Chapter 7

Packaging, Enclosures, Mounts, and Headers

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Introduction

Scope

This chapter covers the packaging to be used for the transformers and inductors in rectangular and cylindrical, epoxy fiberglass cups. These fiberglass cups will have terminals and/or flexible leads exiting for use in electrical circuits. The transformer and inductor will be referred to as, "magnetic component," throughout this chapter.

Application

When selecting the enclosure (package), electrical performance of the magnetic component must have first priority. The magnetic component must function in the circuit with rated electrical conditions at extreme, environmental conditions. The magnetic component enclosure must be designed to meet electrical, environmental conditions and be able to remove the heat generated by the magnetic component, if required. The amount of polymeric material used for impregnating and embedment must be kept to a minimum. Minimizing the amount of polymeric material used to encapsulate the magnetic component will keep undue pressure on the magnetic component to a minimum.

Material

Material

All magnetic components shall be protected from direct exposure to the physical environment by the use of epoxy-glass enclosures. The enclosures for magnetic components shall be fabricated from epoxy-glass laminate, per MIL-P-18177, Type GEE, flame retardant Grade 4, or MIL-P-13949, Type GF (flame retardant).

Enclosure

Enclosure Cup

Magnetic devices shall be protected by properly shaped enclosures designed to maintain structural integrity, provide a conductive heat path to the mounting surface, if required, and anchor the external leads to prevent stresses being applied to the terminals and the magnet wire leads. Typical enclosures are shown in Figure 7-1.

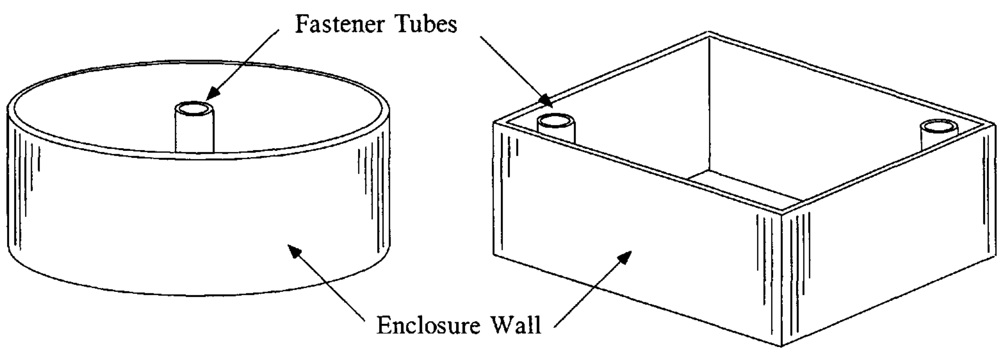

Figure 7-1. Typical, Enclosure for a Magnetic Component.

Enclosure Cover

<u>Enclosure Cover</u>

A cover shall be optional for a magnetic device with radial lead routing. Enclosure covers shall be required on all magnetic components, utilizing the separate impregnating and embedment processes. The enclosure covers shall be enclosed by the cup and be flush with the cup's inner edge. The cover thickness shall be as specified in Table 7-1. The cover shall have holes, as required, to accept the applicable number of fastener holes. The cover shall have two embedment fill holes of 0.125 of an inch in diameter for covers with a maximum dimension of 1.00 inch, and holes of 0.250 of an inch in diameter for covers greater than 1.00 inch. The embedment, fill hole centers shall be located, as shown in Figure 7-2 and Figure 7-3.

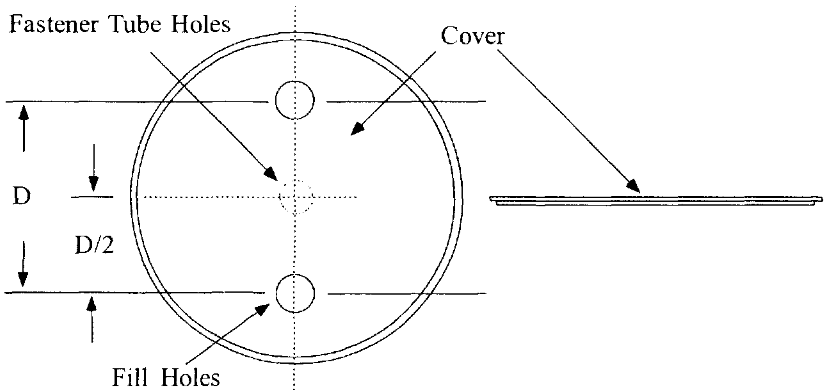

Figure 7-2. Location of the Embedment Fill Holes for a Circular Cover.

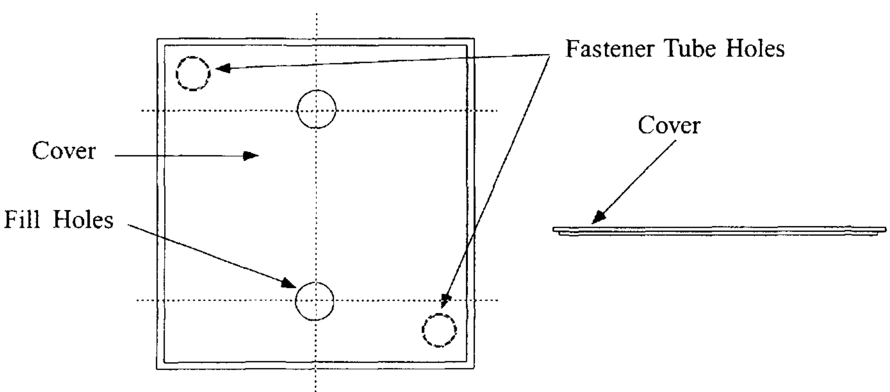

Figure 7-3. Location of the Embedment Fill Holes for a Rectangular Cover.

<u>Dimensions</u>

The enclosure dimensions shall provide a clearance of 0.020 of an inch minimum to 0.10 of an inch maximum to the winding and core assembly, except for the bonding of the winding assembly to the terminal assembly or base. The wall and cover thickness for different enclosure sizes is given in Table 7-1.

Table 7-1

Enclosure Material Thickness			
OD Width or Length	Cover Thickness	Wall Thickness	Type Fastener
< 1.5 inches < 38 mm	0.02 inches 0.51 mm	0.015 inches 0.51 mm	Screw Screw
> 1.5 inches > 38 mm	0.02 inches 0.51 mm	0.025 inches 0.64 mm	Screw Screw
* *	0.031 inches (min) 0.80 mm (min)	0.031 inches (min) 0.80 mm (min)	Bracket Bracket
* Magnetic device mounted by bracket, a clamp, or a similar device.			

Selecting the Enclosure

The enclosure must be selected to best fit the magnetic device. There must be ample room for the terminal board, and space to route the leads. The selected enclosure should provide ease of assembly and inspection. If the selected enclosure is larger than it needs to be, then additional embedment would be required to fill these voids. See Figure 7-4 and Figure 7-5. Always select an enclosure that requires a minimum of embedment. Too much embedment will put undue stress on the magnetic device.

Fastener Tube

Fasteners

The fastener tube wall thickness shall be 0.031 of an inch (0.08 cm), minimum, for all magnetic devices. The fastener tube length shall be identical to the height of the enclosure and extend through the base and cover or spacer, as applicable in all applications. The ID of the fastener tube shall be 0.125 of an inch when, a 4-40 screw is specified and 0.144 of an inch when a 6-32 is the specified screw for single fastener tube application. Fastener tubes are shown in Figure 7-1. Where two or more fastener tubes are used, the internal diameter shall be 0.138 of an inch when, a 4-40 screw is specified and 0.151 of an inch when a 6-32 is the specified screw.

