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MICROWAVE COAXIAL ASSEMBLIES

50 GHz

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AXOWAVE™
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Microwave coaxial assemblies

MARCH 2016

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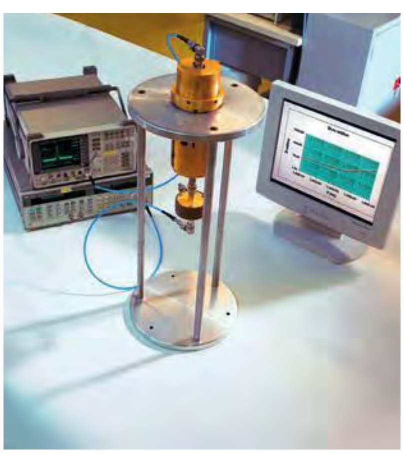

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Axon' Cable offers a wide range of low loss and flexible microwave coaxial assemblies. With a wealth of experience in the manufacture of precision conductors, low loss dielectrics, shielding jacketing and connectors, Axon' is able to design complete custom designed solutions.

The choice of a microwave cable or connector depends on many different technical considerations. This tutorial includes the most important theoretical explanations to help you make the most appropriate choice for your microwave assembly.

Electrical resistance of the materials R(Ω)

The electrical resistance is the capability of a material to prevent the transfer of electrical current.
For a homogeneous solid conductor at a given temperature the equation to calculate its resistance as a function of the material and its dimensions is the following:

$$R(\Omega) = \frac{\rho . L}{S}$$

- ρ resistivity in ohm-meter (Ω.m);
- L length in meters (m);
- S section in square meters (m^2).

Note

The resistance of a conductor increases when the temperature increases and vice versa.
The resistance increases when the diameter decreases and vice versa.

Typical resistivity values for calculation:

MATERIAL	SYMBOL	RESISTIVITY (Ω m)
Silver	Ag	$1.63.10^{-8}$
Copper	Cu	$1.72.10^{-8}$
Aluminium	Al	$2.7.10^{-8}$

Capacitance per unit length C (pF/m)

The capacitance per unit length of a coaxial cable is the property to store electrical charge when a potential difference is applied to the two conductors (central conductor/shielding).

The equation to calculate the capacitance per unit length as a function of the material and dimensions of the coaxial cable is the following:

$$C(\rho F/m) = \frac{24.13.\varepsilon_r}{\log\left(\frac{D}{d}\right)} = \frac{3333.\sqrt{\varepsilon_r}}{Z_c}$$

- ε_r constant as a function of the material;
- d outer diameter of central conductor in mm;
- D diameter on dielectric in mm;
- Z_c characteristic impedance in Ω (see below).

Typical dielectric constant values for calculation:

MATERIAL	DIELECTRIC CONSTANT
Wrapped Celloflon®(*)	1.5 to 1.7
Extruded Celloflon®(*)	1.7 to 1.9
PTFE / FEP/ PFA	2.1
ETFE	2.6

(*) To improve the electrical performances of Axowave™ microwave coaxial cables, Axon' Cable uses dielectric materials made of expanded PTFE (CELLOFLON®). The aim is to obtain a dielectric constant near to the dielectric constant of air, thus improving microwave transmission.

Characteristic impedance Z_c (Ω)

The characteristic impedance (Zc) is one of the most important factors when choosing a cable. At high frequencies, the impedance of cables, connectors and systems has to be optimized to improve performances. The characteristic impedance is the input impedance of a coaxial line of infinite length. It represents the ratio between voltage and current in this line.
For microwave coaxial cables, the equation to calculate the characteristic impedance, a function of both materials and dimensions, is the following.

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The standardized value is 50 Ω and does not depend on the frequency:

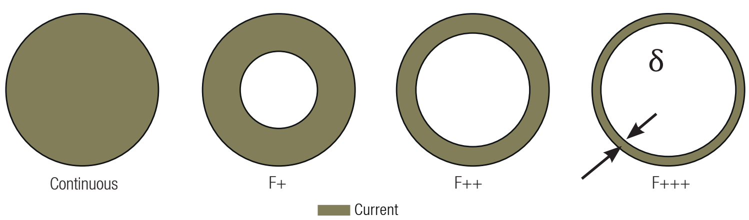
$$Z_c(\Omega) = \frac{138.2}{\sqrt{\varepsilon_r}}.\log\left(\frac{D}{d}\right)$$

- ε_r dielectric constant - a function of the material;
- d outer diameter of the central conductor in mm;
- D diameter on the dielectric in mm.

The requested tolerances of the characteristic impedance value are generally tight. Most of Axon' Cable products are in accordance with tolerances of +/- 1 Ω.

Skin effect δ (μm)

At high frequencies, the density of current concentrates on a fine layer on the conductor surface. This layer decreases as the frequency increases. This phenomenon called "skin effect" is expressed as penetration depth δ.



SKIN EFFECT

For a homogeneous material at a given temperature the equation to calculate the penetration depth δ, as a function of the material and the frequency, is the following:

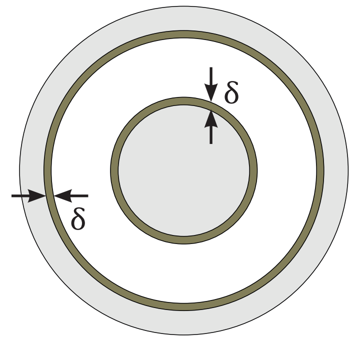
$$\delta(m) = \sqrt{\frac{\rho}{\pi.\mu.F}} \simeq \frac{K}{\sqrt{F}}$$

- δ penetration depth in microns where approx. 40% of the current will circulate;
- ρ resistivity in Ohm.meter;
- μ permeability of the material in H/m = μ_0 x μ_r;
- F frequency in GHz;
- K coefficient depending on the material.

Note

In microwave coaxial cables the current will mainly circulate in the exterior layer of the central conductor and the interior layer of the shielding.

The total thickness the current will circulate in is estimated at 3xδ.



SKIN EFFECT IN MICROWAVE COAXIAL CABLE

Typical skin thickness values of silver

	FREQUENCY	SKIN THICKNESS OF SILVER
Low frequency	50 Hz	9.1 mm
	1 MHz	64 µm
High frequency	1 GHz	2 µm
	10 GHz	0.65 µm
	50 GHz	0.30 µm

Axon' Cable guarantees a minimum silver thickness of 1 µm for its standard microwave products, and 2 µm for space versions.
Other thicknesses are possible upon request.

Cut-off frequency Fc (GHz)

The electromagnetic wave will propagate longitudinally through a coaxial line according to the Transverse Electro-Magnetic (TEM) Mode (Fundamental Mode). The electrical field E and magnetic field H are perpendicular and in the same transversal plan.
Above a certain frequency, called "cut-off" frequency, other modes of propagation will appear and disturb the Fundamental Mode. The cut-off frequency is the maximum operating frequency allowing for correct signal transmission in the cable.
The equation to calculate the cut-off frequency of a coaxial cable, a function of both material and the cable dimensions, is the following:

SPECTRUM ANALYZER

$$Fc(GHz) = \frac{191}{(D + d).\sqrt{\varepsilon_r}}$$

- d outer diameter of central conductor in mm;
- D diameter on dielectric in mm;
- ε_r dielectric constant, a function of the material.

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Standardized frequency band

DESIGNATION	FREQUENCY	LENGTH OF WAVE IN VACUUM
Band L	1 to 2 GHz	30 to 15 cm
Band S	2 to 4 GHz	15 to 7.5 cm
Band C	4 to 8 GHz	7.5 to 3.8 cm
Band X	8 to 12.4 GHz	3.8 to 2.5 cm
Band Ku	12.4 to 18 GHz	2.5 to 1.7 cm
Band K	18 to 26.5 GHz	1.7 to 1.1 cm
Band Ka	26.5 to 40 GHz	1.1 to 0.75 cm
Band V	40 to 75 GHz	0.75 to 0.40 cm
Band W	75 to 110 GHz	0.40 to 0.27 cm

Velocity of propagation V_P (m/s or %)

The velocity of propagation of a wave corresponds to the velocity of propagation of the wave's different electromagnetic constituents in the dielectric. It is generally measured in m/s or in % when compared to the speed of light in a vacuum.

For a homogeneous material, the equation to calculate the velocity of propagation of the wave, a function of the material, is the following:

$$Vp(m/s) = \frac{c}{\sqrt{\varepsilon_r}}$$

$$Vp(\%) = \frac{1}{\sqrt{\varepsilon_r}}$$

- c speed of light in a vacuum ($\approx 3.10^8$ m/s);
- ε_r dielectric constant of the material.

This formula allows to calculate the time of wave propagation on the dielectric between two conductors necessary to manufacture a delay line, for example:

$$Tp(ns/m) = 3.333.\sqrt{\varepsilon_r}$$

Note

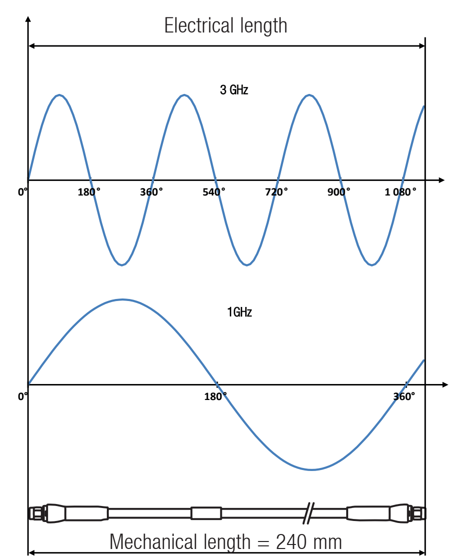
The velocity of propagation is inherent to the material and does not depend on the waves' frequency. (The material has to be homogeneous, present good physical characteristics and its dielectric constant has to be stable even if frequency changes).

Phase, electrical length

The electrical length of a coaxial cable is the difference of phase caused by the wave propagation in the cable:
the phase or electrical length of an assembly can be calculated as follows:

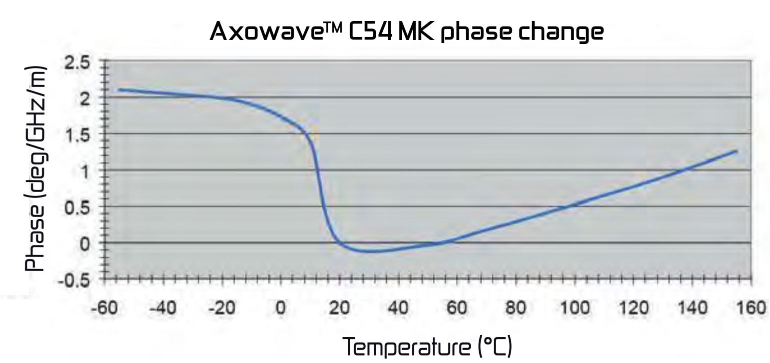
$$\Theta(°) = \frac{360}{c}.F.L_m\sqrt{\varepsilon_r}$$

- F operating frequency of the signal in Hz;
- c speed of light in vaccum (≈ 3.10^8m/s);
- L_m mechanical length of the assembly in m;
- ε_r dielectric constant depending on the material.



Note

Phase varies with temperature change. The phase change is due to the elongation of the cable when temperature rises and to internal changes in the dielectric: below is an example of phase change of an Axowave™ C54 MK at 20°C.



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Phase matching

Phase matching of several microwave assemblies of the same length means the manufacture of assemblies having the same phase (or electrical length), within the tolerances.
This implies the use of high-performance conductor and dielectric materials and a high degree of precision in the manufacturing processes (cables, connectors, termination).
Axon' Cable offers custom phase matched microwave assemblies on request.

Note

Assemblies of the same phase matched batch will have the same phase (within the tolerances).
The higher the frequency, the more difficult phase matching will be.
The tolerances of the phase matching depend on the length of the assembly and on the operating frequency.
Phase changes can be caused by temperature and mechanical influence (such as vibration or flexing).

Insertion loss α (dB/m or dB)

General principle

The insertion loss (or attenuation) α corresponds to the loss of energy that appears during signal propagation in a material.
For a given material, the formula to calculate the signal attenuation as a function of input and output power is the following:

$$\alpha(\mathrm{dB}) = 10.\log\frac{P_s(w)}{P_e(w)} = P_s(\mathrm{dBm}) - P_e(\mathrm{dBm})$$

- P_e input power of the cable;
- P_s output power of the cable.

Note

For so called « passive « systems (cables, systems without amplifying medium, etc):

$$P_e > P_s$$

Signal power is generally measured in dBm:

$$P(dBm) = 10.\log\left(\frac{P(w)}{10^{-3}}\right)$$

Insertion loss of coaxial cables

Generally the insertion loss of a cable is the sum of the insertion loss of the conductors (resistance and skin effect) and those of the insulation (defects of the dielectric). For a given cable construction it is expressed as follows (A and B are constant):

$$\alpha(dB/m) = A.\sqrt{F} + B.F$$

- A loss factor of the conductors;
- B loss factor of the dielectric;
- F frequency in GHz.

Note

The higher the frequency, the higher the losses will be.
The longer the cable, the higher the losses will be.
The smaller the cable diameter, the higher the losses will be.

Axon' Cable micowave coaxial assemblies have been optimized to minimize the insertion losses in a frequency range up to 50 GHz.

Influence of temperature on the insertion loss

Temperature directly influences the cables' insertion losses, as temperature changes modify the properties of the materials. As a result, corrective factors have to be introduced into the theoretical calculation formula of insertion loss:

$$\alpha(\Theta°C) = 1.05.\alpha(23°c).\sqrt{0.0038.(\Theta -23) +1}$$

- θ: temperature (°C);
- α: (θ °C): insertion loss in dB at a temperature θ.

