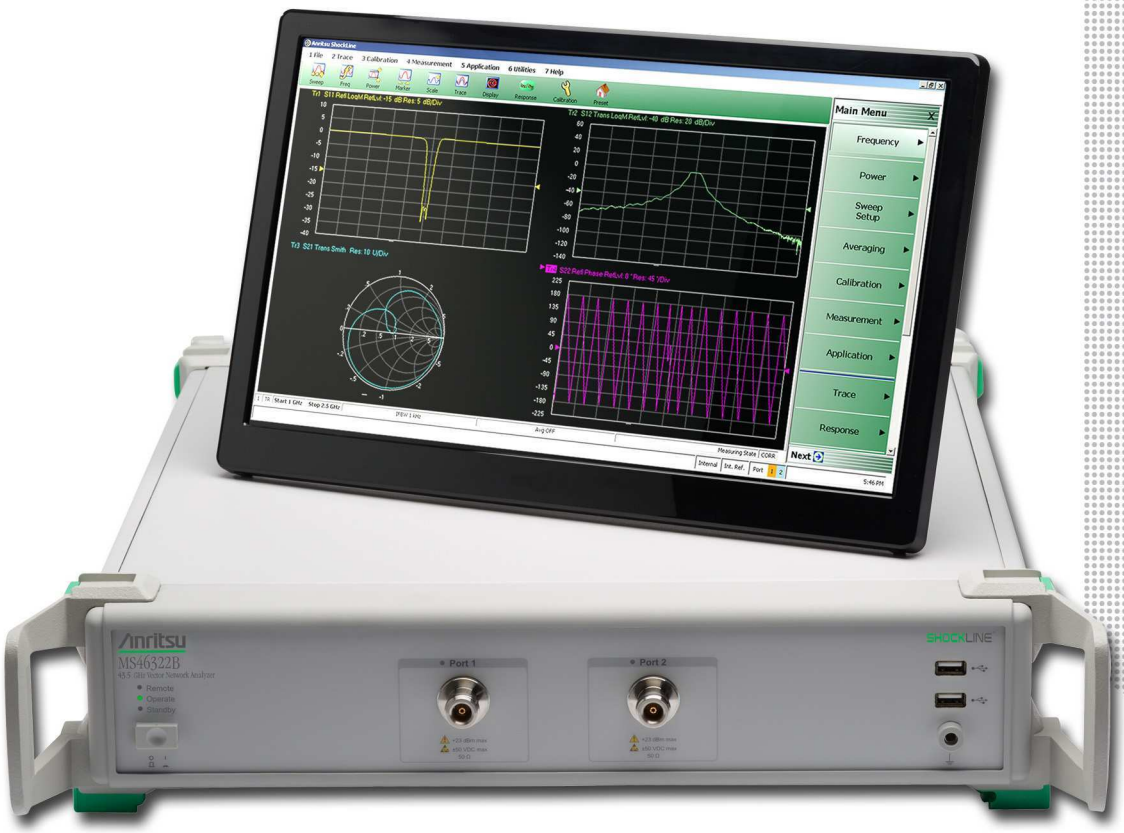
Anritsu envision : ensure

# ShockLine™ Economy Vector Network Analyzers

## MS46322B

1 MHz to 43.5 GHz

SHOCKLINE™



## 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

This technical data sheet applies to the following hardware revisions:
MS46322B base model, revision 2
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.<br>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.<br>It does not include guard-bands and is not covered by the product warranty.<br>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

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[a] | 100 | 115 |
| > 8 GHz to 40 GHz[b] | 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 (≤ 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<br>> 8 GHz to 43.5 GHz | 5 dBm<br>–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 | ± 1.0 ppm (at time of calibration) | ± 1.0 ppm from -10 °C to +55 °C, typical | ± 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

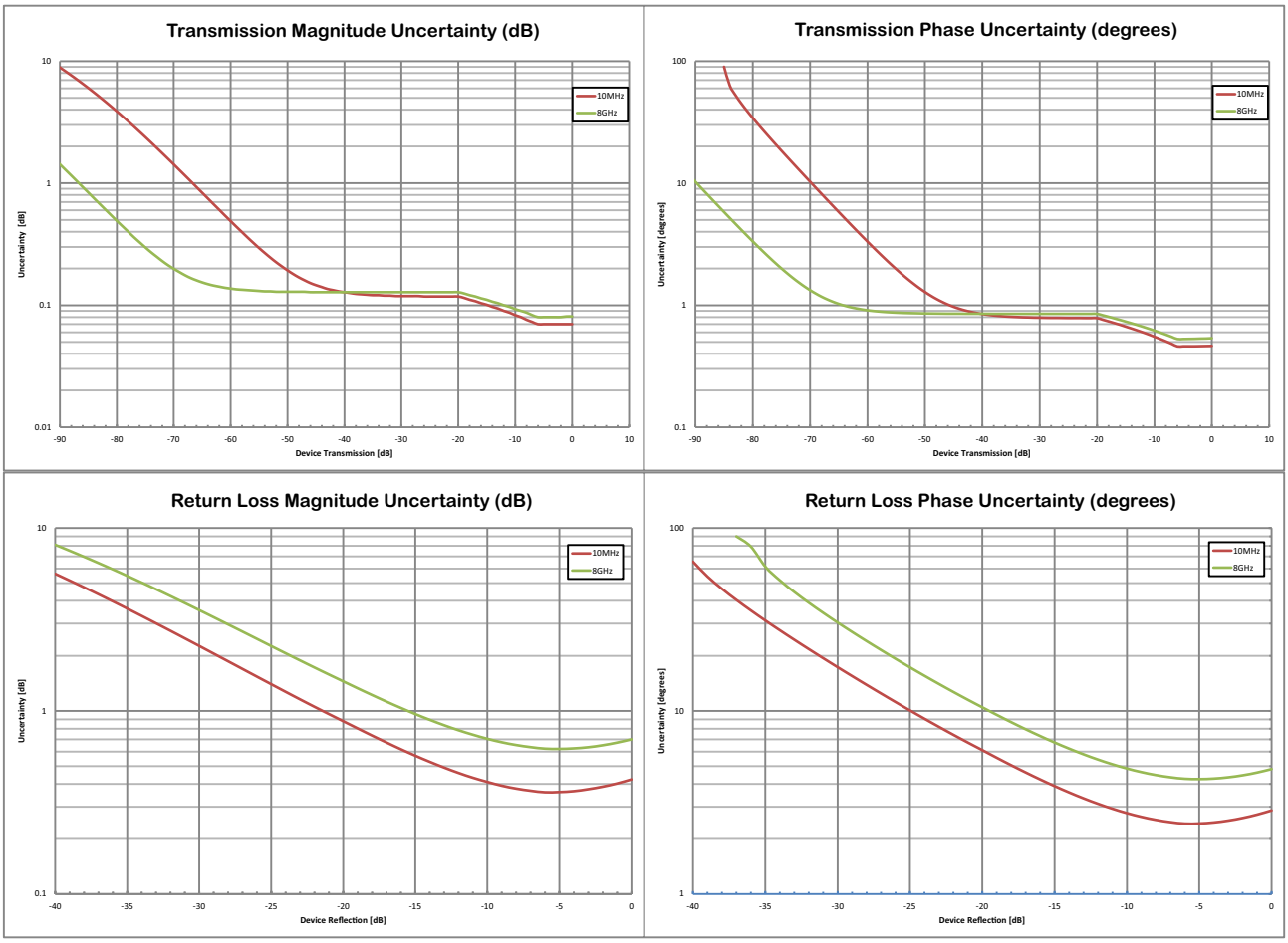
With 12-term SOLT Calibration using TOSLN50A-8 or TOSLNF50A-8 N type connector calibration kits.

