COPPER MOUNTAIN®
TECHNOLOGIES

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TR Series Vector Network Analyzer Extended Specifications

Revision 25.00 08.09.2025

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Contents

The Whole Solution

Warranty, Service, & Repairs - the Crown Service Package

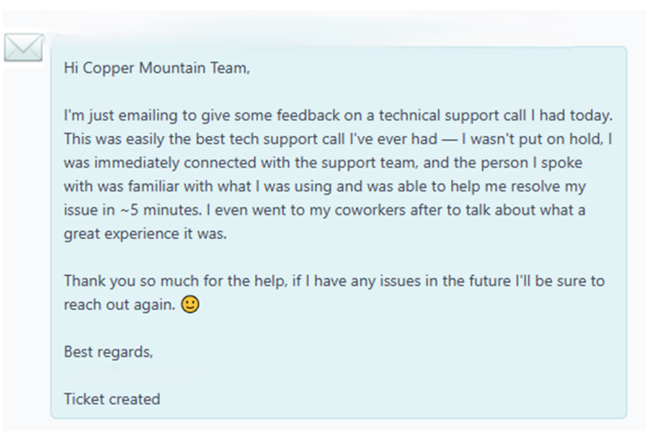
All our products come with a standard three-year warranty from date of shipment. During that time we will repair or replace any product malfunctioning due to defective parts or labor.

While we pride ourselves on quality of our instruments, should your VNA malfunction for any reason, we will gladly offer a loaner unit while we service yours. With our USB VNAs where all data is stored on your PC, a simple swap of the measurement module assures uninterrupted workflow and little or no downtime.

Our Engineers Are an Extension of Your Team

Our team of applications engineers, service technicians, and metrology scientists are here to help you with technical support, application-specific recommendations, annual performance testing, and troubleshooting or repair of your CMT instruments.

Our engineers will work with your team to augment your in-house capabilities. We can write custom applications and test software, develop test automation scripts and help with integrated RF system testing. We can design suitable test setups, assist with advanced calibration techniques such as fixture removal, and help achieve metrology-grade measurements with high accuracy. If the S-parameter measurement fixture involves challenging conditions for repeatability and accuracy we can assist with measurement uncertainty analysis.


Hi Copper Mountain Team,

I'm just emailing to give some feedback on a technical support call I had today. This was easily the best tech support call I've ever had — I wasn't put on hold, I was immediately connected with the support team, and the person I spoke with was familiar with what I was using and was able to help me resolve my issue in ~5 minutes. I even went to my coworkers after to talk about what a great experience it was.

Thank you so much for the help, if I have any issues in the future I'll be sure to reach out again. 🙂

Best regards,

Ticket created

An extensive library of technical materials including application notes, tips on performing VNA measurements, sample automation scripts, and how-to videos are available on our website www.coppermountaintech.com and YouTube channel, CopperMountainTech.

Periodic Verification

Copper Mountain Technologies' Indianapolis calibration laboratory is accredited in accordance with the recognized international standard ISO/IEC 17025:2017 and meets the requirements of ANSI/NCSL Z540-1994-1. All reference standards and equipment in the laboratory are traceable to National Institute of Standards and Technology (NIST) or international equivalent.

Should you prefer to perform the annual verificatiion yourself or use a third party, contact us for information on performing these procedures. Additionally, the VNA Performance Test (VNAPT) software application is available for third party laboratories without restriction. Use of VNAPT to execute performance tests is optional, but the software is designed to automate and streamline VNA performance testing, including automatic generation of test reports. Please contact Copper Mountain Technologies or your local CMT channel partner for recommended calibration options.

The Software Application is Part of the VNA

The software application takes raw measurement data from the data acquisition (measurement) module and recalculates into S-parameters in multiple presentation formats utilizing proprietary algorithms. These new and advanced calibration and other accuracy enhancing algorithms were developed by our metrology experts. Our software can be downloaded free from our website, used on an unlimited number of PCs using either Linux or Windows operating systems, and enables easy VNA integration with other software applications and measurement automation. The software application features a fully functioning Demo Mode, which can be used for exploring the VNAs' features and capabilities without an actual measurement module connected to your PC.

Standard Measurement Capabilities

Measurement Parameters

S11, S21

All models also measure absolute power of the reference and received signals at the port.

Frequency Range

VTR0102	50 MHz to 1.5 GHz
VTR0302	50 MHz to 3.5 GHz

Sweep Types

Linear frequency sweep and logarithmic frequency sweep are performed with fixed output power. Linear power sweep is a fixed frequency.

Dynamic Range

The typical dynamic range of 120 dB is achieved from 50 MHz through the top of the frequency range (at 10 Hz IF bandwidth).

Output Power Adjustment Range

Source power from -25 dBm to 0 dBm with a resolution of 0.05 dB. In frequency sweep mode power slope can be set up to 2 dB/GHz to compensate for high frequency attenuation in fixture cables.

Measurement Time Per Point

The measurement time per point for the VTR0102 and VTR0302 is typically 35 μs.

Number of Measured Points

The number of measured points for the VTR0102 and VTR0302 is up to 200,001.

