News from Rohde & Schwarz

EMI test receiver featuring unparalleled measurement speed

All-in-one solution: phase noise tester and high-end spectrum analyzer

Compact UHF low-power transmitters for closing coverage gaps

2006/II
190

ROHDE & SCHWARZ

44849

The new EMI Test Receivers R&S®ESU comply with all commercial and military standards for EMI measurements. They perform these measurements with maximum accuracy and at unparalleled speed (page 39).

When equipped with the R&S®TSMU-K13 option, the R&S®TSMU, which is a compact test system for coverage measurements in WCDMA and GSM networks, automatically detects the sources of co-channel and adjacent-channel interference in GSM networks (page 4).

A software for the Test System R&S®TS9970 evaluates the radiation characteristics of mobile phone antennas and makes development and certification as well as report generation much easier (page 10).

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Signal analyzers

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Unique: A combination of phase noise tester and high-end spectrum analyzer, the new Signal Source Analyzer R&S®FSUP offers all functions required for completely characterizing oscillators (page 30).

The Power Sensor Modules R&S®NRP-Z27/-Z37 for the Measuring Receiver R&S®FSMR enable absolute level measurements with utmost precision and convenience, eliminating the need for switching between the measuring receiver and the power meter (page 34).

The low-power transmitters of the R&S®SV8000 UHF transmitter family are ideal for closing coverage gaps. They feature compact design, flexibility and intelligent standby systems (page 52).

Phase noise testers

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FIG 1 The R&S®TSMU automatically detects, analyzes and displays the results of co-channel and adjacent-channel interferences in GSM networks during a drive test.

Radio Network Analyzer R&S®TSMU

Automatic detection of interferences in GSM networks

The R&S®TSMU is a compact test system for coverage measurements in WCDMA and GSM networks. With the R&S®TSMU-K13 option, it automatically detects the sources of co-channel and adjacent-channel interference in GSM networks, evaluates the data and displays the results.

Interferences – a frequent impairment in radio networks

In addition to criteria such as attractive prices, a product portfolio matching customer's needs, a comprehensive range of services and effective marketing, a network operator's image and economic success depend primarily on the technical performance of the radio network. Yet precisely the need to ensure and optimize the quality of radio networks poses a permanent challenge to network operators. This involves, for example, detecting the impairments that most frequently occur in radio networks, i.e. interferences. Solving this problem with conventional measuring equipment is very difficult and time-consuming. The Radio Network Analyzer R&S®TSMU from Rohde&Schwarz (FIG 1) makes this task a great deal easier. In conjunction with the R&S®ROMES measurement software, this specialist for the analysis of receive conditions in mobile radio networks automatically detects and analyzes interferences during drive tests and displays the results in a straightforward manner.

Interferences may have a variety of causes. Radio networks are never complete; they are continuously being expanded, for example by adding new base stations or transmit channels. Changes usually have to be made under great pressure of time, which places considerable demands on frequency planning and network operation. Such measures often affect existing frequency plans that were optimized for the original radio scenarios. Interference may also be caused by incorrectly set frequencies or carriers of other networks, both in one's own country and in neighboring countries. The problem of interference is aggravated in areas close to the border.

System components for GSM interference analysis

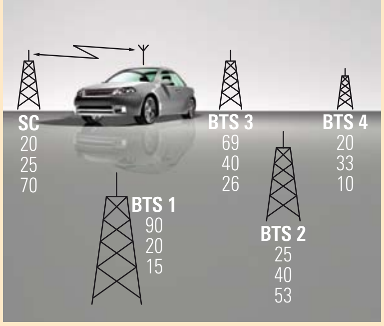
The following components are required for interference analysis in GSM networks (FIG 6):

- PC (e.g. notebook) for performing the measurements
- Radio Network Analyzer R&S®TSMU
- Coverage Measurement Software R&S®ROMES including functionality for GSM interference analysis
- GSM Network Scanner R&S®TSMU-K13 (option)
- Test mobile phone (e.g. Sagem OT290 supporting C/I parameter) and associated driver in R&S®ROMES
- GPS system and associated driver in R&S®ROMES
- List of GSM base stations of network operator

What causes interferences in GSM networks?

Interferences are defined in a variety of ways; the explanations below therefore concentrate on typical problems encountered in the radio field. Interferences are most commonly caused by the mutual interaction of GSM useful frequencies. Co-channel or adjacent-channel interferences cause serious problems in signal reception. Interferences may also result from unwanted external frequencies radiating into the network, e.g. emissions from unshielded appliances or frequencies used by the military.

FIG 2 shows a radio scenario with five base stations (BTS), one of these acting as the serving cell (SC) for the terminal. The base station uses carrier C0 (referred to as the BCCH carrier) of the serving cell to transmit to the terminal the information it requires to identify and synchronize to the cell. This transmission takes place via timeslot T0. In the remaining timeslots of the BCCH carrier, traffic data (voice or data) is transmitted. Channels C1 and C2 transport traffic data only. The other four base stations also transmit data on their respective BCCHs and channels C1 and C2, but are at this moment not actively communicating with the terminal.



	SC	BTS 1	BTS 2	BTS 3	BTS 4
C0 (BCCH)	20	90	25	69	20
C1	25	20	40	40	33
C2	70	15	53	26	10

FIG 2 Radio scenario with five base stations, one of them acting as a serving cell. The channel numbers are listed in the table.

FIG 3 shows all interferences that may occur in this scenario, stating all co-channels and adjacent channels that may impair the current SC. In accordance with the GSM standard, the BCCH transmits at maximum power in each of its timeslots (possibly only dummy bursts) and will therefore be received by the terminal permanently and with the highest level. The traffic channels Cx (C1 and C2) are differently loaded during their eight timeslots, depending on the traffic volume; plus, their transmit power can be controlled. Their total power is as a rule lower than that of the BCCH carrier, and the interferences they cause can therefore usually be considered lower than that caused by the BCCH carrier. Of the eight timeslots of the BCCH carrier, the R&S®TSMU only measures and analyzes timeslot T0 (FIG 4). The remaining timeslots are not considered in the analysis for the reasons stated above. In the case of a C0Cx interference (traffic channel Cx interferes with channel C0), only the BCCH belonging to the Cx is analyzed as an interference frequency.

	Potential interference channels	Type of interference
C0 of serving cell (channel 20)	C0 of BTS 4 (channel 20)	C0C0
	C1 of BTS 1 (channel 20)	C0Cx
C1 of serving cell (channel 25)	C0 of BTS 2 (channel 25)	CxC0
	C2 of BTS 3 (channel 26)	CxCx (adjacent channel)
C2 of serving cell (channel 70)	C0 of BTS 3 (channel 69)	CxC0 (adjacent channel)

FIG 3 Complete list of interferences that may occur in the radio scenario shown in FIG 2.

FIG 4
The eight timeslots of the BCCH carrier.

C0	T0	T1	T2	T3	T4	T5	T6	T7

T0: FCCH, SCH, BCCH, CCCH

Five steps to reach your goal

GSM interference analysis basically is performed in five steps:

1. The test mobile phone is operating in the endless call mode (e.g. voice call). The RxLev and RxQual parameters and, if supported by the phone, the C/I parameter are analyzed.
2. If one or more parameters exceed predefined thresholds, the scanner will identify this as being caused by interference (FIG 8).
3. Potential interference frequencies are determined by comparing the current serving cell channel against co-channels or adjacent channels that are included in the BTS list and lie within the user-defined radius (FIG 9).
4. The cell identities (CIs) measured with the GSM network scanner are compared against the CIs of the potential interference frequencies included in the base station list.
5. Results found are displayed in plain text, giving the name of the cell as stated in the BTS list.

With a rate of up to 80 measurements per second, the analysis system covers all preselected GSM channels. It decodes the channel numbers and the levels as well as the CI, MNC, MCC, LAC and BSIC parameters with reference to both time and position. These measurements require no network authorization by means of a SIM card. If the system detects several BCCH carriers in one channel, it can identify the carriers – depending on their spacing – by their CIs as separate co-channel signals and display them separately (FIG 5).

Within a definable time window, the analysis system measures the N strongest BCCH carriers and saves them in a pool. For the analysis, the final, valid level values of the interference signals are filtered from this pool as a function of the predefined interference thresholds and the results obtained from the mobile phone measurements. These values are then output together with the information included in the BTS list.

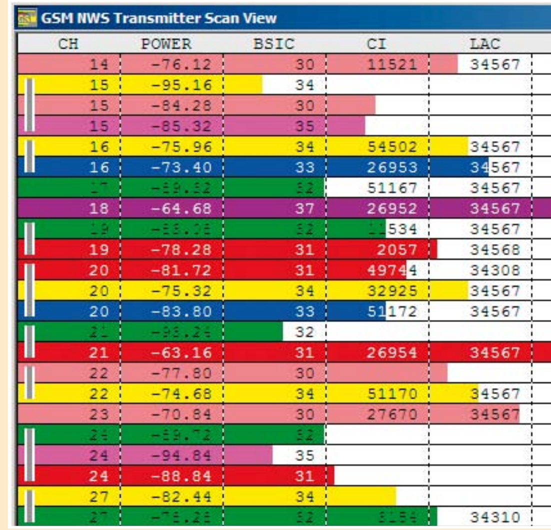
Measured data acquisition and interference analysis take place in realtime. Detected interferences as well as analysis results are displayed and measured values stored already during the measurement. This allows users to subsequently modify interference display criteria by changing threshold values.

Measurement sequence in detail and analysis of results

As with all T&M equipment, preparatory operations are required in order to achieve optimum results (FIG 7). The R&S®ROMES measurement software has to be started and the appropriate map and a base station list have to be loaded. Then the drivers for the test mobile phone and the GSM network scanner have to be loaded and configured. These settings can later be easily loaded by calling a *workspace* in a configuration menu.

Setting options for the analysis algorithm

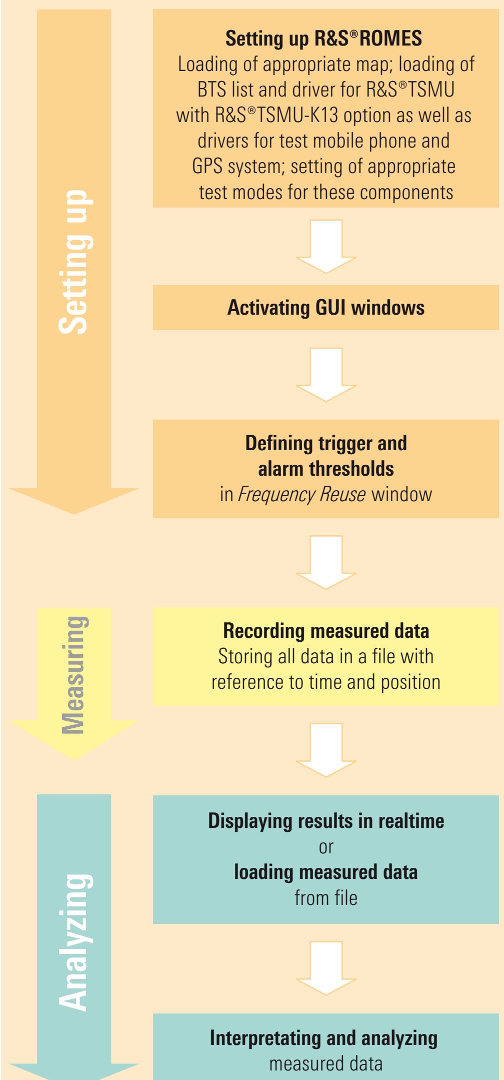
FIG 10 shows the various options for defining interference criteria, using the BTS list, and optimally configuring the Top-N list. All results are presented in windows in a straightforward manner. Each interference is displayed in detail stating the type (C0C0, C0Cx, etc), power, duration and distance covered as well as the interfering BTS (name derived from BTS list). In the *coupled focus* mode, results are additionally displayed in a map (FIG 11). In addition, all interferences are displayed in the clear-cut *Frequency Reuse Event* list. Results can be exported to planning tools.

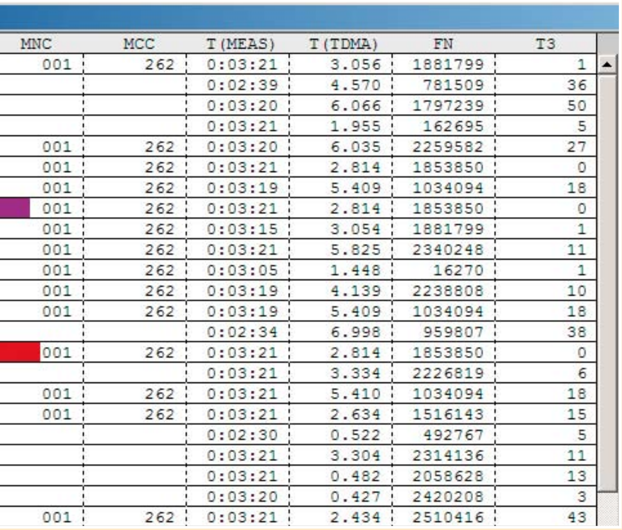

GSM NWS Transmitter Scan View

CH	POWER	BSIC	CI	LAC
14	–76.12	30	11521	34567
15	–95.16	34		
15	–84.28	30		
15	–85.32	35		
16	–75.96	34	54502	34567
16	–73.40	33	26953	34567
17	[illegible]	[illegible]	51167	34567
18	–64.68	37	26952	34567
19	[illegible]	[illegible]	[illegible]534	34567
19	–78.28	31	2057	34568
20	–81.72	31	49744	34308
20	–75.32	34	32925	34567
20	–83.80	33	51172	34567
[illegible]	[illegible]	32		
21	–63.16	31	26954	34567
22	–77.80	30		
22	–74.68	34	51170	34567
23	–70.84	30	27670	34567
[illegible]	[illegible]	[illegible]		
24	–94.84	35		
24	–88.84	31		
27	–82.44	34		
[illegible]	[illegible]	[illegible]	[illegible]	34310

FIG 5 Co-channel signals are identified and displayed separately.

FIG 7 Sequence of GSM interference measurements in detail.





MNC	MCC	T (MEAS)	T (TDMA)	FN	T3
001	262	0:03:21	3.056	1881799	1
		0:02:39	4.570	781509	36
		0:03:20	6.066	1797239	50
		0:03:21	1.955	162695	5
001	262	0:03:20	6.035	2259582	27
001	262	0:03:21	2.814	1853850	0
001	262	0:03:19	5.409	1034094	18
001	262	0:03:21	2.814	1853850	0
001	262	0:03:15	3.054	1881799	1
001	262	0:03:21	5.825	2340248	11
001	262	0:03:05	1.448	16270	1
001	262	0:03:19	4.139	2238808	10
001	262	0:03:19	5.409	1034094	18
		0:02:34	6.998	959807	38
001	262	0:03:21	2.814	1853850	0
		0:03:21	3.334	2226819	6
001	262	0:03:21	5.410	1034094	18
001	262	0:03:21	2.634	1516143	15
		0:02:30	0.522	492767	5
		0:03:21	3.304	2314136	11
		0:03:21	0.482	2058628	13
		0:03:20	0.427	2420208	3
001	262	0:03:21	2.434	2510416	43

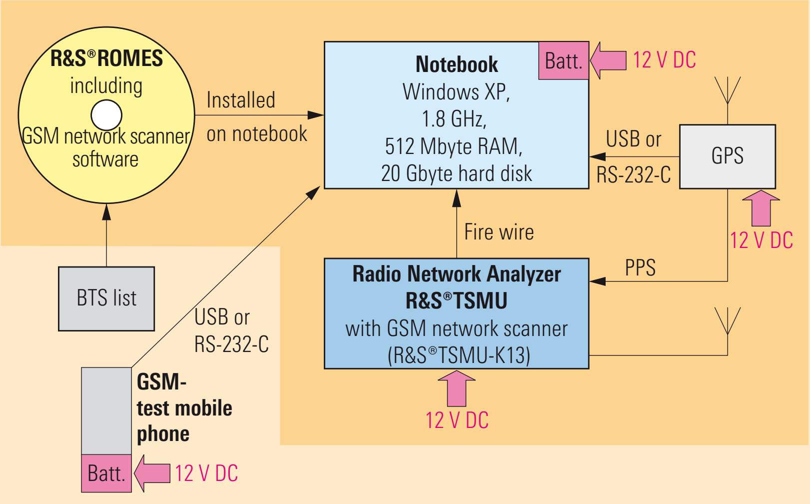
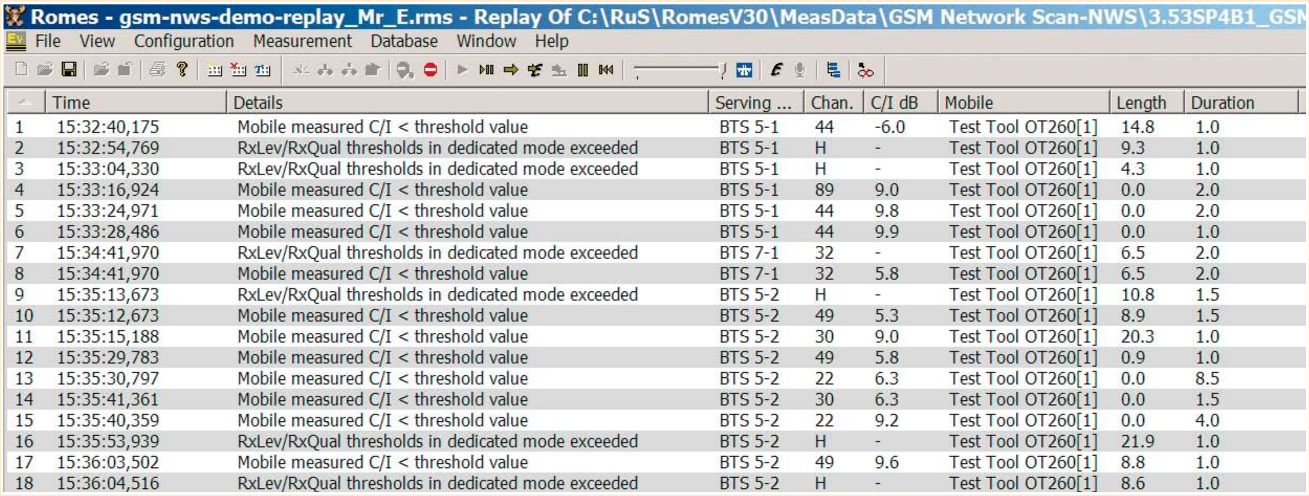


FIG 6 **Components required for GSM interference analysis.**

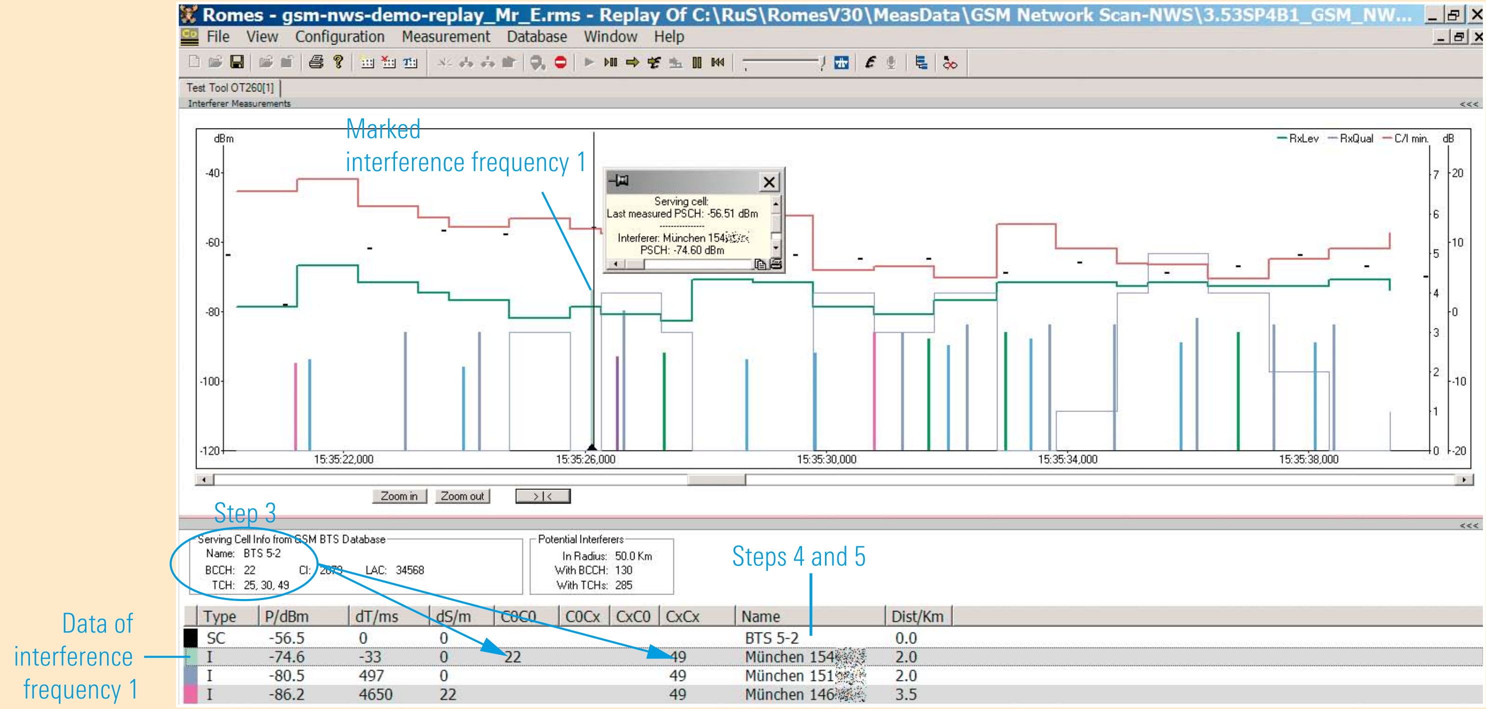


Romes - gsm-nws-demo-replay_Mr_E.rms - Replay Of C:\RuS\RomesV30\MeasData\GSM Network Scan-NWS\3.53SP4B1_GSM

	Time	Details	Serving ...	Chan.	C/I dB	Mobile	Length	Duration
1	15:32:40,175	Mobile measured C/I < threshold value	BTS 5-1	44	-6.0	Test Tool OT260[1]	14.8	1.0
2	15:32:54,769	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 5-1	H	-	Test Tool OT260[1]	9.3	1.0
3	15:33:04,330	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 5-1	H	-	Test Tool OT260[1]	4.3	1.0
4	15:33:16,924	Mobile measured C/I < threshold value	BTS 5-1	89	9.0	Test Tool OT260[1]	0.0	2.0
5	15:33:24,971	Mobile measured C/I < threshold value	BTS 5-1	44	9.8	Test Tool OT260[1]	0.0	2.0
6	15:33:28,486	Mobile measured C/I < threshold value	BTS 5-1	44	9.9	Test Tool OT260[1]	0.0	1.0
7	15:34:41,970	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 7-1	32	-	Test Tool OT260[1]	6.5	2.0
8	15:34:41,970	Mobile measured C/I < threshold value	BTS 7-1	32	5.8	Test Tool OT260[1]	6.5	2.0
9	15:35:13,673	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 5-2	H	-	Test Tool OT260[1]	10.8	1.5
10	15:35:12,673	Mobile measured C/I < threshold value	BTS 5-2	49	5.3	Test Tool OT260[1]	8.9	1.5
11	15:35:15,188	Mobile measured C/I < threshold value	BTS 5-2	30	9.0	Test Tool OT260[1]	20.3	1.0
12	15:35:29,783	Mobile measured C/I < threshold value	BTS 5-2	49	5.8	Test Tool OT260[1]	0.9	1.0
13	15:35:30,797	Mobile measured C/I < threshold value	BTS 5-2	22	6.3	Test Tool OT260[1]	0.0	8.5
14	15:35:41,361	Mobile measured C/I < threshold value	BTS 5-2	30	6.3	Test Tool OT260[1]	0.0	1.5
15	15:35:40,359	Mobile measured C/I < threshold value	BTS 5-2	22	9.2	Test Tool OT260[1]	0.0	4.0
16	15:35:53,939	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 5-2	H	-	Test Tool OT260[1]	21.9	1.0
17	15:36:03,502	Mobile measured C/I < threshold value	BTS 5-2	49	9.6	Test Tool OT260[1]	8.8	1.0
18	15:36:04,516	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 5-2	H	-	Test Tool OT260[1]	8.6	1.0

FIG 8 ***Frequency Reuse Event*** **display listing interferences determined as a function of the set thresholds.**

FIG 9 ***Frequency Reuse C0*** **display.**



Type	P/dBm	dT/ms	dS/m	C0C0	C0Cx	CxC0	CxCx	Name	Dist/Km
SC	-56.5	0	0					BTS 5-2	0.0
I	-74.6	-33	0	22			49	München 154	2.0
I	-80.5	497	0				49	München 151	2.0
I	-86.2	4650	22				49	München 146	3.5

An investment that pays off rapidly

Detecting and identifying interferences used to be an extremely time-consuming procedure. The Radio Network Analyzer R&S®TSMU automatically detects and analyzes interfering base stations in a short time, including plain-text display, without requiring any manual reworking. The R&S®ROMES software ensures highly convenient, flexible and efficient operation of the system.

Summary

The Radio Network Analyzer R&S®TSMU from Rohde&Schwarz is a high-end analysis tool for radio coverage measurements. With the appropriate options installed, this compact solution not only supports network operators in planning and optimizing their GSM networks, but also helps them set up and structure WCDMA and HSDPA networks.

