

# Adjusting Phase



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AdjustingPhase2

II. Computer Controlled  
Phase Adjusters  
50 - 40 GHz



IV.  
Trombone  
Phase Adjusters



HOT NEW HIGHLIGHTS

VI. Phase Matched  
Cable Assemblies



Match in Delay



RECENT

Spectrum Elektrotechnik GmbH is a leading manufacturer of RF and Microwave Components in the Frequency Range of DC to 65 GHz. The products are published in eight individual catalogs, showing detailed information and comprehensive data.

**Adapters, DC - 65 GHz, 50 Ohms**

Coaxial Adapters (In Series and Between Series)  
High Power Adapters  
Push-On Adapters  
Waveguide to Coax Adapters

**Connectors, DC - 65 GHz, 50 Ohms**

Blind Mate Connectors  
Coaxial Connectors  
High Power Connectors  
Multi Pin Connectors  
Push-On Connectors

**Cable Assemblies, DC - 65 GHz, 50 Ohms**

ANA Test Cables  
Flexible Cable Assemblies  
Low Loss Cable Assemblies  
Phase Stable Cable Assemblies  
Semi Rigid Cable Assemblies (Dia. 0.034" to 1")

**Test Necessities and Accessories, DC - 65 GHz, 50 Ohms**

LRL, TRL Calibration and Verification Kits  
ANA Cable Assemblies  
Torque Wrenches  
Interface Gauges  
Calibration Kits  
Terminations

**Components, 50 Ohms**

Attenuators  
Circulators  
CDM-Components  
Couplers  
Custom Components  
DC-Blocks  
Duplexers  
Gain-Equalizers  
Isolators  
Limiters  
Mismatches  
Phase Shifters  
Terminations  
Waveguide Components

**Quick Connections, 50 Ohms**


Blind Mate Connectors  
Push - On Adapters  
Push - On Connectors  
Push - On Cable Assemblies  
SQ-Series, Multi Coax Connections

**Components, 75 Ohms**

Adapters  
Connectors

**Machines and Tools**

Coax Cable Cutting/Stripping Machines  
Flex Cable Cutting/Stripping Machines



**I. Phase Adjusters**  
in flat pack housings

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**II. Computer Controlled Phase Adjusters**  
DC - 18 GHz



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**III. Phase Adjustable Adapters**



DC - 12 GHz  
DC - 18 GHz  
DC - 26 GHz  
DC - 40 GHz  
DC - 58 GHz  
DC - 65 GHz

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**IV. Trombone Phase Adjusters**



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**V. Phase Adjustable Connectors**



In many cases the phase adjustable units look like regular connectors.

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**VI. Phase Matched Cable Assemblies**



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Some Information on other Products  
Pages 40, 48, 50, 51 and 52

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Exploring new methods  
Generating Solutions  
Creating Intelligence



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**Hermetically Sealed Adapters**



**Handy Form**

**de Equalizers in Equalizers**  
6, and linear or slope  
8 GHz to 32.8 GHz

**WG/Coax Adapters**



**SpectrumFlex**

Contents

**INTRODUCTION:** The Precision Phase Shifters, or Phase Adjusters allow the adjustment of the electrical separation between components. A precision mechanical movement provides for smooth and accurate adjustment over the entire frequency range. A secure locking mechanism is furnished with every unit. A wide selection of components is available, offering different mechanical configuration, frequency range, electrical length, and/or connector configuration.

**Phase Adjustment:** The Phase Shifters are mechanical devices, therefore the change of phase depends on the adjustment of the electrical length of a line. For lower frequencies or longer phase adjustments, a trombone line is usually used; for higher frequencies or shorter adjustment, only a straight line may be sufficient. Using an air line results in low insertion loss and good VSWR. The designs of Spectrum Elektrotechnik GmbH employ air lines, whenever possible.

**Frequency Range:** Phase Adjusters are available for different frequency ranges, DC-2.0 GHz, DC-12.4 GHz, DC-18.0 GHz, DC-26.5 GHz, DC-40.0 GHz, DC-50.0 GHz, and DC-65.0 GHz. For economical reasons the components have been engineered for these different frequency bands. A rather simple design will meet all the requirements at lower frequency ranges, while only a most precise design will work satisfactorily at highest frequencies.

**Connector Configuration:** Most of the Phase Adjusters of Spectrum Elektrotechnik GmbH are available with different connector configurations, providing that the frequency range of the connectors do not limit the frequency range of the application. The flatpack phase adjusters can be supplied with 7mm, SMA, N, and TNC, males and females, as standard. Besides the units being supplied with connectors, using the same style but different sex at input and output, it is even possible to have a unit being supplied with connectors of completely different connector styles, e.g. N female as an input connector and SMA male as the output connector, etc.

The Adjustable Adapters and Components, serving to 26.5 GHz are offered with SMA connectors, and are available with male or female connectors at the in- and output or viceversa. To 40.0 GHz usually K\* connectors will be used, and to 50.0 GHz the 2.4mm connectors have been chosen. The ones that work up to 65.0 GHz are assembled with 1.85mm connectors.

**Applications:** Mostly Phase Adjusters will be needed in systems where the adjustment of the phase is done for only a few times. As soon as the phase is set properly as needed in the system, the unit will usually be locked, and remain in this position. In other applications the phase shifters are installed in test sets where the adjustment of phase is made continuously. For these applications, only the Phase Adjusters using ball bearing support and special mechanisms can be recommended.

**VSWR:** Every microwave component shows reflections and discontinuities within the circuit, as no design can be perfect, and manufacturing tolerances unfortunately do not allow theoretical results. VSWR is the ratio of the reflected signal and the incident signal. Phase Shifters are using a high number of parts. Therefore, the tolerances on the dimensions of the piece parts need to be as tight as possible not only for mechanical purposes, but also for electrical reasons, in order to assure that reflections cannot build up after some time of operation.


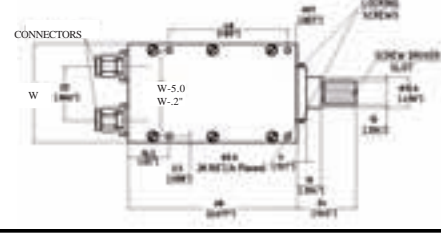
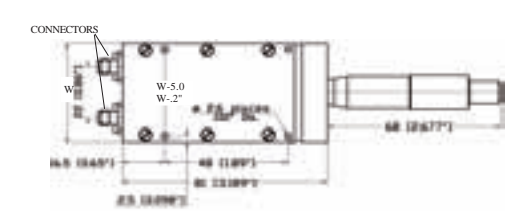
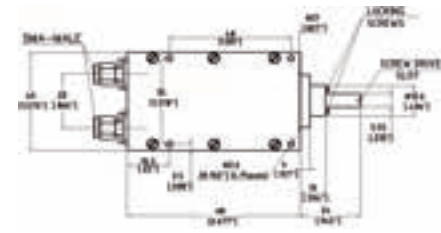

**Power:** The standard components are designed for low or moderate power applications. For higher power applications, units can be supplied as specials, engineered exactly to the customer's needs.

**Custom Units:** Although Spectrum Elektrotechnik GmbH offers a wide variety of standard phase adjusters, there will always be a need for a special component, using different mechanical configuration, wider phase adjustment, other frequency ranges, etc. Spectrum Elektrotechnik GmbH is a very innovative Company. It employs a strong and successful team of experienced engineers. They will always do their best to propose something that will perfectly fit the customer's needs.

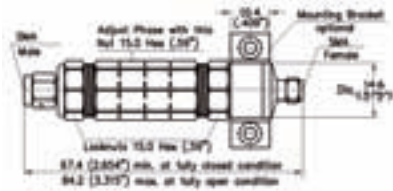
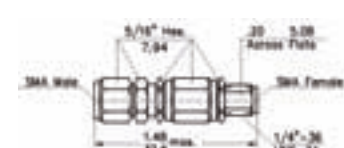
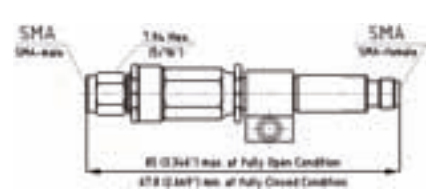
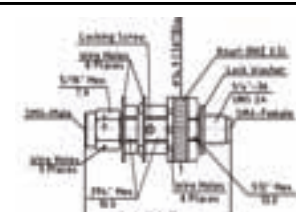
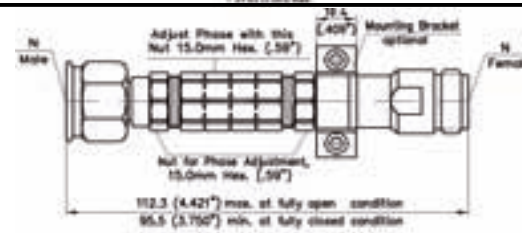
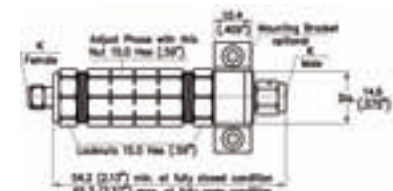
**Phase Adjuster Life:** The life expectancy of a unit will depend in the first place on the operating environment versus unit design. Secondly, it will depend on the lifetime of the ball bearings, seals and contact junctions. Other parameters that are limiting life are rotational speed and external mechanical loading, or pressurizing the unit. Harsh environment, subjecting the component to vibrations, shock, extremely low or high temperatures, humidity, etc. may further shorten the lifetime. It is therefore of utmost importance to identify in detail the environment the device is supposed to operate in.

If the unit is installed in a system where the phase only will be adjusted a few times, it would not be necessary to select a device that is using ball bearings in the design, vice versa will a phase adjuster cause trouble in an environment where it is constantly adjusted, when not the appropriate mechanical design will be used.

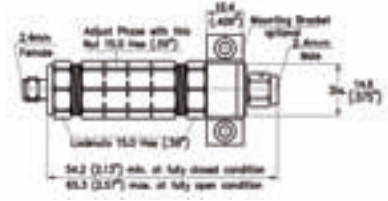
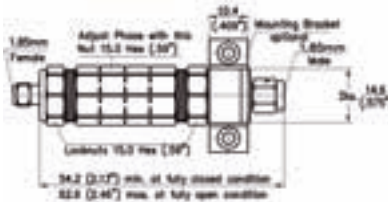
Spectrum Elektrotechnik GmbH has a large number of available designs. Please take the time to decide on the unit that fits exactly your requirements.

<b>I. Phase Adjusters</b>			
Frequency Range (GHz)	Features	Outline	Page
<b>DC - 2.0</b> <b>DC - 12.0</b> <b>DC - 18.0</b>	Phase Adjuster Series <b>LS-00...</b>  Main application: System  Available Connectors: 3.5mm, 7mm, N, SMA, and TNC.		<b>10</b>
<b>DC - 2.0</b> <b>DC - 12.0</b> <b>DC - 18.0</b>	Phase Adjuster using Ball Bearing Adjustment Series <b>LS-B0...</b>  Main application: Test Set  Available Connectors: 3.5mm, 7mm, N, SMA, and TNC.		<b>12</b>
<b>DC - 2.0</b> <b>DC - 12.0</b> <b>DC - 18.0</b>	Phase Adjuster with Micrometer Adjustment Series <b>LS-M...</b>  Main application: Test Set  Available Connectors: 3.5mm, 7mm, N, SMA, and TNC.		<b>14</b>
<b>DC - 12.0</b>	Phase Adjuster with in line locking screws <b>LS-S012-2121</b>  Main application: System  Available Connectors: SMA female to SMA female		<b>16</b>
<b>II. Computer Controlled Phase Adjuster</b>			
Frequency Range (GHz)	Features	Preview	Page
<b>DC - 18.0</b>	Low Cost Computer Controlled Phase Adjuster  700° @ 18 GHz		<b>17</b>

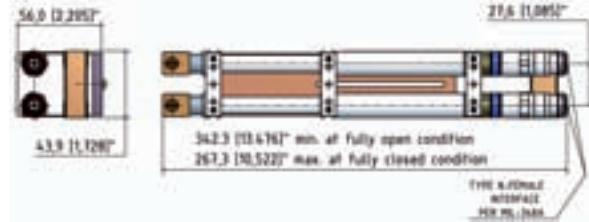
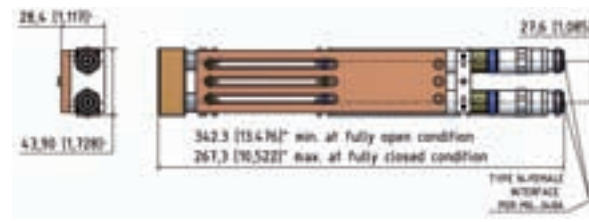
# Selection Chart

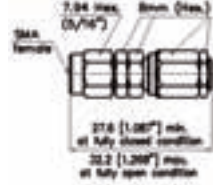
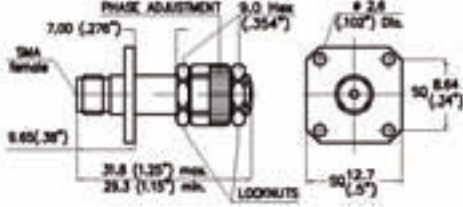
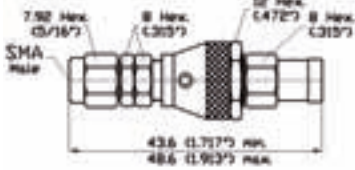
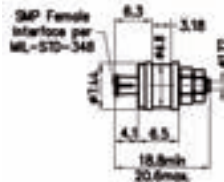

III. Phase Adjustable Adapters			
Page	Frequency Range (GHz)	Features	Outline
22	DC - 12.0 DC - 18.0 DC - 26.0	Phase Adjustable Adapter Main application: System Available Connectors: SMA	
25	DC - 26.0	Phase Adjustable Adapter <b>LS-0170-1121</b> Main application: System Available Connectors: SMA	
26	DC - 26.0	Phase Adjustable Adapter <b>LS-0321-1121</b> Main application: System Available Connectors: SMA	
27	DC - 26.0	Phase Adjustable Adapter <b>LS-S008-1121</b> Main application: System/Test Set Available Connectors: SMA	
28	DC - 18	Phase Adjustable Adapter <b>LS-...118-5161</b> Main application: System Available Connectors: N	
30	DC - 40.0	Phase Adjustable Adapter Series <b>LS-...140-KFKM</b> Main application: System/Test Set Available Connectors: K*	

## III. Phase Adjustable Adapters

Frequency Range (GHz)	Features	Outline	Page
DC - 50.0	<p>Phase Adjustable Adapter Series <b>LS-...150-HFHM</b></p> <p>Main application: System/Test Set</p> <p>Available Connectors: 2.4 mm</p>		32
DC - 63.0	<p>Phase Adjustable Adapter Series <b>LS-...165-VFVM</b></p> <p>Main application: System/Test Set</p> <p>Available Connectors: 1.85mm</p>		34

## IV. Trombone Phase Adjusters

Frequency Range (GHz)	Features	Outline	Page
DC - 3.0	<p>Trombone Phase Adjuster: <b>LS-0103-6161</b></p> <p>Main application: System/Test Set</p> <p>Available Connectors: N</p>		37
DC - 3.0	<p>Trombone Phase Adjuster: <b>LS-0203-6161</b></p> <p>Main application: System/Test Set</p> <p>Available Connectors: N</p>		37

<b>V. Phase Adjustable Connectors</b>			
Page	Frequency Range (GHz)	Features	Outline
<b>42</b>	<b>DC - 26.0</b>	Phase Adjustable Cable Connector of Type SMA Main application: System Available Connectors: SMA	
<b>42</b>	<b>DC - 18.0</b>	Phase Adjustable Cable Connector of Type SMA Series <b>LS-0085-S001</b> Main application: System Available Connectors: SMA	
<b>43</b>	<b>DC - 18.0</b>	Phase Adjustable Cable Connector of Type SMA Series <b>LS-0200-02</b> Main application: System Available Connectors: SMA	
<b>44</b>	<b>DC - 18.0</b>	Phase Adjustable Cable Connector of Type SMP Series <b>1102-65LS-04</b> Main application: System Available Connectors: SMP	
<b>VI. Phase and Delay Matched Cable Assemblies</b>			
Page	Frequency Range (GHz)	Features	Preview
<b>45</b>	<b>DC - 65.0</b>	Cable Assemblies and Harnesses and Delay Lines	





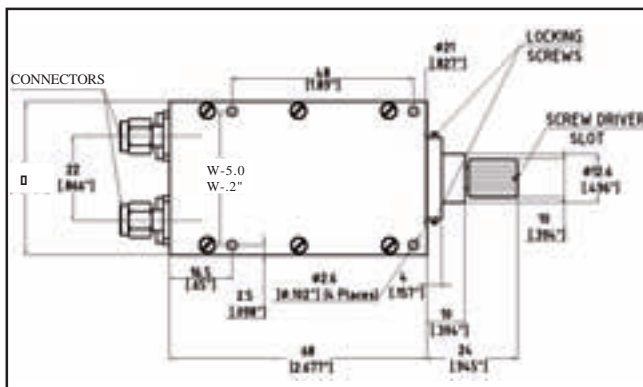
# **I. Phase Adjusters in flat pack housings**

# Phase Adjusters

DC to 2.0 GHz  
 DC to 12.0 GHz  
 DC to 18.0 GHz

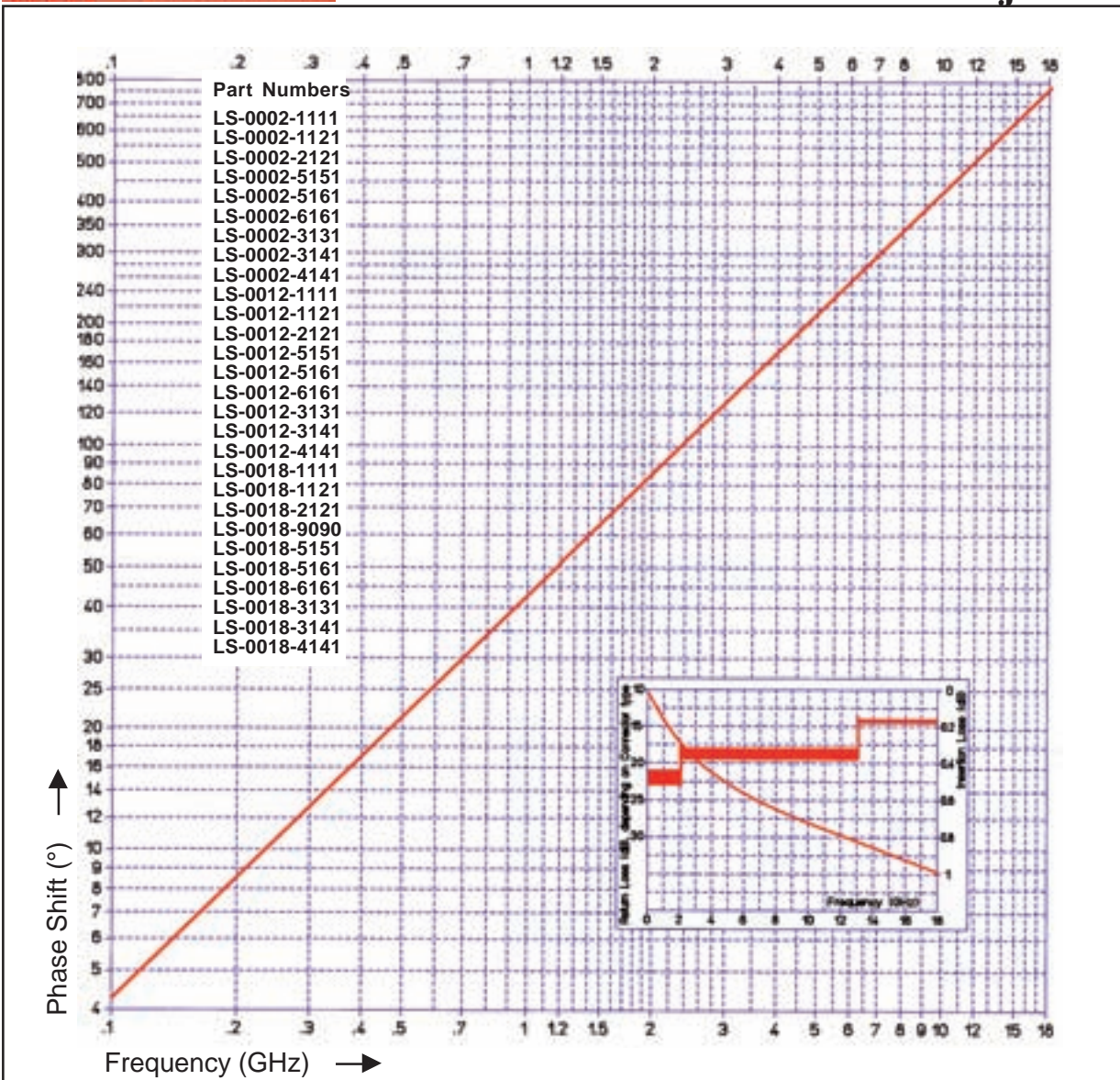


- **Application: System Use:**  
 "Set to the electrical length and lock."
- Precision Phase Adjusters, DC to 2.0, 12.0 and 18.0 GHz.
- Small housing, flat pack configuration.
- Housing Finish: Iridited. On special request, painting can be supplied.
- Four mounting locations are provided.
- Impedance of 50 Ohms is maintained over the full adjustment range.
- Positive resettable locking mechanism.
- Smooth continuous phase adjustment.
- Internal Trombone Line, no external physical length change.
- Rugged construction: housing is made from aluminum, connector outer conductors from stainless steel.
- Bead captivated center contacts.
- Spring fingers and center contacts are made from beryllium copper, heat treated and gold plated per MIL-G-45204, Type II, Grade C.



