

ShockLine™ Compact Vector Network Analyzer

MS46122A/B

1 MHz to 8 GHz

1 MHz to 20 GHz

1 MHz to 43.5 GHz



MS46122A/B 43.5 GHz ShockLine VNA

Anritsu

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Table of Contents

Chapter 1—General Information

1-1	Introduction	1-1
1-2	Description	1-1
	Standard Accessories	1-1
	Available Options	1-1
	Identification Number	1-1
1-3	Related Documents	1-2
1-4	Basic Maintenance	1-2
	Performance Verification	1-2
	Repair Service	1-2
1-5	Anritsu Customer Service Centers	1-2
1-6	Recommended Test Equipment	1-2
1-7	Replaceable Parts and Assemblies	1-6

Chapter 2— MS46122A Performance Verification

2-1	Introduction to Performance Verification	2-1
2-2	VNA Traceability and Uncertainty	2-1
	First Tier of Uncertainty – The VNA Calibration	2-1
	Second Tier of Uncertainty – Systematic Measurement Errors	2-2
	Third Tier of Uncertainty – Random Measurement Error	2-2
	Standards and Verification	2-2
2-3	Electrostatic Discharge Prevention	2-3
2-4	Calibration and Measurement Conditions	2-3
2-5	System Verification	2-4
	Verification Result Determination	2-5
2-6	System Verification Procedure	2-6
	Equipment Required	2-6
	Special Precautions	2-6
	Procedure	2-6
	If Verification Fails	2-8

Chapter 3— MS46122B Performance Verification

3-1	Introduction to Performance Verification	3-1
3-2	VNA Traceability and Uncertainty	3-1
	First Tier of Uncertainty – The VNA Calibration	3-1
	Second Tier of Uncertainty – Systematic Measurement Errors	3-2
	Third Tier of Uncertainty – Random Measurement Error	3-2
	Standards and Verification	3-2
3-3	Electrostatic Discharge Prevention	3-3
3-4	Calibration and Measurement Conditions	3-3
3-5	Performance Verification	3-3

Table of Contents (Continued)

3-6	System Verification	3-4
	Verification Result Determination	3-5
3-7	System Verification Procedure	3-7
	Equipment Required	3-7
	Special Precautions	3-7
	Procedure	3-7
	If Verification Fails	3-8
3-8	Instrument Key Parameter Performance Tests	3-9
	PASS/FAIL Determination for Instrument Key Parameter Performance Tests	3-9
3-9	Frequency Accuracy	3-10
	Equipment Required	3-10
	Procedure	3-10
3-10	Output Power (Operational Test)	3-12
	Equipment Required	3-12
	Procedure	3-12
3-11	System Dynamic Range	3-15
	Equipment Required	3-15
	Procedure	3-15
3-12	High Level Noise (Operational Test)	3-19
	Equipment Required	3-19
	Procedure	3-19

Chapter 4—Adjustment

4-1	Introduction	4-1
4-2	IF Adjustment Procedure	4-1
	Equipment Required	4-1
	Procedure	4-1
4-3	Time Base Adjustment Procedure	4-2
	Equipment Required	4-2
	Procedure	4-2

Chapter 5—Troubleshooting

5-1	Introduction	5-1
5-2	General Safety Warnings	5-1
5-3	Troubleshooting Test – Non-Ratio Power Level Check	5-2
	Equipment Required	5-2
	Procedure	5-2
5-4	Troubleshooting Turn-on Problems	5-3
	Unit Cannot Power Up	5-3
	ShockLine Application Cannot Launch	5-3
	ShockLine Application Displays 'Anritsu hardware is unavailable'	5-3
	ShockLine Application Displays 'No Hardware Found'	5-5
5-5	Troubleshooting Operating Problems	5-6
	Frequency Related Problems	5-6
	RF Power Related Problems	5-6

Table of Contents (Continued)

5-6	Troubleshooting Measurement Problems	5-7
	VNA Measurement Quality	5-7
	Checking Possible Measurement Problems	5-7

Chapter 6—Assembly Removal and Replacement

6-1	Introduction	6-1
6-2	Electrostatic Discharge Prevention	6-1
6-3	Instrument Enclosure Overview	6-1
6-4	Disassembly Procedure	6-3
	Common Disassembly Procedure	6-3
6-5	VNA Assembly and Adapter Board Assembly	6-5
	Replacement Parts	6-5
	Reference Figures	6-5
	Replacement Procedure	6-8
6-6	Front Panel LED PCB Assembly	6-9
	Replacement Part	6-9
	Reference Figure	6-9
	Replacement Procedure	6-10
6-7	Test Port Adapter	6-11
	Replacement Part	6-11
	Reference Figures	6-11
	Replacement Procedure	6-14

Appendix A—Test Records

A-1	Introduction	A-1
A-2	ShockLine MS46122A System Performance Test Record	A-2
	System Performance Verification	A-2
A-3	ShockLine MS46122B Instrument Performance Test Record	A-3
	Frequency Accuracy	A-3
	Output Power Accuracy (Operational Test)	A-3
	System Dynamic Range	A-7
	High-level Noise	A-8

Index

Chapter 1 — General Information

1-1 Introduction

This manual provides service and maintenance information for the Anritsu ShockLine MS46122A/B Vector Network Analyzer. The information includes a product description, performance verification procedures, parts removal and replacement procedures, and troubleshooting information.

1-2 Description

The ShockLine MS46122A/B Vector Network Analyzer is a 1U high, 2-port Compact Vector Network Analyzer. It 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 the MS46122A/B Vector Network Analyzer an ideal candidate for testing RF and Microwave passive devices to 43.5 GHz. The MS46122A/B Vector Network Analyzer is controlled through USB from an external PC.

Standard Accessories

Each instrument includes:

- *Getting Started with Anritsu* flier, provides access to all ShockLine web content and services
- Power Cord
- AC/DC Adapter
- USB 2.0 A to Mini B Cable
- Rack Mount Kit for shelf-mounting into a 19-inch universal rack

Available Options

The main system options are:

- MS46122A-002 MS46122B-002 – Time Domain
- MS46122A-010 MS46122B-010 – Frequency Option, 1 MHz to 8 GHz, type N(f) test ports
- MS46122A-020 MS46122B-020 – Frequency Option, 1 MHz to 20 GHz, type K(m) test ports
- MS46122B-024 – Universal Fixture Extraction Option
- MS46122A-040 MS46122B-040 – Frequency Option, 1 MHz to 43.5 GHz, type K(m) test ports
- MS46122B-043 – Frequency Option, 1 MHz to 43.5 GHz, type K(m) test ports

Identification Number

All Anritsu MS46122A/B instruments are assigned a seven-digit ID number (Serial Number), such as “1334003”. This number appears on a decal affixed to the rear panel.

When corresponding with Anritsu Customer Service, please use this identification number with reference to the specific instrument model number, installed options, and serial number. For example, an MS46122A, Option 2, Option 10, Serial Number 1234567.

1-3 Related Documents

Other documents are available for the MS46122A/B at the Anritsu web site at: www.anritsu.com

- ShockLine MS46122A VNA Technical Data Sheet – part number 11410-00822
- ShockLine MS46122B VNA Technical Data Sheet – part number 11410-00995
- ShockLine MS46122A VNA Operation Manual – part number 10410-00340
- ShockLine MS46121A/B MS46122A MS46322A/B VNA User Interface Reference – part number 10410-00337
- ShockLine MS46122A/B MS46322A/B VNA Measurement Guide – part number 10410-00336
- ShockLine MS46121A/B MS46122A/B MS46322A/B MS4652xB VNA Programming Manual – part number 10410-00338
- ShockLine Product Information, Compliance, and Safety – 10100-00067

1-4 Basic Maintenance

Performance Verification

Test instruments are often put on a regular interval to re-verify their performance to ensure accuracy, reliability, and cost of ownership. The details of the performance verification procedures are included in [Chapter 2 — MS46122A Performance Verification](#) and [Chapter 3 — MS46122B Performance Verification](#).

Repair Service

In the event that the MS46122A/B VNA requires repair, contact your local Anritsu Service Center. See [Section 1-5 “Anritsu Customer Service Centers”](#) for contact information. When contacting an Anritsu Service Center, please provide the following information:

- Your company name and address
- The model number and serial number of the instrument
- A detailed description of the problem

1-5 Anritsu Customer Service Centers

For the latest service and sales information in your area, please visit the following URL:

<http://www.anritsu.com/contact.asp>

Choose a country for regional contact information.

1-6 Recommended Test Equipment

The following test equipment is recommended for use in testing and maintaining the ShockLine MS46122A ([Table 1-1](#)) and MS46122B ([Table 1-2](#)).

Table 1-1. Recommended Test Equipment for MS46122A (1 of 2)

Equipment	Critical Specification	Recommended Manufacturer/Model	Use Codes ^a
Calibration Tee (For Opt. 10)	Frequency: DC to 8 GHz Connector: N(m)	Anritsu Model OSLN50A-8 or TOSLN50A-8	P
Calibration Tee (For Opt. 10)	Frequency: DC to 8 GHz Connector: N(f)	Anritsu Model OSLNF50A-8 or TOSLNF50A-8	P

Table 1-1. Recommended Test Equipment for MS46122A (2 of 2)

Equipment	Critical Specification	Recommended Manufacturer/Model	Use Codes ^a
Verification Kit (For Opt. 10)	Connector: N Type	Anritsu Model 3663-2 (Includes Verification Software)	P
Torque Wrench (For Opt. 10)	3/4 in Open End Wrench 12 lbf·in (1.35 N·m)	Anritsu Model 01-200	P
Adapter (For Opt. 10)	Frequency: DC to 18 GHz Connector: N(m) to K(m)	Anritsu Model 34NK50	P, A
Adapter (For Opt. 10)	Frequency: DC to 18 GHz Connector: N(m) to K(f)	Anritsu Model 34NKF50	P, A
RF Coaxial Cable	Frequency: DC to 40 GHz Impedance: 50 ohm Connector: K(f) to K(m)	Anritsu Model 3670K50-2	P, A
Calibration Tee (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(m)	Anritsu Model TOSLK50A-40	P
Calibration Tee (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(f)	Anritsu Model TOSLK50A-40	P
Verification Kit (For Opt. 20 or 40)	Connector: K Type	Anritsu Model 3668-2 (Includes Verification Software)	P
Adapter (For Opt. 20 or 40)	Connector: K(m) to K(f)	Anritsu Model 33KKF50B	P
Adapter (For Opt. 20 or 40)	Connector: K(f) to K(f)	Anritsu Model 33KFKF50B	P
Torque Wrench (For Opt. 20 or 40)	13/16 in Open End Wrench 8 lbf·in (0.9 N·m)	Anritsu Model 01-203	P
Torque Wrench (For Opt. 20 or 40)	5/16 in Open End Wrench 8 lbf·in (0.9 N·m)	Anritsu Model 01-201	P
Personal Computer	Operating System: Windows 7 or higher Interface: USB 2.0 A Software: National Instruments VISA version 4.4.1 or later	Any	P
Power Sensor (For Opt. 10)	Frequency: 10 MHz to 18 GHz Connector Type: N(m)	Anritsu Model MA24118A	A
Power Sensor (For Opt. 20 or 40)	Frequency: 10 MHz to 40 GHz Connector Type: K(m)	Anritsu Model SC8268	A
Frequency Counter	Frequency: 5 GHz	Anritsu Model MF2412B with Option 3, or MF2412C with Option 3	A
Calibration Kit (For Opt. 10)	Frequency: DC to 18 GHz Connector: N Type	Anritsu Model 3653A	A
Calibration Kit (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K Type	Anritsu Model 3652A	A

a. P = Performance Verification; A = Adjustment

Table 1-2. Recommended Test Equipment for MS46122B (1 of 2)

Equipment	Critical Specification	Recommended Manufacturer/Model	Use Codes ^a
Calibration Tee (For Opt. 10)	Frequency: DC to 8 GHz Connector: N(m)	Anritsu Model OSLN50A-8 or TOSLN50A-8	P
Calibration Tee (For Opt. 10)	Frequency: DC to 8 GHz Connector: N(f)	Anritsu Model OSLNF50A-8 or TOSLNF50A-8	P
Verification Kit (For Opt. 10)	Connector: N Type	Anritsu Model 3663-3 (Includes Verification Software)	P
Torque Wrench (For Opt. 10)	3/4 in Open End Wrench 12 lbf·in (1.35 N·m)	Anritsu Model 01-200	P
Adapter (For Opt. 10)	Frequency: DC to 18 GHz Connector: N(m) to K(m)	Anritsu Model 34NK50	P, A
Adapter (For Opt. 10, 40, or 43)	Frequency: DC to 18 GHz Connector: N(m) to K(f)	Anritsu Model 34NKF50	P, A
RF Coaxial Cable (For Opt. 10, 20, or 40)	Frequency: DC to 40 GHz Impedance: 50 ohm Connector: K(f) to K(m)	Anritsu Model 3670K50-2	P, A
Calibration Tee (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(m)	Anritsu Model TOSLK50A-40	P
Calibration Tee (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(f)	Anritsu Model TOSLK50A-40	P
Verification Kit (For Opt. 20 or 40)	Connector: K Type	Anritsu Model 3668-4 (Includes Verification Software)	P
Adapter (For Opt. 20 or 40)	Connector: K(m) to K(f)	Anritsu Model 33KKF50B	P
Adapter (For Opt. 20 or 40)	Connector: K(f) to K(f)	Anritsu Model 33KFKF50B	P
Torque Wrench (For Opt. 20, 40, or 43)	5/16 in Open End Wrench 8 lbf·in (0.9 N·m)	Anritsu Model 01-201	P
Torque Wrench (For Opt. 20, 40, or 43)	13/16 in Open End Wrench 8 lbf·in (0.9 N·m)	Anritsu Model 01-203	P
Calibration Tee (For Opt. 43)	Frequency: DC to 43.5 GHz Connector: K(m)	Anritsu Model TOSLK50A-43.5	P
Calibration Tee (For Opt. 43)	Frequency: DC to 43.5 GHz Connector: K(f)	Anritsu Model TOSLK50A-43.5	P
Verification Kit (For Opt. 43)	Connector: K Type	Anritsu Model 3668-4 (Includes Verification Software)	P
Adapter (For Opt. 43)	Connector: K(m) to K(f)	Anritsu Model 33KKF50C	P
Adapter (For Opt. 43)	Connector: K(f) to K(f)	Anritsu Model 33KFKF50C	P
RF Coaxial Cable (For Opt. 43)	Frequency: DC to 43.5 GHz Impedance: 50 ohm Connector: K(f) to K(m)	Anritsu Model 3670K50A-2	P, A

Table 1-2. Recommended Test Equipment for MS46122B (2 of 2)

Equipment	Critical Specification	Recommended Manufacturer/Model	Use Codes ^a
Personal Computer	Operating System: Windows 7 or later Interface: USB 2.0 A Software: National Instruments VISA version 4.4.1 or later	Any	P
Power Sensor (For Opt. 10)	Frequency: 10 MHz to 18 GHz Connector Type: N(m)	Anritsu Model MA24118A	A
Frequency Counter	Frequency: 5 GHz	Anritsu Model MF2412B with Option 3 or MF2412C with Option 3	A
Calibration Kit (For Opt. 10)	Frequency: DC to 18 GHz Connector: K Type	Anritsu Model 3653A	A
Calibration Kit (For Opt. 20, 40, or 43)	Frequency: DC to 40 GHz Connector: K Type	Anritsu Model 3652A	A
Power Meter	Power Range: -70 to +20 dBm	Anritsu Model ML2438A	P
Power Sensor (For Opt. 10)	Frequency: 100 kHz to 18 GHz Connector Type: N(m)	Anritsu Model SC7400	P
Power Sensor (For Opt. 20, 40, or 43)	Frequency: 100 kHz to 40 GHz Connector Type: K(m)	Anritsu Model SC7413	P
Termination (For Opt. 20, 40, or 43)	Frequency: DC to 40 GHz Connector Type: K(m)	Anritsu Model 28K50A	P

a. P = Performance Verification; A = Adjustment

1-7 Replaceable Parts and Assemblies

To ensure that the correct options are provided on the replacement assembly when ordering a VNA Module Assembly, all installed instrument options must be declared on the order.

The installed options are listed on a label on the rear panel of the MS46122A/B. They can also be viewed in the ShockLine application **About** box display (Select 9 About | 1.ShockLine Info.).

The tables below summarize the available replaceable parts and assemblies.

Table 1-3. MS46122A Replaceable Parts and Assemblies

Part Number	Description
ND81301-RFB	VNA Assembly of MS46122A instruments with Option 10
ND81302-RFB	VNA Assembly of MS46122A instruments with Option 20
ND81303-RFB	VNA Assembly of MS46122A instruments with Option 40
ND81018	Front Panel LED PCB Assembly
3-80719-3	Adapter Board Assembly
40-187-R	AC/DC Adapter
3-2000-1498	USB 2.0 A to Mini B Cable, 10 ft
3-75651	Ruggedized K male Test Port Adapter
3-1091-438	N female Test Port Adapter

Table 1-4. MS46122B Replaceable Parts and Assemblies

Part Number	Description
3-ND83417-RFB	VNA Assembly of MS46122B instruments with Option 10 with serial number < 1818301
3-ND83985-RFB	VNA Assembly of MS46122B instruments with Option 10 with serial number >= 1818301
3-ND83418-RFB	VNA Assembly of MS46122B instruments with Option 20 with serial number < 1818301
3-ND83986-RFB	VNA Assembly of MS46122B instruments with Option 20 with serial number >= 1818301
3-ND83419-RFB	VNA Assembly of MS46122B instruments with Option 40 with serial number < 1818301
3-ND83987-RFB	VNA Assembly of MS46122B instruments with Option 40 with serial number >= 1818301
3-ND84774-RFB	VNA Assembly of MS46122B instruments with Option 43
3-ND81018	Front Panel LED PCB Assembly
3-80719-3	Adapter Board Assembly
40-187-R	AC/DC Adapter
3-2000-1498	USB 2.0 A to Mini B Cable, 10 ft
3-75651	Ruggedized K male Test Port Adapter for MS46122B instruments with Option 20 or 40
3-84709	Ruggedized K male Test Port Adapter for MS46122B instruments with Option 43
3-82848	N female Test Port Adapter

Chapter 2 — MS46122A Performance Verification

2-1 Introduction to Performance Verification

This chapter provides procedures to be used to verify the performance of the ShockLine MS46122A. There are many levels to the concept of VNA “verification”.

On the explicit VNA hardware level are operational checkout items such as port power and noise levels. On the calibrated instrument level (which includes the VNA and the calibration kit or AutoCal™ automatic calibration module) are the system residual specifications (corrected directivity, source match, load match, and tracking), which are measured using airlines (traceable impedance standards).

The intermediate level looks at overall system behavior (VNA, calibration kit, cables, environment) in a traceable fashion through the use of a verification kit. While not intended for day-to-day use, the verification kit provides a periodic check of system behavior without going through the rigor needed for full residual analysis (which can usually be done less often).

While there are many ways of verifying VNA performance, sometimes simple procedures are desired. The use of a verification kit, available from Anritsu, is a simple method of verifying the measurement capabilities of the instrument by analyzing the measurement of artifacts that are traceable to International System of Units (SI) via national metrology institutes.