Christian Fischer; Johann Maier

More information and data sheets on R&S®TSMU and R&S®ROMES at www.rohde-schwarz.com (search term: TSMU/ROMES)

REFERENCES
Radio Network Analyzer R&S®TSMU: Unprecedented quality for mobile measurements in GSM networks. News from Rohde&Schwarz (2005) No. 186, pp 4–7

Condensed data of the R&S®TSMU with R&S®TSMU-K13 option

Sensitivity	<–112 dBm
Level error	±1 dB
Minimum C/I for initial decoding of CI, MNC, MCC, LAC, etc	>2.5 dB
Level measurement rate including the decoding of CI, BSIC, LAC, MNC, MCC	up to 80 channels/s
Cycle times (typ. / max.)	
GSM900	1.54 s / 3 s
GSM1800	4.65 s / 9 s
GSM-R	0.25 s / 0.5 s

Abbreviations

ARFCN	Absolute radio frequency channel number
BCC	Base station color code
BCCH	Broadcast control channel
BSIC	Base station identity code
BTS	Base transmitter station
C/I	Carrier-to-interference ratio
CI	Cell identity
CCCH	Common control channel
FCCH	Frequency correction channel
LAC	Location area code
MCC	Mobile country code
MNC	Mobile network code
NCC	Network color code
SC	Serving cell
SCH	Synchronization channel

Highlights of the R&S®TSMU with the R&S®TSMU-K13 GSM option

- Efficient, time-saving optimization of GSM, GPRS and EDGE radio networks independently of the infrastructure
- Covers all GSM frequencies (GSM 450/850/900/1800/1900/GSM-E/GSM-R)
- Multichannel capability within a measurement setup
- Higher measurement speed and measurement accuracy than obtainable with test mobile phones
- Requires no network authorization by means of SIM card
- Can be used with GSM, GPRS and EDGE test mobile phones for triggering and signaling
- Identification and analysis of roaming problems and interferences originating, for example, from networks of neighboring countries
- Automatic off-the-air measurement and demodulation of all GSM channels
- Decoding of type 1 to 4 system information such as NCC, BCC, CI, LAC, MNC and MCC; output of ARFCN, RF level, and name and position of base station
- Supplies coverage measurement data, i.e. one measurement value per time stamp and position

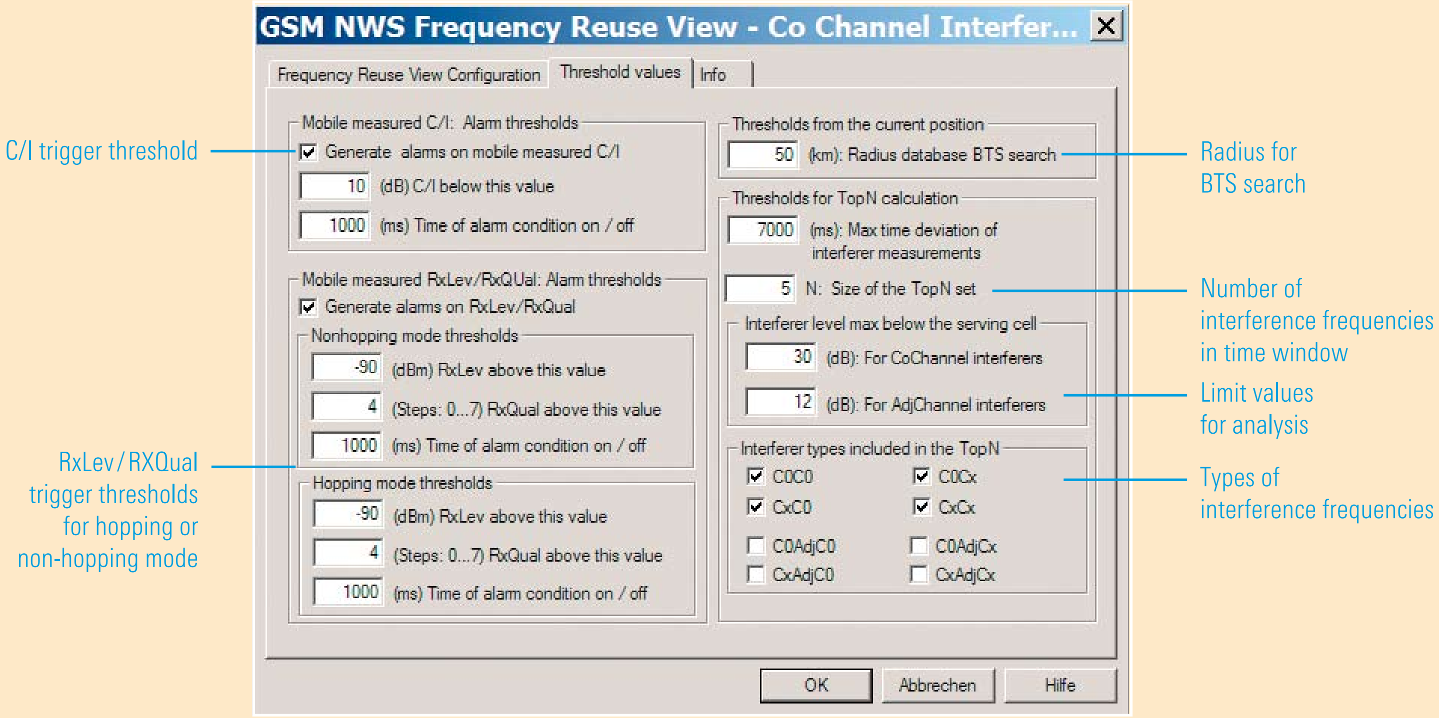
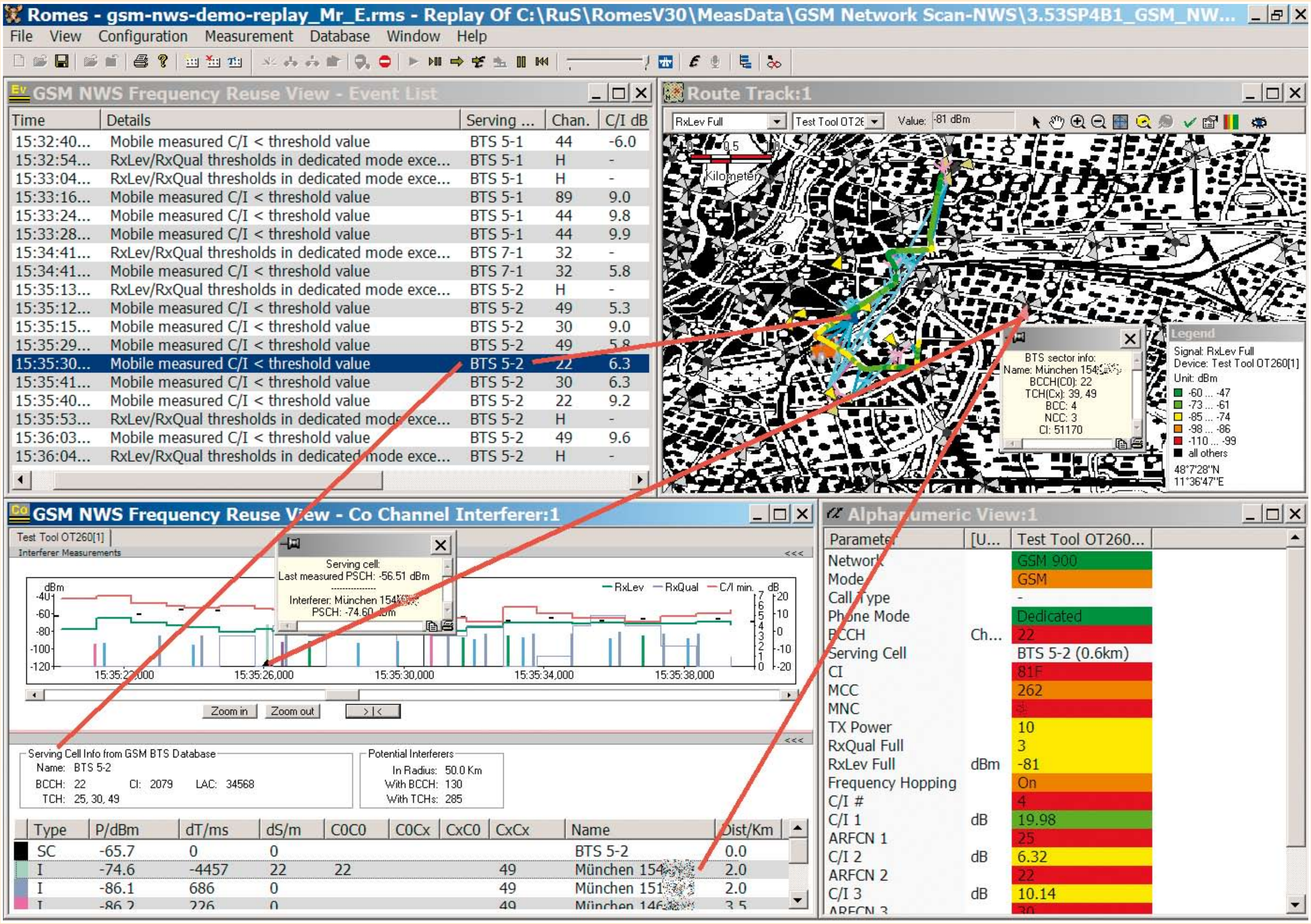


FIG 10 Menu for defining the thresholds and other parameters for interference analysis.

FIG 11 Complete, straightforward and correlated representation of results.



RF Performance Test System R&S®TS 9970

Displaying and evaluating spatial radiation characteristics

The RF Performance Test System R&S®TS 9970 (FIG 1) evaluates the spatial radiation characteristic of mobile phone antennas in accordance with the CTIA standard, for example. Measured data is reduced to a two-dimensional display in the polar diagram. The third dimension can be displayed again by using additional software.

FIG 1 The RF Performance Test System R&S®TS 9970 determines important RF characteristics of wireless communications equipment under realistic operating conditions.

Life is much easier in 3D

Measured values used for evaluating the radiation characteristic of mobile radio antennas, for example, are displayed in tables or in polar diagrams (two-dimensional display). If only a few test points are displayed, experts can easily evaluate the strengths and weaknesses of an EUT. This is quite different if many test points and a complex characteristic are displayed. The R&S®RPS 16-3D extension to the R&S®RPS 16 software makes life much easier; it creates a three-dimensional display fast and easily – a great help in development and certification.

More information and data sheet on the test system at www.rohde-schwarz.com (search term: TS 9970)

REFERENCES

[*] Test Plan for Mobile Station OTA Performance, Revision 2.1; CTIA Certification; April 2005

Use in development

Design engineers would be glad if they could, so to speak, get hold of measured data and analyze it in greater detail. With the new software they can actually do this – in a split second it calculates a three-dimensional representation based on the measured data and displays it (FIG 2). You can interactively rotate the representation or take a closer look at special areas using the zoom function. Data can be colored according to measured values, which makes visual evaluation fast and easy. You can select special test points using a marker and then obtain more detailed information. And you can also display the horizontal and vertical cross section of measured data.

The software makes it fast and easy to evaluate the measured data. For presentation and documentation purposes it also allows you to copy the individual view to the clipboard for further processing, to store it as a graphic or directly send it to a printer without any additional processing steps required.

Reports for certification

In certification, the main focus is on generating clear and conclusive reports which contain the most important criteria. Here, too, this visualization tool is ideal: After loading the measured data, the printout of the most important calculated data and an overview of different views with EUT characteristics can be generated with only two mouse clicks (FIG 3). The currently implemented report function is based on the characteristic values defined in [*]. For further individual requirements regarding report generation, the calculated data and graphics can be exported to programs such as Microsoft Word or Excel.

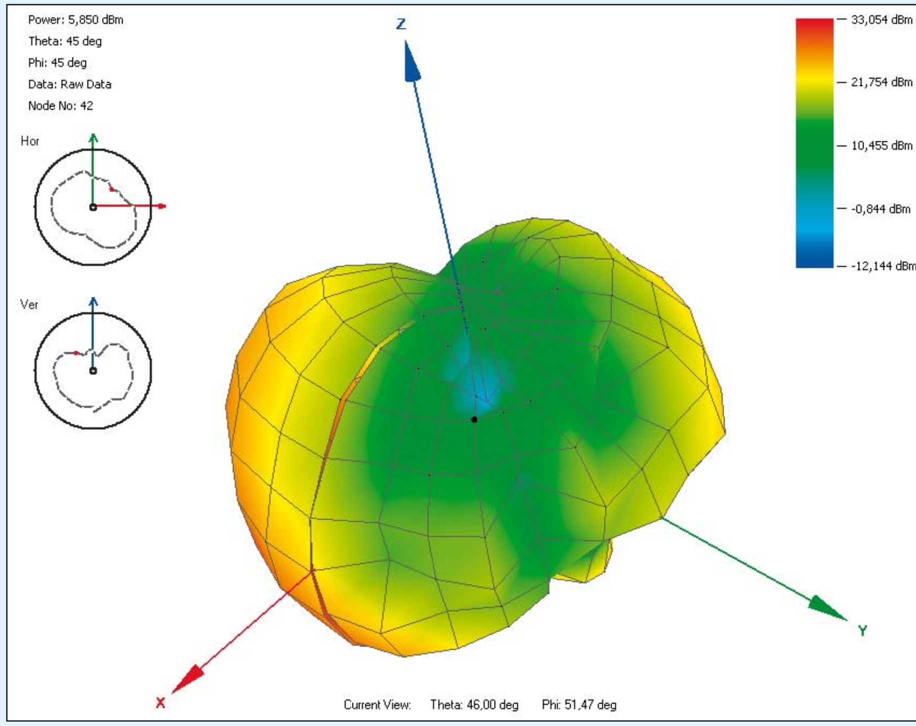


FIG 2 **3D graph with marker and horizontal and vertical cross-sectional information.**

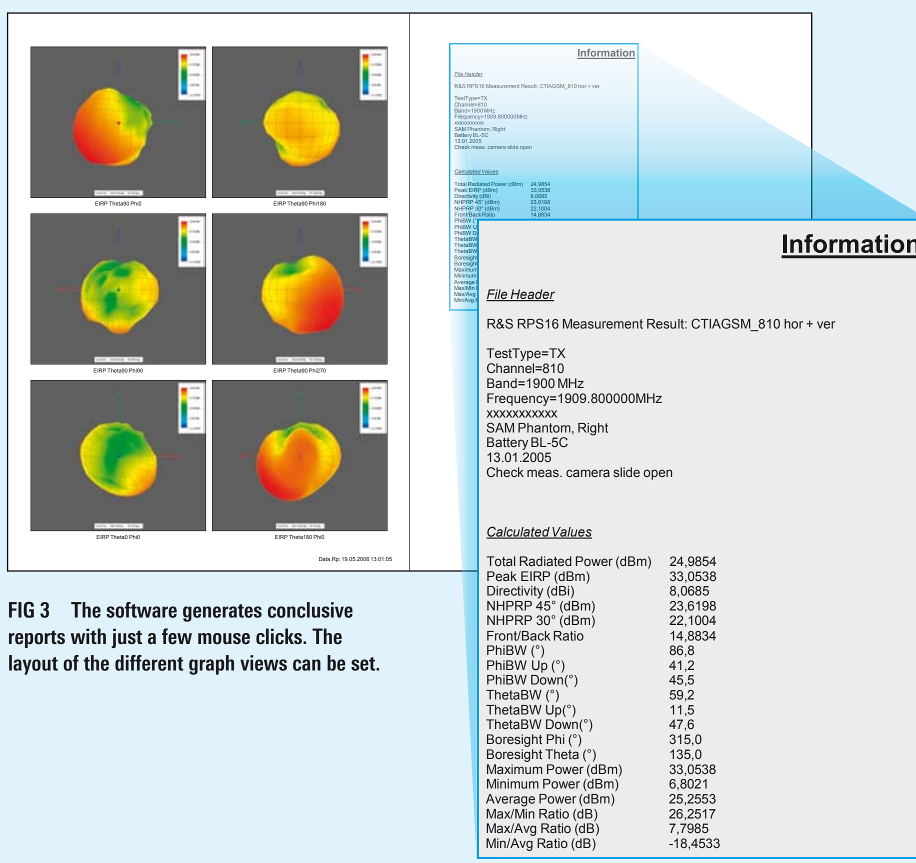


FIG 3 **The software generates conclusive reports with just a few mouse clicks. The layout of the different graph views can be set.**

Convenient operation

The most important values can be entered via a toolbar (FIG 4). Further settings can be made in the menu bar. Different tabs for evaluating data are available depending on the relevant operation. They can be selected via the following tabs:

Raw Data The first tab displays the contents of the loaded file. The contents can be copied to the clipboard or directly printed.

Converted Data The second tab contains the key values in tables, e.g. TRP (Total Radiated Power) / TIS (Total Isotropic Sensitivity), Maximum, Minimum, 3 dB Aperture, etc, as well as data resulting from the horizontal and vertical measurement from which the resulting overall data was calculated and also displayed in a table. You can print this table or copy it for further processing to Excel via the clipboard.

Graph The following three tabs contain the three-dimensional display of measured data – divided into overall data, horizontal and vertical data. Each view can be copied to the clipboard, directly printed or stored as a graphic using the buttons in the toolbar. You can also generate graphics with different fixed views.

Pictures The last tab allows you to look at an overview or preview of the graphics last generated and to store selected graphics or all of them.

Intuitive operation in three dimensions

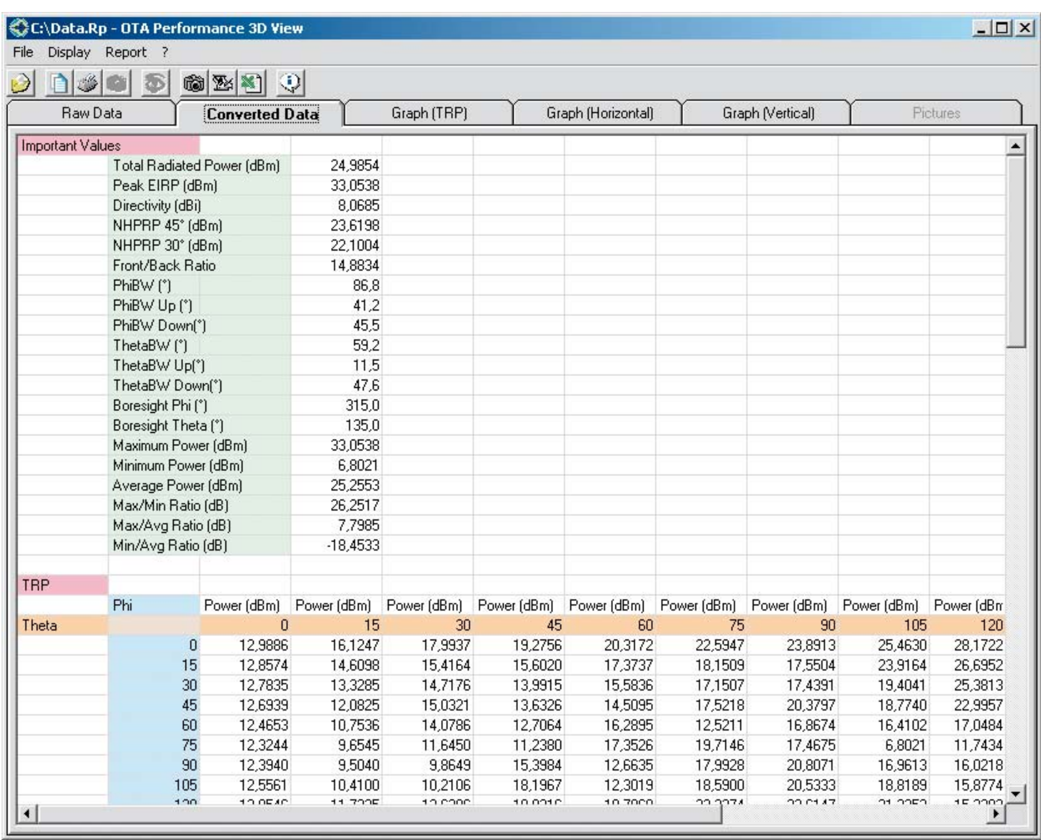
A sophisticated assignment between displayed data and mouse movements as well as an intuitive mouse configuration makes working in the three-dimensional representation convenient and efficient. Various presettings are offered, e.g. for line colors or surface display. But you can also define the colors yourself. A two-stage interpolation allows you to graphically process measurements with a limited number of test points and to set markers between test points.

Summary

The R&S®RPS 16-3D software from Rohde & Schwarz is a postprocessing tool for evaluating radiation characteristics which makes development, certification and report generation convenient and easy. Go and get your third dimension of measured data back!

Andreas Ulm

FIG 4 The graphical user interface of the R&S®RPS 16-3D software.



Important Values		
	Total Radiated Power (dBm)	24,9854
	Peak EIRP (dBm)	33,0538
	Directivity (dBi)	8,0685
	NHPRP 45° (dBm)	23,6198
	NHPRP 30° (dBm)	22,1004
	Front/Back Ratio	14,8834
	PhiBW (°)	86,8
	PhiBW Up (°)	41,2
	PhiBW Down(°)	45,5
	ThetaBW (°)	59,2
	ThetaBW Up(°)	11,5
	ThetaBW Down(°)	47,6
	Boresight Phi (°)	315,0
	Boresight Theta (°)	135,0
	Maximum Power (dBm)	33,0538
	Minimum Power (dBm)	6,8021
	Average Power (dBm)	25,2553
	Max/Min Ratio (dB)	26,2517
	Max/Avg Ratio (dB)	7,7985
	Min/Avg Ratio (dB)	-18,4533

TRP										
	Phi	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm)	Power (dBm
Theta		0	15	30	45	60	75	90	105	120
	0	12,9886	16,1247	17,9937	19,2756	20,3172	22,5947	23,8913	25,4630	28,1722
	15	12,8574	14,6098	15,4164	15,6020	17,3737	18,1509	17,5504	23,9164	26,6952
	30	12,7835	13,3285	14,7176	13,9915	15,5836	17,1507	17,4391	19,4041	25,3813
	45	12,6939	12,0825	15,0321	13,6326	14,5095	17,5218	20,3797	18,7740	22,9957
	60	12,4653	10,7536	14,0786	12,7064	16,2895	12,5211	16,8674	16,4102	17,0484
	75	12,3244	9,6545	11,6450	11,2380	17,3526	19,7146	17,4675	6,8021	11,7434
	90	12,3940	9,5040	9,8649	15,3984	12,6635	17,9928	20,8071	16,9613	16,0218
	105	12,5561	10,4100	10,2106	18,1967	12,3019	18,5900	20,5333	18,8189	15,8774

Protocol Tester R&S®CRTU-W

Validated tests for videotelephony in 3G networks

3G mobile radio standards such as UMTS allow the use of mobile videotelephony to simultaneously transmit audio and video signals. For this purpose, standardization bodies have defined guidelines specifying that video phone calls be made via circuit-switched connections on the basis of the 3G-324M protocol. Whether a mobile phone functions in conformance with these guidelines can now be verified and, if necessary, certified for the first time by performing validated tests with the R&S®CRTU-W protocol tester.

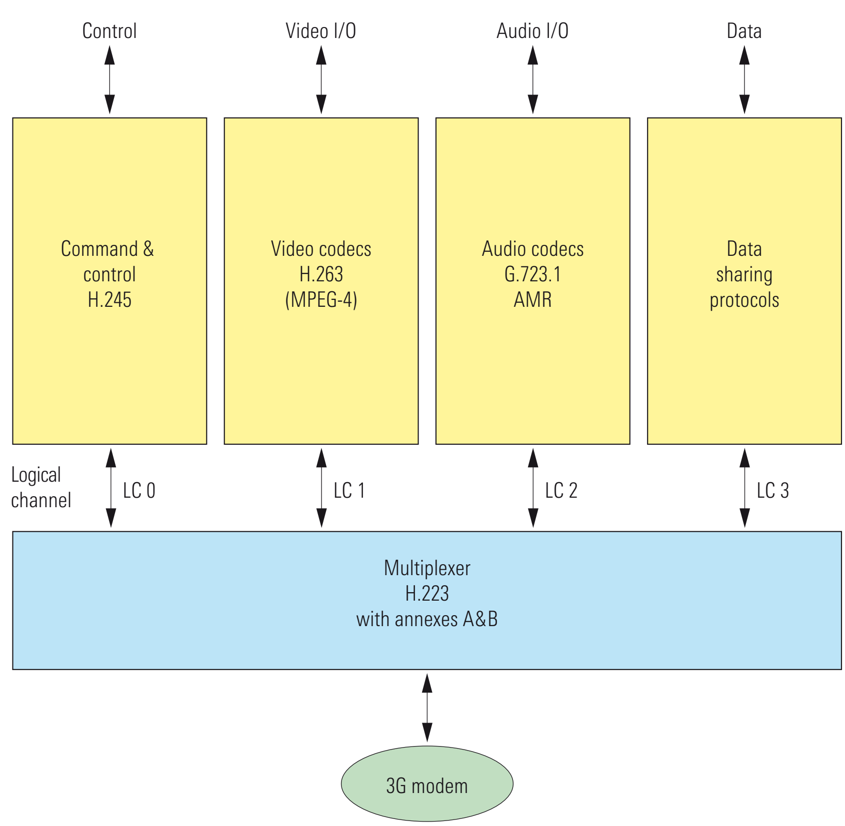
Circuit-switched connections

The standardization bodies' first approach was to base all mobile video applications on the Internet protocol (IP). However, this packet-switched transmission was dropped because latency in transmission is still too high in most current mobile IP networks. Moreover, quality of service (QoS) is insufficient during the entire time of the connection and IP networks require a bandwidth that is several times higher than with circuit-switched connections. Considering these drawbacks, only circuit-switched realtime connections are currently suitable for video applications.

The 3G-324M standard

Based on the H.324 standard, which defines audiovisual communications in public analog telephone networks, the 3G-324M protocol was developed for mobile radio networks, which have a comparatively high susceptibility to transmission errors. The protocol was enhanced by special audio and video codecs for mobile radio. It can thus organize the exchange of audio, video, data and signaling information via separate logical channels on a common transparent 64 kbit/s channel in the transmit and receive direction (FIG 1).

FIG 1 Schematic of a 3G-324M system, derived from the H.324 standard.

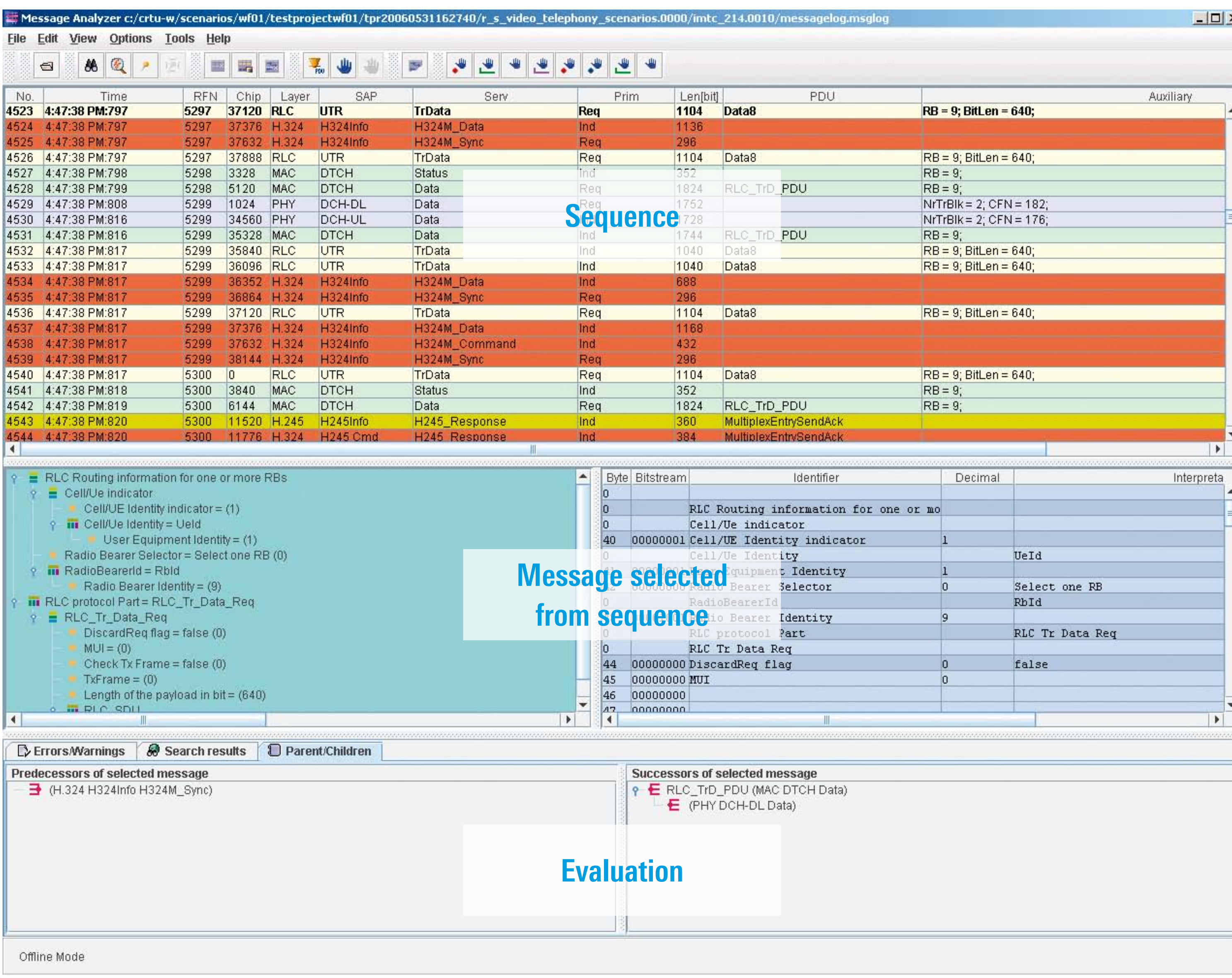


Different logical channels converge in the multiplexers, which play a key role in 3G-324M systems. After a call has been set up between two mobile phones, the multiplexers – in accordance with the 3G-324M protocol – define the start level, which is the highest mobile level supported by both terminals. By selecting the start level, the format and structure of the information to be transmitted is defined. Based on this information, the terminals inform each other about their individual performance features, i.e. about the available audio and video codecs, the multiplexer capacity and the scope of the supported radio options. To avoid potential conflicts during the opening procedures of bidirectional channels, the protocol defines which of the terminals is to act as master and which as slave, and which is to assume control if necessary.