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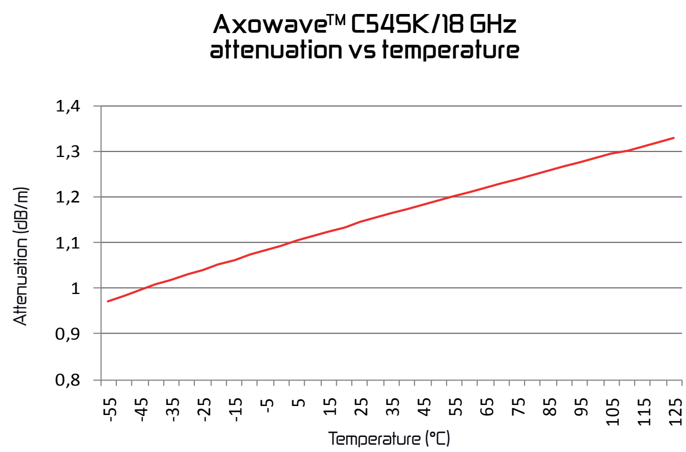
Example of a graph including corrective factors for temperature changes:



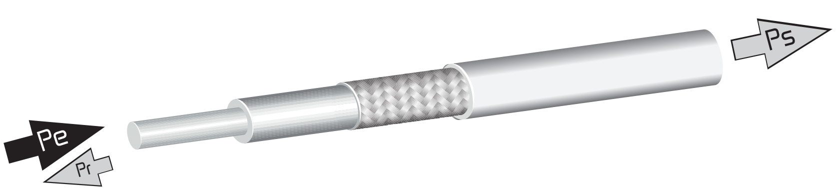
Voltage Standing Wave Ratio (VSWR)

Irregular dimensions, or defects in conductor or dielectric materials can disturb the cable's characteristic impedance. At the locations of these material irregularities reflected waves occur. Combined with the incident signal, these reflected waves create standing waves.
To characterize this impedance mismatch the following parameters are used:

- Reflection coefficient;
- Return Loss;
- VSWR.

Reflection factor

The square of the reflection coefficient gives the ratio between the reflected power and the input power as follows.



$$|\Gamma|^2 = \frac{P_r(W)}{P_e(W)}$$

- P_e input power;
- P_s output power;
- P_r reflected power.

Note

The reflection coefficient of a cable assembly will depend on the mismatch of all its components:

- mismatch between connector and power supply;
- quality of the connector;
- mismatch between connector and cable;
- quality of the cable.

Return Loss RL in dB

The "return loss" of a cable assembly is the logarithmic measure of the reflection coefficient factor as follows:

$$RL = -20.\log(|\Gamma|)$$

Voltage Standing Wave Ratio (VSWR)

In a transmission line two waves are propagated simultaneously. The first one with an amplitude Vi corresponds to the input wave, the second one with amplitude Vr to the reflected wave. The overlapping of these waves will produce a resultant wave with changing amplitude along this line. The Voltage Standing Wave Ratio is the relation of the extreme values of this resultant wave:

$$VSWR = \frac{Vi + Vr}{Vi - Vr}$$

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The VSWR is a quality indicator for the whole transmission line and for the ability of the system to be connected to another without any risk.

The VSWR of microwave assemblies mainly depends on the type of connectors used, the length of the cable as well as the quality of cable and connectors. Sometimes it is easier to define the VSWR as a function of the reflection factor as follows:

$$VSWR = \frac{1 + |r|}{1 - |r|}$$

Note

Ideal VSWR = 1, which means no reflected power.
In the case of a short circuit or an open circuit, the transmitted power is null, so the VSWR is infinite.
VSWR, just as with Return Loss, is an indicator of the quality of the product, and in fact these two parameters are linked, as is shown in the following table:

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VSWR / Return Loss conversion chart

VSWR	RETURN LOSS (dB)
1.01	46.06
1,02	40.09
1,03	38.61
1.04	34.15
1.05	32.26
1.06	30.71
1.07	27.42
1.08	28.30
1.09	27.32
1.10	26.44
1.11	25.66
1.12	24.94
1.13	24.29
1.14	23.69
1.15	23.13
1.16	22.61
1.17	22.12
1.18	21.66
1.19	21.23
1.20	20.83
1.21	20.44
1.22	20.08
1.23	19.73
1.24	19.40
1.25	19.08
1.26	18.78
1.27	18.49
1.28	18.22
1.29	17.95
1.30	17.69
1.31	17.44
1.32	17.21
1.33	16.98
1.34	16.75
1.35	16.54
1.36	16.33
1.37	16.13
1.38	15.94
1.39	15.75
1.40	15.56
1.41	15.38
1.42	15.21
1.43	15.04
1.44	14.88
1.45	14.72

RETURN LOSS (dB)	VSWR
40	1.020
39	1.023
38	1.026
37	1.029
36	1.032
35	1.036
34	1.041
33	1.0446
32	1.052
31	1.058
30	1.065
29	1.074
28	1.083
27	1.094
26	1.106
25	1.119
24	1.135
23	1.152
22	1.173
21	1.196
20	1.222
19	1.253
18	1.288
17.5	1.305
17	1.329
16.5	1.35
16	1.377
15	1.433
14	1.499
13	1.577
12	1.671
11	1.786

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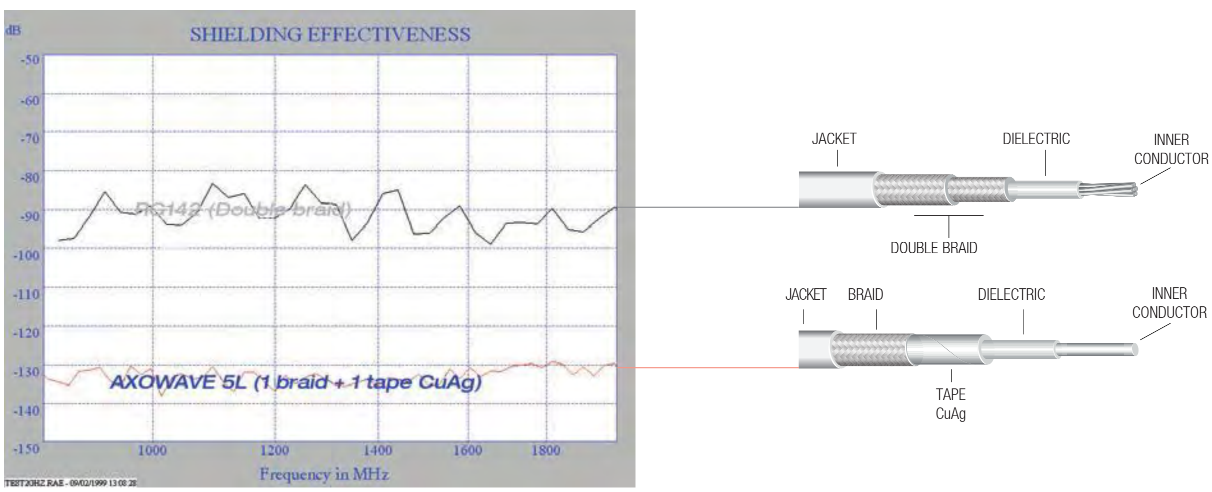
Shielding effectiveness SE (dB)

The shielding effectiveness is the ability of a technology to screen out interference and to prevent RF leakage. For a cable or cable assembly shielding effectiveness has two main tasks: keep radiated emissions produced by the cable inside the coaxial cable or assembly and avoid radiated emissions produced by external equipment to "enter" a cable or assembly. The shielding effectiveness mainly depends on the frequency, on the construction of the shielding, on the connectors and their attachment to the cable.
Axon' Cable is able to measure this parameter in its MIL-STD-1344 mode stirred chamber.
Axon's range of Axowave™ coaxial cables provide optimized shielding effectiveness up to 120 dB at 1 GHz.
Comparison of a double braid RG coaxial cable and an Axowave™ 5L cable:

MODE STIRRED CHAMBER



Power handling: peak and continuous average power (cw)

The power handling of a technology is the maximum power that a cable can withstand before damage. In a coaxial cable, the deterioration results from the temperature rise in the central conductor caused by its resistance.

There are two characteristics to define this phenomenon:

- Continuous Wave cw power handling;
- Peak (maximum instant power value) power handling.

Note

The power handling of a cable depends on:

- The operating frequency;
- The ambiant temperature;
- The altitude;
- And especially the connectors.

Voltage withstanding

Voltage withstanding is the maximum voltage value that a cable can withstand between its active part and the ground without creating a disruptive discharge.
In the case of coaxial cables, there are two different types of phenomena: the dielectric withstanding voltage and the corona effect.

Dielectric withstanding voltage

The dielectric withstanding voltage of an electrical insulation is the minimum voltage that creates electrical discharges between the inner conductor and the shielding. This parameter does not depend on frequency and changes with the distance between the central conductor and the shielding as well as the type of dielectric material.

Corona effect

When the electrical field reaches a certain level, the gas occluded in the micro cavities of the dielectric will be ionizised. The ions will bombard the cavity, which will be enlarged, and damage will be caused to the insulation. This phenomenon can make the dielectric fail. Due to their construction, any electrical wire or cable includes miniature vacuums, for example between the conductor and the insulation. Here the voltage gradient is at its maximum and the ions that might occur will be accelerated by the electrical field and damage the dielectric.

Flexibility

Flexibility is defined as the property of a material to be bent or curved without breaking. Flexibility may be a more or less important factor in the choice of cable according to each application. The following parameters have to be taken into account before making microwave assemblies:

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- Type of applications (static or dynamic);
- Spring effect / memory effect / hand-formable properties;
- Minimum bend radius;
- Stability of electrical performances when bending.

Minimum bend radius, static and dynamic application

The minimum bend radius is the smallest radius that can be applied to a cable without deterioration of its physical or electrical characteristics.

The minimum bend radius is usually calculated as follows:

$$\text{Static bend radius}_{\min} R_S \simeq 5.\text{Ø}$$

$$\text{Dynamic bend radius}_{\min} R_d \simeq 10.\text{Ø}$$

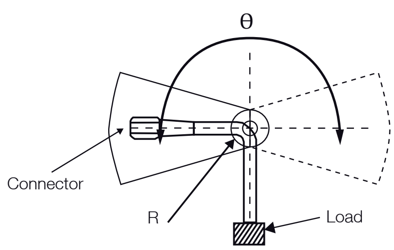
- ∅ outer cable diameter in mm.

Flex-life

The flex-life of a cable is the maximum number of cycles the cable will withstand without damage.
Several methods are available to measure flex-life, one of which is as follows:
One connector of the cable assembly is fixed to the test equipment. A bend radius, a test angle and a test speed (number of cycles per minute) are defined according to the cable properties. A load is fixed on the second connector of the assembly to maintain the bend radius.
This single point folding bend test, used as standard to qualify Axon' cables, is one of the most demanding flex-life test methods.

Test conditions:
- Flex angle: θ
- Bend radius: R (mm)
- Load: M (g)
- Speed: Nb cycles/mn

= Flex-life



FLEX-LIFE TEST

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Note

The flexibility of the assembly depends on the components:

- the nature and composition of the conductors are important. For the same diameter and conductor material, stranded conductors are more flexible than solid conductors (but insertion losses will increase);
- the shield construction will have an influence on the cable's flexibility;
- flex-life is influenced by the type of jacketing material used: for example, Polyurethane jackets are more flexible than FEP jackets.

Outer jacket properties

PROPERTIES	TEST METHOD	UNIT	PTFE	FEP	PFA	POLYIMIDE	ETFE
MECHANICAL PROPERTIES							
Density	ASTM-D-792	kg/m^3 g/cm^3	2150 2.15	2150 2.15	2150 2.15	1550 1.55	1700 1.70
Tensile strength	ASTM-D-638	N/mm^2 kg/m^2	24.5 250	20.6 210	27.5 280	230 2340	44.1 450
Ultimate elongation	ASTM-D-638	%	350	300	300	70	200
Flexural modulus	ASTM-D-790	N/mm^2 kg/cm^2	667 6800	667 6800	667 6800		1373 14000
Flexlife	Tests MIT 0.2 mm, 180°	Number of cycles	750000	100000	200000	285000	30000
Impact strength	ASTM-D-256 23°C -40°C	N-m/m	No break 490	No break 157	No break 157		No break 1090
Hardness	ASTM-D-785	shore D	55	55	55		75
Coefficient of dynamic friction	-	-	0.1	0.3	0.2		0.4
THERMAL PROPERTIES							
Melting point/ Transition temp.	-	°C	327	275	305	Does not melt	270
Operating temperature (20.000 h)	-	°C	260	205	260		155
Non flammability	UL - 94	-	94 V-O	94 V-O	94 V-O	94 V-O	94 V-O
Limiting oxygen index	ASTM-D-2863	%	95	95	95	37	30
Calorific value	ASTM-D-240	MJ/kg	5.0	5.0	5.0		13.8
ELECTRICAL PROPERTIES							
Dielectric constant	ASTM-D-150	(10^3 - 10^6 Hz)	2.1	2.1	2.1	3.1	2.6
Dissipation factor (tg∂)	ASTM-D-150	(10^6 Hz)	0.0002	0.0007	0.0002	0.0015	0.005
Arc Resistance	ASTM-D-495 (STAINLESS STEEL ELECTRODES)	S	> 180	> 180	> 180		15
Volume resistivity	ASTM-D-257	Ohm-cm	$>10^{18}$	$>10^{18}$	$>10^{18}$	$>10^{17}$	$>10^{16}$
Surface resistivity	ASTM-D-257	Ohm	$>10^{16}$	$>10^{16}$	$>10^{17}$		$>10^{14}$
Dielectric strength (short time)		KV/mm	24	24	24	270	16
GENERAL PROPERTIES							
Radiation resistance	-	Mrad	0.1	10	5		200
Weather resistance	Weather 0-meter (2000h)	-	No effect	No effect	No effect	No effect	No effect
Solvent resistance	ASTM-D-543	-	Excellent	Excellent	Excellent	Good	Excellent
Chemical resistance	ASTM-D-543	-	Excellent	Excellent	Excellent	Good	Excellent
Water absorption	ASTM-D-570	%	0.00	0.01	0.03	2.50	0.03

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Microwave connectors selection guide

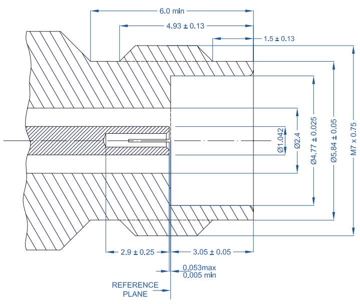
Microwave connectors are key components for the use of microwave coaxial assemblies. They ensure the final connection between the different sub-systems. In addition to electrical parameters defined in this tutorial (operating frequency, VSWR, attenuation, etc), the connector interface plays a major role in selecting the appropriate connector type. The interface is often in compliance with international standards and allows for a good compatibility between the different elements. Be aware that to guarantee optimal performances, the characteristic impedance of the connector has to be the same as the source and the load.

