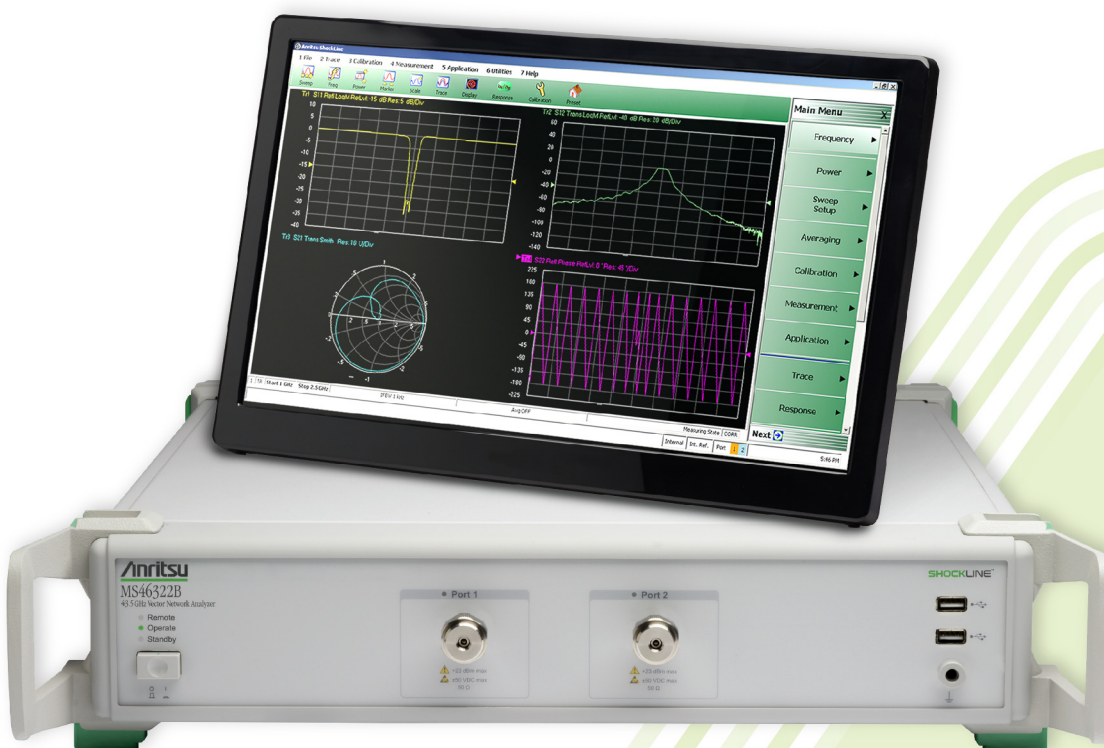


**Anritsu** Advancing beyond

# ShockLine™ Economy Vector Network Analyzers

## MS46322B

1 MHz to 43.5 GHz



## Introduction

The MS46322B is part of the ShockLine™ family of Vector Network Analyzers from Anritsu. It is a low-cost series of 2U high, 2-port Economy Vector Network Analyzers. It is available in three frequency ranges: 1 MHz to 8/20/43.5 GHz, and is capable of S-parameter and time domain measurements.

The MS46322B is based on patented shockline VNA-on-chip technology, which simplifies the internal VNA architecture at high frequencies, reduces instrument cost, and enhances accuracy and measurement repeatability. The combination of low cost and good performance make ShockLine™ VNAs ideal candidates for testing RF and Microwave passive devices to 43.5 GHz.

The MS46322B series supports SCPI command programming and has software driver support for the most common programming environments. The MS46322B use industry standard LAN communications for robust remote control in test applications. ShockLine™ VNAs provide a powerful graphical user interface for manual testing of devices. The full-featured user interface is enabled by attaching a (user-supplied) touchscreen monitor, keyboard, and mouse.

This document provides detailed specifications for the MS46322B series Vector Network Analyzers (VNAs) and related options.

## Instrument Models and Operating Frequencies

### Base Model

- MS46322B, 2-Port ShockLine VNA

### Requires one Frequency Option

- MS46322B-010, 1 MHz to 8 GHz, 2-port
- MS46322B-020, 1 MHz to 20 GHz, 2-Port
- MS46322B-043, 1 MHz to 43.5 GHz, 2-Port

## Principal Options

- MS46322B-002, Time Domain
- MS46322B-024, Universal Fixture Extraction



MS46322B-043 2-Port ShockLine Economy VNA

**Table of Contents**

Definitions.....	3
System Dynamic Range .....	4
Receiver Compression Levels .....	4
High Level Noise .....	4
Output Power Settings .....	4
Measurement Stability .....	4
Frequency Resolution, Accuracy, and Stability .....	4
Uncorrected (Raw) Port Characteristics .....	4
MS46322B-010 VNA System Performance with Manual Cal Kits .....	5
MS46322B-020 VNA System Performance with Manual Cal Kits .....	6
MS46322B-043 VNA System Performance with Manual Cal Kits .....	7
MS46322B-043 VNA System Performance with Manual Cal Kits .....	8
MS46322B-010 VNA System Performance with SmartCal™ .....	9
MS46322B-010 VNA System Performance with SmartCal™ .....	10
MS46322B-010 and MS46322B-020 VNA System Performance with SmartCal™ .....	11
MS46322B-010 and MS46322B-020 VNA System Performance with SmartCal™ .....	12
MS46322B-043 VNA System Performance with Precision AutoCal™ .....	13
Measurement Throughput Summary .....	14
Standard Capabilities .....	14
Calibration and Correction Capabilities .....	16
Optional Capabilities .....	16
Remote Operability .....	16
Front Panel Connections .....	17
Rear Panel Connections .....	17
CPU, Memory, and Security Features .....	18
Mechanical .....	18
Regulatory Compliance .....	18
Environmental .....	18
Warranty .....	18
Ordering Information .....	19

**Definitions**

	This technical data sheet applies to the following hardware revisions: MS46322B base model, revision 3 MS46322B-010 8.5 GHz option, revision 1 MS46322B-020 20 GHz option, revision 2 MS46322B-043 43.5 GHz option, revision 1
Warm-Up Time	After 30 minutes of warm-up time, where the instrument is left in the ON state.
Temperature Range	Over the 25 °C ± 5 °C temperature range.
Error-Corrected Specifications	Specifications are valid over 23 °C ± 3 °C, with < 1 °C variation from calibration temperature. Error-corrected specifications are warranted and include guard-bands, unless otherwise stated.
Frequency Bands in Tables	When a frequency is listed in two rows of the same table, the specification for the common frequency is taken from the lower frequency band.
User Cables	Specifications do not include effects of any user cables attached to the instrument.
Discrete Spurious Responses	Specifications may exclude discrete spurious responses.
Internal Reference Signal	All specifications apply with internal 10 MHz Crystal Oscillator Reference Signal.
Interpolation Mode	All specifications are with Interpolation Mode Off.
Standard	Refers to instruments without Options.
Typical Performance	Typical performance indicates the measured performance of an average unit. It does not include guard-bands and is not covered by the product warranty. Typical specifications are shown in parenthesis, such as (-102 dB), or noted as Typical.
Characteristic Performance	Characteristic performance indicates a performance designed-in and verified during the design phase. It does include guard-bands and is not covered by the product warranty.
Recommended Calibration Cycle	12 months (Residual specifications also require calibration kit calibration cycle adherence.)
Specifications Subject to Change	All specifications subject to change without notice. For the most current data sheet, please visit the Anritsu web site: <a href="http://www.anritsu.com">www.anritsu.com</a>

The instrument may be protected by one or more of the following patents: 6894581, 7088111, 7545151, 7683633, 7924024, 8417189, 8718586, 10778592.

## System Dynamic Range

System dynamic range is calculated as the difference between High source power and the noise floor (RMS) at the specified reference plane at 10 Hz IF Bandwidth with an isolation calibration.

Frequency Range	Standard (dB)	Typical (dB)
1 MHz to 10 MHz	85	105
> 10 MHz to 8 GHz <sup>a</sup>	100	115
> 8 GHz to 40 GHz <sup>b</sup>	100	110
> 40 GHz to 43.5 GHz	97	110

a. Crosstalk may reduce dynamic range up to 20 dB (typical) at lower IF bandwidths ( $\leq 10$  kHz) when measuring highly reflective DUT's from 4 GHz to 8 GHz. Reflection measurements are not affected.

b. Decrease specification by 5 dB between 8 GHz and 14 GHz.

## Receiver Compression Levels

Port power level beyond which the response may be compressed more than 0.1 dB. Performance is characteristic.

Frequency Range	Standard (dBm)
1 MHz to 43.5 GHz	+5 dBm

## High Level Noise

Measured at 100 Hz IF bandwidth and at High power level, RMS. Performance is characteristic.

Frequency	Magnitude (dB)	Phase (deg)
1 MHz to < 20 MHz	0.03 (0.005, typical)	< 0.2 (< 0.035 typical)
20 MHz to 20 GHz	0.006 (0.001, typical)	< 0.1 (< 0.05 typical)
> 20 GHz to 40 GHz	0.006 (0.001, typical)	< 0.15 (< 0.05 typical)
> 40 GHz to 43.5 GHz	0.009 (0.001, typical)	< 0.18 (< 0.05 typical)

## Output Power Settings

Performance is typical

Power Setting	Standard
High (default)	1 MHz to 8 GHz 5 dBm > 8 GHz to 43.5 GHz -3 dBm
Low	1 MHz to 43.5 GHz -20 dBm

## Measurement Stability

Ratio measurement, with ports shorted. Typical.

Frequency	Magnitude (dB/°C)	Phase (deg/°C)
10 MHz to 43.5 GHz	0.02	0.3

## Frequency Resolution, Accuracy, and Stability

Resolution	Accuracy	Stability	Aging
1 Hz	$\pm 1.0$ ppm (at time of calibration)	$\pm 1.0$ ppm from -10 °C to +55 °C, typical	$\pm 1.0$ ppm/yr, typical

## Uncorrected (Raw) Port Characteristics

User and System Correction Off. All specifications are typical.