CMT VNA Software

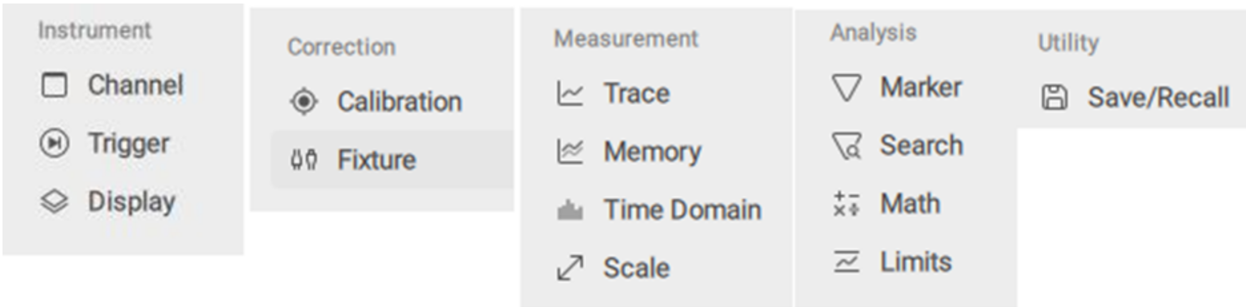
CMT VNA Software Included with Every VNA

TR Series VNAs include the CMTVNA Software for performing S-parameter measurements. It can be installed on as many computers as needed - allowing multiple users to share the same measurement module while storing measurement data on each individual PC. CMTVNA is able to run natively on Windows and Linux. CMTVNA runs on both x86-based or arm-based processors, which allows it to run on Raspberry pi (for example Raspberry pi with Ubuntu 24.04 LTS or Debian 13 Trixie).

Our Applications Engineering team offers support to answer any questions regarding software usage, measurements, or other concerns with CMT products.

Intuitive User Interface

The user interface of CMT VNA allows you to see all available options in each submenu without the need to go through many submenu layers. The main menu panel remains visible unless manually hidden, allowing for quick navigation between different functions.



Capabilities

CMT VNA can be used to perform many different types of measurements and tests such as Peak Limit Testing, , Port Extension, and more.

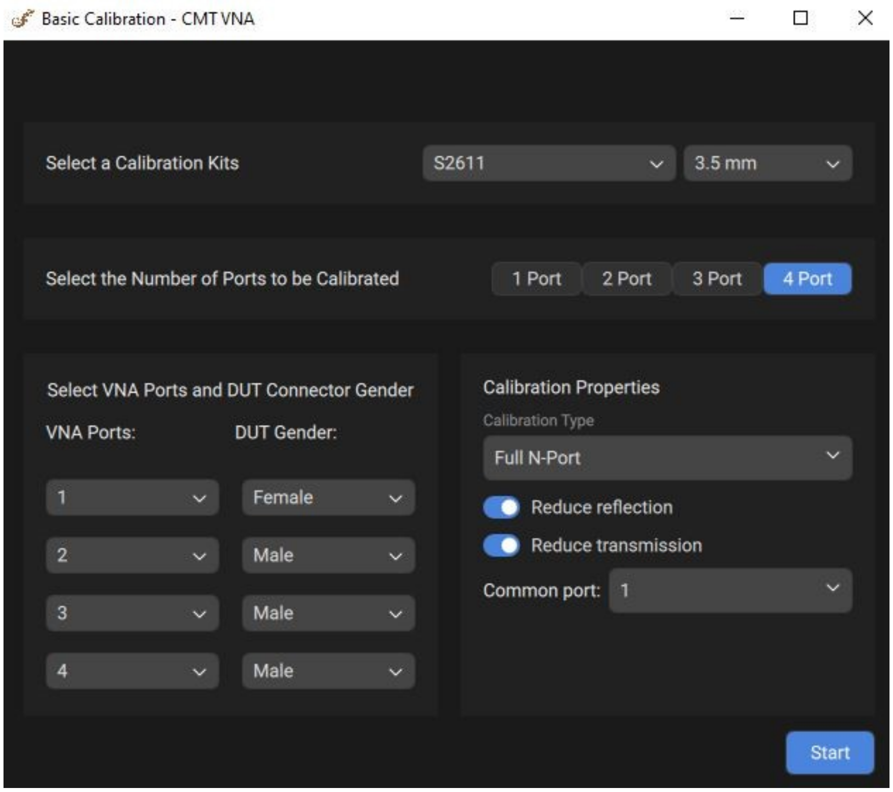
The following are some key measurements that CMT VNA allows users to perform using TR Series VNAs:

- Insertion Loss and Return Loss for Cables
- Insertion Loss and Return Loss for filter/diplexer tuning
- Gain/stability measurement for Amplifiers

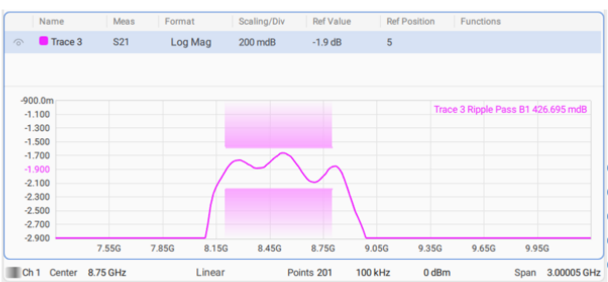
CMT VNA allows user to have as many channels as needed, allowing for precise customization of every measurement through the individualized settings and calibration of each channel. CMT VNA also has a new feature that allows user to zoom in on a portion of the trace by left-clicking over the graph to drag a box around the desired area.

Limit lines may be drawn using the mouse or entered into the limit table directly. The limit line can be drawn in with more than two points. Alternatively, choose the Limit Table button and enter the limit line frequencies and levels numerically.

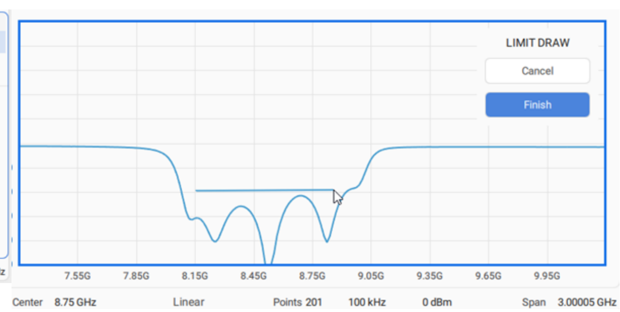
Calibration can be done using the new Basic Calibration Wizard, which allows for easy and intuitive calibration using enabled calibration kits.



