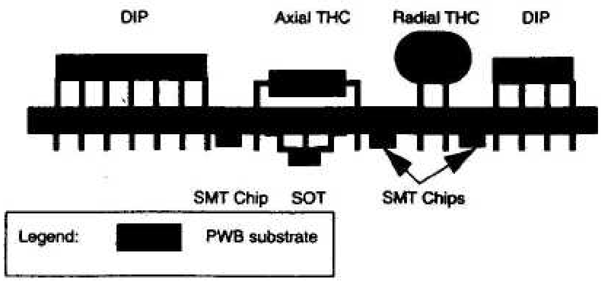

Figure 21.7 Type 2C (S) assembly

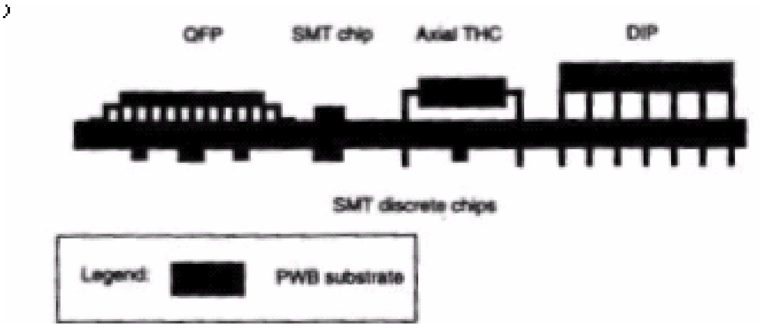

Figure 21.8 Type 2C (C) assembly

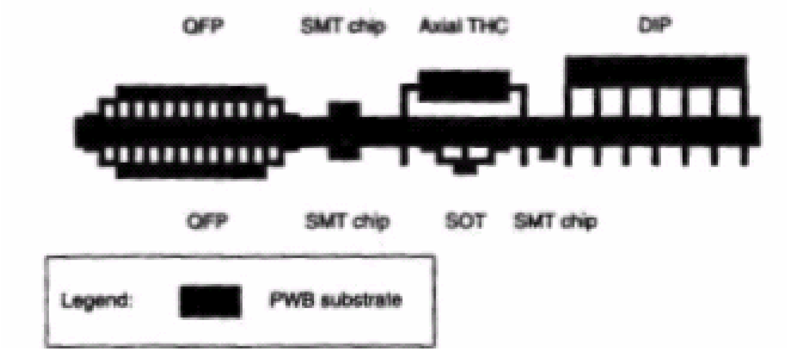

Figure 21.9 Type 2C (VC) assembly

21.3.3 Component Placement Machines

Requirements for accuracy make it necessary to use auto-placement machines for placing surface mount components on the PB. The type of parts to be placed and their volume dictate selection of the appropriate auto-placement machine. There are different types of auto-placement machines available on the market today: (A) in-line, (B) simultaneous, (C) sequential, and (D) sequential/ simultaneous.

In-line placement equipment employs a series of fixed-position placement stations. Each station places its respective component as the PB moves down the line. These machines can be very fast by ganging several in sequence. Simultaneous placement equipment places an entire array of components onto the PC board at the same time. Sequential placement equipment typically utilizes a software-controlled X- Y moving table system. Components are individually placed on the PC board in succession. These are currently the most common high speed machines used in the industry. Sequential/simultaneous placement equipment features a software- controlled X-Y moving table system. Components are individually placed on the PC board from multiple heads in succession. Simultaneous firing of heads is possible. Many models of auto-placement equipment are available in each of the four categories. Selection criteria should consider such issues as the kind of parts are to be handled, whether they come in tube, trays, or tape and reel, and whether the machine can accommodate future changes in other shipping media.

21.3.4 Soldering

Like the selection of auto-placement machines, the type of soldering process required depends upon the type of components to be soldered and whether surface mount and through-hole parts will be combined. For example, if all components are surface mount types, the reflow method will be used. However, for a combination of through-hole and surface mount components, reflow soldering for surface mount components followed by wave soldering for through-hole mount components is optimum.