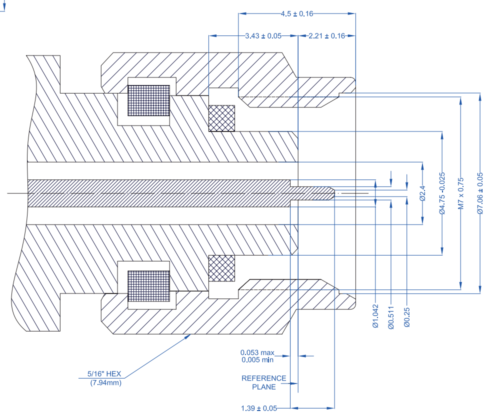
Connector series

2.4 mm series

"Very high precision" 50 Ω connectors optimized up to 50 GHz. Based on a 4.7 mm outer conductor and a 2.4 mm inner conductor, this style cannot be used with any SMA type, 2.9 or 3.5 connectors. Specific adaptors should be used when they are not connected with a connector of the same series.

2.4 MM PLUG CONNECTOR





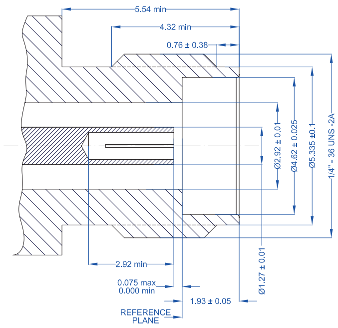
Dimensions are in millimetres

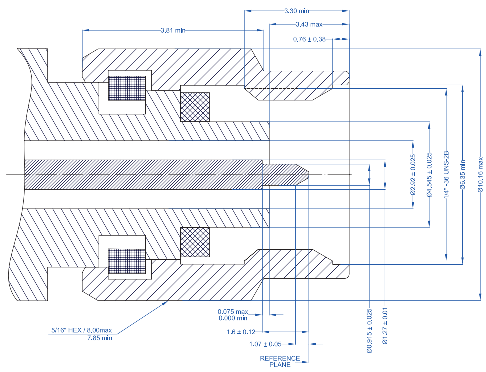
Series	Operating frequency	Power handling
2.4 mm	+++ DC-50 GHz	+

2.9 mm series / K Type

"Very high precision" 50 Ω connectors optimized up to 40 GHz with similar performance to 2.4 mm connectors (can be used with 3.5 mm/SMA series connectors). K type means that they can be used over the complete K frequency band.

K TYPE PLUG CONNECTOR





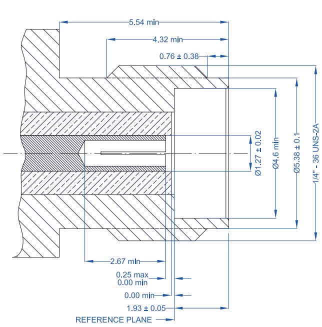
Dimensions are in millimetres

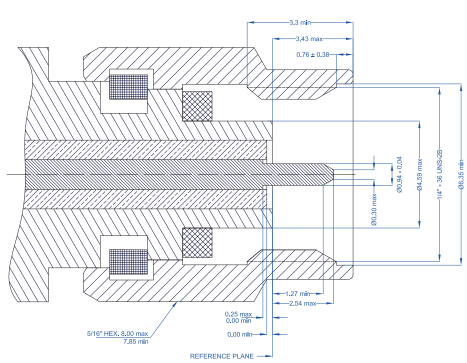
Series	Operating frequency	Power handling
2.9 mm/ K type	+++ DC-40 GHz	+

SMA series

"High precision" 50 Ω connectors optimized up to 26.5 GHz. One of the most widely used connectors for low-power applications. Can be used with 3.5 mm/2.9 mm series connectors. The standard version works from DC to 18 GHz, a precision version can be used up to 26.5 GHz.

SMA PLUG CONNECTOR





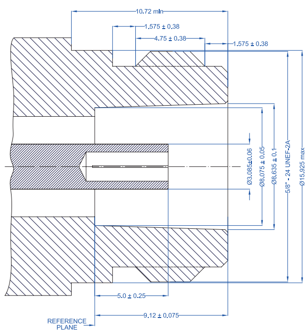
SMA JACK CONNECTOR

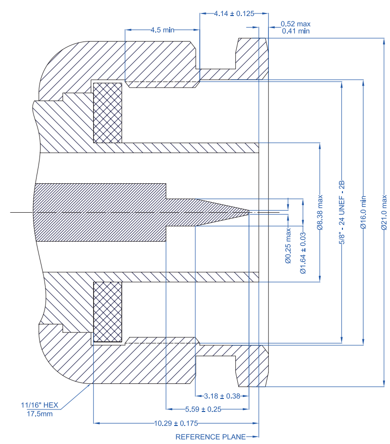
Series	Operating frequency	Power handling
SMA	+++ DC-26,5 GHz	+

Contents

N type

"Precision" 50 Ω connectors optimized up to 18 GHz. One of the most widely used connectors for high frequency applications. The standard version works at 11GHz and a "precision" version is available up to 18 GHz. These connectors provide a stable and secure connection for medium-power applications.






N PLUG CONNECTOR

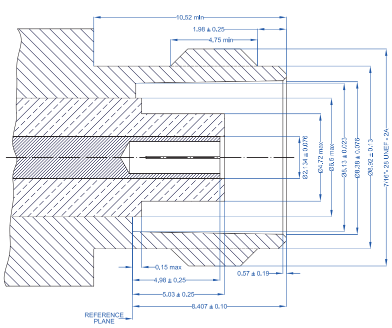

N JACK CONNECTOR

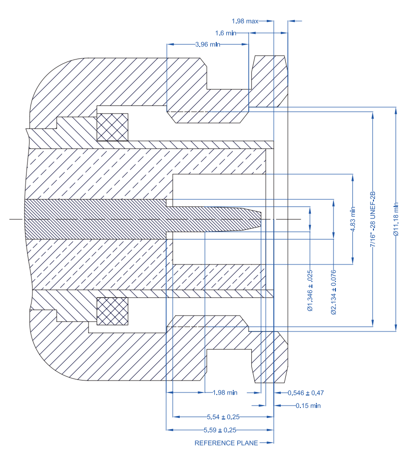
Dimensions are in millimetres

Series	Operating frequency	Power handling
N Type	++ DC- 18 GHz	++

TNC series

"Precision" 50 Ω connectors optimized up to 18 GHz. This is a threaded and improved version of the BNC connector. It provides a secure mechanical connection for better vibration resistance.






TNC PLUG CONNECTOR


TNC JACK CONNECTOR

Dimensions are in millimetres

Series	Operating frequency	Power handling
TNC	++ DC- 18 GHz	++

Connector shape

3 types of shape can be used:

"STRAIGHT" CONNECTOR

Direct "straight" link for optimized performance.

"RIGHT ANGLE" CONNECTOR

Perpendicular link with optimized dimensions but performance slightly lower than the "straight" version.

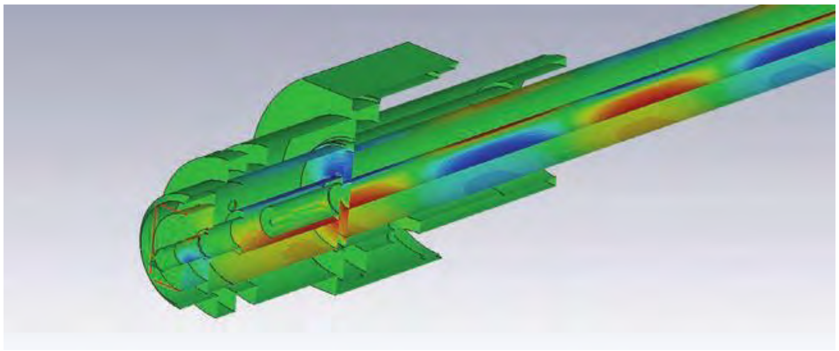
"SWEPT 90" CONNECTOR

Perpendicular link with similar performance to the "straight" version, but requires more space than the "right angle" version.

Contents

EM simulation

Axon’ Cable uses the latest electromagnetic simulation software. This makes it possible to optimize the efficiency of each cable assembly for use at specific frequency bands. The objective is to offer the most appropriate solution to our customers.



In conclusion, it is important to keep in mind that the choice of the cable best suited to your needs depends on the environment it will work in. The final choice will always be a compromise depending on the different mechanical and electrical constraints of the application.

Upon request, Axon’ Cable engineers will study the most appropriate solution for your application.

Summary of constants and formulae

SYMBOL (unit)	NAME	CONSTANTS & FORMULAE
R(Ω)	Electrical resistance	$R(\Omega) = \frac{\rho.L}{S}$
ρ(Ω.m)	Material resistivity	$1.63.10^{-8}$ for Ag $1.72.10^{-8}$ for Cu $2.70.10^{-8}$ for Al
C(pF/m)	Linear capacitance	$C(pF/m) = \frac{24.13.\varepsilon_r}{\log\left(\frac{D}{d}\right)} = \frac{3333.\sqrt{\varepsilon_r}}{Z_c}$
ε_r Zc (Ω)	Dielectric constant Characteristic impedance	1.5 - 1,7 for Celloflon® 2.1 for PTFE $Zc(\Omega) = \frac{138.2}{\sqrt{\varepsilon_r}}.\log\left(\frac{D}{d}\right)$
δ(m)	Skin depth	$\delta(m) = \sqrt{\frac{\rho}{\pi.\mu.F}} \simeq \frac{K}{\sqrt{F}}$
μ (H/m) F_C (GHz)	Permeability Cut-off frequency	μ = μ0 x μr with $\mu 0 = 4\Pi.10^{-7}$ in vacuum $Fc(GHz) = \frac{191}{(D+d).\sqrt{\varepsilon_r}}$
Vp (m/s or %) C (m/s)	Velocity of propagation Speed of light	$Vp(m/s) = \frac{c}{\sqrt{\varepsilon_r}}$ $Vp(\%) = \frac{1}{\sqrt{\varepsilon}}$ 3.10^8 m/s
Tp (ns/m)	Time delay propagation	$Tp(ns/m) = 3.333.\sqrt{\varepsilon_r}$
α (dB/m)	Insertion loss in coaxial cable	$\alpha(dB/m) = A.\sqrt{F} + B.F$
Γ	Reflection coefficient factor	$\lvert\Gamma\rvert^2 = \frac{P_r(W)}{P_e(W)}$
RL (dB)	Return Loss	$RL = -20.\log(\lvert\Gamma\rvert)$
VSWR	Voltage Standing Wave Ratio	$ROS = \frac{Vi + Vr}{Vi - Vr}$
R (mm)	Bend radius	Static bend radius $_{min}$ $R_S \simeq 5.Ø$ Dynamic bend radius $_{min}$ $R_d \simeq 10.Ø$

Contents

Table of equivalence old / new reference

	New identification code	Old identification code	Maximum operating frequency GHz	Inner conductor	Nominal outside diameter (mm)
Axowave™	C32SZ	3Q	50	Solid	3.15
	C37MK	3S	26.5	Stranded	3.7
	C40SK	4H	40	Solid	4.0
	C53MK	5T	26.5	Stranded	5.3
	C54SK	5D	26.5	Solid	5.4
	C54MK	5L	26.5	Stranded	5.4
	C80MK	8M	18	Stranded	8.0
	C80SK	8N	18	Solid	8.0
	C107MK	11X	12.4	Stranded	10.7
	C145MK	15P	9	Stranded	14.5
Axowave™ Pu	C62 MR	5T-Pu	26.5	Stranded	6.2
	C90SR	8N-Pu	18	Solid	9.0
	C90MR	8M-Pu	18	Stranded	9.0
	C152MR	15P-Pu	9	Stranded	15.2
	C200MR	20W	7	Stranded	20.0
Extra-flexible	U25MP	2.5U	18	Stranded	2.5
	U36MR	3.5U	18	Stranded	3.6
	U42MP	4U	18	Stranded	4.2
	U50MR	5U	18	Stranded	5.0
AX™	X15SK	AX047	18	Solid	1.5
	X25SK	AX086	18	Solid	2.5
	X42SK	AX141	18	Solid	4.15
	X73SK	AX250	18	Solid	7.25
QFX®	H22SW	QFX086	18	Solid	2.15
	H36SW	QFX141	18	Solid	3.58
Lightweight	L53SK	-	26.6	Solid	5.3
	L77SK	-	18	Solid	7.7
	L113SK	11Y	12	Solid	11.3
	L127SR	11Y-PU	12	Solid	12.7

CHARACTERISTICS OF MICROWAVE COAXIAL ASSEMBLIES

Contents

TWIST CAPSULE AXOTWIST™

AXOSPEC™ CUSTOM DESIGNED ASSEMBLIES

General information

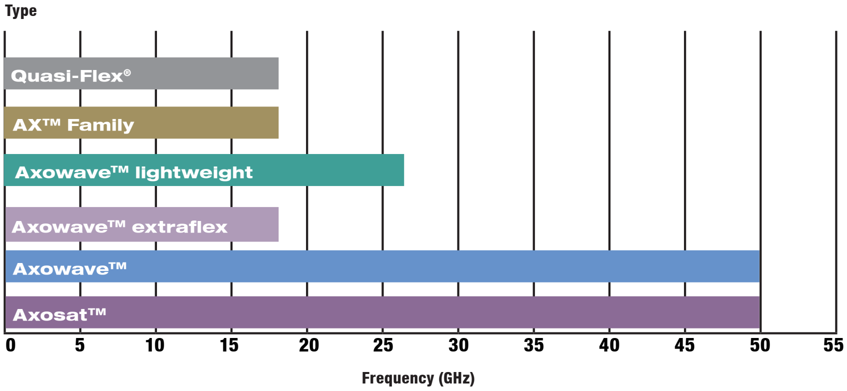
Contents

Axon' Cable range summary

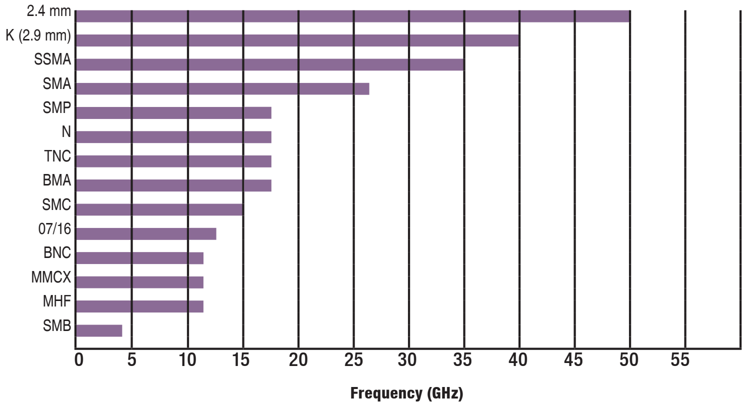
The range of Axon' Cable microwave coaxial assemblies comprises 6 major series with the following characteristics:

- Axowave™ optimized low loss coaxial cables.
- Axowave™ Extraflex, low loss coaxial cables with optimized flex-life.
- Axowave™ lightweight coaxial cables.
- Quasi-Flex® coaxial cables, hand formable semi-rigid substitutes.
- Ax™ coaxial cables, flexible semi-rigid substitutes.
- Axosat™ space grade coaxial cables.

