Anritsu envision:ensure

ShockLine™ Performance Vector Network Analyzers

MS46524B

50 kHz to 43.5 GHz

SHOCKLINE™

Introduction

The MS46524B is part of the ShockLine family of Vector Network Analyzers from Anritsu. It is a high performance, 3U high, 4-port VNA available in broadband frequency ranges from 50 kHz to 43.5 GHz. It is capable of measuring 16 single-ended and mixed-mode S-parameters of passive multiport and differential devices.

The MS46524B series supports SCPI command programming and has software driver support for the most common programming environments. The MS46524B 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 MS46524B series Vector Network Analyzers (VNAs) and related options.

Instrument Models and Operating Frequencies

Base Model

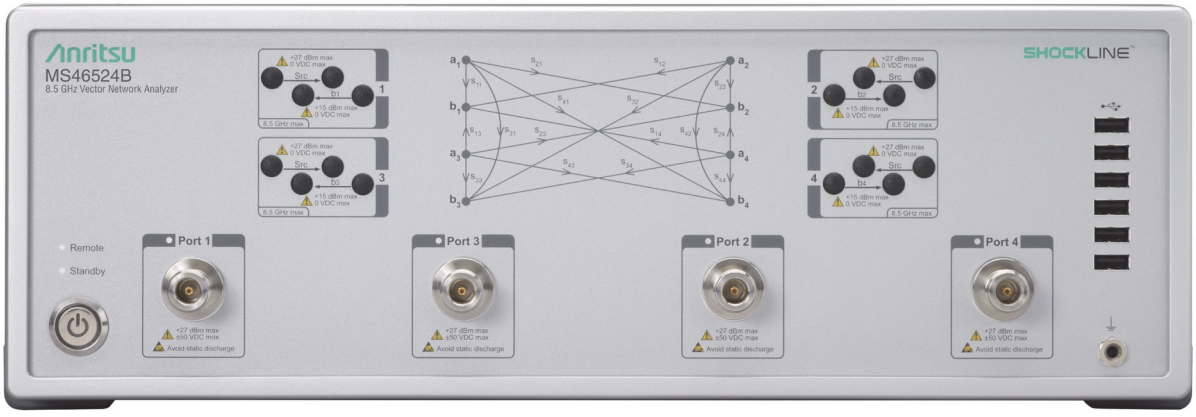
- MS46524B, 4-Port ShockLine VNA

Requires one Frequency Option

- MS46524B-010, 50 kHz to 8.5 GHz
- MS46524B-020, 50 kHz to 20 GHz
- MS46524B-040, 50 kHz to 43.5 GHz

Principal Options

- MS46524B-002, Time Domain
- MS46524B-022, Advanced Time Domain
- MS46524B-051, Access Loops (Only available with Option 10)
- MS46524B-061, Bias Tee (Only available with Option 10)



MS46524B 4-Port ShockLine Performance VNA (8.5 GHz model shown)

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Definitions

All specifications and characteristics apply to Revision 3 instruments under the following conditions, unless otherwise stated:

Warm-Up Time	After 45 minutes of warm-up time, where the instrument is left in the ON state.
Temperature Range	Over the 25 °C ± 5 °C temperature range.
Frequency Range	The instrument operates in the following frequency ranges without any implied or warranted specifications: 50 kHz to 300 kHz, 40 GHz to 43.5 GHz.
Error-Corrected Specifications	For error-corrected specifications, over 23 °C ± 3 °C, with < 1 °C variation from calibration temperature. For error-corrected specifications are warranted and include guard-bands, unless otherwise stated.
Simultaneous Sweep Mode	Specifications are not warranted in simultaneous sweep mode.
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: www.anritsu.com

System Dynamic Range[1]

System dynamic range is calculated as the difference between the test port maximum source power and the RMS noise floor at 10 Hz IF bandwidth with averaging off and smoothing on after calibrating the instrument for transmission frequency response and isolation.

Frequency Range	Standard (dB)	Typical (dB)
300 kHz to 1 MHz	90	101
> 1 MHz to 50 MHz	100	108
> 50 MHz to 2 GHz	140	144
> 2 GHz to 4 GHz	137	142
> 4 GHz to 6 GHz	130	137
> 6 GHz to 8 GHz[a]	128	130
> 8 GHz to 8.5 GHz	120	127[a]
> 8.5 GHz to 25 GHz	117	122
> 25 GHz to 40 GHz	120	127
> 40 GHz to 43.5 GHz	–	120

a. Dynamic range degrades by 6 dB for Options 20 and 40.

Receiver Compression Levels

Port power level beyond which the response may be compressed more than 0.2 dB relative to the normalization level. Measured at 300 Hz IF bandwidth. Match not included. Performance is typical.

Frequency Range	Standard (dBm)
300 kHz to 43.5 GHz	+15

High Level Noise[2]

Measured at 100 Hz IF bandwidth and at default power level, RMS.

Frequency	Magnitude (dB)	Phase (deg)
300 kHz to 1 GHz	0.004 (0.003, typical)	0.04 (0.02, typical)
> 1 GHz to 25 GHz	0.003 (0.002, typical)	0.05 (0.02, typical)
> 25 GHz to 40 GHz	0.004 (0.002, typical)	0.05 (0.04, typical)
> 40 GHz to 43.5 GHz	(0.002, typical)	(0.05, typical)

Output Power Range

Minimum to maximum rated power level. Performance is characteristic.

Frequency	Standard (dBm)	Typical (dBm)
300 kHz to 6 GHz	–30 to + 15	–30 to +17
> 6 GHz to 8 GHz	–30 to + 12[a]	–30 to +13
> 8 GHz to 8.5 GHz	–30 to + 10	–30 to +11
> 8.5 GHz to 40 GHz	–30 to +7	–30 to +10
> 40 GHz to 43.5 GHz	–	–30 to +4

a. Maximum power degrades by 2 dB for Options 20 and 40.

Output Default Power

Instrument default power is 0 dBm. For maximum rated power, refer to Output Power Range above.

Power Accuracy Performance is typical.

Output Power	Standard (dB)	Typical (dB)
At +5 dBm	± 1.0[a]	± 0.7
At 0 dBm	± 1.5[b]	± 0.5
At –30 dBm	± 3.0	± 1.8

a. Power accuracy degrades by 0.5 dB (>8.5 GHz to 25 GHz), and by 1 dB (>25 GHz to 40 GHz).

b. Power accuracy degrades by 0.5 dB (>8.5 GHz).

Setting Resolution

Frequency	Setting Resolution (dB)
300 kHz to 43.5 GHz	0.01

1. System dynamic range is degraded by 20 dB from the standard specifications in simultaneous sweep mode and by 3 dB between ports 1 or 2 and ports 3 or 4 (typical). The dynamic range performance with Option 51 at the b1/b2 ports is +10 dB higher than the standard specification (typical).
2. High level noise specification in simultaneous sweep mode: Magnitude 0.005 dB (typical), Phase 0.05 degree (typical).

Measurement Stability

Ratio measurement, with ports shorted. Typical.

Frequency	Magnitude (dB/°C)	Phase (deg/°C)
300 kHz to 8.5 GHz	0.02	0.5
>8.5 GHz to 40 GHz	0.01	1.0

Frequency Resolution, Accuracy, and Stability

Resolution	Accuracy	Stability/Temperature[a]	Stability[a]
1 Hz	±0.1 (at time of calibration)	± 0.1 ppm/10 °C to 50 °C	± 0.02 ppm/24 hours ± 0.2 ppm/1 month ± 1.0 ppm/1 year ± 2.0 ppm/3 years

a. Typical

Source Harmonics and Non-Harmonics (Spurious)

Measured at 0 dBm. All specifications typical.

Frequency	Harmonics (second and third) (dBc)	Non-Harmonic Spurious (dBc)	Phase Noise @ 10 kHz Offset (dBc/Hz)
300 kHz to 8.5 GHz	< –30	< –30	> 60

Uncorrected (Raw) Port Characteristics

All specifications typical. User correction off, system correction on.

