Measurements on Frequency-Converting DUTs using Vector Network Analyzer ZVR

Application Note 1EZ31_1E

Subject to change

5 November 1996, Peter Kraus

Products:

ZVR with option ZVR-B4

ZVRE with option ZVR-B4

ZVRL with option ZVR-B4

ROHDE&SCHWARZ

Contents:

1. Measurements on TV Converter

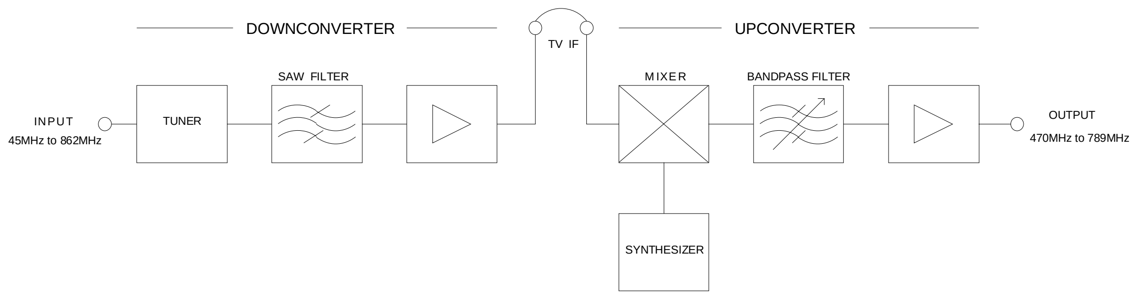

Fig. 1: Block diagram of converter

Measurement problem

ZVR is a vector network analyzer equipped with selective input channels for determining phase relations. Thus a wide dynamic range can be obtained. For measurements on frequency-converting DUTs (output frequency not identical to input frequency), the generator and receiver frequency ranges can be separately set. For measurements on DUTs using a built-in conversion oscillator, as is the case here, the conversion frequency must be exactly known so that the receiver can be accurately tuned to the respective output frequency. The maximum receiving bandwidth is 26.5 kHz. When a wide dynamic range is required, this bandwidth has to be reduced with the consequence that the requirement for the DUT output frequency and the ZVR receive frequency to be in agreement will be greater.

For this reason two characteristics of the DUT are essential: the absolute frequency accuracy and the short-term stability (spurious deviation).

The absolute frequency accuracy can be easily determined by a sweep in the quasi spectrum analyzer mode (center = nominal output frequency, span eg 100 kHz, IF bandwidth 3 kHz); see measurement results. The determined offset is considered in the entry of the receiver offset. If the frequency of the DUT is adjustable, an exact frequency adjustment can be made in this case.

Normally, the short-term stability is not a problem if - as is now common practice - oscillators are used that are coupled to a crystal reference via a phase control circuit. In most cases IF bandwidths up to 3 kHz can be handled.

Display of measurement results:

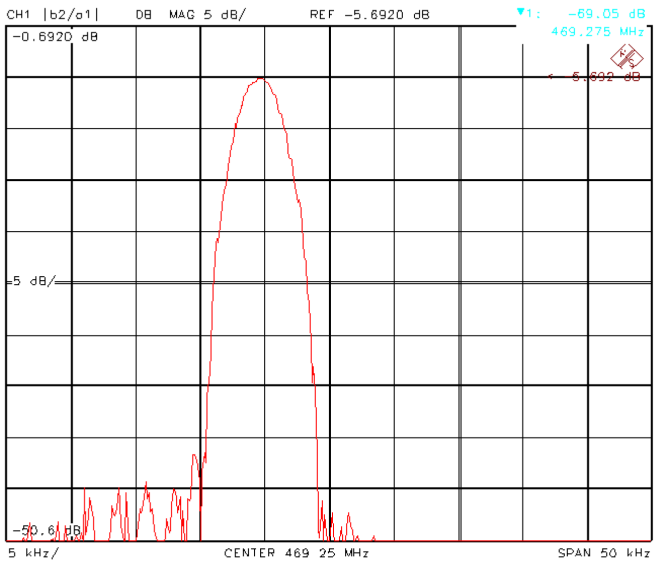

Fig. 2: Measuring the frequency offset of the conversion oscillator (center of diagram = nominal frequency)

