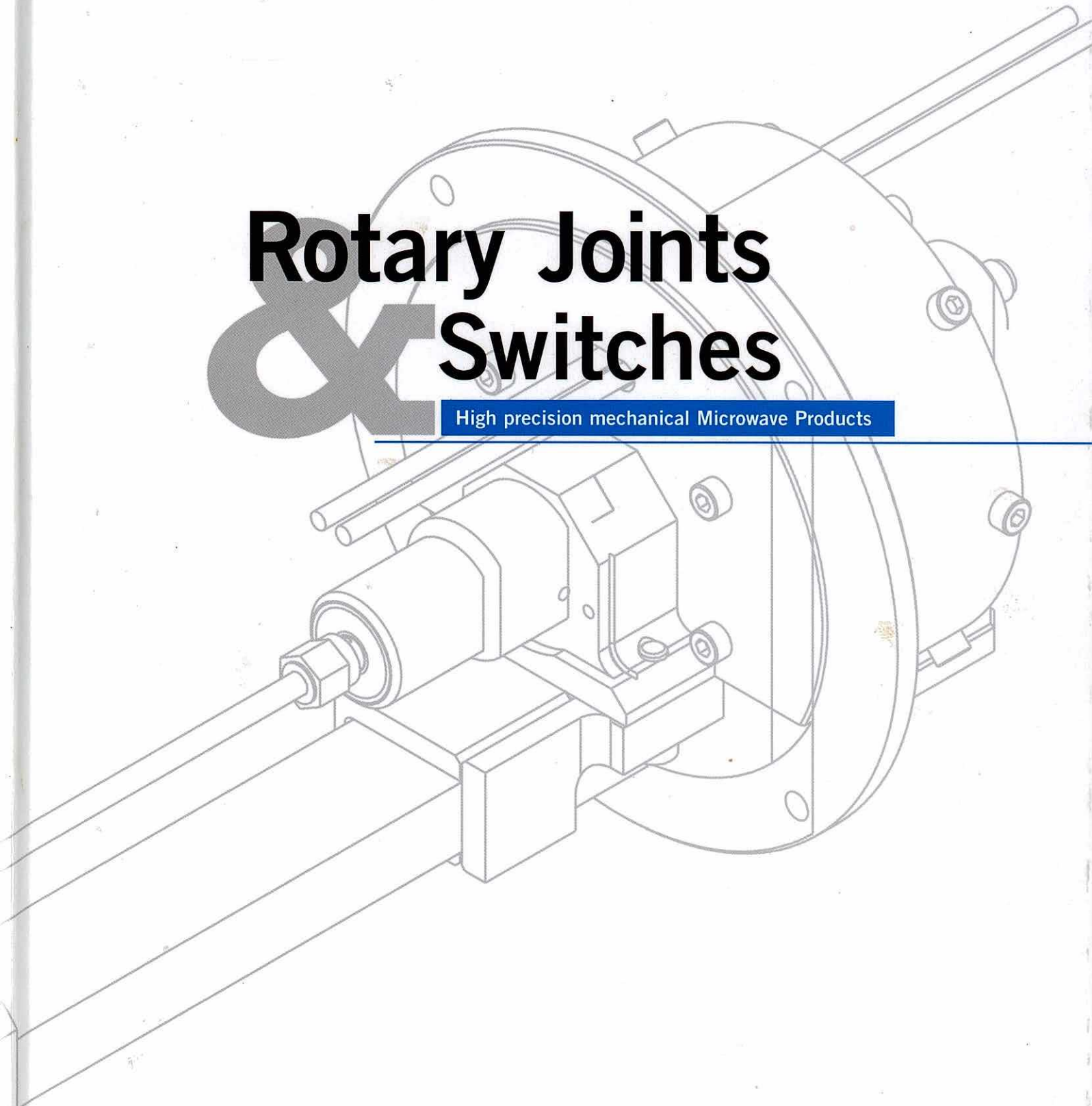
SIVERS

Rotary Joints & Switches

High precision mechanical Microwave Products



A Chelton Group company

About the company

Congratulations!

In your hands you now have the key to the success of Sivers Lab AB, a world-leader in the design and manufacture of Rotary Joints and Switches. We at Sivers Lab AB have a unique competence of combining the skills of microwaves and kinetic mechanics in designing numerous Rotary Joints and Switches.
This 50 years of experience is at your disposal.

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SS-EN ISO 9001

About this catalogue:

The catalogue in your hand is an introduction to Sivers Lab AB. It describes our unique skills, how to specify Rotary Joints and Switches and contains examples of basic designs and some typical customer models

The catalogue has four sections:

- Company description
- Rotary Joints
- Switches
- Useful information

The Rotary Joint and Switch sections include general technical information, basic designs and some typical customer models. If you do not find a product which fully complies with your requirements please let us know. We will be happy to modify an existing design or make a new one based on your requirements.

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About the company

SIVERS LAB AB

The Company

Sivers is a long-established European microwave product manufacturer located in Sweden's largest high-tech area, KISTA, in the northern part of Stockholm.

Carl von Sivers established the company in 1951. With 50 years experience in microwaves, Sivers is a world-leading manufacturer of waveguide and coaxial Rotary Joints and Switches. The 2000 sq.meters (20.000 sq.feet) facilities contain state-of-art technologies and equipment for development, engineering and production. These facilities allow the necessary activities in-house with short lead times and full quality control providing both standard and customised products. Development and production are supported by CAD/CAM systems with highly automated production equipment for low as well as for large quantity production. All activities are guided by a Quality System that complies with ISO-9001.

In addition to common microwave and mechanical test equipment Sivers has also equipment for high power tests, random vibration, burn-in, temperature cycling, low noise measurements etc. For Rotary Joints most of the tests can be performed while rotating.

Sivers forms a part of the Chelton group, a division of Cobham group.

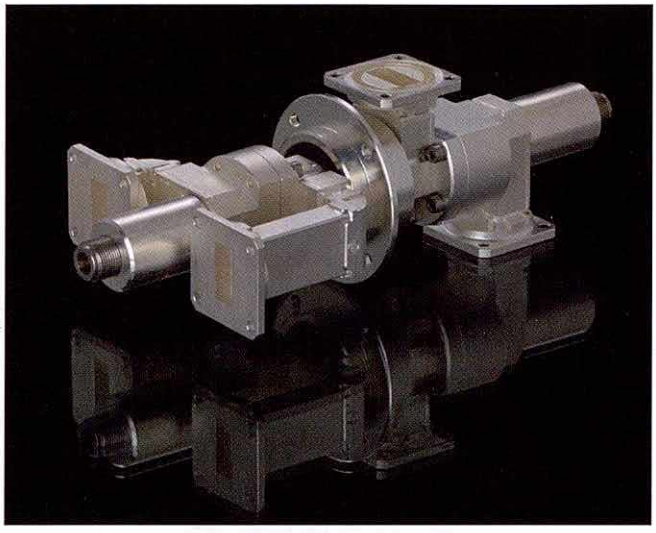
The Cobham group is a substantial British industrial group with companies in Europe and North America, employing over 7000 people and with a turnover of 560 million GBP(2000). It is internationally known as a key supplier to aeronautical and defence industries, particularly in the field of RF and microwave.

The capabilities of the group, particularly the very close co-operation with the leading slipring manufacturer Air Precision, allow Sivers to further improve its commercial technical performance and thus offer you an even better service.

The main application areas are

- Air Traffic Control Radar
- Satellite Communications Ground Stations
- Military Radar Systems ground based, air and ship-born
- Electronic Warfare Systems
- Electronic Countermeasure Systems

Sivers customers are most of the well-known multinational giants supplying defence and telecommunications equipment, as well as highly specialized niche companies.

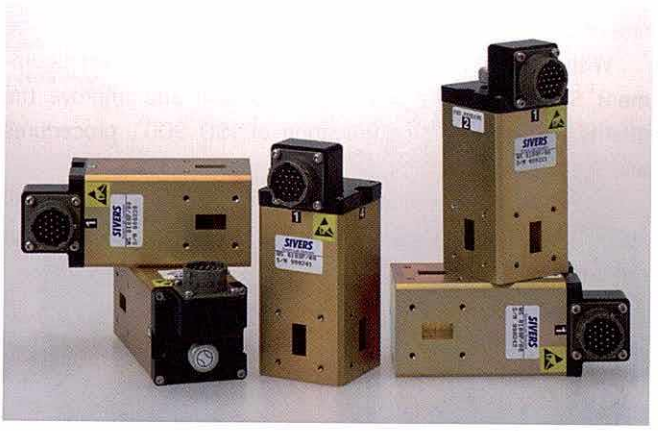


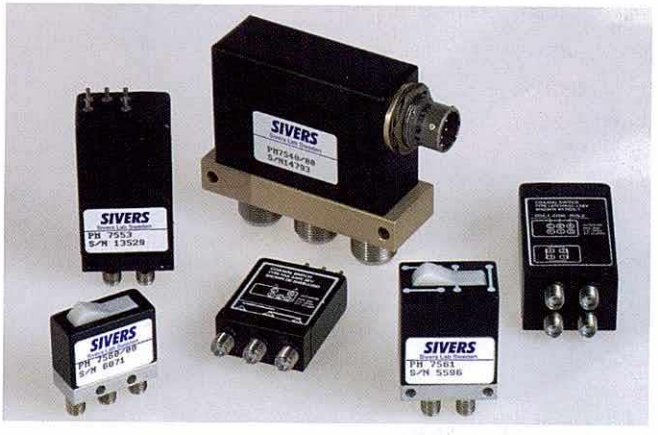
Sivers is onboard most major programs

Sivers customers are the multinational leaders of the electronic companies supplying defence, aerospace and telecommunications systems to the most demanding operators.

Sivers products are onboard DASR-ASR11, ASR-12, ATCBI-6, JAS-Gripen, Eurofighter, Mirage 2000, NH-90, ANZAC frigates, NEC SNG, CV-90, Griffo, Atnavics, Giraffe, ASR-E, Rapier, Dagger, Blue Kestrel, Sea-Spray, Blue Vixen, Foxhunter, SRLM-5, Goal-Keeper, Scout, PAR-52, Watchman, Seaguard, 1802SW, ATCR 33S, SIR-S.

Marketing and sales are carried out both directly and through local representatives enabling the best possible communication with the customer and the shortest lead times.





Rectangular waveguide flanges (cont.)

Waveguide size	Flange type	Alumi	
		MIL F-3922	AN NO
WR 51 (WG 19, R 180)	Cover butt Choke butt Flat butt Grooved butt	70-011 69-005	
WR 42 (WG 20, R 220)	Cover sleeve Choke butt	54-002 59-004	597/ 598A
WR 34 (WG 21, R 260)	Coover sleeve Choke butt	63-010	

Quality

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Quality

Sivers is fully certified as per ISO-9001 and quality remains one of Sivers' main priorities.

With its qualified engineers and sophisticated test equipment Sivers constantly seeks to maintain and improve the quality of products by application of ISO 9001 procedures and instructions.

The Quality Assurance Department is totally involved in all stages of the design, development and manufacturing of our products.

Each product delivered can be accompanied by an individual test document. Our Quality Manager certifies the quality by a Certificate of Conformance.

From request to supply

Some of Sivers' in-house facilities and administrative routines to meet requirements for new products are indicated below. Only a few of the activities below are required for repeat orders or orders for standard off-the-shelf products.

Quotation /Order

A range of standard waveguide rotary joints, coaxial rotary joints, waveguide switches and coaxial switches are available in the frequency range from DC to 40 GHz.

However, most components and assemblies are custom designs, developed to meet specific microwave and mechanical requirements. The assemblies are often a combination of existing standard modules and new designs.

At receipt of a customer request for quotation a technical evaluation and production cost calculation is carried out and a quotation promptly submitted.

The Q-Number, as found in our correspondence with our customers, identifies all documents related to the quotation procedure.

The received order is checked out against the submitted quotation and correspondence and registered in the administrative system. Development and production resources are allocated and the order is confirmed giving a firm delivery date.

Project planning

The customer specification and technical documents are linked to a specific Sivers product number in our computer system. This ensures that all future repeat orders will result in products with identical performance.

A Project group is established to ensure that the products will be designed, produced and delivered in accordance with the order.

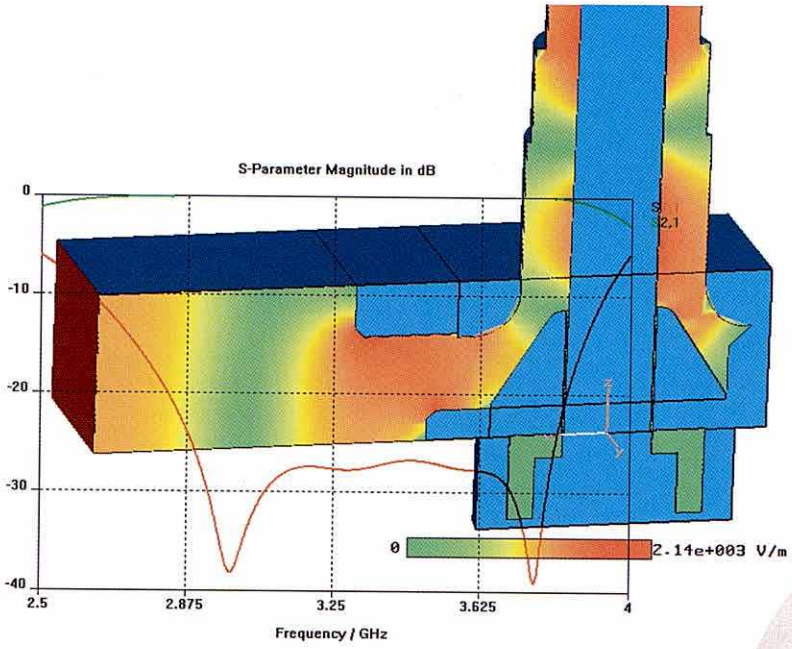
Design and Development

Sivers has a design and development team continuously working on custom designs and on new products and manufacturing processes.

The development process starts with microwave design using a full 3D FEM (three dimensional finite element) electromagnetic field simulator.

The next step is mechanical design in 3D CAD (three dimensional Computer Aided Design) followed by the production of drawings and parts lists.

About the company

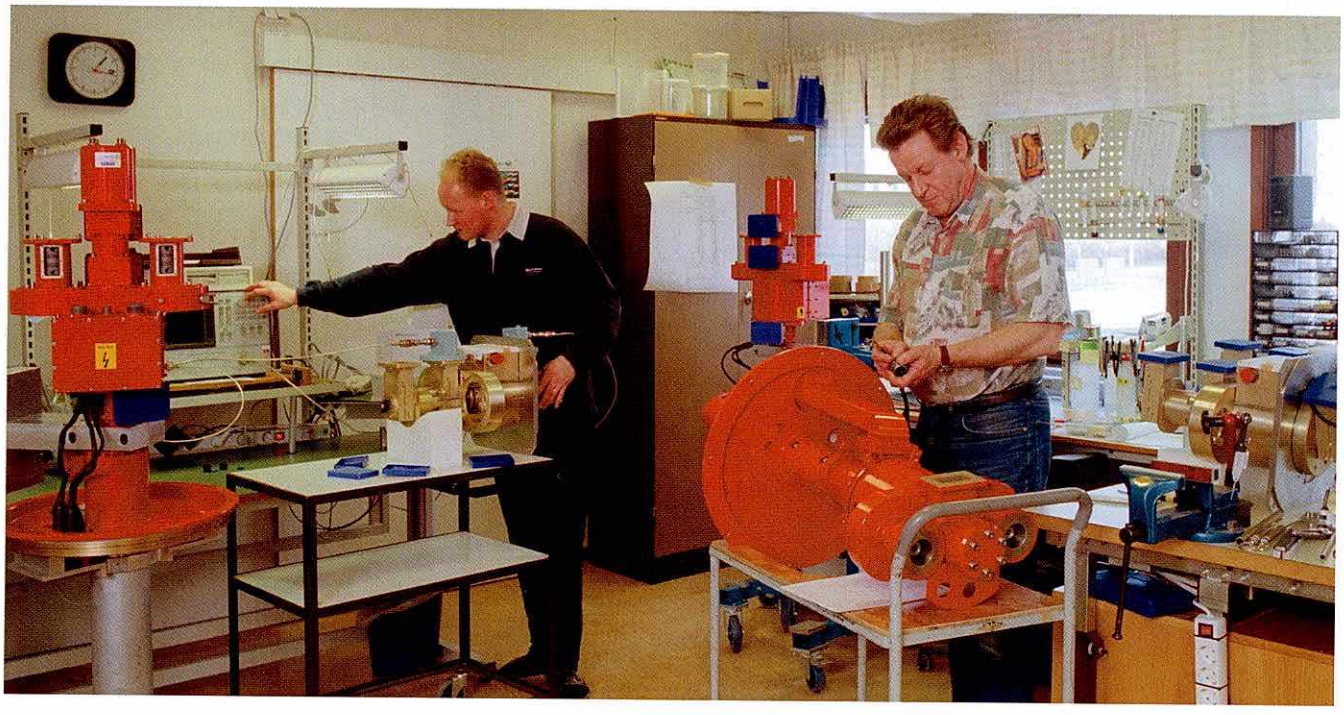


All engineers have 3D mechanical CAD stations connected to a network. Existing product modules with well-proven performance are documented in the CAD files and used for the design of new products.

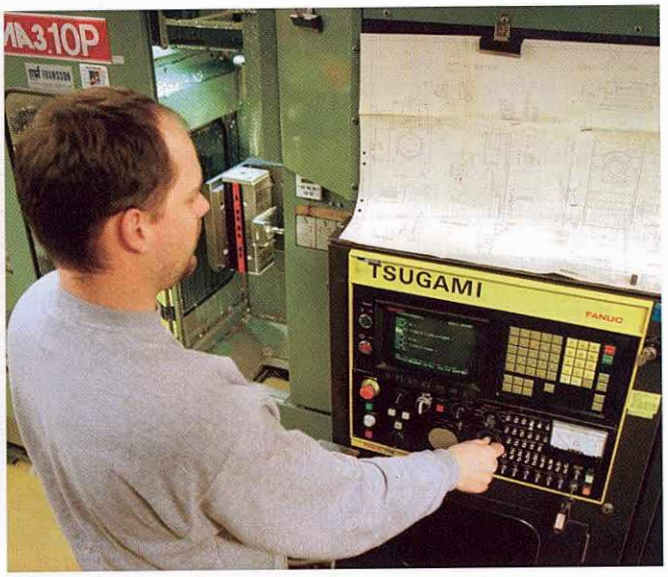
Drawings are stored for further CAM (Computer Aided Manufacturing) processing. More than 60000 drawings are available in the libraries.

Test and qualification are regularly made to verify performance in different environments like temperature, vibration, humidity etc.

Sivers offers qualification and verification tests according to customer requirements.



About the company



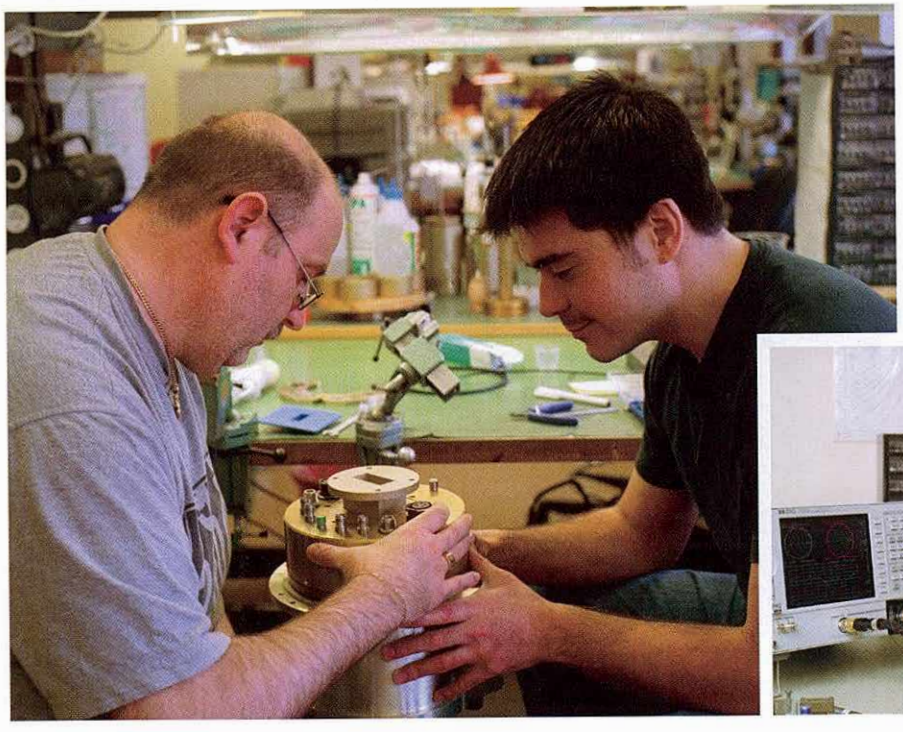
Production

Considerable skill and long experience are a must for the production of experimental prototype work pieces as well as test jigs and fixtures for the production process.

CAD data is transferred to the CAM station where conversion to CNC machine software is done. Experienced operators handle the software conversion and the supervision of the production.

CAM-connected multipurpose 4-axis CNC milling and turning machines with up to 126 calibrated tools in the magazine are used. Pallets with raw materials are loaded in the daytime for automated production around the clock.

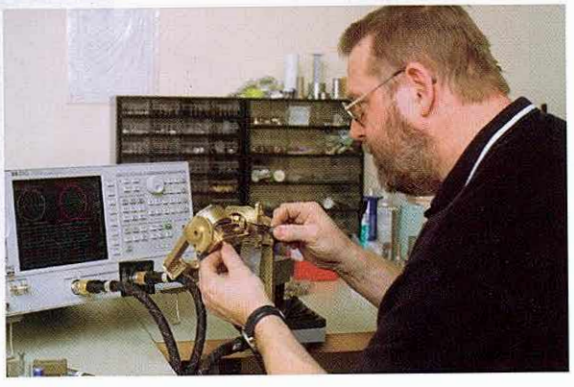
A large range of other production equipment is used for various requirements.



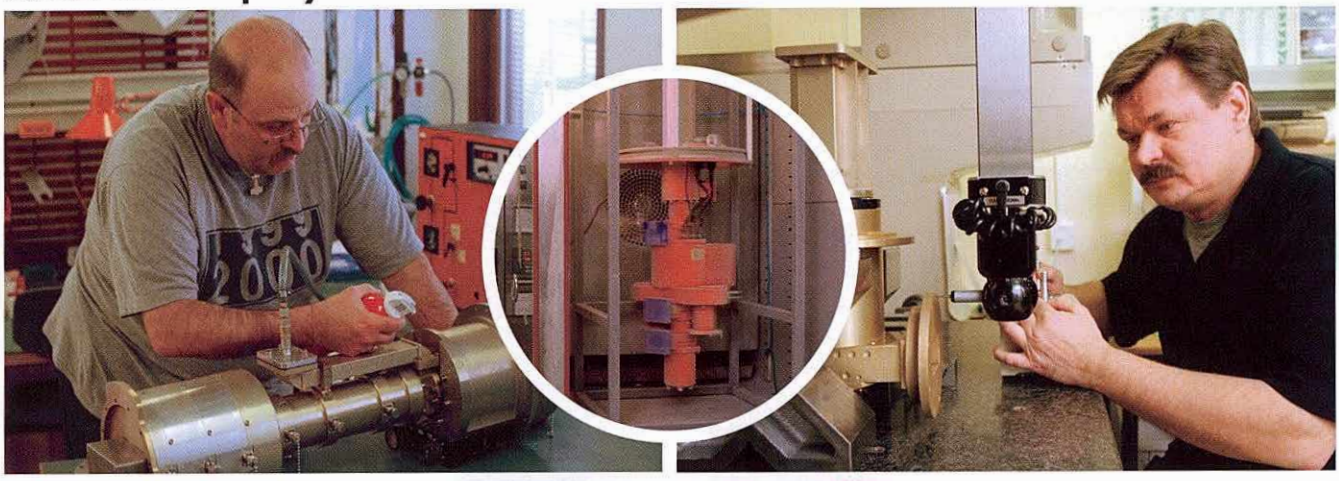
Assembly

Final assembly of a multi-channel Rotary Joint.

The same person will follow his product all the way through final tuning, assembly and production testing and verification.



About the company



Testing

Acceptance Testing is done on all products by specially appointed inspectors in the quality organisation. Qualification Testing of new products often involves test in temperatures, humidity, vibration etc.

The extensive in-house range of test equipment satisfies requirements for:

- military applications requiring documented reliability in extreme testing environments.
- civilian applications where 100% testing of certain key parameters ensures that the customer can use the Sivers' product in his own assembly without any incoming tests.

Some examples:

- 3-axis dimensional measurements with an accuracy better than ± 2 µm
- Vibrators with computer-controlled, sinusoidal and random spectra
- Scalar analyser test set-ups
- Automatic network analyzers up to 40 GHz
- Computer-controlled test set for measuring added noise from, e.g., rotary joints down to the extreme of -170 dBc
- High peak power testing, e.g. 1 MW in S-band and 80 kW in Ku-band and reliable simulated tests up to 2-4 times these values!
- Average power tests of coaxial products up to 1 kW
- Temperature chambers for automatic temperature cycling while actuating or rotating the object.

Certain special tests are also carried out in an external test centre close to the Sivers plant.

After Sales Service

Most of the products from Sivers have a very long life but requires regular maintenance.

Service and overhaul is an essential part of Sivers activity. Our long experience in the microwave and mechanical field makes it possible for us to offer overhaul even for products from other manufacturers.

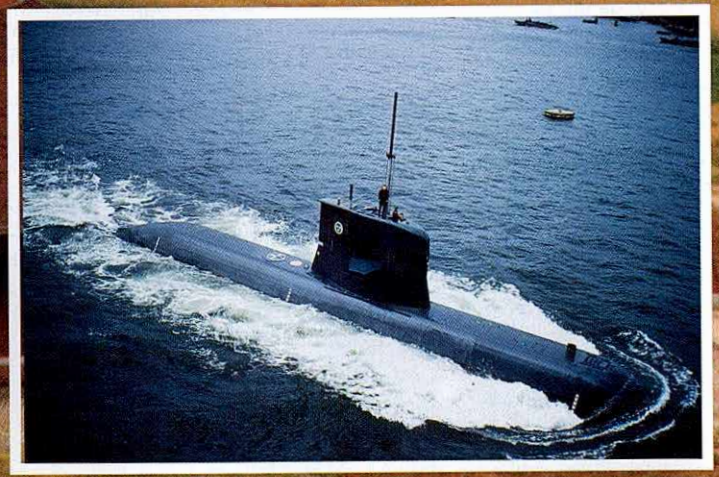
Our Repair Services Manager is completely responsible for the sales of spare parts and the provision of repair services, from customer request to delivery.

Documentation is kept for at least 10 years, depending on customer requirement. Some products are actually still going strong after nearly 50 years.

Shipment

All products are export packed. The mutually agreed shipping agent picks up the goods and, upon request, a notification is sent to the customer. Stockholm-Arlanda International Airport, only 20 minutes away, is the major gateway for our exported products.

Applications



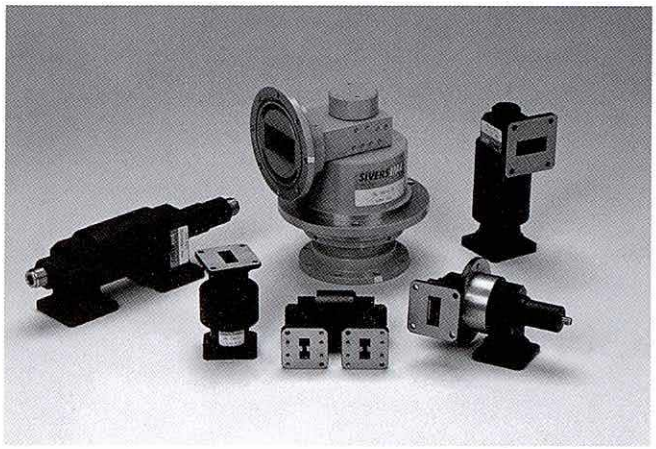
ROTARY JOINTS

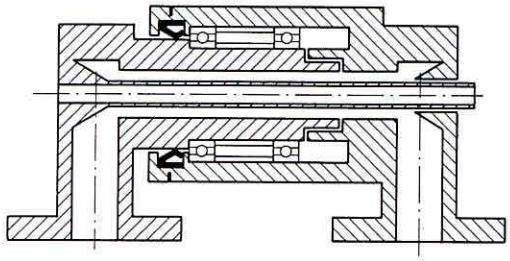
TECHNICAL DESCRIPTION

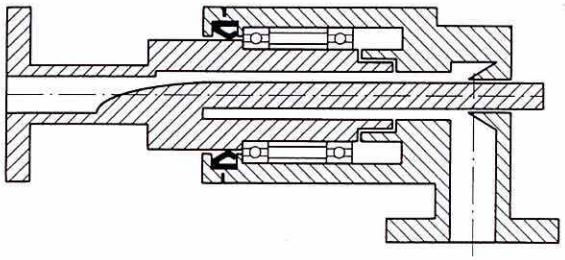
PRODUCTS

OPTIONS

In this catalogue there are a few examples of Sivers Rotary Joints. A great number of other designs are also available.
The specifications are typical for the designs on the different bands and technical data in this catalogue may be changed without notice. For special designs some parameters can often be improved. Our qualified engineering staff is happy to modify a design according to your requirements.







TECHNICAL DESCRIPTION

The Rotary Joint is the link between the stationary and movable parts of a Radar or Microwave communication system, e.g. between the transmitter/receiver and the rotating antenna, for azimuth and elevation of antennas, in foldable masts etc.

A Rotary Joint has often several microwave channels on the same concentric axis. Slip-rings and Encoders can also be integrated in the assembly.

1.1 Waveguide Rotary Joints

The basic design for the SIVERS Lab Rotary Joints is two waveguide to coaxial transitions with a coaxial line in between. This coaxial part is symmetrically circular allowing for free rotation without affecting performance. In the rotating part electrical continuity is achieved by $\lambda/4$ -chokes eliminating metal contacts. This and the use of high quality ball bearings give a long operating life to all our Rotary Joints, in most cases 50 million revolutions before maintenance is required.

The inner conductor of the coaxial line is usually hollow, allowing further coaxial cables to be put through the wave rotary joint and to be used with the coaxial modules when building multi-channel Rotary Joints.

The Rotary Joints can have both waveguide ports at a right angle to the rotational axis, "U-style", one waveguide port at a right angle and one in line, "L-style" or" F-style" or both waveguide ports in line, "I-style".

Waveguide Rotary Joint modules are available from Sivers on most waveguide bands from L-band to Ku-band, including double ridge bands.

The waveguide parts are made of aluminum and dip brazed. This gives a lightweight design providing stable and repeatable mechanical and microwave performance.

On special request some models can be made of brass or be surface treated to match connecting brass waveguides.

Most models have long-life rubber seals to protect the inside of the waveguides and the ball bearings from humidity and dust and also to allow for overpressure of up to 0,1 MPa.

In systems where dry air is not used inside the waveguides the Rotary Joints are fitted with stainless steel ball bearings and allowance for drainage or moisture-absorptive insert (breather).

When high average power is used, the limiting factor is the temperature rise of the centre conductor due to losses. In such applications separate water cooling, heat pipes or air cooling is used.

1.2 Swivel Joints

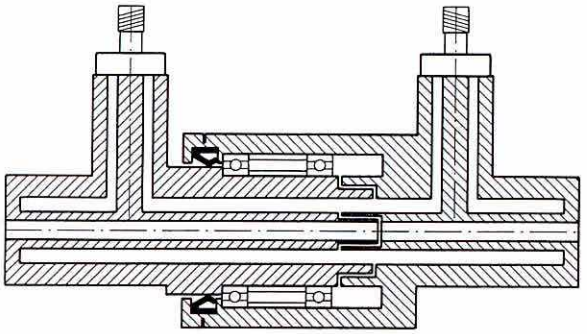
A special type of waveguide Joint is the swivel joint which can be twisted only +/- 60 deg. (+/-90 deg mechanically). It is designed as a number of short waveguide sections. The design is compact and it has high peak power capacity.

1.3 Coaxial Rotary Joints

Hollow shaft Rotary Joints

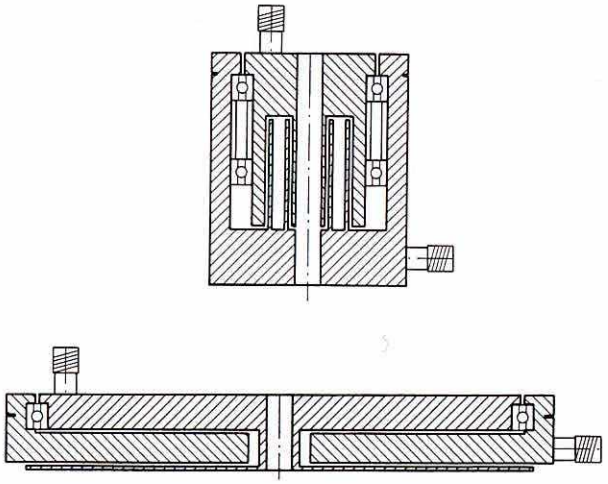
Sivers Lab has two types of hollow shaft models, both with the fundamental design of a "stub coupled" coaxial line with non-contacting "chokes" for electrical continuity.

This gives the same long life as for the waveguide modules since the ball bearings are the only mechanical contact between the rotating and static parts.



One model is compact, has a smaller diameter and is a little longer. The other one is flat but has a larger diameter.

Sivers Lab has "compact" modules on L- through S-band and "flat" modules on L- through X-band with bandwidths of typically 15%.



The "flat" models have generally higher power capability and much lower phase variations with rotation.

These hollow shaft modules are building blocks in SIVERS Lab multi-channel Rotary Joints.

Contacting Rotary Joints

In these models the electrical contact is maintained via precious metal sliding contacts.

This gives a very wide band performance starting from DC.

The sliding contacts are of a well-proven design and can run up to 15 million revolutions before maintenance is required. For most models, maintenance comprises disassembling and cleaning and life can be extended to 50 million revolutions.

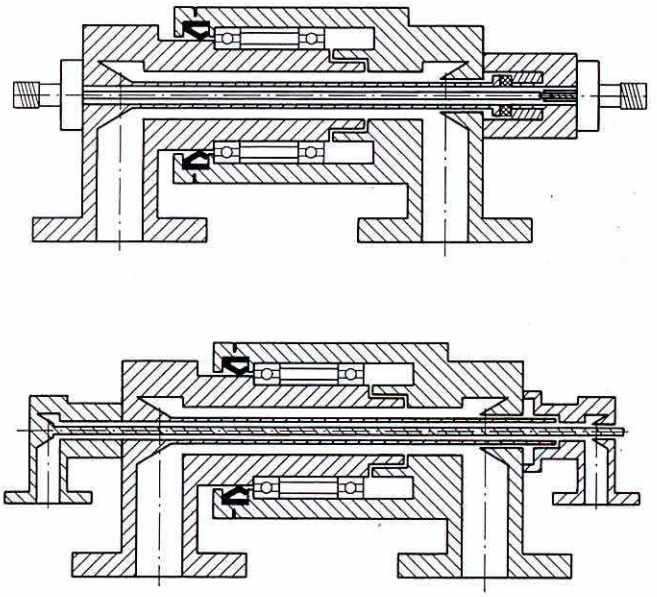
Sivers has contacting single channel coaxial modules with different types of connectors ranging from

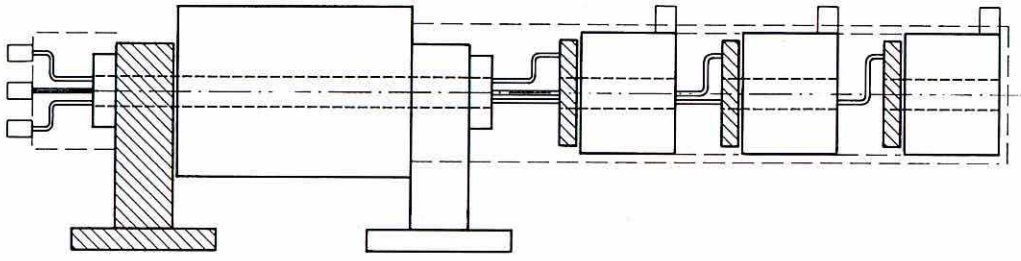
HN connectors for DC -3 GHz to K-connectors for DC - 40 GHz.

A dual channel model, DC -3, DC - 12 GHz is also available.

1.4 Dual channel Rotary Joints

Dual channel assemblies are designed by combining a waveguide Rotary Joint module with a coaxial or waveguide module and using the waveguide centre conductor as the outer conductor for the next module.



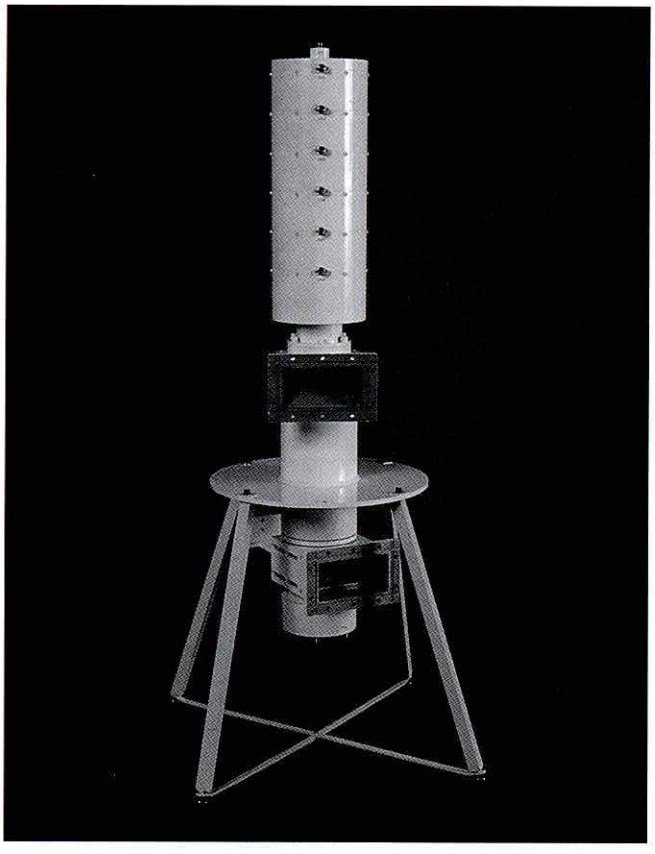


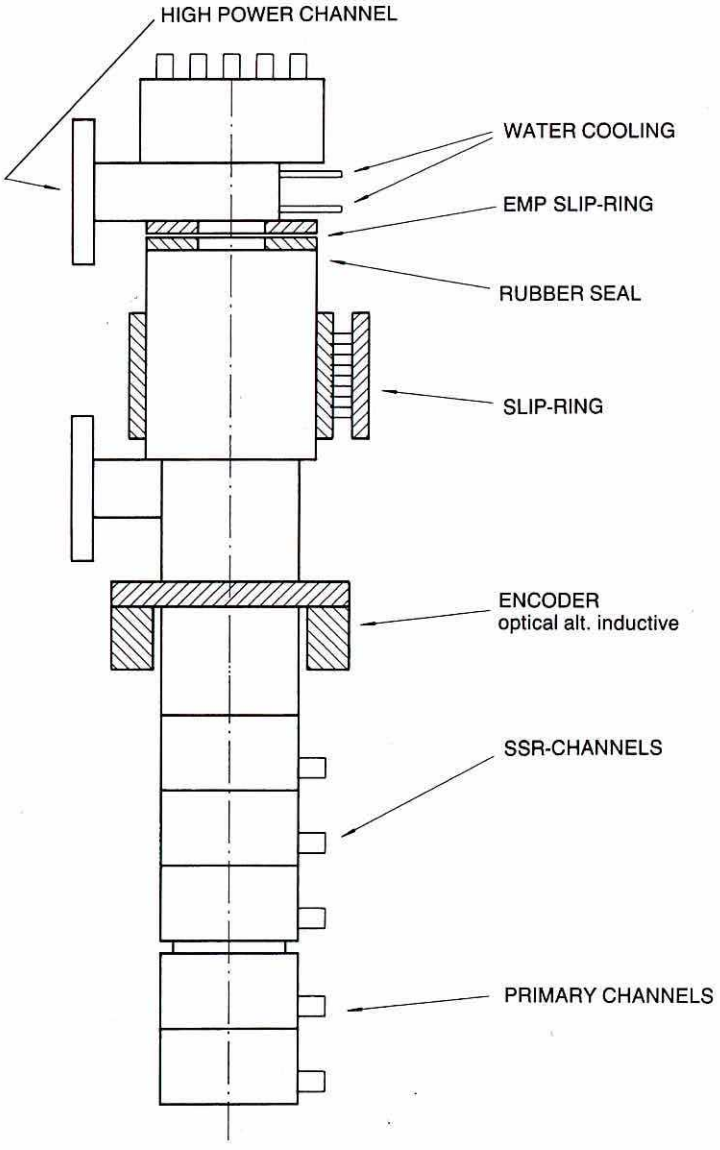
1.5 Multi-channel Rotary Joints

By using the hollow shaft of a waveguide module for coaxial cables a number of coaxial modules can be stacked to form a complete assembly with 5, 6, 7 or even more low power channels.

Also dual channel waveguide Rotary Joints (two waveguide channels) can be used for stacking additional coaxial channels.

The multi-channel Rotary Joints are complete assemblies with all channels inside the cover and with one rotating joint sealed with a rubber seal.





GENERAL DATA and DEFINITIONS

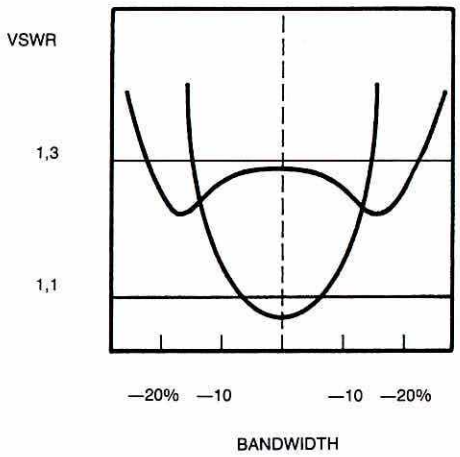
ELECTRICAL PARAMETERS

VSWR:

Typical values for waveguide Rotary Joints are 1.10 for narrow band units increasing to 1.3 for full band units and 1.5 for double ridge bands.

For coaxial modules the VSWR is in the range 1.2 – 1.4 depending on bandwidth.

The variation of VSWR with rotation, WOW, (VSWR max/min) is a classical specification point but phase or insertion loss variations are normally of greater importance.



Insertion Loss:

Typical values for waveguide Rotary Joints are 0.1 – 0.2 dB and up to 0.5 dB for double ridge bands.

Coaxial modules have typically 0.3 dB losses. In multi-channel units the losses from internal cables have to be added and the resulting loss could be in the range of 1 dB. However, this is depends greatly on the exact design. A trade-off between different parameters is often the optimal solution.

Insertion loss variation:

Is the variation of IL over rotation and/or temperature. For most Sivers Lab designs the variation with rotation can be kept below +/- 0.05 dB.

Absolute insertion loss difference:

Is the difference in Insertion loss between channels in a Rotary Joint assembly. It can be kept less than 0,15 dB.

Insertion Loss tracking:

This is the variation in the insertion loss difference between channels caused by rotation, temperature etc.

