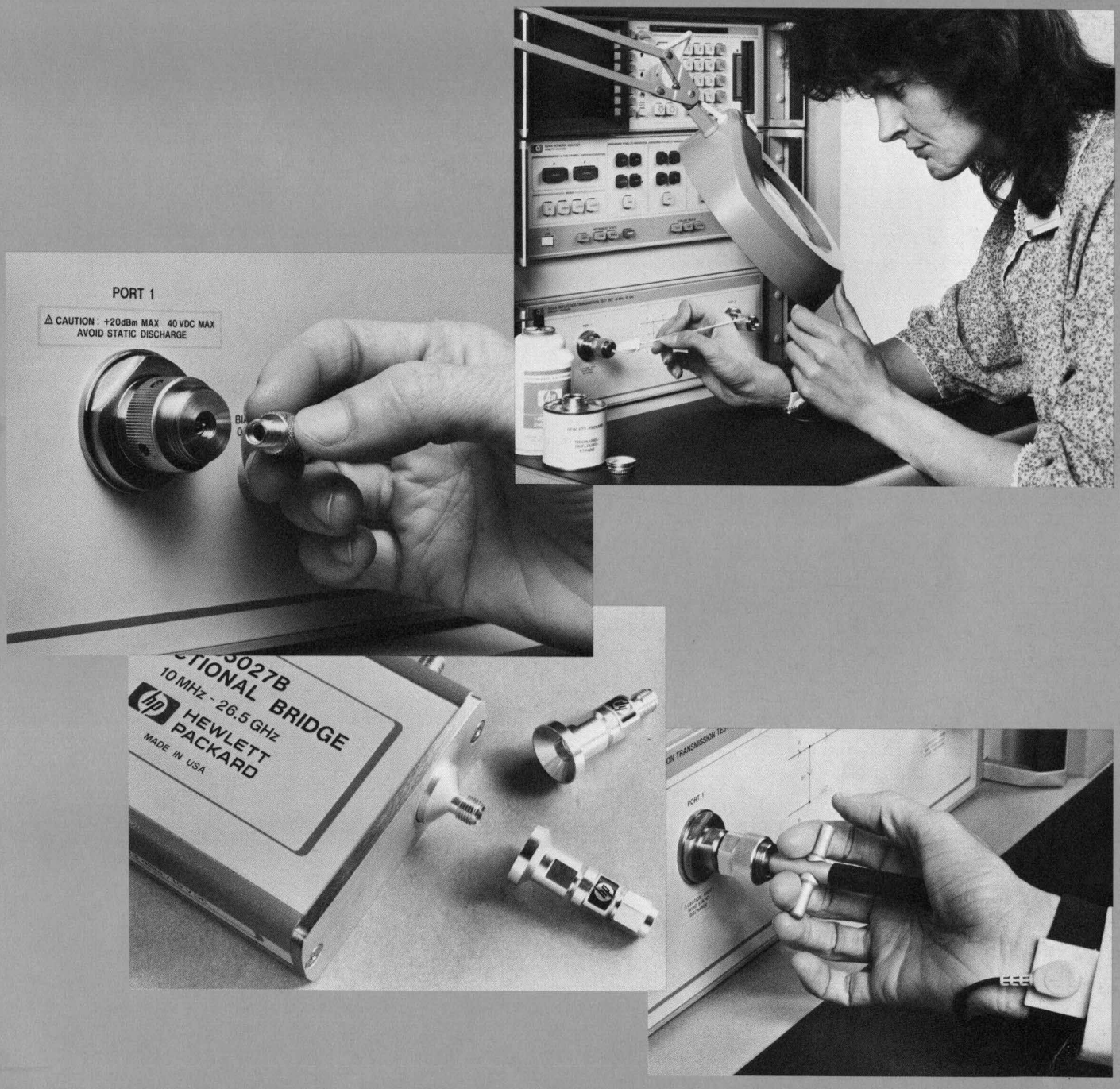
Application Note 326

HEWLETT PACKARD

Coaxial Systems

Principles of microwave connector care
(for higher reliability and better measurements)



Introduction

Recent advances in measurement capabilities have made connectors and connection techniques more important than ever before. Damage to the connectors on calibration and verification devices, and on test ports, cables, and other devices also represents an increasing burden in downtime and expense.