- Different connector configurations available, such as 3.5mm, 7mm, SMA, N, and TNC. For other connector configurations, please consult the factory.
- Operating temperature range: -54°C to +115°C.

Part Number	Frequency	VSWR max.	R.F. Insertion Loss	Phase Shift	Connectors	Outline Dimensions		
						Length	Width	Height
LS-0002-1111	DC to 2.0 GHz	1.15 : 1	0.3 dB max. at 2.0 GHz	85° min. at 2.0 GHz	SMA-M / SMA-M	68 mm 2.677"	42 mm 1.654"	12.7 mm .500"
LS-0002-1121					SMA-M / SMA-F			
LS-0002-2121					SMA-F / SMA-F			
LS-0002-5151		1.20 : 1	0.3 dB max. at 2.0 GHz	85° min. at 2.0 GHz	N - M / N - M	68 mm 2.677"	42 mm 1.654"	22 mm .866"
LS-0002-5161					N - M / N - F			
LS-0002-6161					N - F / N - F			
LS-0002-3131					TNC-M / TNC-M			
LS-0002-3141					TNC-M / TNC-F			
LS-0002-4141					TNC-F / TNC-F			
LS-0012-1111	DC to 12.0 GHz	1.25 : 1	0.8 dB max. at 12.0 GHz	520° min. at 12.0 GHz	SMA-M / SMA-M	68 mm 2.677"	40 mm 1.575"	12.7 mm .500"
LS-0012-1121					SMA-M / SMA-F			
LS-0012-2121					SMA-F / SMA-F			
LS-0012-5151		1.30 : 1	0.8 dB max. at 12.0 GHz	520° min. at 12.0 GHz	N - M / N - M	68 mm 2.677"	42 mm 1.654"	22 mm .866"
LS-0012-5161					N - M / N - F			
LS-0012-6161					N - F / N - F			
LS-0012-3131					TNC-M / TNC-M			
LS-0012-3141					TNC-M / TNC-F			
LS-0012-4141					TNC-F / TNC-F			
LS-0018-1111	DC to 18.0 GHz	1.50 : 1	1.0 dB max. at 18.0 GHz	770° min. at 18.0 GHz	SMA-M / SMA-M	68 mm 2.677"	40 mm 1.575"	12.7 mm .500"
LS-0018-1121					SMA-M / SMA-F			
LS-0018-2121					SMA-F / SMA-F			
LS-0018-9090		1.50 : 1	1.0 dB max. at 18.0 GHz	770° min. at 18.0 GHz	7 mm / 7 mm	68 mm 2.677"	70 mm 2.756"	30 mm 1.181"
LS-0018-5151					N - M / N - M			
LS-0018-5161					N - M / N - F			
LS-0018-6161					N - F / N - F			
LS-0018-3131					TNC-M / TNC-M			
LS-0018-3141					TNC-M / TNC-F			
LS-0018-4141	TNC-F / TNC-F							



Part Number	LS - 0002 - xxxx	LS - 0012 - xxxx	LS - 0018 - xxxx
	xxxx: connector configuration, for details please refer to the table to the left		
Frequency Range (GHz)	DC - 2.0	DC - 12.0	DC - 18.0
Min. Phase Shift (°)	85	520	770
Nominal Phase Shift Deg. / GHz / Shaft Turn	1.15	1.15	1.15
Max. number of Turns	37	37	37
Time Delay (psec)	min.	393	406
	max.	516	530

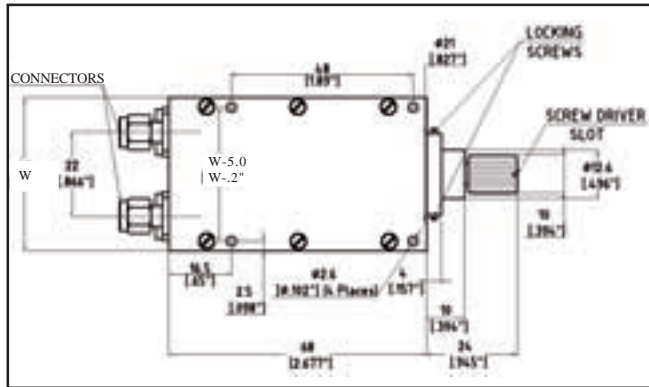
# Phase Adjusters with Ball Bearing Support

DC to 2.0 GHz  
 DC to 12.0 GHz  
 DC to 18.0 GHz



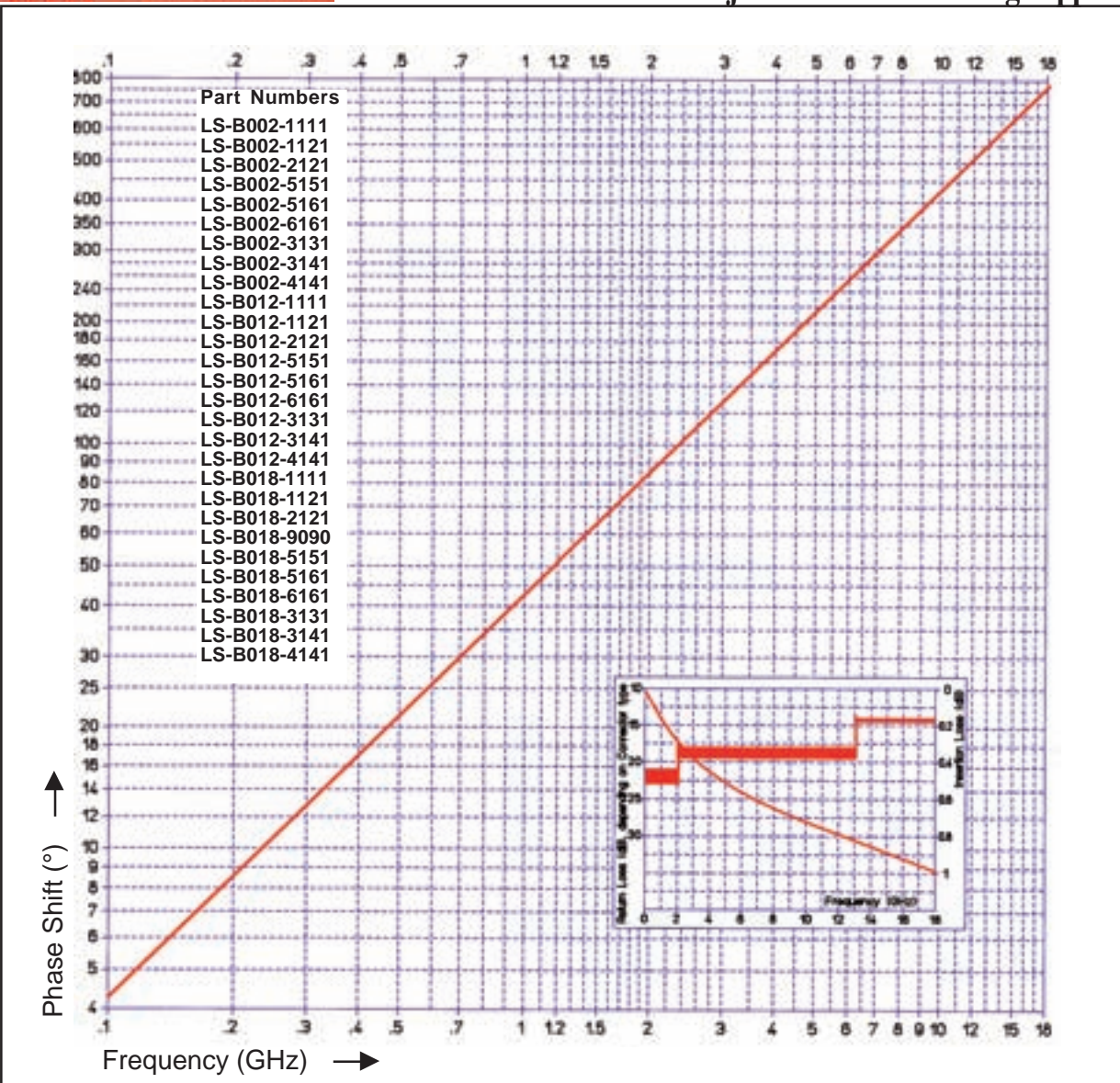
**Spectrum**  
 Elektrotechnik GmbH

- **Application: Test Set & System Use:**  
 "Adjust the electrical length many times"
- Ball Bearings adjustment.
- Precision Phase Adjusters, DC to 2.0, 12.0, and 18.0 GHz.
- Small housing, flat pack configuration.
- Housing Finish: Iridited. On special request, painting can be supplied.
- Four mounting locations are provided.
- Impedance of 50 Ohms is maintained over the full adjustment range.
- Positive resettable locking mechanism.
- Smooth continuous phase adjustment.
- Internal Trombone Line, no external physical length change.
- Rugged construction: housing is made from aluminum, connector outer conductors from stainless steel.
- Bead captivated center contacts.
- Spring fingers and center contacts are made from beryllium copper, heat treated and gold plated per MIL-G-45204, Type II, Grade C.



- Different connector configurations available, such as 3.5mm, 7mm, SMA, N, and TNC. For other connector configurations, please consult the factory.
- Operating temperature range: -54°C to +115°C.

Part Number	Frequency	VSWR max.	R.F. Insertion Loss	Phase Shift	Connectors	Outline Dimensions		
						Length	Width	Height
LS-B002-1111	DC to 2.0 GHz	1.15 : 1	0.3 dB max. at 2.0 GHz	85° min. at 2.0 GHz	SMA-M / SMA-M	68 mm 2.677"	42 mm 1.654"	12.7 mm .500"
LS-B002-1121					SMA-M / SMA-F			
LS-B002-2121					SMA-F / SMA-F			
LS-B002-5151		1.20 : 1	0.3 dB max. at 2.0 GHz	85° min. at 2.0 GHz	N - M / N - M	68 mm 2.677"	42 mm 1.654"	22 mm .866"
LS-B002-5161					N - M / N - F			
LS-B002-6161					N - F / N - F			
LS-B002-3131					TNC-M / TNC-M			
LS-B002-3141					TNC-M / TNC-F			
LS-B002-4141					TNC-F / TNC-F			
LS-B012-1111	DC to 12.0 GHz	1.25 : 1	0.8 dB max. at 12.0 GHz	520° min. at 12.0 GHz	SMA-M / SMA-M	68 mm 2.677"	40 mm 1.575"	12.7 mm .500"
LS-B012-1121					SMA-M / SMA-F			
LS-B012-2121					SMA-F / SMA-F			
LS-B012-5151		1.30 : 1	0.8 dB max. at 12.0 GHz	520° min. at 12.0 GHz	N - M / N - M	68 mm 2.677"	42 mm 1.654"	22 mm .866"
LS-B012-5161					N - M / N - F			
LS-B012-6161					N - F / N - F			
LS-B012-3131					TNC-M / TNC-M			
LS-B012-3141					TNC-M / TNC-F			
LS-B012-4141					TNC-F / TNC-F			
LS-B018-1111	DC to 18.0 GHz	1.50 : 1	1.0 dB max. at 18.0 GHz	770° min. at 18.0 GHz	SMA-M / SMA-M	68 mm 2.677"	40 mm 1.575"	12.7 mm .500"
LS-B018-1121					SMA-M / SMA-F			
LS-B018-2121					SMA-F / SMA-F			
LS-B018-9090		1.50 : 1	1.0 dB max. at 18.0 GHz	770° min. at 18.0 GHz	7 mm / 7 mm	68 mm 2.677"	70 mm 2.756"	30 mm 1.181"
LS-B018-5151					N - M / N - M			
LS-B018-5161					N - M / N - F			
LS-B018-6161					N - F / N - F			
LS-B018-3131					TNC-M / TNC-M			
LS-B018-3141					TNC-M / TNC-F			
LS-B018-4141	TNC-F / TNC-F							



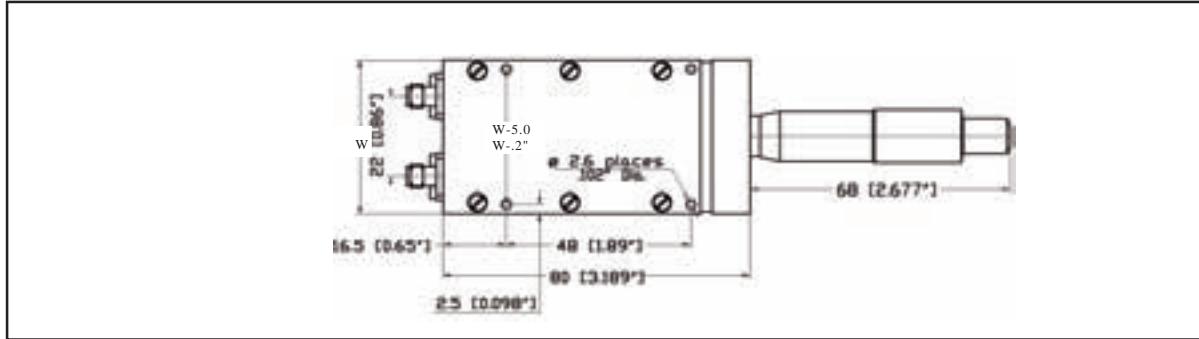
Part Number	LS - B002 - xxxx	LS - B012 - xxxx	LS - B018 - xxxx
	xxxx: connector configuration, for details please refer to the table to the left		
Frequency Range (GHz)	DC - 2.0	DC - 12.0	DC - 18.0
Min. Phase Shift (°)	85	520	770
Nominal Phase Shift Deg. / GHz / Shaft Turn	1.15	1.15	1.15
Max. number of Turns	37	37	37
Time Delay (psec)	min.	393	406
	max.	516	530

# Phase Adjusters with Micrometer Adjustment

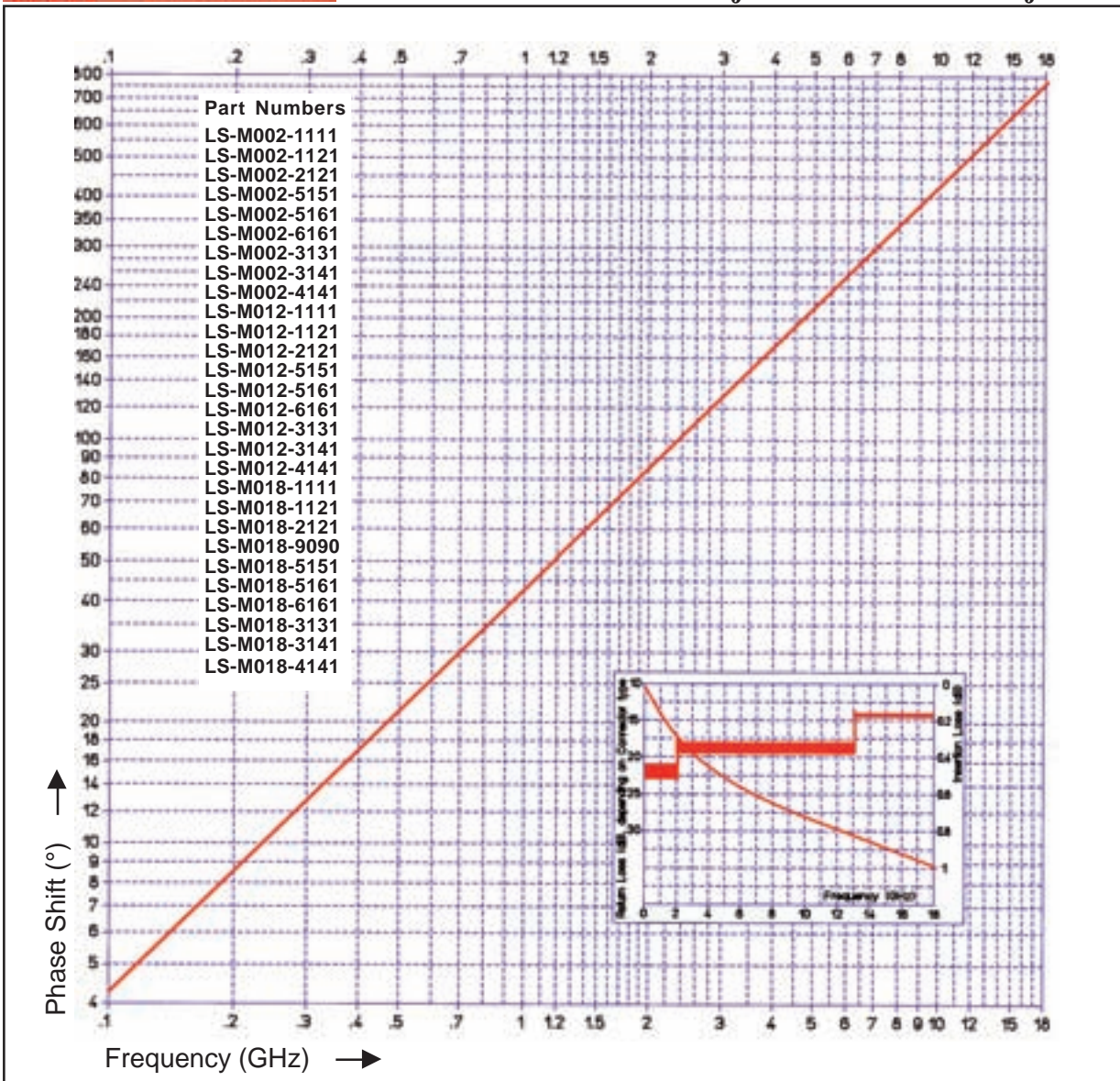
DC to 2.0 GHz  
DC to 12.0 GHz  
DC to 18.0 GHz



