



## SN0904 Vector Network Analyzer Specifications



Frequency range	300 kHz to 9 GHz
Software	S4VNA

**\*Preliminary Specifications - Subject to Change\***

## Software Capabilities

### Software Capabilities 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 measurements	Time-domain transformation enables the user to apply an inverse Fourier transform to frequency-domain data, producing the corresponding time-domain response.
Time domain gating	This function performs a time-domain transformation, selects a region of interest in the time domain, removes the response either inside or outside the selected region, and then transforms the modified 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.

## Available Software Options

Capability	Overview
<a href="#">AFR</a>	Automatic Fixture Removal (AFR) is an intuitive software plug-in that is used to accurately measure hard to access devices, such as SMD sized components mounted on a fixture by de-embedding the fixture effects. The AFR VNA software plug-in enables the measurement of a wide range of components through comprehensive methods tailored to specific fixture properties.
<a href="#">Manufacturing Plug-In</a>	The Manufacturing Test Plug-in supports incorporating VNA software into automated manufacturing and QA process.

## Software Capabilities Extended

The S4VNA 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 S4VNA software.

### Sweep Features

<b>Sweep type</b>	Linear frequency sweep and logarithmic frequency sweep at fixed output power. Linear power sweep at a fixed frequency.
<b>Measured points per sweep</b>	Set by the user up to 500,001
<b>Segment sweep features</b>	<p>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.</p> <p>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.</p>
<b>Output power</b>	Source power from -45 dBm to +10 dBm.
<b>Sweep trigger</b>	<p>Trigger modes: continuous, single, or hold.</p> <p>Trigger sources: internal, manual, external, bus (programmatically controlled).</p>

## Trace Functions

The S4VNA software incorporates many trace functions, such as:

<b>Trace display</b>	Data trace, memory trace, or simultaneous indication of data and memory traces.
<b>Trace math</b>	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.
<b>Autoscaling</b>	Automatic selection of scale division and reference level value to have the trace most effectively displayed.
<b>Electrical delay</b>	Calibration plane movement to compensate for a delay between the calibrated reference plane and the Device Under Test (DUT) input.
<b>Phase offset</b>	Defined in degrees. Applies a chosen constant phase offset to S-parameter measurements at all frequencies.
<b>Sweep trigger</b>	Trigger modes: continuous, single, or hold. Trigger sources: internal, manual, external, bus (program controlled).

## Amplifier Compression Measurement

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

## Mixer/Converter Measurements

<p><b>Scalar mixer/converter measurements</b></p>	<p>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.</p>
<p><b>Scalar mixer/converter calibration</b></p>	<p>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.</p>
<p><b>Vector mixer/converter measurements</b></p>	<p>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.</p>
<p><b>Vector mixer/converter calibration</b></p>	<p>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.</p>
<p><b>Automatic frequency offset adjustment</b></p>	<p>This function performs automatic frequency offset adjustment when the scalar mixer/converter measurements are performed to compensate for LO frequency inaccuracy.</p>
<p><b>Sweep trigger</b></p>	<p>Trigger modes: continuous, single, or hold.  Trigger sources: internal, manual, external, bus (program controlled).</p>

## 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  $\Omega$  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.

<b>State saving</b>	<p><b>Analyzer State</b></p> <p>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 &amp; Cal, State &amp; Trace, or All.</p> <p><b>Channel State</b></p> <p>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.</p>
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## Data Output

<p><b>Trace data CSV file</b></p>	<p>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.</p>
<p><b>Trace data Touchstone file</b></p>	<p>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.</p>
<p><b>Screenshot capture</b></p>	<p>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.</p>

## User Calibration

<p><b>Calibration</b></p>	<p>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.</p>
<p><b>Calibration methods</b></p>	<p>The following calibration methods of various sophistication and accuracy are available:</p> <ul style="list-style-type: none"> <li>• Reflection and transmission normalization</li> <li>• Full one-port calibration</li> <li>• One-path N-port calibration</li> <li>• Full N-port calibration</li> </ul>
<p>Reflection and transmission normalization</p>	<p>This is the simplest calibration method; however, it provides reduced accuracy compared to other methods.</p>
<p>Full 1-port calibration</p>	<p>Method of calibration performed for 1-port reflection measurements. It ensures high accuracy.</p>
<p>1-path 2-port calibration</p>	<p>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.</p>
<p>Full two-port calibration</p>	<p>This method of calibration is performed for full S-parameter matrix measurement of a two-port DUT, ensuring high accuracy.</p>
<p>One port N-path calibration</p>	<p>A one-path N-port calibration combines full one-port calibration with transmission normalization. This method allows for a more accurate estimation of transmission tracking error (Et) than using transmission normalization.</p>
<p>Full N-port calibration</p>	<p>A full N-port calibration (SOLT) combines N full one-port calibrations for each port with measurements of a THRU standard between each test port pair, which provides transmission measurements. Index N is the number of ports involved in the calibration.</p>

<b>Sliding load calibration standard</b>	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.
<b>Unknown thru calibration standard</b>	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.
<b>Defining of calibration standards</b>	Different methods of calibration standard definition are available: standard definition by polynomial model and standard definition by Touchstone data file (S-parameters).
<b>Error correction interpolation</b>	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.
<b>Power calibration</b>	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.
<b>Receiver calibration</b>	This method calibrates the receiver gain at the absolute signal power measurement.
<b>Mechanical calibration kits</b>	The user can select one of the predefined calibration kits of various manufacturers or define a new calibration kit.
<b>Automatic calibration modules</b>	Electronic, or automatic, calibration modules offered by CMT make calibration faster and easier than traditional mechanical calibration. Automatic calibration is superior to mechanical 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

<p><b>SCPI via TCP Socket</b></p>	<p>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.</p>
<p><b>SCPI via HiSlip</b></p>	<p>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 are compatible with either Windows or Linux operating systems.</p>
<p><b>LabVIEW compatible</b></p>	<p>The device and its software are fully compatible with LabVIEW applications for ultimate flexibility in user-generated programming and automation. LabVIEW are only compatible with Windows operating systems.</p>

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.

