APPLICATION NOTE

Probe soldering guidelines for Keysight InfiniiMax probes

Introduction

There are various ways to connect test instrumentation probes to devices under test (DUTs). One such method is soldering, which provides a reliable connection and minimizes parasitic probing effects by keeping wire lengths and connections as short as possible. Many of Keysight's high performance oscilloscope probes utilize soldered connections. As probes and devices continue to shrink in size, using the correct tools and soldering skills becomes even more critical in order to avoid damage and connectivity issues. This guide provides helpful tips, recommended tools, and techniques specific to Keysight probes to help test engineers get the most out of their soldered-in probes and connections.

Tools

Soldering iron

Keysight recommends a high-quality soldering iron with the ability to control the tip temperature. Different solder alloys have different melting points, and keeping the temperature as low as possible while still melting the alloy is essential to prolonging the life of your probe accessories. Additionally, the iron should support the smallest tips possible. The JBC NANE Nano Soldering Station is an excellent choice. For probe soldering, a simple pointed tip is all that is required, although some irons have "tweezer" tips that may be useful for other DUT rework.

Figure 1: A JBC Nano Soldering Station

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Generally, it is not a good idea to use different solder alloys with the same tip. Also, when finished soldering, it is best to leave some solder on the tip before shutting off the iron to prevent tip corrosion. Using a water-soaked sponge to clean probe tips accelerates corrosion; it is best to use brass “wool” or a silicone pad to wipe the tips clean (included with the above referenced iron).

Sometimes, using a larger tip can be helpful to minimize dwell times, even though it might make visibility a bit more challenging. Often, the corner of a chisel-tip can be very effective at delivering heat to a joint.

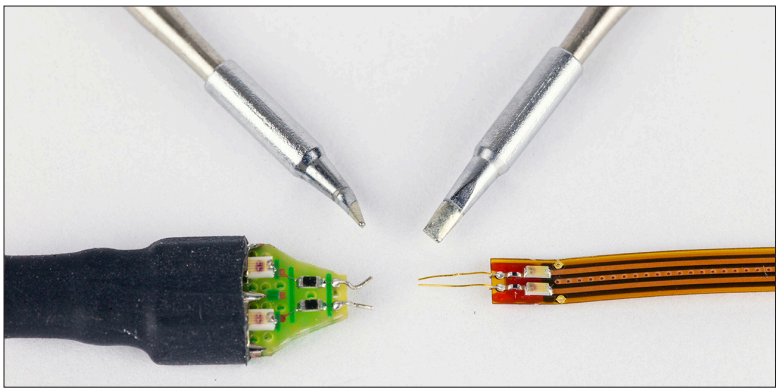

Figure 2: Suitable soldering iron tips should be sized appropriately for probe heads.

Soldering iron tips

It is best to have a variety of tip shapes and sizes to accommodate different DUTs and probes. Different operators may prefer different shaped tips as well. A very small tip (0.1 mm tip diameter, > 5 mm overall length) is crucial, as is a larger chisel tip for larger soldering masses. These tips work well for probe soldering and are compatible with the aforementioned soldering iron:

- JBC Chisel tip C105113
- JBC Conical cartridge C105101

Flux

Flux is a chemical used with soldering processes that cleans the surfaces to be soldered, promoting a better solder joint and a quicker soldering process. Many solders have flux incorporated, either as part of a solder paste or as a component in solder wire. Keysight recommends using a flux pen e.g., (CircuitWorks CW8100)—this provides a convenient way to brush flux onto DUT and probe leads without being too messy. However, any type of liquid flux for electronics rework should suffice. Also, it doesn’t hurt to add flux when soldering probes, even if the solder has integrated flux. Flux residue can be cleaned using various flux cleaners but is typically not necessary for probing work, if care is taken not to get excessive flux on or around the probe tip components.

Solder

There are a number of solder alloys available for use with electronics. Since the majority of customers and products have moved to use lead-free/RoHS compliant solders, Keysight only recommends these types.

For general purpose soldering, a SAC (tin, silver, copper or Sn/Ag/Cu alloy) solder is appropriate. SAC305 is a common lead-free alloy, easy to find, and melts at 220 °C.

For detail work or difficult soldering jobs (such as soldering a small probe tip), Keysight recommends a tin-bismuth solder. This low-temp solder melts at 138 °C and can be joined to existing higher-temp alloys. With a melting temperature this low, joints reflow very quickly and easily, and less thermal stress is placed on probe and DUT components. Chip Quik sells SnBi solder in paste form, and Keysight provides a .010” diameter solder wire as part number MX0102-21303.