| Frequency Range | Directivity (dB) | Source Match (dB) | Load Match[a] (dB) | Reflection Tracking[a] (dB) | Transmission Tracking[a] (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.



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

### Error-Corrected Specifications

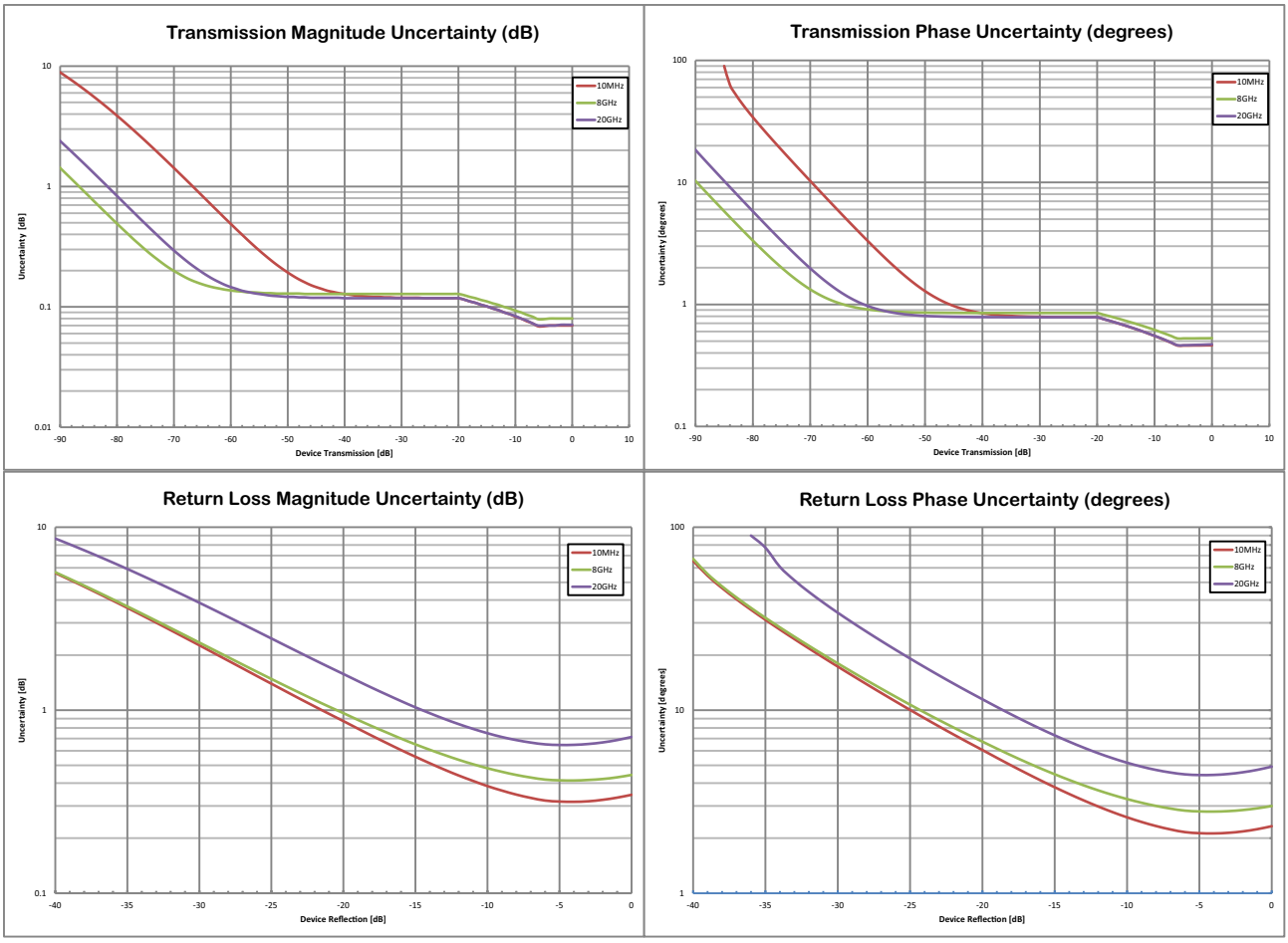
With 12-term SOLT calibration using the TOSLK50A-20 or TOSLKF50A-20 K type connector calibration kits.

| Frequency Range | Directivity (dB) | Source Match (dB) | Load Match[a] (dB) | Reflection Tracking[a] (dB) | Transmission Tracking[a] (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.