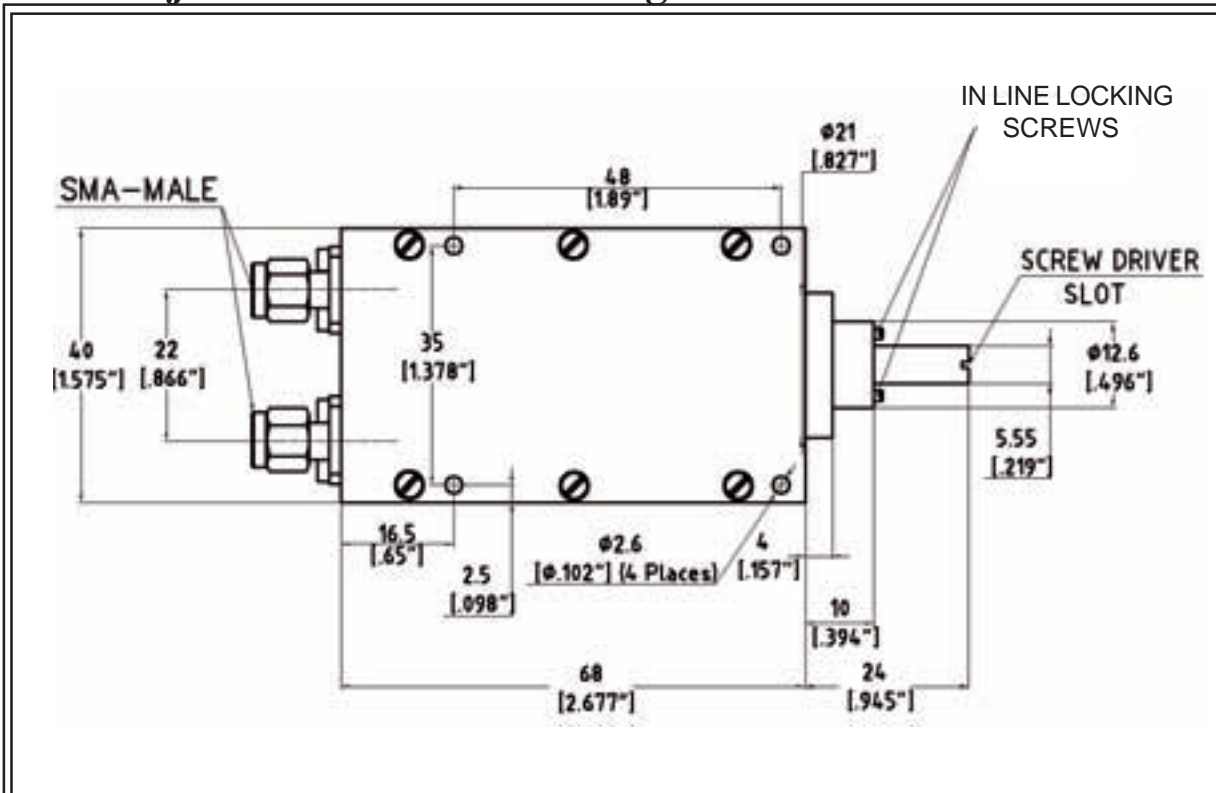
- **Application: Test Set**  
"Set the electrical length by micrometer adjustment".
- Precision Phase Adjusters, DC to 2.0, 12.0, and 18.0 GHz.
- Small housing, flat pack configuration.
- Housing Finish: Iridited. On special request, painting can be supplied.
- Four mounting locations are provided.
- Impedance of 50 Ohms is maintained over the full adjustment range.
- Smooth continuous phase adjustment.
- Internal Trombone Line, no external physical length change.
- Rugged construction: housing is made from aluminum, connector outer conductors from stainless steel.
- Bead captivated center contacts
- Spring fingers and center contacts are made from beryllium copper, heat treated and gold plated per MIL-G-45204, Type II, Grade C.
- Different connector configurations available, such as 3.5mm, 7mm, SMA, N, and TNC. For other connector configurations, please consult the factory.
- Operating temperature range: -54°C to +115°C.



Part Number	Frequency	VSWR max.	R.F. Insertion Loss	Phase Shift	Connectors	Outline Dimensions		
						Length	Width	Height
LS-M002-1111	DC to 2.0 GHz	1.15 : 1	0.3 dB max. at 2.0 GHz	85° min. at 2.0 GHz	SMA-M / SMA-M	81 mm 3.189"	42 mm 1.654"	20.0 mm .787"
LS-M002-1121					SMA-M / SMA-F			
LS-M002-2121					SMA-F / SMA-F			
LS-M002-5151		1.20 : 1	0.3 dB max. at 2.0 GHz	85° min. at 2.0 GHz	N - M / N - M	81 mm 3.189"	42 mm 1.654"	22 mm .866"
LS-M002-5161					N - M / N - F			
LS-M002-6161					N - F / N - F			
LS-M002-3131					TNC-M / TNC-M			
LS-M002-3141					TNC-M / TNC-F			
LS-M002-4141	TNC-F / TNC-F							
LS-M012-1111	DC to 12.0 GHz	1.25 : 1	0.8 dB max. at 12.0 GHz	520° min. at 12.0 GHz	SMA-M / SMA-M	81 mm 3.189"	40 mm 1.575"	20.0 mm .787"
LS-M012-1121					SMA-M / SMA-F			
LS-M012-2121					SMA-F / SMA-F			
LS-M012-5151		1.30 : 1	0.8 dB max. at 12.0 GHz	520° min. at 12.0 GHz	N - M / N - M	81 mm 3.189"	42 mm 1.654"	22 mm .866"
LS-M012-5161					N - M / N - F			
LS-M012-6161					N - F / N - F			
LS-M012-3131					TNC-M / TNC-M			
LS-M012-3141					TNC-M / TNC-F			
LS-M012-4141	TNC-F / TNC-F							
LS-M018-1111	DC to 18.0 GHz	1.50 : 1	1.0 dB max. at 18.0 GHz	770° min. at 18.0 GHz	SMA-M / SMA-M	81 mm 3.189"	40 mm 1.575"	20.0 mm .787"
LS-M018-1121					SMA-M / SMA-F			
LS-M018-2121					SMA-F / SMA-F			
LS-M018-9090		1.50 : 1	1.0 dB max. at 18.0 GHz	770° min. at 18.0 GHz	7 mm / 7 mm	81 mm 3.189"	70 mm 2.756"	30 mm 1.181"
LS-M018-5151					N - M / N - M			
LS-M018-5161					N - M / N - F			
LS-M018-6161					N - F / N - F			
LS-M018-3131					TNC-M / TNC-M			
LS-M018-3141					TNC-M / TNC-F			
LS-M018-4141	TNC-F / TNC-F							



Part Number	LS - M002 - xxxx	LS - M012 - xxxx	LS - M018 - xxxx
	xxxx: connector configuration, for details please refer to the table to the left		
Frequency Range (GHz)	DC - 2.0	DC - 12.0	DC - 18.0
Min. Phase Shift (°)	85	520	770
Nominal Phase Shift Deg. / GHz / Shaft Turn	1.15	1.15	1.15
Max. number of Turns	37	37	37
Time Delay (psec)	min.	393	406
	max.	516	530



All Phase Adjusters with standard locking, as shown on pages 9 through 15 are also available with "In Line Locking", as shown above. For "In Line Locking" the fifth digit in the P/N changes from "0" to "I".

Example:

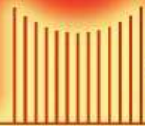
Phase Adjuster LS-0002-1121 uses standard locking

Phase Adjuster LS-0I02-1121 uses "In Line Locking"



# *Electronically Controlled Phase Shifter DC to 18 GHz*

*Phase easily adjusted by your PC,  
Software will be supplied with the unit.*



**Spectrum**  
Elektrotechnik GmbH

**when Quality is needed**

**80905 Munich, Germany**

**P.O. Box 450533**

**Telephone: +49-89-3548-040**

**Facsimile: +49-89-3548-0490**

**WWW.SPECTRUM-ET.COM**

**\***

**Email: Sales@Spectrum-et.com**

CCPhaseShifterE1

## Phase Adjusters - Computer Controlled

**INTRODUCTION:** The computer controlled Phase Adjusters are subsystems, using one or more phase adjusters, allowing the adjustment of the electrical separation between components in increments and cycles, set by individual software, as needed in the project or the test station. Normally, a PC is used to design, drive and control the software, interfacing with driver circuits, operating stepper motor drives, providing a precision mechanical movement for smooth and accurate adjustment over the entire frequency range of the Phase Adjusters.

Practically any of the mechanical Phase Adjusters, shown in this section, can be used and built into subsystems using computer controlled circuits, sometimes with redesigned or modified mechanical or electrical configuration.

**PHASE ADJUSTMENT:** The Phase Adjustment depends on the increments and lengths changes as set by the software and the mechanical properties of the phase devices used in the subsystem.

**FREQUENCY RANGE:** The frequency range of the subsystem depends on the frequency range of the Phase Adjusters. They are available for different frequency ranges, DC-2.0 GHz, DC-12.4 GHz, DC-18.0 GHz, DC-26.5 GHz, DC-40.0 GHz, D\*C-50.0 GHz, and DC-63 GHz. For economical reasons the components have been engineered for these different frequency bands. A rather simple design will meet all the requirements at lower frequency ranges, while usually only a most precise and sometimes also most complicated design needs to be used at higher frequencies. For special requirements, standard units may be redesigned, or components engineered exactly to the customer's needs can be offered.

**CONNECTOR CONFIGURATION:** Most of the Phase Adjusters of Spectrum Elektrotechnik GmbH are available with different connector configurations, providing that the frequency range of the connectors do not limit the frequency range of the application. 7mm, N, SMA and TNC connectors can be used to 18.0 GHz, 3.5mm connectors to 26.5 GHz, or respectively to 35.0 GHz, K\* connectors to 40.0 GHz, 2.4mm connectors to 50.0 GHz, and 1.85 mm connectors to 63 GHz. For the subsystem, almost any connector configuration will be possible, as the subsystem in general will be a custom design anyway. Therefore subsystems could also be supplied with BNC, C, HN, SC or any other connector configuration, assuming that the connectors are still manufactured by Spectrum Elektrotechnik GmbH or are at least available from other sources in the configuration needed.

**POWER:** Phase Adjusters are usually designed for low or moderate power applications. For higher power systems units as specials can be supplied, engineered exactly to the customer's needs.

**VSWR:** Every microwave component shows reflections and discontinuities within the circuit, as no design can be perfect, and manufacturing tolerances unfortunately do not allow theoretical results. VSWR is the ratio of the reflected signal and the incident signal. Phase Shifters are usually using a high number of parts. Therefore the tolerances on the dimensions of the piece parts need to be as tight as possible, not only for mechanical purposes, but also for electrical reasons, in order to assure that reflections cannot build up or increase after some time of operation.

## Phase Adjusters - Computer Controlled

**INTRODUCTION:** The computer controlled Phase Adjusters are subsystems, using one or more phase adjusters, allowing the adjustment of the electrical separation between components in increments and cycles, set by individual software, as needed in the project or the test station. Normally, a PC is used to design, drive and control the software, interfacing with driver circuits, operating stepper motor drives, providing a precision mechanical movement for smooth and accurate adjustment over the entire frequency range of the Phase Adjusters.

Practically any of the mechanical Phase Adjusters, shown in this section, can be used and built into subsystems using computer controlled circuits, sometimes with redesigned or modified mechanical or electrical configuration.

**PHASE ADJUSTMENT:** The Phase Adjustment depends on the increments and lengths changes as set by the software and the mechanical properties of the phase devices used in the subsystem.

**FREQUENCY RANGE:** The frequency range of the subsystem depends on the frequency range of the Phase Adjusters. They are available for different frequency ranges, DC-2.0 GHz, DC-12.4 GHz, DC-18.0 GHz, DC-26.5 GHz, DC-40.0 GHz, D\*C-50.0 GHz, and DC-63 GHz. For economical reasons the components have been engineered for these different frequency bands. A rather simple design will meet all the requirements at lower frequency ranges, while usually only a most precise and sometimes also most complicated design needs to be used at higher frequencies. For special requirements, standard units may be redesigned, or components engineered exactly to the customer's needs can be offered.

**CONNECTOR CONFIGURATION:** Most of the Phase Adjusters of Spectrum Elektrotechnik GmbH are available with different connector configurations, providing that the frequency range of the connectors do not limit the frequency range of the application. 7mm, N, SMA and TNC connectors can be used to 18.0 GHz, 3.5mm connectors to 26.5 GHz, or respectively to 35.0 GHz, K\* connectors to 40.0 GHz, 2.4mm connectors to 50.0 GHz, and 1.85 mm connectors to 63 GHz. For the subsystem, almost any connector configuration will be possible, as the subsystem in general will be a custom design anyway. Therefore subsystems could also be supplied with BNC, C, HN, SC or any other connector configuration, assuming that the connectors are still manufactured by Spectrum Elektrotechnik GmbH or are at least available from other sources in the configuration needed.

**POWER:** Phase Adjusters are usually designed for low or moderate power applications. For higher power systems units as specials can be supplied, engineered exactly to the customer's needs.

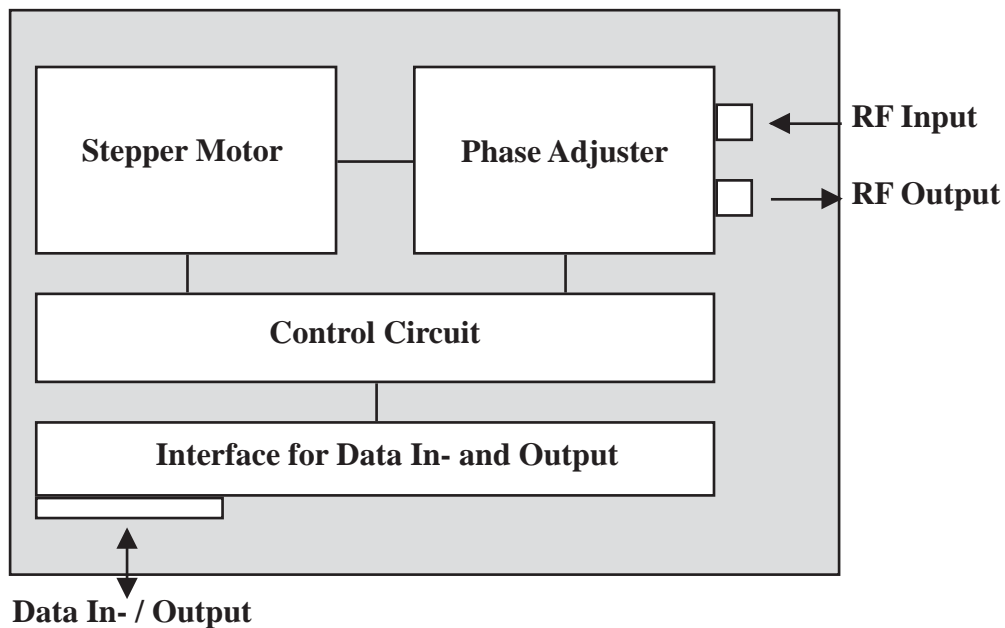
**VSWR:** Every microwave component shows reflections and discontinuities within the circuit, as no design can be perfect, and manufacturing tolerances unfortunately do not allow theoretical results. VSWR is the ratio of the reflected signal and the incident signal. Phase Shifters are usually using a high number of parts. Therefore the tolerances on the dimensions of the piece parts need to be as tight as possible, not only for mechanical purposes, but also for electrical reasons, in order to assure that reflections cannot build up or increase after some time of operation.

## Phase Adjusters - Computer Controlled

**Custom Units:** Computer controlled Phase Adjusters are mainly custom made subsystems, designed and manufactured to the customer's needs, exactly to his specification. Spectrum Elektrotechnik GmbH is a very innovative Company. It employs a strong and successful team of experienced engineers who always do their best to propose something that will perfectly fit the customer's needs.

**Life:** The life expectancy of the subsystem will depend in the first place on the operating environment versus unit design. Secondly, it will depend on the lifetime of the ball bearings, seals, and contact junctions, and of the lifetime of the stepper motor drives itself. Other parameters that are limiting life, are rotational speed, and external mechanical loading, or pressurizing the unit. Harsh environment, subjecting the component to vibrations, shock, extremely low or high temperatures, humidity, etc. may further shorten the lifetime as well. It is therefore of utmost importance to identify in detail the environment in which the device is supposed to operate .

**Applications:** Computer controlled Phase Adjusters are needed in test stations for accurate and repeatable testing where the adjustment of the phase has to be repeated for many times, either in steps, or in cycles, as defined in a program. Subsystems usually work in a lab environment.



