ANAMET REPORT

ANAMET Report 015
February 1998

Guidance on using coaxial connectors in measurement - Draft for comment

A D Skinner

ANAMET reports are produced by, and for, the members of ANAMET. They are intended for fast dissemination of technical information for discussion purposes and do not necessarily represent an official viewpoint. No responsibility is accepted by the author(s) or ANAMET for any use made of the information contained in this report.

For further information about ANAMET and its activities contact:

internet: **http://www.npl.co.uk/npl/collaboration/clubs/anamet/index.html**

e-mail: **anamet@npl.co.uk**

Comments on this report should be sent to:

mail: **ANAMET**
Building 72
National Physical Laboratory
Queens Road
Teddington
Middlesex
TW11 0LW

fax: **0181 943 6037 (UK)**
+44 181 943 6037 (elsewhere)

This report has been approved by the ANAMET Steering Committee.

GUIDANCE ON USING COAXIAL CONNECTORS IN MEASUREMENT

DRAFT FOR COMMENT

Foreword

This report contains a draft version of a document giving guidance on the use of coaxial connectors in measurement. The document was circulated at the ANAMET seminar "What's the best method for calibrating an ANA?", which took place at Hewlett Packard Ltd, South Queensferry, on the 19th and 20th November 1997, and was used as the text to accompany the presentation "Calibration - some good practice tips" given by Doug Skinner.

The draft document has been issued as an ANAMET Report to invite comment from the ANAMET community on its contents and potential application. ANAMET will welcome any comments, opinions and suggestions on this draft of the document. These will be sent to the author of the Report and a selection may also be published in the next issue of ANAMET News.

It should be emphasised that this document must be considered as a draft version. The eventual aim will be to publish an updated version taking into account the comments received on this draft. It is anticipated that such a document will prove to be very useful to the ANAMET membership as well as the wider RF and microwave measurement community.

Nick Ridler
ANAMET Technical Advisor

February 1998

GUIDANCE ON USING COAXIAL CONNECTORS IN MEASUREMENT

DC, Low Frequency
Radio Frequency, Microwave
Millimetre wave

Compiled by . Doug Skinner (Head of Metrology Marconi Instruments Ltd.)

COAXIAL CONNECTORS USED IN DC, LOW FREQUENCY, RADIO FREQUENCY AND MICROWAVE MEASUREMENTS

INTRODUCTION

The requirement for 'Traceability to National Standards' for measurements throughout industry may depend on several different calibration systems 'seeing' the same values for the parameters presented by a device at its coaxial terminals. Connector repeatability determines how precisely this is achieved on each and every occasion.

The importance of the correct use of connectors not only applies at Radio and Microwave frequencies but also at DC and Low frequency. It is of vital importance to note that mechanical damage can be inflicted on a connector when connections and disconnections are made at any time during its use.

The simple concept of a coaxial connector comprises an outer conductor body or contact, an inner conductor contact, and means for mechanical coupling to a cable and/or to another connector. Most connectors, and particularly the general purpose types, comprise plugs and sockets. Some connectors are hermaphroditic, particularly the precision types, in which any two connectors may be mated. Precision connectors essentially have planar butt contacts.

Precision connectors are principally employed for measurement standards and calibration applications. General purpose connectors are employed for interconnection of components and cables in military, space, industrial and domestic applications.

In precision or hermaphroditic connectors, the reference plane is common to both outer and inner conductors. The mechanical and electrical reference planes coincide and, in the case of the precision connectors, a physically realised reference plane is clearly defined.

The choice of connectors, from the range of established designs, must be appropriate to the proposed function and specification of the device or measurement system; repeatability of the inter-connection is generally the most important parameter.

CONNECTOR REPEATABILITY

Connectors in use on test apparatus and measuring instruments at all levels need to be maintained in pristine condition in order to retain the performance of the test apparatus.

Connector repeatability can be greatly impaired through careless assembly, handling, poor storage, unclean working conditions, misalignment, and overtightening forces etc. In extreme cases, permanent damage can be caused to the connectors concerned and possibly to other originally sound connectors to which they are coupled.

Connectors should never be rotated relative to one another when being connected and disconnected. Special care should be taken to avoid rotating the mating plane surfaces against one another

Repeatability assessment

In a particular calibration system, repeatability of the coaxial interconnections of the system can be assessed from measurements of the device after repeatedly disconnecting and reconnecting it. It is clearly necessary to ensure that all the other conditions likely to influence the measured value are maintained as constant as possible. The number of repetitions must be at least 5, but preferably 10 or more, to be statistically valid.

The repeatability determination will normally be carried out when trying to achieve the best measurement capability on a particular device, or when initially calibrating a measuring system.

Repeatability of the insertion loss of coaxial connectors introduces a major contribution to the random component of uncertainty in a measurement process. If a measurement involving connectors is repeated several times, the random uncertainty deduced from the results will include that arising from the connector repeatability if the connection concerned is broken and remade at each repetition. It should be remembered that a connection has to be made at least once when connecting an item under test to the test equipment and this gives rise to a random component of uncertainty associated with the repeatability. When making repeatability tests where there is no keyway to hold the connectors in a fixed position then one connector should be rotated relative to the other (approx 60°) before being reconnected.

Experience has shown that there is little difference in performance between precision and ordinary connectors (when new) so far as the repeatability of connection is concerned, but with many connections and disconnections the ordinary connector performance will become progressively worse when compared with the precision connector.

STANDARD SPECIFICATIONS FOR COAXIAL CONNECTORS

The following specifications define the parameters of established designs of coaxial connectors and should be consulted for full information on electrical performance, mechanical dimensions and tolerances.

IEEE 287- 1968
IEC Publication 457
MIL-C-39012 C dated 11th August 1982
IEC Publication 169
CECC 22000
British Standard 9210

INTERFACE DIMENSIONS AND GAUGING

It is of the utmost importance that connectors do not damage the test equipment interfaces to which they are offered for calibration. Poor performance of many coaxial devices and cable assemblies can often be traced to non-compliance with the mechanical specification.