With careful control of the designs SIVERS Lab can achieve tracking of less than 0.1 dB

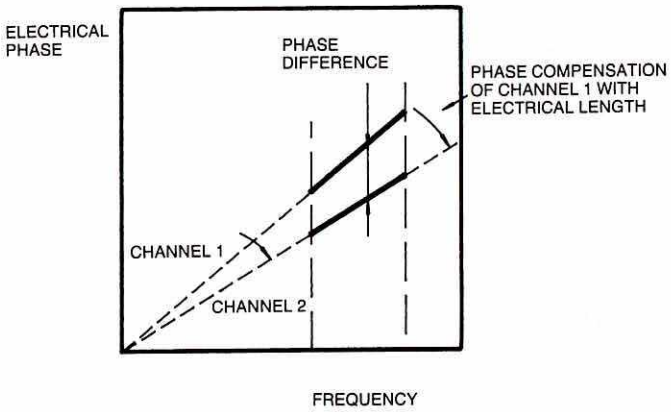
Phase variation:

Is the variation in electrical phase length of one channel over rotation and/or temperature?

For waveguide modules typically <+/- 1 deg. and for coax. modules <+/- 2 deg.

Absolute phase difference:

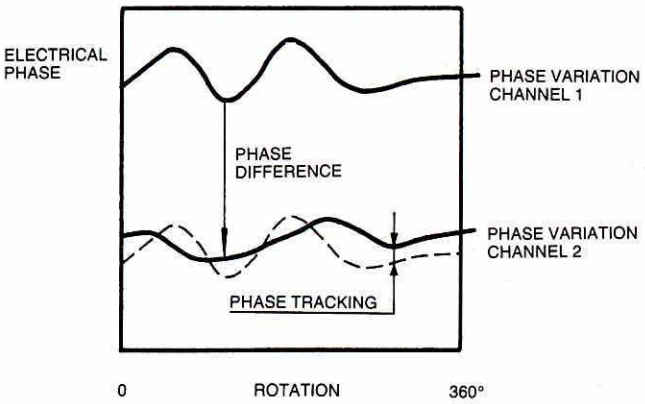
Difference in electrical phase length between channels in the same unit.



Phase tracking:

This is the variation in the difference in phase between channels caused by rotation, temperature etc. The basic phase difference is disregarded.

Sivers modules, both waveguide and coaxial have low phase variation with rotation and phase tracking of less than a few degrees can be specified.



Technical Description

Peak power:

The peak power capability for Sivers waveguide Rotary Joints ranges from 6 MW on L-band to 30 kW on Ku-band.

The ability to withstand microwave pulses without arcing depends on many factors other than the waveguide or coaxial dimensions.

The antenna load causes reflections, which add to the peak power at critical spots.

Long pulses and high average power increase the probability for arcing.

Low air pressure greatly reduces peak power capability and the opposite is valid for higher pressure which is often used to improve the power handling.

High temperature is also a limiting factor.

Spurious signals and harmonics in the transmitted power can also reduce power capacity.

A general rule is that I- and L- style designs have approx. 65% of the peak power capability of the U-style.

A commonly used design rule was published by Ciavolella in 1972 (see General Data). This has to be used with care since in practice it is more complex than theoretically multiplying all the factors. Also observe that the power derating due to VSWR is defined at the output of the component. Sivers Lab uses a number of additional design rules and empirical values to predict peak power capability. Thorough calculations are made for new designs and the results are verified in qualification tests.

Sivers Lab also carries out 100% production testing of peak power on waveguide rotary joints.

For coaxial modules the power capability is typically 5 to 10 kW but up to 300 kW on modules with EIA-connectors is also available.

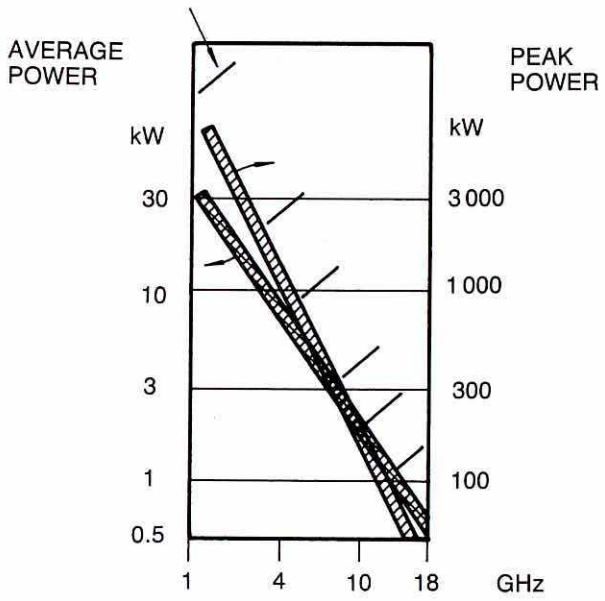
Average power:

The capability for average power in the waveguide Rotary Joints depends on the losses in the coaxial section and the associated temperature rise in the centre conductor. Optimal dimensions and choice of material can keep the temperature rise at a minimum.

Sivers also has designs with water cooled, heat pipes or air cooled centre conductors on S-, C- and X-band Rotary Joints for powers as high as 20 kW.

On Ku-band the limit is 0.5-1 kW without extra cooling.

Coaxial modules have much lower average power capability and the losses of inter-connecting cables must always be considered. The L-band SSR module can handle up to 1 kW average power.



Waveguide Rotary Joint Power capability.

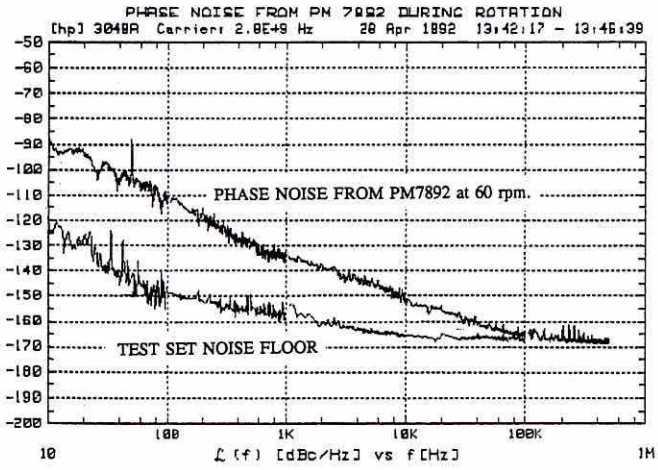
Technical Description

Added noise:

During rotation and/or vibration the Rotary Joint will add some noise at a very low level because of small changes in insertion loss and electrical phase.

This level is in the range of 100 to 150 dBc depending on the design and the frequency.

Sivers Lab has designed Rotary Joints with noise specification and has the knowledge and test equipment for noise measurement at these levels.



Phase noise from Coaxial Rotary Joint PM 7892 during rotation.

ENVIRONMENTAL PARAMETERS

Temperature:

The rotary joints are designed for operating temperature range -40 to + 85°C, and storage of -70 to +125°C.

Other temperature ranges require special seals and lubrication.

MECHANICAL PARAMETERS

Life:

The life of a rotary joint depends on many factors, e.g. temperature, speed, gas pressure, and mechanical loading conditions. For most rotary joints 50 million revolutions are guaranteed without maintenance

Speed:

The max rotational speed range from 5 rpm for pressurised L-band waveguide rotary joints to 2000 rpm for unpressurised coaxial rotary joints

Starting torque:

Max starting torques (Nm) over the whole temperature range and at maximum specified pressure.

(1Nm=0.101972kpm=0.737562 lbf)

Pressurisation:

Maximum permitted pressurisation in atmosphere overpressure (ATO) or absolute pressure (ATA)

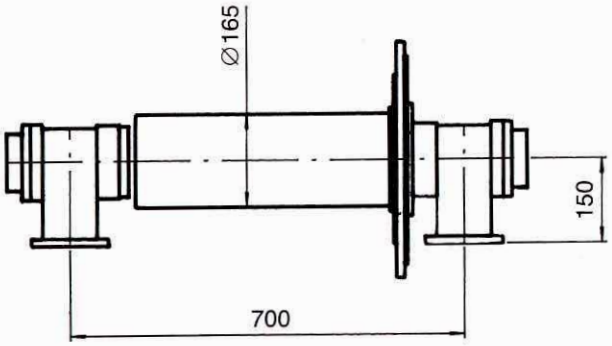
Mechanical load:

To avoid overloading of the Rotary Joint ball bearings it is recommended to use flexible waveguides for interconnections on the rotating side.

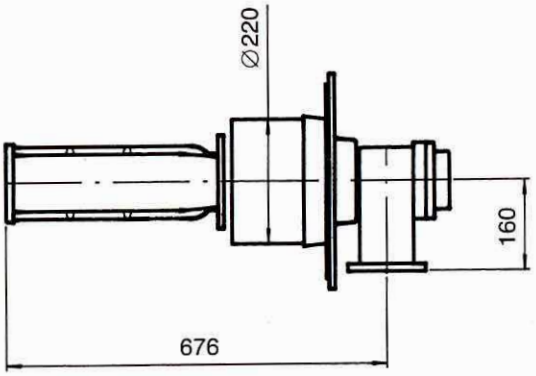
Designs suitable for higher mechanical loads can be provided on special request.

Waveguide Single Channel

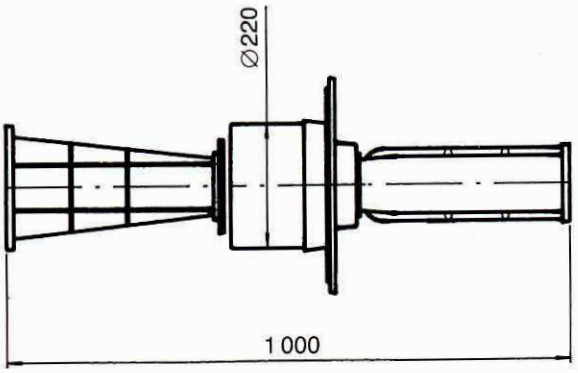
Waveguide R14 (WR650, WG6)					
Model		**PM7364L**	**PM7362L**	**PM7360L**	
Style		U	L	I	I
Frequency	(GHz)	1.25-1.35	1.25-1.35	1.25-1.35	1.15-1.45
VSWR		1.15	1.20	1.10	1.15
Insertion Loss	(dB)	0.10	0.15	0.10	0.10
Peak Power	(kW)	6000	6000	6000	6000
Average Power	(kW)	12	12	30	30



PM 7364L



PM 7362L



PM 7360L

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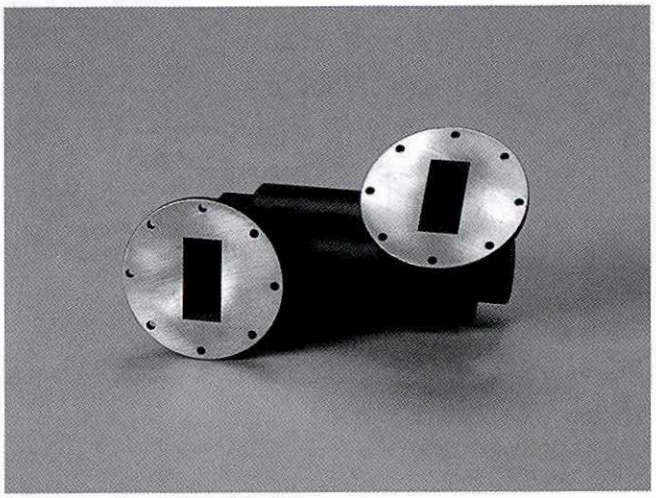
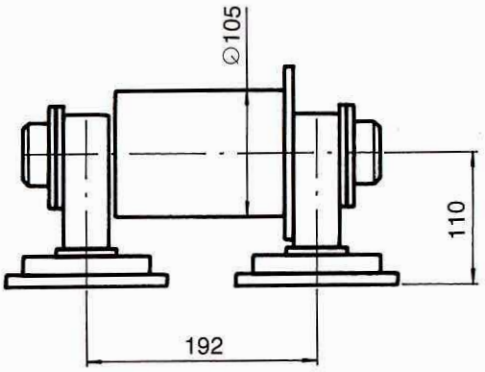
Waveguide Single Channel

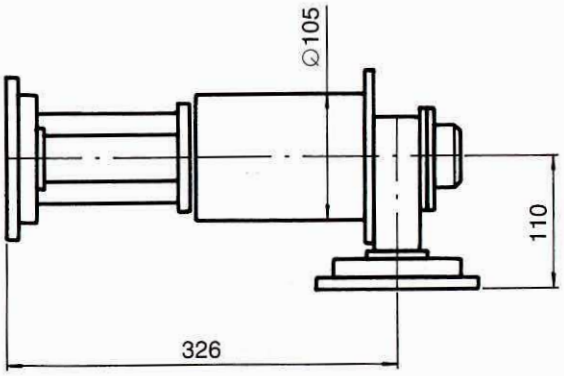
Waveguide R32 (WR284, WG10)

Model		PM7364S		PM7362S		PM7360S
Style		U	U	L	L	I
Frequency	(GHz)	2.7-3.3	3.1-3.6	2.7-3.3	2.7-2.9	2.7-3.4
VSWR		1.15	1.20	1.20	1.15	1.20
Insertion Loss	(dB)	0.15	0.20	0.15	0.15	0.10
Peak Power	(kW)	1500	1500	1000	1000	1000
Average Power	(kW)	5	5	5	5	7.5





PM 7364S



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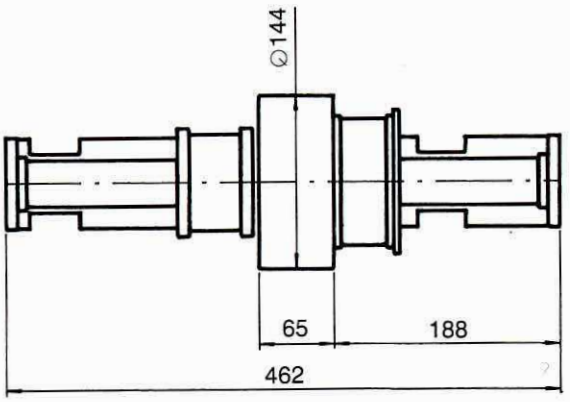

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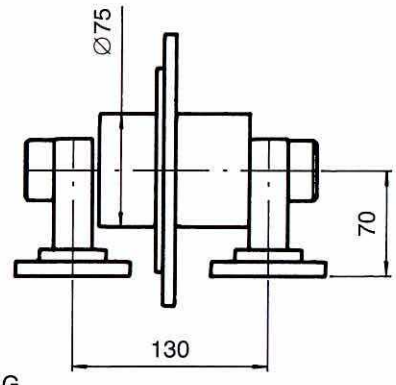
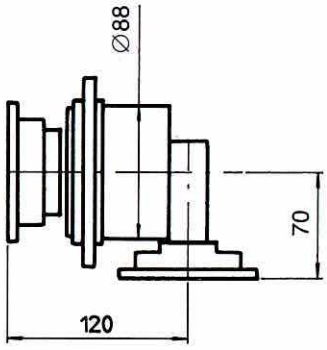
Waveguide Single Channel

Waveguide R48 (WR187, WG12)					
Model		**PM7364G**	**PM7362G**		**PM7360G**
Style		U	L	L	I
Frequency	(GHz)	5.4-5.9	5.4-5.9	4.95-5.10	5.4-5.9
VSWR		1.15	1.15	1.15	1.15
Insertion Loss	(dB)	0.10	0.10	0.10	0.15
Peak Power	(kW)	600	400	400	250
Average Power	(kW)	3	2	2	2



PM 7364G



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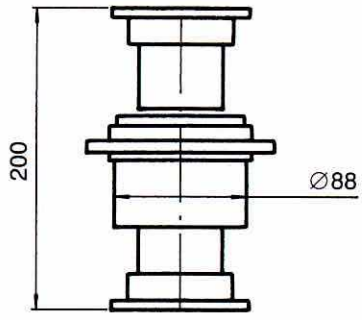

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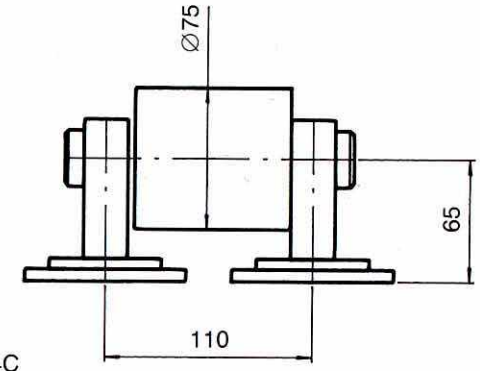
Waveguide Single Channel

Model		PM7364C	PM7362C	PM7360C
		Waveguide R58 (WR159, WG13)		
Style		U	L	I
Frequency	(GHz)	5.4-5.9	5.4-5.9	5.9-6.4
VSWR		1.15	1.15	1.15
Insertion Loss	(dB)	0.20	0.20	0.15
Peak Power	(kW)	300	200	200
Average Power	(kW)	2	2	2



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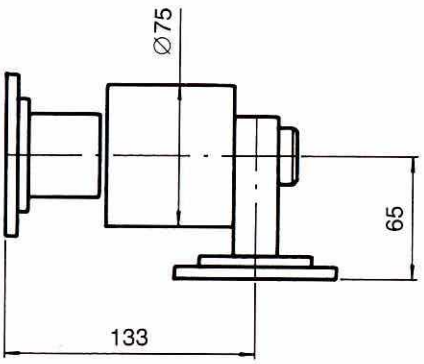

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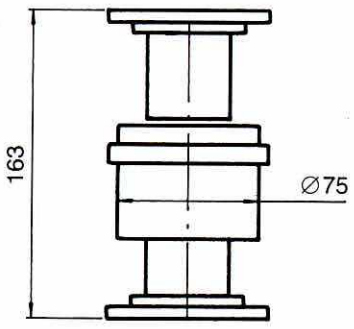

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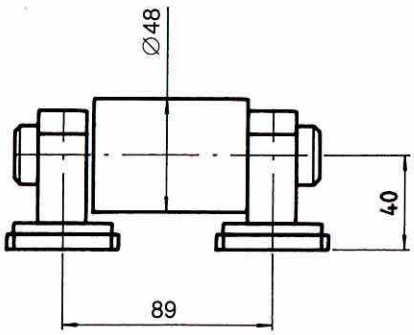
Waveguide Single Channel

Waveguide R84 (WR112, WG15)						
Model		**PM7364H**			**PM7362H**	**PM7360H**
Style		U	U	U	L	I
Frequency	(GHz)	8.5-9.6	7.9-8.4	7-10	8.5-9.6	8.5-9.6
VSWR		1.10	1.20	1.50	1.15	1.15
Insertion Loss	(dB)	0.15	0.20	0.50	0.15	0.15
Peak Power	(kW)	250	250	100	200	200
Average Power	(kW)	1	1.5	1	1	2



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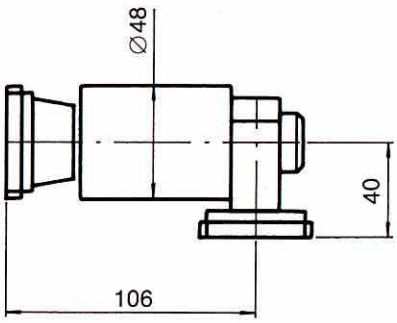

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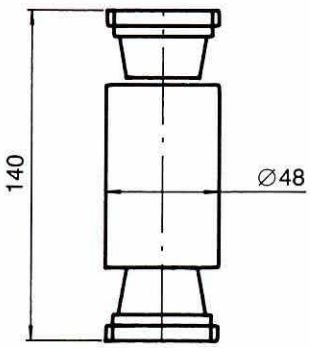

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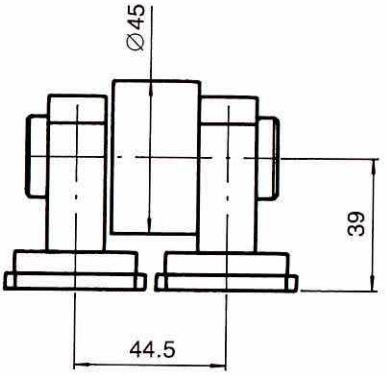
Waveguide Single Channel

Waveguide R100 (WR90, WG16)								
Model		**PM7364X**			**PM7362X**	**PM7360X**		
Style		U	U	U	L	I	I	I
Frequency	(GHz)	8.5-9.6	9.5-10	8.2-12.4	8.5-9.6	8.5-9.6	9.7-10.4	8.2-11
VSWR		1.10	1.10	1.30	1.15	1.10	1.15	1.30
Insertion Loss	(dB)	0.15	0.20	0.20	0.15	0.20	0.20	0.25
Peak Power	(kW)	150	100	75	100	100	100	100
Average Power	(kW)	0.5	0.5	0.5	0.5	1	1	1



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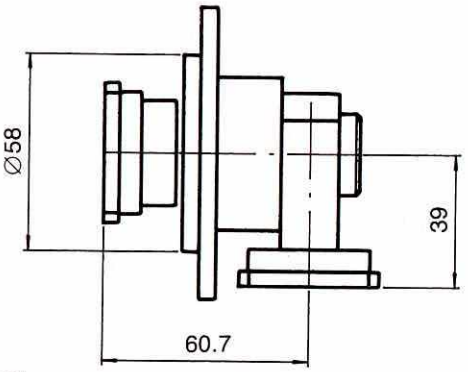

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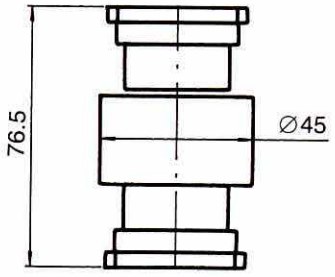

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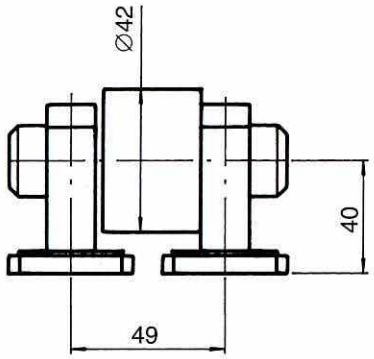
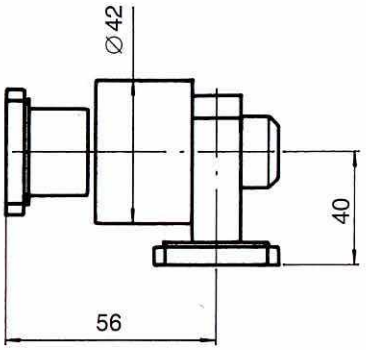
Waveguide Single Channel

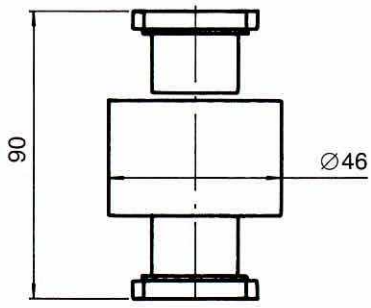
Waveguide R120 (WR75, WG17)					
Model		**PM7364M**	**PM7362M**	**PM7360M**	
Style		U	L	I	I
Frequency	(GHz)	14-14.5	14-14.5	11-13	11-14.5
VSWR		1.25	1.25	1.2	1.5
Insertion Loss	(dB)	0.25	0.25	0.2	0.3
Peak Power	(kW)	50	30	30	30
Average Power	(kW)	0.5	0.5	0.5	0.5



PM 7364M



PM 7362M



PM 7360M

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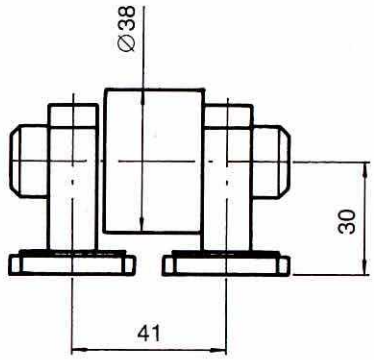
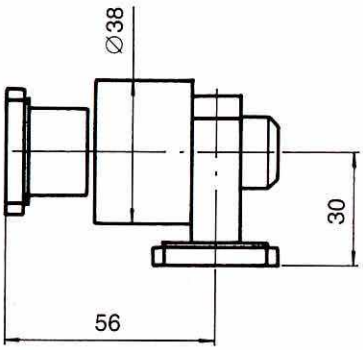
Waveguide Single Channel

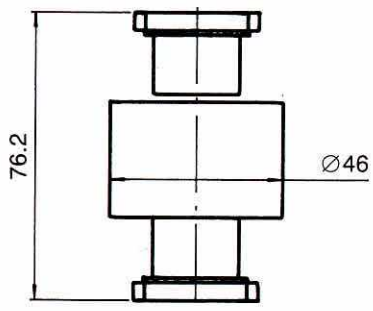
Waveguide R140 (WR62, WG18)						
Model		**PM7364P**		**PM7362P**	**PM7360P**	
Style		U	U	L	I	I
Frequency	(GHz)	14-17.5	12.4-18	16-17	15.5-17.5	12.4-18
VSWR		1.15	1.5	1.15	1.10	1.6
Insertion Loss	(dB)	0.25	0.6	0.25	0.10	0.5
Peak Power	(kW)	60	60	30	30	15
Average Power	(kW)	0.5	0.5	0.5	0.5	0.5



PM 7364P



PM 7362P



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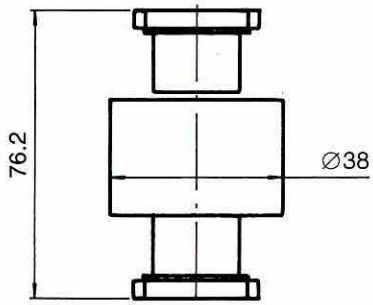
Waveguide Single Channel

Waveguide R180 (WR51, WG19)

Model		PM7360PK
Style		I
Frequency	(GHz)	16.5-18.5
VSWR		1.3
Insertion Loss	(dB)	0.3
Peak Power	(kW)	30
Average Power	(kW)	0.3



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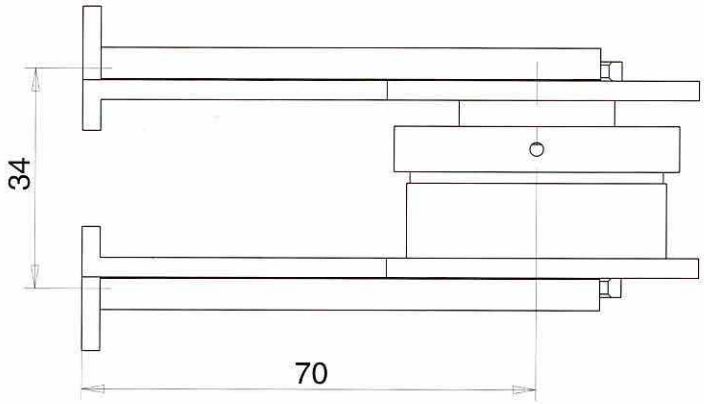
Waveguide Single Channel

Waveguide R320 (WR28, WG22)

Model		PM7364V
Style		U
Frequency	(GHz)	34-35
VSWR		1.3
Insertion Loss	(dB)	0.5
Peak Power	(kW)	10
Average Power	(kW)	0.1



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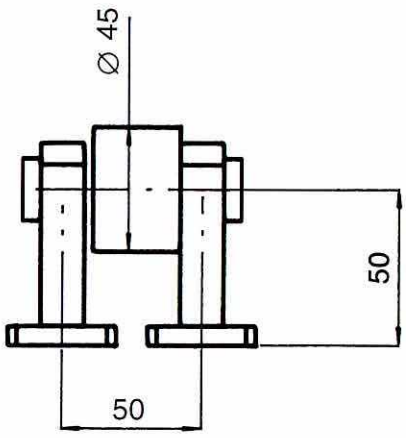
Waveguide Single Channel

Waveguide WRD475

Model		PM7364DX
Style		U
Frequency	(GHz)	4.75-10.8
VSWR		1.5
Insertion Loss	(dB)	0.5
Peak Power	(kW)	30
Average Power	(kW)	0.7



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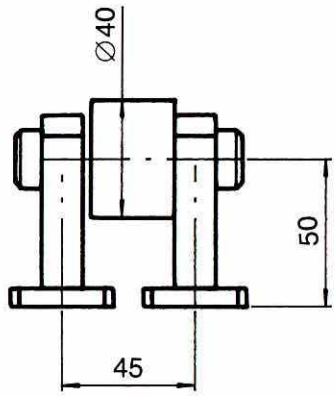
Waveguide Single Channel

Waveguide WRD750					
Model		**PM7364DP**		**PM7362DP**	
Style		U	U	L	L
Frequency	(GHz)	7.5-17.5	7.5-18	7.5-17	7.5-18
VSWR		1.5	1.7	1.5	2
Insertion Loss	(dB)	0.5	0.5	0.5	1.5
Peak Power	(kW)	20	20	20	20
Average Power	(kW)	0.35	0.35	0.35	0.35



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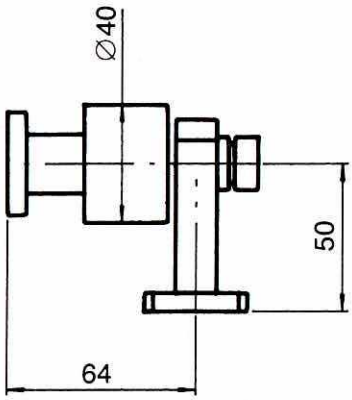

PM 7362DP

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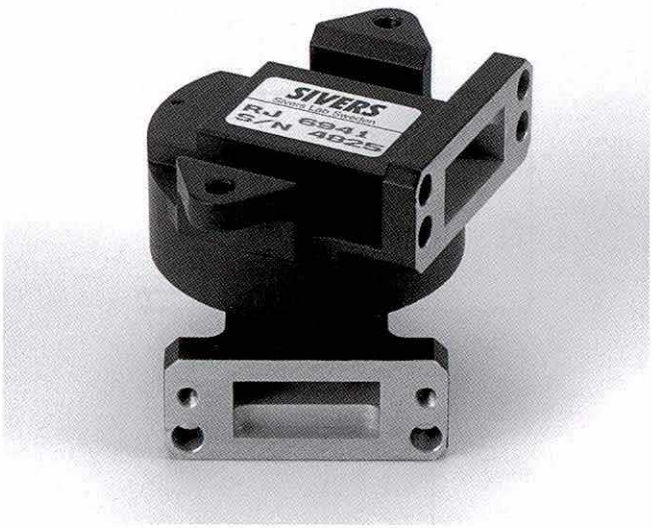
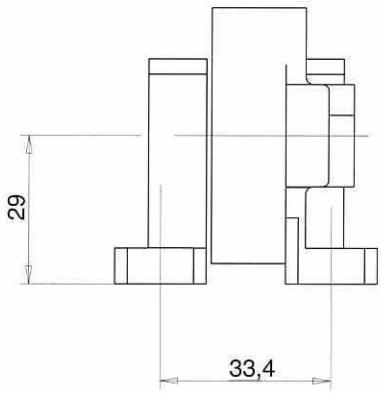
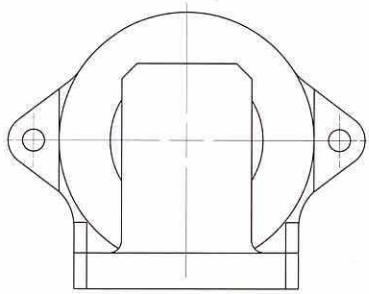
Waveguide Single Channel

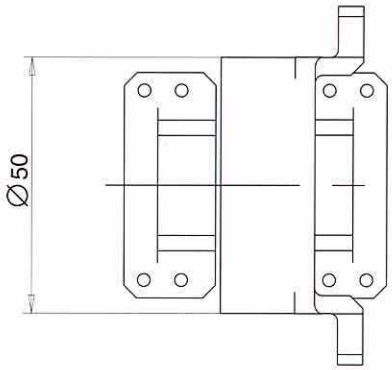
Waveguide R100 (WR90, WG16)

Model		RJ6941
Style		U
Frequency	(GHz)	9.4-10
VSWR		1.2
Insertion Loss	(dB)	0.2
Peak Power	(kW)	50
Average Power	(kW)	1.5









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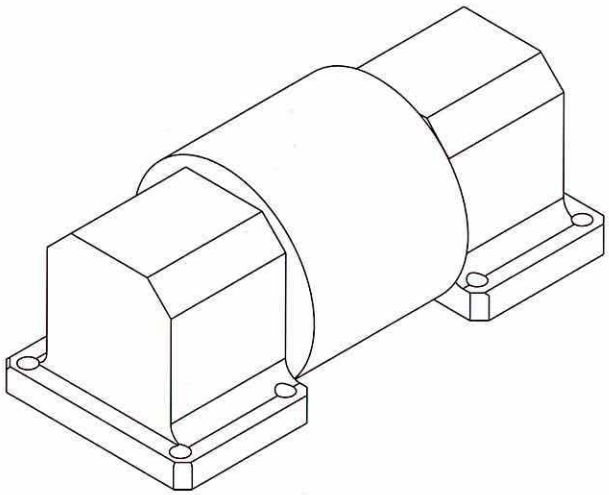
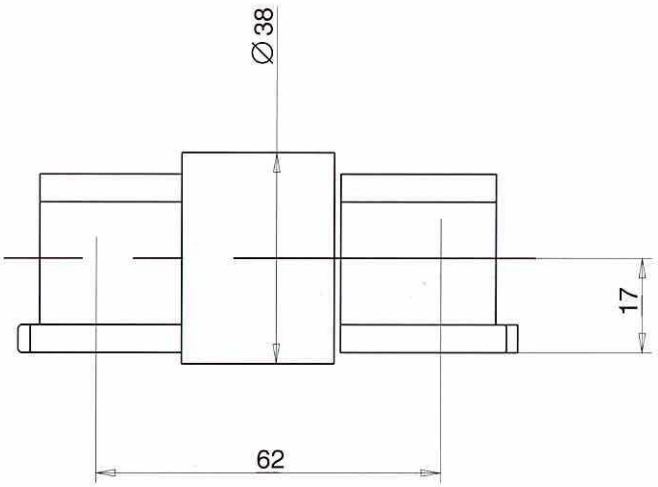
Waveguide Single Channel

Waveguide R100 (WR90, WG16)

Model		RJ6980X
Style		U
Frequency	(GHz)	9.7-10.5
VSWR		1.2
Insertion Loss	(dB)	0.2
Peak Power	(kW)	70
Average Power	(kW)	1.5





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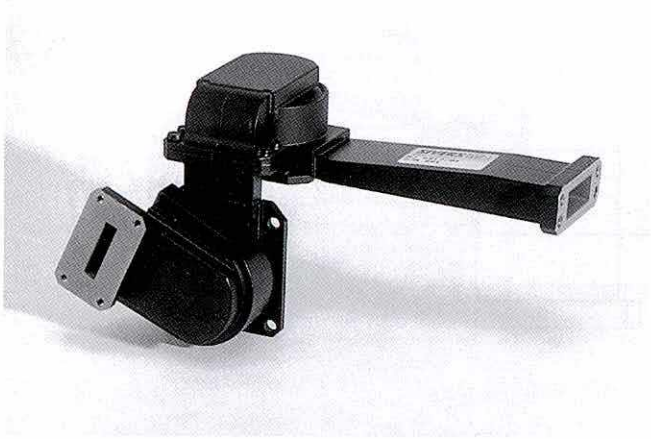
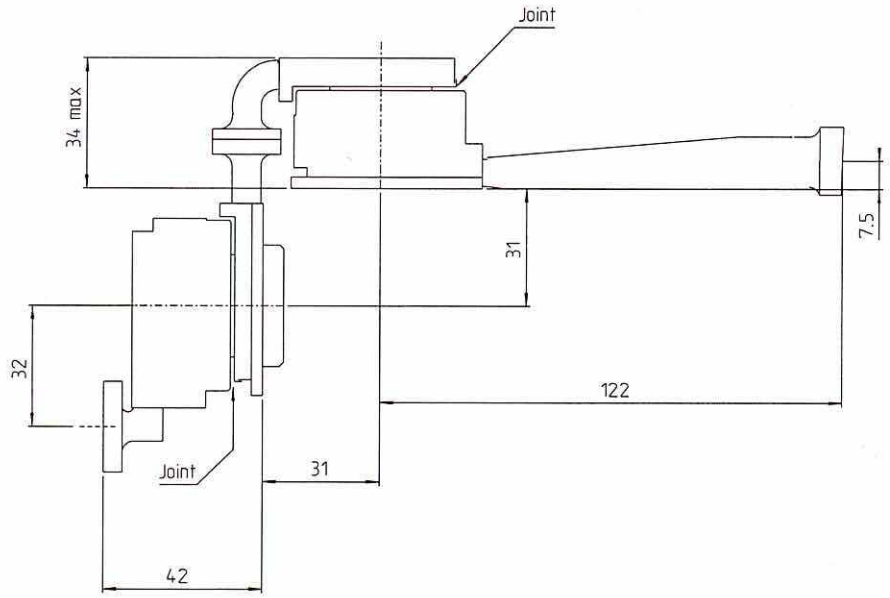
Waveguide Single Channel

Waveguide R100/F100 (WR90/ half height WR90)

Model		RJ6917
Style		2-axis
Frequency	(GHz)	9-9.5
VSWR		1.3
Insertion Loss	(dB)	0.5
Peak Power	(kW)	50
Average Power	(kW)	0.1





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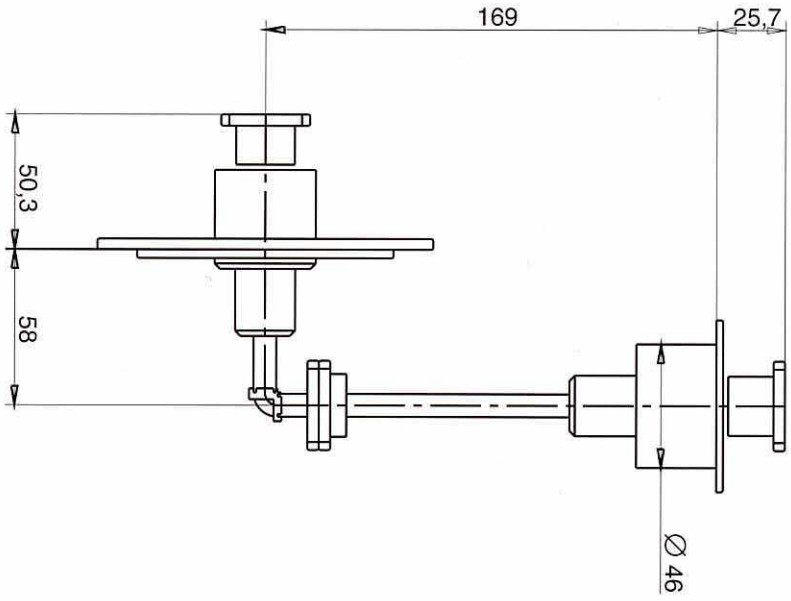
Waveguide Single Channel

Waveguide R180 (WR51, WG19)

Model		RJ6933
Style		2-axis
Frequency	(GHz)	16.5-18.5
VSWR		1.4
Insertion Loss	(dB)	0.5
Peak Power	(kW)	50
Average Power	(kW)	0.3



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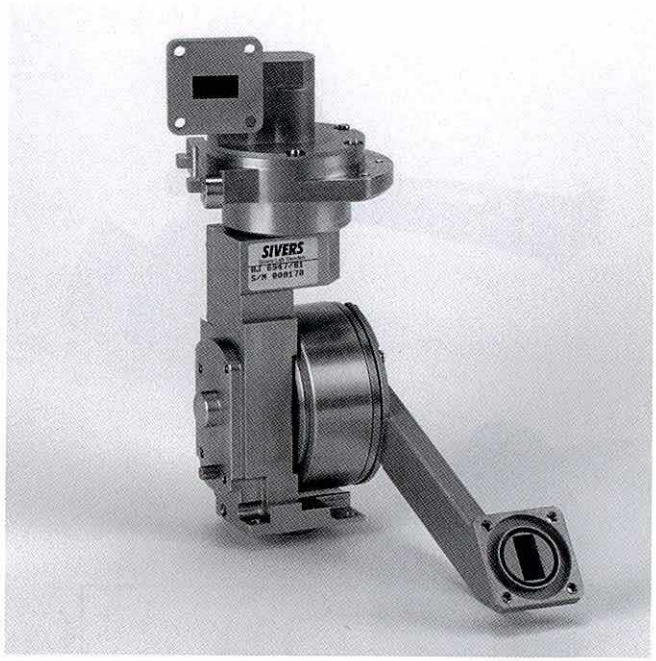
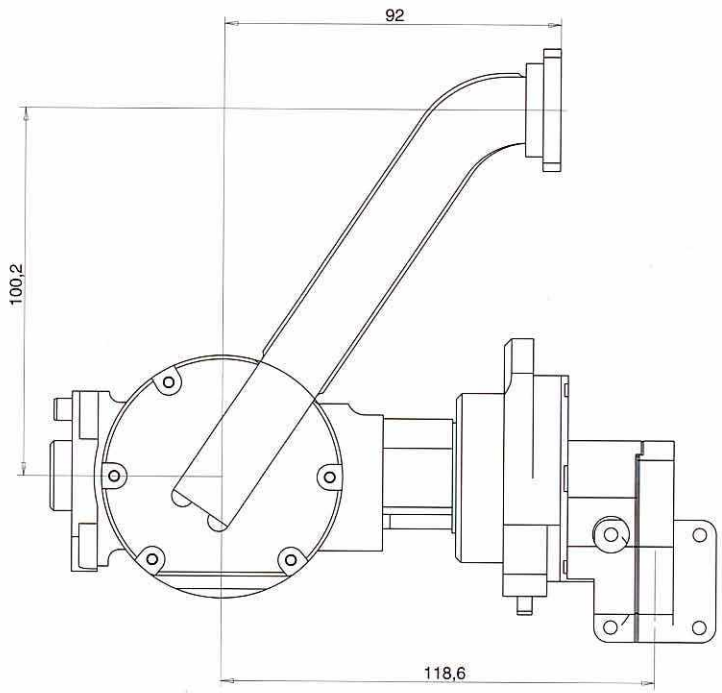
Waveguide Single Channel

Waveguide R140 (WR62, WG18)

Model		RJ6947
Style		2-axis
Frequency	(GHz)	16.2-16.8
VSWR		1.3
Insertion Loss	(dB)	0.5
Peak Power	(kW)	10
Average Power	(kW)	0.1





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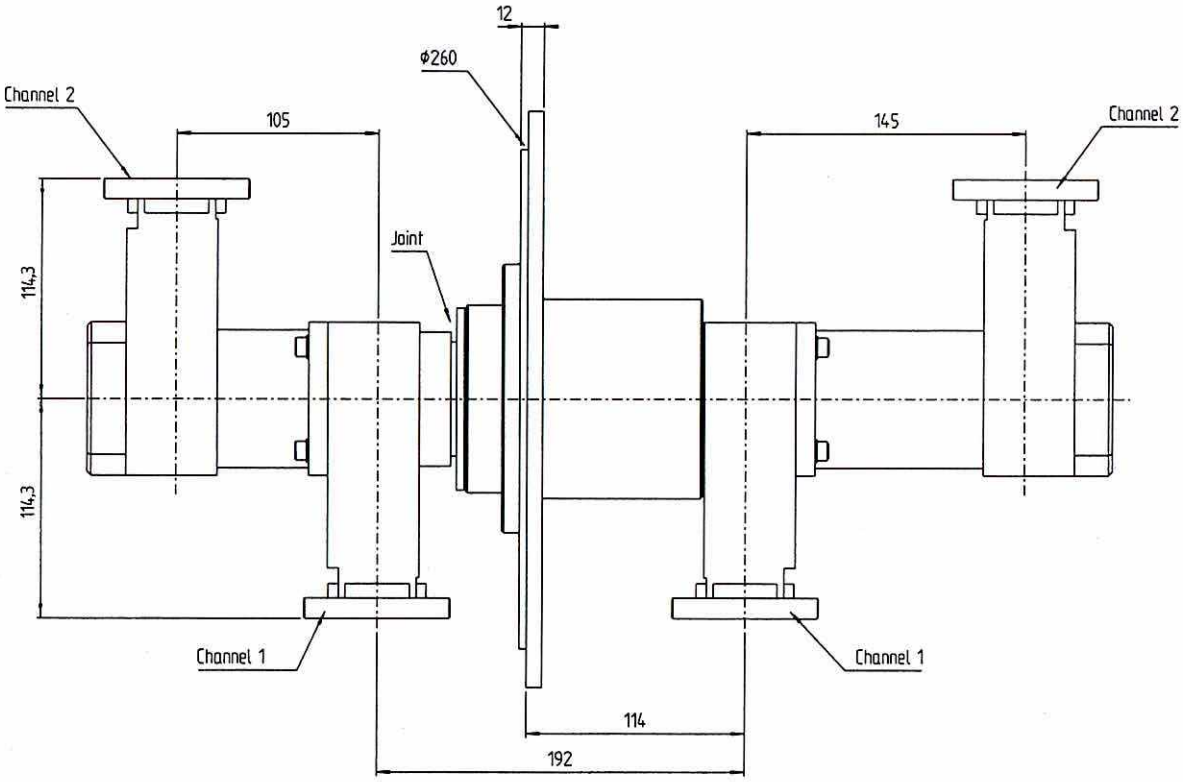
Waveguide Dual Channel