Operating frequency by cable series.



Operating frequency depending on connector type

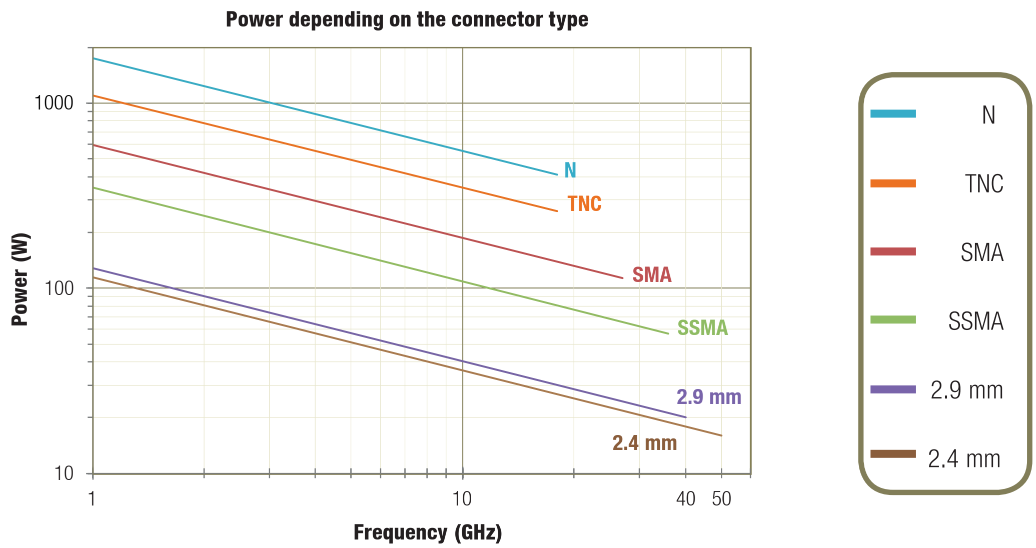


2.4 mm CONNECTOR

2.9 mm CONNECTOR

SMA CONNECTOR

TNC/N CONNECTOR



EMI-EMC

Axon' Cable uses two general methods to evaluate the EMI protection of each assembly:

› Cables: measurement of the Transfer Impedance (Zt):

- Triaxial method up to 80 MHz,
- Micro-strip method up to 2 GHz.

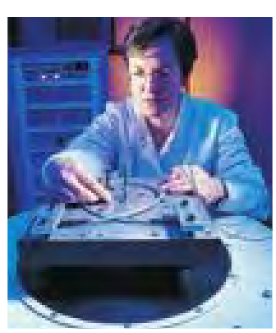
› Assemblies: mode stirred chamber up to 18 GHz.

TRANSFER IMPEDANCE TEST BENCH

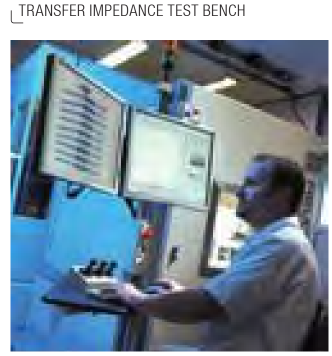
Specific measurements

SALT SPRAY TEST

FLEX-LIFE TEST



VIBRATION TEST



X-RAY ANALYSIS

Contents

CELLOFLON® Dielectric

Axon' Cable uses a porous PTFE dielectric for the manufacture of microwave coaxial assemblies in order to obtain a dielectric constant as close as possible to air. The microwave performance is therefore improved. Axon' Cable has developed and patented its own expanded PTFE products, brand-named CELLOFLON®, available in both taped and extruded versions.

The low dielectric constant of CELLOFLON® helps to considerably improve the electrical performance of the cable, achieving lower insertion losses, a higher cut-off frequency and faster propagation velocity. For identical performances, the dimensions of a CELLOFLON® cable will be smaller and the cable's weight and volume lower. For example, the insertion losses of a 1 m Axowave™ C80SK assembly, terminated by two N straight plug connectors are only 1.0 dB at 18 GHz.

The use of CELLOFLON® improves the phase stability of the assemblies under mechanical stress, as well as when submitted to temperature changes.

CELLOFLON®

Specification

In order for Axon' engineers to offer the most appropriate solution for your requirements, as much as possible of the following information should be provided:

- Conditions of use: frequency, temperature range;
- Electrical characteristics: insertion loss in dB/m at specified frequency, VSWR, characteristic impedance;
- Type of connectors;
- Flex-life;
- Phase matching;
- Shield efficiency.

Cable assemblies are delivered in individual boxes and are identified by a yellow heatshrink tube with the following black marking: "Axon' Cable + plan number", batch number and serial number.

Quality assurance

Axon' Cable is ISO9001/2000 and EN9100 approved

Electrical and dimensional inspections are carried out at each stage of the cable manufacture.
The VSWR (return loss) and insertion losses are measured on 100% of all assemblies produced, and a test certificate is automatically supplied.
Other measurements can be carried out on request: phase matching, shielding efficiency, intermodulation etc.

Identification code

Example C 80 S K 1 S10 S10-100C

CABLE SERIES
C = Celloflon® AxowaveTM - H = Hand-formable (QFX)
L = Ligthweight - S = Space - U = Extraflex - X = AX

REFERENCE DIAMETER
Ø.D. X 10

CONDUCTOR TYPE
S = Solid - M = Stranded

JACKET TYPE
K = FEP - P = PFA - R = Polyurethane
X = Zero halogen Poliax- Z = ETFE - W = none(*)

SERIES
1 = AXOWAVETM
2 = AXOLABTM (stainless steel hose + thermoplastic jacket)
3 = AXOLABTM (stainless steel spring + polylefine jacket)

CONNECTOR TYPE(**)
S: SMA - K: 2.9 - Q: 2.4 - N: N
T: TNC

CONNECTOR STYLE
1 = plug - 2 = jack

CONNECTOR SHAPE
0 = straight - 1 = elbow (right angle) - 2 = 90° swept

LENGTH

LENGTH CODE
M = meter - C = centimeter

(*) Only Quasi-Flex®.

(**) To choose the type of connector, please check the availability on the corresponding datasheet.

Contents

Example

The Axon' Cable identification code is made of 16 or 17 alphanumeric characters. Each character refers to one defined technical characteristic of the cable assembly.
The first 6 characters (maximum 7) refer to the cable type, i.e series, diameter, type of conductor used, jacket type and protection type.
The next 6 characters refer to connectors used, type, version (male/female) and connector shape.
The last 4 characters define the final length of the cable assembly.

5.4 mm diameter CELLOFLON® Axowave™ made with a single-stranded Axowave™ cable insulated with FEP, terminated with a SMA plug connector and a 90° swept SMA connector, 1 m length.

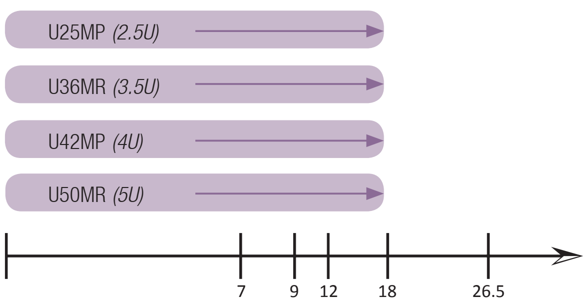
Axowave™ extraflex

Contents

Axowave™ extraflex cable assemblies have been designed for high numbers of repetitive bends - required for dynamic applications, such as surveillance or navigation system and radars. Even after 1 million bends, an extraflex microwave assembly keeps its electrical properties.

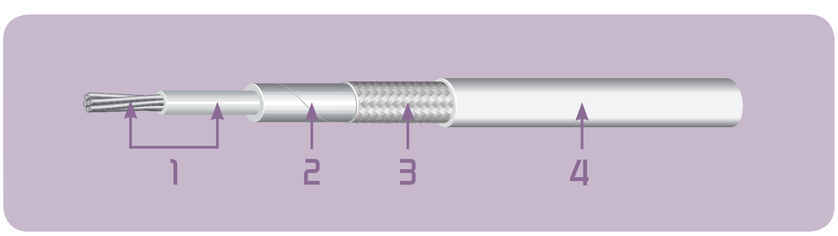
Advantages

> Rated temperature -55°C to +125°C or -40°C to +95°C depending on outer jacket.
> Rated frequency 0 to 18 GHz (depending on the version and connectors).
> Optimized insertion loss up to 18 GHz (depending on the version and connectors).
> Shielding efficiency > 100 dB at 1 GHz.
> Optimized flexible version to withstand a high number of flexes.
> Possible to integrate Axowave™ Extraflex coaxial assemblies into hybrid harnesses (containing additional functions such as power and signal).



Recommended operating frequency (GHz).
Other frequencies upon request.

Construction



1. CORE :
   Inner: copper alloy, stranded.
   Dielectric: Celloflon® expanded PTFE.
2. Taped shield: silver plated copper.
3. Shielded braid: copper alloy, shielded braid.
4. Outer jacket: PFA, PU.

Contents

Applications

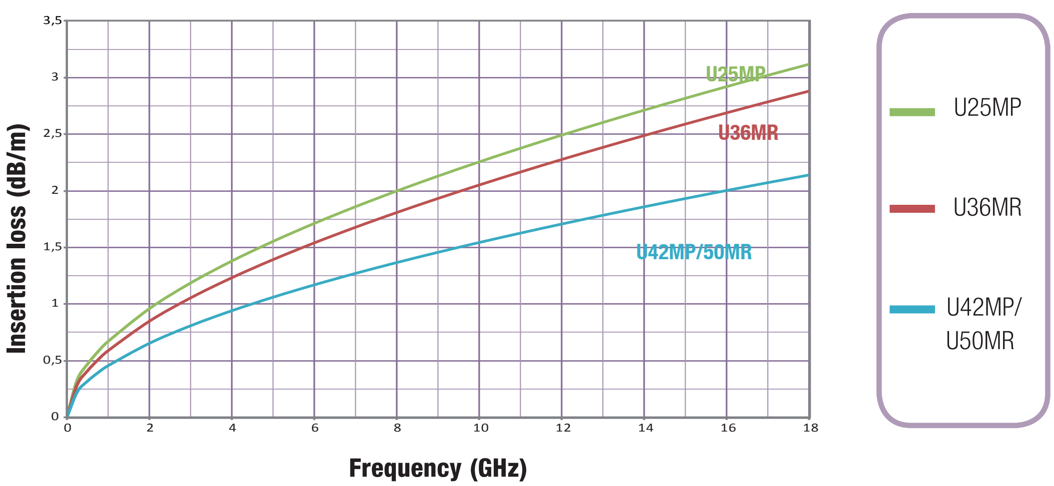
> Dynamic applications (flex-life).
> Antennae.
> Radar.

Technical characteristics

New reference	Old reference	Outer diameter (mm)	Operating frequency (GHz)*	Static bend radius (mm)	Dynamic bend radius (mm)	Approximate weight (g/m)	Flex–life (cycles)*
U25MP	**2.5U**	2.5	18	15	30	15	> 100 000
U36MR	**3.5U**	3.6	18	20	40	26	> 100 000
U42MP	**4U**	4.2	18	20	45	38	> 100 000
U50MR	**5U**	5	18	20	40	40	> 3 000 000

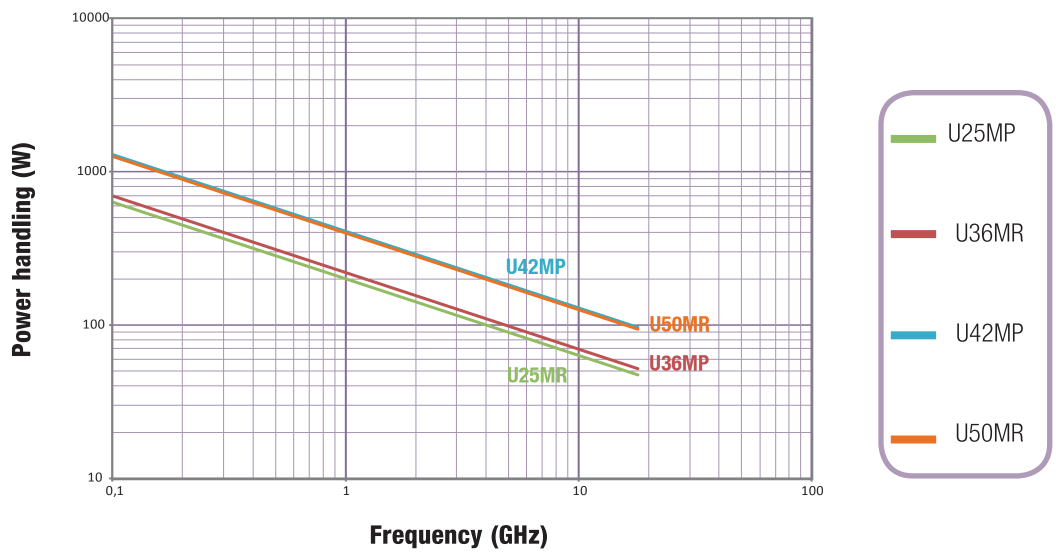
* Indicative values recommended but not maximum.

