



Products: R&S CMU200 (B 21 and B21v14 with B54v14, B41, K29), CMUgo

Measurements on AMPS Phones with the R&S CMU200 and CMUgo

Application Note

This application note describes how to test and perform measurements on AMPS phones both using the remote-control program CMUgo and manually at the R&S CMU200.



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1 Overview

The Radio Communication Tester R&S CMU200 can be used to perform fast and accurate measurements of different mobile radio standards such as GSM, TDMA IS 136, CDMA IS 95A, cdma2000, Bluetooth, WCDMA and AMPS. This application note is based on CMUgo, a Windows application for remote control of the R&S CMU200. It explains how the AMPS tests provided in CMUgo have been implemented. The required remote-control sequences are also explained in particular detail. These remote-control sequences are highlighted in blue. Additionally, the necessary settings and procedures, which in part originate from the test

specifications, are described and the results of the measurements interpreted.

2 Remote Control of the R&S CMU200 with CMUgo

Software features

CMUgo offers a simple user interface for remote control of the R&S CMU200 for all standards available on the R&S CMU200 via a GPIB bus (IEEE488.2) and via the RS232 interface. CMUgo can be used to output test reports. Moreover, a report of remote-control commands with the times of the individual items can be output and the remote-control commands can be copied directly to the Windows clipboard for further processing.

Hardware and software requirements

Hardware requirements

- CPU: min. 300 MHz
- RAM: min. 64 Mbyte
- Monitor: SVGA with min. 800 x 600 pixels
- Hard disk: 50 Mbyte of free memory
- Peripherals: National Instruments GPIB bus or RS232 interface
- Mouse

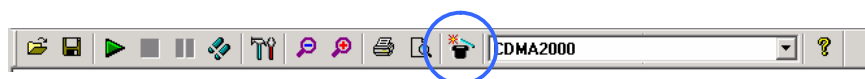
Software requirements

- Windows 98 / ME / 2000 / XP
- CMUgo V1.40
- AMPS module V1.40

Using CMUgo

Read the CMUgo manual [2]. It explains how to connect your computer to the R&S CMU200, how to install the program and how to start CMUgo. It also describes basic operation of CMUgo.

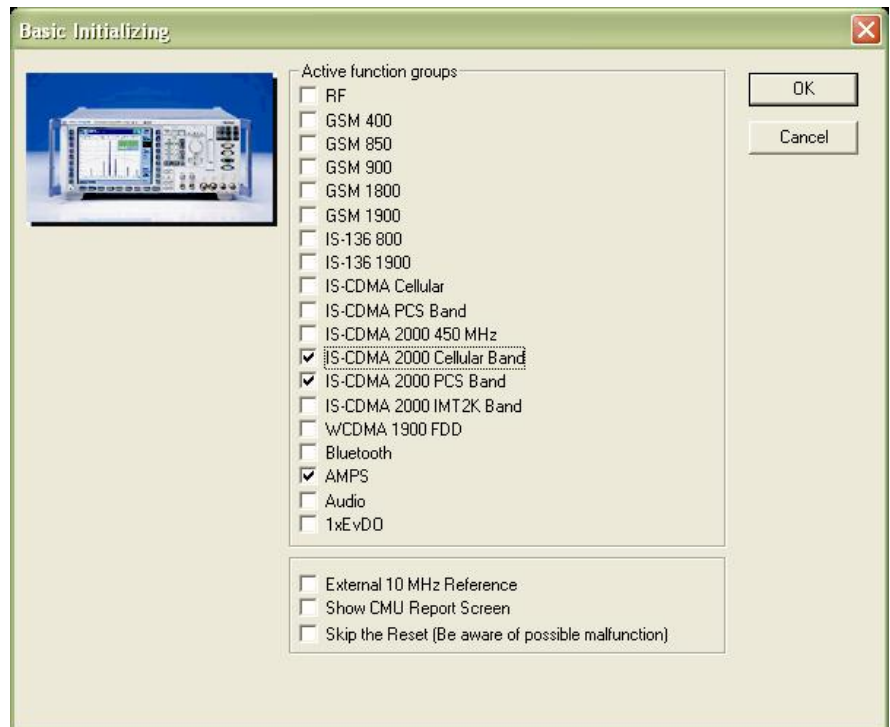
The remote-control sequence can be output using the **Demo** function of CMUgo. You can select this function in the CMUgo toolbar.



Individual sequences can then be created based on this sequence. CMUgo executes the measurement procedures as quickly as possible. Since the program is structured as a sequencer with modules which have been developed independently and which can be used independently, it is sometimes possible to save time by making additional optimizations. As a result, for example, attenuation value settings or level settings are performed even if the value has not changed compared to the previous test item. In the case of time-consuming signalling processes such as

change of channel, the state of the R&S CMU200 is queried before it is decided whether a change of channel is actually required. If necessary, this query can also be removed in a derived sequence. Every test sequence in CMUgo must begin with the “Basic Initializing” test item.

3 Basic Initializing



“Basic Initializing” is always at the beginning of a remote-control sequence. In this test item the available CMU options are queried and “address mapping” (i.e. the assignment of the individual secondary addresses to the respective function groups) is performed.

To minimize the time required for the initialization routine, all function groups which are not involved should be deactivated.

In the bottom block it is possible to select whether an external reference frequency is to be used. You can also choose whether the CMU screen is to show the remote-control sequences.

To save time, it is also possible to disable the “Reset” (i.e. the function used to reset the R&S CMU200 to its default state). However, you must know the precise state of the instrument prior to resetting since in test functions CMUgo does not usually send settings to the instrument unless these settings differ from the default instrument state.

The individual items when executing this test item are:

- Query the CMU and the installed firmware versions.
- Query the CMU options.
- Set the secondary address 0 if the serial interface is used.
- Reset the instrument to its initial state.

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- Prevent the instrument from losing the connection in the case of “Local/Remote” transitions.

```
*IDN?
```

```
*OPT?
```

```
*SEC 0
```

```
SYST:NONV:DIS
```

```
*CLS;*RST;*OPC?
```

```
SYST:GTRM:COMP OFF
```

- Display the received remote-control commands and sent measured values on the CMU screen. The default setting is OFF.
- Use the internal reference frequency.

```
TRAC:REM:MODE:DISP OFF
```

```
CONF:SYNC:FREQ:REF:MODE INT
```

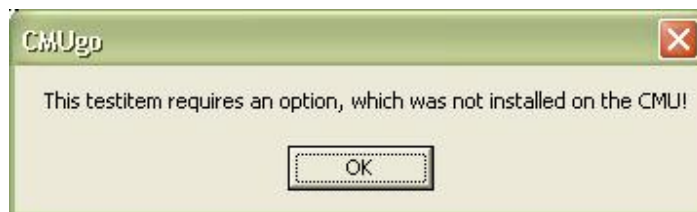
- Reset the status byte to “0”.
- Assign the secondary address 1 for the function group “AMPS Signalling”.
- Assign the secondary address 2 for the function group “AMPS Non-Signalling”.
- Query whether the assignment of the secondary addresses has caused an error. Generally speaking, it is possible to determine whether the “K29” software option has been installed by querying the options described above. However, AMPS could also be available as a result of the “K0” demo option. In addition to this, it is also possible to deactivate individual function groups although the software option has been installed. AMPS function groups are therefore simply addressed by trial and error. In the case of an error, the status byte query will not return “0” but rather “4” to indicate that the error flag of the status byte has been set.

```
*CLS;SYST:REM:ADDR:SEC 1,"AMPSMS_Sig"
```

```
SYST:REM:ADDR:SEC 2,"AMPSMS_NSig"
```

```
*STB?
```

An error message is output during the test if the AMPS option has been deselected or the K29 software option has not been installed on the R&S CMU200.



Remember that CMUgo handles the subaddresses dynamically. The subaddress may therefore change depending on the number of found software options. In the majority of remote-control sequences described in this application note, the subaddress for the function group “AMPS Signalling” is subaddress 1.

Secondary addressing of the R&S CMU200

In examples which deal with the use of 2 function groups (e.g. “handoff” or “fallback” procedures), the instrument is addressed by means of three independent subaddresses. The first subaddress refers to the R&S CMU200 base system and always has a fixed address assignment to the subaddress 0. The second subaddress is the original network, e.g. “cdma2000 Cellular Signalling”, and the third subaddress is the secondary address of the target network (in our case the function group “AMPS Signalling”). The CMU can be addressed in two different ways, described in the following two paragraphs.

Using a dedicated “handle” for each secondary address

Before you can address an instrument on the GPIB bus, you must obtain a “handle” for this instrument. How to do this varies depending on the driver of the used GPIB controller card. With GPIB controller cards from National Instruments, the necessary function is called “ibdev” or “ibfind”.

```
int h_BASE;  
// GPIB board index  
#define BdIdx 0  
// Primary address  
#define pad 20  
// Secondary address for Base Definition (National Instruments specific)  
#define sad 96  
// Timeout  
#define tmo T_30s  
// EOT  
#define eot (int) 1  
// EOS  
#define eos (int) 0
```

```
h_Base = ibdev (BdIdx, pad, sad, tmo, eot, eos);
```

The example in “C” generates a “handle” for accessing the R&S CMU200 base system. The primary address 20 (pad) and the secondary address 0 (sad) are used together with the appropriate timeout and terminator. With controllers from National Instruments, an integer value of 96 is given for a secondary address 0, an integer value of 97 for a secondary address 1, and so on. This offset of 96 is not used for GPIB bus controllers from other manufacturers. With controllers from other manufacturers, the primary address and secondary address are frequently combined in one integer value, i.e. “2000” for primary address “20” and secondary address “00”, “2001” for primary address “20” and secondary address “01”, and so on.

If you now want to address another function group of the R&S CMU200, you can generate another handle to this function group.

```
int h_AMPS_Sig;  
#define sad_amps sad+1  
  
h_AMPS_Sig = ibdev (BdIdx, pad, sad, tmo, eot, eos);
```


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The function group “AMPS MS Signalling” now has its own “handle”. If you write a command to the base address of the R&S CMU200, the associated “handle” is used, as is the case for the identification code “*IDN?” in this example.

```
ibwrt(h_Base, "*IDN?", 5);
```

However, if you then want to address the function group “AMPS MS Signalling”, you use the “AMPS Handle”, as shown here for setting the autoranging mode.

```
ibwrt(h_AMPS_Sig, "LEV:MODE AUT", 12);
```

However, before doing this, do not forget to define the “address mapping” of the R&S CMU200, e.g. with the following command which is sent to the base address.

```
SYST:REM:ADDR:SEC 1,"AMPSMS_Sig"
```

Using only one handle

Another possibility is to use only one handle, i.e. the handle of the function group “Base” (the base system). Here a number followed by a semicolon is placed in front of the command. The command for the function group “AMPS MS Signalling” described above then has the following appearance.

```
ibwrt(h_Base, "1;LEV:MODE AUT", 14);
```

This “remapping” mode of the R&S CMU200 is used with CMUgo. The sequences shown are all based on this mode.

Once again, before doing this, do not forget to define the “address mapping” of the R&S CMU200, e.g. with the following command which is sent to the base address.

```
SYST:REM:ADDR:SEC 1,"AMPSMS_Sig"
```

4 Mobile Radio Standard AMPS

AMPS is one of the oldest mobile radio standards still encountered in the consumer goods sector. It is predominantly found in connection with the TDMA IS 136 mobile radio standard or with mobile phones based on the CDMA IS 95 standard (also known as cdmaOne). While these then new digital standards were rapidly implemented in urban centers, the already existing analog standard AMPS ensured coverage in less densely populated areas. The widespread digital standards of the 2nd generation (which include GSM, TDMA IS 136, CDMA IS 95A) have since been joined by extensions to these standards, such as GPRS, EGPRS and cdma2000. These are often referred to as “2.5 generation” standards. The third generation is, however, already waiting in the wings with the new standard WCDMA FDD (also known as UMTS) and 1xEvDO / 1xEvDV as extensions to cdma2000. However, some already regard cdma2000 as a standard of the third mobile radio generation. This is likely to be of less relevance to the end users of these phones than to those who are responsible for marketing the instruments. The focus of these mobile radio generations could be described in the following way. If the objective of the 1st generation was primarily to enable the actual use of mobile phones, the objective of the second generation was to make calls less susceptible to interference. The extensions to these standards in generation 2.5 were aimed at improving mobile data communication. In the third generation, emphasis is increasingly being placed on the more efficient use of the

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existing resources. After all, more and more people with ever increasing data rates will be using mobile phones in the future. Anyone recognizing the superiority of digital standards in mobile radio telecommunications will find it increasingly difficult to get along with “analog” measurements and test routines. The philosophy behind these tests is also completely different in one crucial point. The influence of “spoken language”, i.e. the audio signal, on the RF signal to be sent is always present in AMPS. In digital standards, however, the testing of an audio signal is of secondary importance. The audio test, which is an essential element of AMPS, is at best used for verifying the AF signal path in digital standards. The results of audio tests for digital standards could equally be obtained by answering the following question: Are the microphone and loudspeaker connected correctly?

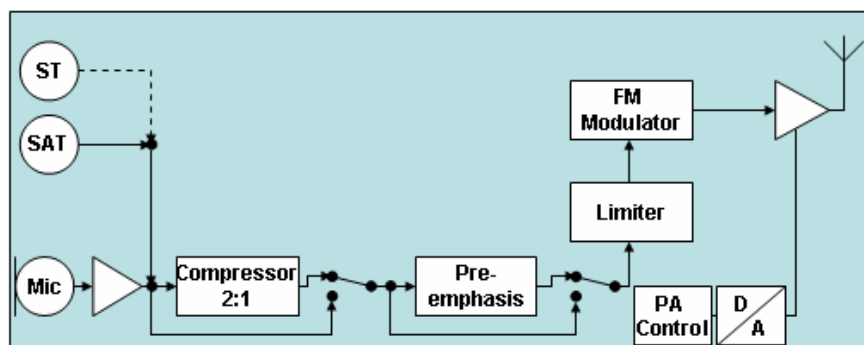
With AMPS, however, you must first decide which audio filter is appropriate for which measurement. Then there is the recurrent question as to which audio level must be applied in order to achieve a particular deviation of the RF output signal.

AMPS uses frequency modulation. The individual phone users are distinguished in the conventional way using FDMA (Frequency Division Multiple Access). The individual channels are arranged with a channel spacing of 30 kHz. The maximum deviation of the signal should therefore not be greater than 11 kHz in order to prevent interference on the adjacent channel.

The voice band between 300 Hz and 3.4 kHz is also joined by the SAT (Supervisory Audio Tone) and, if applicable, the ST (Signalling Tone).

5 TX Signal Path in AMPS

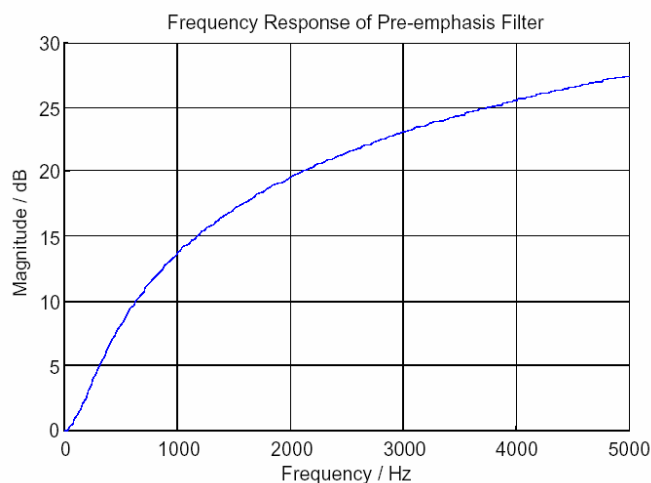
The block diagram below shows the structure of the transmission path for an AMPS mobile phone.



In the AMPS phone, the amplified audio signal from the microphone first enters a “compressor”. The reference deviation for AMPS is 2.9 kHz. This means that the audio signal should generate a deviation of 2.9 kHz at full-scale level. The relationship between audio signal level and deviation is, however, not linear. A 6-dB-lower input level attenuates the deviation by only 3 dB. A 6-dB-higher audio signal amplifies the deviation by only 3 dB.