21.3.4.1 Infrared/Convective Reflow Soldering

There are basically two types of infrared reflow processes: focused (radiant) and non-focused (convective). Focused IR, also known as Lamp IR, uses quartz lamps that produce radiant energy to heat the product. In non- focused or diffused IR, the heat energy is transferred from heaters by convection. A gradual heating of the assembly is necessary to drive off volatiles from the solder paste. This is accomplished by various top and bottom heating zones that are independently controlled. After an appropriate time in preheat, the assembly is raised to the reflow temperature for soldering and then cooled.

The most widely accepted reflow is now "forced convection" reflow. It is considered more suitable for SMT packages and has become the industry standard. The advantage of forced convection reflow is better heat transfer from hot air that is constantly being replenished in large volume thus supplying more consistent heating, and While large mass devices on the PB will heat more slowly than low mass devices.

21.3.5 Conduction Cooling for Components Mounted on PCBs

The electronic components are usually the major heat source in electronic systems. For effective cooling of these components, it is necessary to plan in advance the heat flow mechanism and heat flow path from the component to the sink.

In many cases, it is sufficient to dissipate the heat generated by the components to the PCB. This heat is then conducted through the PCB to a highly conducting plate, usually aluminum, in a good contact with it. The heat is then dissipated laterally to a heat sink cooled by flow of air or sometimes water for highly heat dissipated. This arrange as shown in Figure21.10.

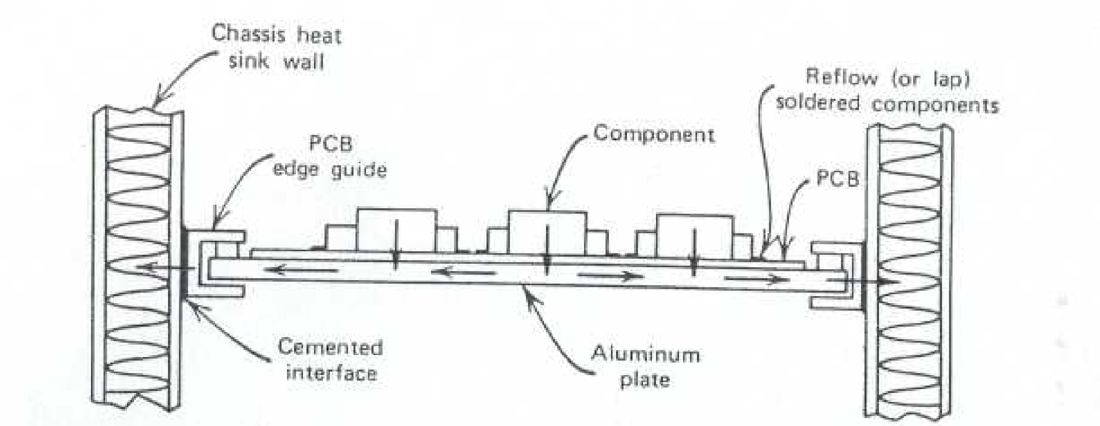

Figure21.10 Conduction heat flow path from component to heat sink

Example 21.1 Several power transistors, which dissipate 5 watts each, are mounted on a power supply circuit board that has a 0.093 in (0.236 cm) thick 5052 aluminum heat sink plate, as shown in Figure 21.11. Determine how much lower the case temperatures will be when these components are mounted close to the edge of the PCB, as shown in Figure 21.11b, instead of the center, as shown in Figure 21.11a.

