Universal Radio Communication Tester CMU200

Successful mobile-radio tester now with US TDMA and AMPS standards

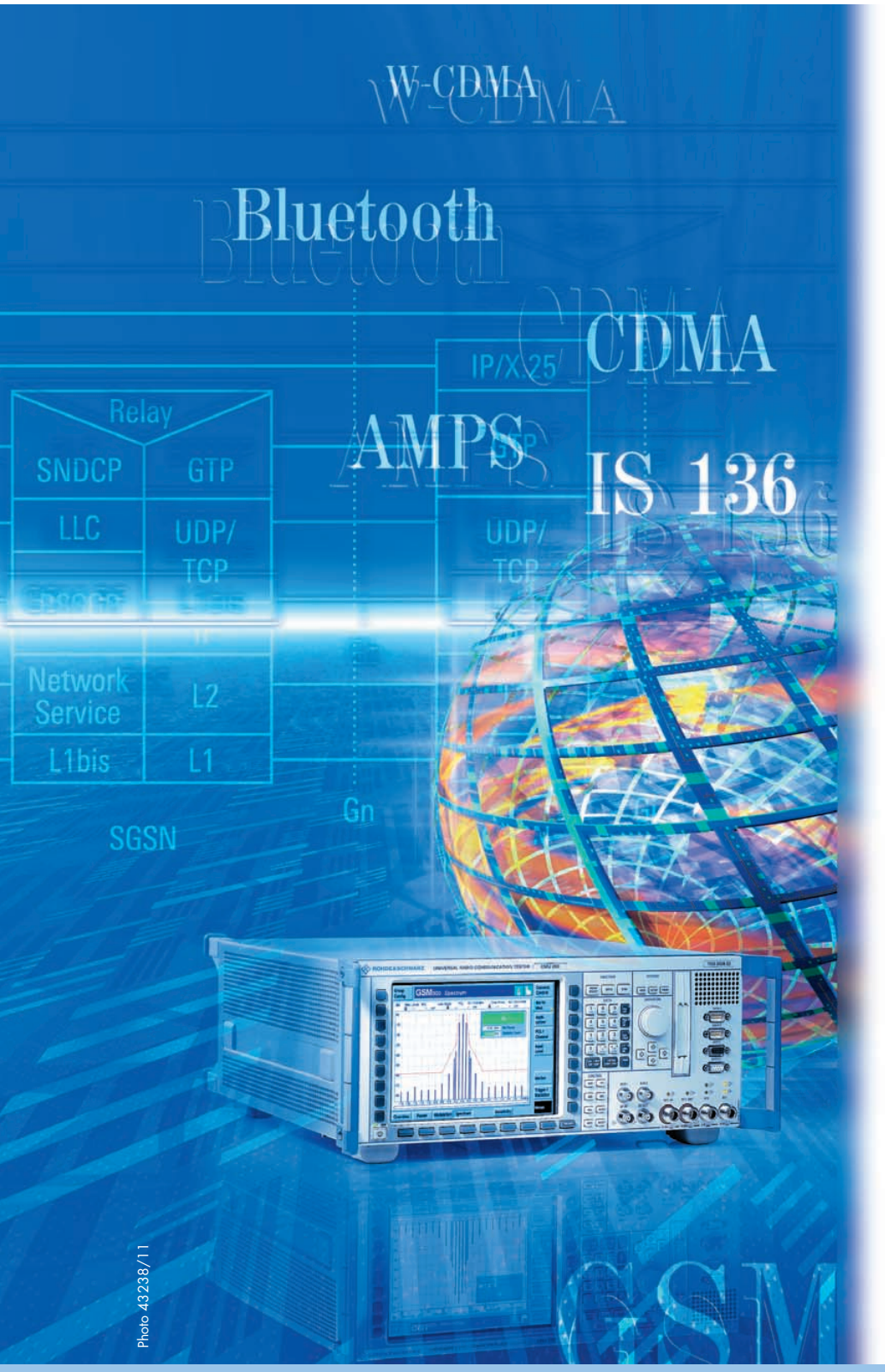


Photo 43238/11

Digital TDMA standard

TDMA (time-division multiple access) is a mobile-radio system based on the TIA/EIA-136 standard, a system similar to GSM. TDMA is used in the United States and South America in the cellular band (800 MHz) and the PCS band (1900 MHz). CMU200 covers both versions with Software CMU-K27 and CMU-K28. The narrow TDMA channel bandwidth of 30 kHz was chosen for reasons of compatibility with analog AMPS. TDMA is in fact a digital extension of AMPS and for this reason is also referred to as DAMPS (digital AMPS) (for more information on AMPS see page 14).

TDMA triples AMPS capacity while boosting speech quality. Users of TDMA mobile phones profit from the advantages of the digital system mainly in conurbations, whereas across the vast expanses of the American continent the excellent coverage provided by AMPS comes into its own.

TDMA fits three calls into the 30 kHz bandwidth, the time being divided into 40 ms frames, each with six timeslots of 6.66 ms. Each call occupies two timeslots, ie the 1st and 4th, 2nd and 5th, or 3rd and 6th slot, meaning that each mobile sends a burst every third timeslot.

The modulation mode used is $\pi/4$ DQPSK (differential quadrature phase-shift keying). Each burst transmits 162 symbols. With every symbol encoding two bits, a total of 324 bits is transmitted.

Universal Radio Communication Tester CMU200 (photo left) is proving itself as a tester for all GSM versions in many mobile-phone production lines all over the world. Now it comes with two extra functions for non-GSM networks – the US TDMA (IS-136) and AMPS standards. Unlike the situation in Europe, there are three competing digital mobile-radio networks in the United States: GSM, CDMA (IS-95) and TDMA (IS-136). Outside the USA, TDMA is becoming increasingly important in South America, which means a significant enlargement of its market. And there is a fourth system, analog AMPS, which serves as the second mode in CDMA and TDMA mobiles, so that a radio tester for their production and service must be able to handle the standard of the first-generation network too.