As is usual with analog transmission systems, higher frequencies are amplified and lower frequencies are attenuated. This is referred to as a “pre-emphasis filter”.

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The signal is then limited by a limiter to ensure that the channel bandwidth is not exceeded, thus preventing interference on adjacent channels.

The signal then enters the FM modulator and is transmitted as an amplified RF signal. The output power of the AMPS phone can be set in levels. These levels are referred to as “**Mobile Attenuation Codes (MAC)**”. The assignment of output power to MAC value depends on the mobile phone class.

MAC	RF output power in dBm			
	Class I	Class II	Class III	Class IV
0	36	32	28	28
1	32	32	28	28
2	28	28	28	28
3	24	24	24	24
4	20	20	20	20
5	16	16	16	16
6	12	12	12	12
7	8	8	8	8

Apart from the actual audio signal, signalling tones are also generated and transmitted together with the audio signal (the “SAT tone” and “ST tone”).

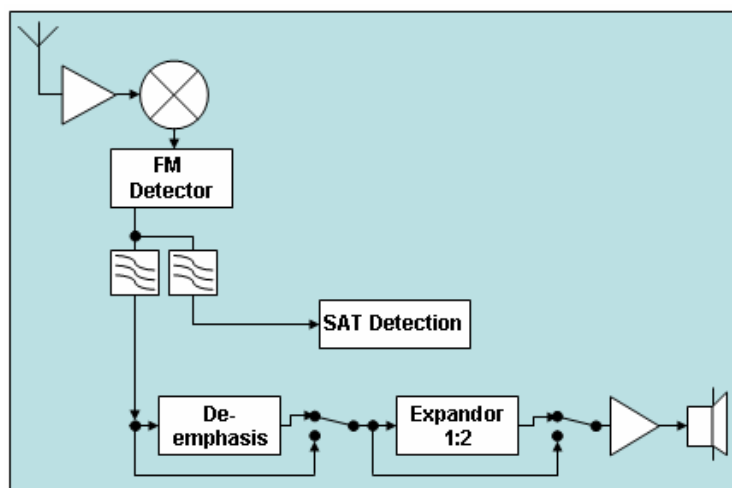
The “**Supervisory Audio Tone**” is continuously transmitted at a frequency of 5970 Hz, 6000 Hz or 6030 Hz. The “**SAT Color Code (SCC)**” “0”, “1” or “2” determines which frequency is used.

The “**Signalling Tone**” is emitted at 10 kHz while signalling is occurring.

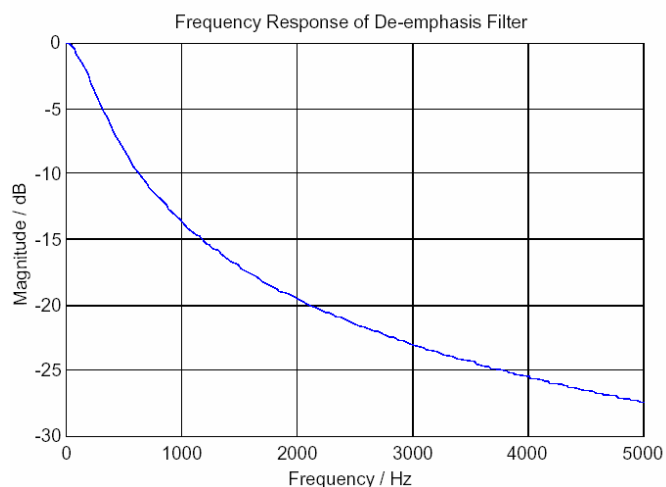
6 RX Signal Path in AMPS

The block diagram below shows the structure of the reception path for an AMPS mobile phone.

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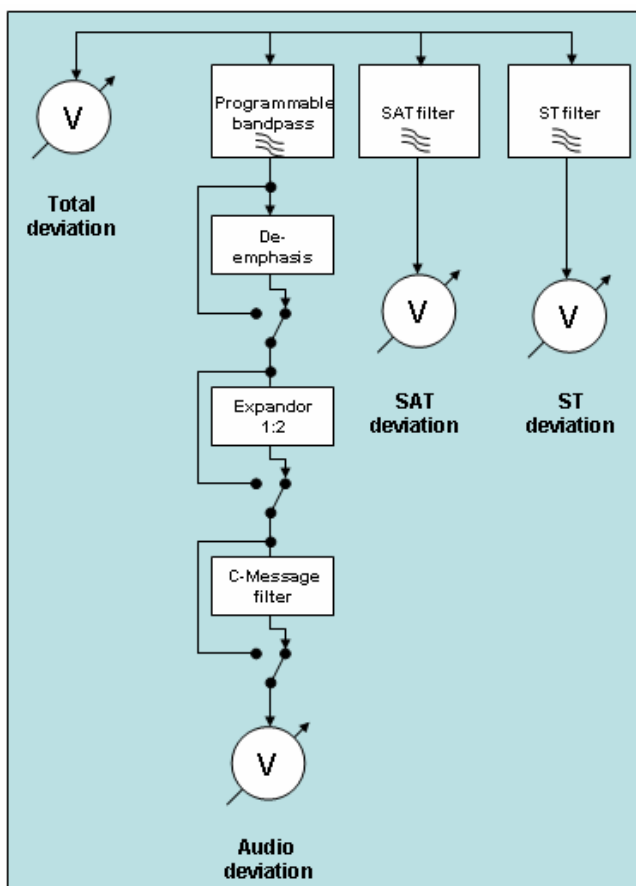
The RF signal is mixed with the baseband and is passed on to an FM detector. Depending on the “SAT Color Code (SCC)”, the signal components “voice” (300 Hz to 4 kHz) and “Supervisory Audio Tone” (5970 Hz, 6000 Hz or 6030 Hz) are filtered out of the demodulated signal.



The audio signal is passed on to the “de-emphasis filter” which should cancel out the effect of the “emphasis filter”. The “expander” is next. This is the counterpart of the “compressor”. With an input deviation of 2.9 kHz, the audio reference level thus returns to 0 dB. An input deviation of -3 dB results in an audio signal which is lower than -6 dB. A 3-dB-higher deviation results in a 6-dB-higher output signal.

The audio signal is then amplified and output at the loudspeaker.

7 Measuring Path of the R&S CMU200

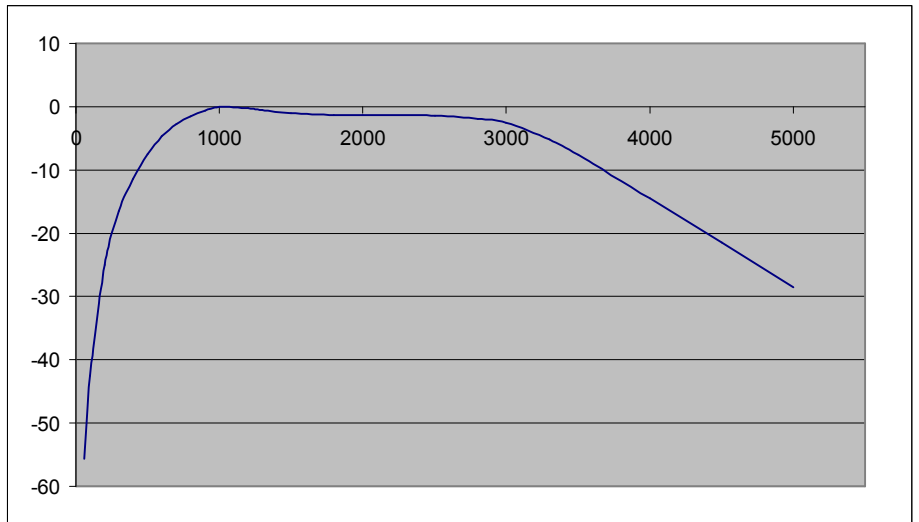


The measuring path of the R&S CMU200 shown in simplified form above is similar in structure to the RX path of the mobile phone. Measurement of the deviation is divided into four components: total deviation, SAT deviation, ST deviation and, of course, audio deviation. The bandpass filter for measuring the SAT is determined automatically according to the set “**SAT Color Code (SCC)**”.

SCC	SAT frequency
0	5970 Hz
1	6000 Hz
2	6030 Hz

The individual filters can be programmed (i.e. jumpered in the signal path). The test specification for AMPS specifies which settings are required for which measurement. The settings for this filter path are explained in detail in the test procedures for an AMPS test described below. The transmission function of the enabled “C-message filter” is shown in the illustration below.

Testing of AMPS Phones

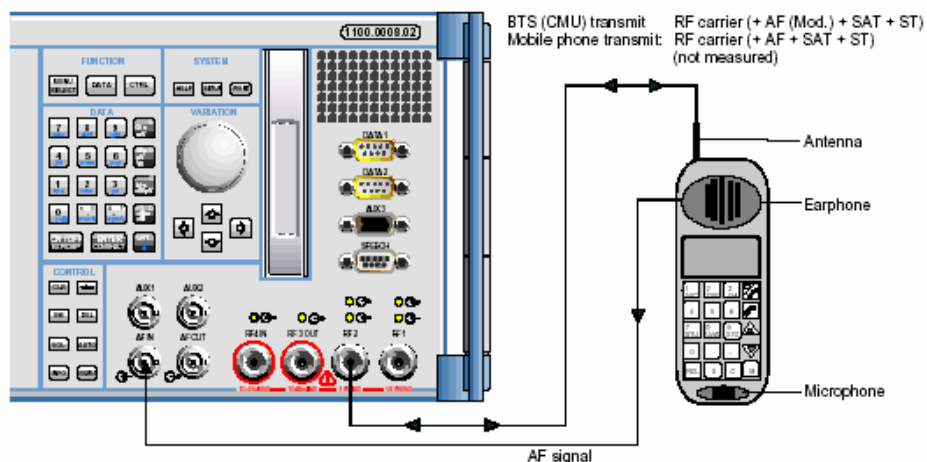


Apart from the individual filters, the measuring path of the R&S CMU200 also has an expander which, however, can also be removed from the signal path. The settings of the filters in the audio measuring path are assigned to the individual R&S CMU200 devices under test, as shown here taking the filter setting command for the Hum & Noise measurement as an example.

CONFigure:TXTests:HNOise:FILTER <Bandpass>, <Expandor>, <Deemphasis>, <Weighting>		Path Configuration: TX Tests – Modulation		
<Bandpass>	Description of parameters	Def. value	Def. unit	Unit ring
BP01	CMU band pass filter with a bandwidth of	BP10	–	
BP02	0 Hz to 250 Hz			
BP03	6 Hz to 250 Hz			
BP04	50 Hz to 250 Hz			
BP05	0 Hz to 3000 Hz			
BP06	6 Hz to 3000 Hz			
BP07	50 Hz to 3000 Hz			
BP08	300 Hz to 3000 Hz			
BP09	0 Hz to 4000 Hz			
BP10	6 Hz to 4000 Hz			
BP11	50 Hz to 4000 Hz			
BP12	300 Hz to 4000 Hz			
BP13	0 Hz to 15000 Hz			
BP14	6 Hz to 15000 Hz			
BP15	50 Hz to 15000 Hz			
BP16	300 Hz to 15000 Hz			
BP17	0 Hz to 20000 Hz			
BP18	6 Hz to 20000 Hz			
BP19	50 Hz to 20000 Hz			
<Deemphasis>	Description of parameters	Def. value	Def. unit	Unit ring
ON OFF,	Switch de-emphasis on or off	ON	–	
<Expandor>	Description of parameters	Def. value	Def. unit	Unit ring
ON OFF,	Switch expandor on or off	ON	–	
<Weighting>	Description of parameters	Def. value	Def. unit	Unit ring
CME	Switch on C-message weighted filter	CME	–	
CCI	Switch on CCITT weighting filter			
OFF	No weighting filter			
Description of command				FW vers.
This command defines the measuring equipment in the <i>TX Tests – Hum & Noise</i> application.				V2.41

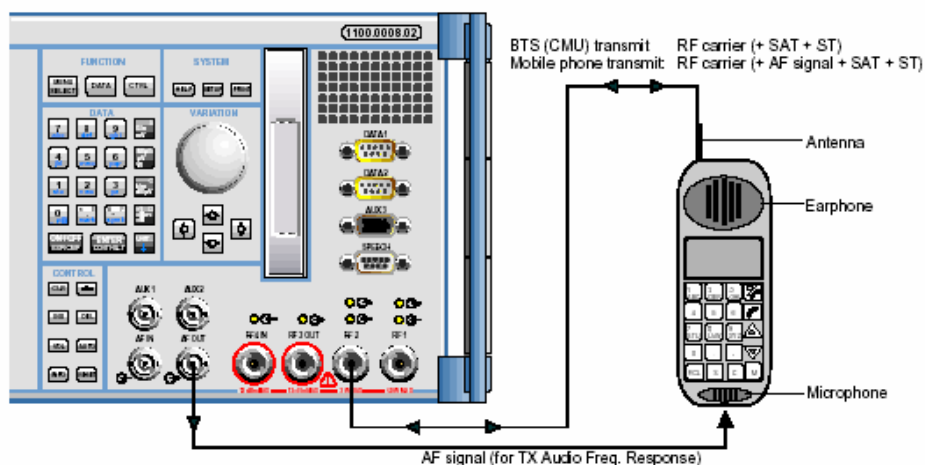
8 Connecting a Mobile Phone to the R&S CMU200

Connection for RX tests



RF2 is normally used for the bidirectional RF connection. It is also possible to use the RF1 connector; however, the dynamic range of this input (and output) is less suitable for testing AMPS phones. There is one exception: if the B99 option is used with the R&S CMU200, the dynamic range of RF1 will be identical to that of RF2. In this case, either of the two connections could be used. The audio output signal of the phone must be connected to the “AF In” connector of the R&S CMU200. If it is not possible to pick off signals directly at the phone, a microphone with preamplifier can also be used. However, it will then be considerably more difficult to perform accurate and repeatable measurements since slight changes to the position of the microphone relative to the phone can result in major variations in audio signal level.

Connection for TX tests



RF2 is normally used for the bidirectional RF connection. It is also possible to use the RF1 connector; however, the dynamic range of this input (and output) is less suitable for testing AMPS phones. There is one exception: if

the “B99” option is used with the R&S CMU200, the dynamic range of RF1 will be identical to that of RF2. In this case, either of the two connections could be used. The audio input signal of the phone must be connected to “AF Out” connector of the R&S CMU200. If it is not possible to pick off signals directly at the phone, a loudspeaker can also be used. However, it will then be considerably more difficult to perform accurate and repeatable measurements since slight changes to the position of the loudspeaker relative to the phone can result in major variations in audio signal level.

9 Call Setup in AMPS

In CMUgo there are four ways of starting an AMPS call:

- AMPS call setup
- TDMA IS 136 handoff
- cdmaOne handoff
- cdma2000 handoff

These test items are described in more detail in the following sections.

10 AMPS Call Setup

The screenshot shows the 'Call Setup Configuration' dialog box. It is divided into several sections:

- Call Setup:** Includes radio buttons for 'Call from Mobile' (selected) and 'Call from Testset CMU'. A text field for 'Maximum Time (sec.)' is set to 30. A checkbox for 'Decimal conversion of the reported ESN' is present.
- Control Channel:** Includes text fields for 'Channel' (333), 'CMAC' (0), and 'RF Level (dBm)' (-50).
- Voice Channel:** Includes text fields for 'Channel' (1), 'VMAC' (2), and 'RF Level (dBm)' (-50).
- Parameter:** Includes text fields for 'SID1' (0) and 'SAT Color Code (SCC)' (0).
- Attenuation:** Includes text fields for 'Input Attenuation (dB)' (0) and 'Output Attenuation (dB)' (0).
- CMU Connector:** Includes radio buttons for 'RF1' and 'RF2' (selected), and a checked checkbox for 'Auto Ranging'.

Buttons for 'OK' and 'Cancel' are located at the bottom right.