Frequency Range	Directivity (dB)	Port Match (dB)
1 MHz to 43.5 GHz	> 8 dB	> 8 dB

# MS46322B-010 VNA System Performance with Manual Cal Kits

## Error-Corrected Specifications

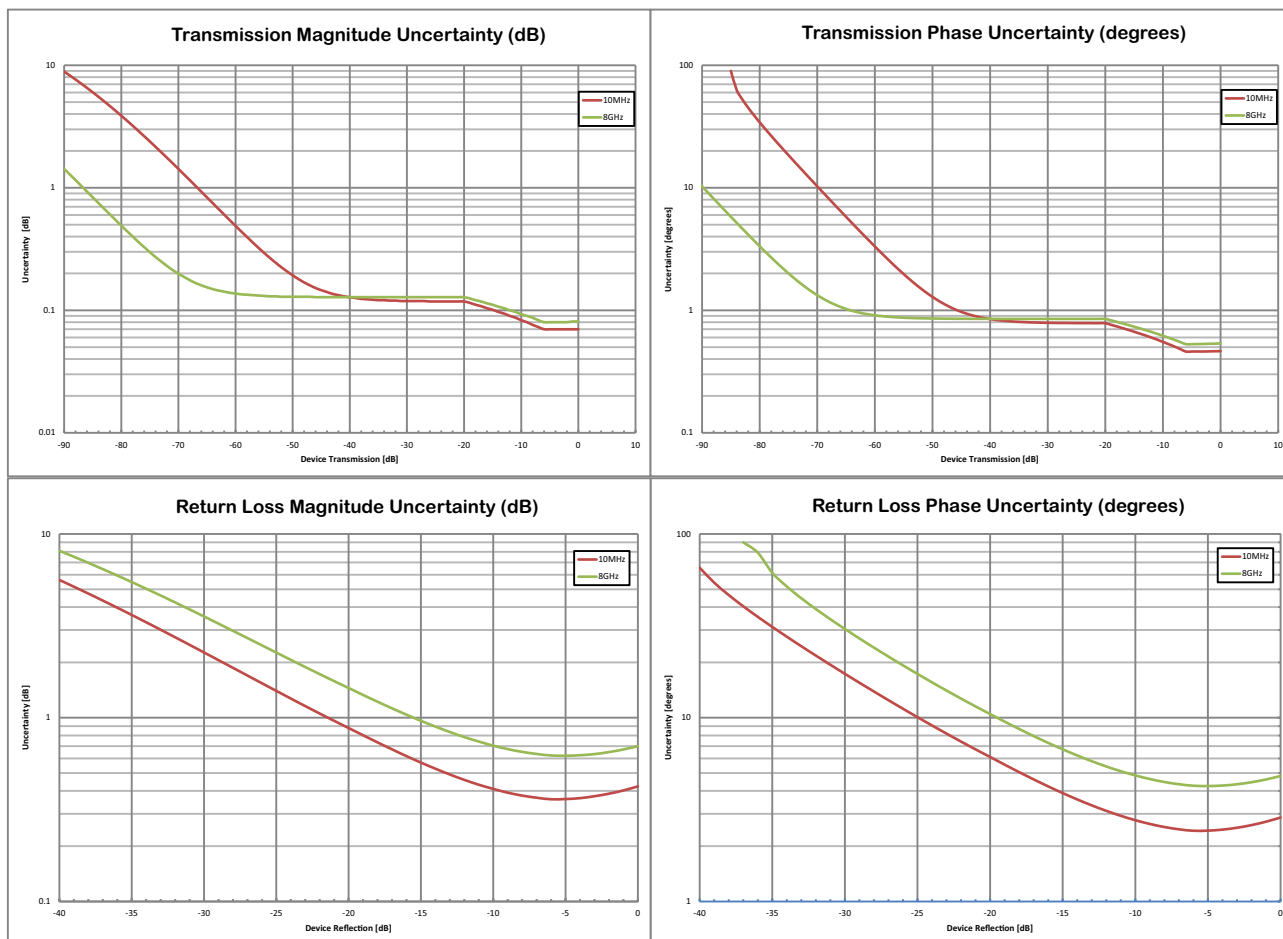
With 12-term SOLT Calibration using TOSLN50A-8 or TOSLNF50A-8 N type connector calibration kits.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match <sup>a</sup> (dB)	Reflection Tracking <sup>a</sup> (dB)	Transmission Tracking <sup>a</sup> (dB)
1 MHz to 6 GHz	≥ 42	≥ 33	≥ 42	±0.15	±0.06
> 6 GHz to 8 GHz	≥ 37	≥ 33	≥ 37	±0.15	±0.06

a. Characteristic performance.

## Measurement Uncertainties

The graphs give measurement uncertainties after the above error-corrected calibration. The errors are a worst-case contribution of residual directivity, load and source match, frequency response and isolation, network analyzer dynamic accuracy, and connector repeatability. 10 Hz IF Bandwidth is used. For transmission uncertainties, it is assumed that  $S_{11} = S_{22} = 0$ . For reflection uncertainties, it is assumed that  $S_{21} = S_{12} = 0$ . All calibrations and measurements were performed at default port power. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at [www.anritsu.com](http://www.anritsu.com).



## MS46322B-020 VNA System Performance with Manual Cal Kits

## Error-Corrected Specifications

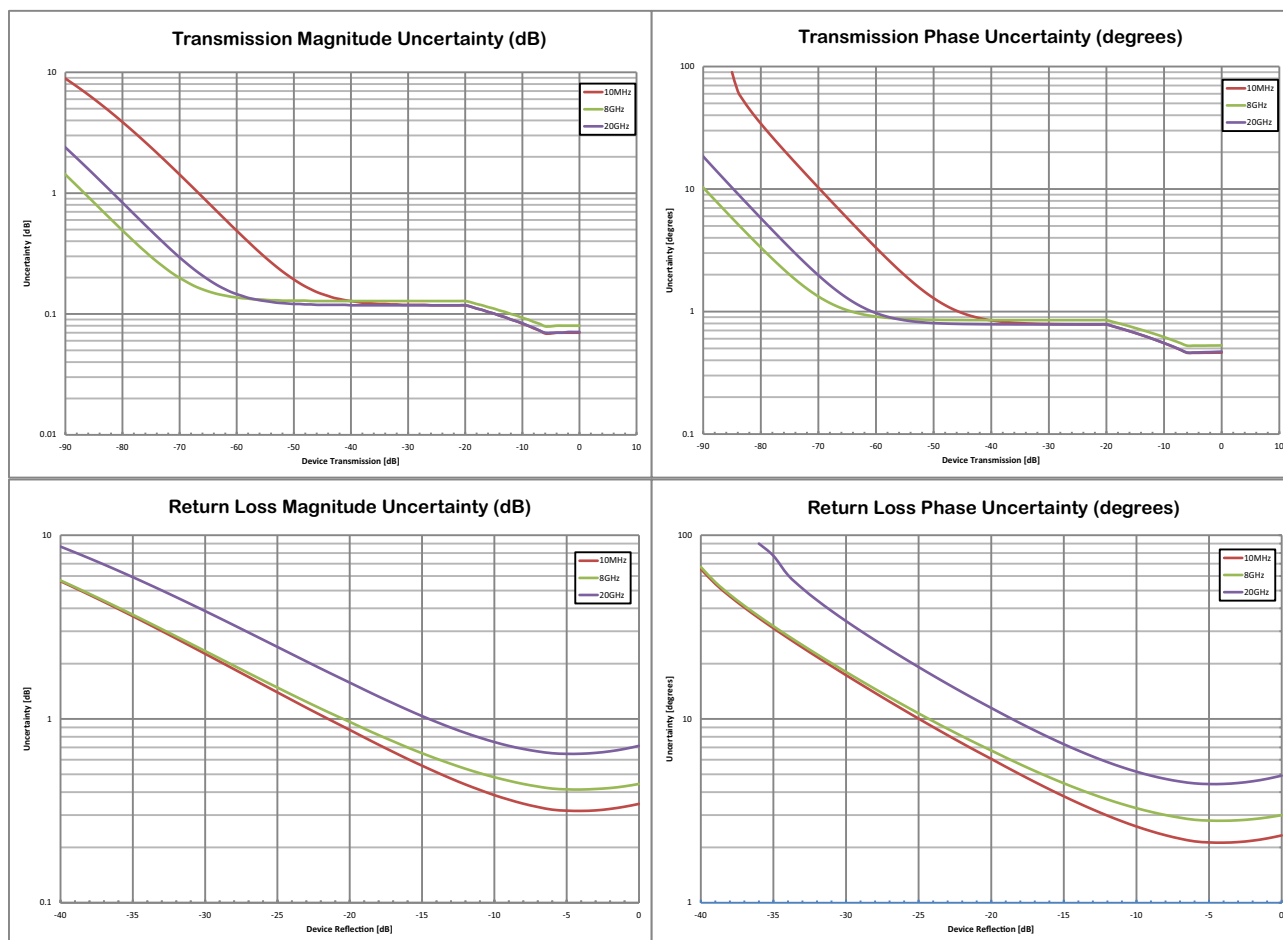
With 12-term SOLT calibration using the TOSLK50A-20 or TOSLK50A-20 K type connector calibration kits.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match <sup>a</sup> (dB)	Reflection Tracking <sup>a</sup> (dB)	Transmission Tracking <sup>a</sup> (dB)
1 MHz to 10 GHz	≥ 42	≥ 33	≥ 42	±0.15	±0.06
> 10 GHz to 20 GHz	≥ 36	≥ 26	≥ 36	±0.15	±0.05

a. Characteristic performance.

## Measurement Uncertainties

The graphs give measurement uncertainties after the above error-corrected calibration. The errors are a worst-case contribution of residual directivity, load and source match, frequency response and isolation, network analyzer dynamic accuracy, and connector repeatability. 10 Hz IF Bandwidth is used. For transmission uncertainties, it is assumed that  $S_{11} = S_{22} = 0$ . For reflection uncertainties, it is assumed that  $S_{21} = S_{12} = 0$ . All calibrations and measurements were performed at default port power. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at [www.anritsu.com](http://www.anritsu.com).