Basic Calibration Wizard



Ripple Limit Test



Drawing a Limit LIne

Software Capabilites

Software Capabilites Overview

Included Software Capabilities

Capability	**Overview**
Port Extension	This function is useful when a fixture is used to connect to the DUT but calibration cannot be performed at the DUT terminals.
Power Sweep	Allows the VNA to sweep the stimulus power from one level to another at a single frequency.
Mixer/Converter Measurements	Our analyzers allow users to perform measurements on mixers and other frequency converting devices using both scalar and vector methods.
Time Domain Gating	This function performs a time domain transformation, selects the region in the time domain, deletes the response (outside or inside) the selected region, and transforms the data back to the frequency domain.
Limit Testing	A function for automatic pass/fail based on measurement results.
Embedding	This function allows the user to mathematically simulate the DUT parameters after adding fixture circuits.
De-Embedding	This function allows the user to mathematically exclude the effect of the fixture circuit existing between the calibration plane and the DUT from the measurement results.

Software Capabilities Extended

The CMT VNA software includes many features that other vendors offer as paid options, including Time Domain capability, S-parameter Embedding and De-Embedding, Frequency Offset, and Vector Mixer Calibration functionality. No integrated PC means faster data processing turnaround and regular updates that are easy to install. Less complexity in the VNA leads to fewer points of failure that impact your design or production time.

All of the features listed below are included in the CMT VNA software.

Sweep Features

Sweep type	Linear frequency sweep and logarithmic frequency sweep at fixed output power. Linear power sweep at a fixed frequency.
Measured points per sweep	Set by the user up to 200,001.
Segment sweep features	In applications where a contiguous sweep may be undesirable, this function allows the user to sweep frequency segments rather than the entire frequency span. This can lead to faster measurement results. A frequency sweep can be made within several independent user-defined segments. Frequency range, number of sweep points, source power, and IF bandwidth can be set for each segment.
Output power	Source power from -25 dBm to 0 dBm for the VTR0102 and VTR0302 models with a resolution of 0.05 dB. In frequency sweep mode power slope can be set up to 2 dB/GHz to compensate for high frequency attenuation in fixture cables.
Sweep trigger	Trigger modes: continuous, single, or hold. Trigger sources: internal, manual, external, bus (programmatically controlled).

Trace Functions

CMT VNA software incorporates many trace functions, such as:

Trace display	Data trace, memory trace, or simultaneous indication of data and memory traces.
Trace math	Data trace modification by math operations: addition, subtraction, multiplication or division of measured complex values and memory data. S-parameters and raw receiver values may be manipulated. Amplifier stability factors can be displayed. Unbalanced to differential measurements may be calculated.
Autoscaling	Automatic selection of scale division and reference level value to have the trace most effectively displayed.
Electrical delay	Calibration plane movement to compensate for a delay between the calibrated reference plane and the Device Under Test (DUT) input.
Phase offset	Defined in degrees. Applies a chosen constant phase offset to S-parameter measurements at all frequencies.

Amplifier Compression Measurement

The power sweep feature allows for fast evaluation of the P1dB compression of an amplfier.

Mixer/Converter Measurements

Scalar mixer/converter measurements	The scalar method allows the user to measure the magnitude of the conversion loss of a mixer or other frequency-translating device. No additional mixers or other devices are required. The scalar method employs port frequency offset when there is a difference between the source port frequency and the receiver port frequency.
Scalar mixer/converter calibration	This is the most accurate method of calibration applied for measurements of mixers in frequency offset mode. Open, Short, and Load calibration standards are used for 1-port calibration on each port. An external USB power meter is then used to accurately measure stimulus source power such that a calculated cross-band Thru is achieved for correction of the transmission tracking error.
Vector mixer/converter measurements	The vector method allows measurement of both the magnitude and phase of the mixer conversion loss. This method requires a reference mixer and an LO common to both the reference mixer and the mixer under test. The reference mixer is required to put Ports 1 and 2 at the same frequency such that phase measurements are possible. The reference mixer is de-embedded during vector mixer calibration.
Vector mixer/converter calibration	This method of calibration is applied for vector mixer measurements. Open, Short, and Load calibration standards are used. The reference mixer is de-embedded by this calibration.
Automatic frequency offset adjustment	This function performs automatic frequency offset adjustment when the scalar mixer/converter measurements are performed to compensate for LO frequency inaccuracy.

Time Domain Measurements

This function performs conversion of the response of the DUT from frequency domain to time domain. Modeled time domain stimulus types are bandpass, lowpass impulse, and lowpass step. The time domain span is determined by the frequency span and the number of measurement points. Windowing functions of various shapes are used for tradeoff between resolution and levels of spurious sidelobes.

Time Domain Gating

This function mathematically removes unwanted responses in the time domain, allowing the user to obtain a frequency response without the effects of fixture elements. Reflections occurring within a chosen time span may be bandpass gated such that all other reflections are suppressed or notch gated such that reflections in the chosen time span are suppressed.

After time domain gating, the result with chosen reflections removed may be viewed in the frequency domain. Gating filter types are bandpass or notch. For a better tradeoff between gate resolution and level of spurious sidelobes the following filter shapes are available: maximum, wide, normal and minimum.

Embedding

This feature allows the user to mathematically add a virtual circuit defined by a Touchstone file to any VNA port. This function might be used to test impedance matching on a DUT.

De-embedding

This feature allows the user to mathematically remove a circuit defined by a Touchstone file from the measurements on any VNA port. This might be used to remove the effects of fixture connections or pigtail cable connections to a DUT.

Limit Testing

Limit testing is a function for automatic pass/fail based on measurement results. Pass/fail is based on a comparison of the trace to the limit line set by the user and can consist of one or several segments.