Frequency Range	Directivity (dB)	Port Match (dB)[a]
300 kHz to 1 GHz	> 21	> 17
> 1 GHz to 4 GHz	> 21	> 17
> 4 GHz to 8.5 GHz	> 15	> 15
> 8.5 GHz to 43.5 GHz	> 15	> 15

a. Port Match is defined as the worst of source and load match.

MS46524B-010 VNA System Performance with Manual Cal Kits

Error-Corrected Specifications

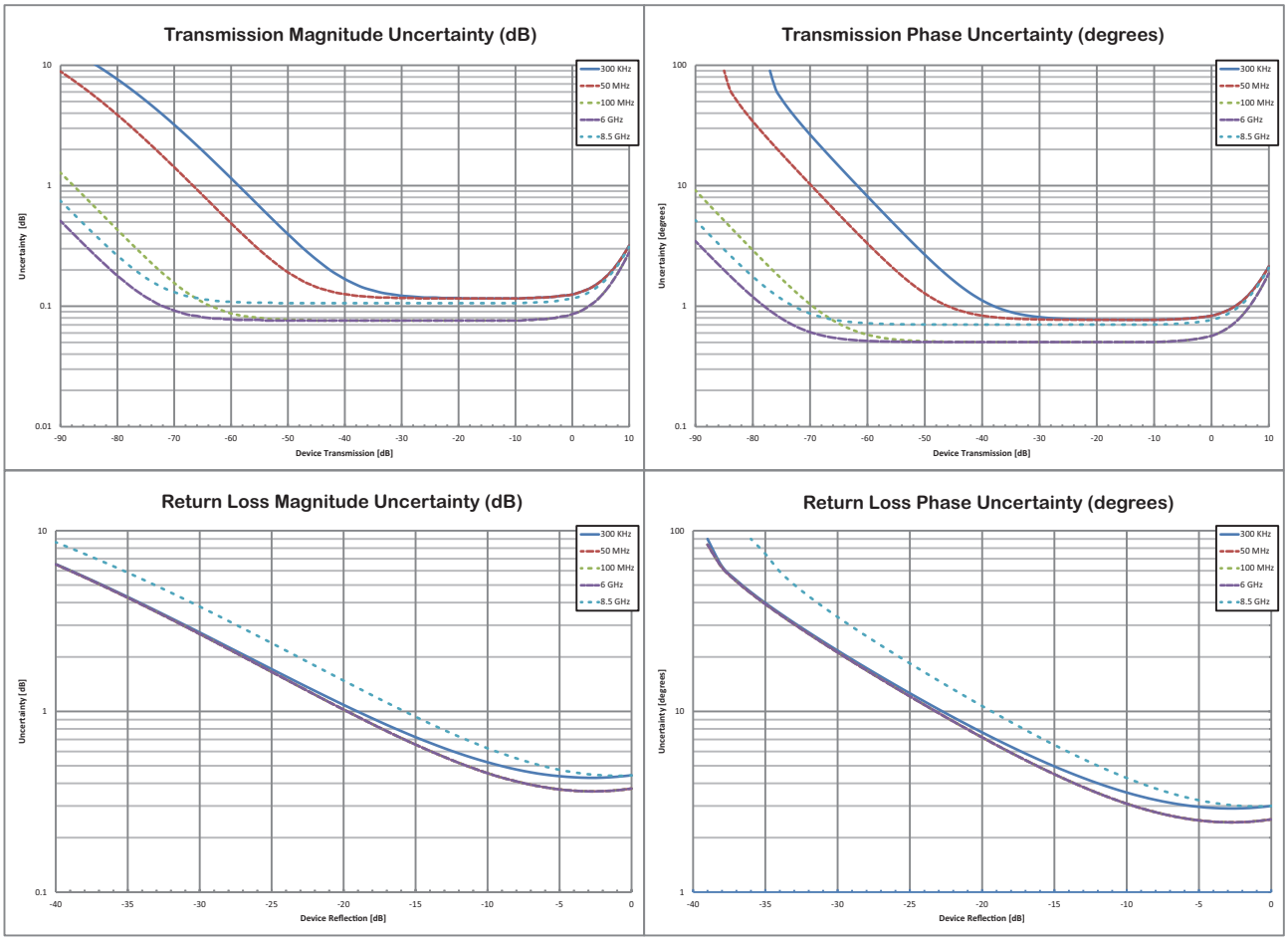
With 12-term SOLT calibration using the TOSLN50A-18 N Type connector calibration kit and two Anritsu 3670N50-1, N(f) to N(m) cables.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match[a] (dB)	Reflection Tracking[a] (dB)	Transmission Tracking[a] (dB)
300 kHz to 50 MHz	> 40	> 35	> 38	±0.15	±0.09
> 50 MHz to 6 GHz	> 40	> 35	> 38	±0.08	±0.05
> 6 GHz to 8 GHz	> 36	> 35	> 34	±0.08	±0.05
> 8 GHz to 8.5 GHz	> 36	> 35	> 34	±0.10	±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 0 dBm or default port power, whichever is less. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at www.anritsu.com.



MS46524B-020 VNA System Performance with Manual Cal Kits

Error-Corrected Specifications

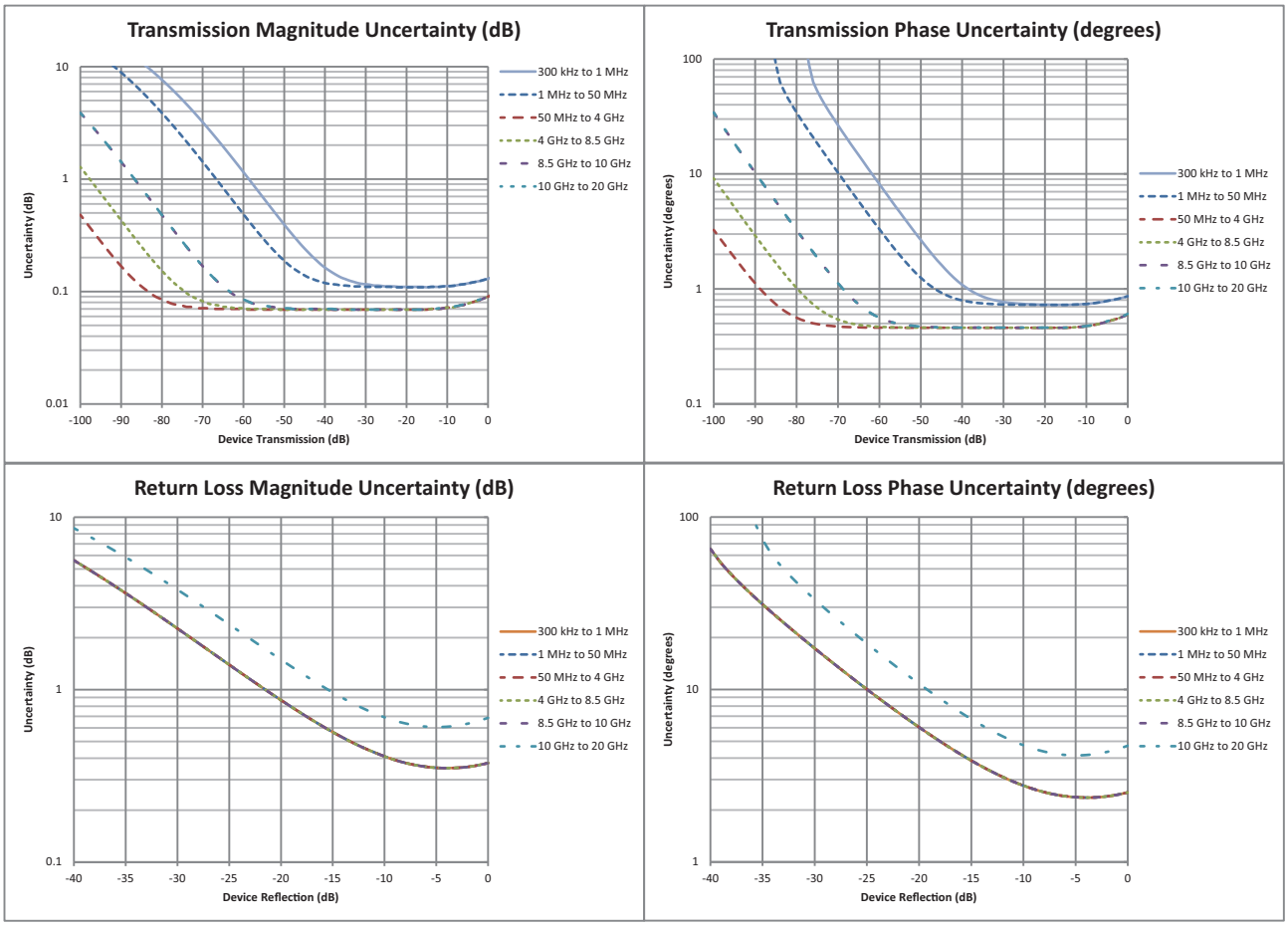
With 12-term SOLT Calibration using the TOSLKF50A-40 K Type Connector Calibration Kit.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match[a] (dB)	Reflection Tracking[a] (dB)	Transmission Tracking[a] (dB)
300 kHz to 50 MHz	> 42	> 35	> 42	±0.10	±0.09
> 50 MHz to 10 GHz	≥ 42	≥ 35	≥ 42	±0.10	±0.05
> 10 GHz to 20 GHz	≥ 36	≥ 26.5	≥ 36	±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 0 dBm or default port power, whichever is less. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at www.anritsu.com.



