Corso di Misure a Microonde

Connettori

Prof. Luca Perregrini

Dipartimento di Elettronica, Università di Pavia
e-mail: luca.perregrini@unipv.it, web: microwave.unipv.it

Sommario

- A cosa servono?
- Perché tanti tipi diversi di connettori?
- Caratteristiche di alcune famiglie di connettori
- Cura dei connettori
- Montaggio dei connettori

A cosa servono?

I connettori servono a collegare dispositivi e circuiti realizzati separatamente.

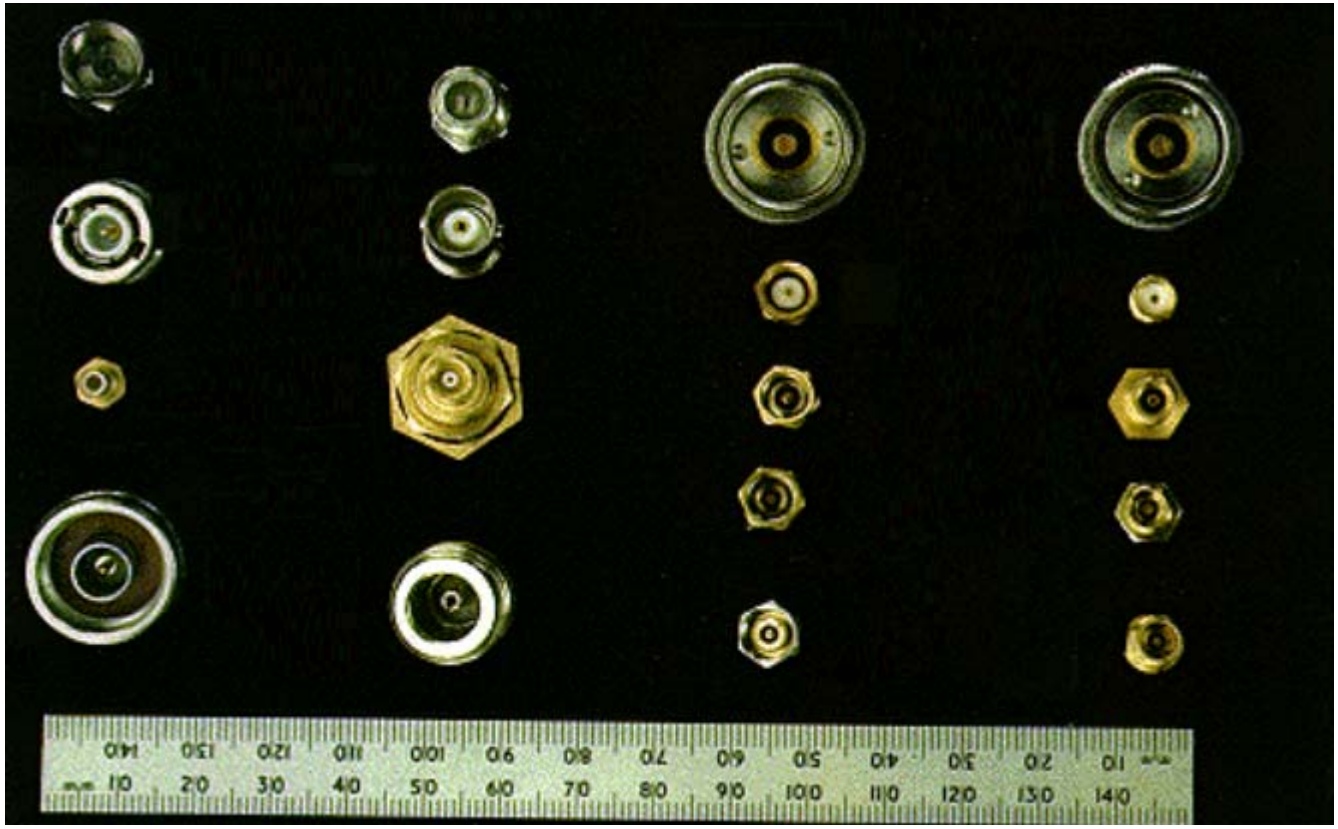
Rappresentano un fattore importante (a volte determinante) nella ripetibilità e accuratezza della misura

Ogni costruttore può utilizzare standard d'interconnessione proprietari (cioè specificatamente realizzati da lui)

Tuttavia, per garantire la compatibilità dei circuiti con quelli realizzati da altri, si utilizzano generalmente connettori appartenenti a particolari famiglie, il cui standard è universalmente accettato.