Model		RJ6937S	
Channel		1	2
Connector Type		WR284	WR284
Frequency	(GHz)	2.7-2.9	2.7-2.9
VSWR		1.2	1.2
Insertion Loss	(dB)	0.15	0.2
Peak Power	(kW)	1000	1000
Avg Power	(kW)	1	1



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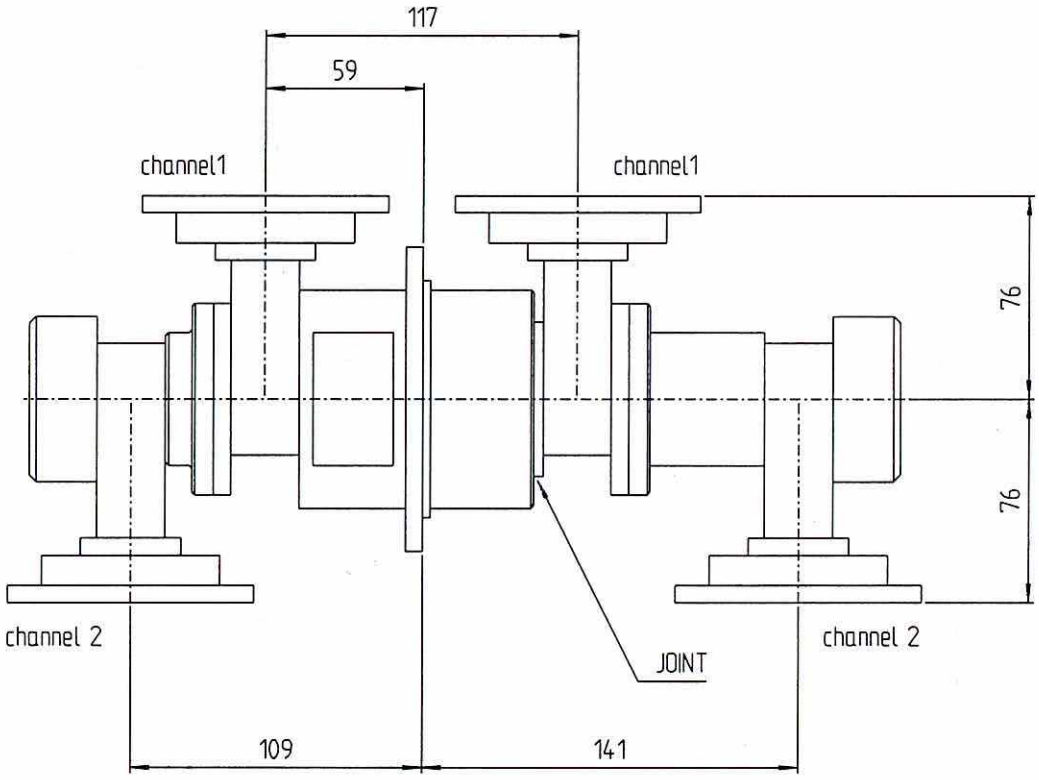
Waveguide Dual Channel

Model		RJ6935G	
Channel		1	2
Connector Type		WR187	WR187
Frequency	(GHz)	5.4-5.7	5.4-5.7
VSWR		1.25	1.3
Insertion Loss	(dB)	0.2	0.35
Peak Power	(kW)	600	600
Avg Power	(kW)	0.6	0.6
Isol. between ch.	(dB)	60	



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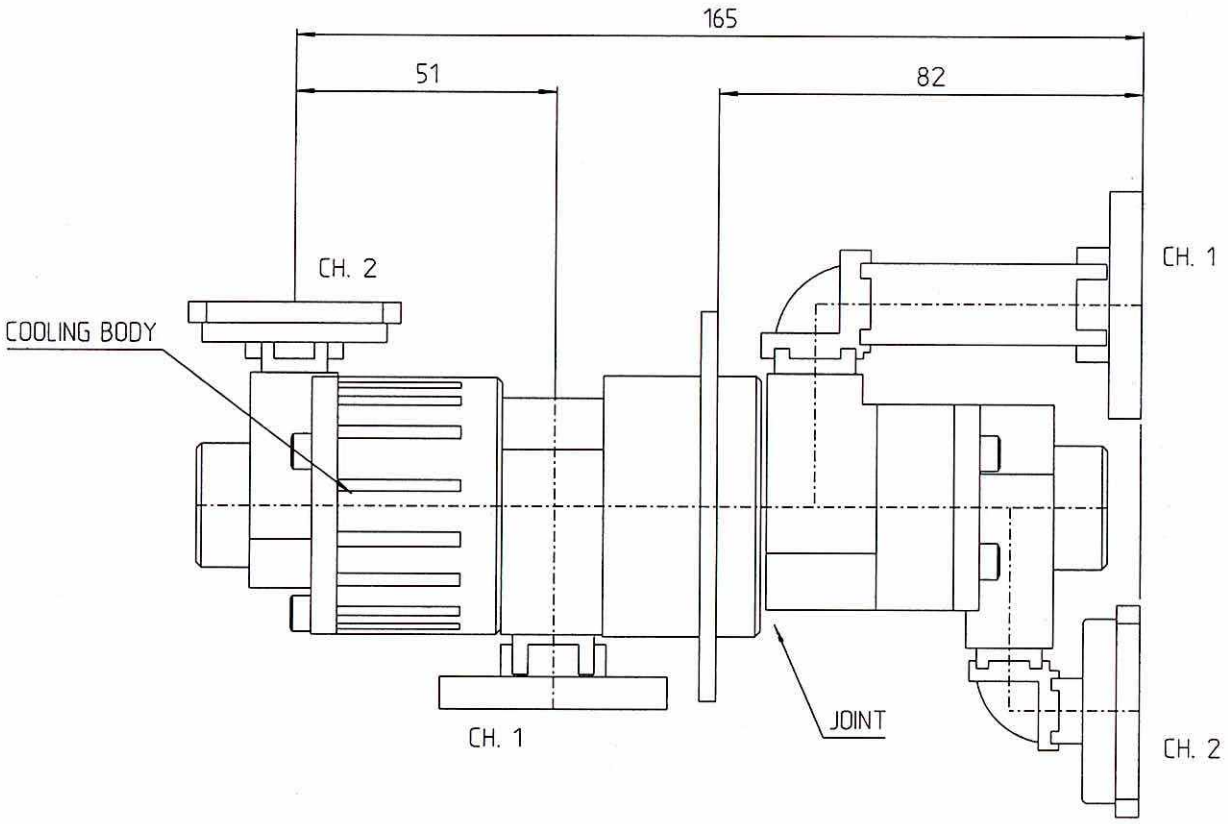
Waveguide Dual Channel

Application: Extra high average power. Material, copper

Model		SL6893H	
Channel		1	2
Connector Type		WR112	WR90
Frequency	(GHz)	8.5-9.6	8.5-10.25
VSWR		1.2	1.3
Insertion Loss	(dB)	0.2	0.4
Peak Power	(kW)	200	5
Avg Power	(kW)	3	0.05
Isol. between ch.	(dB)	60	



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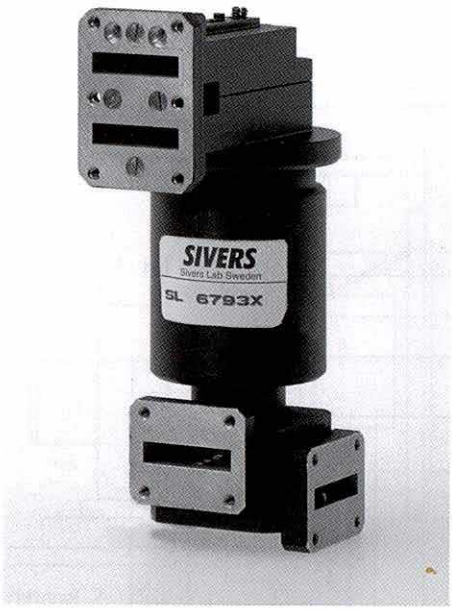
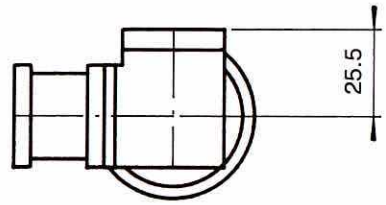
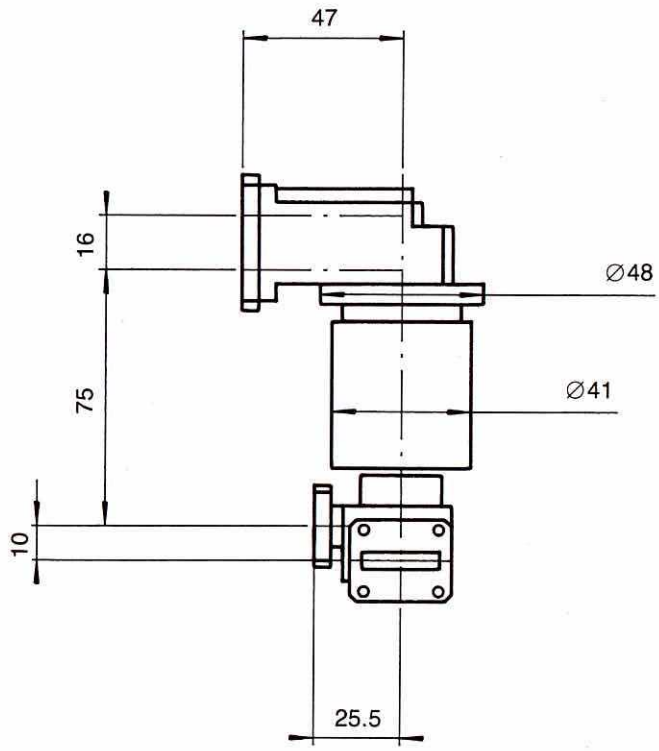
Waveguide Dual Channel

Model		SL6793X	
Channel		1	2
Connector Type		1/2 WR90	1/2 WR90
Frequency	(GHz)	9.7-10.5	9.7-10.5
VSWR		1.2	1.2
Insertion Loss	(dB)	0.3	0.5
Peak Power	(kW)	1	1
Avg Power	(kW)	0.05	0.05
Isol. between ch.	(dB)		45







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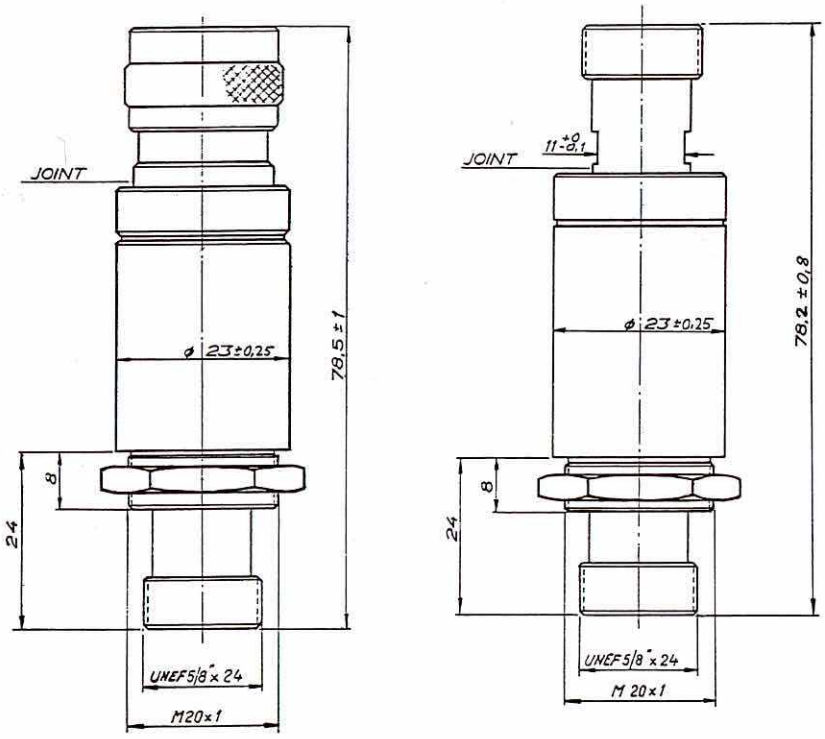
Coaxial Single Channel

Model			PM7890	PM7890/01
Connector Type			N(f) / N(m)	N(f) / N(f)
Frequency		(GHz)	DC-12.4	DC-12.4
VSWR	(DC-8)		1.3	1.3
	(8-12.4)		1.5	1.5
Insertion Loss	(DC-8)	(dB)	0.2	0.2
	(8-12.4)	(dB)	0.3	0.3
Peak Power		(kW)	10	10
Avg Power	(DC-3)	(kW)	0.5	0.5
	(3-12.4)	(kW)	0.1	0.1



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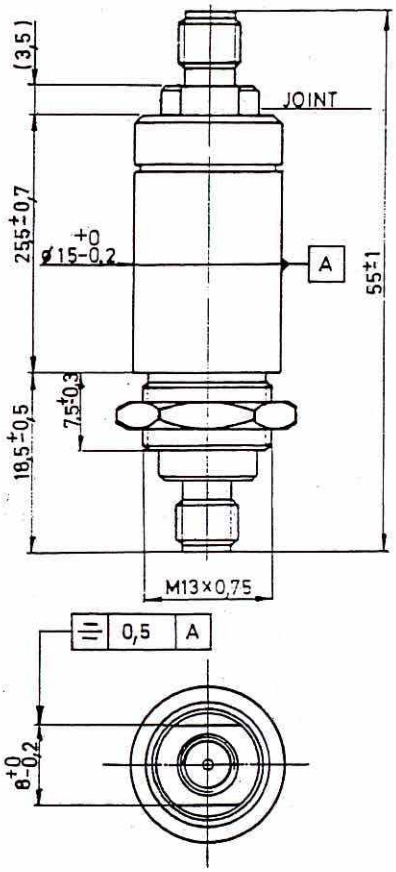
Coaxial Single Channel

Model			PM7892
Connector Type			SMA(f) / SMA(f)
Frequency		(GHz)	DC-18
VSWR	(DC-12)		1.3
	(12-18)		1.5
Insertion Loss	(DC-12)	(dB)	0.3
	(12-18)	(dB)	0.6
Peak Power		(kW)	1
Avg Power		(kW)	0.05



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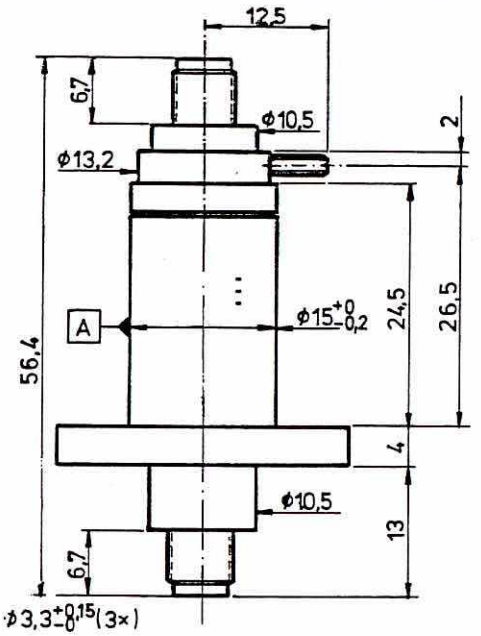
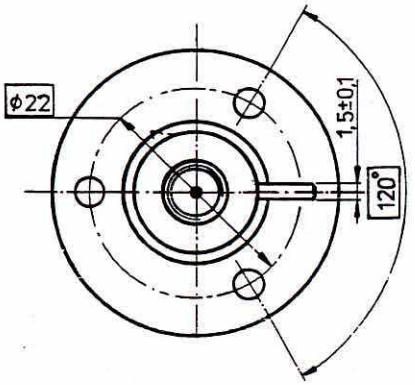
Coaxial Single Channel

Model			PM7889/11
Connector Type			K-connector
Frequency		(GHz)	DC-40
VSWR	(DC-26)		1.75
	(26-40)		2.5
Insertion Loss	(DC-26)	(dB)	1
	(26-40)	(dB)	1.5
Peak Power		(kW)	0.2
Avg Power		(kW)	0.005





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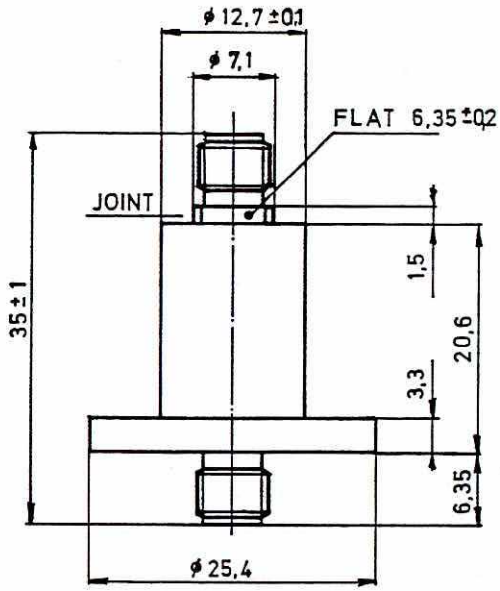
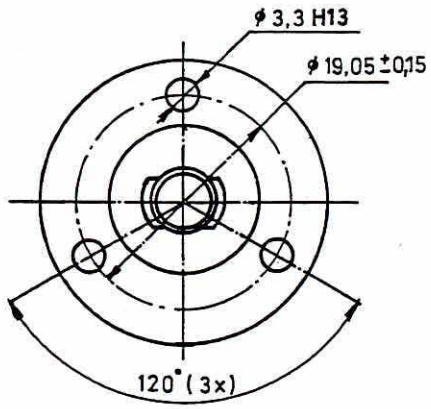
Coaxial Single Channel

Model		SL6778	SL6778/01	
Connector Type		SMA(f)/SMA(f)	SMA(f)/SMA(f)	
Frequency	(GHz)	8.5-9.6	9.8-11	
VSWR		1.5	1.5	
Insertion Loss	(dB)	0.3	0.3	
Peak Power	(kW)	3	3	
Average Power	(kW)	0.05	0.05	Choke coupled, low torque





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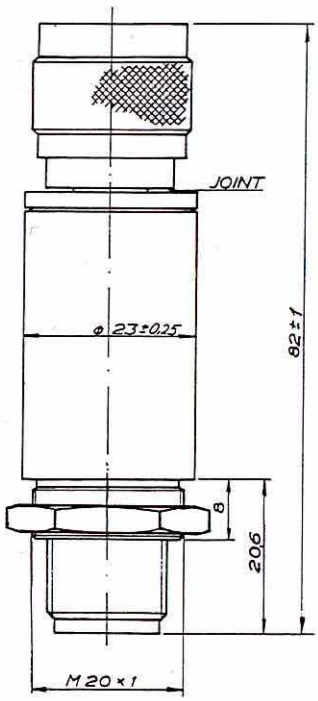
Coaxial Single Channel

Model		PM7893
Connector Type		N(f) / N(m)
Frequency	(GHz)	2-10
VSWR		1.4
Insertion Loss	(dB)	0.3
Peak Power	(kW)	5
Avg Power	(kW)	0.1
Rotation speed	(rpm)	2000



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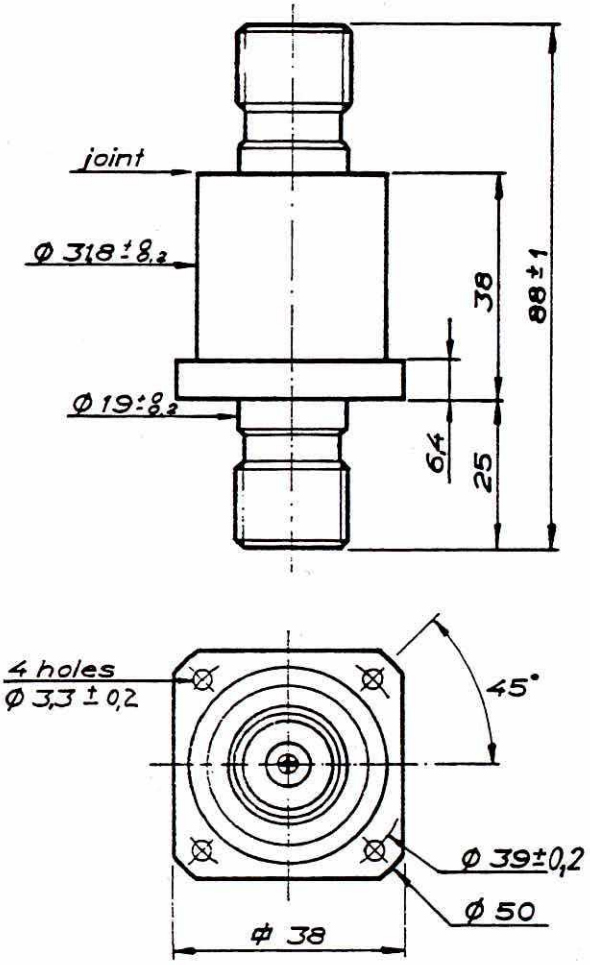
Coaxial Single Channel

Model			PM7894
Connector Type			HN(f) / HN(f)
Frequency		(GHz)	DC-3
VSWR	(DC-1.1)		1.15
	(1.1-3)		1.25
Insertion Loss	(DC-1.1)	(dB)	0.10
	(1.1-3)	(dB)	0.15
Peak Power		(kW)	10
Avg Power		(kW)	0.5
Material			Silverplated brass



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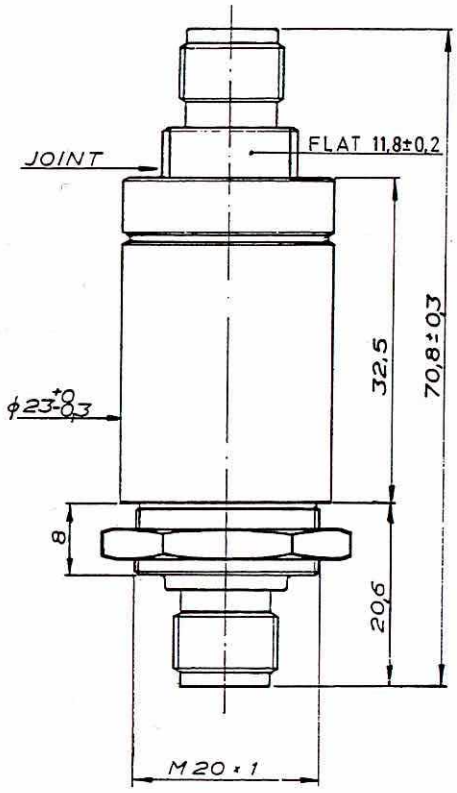
Coaxial Single Channel

Model			PM7895
Connector Type			TNC (f)
Frequency		(GHz)	DC-11
VSWR	(DC-8)		1.3
	(8-11)		1.5
Insertion Loss	(DC-8)	(dB)	0.2
	(8-11)	(dB)	0.3
Peak Power		(kW)	3
Avg Power	(DC-8)	(kW)	0.4
	(8-11)	(kW)	0.2



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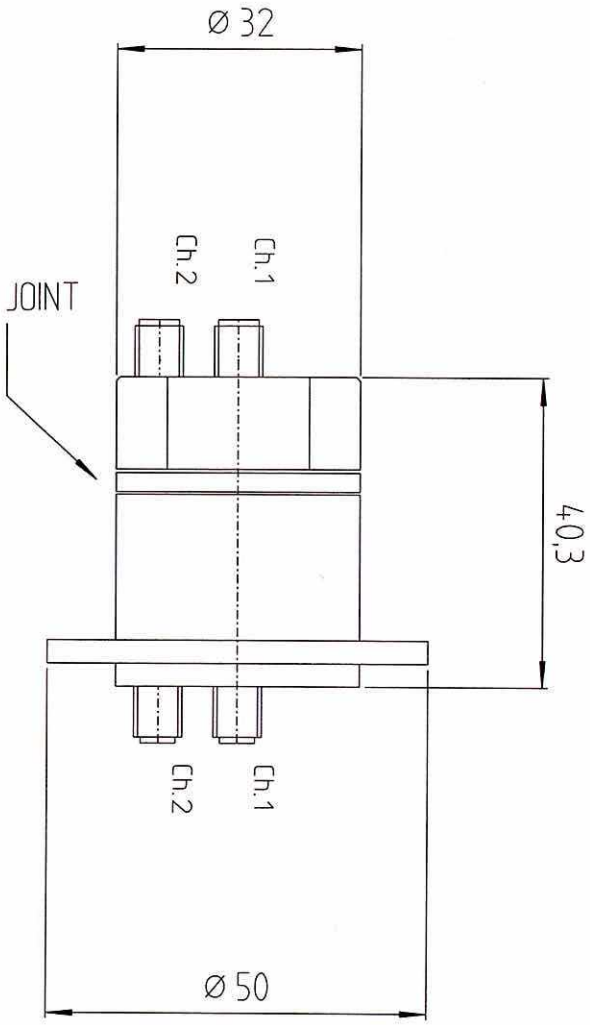
Coaxial Dual Channel

Model		RJ6903	RJ6903/02
Channel		1&2	1&2
Connector Type		SMA (f)	SMA (f)
Frequency	(GHz)	1.0-1.1	1.5-1.8
VSWR		1.25	1.25
Insertion Loss	(dB)	0.2	0.3
Peak Power	(kW)	5	5
Avg Power	(kW)	0.05	0.05



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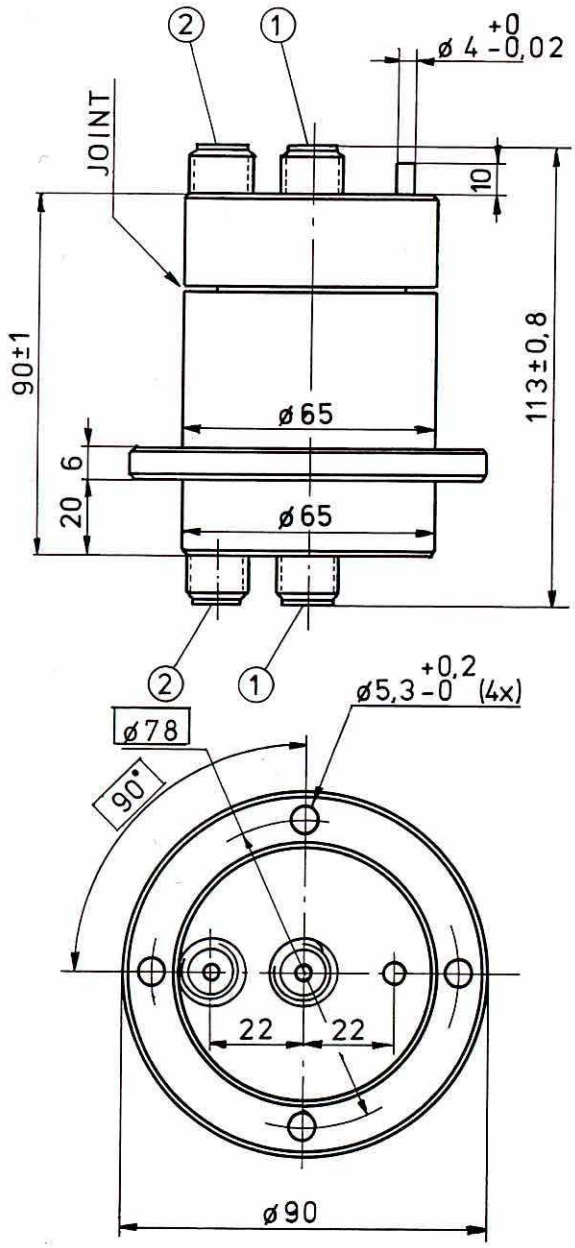
Coaxial Dual Channel

Model		SL6758		SL6786	
Channel		1	2	1	2
Connector Type		N (f)	N (f)		
Frequency	(GHz)	DC-12	DC-3	DC-3.1	DC-3.1
VSWR		1.5	1.7	1.5	1.7
Insertion Loss	(dB)	0.5	0.5	0.5	0.5
Peak Power	(kW)	15	15	15	15
Avg Power	(kW)	0.05	0.05	0.4	0.05
Isol. between ch.	(dB)	55		55	



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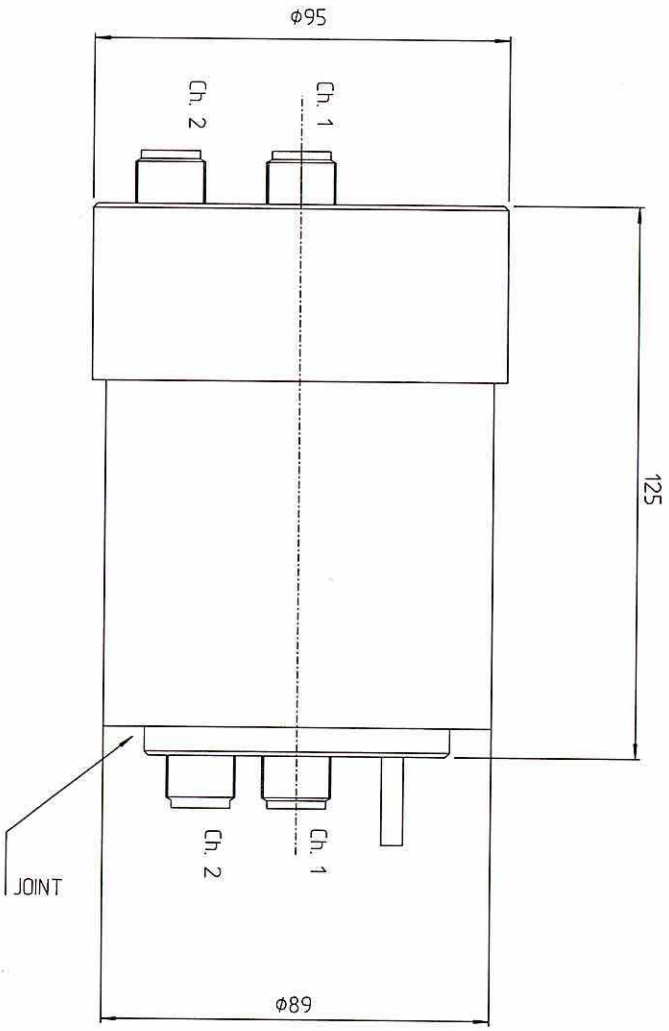
Coaxial Dual Channel

Model	RJ6899
Channel	1&2
Connector Type	N(f)
Frequency (GHz)	1.0-1.11
VSWR	1.2
Insertion Loss (dB)	0.1
Peak Power (kW)	10
Avg Power (kW)	0.3
Isol. between ch.dB	60



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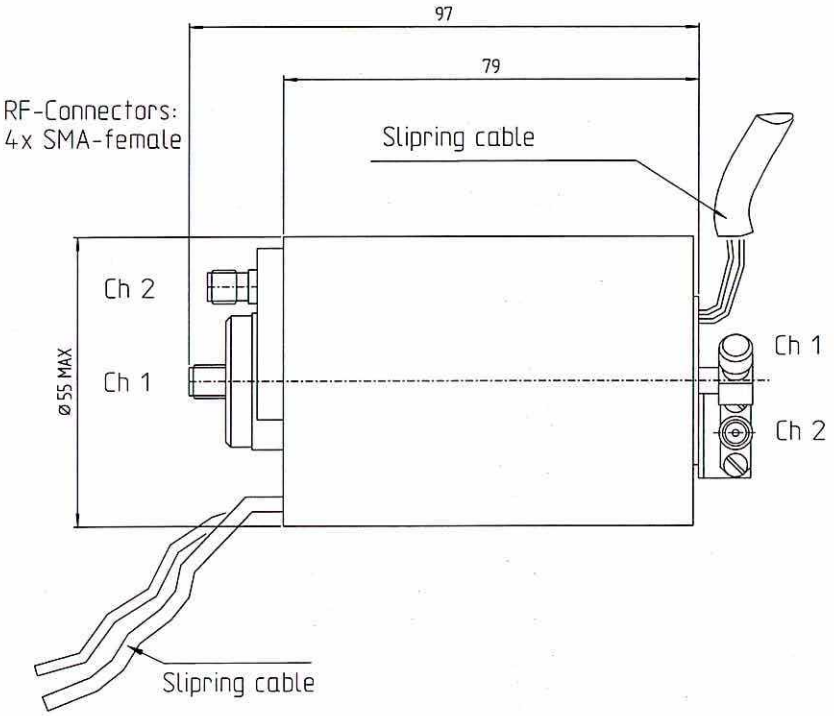
Coaxial Dual Channel

Application: Airborne DBS (Satellite)TV
Two RF channels at 12.2-12.7 GHz
Twelve Slip-rings for DC/AC power and data communication.

Model		RJ6927/03	
Channel		1&2	12 Slip-rings
Connector Type		SMA(f)	
Frequency	(GHz)	12.2-12.7	
VSWR		1.5	
Insertion Loss	(dB)	0.9	
Peak Power	(kW)	5	
Avg Power	(kW)	0.05	
Isol. between ch.	(dB)	40	



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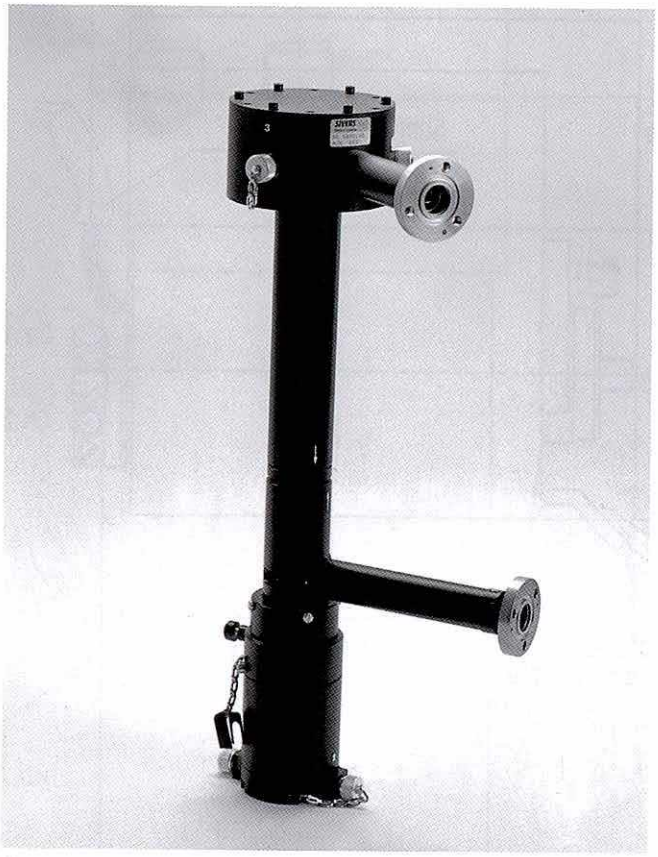
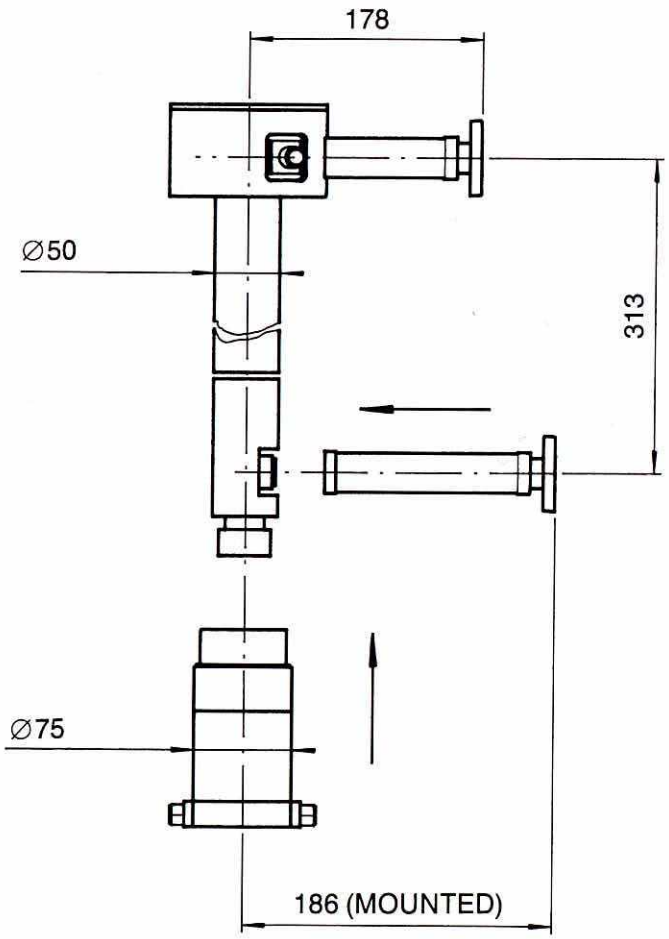
Coaxial Three Channel

Application: Marine radar.
Material: Sivlerplated brass.
The Rotary Joint is designed to be installed in an existing turntable with a narrow hole.
The unit can be disassembled, installed and then reassembled in a few easy operations.

Model		SL6890	
Channel		1	2&3
Connector Type		IEA 7/8	N
Frequency	(GHz)	3.02-3.08	1.0-1.1
VSWR		1.1	1.3
Insertion Loss	(dB)	0.3	0.7
Peak Power	(kW)	30	2
Avg Power	(kW)	0.05	0.1





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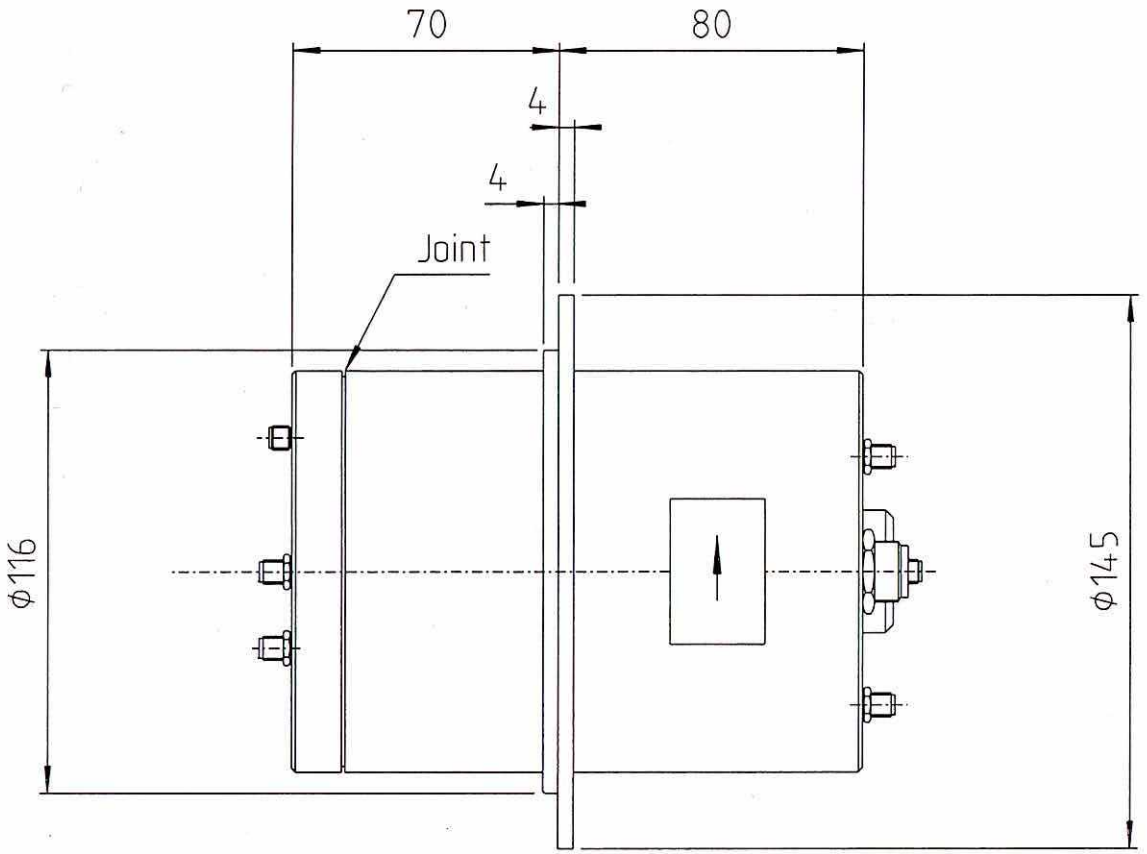
Coaxial Three Channel

Application: Surveillance radar. Ground mobile

Model		RJ6909	
Channel		1&2	3
Connector Type		SMA	SMA
Frequency	(GHz)	3.0-3.4	1.6-1.9
VSWR		1.3	1.3
Insertion Loss	(dB)	0.5	0.4
Peak Power	(kW)	5	5
Avg Power	(kW)	0.1	0.05



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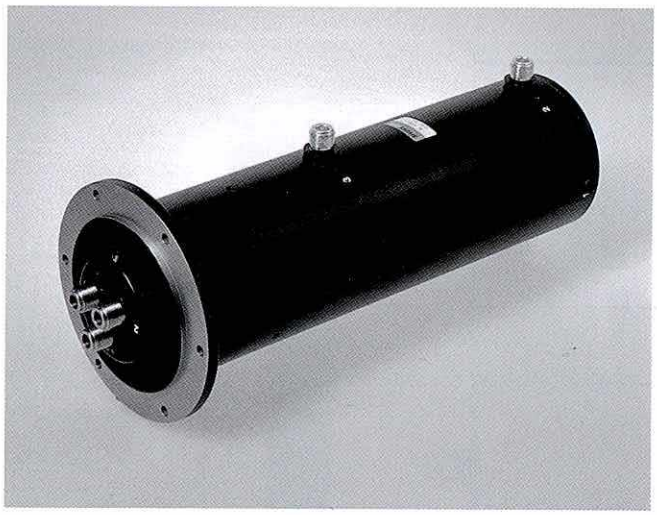
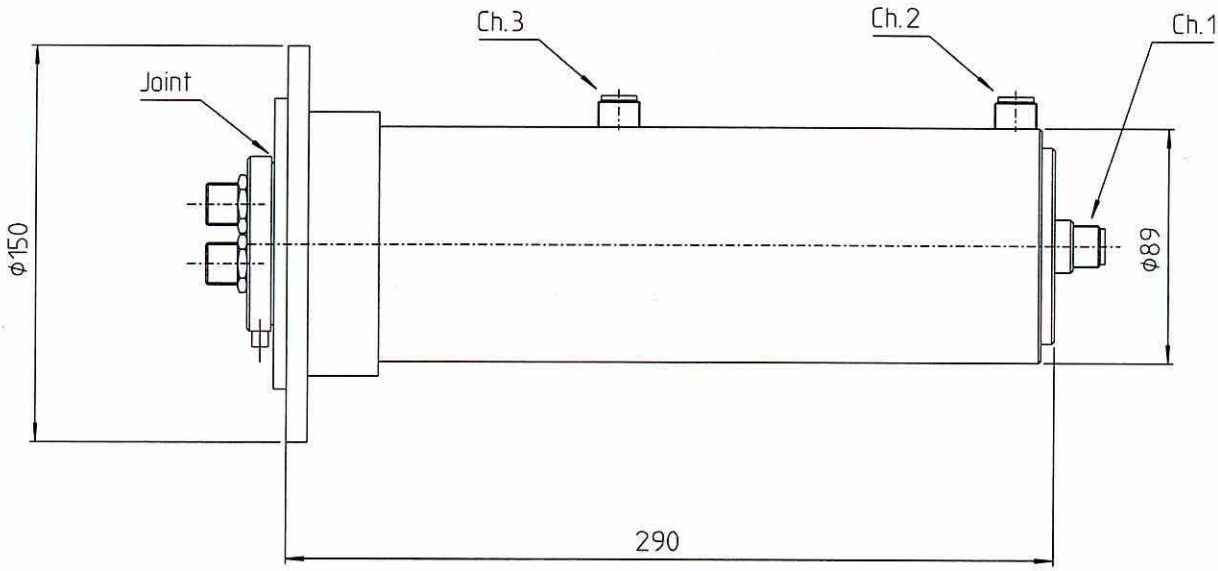
Coaxial Three Channel

Application: Air Traffic Control (ATC).
Secondary Radar. Three coaxial channels for MSSR, S-mode, 1.0-1.1 GHz.