Solder comes in several forms, each of which has advantages and disadvantages:

- The simplest form of solder is wire. Electronics solder wire of many different alloys can be found at distributors. Wire typically has flux integrated but it helps to add additional flux when soldering. Keysight recommends the smallest diameter solder wire possible for probe soldering; Loctite makes a .009” diameter wire using SAC387 alloy that works well. This wire is available from Keysight as part number MX0102-21302.
- Solder alloys can also be purchased in what are known as “preforms”. These are pre-cut (often custom) pieces of solder than can be placed at a joint and reflowed using an iron or even in an oven. These can be cut in a variety of shapes, including discs, washers, squares, etc. Preforms allow the user to very carefully control the amount of solder applied to a joint.
- Solder in paste form can allow a very specific amount of solder to be applied to a joint. However, it can be extremely messy and difficult to work with. Most pastes have flux incorporated as well. Keysight does not recommend using pastes to solder probes. It is best to apply solder paste very judiciously, taking care not to get any on unintended joints—a sharp pick or hobby knife blade works well for this. It is not advised to dispense the paste from a tube/etc. when using paste with probes, because it can be too easy to over-apply. The best way to clean off excess solder paste is with an ultrasonic bath, but that’s likely not feasible once probes are attached; the next best alternative is to manually remove excess paste using a tissue or brush. Again, Keysight does not recommend using pastes for precisely this reason. Equipment for precisely dispensing solder pastes is available and useful but not common among Keysight probe users.

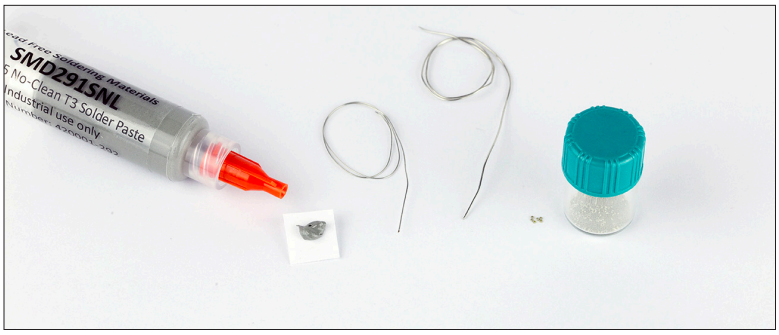

Figure 3: Solder paste, solder wire of two sizes, and solder preforms

Clamps and fixtures

Difficult soldering tasks can be made much easier by securing components prior to applying heat. Bench vises do a good job of holding probe PCBs, DUT PCBs, and wires, and can be easily found at a variety of distributors. When using a bench vise, care should be taken to avoid sinking heat into the vise during soldering. For instance, clamping to a DUT PCB ground plane will make it much harder for the soldering iron to heat the ground plane. Kapton tape can be added to the grips of the vise to thermally insulate it from the soldering specimens. Keysight's N2787A probe positioner is very effective for holding probes during soldering operations.

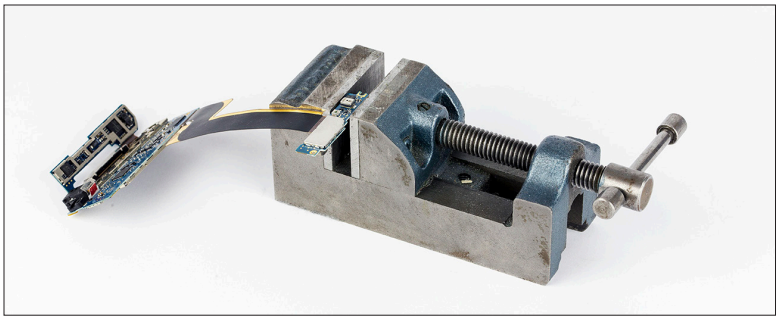

Figure 4: A bench vise works well for securing PCBs during soldering.

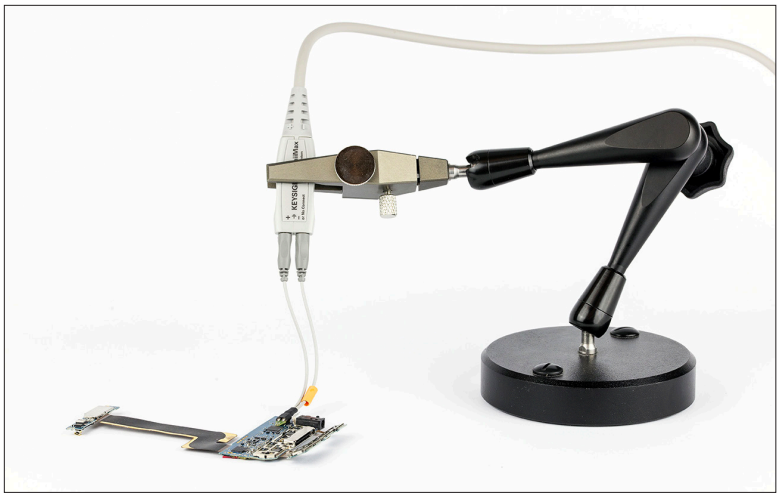

Figure 5: Keysight's N2787A Probe Positioner can be used to hold soldered-in probes.