Famiglie di connettori

BNC, SMB, OSMT, OSX, MCX, PCX, MMCX, SMC, SMA, TNC, N, APC-7, 7mm, OSP, 3.5mm, OSSP, SSMA, 2.92mm, K, GPO, OSMP, SMP, OS-50P, 2.4mm, 1.85mm, V, 1mm, …



Perché tanti tipi di connettori?

Ciascuna famiglia presenta caratteristiche diverse in termini di:

- frequenza massima di utilizzo
- potenza massima sopportabile
- prestazioni (perdita d'inserzione/adattamento)
- impedenza (50Ω/75Ω)
- robustezza meccanica
- durata (cicli di connessione/disconnessione)
- semplicità/rapidità d'interconnessione

Rassegna delle varie tipologie

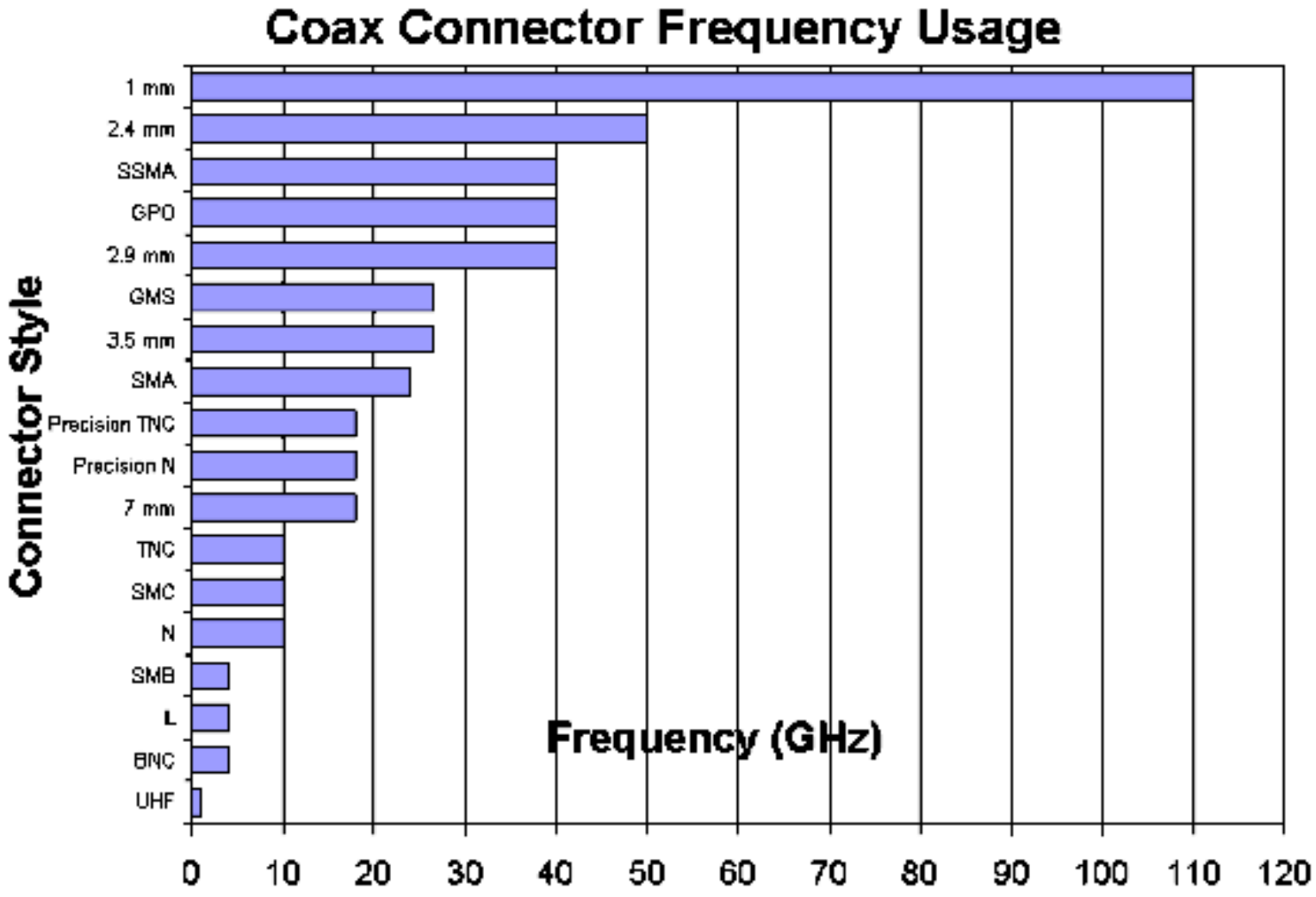
Connector type	Frequency Limit	Dielectric	Comments and history
BNC	4 GHz	PTFE	"Bayonet type-N connector", or "Bayonet Neill-Concelman" according to Johnson Components. Developed in the early 1950s at Bell Labs. Could also stand for "baby N connector".
SMB	4 GHz	PTFE	"Sub-miniature type B", a snap-on subminiature connector, available in 50 and 75 ohms.
OSMT	6 GHz	PTFE	A surface mount connector
OSX, MCX, PCX	6 GHz	PTFE	MCX was the original name of the Snap-On"micro-coax" connector species. Available in 50 and 75 ohms.
MMCX		PTFE	Micro-miniature coax connector, popular in the wire industry because its small size and cheap price.
SMC	10 GHz	PTFE	Sub-miniature type C, a threaded subminiature connector, not widely used.
SMA	12.4 GHz	PTFE	Sub-miniature type A developed in the 1960s, perhaps the most widely-used microwave connector system in the universe.
TNC	15 GHz	PTFE	"Threaded Neill-Concelman" connector, according to Johnson Components, or simply "threaded N connector". Not used much today. Carl Concelman was an engineer at Amphenol.
N	11 GHz normal 18 GHz precision	PTFE	Named for Paul Neill of Bell Labs in the 1940s, available in 50 and 75 ohms. Cheap and rugged, it is still widely in use. Originally was usable up to one GHz, but over the years this species has been extended to 18 GHz, including work by Julius Botka at Hewlett Packard.
APC-7, 7 mm	18 GHz	PTFE	APC-7 stands for "Amphenol precision connector", 7mm. Developed in the swinging 60s, ironically a truly sexless connector, which provides the lowest VSWR of any connector up to 18 GHz.