2-2 VNA Traceability and Uncertainty

Vector network analyzers (VNAs) are precision instruments for making high frequency and broadband measurements in devices, components, and instrumentations. The accuracy of these measurements is affirmed by demonstrated and adequate traceability of measurement standards. Metrological traceability, per International vocabulary of metrology, JCGM 200:2012, is property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty. For the accuracy of VNAs and quality assurance by users, two standard approaches were created to ensure sound metrology traceability. One is to construct tight uncertainty budget and specifications in three tiers from the ground up, and the other is to develop a calibration hierarchy for systematic verification. The three-tier process is depicted in the sections below.

First Tier of Uncertainty – The VNA Calibration

A traceable VNA itself requires proper calibration for several key quantities; for example frequency, power level, and high level noise via traceable standards to the SI units. Each contributing uncertainty was evaluated at the time of instrument calibration.

The inception of a precision VNA is accuracy-enhanced 50 ohm impedance, which is characterized in lieu of coaxial transmission lines all with proper propagation properties throughout the whole measurement systems including the device-under-test. A transmission line for VNAs is best represented by a coaxial airline, which was precisely selected and machined based on the electromagnetic properties of conductivity and skin depth, etc. Therefore, the dimensional measurement accuracy of the airline gives out the first tier of measurement uncertainty of impedance quantity.

Second Tier of Uncertainty – Systematic Measurement Errors

The second tier of uncertainty, corrected or residual uncertainty, is the result of the accuracy enhancement of VNA calibration to remove systematic errors. Systematic measurement errors are components of measurement error that in replicate measurements remains constant or values in a predictable manner. This accuracy enhancement is usually the function of calibration kits. The choice of calibration kits used dictates the level of uncertainties for the intended measurements or applications.

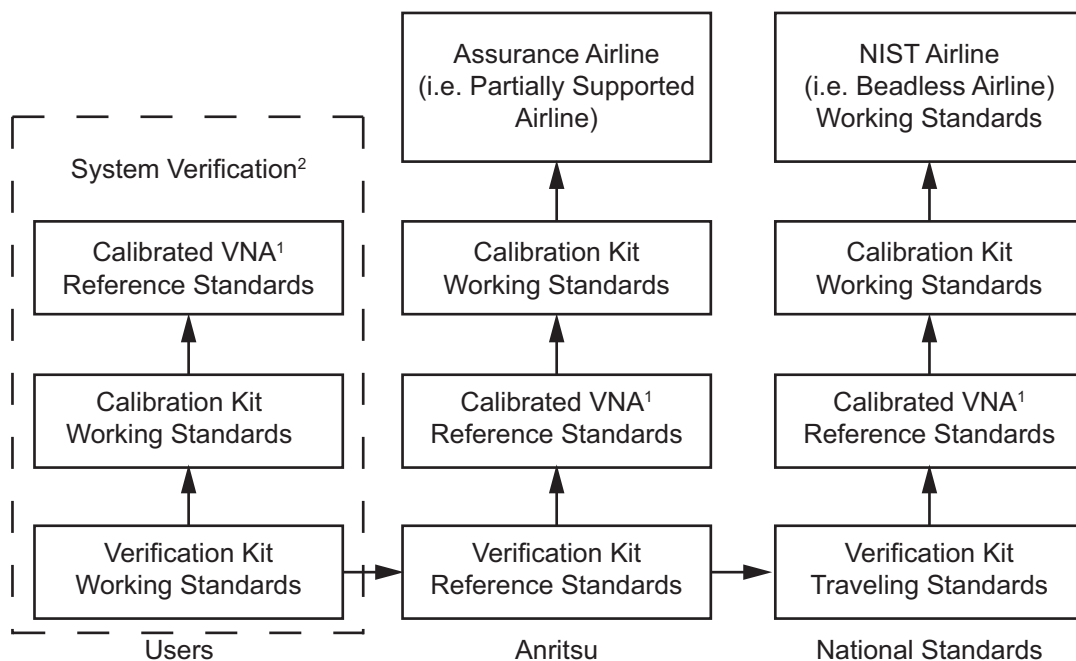
Third Tier of Uncertainty – Random Measurement Error

The third tier of uncertainty is random measurement error that in replicate measurements varies in an unpredictable manner. The examples are connector repeatability and cable stability, etc. Random measurement error equals measurement error minus systematic measurement error.

Standards and Verification

Most often, instrument end users demand system verifications in order to provide quality assurance. This is accomplished by utilizing a set of known or characterized devices; for example verification kits for comparison. It can also be done by using devices that are different from the calibration kit. The calibration hierarchy of verification uncertainty is built through unbroken chain comparisons with the national standards, as illustrated in [Figure 2-1](#).

- Physical standards → airline dimensionality → impedance standard → residuals and port parameters
- Basic power standards → power sensors → power accuracy specifications
- Basic time standards → frequency reference source → frequency accuracy



Calibrated VNA¹ - Without error-correction (accuracy enhancement) by calibration kit
 System Verification² - S-parameter measurements with error-correction

Figure 2-1. VNA Traceability

2-3 Electrostatic Discharge Prevention

A VNA is a precision electronic instrument consisting of components and/or circuitries that are sensitive to electrostatic discharge (ESD). In order to prevent intrusion of electrostatic charge and mitigate risk of costly ESD damage, it is important to take preventive measures to protect against ESD before and during usage. For example, prior to connecting a test port cable to the VNA test port, take steps to eliminate the static charges built up on the test port cable. This can be done by terminating the open end of the cable with the short from the calibration kit and then grounding the outer conductor of the connector on the cable.

2-4 Calibration and Measurement Conditions

The surrounding environmental conditions and the condition and stability of the test port connectors, through cable, and calibration kit determine system measurement integrity to a large extent. These are all user controlled conditions, and as such, should be evaluated periodically for impact on system performance.

The standard conditions specified below must be observed when performing any of the operations in this chapter – both during calibration and during measurement.

- Warm-up Time:
 - 30 minutes
- Environmental Conditions
 - Temperature
 - $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$, with $< 1\text{ }^{\circ}\text{C}$ variation from calibration temperature
 - Relative Humidity
 - 20 % to 50 % recommended

Using best measurement practices and maintaining environmental conditions within specified limits during calibration and measurements are critical requirements for performing system verification that involves reliable high-quality measurements with associated measurement uncertainties. Note that both of these key factors affect the measurement uncertainty.

2-5 System Verification

The system verification procedures verify the measurement capabilities of the VNA, calibration kit, test port cables, and any required adapters as a system by analyzing the measurement of artifacts that are traceable to national standards laboratories. The procedures are automated by using automated System Performance Verification Software, in conjunction with the appropriate Anritsu Calibration and Verification Kits listed in the table below.

Table 2-1. Equipment Required for System Verification

Equipment	Critical Specification	Recommended Manufacturer/Model
Calibration Tee (For Opt. 10)	Frequency: DC to 8 GHz Connector: N(m)	Anritsu Model OSLN50A-8 or TOSLN50A-8
Calibration Tee (For Opt. 10)	Frequency: DC to 8 GHz Connector: N(f)	Anritsu Model OSLNF50A-8 or TOSLNF50A-8
Verification Kit (For Opt. 10)	Connector: N Type	Anritsu Model 3663-2 (Includes System Verification Software)
Adapter	Frequency: DC to 18 GHz Connector: N(m) to K(m)	Anritsu Model 34NK50
Adapter	Frequency: DC to 18 GHz Connector: N(m) to K(f)	Anritsu Model 34NKF50
Torque Wrench	3/4 in. (0.75 in.) Open End Wrench 12 lbf·in (1.35 N·m)	Anritsu Model 01-200
RF Coaxial Cable	Frequency: DC to 40 GHz Impedance: 50 ohm Connector: K(f) to K(m)	Anritsu Model 3670K50-2
Calibration Tee (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(m)	Anritsu Model TOSLK50A-40
Calibration Tee (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(f)	Anritsu Model TOSLKF50A-40
Verification Kit (For Opt. 20 or 40)	Connector: K Type	Anritsu Model 3668-2 (Includes System Verification Software)
Adapter (For Opt. 20 or 40)	Connector: K(m) to K(f)	Anritsu Model 33KKF50B
Adapter (For Opt. 20 or 40)	Connector: K(f) to K(f)	Anritsu Model 33KFKF50B
Torque Wrench (For Opt. 20 or 40)	5/16 in. Open End Wrench 8 lbf·in (0.9 N·m)	Anritsu Model 01-201
Torque Wrench (For Opt. 20 or 40)	13/16 in. Open End Wrench 8 lbf·in (0.9 N·m)	Anritsu Model 01-203
Interface Cable	USB 2.0 A to Mini B Cable	Anritsu Part Number 3-2000-1498
Personal Computer	Operating System: Windows 7 or higher Interface: USB 2.0 A Software: National Instruments VISA version 4.4.1 or later	Any

Caution The use of non-Anritsu calibration kits or verification kits is not supported.

The System Performance Verification Software guides the user to perform a full 12-Term calibration on the VNA using the appropriate calibration kit, to measure the S-parameters of the impedance transfer standards in the verification kit, and to confirm that the measured values are within the specified measurement uncertainty.

The verification kit consists of four impedance transfer standards, and each are supplied with S-parameter data. Each standard verifies a primary S-parameter, with uncertainty windows provided at each data point, as follows:

- 20 dB Attenuation Standard – S_{21} , S_{12} Magnitude and Phase
- 50 dB Attenuation Standard – S_{21} , S_{12} Magnitude and Phase
- 50 ohm Air Line Standard – S_{21} , S_{12} Phase
- 25 ohm Mismatch (Beatty) Standard – S_{11} , S_{22} Magnitude

Pass/Fail status of the measurements is displayed on the computer. The software can also provide hardcopy (printout) of the test reports which include the measured data, the measurement uncertainties, and the Pass/Fail status.

Verification Result Determination

The software verification process compares the measured S-parameter data of the impedance transfer standards against the original standard (characterization) data for those devices that was obtained using the factory standard vector network analyzer (at Anritsu). The factory standard vector network analyzer system is traceable to International System of Units (SI) through the impedance standards of the Anritsu calibration laboratory. These standards are traceable to International System of Units (SI) through precision mechanical measurements, microwave theory impedance derivation methods, and electrical impedance comparison measurements.

At each frequency point, the verification measurement is compared to the characterization measurement in the context of the uncertainties. If the delta between the two measurements is consistent with the uncertainty window, the measurement is considered acceptable at that point. The metric of comparison, termed E_n , is a check to see if the measurement differences are consistent with the uncertainty windows of both the characterization and the verification measurements. The quantity is shown in the formula below:

$$E_n = \frac{|X_{xy}^{\text{char}} - X_{xy}^{\text{ver}}|}{\sqrt{(U_{xy}^{\text{char}})^2 + (U_{xy}^{\text{ver}})^2}}$$

where:

- The numerator contains the magnitude or phase of S-parameters measured during characterization (by Anritsu) and during verification (by the user).
- The denominator contains the respective uncertainties.

These uncertainties are calculated based on the VNA, the calibration kit, and repeatability. If this quantity E_n is less than 1, then the measurements during the two phases are within the overlap of the uncertainties and one can consider the measurements “equivalent” and, in some sense, verified.

The quality of the verification results is very dependent on the degree of care taken by the user in maintaining, calibrating, and using the system. The most critical factors are:

- The stability and quality of the devices in the calibration kit and verification kit.
- The condition of the VNA test port connectors and test port cables.
- The pin depths of all connectors and the proper torquing of connections. These same factors also affect the VNA measurement quality.

Consult the reference manual supplied with Anritsu Calibration Kits and Verification Kits for proper use, care, and maintenance of the devices contained in these kits.

2-6 System Verification Procedure

The system verification procedure is described below. The procedure assumes that the system verification software has been installed to an external personal computer running Microsoft Windows operating system and the National Instruments VISA runtime.

Equipment Required

- Personal Computer:
 - With Microsoft Windows operating system
 - With National Instruments VISA runtime
 - USB 2.0 A to Mini B cable
- Anritsu Calibration Tees (Refer to [Table 2-1, “Equipment Required for System Verification” on page 2-4](#))
- Anritsu Verification Kit (Refer to [Table 2-1](#))
- Anritsu Test Port Cables (Refer to [Table 2-1](#))

Special Precautions

When performing the procedures, observe the following precautions:

- Minimize vibration and movement of the system, attached components, and test cables.
- Clean and check the pin depth and condition of all adapters, test port cables, calibration components, and impedance transfer standards.
- Pre-shape the test cables so as to minimize their movement during calibration and measurement activities.

Procedure

1. Turn on power to the PC controller.
2. Install the ShockLine application software to the PC controller.
3. Install the MS46122A system verification software, which can be found on the USB memory stick supplied with the 366x-2 verification kit, to the PC controller.
4. Connect a USB 2.0 A to Mini B cable between the Mini B port of the ShockLine MS46122A and the USB 2.0 A port of the PC controller. Refer to the MS46122A/B Operation Manual, PN 10410-00340, for setup procedures
5. Turn on the ShockLine MS46122A and allow the instrument to warm up for 30 minutes.
6. When verifying an MS46122A with Option 10:
 - a. Install the 34NKF50 and 34NKF50 Adapters to the 3670K50-2 Through Cable. Use a torque wrench to tighten the K connectors to ensure that the connections do not become loose during the test.
 - b. Install the through cable with the adapter to Port 2 of the ShockLine MS46122A.

7. When verifying an MS46122A with Option 20 or 40:
 - a. Install the 33KFKF50B adapter to Port 1 of the ShockLine MS46122A.
 - b. Install the through cable to Port 2 of the ShockLine MS46122A.
 - c. Install the 33KKF50B adapter on the open end of the through cable.

Caution	Use an appropriate torque wrench to ensure proper connection of calibration devices during calibration.
----------------	---

8. Run the ShockLine MS46122A verification software on the PC controller.
9. Click on the **Begin VNA Verification** button and then select **TCP/IP**.
10. Enter 127.0.0.1 to the IP Address text box in the TCP/IP section as shown in [Figure 2-2](#).

Instrument Address

☐ VXI-11 Port Number : 5000
IP Address : 127.0.0.1

☒ TCP/IP Port Number : 5001
IP Address : 127.0.0.1

Figure 2-2. TCP/IP IP Address

11. Verify that the PC controller is communicating with the ShockLine MS46122A by clicking the **Check VNA Connection** button of the verification software.
12. Insert the USB flash drive that is supplied with the verification kit into an available USB port on the PC controller. Set the data location of the verification software to the USB flash drive when prompted.
13. Follow the directions that are displayed on the computer to perform the calibration with the four impedance transfer standards for the appropriate calibration kit.

The user can run all the automated tests in a consecutive fashion or run individual test selectively. If all are selected, the test sequence is:

Note

1. VNA Calibration
2. Airline (DAT) Measurements [Taking measurement data of the device]
3. Airline (UNC) Uncertainty Computation [Pass/Fail Determination]
4. Beatty Airline (DAT) Measurements
5. Beatty Airline (UNC) Uncertainty Computation
6. 20 dB Offset (Pad) (DAT) Measurements
7. 20 dB Offset (Pad) (UNC) Uncertainty Computation
8. 50 dB Offset (Pad) (DAT) Measurements
9. 50 dB Offset (Pad) (UNC) Uncertainty Computation

14. After all tests are complete, print the test results and attach the printouts to the test record in [Appendix A, “ShockLine MS46122A System Performance Test Record”](#)

Each test generates a data report file in TEXT (ASCII) file format. The data report files can be viewed and printed either using the software built-in “Print” function or other software applications, such as Notepad or other word processors. The data report files are:

Note

- 20 DB OFFSET (UNC) #VER.TXT
- 50 DB OFFSET (UNC) #VER.TXT
- AIRLINE (UNC) #VER.TXT
- BEATTY (UNC) #VER.TXT

These files can be found in the following folder on the hard drive of the PC controller:

C:\Anritsu ShockLine Verification\VNA_Reports\MS46122A_xxxxxxx

[where xxxxxx is the serial number of the ShockLine™ MS46122A being tested]

If Verification Fails

If the verification fails, then check the quality, cleanliness, and installation methods for the calibration and verification components. Specifically, check for the most common causes for verification failures:

- The VNA test port connectors
- The calibration tee
- The impedance transfer standards
- The test port cables, for damage and cleanliness
- The test port cables, for proper connection and torquing
- The test port cables, for phase stability

Chapter 3 — MS46122B Performance Verification

3-1 Introduction to Performance Verification

This chapter provides procedures to be used to verify the performance of the ShockLine MS46122B. There are many levels to the concept of VNA “verification”.

On the explicit VNA hardware level are operational checkout items such as port power and noise levels. On the calibrated instrument level (which includes the VNA and the calibration kit or AutoCal automatic calibration module) are the system residual specifications (corrected directivity, source match, load match, and tracking), which are measured using airlines (traceable impedance standards).

The intermediate level looks at overall system behavior (VNA, calibration kit, cables, environment) in a traceable fashion through the use of a verification kit. While not intended for day-to-day use, the verification kit provides a periodic check of system behavior without going through the rigor needed for full residual analysis (which can usually be done less often).

While there are many ways of verifying VNA performance, sometimes simple procedures are desired. The use of a verification kit, available from Anritsu, is a simple method of verifying the measurement capabilities of the instrument by analyzing the measurement of artifacts that are traceable to International System of Units (SI) via national metrology institutes.

3-2 VNA Traceability and Uncertainty

Vector network analyzers (VNAs) are precision instruments for making high frequency and broadband measurements in devices, components, and instrumentations. The accuracy of these measurements is affirmed by demonstrated and adequate traceability of measurement standards. Metrological traceability, per International vocabulary of metrology, JCGM 200:2012, is property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty. For the accuracy of VNAs and quality assurance by users, two standard approaches were created to ensure sound metrology traceability. One is to construct tight uncertainty budget and specifications in three tiers from the ground up, and the other is to develop a calibration hierarchy for systematic verification. The three-tier process is depicted in the sections below.

First Tier of Uncertainty – The VNA Calibration

A traceable VNA itself requires proper calibration for several key quantities; for example frequency, power level, and high level noise via traceable standards to the SI units. Each contributing uncertainty was evaluated at the time of instrument calibration.

The inception of a precision VNA is accuracy-enhanced 50 ohm impedance, which is characterized in lieu of coaxial transmission lines all with proper propagation properties throughout the whole measurement systems including the device-under-test. A transmission line for VNAs is best represented by a coaxial airline, which was precisely selected and machined based on the electromagnetic properties of conductivity and skin depth, etc. Therefore, the dimensional measurement accuracy of the airline gives out the first tier of measurement uncertainty of impedance quantity.

Second Tier of Uncertainty – Systematic Measurement Errors

The second tier of uncertainty, corrected or residual uncertainty, is the result of the accuracy enhancement of VNA calibration to remove systematic errors. Systematic measurement errors are components of measurement error that in replicate measurements remains constant or values in a predictable manner. This accuracy enhancement is usually the function of calibration kits. The choice of calibration kits used dictates the level of uncertainties for the intended measurements or applications.

Third Tier of Uncertainty – Random Measurement Error

The third tier of uncertainty is random measurement error that in replicate measurements varies in an unpredictable manner. The examples are connector repeatability and cable stability, etc. Random measurement error equals measurement error minus systematic measurement error.