## Phase Adjusters - Computer Controlled



### Specifications:

**Frequency Range: DC to 18 GHz**  
**Phase adjustable range: 700° at 18 GHz**  
**Delay Time min.: ~400ps@18GHz**  
**Delay Time max.: ~510ps@18GHz**  
**Step Size (Resolution): ~0.2ps**  
**Setting Time (relatively 0 ps to 110ps at 1ps step) : less than 30 seconds**  
**Repeatability : less than 0.1 ps when moving in the same direction**  
**Insertion Loss max.: 1dB@18GHz**  
**Return Loss : -14dB@18GHz**  
**Life Time: tbd**  
**Operating Temperature : 0°C to +55°C**  
**Storage Temperature : 0°C to +55°C**  
**RF input/output connectors: SMA fem., other connector styles on request**  
**Interface: RS232**  
**Supply Voltage: 12V**

**Electronic Phase Shifter**

Enable    Disable    Diagnostics    Find Reference

Electrical Length     Phase

**Position**

Position Target: 0 mm  
 Relative Move

Define Position: 0 mm  
Position Start: 0 mm  
Position Actual Value: 0 mm

**Phase**

Phase Target: 20 °  
 Relative Move

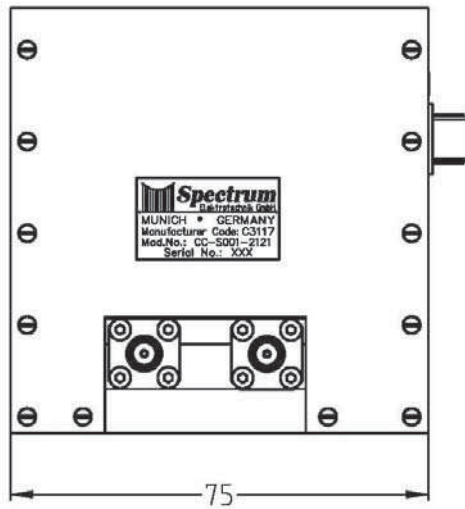
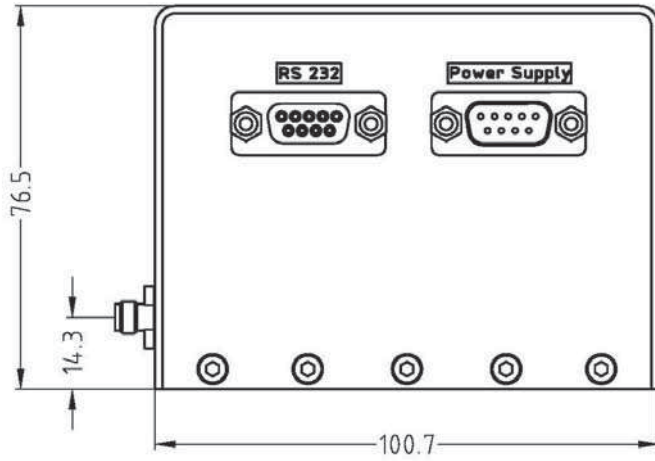
Define Phase: 50 °  
Phase Start: 0 °  
Phase Actual Value: 0 °

Move    Stop    Cancel    OK

PhaseAdjusterDC-18

# Outline Drawing

Dimensions are in mm





# III. Phase



# Adjustable Adapters

**DC - 12 GHz**

**DC - 18 GHz**

**DC - 26 GHz**

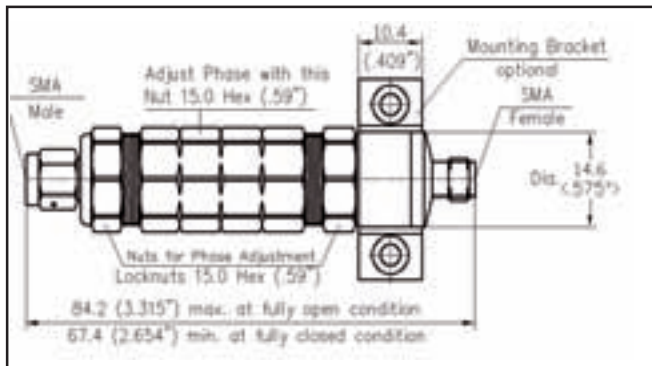
**DC - 40 GHz**

**DC - 50 GHz**

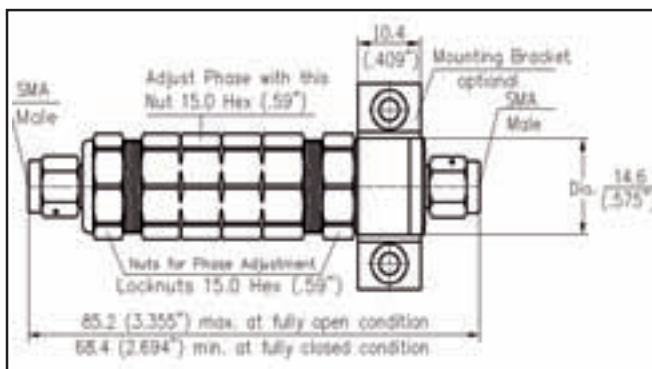
**DC - 65 GHz**

# Phase Adjustable Adapters

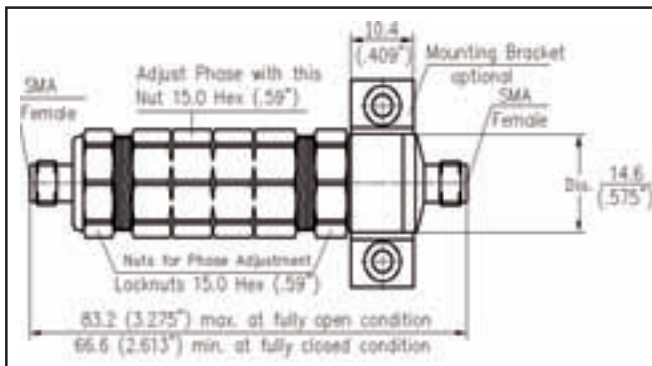
DC to 12.0 GHz  
DC to 18.0 GHz  
DC to 26.0 GHz



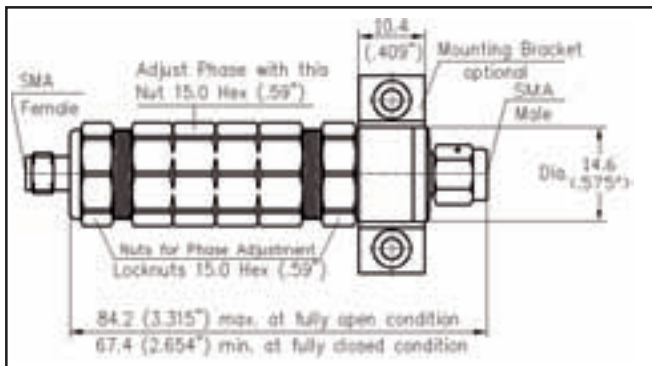
SMA Male to SMA Female		
Part Number	Frequency Range	Material
LS-0112-1121	DC - 12.0 GHz	Stainless Steel Body
LS-0118-1121	DC - 18.0 GHz	
LS-0121-1121	DC - 26.0 GHz	
LS-A112-1121	DC - 12.0 GHz	Aluminum Body
LS-A118-1121	DC - 18.0 GHz	
LS-A121-1121	DC - 26.0 GHz	



SMA Male to SMA Male		
Part Number	Frequency Range	Material
LS-0112-1111	DC - 12.0 GHz	Stainless Steel Body
LS-0118-1111	DC - 18.0 GHz	
LS-0121-1111	DC - 26.0 GHz	
LS-A112-1111	DC - 12.0 GHz	Aluminum Body
LS-A118-1111	DC - 18.0 GHz	
LS-A121-1111	DC - 26.0 GHz	



SMA Female to SMA Female		
Part Number	Frequency Range	Material
LS-0112-2121	DC - 12.0 GHz	Stainless Steel Body
LS-0118-2121	DC - 18.0 GHz	
LS-0121-2121	DC - 26.0 GHz	
LS-A112-2121	DC - 12.0 GHz	Aluminum Body
LS-A118-2121	DC - 18.0 GHz	
LS-A121-2121	DC - 26.0 GHz	



SMA Female to SMA Male		
Part Number	Frequency Range	Material
LS-0212-1121	DC - 12.0 GHz	Stainless Steel Body
LS-0218-1121	DC - 18.0 GHz	
LS-0221-1121	DC - 26.0 GHz	
LS-A212-1121	DC - 12.0 GHz	Aluminum Body
LS-A218-1121	DC - 18.0 GHz	
LS-A221-1121	DC - 26.0 GHz	



- Precision phase adjustable adapters, DC to 12.0, 18.0 and 26.0 GHz.
- Impedance of 50 Ohms is maintained over the full adjustment range.
- Positive resettable locking mechanism.
- Smooth continuous phase adjustment.
- Physical length change of the unit equals the electrical length change.
- Rugged construction, housing and outer conductors are made from stainless steel.
- Light weight components are available, using aluminum for the housing, but for physical endurance connector outer shells are still supplied in stainless steel.
- Captivated center contacts.
- Spring fingers and center contacts are made from beryllium copper, heat treated and gold plated per MIL-G-45204, Type II, Grade C.
- SMA connector interface specification per MIL-STD-348A.
- Four different connector configurations can be obtained, as shown in the drawings: SMAm - SMAf, SMAm - SMAm, SMAf - SMAf, SMAf - SMAm.
- Operating temperature range: -54°C to +115°C, units with extended temperature range are available on request.
- Mounting Brackets are optional and are shown on the drawings on the next page.
- Diagram Phase Shift (°) versus Frequency (GHz), please refer to page 24.

**Table for Phase Adjustable Adapters, as shown to the left.**

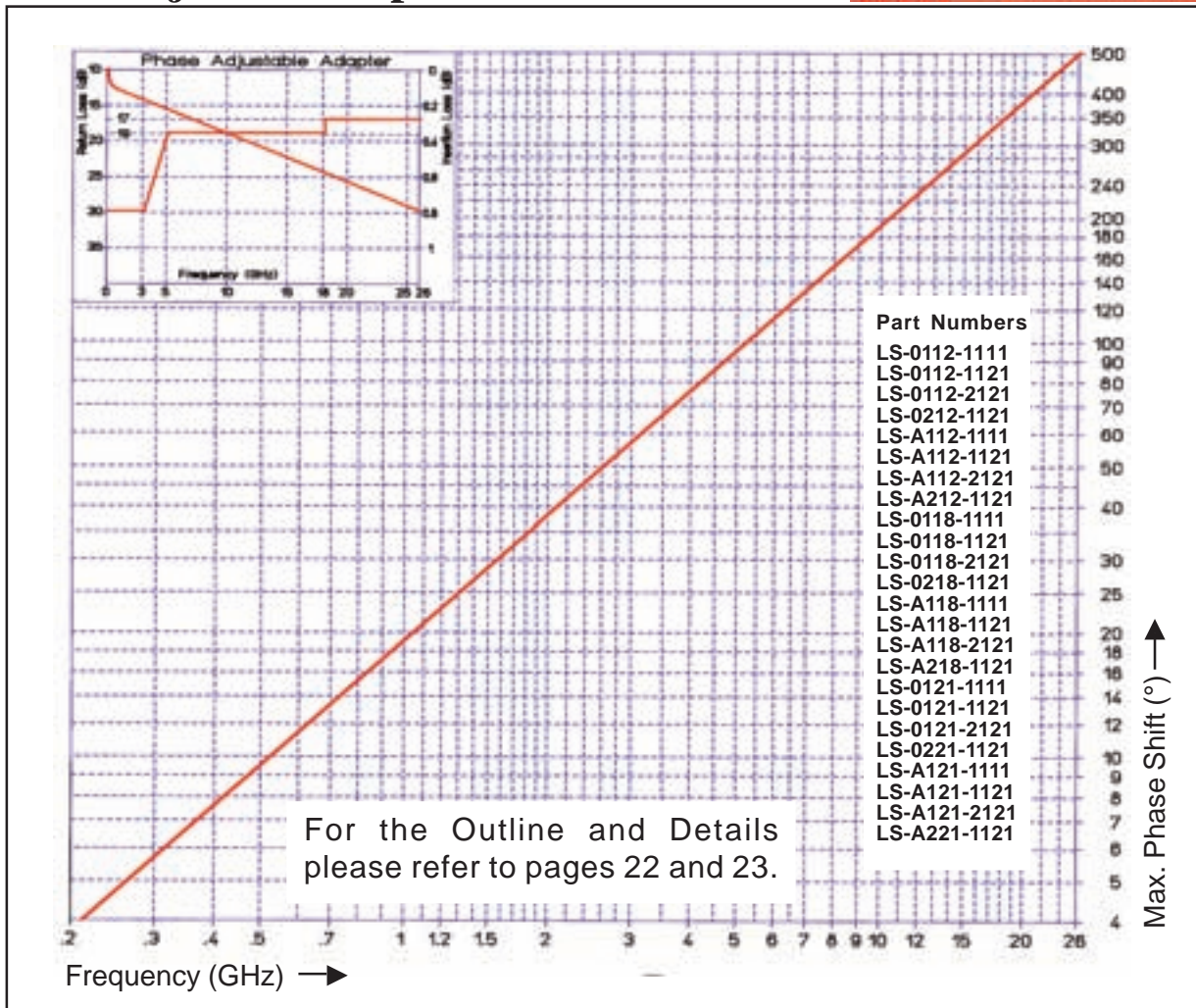
Part Number	Sex	Frequency Range	VSWR max.	Insertion Loss max.	Phase Shift min.	No. of Turns	Nom. Phase Shift Deg./GHz/Turn	Time Delay (psec.) min. max.	Material/Weight max.								
LS-0112-1111	M - M	DC - 12.0 GHz	1.25 : 1	0.4 dB	230° at 12.0 GHz	16.5	1.2	238 293	Stainless Steel								
LS-0112-1121	M - F								70 g								
LS-0112-2121	F - F								Aluminum								
LS-0212-1121	M - F									47 g							
LS-A112-1111	M - M									DC - 18.0 GHz	1.25 : 1	0.6 dB	350° at 18.0 GHz	16.5	1.2	238 293	
LS-A112-1121	M - F																70 g
LS-A112-2121	F - F																Aluminum
LS-A212-1121	M - F																
LS-0118-1111	M - M	DC - 26.0 GHz	1.30 : 1	0.8 dB	500° at 26.0 GHz	16.5	1.2	238 293									
LS-0118-1121	M - F								Stainless Steel								
LS-0118-2121	F - F								70 g								
LS-0218-1121	M - F								Aluminum								
LS-A118-1111	M - M									47 g							
LS-A118-1121	M - F									DC - 26.0 GHz	1.30 : 1	0.8 dB	500° at 26.0 GHz	16.5	1.2	238 293	
LS-A118-2121	F - F																Stainless Steel
LS-A218-1121	M - F																70 g
LS-0121-1111	M - M	Aluminum															
LS-0121-1121	M - F		47 g														
LS-0121-2121	F - F		Aluminum														
LS-0221-1121	M - F			70 g													
LS-A121-1111	M - M			Aluminum													
LS-A121-1121	M - F				47 g												
LS-A121-2121	F - F	Aluminum															
LS-A221-1121	M - F				47 g												

# Phase Adjustable Adapters

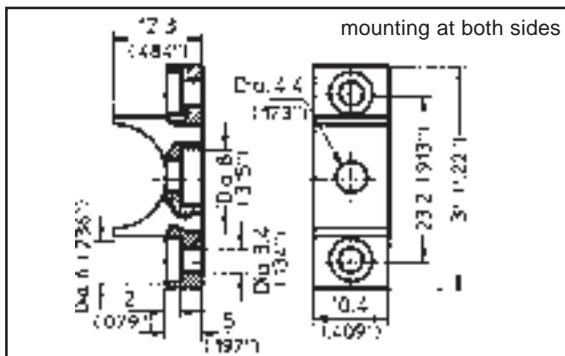
DC to 12.0 GHz  
 DC to 18.0 GHz  
 DC to 26.0 GHz



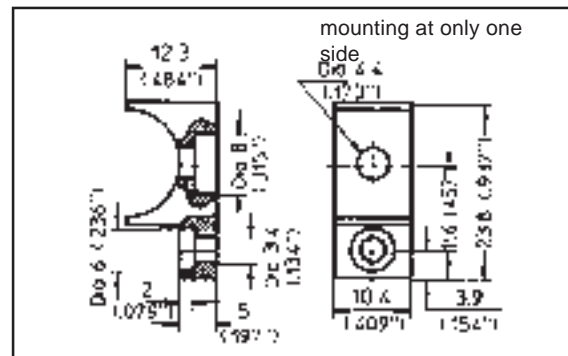
**Spectrum**  
 Elektrotechnik GmbH



Two different Mounting Brackets are offered. They can easily be added to any Precision Phase Adjuster. Using these standard attachments makes it easy to mount the Phase Shifter in the system or to the test setup and ensures proper operation.

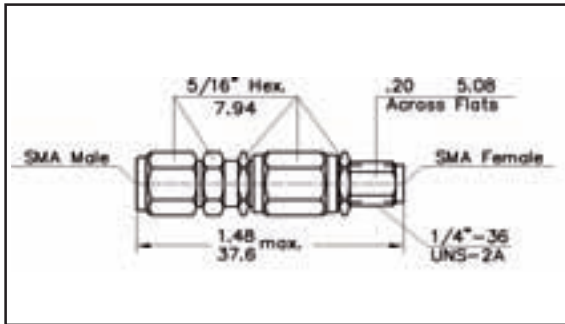


Bracket, Part No.: MB-0200-07  
 Material: Aluminium iridited



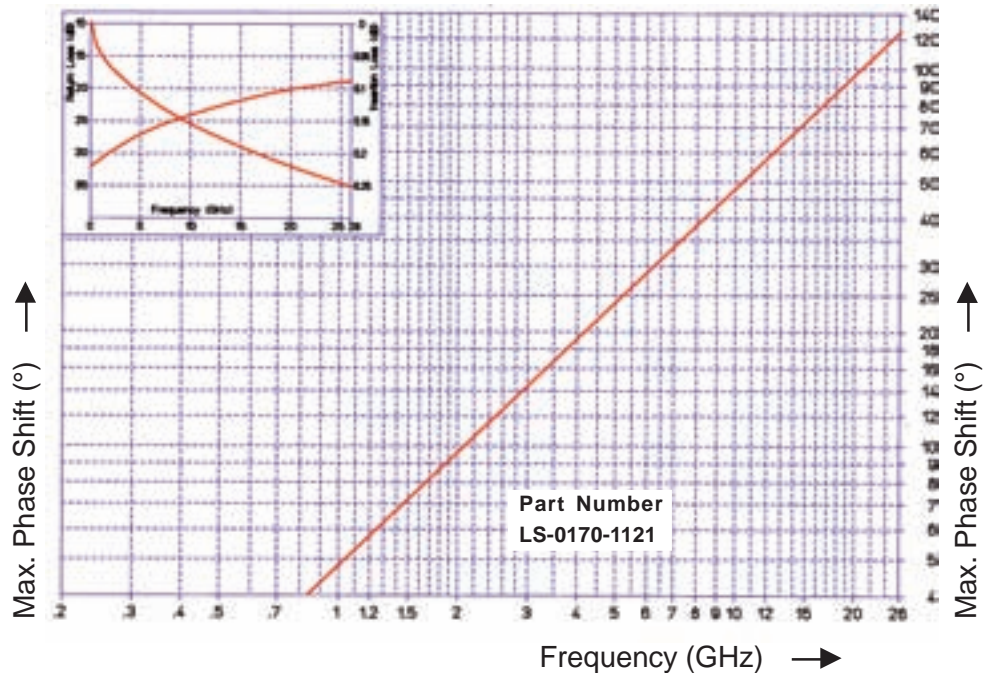
Bracket, Part No.: MB-0100-07  
 Material: Aluminium iridited

- Precision phase adjustable adapters, DC to 26.0 GHz.
- Impedance of 50 Ohms is maintained over the full adjustment range.
- Positive resettable locking mechanism.
- Smooth continuous phase adjustment.
- Physical length change of the unit equals the electrical length change.
- Rugged construction, housing and outer conductors are made from stainless steel.
- Captivated center contacts.
- Spring fingers and center contacts are made from beryllium copper, heat treated and gold plated per MIL-G-45204, Type II, Grade C.
- SMA connector interface specification per MIL-STD-348A.
- Operating temperature range: -54°C to +115°C, units with extended temperature range are available on request.