When to gauge Connectors

A Connector should be gauged before it is used for the very first time or if someone else has used the device on which it is fitted.

If the connector is to be used on another item of equipment. The connector on the equipment to be tested should also be measured.

Connectors should never be forced together when making connection since forcing often indicates incorrectness and incompatibility. Many connector screw coupling mechanisms, for instance, rarely need to be more than hand tight for electrical calibration purposes; most coaxial connectors usually function satisfactorily, giving adequately repeatable results, unless damaged. There are some dimensions that are critical for the mechanical integrity, non-destructive mating and electrical performance of the connector.

This means that all coaxial connectors fitted on all equipment, cables and terminations etc. should be gauged on a routine basis in order to detect any out of tolerance conditions that may impair the electrical performance.

Connector gauge kits are available for many connector types but it is also easy to manufacture simple low cost test pieces for use with a micrometer depth gauge or other device to ensure that the important dimensions can be measured or verified.

The gauging of connectors will detect and prevent the following problems:

a. Interference mating.

This may result in buckling of the female contacts or damage to the internal structure of a device due to the axial forces generated.

b. Excessive gap.

This will result in poor voltage reflection coefficient, possibly unreliable contact and could even cause breakdown under peak power conditions.

Appendix A gives a list of the most common types of coaxial connector in use in Industry.

Appendix B gives a list of the critical mechanical dimensions which need measuring for these connectors.

CONNECTOR CLEANING

To ensure a long and reliable connector life, careful regular inspection and if necessary cleaning of connectors is essential.

Connectors should be inspected initially for dents, raised edges, and scratches on the mating surfaces. Connectors that have dents on the mating surfaces will usually also have raised edges around them and will make less than perfect contact; further to this, raised edges on mating interfaces will make dents in other connectors to which they are mated. Connectors should be replaced unless the damage is very slight.

Awareness of the advantage of ensuring good connector repeatability and its effect on the overall uncertainty of a measurement procedure should encourage careful inspection, interface gauging and handling of coaxial connectors.

Prior to use a visual examination should be made of a connector or adaptor, particularly for concentricity of the centre contacts and for dirt on the PTFE dielectric. It is essential that the axial position of the centre contact of all items offered for calibration should be gauged because the butting surfaces of mated centre contacts must not touch. If the centre contacts do touch, there could be damage to the connector or possibly to other parts of the device to which the connector is fitted.

Small particles, usually of metal, are often found on connector mating planes, threads, inside of the connector and on the dielectric.

It is recommended that the procedure below is followed for connector cleaning.

The recommended items required for cleaning connectors are :

a. Low pressure compressed air (solvent free)

b. Cotton swabs

c. Lint free cleaning cloth

d. Isopropanol

e. Illuminated Magnifier

Note:

Isopropanol that contains additives should not be used for cleaning connectors as it may cause damage to plastic dielectric support beads in coaxial and microwave connectors. It is important to take any necessary safety precautions when using chemicals or solvents.

Cleaning procedure

First Step.

Remove loose particles on the mating surfaces and threads etc. using low pressure compressed air.

Second Step.

Clean surfaces using Isopropanol on cotton swabs or lint free cloth. Use only sufficient solvent to clean the surface. When using swabs or lint free cloth, use the least possible pressure to avoid damaging connector surfaces. Do not spray solvents directly on to connector surfaces or use contaminated solvents.

Third Step.

Use the low pressure compressed air once again to remove any remaining small particles and to dry the surfaces of the connector to complete the cleaning process before using the connector.

Cleaning connectors on static sensitive devices.

Special care is required when cleaning connectors on test equipment containing static sensitive devices. When cleaning such connectors always wear a grounded wrist strap and observe correct procedures. The cleaning should be carried out in a special handling area. These precautions will prevent electrostatic charge (ESD) and possible damage to circuits.

CONNECTOR LIFE

The number of times that a connector can be used is very difficult to predict and it is quite clear that the number of connections and disconnections that can be achieved is dependent on the environmental conditions and the care taken when making a connection. Connectors which are made using stainless steel have a superior performance and a longer useful life.

For many connector types the manufacturer's specification will quote the number of connections and disconnections that can be made. The figure quoted may be as high as >5000 times but this figure assumes that the connectors are maintained in pristine condition and correctly used. The type SMA connector, for example, was originally designed to be used within equipment in order to join two items together and its connector life is therefore relatively short in repetitive use situations.

However, by following the guidance given in this document it should be possible to maximise the lifetime of a connector used in the laboratory

ADAPTORS

Buffer adaptors or 'connector savers' can be made use of in order to reduce possible damage to output connectors on signal sources and other similar devices. It should be remembered that the use of buffer adaptors and connector savers may have an adverse effect on the performance of a measurement system and may result in significant effects on uncertainty budgets.

Use adaptors for the following reasons

To reduce wear on expensive or difficult to replace connectors.

When measuring a coaxial device that has an SMA connector.

SMA connectors are

Not precision connectors

Not designed for repeated connections and are quickly worn out

Often out of specification and therefore potentially destructive

CONCLUSIONS

The importance of the interconnections in measurement work should never be under estimated and the choice of or the replacement of a connector may enable the random uncertainty contribution in a measurement process to be reduced significantly. Careful consideration must be given, when choosing a connector, to select the correct connector for the measurement task. In modern measuring instruments, such as power meters, spectrum analyzers and signal generators the coaxial connector socket on the front panel is often an integral part of a complex subassembly and any damage to this connector may result in a very expensive repair.

It is particularly important when using coaxial cables, with connectors which are locally fitted or repaired, that they are tested before use to ensure that the connector complies with the relevant mechanical specification limits. Even new cables, which are obtained from specialist manufacturers, should be tested before use.

Any connector which does not pass the relevant mechanical tests should be rejected and replaced.

APPENDIX A

FREQUENCY RANGE OF COMMON COAXIAL CONNECTORS

The tables below list common types of coaxial connectors and the frequency range over which they are often used.