The suggestions in this Application Note will help you get the best performance from all coaxial microwave connectors: to know what to look for when cleaning and inspecting them, in order to preserve their precision and extend their life; and to make the best possible microwave connections, improving the accuracy and repeatability of all of your measurements, saving both time and money.

Handling and Storage. Microwave connectors must be handled carefully, inspected before use, and when not in use stored in a way that gives them maximum protection. Avoid touching the connector mating plane surfaces and avoid setting the connectors contact-end down, especially on a hard surface.

Never store connectors with the contact end exposed. Plastic end caps are provided with all Hewlett-Packard connectors, and these should be retained after unpacking and placed over the ends of the connectors whenever they are not in use. Extend the threads of connectors that have a retractable sleeve or sliding connector nut. Then put the plastic end cap over the end of the connector.

See table 5 in the Addendum (inside back cover) for replacement end caps.

Above all, never store any devices loose in a box or in a desk or a bench drawer. Careless handling of this kind is the most common cause of connector damage during storage.

Visual Inspection

Visual inspection and, if necessary, cleaning should be done every time a connection is made.

Metal and metal by-product particles from the connector threads often find their way onto the mating plane surfaces when a connection is disconnected, and even one connection made with a dirty or damaged connector can damage both connectors beyond repair.

Magnification is helpful when inspecting connectors, but it is not required and may actually be misleading. Defects and damage that cannot be seen without magnification generally have no effect on electrical or mechanical performance. Magnification is of great use in analyzing the nature and cause of damage, and in cleaning connectors, but it is not required for inspection.

Obvious Defects or Damage. Examine the connectors first for obvious defects or damage: badly worn plating, deformed threads or bent, broken, or misaligned center conductors. Connector nuts should move smoothly and be free of burrs, loose metal particles, and rough spots.

Immediately discard, or mark and send away for repair, any connector that has obvious defects like these.

Mating Plane Surfaces. Next concentrate on the mating plane surfaces. Flat contact between the connectors at all points on their mating plane surfaces is required for a good connection. Therefore, particular attention should be paid to deep scratches or dents, and to dirt and metal or metal by-product particles on the connector mating plane surfaces.

Also look for bent or rounded edges on the mating plane surfaces of the center and outer conductors and for any signs of damage due to excessive or uneven wear or misalignment.

Light burnishing of the mating plane surfaces is normal, and is evident as light scratches or shallow circular marks distributed more or less uniformly over the mating plane surface. Other small defects and cosmetic imperfections are also normal. None of these affect electrical or mechanical performance.

If a connector shows deep scratches or dents, particles clinging to the mating plane surfaces, or uneven wear, clean it and inspect it again. Damage or defects of these kinds – dents or scratches deep enough to displace metal on the mating plane surface of the connector – may indicate that the connector itself is damaged and should not be used. Try to determine the cause of the damage before making further connections.

Precision 7mm Connectors. Precision 7mm connectors, among them APC-7® connectors, should be inspected visually with the center conductor collets in place, and whenever the collet has been removed. See Figure 1.

The collet itself should be inspected for edge or surface damage and for any signs that the spring contacts are bent or twisted. If they are, replace the collet. When the collet has been re-inserted, verify that it springs back immediately when pressed with a blunt plastic rod or with the rounded plastic handle of the collet removing tool. Never use a pencil or your finger for this purpose.

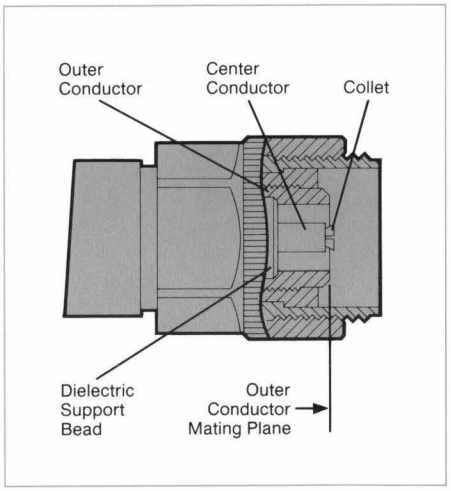


Figure 1. Precision 7mm connector

APC-7 is a U.S.-registered trademark of the Bunker Ramo Corporation.