The following general settings can be made in the “AMPS Call Setup” dialog shown above:

- The mobile phone is connected to RF connector “RF1” or “RF2”.
- The attenuation of the RF connection between the measuring instrument and the mobile phone. The output level of the RF signal at the R&S CMU200 is set such that this attenuation is compensated. The measuring results are corrected according to the specified input attenuation. This parameter also influences the signal path settings of the CMU. These attenuation values should therefore always be specified. The input and output attenuation values can be set independently of each other.

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- The autoranging function of the R&S CMU200 is to be used for the measurements.

In remote-control mode, this results in the following sequence.

```
1;INP:STAT RF2
1;OUTP:STAT RF2
1;SENS:CORR:LOSS:INP2 0.0
1;SENS:CORR:LOSS:OUTP2 0.0
1;LEV:MODE AUT
```

The other settings concern the control channel in AMPS. The parameters for this control channel are:

- channel number
- control channel level
- MAC setting of control channel, i.e. level sent by mobile phone

```
1;CONF:BSS:ACC:CHAN 333
1;CONF:BSS:ACC:LEV -50.0
1;CONF:NETW:CMAC 0
```

The settings for the voice channel are determined by the following parameters:

- channel number
- voice channel level
- MAC setting of voice channel, i.e. level sent by mobile phone

```
1;CONF:BSS:AVC:CHAN 1
1;CONF:BSS:AVC:LEV -50.0
1;CONF:NETW:VMAC 2
```

The network parameters of the simulated base station signal concern:

- **SAT Color Code (SCC)**
- **System IDentity Code1 (SID1)**

```
1;CONF:BSS:SAT:SCC 0
1;CONF:NETW:IDEN:SID1 0
```

In this test procedure, the generator of the CMU is switched on and the system waits for the mobile phone to register at the “base station”. The call state is queried to check this.

```
1;PROC:SIGN:ACT SON;*OPC?
1;SIGN:STAT?
```

Following registration, the value returned by the status query changes from “SON” to “REG”. The “**M**obile **P**rotocol **C**apability **I**ndicator (MPCI)”, the “**M**obile **S**tation **I**dentification **N**umber (MIN)”, the serial number and the power class of the phone can now be queried.

```
1;MSS:MPCI?
1;MSS:MIN?
1;MSS:SN?
1;MSS:PCL?
```

The serial number can be converted from hexadecimal format to decimal format by means of CMUgo.

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Finally, the call is set up. The type of call setup can be selected by activating “Call from Mobile” or “Call from Testset CMU”. With a “**Mobile Terminated Call (MTC)**”, the following command is sent:

```
1:PROC:SIGN:ACT CTM;*OPC?
```

Regardless of how the call is to be set up, the call state is repeatedly queried until the returned value is “CEST”. In CMUgo, it is possible to specify the maximum time which the system should wait until the call has been set up.

```
1:SIGN:STAT?
```

The test report has the following appearance:

Test Name and Condition	Lower Limit	Upper Limit	Measured Value	P/F
<i>Control Channel 333, CC MAC 0, CC RF Level -30.0 dBm</i>				
<i>Voice Channel 1, VC MAC 2, VC RF Level -30.0 dBm</i>				
<i>SID1: 0, SCC 0, Attenuation (In/Out) 2.0 / 2.0 dB</i>				
<i>MIN: 12345678, Serial Number: 12345678, Power Class: 4, MPC: TIA/EIA-136</i>				
Call from Mobile:			passed	✓

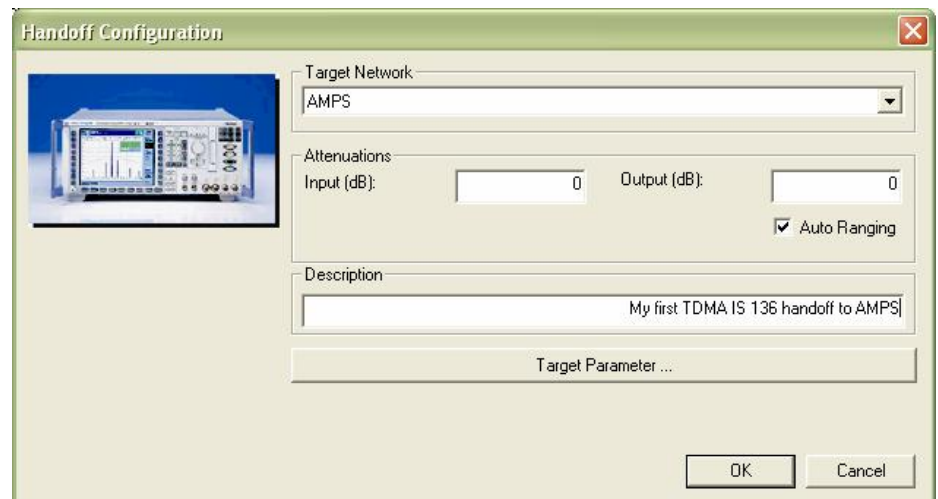
The distinction made between control channel and voice channel is defined in the AMPS specification. Unlike many other mobile radio standards, however, this does not mean that in AMPS two channels would be active simultaneously. The control channel describes the channel configuration prior to the call, and the voice channel describes the channel configuration during the call.

11 TDMA IS 136 Handoff

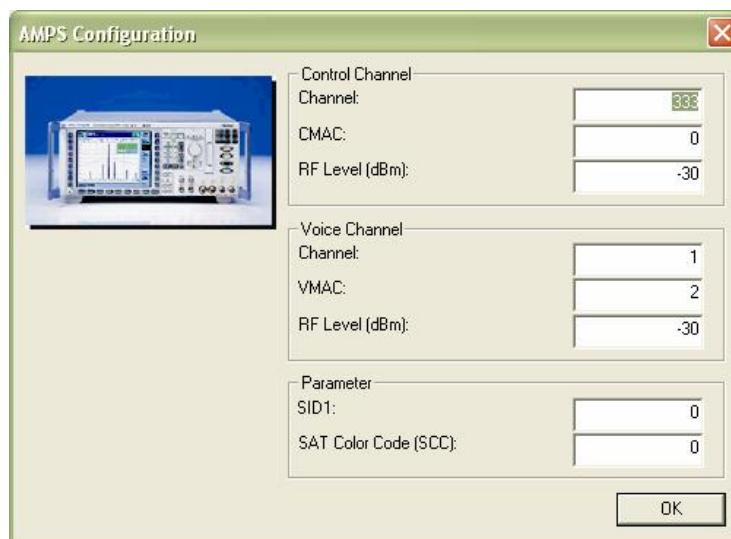
In AMPS the call can also be set up from a TDMA IS 136 connection. This is, of course, only possible with suitable dual-mode phones. For this purpose, the test item “TDMA IS 136 Handoff” has been integrated in the CMUgo test sequence.

When configuring this test item, you must specify AMPS as the “Target Network” and also define the attenuation values in the same dialog.

As with the test item “AMPS Call Setup”, the individual settings are made to define the AMPS “mobile radio cell”.



Testing of AMPS Phones



The individual items are:

- querying of call state in original network "TDMA IS 136"
- configuration of channel number of AMPS control channel
- AMPS control channel level
- MAC of AMPS control channel
- configuration of channel number of AMPS voice channel
- AMPS voice channel level
- MAC of AMPS voice channel
- **SAT Color Code (SCC)**
- **System IDentity Code1 (SID1)**
- attenuation of RF connection between measuring instrument and mobile phone following handoff
- autoranging in AMPS

```
3:SIGN:STAT?
1:CONF:BSS:ACC:CHAN 333
1:CONF:BSS:ACC:LEV -30.0
1:CONF:NETW:CMAC 0
1:CONF:BSS:OCH:AVC:CHAN 1
1:CONF:BSS:OCH:AVC:LEV -30.0
1:CONF:NETW:OCH:VMAC 2
1:CONF:BSS:OCH:SAT:SCC 0
1:CONF:NETW:IDEN:SID1 0
1:SENS:CORR:LOSS:INP2 0.0
1:SENS:CORR:LOSS:OUTP2 0.0
1:LEV:MODE AUT
```

Testing of AMPS Phones

The actual handoff is started by means of the following commands in the original network. A handoff without fallback is prepared using the following command.

```
3;CONF:HAND:TARG 'AMPSMS'
```

If you want to return to the TDMA IS 136 network after the connection has been terminated, you must use this command to prepare the handoff.

```
3;CONF:HAND:TARG 'AMPSMSFallback'
```

This is then followed by the actual “handoff” signalling procedure.

```
3;PROC:SIGN:ACT HAND;*OPC?
```

The call state is queried in the target network.

```
1;SIGN:STAT?
```

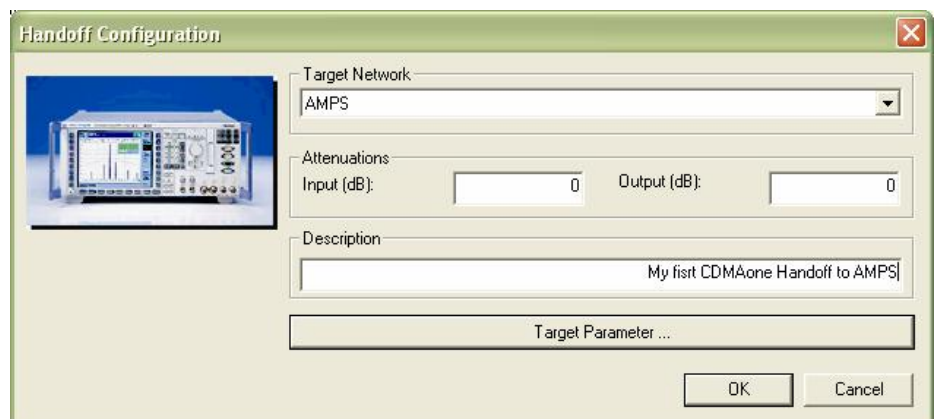
Note that two secondary addresses of the R&S CMU200 are addressed in this sequence. On the one hand the secondary address 3 of the function group TDMA IS 136, and on the other the secondary address 1 of AMPS.

12 cdmaOne Handoff

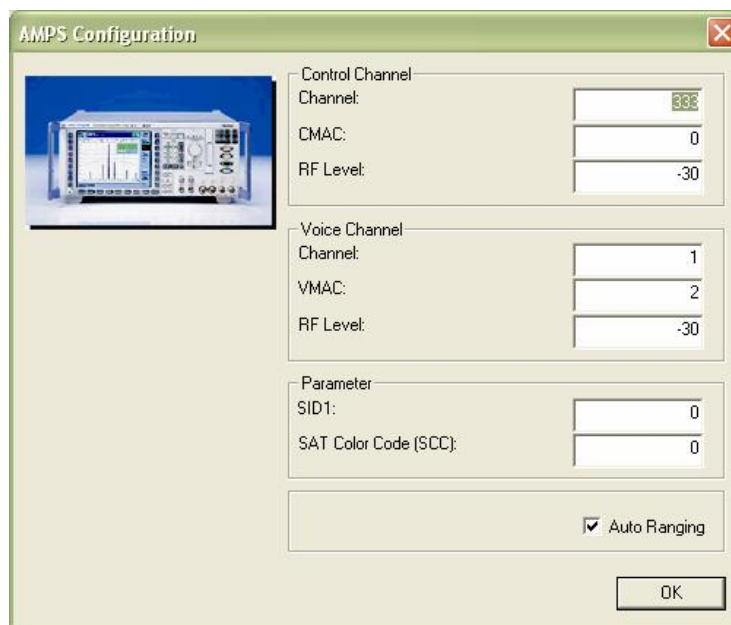
In AMPS the call can also be set up from a cdmaOne connection. This is, of course, only possible with suitable dual-mode phones. For this purpose, the test item “cdmaOne Handoff” has been integrated in the CMUgo test sequence. This test item is based on the B81 option of the R&S CMU200. If you use a B83 option in the R&S CMU200, select the test item “cdma2000 Handoff”. The B83 option of the R&S CMU200 has all the functions of the B81 option, including testing of a cdmaOne phone.

When configuring this test item, you must specify AMPS as the “Target Network” and also define the attenuation values in the same dialog.

As with the test item “AMPS Call Setup”, the individual settings are made to define the AMPS “mobile radio cell”.



Testing of AMPS Phones



The individual items are:

- querying of call state in original network “CDMA IS 95”
- configuration of channel number of AMPS control channel
- AMPS control channel level
- MAC of AMPS control channel
- configuration of channel number of AMPS voice channel
- AMPS voice channel level
- MAC of AMPS voice channel
- **SAT Color Code (SCC)**
- **System IDentity Code1 (SID1)**
- attenuation of RF connection between measuring instrument and mobile phone following handoff
- autoranging in AMPS

```
3;SIGN:STAT?
1;CONF:BSS:ACC:CHAN 333
1;CONF:BSS:ACC:LEV -30.0
1;CONF:NETW:CMAC 0
1;CONF:BSS:OCH:AVC:CHAN 1
1;CONF:BSS:OCH:AVC:LEV -30.0
1;CONF:NETW:OCH:VMAC 2
1;CONF:BSS:OCH:SAT:SCC 0
1;CONF:NETW:IDEN:SID1 0
1;SENS:CORR:LOSS:INP2 0.0
1;SENS:CORR:LOSS:OUTP2 0.0
1;LEV:MODE AUT
```

Testing of AMPS Phones

The actual handoff is started by means of the following commands in the original network. A handoff without fallback is prepared using the following command.

```
3;CONF:HAND:TARG 'AMPSMS'
```

If you want to return to the CDMA network after the connection has been terminated, you must use this command to prepare the handoff.

```
3;CONF:HAND:TARG 'AMPSMSFallback'
```

This is then followed by the actual “handoff” signalling procedure.

```
3;PROC:SIGN:ACT HAND;*OPC?
```

The call state is queried in the target network.

```
1;SIGN:STAT?
```

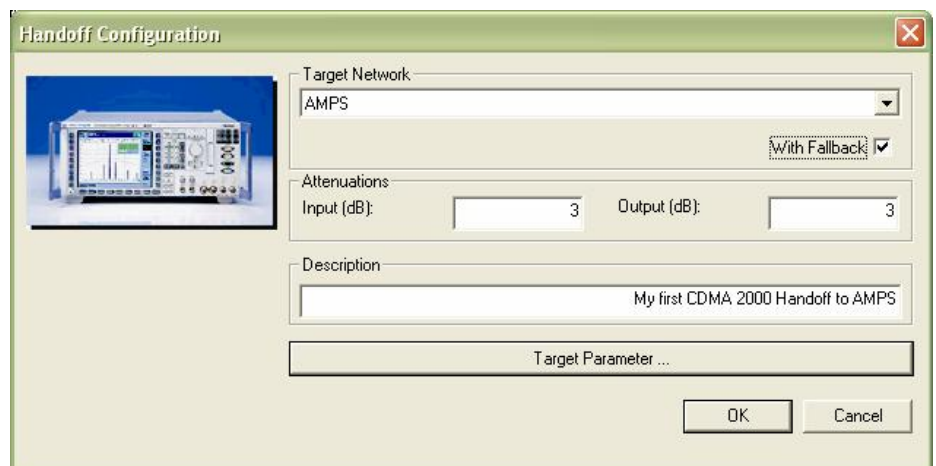
Note that two secondary addresses of the R&S CMU200 are addressed in this sequence. On the one hand the secondary address 3 of the function group “CDMA IS 95”, and on the other the secondary address 1 of AMPS.

