MICROWAVE CONNECTOR CARE

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HEWLETT PACKARD

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General 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.

This publication, the Hewlett-Packard **Microwave Connector Care Manual**, is an inclusive general reference. Its purpose is to help you get the best performance from all coaxial microwave connectors regardless of type or application: 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 both the accuracy and repeatability of all of your measurements, saving both time and money.

Part One provides general information that applies to all connector types and gives Hewlett-Packard's recommendations on:

- handling and storing microwave connectors
- preventing electrostatic discharge
- inspecting microwave connectors visually for damage, dirt, and contamination
- cleaning microwave connectors using compressed air and, if required, a cleaning solvent
- inspecting microwave connectors mechanically, using precision connector gages, and
- making connections with microwave connectors.

These general recommendations are summarized in Hewlett-Packard Application Note 326, **Principles of Microwave Connector Care**. One copy of this summary is also included with each copy of this **Microwave Connector Care Manual**, bound separately for easy removal. Besides the text, it includes a quick-reference card suitable for bench use. Additional copies are available by contacting your local Hewlett-Packard representative.

Part Two of the present manual provides detailed information on each main connector type. It reviews the information in Part One that applies to each connector type, and it explains special points about cleaning, mechanical inspection, connection, and disconnection that apply to individual connector types. It also gives the critical mechanical dimensions of each connector interface.

Your comments on all Hewlett-Packard publications are welcome. For your convenience, a Reader Comment Sheet is included, postage paid in the United States.

PART ONE – PRINCIPLES OF CONNECTOR CARE

Part One – Principles of Connector Care

INTRODUCTION

Dimensions of microwave connectors are small and some of the mechanical tolerances are very precise, on the order of a few ten-thousandths of an inch. Seemingly minor defects, damage, and dirt can significantly degrade repeatability and accuracy. In addition, the mating surfaces of most precision connectors are gold, plated over a beryllium-copper alloy. This makes them very susceptible to mechanical damage, due to the comparative softness of the metals.

Part One of this Hewlett-Packard **Microwave Connector Care Manual** provides general information that applies to all connector types. It gives Hewlett-Packard's recommendations on handling and storage of all microwave connectors, on visual and mechanical inspection of connectors using a connector gage, and on making connections.

Among the most important general recommendations made in Part One of this manual are these:

- microwave connectors must be kept clean and the mating plane surfaces protected from harm during storage; never store connectors loose in a box or a drawer
- connectors should be inspected visually before every connection and damaged connectors discarded immediately
- connectors should be cleaned first with compressed air; if a solvent must be used, pure liquid Freon is the best
- solvent should never be sprayed into a connector; use a cotton swab or lint-free cloth and the least amount of solvent possible; avoid wetting plastic support beads with solvent
- connectors should be inspected mechanically, using a connector gage, before being used for the first time and periodically after that
- in making a connection, the connectors should be aligned carefully, a preliminary connection made lightly by turning the connector nut (only) to pull the connectors together, and the final connection made using a torque wrench
- connections and disconnections should never be made by screwing one connector into the other; this is extremely harmful and can occur whenever the device body rather than the connector nut alone is turned.

Part Two of this manual provides detailed information on each main connector type, repeating and expanding upon key points presented in Part One.

HANDLING AND STORAGE

- **Keep connectors clean.**
- **Do not touch the mating plane surfaces.**
- **Do not set connectors contact-end down.**
- **Before storing, extend the sleeve or connector nut.**
- **Use plastic end caps over the mating plane surfaces.**
- **Never store connectors loose in a box or a drawer.**

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 on any hard surface. Natural skin oils and microscopic particles of dirt are easily transferred to the connector interface and are very difficult to remove. Damage to the plating and to the mating plane surfaces occurs readily when the interface comes in contact with any 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.

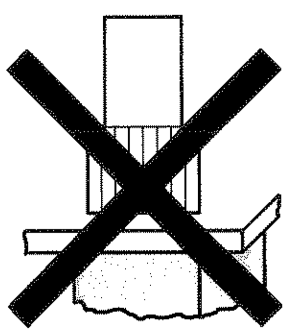
Above all, never store any devices loose in a box or in a desk or a bench drawer. Careless handling of this kind is the most common cause of connector damage during storage.

Calibration and verification devices and test fixtures should be stored in a foam-lined storage case, and protective plastic end caps should always be placed over the ends of all connectors.

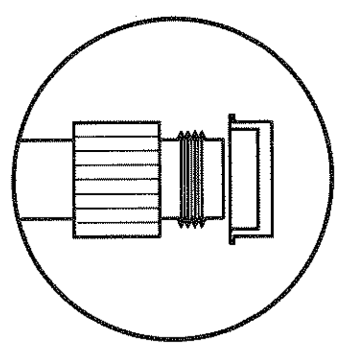
Cables should be stored in the same shape as they have when they are used – **they should not be straightened** – and plastic end caps should be placed over both connectors.

Figure 1 summarizes these Hewlett-Packard recommendations on handling and storing devices that have microwave connectors.

HANDLE AND STORE CONNECTORS CAREFULLY



NEVER PLACE CONNECTORS CONTACT-END DOWN



EXTEND THREADS FULLY, USE PLASTIC END CAPS

- Use foam-lined storage cases if available
- Never store devices loose in a box or in a desk or bench drawer

Figure 1. Handling and Storage

ELECTROSTATIC DISCHARGE

- **Wear a grounded wrist strap.**
- **Use an anti-static mat.**
- **Discharge static electricity from your body and from all devices before making connections or cleaning connectors.**

Protection against electrostatic discharge is essential before cleaning or inspecting connectors attached to any static-sensitive circuits (such as those found in bridges and detectors) or to test ports which may be connected to similar circuits.

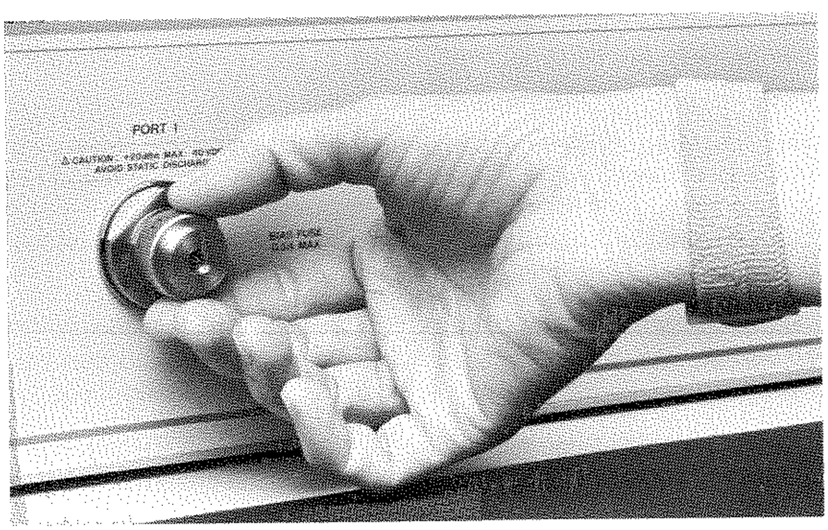
Static electricity builds up on the body and can easily damage sensitive internal circuit elements when discharged by contact with the center conductor. Static discharges too small to be felt can nevertheless cause permanent damage. Devices such as calibration components and devices under test can also carry an electrostatic charge.

Always install a grounded anti-static mat in front of the test equipment and wear the grounded wrist strap attached to it. Such a mat, including installation hardware and a grounded wrist strap, is available as HP Part Number 85043-80013.

In addition, before cleaning, inspecting, or making any connection to a static-sensitive device or test port, ground yourself – for example by grasping the grounded, outer shell of the test port briefly, as shown in Figure 2.

Also discharge static electricity from all devices before connecting them by touching the device briefly to the outer shell of the test port or to another exposed ground. This will discharge any static electricity on your body or the device and protect the circuitry of the test equipment.

AVOID ELECTROSTATIC DISCHARGE



- Wear a grounded wrist strap.
- Use an anti-static mat.
- Ground yourself to discharge static electricity.
  Also discharge all devices before connecting them.

Figure 2. Electrostatic Discharge

VISUAL INSPECTION

- **Inspect all connectors carefully before every connection.**
- **Look for metal particles, scratches, dents.**
- **Never use a damaged connector.**

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

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.

Sexed Connectors. On sexed connectors, especially precision 3.5mm (APC-3.5) and SMA connectors, pay special attention to the female center conductor contact fingers. 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.

Scratches

Light burnishing of the mating plane surfaces is normal, and it consists of uniform, shallow, concentric scratches distributed more or less uniformly over the plated surface. These are caused by the normal slight rotation of the mating planes against one another as the connection is made and generally do not affect performance.

Deep scratches are caused by individual hard particles, generally metal or metal by-product particles, or burrs left from machining, sliding across the mating plane surface and displacing metal in the same way as a plow moves dirt.

Deep scratches *running concentrically* (as do the grooves in a phonograph record) generally indicate that one or both of the connector mating plane surfaces was not perfectly clean when the connection was made, or that the one of the connectors has a burr or high spot somewhere on its surface. Deep scratches running *across* the mating plane surface are generally the result of rough handling during connection, disconnection, or storage.

On gold plated connectors, any scratch that goes through the gold plating to the beryllium copper underneath is a possible source of trouble. Inspect the scratch carefully under magnification to see whether the scratch has left a high spot of pushed-up metal on the mating plane surface. If it has, do not use the connector. It will only damage other connectors it is mated to, by cutting into the plating.

If all of the metal displaced in the scratch has been removed or has worn away, and no high spots remain, the connector may still be usable. Full, flat circular contact between the mating plane surfaces will not occur, but the connection may still be satisfactory for most purposes.

Dents

Dents occur most often on the outside edges of mating plane surfaces, and under magnification they look like small craters or valleys. Metal is pushed outward and upward from the point of impact.

Sometimes dents are caused by careless handling or assembly of connectors during manufacture. Much more often, however, they are caused by dirt or metallic particles being pressed into the mating plane surface, either during connection or while the connector is not in use. Even an apparently clean work surface may have particles on it large and hard enough to dent or scratch a connector if any pressure is applied. Dents are also caused by sudden, sharp, metal-to-metal impact, as occurs most often when a connector is dropped or another metal part is bumped against it.

Connectors that have dents anywhere on the mating plane surfaces will not make perfect contact, and the raised edges will dent any connectors they are mated to. Unless the damage is very slight, all such connectors should be replaced.

Metal and Metal By-Product Particles

Metal and metal by-product particles such as metallic salts on the connector mating plane surfaces are the most common kinds of dirt found on connectors, and these particles can be extremely damaging. They are very hard and can quickly scratch or dent the gold plating on connectors they are mated to.

Metal and metal by-product particles originate most often on the connector nut threads, and if such particles are found, the connector should be cleaned completely. First clean and re-inspect the connector nut threads, then clean the mating plane surfaces and blow the entire connector dry with compressed air. Details on cleaning appear in the next section of this **Microwave Connector Care Manual**.

Particle contamination can also result from setting the connectors contact-end down on a work surface, even on one that appears to be clean, and from touching the mating plane surfaces, even with clean hands. Particles left behind after cleaning, for example fibers from cleaning swabs, can generally be removed by blowing the connector dry with clean compressed air.

CLEANING

- **Try compressed air first.**
- **If a solvent is necessary, use pure liquid Freon.
Clean very dirty connectors with pure isopropanol.
Other solvents should not be used.**
- **Use the least amount of solvent possible, and avoid wetting any plastic parts in the connectors with the solvent.**
- **Never spray solvent directly into a connector.**
- **Check solvents periodically for contamination.**

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 shown in Figure 3. Cotton swabs are the most useful generally, for cleaning connector threads and mating plane surfaces. A lint-free cleaning cloth is useful for cleaning precision 7mm connectors and the interior surfaces of all connectors.

Compressed Air

Always use protective eyewear when using compressed air, even if the source is a small pressurized can.

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. Clean air cannot damage the connectors or leave particles or residues behind.

Any source of clean, dry, low-pressure compressed air can be used if it has an effective oil-vapor filter and liquid condensation trap placed just before the outlet hose. The hose nozzle should be grounded to prevent electrostatic discharge, and the air pressure set for a very low velocity ($<$ 60 psi). High-velocity air can cause undesirable electrostatic effects when directed into a connector.

But 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. The liquid (propellant) will not damage the connectors. But rapid vaporization and expansion of the liquid as it escapes from the end of the plastic tube can cool the connector very rapidly. The undesirable result is that water vapor from the atmosphere condenses on and inside the the connector, and sometimes the interior support bead may be cracked or shift position.

If liquid is accidentally sprayed onto a connector, immediately move the air source away from the connector and purge the liquid from the plastic tube with more vapor. When the tube is empty, spray the connector with vapor from a distance of about 6 inches (15 cm) to evaporate any condensation. Then allow the connector to return to normal room temperature before using it. If the bead has cracked or shifted position, the connector will have to be repaired or replaced.

Cleaning Solvents

Use solvents only in well ventilated areas. Avoid prolonged breathing of solvent vapors and contact of solvents with the skin.

Dirt and stubborn contaminants that cannot be removed with compressed air can often be removed with a cotton swab (HP Part Number 8520-0023) or lint-free cleaning cloth (HP Part Number 9310-4242) moistened with a solvent.

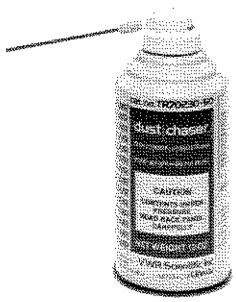
Use the least amount of solvent possible, and avoid wetting any plastic parts in the connectors with the solvent.

Recommended Solvents. Generally, pure liquid Freon (trichlorotrifluoroethane), available as HP Part Number 8500-1251, 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 isopropanol. Be aware that isopropanol quickly absorbs water from the atmosphere, however. Water applied to connectors even in this way takes a long time to evaporate and until it evaporates may result in a loss of measurement repeatability. Use at least 92 per cent isopropanol and a very small container, and replace the supply often.

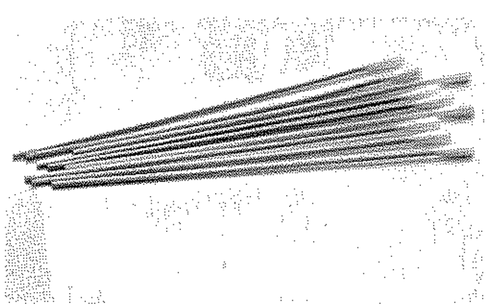
Other solvents, including types of liquid Freon and isopropanol that contain additives, should not be used.

Acetone, methanol, denatured alcohol, and chlorinated hydrocarbons such as trichloroethylene (TCE), are all harmful to the plastic dielectric support beads in microwave connectors. Alcohols such as ethanol or isopropanol are less harmful than methanol but are not always easy to obtain in sufficiently pure form. Ethanol is often denatured with methanol; isopropanol, especially in the common form of rubbing alcohol, often contains large amounts of water and additives such as glycerine, oils, and perfume. Pure liquid Freon is inexpensive, it is easy to obtain and use, and with very few exceptions is not harmful to plastic parts.

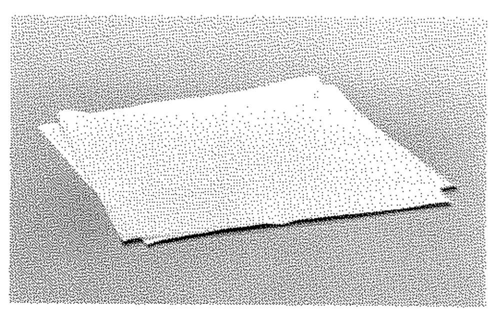


COMPRESSED "AIR"
HP Part Number 8500-2503

LIQUID FREON
HP Part Number 8500-1251



COTTON SWABS
HP Part Number 8520-0023



LINT-FREE CLEANING CLOTH
HP Part Number 9310-4242

Figure 3. Recommended Cleaning Supplies

Using Solvents. Whichever solvent is used, always use the least amount of solvent possible, and 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.

Use solvents 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.

Check the solvent periodically for contamination by pouring a few drops of the solvent onto a clean glass plate or microscope slide and letting it evaporate. Then examine the glass in reflected light. It should be perfectly clean and free of residue. If it is not, do not use solvent from that container.

Cleaning Technique

In cleaning connectors, apply a very small amount of solvent to a cotton swab or a lint-free cleaning cloth. Then clean the connector as gently as you can. Do not apply solvent directly to the connector, for example from a spray can, because this can lead to excessive cooling of the connector as the excess solvent evaporates.