Standards and Verification

Most often, instrument end users demand system verifications in order to provide quality assurance. This is accomplished by utilizing a set of known or characterized devices; for example verification kits for comparison. It can also be done by using devices that are different from the calibration kit. The calibration hierarchy of verification uncertainty is built through unbroken chain comparisons with the national standards, as illustrated in Figure 3-1.

- Physical standards → airline dimensionality → impedance standard → residuals and port parameters
- Basic power standards → power sensors → power accuracy specifications
- Basic time standards → frequency reference source → frequency accuracy

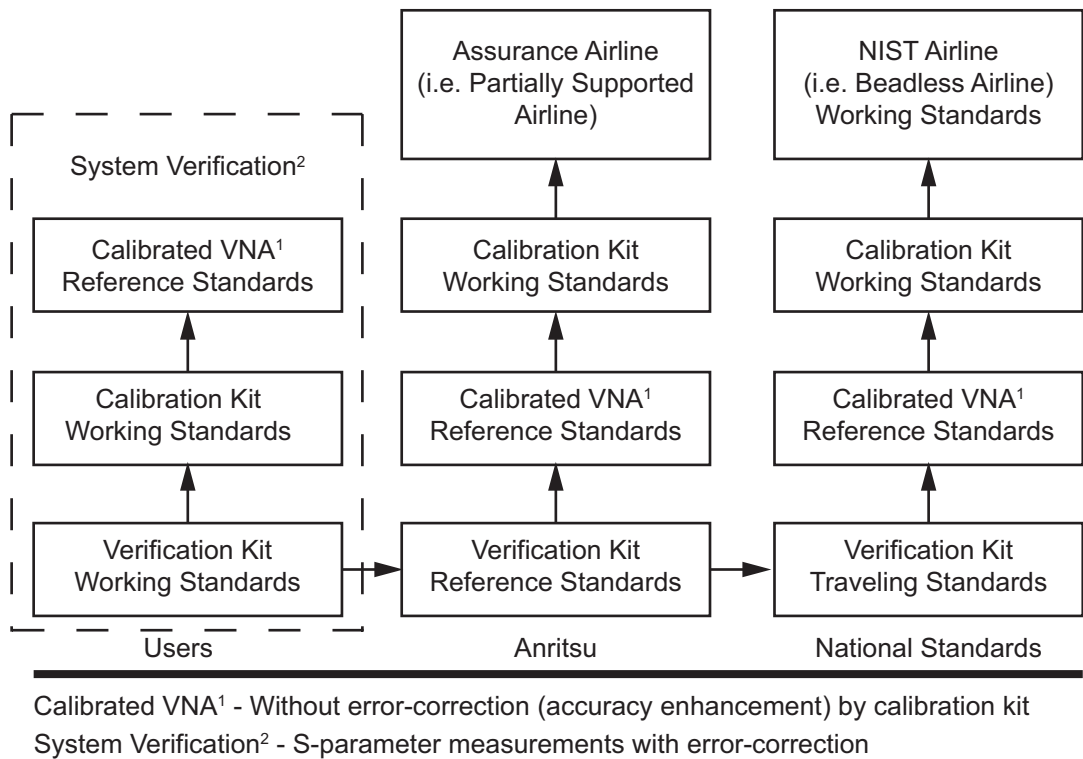


Figure 3-1. Process for Creation and Use of a Verification Kit

3-3 Electrostatic Discharge Prevention

A VNA is a precision electronic instrument consisting of components and/or circuitries that are sensitive to electrostatic discharge (ESD). In order to prevent intrusion of electrostatic charge and mitigate risk of costly ESD damage, it is important to take preventive measures to protect against ESD before and during usage. For example, prior to connecting a test port cable to the VNA test port, take steps to eliminate the static charges built up on the test port cable. This can be done by terminating the open end of the cable with the short from the calibration kit and then grounding the outer conductor of the connector on the cable.

3-4 Calibration and Measurement Conditions

The surrounding environmental conditions and the condition and stability of the test port connectors, through cable, and calibration kit determine system measurement integrity to a large extent. These are all user controlled conditions, and as such, should be evaluated periodically for impact on system performance.

The standard conditions specified below must be observed when performing any of the operations in this chapter – both during calibration and during measurement.

- Warm-up Time:
 - 30 minutes
- Environmental Conditions
 - Temperature
 - For system verification, $23\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$, with $< 1\text{ }^{\circ}\text{C}$ variation from calibration temperature
 - For other tests, $25\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$
 - Relative Humidity
 - 20 % to 50 % recommended

Using best measurement practices and maintaining environmental conditions within specified limits during calibration and measurements are critical requirements for performing system verification that involves reliable high-quality measurements with associated measurement uncertainties. Note that both of these key factors affect the measurement uncertainty.

3-5 Performance Verification

The Performance of MS46122B VNA can be verified using either verification procedures below:

- System Verification Procedure in [“System Verification” on page 3-4](#)
 - The VNA, calibration kit, test cable, and any required adapter(s) are verified as a system
- Instrument Key Performance Parameter Verification procedure in [“Instrument Key Parameter Performance Tests” on page 3-9](#).
 - The VNA is verified as an independent instrument

3-6 System Verification

The system verification procedures verify the measurement capabilities of the VNA, calibration kit, test port cables, and any required adapters as a system by analyzing the measurement of artifacts that are traceable to national standards laboratories. The procedures are automated by using automated System Performance Verification Software, in conjunction with the appropriate Anritsu Calibration and Verification Kits listed in the table below.

Table 3-1. Equipment Required for System Verification (1 of 2)

Equipment	Critical Specification	Recommended Manufacturer/Model
Calibration Tee (For Opt. 10)	Frequency: DC to 8 GHz Connector: N(m)	Anritsu Model OSLN50A-8 or TOSLN50A-8
Calibration Tee (For Opt. 10)	Frequency: DC to 8 GHz Connector: N(f)	Anritsu Model OSLNF50A-8 or TOSLNF50A-8
Verification Kit (For Opt. 10)	Connector: N Type	Anritsu Model 3663-3 (Includes System Verification Software)
Adapter (For Opt. 10)	Frequency: DC to 18 GHz Connector: N(m) to K(m)	Anritsu Model 34NK50
Adapter (For Opt. 10)	Frequency: DC to 18 GHz Connector: N(m) to K(f)	Anritsu Model 34NKF50
Torque Wrench (For Opt. 10)	3/4 in. (0.75 in.) Open End Wrench 12 lbf·in (1.35 N·m)	Anritsu Model 01-200
RF Coaxial Cable (For Opt. 10, 20, or 40)	Frequency: DC to 40 GHz Impedance: 50 ohm Connector: K(f) to K(m)	Anritsu Model 3670K50-2
RF Coaxial Cable (For Opt. 43)	Frequency: DC to 43.5 GHz Impedance: 50 ohm Connector: K(f) to K(m)	Anritsu Model 3670K50A-2
Calibration Tee (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(m)	Anritsu Model TOSLK50A-40
Calibration Tee (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(f)	Anritsu Model TOSLK50A-40
Verification Kit (For Opt. 20 or 40)	Connector: K Type	Anritsu Model 3668-3 (Includes System Verification Software)
Adapter (For Opt. 20 or 40)	Connector: K(m) to K(f)	Anritsu Model 33KKF50B
Adapter (For Opt. 20 or 40)	Connector: K(f) to K(f)	Anritsu Model 33KFKF50B
Torque Wrench (For Opt. 20, 40, or 43)	5/16 in. Open End Wrench 8 lbf·in (0.9 N·m)	Anritsu Model 01-201
Torque Wrench (For Opt. 20, 40, or 43)	13/16 in. Open End Wrench 8 lbf·in (0.9 N·m)	Anritsu Model 01-203
Calibration Tee (For Opt. 43)	Frequency: DC to 43.5 GHz Connector: K(m)	Anritsu Model TOSLK50A-43.5
Calibration Tee (For Opt. 43)	Frequency: DC to 43.5 GHz Connector: K(f)	Anritsu Model TOSLK50A-43.5
Verification Kit (For Opt. 43)	Connector: K Type	Anritsu Model 3668-4 (Includes System Verification Software)

Table 3-1. Equipment Required for System Verification (2 of 2)

Equipment	Critical Specification	Recommended Manufacturer/Model
Adapter (For Opt. 43)	Connector: K(m) to K(f)	Anritsu Model 33KKF50C
Adapter (For Opt. 43)	Connector: K(f) to K(f)	Anritsu Model 33KFKF50C
Interface Cable	USB 2.0 A to Mini B Cable	Anritsu Part Number 3-2000-1498
Personal Computer	Operating System: Windows 7 or higher Interface: USB 2.0 A Software: National Instruments VISA version 4.4.1 or later	Any

Caution The use of non-Anritsu calibration kits or verification kits is not supported.

The System Performance Verification Software guides the user to perform a full 12-Term calibration on the VNA using the appropriate calibration kit, to measure the S-parameters of the impedance transfer standards in the verification kit, and to confirm that the measured values are within the specified measurement uncertainty.

The verification kit consists of four impedance transfer standards, and each are supplied with S-parameter data. Each standard verifies a primary S-parameter, with uncertainty windows provided at each data point, as follows:

- 20 dB Attenuation Standard – S_{21} , S_{12} Magnitude and Phase
- 50 dB Attenuation Standard – S_{21} , S_{12} Magnitude and Phase
- 50 ohm Air Line Standard – S_{21} , S_{12} Phase
- 25 ohm Mismatch (Beatty) Standard – S_{11} , S_{22} Magnitude

Pass/Fail status of the measurements is displayed on the computer. The software can also provide hardcopy (printout) of the test reports which include the measured data, the measurement uncertainties, and the Pass/Fail status.

Verification Result Determination

The software verification process compares the measured S-parameter data of the impedance transfer standards against the original standard (characterization) data for those devices that was obtained using the factory standard vector network analyzer (at Anritsu). The factory standard vector network analyzer system is traceable to International System of Units (SI) through the impedance standards of the Anritsu calibration laboratory. These standards are traceable to International System of Units (SI) through precision mechanical measurements, microwave theory impedance derivation methods, and electrical impedance comparison measurements.

At each frequency point, the verification measurement is compared to the characterization measurement in the context of the uncertainties. If the delta between the two measurements is consistent with the uncertainty window, the measurement is considered acceptable at that point. The metric of comparison, termed En , is a check to see if the measurement differences are consistent with the uncertainty windows of both the characterization and the verification measurements. The quantity is shown in the formula below:

where:

- The numerator contains the magnitude or phase of S-parameters measured during characterization (by Anritsu) and during verification (by the user).
- The denominator contains the respective uncertainties.

$$E_n = \frac{|X_{xy}^{\text{char}} - X_{xy}^{\text{ver}}|}{\sqrt{(U_{xy}^{\text{char}})^2 + (U_{xy}^{\text{ver}})^2}}$$

These uncertainties are calculated based on the VNA, the calibration kit, and repeatability. If this quantity E_n is less than 1, then the measurements during the two phases are within the overlap of the uncertainties and one can consider the measurements “equivalent” and, in some sense, verified.

The quality of the verification results is very dependent on the degree of care taken by the user in maintaining, calibrating, and using the system. The most critical factors are:

- The stability and quality of the devices in the calibration kit and verification kit.
- The condition of the VNA test port connectors and test port cables.
- The pin depths of all connectors and the proper torquing of connections. These same factors also affect the VNA measurement quality.

Consult the reference manual supplied with Anritsu Calibration Kits and Verification Kits for proper use, care, and maintenance of the devices contained in these kits.

3-7 System Verification Procedure

The system verification procedure is described below. The procedure assumes that the system verification software has been installed to an external personal computer running Microsoft Windows operating system and the National Instruments VISA runtime.

Equipment Required

- Personal Computer:
 - With Microsoft Windows operating system
 - With National Instruments VISA runtime
 - USB 2.0 A to Mini B cable
- Anritsu Calibration Tees (Refer to [Table 3-1, “Equipment Required for System Verification” on page 3-4](#))
- Anritsu Verification Kit (Refer to [Table 3-1](#))
- Anritsu Test Port Cables (Refer to [Table 3-1](#))

Special Precautions

When performing the procedures, observe the following precautions:

- Minimize vibration and movement of the system, attached components, and test cables.
- Clean and check the pin depth and condition of all adapters, test port cables, calibration components, and impedance transfer standards.
- Pre-shape the test cables so as to minimize their movement during calibration and measurement activities.

Procedure

1. Turn on power to the PC controller.
2. Install the ShockLine application software to the PC controller.
3. Install the MS46122B system verification software, which can be found on the USB memory stick supplied with the 366x-3 or 3668-4 verification kit, to the PC controller. Refer to Section 5 of the ShockLine Series Vector Network Analyzers Verification Kits and Performance Verification Software Quick Start Guide, PN 10410-00766, for instructions.
4. Connect a USB 2.0 A to Mini B cable between the Mini B port of the ShockLine MS46122B and the USB 2.0 A port of the PC controller. Refer to Section 4 of the ShockLine Series Vector Network Analyzers Verification Kits and Performance Verification Software Quick Start Guide, PN 10410-00766, for instructions.
5. Turn on the ShockLine MS46122B and allow the instrument to warm up for 30 minutes.
6. When verifying an MS46122B with Option 10:
 - a. Install the 34NK50 and 34NKF50 Adapters to the 3670K50-2 Through Cable. Use a torque wrench to tighten the K connectors to ensure that the connections do not become loose during the test.
 - b. Install the through cable with the adapter to Port 2 of the ShockLine MS46122B.
7. When verifying an MS46122B with Option 20, 40, or 43:
 - a. Install the 33KFKF50x adapter to Port 1 of the ShockLine MS46122B.
 - b. Install the through cable to Port 2 of the ShockLine MS46122B.
 - c. Install the 33KKF50x adapter on the open end of the through cable.
8. Run the MS46122B VNA verification software on the PC controller.

9. Insert the USB flash drive that is supplied with the 366x-x verification kit to an available USB port on the PC controller. Follow the instructions in Section 6 of the ShockLine Series Vector Network Analyzers Verification Kits and Performance Verification Software Quick Start Guide, PN 10410-00766, to add the four impedance transfer standards to the verification tools database.
10. Follow the instructions in Section 6 of the Quick Start Guide to add the calibration kits to the verification tools database.
11. On the verification software graphic user interface (GUI) displayed on the PC controller, locate the Select Interface field and then select TCP/IP using the drop-down menu.
12. Enter the Local Host address 127.0.0.1::5001 into the Address field of the verification software GUI.
13. On the VNA, select: MAIN MENU | System | Network Interface.
14. Enter 127.0.0.1 to the IP Address.
15. Follow the instructions in Section 7 of the Quick Start Guide to start the performance verification testing.

Caution	Use an appropriate torque wrench to ensure proper connection of calibration devices during calibration.
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16. After all tests are complete, print the test results and attach the printouts to the test record in [Appendix A, “ShockLine MS46122A System Performance Test Record”](#)

If Verification Fails

If the verification fails, then check the quality, cleanliness, and installation methods for the calibration and verification components. Specifically, check for the most common causes for verification failures:

- The VNA test port connectors
- The calibration tee
- The impedance transfer standards
- The test port cables, for damage and cleanliness
- The test port cables, for proper connection and torquing
- The test port cables, for phase stability

3-8 Instrument Key Parameter Performance Tests

The Instrument Key Parameter Performance tests verify the key performance parameter of the MS46122B Vector Network Analyzer as an independent instrument.

The Instrument Key Performance tests consist of the following:

- Frequency Accuracy
- Output Power – High and Low Power Characterization (Operational Test)
- System Dynamic Range
- High Level Noise (Operational Test)

PASS/FAIL Determination for Instrument Key Parameter Performance Tests

Figure 3-2 shows the rule that is used to determine the pass/fail status of test results that are associated with warranted specifications.

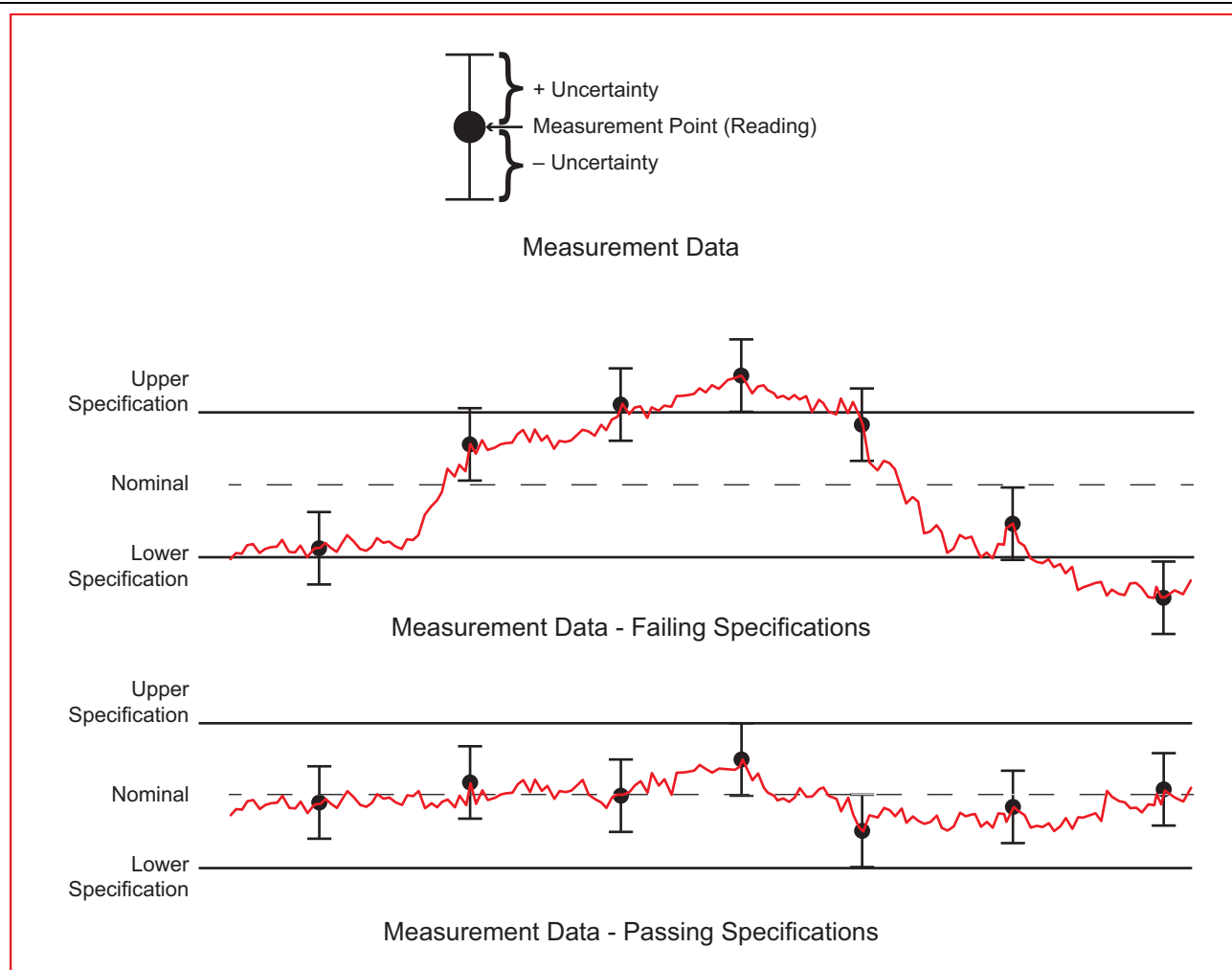


Figure 3-2. Pass/Fail Determination

The measurement uncertainty listed in each test record includes the best estimate of the errors contributed by the measurement, test equipment, standards, and other correction factors (for example, calibration factors and mismatch error) based on the suggested equipment, the equipment setup, and the prescribed test procedure. Most of the uncertainties are type-B per ISO/IEC Guide 98-3, Guide to the Expression of Uncertainty in Measurement (GUM).

