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Environmental Test System Stability

Component manufacturers need to perform reliability testing to determine the long-term behavior of passive components. Reliability testing includes, among others, environmental qualification of devices, where these are placed inside an environmental chamber and their transmission performance is monitored during cycles of varying temperature and humidity conditions.

Demystifying Repeatability

It is well known to the passive component qualification industry that the performance of any environmental test system is directly related to the performance of the switches that direct the test signal through the devices under test. However, the relationship is more intricate than what is commonly thought and a careful analysis of the interaction between parameters is necessary to determine the true performance of an environmental test system.

Some of the switch specifications that affect the results are repeatability, stability and, in some cases, uniformity. The test system specification that is most directly touched by these parameters is its stability in time.

Repeatability

Repeatability is a specification that is commonly applied to switches. Generally speaking, it indicates the maximum power difference that can be expected when the switch comes back to the same channel after a previous measurement cycle. This cycle can be either sequential or random and different repeatability values are attributed to the type of cycling that is performed.

Repeatability is a key parameter in long-term testing since the measurement cycles are repeated a high number of times without handling the connections, until the end of the test, which could be as long as 5000 hours. Simply stated, repeatability is the contribution of the switch to the global measurement uncertainty.

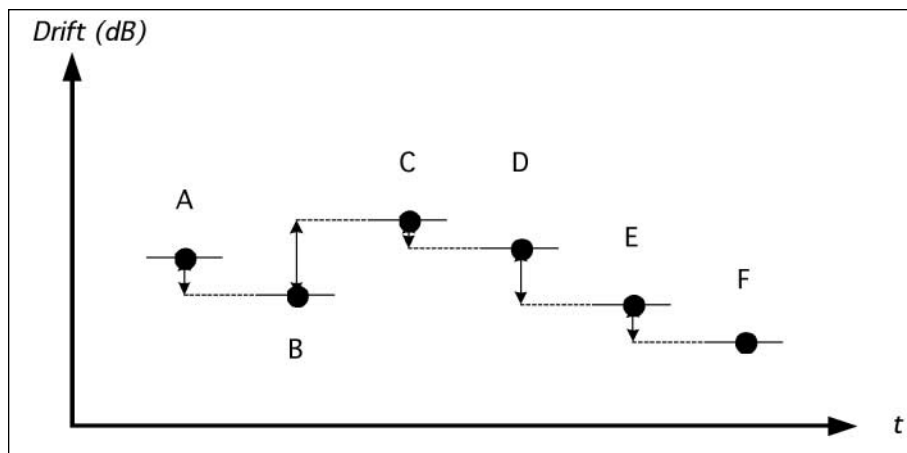


Figure 1. Switch repeatability is the difference in insertion loss between two adjacent points for the same channel.

Stability

Stability is the value obtained by comparing any data point to the first point in the series. It is important to obtain the duration over which this repeatability can be expected, as some switches tend to degrade quickly after a specific number of cycles.

In environmental testing, where the devices are being tested for their transmission stability during a long time span, the switch stability is a critical specification.

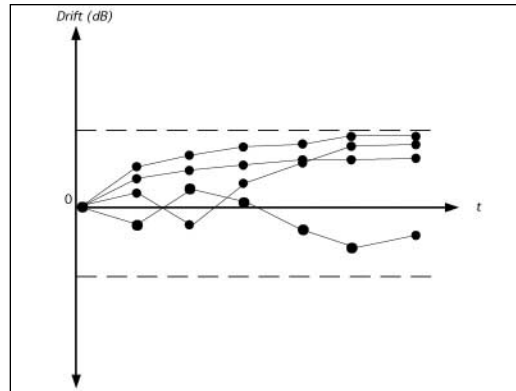


Figure 2. Stability is determined by the highest difference between the first data point and the last point over a given time span.

The image above represents the stability necessary for a particular test. The lines represent the different test channels. Inside the shadowed region, stability is within specifications. Any excursion from this shadowed region represents an increase in error and an increased possibility of the device failing the test due to system instability.

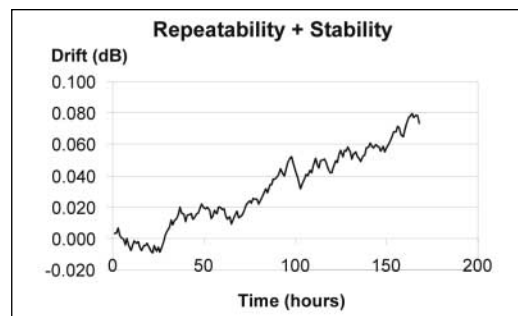


Figure 3. Stability is the cumulative repeatability over a given time span. In this case, the manufacturer specifies a repeatability of ± 0.005 dB.