Various forms of tape can be used to secure a probe head or tip to a DUT PCB prior to soldering. Double-sided foam tape works well, and various thicknesses of foam can be found to accommodate different surfaces. Single-sided Kapton tape can be used simply across the top of probe cables to keep things in place during soldering. On flex-circuit based probes and user DUTs, care should be taken to minimize the amount of tape across controlled impedance lines.

Clamping tweezers (inverse tweezers) can be very useful for holding small components during soldering. Typically, use of these types of tweezers requires a vise to hold them to avoid occupying all of the user's hands. Selecting tweezers with small points keeps their thermal mass low and will make soldering a joint very close to the tweezers easier.

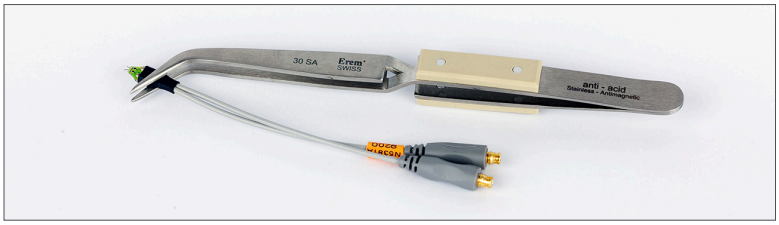

Figure 6: Clamping tweezers holding a probe head

Tweezers and toothpicks

General-purpose tweezers are incredibly useful for dealing with small probe parts. They can be used to adjust tip wires, hold wires during soldering, position preforms, hold probe tips, etc. It is best to have several different tweezer sizes for a variety of different jobs. Keysight recommends a sharp metal tweezer such as part number 8710-2837 for most of these tasks.

Cutting tweezers can be a great way to precisely cut small probe tips wires, particularly on high-performance probes where minimizing the probe tip wire length is critical for maximizing performance (bandwidth, loading, etc.). These can also cut wires very flush. Keysight offers cutting tweezers as part number 8710-2838.

Toothpicks can be used to push tip wires and spread flux, especially if sharpened first with a knife.

Figure 7: A variety of tweezers is useful for soldering probes. From left to right, cutting tweezers, general purpose tweezers, fine-point tweezers, sharpened toothpick, clamping tweezers.

Microscope

It is absolutely critical when working with small electronic devices to have a quality microscope. There are many probe/DUT soldering tasks that simply cannot be performed without significant magnification and good lighting. While simple magnifying glasses or hoods do help, Keysight has found that these are insufficient and can be uncomfortable to use.

A good microscope setup has the following features: binocular eyepieces, adjustable magnification (at least 20x), good working distance from the sample (at least 4”), an adjustable arm, and an integrated ring light around the objective lens.

A boom-type adjustable arm works well for the microscope; this allows a tabletop to act as the work surface, which is more flexible than using an integrated microscope stand.

Keysight engineers use microscopes from Meiji and Leica.

Figure 8: An ideal microscope setup

General Soldering Tips and Techniques

It is important to remember that there are many possible tools and techniques—it is not critical to follow this guide precisely as long as some general rules are followed.

The most critical consideration when soldering heat-sensitive devices is keeping the temperature as low as possible while still reflowing the solder at the joint of concern. A temperature-controlled soldering iron is the best way to do this. Set it to no more than 350 °C if using standard lead-free solders and 150 °C for tin-bismuth solder.

To keep your DUT and probe temperatures low during soldering, it is also critical to limit heat transfer to anything except the solder joint—there are several ways to do this:

- Dwell time: You should never need to rest a soldering iron on a probe joint for more than a few seconds (unless a huge thermal mass is present; an RF connector for instance). Minimize dwell times! A skilled operator can reflow a probe tip solder joint in less than one second.
- If you're having trouble keeping dwell times low, make sure you're using an appropriately-sized solder iron tip. While it may be convenient to pick a tiny tip, it may not be able to deliver heat quickly enough if the joint is too thermally massive.
- Supplemental heat can be used to help with dwell times. Typically, this is done through the use of a hot plate. The solder target (usually a PCB) is placed on the hot plate, which is set to some temperature lower than the solder melting point. In this way, the DUT is pre-heated and the soldering iron is used to melt the joint. Since not much additional heat is required, the joint can reflow more quickly. Supplemental heat can also be added with a hot air gun but this is less easily controllable than a hot plate.
- Use plenty of flux, even if your solder already contains flux. This cleans the solder joint and allows for easier solder flowing and quicker dwell times.

Strain relief

After a probe head or tip is connected electrically to a DUT via solder, it is best to secure it mechanically as well. This protects the electrical connection from accidental bumps and shakes. There are a handful of ways to do this:

Figure 9: A variety of strain-relief materials can be useful for securing probes.