Title	Line Size	Impedance	Frequency Range
GPC14,	14mm	50Ω	dc to 8.5GHz
GPC14	14mm	75Ω	dc to 2.0GHz
GPC7	7mm	50Ω	dc to 18GHz

Table 1 PRECISION (Standards IEEE 287 and IEC 457 apply)

Title	Line Size	Impedance	Frequency Range
GPC 3.5	3.5mm	50Ω	dc to 34GHz
MIGPC 3.5	3.5mm	50Ω	dc to 31GHz
Type K	2.92mm	50Ω	dc to 46GHz
Type Q	2.4mm	50Ω	dc to 60GHz
Type V	1.85mm	50Ω	dc to 75GHz
Type ?	1.1mm	50Ω	dc to 110GHz
Type W	1.0mm	50Ω	dc to 110GHz

Table 2 SEMI PRECISION

Title	Line Size	Impedance	Frequency Range
Type N	7mm	50Ω	dc to 18GHz
Type N	7mm	75Ω	dc to 3GHz
SMA	3.5mm	50Ω	dc to 26GHz

Table 3 ORDINARY (MIL-C-39012, CECC 22000 and BS 9210 apply.)

APPENDIX B

THE 14 MILLIMETRE PRECISION CONNECTOR

The 14mm precision connector was developed in the early 1960s by the General Radio Company and is known as the GR900 connector. It has seen limited usage and is primarily used in primary standards laboratories and in military metrology. It is the best coaxial connector ever built in terms of its performance and it has low insertion loss, low reflection and extremely good repeatability. However, it is bulky and expensive.

The interface dimensions for the GPC14 connector are given in IEEE Standard 287 and IEC Publication 457.

Before calibration, a visual examination, particularly of the centre contacts should be made. Contact in the centre is made through sprung inserts and these should be examined carefully. A flat smooth disc pressed against the interface can be used to verify correct functioning of the centre contact. The disc must fit inside the castellated coupling ring which protects the end surface of the outer connector and ensures correct alignment of the two connectors when mated. This is the only mechanical testing that needs to be carried out on GR 900 precision conductors.

There are 50Ω and 75Ω versions of the GR900 connector available

The GR900 connector is made in two types

LPC	**Laboratory precision connector**	**Air dielectric**
GPC	**General precision connector**	**Dielectric support**

There is also a lower performance version of the GR900 connector designated the GR890. It can be identified by the marking on the locking ring and it has a much reduced frequency range of operation e.g. 3GHz approx.

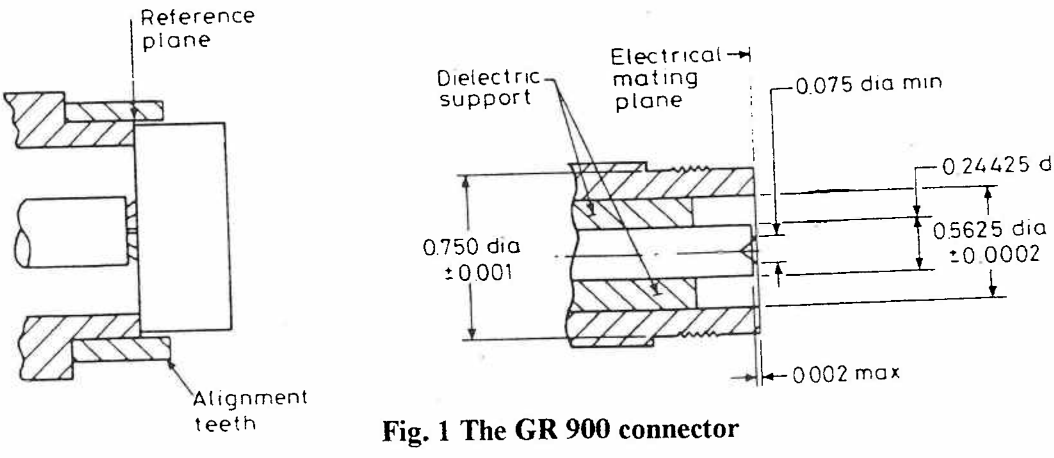

Fig. 1 The GR 900 connector

THE 7 MILLIMETRE PRECISION CONNECTOR

This connector series was developed to meet the need for precision connectors for use in laboratory measurements over the frequency range dc to 18GHz. This connector is known as the Type GPC 7 connector and it is designed as an hermaphroditic connector with an elaborate coupling mechanism. The connector interface features a butt co-planar contact for the inner and outer contacts, with both the mechanical and electrical interfaces at the same location.

The connectors is made in two types

LPC	**Laboratory precision connector**	**Air dielectric**
GPC	**General precision connector**	**Dielectric support**

A feature of the GPC7 connector is its ruggedness and good repeatability over multiple matings in a laboratory environment.

The interface dimensions for the GPC7 connector are given in IEEE Standard No. 287 and IEC 457. The most common connector of this type in the UK has a centre contact comprising a slotted resilient insert within a fixed centre conductor. The solid part of the centre conductor must not protrude beyond the planar connector reference plane, although the resilient inserts must protrude beyond the reference plane. However, the inserts must be capable of taking up co-planar position under pressure. A flat, smooth plate or disc, pressed against the interfaces can verify correct functioning of the centre contact.

It is important to use the correct procedure when connecting or disconnecting GPC7 connectors to prevent damage and to ensure along working life and consistent electrical performance. The following procedure is recommended for GPC7 connectors.

Connection.

1. On one connector, retract the coupling sleeve by turning the coupling nut counterclockwise until the sleeve and the nut become disengaged. The coupling nut can then be spun freely with no motion of the coupling sleeve.
2. On the other connector, the coupling sleeve should be fully extended by turning the coupling nut clockwise. Once again the coupling nut can be spun freely with no motion of the coupling sleeve.
3. Put the connectors together carefully but firmly, and thread the coupling nut of the connector with the retracted sleeve over the extended sleeve.

Disconnection.

1. Loosen the coupling nut of the connector showing the wide gold band behind the coupling nut. This is the one that had the coupling sleeve fully retracted when connected.
2. Part the connectors carefully to prevent damage to the inner conductor contact.

It is a common, but bad practice, with hermaphroditic connectors to screw the second coupling ring against the first in the belief that there should be no loose parts in the coupled pair. This reduces the pressure between the two outer contacts of the connectors, leading to higher contact resistance and less reliable contact.

