Configurable Kelvin Technology for Test Optimization

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Abstract

This paper is meant to show how Configurable Kelvin technology can optimize test productivity in several ways for Analog, Mixed Signal, and High Frequency component testing. Kelvin testing will also allow for better monitoring of device quality.

1. Introduction

Given the fact that many semiconductor companies have become 'fabless' or 'fablite,' configurability is very important in design and test productivity. In analog and mixed signal designs it will be even more important. A Kelvin contacting system is used on devices that require precise measurements such as power management devices, precision op amps, and high BIT count ADCs or DACs. Because of Kelvin's initial costs, it is used when no other test method accurately can test the devices. The cost of these nonflexible test systems tends to be higher and typically requires a more difficult load board layout. In developing a *configurable* Kelvin contacting system, Johnstech wanted to design a robust system that improved on existing Kelvin test sockets or contactors. We queried the industry and developed the following list, which presents the most important requirements to included in developing a new Kelvin contactor or socket.

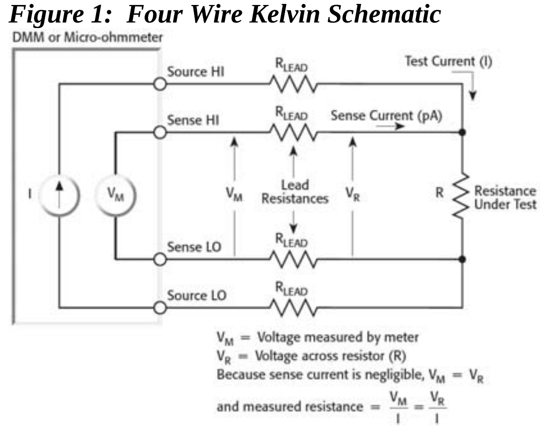
- **Force and sense contacts repeatedly hit device I/O**
- **Load board layout doesn't require tight tolerances**
- **Force line can handle high current**
- **Can configure Kelvin where you need it**
- **Can work for small devices and small pads and leads**
- **Can use Kelvin on RF devices**
- **Standardized and cost effective system**
- **Reduced maintenance and long contact life**
- **Easy to replace contacts and can reuse housing**

The *configurable* Kelvin solution was developed with these customer requirements in mind. By keeping the force line similar to existing technology, the force contact can handle much more current with a much more reliable contact resistance than a rigid one piece contact offers. With device pads controlled by JEDEC, the variances in package parameters require that the force contact be designed to hit the center of the device pad. To assure the sense contact also will always connect with the device pad or lead, we constructed a sense contact with two tines, one on each side of the force contact tip, to assure any misalignment in device presentation would always result in the sense contact still connecting with the device pad or lead. With updated manufacturing processes and the ability to hold tighter tolerances, Monte Carlo analysis shows that the force and sense contacts don't have the potential for shorting or missing the device pad and creating an open condition.

Pad Kelvin solutions often require very expensive load boards because the Kelvin force and sense lines are in close proximity, which makes routing difficult and presents the potential for shorts or opens. Shorts and opens occur between the force and sense contacts at the device and at the load board side. This problem was fixed by using two different technologies with the understanding that the force and sense lines don't need to be similar to accurately measure the device under test (DUT). For both the pad (non-leaded) and leaded Kelvin solutions, the gap between load board pads for the force and sense lines is greater than 5mm, which leaves plenty of room to route signals.

Kelvin contacting systems make use of 4-wire measurements (force and sense connect to the signal on the device and force and sense connect to the signal return). This essentially is a feedback system. It gives the customers the ability to monitor the signal levels at the device and adjust the forcing signal to get the correct value of DC power at the device, resulting in precision measurements. A 4-wire Kelvin connection schematic is pictured in Figure 1.

Figure 1: Four Wire Kelvin Schematic



Source: Keithley, J.E., Low Level Measurements, 5th Ed. p.3-19

In a Kelvin system, the sense line is only monitoring the voltage at the DUT and is connected to a voltmeter with a very high internal resistance (10 to 100 mega ohms). This high resistance results in mere picoamps allowed to pass through the sense contact. Any sense resistance basically has no effect on the sense measurement because it is small in comparison to the voltmeters resistance that is part of the loop.

If the Kelvin sense line contact is not needed, it can be easily removed with no need to keep the sense line load board pad for that device I/O, further increasing the real estate to route traces. This allows RF or high-speed signals to be routed straight out from the device to RF connectors for optimized performance. For RF testing, this also removes the stub, and the normal Kelvin force contact can test devices with frequencies above 20 GHz.

If done properly, this feedback network can greatly reduce false failures and extend contact mean time between assist (MTBA) by extending the cleaning intervals and life. The feedback from the sense line is used by the pin electronics' parametric measurement unit (PMU) in the tester to increase or decrease the voltage difference at the pad/lead of the DUT. This can be very important in improving yields of RF devices where the RF output power fluctuates depending on the DC power. If the DC input power is always known at the device pad or lead, by using Kelvin, all failed devices are truly failed devices and do not require unnecessary retesting. The purpose of this paper is to show, from a customer's perspective, the needs for the next-generation Kelvin testing.