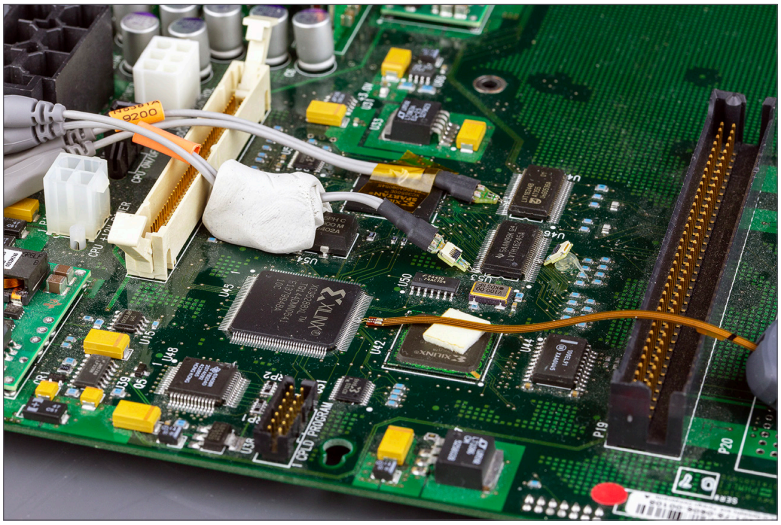

Figure 10: Probe heads secured with a variety of strain-relieving methods.

- Tape is a good method for semi-permanent strain relief, and a large variety is available, with different levels of adhesion and foam thicknesses to suit each application. As mentioned above, double-sided foam tape can be used underneath probe heads and tips.
- "Poster" putty can also be used to secure probe head cables in a manner that is easy to remove. Some putties can leave residue behind—Keysight part number N5439-65201 doesn't leave residue and adheres quite well.

- Glue can be a good strain relieving solution with some caveats. First, no matter the glue type, it is almost always a permanent solution. It will be impossible to get all the glue residue off of a DUT PCB or a probe. The upside of glue is that the strain-relieving performance is superior to all other methods. The only glue type that Keysight recommends for use with probes is low-temperature hot melt glue. This is typically called “craft” glue where the melting point of the glue is below 100 °C. It is critical to stay below the maximum non-operating temperature of the probe. This low temperature glue can also be softened using a hot-air gun or hair dryer, which makes re-using glued probes more reasonable. Avoid placing glue near the probe tips themselves where signal integrity could be affected; usually glue on the cables is fine.

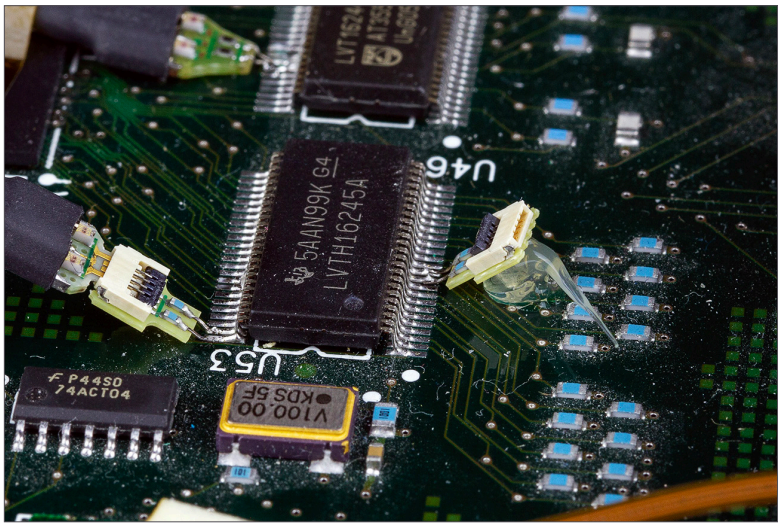

Figure 11: Proper application of low-temp hot melt glue to a ZIF tip.

- For all methods of strain relief, test adhesion first on a non-critical area of the DUT to ensure there is no unwanted residue left behind or other damage to the DUT. Also, make sure the location of the probe on the DUT doesn’t interfere with DUT operation, such as on top of a controlled impedance line or thermally sensitive component.

Specific Techniques for Keysight Infiniimax Products

Attaching probe heads to your circuits

Keysight offers a variety of probe heads to accommodate different DUT geometries and performance requirements. Soldered-in probe heads generally provide the highest performance and most reliable connection, with a trade-off of slightly more up-front time making the connection.

Keysight recommends the same general attachment procedure for all solder-in probes:

1. Prepare the device. Add a small amount of solder to the DUT leads where the solder-in probe will be attached. Sometimes it is helpful to add flux before adding solder.