Insertion loss Axowave™ extraflex



The frequency of use is limited by the type of connector.

Power handling - Axowave™ extraflex



The frequency of use is limited by the type of connector.

Choice of connectors

New reference	Old reference	SMA plug straight	SMA jack straight	TNC plug straight
U25MP	2.5U	●		
U36MR	3.5U	●		
U42MP	4U	●	●	●
U50MR	5U	●	●	●

Other connectors available on request.

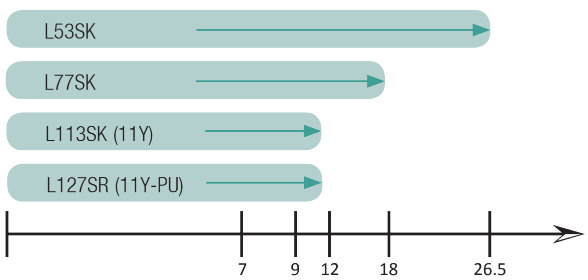
Axowave™ lightweight

Contents

30 % ! This is the weight saved by Axowave™ lightweight cable assemblies. Compared to the standard Axowave™ range, they are lighter and thinner and exhibit excellent mechanical and electrical performance. Axowave™ lightweight cable assemblies are particularly designed for the cabling of aircraft and helicopters.

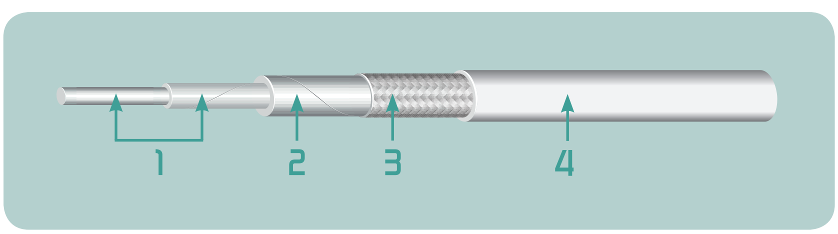
Advantages

> 30% lighter than the avionics standard.
> Excellent attenuation values.
> Rated temperature -55°C to +125°C or -40°C to +95°C depending on outer jacket.
> Characteristic impedance : 50 Ω.
> Lightweight and small diameter, they are designed for the cabling of aircraft and helicopters.
> Cables assembled and delivered with Axon' Cable connectors such as N, TNC, SMA or others on request.



Recommended operating frequency (GHz).
Other frequencies upon request.

Construction



1. CORE:
   Inner conductor: Silver plated copper clad aluminium/Copper clad aluminium.
   Dielectric: Celloflon® expanded PTFE.
2. Taped shield: silver plated copper.
3. Shielding braid: silver plated copper clad aluminium/silver plated copper.
4. Outer jacket: FEP/PU.

Applications

> Aircraft.
> Helicopters.
> For all applications where weight saving is required, whilst retaining excellent electrical performance.

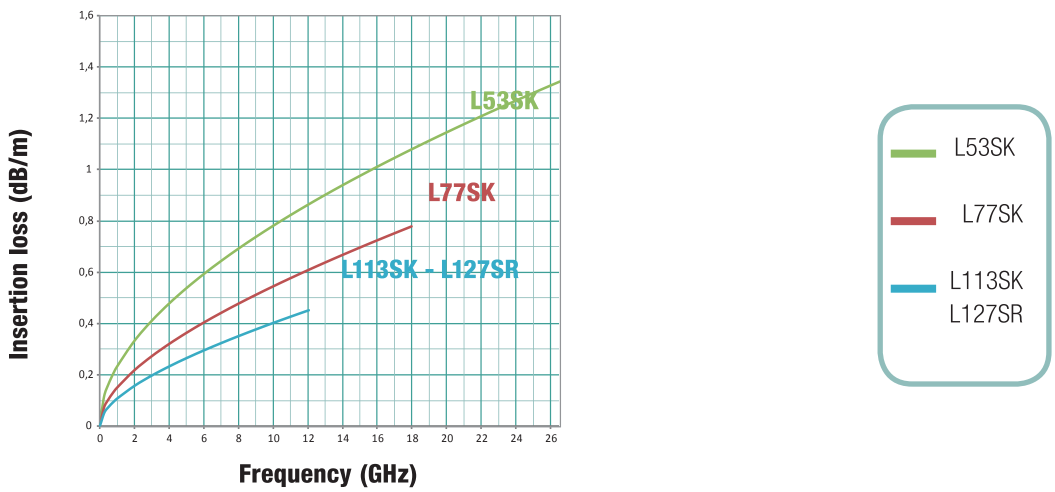
Contents

Technical characteristics

New reference	Old reference	Outer diameter (mm)	Cut–off frequency (GHz)	Static bend radius (mm)	Dynamic bend radius (mm)	Approximate weight (g/m)	Flex–life (cycles)*
L53SK	–	5.3	26.5	30	55	47	500
L77SK	–	7.7	18	60	80	93	500
L113SK	11Y	11.3	12	80	125	200	500
L127SR	11Y–PU	12.7	12	80	125	215	500

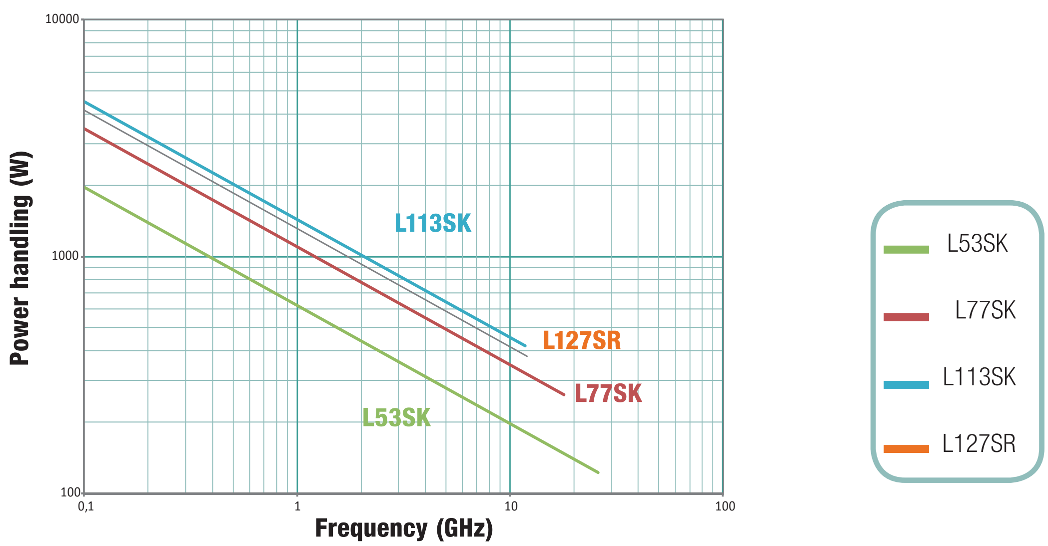
* Indicative values recommended but not maximum.

Insertion loss Axowave™ lightweight



The frequency of use is limited by the type of connector.

Power handling Axowave™ lightweight



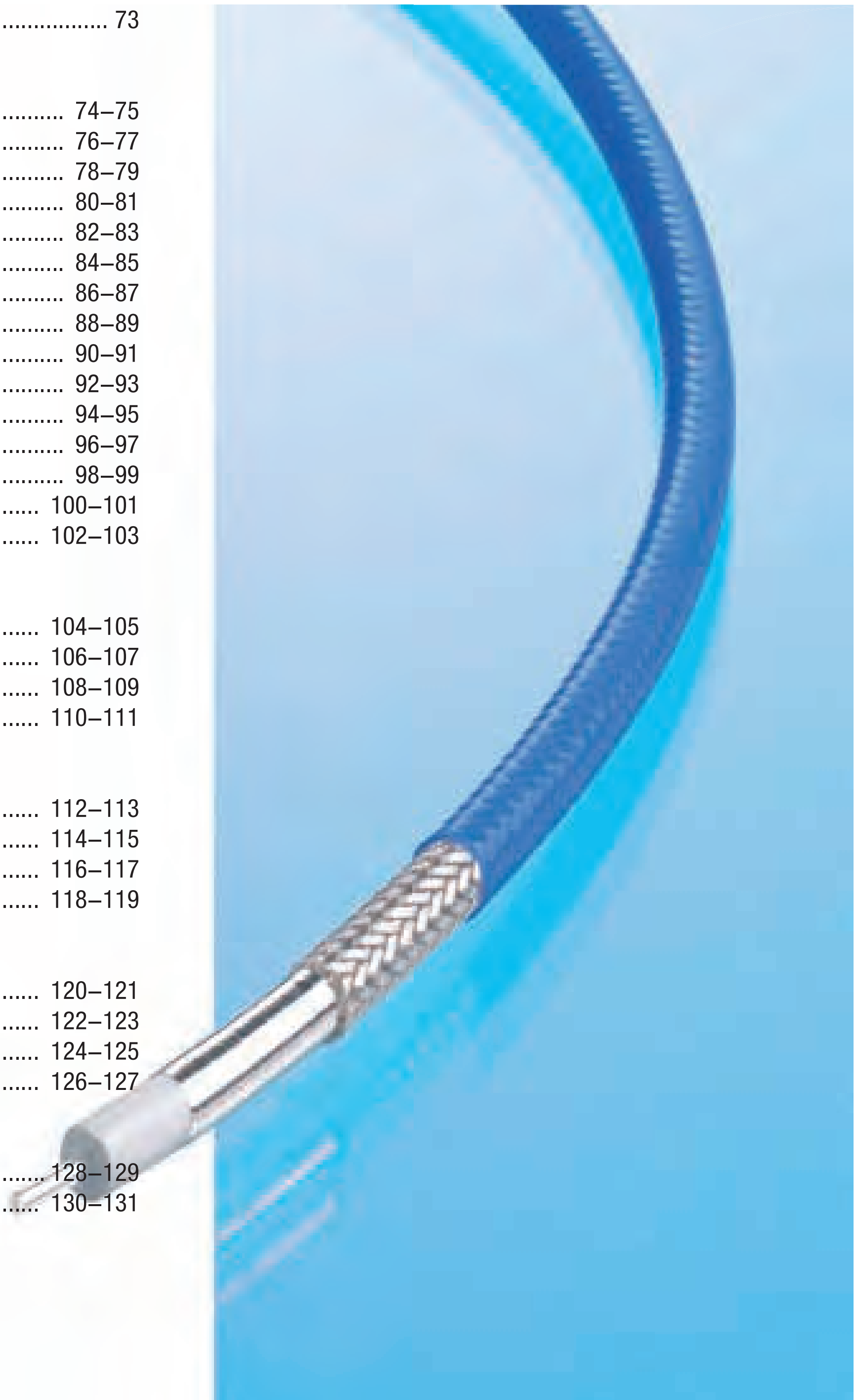
Choice of connectors

New reference	Old reference	SMA plug straight	SMA plug swept 90°	SMA jack straight	SMA jack swept 90°	N plug straight	N jack straight	N plug swept 90°	TNC plug straight	TNC swept
L53SK	–	●	●	●	●	●	●	●	●	●
L77SK	–	●	●			●	●	●	●	●
L113SK	11Y					●				
L127SR	11Y–PU					●				


AXOWAVE™ LIGHTWEIGHT

Technical data sheets

Contents



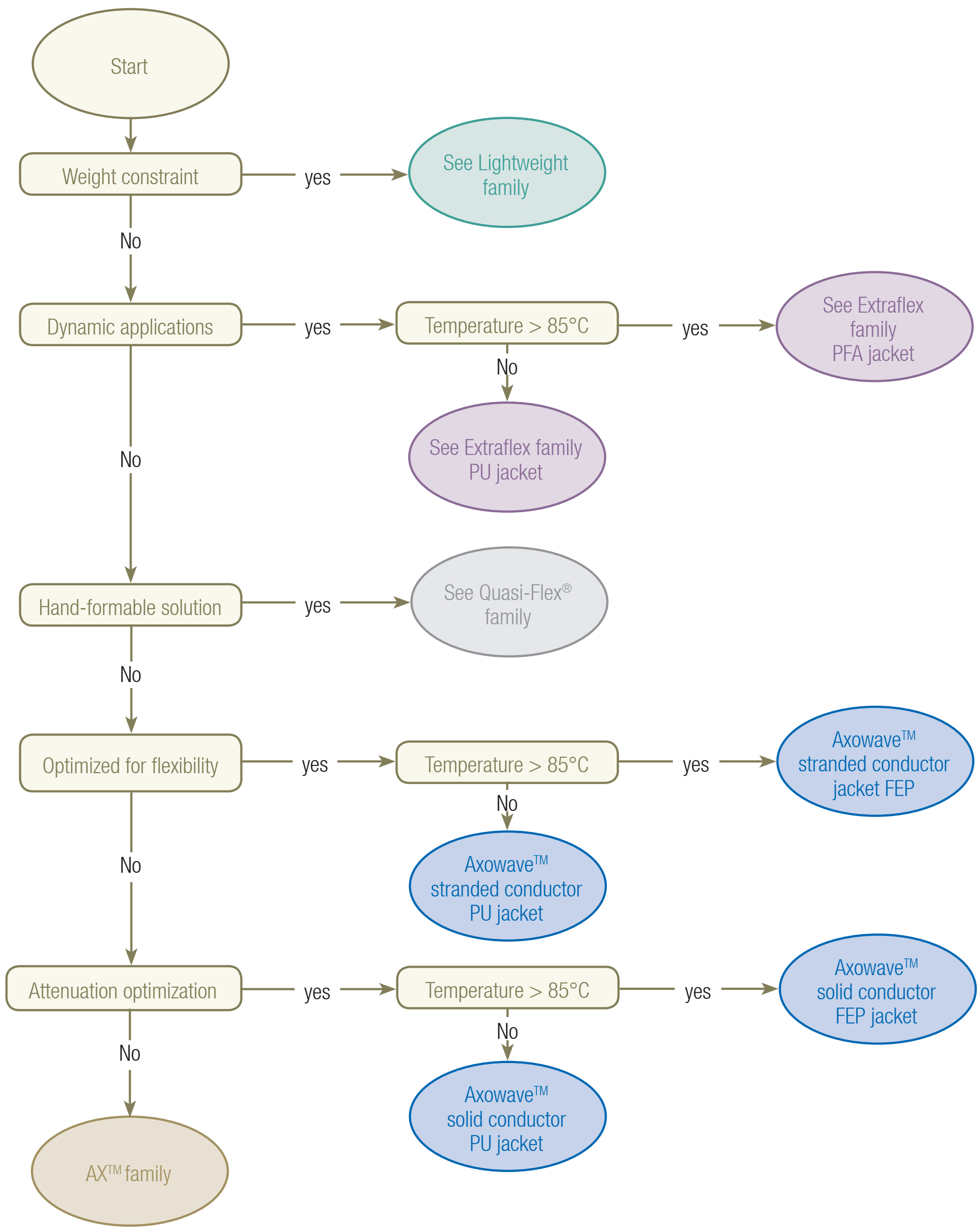
STANDARD AXOWAVE

Selection guide

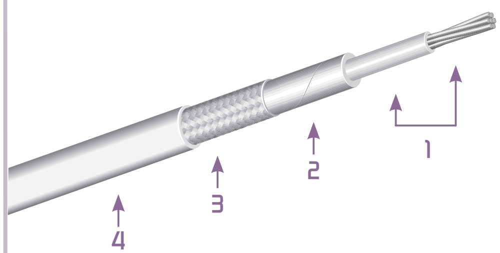
Use the following chart to identify the selected product family that best suits your application.