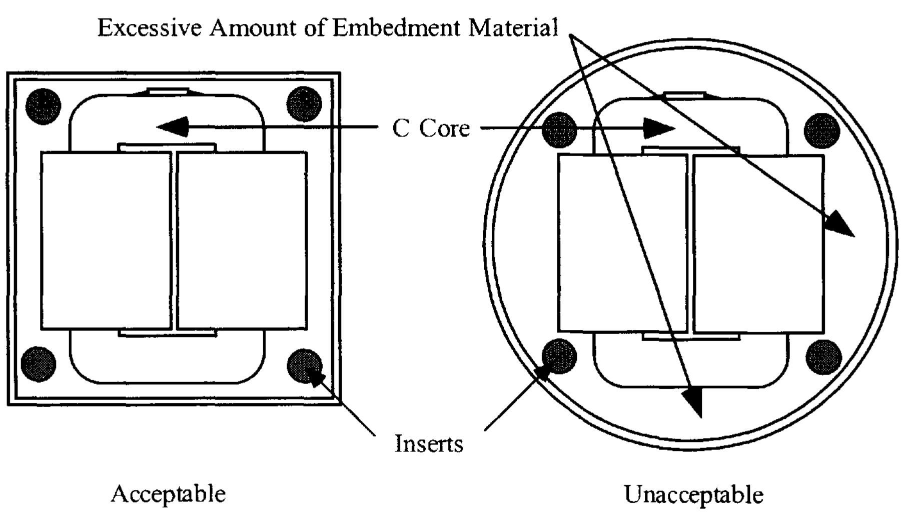

Figure 7-4. Comparing Enclosures C Cores.

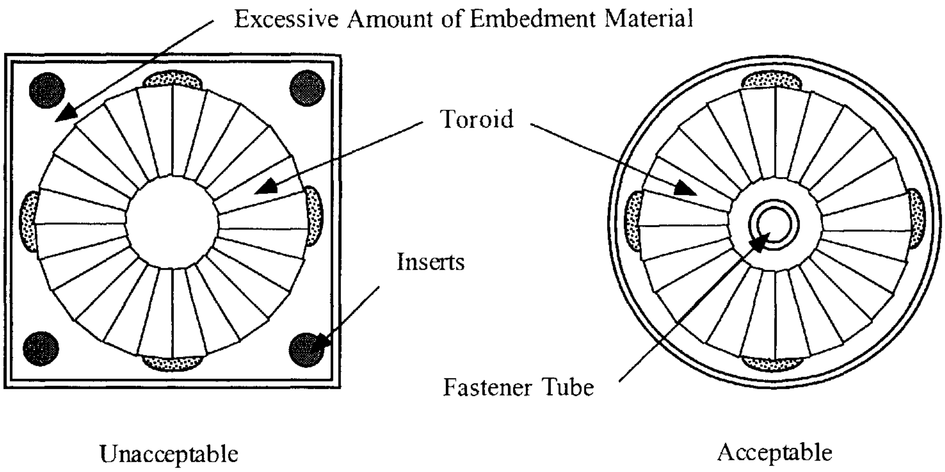

Figure 7-5. Comparing Enclosures C Cores.

Threaded Fasteners

<u>Threaded Fasteners</u>

Threaded Fasteners, embedded in the encapsulation material, shall be of the blind type. The threaded fasteners will be secured in place with a 360 degrees bead of epoxy adhesive. The threaded fasteners or blind type inserts are shown in Figure 7-6.

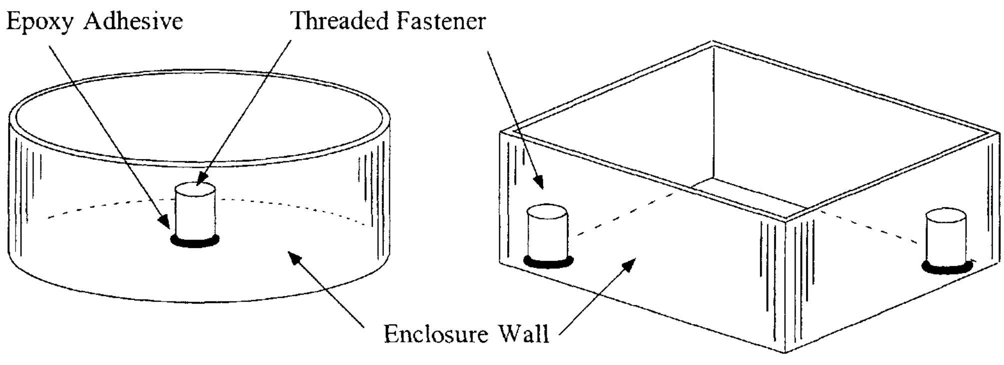

Figure 7-6. Enclosures with Blind Type Threaded Fasteners.

Terminal Board

<u>Terminal Board Material</u>

The internal terminal boards shall be fabricated from epoxy-glass laminate, per MIL-P-18177, Type GEE, flame retardant Grade 4, or MIL-P-13949, Type GF (flame retardant).

Terminal Board Position

The terminal board shall be positioned as follows:

1. Bonded to the wall of a rectangular cup, as shown in Figure 7-7.
2. Bonded to the wall of a round cup, as shown in Figure 7-8.
3. Bonded to the core, as shown in Figure 7-9.

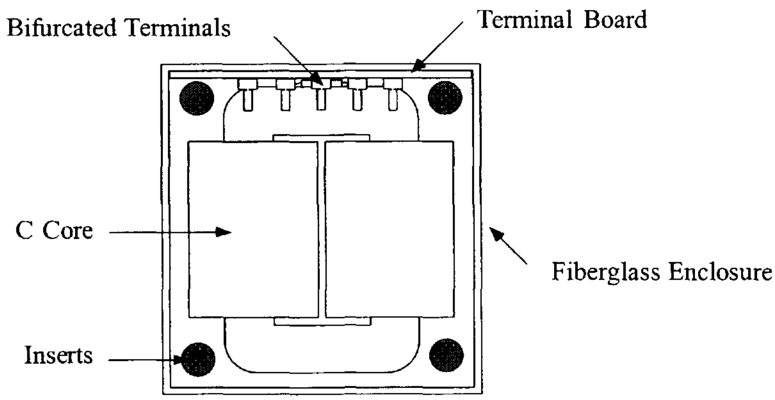

Figure 7-7. Terminal Boards, Bonded to the Wall of Rectangular Cup.

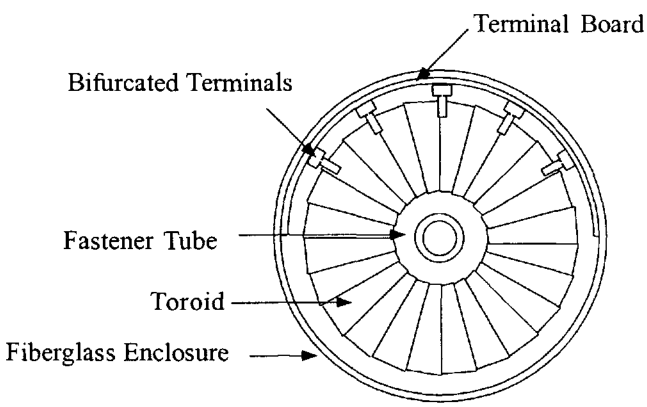

Figure 7-8. Terminal Boards, Bonded to the Wall Round Cup.