Each segment checks the measurement value for failing either the upper or lower limit, or both. The limit line segment is defined by specifying the coordinates of the beginning (X0, Y0) and the end (X1, Y1) of the segment, and the type of limit. The MAX or MIN limit types check if the trace falls below or above the limit line, respectively.

Port Impedance Conversion

This function converts the S-parameters measured at a 50 Ω port into values which would be seen if measured at a test port with an arbitrary impedance.

S-Parameter Conversion

This function allows for conversion of measured S-parameters to the following parameters: reflection impedance and admittance looking at a grounded DUT, transmission impedance and admittance looking through a DUT, transmission impedance and admittance looking across the top of a grounded DUT using a 2-Port measurement, and inverse S-parameters.

Differential measurement	This feature allows for conversion from unbalanced to balanced measurement, allowing measurement of twisted pairs or other differential balanced transmission lines.
State saving	Analyzer State All state, calibration and measurement data can be saved to an Analyzer state file on the hard disk and later recalled into the software program. The following four types of states are available: State, State & Cal, State & Trace, or All. Channel State A channel state can be saved into the Analyzer state. The procedure is similar to saving of the Analyzer state, and the same types are applied to channel saving. Unlike Analyzer state, channel state is saved into the Analyzer volatile memory (not to the hard disk) and is cleared when power to the Analyzer is switched off. For channel state, there are four memory registers A, B, C, D. Channel state saving allows the user to easily copy the settings of one channel to another one.

Data Output

Trace data CSV file	The Analyzer allows the user to save an individual trace's data as a CSV file (comma separated values). The active trace stimulus and response values in its current format are saved to a *.CSV file.
Trace data Touchstone file	Allows the user to save S-parameters to a Touchstone file. The Touchstone file contains frequency values and S-parameters. Files of this format are industry-standard for most circuit simulator programs. The .s2p files are used for saving all S-parameters of a 2-port device. The .s1p files are used for saving S11 or S22 parameters of a 1-port device. The Touchstone file saving function is applied to individual channels. In addition, the software can be used as a Touchstone file viewer, which allows the user to graphically display and work with previously saved Touchstone files. Normally, trace transforms such as time-domain gating are not saved to a Touchstone file, but enabling "Including Trace Transform" will allow this.
Screenshot capture	A print function is provided with a preview feature, which allows for viewing an image of the screen, and/or save it to a file. Screenshots can be printed using three different applications: MS Word, Image Viewer for Windows, or the Print Wizard of the Analyzer. Each screenshot can be printed in color, grayscale, black and white, or inverted for visibility or to save ink. The current date and time can be added to each capture before it is transferred to the printing application, resulting in quick and easy test reporting. A Word template file in the C drive VNA folder image directory may be customized to change the appearance of the MS Word file output.

User Calibration

Calibration	Calibration of a test setup (which includes the VNA, cables, and adapters) significantly increases the accuracy of measurements. Calibration allows for correction of errors caused by imperfections in the measurement system: system directivity, source and load match, tracking, and isolation.
Calibration methods	The following calibration methods of various sophistication and accuracy are available: • Reflection and transmission normalization • Full 1-port calibration • 1-path 2-port calibration
Reflection and transmission normalization	This is the simplest calibration method; however, it provides reduced accuracy compared to other methods.
Full 1-port calibration	Method of calibration performed for 1-port reflection measurements. It ensures high accuracy.
1-path 2-port calibration	Method of calibration performed for reflection and one-way transmission measurements; for example, for measuring s11 and s21 only. It ensures high accuracy for reflection measurements, and moderate accuracy for transmission measurements. Commonly used when an attenuator must be attached to the receiving port as in the measurement of a high-power amplifier.
Mechanical calibration kits	The user can select one of the predefined calibration kits of various manufacturers or define a new calibration kit.
Automatic calibration modules	Electronic, or automatic, calibration modules offered by CMT make calibration faster and easier than traditional mechanical calibration. Automatic calibration is superior to mechanical calibration.

Sliding load calibration standard	The use of a sliding load calibration standard allows for a significant increase in calibration accuracy at high frequencies compared to the fixed load calibration standard.
Unknown thru calibration standard	The use of a generic 2-port reciprocal circuit instead of a characterized Thru in full 2-port calibration allows the user to calibrate the VNA for measurement of “non-insertable” devices. Unknown thru should be used by default for SOLT (SOLR) calibrations.
Defining of calibration standards	Different methods of calibration standard definition are available: standard definition by polynomial model and standard definition by Touchstone data file (S-parameters).
Error correction interpolation	When the user changes any settings such as the start/stop frequencies or the number of sweep points, compared to the settings at the moment of calibration, interpolation or extrapolation of the calibration coefficients will be applied. Extrapolation is not recommended for accurate measurements.
Power calibration	Power calibration allows a more stable power level setting at the DUT input. An external power meter should be connected to the USB port directly or via a USB/GPIB adapter. VNA output power accuracy is only of concern when measuring a non-linear DUT.
N1.2 calibration kit	The N1.2 calibration kit is suitable for calibration of the TR1300/1 and other VNAs in the frequency range up to 1.5 GHz. While the VNA can be used with any calibration kit on the market suitable for its specifications, the N1.2 is recommended as an economy option for basic calibration.

Automation Languages

We maintain code examples and guides in the following languages:

- Python*
- C++*
- LabVIEW
- VBA
- MATLAB

*Available for use with Linux operating system

Measurement Automation

SCPI via TCP Socket	A TCP socket is provided for automation from either localhost--the same machine running the VNA software application--or from a second PC connected by an IP network. SCPI commands are largely compatible with legacy instruments, maximizing code reuse for existing test automation platforms. SCPI via TCP Socket is compatible with either Windows or Linux operating systems.
SCPI via HiSlip	Based on VXI-11, the HiSlip interface uses the same SCPI command set but further allows for instrument discovery and provides ease of automation through Visa library of your choice. SCPI via HiSlip is able to be used with either Windows or Linux operating systems.
LabVIEW compatible	The device and its software are fully compatible with LabVIEW applications for ultimate flexibility in user-generated programming and automation. LabVIEW is only able to be used with Windows operating systems.