2. Kelvin Contacting

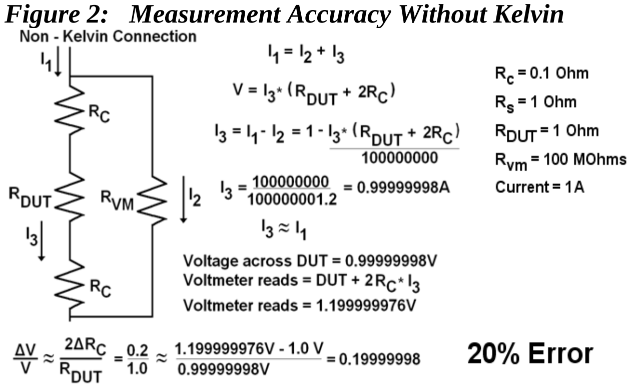
2.1 Precision Measurement

Kelvin testing in the precision analog marketplace is becoming more popular to test today's advanced devices, which may include both analog and mixed signal components. Some devices require both RF and Kelvin testing to adequately test devices that include both RF and precision analog chips within the same package. In addition, there is a focus on making devices small with larger numbers of I/Os, which in turn leads to devices with smaller pads and finer pitches.

From the 4-wire Kelvin schematic in Figure 1, it can be seen that, if the voltmeter monitoring the sense line has a high enough resistance, the sense line resistance can be rather large and not effect the measurement accuracy as long as it makes good contact to the device pad. Intuitively, given the very high impedance of the micro-ohmmeter (>10^{12} ohms), the conclusion drawn in the sketch (where, "Because sense current is negligible, $V_M = V_R$ and measured resistance = $V_M/I = V_R/I$") is justified.

Therefore, the main goal of a reliable Kelvin system is to assure that the defined sense contact is always contacting the device pad to provide feedback to the measuring system. The best solution to assure contact is to have built-in redundancy in the sense contact. With this, you are assured of making contact to the device pad no matter how the device is aligned in the contactor. This gets extremely tricky as the device pitches and pad sizes get smaller. With the monitoring of the sense line voltage, the current required through the sense contact would be in the pA range. The sense contact's requirement to carry very low current levels allows for potential improvement to the force contact, which, in some cases, needs to handle very high current levels (as in some battery management devices). See Figures 2 and 3 for an example calculation of accuracy in a non-Kelvin setup (Figure 2) and a Kelvin measurement system (Figure 3).

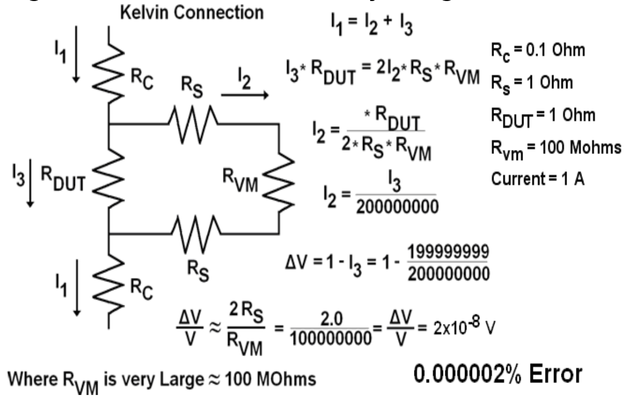
Figure 2: Measurement Accuracy Without Kelvin



In Figures 2 and 3, R_c is the resistance of the force contact, R_s is resistance of sense contact, R_{DUT} is resistance of the DUT, and Rvm is the internal resistance of the voltmeter. In both examples, resistances and currents were chosen to make the math easier and some intermediate calculations were left out. The equation for change in voltage measured across the DUT is derived from Ohm's and Kirchoff's laws and assumes R_{VM} is large, so $V_m = V_r$ as shown in Figure 1. In the non-Kelvin case in Figure 2, the force contact resistance is part of the loop involving the voltmeter resistance R_{vm}. In the Kelvin case in Figure 3, the force contact resistance is not part of the loop and has no effect on the measurement except that it needs to supply the current required to test the device.