13 cdma2000 Handoff

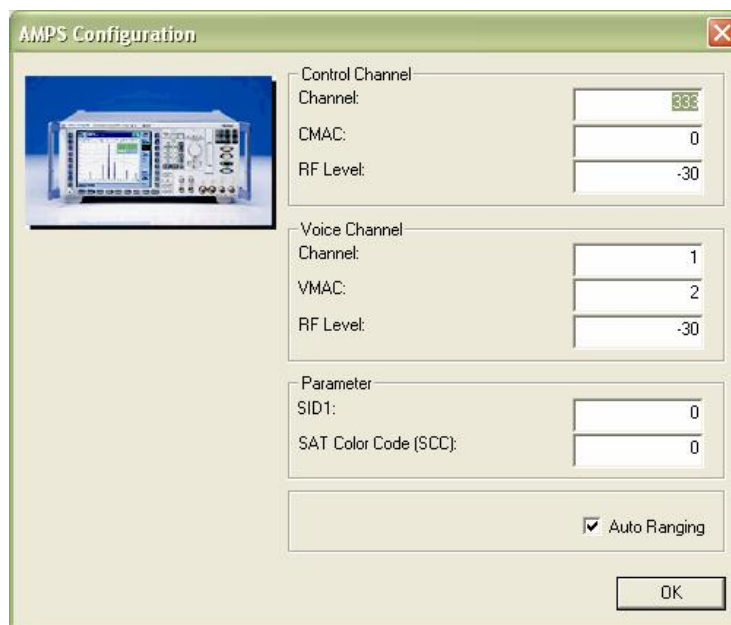
In AMPS the call can also be set up from a cdma2000 connection. This is, of course, only possible with suitable dual-mode phones. For this purpose, the test item “cdma2000 Handoff” has been integrated in the CMUgo test sequence. This test item is based on the B83 option of the R&S CMU200. If you use a B81 option in the R&S CMU200, select the test item “cdmaOne Handoff”.

When configuring this test item, you must specify “AMPS” or “AMPS With Fallback” as the “Target Network” and also define the attenuation values in the target network in the same dialog.

As with the test item “AMPS Call Setup”, the individual settings are made to define the AMPS “mobile radio cell”.



Testing of AMPS Phones



The individual items are:

- querying of call state in original network “cdma2000”
- configuration of channel number of AMPS control channel
- AMPS control channel level
- MAC of AMPS control channel
- configuration of channel number of AMPS voice channel
- AMPS voice channel level
- MAC of AMPS voice channel
- **SAT Color Code (SCC)**
- **System IDentity Code1 (SID1)**
- attenuation of RF connection between measuring instrument and mobile phone following handoff
- autoranging in AMPS

```
3;SIGN:STAT?
1;CONF:BSS:ACC:CHAN 333
1;CONF:BSS:ACC:LEV -30.0
1;CONF:NETW:CMAC 0
1;CONF:BSS:OCH:AVC:CHAN 1
1;CONF:BSS:OCH:AVC:LEV -30.0
1;CONF:NETW:OCH:VMAC 2
1;CONF:BSS:OCH:SAT:SCC 0
1;CONF:NETW:IDEN:SID1 0
1;SENS:CORR:LOSS:INP2 0.0
1;SENS:CORR:LOSS:OUTP2 0.0
1;LEV:MODE AUT
```

Testing of AMPS Phones

The actual handoff is started by means of the following commands in the original network. A handoff without fallback is prepared using the following command.

```
3:CONF:HAND:TARG 'AMPSMS'
```

If you want to return to the cdma2000 network after the connection has been terminated, you must use this command to prepare the handoff.

```
3:CONF:HAND:TARG 'AMPSMSFallback'
```

This is then followed by the actual “handoff” signalling procedure.

```
3:PROC:SIGN:ACT HAND;*OPC?
```

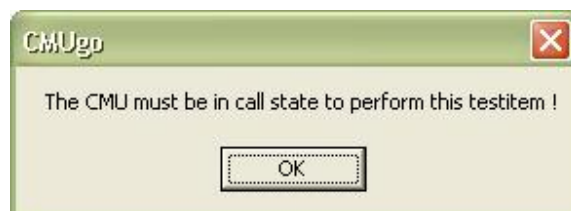
The call state is queried in the target network.

```
1:SIGN:STAT?
```

Note that two secondary addresses of the R&S CMU200 are addressed in this sequence. On the one hand the secondary address 3 of the function group “cdma2000”, and on the other the secondary address 1 of AMPS.

14 General Routines of Test Items

The individual test items in an AMPS connection always follow the same pattern. The call state is first checked and an error message is output if the connection is interrupted.



The configuration of the currently active voice channel is then queried. This query ensures that time-consuming signalling processes are avoided if they are unnecessary.

```
1: INP:STAT?
```

```
1: SIGN:STAT?
```

```
1: PROC:SIGN:CHAN?
```

A new voice channel is configured if required.

```
1:PROC:SIGN:CHAN 1
```

The same applies for setting the power level in the phone. If the value needs to be changed, the appropriate command for signalling a new MAC value is sent.

```
1:PROC:SIGN:MAC?
```

```
1:PROC:SIGN:MAC 2
```

As with the voice channel and MAC value, the used **SAT Color Code** (SCC) is queried and only adjusted if it has changed compared to a previous test item.

```
1:PROC:SIGN:SAT:SCC?
```

```
1:PROC:SIGN:SAT:SCC 0
```

Testing of AMPS Phones

Setting of the generator level (“base station level”) does not require an additional query since this procedure is not a signalling procedure. This setting is therefore made extremely rapidly by the R&S CMU200. In addition, in CMUgo it is possible to change the attenuation values separately for each individual test item.

```
1:PROC:BSS:LEV -50.0
```

```
1:SENS:CORR:LOSS:INP2 0.0
```

```
1:SENS:CORR:LOSS:OUTP2 0.0
```

All of the above items are specific to CMUgo. Since the individual test items do not have any common parameters, the instrument itself is queried for the values which have just been set. The above-mentioned items could actually be omitted if a dedicated program is created.

15 AMPS MAC Power Test

MAC Power Test Configuration

Voice Channel
Channel:
RF Level (dBm):
SAT Color Code (SCC):

Predefined Limits
Power Class 2

	Lower Limit (dBm):	Upper Limit (dBm):
<input checked="" type="checkbox"/> MAC0:	<input type="text" value="24"/>	<input type="text" value="30"/>
<input checked="" type="checkbox"/> MAC1:	<input type="text" value="24"/>	<input type="text" value="30"/>
<input checked="" type="checkbox"/> MAC2:	<input type="text" value="24"/>	<input type="text" value="30"/>
<input checked="" type="checkbox"/> MAC3:	<input type="text" value="20"/>	<input type="text" value="26"/>
<input checked="" type="checkbox"/> MAC4:	<input type="text" value="16"/>	<input type="text" value="22"/>
<input checked="" type="checkbox"/> MAC5:	<input type="text" value="12"/>	<input type="text" value="18"/>
<input checked="" type="checkbox"/> MAC6:	<input type="text" value="8"/>	<input type="text" value="14"/>
<input checked="" type="checkbox"/> MAC7:	<input type="text" value="4"/>	<input type="text" value="10"/>

Delay before Measurement (msec.):

Attenuations
Input (dB):
Output (dB):

Description

OK Cancel

The purpose of this test is to test the individual power levels of an AMPS mobile phone on a predetermined voice channel. You have to enter the following parameters for this test:

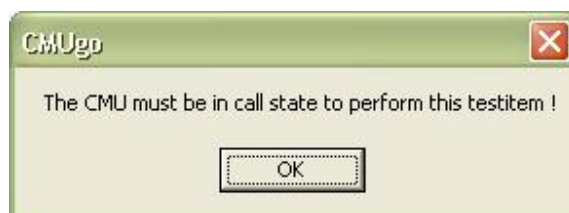
- voice channel
- base station level

Testing of AMPS Phones

- SCC
- attenuation values
- delay before power measurement
- number of MAC levels to be tested
- limits (predefined limits for the various power classes can also be transmitted)

The test sequence is as follows:

The call state is first checked and an error message is output if the connection is interrupted.



The currently active voice channel is then queried. This query ensures that time-consuming signalling processes are avoided if they are unnecessary.

```
3;INP:STAT?
```

```
3;SIGN:STAT?
```

```
3;PROC:SIGN:CHAN?
```

A new voice channel is configured if required.

```
3;PROC:SIGN:CHAN 1
```

As with the voice channel, the used **SAT Color Code (SCC)** is queried and only adjusted if it has changed compared to a previous test item.

```
3;PROC:SIGN:SAT:SCC?
```

```
3;PROC:SIGN:SAT:SCC 0
```

Setting of the generator level (“base station level”) does not require an additional query since this procedure is not a signalling procedure. This setting is therefore made extremely rapidly by the R&S CMU200. In addition, in CMUgo it is possible to change the attenuation values separately for each individual test item.

```
3;PROC:BSS:LEV -50.0
```

```
3;SENS:CORR:LOSS:INP2 0.0
```

```
3;SENS:CORR:LOSS:OUTP2 0.0
```

All of the above items are specific to CMUgo. Since the individual test items do not have any common parameters, the instrument itself is queried for the values which have just been set. The above-mentioned items could actually be omitted if a dedicated program is created.

The individual test procedures, which are each based on the setting for the “**Mobile Attenuation Codes (MAC)**”, are then performed followed by measurement of the mobile phone power. Note that there are several TX test modulation measurements with the R&S CMU200. The used command “**READ:TXT:MOD:CPOW?**” differs from a “**READ:TXT:MOD?**” command in that it does not return all of the measured values and is thus considerably faster. Before each measurement is started, a predefined waiting time during which the mobile phone state “settles” must elapse.

Testing of AMPS Phones

```

3;PROC:SIGN:MAC 0;*OPC?
3;READ:TXT:MOD:CPOW?
3;PROC:SIGN:MAC 1;*OPC?
3;READ:TXT:MOD:CPOW?
3;PROC:SIGN:MAC 2;*OPC?
3;READ:TXT:MOD:CPOW?
3;PROC:SIGN:MAC 3;*OPC?
3;READ:TXT:MOD:CPOW?
3;PROC:SIGN:MAC 4;*OPC?
3;READ:TXT:MOD:CPOW?
3;PROC:SIGN:MAC 5;*OPC?
3;READ:TXT:MOD:CPOW?
3;PROC:SIGN:MAC 6;*OPC?
3;READ:TXT:MOD:CPOW?
3;PROC:SIGN:MAC 7;*OPC?
3;READ:TXT:MOD:CPOW?

```

The entries in the test report have the following form:

<i>Voice Channel 1, AVC RF Level -30.0 dBm, SAT SCC 0, Attenuation (In/Out) 2.0 / 2.0 dB</i>				
Power at MAC0:	24.00 dBm	30.00 dBm	26.49 dBm	✓
Power at MAC1:	24.00 dBm	30.00 dBm	26.49 dBm	✓
Power at MAC2:	24.00 dBm	30.00 dBm	26.38 dBm	✓
Power at MAC3:	20.00 dBm	26.00 dBm	20.69 dBm	✓
Power at MAC4:	16.00 dBm	22.00 dBm	19.60 dBm	✓
Power at MAC5:	12.00 dBm	18.00 dBm	14.24 dBm	✓
Power at MAC6:	8.00 dBm	14.00 dBm	12.46 dBm	✓
Power at MAC7:	4.00 dBm	10.00 dBm	7.89 dBm	✓

16 AMPS Modulation Test

Modulation Test Configuration

Voice Channel

Channel: 1

VMAC: 2

RF Level (dBm): -50

SAT Color Code (SCC): 0

Carrier Frequency Error (kHz): Upper Limit 2

Total Peak Deviation (kHz): 14

SAT Frequency Error (Hz): Lower Limit Upper Limit 1.8 2.2

ST Frequency Error (Hz): Lower Limit Upper Limit 7.2 8.8

Measurement Leadtime (ms): 200

include ST Tone Test

Attenuations

Input (dB): 0

Output (dB): 0

Description: My first AMPS Modulation Test

The purpose of this test is to test the frequency error of the phone and to check whether the modulation deviation for the voice signal, SAT and ST is correct. You have to enter the following parameters for this test:

- voice channel
- base station level
- SCC
- attenuation values

The “ST Tone Test” can be deselected since, unlike the SAT, the ST is not always sent with the other signals. As already described in the general section, the test is first prepared by checking (and, if necessary, changing) the call state, channel setting and SCC setting.

```
1; INP:STAT?
```

```
1; SIGN:STAT?
```

```
1; PROC:SIGN:CHAN?
```

```
1; PROC:SIGN:CHAN 1
```

```
1; PROC:SIGN:MAC?
```

```
1; PROC:SIGN:MAC 2
```

```
1; PROC:SIGN:SAT:SCC?
```


Testing of AMPS Phones

```
1;PROC:SIGN:SAT:SCC 0
1;PROC:BSS:LEV -50.0
1;SENS:CORR:LOSS:INP2 0.0
1;SENS:CORR:LOSS:OUTP2 0.0
```

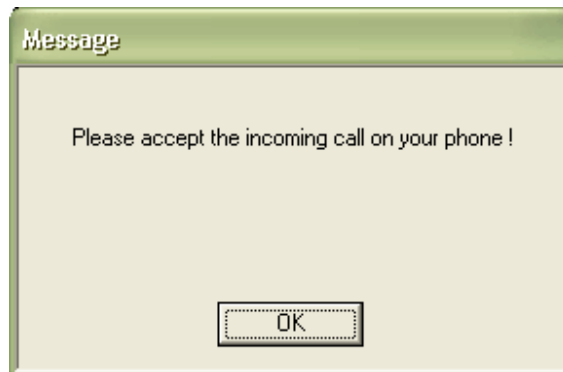
The frequency error, total deviation and SAT modulation characteristic are then measured.

```
1;READ:TXT:MOD?
```

The ST cannot be measured together with the SAT since the two tones are not to be sent at the same time. The ST is forced by means of a fictive call.

```
1;PROC:SIGN:ACT FST
```

The following message is generated by CMUgo.



The measurement is the same measurement as before. However, before the next test item can be performed, it must be ensured that the ST tone is no longer active. A call state query which waits for the call state “CEST” is used for this purpose.

```
1;READ:TXT:MOD?
```

```
1;SIGN:STAT?
```

No filter settings have to be made in the test since the measurement does not include audio deviation measurement.

The test report displays the results as follows:

Voice Channel 1, VMAC 2, AVC RF Level -30.0 dBm, SAT SCC 0, Attenuation (In/Out) 2.0 / 2.0 dB				
Frequency Error:	-2.00 kHz	2.00 kHz	-1.40 kHz	✓
Total Peak Deviation:		14.00 kHz	-9.82 kHz	✓
SAT Frequency Error:	-1.00 Hz	1.00 Hz	-0.70 Hz	✓
SAT Peak Deviation:	1.80 kHz	2.20 kHz	1.86 kHz	✓
ST Frequency Error:	-1.00 Hz	1.00 Hz	-0.70 Hz	✓
ST Peak Deviation:	7.20 kHz	8.80 kHz	7.44 kHz	✓

17 AMPS TX Compressor Test

TX Compressor Test Configuration

Voice Channel
Channel: 1
VMAC: 2
RF Level (dBm): -50
SAT Color Code (SCC): 0

Attenuations
Input (dB): 0
Output (dB): 0

Analyzer Settings
Bandpass: 50 Hz to 4000 Hz
Weighting: OFF

AF Generator / Peak Deviation Search
AF Start Level (mV): 0.02
Target of Ref. (kHz): 2.9
Tolerance (kHz): 0.029
Start Gain (dB): -30
Stop Gain (dB): 20
Lead Delay (ms): 100
Stepsize: 1 dB 2 dB 5 dB

Description
My first TX Compressor Test

Limits... OK Cancel

The purpose of this test is to measure the compressor of the AMPS phone. You have to enter the following parameters for this test:

- voice channel
- base station level
- SCC
- attenuation values
- audio level at start of “AF Level Search”
- target deviation of “AF Level Search”
- deviation from target value permitted during “AF Level Search”
- step size of test
- audio filter settings

As already described in the general section, the test is first prepared by checking (and, if necessary, changing) the call state, channel setting and SCC setting.

```
1; INP: STAT?  
1; SIGN: STAT?  
1; PROC: SIGN: CHAN?  
1; PROC: SIGN: CHAN 1  
1; PROC: SIGN: MAC?  
1; PROC: SIGN: MAC 2  
1; PROC: SIGN: SAT: SCC?  
1; PROC: SIGN: SAT: SCC 0  
1; PROC: BSS: LEV -50.0  
1; SENS: CORR: LOSS: INP2 0.0
```

Testing of AMPS Phones

```
1;SENS:CORR:LOSS:OUTP2 0.0
```

The same filter settings are used for the modulation measurement and the “AF Level Search”. Here it makes sense to allow the voice band to pass through.

```
1;CONF:TXT:AFLS:FILT BP10,OFF,OFF,OFF
```

```
1;CONF:TXT:MOD:FILT BP10,OFF,OFF,OFF
```

The start level of the “AF Level Search” is set.

```
1;SOUR:AFG:SLEV 0.00002
```

The audio frequency of the AFG is set to 1004 Hz.

```
1;SOUR:AFG:FREQ 1004
```

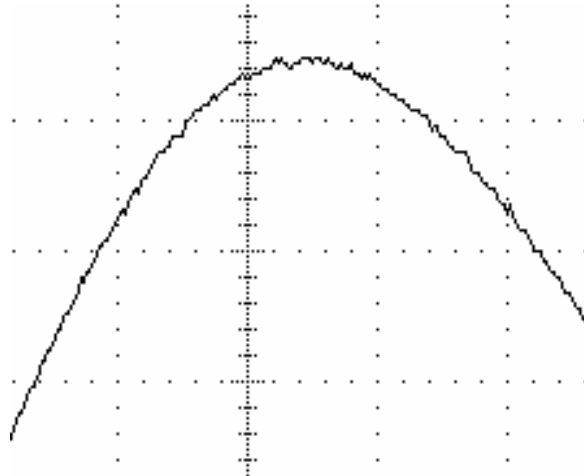
The sought level and the tolerance for the search result are set.

```
1;CONF:TXT:AFLS:CONT:TAPD 2900.00
```

```
1;CONF:TXT:AFLS:CONT:TDER 29.00
```

The level search is now performed. The R&S CMU200 varies the audio level at the audio generator until the target deviation is measured.