MS46524B-040 VNA System Performance with Manual Cal Kits

Error-Corrected Specifications

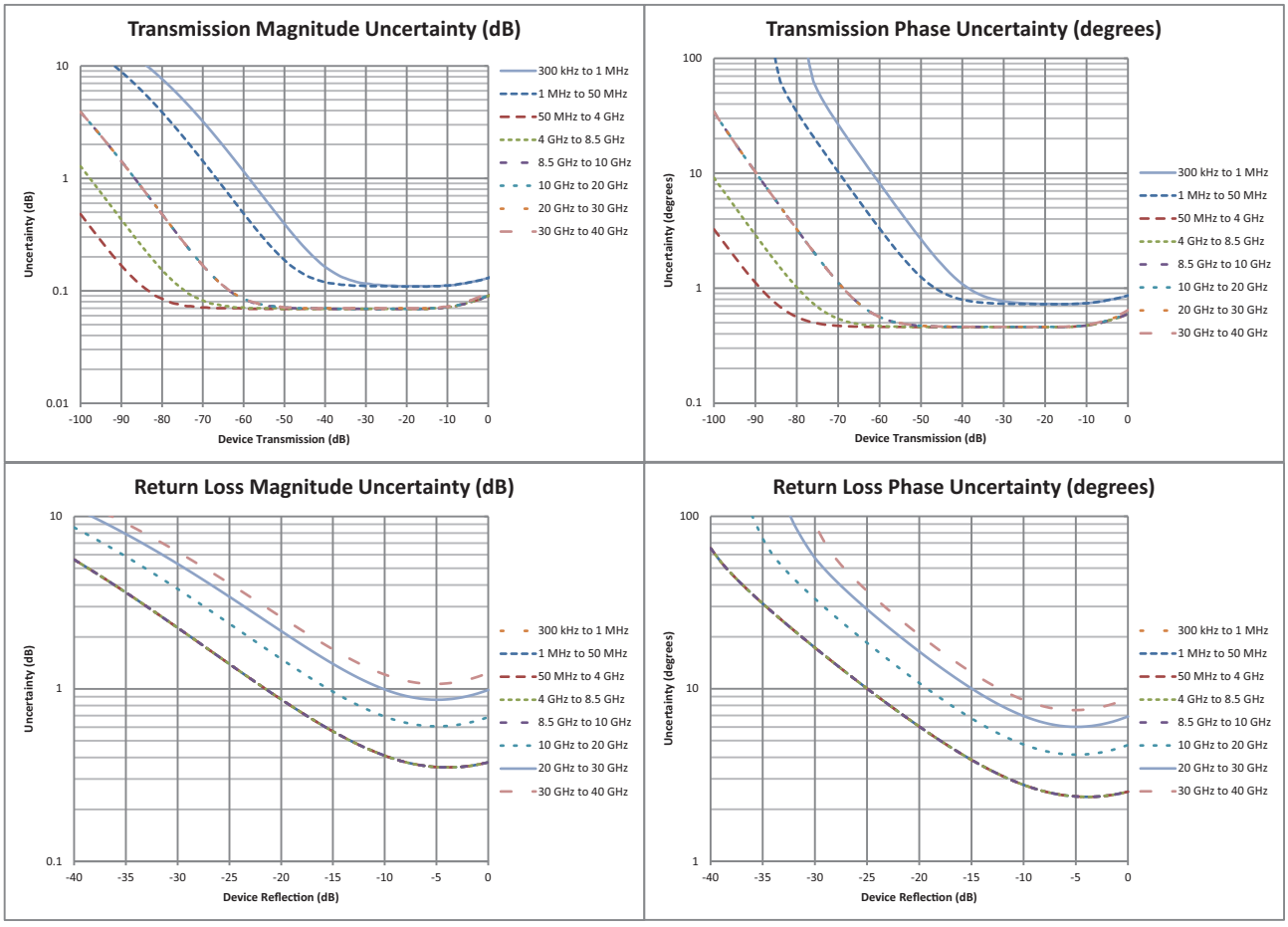
With 12-term SOLT Calibration using the TOSLKF50A-40 K Type Connector Calibration Kit.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match[a] (dB)	Reflection Tracking[a] (dB)	Transmission Tracking[a] (dB)
300 kHz to 50 MHz	> 42	> 35	> 42	±0.10	±0.09
> 50 MHz to 10 GHz	≥ 42	≥ 35	≥ 42	±0.10	±0.05
> 10 GHz to 20 GHz	≥ 36	≥ 26.5	≥ 36	±0.10	±0.05
> 20 GHz to 30 GHz	≥ 32	≥ 22.5	≥ 32	±0.10	±0.05
> 30 GHz to 43.5 GHz	≥ 30	≥ 20	≥ 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 0 dBm or default port power, whichever is less. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at www.anritsu.com.