Milliseconds are key to acceptance

The duration of the call setup, the length of the time delay and the synchronization accuracy of voice and pictures significantly contribute to the acceptance and success of videotelephony. Setting up a videotelephony call takes about four seconds, which is twice as long as with pure voice telephony, but is still within the generally accepted limits.

FIG 2 **Complete decoding of an ASN.1 (abstract syntax notation) message of the H.245 protocol.**



Latency and synchronization of audio and video applications strongly influence how subscribers perceive a mobile videotelephony call. End-to-end latency should therefore be no more than 150 ms; however, modern mobile video services exhibit latencies up to 300 ms. A suitably implemented multiplexer provides considerable room for improvement because the entire data flow is handled via the multiplexer, which makes it a main cause of latencies.

For subscribers to experience video conversations as being natural, the picture / sound skew (lip synchronicity) must be 50 ms or less. However, as it takes much longer to process a video signal than a voice signal, the audio data must be adequately delayed in the multiplexer to achieve a satisfying lip synchronicity result.

Indispensable: the test solution from Rohde & Schwarz

The R&S®CRTU-WF01 option for the R&S®CRTU-W protocol tester from Rohde & Schwarz allows the videotelephony functions of WCDMA mobile phones to be verified and certified by using validated test cases. These test cases, which are part of the GCF WI-19 (Global Certification Forum Work Item) document, help to prove whether signaling, i.e. the exchange of command and control information, is carried out in accordance with the specification. By using specification-conforming useful data, a videotelephony sequence on mobile phones can be tested for proper audiovisual quality.

While a test case is running, the protocol tester records the exchanged signaling information in a message log file (FIGs 2 and 3). By activating several filters, the data volume can be processed for possible subsequent analysis from different angles. A sophisticated algorithm facilitates and visualizes the tracking of the messages via the individual protocol layers. In addition to signaling information, audio and video information is recorded in separate files and is available for postprocessing and analysis.

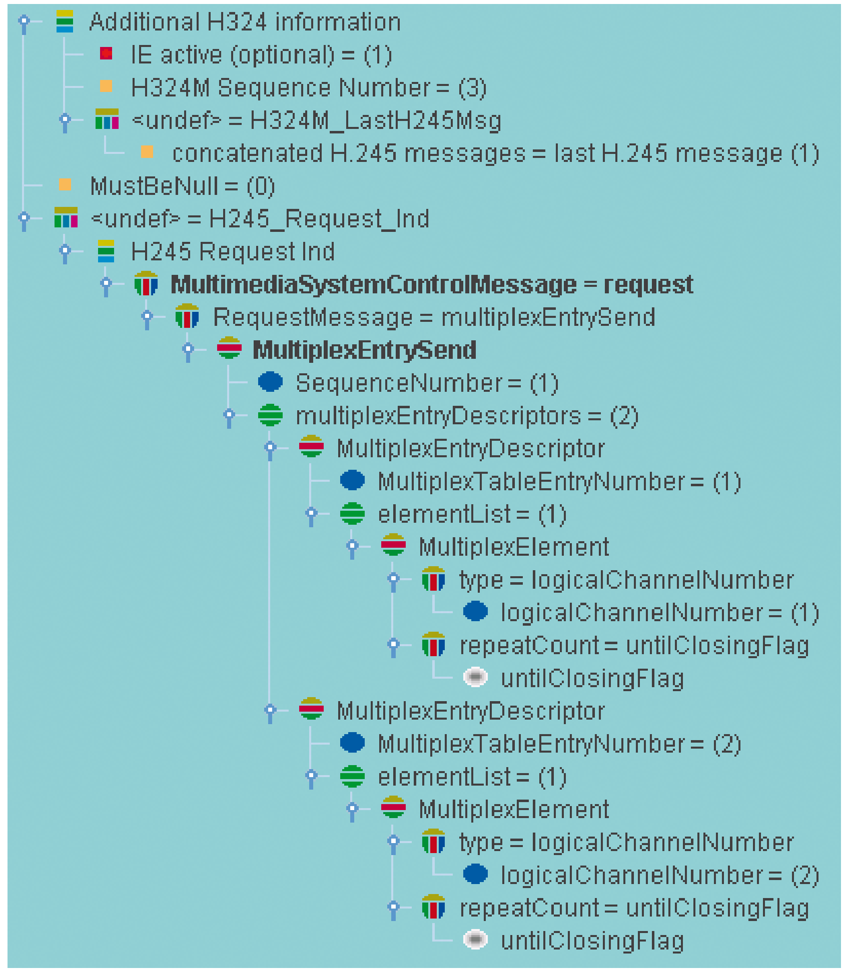


FIG 3 Extract from a message log file.

Future prospects

Limited video services such as multimedia messaging service (MMS) for pictures, video clips and sound are already being exchanged via IP in the mobile radio network. Until IP-based realtime video communications is feasible, manufacturers of mobile phones for videotelephony must rely on the 3G-324M protocol and suitable test methods. The test cases provided by Rohde & Schwarz are indispensable for certification purposes – in addition to being a powerful development tool.

Thomas A. Kneidel

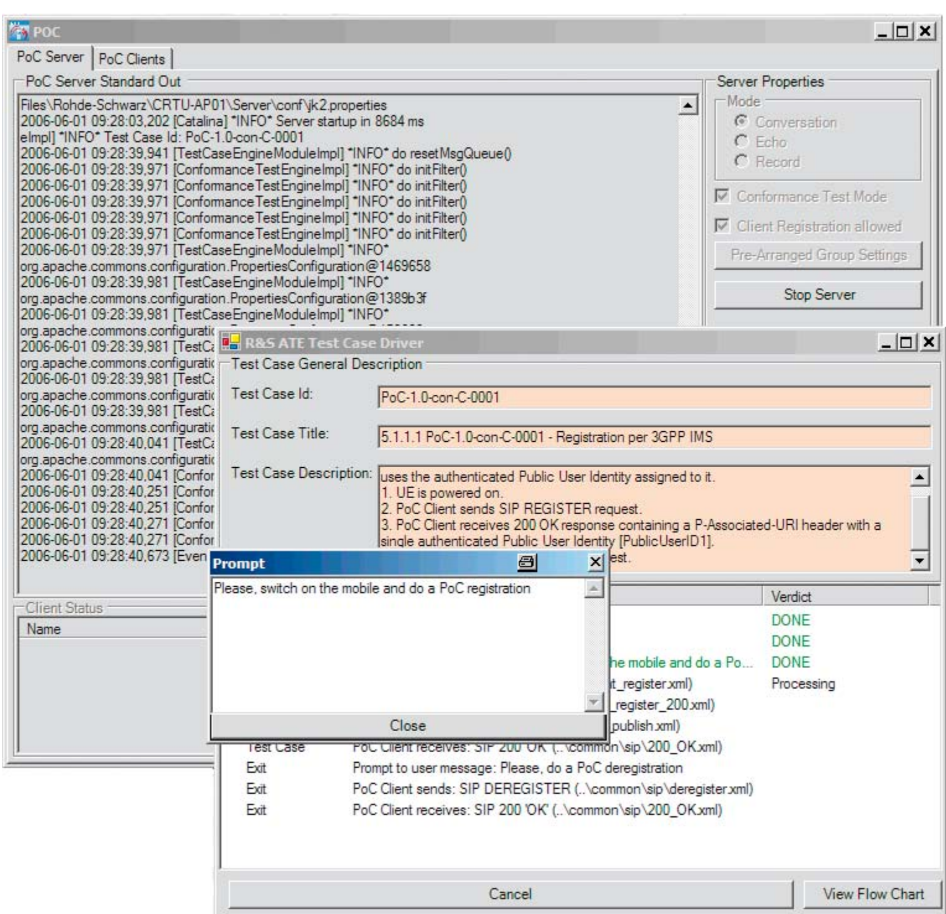
More information and data sheet on the R&S®CRTU at www.rohde-schwarz.com (search term: CRTU)

R&S®CRTU / R&S®CMU 200

Test cases for "Push to talk over Cellular"

The new "Push to talk over Cellular" (PoC) service as an application in mobile phones permits half-duplex communication with several users. It is thus the modern version of a walkie-talkie system. For testing this service, Rohde & Schwarz has added a comprehensive test package to its product portfolio.

FIG 1 ATE desktop: a PoC test case is started.



Mobile phone used as walkie-talkie

Now that the PoC V1.0 standard based on the IP multimedia subsystem (IMS) has been finalized by the Open Mobile Alliance (OMA), cross-provider communication is possible, even across borders. Current limits of other standards, such as those requiring the identical type of mobile phone, are thus a thing of the past. So there is nothing that stands in the way of a thorough penetration of the market. The new service will not be of interest to end users unless enough PoC-capable mobile phones are on the market.

In addition to a pure voice transmission ("1–1" or "1–Many"), the new PoC service offers various ways of influencing the transmission: In the manual answer mode, for example, every voice message is first confirmed before it is played by the PoC client.

Comprehensive protocol tests for PoC

PoC relies largely on tried-and-tested IP-based protocols, such as the Session Initiation Protocol (SIP), Realtime Transport Protocol (RTP), RTP Control Protocol (RTCP) and Session Description Protocol (SDP). For this reason, PoC-specific parameters have been added to these protocols.

These additions and the interaction of the protocols used can be checked with the test cases classified by the Global Certification Forum (GCF). The test cases are first defined by OMA and will then be adopted by GCF.

Using the R&S®CRTU-ATE (Application Test Environment) (FIG 1), Rohde & Schwarz now offers the comprehensive R&S®CA-AC 02 test package for PoC V1.0. It is based on the test cases classified by GCF and also permits you to easily define your own tests.

Similar to MMS [1], a special R&S®CA-AA 02 PoC test server is required for the PoC test cases. The server not only forms the basis for the test cases, but also supports the functional test of PoC-capable mobile phones.

The R&S®CA-AA02 PoC test server offers the following test modes [2]:

- **Conversation** Several PoC clients can communicate with each other
- **Echo** A PoC client gets its own voice messages back
- **Record** The voice messages are saved as a file

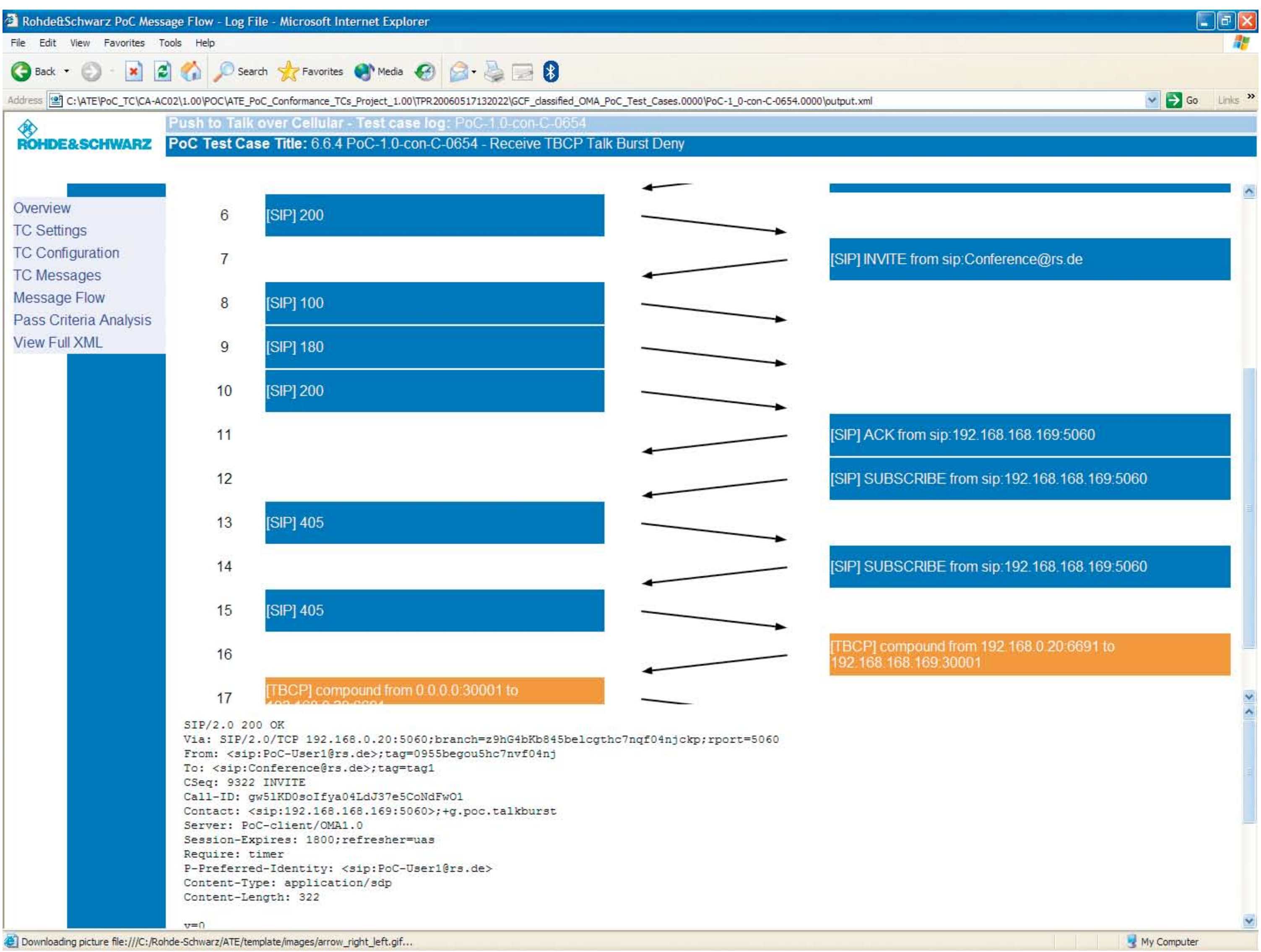
Separating the test cases from the functional elements in the test server has made the various protocols less complex. You can therefore easily compile the desired messages and parameters without having to know the protocol in detail.

As with MMS, the test cases are defined in the eXtensible Markup Language (XML) and can thus be expanded or modified without any complex tools. A simple text or XML editor is sufficient.

The message flow, the parameters to be tested and the response messages can be flexibly defined. The PoC test suite from Rohde&Schwarz is thus not only of interest for conformance tests but – owing to its flexibility – also offers a wide range of applications in development:

- Regression testing
- Stability tests
- Testing the insensitivity to errored messages (robust implementation)
- Testing the behavior of compliant protocol variants

FIG 2 **Analysis following a PoC test – the message flow is displayed here.**



The generated analyses of the tested scenario (message flow, log file) are crucial for protocol tests. The PoC test suite not only offers straightforward error analysis but also a graphically processed message flow between the DUT and the test server. Potential errors in the implementation can thus be determined fast and accurately (FIG 2).

Connection

The R&S®CRTU-ATE runs on any commercial PC with Windows XP or 2000. This PC needs an IP connection to a Universal Radio Communication Tester R&S®CMU 200 or to a Protocol Tester R&S®CRTU-G / -W with the corresponding software (FIG 3). Since PoC is a purely IP-based service, it can be utilized independent of the radio access network (RAN) used. Standards such as WCDMA, GSM / GPRS or CDMA2000® can thus be used as RAN.

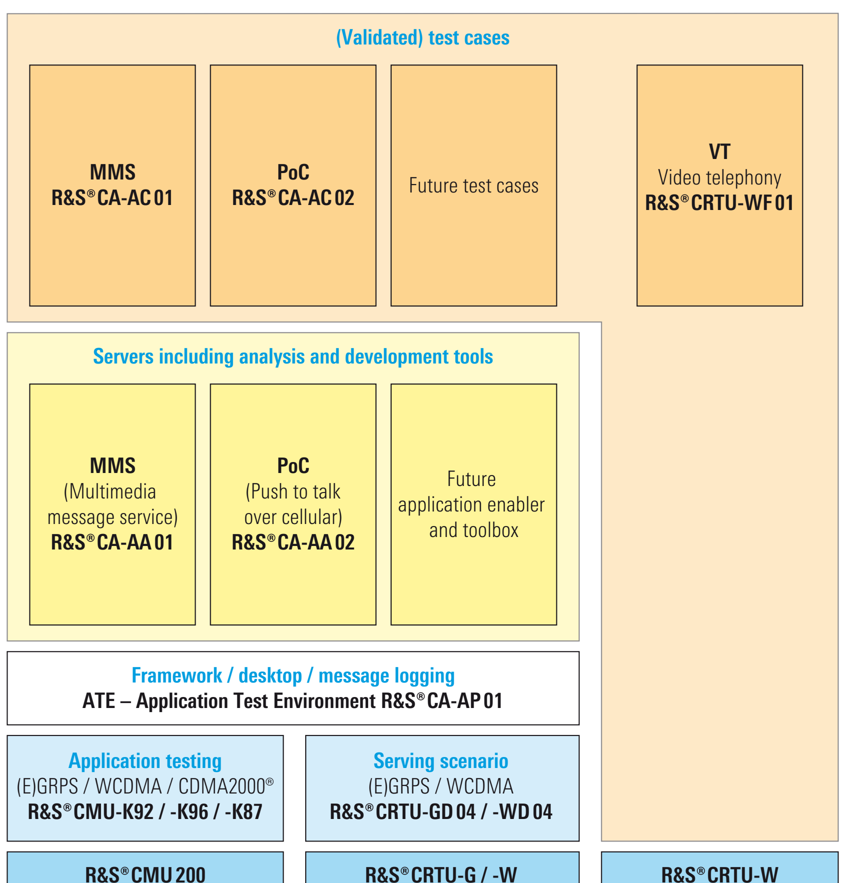
Owing to the flexibility of IP and the PoC test suite from Rohde & Schwarz, you can not only operate the test suite via a system simulator but also connect a DUT – e.g. via a test or live network – for development purposes. The only prerequisite is a direct IP connection between PoC client and test server.

Summary

The integrated PoC test solution from Rohde & Schwarz allows you to easily and conveniently test PoC implementations in compliance with GCF criteria. The available test cases are based on the OMA specifications. The structure of the test cases lets you define your own test cases and scenarios fast and easily. For this reason, the R&S®CA-AA 02 and R&S®CA-AC 02 PoC test suites are not only of interest for conformance tests but also for the development of PoC-capable user equipment.

Stefan Diebenbusch

FIG 3 Test software program for the R&S®CMU 200 and the R&S®CRTU-G / -W.



More information and data sheet on the R&S®CMU 200 and the R&S®CRTU-G/-W at www.rohde-schwarz.com (search term: type designation)

REFERENCES

[1] R&S®CRTU-G / -W: MMS tests on multimedia mobile phones. News from Rohde & Schwarz (2005) No. 185, pp 4–6

[2] R&S®CMU 200 / CRTU-G / -W: Standardized test solutions for PoC mobile phones. News from Rohde & Schwarz (2005) No. 188, pp 14–16

43 836

Spectrum Analyzers R&S®FSP/R&S®FSU

Analyzing HSDPA and HSUPA signals

Using firmware options R&S®FS-K73 / -K74, the Spectrum Analyzers R&S®FSP and R&S®FSU and the Signal Analyzer R&S®FSQ can perform code domain measurements on HSDPA and HSUPA signals for WCDMA FDD transmissions.

High-speed packet access

One of the objectives of the 3G system was to significantly increase data transmission speed as compared with 2G systems. Even the first releases of the 3GPP WCDMA standard provided for a maximum transfer rate of 384 kbit/s – an impressive increase that made it possible for subscribers to download e-mails or make video phone calls. Network providers were able to offer new services such as mobile TV and the capability to download video clips. The new functions met with a positive response, but this also caused the demand for transmission capacities to grow further.

The first release included a limitation that was due to the use of circuit-switched links, which meant that system resources were dedicated to subscribers who might not even need them, thus wasting valuable capacities.

These circumstances and the need to hold ground against competing radio technologies such as Wi-Fi and WiMAX prompted the 3GPP standardization body to further improve the radio standard. The objectives were to boost data throughput and reduce access times.

Enhancement was implemented in two steps, always bearing in mind compatibility with existing networks. The first step – high-speed downlink packet access (HSDPA) – has yielded transfer rates up to 14 Mbit/s. Rohde&Schwarz provided T&M technology for this enhancement at an early stage [*].

High-speed uplink packet access (HSUPA) – the second and latest enhancement of the standard – has increased uplink transfer rates to 5.76 Mbit/s. HSDPA and HSUPA together are referred to as HSPA (high-speed packet access). HSPA transfer rates by far exceed the rate of 2 Mbit/s specified by ITU for 3G systems. HSPA-compatible WCDMA networks are therefore also called 3.5G systems.

HSPA measurements using R&S® FSx analyzers

Rohde&Schwarz has already adapted part of its T&M product portfolio to meet the new requirements of the standard, thus supporting manufacturers of terminal equipment and network components in designing their HSPA solutions.

Rohde&Schwarz has added HSUPA capability to the R&S®FS-K72/-K73/-K74 application firmware packages for its R&S®FSQ, R&S®FSP and R&S®FSU signal and spectrum analyzers. Thus, besides HSDPA functionality, the firmware now also includes extensive functions for transmitter measurements on HSUPA base stations and modules. R&S®FS-K74 is integrated into R&S®FS-K72 and provides modulation test capabilities for HSDPA and HSUPA signals in the downlink. The R&S®FS-K73 option provides HSDPA and HSUPA measurements in the uplink.

Higher-order modulation

A very common method of increasing data throughput is to adapt the modulation to the current propagation conditions. This method is used by several standards such as GSM/EDGE, 1xEV-DO or Wi-Fi.

In accordance with the first WCDMA release, a specific code in the code domain was assigned to each subscriber in the downlink for their payload. This code is referred to as DPCH and is always QPSK-modulated. With HSDPA, each subscriber is also assigned a DPCH for the payload and control information. In addition, each mobile terminal shares one or more high-speed channels (HS-PDSCH) with other subscribers for data reception. Via one or more HS-SCCHs, the base station signals which terminal it will send data to. QPSK or 16QAM modulation is used, depending on the propagation conditions.

The analyzer firmware must be able to identify the modulation type in order to demodulate signals correctly. The R&S®FS-K74 option performs this task automatically (FIG 1).

For HSDPA base station tests, the 3GPP TS 25.141 standard specifies a new measurement for determining modulation quality. Test model 5 contains the signals for this measurement. The signals include control channels, traffic channels and two, four or eight 16QAM HSDPA channels and are used to determine the error vector magnitude (EVM). The new measurement using test model 5 places substantially higher demands on base stations.

Previous releases provided for two measurements for determining modulation quality; these covered the peak code domain error (PCDE) and the EVM. The EVM is measured using one or optionally two active codes. The PCDE measurement is a highly demanding task for developers of transmitters because the test signal has a higher crest factor, which means correspondingly greater stress for the transmitter. The stipulated PCDE of approx. –33 dB corresponds to a composite EVM of 30%.

Requirements for HSDPA are even more stringent, stipulating an EVM of <12.5% as well as the use of a considerably more complex signal. This makes EVM measurements very demanding. Using the R&S®FS-K74 option, these measurements pose no problems. Featuring an internal EVM as low as <1.5%, the option has virtually no effect on measurement results.

HPSK modulation, which may also be understood to be "scrambled dual BPSK", is used in the uplink. HSPA is a multicode transmission method, with the peak value of the signal increasing from approx. 3.5 dB to approx. 6.5 dB relative to the average value. This means greater stress for the modulator and the power amplifier in the terminal. New test procedures defining the signal structure are currently under development. An EVM of 12.5% is allowed; however, a signal with a higher crest factor must be used for measuring the EVM. The R&S®FS-K73 option supports multicode EVM measurements (FIG 2).

Abbreviations

BPSK	Binary phase shift keying
CPICH	Common pilot channel
DPCH	Dedicated physical channel
E-DPDCH	Enhanced dedicated physical data channel
HPSK	Hybrid phase shift keying
HS-PDSCH	High-speed physical downlink shared channel
HS-SCCH	High-speed shared control channel
PCDE	Peak code domain error
P-CCPCH	Primary common control physical channel
PICH	Pilot channel
QPSK	Quadrature phase-shift keying
S-CCPCH	Secondary common control physical channel

Full demodulation down to bit level

To be able to adapt modulation and coding appropriately, the base station and the mobile terminal continuously monitor propagation conditions and signal current conditions to each other. Moreover, they exchange information as to whether demodulation was successful or transmission has to be repeated.

The analysis firmware demodulates signals down to bit level (FIG 3). In conjunction with the R&S®FSQ's large memory capable of saving up to 100 frames, the firmware is an excellent tool for analyzing the signaling procedures described above.

Johan Nilsson

FIG 1 Shown in red: 16QAM modulation automatically detected by the software.

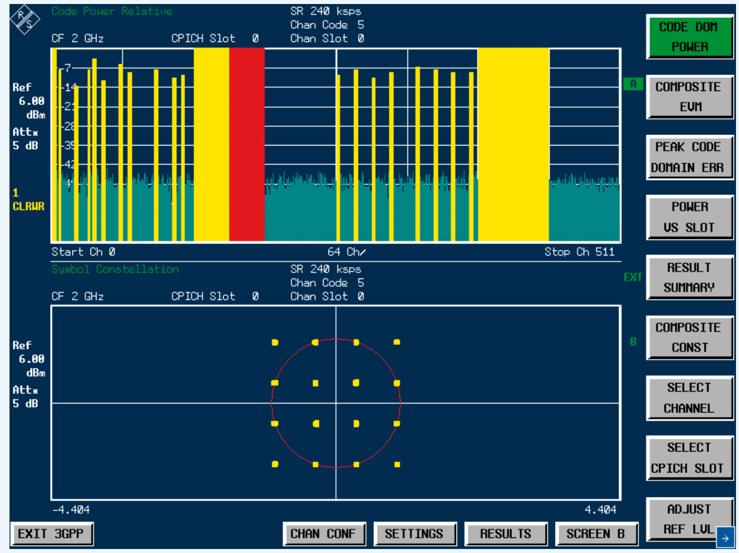


FIG 2 The upper half of the screen shows the code domain in the Q component of the signal. The signal contains various codes; the code marked red represents an E-DPDCH with 1920 kbit/s.

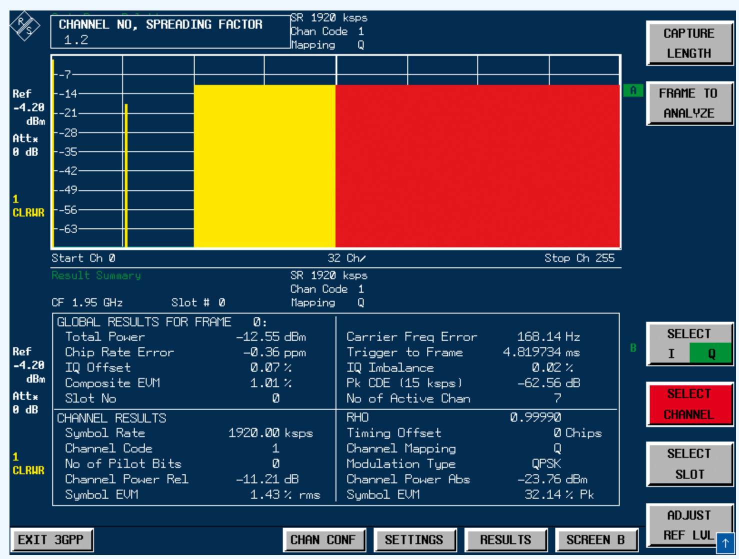
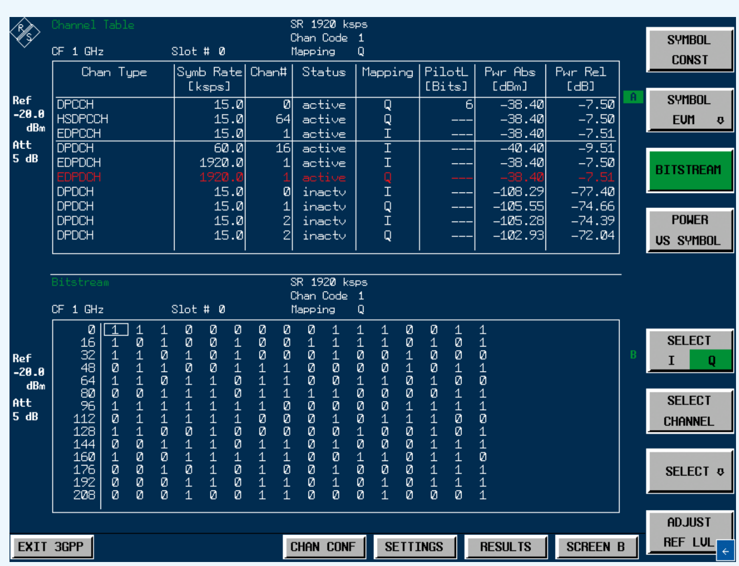


FIG 3 Demodulation down to bit level.