When connecting terminations or mismatches etc. do not allow the body of the termination to rotate. To avoid damage, connectors with retractable sleeves (e.g. GPC7) should not be placed face down on their reference plane on work surfaces. When not in use withdraw the threaded sleeve from under the coupling nut and fit plastic protective caps.

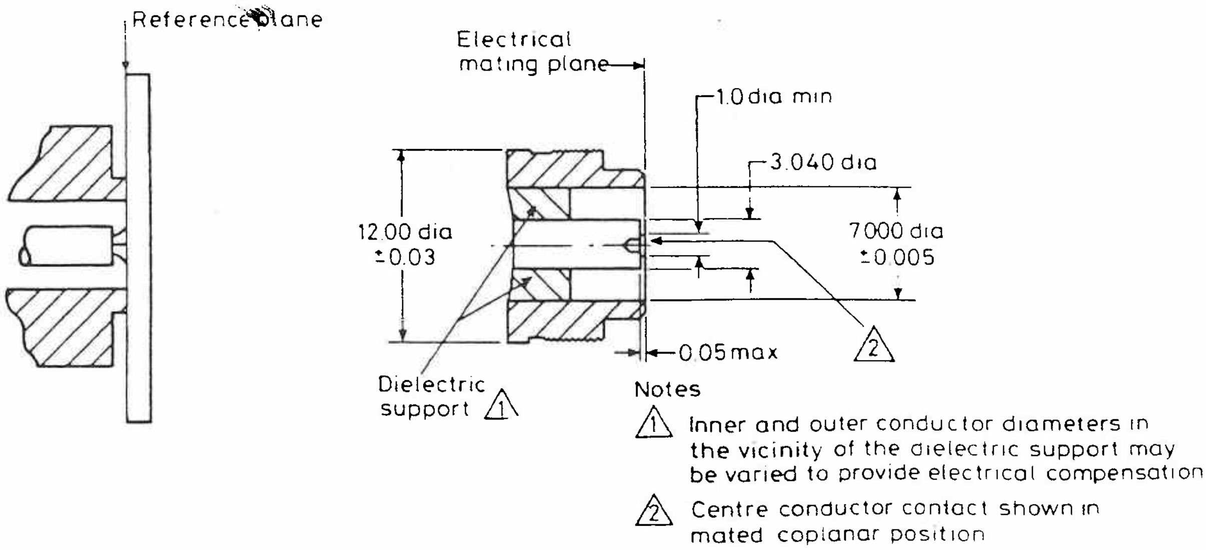

Fig. 2 The GPC 7 connector

THE TYPE N CONNECTOR

The type N connector is a rugged connector that is often used on portable equipment and military systems because of its large size and robust nature. The design of the connector makes it immune to accidental damage due to misalignment during mating (subject to it being made and aligned correctly). The type N connector is made in both 50Ω and 75Ω versions and both the 50Ω and 75Ω types are in common use.

Type N connectors need only be connected finger tight but torque settings are given in Table 13 when used in metrology applications

Contact pin location dimension requirements for the type N connector are shown in Fig 3 and gauging limits are listed in Table 4 and apply to both 50Ω and 75Ω connector types.

Warning

75Ω Type N Connectors

The 75Ω socket centre contact can be physically destroyed by a 50Ω pin centre contact so that the cross coupling of 50Ω and 75Ω connectors is not admissible. Special adaptors can be purchased, which are commonly known as `short transitions', to enable connection to be made if necessary, but these transitions should used with caution. If possible it is best to use a minimum loss attenuation pad to transfer from one impedance to another.

The type N connector is designed to operate up to 18GHz but special versions are available that can operate up to 22GHz. When gauging the special version type N connector it is not possible to gauge the connector in the usual way and so they should be used with caution.

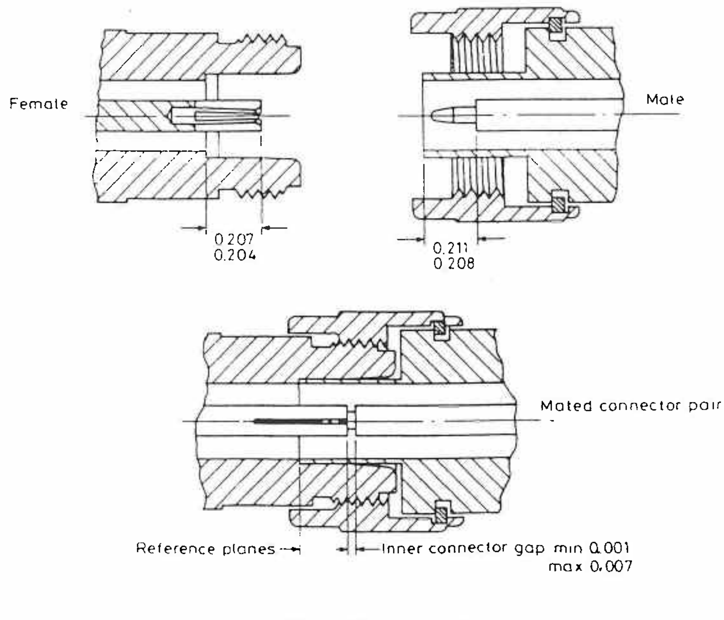

Figure 3. The Type N Connector

Table 4

Type N	Dimensions (inches)		Gap between mated centre contacts		
Specification	Female	Male	Min	Nom	Max
MMC Precision also HP Precision	0.207 + 0.000 −0.003	0.207 + 0.003 − 0.000	0.000	0.000	0.006
MIL-C-39012 Standard Test	0.207 + 0.000 − 0.003	0.208 + 0.003 − 0.000	0.001	0.001	0.007
MIL-C-39012 Class 2 Present type N	0.207 max	0.208 min	–	0.000	–
MMC Type N equivalent to MIL-C-71B	0.197 + 0.005 − 0.005	0.223 + 0.005 − 0.005	0.021	0.026	0.036
MIL-C-71B Old type N	0.197 + 0.010 − 0.010	0.223 + 0.010 − 0.010	0.016	0.026	0.046

Male type N connector

A clockwise deflection of the gauge pointer (a "plus") 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. This will cause damage to other connectors to which it is mated.

