

# Enhancing Semiconductor Testing: Understanding the Importance of Test Contactor Specifications

By Johnstech International Engineering Staff

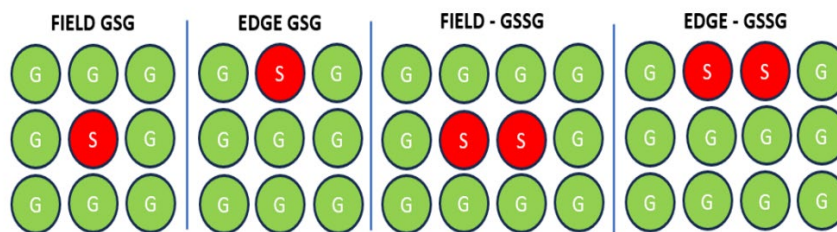
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## Introduction:

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 in optimizing semiconductor testing.

## RF Performance:

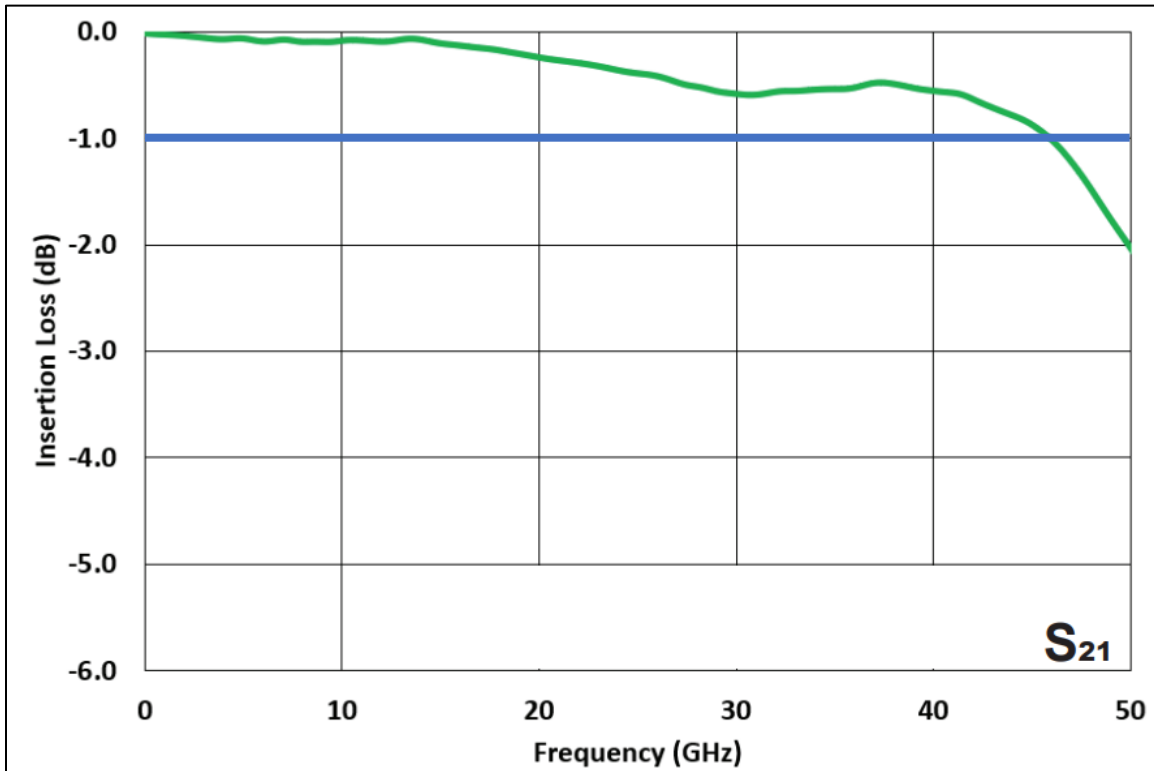
The RF performance characteristics of a test socket are important parameters to understand. Two prevalent RF performance characteristics are insertion loss and return loss. Before explaining each, it is also important to note the signal configuration that is quoted on a source document as it relates to the desired application. Various common signal configurations are shown in Figure 1. In many instances a ground-signal-ground (GSG) configuration is used. The RF signal is between two ground contacts in this GSG setup. Another common configuration is ground-signal-signal-ground (GSSG) in which two adjacent RF signals are bookended with ground contacts. The signal configuration will influence RF performance by impacting impedance. Test contactors are designed to match the impedance of the DUT, thereby making the test results more reflective of the DUT performance alone. Different device types tend to use specific configuration profiles. Spec sheets quote performance for one configuration but Johnstech can provide specific RF performance characteristics for a variety of signal configurations.



