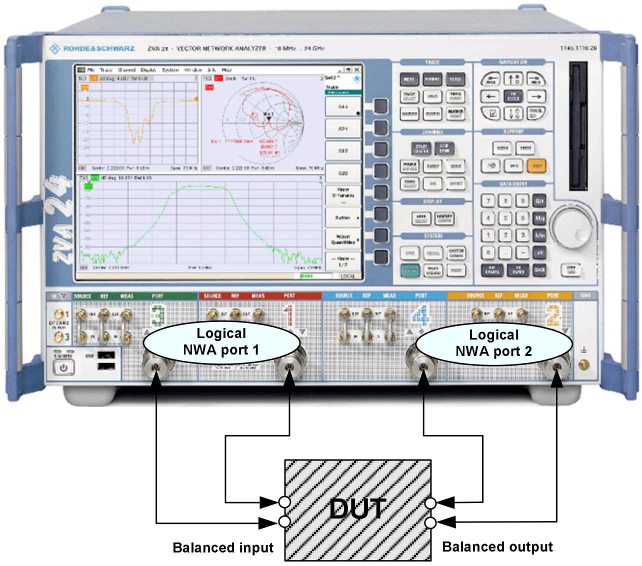
True Differential Mode

This application sheet describes the use of option R&S ZVA-K6, True Differential Mode, on R&S ZVA or R&S ZVT vector network analyzers. In this mode, the analyzers can generate true differential and common mode stimuli at arbitrary reference planes in the test setup and determine mixed-mode S-parameters, wave quantities and ratios. The true differential mode is suitable for testing nonlinear balanced devices under real operating conditions.

Test Setup and Preparations

The true differential mode requires a port configuration with at least one balanced port. In the following we use a four-port network analyzer to measure a 2-port DUT with balanced input and balanced output.



Calibration and stimulus power

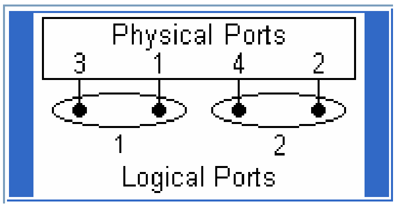
A consistent system error correction is essential for accurate balanced waves at the reference planes and accurate measurement results. You should always perform a full n-port calibration (TOSM, UOSM or one of the Txx calibration types) of all physical ports involved in the true differential measurement and change the port impedances, if they differ from the default settings. A subsequent source power calibration is recommended.

Note that the power setting of a true differential source refers to the differential and common modes directly.

Measuring Balanced S-Parameters

The following example shows how to activate the true differential mode in order to obtain mixed-mode S-parameters for the test setup shown above.

1. Perform a full calibration of all four analyzer ports, preferably using a calibration unit for automatic (TOSM) calibration.
2. Preferably, perform a source power calibration at the input of your DUT.
3. Click “Trace > Measure > More S-Params...”.
4. In the “Port Configuration” panel of the “More S-Parameters” dialog opened, click “Balanced and Measured Ports”.
5. In the “Predefined Configs” tab of the “Balanced and Measured Ports” dialog opened, select the port configuration that is suitable for your DUT.



Allowed port combinations

The true differential mode requires logical port combinations with independent power sources. Do not use ports 1/2 or ports 3/4 to create a logical port.

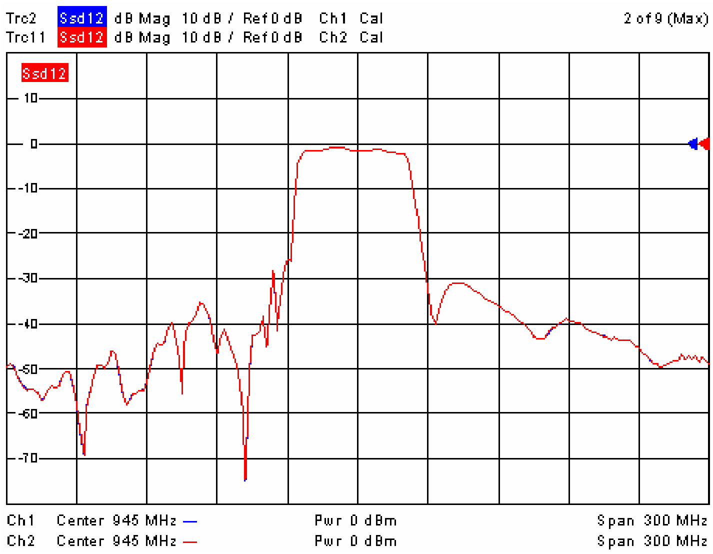
6. Still in the “Predefined Configs” tab, enable “True Differential Mode”.
7. Open the “Def Balanced Port” tab and assign the appropriate differential and common mode reference impedances to both logical ports.
8. Click “OK” to close the “Balanced and Measured Ports” dialog.
9. Connect one balanced port of your DUT to ports 1 and 3 of the network analyzer, the other balanced port of your DUT to ports 2 and 4 of the network analyzer, in accordance with the selected port combination and reference impedances.
10. Back in the “More S-Parameters” dialog, select the mixed-mode S-parameter that you wish to measure.
11. Click OK to close the “More S-Parameters” dialog and observe the measurement result in the diagram area.