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

### Error-Corrected Specifications

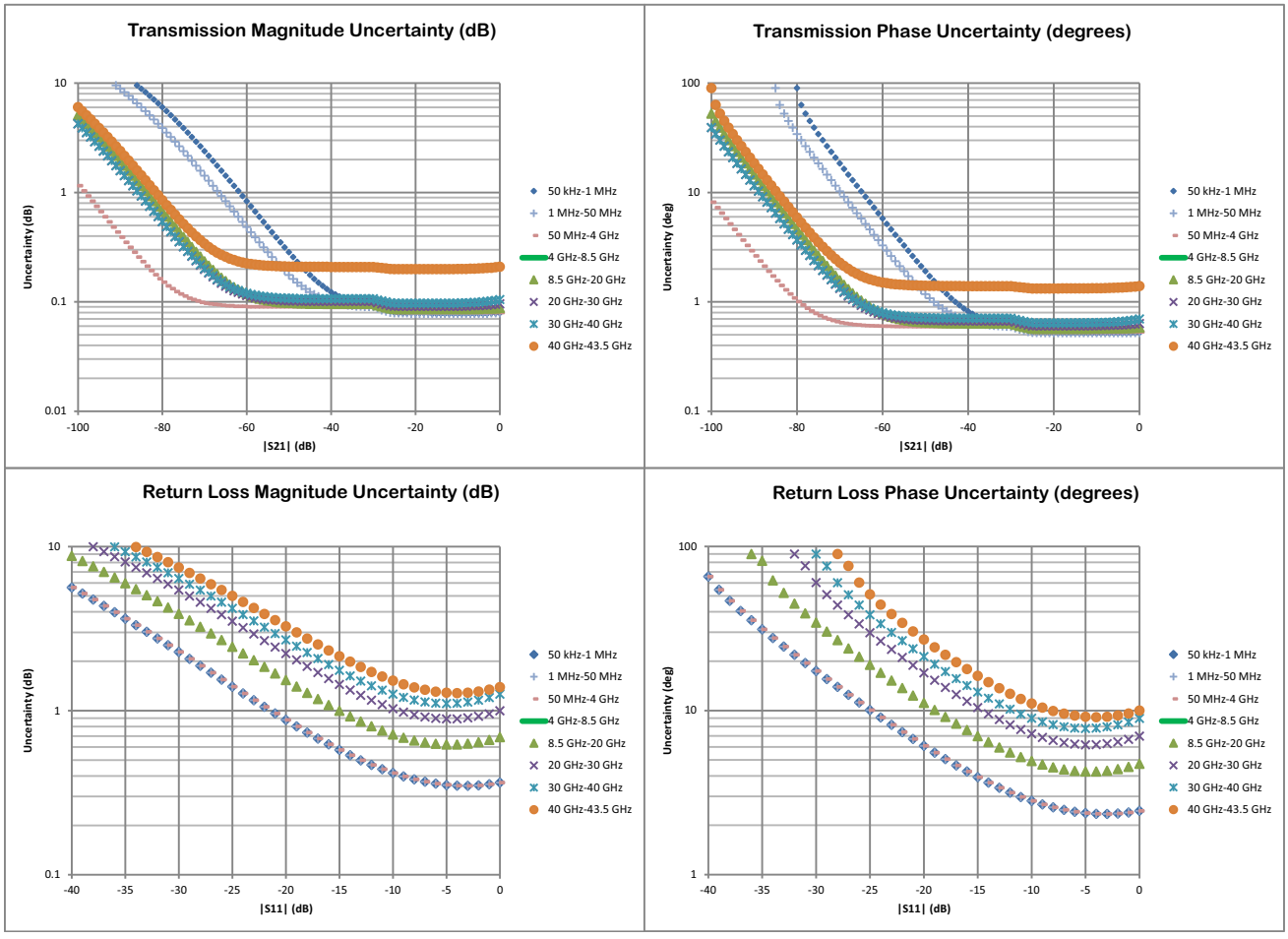
With 12-term SOLT Calibration using TOSLK50A-43.5 or TOSLKF50A-43.5 K type connector calibration kits with generic calibration coefficients.

| Frequency Range | Directivity (dB) | Source Match (dB) | Load Match[a] (dB) | Reflection Tracking[a] (dB) | Transmission Tracking[a] (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.