The R&S CMU200 searches for the level with weighting to $\text{RMS} * \sqrt{2}$. Differences may result between this value and the peak value if the modulated TX signal of the device under test exhibits severe interference. This interference may be low-frequency interference and may be due to a higher harmonics content in the signal spectrum. The modulated signal of the phone will then look something like the example below:



The value to $\text{RMS} * \sqrt{2}$ yields much more stable values for the level search since it “filters out” any interference. These values are then, however, lower than the displayed peak value. Consequently, the audio level found using the level search is higher than that for instruments which only provide peak weighting.

The value returned for this measurement “READ:TXT:AFLS?” is therefore the found audio level. It is essential to abort this measurement (“ABOR:TXT:AFLS”) so that the audio generator can be started. The audio generator is then switched on.

```
1;READ:TXT:AFLS?
```

```
1;SOUR:AFG:FREQ 1004
```

```
1;ABOR:TXT:AFLS
```

```
1;INIT:AFG;*OPC?
```

Testing of AMPS Phones

The deviation is then measured with various audio levels. Contrary to the AMPS specification, the level at which the limiter begins level limitation is not sought since this process is unnecessary and would take too much time. In contrast, a predefined level range is therefore measured. The level of the audio signal (<Level>) depends on the audio level previously found for a deviation of 2.9 kHz, which serves as the reference deviation (0 dB).

```
1;SOUR:AFG:LEV <Level>;*OPC?
```

```
1;READ:TXT:MOD:TAD?
```

Finally, the audio generator should be switched off to permit further audio measurements using a generated audio signal.

```
1;ABOR:AFG
```

Voice Channel 1, VMAC 2, AVC RF Level -50.0 dBm, Attenuation (In/Out) 0.0 / 0.0 dB

Analyzer Filters: Bandpass 50 Hz to 4000 Hz, Weighting: off

Audio Peak Deviation: Target 2.90 kHz, Tolerance 0.029 kHz, Measured 2.91 kHz

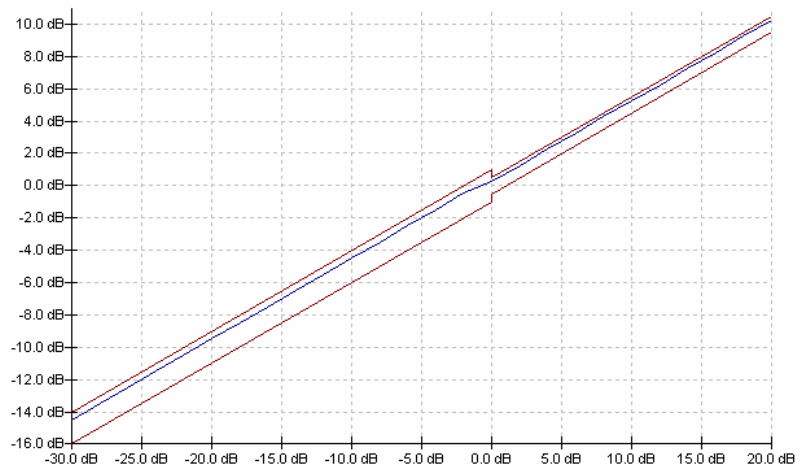
RX Compressor Test:

passed

The relationship between deviation and input level can be clearly seen in the test report. Each time the audio generator level changes by 2 dB, the deviation changes by precisely 1 dB. The displayed limits are defined in the AMPS specification, which requires ± 1 dB for values above a deviation of 2.9 kHz and ± 2 dB for values below a deviation of 2.9 kHz.

Annex: TX Compressor Graphic

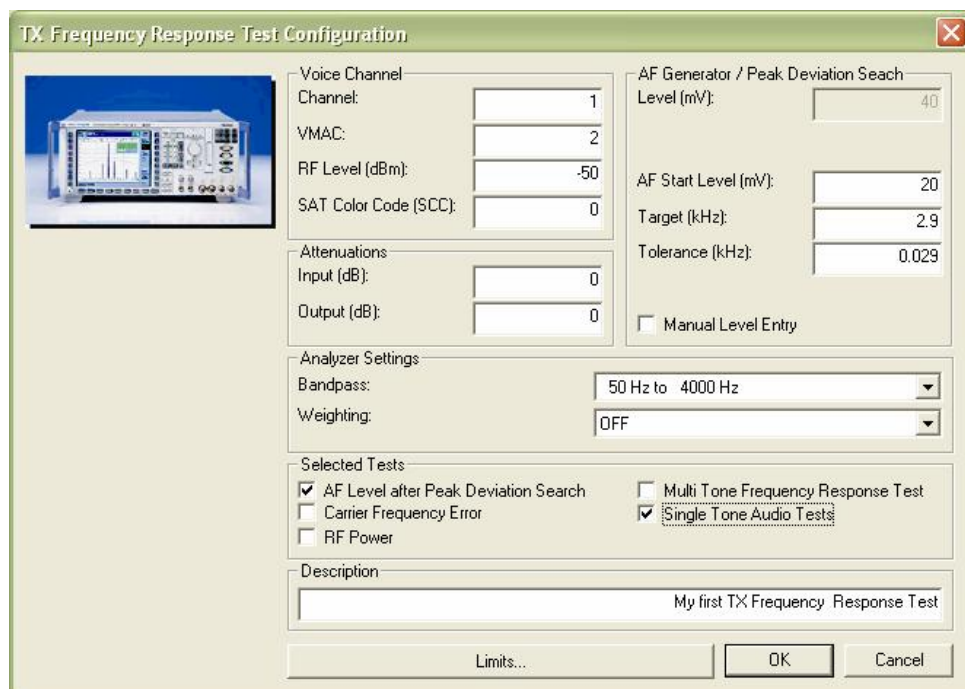
Voicechannel 1, VMAC 2, AVC RF Level -50.0 dBm, SAT SCC 0, Start 20.0 dB, Stop -30.0 dB, Ref: 27927.4 mV (@1004 Hz)



18 AMPS TX Frequency Response Test

Testing of AMPS Phones

TX Frequency Response Test Configuration



Voice Channel
Channel:

VMAC:

RF Level (dBm):

SAT Color Code (SCC):

Attenuations
Input (dB):

Output (dB):

AF Generator / Peak Deviation Search
Level (mV):

AF Start Level (mV):

Target (kHz):

Tolerance (kHz):

Manual Level Entry

Analyzer Settings
Bandpass:

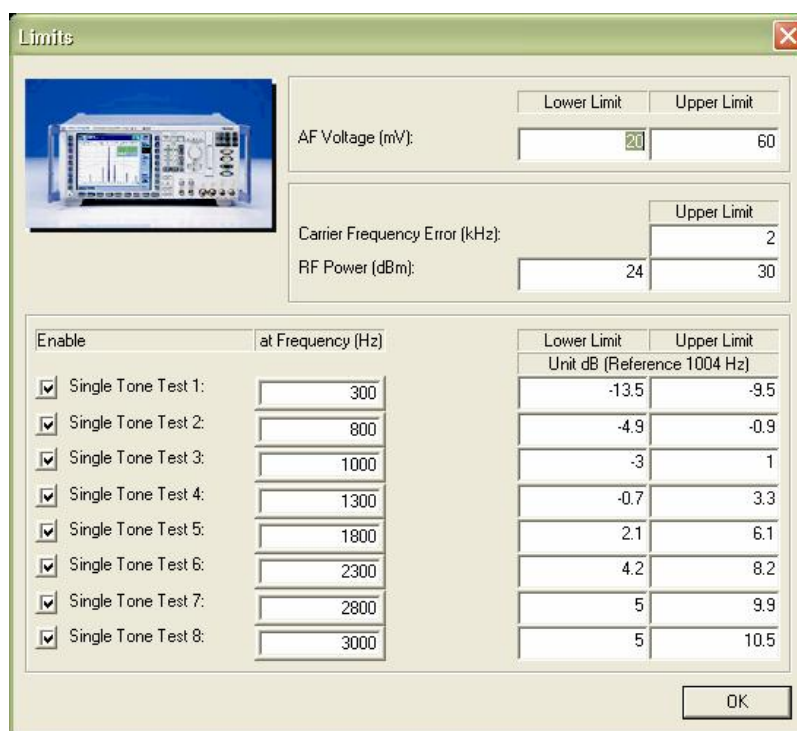
Weighting:

Selected Tests
 AF Level after Peak Deviation Search
 Carrier Frequency Error
 RF Power
 Multi Tone Frequency Response Test
 Single Tone Audio Tests

Description

Limits... OK Cancel

Limits



AF Voltage (mV): Lower Limit Upper Limit 60

Carrier Frequency Error (kHz): Upper Limit

RF Power (dBm): Upper Limit 30

Enable	at Frequency (Hz)	Lower Limit	Upper Limit
Unit dB (Reference 1004 Hz)			
<input checked="" type="checkbox"/> Single Tone Test 1:	<input type="text" value="300"/>	-13.5	-9.5
<input checked="" type="checkbox"/> Single Tone Test 2:	<input type="text" value="800"/>	-4.9	-0.9
<input checked="" type="checkbox"/> Single Tone Test 3:	<input type="text" value="1000"/>	-3	1
<input checked="" type="checkbox"/> Single Tone Test 4:	<input type="text" value="1300"/>	-0.7	3.3
<input checked="" type="checkbox"/> Single Tone Test 5:	<input type="text" value="1800"/>	2.1	6.1
<input checked="" type="checkbox"/> Single Tone Test 6:	<input type="text" value="2300"/>	4.2	8.2
<input checked="" type="checkbox"/> Single Tone Test 7:	<input type="text" value="2800"/>	5	9.9
<input checked="" type="checkbox"/> Single Tone Test 8:	<input type="text" value="3000"/>	5	10.5

OK

The audio frequency response of the mobile phone TX path is measured in this test. You have to enter the following parameters for this test:

- voice channel
- base station level
- SCC
- attenuation values
- audio level at start of "AF Level Search"

Testing of AMPS Phones

- target deviation of “AF Level Search”
- deviation from target value permitted during “AF Level Search”
- selection of TX test results which can be derived from “AF Level Search” process
- selection of “single-tone” test method
- selection of “multi-tone” test method
- audio filter settings
- single-tone measurement limits (default values are taken from specification)
- limits for “AF Level Search”
- limits for optional TX tests

As already described in the general section, the test is first prepared by checking (and, if necessary, changing) the call state, channel setting and SCC setting.

```
1;INP:STAT?
1;SIGN:STAT?
1;PROC:SIGN:CHAN?
1;PROC:SIGN:CHAN 1
1;PROC:SIGN:MAC?
1;PROC:SIGN:MAC 2
1;PROC:SIGN:SAT:SCC?
1;PROC:SIGN:SAT:SCC 0
1;PROC:BSS:LEV -50.0
1;SENS:CORR:LOSS:INP2 0.0
1;SENS:CORR:LOSS:OUTP2 0.0
```

The same filter settings are used for the modulation measurement, the multi-tone measurement and the “AF Level Search”. Here it makes sense to allow the voice band to pass through.

```
1;CONF:TXT:AFLS:FILT BP10,OFF,OFF,OFF
1;CONF:TXAF:FILT BP10,OFF,OFF,OFF
1;CONF:TXT:MOD:FILT BP10,OFF,OFF,OFF
```

The start level of the “AF Level Search” is set.

```
1;SOUR:AFG:SLEV 0.00002
```

The audio frequency of the AFG is set to 1004 Hz.

```
1;SOUR:AFG:FREQ 1004
```

The sought level and the tolerance for the search result are set.

```
1;CONF:TXT:AFLS:CONT:TAPD 2900.00
1;CONF:TXT:AFLS:CONT:TDER 29.00
```

The level search is now performed. The R&S CMU200 varies the audio level at the audio generator until the target deviation is measured. The returned value is the found audio level. It is essential to abort this measurement (“ABOR:TXT:AFLS”) later on so that the audio generator can be started for other measurements. `1;READ:TXT:AFLS?`

Testing of AMPS Phones

The level search does not only return the audio level, but also other measured values (refer to the K29 manual).

Returned values	Value range	Def. value	Def. unit	Unit ring
CarrierFreqError	–48 000 Hz to +48 000 Hz	NAN	Hz	
AudioPeakDeviation,	–6 000 Hz to +10 000 Hz	NAN	Hz	
AudioRMSDeviation,	0 Hz to +48 000 Hz	NAN	Hz	
CarrierPower,	0 dB to 100 dB	NAN	dBm	
AFSearchLevel	0 V to +5 V	NAN	V	
Description of command				FW vers.
These commands are always queries. They start a <i>TX Tests – AF Level Search</i> measurement and output all measurement results (see chapter 4).				V2.41

Measurement is normally performed with a deviation of 2.9 kHz, i.e. the reference deviation in AMPS.