More information, data sheet and brochure at www.rohde-schwarz.com (search term: FS-K73 / -K74)

REFERENCES

[*] Analyzers R&S®FSP/FSU/FSQ: Test of HSDPA base stations. News from Rohde&Schwarz (2004) No. 181, pp 16–17

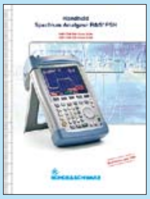
Handheld Spectrum Analyzer R&S®FSH3

Code domain power measurement on 3GPP base stations

For more than three years, the Handheld Spectrum Analyzer R&S®FSH3 has been used to perform a variety of T&M tasks that are instrumental in installing and maintaining mobile radio base stations. The new R&S®FSH-K4 software option now also provides code domain power analysis for 3G base stations, including EVM and scrambling code determination.

FIG 1 The versatile measurement functions of the R&S®FSH3 offer a broad scope of applications, including the installation and maintenance of a mobile radio base station, on-site analyses of faults in RF cables and applications in development and service.

More information and data sheet at www.rohde-schwarz.com (search term: FSH3)



Measuring the code domain power in the field

So far, only high-end spectrum analyzers have been able to analyze the code domain power of 3G base stations. However, due to their size and weight, they are suitable for field applications only to a limited extent. The R&S®FSH3 (FIG 1), however, was specially designed for on-site operation: This compact, lightweight tool can even be operated without AC supply.

To perform code domain analysis, the R&S®FSH3 has now been enhanced by an additional memory for I/Q data. The analyzer can thus record a signal section with a length of approx. 1.2 ms, which is sufficient to detect the code channels required for code domain analysis and determine their power as well as other characteristics.

In addition to the overall power of the 3G signal, the R&S®FSH3 also outputs the power values of the following code channels:

- Common pilot channel (CPICH)
- Primary common control physical channel (P-CCPCH)
- Primary synchronization channel (P-SCH)
- Secondary synchronization channel (S-SCH)

But analyzing the signal quality is even more beneficial: If required, the analyzer additionally determines the error vector magnitude (EVM) of the CPICH and the P-CCPCH. The signal-to-noise ratio also considerably affects signal quality. In a WCDMA system, the E_c/I_0 value, i.e. the ratio of the chip energy (E_c) to the power density of the interference signal (I_0), is decisive. Naturally, the R&S®FSH3 also supports this measurement (FIG 2). Last but not least, the carrier frequency error is measured and displayed. By directly feeding the base station reference frequency into the R&S®FSH3, measurement accuracy can be enhanced.

FIG 2
The R&S®FSH3 displays all results in clear, concise tables.

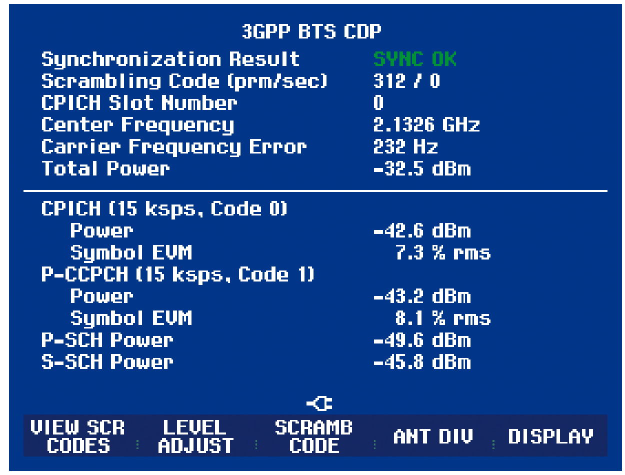
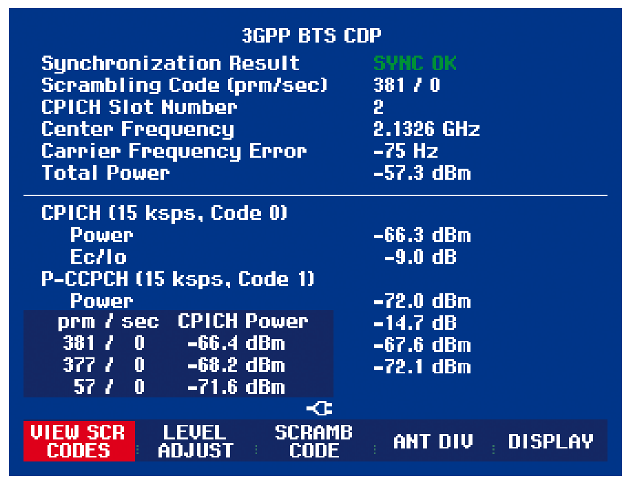


FIG 3
Display of all detected scrambling codes with their CPICH power.



Indispensable: Level Adjust and scrambling code search

What's the base station's transmit power? Which scrambling code has been used for the code channels? These are key questions posed prior to starting measurements on a base station, and the R&S®FSH3 automatically gives the answers. Simply press the Level Adjust function button, and the analyzer will search for the optimum level setting for the applied power. Another press of a button, and the R&S®FSH3 determines the scrambling code of the base station and automatically uses it for decoding the code channels. You can also get a quick overview of adjacent base stations. If required, up to eight scrambling codes and their CPICH power are displayed in a list. The list is automatically sorted according to the magnitude of the power values (FIG 3).

In practice, only four operating steps are required to display the measured code domain values:

- Select the 3GPP CDP function
- Enter the center frequency
- Use "Level Adjust" to optimize the level setting
- Start the scrambling code search

For base stations with two antennas, you can additionally select the antenna the R&S®FSH3 should synchronize to (antenna diversity).

Summary

Installing and maintaining a base station without the aid of the R&S®FSH3 is almost inconceivable. Equipped with a vector transmission and reflection measurement option (R&S®FSH-K2), a distance-to-fault option (R&S®FSH-B2) and the new code domain power analysis option (R&S®FSH-K4), the R&S®FSH3 provides in a compact and lightweight box all the features that make an engineer's heart swell.

Rainer Wagner

Signal Generators R&S®SMx / Analyzers R&S®FSQ / FSL

WiMAX goes mobile – new T&M solutions are required

Now that the IEEE 802.16e-2005 standard has been adopted, WiMAX radio technology will also support mobile applications. This will place additional demands on the required T&M equipment.

The new IEEE 802.16e-2005 standard ensures mobility

Worldwide interoperability for microwave access (WiMAX) was originally introduced to replace broadband cable networks such as DSL. Now that the IEEE 802.16e-2005 standard has been adopted, WiMAX will also support mobile applications. This was made possible by extensions in the MAC layer, which handles communications setup and data processing. There have also been significant improvements in the physical layer of the standard.

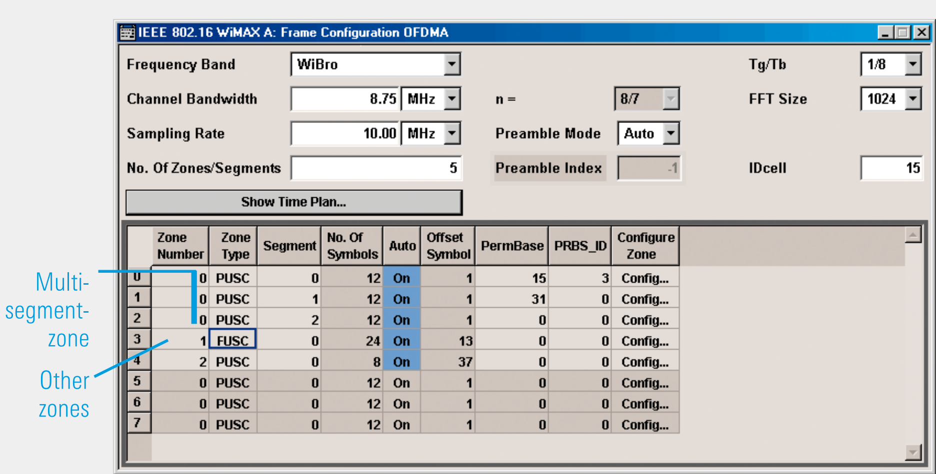
Stationary applications primarily employ the OFDM [1] multicarrier method, which serves all subscribers one after the other. This means that all carriers are each assigned to one and only one subscriber and that they each have the same modulation type and power value per timeslot.

For mobile applications, the expanded OFDMA method is used. It can handle different subscribers simultaneously. Several physical carriers are combined into subchannels, and each subscriber is assigned a specific number of subchannels, depending on the bandwidth required. Downlink (DL) and uplink (UL) maps show which channels are allocated and when and to whom they are allocated. The physical carriers are allocated to the subchannels via permutation algorithms (DL-PUSC, DL-FUSC, UL-PUSC, etc), which change over time and thus define various zones.

In comparison to OFDM, ODFMA also allows a variable number of carriers (128, 512, 1024 or 2048), which makes it possible to optimally adapt modulation to transmission requirements with different bandwidths.

These extensive enhancements of the physical layer place new demands on T&M equipment. Signal generation equipment is responsible for coding the data and modulation for the different subscribers in accordance with the standard, for distributing the data and modulation to the corresponding carriers and for creating the maps. In signal analysis, the carriers must then be reallocated to the different subscribers on the basis of these maps and demodulated, and the results must be clearly displayed for the operator.

FIG 1 By means of the zone table, it is possible to configure various zones within a frame as well as several segments in a zone.



	Zone Number	Zone Type	Segment	No. Of Symbols	Auto	Offset Symbol	PermBase	PRBS_ID	Configure Zone
0	0	PUSC	0	12	On	1	15	3	Config...
1	0	PUSC	1	12	On	1	31	0	Config...
2	0	PUSC	2	12	On	1	0	0	Config...
3	1	FUSC	0	24	On	13	0	0	Config...
4	2	PUSC	0	8	On	37	0	0	Config...
5	0	PUSC	0	12	On	1	0	0	Config...
6	0	PUSC	0	12	On	1	0	0	Config...
7	0	PUSC	0	12	On	1	0	0	Config...

WiMAX signals with the R&S®SMx vector signal generators

The new R&S®SMx-K49 option, which is available for the R&S®SMU200A, SMJ100A and SMATE200A signal generators as well as with R&S®WinIQSIM2 software for the I/Q Modulation Generator R&S®AFQ100A, delivers OFDM signals in accordance with the IEEE802.16-2004 standard and OFDMA signals in accordance with the IEEE802.16e-2005 standard. The latest firmware version 2.02 includes a multicarrier system that allows the generation of WiMAX multicarrier scenarios even when the generator is equipped with only a single baseband path and RF path. For this purpose, you select the desired scenario in the WiMAX main menu of the generator; this scenario is saved as a waveform by simply pressing a button and is then available to the multicarrier system as input signal. The multicarrier system calculates a total signal with the set frequency offset of the individual signals.

In the Frame Configuration menu you can determine the zones within a frame as well as the segments within a zone. In the example shown in FIG 1, the first PUSC zone is occupied by three segments. It is followed by a FUSC zone as well as another PUSC zone. FIG 2 graphically displays the assignment of the bursts, i.e. the zone allocated to a subscriber in the DL map, as a time characteristic within the zones. The R&S®SMU200A generates this graphic at the press of a button and illustrates the currently set signal configuration in realtime.

In the configuration menu for bursts, you can set up to 64 differently configured bursts per zone (FIG 3). For each burst, the QPSK, 16QAM and 64QAM modulation modes as well as the complete channel coding with standard convolution codes or turbo codes are available. The automatically generated FCH, DL-MAP and UL-MAP bursts send all the necessary details about the signal setup to the receiver, thus allowing quick and easy receiver tests.

The new R&S®SMx-K49 option also offers transmit diversity (space-time coding, STC) for two antennas. Equipped with this option, an R&S®SMU200A with two baseband paths and two RF paths can generate both STC transmit signals simultaneously. This feature will make it possible to test MIMO applications.

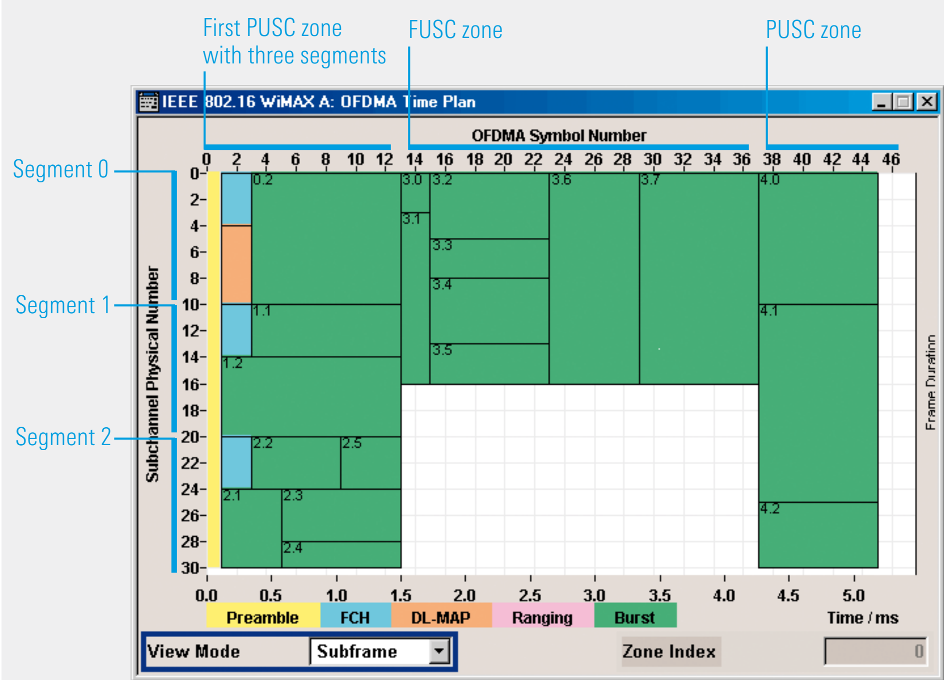
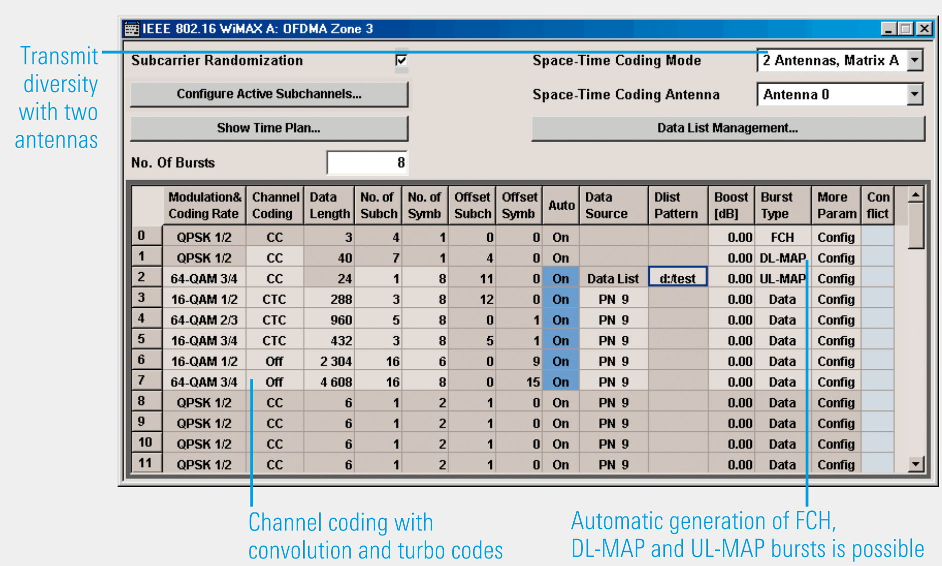


FIG 2 Graphical display of the bursts (green) within the zones.

FIG 3 Configuration menu for the bursts within a zone.



Signal analysis with the R&S®FSQ

The new R&S®FSQ-K93 option is an enhancement of the R&S®FSQ-K92 option for the Signal Analyzer R&S®FSQ. Equipped with this option, the R&S®FSQ can be used for measurements on OFDMA signals in accordance with the IEEE802.16-2004 and 802.16e-2005 standards. You can perform measurements on WiMAX OFDMA signals directly on the analyzer without requiring an external PC.

Before you can analyze signals of base stations, for example, you have to exactly define the DL map. For this purpose, the new option provides a convenient editor that allows you to determine the number of subscribers and modulation modes, the number of active subchannels, as well as the number and type of permutation zones (FIG 4). This map can also be read in directly by the R&S®FSQ if it is connected to an R&S®SMU200A; otherwise you can use the setting files of the generator. In future, the R&S®FSQ-K93 option will be able to detect DL maps automatically and thus allow automatic demodulation.

If you have set the other parameters such as frequency, guard interval, recording time, etc, the measurement can be started. As already known from the R&S®FSQ-K92 option, channel estimation in signal analysis can be performed during the preamble or during the entire data transmission. You can also adapt the tracking parameters to the measurement tasks. After the measurement is started, the measured burst is displayed on the screen (FIG 5). A green bar at the bottom edge of the screen shows that the pulse has been detected and demodulated.

Now you can query all data that is necessary for analyzing WiMAX OFDMA signals. A list shows all important parameters such as EVM, I/Q error, frequency error and symbol time error at a glance (FIG 6). Especially in OFDMA applications, it is important that the individual parameters are also available for each subscriber. For each subscriber, EVM and power are therefore individually listed in a submenu. In addition,

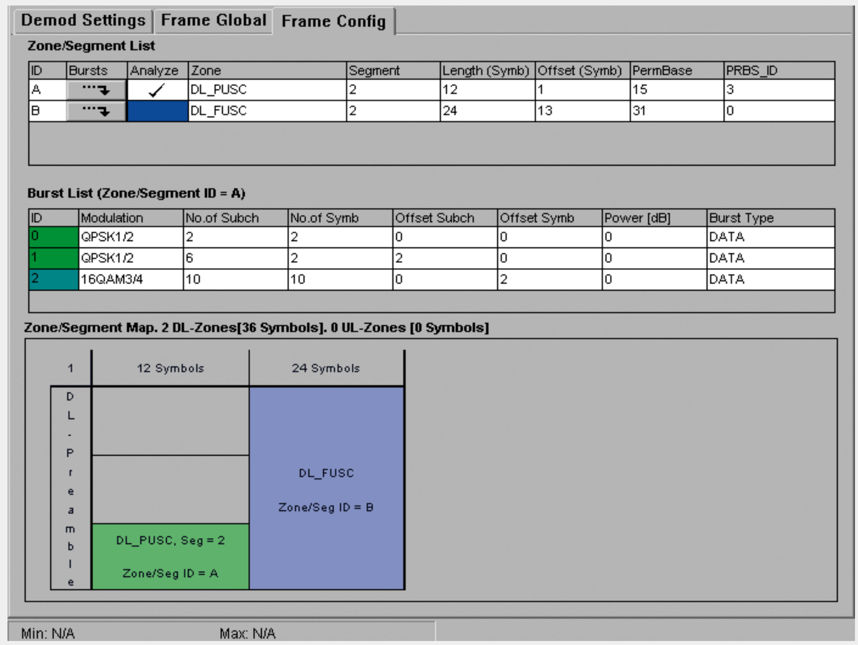
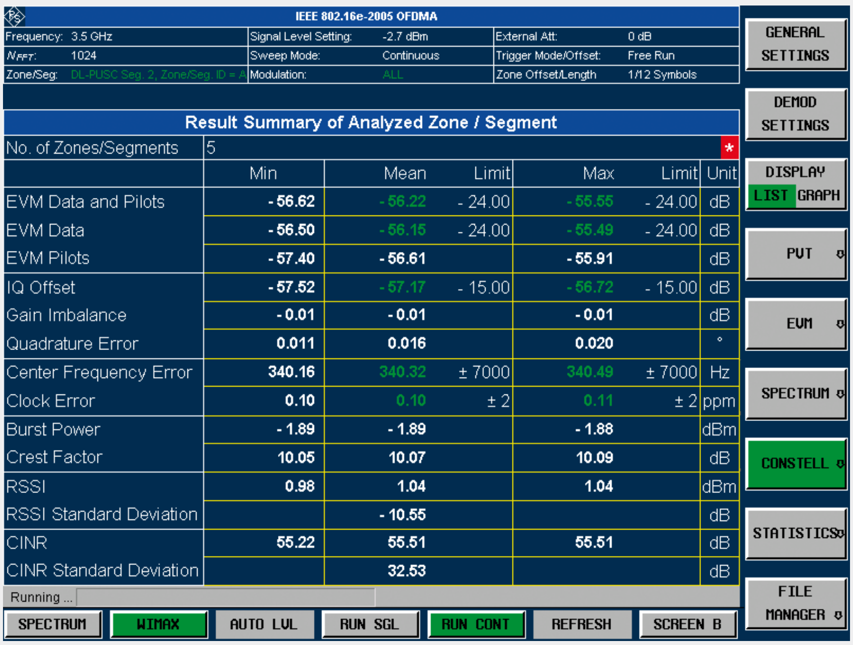


FIG 4 Definition of the DL map. The WiMAX signal consists of a PUSC zone, which is analyzed (see check mark in first table), and a FUSC zone. The second table shows the burst configuration; it can also be displayed graphically.

FIG 5 The upper part of the screen shows the recorded signal (power versus time). The lower part of the screen shows the constellation diagram. Since different bursts exhibit different modulation modes 64QAM, 16QAM and QPSK are displayed.

the demodulated raw data – i.e. the bit stream – can be read out. Besides this numeric data, the R&S®FSQ-K93 option can also generate graphics such as spectrum flatness, constellation diagram, EVM versus carriers (FIG 7) or versus symbols, which is helpful when developing WiMAX applications.


IEEE 802.16e-2005 OFDMA

Frequency: 3.5 GHz	Signal Level Setting: -2.7 dBm	External Att: 0 dB				
N_{FFT}: 1024	Sweep Mode: Continuous	Trigger Mode/Offset: Free Run				
Zone/Seg: DL-PUSC Seg. 2, Zone/Seg. ID = A	Modulation: ALL	Zone Offset/Length 1/12 Symbols				

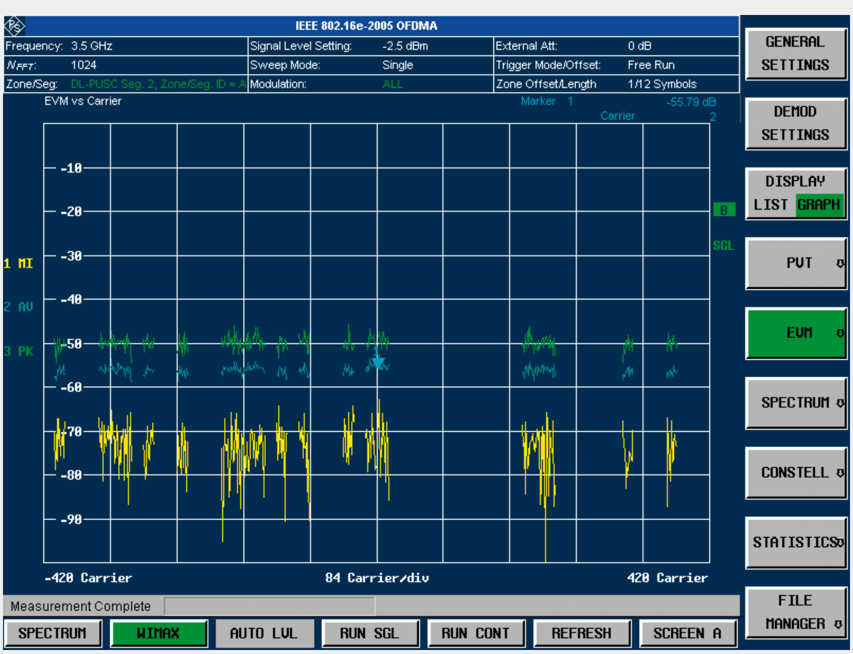
Result Summary of Analyzed Zone / Segment

No. of Zones/Segments 5

	Min	Mean	Limit	Max	Limit	Unit
EVM Data and Pilots	-56.62	-56.22	-24.00	-55.55	-24.00	dB
EVM Data	-56.50	-56.15	-24.00	-55.49	-24.00	dB
EVM Pilots	-57.40	-56.61		-55.91		dB
IQ Offset	-57.52	-57.17	-15.00	-56.72	-15.00	dB
Gain Imbalance	-0.01	-0.01		-0.01		dB
Quadrature Error	0.011	0.016		0.020		°
Center Frequency Error	340.16	340.32	± 7000	340.49	± 7000	Hz
Clock Error	0.10	0.10	± 2	0.11	± 2	ppm
Burst Power	-1.89	-1.89		-1.88		dBm
Crest Factor	10.05	10.07		10.09		dB
RSSI	0.98	1.04		1.04		dBm
RSSI Standard Deviation		-10.55				dB
CINR	55.22	55.51		55.51		dB
CINR Standard Deviation		32.53				dB

FIG 6 List of all relevant parameters, averaged over all bursts, that were detected within the recording period.

FIG 7 Display of the EVM values versus the physical carriers, here N_{FFT} of 1024. The gaps in the traces indicate that not all carriers are used (PUSC zone).



Summary – an all-in-one measurement solution

The combination of the Signal Generator R&S®SMx and the Signal Analyzer R&S®FSQ offers an all-in-one measurement solution for the physical characteristics of stationary and mobile WiMAX applications. The two instruments also provide the basis for special WiMAX system solutions from Rohde & Schwarz, such as radio conformance test systems. Due to its demodulation bandwidth, which is unique in this price class, the Spectrum Analyzer R&S®FSL can also be used to analyze WiMAX signals and thus provides a cost-efficient solution for production applications. Although the R&S®FSL does not feature the outstanding RF characteristics of the R&S®FSQ – its sensitivity is not quite as high, e.g. its EVM values are 10 dB less – it is still absolutely sufficient for production purposes.

Gernot Bauer; Dr Wolfgang Wendler

Abbreviations

EVM	Error vector magnitude
FCH	Frame control header
FUSC	Fully utilized subchannel allocation
MAC	Medium access control
MIMO	Multiple input multiple output
OFDM	Orthogonal frequency division multiplexing
OFDMA	Orthogonal frequency division multiple access
PUSC	Partially utilized subchannel allocation
QAM	Quadrature amplitude modulation
QPSK	Quadrature phase shift keying

More information and data sheets at www.rohde-schwarz.com (search term: type designation)

REFERENCE

[1] Signal Generator R&S®SMU200A / Signal Analyzer R&S®FSQ: Complete test solution for WiMAX applications. News from Rohde & Schwarz (2005) No. 187, pp 33–37

Spectrum Analyzer R&S®FSL

Analyzing TV signals in cable networks

A new application software option adds measurements on analog and digital TV signals in cable networks to the application range of the Spectrum Analyzer R&S®FSL. Using this option, service technicians can perform complete measurements by pressing a single button; it also offers various setting capabilities for laboratory use.