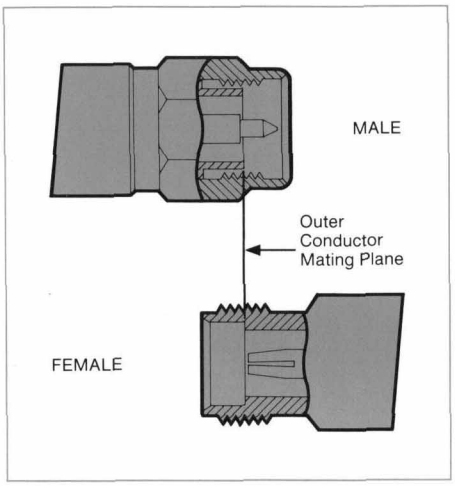


Figure 2. Precision 3.5mm connectors

Sexed Connectors. On sexed connectors, especially precision 3.5mm and SMA connectors, pay special attention to the female center conductor contact fingers (Figures 2 and 3). These are very easily bent or broken, and damage to them is not always easy to see. Any connector with damaged contact fingers will not make good electrical contact and must be replaced.

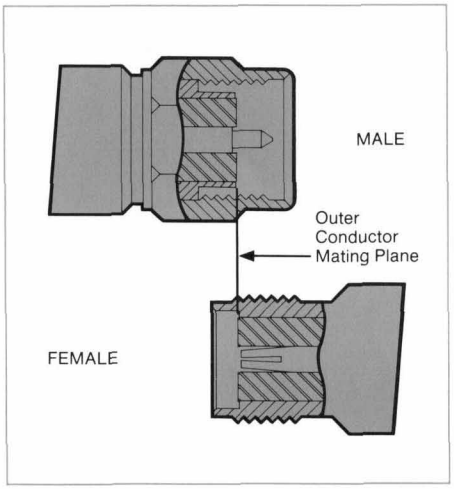


Figure 3. SMA connectors

Cleaning

Careful cleaning of all connectors is essential to assure long, reliable connector life, to prevent accidental damage to connectors, and to obtain maximum measurement accuracy and repeatability. Yet it is the one step most often neglected or done improperly. Supplies recommended for cleaning microwave connectors are listed in Table 1.

Table 1. Recommended cleaning supplies

Description	HP Part Number
Compressed "Air"	8500-2503
Liquid Freon	92193F
Cotton Swabs	5080-5400
Lint-Free Cleaning Cloth	9310-4242

Compressed Air. Loose particles on the connector mating plane surfaces can usually be removed with a quick blast of compressed air. This is very easy to do and should always be tried first.

The easiest method is to use compressed air (actually compressed Freon) from a small pressurized can. This is available as HP Part Number 8500-2503, and the stream of air can be directed exactly where it is wanted through a plastic (not metal) nozzle. No hoses or other connections are needed. Hold the can upright, to avoid spraying liquid along with the vapor.

Cleaning Solvents. Dirt and stubborn contaminants that cannot be removed with compressed air can often be removed with a cotton swab (HP Part Number 5080-5400) or lint-free cleaning cloth (HP Part Number 9310-4242) moistened with a solvent.

Use the least amount of solvent possible, and avoid wetting any plastic parts in the connectors with the solvent.

Solvents should be used in liquid rather than spray form. If a spray must be used, always spray the solvent onto a cloth or swab, never directly into a connector.

Generally, pure liquid Freon (trichlorotrifluoroethane), available as HP Part Number 92193F, is the best solvent for cleaning microwave connectors. It is chemically inert and evaporates cleanly, without leaving a residue or film.

Very dirty connectors can be cleaned with pure isopropanol. Other solvents, including other types of Freon or isopropanol that contain additives, should not be used.

Whichever solvent is used, carefully avoid wetting the plastic support bead inside the connector and blow the connector dry immediately with a gentle stream of compressed air. Support beads are easily damaged by solvents.

Precision 7mm Connectors. When precision 7mm connectors have been cleaned with the center conductor collet removed, insert the collet and clean the mating plane surfaces again.

When the connector is attached to a small component, or to a cable or calibration or verification standard, the easiest way to do this is to put a lint-free cleaning cloth flat on a table and to put a drop or two of cleaning solvent in the center of the cloth. Note that it is not necessary to remove the collet to use this cleaning method.

Retract the connector sleeve threads so that the connector interface is exposed. Then gently press the contact end of the connector into the cloth moistened with solvent and turn it.