The “multi-tone” measurement of the TX frequency response is configured in such a way that it uses the found audio level as the reference level.

```
1:CONF:TXAF:AFG:LEV:LMOD SRES
```

```
1:ABOR:TXT:AFLS
```

The “multi-tone” frequency response test consists of just one line.

```
1:READ:ARR:TXAF?
```

The “single-tone” frequency response test sets individual frequencies at the audio generator and then measures the audio deviation.

```
1:INIT:AFG
```

```
1:SOUR:AFG:LEV <Level>
```

```
1:SOUR:AFG:FREQ 300.0
```

```
1:READ:TXT:MOD:TAD?
```

```
1:SOUR:AFG:FREQ 800.0
```

```
1:READ:TXT:MOD:TAD?
```

```
1:SOUR:AFG:FREQ 1000.0
```

```
1:READ:TXT:MOD:TAD?
```

```
1:SOUR:AFG:FREQ 1300.0
```

```
1:READ:TXT:MOD:TAD?
```

```
1:SOUR:AFG:FREQ 1800.0
```

```
1:READ:TXT:MOD:TAD?
```

```
1:SOUR:AFG:FREQ 2300.0
```

```
1:READ:TXT:MOD:TAD?
```

```
1:SOUR:AFG:FREQ 2800.0
```

```
1:READ:TXT:MOD:TAD?
```

```
1:SOUR:AFG:FREQ 3000.0
```

```
1:READ:TXT:MOD:TAD?
```

The entry in the test report has the following appearance:

Testing of AMPS Phones

Voice Channel 1, VMAC 2, AVC RF Level -50.0 dBm, SAT SCC 0, Attenuation (In/Out) 0.0 / 0.0 dB

Analyzer Filters: Bandpass 50 Hz to 4000 Hz, Weighting: off

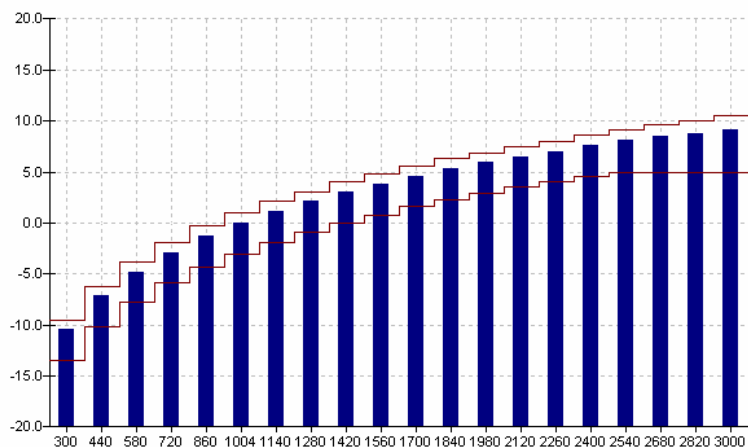
Audio Peak Deviation: Target 2.90 kHz, Tolerance 0.029 kHz, Measured 2.91 kHz

AF Voltmeter	20.00 mV	60.00 mV	48.03 mV	✓
Reference --- mV @ 1004 Hz				
TX Audio Frequency Response (Multitone):			passed	✓
TX Audio Singletone Test 1: @ Frequency 300.0 Hz	-13.50 dB	-9.50 dB	-10.70 dB	✓
TX Audio Singletone Test 2: @ Frequency 800.0 Hz	-4.90 dB	-0.90 dB	-2.10 dB	✓
TX Audio Singletone Test 3: @ Frequency 1000.0 Hz	-3.00 dB	1.00 dB	-0.20 dB	✓
TX Audio Singletone Test 4: @ Frequency 1300.0 Hz	-0.70 dB	3.30 dB	2.10 dB	✓
TX Audio Singletone Test 5: @ Frequency 1800.0 Hz	2.10 dB	6.10 dB	4.90 dB	✓
TX Audio Singletone Test 6: @ Frequency 2300.0 Hz	4.20 dB	8.20 dB	7.00 dB	✓
TX Audio Singletone Test 7: @ Frequency 2800.0 Hz	5.00 dB	9.90 dB	8.43 dB	✓
TX Audio Singletone Test 8: @ Frequency 3000.0 Hz	5.00 dB	10.50 dB	8.85 dB	✓
RF Power:	24.00 dBm	30.00 dBm	28.20 dBm	✓
Carrier Frequency Error:	-2.00 kHz	2.00 kHz	0.80 kHz	✓

The frequency response diagram shows the relationship between audio deviation and frequency. The limits characteristic indicates that we have actually measured the effect of the “pre-emphasis” filter.

Annex: TX Audio Frequency Response (Multitone)

Voice Channel 1, VMAC 2, AVC RF Level -50.0 dBm, SAT SCC 0, Attenuation (In/Out) 0.0 / 0.0 dB, Ref.: --- mV (@1004 Hz)



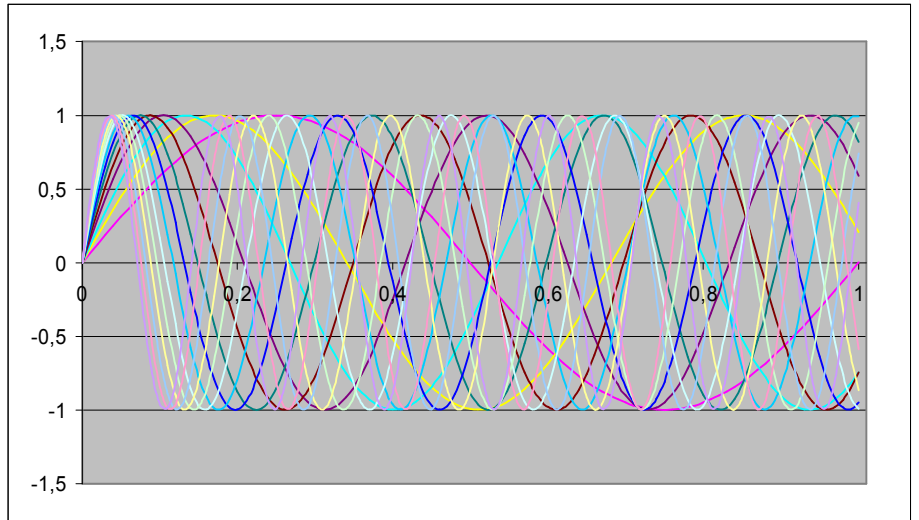
There is, of course, no sense in performing both the “single-tone” and the “multi-tone” measurement. A number of points should, however, be noted when determining the frequency response in the TX test.

The specification defining this test actually requires that a deviation of 2.9 kHz be sought for each individual tone. According to this, therefore, the difference in input level over frequency is to be measured. For some inexplicable reason, this method requires a long processing time which is why here it is used for neither the “single-tone” nor the “multi-tone” test. In the application, only a reference deviation at the reference frequency of 1004 Hz is sought. The difference of deviation over frequency is then measured. This difference should not, however, weaken the validity of this measurement.

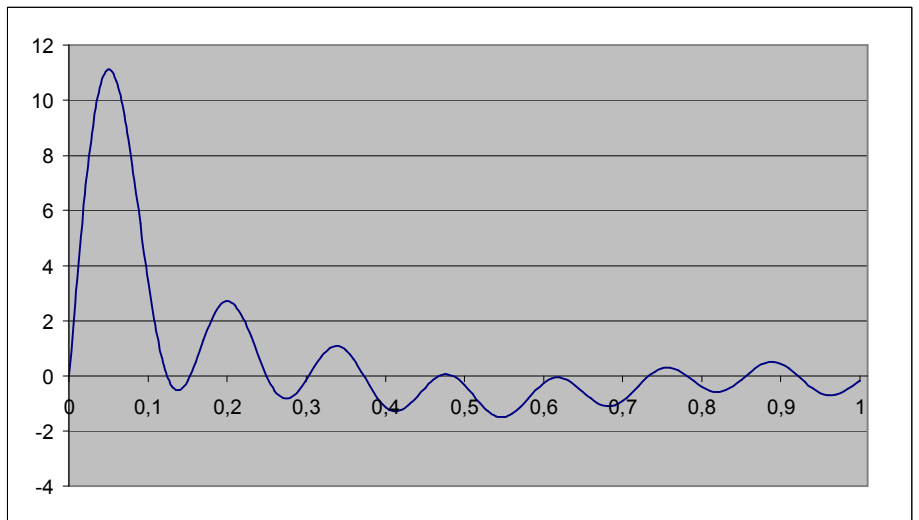
If the “multi-tone” measurement is used, the signal characteristic over time (“time domain”) must also be considered.

Let us first consider the curve characteristics of the individual signals used by default. The time axis relates to one cycle (0...1) of the 1st frequency 300 Hz.

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The diagram shows that all tones begin at time 0 and at the zero point. If we now consider the amplitude-related summation of all the individual signals, we notice considerable level increase at the beginning of the signal cycle.



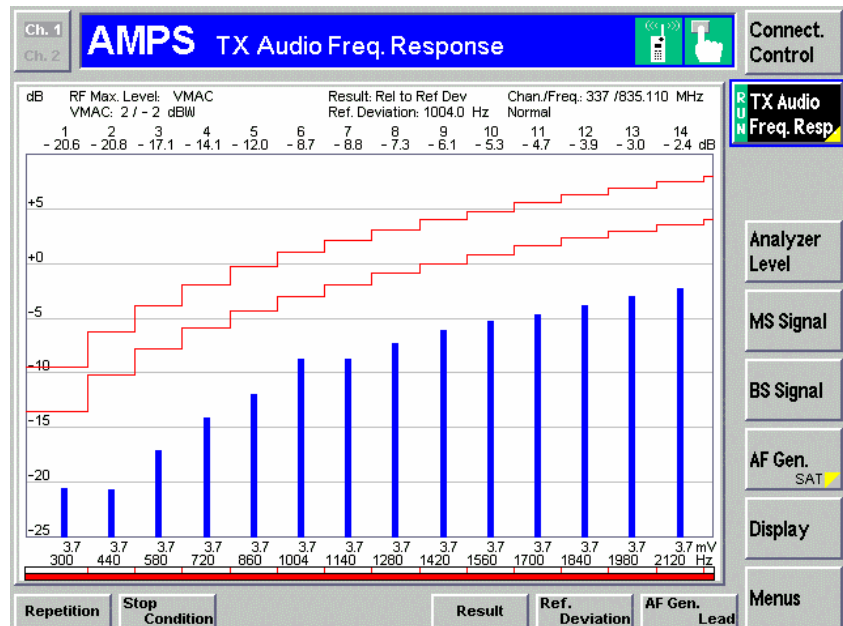
This gives rise to the problem as to which level is to be selected as the reference level for the display, and which level is to be sent by the generator.

CONFIGure:TXAFresp:CONTROL:RREQuest <Reference>		Default Settings		
<Reference>	Description of parameters	Def. value	Def. unit	Unit rmg
RDEV TON<nr>	Results relative to the reference deviation Results relative to freq. response at test tone <nr>, where <nr> = 1 to 20	TON6	-	
Description of command				FW vers.
This command defines the reference value for the results of the TX Audio Freq. Response measurement. The reference deviation is defined via CONFIGure:TXAFresp:CONTROL:RDEVIation. To choose one of the test tones no. 1 to 20, it must be enabled via the CONFIGure:TXAFresp:TDEfinition:TONE<nr> command.				V2.41

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CONFigure:TXAF resp:AFGenerator:LEVel:LMODE <Mode>		Level Selection		
<Mode>	Description of parameters	Def. value	Def. unit	Unit ring
TLEV	Use total level (manual)	TLEV	Hz	
SLEV	Use separate levels for each tone			
SRES	Use AF Level Search result (as total level)			

The following example illustrates the result of the “multi-tone” measurement performed with unsuitable references. It is clear to see that although the curve characteristic has the expected appearance, the level is generally too low. It would be better to replace the reference to the reference deviation with the reference to tone 6 at the frequency of 1004 Hz.



But what actually went wrong?

The reference level is the level of the overall signal with the described level exaggeration. The individual level of each separate tone, including that of tone 6 at 1004 Hz, is therefore much lower. The -9 dB for tone 6 in the measurement shown above is even to be expected. However, if we work backwards, these results could also suggest that, contrary to the rules defined in the specification, single-tone amplitudes were used which were much too low.

Simply increasing the level so that the level of the single tone at 1004 Hz corresponds to the level found in the search cycle has an even greater effect on the measurement result since the transmitter is usually overloaded by the peak level in the overall signal or the limiter has already begun restricting the signal.

So which measurement should be used?

This question could be answered in the following way:

If the frequency response of a certain phone is relatively independent of the magnitude of the input level, the “multi-tone” measurement should be selected. This measurement gives roughly twice as many measuring points over the same period of time as the “single-tone” method. If you are not familiar with the characteristics of the phone, it would be better to use the “single-tone” method. With the TX frequency response measurement, it

Testing of AMPS Phones

may also be worth considering not using the level search and performing all measurements at a fixed level.


If during multi-tone measurement the total deviation exceeds 2.9 kHz, the results are usually rather “strange” with severe exaggeration of individual frequencies. Here, the behaviour of the compressor plays an important role, especially since the compressor is a non-linear component in the signal path. If it is possible to remove the compressor in the mobile phone from the signal path, no adverse affects are to be expected from the “multi-tone” measurement.

19 AMPS TX Hum & Noise Test

Hum & Noise refers to the ratio of residual FM modulation to the FM modulation of an applied test signal. The signal is controlled automatically by the R&S CMU200 to allow this signal ratio to be measured with and without modulation.

The Hum & Noise measurement is usually performed with a signal deviation of 8 kHz, i.e. at full-scale level. The compressor of the phone must be switched on when this test is performed. The “de-emphasis” filter, the expander and the C-message filter in the test receiver should be activated in the signal path.

TX Hum & Noise Test Configuration



Voice Channel

Channel:

VMAC:

RF Level (dBm):

SAT Color Code (SCC):

Attenuations

Input (dB):

Output (dB):

Analyzer Settings

Bandpass:

Weighting:

AF Generator / Peak Deviation Search

Level (mV):

AF Start Level (mV):

Target (kHz):

Tolerance (kHz):

Manual Level Entry

Selected Tests

AF Level after Peak Deviation Search RF Power

Audio Deviation for entered AF Level SAT Tests

Hum & Noise

Carrier Frequency Error

Description

Testing of AMPS Phones

	Lower Limit	Upper Limit
AF Voltage (mV):	200	400
Audio Peak Deviation (kHz):	7920	8080
Hum & Noise (dB):	32	

	Upper Limit
Carrier Frequency Error (kHz):	2
RF Power (dBm):	30

	Lower Limit	Upper Limit
SAT Frequency Error (Hz):		1
SAT Peak Deviation (kHz):	1.8	2.2

For this test you should enter the following values as the test parameters:

- voice channel
- base station level
- SCC
- attenuation values
- audio level at start of “AF Level Search”
- target deviation of “AF Level Search”
- deviation from target value permitted during “AF Level Search”
- selection of TX test results which can be derived from “AF Level Search” process or can be output in R&S CMU200 Hum & Noise measurement
- audio filter settings
- lower limits for signal-to-noise ratio
- limits for “AF Level Search”

As already described in the general section, the test is first prepared by checking (and, if necessary, changing) the call state, channel setting and SCC setting.

```
1;INP:STAT?  
1;SIGN:STAT?  
1;PROC:SIGN:CHAN?  
1;PROC:SIGN:CHAN 1  
1;PROC:SIGN:MAC?  
1;PROC:SIGN:MAC 2  
1;PROC:SIGN:SAT:SCC?  
1;PROC:SIGN:SAT:SCC 0  
1;PROC:BSS:LEV -50.0  
1;SENS:CORR:LOSS:INP2 0.0  
1;SENS:CORR:LOSS:OUTP2 0.0
```

Testing of AMPS Phones

The filter settings used for the Hum & Noise measurement and “AF Level Search” are virtually identical; however, the search is performed without “de-emphasis” filter and expander. The typical voice band is allowed to pass through in both cases.

```
1;CONF:TXT:AFLS:FILT BP10,OFF,OFF,CME
```

```
1;CONF:TXT:HNO:FILT BP10,ON,ON,CME
```

The start level of the “AF Level Search” is set.

```
1;SOUR:AFG:SLEV 0.00020
```

The audio frequency of the AFG is set to 1004 Hz.

```
1;SOUR:AFG:FREQ 1004
```

The sought level and the tolerance for the search result are set.

```
1;CONF:TXT:AFLS:CONT:TAPD 8000.00
```


```
1;CONF:TXT:AFLS:CONT:TDER 80.00
```

The level search is now performed. The R&S CMU200 changes the audio level at the audio generator until the target deviation is measured. The returned value is the found audio level.

```
1;READ:TXT:AFLS?
```

The actual TX Hum & Noise measurement is then performed.

```
1;READ:TXT:HNO:FHN?
```

<i>Voice Channel 1, V/MAC 2, A/V C RF Level -50.0 dBm, SAT SCC 0, Attenuation (In/Out) 0.0 / 0.0 dB</i>				
<i>Analyzer Filters: Bandpass 50 Hz to 4000 Hz, Weighting: C-Message</i>				
<i>Audio Peak Deviation: Target 8.00 kHz, Tolerance 0.080 kHz, Measured 8.02 kHz</i>				
AF Voltmeter	200.00 mV	400.00 mV	321.27 mV	✓
TX Hum & Noise:	32.00 dB		44.13 dB	✓

20 AMPS TX Modulation Limiting Test

TX Modulation Limiting Test Configuration

Voice Channel
Channel: 1

VMAC: 2

RF Level (dBm): -50

SAT Color Code (SCC): 0

AF Generator / Peak Deviation Search
AF Start Level (mV): 0.2
Target (kHz): 8
Tolerance (kHz): 0.08

Limiting Test at Audio Gain (dB): 20

Attenuations
Input (dB): 0
Output (dB): 0

Analyzer Settings
Bandpass: 50 Hz to 4000 Hz
Weighting: OFF

Selected Tests
 AF Level after Peak Deviation Search
 incl. Frequency Range Check
 Carrier Frequency Error
 RF Power

Description
My first TX Modulation Limiting Test

Limits... OK Cancel

Limits

Measurement after Level Search

	Lower Limit	Upper Limit
AF Voltage (mV):	200	400

Measurement at Limiting

	Upper Limit
Audio Peak Deviation (kHz):	11

	Lower Limit	Upper Limit
Carrier Frequency Error (kHz):		2
RF Power (dBm):	24	30

OK

The last TX test concerns the limiter shown in the block diagram. The deviation is limited from a deviation of approx. 8 kHz and higher, and should not usually exceed 11 kHz or 12 kHz. While the AMPS specification permits 12 kHz as the upper limit, a number of mobile phone manufacturers set a lower upper limit of 11 kHz.