For aeromil applications we recommend FEP jackets.

Don't hesitate to contact us for any special request.



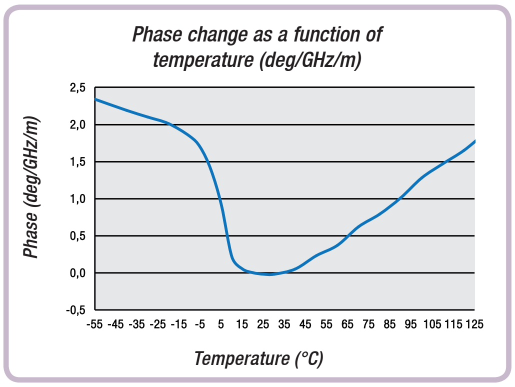
Axowave™ U25MP (2.5U)



Coaxial cable construction U25MP (2.5U)

1. Core	Inner conductor	Silver Plated Copper Alloy, Stranded	-
	Dielectric	Celloflon® (expanded PTFE)	-
2. Taped shield		Silver Plated Copper	-
3. Braided shield		Silver Plated Copper Alloy, shielded braid	-
4. Outer jacket		PFA	2.50 mm

Coaxial cable characteristics



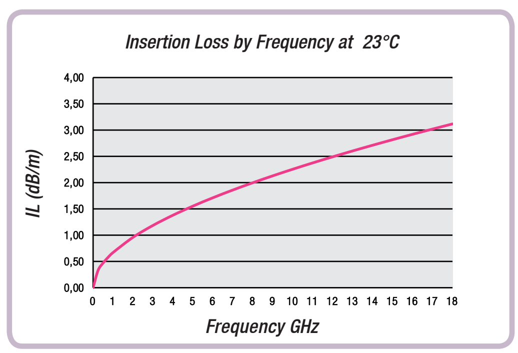
Max. Insertion Loss by Frequency at 18 GHz (coax only)	3.12 dB/m
Characteristic impedance	50 ±1 Ω
Capacitance	87 pF/m
Velocity of Propagation	76 %
Nominal phase	1565 °/m/GHz
Approximate weight	15 g/m
Outer jacket material (colour)	PFA (blue)
Inner conductor type	stranded
Flexlife (*)	> 100 000 cycles
Min. bending radius for static applications	15 mm
Min. bending radius for dynamic applications	30 mm
Crush resistance (*)	150 N/ 10 cm
Power handling at 23°C and 18 GHz (**)	47 W

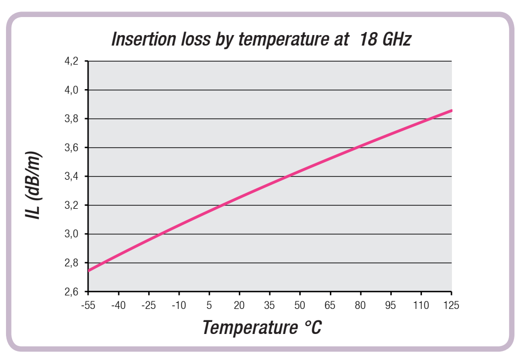
(*) Recommended but not max. values. - (**) Values limited due to the connectors see p 36.

Calculation of insertion loss

$$\alpha_{max.}(F) = 0.65 \times \sqrt{F} + 0.02 \times F$$

Frequency (GHz)	Nom. insertion loss (dB/m)	Max. insertion loss (dB/m)
1	0.63	0.67
2	0.90	0.96
4	1.29	1.38
6	1.61	1.72
8	1.87	2.00
12	2.34	2.50
18	2.92	3.12





EXTRAFLEX

Contents

Axowave™ U25MP (2.5U)

Coaxial cable assembly characteristics

Operating frequency	0-18 GHz
Insertion Loss by Frequency at 18 GHz (1 m assembly, SMA plug straight)	3.40 dB max.
Insertion Loss by Frequency at 18 GHz (1 m assembly, SMA plug straight)	3.17 dB nom.
Shielding efficiency at 1 GHz	-100 dB max.
VSWR (1 m assembly, SMA plug straight)	1.30 max.
Operating temperature	-55/+125°C
Phase change at 1 GHz	2.40 °/m
Stability of insertion loss after bending at 18 GHz (bending radius = 30 mm)	0.10 dB
Coaxial cable / connector retention force (Recommended but not max. values)	45 N

Available connectors

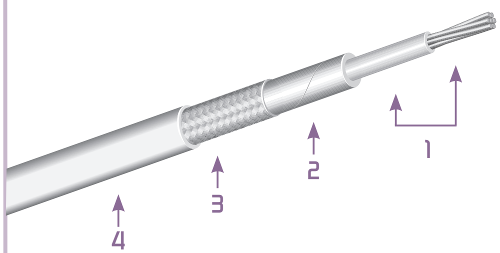
Up to 18 GHz :

- SMA plug, straight.

Applications / Advantages

- Good flexlife.
- High shielding effectiveness.
- High resistance to chemicals.
- Dynamic applications.

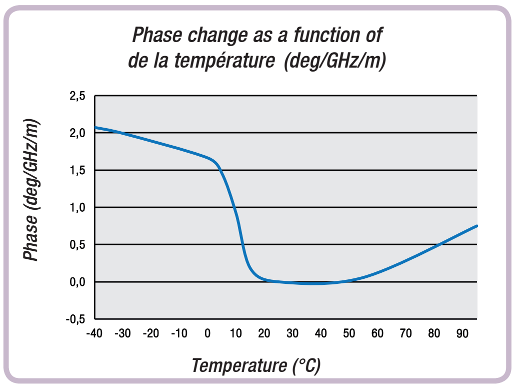
Axowave™ U36MR (3.5U)



Coaxial cable construction U36MR (3.5U)

1. Core	Inner conductor	Silver Plated Copper Alloy, Stranded	-
	Dielectric	Celloflon® (expanded PTFE)	-
2. Taped shield		Silver Plated Copper	-
3. Braided shield		Silver Plated Copper Alloy, shielded braid	-
4. Outer jacket		PU	3.60 mm

Coaxial cable characteristics



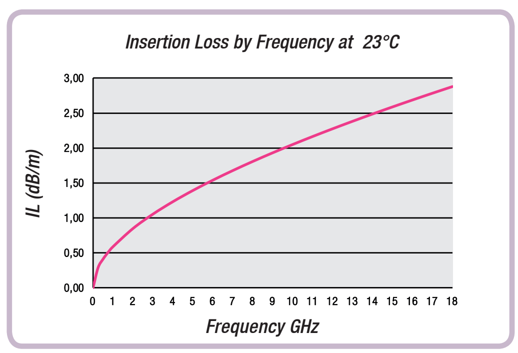
Max. Insertion Loss by Frequency at 18 GHz (coax only)	2.88 dB/m
Characteristic impedance	50 ±1 Ω
Capacitance	87 pF/m
Velocity of Propagation	76 %
Nominal phase	1565 °/m/GHz
Approximate weight	26 g/m
Outer jacket material (colour)	PU (black)
Inner conductor type	stranded
Flexlife (*)	> 100 000 cycles
Min. bending radius for static applications	20 mm
Min. bending radius for dynamic applications	40 mm
Crush resistance (*)	250 N/ 10 cm
Power handling at 23°C and 18 GHz (**)	52 W

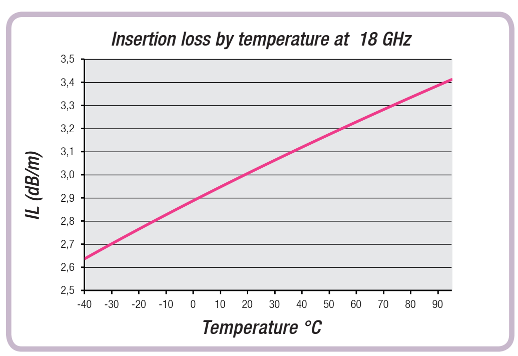
(*) Recommended but not max. values. - (**) Values limited due to the connectors see p 36.

Calculation of insertion loss

$$\alpha_{max.}(F) = 0.56 \times \sqrt{F} + 0.028 \times F$$

Frequency (GHz)	Nom. insertion loss (dB/m)	Max. insertion loss (dB/m)
1	0.55	0.59
2	0.79	0.85
4	1.16	1.24
6	1.44	1.54
8	1.69	1.81
12	2.13	2.28
18	2.69	2.88





EXTRAFLEX

Contents

AxowaveTM U36MR (3.5U)

Coaxial cable assembly characteristics

Operating frequency	0-18 GHz
Insertion Loss by Frequency at 18 GHz (1 m assembly, SMA plug straight)	3.15 dB max.
Insertion Loss by Frequency at 18 GHz (1 m assembly, SMA plug straight)	2.95 dB nom.
Shielding efficiency at 1 GHz	-100 dB max.
VSWR (1 m assembly, SMA plug straight)	1.30 max.
Operating temperature	-40/+95°C
Phase change at 1 GHz	2.10 °/m
Stability of insertion loss after bending at 18 GHz (bending radius = 40 mm)	0.10 dB
Coaxial cable / connector retention force (Recommended but not max. values)	80 N

Available connectors

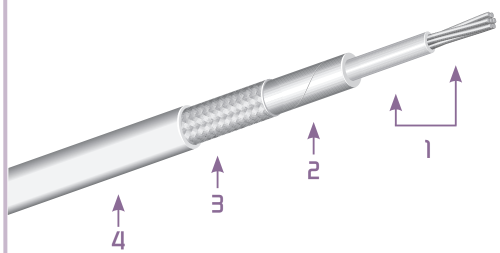
Up to 18 GHz :

- SMA plug, straight.

Applications / Advantages

- Good flexlife.
- High shielding effectiveness.
- High resistance to abrasion.
- Dynamic applications.

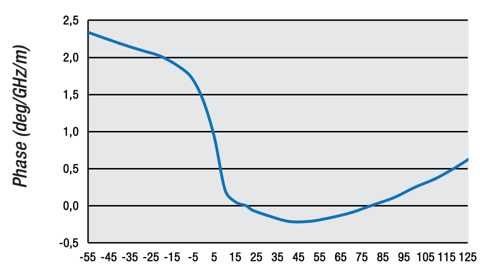
Axowave™ U42MP (4U)



Coaxial cable construction U42MP (4U)

1. Core	Inner conductor	Silver Plated Copper Alloy, Stranded	-
	Dielectric	Celloflon® (expanded PTFE)	-
2. Taped shield		Silver Plated Copper	-
3. Braided shield		Silver Plated Copper Alloy, shielded braid	-
4. Outer jacket		PFA	4.20 mm

Coaxial cable characteristics



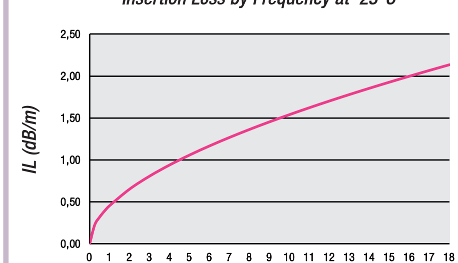
Max. Insertion Loss by Frequency at 18 GHz (coax only)	2.14 dB/m
Characteristic impedance	50 ±1 Ω
Capacitance	87 pF/m
Velocity of Propagation	76 %
Nominal phase	1565 °/m/GHz
Approximate weight	38 g/m
Outer jacket material (colour)	PFA (blue)
Inner conductor type	stranded
Flexlife (*)	> 100 000 cycles
Min. bending radius for static applications	20 mm
Min. bending radius for dynamic applications	45 mm
Crush resistance (*)	250 N/ 10 cm
Power handling at 23°C and 18 GHz (**)	97 W

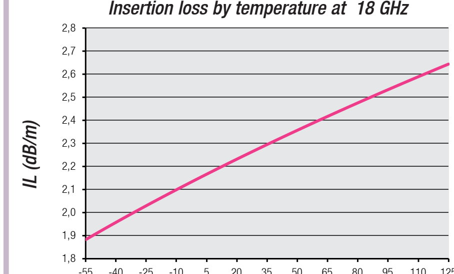
(*) Recommended but not max. values. - (**) Values limited due to the connectors see p 36.