Cleaning Connector Threads. Clean the threads of the connectors first. Every time a connection or a disconnection is made, a small amount of metal wears off of the threads, and this metal often finds its way onto the mating plane surfaces of the connectors.

Use a cotton swab and pure liquid Freon to scrub all connector threads. Allow the solvent to evaporate and then blow the threads dry with a gentle stream of clean, low-pressure compressed air.

Cleaning the Connector Mating Plane Surfaces. When the connector threads have been cleaned, apply a small amount of solvent to a new swab and clean the mating plane surfaces. If the connector is a precision 7mm connector, this should be done first with the center conductor collet removed.

Use very short horizontal or vertical strokes (across the connector), and the least pressure possible, to avoid damaging the center conductor. This is especially necessary when when female connectors are being cleaned, to avoid snagging the cleaning swab on the center conductor contact fingers. An illuminated magnifying glass is very helpful in making these small areas easy to see.

Cleaning Connectors on Static-Sensitive Devices. Cleaning connectors attached to static-sensitive circuits, test set connectors for example, requires special care to avoid static discharge. When cleaning such connectors (Figure 4), always wear a grounded wrist strap and before touching the connector itself (even with a plastic swab) discharge static electricity to ground. This is easily done by grasping the outer shell of the test port briefly. These precautions will prevent electrostatic discharge (ESD) and possible circuit damage.

CLEAN CONNECTORS CAREFULLY

- Try clean compressed "air" (Freon) first.
- If solvent is necessary, use pure liquid Freon.
- Use as little solvent as possible, and avoid wetting plastic connector parts.
- Clean connector threads first.
- Clean hard-to-reach areas by wrapping lint-free cloth around a thin wooden or plastic rod.
- After cleaning them, blow connectors dry with clean compressed "air" (Freon).

CLEANING CONNECTORS ON STATIC-SENSITIVE DEVICES

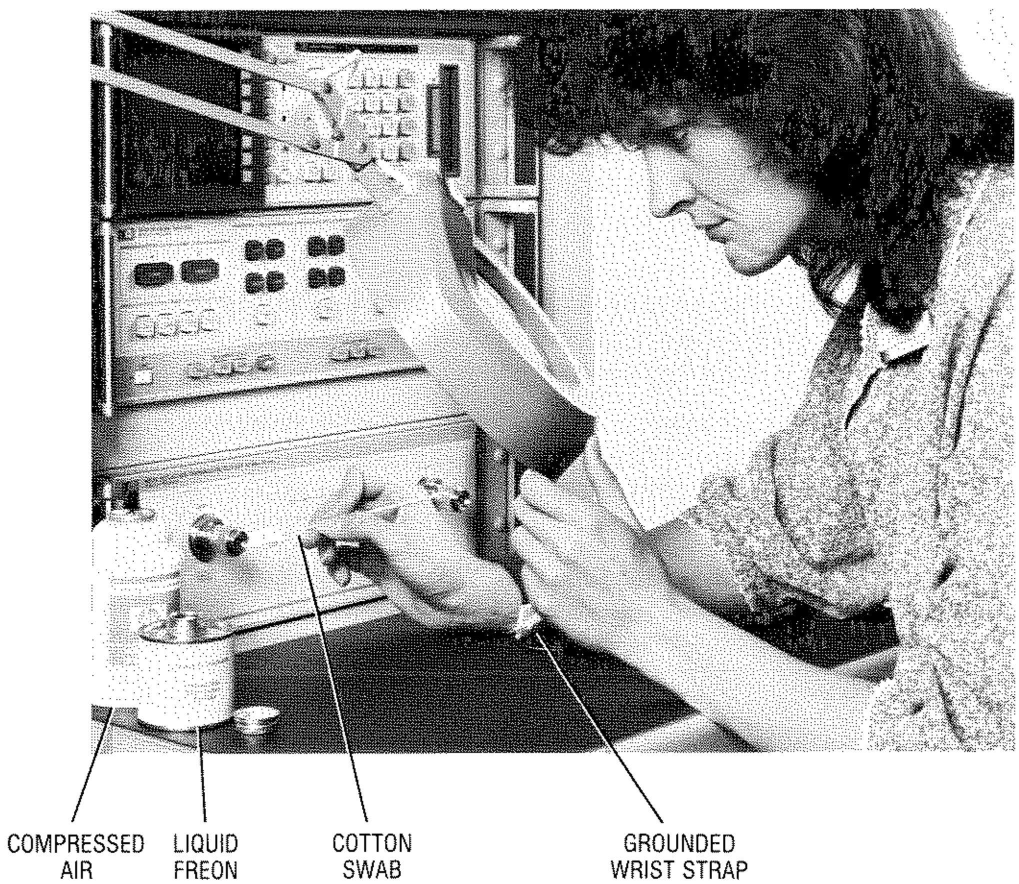


Figure 4. Cleaning Microwave Connectors

Cleaning Interior Surfaces. Interior surfaces, especially on 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 5) 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.

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.

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.

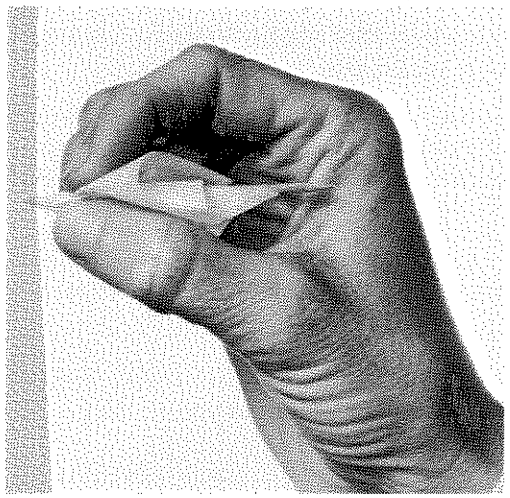
When the connector is attached to a small component, or to a cable or calibration of verification standard, the easiest way to do this is to put a lint-free cleaning cloth flat on a table and to put a drop or two of cleaning solvent in the center of the cloth (Figure 5). Note that it is not necessary to remove the collet in order 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. Keep the cloth in a plastic bag or box so that it does not collect dust or get dirty when not in use.

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.

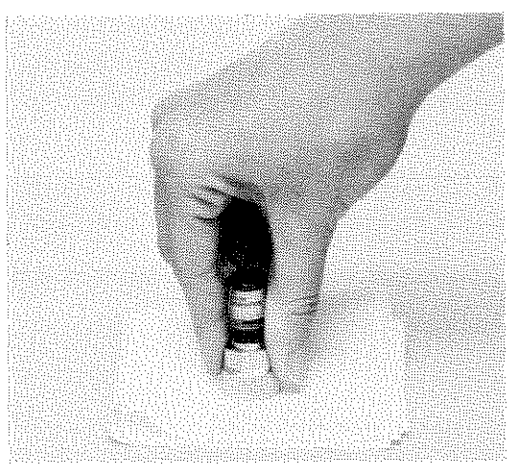
Drying Connectors. When you have cleaned a connector, always be sure that it is completely dry before reassembling or using it. Blow the connector dry with a gentle stream of clean compressed air and inspect it again under a magnifying glass to be sure that no particles or solvent residues remain.

CLEANING INTERIOR SURFACES



CLEANING PRECISION 7mm CONNECTORS

- Put a drop or two of cleaning solvent in the center of a lint-free cleaning cloth.
- Retract the connector sleeve threads. Press the contact end of the connector into the cloth and turn it.
- Removing the collet is not necessary.



- Blow the connector dry with a gentle stream of compressed air.
- Keep the cloth clean in a plastic bag or box when it is not in use.

Figure 5. Cleaning Interior Surfaces and Precision 7mm Connectors

MECHANICAL INSPECTION: CONNECTOR GAGES

- **Inspect connectors mechanically, using a connector gage, before they are used for the first time and periodically after that.**
- **Use the correct gage type and gage calibration block for the connector being gaged.**
- **Inspect, clean, and zero the gage before using it. Check the zero setting again before each measurement.**
- **Connector specifications depend on the device. Consult the mechanical specifications provided with the connector or the device itself to determine whether it is within specification.**

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.

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. See Figures 6 through 9.

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 (Figure 6), 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.

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.

PRECISION 7mm CONNECTOR
CENTER CONDUCTOR COLLET IN PLACE

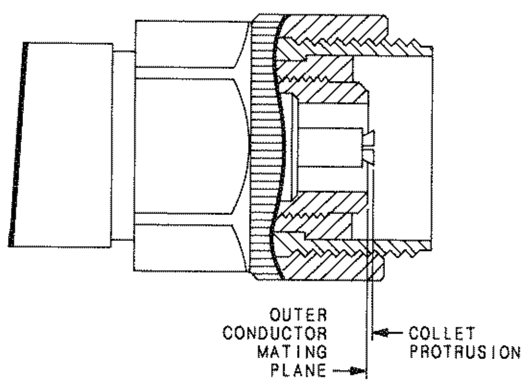


Figure 6. Precision 7mm Connector

Type-N Connectors. Type-N connectors differ from other connector types in that the outer conductor mating plane is offset from the mating plane of the center conductors (Figure 7). 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 plane defined by the tip of the female contact fingers.

In Type-N 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.

Hence the critical mechanical specifications of Type-N connectors are 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.

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.

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.

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 all smaller. Therefore, mating any 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.

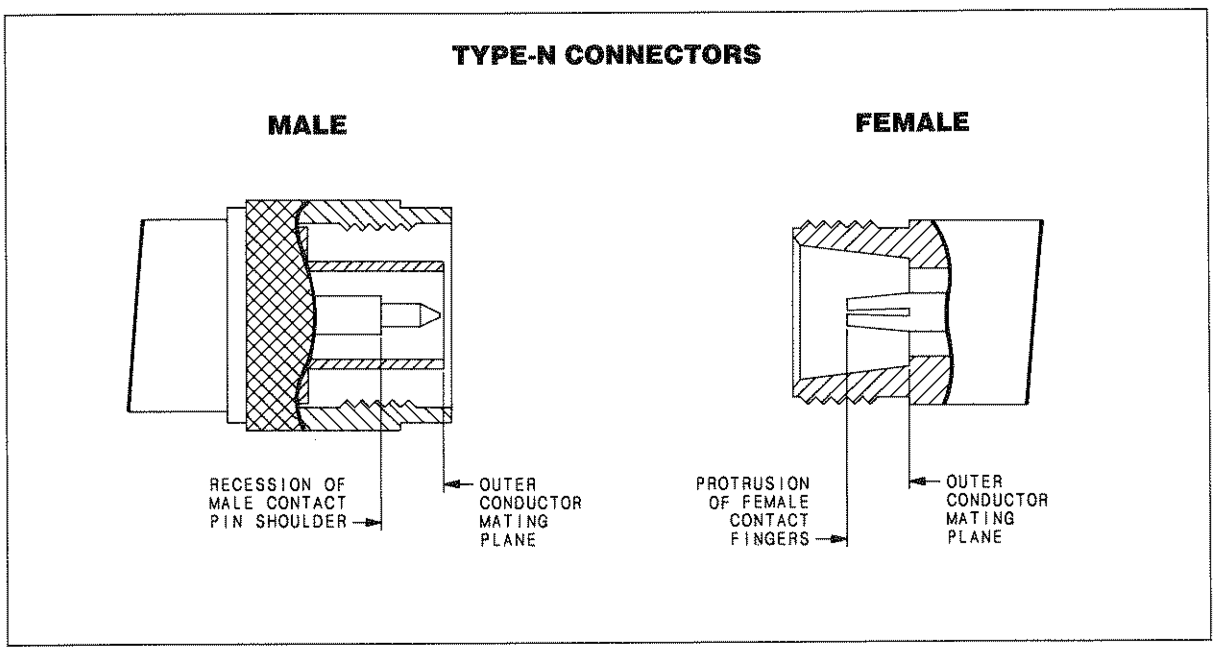


Figure 7. Type-N Connectors

SMA and Precision 3.5mm Connectors. Because of their smaller size, SMA and precision 3.5mm connectors can be used at higher frequencies than 7mm and Type-N connectors can. Both types are in common use today.

SMA connectors (Figure 8) are low-cost connectors generally used up to about 23 GHz. A solid plastic dielectric separates the center and outer conductors. Precision 3.5mm connectors, also known as APC-3.5 connectors, are precision air-dielectric connectors that will mate with SMA connectors. They offer much greater repeatability of connection than SMA connectors do, and for this reason they are widely used on electronic test equipment. Precision 3.5mm connectors can be used up to about 34 GHz.

Both SMA and precision 3.5mm connectors are sexed connectors. 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. The mechanical specifications for both SMA and precision 3.5mm connectors give a maximum and a minimum *recession of the shoulder of the male contact pin* and a maximum and a minimum *recession of the tip of the female contact fingers* behind the outer conductor mating plane.

No protrusion of the shoulder of the male contact pin or of the tip of the female contact fingers in front of the outer conductor mating plane is ever allowable, and sometimes a minimum recession (other than zero) is also required. Consult the mechanical specifications provided with the connector or the device itself.

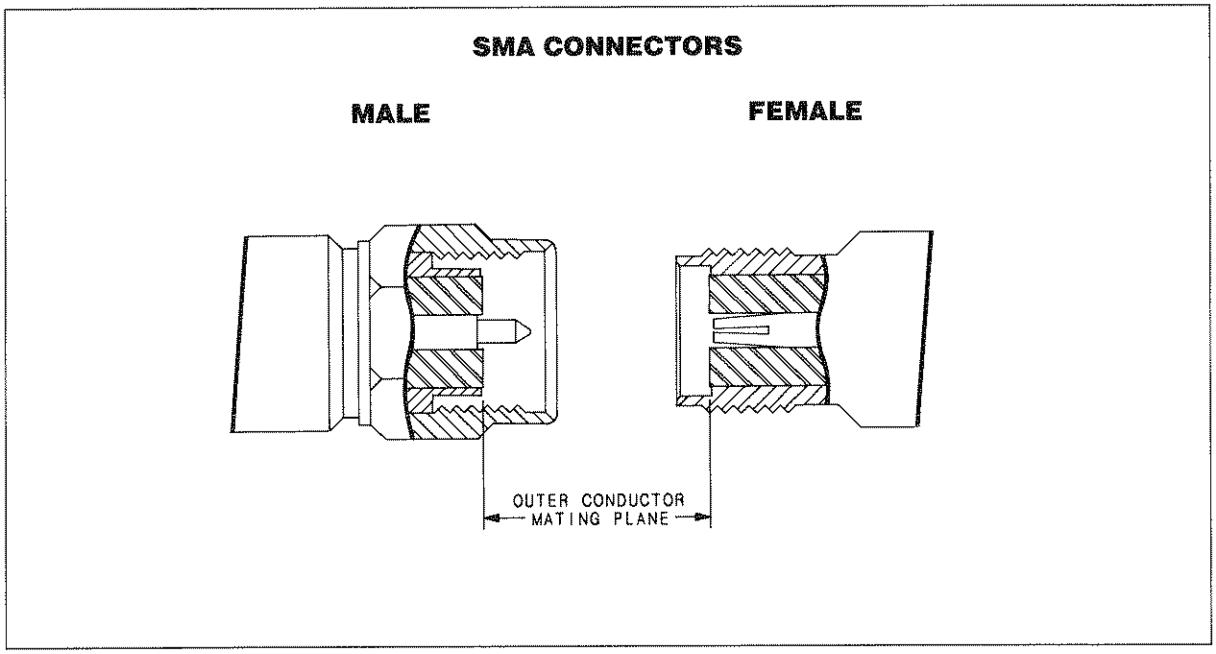


Figure 8. SMA Connectors

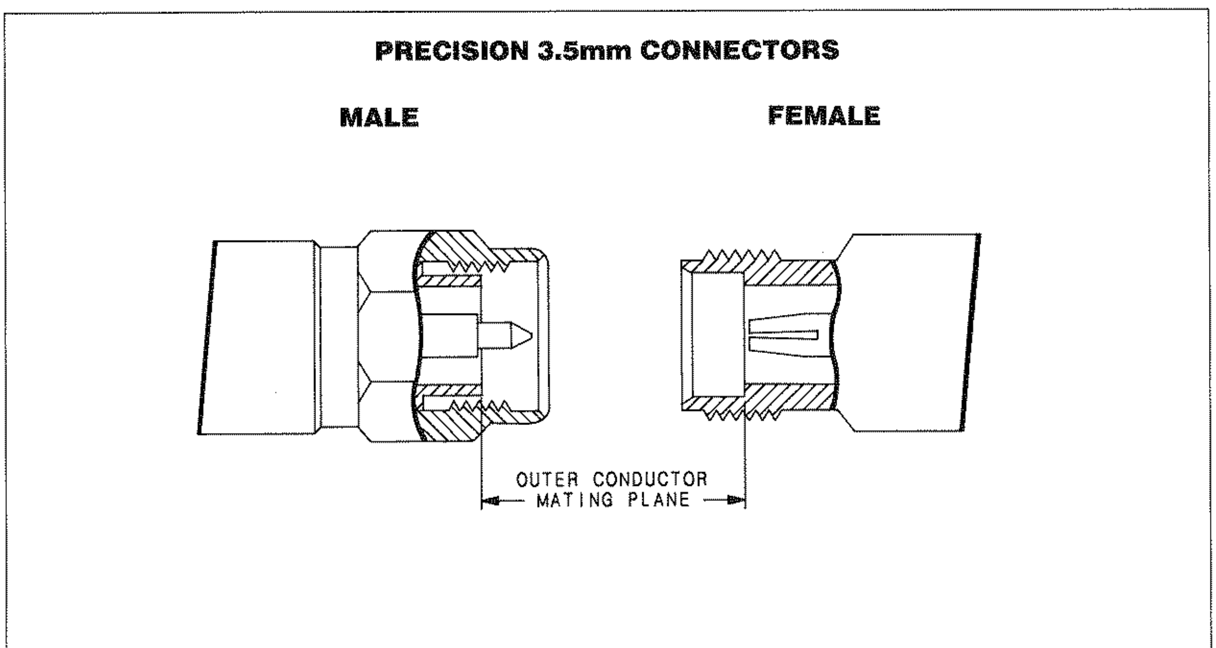


Figure 9. Precision 3.5mm Connectors

Types of Gages

A different connector gage is required for each type of connector. Sexed connectors require two gages, male and female, or (in the case of Type-N connectors) a single gage and male and female adapter bushings, and every connector gage requires a gage calibration block for zeroing the gage. Connector gages for precision 7mm connectors also require an aligning pin and pin wrench in order to measure the center conductor depth of beadless airlines with the centering pin removed.