- Physical length change per revolution of adjustment nut: ~ 0.30 mm
- Electrical length change per revolution of adjustment nut: ~ 0.30 mm
- Maximum change in physical length:  $4.06 \pm 0.25$  mm of air

Part Number	Frequency Range	VSWR max.	Insertion Loss max.	Phase Shift min.	No. of Turns	Nom. Phase Shift Deg./GHz/Turnh	Time Delay (psec.) min. max.	Weight max.
LS-0170-1121	DC-26.0 GHz	$1.05 + .008 * f(\text{GHz})$	0.26 dB	127° at 26.0 GHz	13.5	0.36	109.2 122.8	9 g

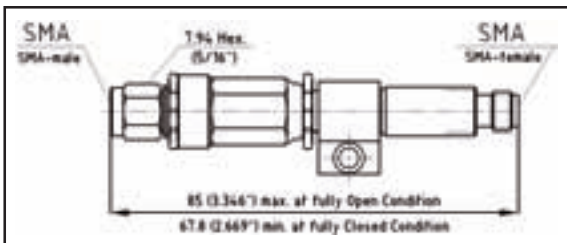


# Phase Adjustable Adapter DC to 26.0 GHz



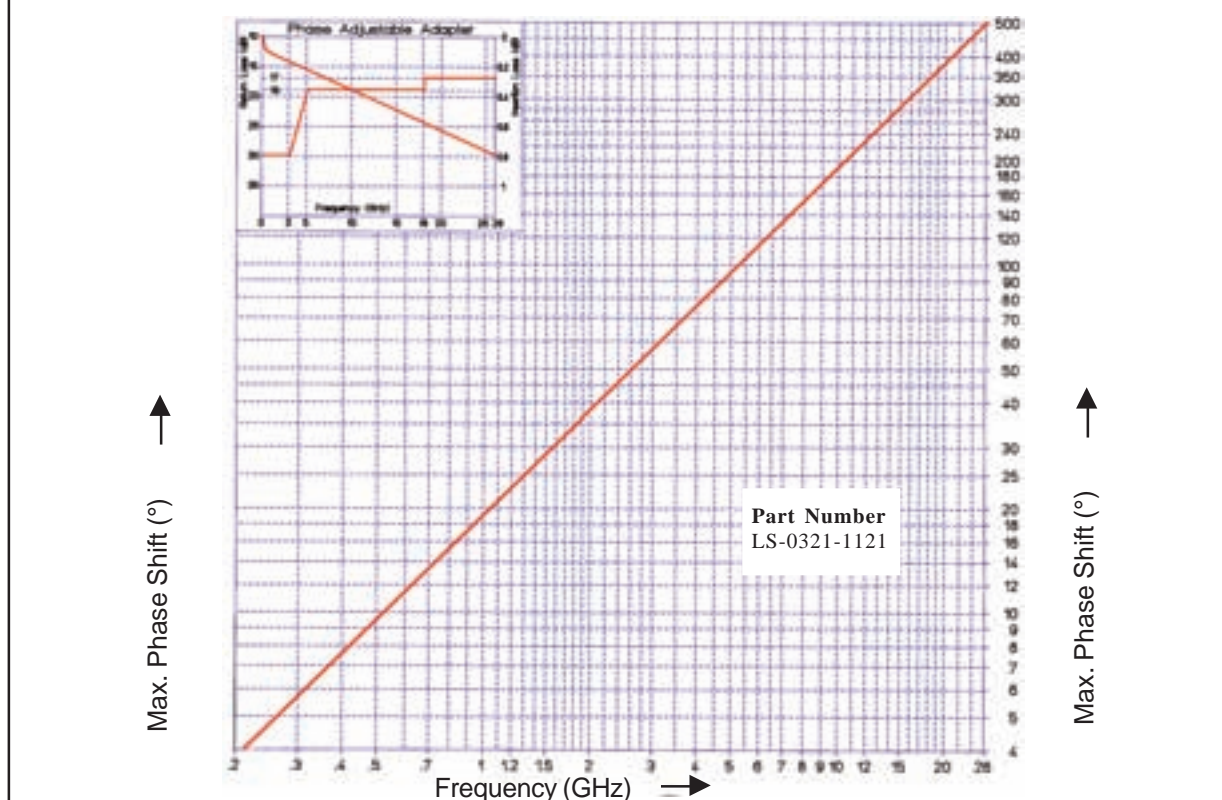
- Precision phase adjustable adapters, DC to 26.0 GHz.
- Impedance of 50 Ohms is maintained over the full adjustment range.
- Positive resettable locking mechanism.
- Smooth continuous phase adjustment.
- Physical length change of the unit equals the electrical length change.
- Rugged construction, housing and outer conductors are made from stainless steel.

- Captivated center contacts.
- Spring fingers and center contacts are made from beryllium copper, heat treated and gold plated per MIL-G-45204, Type II, Grade C.
- SMA connector interface specification per MIL-STD-348A.
- Operating temperature range: -54°C to +115°C, units with extended temperature range are available on request.



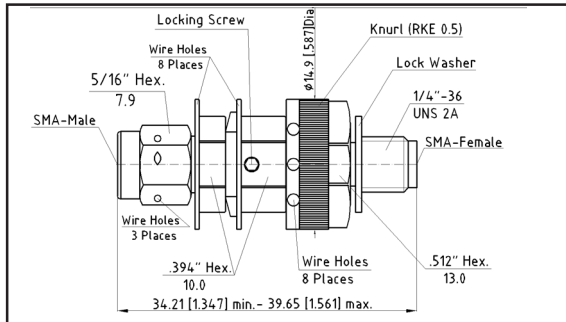
- Physical length change per revolution of adjustment nut: ~ 0.5mm
- Electrical length change per revolution of adjustment nut: ~ 0.5mm
- Maximum change in physical length:  $17.5 \pm 0.25\text{mm}$
- Maximum change in electrical length:  $17.5 \pm 0.25\text{mm}$  of air

Part Number	Frequency Range	VSWR max.	Insertion Loss max.	Phase Shift min.	No. of Turns	Nom. Phase Shift Deg./GHz/Turnh	Time Delay (psec.) min. max.	Weight max.
LS-0321-1121	DC-26.0 GHz	$1.1 + .008 * f(\text{GHz})$	0.8 dB	500° at 26.0 GHz	35	0.6	236.7 290.5	30 g



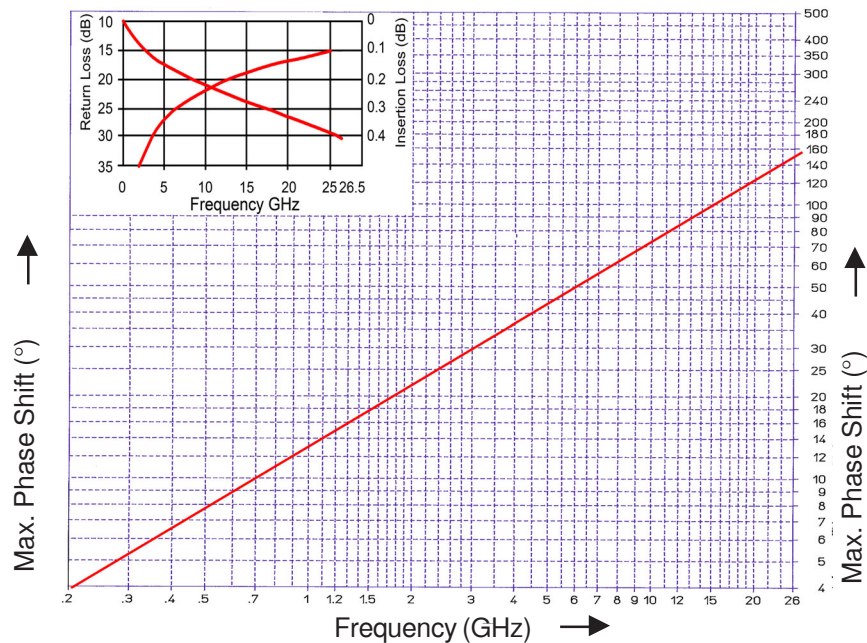
- Developed for airborne applications, using locking screws for safe adjustment.
- Precision phase adjustable adapters, DC to 26.5 GHz.
- Impedance of 50 Ohms is maintained over the full adjustment range.
- Positive resettable locking mechanism.
- Smooth continuous phase adjustment.
- Physical length change of the unit equals the electrical length change.
- Rugged construction, housing and outer conductors are made from stainless steel.

- Captivated center contacts.
- Spring fingers and center contacts are made from beryllium copper, heat treated and gold plated per MIL-G-45204, Type II, Grade C.  
SMA connector interface specification per MIL-STD-348A.
- Operating temperature range: -54°C to +115°C, units with extended temperature range are available on request.
- Different connector configuration can be supplied on request



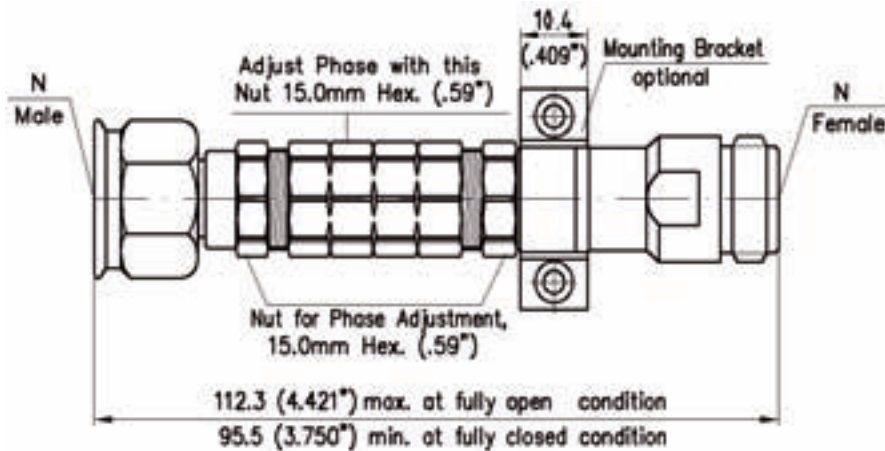
- Physical length change per revolution of adjustment nut: ~ 0.5mm
- Electrical length change per revolution of adjustment nut: ~ 0.5mm
- Maximum change in physical length:  $5 \pm 0.25\text{mm}$
- Maximum change in electrical length:  $5 \pm 0.25\text{mm}$  of air

Part Number	Frequency Range	VSWR max.	Insertion Loss max.	Phase Shift min.	No. of Turns	Nom. Phase Shift Deg./GHz/Turnh	Time Delay (psec.) min. max.	Weight max.
LS-S008-1121	DC - 26 GHz	1.5:1	0.4 dB	155° at 26.5 GHz	10	0.60	118.6 135.1	19.35g

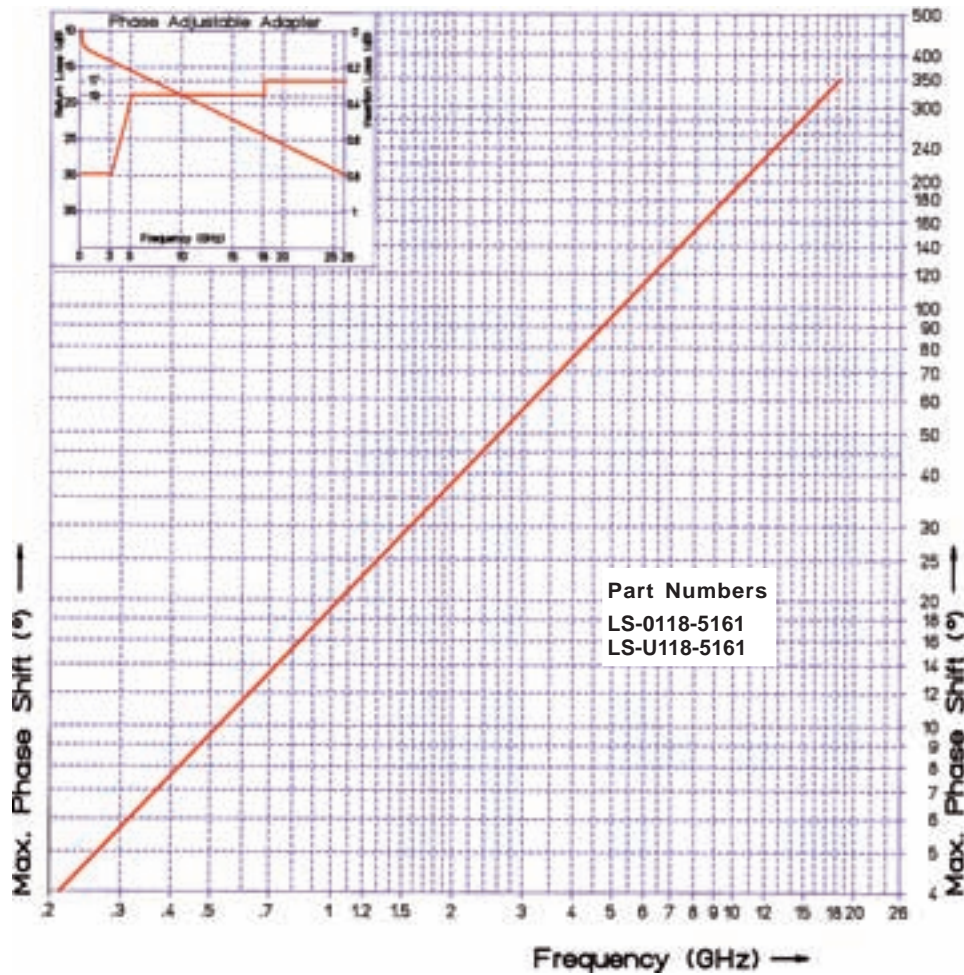


# Phase Adjustable Adapters DC to 18.0 GHz

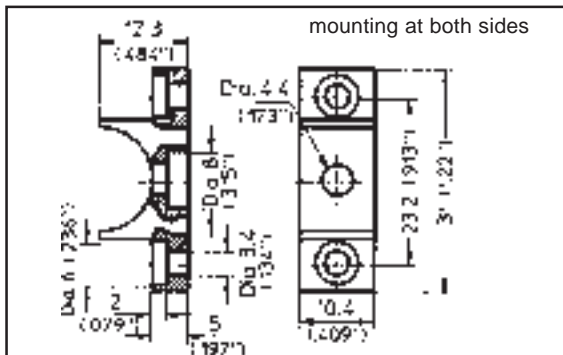
- Precision phase adjustable adapters, DC to 18.0 GHz.
- Impedance of 50 Ohms is maintained over the full adjustment range.
- High power solution available.
- Positive resettable locking mechanism.
- Smooth continuous phase adjustment.
- Physical length change of the unit equals the electrical length change.
- Rugged construction, housing and outer conductors are made from stainless steel.
- Captivated center contacts
- Spring fingers and center contacts are made from beryllium copper, heat treated and gold plated per MIL-G-45204, Type II, Grade C.
- N connector interface specification per MIL-STD-348A.
- Operating temperature range: -65°C to +70°C, units with extended temperature range are available on request.
- Mounting Brackets are optional and are shown on the drawings on the next page.
- Diagram Phase Shift (°) versus Frequency (GHz), please refer to page 20.



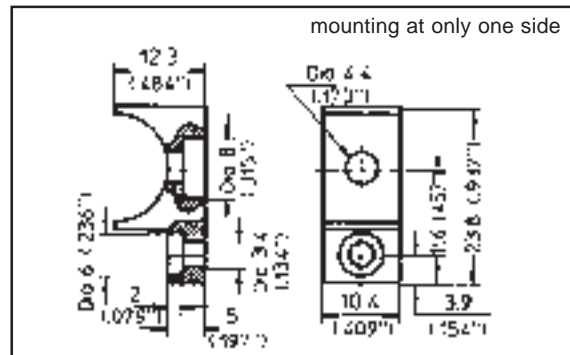
Part Number	Temperature Range	Frequency Range	VSWR max.	Insertion Loss max.	Phase Shift max.	No. of Turns	Nom. Phase Shift		Time Delay (psec.)		Weight max.
							Deg./GHz/Turnh		min.	max.	
LS-0118-5161	-65° to +70° C	DC - 18.0 GHz	1.25:1	0.5 dB	350° at 18.0 GHz	16.5	1.2	300	355	105g	
LS-U118-5161	-65° to +165°C										



Two different Mounting Brackets are offered. They can easily be added to any Precision Phase Adjuster. Using these standard attachments makes it easy to mount the Phase Shifter in the system or to the test setup and ensures proper operation.



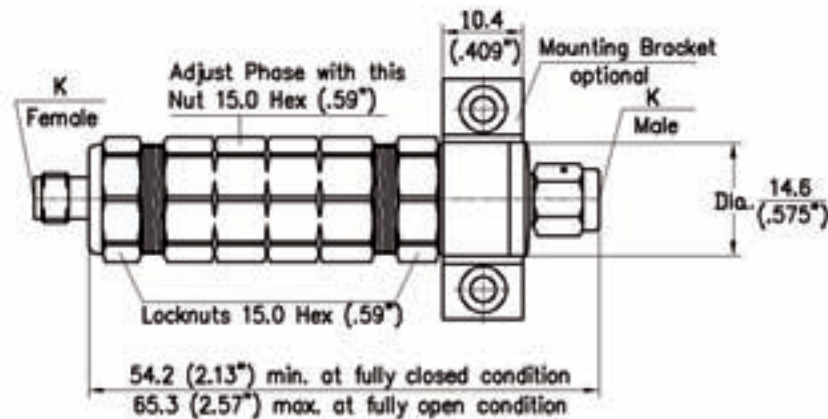
Bracket, Part No.: MB-0200-07  
Material: Aluminium iridited



Bracket, Part No.: MB-0100-07  
Material: Aluminium iridited

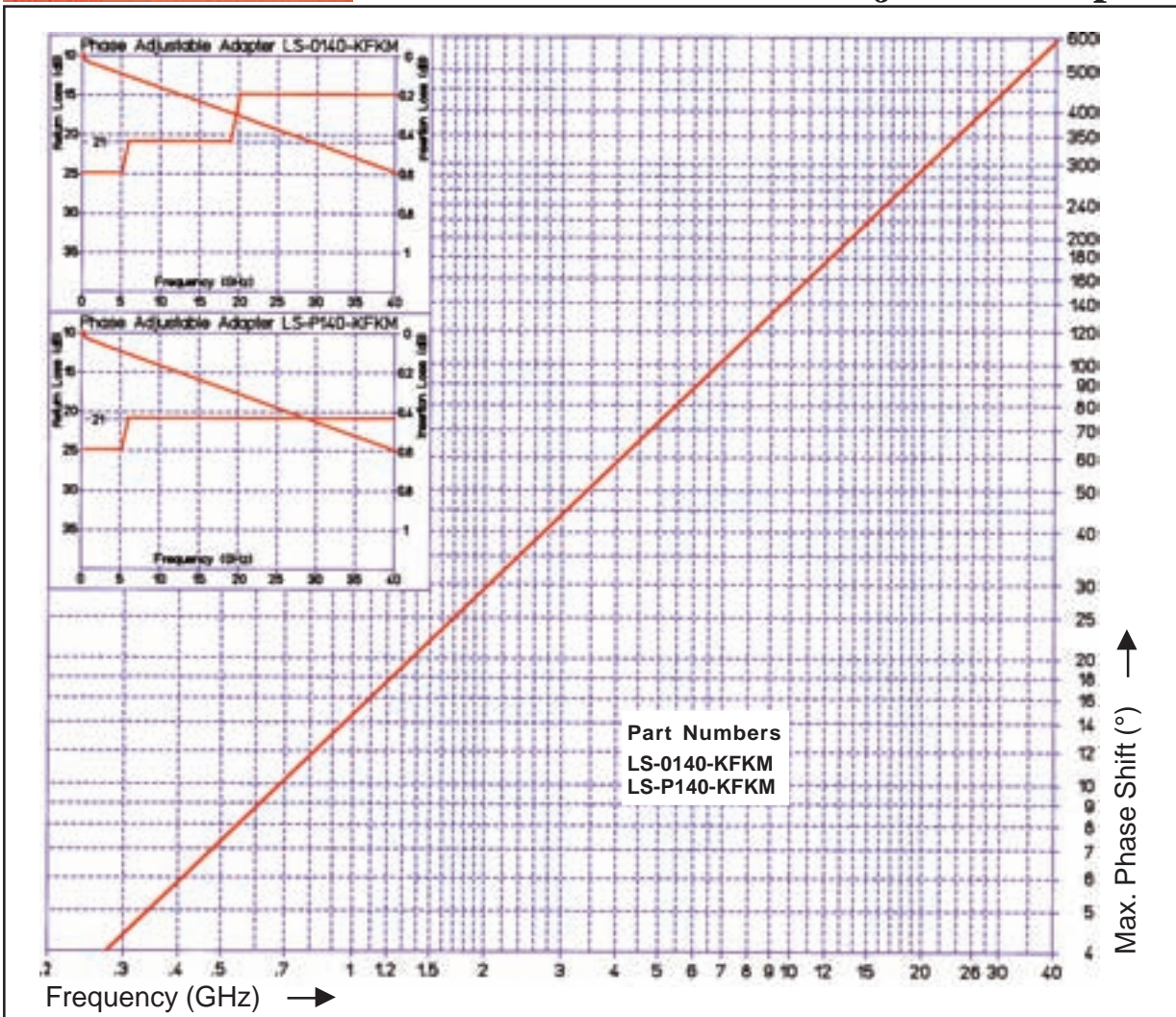
# Phase Adjustable Adapters DC to 40.0 GHz

- Precision phase adjustable adapters, DC to 40.0 GHz.
- Impedance of 50 Ohms is maintained over the full adjustment range.
- Positive resettable locking mechanism.
- Smooth continuous phase adjustment.
- Physical length change of the unit equals the electrical length change.
- Rugged construction, housing and outer conductors are made from stainless steel.
- Besides the Standard Units, High Precision Components are offered, showing superior electrical performance to 40.0 GHz, being easily identified by their gold plated body.
- Bead captivated center contacts.
- Spring fingers and center contacts are made from beryllium copper, heat treated and gold plated per MIL-G-45204, Type II, Grade C.
- K\* connector interface specification per Spectrum's Specification, as published in Spectrum's Adapters and Connectors Handbooks and also available on request.
- Operating temperature range: -54°C to +85°C.
- Mounting Brackets are optional and are shown on the drawings below and to the right.