# MS46322B-043 VNA System Performance with Manual Cal Kits

## Error-Corrected Specifications

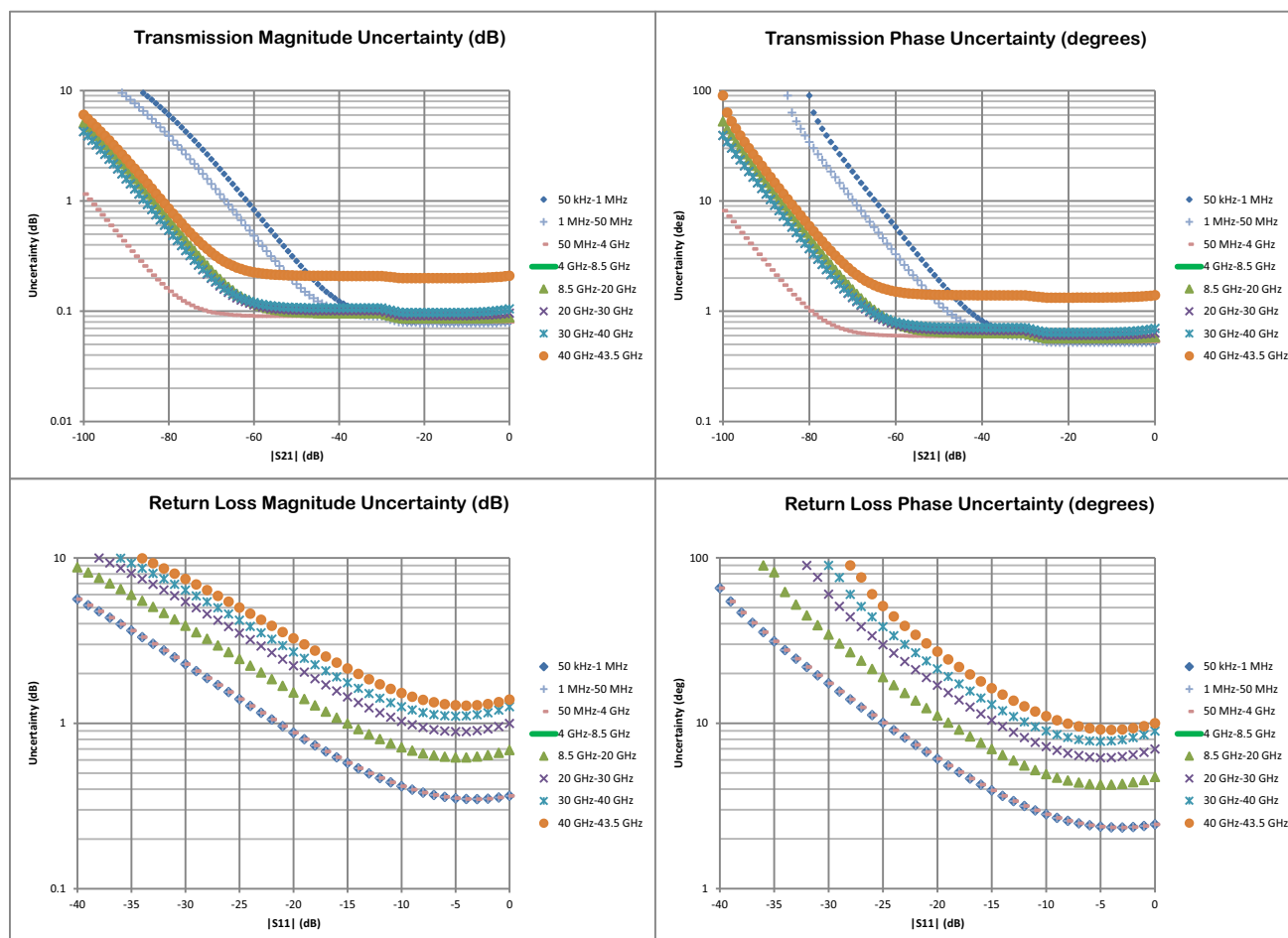
With 12-term SOLT Calibration using TOSLK50A-43.5 or TOSLKF50A-43.5 K type connector calibration kits with generic calibration coefficients.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match <sup>a</sup> (dB)	Reflection Tracking <sup>a</sup> (dB)	Transmission Tracking <sup>a</sup> (dB)
1 MHz to 10 GHz	≥ 42	≥ 33	≥ 42	±0.15	±0.06
> 10 GHz to 20 GHz	≥ 36	≥ 26	≥ 36	±0.15	±0.06
> 20 GHz to 30 GHz	≥ 32	≥ 22	≥ 32	±0.15	±0.06
> 30 GHz to 40 GHz	≥ 30	≥ 20	≥ 30	±0.15	±0.06
> 40 GHz to 43.5 GHz	≥ 28	≥ 20	≥ 28	±0.20	±0.16

a. Characteristic performance.

## Measurement Uncertainties

The graphs give measurement uncertainties after the above error-corrected calibration. The errors are a worst-case contribution of residual directivity, load and source match, frequency response and isolation, network analyzer dynamic accuracy, and connector repeatability. 10 Hz IF Bandwidth is used. For transmission uncertainties, it is assumed that  $S_{11} = S_{22} = 0$ . For reflection uncertainties, it is assumed that  $S_{21} = S_{12} = 0$ . All calibrations and measurements were performed at default port power. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at [www.anritsu.com](http://www.anritsu.com).



## MS46322B-043 VNA System Performance with Manual Cal Kits

## Error-Corrected Specifications

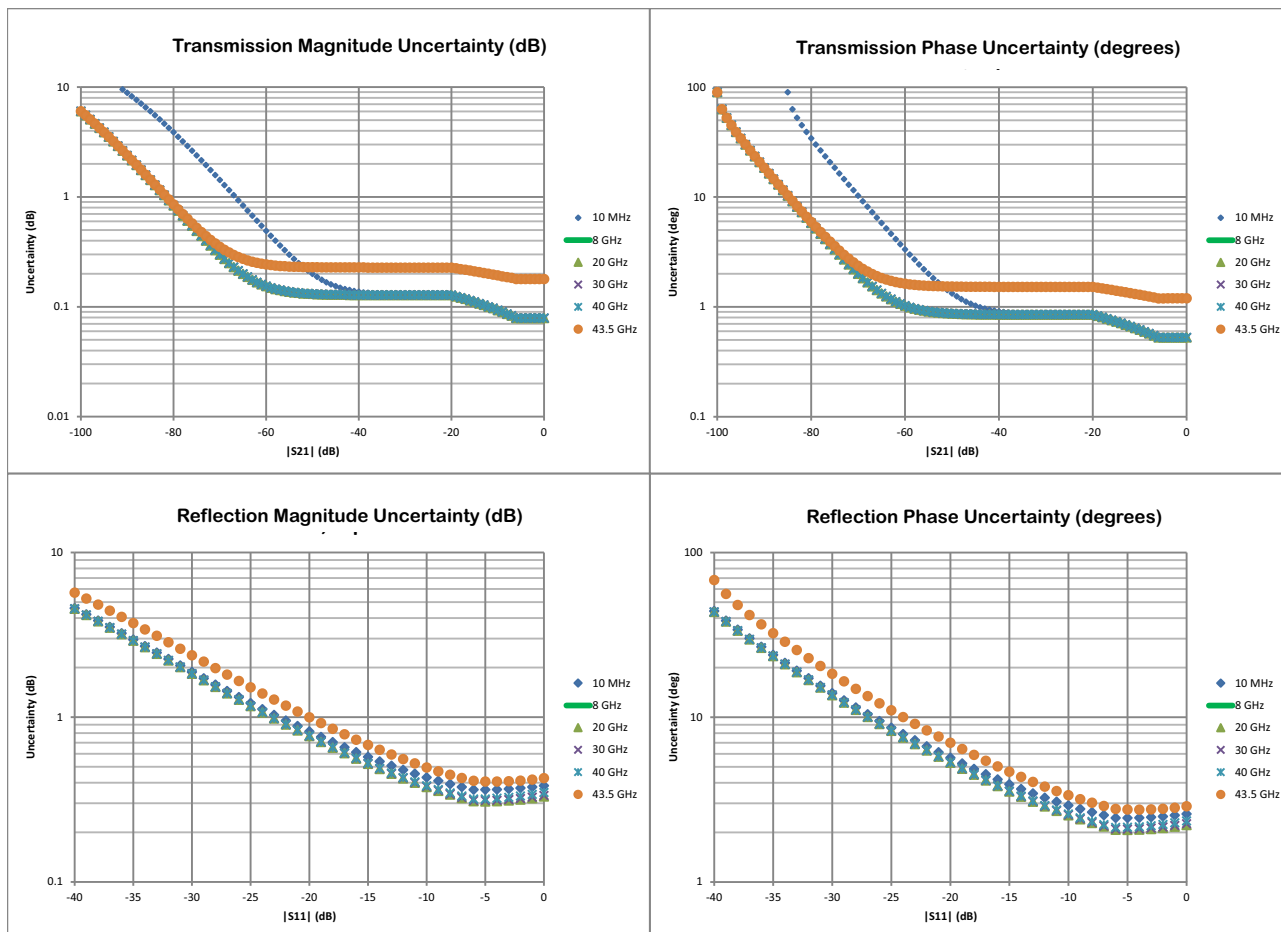
With 12-term SOLT Calibration using TOSLK50A-43.5 or TOSLK50A-43.5 K type connector calibration kits with .s1p definitions.

Frequency Range GHz	Directivity (dB)	Source Match (dB)	Load Match <sup>a</sup> (dB)	Reflection Tracking <sup>a</sup> (dB)	Transmission Tracking <sup>a</sup> (dB)
< 50 MHz	≥ 45	≥ 45	≥ 44	±0.15	±0.06
> 0.05 GHz to 10 GHz	≥ 45	≥ 45	≥ 44	±0.15	±0.06
> 10 GHz to 20 GHz	≥ 45	≥ 45	≥ 44	±0.15	±0.06
> 20 GHz to 30 GHz	≥ 45	≥ 44	≥ 44	±0.15	±0.06
> 30 GHz to 40 GHz	≥ 45	≥ 42	≥ 44	±0.15	±0.06
> 40 GHz to 43.5 GHz	≥ 42	≥ 41	≥ 41	±0.2	±0.16

a. Characteristic performance.

## Measurement Uncertainties

The graphs give measurement uncertainties after the above error-corrected calibration. The errors are a worst-case contribution of residual directivity, load and source match, frequency response and isolation, network analyzer dynamic accuracy, and connector repeatability. 10 Hz IF Bandwidth is used. For transmission uncertainties, it is assumed that  $S_{11} = S_{22} = 0$ . For reflection uncertainties, it is assumed that  $S_{21} = S_{12} = 0$ . All calibrations and measurements were performed at default port power. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at [www.anritsu.com](http://www.anritsu.com).