3-9 Frequency Accuracy

This test verifies the internal time base of the MS46122B.

Equipment Required

Equipment required for Frequency Accuracy Verification is listed in [Table 3-2](#).

Table 3-2. Equipment Required for Frequency Accuracy Verification

Equipment	Critical Specification	Recommended Manufacturer/Model
Frequency Reference	Frequency: 10 MHz	Symmetricon Model RubiSource T&M
Frequency Counter	Frequency: 10 MHz to 20 GHz	Anritsu Model MF2412B or MF2412C with Option 3
Adapter	Frequency: DC to 18 GHz Connector: N(m) to K(m)	Anritsu Model 34NK50
Adapter	Frequency: DC to 18 GHz Connector: N(m) to K(f)	Anritsu Model 34NKF50
RF Coaxial Cable	Frequency: DC to 40 GHz Impedance: 50 ohm Connector: K(f) to K(m)	Anritsu Model 3670K50-2
RF Coaxial Cable	Frequency: 10 MHz Impedance: 50 ohm Connector: BNC(m) to BNC(m)	Anritsu Model 2000-1627-R

Procedure

1. Connect the BNC cable between the output BNC(f) connector of the external Time Base Reference to the Reference Input BNC(f) connector of the Frequency Counter.
2. Install the Through Cable to Input 1 N(f) connector of the Frequency Counter with appropriate adapters.
3. Power on both the external Time Base Reference and Frequency Counter.
4. Setup the Frequency Counter as follows:
 - a. Press the Preset key to restore the factory setting
 - b. Set the Resolution to 0.1 Hz
 - c. set the Sample rate to 11 ms.
5. Power on the MS46122B and allow the instrument to warm up for 30 minutes.
6. Select Preset button on the Icon Bar and then the OK button.
7. Set up the VNA display as follows:
 - a. Select Averaging
 - b. Change IFBW to 100 Hz.
 - c. Select Trace.
 - d. Change # of Traces to 1.
 - e. Select Trace Max.
 - f. Select Frequency and then turn CW Mode to ON (Note: CW Frequency is defaulted to 10 MHz).
 - g. Change # of Points to 801.

- h.** Change Start Frequency to 1 GHz. (This changes the CW Frequency to 1 GHz.)
- 8.** Connect the Through Cable from the Frequency Counter to VNA Port 1.
- 9.** Record the Frequency Counter reading in [Table A-1, “Frequency Accuracy”](#).

3-10 Output Power (Operational Test)

The section provides the procedure to characterize the output power at each VNA port of the MS46122B.

Equipment Required

Equipment required for Output Power Accuracy characterization is listed in [Table 3-3](#).

Table 3-3. Equipment Required for Output Power Characterization

Equipment	Critical Specification	Recommended Manufacturer/Model
Power Meter	Power Range: -70 to +20 dBm	Anritsu Model ML2438A
Power Sensor (For Opt. 10)	Frequency: 100 kHz to 18 GHz Connector Type: N(m)	Anritsu Model SC7400
Power Sensor (For Opt. 20, 40, or 43)	Frequency: 100 kHz to 40 GHz Connector Type: K(m)	Anritsu Model SC7413
Adapter (For Opt. 20, 40, or 43)	Frequency: DC to 18 GHz Connector: N(m) to K(f)	Anritsu Model 34NKF50
Adapter (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(f) to K(f)	Anritsu Model 33KFKF50B
Torque Wrench (For Opt. 10)	3/4 in. (0.75 in.) Open End 12 lbf · in (1.35 N · m)	Anritsu Model 01-200
Torque Wrench (For Opt. 20, 40, or 43)	5/16 in. (0.3125 in.) Open End 8 lbf · in (0.90 N · m)	Anritsu Model 01-201
Torque Wrench (For Opt. 20, 40, or 43)	13/16 in. (0.8125 in.) Open End 8 lbf · in (0.90 N · m)	Anritsu Model 01-203

Procedure

1. Power on the MS46122B and ML2438A. Allow both instruments to warm up for 30 minutes.
2. Preset the VNA as follows:
 - a. Select **Preset** button on the Icon Bar and then the OK button.
3. Set up the VNA display as follows:
 - a. Select **Trace**.
 - b. Change # of Traces to 1.
 - c. Select **Trace Max**.
 - d. Select **Frequency** and then turn **CW Mode** to **ON** (Note: CW Frequency is defaulted to 10 MHz)
 - e. Change # of Points to 801.
4. Zero and calibrate the Power Sensor(s) on the Power Meter.

High Power Characterization

5. Connect the Power Sensor to VNA Port 1.

Note For MS46122B with Options 20, 40, or 43, install a 33KFKF50B adapter to the power sensor input.

6. On the VNA, set the Start Frequency to the test frequency in [Table 3-4](#). (e.g. Set Start Frequency to 1 MHz when it is the first time that this step is executed). The CW Frequency will match the Start Frequency after the change.

Note

The ShockLine VNA software has a minimum sweep span limit of 20 Hz, so it does not allow the CW Frequency to match the Start Frequency when entering the last test frequency. Instead, select CW Frequency to set the proper test CW frequency.

Table 3-4. Test Frequency List for Output Power Accuracy Characterization

Frequency (MHz)	Frequency (MHz)	Frequency (MHz)	Frequency (MHz)
1	8000	19000	30000
10	9000	20000	31000
45	10000	21000	32000
100	11000	22000	33000
1000	12000	23000	34000
2000	13000	24000	35000
3000	14000	25000	36000
4000	15000	26000	37000
5000	16000	27000	38000
6000	17000	28000	39000
7000	18000	29000	40000

7. On the Power Meter, press the **Sensor** key, the **Cal Factor** soft key, and then the **Freq** soft key. Use the keypad to enter the value matching the CW frequency of the VNA as the input signal frequency, which sets the power meter to the proper power sensor calibration factor. Press **System** key to display the power reading
8. Record the power meter reading in [Table A-2](#), “High Output Power Accuracy.”

Note

For Low Power measurement, record the power meter reading in [Table A-3](#), “Low Output Power Accuracy.”

9. Repeat [Step 6](#) through [Step 8](#) for the next frequency point in [Table 3-4](#) until it reaches the appropriate end frequency point of the VNA being tested (8000 MHz for Option 10 unit, 20000 MHz for Option 20 unit or 40000 MHz for Option 40 or Option 43 unit).
10. Change the VNA display as follows:
 - a. Click on Tr1 on the top of the S11 trace on the screen.
 - b. Select **Response** and then **S22**. Verify that Tr1 is displaying S22 response.
11. Connect the power sensor to VNA Port 2.
12. Repeat [Step 6](#) through [Step 9](#).

Low Power Characterization

13. Select Home, Power and then Low Power.
14. Change the VNA display as follows:
 - a. Click on Tr1 on the top of the S22 trace on the screen.
 - b. Select Response and then S11. Verify that Tr1 is displaying S11 response.
15. Repeat [Step 5](#) through [Step 12](#).

3-11 System Dynamic Range

This section provides the procedure to measure the System Dynamic Range of the MS46122B.

Equipment Required

Equipment required for System Dynamic Range test is listed in [Table 3-5](#).

Table 3-5. Equipment Required for System Dynamic Range Test

Equipment	Critical Specification	Recommended Manufacturer/Model
Adapter (For Opt. 10)	Frequency: DC to 18 GHz Connector: N(m) to K(m)	Anritsu Model 34NK50
Adapter (For Opt. 10)	Frequency: DC to 18 GHz Connector: N(m) to K(f)	Anritsu Model 34NKF50
Adapter (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(f) to K(f)	Anritsu Model 33KFKF50B
Adapter (For Opt. 43)	Frequency: DC to 43.5 GHz Connector: K(f) to K(f)	Anritsu Model 33KFKF50C
Torque Wrench (For Opt. 10)	3/4 in. (0.75 in.) Open End 12 lbf · in (1.35 N · m)	Anritsu Model 01-200
Torque Wrench (For Opt. 20, 40, or 43)	5/16 in. (0.3125 in.) Open End 8 lbf · in (0.90 N · m)	Anritsu Model 01-201
Torque Wrench (For Opt. 20, 40, or 43)	13/16 in. (0.8125 in.) Open End 8 lbf · in (0.90 N · m)	Anritsu Model 01-203
RF Coaxial Cable (For Opt. 10, 20, or 40)	Frequency: DC to 40 GHz Impedance: 50 ohm Connector: K(f) to K(m)	Anritsu Model 3670K50-2
RF Coaxial Cable (For Opt. 43)	Frequency: DC to 43.5 GHz Impedance: 50 ohm Connector: K(f) to K(m)	Anritsu Model 3670K50A-2
Calibration Kit (For Opt. 10)	Frequency: DC to 8 GHz Connector: N(f) Type	Anritsu Model OSLN50A-8
Calibration Kit (For Opt. 10)	Frequency: DC to 8 GHz Connector: N(m) Type	Anritsu Model OSLNF50A-8
Calibration Kit (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(f) Type	Anritsu Model TOSLKF50A-40
Calibration Kit (For Opt. 43)	Frequency: DC to 43.5 GHz Connector: K(f) Type	Anritsu Model TOSLKF50A-43.5
Termination (For Opt. 20, 40, or 43)	Frequency: DC to 40 GHz Connector: K(m) Type	Anritsu Model 28K50A

Procedure

1. Power on the MS46122B and allow the instrument to warm up for 30 minutes.
2. Preset the VNA as follows:
 - a. Select Preset button on the Icon Bar and then the OK button.

3. Prepare the Through Cable or MS46122B as follows:
 - a. For ShockLine MS46122B with Option 10:
Install the 34NK50 and 34NKF50 Adapters to the 3670K50-2 Through Cable. Use torque wrench to tighten the K connectors to ensure that the connections do not work themselves loose during the test.
 - b. For ShockLine MS46122B with Option 20, 40, or 43:
Install the 33KFKF50x Adapter to the VNA Port 1. Use torque wrench to tighten the K connectors to ensure that the connections do not work themselves loose during the test.
4. Install the Through Cable to Port 2.
5. Set up the VNA for segmented sweep as follows:
 - a. Select Sweep Setup.
 - b. Select Freq-based Seg. Sweep Setup.
 - c. Enter the data from the first row of [Table 3-6](#) into the setup table on the bottom of the VNA display.
 - d. Select Add.
 - e. Enter the data in the next row of [Table 3-6](#) into the VNA.
 - f. Repeat [Step d](#) through [Step e](#) until F2 = 8000 MHz for Option 10 unit, F2 = 20000 MHz for Option 20 unit, F2 = 40000 MHz for Option 40 unit, or F2 = 43500 MHz for Option 43 unit.
 - g. Select Back.
 - h. Select Sweep type and then Segmented Sweep (Freq-based).
 - i. Select Back.
 - j. This completes the Segmented Sweep setup.

Table 3-6. VNA Segmented Sweep Setup for System Dynamic Range Test

F1	F2	# of Pts	IFBW	Src Pwr	Avg
1 MHz	550 MHz	201	10 Hz	High	1
648 MHz	4005 MHz	40	10 Hz	High	1
4105 MHz	8000 MHz	41	10 Hz	High	1
8000.001 MHz	14000 MHz	61	10 Hz	High	1
14000.001 MHz	20000 MHz	60	10 Hz	High	1
20000.001 MHz	30000 MHz	102	10 Hz	High	1
30000.001 MHz	40000 MHz	101	10 Hz	High	1
40000.001 MHz	43500 MHz	36	10 Hz	High	1

6. Perform a Transmission Response calibration as follows:
 - a. Select Calibration.
 - b. Select Calibrate and then Manual Cal.
 - c. Select Transmission Freq. Response.
 - d. Select Thru/Recip.
 - e. Connect the Through Cable from Port 2 to Port 1.
 - f. Select Thru 1-2 and then allow the VNA to complete the measurements.

- g. Click on the OK button on the displayed dialog.
 - h. Disconnect the Through Cable from Port 1.
 - i. Select Isolation (Optional).
 - j. Install Loads to Port 1 and Port 2 (at the end of the Through Cable).
 - k. Select Isolation 1-2 and then allow the VNA to complete the measurements.
 - l. Select Back.
 - m. Select Done.
 - n. This completes the 2-port Transmission Response calibration.
 - o. Leave the Loads connected to both Port 1 and Port 2.
7. Set up the VNA display as follows:
 - a. Select Trace and then set # of Traces to 2.
 - b. Select Response and then S12. Verify that Tr1 is displaying S12 response.
 - c. Select Display and set Trace Format to Linear Mag.
 - d. Click on Tr2 on the top of the S21 trace on the screen and then set Trace Format to Linear Mag.
8. Select Sweep, select Hold Functions and then select Single Sweep & Hold.
9. Select File and then Save Data.
10. Change the Type of File to Active Channel TXT File (*.txt).
11. Change the file name to SDR#1.txt and then click the Save button. Note the location of the data file being saved to.
12. Repeat Step 8 through Step 11 seven (7) more times. When saving the data, increment the number at the end of the file name by one (e.g. SDR#2.txt, SDR#3.txt and etc.).
13. Copy the saved data files off the MS46122B onto a USB flash drive for transferring to a Personal Computer.
14. On a separate Windows Personal Computer, import the saved data from the SDR#n.txt into Microsoft Excel so the RMS values can be calculated.
15. There are many ways one can set up Microsoft Excel for calculating the System Dynamic Range in dB RMS values. Below is an example:
 - a. Assume the data are in an Excel worksheet as follows:
 - Row 1 is the header – Freq, Data1 through Data8, RMS Linear Mag, RMS Log Mag, SDR
 - Column A – Freq (Imported from the SDR#n.txt files)
 - Column B through Column I – Data1 through Data8 (Imported from the SDR#n.txt files)
 - Column J – Calculated Linear Mag RMS values
 - Column K – Calculating Log Mag rms values
 - Column L – Calculated Noise Floor values
 - Column M – High Power values. +5 dBm from 1 MHz to 8 GHz and -3 dBm from > 8 GHz to 43.5 GHz.
 - Column N – Calculated System Dynamic Range values
 - b. Import the frequency data from the SDR#n.txt file.
 - c. Set up Cell J2 to calculate the RMS value in Linear Mag by entering the following Formula into the Cell:
$$= \text{SQRT}(\text{SUMSQ}(\text{B2:I2})/8)$$
 - d. Copy the formula to the next cell on Column J until it reaches the last frequency point.

- e. Set up Cell K2 to calculate the RMS value in Log Mag by entering the following Formula into the Cell:
$$= 20 * \text{LOG}(J2, 10)$$
 - f. Copy the formula to the next cell on Column K until it reaches the last frequency point.
 - g. Set up Cell L2 to calculate Noise Floor in dBm by entering the following formula into the cell:
$$= -K2$$
 - h. Copy the formula to the next cell on Column L until it reaches the last frequency point.
 - i. Set up Cell N2 to calculate the System Dynamic Range by entering the following formula in the cell:
$$= M2 - L2$$
 - j. Copy the formula to the next cell on Column N until it reaches the last frequency point.
 - k. Rename 'Sheet 1' to 'SDR S12' by right-clicking on the Sheet 1 tab, selecting **Rename** and typing in the new name.
 - l. Copy 'SDR S12' sheet by right-clicking on the SDR S12 tab, selecting **Move or Copy...**, selecting '(move to end)', checking the **Create a copy** checkbox, and then clicking **OK**.
 - m. Rename the new sheet as 'S21 Magnitude'.
 - n. Import the S12 data and S21 data to appropriate Excel worksheet for System Dynamic Range calculation.
16. Record the worst case calculated SDR value of each frequency band in [Table A-4, "S12 System Dynamic Range"](#) and [Table A-5, "S21 System Dynamic Range"](#).

3-12 High Level Noise (Operational Test)

This test checks the High Level Noise performance of the MS46122B.

Equipment Required

Equipment required for High Level Noise test is listed in [Table 3-7](#).

Table 3-7. Equipment Required for High Level Noise Test

Equipment	Critical Specification	Recommended Manufacturer/Model
Adapter (For Opt. 10)	Frequency: DC to 18 GHz Connector: N(m) to K(m)	Anritsu Model 34NK50
Adapter (For Opt. 10)	Frequency: DC to 18 GHz Connector: N(m) to K(f)	Anritsu Model 34NKF50
Adapter (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(m) to K(f)	Anritsu Model 33KKF50B
Adapter (For Opt. 20 or 40)	Frequency: DC to 40 GHz Connector: K(f) to K(f)	Anritsu Model 33KFKF50B
Adapter (For Opt. 43)	Frequency: DC to 43.5 GHz Connector: K(m) to K(f)	Anritsu Model 33KKF50C
Adapter (For Opt. 43)	Frequency: DC to 43.5 GHz Connector: K(f) to K(f)	Anritsu Model 33KFKF50C
Torque Wrench (For Opt. 10)	3/4 in. (0.75 in.) Open End 12 lbf · in (1.35 N · m)	Anritsu Model 01-200
Torque Wrench (For Opt. 20, 40, or 43)	5/16 in. (0.3125 in.) Open End 8 lbf · in (0.90 N · m)	Anritsu Model 01-201
Torque Wrench (For Opt. 20, 40, or 43)	13/16 in. (0.8125 in.) Open End 8 lbf · in (0.90 N · m)	Anritsu Model 01-203
RF Coaxial Cable (For Opt. 10, 20, or 40)	Frequency: DC to 40 GHz Impedance: 50 ohm Connector: K(f) to K(m)	Anritsu Model 3670K50-2
RF Coaxial Cable (For Opt. 43)	Frequency: DC to 43.5 GHz Impedance: 50 ohm Connector: K(f) to K(m)	Anritsu Model 3670K50A-2

Procedure

- Power on the MS46122B and allow the instrument to warm up for 30 minutes.
- Preset the VNA as follows:
 - Select Preset button on the Icon Bar and then the OK button.
- Prepare the Through Cable or MS46122B as follows:
 - For ShockLine MS46122B with Option 10:
Install the 34NK50 and 34NKF50 Adapters to the 3670K50-2 Through Cable. Use torque wrench to tighten the K connectors to ensure that the connections do not work themselves loose during the test.
 - For ShockLine MS46122B with Option 20, 40, or 43:
Install the 33KFKF50x Adapter to the VNA Port 1. Use torque wrench to tighten the K connectors to ensure that the connections do not work themselves loose during the test.

4. Install the Through Cable to Port 2.
5. Set up the VNA for segmented sweep as follows:
 - a. Select Sweep Setup.
 - b. Select Freq-based Seg. Sweep Setup.
 - c. Enter the data from the first row of [Table 3-8](#) into the setup table on the bottom of the VNA display.
 - d. Select Add.
 - e. Enter the data in the next row of [Table 3-8](#). into the VNA
 - f. Repeat [Step d](#) through [Step e](#) until F2 = 8000 MHz for Option 10 unit, F2 = 20000 MHz for Option 20 unit, or F2 = 43500 MHz for Option 40 or 43 unit.
 - g. Select Back.
 - h. Select Sweep type and then Segmented Sweep (Freq-based).
 - i. Select Back.
 - j. This completes the Segmented Sweep setup.

