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**3-Port Measurements  
with  
Vector Network Analyzer  
ZVR**

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Application Note 1EZ26\_1E

Subject to change

26 July 1996, Olaf Ostwald

Products:

**ZVR incl. Option ZVR-B8**

**ZVRE incl. Option ZVR-B8**

**ZVRL incl. Option ZVR-B8**



**ROHDE & SCHWARZ**

# 1 Function

**3-Port Adapter ZVR-B8** is an optional accessory to all Vector Network Analyzers of the ZVR family, namely ZVRL, ZVRE, and ZVR, and extends the two test ports PORT1 and PORT2 to a total of **three test ports PORT1, PORT2 and PORT3**. The option comprises an electronic single-pole double-throw switch (SPDT)

by means of which PORT1 of the analyzer is switched to either PORT1 or PORT3 of *3-Port Adapter*. Test port PORT2 of the analyzer is directly connected to PORT2 of the *3-Port Adapter* and is not switched over.

The principal functions and design of the *3-Port Adapter* is shown by a diagram on the cover:

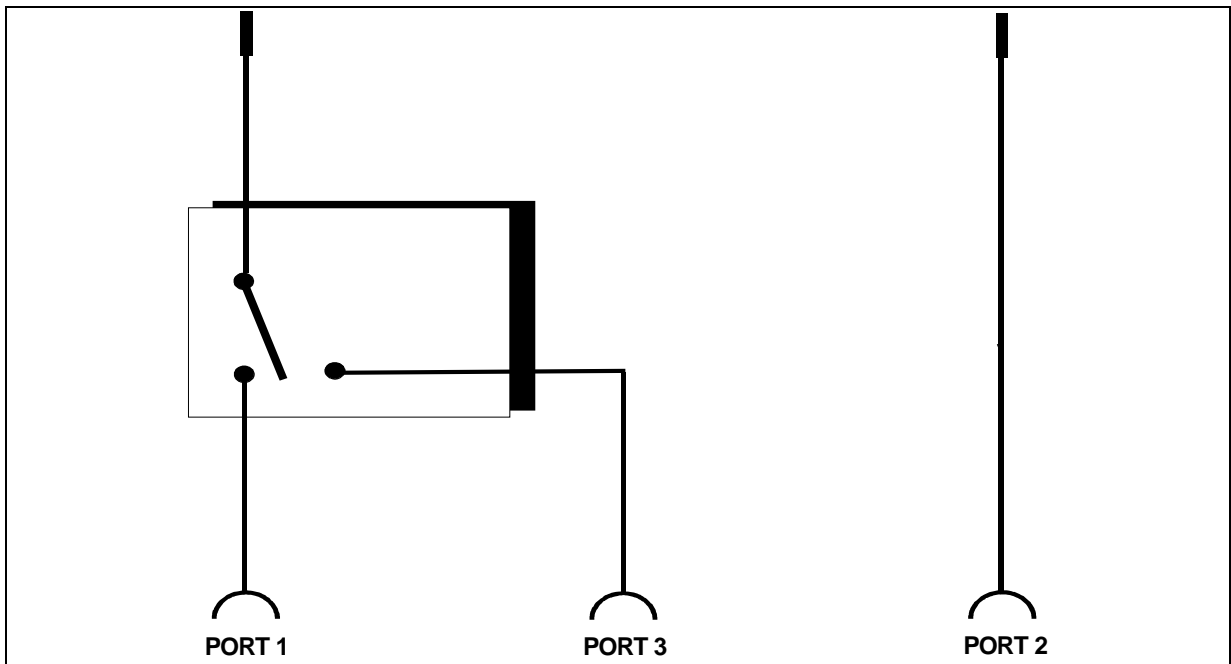


Fig.: Block diagram of *3-Port Adapter*

*3-Port Adapter* is especially suitable for measurements on special 3-ports such as **antenna diplexers**. It has a first port to which the generator signal is fed. The signal is taken to the second port via the diplexer. The receiving and transmitting antenna is usually connected to the second port. The signal received by the antenna is taken to the third port via the diplexer. The receiver is connected to the third port.

For measurements on such an antenna diplexer (as a practical example of a 3-port) connect generator input to PORT1, antenna output/input to PORT2 and the receiver output to PORT3 of the *3-Port Adapter*. It is now possible to measure the reflections at all the three ports of the diplexer and to measure the transmissions from port 1 to port 2 and vice versa as well as the transmissions from port 3 to port 2 and vice versa. A direct measurement of the transmissions from port 1 to port 3 or vice versa is not possible as these two ports are connected to

the same test port of the analyzer, i.e. PORT1, via the SPDT switch of the *3-port adapter*. **Seven** of the 3 x 3 different **S-parameters** of a 3-port device under test (DUT) can thus be measured directly by means of the *3-Port Adapter* and without rewiring the DUT. These parameters are shown in bold print in the following scattering matrix of a 3-port:

$$(S) = \begin{pmatrix} \mathbf{S}_{11} & \mathbf{S}_{12} & S_{13} \\ \mathbf{S}_{21} & \mathbf{S}_{22} & \mathbf{S}_{23} \\ S_{31} & \mathbf{S}_{32} & \mathbf{S}_{33} \end{pmatrix}$$

The two not directly measurable S-parameters  $S_{31}$  and  $S_{13}$  can be measured by rewiring the DUT. In many cases in practice, for instance for antenna diplexers as mentioned above, the knowledge of these two S-parameters is not required and thus additional measurements are not necessary.