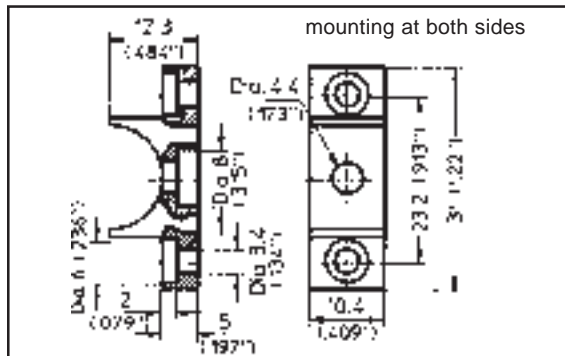


Part Number	Frequency Range	VSWR max.	Insertion Loss max.	Phase Shift min.	No. of Turns	Nom. Phase Shift Deg./GHz/Turn	Time Delay (psec.) min. max.	Weight max.
LS-0140-KFKM	DC - 40.0 GHz	1.40 : 1	0.6 dB	590° at 40.0 GHz	12	1.2	168 208	49 g
LS-P140-KFKM		1.20:1						51 g

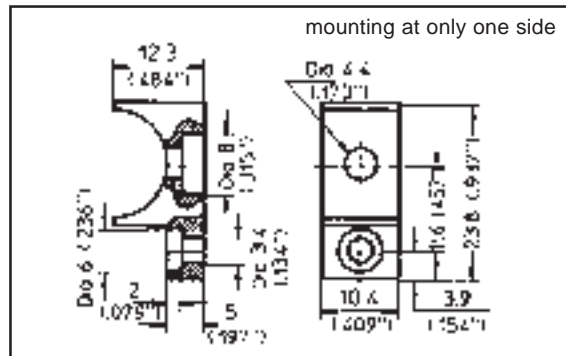




Two different Mounting Brackets are offered. They can easily be added to any Precision Phase Adjuster. Using these standard attachments makes it easy to mount the Phase Shifter in the system or to the test setup and ensures proper operation.

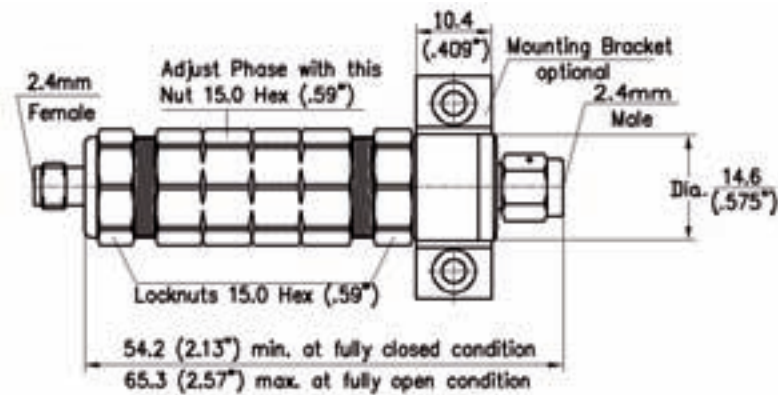


Bracket, Part No.: MB-0200-07  
Material: Aluminium iridited

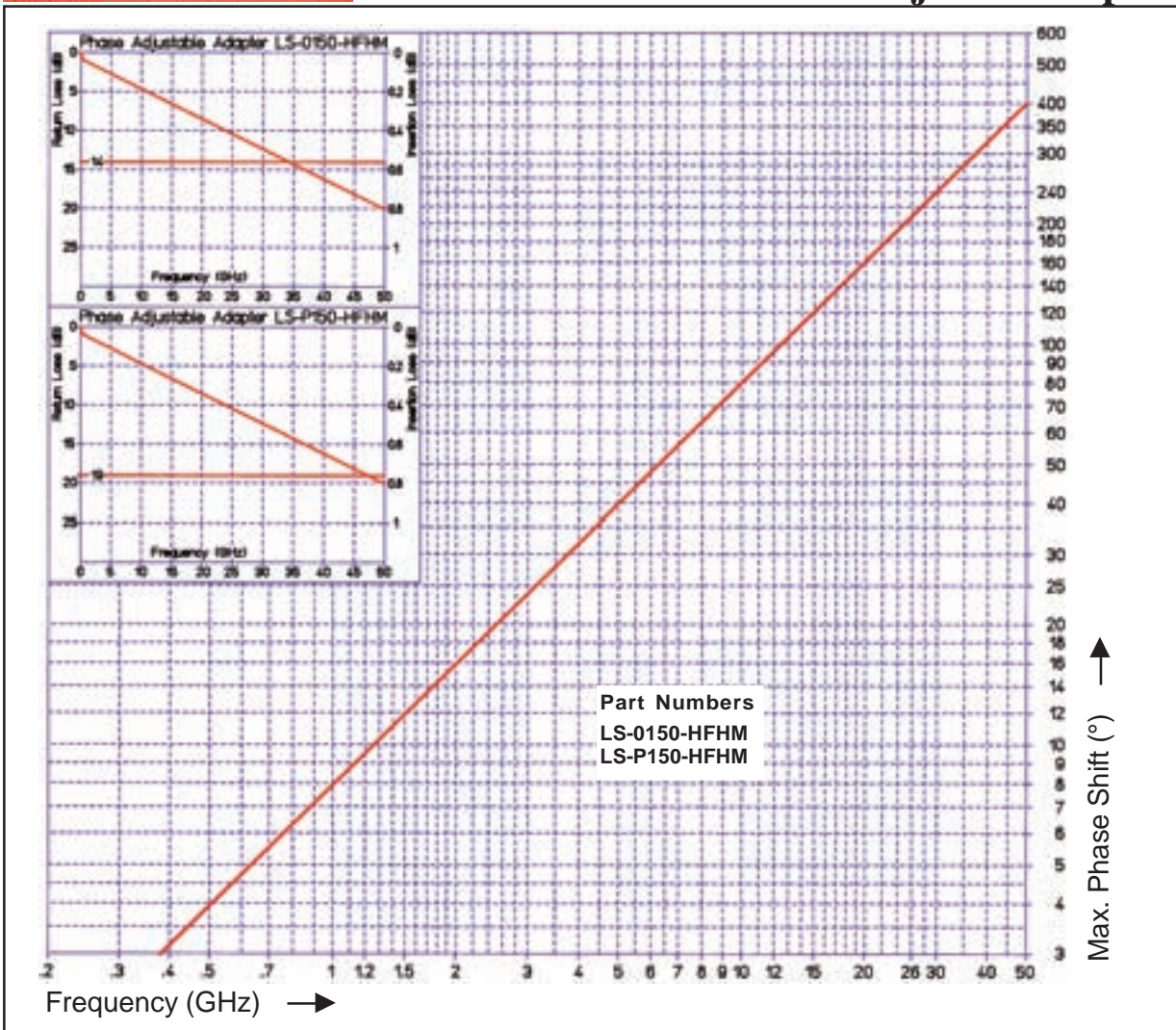


Bracket, Part No.: MB-0100-07  
Material: Aluminium iridited

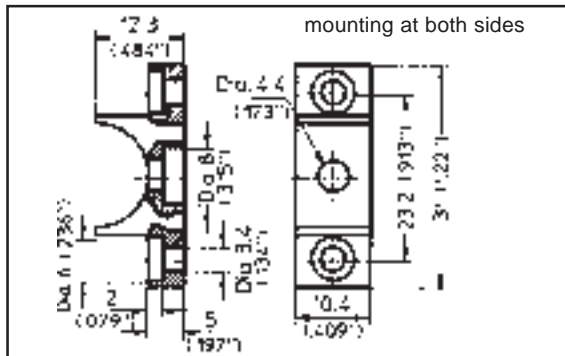
- Precision phase adjustable adapters, DC to 50.0 GHz.
- Impedance of 50 Ohms is maintained over the full adjustment range.
- Positive resettable locking mechanism.
- Smooth continuous phase adjustment.
- Physical length change of the unit equals the electrical length change.
- Rugged construction, housing and outer conductors are made from stainless steel.
- Besides the Standard Units, High Precision Components are offered, showing superior electrical performance to 50.0 GHz, being easily identified by their gold plated body.
- Bead captivated center contacts.
- Spring fingers and center contacts are made from beryllium copper, heat treated and gold plated per MIL-G-45204, Type II, Grade C.
- 2.4mm connector interface specification per Spectrum's Specification, as published in Spectrum's Adapters and Connectors Handbooks, and are also available upon request.
- Operating temperature range: -54°C to +85°C.
- Mounting Brackets are optional and are shown on the drawings below and to the right.



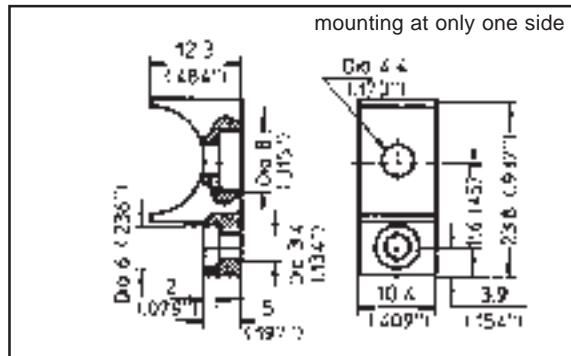
Part Number	Frequency Range	VSWR max.	Insertion Loss max.	Phase Shift min.	No. of Turns	Nom. Phase Shift Deg./GHz/Turn	Time Delay (psec.)		Weight max.
							min.	max.	
LS-0150-HFHM	DC - 50.0 GHz	1.50 : 1	0.8 dB	400° at 50.0 GHz	7	1.2	172	195	53 g
LS-P150-HFHM		1.30 : 1							55 g



Two different Mounting Brackets are offered. They can easily be added to any Precision Phase Adjuster. Using these standard attachments makes it easy to mount the Phase Shifter in the system or to the test setup and ensures proper operation.



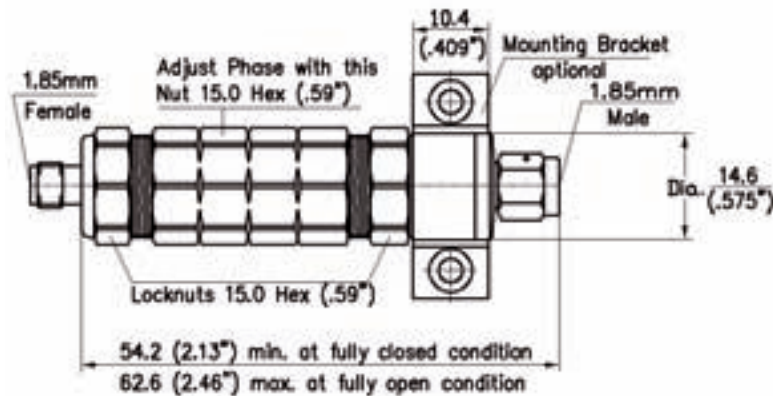
Bracket, Part No.: MB-0200-07  
Material: Aluminium iridited



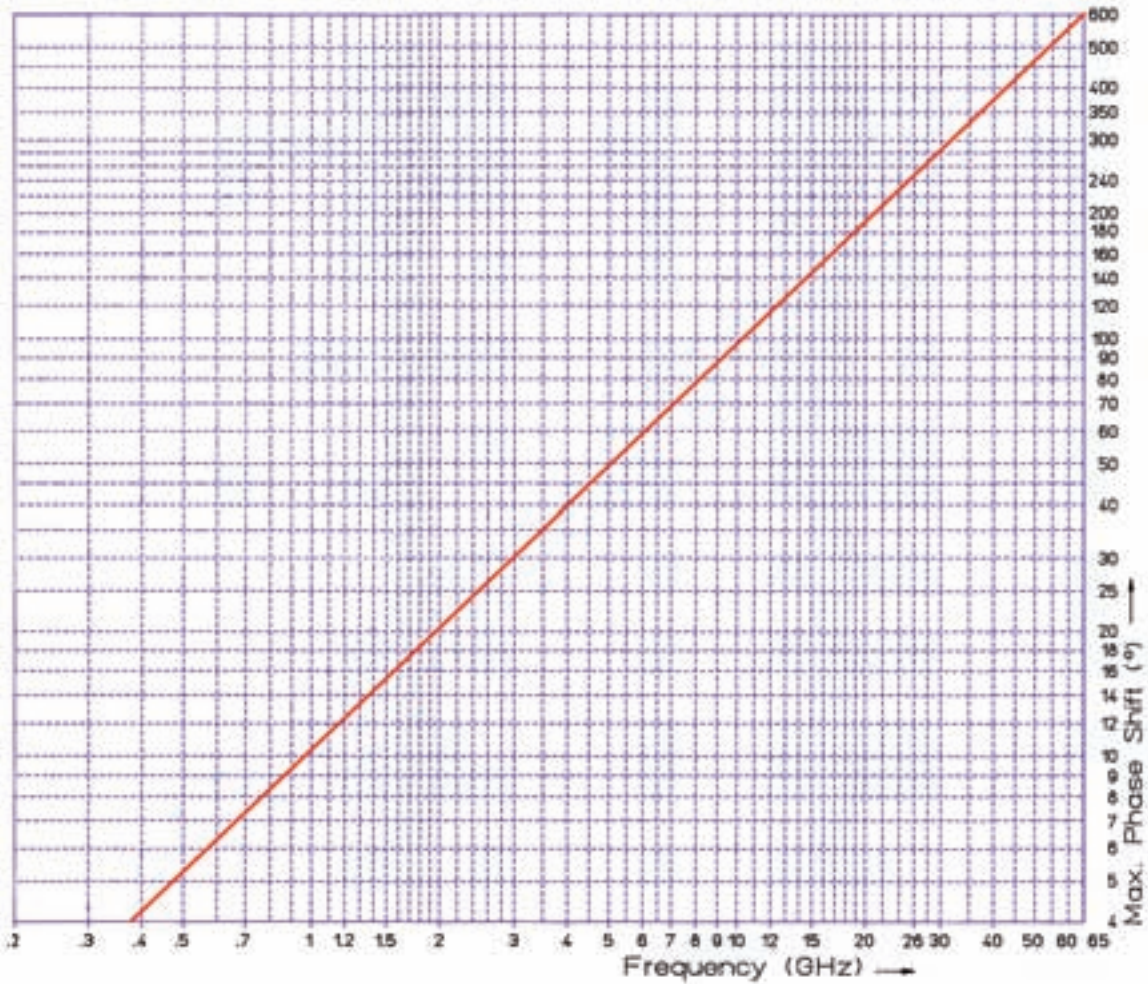
Bracket, Part No.: MB-0100-07  
Material: Aluminium iridited

# Phase Adjustable Adapters DC to 63.0 GHz

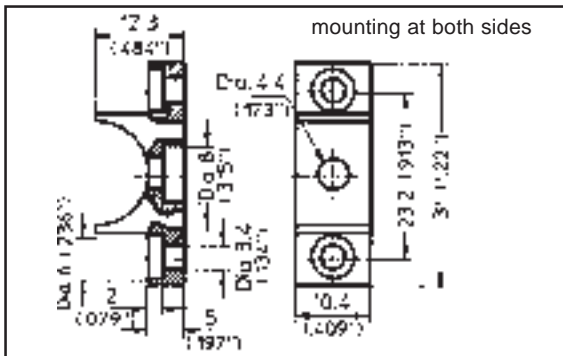
- Precision phase adjustable adapters, DC to 63.0 GHz.
- Impedance of 50 Ohms is maintained over the full adjustment range.
- Positive resettable locking mechanism.
- Smooth continuous phase adjustment.
- Physical length change of the unit equals the electrical length change.
- Rugged construction, housing and outer conductors are made from stainless steel.
- Besides the Standard Units, High Precision Components are offered, showing superior electrical performance to 63.0 GHz, being easily identified by their gold plated body.
- Bead captivated center contacts.
- Spring fingers and center contacts are made from beryllium copper, heat treated and gold plated per MIL-G-45204, Type II, Grade C.
- The product is needed for adjusting the electrical lengths of lines in applications where data rates 40 GBit/sec and above are being transferred in optical systems.
- Operating temperature range: -54°C to +85°C.
- Mounting Brackets are optional and are shown on the drawings below and to the right.
- The product is also available as Precision Programmable Phase Shifter.



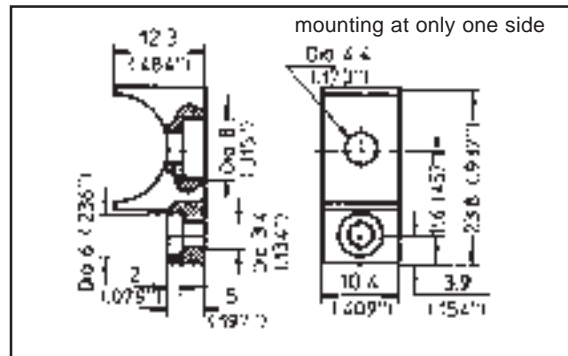
Part Number	Frequency Range	VSWR max.	Insertion Loss max.	Phase Shift min.	No. of Turns	Nom. Phase Shift Deg./GHz/Turnh	Time Delay (psec.)		Weight max.
							min.	max.	
LS-0165-VFVM	DC - 63.0 GHz	1.50:1	0.8 dB	600° at 63.0 GHz	8	1.2	167	195	53 g
LS-P165-VFVM		1.40:1							55 g



Two different Mounting Brackets are offered. They can easily be added to any Precision Phase Adjuster. Using these standard attachments makes it easy to mount the Phase Shifter in the system or to the test setup and ensures proper operation.