## Standard Software Features

- Segmented frequency sweeps
- Linear/logarithmic sweeps
- Power sweeps
- Multiple trace formats
- 16 channels max with up to 16 traces each
- Marker math
- Trace math
- Limit tests

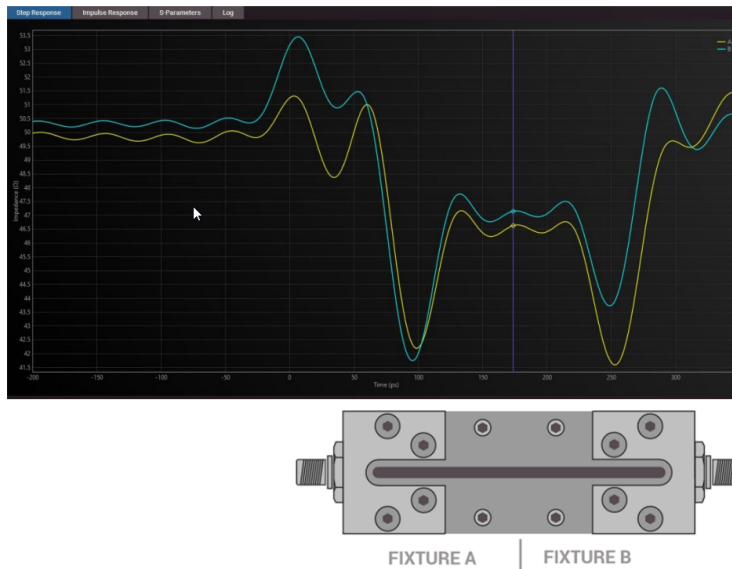
## Available Software Options

### Optionally Available Features

Software plug-ins can add wide ranges of functionality and can be developed upon request. Examples include streamlined production applications, functionality to trigger with external generators, and virtual circuit impedance match modeling.

### Automatic Fixture Removal

Automatic Fixture Removal (AFR) VNA software option enables the measurement of a wide range of components through comprehensive methods tailored to specific fixture properties. The intuitive AFR software moves the calibration plane towards hard-to-access DUTs and guides the de-embedding process using either time-gating, filtering, or bisection methods. These methods eliminate the effects of fixture reflections and allow accurate measurement of the DUT alone. The AFR software option is easy to use and is compatible with most CMT VNAs.



Automatic Fixture Removal

The Automatic Fixture Removal (AFR) option uses metrology grade de-embedding algorithms to eliminate fixture effects on your DUT. AFR supports three methods of de-embedding methodologies:

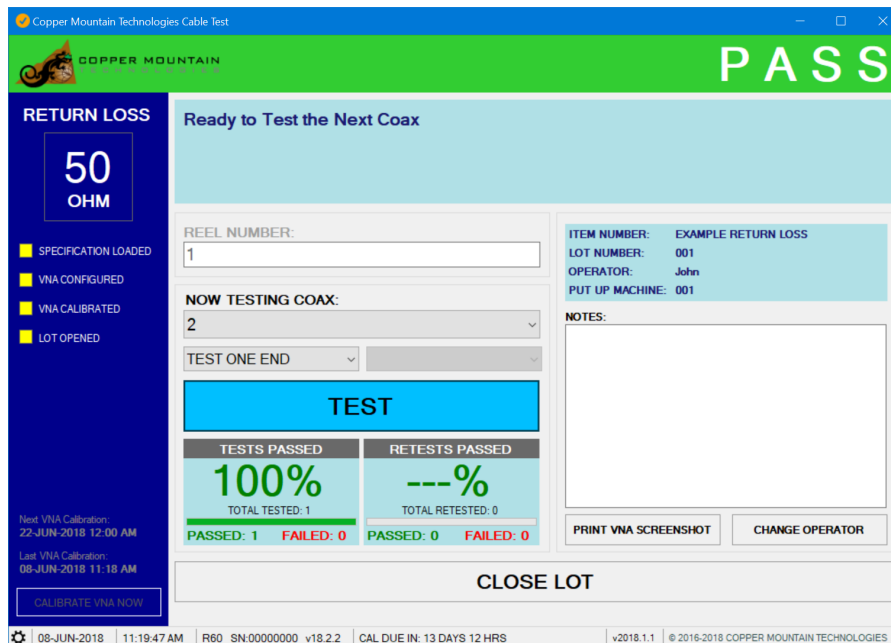
- Time-gating approach is ideal for fixtures with fixture lead-in and lead-out lengths long enough to support two or more wavelengths of the highest measurement frequency.

- Filtering algorithm is useful in cases where fixture lead-in and lead-out lengths are at the minimum for time domain gating.
- Bisect method covers instances with short electrical length of fixture lead-in and lead-out where there is not two or more wavelengths of the highest measurement frequency and the fixture has insufficient length to support time-domain gating.

## Manufacturing Test Plug-in

The Manufacturing Test Plug-in automates VNA measurement for the manufacturing and QA process:

- Streamline production test processes in an intuitive wizard-like UI, built for non-technical users.
- Ensure consistency of test process across multiple operators and workstations.
- Easily create and manage pass/fail limits across multiple workstations. Pass/fail limits and instrument configuration are stored in a human-readable plaintext specifications file, which can be maintained by an authorized test engineer.
- Organize test results for subsequent retrieval and analysis.
- 20 hours of customization by our Engineering staff included
- Can adapt to any specific production test process and QMS requirements.



Manufacturing Test Plug-in

## Hardware Specifications

### SN0904

#### Measurement Range<sup>1</sup>

Impedance	50 Ohm
Test port connector	type N, female
Number of test ports	4
Frequency range	300 kHz to 9 GHz
Full frequency accuracy	$\pm 5 \cdot 10^{-6}$
Frequency resolution	1 Hz
Number of measurement points	2 to 500,001
Measurement bandwidths (with 1/1.5/2/3/5/7 steps)	1 Hz to 300 kHz
Dynamic range <sup>2</sup>	
300 kHz to 5 MHz	110 dB (125 dB typ.)
5 MHz to 6 GHz	135 dB (140 dB typ.)
6 GHz to 9 GHz	122 dB (130 dB typ.)