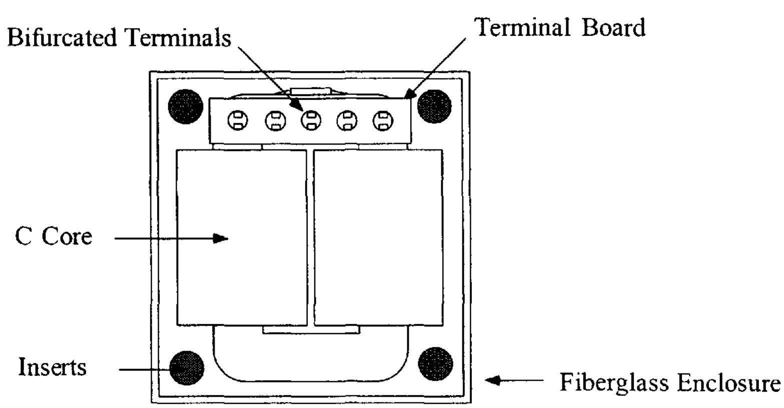

Figure 7-9. Terminal Board, Bonded to the C Core.

Terminal Board Outline

The terminal board shall have embedment, flow-through holes. The holes shall be 0.125 to 0.25 of an inch in diameter and shall number four to each square inch of board surface. The holes shall be located a minimum of 0.050 of an inch from any edge or installed terminal. See Figure 7-10.

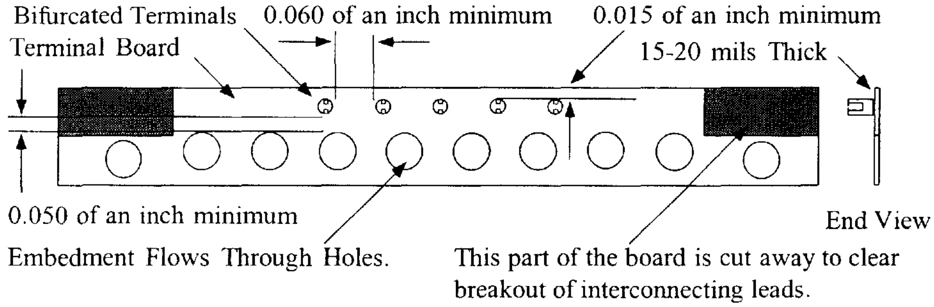

Figure 7-10. Terminal Board.

Terminals and Leads

Terminal Description

Terminals shall be bifurcated or turret, solderable, and capable of being permanently fastened to epoxy glass board. Terminals shall be procured, to the latest Mil Spec. It is common for a single bifurcated terminal to handle multiple terminations. See Figure 7-11. The terminal selected must be able to handle the required number of connecting lead wires.

Terminal Installation

Terminal Installation

Terminals shall be swaged using the force, specified in Table 7-2.

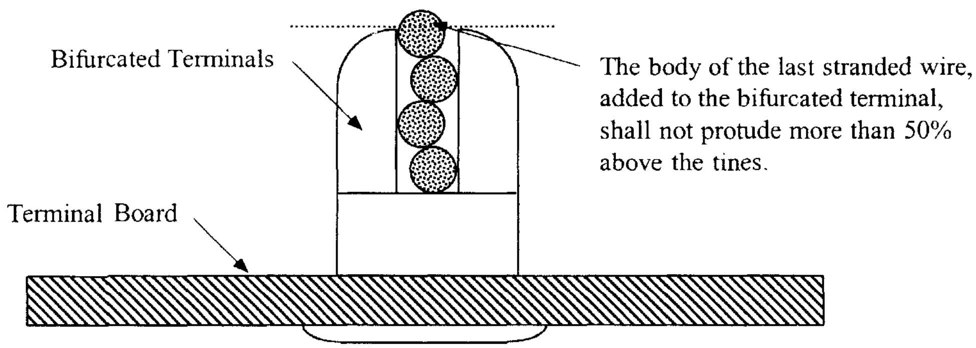

Figure 7-11. Terminal Board.

Table 7-2. Swage Force for Terminals.

Swaging Force for Terminals			
Approximate Size Swage Barrel	Units	*Nominal Force (pounds/kilograms)	Maximum Force (pounds/kilograms)
0.041	pounds kilograms	80 36	100 45
0.062	pounds kilograms	130 59	150 68
0.078	pounds kilograms	200 91	225 102
0.09	pounds kilograms	250 113	300 136
0.112	pounds kilograms	500 227	800 363
*This is the force which is required to just meet minimum, roll-over requirements.			

Terminal Flange

The swage flange of the terminal shall be seated and then, there will be sufficient tightness to assure that the terminal will not move. Maximum permissible height of the terminal swage above the plane of the wiring board shall be 0.012 of an inch and the edge of the rollover shall not be more than 0.004 of an inch above the board surface.

Damaged Terminals

Damaged Terminals

Damage to the funnel type swage and loose terminals is unacceptable. See Figure 7-12.

1. Acceptable
2. More than two cracks in the terminal flange are unacceptable.
3. A loose terminal, as a result of insufficient swage force, is unacceptable.

   An edge of rollover, more than 0.004 of an inch above the board surface is unacceptable.
4. Funnel type swage is unacceptable.

Bifurcated Terminals Installation

The bifurcated terminals shall show no evidence of damage caused by the swaging tools. See Figure 7-13.

1. Acceptable
2. If the installation is not perpendicular to the plane of terminal area, it is unacceptable.
3. Bent tines are unacceptable.

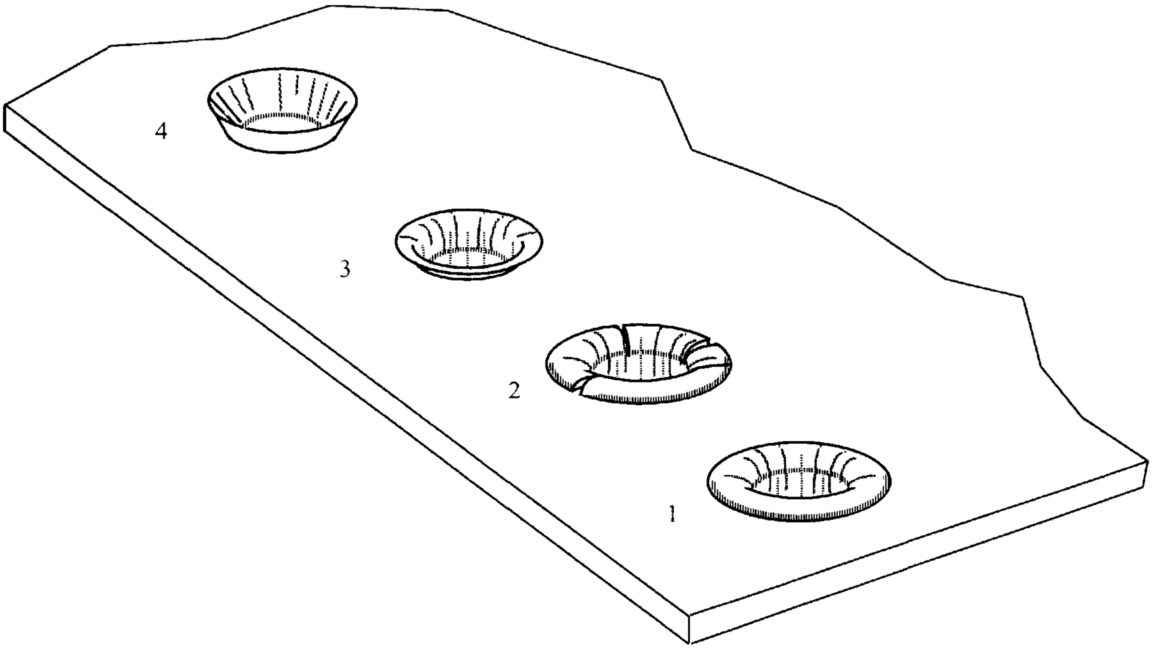

Figure 7-12. Terminal Swaging.