Care is necessary in selecting a connector gage to measure microwave connectors. Some gages have a very strong gage plunger spring – strong enough, in some cases, to push the center conductor back through the connector, damaging the device itself. Other gages may compress the center conductor collet in precision 7mm connectors during the measurement, giving an inaccurate reading when the collet protrusion is measured.

Connector gage kits containing gages recommended for microwave connectors and all of the other items required are included in many Hewlett-Packard calibration kits, and they are also available separately. Part numbers are given in Table 1.

Table 1. Recommended Connector Gages

Connector Type	Manufacturer's Part Number	HP Part Number
Precision 7mm		
Gage Kit	—	1250-1875
Gage	MMC 299-D-009 *or* Starrett 81-11-624	
Calibration Block	MMC 028-2	
Aligning Pin	MMC 024-4	
Pin Wrench	MMC 024-5	
Precision 3.5mm		
Gage Kit	—	1250-1862
Male Gage	MMC A034B-M	
Female Gage	MMC A034B-F	
Calibration Block	MMC 027-3	
Type-N		
Gage Kit		85054-60024
SMA		
Gage Kit	MMC A-027A	

MMC = Maury Microwave Corporation, 8610 Helms Avenue, Cucamonga, California 91730
Telephone: 714-987-4715 TWX: 910-581-3408

Starrett = L. S. Starrett Company, Athol, Massachusetts 01331
Telephone: 617-249-3551 TWX: 710-390-0271

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 and shown in Figure 10. 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 connectors and female precision 3.5mm 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 10). 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.

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.

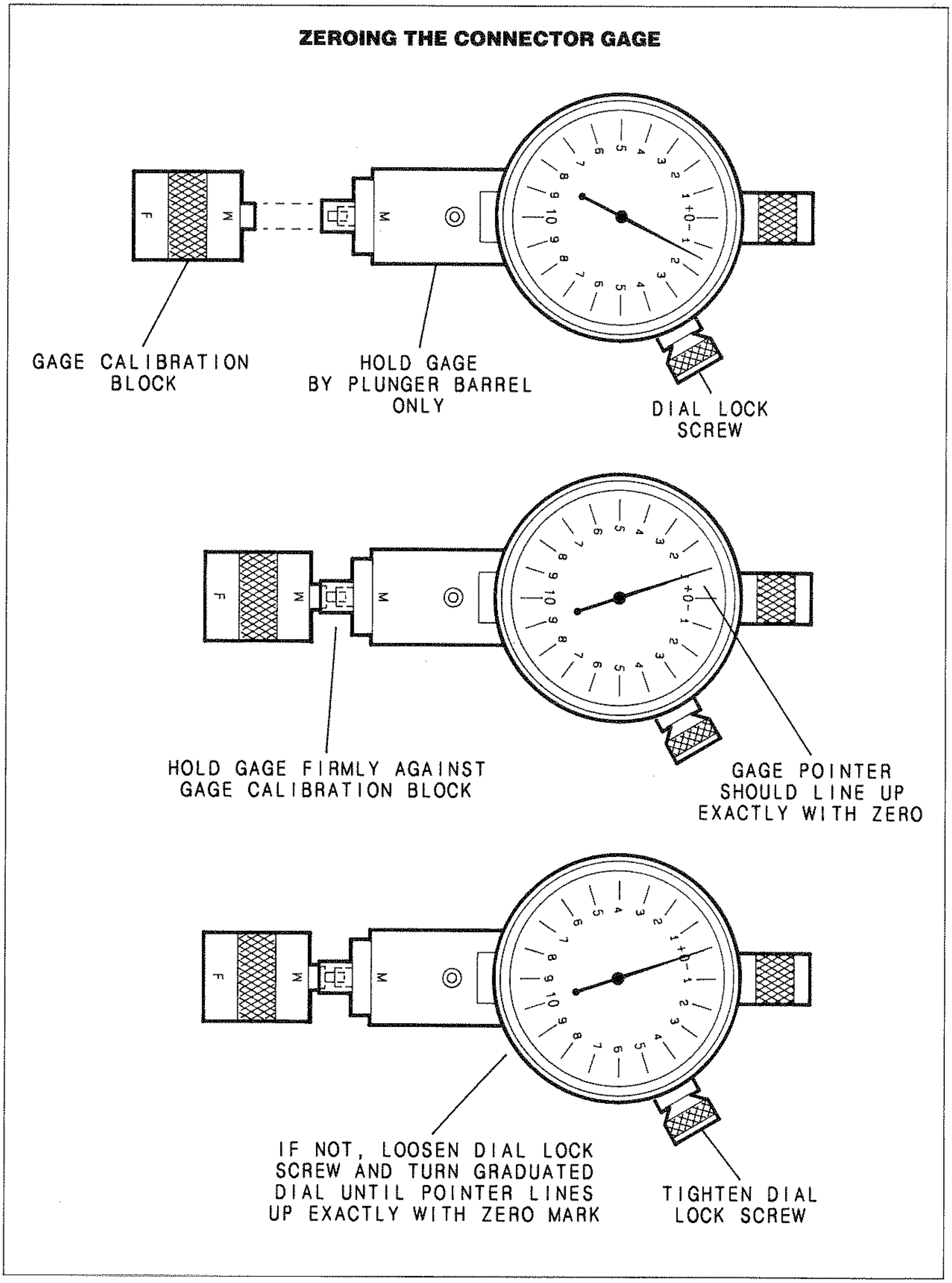


Figure 10. Zeroing the Connector Gage

Gage Accuracy

An important general point about measuring connectors is that setback dimensions are difficult to measure, owing to measurement uncertainties of the connector gages (typically one small division on the dial) and to variations in technique from user to user.

For example, using a gage with 0.0001-inch small divisions on the dial to measure a connector that has an actual setback of 0.0005 inches may result in gage readings from 0.0004 to 0.0006 inches, depending on the gage. Note that this range of readings is possible due strictly to the measurement uncertainty of the gage. Other variables such as cleaning and gage technique can cause still further variations to appear between measurements of exactly the same connector.

For these reasons, Hewlett-Packard recommends that before deciding that a connector is out of specification, at least four things be done:

- Clean the connector, the connector gage, and the gage block again, following carefully the suggestions on cleaning made earlier in this **Microwave Connector Care Manual**. Zero the gage again and repeat the measurement. Measurements in which differences of 0.0001 inch are significant can be affected greatly by dirt and contamination.
- Measure the connector several times yourself, and also have another person make some measurements, in order to determine an average reading. This technique will help reduce uncertainties due to differences of technique and random variations in gage accuracy.
- Measure the connector using several different orientations of the gage within the connector. Averaging several readings, each taken after a quarter-turn rotation of the gage, will reduce measurement variations that result from the gage or the connector face not being exactly perpendicular to the center axis.
- Avoid holding the connector gage any other way than by the gage barrel, below the dial indicator. Holding the gage by the barrel offers maximum stability. It also improves measurement accuracy by preventing stresses from being applied to the gage plunger mechanism through the dial indicator housing – as occurs when the gage is cradled in the hand or held by the dial indicator.

In addition, keep records of the setback measurements made for each device over time. Noticeable differences from one set of measurements to the next may indicate errors in measurement technique or that the connector is damaged and needs to be replaced.

MAKING CONNECTIONS

- **Align connectors carefully.**
- **Make a preliminary connection lightly.**
- **Turn the connector nut ONLY in making connections.**
- **Do not rotate devices in making connections.**
- **Use a torque wrench for the final connection.**

Operator skill is essential in making good connections. The sensitivity of modern test instruments and the mechanical tolerances of the precision microwave connectors that are used today are such that slight errors in operator technique that once went unnoticed now have a significant effect on measurements and measurement uncertainties.

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.

General Connection Technique

The steps to follow generally in making microwave connections are shown in Figures 11 and 12. For illustration, a fixed load that has a precision 7mm connector is shown being connected to a 7mm test port connector. But the steps and principles are the same regardless of connector type.

Before making any connections, inspect all connectors visually, clean them if necessary, and use a connector gage to verify that all center conductors are within specification.

If connections are made to any static-sensitive device, avoid electrostatic discharge by wearing a grounded wrist strap and grounding yourself and all devices before making any connections.

• 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.

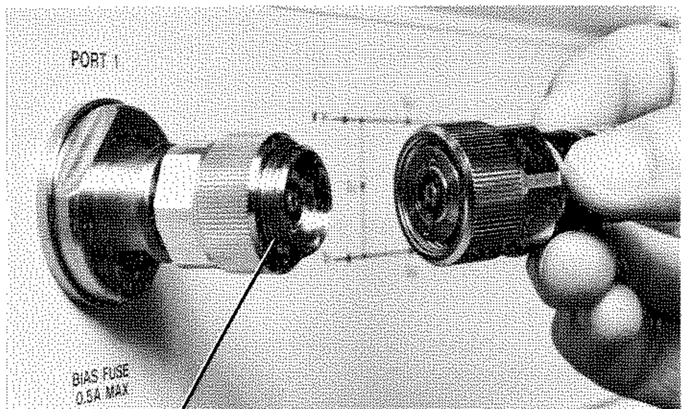
Do NOT twist one connector into the other as one might drive a screw or insert a light bulb. This is extremely harmful and can occur whenever the device body rather than the connector nut alone is turned.

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.

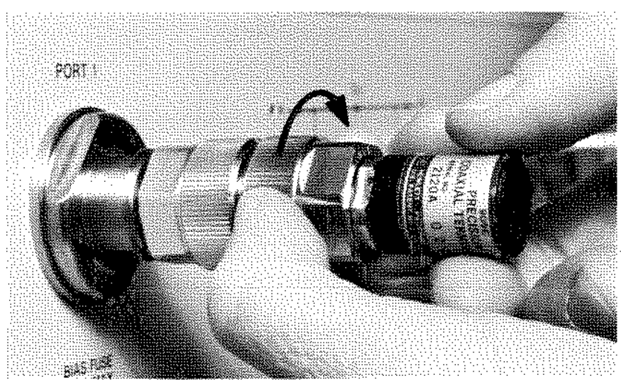
GENERAL CONNECTION TECHNIQUE

- **Align connectors carefully**



PRECISION 7mm CONNECTORS:
EXTEND CONNECTOR SLEEVE

- **Make preliminary connection lightly**



Engage connector nut over exposed threads. Turn *connector nut only* to tighten connection.

Light finger pressure (< 2 in-ounces) is enough. Connectors only need to make uniform, light contact. Do not overtighten.

Figure 11. General Connection Technique

• 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 (Figure 12). 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 2.

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.

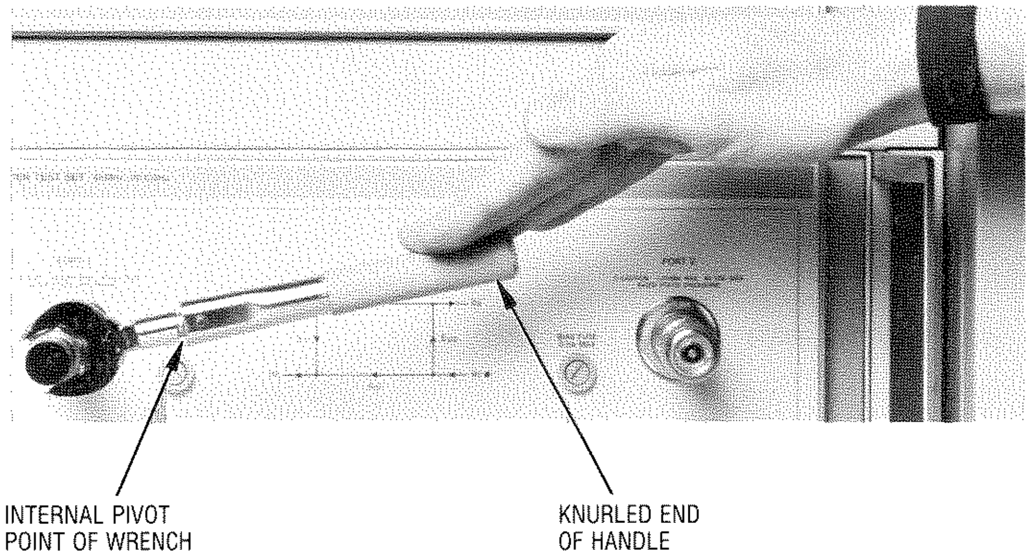
Hold the torque wrench lightly by the knurled end of the handle only, in the manner shown in Figure 12. Apply force at the end of the torque wrench only, perpendicular to the wrench and always in a plane parallel to the outer conductor mating planes. This will result in torque being applied to the connection 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.

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. When possible, begin tightening the connection with the wrench held nearly horizontal.

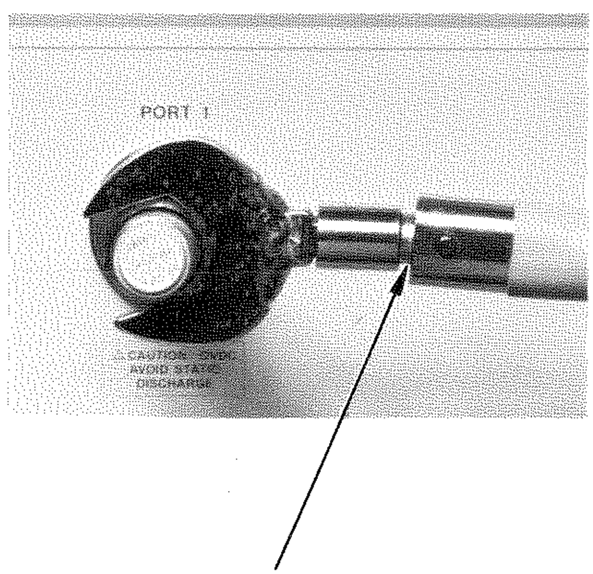
- **Use a torque wrench to make the final connection**



Hold the wrench lightly by the knurled end of the handle only.

Apply force on one side of the wrench only, perpendicular to the wrench and parallel to the plane of the outer conductors.

Allow the wrench to transmit force to the connection, through its internal pivot point. Do not twist the wrench.

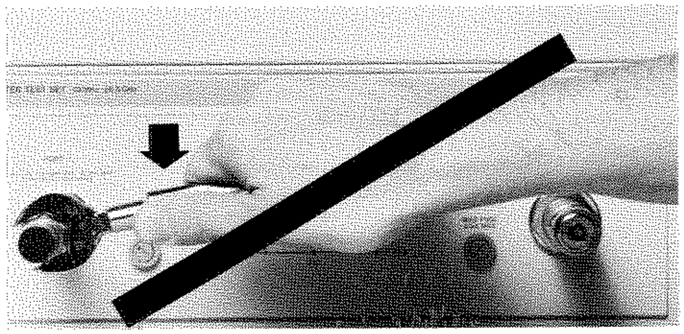


Proper torque has been achieved when the "break" point of the wrench is reached. Do not overtighten.