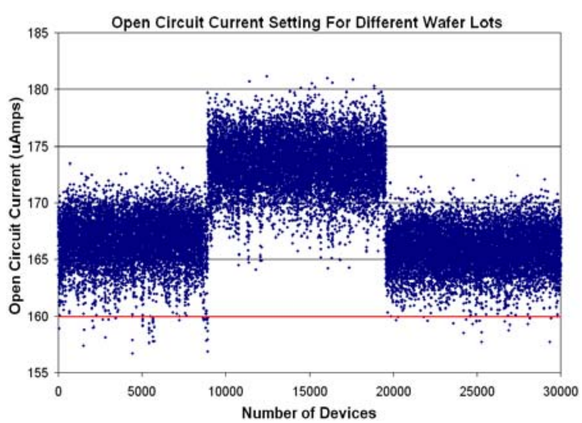
The resulting error in measurement for the non-Kelvin case is dependent on the contact resistance of the force contact. The error can be very high if the device resistance is very low or if the contact resistance of the force contact is fairly high. On the other hand, Figure 3 shows that, when using Kelvin, the resulting error is not dependent on contact resistance of the force contact and only slightly dependent on the sense resistance. This is because the voltmeter used to measure the voltage across the DUT has a very high resistance and, typically, many orders of magnitude higher than the sense contact. Therefore, the resulting error in the measurement is very low.

Figure 3: Measurement Accuracy Using Kelvin



Another benefit of a Kelvin test system is the precision measurement capability. This allows test limits to be tighter and lot to lot variations can easily be seen. Shown in Figure 4 is the open circuit current of three different test lots of approximately 10K units each. The Kelvin test contactor was not cleaned between lots or for the duration of the test on these matte tin plated devices. As can be seen from the data, there is a definite difference in the average values and number of failed parts between lots. In the graph, the red line constitutes the limit for this test.

Figure 4: Open Circuit Current Measurement for Three Different 10K Lots



3. Design Requirements

3.1 Contact Optimization

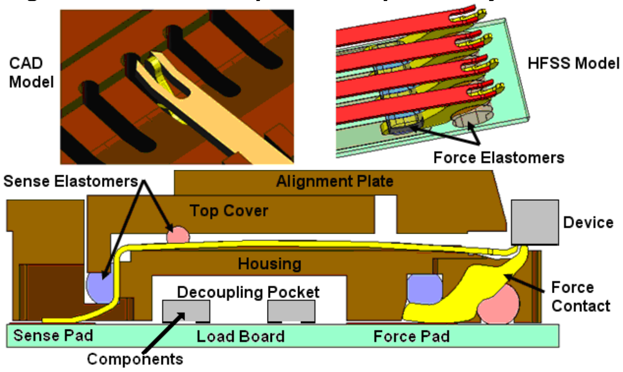
Both Johnstech pad and leaded versions of Kelvin make use of a flexible sense contact layout with two points of contact, one on each side of a fine tip force contact. Both Kelvin schemes use a modified, rigid, one-piece ROL™200 contact with a slightly thinner tip made of harder material and a low shoulder to prevent shorting between the force and sense contact during sense connection with the device pad.

Through finite element analysis (FEA), the gap between the force and sense contact was optimized to prevent shorting and to maximize the sense contact life. The use of two different technologies allowed us to use an existing rigid contact as the force contact to provide the best current carrying capability, highest RF bandwidth when the sense contact wasn't required for testing RF signals, and the best self-cleaning wipe function to break through oxide layers present on many device pads. The flexible sense contact was made to have a smaller wipe function with a more pointed contact probe for accurate voltage measurements. The sense contact was designed to optimize life (more than 1 million insertions in production environment) and route sense signals away from force signals to make it much easier for board layout and decoupling part placement. Both force and sense contacts were gold plated to obtain the lowest possible contact resistance at the interfaces.

Unlike spring pin socket designs that are held together by two housing pieces or cantilever solutions that are not replaceable in the field, our design uses the alignment plate, or cover if handlers are more precise at presenting devices into the test contactor, to keep the sense contacts in place. Removing the alignment plate or cover that is attached to the housing results in easy access to the sense contacts making it extremely easy to replace the contacts.

Figure 5 depicts an isometric CAD view, along with a high-frequency structure simulator (HFSS) top view of the Kelvin contactor without the housing and alignment plate, to show the relationship between the sense and force contact. The bottom of the figure depicts the side view of the Kelvin system showing the housing, cover for handlers that have precise placement capabilities, and alignment plate for precise alignment if needed. The Kelvin sense contact color was changed in the upper right HFSS view to red to better show contrast to the force contact at the device interface in the figure. The HFSS side view on the bottom depicts both contacts, in normal test mode, in the compressed state. The force contact's self-cleaning wipe function is left to right and the sense contact's wipe function is up and down.