TDMA measurements in detail

Similar to the case with GSM, CMU200 [1] offers clear pop-up menus for all TDMA measurements; its operating concept is identical for all networks. Remote-control programs created for one network can for the most part also be used for other networks.

The tester offers statistical evaluation and automatic limit-value checks for most measurements. Averaging is carried out by signal processors in the background, so measurement time is not slowed down by the output of pictures.

Measurements are possible both in the signalling mode (with a call set up) and non-signalling mode. The latter is suitable for modules that do not allow complete call setup. For these measurements CMU200's transmitter and receiver can be set in the frequency range 10 MHz to 2.7 GHz separately and independently of frequency band and channel spacing.

Power versus time

For TDMA systems it is essential that power be switched on and off exactly at the right times. The standard stipulates a 100 kHz filter for power-versus-time measurements. Since this is not a matched filter, power is not constant, not even at the symbol times. Power versus time can be displayed with simple or eightfold oversampling. Marked power drops dependent on the modulation mode are visible only with a factor of 8 (FIG 1).

Leakage power is the transmit power of a mobile between bursts. Here a maximum level of –60 dBm is allowed. High transmit power of the mobile calls for a wide dynamic range; for example, 30 dBm transmit power necessitates a dynamic range of 90 dB to check the stipulated switch-off level. This is not possible with a test filter of 100 kHz bandwidth in one and the same measurement. So CMU200 automatically performs a two-step measurement with range switching, thus providing the required dynamic range.

For power-versus-time measurements in signalling mode, CMU200 features another application, ie checking of what are called shortened bursts. Shortened bursts are used for timeslot synchronization during handoff and call setup. If this application is selected, the signalling unit of the tester causes the mobile to send shortened bursts and evaluates them in the power-versus-time measurement.