[1] All specifications subject to change without notice.

[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<sup>[3]</sup>

Accuracy of transmission measurements <sup>4</sup>	Magnitude/Phase
300 kHz to 5 MHz	
0 dB to +10 dB	±0.25 dB / ±2.5°
-30 dB to 0 dB	±0.15 dB / ±1.5°
-50 dB to -30 dB	±0.25 dB / ±2.5°
-70 dB to -50 dB	±1.1 dB / ±7.5°
5 MHz to 6 GHz	
0 dB to +10 dB	±0.25 dB / ±2.5°
-55 dB to 0 dB	±0.15 dB / ±1.5°
-75 dB to -55 dB	±0.25 dB / ±2.5°
-95 dB to -75 dB	±1.1 dB / ±7.5°
6 GHz to 9 GHz	
0 dB to +10 dB	±0.25 dB / ±2.5°
-50 dB to 0 dB	±0.15 dB / ±1.5°
-70 dB to -50 dB	±0.25 dB / ±2.5°
-90 dB to -70 dB	±1.1 dB / ±7.5°
Accuracy of reflection measurements <sup>5</sup>	Magnitude/Phase
-15 dB to 0 dB	±0.5 dB / ±4°
-25 dB to -15 dB	±1.5 dB / ±10°
-35 dB to -25 dB	±5.5 dB / ±30°
Trace noise magnitude (IF bandwidth 3 kHz)	
300 kHz to 6 GHz	0.002 dB rms
6 GHz to 9 GHz	0.004 dB rms
Temperature dependence	
300 kHz to 6 GHz	0.02 dB/°C
6 GHz to 9 GHz	0.04 dB/°C

[3] Reflection and transmission measurement accuracy applies over the temperature range of  $(73 \pm 9) ^\circ\text{F}$  or  $(23 \pm 5) ^\circ\text{C}$  after 30 minutes of warming up, with less than  $1^\circ\text{C}$  deviation from the full two-port calibration temperature, at output power of  $-5 \text{ dBm}$ . Frequency points have to be identical for measurement and calibration (no interpolation allowed).

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

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

## Effective System Data

Directivity	42 dB
Source match	38 dB
Load match	42 dB
Reflection tracking	±0.10 dB
Transmission tracking	±0.14 dB

## Uncorrected System Performance

<b>300 kHz to 6 GHz</b>	
Directivity	15 dB
Source match	15 dB
Load match	15 dB
<b>6 GHz to 9 GHz</b>	
Directivity	10 dB
Source match	15 dB
Load match	15 dB

## Test Port Output

<b>Power range</b>	
300 kHz to 6 GHz	-45 dBm to +10 dBm
6 GHz to 9 GHz	-45 dBm to +2 dBm
<b>Power accuracy</b>	±1.5 dB
<b>Power resolution</b>	0.05 dB
<b>Harmonic distortion<sup>6</sup></b>	
300 kHz to 1 GHz	-8 dBc
1 GHz to 9 GHz	-15 dBc
<b>Non-harmonic spurious<sup>6</sup></b>	-15 dBc (-22 dBc typ.)

[6] Specification applies over the entire frequency range, at output power of 0 dBm.

## Test Port Input

<b>Noise floor</b>	
300 kHz to 5 MHz	-110 dBm/Hz
5 MHz to 6 GHz	-135 dBm/Hz
6 GHz to 9 GHz	-130 dBm/Hz
<b>Damage level</b>	+23 dBm
<b>Damage DC voltage</b>	25 V

## Measurement Speed

<b>Time per point</b>	24 $\mu$ s typ.
<b>Port switchover time</b>	200 $\mu$ s

## Frequency Reference Input

<b>Port</b>	Ref IN 10 MHz
<b>External reference frequency</b>	10 MHz
<b>Input level</b>	-3 dBm to 3 dBm
<b>Input impedance</b>	50 Ohm
<b>Connector type</b>	BNC, female

## Frequency Reference Output

<b>Port</b>	Ref OUT 10 MHz
<b>Internal reference frequency</b>	10 MHz
<b>Output reference signal level at 50 Ohm impedance</b>	-1 dBm to 3 dBm
<b>Connector type</b>	BNC, female

## Trigger Input

Port	Ext Trig In
<b>Input level</b>	
Low threshold voltage	1.1 V
High threshold voltage	2.6 V
<b>Input level range</b>	0 V to +5 V
<b>Pulse width</b>	≥2 μs
<b>Polarity</b>	positive or negative
<b>Input impedance</b>	≥2 kOhm
<b>Connector type</b>	BNC, female

## Trigger Output

Port	Ext Trig Out
<b>Maximum output current</b>	20 mA
<b>Output level</b>	
Low level voltage	0.0 to 0.6 V
High level voltage	3.0 to 3.8 V
<b>Polarity</b>	positive or negative
<b>Connector type</b>	BNC, female

## System & Power

<b>Operating system</b>	Windows 10 and above
<b>CPU</b>	4 core 2.0 GHz (x64)
<b>RAM</b>	4 GB
<b>Interface</b>	USB 2.0
<b>Connector type</b>	Type C
<b>Power supply</b>	110-240 V, 50/60 Hz
<b>Power consumption</b>	32 W

## Calibration

<b>Recommended factory adjustment interval</b>	3 Years
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## Dimensions