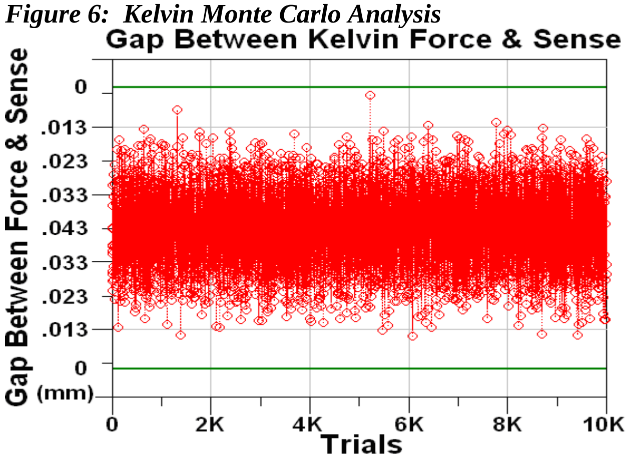
Figure 5: Device Interface View of Kelvin System



These two separate wiping functions tend to move away any debris that might form, such as tin oxide from the device pad or molding debris from sawed packages. Molding debris is caused when sawed devices are not precisely aligned prior to insertion into the contactor or socket and allows the flash or debris gets rubbed off during the interface with the alignment plate. This debris may land on the contacts and possibly create an open or form a bridge between the force and sense contact that would create a short if the debris was conductive.

Tolerances were tightened on all parts of the system through improved manufacturing processes. This also allowed the sensitive parts to be designed with enhanced robustness. Both mechanical FEA simulations and measured data from extensive lab experiments, as well as customer beta site testing, showed that the life of product was greatly extended. Sense contacts routinely lasted more than one million insertions, even when contacting devices using NiPdAu plating, which is much harder than the matte tin plating found on less expensive packages. Figure 6 shows an in-depth Monte Carlo analysis between the force and sense interaction to verify that they will never simultaneously short during testing. In the analysis, all standard tolerances were used that are called out on all effected parts of the Kelvin system.

Figure 6: Kelvin Monte Carlo Analysis



In Figure 6, the green lines indicate where a short would occur between the force and sense contact. Both the leaded and pad force contacts have the same tip width. and the sense contacts have the same gap between the tines. Both types of Kelvin products are built to the same design rules and tolerances so the analysis is good for both pad and leaded packaged devices. Because the force contact moves front to back and the sense contact moves downward, the different motions tend to eliminate debris getting caught between the two Kelvin contacts, thus improving MTBA.

3.2 Field Configurability

Many competitive Kelvin systems have the same force and sense contact design. The customer can determine which contact will be the force contact and which one will be the sense contact. However, these concepts don't address many customer requirements for a Kelvin system, such as the ability to place Kelvin where necessary without the need to buy a new Kelvin solution for every similar package. Kelvin isn't needed on all devices, so it would be cost effective to use the same test socket or contactor to test all similar packaged devices. For normal devices, RF, analog, or mixed signal devices only the ROL™200 force contact needs to be installed into the housing. This would handle any scenario up to 20 GHz. If precision measurements are required or a feedback loop is desirable to reduce false failures, the Kelvin sense contacts could then be installed on one, a few, or all of the signal lines. In other words, the perfect solution is a configurable contactor with easy to replace building blocks that can use the same housing to test different devices using the same package and device I/O pitch. With the alignment plate or top cover removed from the Kelvin system the sense contacts can be removed, installed, or replaced in less than 15 seconds without undocking the contactor from the load board if needed. This is much faster than the 30 minutes it often takes to recalibrate and setup the test system after the test socket is removed from the board.

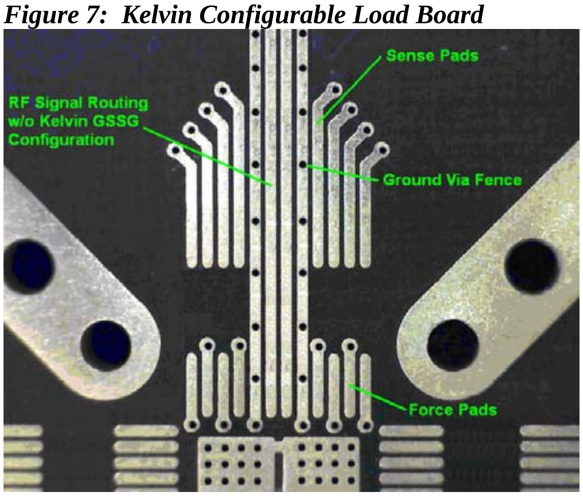
Not all device I/Os require measuring very small voltages and currents. Designing a contactor that must have Kelvin on every pad is costly. With an approach using the "Kelvin-ready housing," the housing is made assuming that all device I/Os need Kelvin. The housing will work the same as an existing ROL™200 housing. If the "Kelvin-ready housing" load board layout rules are observed, then one housing can test in both Kelvin mode and normal ROL™200 mode. This allows the customer to populate Kelvin where needed and allows them to purchase fewer engineering test contactors because the same housing can test multiple devices with the same package outline and pad locations. This is extremely important to control engineering test costs, as typically only 25% of the devices designed make it to high-volume production. With a configurable and reusable "Kelvin-ready housing" the customer only needs to change the Kelvin configuration and replace the load board with the one that corresponds to the DUT. *Note: If the device package tolerances are different, it is possible that a different alignment plate may be needed.*

If the type of handler is known at the time of ordering the test contactors, the design can be "productionized" so the same contactors can be used in production once engineering test is completed. This reduces the need for procuring extra contactors for low-volume production runs, This means that customers can be faster in getting their devices to market.