PTFE = politetrafluoroetilene
E' il polimero del tetrafluoroetene. Normalmente è più conosciuto attraverso le sue denominazioni commerciali **Teflon**, Fluon, Algoflon, Hostaflon.

Rassegna delle varie tipologie

Connector type	Frequency Limit	Dielectric	Comments and history
OSP	22 GHz	PTFE	OSP stands for "Omni-Spectra push-on", a blind-mate connector with zero detent. Often used in equipment racks.
3.5 mm	26.5 GHz	Air	A precision (expensive) connector, it mates to cheaper SMA connectors.
OSSP	28 GHz	PTFE	OSP stands for "Omni-Spectra subminiature push-on", a smaller version of OSP connector.
SSMA	38 GHz	PTFE	Smaller than an SMA.
2.92 mm	40 GHz	Air	Precision connector, developed by Mario Maury in 1974. 2.92 mm will thread to cheaper SMA and 3.5 mm connectors. Often called "2.9 mm".
K	40 GHz	Air	The original mass-marketed 2.92 mm connector, made by Wiltron (now Anritsu). Named the "K" connector, meaning it covers all of the K frequency bands.
GPO, OSMP, SMP	40 GHz	PTFE	"Gilbert push-on", "Omni-spectra microminiature push-on"
OS-50P	40 GHz		Smaller version of OSP blind-mate connector.
2.4 mm	50 GHz	Air	2.4 mm, and 1.85 mm will mate with each other without damage. Developed by Julius Botka and Paul Watson in 1986, along with the 1.85 mm connector.
1.85 mm	60 GHz	Air	Mechanically compatible with 2.4 mm connectors.
V	60	Air	Anritsu's term for 1.85 mm connectors because they span the V frequency band.
1 mm	110 GHz	Air	The Rolls Royce of connectors. This connector species works up to 110 GHz. It costs a fortune! Developed at Hewlett Packard (now Agilent) by Paul Watson in 1989.