Female type N connector

A clockwise deflection of the gauge pointer (a "plus") indicates that the tip of the female mating fingers are protruding more than the maximum of 0.207 inches in front of the outer conductor mating plane. This will cause damage to other connectors to which it is mated.

THE SMA CONNECTOR

The interface dimensions for SMA connectors are listed in MIL-C-39012.

BS 9210 N0006 Part 2, published primarily for manufacturers and inspectorates, also gives the SMA interface but some of the requirements and detail differ. For example, wall thickness maybe a little thinner and hence a little weaker. However, MIL-C-39012 does not preclude thin walls in connectors meeting this specification although physical requirements and arrangements will probably ensure thicker walls against both specifications.

The SMA connector is **NOT** a precision connector and they should be carefully gauged and inspected before use. The user should be aware of their limitations and look for possible problems with the solid plastic dielectric and any damage to the male pin.

Connector users are advised that manufacturers' specifications vary in the value of coupling torque needed to make a correct connection. Unsatisfactory performance with hand tightening can indicate damage or dirty connector interfaces. It is common but bad practice to use ordinary spanners to tighten SMA connectors; excessive tightening (>15 lb. in) can easily cause collapse of the tubular portion of the pin connector.

Destructive interference may result if the contacts protrude beyond the outer conductor mating planes; this may cause buckling of the female contact fingers or damage to associated equipment during mating.

The dielectric interface is also critical since protrusion beyond the outer conductor mating plane may prevent proper electrical contact, whereas an excessively recessed condition can introduce unwanted reflections in a mated pair.

The critical axial interface of SMA type connectors is shown in Figure 4 and Table 5 where the dimensions are given in inches.

Table 5

SMA	Dimensions (inches)			
Specification	**Female Pin**	**Female dielectric**	**Male Pin**	**Male dielectric**
MIL-C-39012 Class 2	0.000 +0.030 −0.000	*	0.000 min	*
MMC Standard	0.000 +0.015 −0.000	0.000 +0.002 −0.002	0.000 +0.010 −0.000	0.000 +0.002 −0.002
MMC Precision	0.000 +0.005 −0.000	0.000 +0.002 −0.000	0.000 +0.005 −0.000	0.000 +0.002 −0.000
MIL-C-39012 Standard Test	0.000 +0.003 −0.000	0.000 +0.002 −0.000	0.000 +0.003 −0.000	0.000 +0.002 −0.000
OSM	0.000 +0.010 −0.000	0.000 +0.010 −0.002	0.000 +0.010 −0.000	0.000 +0.010 −0.002

*

Specification allows dielectric to protrude past outer conductor mating plane to 0.002 max.

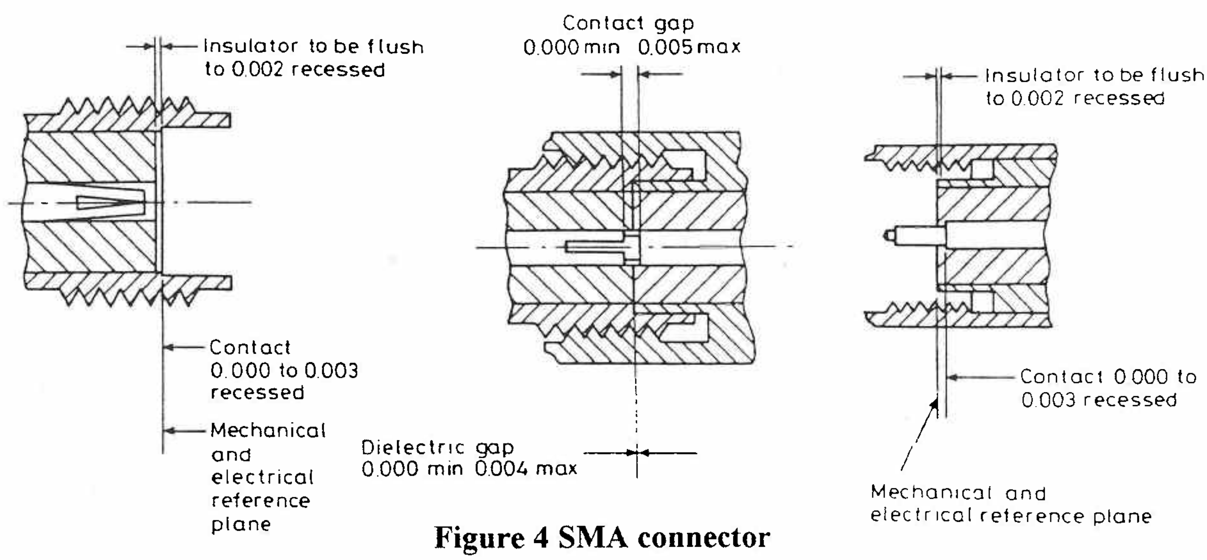

Figure 4 SMA connector

THE 3.5 MILLIMETRE CONNECTOR

This Connector is physically compatible with the SMA connector and it is known as the GPC3.5mm connector. It has an air dielectric interface and closely controlled centre conductor support bead providing mechanical interface tolerances similar to hermaphroditic connectors. However, although in some ways planar, it is not an IEEE 287 precision connector and there is a discontinuity capacitance when coupled with SMA connectors.