3.3 Load Board Simplification

Figure 7 shows the load board layout of the force and sense pads on a board set up to do testing on a handler for both Kelvin and a ground-signal-signal-ground differential RF signal. The force pads (located closest to device and ground pad with vias) use the same requirements and design rules as the standard non-Kelvin contactor. The sense lines have the same pad width and spacing as the force contact pad, so no extra board processing is required to design with the Johnstech Kelvin contactor.

Figure 7: Kelvin Configurable Load Board



The spacing between the force and sense lines allows signals to be easily routed to the edge connectors. In this picture, the low frequency lines and Kelvin sense lines are routed to internal layers separated from top layer RF signals by a ground plane. With the RF differential lines in the middle, the RF signals are routed directly to connectors on the edge of the board. Each RF line has its own RF connector. Ground traces next to the differential RF signal lines have vias placed in the lines to provide a high isolation ground fence to the ground plane to enhance signal integrity. This also provides a via fence to adjacent lower frequency lines that are laid out for use either as regular signal lines or connected in a Kelvin setup.

If decoupling parts were needed, they would be placed between the force and sense pads corresponding to the decoupling area machined into the housing. Placing decoupling parts as close as possible to the DUT reduces unwanted signals interfering with the test.

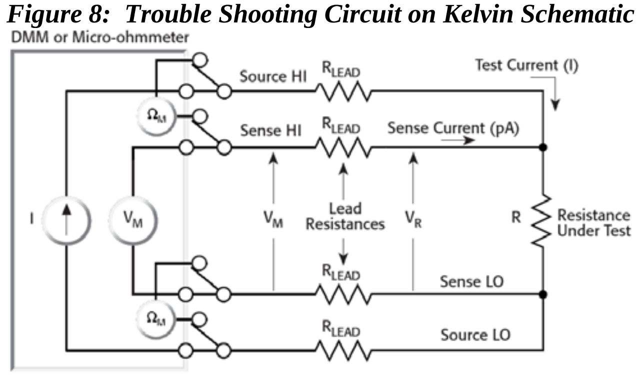
4. Test Results

4.1 Increased MTBA

Figure 8 shows a Kelvin connection with extra switches in place on the force/sense pairs. These are put in place to determine if cleaning or maintenance is required. The path is normally a Kelvin connection with the contact connecting with the other switch position. When a device fails, the switches can be used as shown to provide a feedback path that is measured and compared to some baseline resistance. This resistance is typically dependent on the accuracy needed and on the values of resistance for the force and sense contact.

If the value measured by the ohmmeter is above the resistance of the measured path limit, either the contacts are dirty, there is debris present in the contactor, or the contactor is broken and causing a false failure. If the loop-back circuit resistance is lower than the feedback limit, then the part is determined to be bad. If the loop-back circuit resistance is higher than the feedback limit, the part could still be bad, but the contactor definitely needs to be cleaned or maintained before the device can be remeasured.

Figure 8: Trouble Shooting Circuit on Kelvin Schematic



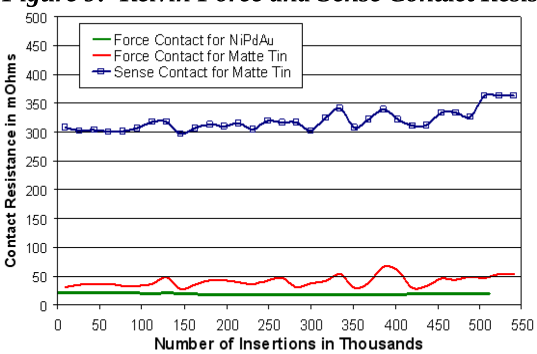
Modified from original source: Keithley, J.E., Low Level Measurements, 5th Ed. p.3-19

Because many packaged devices are completely tested in a fraction of a second, the feedback mechanism in Figure 8 (force and sense contact resistances) isn't tested on every device. Many times, it is only checked if the device fails to determine if cleaning is needed on the Kelvin system. Using this checking method helps reduce false failures and in many cases eliminates the need for retesting parts.

The graph in Figure 9 is the Cres for the Kelvin force and sense contact made out of the new XL-2 material designed for even longer life. The data for the force contact shows the testing done with both matte tin and NiPdAu devices for comparison purposes. Matte tin is a softer material that forms oxides readily and tends to require cleaning more often. NiPdAu is a harder material that doesn't contain any oxides, so its contact resistance is more stable and typically lower. However, NiPdAu-based devices tend to wear the contact more and reduce the contact's life expectancy. The sense contact data was taken with matte tin devices at each interval, but between intervals it was tested with a very hard tool steel surrogate. The purpose of this was to get expected contact resistance values, in addition to getting a sense of life expectancy. The data shown is based on over 500K insertions because that is the proven life expectancy of the force contacts. Because the sense contact has a smaller wipe function, other test data has shown similar results to beyond 1 million insertions.