Frequenza massima di utilizzo



Connettore tipo “BNC” e “TNC”

The "Bayonet Neil-Concelman" or "Bayonet Navy Connector" or "Baby Neil Connector", depending on the information source. Karl W. Concelman is believed to have created the "C“ connector. The BNC was designed for military use and has gained wide acceptance in video and RF applications to 2 GHz. The BNC uses a slotted outer conductor and some plastic dielectric on each gender connector. This dielectric causes increasing losses at higher frequencies. Above 4 GHz, the slots may radiate signals, so the connector is usable, but not necessarily mechanically stable up to about 10 GHz. Both 50 ohm and 75 ohm versions are available.

A threaded version (TNC) helps resolve leakage and geometric stability problems, permitting applications up to 12 GHz. The specifications for N, BNC and TNC connectors are found in MILC-39012. There are special "extended frequency" versions of the TNC that adhere to the IEC 169-17 specification for operation to 11 GHz or 16 GHz, and the IEC 169-26 specification that operate mode-free to 18 Ghz (but with significant losses).

The TNC connector is in wide use in cellular telephone RF/antenna connections. Because the mating geometries are compatible with the N connector, it is possible to temporarily mate some gender combinations of BNC and N. This is not a recommended use because the connection is not mechanically stable, and there will be significant impedance changes at the interface.

Connettore tipo “N”

The Type N 50 ohm connector was designed in the 1940s for military systems operating below 5 GHz. One resource identifies the origin of the name as meaning "Navy". Several other sources attribute it to Mr. Paul Neil, an RF engineer at Bell Labs.
The Type N uses an internal gasket to seal out the environment, and is hand tightened. There is an air gap between center and outer conductor. In the 1960s, improvements pushed performance to 12 GHz and later, mode-free, to 18 GHz. Hewlett Packard, Kings, Amphenol, and others offer some products with slotless type-N outer conductors for improved performance to 18 GHz. Type-N connectors follow the military standard MIL-C-39012.
Even the best specialized type-N connectors will begin to mode around 20 GHz, producing unpredictable results if used at that frequency or higher. A 75 ohm version, with a reduced center pin is available and in wide use by the cable-TV industry.
These are cheap and rugged, for these reasons you will find them all over your laboratory.

Connettore tipo “SMA”

The SMA (sub-miniature A) connector is the workhorse of the RF and microwave industries. The basic design uses a 4.2 millimeter diameter outer coax, filled with PTFE dielectric. About a zillion companies make SMA-style connectors. Their upper frequency limit is anywhere from 18 to 26 GHz, depending on the tolerances held during manufacturing. SMAs, like many other coax connector families, are sized to fit a 5/16 inch wrench.

SMA connectors will mate with 3.5mm and 2.92mm connectors. However, you should always inspect and gage an SMA connector that you will be mixing with the more expensive connectors to be sure that you don't damage them.

As you can see from the SMA female photo, SMA connectors can be supplied with gold plated threads. This is not always a good thing, because cheap gold plating can flake off of connectors and cause you severe headaches. The best connectors use stainless steel on their outer jackets.

What about SSMA connectors? They work up to a higher frequency (from 26 GHz up to 40 GHz) than SMA because they have a smaller geometry (about 70% size). They are more expensive. And they suck because they generally can't handle the normal torque used in loosening and tightening them.

