Improved Test Performance for Amplifiers

By Jeff Sherry, Principal Engineer, Custom Products/Custom Engineers

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Introduction:

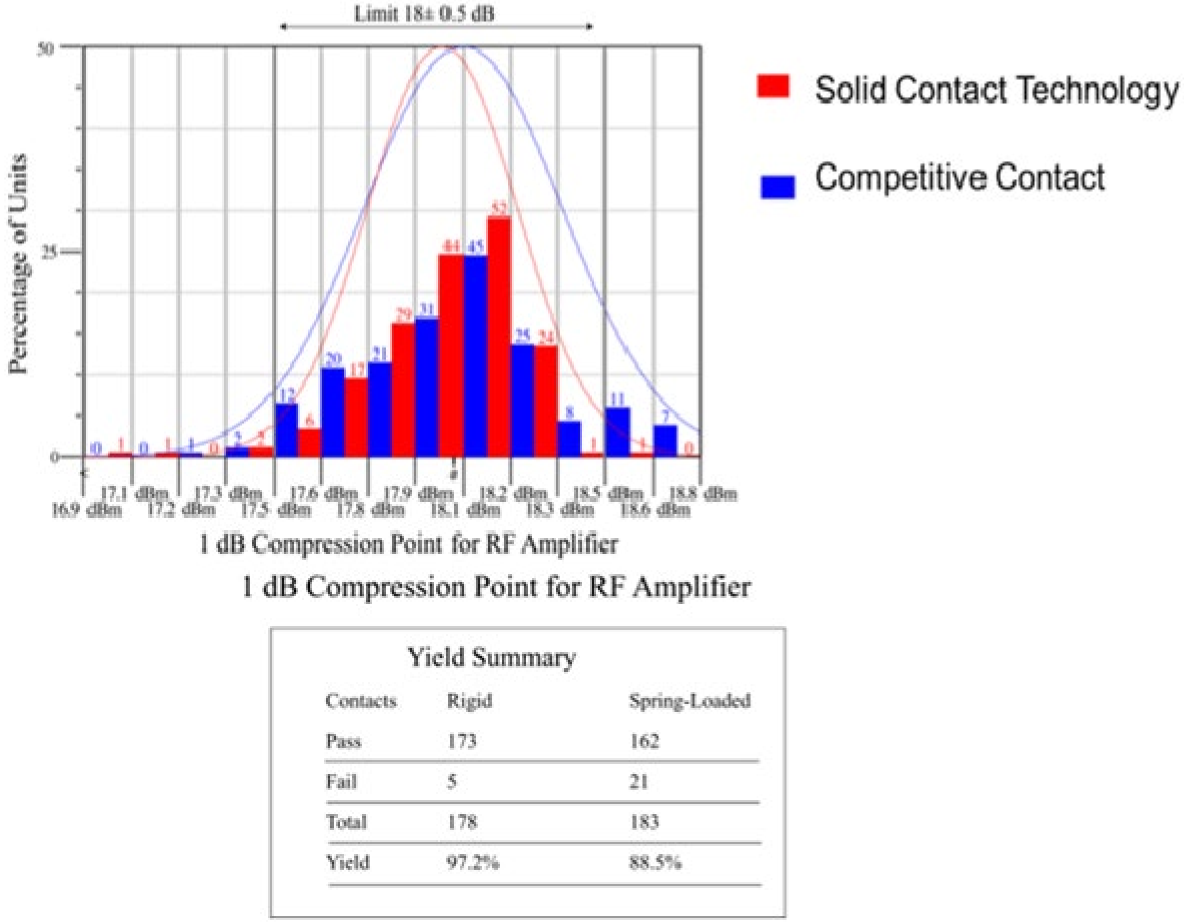
In semiconductor testing, the effectiveness of test sockets is crucial for accurate and reliable results. This white paper, presented by Johnstech International Corporation, explains why contactor design is critical to Power Amplifier testing. Power amplifiers usually are very sensitive to ground inductance because when the amplifier gain is higher than 20 dB and/or the frequency of operation is higher than 3 GHz, the ground inductance needs to be minimized more than most other semiconductor devices. Every test contactor or socket will add inductance and parasitics to the measured results and sometimes amplifiers were not designed to work when inductance values are larger than soldering the device to the circuit board. The goal in these cases is to design the contactor to provide the most reliable and lowest inductance possible to the board ground plane.

Discussion:

Semiconductor testing is vital for ensuring semiconductor devices meet quality standards before reaching the market. Test sockets serve as the interface between the device under test (DUT) and testing equipment. Johnstech International Corporation provides innovative test socket solutions tailored to the needs of the semiconductor industry. This white paper aims to clarify the importance of test socket specifications when testing amplifiers. This paper will show how the amplifier gain is affected when the grounding scheme is insufficient and present a solution that will result in minimal changes in amplifier performance when testing in production.