Dirt on the connector interface will be scrubbed away by the cloth without damaging the connector. Blow the connector dry with a gentle stream of compressed air.

This cleaning method can be adapted even for fixed connectors such as those attached to test ports. Simply fold the cloth into several layers of thickness, moisten it, press it against the connector interface, and turn it to clean the connector. Blow the connector dry with a gentle stream of compressed air.

Cleaning Interior Surfaces. Interior surfaces, especially on precision 3.5mm connectors, are very difficult to reach, and it is easy to damage connectors in trying to clean them. The openings are very small, and generally the center conductor is supported only at the inner end, by a plastic dielectric support bead. This makes it very easy to bend or break the center conductor.

One suitable method (Figure 4) is to cut off the sharp tip of a round wooden toothpick and then to wrap it with a single layer of lint-free cleaning cloth.

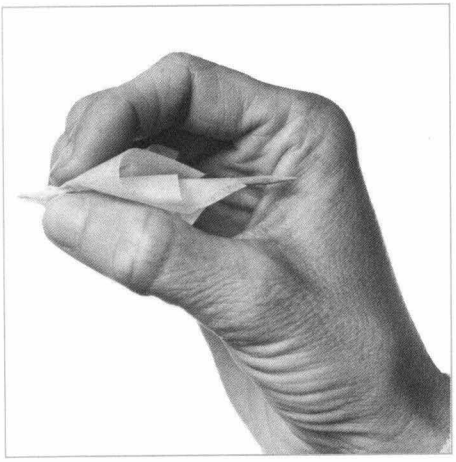


Figure 4. Cleaning interior surfaces

A round wooden toothpick or a very small diameter wooden rod is required: metal must never be used (it will scratch the plated surfaces), and in cleaning precision 3.5mm connectors the diameter must not exceed 0.070 in. (1.7 mm). The wooden handle of a cotton swab, for example, is too large for this purpose. Even though the handle can sometimes be inserted into the connector, even when wrapped in lint-free cloth, movement of the handle against the center conductor can exert enough force on the center conductor to damage it severely.

Moisten the cloth with a small amount of cleaning solvent and carefully insert it into the connector to clean the interior surfaces. Use an illuminated magnifying glass or microscope to see clearly the areas you wish to clean.

Drying Connectors. When you have cleaned a connector, always be sure that it is completely dry before reassembling or using it. Blow the connector dry with a gentle stream of clean compressed air and inspect it again under a magnifying glass to be sure that no particles or solvent residues remain.

Mechanical Inspection: Connector Gages

Even a perfectly clean, unused connector can cause trouble if it is mechanically out of specification. Since the critical tolerances in microwave connectors are on the order of a few ten-thousandths of an inch, using a connector gage is essential.

Before using any connector for the first time, inspect it mechanically using a connector gage. How often connectors should be gaged after that depends upon usage.

In general, connectors should be gaged whenever visual inspection or electrical performance suggests that the connector interface may be out of specification, for example due to wear or damage. Connectors on calibration and verification devices should also be gaged whenever they have been used by someone else or on another system or piece of equipment.

Precision 3.5mm and SMA connectors should be gaged relatively more often than other connectors, owing to the ease with which the center pins can be pulled out of specification during disconnection.

Connectors should also be gaged as a matter of routine – after every 100 connections and disconnections initially, more or less often after that as experience suggests.

Table 2. Recommended connector gages

Connector gage kits containing all of the items required are included in many Hewlett-Packard calibration kits, and they are also available separately. Part numbers are as follows.	
Type	**Part Number/Ordering Information**
Precision 7mm (APC-7)	1250-1875
Precision 3.5mm	1250-1862
SMA	A-027A Maury Microwave Corporation 8610 Helms Avenue Cucamonga, California 91730 Telephone: 714-987-4715 TWX: 910-581-3408
Type-N	85054-60024

Mechanical Specifications

The critical dimension to be measured, regardless of connector type, is the position (generally, the recession or setback) of the center conductor relative to the outer conductor mating plane.

Mechanical specifications for connectors specify a maximum distance and a minimum distance that the center conductor can be positioned behind (or, in female Type-N connectors, in front of) the outer conductor mating plane.

