Precision Calibration Solutions

—PRECISION CALIBRATION SOLUTIONS

Insight VNA Calibration and Measurement Software

insight™
Maury Microwave

Introduction

From their introduction in the 1980s, Vector Network Analyzers, VNAs, have been used to measure network scattering parameters, S-parameters, of linear electrical networks. Since that time, S-parameters have become so common that they are used in nearly all aspects of an RF device's life cycle including research and development, design validation test and production test.

It is not uncommon to walk into an RF lab and see VNAs from various vendors spanning multiple generations being used interchangeably, from the original HP 8510 to the latest Keysight PNA-X. With so many different VNAs in use, each with different interfaces and capabilities, several challenges arise:

- How can we ensure VNA users are properly trained on every model available in their labs?
- How can simple mistakes due to differences in terminologies, calibration standards definitions and calibration flows be avoided?
- How can we validate VNA calibrations in a meaningful way so that users can have confidence in their measurements?

And it's not enough to think about a single lab; today's global organizations have multiple labs across various countries and multinational teams that collaborate on projects. This introduces another set of challenges:

- How can users save important measurement data in a format that is usable by everyone?
- How can the visualization and analysis process be simplified yet made more powerful to that better decisions can be made more efficiently?

And finally, as we strive to understand more about our RF device's performance, challenges related to uncertainty arise:

- How can we identify all the sources of uncertainty in our measurement setup?
- How can we quantify the uncertainty and use it in making better decisions?

Insight VNA Calibration and Measurement Software

Welcome to Insight, the industry's first commercial software suite designed to empower VNA users and help them make better decisions. Insight represents a paradigm shift in the way users approach VNA calibration, validation, measurement, visualization and analysis. With Insight, users can:

- Use a single software platform with most commercial VNAs*
- Define mechanical calibration standards from any vendor and use with all VNAs
- Avoid common errors with a simplified calibration process empowered by an intuitive GUI and wizard
- Validate VNA calibration using airlines and individually characterized verification kits
- Measure S-parameters and save S2P files for easy sharing
- Understand measurement re sults better with advanced visualization and analysis tools
- Identify and quantify the individual contributions of uncertainty**
- Display uncertainty boundaries alongside measurement results

** Insight ships with an extensive library of VNA drivers; additional drivers may be added upon request*
***Utilizing techniques described by EURAMET*

MT940A Insight Calibration and Measurement

MT940A Insight Calibration and Measurement software module includes everything needed to calibrate a VNA, validate VNA calibration, measure an RF device's S-parameters, and visualize and analyze the measurement results. Features of MT940A include:

- System library
- Calibration wizard
- Calibration validation wizard
- Real-time measurement interface
- Visualization and data analysis tool

System library

The system library is the database of instruments and accessories used to calibrate, validate and measure an RF devices' S-parameters. This includes:

- VNA – create a database of available VNAs including selecting the appropriate VNA driver and defining the GPIB or network address
- Cal kits – create a database of available VNA calibration kits, including connector type and gender, and whether the kit uses polynomial definitions or individually Characterized Device (CD) standards
- Verification kits – create a database of available Maury VNA calibration verification kits

Calibration wizard

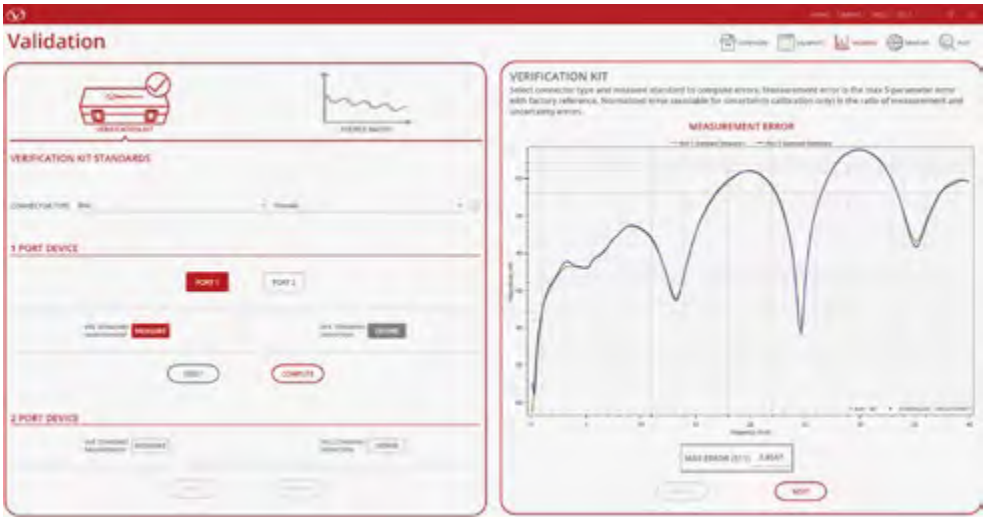
The calibration wizard guides users through the calibration process, including:

- Selecting the VNA from the database and defining the VNA properties (port numbers, power, averaging, IF bandwidth...)
- Defining the frequencies for calibration (linear step or custom list)
- Selecting the calibration kit from the dataset and defining the calibration method
- Calibrating by connecting and measuring each standard and computing error terms

Calibration validation wizard

The calibration validation wizard guides users through the validation process, including:

- Selecting the VNA calibration verification kit from the database
- Validating Source Match using beadless airlines
- Validating using Characterized Device (CD) verification kit which compares a user's measured data against factory-measured data and calculates error vector



Real-time measurement interface

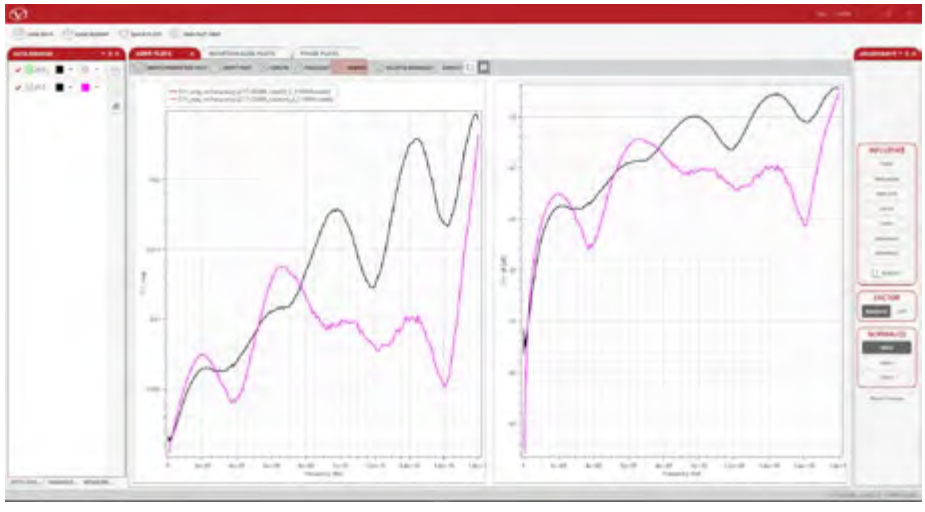
The real-time measurement interface empowers RF device measurements, including:

- Setting VNA options (IF bandwidth, averaging, port power)
- Defining plots to visualize measurement data
- Setting sweep mode (single, continuous, hold)
- Saving measurement data to memory or as S2P files
- Comparing/normalizing data sets for analysis
- Creating specifications files for comparison and analysis

Visualization and data analysis tool

The visualization and data analysis tool empowers users to visualize and analyze measurement data, by:

- Creating, saving and sharing visualization templates, or use a quick plot, to ensure consistent and repeatable measurement analysis
- Creating sessions (template and measurements data) to share among collaborators
- Loading and comparing multiple saved data sets
- Creating custom expressions from measured S-parameters
- Exporting data as CSV and image files



MT940B Insight Real Time Uncertainty Add-On

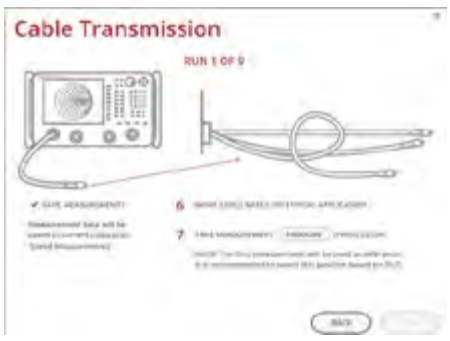
MT940B is an add-on module for MT940A which enables real-time uncertainty analysis based on EURAMET guidelines, including:

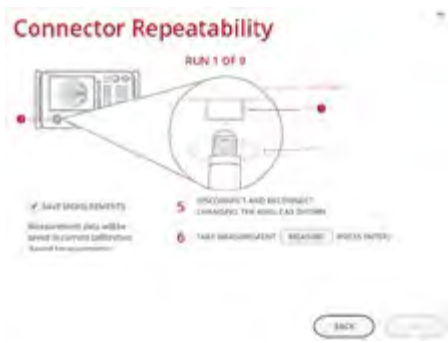
- Uncertainty quantification
- Uncertainty calibration validation
- Uncertainty measurements
- Uncertainty budget

Uncertainty quantification

Identifies and quantifies the uncertainty contribution of each component in a measurement setup. This includes:

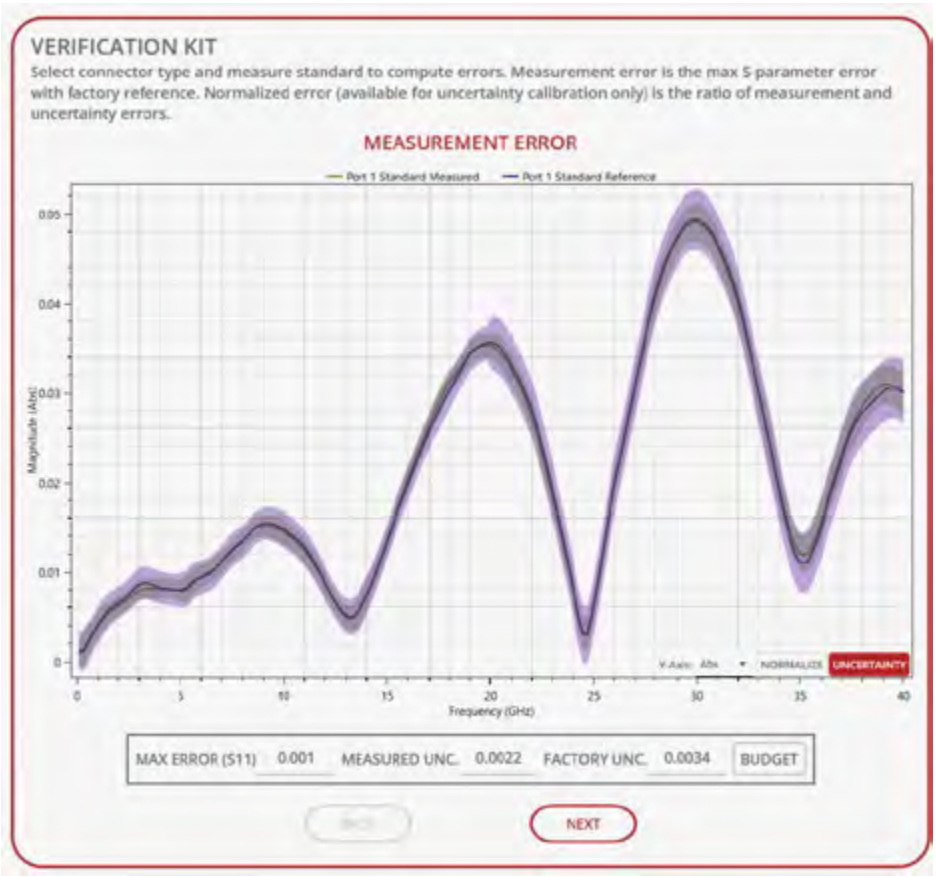
- VNA – characterize VNA drift and noise floor
- Cal kit – load factory uncertainty data
- Cables – characterize the transmission and reflection stability of the cables used in a measurement setup (related to amplitude and phase stability with flexure)
- Connectors – characterize connector repeatability of the connectors used in a measurement setup (related to the impact of pin depth, concentricity, user etiquette)





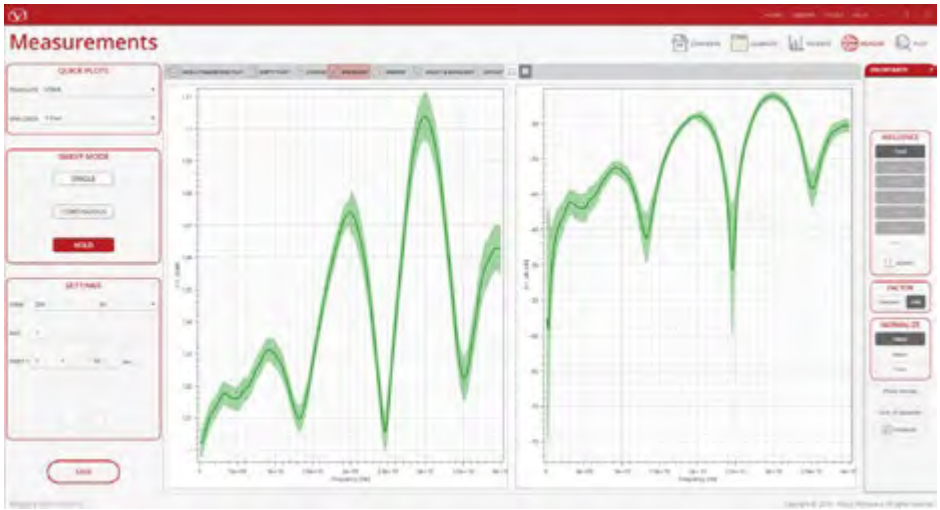
Uncertainty calibration validation

When used with a Characterized Device (CD) calibration kit and Characterized Device (CD) verification kit, uncertainty calibration validation compares the uncertainty boundaries measured on a verification device by the user with the uncertainty boundaries measured on the same verification device at the factory, and defines a passing validation as one where the measurement uncertainty boundaries overlap.



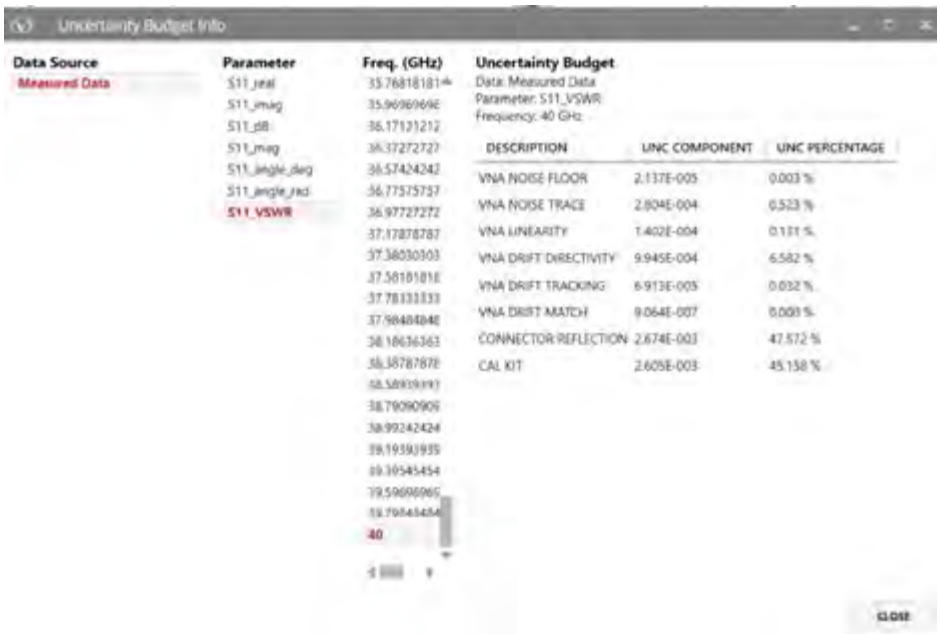
Uncertainty measurements

Individual uncertainty contributors can be activated, or de-activated and measurement data can be plotted with uncertainty boundaries.