Calculation of insertion loss

$$\alpha_{max.}(F) = 0.44 \times \sqrt{F} + 0.015 \times F$$

Frequency (GHz)	Nom. insertion loss (dB/m)	Max. insertion loss (dB/m)
1	0.43	0.46
2	0.62	0.66
4	0.88	0.94
6	1.09	1.17
8	1.28	1.37
12	1.60	1.71
18	2.00	2.14





EXTRAFLEX

Contents

Axowave™ U42MP (4U)

EXTRAFLEX

Coaxial cable assembly characteristics

Operating frequency	0-18 GHz
Insertion Loss by Frequency at 18 GHz (1 m assembly, SMA plug straight)	2.40 dB max.
Insertion Loss by Frequency at 18 GHz (1 m assembly, SMA plug straight)	2.25 dB nom.
Shielding efficiency at 1 GHz	-100 dB max.
VSWR (1 m assembly, SMA plug straight)	1.30 max.
Operating temperature	-55/+125°C
Phase change at 1 GHz	2.60 °/m
Stability of insertion loss after bending at 18 GHz (bending radius = 45 mm)	0.10 dB
Coaxial cable / connector retention force (Recommended but not max. values)	80 N

Available connectors

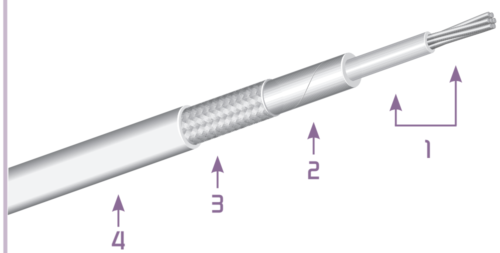
Up to 18 GHz :

- SMA plug, straight.
- SMA bulkhead feedthrough jack, straight.
- TNC plug, straight.

Applications / Advantages

- Good flexlife.
- High shielding effectiveness.
- High resistance to chemicals.
- Dynamic applications.

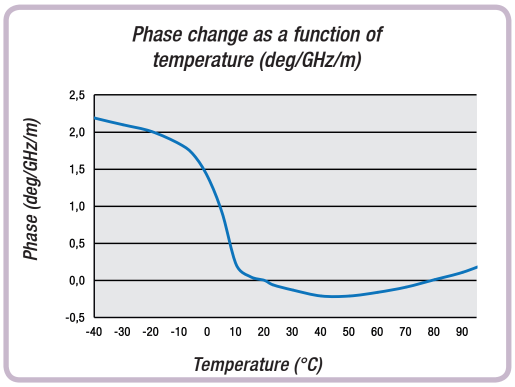
Axowave™ U50MR (5U)



Coaxial cable construction U50MR (5U)

1. Core	Inner conductor	Silver Plated Copper Alloy, Stranded	-
	Dielectric	Celloflon® (expanded PTFE)	-
2. Taped shield		Silver Plated Copper	-
3. Braided shield		Silver Plated Copper Alloy, shielded braid	-
4. Outer jacket		PU	5.00 mm

Coaxial cable characteristics



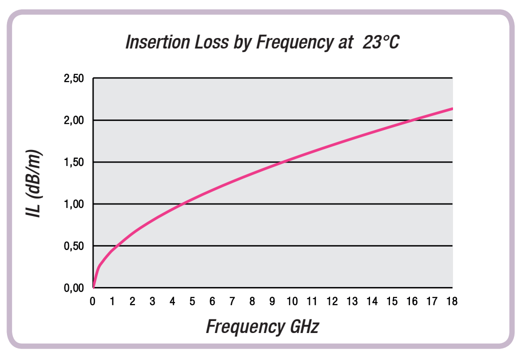
Max. Insertion Loss by Frequency at 18 GHz (coax only)	2.14 dB/m
Characteristic impedance	50 ±1 Ω
Capacitance	87 pF/m
Velocity of Propagation	76 %
Nominal phase	1565 °/m/GHz
Approximate weight	40 g/m
Outer jacket material (colour)	PU (black)
Inner conductor type	stranded
Flexlife (*)	> 3.10^6 cycles
Min. bending radius for static applications	20 mm
Min. bending radius for dynamic applications	40 mm
Crush resistance (*)	600 N/ 10 cm
Power handling at 23°C and 18 GHz (**)	93 W

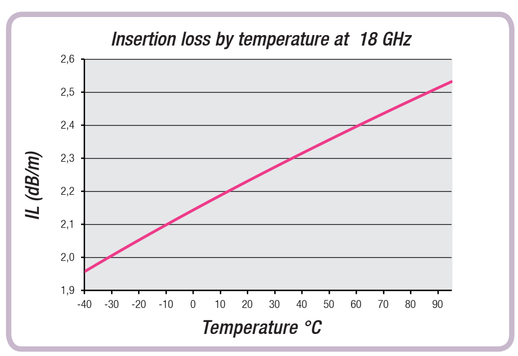
(*) Recommended but not max. values. - (**) Values limited due to the connectors see p 36.

Calculation of insertion loss

Frequency (GHz)	Nom. insertion loss (dB/m)	Max. insertion loss (dB/m)
1	0.43	0.46
2	0.62	0.66
4	0.88	0.94
6	1.09	1.17
8	1.28	1.37
12	1.60	1.71
18	2.00	2.14

$$\alpha_{max.} (F) = 0.44 \times \sqrt{F} + 0.015 \times F$$





EXTRAFLEX

Contents

Axowave™ U50MR (5U)

Coaxial cable assembly characteristics

Operating frequency	0-18 GHz
Insertion Loss by Frequency at 18 GHz (1 m assembly, SMA plug straight)	2.40 dB max.
Insertion Loss by Frequency at 18 GHz (1 m assembly, SMA plug straight)	2.25 dB nom.
Shielding efficiency at 1 GHz	-100 dB max.
VSWR (1 m assembly, SMA plug straight)	1.30 max.
Operating temperature	-40/+95°C
Phase change at 1 GHz	2.40 °/m
Stability of insertion loss after bending at 18 GHz (Bending radius = 40 mm)	0.10 dB
Coaxial cable / connector retention force (Recommended but not max. values)	80 N

Available connectors

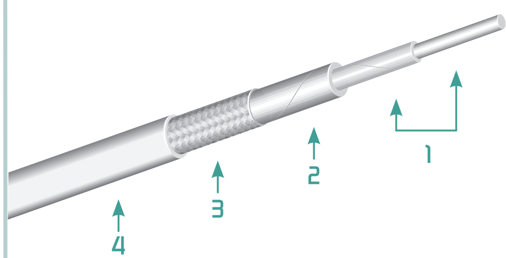
Up to 18 GHz :

- SMA plug, straight.
- SMA bulkhead feedthrough jack, straight.
- TNC plug, straight.

Applications / Advantages

- Good flexlife.
- High shielding effectiveness.
- High resistance to chemicals.
- Dynamic applications.

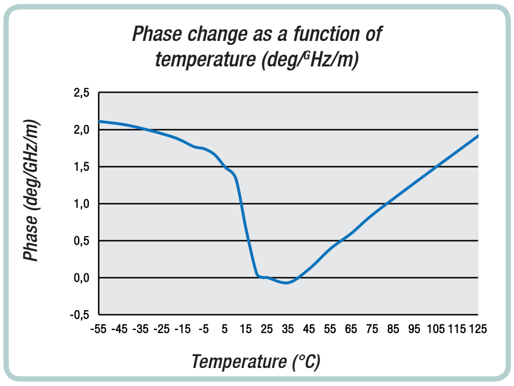
Axowave™ L53SK



Coaxial cable construction L53SK

1. Core	Inner conductor	Silver Plated Copper Clad Aluminium, Solid	-
	Dielectric	Celloflon® (expanded PTFE)	-
2. Taped shield		Silver Plated Copper	-
3. Braided shield		Silver Plated Copper Clad Aluminium	-
4. Outer jacket		FEP	5.30 mm

Coaxial cable characteristics



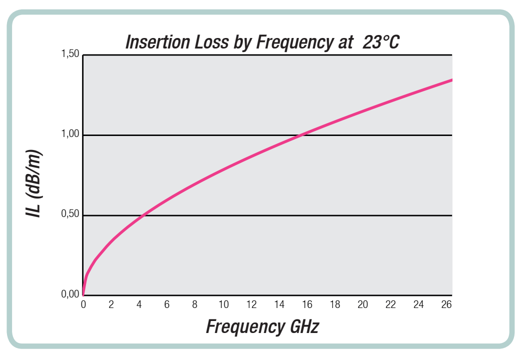
Max. Insertion Loss by Frequency at 26.5 GHz (coax only)	1.35 dB/m
Characteristic impedance	50 ±1 Ω
Capacitance	87 pF/m
Velocity of Propagation	76 %
Nominal phase	1555 °/m/GHz
Approximate weight	45 g/m
Outer jacket material (colour)	FEP (blue)
Inner conductor type	solid
Flexlife (*)	500 cycles
Min. bending radius for static applications	30 mm
Min. bending radius for dynamic applications	55 mm
Crush resistance (*)	650 N/ 10 cm
Power handling at 23°C and 26.5 GHz (**)	121 W

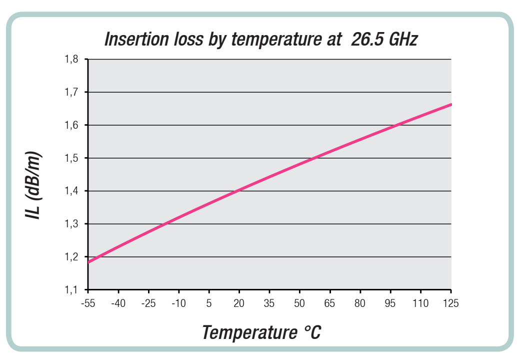
(*) Recommended but not max. values. - (**) Values limited due to the connectors see p 36.

Calculation of insertion loss

$$\alpha_{max.}(F) = 0.225 \times \sqrt{F} + 0.007 \times F$$

Frequency (GHz)	Nom. insertion loss (dB/m)	Max. insertion loss (dB/m)
1	0.22	0.24
2	0.32	0.34
4	0.45	0.48
6	0.56	0.60
8	0.65	0.70
12	0.81	0.87
18	1.02	1.09
26.5	1.26	1.35





Axowave™ L53SK

Coaxial cable assembly characteristics

Operating frequency	0-26.5 GHz
Insertion Loss by Frequency at 26.5 GHz (1 m assembly, SMA plug straight)	1.70 dB max.
Insertion Loss by Frequency at 26.5 GHz (1 m assembly, SMA plug straight)	1.56 dB nom.
Shielding efficiency at 1 GHz	-90 dB max.
VSWR (1 m assembly, SMA plug straight)	1.30 max. (0-18GHz) / 1.35 max. (18-26.5 GHz)
Operating temperature	-55/+125°C
Phase change at 1 GHz	2.20 °/m
Stability of insertion loss after bending at 26.5 GHz (bending radius = 55 mm)	0.15 dB
Coaxial cable / connector retention force (Recommended but not max. values)	90 N

Available connectors

Up to 26.5 GHz :

- SMA plug, straight.
- SMA plug, swept 90°.
- SMA bulkhead feedthrough jack, straight.
- SMA bulkhead feedthrough jack, swept 90°.

Up to 18 GHz :

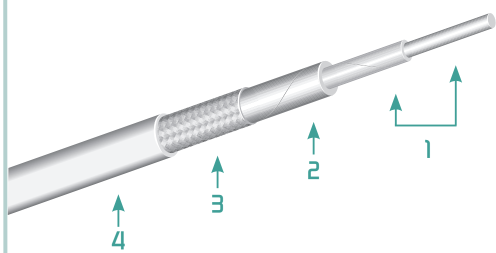
- N plug, straight.
- N plug, swept 90°.
- TNC plug, straight.
- TNC plug, swept 90°.

LIGHTWEIGHT

Applications / Advantages

- Weight saving.
- High shielding effectiveness.
- High resistance to chemicals.
- Avionics applications.

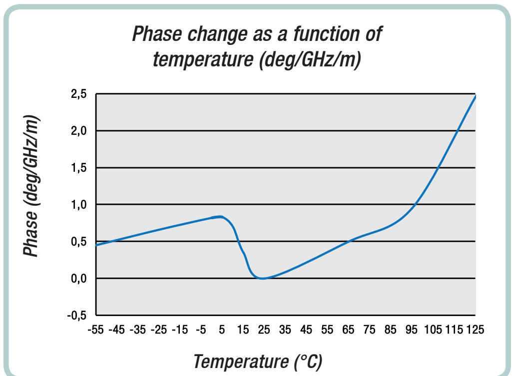
Axowave™ L77SK



Coaxial cable construction L77SK

1. Core	Inner conductor	Silver Plated Copper Clad Aluminium, Solid	-
	Dielectric	Celloflon® (expanded PTFE)	-
2. Taped shield		Silver Plated Copper	-
3. Braided shield		Silver Plated Copper Clad Aluminium, Silver Copper	-
4. Outer jacket		FEP	7.70 mm

Coaxial cable characteristics



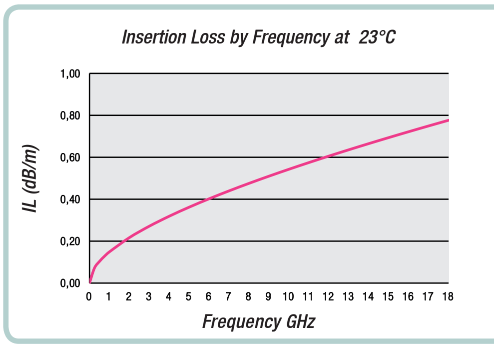
Max. Insertion Loss by Frequency at 18 GHz (coax only)	0.78 dB/m
Characteristic impedance	50 ±2 Ω
Capacitance	80 pF/m
Velocity of Propagation	83 %
Nominal phase	1440 °/m/GHz
Approximate weight	93 g/m
Outer jacket material (colour)	FEP (blue)
Inner conductor type	solid
Flexlife (*)	500 cycles
Min. bending radius for static applications	60 mm
Min. bending radius for dynamic applications	80 mm
Crush resistance (*)	900 N/ 10 cm
Power handling at 23°C and 18 GHz (**)	260 W

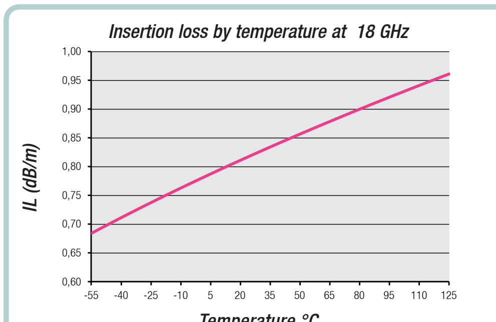
(*) Recommended but not max. values. - (**) Values limited due to the connectors see p 36.