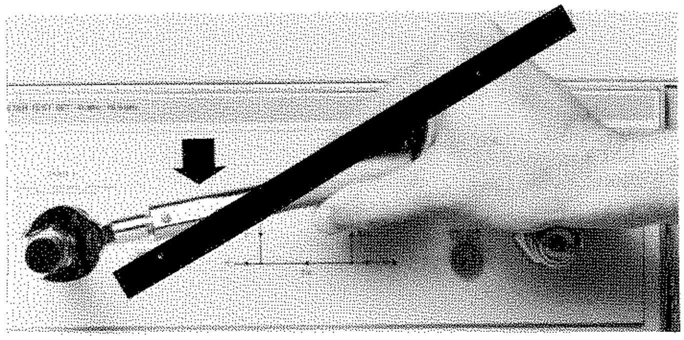
Figure 12. Using the Torque Wrench (1 of 2)

- **Avoid holding the torque wrench incorrectly**

NOT RECOMMENDED - Wrench gripped tightly

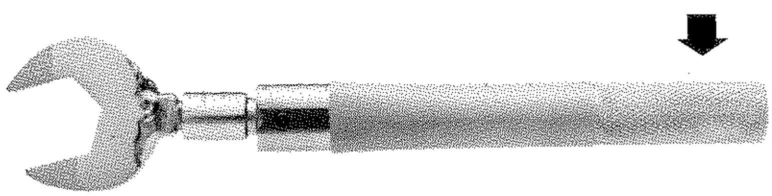


NOT RECOMMENDED - Wrench pivoted on thumb



- **Always use the wrench in the correct orientation**

RECOMMENDED



NOT RECOMMENDED

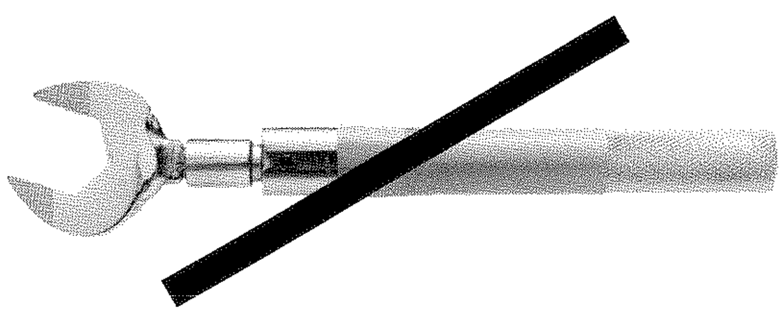


Figure 12. Using the Torque Wrench (2 of 2)

Table 2. Torque Wrenches

Connector Type	Torque Setting	HP Part Number
Precision 7mm	12lb-in 136 N-cm	1250-1874
Precision 3.5mm	8 lb-in 90 N-cm	1250-1863
Type-N	NOT REQUIRED Type-N connectors may be connected finger tight. If a torque wrench is used, 12 lb-in (136 N-cm) is recommended.	
SMA	5 lb-in 56 N-cm Use this wrench also when connecting 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).	8710-1582

Type-N and "NMD-3.5" Connectors. Note that Type-N connectors, unlike other connectors, do not have wrench flats and thus can only be connected by hand. Connect Type-N connectors finger tight. The same is true of the "NMD-3.5" precision 3.5mm connectors used (for example) on the HP 8513A and HP 8515A test sets and on the HP 85131A/B 3.5mm test port return cables. These connectors are also designed to give the correct torque when the connector nut is connected finger tight.

Excessive Connector Nut Tightness, Precision 7mm Connectors. Sometimes it is almost impossible to apply torque to a precision 7mm connector without causing the device itself to turn. If this occurs, clean the connector nut threads carefully and make the connection again. If great resistance is still encountered, probably the outer nut and the inner sleeve are locking together at the back plane of the connector where the force of the torque is transferred to the inner sleeve.

Disassemble the connector nut assembly and inspect the interior bearing surfaces for galling of the stainless steel on these surfaces. If galling is evident, replace the connector nut assembly. This can generally be done without any degradation of connection repeatability or measured data because the connector interface is not disturbed.

If the interior bearing surfaces are undamaged, a small amount of molybdenum disulfide lubricant can be applied, **provided that great care is taken to avoid getting any lubricant on the mating plane surfaces or the connector threads.** Lubricant on the connector nut threads tends to collect dirt and thus counteract the benefits of the lubricant.

• Disconnection

Disconnect connectors by grasping the device body firmly to prevent it from turning. Then loosen 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 connector mating plane surfaces.

Complete the disconnection by disconnecting the connector nut completely. As in making connections, turn only the connector nut.

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.

If such a male pin is then inserted into a female connector it will damage the female connector by pushing its center conductor back too far. Be aware of this possibility and measure the center conductor recession of all such connectors before mating them again.

PART TWO – CONNECTOR TYPES

Precision 7mm Connectors

Precision 7mm connectors, among them APC-7® connectors, are used in the dc to 18 GHz range and offer the lowest SWR and the most repeatable connections of any 7mm connector type. Development of these connectors was begun by Hewlett-Packard in the mid-1960's and improved upon by Amphenol Corporation, now one of the principal manufacturers of the connector. APC-7 is a U.S.-registered trademark of the Bunker Ramo Corporation.

Precision 7mm connectors (Figure 13) are air dielectric devices. The center conductor is supported only by a plastic support bead inside the connector body.

Precision 7mm connectors are durable, making them suitable for many connections and disconnections. For this reason, they are widely used in test and measurement applications requiring a high degree of accuracy and repeatability. They are generally made of beryllium copper alloy plated with gold.

Precision 7mm connectors are generally designed for use as sexless connectors, able to mate with all other precision 7mm connectors. There is no male or female, and contact between the center conductors is made by replaceable inserts called collets designed to make spring-loaded butt contact when the connection is tightened.

Small mechanical differences do sometimes exist between precision 7mm connectors made by different manufacturers, and occasionally these differences can cause difficulty in making connections. Always inspect all connectors mechanically, using a precision connector gage, to make sure that they meet their critical specifications.

MECHANICAL SPECIFICATIONS OF PRECISION 7mm CONNECTORS

- **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.**
- **The center conductor collet should spring back immediately when pressed with a blunt plastic rod or with the rounded plastic handle of the collet removing tool.**

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 and minimum *recession of the center conductor* behind the outer conductor mating plane with the center conductor collet removed
- 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 critical mechanical specification is the recession (setback) of the center conductor relative to the outer conductor mating plane 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.

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.

Nominal specifications for precision 7mm connectors exist. But the allowable tolerances (and sometimes the dimensions themselves) differ from manufacturer to manufacturer and from device to device.

Before gaging any precision 7mm connector, therefore, consult the mechanical specifications provided with the connector or the device itself.

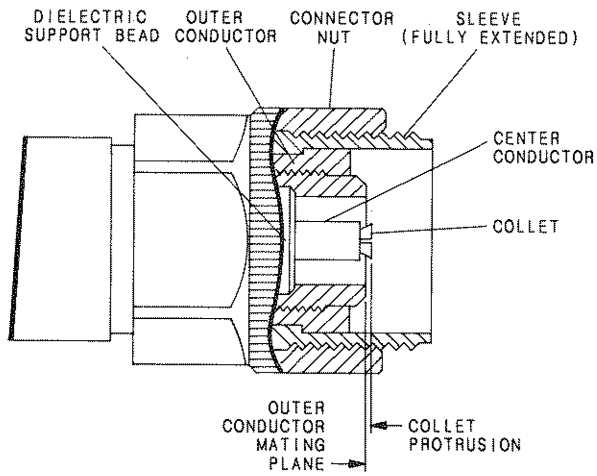
Cleaning Precision 7mm Connectors

Cleaning is discussed in detail in Part One of this **Microwave Connector Care Manual**, which should be consulted for further information.

Whenever the center conductor collet has been removed from a precision 7mm connector, the interior surfaces should be inspected carefully and (if necessary) cleaned. The most suitable method is to cut off the sharp tip of a round wooden toothpick and to wrap it with a single layer of lint-free cleaning cloth. 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.

With the center conductor collet in place, the easiest and best way to clean precision 7mm connectors on small components, cables, and calibration or verification standards is to put a lint-free cleaning cloth flat on a table and put a drop or two of cleaning solvent in the center of the cloth. 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. Blow the connector dry with a gentle stream of compressed air. This method can be adapted for fixed connectors (such as those attached to test ports) by folding the cloth and pressing it onto the connector.

PRECISION 7mm CONNECTOR



CENTER CONDUCTOR COLLET IN PLACE

Measure collet protrusion.

If attached, remove aligning pin from connector gage.

Use flat end of gage calibration block.

CENTER CONDUCTOR COLLET REMOVED

Measure center conductor recession.

Center conductor must not protrude beyond outer conductor mating plane.

Airlines require attaching the aligning pin to the connector gage: in these cases, use the recessed end of the gage calibration block.

Figure 13. Precision 7mm Connector

Removing Center Conductor Collets

Figure 14 shows how to remove the center conductor collet from a precision 7mm connector. This is required in order to gage the connector with the collet removed, if the collet is damaged, or if the protrusion of the collet is not within specification.

Pull back the handle of the collet removing tool (Figure 14) to open the interior collet removal jaws fully. Keep the handle pulled back and the jaws open and insert the tool carefully but completely into the connector, inside the outer conductor, until it comes to rest lightly on the interior support bead. Release the handle and remove the tool (and collet) from the connector. The collet removing tool required for this purpose is supplied in many Hewlett-Packard calibration kits and is also available separately, as HP Part Number 5060-0236.

Two types of center conductor collets exist: 4-slot collets (HP Part Number 1250-0907) and 6-slot precision collets (HP Part Number 85050-20001). The two types are interchangeable, and the 6-slot type is recommended for maximum durability and repeatability of connections.

Both types of collets can be re-used after they are removed, but before doing so the collet should be inspected carefully.

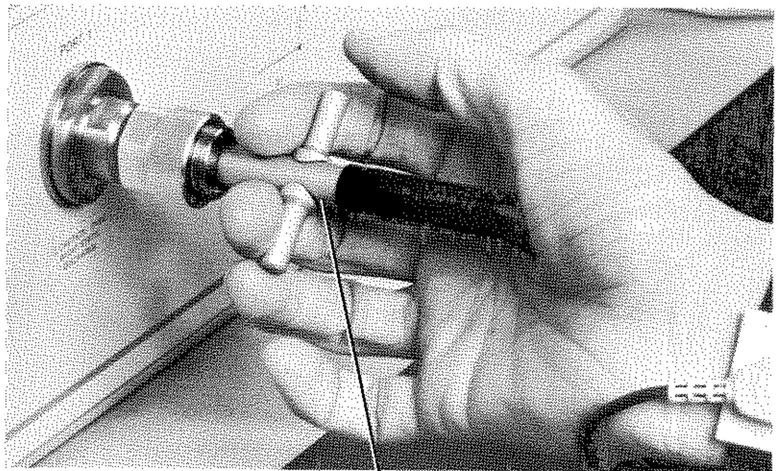
Look especially for edge or surface damage and for any signs that the spring contacts are bent or twisted. If they are, replace the collet and the collet removing tool. No damage to the collet should occur due to the removing tool.

To insert a collet, pick up the collet by the slotted end, using tweezers, and insert it carefully (flat end first) into the center conductor of the connector. Press the collet gently until it snaps into place, using a blunt plastic rod or the rounded plastic handle of the collet removing tool. Do not use a pencil or your finger for this purpose.

When the collet has been re-inserted, verify that it springs back immediately when pressed with a blunt plastic rod or the rounded plastic handle of the collet removing tool.

When removing or replacing collets in test port connectors, take care to avoid electrostatic discharge. Wear a grounded wrist strap and grasp the outer, grounded shell of the test port briefly before removing or inserting the collet. Ground all tools in the same way.

COLLET REMOVAL

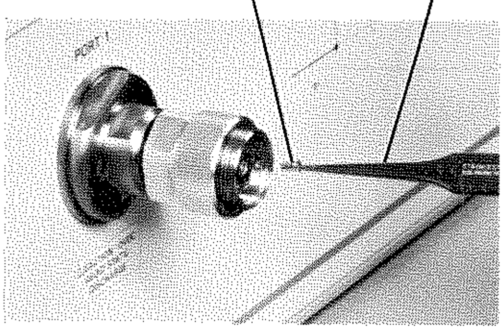


COLLET REMOVING TOOL
HP Part Number 5060-0236

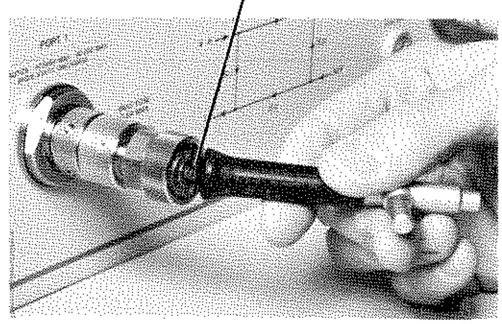
Pull back the handle of the collet removing tool. Keep the handle pulled back and insert the tool into the connector until it comes to rest lightly on the interior support bead. Release the handle and remove the old collet and the tool.

COLLET INSERTION

COLLET TWEEZERS



PUSH LIGHTLY TO SNAP INTO PLACE



4-SLOT COLLET
HP Part Number 1250-0907

6-SLOT PRECISION COLLET
HP Part Number 85050-20001

Figure 14. Center Conductor Collet Removal and Insertion

Selecting a Connector Gage

Care is necessary in selecting a connector gage to measure precision 7mm connectors. Some gages have a very strong gage plunger spring – strong enough, in some cases, to push the center conductor back through the connector, damaging the device itself. Other gages may compress the center conductor collet during the measurement, giving an inaccurately low reading of the actual collet protrusion.

Connector gage kits containing a gage recommended for precision 7mm connectors and all of the other items required are included in many Hewlett-Packard calibration kits, and they are also available separately. Part numbers are given in Part One of this **Microwave Connector Care Manual**.

Gaging Precision 7mm Connectors

Gaging is discussed in detail in Part One of this **Microwave Connector Care Manual**, which should be consulted for further information.

The critical mechanical specification in precision 7mm connectors is the recession (setback) of the center conductor relative to the outer conductor mating plane 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.

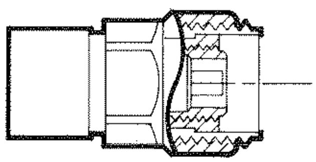
Gaging precision 7mm connectors (Figure 15) is done with the aligning pin removed from the gage plunger and using the flat end of the gage calibration block – except when the connectors have no support beads, as in the case of beadless airlines. In these cases, the (removable) aligning pin is installed into the gage plunger and is used to center the gage and center conductor within the connector. When the aligning pin is used, the recessed end of the gage calibration block is used.

Before gaging the connector, always extend the sleeve of the connector fully. This creates a cylinder into which the gage can fit and greatly reduces the danger of damage to the connector due to the gage slipping sideways during gaging.

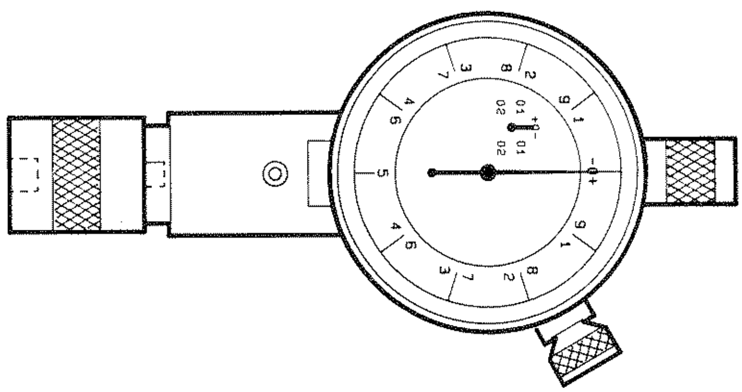
If the connector is within specification, re-insert the collet or insert a new one, and gage the connector again with the center conductor collet in place. This is necessary to verify that the connector is still within specification after assembly. Also verify that the new collet recesses completely and springs back immediately by pressing on it gently with a blunt plastic rod or with the rounded plastic handle of the collet removing tool. If it does, the connector is ready to use.

GAGING PRECISION 7mm CONNECTORS

- Extend connector sleeve fully.



- Zero gage using flat end of gage calibration block.



- Insert gage into connector.