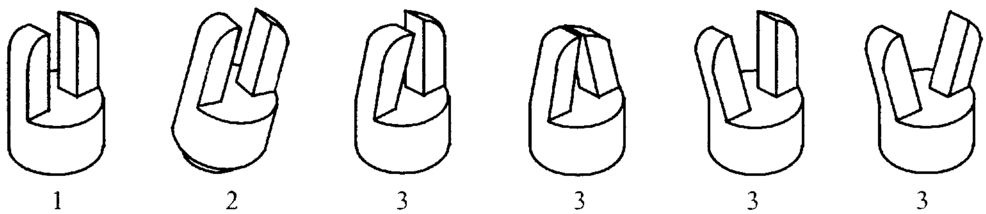

Figure 7-13. Bifurcated Terminal Installation.

<u>Turret Terminals Installation</u>

The turret terminals shall show no evidence of damage caused by the swaging tools. See Figure 7-14.

1. Acceptable
2. If the installation is not perpendicular to the plane of terminal area, it is unacceptable.
3. Bent terminals are unacceptable.

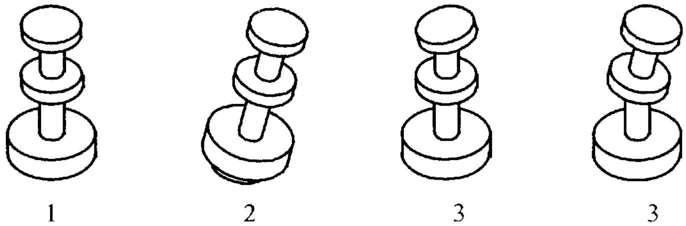

Figure 7-14. Turret Terminal Installation.

Measles

Terminal Installation (measles)

Small white spots, or "measles", caused by terminal installation, shall be acceptable provided they do not form a continuous path between terminals, as shown in Figure 7-15. The small white spots, or "measles" can appear after time or temperature.

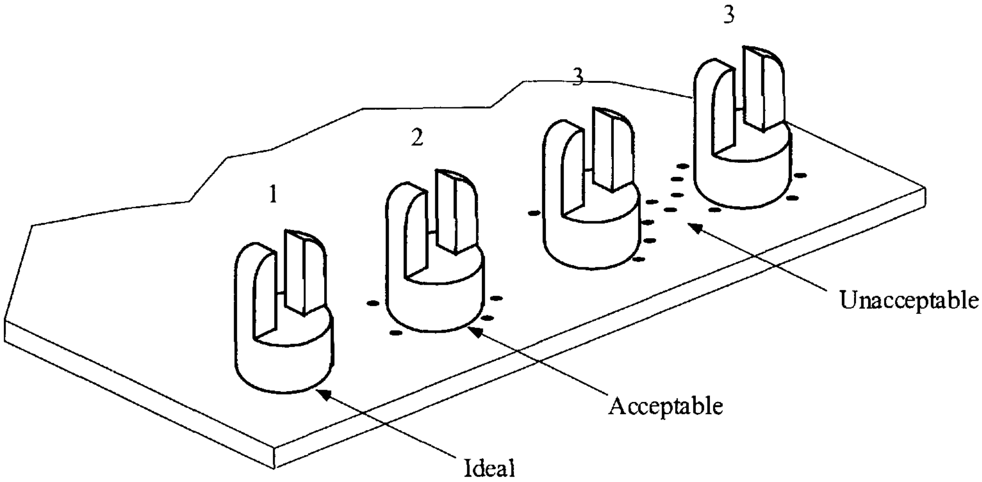

Figure 7-15. Terminal Board with Spots Called, "measles."

Leads

Terminal Leads

A stranded, insulated terminal lead, with a minimum length to facilitate testing and assembly, shall be used for connection to the magnetic device.

External Wire Size

The external lead wire size shall be equal to, or greater than, the area of the magnet wire used in the magnetic device. The minimum external conductor size shall be 26 AWG, stranded wire. Bifurcated terminals, or solder ferrules shall provide the solder interconnection between the coil and external leads for Wire 15, AWG, and smaller. The solder interconnection for wire sizes, 14 AWG, and larger, shall be soldered directly to the external lead by the use of a ferrule appropriately sized.

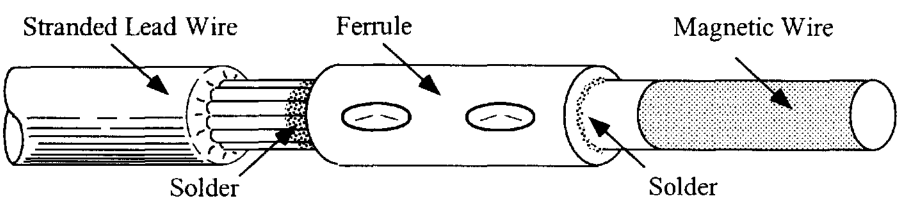

Figure 7-16. Ferrule Connection Using Stranded and Magnetic Wire.

Magnetic Wire Termination

Small Leads

Winding leads of 33 AWG, shall be wrapped around a tine of the terminal, a maximum of 180°. See Figure 7-17.

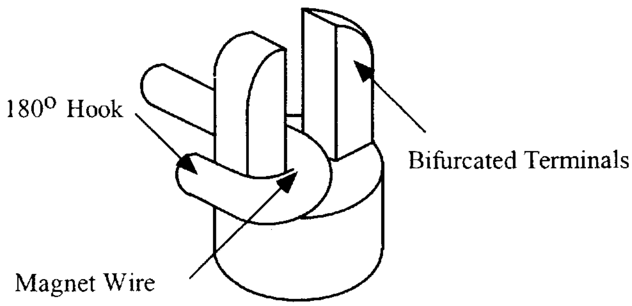

Figure 7-17. Winding Lead Termination for a 33 AWG.

Large leads

Winding leads of 32 AWG up to 15 AWG, shall be terminated without wrapping. See Figure 7-18.

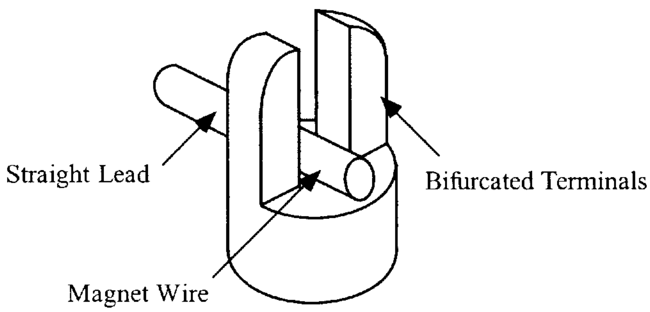

Figure 7-18. Winding Lead Termination for a 32 to 15 AWG.