Uncertainty budget

Reports the individual uncertainty contributions of VNA, cal kit, cable and connector as a percentage of the total for each frequency and enables users to concentrate on improving the largest contributors for more certain measurement results.



A Note About Validating a Calibration by Using Uncertainty Boundaries

Validation is by far the most important step in a measurement process; without validating, how can RF device measurements be trusted?

Conventional validation techniques rely on an estimate of the residual errors after a calibration, source match, directivity and tracking, and are typically evaluated by measuring peak-to-peak ripple through a TDR method. These techniques rely on an airline as the validation standard, and the accuracy of the validation can be severely impacted by how well the airline has been machined and handled.

A more thorough approach is based on the use of verification standards. This method involves a user measuring pre-characterized verification devices with similar performances to their own device. However, there is no clear pass-fail criteria that identifies whether a calibration is sufficiently accurate to proceed to device measurement, or whether a calibration needs to be repeated.

Insight solves the problem by defining clear pass-fail criteria based on using uncertainty boundaries. When the uncertainty boundaries measured on a verification device by the user overlaps the uncertainty boundaries measured on the same verification device at the factory, it is defined as an accurate calibration. If the boundaries do not overlap, then recalibration is recommended. Insight automates this process by guiding users through the calibration validation and clearly identifies whether the calibration can be used or must be repeated

Recommended Accessories

Verification Kits:

Have confidence in your S-parameter measurements by validating your VNA calibration. Maury verification kits are designed for 1-port and 2-port VNA calibration validation for well-matched and mismatched DUTs by comparing the S-parameters of user-characterized and factory- characterized verification standards, with or without measured uncertainty boundaries. More information regarding Verification Kits can be found in data sheet 2Z-077.

VNA Calibration Kits:

Maury offers coaxial VNA calibration kits up to 67 GHz and waveguide calibration kits up to 50 GHz in standard connector and waveguide sizes. Coaxial 2.4mm, 2.92mm, 3.5mm, 7mm and Type N calibration kits are available as fixed-load SOLT kits with either standard polynomial equations or characterized device (CD) with individually characterized standards. More information can be found in data sheets 2Z-056 (1.85mm), 2Z-072 (2.4mm), 2Z-073 (2.92mm), 2Z-074 (3.5mm), 2Z-075 (7mm), and 2Z-076 (Type N), 2Z-062 (TNC), 2Z-069 (BNC) and 3H-081 (WR284 Through WR22).

Maury Precision
VNA Calibration Kits

Network Analyzer Calibration Methodologies

Why do we need to calibrate?

Systematic errors that are present in any measurement equipment and setup must be removed in order to measure a DUT accurately. The basis of network analyzer error correction is the measurement of known electrical standards, such as a through, open circuit, short circuit, and precision load impedance. By calibrating your network analyzer with these known standards, you can connect for systematic errors that are a result of the VNA itself along with errors due to measurement setup (cables, adapters, fixtures, etc). The information below addresses some of the most critical factors in VNA calibration, ending with a brief survey of the more widely used calibration methodologies that can be performed with Maury Precision VNA Calibration Kits.

Calibration Procedures

Calibration procedures include the popular Short-Open-Load or Short-Open-Load-Thru (SOLT) calibration technique, SSLT for waveguide, and Thru-Reflect-Line (TRL).

Sources and Types of Errors

All measurement systems, including those employing network analyzers, have three types of measurement errors:

- Systematic errors
- Random errors
- Drift errors

Systematic errors are caused by imperfections in the test equipment and test setup. As the name suggest, systematic errors are non random in nature and hence can be characterized through calibration and removed during device measurements. Random and drift errors cannot be systematically be characterized and can affect measurement accuracy if the measurement setup and equipment are not validated prior to device measurement.

Error Correction

Vector error correction is the more thorough method of removing systematic errors. This type of error correction requires a network analyzer capable of measuring (but not necessarily displaying) phase as well as magnitude, and a set of calibration standards with known, precise electrical characteristics.

The vector-correction process requires the open, short, load, and sometimes thru calibration standards. The two main types of vector error correction are the one-port and two-port calibrations.

One-Port Calibration

A one-port calibration can measure and minimize three systematic error terms (directivity, source match, and reflection tracking) from reflection measurements. Three known calibration standards must be measured, such as a Short, Open, and a Load (the load value is usually the same as the characteristic impedance of the test system, generally either 50 or 75 ohm). One-port calibration makes it possible to derive the DUT's actual reflection S-parameters.

Two-Port Error Correction

Two-port error correction yields the most complete calibration because it accounts for the three major sources of systematic error addressed by one-port calibration at both ports of a two-port DUT. Traditional full two-port calibrations utilize three impedance standards and one transmission standard to define the calibrated reference plane. These standards, typically a Short, Open, Load, and Thru, make up the SOLT calibration kit. The most common Thru used is the test ports connected directly together.

Fixed-Load SOLT using Polynomial Equations

SOLT calibration is performed using Short, Open and Load standards, which are described by a polynomial equation. The equation is developed using the average performance of a large sample of identical standards, and is then shared by all calibration kits of the same series. In addition, the fixed-load SOLT methodology uses a fixed termination to define the 50ohm reference, where the lowest measurable return loss is determined by the return loss of the fixed termination, typically better than 20dB. This makes fixed-load SOLT with polynomial definitions ideal for measuring devices with mid-rage reflection coefficients.

Fixed-Load SOLT using Characterized Device (CD) Standards

SOLT calibration can also be performed using individually characterized standards, referred to as Characterized Device (CD) fixed-load SOLT calibration. In this case, each standard is individually measured and its S-parameters are used as an integral part of the calibration, and the polynomial equation is no longer used. The advantage of this technique is that the calibration accuracy is increased due to the elimination of average performance in the polynomial definition, and the lowest measurable return loss is improved.

Calibrating with Uncertainty

Characterized Device (CD) kits also allow for uncertainty evaluation of a device under test. Each CD kit is shipped with a set of factory uncertainty data compatible with MT940-series Insight VNA calibration and measurement software.

TRL Calibration

Following SOLT in popularity, the next most common form of two-port calibration is called a Thru-Reflect-Line (TRL) calibration. TRL corrects the same error terms as a SOLT calibration, although it uses different calibration standards.

Other variations of TRL are Line-Reflect-Line (LRL), (LRM) based on Line-Reflect-Match (load) calibration standards or Thru-Reflect-Match (TRM) calibration standards.

In non-coaxial applications such as waveguide, TRL usually achieves better source match and load match corrections than SOLT. While not as commonly used, coaxial TRL can also provide more accuracy than SOLT, but only if very-high quality coaxial transmission lines (such as beadless airlines) are used.

1.85mm VNA Calibration Kits

7850CK30/31 SERIES

These precision 1.85mm TRL/LRL calibration kits are designed for use with a broad range of vector network analyzers (VNAs) and are used to make error-corrected measurements, from DC to 67 GHz, for devices supplied with 1.85mm connectors. Each kit includes a full complement of calibration standards (shorts, fixed loads and air lines). Three 1.85mm in-series, calibration-grade (metrology), adapters are included in the 7850CK31 kits but are not included in the 7850CK30 kits. All kit components are provided in an attractive foam-lined, wood instrument case.

Features

- 1.85mm Connectors
- DC to 67 GHz (Operates to 70 GHz)
- Keysight, Rohde & Schwarz and Anritsu VNAs Supported

Calibration Methods Supported

- TRM – Thru-Reflect-Match (DC to 800 MHz)
- TRL – Thru-Reflect-Line (800 MHz to 13.0 GHz)
- LRL – Line-Reflect-Line (13.0 to 67.0 GHz)

7850CK30

7850CK31

Components Included in 7850CK30 Kits

QUANTITY	DESCRIPTION	MODEL
1	1.85mm female fixed short circuit (0.5cm)	7846A
1	1.85mm male fixed short circuit (0.5cm)	7847A
1	1.85mm female fixed termination	7831A1
1	1.85mm male fixed termination	7831B1
1	1.85mm female to male air line (0.96cm)	7843S0.96
1	1.85mm female to male air line (1.15cm)	7843S1.15
1	1.85mm female to male air line (3.00)	7843S3.00
1	Torque wrench (8 in. lbs)	8799A1
1	5/16-inch double end wrench	8770Z6
1	3/16-inch double end wrench	7960Z1
1	Foam-lined wood instrument case	—

Components Included in 7850CK31 Kits

QUANTITY	DESCRIPTION	MODEL
1	1.85mm female fixed short circuit (0.5cm)	7846A
1	1.85mm male fixed short circuit (0.5cm)	7847A
1	1.85mm female fixed termination	7831A1
1	1.85mm male fixed termination	7831B1
1	1.85mm female to male air line (0.96cm)	7843S0.96
1	1.85mm female to male air line (1.15cm)	7843S1.15
1	1.85mm female to male air line (3.00)	7843S3.00
1	1.85mm female to 1.85mm female	7821A
1	1.85mm male to 1.85mm male	7821B
1	1.85mm female to 1.85mm male	7821C
1	Torque wrench (8 in. lbs)	8799A1
1	5/16-inch double end wrench	8770Z6
1	3/16-inch double end wrench	7960Z1
1	Foam-lined wood instrument case	—

2.4mm VNA Calibration Kits

7950CK40/41 SERIES AND
7950CK50/51 SERIES

Maury precision 2.4mm VNA calibration kits include each of the calibration standards and tools shown in the tables at the right. The 7950CK40/50 kits do not include adapters; the 7950CK41/51 kits include one each of the in-series adapters shown. Other in-series and between series adapters are sold separately.

Features

- 2.4mm Connectors
- DC to 50 GHz
- Compatible with Insight calibration SW and uncertainty analysis*
- Keysight, Rohde & Schwarz and Anritsu VNAs Supported

Calibration Methods Supported

- 7950CK40/41 – Fixed Load SOLT (DC–50 GHz)
- 7950CK50/51 – Characterized Device (CD) SOLT (0.05–50 GHz)

7950CK40

7950CK41

Components Included in 7950CK40/41 Kits

QUANTITY	DESCRIPTION	MODEL
1	2.4mm female fixed short circuit	7946A2
1	2.4mm male fixed short circuit	7946B2
1	2.4mm female open circuit termination	7948A2
1	2.4mm male open circuit termination	7948B2
1	2.4mm female fixed termination	7931A2
1	2.4mm male fixed termination	7931B2
1*	2.4mm female to 2.4mm female adapter	7921A1
1*	2.4mm male to 2.4mm male adapter	7921B1
1*	2.4mm female to 2.4mm male adapter	7921C1
1	Foam-lined wood Instrument case	—
1	5/16-inch torque wrench — 8 in. lbs.	8799A1
1	5/16-inch double end wrench	8770Z6

** These adapters are provided in the 7950CK41 kits, but are not included in the 7950CK40 kits.*

Components Included in 7950CK50/51 Kits

QUANTITY	DESCRIPTION	MODEL
1	2.4mm female fixed short circuit	7946A2
1	2.4mm male fixed short circuit	7946B2
1	2.4mm female open circuit termination	7948A2
1	2.4mm male open circuit termination	7948B2
1	2.4mm female fixed termination	7931A2
1	2.4mm male fixed termination	7931B2
1*	2.4mm female to 2.4mm female adapter	7921A1
1*	2.4mm male to 2.4mm male adapter	7921B1
1*	2.4mm female to 2.4mm male adapter	7921C1
1	Foam-lined wood Instrument case	—
1	5/16-inch torque wrench — 8 in. lbs.	8799A1
1	5/16-inch double end wrench	8770Z6

** These adapters are provided in the 7950CK51 kits, but are not included in the 7950CK50 kits.*

2.92mm VNA Calibration Kits

8770CK40/41 SERIES, AND
8770CK50/51 SERIES

Maury precision 2.92mm VNA calibration kits include each of the calibration standards and tools shown in the tables at the right. The 8770CK40/50 kits do not include adapters; the 8770CK41/51 kits include one each of the in-series adapters shown. Other in-series and between-series adapters are sold separately.

Features

- 2.92mm Connectors
- DC to 40 GHz
- Compatible with Insight calibration SW and uncertainty analysis*
- Keysight, Rohde & Schwarz and Anritsu VNAs Supported

Calibration Methods Supported

- 8770CK40/41 – Fixed Load SOLT (DC–40 GHz)
- 8770CK50/51 – Characterized Device (CD) SOLT (0.05–40 GHz)

8770CK40

8770CK41

Components Included in 8770CK40/41 Kits

QUANTITY	DESCRIPTION	MODEL
1	2.92mm female fixed short circuit	8771F4
1	2.92mm male fixed short circuit	8772F4
1	2.92mm female open circuit termination	8773A4
1	2.92mm male open circuit termination	8773B4
1	2.92mm female fixed termination	8775A4
1	2.92mm male fixed termination	8775B4
1*	2.92mm female to 2.92mm female adapter	8714A2
1*	2.92mm male to 2.92mm male adapter	8714B2
1*	2.92mm female to 2.92mm male adapter	8714C2
1	Foam-lined wood Instrument case	—
1	5/16-inch torque wrench — 8 in. lbs.	8799A1
1	5/16-inch double end wrench	8770Z6

** These adapters are provided in the 8770CK41 kits, but are not included in the 8770CK40 kits.*

Components Included in 8770CK50/51 Kits

QUANTITY	DESCRIPTION	MODEL
1	2.92mm female fixed short circuit	8771F4
1	2.92mm male fixed short circuit	8772F4
1	2.92mm female open circuit termination	8773A4
1	2.92mm male open circuit termination	8773B4
1	2.92mm female fixed termination	8775A4
1	2.92mm male fixed termination	8775B4
1*	2.92mm female to 2.92mm female adapter	8714A2
1*	2.92mm male to 2.92mm male adapter	8714B2
1*	2.92mm female to 2.92mm male adapter	8714C2
1	Foam-lined wood Instrument case	—
1	5/16-inch torque wrench — 8 in. lbs.	8799A1
1	5/16-inch double end wrench	8770Z6

** These adapters are provided in the 8770CK51 kits, but are not included in the 8770CK50 kits.*

3.5mm VNA Calibration Kits

8050CK40/41 SERIES, AND
8050CK50/51 SERIES

Maury precision 3.5mm VNA calibration kits include each of the calibration standards and tools shown in the tables at the right. The 8050CK40/50 kits do not include adapters; the 8050CK41/51 kits include one each of the in-series adapters shown. Other in-series and between-series adapters are sold separately.

