FLUKE®

Calibration

Making repeatable RF connections during RF calibration

Application Note

RF measurements and the associated uncertainty depend on the integrity of the cables and connectors used to interconnect the various instruments and devices involved.

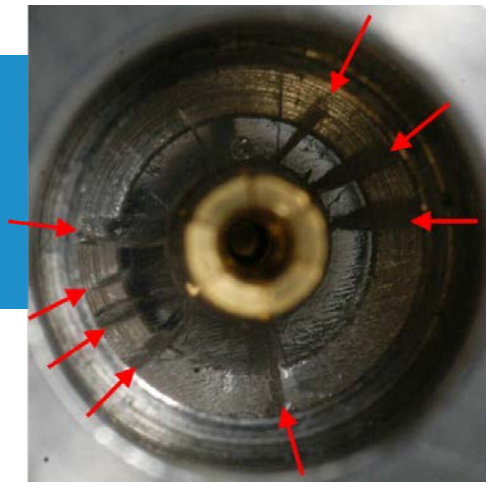


Figure 1. N-type coaxial attenuator connector with cracked center contact supporting disk, which caused poor measurement repeatability. The arrows indicate the cracks in the dielectric supporting disk.

Employing best practice is essential to avoid and reduce uncertainty contributions. Poor performance of coaxial devices and interconnections can be traced directly to problems with out-of-tolerance dimensions, cleanliness, damage or incorrect tightening of connectors. Furthermore, a dirty, damaged or out-of-tolerance connector mated to an otherwise good connector can cause it to become damaged, clearly undesirable if the resulting damage is to a connector on a customer's unit or a laboratory standard. Figure 1 shows a damaged N-type connector on one end of a coaxial attenuator, with arrows indicating cracks in the dielectric disc supporting the center contact. Poor and variable alignment of the center contact arising from this damage was ultimately found to be responsible for bad repeatability in measurements made using this device.

Connectors must be inspected for damage and dirt before they are connected to one another—ideally every time a connection is made—or at least daily. Connector threads and contacts can become dirty from finger oils, airborne contaminants, and from swarf (fine chips or filings of stone, metal, or other material produced by a machining operation) generated in the threads when the connectors are tightened. Dirty or contaminated contacts can cause undesirable effects that degrade the characteristics of the connector; in particular, poor repeatability and high/variable VSWR (match). Look for dents, raised edges, and scratches on the mating surfaces. Connectors that have dents on the mating surfaces usually also have raised edges around them and will make less than perfect contact. Raised edges on mating interfaces make dents in other connectors to which they are mated.

An illuminated magnifier or eye glass is very useful, and small wooden cocktail sticks can be used to remove small particles. Any loose particles on the connector surfaces, contacts and threads should be removed using low-pressure solvent-free compressed air. Cans of compressed air for this and other equipment cleaning and maintenance purposes are readily available. Never blow into a connector because moist breath will contaminate the connector even further!

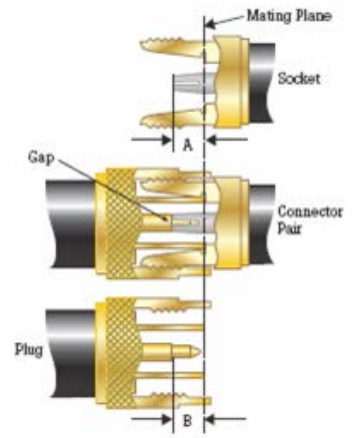
Once loose particles are removed, clean the connector with a small amount of solvent to remove any attached dirt and contamination. Isopropyl alcohol (isopropanol) is the solvent of choice, applied with a cotton swab or lint free cloth. Take care to avoid exerting any force on the connector that might damage or bend the connector pins or sockets. Cover connectors with protective end caps when not in use to prevent contamination or damage by foreign bodies.

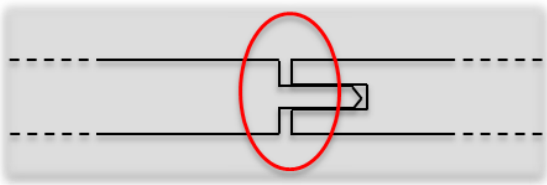
Best practice requires that all coaxial connectors fitted on all equipment, cables and terminations should be gauged on a routine basis, to detect any out-of-tolerance mechanical conditions that might impair the electrical performance or cause connector damage. Never force coaxial connectors together when making a connection, because forcing often indicates incorrectness, damage or incompatibility.

Gauge kits for checking the mechanical dimensions for all connector types are available from a variety of manufacturers. Certain dimensions (see figure 2 for a precision N-type connector) are critical for the mechanical integrity, nondestructive mating and electrical performance of

Figure 2. Cross-section of an N-type connector showing the reference (mating) plane and the relevant connector critical dimensions.

Connector Type	Socket dimension A (inches)	Plug dimension B (inches)	Gap between the mated center contacts (inches)		
			min	nom	max
Precision N	0.207 $^{0.000}_{-0.003}$	0.208 $^{+0.003}_{0.000}$	0.001	0.001	0.007





The center pin gap represents a change in transmission line inner conductor diameter, resulting in a small mismatch. Ensuring the correct gap minimizes mismatch.

the connector. There are a number of different mechanical specifications for the type N connector and users should be clear on the mechanical requirement needed for a particular application (for example, precision or general purpose). Figure 2 shows that the precision Type N connector has the junction mating surface offset from the reference plane to reduce mechanical damage or misalignment when making connections. Also, the inner female pin of the Type N socket connector is of the non-slotted type, to produce characteristic impedance that is independent of the mating pin. Other connectors such as the PC3.5, 2.92 mm, 2.4 mm and 1.85 mm, etc, are also used for higher frequencies. Like the N-type, these connectors also have critical mechanical dimensions and tolerances and should be inspected, cleaned and gauged in a similar manner.

When connecting or disconnecting, avoid misalignment and rotate the connector nut, not the body. Damage can be caused if the mating surfaces rub against each other or the center contacts are twisted. Correct tightening torque will ensure a good connection and avoid damage. Excessive torque can lead to mechanical damage, deformation of the contacts, and result in degraded VSWR. Tighten connectors to the manufacturer's recommended torque with a torque wrench. Apply a gentle smooth pressure directly through the axis, until the wrench "breaks" at the correct torque setting. No further pressure should be applied.

With torque wrenches, it is possible to get substantially the wrong applied torque by using a twisting action. It is sometimes useful to use a small flat wrench on a connector body to prevent any rotation when making connection. Always make sure that the torque wrench is at the correct setting before use. The torque wrench used should be routinely checked or calibrated. If it is an adjustable type wrench, it should be adjusted to the correct torque settings for the specific connector and clearly marked. If a connector nut has only a knurl and a torque wrench cannot be used the connector should be "finger tight". Be aware it is possible to over-torque a connector by hand tightening with excessive force.

Connector repeatability is typically one of the most significant contributors to measurement uncertainty in RF and microwave calibrations. It is a type A uncertainty contribution, to be assessed and accounted for within the uncertainty budget, by making repeat measurements. To properly account for connector repeatability it is necessary to make measurements with several connect/disconnect cycles. Furthermore, best practice is to make each repeat measurement with a different connector orientation, ideally three to five orientations covering the full 360 degrees. This ensures potential changes in contact conditions of the mated connectors at different axial orientations and their impact on attenuation, match, and so forth are accounted for within the connector repeatability uncertainty contribution.

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