General introduction

In modern communications systems, RF cables are best connected by means of coaxial connectors.
These connectors feature high make/break capacity, excellent electrical properties and are practically immune to electromagnetic interference. The characteristic impedances of coaxial connectors can be matched very well to the differing characteristic impedances of cables and lines.
The mechanical, environmental and electrical operating conditions of communications equipment vary considerably, thus necessitating a broad range of connector types. Each connection involves a male and female connector which must be compatible both electrically and mechanically in the radio frequency transmission path.
The general demands placed on RF connectors are stipulated in the following standards:

RF connectors, survey	DIN 47280 Parts 1 to 4
RF connectors, definitions and connection systems	DIN47299
RF connectors, requirements and testing	DIN 47275 Parts 1 to 4 IEC Publ. 169-1
RF cables, coaxial 75 Ω	DIN 47269

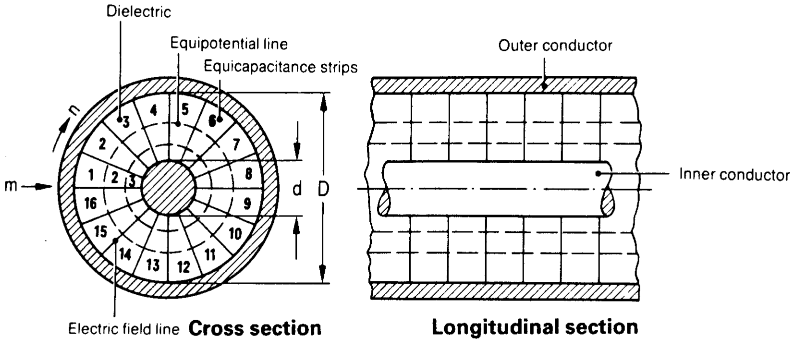
All electrical characteristics of a coaxial cable connector can only be assessed and tested in conjunction with the associated cable.

Basic definitions
The following basic definitions apply in particular to RF connectors.

Characteristic impedance
The connector must produce a constant connection free of reflection between two cables with the same characteristic impedance. In other words, an homogenous RF path with the same characteristic impedance must be provided within the connector also. If this precondition is fullfilled, a radio frequency electromagnetic wave is propagated without disturbance along a concentrically arranged line. The cylindrical conductor, shown in the figure, with the same axis, is called a coaxial conductor. The electrical lines of field strength, of the so-called coaxial wave, in which no component of the field strength occurs in the direction of the cable axis, are orientated radially to the plane of the cross section. The character of the field is also determined by the annular equipotential lines shown as dotted lines in the figure. The voltage difference between two neighboring equipotential lines is always constant. The lines of the field dissect the cross section into *n* strips of equal capacitance. The capacitance of a strip of this kind is produced by the series connection of the elementary capacitances formed by the field lines. The line capacitance per cm of line length, the so-called capacitance per unit length, is then determined by parallel connecting equicapacitances.

RF connectors

Configuration of an electrostatic field in a coaxial cable:



Cross section **Longitudinal section**

D: Inside diameter of outer conductor
d: Outer diameter of inner conductor
$_r$ Dielectric constant of the dielectric
m: Number of strips of equal potential difference (in the figure: $m = 3$)
n: Number of strips of equal capacitance (equicapacitance strips; in the figure: $n = 16$)
Z_L: Characteristic impedance of coaxial cable (nominal value)

The inductance of the cable per cm cable length, the so-called inductance per unit length can also be seen in the field configuration.
The characteristic impedance *Z* is the quotient of the voltage and current of the propagating wave measured at any point along an RF cable which has no loss.
Since the characteristic impedance is a constant value throughout the total length of the coaxial cable, it can be stated as a function of the inside diameter *D* of the outer conductor and the outer diameter *d* of the inner conductor:

$$Z = \frac{60}{\sqrt{\ }_r} \cdot \ln \frac{D}{d} \quad [\Omega]$$

The crucial factor of a coaxial connector is thus the characteristic impedance *Z*. For this reason, all types of connectors are identified by relating the ratio of the diameter of the inner conductor to that of the outer conductor. The characteristic impedances mainly on an international scale are 50 Ω, 60 Ω and 75 Ω.