Features

- 3.5mm Connectors
- DC to 26.5 GHz
- Compatible with Insight calibration SW and uncertainty analysis*
- Keysight, Rohde & Schwarz and Anritsu VNAs Supported

Calibration Methods Supported

- 8050CK40/41 – Fixed Load SOLT (DC–26.5 GHz)
- 8050CK50/51 – Characterized Device (CD) SOLT (0.05–26.5 GHz)

8050CK40

8050CK41

Components Included in 8050CK40/41 Kits

QUANTITY	DESCRIPTION	MODEL
1	3.5mm female fixed short circuit	8046F6
1	3.5mm male fixed short circuit	8047F6
1	3.5mm female open circuit termination	8048A6
1	3.5mm male open circuit termination	8048B6
1	3.5mm female fixed termination	8031A6
1	3.5mm male fixed termination	8031B6
1*	3.5mm female to 3.5mm female adapter	8021A3
1*	3.5mm male to 3 .5mm male adapter	8021B3
1*	3.5mm female to 3.5mm male adapter	8021C3
1	5/16-inch torque wrench — 8 in. lbs.	8799A1
1	7/16-inch double end wrench	8770Z7
1	5/16-inch double end wrench	8770Z6
1	Foam-lined wood Instrument case	—

** These adapters are provided in the 8050CK41 kits, but are not included in the 8050CK40 kits.*

Components Included in 8050CK50/51 Kits

QUANTITY	DESCRIPTION	MODEL
1	3.5mm female fixed short circuit	8046F6
1	3.5mm male fixed short circuit	8047F6
1	3.5mm female open circuit termination	8048A6
1	3.5mm male open circuit termination	8048B6
1	3.5mm female fixed termination	8031A6
1	3.5mm male fixed termination	8031B6
1*	3.5mm female to 3.5mm female adapter	8021A3
1*	3.5mm male to 3 .5mm male adapter	8021B3
1*	3.5mm female to 3.5mm male adapter	8021C3
1	5/16-inch torque wrench — 8 in. lbs.	8799A1
1	7/16-inch double end wrench	8770Z7
1	5/16-inch double end wrench	8770Z6
1	Foam-lined wood Instrument case	—

** These adapters are provided in the 8050CK51 kits, but are not included in the 8050CK50 kits.*

7mm VNA Calibration Kits

MODELS 2650CK40 AND 2650CK50

Maury precision 7mm VNA calibration kits include each of the calibration standards and tools shown in the tables at the right. The 2650CK40/50 kits do not include adapters; in-series and between-series adapters are sold separately.

Features

- 7mm Connectors
- DC to 18 GHz
- Compatible with Insight calibration SW and uncertainty analysis*
- Keysight, Rohde & Schwarz and Anritsu VNAs Supported

Calibration Methods Supported

- 2650CK40 – Fixed Load SOLT (DC–18.0 GHz)
- 2650CK50 – Characterized Device (CD) SOLT (0.05–18.0 GHz)

2650CK40

2650CK50

Components Included in 2650CK40 Kits

QUANTITY	DESCRIPTION	MODEL
1	7mm fixed short circuit	2615D3
1	7mm open circuit termination	2616F1
1	7mm fixed termination	2610F1
1	3/4-inch torque wrench — 12 in. lbs.	2698C2
1	Foam-lined wood Instrument case	—

Components Included in 2650CK50 Kits

QUANTITY	DESCRIPTION	MODEL
1	7mm fixed short circuit	2615D3
1	7mm open circuit termination	2616F1
1	7mm fixed termination	2610F1
1	3/4-inch torque wrench — 12 in. lbs.	2698C2
1	Foam-lined wood Instrument case	—

Type N VNA Calibration Kits

8850CK40/41 SERIES AND
8850CK50/51 SERIES

Maury precision Type N VNA calibration kits include each of the calibration standards and tools shown in the tables at the right. The 8850CK40/50 kits do not include adapters; the 8850CK41/51 kits include one each of the in-series adapters shown. Other in-series and between-series adapters are sold separately.

Features

- Type N Connectors
- DC to 18 GHz
- Compatible with Insight calibration SW and uncertainty analysis*
- Keysight, Rohde & Schwarz and Anritsu VNAs Supported

Calibration Methods Supported

- 8850CK40/41 – Fixed Load SOLT (DC–18.0 GHz)
- 8850CK50/51 – haracterized Device (CD) SOLT (0.05–18.0 GHz)

8850CK40

8850CK41

Components Included in 8850CK40/41 Kits

QUANTITY	DESCRIPTION	MODEL
1	Type N female fixed short circuit	8806G2
1	Type N male fixed short circuit	8807C2
1	Type N female open circuit termination	8809B2
1	Type N male open circuit termination	8810B2
1	Type N female fixed termination	2510E2
1	Type N male fixed termination	2510F2
1*	Type N female to Type N female adapter	8828A2
1*	Type N male to Type N male adapter	8828B2
1*	Type N female to Type N male adapter	8828C2
1	3/4-inch torque wrench — 12.0 in. lbs.	2698C2
1	Foam-lined wood Instrument case	—
1	1/2 - 9/16 inch end wrench	2517S3

** These adapters are provided in the 8850CK41 kits, but are not included in the 8850CK40 kits.*

Components Included in 8850CK50/51 Kits

QUANTITY	DESCRIPTION	MODEL
1	Type N female fixed short circuit	8806G2
1	Type N male fixed short circuit	8807C2
1	Type N female open circuit termination	8809B2
1	Type N male open circuit termination	8810B2
1	Type N female fixed termination	2510E2
1	Type N male fixed termination	2510F2
1*	Type N female to Type N female adapter	8828A2
1*	Type N male to Type N male adapter	8828B2
1*	Type N female to Type N male adapter	8828C2
1	3/4-inch torque wrench — 12.0 in. lbs.	2698C2
1	Foam-lined wood Instrument case	—
1	1/2 - 9/16 inch end wrench	2517S3

** These adapters are provided in the 8850CK51 kits, but are not included in the 8850CK50 kits.*

75Ω Type N VNA Calibration Kits

888040/41 SERIES

Maury precision 75Ω Type N VNA calibration kits include each of the calibration standards shown in the tables below. The 8880CK40 kits do not include adapters; the 8880CK41 kits include one each of the in-series adapters shown.

Features

- 75Ω Type N Connectors
- DC to 18 GHz
- Simple Fixed Load Calibration
- Keysight, Rohde & Schwarz and Anritsu VNAs Supported

Calibration Methods Supported

- 8880CK40/41 – Fixed Load SOLT (DC–18 GHz)

8880CK40

8880CK41

Components Included in 8880CK40 Kits

QUANTITY	DESCRIPTION	MODEL
1	75Ω Type N female fixed short circuit	8884A1
1	75Ω Type N male fixed short circuit	8884B1
1	75Ω Type N female open circuit	8885A1
1	75Ω Type N male open circuit	8885B1
1	75Ω Type N female fixed termination	8883A1
1	75Ω Type N male fixed termination	8883B1
1	Foam-lined wood Instrument case	—

Components Included in 8880CK41 Kits

QUANTITY	DESCRIPTION	MODEL
1	75Ω Type N female fixed short circuit	8884A1
1	75Ω Type N male fixed short circuit	8884B1
1	75Ω Type N female open circuit	8885A1
1	75Ω Type N male open circuit	8885B1
1	75Ω Type N female fixed termination	8883A1
1	75Ω Type N male fixed termination	8883B1
1*	75Ω Type N female to 75Ω Type N female adapter	8882A1
1*	75Ω Type N male to 75Ω Type N male adapter	8882B1
1*	75Ω Type N female to 75Ω Type N male adapter	8882C1
1	Foam-lined wood Instrument case	—

** These adapters are provided in the 8880CK41 kits, but are not included in the 8880CK40 kits.*

TNC VNA Calibration Kits

MODELS 8650CK10/11 AND 8650CK20/21

Features

- TNC Connectors
- DC to 18 GHz
- High Performance
- Keysight, Rohde & Schwarz and Anritsu VNAs Supported

Calibration Methods Supported

- 8650CK10 & 8650CK11 – Fixed Load SOLT (DC–18.0 GHz)
- 8650CK20 & 8650CK21 – Sliding/ Fixed Load SOLT (DC–18.0 GHz)

8650CK10

8650CK11

Maury precision TNC VNA calibration kits include each of the calibration standards and tools shown in the tables at the right. The 8650CK10/20 kits do not include adapters; the 8650CK11/21 kits include one each of the in-series adapters shown. Other in-series and between-series adapters are sold separately.

Components Included in 8650CK10/11 Kits

QUANTITY	DESCRIPTION	MODEL
1	TNC female fixed short circuit	8615A
1	TNC male fixed short circuit	8615B
1	TNC female open circuit	8609B
1	TNC male open circuit	8610B
1	TNC female fixed termination	332E
1	TNC male fixed termination	332F
1*	TNC female to TNC female adapter	232A11
1*	TNC male to TNC male adapter	232B11
1*	TNC female to TNC male adapter	232C11
1	Foam-lined wood instrument case	—

** These adapters are provided in the 8650CK11 kits, but are not included in the 8650CK10 kits.*

Components Included in 8650CK20/21 Kits

QUANTITY	DESCRIPTION	MODEL
1	TNC female fixed short circuit	8615A
1	TNC male fixed short circuit	8615B
1	TNC female open circuit	8609B
1	TNC male open circuit	8610B
1	TNC female fixed termination	332E
1	TNC male fixed termination	332F
1*	TNC female to TNC female adapter	232A11
1*	TNC male to TNC male adapter	232B11
1*	TNC female to TNC male adapter	232C11
1	TNC female sliding termination	452A1
1	TNC male sliding termination	452B1
1	9/16-inch torque wrench — 12 in. lbs.	2698G1
1	7/16-inch open end wrench	8770Z7
1	Foam-lined wood instrument case	—

** These adapters are provided in the 8650CK21 kits, but are not included in the 8650CK20 kits.*

AFTNC VNA Calibration Kits

MODELS 8680CK10/11 AND 8680CK20/21

Maury precision AFTNC VNA calibration kits include each of the calibration standards and tools shown in the tables at the right. The 8680CK10/20 kits do not include adapters; the 8680CK11/21 kits include one each of the in-series adapters shown. Other in-series and between-series adapters are sold separately.

Features

- AFTNC Connectors
- DC to 20 GHz
- High Performance
- Keysight, Rohde & Schwarz and Anritsu VNAs Supported

Calibration Methods Supported

- 8680CK10 & 8680CK11 – Fixed Load SOLT (DC–20.0 GHz)
- 8680CK20 & 8680CK21 – Sliding/ Fixed Load SOLT (DC–20.0 GHz)

8680CK10

8680CK11

Components Included in 8680CK10/11 Kits

QUANTITY	DESCRIPTION	MODEL
1	AFTNC female fixed short circuit	8686A
1	AFTNC male fixed short circuit	8687A
1	AFTNC female open circuit	8685A
1	AFTNC male open circuit	8685B
1	AFTNC female fixed termination	8684A
1	AFTNC male fixed termination	8684B
1*	AFTNC female to AFTNC female adapter	8688A
1*	AFTNC male to AFTNC male adapter	8688B
1*	AFTNC female to AFTNC male adapter	8688C
1	Foam-lined wood instrument case	—

** These adapters are provided in the 8680CK11 kits, but are not included in the 8680CK10 kits.*

Components Included in 8680CK20/21 Kits

QUANTITY	DESCRIPTION	MODEL
1	AFTNC female fixed short circuit	8686A
1	AFTNC male fixed short circuit	8687A
1	AFTNC female open circuit	8685A
1	AFTNC male open circuit	8685B
1	AFTNC female fixed termination	8684A
1	AFTNC male fixed termination	8684B
1*	AFTNC female to AFTNC female adapter	8688A
1*	AFTNC male to AFTNC male adapter	8688B
1*	AFTNC female to AFTNC male adapter	8688C
1	AFTNC female sliding termination	8683A
1	AFTNC male sliding termination	8683B
1	9/16-inch torque wrench — 12 in. lbs.	2698G1
1	7/16-inch open end wrench	8770Z7
1	Foam-lined wood instrument case	—

** These adapters are provided in the 8680CK21 kits, but are not included in the 8680CK20 kits.*

BNC VNA Calibration Kits

8550CK10 & 8580CK10 MODELS

Features

- 50Ω or 75Ω BNC Connectors
- DC to 10.0 GHz & DC to 12.0 GHz
- Simple Fixed Load Calibration
- Keysight, Rohde & Schwarz and Anritsu VNAs Supported

Calibration Methods Supported

- 8550CK10 (50Ω) – Fixed Load SOLT (DC–10.0 GHz)
- 8580CK10 (75Ω) – Fixed Load SOLT (DC–12.0 GHz)

8550CK10

8580CK10

Maury precision BNC VNA calibration kits include each of the calibration standards and tools shown in the tables at the right. Between-series adapters are sold separately.

Components Included in 8550CK10 Kits

QUANTITY	DESCRIPTION	MODEL
1	50Ω BNC female fixed short circuit	361N2
1	50Ω BNC male fixed short circuit	361P2
1	50Ω BNC female open circuit	371N2
1	50Ω BNC male open circuit	371P2
1	50Ω BNC female fixed termination	351A2
1	50Ω BNC male fixed termination	351B2
1	Foam-lined wood instrument case	—

Between series adapters are available by separate order. Go to maurymw.com for more information.

Components Included in 8580CK10 Kits

QUANTITY	DESCRIPTION	MODEL
1	75Ω BNC female fixed short circuit	8584A1
1	75Ω BNC male fixed short circuit	8584B1
1	75Ω BNC female open circuit	8585A1
1	75Ω BNC male open circuit	8585B1
1	75Ω BNC female fixed termination	8583A1
1	75Ω BNC male fixed termination	8583B1
1	Foam-lined wood instrument case	—

Between series adapters are available by separate order. Go to maurymw.com for more information.

Waveguide VNA Calibration Kits

CK10/12 & CK30/32 MODELS

Features

- 2.6 to 50 GHz
- WR284 Through WR22
- SSLT and TRL calibration
- Keysight, Rohde & Schwarz and Anritsu VNAs Supported

Components Included in CK10/12 Kits

Qty	Description	Model
1**	Fixed flush (reference plane) short	344 series
1	1/8-λ fixed offset short	340 series
1	3/8-λ fixed offset short	340 series
1	Precision fixed termination	301 series
1**	Straight section (rectangular)	102/3/6 series
1*	3/32-in. hex ball driver *	J998T2
1	Flange hardware (including the indexing pin set)	—
1	Instrument case	—

Components Included in CK30/32 Kits

Qty	Description	Model
1	Fixed flush (reference plane) short	344 series
1	1/4-λ straight section (shim)	322 series
1	Precision fixed termination	301 series
1**	Straight section (rectangular)	102/3/6 series
1*	3/32-in. hex ball driver *	J998T2
1	Flange hardware (including the indexing pin set)	—
1	Instrument case	—

** Included in the K, Q, U and J band kits only.*

*** Included in CK12/32 kits.*

The Importance of VNA Calibration

Any uncalibrated test setup has systematic errors inherent in the equipment used. The ability to obtain an accurate measurement of a device under test. The basis of network analyzer error correction is the measurement of known electrical standards, such as a thru, open circuit, short circuit, and precision load impedance. By calibrating your network analyzer with these standards, you can compensate for the inherent imperfections.

