

Products: R&S® Network Analyzer ZVL, ZVA, ZVB, ZVT

Balanced Reflection Measurement with R&S[®] ZVL

Application Note

This application note describes how to measure balanced reflection mixed mode S-Parameters with a 2-port Network Analyzer like R&S[®] ZVL. The application note directly transfers S-Parameter Trace Data from R&S[®] Network Analyzers to Microsoft[™] Excel[™] using a direct connection like GPIB or LAN and does the mode conversion to Mixed Mode inside Excel[™] with a VBA Macro.



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1. Overview

This application note describes how to measure balanced reflection mixed mode S-Parameters with a 2-port Network Analyzer like ZVL. The application note directly transfers S-Parameter Trace Data from R&S[®] Network Analyzers to Microsoft[™] Excel[™] using a direct connection like GPIB or LAN and does the mode conversion to Mixed Mode inside Excel[™] with a VBA Macro.

Prerequisites are a PC running Microsoft Excel[™], a R&S® Network analyzer like ZVL, ZVA, ZVB or ZVT as well as a working remote control connection between PC and instrument like GPIB or LAN/Ethernet.

The following abbreviations are used in the text for R&S® test equipment:

ZVA	R&S® ZVA Vector Network Analyzer
ZVB	R&S® ZVB Vector Network Analyzer
ZVL	R&S® ZVL Vector Network Analyzer
ZVT	R&S® ZVT Vector Network Analyzer
R&S	Rohde & Schwarz GmbH und Co. KG

2. Preparation

In order to use this application note, you need a remote control connection between the PC operating MS Excel[™] and the R&S[®] Network Analyzer. There are following possibilities for this connection:

1. GPIB



2. LAN/Ethernet using Intranet or Internet



3. LAN/Ethernet using direct LAN or Crosslink LAN connection between PC and Network Analyzer



2.1. GPIB for Control PC

In order to use the GPIB interface, your PC must be equipped with a GPIB interface hardware.

In addition, the remote control library "VISA" needs to be installed on the PC. The VISA library is available e.g. at <u>www.nationalinstruments.com</u>

2.2. Preparations for LAN: RSIB32.dll

This Application Note shows how to use remote control of Rohde & Schwarz Network Analyzers over a local area network. Rohde & Schwarz VXIpnp instrument drivers are based on VISA. Instrument Drivers as well as this Trace-To-Excel application can control the instrument via LAN if the RSIB interface and passport are installed.

The RSIB interface is a R&S $^{\mbox{$\mathbb{R}$}}$ defined protocol that uses the TCPIP protocol for communication with the instrument. It consists of a set of I/O functions very similar to the National Instruments NI-488.2 interface for GPIB.

The following table shows some corresponding functions:

NI-488.2 functions	RSIB functions	
ibfind	RSDLLibfind	
ibwrt	RSDLLibwrt	
ibrd	RSDLLibrd	

A more detailed explanation of RSIB can be found in the Rohde&Schwarz application note *1EF47*, *"Remote Control of R&S® Spectrum and Network Analyzers via LAN"*. This application note is available at <u>www.rohde-schwarz.com/appnote/1EF47.html</u>. The application note comes together with the RSIB Passport as well as the necessary RSIB.dll library.

Please install the RSIB Passport according to application note 1EF47. Make sure the RSIB32.dll library is available in the Windows System folder of your remote control PC.

File Edit	: View Favorites Tools Help			
3 Back	• 🕤 • 🎓 📝 💕 🔎 Search	Folders	🌢 这 🗙 🗐 🔟 •	
Address	C:\WINNT\system32			
Folders ×	Name -	Size	Type	Date Modified
	SRsClassInstall.dll	48 KB	Application Extension	23.08.2005
-	Sirsfsaps.dll	28 KB	Application Extension	23.08.2001
	□ rsh.exe	15 KB	Application	04.08.2004
	Arstw32 dll	39.KB	Application Extension	04.08.2004
	🗟 Rsib 32.dll	101 KB	Application Extension	04.09.2002
	- Ersm.exe	40 KB	Application	23.08.2001
	Sirsmos di	19 KB	Application Extension	04 08 2004

2.3. LAN/Ethernet

Both, PC and Instrument must be connected to the Local Area Network LAN and have a valid IP address inside the LAN. You can check the IP adress of your PC from the Windows Control Panel inside the Network Connections.