MS46524B-010 VNA System Performance with SmartCal™

Error-Corrected Specifications

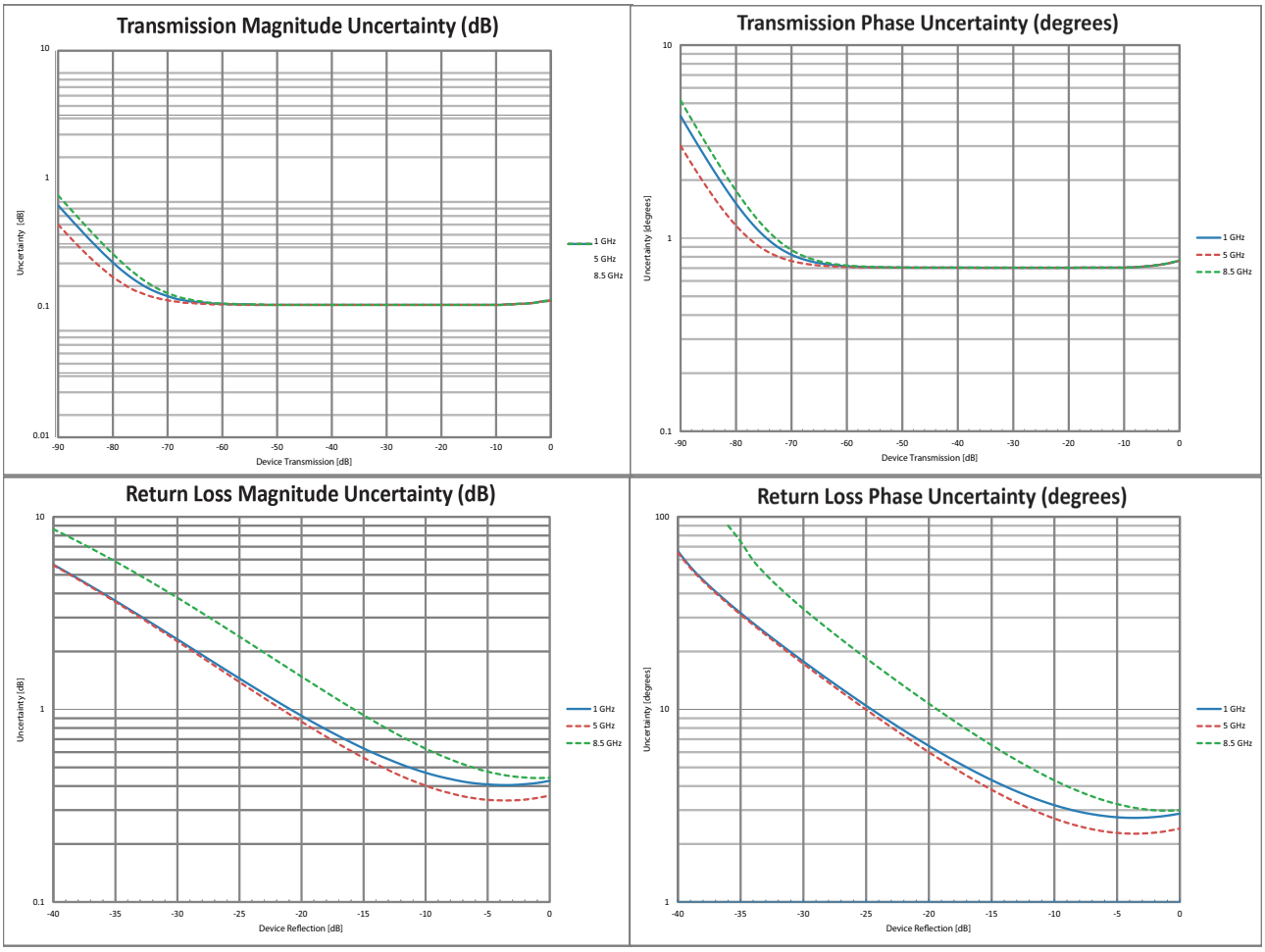
With 12-term calibration using the MN25208A SmartCal™ automatic calibration kit with connector options MN25208A-001, -002, -003

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match[a] (dB)	Reflection Tracking[a] (dB)	Transmission Tracking[a] (dB)
300 kHz to 1 GHz	> 42	> 35	> 38	±0.15	±0.08
> 1 GHz to 5 GHz	> 42	> 35	> 38	±0.08	±0.08
> 5 GHz to 8.5 GHz	> 36	> 35	> 33	±0.10	±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 0 dBm or default port power, whichever is less. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at www.anritsu.com.



MS46524B-010 VNA System Performance with SmartCal™

Error-Corrected Specifications

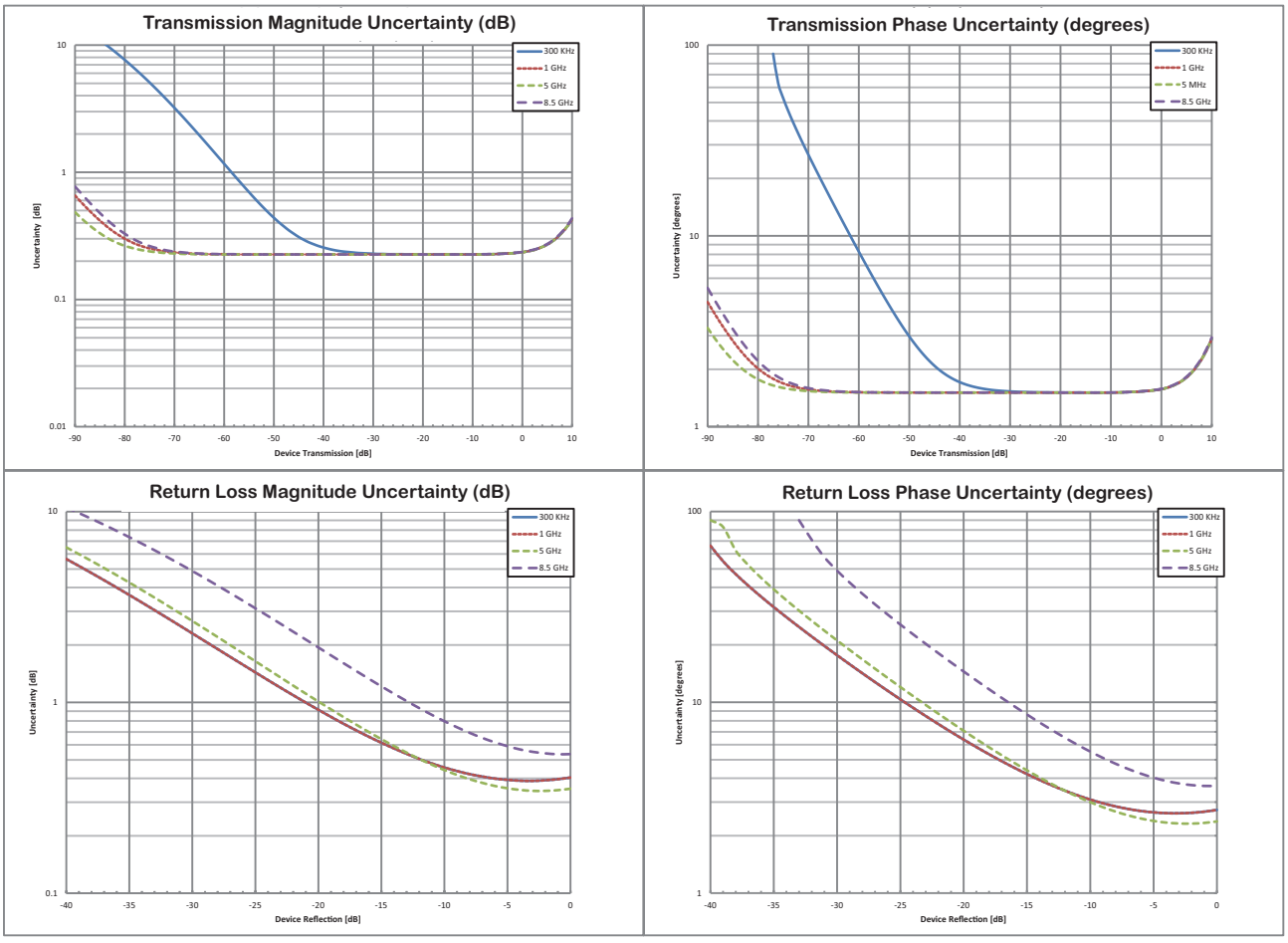
With 12-term calibration using the MN25408A SmartCal™ automatic calibration kit with option MN25408A-001, -002, -003

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match[a] (dB)	Reflection Tracking[a] (dB)	Transmission Tracking[a] (dB)
300 kHz to 1 GHz	> 42	> 35	> 38	±0.15	±0.2
> 1 GHz to 5 GHz	> 40	> 35	> 38	±0.08	±0.2
> 5 GHz to 8.5 GHz	> 33	> 32	> 33	±0.10	±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 0 dBm or default port power, whichever is less. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at www.anritsu.com.