A special version of the GPC 3.5mm connector has been designed at Marconi Instruments. The design incorporates a shortened male pin and allows the centre conductors to be prealigned before contact thus considerably reducing the likelihood of damage when connecting or disconnecting the 3.5mm connector pair. The figures 5 and 6 show the difference between two types of GPC 3.5mm connectors. Table 5 shows t he gauging distances are the same for both types

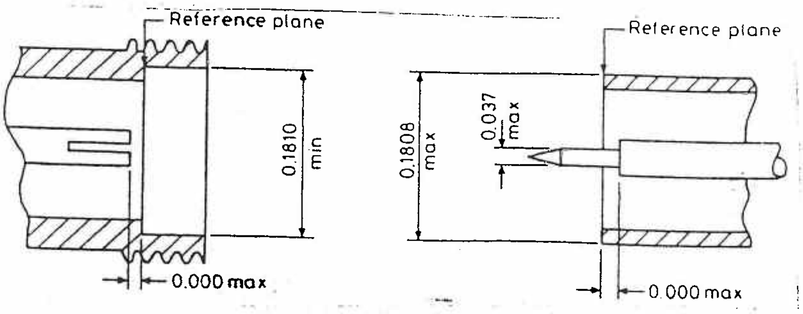

Figure 5 GPC 3.5 Connector (Normal version)

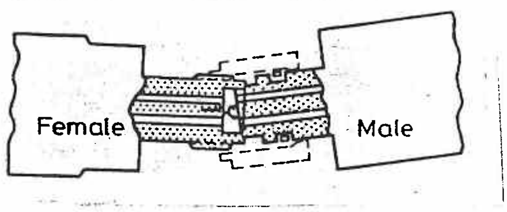

Figure 6 GPC 3.5 Connector (Marconi Instruments Special version)

Table 6

3.5mm	**Dimensions (inches)**	
Specification	**Female Pin**	**Male Pin**
LPC	**0 to -0.0005**	**0 to -0.0005**
GPC	**0 to -0.003**	**0 to -0.003**

THE 2.92 MILLIMETRE CONNECTOR

The 2.92mm connector is a reliable connector that operates up to 46GHz and it is used in measurement systems, high performance components, calibration and verification standards. It is also known as the Type K™ connector. The K connector interfaces electrically and mechanically with 3.5mm and SMA connectors. However, when mated with the 3.5mm or SMA connector the junction creates a discontinuity that must be accounted for in use.

The 2.92mm connector was designed to provide a coaxial connector to cover up to 40GHz.

Compared to the 3.5mm and the SMA connector the 2.92mm connector has a shorter pin that allows the outer conductor alignment before the pin encounters the socket contact when mating a connector pair. The type K connector is therefore less prone to damage in industrial use.

Figure 7 shows the diagram of the Type K connector and Table 7 gives the important gauging dimensions.

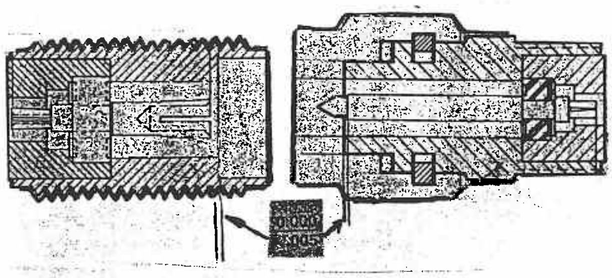

Figure 7 Type K Connector

Table 7

2.92 mm	Dimensions (inches)	
Specification	**Female Pin**	**Male Pin**
LPC	**0 to -0.0005**	**0 to -0.0005**
GPC	**0 to -0.0005**	**0 to -0.0005**
Anritsu	**0 to -0.005**	**0 to -0.005**
Marconi instruments	**0 to -0.003**	**0 to -0.003**

™Trade Mark of the Wiltron Co.

THE 2.4 MILLIMETRE CONNECTOR

The 2.4mm connector was designed by the Hewlett Packard company and the connector assures mode free operation up to 50GHz. It is also known as the Type Q connector. The 2.4mm connector is a pin and socket type connector which ultilises an air dielectric filled interface. The 2.4mm interface is only compatible with the 1.85mm connector.

The coupling engagement of the outer conductors is designed to insure that the outer conductors are coupled before the inner conductors can engage to ensure a damage free fit.

Figure 8 shows the diagram of the 2.4mm connector and Table 8 gives the important gauging dimensions

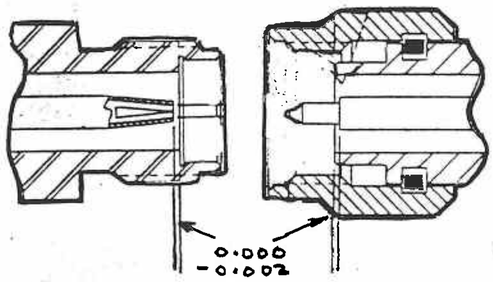

Figure 8. The 2.4mm Connector

Table 8

2.4 mm	Dimensions (inches)	
Specification	**Female Pin**	**Male Pin**
LPC	**0 to -0.0005**	**0 to -0.0005**
GPC	**0 to -0.002**	**0 to -0.002**
Hewlett Packard	**0 to -0.002**	**0 to -0.002**

THE 1.85 MILLIMETRE CONNECTOR

The 1.85mm connector was designed by the Hewlett Packard company and the connector assures mode free operation up to 65GHz. . It is also known as the Type V™ connector. The 1.85mm connector is a pin and socket type connector which ultilises an air dielectric filled interface. The 1.8mm interface is only compatible with the 2.4mm connector.

The coupling engagement of the outer conductors is designed to insure that the outer conductors are coupled before the inner conductors can engage to ensure a damage free fit.

Figure 9 shows the diagram of the 1.85mm Connector and Table 9 shows the important gauging dimensions

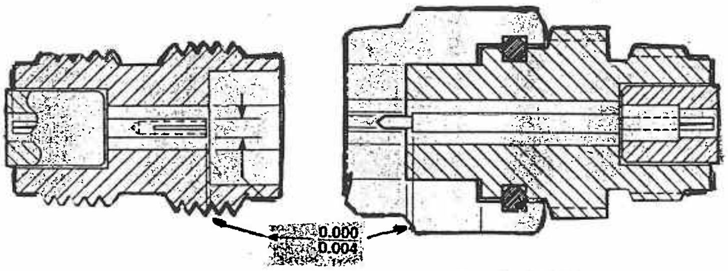

Figure 9. The 1.85mm Connector

Table 9

1.85 mm	Dimensions (inches)	
Specification	**Female Pin**	**Male Pin**
LPC	**0 to -0.0005**	**0 to -0.0005**
GPC	**0 to -0.002**	**0 to -0.002**
Anritsu	**0 to -0.004**	**0 to -0.004**

™Trade Mark of the Wiltron Co.