Table 3-8. VNA Segmented Sweep Setup for High Level Noise Test

F1	F2	# of Pts	IFBW	Src Pwr	Avg
1 MHz	10 MHz	10	100 Hz	High	1
15 MHz	100 MHz	2	100 Hz	High	1
250 MHz	501 MHz	2	100 Hz	High	1
701 MHz	1000 MHz	2	100 Hz	High	1
1101 MHz	1501 MHz	5	100 Hz	High	1
1550 MHz	2450 MHz	19	100 Hz	High	1
2499.99 MHz	2500.01 MHz	2	100 Hz	High	1
2600 MHz	3900 MHz	14	100 Hz	High	1
3975 MHz	4001 MHz	2	100 Hz	High	1
4100 MHz	8000 MHz	40	100 Hz	High	1
8100 MHz	20000 MHz	120	100 Hz	High	1
21000 MHz	40000 MHz	191	100 Hz	High	1
41000 MHz	43500 MHz	51	100 Hz	High	1

6. Perform a Transmission Response calibration as follows:
 - a. Select Calibration.
 - b. Select Calibrate and then Manual Cal.
 - c. Select Transmission Freq. Response.
 - d. Select Thru/Recip.
 - e. Connect the Through Cable from Port 2 to Port 1.
 - f. Select Thru 1-2 and then allow the VNA to complete the measurements.
 - g. Click the OK button on the displayed dialog.

- h. Select Done.
 - i. This completes the 2-port Transmission Response calibration.
 - j. Leave the Through Cable connected between Port 1 and Port 2.
7. Set up the VNA display as follows:
 - a. Select Trace and then set # of Traces to 2.
 - b. Select Response and then S12. Verify that Tr1 is displaying S12 response.
 - c. Select Display and set Trace Format to Linear Mag And Phase.
 - d. Click on Tr2 on the top of the S21 trace on the screen and then set Trace Format to Linear Mag And Phase.
8. Select Sweep and then Hold Functions. Select Single Sweep & Hold
9. Select File and then Save Data
10. Change the Type of File to Active Channel TXT File (*.txt)
11. Change the file name to HLN#1 and then click the Save button. Note the location of the data file being saved to.
12. Repeat Step 8 through Step 11 thirty-nine (39) more times. When saving the data, increment the number at the end of the file name by one (e.g. HLN#2, HLN#3 and etc.).
13. Copy the thirty-nine (39) saved data files off the MS46122B onto a USB flash drive for transferring to a Personal Computer.
14. On a separate Windows Personal Computer, import the saved data from the HLN#n files into Microsoft Excel so the RMS values can be calculated.
15. There are many ways one can set up Microsoft Excel for calculating the RMS values. Below is an example:
 - a. Assume the data are in an Excel worksheet as follows:
 - Row 1 is the header – Freq, Data1 through Data40, RMS Linear Mag, RMS Log Mag (or RMS Deg)
 - Column A – Freq (Imported from the HLN#n files)
 - Column B through Column AO – Data1 through Data40 (Imported from the HLN#n files)
 - b. Set up Cell AP2 to calculate the RMS value in Linear Mag by entering the following Formula into the Cell:
$$=STDEV.P(B2:AO2)$$
 - c. Copy the formula to the next cell on Column AP until it reaches the last frequency point.
 - d. For magnitude measurements only,
 - a. Set up Cell AQ2 to calculate the RMS value in Log Mag by entering the following Formula into the Cell:
$$=20*LOG(AP2+1,10)$$
 - b. Copy the formula to the next cell on Column AQ until it reaches the last frequency point.
 - e. Rename 'Sheet 1' to 'S12 Magnitude' by right-clicking on the Sheet 1 tab, selecting Rename and typing in the new name.
 - f. Copy 'S12 Magnitude' sheet by right-clicking on the S12 Magnitude tab, selecting Move or Copy..., selecting (move to end), checking the Create a copy checkbox, and then clicking OK.
 - g. Rename the new sheet as 'S21 Magnitude'.
 - h. Use Move or Copy... in Excel to create as many new sheets as required for both magnitude and phase measurements. Rename the sheets as necessary to indicate which measurement is being computed on the worksheet (e.g. S12 Phase, and etc.).

- i. Import the Magnitude and Phase data to the appropriate worksheet for RMS value calculation as required.
16. Record the calculated RMS value of each frequency point listed in [Table A-6, “High Level Noise – S12 Magnitude”](#) through [Table A-9, “High Level Noise – S21 Phase”](#).

Chapter 4 — Adjustment

4-1 Introduction

This chapter contains procedures that are used to restore and optimize the operation of the MS46122A/B Vector Network Analyzer.

4-2 IF Adjustment Procedure

This section provides the procedure to restore or optimize the operation of the MS46122A/B related to the IF level in the VNA receivers.

Note

Performing the IF adjustment procedure is normally not required after the VNA module assembly has been replaced. Each replacement VNA module is fully pre-calibrated / pre-adjusted prior to shipping from the factory.

Equipment Required

- For Instruments with N(f) Test Ports:
 - Anritsu Model 3670K50-2 Through Cable
 - Anritsu Model 34NK50 N(m) to K(m) Adapter
 - Anritsu Model 34NKF50 N(m) to K(f) Adapter
- For Instruments with K(m) Test Ports:
 - Anritsu Model 3670K50-2 or 3670K50A-2 (For Opt 43) Through Cable
 - Anritsu Model 33KFKF50B or 33KFKF50C (For Opt 43) K(f) to K(f) Adapter

Procedure

1. Power on the VNA and allow the instrument to warm up for at least 45 minutes.
2. On the PC controller, launch the ShockLine application software.
3. Connect the through cable between Port 1 and Port 2.
4. Press the **Calibration** button on the right side menu.
5. Press the **IF Cal** button and follow the prompt to perform the calibration.
6. Select **File | Exit** to shut down the ShockLine application software.
7. Launch the ShockLine application software from the Windows desktop. The new calibration coefficients are in effect.

4-3 Time Base Adjustment Procedure

This section provides the procedure to adjust the internal Time Base in the MS46122A/B.

Note

Performing the Time Base adjustment procedure is normally not required after the VNA module assembly has been replaced. Each replacement VNA module is fully pre-calibrated / pre-adjusted prior to shipping from the factory.

Equipment Required

- Instruments with N(f) Test Ports:
 - Anritsu Model MF2412x Frequency Counter with Option 3
 - Anritsu Model 3670K50-2 Through Cable
 - Anritsu Model 34NK50 N(m) to K(m) Adapter
 - Anritsu Model 34NKF50 N(m) to K(f) Adapter
- Instruments with K(m) Test Ports:
 - Anritsu Model MF2412x Frequency Counter with Option 3
 - Anritsu Model 3670K50-2 Through Cable
 - Anritsu Model 34NKF50 N(m) to K(f) Adapter

Procedure

1. Power on the Frequency Counter and then press the Preset key.
2. Power on the VNA and allow the instrument to warm up for at least 45 minutes.
3. On the PC controller, launch the ShockLine application software.
4. Connect the through cable between the Frequency Counter Input 1 and VNA Port 1.
5. On the PC controller right-side menu, click the System button, then the Diagnostics button.
6. The DIAGNOSTICS ACCESS dialog box appears providing an entry field to enter the diagnostics access password as shown in [Figure 4-1](#).

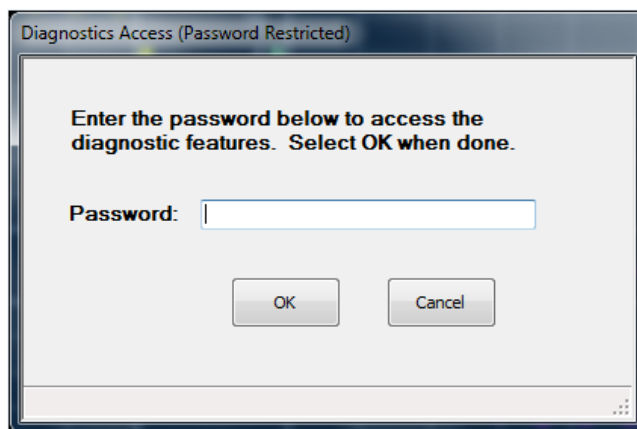


Figure 4-1. Diagnostics Access Dialog Box

7. Enter "ModVna" in the password field and click OK.
8. Click the Hardware Cal button, then the Time Base Cal button.
9. Change the DAC Number value in the TIME BASE CALIBRATION dialog box as shown in [Figure 4-2](#) so that the frequency displayed on the frequency counter is within 5 GHz $\pm$ 2 kHz.

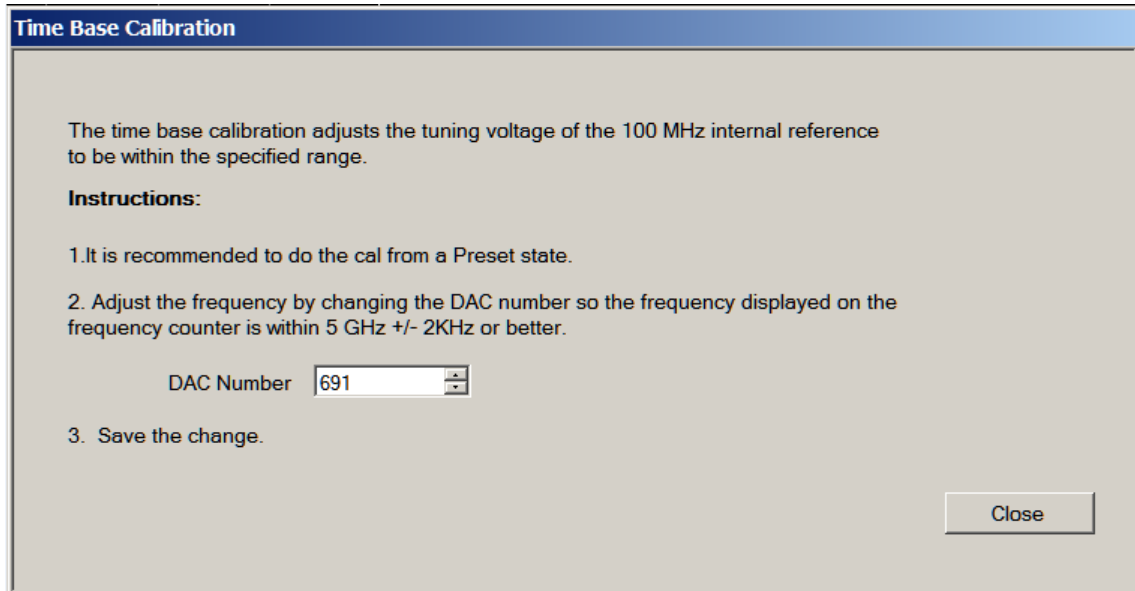


Figure 4-2. Time Base Calibration Dialog Box

10. Click the Close button when done.

Chapter 5 — Troubleshooting

5-1 Introduction

This chapter provides information about troubleshooting tests that can be used to check the MS46122A/B Vector Network Analyzer for proper operation. These tests are intended to be used as a troubleshooting tool for identifying the faulty components and checking the functionality of internal components and sub-assemblies in the MS46122A/B VNA.

Only qualified service personnel should replace internal assemblies. Major subassemblies that are shown in the replaceable parts list are typically the items that may be replaced. Because they are highly fragile, items that must be soldered may not be replaced without special training. Removal of RF shields from PC boards or adjustment of screws on or near the RF shields will de-tune sensitive RF circuits and result in degraded instrument performance.

5-2 General Safety Warnings

Many of the troubleshooting procedures presented in this chapter require the removal of the instrument covers to access sub-assemblies and modules. When using these procedures, please observe the warning and caution notices.

Caution

The assemblies and modules in the MS46122A/B VNA contain static-sensitive components. Improper handling of these assemblies and modules may result in damage to the assemblies and modules. An ESD safe work area and proper ESD handling procedures that conform to ANSI/ESD S20.20-1999 or ANSI/ESD S20.20-2007 is mandatory to avoid ESD damage when handling sub-assemblies or components found in the instrument.

5-3 Troubleshooting Test – Non-Ratio Power Level Check

The non-ratio power level check verifies the VNA module assembly for faults.

Equipment Required

- For Instruments with N(f) Test Ports:
 - Anritsu Model 3670K50-2 RF Coaxial Cable
 - Anritsu Model 34NK50 N(m) to K(m) Adapter
 - Anritsu Model 34NKF50 N(m) to K(m) Adapter
- For Instruments with K(m) Test Ports:
 - Anritsu Model 3670K50-2 or 3670K50A-2 (For Opt 43) RF Coaxial Cable
 - Anritsu Model 33KFKF50B or 33KFKF50C (For Opt 43) K(f) to K(f) Adapter

Procedure

1. Power on the PC controller.
2. For instruments with N(f) test ports, install the 34NK50 and 34NKF50 adapters to the 3670K50-2 RF coaxial cable to convert both ends into N(m) connector port.
3. For instruments with K(m) test ports, install the 33KFKF50B or 33KFKF50C to the male end of the 3670K50-2 RF or 3670K50A-2 coaxial cable.
4. Turn on the MS46122A/B.
5. Connect the coaxial cable between test port 1 and test port 2.
6. Select Trace 1 and then select Display | Trace Format. Set Trace Format to Log Mag.
7. Select Response | User-defined. The USER-DEFINED menu appears.
8. Set Numerator to A1, Denominator to 1, and Driver Port to Port 1.
9. Use a mouse to move the reference line to one graticule below top scale.
10. Repeat [Step 4](#) through [Step 7](#) for Trace 2, setting Numerator to B2, Denominator to 1, and Driver Port to Port 1.
11. Repeat [Step 4](#) through [Step 7](#) for Trace 3, setting Numerator to B1, Denominator to 1, and Driver Port to Port 2.
12. Repeat [Step 4](#) through [Step 7](#) for Trace 4, setting Numerator to A2, Denominator to 1, and Driver Port to Port 2.
13. Observe whether any portions of these traces show any abnormality (for example, very low power level).

5-4 Troubleshooting Turn-on Problems

Unit Cannot Power Up

Unit cannot power up; Power LED is not lit when the **Power** key is toggled:

1. Use a digital volt meter to verify that +12 V is present at the output jack of the AC/DC adapter.
 - a. If +12 V is not present, replace the AC/DC adapter.
 - b. If +12 V is present, then replace the VNA assembly.

ShockLine Application Stuck on Startup

Unit can power up, but the ShockLine application becomes stuck on the startup screen as shown in [Figure 5-1](#) and does not complete launch.



Figure 5-1. ShockLine Application Startup Screen.

1. Close the application.
2. Click the PC system tray caret.
3. Right click on ShockLine application icon.
4. Select “Clear Cache” as shown in [Figure 5-2](#).
5. Re-launch the ShockLine application.

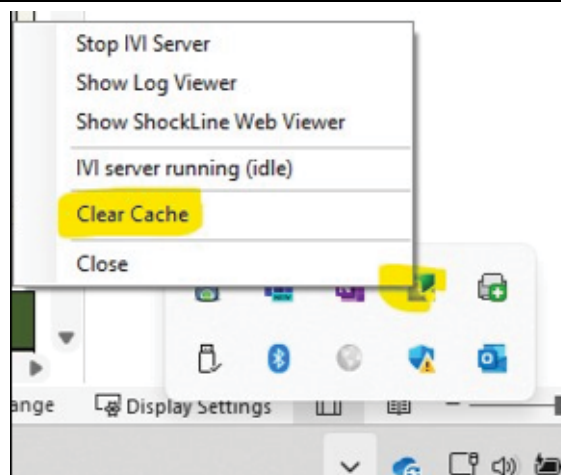


Figure 5-2. ShockLine Application Clear Cache

ShockLine Application Cannot Launch

Unit can power up, but the ShockLine application does not launch on the PC controller:

1. The ShockLine application software update may not have completed. Re-install the software.
2. If the problem still exists, verify that the PC controller USB port is functioning properly or verify that the MS46122A/B is working properly with another PC controller.
3. If the MS46122A/B is not working with another PC controller, replace the VNA assembly.
4. If the MS46122A/B is working with another PC controller, Windows dependencies files on the non-operating PC controller might have been corrupted or changed. Verify that Microsoft Visual C++ 2015 Redistributable (x86) version 14.0.24212 is installed on the PC controller using Programs and Features in Windows Control Panel. If necessary, download the 'Redistributable' from <https://www.microsoft.com> and then reinstall.

ShockLine Application Displays 'Anritsu hardware is unavailable'

If the instrument can power up and the ShockLine application displays 'Anritsu hardware is unavailable' message, do the following:

1. Wait until the IVI client finishes its task and re-try after 15 minutes.

Note

ShockLine application and IVI client cannot be run simultaneously. If ShockLine application is running and an IVI client is being started, then ShockLine application will be automatically stopped. If an IVI client is running, ShockLine application will not be able to start and the following message will be displayed.

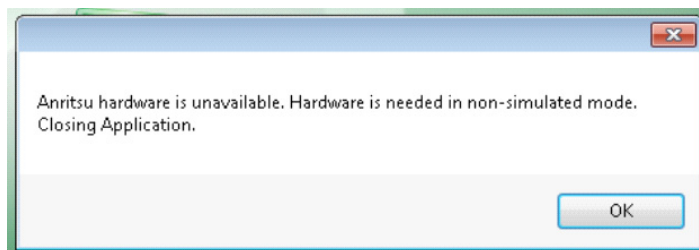
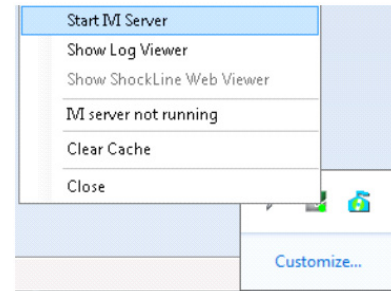
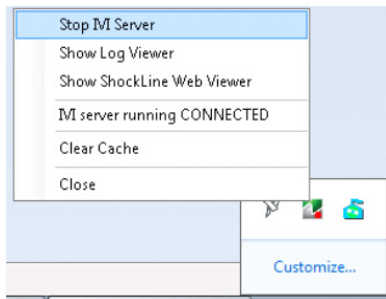


Figure 5-3. Anritsu hardware is unavailable message

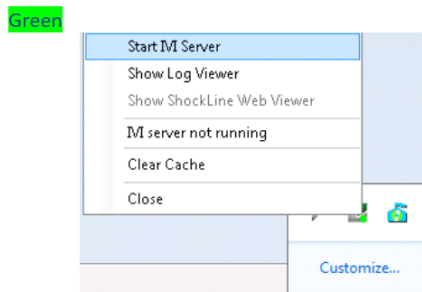
2. If the problem still exists, the IVI client might not be properly closed. Try manually restarting the IVI Server to release the hardware as follows:
 - a. Right click on the ShockLine Tray Daemon icon on the lower right hand corner of the display. Select 'Stop IVI Server' and then select 'Start IVI Server'.