FIG 1 Results of power-versus-time measurement with eightfold oversampling shown in tolerance mask. A defective mobile would disturb communication in the adjacent timeslot

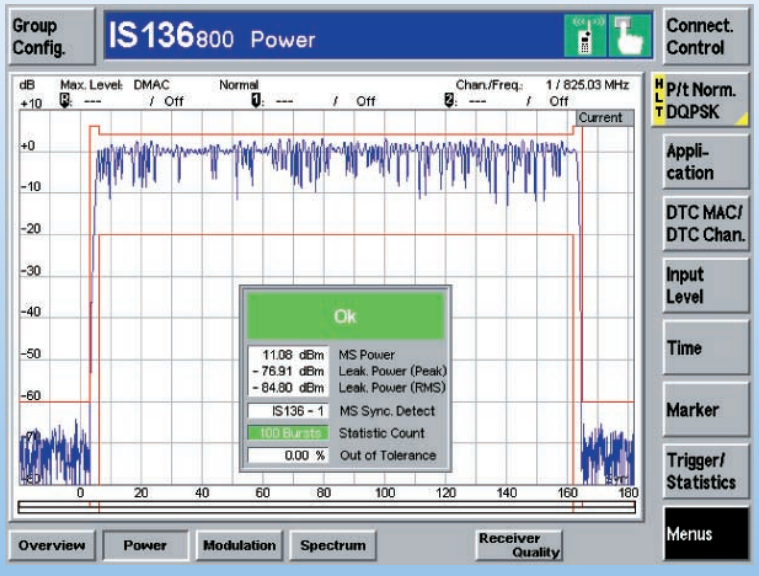
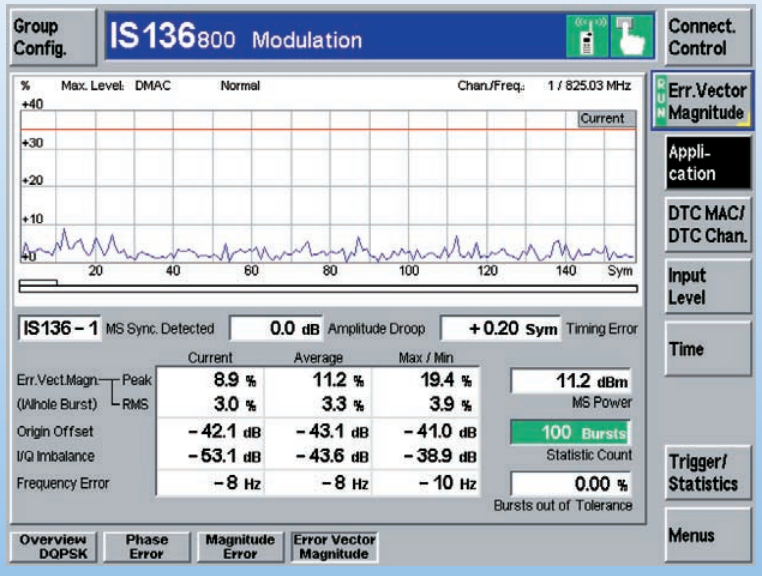


FIG 2 Simultaneous and clear presentation of all results of modulation analysis with CMU200



Modulation analysis

Modulation quality is analyzed by measuring the error vector magnitude (EVM). The tester determines the error vector, ie the vector between the ideal and measured signal, at the symbol times and outputs the magnitude versus time. From the resulting data record, further parameters like peak EVM and rms EVM are calculated.

To be able to use the measured data record for determining EVM however, other modulation errors like frequency error, timing error, origin offset and I/Q imbalance have to be determined and corrected in the data record. According to definition, they do not contribute to EVM and are to be regarded as separate error sources. CMU200 calculates all these parameters simultaneously and presents them in clear form (FIG 2).

CMU200 offers two more applications in modulation analysis: phase-error and magnitude-error measurement. As with EVM, these major parameters are output in graphical and numerical form. The overview menu for modulation analysis presents all numerical results at a glance (FIG 3). Measurements are repeated at a fast rate, allowing realtime adjustment of mobile-phone parameters.

