Overview

The following chapters contain soldering information for the following Vicor product families; Maxi, Mini, Micro; VI-200™, VI-J00™; VI Brick® and similar package filters and front-ends. This document is intended to provide guidance in utilizing soldering practices to make high-quality connections of Vicor power modules to printed circuit boards. Some care will be taken to outline appropriate soldering procedures as well as the evaluation of solder joints in a manner that enables the customer to ensure that the end application has an optimal connection to the power module. Common soldering defects will be examined and direction will be provided for detecting and handling the common defects.

Vicor manufacturing facilities use the IPC-A-610C standards as a means of establishing quality solder joints. It is recommended that manufacturing processes using Vicor modules refer to these same standards, which can be found, along with supporting documentation at: www.ipc.org.

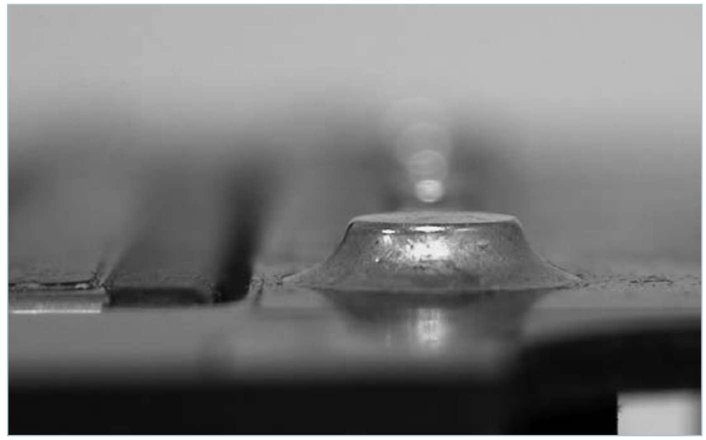

***Figure 14.1** — Side profile of a Mini module solder joint*

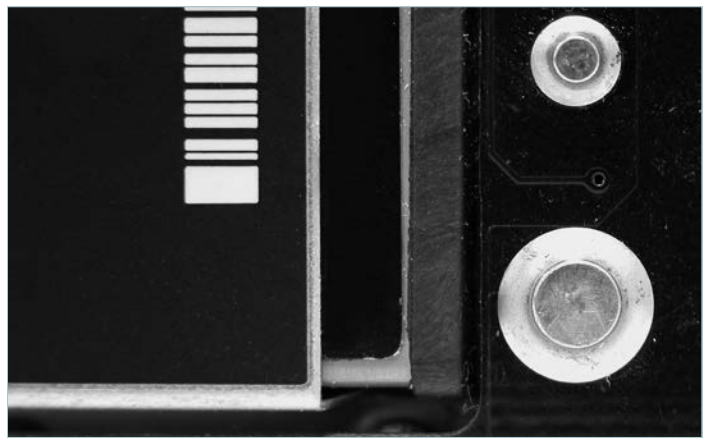

***Figure 14.2** — Maxi / Mini output power pin and sense pin*

Analysis of a Good Solder Joint

The IPC-A-610C standard requires that solder fill at least 75% of the barrel in order to ensure a solid connection. Ideally, all connections should have a 100% fill. In order to accomplish this, the solder applied to both the barrel and the pin must exhibit a process known as wetting. Wetting occurs when liquid solder on a surface is heated to the point that it loses a significant amount of latent surface tension and evenly coats the surface via capillary action (both cohesion and adhesion).

During the soldering process wetting can be identified by an even coating of solder on the barrel and pin. In addition to coating the surface of barrel and pin, the solder will gather at the intersection of the two and produce a trailing fillet along each surface.
Once wetting has occurred, then upon solidification it will bond appropriately to both components, producing a quality connection. Figure 14.1 shows a side profile of a good solder joint with a Mini power module. Notice that for both examples the solder forms a concave meniscus between pin and barrel. This is an example of a properly formed fillet and is evidence of good wetting during the soldering process. The joint between solder and pin as well as solder and pad should always exhibit a feathered edge.
In Figure 14.1 it can also be seen that the solder covers a good deal of the surface area of both the pin and the pad. This is also evidence of good wetting. Notice also that the solder joint has a smooth surface with a silver color. This is evidence of good immobilization of the joint during cooling as well as good cleaning of the board prior to soldering. All soldering connections should exhibit similar characteristics regardless of whether they are soldered by hand or wave soldered.