Magnetic Component Lead Preparation (Pattern)

If the spec control drawing (SCD) does not call out the length of the finish leads, then do the following: Using an enclosure with terminals as a pattern, place the magnetic device in the enclosure, and align the leads with the terminals. With the magnetic device in place, route the leads to provide suitable strain relief, plus sufficient length to rework the solder joint once. See Figure 7-19.

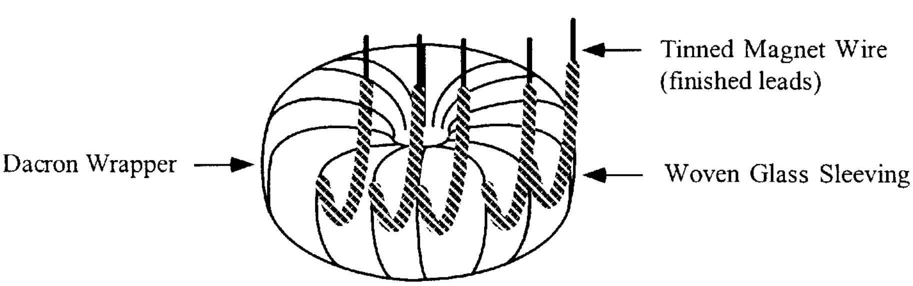

Figure 7-19. Toroidal Winding Leads Breakout.

External Leads

External Lead Connection

External leads connected to an internal board shall extend through a separate opening in the enclosure, or encapsulation material, with spacing of 0.125 of an inch minimum on the centers, as shown in Figure 7-20. The external leads shall emerge, evenly spaced within a 90° sector or side, unless minimum spacing limits require a larger angle, as shown in Figure 7-21. If the number of leads is greater than that which can be accommodated around the periphery, the leads may be aligned in two rows. The external lead length will be six inches long, unless otherwise specified in the spec control drawing (SCD).

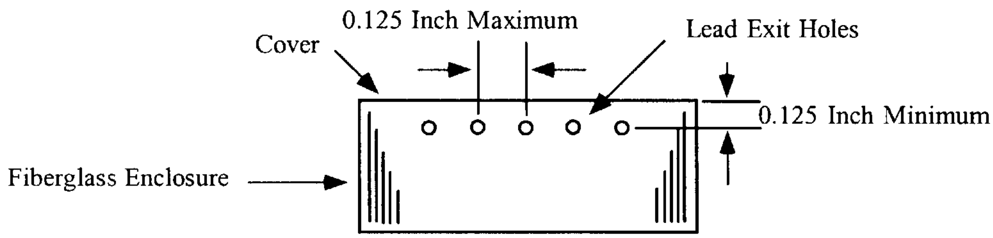

Figure 7-20. External Leads Breakout Location.

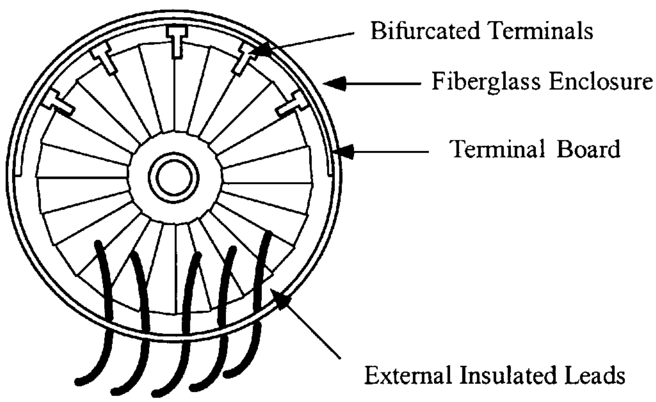

Figure 7-21. Top View Showing Leads Breakout.

Installing the Magnetic Component

Installation of Magnetic Device

The magnetic component shall be placed into the enclosure in the location specified on the drawing. If the location is not specified, the magnetic device shall be located, as centrally in the enclosure cavity as practicable. The magnetic device may be spot-bonded in place, when properly located. See Figure 7-22. For an approved spot bonding material, refer to Chapter 8.

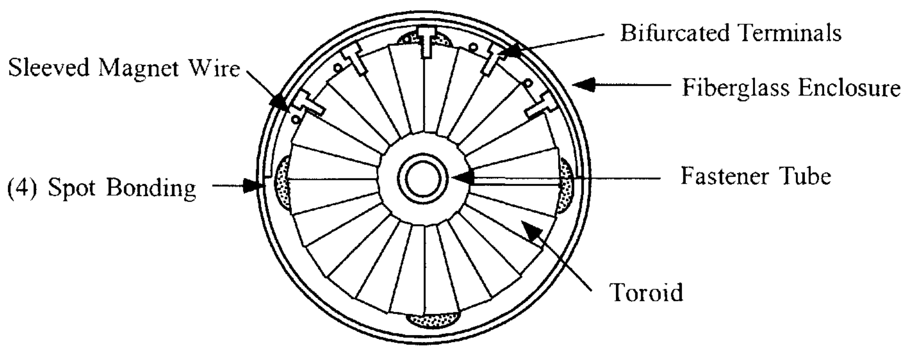

Figure 7-22. Spot Bonding the Toroid.

Terminating the Leads

Terminating the Leads

After the magnet wire leads are terminated, with suitable strain relief, the external leads are attached to the terminals and soldered. The design of the enclosure and internal terminal boards shall be such that flexing of external lead wires, prior to encapsulation, shall not apply appreciable strain to the terminals. The standard length for lead wires is 6 inches; if the external lead wire is to be longer, it must be called out in the spec control drawing (SCD). After the lead wires have been soldered, a verification is done of the lead wire numbers, with the numbers on the magnetic device being the same, then the solder joints will be inspected. After inspection of solder joints and lead numbers, the magnetic device is ready for a pre-pot test. See Figure 7-23.

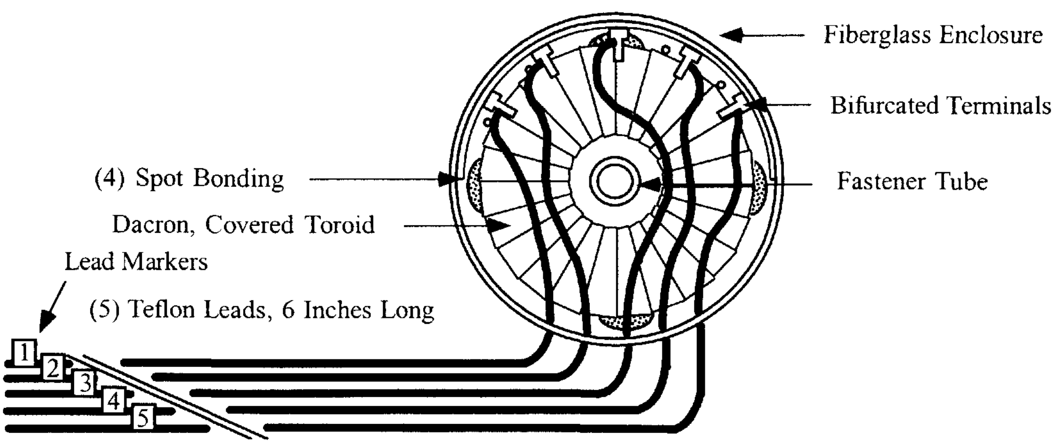

Figure 7-23. Magnetic Device in Final Assembly.