Nominal specifications for each connector type exist. But the allowable tolerances (and sometimes the dimensions themselves) differ from manufacturer to manufacturer and from device to device.

Therefore, before gaging any connector, consult the mechanical specifications provided with the connector or the device itself.

Precision 7mm Connectors. In precision 7mm connectors, contact between the center conductors is made by spring-loaded contacts called collets. These protrude slightly in front of the outer conductor mating plane when the connectors are apart. When the connection is tightened, the collets are compressed into the same plane as the outer conductors.

For this reason, two mechanical specifications are generally given for precision 7mm connectors: the maximum *recession of the center conductor* behind the outer conductor mating plane with the center conductor collet removed; and a minimum and maximum allowable *protrusion of the center conductor collet* in front of the outer conductor mating plane with the collet in place.

The center conductor collet should also spring back immediately when pressed with a blunt plastic rod or with the rounded plastic handle of the collet removing tool. Never use a pencil or your finger for this purpose.

With the center conductor collet removed, no protrusion of the center conductor in front of the outer conductor mating plane is ever allowable, and sometimes a minimum recession is required. Consult the mechanical specifications provided with the connector or the device itself.

Sexed Connectors. In Type-N and precision 3.5mm connectors, the position of the center conductor in the male connector is defined as the position of the shoulder of the male contact pin – not the position of the tip. The male contact pin slides into the female contact fingers and electrical contact is made by the inside surfaces of the tip of the female contact fingers on the sides of the male contact pin.

Type-N Connectors. Type-N connectors also differ from other connector types in that the outer conductor mating plane is offset from the mating plane of the center conductors. The outer conductor sleeve in the male connector extends in front of the shoulder of the male contact pin. When the connection is made, this outer conductor sleeve fits into a recess in the female outer conductor behind the tip of the female contact fingers (Figure 5).

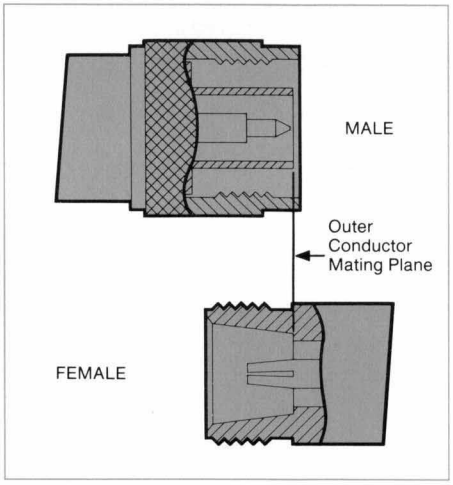


Figure 5. *Type-N Connectors*

Hence the mechanical specifications of Type-N connectors give a *maximum protrusion of the female contact fingers* in front of the outer conductor mating plane and a *minimum recession of the shoulder of the male contact pin* behind the outer conductor mating plane.

No Type-N connector should ever be used when there is any possibility of interference between the shoulder of the male contact pin and the tip of the female contact fingers when the connectors are mated. In practice this means that no Type-N connector pair should be mated when the separation between the tip of the female contact fingers and the shoulder of the male contact pin could be less than zero when the connectors are mated. Gage Type-N connectors carefully to avoid damage.

As Type-N connectors wear, the protrusion of the female contact fingers generally increases, due to wear of the outer conductor mating plane inside the female connector. This decreases the total center conductor contact separation and should be monitored carefully.

75Ω Type-N Connectors. 75Ω Type-N connectors differ from 50Ω Type-N connectors most significantly in that the center conductor, male contact pin, and female contact hole are smaller. Therefore, mating a male 50Ω Type-N connector with a female 75Ω Type-N connector will destroy the female 75Ω connector by spreading the female contact fingers apart permanently or even breaking them.

If both 75Ω and 50Ω Type-N connectors are among those on the devices you are using, mark the 75Ω Type-N connectors to be sure that they are never mated with any 50Ω Type-N connectors.

Using Connector Gages

Before a connector gage is used, it must be inspected, cleaned, and zeroed.

Inspecting and Cleaning the Gage. Inspect the connector gage and the gage calibration block carefully, exactly as you have inspected the connector itself, and clean or replace them if necessary. Dirt on the gage or the gage calibration block will make the gage measurements of the connectors inaccurate and can transfer dirt to the connectors themselves, damaging them during gaging or when the connection is made.