Description

CK10/12 - The CK10/12 SSLT Waveguide Calibration Kits are designed to provide accurate calibration of vector network analyzers (VNAs) that are used for measurements in standard rectangular waveguide from 2.6 to 50 GHz (WR284–WR22). Each kit includes all the components needed for accurate calibration of most VNAs to ensure high effective directivity after calibration.

CK30/32 - Maury CK30/32 calibration kits are designed to provide accurate Thru-Reflect-Line (TRL), Short-Short-Load-Thru (SSLT) and Offset Load calibrations of vector network analyzers (VNAs) for measurements in rectangular waveguide from 2.6 to 50 GHz (WR284 to WR22). Each kit includes all the components needed for accurate TRL, SSLT or Offset Load calibration of supported VNA models.

**Precision straight sections and a fixed (reference plane) short are also provide as verification standards in the CK12 or CK32 options.*

Flange Description

The components in these kits are equipped with Maury Precision Flanges (MPF) which conform to EIA WR standards for rectangular or round waveguide flanges. MPF flanges have precision indexing holes and corresponding indexing pins for precise alignment when mating, which ensures excellent measurement repeatability. Flange diagrams and other details can be found at http://www.maurymw.com. (Use the search feature with search term “MPF”.)

Calibration Methods

CK10/12 - These kits are configured for use in performing one-port SSL (Short-Short-Load) calibrations for measuring VSWR/Return Loss, or full two-port SSLT (Short-Short-Load-Thru) calibrations to perform forward and reverse transmission and reflection measurements.

CK30/32 - These kits are configured for use in performing full two-port TRL (Thru-Reflect-Line) and SSLT (Short-Short-Load-Thru) calibrations; two standard methods for measuring forward and reverse transmission and reflection measurements). They can also be used to perform Offset Load calibrations on VNAs that support that calibration method.

Component Specifications

CK10/12 SSLT & CK30/32 TRL Kits

Fixed Flush Shorts – Model Series 344

These machined fixed shorts are flat-face/flat-plane shorts designed to terminate round or rectangular waveguide connectors at the mating plane, over a frequency range from 2.6 to 50 GHz. They are used to establish a reference plane in systems and in making loss measurements.

1/8λ & 3/8λ Fixed Offset Shorts – Model Series 340

These fixed offset shorts are considered one of the more accurate means of obtaining a 180° phase difference in waveguide. Using these single-piece devices reduces the number of flange interfaces during calibration; helping to maintain an essentially constant magnitude of current flow across the calibration plane. Those in rectangular waveguide are nominally 1/8λ and 3/8λ offset at frequencies near the waveguide band centers. These frequencies are chosen to equalize phase differences at band edges, and thus are not at the exact band centers.

Offset delay ranges from 50.835 – 4.007 ps for the 1/8λ shorts and 152.506 – 12.002 for the 3/8λ shorts; calculated without consideration for the dispersive effect of waveguide if the short is in air dielectric coaxial line. This conforms to the convention established for Agilent network analyzers. Anritsu analyzers use the actual mechanical offset in centimeters.

1/4λ Precision Straight Sections – Model Series 322B

These 322B series 1/4λ straight sections are reduced height spacers or shims which provide an accurately known VSWR which is directly calculable from their mechanical dimensions. The shims are designed for a theoretical VSWR of 1.00. The shims are fabricated from aluminum and are provided with precision indexing holes for excellent flange alignment. Their simple geometry allows direct calculation of reflection, loss, transfer and group delay characteristics and makes them ideally suited for quickly checking the performance and accuracy of automated network analyzers.

Precision Fixed Terminations – Model Series 301

These low power fixed terminations feature low VSWR (1.025 – 1.040 max up to 50.0 GHz; typically <1.02 from 3.95 to 18.0 GHz). Power handling is rated from 25W (avg)/10kW (peak) to 0.2W (avg)/0.03kW (peak) depending on frequency range.

Verification Stds – Precision Straight Sections

These precision straight sections exhibit low VSWR (1.025 max) across the frequency range of operation. These precision stds can be used along with the fixed flush shorts as verification stds to validate accuracy of calibration.

Available Models

Waveguide Designation (EIA WR NO.)	FREQUENCY RANGE (GHz)	MMC WAVEGUIDE BAND	SSLT CALIBRATION KIT	SSLT CALIBRATION KIT w\ VERIFICATION STD.	TRL CALIBRATION KIT	TRL CALIBRATION KIT w\ VERIFICATION STD.	FLANGE DESIGN
WR284	2.60 - 3.95	S	WR284CK10	WR284CK12	WR284CK30	WR284CK32	MPF284C
WR229	3.30 - 4.90	E	WR229CK10	WR229CK12	WR229CK30	WR229CK32	MPF229B
WR187	3.95 - 5.85	G	WR187CK10	WR187CK12	WR187CK30	WR187CK32	MPF187C
WR159	4.90 - 7.05	F	WR159CK10	WR159CK12	WR159CK30	WR159CK32	MPF159B
WR137	5.85 - 8.20	C	WR137CK10	WR137CK12	WR137CK30	WR137CK32	MPF137C
WR112	7.05 - 10.0	H	WR112CK10	WR112CK12	WR112CK30	WR112CK32	MPF112B
WR90	8.20 - 12.4	X	WR90CK10	WR90CK12	WR90CK30	WR90CK32	MPF90C
WR75	10.0 - 15.0	M	WR75CK10	WR75CK12	WR75CK30	WR75CK32	MPF75B
WR62	12.4 - 18.0	P	WR62CK10	WR62CK12	WR62CK30	WR62CK32	MPF62
WR51	15.0 - 22.0	N	WR51CK10	WR51CK12	WR51CK30	WR51CK32	MPF51B
WR42	18.0 - 26.5	K	WR42CK10	WR42CK12	WR42CK30	WR42CK32	MPF42
WR34	22.0 - 33.0	Q	—	—	WR34CK30	WR34CK32	MPF34
WR28	26.5 - 40.0	U	WR28CK10	WR28CK12	WR28CK30	WR28CK32	MPF28
WR22	33.0 - 50.0	J	WR22CK10	WR22CK12	WR22CK30	WR22CK32	MPF22

Verification Kits

The Importance of VNA Calibration Validation

VNA calibration is performed to correct for the systematic imperfections which existing in all network analyzers and allow for users to shift the reference plane from the instrument test ports to a user-defined reference plane. However, how can one be sure that the calibration performed will result in accurate measurements?

Validation is by far the most important step in a measurement process. Conventional validation techniques rely on an estimate of the residual errors after a calibration, source match, directivity and tracking, and are typically evaluated by measuring peak-to-peak ripple through a TDR method. These techniques rely on an airline as the validation standard, and the accuracy of the validation can be severely impacted by how well the airline has been machined and handled.

Maury's new line of Verification Kits allows for a more thorough and definitive validation.

VNA Validation Methods

Maury Verification Kits consist of the following verification standards and allow for 1-port and 2-port calibration validation for well-matched and mismatched DUTs:

- Loads (Male and Female)
- Offset Short (Male and Female)
- Beaded Airline (Male to Female)
- Beaded Mismatch (Male to Female)

These standard can be used to validate the calibration using one of the following methods:

Method 1- S parameters comparison of User-Characterized and Factory-Characterized Verification Standards

This method involves a user measuring pre-characterized verification devices with similar performances to their own device; i.e. using a short as a validation of a high-reflection single-port device, or an airline for well-matched low-loss devices. The measurement data is then compared to the factory-measured data and the user determines whether the calibration is valid or not, based on experience or general guidelines. There is no clear pass-fail criteria that quantifies whether a calibration is sufficiently accurate to proceed to device measurement, or whether a calibration needs to be repeated.

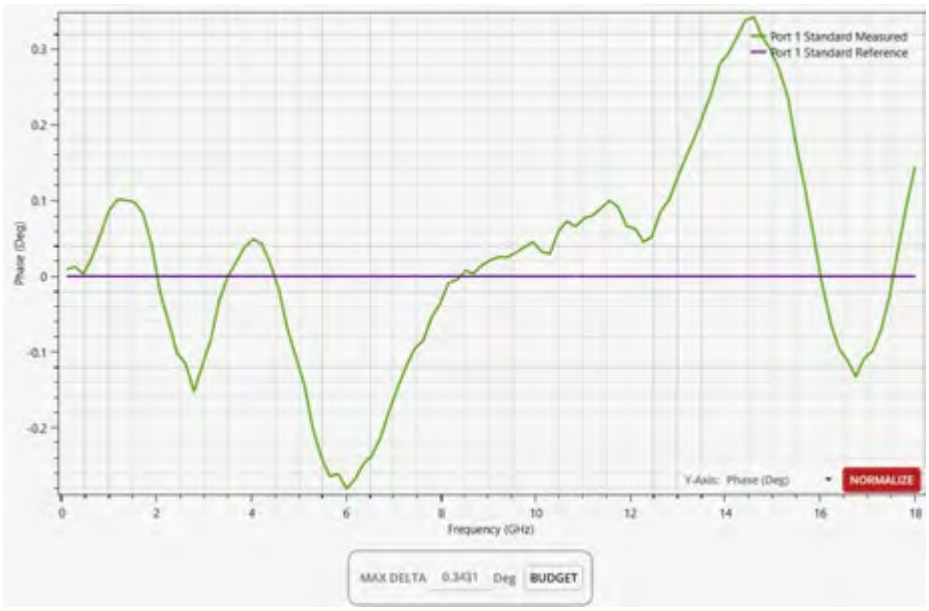


Figure 1. Normalized phase response between user-measured and factory-measured standard

Method 2 – S-parameters Comparison of User-Characterized and Factory-Characterized Verification Standards including Measured Uncertainty Boundaries

It is possible to define clear pass-fail criteria based on the use of uncertainty boundaries. When the uncertainty boundaries measured on a verification device by the user overlaps the uncertainty boundaries measured on the same verification device at the factory, it is defined as an accurate calibration. If the boundaries do not overlap, then recalibration is recommended. Maury offers a VNA Calibration and Measurement software suite, Insight, which among other things automates this process by guiding users through the calibration validation and clearly identifies whether the calibration can be used or must be repeated. For more information on Insight, please visit maurymw.com.

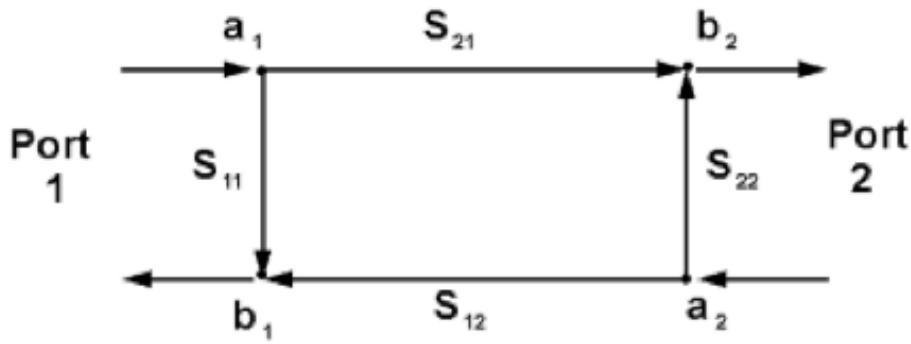


Figure 2. Normalized amplitude response between user-characterized and factory-characterized standard including uncertainty boundaries.

Recommended Accessories

Insight Calibration and Measurement Software:

Insight is the industry's first commercial software suite designed to empower VNA users and help them make better decisions by quantifying measurement uncertainty. Insight is an agnostic software tool compatible with most commercial VNAs and represents a paradigm shift in the way users approach VNA calibration, validation, measurement, visualization and analysis. More information regarding Insight can be found in data sheet 4T-023.

VNA Calibration Kits:

Maury offers coaxial VNA calibration kits up to 67 GHz and waveguide calibration kits up to 50 GHz in standard connector and waveguide sizes. Coaxial 2.4mm, 2.92mm, 3.5mm, 7mm and Type N calibration kits are available as fixed-load SOLT kits with either standard polynomial equations or characterized device (CD) with individually characterized standards. More information can be found in data sheets 2Z-056 (1.85mm), 2Z-072 (2.4mm), 2Z-073 (2.92mm), 2Z-074 (3.5mm), 2Z-075 (7mm), and 2Z-076 (Type N), 2Z-062 (TNC), 2Z-069 (BNC) and 3H-081 (WR284 Through WR22).

Available Models

Model	Connector	Frequency (GHz)	Included Verification Standards					
			Load (male)	Load (female)	Offset Short (male)	Offset Short (female)	Beaded Airline	Mismatch Airline
7950CK60	2.4mm	0.05--50	7931B2	7913A2	7946D2	7946C2	7942C	7942C25
8770CK60	2.92mm	0.05-40	8775B4	8775A4	8772A2	8771A2	8776C	8776C25
8050CK60	3.5mm	0.05-26.5	8031B6	8031A6	8047A6	8046A6	8042C1	8042C25
2650CK60	7mm	0.05-18	2610F1		2649A1		2603F1	2603F75
8850CK60	Type N	0.05-18	2510F2	2510E2	8807A2	8806A2	2503H	2503H75

7950CK60

8770CK60

8050CK60

2650CK60

8850CK60

Precision Fixed Terminations

GENERAL INFORMATION

Fixed Terminations

A precision fixed termination (or load) consists of an immovable, (fixed) termination which, when mated to the end of a trans-mission line or cable, absorbs nearly all of the signal energy traveling toward it. An ideal “matched” condition exists when a termination with an impedance value of Z0, is connected to the end of a transmission line or cable that also has a characteristic impedance of Z0. Such an ideal “matched” condition (one with no mismatch between the termination and its mated line or cable) is critical if a voltage standing wave ratio (VSWR) of 1.0:1 is to be achieved in a system with a 50 or 75 ohm impedance value. Simply put, the more closely the 1.0:1 ratio is approached, the more accurate the measurements that can be made from a system.

Maury precision fixed terminations are designed to exacting specifications and are as close to the ideal impedance as it is mechanically possible to make them. The following pages provide detailed information about the various types of precision fixed terminations offered by Maury. Most are normally sold as components of Maury VNA calibration kits, but may also be purchased separately as replacement parts or spares.

Precision Fixed Terminations Available Models

Model	Sex	Connector Type	Frequency Range (GHz)	VSWR	Power Rating
7831A1	Female	1.85mm	DC — 1.0 1.0 — 10.0 10.0 — 26.5 26.5 — 67.0	1.02 1.07 1.10 1.20	0.5 watt CW 0.25 kW peak
7831B1	Male				
7931A2	Female	2.4mm	DC — 4.0 4.0 — 50.0	1.02 1.16	0.5 watt CW 0.25 kW peak
7931B2	Male				
8775A4	Female	2.92mm	DC — 4.0 4.0 — 40.0	1.02 1.12	0.5 watt CW 0.25 kW peak
8775B4	Male				
8031A6	Female	3.5mm	DC — 2.0 2.0 — 18.0 18.0 — 26.5	1.025 1.045 1.085	0.5 watt CW 0.25 kW peak
8031B6	Male				
2610F1	—	7mm	DC — 2.0 2.0 — 8.0 8.0 — 18.0	1.02 1.03 1.06	1 watt CW 1 kW peak
2510E2	Female	Type N	DC — 2.0 2.0 — 4.0 4.0 — 18.0	1.025 1.04 1.065	1 watt CW 1 kW peak
2510F2	Male				
8583A1	Female	BNC 75Ω	DC — 2.0 2.0 — 4.0 4.0 — 12.0	1.02 1.04 1.10	1 watt CW
8583B1	Male				
351A2	Female	BNC 50Ω	DC — 2.0 2.0 — 4.0 4.0 — 10.0	1.04 1.10 1.20	2 watt CW 1 kW peak
351B2	Male				
332E	Female	TNC	DC — 4.0 4.0 — 12.0 12.0 — 18.0	1.06 1.10 1.15	1 watt CW 1 kW peak
332F	Male				

Precision Fixed Terminations

WAVEGUIDE (301 SERIES)

G301

S301A

K301

Features

- Low VSWR
- 2.6 to 50 GHz
- Moderate Power Handling

Description

The 301 series low power waveguide fixed terminations are precision, low VSWR terminations suited to a wide variety of general purpose and precision laboratory applications. They can be used for full band one-port calibration and full two-port, isolation calibration.