Model	RJ6907
Channel	1,2&3
Connector Type	N(f)
Frequency (GHz)	1.0-1.1
VSWR	1.2
Insertion Loss (dB)	0.3
Peak Power (kW)	10
Avg Power (kW)	0.1 (0.4)
Isol. between ch.(dB)	60





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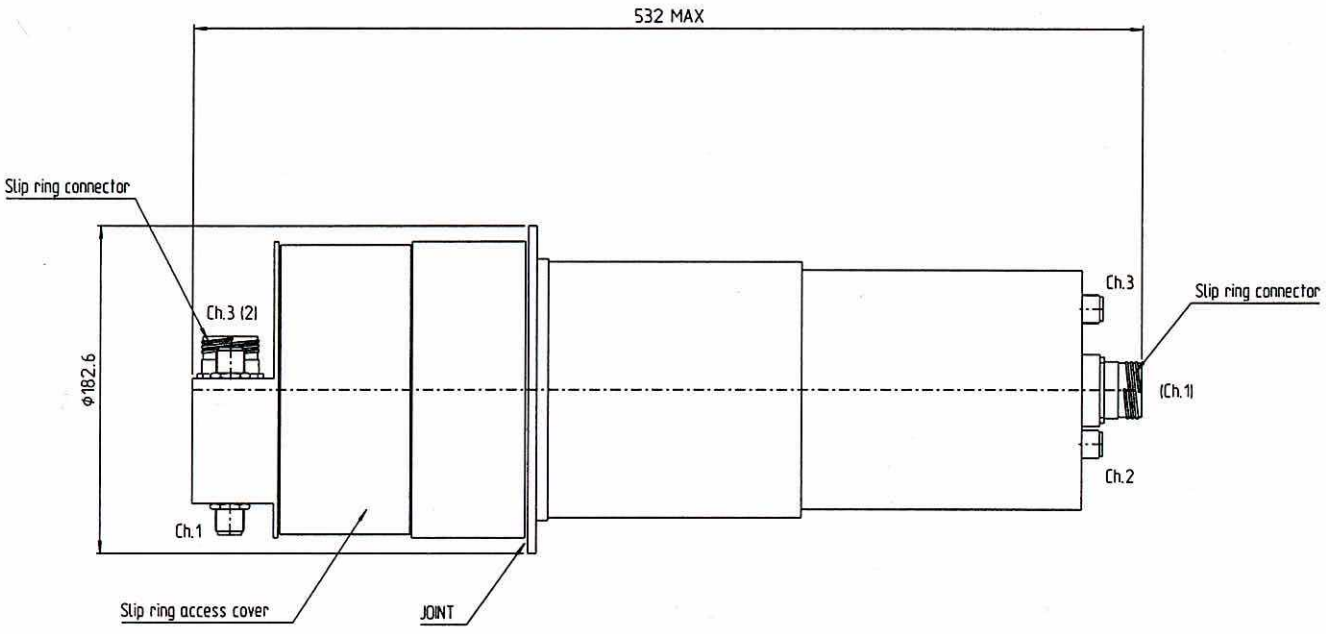
Coaxial Three Channel

Application: Air Traffic Control (ATC).
Primary Radar. Coaxial channel at 2.7-2.9 GHz
Secondary Radar. Two coaxial channels for SSR, 1.0-1.1 GHz.
14-bit Azimuth pulse generation via optical Encoder
Eleven Slip-rings for DC/AC power and communication.

Model		RJ6930			
Channel		1	2&3	11 Slip-rings	Encoder
Connector Type		N(f)	N(f)		
Frequency	(GHz)	2.7-2.9	1.0-1.1		
VSWR		1.2	1.2		
Insertion Loss	(dB)	0.3	0.5		
Peak Power	(kW)	10	10		
Avg Power	(kW)	0.15	0.05		
Isol. between ch.	(dB)	60			



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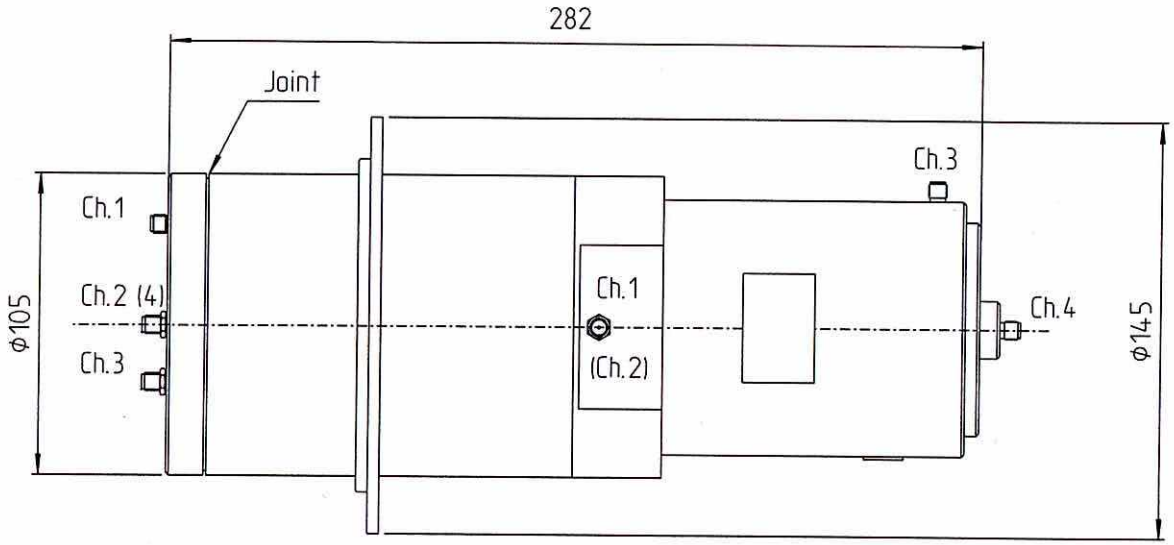
Coaxial Multi Channel

Application: Surveillance radar
Primary Radar. Two coaxial channels at 3-3.4 GHz
Secondary Radar. Two coaxial channels for IFF, 1.0-1.1 GHz.

Model		RJ6939	
Channel		1&2	3&4
Connector Type		N(f)	N(f)
Frequency	(GHz)	3-3.4	1.0-1.1
VSWR		1.3	1.3
Insertion Loss	(dB)	0.5	0.6
Peak Power	(kW)	10	10
Avg Power	(kW)	0.1	0.05



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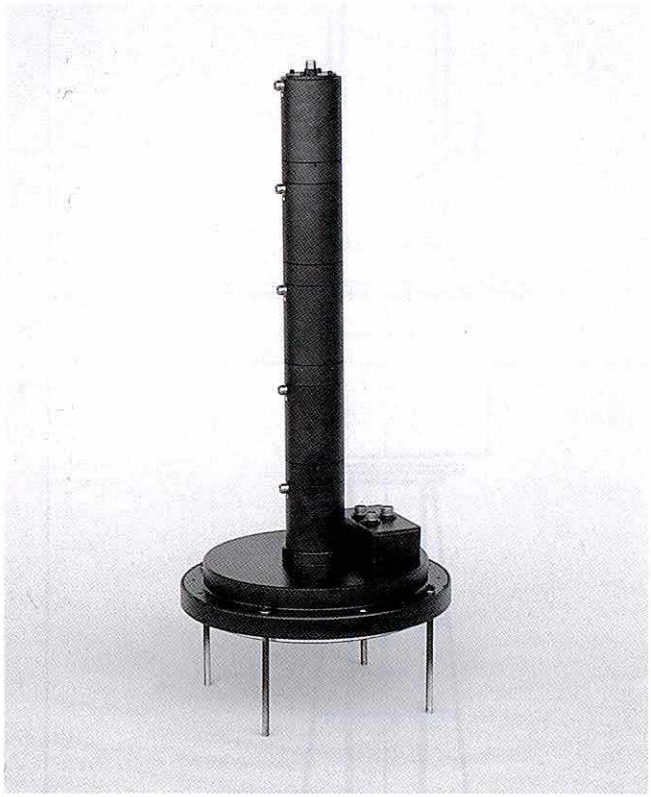
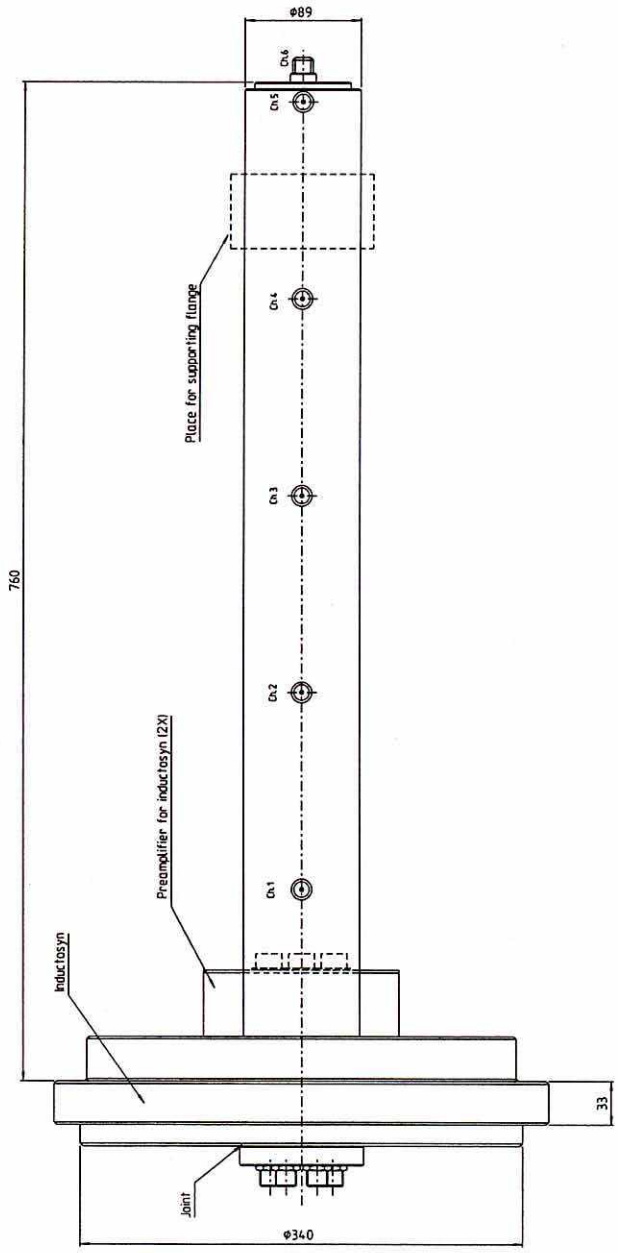
Coaxial, Multi Channel

Application: Air Traffic Control (ATC).
Secondary Radar. Six (2*3) coaxial channels for SSR S-mode, 1.0-1.1 GHz.
Azimuth position indication via inductive Encoder.

Model		RJ6902	
Channel		1 to 6	Encoder
Connector Type		N(f)	
Frequency	(GHz)	1.0-1.1	
VSWR		1.2	
Insertion Loss	(dB)	0.75	
Peak Power	(kW)	10	
Avg Power	(kW)	0.1 (0.4)	
Isol. between ch.	(dB)	60	





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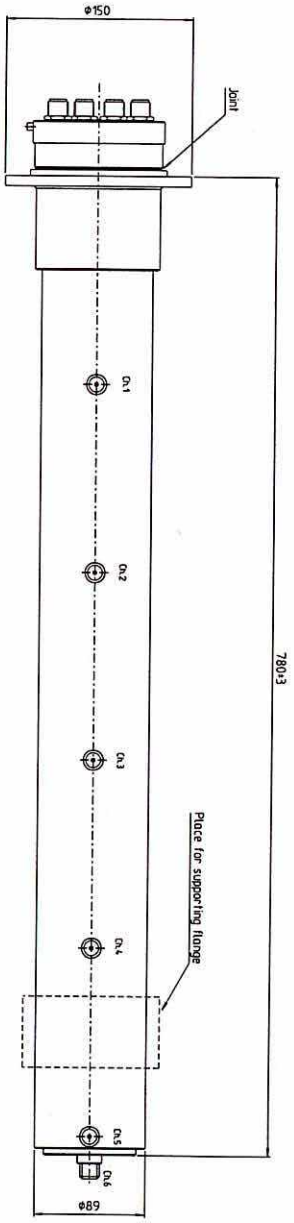
Coaxial, Multi Channel

Application: Air Traffic Control (ATC).
Secondary Radar. Six (2*3) coaxial channels for MSSR, S-mode, 1.0-1.1 GHz.

Model	RJ6915
Channel	1 to 6
Connector Type	N(f)
Frequency (GHz)	1.0-1.1
VSWR	1.3
Insertion Loss (dB)	0.5
Peak Power (kW)	10
Avg Power (kW)	0.1
Isol. between ch.(dB)	60
1,2&3 and 4,5&6 (dB)	90



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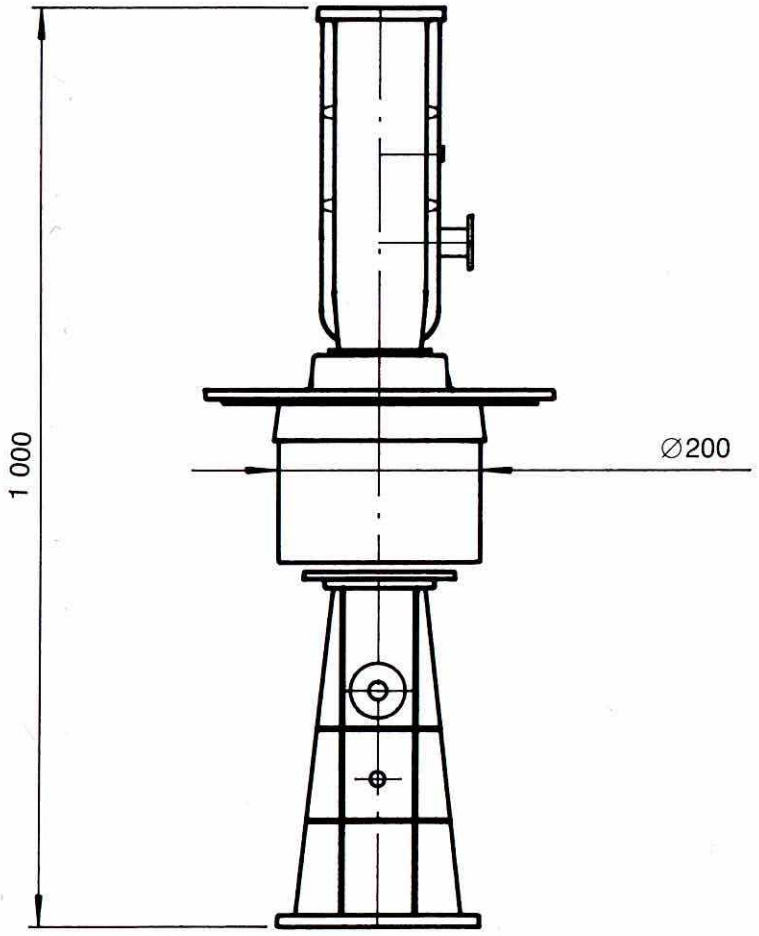
Waveguide/Coaxial, Dual Channel

Model	PM7899L/06	
Channel	1	2
Connector Type	WR650	7/8 EIA
Frequency (GHz)	1.25-1.35	1.5-2
VSWR	1.10	1.35
Insertion Loss (dB)	0.10	0.5
Peak Power (kW)	6000	10
Avg Power (kW)	30	0.5
Isol. between ch.(dB)	50	



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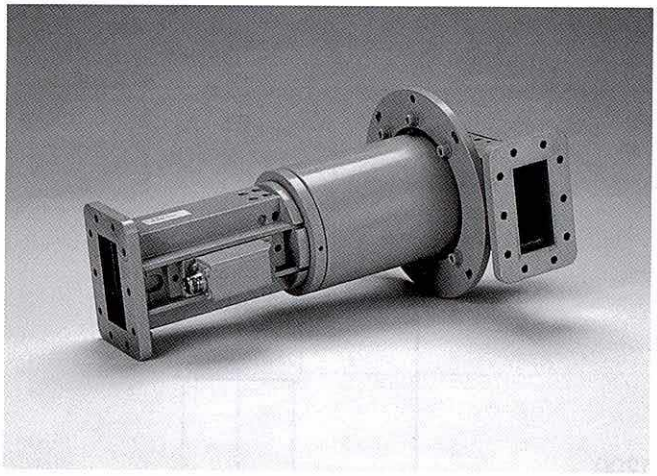
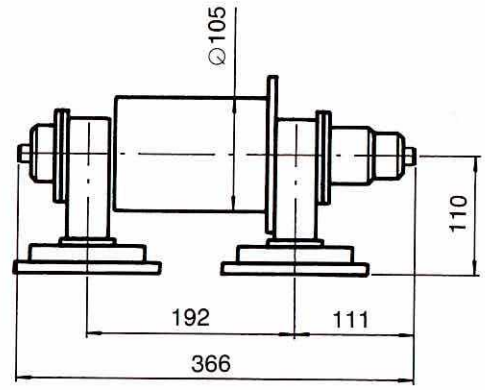
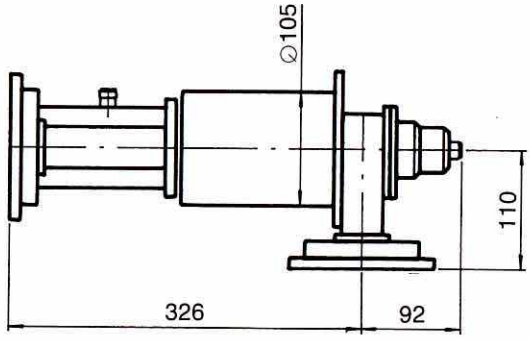
Waveguide/Coaxial, Dual Channel

Model	PM7896S		PM7363S	
Channel	1	2	1	2
Connector Type	WR284	N	WR284	N
Frequency (GHz)	2.7-3.3	DC-3.4	2.7-3.3	DC-3.4
VSWR	1.15	1.3	1.20	1.3
Insertion Loss (dB)	0.15	0.5	0.15	0.5
Peak Power (kW)	1500	10	1000	10
Avg Power (kW)	5	0.5	5	0.5
Isol. between ch.(dB)	50		50	





PM 7896S



PM 7363S

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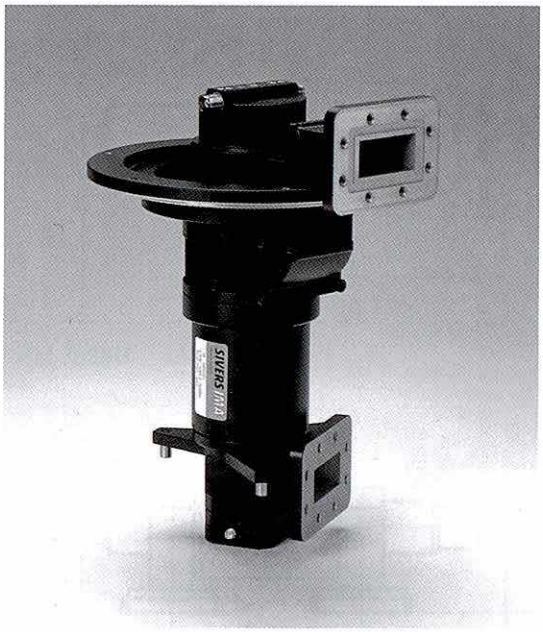
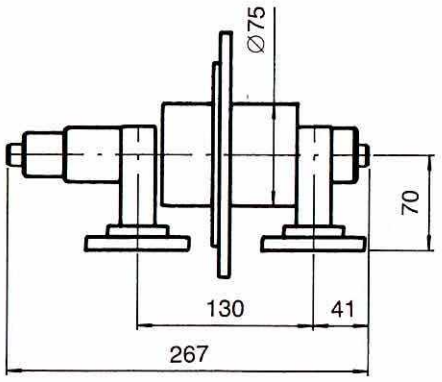
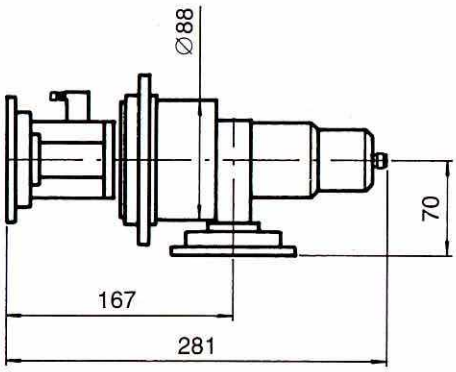
Waveguide/Coaxial, Dual Channel

Model	PM7896G		SL6766G	
Channel	1	2	1	2
Connector Type	WR187	N	WR187	TNC/SMA
Frequency (GHz)	5.4-5.9	DC-12	5.4-5.9	DC-5.9
VSWR	1.15	1.5	1.51	1.3
Insertion Loss (dB)	0.10	1	0.10	0.7
Peak Power (kW)	600	10	400	10
Avg Power (kW)	3	0.1	2	0.3
Isol. between ch.(dB)	50		50	





PM 7896G



SL 6766G

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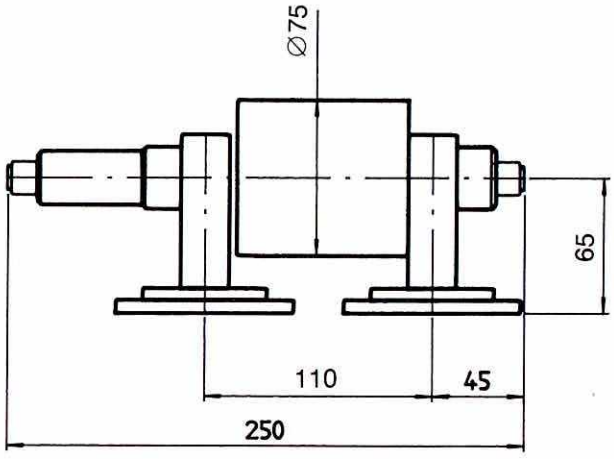
Waveguide/Coaxial, Dual Channel

Model		PM7896C	
Channel		1	2
Connector Type		WR159	N
Frequency	(GHz)	5.4-5.9	DC-6.4
VSWR		1.15	1.3
Insertion Loss	(dB)	0.20	0.7
Peak Power	(kW)	300	10
Avg Power	(kW)	2	0.3
Isol. between ch.	(dB)	50	



PM 7896C

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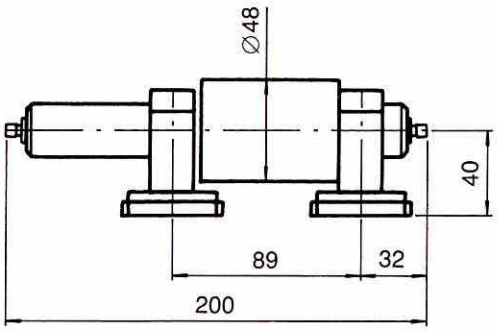
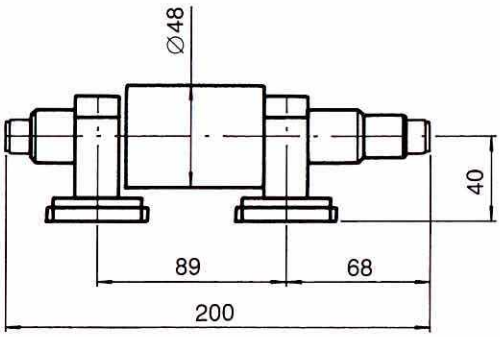
Waveguide/Coaxial, Dual Channel

Model	PM7896H		PM7896H/01	
Channel	1	2	1	2
Connector Type	WR112	SMA	WR112	N
Frequency (GHz)	8.5-9.6	DC-10	8.5-9.6	8.5-9.6
VSWR	1.10	1.5	1.15	1.3
Insertion Loss (dB)	0.15	1	0.15	0.5
Peak Power (kW)	250	5	200	5
Avg Power (kW)	1	0.1	1	0.3
Isol. between ch.(dB)	50		50	



PM 7896H



PM 7896H/01

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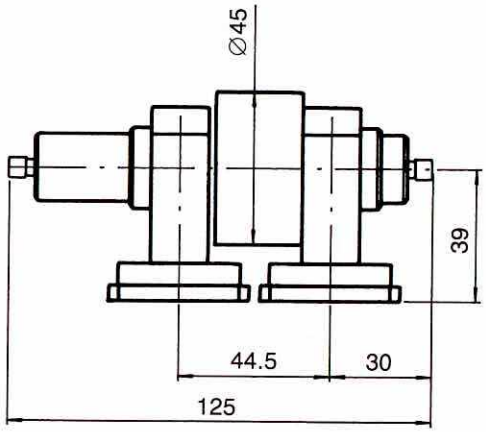
Waveguide/Coaxial, Dual Channel

Model		PM7896X	
Channel		1	2
Connector Type		WR90	SMA
Frequency	(GHz)	8.5-9.6	DC-12.4
VSWR		1.10	1.3
Insertion Loss	(dB)	0.15	1
Peak Power	(kW)	150	1
Avg Power	(kW)	0.5	0.05
Isol. between ch.	(dB)	50	



PM 7896X

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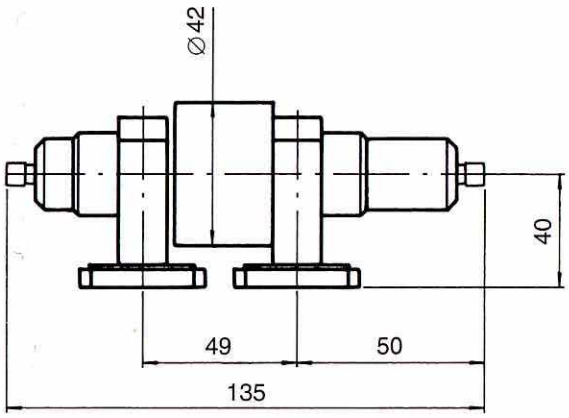
Waveguide/Coaxial, Dual Channel

Model	PM7896M	
Channel	1	2
Connector Type	WR75	SMA
Frequency (GHz)	14-14.5	DC-13
VSWR	1.25	1.3
Insertion Loss (dB)	0.25	0.5
Peak Power (kW)	50	5
Avg Power (kW)	0.5	0.05
Isol. between ch.(dB)	50	



PM 7896M

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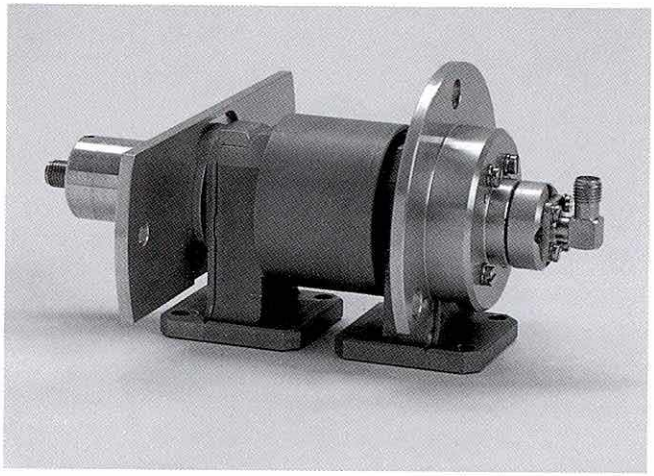
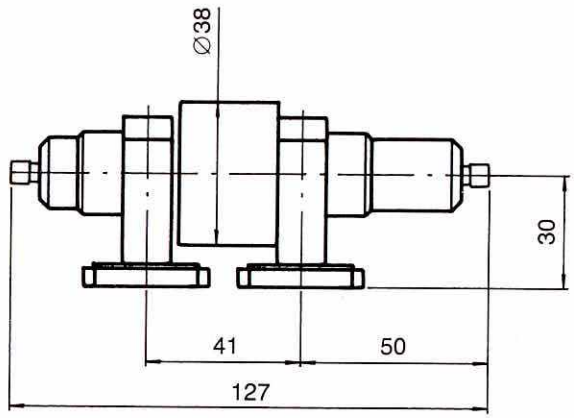
Waveguide/Coaxial, Dual Channel

Model	PM7896P	
Channel	1	2
Connector Type	WR62	SMA
Frequency (GHz)	14-17.5	DC-18
VSWR	1.15	1.5
Insertion Loss (dB)	0.25	1.5
Peak Power (kW)	60	1
Avg Power (kW)	0.5	0.05
Isol. between ch.(dB)	50	





PM 7896P

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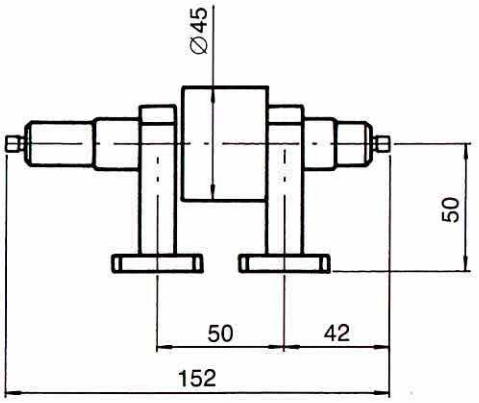
Waveguide/Coaxial, Dual Channel

Model	PM7896DX	
Channel	1	2
Connector Type	WRD475	SMA
Frequency (GHz)	4.75-10.8	DC-18
VSWR	1.5	1.5
Insertion Loss (dB)	0.5	1.5
Peak Power (kW)	30	1
Avg Power (kW)	0.7	0.05
Isol. between ch.(dB)	50	



PM 7896DX

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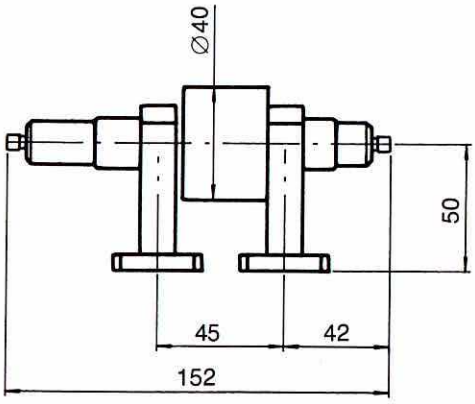
Waveguide/Coaxial, Dual Channel

Model		PM7896DP	
Channel		1	2
Connector Type		WRD750	SMA
Frequency	(GHz)	7.5-17.5	DC-18
VSWR		1.5	1.5
Insertion Loss	(dB)	0.5	1.5
Peak Power	(kW)	20	1
Avg Power	(kW)	0.35	0.05
Isol. between ch.	(dB)	50	



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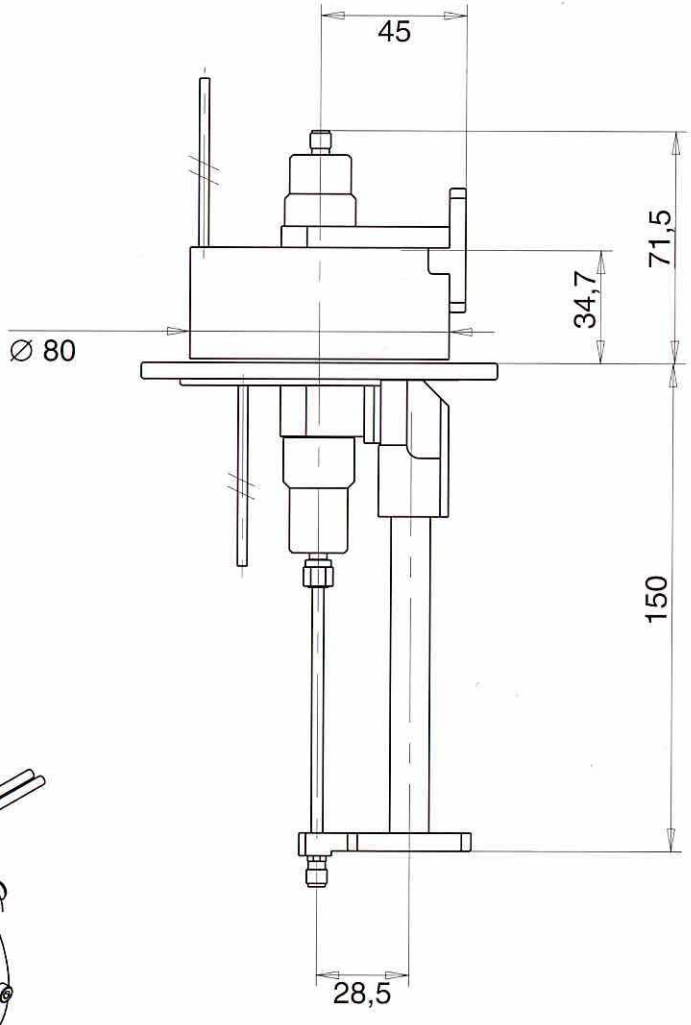
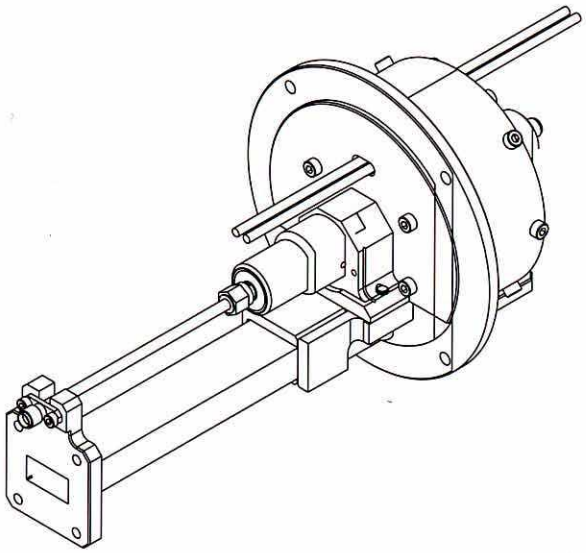
Waveguide/Coaxial, Dual Channel

Application: Satellite communication

Model		SL6946	
Channel		1	2
Connector Type		WR75	SMA
Frequency	(GHz)	14-14.5	12.25-12.75
VSWR		1.3	1.3
Insertion Loss	(dB)	0.3	0.5
Peak Power	(kW)	50	5
Avg Power	(kW)	0.1	0.05
Isol. between ch.	(dB)	50	





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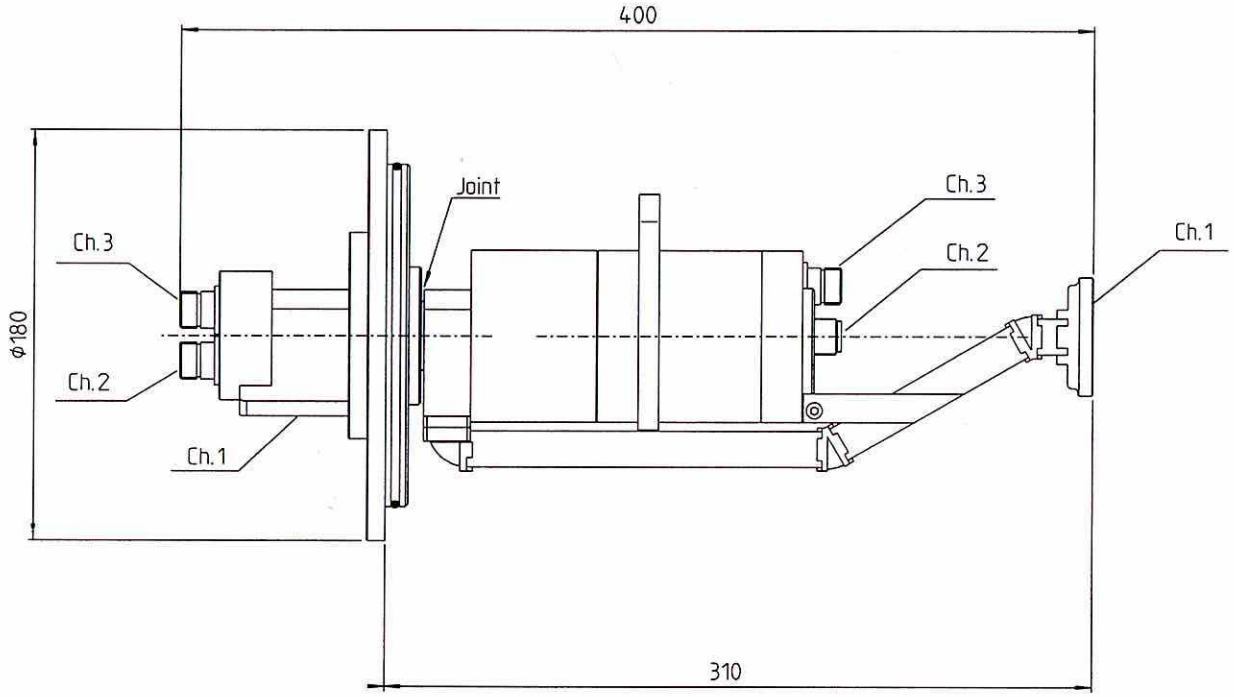
Waveguide/Coaxial, Three Channel

Application: Surveillance
Primary radar: Waveguide channel.
Secondary radar: Two SSR/IFF channels

Model		SL6891H	
Channel		1	2&3
Connector Type		WR112	N
Frequency	(GHz)	8.5-9.6	1.0-1.1
VSWR		1.2	1.3
Insertion Loss	(dB)	0.3	0.5
Peak Power	(kW)	250	10
Avg Power	(kW)	0.5	0.05



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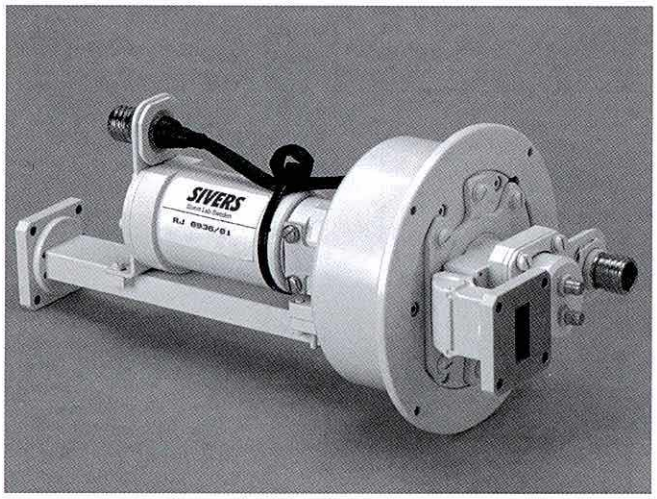
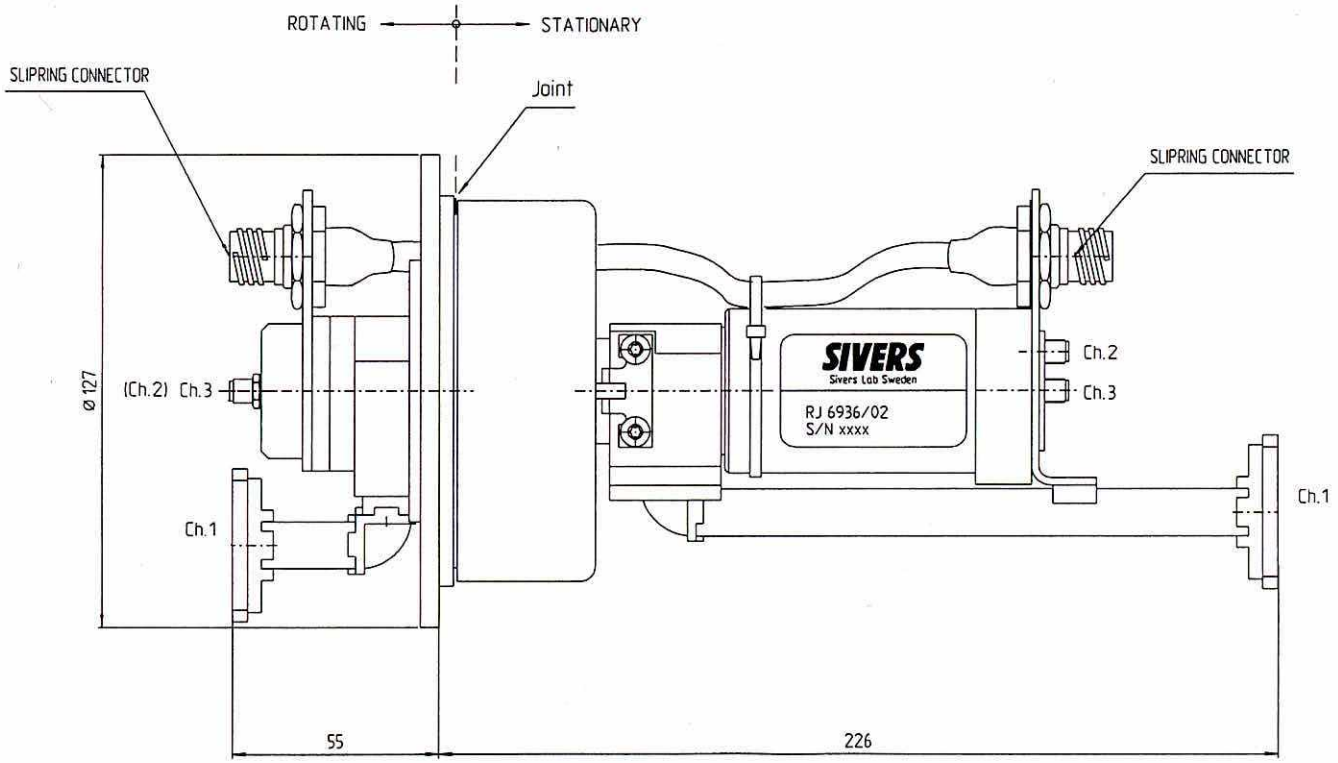
Waveguide/Coaxial, Three Channel

Application: Surveillance
Primary radar: Waveguide channel.
Secondary radar: Two SSR/IFF channels
Six slip-ring channels

Model		RJ6936		
Channel		1	2&3	Slip-rings
Connector Type		WR90	SMA	
Frequency	(GHz)	9.0-9.5	1.0-1.1	
VSWR		1.2	1.3	
Insertion Loss	(dB)	0.3	0.6	
Peak Power	(kW)	100	1	
Avg Power	(kW)	0.5	0.05	