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

### Error-Corrected Specifications

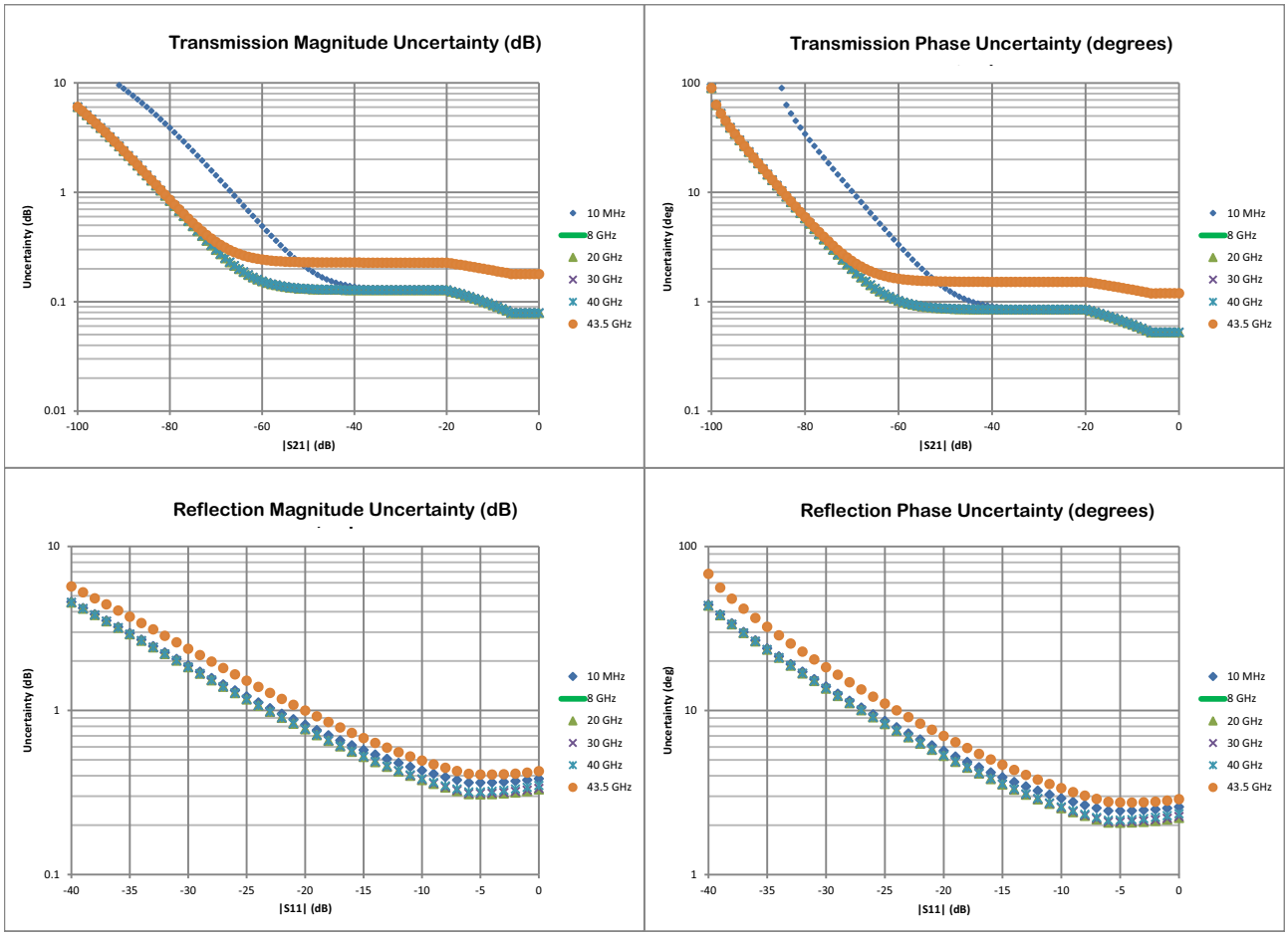
With 12-term SOLT Calibration using TOSLK50A-43.5 or TOSLKF50A-43.5 K type connector calibration kits with .s1p definitions.

| Frequency Range GHz | Directivity (dB) | Source Match (dB) | Load Match[a] (dB) | Reflection Tracking[a] (dB) | Transmission Tracking[a] (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.



## MS46322B-010 VNA System Performance with SmartCal™

### Error-Corrected Specifications

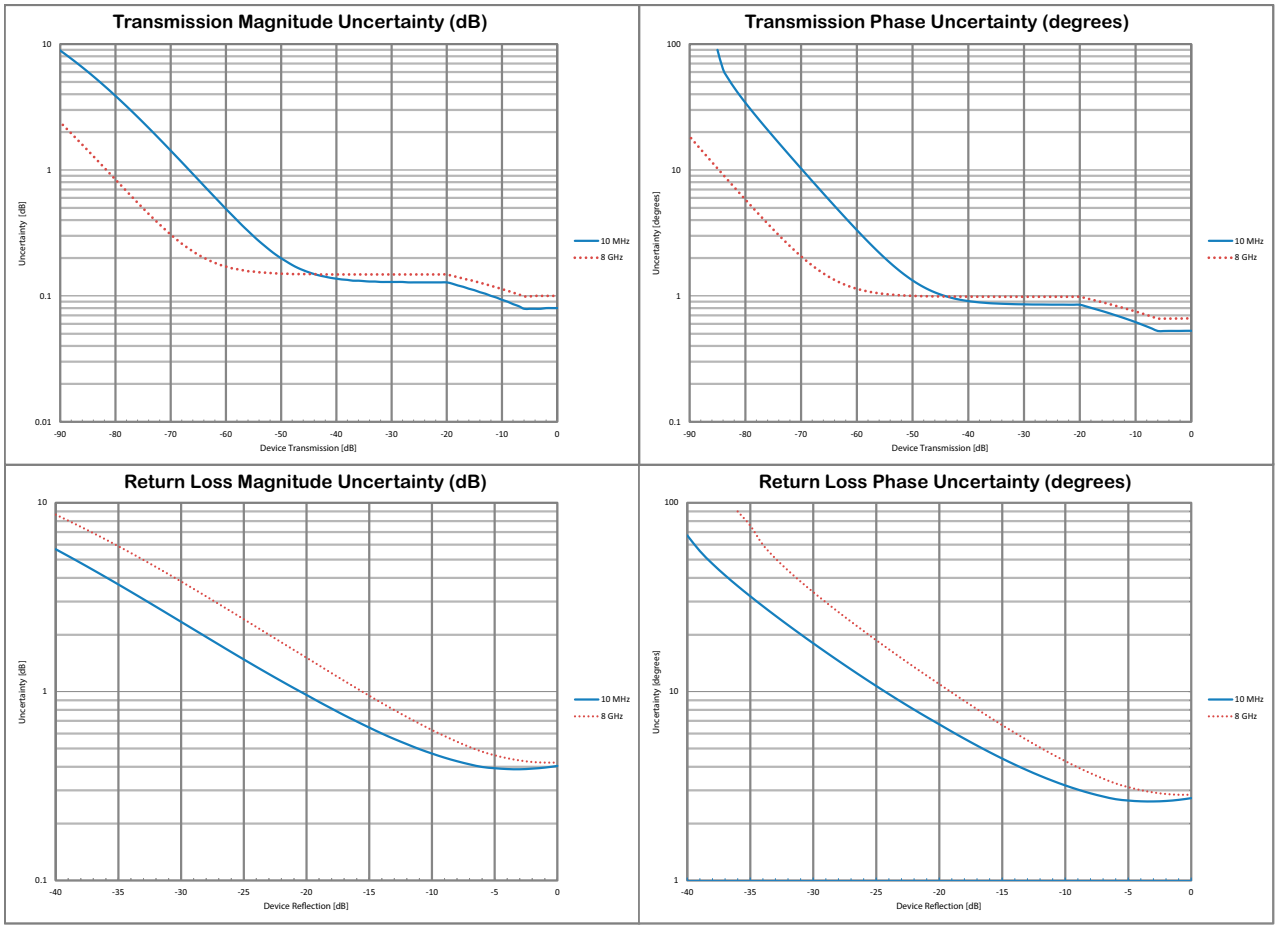
With 12-term calibration using the MN25208A SmartCal™ automatic calibration kit with connector options MN25208A-001, -002, -003.