Measurements on analog and digital TV signals

Equipped with the new Cable TV Measurements R&S®FSL-K20 option, the R&S®FSL (FIGs 1 and 2) combines the advantages of a full-featured spectrum analyzer with those of a TV analyzer. It is extremely versatile – regardless of whether you use it for regular maintenance of cable networks, development of TV components or servicing. In the lab, flexible setting capabilities are important whereas during work in the cable duct, performing the necessary measurements quickly and easily, ideally at the press of a button, is what counts.

The special thing about measurements in cable networks is that usually you have to repeat the same measurements in many channels – also on different measurement points such as amplifiers or building entrance facilities. For any measurement, the R&S®FSL-K20 option offers the appropriate presettings that are based on a channel table. The typical procedure when performing a measurement on a cable, for example, is to select the channel table, set the channel number, and you're done! It doesn't matter whether you have a mix of analog and digital channels – the R&S®FSL-K20 option masters all typical measurements in all important TV standards, including CSO and CTB for analog requirements as well as MER, constellation and APD for digital requirements (FIGs 3 to 7). Most measurements can even be performed in the In-Service mode, i.e. without individual channels being switched off by the network operator. Users in the lab can of course manually adapt the instrument default settings to meet their specific measurement requirements.

Predefined or user-generated channel tables minimize the operating steps for measurements in cable networks to a minimum by providing typical channel spacings. Once tables have been set up, they can be copied and distributed to all field technicians. By means of convenient dialogs, you can easily adapt the supplied channel tables to the local transmitter assignment.

The R&S®FSL is an indispensable tool: powerful, versatile and easy to handle.

Thomas Reichert; Jochen Pliquett

FIG 1 The Spectrum Analyzer R&S®FSL: compact, easy to carry …

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More information and data sheet at www.rohde-schwarz.com (search term: FSL)

44277/14

FIG 2 … and well protected for use in the field.

	In-Service mode	Off-Service mode
Analog TV		
Spectrum	✓	✓
Carriers: level and frequencies of vision and sound carriers	✓	
Carrier to noise ratio (C/N)	✓	✓
Composite second (order) beat (CSO)	✓	✓
Composite triple beat (CTB)		✓
Video scope	✓	
Vision modulation	✓	
Hum	✓	
Digital TV		
Spectrum	✓	✓
Modulation errors: EVM, MER, phase jitter, carrier frequency offset, symbol rate offset, carrier suppression, quadrature offset, amplitude imbalance	✓	
Constellation	✓	
Echo pattern: channel impulse response	✓	
Channel power	✓	✓
Amplitude probability distribution (APD)	✓	✓
Cumulative complementary distribution function (CCDF)	✓	✓
TV analyzer		
Tilt	✓	✓

FIG 3 The Cable TV Measurements R&S®FSL-K20 option handles all typical measurements on analog and digital TV signals.

FIG 4 Vision modulation measurement of an analog TV signal.

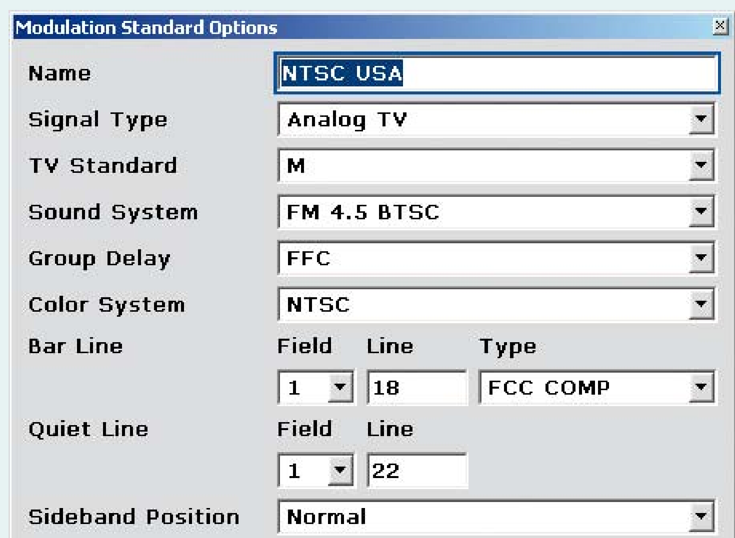


FIG 5 Setting menu for analog TV signals.

FIG 6 Result table with modulation errors of a digital TV signal.

Pass	Limit <	Result	< Limit	Unit
MER (rms)	24.0	40.6	-----	dB
MER (peak)	10.0	29.5	-----	dB
EVM (rms)	-----	0.61	4.40	%
EVM (peak)	-----	2.20	22.00	%
Carrier Freq Offset	-30000.0	-27.5	30000.0	Hz
Symbol Rate Offset	-10000.0	-0.3	10000.0	Symb/s

FIG 7 The R&S®FSL-K20 option supports all important TV standards.

Analog TV	Digital TV
B / G, D / K, I, K1, L, M, N	QAM J.83/A (DVB-C Europe) QAM J.83/B (US Cable) QAM J.83/C (Japanese Cable)
PAL, NTSC, SECAM	16QAM to 1024QAM Symbol rates 0.1 to 7.15 Msymbol/s

Signal Source Analyzer R&S®FSUP

Phase noise tester and spectrum analyzer up to 50 GHz

The new Signal Source Analyzer R&S®FSUP (FIG 1) is unique. A combination of phase noise tester and high-end spectrum analyzer, the R&S®FSUP offers all functions required for completely characterizing oscillators. It is thus the ideal all-in-one instrument for developing high-end transmit and receive modules.

Measurements at a keystroke

In simple commercial applications, phase noise can usually be measured by a spectrum analyzer such as the R&S®FSP with the R&S®FS-K40 application firmware for phase noise measurements [1]. However, if more accuracy and flexibility are called for, for example when analyzing DRO, SAW or YIG oscillators, measurements with the phase-locked loop (PLL) or phase comparator method are preferable (see box).

The phase comparator method usually requires complex test setups. Moreover, the effort involved in calibrating the tester is considerably higher than with spectrum analyzer measurements. But this does not apply to the R&S®FSUP – it performs phase comparator measurements at a keystroke. Plus, it is a very flexible tool that allows you to easily adapt the test setup to specific requirements. Both external and internal reference sources can be used. You can decide which source is to be used to adjust the 90° phase offset on the comparator.

Moreover, you can conveniently configure the measurement parameters bandwidth, filter type and number of averages as well as the offset frequency

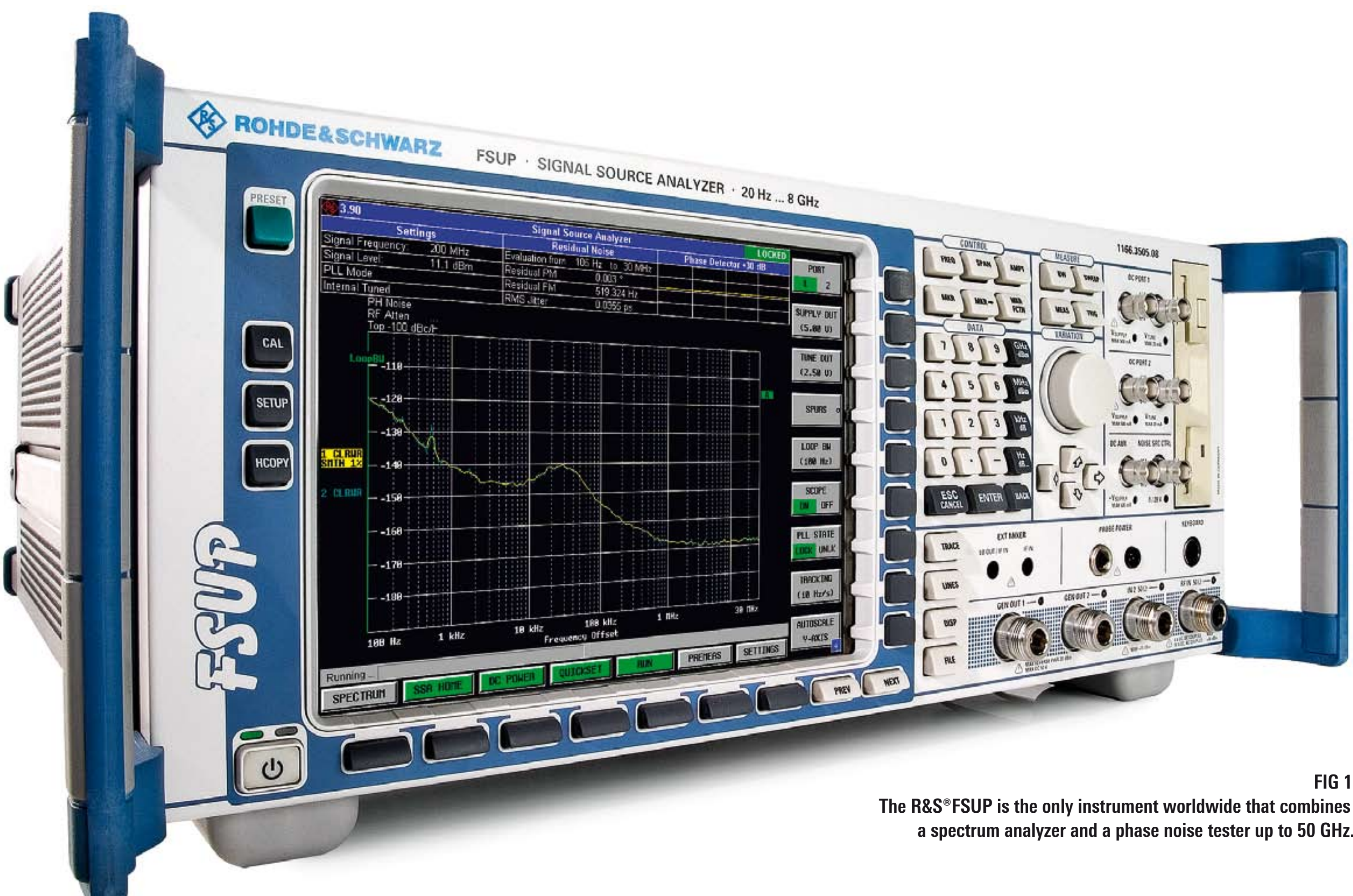


FIG 1
The R&S®FSUP is the only instrument worldwide that combines a spectrum analyzer and a phase noise tester up to 50 GHz.

range. The menu layout is similar to that of Application Firmware R&S®FS-K40, making operation – as usual – very easy, especially switching between the different measurement modes. Predefined settings for fast and highly stable measurements also facilitate operation.

After you start the phase noise measurement, UNLOCKED, LOCKING or LOCKED will be displayed to indicate the state of the PLL as well as to show whether the PLL is locked and a successful measurement can be started. You can adjust the loop bandwidth to your specific requirements; the voltage on the phase detector will be displayed during the measurement.

Other convenient functions

During the measurement, an efficient algorithm can list any interference that is sinusoidally caused by power frequency interference or phase detector frequency, for example (FIG 3). Alternatively, you can eliminate clearly defined interference by calculation or suppress it. The R&S®FSUP also displays integral parameters such as residual phase or residual frequency modulation (residual FM/φM) or RMS jitter. The calculation includes the entire measurement range as standard, but you can also define integration limits.

To perform exact measurements on oscillators, the phase noise of the internal reference signal must be negligible compared to that of the DUT. The internal source of the R&S®FSUP exhibits outstanding phase noise measurement values (FIG 4): At an input frequency of 1 GHz and a frequency offset of 10 kHz, the value is –134 dBc(1 Hz), at a frequency offset of 10 MHz only –170 dBc(1 Hz).

How the phase comparator measurement method works

Applying this method, the DUT signal is mixed with the signal from the reference source. If both signals exhibit the same frequency, a DC voltage is obtained at the output of the mixer or phase comparator that is superimposed by the noise of the DUT and the reference source (FIG 2). If the signals exhibit a 90° phase offset on the phase comparator, pure phase noise can be measured. In this case, the amplitude noise is suppressed by up to 30 dB. With 0° phase offset, only the amplitude noise is output.

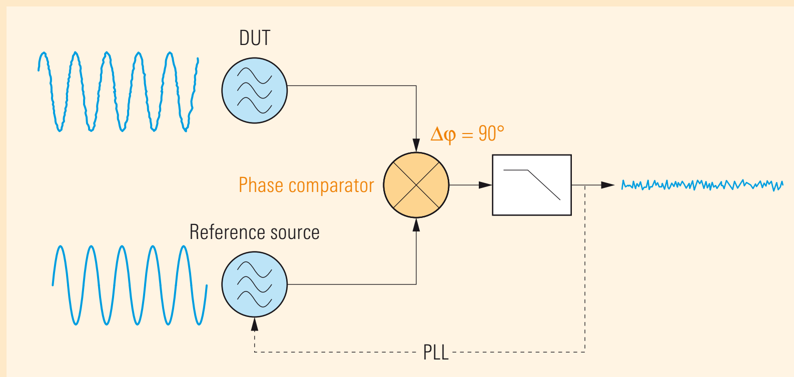


FIG 2 Schematic of the phase comparator method: The reference signal is mixed with the DUT signal; the phase noise can be measured at the output after a lowpass. The 90° offset is adjusted at the reference signal source.

FIG 3 Typical measurement using the phase comparator method: Signal frequency, level and residual noise can be read off the display. The R&S®FSUP automatically detects unwanted interference, which can be blanked out. Spurious – including accurate frequency values – is listed in the display's top right corner.

Cross-correlation for reduced phase noise

The R&S®FSUP-B60 option enhances the signal source analyzer with a second parallel receive path up to 8 GHz (FIG 5), permitting cross-correlation between the two symmetrical paths and thus eliminating the uncorrelated inherent noise of the two reference sources. As a result, sensitivity is no longer limited by the phase noise of the internal reference sources. This improves the dynamic range by up to 20 dB, depending on the number of averages (FIG 6).

Integrated high-end spectrum analyzer

The R&S®FSUP signal source analyzer includes a high-end spectrum analyzer that also allows phase noise to be measured directly in the spectrum. This method determines the spectral power density in the sidebands. It is, however, more time-consuming. Sensitivity is lower because the carrier is not suppressed, which significantly limits the dynamic range. Moreover, cross-correlation cannot be performed; amplitude and phase noise cannot be differentiated. Last but not least, this method makes the calculation and suppression of spurious more difficult.

Nevertheless, phase noise measurements with the spectrum analyzer are a must in some applications because they allow considerably higher frequency offsets to be measured. This method inevitably complements phase noise measurements and is indispensable when measuring harmonics or spurious.

The R&S®FSUP offers attractive features such as the spurious emissions measurement function, which are not included in the usual scope of functions provided by a spectrum analyzer. You can define different sweep ranges including special parameters in a list. The analyzer then automatically searches for interference and spurious in these sweep ranges. The analyzer evaluates up to 100 000 measurement points and lists the result in a table.

Another important function for characterizing signal sources is the adjacent-channel power (ACP) measurement. Convenient functions in the R&S®FSUP ensure quick measurements. Predefined standard settings are available, but you can also define channel widths and channel spacing. Plus, the analyzer's wide dynamic range is setting new standards in signal source analysis.

In the time domain, the R&S®FSUP functions similar to an AM / FM / φM demodulator. It records the oscillator signal as a function of time, and thus displays settling and switching processes of high-frequency sources with high resolution.

Complete oscillator characterization

To record an oscillator's characteristics and measure its phase noise by means of the phase comparator method, the supply and tuning voltage of the oscillator must be accurately set. For this purpose, the R&S®FSUP provides two independent, very low-noise DC outputs whose supply and tuning voltages can be set separately in clear-cut menus (FIG 7). Plus, you can define the order in which the various voltages are added after the measurement has been started. An additional output with negative supply voltage is provided for special applications.

The R&S®FSUP takes into account practical considerations by allowing you to modify the tuning voltage at a constant supply voltage (tuning characteristic) or, vice versa, the supply voltage at a constant tuning voltage (DC dependencies). A combination of both versions, referred to as pushing, is also available. Moreover, the analyzer can measure typical fundamental as well as harmonic parameters. You can select the tuning voltage or the frequency for scaling the x-axis.

Summary

The R&S®FSUP, which provides a maximum input frequency of 50 GHz, is the world's only tool that combines a phase noise tester and a spectrum analyzer in a single box. It is thus ideal for development and production as it reduces the costs for signal source analysis, provides straightforward test setups and offers higher flexibility. In addition, all functions can be remote-controlled via LAN or GPIB, making it easy to integrate the signal source analyzer into production lines.

Hagen Eckert; Dr Wolfgang Wendler

More information and data sheet at www.rohde-schwarz.com (search term: FSUP)

REFERENCES

[1] Spectrum Analyzers R&S®FSP / FSU / FSQ: Phase noise testers of unparalleled quality. News from Rohde & Schwarz (2005) No. 186, pp 24–26

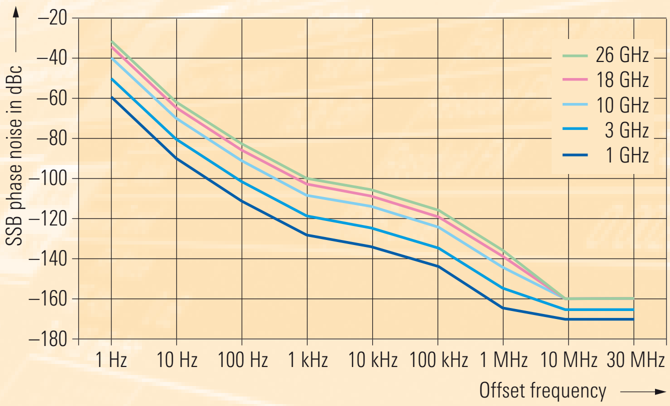


FIG 4 Typical phase noise of the internal reference source of the R&S®FSUP at different input frequencies.

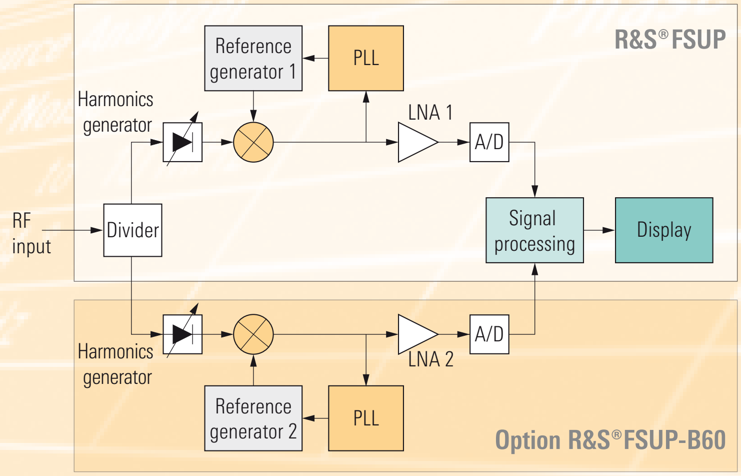


FIG 5 Schematic of the cross-correlation for increasing sensitivity during phase noise measurements.

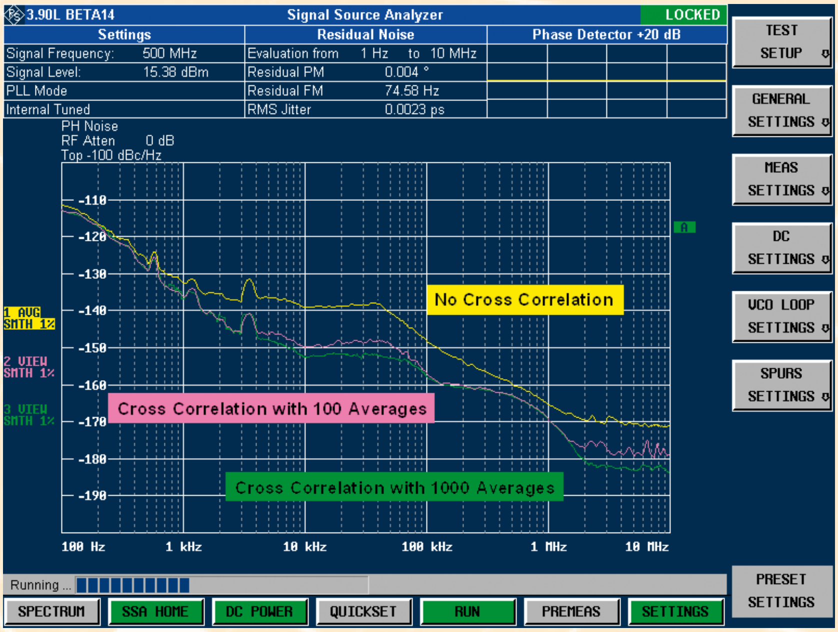
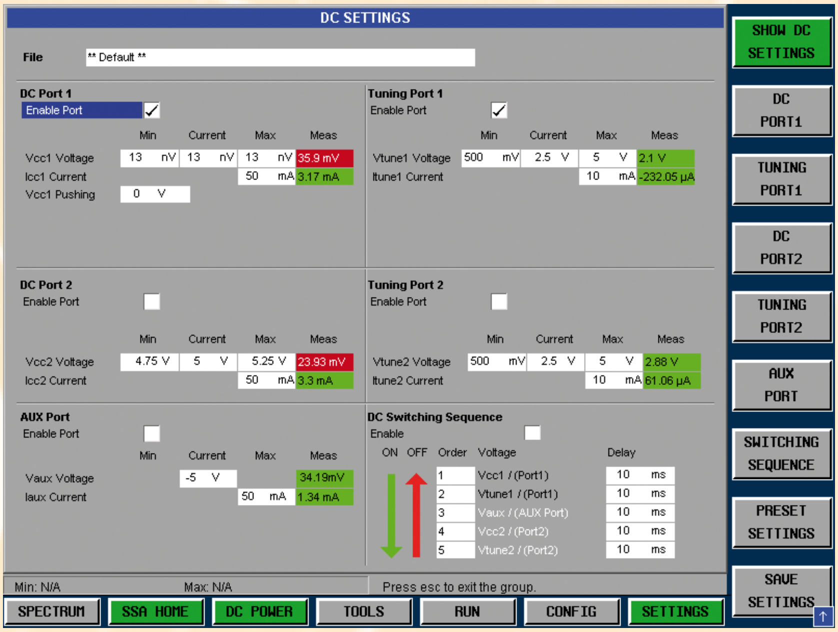


FIG 6
The measurement on an oscillator with subsequent filter illustrates the increase in sensitivity due to cross-correlation. The yellow trace represents a measurement without cross-correlation; the two other measurements were performed with cross-correlation. You can clearly see how sensitivity can be augmented by up to 20 dB, depending on the number of averages.

FIG 7
Menu for setting the DC output and the output for negative supply voltage.



Abbreviations

DRO	Dielectric resonator oscillator
PLL	Phase-locked loop
SAW	Surface acoustic wave
VCO	Voltage-controlled oscillator
YIG	Yttrium iron garnet

Measuring Receiver R&S®FSMR

High-precision sensor modules for convenient measurements

The new Power Sensor Modules R&S®NRP-Z27 and -Z37 for the Measuring Receiver R&S®FSMR (FIG 1) enable absolute level measurements with utmost precision and convenience, eliminating the need for switching between the measuring receiver and the power sensor.

Level calibration with utmost precision

The Measuring Receiver R&S®FSMR [*] combines a power meter, a modulation and audio analyzer and a high-grade spectrum analyzer in a single unit. It is a specialist for high-precision measurements for calibrating signal generators and attenuators. The R&S®FSMR is ideal for measuring the output level of signal sources with levels typically ranging from +10 dBm to –130 dBm. The new power sensor modules for the R&S®FSMR enable high-precision level measurements at maximum user convenience as they include a power sensor and a power splitter, which makes the tedious and error-prone switching between the power sensor and the measuring receiver unnecessary.

Previously, such measurements were performed as follows: First, the power sensor was connected to the device under test (DUT) and the absolute power determined; the resulting value was used as a reference for the subsequent measurements. Second, the power sensor was screwed off, and the RF inputs of the measuring receiver and the DUT were connected via a cable. With the generator settings remaining unchanged, the level was measured with the measuring receiver and normalized to the reference value previously determined. Based on this normalization, it was possible to perform absolute measurements with utmost precision – due to the R&S®FSMR's extremely high linearity and large measurement range. If several frequencies had to be covered, these steps had to be repeated for each test frequency involved.

The new Power Sensor Modules R&S®NRP-Z27 and -Z37 now greatly enhance the convenience as well as accuracy of such measurements, because the power sensor and the measuring receiver are connected in parallel via an integrated power splitter. The time-consuming and error-prone switching between the power sensor and the measuring receiver is thus a thing of the past. And the power sensor modules offer an additional advantage: They perform all necessary corrections automatically (see box). So why choose a tedious method when a convenient one is available?

Michael Wöhrle

FIG 1 The R&S®FSMR with the Power Sensor Module R&S®NRP-Z27.

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Accuracy is what counts:
What distinguishes the power sensor modules for the Measuring Receiver R&S®FSMR

At first glance, the new power sensor modules do not seem to include any striking features: They contain a power splitter that routes part of the DUT output power to the measuring receiver, and a thermal power sensor that measures the DUT power (FIG 2). A common setup used before, of identical or slightly varied design. Accepting this solution, however, means putting up with a loss in accuracy.

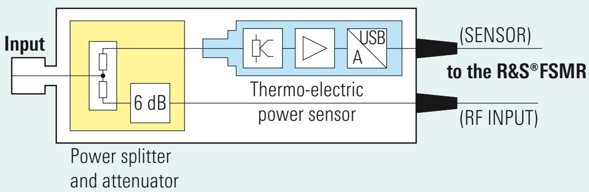

FIG 2 Block diagram of the Power Sensor Modules R&S®NRP-Z27 and -Z37.

The core of the problem is inadequate isolation between the outputs of the power splitter. As a result, the power sensor will be affected by any mismatch of the other output, as well as any variation of such mismatch. Even slightly bending the connection cable or switching the attenuator of the measuring receiver, let alone replacing the measuring receiver, will immediately increase measurement uncertainty. Calibrating the setup would necessitate calibration points every 10 MHz – assuming spline interpolation between the calibration points.

In its Power Sensor Modules R&S®NRP-Z27 and -Z37, Rohde & Schwarz combines several measures to ensure that the modules offer unequaled measuring convenience while still featuring extremely high accuracy. A 6 dB attenuator integrated into the power splitter increases isolation by 12 dB. This reduces the uncertainty of the power display caused by the aforementioned effects by a factor of four. The level reduction involved in this method is fully compensated for by the unparalleled sensitivity of the R&S®FSMR.

The nominal isolation of 24 dB achieved in this way is still insufficient; numeric compensation measures are therefore used to increase it further. This requires full characterization of the power splitter at a spacing of 12.5 MHz, knowledge of the complex reflection coefficient of the R&S®FSMR, and use of a phase-stable connection cable. A set of calibration data for the power splitter is created once during production and then used as an integral part of the power sensor. The specific reflection coefficients of each Measuring Receiver R&S®FSMR are likewise determined during production and can be updated if required. Compensation is performed by the intelligent power sensor itself: It corrects the effects of mismatch using the stored calibration data of the power splitter and the R&S®FSMR reflection coefficient. The measuring receiver communicates the reflection coefficient to the power sensor via USB, and also keeps the attenuator fixed at 10 dB during the power measurement. An armored, phase-stable microwave cable from the leading manufacturer is used as a connection cable. It is robust and reliable, and will even withstand your accidentally stepping on it.

The result yielded by the combination of these measures is impressive in every respect (FIG 3). Moreover, the characterization of the power splitter has a positive side effect: The frequency spacing for the calibration of the power sensor as a whole could be increased to 100 MHz. This ensures cost-efficient recalibration, even when customer-specific power calibration systems are used.