For the R&S Network Analyzer instrument, please check first if the automatic assignment of an IP address (DHCP) is activated.

- In case of ZVA, ZVB or ZVT, Press the "Windows" button on the ZVx frontpanel in order to display the Windows Taskbar



- In case of ZVL, access Windows XP using an external keyboard
- Open Start->Settings->Network Connections->Local Area Network Connection
- In the dialog, select "Internet Protocol (TCP/IP) and go to

"Properties"



- Make sure that the settings are "Obtain IP address automatically" and "Obtain DNS address automatically"

Internet Protocol () General Alternate Configuration	「CP/IP) Proper <mark>@?</mark> ×
You can get IP settings assigned a this capability. Otherwise, you need the appropriate IP settings.	utomatically if your network supports to ask your network administrator for
 Obtain an IP address automat 	tically
C Use the following IP address:	
IP address:	
Subnet mask:	
Default gateway:	
Obtain DNS server address a	utomatically
O Use the rollowing Divid server	audresses:
Preferred DNS server:	
Alternate DNS server:	
	Advanced
	OK Cancel

After confirmation of the automatic network settings, please check the obtained Network Analyzer IP address. You can do this in the following way:

2.3.1. ZVL

To check the IP address, proceed as follows:

- 1. Press hardkey "Setup"
- 2. Press softkey "General Setup"
- 3. Press softkey "IP Address" to display the ZVL IP address

2.3.2. ZVA, ZVB, ZVT

- Press Info Button

	50	PPURI	
	MENU	UN	00
-	5		-
		INFO	HELP

Press the softkey "Hardware Info"

ĺ	Set1 * 🛛 🚸
I	Info
	Setup Info
ĺ	Option Info
2	Hardwaro
	Hardware Info
	Hardware Info Selftest
	Hardware Info Selftest Error Log

Now you can find the IP address of the analyzer below the "IP adresses" section

Hardware Configuration
Instrument Type: ZVA24 with 4 Ports Part Number: 1145.1110k26 Serial Number: 100121
Product Index: 01.00
IEC Bus Address: 20 IP Addresses
IP Address: 0.0.0.0 Subnet Mask: 0.0.0.0 IP Address: 10.7.11.54 Subnet Mask: 255.255.0.0 IP Address: 127.0.0.1 (Localhost) Subnet Mask: 255.0.0.0
SyMapping: ZVA_P4
LO Divider: is not active
Firmware Version: 2.01 Image:
Version 02.10

Please note that the ZVA, ZVB or ZVT instrument has two LAN ports. Depending on the port you are using, please use the first or second IP adress in the Hardware info field.

- Final preparation step: Make sure that you have the LAN remote control library RSIB32.dll installed on your PC remote computer (see section 2.2).

2.4. LAN/Ethernet using direct Crossover connection between PC and Network Analyzer

You can also directly connect your remote PC to the ZVx Network Analyzer instrument by means of a normal LAN cable or by a crossover LAN cable.

A crossover LAN cable has same connector types as a normal LAN cable, however the wires inside the crossover cable are crossed.

3. Operation of the ZVx_Balanced.xls Tool

This application note comes with an Excel[™] file tool which enables you to directly transfer S-parameter trace data from Instrument to Excel[™] and which does the mode conversion to Mixed Mode S-Parameters.

The mode conversion algorithm is documented in literature, see. e.g. [2] for the theoretical background an an algorithm explanation.

The supplied Excel-file ZVx_Balanced.xls consists of a spreadsheet and a software macro function written in Visual Basic for Applications VBA.

When opening the file ZVx_Balanced.xls, you will be asked to enable the macros. Attention: It is absolutely necessary to press "Enable Macro" here. The tool will not work without the macros.