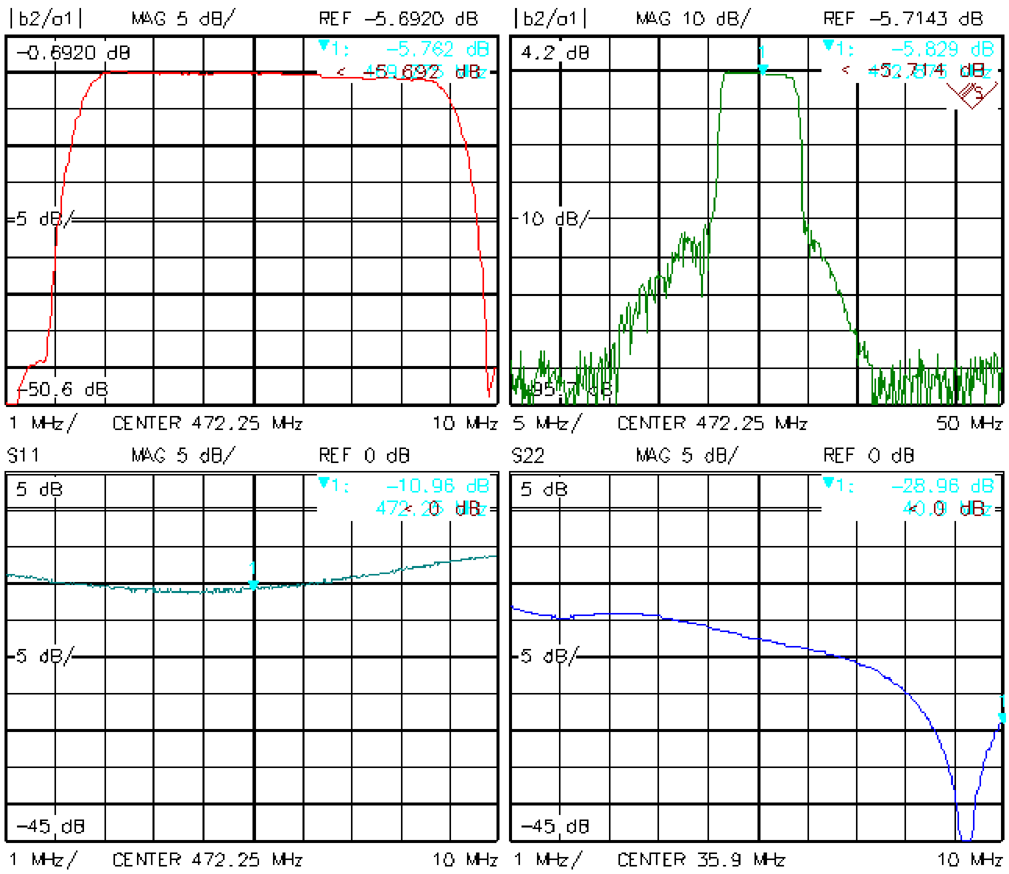

Fig. 3: Downconverter: transmission response, selectivity; input and output matching