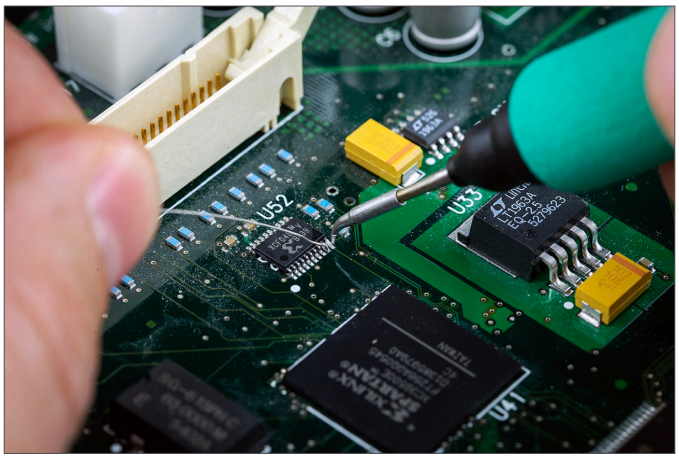

Figure 12: Add solder to target leads.

2. Prepare the probe head. Trim tip or damping resistor wire lengths as short as possible to maximize measurement performance. Shape the tips wires with tweezers to match the DUT leads.

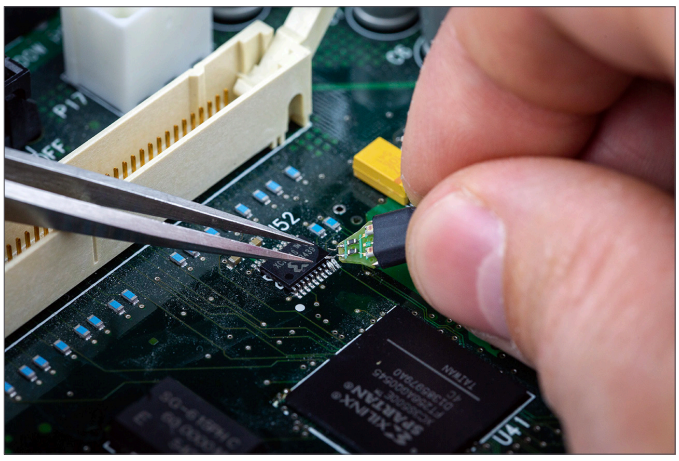

Figure 13: Adjust the tip leads using tweezers if necessary.

3. Apply more flux to the DUT and probe tip wires (a flux pen works well for this).

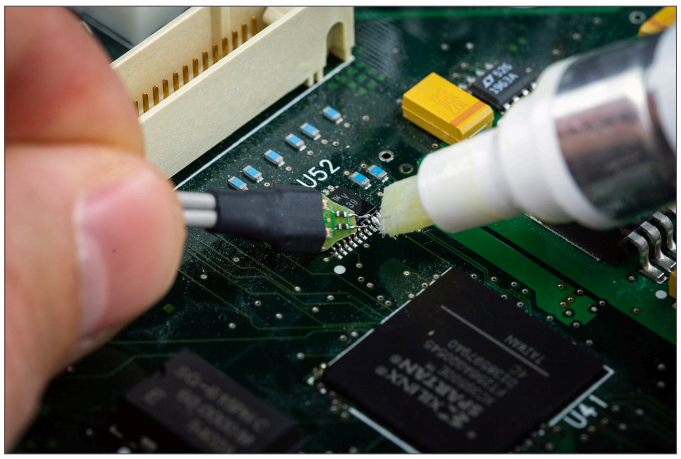

Figure 14: Apply flux.

4. Position the probe head with the tip wires lined up on the DUT pads/leads. Reflow both portions of the joint as quickly as possible with an appropriately sized iron. Repeat for the second tip wire.

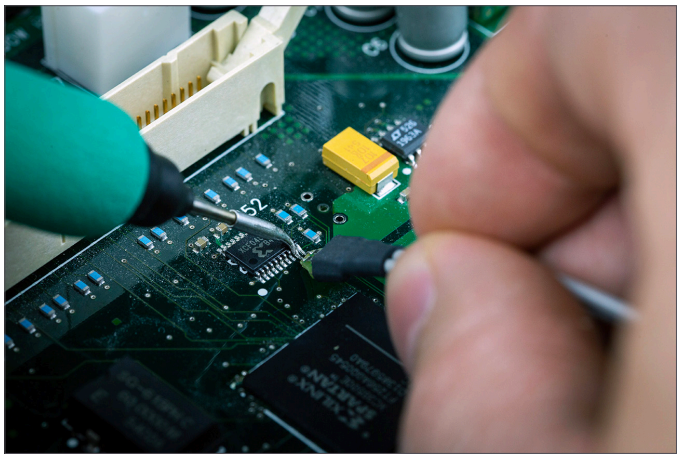

Figure 15: Reflow joints to secure probe head.

5. Relieve the strain of the probing system on this joint by using one of the strain relief methods outlined above.

The above procedure works well for differential measurements using the following Keysight probe heads: N5381B, N2836A, E2677B, E2679B, MX0100A.

For InfiniiMode measurements utilizing a ground connection, a similar process can be followed (for instance the N2836A):

1. Prepare the device. Add a small amount of solder to the DUT leads where the solder-in probe will be attached. Sometimes it is helpful to add flux before adding solder.