3.1. Screen of ZVx_Balanced-Tool

After opening the Excel™tool, you will find see a spreadsheet as shown below:

Ele	Edit View Insert	Format Iook	ls <u>D</u> ata <u>W</u> ind	ow Help				Type a que	stion for help	- 6 3
16		* 》即题	0-0	- 🤮 Σ •	21 X1 🛍	75% • [2).			
vrial	• 10	• B I U	新 章 章 音	39%,	.d -% (Z	律	· 🛆 · .			
Al	- f.	RESOURCE:								
C. NUMBER	Å	8	C	D	E	- F	G	н		. J -
RES	DURCE	RSIB-locathost-IN	STR			For control via LAN	Resource a		RSID:89.13.1241-INS	TR _
		Fichdel/Solwarz,2 VA28- 4Port,114530101010		Read Trace D	ata .	For and all in Other	5 Distantia		0000.00.8070	1
: ID:	Manufact Cone (China	Cd411 man	Cddll abors	C.d. II man	CA.Habara	For control via tara	St Hesource :	Continue	GPE0-20-INS IN	
-	commus r red [caris]	5 DECEMBER	CONTENASE	Socii mag	DOCIT PRASE	Scall mag	Scoll phase	A CORRECT	too coepee	
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1	1050	£ 470570622	R9 9464(712	20.01501229	AK 00105442	20 7705 7296	45 64240472	-3 612779992	127 0004 175	
	1075	6.959572361	55 97894857	20 50533247	5141076324	20 4085026	5145452559	3.421202573	-100 520162	
	1100	7.246262405	5158801807	20 23803065	56 72971711	20.26465124	SE ENESDED	1 220226856	123.0969928	
	1125	7 657327878	47.2729344	20.00045514	6159560663	-20.02959323	£165467245	3.060952053	135 5253573	
0	1150	8 092694445	4272353141	-19.78818683	-66 28310338	-19 77528022	66.4413679	-2 89388766	138 1380388	
	1175	-8 550384569	36 19375623	-19-60407236	-70,73724792	-19:634.91916	-70.6934012	-2 73376866	-140,7038413	
2	1200	9.835387756	2240829148	-19.44855414	-74 58724203	19 474 25886	74 19077904	-2 575021207	-140.2149224	
5	1225	-9.571317024	29.38501428	19.34208997	-77,77707935	-19.01124264	-77.81495969	-2,415862604	-145.7244408	
	1,250	-1014946027	23,2385968	-19 20865045	-60.94938261	-19,21631608	-80.85647197	-2.261079612	-148 1913422	
5	1,275	-10.72844689	17.85491304	-19.1334036	-83.62497944	-19.14940729	-83.45260249	-2.113092778	-150.6790714	
6	1.300	-11.01459262	12.27095658	-19.06323487	-05.51293683	-19.0724318	-85.25185454	-1.965815099	-153.1205291	
7	1.325	-11.94829395	6.423298059	-19.00330002	-86.61955825	-19.00802932	-8E-36224217	-1.832285516	-155.63894	
0	1.050	-12.64542215	0.188250171	-18.87091498	-87.20308676	-18.90001035	-87.04374612	-1.685441021	-158.1837978	
9	1.375	-13.37769519	-6.455945018	-18.74802882	-87.47856563	-18,71534924	-87.53541318	-1.546731062	-160.7534739	
0	1.400	-14.13210642	-13.16191918	-10.51931452	-07.39944621	-18.51353438	-87.29602055	-1.414668237	-163,2953953	
1	1.425	-14.90923833	-20.17097889	+18.18793276	-86.97315401	-38.17502922	486.91857629	4,291037258	465,9436732	
2	1,450	-15.82779272	-26.98021322	-17,75558082	-86.44126954	-17.71337754	-86.43150031	-1171078321	168.7182936	
3	1.475	16.80894747	-33.66745817	+17.22284891	-86.47063514	-17,21723078	-86.00470156	-1.060412145	-171.6190053	
41	1.500	-17.90934967	-40.37648716	+16.61508624	-86:74101915	-16.57994966	-86.83097868	-0.954557201	-174.5559777	
5	1525	-15.02003916	-47.26877834	-15.91088041	-87.76703971	-15.91800097	-87.79902781	-0.86729374	-177.590315	
8	1.550	-20.26220207	-52,85737989	-15.17449006	-89.71037709	-15.17272812	-89,744503E	-0.811140007	179.3698309	
7	1.575	-2170219513	-56,13445636	-14.41267535	-92 22693537	-14.38387653	-52.21492347	-0.776868369	176.1683927	
1	1.600	-23.22739709	-56.53460613	+13.71456235	-95,61263923	-13.67490221	-95.68906021	-0.768283573	172.9286691	
	1236 Date (2441	24 60474371	5107449067		10 R 19 R 19 P.	19 06363636	.9962003643	.0 77%679017	169 7517110	- AL
2 8 8 8 9 1	ALLER Data V 2001	1 X 20011 X 2001	1 X See 11							111