MS46524B-010 and MS46524B-020 VNA System Performance with SmartCal™

Error-Corrected Specifications

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

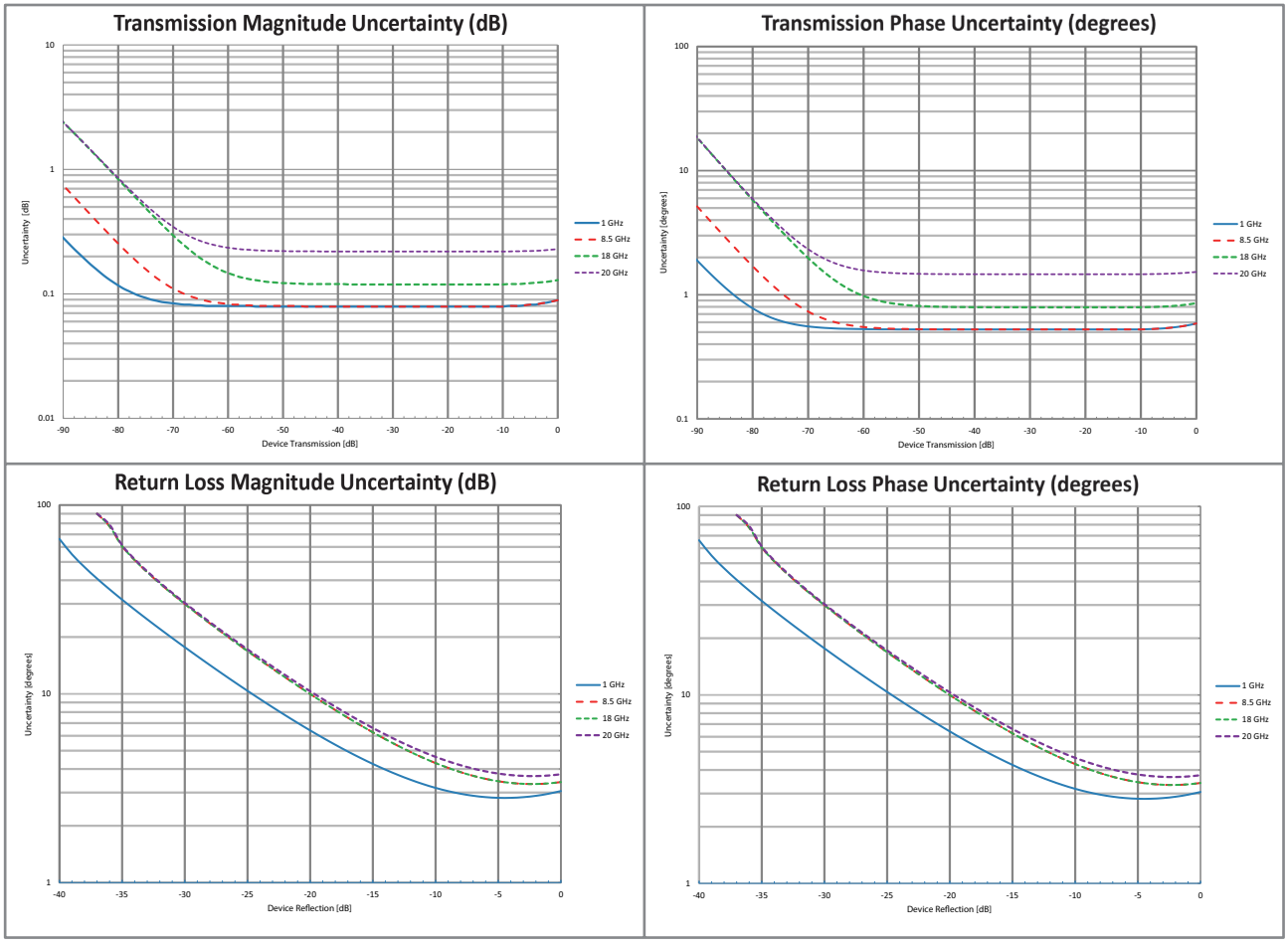
Frequency Range	Directivity (dB)	Source Match (dB)	Load Match[a] (dB)	Reflection Tracking[a] (dB)	Transmission Tracking[a] (dB)
300 kHz to 1 GHz[b]	> 42	> 33	> 42	±0.15	±0.06
> 1 GHz to 10 GHz	> 37	> 33	> 42	±0.15	±0.06
> 10 GHz to 18 GHz	> 37	> 33	> 37	±0.15	±0.10
> 18 GHz to 20 GHz	> 37	> 33	> 37	±0.20	±0.20

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 0 dBm or default port power, whichever is less. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at www.anritsu.com.



MS46524B-010 and MS46524B-020 VNA System Performance with SmartCal™

Error-Corrected Specifications

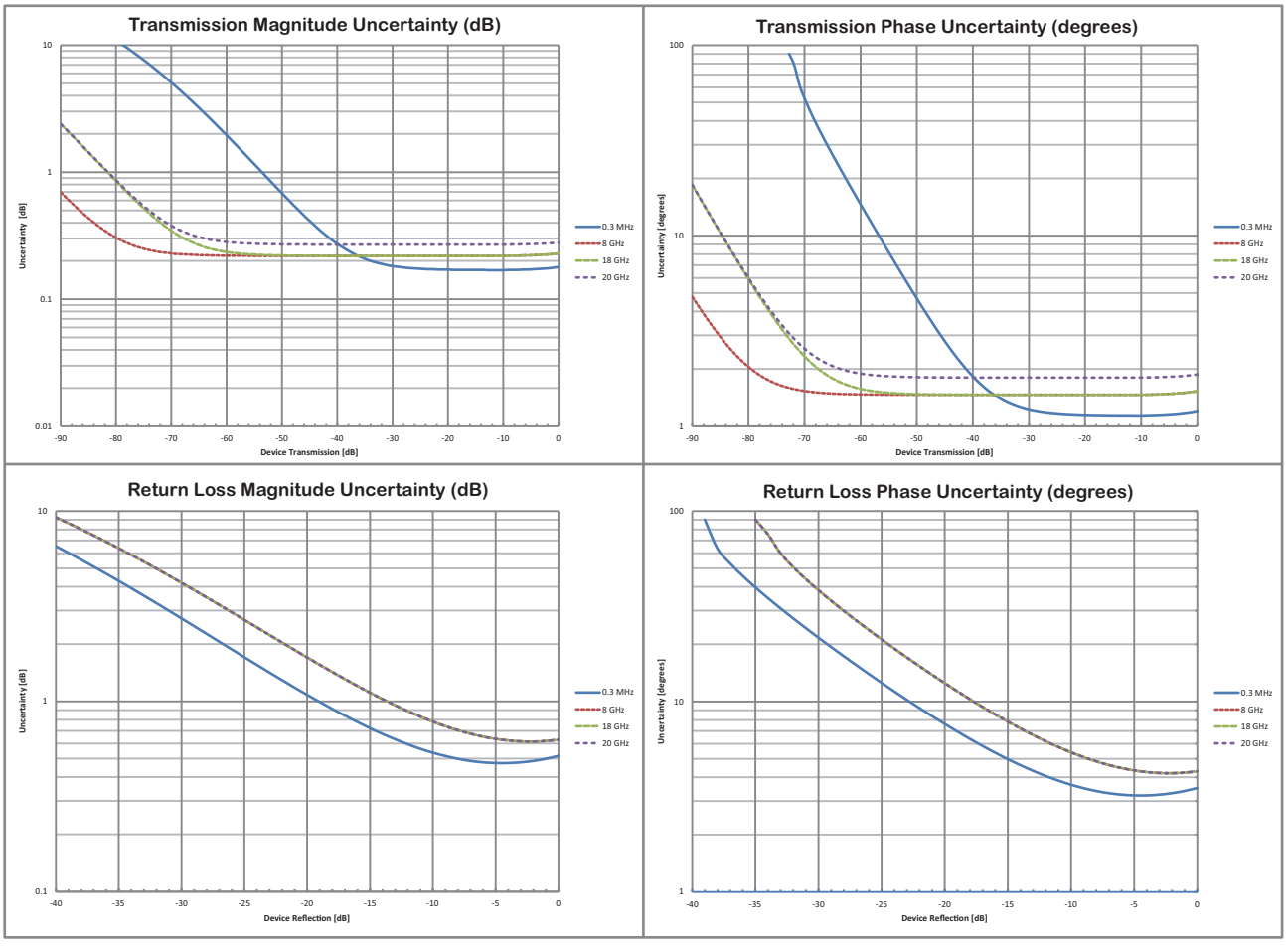
With 12-term calibration using the MN25418A SmartCal™ automatic calibration kit.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match[a] (dB)	Reflection Tracking[a] (dB)	Transmission Tracking[a] (dB)
300 kHz 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 0 dBm or default port power, whichever is less. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at www.anritsu.com.