For this test you should enter the following values as the test parameters:

- voice channel
- base station level
- SCC
- attenuation values

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- audio level at start of “AF Level Search”
- target deviation of “AF Level Search”
- deviation from target value permitted during “AF Level Search”
- selection of TX test results which can be derived from “AF Level Search” process
- audio filter settings
- limits for total deviation

As already described in the general section, the test is first prepared by checking (and, if necessary, changing) the call state, channel setting and SCC setting.

```
1;INP:STAT?
1;SIGN:STAT?
1;PROC:SIGN:CHAN?
1;PROC:SIGN:CHAN 1
1;PROC:SIGN:MAC?
1;PROC:SIGN:MAC 2
1;PROC:SIGN:SAT:SCC?
1;PROC:SIGN:SAT:SCC 0
1;PROC:BSS:LEV -50.0
1;SENS:CORR:LOSS:INP2 0.0
1;SENS:CORR:LOSS:OUTP2 0.0
```

The same filter settings are used for the modulation measurement and the “AF Level Search”. Here it once again makes sense to allow the voice band to pass through. Although the “C-message” filter is enabled during the search, the measurement is started without this filter since measurements are to be performed at frequencies other than the reference frequency of 1004 Hz.

```
1;CONF:TXT:AFLS:FILT BP10,OFF,OFF,CME
1;CONF:TXT:MOD:FILT BP10,OFF,OFF,OFF
```

The level search is now performed. The R&S CMU200 varies the audio level at the audio generator until the target deviation is measured. The returned value is the found audio level. It is essential to abort this measurement (“ABOR:TXT:AFLS”) later on so that the audio generator can be started.

```
1;READ:TXT:AFLS?
```

The level search does not only return the audio level, but (as already described above) other measured values as well which can also be used as test items.

The start level of the “AF Level Search” is set.

```
1;SOUR:AFG:SLEV 0.00020
```

The audio frequency of the AFG is set to 1004 Hz.

```
1;SOUR:AFG:FREQ 1004
```

The sought level and the tolerance for the search result are set.

```
1;CONF:TXT:AFLS:CONT:TAPD 8000.00
1;CONF:TXT:AFLS:CONT:TDER 80.00
```

Testing of AMPS Phones

The level search is now performed. The R&S CMU200 changes the audio level at the audio generator until the target deviation is measured. The returned value is the found audio level.

```
1;READ:TXT:AFLS?
```

```
1;ABOR:TXT:AFLS
```

In this measurement, an audio signal with a gain specified during configuration is used (typically 20 dB higher than for the reference value). The value found during the level search is used as the basis. It would actually be impossible to perform this test according to the specification during a call because a SAT should not be active during the measurement. This tone is, however, always available during the call in signalled mode.

```
1;SOUR:AFG:LEV <Level>
```

The audio generator is switched on.

```
1;INIT:AFG
```

The first measurement is then performed in the center channel.

```
1;READ:TXT:MOD:TAD?
```

Further measurements are then performed over the entire audio voice band at 300 Hz, 800 Hz, 1.3 kHz, 1.8 kHz, 2.3 kHz, 2.8 kHz and finally at 3.0 kHz.

```
1;SOUR:AFG:FREQ 300
```

```
1;READ:TXT:MOD:TAD?
```

```
1;SOUR:AFG:FREQ 800
```

```
1;READ:TXT:MOD:TAD?
```

```
1;SOUR:AFG:FREQ 1300
```

```
1;READ:TXT:MOD:TAD?
```

```
1;SOUR:AFG:FREQ 1800
```

```
1;READ:TXT:MOD:TAD?
```

```
1;SOUR:AFG:FREQ 2300
```

```
1;READ:TXT:MOD:TAD?
```

```
1;SOUR:AFG:FREQ 2800
```

```
1;READ:TXT:MOD:TAD?
```

```
1;SOUR:AFG:FREQ 3000
```

```
1;READ:TXT:MOD:TAD?
```

The report containing the measured values has the following appearance:

Voice Channel 1, VIMAC 2, AVC RF Level -50.0 dBm, SAT SCC 0, Attenuation (In/Out) 0.0 / 0.0 dB				
Analyzer Filters: Bandpass 50 Hz to 4000 Hz, Weighting: off				
Audio Peak Deviation: Target 8.00 kHz, Tolerance 0.080 kHz, Measured 8.02 kHz				
AF Voltmeter	200.00 mV	400.00 mV	321.27 mV	✓
TX Limiting Deviation: @ Frequency 1004.0 Hz, -- dB Gain		11.00 kHz	10.21 kHz	✓
TX Limiting Deviation: @ Frequency 300.0 Hz, -- dB Gain		11.00 kHz	10.21 kHz	✓
TX Limiting Deviation: @ Frequency 800.0 Hz, -- dB Gain		11.00 kHz	10.21 kHz	✓
TX Limiting Deviation: @ Frequency 1300.0 Hz, -- dB Gain		11.00 kHz	10.21 kHz	✓
TX Limiting Deviation: @ Frequency 1800.0 Hz, -- dB Gain		11.00 kHz	10.21 kHz	✓
TX Limiting Deviation: @ Frequency 2300.0 Hz, -- dB Gain		11.00 kHz	10.21 kHz	✓
TX Limiting Deviation: @ Frequency 2800.0 Hz, -- dB Gain		11.00 kHz	10.21 kHz	✓
TX Limiting Deviation: @ Frequency 3000.0 Hz, -- dB Gain		11.00 kHz	10.21 kHz	✓

21 AMPS RX Expander Test

The RX measurements are more simple because an audio level search does not have to be performed. In the RX test, you control the deviation settings for the RF signal yourself and you no longer have to derive them from an audio signal.

RX Expander Test Configuration

Voice Channel

Channel:

VMAC:

RF Level (dBm):

SAT Color Code (SCC):

Modulation Generator

Frequency (Hz):

Reference Deviation (Hz):

Maximal Deviation (Hz):

Minimal Deviation (Hz):

Stepsize: 1 dB 2 dB 5 dB

Analyzer Settings

Bandpass:

Weighting:

Manual Level (V):

Auto Ranging

Attenuations

Input (dB):

Output (dB):

Description

The following parameters are specified when configuring the test:

- voice channel
- base station level
- SCC
- audio frequency
- reference deviation
- start value and end value for deviation
- step size
- audio filter settings
- autoranging, or manual range setting if expected audio level is specified

The same initialization routine used for the AMPS test is then performed.

```
1; INP: STAT?
```

```
1; SIGN: STAT?
```

```
1; PROC: SIGN: CHAN?
```

```
1; PROC: SIGN: CHAN 1
```

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```

1;PROC:SIGN:MAC?
1;PROC:SIGN:MAC 2
1;PROC:SIGN:SAT:SCC?
1;PROC:SIGN:SAT:SCC 0
1;PROC:BSS:LEV -50.0
1;SENS:CORR:LOSS:INP2 0.0
1;SENS:CORR:LOSS:OUTP2 0.0

```

Autoranging for the audio analyzer of the R&S CMU200 is then set.

```
1;AFL:MODE AUT
```

Or, in the case of manual range setting, the expected maximum value is specified.

```

1;AFL:MAX 0.5
1;AFL:MODE MAN

```

This is followed by the filter setting which, apart from the audio range, also uses the required C-message filter. The measuring time is set to 25 milliseconds in order to optimize speed.

```

1;CONF:RXT:AFAN:FILT BP10,CME
1;CONF:RXT:AFAN:VMS:CONT:MTIM 0.025

```

The audio frequency and the modulation deviation of the modulation generator are specified. The modulation generator is then switched on.

```

1;SOUR:MODG:FREQ 1004.0
1;SOUR:MODG:DEV 2900.0
1;INIT:MODG;*OPC?

```

As with the TX power measurement, the R&S CMU200 offers two different measurements suitable for measuring the audio signal. As can be seen from the description in the manual, a measuring command which does not perform a distortion measurement has been added for speed reasons.

Returned values		Value range	Def. value	Def. unit	Unit ring
AF Voltmeter,		0 V to 30 V	NAN	V	
AF SINAD,		0 dB to 100 dB	NAN	dB	
AF Distortion,		0% to 100%	NAN	%	
Dist&SINADat		–	NAN	Hz	
Description of command					FW vers.
These commands are always queries. They start a <i>RX Tests – AF Analyzer</i> measurement and output all measurement results (see chapter 4).					V2.41

Testing of AMPS Phones

READ[:SCALar]:RXTests:AFANalyzer:VMSinad[:RESult]? Start single shot measurement and return results		Scalar Results:		
FETCh[:SCALar]:RXTests:AFANalyzer:VMSinad[:RESult]? Read out meas. results (unsynchronized)				
SAMPle[:SCALar]:RXTests:AFANalyzer:VMSinad[:RESult]? Read out measurement results (synchronized)				
Returned values	Value range	Def. value	Def. unit	Unit ring
AFVoltmeter,	0 V to 30 V	NAN	V	
AFSINAD,	0 dB to 100 dB	NAN	dB	
SINADat	–	NAN	Hz	
Description of command				FW vers.
These commands are always queries. They start a <i>RX Tests – AF Analyzer</i> measurement and output all measurement results (see chapter 4).				V3.00

Since we are not interested in the distortion, we will, of course, choose the faster measuring command.

```
1;READ:RXT:AFAN:VMS?
```

This measurement based on the reference deviation is followed by the measurements for the specified start and end value of the deviation.

```
1;SOUR:MODG:DEV 12000.0
```

```
1;READ:RXT:AFAN:VMS?
```

With a step size setting of 1 dB as shown above, this results in deviation settings of 12000.0 Hz, 10695.0 Hz, 9531.9 Hz, 8495.3 Hz, 7571.5 Hz, 6748.1 Hz, 6014.2 Hz, 5360.2 Hz, 4777.3 Hz, 4257.8 Hz, 3794.7 Hz, 3382.1 Hz, 3014.3 Hz, 2686.5 Hz, 2394.3 Hz, 2133.9 Hz, 1901.9 Hz, 1695.0 Hz, 1510.7 Hz, 1346.4 Hz, 1200.0 Hz, 1069.5 Hz, 953.2 Hz, 849.5 Hz, 757.1 Hz, 674.8 Hz, 601.4 Hz, 536.0 Hz, 477.7 Hz, 425.8 Hz, 379.5 Hz, 338.2 Hz, 301.4 Hz, 268.6 Hz and 239.4 Hz.

```
1;SOUR:MODG:DEV 12000.0
```

```
1;READ:RXT:AFAN:VMS?
```

The modulation generator should be switched off as soon as the measurements have been completed. This is strongly recommended as it prevents other measurements from being hindered.

```
1;ABOR:MODG
```

The entry in the test report has the following appearance:

Voice Channel 1, VMAC 2, AVC RF Level -30.0 dBm, Attenuation (In/Out) 0.0 / 0.0 dB			
Analyzer Filters: Bandpass 50 Hz to 4000 Hz, Weighting: C-Message			
Reference Deviation 2900.0 Hz, Modulated Frequency 1004.0 Hz			
Start Level -21.7 dB (239.4 Hz Deviation), Stop Level 12.3 dB (12000.0 Hz Deviation)			
RX Expandor Test:	<input type="text"/>	<input type="text"/>	passed <input checked="" type="checkbox"/>

The diagram illustrates the relationship between the measured audio level and the input deviation at the phone. Each time the audio level changes by precisely 2 dB, the deviation changes by 1 dB. The displayed limits are defined in the AMPS specification, which requires ± 1 dB for values above a deviation of 2.9 kHz and ± 2 dB for values below a deviation of 2.9 kHz.

Testing of AMPS Phones


Annex: RX Expander Graphics

Voice Channel 1, VMAC 2, AVC RF Level -50.0 dBm, SAT SCC 0, Start 239.4 Hz, Stop 12000.0 Hz, Ref. 2900.0 Hz Deviation.



22 AMPS RX Frequency Response Test

RX Frequency Response Test Configuration



Voice Channel Channel: RF Level (dBm):
VMAC: SAT Color Code (SCC):

Modulation Generator Deviation (Hz):

Analyzer Settings Bandpass:
Weighting:
Manual Level (V): Autoranging

Attenuations Input (dB): Output (dB):

Selected Tests Multi Tone Frequency Response Test Single Tone Audio Tests

Enable	at Frequency (Hz)	Lower Limit Unit dB (Reference 1004 Hz)	Upper Limit
<input checked="" type="checkbox"/>	Single Tone Test 1: <input type="text" value="300"/>	4.5	11.5
<input checked="" type="checkbox"/>	Single Tone Test 2: <input type="text" value="800"/>	-1	3
<input checked="" type="checkbox"/>	Single Tone Test 3: <input type="text" value="1000"/>	-3	1
<input checked="" type="checkbox"/>	Single Tone Test 4: <input type="text" value="1300"/>	-5.2	-1.2
<input checked="" type="checkbox"/>	Single Tone Test 5: <input type="text" value="1800"/>	-8.1	-4.1
<input checked="" type="checkbox"/>	Single Tone Test 6: <input type="text" value="2300"/>	-10.2	-6.2
<input checked="" type="checkbox"/>	Single Tone Test 7: <input type="text" value="2800"/>	-14.9	-7.9
<input checked="" type="checkbox"/>	Single Tone Test 8: <input type="text" value="3000"/>	-15.5	-8.5

Description:

The following parameters are specified when configuring the test:

- voice channel
- base station level

Testing of AMPS Phones

- SCC
- audio frequency
- reference deviation
- selection for “multi-tone” measurement
- selection for “single-tone” measurements (frequency must be entered); max. 8 single tones are available
- limits for measured audio levels in “single-tone” test
- audio filter settings
- autoranging, or manual range setting if expected audio level is specified

The same initialization routine used for the AMPS test is then performed.

```
1;INP:STAT?
1;SIGN:STAT?
1;PROC:SIGN:CHAN?
1;PROC:SIGN:CHAN 1
1;PROC:SIGN:MAC?
1;PROC:SIGN:MAC 2
1;PROC:SIGN:SAT:SCC?
1;PROC:SIGN:SAT:SCC 0
1;PROC:BSS:LEV -50.0
1;SENS:CORR:LOSS:INP2 0.0
1;SENS:CORR:LOSS:OUTP2 0.0
```

Autoranging for the audio analyzer of the R&S CMU200 is then set.

```
1;AFL:MODE AUT
```

Or, in the case of manual range setting, the expected maximum value is specified.

```
1;AFL:MAX 0.5
1;AFL:MODE MAN
```

This is followed by the filter setting for the “multi-tone” measurement and the settings for the audio analyzer for the “single-tone” measurements. The standard setting for all filters is OFF.

```
1;CONF:RXAF:FILT BP16,OFF
1;CONF:RXT:AFAN:FILT BP16,OFF
```

The “TDEV” setting is used as the reference for the “multi-tone” measurement. The total deviation of the frequency mix is therefore taken as the reference. As standard, 2.9 kHz is used as the reference value for this “multi-tone” measurement.