RF connectors

Attenuation

The sum of the following loss components results in the attenuation of electromagnetic waves through a coaxial cable:

α_i Resistive attenuation of the inner conductor

α_a Resistive attenuation of the outer conductor

α_G Leakage attenuation

The following generally applies to the attenuation α

$\alpha = \alpha_R + \alpha_G$ where $\alpha_R = \alpha_i + \alpha_a$

The resistive loss (attenuation) is mainly effected by the skin effect which occurs at high frequencies. The losses involved are calculated on the assumption that the currents can only flow uniformly in the so-called equivalent conducting layer.

It can be shown that the resistive losses of the inner conductor α_i and the outer conductor α_a mainly depend on $\sqrt{f}$. Conductors with rough surfaces have longer current paths and their effective resistances and losses are higher than for conductors with smooth surfaces. The leakage losses increase proportionally with *f*.

Reflection factor

The reflection factor *r* determines the quality of a coaxial connection and is defined relative to the nominal value of the characteristic impedance Z_L.

The reflection can be determined by establishing the voltage distribution along a measurement cable.

The corresponding measurement procedure is defined in DIN 47275, part 3.

RF connectors

The lower a reflection factor for a comparable frequency, the better is the coaxial connecting system.

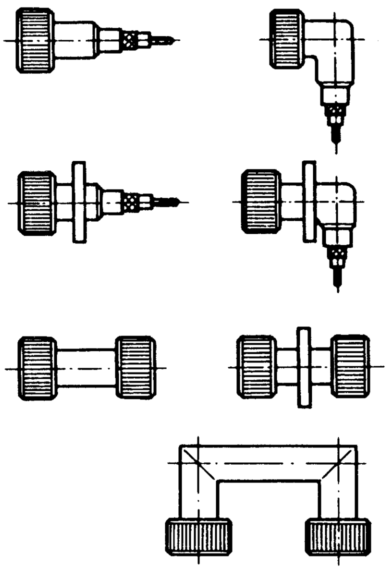
Coupling impedance
The effectiveness of the screening at the interface between two coupled connectors and the cable strain-relief point is given by the coupling impedance. By means of two separate measurements (DIN 47275), the voltage is fed into the coaxial system under test and then the induced voltage in an outer coaxial measurement system short-circuited at one end is established:
The coupling impedance increases proportionally with the frequency *f*. The lower the coupling impedance for a given frequency, the better the high frequency screening effectiveness of the coaxial connecting system.

Design principles
Coaxial connecting systems are designed on the basis of their electrical and mechanical connection modes, the nature of the insulation and the kind of termination used.

Connector systems
The types of electrical and mechanical conductor connectors are distinguished as follows:
Pin-socket connections in which the plug has a pin as an inner conductor and the jack has a socket as the inner conductor.
Connectors with an adapter permit connections with two identical pin plugs or socket plugs and an additional connecting element.

Non-latching, screw-type, panel-mount, and snap-locked connectors. Bulkhead connectors in which connection is made by inserting a screened module into a chassis.

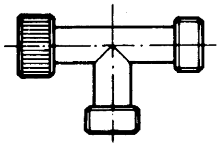
Connector types
A distinction is made between the following coaxial connector mountings in the cable section:
Cable connection-body connection-circuit connection.



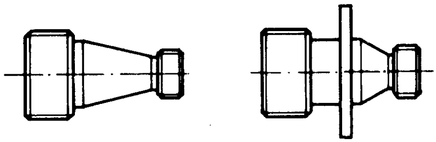
Main types of connector
The connector type depends on the individual application

Cable connectors:	straight and angle connectors fitted to RF cables
Bulkhead connectors with cable connection:	part of the connector is secured to the panel
Couplers:	this is a coupling element between two identical connectors
U connectors:	between two connectors

RF connectors



T connectors:	connectors with three connections



Adapters:	to interconnect two different connector types

PCB connectors

Connectors series and design
German standard DIN 47280 presents an overall survey of standard coaxial connectors. The problems in developing coaxial connectors are that a wealth of different applications requires differing electrical and mechanical characteristics.