Surface Mounts for High-Rel, Power Magnetics

The surface mount carrier (SMC) is a means of attaching a component to a printed circuit board (PCB). There are many types of packages, and headers for mounting magnetic components to printed circuit boards. These mountings come in different configurations and styles. There are horizontal, vertical, open, and surface mounting, all of which are designed for the printed circuit board. The design engineer must select which configuration will best fulfill the design requirement. There are five areas to investigate when selecting a surface mount carrier (SMC) for use in a Hi-Rel environment: (1) molding material; (2) mechanical integrity; (3) terminal material; (4) solderability; (5) inspectability.

Introduction

Mounting and packaging for magnetic components have become more important in recent years because the size of the power converter has become smaller. The reduction in size of the magnetic component is due to the higher operating frequency, and the power demand required by new scientific instruments and microprocessors. The surface mount carrier (SMC) is ideally suited for high frequency converters. However, using standard packaging has its drawbacks, such as a limited number of sizes for a given configuration. This could lead to design trade-offs, in order to get an adequate fit. Another factor is the current carrying capacity of the surface mount carrier pins. The output power of the converter has drop, but the output current could remain the same. The conductor material of the pins should be of high conductance for a minimum voltage drop. Even with copper pins, the cross section of the pin is not enough to handle the current capacity, and pins have to be paralleled to minimize the voltage drop.

Selecting the Best Plastic for Your Application

Plastics used in molding toroid mounts and headers come in two broad categories: thermoset and thermoplastic. Thermoset plastics include epoxies, phenolics, and diallyl phthalate, (DAP), which are known for their environmental stability, and ability to tolerate over 400°C (750°F) without melting. Thermoplastics include nylon, polypropylene, polycarbonate, polyester, (Valox, Rynite), LCP (Vectra), and PPS (Ryton), which will begin to melt if they experience temperatures much above 260°C (500°F) for an extended period. The chemistry that gives thermoplastics a lower melting point also makes it less expensive to mold, giving it a cost advantage over the thermoset plastics.

Thermoplastics are widely used in applications that do not experience temperatures above 260°C (500°F), except for a few seconds during the winding lead to terminal, and component to a PCB soldering process. Thermoset plastics, on the other hand, are popular in magnetic applications when they are used in conjunction with self-stripping magnetic wire. The unstripped and untinned magnetic wire is wrapped around the terminal, molded into a thermoset header or toroid mount, and then, dipped into a 400°C (750°F) solder pot. The high temperature solder will burn off the wire's insulation, tin the wire, and solder it to the terminal in a cost-effective way, without melting the mount.

There are trade-offs between the two plastic types that must be considered. Parts molded from thermoplastic, will require pretinning the winding leads, and careful heat management while soldering the leads to the mount, and soldering the mount to the circuit board. The thermoset parts can be used with self-stripping magnetic wire. Several terminations can be soldered at once. This type of termination makes it ideal for fine insulated, magnet wire.

Through-Hole Toroid Mounts

Through-hole headers and mounts connect components to a printed-circuit board by inserting a terminal or lead through a hole in the board and soldering it to the opposite side. Through-hole headers and mounts have two basic configurations, horizontal or vertical.

Horizontal Toroid Mounts

Horizontal through-hole headers or toroid mounts are widely used as a platform or holder for mounting wound toroids on their side. They are usually molded from plastic, with the size, shape, and number of termination points specific to the wound toroid. They are most often either a platform, as shown in Figure 7-24, or cup-shaped, like Figure 7-25. The molding of either configuration will typically include standoffs, which allows the printed circuit board's, cleaning solutions to easily flow under the component. The minimum standoff is usually 0.0015 in.

The leads from the toroidal winding are attached to the mount's terminals, usually by soldering. Once the toroid is attached to the mount, this component is ready for insertion into a printed circuit board. Magnetic components are heavy, and the mechanical characteristics of the solder connection are as important as the electrical integrity. Printed circuit boards, with unplated through holes using heavy components, may require a clinched terminal, as described in Figure 7-26. Printed circuit boards, with printed through holes, offer good mechanical integrity without clinching, providing a successful intermetallic bond. This bond is created during the board solder process, as shown in Figure 7-27.

The toroids can be attached to the mount with either adhesives or mechanical means. Cup-shaped toroid mounts can be filled with a potting or encapsulation compound to both adhere and protect the wound toroid. Horizontal mounting offers both a low profile and a low center of gravity in applications that will experience shock and vibration. As the toroid's diameter gets larger, horizontal mounting begins to use up valuable circuit board real estate. If there is room in the enclosure, vertical mounting is used to save board space.

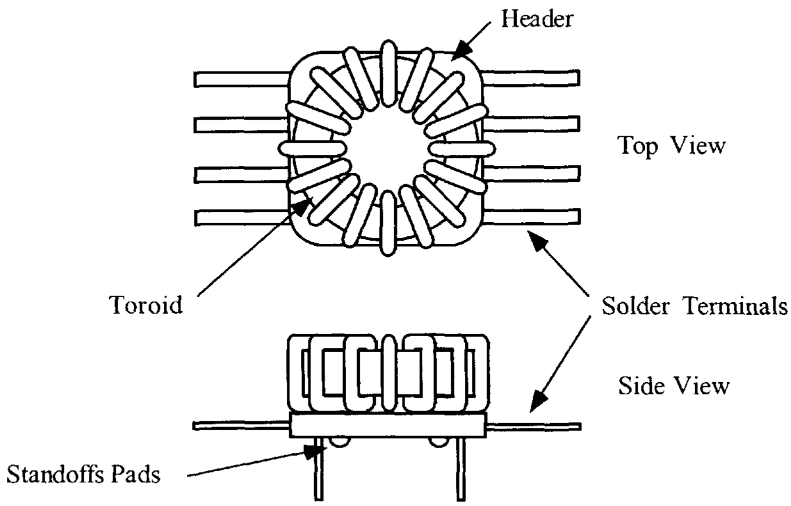

Figure 7-24. Horizontal Platform with Through Hole.

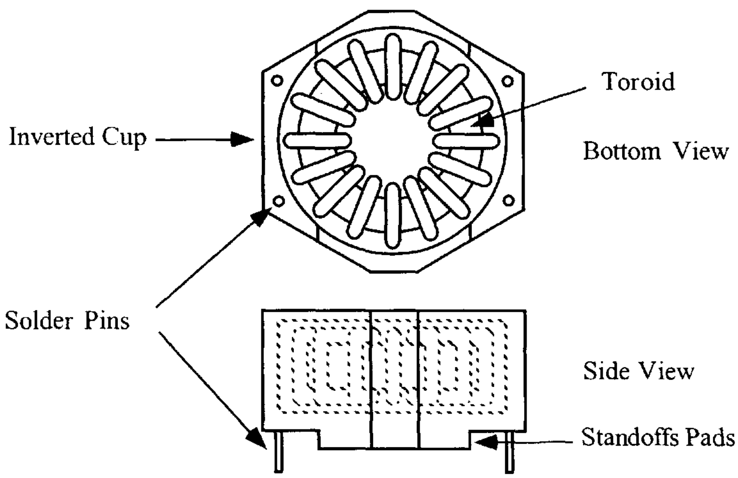

Figure 7-25. Horizontal Cup with Through Hole.