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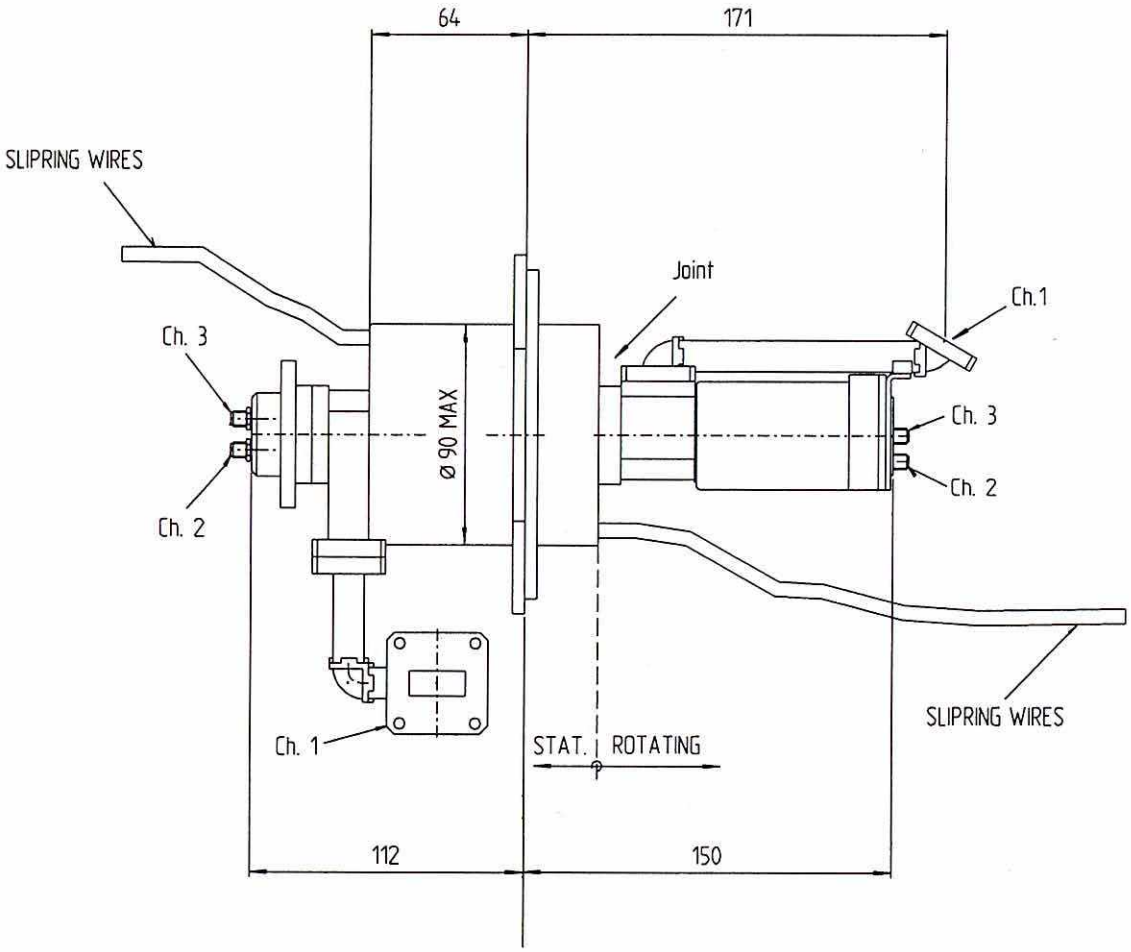
Waveguide/Coaxial, Three Channel

Application: Surveillance
Primary radar: Waveguide channel.
Secondary radar: Two SSR/IFF channels
33 slip-ring channels

Model	RJ6943		
Channel	1	2&3	Slip-rings
Connector Type	WR90	SMA	
Frequency (GHz)	9-9.5	1.0-1.1	
VSWR	1.2	1.3	
Insertion Loss (dB)	0.3	0.5	
Peak Power (kW)	100	2	
Avg Power (kW)	0.5	0.05	
Isol. between ch.(dB)	55		



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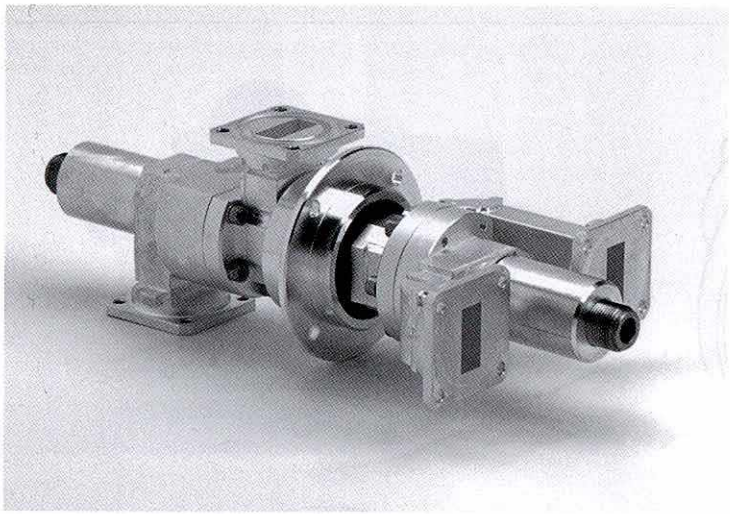
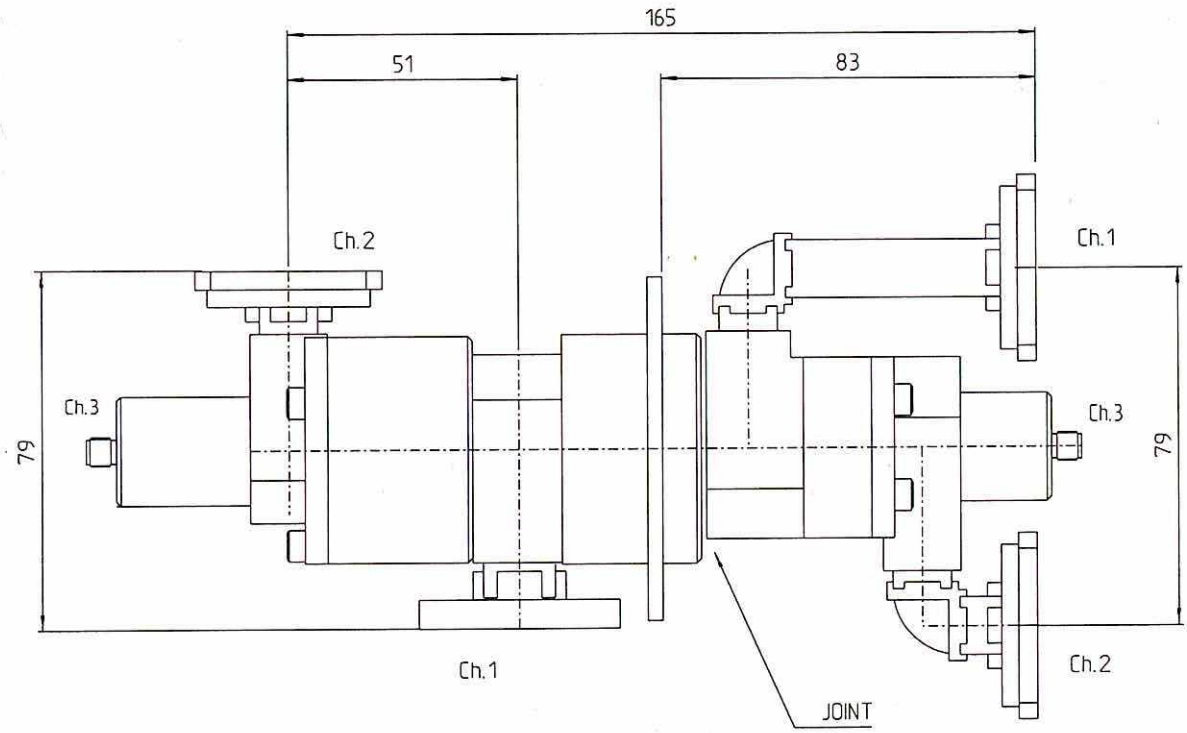
Waveguide/Coaxial, Three Channel

Material: Brass

Model		RJ6929		
Channel		1	2	3
Connector Type		WR90	WR90	SMA
Frequency	(GHz)	8.5-9.6	8.5-9.6	DC-12
VSWR		1.2	1.4	1.5
Insertion Loss	(dB)	0.2	0.5	0.8
Peak Power	(kW)	100	20	5
Avg Power	(kW)	0.5	0.05	0.05
Isol. between ch.	(dB)	60		





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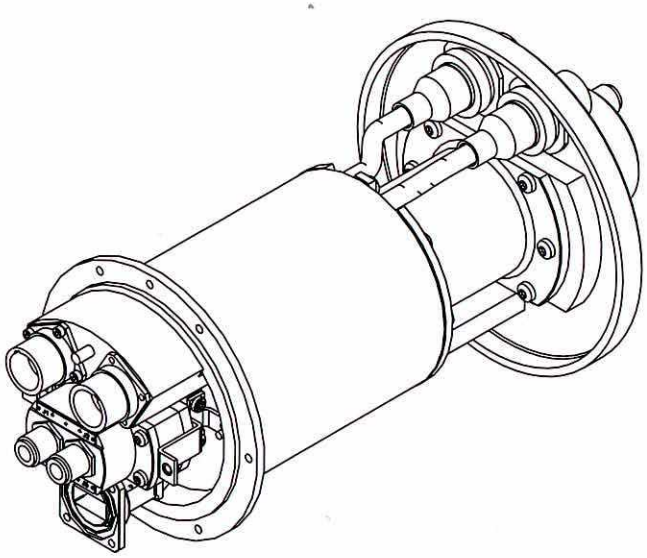
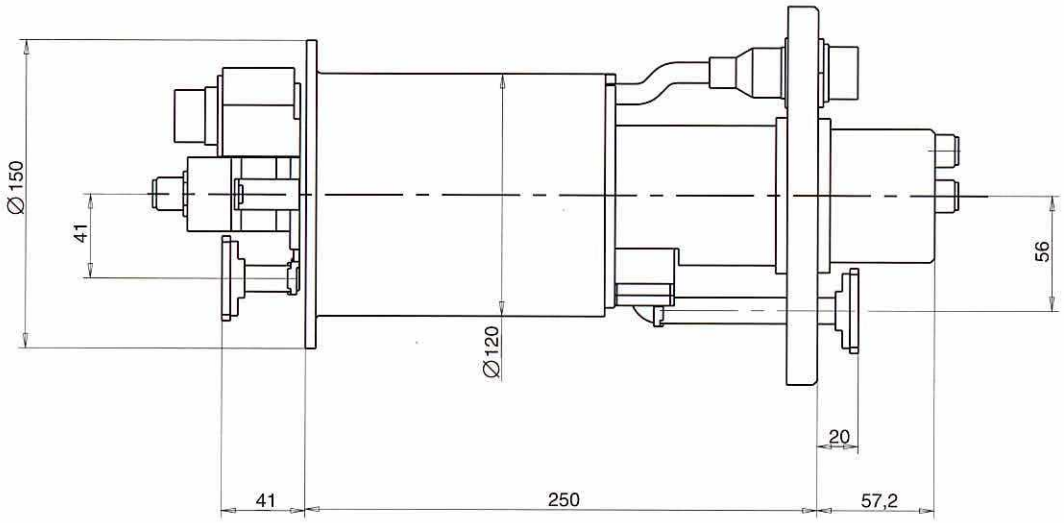
Waveguide/Coaxial, Three Channel

Application: Surveillance radar. Marine environment
Primary radar: Waveguide channel.
Secondary radar: Two SSR/IFF channels
35 slip-ring channels

Model		RJ6948			
Channel		1	2	3	Slip-rings
Connector Type		WR90	SMA	SMA	
Frequency	(GHz)	8.5-9.5	1.0-1.1	1.0-1.1	
VSWR		1.3	1.3	1.4	
Insertion Loss	(dB)	0.3	0.6	0.6	
Peak Power	(kW)	100	5	5	
Avg Power	(kW)	0.5	0.2	0.2	





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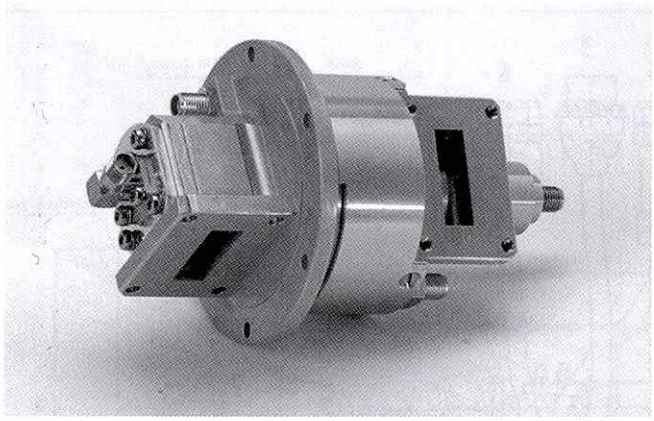
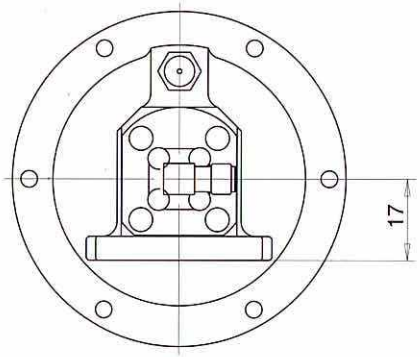
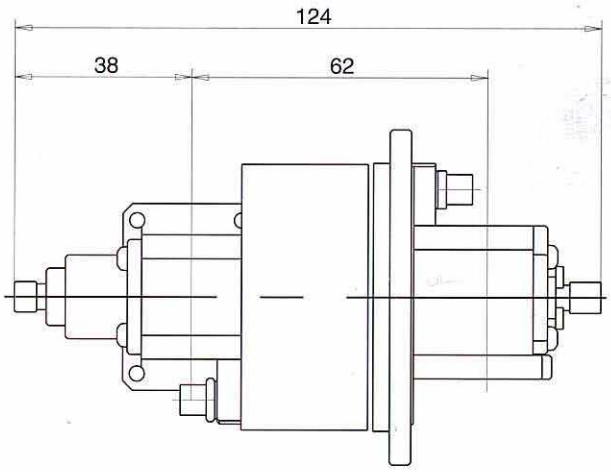
Waveguide/Coaxial, Three Channel

Application: Air borne.
Limited rotation angle.

Model		RJ6974		
Channel		1	2	3
Connector Type		WR90	SMA	SMA
Frequency	(GHz)	9.7-10.5	9.7-10.5	9.7-10.5
VSWR		1.2	1.3	1.3
Insertion Loss	(dB)	0.2	0.5	3
Peak Power	(kW)	100	1	1
Avg Power	(kW)	1.5	0.05	0.05
Isol. between ch.	(dB)	70		







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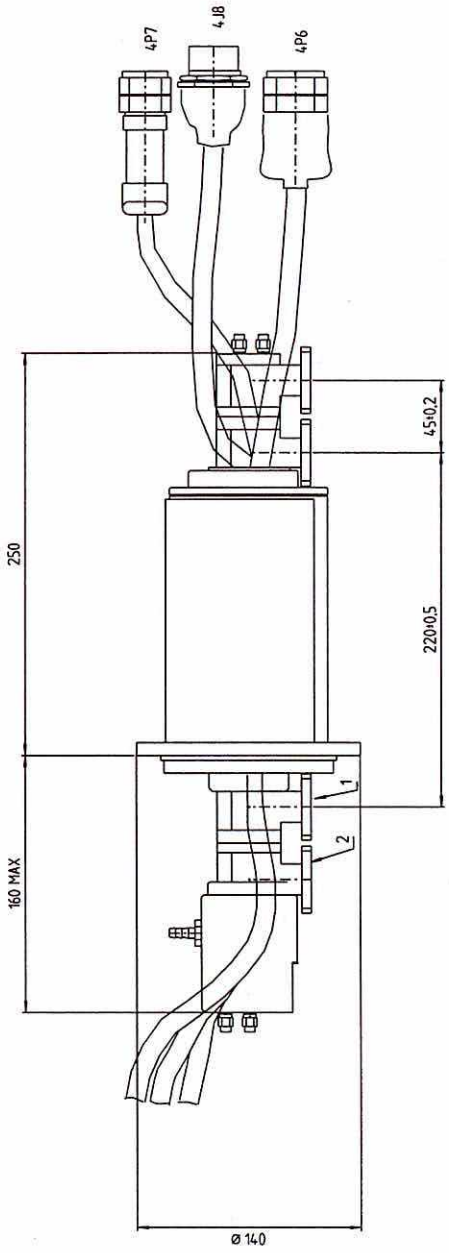
Waveguide/Coaxial, Four Channel

Application: Air borne. Helicopter.
Two waveguide channels and two coaxial channels.
Air cooled.
55 slip-ring channels

Model	RJ6910		
Channel	1&2	3&4	Slip-rings
Connector Type	WR90	SMA	
Frequency (GHz)	9.4-10	9.4-10	
VSWR	1.3	1.5	
Insertion Loss (dB)	0.5	3	
Peak Power (kW)	20	1	
Avg Power (kW)	0.5	0.02	
Isol. between ch.(dB)	50		



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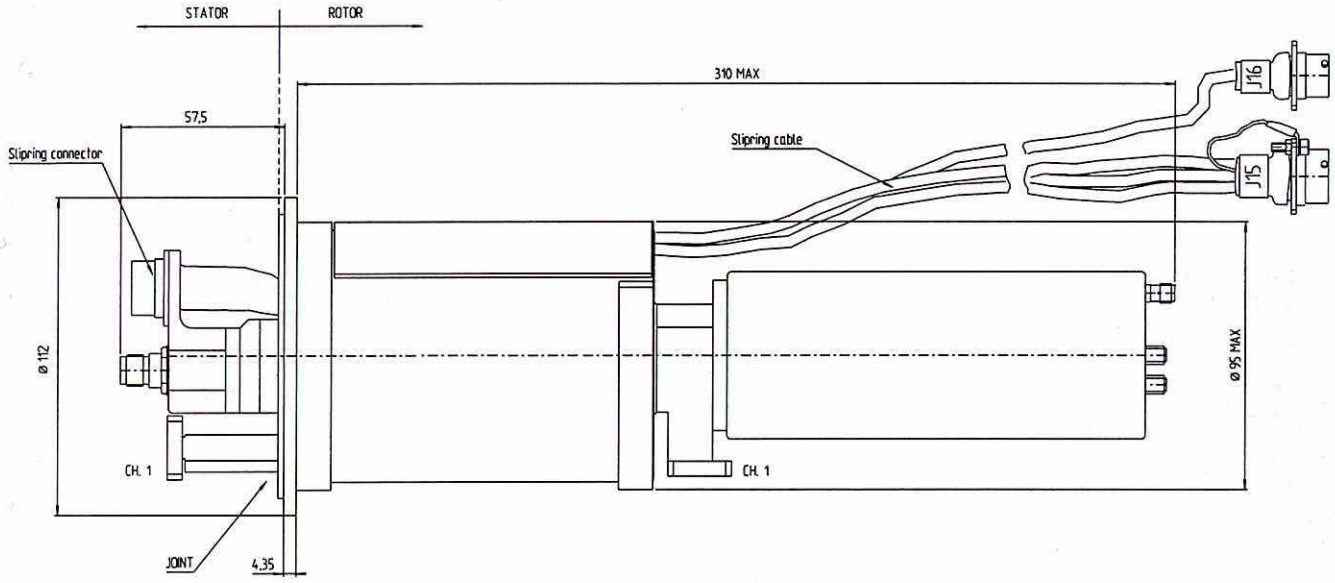
Waveguide/Coaxial, Four Channel

Application: Air borne
Waveguide and coaxial X-band channels
Two coaxial SSR/IFF channels.
26 slip-ring channels

Model		RJ6900			
Channel		1	2	3&4	Slip-rings
Connector Type		WR90	SMA/TNC	SMA/TNC	
Frequency	(GHz)	8.7-9.4	8.7-9.4	1.0-1.1	
VSWR		1.2	1.5	1.4	
Insertion Loss	(dB)	0.2	1.2	0.6	
Peak Power	(kW)	20	2	2	
Avg Power	(kW)	0.3	0.05	0.05	
Isol. between ch.	(dB)		50		



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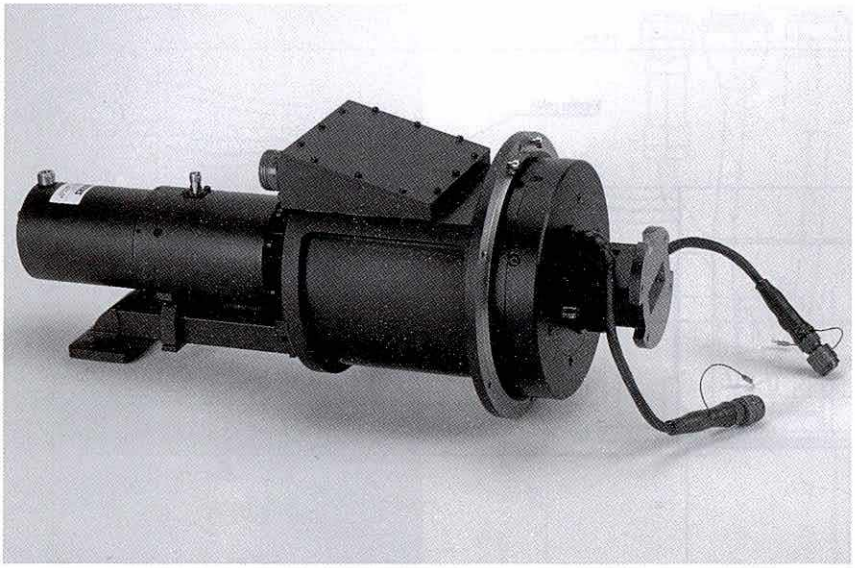
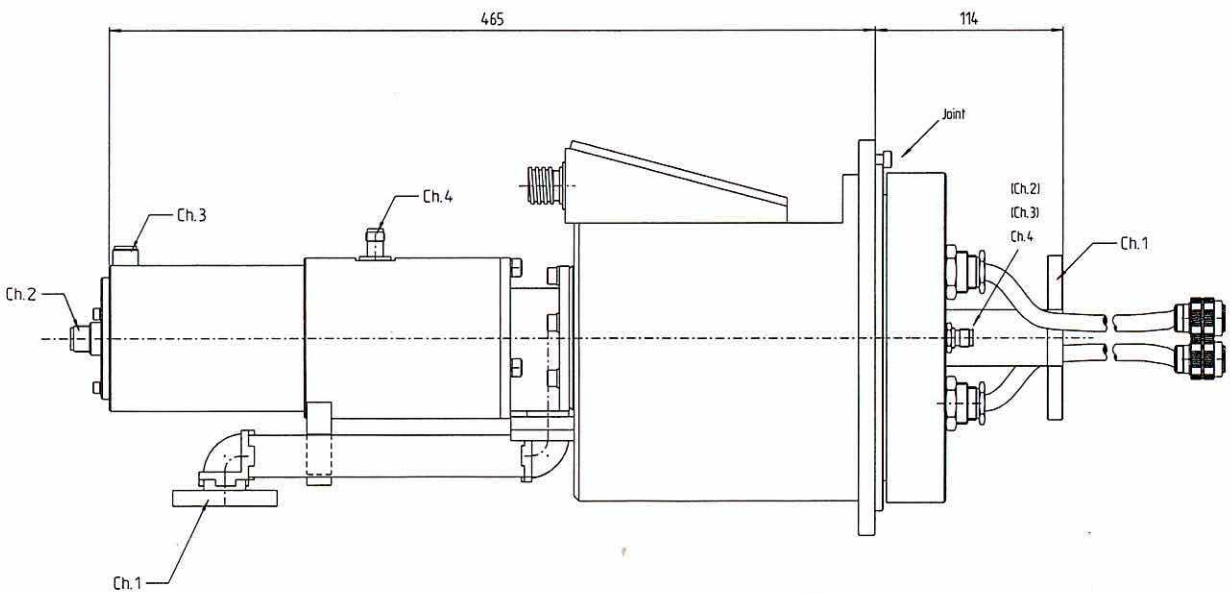
Waveguide/Coaxial, Four Channel

Application: Surveillance radar. Ground mobile.
Waveguide channel
Two coaxial SSR/IFF channels
Low frequency channel.
35 slip-ring channels

Model		RJ6945			
Channel		1	2&3	4	Slip-rings
Connector Type		WR187	N / SMA	TNC	
Frequency	(GHz)	5.4-5.9	1.0-1.1	DC-1	
VSWR		1.2	1.3	1.3	
Insertion Loss	(dB)	0.3	0.6	0.5	
Peak Power	(kW)	200	5	1	
Avg Power	(kW)	1	0.05	0.2	
Isol. between ch.	(dB)	50			





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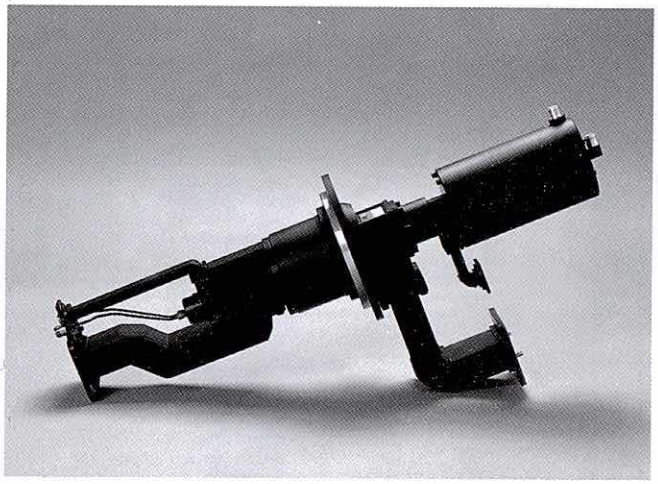
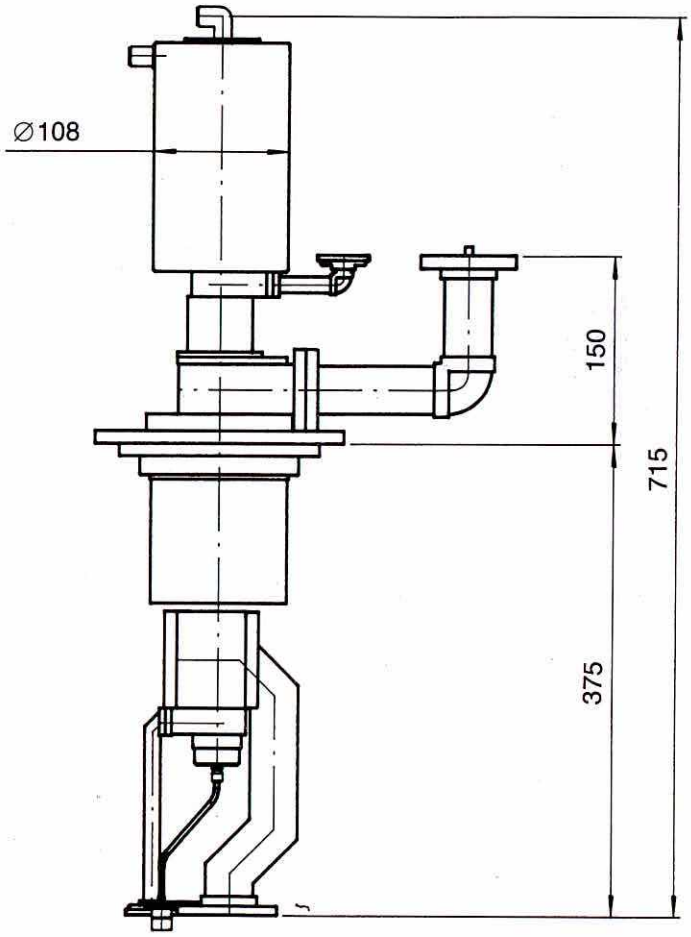
Waveguide/Coaxial, Four Channel

Application: Marine surveillance radar.

Model		SL6888S		
Channel		1	2	3&4
Connector Type		WR284	WR90	N
Frequency	(GHz)	3.0-3.1	9.3-9.5	1.0-1.1
VSWR		1.15	1.15	1.3
Insertion Loss	(dB)	0.15	0.3	0.6
Peak Power	(kW)	500	100	5
Avg Power	(kW)	0.5	0.12	0.04
Isol. between ch.	(dB)	60		





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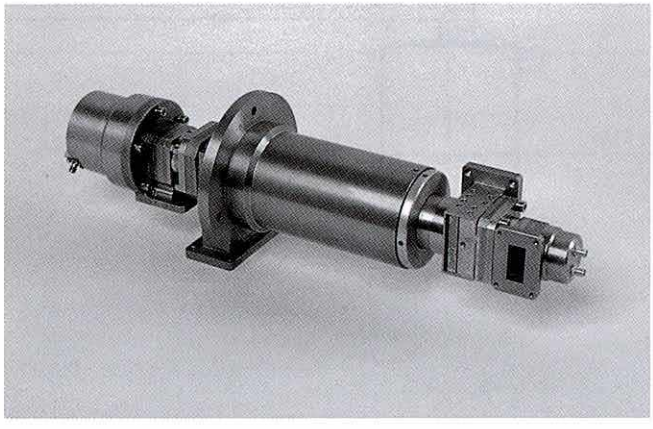
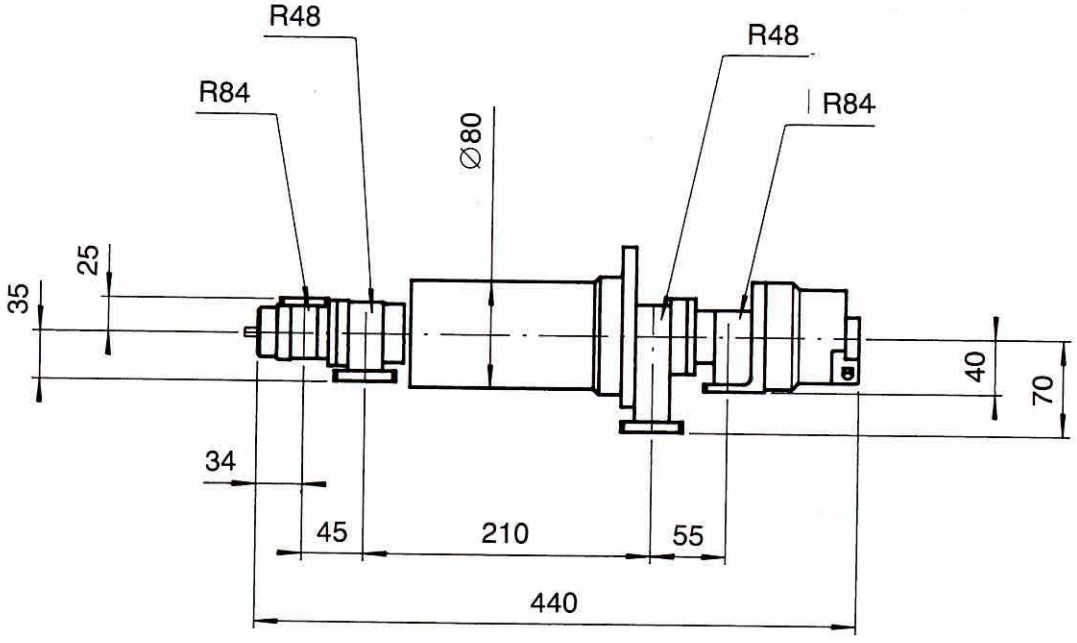
Waveguide/Coaxial, Four Channel

Application: Marine surveillance radar.

Model		PM7851G		
Channel		1	2	3&4
Connector Type		WR187	WR112	N
Frequency	(GHz)	5.4-5.9	8.5-9.6	1.0-1.9
VSWR		1.25	1.35	1.35
Insertion Loss	(dB)	0.35	0.5	0.9
Peak Power	(kW)	250	150	2
Avg Power	(kW)	2	0.2	0.05
Isol. between ch.	(dB)	50		





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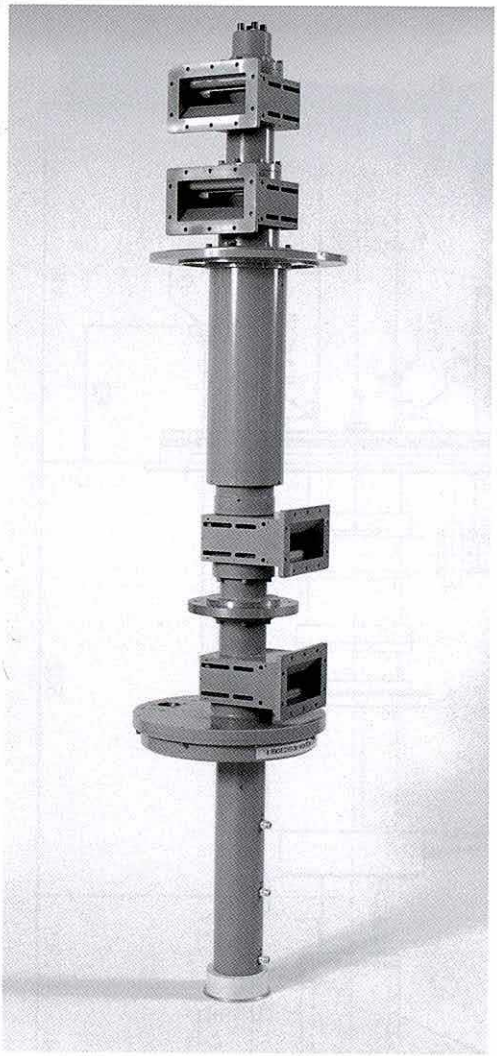
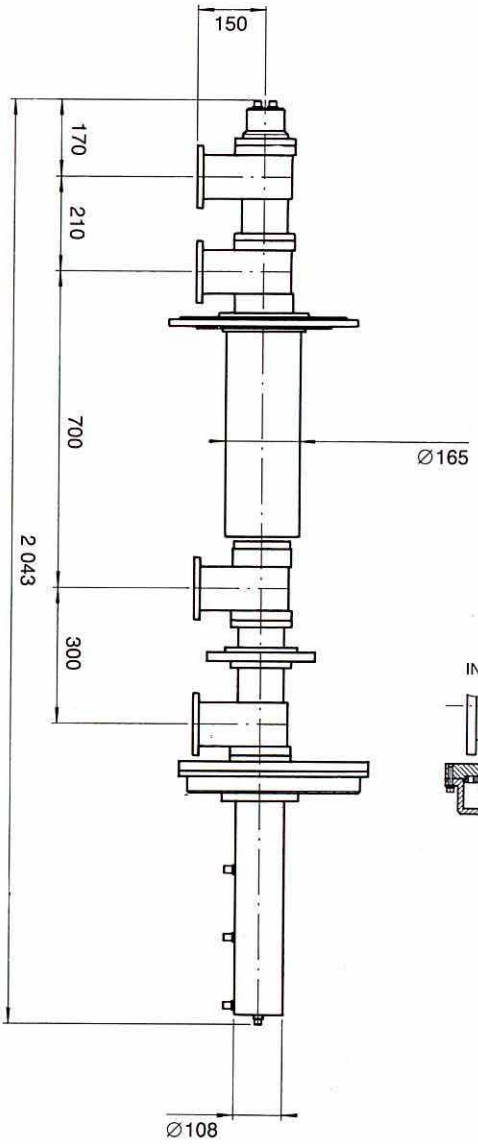
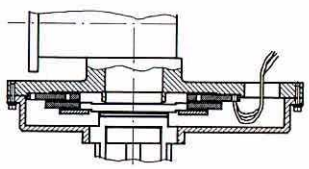
Waveguide/Coaxial, Multi Channel

Application: Air traffic control (ATC)
Primary radar: Two Waveguide channels
Weather radar: Coaxial channel
Secondary radar: Three coaxial MSSR, S-mode channels.
Azimuth position indication via inductive Encoder

Model		SL6768L				
Channel		1	2	3,4,5	6	Encoder
Connector Type		WR650	WR650	N	N	
Frequency	(GHz)	1.25-1.35	1.25-1.35	1.0-1.1	1.25-1.35	
VSWR		1.2	1.2	1.3	1.3	
Insertion Loss	(dB)	0.3	0.3	1.1	1	
Peak Power	(kW)	6000	250	10	10	
Avg Power	(kW)	12	3	0.1/0.4	0.02	
Isol. between ch.	(dB)	50				







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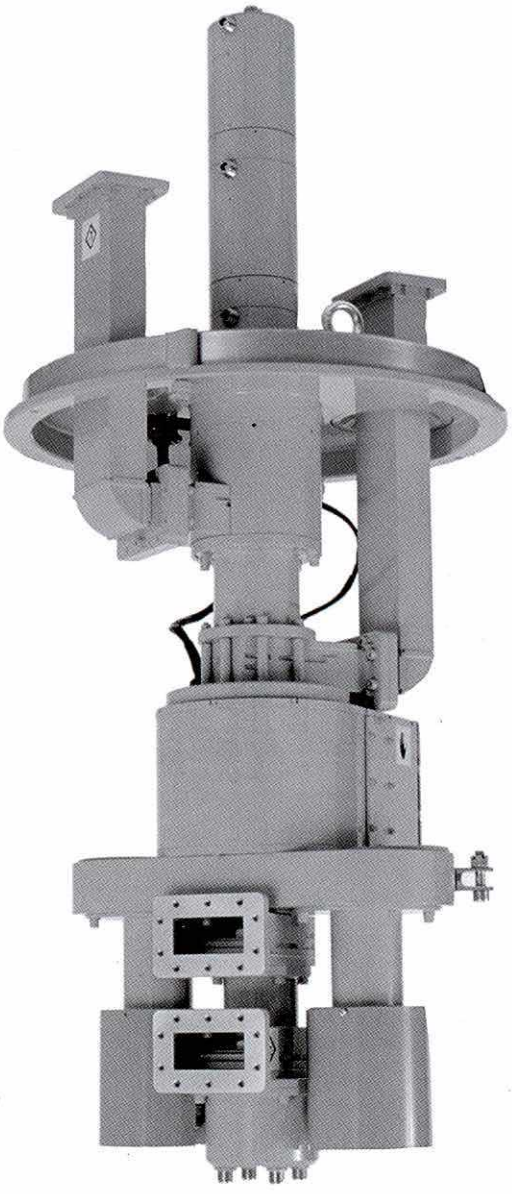
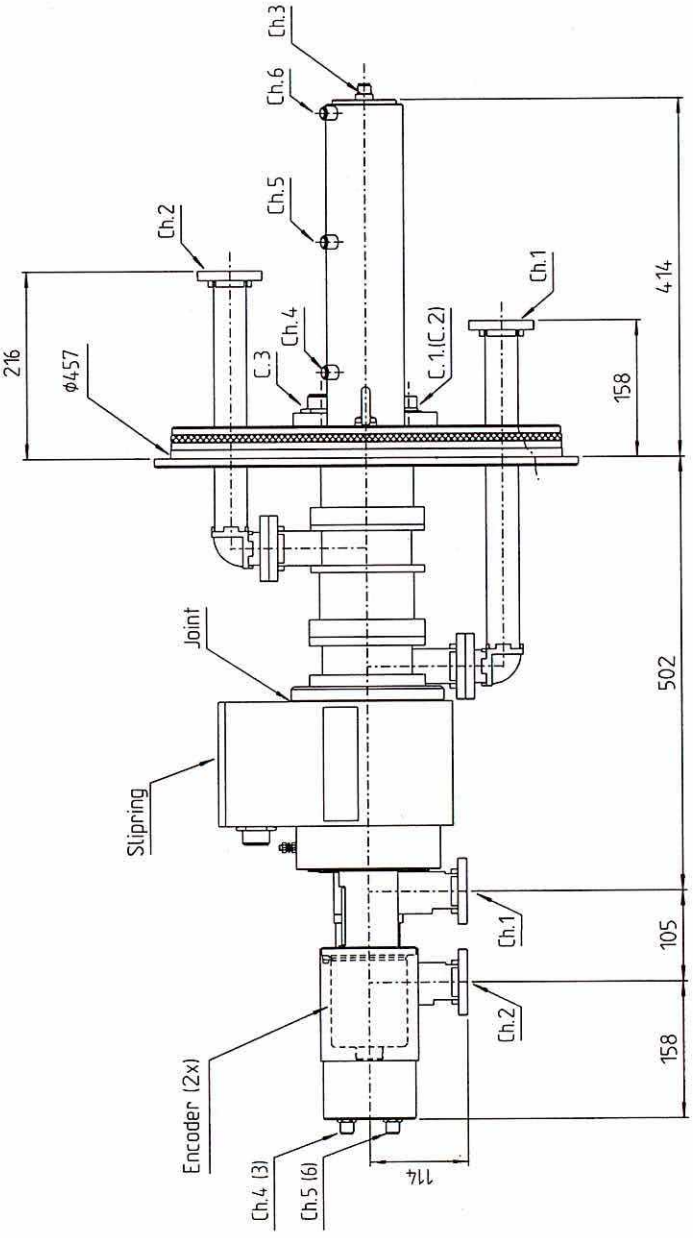
Waveguide/Coaxial, Multi Channel

Application: Air Traffic Control (ATC).
Primary Radar:. Waveguide channels for low beam and high beam at 2.7-2.9 GHz
Weather Radar: Coaxial channel, 2.7-2.9 GHz.
Secondary Radar: Three coaxial channels for MSSR S-mode, 1.0-1.1 GHz.
14-bit Azimuth pulse generation via two parallel optical Encoders.
28 Slip-ring channels for DC/AC power and data communication.

Model		RJ6940					
Channel		1	2	6	3,4,5	Encoders	Slip-rings
Connector Type		WR284	WR284	N	N		
Frequency	(GHz)	2.7-2.9	2.7-2.9	2.7-2.9	1.0-1.1		
VSWR		1.2	1.3	1.3	1.3		
Insertion Loss	(dB)	0.15	0.3	0.65	0.95		
Peak Power	(kW)	200	5	5	5		
Avg Power	(kW)	5	0.4	0.4	0.1/0.4		
Isol. between ch.	(dB)	60					





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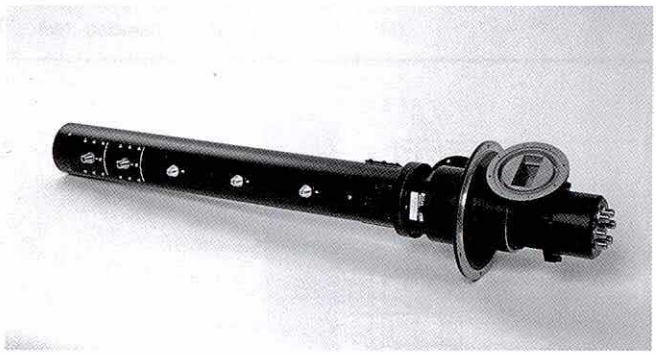
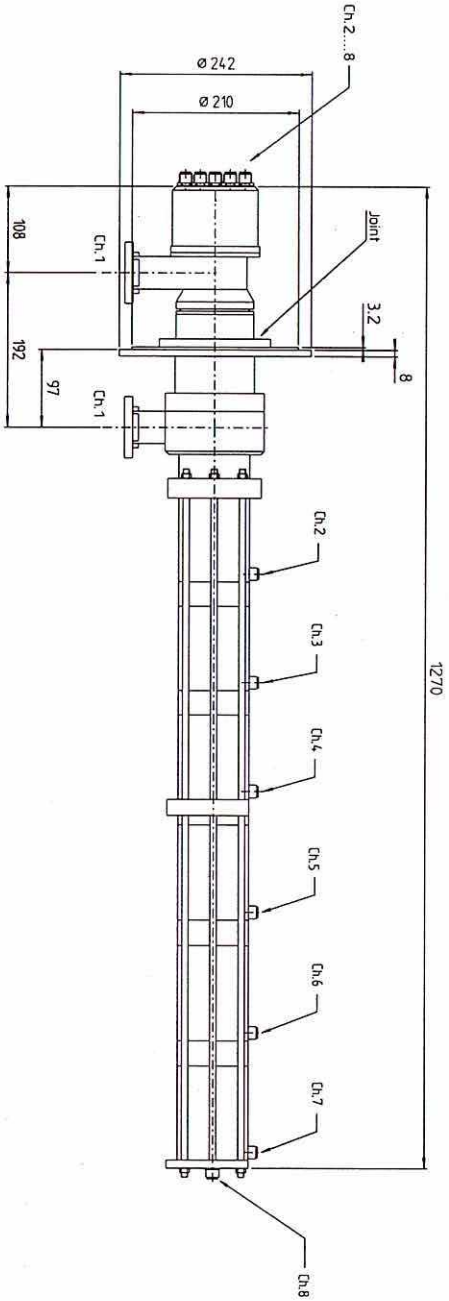
Waveguide/Coaxial, Multi Channel

Application: Air Traffic Control (ATC).
Primary Radar: Waveguide channel and four Coaxial channels, 2.7-3.0 GHz.
Secondary Radar: Three coaxial channels for MSSR, S-mode, 1.0-1.1 GHz.