Because NiPdAu is a hard material and doesn't contain any oxides, a low force elastomer can be used to help extend the contact's life. For NiPdAu testing, the average Cres is very flat and its standard deviation is less than 5 mOhms for the entire test. This variation is extremely small considering that the NiPdAu contact was run continuously to 500K insertions without cleaning because the test devices were free of package molding debris.

Figure 9: Kelvin Force and Sense Contact Resistances



4.2 Reducing False Failures

By having this Kelvin circuitry (in Figure 8) checked every time a failure occurs, it eliminates the need for devices to be rechecked. Since the sense contact is only measuring a voltage at the device, and you know the input current, you can maintain a stable DC power into the device. On some RF devices there is a correlation between the DC power input and RF power output. In many cases, false failures occur when the DC input is lowered, causing the RF power output to degrade. With a Kelvin feedback system, you can tell which parts pass for a given constant input. This also may allow up-binning of devices with better performance and can be sold at a higher price. On a rigid, one-piece contact, the data on one force/sense pair has much less variability than a similar spring pin pair, which has 3-5 moving parts that may or may not make contact with each other at the same locations. Therefore, it might be advantageous to use Kelvin on the voltage lines and calibrate that data from the rest of the connections to the package.

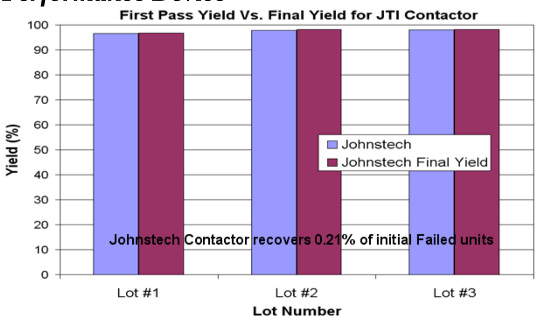
With the device still in the contactor, the loop-back also has the benefit of determining if either the force or sense contact is not connecting to the device pad. If either the force or sense contact is not touching, an open will be measured by the ohmmeter. The only way a short between the force and sense can be measured is by running a signal through the feedback network without a device present. If a short is measured, the force and sense are shorted together. If either a short or open occurs, the testing should be stopped and the contactor should be maintained.

In some cases when using contacts that have a wiping action with a self-cleaning scrub on device I/Os, the short or open can fix itself. This is especially important in hot and cold testing, when maintaining a tester is much more time consuming. A failure at hot or cold results in bringing the tester back to ambient, fixing the problem, then reprogramming the tester back to the correct temperature and letting it stabilize. Sometimes it is better to suffer a slight yield loss, while the contactor is trying to remove the debris, rather than stop the test and restart after cleaning. Using the loop-back circuitry, it can be determined which devices need to be retested at hot or cold due to the contactor or because excessive oxide buildup or debris is present. These will be the devices that failed both the device parameter test and the ones that failed the loop-back test.

One very effective way to remove debris or excessive tin oxides from the contacts in a self-cleaning contactor is to periodically insert a cleaning device in the contactor. If a cleaning chip is not available, a device upside down in the tray periodically can be a suitable equivalent. This is achieved by flipping a device over in the tray. Most devices are molded with a very hard mold compound. They tend to scrape off some of the tin oxide layer left by matte tin devices when the contacts rub against them just like a cleaning chip. Because there is no electrical contact with the cleaning device, a failure will occur and the device will be placed in the appropriate failure bin. How often a contactor needs to be cleaned depends on the test setup, as well as the plating, on the DUT.

Figure 10 shows first-pass yield vs. final yield for three lots of parts tested at a Kelvin beta site with Johnstech's Pad Kelvin Contactor. From the combined data, the final yield only improved 0.21%, making it an easy decision for customers on whether to retest. In some cases, where the customer is precisely matching a package part and using a laser to adjust or trim values, the Kelvin feedback system is essential to ensure the devices are properly matched.

Figure 10: First Pass vs. Final Yield for High Performance Device

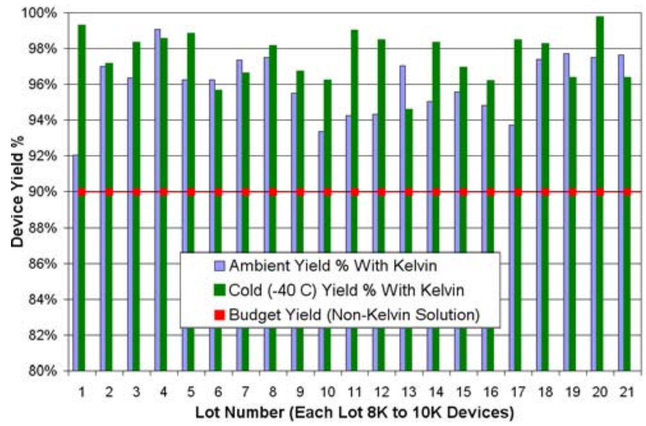


4.3 Increased Yields

Figure 11 shows production data with yield results from testing a voltage monitor device for an automotive application that is sensitive to contact resistance. It shows that if the device is sensitive enough to contact resistance, big improvements in yield can be attained using a self-cleaning Kelvin contacting system and its feedback. The red line is the average yield results using a non-Kelvin solution to test this device. With no feedback in the non-Kelvin solution, the contactor had to be cleaned more often, resulting in yields slightly above the 90% yield limit that the customer expected.