| Frequency Range | Directivity (dB) | Source Match (dB) | Load Match[a] (dB) | Reflection Tracking[a] (dB) | Transmission Tracking[a] (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.



## MS46322B-010 VNA System Performance with SmartCal™

### Error-Corrected Specifications

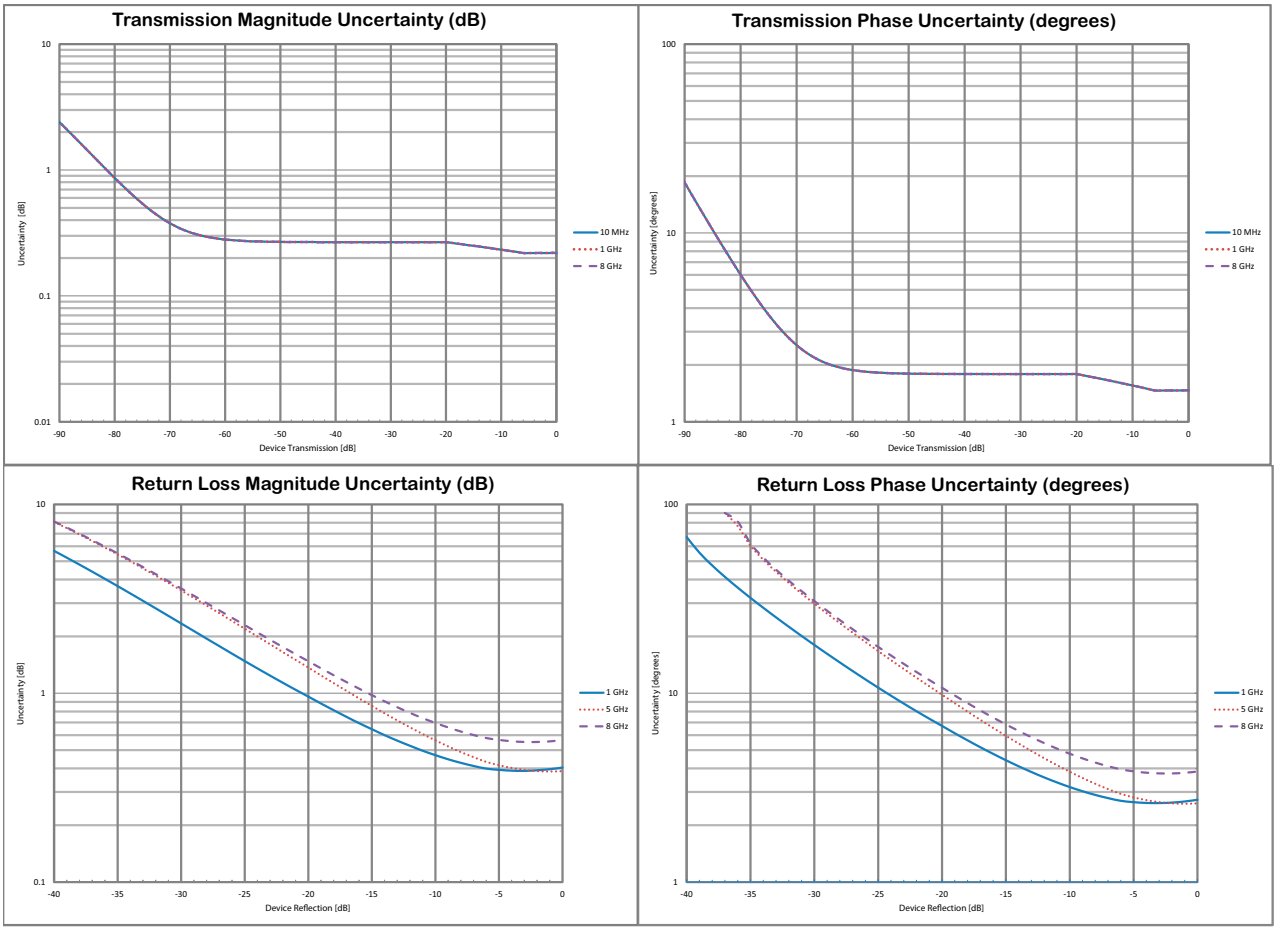
With 12-term calibration using the MN25408A SmartCal™ automatic calibration kit with connector options MN25408A-001, -002, -003.

| Frequency Range | Directivity (dB) | Source Match (dB) | Load Match[a] (dB) | Reflection Tracking[a] (dB) | Transmission Tracking[a] (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.