The spreadsheet consists of following elements:

- Resource String
- Instrument Identification
- Execution Button for download of trace data
- Frequency List
- Magnitude and Phase of Mixed Mode S-Parameter Trace Data (Sdd11, Sdc11, Scd11, Scc11)

3.1.1. Resource String of instrument

This string is located in cell "B1" of the Excel[™]spreadsheet (green color). Depending on the interface type, a different resource string is used to address the instrument.

GPIB Interface:

Use Resource String **"GPIB0::20::INSTR"**, where "GPIB0" = Name of GPIB interface and "20" = GPIB address of Network Analyzer

LAN Interface:

Use Resource String "**RSIB**::**89.13.1.241**::**INSTR**", where "RSIB" = Name of interface, don't change, and "89.13.1.241" = actual IP address of your network Analyzer

ſ		A	В	С	D	E	
	1	RESOURCE:	GPIB0::20::INSTR	>			For contr
			Rohde&Schwarz,				
1			ZVA24-		Read Trace D:	ata	
1			4Port,1145101010		ricad hace b		
I	2	ID:	100001,2.30	4			For contr
ĺ	3	Stimulus Freq [GHz]	Sdd11 mag	Sdd11 phase	Sdc11 mag	Sdc11 phase	Scd1
ĺ	4	1.000	-5.785411621	67.69949822	-21.51690945	-32.89314139	-21.
[5	1.025	-6.117664028	63.88621095	-21.12512243	-39.57838282	-21.14
I	6	1.050	-6.476670622	59.94641712	-20.81501239	-45.89185442	-20.77

3.1.2. Instrument Identification

This string is located in cell "B2" of the Excel™spreadsheet (light blue color). The instrument identification string shows instrument type, model, serial number as well as FW version. The string is updated after each trace download from the instrument.

	A	В	С	D	
1	RESOURCE:	GPIB0::20::INSTR			
2	ID:	Rohde&Schwerz ZVA24- 4Port,1145101010 100001,2.30)	Read Trace Da	ata
3	Stimulus Freq [GHz]	Sdd11 mag	Sdd11 phase	Sdc11 mag	Sdc11
4	1.000	-5.785411621	67.69949822	-21.51690945	-32.89
5	1.025	-6.117664028	63.88621095	-21.12512243	-39.57
6	1.050	-6.476670622	59.94641712	-20.81501239	-45.89

In the neighboring cell "C2", you can find the detected number of ports (orange color).

In case of any problem with the instrument connection, there will be the message "Instrument not found" in this cell.

The string corresponds to the return value of the "*IDN?" remote control command.

3.1.3. Instrument Execution Button for download of trace data

With this button you can execute the download of the trace data from the instrument and start the conversion calculation to Mixed Mode S-Parameters.

	A	В	С	D	E	
1	RESOURCE:	GPIB0::20::INSTR				For con
2	ID:	Rohde&Schwarz, ZVA24- 4Port,1145101010 100001,2.30	4	Read Trace Da	ata	For con
3	Stimulus Freq [GHz]	Sdd11 mag	Sdd11 phase	Sdc11 mag	Sdc11 phase	Scď
4	1.000	-5.785411621	67.69949822	-21.51690945	-32.89314139	-21
5	1.025	-6.117664028	63.88621095	-21.12512243	-39.57838282	-21.1
6	1.050	-6.476670622	59.94641712	-20.81501239	-45.89185442	-20.73

After pressing the "Download" button, the VBA Macro downloads all 4 S-Parameters of the currently active ZVx channel. Subsequently, the S-Matrix is converted to Mixed Mode S-Parameters. The results (Sdd11, Sdc11, Scd11, Scc11) will be shown in the spreadsheet by magnitude and phase each.

If the current instrument setup contains several channels, the Excel[™] Macro will use the currently active channel settings for the trace download.