Below is a customer provided chart (Figure 1) showing the distribution of a ROL solid contact performance compared to a competitive contact technology. The ROL solid contact has a much tighter distribution (better repeatability) and leads to more accurate test data with fewer false failures. False failures contribute to higher than necessary retest rates, which increase test time and costs.

In the chart within Figure 1, a small sample of similar parts was tested using 2 different contactor technologies to determine the initial yield. ROL contacts, labeled as “Rigid” demonstrated a noticeably higher first pass yield in comparison to the competitor, labeled as “Competitive Contact”. ROL contacts have a self-cleaning wipe function which allows the test contactors to go a longer period of time without interruption for cleaning as compared to the competitive contact. Much of the elevated yield underperformance of the competitive contact was attributed to opens – likely made worse by dirty contacts. Note that in the instance of opens, the data for the competitive contact wasn't even graphed in the distribution performance as no values were obtained.

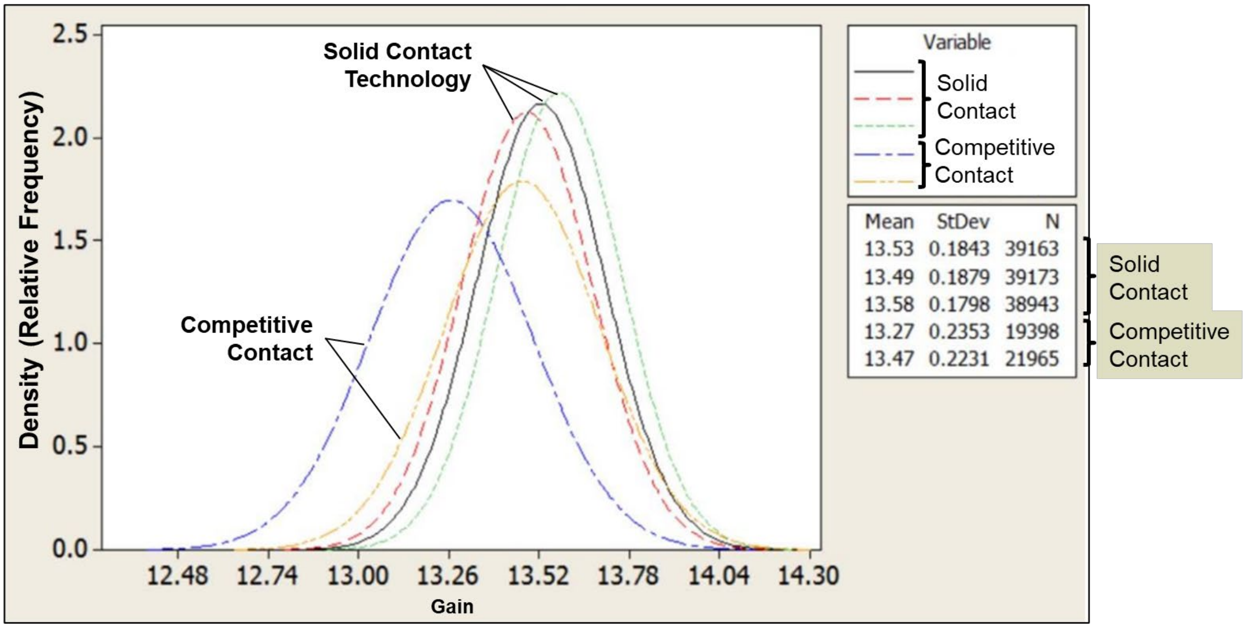


Contacts	Rigid	Spring-Loaded
Pass	173	162
Fail	5	21
Total	178	183
Yield	97.2%	88.5%

Figure 1: Customer Variation Between Solid ROL and Multiple Part Contact

Figure 2 shows the performance difference between ROL, labeled as "Solid Contactor Technology" and "Competitive Contact". The data was taken on QFN packaging and demonstrates the magnitude of improvement that ROL (or the newer VROL) solid contactors offer in reducing insertion loss, which improves the actual gain measured in the test contactor. Repeatability is critical for calibrating out the test contactor as variation can't be calibrated.

In addition to measuring closer to the actual gain because of the lower contact insertion loss for ROL (and VROL), Figure 2 shows that the standard deviation is also lower for the solid ROL (and VROL) contacts compared to the competitive contact. This translates to better repeatability and fewer false failures. As previously noted, false failures increase cost of test by forcing otherwise good parts to be retested. The number of devices tested is diplayed as “N” within the imbedded table in Figure 2. The much higher N values for the Solid Contact indicate that the self-cleaning wiping function that is patented for ROL and VROL technologies requires less maintenance, so many more parts can be tested accurately within any given time frame.