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

### Error-Corrected Specifications

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

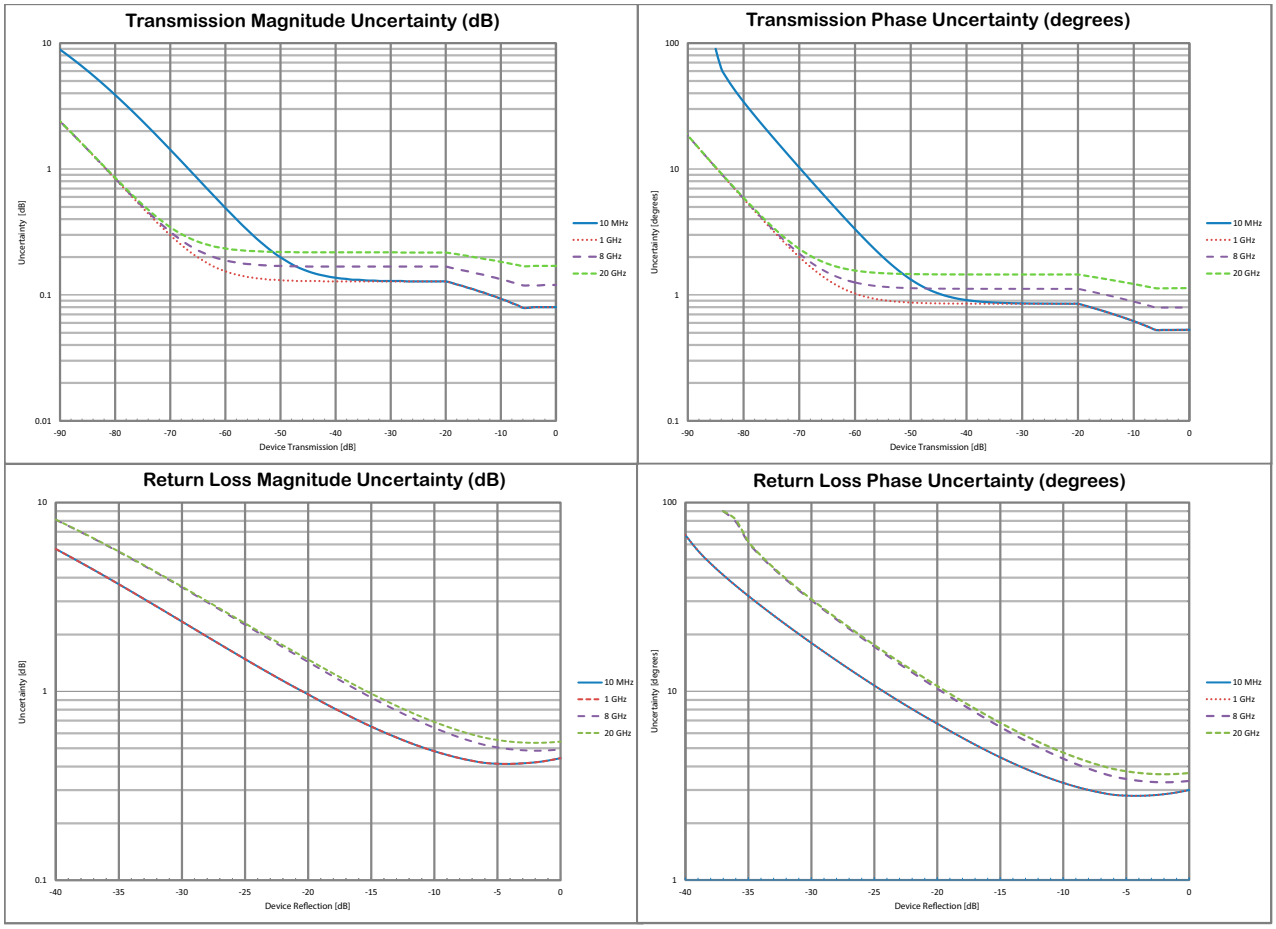
| Frequency Range | Directivity (dB) | Source Match (dB) | Load Match[a] (dB) | Reflection Tracking[a] (dB) | Transmission Tracking[a] (dB) |
|---|---|---|---|---|---|
| 1 MHz to 1 GHz[b] | ≥ 42 | ≥ 33 | ≥ 42 | ±0.15 | ±0.06 |
| > 1 GHz to 10 GHz | ≥ 37 | ≥ 33 | ≥ 42 | ±0.15 | ±0.1 |
| > 10 GHz to 18 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.