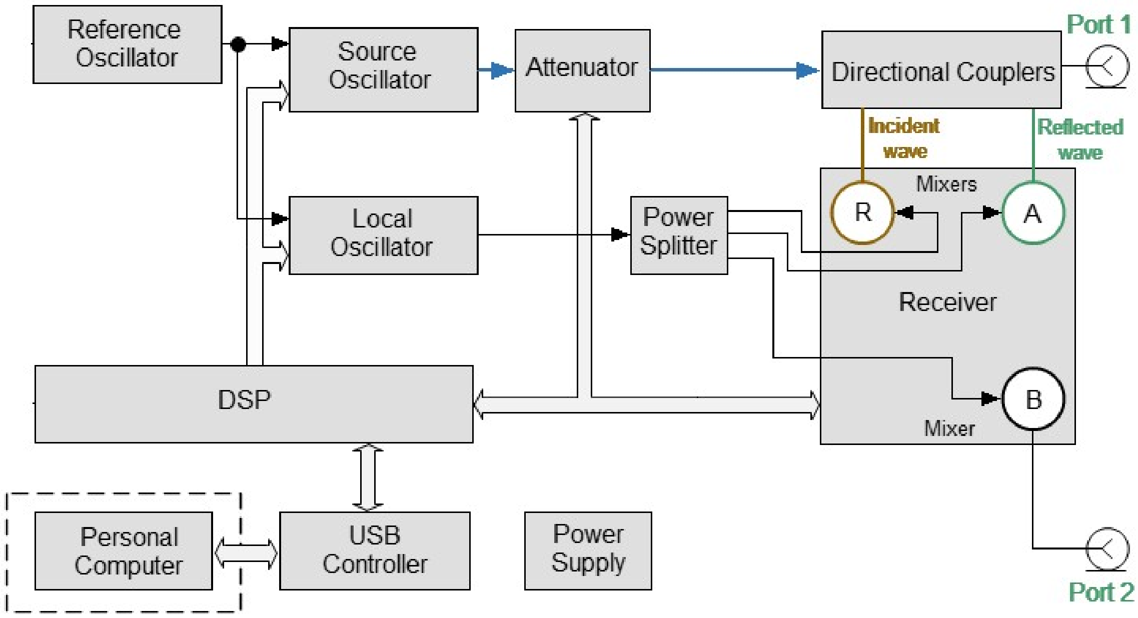
Our command set is modeled after industry-standard legacy equipment; porting code is straightforward, and we can help. Complete installation of CMT software comes with multiple programming examples and guides installed in the C drive VNA folder under Programming Examples and Guides directory on Windows or ~/Documents/VNA directory on Linux.

Automation Features

- Segmented frequency sweeps
- Linear/logarithmic sweeps
- Power sweeps
- Multiple trace formats
- Marker math
- Trace math
- Limit tests