Model		RJ6934			
Channel		1	2,3,4	5,6,7	8
Connector Type		WR284	N	N	N
Frequency	(GHz)	2.7-3.0	2.7-3.0	1.0-1.1	2.7-3.0
VSWR		1.2	1.3	1.3	1.3
Insertion Loss	(dB)	0.2	0.7	0.75	1
Peak Power	(kW)	200	5	10	10
Avg Power	(kW)	5	0.05	0.1/0.4	0.05
Isol. between ch.	(dB)	50			





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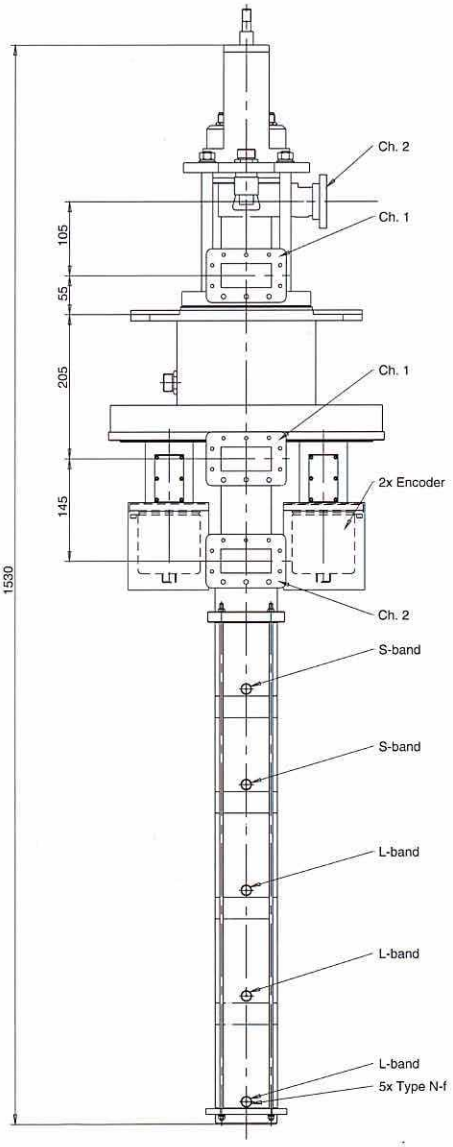
Waveguide/Coaxial, Multi Channel

Application: Air Traffic Control (ATC).
Primary Radar: Waveguide channels for low beam and high beam at 2.7-2.9 GHz
Weather Radar: Coaxial channels, 2.7-2.9 GHz.
Secondary Radar: Three coaxial channels for MSSR, S-mode, 1.0-1.1 GHz.
14-bit Azimuth pulse generation via two parallel optical Encoders.
12 Slip-ring channels for DC power.

Model		RJ6926					
Channel		1	2	3,4	5,6,7	Encoders	Slip-rings
Connector Type		WR284	N	N	N		
Frequency	(GHz)	2.7-2.9	2.7-2.9	2.7-2.9	1.0-1.1		
VSWR		1.2	1.2	1.2	1.2		
Insertion Loss	(dB)	0.2	0.5	0.8	0.75		
Peak Power	(kW)	200	5	5	10		
Avg Power	(kW)	3	0.05	0.05	0.1		
Isol. between ch.	(dB)	50					



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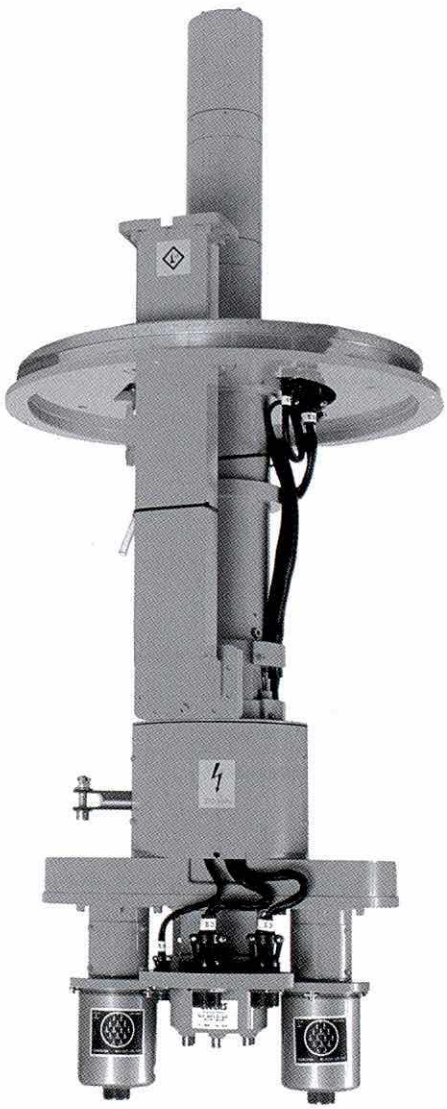
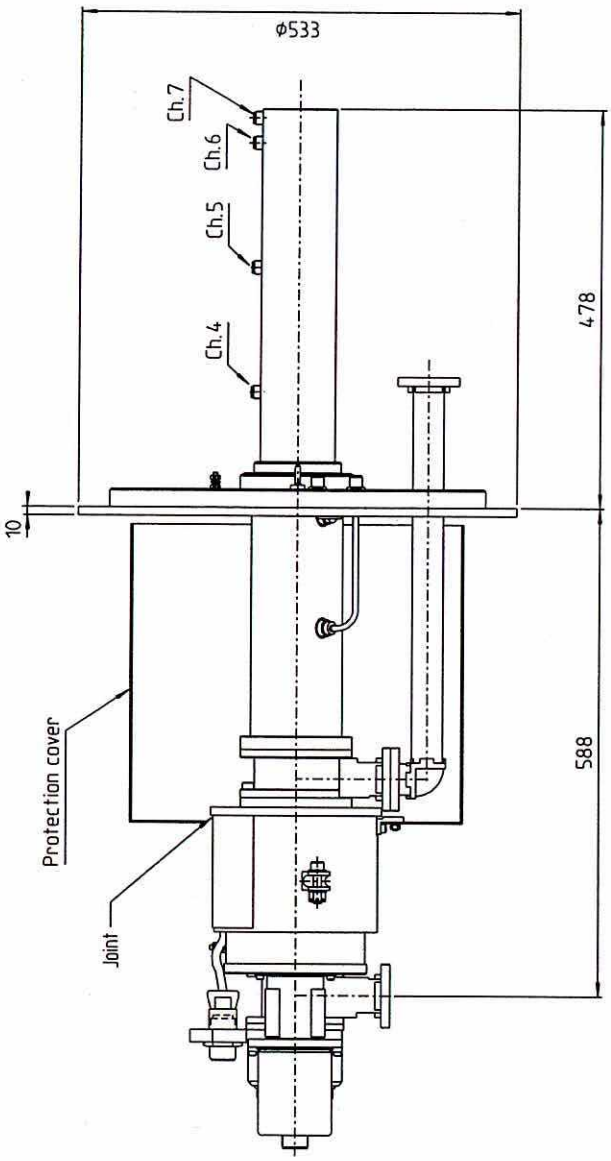
Waveguide/Coaxial, Multi Channel

Application: Air Traffic Control (ATC).
Primary Radar: Waveguide and Coaxial channels for low beam and high beam at 2.7-2.9 GHz
Weather Radar: Coaxial channel , 2.7-2.9 GHz.
Secondary Radar: Three coaxial channels for MSSR, S-mode, 1.0-1.1 GHz.
14-bit Azimuth pulse generation via two parallel optical Encoders.
26 Slip-ring channels for DC/AC power and data communication.

Model	RJ6914				
Channel	1	2,3	3,4,5	Encoders	Slip-rings
Connector Type	WR284	N	N		
Frequency (GHz)	2.7-2.9	2.7-2.9	1.0-1.1		
VSWR	1.2	1.3	1.3		
Insertion Loss (dB)	0.15	0.65	0.95		
Peak Power (kW)	200	5	5		
Avg Power (kW)	5	0.4	0.1/0.4		
Isol. between ch.(dB)	60				





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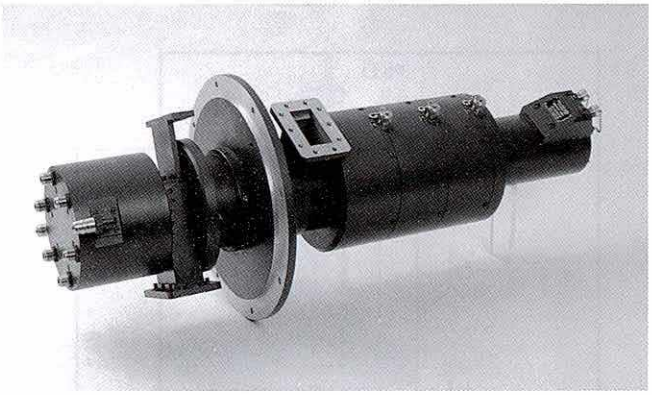
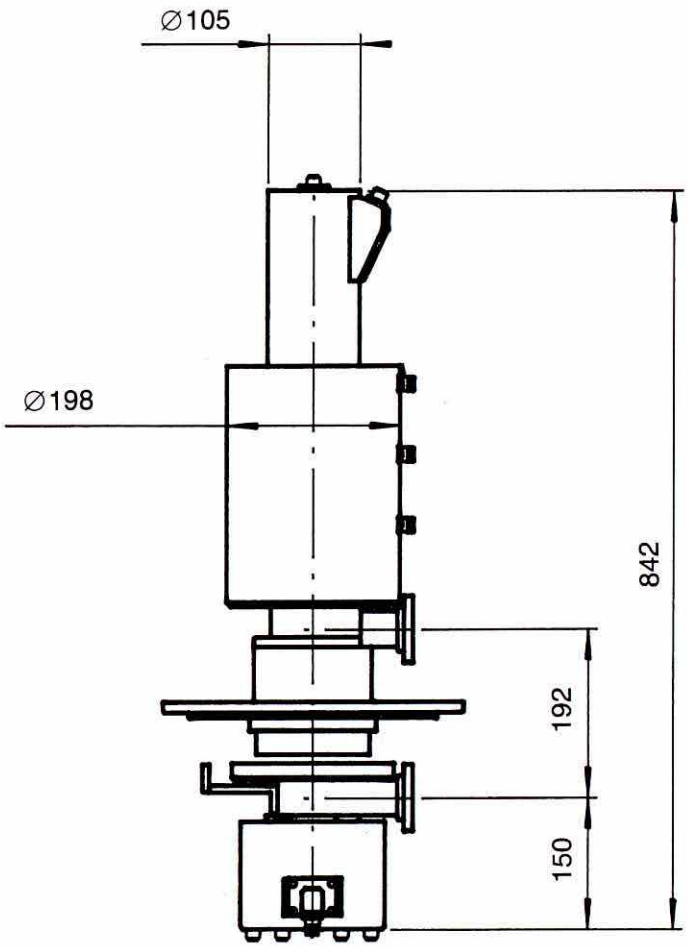
Waveguide/Coaxial, Multi Channel

Application: Surveillance radar.
Extra high average power requirements are met by cooling with heat pipes.
Primary Radar:. Waveguide channel and three coaxial channels at 3.1-3.6 GHz.
Secondary Radar: Three coaxial channels for MSSR, S-mode, 1.0-1.1 GHz.

Model		SL6820S			
Channel		1	2	3&4	5,6&7
Connector Type		WR284	N	N	N
Frequency	(GHz)	3.1-3.6	3.1-3.6	3.1-3.6	1.0-1.1
VSWR		1.2	1.3	1.4	1.2
Insertion Loss	(dB)	0.2	1	1.1	0.9
Peak Power	(kW)	500	5	5	10
Avg. Power	(kW)	18	0.2	0.01	0.1/0.4
Isol. between ch.		(dB)		60	





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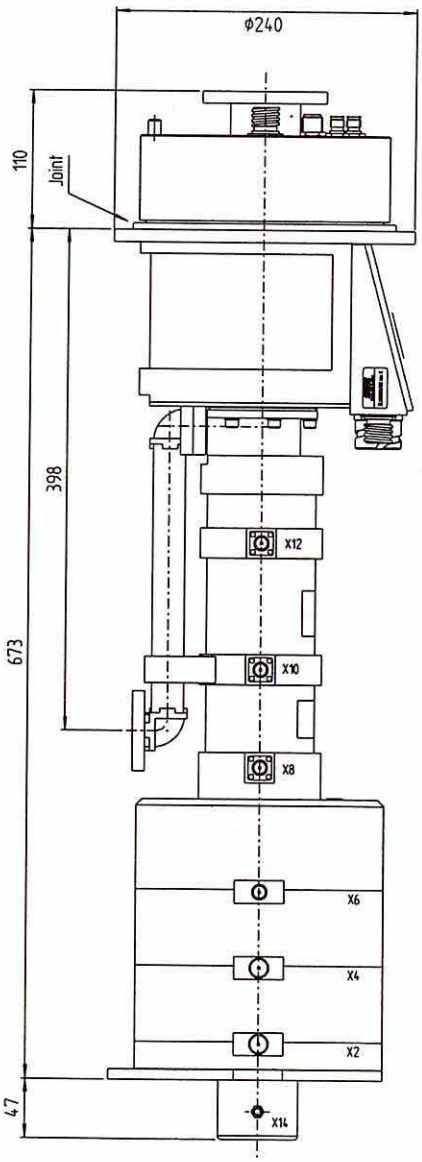
Waveguide/Coaxial, Multi Channel

Application: Surveillance radar. Ground mobile.
Waveguide channel.
Three Coaxial channels
Three Coaxial channels for SSR/IFF.
Optical channel.
17 Slip-ring channels for DC/AC power and data communication.

Model	RJ6920					
Channel	1	2,3,4	5,6	7	8	Slip-rings
Connector Type	WR187	N	N	N	Optical	
Frequency (GHz)	5.4-5.9	1.0-1.1	5.4-5.9	DC-1	800-1600 nm	
VSWR	1.2	1.3	1.3	1.3		
Insertion Loss (dB)	0.3	0.8	1.4	0.5		
Peak Power (kW)	200	5	5	1		
Avg Power (kW)	3	0.05	0.05	0.01		
Isol. between ch.(dB)	50					



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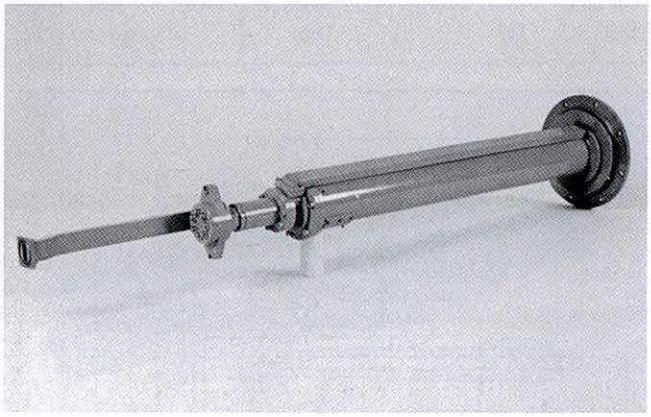
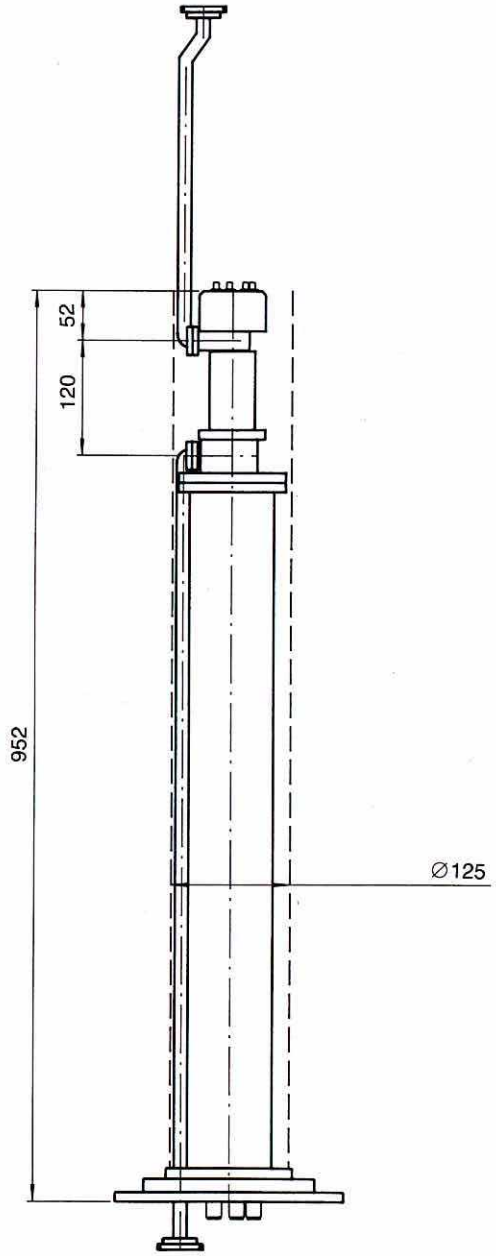
Waveguide/Coaxial, Multi Channel

Application: Surveillance and tracking radar

Model		PM7850H			
Channel		1	Ch 2&6	Ch 3,4,5&7	Ch 8
Connector Type		WR90	N/SMA	N/SMA	N/SMA
Frequency	(GHz)	8.5-9.6	X-band	L-band	DC-10
VSWR		1.2	2	1.5	1.7
Insertion Loss	(dB)	0.5	2.9	1.5	2.9
Peak Power	(kW)	250	1	1	1
Avg Power	(kW)	0.5	0.01	0.01	0.01
Isol. between ch.	(dB)	50			





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Swivel Joints

This is a joint for applications where full rotation is not required. The swivel is compact, with a low mechanical torque, and high peak power capacity.

Model		PM7380S	PM7380H	PM7380X	PM7380P	PM7380DX	PM7380DP
Waveguide		WR284	WR112	WR90	WR62	WRD475	WRD750
Flange		UAR32	UBR84	UBR100	UBR140	39000/3-038	39000/3-072
Frequency	(GHz)	2.7-3.5	7.05-10	8.2-12.4	12.4-18	4.75-11	7.5-18
VSWR		1.15	1.15	1.15	1.15	1.35	1.35
Insertion Loss	(dB)	0.15	0.3	0.35	0.35	0.75	0.75
Peak power	(kW)	2000	200	150	60	20	10
Av. Power	(kW)	5	0.5	1	0.5	0.75	0.75
Start. Torque	(Nm)	10	0.7	0.4	0.3	0.7	0.4
Dimensions: A	(mm)	155	70	52	35	76	50
B	(mm)	163	76	60	50	81	55
Weight	(kg)	7.2	1.0	0.38	0.25	1.1	0.35

Rotation: ± 60° (± 90° mechanically)

Flanges: Conforms to MIL-F-3922/53 or IEC 154, type B for rectangular waveguide.
USA MIL-39000/3, for double ridge waveguide.

Power: The power capacity of rotary joints is given for +25°C, 1 ATA, 2ms pulse width, 500 Hz repetition rate and matched load.

Material: Aluminium

Finish: Chromate per MIL-C-5541C and black paint.

Pressurizaton: 0.2 MPa diff (2 ATO)

Leakage: max 25 cc/min at 0.2 MPa diff.

Temperature range: -40°C to +85°C operating. -70°C to +125°C storage.

Life: min $15*10^6$ cycles garantees.

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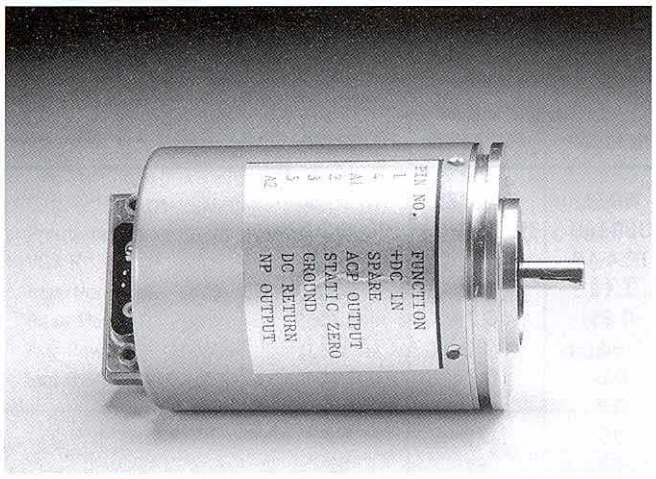
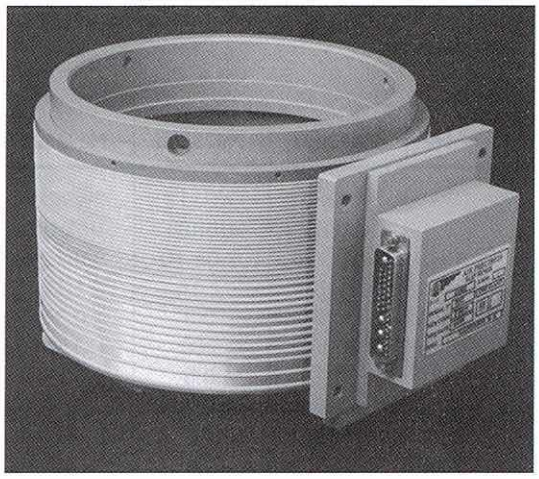


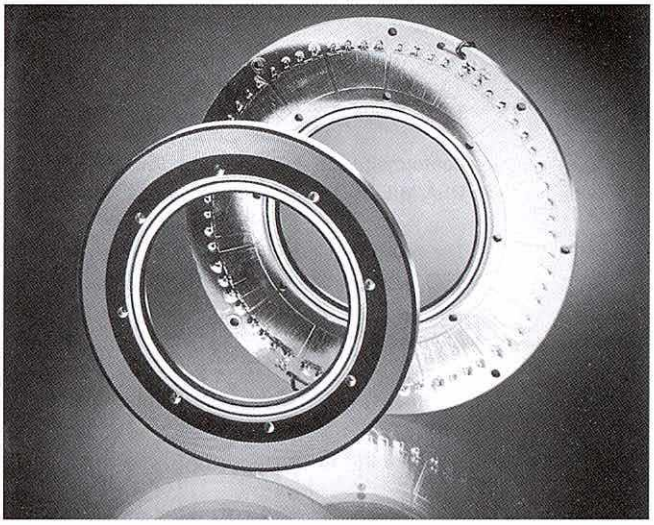


SLIP-RINGS and ENCODERS

SLIP-RINGS

The turntable of a radar antenna is used not only for microwave transmission but often also for various transmission and control demands, e.g. antenna alignment. Sivers Lab works closely with leading slip-ring manufacturers and thus can offer complete packages with built-in to sliprings. The slipring package can be from a few rings built-in to the rotary joint to multi-slip-rings outside the joint. Common to all solutions is that the dimensions of the turntable may be reduced and that the electrical and microwave transmission of the turntable is integrated into one package. Another advantage is that when integrating the complete electrical/microwave-transmission into one package a reconstruction of the turntable is not always necessary when the whole system is to be refurbished.

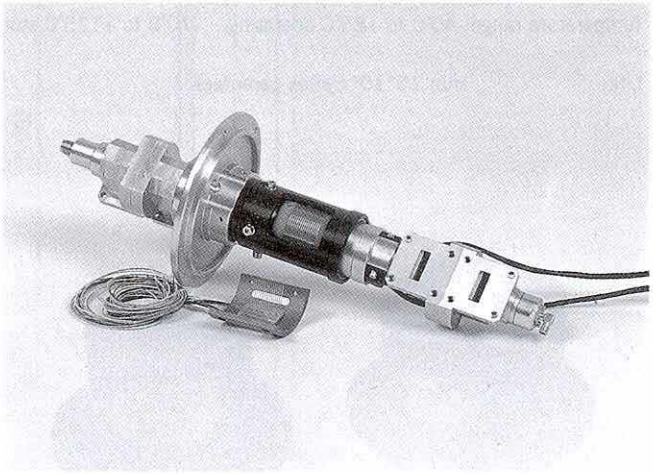
The slipring can be conventional DC or AC rings for high currents or shielded high frequency rings for frequencies up to 300MHz.



ENCODERS

Encoders can also be integrated into the Rotary Joint assembly.

Optical encoders are driven via gearwheels and *Inductive* encoders have a wide hollow shaft and can be *Fitted* directly to the Rotary Joint shaft giving *Highest* accuracy. Typical encoder resolutions are 12 – 14 bits.



WAVEGUIDE SWITCHES

TECHNICAL DESCRIPTION

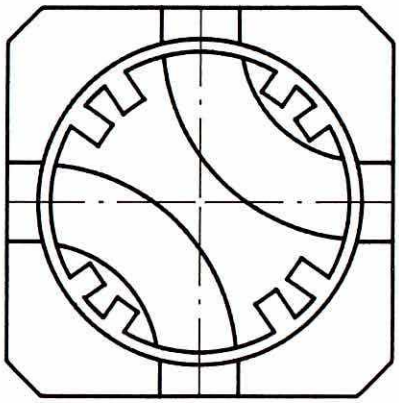
PRODUCTS

COAXIAL SWITCHES

TECHNICAL DESCRIPTION

PRODUCTS

Technical description



General

This section describes the design of standard manual and automatic waveguide switches. Switches are available in frequencies ranging from 2.7 to 40 GHz. For particular applications special types of switches can be designed.

Waveguide switches are widely used in microwave systems.

- In radars for redundancy transmitters.
- In radars for connection to high power dummy load.
- In radars for test purposes.
- In satellite communications for redundancy applications.
- In test systems to select various signal paths etc.

Common to all mechanical waveguide switches are:

- High isolation.
- Low insertion loss.
- High power capability.
- Long life.

General design

The switches have a square stator with four waveguide ports. The rotor, which is fitted in the stator, has two or three channels. Electrical continuity between rotor and stator is achieved by means of quarter wave chokes. These chokes give extremely high isolation between the channels and also ensure unchanged high electrical performance throughout the lifetime of the switch.

All models have low VSWR and high power handling capacity. They withstand the full power rating of the waveguide and most models can be pressurised to 0.2 MPa (2 ATO) for high peak power applications.

All switches have E-plane bends for small dimensions.

The switches are made of copper-free aluminium alloy, which is chromated. The rotor is supported by stainless steel ball bearings.

The flange connections are, for most models, standard flat flanges with threaded holes. Special flange drilling and/or helical steel inserts are available on request.

The stator dimensions for the different models are defined in the tables on the following pages.

Switches are available with:

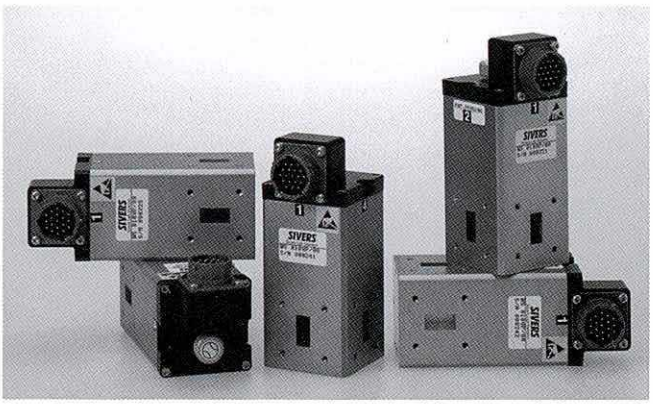
- standard rectangular waveguides
- double-ridge waveguides

Configuration

All switches have a square stator with four ports. The rotor has two channels.

Four ports—two channels (transfer)

Position 1 Position 2



Technical description/Definitions

Actuators

Manual and automatic (electromagnetic) actuators are available.

The automatic types are fail-safe or latching. The fail-safe type returns to the de-energized position when the power is disconnected and requires a small holding current in the energized position. The latching type is stabile in both positions without holding current.

In applications like safety-circuits, where it is required that the switch returns to its original position, if power supply fails, a fail-safe type is the natural choice. In other applications it might be an advantage to have low power consumption and no holding current.

Several models of automatic actuators are available for switches in the frequency range 4 to 40 GHz. All standard models operate at 28 Volts and have a maximum switch current of 1 Ampere and a maximum holding current of 0.3 Ampere.

For all latching models the current is automatically switched off when the rotor is in position and in fail-safe models the current is automatically reduced to holding current when the rotor is in position.

One or several sets of position indicators are available with all models of actuators.

Some models can be supplied with manual override (knob for manual setting of position).

- **Standard model.** Type number **80--**.
  Theses model has the smallest dimensions. It has one set of position indicators and the electrical connection is via soldering pins or circular MIL- connector. Switch time is 100 to 250 ms (depending on frequency band). The models are in most cases specified for full temperature range.

- **SatCom model.** Type number **81--**.
  This model can be supplied with up to 4 sets of position indicators. One set of indicators can be arranged to have "inhibit" function, which is a closed contact at end positions and an open contact during transition. The actuator has manual override and cannot be pressurised. Switch time is 100 to 150 ms. The electrical connection is via a circular MIL- connector.

- **Special model.** Type number **82--**.
  These models are custom designs.
  The models are often specified for extended temperature range and high vibration levels.
  The mechanical dimensions may also be different than for standard models.

VSWR	1.05 to 1.08 for rectangular waveguides and 1.20 for double ridge models
Insertion Loss	< 0.1 dB (except for double ridge models, which have 0.2 to 0.4 dB) Power capacity. See datasheets for each model.
Flanges	MIL-F-3922 for rectangular waveguides and MIL-F-39000 for double ridge waveguides.
Actuator voltage	28±3 V DC as standard. Some models may have a different voltage.
Actuator current	1 A for standard models.
Switch time	100 to 1000 ms depending on model.
Position indicators	60 V/ 500 mA rating.
Connectors	soldering pins, flying lead or circular MIL connector according to datasheet.
Pressurisation	Max. 0.2 MPa (not for 81-- models)
Leakage	Max. 10 cc/minute
Material	Stator and rotor; aluminium alloy copper free
Finish	Stator and rotor; Chromate per MIL-C-5541C
Life	250 000 actuations minimum
Temperature range	-40 to +85 °C operating (except 81-- models which have 0 to 50 °C
Vibration	10 G for standard models. Up to 30 G for special models.
Duty	2 actuations/second at temperatures up to +40 °C decreasing to one actuation per 2 seconds at +85 °C
Reliability: 100% testing:	All switches are actuated and the function monitored for 1000 actuations at room temperature, highest and lowest specified temperature.

Manual Waveguide Switches

Waveguide WR284, (R32, WG10).
Frequency: 2.7-3.95 GHz
Power capacity: 3000 kW peak power, 10 kW average power

Type number		PM7295S
Dimension	(mm)	□ 167
Isolation	(dB)	90

Waveguide WR187, (R48, WG12).
Frequency: 3.95-5.95 GHz
Power capacity: 1000 kW peak power, 4 kW average power

Type number		PM7295G
Dimension	(mm)	□ 132
Isolation	(dB)	80

Waveguide WR90, (R100, WG16).
Frequency: 8.2-12.4 GHz
Power capacity: 250kW peak power, 3 kW average power

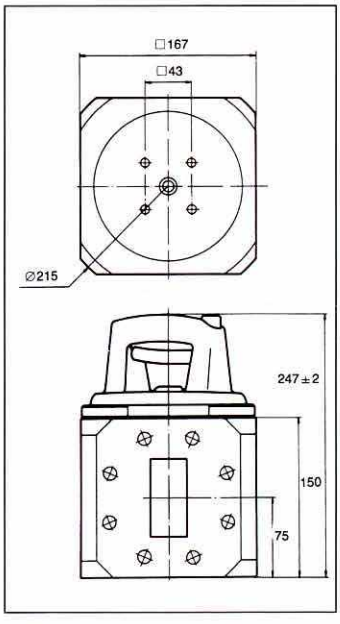
Type number		PM 7295X	PM 7305X	
Dimension	(mm)	□ 74	□ 74	3-channel
Isolation	(dB)	90	70	

Waveguide WR75, (R129, WG17).
Frequency: 10-15 GHz
Power capacity: 250kW peak power, 2 kW average power

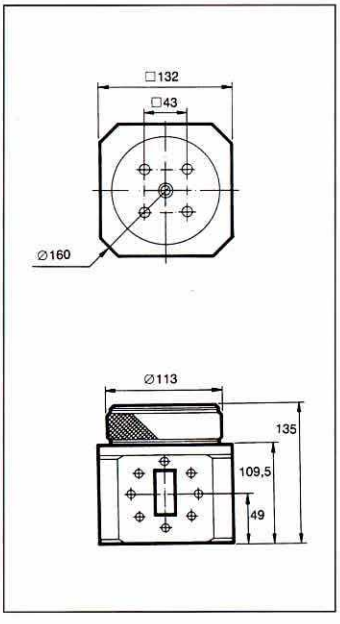
Type number		PM 7305 M	
Dimension	(mm)	□ 74	3-channel
Isolation	(dB)	80	

Waveguide WR62, (R140, WG18).
Frequency: 12,4-18 GHz
Power capacity: 125kW peak power, 2 kW average power

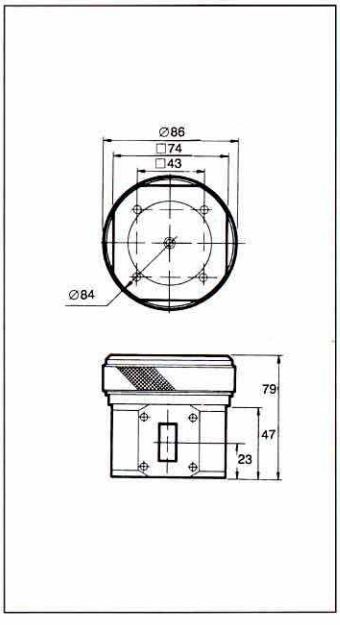
Type number		PM 7305 P	
Dimension	(mm)	□ 74	3-channel
Isolation	(dB)	90	



PM 7295S



PM 7295G



PM 7295X
PM 7305X

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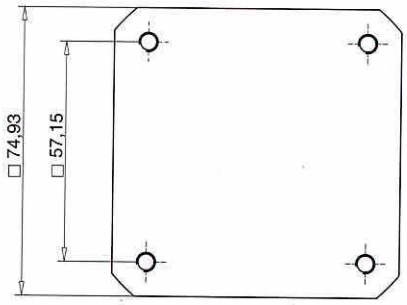
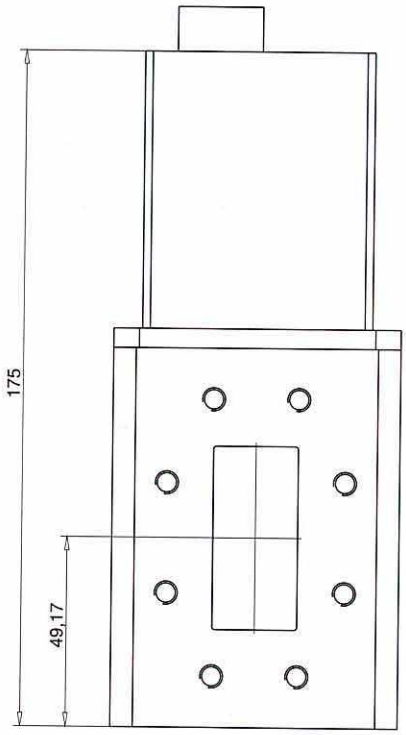
Waveguide Switches

Waveguide WR187
Frequency: 3.95-5.95 GHz.
Power capacity: 1000 kW peak power, 4 kW average power

Type number		WS8286G
Actuator		Latching
Dimension	(mm)	□ 74.93
Isolation	(dB)	80
Switch time	(ms)	1000
No. of position indicators		1
Connector		Circular MIL





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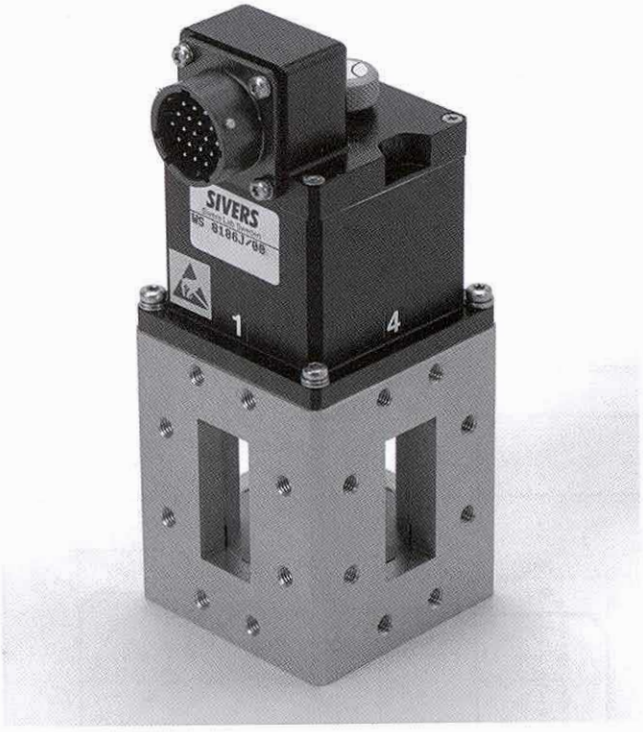
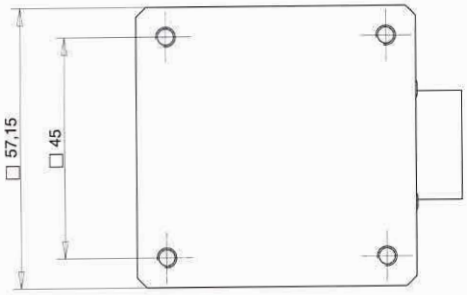
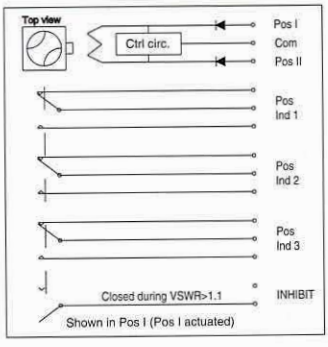
Waveguide Switches

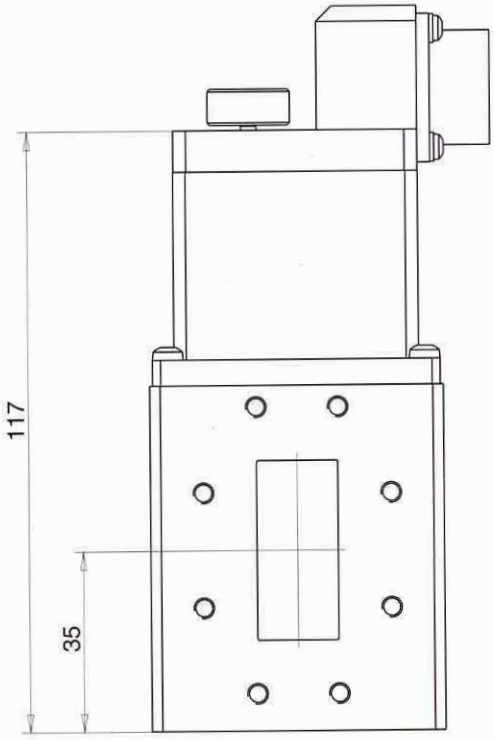
Waveguide WR137
Frequency: 5,85-8,2 GHz.
Power capacity: 250 kW peak power, 3 kW average power

Type number		WS8186J
Actuator		Latching
Dimension	(mm)	□ 57.15
Isolation	(dB)	75
Switch time	(ms)	250
No. of position indicators		4
Connector		Circular MIL









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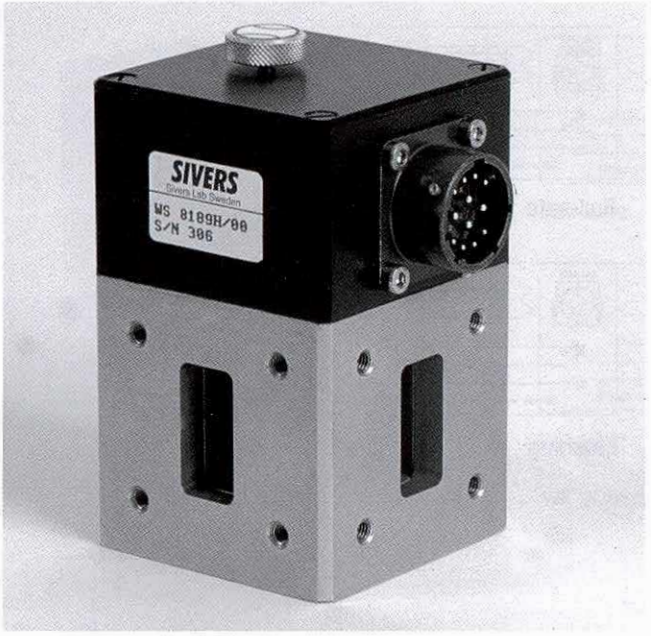
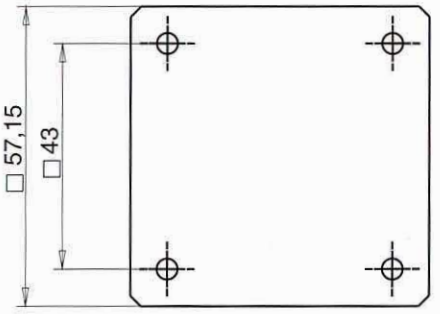
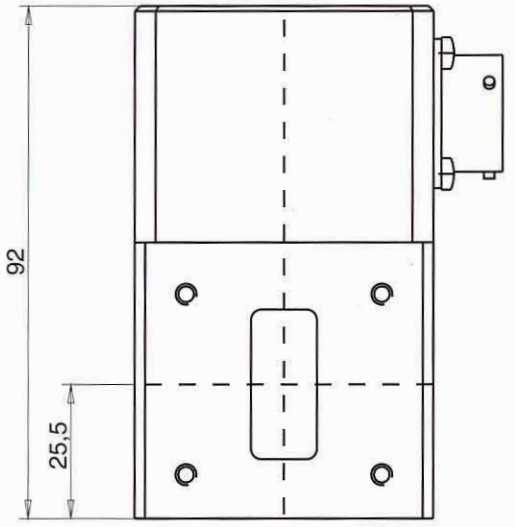
Waveguide Switches

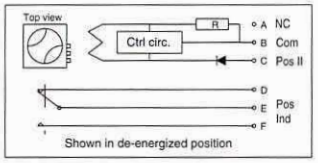
Waveguide WR112
Frequency: 7,05 - 10 GHz.
Power capacity: 350 kW peak power, 4 kW average power

Type number	WS8086H	WS8087H	WS8186H
Actuator	Latching	Fail-safe	Latching
Dimension (mm)	□ 57.15	□ 57.15	□ 57.15
Isolation (dB)	70	70	70
Switch time (ms)	250	250	250
No. of position indicators	1	1	4
Connector	Circular MIL	Circular MIL	Circular MIL

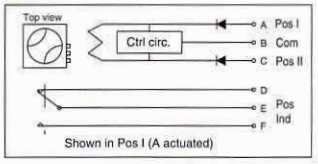








Fail-safe



Latching

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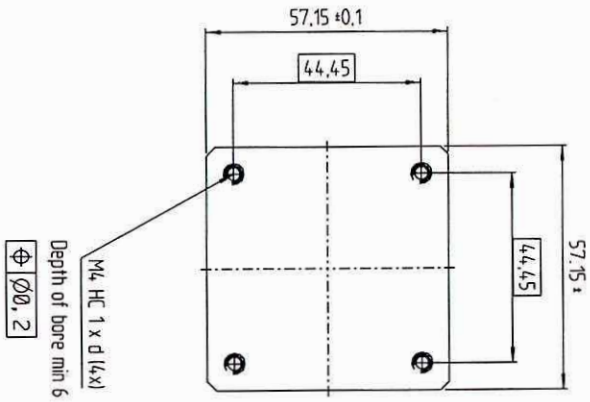
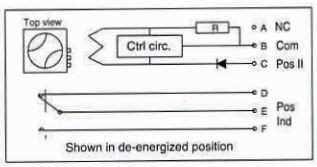
Waveguide Switches