3.1.4. Frequency List

After the successful download of the trace data, you will find the corresponding frequency list in column A (pink color).

	A	В	С
1	RESOURCE:	GPIB0::20::INSTR	
		Rohde&Schwarz,	
		ZVA24-	
		4Port,1145101010	
2	ID:	100001,2.30	4
3	Stimulus Freq [GHz]	Sdd11 mag	Sdd11 phase
4	1.000	-5.785411621	67.69949822
5	1.025	-6.117664028	63.88621095
6	1.050 🚶	-6.476670622	59.94641712
7	1.075	-6.859572361	55.87894857
8	1.100	-7.246262405	51.58801807
9	1.125	-7.657327676	47.2739344
10	1.150	-8.092694445	42.72353141
11	1.175	-8.550384569	38.19375633
12	1,200	-9.035387756	33.40829148
13	1 225	-9.571317024	28.38501428

3.1.5. Magnitude (dB) and Phase parameter of Mixed Mode S-Parameter Trace Data

The Mag(dB) and phase values of the mixed mode S-Parameters of S11 can be found in columns B to I (yellow color).

This data is actually not directly downloaded from the instrument, but it is calculated within $Excel^{TM}$ VBA from the normal (single-ended) S-Parameters.

	A	B	C	D	E	F	6	н	1
1	RESOURCE.	GPIB0-20-INSTR				For control via LAN	I Resource =		RSIB:89.13.1.241:INS
2	10:	Pohde&Schwarz,2 VA24- 4Port,114510101010 0001,2:30		Read Trace D	ata	For control via GPI	B: Resource =		GPIB0-20:INSTR
3	Stimulus Freq [GHz]	Sddtt mag	Sdd11 phase	Sdc11 mag	Sdc11 phase	Sed11 mag	Sod11 phase	Seefl mag	Soott phase
4	1.000	-5.785411621	67.69949822	-21,51690945	-32.89314139	-21.52425318	-32 48620337	-4.026076524	-122.6266695
5	1.025	-6.117661-028	6549621095	-21.12512349	5057838282	-21 465767	-39.947802	-3.815974770	125.3223311
8	1.050	-6 4 6670622	59.9464012	-20 1501229	45.89103442	A017051264	45.64240473	1012779982	-127.93-4375
7	1.075	685 Carl	· 56.878948-7	(050 0 C	51,41876324	/ Miletel I	-51,4545255	-3.42402573	100.500102
8	1,100	7.246262405	51 5880180	-20.23803065	-56.72971713	-20.26465124	-56.59451061	0.2300 854	03.0869928
9	1.125	657327676	47.27393 4	20.00049514	-6159560867	-20.02959323	-61.6546724	-3.060952059	-135.575957
10	1.150	-8.042694445	42.7235 5141	12,78818683	-66,29310,038	10 77528322	-66.4410079	2.89388766	-138.1380.08
11	1.175	-8.550384448	2019375633	-19.60407226	70 20124792	19.63494046	70.6934012	-2.7 10 76 1666	1497098413
**	1200	0005007750	0110000100	NO AAOREAM	74 60724202	19 47415000	74 10077004	2575021207	147 314 0224

3.2. Graphical Result View in Excel™

With the graphical functions inside MS $\mathsf{Excel}^{\mathsf{TM}}$, it is possible to display the downloaded trace data as a diagram.

An example is shown in ZVx_Balanced.xls in the four diagram pages "Sdd11", "Sdc11", "Scd11", "Scc11".

	A	В	С	D	E
1	RESOURCE:	GPIB0::20:INSTR			
		Rohde&Schwarz,Z			
		VA24-		Read Trace Data	
		4Port,114510101010			
2	ID:	0001,2.30	4		
3	Stimulus Freq [GHz]	Sdd11 mag	Sdd11 phase	Sdc11 mag	Sdc11 phase
4	1.000	-5.785411621	67.69949822	-21.51690945	-32.89314139
5	1.025	-6.117664028	63.88621095	-21.12512243	-39.57838282
6	1.050	-6.476670622	59.94641712	-20.81501239	-45.89185442
7	1.075	-6.859572361	55.87894857	-20.50533247	-51.41876324
8	1.100	-7.246262405	51.58801807	-20.23803065	-56.72971713
9	1.125	-7.657327676	41.2729344	-20.00049514	-61.59560863
II I → III \ZVx_Dato / Sdd11 / Sdc11 / Scd11 / Scc11)					
🛛 Draw 🔹 📐 🛛 AutoShapes 🔹 🔍 🔍 🦳 😁 🔛 🕼 📶 🐔 🔅 🔯 🐼 🖉 🎿 🖌 🗸 🗸 📼					