For this device, a yield falling below 90% triggered a cleaning interval or investigation into the type of failures. Because there were no false failures in the Kelvin testing, there was no need to retest parts that failed at ambient. This is the reason the yields in ambient tests (95.98%) were lower than yields in cold testing (97.46%). The same contactor was used for both ambient and cold testing, the only difference being the handler was soaked at -40 degrees with the parts prior to testing. Each ambient or cold lot consisted of eight to ten thousand packaged devices. The graph represents almost 400K test insertions and the one contactor is still testing parts. The variation in data indicates wafer to wafer variations because there is no trend in the data to indicate a problem with the Kelvin contactor.

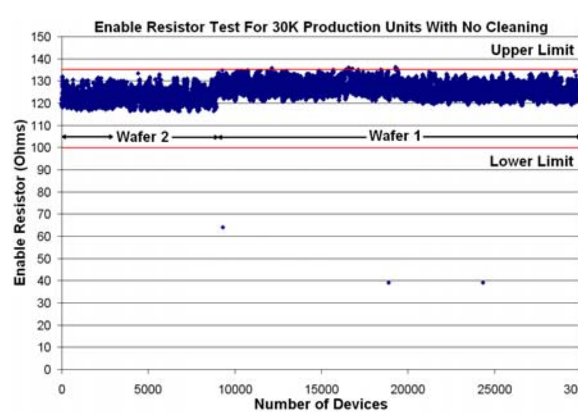
Figure 11: High Voltage Monitor With and W/O Kelvin



4.4 Up Binning

Figure 12 shows data from a Kelvin beta site doing a preproduction run before running high-volume production, which shows that the Kelvin solution even can find differences in wafers. The first half of wafer #1 is from one section of the wafer and last part of the data is from a different section of the wafer, which shows a slightly lower enable-resistance average value. Wafer #2 has a more centered enable-resistance value and generated no failures during testing. Wafer #1 showed both low value and high value failures. During the 30K units tested, the contactor was not cleaned so no variable was changed other than the wafer. As expected, the wafer #1 results show that, across the wafer, the processing is slightly different resulting in differences in the average enable-resistor measurement for this device. On both wafers the variation in data is 3.8 ohms.

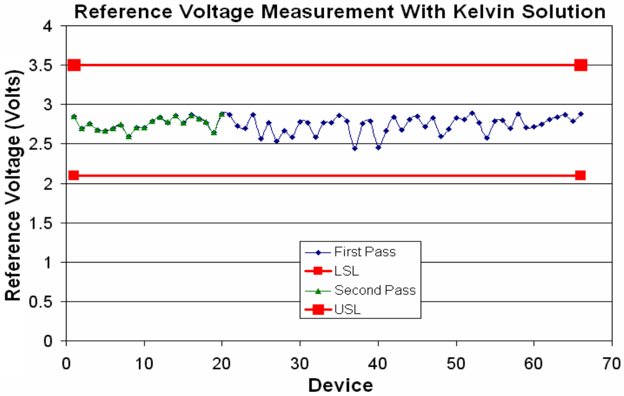
Figure 12: Differences in Performance at Wafer Level



4.5 Repeatability

When testing devices it is always important to measure accurately and repeatedly. The graph in Figure 13 shows just a handful of devices tested manually one day (Blue line) for reference voltage and some of the same devices tested the next day (green line). No cleaning or calibration was performed between days so differences in lines are a result of Kelvin Contactor variations.

Figure 13: Manual Testing for Reference Voltage Variations



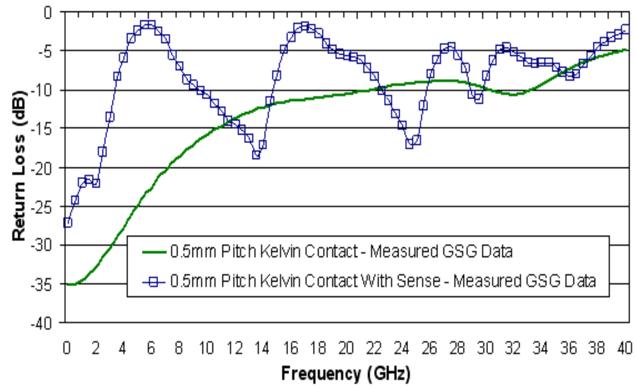
The sense line monitors the voltage and provides a feedback to the test system, therefore no variations between the data taken on separate days for the devices occurred. This measurement accuracy allows for potentially tighter test limits and may allow customers to charge a premium for parts that have more consistent test data. For instance, it is much easier to design a system when all the gains of amplifiers are +/- 0.25 dB as opposed to +/- 2 dB. With tighter tolerances on devices, Monte Carlo analysis will show tighter distributions and potentially higher yields.