Figure 14.2 is a top view of the signal and power pin of a Maxi or Mini module properly soldered to a printed circuit board. Notice that both the joint and the area around the joint are clean and free from resin and solder residue. Also the pad and printed circuit board adjacent to the barrel are not burnt or discolored and are solidly attached to each other. In examining a solder joint, be sure that there is no solder connecting one pad to another. This is known as a solder bridge and will be discussed further along with other potential soldering defects.

Soldering Procedures

Hand Soldering: Before soldering, make sure that the PCB is clean and free of debris, chemical residue or liquid. It is not recommended that additional flux other than what is contained in the solder be used during soldering as it potentially leaves a residue that cannot be removed without potentially damaging or compromising the power module. Also, the presence of these residues themselves on the modules may cause harm or improper operation. The pins on Vicor modules are optimized in design for providing a low-resistance electrical connection. The final mounting scheme for any module should be designed so as to minimize any potential mechanical stress on the pins and solder joints. Modules with heat sinks or modules used in systems that are subject to shock or vibration should use standoffs to minimize stress on the pins. Tin / lead pins are specifically designed for soldering applications while gold pin options are specified for socketed applications (see SurfMate or InMate mounting systems). It is not recommended that discrete wires or connectors be soldered directly onto a module.

Also necessary for a good solder connection is pin protrusion from the PCB. It is not possible to create a good solder joint without some protrusion of module pins from the PCB. If the PCB is too thick to allow good pin protrusion, consider using Vicor module accessories such as sockets to allow proper mounting.

Before soldering, the module should be mechanically affixed or immobilized with respect to the PCB to ensure no movement during the soldering process. The standoffs can be used for this process.

Vicor power modules contain two types of pins: power pins (which deliver the power to the load and are typically sized according to the rated output current) and signal pins (which typically carry very little current and are of a uniform size across a given product family). The larger the pin, the more soldering time required to form an adequate connection. In addition to the sizing of the pin the time required to create a robust connection will vary depending on several parameters:

1. *PCB Thickness:* The thicker the printed circuit board is, the more heat it is able to dissipate and thus it will require more soldering time.
2. *Copper Trace Area:* Power pins require large copper traces to minimize resistive power losses in carrying the power to the load. Since the copper tends to conduct heat rather well, the actual size of these copper traces directly affect the amount of time necessary to heat the PCB socket.
3. *Copper Trace Thickness:* As above, the thickness of the copper trace is a function of output current of the module, and has a direct impact on the amount of soldering time. Typically, PCB copper thickness is specified in terms of weight per square foot, typically 2 or 3oz copper for current-carrying planes.
4. *Soldering Iron Power:* A higher power soldering iron can source more heat and thus take less time to heat a PCB trace. When a soldering iron is heating a point on the board, everything that is adjacent to this point is being heated as well, including the Vicor power module. A large copper trace, because it conducts heat very well, will exhibit less of a thermal gradient and thus a low-power soldering iron will have to heat the whole trace to a higher temperature before the area close to the iron is hot enough to flow solder. Because the trace and board are both dissipating and conducting thermal energy, some irons may not have enough power to heat a trace to the temperature that will allow proper soldering.
5. *Tip Temperature:* Typical 63 / 37 solder melts at 392°F [200°C]. A higher tip temperature will bring the barrel and pin above the melting point of solder faster. However, a higher tip temperature may cause damage to the pad, printed circuit board or module pin.
6. *Type of Solder:* The actual melting point of the solder varies depending on the type of solder used and affects the necessary temperature of the pad and pin for flow. Vicor recommends 63 / 37 SnPb solder for use on Vicor power modules.
7. *Tip Size:* A larger tip will be able to heat a larger surface area, thus lowering soldering time.

Since there are so many factors that influence soldering time, listing actual times is difficult. In general, it is recommended that the joint be examined post-process to ensure a quality soldering joint. If necessary, different parameters can then be varied in order to ensure a solid process. The soldering times listed in Table 14.1 can be used as a guideline for establishing more application and process-specific parameters. Below are some recommendations for general practice:

1. Do not run tip temperature above 750°F [400°C] because it will greatly increase the risk of damagingthe pads, traces, printed circuit board or Vicor power module. Check with the printed circuit board manufacturer for any additional recommendations with regards to temperature.
2. Apply the soldering iron to one side of the pin and pad and apply the solder to the other, allowing the heat from the pin and pad to melt the solder. Do not apply solder to the soldering iron and subsequently attempt to transfer it to the pad and pin. Melting the solder by applying it directly to the soldering iron does not guarantee adequate wetting on the joint and is not considered good technique.
3. Do not apply excessive pressure with the soldering iron to the printed circuit board, barrel or pad. This could result in breaking a trace, dislodging a barrel or damaging the PCB, which becomes noticeably softer when heated.
4. Do not apply the soldering iron to a connection for an extended period of time or damage to the module could result. If the soldering times exceed the upper limit listed in Table 14.1, consider using a larger tip or a higher power soldering iron.
5. Make sure PCB pads and holes are clean prior to soldering.
6. Solders with no-clean flux may be used to facilitate soldering.
7. Keep the tip of the soldering iron clean and free from resin. Apply a small amount of solder directly to the tip of the iron. This process is known as tinning.
8. Be careful not to jar the module or PCB while the solder is cooling. This could result in a cold solder joint, a void in the barrel, or a cracked joint.
9. If it is necessary to re-solder a joint, remove all existing solder from the pad and pin prior to reapplying solder.
10. Use of a soldering gun is not recommended for soldering Vicor modules.
11. It is not recommended that Maxi, Mini, Micro module pins be trimmed under any circumstances.
12. The caps of the InMate socket are designed to repel solder. It is normal for this surface to be free of solder.

As a procedural benchmark, given a 750°F [400°C] temperature on a 60W iron with a 0.19in [3mm] tip, approximate times to solder a Vicor power module to a 0.062in [1,5mm] thick PCB board with an appropriately sized copper trace would be in the range of Table 14.1.

Converter Family	Pin Type	Soldering Time (Range)
VI-200™ / VI-J00™	Signal	3 – 5s
VI-200	Power	5 – 8s
VI-J00	Power	4 – 7s
Maxi / Mini / Micro	Signal	3 – 5s
Maxi	Power	5 – 8s
Mini	Power	4 – 7s
Micro	Power	3 – 5s

Table 14.1 *— Recommended pin soldering times for Vicor modules*

Again, please note that soldering for significantly longer periods of time than the time listed above could result in damage to the module. The time listed in Table 14.1 should not be used without verifying that the times will produce a quality soldering joint as defined in the previous sections.

Wave Soldering: Vicor modules achieve an adequate solder connection on a wave soldering machine with conveyor speeds from three to seven feet per minute. As with hand soldering, times and parameters vary with the properties of the PCB and copper traces. As a standard benchmark the parameters below may be used. As with hand-soldered boards, the results should be examined to ensure a quality soldering joint and a sound process.

Wave Soldering Profile:

1. Bottom-side preheaters: Zone 1: 650°F [343°C], Zone 2: 750°F [398°C]
2. Top-side preheaters: 203 – 248°F [95 – 120°C]
3. Wave temperature: 500°F [260°C]
4. Wave type: 4.25in [107,9mm] standard laminar wave

Preheating of the PCB is generally required for wave soldering operations to ensure adequate wetting of the solder to the PCB. The recommended temperature for PCB topside is 203 – 248°F [95 – 120°C] prior to the molten wave. Thick, multilayer PCBs should be heated toward the upper limit of this range, while simple two-layer PCBs should be heated to the lower limit. These parameters are consistent with generally accepted requirements for circuit-card assembly.

The power module is often much more massive than other components mounted to the PCB. During wave solder preheating, the pins will dissipate much of their absorbed heat within the module. Adjustments to preheaters alone, therefore, will not improve module soldering significantly.

A more effective way to improve the soldering of the module is to lower the conveyor speed and increase the dwell time in the molten wave. Approximately five seconds of exposure to the molten wave is required to achieve an acceptable solder joint for a Maxi, Mini or Micro power module.

Post-Solder Cleaning: Vicor modules are not hermetically sealed and must not be exposed to liquid, including but not limited to cleaning solvents, aqueous washing solutions or pressurized sprays. Cleaning the backside of the PCB is acceptable provided no solvent contacts the body of the module.

When soldering, it is recommended that no-clean flux solder be used, as this will ensure that potentially corrosive mobile ions will not remain on, around, or under the module following the soldering process.

If the application requires the PCB to be subject to an aqueous wash after soldering, then it is recommended that Vicor module accessories such as through-hole or surface-mount sockets be used. These sockets should be mounted to the PCB and the modules subsequently inserted following the aqueous washing sequence.