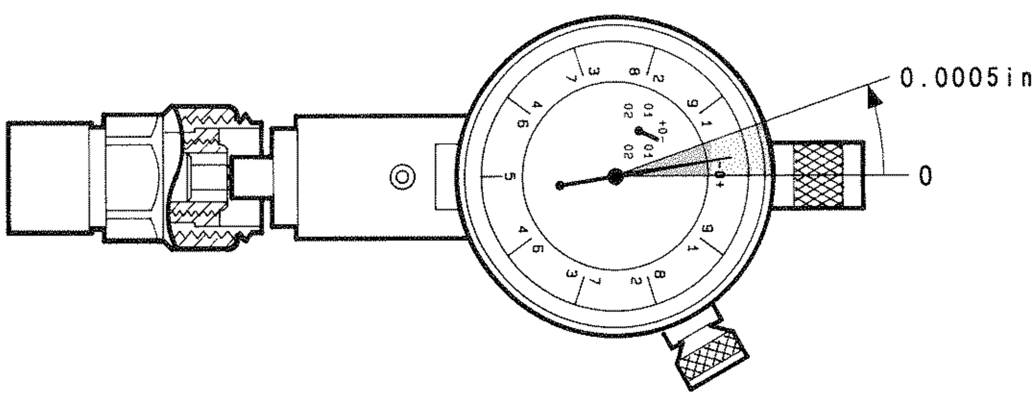
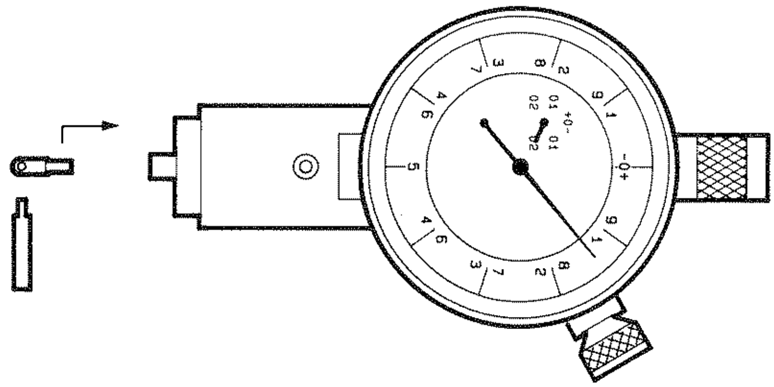


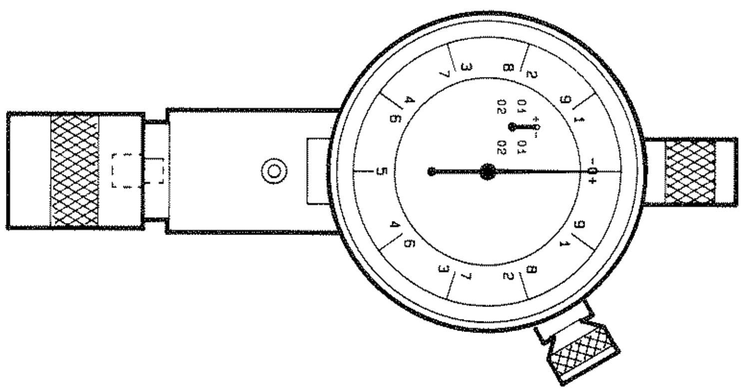
Figure 15. Gaging Precision 7mm Connectors (1 of 2)

GAGING PRECISION 7mm CONNECTORS
USING GAGE ALIGNING PIN

- Use pin wrench to attach aligning pin to gage plunger.



- Zero gage using recessed end of gage calibration block.



- Insert aligning pin into center conductor and gage into connector.

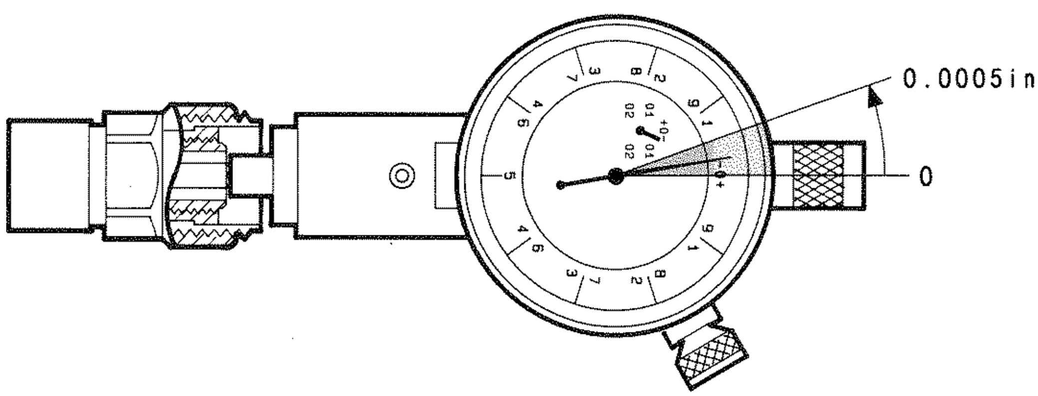


Figure 15. Gaging Precision 7mm Connectors (2 of 2)

Making Connections

Before making connections between precision 7mm connectors, review the general principles outlined in Part One of this manual. Connectors must be undamaged, clean, and within mechanical specification. They must be aligned carefully, connected by turning the connector nut only, and final connections should always be made with a torque wrench.

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 of the other connector retracted fully) in order to make the connection. Extending the sleeve creates a cylinder into which the other connector fits. Spin the knurled connector nut to make sure that the threads are fully extended.

Seating Precision 7mm Connectors. In applications requiring the utmost in repeatability and accuracy, one additional step has been found to be helpful in making connections between precision 7mm connectors. It is called seating and is recommended only for the most demanding measurement applications and only for gold-plated precision 7mm connectors.

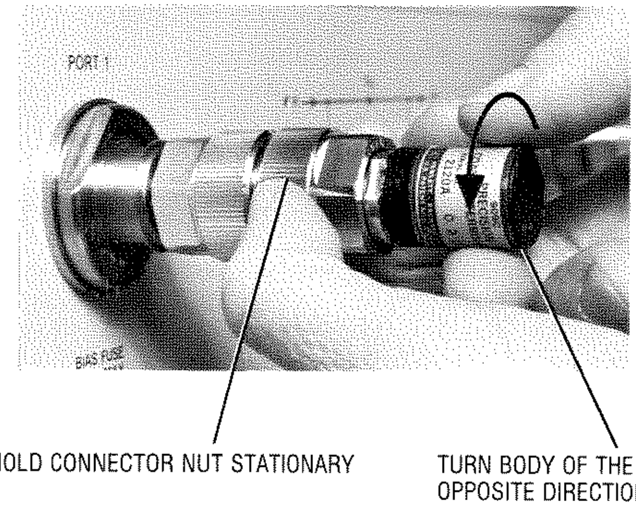
After the preliminary connection has been made using very light finger pressure (2 inch-ounces of torque), hold the connector nut stationary with one hand and with the other hand gently turn *the body of the device being connected* 5 to 15 degrees in a direction opposite to the direction of tightening. A few degrees is enough: on a clock face, one hourly division is 30 degrees, twice the maximum amount of rotation recommended for seating. Smooth, uniform movement without resistance should occur almost immediately.

Often a sudden, slight "breaking loose" of the connection is felt when the device being connected is rotated. This is not abnormal and occurs as the mating plane surfaces or connector nut threads move into correct alignment. It results in a slight loosening of the connector nut, however. Therefore, if it occurs, tighten the connector nut slightly and repeat the rotation. Smooth, uniform motion without resistance should now occur. Make the final connection using the recommended torque wrench.

Some wear of the gold plating on the mating plane surfaces due to abrasion does occur when this technique is used, and for this reason seating is generally omitted except in the most demanding measurement applications, in order to extend the life of the connectors. This latter consideration may be primary in high-volume and production environments, in most lower-frequency applications, and when the utmost in repeatability is not required.

Above all, even when seating is not used it is essential that the connectors be clean and undamaged. Connector wear is greatly accelerated if the connectors have not first been inspected visually, cleaned, and gaged correctly, or if the connection is very tight when the connectors are rotated. The seating technique described here must never be used as a substitute for careful cleaning and complete mechanical inspection of connectors. Inspect and clean connectors carefully. Do not overtighten the preliminary connection.

• **Seating Precision 7mm Connectors**



Make the preliminary connection lightly (2 inch-ounces). Do not turn devices more than 15 degrees. Use a torque wrench to make the final connection.

Figure 16. Seating Precision 7mm Connectors

ADAPTERS FOR PRECISION 7mm CONNECTORS

- **Use adapters to reduce wear on connectors that may be difficult or expensive to replace.**
- **Use adapters to change the connector interface.**
- **Use adapters whenever devices that have SMA connectors must be measured.**

Adapters are used to connect devices 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. Adapters are often used to connect devices that have Type-N, precision 3.5mm, or SMA connectors to test instruments that have precision 7mm connectors. They are also used to minimize connector wear, especially when the devices-under-test have SMA connectors.

Figure 17 shows the adapters that are recommended for converting a precision 7mm interface to various other interfaces. When an SMA interface is desired, use an adapter that has a precision 3.5mm interface. Precision 3.5mm connectors are compatible with SMA connectors. There are no separate 7mm-to-SMA adapters.

Using adapters is strongly recommended whenever devices that have SMA connectors must be measured. SMA connectors are low-cost connectors and 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. It is much easier (and much cheaper) to replace an adapter than it is to repair or replace test equipment.

In all instances, the new interface will have the connector type listed in Figure 17. For example, using a male precision 3.5mm (SMA-compatible) adapter, HP Part Number 1250-1746, will result in a **male precision 3.5mm interface** to which devices or cables with female 3.5mm or SMA connectors can be connected. In most applications, two adapters will be required, one each at the input and the output of the device. Adapters are included in many HP calibration kits or may be ordered separately using the part numbers given in Figure 17.

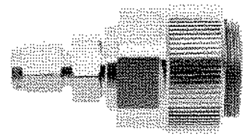
SMA-Compatible Adapters for HP 85021/27-series Directional Bridges. When devices with SMA connectors are to be measured at frequencies from 10 MHz to 18 GHz using an HP 85021/27-series directional bridge, Hewlett-Packard recommends using the HP 85021/27A (7mm) directional bridge and 7mm-to-3.5mm adapters. If a slight loss in directivity can be tolerated, this arrangement is much better than using the HP 85021/27B (3.5mm) directional bridge and connecting the SMA devices directly to it.

It is much easier (and much cheaper) to replace a male or female 3.5mm-to-7mm adapter than it is to repair a bridge.

HP 85130A Special Adapter Kit. In order to produce a 7mm interface on the 3.5mm test ports of the HP 8513A and HP 8515A test sets, for example to use 7mm calibration or verification devices or the HP 85041A transistor test fixture with these test sets, the adapters in the HP 85130A special 3.5mm (F) to 7mm adapter kit should be used at the test ports instead of any other adapters. This kit has been developed expressly for this single purpose.

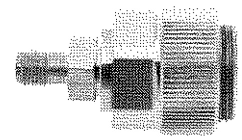
The adapters in the HP 85130A special adapter kit have two special features: (1) the 3.5mm side is a special "NMD-3.5" connector designed specifically to mate with HP 3.5mm test ports, and (2) the 7mm side has a center conductor setback that is the same as the setback on HP 7mm test ports. Thus the 7mm interface that results is the same as is found on test sets with 7mm connectors. Other adapters may be used at non-port connections, to connect ordinary 7mm devices to ordinary 3.5mm devices.

7mm-to-3.5mm (SMA-COMPATIBLE) ADAPTERS



male precision 3.5mm – precision 7mm

HP Part Number 1250-1746



female precision 3.5mm – precision 7mm

HP Part Number 1250-1747

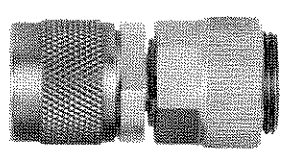
[4-slot center conductor collets]

HP Part Number 85052-60004

HP Part Number 85052-60003

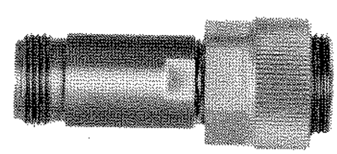
[6-slot precision center conductor collets]

7mm-to-Type-N ADAPTERS



male Type-N – precision 7mm

HP Part Number 85054-60009



female Type-N – precision 7mm

HP Part Number 85054-60001

Figure 17. Precision 7mm Adapters

Type-N Connectors

Type-N connectors are relatively inexpensive, rugged 7mm connectors developed for severe operating environments and for applications in which many connections and disconnections must be made. They are among the most popular general-purpose connectors used in the dc to 18 GHz frequency range. HP Precision Type-N connectors are stainless steel or beryllium copper Type-N connectors developed for measurement applications.

Unlike precision 7mm connectors, Type-N connectors (Figure 18) are sexed connectors. 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. 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.

Type-N connectors differ from other connectors 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.

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.

MECHANICAL SPECIFICATIONS OF TYPE-N CONNECTORS

- **Type-N connectors require a minimum recession of the shoulder of the male contact pin of 0.207 inches and allow a maximum protrusion of the tip of the female contact fingers in front of the outer conductor mating plane of 0.207 inches.**
- **Pin depth specifications for 75Ω Type-N connectors are the same as for 50Ω Type-N connectors. The connector types differ in the size of the center pin, not in the mating plane offsets.**

Several mechanical specifications for Type-N connectors exist, among them those listed in Table 4. All specify a minimum recession of the shoulder of the male contact pin and a maximum protrusion of the tip of the female contact fingers.

The strictest specification is the HP Precision specification, which differs from MIL-C-39012, Class II, in reducing (by 0.001 in) the minimum allowable recession of the shoulder of the male contact pin. None of the specifications allows the total contact separation to be zero or less, and most require a minimum contact separation of 0.001 in (or more). Only the HP Precision specification allows a separation of zero.

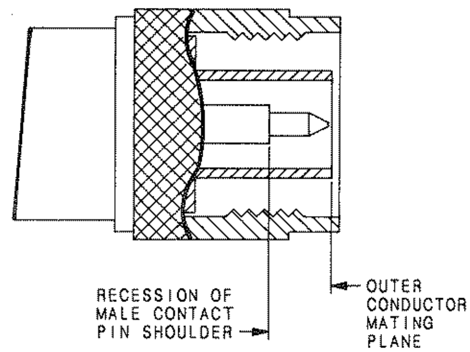
Before gaging any Type-N connector, therefore, consult the mechanical specifications provided with the connector or the device itself.

Table 3. Mechanical Specifications, Type-N Connectors

Specification	Recession (Male)	Protrusion (Female)
MIL-C-71B	0.214 – 0.232 in CONTACT SEPARATION	0.187 – 0.207 in 0.007 – 0.045 in
MIL-C-39012 Class II	0.208 in, minimum CONTACT SEPARATION	0.207 in, maximum 0.001 in, minimum
MIL-C-39012 Class I	0.208 – 0.211 in CONTACT SEPARATION	0.204 – 0.207 in 0.001 – 0.007 in
HP Precision	0.207 – 0.210 in CONTACT SEPARATION	0.204 – 0.207 in 0.000 – 0.006 in

TYPE-N CONNECTORS

MALE



FEMALE

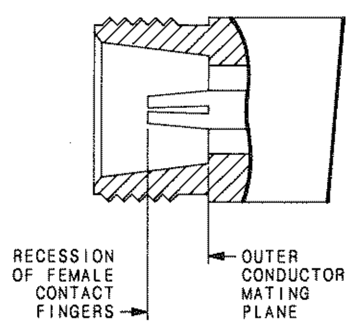


Figure 18. Type-N Connectors

Electrical Effects of Contact Separation

Type-N connectors are often usable in many applications even when the total separation between the shoulder of the male contact pin and the tip of the female contact fingers exceeds the maximum implied by the mechanical specifications. Figure 19 shows the approximate effects of total contact separation on the reflection coefficient of Type-N connections. As can be seen, at lower frequencies the effects even of fairly wide total contact separations are small. Only at higher frequencies does contact separation become important.