Length	439 mm
Width	362 mm
Height	90 mm
Weight	6.5 kg

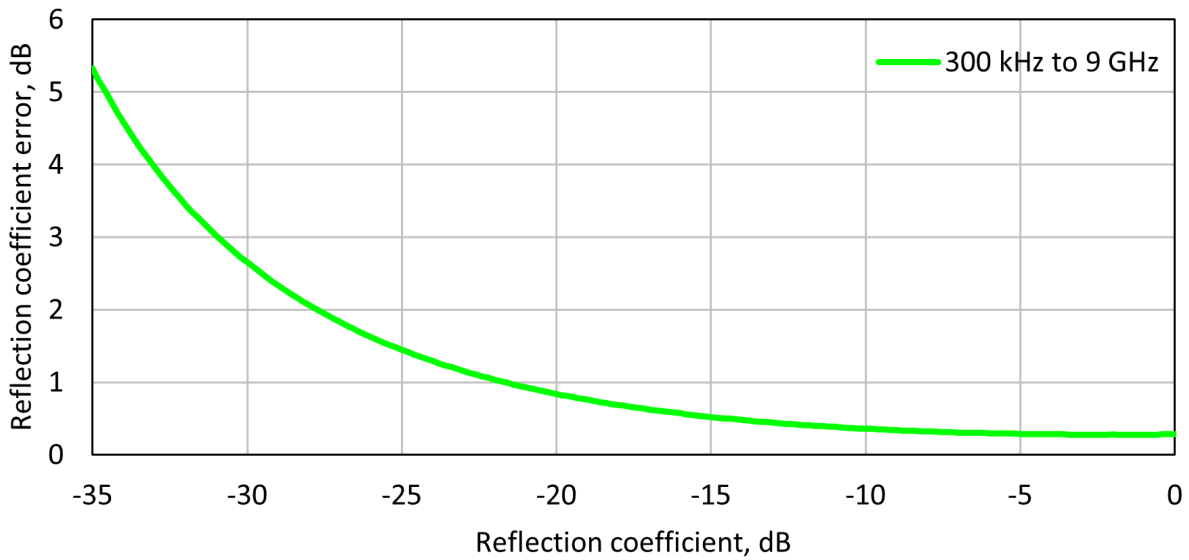
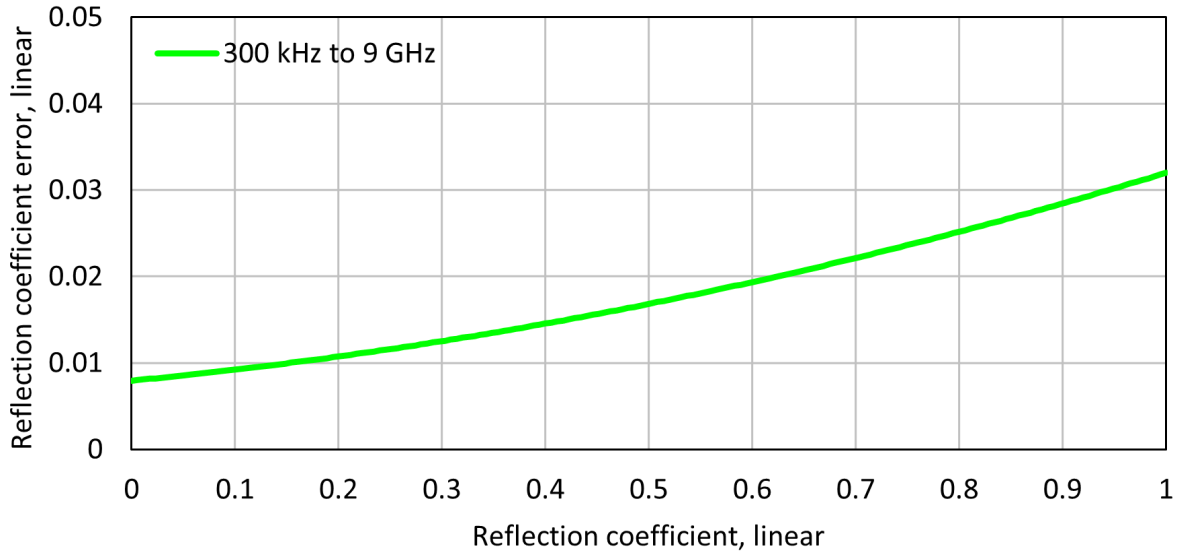
## Environmental Specifications

<b>Operating condition</b>	
Temperature	+5 °C to +40 °C (41 °F to 104 °F)
Humidity	90 % at 25 °C (77 °F)
<b>Storage</b>	
Temperature	0 °C to +40 °C (32 °F to 104 °F)
Humidity	80 % at 35 °C (95 °F)
<b>Non-operating temperature<sup>8</sup></b>	-50 °C to +70 °C (-58 °F to 158 °F)
<b>Atmospheric pressure</b>	70.0 kPa to 106.7 kPa

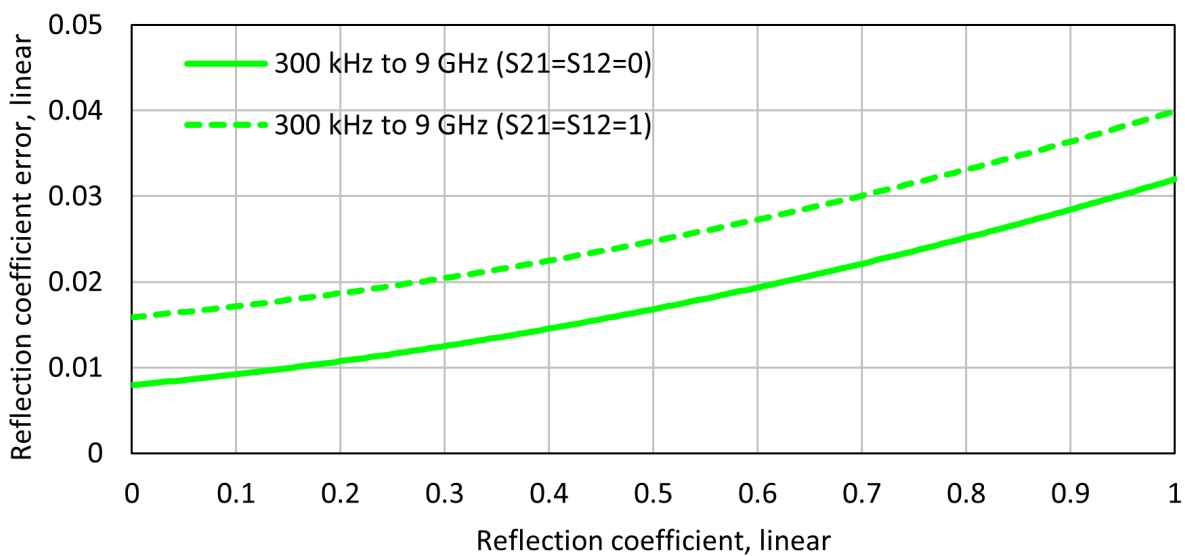
*[8] Non-operating temperature specifies the allowable environmental conditions for transporting the instrument. Storage conditions are listed separately.*