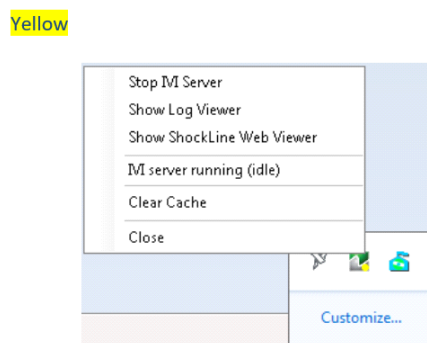
ShockLine Tray Daemon Status

The status indicator of the ShockLine Tray Daemon icon has three states: Green, Yellow, and Red.

- When the indicator is 'Green', the IVI Server is not running. No IVI connections is available and only ShockLine application can be used.

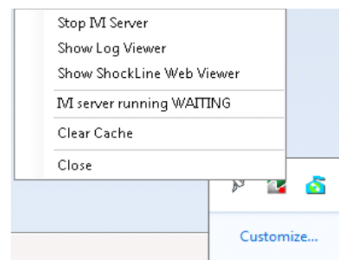
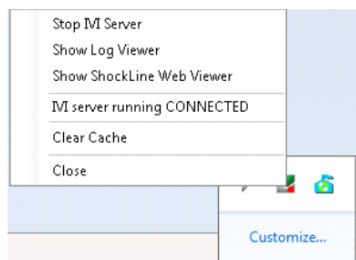


- When the indicator is 'Yellow', the IVI Server is running. IVI clients or ShockLine application can be run.



- When the indicator is 'Red', the IVI Server is running. If the state is "CONNECTED", an IVI client is connected and the hardware is busy so ShockLine application could not be used. If the state is "WAITING", the server is waiting for an IVI client but the hardware is not busy so the ShockLine application or an IVI client can be run.

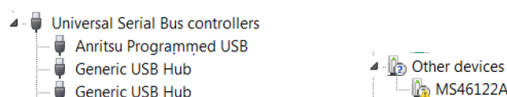
Red



ShockLine Application Displays 'No Hardware Found'

If the instrument can power up and the ShockLine application displays 'No Hardware Found' on the PC controller, do the following:

- Go to Windows Device Manager and check if an exclamation mark (!) on either 'Anritsu Programmed USB' under 'Universal Serial Bus controllers' or MS46122A (MS46122B) under 'Other devices' if ShockLine Software has never been installed on the PC controller.

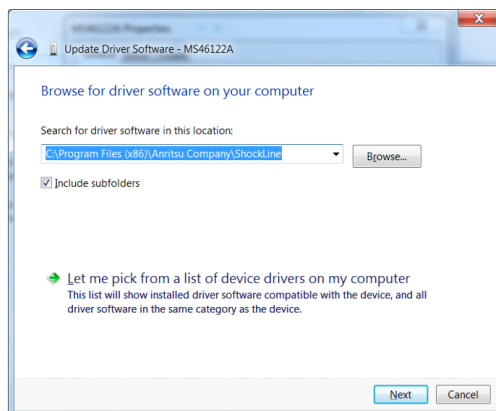


- If 'Anritsu Programmed USB' with exclamation mark is present, uninstall and delete the driver software until it is not listed under 'Universal Serial Bus controllers' but MS46122A or MS46122B is listed under 'Other devices'. You might have to do this step for several times. Make sure to check the 'Delete the driver software for this device' on the dialog shown below:



- Install the latest release of ShockLine application which will automatically install the driver software.

4. If the driver software is not installed, try manually installing the driver software from "C:\Program Files (x86)\Anritsu Company\ShockLine\Application" folder.



5-5 Troubleshooting Operating Problems

Frequency Related Problems

If the instrument exhibits frequency related problem, do the following:

1. Perform a time base calibration (refer to [Section 4-3 "Time Base Adjustment Procedure"](#)).
2. Apply an external 10 MHz reference to the front panel **10 MHz Ref In**.
3. If the problem does not show with the external reference, the problem is in the internal reference oscillator. Replace the VNA assembly.

RF Power Related Problems

If the instrument exhibits RF power related problems, do the following:

1. Perform the ["Troubleshooting Test – Non-Ratio Power Level Check"](#) on page 5-2.
2. If the power level shows any abnormality, do the following:
 - a. Verify that the connection between the test port adapter and the VNA assembly is secure. Re-torque if necessary.
 - b. Verify that the test port adapter is not worn or damaged. Replace the test port adapter if necessary.
 - c. Replace the VNA assembly.

5-6 Troubleshooting Measurement Problems

If the MS46122A/B measurement quality is suspect, the following paragraphs provide guidelines and hints for determining possible quality problems.

VNA Measurement Quality

The quality of MS46122A/B VNA measurements is determined by the following:

- The condition of the MS46122A/B.
- The quality and condition of the interface connections and connectors.
- The quality and condition of the calibration components, through cables, adapters, and fixtures.
- The surrounding environmental conditions at the time of the measurement.
- The selection and performance of the calibration for the DUT being measured.

Checking Possible Measurement Problems

When determining possible measurement problems, check the following items:

1. Check the DUT and the calibration conditions:
 - a. Ensure that the calibration components coefficients data has been installed into the VNA for the calibration kit in use.
 - b. Ensure that the proper calibration was done for the device being measured:
 - For high insertion-loss device measurements, the calibration should include isolation, high number of averages, and a narrow IF bandwidth setting during calibration.
 - For high return-loss device measurements, a high quality precision load should be used during calibration.
 - c. Check the condition of mating connectors and their pin depth.
 - d. If possible, measure an alternate known good device.
 - e. Check if the environment is stable enough for the accuracy required for the device measurement.
 - The VNA should not be subjected to variations in temperature.
 - The VNA should not be placed in direct sunlight or next to a changing cooling source, such as a fan or air conditioning unit.
2. Check the calibration using known good components from the calibration kit. If measurements of these devices do not produce good results, try the following:
 - a. Check through-cable stability including connector condition and pin depth. Replace with a known good cable, if necessary.
 - b. Check the condition and pin depth of the calibration kit components. Replace with known good components, if necessary.
 - c. Check the condition and pin depth of the test port adapters. Replace with known good adapters, if necessary.
3. Check the system performance as described in [Chapter 2 — MS46122A Performance Verification](#) and [Chapter 3 — MS46122B Performance Verification](#)

Chapter 6 — Assembly Removal and Replacement

6-1 Introduction

This chapter describes the removal and replacement procedures for the various internal assemblies. Illustrations (drawings or photographs) in this manual may differ slightly from the instrument that you are servicing, but the basic removal and replacement functions will remain as specified. The illustrations are meant to provide assistance with identifying parts and their locations.

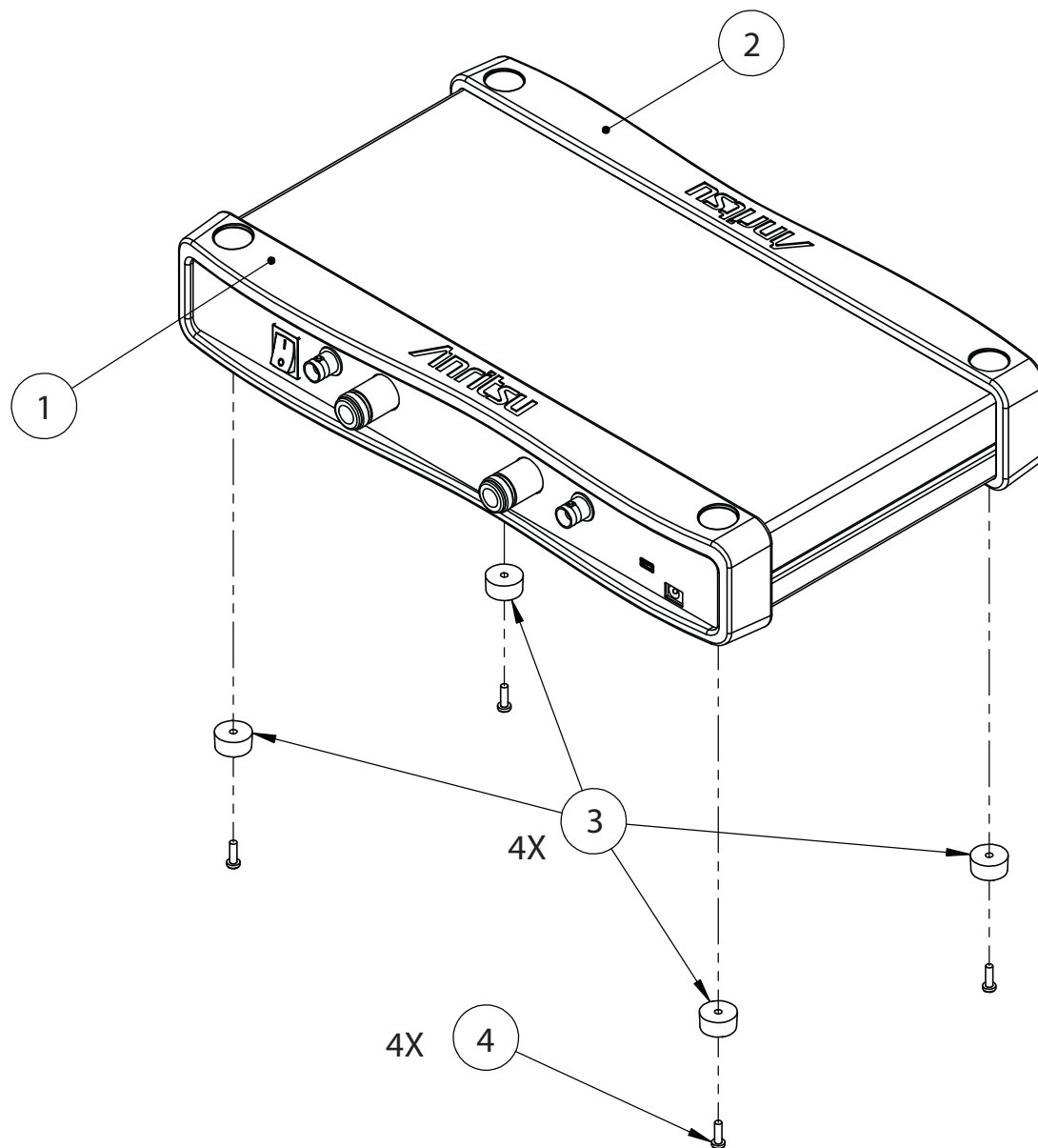
6-2 Electrostatic Discharge Prevention

An ESD safe work area and proper ESD handling procedures that conform to ANSI/ESD S20.20-1999 or ANSI/ESD S20.20-2007 is mandatory to avoid ESD damage when handling sub-assemblies or components found in the MS46122A/B Vector Network Analyzer.

Caution	All electronic devices, components, and instruments can be damaged by electrostatic discharge. It is important to take preventive measures to protect the instrument and its internal sub-assemblies from electrostatic discharge.
----------------	--

6-3 Instrument Enclosure Overview

[Figure 6-1 on page 6-2](#) shows the instrument enclosure overview of the MS46122A/B Vector Network Analyzer.



1 – Front Bumper

2 – Rear Bumper

3 – Bottom Foot

4 – Bottom Foot Mounting Screws

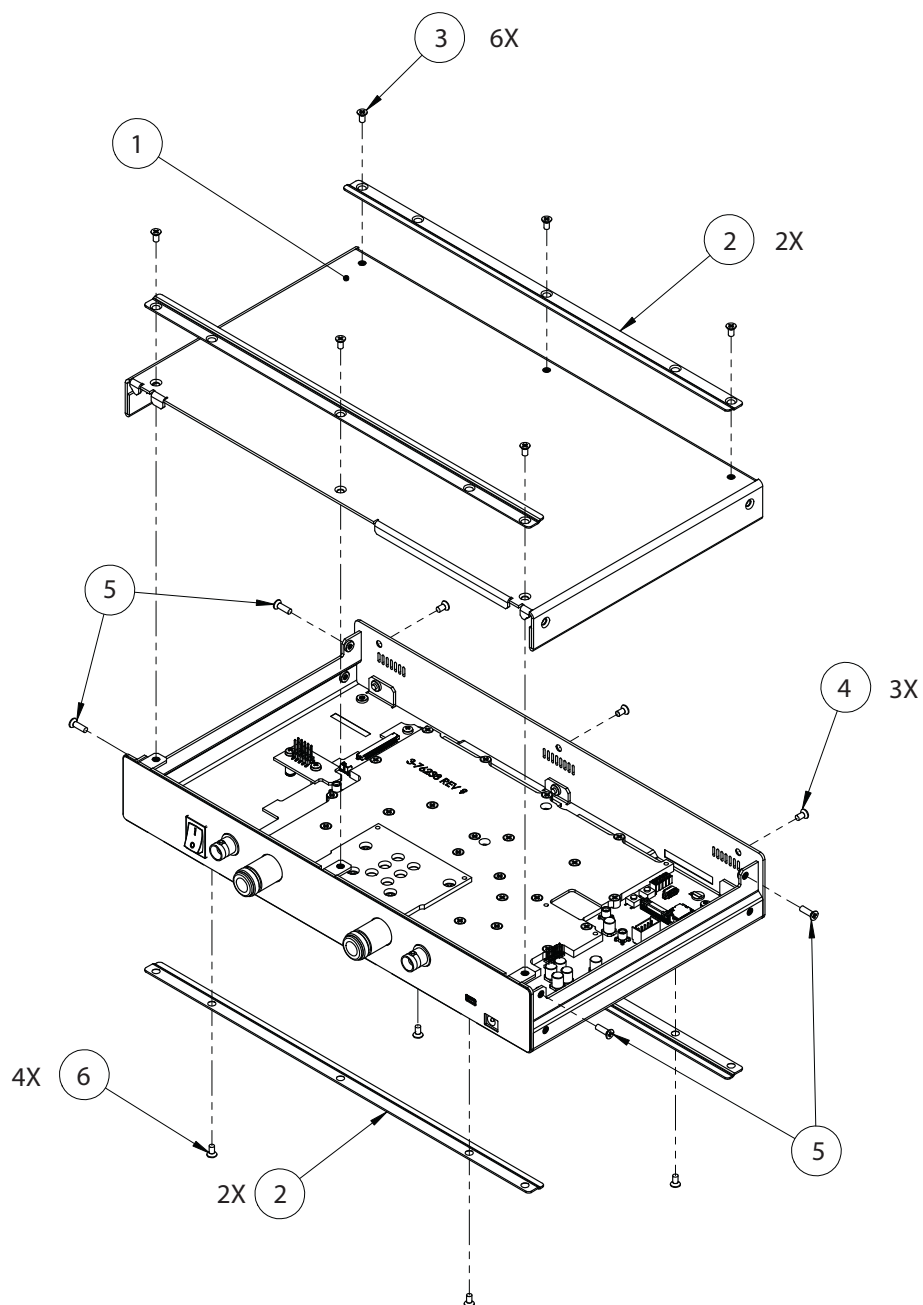
Figure 6-1. MS46122A/B Instrument Enclosure Overview

6-4 Disassembly Procedure

Use this procedure to prepare the MS46122A/B for removal and replacement procedures for all of its replaceable components. All replacement components require this common disassembly procedure.

Common Disassembly Procedure

1. Prepare a clean and static free work area. Make sure that the work area is well grounded. Cover the work surface with a soft, clean anti-static mat.
2. Provide all personnel with appropriate anti-static grounding wrist straps and similar equipment.
3. Power down the VNA and then unplug the AC power cord and USB cable.
4. Place the VNA on the anti-static mat.
5. Refer to [Figure 6-2 on page 6-4](#) and remove the top case as follows:
 - a. Remove the front and rear bumpers.
 - b. Remove the six screws that secure the top bumper mounting strips to the top case.
 - c. Remove the four side mounting screws.
 - d. Remove the three rear panel screws.
 - e. Remove the top case.
6. Refer to [Figure 6-2 on page 6-4](#) and remove the front panel assembly as follows:
 - a. Place the instrument upside down on the working surface.
 - b. Remove the two screws that secure the front bottom bumper mounting strip to the bottom case.
 - c. Remove the four screws that secure the front panel assembly to the bottom case.
 - d. Place the instrument with its top side facing upward.
 - e. Unplug the 10 MHz Reference In cable from J30 of the VNA assembly.
 - f. Unplug the Trigger In cable from J34 of the VNA assembly.
 - g. Unplug the front panel ribbon cable from the VNA assembly.
 - h. For units with N(f) test ports, disconnect the Port 1 coaxial cable from J1 of the VNA assembly and then disconnect the Port 2 coaxial cable from J2 of the VNA assembly.
 - i. For units with K(m) test ports, disconnect both the SMA(m) end of the Port 1 test port adapter and the Port 2 test port adapter from the VNA assembly.
 - j. Carefully remove the front panel assembly from the bottom case.



1. Top Case
2. Bumper Mounting Strips
3. Top Bumper Mounting Strip Screws
4. Rear Screws
5. Side Mounting Screws
6. Bottom Bumper Mounting Strip Screws

Figure 6-2. MS46122A/B Dis-assembling Drawing

6-5 VNA Assembly and Adapter Board Assembly

Use this procedure to replace the VNA Assembly and Adapter Board Assembly. The VNA Assembly is secured to the bottom case using six (6) Phillips screws. The Adapter Board Assembly which is replaced separately is plugged into J31 of the VNA Assembly.