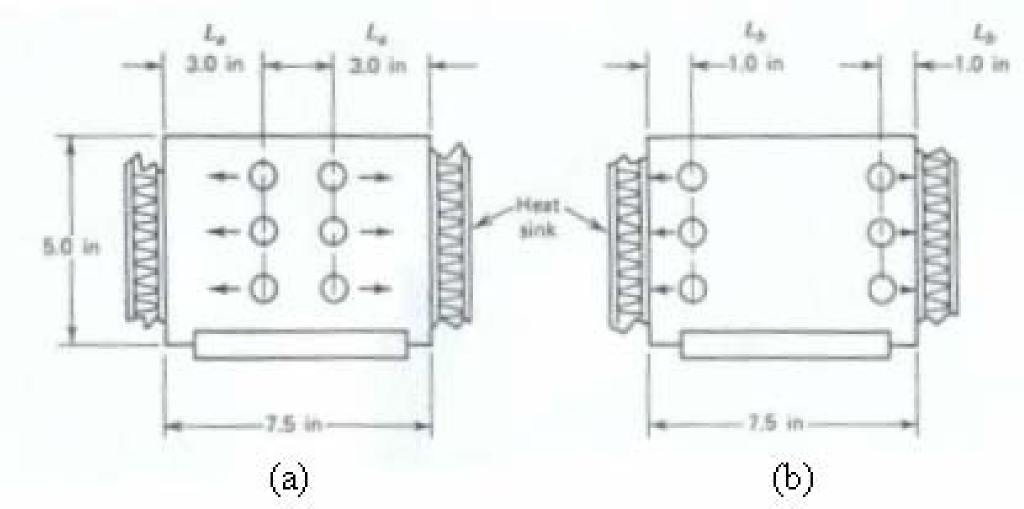

Figure 21.11 Power transistors mounted on an aluminum heat sink plate. (a) Old design (b) new design.

Solution:
Since both plug-in PCBs are Symmetrical about the center, consider each half of the board for the analysis.
Q = 3 x 5 = 15 watts
L_a = 3.0 in = 7.62 cm (length of old design)
L_b= 1.0 in = 2.54 cm (length of new design)
k = 143.8 W/m.K (5052 aluminum)
A = (5.0) (0.093) = 0.465 in^2 = 3.0 cm^2 (area)

The temperature rise at the old design locations:

$$\Delta t_a = \frac{(15)(0.0762)}{(3/10000)(143.8)} = 26.5\ ^oC$$

The temperature rise for the mounting position near the edge of the PCB, new design:

$$\Delta t_b = \frac{(15)(0.0254)}{(3/10000)(143.8)} = 8.83\ ^oC$$

This shows that moving the transistors closer to the edge of the PCB can reduce the component surface mounting temperature by 26.5 – 8.83 = 17.7 °C.

21.4 Electronics Chassis Design Procedures

Electronic systems normally consist of many different electronic component parts, such as resistors, capacitors, diodes, transistors, microprocessors, and transformers, which are enclosed within a support structure called the chassis, such as a chassis used in a space craft as shown in Figure21.12.