Thomas Reichel

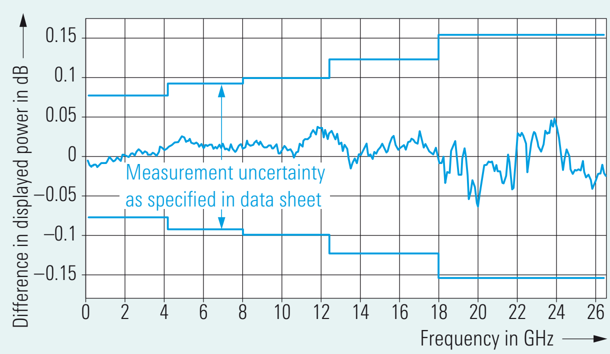

FIG 3 Result of a comparison measurement between a Power Sensor Module R&S®NRP-Z37 and an R&S®NRV-Z55 terminating power sensor, where the latter is used as a reference. The R&S®NRV-Z55 is directly traceable to a primary standard of the PTB, Germany's national metrology institute, i.e. it was calibrated there. The Power Sensor Module R&S®NRP-Z37 is also traceable to primary standards of the PTB. However, different standards were used in this case, and three calibration hierarchies introduced in between. The small differences obtained in the two measurements demonstrate the high quality of the Power Sensor Module R&S®NRP-Z37 and the calibration chain involved..

More information at www.rohde-schwarz.com (search term: NRP-Z27 / -Z37)

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[*] Measuring Receiver R&S®FSMR – Single, compact instrument for calibrating signal generators. News from Rohde & Schwarz (2005) No.185, pp 18–21

– Measurement Uncertainties in RF Level Measurements Using the Measuring Receiver R&S®FSMR. Application Note 1MA92 from Rohde & Schwarz

Condensed data of the R&S®NRP-Z27

Frequency range	DC to 18 GHz
Level range	–24 dBm to +26 dBm
Connector	N male

Condensed data of the R&S®NRP-Z37

Frequency range	DC to 26.5 GHz
Level range	–24 dBm to +26 dBm
Connector	3.5 mm, male

LXI – the new LAN standard for networking T&M equipment

The LXI standard is based on Ethernet, the widely used communications standard for LANs. This is just one of the reasons why LXI is widely supported by leading manufacturers of T&M equipment.

LXI – the successor of GPIB

The LAN eXtensions for Instrumentation (LXI) standard for controlling T&M equipment and test systems combines the advantages of rack&stack instruments, offering GPIB interfaces and powerful firmware functions, with the benefits of modular, compact VXI/PXI systems (see box on next page). LXI, which is based on the Ethernet standard, defines a uniform, interoperable LAN implementation, allowing T&M instruments to be easily integrated into modular test systems. As the LAN standard is backward compatible with previous versions, it protects existing investments.

Ethernet has a long tradition: At about the same time that the GPIB interface was introduced, Ethernet was developed and also standardized (IEEE 802.3). Unlike the GPIB interface, whose transfer rate is limited due to technological reasons, Ethernet technology could be continuously accelerated. Initially providing a meager 3 Mbit/s, 100BaseT and Gigabit LANs are now state of the art – with further enhancements in the pipeline.

The spreading use of the Internet further advanced Ethernet; today, every PC is equipped with a LAN interface as standard. Moreover, the new wireless technologies enhance the LAN capabilities by additional applications.

These are ample reasons for leading manufacturers of T&M equipment to support the new LXI standard. Web servers are integrated in LXI devices, allowing interface and instrument settings to be made simply via a web browser. The programming interfaces for the test software are IVI-C or IVI-COM drivers (IVI stands for interchangeable virtual instrumentation). In addition, the precision timing protocol (PTP) of the IEEE 1588 standard for synchronizing clocks in

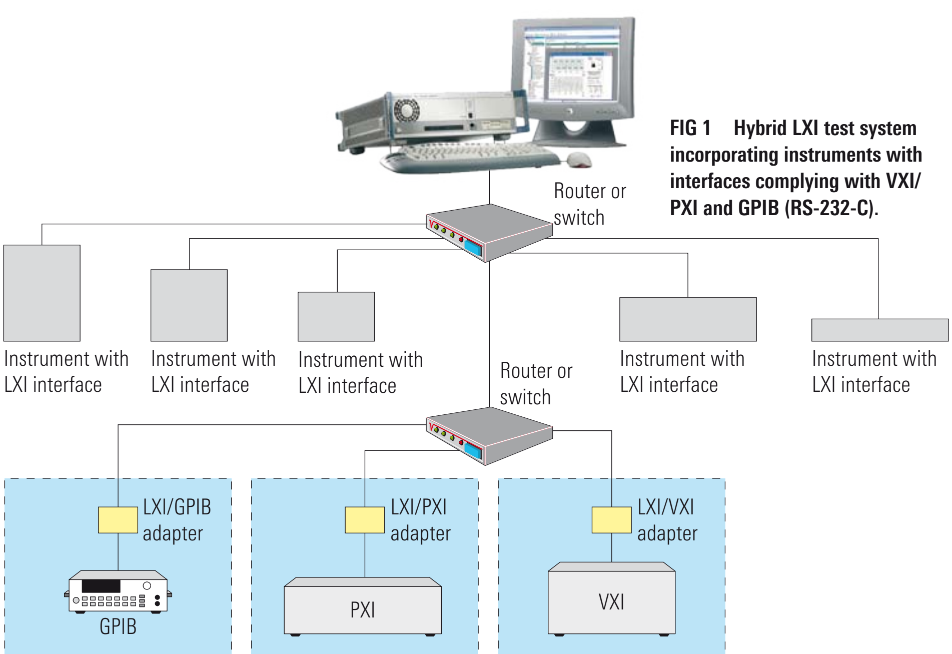
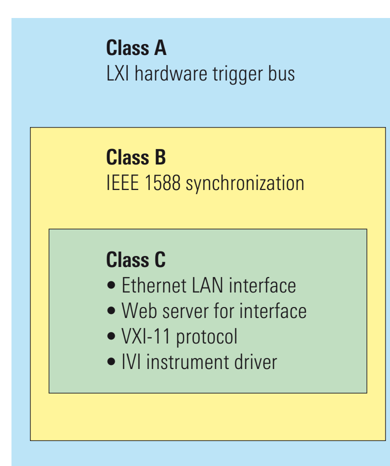


FIG 1 Hybrid LXI test system incorporating instruments with interfaces complying with VXI/PXI and GPIB (RS-232-C).

FIG 2 The functionality of the three classes of LXI instruments.



LAN nodes as well as an eight-channel hardware trigger interface are earmarked for LXI to further expand trigger and synchronization functions. Another future capability is the configuration of hybrid test systems, which will integrate VXI/PXI systems and conventional GPIB instruments via LXI adapters (FIG 1).

Three classes of LXI instruments

LXI-compliant instruments or modules are divided into three classes, A, B and C, with the functionality of the classes hierarchically based one upon the other (FIG 2). All instruments of these three classes can be integrated in a test system and combined with each other according to the requirements and application at hand.

Class C

LXI instruments complying with class C are characterized by a common LAN implementation. This includes the capability of automatically detecting LXI instruments in a LAN via the Discovery protocol in accordance with VXI-11. Other definitions and functions such as LAN configuration initialize (LCI) – which resets the LAN configuration – make it easy to integrate these LXI instruments in a LAN-based test system. Owing to a uniform interface, the instruments can be configured via a web browser.

Class C instruments are programmed by means of IVI drivers (APIs), which were standardized by the IVI Foundation. The architecture of these drivers and their interoperability are important prerequisites for system integration.

Class B

Class B compliant instruments are additionally equipped with synchronization

GPIB – reliable for 30 years

The GPIB interface has been the standard for controlling T&M equipment in automatic test systems for more than 30 years. It has proved to be a reliable and flexible tool in a wide variety of implementations and systems. The GPIB interface was steadily improved during this time to make the integration of test systems faster and less expensive: The standard was enhanced by standardizing the programming commands (SCPI). Moreover, based on this standardization, a uniform driver architecture was implemented and the APIs for the instrument classes (IVI drivers) defined.

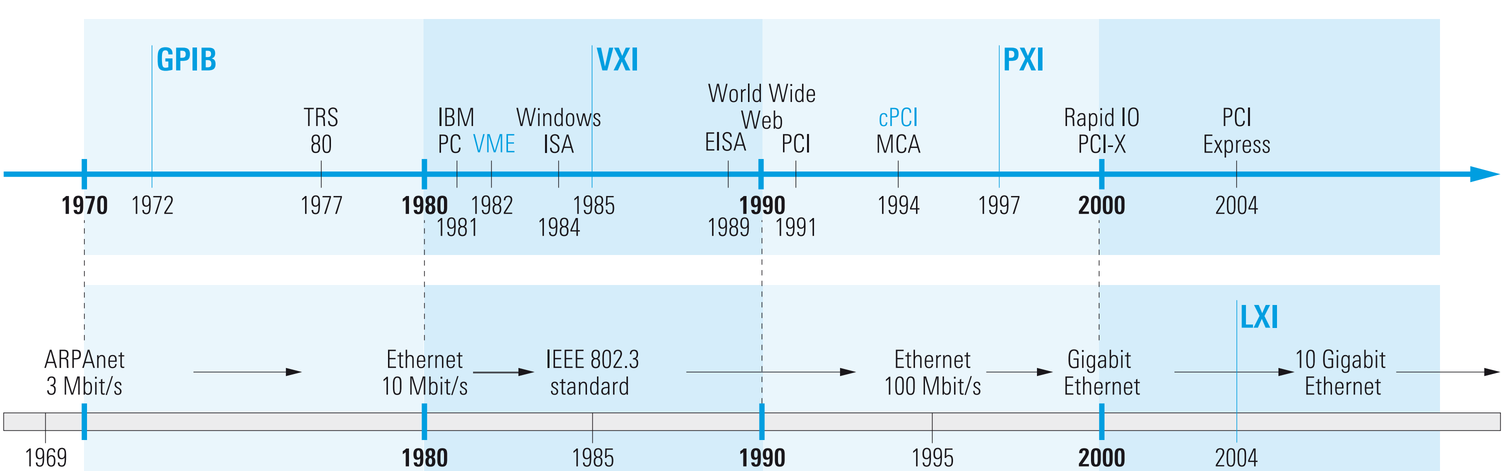
Today, the GPIB interface is increasingly faced with its limitations – first, it was never able to establish itself as a standard PC interface (and must therefore be retrofitted); second, the transfer rate, being limited to maximally 1 Mbyte/s for technological reasons, is very narrow.

Widely used: VXI and PXI

Parallel to the conventional rack&stack instruments with GPIB interface, compact systems based on card bus technology were developed, particularly for military and aerospace test systems (VME and PCI bus). This solution was continuously enhanced and established itself as standard (VXI and subsequently PXI). These modular T&M instruments and systems with plug-in cards are used in a wide range of test applications that require high data throughput and compact dimensions. However, a drawback of the VXI and PXI systems is the module chassis required for accommodating the plug-in cards as well as the slot 0 controller for controlling the modules.

FIG 3 shows the development of the different systems and standards over the years.

FIG 3 The evolution of GPIB, VXI and PXI compared with the Ethernet LAN technology.



mechanisms defined in the IEEE 1588 standard. Thus, high-precision time synchronization of better than 10 ns can be achieved in a 100BaseT LAN. This technique largely avoids the latency times typical of LAN and ensures precise timing, which is indispensable in T&M applications.

Class B is based on common timer events tied to absolute times, which consequently allow very precise synchronization of test system sequences. Data that is to be transferred via LAN can be marked with the exact detection time by means of time stamps. Thus, the recorded data can also be correlated from different sources in distributed systems. Especially the capability to exactly trigger and synchronize widely distributed systems via the precision timing protocol of the IEEE 1588 standard opens up completely new applications.

Class A

In addition to the functions of the other two instrument classes, LXI instruments in accordance with class A are equipped with an eight-channel hardware trigger interface (LVDS interface), whose type of connector, pin assignment and electrical characteristics are defined in the LXI standard. Via this interface, instruments can be connected either in a daisy chain or star configuration (FIG 4). Trigger cable lengths of up to 20 m are thus feasible. The trigger channels can be configured individually as input or output channels; plus, they offer a wired-or function.

The LXI Consortium

The LXI Consortium was founded in September 2004 with the objective to define an open, LAN-based standard for test systems. Today, the LXI Consortium has more than 40 members, including the most renowned manufacturers of T&M equipment, numerous system integrators and end customers. Rohde & Schwarz has been a strategic member since November 2004 and is represented, together with eight other companies, on the Consortium's Board of Directors (www.lxistandard.org).

Instruments of classes A and B can generate and receive software triggers via LAN messages (UDP and TCP/IP messages) – as currently done in test systems as well. Thus, LXI instruments can communicate with each other without involving the controller (peer to peer). The different trigger and synchronization capabilities in LXI can be configured via the controller by means of an enhanced IVI interface (LXI Sync).

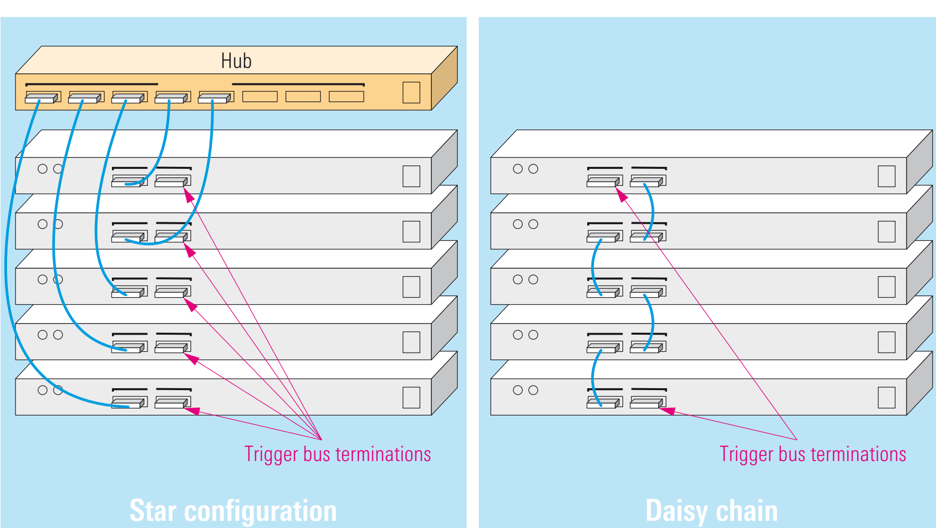
The world's first LXI-validated spectrum analyzers

The LXI Consortium has already confirmed the compliance of the first instruments with the standard: In February 2006, the R&S®FSL, R&S®FSP, R&S®FSU and R&S®FSQ families from Rohde & Schwarz were the world's first spectrum analyzers to be officially certified as compliant with LXI class C. They may now carry the LXI logo.

As a strategic member of the LXI Consortium, Rohde & Schwarz promotes the development of the standard: In April 2006, the first Plug Fest outside the USA was held at the company's headquarters in Munich – with more than 65 representatives from instrument manufacturers, system integrators, customers and the press participating. During this meeting, the R&S®SMU 200 A and R&S®SMATE 200 A vector signal generators were also tested and certified to be LXI-compliant.

Jochen Wolle

FIG 4 Class A instruments are equipped with an LXI hardware trigger interface and can be connected in a daisy chain or star configuration.



EMI Test Receiver R&S®ESU

Maximum precision at unparalleled measurement speed

The EMI Test Receivers R&S®ESIB are the number one choice for EMC emission measurements in accordance with civil and military standards. Now, they are being succeeded by the new EMI Test Receivers R&S®ESU (FIG 1), which focus on maximum productivity and increased measurement accuracy.

Overview of new features

The new receivers feature an unrivaled measurement speed: A test method based on fast Fourier transformation (FFT) allows overview measurements to be performed much faster, significantly reducing the costs per measurement. Further highlights include realtime IF analysis and extensive report functions. The CISPR16-1-1 compliant receivers have been designed to meet civil and military EMC standards for all emission measurements. They also perform all spectrum analysis functions and are available for the frequency ranges 20 Hz to 8 GHz, 26.5 GHz or 40 GHz.

Extremely quick in the time-domain scan

Measurements performed in EMC labs are often time-consuming, especially when unknown DUTs are involved. Although methods such as the preview measurement with the max peak detector and the final measurement with the quasi-peak detector on selected frequencies significantly reduce the total measurement time, preview measurements alone, as they need to be carried out during emission measurements between 30 MHz and 1000 MHz, still often take several hours. The reason: To detect pulse-like interference reliably,

FIG 1 The new EMI Test Receivers R&S®ESU not only outdo their predecessors in terms of measurement speed but also feature higher dynamic range, lower inherent noise and lower measurement uncertainty.

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the observation time per frequency point must be at least as large as the reciprocal of the pulse rate. And this takes time. Analyzing the above-mentioned frequency range with a resolution bandwidth of 9 kHz, for example, produces a total of 242500 measurement values at a step size of 4 kHz. At 10 ms per measurement value, this results in a total measurement time of 45 minutes for just one preview measurement.

How can measurement times be reduced? Performing measurements in the time domain as a possible method has long been under discussion [1]. The R&S®ESU is the first EMI test receiver to provide a rapid, FFT-based time-domain scan for overview measurements (FIG 2). In this mode, the instrument samples successive ranges of the frequency spectrum at the IF, i.e. after preselection, not with only 9 kHz as in the above example, but with a width of up to 7 MHz. It calculates each subspectrum in one go with the desired resolution using FFT. Lined up next to each other, these subspectra yield the picture normally provided by a classic receiver.

The gain in speed is astounding – at the same measurement accuracy and sensitivity, it takes the R&S®ESU less than 20 seconds instead of the aforementioned 45 minutes to perform measurements – which is 150 times faster! The algorithms used can correctly measure and analyze all signal shapes, from CW signals to standard pulses.

On individual critical frequencies, this quick preview measurement, which is performed with the peak, average or RMS detectors, is followed by a final measurement using standard-compliant detectors such as quasi-peak, CISPR-AV and CISPR-RMS for evaluating interference.

Manual measurements made easy

Manual measurements continue to be an effective means of identifying sources of electromagnetic interference. For this purpose, the R&S®ESU features a large, easy-to-read LC TFT display on which users can see all important information at a glance. The measured values for the different detectors are displayed not only numerically but also in analog bargraphs (FIG 3). The effect of changes on the DUT can thus be seen immediately. If you change the frequency on the receiver, the bargraph will follow the signal without interruption, exactly as you would expect from a classic test receiver, thus facilitating the search for the highest signal level. In addition, the highest level value and the associated frequency are registered and displayed.

Audio demodulators for AM and FM make it possible to identify signals – for example, if ambient interferers are to be detected during open-area tests.

The realtime IF analysis (FIG 4) is the best means of frequency tuning. It is displayed parallel to the bargraph measurement in the lower part of the screen and gives you an impression of the signal spectrum around the set frequency. With a large IF bandwidth, the realtime IF analysis displays the spectral distribution of a modulated signal in the measurement channel in addition to a quick overview of the spectrum occupancy outside the actual measurement channel. Interference of a received useful signal can also be detected quickly – no matter whether this involves CW interferers appearing as unmodulated carriers or pulse-like interference displayed as narrow lines on the screen.

The test receiver always displays the current, the averaged or the maximum and minimum measurement value of consecutive test sequences. With modulated signals, the spectrum is gradually filled in the MAX Hold display until all existing spectral maxima have been achieved (FIG 5). Pulse-like signals also fill the MAX Hold display until the spectrum is completely displayed. In contrast, pulse-like signals are suppressed by the MIN Hold display, while sinewave signals are shown unchanged. The combination of the MAX Hold and MIN Hold displays allows you to easily identify, for example, CW interferers with very low levels within a TV signal.

Planned standards can already be tested

Advanced radio services such as mobile radio or current sound and TV broadcasting systems use digital methods for processing and transmitting messages. For analyzing effect of pulse-like interference on radio systems, the quasi-peak detector, which was described already 60 years ago with the emergence of sound broadcasting, is still used [2]. However, numerous tests have shown that this detector is not suitable for these radio services [3].

The search for a better weighting characteristic revealed that the combination of an RMS detector and a linear average detector including an instrument time constant is the ideal compromise [4]. This CISPR-RMS detector has been proposed for standardization (for details on the new detector, see page 46).

This detector is already implemented in the R&S®ESU models as standard to allow developers and EMC testers to perform electromagnetic interference measurements (FIG 6). Like the CISPR-RMS detector, all other detec-

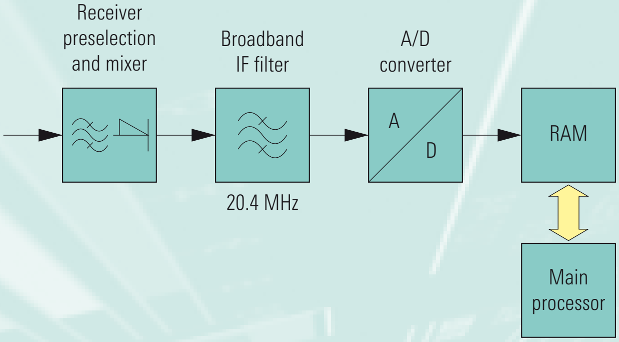


FIG 2 Processing stages in the time-domain scan. After preselection and mixer, the IF is band-limited and digitally converted. All values are saved in the RAM. The main processor calculates the subspectra by means of FFT.

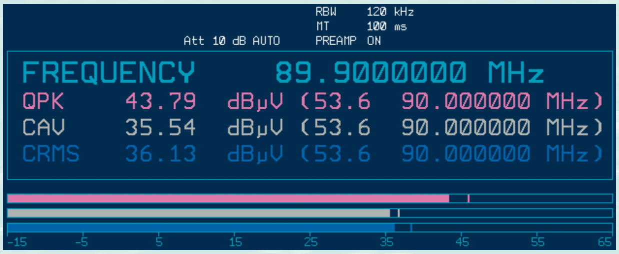


FIG 3 The CISPR detectors with MAX Hold display.

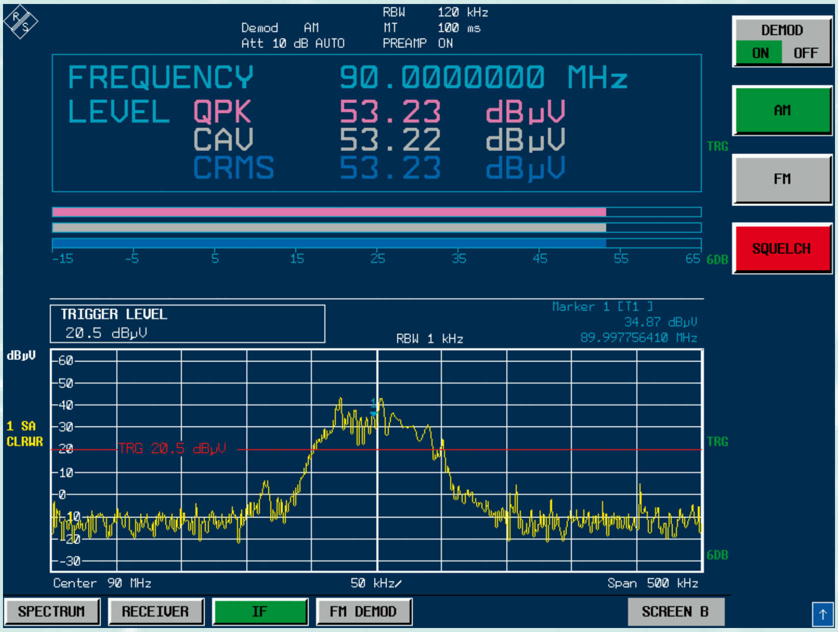


FIG 4 Screen display in the IF analysis mode.
Upper part of screen: Numeric display of receiver frequency and level for max. three different detectors with parallel and quasi-analog bargraph (RBW = 120 kHz; measurement time 100 ms).
Lower part of screen: Spectrum around the receiver frequency and marker peak measurement (RBW = 10 kHz; span 500 kHz). An interfering signal can thus be analyzed in up to three different ways simultaneously: Measured by means of standard-compliant detectors, acoustically with the audio demodulator and visually by means of IF analysis.

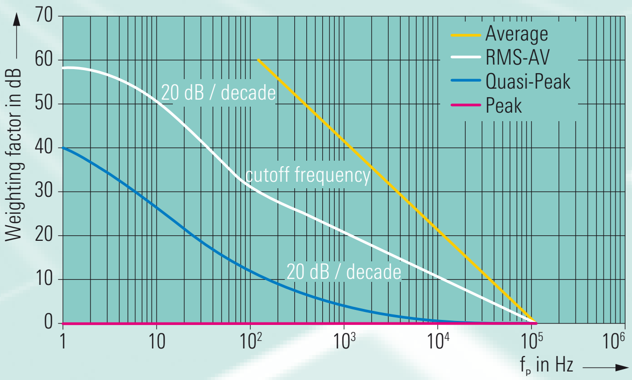


FIG 6 The suggested weighting characteristics of the CISPR-RMS (RMS-AV) detector (blue) in comparison to the current peak, quasi-peak and average detectors for the CISPR C/D frequency band (30 MHz to 1000 MHz).

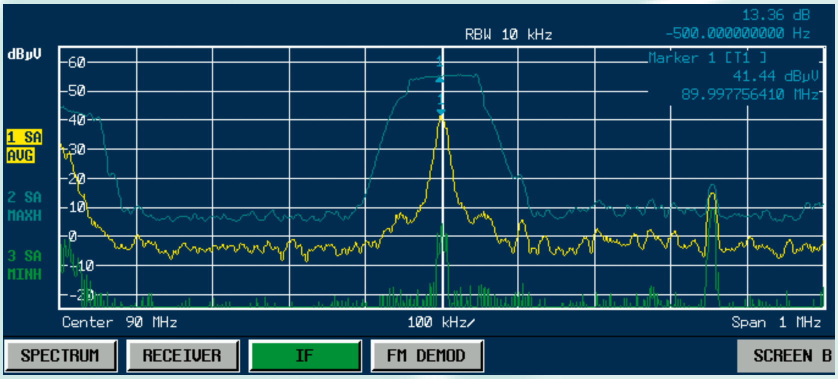


FIG 5 The IF analysis provides a convenient way of tuning the receiver to the exact signal frequency, of identifying signals and assessing their bandwidth.

tors such as peak, average, quasi-peak, CISPR-AV and RMS have also been implemented digitally. This ensures an absolutely stable and reproducible evaluation of the test results in the long run.

Documentation at the press of a button

Documentation of EMC measurement results must be conclusive, complete and also easy and quick to compile. This is no problem for the powerful R&S®ESU report generator, which provides a tool that allows you to generate complete test reports at the press of a button without using any external software (FIGs 7 and 8).

For output to a file, the most common formats are available:

- **PDF** as standard for documentation
- **RTF** (rich text format) for further processing and providing additional information in word processing programs
- **HTML** for convenient viewing with a web browser

The file including the test report is saved on the built-in hard disk or on a memory stick. Alternatively, you can also save the file on a network server via the Ethernet interface.

More than just EMC applications

The R&S®ESU also offers the tried-and-tested and effective one-box concept that combines an EMI test receiver and a full-featured spectrum analyzer – in this case, the high-end Spectrum Analyzer R&S®FSU [5]. The test receiver thus provides a range of functions that also meet the demands of development labs to a high degree, which helps to reduce costs even further.

In addition to the spectrum analyzer's standard functions, a variety of automatic measurement functions are included:

- Power measurement in the frequency and time domain (channel/adjacent channel)
- Amplitude probability distribution (APD)[1] signal statistics
- Complementary cumulative distribution function (CCDF)
- Noise and phase noise measurements
- Third-order intercept (TOI) measurement

Flexibility combined with the broad range of applications of a high-quality spectrum analyzer including the specific characteristics of an EMI test receiver make the R&S®ESU ideal not only for certification measurements in accordance with the relevant EMC standards but also for all general measurement applications in the lab, for example, during the development phase of a product as well as for measuring radio parameters in EMC labs.

Summary – a real champion

As a market leader for EMC test and measurement, Rohde & Schwarz has demonstrated expertise in the field of EMI test receivers for years. The existing high-end EMI Test Receivers R&S®ESIB have already stood their test and are internationally acknowledged reference instruments. The new R&S®ESU test receivers not only outdo their predecessors in terms of measurement speed but also feature a higher dynamic range, lower inherent noise and lower measurement uncertainty – although they are much more compact and weigh significantly less. The R&S®ESU helps to increase customer benefit by performing faster, more accurate measurements.