Spectral measurements

The standard calls for measurements in the three nearest adjacent channels above and below the transmission channel. A distinction is made between two types of interference spectrum. Firstly, there are transients caused by switching power on and off. They occur at the beginning and end of the burst (spectrum due to switching). These spectral components are determined in a peak-value measurement (ACP peak).

The second type of interference spectrum is caused by modulation (spectrum due to modulation). The spectral components can be determined by averaging adjacent-channel power over a defined range in the middle of the burst (ACP rms). Here too, CMU200 stands out for extremely high measurement speed. It covers all seven channels in a single broadband measurement (FIG 4) and provides a statistical evaluation of results.

For more in-depth analysis, for example of outliers, each channel can be displayed in the time domain and analyzed by the ACP Time Domain application. In this way the cause of excessive adjacent-channel power can be analyzed, for example high switching transients at one of the two edges (FIG 5).

Receiver measurements

Receiver measurements usually focus on bit error rate (BER); in CMU200 they can be found in the Receiver Quality menu. The TDMA standard specifies a special mode of the mobile phone for BER in which it is able to establish a voice channel independently – ie without signalling – and return received data to the tester for evaluation (loopback). BER measurement for TDMA is therefore included in the non-signalling group. An RF generator creates the voice channel with random data, to which the mobile synchronizes in the service mode. The bit errors are then evaluated in the Receiver Quality menu.

During a call, the mobile sends information to the base station. From this

FIG 3 Summary of all numerical results of modulation analysis in Overview menu

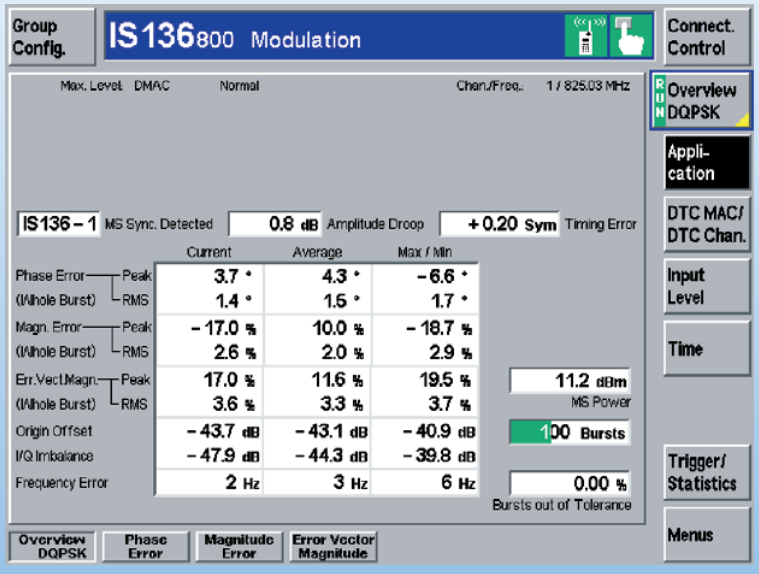
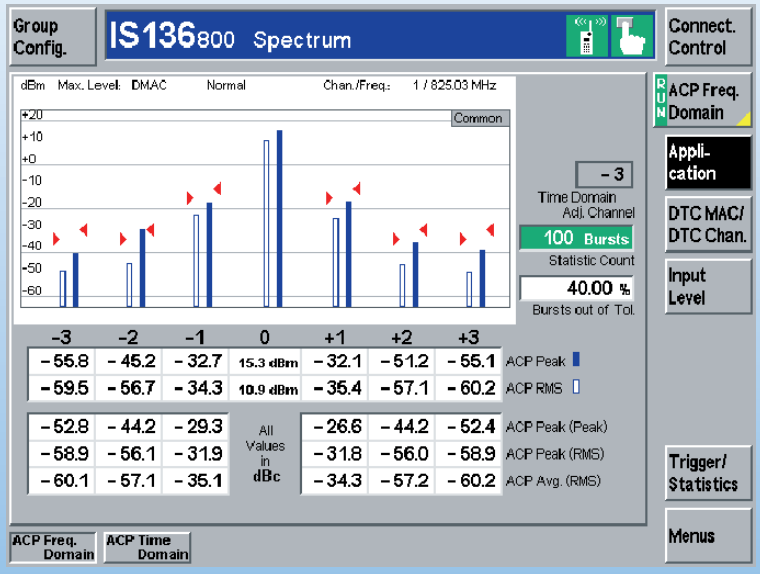