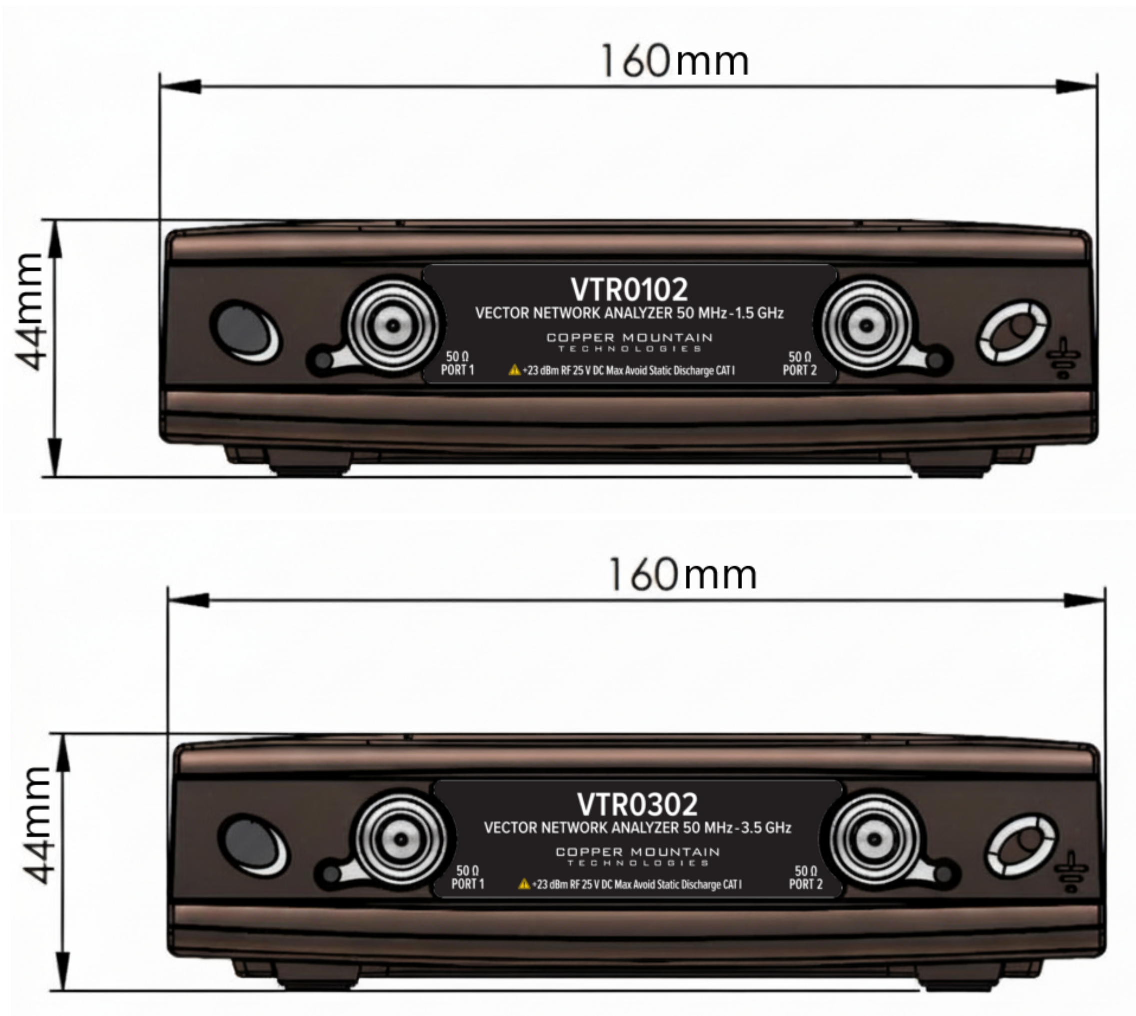
Hardware Specifications

Block Diagrams



VTR0102 and VTR0302 Block Diagram

Panels with Dimensions



VTR0102 and VTR0302 Front Panel

VTR0102 and VTR0302 Rear Panel

TR Series
VTR0102 and VTR0302

All specifications subject to change without notice.

Measurement Range

Impedance	50 Ohm
Test port connector	type N, female
Configuration	2-port, 1-path
Number of transmitter ports	1
Number of receiver ports	1
Frequency range	
VTR0102	50 MHz to 1.5 GHz
VTR0302	50 MHz to 3.5 GHz
Full frequency accuracy	$\pm 10 \cdot 10^{-6}$
Frequency resolution	1 Hz
Number of measurement points	2 to 200,001
Measurement bandwidths (with 1/1.5/2/3/5/7 steps)	1 Hz to 300 kHz
Dynamic range[2] (receiver att = 12dB)	110 dB (120 dB typ.)

[2] The dynamic range is defined as the difference between the specified maximum power level and the specified noise floor.

The specification applies at 10 Hz IF bandwidth.

Measurement Accuracy[3]

Accuracy of transmission measurements[4]	Magnitude / Phase ($S_{11} = S_{22} = 0$)	Magnitude / Phase ($S_{11} = S_{22} = 0.1$)
0 dB to 10 dB	±0.30 dB / ±2.5°	±0.40 dB / ±3.0°
-30 dB to 0 dB	±0.20 dB / ±2.0°	±0.30 dB / ±2.5°
-50 dB to -30 dB	±0.30 dB / ±2.5°	±0.40 dB / ±3.0°
-70 dB to -50 dB	±1.2 dB / ±8.0°	±1.3 dB / ±8.5°

Accuracy of reflection measurements[5]	Magnitude/Phase
-10 dB to 0 dB	±0.5 dB / ±4.5°
-20 dB to -10 dB	±1.1 dB / ±8.0°
-30 dB to -20 dB	±3.5 dB / ±20.5°
Trace noise magnitude	0.004 dB rms
Temperature dependence	0.03 dB/°C

[3] Reflection and transmission measurement accuracy applies over the temperature range of (73 ± 9) °F or (23 ± 5) °C after 40 minutes of warming-up,

with less than 1 °C deviation from the full two-port calibration temperature, at output power of 0 dBm. Frequency points have to be identical for measurement and calibration (no interpolation allowed).

[4] Transmission specifications are based on a matched DUT, and IF bandwidth of 10 Hz.

[5] Reflection specifications are based on an isolating DUT.

Effective System Data

50 MHz to 3.5 GHz	
Directivity	40 dB
Source match	36 dB
Load match	20 dB
Reflection tracking	±0.15 dB
Transmission tracking	±0.20 dB

Uncorrected System Performance

50 MHz to 2.5 GHz	
Directivity	15 dB (18 dB typ.)
Source match	15 dB
Load match	20 dB (25 dB typ.)
2.5 GHz to 3.5 GHz	
Directivity	8 dB (10 dB typ.)
Source match	12 dB
Load match	20 dB (25 dB typ.)

Transmitter Output

Power range	-25 dBm to +0 dBm
Power accuracy	±2 dB
Harmonic distortion[6]	
50 MHz to 1.0 GHz	-9 dBc
1.0 GHz to 5.5 GHz	-15 dBc

[6] Specification applies over full frequency range, at max output power.

Receiver Input

Receiver max input power (receiver att = 12 dB)	0 dBm
Noise floor[7]	-120 dBm/Hz
Receiver attenuator range	18 dB
Damage level	+23 dBm
Damage DC voltage	35V

[7] Receiver noise floor specification includes crosstalk effect.

Measurement Speed

Time per point	35 μs typ.

System and Power

CMT VNA software:	
Operating system (min requirements)	Windows 10, Ubuntu 24.04
CPU	4 core 2.0 GHz (x64 or arm64)
RAM	8 GB
Interface	USB 2.0
Connector type	Type C
Input power	
Voltage range	9 V DC to 15 V DC
Power consumption	10 W
Connector designation	12 V DC 1.2 A
Connector type	KPJX-4S-S

Dimensions

Length	160 mm
Width	297 mm
Height	44 mm
Weight	1.5 kg (53 oz)