Waveguide Flange Description

The waveguide flanges used on these terminations are Maury Precision Flanges (MPF) in rectangular, or round configurations. MPF flanges have precision indexing holes and removable indexing pins for excellent measurement repeatability. The millimeter waveguide flanges in the WR22 and smaller sizes are of a unique Maury-pioneered design featuring a raised outer rim to prevent the flanges from cocking during connection. These flanges will mate with corresponding UG ( )/U flanges. (See page 134 for flange details.)

Available Models

MODEL	FREQUENCY RANGE (GHz)	VSWR (Maximum)	EIA WR NUMBER	EQUIVALENT FLANGE	POWER RATING		LENGTH	
					AVE. (W)	PEAK (kW)	inches	(cm)
S301A	2.60 — 3.95	1.025	284	UG584/U	5.0	2.0	10.4	(26.4)
E301F	3.30 — 4.90	1.020	229	CPR229F	5.0	2.0	7.4	(18.8)
G301	3.95 — 5.85	1.020	187	UG149A/U	5.0	2.0	6.4	(16.3)
F301C	4.90 — 7.05	1.020	159	CPR159F	3.0	1.0	5.8	(14.7)
C301	5.85 — 8.20	1.020	137	UG344/U	2.5	1.0	5.2	(13.2)
H301A	7.05 — 10.00	1.015	112	UG51/U	2.0	1.0	5.0	(12.7)
X301A	8.20 — 12.40	1.015	90	UG39/U	1.0	1.0	5.0	(12.7)
M301A	10.00 — 15.00	1.020	75	MPF75	1.0	1.0	5.0	(12.7)
P301A	12.40 — 18.00	1.020	62	UG419/U	1.0	1.0	4.0	(10.2)
N301	15.00 — 22.00	1.025	51	MPF51	0.5	0.2	3.1	(7.9)
K301	18.00 — 26.50	1.025	42	UG595/U	0.5	0.2	2.8	(7.1)
Q301A	22.00 — 33.00	1.025	34	UG1530/U	0.5	0.2	4.25	(10.8)
U301	26.50 — 40.00	1.025	28	UG599/U	0.5	0.2	2.2	(5.6)
J301A	33.00 — 50.00	1.040	22	UG383[1]	0.5	0.1	1.6	(4.1)

[1] Units are supplied with Maury precision flanges (MPF) which mate with the UG flanges shown.

Fixed Flush and Fixed Offset Shorts

GENERAL INFORMATION

Fixed flush and fixed offset short circuit terminations (shorts) are used to establish reference planes in transmission systems and as key elements in the calibration of vector network analyzers (VNAs). Offset shorts can be used for banded calibrations of VNA. Those with the longest offset are often used to evaluate the calibration effectiveness of a VNA by measuring the effective source match after calibration.

In general, the shorting plane of fixed flush shorts is at the connector reference plane, and at some predetermined offset in offset shorts.

Many of the shorts listed in this section are components of the Maury VNA calibration kits described on pages 107-116 of this catalog. Others are available as supplements to the components in these kits. In all cases, the specification “Phase Accuracy” is defined in this section as phase deviation from a nominal unit.

Available Models

Model	Sex	Connector Type	Frequency Range (GHz)	Phase Accuracy	Reflection Coefficient	Offset Length (Inches)
7846A	Female	1.85mm	DC — 67.0	± 4.0°	0.98	0.1968
7847A	Male					
7946A2	Female	2.4mm	DC — 50.0	± 2.0°	0.98	0.2000
7946B2	Male					
7946C2	Female			N/A		1.2000
7946D2	Male					
8771F4	Female	2.92mm	DC — 40.0	± 2.0°	0.98	0.1970
8772F4	Male					
8771A2	Female			N/A		1.1803
8772A2	Male					
8046F6	Female	3.5mm	DC — 26.5	± 2.0°	0.98	0.1970
8047F6	Male					
8046A6	Female			N/A		1.1803
8047A6	Male					
360D	Female	3.5mm\SMA*	DC — 40.0	± 2.0°	0.99	0.0000
360B	Male					
2615D3	-	7mm	DC — 18.0	± 0.3°	0.995	0.0000
2649A1	-			N/A		1.0050
8806G2	Female	Type N	DC - 18.0	± 2.0°	0.98	0.4972
8807C2	Male					
8806A2	Female			N/A		0.9833
8807A2	Male					1.1913
8584A1	Female	BNC 75Ω	DC — 2.0 2.0 — 3.0 3.0 — 12.0	± 1.0° ± 2.0° ± 6.0°	0.98	0.3937
8584B1	Male					
361N2	Female	BNC 50Ω	DC — 12.4	± 5.0°	0.98	0.1410
361P2	Male					
8615A	Female	TNC	DC — 18.0	± 5.0°	0.98	0.5000
8615B	Male					0.7000
8686A	Female	AFTNC	DC — 20.0	± 2.0°	0.98	0.9833
8687A	Male					0.4915

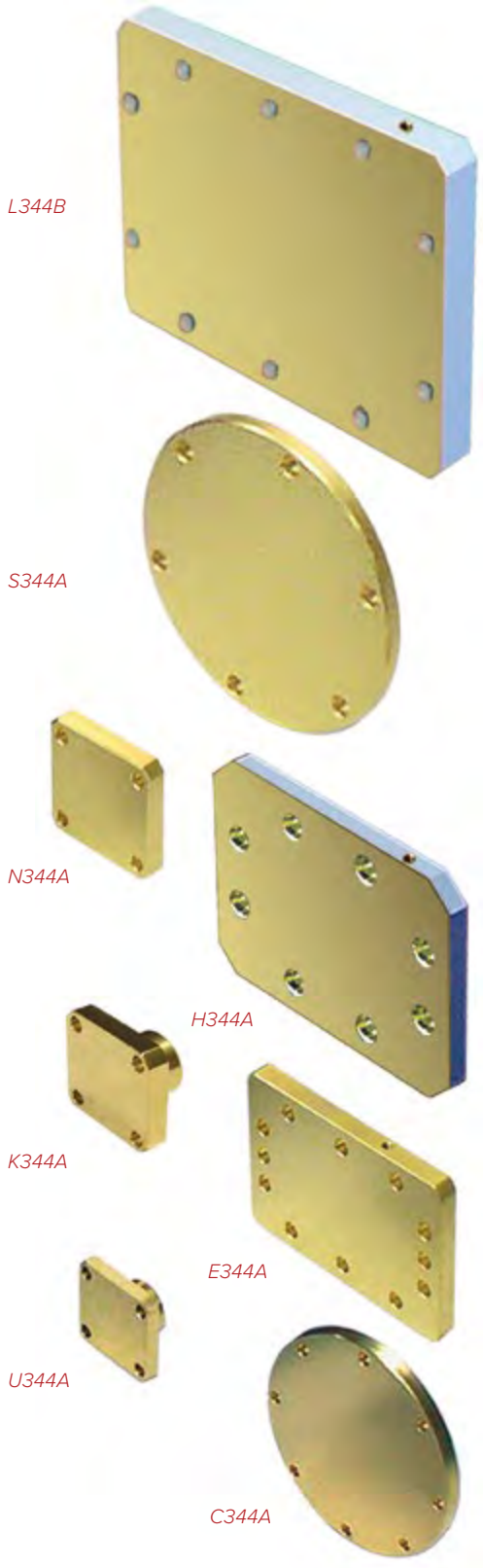
** Flush shorts that can be used with SMA, 3.5mm and 2.92mm*

Waveguide Fixed Flush Shorts

MODEL SERIES 344

Description

These machined fixed shorts are designed to terminate round or rectangular waveguide connectors at the mating plane. They are used to establish a reference plane in systems and in making loss measurements. They are flat face/flat plane shorts that cover frequencies from 2.6 to 50.0 GHz. They may be ordered with user-specified flanges; with or without Maury precision indexing holes. These shorts are included as components of Maury's CK12/30/32 series VNA calibration kits as listed on pages 117-118. They may also be purchased separately as spare or replacement parts for these kits.

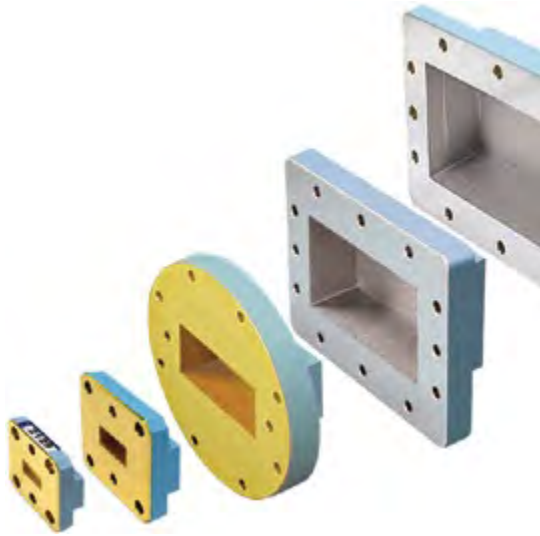


Available models

MODEL	MATES WITH EQUIVALENT FLANGE	EIA WR NUMBER	FREQUENCY RANGE (GHz)
S344A	UG53/U	284	2.6 — 3.95
E344B	CPR229F	229	3.3 — 4.9
G344A	UG149A/U	187	3.95 — 5.85
F344B	CPR159F	159	4.9 — 7.05
C344A	UG344/U	137	5.85 — 8.2
H344A	UG51/U	112	7.05 — 10.0
X344A	UG39/U	90	8.2 — 12.4
M344A	MPF75	75	10.0 — 15.0
P344A	UG419U	62	12.4 — 18.0
N344A	MPF51	51	15.0 — 22.0
K344A	UG595/U	42	18.0 — 26.5
		34	22.0 — 33.0
U344A	UG599/U	28	26.5 — 40.0
K344D	UG383/U	22	33.0 — 50.0

Waveguide Fixed Offset Shorts

MODEL SERIES 340



Description

Offset shorts with 1/8 and 3/8 wavelength offsets are considered one of the more accurate means of obtaining a 180° phase difference in waveguide. Using these single-piece devices will reduce the number of flange interfaces during calibration. This helps to maintain an essentially constant magnitude of current flow across the calibration plane.

The chart below lists the offset shorts available from Maury. Those in rectangular guide are nominally 1/8 and 3/8 wavelength offset at a frequency near the waveguide band center. These will not be the exact band center as the frequency is chosen to equalize the phase differences at the band edges.

Available Models

BAND	EIA WR NUMBER	FREQUENCY RANGE (GHz)	MODEL	OFFSET (cm)	DELAY (ps) [1]
S	WR284	2.6 — 3.95	S340B1	1.524	50.852
			S340B2	4.572	152.555
E	WR229	3.3 — 4.9	E340B3	1.359	45.346
			E340B4	4.077	136.038
G	WR187	3.95 — 5.85	G340B1	1.026	34.235
			G340B3	3.078	102.704
F	WR159	4.9 — 7.05	F340C1	0.815	27.194
			F340C3	2.446	81.616
C	WR137	5.85 — 8.2	C340F1	0.686	22.890
			C340F3	2.058	68.670
H	WR112	7.05 — 10.0	H340B1	0.571	19.067
			H340B3	1.714	57.191
X	WR90	8.2 — 12.4	X340B1	0.483	16.116
			X340B3	1.448	48.316
M	WR75	10.0 — 15.0	M340C1	0.396	13.213
			M340C3	1.189	39.674
P	WR62	12.4 — 18.0	P340A1	0.352	11.745
			P340A2	1.055	35.202
N	WR51	15.0 — 22.0	N340A	0.267	8.909
			N340B	0.800	26.694
K	WR42	18.0 — 26.5	K340A1	0.251	8.365
			K340A2	0.752	25.095
U	WR28	26.5 — 40.0	U340B	0.150	5.005
			U340C	0.450	15.015
J	WR22	33.0 — 50.0	J340A1	0.120	4.007
			J340B1	0.360	12.022

[1] Offset delay is calculated without consideration for the dispersive effect of waveguide, that is, assuming the short is in air dielectric coaxial line. This conforms to the convention established for Keysight network analyzers. Anritsu analyzers use the actual mechanical offset in centimeters.

Opens

GENERAL
INFORMATION

Shielded, coaxial opens are used in the calibration of vector network analyzers to provide a nominal 180° phase offset from a compatible reference short over a wide range of frequencies.

At these frequencies, open circuit terminations are inherently imperfect. Shielding the open essentially eliminates radiation loss, but creates a residual frequency-sensitive capacitance. An accurate knowledge of the open's effective capacitance is essential to an accurate calibration of the analyzer.

Maury opens are characterized for effective capacitance versus frequency by means of a fourth order polynomial curve fit, and the nominal capacitance coefficients are provided with each unit. We offer several innovative designs that improve the consistency and repeatability of the open's capacitance coefficients resulting in improved effective source match of the calibrated VNA [1].

One design (seen in the 7mm models shown below) uses a beadless captivated dielectric rod in place of the center conductor contact. This rod depresses the spring-loaded contact of the test port connector so that it is flush with the outer conductor mating plane. This creates highly accurate, precisely repeatable open circuit conditions which improve the calibration effectiveness and measurement accuracy of the open.

Another design (seen in most of the sexed models listed below) uses a center contact that is captivated and set at the factory to be essentially flush with the outer conductor mating plane, thereby eliminating dependence on test port connector tolerances and adding a high degree of performance consistency to the open.

The 371N2/P2 and 8585A1/B1 models are designed for limited frequency ranges as determined by their connector types.

In all cases, the specification "Phase Accuracy" is defined as phase deviation from a nominal unit.

Available Models

MODEL	SEX	CONNECTOR TYPE	FREQUENCY RANGE (GHZ)	PHASE ACCURACY	MINIMUM REFLECTION COEFFICIENT
7948A2 7948B2	female male	2.4mm	DC — 50.0	±2.0°	0.98
8773A4 8773B4	female male	2.92mm (K)	DC — 40.0	±1.5°	0.98
8048A6 8048B6	female male	3.5mm	DC — 26.5	±1.4°	0.98
2616D3	—	7mm	DC — 18.0	±0.3°	0.995
8809B2 8810B2	female male	Type N	DC — 18.0	±2.0°	0.99
8609B 8610B	female male	TNC	DC — 18.0	±5.0°	0.98
371N2 371P2	female male	BNC 50Ω	DC — 12.4	±5.0°	0.98
8585A1 8585B1	female male	BNC 75Ω	DC — 12.0	DC — 2.0 = ±1.0° 2.0 — 3.0 = ±2.0° 3.0 — 12.0 = ±6.0°	0.98

[1] *See Maury data sheet 5C-027.*

Precision Air Lines

GENERAL INFORMATION

7943S6.25

7943S1.25
2503B1

Bead-Supported

7943S1.50
8043S15

Unsupported (air dielectric)

Coaxial air lines are air-dielectric transmission lines with highly accurate dimensions that can be used as fundamental impedance standards in measurement and calibration applications, and may also be used to establish reference positions for measurements.