SMA male

SMA female

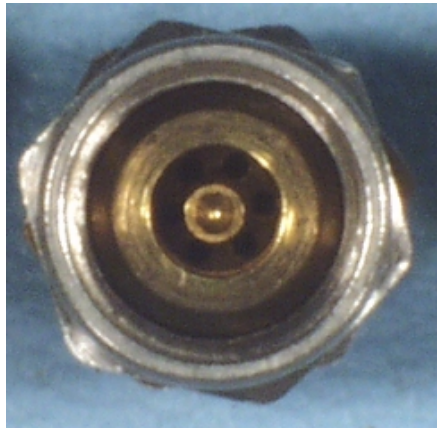
Connettore tipo “APC-7”

The APC-7 (Amphenol Precision Connector - 7 mm) offers the lowest reflection coefficient and most repeatable measurement of all 18 GHz connectors. Development of this connector was a joint effort between HP and Amphenol which began in the early 1960s. This is a sexless design and is the preferred connector for the most demanding applications, notably metrology and calibration. These connectors are designed to perform repeatably for thousands of interconnect cycles as long as the mating surfaces are kept clean.
You will find these connectors on the front of some network analyzers.
Adapters are available to SMA, N, Waveguide and other precision connections.

Connettore tipo “3.5mm” e “2.92mm” (“K”)

These three connector styles use air dielectric, and will mate with each other as well as the cheaper SMA styles. The 3.5 mm connector is the next upgrade from using SMA, it performs well up to 26 GHz. The 2.92 mm connector (often called simply "2.9 millimeter") works up through 40 GHz. The K-connector is Anritsu's version of the 2.92 mm connector.
As you can see from the pictures below, the outer diameter of the coax decreases slightly from 3.5 to 2.92 mm coax. After a while you will be able to identify the different species of connectors by looking into them to see the relative sizes of the outer diameter.

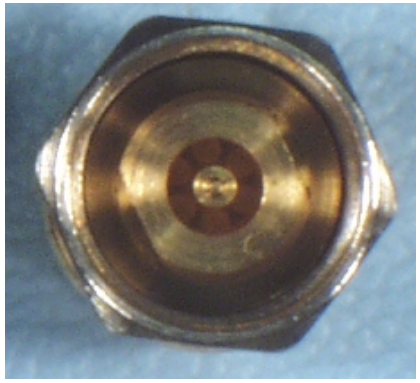
3.5 mm male connector



2.92 mm male connector

Connettore tipo “2.4mm” e “1.85mm” (“V”)

The 2.4 and 1.85 connectors are mechanically compatible with each other, but neither one will thread onto an SMA, 3.5 or 2.92 mm connector. This is on purpose, so you won't mix these expensive connectors in with less precise connectors such as SMA and cause them irreparable harm.
The 1.85 connector is often called the "V connector". Both the 2.4 and 1.85 mm connector require a 5/16 inch wrench.
The price keeps climbing as you go up in frequency. A V-connector can cost $500!