Mean	StDev	N	
13.53	0.1843	39163	Solid Contact
13.49	0.1879	39173	
13.58	0.1798	38943	
13.27	0.2353	19398	Competitive Contact
13.47	0.2231	21965	

Figure 2: Performance Differences Between ROL and Competitor Contacts

Figure 3 below shows how the ground inductance of a contactor affects the gain of an amplifier, even at relatively low RF frequencies. Typically, the ground inductance of the contactor is determined by how many ground path connections there are from the ground of the device in the contactor to the ground plane of the board. The more ground paths or connections, the lower the effective ground inductance of the contactor. For similar connections, the overall ground inductance is calculated as the ground inductance of one connection divided by the number of connections. For instance, a 1mm length contact with 0.23 nH for each contact present 0.023 nH of total contactor ground inductance if there are 10 ground contacts in parallel. If those contacts are in a metal insert, the insert inductance is in parallel with the contacts, further reducing the total contactor inductance.

A metal insert will lower the total ground inductance of the contacts. This is because with contacts in a metal insert there is metal shorted to ground between the contacts so the mutual inductance is shorted to ground or zero. Therefore, the ground inductance of the contacts is the self-inductance of one contact divided by the number of contacts. The final ground inductance is inductance of contacts in parallel to the inductance of the insert defined by the formula: GND Inductance = $L_{contacts} * L_{insert} / (L_{contacts} + L_{insert})$. Having contacts in a metal ground insert provides some compliance and self-cleaning wiping action. This not only reduces the contact resistance but improves the repeatability by breaking through a potential oxide layer on the DUT.

Johnstech has a patented technology called Performance Plus that delivers the lowest possible ground inductance. This is accomplished by providing a large ground surface area with multiple ground paths using a metal housing with coaxial-like inserts. This grounding solution provides a 50 ohm connection to RF signals and the metal housing provides a direct ground short from the DUT ground to the board ground plane. Originally, this technology was developed for an application that was operating at a high frequency but lacked ground connections in the package to peripheral pads on either side of the RF signal. This forced the ground path through the center body ground, contactor ground, to vias on the ground pad of the board, to board ground plane, then board plane to vias, to ground next to RF signal. This is a long inductive ground path. By shorting the ground pad in the middle of the DUT to adjacent pads next to the RF signal, it provided a very short ground path. Years later the same customer provided ground paths from the device in package to adjacent ground pads on the peripheral of the device. The devices were able to be tested in the original contactor without oscillating, however the Performance Plus contactor still provided superior performance (higher measured gain) due to its lowest possible ground inductance. The patented approach of the Performance Plus contactor provides a shorted path to ground so it is the closest thing to solder-to-board testing without soldering devices to the board.

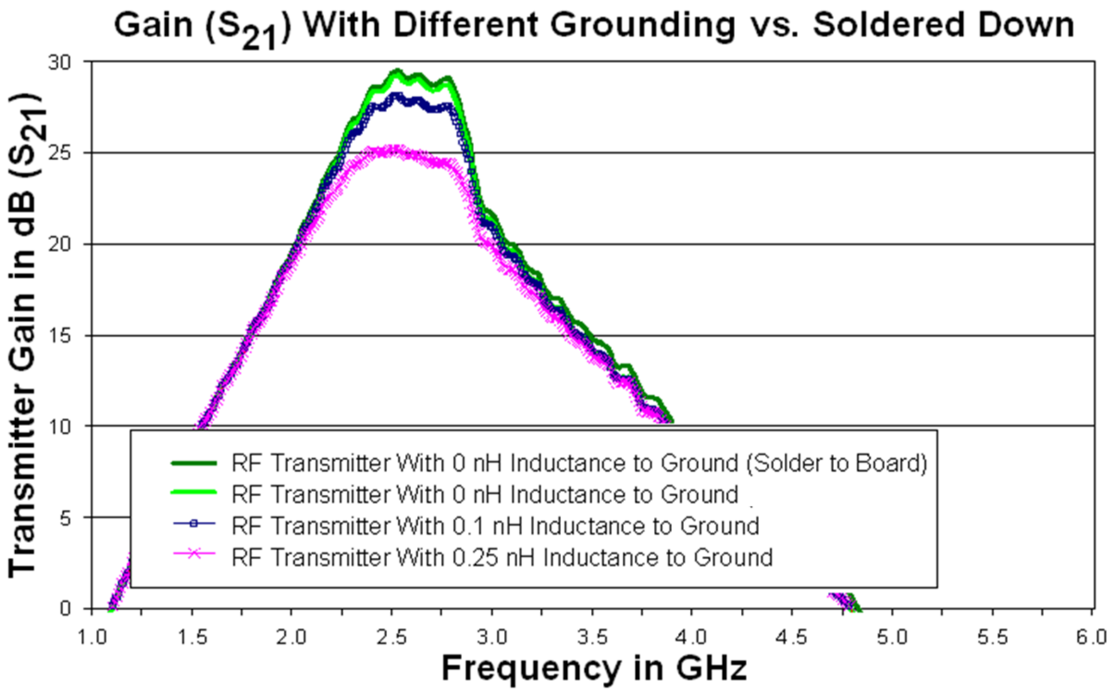


Figure 3: Effects of Ground Inductance on Gain of Device Compared to Soldered Down