Maury offers air lines with bead supported and/or beadless connectors in a variety of popular types including, 1.85mm, 2.4mm, 2.92mm (K), 3.5mm, 7mm and type N.

Bead supported air lines offer greater convenience and easier connections (the center conductor is automatically aligned by the dielectric bead for easy connection); beadless air lines offer better impedance and electrical length accuracies, as well as lower VSWR (the center conductor floats free in the air line body, and the male connector nut is retractable to facilitate insertion of the center conductor contact before the thread- on connection tightened.

The photos at the right (above) show end views of two type N air lines. On the left is a model 2503A (representing Maury's bead supported design) and on the right is a model 2553T15 (representing Maury's beadless design). The low-loss dielectric bead in the 2503A keeps the center conductor precisely centered in the body of the air line. The photo on the right shows how the unsupported center conductor of the 2553T15 has shifted to the left, and floats freely in the air line body until it is connected at both ends. The beadless design is a true "air" line in that it does not include any discontinuities caused by having the center conductor supported by dielectric beads. Beadless air lines are often used as "sample holders" where samples of various materials can be inserted in the air line and measured to determine the material's dielectric properties.

Specifications given for the air line models in this section include the odd 1/4-λ frequency rating. This rating indicates the frequencies at which the electrical length is an odd multiple of a 1/4 wavelength where n = zero or an integer.

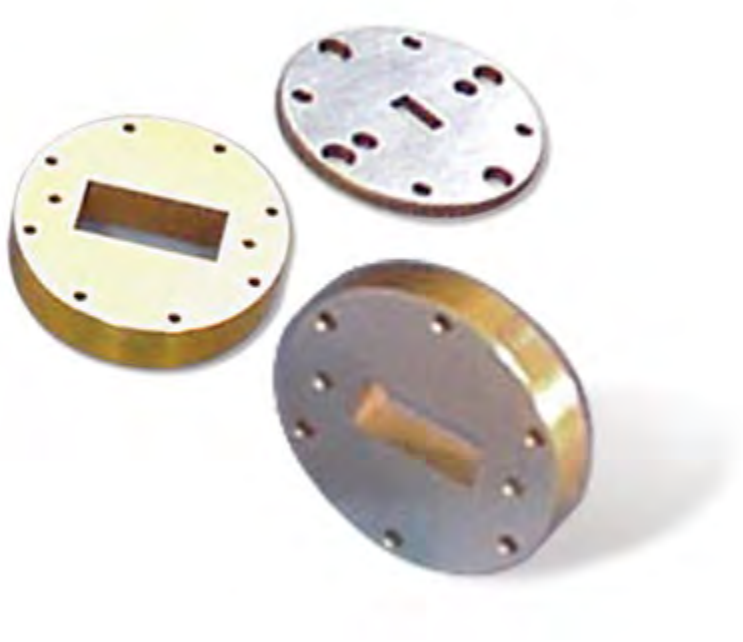
Precision Air Lines Available Models

Model	Connector Type	Frequency Range (GHz)	Electrical Length (cm)	Electrical Length Accuracy	Maximum VSWR	Odd 1/4 Wavelength Frequency (GHz)
7843S0.96	1.85mm	DC — 67.0	0.960	±0.0025	< 1.008	(2n + 1) 7.8
7843S1.15			1.150			(2n + 1) 6.5
7843S3.00			3.000			(2n + 1) 2.5
7943S1.25	2.4mm	DC — 50.0	1.250	±0.0025	< 1.008	(2n + 1) 6.0
7943S1.50			1.500			(2n + 1) 5.0
7943S6.25			6.250			(2n + 1) 1.2
7942C	2.4mm*		4.110	±0.02		(2n + 1) 1.8
8774S15	2.92mm	DC — 40.0	14.990	±0.0025	< 1.008	(2n + 1) 0.50
8774S6			6.000			(2n + 1) 1.25
8774S5.25			5.250			(2n + 1) 1.43
8774S5			4.997			(2n + 1) 1.50
8776C	2.92mm*		14.990	±0.02		(2n + 1) 0.5
8043S15	3.5mm	DC — 26.5	14.990	±0.0025	< 1.008	(2n + 1) 0.50
8043S6			6.000			(2n + 1) 1.25
8043S5.3			5.298			(2n + 1) 1.41
8043S5			4.997			(2n + 1) 1.50
8042C1	3.5mm*		14.990	±0.02	DC — 18.0 ≤ 1.04	(2n + 1) 0.50
8042D1			9.993		18.0 — 26.5 ≤ 1.055	(2n + 1) 0.75
2653S15	7mm	DC — 18.0	14.983	±0.005	<1.005	(2n + 1) 0.50
2653S3.12			3.120			(2n + 1) 1.50
2653L			0.693			(2n + 1) 10.81
2603A	7mm*		29.979	±0.015	DC — 4.0 ≤ 1.02	(2n + 1) 0.25
2603B			19.986		4.0 — 9.0 ≤ 1.03	(2n + 1) 0.375
2603F1			5.996		9.0 — 18.0 ≤ 1.06	(2n + 1) 1.25
2553T15	Type N		14.983	±0.01	<1.004 + 0.001f(GHz)	(2n + 1) 0.50
2553T3.82			3.816			(2n + 1) 1.96
2553T3.12			3.123			(2n + 1) 2.40
2503A1	Type N*		29.979	±0.02	DC — 3.0 ≤ 1.03	(2n + 1) 0.83
2503B1			19.986		3.0 — 10.0 ≤ 1.05	(2n + 1) 0.84
2503H			6.604		10.0 — 18.0 ≤ 1.09	(2n + 1) 1.14

** Indicates Bead Supported Airlines*

Waveguide Precision Straight Section (Shim)

MODEL SERIES 322B



These 322B series 1/4l straight sections are reduced height spacers or shims which provide an accurately known VSWR which is directly calculable from their mechanical dimensions. The shims are designed for a theoretical VSWR of 1.00. The shims are fabricated from aluminum and are provided with precision indexing holes for excellent flange alignment. Their simple geometry allows direct calculation of reflection, loss, transfer and group delay characteristics and makes them ideally suited for quickly checking the performance and accuracy of automated network analyzers.

Available Models

Model	Frequency Range (GHz)	EIA WR Number	Length		Delay (pS)
			Inches	(CM)	
S322B1.198	2.6 — 3.95	284	1.198	(3.0429)	101.5334
E322B0.9468	3.3 — 4.9	229	0.948	(2.4079)	80.34527
G322B0.807	3.95 — 5.85	187	0.807	(2.0498)	68.39518
F322B0.641	4.9 — 7.05	159	0.642	(1.6307)	54.41104
C322B0.539	5.85 — 8.2	137	0.539	(1.3691)	45.68154
H322B0.447	7.05 — 10.0	112	0.447	(1.1354)	37.88432
X322B0.382	8.2 — 12.4	90	0.382	(0.9703)	32.37541
M322B0.311	10.0 — 15.0	75	0.311	(0.7899)	26.35799
P322B0.253	12.4 — 18.0	62	0.253	(0.6426)	21.44236
N322B0.209	15.0 — 22.0	51	0.209	(0.5309)	17.71325
K322B0.175	18.0 — 26.5	42	0.175	(0.4445)	14.83167
Q322B0.1418	22.0 — 33.0	34	0.142	(0.3601)	12.01789
U322B0.118	26.5 — 40.0	28	0.118	(0.2997)	10.00078
J322B0.0946	33.0 — 50.0	22	0.0946	(0.2403)	8.017576

Waveguide Straight Sections

STRAIGHT SECTIONS AND TRANSITIONS

Description

Maury produces waveguide components in many EIA WR sizes. A comprehensive line of standard rectangular products is available in the sizes shown below. They are generally supplied with cover flanges. Units from S through P bands are normally aluminum construction with irridite finish; K band and above are copper alloy with a plated finish. All units are painted with highly durable paint, or other special order finishes.

Available Models

MODEL	FREQUENCY RANGE (GHz)	LENGTH	
		INCHES	(CM)
S102C5	2.60 — 3.95	5.0	(12.7)
E102G5	3.30 — 4.90	5.0	(12.7)
G102C5	3.95 — 5.85	5.0	(12.7)
F102C5	4.90 — 7.50	5.0	(12.7)
C103C5	5.85 — 8.20	5.0	(12.7)
H103A5	7.05 — 10.0	5.0	(12.7)
X103A5	8.20 — 12.4	5.0	(12.7)
M103A5	10.0 — 15.0	5.0	(12.7)
P103A5	12.4 — 18.0	5.0	(12.7)
N102F4	15.0 — 22.0	4.0	(10.2)
K103A4	18.0 — 26.5	4.0	(10.2)
Q106D	22.0 — 33.0	4.0	(10.2)
U103A4	26.5 — 40.0	4.0	(10.2)
J106B1	33.0 — 50.0	2.2	(5.6)

Precision Mismatches

GENERAL INFORMATION

Precision standard mismatches are fixed coaxial terminations, which are used to introduce a known VSWR into a 50 ohm transmission system. These mismatches are extremely useful in a wide variety of applications and are quick and easy to use. They can be used to calibrate swept reflectometers, verify network analyzer calibration, establish impedance references in TDR measurements, etc.

Maury standard mismatches are quality constructed using thin film resistors and a unique grounding method that ensures stable operation. For ease of identification, the VSWR value of the mismatch is engraved on the end cap.

The standard units in this section are fitted with 2.4mm, 2.92mm, 3.5mm, 7mm and type N connectors. Please consult with our sales staff for application assistance. The units are also available as sets or kits packaged in foam-lined wood instrument cases.

Available Models

Model		Connector Type	Frequency Range (GHz)	Nominal VSWR	Accuracy (GHz)	
Female	Male				DC - 12.0	12.0 - 50.0
7933A1.20	7933B1.20	2.4mm	DC - 50.0	1.20	±0.09	±0.13
7933A1.50	7933B1.50			1.50	±0.10	±0.20
7933A2.00	7933B2.00			2.00	±0.14	±0.25

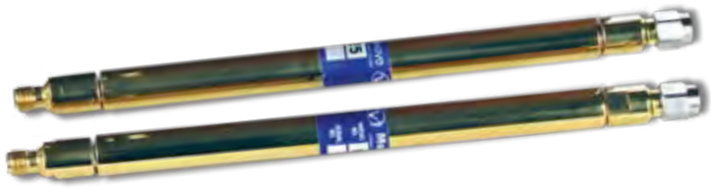
Model		Connector Type	Frequency Range (GHz)	Nominal VSWR	Accuracy (GHz)	
Female	Male				DC - 12.0	12.0 - 40.0
8778A1.20	8778B1.20	2.92mm	DC - 40.0	1.20	±0.08	±0.13
8778A1.50	8778B1.50			1.50	±0.10	±0.20
8778A2.00	8778B2.00			2.00	±0.14	±0.25

Model		Connector Type	Frequency Range (GHz)	Nominal VSWR	Accuracy (GHz)	
Female	Male				DC - 12.0	12.0 - 26.5
8033A1.20	8033B1.20	3.5mm	DC — 26.5	1.20	±0.07	±0.10
8033A1.50	8033B1.50			1.50	±0.09	±0.17
8033A2.00	8033B2.00			2.00	±0.12	±0.22

Model		Connector Type	Frequency Range (GHz)	Nominal VSWR	Accuracy (GHz)		
Female	Male				DC - 8.0	8.0 - 12.4	12.4 - 18.0
2611C		7mm	DC — 18.0	1.20	±0.05	±0.06	±0.10
2611E				1.50	±0.06	±0.08	±0.17
2611G				2.00	±0.10	±0.12	±0.22

Model		Connector Type	Frequency Range (GHz)	Nominal VSWR	Accuracy (GHz)		
Female	Male				DC - 8.0	8.0 - 12.4	12.4 - 18.0
2561C	2562C	Type N	DC — 18.0	1.20	±0.06	±0.07	±0.10
2561E	2562E			1.50	±0.08	±0.09	±0.15
2561G	2562G			2.00	±0.12	±0.12	±0.20

Mismatch Airlines



Description

Maury mismatch airlines have been designed as verification standards to be used in VNA calibration validation. Each mismatch airline is provided with factory S-parameters data that can be compared with user-measured S-parameters for VNA calibration validation. Measurement uncertainty is also provided, and uncertainty boundaries can be used for definitive calibration validation when used in conjunction with MT940B Insight Real-Time Uncertainty Add-On.

Recommended Accessories

Insight Calibration and Measurement Software:

Insight is the industry's first commercial software suite designed to empower VNA users and help them make better decisions by quantifying measurement uncertainty. Insight is an agnostic software tool compatible with most commercial VNAs and represents a paradigm shift in the way users approach VNA calibration, validation, measurement, visualization and analysis. More information regarding Insight can be found in data sheet 4T-023.

VNA Calibration Kits:

Maury offers coaxial VNA calibration kits up to 67 GHz and waveguide calibration kits up to 50 GHz in standard connector and waveguide sizes. Coaxial 2.4mm, 2.92mm, 3.5mm, 7mm and Type N calibration kits are available as fixed-load SOLT kits with either standard polynomial equations or characterized device (CD) with individually characterized standards. More information can be found in data sheets 2Z-056 (1.85mm), 2Z-072 (2.4mm), 2Z-073 (2.92mm), 2Z-074 (3.5mm), 2Z-075 (7mm), and 2Z-076 (Type N), 2Z-062 (TNC), 2Z-069 (BNC) and 3H-081 (WR284 Through WR22).

Available Models

Model	Connector Type	Frequency Range (GHz)	Electrical Length (cm)	Electrical Length Accuracy	Impedence
7942C25	2.4mm	DC - 50.0	4.110	±0.02	25Ω
8776C25	2.92mm	DC - 40.0	14.990	±0.02	25Ω
8042C25	3.5mm	DC - 26.5	14.990	±0.02	25Ω
2603F75	7mm	DC - 18.0	5.996	±0.015	75Ω
2503H75	Type N	DC - 18.0	6.604	±0.02	75Ω

Waveguide Flange Information

MAURY PRECISION FLANGES (MPF)

Description

Maury MPF flanges are designed to provide precise mating of flanges when repeated connections are required or in systems where optimum waveguide alignment is critical. Some MPF series flanges also allow mating to more than one type of flange interface, which amplifies their versatility and economy when mating different flange types within a band. Please refer to the "mates with" column in the chart below to see the possible combinations. Please note that Maury does not sell flanges alone.

MPF flanges are provided on components used in Maury calibration kits or on low VSWR components such as waveguide to coax adapters with VSWR of 1.10 or better.