2.4 mm male connector

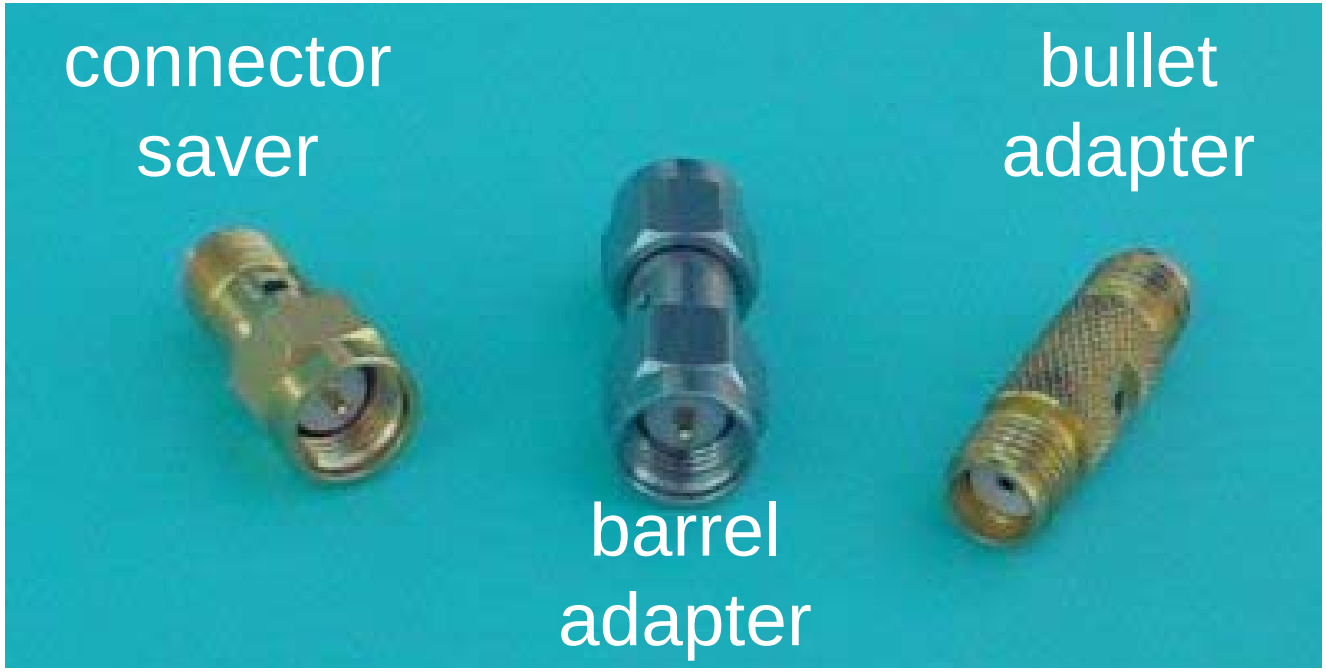
1.85 mm (V) male connector

Connettore tipo “1mm”

An HP (now Agilent) development, this 1.0 mm connector supports transmission and repeatable interconnections from DC to 110 GHz. Laboratory instrumentation technicians and engineers are beginning to use the 1.0 mm for millimeter-wave analysis. This connector is also often used on semiconductor probe stations for the evaluation of millimeter-wave RF MMICs. The use of coaxial connections greatly simplifies what would otherwise require several sets of waveguide-based measurements to a single step.

Adattatori

Within any connector family there are three adapters you can use. A male-to-male adapter refers to an adapter with two male ends. This is often referred to as a "barrel" adapter. A female-to-female adapter has two female ends; it is often referred to as a "bullet" adapter. An adapter with one male end and one female end is often referred to as a "connector saver". This is because this type of adapter is often screwed onto an expensive piece of test equipment or component that requires a lot of connect/disconnect cycles. If an incident occurs where one of the connectors is damaged, it is far cheaper to throw away and replace the connector saver than to repair expensive equipment that it is protecting.



Adattatori

Between species adapters are a huge part of the RF connector industry. For sake of argument, if we accept that there are 10 different connector species (and there are a whole lot more than 10), and each has two sexes, there are 20+19+18+17+16+... different permutations, which adds up to 210 total! This is why connector catalogs are so thick. Of course, there are some permutations that would have a limited market, so they are deleted from the lineup. For example, no one is going to buy a 1 mm to type BNC adapter.

Cura dei connettori

Your connectors and adapters cost someone a lot of money.

Show some respect!

Read below so you'll know how to treat connectors so they'll have a long and productive life.

1. Don't use pliers on a "stuck" connector for any reason. There are wrenches for every size adapter, even SMA bullets. If you can't fit a wrench to your stuck connector, see below.
2. Learn how to clean connectors with alcohol and cotton swabs. Cleaning the threads is good practice, but stay away from cleaning the center conductor of an air dielectric connectors such as 3.5mm, 2.9mm and 2.4mm.
3. Learn how to gage connectors to determine if they are out of spec. One bad connector can damage many.
4. Don't use higher frequency connector than you need. Save the 2.9mm and 2.4mm parts for millimeter-wave measurements.
5. Never use any part of a calibration kit as an adapter. Ever. If you need a special adapter, buy it, borrow it or steal it, but not from the cal kit.
6. Use a torque wrench. For most connectors with 5/16 inch hex nuts, use 6-8 inch-pounds. It's OK to use less torque, but not more.
7. Remember, righty-tighty, lefty-losey! The total damage done by people turning stuff in the wrong direction is second only to damage caused by klutzes who "thumb" hybrids.
8. Remember, you are not tightening lug nuts. The hardware you hold in your hands could very well be worth more than your automobile. So be gentle with it. Pretend it is made of eggshells and filled with explosives!
9. When you are tightening or loosening a connector, try not to spin the mating surfaces against each other. You should only be turning the threaded sleeve. Turning the mating surfaces means you are wearing out the connector for no reason.