Measurement Wizard

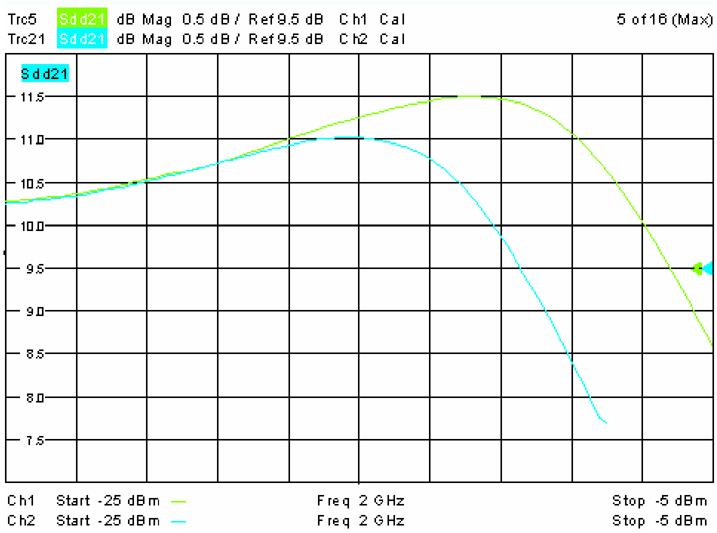
You can also access all the described settings from the „Measurement Wizard“.
You can also use the calibration wizard for step no. 1, e.g. if you want to use one of the 7-term calibration types (TNA, TRL, ...).

Discussion of Results

For linear DUTs, the S-matrices acquired in virtual and in true differential mode are expected to be equal. The following figure shows a comparison for the transmission coefficient S_{sd12}. The red trace was measured in true differential mode. The blue trace (below, measured in virtual differential mode) is almost identical over the entire sweep range.



Differences may appear for nonlinear devices at high stimulus power levels. For example, the bias of semiconductor devices like transistors may depend on the kind of stimulus signal. The following figure shows a power sweep performed in virtual differential mode (green) and in true differential mode (magenta). In true differential mode, the compression effects occur at much smaller stimulus powers.



Possible Extensions

In true differential mode, can also determine mixed-mode wave quantities and ratios of wave quantities. Furthermore, the true differential mode also provides two additional sweep types, the amplitude imbalance and phase imbalance sweeps:

- In an amplitude imbalance sweep, the analyzer generates a balanced signal at one of its logical ports, however, the amplitude of one signal component is varied according to the selected power sweep range.
- In a phase imbalance sweep, the analyzer generates a balanced signal at one of its logical ports, however, the relative phase of the two signal components is varied according to the selected phase range.

Related Measurements and Products

In **virtual** differential mode, the R&S vector network analyzers generate unbalanced stimulus signals and use a mathematical transformation to convert unbalanced wave quantities into balanced S-parameters. Linear balanced devices can be tested with sufficient accuracy in this mode. The virtual differential mode is available on all R&S ZVB, R&S ZVA, and R&S ZVT vector network analyzers.

Equipment Required

Measurements in true differential mode can be carried out with the following equipment:

- Vector network analyzer R&S ZVA or R&S ZVT
- Option R&S ZVA-K6, True Differential Mode
- A calibration unit R&S ZV-Z52/Z53 or R&S ZV-Z58 (for R&S ZVT network analyzers) is recommended

Additional Information

For a comprehensive description of the true differential mode including remote control refer to the R&S ZVA/ZVT online help system or to the printable operating manual, which is available for download at http://www.rohde-schwarz.com/product/zva.

The text book "Fundamentals of Vector Network Analysis" by Michael Hiebel is an ideal complement for the information given in the user documentation. The book combines theoretical background and practical measurements on an R&S ZVA network analyzer. In case of interest please contact your local R&S office.