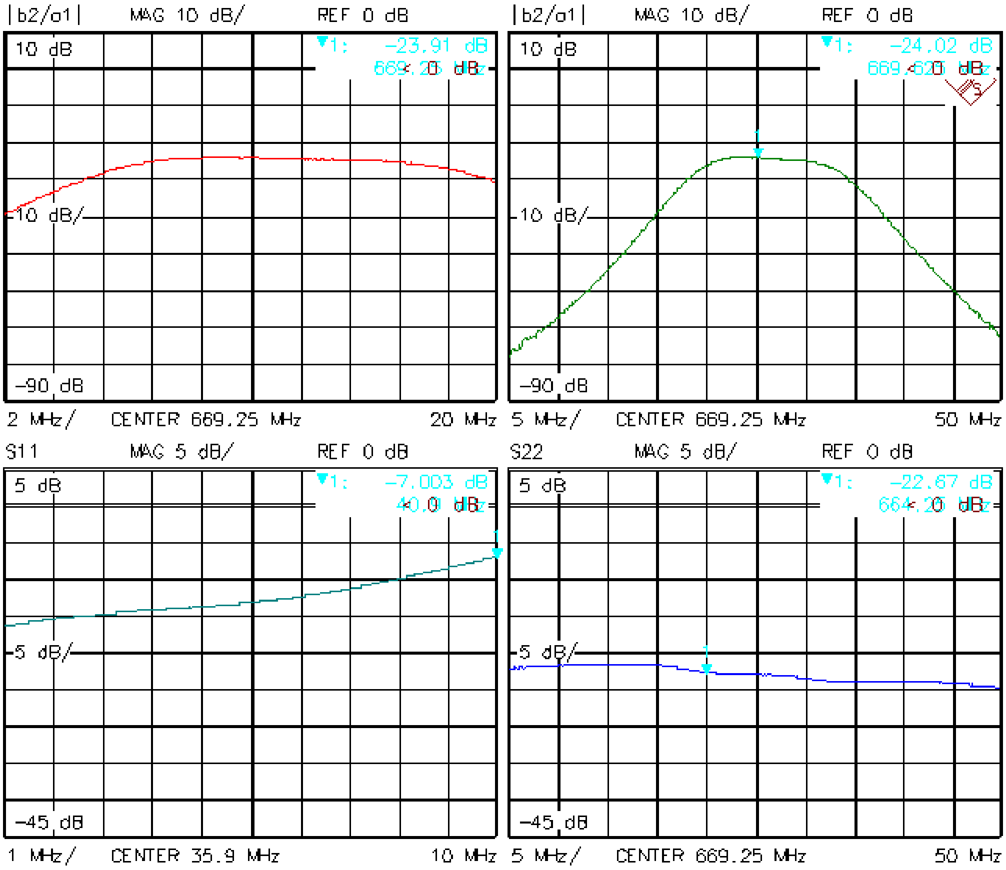

Fig. 4: Upconverter: transmission response, selectivity; input and output matching

Settings required for the measurement:

ARBITRARY SYSTEM FREQUENCIES										
FUNDAMENTAL FREQUENCY: 467.25 MHz ... 477.25 MHz										
FREQ	ON	POWER		NUM		DEN	xF	OFFSET		RESULT
INT SRC		-10 dBm	(	1	/	1	)xF		=	467 MHz..477 MHz
EXT SRC1										
EXT SRC2										
RECEIVE			(	1	/	1	)xF	-508.1 MHz	=	40.9MHz..30.9MHz

Fig. 5: Downconverter: frequency setting for transmission response

ARBITRARY SYSTEM FREQUENCIES										
FUNDAMENTAL FREQUENCY: 447.25 MHz ... 497.25 MHz										
FREQ	ON	POWER		NUM		DEN	xF	OFFSET		RESULT
INT SRC		-10 dBm	(	1	/	1	)xF		=	447 MHz..497 MHz
EXT SRC1										
EXT SRC2										
RECEIVE			(	1	/	1	)xF	-508.1 MHz	=	60.9MHz..10.9MHz

Fig. 6: Downconverter: frequency setting for selectivity measurement

ARBITRARY SYSTEM FREQUENCIES										
FUNDAMENTAL FREQUENCY: 659.25 MHz ... 679.25 MHz										
FREQ	ON	POWER		NUM		DEN	xF	OFFSET		RESULT
INT SRC		-10 dBm	(	1	/	1	)xF	-708 2 MHz	=	48.9MHz..28.9MHz
EXT SRC1										
EXT SRC2										
RECEIVE			(	1	/	1	)xF		=	659 MHz..679 MHz

Fig. 7: Upconverter: frequency setting for transmission response

ARBITRARY SYSTEM FREQUENCIES										
FUNDAMENTAL FREQUENCY: 644.25 MHz ... 694.25 MHz										
FREQ	ON	POWER		NUM		DEN	xF	OFFSET		RESULT
INT SRC		-10 dBm	(	1	/	1	)xF	-708 2 MHz	=	63.9MHz..13.9MHz
EXT SRC1										
EXT SRC2										
RECEIVE			(	1	/	1	)xF		=	644 MHz..694 MHz

Fig. 8: Upconverter: frequency setting for selectivity measurement

2. Simulating Frequency Conversion from 1st SAT-TV IF to Baseband

Measurement problem:

When an input signal in the frequency range of eg ±12 MHz is converted to zero IF, an output frequency range of 0 ±12 MHz is obtained.

Since this conversion cannot be measured with the ZVR, the frequency range is split up in two subranges, each of which is measured by one of the four measurement channels:

f +12 MHz → 0 to 12 MHz
f -12 MHz → 12 MHz to 0

Since ZVR has a lower limit frequency of 9 kHz (10 Hz with external measurements option), the ranges are selected as follows:

f +10 kHz (10 Hz) +12 MHz → 10 kHz (10 Hz) to 12 MHz

f -10 kHz (10 Hz) -12 MHz → 12 MHz to 10 kHz (10 Hz)

Provided adequate conversion conditions are selected in the ZVR, the direction of the output frequency variation can be varied as required (eg upper band section rising, lower section falling).

Test setup:

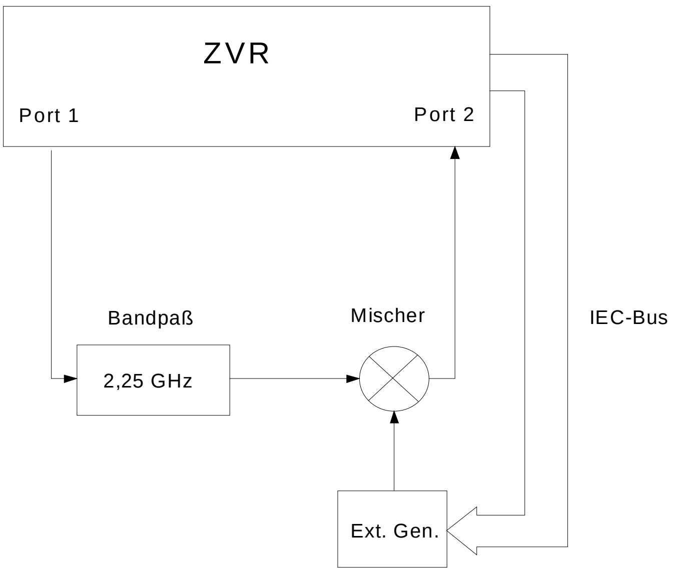

Fig. 9: Block diagram of test setup

Display of measurement results:

Results can be displayed in two ways:

1. Dual-Channel Overlay

In this case the lower band is folded up at the zero frequency and the two band are displayed simultaneously.

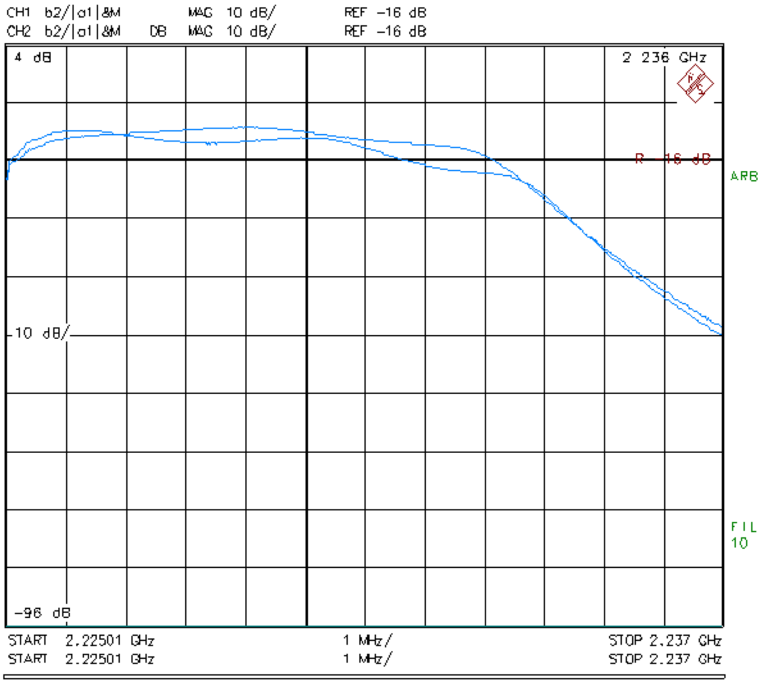

Fig. 10: DUAL CHN OVERLAY display

2. Quad-Channel Splitting

The lower and the upper bands are displayed with increasing input frequency. When measurement channels 1 and 3 are selected, the bands are positioned next to each other so that a continuous passband characteristic is obtained.

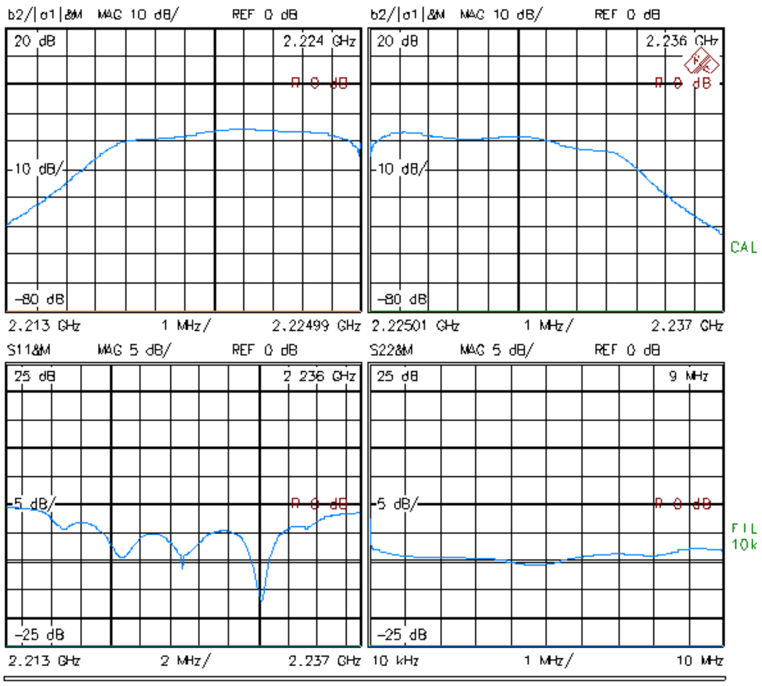

Fig. 11: QUAD CHN SPLIT display

Settings required for the measurement:

ARBITRARY SYSTEM FREQUENCIES										
FUNDAMENTAL FREQUENCY: 2.22501 GHz ... 2.237 GHz										
FREQ	ON	POWER		NUM		DEN	×F	OFFSET		RESULT
INT SRC		-10 dBm	(	-1	/	1	)×F	+4.45 GHz	=	2.22GHz..2.21GHz
EXT SRC1	√	10 dBm						2.225 GHz	=	2.23GHz
EXT SRC2										
RECEIVE			(	-1	/	1	)×F	+2.225 GHz	=	10kHz..12MHz

EXT SOURCES CONFIG			
SRC	REMOTE	IEC ADDR	TYPE
1	IEC	19	SMP02
2	OFF	19	

Fig. 12: **Channel 1** for DUAL CHN OVERLAY display

ARBITRARY SYSTEM FREQUENCIES										
FUNDAMENTAL FREQUENCY: 2.22501 GHz ... 2.237 GHz										
FREQ	ON	POWER		NUM		DEN	×F	OFFSET		RESULT
INT SRC		-10 dBm	(	1	/	1	)×F		=	2.23GHz..2.24GHz
EXT SRC1	√	10 dBm						2.225 GHz	=	2.23GHz
EXT SRC2										
RECEIVE			(	-1	/	1	)×F	+2.225 GHz	=	10kHz..12MHz

EXT SOURCES CONFIG			
SRC	REMOTE	IEC ADDR	TYPE
1	IEC	19	SMP02
2	OFF	19	

Fig. 13: **Channel 2** for DUAL CHN OVERLAY display

ARBITRARY SYSTEM FREQUENCIES

FUNDAMENTAL FREQUENCY: 2.213 GHz ... 2.22499 GHz

FREQ	ON	POWER		NUM		DEN	×F	OFFSET		RESULT
INT SRC		-10 dBm	(	1	/	1	)×F		=	2.21GHz..2.22GHz
EXT SRC1	√	10 dBm						2.225 GHz	=	2.23GHz
EXT SRC2										
RECEIVE			(	-1	/	1	)×F	+2.225 GHz	=	12MHz..10kHz

EXT SOURCES CONFIG

SRC	REMOTE	IEC ADDR	TYPE
1	IEC	19	SMP02
2	OFF	19	

Fig. 14: **Channel 1** for QUAD CHN SPLIT display

ARBITRARY SYSTEM FREQUENCIES

FUNDAMENTAL FREQUENCY: 2.22501 GHz ... 2.237 GHz

FREQ	ON	POWER		NUM		DEN	×F	OFFSET		RESULT
INT SRC		-10 dBm	(	1	/	1	)×F		=	2.23GHz..2.24GHz
EXT SRC1	√	10 dBm						2.225 GHz	=	2.23GHz
EXT SRC2										
RECEIVE			(	-1	/	1	)×F	+2.225 GHz	=	10kHz..12MHz