Cura dei connettori

Storage

Do

- Keep connectors clean
- Extend coupling sleeve on 7mm connectors
- Use dust caps during storage

Don't

- Don't touch mating-plane surfaces
- Don't set connectors contact-end down
- Don't store connectors with common hardware
- Don't keep connectors in your pocket

Cura dei connettori

Cleaning

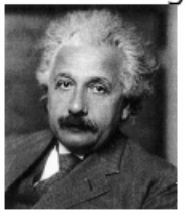
Do

- Use clean compressed air
- Use swabs and isopropyl alcohol
- Clean connector threads

Don't

- Don't use any solvent but isopropyl alcohol
- Don't use any abrasives
- Don't apply pressure to male ends of precision connectors
- Don't soak connectors in any liquid

Cura dei connettori

Inspection	
Do • Inspect all connectors before every connection • Look for metal particles, scratches, and dents • Discard and replace damaged connectors 	**Don't**  • Don't use a damaged connector, ever!

Cura dei connettori

Calibration	
Do  • Gauge all connectors before first use • Use the correct gauge and calibration block • Clean and zero gauges each time used	**Don't** • Don't use (or even keep!) an out-of-spec connector • Don't use a calibration standard as an adapter, ever! 

Cura dei connettori

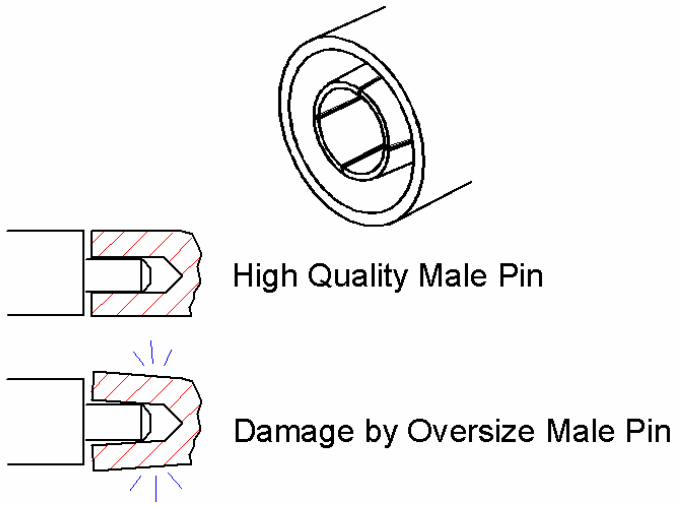
Connection	
Do	**Don't**
	
• Tighten connectors with a torque wrench • Use soft-jaw pliers to remove stuck connectors	• Don't tighten connectors with common pliers • Don't ever exceed 8 inch-ounces torque

Cura dei connettori

I connettori sono materiale di consumo:

- hanno una vita limitata
- possono essere anche molto costosi
- l'uso di connettori fuori specifica può danneggiarne molti altri
- un'adeguata cura ne massimizza la durata

Item	Replacement Cost ($)
3.5 mm Sliding Load	2,000.00
2.4 mm Sliding Load	2,200.00
2.4 mm Flexible Cable	1,600.00
8515A Test Port	1,000.00
2.4 mm PSC Short	550.00
3.5 mm PSC Short	340.00



Esempio di montaggio su cavo

Assembly instruction Series SMA 0000178687

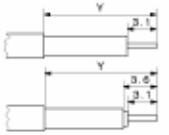
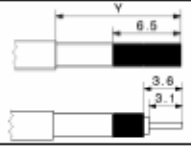
Connector type: (e.g.)		Suitable cables:
11 SMA-50-2-15 11 SMA-50-2-65	15 SMA-50-2-1 11 SMA-50-2-165	EZ-86 , SM-86 , MF-86
11 SMA-50-3-15 11 SMA-50-3-65	11 SMA-50-3-34	EZ-141 , SM 141 , MF-141