FIG 4 Spectrum due to modulation. In addition to current results, longterm peak value (ACP Peak (Peak)), max. rms value (ACP Peak (RMS)) and average rms value (ACP Avg (RMS)) are output for all channels



information, the base station decides whether its transmit level has to be adjusted or the call handed over to another base station. CMU200 presents all information received from the mobile in the Receiver Quality menu (FIG 6).

The values for BER and RSSI (radio signal strength indicator) refer to the currently active voice channel used by the mobile and the base station. BER is the bit error rate in coarse steps that the mobile recognizes during reception. RSSI is the power of the base station measured on the mobile's antenna. Apart from information about its own channel, the mobile transmits power values measured on up to 24 adjacent channels. The channels to be logged are signalled to the mobile by the base station. These channels can be selected from a list in the Connection Control/ Network menu.

Handoffs

CMU200 of course supports all basic signalling functions such as registration, call setup, channel and timeslot handoff. Since TDMA mobiles usually support the three systems TDM (800 MHz), TDMA (1900 MHz) and AMPS, handoffs, ie changes between these systems, play an important role. CMU200 offers handoff from any of the three networks into any other.

Handoffs not only serve for testing the handoff capability of mobiles. In production, they are used for rapidly changing from one band or network to the next, thus saving the time required for renewed registration and call setup.

An interesting feature of CMU200 is the possibility of defining the mobile's response after breakdown of a call in a new network. There are two possible versions: the old control channel in the old network still exists, or a new control channel is set up in the new system. Here, the mobile's response and roaming time are of interest, ie the time the mobile needs to find a new control channel and, if necessary, register anew. The handoff menu provides for complete handoff and handoff with fallback, the latter meaning a return to the original network after a call breakdown.

Other calls

Standard IS-54 is a step on the way to TDMA. Although it utilizes analog AMPS control channels, the voice channel is digital. It also tripled voice-channel capacity. This mechanism still exists in the system. Plus, if a mobile is registered in one of the three networks, the protocol enables direct call setup to any other network. CMU200 supports these versions too.

AMPS measurements in detail

Here, classic analog measurement engineering is used, in which CMU200 is also at home thanks to its flexible, signal-processor-based concept. Measurements are organized into FM and audio measurements for transmitters and receivers. AMPS measurements are possible in signalling and non-signalling mode, which corresponds to normal call and service mode. In non-signalling mode, the full CMU200 frequency range from 10 MHz to 2.7 GHz is available with 1 Hz resolution. So this mode is also suitable for measurements on modules or for analyzing intermediate frequencies.