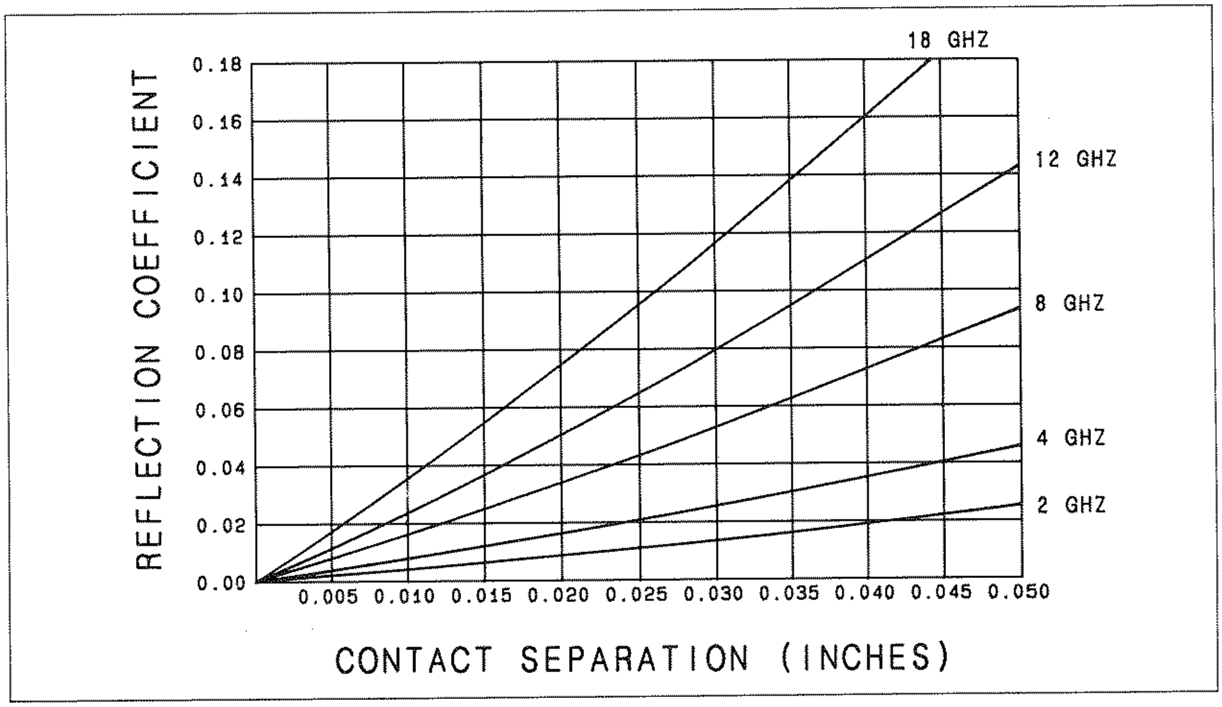


Figure 19. Approximate Effects of Contact Separation on Reflection Coefficient, Type-N Connectors

Gaging Type-N Connectors

A single gage that has separate bushings for male and female connectors is used to gage Type-N connectors. A connector gage kit containing all of the items required is available as HP Part Number 85054-60024.

Male Type-N Connectors. To gage male Type-N connectors (Figure 20), first attach the bushing for male connectors to the dial indicator assembly. Slip the bushing over the gage plunger assembly on the gage and fasten it there using the two Allen screws in the bushing.

The outer end of the male bushing is flat and has a hole in it, and the gage plunger is inserted through the bushing so that the plunger protrudes from the bushing when the bushing has been attached.

Zero the gage using the recessed end of the gage calibration block. Insert the gage plunger into the hole in the gage calibration block and zero the gage according to the instructions given in Part One of this **Microwave Connector Care Manual**. Then measure the connector.

Insert the gage carefully into the male connector so that it is centered and the flat outer part of the gage bushing rests on the outer conductor. The male contact pin slips into the hole for this purpose in the gage plunger.

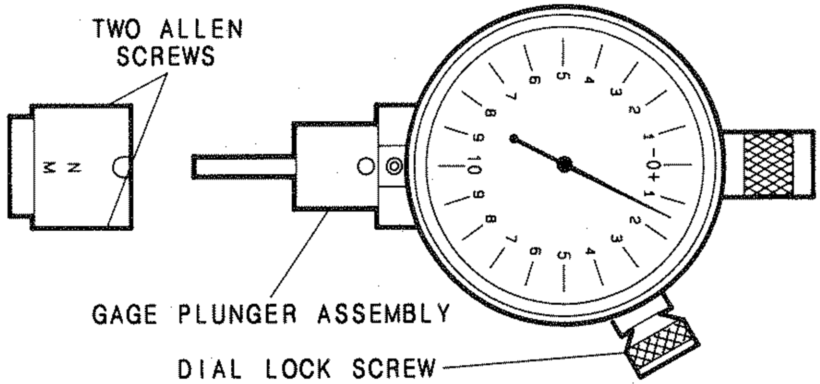
Gently rock the connector gage within the connector, to make sure that the gage and the outer conductor have come together flatly. When the gage pointer settles consistently at a reading, read the gage indicator dial.

Counterclockwise deflection of the gage pointer (a "minus" reading on the gage indicator dial) indicates that the shoulder of the male contact pin meets its minimum specification of being recessed at least 0.207 inches. The amount of deflection tells how much more than the minimum the shoulder of the contact pin is recessed. A reading of "minus" 0.003 inches, for example, indicates a recession of 0.210 inches, the maximum recession allowed in HP Precision Type-N connectors.

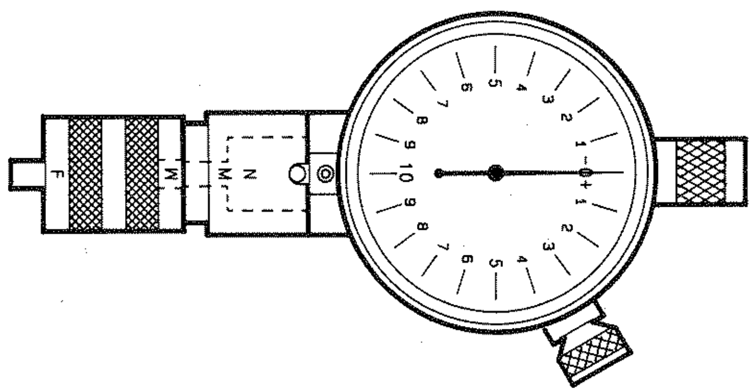
In the same way, clockwise deflection of the gage pointer (a "plus" reading on the gage indicator dial) indicates that the shoulder of the male contact pin is recessed less than the minimum recession of 0.207 inches behind the outer conductor mating plane. Such a connector is out of specification. It will damage other connectors to which it is mated and should not be used.

MALE TYPE-N CONNECTORS

- Attach male bushing to dial indicator assembly.



- Zero gage using recessed end of gage calibration block.



- Insert gage into connector.

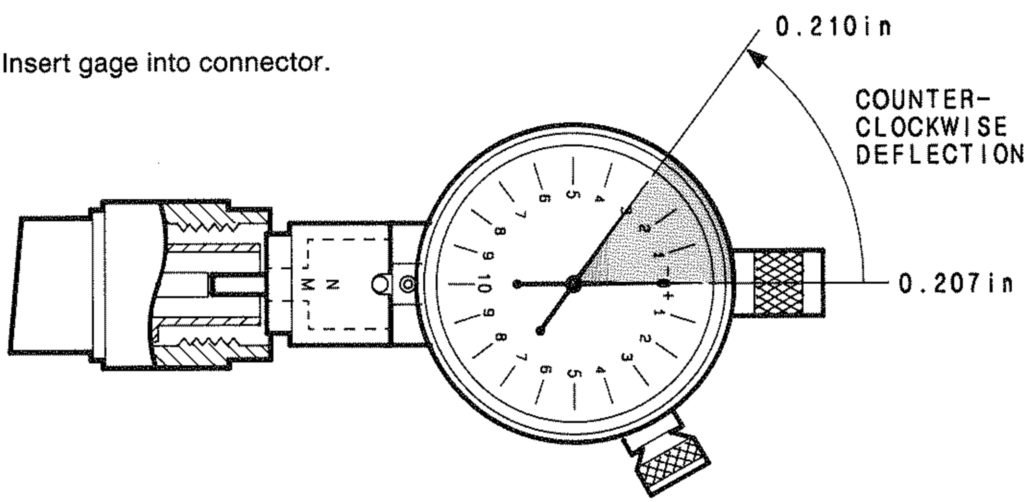
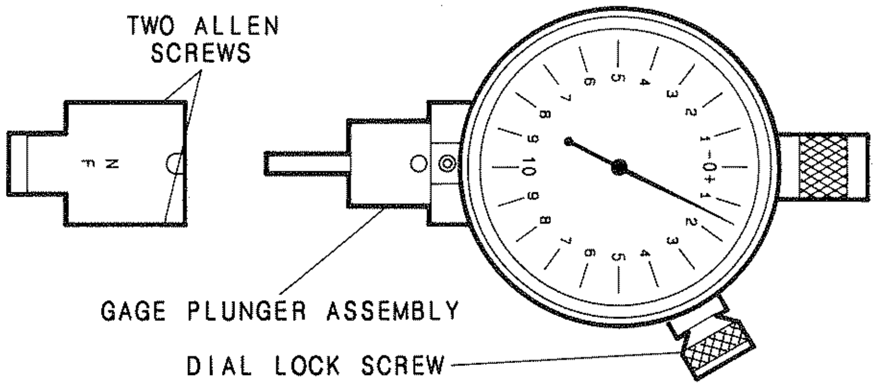


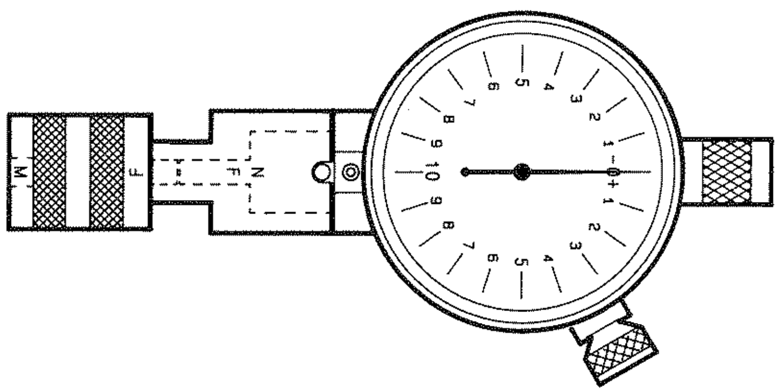
Figure 20. Gaging Type-N Connectors (1 of 2)

FEMALE TYPE-N CONNECTORS

- Attach female bushing to dial indicator assembly.



- Zero gage using protruding end of gage calibration block.



- Insert gage into connector.

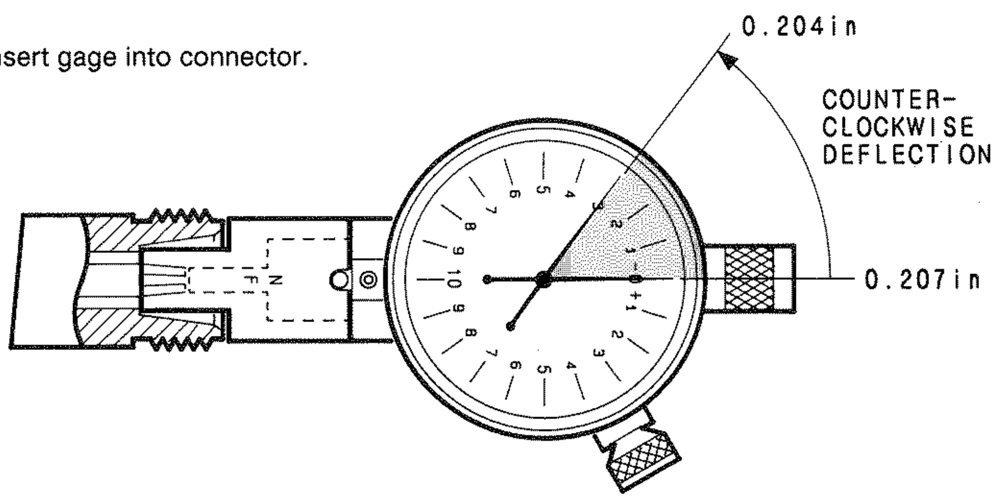


Figure 20. Gaging Type-N Connectors (2 of 2)

Female Type-N Connectors. To gage female Type-N connectors (Figure 20), first attach the bushing for female connectors to the dial indicator assembly. This bushing has a protruding circular sleeve, and when the bushing has been attached to the dial indicator assembly the gage plunger will be inside this circular sleeve. The bushing is fastened to the gage plunger assembly using the two Allen screws in the bushing.

Zero the gage using the protruding end of the gage calibration block. Insert the protruding end of the block into the circular sleeve so it comes to rest on the gage plunger inside the female bushing. Zero the gage according to the instructions given in Part One of this manual. Then measure the connector.

Insert the gage carefully into the female connector so that it is centered and the female contact fingers in the connector slip inside the protruding circular sleeve on the gage. The circular sleeve on the bushing should come to rest on the outer conductor mating plane inside the connector, behind the female contact fingers.

Gently rock the connector gage within the connector, to make sure that the gage and the outer conductor have come together flatly. When the gage pointer settles consistently at a reading, read the gage indicator dial.

Counterclockwise deflection of the gage pointer (a "minus" reading on the gage indicator dial) indicates that the tip of the female contact fingers meets the specification of protruding no more than 0.207 inches. The amount of deflection tells how much less than this maximum the tip of the female contact fingers is protruding. A reading of "minus" 0.003 inches, for example, indicates a protrusion of 0.204 inches, the minimum protrusion allowed in HP Precision Type-N connectors.

In the same way, clockwise deflection of the gage pointer (a "plus" reading on the gage indicator dial) indicates that the tip of the female contact fingers is protruding more than the maximum of 0.207 inches in front of the outer conductor mating plane. Such a connector is out of specification. It will damage other connectors to which it is mated and should not be used.

Connection Technique

In two important respects, connections made between Type-N connectors differ from those made between other connectors:

- Type-N connectors are never rotated relative to one another
- Type-N connectors are connected finger tight

Because Type-N connectors are made of brass or (in the case of HP Precision Type-N connectors) stainless steel, special care should be taken to avoid rotating the mating plane surfaces against one another.

In particular, the optional step recommended for seating precision 7mm connectors must never be used when connecting Type-N connectors together.

A torque wrench is not needed (and generally cannot be used) in making the final connection of Type-N connectors because the standard connector nuts on male Type-N connectors do not have wrench flats. Connections will be tight enough when the nuts are connected finger tight. If a torque wrench is used (for example, a wrench equipped with a special non-slip end), the correct torque setting is the same as for precision 7mm connectors: 12 lb-in (136 N-cm). As with other connectors, always turn the connector nut only to tighten the connection.

Careful inspection and cleaning of Type-N connectors is also essential, and the recommendations on these subjects in Part One of this **Microwave Connector Care Manual** should be followed carefully.

SMA and Precision 3.5mm Connectors

Because of their smaller size, SMA and precision 3.5mm connectors can be used at higher frequencies than 7mm connectors can. SMA connectors are low-cost 3.5mm connectors generally used up to about 23 GHz. The name is an abbreviation of the connector type: **S**ub**M**iniature connector, type **A**. A solid plastic dielectric separates the center and outer conductors.

Precision 3.5mm connectors, also known as APC-3.5 connectors, are precision air-dielectric connectors that will mate with SMA connectors. They offer much greater repeatability of connection than SMA connectors do, and for this reason they are widely used on electronic test equipment. Precision 3.5mm connectors can be used up to about 34 GHz.

Both SMA and precision 3.5mm connectors are sexed connectors. 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. The mechanical specifications for both SMA and precision 3.5mm connectors give a maximum and a minimum *recession of the shoulder of the male contact pin* and a maximum and a minimum *recession of the tip of the female contact fingers* behind the outer conductor mating plane.

SMA CONNECTORS

- **SMA connectors are not precision devices. Inspect them and use them carefully, with a knowledge of their limitations.**
- **Inspect all male SMA connectors mechanically, using a precision connector gage, and for misalignment or burrs on the male contact pin. Do not use any connectors that are out-of-specification or damaged.**

SMA connectors (Figure 21) are inexpensive 3.5mm connectors in which a solid plastic dielectric is used between the center and outer conductors. SMA connectors are not precision devices. They are not designed for repeated connections and disconnections, they wear out quickly, and they are very often found, upon initial assembly, to be out of specification – even before they have been used. They are used most often as one-time-only connectors in internal component assemblies and in similar applications in which few connections or disconnections will be made.

Specifications and manufacturing tolerances of SMA connectors are fairly loose. This helps keep their cost low, but it also makes SMA connectors potentially destructive both to one another and – especially – to any precision 3.5mm connectors with which they might be mated. See the discussion later in this section before mating SMA and precision 3.5mm connectors.