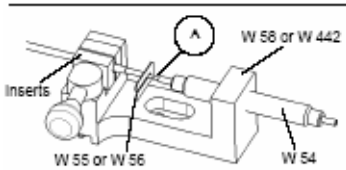
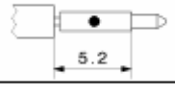
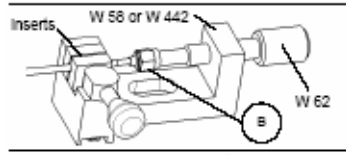
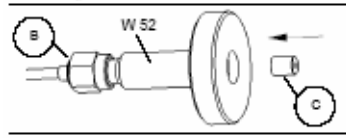
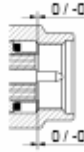
Inner conductor contact:	Soldered
Outer conductor contact:	Soldered

Parts list connector:

Note 1
If it is not possible to fullfill the electrical requirements, leave dimension 3,6 out (same stripping dimension like the EZ cables).
CAUTION: Without this aditional shoulder, we recommend to test 100 % for short circuit.

Assembly steps:

Picture	Process	Feature / Check	Tools required
	For EZ and SM cables The tool must be set for a stripping dimension X. EZ cable : X = 3.1mm SM cable : X = 3.6mm	Cut cable end perpendicular to cable axis.	Stripping tool W 157. See instruction sheet No. 9144 for detailed description.
 EZ cable SM cable	Remove dielectric according to diagram. Dimension Y applies to cables with jacket. Deburr centre contact. For 11 SMA types : Y = 12mm For 15 SMA types : Y = 17mm	Do not damage centre contact, dielectric and braid. If a SM cables is used see note 1.	Blades (74 Z 0-0-68) Tip trimmer tool W 164.
 MF cable	For Multiflex 141 Dive the on length cutted cable in flux and tin. Cut in jacket until screen. Remove jacket. Remove cable dielectric and tinned braid according to diagram. For 11 SMA types : Y = 12mm For 15 SMA types : Y = 17mm	The solder must flow at behind for min. 6.5 mm. If the cable does not fit into the cable entry, use a flat-nose plier to calibrate the outer contact. See note 1.	Activated rosin flux Solder Blades (74 Z 0-0-68) Flat-nose plier

	Push contact A onto contact holder W 54. Fix cable in soldering fixture W 58. Place soldering gauge on centre contact. Flow small amount of solder into bore of contact. Push contact holder against soldering gauge and solder.	Clean contact A and cable dielectric. Remove excess solder. Check dimension 5.2mm. 	Soldering iron, Solder Activated rosin flux Gauge W56: EZ,MF,SM-86 (0.4) Gauge W55: EZ,MF,SM-141(0.25) Contact holder W 54. Soldering fixture W58, W442 Inserts W 60 (EZ or SM-86) Inserts W 364 (MF-86) Inserts W 59 (EZ or SM-141) Inserts W 365 (MF-141)
	Slide body B over cable. Push body B completely against locator tool W 62. Solder body B to cable.	Avoid excessive heat. Promptly swap soldered area with alcohol to cool joint and remove any residual flux.	Soldering iron, Solder Activated rosin flux Alcohol and brush Locator tool W 62 Soldering fixture W58, W442 Inserts as described above
	Screw dielectric insert tool W 52 onto connector. Place insulator C in rear opening of insert tool and press fully through insert tool into connector.	Press in insulator until stop	Dielectric insert tool W 52
	Check interface dimension.	Distance shoulder of pin and insulator to reference plane.	

The cable assembly of R.F. connectors can only be done by well trained assembly stuff and suitable assembly equipment.
Huber+Suhner's skilled stuff and specialised equipment are available to carry out complete R.F. lead-assembly on your behalf.
We mount your connectors on cables at economic prices! Please contact our representative for further details of this service.

Revision	C
Date	26.03.04
Initiator	4186/MAP

Old Assembly instruction No. : **09056**

Deutscher Text: siehe Rückseite