# MS46322B-010 VNA System Performance with SmartCal™

## Error-Corrected Specifications

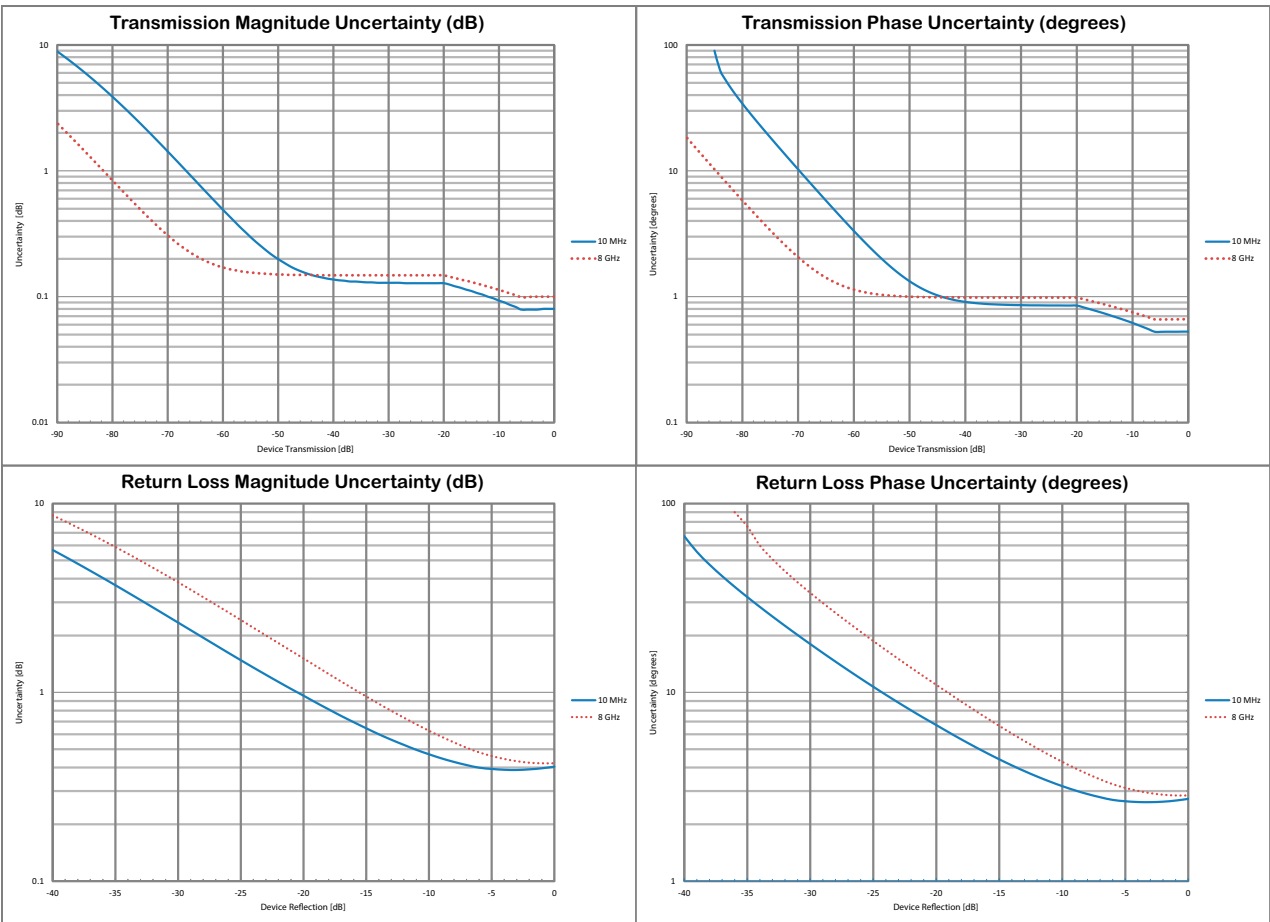
With 12-term calibration using the MN25208A SmartCal™ automatic calibration kit with connector options MN25208A-001, -002, -003.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match <sup>a</sup> (dB)	Reflection Tracking <sup>a</sup> (dB)	Transmission Tracking <sup>a</sup> (dB)
1 MHz to 1 GHz	≥ 42	≥ 35	≥ 42	±0.15	±0.06
> 1 GHz to 5 GHz	≥ 42	≥ 35	≥ 42	±0.08	±0.08
> 5 GHz to 8 GHz	≥ 36	≥ 35	≥ 37	±0.1	±0.08

a. Characteristic performance.

## Measurement Uncertainties

The graphs give measurement uncertainties after the above error-corrected calibration. The errors are a worst-case contribution of residual directivity, load and source match, frequency response and isolation, network analyzer dynamic accuracy, and connector repeatability. 10 Hz IF Bandwidth is used. For transmission uncertainties, it is assumed that  $S_{11} = S_{22} = 0$ . For reflection uncertainties, it is assumed that  $S_{21} = S_{12} = 0$ . All calibrations and measurements were performed at default port power. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at [www.anritsu.com](http://www.anritsu.com).



## MS46322B-010 VNA System Performance with SmartCal™

## Error-Corrected Specifications

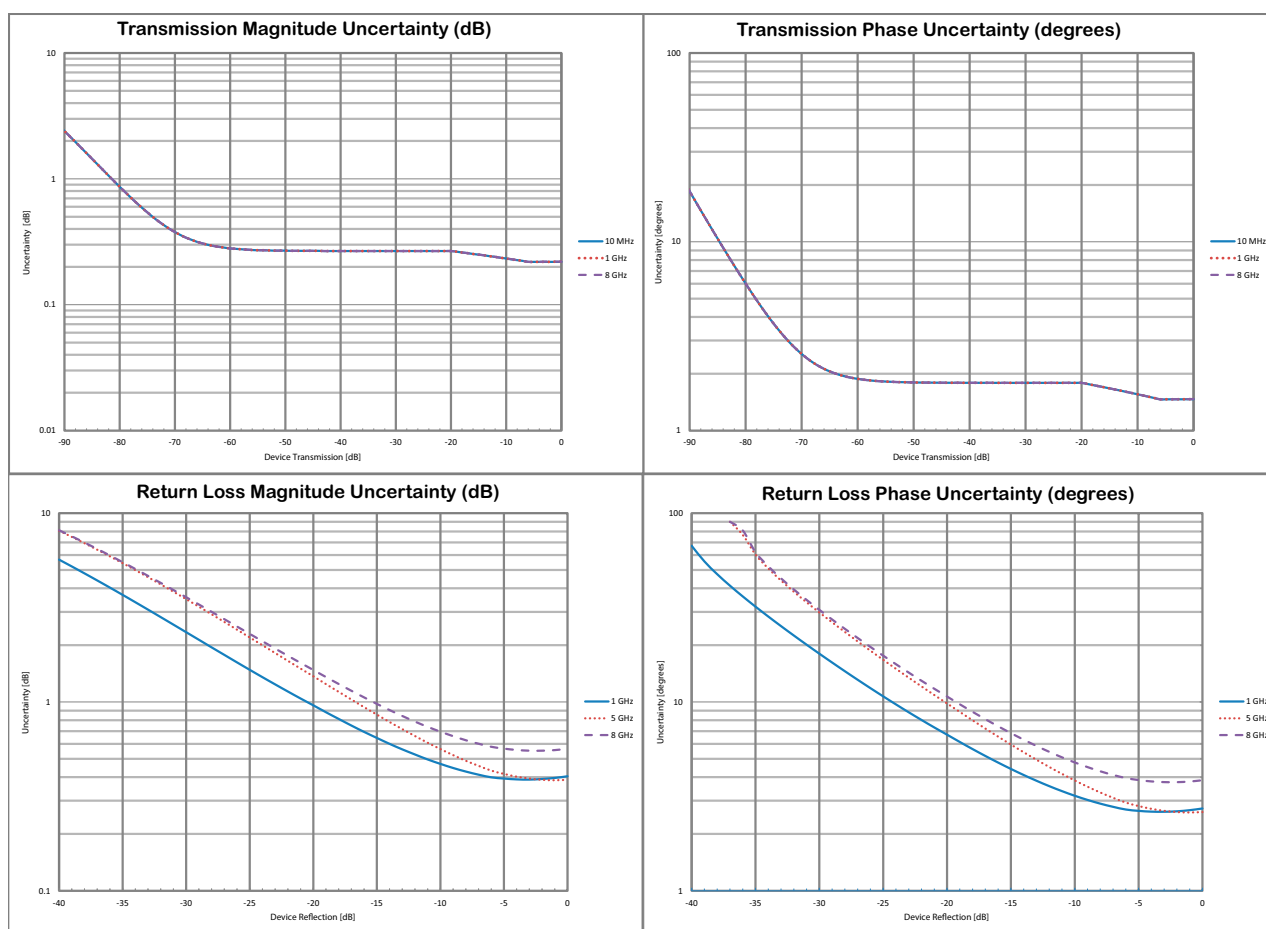
With 12-term calibration using the MN25408A SmartCal™ automatic calibration kit with connector options MN25408A-001, -002, -003.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match <sup>a</sup> (dB)	Reflection Tracking <sup>a</sup> (dB)	Transmission Tracking <sup>a</sup> (dB)
1 MHz - 1 GHz	≥ 42	≥ 35	≥ 42	±0.15	±0.2
> 1 GHz - 5 GHz	≥ 37	≥ 35	≥ 37	±0.08	±0.2
> 5 GHz - 8 GHz	≥ 37	≥ 32	≥ 37	±0.2	±0.2

a. Characteristic performance.

## Measurement Uncertainties

The graphs give measurement uncertainties after the above error-corrected calibration. The errors are a worst-case contribution of residual directivity, load and source match, frequency response and isolation, network analyzer dynamic accuracy, and connector repeatability. 10 Hz IF Bandwidth is used. For transmission uncertainties, it is assumed that  $S_{11} = S_{22} = 0$ . For reflection uncertainties, it is assumed that  $S_{21} = S_{12} = 0$ . All calibrations and measurements were performed at default port power. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at [www.anritsu.com](http://www.anritsu.com).



# MS46322B-010 and MS46322B-020 VNA System Performance with SmartCal™

## Error-Corrected Specifications

With 12-term calibration using the MN25218A SmartCal™ automatic calibration kit.