MS46524B-040 VNA System Performance with Precision AutoCal™

Error-Corrected Specifications

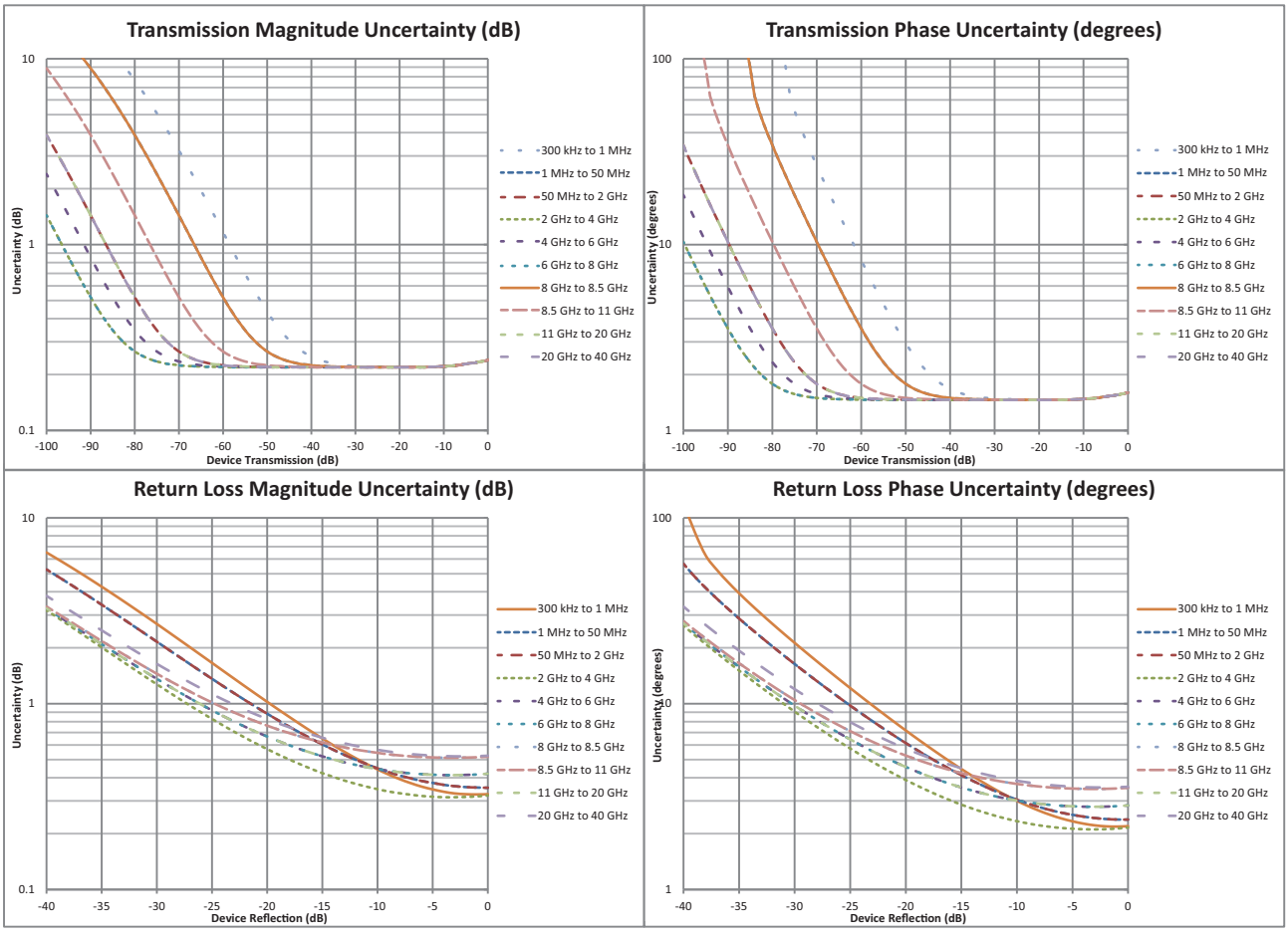
With 12-term calibration using the 36585K automatic calibration kit with type K connectors. Performance is typical.

Frequency Range	Directivity (dB)	Source Match (dB)	Load Match[a] (dB)	Reflection Tracking[a] (dB)	Transmission Tracking[a] (dB)
300 kHz to < 10 MHz	≥ 40	≥ 40	≥ 40	±0.10	±0.20
10 MHz to < 2.5 GHz	≥ 43	≥ 47	≥ 43	±0.20	±0.20
2.5 GHz to < 4 GHz	≥ 50	≥ 47	≥ 50	±0.20	±0.20
4 GHz to < 8 GHz	≥ 50	≥ 47	≥ 50	±0.30	±0.20
8 GHz to < 11 GHz	≥ 50	≥ 47	≥ 50	±0.40	±0.20
11 GHz to < 20 GHz	≥ 50	≥ 47	≥ 50	±0.30	±0.20
20 GHz to 40 GHz	≥ 48	≥ 47	≥ 48	±0.40	±0.20

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 0 dBm or default port power, whichever is less. For other conditions, please use our free Exact Uncertainty Calculator software, available for download from the Anritsu web site at www.anritsu.com.



Measurement Throughput Summary

Cycle Time for Measurement Completion (ms)

Number of traces = 1; system error correction on. Typical performance data.

	500 kHz IF Bandwidth				100 kHz IF Bandwidth				1 kHz IF Bandwidth			
Number of Points	**51**	**201**	**401**	**1601**	**51**	**201**	**401**	**1601**	**51**	**201**	**401**	**1601**
Start 1 GHz, stop 1.2 GHz												
Uncorrected	2	6	12	46	2	7	12	46	56	213	422	1679
2-Port Cal, S21	4	12	24	91	4	12	24	91	114	428	1692	3360
4-Port Cal	12	40	78	307	13	41	78	303	227	854	1692	6719
Start 300 kHz, stop 4.5 GHz												
Uncorrected	3	7	13	48	4	8	13	52	57	214	423	1683
2-Port Cal, S21	6	14	26	95	6	15	26	95	116	430	849	3368
4-Port Cal	13	41	79	309	13	41	78	312	231	860	1698	6734
Start 300 kHz, stop 8.5 GHz												
Uncorrected	4	7	13	48	4	8	14	48	57	215	424	1681
2-Port Cal, S21	6	14	26	94	7	16	27	95	116	431	851	3368
4-Port Cal	13	41	78	306	14	40	78	306	249	862	1701	6734

Data Transfer Time (ms)

Transferred complex S11 data, using "`CALC:DATA:SDATA?`" command. Typical performance data.[a]

Number of Points	**51**	**201**	**401**	**1601**
SCPI over LAN				
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

Operating Frequencies

MS46524B-010	50 kHz to 8.5 GHz
MS46524B-020	50 kHz to 20 GHz
MS46524B-040	50 kHz to 43.5 GHz

Measurement Parameters

4-Port Measurements	16 single-ended S-parameters, and any user-defined combination of a_{1-4}, b_{1-4}, and 1. 16 mixed-mode S-parameters (DD, CC, DC, CD); uses the superposition technique Maximum Efficiency Analysis
Domains	Frequency Domain, Time (Distance) Domain (Option 2), Power Domain

Sweeps

Sweep Configurations	Standard or Simultaneous (MS46524B-010 option only)
Frequency Sweep Types	Linear, Log, or Segmented
Power Sweep Types	Linear

Display Graphs

Single Rectilinear Graph Types	Log Magnitude, Phase, Group Delay, Linear Magnitude, Real, Imaginary, SWR, Impedance, KQ and η Max
Dual Rectilinear Graph Types	Log Mag and Phase, Linear Mag and Phase, Real and Imaginary, KQ and η Max
Circular Graph Types	Smith Chart (Impedance), Polar

Measurements Data Points

Maximum Data Points	2 to 20,001 points

Limit Lines

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.

Ripple Limit Lines

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.