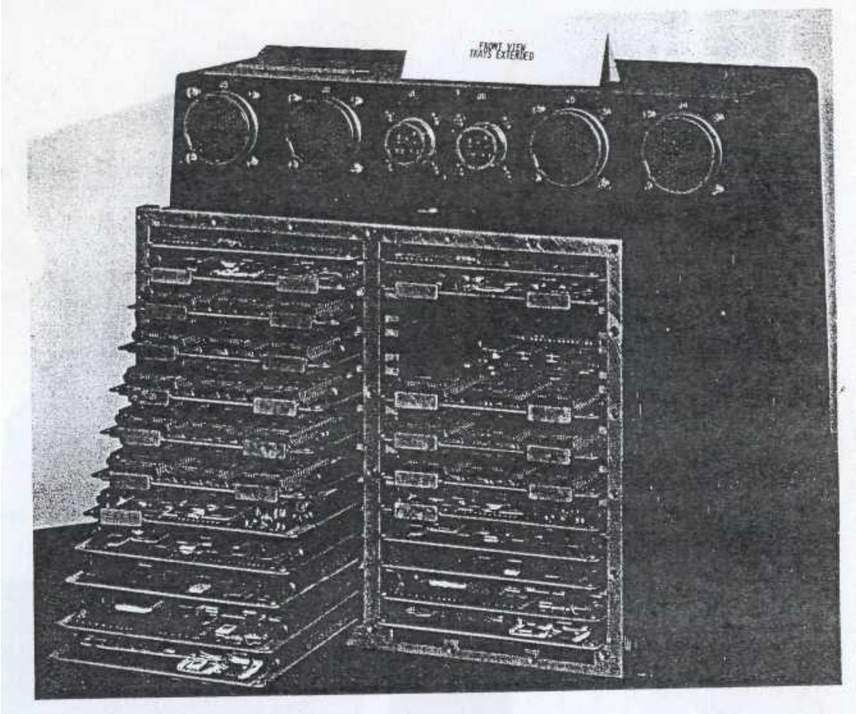

Figure21.12 Electronic box uses in a space craft

The purpose of the electronic chassis is to support the components while providing a low thermal resistance path to a heat sink, which will absorb this waste heat with a minimum rise in the temperature of the components. The heat sink may be the ambient air surrounding the chassis or a liquid-cooled cold plate is an integral part of the chassis wall.

Whatever method of heat transfer is selected, the technique should be as simple and as cost effective as possible. Many factors will have to be considered, such as space available, the power requirements of the cooling system, the maximum allowable component temperatures, component sizes, power densities, and the heat sink temperature. Other factors, such as shock and vibration, may have to be considered together with the thermal environment to ensure an adequate chassis design.

21.4.1 Formed Sheet Metal Electronic Assemblies

Sheet metal structures are often used for many different types of electronic boxes because the manufacturing costs are so low. Thin-gauge aluminum or steel sheets can be blanked and formed into a lightweight chassis with the use of rivets, spot welding or arc welding. The final assembly is usually painted for protection and appearance. This type of construction can be used for 7 or 70 in high.

Light-gauge steel sheet metal structures are usually not suitable for cooling high power electronic systems by means of conduction. The cross-sectional areas are small because the metal is thin and the thermal conductance is low. This increases the thermal resistance, which also increases the component hot spot temperatures. Also light-gauge steel sheet metal structures are not generally capable of withstand high vibration and shock levels, so that their use in theses environments is very limited.

Lightweight sheet metal structures may tend to amplify any acoustic noise generated by cooling fans or pumps. If large, thin flat panels are used on electronic box that is to be fan-cooled, make sure that it is not too close to workers, who may object to the acoustic noise that is generated.

Structural epoxies are being used very successfully for assembling small electronic boxes. These epoxies have high shear strength, with a short cure time at 100 ^{o}C, which makes them very cost effective.

21.4.2 Dip-Brazed Boxes with Integral Cold Plates

Dip-brazed aluminum boxes as shown in Figure 21.13 are convenient to use for small, light weight systems when quantities are small, usually less than about 8 or 10 boxes. Most electronic boxes will require shelves and brackets for mounting electronic components, ribs for stiffening the chassis to resist vibration, and cutouts for the cables and electrical harness. A dip-brazed electronic chassis can often provide these features at a relatively low cost.

The size of the dip-brazed assembly is usually limited by the size of the dip-brazed tank, or salt bath, which is used to completely submerge the structure that is to be brazed. The individual parts of the chassis are joined together like a three-dimensional jigsaw puzzle. Sometimes, a stainless steel fixture is used to hold the individual parts together during the dip-brazing process. Sometimes the parts are tack welded, riveted, or screwed together with aluminum screws. Aluminum slurry or a brazing strip, with a melting temperature slightly lower than the temperature of the salt bath, is used to join the individual structural members, which have a melting temperature slightly higher than that of the salt bath. As the slurry melts, capillary action draws the molten aluminum into the small voids between the individual parts and joins them rigidly.