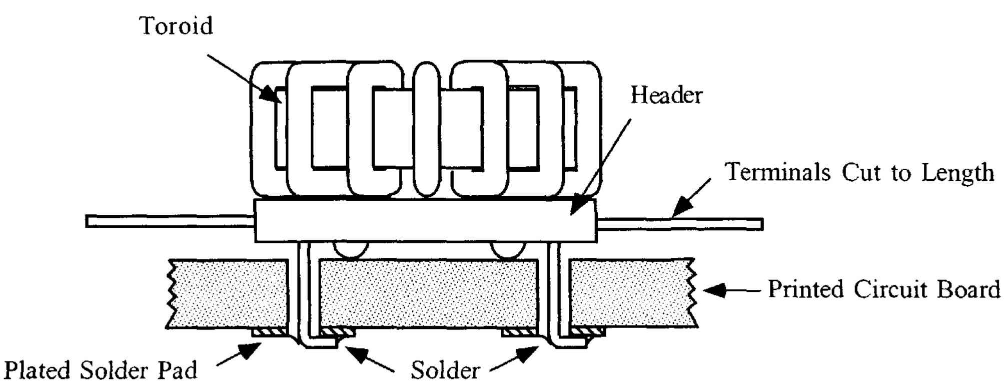

Figure 7-26. Clinched Terminals.

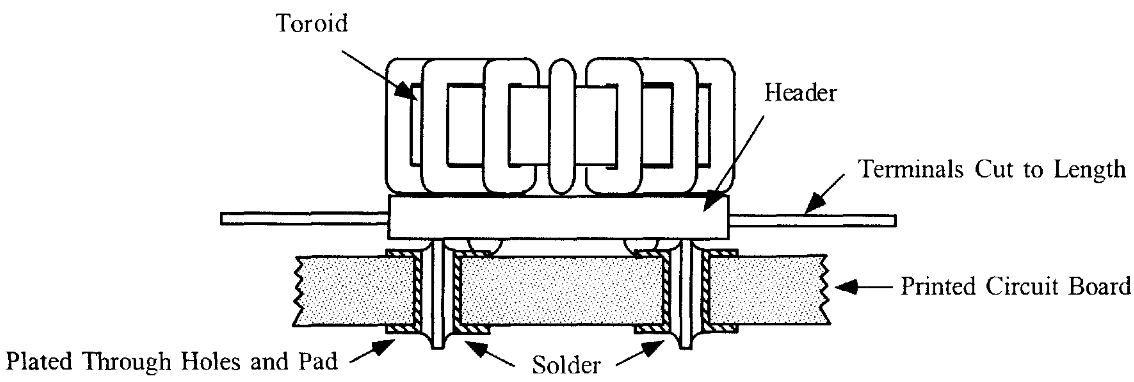

Figure 7-27. Clinched Terminals.

Vertical Toroid Mounts

Toroids using vertical through-hole headers and vertical cups, are used to save circuit board real estate. As, with horizontal mounts, vertical mounts are usually molded from plastic, with the size, shape, and number of termination points specific to the application. The molding of either configuration will typically include standoffs, which allow the printed circuit board cleaning solutions to flow easily under the component. The minimum standoff is usually 0.015 in. Vertical toroid mounts come in many configurations, several of which are shown in Figures 7-28 and Figure 7-29. Much of their structure is devoted to supporting the vertical toroid and creating a stable base for connection to the printed circuit board.

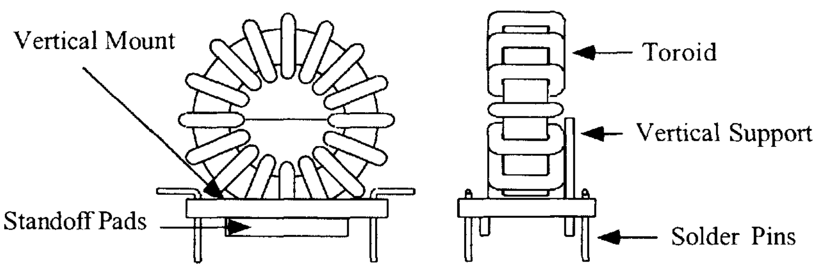

Figure 7-28. Vertical Mount with Through Hole.

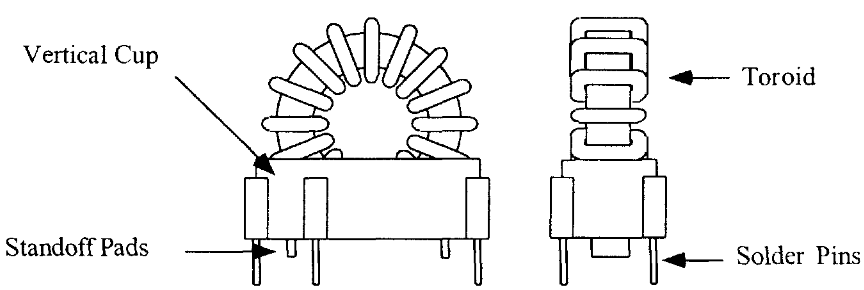

Figure 7-29. Vertical, Open Cup with Through Hole.

The leads from the toroidal winding are attached to the mount's terminals, by soldering, as shown in Figure 7-28. The toroids can be attached to the mount with either adhesives or mechanical means, or by encapsulation. The cup-shaped toroid mounts shown in Figure 7-29 and Figure 7-30, can be filled with a potting or encapsulation compound to both adhere and protect the wound toroid.

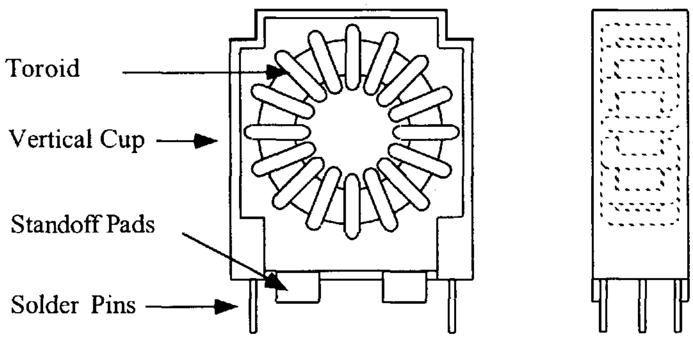

Figure 7-30. Vertical Cup with Through Hole.

Vertical mounting saves circuit board real estate when a toroid's diameter gets larger, but it creates a component height issue. Vertical mounting also raises the component's center of gravity, making it vulnerable to shock and vibration.

Surface Mount, Toroid Mounts

Surface mount components are a direct response to smaller size magnetic components and improved circuit board real estate. Instead of a pin or terminal passing through a printed circuit board, and being soldered on the opposite side, surface mount components utilize a flat solderable surface that is soldered to a flat solderable pad on the face of the printed circuit board. See Figures 7-31 and 7-32. For ease of manufacturing, the circuit board is usually coated with a paste-like formulation of solder and flux. With careful placement, surface mount style components on solder paste will stay in position until temperatures are elevated, usually from an infrared oven. The temperature melts the solder paste and solders the mount's flat terminals to the circuit board's pad.

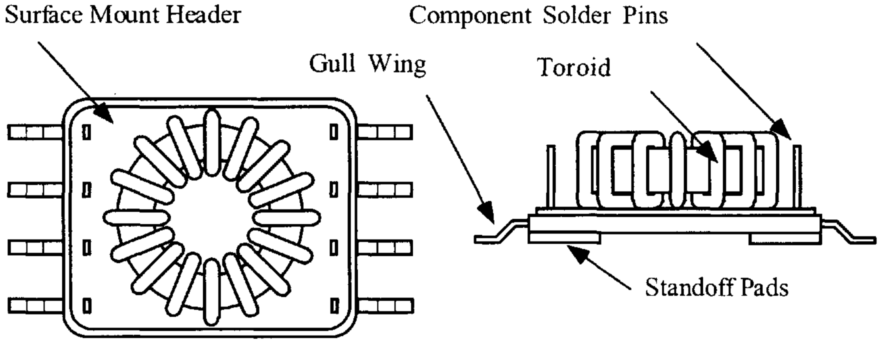

Figure 7-31. Gull Wing Surface Mount Carrier (SMC).