SMA Connector Problems

Two types of problems are the most common with SMA connectors:

- problems due to the solid plastic dielectric
- problems due to SMA male pins

Dielectric Protrusion. Some SMA connector specifications allow protrusion of the solid plastic dielectric in front of the outer conductor mating plane, sometimes as much as 0.002 or 0.003 inches. This is not necessarily harmful when SMA connectors are mated to one another because some compression of the dielectric can occur. But it can be extremely harmful if the SMA connector is mated to a precision 3.5mm connector. The protruding dielectric can force the rigid center conductor of the precision 3.5mm connector back through the connector itself, damaging not only the connector but sometimes the device to which it is attached.

For this reason, SMA connectors in which the solid plastic dielectric protrudes in front of the outer conductor mating plane must never be mated to precision 3.5mm connectors. Always inspect SMA connectors for protrusion of the solid plastic dielectric before mating them to precision 3.5mm connectors.

Protrusion of the dielectric can also occur due merely to connection and disconnection. The mechanical force of pulling the connectors apart can result in movement of the dielectric. Aging and temperature cycling can also cause the dielectric to move out of specification.

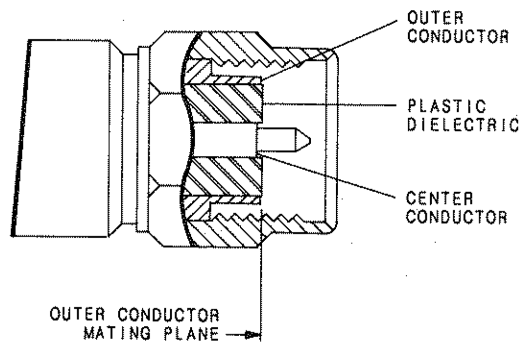
Out-of-Specification SMA Male Pins. The other main source of problems is the SMA male pin. Partly because low manufacturing costs are desirable in SMA connectors, the male contact pins in some SMA connectors are not held securely in position. These pins are very easily pulled out of specification, especially if the female contact fingers in the other connector are unusually tight. A male SMA connector pin that is bent or is too long may smash or break the delicate fingers on the female connector, especially if it is a precision 3.5mm connector.

Very often, too, SMA male pins are actually not pins at all but the cut-off ends of the center conductor in ordinary semi-rigid coaxial cable. Misalignment and burrs are common in this situation, and burrs on the end of the male pin can ruin any female SMA or precision 3.5mm connector that they are mated to.

Inspect all male SMA connectors for misalignment or burrs on the male contact pin and discard any that are damaged.

SMA CONNECTORS

MALE



FEMALE

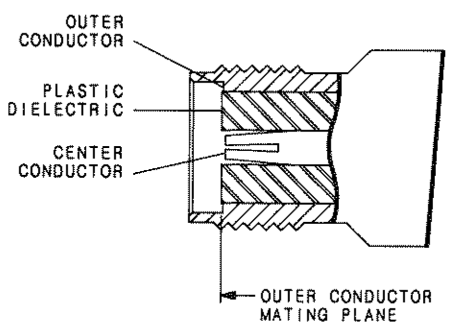


Figure 21. SMA Connectors

Precision 3.5mm Connectors

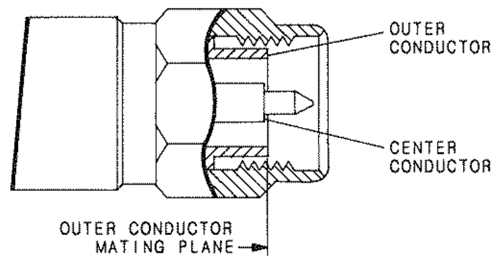
Precision 3.5mm connectors, also known as APC-3.5 connectors, were developed during the early 1970's jointly by Hewlett-Packard and Amphenol Corporation. The design objective was to produce a durable high-frequency microwave connector that would mate with SMA connectors, exhibit low SWR and insertion loss, and be mode free up to about 34 GHz.

Unlike SMA connectors, precision 3.5mm connectors are air dielectric devices (Figure 22). Air is the insulating dielectric between the center and outer conductors, and the center conductor is supported by a plastic support bead inside the connector body. Precision 3.5mm connectors are precision devices. They are more expensive than SMA connectors and they are durable enough to permit repeated connections and disconnections.

NMD-3.5 connectors are precision 3.5mm connectors recently developed by Hewlett-Packard and used on cables, test port connectors, and in the HP 85130A special 3.5mm-to-7mm adapter set. These connectors are especially rugged and are designed to provide an exceptionally strong coupling mechanism for measurement applications.

PRECISION 3.5mm CONNECTORS

MALE



FEMALE

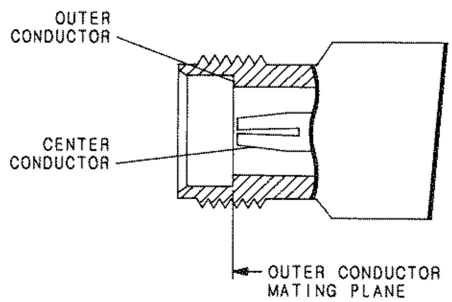


Figure 22. Precision 3.5mm Connectors

MATING SMA AND PRECISION 3.5mm CONNECTORS

- **All SMA connectors should be inspected mechanically, using a precision connector gage, before use and before being mated to any precision 3.5mm connector. Out-of-specification SMA connectors can damage other connectors permanently even on the very first connection.**
- **If an SMA connector is to be mated to a precision 3.5mm connector, the SMA connector must meet the setback specifications of precision 3.5mm connectors. In particular, there must be no protrusion of the plastic dielectric, or of the shoulder of the male contact pin or the tip of the female contact fingers, in front of the outer conductor mating plane.**
- **Take great care with alignment. Dimensions of SMA and precision 3.5mm connectors differ enough that the male SMA pin can slip to the side of the female contact fingers in the precision connector. Align the connectors carefully and avoid twisting the connectors or devices as the connection is made.**
- **Whenever possible, use 3.5mm-to-3.5mm adapters as "connector-savers" between the SMA connector and the precision 3.5mm connector. Using an adapter has only a small effect on electrical performance, and wear or damage occurs only on the adapter – not on expensive components or devices.**

One key feature of precision 3.5mm connectors is that they can be mated with SMA connectors (Figure 23). This was among the original design objectives for the connector. But great care is necessary when making such connections, to avoid damaging the connectors owing to their slightly different dimensions and mechanical characteristics.

The recommendations above will help prevent damage when SMA connectors are mated to precision 3.5mm connectors. Gage both connectors carefully; be sure that the setback specifications for precision 3.5mm connectors are also met by the SMA connector; and take great care with alignment.

Push the two connectors straight together, with the male contact pin precisely concentric with the female. Do not rotate either connector or overtighten the connection. Turn only the outer nut of the male connector and use a torque wrench (5 lb-in, 56 N-cm) for the final connection.

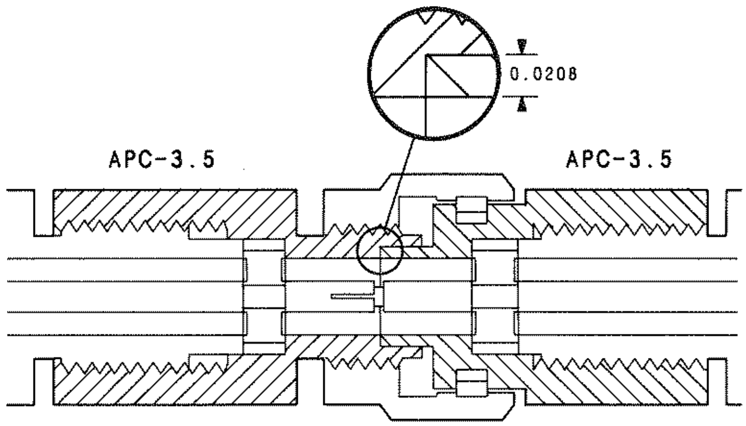
Note that this torque is less than is used when mating precision 3.5mm connectors with each other. A torque wrench suitable for SMA connectors, preset to 5 lb-in (56 N-cm), is available as HP Part Number 8710-1582.

These precautions are all necessary because of the nature of SMA connectors. SMA connectors are designed to be inexpensive, one-time-only connectors. They are not precision mechanical devices, and they should be used carefully, with a full knowledge of their limitations.

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

When more than a few connections of SMA connectors to a precision 3.5mm interface will be made, a 3.5mm-to-3.5mm adapter (sometimes called a "connector saver") is generally installed on the 3.5mm connector. In this way, the original connector is protected from damage and only the adapter needs to be replaced when it is worn. Adapters are discussed later in this section.

PRECISION 3.5mm INTERFACE



PRECISION 3.5mm – SMA INTERFACE

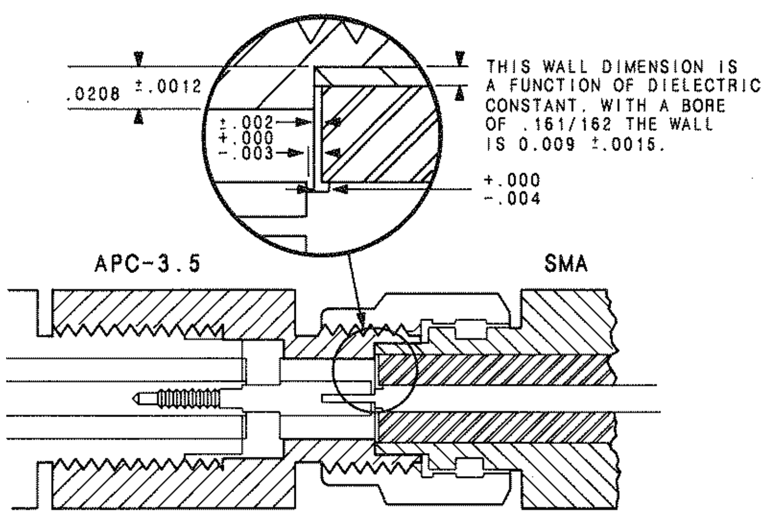


Figure 23. Precision 3.5mm Connector and Precision 3.5mm-SMA Connector Interfaces

Electrical Performance

Electrically, junctions coupled with precision 3.5mm connectors (only) exhibit greatly superior electrical performance compared to junctions coupled with SMA connectors or with an SMA connector connected to a precision 3.5mm connector. Typical values are shown in Figure 24.

As will be seen, when an SMA connector is mated with a precision 3.5mm connector the connection itself exhibits a mismatch (SWR), typically about 1.10 at 20 GHz. This mismatch is less than is obtained when two SMA connectors are mated. But it is still much higher than occurs when precision 3.5mm connectors alone are used. Keep this fact in mind when making measurements on SMA and precision 3.5mm coupled junctions.

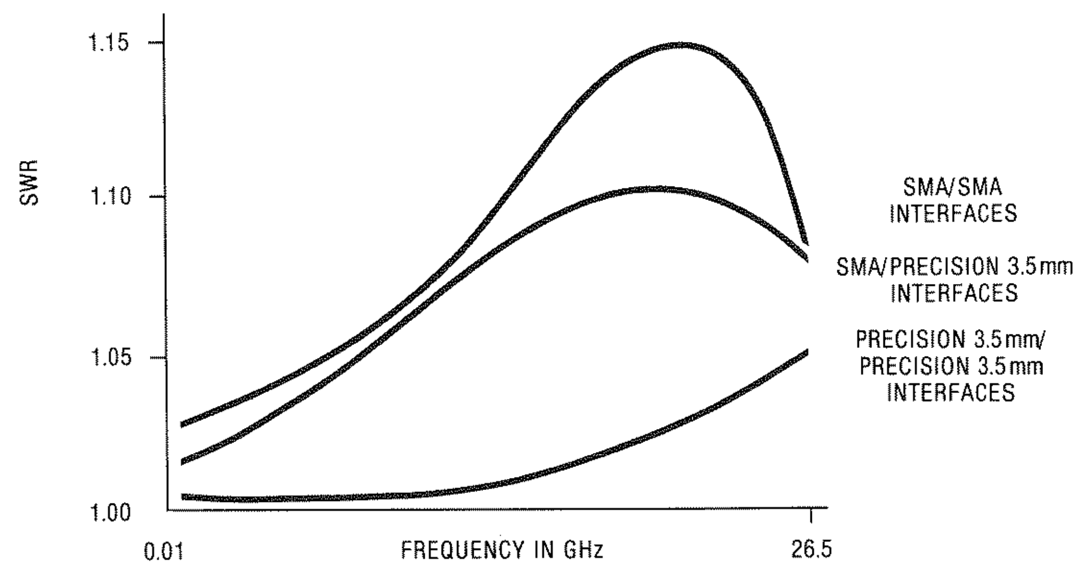


Figure 24. Typical SWR of Precision 3.5mm and SMA Coupled Junctions

Adapters

Adapters are used for two main purposes with SMA and precision 3.5mm connectors: 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.

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.

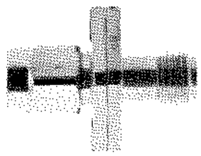
Same-sex adapters (male-male, female-female) change the sex of the interface. For example, if the original interface presents a male connector, attaching a female-female adapter will result in a female interface to which devices or cables that have male SMA (or male precision 3.5mm) connectors can be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

3.5mm-to-3.5mm (or SMA) Adapters. High-quality precision adapters, sometimes called "connector savers," are recommended whenever more than a few connections will be made between SMA and precision 3.5mm connectors. In this way, only the adapter needs to be replaced when it is worn and the precision connector is at all times protected from accidental damage due to the SMA connector.

Figure 25 shows the 3.5mm-to-3.5mm adapters that are available for making through or "connector-saver" connections between SMA and precision 3.5mm connectors or for changing the sex of a connector interface. The HP 85052-series adapters, available in all three types, are high-performance adapters that can be used in any application. The HP 85027-series adapters, available in male-female and male-male form only, are designed to be used only with HP 85021/27-series directional bridges.

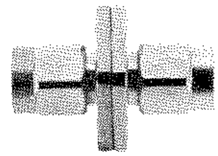
7mm-to-3.5mm (or SMA) Adapters. Devices or cables that have SMA or precision 3.5mm connectors can be connected to devices or cables that have a precision 7mm interface using the 7mm-to-3.5mm (or SMA) adapters shown in Figure 25. This use of adapters is especially recommended to reduce wear on connectors that may be difficult or expensive to replace. Adapters with precision 6-slot collets are recommended for the utmost in repeatability and performance. Adapters with 4-slot collets are good general purpose adapters.

3.5mm-to-3.5mm ADAPTERS
(SMA COMPATIBLE)



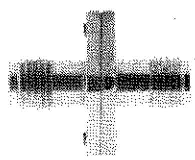
male 3.5mm –
female 3.5mm

HP Part Number 1250-1866



male 3.5mm –
male 3.5mm

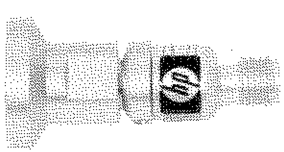
HP Part Number 1250-1864



female 3.5mm –
female 3.5mm

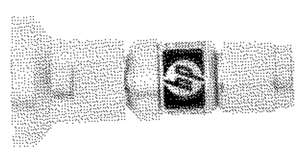
HP Part Number 1250-1865

3.5mm "CONNECTOR-SAVERS" FOR HP 85021/27
DIRECTIONAL BRIDGES



male 3.5mm –
female 3.5mm

HP Part Number 85027-60003

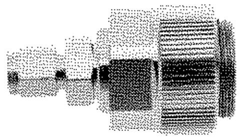


male 3.5mm –
male 3.5mm

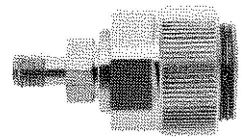
HP Part Number 85027-60002

Figure 25. 3.5mm Adapters (1 of 2)

7mm-to-3.5mm (SMA-COMPATIBLE) ADAPTERS



male precision 3.5mm –
precision 7mm



female precision 3.5mm –
precision 7mm

HP Part Number 1250-1746 HP Part Number 1250-1747
[4-slot center conductor collets]

HP Part Number 85052-60004 HP Part Number 85052-60003
[6-slot precision center conductor collets]

Figure 25. 3.5mm Adapters (2 of 2)

HP 85021/27-series Directional Bridges. Reducing wear due to SMA connectors may also influence the choice of equipment. For example, when devices with SMA connectors are to be measured at frequencies from 10 MHz to 18 GHz using an HP 85027-series directional bridge, Hewlett-Packard recommends using the HP 85027A (7mm) directional bridge and 7mm-to-3.5mm adapters.

If a slight loss in directivity can be tolerated, this arrangement is much better than using the HP 85027B (3.5mm) directional bridge and connecting the SMA devices directly to it – in part because the 7mm interface, because it is larger, is more rigid and durable. The 7mm-to-3.5mm adapter serves as a "connector saver" in this application. It is much easier (and much cheaper) to replace an adapter than it is to repair the bridge.