## Reflection Accuracy Plots

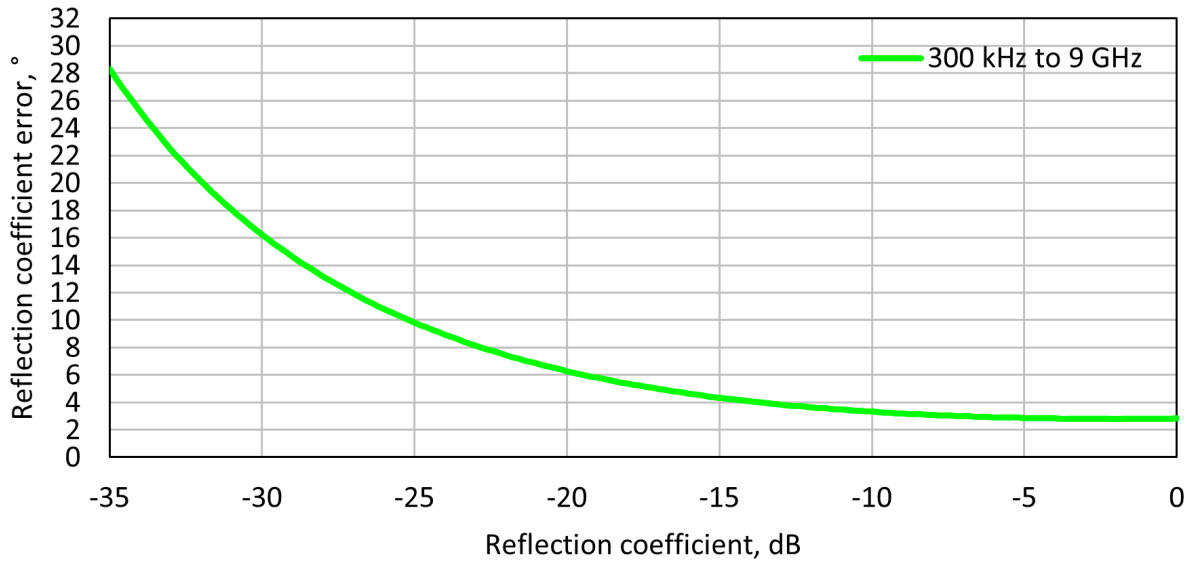
### Reflection Magnitude Errors



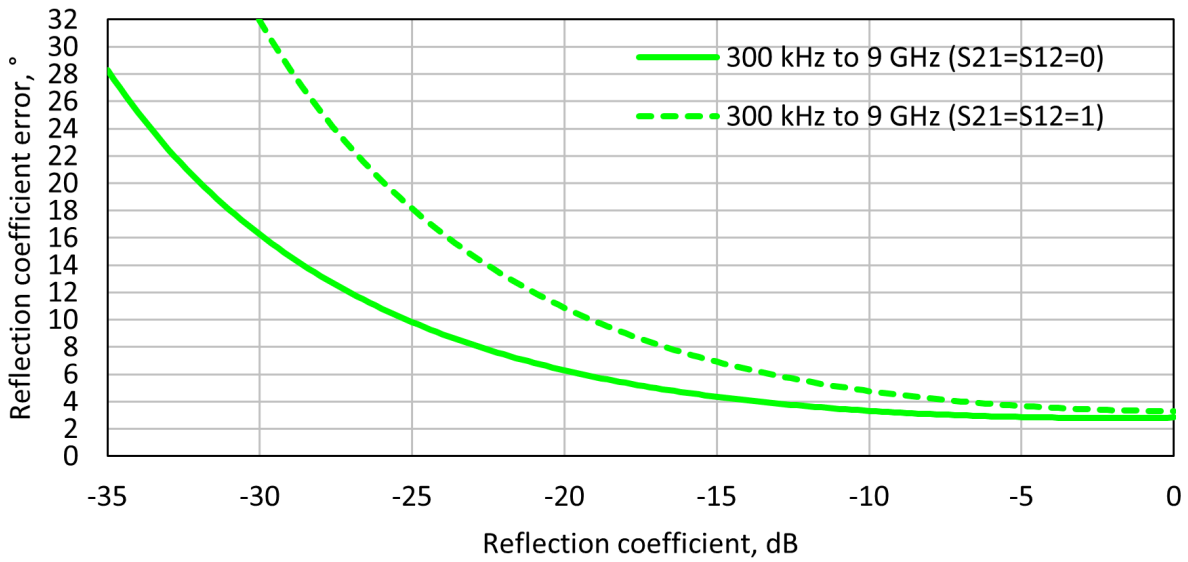
Specifications are based on an isolating DUT ( $S_{21} = S_{12} = 0$ )