Repeatability and stability are closely related. The stability determines the maximum passband of the repeatability specification, where a maximum of cumulative repeatability is allowed. The stability passband should be a fraction of the passband expected for the passive components under test.

Uniformity

Uniformity is the drift of any channel relative to another channel selected as reference. That is, the maximum deviation in insertion loss of any channel when compared to a particular channel. This specification is a function of time and is affected by ambient temperature fluctuations. This specification is of particular importance in any test system that compares the output power of multiple port devices with no source drift compensation, such as any system that uses multiple detectors (i.e. one detector per test channel) at the output end. It is also important when monitoring the performance of one device while using a similar device as reference. Any deviation from the reference that is greater than the uniformity value may imply a change in the transmission characteristics of the device being monitored. However, when a test consists of monitoring the performance of a device when the reference value is given by the device itself at $t=0$, the insertion loss uniformity is of less importance.

Other Parameters that Affect System Stability

System drift stability is the direct effect of the interaction between switch stability and repeatability. The stability specification is a function of time and, since the devices are being tested for their transmission stability over long periods of time, it is a critical specification in environmental test systems. However, there is more to system stability than switch repeatability. Light signal quality, source stability during the acquisition cycle, and detector linearity are all important factors to consider and control in an environmental test system. Power referencing and controlling signal quality are some of the techniques that must be applied to ensure good quality of results.

Power Referencing

The mechanism to reference out source drift and power fluctuations induced by the test equipment varies from one system manufacturer to another. The most basic approach consists of using at least one channel between the test switches as a reference that continually monitors source drift.

Additional mechanisms consist of making a power reading just before the signal reaches the switch. It is an alternative referencing mechanism when no test channels are available. The opportunities to reference out power fluctuations are given by the design of the environmental test system itself.

Test signal characteristics

If an environmental test system performance is to a great extent determined by the quality of the selected switches, the quality of the signal that is sent through the device under test is even more important.

The quantity of test equipment, especially switches, required to configure an environmental test system creates a non-negligible amount of insertion loss. The selected test sources must then provide adequate power so that reliable measurements can be made within the high linearity range of the power meter. The source must remain stable during the acquisition cycle to ensure reliable results. For insertion loss, drift and return loss testing, the source should offer a depolarized output.

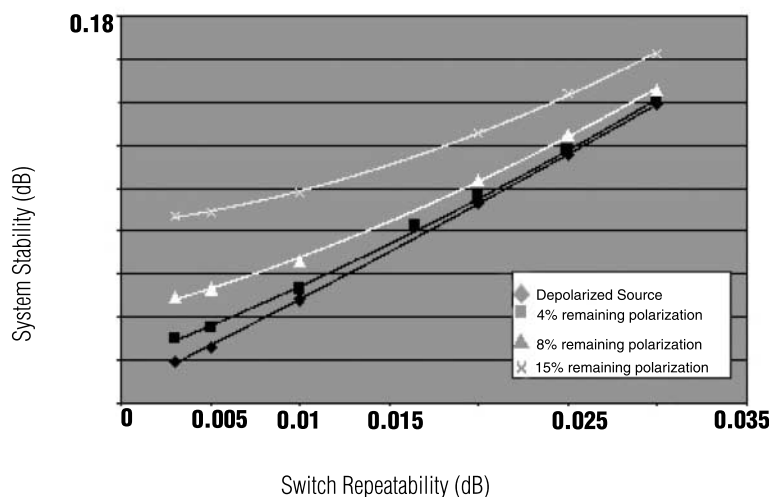


Figure 4. Switch repeatability and its effect on system stability.

The quality of the depolarization affects system stability in conjunction with the switch repeatability. Depolarized output can be provided by certain wideband sources. Narrowband sources must be depolarized to minimize any polarization-dependent effects. Using adequate polarization techniques, narrowband sources can be depolarized 90% or more.

By optimizing these two parameters, switch stability and the polarization degree of the source, system stability can be made suitable for long term tests of passive components. Figure 4 demonstrates the interaction between switch repeatability and source depolarization and how it affects environmental measurement stability.

Conclusion

All the specifications described above interact to provide a test system specification. Random fluctuations and component degradation make it difficult to maintain system behavior under control, especially during long-term tests.

Environmental test system manufacturers must be able to guarantee the stability of their system over a defined period of time, since these excursions cannot be seen during the test and a consequent failure cannot be clearly attributed to the device under test or the test system.

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