Some idea of the effects on electrical performance when "connector-saver" adapters are used may be seen in Figure 26. Typical directivity of the HP 85021/27 directional bridges with "connector-saver" adapters in place is compared to the 40-dB directivity (up to 18GHz) specification of the bridges alone. As will be seen, the minimum directivity is typically 34 dB when 7mm-to-3.5mm adapters are used with an HP 85021/27A directional bridge. The minimum directivity is also 34 dB when 3.5mm-to-3.5mm adapters are used with an HP 85021/27B bridge, but these bridges are usable up to 26.5 GHz.

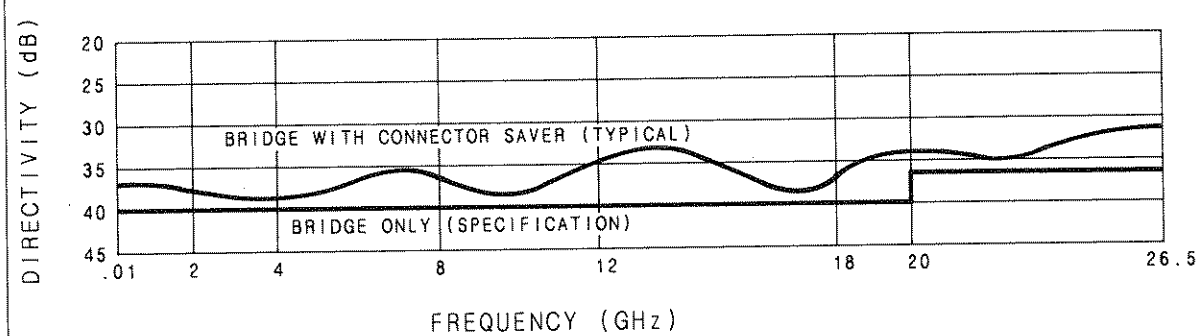


Figure 26. Typical Directivity Using "Connector-Saver" Adapters

Special 3.5mm (F)-to-Precision 7mm Adapters. One special use of adapters should be noted. In order to produce a 7mm interface on the 3.5mm test ports of the HP 8513A and HP 8515A test sets, for example to use 7mm calibration or verification devices or the HP 85041A transistor test fixture with these test sets, the adapters in the HP 85130A special 3.5mm (F) to 7mm adapter kit should be used at the test ports instead of any other adapters.

The adapters in the HP 85130A special adapter kit have two special features: (1) the 3.5mm side is a special "NMD-3.5" connector designed specifically to mate with HP 3.5mm test ports, and (2) the 7mm side has a center conductor setback that is the same as the setback on HP 7mm test ports. Thus the 7mm interface that results is the same as is found on test sets with 7mm connectors. Other adapters may be used at non-port connections, to connect ordinary 7mm devices to ordinary 3.5mm devices.

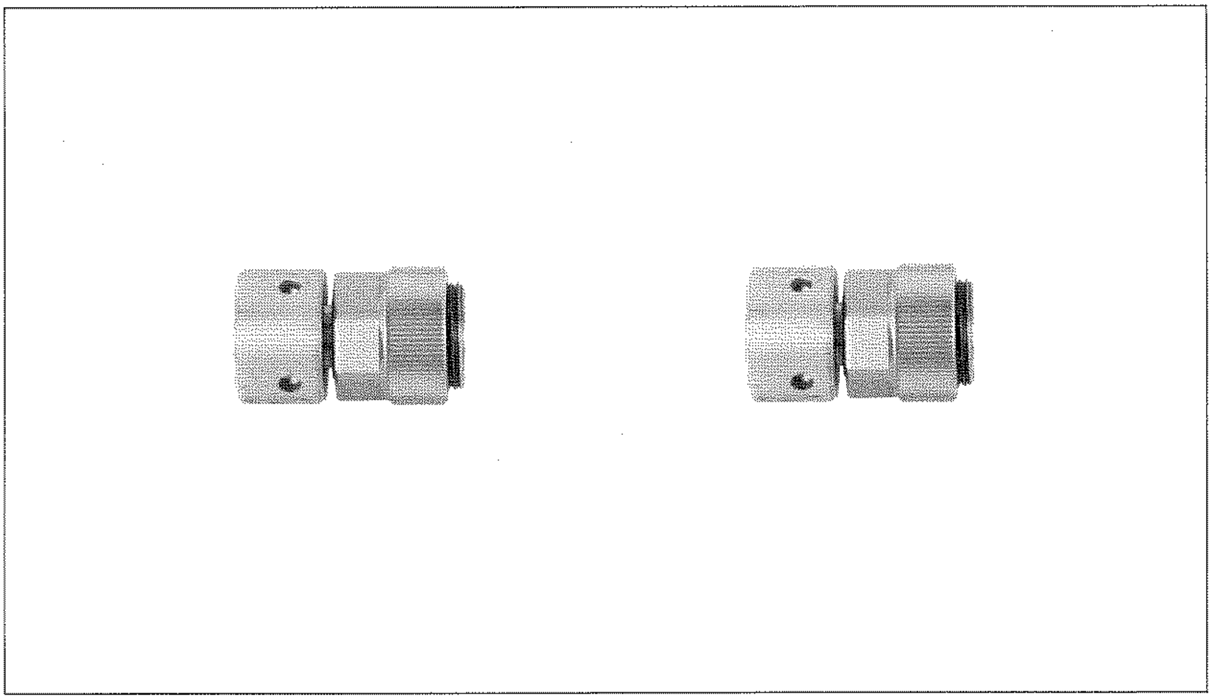


Figure 27. HP 85130A Special 3.5mm (F)-to-Precision 7mm Adapters

CLEANING SMA AND PRECISION 3.5mm CONNECTORS

- **Use great care to avoid bending or breaking the center conductor pins. Female contact fingers in precision 3.5mm connectors are especially easy to damage.**
- **Avoid wetting plastic support parts. Use the least amount of solvent possible and blow connectors dry with a gentle stream of compressed air.**

SMA and precision 3.5mm connectors require special care in cleaning, because of their delicacy, small size, and intricate geometry. Center conductor contact pins (especially the contact fingers on female connectors) are very easily bent or broken. In precision 3.5mm connectors, moreover, 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.

Magnification and good lighting are helpful, and especially for cleaning the interior surfaces of these connectors the method given in Part One of this **Microwave Connector Care Manual** is recommended: cutting off the sharp tip of a round wooden toothpick, wrapping it with a single layer of lint-free cleaning cloth, and moistening the cloth with liquid Freon. Insert the cloth carefully into the connector to clean the interior surfaces. When it has been cleaned, blow the connector dry with a gentle stream of compressed air.

Cleaning Solvents. Contact with solvents can affect the plastic dielectric that surrounds the center conductor in SMA connectors and the plastic interior support beads in precision 3.5mm connectors. Generally this is not a problem if the solvent is applied with a cloth or swab and if the least possible solvent is used. It can be a problem if the connector is sprayed directly with solvent or if the connector is immersed in solvent. Both of these practices should be avoided.

If a connector does become wet with solvent during cleaning, immediately invert the connector to allow the liquid to flow out, then purge the remaining solvent using a gentle stream of compressed air. This should be done slowly, to prevent damage to the connector due to excessive cooling due to rapid evaporation of the solvent. Allow the connector to return to room temperature before use. If contact with the solvent has been prolonged, inspect the plastic dielectric or support bead for signs of swelling or deterioration before using the connector and discard any connectors that are damaged.

GAGING SMA AND PRECISION 3.5mm CONNECTORS

- **No protrusion of the shoulder of the male contact pin or of the female contact fingers 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.**
- **If an SMA connector is to be mated to a precision 3.5mm connector, the SMA connector must meet the setback specifications of precision 3.5mm connectors. In particular, there must be no protrusion of the plastic dielectric, or of the shoulder of the male contact pin or the tip of the female contact fingers, in front of the outer conductor mating plane.**

The same gages can be used to measure SMA and precision 3.5mm connectors. Separate male and female gages are required, and connector gage kits containing all the items required are included in many Hewlett-Packard calibration kits. Gage kits are also available separately. Part numbers are given in Part One of this **Microwave Connector Care Manual**.

Male SMA and Precision 3.5mm Connectors. Gages used to measure male SMA and precision 3.5mm connectors are usually marked M and have a circular metal bushing surrounding the gage plunger (Figure 28). When the connector is gaged, the outer bushing rests on the outer conductor mating plane and the male contact pin slips inside the gage plunger. In this way the recession of the shoulder of the male contact pin is measured relative to the outer conductor mating plane.

Male gages are zeroed using the protruding end of the gage calibration block supplied with the gage. This end of the gage block is usually also marked M. Slip the calibration block into the outer bushing so that this bushing comes to rest on the outer flat area of the calibration block. When the connector is measured, this outer bushing will rest on the outer conductor mating plane inside the connector. Follow the instructions for zeroing the gage given in Part One of this **Microwave Connector Care Manual**.

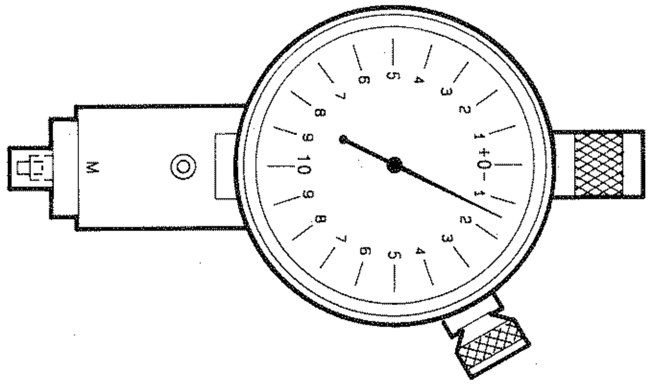
To gage male SMA and precision 3.5mm connectors, center the gage carefully relative to the connector before inserting it. As you insert the gage, be sure that the male contact pin slips into the hole for this purpose in the gage plunger, as it will if the gage is exactly centered in the connector. This is required to give the correct center conductor measurement for male connectors: the position of the shoulder of the male contact pin (not the tip) relative to the outer conductor mating plane. 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.

Female SMA and Precision 3.5mm Connectors. Gages used to measure female SMA and precision 3.5mm connectors are usually marked F and are zeroed using the flat end of the calibration block supplied with the gage (Figure 28). This end of the gage block is usually marked F. When the connector is measured, the gage plunger comes to rest on the outer end of the female contact fingers.

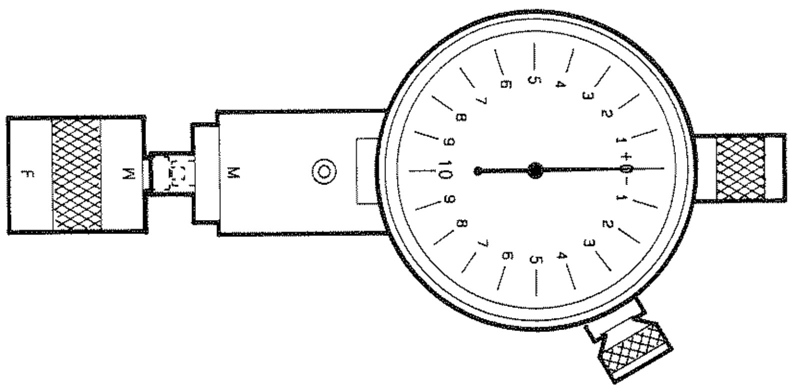
Gaging female SMA and precision 3.5mm connectors is done in the same way as it is for male connectors.

MALE SMA AND PRECISION 3.5mm CONNECTORS

- Use male connector gage (has circular bushing).



- Zero gage using protruding end of gage calibration block.



- Insert gage into connector.
  Male pin slips into gage plunger.

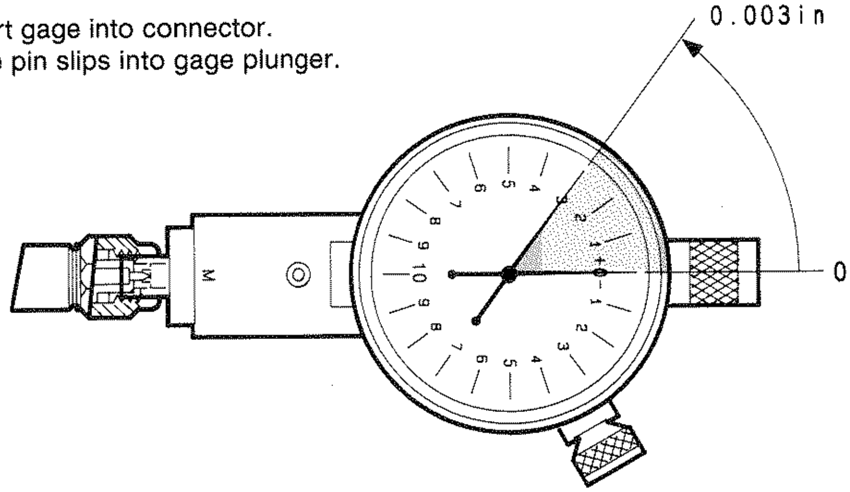
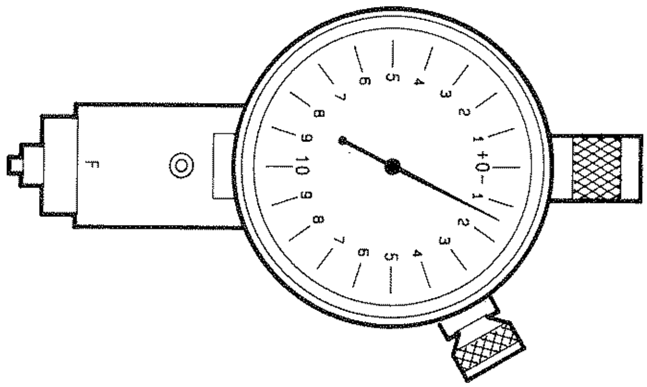


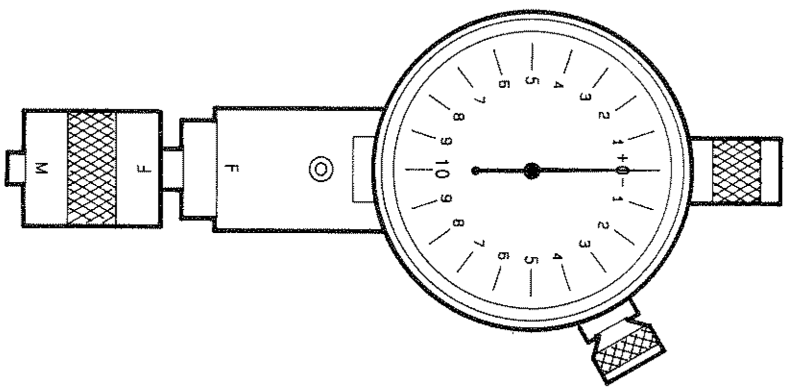
Figure 28. Gaging SMA and Precision 3.5mm Connectors (1 of 2)

FEMALE SMA AND PRECISION 3.5mm CONNECTORS

- Use female connector gage (has no circular bushing).



- Zero gage using flat end of gage calibration block



- Insert gage into connector.
  Plunger rests on end of female contact fingers.

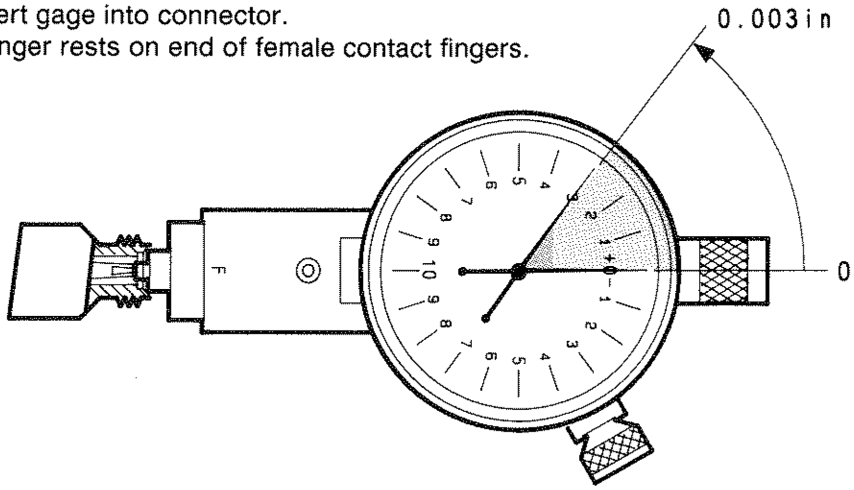


Figure 28. Gaging SMA and Precision 3.5mm Connectors (2 of 2)