## Reflection Phase Errors

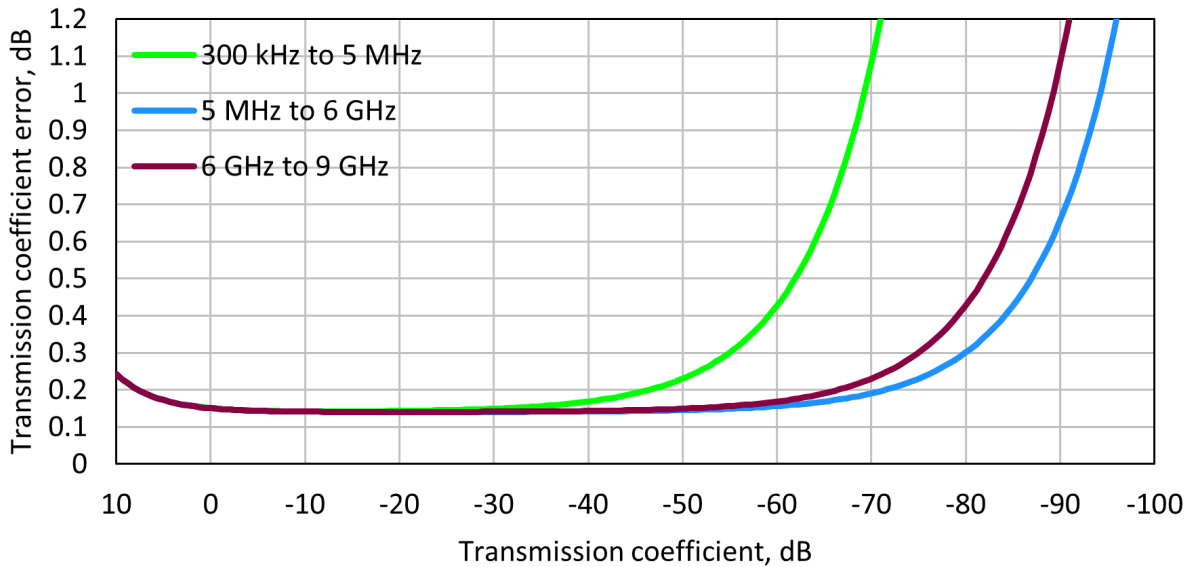


Specifications are based on an isolating DUT ( $S_{21} = S_{12} = 0$ )