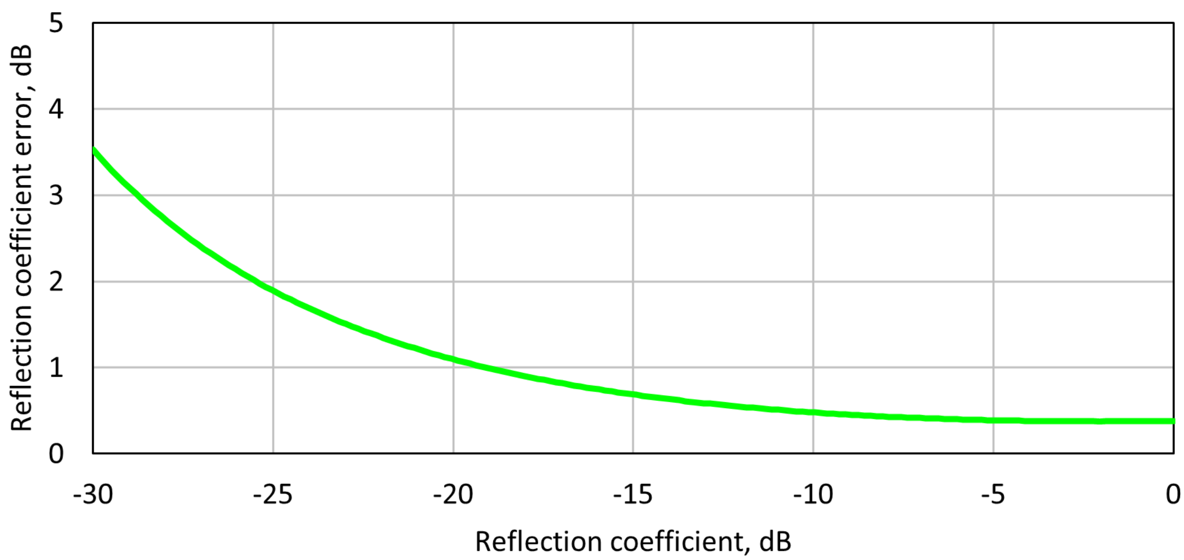
Environmental Specifications

Operating condition	
Temperature	+5 °C to +40 °C (41 °F to 104 °F)
Humidity	90 % at 25 °C (77 °F)
Storage	
Temperature	+0 °C to +40 °C (32 °F to 104 °F)
Humidity	80 % at 35 °C (95 °F)
Non-operating temperature	-50 °C to +70 °C (-58 °F to 158 °F)
Atmospheric pressure	70.0 kPa to 106.7 kPa

VTR0102 and VTR0302 Plots

Reflection Accuracy Plots

Reflection Magnitude Errors



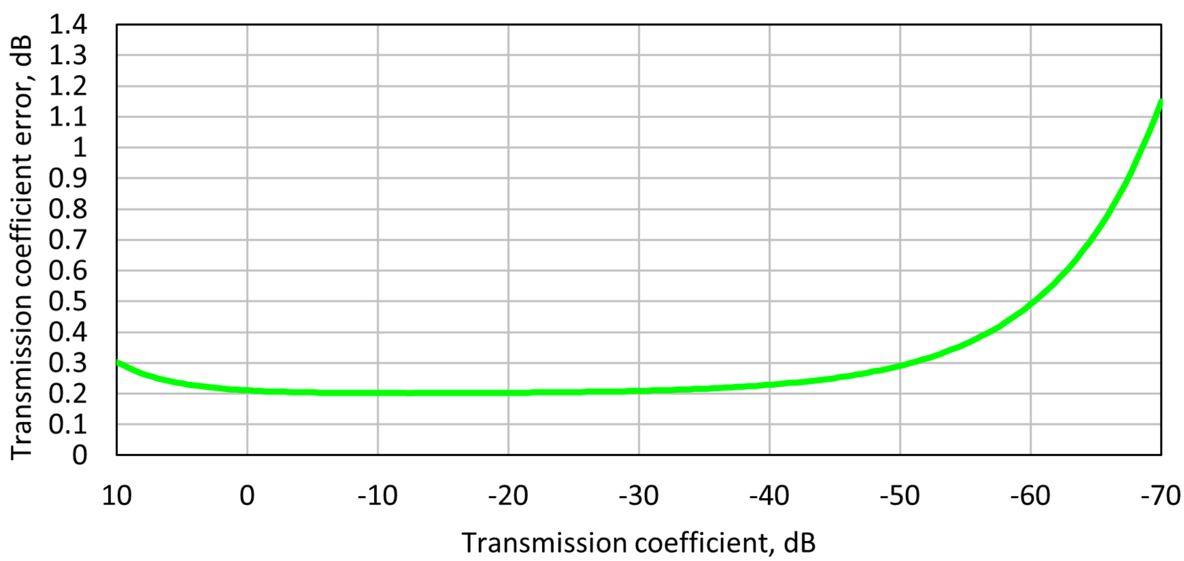
Specifications are based on isolating DUT (S21 = S12 = 0)

Reflection Phase Errors

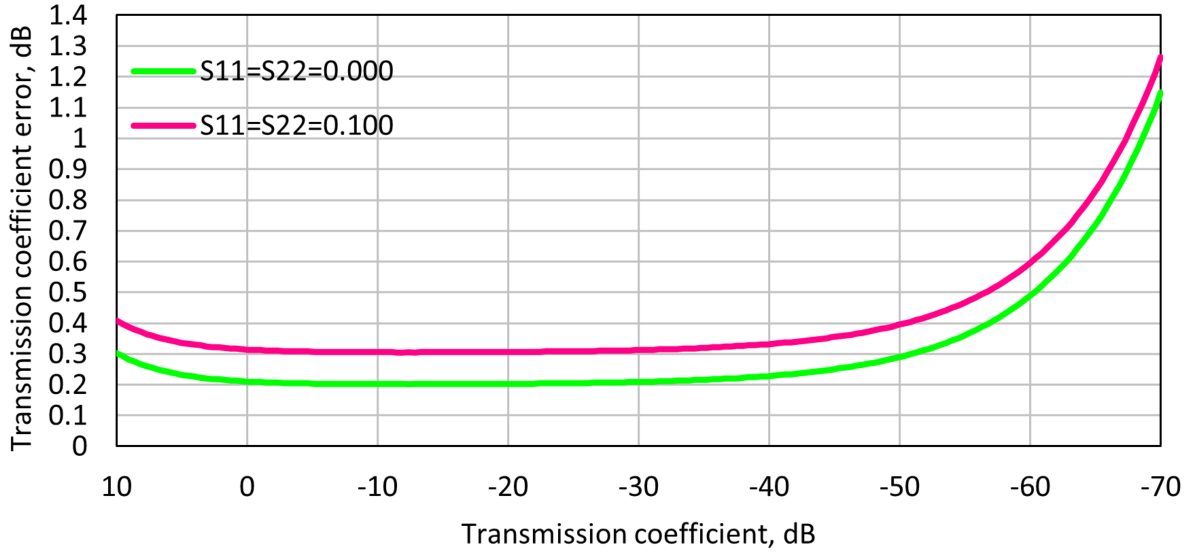
Specifications are based on isolating DUT (S21 = S12 = 0)