In addition to power amplifiers, or any amplifier with higher gain or higher frequency bandwidth, there are also other semiconductor devices that are sensitive to ground inductance. The devices sensitive to ground inductance include Surface Acoustic Wave (SAW) and Bulk Acoustic Wave (BAW) filters, High-Speed digital designs above 10 GBits/sec, devices that incorporate RX and TX into the same device, and voltage-sensitive devices such as high bit count DACs and ADCs where the voltage per BIT is small. There are other devices that are also sensitive to ground inductance. To determine if a device is sensitive to ground inductance, add an inductance value between the device and the ground reference and monitor how it affects the device response. This can be done easily in Advanced Design System (ADS) or other equivalent software. If adding ground inductance between the device and the ground plane effects the key parameters of the DUT, then the ground inductance is affecting the device.

Figure 4 shows a model of a device in a contactor in ADS software. Notice that to get a good representation, the same S-parameter of the contact in the contactor is used for both the input side (Board to device) and output side (device to board). In the output side, the S-parameter model is flipped to get the correct signal flow represented. Also, the Ground inductance from the top of the contactor (the interface from the bottom of the device) to the load board is represented by the inductance from the device reference (the ground paddle under the device) to the load board. This inductance changes for different devices, as it depends on the number of ground paths from the device ground to the load board. In this example, the inductance of 0.015 nH was chosen. The more discreet paths to the board ground plane, the lower the ground inductance. As previously mentioned, the collective similar path inductance can be calculated as the inductance of one path divided by the number of similar paths. If those contacts are in a metal housing or insert, the mutual inductance of contact is shorted out, so the ground inductance path is then reduced to series inductance divided by the number of paths.

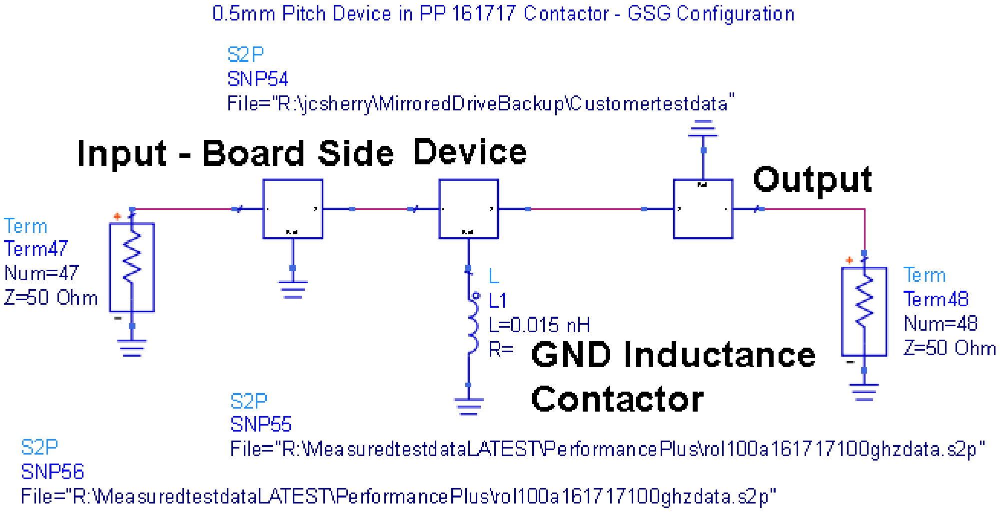


Figure 4: ADS Representation of Device in Contactor

Conclusion:

It was shown in this paper how the type of contact technology can affect measured performance in production testing of amplifiers. The commentary further described how contactor design can be used with device S-parameters to determine the expected results of testing in the contactor and how the ground inductance of the system can affect device performance. Also discussed is how a solid contact technology with a self-cleaning wiping function can improve test repeatability. The self-cleaning wiping function also allows less frequent contactor maintenance cycles, which lowers the overall cost of test by driving higher uptime.

For more information on Johnstech's comprehensive range of test socket solutions, please visit Johnstech.com or contact our team of experts.

Website: https://www.Johnstech.com/

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