MPF flanges in WR22 waveguide (millimeter wave sizes) provide dramatic improvements in connection consistency, repeatability and serviceability versus standard UG flanges, while still maintaining mating compatibility with these older designs (see Maury data sheet 5E-030). As in larger waveguide sizes, these flanges have two precision index holes and slip-fit alignment pins. (Threaded pins may also be installed in the standard four-pin pattern when mating to standard UG flanges. Both types of pins are removable, making the flange face available for servicing.)

MPF flanges also have a raised outer ring which prevents the mating surfaces from cocking due to uneven torque applied to the flange bolts. To obtain complete technical descriptions, please request the data sheets shown in the Maury Data Sheet column.

NOTE: All Maury MPF flanges have precision index holes. Corresponding slip-fit alignment pins are also available. Together, these ensure precise alignment and repeatable mating in waveguide connections. All Maury waveguide VNA calibration kit components come with MPF flanges. Alignment pins are available separately. See Maury data sheet 3A-996 for details.

Maury Precision Flange Reference Chart

BAND	EIA WR NUMBER	MPF DESIGNATION	MATES WITH	MAURY DATA SHEET
S	284	MPF284	UG53/U, UG54A/U, CPR284	5E-002
S	284	MPF284B	UG53/U, UG54A/U, CPR284, CMR284	5E-002A
S	284	MPF284C	UG53/U, UG54A/U	5E-002B
E	229	MPF229	CPR229, CMR229	5E-003
E	229	MPF229B	CPR229	5E-003A
G	187	MPF187	UG149A/U, UG148B/U, CPR187	5E-004
G	187	MPF187C	UG149A/U, UG148B/U	5E-004A
F	159	MPF159	CPR159, CMR159	5E-011
F	159	MPF159B	CPR159	5E-011A
C	137	MPF137	UG344/U, UG343A/U, CPR137	5E-005
C	137	MPF137C	UG344/U, UG343A/U	5E-005A
H	112	MPF112	UG51/U, UG138/U, CPR112F & G	5E-001
H	112	MPF112B	UG51/U, UG52/U	5E-001A
H	112	MPF112C	UG51/U, UG52/U, CMR112	5E-001C
HS	102	MPF102	UG1493	5E-014
X	90	MPF90	UG39/U, UG40A/U, CPR90	5E-006
X	90	MPF90A	UG39/U, UG40A/U, CMR90	5E-006
X	90	MPF90B	UG39/U, UG40A/U	5E-006A
M	75	MPF75A & B	M3922/70-004 & -005	5E-007
P	62	MPF62	UG419/U, UG541A/U	5E-008
N	51	MPF51A & B	M3922/70-010, -011, -012, -022, -023, -024	5E-012
N	51	MPF51C	Keysight Type, UBR180	5E-013
K	42	MPF42	UG595/U, UG596/U	5E-009
Q	34	MPF34	UG595U, UG596/U, UG1530/U	5E-019
U	28	MPF28	UG599/U, UG600/U	5E-010
J	22	MPF22	UG383/U	5E-030

Coaxial Stub Tuners

Description

Maury stub tuners are basic laboratory tools used for matching load impedances to provide for maximum power transfer between a generator and a load, and for introducing a mismatch into an otherwise matched system. Typical applications include power and attenuation measurements, tuned reflectometer systems and providing a DC return for single-ended mixers and detectors. Maury stub tuners are available in double- and triple-stub configurations with frequency ranges extending from 0.2 to 18.0 GHz.

Stub tuners work as impedance transformers to introduce a variable shunt susceptance into a coaxial transmission line. They consist of one or more short-circuited, variable length lines (stubs) connected at right angles to the primary transmission line. To provide all possible shunt susceptances, each stub must be movable over 1/2 wavelength at the lowest frequency of operation; therefore, the lower frequency limit of a tuner is determined by the frequency at which the maximum stub travel equals 1/2 wavelength. The upper frequency limit for a stub tuner is established by its connectors.

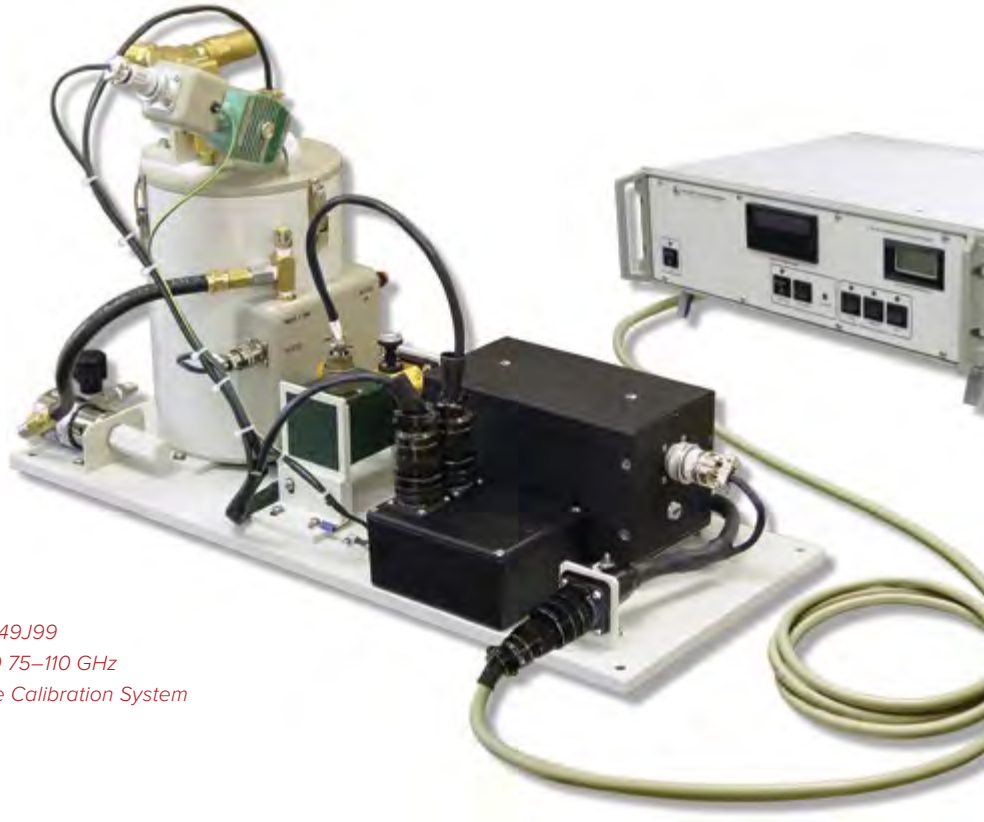
The inter-stub spacing of multiple-stub tuners determines the range of impedances that can be matched and the ease of tuning. Compared with single- and double-stub tuners, triple-stub tuners are more convenient to use since tuning sensitivity is relatively independent of stub spacing.

1819C Triple-Stub Tuner

Available Models

STUB CONFIGURATION	FREQUENCY RANGE (GHz)	MODEL (BY CONNECTOR TYPE) TYPE N	SMA	STUB TRAVEL INCHES	(cm)	STUB SPACING INCHES	(cm)
TRIPLE-STUB	0.2 — 0.5	1878G	—	30.0	(76.2)	4.6 (11.7) /	2.0 (5.1)
	0.4 — 1.0	1878A	1819A	15.0	(38.1)	4.6 (11.7) /	2.0 (5.1)
	0.8 — 4.0	1878B	1819B	7.5	(19.1)	1.0 (2.5) /	0.75 (1.9)
	2.0 — 18.0	1878C	1819C	3.0	(7.6)	0.75 (1.9) /	0.5 (1.3)
	4.0 — 18.0	1878D	1819D	1.75	(4.4)	0.75 (1.9) /	0.5 (1.3)

Noise Calibration Systems and Components



MT7149J99
WR10 75–110 GHz
Noise Calibration System

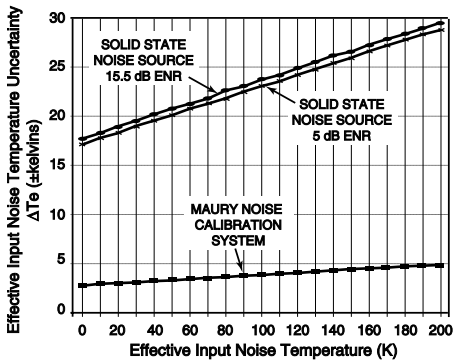
Introduction

The Maury Noise Calibration Systems (NCS) are self-contained, highly accurate sources of RF and microwave noise power. These systems are used wherever noise source accuracy is critical. Examples are: receiver noise measurements such as noise figure and effective input noise temperature; calibration of solid state noise sources; evaluation and verification of earth station receivers; and as radiometer reference sources.

Each NCS consists of one (hot or cold), two (hot and cold) or three (hot/ambient/cold) thermal noise sources whose outputs can be conveniently switched into a single calibrated output port. This capability makes for a unique combination of accuracy and convenience. The incorporation of the output switch makes the operation of the NCS in a noise performance measurement as convenient as a solid state noise generator – without the accuracy penalty associated with the latter. The plot shown at right illustrates the improvement in accuracy that can be gained by the use of an NCS in a typical measurement application (effective input noise temperature).

The cold noise source is a liquid nitrogen (LN2) cooled termination. A liquid nitrogen level sensor and an automatic fill system maintains the proper nitrogen level. The user must provide a suitable liquid nitrogen reservoir. The cold termination is also pressurized with helium at 2 psi. Pressure is maintained by a regulator that requires 20 psi maximum from an external user-supplied source. Since most helium bottles are pressurized to about 1,000 psi or more, the MT152C pressurizing system is included.

The hot noise source is a heated termination whose temperature is maintained by proportional control to better than ±0.2K by the MT155J controller. Actual temperature is indicated by a digital readout on the controller front panel.



Noise Calibration Systems and Components

(CONTINUED)

Typical NCS Models

The table below shows a some of the more popular NCS available from Maury. Each model is a complete system made up of the appropriate terminations assembled on a mounting plate, the MT155J controller and the interconnecting cable. All dual-load systems shown consist of cold (LN2) and heated terminations. The tri-load system (MT7208J99) includes an ambient termination as well. Please consult our Sales Department if you do not see a noise calibration system in this table suitable for your application or if you would like more detailed information on any of these systems.

Frequency Range	Transmission Line	Connector or Flange	Cryogenic	Thermal	Dual-Load	Tri-Load
DC — 18.0	Coaxial	7mm	MT7118J99	MT7108J99	MT7098J99	MT7208J99
3.3 — 4.9	WR229	MPF229B	N/A	MT7005J99	N/A	N/A
7.05 — 10.0	WR112	UG51/U	MT7040J99	N/A	N/A	N/A
8.2 — 12.4	WR90	MPF90	MT7041J99	MT7081J99	MT7091J99	N/A
10.0 — 15.0	WR75	MPF75B	MT7042J99	MT7082J99	MT7093J99	N/A
12.4 — 18.0	WR62	UG419/U	MT7043J99	N/A	N/A	N/A
15.0 — 22.0	WR51	MPF51B	MT7044J99	MT7009J99	MT7094J99	N/A
18.0 — 26.5	WR42	UG595/U	MT7021J99	MT7084J99	MT7095J99	N/A
26.5 — 40.0	WR28	UG599/U	MT7022J99	MT7085J99	MT7096J99	N/A
33.0 — 50.0	WR22	UG383/U	MT7023J99	MT7086J99	MT7097J99	N/A
50.0 — 75.0	WR15	UG385/U	MT7025J99	MT7088J99	MT7100J99	N/A
60.0 — 90.0	WR12	UG385/U	MT7026J99	MT7089J99	MT7101J99	N/A
75.0 — 110.0	WR10	UG385/U	MT7027J99	MT7090J99	MT7149J99	N/A

Cryogenic Noise Terminations (Cold Loads)

MT7025J99 with Power Supply and Foam-lined Wood Carrying Case.

Introduction

Maury cryogenic terminations are liquid nitrogen cooled loads which provide accurately known noise power at a well matched output port. Used with ambient and/or thermal terminations and a noise figure meter, these terminations provide cold reference temperatures needed for highly accurate noise figure or effective input noise temperature measurements. Because of the accuracy of their noise output, cryogenic terminations are often used as a noise standard for calibration of solid state noise generators.

The accuracy achieved by these terminations is possible because they utilize the known temperature of boiling liquid nitrogen as a constant for calculating noise temperature. Because of this, measurements made with these terminations are traceable to the fundamental quantity, temperature and NIST via temperature and network calibration standards. Each unit is provided with a swept data calibration report which includes VSWR and available output noise temperature data at standard frequencies. See Maury data sheet 4E-020, which provides specifics for the MT7250 series Noise Calibration Swept Data Module, a software tool that allows users to work with non-standard data points in addition to, or in place of the factory standards.

The cryogenic terminations require user-provided liquid nitrogen and dry helium gas at 2 psi. Maury's MT152A pressurization system is available as an optional accessory to regulate the helium pressure (see page 137). The terminations include a heater circuit to prevent frosting on the output connector and to prevent the heat load of the device under test from affecting the output noise temperature.

MT7118J99 7mm Coaxial Cryogenic Terminations

DC TO 18.0 GHZ

Features

- Accurate Noise Temperature at Specified Calibration Frequencies
- Low VSWR Across the Full Frequency Range
- Liquid Nitrogen Cooled
- Metrology Grade Calibration for Solid State Noise Generators
- Low Noise Figure/Temperature Measurements

MT7118J99

Description

The MT7118J99 cryogenic termination is a liquid nitrogen cooled noise source that provides accurately known noise temperatures at specified calibration frequencies and low VSWR over the full frequency range. It is used for performing accurate noise temperature measurements in 7mm applications such as certification of the noise performance of low noise earth stations. It is also used for general purpose, low noise figure/temperature measurements and calibration of solid state noise generators.

The MT7118J99 comes with a linear power supply that operates on line voltages of 120 VAC/60 Hz or 240 VAC/50 Hz, while supplying 48 VDC to the device power input.

The MT7118J99 can be packaged with an extensive complement of options and accessories, including calibrated adapters to other coaxial connector series and waveguide, and user specified calibration frequencies. Our sales staff will be happy to assist in tailoring the best package for your application.

The MT7118J99 can be optimized for VSWR and input noise temperature over other bandwidths. For calibration frequencies see Maury data sheet 4E-020, which covers the maury MT7250 series Noise Calibration Swept Data Module; a software tool that works with Microsoft® Excel® 2003 (or later) to provide an Effective Noise Temperature Interpolator. Please contact our Sales Department for additional information.

Maury also produces an extensive line of precision hot, cold and ambient terminations in both coaxial and waveguide configurations. Our sales staff is ready to assist you in ordering the right noise calibration solution for your applications.

Pressurizing System

Maury cryogenic terminations require helium gas pressurization at 2 psi. The optional MT152A pressurizing system (see page 141) provides the valves, gages, and hardware necessary to connect an external helium gas supply to Maury cryogenic terminations (helium gas supply is not provided).

Specifications

Frequency Range. // DC to 18.0 GHz
Maximum VSWR: //
1.06, DC to 4.0 GHz
1.10, 4.0 to 12.0 GHz
1.15, 12.0 to 18.0 GHz
Operating Temperature (Load) //
77.36°K (liquid N cooled)

Calibration Frequencies & Noise Temperature
Uncertainty // ±1.5 K
Connector // 7mm
Operating Orientation // Horizontal
Operating Life // 2 hours minimum (one fill)
Dewar Capacity // 1 liter
Weight // 7 lbs approximate (empty)
Pressurization //
2 psi helium gas (external supply)
AC Power //
100 to 240 VAC, 47 to 63 Hz
6.0 amps maximum
Accessories (provided) //
One (1) two meter power cord and a wooden instrument case

Note: For calibration frequencies, see the information on Maury's MT7250 series Noise Calibration Swept Data Module software (page 146), or consult our Sales Department.