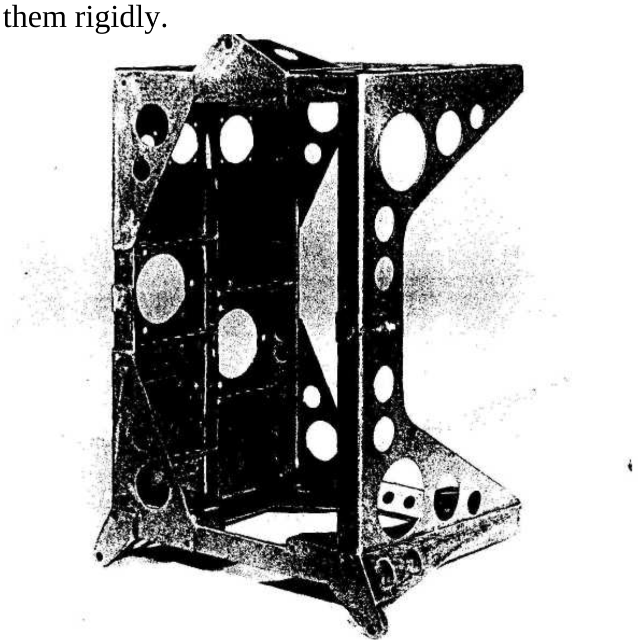

Figure21.13 Dip-brazed electronic chassis with tack welds for positioning piece parts

Thin-plate fin types of heat exchangers are often used for the side walls of chassis. The heat exchangers (or cold plates) are often dip-brazed first as a subassembly and then cemented together to form a chassis. Sometimes the heat exchangers can be dip-brazed as an integral part of the chassis without first forming a subassembly. The multiple fins provide a large surface area, which sharply in creases the amount of heat that can be removed from the chassis with air or with liquids. A typical cross section through a chassis with finned sidewall heat exchangers as shown in Figure 21.14.

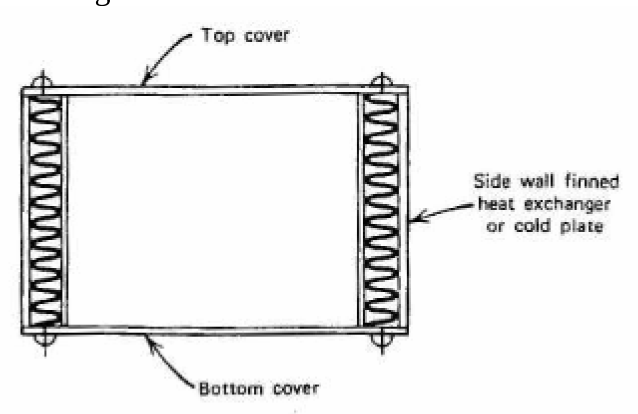

Figure 21.14 Chassis with side wall heat exchanger

The plate fin material is usually about 0.006 in (0.0152 cm) or 0.008 in (0.0203 cm) thick so that many fins can be spaced close together. The typical spacing is about 14 to 18 fins per inch. Some companies can dip-braze as many as 23 to 25 fins per inch.

When the fins get very close together, it becomes very difficult to clean out the salts left from the dip-brazed tank, so that they may become trapped. This can block the fin passages and reduce the cooling effectiveness. Also, trapped salts can corrode the metal and weaken the structure.

It is desirable to have some method for checking the dip-brazed heat exchangers to make sure that the fins are not blocked. A visual check is very valuable. If it is possible to look down the heat exchanger, blocked fins can be spotted and either rejected or cleaned. If a visual check is not possible, a pressure drop check should be made with a known flow passing through the fins. If a blockage occurs, the pressure drop across the fins will be very high.

The fin material is generally very soft, so that it can be deformed easily. If fins in an air-cooled cold plate are allowed to extend to extend to the end of the chassis opening, they can become bent or deformed by foreign objects, such as bolts, nuts, screw drivers, and even pencils. Therefore, for added protection, the ends of the fins should be recessed at least 1/4 in.

21.4.3 Plaster Mold and Investment Casting with Cooling Fins

Plaster mold castings and investment castings are very popular for small electronic support structures or small electronic enclosures. Plaster mold castings and investment castings use plaster for the mold, into which a molten metal is poured. Typical metals are usually aluminum, magnesium, zinc, bronzes, and some steels. Wall thicknesses of 0.040 to 0.060 in (0.102 to 0.152 cm) can be readily obtained with both methods.