Bracket, Part No.: MB-0200-07  
Material: Aluminium iridited



Bracket, Part No.: MB-0100-07  
Material: Aluminium iridited

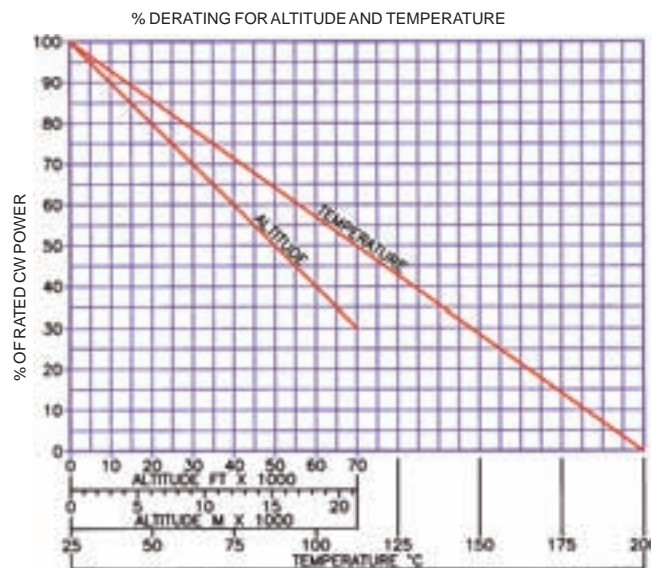
Max. Power of Phase Adjusters at max. operating frequency			
Frequency in (GHz)	2	10 12 14 20 24 26.5 30 40	50 60
Operational Range			
Power (W)	300	2.0 GHz	LS - 0002 - xxxx, LS - B002 - xxxx, LS - M002 - xxxx
	150	LS - 0112 - xxxx, LS - 0212 - xxxx, LS - A112 - xxxx, LS - A212 - xxxx	12.0 GHz
	120	LS - 0118 - xxxx, LS - 218 - xxxx, LS - A118 - xxxx, LS - A218 - xxxx	18.0 GHz
	100	LS - 0121 - xxxx, LS - 0221 - xxxx, LS - A121 - xxxx, LS - A221 - xxxx	26.0 GHz
		LS - 0170 - 1121	26.0 GHz
		LS - 0321 - 1121	26.0 GHz
	50	LS - 0141 - 02	26.0 GHz
		LS - 0200 - 02	26.0 GHz
	50	LS - 0012 - xxxx, LS - B012 - xxxx, LS - M012 - xxxx	12.0 GHz
	30	LS - 0085 - S001	18.0 GHz
LS - 0085 - 02		18.0 GHz	
20	LS - 0018 - xxxx, LS - B018 - xxxx, LS - M018 - xxxx	18.0 GHz	
6	LS - 0140 - KFKM, LS - P140 - KFKM	40.0 GHz	
5	LS - 0150 - HFHM, LS - P150 - HFHM	50.0 GHz	
	LS - 0165 - VFVM, LS - P156 - VFVM	63.0 GHz	

## Power Limiting Factors, Phase Adjusters

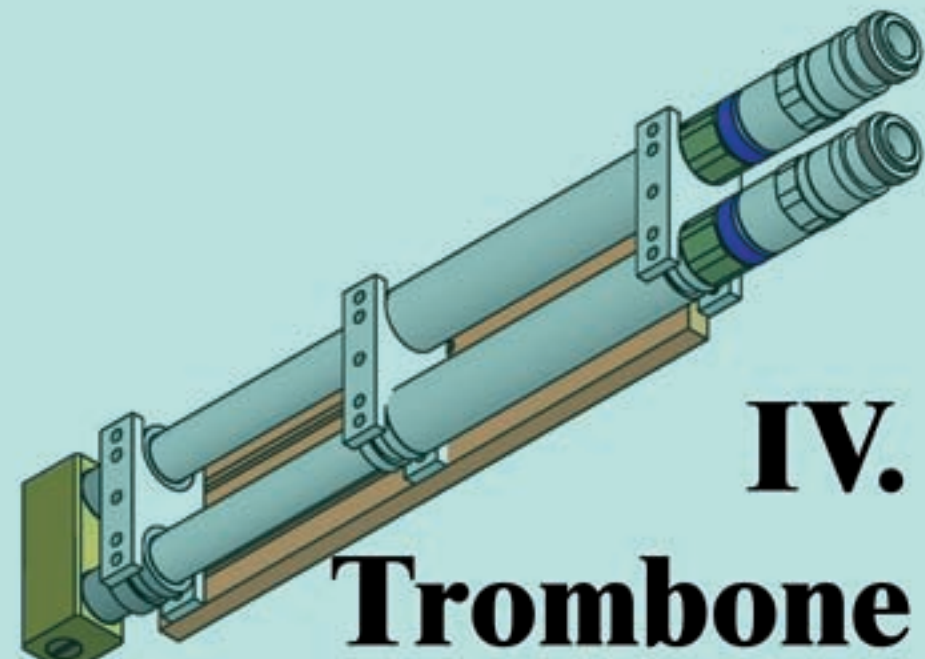
The Power Specifications, as listed on the Data Sheets, are based on Sea Level and an Ambient Temperature of 25°C. Other altitudes and/or higher temperatures will limit the power. The power derating diagram below can be used to calculate the maximum power at certain altitudes and temperatures.

For information on Power Limits of the components, power limiting information on the connectors is also needed. To obtain this information, the factory may be consulted.

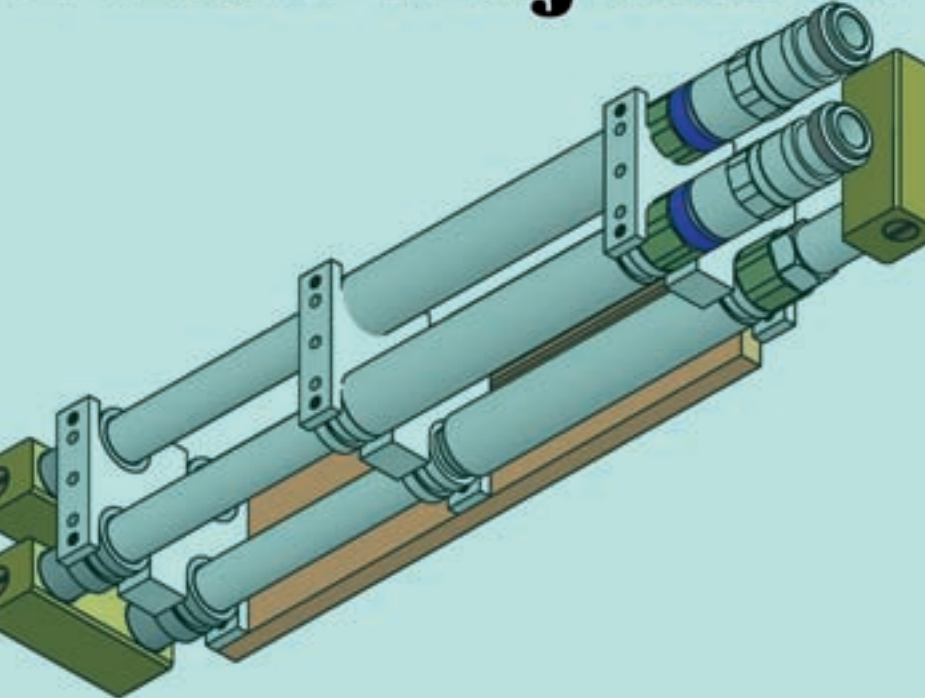
Additional Power Limits can be borne in the application, or the size and the heat dissipation of the unit. In addition, mechanical stress can be limiting the power.



$$\text{COMPONENT POWER CAPABILITY} = (\text{RATED POWER}) \times (\text{TEMPERATURE DERATING}) \times (\text{ALTITUDE DERATING})$$



**IV.**  
**Trombone**  
**Phase Adjusters**



The image shows two 3D cutaway diagrams of a trombone phase adjuster. The top diagram shows the device from a perspective where the left end is fixed to a green mounting block. The bottom diagram shows the device from a perspective where the right end is fixed to a green mounting block. Both diagrams show two parallel cylindrical tubes mounted on a brown base, with various electrical connections and adjustment points.

**Trombone Line Phase Adjusters are needed at lower frequency applications where the phase adjustment of the components shown in the chapters before is not sufficient. Also Trombone Line Phase Adjusters are designed for constant impedance over the whole adjustment range. They are employed to adjust the electrical separation of other components without introducing additional mismatch. All step discontinuities have been carefully compensated. Locking screws are provided to comfort the sliding tension and to lock at the desired adjustment. The best materials have been used, beryllium copper contacts assuring long life and noise-free operation, aluminum, brass and stainless steel parts for low weight, best performance and ruggedness, where needed. Stops at both ends of travel are preventing damage of the unit and do not allow accidental disassembly.**



## **LS-0103-6161**

**This unit consists of a single in-line phase adjuster. The component is normally supplied with N-Type female connectors. Other connector configurations are available on request.**



## **LS-0203-6161**

**This component consists of two phase adjusters mounted in parallel and joined at one end, permitting adjustment of 360° @ 1 GHz. The component is normally supplied with N-Type female connectors. Other, or mixed connector configurations are available on request.**

**Above Phase Adjusters have been designed and are currently in manufacturing and it is expected that they are released from testing in summer / fall 2008.**





<b>Electrical</b>		
Part Number	<b>LS-0203-6161</b>	<b>LS-0103-6161</b>
Impedance	50.0	
Frequency Range	DC- 3.0 GHz	
Adjustment	360° at 1.0 GHz 1080° at 3.0 GHz	180° at 1.0 GHz 540° at 3.0 GHz
Return Loss	25 dB at 3 GHz	
Dielectric Withstanding Voltage	2,500 volts rms at sea level	
Insulation Resistance	5,000 MO minimum	
RF Leakage	-(90-f(GHz))dB	
<b>Mechanical</b>		
Interface	MIL-STD-348A	
Connector Durability	500 cycles, 12 cycles/minute	
<b>Material</b>		
Fixture and Outer Conductor: Aluminium	AlMg4.5Mn and AlMgSiPb per DIN EN 573-3 ( QQ-A-225/8)	
Fixture and Outer Conductor: Stainless Steel	Corrosion resistant 1.4305 per DIN EN 10088-3( ASTM-A-582-80)	
Outer Conductor: Brass	CuZn39Pb3 per DIN EN 12163/12164 (ASTM B 455)	
Center Contacts: Copper Beryllium	33-25 CuBe2Pb H per DIN 17666 (ASTM-B-196 )	
Insulators	TFE: Fluorocarbon per ASTM D 1710 Other Dielectrics: per inhouse specification.	
<b>Finish</b>		
Copper Beryllium	Centre Contacts shall be gold plated to a minimum thickness of .00005 inch (1.25 µm) in accordance with ASTM B 488, Type 2, Code C, Class 1.25.	
Stainless Steel	Passivated per ASTM A 967	
Brass	.00003 inch (0.75 µm) min.gold plating per ASTM B 488, Type 2, Code C, Class 0.75, over nickle plating.	
Aluminium	Conductive Parts shall have an iridited finish per MIL-C-5541	
<b>Environmental</b>		
Temperature Range	Operating: -65°C to +115°C	

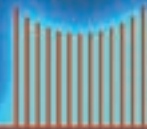
# Engineering Perfection

*Striving for excellence  
Exploring new methods  
Generating Solutions  
Creating Intelligence*

*Developping  
products as needed  
in your system for  
the success of your  
Program.*



*The 135° angled Connectors and Adapters  
where straight and mitred units do not fit.*



**Spectrum**  
Elektrotechnik GmbH

**when Quality is needed**

**80905 Munich, Germany**

**P.O. Box 450533**

**Telephone: +49-89-3548-040**

**Facsimile: +49-89-3548-0490**

**WWW.SPECTRUM-ET.COM \* Email: [specelek@compuserve.com](mailto:specelek@compuserve.com)**

Phase 540-135Grad Winkel



# V. Phase Adjustable Connectors



**In many cases the phase adjustable units look like regular connectors.**

**PhaseAdjConn**

## Phase & Amplitude Matched Cable Assemblies

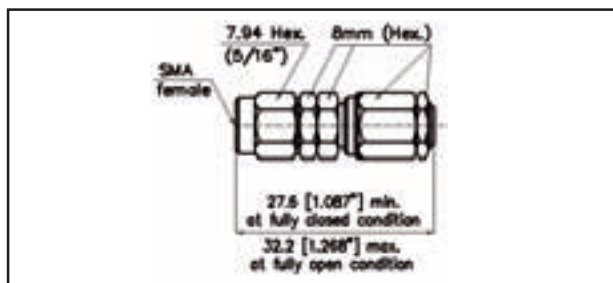
Since 1981 Spectrum Elektrotechnik GmbH has been manufacturing high quality phase and amplitude matched cable assemblies. Experienced staff is available to assist the customer to select the proper component for the specific application and to provide information on the product performance.

Matching cable assemblies for phase must not necessarily mean to trim the cables to the exact lengths. Spectrum Elektrotechnik GmbH manufactures a variety of Phase Adjusters that can be attached directly to the cable. Using these devices, cable assemblies can easily be matched to perfection, at any frequency. Examples of phase adjustable connectors are shown below.

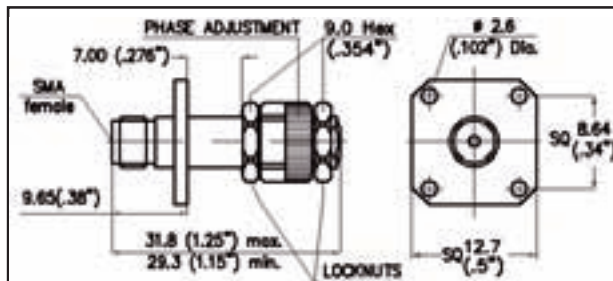
Phase Shifters practically eliminate the need to trim cables to predetermined lengths, in order to achieve the exact phase requirements of a microwave network. Cables only need to be trimmed to the approximate electrical length. The Phase Shifter then allows to make the necessary adjustment between the other components in the system. As a result of the small size and light weight, these Phase Shifters can be used in applications with space limitations, such as airborne and satellite equipment.

## Phase Adjustable SMA Connectors for Semi-Rigid Cables

Adjustable coaxial Phase Shifters Models LS-0141-02 and LS-0085-02	
Frequency Range	DC - 26.0 GHz
Adjustment	Max. 126° at 26.0 GHz
Impedance	50 Ohms
Max. VSWR	1.05 + .008f(GHz)
Insertion Loss	(.05 SQT(f(GHz)))dB
R.F. Leakage	-90 dB
Temperature Range	-65°C to +115°C



Adjustable coaxial Phase Shifter Model LS-0085-S001	
Frequency Range	DC - 18.0 GHz
Adjustment	Max. 50° at 18.0 GHz
Impedance	50 Ohms
Max. VSWR	1.12:1 at 18.0 GHz
Insertion Loss	0.25 dB at 18.0 GHz
R.F. Leakage	-90 dB
Temperature Range	-65°C to +115°C

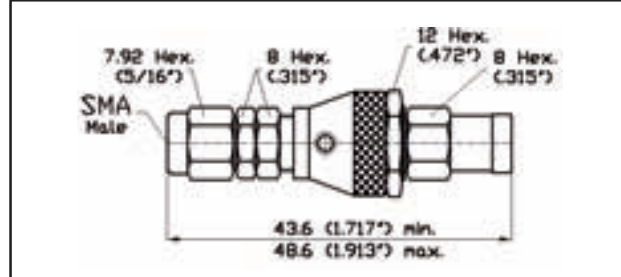


Part Number	Cable Type	Frequency Range	VSWR max.	Insertion Loss max.	Phase Shift min.	No. of Turns	Nom. Phase Shift Deg./GHz/Turn	Time Delay (psec.)		Weight max.
								min.	max.	
LS-0141-02	0.141" Semi-Rigid	DC - 26.0 GHz	1.25 : 1	0.26 dB	127° at 26.0 GHz	9	0.55	72.2	87.6	9 g
LS-0085-02	0.085" Semi-Rigid							9 g		
LS-0085-S001	0.085" Semi-Rigid	DC - 18.0 GHz	1.12 : 1	0.25 dB	50° at 18.0 GHz	5	0.55	85.3	93.7	9 g

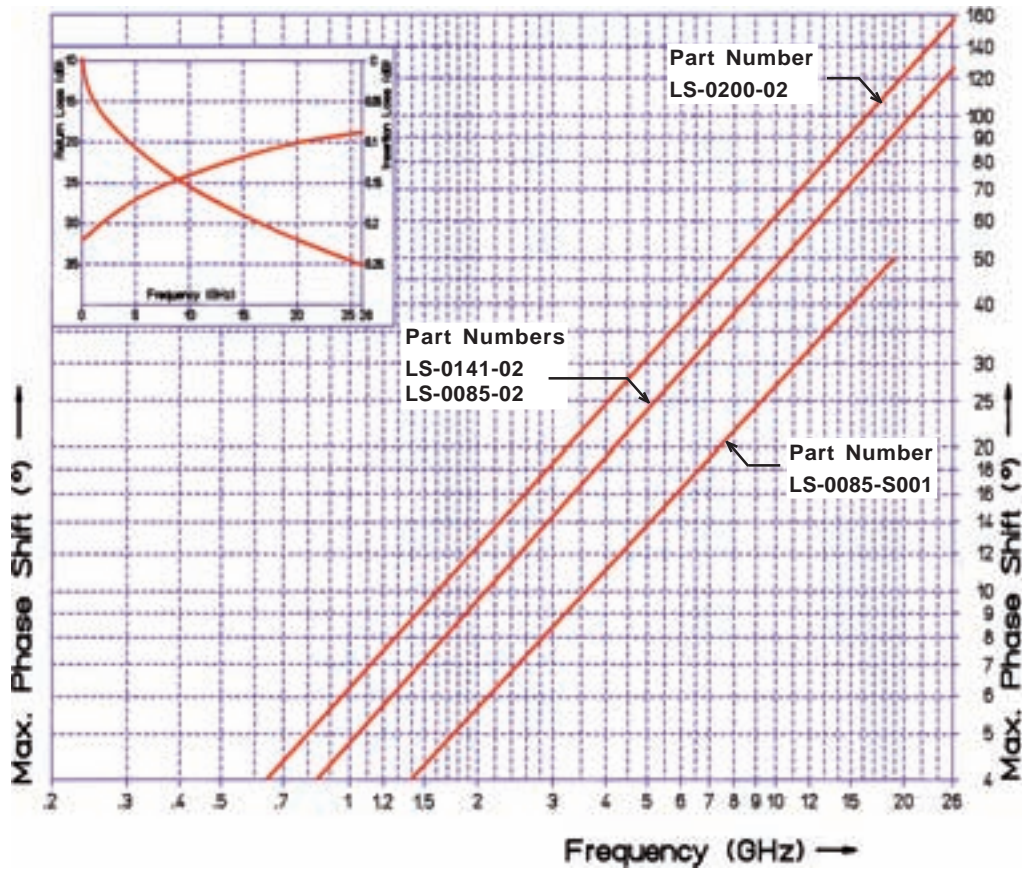


## Phase Adjustable SMA Connectors for Flexible Cables

Adjustable coaxial Phase Shifters Models LS-0200-02	
Frequency Range	DC - 26.0 GHz
Adjustment	155°
Impedance	50 Ohms
Max. VSWR	1.05+.008f(GHz)
Insertion Loss	(.05 SQT(f(GHz))) dB
R.F. Leakage	-90dB
Temperature Range	-65°C to +115°C

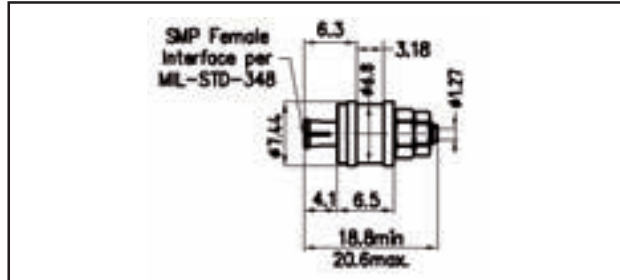


Part Number	Cable Type	Frequency Range	VSWR max.	Insertion Loss max.	Phase Shift min.	No. of Turns	Nom. Phase Shift Deg./GHz/Turn	Time Delay (psec.) min. max.	Weight max.
LS-0200-02	100	DC-26.0 GHz	1.25:1	0.26 dB	155° at 26.5 GHz	10	0.60	80.1 96.8	tb.d.