3.2.1. Example: View for Sdd11



The display shows two traces: One for magnitude (blue), the other for phase (red). The corresponding Y-axes can be found on the left side (magnitude) and right side (phase).

4. Hardware and Software Requirements

4.1. PC Hardware Requirements

	Minimum	Recommended
CPU	Pentium 133 MHz	Pentium II 450 MHz or higher
RAM	32 Mbyte	128 MByte
Harddisc	10 MByte free space	50 MByte free harddisc space
Monitor	VGA monitor (640x480)	SVGA color monitor, resolution 800x600 or better
IEEE Bus or LAN/Ethernet	required	

4.2. PC Software Requirements

	Minimum	Recommended	
os	Windows 95 / 98 / NT 4.0 / 2000 / Me / XP	Windows 98 / 2000 / Me / XP	
os		Microsoft Internet Explorer 5.0 or above	
add-ons		Microsoft Excel™2002 or above	
IEEE Bus Driver	Version 1.70 (or above)	Version 1.70 (or above)	
VISA	VISA 4.0	VISA 4.0	
RSIB	RSIB 1.0	RSIB 1.0	

5. Literature

[1] R&S Application note 1EF47, "Remote Control of R&S Spectrum and Network Analyzers via LAN", available at www.rohde-schwarz.com

[2] D. E. Bockelman, W. R. Eisenstadt, "Combined Differential and Common-Mode Scatterin Parameters: Theory and Simulation", IEEE Trans. on MTT, Vol. 43, No. 7, July 1995, pp. 1530-1539

6. Additional Information

This application note and the associated program are updated from time to time. Please visit the website <u>www.rohde-schwarz.com/appnote</u> in order to download new versions. Please send any comments or suggestions about this application note to <u>TM-Applications@rsd.rohde-schwarz.com</u>.

7. Ordering information

2-port Network Analyzers		
R&S® ZVL3	9 kHz to 3 GHz	1303.6509.03 (2 ports)
R&S® ZVL6	9 kHz to 6 GHz	1303.6509.06 (2 ports)
R&S® ZVA8	300 kHz to 8 GHz	1145.1110.08 (2 ports)
R&S® ZVA24	10 MHz to 24 GHz	1145.1110.24 (2 ports)
R&S® ZVA40	10 MHz to 40 GHz	1145.1110.40 (2 ports)
R&S® ZVA50	10 MHz to 40 GHz	1145.1110.50 (2 ports)
R&S® ZVB4	300 kHz to 4 GHz	1145.1010.04 (2 ports)
R&S® ZVB8	300 kHz to 8 GHz	1145.1010.08 (2 ports)
R&S® ZVB14	10MHz to 14 GHz	1145.1010.14 (2 ports)
R&S® ZVB20	10 MHz to 20 GHz	1145.1010.20 (2 ports)
R&S® ZVT8	300 kHz to 8 GHz	1300.0000.08 (2 ports to 8 ports)

Apart from the 2-port Network analyzers listed above, also multiport Network analyzer with 3, 4 ports (ZVB, ZVA) as well as 8-ports (ZVT) are available from Rohde & Schwarz.

Please note, that complete solutions for signal generation and signal analysis for various applications are available from Rohde & Schwarz.

For additional information about equipment, see the Rohde & Schwarz website <u>www.rohde-schwarz.com</u>.



ROHDE & SCHWARZ GmbH & Co. KG · Mühldorfstraße 15 · D-81671 München · Postfach 80 14 69 · D-81614 München · Tel (089) 4129 - 0 · Fax (089) 4129 - 13777 · Internet: <u>http://www.rohde-schwarz.com</u>

This application note and the supplied programs may only be used subject to the conditions of use set forth in the download area of the Rohde & Schwarz website.