Zeroing the Gage. Zero the gage by following the steps described below. Be sure that you are using the correct connector gage and correct end of the gage calibration block for the connector being measured.

Hold the gage by the plunger barrel (not the dial housing or cap) and, for male connectors, slip the protruding end of the calibration block into the circular bushing on the connector gage. For precision 7mm and female precision 3.5mm and SMA connectors, use the flat end of the gage calibration block. For female Type-N connectors, use the recessed end of the gage calibration block.

Hold the gage by the plunger barrel *only* (Figure 6). Doing so will prevent errors in gage readings due to the application of stresses to the gage plunger mechanism through the dial indicator housing.

Carefully bring the gage and gage block together, applying only enough pressure to the gage and gage block to result in the dial indicator pointer settling at a reading.

Gently rock the two surfaces together, to make sure that they have come together flatly. The gage pointer should now line up exactly with the zero mark on the gage. If it does not, inspect and clean the gage and gage calibration block again and repeat this process. If the gage pointer still does not line up with the zero mark on the gage, loosen the dial lock screw and turn the graduated dial until the gage pointer exactly lines up with zero. Then re-tighten the lock screw.

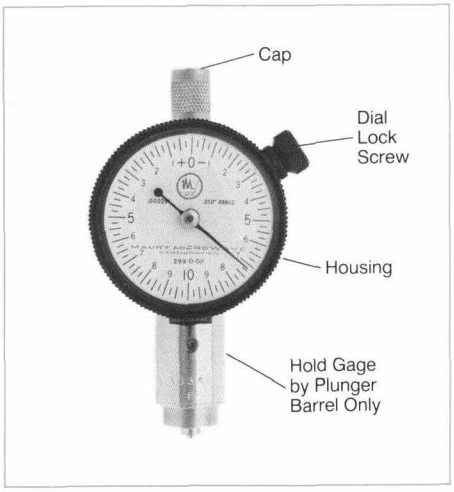


Figure 6. Using the Connector Gage

Gages should be checked often, to make sure that the zero setting has not changed. Generally, when the gage pointer on a gage that has been zeroed recently does not line up exactly with the zero mark, the gage or calibration block needs cleaning. Clean both of these carefully and check the zero setting again.

Measuring Connectors. Measuring the recession of the center conductor behind the outer conductor mating plane in a connector is done in exactly the same way as zeroing the gage, except of course that the graduated dial is not re-set when the measurement is made.

If the connector has a retractable sleeve or sliding connector nut – precision 7mm connectors, for example – extend the sleeve or nut fully. This makes it easier to keep the gage centered in the connector.

Hold the gage by the plunger barrel and slip the gage into the connector so that the gage plunger rests against the center conductor. Carefully bring the gage into firm contact with the outer conductor mating plane.

Apply only enough pressure to the gage as results in the gage pointer settling at a reading.

Gently rock the connector gage within the connector, to make sure that the gage and the outer conductor have come together flatly. Then read the recession (or protrusion) from the gage dial.

For maximum accuracy, measure the connector several times and take an average of the readings.

Rotate the gage relative to the connector between each measurement. To monitor connector wear, record the readings for each connector over time.

Making Connections

Making good connections is easy if a few simple principles are kept in mind:

- all connectors must be undamaged, clean, and within mechanical specification
- the connectors must be precisely aligned with one another and in flat physical contact at all points on the mating plane surfaces
- the connection must not be too tight or too loose
- lateral or horizontal (bending) force must not be applied to the connection, nor should any connection ever be twisted.

Align Connectors Carefully. Careful alignment of the connectors is critical in making a good connection, both to avoid damaging connectors and devices and to assure accurate measurements.

As you bring one connector up to the other and as you make the actual connection, be alert for any sign that the two connectors are not aligned perfectly. If you suspect that misalignment has occurred, stop and begin again.

Alignment is especially important in the case of sexed connectors such as precision 3.5mm and SMA connectors, to avoid bending or breaking the contact pins. The center pin on the male connector must slip concentrically into the contact fingers of the female connector, and this requires great care in aligning the two connectors before and as they are mated.

When they have been aligned, the center conductors must be pushed straight together, not twisted or screwed together, and only the connector nut (not the device itself) should then be rotated to make the connection. Slight resistance is generally felt as the center conductors mate.