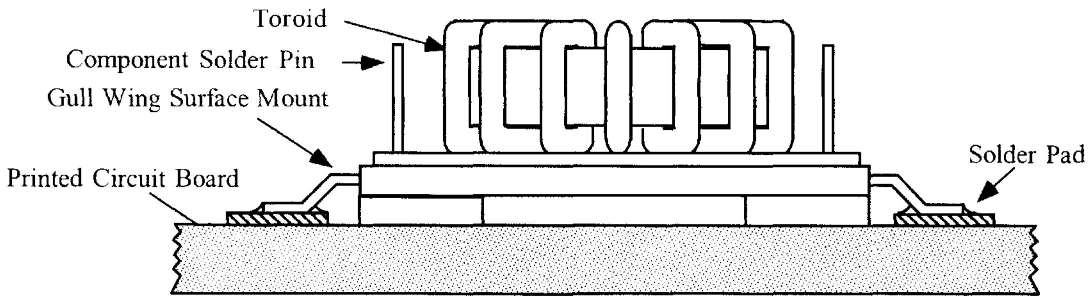

Figure 7-32. End View of a Soldered in Gull Wing.

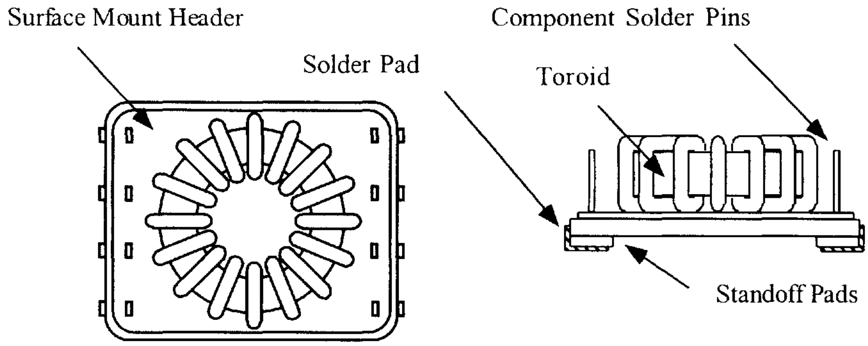

Figure 7-33. "J" Type Lead Surface Mount Carrier (SMC).

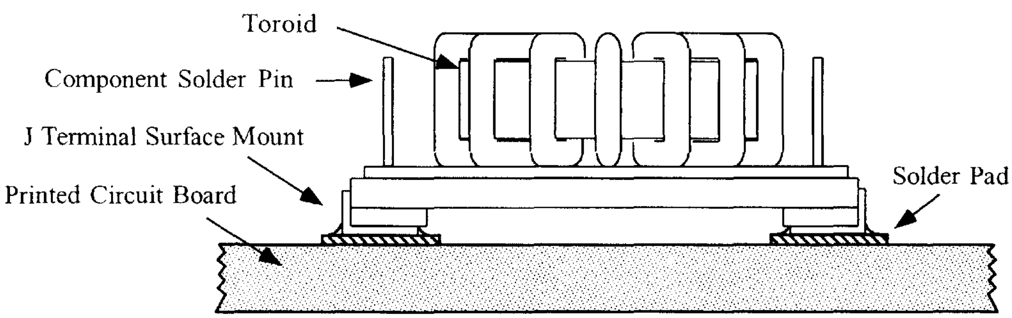

Figure 7-34. End View of a Soldered in, "J" Type.

Because the mount's leads lay on the printed circuit board, it is important that all the mount's leads are flat and on the same plane. If one or several of the leads are out of position, or not on the same plane as the others, the solder connection can be defective. The industry specification for lead "co-planarity" allows a tolerance of 0.004 of an inch from the plane of the printed circuit board. The use of a holding fixture is imperative when mounting the toroid.

The most familiar styles are either gull wing, as shown in Figure 7-31, or "J" lead, as shown in Figure 7-32. Both are horizontal surface mount devices. The gull wings are flexible to withstand thermal expansion and contraction, and it is easy to inspect the integrity of the gull wing lead to circuit board solder connection. The "J" lead also has wide acceptance because it uses up less board real estate than the gull wing. However, the "J" lead to the board solder connections is hidden from inspection, and the leads are more difficult to form. Once the toroids are attached to the mount, with either adhesives or mechanical means, or by encapsulation, the winding leads are soldered to the mount's terminations. Both the gull wing and "J" lead are subject to co-planarity problems, if packaging for shipment and production handling is not carefully considered.

There is another surface mount technique called the "Lunar Lander," which is shown in Figures 7-35 and 7-36. The "Lunar Lander" incorporates a lead style that is more rigidly supported by the plastic molding. This style is very robust, and will tolerate handling and shipping with little or no effect on the co-planarity. This style solders well with the mount to board connections mostly visible for inspection. Figure 7-35 shows the Lunar Lander lead style incorporated with a cup-shaped mount. This can be filled with a potting or encapsulation compound to both adhere and protect the wound toroid.

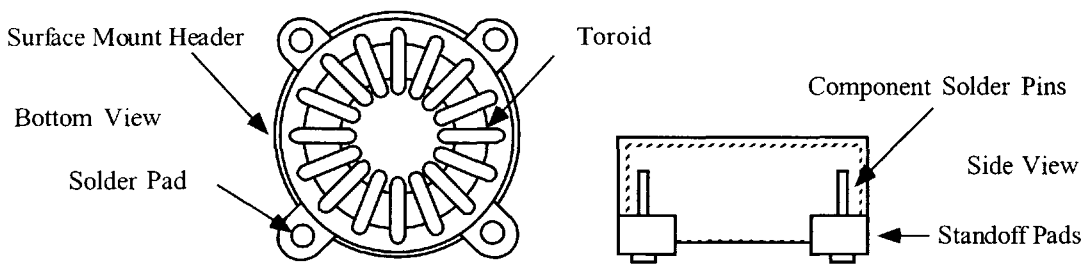

Figure 7-35. Lunar Lander Surface Mount Carrier (SMC).

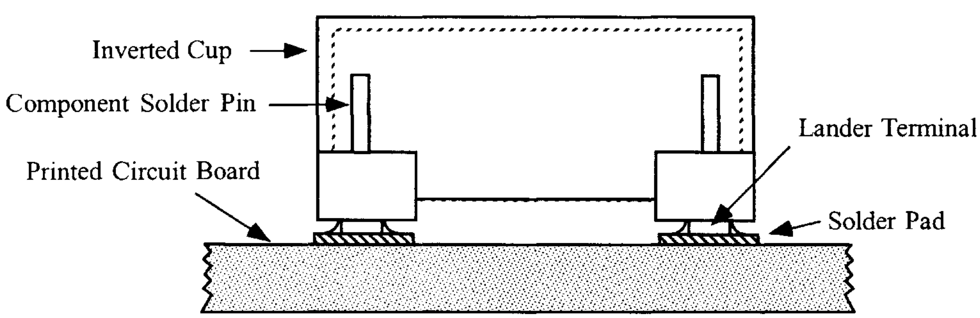

Figure 7-36. End View of a Soldered Lunar Lander.

Reference

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