Waveguide Cryogenic Terminations

MT70XX SERIES

Features

- Accurate Noise Temperature at Specified Calibration Frequencies
- Low VSWR Across the Full Frequency Range
- Liquid Nitrogen Cooled
- Metrology Grade Calibration for Solid State Noise Generators
- Low Noise Figure/Temperature Measurements

MT7025J99

Description

Maury offers waveguide cryogenic terminations in several styles and a wide range of waveguide sizes from WR430 through WR15. The table below represents a typical sample of the available terminations.

Waveguide terminations are calibrated within the waveguide band (using Maury MT7250 Noise Calibration Swept Data Module (see page 146). Additional user-specified calibration frequencies are also available as an option.

In addition to liquid nitrogen, these terminations require pressurization with helium gas (not provided) at 2 psi. The MT152A pressurizing system (see page 141) is available to provide proper regulation of the helium supply.

The MT70xx series units come with a universal input power supply that operates on line voltages of 100–240 VAC and 47–63 Hz, while supplying 48 VDC to the device power input.

Available Model Series (Typical)

Model	Frequency Range (GHz)	EIA Waveguide Size	VSWR (maximum)
MT7040J99	7.05 — 10.0	WR112 [1]	1.08
MT7041J99	8.2 — 12.4	WR90 [1]	1.10
MT7042J99	10.0 — 15.0	WR75	1.08
MT7043J99	12.4 — 18.0	WR62 [1]	1.10
MT7044J99	15.0 — 22.0	WR51 [1]	1.10
MT7021J99	18.0 — 26.5	WR42 [1]	1.08
MT7022J99	26.5 — 40.0	WR28 [1]	1.10
MT7023J99	33.0 — 50.0	WR22 [1]	1.15
MT7025J99	50.0 — 75.0	WR15 [1]	1.15
MT7026J99	60.0 — 90.0	WR12 [1]	1.15
MT7027J99	75.0 — 110.0	WR10 [1]	1.15

Calibration Uncertainty

Frequency Range (GHz)	Calibration Uncertainty
< 18.0	±1.5 K
18.0 — 40.0	±1.5 K
40.0 — 50.0	±1.8 K
50.0 — 110.0	±2.6 K

[1] Flange mates with the applicable military (UG) flange.

Cryogenic Termination Accessories

MT152A/C Helium Pressurizing Systems

Maury cryogenic terminations must be supplied with helium gas at about 2 psi to purge contaminants (air, carbon dioxide, etc.) from the coaxial or waveguide transmission line (connecting the cooled termination to the output connector) before the dewar is filled with liquid nitrogen. For stand-alone cryogenic terminations, the MT152A regulates the helium supply by use of a two-stage pressure regulator preset to provide 2 to 3 psi output pressure and a safety pressure relief valve set to 4 psi.

These are included with an 8 foot hose and CGA-580 fittings for connecting your helium supply to the termination.

Maury dual-load and tri-load noise calibration systems are provided with the MT152C helium pressurizing system, a modified version of the MT152A, which serves the same purpose.

MT152A

Thermal Noise Terminations (Hot Loads)

MT151C

MT7090J99

Introduction

Maury thermal terminations are low-mismatch, heated loads in a precisely controlled thermal environment which provide an accurately known noise power. Used with ambient and/or cryogenic terminations and a noise figure meter, these terminations provide the hot termination temperature needed for highly accurate noise figure or effective input noise temperature measurements. Because of the accuracy of the noise output, thermal terminations are often used as a noise standard for calibration of solid state noise generators.

The accuracy achieved by these terminations is possible because they utilize the proven concept of thermal (Johnson) noise operating in a precision thermal environment provided by the MT151C temperature controller. (The MT151C is a highly stable, proportional temperature controller that is accurately calibrated against NIST-traceable temperature measuring equipment.) This is the same concept used in several national standards laboratories and NIST at the higher microwave frequencies.

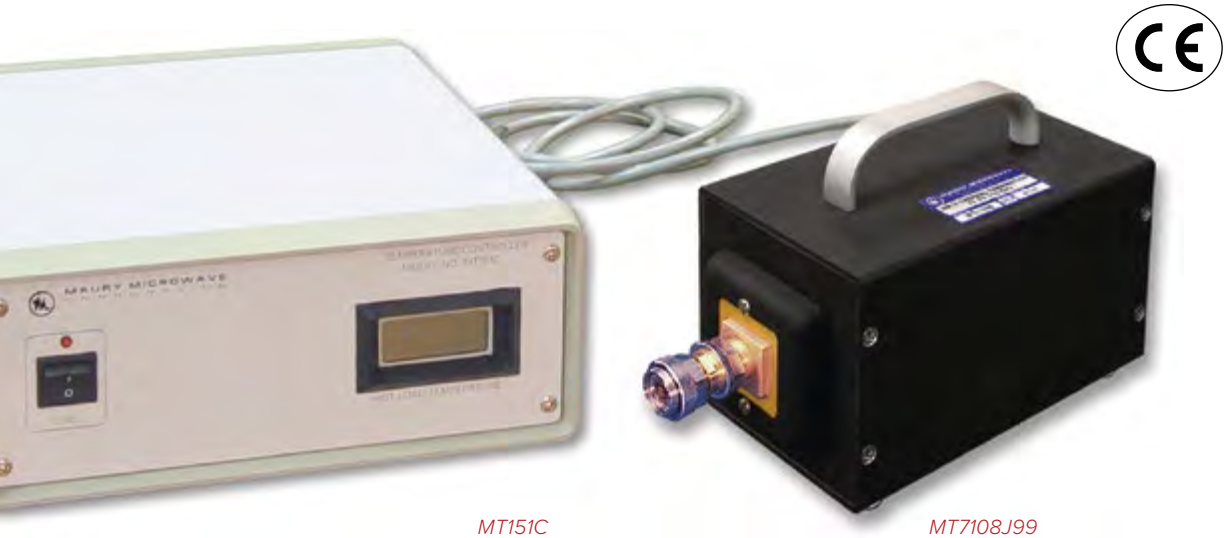
The termination and the controller are matched during calibration; therefore, the two instruments must be purchased as a unit. In addition, a line voltage option must be specified. Each unit is provided with a calibration report which includes VSWR and available output noise temperature at specific frequencies.

Maury offers the MT7250 series Noise Calibration Swept Data Module as a tool that allows users to work with non-standard data points in addition to, or in place of the factory standards[1]. Other accessories such as special instrument cases and calibrated adapters to other coaxial series or waveguide are also available.

[1] See Maury Data Sheet 4E-020. See also page 146.

Coaxial Thermal Termination

MT7108J99



MT151C *MT7108J99*

Description

Maury offers a single thermal noise termination model (the MT7108J99), which is equipped with a precision 7mm coaxial output connector, and operates from DC to 18 GHz. This compact, reliable instrument is equally suited for both field measurements and laboratory use. It is generally used to make accurate low noise figure/temperature measurements and for calibration of solid state noise generators. The flexibility and versatility of the MT7108J99 are enhanced by an extensive selection of options and accessories. These include calibrated adapters to other coaxial connector series and waveguide flanges, and factory calibration specified frequencies. (Maury's MT7250 series Noise Calibration Swept Data Module is included as a tool that allows users to work with non-standard data points in addition to, or in place of the factory standards[1].)

The MT7108J99 comes with a MT151C controller, with which it is precisely matched during the initial factory calibration. For accurate performance, these units must be used together. The MT151C's internal proportional controller responds to sensors in physical proximity to the termination and directs the MT7108J99's heater circuit to maintain the physical temperature of the termination at 373.1 kelvins (100°C). Heavy insulation of the entire termination assembly minimizes the effects of the external environment. The MT151C's line voltage must be specified at the time of order. This ensures that the MT151C will be properly fuzed and shipped with the appropriate power cable (AC power option 22 for 100/120 VAC, 50/60 Hz, or option 32 for 220/240 VAC, 50/60 Hz).

A certified calibration report with traceability to NIST is provided with each unit.

Specifications

Frequency Range // DC to 18 GHz
Nominal Physical Load Temperature // 373.1 K
Load Temperature Stability // ±0.2 K

VSWR (maximum):
- DC to 4 GHz // 1.06
- 4 to 12 GHz // 1.10
- 12 to 18 GHz // 1.15

AC Power (User specifies one of two options):
- Option 22 // 100/120 VAC, 50/60 Hz
- Option 32 // 220/240 VAC, 50/60 Hz

Noise Temperature Uncertainty // ±0.7 K
Connector // Precision 7mm [2]

Accessories Provided

- One (1) MT151C controller
- One (1) MT151P controller cable
- One (1) Instrument case

[1] See Maury data sheet 4E-020 for details, and page 146 in this volume.
[2] Precision 7mm per Maury data sheet 5E-060.

Waveguide Thermal Terminations

MT70XX SERIES

MT151C

MT7090J99

Description

Maury offers waveguide thermal terminations in several styles and a wide range of waveguide sizes, from WR430 through WR10. The chart below represents a typical sample of the available terminations.

Waveguide terminations are calibrated at frequencies within the applicable frequency range. Maury's MT7250 series Noise Calibration Swept Data Module is included as a tool that allows users to work with non-standard data points in addition to, or in place of the factory standards[1]. Please contact our Sales Department for more information.

The physical temperature of the waveguide terminations is 350 kelvins with a stability of ±0.2 kelvins. These terminations are calibrated with a specific temperature controller, and the two instruments are provided as a unit. A line voltage option must be specified at the time of order.

Available Models

Model	Frequency Range (GHz)	EIA Waveguide Size	Maximum VSWR
MT7005J99	3.3 – 4.9	WR229 [2]	1.07
MT7081J99	8.2 – 12.4	WR90 [3]	1.10
MT7082J99	10.0 – 15.0	WR75	1.08
MT7009J99	15.0 – 22.0	WR51 [3]	1.10
MT7084J99	18.0 – 26.5	WR42 [3]	1.08
MT7085J99	26.5 – 40.0	WR28 [3]	1.10
MT7086J99	33.0 – 50.0	WR22 [3]	1.15
MT7088J99	50.0 – 75.0	WR15 [3]	1.15
MT7089J99	60.0 – 90.0	WR12 [3]	1.15
MT7090J99	75.0 – 110.0	WR10 [3]	1.15

[1] See Maury data sheet 4E-020 and page 146 in this volume.
[2] Flange mates with applicable CPR and CMR flanges.
[3] Flange mates with the applicable military (UG) flange.

Calibration Uncertainty

Frequency Band (GHz)	Uncertainty (Kelvins)
< 18.0	±0.70 K
18.0 – 40.0	±0.60 K
40.0 – 50.0	±0.65 K
50.0 – 110.0	±1.00 K

Accessories Provided

- One (1) MT151C controller
- One (1) MT151P controller cable
- One (1) Instrument case

Thermal Terminations – Options and Accessories

MT151C

Temperature Controller, MT151C

A temperature controller is provided with each thermal termination. The controller and the termination are calibrated together and are sold as a unit. A line voltage must be specified at the time of order:

- Option 22 // 100/120 VAC
- Option 32 // 220.240 VAC

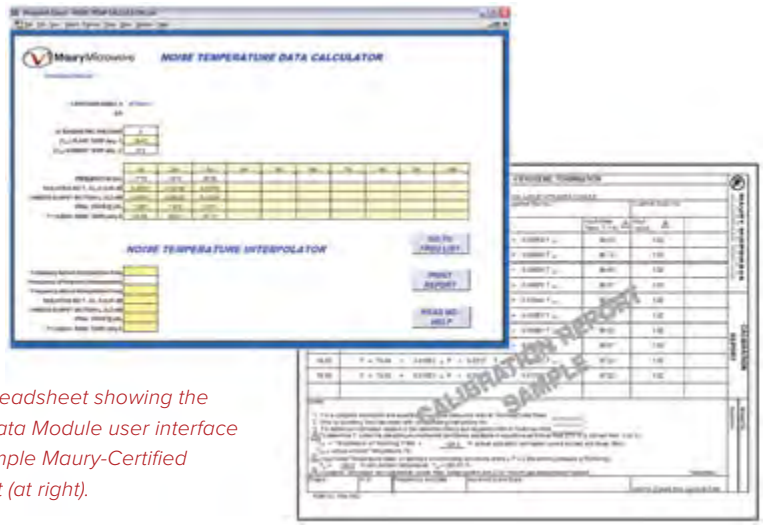
Instrument Case

Most Maury heated terminations are supplied in a foam-lined instrument case (like the one shown at below) for convenient handling and storage. Please contact our Sales Department for details.

*A typical foam-lined Instrument case with one (1) model **MT7090J99**, one (1) calibrated **MT151C** Controller and one (1)Operating Manual.*

Noise Calibration Swept Data Module

MT7250 SERIES



Typical Excel® spreadsheet showing the MT7250 Swept Data Module user interface (above) and a sample Maury-Certified Calibration Report (at right).

Features

- Multiple Data Points
- Effective Noise Temperature Calculator
- Effective Noise Temperature Interpolator
- Certified Calibration Report Generator
- Standard and User-Defined Frequencies

Description

Maury cryogenic and thermal terminations, whether stand-alone models or components of Maury noise calibration systems, are calibrated for hot/cold noise temperatures at their output connectors for a number of frequencies. Waveguide units are typically calibrated at specific standard frequencies or data points at the band edges and the arithmetic center frequency of the waveguide. Coaxial units are calibrated within the frequency range the connector type is rated for. Maury offers the MT7250 series Noise Calibration Swept Data Module as a tool that allows users to work with other, non-standard, data points in addition to, or in place of, the factory standards.

The MT7250 series Swept Data Module Software works with Microsoft® Excel® 2003[1] (or later) to give users the ability to generate standardized, or customized, Maury-certified calibration reports for any Maury cryogenic termination, thermal termination or noise calibration system. The data module can be supplied with a new unit at time of purchase, or with a re-certified unit.

[1] Not provided.

The Effective Noise Temperature Calculator

The Effective Noise Temperature Calculator uses measured loss and actual temperature data to produce Maury-certified calibration reports. These reports are based on a) pre-measured data points as shown in the table below, or b) a user-defined or customized set of measured data points, or c) a combination of both.

The Effective Noise Temperature Interpolator

For use as a reference tool, the built-in Effective Noise Temperature Interpolator can be used to generate noise temperatures for non-measured data points within the data band of interest.

Standard Pre-Measured Data Points

Waveguide or Line	Frequency Band (GHz)	Step Size
7mm	0.2 — 18.0	0.20
WR229	3.3 — 4.9	0.01
WR112	7.05 — 10.0	0.05
WR90	8.2 — 12.4	0.05
WR75	10.0 — 15.0	0.10
WR62	12.4 — 18.0	0.10
WR51	15.0 — 22.0	0.10
WR42	18.0 — 26.5	0.10
WR28	26.5 — 40.0	0.25
WR22	33.0 — 50.0	0.25
WR15	50.0 — 75.0	0.50
WR12	60.0 — 90.0	0.50
WR10	75.0 — 110.0	0.50