THE 1.1 MILLIMETRE TYPE ? CONNECTOR

Note

This is a new version of the 1.0mm connector and this section needs modifying and rewriting

The 1.1mm connector was designed by the Anritsu and the connector assures mode free operation up to 110GHz. It is also known as the Type ? connector.

The 1.1mm connector is a pin and socket type connector which ultilises an air dielectric filled interface.

The coupling diameter and thread size were chosen to maximise strength, increase durability, and provide

The coupling engagement of the outer conductors is designed to insure the outer conductors are coupled before the inner conductors can engage to ensure a damage free fit.

The W connector is designed for use with UT47 semi-rigid cable. A simple sleeve and locking screw assembly allows connection to a waveguide-to-coaxial adaptor and to a type K or V connector.

Figure 10 shows the diagram of the 1.1 mm Connector and Table 10 shows the important gauging dimensions.

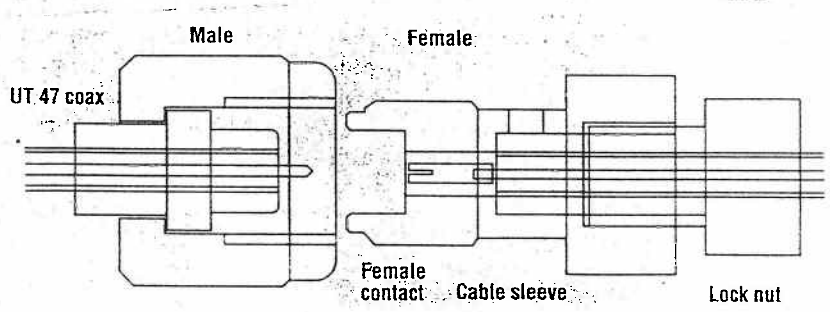

Figure 10. The ? connector

Table 10

1.10 mm	**Dimensions (inches)**	
Specification	**Female Pin**	**Male Pin**
LPC	?	?
GPC	?	?
Anritsu	?	?

TM Trade Mark of the Wiltron Co.

THE 1 MILLIMETRE TYPE W CONNECTOR

The 1mm connector was designed by the Hewlett Packard Company and the connector assures mode free operation up to 110GHz. It is also known as the Type W™ connector.

The 1mm connector is a pin and socket type connector which ultilises an air dielectric filled interface.

The coupling diameter and thread size were chosen to maximise strength, increase durability, and provide

The coupling engagement of the outer conductors is designed to insure the outer conductors are coupled before the inner conductors can engage to ensure a damage free fit.

The W connector is designed for use with UT47 semi-rigid cable. A simple sleeve and locking screw assembly allows connection to a waveguide-to-coaxial adaptor and to a type K or V connector.

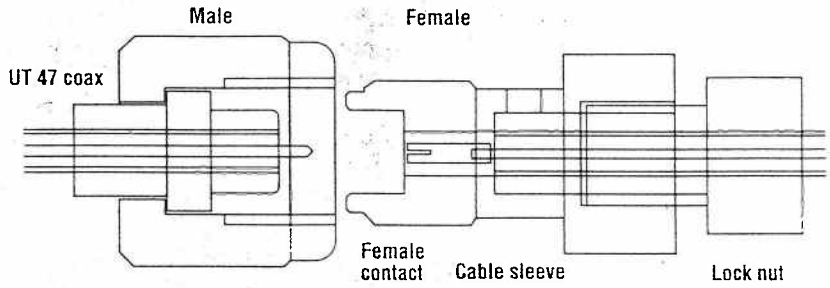

Figure 11.The W Connector

Table 11

1.00 mm	Dimensions (inches)	
Specification	**Female Pin**	**Male Pin**
LPC	**0 to -0.0005**	**0 to -0.0005**
GPC	**0 to -0.002**	**0 to -0.002**
Anritsu	**0 to -0.001**	**0 to -0.001**

™Trade Mark of the Wiltron Co.

APPENDIX C

REPEATABILITY OF CONNECTOR-PAIR INSERTION LOSS

The values shown in Table 12 show some insertion loss repeatability provided that the connector-pairs are in good mechanical condition and clean; further, that in use, they are not subjected to stresses and strains due to misalignment or transverse loads.

These **guidance** figures will serve two purposes :

1. They give lower limits for connector repeatability for uncertainty estimates where unknown connectors may be involved;
2. Provide a measure against which a "real" repeatability assessment can be judged.

Table 12

Connector	Repeatability dB		
GR900 - 14mm	0.001 (DC to 0.5GHz)	0.002 (0.5 to 8.5GHz)	
GPC7 - 7mm	0.001 (2GHz)	0.007 (12GHz)	0.015 (18GHz)
Type N - 7mm	0.001 (DC to 1 GHz)	0.004 (1 to 12GHz)	0.008 (12 to 18GHz)
GPC3.5 - 3.5mm	0.002 (DC to 1GHz)	0.006 (1 to 12GHz)	
SMA 3.5mm	0.002(DC to 1GHz)	0.006 (1 to 12GHz)	

Experimental Data on Connector Repeatability

The Figures shown are based on measurement experience at the NPL, SESC, NAMAS Calibration Laboratories and from the following sources of published information.

Insertion Loss Repeatability Versus Life of Some Coaxial Connectors; Dietrich Bergfield and Helmut Fischer. IEEE Trans. Instrumentation and Measurement - November 1970

Report on Repeatability of APC7 Connectors; J.D. Bradshaw and E.J. Griffin. BCS Panel 2.2 Paper, BCS/2.2/83/197 - September 1983

APPENDIX D

TORQUE WRENCH SETTING VALUES FOR PRECISION COAXIAL CONNECTORS

Table 13 gives a list of recommended connector tightening torque values to be used for metrology purposes for each connector type

This list is based on the best available information from various sources and should be used with care. Some manufacturers recommend slightly different values for torque settings in their published performance data. Where this is the case the manufacturers data should be used.