**Figure 1:** Common signal configurations used in integrated circuit design.

Insertion loss refers to the weakening of signals passing through the test socket. In a test socket, insertion loss is the magnitude of signal loss from the load board to the DUT interface with the socket. It is critical to minimize insertion loss to maintain signal accuracy during testing. Insertion loss is measured on a logarithmic scale and assumes a 50-ohm system impedance. A -1 dB insertion loss means that 1/10<sup>th</sup> of the RF signal that originated at the load board has been lost through the test socket. A -1 dB

insertion loss is a common consideration point as shown in Figure 2 below, but different DUT test needs may result in a different boundary value.

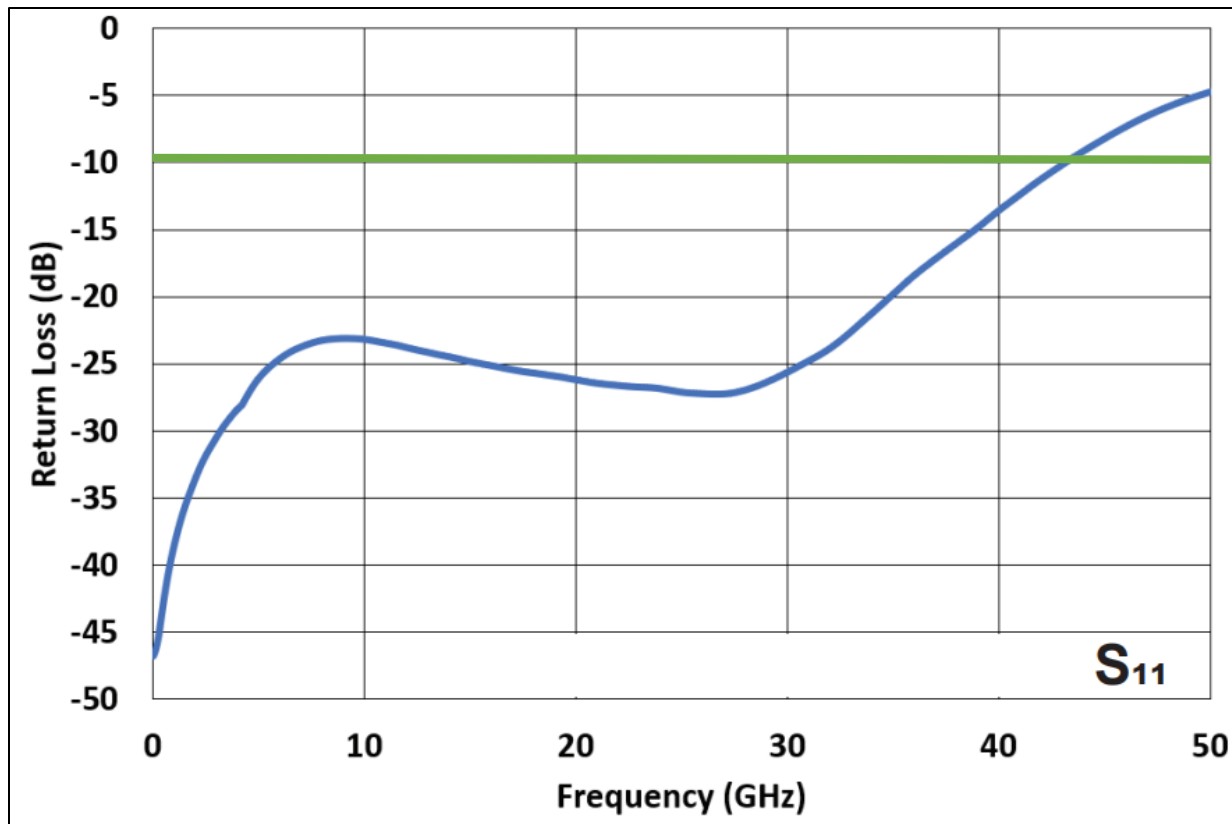


**Figure 2:** An example of insertion loss over a frequency range is shown

Return Loss refers to the amount of signal that is reflected back to the source, again with a 50-ohm system impedance. Signal reflections occur for numerous reasons including impedance mismatch, transmission imperfections, and electromagnetic interference. Like insertion loss, return loss is measured on a logarithmic scale. For test sockets, a -10 dB return loss is a common consideration point and equates to the frequency at which 1/10<sup>th</sup> of the signal is being reflected back to the source according to the following formula:

$$\text{Return Loss (dB)} = -10 * \log_{10}(\text{Reflection coefficient})$$

Different DUT test needs may drive a higher or lower acceptable return loss boundary value. Figure 3 below shows a return loss graph highlighting the commonly used -10 dB boundary value.