Averaging		
	Point-by-Point	Point-by-point (default), maximum number of averages = 4096
	Sweep-by-Sweep	Sweep-by-sweep, maximum number of averages = 4096
IF Bandwidth		10, 20, 30, 50, 70, 100, 200, 300, 500, 700 Hz 1, 2, 3, 5, 7, 10, 20, 30, 50, 70, 100, 200, 300, 500 kHz
Reference Plane		
	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.
Measurement Frequency Range		
	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.
Group Delay		
	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
Channels, Display, and Traces		
	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.
Scale Resolution		Minimum per division, varies with graph type.
	Log Magnitude	0.001 dB
	Linear Magnitude	10 μU
	Phase	0.01°
	Group Delay	0.1 ps
	Time	0.0001 ps
	Distance	0.1 μm
	SWR	10 μU
	Power	0.001 dB
Markers		
	Markers	12 markers + 1 reference marker per trace
	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
Other	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

Calibration Methods	
	Short-Open-Load-Through (SOLT) Short-Open-Load-Reciprocal (SOLR) Offset-Short-Offset-Short-Load-Through (SSLT) Triple-Offset-Short-Through (SSST) Line-Reflect-Line (LRL) / Line-Reflect-Match (LRM) Source Calibration Receiver Calibration SmartCal™, AutoCal™ Thru Update available Secondary match correction available for improved low insertion loss measurements
Correction Models	
	4-port Cals (uses two Full 2-port Cals and up to 4 additional Thru/Reciprocals, minimum of 1) 3-port Cals (uses one Full 2-port Cal, one Full 1-port Cal, and up to 2 additional Thru/Reciprocals, minimum of 1) 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)
Coefficients for Calibration Standards	
	Use the Anritsu calibration kit USB memory device to load kit coefficients and characterization files. Use predefined coefficients for Anritsu calibration kits in ShockLine software. Enter coefficients into user-defined locations. Use complex load models.
Interpolation	Allows interpolation between calibration frequency points.
Adapter Removal Calibration	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.
Dispersion Compensation	Selectable as Coaxial, other non-dispersive (e.g., for coplanar waveguide), Waveguide, or Microstrip.
Power	
Power Meter Correction	Different power meter calibrations are available to enhance power accuracy at the desired reference plane. The source power will match the target calibration power, as read by the power meter, to within ~0.1 dB for short periods of time (determined by thermal drift of the system and the power meter). The absolute accuracy of the calibrated power will be dependent on the power meter and sensor used.
Flat Power Calibrations	A flat power calibration (when in frequency sweep mode) is available at a user-selectable power level, if it is within the power adjustment range of the internal source. The flat power correction is applied to other power levels.
Linear Power Calibrations	A linear power calibration is performed over a range of power levels for use in power sweep mode and is performed at a specified frequency or frequency range.
External Power Meter	Both calibrations are performed using an external USB power sensor (Anritsu MA24106A, MA24108A, MA24118A, MA24126A, MA24330A, MA24340A, MA24350A) over a USB 2.0 port.
Embedding/De-embedding	The MS46524B 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.
Optical/Electrical Conversion	
O/E, E/O, & O/O	O/E, E/O, and O/O setup wizards are provided.
Impedance Conversion	Allows entry of different reference impedances (complex values) for different ports.

Optional Capabilities

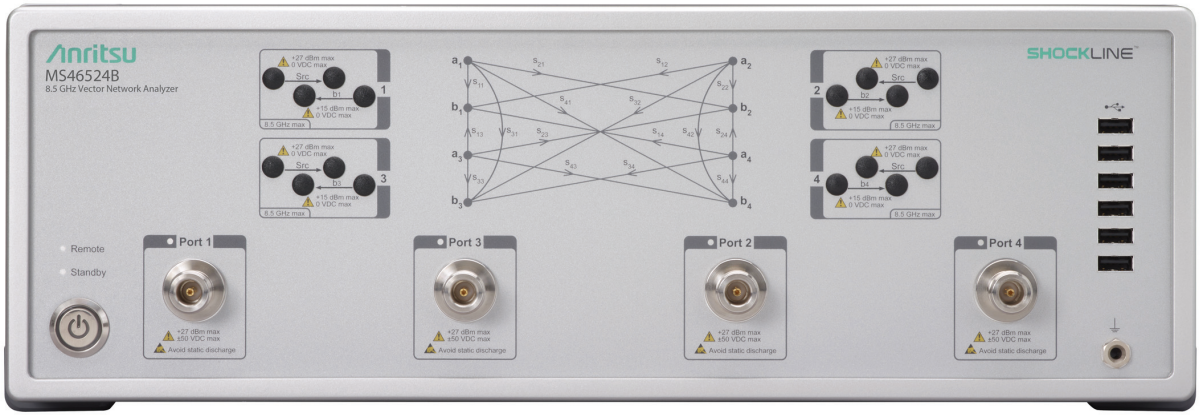
Time Domain Measurements, Option 2	Displays all S-parameters and overlays with Frequency Domain, Low-pass Mode with added harmonics frequency list flexibility, Band-pass Mode, Phasor Impulse Mode, Windowing, Gating (pass-band or reject-band), and Frequency with Time Gate.
Advanced Time Domain Measurements, Option 22	The ATD option has two basic elements. The first element is an Eye Diagram automatically created from a stored .SnP data file after launching the ADK software. The second element accesses the following functions: Check Passivity and Causality, Combine .SnP Files, Plot Eye Diagram, Plot Crosstalk, Plot TDT/TDR/Skew, and Perform Compliance Test. Option 2 recommended with Option 22, but is not required.

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 µs, typical	

Front Panel Connections



MS46524B Front Panel (8.5 GHz model shown)

Test Ports 1 through 4		
	MS46524B-010	N(f)
	MS46524B-020	K(m)
	MS46524B-040	K(m)
	Damage Input Levels	+27 dBm maximum, 50 VDC maximum
Ports 1 to 4 Access Loops (Only available with Option 10)		
	Source Path	K(f)
	Damage Input Levels	+27 dBm max, 0 VDC max
	Required	Only available with frequency Option 10
	Receiver path	K(f)
	Damage Input Levels	+15 dBm max, 0 VDC max
	Required	Only available with frequency Option 10
USB Ports		Six type A USB 2.0 Ports for peripherals such as keyboard, mouse, memory stick, hardware key, and similar devices.
Chassis Grounding Port		Banana(f)

Rear Panel Connections

MS46524B 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 ports for peripherals such as keyboard, mouse, flash drive, USB monitor, and hardware key.
	LAN Port	Gigabit Ethernet
Media	HDMI and Display Port	Video output, touchscreen compatible
	Audio	External stereo speaker and microphone (3.5 mm)

10 MHz In	Signal presence is auto-sensing (better than 10 ppm frequency accuracy is recommended).
Connector Type	BNC(f)
Signal	+0 dBm, typical; 50 Ω, nominal
10 MHz Out	Signal presence is synchronized to and dependent upon the 10 MHz input signal
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
External Trigger Output	
Connector type	BNC(f)
Voltage Output	0 to 3.3 V (HCMOS logic)
Drive Current	24 mA maximum
Pulse Width	1 µs, typical
Bias Inputs (Only available with Option 10)	
Connector	BNC(f) (one input per port); 50 VDC maximum, 0.5 A maximum
Required	Only available with frequency Option 10

CPU, Memory, and Security Features

CPU	Intel Core i5
Storage	Serial-ATA (SATA) Solid State Drive for OS, Programs, and Data (> 30 GB).
Security Features	If the VNA is attached to a network, best practices recommend installing anti-virus software.