2. Add ground connection wires to your probe head. To minimize wire lengths, it is best to have the wire exit the bottom of the probe head. Insert plenty of fresh wire into the ground hole and add a minimal amount of solder to secure the wire. Any excess wire coming out of the top of the hole can be trimmed with cutting tweezers.

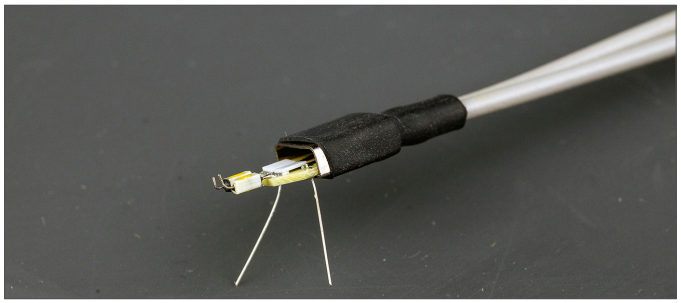

Figure 16: Add ground wires to probe head.

3. Prepare the probe head. Trim tip wire lengths as short as possible to maximize measurement performance. Shape the tips wires with tweezers to match the DUT leads. Keep the ground wires long at this step.
4. Apply more flux to the DUT and probe tip wires (a flux pen works well for this).
5. Position the probe head with the tip wires lined up on the input DUT pads/ leads. Reflow both portions of the joint as quickly as possible with an appropriately sized iron. Repeat for the second tip wire.
6. Position the probe head (now attached to the DUT at the probe inputs) to line up the ground wires with the DUT ground pads. Try to minimize the ground wire lengths.

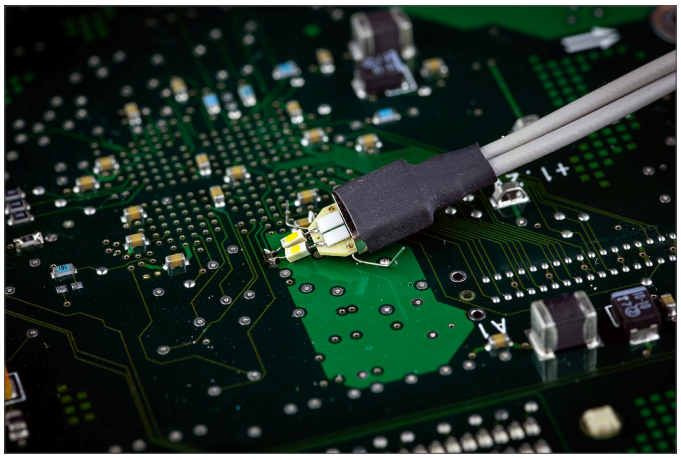

Figure 17: Probe head with signal inputs soldered and ground wires free.

7. Solder the ground wires to the ground pads on the DUT. Clip excess wire with cutting tweezers.

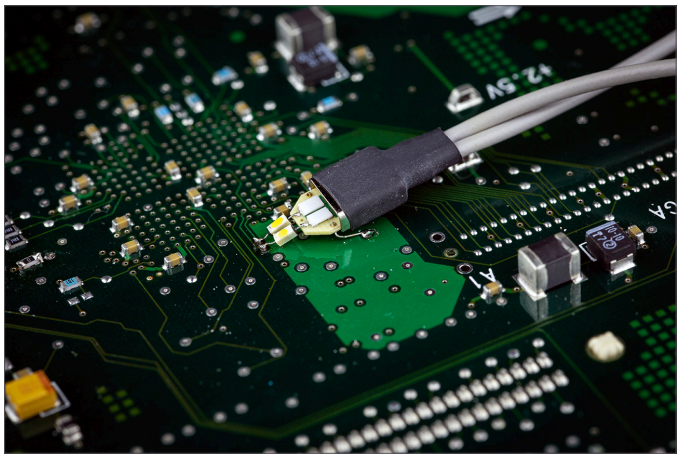

Figure 18: Probe head with all leads soldered.

8. Relieve the strain of the probing system on this joint by using one of the strain relief methods outlined above.

Replacing probe head tip wires and resistors

Many of Keysight's solder-in probes have user-replaceable tip wires or damping resistors. Although this may initially seem daunting, with the right tools and techniques, most probe heads can be repaired many times without damaging the probe head.

Product manuals contain more detailed information, but here is a general procedure for replacing tip wires on probe heads with damping resistors integrated on the PCB (N5381B, MX0100A):

1. Use a vise to gently clamp the probe tip under a microscope for easier viewing.

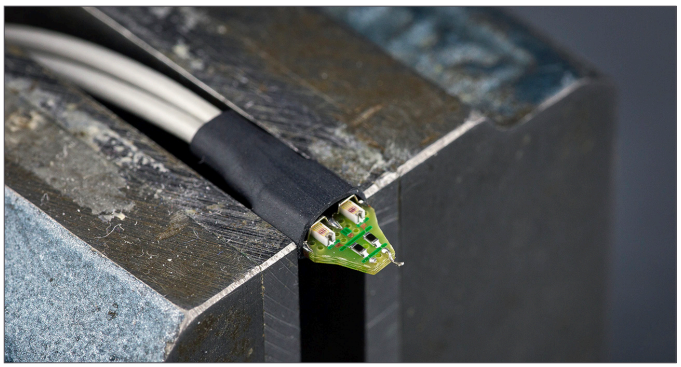

Figure 19: Probe head clamped in vise.