EXT SOURCES CONFIG

SRC	REMOTE	IEC ADDR	TYPE
1	IEC	19	SMP02
2	OFF	19	

Fig. 15: **Channel 3** for QUAD CHN SPLIT display

3. Measurements on Front End with Double Conversion

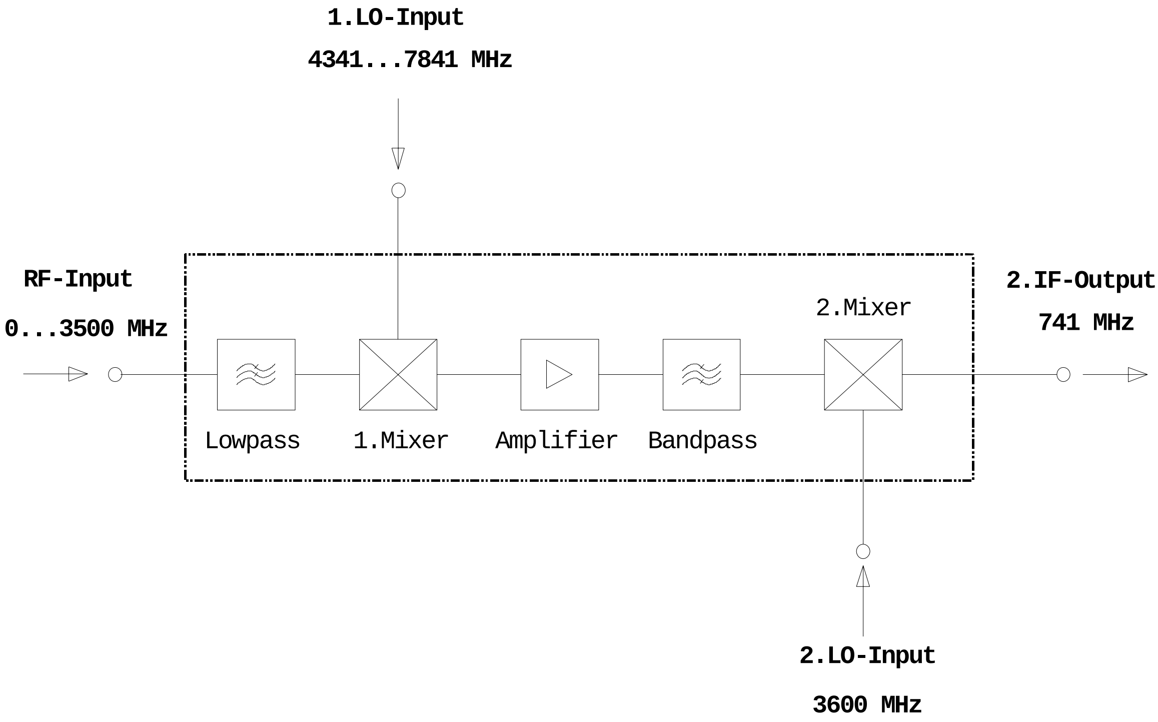

Fig. 16: Block diagram of front end

The Vector Network Analyzer ZVR is able to control two external generators via the IEC/IEEE-bus interface. This permits DUTs performing up to two frequency conversions to be automatically measured. For measuring the conversion frequency response over the entire frequency range of the DUT, the frequency of one of the two generators has to be varied. Since this variation is made via the IEC/IEEE bus, the sweep time becomes shorter depending on the generator used. However, the full speed can be used when the passband characteristic is measured, as in this case the two external generators are set to a fixed frequency.

To be able to measure the transmission response with maximum accuracy, the power calibration option (ZVR-B7) should be used.

With the aid of this option the frequency response of the internal generators and ZVR receive sections are corrected. Thus errors caused by different generator and receive frequency ranges can be avoided. Parameters S11, $|S21|$ and S22 can be measured.

Another way to increase the measurement accuracy is to use an external reference converter (option ZVR-B6), which corresponds to the DUT or serves as a reference for comparison. This has the advantage that no calibration or level correction is required and that the phase difference of the transmission response between the two DUTs (group delay) can be measured. A disadvantage is that the measurements do not yield absolute values.