Transmission Accuracy Plots

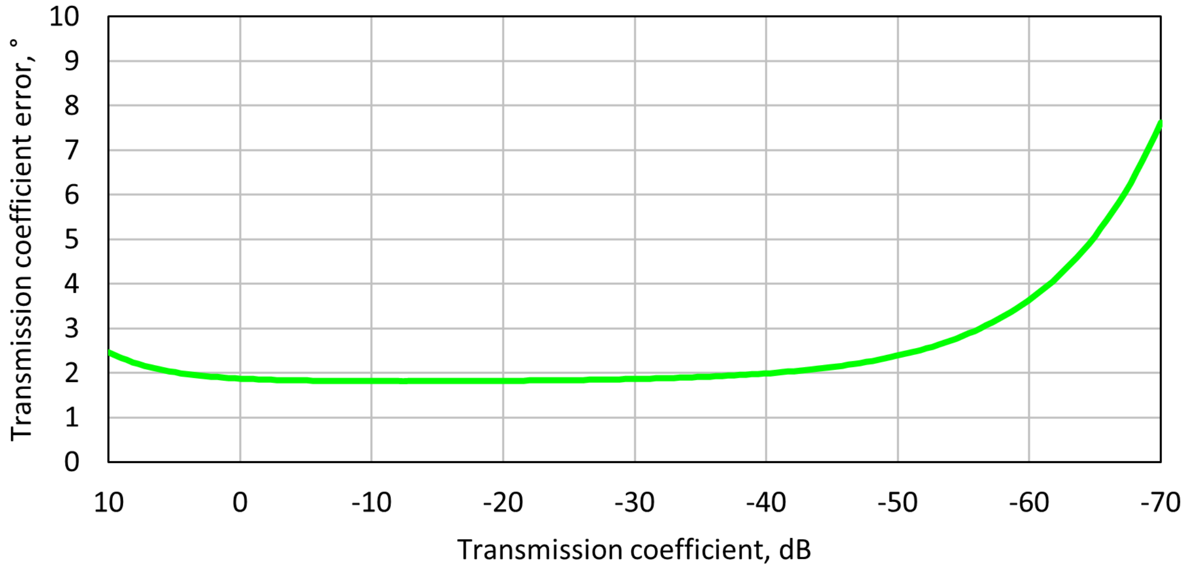
Transmission Magnitude Errors



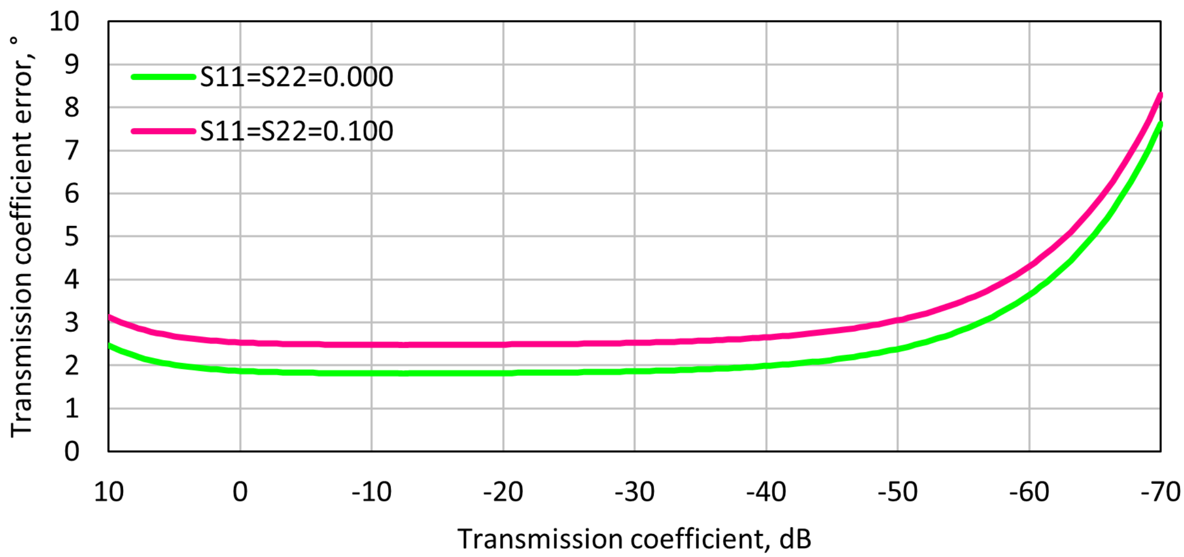
Specifications are based on matched DUT, and IF bandwidth of 10 Hz


Transmission coefficient error, dB
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
S11=S22=0.000
S11=S22=0.100
10
0
-10
-20
-30
-40
-50
-60
-70
Transmission coefficient, dB

Transmission Phase Errors



Specifications are based on matched DUT, and IF bandwidth of 10 Hz



STEP Files

Use the links below to find the STEP files for your product.

- VTR0102
- VTR0302