2. Grab the remaining wire with tweezers and then momentarily touch the solder joint from the underside with a fine solder iron tip and remove the wire. Cutting tweezers can grip a very short wire. If there isn't enough wire to grab with tweezers, fresh wire can be used to push the old wire out of the hole.

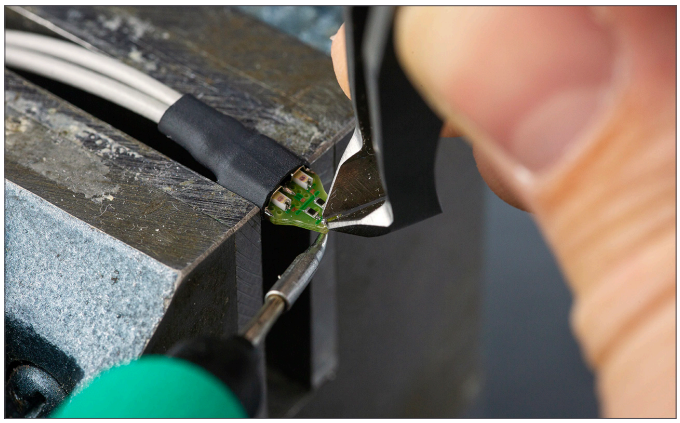

Figure 20: Tug the broken wire while reflowing the via.

3. Use a flux pen to apply flux to the via area.

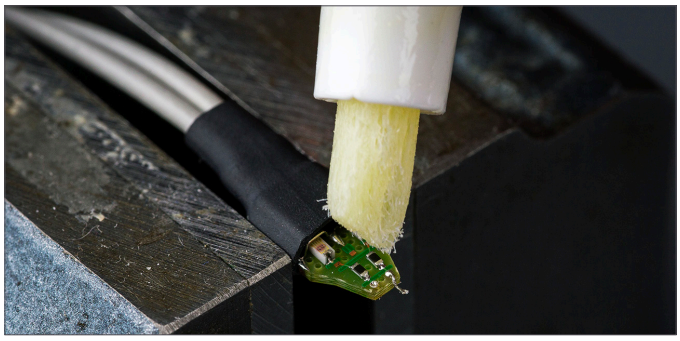

Figure 21: Apply flux.

4. Reflow the via while simultaneously inserting the new wire into the via. Start with a long piece of wire—it is easy to trim excess afterwards. Take care not to dwell too long at this step. If this is challenging, it is possible on some probe heads to use a solder wick to first remove all solder from the via. However, this step will make probe head damage more likely.

Figure 22: Reflow the via and insert new wire.

5. Apply a small amount of solder to tip of the soldering iron, and touch the solder tip with the solder on it to the via and wire to reinforce the joint.

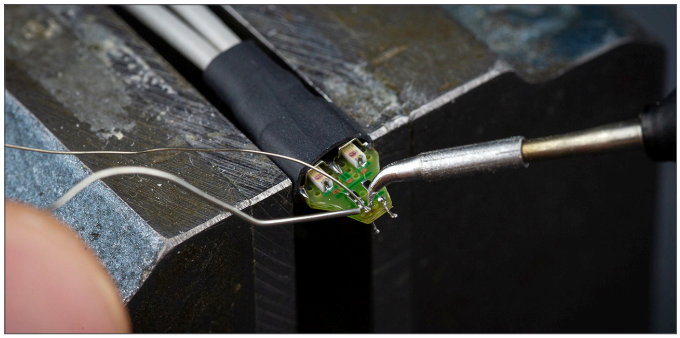

Figure 23: Reinforce the solder joint with additional solder.

6. With cutting tweezers, trim the excess wire flush with the bottom of the probe head PCB. Cut the input wire off with plenty of length (1/4” or so).

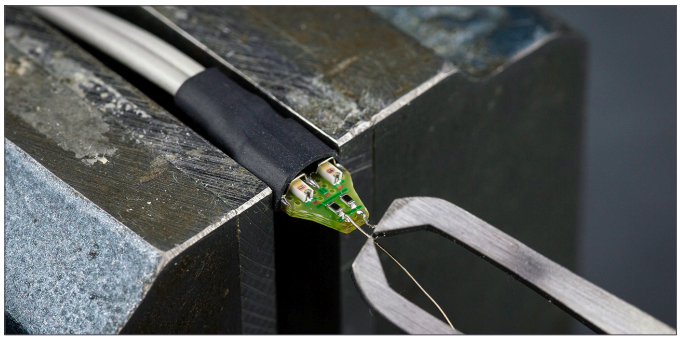

Figure 24: Trim the excess wire on the bottom (flush) and top (per trim gage).