*Figure 3: An example of return loss over a frequency range is shown*

**Operating Temperature Range:**

The operating temperature range indicates the temperatures at which a test socket works best. Semiconductor testing may involve intentionally measuring performance at temperature extremes. Extreme temperature testing is often necessary to ensure desirable performance characteristics of the DUT across the anticipated operating temperature range. DUT performance characteristics such as leakage current, threshold voltage, carrier mobility, propagation delay, dynamic power consumption, and timing characteristics are subject to dynamic changes across operating temperature range.

When planning for the test of any device under extreme temperatures, it is important to be aware of the impact that temperature has on the DUT. For example, devices that are constructed with layers of materials with different coefficients of thermal expansion could be flat at ambient temperature but could warp at extreme hot or cold temperatures. Factoring in such possibilities is important to the ultimate testing performance by ensuring that the test socket has sufficient compliance to make good DUT contact, even if the DUT is warped. In addition to warpage, temperature extremes can soften material and accelerate oxide growth.

### **Contact Resistance:**

Contact resistance is the electrical resistance encountered at the interface between the test socket contacts and the DUT. High contact resistance can disrupt signal transmission and affect test results. Contact resistance can increase as thin oxide layers build up on either the DUT contacts or the test contactor contacts. Modern, Pb-free DUT leads and pads are often made with Matte-Tin which is susceptible to oxide buildup. Even if NiPdAu plating is used to minimize oxide buildup, non-conductive byproducts from the package assembly process can still be common on DUT leads and pads. Modern, Pb-free BGA solder balls are often made of SnAgCu and are also susceptible to oxide buildup. Johnstech DUT contacts feature homogeneous, low-resistance materials such as palladium alloys or copper alloys. Homogeneous tip design ensures that the desired material contacts the DUT even as the tip wears over usage.

Further, different contactor types overcome oxide buildup or debris through a variety of ways. Johnstech spring probes are designed with optimal force at test height to break through oxides or debris at the DUT-contactor interface. For the Johnstech solid contactors, ROL and VROL, a different mechanism is used. Johnstech ROL and VROL products have a self-cleaning, wiping technique to clear oxides and debris from the DUT-contactor interface. If contact resistance is of paramount importance to testing results, the self-cleaning wipe action of Johnstech solid contactors are the optimal choice, whenever possible.

### **Inductance:**

Inductance affects a test socket's response to rapidly changing electrical signals. High inductance can distort signals and affect test results. Inductive reactance is the opposition that an inductor presents to alternating current (AC) due to its inductance. Inductive reactance is proportional to the frequency of the AC signal and the inductance of the component. The formula for inductive reactance is:

$$X_L = 2\pi fL$$

Where:

- $X_L$  is the inductive reactance (measured in ohms)
- $f$  is the frequency of the AC signal (measured in hertz)
- $L$  is the inductance of the inductor (measured in henries).

From this formula, it's evident that as frequency increases, the inductive reactance also increases linearly. For this reason, test engineers often try to minimize inductance as the only available lever when testing high frequency devices to minimize overall inductive reactance.

RF circuits that operate at high frequencies such as some amplifiers, mixers, oscillators and filters may require minimal test socket inductance for optimal test results. Likewise, high-speed digital circuits such as those found in microprocessors, FPGAs, and high-speed communication interfaces may require low inductance. Additionally, analog and mixed-signal devices including ADCs and DACs may require low inductance due to noise concerns. And finally, millimeter-wave and terahertz devices may require low

inductance due to the high sensitivity to parasitic effects, including parasitic inductance which is added to test socket inductance when considering inductive reactance.

### **Current Carrying Capacity:**

The current carrying capacity (CCC) indicates the maximum current a test socket can handle without overheating or performance degradation. Overheating can damage the contactor and in extreme circumstances, even the DUT as well. The convention most often used to state CCC indicates the maximum current at which the test socket experiences a maximum temperature increase of 20°C. Most specification sheets offer a single CCC value at a specific duty cycle (often 100%), but some include CCC at other duty cycles such as 50% and 1%.

In high-current applications like power device testing, ensuring sufficient current carrying capacity is crucial. Solid contactor test sockets such as Johnstech's ROL and VROL product lines offer inherently better CCC when compared to similar spring probe test sockets of identical pitch.

### **Conclusion:**

In semiconductor testing, test socket effectiveness is vital for accurate and efficient testing processes. Understanding test socket specifications is essential for semiconductor test engineers. Johnstech International Corporation provides innovative socket solutions to meet industry needs. By focusing on specifications like insertion loss, operating temperature range, contact resistance, inductance, current carrying capacity, and frequency range, engineers can optimize testing processes and achieve better results.

For more information or to explore Johnstech's test socket solutions, please visit the website or follow Johnstech International on LinkedIn.

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

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