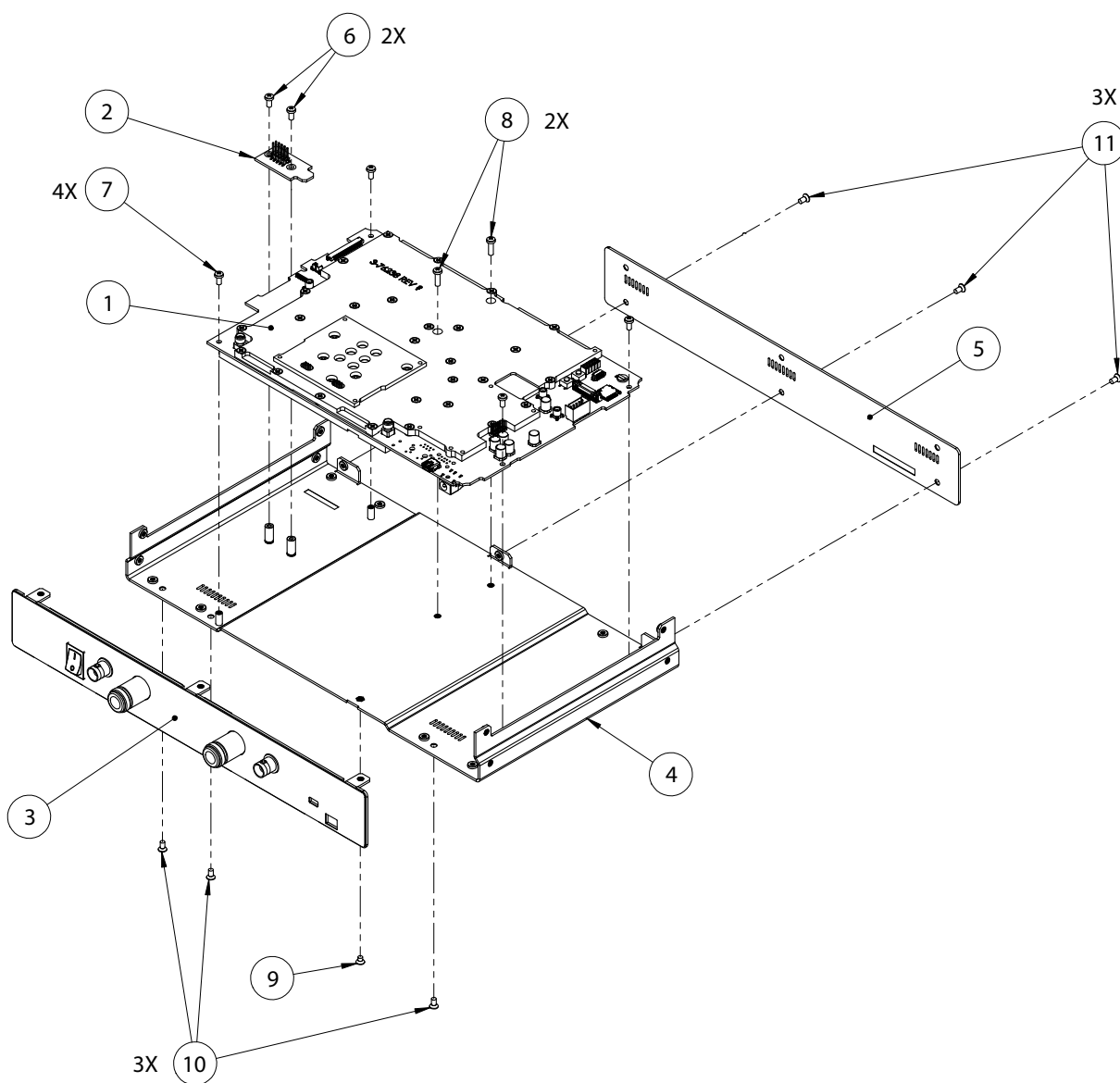
Replacement Parts

Table 6-1. Replacement Parts

Description	Model	Option	Part Number	Serial Number
VNA Assembly	MS46122A	Option 10	ND81301-RFB	All
VNA Assembly	MS46122A	Option 20	ND81302-RFB	All
VNA Assembly	MS46122A	Option 40	ND81303-RFB	All
VNA Assembly	MS46122B	Option 10	3-ND83417-RFB	< 1818301
VNA Assembly	MS46122B	Option 10	3-ND83985-RFB	≥ 1818301
VNA Assembly	MS46122B	Option 20	3-ND83418-RFB	< 1818301
VNA Assembly	MS46122B	Option 20	3-ND83986-RFB	≥ 1818301
VNA Assembly	MS46122B	Option 40	3-ND83419-RFB	< 1818301
VNA Assembly	MS46122B	Option 40	3-ND83987-RFB	≥ 1818301
VNA Assembly	MS46122B	Option 43	3-ND84774-RFB	All
Adapter Board Assembly	MS46122A/B	All	3-80719-3	All
Front Panel LED PCB Assembly	MS46122A/B	All	3-ND81018	All

Reference Figures

- [Figure 6-3 on page 6-6](#) shows the VNA assembly of the MS46122A/B with Option 10.
- [Figure 6-4 on page 6-7](#) shows the VNA assembly of the MS46122A/B with Option 20, Option 40, or Option 43.



1 – VNA Assembly of MS46122A/B with Option 10

2 – Adapter Board Assembly

3 – Front Panel Assembly

4 – Bottom Case

5 – Rear Panel Plate

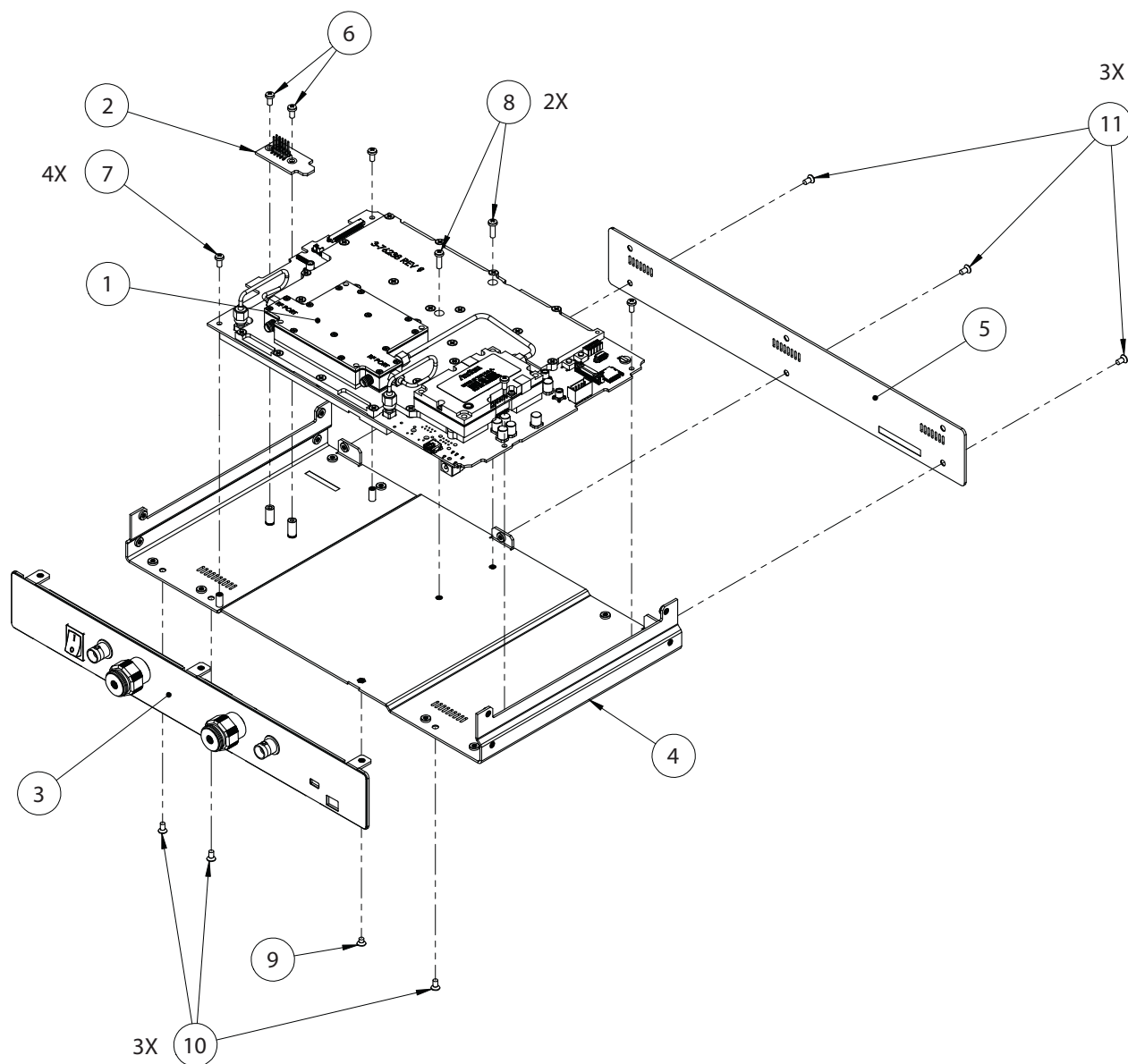
6 – Adapter Board Assembly mounting screws

7, 8 – VNA Assembly mounting screws

9, 10 – Front Panel Assembly mounting screws

11 – Rear Panel Plate mounting screws

Figure 6-3. VNA Assembly of the MS46122A/B with Option 10



1 – VNA Assembly of MS46122A/B with Option 20, Option 40, or Option 43

2 – Adapter Board Assembly

3 – Front Panel Assembly

4 – Bottom Case

5 – Rear Panel Plate

6 – Adapter Board Assembly mounting screws

7, 8 – VNA Assembly mounting screws

9, 10 – Front Panel Assembly mounting screws

11 – Rear Panel Plate mounting screws

Figure 6-4. VNA Assembly of the MS46122A/B with Option 20, Option 40, or Option 43

Replacement Procedure

1. Remove the top case and front panel assembly as described in the [“Common Disassembly Procedure” on page 6-3](#).
2. Remove the two Phillips screws that secure the Adapter Board assembly.
3. Unplug the Adapter Board assembly from the VNA assembly.
4. Remove the six Phillips screws that secure the VNA assembly as shown in [Figure 6-3 on page 6-6](#) for units with Option 10 or in [Figure 6-4 on page 6-7](#) for units with Option 20, Option 40, or Option 43.
5. Remove the VNA assembly.
6. Install the replacement VNA assembly into the bottom case.
7. Secure the VNA assembly with screws that were removed in [Step 4](#).
8. Install the Adapter Board assembly to J31 of the VNA assembly and secure with the screws that were removed in [Step 2](#).
9. For an MS46122A/B with Option 10:
 - a. Re-connect the Port 1 coaxial cable to J1 connector of the VNA assembly.
 - b. Re-connect the Port 2 coaxial cable to J2 connector of the VNA assembly.
 - c. Torque the cable connection to 8 in-lb.
 - d. Install the front panel assembly.
10. For an MS46122A/B with Option 20, Option 40, or Option 43:
 - a. Re-connect Port 1 test port adapter and Port 2 test port adapter to the receiver module of the VNA assembly.
 - b. Torque the connection to 8 in-lb.
 - c. Secure the front panel assembly with screws.
11. Re-connect the 10 MHz Reference In cable to J30 of the VNA assembly.
12. Re-connect the Trigger In cable to J34 of the VNA assembly.
13. Install the top case.
14. Install the bumper mounting strips.
15. Install the bumpers.

6-6 Front Panel LED PCB Assembly

Use this procedure to replace the front panel LED PCB assembly.

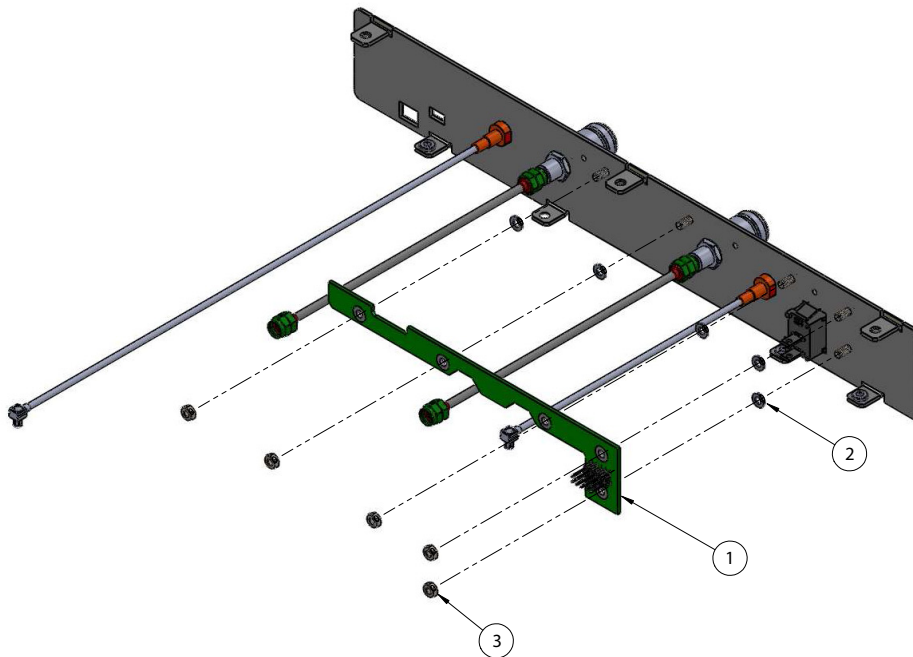
The front panel LED PCB assembly is secured to the front panel plate with five (5) kep nuts.

Replacement Part

- Front Panel LED PCB Assembly for MS46122A – ND81018
- Front Panel LED PCB Assembly for MS46122B – 3-ND81018

Reference Figure

- [Figure 6-5](#) below shows the location of the front panel LED PCB assembly.



1 – Front Panel LED PCB Assembly

2 – Nylon washers

3 – Kep Nuts

Figure 6-5. Front Panel LED PCB Assembly

Replacement Procedure

1. Remove the top case and front panel assembly as described in the [“Common Disassembly Procedure” on page 6-3](#).
2. Unplug the ribbon cable from J1 of the front panel LED PCB assembly.
3. Remove the five (5) keps nuts that secure the front panel LED PCB assembly to the front panel plate.
4. Remove the front panel LED PCB assembly.

Note

Be careful not to lose the nylon washers that are placed between the front panel plate and the front panel LED PCB assembly.

5. Install the replacement front panel LED PCB assembly to the front panel and secure it with the keps nuts that were removed in [Step 3](#).
6. Install the front panel assembly to the bottom case.
7. Re-connect the ribbon cable to J1 of the front panel LED PCB assembly.
8. Install the top case.
9. Install the bumper mounting strips
10. Install the bumpers.

6-7 Test Port Adapter

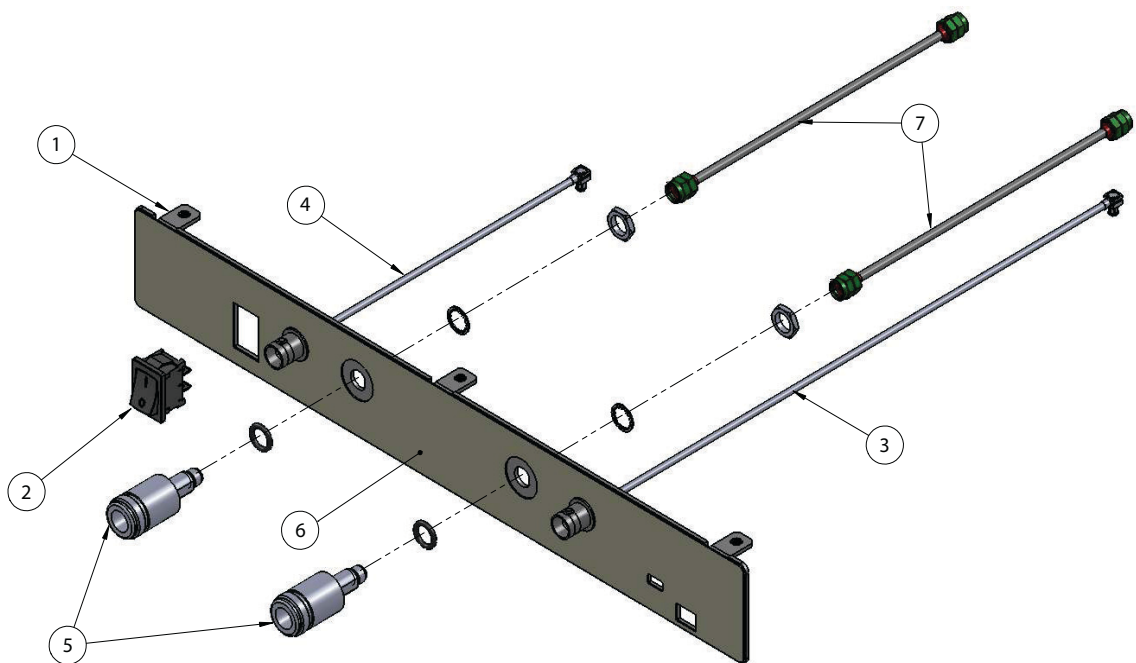
Use this procedure to replace the front panel test port adapters.

Replacement Part

- Test Port Adapter of MS46122A with Option 10 – 3-1091-438
- Test Port Adapter of MS46122B with Option 10 – 3-82848
- Test Port Adapter of MS46122A/B with Option 20 or Option 40 – 3-75651
- Test Port Adapter of MS46122B with Option 43 – 3-84709

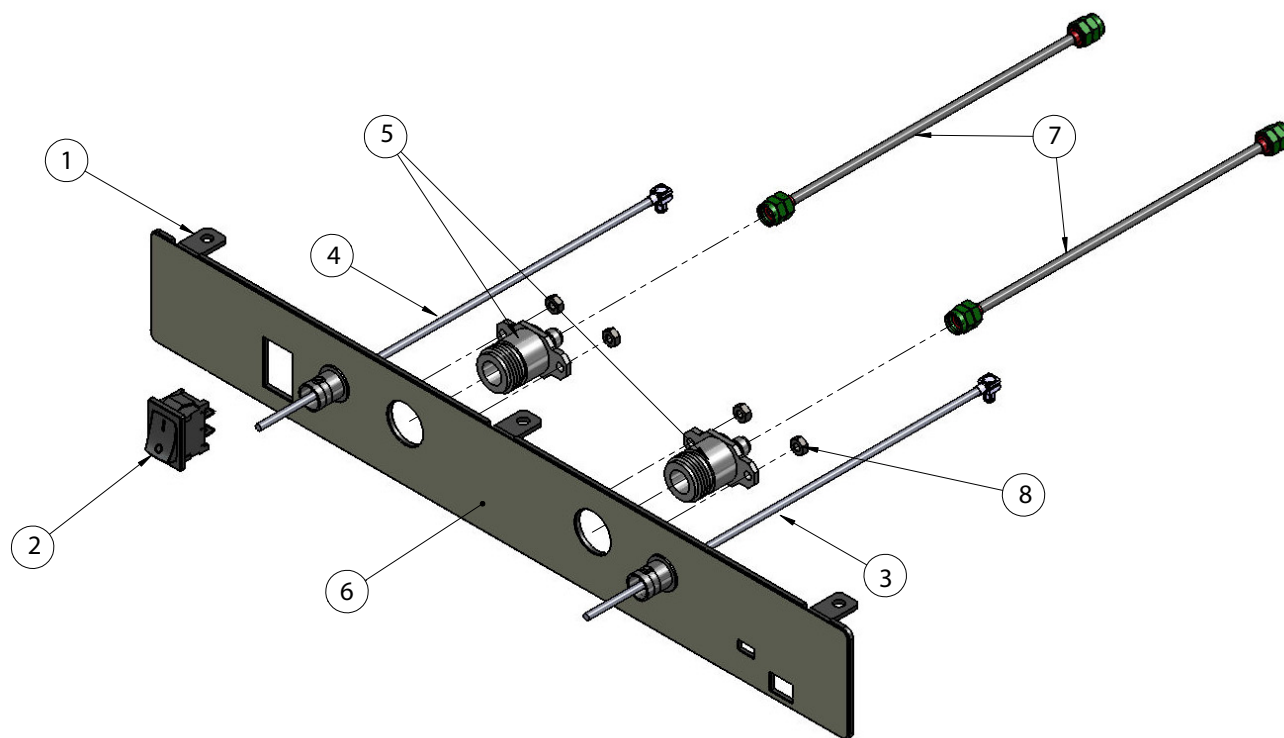
Reference Figures

- [Figure 6-6](#) below shows how the N(f) test port adapters are mounted to the front panel of MS46122A.
- [Figure 6-8 on page 6-13](#) shows how the K(m) test port adapters are mounted to the front panel. .