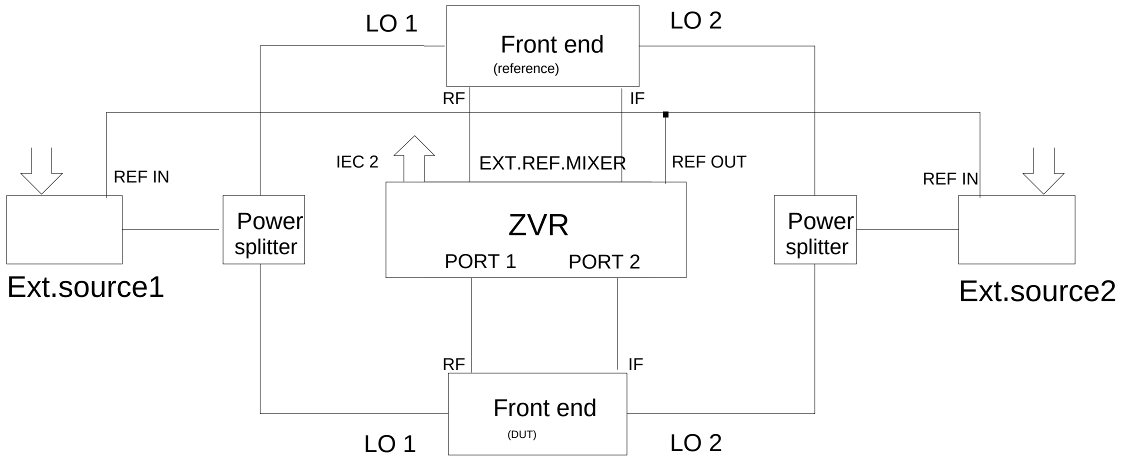

Fig. 17: Test setup with external reference converter

Measurement results

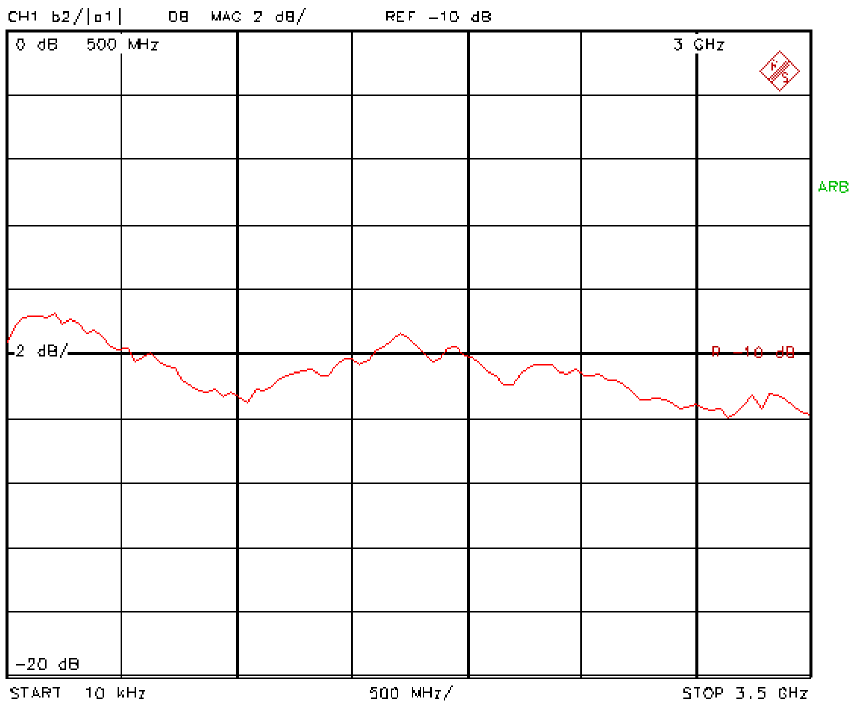

Fig. 18: Frequency response of front end

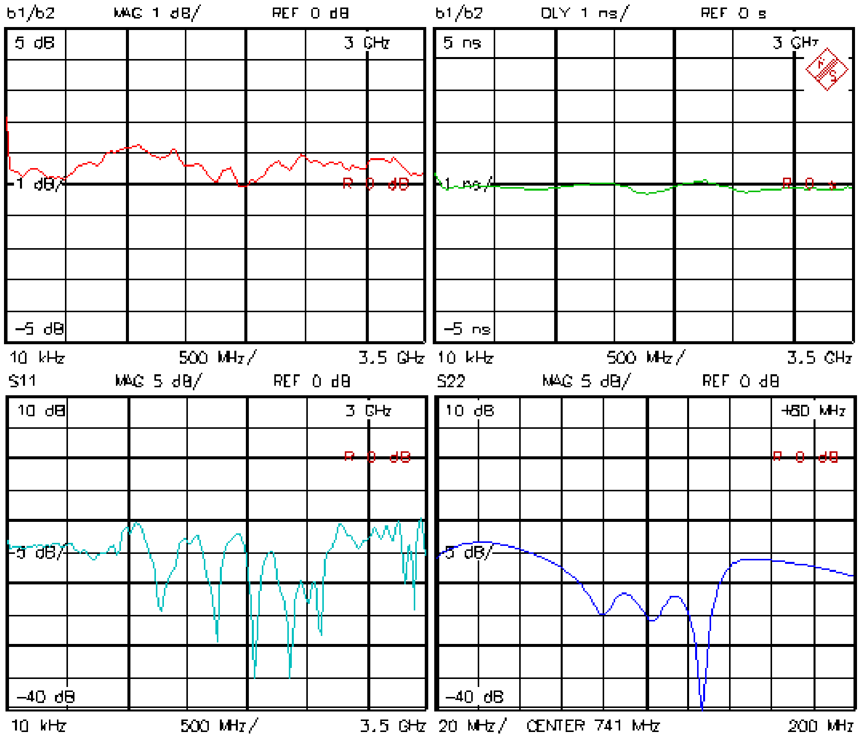

Fig. 19: Frequency response and delay deviation compared to front end; input and output matching