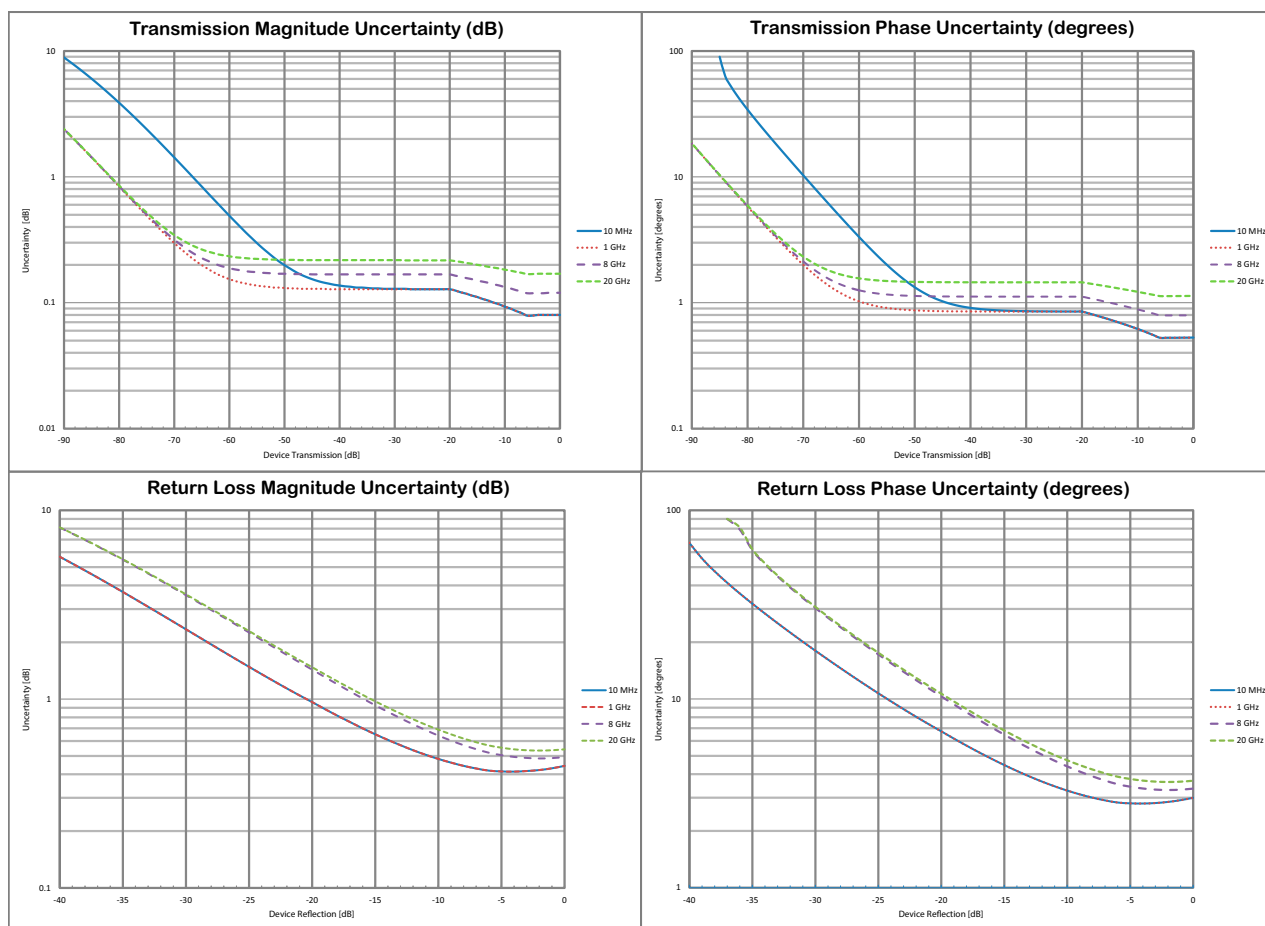
Frequency Range	Directivity (dB)	Source Match (dB)	Load Match <sup>a</sup> (dB)	Reflection Tracking <sup>a</sup> (dB)	Transmission Tracking <sup>a</sup> (dB)
1 MHz to 1 GHz <sup>b</sup>	≥ 42	≥ 33	≥ 42	±0.15	±0.06
> 1 GHz to 10 GHz	≥ 37	≥ 33	≥ 42	±0.15	±0.1
> 10 GHz to 18 GHz	≥ 37	≥ 33	≥ 36	±0.15	±0.1
> 18 GHz to 20 GHz	≥ 37	≥ 33	≥ 36	±0.20	±0.15

a. Characteristic performance.

b. Applies to Rev 2 SmartCal Modules. MN25218A with serial numbers <1817999 operate from 1 MHz to 20 GHz.

## Measurement Uncertainties

The graphs give measurement uncertainties after the above error-corrected calibration. The errors are a worst-case contribution of residual directivity, load and source match, frequency response and isolation, network analyzer dynamic accuracy, and connector repeatability. 10 Hz IF Bandwidth is used. For transmission uncertainties, it is assumed that  $S_{11} = S_{22} = 0$ . For reflection uncertainties, it is assumed that  $S_{21} = S_{12} = 0$ . All calibrations and measurements were performed at default port power. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at [www.anritsu.com](http://www.anritsu.com).



## MS46322B-010 and MS46322B-020 VNA System Performance with SmartCal™

## Error-Corrected Specifications

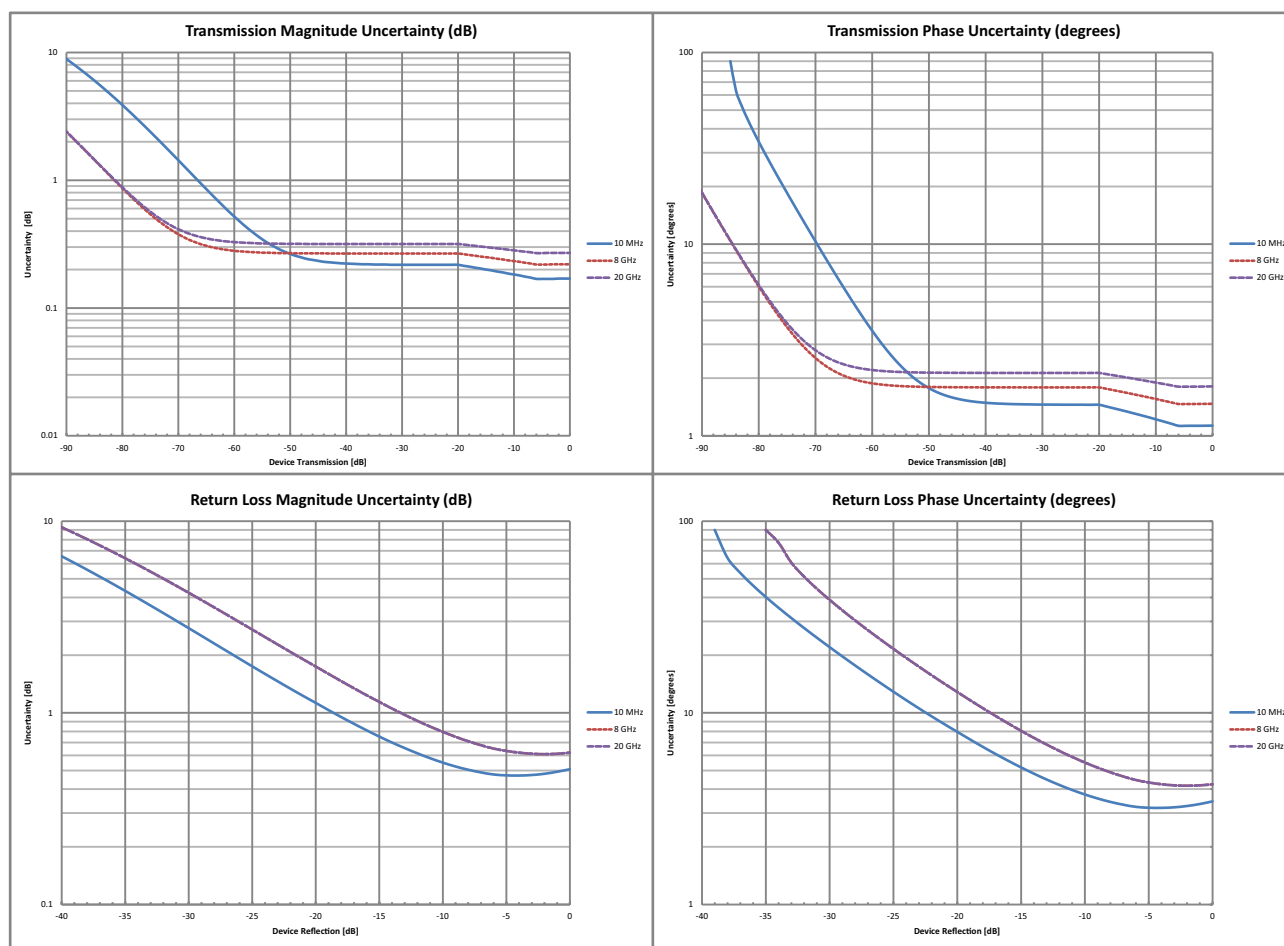
With 12-term calibration using the MN25418A SmartCal™ automatic calibration kit.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match <sup>a</sup> (dB)	Reflection Tracking <sup>a</sup> (dB)	Transmission Tracking <sup>a</sup> (dB)
1 MHz to < 10 MHz	≥ 40	≥ 31	≥ 42	±0.20	±0.20
10 MHz to 6 GHz	≥ 40	≥ 31	≥ 42	±0.15	±0.15
> 6 GHz to 18 GHz	≥ 35	≥ 31	≥ 37	±0.20	±0.20
> 18 GHz to 20 GHz	≥ 35	≥ 31	≥ 34	±0.20	±0.25

a. Characteristic performance.

## Measurement Uncertainties

The graphs give measurement uncertainties after the above error-corrected calibration. The errors are a worst-case contribution of residual directivity, load and source match, frequency response and isolation, network analyzer dynamic accuracy, and connector repeatability. 10 Hz IF Bandwidth is used. For transmission uncertainties, it is assumed that  $S_{11} = S_{22} = 0$ . For reflection uncertainties, it is assumed that  $S_{21} = S_{12} = 0$ . All calibrations and measurements were performed at default port power. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at [www.anritsu.com](http://www.anritsu.com).