Calculation of insertion loss

$$\alpha_{max.}(F) = 0.1386 \times \sqrt{F} + 0.0105 \times F$$

Frequency (GHz)	Nom. insertion loss (dB/m)	Max. insertion loss (dB/m)
1	0.14	0.15
2	0.21	0.22
4	0.30	0.32
6	0.38	0.41
8	0.45	0.48
12	0.57	0.61
18	0.73	0.78





AxowaveTM L77SK

Coaxial cable assembly characteristics

Operating frequency	0-18 GHz
Insertion Loss by Frequency at 18 GHz (1 m assembly, N plug straight)	1.05 dB max.
Insertion Loss by Frequency at 18 GHz (1 m assembly, N plug straight)	0.98 dB nom.
Shielding efficiency at 1 GHz	-110 dB max.
VSWR (1 m assembly, N plug straight)	1.35 max.
Operating temperature	-55/+125°C
Phase change at 1 GHz	2.50 °/m
Stability of insertion loss after bending at 18 GHz (bending radius = 80 mm)	0.10 dB
Coaxial cable / connector retention force (Recommended but not max. values)	90 N

Available connectors

Up to 18 GHz :

- SMA plug, straight.
- SMA plug, swept 90°.
- N plug, straight.
- N plug, swept 90°.
- TNC plug, straight.
- TNC plug, swept 90 °.

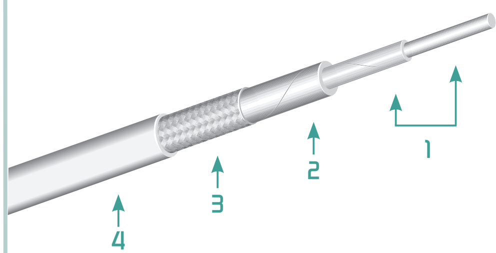
Up to 6 GHz :

- N bulkhead feedthrough jack, straight.

Applications / Advantages

- Weight saving.
- High shielding effectiveness.
- High resistance to chemicals.
- Avionics applications.

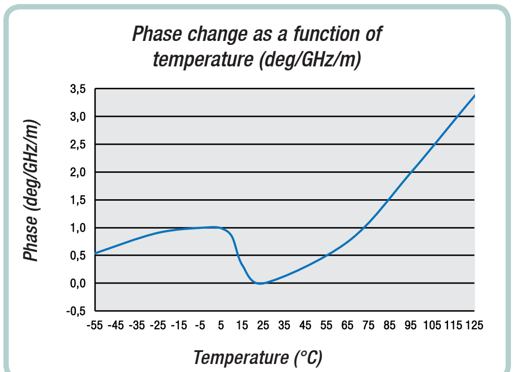
Axowave™ L113SK (11Y)



Coaxial cable construction L113SK (11Y)

1. Core	Inner conductor	Silver Plated Copper Clad Aluminium, Solid	-
	Dielectric	Celloflon® (expanded PTFE)	-
2. Taped shield		Silver Plated Copper	-
3. Braided shield		Silver Plated Copper	-
4. Outer jacket		FEP	11.30 mm

Coaxial cable characteristics



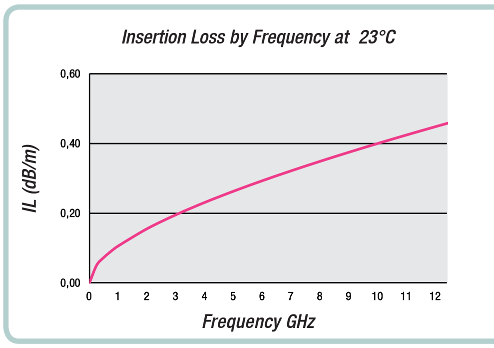
Max. Insertion Loss by Frequency at 12 GHz (coax only)	0.45 dB/m
Characteristic impedance	50 ±2 Ω
Capacitance	82 pF/m
Velocity of Propagation	77 %
Nominal phase	1420 °/m/GHz
Approximate weight	200 g/m
Outer jacket material (colour)	FEP (blue)
Inner conductor type	solid
Flexlife (*)	500 cycles
Min. bending radius for static applications	80 mm
Min. bending radius for dynamic applications	125 mm
Crush resistance (*)	2 000 N/ 10 cm
Power handling at 23°C and 12 GHz (**)	418 W

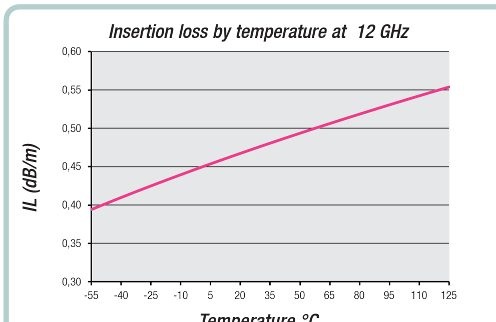
(*) Recommended but not max. values. - (**) Values limited due to the connectors see p 36.

Calculation of insertion loss

$$\alpha_{max.}(F) = 0.096 \times \sqrt{F} + 0.0096 \times F$$

Frequency (GHz)	Nom. insertion loss (dB/m)	Max. insertion loss (dB/m)
1	0.10	0.11
2	0.15	0.16
4	0.22	0.24
6	0.28	0.30
8	0.33	0.35
12	0.42	0.45





Axowave™ L113SK (11Y)

Coaxial cable assembly characteristics

Operating frequency	0-12 GHz
Insertion Loss by Frequency at 12 GHz (1 m assembly, N plug straight)	0.70 dB max.
Insertion Loss by Frequency at 12 GHz (1 m assembly, N plug straight)	0.63 dB nom.
Shielding efficiency at 1 GHz	-100 dB max.
VSWR (1 m assembly, N plug straight)	1.35 max.
Operating temperature	-55/+125°C
Phase change at 1 GHz	3.40 °/m
Stability of insertion loss after bending at 12 GHz (bending radius = 125 mm)	0.10 dB
Coaxial cable / connector retention force (Recommended but not max. values)	110 N

Available connectors

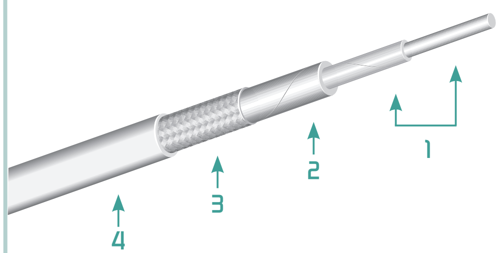
Up to 12 GHz :

- N plug, straight.

Applications / Advantages

- Weight saving.
- High shielding effectiveness.
- High resistance to chemicals.

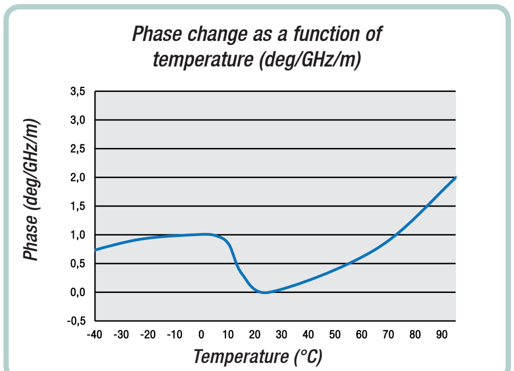
Axowave™ L127SR (11Y-Pu)



Coaxial cable construction L127SR (11Y-Pu)

1. Core	Inner conductor	Silver Plated Copper Clad Aluminium, Solid	-
	Dielectric	Celloflon® (expanded PTFE)	-
2. Taped shield		Silver Plated Copper	-
3. Braided shield		Silver Plated Copper	-
4. Outer jacket		PU	12.70 mm

Coaxial cable characteristics



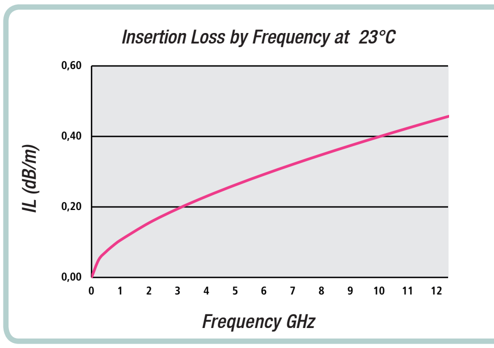
Max. Insertion Loss by Frequency at 12 GHz (coax only)	0.45 dB/m
Characteristic impedance	50 ±2 Ω
Capacitance	82 pF/m
Velocity of Propagation	77 %
Nominal phase	1420 °/m/GHz
Approximate weight	215 g/m
Outer jacket material (colour)	PU (black)
Inner conductor type	solid
Flexlife (*)	500 cycles
Min. bending radius for static applications	80 mm
Min. bending radius for dynamic applications	125 mm
Crush resistance (*)	2 000 N/ 10 cm
Power handling at 23°C and 12 GHz (**)	380 W

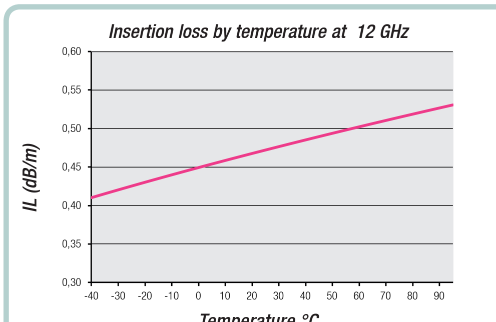
(*) Recommended but not max. values. - (**) Values limited due to the connectors see p 36.

Calculation of insertion loss

$$\alpha_{max.}(F) = 0.096 \times \sqrt{F} + 0.0096 \times F$$

Frequency (GHz)	Nom. insertion loss (dB/m)	Max. insertion loss (dB/m)
1	0.10	0.11
2	0.15	0.16
4	0.22	0.24
6	0.28	0.30
8	0.33	0.35
12	0.42	0.45





Contents

Axowave™ L127SR (11Y-Pu)

Coaxial cable assembly characteristics

Operating frequency	0-12 GHz
Insertion Loss by Frequency at 12 GHz (1 m assembly, N plug straight)	0.70 dB max.
Insertion Loss by Frequency at 12 GHz (1 m assembly, N plug straight)	0.63 dB nom.
Shielding efficiency at 1 GHz	-100 dB max.
VSWR (1 m assembly, N plug straight)	1.35 max.
Operating temperature	-40/+95°C
Phase change at 1 GHz	2.00 °/m
Stability of insertion loss after bending at 12 GHz (bending radius = 125 mm)	0.10 dB
Coaxial cable / connector retention force (Recommended but not max. values)	110 N

Available connectors

Up to 12 GHz :

- N plug, straight.

Applications / Advantages

- Weight saving.
- High shielding effectiveness.
- High resistance to abrasion.
- Outdoor applications.

BRAZIL
AXON' CABLE INDUSTRIA E COMÉRCIO LTDA
AV.AFONSO ARINOS DE MELO FRANCO
222 SALA 276 BLOCO 2B
BARRA DA TIJUCA, CEP:22631-455
RIO DE JANEIRO-RJ
TEL: +55 21 3596-8002
e-mail: l.moreira@axon-cable.com

CHINA
AXON' INTERCONNECT Ltd
HIGH TECH INDUSTRIAL PARK
CHANG BAO XI ROAD
RONGGUI, 528306
SHUNDE, GUANGDONG
TEL: + 86 757 2838 7200
FAX: + 86 757 2838 7212
e-mail: sales@axon-interconnect.com

GERMANY
AXON' KABEL GmbH
POSTFACH 1131 - 71201 LEONBERG
HERTICHSTR. 43 - 71229 LEONBERG
TEL: +49 7152-97992-0
FAX: +49 7152-97992-7
e-mail: sales@axon-cable.de

HUNGARY
AXON' KÁBELGYÁRTÓ KFT.
H-6000 KECSKEMÉT,
WÉBER EDE U. 10/A
TEL: +36 76 508 195
FAX: +36 76 508 196
e-mail: axon@axon-cable.hu

INDIA
AXON' INTERCONNECTORS AND WIRES PVT Ltd
#117, Neil Rao Towers, Suite NO. 1W,
ROAD NO:3, EPIP, WHITEFIELD
BANGALORE 560066
TEL: +91 80 40918186
FAX: +91 80 40918185
e-mail: sales@axon-cable.in

JAPAN
AXON' CABLE JAPAN OFFICE
TEL/FAX: +81 26 244 2261
e-mail: axon-japan@nifty.com

LATVIA
AXON' CABLE SIA
Višku Iela, 21 C - LV-5410 DAUGAVPILS
TEL: +371 6540 78 91
FAX: +371 6540 78 93
e-mail: axon@axoncable.lv

MEXICO
AXON' INTERCONEX, S.A. DE C.V
Av. Peñuelas 21-A1.
Industrial San Pedrito Peñuelas
Querétaro Park
76148 Querétaro, QRO. - MÉXICO
TEL: +52 442 215 2713
FAX: +52 442 220 6464
e-mail: b.aguilar@axoncable.com

SPAIN
AXON' CABLE SPANISH OFFICE
C/Capitán Haya, N°1, Planta 15
28020 MADRID
TEL: +34 91 418 43 46
FAX: +34 91 556 28 80
e-mail: sales@axon-cable.com

UNITED KINGDOM
AXON' CABLE Ltd
AXON' AGORA
ADMIRALTY PARK - ROSYTH - DUNFERMLINE
FIFE - KY11 2YW
TEL: +44 1383 421500
FAX: +44 8715 282789
e-mail: sales@axon-cable.co.uk

USA
AXON' CABLE INC.
1314 N PLUM GROVE ROAD
SCHAUMBURG, IL. 60173
TEL: +1 847 230 7800
FAX: +1 847 230 7849
e-mail: sales@axoncable.com

VISIT OUR WEBSITE
www.axon-cable.com

HEADQUARTERS
France

AXON' CABLE S.A.S.
2 ROUTE DE CHALONS EN CHAMPAGNE - 51210 MONTMIRAIL
TEL : +33 3 26 81 70 00 - FAX : +33 3 26 81 28 83
e-mail : sales@axon-cable.com - http://www.axon-cable.com

axon' cable & interconnect