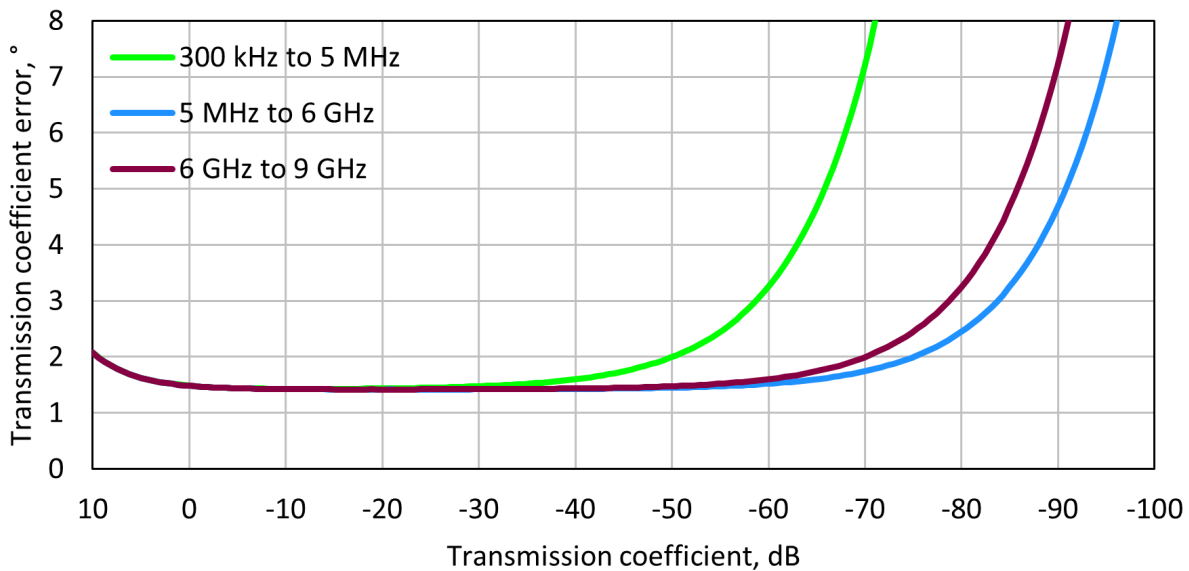
## Transmission Accuracy Plots

### Transmission Magnitude Errors



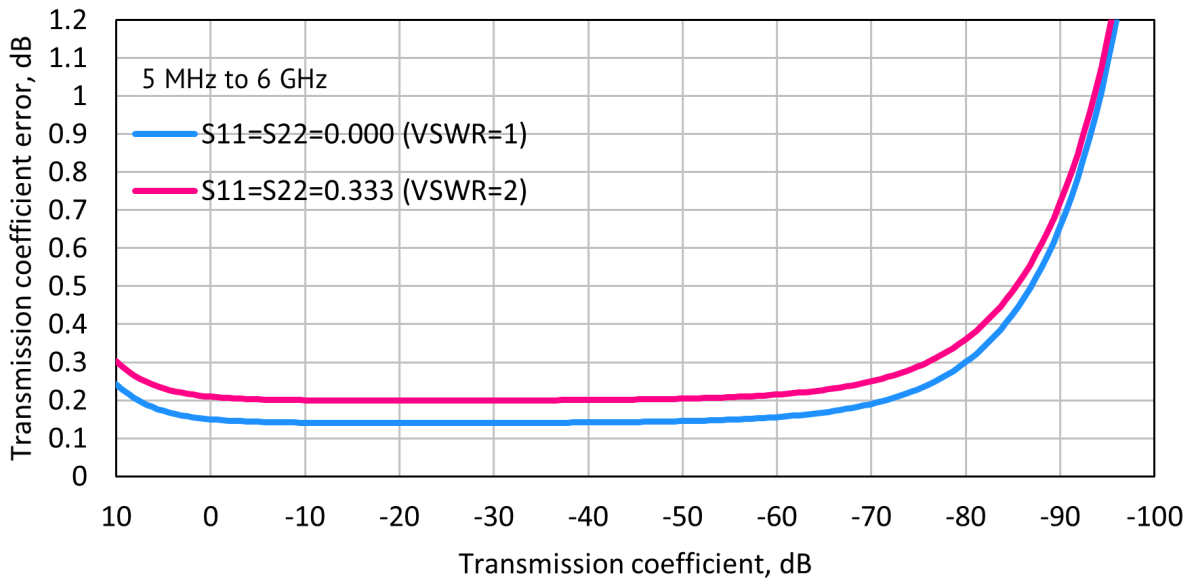
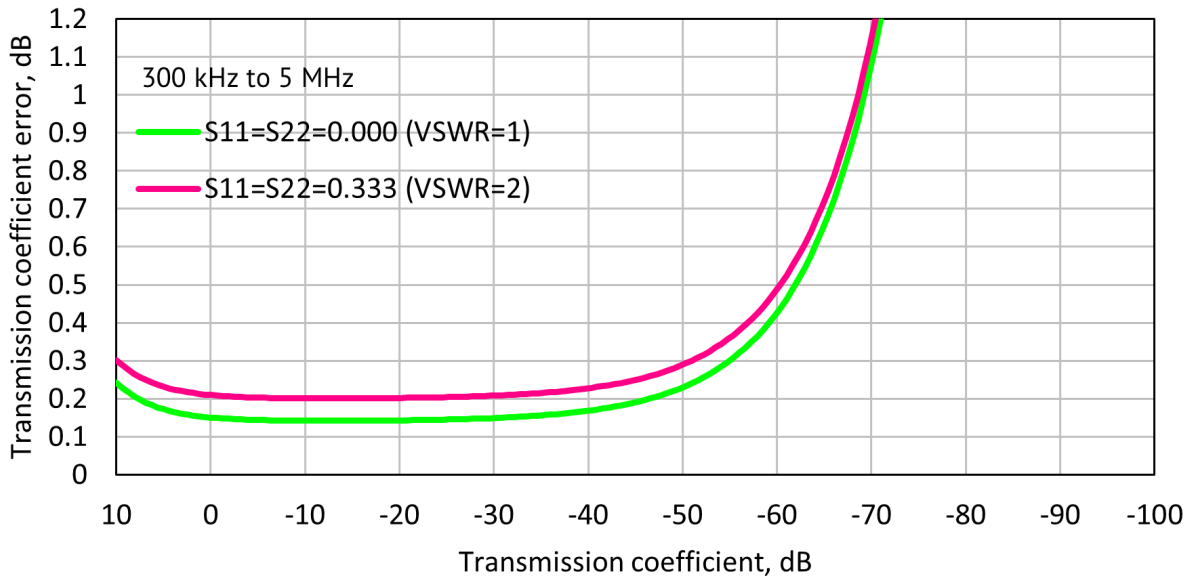
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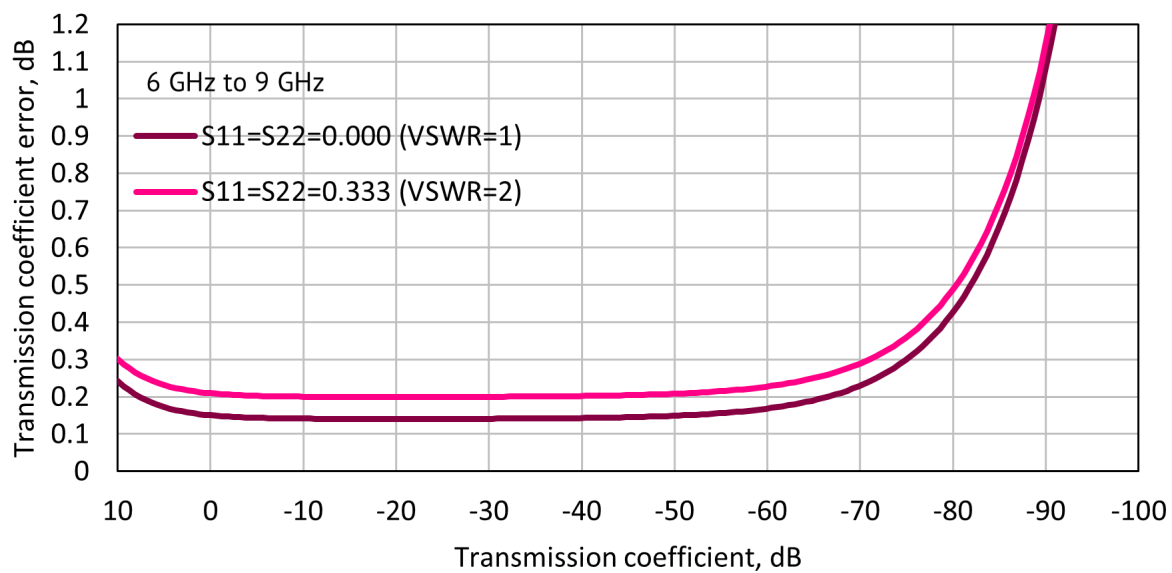
### Transmission Phase Errors