## 2 Applications

*3-Port Adapter* is supplied with operating voltages and controlled via the optional rear-panel connector labelled 3-PORT ADAPTER. A TTL signal (CHNBIT0) of this connector controls the SPDT switch. This signal changes its polarity synchronous to the active display channel (CH1 to CH4) for an **uncoupled channels sweep** (not for coupled channels):

- For the two uneven channels, i.e. CH1 and CH3, the switch is set for PORT1.
- For the two even channels, i.e. CH2 and CH4, the switch is set for PORT3.

This feature can be used to display several parameters of a 3-port DUT at the same time. Up to four S-parameters can be displayed at the same time in a split or overlay display on the screen of the network analyzer. If transmission  $S_{21}$  from PORT1 to PORT2 and the transmission  $S_{23}$  from PORT3 to PORT2 of a 3-port is to be measured, it is possible to display  $S_{21}$  in channel CH1 (PORT1 throughconnected) and  $S_{23}$  in channel CH2 (PORT3 throughconnected). Thus, two different transmission paths of the 3-port DUT can be measured and displayed at the same time. The measuring and switchover speed is sufficiently high so that an alignment of the DUT is possible without delay.

Further applications are possible by combining **more than one 3-Port Adapter** and a network analyzer. For example, one can use two *3-Port Adapters* and connect the SPDT input port of the first *3-Port Adapter* to PORT1 of the analyzer and the input of the second one to PORT2. In this way two 2-port DUTs can be simultaneously measured and compared. For this, two *3-Port Adapters* are provided and controlled in parallel via the above mentioned rear-panel connector by simply using a Y-cable.

Another possibility is to use not the TTL signal CHNBIT0 for controlling the SPDT switch but a different TTL signal, namely CHNBIT1. For that, only a slight internal modification of the *3-Port Adapter* is necessary. The signal CHNBIT1 is already available via the above mentioned rear-panel connector and it also changes its polarity synchronous to the active display channel (CH1 to CH4), with the difference that for the two lower channels, i.e. CH1 and CH2, the switch is set for PORT1, and for the two higher channels, i.e. CH3 and CH4, the switch is set for PORT3.

All control possibilities for the SPDT switches are summarized in the following table:

Display channel	CH1	CH2	CH3	CH4
CHN BIT 1	1	1	0	0
CHN BIT 0	1	0	1	0
SPDT position	PORT 1	PORT 3	PORT 1	PORT 3
4-port S-param	$S_{31}$ and $S_{13}$	$S_{32}$ and $S_{23}$	$S_{41}$ and $S_{14}$	$S_{42}$ and $S_{24}$

Table: Active display channel and correspondig SPDT switch position of *3-Port Adapter*

A **combination of two 3-Port Adapters**, one controlled via CHNBIT1 the other via CHNBIT0 allows a plurality of further applications, as for instance even the measurement of a 4-port DUT. With port 1 and 2 of the 4-port DUT connected to the first *3-Port Adapter* and port 3 and 4 to the second one, the reflection coefficients  $S_{ij}$  at all four ports of the 4-port DUT as well as eight (in total of twelve) transmission S-parameters  $S_{ij}$ , as indicated in the table above, can be measured without reconnecting the 4-port DUT.

All **full two port calibration** techniques e.g. TOM can be additionally utilized and are performed as usual. For 3-port applications two separate TOM calibrations are recommended. One with SPDT switch in position PORT 1, for instance with display channel CH1 active. The other with SPDT switch in position PORT 3, with display channel CH2 active. During measurements the matching calibration data sets are automatically switched over when the active display channel is changed.

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26 July 1996

### 3 Further Application Notes

- [1] O. Ostwald: 3-Port Measurements with Vector Network Analyzer ZVR, Appl. Note 1EZ26\_1E.
- [2] H.-G. Krekels: Automatic Calibration of Vector Network Analyzer ZVR, Appl. Note 1EZ30\_1E.
- [3] O. Ostwald: 4-Port Measurements with Vector Network Analyzer ZVR, Appl. Note 1EZ25\_1E.
- [4] T. Bednorz: Measurement Uncertainties for Vector Network Analysis, Appl. Note 1EZ29\_1E.
- [5] P. Kraus: Measurements on Frequency-Converting DUTs using Vector Network Analyzer ZVR, Appl. Note 1EZ32\_1E.
- [6] J. Ganzert: Accessing Measurement Data and Controlling the Vector Network Analyzer via DDE, Appl. Note 1EZ33\_1E.
- [7] J. Ganzert: File Transfer between Analyzers FSE or ZVR and PC using MS-DOS Interlink, Appl. Note 1EZ34\_1E.
- [8] O. Ostwald: Group and Phase Delay Measurements with Vector Network Analyzer ZVR, Appl. Note 1EZ35\_1E.
- [9] O. Ostwald: Multipoint Measurements using Vector Network Analyzer, Appl. Note 1EZ37\_1E.
- [10] O. Ostwald: Frequently Asked Questions about Vector Network Analyzer ZVR, Appl. Note 1EZ38\_3E.
- [11] A. Gleißner: Internal Data Transfer between Windows 3.1 / Excel and Vector Network Analyzer ZVR, Appl. Note 1EZ39\_1E.
- [12] A. Gleißner: Power Calibration of Vector Network Analyzer ZVR, Appl. Note 1EZ41\_2E
- [13] O. Ostwald: Pulsed Measurements on GSM Amplifier SMD ICs with Vector Analyzer ZVR, Appl. Note 1EZ42\_1E.
- [14] O. Ostwald: Zeitbereichsmessungen mit dem Netzwerkanalysator ZVR, Appl. Note 1EZ44\_1D.