FIG 5 Excessive adjacent-channel power caused by high switching transients

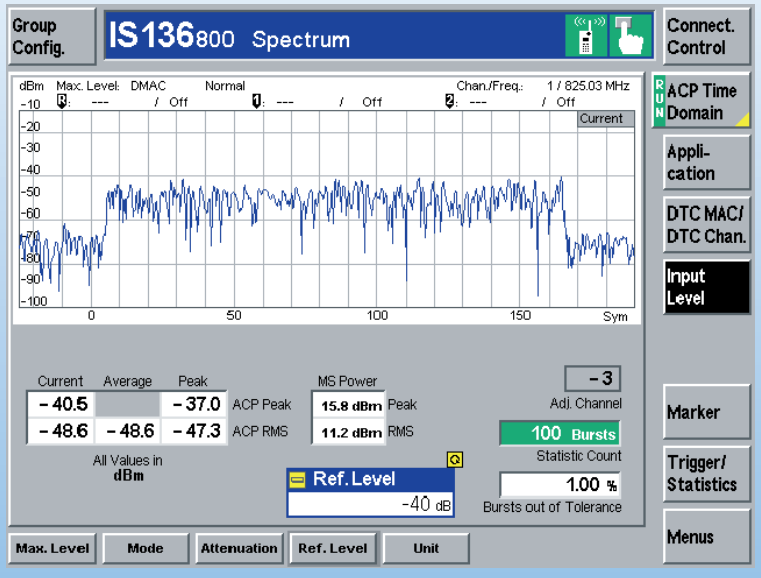
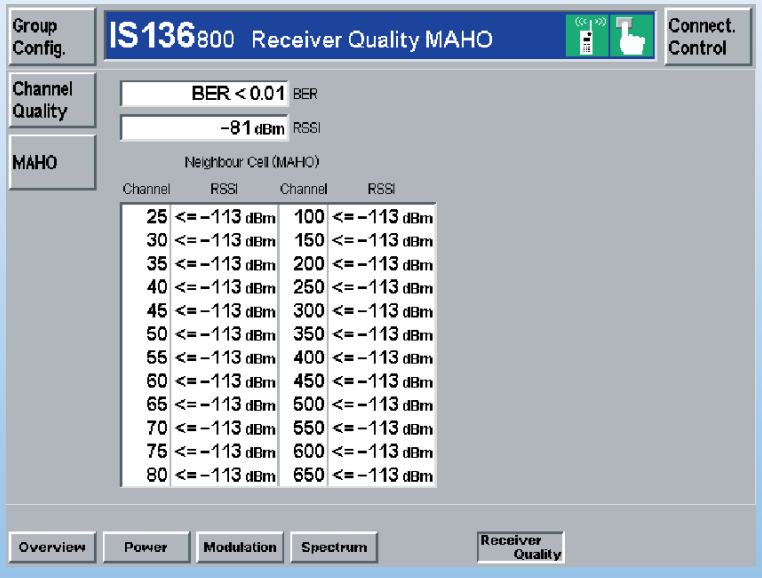


FIG 6 Mobile-assisted handoff (MAHO): information sent by mobile to base station is listed in Receiver Quality menu of CMU200 signalling function group



Analog AMPS standard

AMPS (advanced mobile phone system) is an analog standard of the first generation based on frequency modulation in the 800 MHz band [2]. Channel bandwidth is 30 kHz, as with TDMA. Signalling information is partly transmitted in the form of simple tones (SAT and ST), and for longer telegrams – especially in the control channel – in the form of PSK-modulated AF signals at 10 kbit/s.

It is still hard to imagine North and South American mobile radio without the "old" analog AMPS; its unparalleled advantage is excellent coverage. In addition to the modern networks, CMU200 supports AMPS, which still features in all CDMA and TDMA mobiles as a second mode. This combination benefits from the advantages of both techniques, ie the good coverage provided by AMPS and the quality offered by digital networks. Option CMU-K29 adds AMPS functionality to Radio Communication Tester CMU200, firming its reputation as a highly versatile multimode tester.

Audio measurements can be performed with option CMU-B41, which is entirely based on digital signal processing. The filters in the audio path can be set over wide ranges. To ensure maximum ease of operation despite this high versatility, the default settings of filters and signals paths are those of the test specifications.

In signalling mode the Analyzer/Generator and Overview menus provide a fast overview of the main measurements and settings (FIG 7).

Transmitter tests

In the TX Tests/Modulation menu, all static transmitter measurements are carried out simultaneously (FIG 8). "Static" means measurements performed continuously with constant instrument settings.