# MS46322B-043 VNA System Performance with Precision AutoCal™

## Error-Corrected Specifications

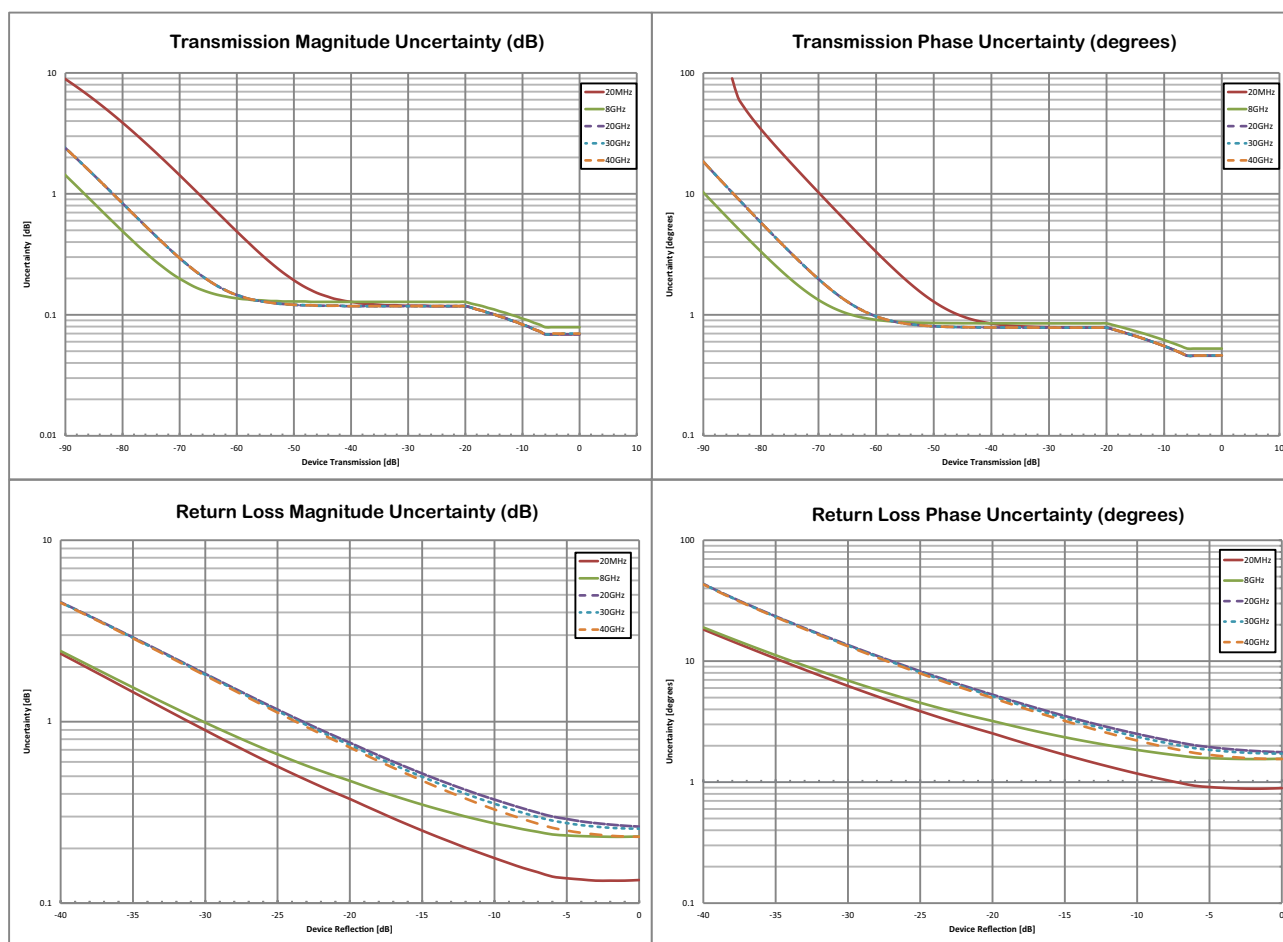
With 12-term calibration using the 36585K automatic calibration kit with type K connectors. Performance is typical.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match <sup>a</sup> (dB)	Reflection Tracking <sup>a</sup> (dB)	Transmission Tracking <sup>a</sup> (dB)
1 MHz to < 10 GHz	≥ 50	≥ 49	≥ 42	±0.15	±0.06
10 GHz to < 20 GHz	≥ 45	≥ 49	≥ 36	±0.15	±0.05
20 GHz to < 30 GHz	≥ 45	≥ 45	≥ 36	±0.10	±0.05
30 GHz to 40 GHz	≥ 45	≥ 45	≥ 30	±0.10	±0.05

a. Characteristic performance.

## Measurement Uncertainties

The graphs give measurement uncertainties after the above error-corrected calibration. The errors are a worst-case contribution of residual directivity, load and source match, frequency response and isolation, network analyzer dynamic accuracy, and connector repeatability. 10 Hz IF Bandwidth is used. For transmission uncertainties, it is assumed that  $S_{11} = S_{22} = 0$ . For reflection uncertainties, it is assumed that  $S_{21} = S_{12} = 0$ . All calibrations and measurements were performed at default port power. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at [www.anritsu.com](http://www.anritsu.com).



## Measurement Throughput Summary

<b>Measurement Speed</b>	140 $\mu$ s/point, typical. Per point single sweep time, including placing measurement data into memory. Average of narrow, mid, and wide frequency span sweeps. 300 kHz IFBW, 1601 points, 2-port calibrated data measurement.			
<b>Data Transfer Time (ms)</b>	Transferred complex S11 data, using the "CALC:DATA:SDATA?" command. Typical performance data. <sup>a</sup>			
<b>Number of Points</b>	<b>51</b>	<b>201</b>	<b>401</b>	<b>1601</b>
<b>SCPI over LAN</b>				
REAL 64	4	4	4	8
REAL 32	4	4	4	8
ASCII	14	34	60	209

a. Data transfer time varies depending on the PC and control software used with the VNA.

## Standard Capabilities

<b>Operating Frequencies</b>		
MS46322B-010	1 MHz to 8 GHz	
MS46322B-020	1 MHz to 20 GHz	
MS46322B-043	1 MHz to 43.5 GHz	
<b>Measurement Parameters</b>		
2-Port Measurements	$S_{11}$ , $S_{21}$ , $S_{22}$ , $S_{12}$ , and any user-defined combination of $a_1$ , $a_2$ , $b_1$ , $b_2$ , 1 Maximum Efficiency Analysis, Mixed-mode SDD, SDC, SCD, SCC	
Domains	Frequency Domain, Time (Distance) Domain (Option 2)	
<b>Sweeps</b>		
Frequency Sweep Types	Linear, Log, CW, or Segmented	
<b>Display Graphs</b>		
Single Rectilinear Graph Types	Log Magnitude, Phase, Group Delay, Linear Magnitude, Real, Imaginary, SWR, Impedance, KQ and $\eta$ Max	
Dual Rectilinear Graph Types	Log Mag and Phase, Linear Mag and Phase, Real and Imaginary, KQ and $\eta$ Max	
Circular Graph Types	Smith Chart (Impedance), Polar	
<b>Measurements Data Points</b>		
Maximum Data Points	2 to 16,001 points	
<b>Limit Lines</b>		
Limit Lines	Single or segmented. 2 limit lines per trace. 50 segments per trace.	
Single Limit Readouts	Uses interpolation to determine the intersection frequency.	
Test Limits	Both single and segmented limits can be used for PASS/FAIL testing.	
<b>Ripple Limit Lines</b>		
Limit Lines	Single or segmented. 2 limit lines per trace. 50 segments per trace.	
Ripple Value	Absolute Value or Margin	
Test Limits	Both single and segmented limits can be used for PASS/FAIL testing.	
<b>Averaging</b>		
Point-by-Point	Point-by-point (default), maximum number of averages = 200	
Sweep-by-Sweep	Sweep-by-sweep, maximum number of averages = 4096	
<b>IF Bandwidth</b>		
	10, 20, 50, 70, 100, 200, 300, 500, 700 Hz 1, 2, 3, 5, 7, 10, 20, 30, 50, 70, 100, 200, 300 kHz	
<b>Reference Plane</b>		
Line Length or Time Delay	The reference planes of a calibration or other normalization can be changed by entering a line length or time delay.	
Dielectric Constants	Dielectric constants may be entered for different media so the length entry can be physically meaningful.	
Dispersion Modeling	Dispersion modeling is used in the cases of microstrip and waveguide to take into account frequency dependent phase velocities.	
Attenuation	Attenuation (with frequency slope) and constant phase offsets can be entered to better describe any reference plane distortions. The frequency dependence exponent is changeable.	
Auto Modes	Automatic reference plane finding tools are available for phase alone or phase + magnitude. These routines do a fitting process on phase or phase and magnitude to estimate the reference plane location and enter correcting values.	
De-embedding	For more complete reference plane manipulation, the full de-embedding system can also be used.	