Alignment of precision 7mm connectors is made easier by the fact that the connector sleeve on one of the connectors must be extended fully (and the sleeve on the other connector retracted fully) in order to make the connection. Extending the sleeve creates a cylinder into which the other connector fits.

If one of the connectors is fixed, as on a test port, extend that connector sleeve and spin its knurled connector nut to make sure that the threads are fully extended. Fully retract the connector sleeve on the other connector.

Make a Preliminary Connection Lightly. Align the two connectors carefully and engage the connector nut over the exposed connector sleeve threads on the other connector. Then **turn the connector nut only** to make the preliminary connection.

Let the connector nut pull the two connectors straight together.

Do NOT twist one connector into the other as one might drive a screw or insert a light bulb. This is extremely harmful and can occur whenever the device body rather than the connector nut alone is turned.

When the mating plane surfaces make uniform, light contact, the preliminary connection is tight enough. **Do not overtighten this connection**.

At this point all you want is a connection in which the outer conductors make gentle contact at all points on both mating surfaces. Very light finger pressure (no more than 2 inch-ounces of torque) is enough.

Use a Torque Wrench to Make the Final Connection. When the preliminary connection has been made, use a torque wrench to make the final connection. Tighten the connection only until the "break" point of the wrench is reached, when the wrench handle gives way at its internal pivot point. **Do not tighten the connection further.**

Also make sure that torque actually is being applied to the connection through the torque wrench, not only to the wrench handle or in any way that prevents the "break" point of the wrench from controlling the torque applied to the connection. Suggestions are given below.

Using a torque wrench guarantees that the connection will not be too tight, thus preventing possible damage to the connectors and impaired electrical performance. It also guarantees that all connections will be made with the same degree of tightness every time they are made.

Torque wrenches pre-set to the correct value for each connector type are included in many Hewlett-Packard calibration kits, and they are also available separately. Torque settings and part numbers appear in Table 3.

In using a torque wrench, prevent rotation of anything other than the connector nut that is being tightened with the torque wrench. Generally this is easy to do by hand, all the more so if one of the connectors is fixed, as on a test port. In other situations, an open-end wrench can be used to keep the bodies of the connectors from turning.

Hold the torque wrench lightly by the knurled end of the handle only. Apply force at the end of the torque wrench only, perpendicular to the wrench and always in a plane parallel to the outer conductor mating planes. This will result in torque being applied to the connection through the wrench until the "break" point of the wrench is reached.

Avoid pivoting the wrench handle on the thumb or other fingers. This results in an unknown amount of torque being applied to the connection when the "break" point of the wrench is reached. Avoid twisting the head of the wrench relative to the outer conductor mating plane. This results in applying more than the recommended torque.

Table 3. Recommended Torque Wrenches

Type	Description/HP Part Number
Precision 7mm	12 lb-in (136 N-cm) 1250-1874
Precision 3.5mm	8 lb-in (90 N-cm) 1250-1863
SMA	5 lb-in (56 N-cm) 8710-1582 Use the SMA wrench to connect male SMA connectors to female precision 3.5mm connectors. Connections of male precision 3.5mm connectors to female SMA connectors can be made with the precision 3.5mm torque wrench (8 lb-in).
Type-N	Type-N connectors may be connected finger tight. If a torque wrench is used, 12 lb-in (136 N-cm) is recommended.

Above all, avoid holding the wrench tightly, in such a way that the handle is not pivoted but simply pushed downward the same amount throughout its length. If this is done, an unlimited amount of torque can be applied.

Hold the wrench at the same point near the end of the handle every time, and always in the same orientation. Whenever possible, begin tightening the connection with the wrench held horizontally.

Disconnection. Disconnect connectors by first loosening the connector nut that was tightened in order to make the connection. If necessary, use the torque wrench or an open-end wrench to start the process, but leave the connection finger tight. At all times support the devices and the connection to avoid putting lateral (bending) force on the connectors.

Complete the disconnection by disconnecting the connector nut completely.

Never disconnect connectors by twisting one connector or device out of the other as one might remove a screw or a light bulb. This is extremely harmful and can occur whenever the device body rather than the connector nut alone is turned.

If the connection is between sexed connectors, pull the connectors straight apart, and be especially careful not to twist the body of any device as you do so.