There are also some differences on the torque settings used when making a permanent connection (within an instrument) rather than for metrology purposes.

For combinations of GPC3.5/SMA connectors the torque should be set to the lowest value e.g. 5 in-lb.

The torque spanners used should be regularly calibrated, and set to the correct torque settings and clearly marked.

Table 13

Connector	Torque	Information source
Type GR900 - 14mm	10 in-lb (113 N-cm)	NPL
Type GPC 7 - 7mm	12 in-lb (136 N-cm)	HP App. Note 326
Type N - 7mm	12 in-lb (136 N-cm)	HP App. Note 326
Type GPC 3.5 - 3.5mm	8 in-lb (90 N-cm)	HP App. Note 326
Type SMA - 3.5mm	5 in-lb (56 N-cm)	HP App. Note 326
Type K - 2.92mm	5 in-lb (56 N-cm) or 8 in-lb (90 N-cm)	Manufacturer's Data
Type Q - 2.4mm	8 in-lb (90 N-cm)	Manufacturer's Data
Type V - 1.85mm	8 in-lb (90 N-cm)	Manufacturer's Data
Type W - 1mm	3 in-lb (34 N-cm)	Manufacturer's Data

APPENDIX E

CALIBRATING DIAL GAUGES AND TEST PIECES

There are a number of different types of Dial Gauges and Gauge Calibration Blocks used for gauging connectors and they require regular calibration to ensure that they are perfoming correctly. There is a British standard BS 970 which covers the calibration of Dial Gauges and this should be used. However, the calibration of the Calibration Blocks is not covered by a British Standard, but they can be measured in a Mechanical Metrology Laboratory.

It is important to use the correct gauge for each connector type to avoid damage to the connector under test. Some gauges have very a strong gauge plunger spring that, if used on the wrong connector, can push the centre block through the connector resulting in damage.

Types of Dial Gauges

Dial gauges used for the testing of connectors for correct mechanical compliance are basically of two types :

Push on type

The push on type is used for general purpose connectors. For sexed connectors two gauges are normally used (one male and one female) or a single gauge with male and female adaptor bushings.

Screw on type

The screw on type is used for the best measurement on precision connectors and for sexed connectors it is made in both male and female versions. The screw-on type is made in the form of a connector of the opposite sex to one being measured. When the Gauge Block is used to initially calibrate the Dial gauge a torque spanner is used to tighten up the Gauge Block to the correct torque.

Gauge Calibration Blocks

Every connector gauge requires a gauge calibration block which is used to zero the gauge before use.

Because of connector gauge measurement uncertainties (one small division on the dial)and variations in measurement technique from user to user connector set back dimensions are difficult to measure. For a gauge with 0.0001-inch small division on the dial scale when measuring a setback of 0.0005 inches the gauge reading could vary between 0.0004 and 0.0006 depending on the gauge . In addition how the gauge is used and the cleaning of the connector can result in larger variations.

The Photograph in Figure 11 shows a set of dial gauges and calibration Blocks for a Type N Connector screw on type gauge.

The Photograph in Figure 12 shows a Type N dial gauge of the push on type with its calibration block.

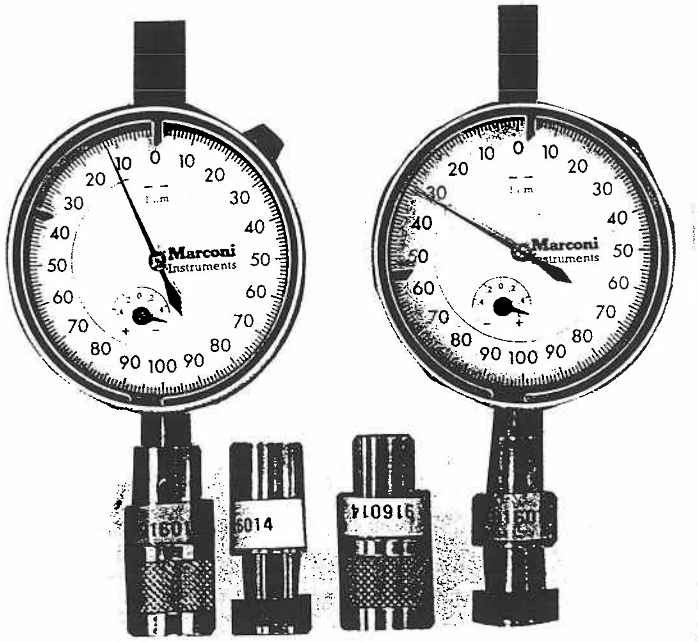

Figure 11 Type N Screw-on Dial gauge and calibration Block

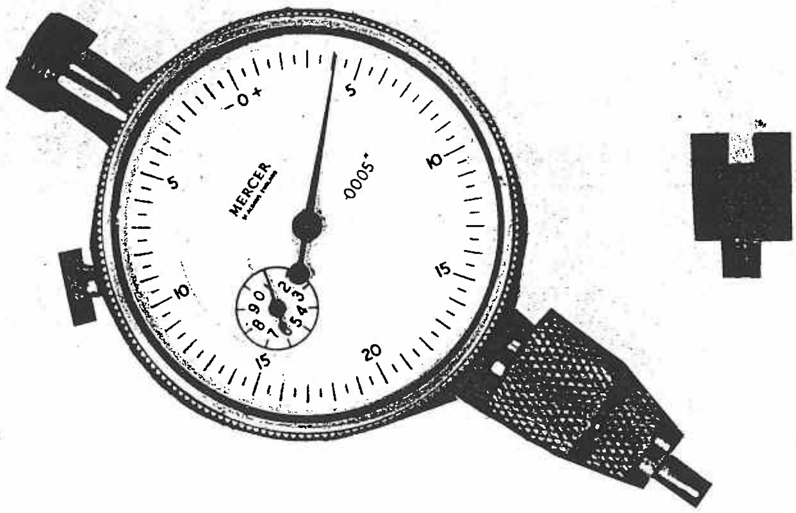

Figure 12 Type N Push - on type Dial Gauge and Calibration Block