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

### Error-Corrected Specifications

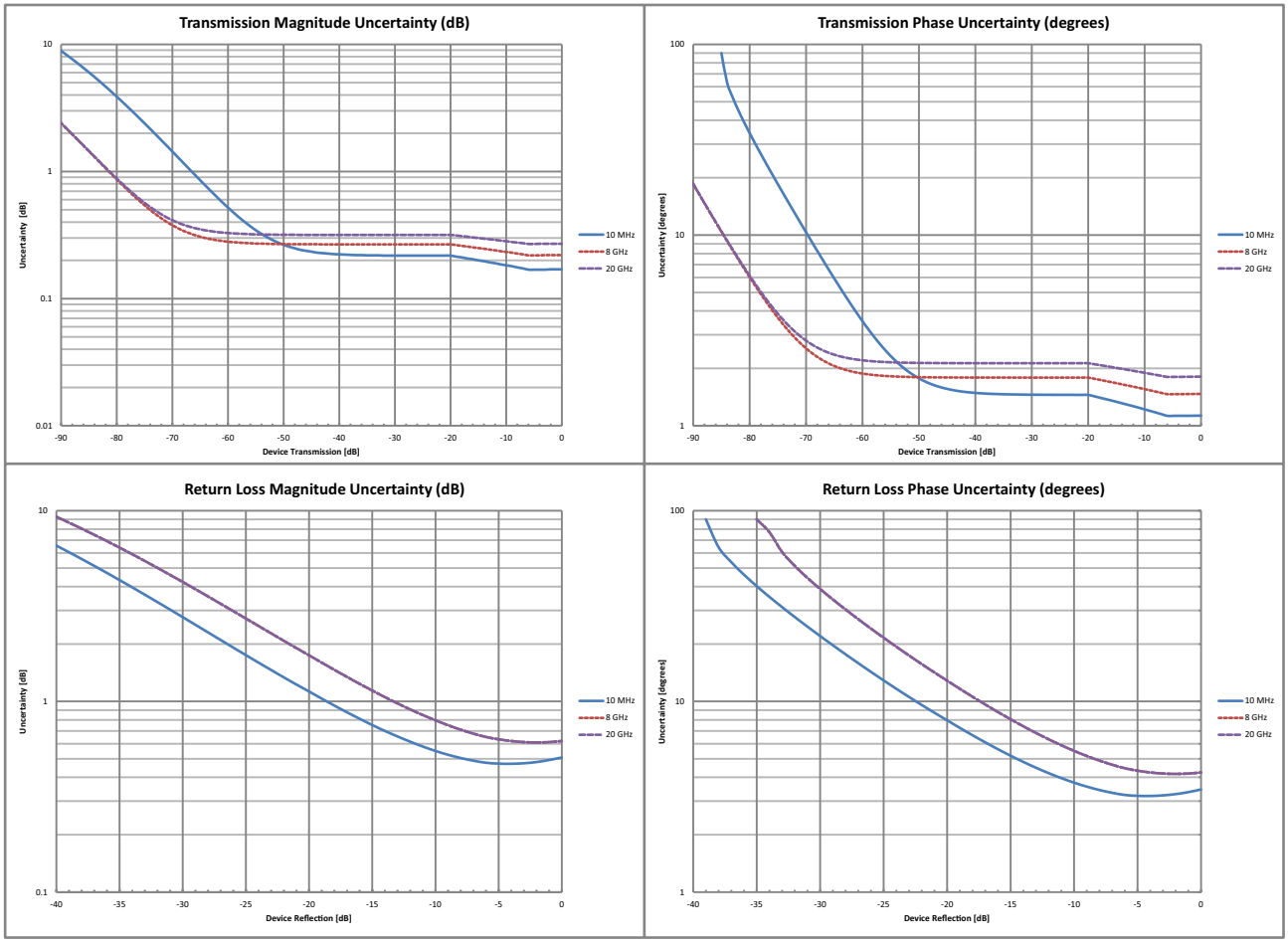
With 12-term calibration using the MN25418A SmartCal™ automatic calibration kit.

| Frequency Range | Directivity (dB) | Source Match (dB) | Load Match[a] (dB) | Reflection Tracking[a] (dB) | Transmission Tracking[a] (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.



## MS46322B-043 VNA System Performance with Precision AutoCal™

### Error-Corrected Specifications

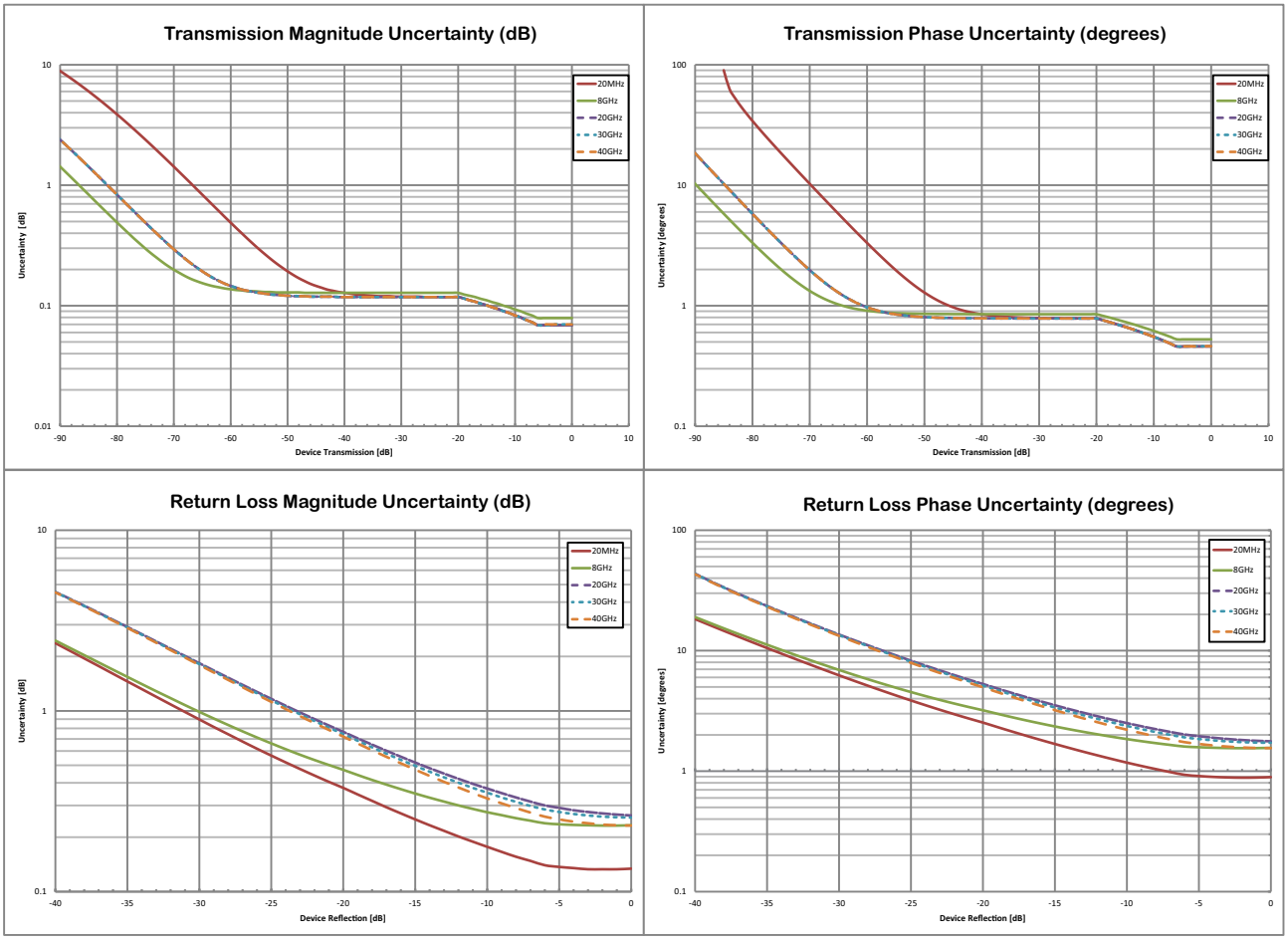
With 12-term calibration using the 36585K automatic calibration kit with type K connectors. Performance is typical.