De-soldering Vicor Modules: Vicor modules should not be re-used after desoldering for the following reasons:

1. Most de-soldering procedures introduce damaging mechanical and thermal stresses to the module.

2. Devices or processes that may be capable of de-soldering a Vicor module from a printed circuit board without causing damage have not been qualified for use with Vicor modules. For applications that require removal of a module with the intent of reuse, use Vicor socketing systems.

Index of Common Soldering defect:.

1. *Solder Bridge:* A short circuit between two electrically unconnected points caused by a piece of solder inadvertently forming a "bridge" or connection between the two points.

Recommended Solution: Use a smaller soldering tip or hold the tip at a different angle when soldering, so as to only contact one pad at a time.

2. *Cold Solder:* An incomplete or poor connection caused by either the barrel or the pin not being heated to the flow temperature of solder. A cold-solder joint will typically exhibit a convex meniscus with possibly a dark spot around the barrel or pad. Also a cold-solder joint will not be shiny, but will typically have a "dirty"appearance.

CAUTION: A cold-solder joint is not necessarily an open connection electrically and cannot be diagnosed by a simple continuity check. A cold-solder joint is frequently an electrically intermittent connection and is best diagnosed by visual inspection. A cold-solder joint will likely become electrically open following a period of temperature cycling.

Recommended Solution: Increase soldering iron temperature, soldering time or use a soldering iron with a higher output wattage if hand soldering. If wave soldering, lower conveyor speed or increase preheat temperature.

3. *PC Board Damage:* An intermittent or poor connection caused by damage to a trace, pad or barrel. A damaged pad is best identified by a burn mark on the PCB or a trace of pad that moves when prodded with a mechanical object.

Recommended Solution: Lower the soldering iron temperature or the soldering time. If damage persists use a lower-power iron or consult with the manufacturer of the PCB for recommended soldering guidelines.

4. *De-wetting:* The solder initially appears to wet but then pulls back to expose the pad surface, more common in wave soldering.

Recommended Solution: Make sure the PCB is clean prior to soldering.

5. *Dry Joint:* The solder has a dull gray appearance as opposed to a bright silver surface. The solder joint may have a mottled look as well, with jagged ridges. It is caused by the solder joint moving before completely cooled.

Recommended Solution: Immobilize the module with respect to the PCB to ensure that the solder joint cools properly.

6. *Icicles:* Jagged or conical extensions from solder fillet. These are caused by soldering with the temperature too low or soldering to a highly heat-absorbent surface.

Recommended Solution: Increase the soldering temperature, but not outside the recommended limits. If necessary, use a higher power soldering iron.

7. *Pinholes:* Small or large holes in surface of solder joint, most commonly occurring in wave-solder systems.

Recommended Solution: Increase preheat or topside heater temperature, but not outside the recommended limits.

References
Organizations www.ipc.org Commercial www.aimsolder.com www.alphaassembly.com www.kester.com

Maxi / Mini / Micro Standoff Kits for Solder-Mounted Modules							
Board Thickness	Mounting Options		Slotted Baseplate		Through-Hole Baseplate		Threaded Baseplate
Nominal [Min / Max]	Mounting Style	Pin Style	Through-Hole Heat Sink	Threaded Heat Sink	Through-Hole Heat Sink	Threaded Heat Sink	Through-Hole Heat Sink
0.062in (0.055in/0.071in) 1,5mm (1,4mm /1,8mm)	Inboard	Short Tin / Lead	Kit-18150	Kit-18151	Kit-18146	Kit-18147	Kit-18146
			Bag-19126	Bag-19127	Bag-19122	Bag-19123	Bag-19122
	Onboard	L	Kit-18156	Kit-18157	Kit-18150	Kit-18152	Kit-18150
			Bag-19132	Bag-19133	Bag-19126	Bag-19128	Bag-19126
0.093in (0.084in/0.104in) 2,4mm (2,1mm /2,6mm)	Inboard	L	Kit-18150	Kit-18151	Kit-18146	Kit-18147	Kit-18146
			Bag-19126	Bag-19127	Bag-19122	Bag-19123	Bag-19122
Kits include six (6) standoffs and screws. Mini and Micro modules require a minimum of four (4) standoffs. Bags contain 100 standoffs only (#4-40 screws required).							

Table 13.2 *— Standoff Kits for solder mounted modules*