Twisting the connection can damage the connector by damaging the center conductors or the interior component parts to which the connectors themselves are attached. It can also scrape the plating off of the male contact pin or even (in rare instances) unscrew the male or female contact pin slightly from its interior mounting, bringing it out of specification. This can also occur if the female contact fingers are unusually tight.

Adapters

Adapters are used to connect a device with one connector interface to a device or to test equipment that has another interface, or to reduce wear on connectors that may be difficult or expensive to replace. Reducing wear is possibly the most important use of adapters, especially when devices that have SMA connectors are being used.

SMA connectors are low-cost connectors generally used up to about 23 GHz. They are not precision mechanical devices. They are not designed for repeated connections and disconnections, they wear out quickly, and they are very often found, upon assembly, to be out of specification – even before they have been used. This makes them potentially destructive to any precision 3.5mm connectors with which they might be mated.

Worn, damaged, or out-of-specification SMA connectors can destroy a precision 3.5mm connector even on the very first connection.

For this reason it is recommended that you use high-quality precision adapters, sometimes called "connector savers," when ever more than a few connections will be made between SMA and precision 3.5mm connectors.

In most applications, two adapters will be required, one each at the input and the output of the device. Male-female adapters cause no change in the sex of the interface. The same interface is presented when the adapter is in place as is presented in the original setup.

Same-sex adapters (male-male, female-female) change the sex of the interface. For example, if the original interface presents a male connector, attaching a female-female adapter will result in a female interface to which devices or cables that have male SMA (or male precision 3.5mm) connectors can be connected.

Adapters are included in many HP calibration kits and with many HP devices. Or they may be ordered separately using the part numbers given in Table 4.

Additional Information

For more information on microwave connectors and connector care, consult the Hewlett-Packard **Microwave Connector Care Manual,** HP Part Number 08510-90064, and the Operating and Service information supplied with Hewlett-Packard products.

Table 4. Adapters

Type	Description	HP Part Number
Precision 7mm and Type-N	Precision 7mm / male 3.5mm	1250-1746
	Precision 7mm / female 3.5mm	1250-1747
	Precision 7mm / male 50Ω Type-N	85054-60009
	Precision 7mm / female 50Ω Type-N	85054-60001
Precision 3.5mm and SMA	Male 3.5mm / female 3.5mm	1250-1866
	Male 3.5mm / male 3.5mm	1250-1864
	Female 3.5mm / female 3.5mm	1250-1865
	Precision 7mm / male 3.5mm	85052-60004
	Precision 7mm / female 3.5mm	85052-60003
	"Connector saver" male 3.5mm / female 3.5mm	85027-60003*
	"Connector saver" male 3.5mm / male 3.5mm	85027-60002*

**used with HP 85021/27-series bridges only*

Principles of Microwave Connector Care

Tear along perforation

Handling and Storage

DO	DO NOT
• Keep connectors clean • Extend sleeve or connector nut • Use plastic end caps during storage	• Touch mating plane surfaces • Set connectors contact-end down

Visual Inspection

DO	DO NOT
• Inspect all connectors carefully before every connection • Look for metal particles, scratches, dents	• Use a damaged connector – ever

Cleaning

DO	DO NOT
• Try compressed air first • Use pure *liquid* Freon • Clean connector threads	• Use any abrasives • Get liquid onto plastic support beads

Gaging

DO	DO NOT
• Clean and zero the gage before using • Use correct gage type • Use correct end of calibration block • Gage all connectors before first use	• Use an out-of-spec connector

Making Connections

DO	DO NOT
• Align connectors carefully • Make preliminary connection lightly • Turn *connector nut only* to tighten • Use a torque wrench for final connection	• Apply bending force to connection • Overtighten preliminary connection • Twist or screw in connectors • Tighten past "break" point of torque wrench

Ref. Application Note 326 (5954-1566)

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Addendum

Table 5. Recommended protective end caps for connectors

Type	HP Part Number
Precision 7mm	1401-0123
Precision 3.5mm and SMA	1401-0208 (male) 1401-0202 (female) 1401-0124 (oversized knurled nut)
Type-N	1401-0124 (male) 1401-0225 (female)

For more information
call your local HP sales office listed
in the telephone directory white pages.
Or write to Hewlett-Packard:

United States:
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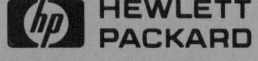

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