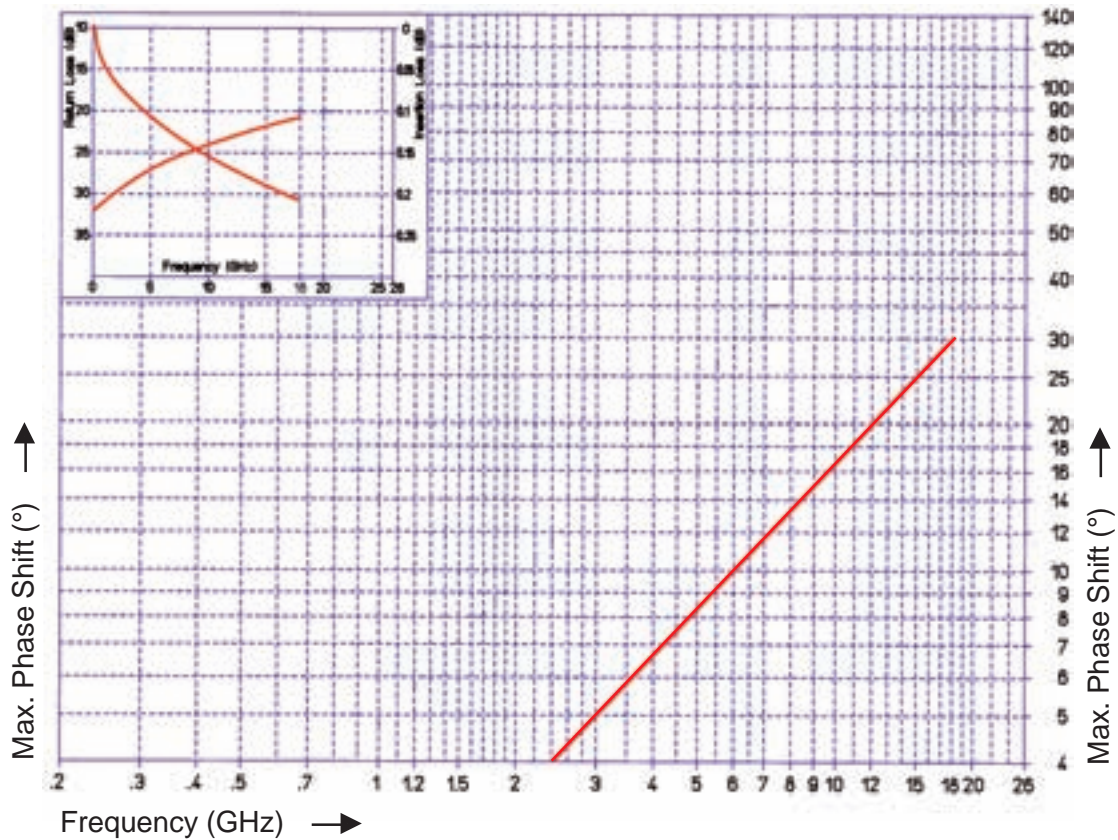


## Phase Adjustable SMP Connectors for Semi-Rigid Cables

Adjustable coaxial Phase Shifters Models 1102-65LS-04	
Frequency Range	DC - 18.0 GHz
Adjustment	30° at 18.0 GHz
Impedance	50 Ohms
Max. VSWR	1.1:1 max. to 18.0 GHz
Insertion Loss	(.05 SQT(f(GHz)))dB
R.F. Leakage	Not applicable
Temperature Range	-65°C to +115°C



Part Number	Cable Type	Frequency Range	VSWR max.	Insertion Loss max.	Phase Shift min.	No. of Turns	Nom. Phase Shift Deg./GHz/Turn	Time Delay (psec.) min. max.	Weight max.
1102-65LS-04	0.047" Semi-Rigid	DC - 18.0 GHz	1.1 : 1	0.21 dB	30° at 18.0 GHz	5.5	0.3°	57.4 62.0	2.6 g





# VI. Matched Cable Assemblies



PhaseMatchedSQ-12

## Discussing Phase Matching

Cable Assemblies can be matched in **Phase, Delay, and Amplitude**. The most common matching required is **Phase matching**. The match can be specified in electrical degrees at a specified frequency or in time delay.

Of interest are 3 groups of candidates for phase matched cable assemblies:

- **Semi Rigid Cables**, using copper or stainless steel for the outer conductor
- **Semi Flexible Cables**, easier formable by hand, using aluminum tubing as outer conductor
- **Flexible Cables**, having one or more layers of braid as outer conductor

## Phase Matched Cable Assemblies in a Set

Normally two specifications are used for phase matched sets of cables assemblies:

- Matching to a Standard:** The phase standard is usually a piece of hardware, a “Gold Standard”, it also could be an unchanging software standard; i.e. a specified electrical length at a certain frequency.
- Matching as a Set:** Cable assemblies matched as a set means that the assemblies of the same set are matched to each other. The cables in one set may not match those of another set.



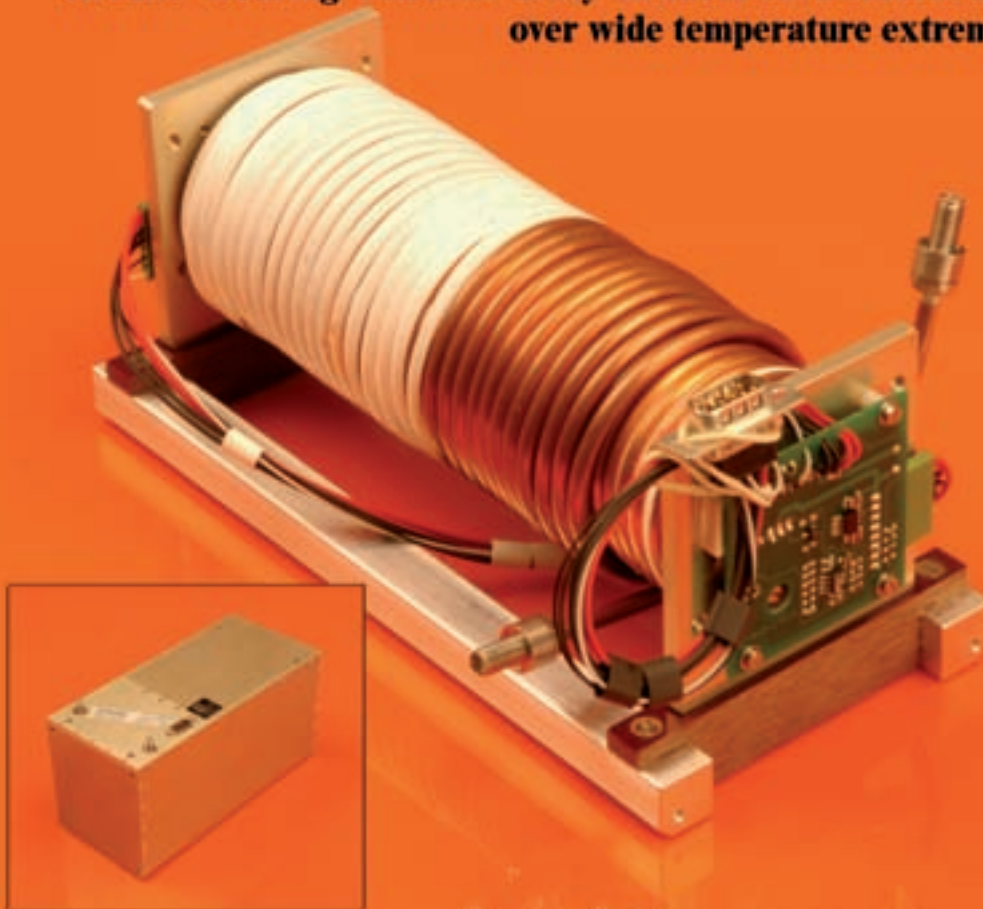


## Governing Parameters on Phase Matching

- 1) **Frequency of Operation:** The higher the operating frequency and the closer the required phase match, the more difficult the matching process and the cost will be.
- 2) **Length of Cable Assemblies:** Short Cable Assemblies are usually easier to match and to test than longer assemblies. With longer assemblies there is already the problem that they need to be coiled for testing and this results in phase changes already, a wider match window is required.
- 3) **Connectors of the Assemblies in one set:** There is no problem to use different connector styles in a set of matched cable assemblies; it may add additional cost though, as the matching process may get more complicated because of different connector lengths and dielectrics.
- 4) **Installation Process:** Especially for matched sets with long cable assemblies phase changes can be expected during installation. Phase adjustable connectors or adapters can be used for phase correction after installation.
- 5) **Variation of Velocity of Propagation:** Manufacturing without tolerance is not possible, unfortunately. For a cable the velocity of propagation is usually specified at +/- 2%, or maybe at +/- 1%, resulting in different electrical lengths of cable assemblies with identical physical lengths. This will be noticeable especially with long cable assemblies or when using cable manufactured from different lots.
- 6) **Temperature** Change in temperature will result in change of electrical length of the cable assembly, caused by the dielectric of the cable. Cables using solid extruded PTFE dielectric are generally strong mechanically but higher for insertion loss and show worst phase changes over temperature when compared to cables using air content in their dielectric. These latter cables are weaker mechanically but lower in insertion loss and have better phase versus temperature characteristics.
- 7) **Testing Phase Match:** Usually Vector Network Analyzers will be used in a temperature-controlled room. But it has to be taken into consideration that test results taken even with the best equipment are subjected to tolerances.
- 8) **Phase Tracking** Phase tracking is usually caused by three parameters:  
**Preconditioning:** The cables of a phase-matched set need to be thermally stress relieved before phase matching. At Spectrum Elektrotechnik GmbH the cable is preconditioned by exposing it several times to temperatures of -54°C to +125°C, in some cases even between -71°C to +200°C. This will assure good phase tracking.  
**Temperature:** The phase change with temperature may not be that critical if the complete set is exposed to the changing temperature, as the phase will shift equally in all of the assemblies of the set, assuming that assemblies are not formed in a bundle where the inner assemblies will see the temperature change much later than the outer assemblies. It will be most critical when assemblies of the same set, matched at ambient, are subjected to different temperatures in the system.  
**Bending:** As outlined earlier for sets with long cable assemblies phase changes can be expected already after static installation. For dynamic installation phase tracking will depend on the bend radii, the number of cycles, and the similarity of the flexure cycles of the assemblies in the set.

## Match in Delay

**Spectrum Elektrotechnik GmbH manufactures a variety of Delay Lines in the range of a few nanoseconds to several hundred nanoseconds, mostly using cable with low density dielectric. Some of the delay lines are completely housed, operating with internal heaters and temperature stabilizing circuits securing constant delay in harsh environment and over wide temperature extremes.**



## Ordering

Please include both, Spectrum Elektrotechnik GmbH part number, and a description of the item(s) ordered. If special features are required, describe them as completely as possible and include an engineering sketch. Orders may be placed directly with the factory in Munich or with any authorized Spectrum Elektrotechnik GmbH Representative. Minimum Factory Order is EUR 250.00.

## Acceptance of Orders

All orders are subject to acceptance at the discretion of the factory and with an Order Acknowledgment from Spectrum Elektrotechnik GmbH.

## Terms

Upon approval of credit, payment is due Net 30 days from date of invoice. Late payments are subject to a 1.5 % monthly charge on past due balances.

## Shipments

Spectrum Elektrotechnik GmbH ships via the most expedient reliable carrier. Shipment F.O.B., Spectrum Elektrotechnik GmbH plant, will be sent freight prepaid and billed unless other prior arrangements are made. Spectrum Elektrotechnik GmbH will use any acceptable method of delivery specifically requested by the customer.

## Damaged Materials/Shortages

All orders should be inspected upon receipt for both completeness and to insure receipt of materials in proper condition. All claims for shortages must be made within thirty (30) days after date of shipment of material from Spectrum Elektrotechnik GmbH plant. Title to goods passes to the Buyer upon delivery to the carrier and risk of loss or damage shall thereafter rest with the Buyer. Claims for damage or loss while material is in transit must be made against the carrier by the Buyer.

## Cancellation

Cancellation of, or changes to an order acknowledged by Spectrum Elektrotechnik GmbH are accepted only upon terms that protect Spectrum Elektrotechnik GmbH against loss.

## Returns

Excess or unused material cannot be returned for credit without factory authorization. Such material is subject to a handling charge of not less than 15 % upon return and inspection of material at the factory. In no case will Spectrum Elektrotechnik GmbH authorize return of material beyond ninety (90) days after shipment from the factory. Credit for returned material is issued by Spectrum Elektrotechnik GmbH only to the original purchaser. Freight charges for returned material is the responsibility of the Buyer.

## Defective Material

Claims for defective material or workmanship are subject to verification by Spectrum Elektrotechnik GmbH Quality Control, and must have prior factory authorization. Upon verification, Spectrum Elektrotechnik GmbH reserves the right to repair or replace, as deemed necessary.

## Prices / Specifications

Unless otherwise specified, prices quoted are F. O. B. Spectrum Elektrotechnik GmbH plant. Both prices and specifications are subject to modification without prior notice.

## Patent and Trademark Indemnity

Buyer agrees at Buyer's expense to protect and defend Seller against any and all claims of patent or trademark infringement arising from Seller's compliance with Buyer's designs or specifications or instruction and to hold Seller harmless from all losses, damages, costs and expenses attributable to any such claim or claims. Seller shall have the right to approve or disapprove counsel designated by Buyer to defend such claims.

## Warranty

Spectrum Elektrotechnik GmbH warrants products of its manufacture to be free from defects in material and work-manship under conditions of normal use. If, within one year after delivery of the original owner and after prepaid return by the original owner, any Spectrum Elektrotechnik GmbH product is found to be defective, Spectrum Elektrotechnik GmbH shall, at its option, repair or replace said defective item. This warranty does not apply to products which have been disassembled, modified or subjected to conditions exceeding the applicable specifications or ratings.

Spectrum Elektrotechnik GmbH reserves the right to make design changes without notice on any of its products and without any obligation to make same or similar changes to items previously purchased. In no event does Spectrum Elektrotechnik GmbH assume liability for installation labor or for consequential damages. This warranty is the extent of the obligation or liability assumed by Spectrum Elektrotechnik GmbH with respect to its products, and no other warranty or guarantee is either expressed or implied.

Adapters, Attenuators, Blind Mate Connectors, Cable Assemblies, Connectors, Delay Lines, Duplexers Equalizers, Fine Grain Equalizers, Gain Amplitude Equalizers, Line Stretchers, Machines, Phase Adjusters, Push - On Connectors & Adapters, Quick Connections, Terminations (Coax-), Tools, Waveguide to Coax - Adapters & Transmissions, and.....

**Advanced  
Designs  
to your  
needs!**



**Spectrum** when Quality is needed  
Elektrotechnik GmbH

80905 Munich, Germany P.O. Box 450533  
Telephone: +49-89-3548-040 Facsimile: +49-89-3548-0490  
WWW.SPECTRUM-ET.COM \* Email: specelek@compuserve.com

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## WG/Coax Adapters

Rectangular WG & Double Ridge WG, End Launched & Top Launched Aluminum, Copper, Brass, All Standard Flanges available  
WR 650 to WR 22, Frequency: 1.12 GHz to 50.8 GHz  
Most Coax Connectors Series at NO Surcharge.



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**Handy  
Form**

\* Easy formable by hand  
\* Electrical Specification similar to Semi - Rigid  
\* Reduced Weight!



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**Gain Amplitude Equalizers  
and Fine Grain Equalizers**  
parabolic or sinusoidal, and linear or slope  
Frequency Range: 2.0 GHz to 32.0 GHz



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Elektrotechnik GmbH

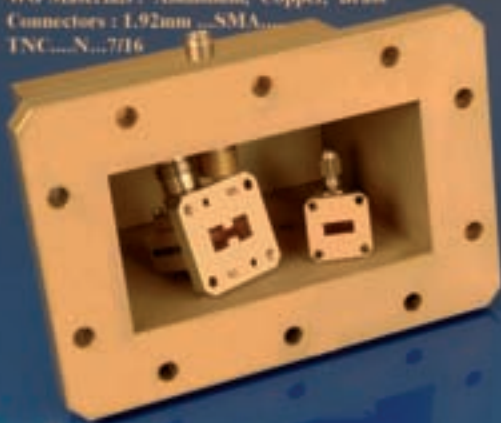
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# Big and Small,

we have 'em all

Almost any Waveguide to almost any Conn. Connector  
 WG Materials: Aluminum, Copper, Brass  
 Connectors: 1.92mm, SMA, TNC, N, 7/16



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Are you still Threading?  
 Torquing? Untorquing?  
 Unthreadening?

Never ever heard of  
**Push-Ons?**  
**Slide On!**  
**Pull Off!**  
**Done!**



Push - On Connectors do fit all  
 standard SMA, N, TNC, 7/16

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# SpectrumFlex

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# Hermetically Sealed Adapters



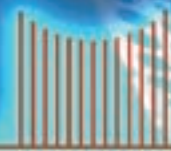
2.92mm, TNC, N, Feedthroughs  
 with venting holes for Vacuum Test Chambers

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**The Push-On Family: SMA, N, TNC, 7/16 & F**  
**SQ-8 = Connecting 8 Coaxial RF-Lines at once**  
**SQ-12 = Connecting 12 Coaxial RF-Lines at once**  
**SM23-DC26 = Connecting 23 Coaxial RF - Lines**  
**and as well as 26 Signal Lines at once**



**Spectrum**  
Elektrotechnik GmbH

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