| Frequency Range | Directivity (dB) | Source Match (dB) | Load Match[a] (dB) | Reflection Tracking[a] (dB) | Transmission Tracking[a] (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.



## Measurement Throughput Summary

**Measurement Speed**

130 µs/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.

**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**

| | |
|---|---|
| MS46322B-010 | 1 MHz to 8 GHz |
| MS46322B-020 | 1 MHz to 20 GHz |
| MS46322B-043 | 1 MHz to 43.5 GHz |

**Measurement Parameters**

| | |
|---|---|
| 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<br>Maximum Efficiency Analysis, Mixed-mode SDD, SDC, SCD, SCC |
| Domains | Frequency Domain, Time (Distance) Domain (Option 2) |

**Sweeps**

| | |
|---|---|
| Frequency Sweep Types | Linear, Log, CW, or Segmented |

**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 16,001 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 = 200 |
| Sweep-by-Sweep | Sweep-by-sweep, maximum number of averages = 4096 |

**IF Bandwidth**

10, 20, 50, 70, 100, 200, 300, 500, 700 Hz
1, 2, 3, 5, 7, 10, 20, 30, 50, 70, 100, 200, 300 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 | 0.01 dB |
| **Markers** | | |
| | Markers | 12 markers + 1 reference marker |
| | Marker Coupling | Coupled or decoupled |
| | Marker Overlay | Display markers on active trace only or<br>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<br>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<br>Z Transmission Impedance<br>Y Reflection Admittance<br>Y Transmission Admittance<br>1/S |

## Calibration and Correction Capabilities

| | |
|---|---|
| **Calibration Methods** | |
| | Short-Open-Load-Through (SOLT)<br>Offset-Short-Offset-Short-Load-Through (SSLT)<br>Triple-Offset-Short-Through (SSST)<br>Short-Open-Load-Reciprocal (SOLR)<br>Line-Reflect-Line (LRL) / Line-Reflect-Match (LRM)<br>SmartCal™<br>AutoCal™<br>Thru Update available<br>Secondary match correction available for improved low insertion loss measurements |
| **Correction Models** | |
| | 2-Port (Forward, Reverse, or both directions)<br>1-Port ($S_{11}$, $S_{22}$, or both)<br>Transmission Frequency Response (Forward, Reverse, or both directions)<br>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.<br>Enter coefficients into user-defined locations.<br>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 |
| **Embedding/De-embedding** | 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. |
| **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. |
| 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 µs, 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** | | 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 |

## CPU, Memory, and Security Features

| | |
|---|---|
| CPU | Intel Core™ i5 |
| Storage | Serial-ATA (SATA) Solid State Drive (> 30 GB SSD, removable) for OS, Programs, and Data |

**Security Features**

| | |
|---|---|
| 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

**Dimensions** 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 |

**Weight** < 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 61000-4-2/3/4/5/6/8/11<br>Low Voltage Directive 2014/35/EU<br>Safety EN 61010-1:2010<br>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 |
| 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** | |
| 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) |
| **Included Accessories** | Each VNA comes with a power cord and instructions on where to download software and related literature. |
| **Main VNA Options** | |
| 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 |
| **Removable SSD Kit** | |
| 2000-1858-R | Spare SSD Disk Drive Kit |
| **Calibration Options** | |
| MS46322B-097 | Accredited Calibration, with data |
| MS46322B-098 | Standard Calibration, ISO 17025 compliant, without data |
| MS46322B-099 | Premium Calibration, ISO 17025 compliant, with data |
| **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 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) |
| **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 |
| TOSLK50A-43.5 | Precision K Male Through/Open/Short/Load Mechanical Calibration Tee, DC to 43.5GHz, 50 Ω Includes .s1p files for data-based calibration support |
| 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 |
| **Verification Kit** | |
| 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 |
| 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 |
| 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 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 |

### 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 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 |
| 3670K50A-1 | 0.3 m (12″), DC to 43.5 GHz, K(f) to K(m), 50 Ω |
| 3670K50A-2 | 0.6 m (24″), DC to 43.5 GHz, K(f) to K(m), 50 Ω |

### 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 Ω |
| 3671KFSF50-60 | 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 |

### Transit Case

| | |
|---|---|
| 760-269 | ShockLine VNA Transit Case, Hard plastic with wheels |

### 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)<br>(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)<br>(for tightening ruggedized SMA, 2.4 mm, K and V test port connectors) |
| 01-204 | End Wrench, 5/16 in, Universal, Circular, Open-ended<br>(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 ShockLineVNA.support@Anritsu.com. |
| 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 |

**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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