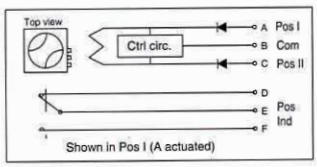
Waveguide WR102
Frequency: 7 - 11 GHz.
Power capacity: 350 kW peak power, 4 kW average power

Type number		WS8286T	WS8287T
Actuator		Latching	Fail-safe
Dimension	(mm)	□ 60 alt. 57	□ 60 alt. 57
Isolation	(dB)	60	60
Switch time	(ms)	150	150
No. of position indicators		1	1
Connector		Circular MIL	Circular MIL

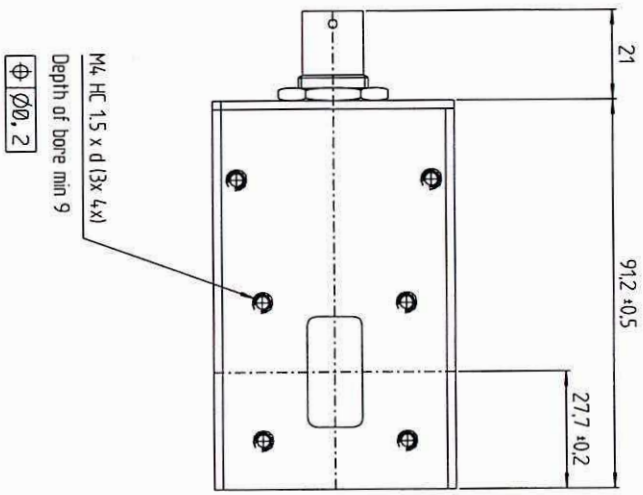




Fail-safe



Latching



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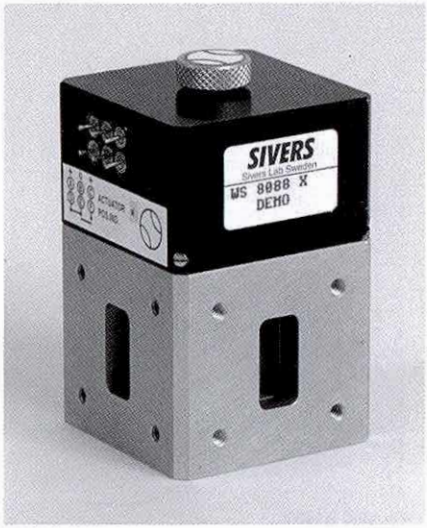
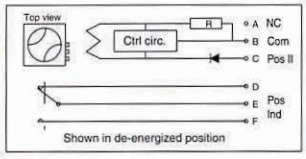
Waveguide Switches

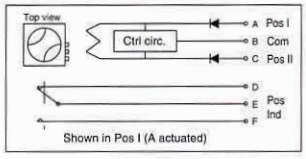
Waveguide WR90, (R100, WG16).
Freequency: 8.2-12.4 GHz
Power capacity: 250 kW peak power, 3 kW average power

Type number	WS8086X	WS8087X	WS8088X	WS8089X	WS8189X	WS8088X/45	WS8088X/51	WS8186X
Actuator	Latching	Fail-safe	Fail-safe	Latching	Latching	Fail-safe	Fail-safe	Latching
Dimension (mm)	□ 57	□ 57	□ 47,6	□ 47,6	□ 47,6	□ 45	□ 40	□ 57,15
Isolation (dB)	90	90	60/80	60/80	60/80	60/80	50	90
Switch time (ms)	300	300	200	200	100	100	200	300
No. of position indicators	1	1	1	1	4	1	1	4
Connector	Circular MIL	Circular MIL	Solder pins	Solder pins	Circular MIL	Solder pins	Flying lead	Circular MIL



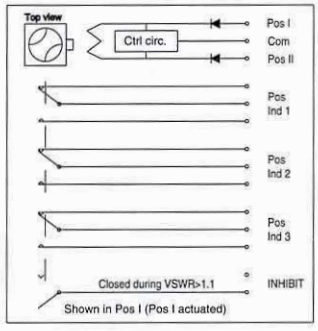


Fail-safe

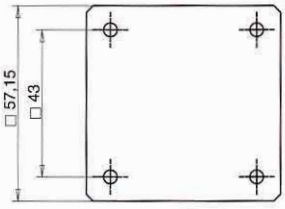


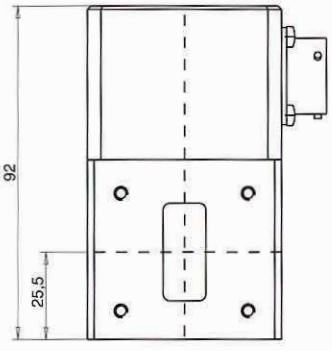
Latching

WS 8086/87/88/89

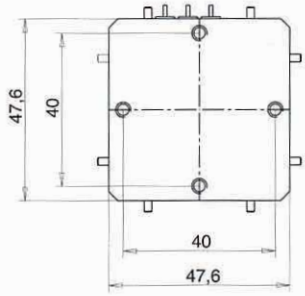


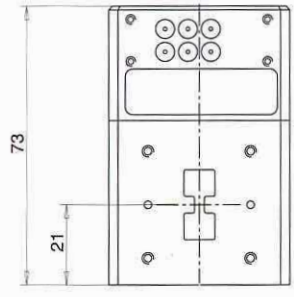
WS 8189



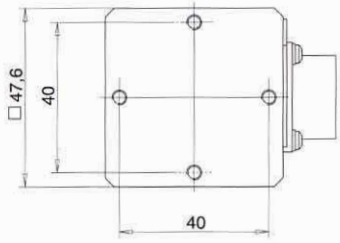


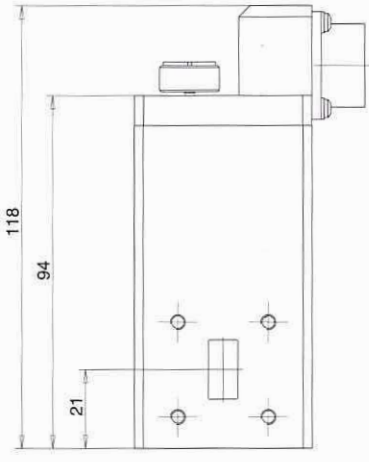
WS 8086/87





WS 8088/89





WS 8189

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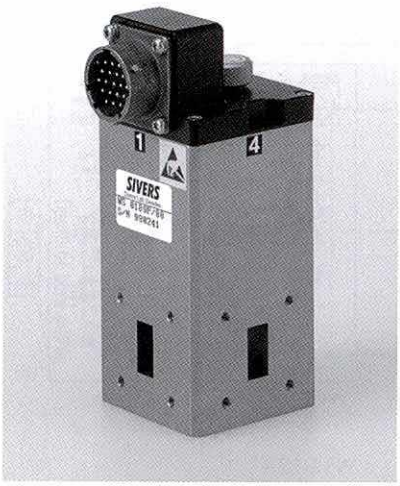
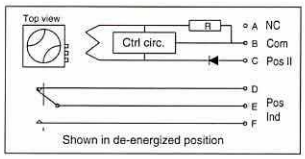
Waveguide Switches

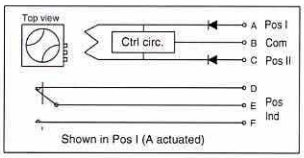
Waveguide WR75, (R120, WG17).
Frequency: 10 - 15 GHz.
Power capacity: 250 kW peak power, 2 kW average power

Type number		WS8086M	WS8087M	WS8088M	WS8089M	WS8189M	WS8186M
Actuator		Latching	Fail-safe	Fail-safe	Latching	Latching	Latching
Dimension	(mm)	□ 57	□ 57	□ 47,6	□ 47,6	□ 47,6	□ 57
Isolation	(dB)	90	90	60/80	60/80	60/80	90
Switch time	(ms)	300	300	200/100	200/100	100	300
No. of position indicators		1	1	1	1	4	4
Connector		Circular MIL	Circular MIL	Solder pins	Solder pins	Circular MIL	Circular MIL



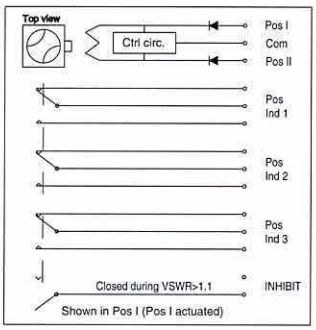


Fail-safe

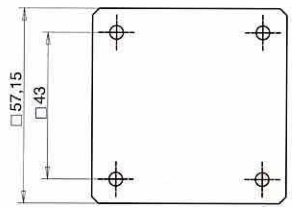


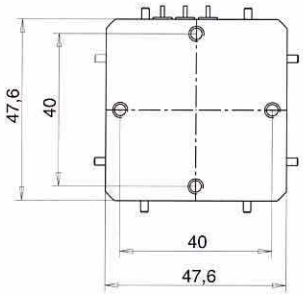
Latching

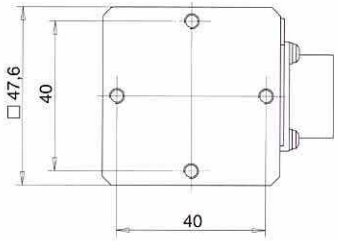
WS 8086/87/88/89

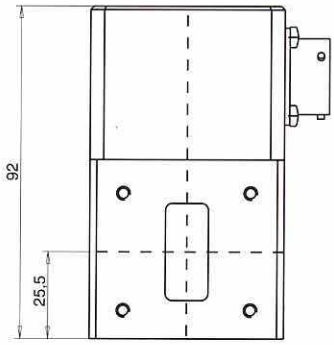


WS 8189

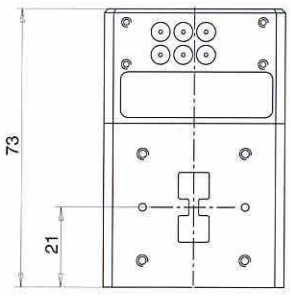




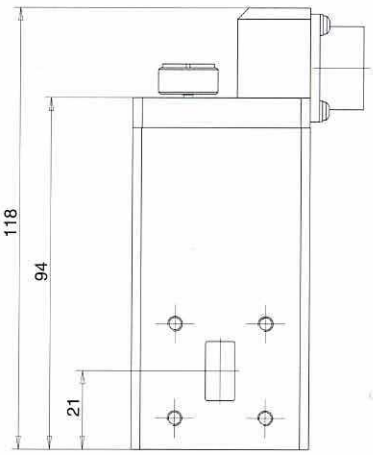




WS 8086/87



WS 8088/89



WS 8189

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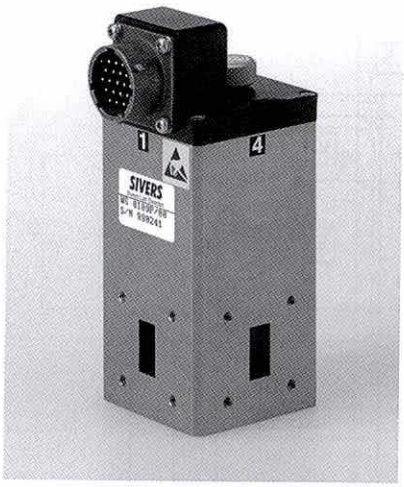
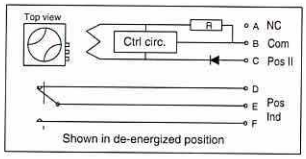
Waveguide Switches

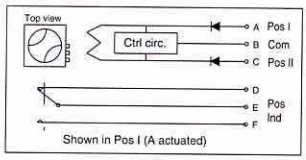
Waveguide WR62, (R140, WG18).
Frequency: 12,4 - 18 GHz.
Power capacity: 125 kW peak power, 2 kW average power

Type number	WS8086P	WS8087P	WS8088P	WS8089P	WS8189P	WS8186P
Actuator	Latching	Fail-safe	Fail-safe	Latching	Latching	Latching
Dimension (mm)	□ 57	□ 57	□ 47,6	□ 47,6	□ 47,6	□ 57
Isolation (dB)	90	90	60/80	60/80	60/80	90
Switch time (ms)	300	300	200/100	200/100	100	300
No. of position indicators	1	1	1	1	4	4
Connector	Circular MIL	Circular MIL	Solder pins	Solder pins	Circular MIL	Circular MIL



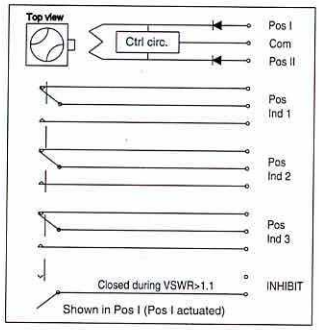


Fail-safe

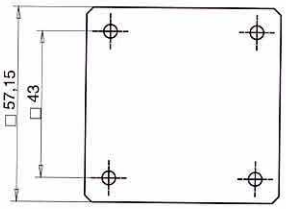


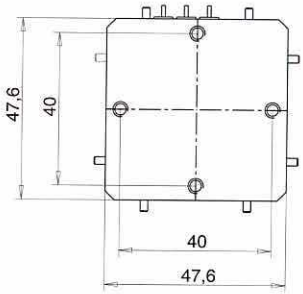
Latching

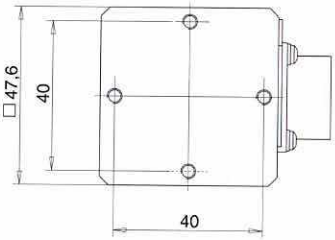
WS 8086/87/88/89

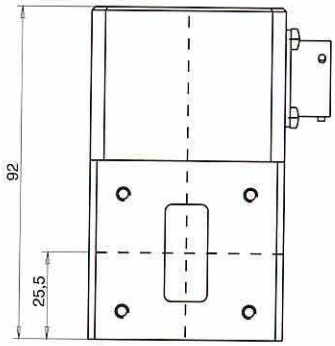


WS 8189

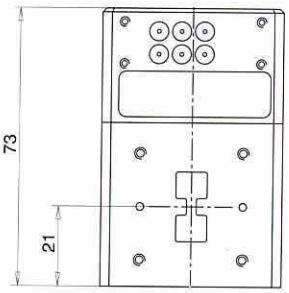




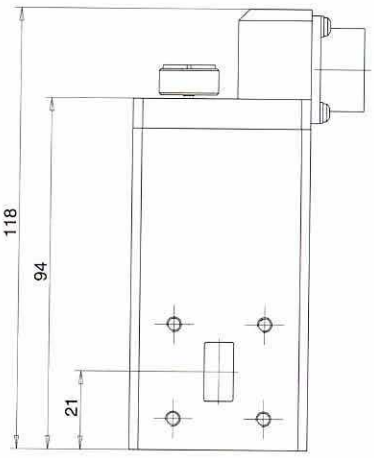




WS 8086/87



WS 8088/89



WS 8189

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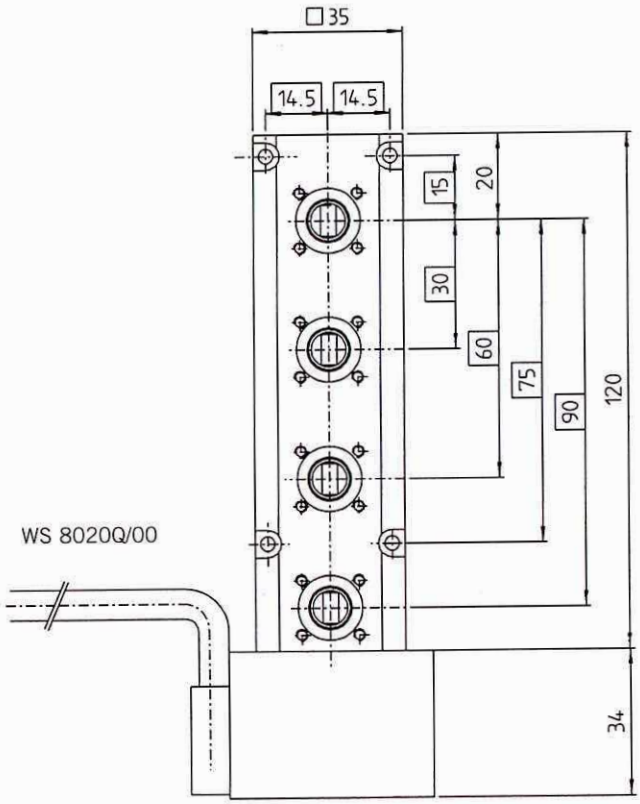
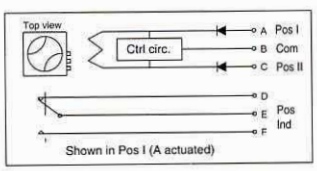
Waveguide Switches

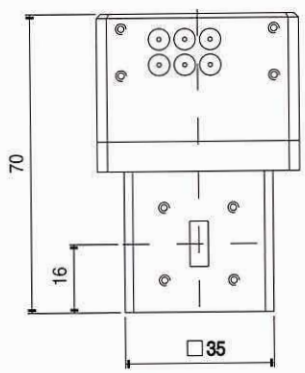
Waveguide WR28
Frequency: 26,5 - 40 GHz.
Power capacity: 10 kW peak power, 0.1 kW average power

Type number		WS8089Q	WS8020Q/00 4 levels of switches
Actuator		Latching	Latching
Dimension	(mm)	□ 35	□ 35
Isolation	(dB)	60	60
Switch time	(ms)	200	200
No. of position indicators		1	1
Connector		Solder pins	Flying lead





Latching



WS 8089Q

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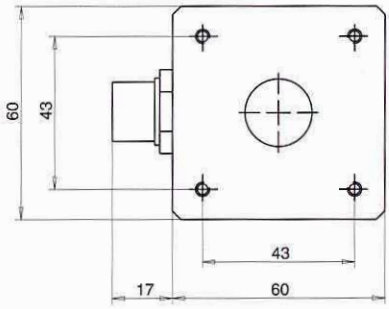
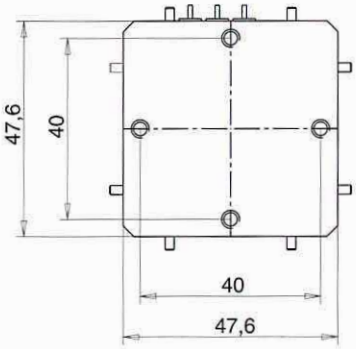
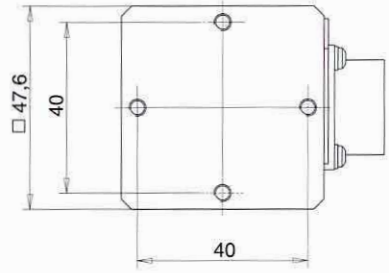
Waveguide Switches

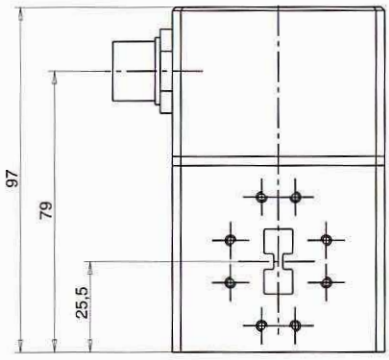
Waveguide: WRD475, WRD750, WRD580.

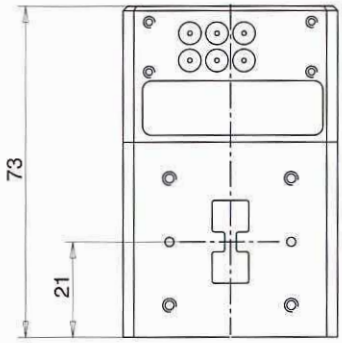
Type number		WS8086D475	WS8087D475	WS8088D750	WS8089D750	WS8189D580
Actuator		Latching	Fail-safe	Fail-safe	Latching	Latching
Frequency	(GHz)	4.75-11	4.75-11	7.5-18	7.5-18	5.8-16
Peak power	(kW)	80	80	30	30	30
Average power	(kW)	1.5	1.5	0.75	0.75	0.75
Dimension	(mm)	□ 60 alt. 57	□ 60 alt. 57	□ 47,6	□ 47,6	□ 47,6
Isolation	(dB)	40/60	40/60	40/60	40/60	40/60
Switch time	(ms)	200	200	200	200	100
No. of position indicators		1	1	1	1	4
Connector		Solder pins	Solder pins	Solder pins	Solder pins	Circular MIL

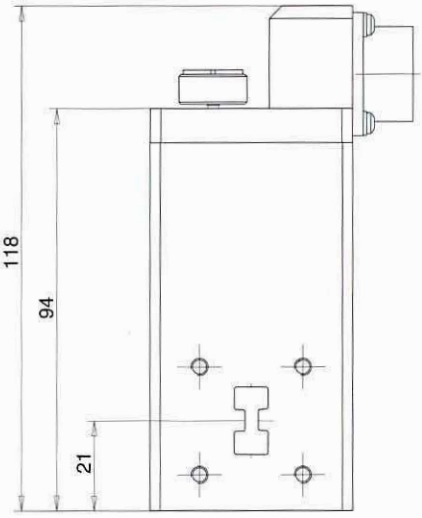








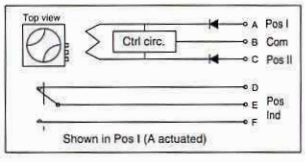




WS 8086/87 D475

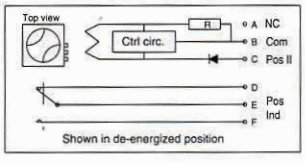
WS 8088/89 D750
WS 8088/89 D580

WS 8189 D580

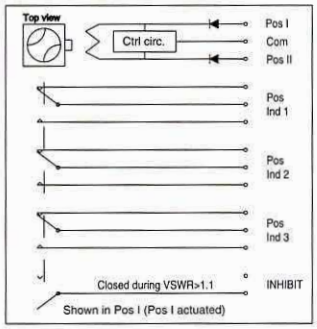


Latching

WS 8086/87/88/89



Fail-safe



WS 8189 D580

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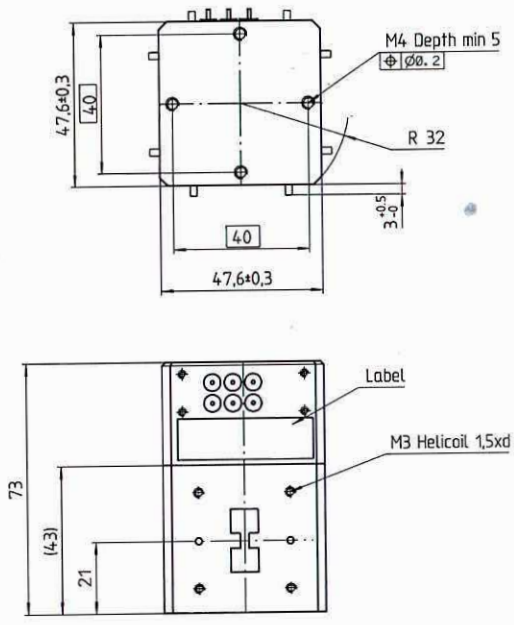
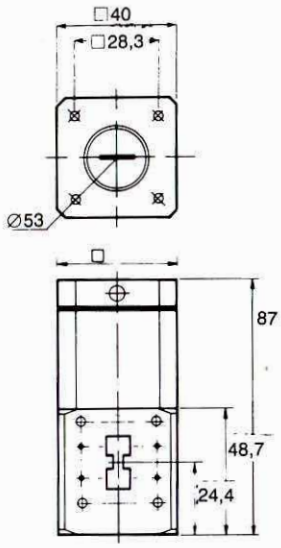
Waveguide Switches

Waveguide WRD650.
Frequency: 6.5-18 GHz
Power capacity: 20 kW peak power, 0.5 kW average power

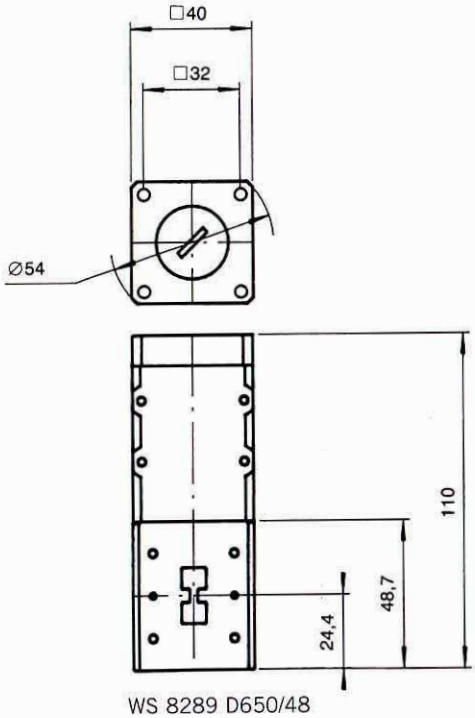
Type number	WS8088D650	WS8089D650	WS8088D650/01	WS8089D650/01	WS8289D650/45	WS8289D650/48
Actuator	Fail-safe	Latching	Fail-safe	Latching	Latching	Latching
Dimension (mm)	□ 47,6	□ 47,6	□ 40	□ 40	□ 40	□ 40
Isolation (dB)	40/60	40/60	40/60	40/60	40/60	40/60
Switch time (ms)	200	200	200	200	60	200
					5Amp.)	(TTL 0.5Amp @ 12 V.)
No. of position indicators	1	1	1	1	1	1
Connector	Solder pins	Solder pins	Solder pins	Solder pins	Solder pins	Flying lead



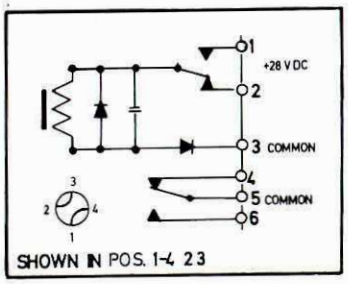
WS 8088/89 D650



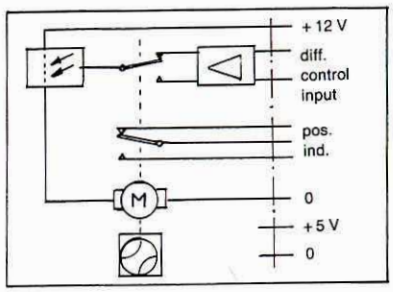
WS 8289 D650/45



WS 8289 D650/48



WS 8289 D650/45



WS 8289 D650/48

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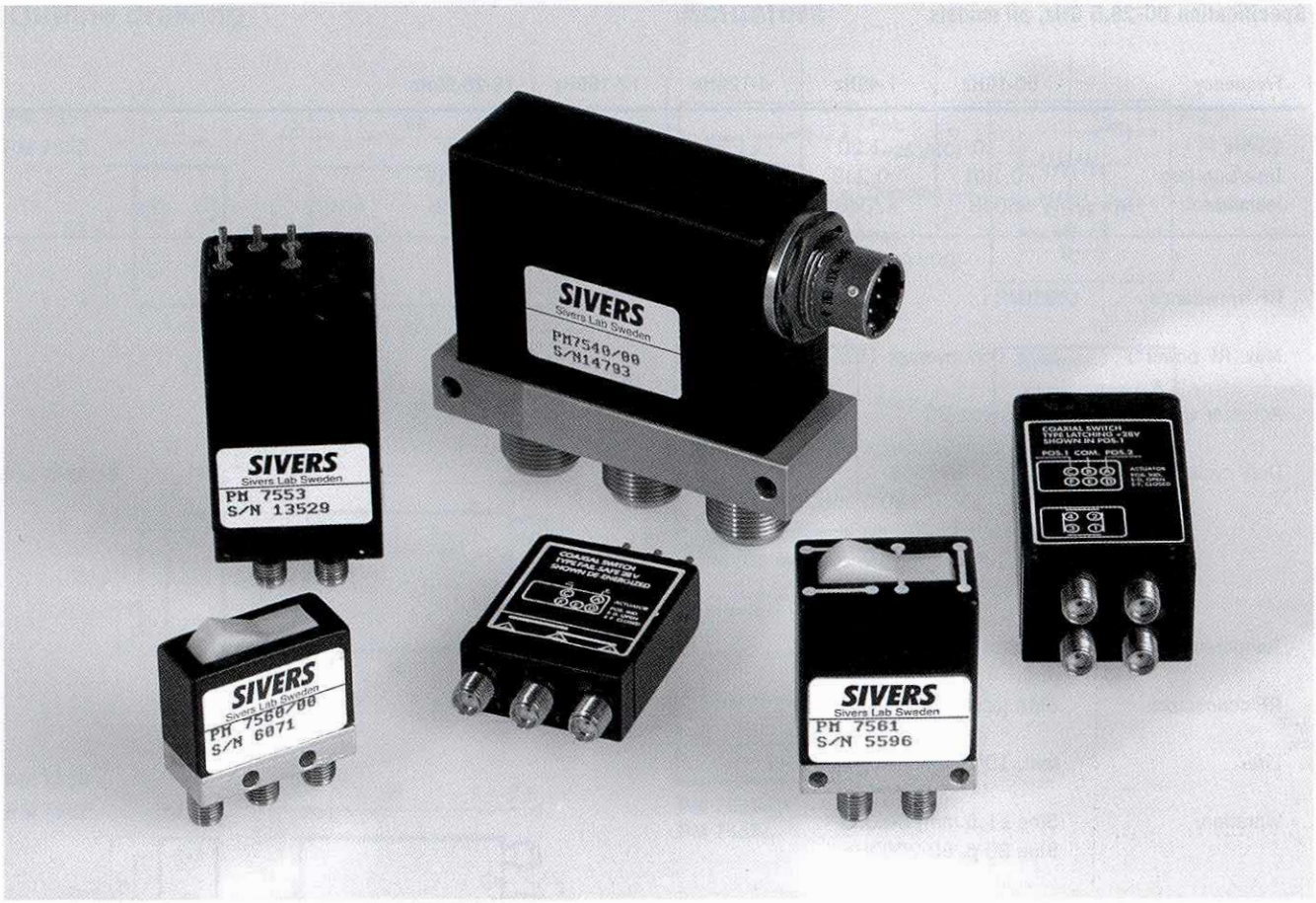

SMA

General

The lightweight coaxial switches of the PM7550-series are designed for use in wide band, miniaturised microwave systems under severe environmental conditions. Advanced strip line technique provides excellent electrical performance up to 18GHz and reduced data to 26.5GHz. The contacting points have low-resistivity, long-life gold plating.

Latching or failsafe

Latching models require no holding current, whereas the failsafe models have a small holding current. Switching is break-before-make.

Protection circuit

Supply line interference suppression and reversed polarity protection are incorporated in transfer models.

Environmental

The switches are designed to be used in equipment that meets MIL-E-5400 and MIL-E-16400. A balanced actuator construction having a small mass ensures that the switches withstand shocks and vibrations.

Position indicator

For remote indication of the switch position additional contacts are incorporated in most models.

Mounting

The switches are provided with mounting holes, which also enable easy stacking of several units. This facilitates more complicated switching configurations (matrixing). Min. distance between adjacent switches is 5 mm for latching models, 10 mm for fail-safe models.

Reliability-100% testing

All switches pass an extensive screening procedure, where all circuit parameters are checked across the frequency range, and continuous operating (running-in more than 5000 actuations) is checked during temperature cycling. This enables the detection of early and intermittent failures.

Low Power Models SMA

Specification DC-26.5 GHz, all models

Frequency	DC-1GHz	1-4GHz	4-12GHz	12-18GHz	18-26,5GHz
VSWR	<1.10	<1.20	<1.35	<1.50	<1.8
Insertion loss	<0.1dB	<0.2dB	<0.3dB	<0.5dB	<0.8 dB
Isolation	>80dB	>70dB	>65dB	>60dB	>40 dB

RF impedance: 50Ω

Max. RF power*) peak 1kW, average 15W

Actuator voltage 28 ±5 Volt DC

Duty cycle: PM7551-PM7553
50ms - 55°C - +40°C linearity
increasing to 200 ms at +85°C
(min. time between successive operations)
PM7555 - PM7557 100%

Temperature: -55°C to +85°C ambient

RF connectors: SMA jack per MIL-39012C

Life: min. 10^6 actuations guaranteed

Vibration: Sine ±1.5 mm, 5-60Hz
Sine 20 g, 60-2000Hz

Material: RF-house: aluminium

RF-connectors: stainless steel,
gold plated beryllium-copper
terminals: soldering pins

Finish: dull black paint

*) Under steady-state condition, switching RF power will damage the components

	Automatic				Manual	
Model	**PM7551/00**	**PM7553/00**	**PM7555/01**	**PM7557/01**	**PM7560/00**	**PM7561/00**
Switch function	Transfer	Transfer	SPDT	SPDT	SPDT	Transfer
Actuator	latching	failsafe	latching	failsafe	manual	manual
Switching time	15 ms	15 ms	20 ms	20 ms	n/a	n/a
Pull-in holding current at 25°C/ max	350/-mA	400/40 mA	60/-mA	60/60 mA	n/a	n/a
Position indicator	yes	yes	yes	yes	no	no
Self cut off	yes	n/a	no **)	n/a	n/a	n/a
Weight max	85 g	85 g	55 g	55 g	35 g	60 g

**) Recommended pulse width 20-30 ms

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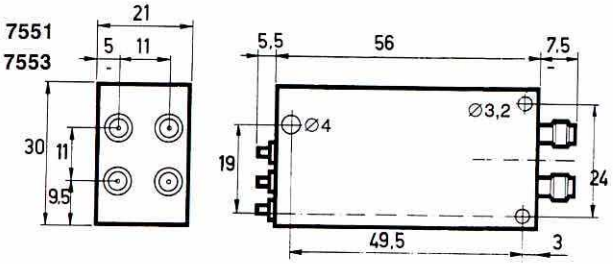
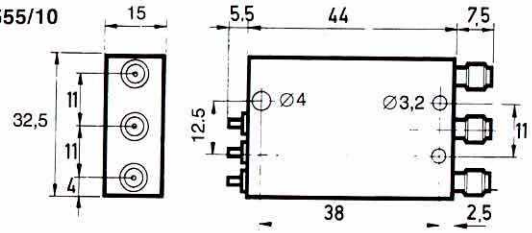
Outline drawing

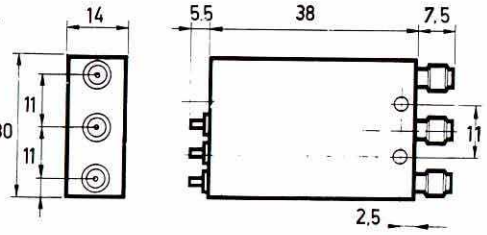
PM 7551
PM 7553



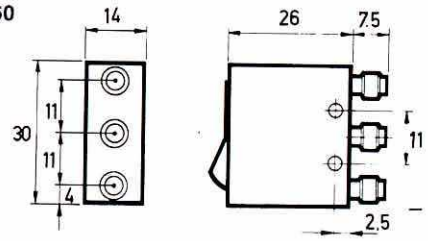
PM 7555/10



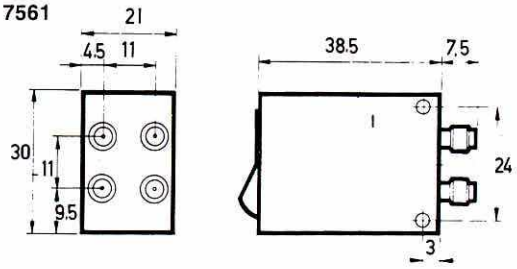
PM 7555
PM 7557



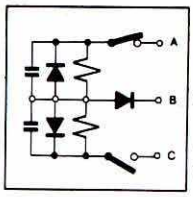
PM 7560



PM 7561

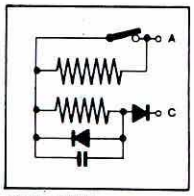


Actuators



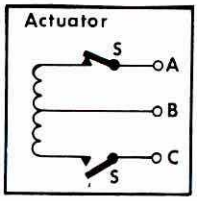
Pos. II (+28 VDC)
Common (—)
Pos. I (+28 VDC)

PM 7551



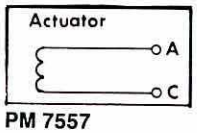
Pos. II +28 VDC
Common (—)

PM 7553

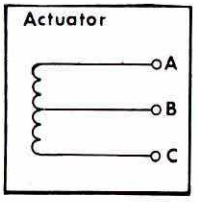


Pos 2+
Common
Pos 1+

PM 7555



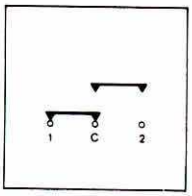
PM 7557
PM 7557/01



Pos 2+
Common
Pos 1+

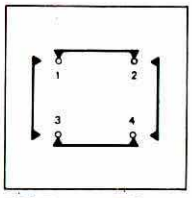
PM 7555/01
PM 7555/..

RF circuits



Pos. 1: C-1
Pos. 2: C-2

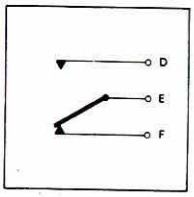
PM 7555 PM 7557
PM 7560



Pos. I: 1—2, 3—4
Pos. II: 1—3, 2—4

PM 7551 PM 7553
PM 7561

Position indicators



Pos. II
Common
Pos. I

PM 7551
PM 7553
PM 7555/01
PM 7557/01
PM 7555/10

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High Power Models Type-N, TNC

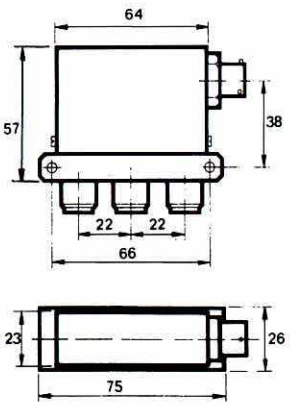
High power model PM7540 and PM7541
The high power coaxial SPDT switches are designed with excellent thermal conduction between the centre conductor and housing to enable high power operation. This is achieved by using special thermoconductive materials as dielectricum.
The actuator is fail-safe and the RF-contacts operate in a break-before-make model.