Investment piece part castings are generally slightly more expensive than plaster mold castings because an intermediate wax core is required. This core is made up in the exact detail required by the finished product. It is coated with several thin coats of plaster or refractory material and thoroughly dried. The coated core is heated to melt the wax, which is then drained, leaving the hollow mold. The mold is filled with molten metal while a vacuum is applied to remove tiny air pockets from the porous plaster or refractory outer shell. This permits the molten metal to fill in every small corner in the mold for excellent detail, surface finish, and accuracy. The outer shell must be broken away and destroyed to obtain the finished product.

Investment castings are somewhat limited in their size, depending upon the complexity. Intricate chassis castings 15 x 8 x 10 in (38.10 x 20.32 x 25.40 cm), with wall thicknesses of 0.070 in (0.178 cm), can be readily obtained.

Plaster mold casted piece parts are normally less expensive than investment castings because the process does not require the use of an intermediate disposable wax pattern. However, tooling costs for the plaster mold casting will be higher if permanent molds are used, because of the extra machining required.

Very large plaster mold castings can be made, up to 100 in (254 cm) in length if required, with considerable detail. However, plaster castings usually cannot produce small details as well as can investment castings.

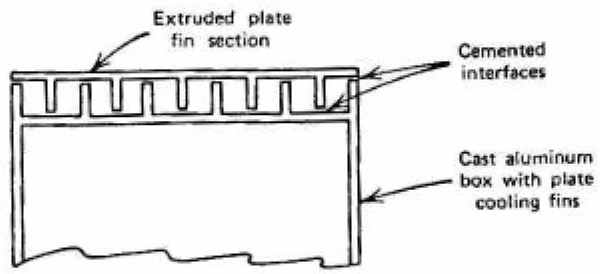

Figure 21.15 Plate fin extrusion cemented to a cast plate fin to form a multiple-fin heat exchanger

Investment castings and plaster castings methods can be used to make very efficient, lightweight heat exchangers and cold plates with integrally cast pin fins. Typical pin fins are about 0.062 in (0.157 cm) in diameter, 0.50 in (1.27 cm) long, and spaced on 0.200 in (0.508 cm) centers. Plate fin types of heat exchangers and cold plates are much more difficult to cast. Continuous plate fins require cores that must be supported as the molten metal is poured. These cores can shift and crack if the ribs are very long. If plate fins are desired, it might be better to cast them in short lengths instead of in a continuous length, to provide a means for supporting the cores.

Cemented construction techniques can often be combined with castings to provide a plate fin heat exchanger or cold plate. Extruded plate fin sections can be cemented to cast plate fin sections to provide a plate fin heat exchanger, as shown in Figure 21.15.

21.4.4 Die Cast Housing

The die casting process is capable of providing the lowest cost piece parts, with high quality and excellent appearance. However, tooling costs are very high, tools take a long time to fabricate, and modifications or design changes are very expensive. Die castings should therefore not be considered for production runs of less than about 1000 piece parts. This requires long range planning, scheduling, and coordinating to ensure a satisfactory product. For large production runs it may even be possible to use investment castings or plaster mold castings as a buffer until the die casting tools have been fabricated, installed, and proven out.

21.4.5 Extruded Sections for Large Cabinet

Weight is often a problem with large cabinets that must be designed to withstand the Navy shock and vibration. Thick cast walls can provide the required rigidity, but with a high-weight penalty. Under these circumstances extruded sections, with ribs or hollow cores, are capable of providing a rigid but relatively lightweight electronic enclosure. This type of structure can be welded, bolted, or riveted together to form a very rugged console. The hollow core type of extrusion is very convenient for ducting cooling air to various parts of the cabinet with fans or blowers. Large hollow core cross sections can carry large quantities of cooling air with a small pressure drop. Openings can be placed at various points in the extruded wall sections to direct the cooling air to hot spot areas. These openings can be blocked or reduced in size with plugs if the power distribution is changed at a later date.

Extruded sidewall sections are convenient to use with closed forced-air cooling systems, where a water-cooled heat exchanger or a refrigeration unit cools the recirculated air. One vertical sidewall can be used as the supply plenum, and the opposite sidewall can be used as the return plenum, as shown in Figure 21.16.