The **transmitter hum & noise** measurement is carried out in two steps and is therefore separate from static measurements. In this application, two audio deviation measurements – with and without predefined modulation of the mobile transmitter – are performed. At the same time a modulated RF carrier is applied to the receiver. In the second step, the hum caused by crosstalk of the demodulator is measured. The hum & noise result is the ratio of the two measured results in dB.

A special feature is **AF level search**. This finds the level of the CMU200 AF generator at which the desired target deviation of the mobile modulator is obtained. Since the deviation of the mobile transmitter is precisely defined for all modulation measurements and deviation varies from mobile to mobile, this is a highly efficient means of fulfilling the test specification. In this search routine, the user can freely select the start level and accuracy with which the target deviation has to be found. The required AF level is in most cases approximately known, so measurement time can be reduced to a fraction of a second. This is not possible with an IEC/IEEE-bus search routine or with manual control.

Checking the **AF frequency response** is a very complex transmitter measurement. Test specifications stipulate a time-consuming sweep across the audio frequency range. With its TX Audio

FIG 7 Main measurements at a glance: analyzer results and settings are shown on left, generator settings on right

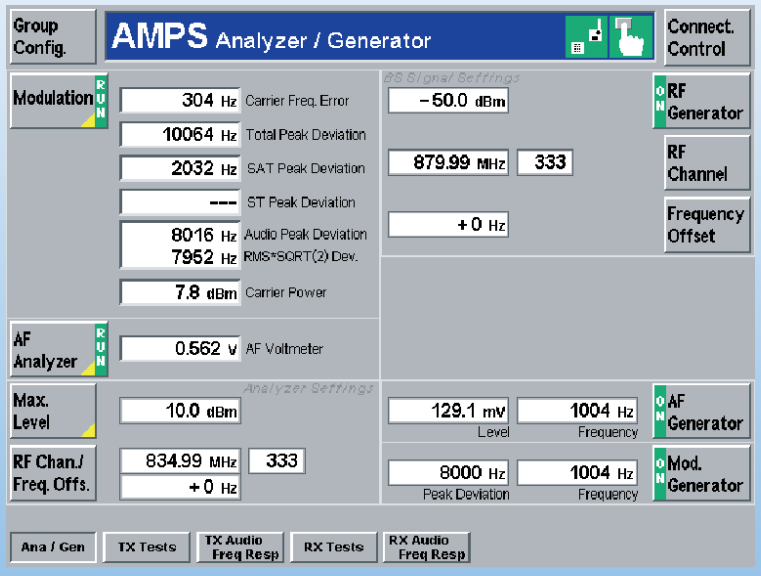
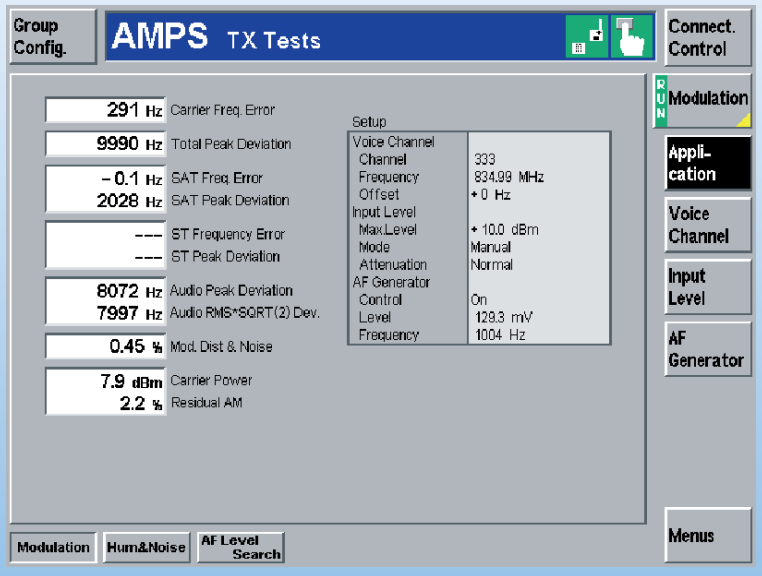