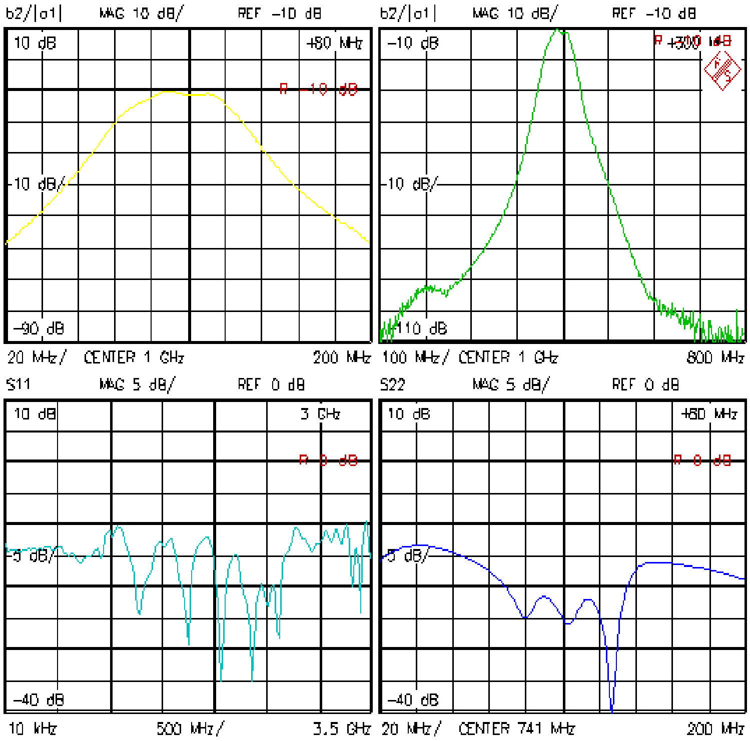

Fig. 20: Passband characteristic for nearby and far-off selectivity; input and output matching

Settings required for the measurement

ARBITRARY SYSTEM FREQUENCIES

FUNDAMENTAL FREQUENCY: 10 kHz ... 3.5 GHz

FREQ	ON	POWER		NUM		DEN	*F	OFFSET		RESULT
INT SRC		-10 dBm	(	1	/	1	)*F		=	10kHz..3.5GHz
EXT SRC1	√	0 dBm	(	1	/	1	)*F	+4.341 GHz	=	4.34GHz..7.84GHz
EXT SRC2	√	0 dBm						3.6 GHz	=	3.6GHz
RECEIVE			(	0	/	1	)*F	+741 MHz	=	741 MHz

EXT SOURCES CONFIG

SRC	REMOTE	IEC ADDR	TYPE
1	IEC	28	SMP02
2	IEC	19	SMT06

Fig. 21: Frequency response of front end

ARBITRARY SYSTEM FREQUENCIES

FUNDAMENTAL FREQUENCY: 900 MHz ... 1.1 GHz

FREQ	ON	POWER		NUM		DEN	*F	OFFSET		RESULT
INT SRC		-10 dBm	(	1	/	1	)*F		=	900 MHz..1.1GHz
EXT SRC1	√	0 dBm	(	0	/	1	)*F	+5.341 GHz	=	5.34GHz
EXT SRC2	√	10 dBm						3.6 GHz	=	3.6GHz
RECEIVE			(	1	/	1	)*F	-1.741 GHz	=	841 MHz..641 MHz

EXT SOURCES CONFIG

SRC	REMOTE	IEC ADDR	TYPE
1	IEC	28	SMP02
2	IEC	19	SMT06

Fig. 22: Passband characteristic

ARBITRARY SYSTEM FREQUENCIES

FUNDAMENTAL FREQUENCY: 600 MHz ... 1.4 GHz

FREQ	ON	POWER		NUM		DEN	*F	OFFSET		RESULT
INT SRC		-10 dBm	(	1	/	1	)*F		=	600 MHz..1.4GHz
EXT SRC1	√	0 dBm	(	0	/	1	)*F	+5.341 GHz	=	5.34GHz
EXT SRC2	√	10 dBm						3.6 GHz	=	3.6GHz
RECEIVE			(	1	/	1	)*F	-1.741 GHz	=	1.14GHz..341 MHz

EXT SOURCES CONFIG

SRC	REMOTE	IEC ADDR	TYPE
1	IEC	28	SMP02
2	IEC	19	SMT06

Fig. 23: Far-off selectivity

Peter Kraus, 1ES3
Rohde & Schwarz
5 November 1996

4 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: Multiport 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.

5 Ordering Information

Order designation	Type	Frequency range	Order No.
Vector Network Analyzers (test sets included) *			
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
Alternative Test Sets *			
75 Ω SWR Bridge for ZVRL (instead of 50 Ω) [1]			
75 Ω, passive	ZVR-A71	9 kHz to 4 GHz	1043.7690.18
75 Ω SWR Bridge Pairs for ZVRE and ZVR (instead of 50 Ω) [1]			
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
Options			
AutoKal	ZVR-B1	0 to 8 GHz	1044.0625.02
Time Domain	ZVR-B2	same as analyzer	1044.1009.02
Mixer Measurements [2]	ZVR-B4	same as analyzer	1044.1215.02
Reference Channel Ports	ZVR-B6	same as analyzer	1044.1415.02
Power Calibration [3]	ZVR-B7	same as analyzer	1044.1544.02
3-Port Adapter	ZVR-B8	0 to 4 GHz	1086.0000.02
Virtual Embedding Networks [4]	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) [5]	ZVR-B15	-	1044.0290.02
Controller (English) [5]	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 [6]	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 [7]	ZVR-B25	10 Hz to 4 GHz (ZVR/E/L) 20 kHz to 8 GHz (ZVC/E)	1044.0460.02

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

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