<b>Measurement Frequency Range</b>		
Frequency Range Change	Frequency range of the measurement can be narrowed within the calibration range without recalibration.	
CW Mode	CW mode permits single frequency measurements also without recalibration.	
Interpolation Not Activated	If interpolation is not activated, the subset frequency range is forced to use calibration frequency points.	
Interpolation Activated	If interpolation is activated, any frequency range that is a subset of the calibration frequency range can be used, but there may be some added interpolation error.	
<b>Group Delay</b>		
Group Delay Aperture	Defined as the frequency span over which the phase change is computed at a given frequency point.	
Aperture	The aperture can be changed without recalibration.	
Minimum Aperture	The minimum aperture is the frequency range divided by the number of points in calibration and can be increased to 20% of the frequency range.	
Group Delay Range	< 180° of phase change within the aperture	
<b>Channels, Display, and Traces</b>		
Channels and Traces	16 channels, each with up to 16 traces	
Display Colors	Unlimited colors for data traces, memory, text, markers, graticules, and limit lines	
Trace Memory and Math	A separate memory for each trace can be used to store measurement data for later display or subtraction, addition, multiplication or division with current measurement data. The trace data can be saved and recalled.	
Intra-trace Math	Any two traces within a channel can be combined (via addition, subtraction, multiplication, or division) and displayed on another trace. An equation editor mode is also available that allows the combination of trace data, trace memory and S-parameter data in more complex equations. Over 30 built-in functions are available. Simple editing tools and the ability to save/recall equations are also provided.	
<b>Scale Resolution</b>		Minimum per division, varies with graph type.
Log Magnitude	0.001 dB	
Linear Magnitude	10 $\mu$ U	
Phase	0.01°	
Group Delay	0.1 ps	
Time	0.0001 ps	
Distance	0.1 $\mu$ m	
SWR	10 $\mu$ U	
Power	0.01 dB	
<b>Markers</b>		
Markers	12 markers + 1 reference marker	
Marker Coupling	Coupled or decoupled	
Marker Overlay	Display markers on active trace only or on all traces when multiple trace responses are present on the same trace	
Marker Data	Data displayed in graph area or in table form	
Reference Marker	Additional marker per trace for reference	
Marker Statistics	Mean, maximum, minimum, standard deviation	
	Per trace or over a marker region	
Marker Search and Tracking	Search and/or track for minimum, maximum, peak, or target value	
<b>Other</b>		
Filter Parameters	Display bandwidth (user-selectable loss value), corner and center frequencies, loss, Q, and shape factors.	
S-Parameter Conversion	Z Reflection Impedance Z Transmission Impedance Y Reflection Admittance Y Transmission Admittance 1/S	

## Calibration and Correction Capabilities

<b>Calibration Methods</b>		Short-Open-Load-Through (SOLT) Offset-Short-Offset-Short-Load-Through (SSLT) Triple-Offset-Short-Through (SSST) Short-Open-Load-Reciprocal (SOLR) Line-Reflect-Line (LRL) / Line-Reflect-Match (LRM) Thru-Reflect-Line (TRL) / Thru-Reflect-Match (TRM) SmartCal™ AutoCal™ Thru Update available Secondary match correction available for improved low insertion loss measurements
<b>Correction Models</b>		2-Port (Forward, Reverse, or both directions) 1-Port ( $S_{11}$ , $S_{22}$ , or both) Transmission Frequency Response (Forward, Reverse, or both directions) Reflection Frequency Response ( $S_{11}$ , $S_{22}$ , or both)
<b>Coefficients for Calibration Standards</b>		Use the Anritsu calibration kit USB memory device to load kit coefficients and characterization files. Enter coefficients into user-defined locations. Use complex load models.
<b>Interpolation</b>		Allows interpolation between calibration frequency points.
<b>Adapter Removal Calibration</b>		Characterizes and “removes” an adapter that is used during calibration that will not be used for subsequent device measurements; for accurate measurement of non-insertable devices.
<b>Dispersion Compensation</b>		Selectable as Coaxial, other non-dispersive (e.g., for coplanar waveguide), Waveguide, or Microstrip
<b>Embedding/De-embedding</b>		The MS46322B is equipped with an Embedding/De-embedding system.
	De-embedding	De-embedding is generally used for removal of test fixture contributions, modeled networks, and other networks described by S-parameters (s2p files) from measurements.
	Embedding	Similarly, the Embedding function can be used to simulate matching circuits for optimizing amplifier designs or simply adding effects of a known structure to a measurement.
	Multiple Networks	Multiple networks can be embedded/de-embedded and changing the port and network orientations is handled easily.
	Extraction Utility	An extraction utility is part of this package that allows easier computation of de-embedding files based on additional calibration steps and measurements.
<b>Optical/Electrical Conversion</b>		
	O/E, E/O, & O/O	O/E, E/O, and O/O setup wizards are provided
<b>Impedance Conversion</b>		Allows entry of different reference impedances (complex values) for different ports

## Optional Capabilities

Time Domain Measurements, Option 2	Displays all S-parameters and overlays with Frequency Domain, Low-pass Mode with added harmonics frequency list flexibility, Band-pass Mode, Phasor Impulse Mode, Windowing, Gating (pass-band or reject-band), and Frequency with Time Gate.
Universal Fixture Extraction, Option 24	Provides a suite of additional network extraction techniques for different de-embedding problems, particularly those when only partial interface information is available at the DUT plane. These are often useful for on-wafer and fixtured environments with more complex DUT interfaces where traditional standards may not be available. In most cases, .s1p definition/model of reflect standards is allowed and generally automatic fixture length detection is available. In addition, a sequential extraction (peeling) of isolated fixture defects is possible and allows one to generate sNp files for portions of the fixture for design analysis.

## Remote Operability

ShockLine supports several remote operability options.

Communication Type	Data Format	Performance	Description
Via LAN	Using VXI-11 Protocol	Gigabit Data Transfer Speed	Use SCPI commands
Drivers for LAN	IVI-C drivers are available for download from the Anritsu website. The IVI-C package supports National Instruments LabVIEW and LabWindows, C#, .NET, MATLAB, and Python programming environments.		
Triggering	Start Trigger	Software and Digital Edge	
	Input Range	+3.3 V logic level (+5 V tolerant)	
	Minimum Trigger Width	50 ns	
	Trigger Delay	6 $\mu$ s, typical	



## Front Panel Connections



MS46322B Front Panel

## Test Ports 1 and 2

MS46322B-010	N(f)
MS46322B-020	Ruggedized K(m)
MS46322B-043	Ruggedized Extended-K™(m)
Damage Input Levels	+23 dBm maximum, ±50 VDC maximum

## USB Ports

Two type A USB 2.0 Ports for peripherals such as keyboard, mouse, flash drive, hardware key, and similar devices.

## Chassis Grounding Port

Banana(f)

## Rear Panel Connections



MS46322B Rear Panel

## AC Power Input

AC Input connector, with On/Off switch, and fuses 350 VA maximum, 90 to 264 VAC, 47 to 63 Hz (power factor controlled)

## USB and LAN

USB Ports	Four type A USB 3.0 for peripherals such as keyboard, mouse, memory stick, USB monitor, and hardware key.
LAN Port	Gigabit Ethernet

## Media

HDMI Port	Video output, touchscreen compatible
Audio	External stereo speaker and microphone (3.5 mm)
HDD	Standard removable hard disc drive

## 10 MHz In

Connector Type	BNC(f)
Signal	+0 dBm, typical; 50 Ω, nominal

## 10 MHz Out

Connector Type	BNC(f)
Signal	+8 dBm, typical; 50 Ω, nominal

## External Trigger Input

Connector Type	BNC(f)
Voltage Input	0 to 3.3 V input (5 V tolerant)
Impedance	High impedance (> 100 kΩ)
Pulse Width	50 ns minimum input pulse width
Trigger Delay	6 μs typical

## CPU, Memory, and Security Features

CPU	Intel Core™ i5/i7
Storage	Serial-ATA (SATA) Solid State Drive (> 30 GB SSD, removable) for OS, Programs, and Data
<b>Security Features</b>	
Virus Protection, Best Practices	If the VNA is attached to a network, best practices recommend installing anti-virus software.
Display Blanking	ShockLine software can obscure frequency on the system display for security.
Removable Internal Drive	Rear Panel accessible Solid State Drive (SSD) is quickly removable and easy to secure.
2000-1858-R Spare SSD	A bootable SSD module is available as a spare for MS46322B units used in multiple or compartmentalized locations. The operating system and software are pre-installed on each 2000-1858-R SSD.

## Mechanical

<b>Dimensions</b>	Dimensions listed are for the instrument body without rack mount option attached.
H x W x D	108 mm x 484 mm x 590 mm
<b>Weight</b>	< 11 kg (< 25 lb), typical weight for a fully-loaded MS46322B VNA

## Regulatory Compliance

European Union	EMC 2014/30/EU, EN 61326:2013, CISPR 11/EN 55011, IEC/EN 61000-4-2/3/4/5/6/11 Low Voltage Directive 2014/35/EU Safety EN 61010-1:2010 RoHS Directive 2011/65/EU & Amendment 2015/863
United Kingdom	EMC SI 2016/1091; BS EN 55011 & BS EN 61000-4-2/3/4/5/6/8/11 Consumer Protection (Safety) SI 2016/1101; BS EN 61010-1:2010 Environmental Protection SI 2012/3032; 2011/65/EU & 2015/863
Canada	ICES-1(A)/NMB-1(A)
Australia and New Zealand	RCM AS/NZS 4417:2012
South Korea	R-R-A2J-1009

## Environmental

	MIL-PRF-28800F Class 3
Operating Temperature Range	0 °C to 50 °C
Storage Temperature Range	-40 °C to 71 °C
Maximum Relative Humidity	95 % RH at 30 °C, non-condensing
Altitude	4600 meters, operating and non-operating

## Warranty

Instrument and Built-In Options	1 year from the date of shipment (standard warranty)
Calibration Kits	Typically 1 year from the date of shipment
Test Port Cables	Typically 1 year from the date of shipment
Warranty Options	Additional warranty available