7. Repeat the wire replacement for the other via hole if necessary.

8. Trim the two tip wires to the same length using cutting tweezers. Probe heads include either a physical gauge or a template to help attain the correct length.

Replacing probe head tip mini-axial resistors

“Mini-axial” style resistors are used for damping on several Keysight probe heads (N2836A, E2677B, E2679B). These can be replaced when broken or mangled by following roughly the same procedure as outlined above for probe tip wires, with the added step of properly orienting the new damping resistor during soldering. Some damping resistors appear symmetric—these can be oriented with either wire in the probe head via. The damping resistors with black epoxy on one side should be oriented with this epoxy toward the probe head—this will protect the epoxy from the high temperatures the input-side of the wires will experience during repeated soldering/desoldering from the DUT.

Securing Keysight probe heads.

As outlined previously, there are a variety of ways to secure or relieve strain on probe components. Securing probe heads not only protects delicate tip wires from accidental damage but keeps the probe in a consistent orientation and position, which can lead to more repeatable measurements. For Keysight’s InfiniiMax, it is recommended to use either double-sided foam tape or putty, attached to the coaxial cable of the probe head. Low-temp melt glue is also acceptable if a more permanent attachment is desired; it is best to use this on the probe head coaxial cable as well. Adhesives near the probe tips themselves are not recommended due to possible impacts on probe performance. After a probe head is secured, it can also be helpful to secure the probe amplifier using the above methods.

Flex-circuit probe heads (such as the MX0100A) should be secured only on their undersides—these probe heads have controlled impedance microstrips on the top surface and any foreign objects will lead to a change in impedance and possible measurement errors.

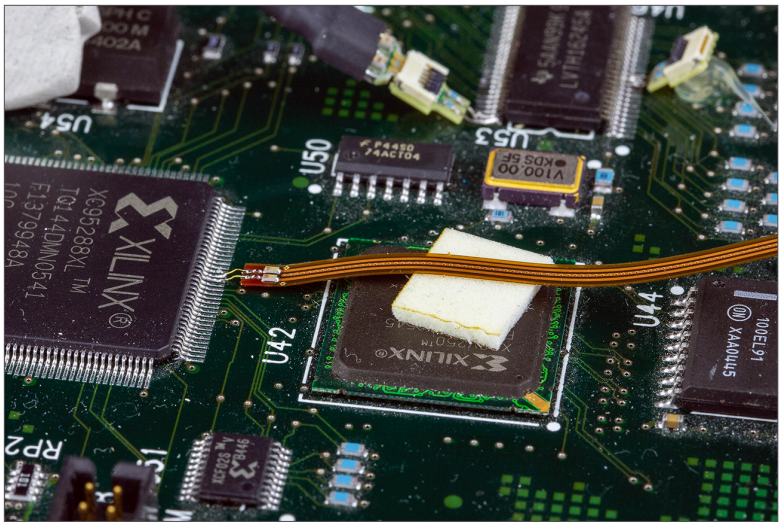

Figure 25: A flat flex-based probe head properly strain relieved.

Working with Keysight probe “tips”

Some of Keysight’s probing products such as ZIF head/tip or QuickTip head/tip include a “consumable” portion of the probe intended to be left permanently on a DUT that connects to a larger, more robust probe head. Splitting the probe head into two components can keep the total cost of a probing solution lower, particularly for users who probe many sites repeatedly on a DUT.

The tips and processes outlined above for regular solder-in probe heads apply to probe tips, but there are a few additional things to pay attention to:

- If a probe tip kit includes “arms” to help position the tips while soldering, use them. These tips (N2838A, N5440A, N5447A) can be challenging to grip and position and these arms help do so without damage.
- With the exception of N5451A long wire ZIF tips, Keysight does not recommend replacing wires or resistors on consumable tips.
- Only N5426A tips should be directly strain-relieved, under the probe head with double-sided foam tape. All other Keysight tips mate inside their respective probe heads and most strain relief techniques will interfere with this connection.
- Several InfiniiMax tips support InfiniiMode operation (for instance, N2838A, N2849A). For the best signal fidelity, For the best signal fidelity, it is best to connect ground wires when making single-ended or common mode measurement.

Conclusion

For the best connection fidelity, Keysight recommends using soldered-in probes. Not only does soldering form a reliable joint that can maintain electrical connection during DUT movement, it keeps parasitics low by minimizing wire lengths. Soldering probes can be a bit tricky, but with the right tools, techniques, and a bit of practice, anybody can make high-quality probe connections. Following the guidelines in this application note should ensure high-quality measurements and the maximum lifetime from your Keysight InfiniiMax probing system.

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