### 4 Ordering Information

Order designation	Type	Frequency range	Order No.
<b>Vector Network Analyzers (test sets included) *</b>			
3-channel, unidirectional, 50 Ω, passive	ZVRL	9 kHz to 4 GHz	1043.0009.41
3-channel, bidirectional, 50 Ω, passive	ZVRE	9 kHz to 4 GHz	1043.0009.51
3-channel, bidirectional, 50 Ω, active	ZVRE	300 kHz to 4 GHz	1043.0009.52
4-channel, bidirectional, 50 Ω, passive	ZVR	9 kHz to 4 GHz	1043.0009.61
4-channel, bidirectional, 50 Ω, active	ZVR	300 kHz to 4 GHz	1043.0009.62
3-channel, bidirectional, 50 Ω, active	ZVCE	20 kHz to 8 GHz	1106.9020.50
4-channel, bidirectional, 50 Ω, active	ZVC	20 kHz to 8 GHz	1106.9020.60
<b>Alternative Test Sets *</b>			
<b>75 Ω SWR Bridge for ZVRL (instead of 50 Ω) <sup>1)</sup></b>			
75 Ω, passive	ZVR-A71	9 kHz to 4 GHz	1043.7690.18
<b>75 Ω SWR Bridge Pairs for ZVRE and ZVR (instead of 50 Ω) <sup>1)</sup></b>			
75 Ω, passive	ZVR-A75	9 kHz to 4 GHz	1043.7755.28
75 Ω, active	ZVR-A76	300 kHz to 4 GHz	1043.7755.29
<b>Options</b>			
AutoKal	ZVR-B1	0 to 8 GHz	1044.0625.02
Time Domain	ZVR-B2	same as analyzer	1044.1009.02
Mixer Measurements <sup>2)</sup>	ZVR-B4	same as analyzer	1044.1215.02
Reference Channel Ports	ZVR-B6	same as analyzer	1044.1415.02
Power Calibration <sup>3)</sup>	ZVR-B7	same as analyzer	1044.1544.02
3-Port Adapter	ZVR-B8	0 to 4 GHz	1086.0000.02
Virtual Embedding Networks <sup>4)</sup>	ZVR-K9	same as analyzer	1106.8830.02
4-Port Adapter (2xSPDT)	ZVR-B14	0 to 4 GHz	1106.7510.02
4-Port Adapter (SP3T)	ZVR-B14	0 to 4 GHz	1106.7510.03
Controller (German) <sup>5)</sup>	ZVR-B15	-	1044.0290.02
Controller (English) <sup>5)</sup>	ZVR-B15	-	1044.0290.03
Ethernet BNC for ZVR-B15	FSE-B16	-	1073.5973.02
Ethernet AUI for ZVR-B15	FSE-B16	-	1073.5973.03
IEC/IEEE-Bus Interface for ZVR-B15	FSE-B17	-	1066.4017.02
Generator Step Attenuator PORT 1	ZVR-B21	same as analyzer	1044.0025.11
Generator Step Attenuator PORT 2 <sup>6)</sup>	ZVR-B22	same as analyzer	1044.0025.21
Receiver Step Attenuator PORT 1	ZVR-B23	same as analyzer	1044.0025.12
Receiver Step Attenuator PORT 2	ZVR-B24	same as analyzer	1044.0025.22
External Measurements, 50 Ω <sup>7)</sup>	ZVR-B25	10 Hz to 4 GHz (ZVR/E/L) 20 kHz to 8 GHz (ZVC/E)	1044.0460.02

<sup>1)</sup> To be ordered together with the analyzer.  
<sup>2)</sup> Harmonics measurements included.  
<sup>3)</sup> Power meter and sensor required.  
<sup>4)</sup> Only for ZVR or ZVC with ZVR-B15.  
<sup>5)</sup> DOS, Windows 3.11, keyboard and mouse included.  
<sup>6)</sup> For ZVR or ZVC only.  
<sup>7)</sup> Step attenuators required.

**\* Note:**

Active test sets, in contrast to passive test sets, comprise internal bias networks, eg to supply DUTs.