Model	PM7540/41
Switch function	SPDT
Actuator	fail-safe
Switch time	100 ms
Actuator voltage	28 +2/-8 Volt
Pull-in/holding current	220/220 mA
Position indicator	yes
Terminals	Connector MIL 3114E-10-6P
Weight	350 g

Specification DC-12.4 GHz

Frequency	DC-1GHz	1-7GHz	7-12.4GHz
VSWR	<1.10	<1.35	<1.50
Insertion loss	<0.2dB	<0.3dB	<0.5dB
Isolation	>70dB	>65dB	>60dB

RF impedance:	50Ω
Max. RF power*)	peak 10kW, average 1 kW at 1 GHz, 300 W at 10 GHz
Temperature:	-55°C to +85°C ambient
RF connectors:	N-type jack for PM7540 and TNC for PM5741 per MIL-39012
Life:	min. 10^6 actuations guaranteed
Vibration:	Sine ±1.5 mm, 5-40Hz Sine 10 g, 40-2000Hz
Material:	RF-house: aluminium RF-connectors: stainless steel, gold plated beryllium-copper terminals
Finish:	dull black paint



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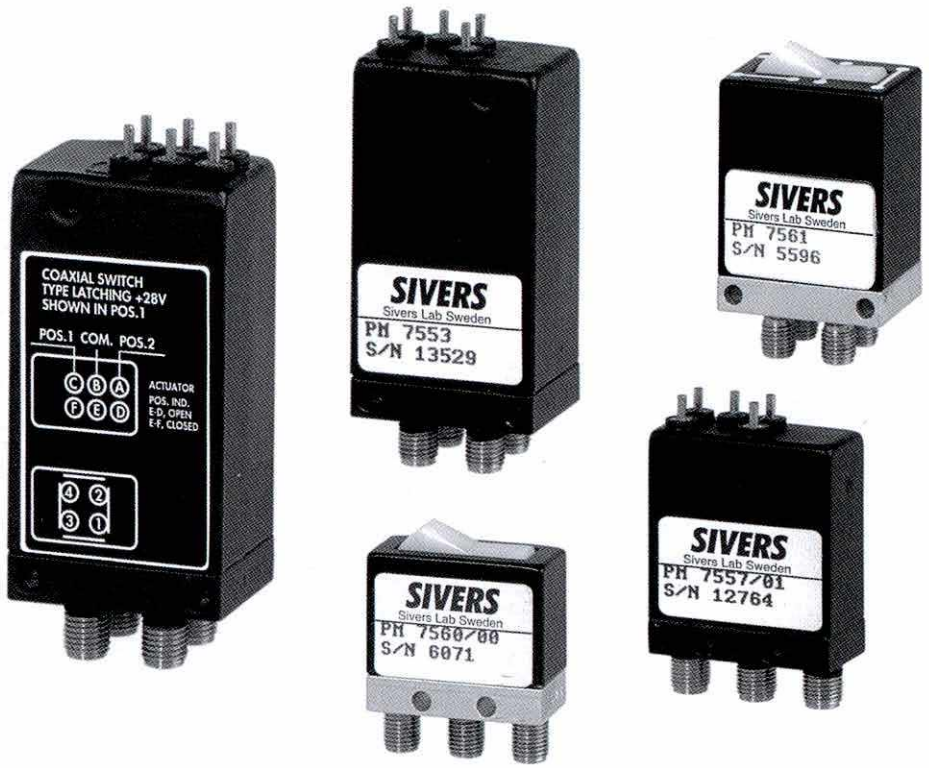
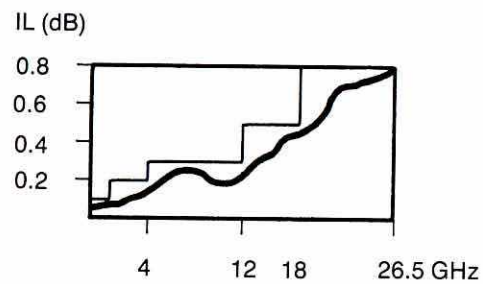
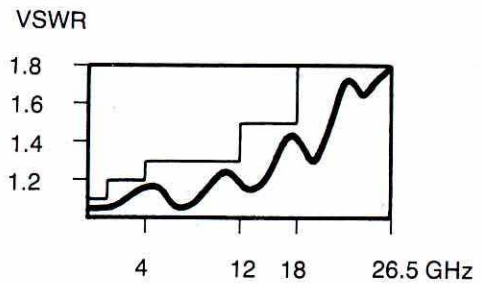
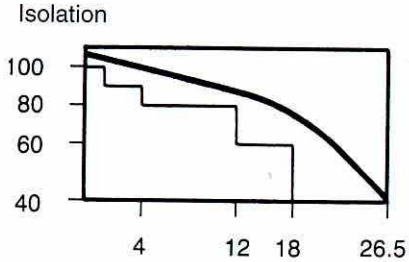


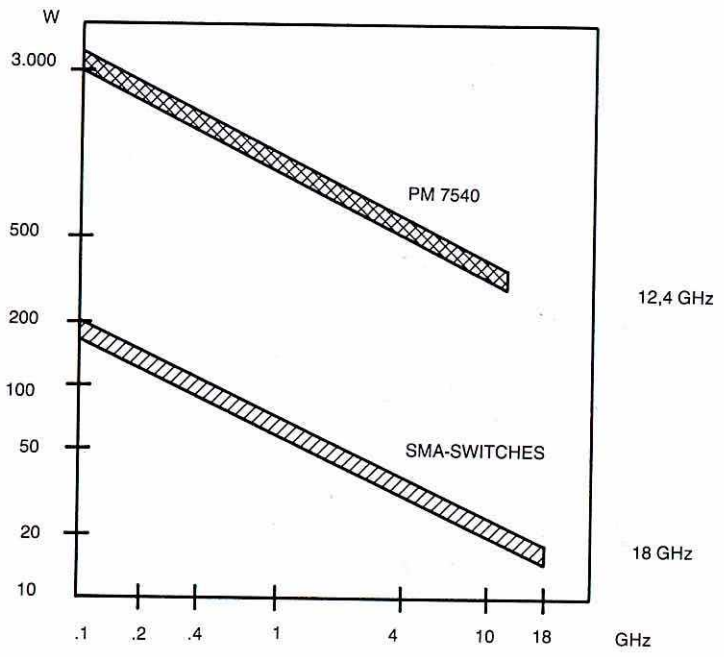






Average power capacity

Max, RF-power at +85±C,
load VSWR=1:1



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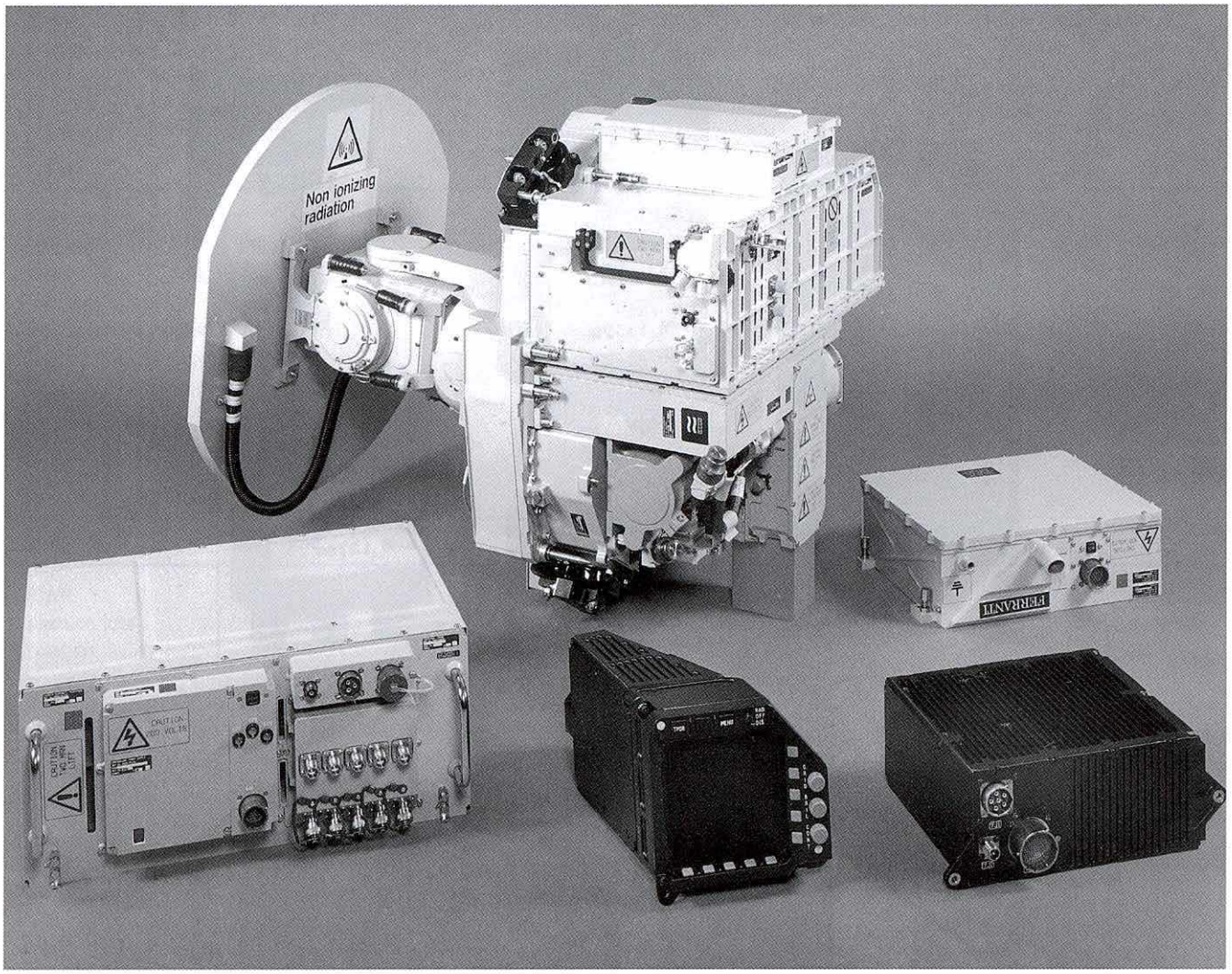
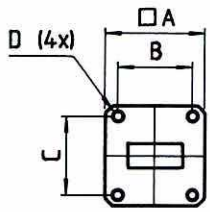
Applications



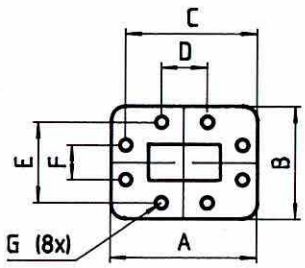
GENERAL DATA

SIVERS STANDARD FLANGE DIMENSIONS



W/G SIZE	A	B	C	D
R 84	47,63	34,34	37,44	ϕ 4,29 / M4
R 100	41,28	30,98	32,5	ϕ 4,29 / M4
R 140	33,35	25,24	24,28	ϕ 3,66 / 6-32 UNC-2B

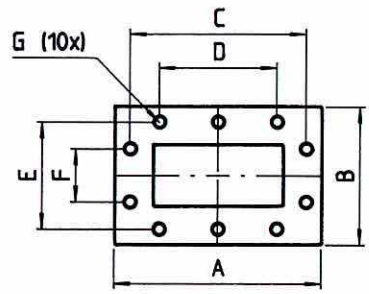
ALL DIMENSIONS, EXCEPT THREADED HOLES FOR R84 AND R100, ACCORDING TO MIL-F-3922/53.



W/G SIZE	A	B	C	D	E
R 58	81,03	61,98	64,66	25,4	44,44

F	G
19,04	ϕ 6, 53 / M5

ALL DIMENSIONS, EXCEPT THREADED HOLES, ACCORDING TO MIL-F-3922/52.

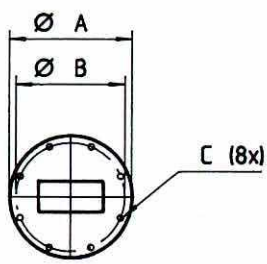


ALL DIMENSIONS,
EXCEPT THREADED HOLES,
ACCORDING TO MIL-F-3922/52.

W/G SIZE	A	B	C	D	E
R 14	220,73	138,18	200	120,6	117.4
R 32	114,3	76,2	97,24	65,08	59,14
R 48	88,9	63,5	71,84	28,6	46,44

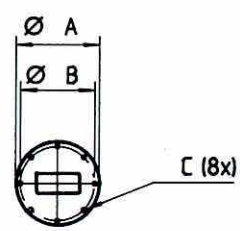
W/G SIZE	F	G
R 14	63,44	ϕ 8,38 / M8
R 32	29,36	ϕ 6,53 / M6
R 48	22,24	ϕ 6,53 / M6

ALL DIMENSIONS,
EXCEPT THREADED HOLES,
ACC. TO MIL-F-3922/61.



W/G SIZE	A	B	C
R 32	ϕ 134,95	ϕ 120,65	ϕ 6,53 / M6

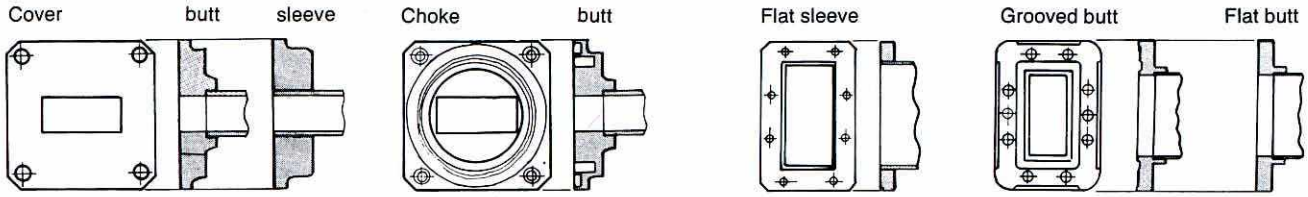
ALL DIMENSIONS,
EXCEPT THREADED HOLES,
ACC. TO MIL-F-3922/57.



W/G SIZE	A	B	C
R 48	ϕ 92,08	ϕ 82,55	ϕ 5,05 / M5

Waveguide and Flange Data

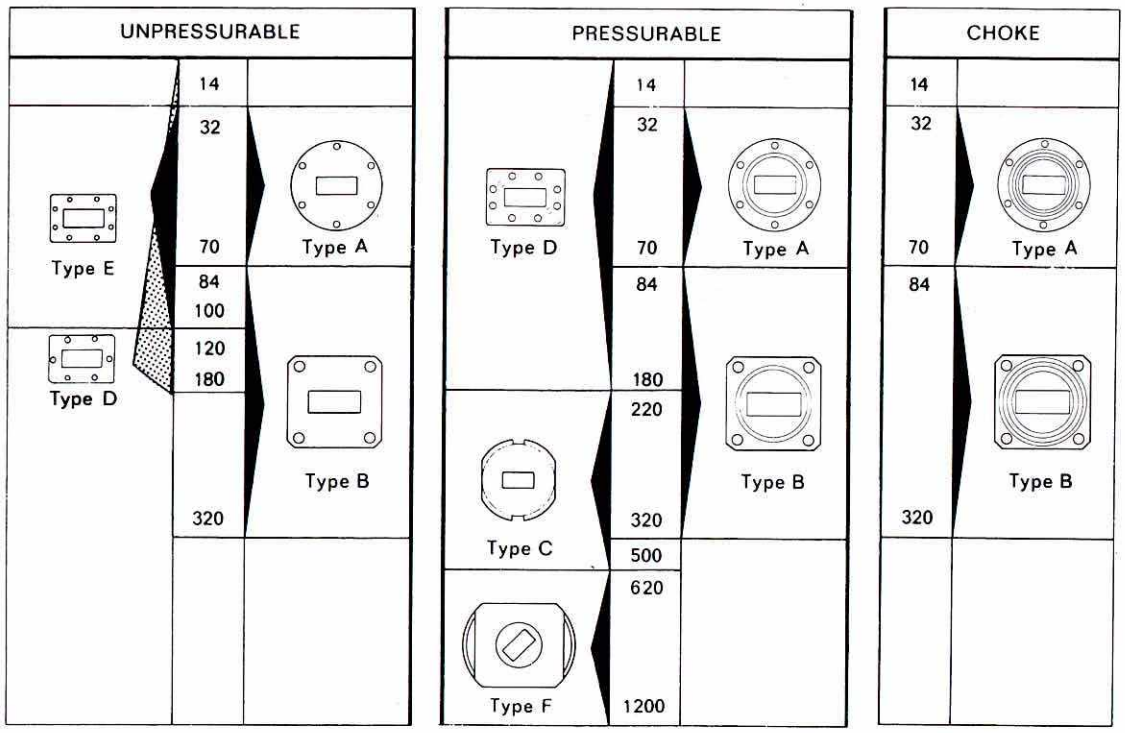
Flange types



IEC

Waveguide flanges covered by IEC recommendation shall be indicated by a reference number comprising the following information:

a. The number of the present IEC publication.
b. The letter "IEC".
c. A dash.
d. A letter relating to the basic construction of the flange
   P=pressurable
   C=choke, pressurizable
   U=unpressurizable.
e. A letter for the type according to the drawing. Flanges with the same letter and of the same waveguide size can be mated.
f. The letter and number of the waveguide for which the flange is designed.



* IEC Recommendations are obtained from:
Central Office of the
International Electrotechnical Commission
1. rue de Varembé
GENEVA, Switzerland

Waveguide and Flange Data

Rectangular waveguide flanges

Waveguide size	Flange type	Aluminium			Brass	
		MIL F-3922	AN NO, U/G	154-IEC	MIL F-3922	AN NO, U/G
WR 650	Flat butt	52-002	1 720/U	UDR 14	52-001	1 714/U
(WG 6, R 14)	Grooved butt	52-024	1 343/U	PDR 14	52-023	1 362/U
WR 510	Flat butt	52-004	1 717/U	UDR 18	52-003	1 715/U
(WG 7, R 18)	Grooved butt	52-026	1 719/U	PDR 18	52-025	1 718/U
WR 430	Flat butt	52-006	1 711/U	UDR 22	52-005	1 716/U
(WG 8, R 22)	Grooved butt	52-028	1 345/U	PDR 22	52-027	1 344/U
WR 340	Flat butt	52-008	1 713/U	UDR 26	52-007	1 712/U
(WG 9A, R 26)	Grooved butt	52-030	1 347/U	PDR 26	52-029	1 346/U
	Cover sleeve	56-002	584/U	UAR 32	56-001	53/U
	Choke butt	61-001	585A/U	CAR 32	61-002	54B/U
WR 284	Flat butt	52-010	1 725/U	UDR 32	52-009	1 724/U
(WG 10, R 32)	Grooved butt	52-032	1 349/U	PDR 32	52-031	1 348/U
	Flat sleeve	64-002	1 484/U	UER 32	64-001	1 479/U
	Flat butt	52-012	1 727/U	UDR 40	52-011	1 726/U
WR 229	Grooved butt	52-034	1 351/U	PDR 40	52-033	1 350/U
(WG 11A, R 40)	Flat sleeve			UER 40		
	Cover sleeve	57-001	407/U	UAR 48	57-002	149 A/U
	Choke butt	62-001	406B/U	CAR 48	62-002	148C/U
WR 187	Flat butt	52-014	1 729/U	UDR 48	52-013	1 728/U
(WG 12, R 48)	Grooved butt	52-036	1 353/U	PDR 48	52-035	1 352/U
	Flat sleeve	63-005	1 480/U	UER 48	63-001	1 475/U
	Cover sleeve			UAR 58		
	Choke butt			CAR 58		
WR 159	Flat butt	52-016	1 731/U	UDR 58	52-015	1 730/U
(WG 13, R 58)	Grooved butt	52-038	1 355/U	PDR 58	52-037	1 354/U
	Flat sleeve			UER 58		
	Cover sleeve	55-002	441/U	UAR 70	55-001	344/U
	Choke butt	60-002	440B/U	CAR 70	60-001	343B/U
WR 137	Flat butt	52-018	1 733/U	UDR 70	52-017	1 732/U
(WG 14, R 70)	Grooved butt	52-040	1 357/U	PDR 70	52-039	1 456/U
	Flat sleeve	63-006	1 481/U	UER 70	63-002	1 476/U
	Cover sleeve	53-004	138/U	UBR84	53-002	51/U
	Choke butt	59-009	137B/U	CBR 84	59-007	52B/U
WR 112	Flat butt	52-020	1 735/U	UDR 84	52-019	1 734/U
(WG 15, R 84)	Grooved butt	52-042	1 359/U	PDR 84	52-041	1 358/U
	Flat sleeve	63-007	1 482/U	UER 84	63-003	1 477/U
	Cover butt	70-002			70-001	1 493/U
WR 102	Choke butt	69-002			69-001	1 494/U
	Cover sleeve	53-003	135/U	UBR 100	53-001	39/U
	Choke butt	59-008	136B/U	CBR 100	59-006	40B/U
WR 90	Flat butt	52-022	1 737/U	UDR 100	52-021	1 736/U
(WG 16, R 100)	Grooved butt	52-044	1 361/U	PDR 100	52-043	1 360/U
	Flat sleeve	63-008	1 483/U	UER 100	63-004	1 478/U
	Cover sleeve	70-005		UBR 120	70-004	
WR 75	Choke butt	59-011		CBR 120	59-010	
(WG 17, R 120)	Flat butt			UDR 120		
	Grooved butt			PDR 120		
	Cover sleeve	53-006	1 665/U	UBR 140	53-005	419/U
WR 62	Choke butt	59-002	1 666/U	CBR 140	59-001	541A/U
(WG 18, R 140)	Flat butt			UDR 140		
	Grooved butt			PDR 140		

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Waveguide and Flange Data

Rectangular waveguide flanges (cont.)

Waveguide size	Flange type	Aluminium			Brass	
		MIL F-3922	AN NO, U/G	154-IEC	MIL F-3922	AN NO, U/G
WR 51 **(WG 19, R 180)**	Cover butt Choke butt Flat butt Grooved butt	70-011 69-005		UBR 180 CBR 180 UDR 180 PDR 180	70-010 69-004	
WR 42 **(WG 20, R 220)**	Cover sleeve Choke butt	54-002 59-004	597/U 598A/U	UBR 220 CBR 220	54-001 59-003	595/U 596A/U
WR 34 **(WG 21, R 260)**	Coover sleeve Choke butt	63-010		UBR 260 CBR 260	63-009	1 530/U
WR 28 **(WG 22, R 320)**	Coover sleeve Choke butt			UBR 320 CBR 320	54-003 59-005	599/U 600A/U

Double-ridge flanges

Waveguide size	Flange type	Aluminium MIL-F-39000/3	Brass MIL-F-39000/3	Holes
WRD 150 D 24	Flat butt	—004	—005	1/4-20 UNC (6X) ∅ 6,63 (6X)
WRD 200 D 24	Flat butt	—024	—025	6-32 UNC (4X) ∅ 3,68 (4X)
	Flat butt	—026	—027	6-32 UNC (8X)
	Flat butt	—028	—029	∅ 3,68 (8X)
	Grooved butt	—048	—049	6-32 UNC (4X) ∅ 3,68 (4X)
	Grooved butt	—050	—051	6-32 UNC (8X)
	Grooved butt	—052	—053	∅ 3,68 (8X)
WRD 350 D 24	Flat butt	—030	—031	6-32 UNC (4X) ∅ 3,68 (4X)
	Flat butt	—032	—033	6-32 UNC (8X)
	Flat butt	—034	—035	∅ 3,68 (8X)
	Grooved butt	—054	—055	6-32 UNC (4X) ∅ 3,68 (4X)
	Grooved butt	—056	—057	6-32 (8X)
	Grooved butt	—058	—059	∅ 3,68 (8X)
WRD 475 D 24	Flat butt	—036	—037	6-32 UNC (4X) ∅ 3,68 (4X)
	Flat butt	—038	—039	6-32 UNC (8X)
	Flat butt	—040	—041	∅ 3,68 (8X)
	Grooved butt	—060	—061	6-32 UNC (4X) ∅ 3,68 (4X)
	Grooved butt	—062	—063	6-32 UNC (8X)
	Grooved butt	—064	—065	∅ 3,68 (8X)
WRD 750 D 24	FLat butt	—072	—073	6-32 UNC (2X) ∅ 3,68 (2X)
	Flat butt	—074	—075	6-32 UNC (4X)
	Flat butt	—076	—077	∅ 3,68 (4X)
	Grooved butt	—078	—079	6-32 UNC (2X) ∅ 3,68 (2X)
	Grooved butt	—080	—081	6-32 UNC (4X)
	Grooved butt	—082	—083	∅ 3,68 (4X)

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Waveguide and Flange Data

Rectangular waveguides

Frequency range GHz	Cut-off freq TE_{10} Mode GHz	Waveguide designation					Band prefix	Waveguide Inner cross-section 153-IEC*		
		153-IEC*	British standard	Retma	brass	Jan RG-/U alum		Width mm	Height mm	Tolerance on width and height ±
1,12—1,7	0,908	R14	WG6	WR650	69	103	L	165,10	82,55	0,33
1,45—2,2	1,158	R18	WG7	WR510	—	—	D	129,54	64,77	0,26
1,7—2,6	1,375	R22	WG8	WR430	104	105	—	109,22	54,61	0,22
2,2—3,3	1,737	R26	WG9A	WR340	112	113	—	86,36	43,18	0,17
2,6—3,95	2,080	R32	WG10	WR284	48	75	S	72,14	34,04	0,14
3,3—4,9	2,579	R40	WG11A	WR229	—	—	A	58,17	29,083	0,12
3,95—5,85	3,155	R48	WG12	WR187	49	95	G	47,55	22,149	0,095
4,9—7,05	3,714	R58	WG13	WR159	—	—	C	40,39	20,193	0,081
5,85—8,2	4,285	R70	WG14	WR137	50	106	J	34,85	15,799	0,070
7,05—10	5,260	R84	WG15	WR112	51	68	H	28,499	12,624	0,057
7—11	5,790	—	—	WR102	—	320	T	25,90	12,95	0,125
8,2—12,4	6,560	R100	WG16	WR90	52	67	X	22,860	10,160	0,046
10—15	7,873	R120	WG17	WR75	—	—	M	19,050	9,525	0,038
12,4—18	9,490	R140	WG18	WR62	91	107	P	15,799	7,899	0,031
15—22	11, 578	R180	WG19	WR51	—	—	—	12,954	6,477	0,026
18—26,5	14,080	R220	WG20	WR42	53	121	—	10,668	4,318	0,021
22—33	17,368	R260	WG21	WR34	—	—	—	8,636	4,318	0,020
26,5—40	21,100	R320	WG22	WR28	96	—	Q	7,112	3,556	0,020

* IEC Recommendations are obtainable from:
Central Office of the International Electrotechnical Commission
1, rue de Varembé
GENEVA, Switzerland

Double-ridge waveguides

Type	Bandwidth ratio 2,4:1							$f=\sqrt{3}\cdot f_{e10}$	
	Frequency range GHz	f_{e10} GHz	f_{e20} GHz	Dimensions in mm				Attenuation in dB/m for copper waveguide. Theoretical value	Theoretical power handling capacity MW[1]
				a	b	d	s		
WRD 150 D 24	1,50—3,60	1 249	3 692	87,76	40,82	17,35	21,95	0.0194	0.446
WRD 200 D 24	2,00—4,80	1,666	4 925	65,78	30,61	13,00	16,46	0.0298	0.251
WRD 350 D 24	3,50—8,20	2 915	8 620	37,59	17,48	7,42	9,40	0.0696	0.0819
WRD 475 D 24	4,75—11,00	3 961	11 705	27,69	12,85	5,46	6,91	0.109	0.0444
WRD 650 D 28	6,50—18,00*	—	—	18,29	8,15	2,56	4,39	—	—
WRD 750 D 24	7,50—18,00	6 239	18 464	17,55	8,15	3,45	4,39	0.217	0.0178
DR 19	7,50—11,00	4,1	—	26,04	12,06	4,85	6,50	—	—

* Bandwidth ratio 2,8:1. f_{c10}=cut-off frequency for TE_{10}-mode
f_{c20}=cut-off frequency for TE_{20}-mode

[1] Based on breakdown of air —15 000 volt per cm (safety factor of approx 2 at sea level) corner radii considered.

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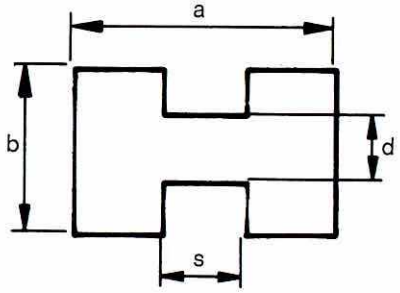
Waveguide and Flange Data

Waveguide Outer cross-section 153-IEC*			Attenuation in dB/M for copper waveguide 153-IEC*			Theoretical peak power rating** lowest to highest frequency MW
Width mm	Height mm	Tolerance on width and height ±	Frequency GHz	Theoretical value	Maximum value	
169,16	86,61	0,20	1,36	0,00522	0,007	12,0—17,0
133,60	68,83	0,20	1,74	0,00749	0,010	7,5—11,0
113,28	58,67	0,20	2,06	0,00970	0,013	5,2—7,5
90,42	47,24	0,17	2,61	0,0138	0,018	3,4—4,8
76,20	38,10	0,14	3,12	0,0189	0,025	2,2—3,2
61,42	32,33	0,12	3,87	0,0249	0,032	1,6—2,2
50,80	25,40	0,095	4,73	0,0355	0,046	0,94—1,32
43,64	23,44	0,081	5,57	0,0431	0,056	0,79—1,0
38,10	19,05	0,070	6,46	0,0576	0,075	0,56—0,71
31,75	15,88	0,057	7,89	0,0794	0,103	0,35—0,46
29,16	16,21	0,125	—	—	—	0,33—0,43
25,40	12,70	0,05	9,84	0,110	0,143	0,20—0,29
21,59	12,06	0,05	11,8	0,133	—	0,17—0,23
17,83	9,93	0,05	14,2	0,176	—	0,12—0,16
14,99	8,51	0,05	17,4	0,238	—	0,080—0,107
12,70	6,35	0,05	21,1	0,370	—	0,043—0,058
10,67	6,35	0,05	26,1	0,435	—	0,034—0,048
9,14	5,59	0,05	31,6	0,583	—	0,022—0,031

** Based on breakdown of air of 15 000 volts per cm (safety factor of approx 2 at sea level)



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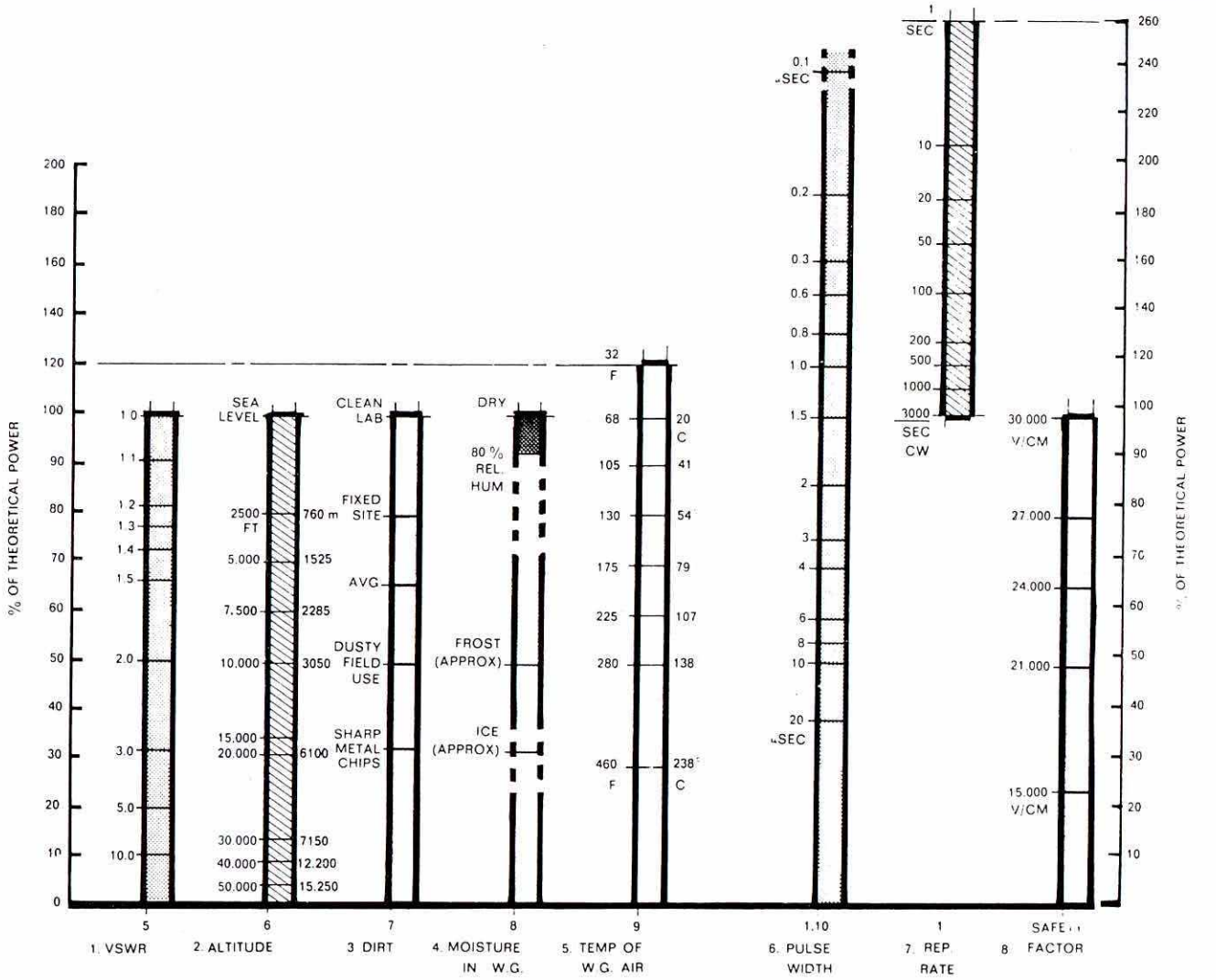
Formulas



System parameters affecting waveguide power handling capacity are derived by aligning each parameter horizontally with the vertical scales.

How to use the chart

Consider a ground-based radar set used from sea level to 10000 feet, which operates with a peak output of 4 MW at 3.9 GHz. The pulse width is 6 µsec at 300 pulses per second, and the VSWR at the transmitter output is 1.4 using WR 284 waveguide. System components most directly affecting the power capacity includes straight waveguide and bends, side wall couplers and rotary joint with a type door knob transition. The temperature at 10000 feet, the extreme case, is approximated at 90° due to ambient plus 20° temperature rise due to signal attenuation in the waveguide, a total of 110 °F.

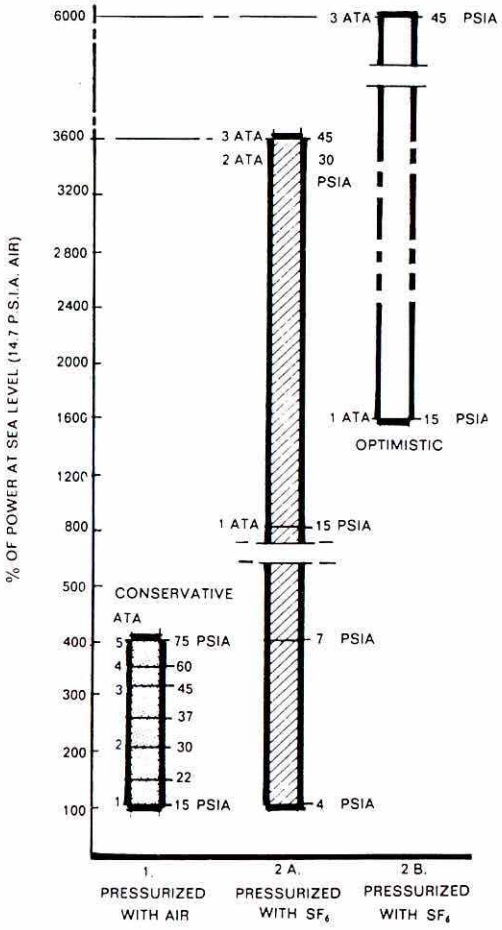
From Figure 1 using a straight edge, the percentages of theoretical power realized due to each condition may be read off as follows:

VSWR of 1.4 results in 73%.
Altitude of 10000 feet results in 50%.
Dirt (fixed site) results in 80%.
Temperature (110F) results in 88%.
Pulse width (6 msec) results in 60%.
Repetition rate (300) results in 125%.
Safety factor, E (using 30000 V/cm) results in 100%.
(No safety factor will be considered in this first try).
Components result in 35%.
(The rotary joint is the critical one here).

The cumulative effect of all these parameters is found by multiplying all percentages; (0.73 (0.50) (0.80) (0.88) (0.60) (1.25) (1.00) (0.35) = 0.0675 or 6.75%.

The rapid calculation indicates that under practical operating conditions, the waveguide system can only handle 6.75% of the theoretical power of 10 MW or 675000 W peak. This figure does not even approach the desired peak power output of the radar of 4 MW, so steps must be taken to increase the power handling capacity of the system.

Formulas



Ways to increase power handling capacity include pressurizing with air or SF, as well as special methods such as cooling, purging air through the guide, or creating special waveguide sizes.

Pressurization

Since Figure 1 is referenced to power handling capacity with 14.7 psia or 1 atmosphere (air) in the waveguide line and in the previous calculations it was assumed an altitude of 10000 feet existed (resulting in 50% of theoretical power), the next step is to re-evaluate the power capacity at sea level. From Figure 1, 14.7 psia power equals 100% of the theoretical. Therefore , with 14.7 psia (air) in the waveguide, the power capacity is double that at 10000 feet or 1.35 MW. To further increase the system power capacity, various means described in Figure 1 may be considered. The most common used method consists of pressurizing the system (waveguide and related components) with air since this is readily available and equipment for this purpose is available from numerous manufacturers at reasonable prices and delivery. Since the desired power to carry 4 MW and the power handled at 15 psia is 13.5 MW, the increase still required = 4.00/1.35*100 = 300%. On reading the pressurized with air scale at 300% it is seen that an air pressure of approximately 41 psia is required. By using 45 psia (35 psi gauge at 10000 feet altitude) a safety factor will be introduced. Since pressurization is required, all components in the line must be designed to withstand this pressure.

MICROWAVES, June 1972, J.Ciavolella

Formulas

Reflection

VSWR : Voltage Standing Wave Ratio. E_{max} / E_{min} along the line.
ϱ : Voltage reflection coefficient. $E_{refl} / E_{incident}$
RL (dB) : Return Loss (reflected power)

$$VSWR = \frac{1+\varrho}{1-\varrho} \qquad \varrho = \frac{VSWR-1}{VSWR+1} \qquad RL = -20 \log \varrho$$

RL variation caused by reflections from two points

$$RL_{1,2} = 20 \log (1 \pm \varrho_1 \cdot \varrho_2)$$

For small VSWR's (<1,5) the total VSWR is

max: $VSWR_1 * VSRW_2$
min: $VSWR_1 / VSWR_2$

For a line with characteristic impedance Z_o terminated in a resistive load R

$$VSWR = \frac{Z_o}{R} \quad \text{for } R<Z_o \quad \text{and} \quad = \frac{R}{Z_o} \quad \text{for} \quad R>Z_o$$

Transmission

$$\text{Power relation (dB)} = 10 \log \frac{P_1}{P_2}$$

Maximum Voltage along line with VSWR: $E_{max} = E_i (1+\varrho)$

Incident, Transmitted and Reflected Power in a zero-loss line.

$$\frac{P_r}{P_i} = \varrho^2 \qquad \frac{P_t}{P_i} = 1-\varrho^2 = \frac{4\,VSWR}{(VSWR+1)^2}$$

Mismatch loss (dB) $= -10 \log (1-\varrho^2)$

Characteristic impedance

for a Coaxial line $Z_o = \frac{138}{\sqrt{\epsilon}} \log \frac{D}{d}$ (ϵ=dielectric constant, $\epsilon = 1$ in air)

for Rectangular Waveguide $Z_o = k\,377 \frac{b}{a} \frac{\lambda_g}{\lambda_o}$;

a = broad side and b = short side of waveguide

k is approx 1 to 2 depending of way of definition.

Formulas

Wavelength

for free space $\lambda_o = \frac{c}{f}$

for Coaxial line $\lambda = \lambda_o / \sqrt{\epsilon}$

for Waveguide $\lambda_g = \frac{\lambda_o}{\sqrt{1-\left(\frac{\lambda_o}{\lambda_c}\right)^2}}$

λ_c = Cut off Wavelength: (corresponding to lowest frequency which can pass the line)

For coaxial line; Fundamental TEM mode. Cut off: None

Next higher order mode TE_{11}. λ_c approx. $= \frac{\pi}{2}(D+d)$

Attenuation for TE_{11} below Cut off: $\alpha\,(dB/\lambda) = \frac{54{,}6}{\lambda_c}\sqrt{1-\left(\frac{\lambda_c}{\lambda}\right)^2}$

For Rectangular Waveguide: TE_{10} $\lambda_c = 2a$

Next higher mode: TE_{20} $\lambda_c = a$

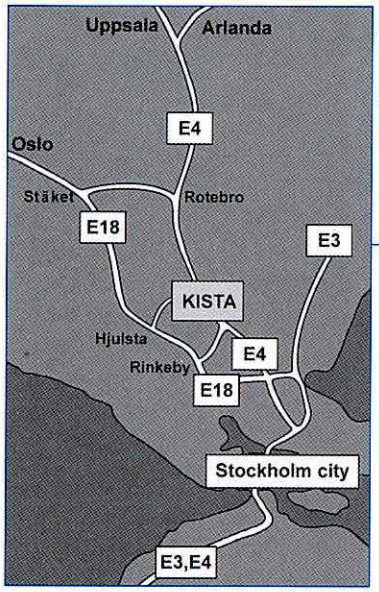
Attenuation well below Cut off frequency: $\alpha(dB/\lambda) = 54{,}6\,\frac{1}{\lambda_c}$

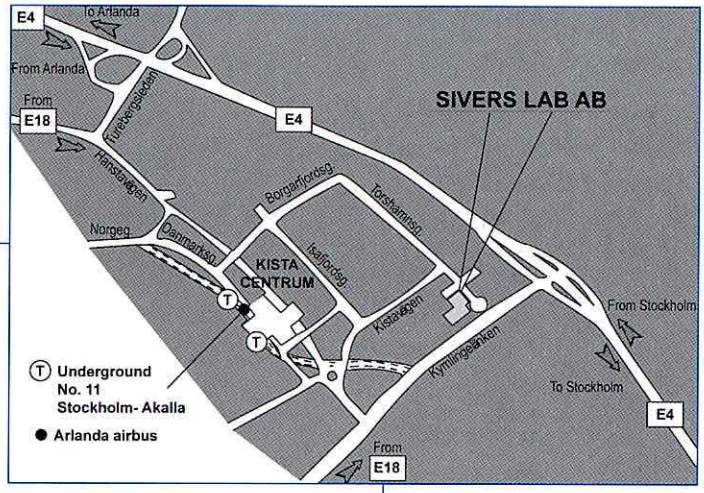
VSWR	ϱ	RL (dB)	Trans. loss (dB)	Trans. power %	Refl. power %
1,0	0		0	100	0
1,05	0,02	32,3	0,002	99,9	0,1
1,1	0,05	26,4	0,010	99,8	0,2
1,15	0,07	23,1	0,021	99,5	0,5
1,2	0,09	20,8	0,036	99,2	0,8
1,25	0,11	19,1	0,054	98,8	1,2
1,3	0,13	17,7	0,075	98,3	1,7
1,35	0,15	16,5	0,10	97,8	2,2
1,4	0,17	15,6	0,12	97,2	2,8
1,45	0,18	14,7	0,15	96,6	3,4
1,5	0,20	14,0	0,18	96,0	4,0
1,55	0,21	13,3	0,21	95,3	4,7
1,6	0,23	12,7	0,24	94,7	5,3
1,7	0,26	11,7	0,30	93,3	6,7
1,8	0,29	10,9	0,37	91,8	8,2
1,9	0,31	10,2	0,44	90,4	9,6
2,0	0,33	9,5	0,51	88,9	11,1
2,5	0,43	7,4	0,88	81,6	18,4
3,0	0,5	6,0	1,25	75	25

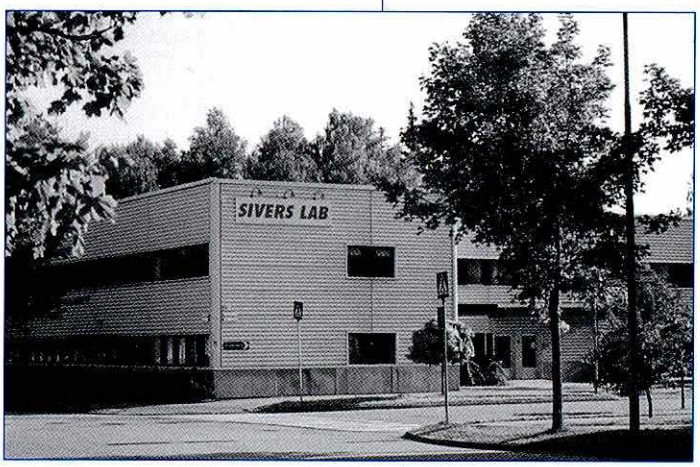
Power: P
1 mW = 0 dBm,
1 W = 30 dBm,
1 kW = 60 dBm,
1 MW = 90 dBm

Ref.: Ragan; Microwave Transmission Circuits, MacGraw Hill 1948
Moreno; Microwave Design Data. Dover publications 1948.
The Microvawe Engineers Handbook, Horizon House 1963.

Index







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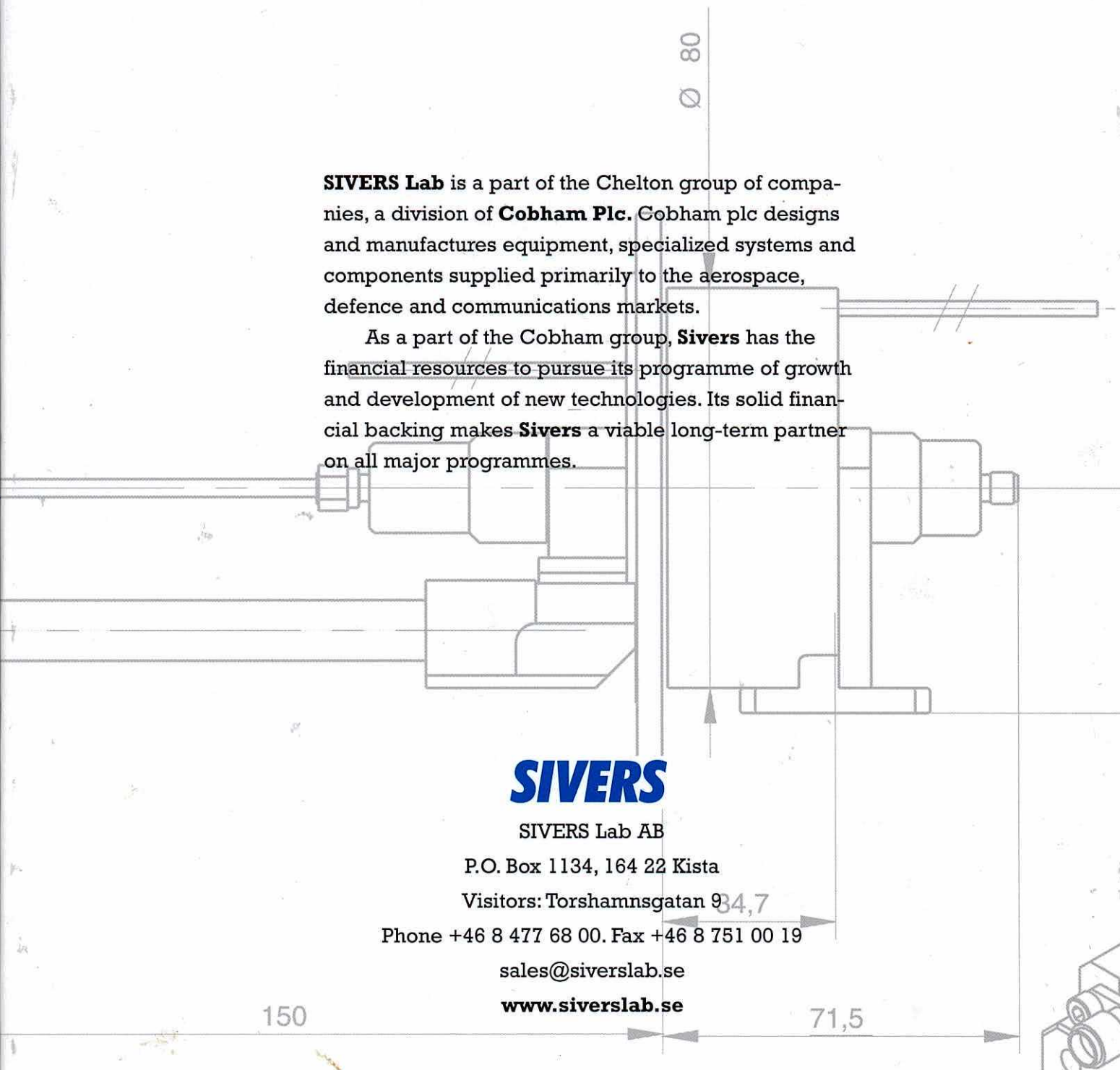

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