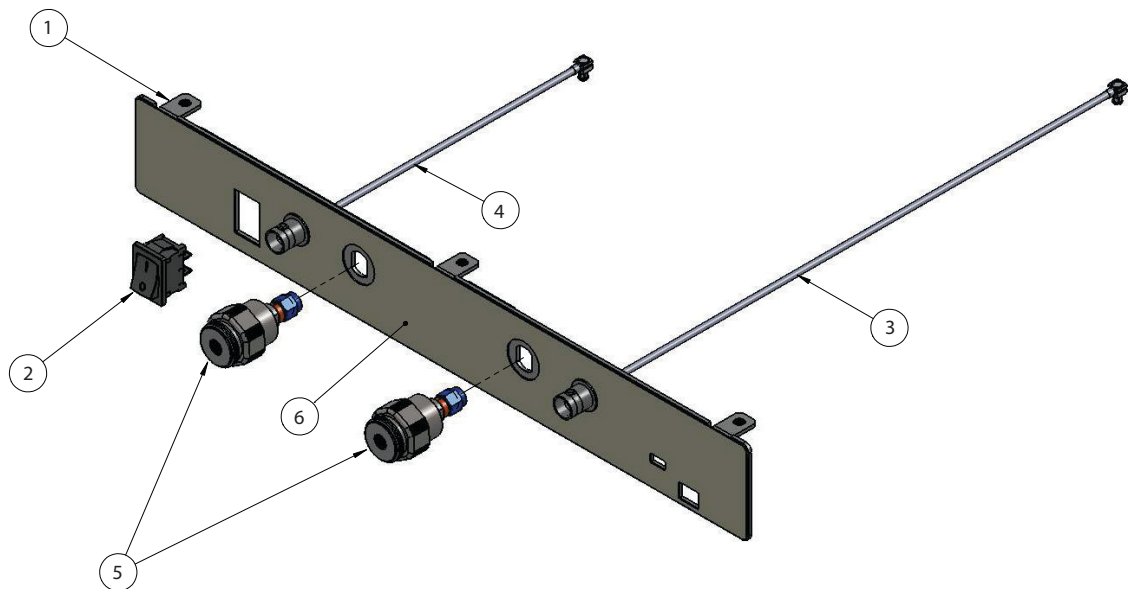
- 1 – Front Panel Plate
- 2 – Power Switch
- 3 – 10 MHz Reference In cable
- 4 – Trigger In Cable
- 5 – Test Port Adapters (Washer and Hex Nut are included in replacement package)
- 6 – Front Panel Assembly
- 7 – Test Port Coaxial Cables

Figure 6-6. Test Port Adapters of the MS46122A with Option 10



- 1 – Front Panel Plate
- 2 – Power Switch
- 3 – 10 MHz Reference In cable
- 4 – Trigger In Cable
- 5 – Test Port Adapters
- 6 – Front Panel Assembly
- 7 – Test Port Coaxial Cables
- 8 – Hex Nuts

Figure 6-7. Test Port Adapters of the MS46122B with Option 10



- 1 – Front Panel Plate
- 2 – Power Switch
- 3 – 10 MHz Reference In cable
- 4 – Trigger In Cable
- 5 – Test Port Adapters (Washer and Hex Nut are included in replacement package but not shown in this figure)
- 6 – Front Panel Assembly

Figure 6-8. Test Port Adapters of the MS46122A/B with Option 20, Option 40, or Option 43

Replacement Procedure

1. Remove the top case and front panel assembly as described in the [“Common Disassembly Procedure” on page 6-3](#).
2. Disconnect the flexible coaxial cable from the SMA(f) connector of the test port adapter.
3. For MS46122A with Option 10 and MS46122A/B with Option 20, 40, or 43, use a ratchet wrench with a 1/4 inch deep socket to remove the hex nut that secures the test port adapter to the front panel.
4. For MS46122B with Option 10, remove the two (2) hex nuts that secure the test port adapter to the front panel.
5. Remove the test port adapter from the front panel.
6. Install the replacement test port adapter to the front panel. Install the washer and then the hex nut. Tighten the hex nut with fingers.
7. For MS46122A with Option 10 and MS46122A/B with Option 20, 40, or 43, use a ratchet wrench with the 1/4 inch deep socket to tighten the hex nut. Torque to 15 ft·lb (~20.33 N·m).
8. For MS46122B with Option 10, use a wrench to tighten the hex nuts.
9. Re-connect the flexible coaxial cable to the SMA(f) connector of the test port adapter.
10. Install the top cover.

Appendix A — Test Records

A-1 Introduction

This appendix provides a test record that can be used to record the performance of the ShockLine MS46122A/B.

Make a copy of the following test record pages and document the measured values each time performance verification is performed. Continuing to document this process for each performance verification session provides a detailed history of the instrument's performance.

The following test record form is available:

- [“ShockLine MS46122A System Performance Test Record” on page A-2](#)
- [“ShockLine MS46122B Instrument Performance Test Record” on page A-3](#)

Instrument Information

Serial Number:	Firmware Revision:	Operator:
Options:		Date:

A-2 ShockLine MS46122A System Performance Test Record

System Performance Verification

This test is automated using the System Verification software that is included with 3663-x or 3668-x Verification Kits.

Note

Pass/Fail criteria is determined from EnR, EnR <=1 = PASS, EnR >1 = FAIL
Where EnR = [Ma-Mb/sqrt(Ua^2+Ub^2)]

Test Data Report generated by System Verification software is attached. []

Instrument Information

Serial Number:	Firmware Revision:	Operator:
Options:		Date:

A-3 ShockLine MS46122B Instrument Performance Test Record

Frequency Accuracy

Table A-1. Frequency Accuracy

Frequency	Measured Value	Measurement Uncertainty	Specification (See Note below)	Pass/Fail
1 GHz	Hz	32 Hz	Hz	

Note

Specification is ± 1 ppm (1 kHz at 1 GHz) at time of calibration (adjustment). Stability and Aging values must be added to determine the limit when the instrument is re-verified at its regular calibration intervals.

Output Power Accuracy (Operational Test)

(Output Power = High)

Table A-2. High Output Power Accuracy (1 of 2)

Frequency (MHz)	Port 1 Measured Power (dBm)	Port 2 Measured Power (dBm)	Measurement Uncertainty
1			0.38
10			0.38
45			0.38
100			0.48
1000			0.48
2000			0.48
3000			0.48
4000			0.48
5000			0.48
6000			0.48
7000			0.48
8000			0.48
8500			0.48
9000			0.48
10000			0.48
11000			0.51
12000			0.51

Table A-2. High Output Power Accuracy (2 of 2)

Frequency (MHz)	Port 1 Measured Power (dBm)	Port 2 Measured Power (dBm)	Measurement Uncertainty
13000			0.51
14000			0.51
15000			0.51
16000			0.51
17000			0.51
18000			0.51
19000			0.51
20000			0.51
21000			0.66
22000			0.66
23000			0.66
24000			0.66
25000			0.66
26000			0.66
27000			0.66
28000			0.66
29000			0.66
30000			0.66
31000			0.66
32000			0.66
33000			0.66
34000			0.66
35000			0.66
36000			0.66
37000			0.66
38000			0.66
39000			0.66
40000			0.66

*(Output Power = Low)***Table A-3.** Low Output Power Accuracy (1 of 2)

Frequency (MHz)	Port 1 Measured Power (dBm)	Port 2 Measured Power (dBm)	Measurement Uncertainty
1			0.38
10			0.38
45			0.38
100			0.48
1000			0.48
2000			0.48
3000			0.48
4000			0.48
5000			0.48
6000			0.48
7000			0.48
8000			0.48
8500			0.48
9000			0.48
10000			0.48
11000			0.51
12000			0.51
13000			0.51
14000			0.51
15000			0.51
16000			0.51
17000			0.51
18000			0.51
19000			0.51
20000			0.51
21000			0.66
22000			0.66
23000			0.66
24000			0.66
25000			0.66
26000			0.66
27000			0.66
28000			0.66
29000			0.66
30000			0.66
31000			0.66
32000			0.66
33000			0.66

Table A-3. Low Output Power Accuracy (2 of 2)

Frequency (MHz)	Port 1 Measured Power (dBm)	Port 2 Measured Power (dBm)	Measurement Uncertainty
34000			0.66
35000			0.66
36000			0.66
37000			0.66
38000			0.66
39000			0.66
40000			0.66

System Dynamic Range

(High Power, 10 Hz IFBW, RMS)

Table A-4. S12 System Dynamic Range

Frequency	Measured Value	Measurement Uncertainty	Specification	Pass/Fail
1 MHz to 10 MHz	dB rms	0.16 dB rms	85 dB rms	
>10 MHz to 8 GHz	dB rms	1.1 dB rms	100 dB rms	
>8 GHz to 14 GHz	dB rms	0.44 dB rms	95 dB rms	
>14 GHz to 20 GHz	dB rms	0.43 dB rms	100 dB rms	
>20 GHz to 30 GHz	dB rms	0.43 dB rms	100 dB rms	
>30 GHz to 40 GHz	dB rms	0.43 dB rms	100 dB rms	
>40 GHz to 43.5 GHz	dB rms	1.1 dB rms	97 dB rms	

Table A-5. S21 System Dynamic Range

Frequency	Measured Value	Measurement Uncertainty	Specification	Pass/Fail
1 MHz to 10 MHz	dB rms	0.16 dB rms	85 dB rms	
>10 MHz to 8 GHz	dB rms	1.1 dB rms	100 dB rms	
>8 GHz to 14 GHz	dB rms	0.441 dB rms	95 dB rms	
>14 GHz to 20 GHz	dB rms	0.43 dB rms	100 dB rms	
>20 GHz to 30 GHz	dB rms	0.43 dB rms	100 dB rms	
>30 GHz to 40 GHz	dB rms	0.43 dB rms	100 dB rms	
>40 GHz to 43.5 GHz	dB rms	1.1 dB rms	97 dB rms	

High-level Noise*(100 Hz IFBW, RMS)***Table A-6.** High Level Noise – S12 Magnitude (1 of 2)

Frequency (MHz)	Measured Value (dB rms)	Measurement Uncertainty (dB rms)
1		0.00059
10		0.00059
50		0.0029
100		0.0029
501		0.0029
1000		0.0029
2000		0.0029
3000		0.0029
4001		0.0029
5000		0.0029
6000		0.0029
7000		0.0029
8000		0.0029
8500		0.0029
9000		0.0029
10000		0.0029
11000		0.0029
12000		0.0029
13000		0.0029
14000		0.0029
15000		0.0029
16000		0.0029
17000		0.0029
18000		0.0029
19000		0.0029
20000		0.0029
21000		0.0029
22000		0.0029
23000		0.0029
24000		0.0029
25000		0.0029
26000		0.0029
27000		0.0029
28000		0.0029
29000		0.0029

Table A-6. High Level Noise – S12 Magnitude (2 of 2)

Frequency (MHz)	Measured Value (dB rms)	Measurement Uncertainty (dB rms)
30000		0.0029
31000		0.0029
32000		0.0029
33000		0.0029
34000		0.0029
35000		0.0029
36000		0.0029
37000		0.0029
38000		0.0029
39000		0.0029
40000		0.0029
41000		0.0043
42000		0.0043
43000		0.0043
43500		0.0043

Table A-7. High Level Noise – S12 Phase (1 of 2)

Frequency (MHz)	Measured Value (Deg rms)	Measurement Uncertainty (Deg rms)
1		0.0051
10		0.0051
50		0.0018
100		0.0018
501		0.0018
1000		0.0018
2000		0.0018
3000		0.0018
4001		0.0018
5000		0.0018
6000		0.0018
7000		0.0018
8000		0.0018
8500		0.0018
9000		0.0018
10000		0.0018
11000		0.0018

Table A-7. High Level Noise – S12 Phase (2 of 2)

Frequency (MHz)	Measured Value (Deg rms)	Measurement Uncertainty (Deg rms)
12000		0.0018
13000		0.0018
14000		0.0018
15000		0.0018
16000		0.0018
17000		0.0018
18000		0.0018
19000		0.0018
20000		0.0018
21000		0.0018
22000		0.0018
23000		0.0018
24000		0.0018
25000		0.0018
26000		0.0018
27000		0.0018
28000		0.0018
29000		0.0018
30000		0.0018
31000		0.0018
32000		0.0018
33000		0.0018
34000		0.0018
35000		0.0018
36000		0.0018
37000		0.0018
38000		0.0018
39000		0.0018
40000		0.0018
41000		0.0013
42000		0.0013
43000		0.0013
43500		0.0013

Table A-8. High Level Noise – S21 Magnitude (1 of 2)

Frequency (MHz)	Measured Value (dB rms)	Measurement Uncertainty (dB rms)
1		0.00059
10		0.00059
50		0.0029
100		0.0029
501		0.0029
1000		0.0029
2000		0.0029
3000		0.0029
4001		0.0029
5000		0.0029
6000		0.0029
7000		0.0029
8000		0.0029
8500		0.0029
9000		0.0029
10000		0.0029
11000		0.0029
12000		0.0029
13000		0.0029
14000		0.0029
15000		0.0029
16000		0.0029
17000		0.0029
18000		0.0029
19000		0.0029
20000		0.0029
21000		0.0029
22000		0.0029
23000		0.0029
24000		0.0029
25000		0.0029
26000		0.0029
27000		0.0029
28000		0.0029
29000		0.0029
30000		0.0029
31000		0.0029

Table A-8. High Level Noise – S21 Magnitude (2 of 2)

Frequency (MHz)	Measured Value (dB rms)	Measurement Uncertainty (dB rms)
32000		0.0029
33000		0.0029
34000		0.0029
35000		0.0029
36000		0.0029
37000		0.0029
38000		0.0029
39000		0.0029
40000		0.0029
41000		0.0043
42000		0.0043
43000		0.0043
43500		0.0043

Table A-9. High Level Noise – S21 Phase (1 of 2)

Frequency (MHz)	Measured Value (Deg rms)	Measurement Uncertainty (Deg rms)
1		0.0051
10		0.0051
50		0.0018
100		0.0018
501		0.0018
1000		0.0018
2000		0.0018
3000		0.0018
4001		0.0018
5000		0.0018
6000		0.0018
7000		0.0018
8000		0.0018
8500		0.0018
9000		0.0018
10000		0.0018
11000		0.0018
12000		0.0018
13000		0.0018

Table A-9. High Level Noise – S21 Phase (2 of 2)

Frequency (MHz)	Measured Value (Deg rms)	Measurement Uncertainty (Deg rms)
14000		0.0018
15000		0.0018
16000		0.0018
17000		0.0018
18000		0.0018
19000		0.0018
20000		0.0018
21000		0.0018
22000		0.0018
23000		0.0018
24000		0.0018
25000		0.0018
26000		0.0018
27000		0.0018
28000		0.0018
29000		0.0018
30000		0.0018
31000		0.0018
32000		0.0018
33000		0.0018
34000		0.0018
35000		0.0018
36000		0.0018
37000		0.0018
38000		0.0018
39000		0.0018
40000		0.0018
41000		0.0013
42000		0.0013
43000		0.0013
43500		0.0013

Index

Numerics

20 dB attenuation standard	
MS46122A	2-5, 3-5
25 ohm mismatch (Beatty) standard	
MS46122A	2-5, 3-5
50 dB attenuation standard	
MS46122A	2-5, 3-5
50 ohm air line standard	
MS46122A	2-5, 3-5

A

accessories, standard	1-1
adjustment procedure	
time base	4-2
air line standard, 50 ohm	
MS46122A	2-5, 3-5
Anritsu	
repair service	1-2
service center	1-2
Anritsu hardware is unavailable, troubleshooting	5-3
available ShockLine options	1-1

B

Beatty standards, 25 ohm mismatch	
MS46122A	2-5, 3-5

C

cables, preshapping	
MS46122A	2-6
MS46122B	3-7
calibration	1-2
cannot power up unit, troubleshooting	5-3
causes of verification failure	
MS46122A	2-8
MS46122B	3-8
caution	
electrostatic discharge (ESD)	5-1, 6-1
non-Anritsu test equipment	
MS46122A	2-4
MS46122B	3-5
use torque wrench	
MS46122A	2-7
MS46122B	3-8
common disassembly procedure	6-3
conditions	
relative humidity	
MS46122A	2-3
MS46122B	3-3
temperature	
MS46122A	2-3
MS46122B	3-3
warm-up time	
MS46122A	2-3
MS46122B	3-3

D

daemon icon status	5-4
documentation, related	1-2

E

ESD caution	5-1, 6-1
-------------	----------

F

frequency related troubleshooting	5-6
front panel LED assembly	6-9

H

humidity, relative	
MS46122A	2-3

I

icon	
daemon status	5-4
identification number	1-1
IF adjustment procedure	4-1
impedance transfer standards	
MS46122A	2-5, 3-5

M

maintain operating system integrity	1-2
measurement problems troubleshooting	5-7
metrological traceability	
MS46122A	2-1
MS46122B	3-1
minimize vibration	
MS46122A	2-6
MS46122B	3-7

N

no hardware found, troubleshooting	5-5
non-Anritsu test equipment caution	
MS46122A	2-4
MS46122B	3-5
non-ratio power level check	5-2
number, identification	1-1

O

operating system integrity, maintain	1-2
options, available ShockLine	1-1

P

performance verification	
special precautions	
MS46122A	2-6
MS46122B	3-7
standard conditions	
MS46122A	2-3
MS46122B	3-3
preshape test port cables	
MS46122A	2-6
MS46122B	3-7

procedure	
common disassembly	6-3
front panel LED assembly	6-9
IF adjustment	4-1
test port adapter assembly	6-11
VNA and adapter board assembly	6-5

Q

quality of verification results	
MS46122A	2-6
MS46122B	3-6

R

recommended test equipment	1-2
related documentation	1-2
relative humidity	
MS46122A	2-3
MS46122B	3-3
repair service, Anritsu	1-2
RF power related troubleshooting	5-6

S

service center, Anritsu	1-2
ShockLine app does not launch, troubleshooting	5-3
ShockLine, available options	1-1
standard accessories	1-1
standard conditions for performance verification	
MS46122A	2-3
MS46122B	3-3
standards	
20 dB attenuation	
MS46122A	2-5, 3-5
25 ohm mismatch (Beatty)	
MS46122A	2-5, 3-5
50 dB attenuation	
MS46122A	2-5, 3-5
50 ohm air line	
MS46122A	2-5, 3-5
impedance transfer	
MS46122A	2-5, 3-5
system verification procedure	
MS46122A	2-6
MS46122B	3-7

T

temperature	
MS46122A	2-3
MS46122B	3-3
test equipment, recommended	1-2
test port adapter assembly	6-11

test port cables	
MS46122A	2-6
MS46122B	3-7
time base adjustment procedure	4-2
torque wrench caution	
MS46122A	2-7
MS46122B	3-8
traceability, metrological	
MS46122A	2-1
MS46122B	3-1
troubleshooting	
Anritsu hardware is unavailable	5-3
cannot power up unit	5-3
frequency related	5-6
measurement problems	5-7
no hardware found	5-5
non-ratio power level check	5-2
RF power related	5-6
ShockLine app does not launch	5-3
turn-on problems	5-3
turn-on problems, troubleshooting	5-3

U

uncertainty	
MS46122A	2-1
MS46122B	3-1
updates, Windows OS	1-2

V

verification	
causes of failure	
MS46122A	2-8
MS46122B	3-8
result determination	
MS46122A	2-5
MS46122B	3-5
results, quality of	
MS46122A	2-6
MS46122B	3-6
system verification procedure	
MS46122A	2-6
MS46122B	3-7
VNA and adapter board assembly	6-5

W

warm-up time	
MS46122A	2-3
MS46122B	3-3
Windows OS updates	1-2



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