Additional functions such as the time domain analysis for analyzing interference versus time, starting a complete measurement with preview measurement, data reduction and final measurement at the press of a button as well as the integrated report generator allow complex tests to be performed easily and conveniently – ensuring a quick return on investment.

Matthias Keller; Karl-Heinz Weidner

1) This is not the measurement function defined in the CISPR 16-1-1 standard, which, however, is planned for the R&S®ESU.

FIG 7 Editable templates for designing reports. A separate logo is also output with the header. Different report templates can be configured and saved.

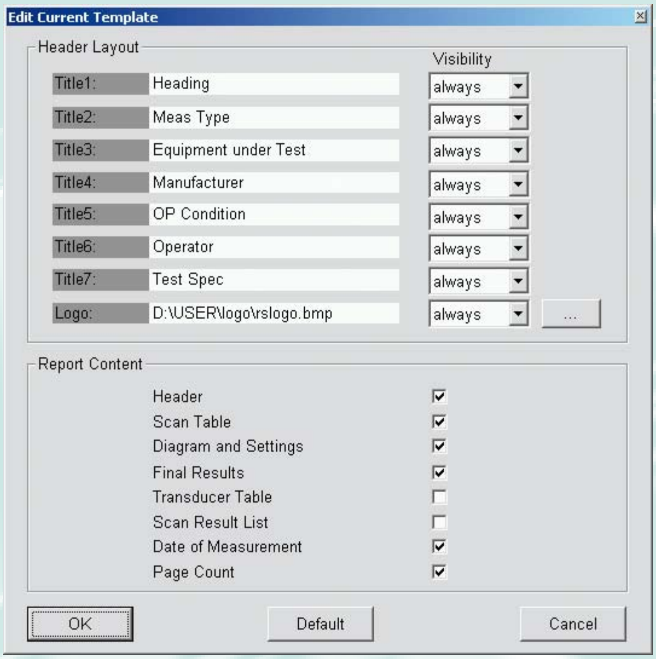
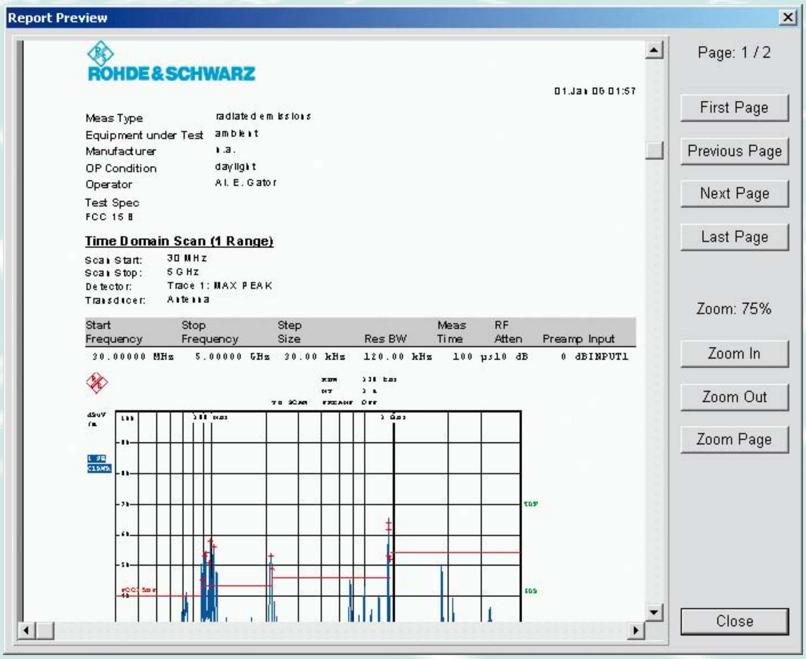


FIG 8 The report can be checked by means of the preview function. Different zoom stages can adapt the report size to the screen. Several measurements can be combined in a single report.



More information and data sheet at www.rohde-schwarz.com (search term: ESU)

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Condensed data of the R&S®ESU

Frequency range	20 Hz to 8 GHz / 26.5 GHz / 40 GHz, depending on the model
Frequency accuracy	aging 1 × 10^{-7}/year, optional 2 × 10^{-8}/year
Spectral purity	<–120 dBc(1 Hz), typ. –123 dBc(1 Hz) at 10 kHz
Amplitude measurement uncertainty	<0.6 dB (f ≤ 3.6 GHz) <2.0 dB (3.6 GHz ≤ f ≤ 8 GHz) <3.0 dB (8 GHz ≤ f ≤ 40 GHz)
1 dB compression point	>+13 dBm nominal (≤3.6 GHz; without preselection)
RF attenuation	0 dB to 75 dB in 5 dB steps
Pulse immunity (10 µs; input 2)	450 V / 20 mWs
Frequency sweep	
In receiver mode	scan table with max. 10 subranges and various settings, optionally for time-domain scan (FFT) and frequency scan
In analyzer mode	span >10 Hz: 2.5 ms to 16000 s zero span (0 Hz): 1 µs to 16000 s
Detectors	max. / min. peak, RMS, average, quasi-peak, CISPR-AV, CISPR-RMS
Bandwidths	
3 dB	10 Hz to 10 MHz in steps of 1/2/3/5
6 dBm (EMI)	10 Hz, 100 Hz, 200 Hz, 1 kHz, 9 kHz, 10 kHz, 100 kHz, 120 kHz, 1 MHz
Noise display (receiver mode; average detector, preamplifier on; 0 dB RF attenuation)	
100 kHz (BW = 200 Hz)	<–10 dBµV
10 MHz (BW = 9 kHz)	<–18 dBµV
30 MHz (BW = 120 kHz)	<–7 dBµV
1 GHz (BW = 1 MHz)	<4 dBµV (R&S®ESU8)
3 GHz (BW = 1 MHz)	<6 dBµV (R&S®ESU8)

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FIG 1 The Spectrum Analyzer R&S®FSU now also performs reproducible, reliable and fast EMI precompliance measurements.

Spectrum Analyzer R&S®FSU

Scope of functions expanded for EMI precompliance measurements

You can now use the R&S®FSU family of spectrum analyzers (FIG 1) also for EMI precompliance measurement tasks: It offers EMI bandwidths, state-of-the-art EMI detectors, increased sweep resolution and logarithmic frequency axes.

Reducing development time

State-of-the-art products feature impressive innovative characteristics yet are developed and ready for market within a very short time. And on top of that, extensive measurements are required to ensure their electromagnetic compatibility. It is thus quite natural to want to use spectrum analyzers applied in the laboratory for EMI tasks as well.

The R&S®FSU high-end spectrum analyzers [1] are just one example: Owing to their high measurement speed, accuracy and high dynamic range, they are indispensable in development and production. Since their scope of functions now includes EMI bandwidths, state-of-the-art detectors, increased sweep resolution and logarithmic frequency axes, they can be used for EMI tasks – and thus save valuable development time.

Innovations in detail

All the analyzers of the R&S®FSU family running on Windows XP and firmware version 3.91 or later include these new features. Five models with different frequency ranges (FIG 2) are thus available for performing EMI precompliance measurements between 20 Hz and 50 GHz.

CISPR bandwidths (6 dB) for correct pulse weighting

If you want to perform EMC measurements during development, e.g. localizing interference sources by probes or near-field probes, you often get by with a qualitative assessment of average accuracy. If the RFI voltage, RFI power and RFI field strength have to be measured on an EUT together with test setups and coupling devices, however, and if results have to be compared with emission limits, you definitely need precise, reproducible, quantitative weighting. For predefined CISPR bandwidths, this is done using quasi-peak or average detectors appropriate for the frequency bands. For bands A to D, measurement bandwidths are specified as 6 dB bandwidths and as impulse bandwidth for band E:

CISPR band A (9 kHz to 150 kHz):
B_{res} = 200 Hz
CISPR band B (150 kHz to 30 MHz):
B_{res} = 9 kHz
CISPR band C (30 MHz to 300 MHz):
B_{res} = 120 kHz
CISPR band D (300 MHz to 1 GHz):
B_{res} = 120 kHz
CISPR band E (1 GHz to 18 GHz):
B_{res} = 1 MHz

Most of the spectrum analyzers use filters with several stages and define 3 dB bandwidths. Filters to be used for EMC tasks in interference measurements must adhere to the 6 dB bandwidth, however. The R&S®FSU thus includes the FILTER TYPE function, which offers a wide variety of options: resolution bandwidths from 10 Hz to 50 MHz (3 dB bandwidth), FFT filters, channel filters, RRC filters and also CISPR filters with 6 dB bandwidth from 200 Hz to 1 MHz for commercial EMC standards (e.g. EN standards).

Innovations at a glance:

- **6 dB bandwidths or bandwidths in line with CISPR 16-1-1**
  200 Hz, 9 kHz, 120 kHz, 1 MHz
- **EMI measurement detectors**
  Pk, QP, RMS, AV as well as CISPR-AV and CISPR-RMS
- **Resolution during sweep**
  30001 test points, logarithmic frequency axis

New EMI measurement detector CISPR-AV (CAV)

To compare the amplitudes of noise signal spectra with emission limits laid down in product family standards (EN 55011 to EN 55025), CISPR measurement bandwidths and measurement detectors must be used. Since detectors with CISPR time constants are slower – which is due to the stipulated transient response – they are not suitable for fast preview measurements.

To perform fast preview measurements, select a short measurement time and use peak and average detectors to determine high interference levels and their frequencies. The R&S®FSU offers a fast sweep and simultaneously displays up to three curves of different detectors (e.g. Pk+ and AV).

Critical frequencies with high signal levels that exceed or are close to the limit, on the other hand, are best determined by final tests, which make use of detectors with CISPR time constants. The measurement time required for the final test is approx. one second so that single pulses or low pulse repetition frequencies can be weighted correctly. So far, these measurements have been made with the quasi-peak detector for broadband interference and with the average detector for narrowband interferers. The latest version of the basic CISPR 16-1-1 (2006-03) standard also assigns time constants to the linear average detector. Rohde&Schwarz calls this linear average detector CISPR average detector (CAV) – to distinguish it from the linear average detector (Average), which does not take time constants into account. In contrast to simple average weighting, the level increases at low pulse repetition frequencies when corrected by instrument time constants (depending on the CISPR band). A signal with f_P = 1 Hz will then be weighted 7.4 dB higher in the CISPR band A / B. In CISPR bands C / D / E, the increase will be 11.3 dB (FIG 3). The latest version of the CISPR 16-1-1 standard thus includes more stringent weighting. The CISPR-AV detector will – after a transition period and by referencing to CISPR 16-1-1 (2005) – also be included in the product family standard.

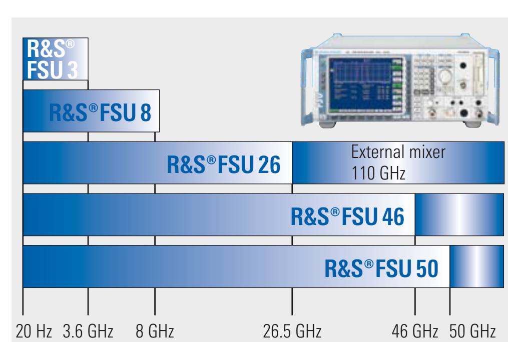

FIG 2
The R&S®FSU family of high-end spectrum analyzers with five models between 20 Hz and 50 GHz is highly valued in development and production owing to its excellent RF characteristics.

New EMI measurement detector CISPR-RMS (CRMS)

Technology has undergone significant changes since the QP detector for weighting the interference of AM signals up to 30 MHz was launched more than 60 years ago. Today, mobile radio networks, digital broadcasting and TV as well as multimedia equipment are state-of-the-art technology. They all use digitally modulated signals. So far, we have lived without a reliable, standardized circuit for weighting such signals and their noise spectra. The Pk, QP and AV detectors used up to now indicate an over- or underweighting of pulse interference which, depending on the relevant mobile radio standard, may lead to different disturbing effects. To improve the reproducibility of measurements, measurement sequences have been used and comparisons have been made for quite some time with a circuit for weighting such signals. This circuit is based on a combination of RMS detector followed by an average detector circuit (including the instrument time constant). The results were discussed at various symposia throughout the world and finally taken into account in the form of corresponding correction curves in the CISPR-RMS detector (CRMS) (FIG 4). The new detector for weighting disturbance for its effects on digitally modulated signals has been included in a Committee Draft for Vote (CDV) and submitted to national committees.

In addition to all common EMI measurement detectors such as Pk, QP, RMS, AV, the R&S®FSU family of spectrum analyzers now also includes the new CISPR-AV and CISPR-RMS detectors

EMI limit lines, transducer tables

To perform EMI precompliance measurements, the R&S®FSU spectrum analyzers offer limit lines for product standards. These limit lines can be activated quite easily, and potential out-of-limit conditions can already be displayed during the measurement (LIMIT CHECK). Other limits, e.g. for in-house standards of the automotive industry, can be quickly inserted as limit line points into a new table for limit lines which are stored under an individual file name on the hard disk. The table can be selected and activated in the default menu.

If additional attenuator pads and pulse limiters are used or if cable attenuation, the frequency response of an external preamplifier or antenna factors have

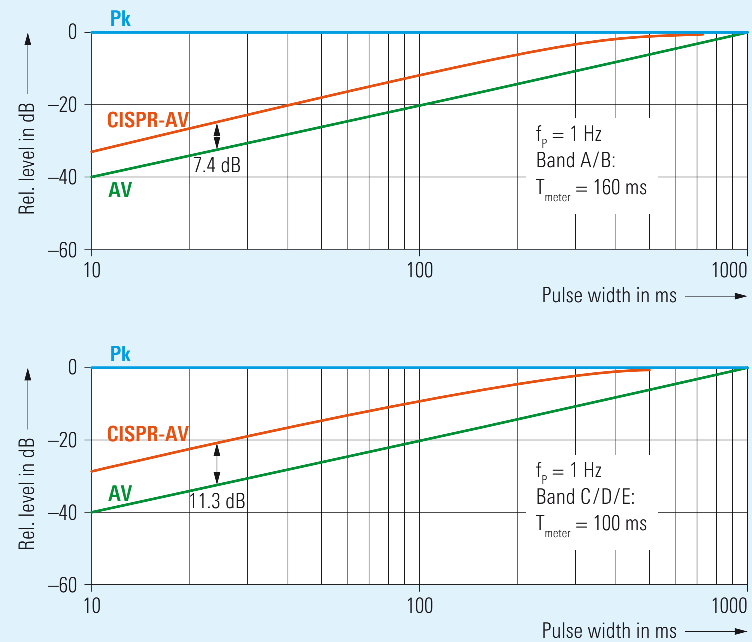

FIG 3 In contrast to the linear average detector, the CISPR average detector (CAV) includes an instrument time constant with a subsequent Max Hold function. Low pulse repetition frequency weighting is thus higher, i.e. weighting is more stringent.

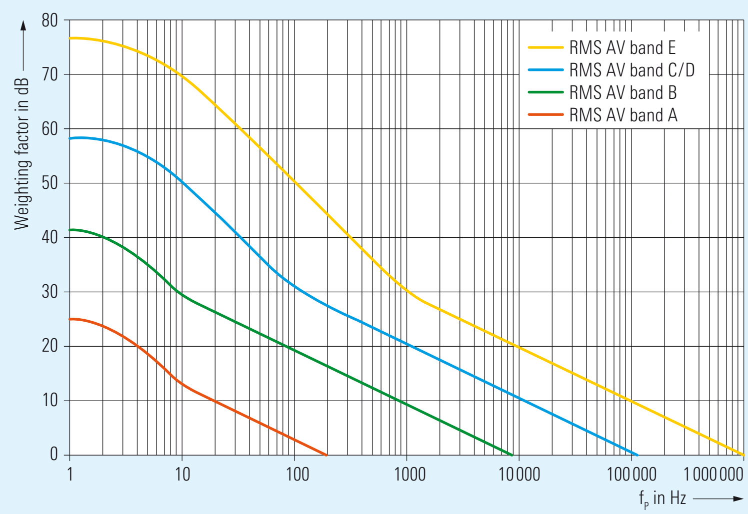

FIG 4 The CISPR-RMS detector (CRMS) is a standard proposal for weighting pulse-shaped signals. The correction curves for weighting different pulse frequencies differ depending on CISPR band A to E.

to be taken into account, correction values are entered in transducer tables. Depending on their application and activation, the analyzer considers these correction values when calculating the current results – without affecting the measurement speed. This increases the measurement accuracy and the reproducibility of measurement results.

Sweep with up to 30001 test points

The number of test points defined prior to the sweep was increased. The analyzer permits up to 30001 test points per trace – standard T&M equipment only offers 501 or 625 test points. The high resolution of the R&S®FSU makes it easier for you to pinpoint critical interfering frequencies that are required for final tests.

EMC measurement results are usually displayed with logarithmic scaling versus frequency. With the SWEEP LOG function, the R&S®FSU displays the test points on a logarithmically scaled frequency axis and thus facilitates the direct comparison with graphics obtained, for example, with full compliance test receivers (FIGs 5 and 6).

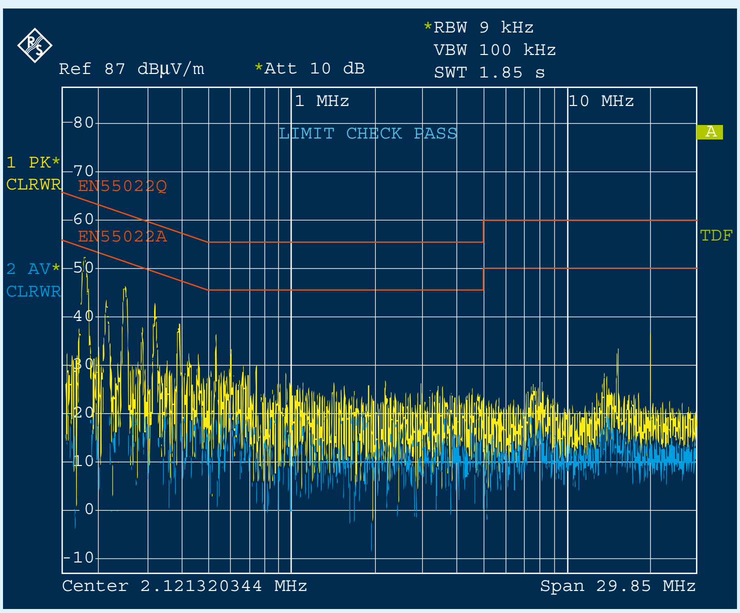

FIG 5
Measurement of conducted EMI in the 150 kHz to 30 MHz range. The R&S®FSU displays limit lines with the LIMIT CHECK function, logarithmic scaling with 8001 test points and the use of 9 kHz (6 dB) bandwidth.

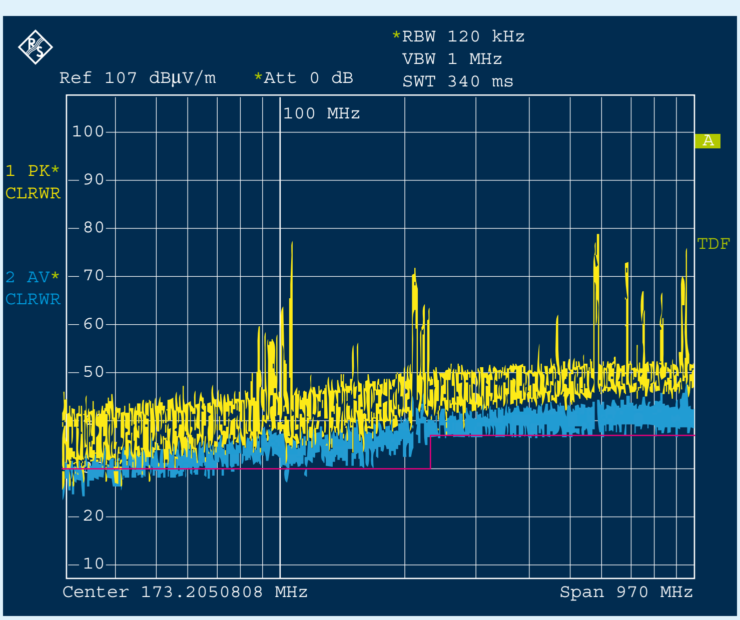

FIG 6
Measurement of radiated EMI in the 30 MHz to 1000 MHz range. The R&S®FSU displays logarithmic scaling with 8001 test points, 120 kHz (6 dB) resolution bandwidth and the use of a transducer TDF (antenna correction table).

Summary

The R&S®FSU can now also perform reproducible, reliable and fast EMC precompliance measurements due to its new EMC functions such as CISPR bandwidths, state-of-the-art CISPR detectors, limit lines, consideration of correction value tables and logarithmic sweep display with up to 30001 test points. These functions and the powerful hardware of the spectrum analyzer are not only very useful when performing measurements during development and EMC precompliance measurements but also help to solve difficult EMI measurement problems in the preliminary product development stages.

Volker Janssen

More information and data sheet at www.rohde-schwarz.com (search term: FSU)

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– CISPR 16: 2003-11: Specification for radio disturbance and immunity measuring apparatus and methods.

VHF FM broadcast transmitters for foreign missions of the German Armed Forces

The German Armed Forces ordered ten mobile VHF FM broadcast transmitter systems from R&S Systems GmbH for international missions of the Psychological Operations branch (PSYOPS).

Establishing and improving contacts using sound broadcasting

On their international missions, the Psychological Operations branch (PSYOPS) of the German Armed Forces is called upon to establish and improve contacts with the local population in the corresponding language by applying a broad scope of information media and broadcast programs. Signal processing and the transmission of sound broadcasting programs is performed by mobile VHF FM broadcast transmitter systems (FIG 1).

FIG 1 Mobile VHF FM broadcast transmitter system with setting-up unit (left), transmit antenna on the 25 m mobile antenna mast (center) and shelter (right).

Wanted: know-how in system integration

In April 2005, R&S Systems GmbH obtained the order to add another ten VHF FM broadcast transmitter systems to the already existing ones of the German Armed Forces. A major advantage of the company was its many years of experience and comprehensive know-how in integrating systems for mobile applications of both military and civil customers. It was thus able to face the great challenge and tackle the difficult problem of producing systems of exactly the same design as those already existing. Production documentation was practically nonexistent and systems were unavailable as a sample, since they were in continuous use.

Owing to the close and fruitful cooperation between the contractor, the suppliers and R&S Systems GmbH, the project could be implemented within the specified time. At the end of 2005 R&S Systems GmbH supplied ten new systems to the German Armed Forces.

FIG 2 Shelter with power distribution (left), VHF FM transmitter (center) and resilience audio supply unit (right).

Systems at a glance

The transmitter system is integrated into a shelter together with the resilience audio supply system (FIG 2). From a sound broadcasting studio accommodated in a separate shelter, the radio program is fed to the transmitter either via a direct cable connection, a telecommunications circuit or via a relay receiver.

VHF FM Transmitter R&S®SR 605 E1

The VHF FM Transmitter R&S®SR 605 E1 from Rohde & Schwarz (FIG 2) is the core of the system. The transmitter includes two VHF Amplifiers R&S®VU 320 yielding an output power of max. 5 kW in the frequency range 87.5 MHz to 108.0 MHz. The transmitter is operated via menus using the VHF FM Exciter R&S®SU 135, which also creates the carrier frequency and the modulation. The transmitter is cooled by a fresh-air ventilation system provided at the rear. An air-conditioning system cools the shelter. Under extremely hot climatic conditions, cool air from the air conditioning system can be added to cool the amplifier output stages of the transmitter.

The transmit antenna includes four dipoles arranged on top of each other and, mounted on a mobile antenna mast, attains a radiation height of 27 m.

Resilience audio supply system

The resilience audio supply system (FIG 2) was supplied by Thum + Mahr GmbH. If a program cannot be transmitted from the sound broadcasting studio, a prerecorded radio program can be loaded from the shelter into the transmitter via the resilience audio supply system. Professional audio equipment such as stereo cassette recorder, minidisk recorder, CD player as well as an audio codec for transmitting audio data via ISDN is available for loading. A digital / analog crossbar is used as the input matrix. It connects either the studio, the telecommunications circuit or – in case of resilience audio supply – one of the audio devices with the FM transmitter. The audio signals, which are available in different qualities, can be optimized for transmission via a digital dynamic processor and a limiter.

Klemens Schwadorf

Shenzhen subway equipped with DVB-T transmitter technology from Rohde & Schwarz

The continuously growing city of Shenzhen in southern China at the Hong Kong border is the first Chinese city to supply passengers traveling in the new Shenzhen subway with TV programs via DVB-T.

Trustworthy cooperation

The Shenzhen Broadcasting Transmission Center (SBTC), which was entrusted with the technical implementation of the DVB-T project, opted for a solution with Rohde & Schwarz transmitters. The favorable price of the transmitters, many years of fruitful cooperation and the positive experience made with Rohde & Schwarz in the field of analog TV transmitters were of prime importance for the decision. Since 1998, for example, two 20 kW transmitters from Rohde & Schwarz cover an area of approx. 16 million inhabitants.

Free-running SFN

The baseband signal processed in the control center is taken to the headend, which feeds the programs almost simultaneously to the individual sections via commercial fiber-optic cables (FIG 2). The SFN system is thus a free-running system which is not synchronized via GPS receivers, as is usually the case. In each section, a 50 W UHF Amplifier R&S®VH 610 A2 (FIG 1) [1] feeds a $1\frac{5}{8}$" leakage cable. Since the production tolerance of the 50 W amplifiers is very small, a typical precorrector setting in the exciters is sufficient to correct all the

FIG 1 The 50 W Amplifier R&S® VH 610 A2 (bottom) and the Exciter R&S® SV 702 (top) form a compact unit.

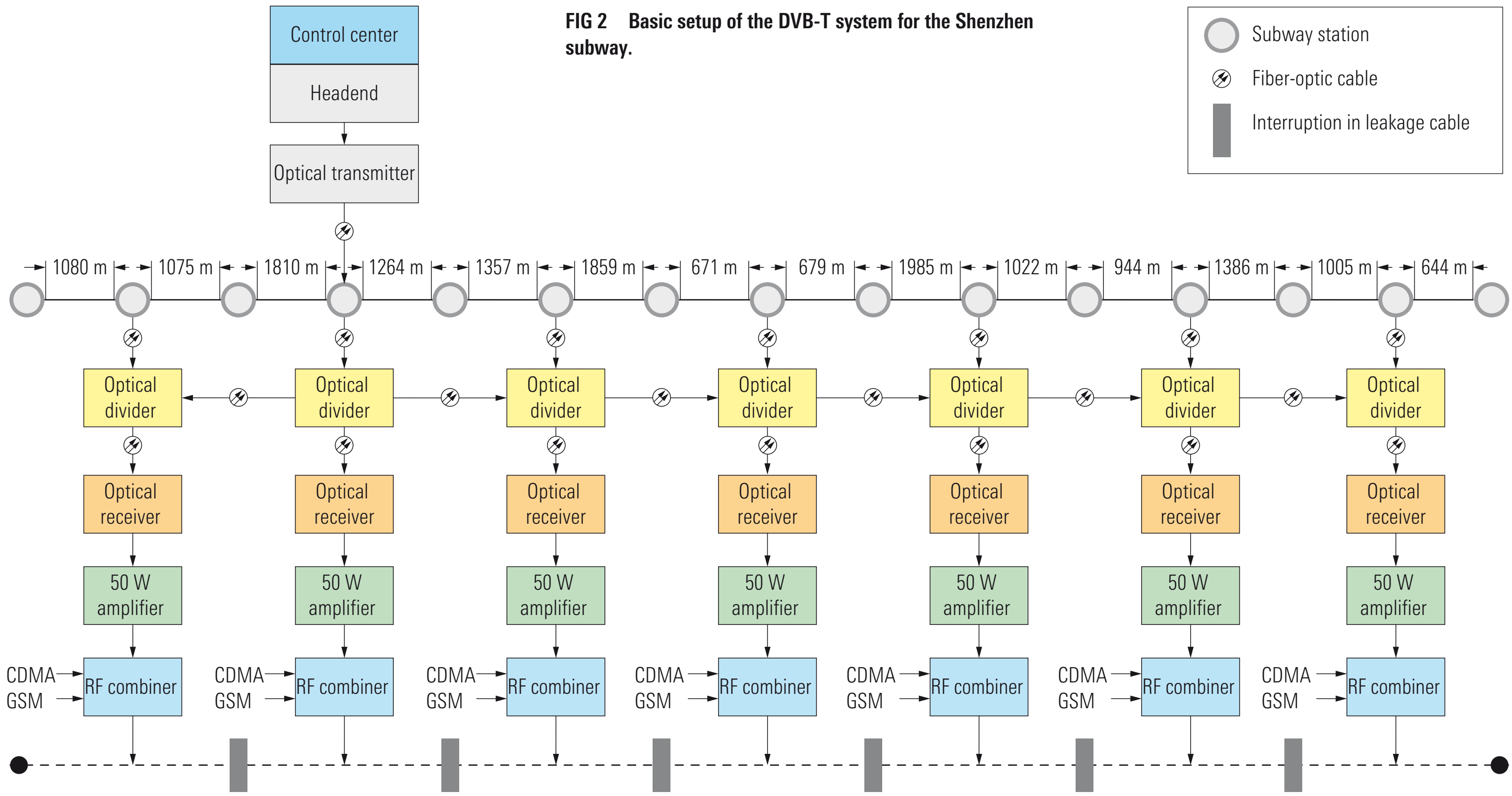

FIG 2 Basic setup of the DVB-T system for the Shenzhen subway.

amplifiers in the network. An RF combiner following to the amplifiers couples the mobile phones of the subway passengers to the CDMA or GSM network.