Even though the Kelvin sense line resistance doesn't matter, we still use our standard gold plating process on the contacts to improve the contact resistance and variability in contact resistance to increase MTBA cycles. Plating more gold on the contacts does increase contact cost, but it also extends the contact's useful life, reducing the number of times the contacts have to be replaced in production. This can far outweigh the cost of idling high-priced production test equipment. More gold plating also allows the contacts to be cleaned with some of the newer cleaning processes found on production floors, including the use of laser cleaning methods. This allows the contacts to have superior MTBA due to the wiping action. This as opposed to on-center technologies that tend to probe devices, thus getting oxides and debris to quickly form on the spring pin tips.

4.6 RF Performance

Figure 14 shows the return loss of the Kelvin system with the sense contact in place creating a large stub vs. using only the force contact to connect to the device pad in a conventional manner without the Kelvin sense contact. Both sets of measured data resulted when the force and sense contacts were compressed and in the normal test state. Both contacts are a one-piece construction, so the data or path length won't vary depending on the amount of compression in the elastomers, which act as shock absorbers. Without the sense attached the -20 dB return loss is about 7 GHz.

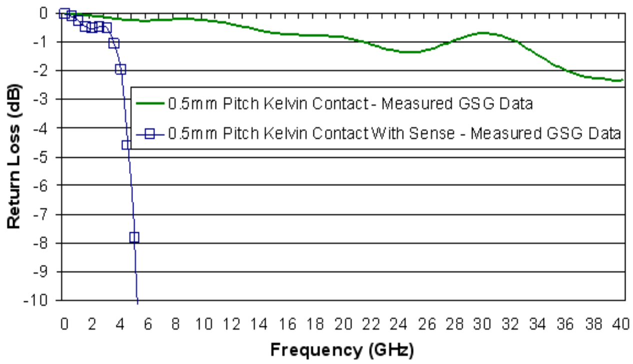
Figure 14: RF Return Loss With and W/O Sense



Most Kelvin applications have performance requirements for a small bandwidth and typically don't need to process frequencies above 1 GHz. This allows Kelvin to be put on non-RF lines in an RF device to provide feedback to improve on MTBA cycle times, as well as reduce tester down times. This is important for customers that want to supply their devices with exactly the same DC power every time so variations in test data are only due to variations in the devices.

Figure 15 shows the insertion loss of the Kelvin system with the sense contact in place creating a large stub vs. using only the force contact to hit the device pad in a conventional manner without the Kelvin sense contact. Without the sense attached, the -1 dB insertion loss bandwidth is about 33 GHz and -3 dB bandwidth is beyond the upper test limit (40 GHz) of the network analyzer used to measure the contact. Even with the Kelvin sense attached and properly terminated, the 1 dB bandwidth for Kelvin testing is 3 GHz, which is more than sufficient for a Kelvin connection. The data plotted for both Figure 14 and 15 resulted from a ground-signal-ground (GSG) configuration setup. This is the preferred layout for high frequency lines and signals that require the best crosstalk between adjacent signals.

Figure 15: RF Insertion Loss With and W/O Sense



5. Conclusions

Contactor reusability is extremely important to reducing lead times and test costs. The configurable Kelvin solution offers the adaptability needed for today's continuously changing test environments, and provides the flexibility to accommodate future test needs. Using Kelvin techniques, customers can sell higher performing devices for more, and potentially increase the time between maintenance cycles or cleaning. Any time the customer has tester down-time, they can't test and ship devices. Many false failures occur because normal testing has no feedback mechanism to determine if the failure is due to device, tester, or socket. With an extra switch in the force and sense path on the load board that is routed to an ohmmeter, the force and sense path can be checked after a device fails to decipher if the failure is due to device or socket. In this scenario, only socket-induced failures need to be retested. If the sense contact has redundancy, the socket-induced failures are extremely low and typically caused by excessive debris from package molding or oxides on the device pads.

6. Acknowledgements

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7. References

All sources for images and information cited directly within content.

About the Author

Jeff Sherry is a Senior RF/High Speed Digital R&D Engineer with 27 years semiconductor industry experience, and specifically in designing and modeling microwave circuits up to 100 GHz. He has a BSEE, an MSEE, and an MBA from the University of Minnesota, with an Advanced Technology Degree through Honeywell. He is a licensed professional engineer.

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