## Ordering Information

<b>Instrument Models</b>		
	MS46322B	2-Port ShockLine Economy VNA (base model)
Requires One Frequency Option		
	MS46322B-010	1 MHz to 8 GHz, type N(f) ports
	MS46322B-020	1 MHz to 20 GHz, type Ruggedized K(m) ports (compatible with 3.5 mm and SMA connectors)
	MS46322B-043	1 MHz to 43.5 GHz, type Ruggedized Extended-K™(m) ports (compatible with standard K (2.92 mm), 3.5 mm and SMA connectors)
<b>Included Accessories</b>		
Each VNA comes with a power cord and instructions on where to download software and related literature.		
<b>Main VNA Options</b>		
	MS46322B-001	Rack Mount, adds handles and removes feet for shelf-mounting into a 19 inch universal rack
	MS46322B-002	Time Domain with Time Gating
	MS46322B-024	Universal Fixture Extraction
<b>Removable SSD Kit</b>		
	2000-1858-R	Spare SSD Disk Drive Kit
<b>Calibration Options</b>		
	MS46322B-097	Accredited Calibration, with data
	MS46322B-098	Standard Calibration, ISO 17025 compliant, without data
	MS46322B-099	Premium Calibration, ISO 17025 compliant, with data
<b>Precision Automatic Calibrator Modules</b>		
	MN25208A	2-port USB SmartCal Module, 300 kHz to 8.5 GHz (available with connector Options -001 N(f), -002 K(f), -003 3.5 mm(f))
	MN25408A	4-port USB SmartCal Module, 300 kHz to 8.5 GHz (available with connector Options -001 N(f), -002 K(f), -003 3.5 mm(f))
	MN25218A <sup>1</sup>	2-port USB SmartCal Module, 300 kHz to 20 GHz (available with connector Option -002 K(f))
	MN25418A	4-port USB SmartCal Module, 300 kHz to 20 GHz (available with connector Option -002 K(f))
	36585K-2M	K Connector Precision AutoCal Module, 70 kHz to 40 GHz, K(m) to K(m)
	36585K-2F	K Connector Precision AutoCal Module, 70 kHz to 40 GHz, K(f) to K(f)
	36585K-2MF	K Connector Precision AutoCal Module, 70 kHz to 40 GHz, K(m) to K(f)
	2000-1809-R	Serial to USB Adapter (required for use with 36585 AutoCal module)
<b>Mechanical Calibration Kits</b>		
	3650A	SMA/3.5 mm Calibration Kit, Without Sliding Loads, DC to 26.5 GHz, 50 Ω
	3652A	K Connector Calibration Kit, Without Sliding Loads, DC to 40 GHz, 50 Ω
	3653A	N Connector Calibration Kit, Without Sliding Loads, DC to 18 GHz, 50 Ω
	OSLN50A-8	Precision N Male Open/Short/Load Mechanical Calibration Tee, DC to 8 GHz, 50 Ω
	OSLNF50A-8	Precision N Female Open/Short/Load Mechanical Calibration Tee, DC to 8 GHz, 50 Ω
	TOSLN50A-8	Precision N Male Through/Open/Short/Load Mechanical Calibration Tee, DC to 8 GHz, 50 Ω
	TOSLNF50A-8	Precision N Female Through/Open/Short/Load Mechanical Calibration Tee, DC to 8 GHz, 50 Ω
	OSLN50A-18	Precision N Male Open/Short/Load Mechanical Calibration Tee, DC to 18 GHz, 50 Ω
	OSLNF50A-18	Precision N Female Open/Short/Load Mechanical Calibration Tee, DC to 18 GHz, 50 Ω
	TOSLN50A-18	Precision N Male Through/Open/Short/Load Mechanical Calibration Tee, DC to 18 GHz, 50 Ω
	TOSLNF50A-18	Precision N Female Through/Open/Short/Load Mechanical Calibration Tee, DC to 18 GHz, 50 Ω
	TOSLK50A-20	Precision K Male Through/Open/Short/Load Mechanical Calibration Tee, DC to 20 GHz, 50 Ω
	TOSLKF50A-20	Precision K Female Through/Open/Short/Load Mechanical Calibration Tee, DC to 20 GHz, 50 Ω
	TOSLK50A-40	Precision K Male Through/Open/Short/Load Mechanical Calibration Tee, DC to 40 GHz, 50 Ω
	TOSLKF50A-40	Precision K Female Through/Open/Short/Load Mechanical Calibration Tee, DC to 40 GHz, 50 Ω
	TOSLK50A-43.5	Precision K Male Through/Open/Short/Load Mechanical Calibration Tee, DC to 43.5GHz, 50 Ω
	TOSLKF50A-43.5	Precision K Female Through/Open/Short/Load Mechanical Calibration Tee, DC to 43.5 GHz, 50 Ω
		Includes .s1p files for data-based calibration support
		Includes .s1p files for data-based calibration support
<b>Verification Kits</b>		
	3663-3	N Connector Verification Kit
	3668-4	K Connector Verification Kit

1. Applies to Rev 2 SmartCal Modules. MN25218A with serial numbers <1817999 operate from 1 MHz to 20 GHz.

**RF Cables and Adapters**

N120-6	RF Cables, Semi-Rigid, N(m) to N(m), 1 each, 0.01 to 18 GHz, 50 Ω, 15 cm (5.9 in)
NS120MF-6	RF Cables, Semi-Rigid, N(f) to N(f), 1 each, 0.01 to 18 GHz, 50 Ω, 15 cm (5.9 in)
1091-26-R	Adapter, SMA(m) to N(m), DC to 18 GHz, 50 Ω
1091-27-R	Adapter, SMA(f) to N(m), DC to 18 GHz, 50 Ω
1091-80-R	Adapter, SMA(m) to N(f), DC to 18 GHz, 50 Ω
1091-81-R	Adapter, SMA(f) to N(f), DC to 18 GHz, 50 Ω
71693-R	Ruggedized adapter, K(f) to N(f), DC to 18 GHz, 50 Ω
33KK50C	Calibration Grade Adapter, DC to 43.5 GHz, K(m) to K(m), 50 Ω
33KKF50C	Calibration Grade Adapter, DC to 43.5 GHz, K(m) to K(f), 50 Ω
33KFKF50C	Calibration Grade Adapter, DC to 43.5 GHz, K(f) to K(f), 50 Ω
34NN50A	Precision Adapter, N(m) to N(m), DC to 18 GHz, 50 Ω
34NFN50	Precision Adapter, N(f) to N(f), DC to 18 GHz, 50 Ω
34NK50	Precision Adapter, N(m) to K(m), DC to 18 GHz, 50 Ω
34NKF50	Precision Adapter, N(m) to K(f), DC to 18 GHz, 50 Ω
34NFK50	Precision Adapter, N(f) to K(m), DC to 18 GHz, 50 Ω
34NFKF50	Precision Adapter, N(f) to K(f), DC to 18 GHz, 50 Ω
34VFK50A	Precision Adapter, DC to 43.5 GHz, V(f) - K(m), 50 Ω
34VFKF50A	Precision Adapter, DC to 43.5 GHz, V(f) - K(f), 50 Ω
34VK50A	Precision Adapter, DC to 43.5 GHz, V(m) - K(m), 50 Ω
34VKF50A	Precision Adapter, DC to 43.5 GHz, V(m) - K(f), 50 Ω
K220B	Precision Adapter, DC to 40 GHz, K(m) to K(m), 50 Ω
K222B	Precision Adapter, DC to 40 GHz, K(f) to K(f), 50 Ω
K224B	Precision Adapter, DC to 40 GHz, K(m) to K(f), 50 Ω

**Test Port Cables, Flexible, Ruggedized, Phase Stable**

15 Series Cable Example

15NNF50-1.0B	Test Port Cable, Flexible, Phase Stable, N(f) to N(m), 1.0 m
15NNF50-1.5B	Test Port Cable, Flexible, Phase Stable, N(f) to N(m), 1.5 m
15NN50-1.0B	Test Port Cable, Flexible, Phase Stable, N(m) to N(m), 1.0 m
15LL50-1.0A	Test Port Extension Cable, Armored, Phase Stable, DC to 26.5 GHz, 3.5 mm(m) to 3.5 mm(m), 1.0 m, 50 Ω
15LLF50-1.0A	Test Port Extension Cable, Armored, Phase Stable, DC to 26.5 GHz, 3.5 mm(m) to 3.5 mm(f), 1.0 m, 50 Ω
15KK50-1.0A	Test Port Extension Cable, Armored, Phase Stable, DC to 26.5 GHz, K(m) to K(m), 1.0 m, 50 Ω
15KKF50-1.0A	Test Port Extension Cable, Armored, Phase Stable, DC to 26.5 GHz, K(m) to K(f), 1.0 m, 50 Ω

Phase-Stable 18 GHz and 43.5 GHz Semi-Rigid Cables (Armored)



3670 Series Cable Example

3670N50-1	0.3 m (12"), DC to 18 GHz, N(f) to N(m), 50 $\Omega$
3670NN50-1	0.3 m (12"), DC to 18 GHz, N(m) to N(m), 50 $\Omega$
3670N50-2	0.6 m (24"), DC to 18 GHz, N(f) to N(m), 50 $\Omega$
3670NN50-2	0.6 m (24"), DC to 18 GHz, N(m) to N(m), 50 $\Omega$
3670K50A-1	0.3 m (12"), DC to 43.5 GHz, K(f) to K(m), 50 $\Omega$
3670K50A-2	0.6 m (24"), DC to 43.5 GHz, K(f) to K(m), 50 $\Omega$

Phase-Stable 20 GHz and 40 GHz Test Port Cables (Flexible)



3671 Series Cable Example

3671KFS50-60	60 cm (23.6 in), DC to 20 GHz, K(f) to 3.5 mm(m), 50 $\Omega$
3671KFSF50-60	60 cm (23.6 in), DC to 20 GHz, K(f) to 3.5 mm(f), 50 $\Omega$
3671KFKF50-60	60 cm (23.6 in), DC to 40 GHz, K(f) to K(f), 50 $\Omega$
3671KFK50-100	100 cm (39.4 in), DC to 40 GHz, K(f) to K(m), 50 $\Omega$



806-304-R Cable Example

806-304-R	91.5 cm (36 in), DC to 40 GHz, K(m) to K(f), 50 $\Omega$
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806-423-R Cable Example

806-423-R	60 cm (23.6 in), DC to 43.5 GHz, K(f) - K(f), 50 $\Omega$
806-424-R	60 cm (23.6 in), DC to 43.5 GHz, K(m) - K(f), 50 $\Omega$
806-425-R	100 cm (39.4 in), DC to 43.5 GHz, K(f) - K(f), 50 $\Omega$
806-426-R	100 cm (39.4 in), DC to 43.5 GHz, K(m) - K(f), 50 $\Omega$

Tools

01-200	Calibrated Torque End Wrench, GPC-7 and Type N
01-201	Torque End Wrench, 5/16 in, 0.9 N·m (8 lbf·in) (for tightening male devices, for SMA, 3.5 mm, 2.4 mm, K, and V connectors)
01-203	Torque End Wrench, 13/16 in, 0.9 N·m (8 lbf·in) (for tightening ruggedized SMA, 2.4 mm, K and V test port connectors)
01-204	End Wrench, 5/16 in, Universal, Circular, Open-ended (for SMA, 3.5 mm, 2.4 mm, K, and V connectors)
More Information	Refer to our Precision RF & Microwave Components Catalog for descriptions of adapters and other components.

Documentation

User Documentation	Soft copies of the manuals as Adobe Acrobat PDF files are included on the User Documentation USB memory device provided with the instrument. The Maintenance Manual is available from Anritsu Customer Service. For more information, please contact <a href="http://www.anritsu.com/contact-us">www.anritsu.com/contact-us</a> .
10100-00067	ShockLine Product Information, Compliance, and Safety
10410-00335	MS46322A/B Series VNA Operation Manual
10410-00336	MS46322A/B Series VNA Calibration and Measurement Guide
10410-00337	MS46121A/B, MS46122A/B, MS46131A, and MS46322A/B Series VNA User Interface Reference Manual
10410-00746	ShockLine Programming Manual

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