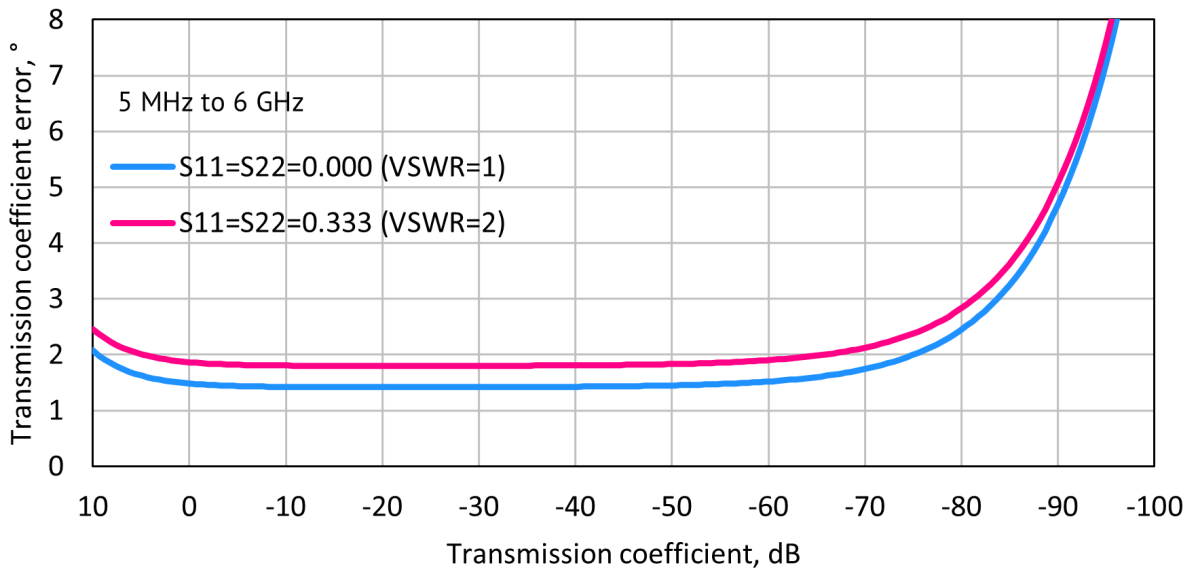
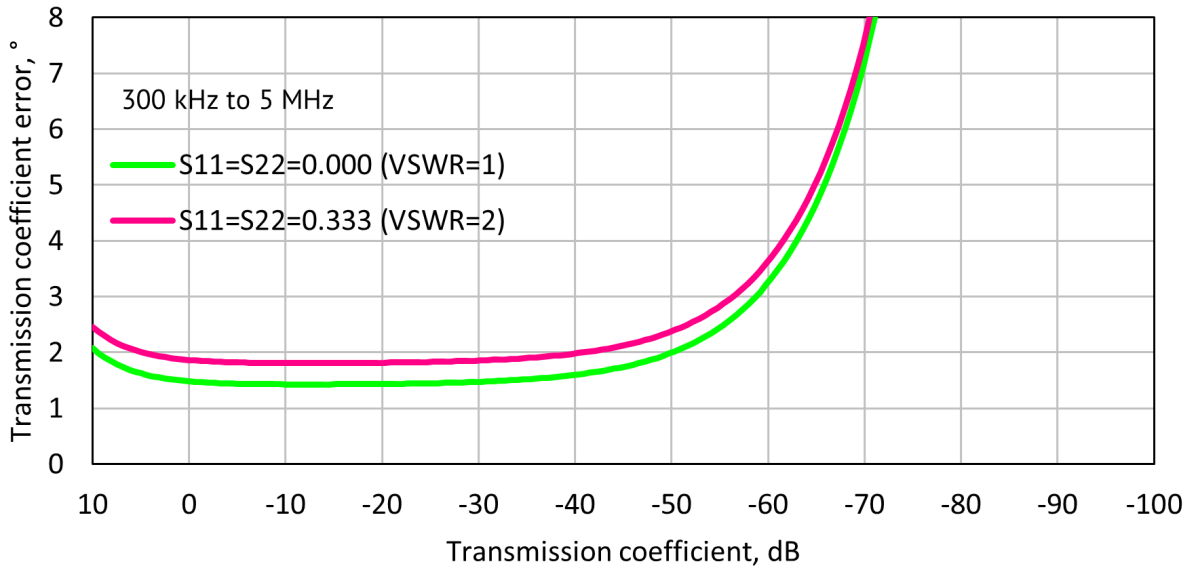
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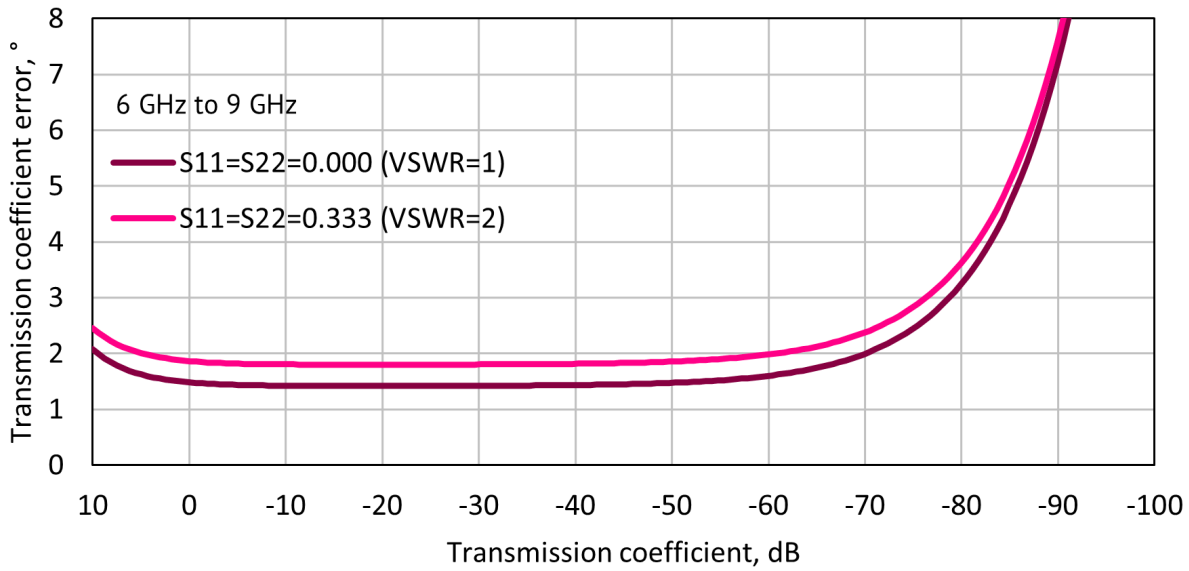
## Transmission Magnitude Errors for Unmatched Devices





## Transmission Phase Errors for Unmatched Devices





## Transmission Errors for Matched Devices vs Output Power and IF Bandwidth