FIG 8 TX Tests/Modulation menu: all current instrument settings are shown on right. Frequency as well as AF generator level and frequency can be set with softkeys on right



Frequency Response menu, CMU200 offers a much faster alternative: it generates up to 20 simultaneous tones with freely selectable frequency and level. This composite signal is then used to modulate the mobile transmitter. The analyzer measures the levels of the returned and demodulated tones. The audio frequency response is thus checked in one go (FIG 9).

Receiver tests

The RX Tests menu (FIG 10) offers more in-depth receiver measurements. The AF signal demodulated by the mobile is evaluated. The AF analyzer measures the rms value, SINAD and distortion at the same time. For maximum measurement speed in production, CMU200 has a special SINAD remote-control command with selectable length of the test interval.

The **receiver hum & noise** application is a two-step measurement. In this case, the hum on the demodulated AF signal is measured, caused for example by crosstalk of the mobile transmitter on the demodulator.

Another application is **receiver sensitivity**. This parameter is defined as the input signal level at which the SINAD of the demodulated signal is still 12 dB. CMU200 performs this complex search automatically and at high speed.

Just as for transmitters, a time-consuming sweep is stipulated for checking **receiver AF frequency response**. CMU200 again offers multitone analysis, the RX Audio Frequency Response measurement, as an alternative.

State-of-the-art measurement capability

In the advanced features of CMU200, Rohde&Schwarz puts "old" mobile-radio measurement techniques on a new footing, satisfying the high standards of mobile-radio production in the AMPS sector too.

Ralf Plaumann

Reader service card 168/03

REFERENCES

[1] Mittermaier, Werner; Schmitz, Walter: Universal Radio Communication Tester CMU200 – On the fast lane into the mobile radio future. News from Rohde&Schwarz (1999) No. 165, pp 4–7

[2] Rösner, Thomas: Digital Radiocommunication Tester CMD80 – CDMA, AMPS and IS-136 measurements with one unit. News from Rohde&Schwarz (1999) No. 165, pp 10–12

FIG 9 Measurement of audio frequency response. Preset tolerance limits (red) mark expected preemphasis frequency response of transmitter. They are freely configurable

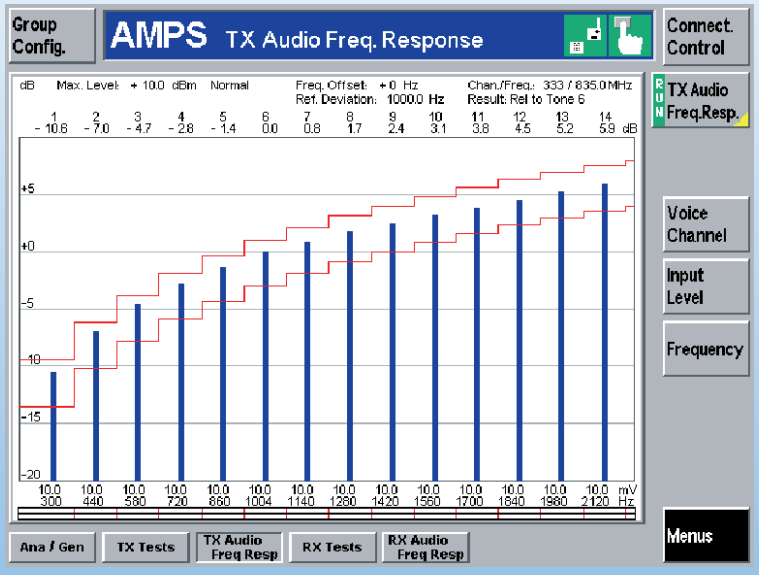


FIG 10 AMPS RX Tests menu for more in-depth receiver measurements. Current generator settings are listed on right