Two Exciters R&S®SV702 [1] operating in passive standby are used in the headend (FIG 3). Remote control is via the Control Unit R&S®NetCCU700 [2]. Commercial DVB-T receivers in the subway trains receiving the signal from the slot antennas supply the passengers with the programs.

The DVB-T system has been in operation for more than a year and will be enhanced when the Shenzhen subway network is expanded. Rohde & Schwarz China installed and commissioned the system in close cooperation with SBTC.

This subway system is the third DVB-T application so far in public transport in China: More than 4000 busses in Beijing and several hundred busses in Guangzhou have already been equipped with DVB-T receivers, allowing passengers to enjoy the programs while caught in day-to-day traffic jams.

Gerhard-Karl Strauss

More information and data sheets at www.rohde-schwarz.com (search term: SV7002 / NetCCU700)

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[1] UHF Transmitter Family R&S®SV7002: DTV low-power transmitters – modular and space-saving. News from Rohde & Schwarz No. 178 (2003), pp 48–50
[2] Control Unit R&S®NetCCU700: Transmitter control and remote monitoring in one unit. News from Rohde & Schwarz No. 179 (2003), pp 26–28

FIG 3 The headend in the Shenzhen subway feeds in programs.

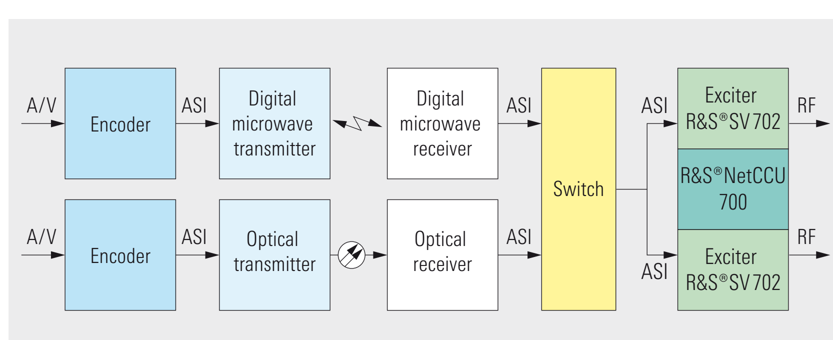


FIG 1 Front view of 25 W (DVB-T/-H) or 30 W (ATSC) R&S®VH6020A2 amplifier with Exciter R&S®SX800 (top).

UHF Low-Power Transmitter Family R&S®SV8000

Power is not always a matter of size

Now that digital broadcasting networks have been expanded with high-power transmitters, it is time to optimize coverage by eliminating areas that are not covered or where field strengths are too low.

Reliable technology combined

The low-power transmitters of the R&S®SV8000 UHF transmitter family (FIG 1) are ideal for covering small urban areas and valleys and for closing coverage gaps in digital broadcasting networks. Featuring a compact design, flexibility and intelligent standby systems, they combine advanced digital technology with reliable digital amplifier technology (FIG 2).

The **Exciter R&S®SX800** [1] was introduced one year ago together with the new R&S®Nx8200 [2] medium-power transmitter generation. The fully digital and highly compact exciter of only one height unit processes signals in compliance with the most important digital standards from the baseband to the RF output signal.

The **Amplifiers R&S®VH60xxA2** have already proven their high reliability in the previous R&S®SV7002 series and are used without any modifications.

One for all – Exciter R&S®SX800

The fully digital signal processing in the exciter sets standards for signal quality and reliability. Owing to this technology, the same hardware can be used for all common digital TV standards (DVB-T/-H, ATSC). The R&S®SX800 takes all peculiarities of digital networks into account, e.g. the operation of transmitter systems in single-frequency networks or the use of hierarchical modulation. And, of course, it is future-oriented, since its software can be easily updated to match any modifications or future standards.

An optional demodulator path makes it possible to perform adaptive digital equalization (ADE) and thus optimize the output signal to utmost quality during operation. If a channel needs to be changed, the transmitter system can be precorrected via ADE by merely pressing a button.

Key characteristics

- DTV standards: DVB-T/-H and ATSC
- Frequency range 470 MHz to 862 MHz (UHF band IV and V)
- DVB-T/-H output power levels 5 W to 400 W (rms)
- Web, SNMP (optional)
- Adaptive digital equalization (ADE), optional
- Flexible standby configuration
- Compact design (>3 height units)

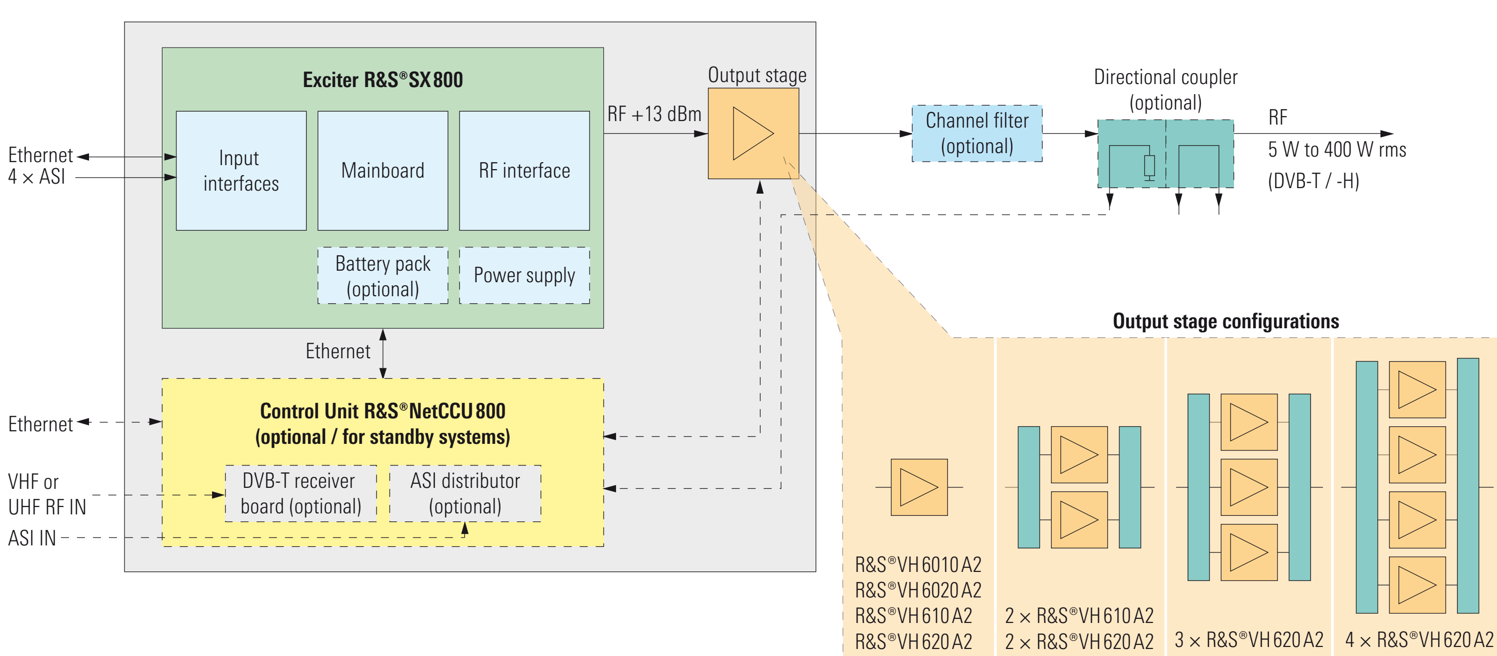
A restart of the exciter due to a short power failure would additionally waste valuable transmit time. You can avoid this by using the optional battery pack.

The built-in Ethernet interface allows you easily to view all parameters using a conventional browser. With an SNMP agent (optional) you can integrate the systems into an existing infrastructure for remote monitoring.

Amplifiers R&S®VH60xxA2 – flexibility by modularity

The reliable Rohde&Schwarz amplifier design based on LDMOS power transistors is used consistently in all UHF amplifiers from Rohde&Schwarz. The R&S®VH60xxA2 amplifiers are available in different versions. Modules with 12 W, 25 W, 50 W and 100 W are available for DVB-T/-H. Power levels of 15 W, 30 W, 70 W or 130 W can be used for ATSC. By combining the four amplifier versions for the R&S®SV8000 UHF low-power transmitter family, configurations with output power levels from 5 W to 400 W (rms) in the frequency range 470 MHz to 862 MHz can be attained. Each amplifier has its own power supply and its own cooling system. Protective circuits monitor the temperature and the VSWR in the individual modules. Systems with two, three or four couplers allow you to set up redundant systems – even with low power levels.

FIG 2 Basic design of the R&S®SV8000 UHF low-power transmitter family.



Everything under control: Control Unit R&S®NetCCU 800

The Control Unit R&S®NetCCU 800 [3] (FIG 3), which can also be integrated into the R&S®SV 8000 systems, offers a number of applications. It allows the transmitter to be operated, for example, via a color display and a keypad. It also operates as a switchover control unit in all R&S®SV 8000 standby configurations and communicates with the individual transmitters via Ethernet. All parameters of the individual systems can thus be displayed via the Control Unit R&S®NetCCU 800 – locally or remotely.

Directional couplers connected to the appropriate input of the R&S®NetCCU 800 are used to display the forward and reflected power (optional). An optional ASI distributor can be integrated to distribute the input data stream for standby configurations.

A DVB-T receiver board can be installed in the unit, too. If the RF output signal is returned from a directional coupler to the input of the board, the board functions as a monitoring receiver and can monitor the quality of the transmitter output. Alternatively, it can be used as a cost-effective signal feed for the transmitter. For this purpose, an off-air signal is demodulated and processed, which yields an error-corrected data stream. Due to the long signal processing time, this retransmitter setup can only be used in multifrequency networks.

Summary

The modular and flexible concept of the transmitter family meets all the requirements placed on digital TV networks. All units have been developed for absolute reliability, and the options described allow you to expand basic transmitter functionality to suit your own needs. No matter if it is used as a stand-alone device or as a system including several transmitters in a rack, the versatile R&S®SV 8000 UHF low-power transmitter family can meet a wide range of requirements.

Hannes Strobel

More information at www.rohde-schwarz.com (search term: type designation)

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[3] Control Unit R&S®NetCCU 800: Common control unit for FM and TV transmitters. News from Rohde & Schwarz (2005) No. 188, pp 44–45

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FIG 3 The optional R&S®NetCCU 800 serves as a local control unit or switching unit for standby configurations. A DVB-T receiver board for monitoring or retransmitter applications and an ASI distributor can also be integrated.

R&S®DV-H264 transport stream library

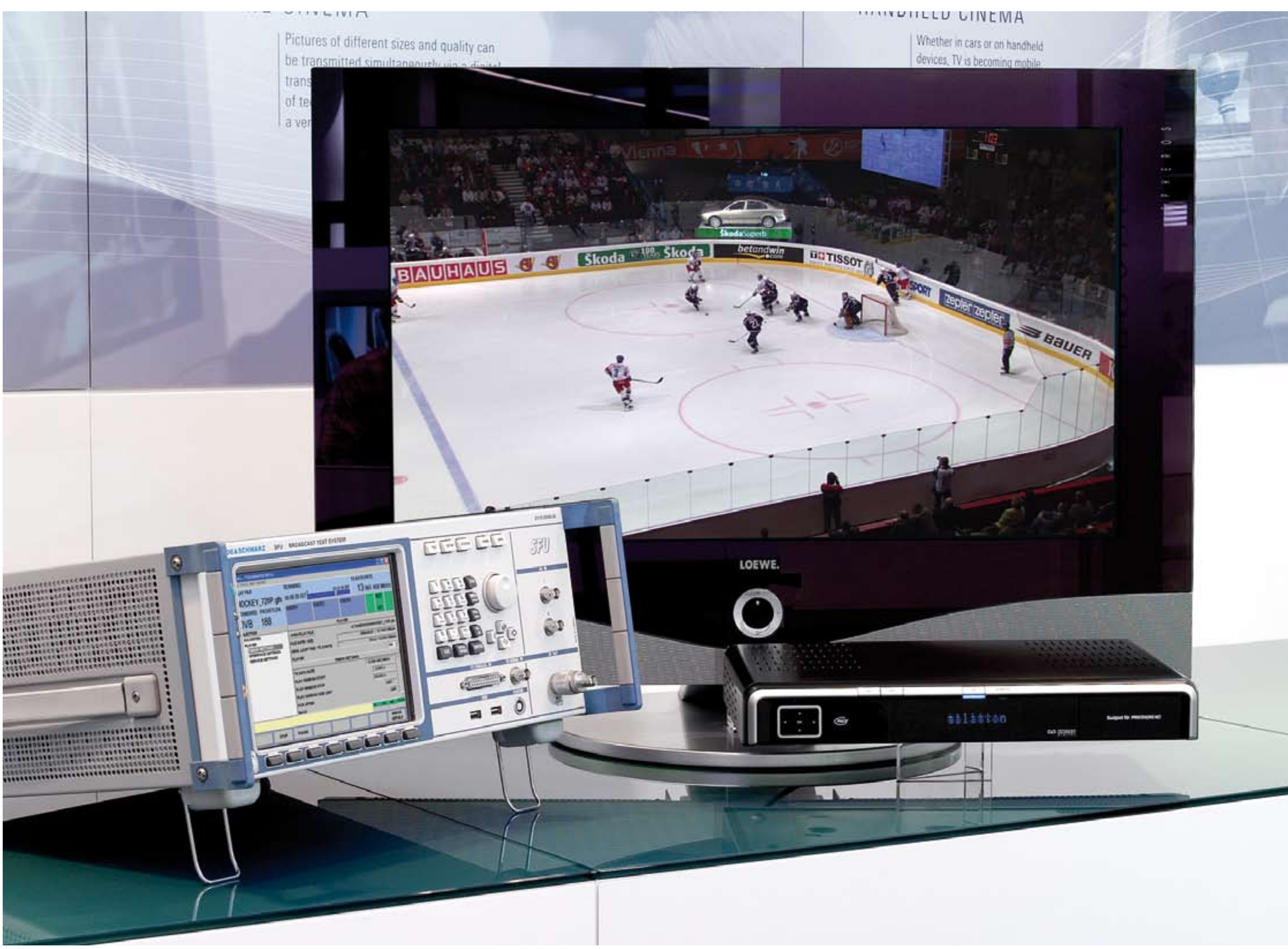
Transport and elementary streams for the H.264 compression standard

The next innovation for digital TV is coming: A new standard for compressing video data. To perform tests in this environment, Rohde&Schwarz presents a new signal library.

Shrinking the data volume for HDTV

H.264 is the designation for the new video data compression standard. This method is also known as MPEG-4/Part 10 or MPEG-4/AVC (advanced video coding). Basically, it is a further development of MPEG-2 (H.262). Since this new method reduces data volume by approx. 50%, the necessary transmission capacity is also decreased meaning lower costs when pictures are "transported" to viewers. Together with further progress in coding, modulation and error correction methods as offered by the DVB-S2 standard for example, H.264 will make the transmission of high-definition TV (HDTV) more effective and thus promote it further.

The R&S®DV-H264 transport stream library contains an extensive collection of high-quality transport and elementary streams for testing TV sets, set-top boxes, displays and decoders.



An extensive transport stream collection …

To introduce this new technology on a broad basis, Rohde&Schwarz provides the complete T&M equipment – one component from this wide-ranging portfolio is the new H.264 Stream Library R&S®DV-H264. Using this extensive collection of high-quality transport and elementary streams, you can easily arrange reproducible test scenarios that allow TV studios, network operators and producers of TV broadcasting equipment to test their services and products quickly and with high test depth. The associated audio signals are AC-3 or MPEG-1 Layer II coded. The library contains signals with all commonly used frame frequencies and frame sizes. This also includes film formats that are still uncommon for TV:

- 24 frames per second, 1080 lines, progressive scan
- 23.97 frames per second, 1080 lines, progressive scan

as well as signals with:

- 25, 29.97 and 30 frames per second, SDTV (480 and 576 lines, interlaced) and HDTV (1080 lines, interlaced)

and signals with:

- 50, 59.94 and 60 frames per second, HDTV (480, 576 and 720 lines, progressive scan)

Also with respect to picture contents, everything that is important is included. In addition to two live trailers that can be examined visually – i.e. simulating normal operation – the transport stream collection also offers "real" test pictures that can be analyzed. Apart from monitor geometry (4:3 / 16:9) and color and field/frame display, the collection also contains signals for testing the electromagnetic compatibility (EMC) of receivers. All in all, the library is an unparalleled reference that supports the development and production of TV sets, settop boxes, displays and decoders.

… for excellent T&M equipment

The library is available for the following instruments:

- Digital Video Measurement System R&S®DVM400 [1], the universal transport stream measurement platform
- Broadcast Test System R&S®SFU [2]
- DTV Recorder Generator R&S®DVRG [3].

The library contains all elementary stream data as separate files. Used in combination with the Advanced Stream Combiner R&S®DV-ASC software option from Rohde&Schwarz [4], the library makes it easy to generate customized transport streams.

Summary

With this new signal library, Rohde&Schwarz is guiding digital TV further into the next evolutionary phase, where displays carrying the HD ready certificate will soon be able to show HDTV – truly home cinema.

Harald Weigold

More information and data sheets at www.rohde-schwarz.com (search term: type designation)

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[2] Broadcast Test System R&S®SFU: Universal test platform for digital TV. News from Rohde&Schwarz (2004) No. 183, pp 39–43
[3] MPEG-2 Generators R&S®DVG / R&S®DVRG: Transport stream signal library for comprehensive tests in production. News from Rohde&Schwarz (2003) No. 177, pp 37–39
[4] Generating and analyzing transport streams for DVB-H. News from Rohde&Schwarz (2005) No. 188, pp 42–43

Around 150 Bluetooth® testers for LG Electronics Korea

The new V2.0 + EDR Bluetooth® standard enables data transmission rates that are up to three times higher than the previous V1.1 and V1.2 standards. To ensure reliable data services also with the new standard, the Korean company uses T&M equipment from Rohde & Schwarz to test the relevant EDR parameters.

From exchanging calling cards via mobile phones to downloading music from the Internet, LG Electronics offers subscribers attractive applications on state-of-the-art Bluetooth® mobile phones. For its production of Bluetooth®-capable mobile phones, LG Electronics in Korea has ordered around 150 Bluetooth® testers from Rohde & Schwarz. The high measurement speed of the R&S®CBT32 tipped the scales in favor of this decision. Testing times and testing costs in production can thus be considerably reduced. Moreover, if audio signals have to be generated and analyzed, the Bluetooth® testers from Rohde & Schwarz can be retrofitted with the R&S®CBT-B41 option.

New TETRA network for public transit services in the Rhône and Lyon region

In future, the communications of the public transit services in the Lyon metropolitan area will be handled by the *ACCESSNET*®-T TETRA system. This April, R&S BICK Mobilfunk received the order from its French system partner, Sabatier SA. The main contractor is Sytral (Syndicat Mixte des Transports pour le Rhône et l'Agglomération Lyonnaise), which is the region's public transit authority.

Before the order was awarded, the system had to undergo a load test to confirm its expandability and performance. The network operator Keolis, a subsidiary of the French railway company SNCF, will use the system primarily as a data transmission network. The future TETRA system will transmit GPS and maintenance data of all Sytral buses and streetcars to the control center.

Dr Udo Helmbrecht, President of the BSI (left), receives the 2000th ELCRODAT 6-2 encryption unit from Henning Krieghoff, President of Rohde & Schwarz SIT GmbH.

Collaboration strengthens confidence in German encryption technology

International organizations and government authorities increasingly rely on the ELCRODAT 6-2, a German ISDN encryption system: Soon, 2000 units will be in use worldwide by NATO, the European Union and German security authorities.

The ELCRODAT 6-2 was designed in close cooperation between the German Federal Office for Information Security (BSI) and Rohde & Schwarz SIT GmbH. At an official ceremony held at the Rohde & Schwarz Memmingen plant on March 6, 2006, Henning Krieghoff, President of Rohde & Schwarz SIT GmbH, presented the 2000th unit to Dr Udo Helmbrecht, President of BSI.

DVB-T transmitters for Mordovia

At the end of 2005, the regional DVB-T network was put into operation in the Republic of Mordovia, making it the first country in the Russian Federation to set up a digital broadcasting network. Rohde & Schwarz supplied the digital transmitters for the TV stations.

The Mordovian representative of OJSC VolgaTelecom implemented the project; the Rohde & Schwarz office in Moscow managed to reel in the contract. A total of six subregions in Mordovia will be covered by ten TV and four sound broadcasting transmitters. The Republic of Mordovia, which is a member of the Russian Federation, is located in the central part of the Russian Plain between Oka and Sura. Its capital is Saransk.

Rohde & Schwarz closely cooperates with universities

Nationwide contest for young engineers

Co-sponsoring the case studies competition, Rohde & Schwarz demonstrated for the third time that close cooperation between industry and universities is anything but dull.

Leave the lecture hall and tackle practical challenges – more than 120 students from eleven German universities responded to this cue also this year. The case studies contest provides young engineers with the opportunity to test their theoretical knowledge against the everyday challenges engineers face. Under the catchphrase *HDTV – get it now!*, the competitors had to solve a T&M problem from the field of high-definition TV, initially in a preliminary round at the universities. Qualified local juries assessed the solutions and selected one team from each university to compete in the finals in Munich. On June 23, 2006, 45 participants from eleven teams vied with each other in the finals, which were held at the Rohde & Schwarz technology center. This time, the award for the most convincing solution went to the University of Dortmund.
www.fallstudienwettbewerb.de

Network analyzer for the University of Hanover

As part of a cooperation agreement, Rohde & Schwarz presented the University of Hanover with a vector network analyzer. Professor Ilona Rolfes from the faculty of radiofrequency engineering in Hanover accepted the R&S®ZVA24 from Jörg Fries, Head of the Product Management of Spectrum and Network Analyzers as well as EMC Test Equipment.

The students develop theories about specific problems, and then program and verify the results by using the analyzer. The results are subsequently exchanged with Rohde & Schwarz. "This is a valuable help for us because the faculty can contribute to our day-to-day work through additional research work", says Christian Evers, Head of the Center of Competence for Microwave Development and Production as well as Microelectronics. By using the analyzer, internships can now be performed in the the university's RF labs.

Josef Kirchner (second from right), Director of Broadcasting Test and Measurement Products, hands over the R&S®FSH3-TV to Prof. Dr Markus Stichler (second from left). Mathias Leutiger (left) and Christoph Balz (right) also give the professor valuable tips.

Rohde & Schwarz President and CEO Michael Vohrer (right) and the Dean of the Electrical Engineering Faculty, Prof. Dr Ulrich Wagner, sign the cooperation agreement.

Professor Ilona Rolfes gladly accepts the R&S®ZVA24 vector network analyzer from Jörg Fries.

The Rosenheim University of Applied Sciences receives an R&S®FSH3-TV

Rohde&Schwarz collaborates even more strongly with the universities.

Rohde&Schwarz recently presented the Rosenheim University of Applied Sciences with a Handheld TV Analyzer R&S®FSH3-TV. Each semester, 40 diploma candidates and master students are trained on the instrument, which allows them to gain their first experience in analyzing TV signals. Its simple operation makes the R&S®FSH3-TV ideal for use in training. Rohde&Schwarz believes that the students' interest in the company will be reflected in dissertations and internships.

Cooperation with the Technical University of Munich finalized

Already last year, the Technical University and the University of Applied Sciences of Munich received equipment and software worth a six-figure sum to equip their labs.

In signing the cooperation contract with Rohde&Schwarz, the Technical University of Munich has committed itself to recommending suitable trainee or working students as well as students writing their dissertations. Joint engineering workshops about current topics will also be performed. Plus, Rohde&Schwarz gets the opportunity to present itself at events and in relevant university media.

Rohde&Schwarz recruits more than half of its entry-level employees from graduates of the Technical University and the University of Applied Sciences of Munich.

New office in Hong Kong

ROHDE&SCHWARZ Hong Kong Ltd. office in operation since July 1, 2006.

Five employees will handle sales locally. To ensure a uniform market presence, Rohde&Schwarz Hong Kong took over the sales rights from the previous distributor, Electronic Scientific Engineering Ltd. Heino Gregorek is Managing Director and Regional Manager, Frank Wong General Manager. Gregorek – Regional Support Director for Asia/Pacific for the last five years – has been with Rohde&Schwarz for more than 25 years.

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A representative office in Hong Kong: Rohde&Schwarz in Kowloon.

EADS Astrium trains at Rohde&Schwarz UK

To familiarize themselves with radiofrequency engineering as well as spectrum and network analysis, 24 employees from EADS Astrium attended a fundamentals training seminar at Rohde&Schwarz UK in July.

The training offered theoretical and practical contents: The participants could sample the Rohde&Schwarz product portfolio and perform measurements using network and spectrum analyzers, signal generators and power meters.

Rohde&Schwarz UK offers these training seminars as an extra service to its key account customers from the military sector.

WiMAX Forum™ selects Rohde&Schwarz as a manufacturer of RCT systems

The WiMAX Forum™ (WMF), an industry-led non-profit corporation, was formed to promote and certify compatibility and interoperability of broadband wireless products. The Certification and Technical Working Groups (CWG/TWG) of the WMF have now selected Rohde&Schwarz as one of the manufacturers of radio conformance testers (RCT) in accordance with the mobile WiMAX IEEE 802.16e standard. The R&S®TS8970 test system, which is based on validated test cases, is a reference solution for the certification of WiMAX end products, which are manufactured in accordance with the IEEE802.16e-2005 specification.

Welcome to the club

In May, Rohde&Schwarz China again organized a user club meeting for its customers who work with civil radiomonitoring systems. The event was staged in Wuhan in the province of Hubei. Since the 1990s, the meeting has served as a platform for users to exchange views regarding Rohde&Schwarz equipment. Rohde&Schwarz, in turn, can get valuable ideas for future product development as new trends are presented and discussed. The meeting is held on an annual to biannual basis in different Chinese provinces.

In addition to the staff from the Beijing office, participants from Rohde&Schwarz Munich and numerous honorary guests from industry and politics attended the meeting.

ROHDE & SCHWARZ

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