Mechanical

Dimensions	Dimensions listed are for the instrument body without rack mount option attached.
W x H x D	445 mm x 152 mm x 442 mm
Weight	< 13.6 kg (< 30 lb), typical weight for a fully-loaded MS46524B-010 VNA < 15.9 kg (< 35 lb), typical weight for a fully-loaded MS46524B-20 or MS46524B-040 VNA

Regulatory Compliance

European Union	EMC 2014/30/EU, EN 61326:2013, CISPR 11/EN 55011, IEC/EN 61000-4-2/3/4/5/6/8/11 Low Voltage Directive 2014/35/EU Safety EN 61010-1:2010 RoHS Directive 2011/65/EU applies to instruments with CE marking placed on the market after July 22, 2017
Australia and New Zealand	RCM AS/NZS 4417:2012
South Korea	KCC-REM-A21-0004

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
Vibration, Sinusoidal	5 Hz to 55 Hz
Vibration, Random	10 Hz to 500 Hz
Half Sine Shock	30 g_n
Altitude	4600 meters, operating and non-operating

Warranty

Instrument and Built-In Options	3 years 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

Instrument Models	
MS46524B	ShockLine 4-Port Vector Network Analyzer (base model)
Requires One Frequency Option	
MS46524B-010	50 kHz to 8.5 GHz, type N(f) ports
MS46524B-020	50 kHz to 20 GHz, type K(m) Ruggedized ports (compatible with 3.5 mm and SMA connectors)
MS46524B-040	50 kHz to 43.5 GHz, type K(m) Ruggedized ports (compatible with 3.5 mm and SMA connectors)
Included Accessories	Each VNA comes with a power cord and instructions on where to download software and related literature.
Main VNA Options	
MS46524B-001	Rack Mount, adds handles and removes feet for shelf-mounting into a 19 inch universal rack
MS46524B-002	Time Domain with Time Gating
MS46524B-022	Advanced Time Domain
MS46524B-051	Access Loops (Only available with Option 10)
MS46524B-061	Bias Tee (Only available with Option 10)
Calibration Options	
MS46524B-097	Accredited Calibration, with data
MS46524B-098	Standard Calibration, ISO 17025 compliant, without data
MS46524B-099	Premium Calibration, ISO 17025 compliant, with data
OE Calibration Module	
MN4765B-0040	Configured for 70 kHz to 40 GHz range, with 850 nm wavelength coverage
MN4765B-0042	Configured for 70 kHz to 40 GHz range, with 850 and 1060 nm wavelength coverage
MN4765B-0043	Configured for 70 kHz to 40 GHz range, with 850/1060/1310/1550 nm wavelength coverage
MN4765B-0070	Configured for 70 kHz to 70 GHz range, with 1550 nm wavelength coverage
MN4765B-0071	Configured for 70 kHz to 70 GHz range, with 1310 nm wavelength coverage
MN4765B-0072	Configured for 70 kHz to 70 GHz range, with 1310 and 1550 nm wavelength coverage
MN4765B-0110	Configured for 70 kHz to 110 GHz range, with 1550 nm wavelength coverage
Precision Automatic Calibrator Modules	
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[1]	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 Precision AutoCal Module, 70 kHz to 40 GHz, K(m) to K(m)
36585K-2F	K Precision AutoCal Module, 70 kHz to 40 GHz, K(f) to K(f)
36585K-2MF	K 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)
Mechanical Calibration Kits	
3650A	SMA/3.5 mm Calibration Kit, Without Sliding Loads, DC to 26.5 GHz, 50 Ω
3650A-1	SMA/3.5 mm Calibration Kit, With Sliding Loads, DC to 26.5 GHz, 50 Ω
3652A	K Connector Calibration Kit, Without Sliding Loads, DC to 40 GHz, 50 Ω
3652A-1	K Connector Calibration Kit, With 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

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

USB Power Sensors

MA24106A	True-RMS USB Power Sensor, 50 MHz to 6 GHz
MA24108A	True-RMS USB Power Sensor, 10 MHz to 8 GHz
MA24118A	True-RMS USB Power Sensor, 10 MHz to 18 GHz
MA24126A	True-RMS USB Power Sensor, 10 MHz to 26 GHz
MA24330A	Microwave CW USB Power Sensor, 10 MHz to 33 GHz
MA24340A	Microwave CW USB Power Sensor, 10 MHz to 40 GHz
MA24350A	Microwave CW USB Power Sensor, 10 MHz to 50 GHz

Verification Kit

3663-3	N Connector Verification Kit
3668-3	K Connector Verification Kit

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	SMA(m) to N(m), DC to 18 GHz, 50 Ω
1091-27-R	SMA(f) to N(m), DC to 18 GHz, 50 Ω
1091-80-R	SMA(m) to N(f), DC to 18 GHz, 50 Ω
1091-81-R	SMA(f) to N(f), DC to 18 GHz, 50 Ω
34NN50A	Precision Adapter, N(m) to N(m), DC to 18 GHz, 50 Ω
34NFNF50	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
K220B	Precision Adapter, K(m) to K(m), DC to 40 GHz, 50 Ω
K222B	Precision Adapter, K(f) to K(f), DC to 40 GHz, 50 Ω
K224B	Precision Adapter, K(m) to K(f), DC to 40 GHz, 50 Ω
SC7260	WR12 to W1(m) Adapter, W1 (1 mm) to WR12 Waveguide
SC7442	WR12 to W1(f) Adapter, W1 (1 mm) to WR12 Waveguide
35WR12WF-EE	Precision Waveguide to Coax Adapter Kit, 56 GHz to 94 GHz, WR-12 to 1.0 mm(f)

Test Port Cables, Flexible, Ruggedized, Phase Stable

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 Cable, Armored, Phase Stable, DC to 20 GHz, 3.5 mm(m) to 3.5 mm(m), 1.0 m, 50 Ω
15LLF50-1.0A	Test Port Cable, Armored, Phase Stable, DC to 20 GHz, 3.5 mm(m) to 3.5 mm(f), 1.0 m, 50 Ω
15KK50-1.0A	Test Port Cable, Armored, Phase Stable, DC to 20 GHz, K(m) to K(m), 1.0 m, 50 Ω
15KKF50-1.0A	Test Port Cable, Armored, Phase Stable, DC to 20 GHz, K(m) to K(f), 1.0 m, 50 Ω
3671KFS50-60	Test Port Cable, Flexible, Phase Stable, DC to 26.5 GHz, K(f) to 3.5 mm(m), 63.5 cm, 50 Ω
3671KFK50-60	Test Port Cable, Flexible, Phase Stable, DC to 40 GHz, K(f) to K(m), 63.5 cm (25 in), 50 Ω
3671KFKF50-60	Test Port Cable, Flexible, Phase Stable, DC to 40 GHz, K(f) to K(f), 63.5 cm (25 in), 50 Ω
3671KFK50-100	Test Port Cable, Flexible, Phase Stable, DC to 40 GHz, K(f) to K(m), 1 m (38 in), 50 Ω

Phase-Stable 18 GHz and 40 GHz Semi-Rigid Cables (Armored)

3670N50-1	0.3 m (12”), DC to 18 GHz, N(f) to N(m), 50 Ω
3670NN50-1	0.3 m (12”), DC to 18 GHz, N(m) to N(m), 50 Ω
3670N50-2	0.6 m (24”), DC to 18 GHz, N(f) to N(m), 50 Ω
3670NN50-2	0.6 m (24”), DC to 18 GHz, N(m) to N(m), 50 Ω
3670K50-1	0.3 m (12”), DC to 40 GHz, K(f) to K(m), 50 Ω
3670K50-2	0.6 m (24”), DC to 40 GHz, K(f) to K(m), 50 Ω

Phase-Stable 18 GHz and 40 GHz Test Port Cables (Flexible)

3671KFS50-60	60 cm (23.6 in), DC to 20 GHz, K (f) to 3.5 mm (m), 50 Ω
36671KFSF50-60	60 cm (23.6 in), DC to 20 GHz, K (f) to 3.5 mm (f), 50 Ω
3671KFKF50-60	60 cm (23.6 in), DC to 40 GHz, K (f) to K (f), 50 Ω
3671KFK50-100	100 cm (39.4 in), DC to 40 GHz, K (f) to K (m), 50 Ω
3671VFV50-60	60 cm (23.6 in), DC to 70 GHz, V (f) to V (m), 50 Ω
3671VFVF50-60	60 cm (23.6 in), DC to 70 GHz, V (f) to V (f), 50 Ω
3671VFV50-100	100 cm (39.4 in), DC to 70 GHz, V (f) to V (m), 50 Ω

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)
01-204	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 available for download from the instrument model web page at www.anritsu.com. For more information and product support, please contact ShockLineVNA.support@Anritsu.com.
10100-00067	Product information, compliance, and safety
10410-00743	MS46522B/524B VNA Operation Manual
10410-00744	MS46522B/524B VNA User Interface Reference Manual
10410-00746	ShockLine Series VNA Programming Manual, for IEEE 488.2 and SCPI Commands
10410-00753	MS46522B/524B VNA Calibration and Measurement Guide

Notes

Training at Anritsu

Anritsu has designed courses to help you stay up to date with technologies important to your job. For available training courses, visit: www.anritsu.com/training

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