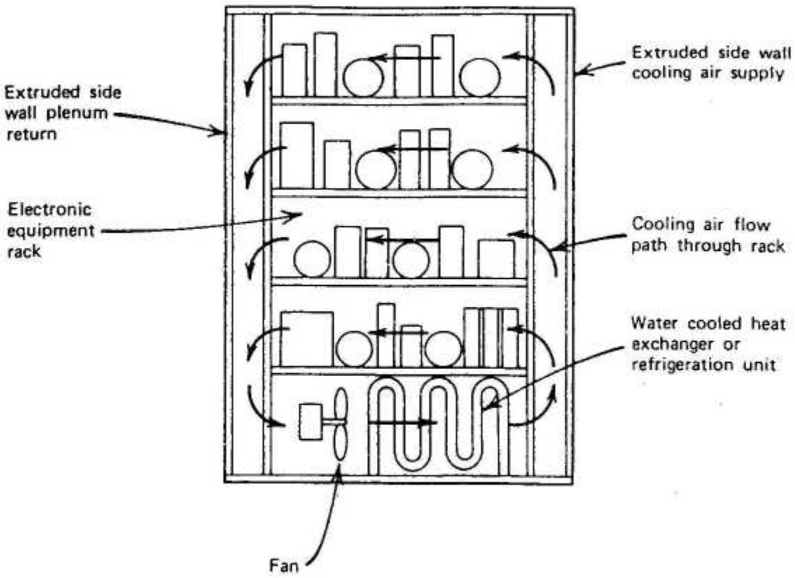

Figure 21.16 Closed-cooling air recirculating systems for electronic equipment rack

21.4.6 Humidity Considerations in Electronic Boxes

Electronic equipment must often be capable of operating in very humid environments, where condensation will produce large amounts of water over a long period of time.

When high-humidity environments are encountered, equipment designers must make a choice. They can seal the box against moisture or let the box breathe. Past experience with moisture problems shows that it is better to let the box breathe, because it is extremely difficult to seal an electronic box against moisture.

Humidity can cause serious problems in the electronic equipment when the internal circulating air is cooler than the outside ambient air. Moisture can condense on the electronic components, connectors, and circuit boards, producing short circuits or radical changes in the resistance between electronic components.

A moisture drainage path should be provided that permits the condensation to drain from the console walls, circuit boards, connectors, and wire harness to a drip pan at the bottom of the unit, where the moisture can evaporate or drain out of the system. Avoid moisture traps where the condensate can settle and cause corrosion. Drill holes, with a minimum diameter of 0.25 in, in the corners of horizontal bulkheads, away from the electronic components, to provide a moisture drainage path through the cabinet.

Use vertically oriented circuit boards and connectors, if possible, to provide a natural moisture drainage path away from the boards to the bottom of the chassis.

Offset drain holes may be required in the base of the chassis to prevent foreign objects, such as screwdrivers, from being poked into these holes and causing internal damage. Drain holes similar to the one shown in Figure 21.17 will reduce the possibility of foreign objects entering the chassis.

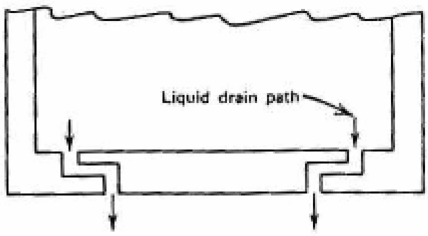

Figure 21.17 Offset drain holes in bottom of chassis

21.4.7 Conformal Coatings

There are five popular types of conformal coatings: acrylic, epoxy, polyurethane, silicone, and parylene. A thin conformal coating 0.0003 to 0.005 in (0.00076 to 0.0127 cm) thick may be required to protect the circuit boards from moisture. However, these coatings should be applied only if they are absolutely necessary In general, coatings are expensive to apply. They require special cleaning processes, special tools to apply the coatings, and the circuit boards are difficult to rework. In addition, many coatings tend to crack, chip, and peel, and they will contaminate the connector contacts unless they are masked during the application. Also, water vapor tends to creep under the coatings and condense, so that coatings can change the electrical resistance between the circuits they are supposed to help. Therefore, if it becomes necessary to apply a conformal coating for moisture protection, make sure that the cleaning and application procedures are carefully followed, or the coatings may create more problems than they solve.

The conformal coat should not be applied so that it bridges the strain relief on the component lead wires. The purpose of the strain relief is to reduce stresses in the wire and in the solder joints. If the strain relief is bridged (completely filled), it will act like a short circuit and will not provide strain relief during vibration as the PCB flexes. Also, a filled strain relief will restrict the relative motion that results during temperature cycling tests. This will increase the stresses in the solder joints, which will increase the chance of failure.

21.4.8 Sealed Electronic Boxes

Electronic systems with high-impedance circuits are usually very sensitive to humidity and moisture in the ambient air. Slight amounts of condensation on sensitive components, printed circuits, or electrical connectors can often produce large changes in the operating characteristics of the system. Therefore, to minimize potential problems resulting from humidity, moisture, and condensation, sensitive electronic systems are often packaged in sealed electronic boxes.

Sealed electronic boxes are also used for some air-cooled electronic systems, which must be capable of operating in the hard-vacuum environment of outer space. The sealed box is used to prevent the loss of air, which is required to cool the electronic components.

Many different types of seals can be used, depending upon the size of the unit, the cost, and the ease of repair. Solder seals are very effective for small covers on boxes, but repairs are inconvenient. O-ring seals are popular and easy to use for large or small boxes.

A large, stiff, machined mounting flange with many high-strength screws is required for the box and the cover, to provide an effective seal. A typical O-ring seal is shown in Figure 21.18.

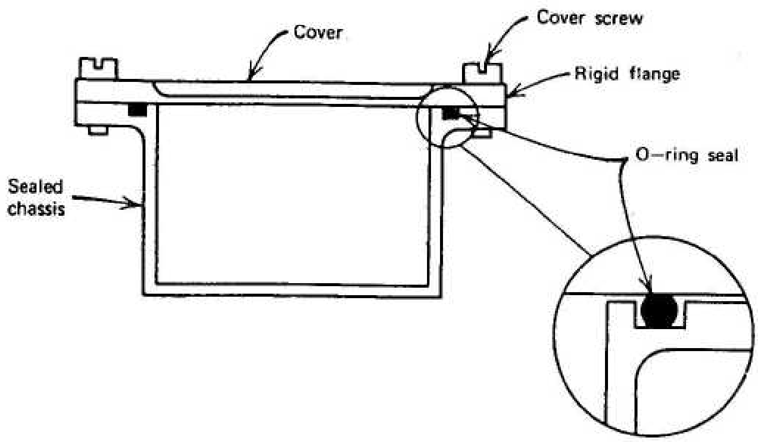

Figure 21.18 O-ring for electronic box

21.4.9 Standard Electronic Box Sizes

Electronic boxes can come in a wide variety of sizes and shapes, depending upon the application and environment. One organization, however, has made an attempt to standardize the size, shape, and mounting for electronic boxes used in air transport equipment. This has become the standard known as ARINC, which is an acronym for Aeronautical Radio Inc. This specification, ARINC 404, Air Transport Equipment Cases and Racking (ATR), December 31, 1970, defines a group of rectangular plug-in types of electronic equipment cases, which have the outer dimensions listed in Table 21.1.

Table 21.1 ARINC standard rectangular box sizes

Description	Width (in)	Length (in)	Height (in)
Short one quarter ATR	2.250	12.5625	7.625
Long one quarter ATR	2.250	19.5625	7.625
Short three eights ATR	3.5625	12.5625	7.625
Long three eights ATR	3.5625	19.5625	7.625
Short half ATR	4.875	12.5625	7.625
Long half ATR	4.875	19.5625	7.625
Short three quarters ATR	7.50	12.5625	7.625
Long three quarters ATR	7.50	19.5625	7.625
One ATR	10.125	19.5625	7.625
One and one half ATR	15.375	19.5625	7.625