```
1;CONF:RXAF:MODG:FDEV:FDM TDEV
1;CONF:RXAF:MODG:FDEV:TFD 2900.0
```

2.9 kHz is also used as standard as the reference for the following single-tone measurements.

```
1;SOUR:MODG:DEV 2900.0
```

The frequency response measurement using “multi-tones” is then performed.

Testing of AMPS Phones

```
1;READ:ARR:RXAF?
```

Here too the measurement is aborted to prevent blocking of the modulation generator.

```
1;ABOR:RXAF
```

The “single-tone” measurements are then performed with the measuring time set to 25 milliseconds and with the appropriate frequency setting of the modulation generator. Afterwards the modulation generator is switched on.

```
1;CONF:RXT:AFAN:VMS:CONT:MTIM 0.025
```

```
1;SOUR:MODG:FREQ 1004
```

```
1;INIT:MODG;*OPC?
```

The measurement is then performed at the reference frequency.

```
1;READ:RXT:AFAN:VMS?
```

The measurements are then performed at the other frequencies.

```
1;SOUR:MODG:FREQ 300.0
```

```
1;READ:RXT:AFAN:VMS?
```

```
1;SOUR:MODG:FREQ 800.0
```

```
1;READ:RXT:AFAN:VMS?
```

```
1;SOUR:MODG:FREQ 1000.0
```

```
1;READ:RXT:AFAN:VMS?
```

```
1;SOUR:MODG:FREQ 1300.0
```

```
1;READ:RXT:AFAN:VMS?
```

```
1;SOUR:MODG:FREQ 1800.0
```

```
1;READ:RXT:AFAN:VMS?
```

```
1;SOUR:MODG:FREQ 2300.0
```

```
1;READ:RXT:AFAN:VMS?
```

```
1;SOUR:MODG:FREQ 2800.0
```

```
1;READ:RXT:AFAN:VMS?
```

```
1;SOUR:MODG:FREQ 3000.0
```

```
1;READ:RXT:AFAN:VMS?
```

Finally, the modulation generator is switched off.

```
1;ABOR:MODG
```

The “multi-tone” measurement appears as follows in the test report. First as an individual test item.

```
Voice Channel 1, VMAC 2, AVC RF Level -30.0 dBm, Attenuation (In/Out) 0.0 / 0.0 dB
Analyzer Filters: Bandpass 0 Hz to 21000 Hz, Weighting: off
RX Audio Frequency Response (Multitone): 

|  |  |        |   |
|--|--|--------|---|
|  |  | passed | ✓ |
|--|--|--------|---|

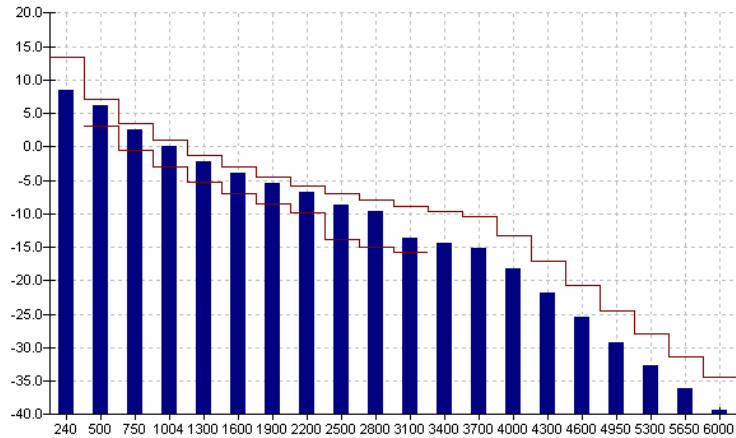

```

And then in graphical form. This diagram shows two things. Firstly the effect of the “de-emphasis” filter. Secondly that measurements are also taken outside the “audio band” in order to detect any interference. This includes interference which may be caused by the SAT tone.

Testing of AMPS Phones

Annex: RX Audio Frequency Response (Multitone)

Voice Channel 1, VMAC 2, AVC RF Level -50.0 dBm, SAT SCC 0, Attenuation (In/Out) 0.0 / 0.0 dB, Ref.: 35.2 mV (@1004 Hz)



Finally, the “single-tone” measurements are listed in the test report.

No major interference is expected in the multi-tone test, which was not the case for TX frequency response measurement. A difference between the “multi-tone” and “single-tone” measurement is nevertheless to be expected. The total deviation was used as the reference for the “multi-tone” measurement. However, remember the time characteristic of the signal mix and the severe exaggeration at the beginning of the signal. This inevitably causes shifting of the operating point for the phone demodulator and may thus result in shifting of the test results.

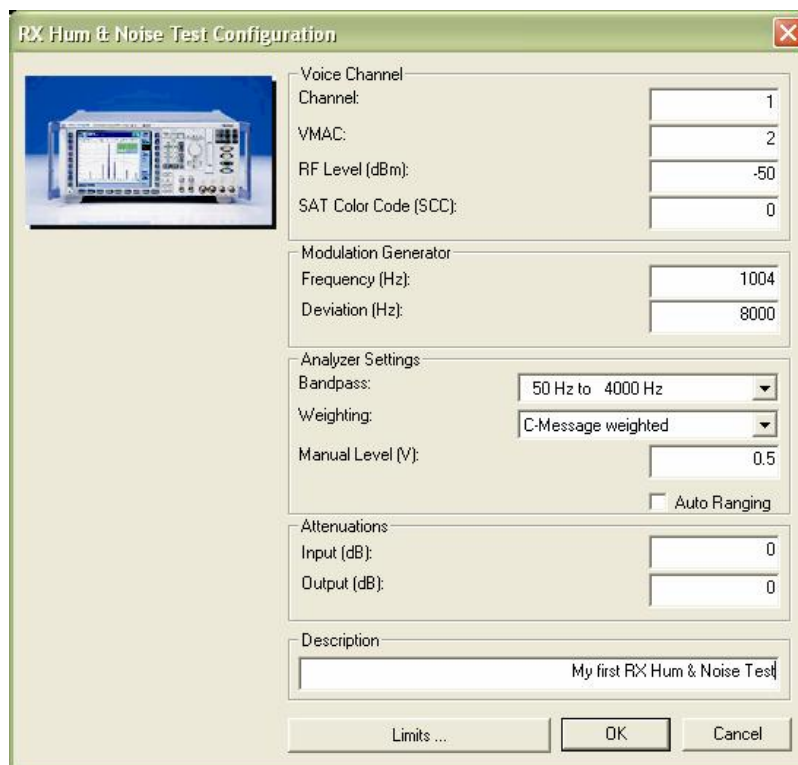
Reference 32.1 mV @ 1004 Hz

RX Audio Singletone Test 1: @ Frequency 300.0 Hz	4.50 dB	11.50 dB	8.74 dB	✓
RX Audio Singletone Test 2: @ Frequency 800.0 Hz	-1.00 dB	3.00 dB	1.42 dB	✓
RX Audio Singletone Test 3: @ Frequency 1000.0 Hz	-3.00 dB	1.00 dB	-0.58 dB	✓
RX Audio Singletone Test 4: @ Frequency 1300.0 Hz	-5.20 dB	-1.20 dB	-2.78 dB	✓
RX Audio Singletone Test 5: @ Frequency 1800.0 Hz	-8.10 dB	-4.10 dB	-5.68 dB	✓
RX Audio Singletone Test 6: @ Frequency 2300.0 Hz	-10.20 dB	-6.20 dB	-7.78 dB	✓
RX Audio Singletone Test 7: @ Frequency 2800.0 Hz	-14.90 dB	-7.90 dB	-10.66 dB	✓
RX Audio Singletone Test 8: @ Frequency 3000.0 Hz	-15.50 dB	-8.50 dB	-11.26 dB	✓


23 AMPS RX Hum & Noise Test

Hum & Noise refers to the difference in audio signal level for an applied modulated signal compared to an unmodulated signal. The “C-Message” filter should be used for this measurement.

Testing of AMPS Phones



RX Hum & Noise Test Configuration



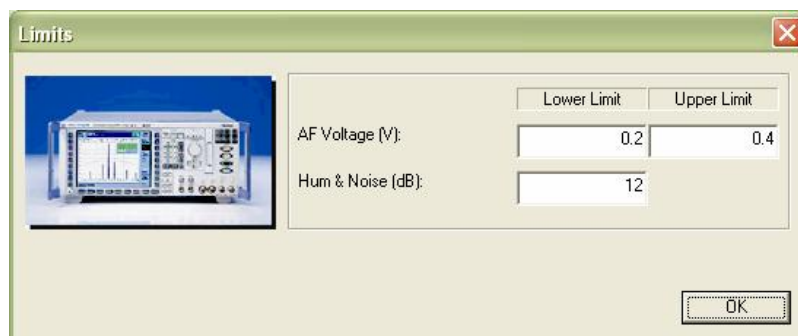
Voice Channel
Channel:
VMAC:
RF Level (dBm):
SAT Color Code (SCC):

Modulation Generator
Frequency (Hz):
Deviation (Hz):


Analyzer Settings
Bandpass:
Weighting:
Manual Level (V):
 Auto Ranging

Attenuations
Input (dB):
Output (dB):

Description



Limits



	Lower Limit	Upper Limit
AF Voltage (V):	<input type="text" value="0.2"/>	<input type="text" value="0.4"/>
Hum & Noise (dB):	<input type="text" value="12"/>	

The following parameters are specified when configuring the test:

- voice channel
- base station level
- SCC
- audio frequency
- reference deviation for measurement
- limits for measured audio level
- limit for signal-to-noise ratio
- audio filter settings
- autoranging, or manual range setting if expected audio level is specified

Testing of AMPS Phones

As already described in the general section, the test is first prepared by checking (and, if necessary, changing) the call state, channel setting and SCC setting.

```
1;INP:STAT?
1;SIGN:STAT?
1;PROC:SIGN:CHAN?
1;PROC:SIGN:CHAN 1
1;PROC:SIGN:MAC?
1;PROC:SIGN:MAC 2
1;PROC:SIGN:SAT:SCC?
1;PROC:SIGN:SAT:SCC 0
1;PROC:BSS:LEV -50.0
1;SENS:CORR:LOSS:INP2 0.0
1;SENS:CORR:LOSS:OUTP2 0.0
```

Autoranging for the audio analyzer of the R&S CMU200 is then set.

```
1;AFL:MODE AUT
```

Or, in the case of manual range setting, the expected maximum value is specified.

```
1;AFL:MAX 0.5
1;AFL:MODE MAN
```

The filter setting for the audio analyzer is then made.

```
1;CONF:RXT:AFAN:FILT BP10,CME
```

The modulation deviation and the frequency of the modulation generator are set. Afterwards the modulation generator is switched on.

```
1;SOUR:MODG:DEV 8000.0
1;SOUR:MODG:FREQ 1004.0
1;INIT:MODG;*OPC?
```



The actual Hum & Noise measurement is then performed.

```
1;READ:RXT:HNO?
```

The measurement is then aborted and the modulation generator switched off.

```
1;ABOR:RXT:HNO
1;ABOR:MODG
```

The test report is very short. This is because the test involves just one measurement.

```
-----
Voice Channel 1, VMAC 2, AVC RF Level -50.0 dBm, Attenuation (In/Out) 0.0 / 0.0 dB
Analyzer Filters: Bandpass 50 Hz to 4000 Hz, Weighting: C-Message
RX Hum & Noise: 12.00 dB  19.27 dB 
```

24 AMPS SINAD Test

SINAD Test Configuration

Voice Channel
Channel: 1
VMAC: 2
RF Level (dBm): -50
SAT Color Code (SCC): 0

Modulation Generator
Frequency (Hz): 1004
Deviation (Hz): 8000

Analyzer Settings
Bandpass: 50 Hz to 4000 Hz
Weighting: C-Message weighted
Manual Level (V): 0.5
 Auto Ranging

Selected Tests
 AF Voltage
 SINAD
 Distortion

Attenuations
Input (dB): 0
Output (dB): 0

Description
First first SINAD Test

Limits ... OK Cancel

The last RX measurement is the SINAD measurement (signal-to-noise ratio). This test is used to measure the audio distortion of the phone at the loudspeaker output. It is also possible to check whether the output voltage of the audio signal is within the expected range.

Limits

	Lower Limit	Upper Limit
AF Voltage (V):	0.2	0.4
AF SINAD (dB):	12	
AF Distortion (%):		5

OK

The following parameters are specified when configuring the test:

- voice channel
- base station level
- SCC
- audio frequency
- reference deviation for measurement

Testing of AMPS Phones

- selection of possible test items
- limits for measured audio level
- limit for noise-to-signal ratio (SINAD)
- limit for distortion
- audio filter settings
- autoranging, or manual range setting if expected audio level is specified

The same initialization routine used for the AMPS test is then performed.

```
1;INP:STAT?
1;SIGN:STAT?
1;PROC:SIGN:CHAN?
1;PROC:SIGN:CHAN 1
1;PROC:SIGN:MAC?
1;PROC:SIGN:MAC 2
1;PROC:SIGN:SAT:SCC?
1;PROC:SIGN:SAT:SCC 0
1;PROC:BSS:LEV -50.0
1;SENS:CORR:LOSS:INP2 0.0
1;SENS:CORR:LOSS:OUTP2 0.0
```

Autoranging for the audio analyzer of the R&S CMU200 is then set.

```
1;AFL:MODE AUT
```

Or, in the case of manual range setting, the expected maximum value is specified.

```
1;AFL:MAX 0.5
1;AFL:MODE MAN
```

This is followed by the filter setting for the audio analyzer (the “C-Message” filter is used and only the voice band is allowed to pass through).

```
1;CONF:RXT:AFAN:FILT BP10,CME
```

The modulation deviation and the frequency of the modulation generator are set. Afterwards the modulation generator is switched on.

```
1;SOUR:MODG:DEV 8000.0
1;SOUR:MODG:FREQ 1004.0
1;INIT:MODG;*OPC?
```

The audio analyzer measurement is then performed.

```
1;READ:RXT:AFAN?
```

The measurement is then aborted and the modulation generator deactivated.

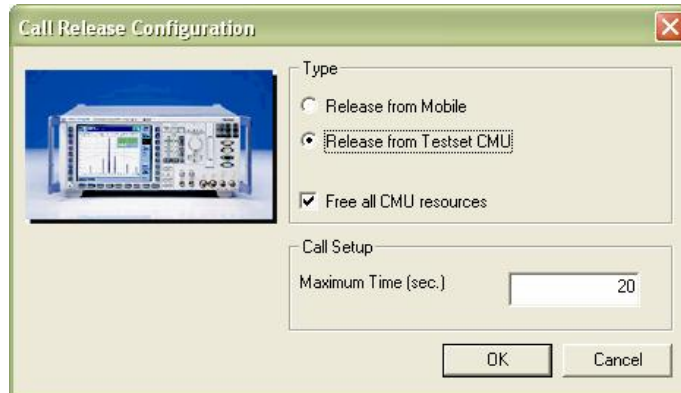
```
1;ABOR:RXT:ANAN
1;ABOR:MODG
```

The test report is very short since the test involves just one measurement.

Testing of AMPS Phones

Voice Channel 1, VIMAC 2, AVC RF Level -50.0 dBm, SAT SCC 0, Attenuation (In/Out) 0.0 / 0.0 dB			
Analyzer Filters: Bandpass 50 Hz to 4000 Hz, Weighting: C-Message			
AF SIIAD:	12.00 dB	<input type="text"/>	19.27 dB <input checked="" type="checkbox"/>

25 AMPS Call Release



The following parameters are specified when configuring the test:

- type of call release
- maximum time for call release
- release of R&S CMU resources

The call state is first checked.

```
1:SIGN:STAT?
```

This is followed by the following command if the call release is to be initiated by the tester.

```
1:PROC:SIGN:ACT CREL
```

The call state is checked. The state changes from “CEST” to “REG”. It is recommended to check the call state both at the mobile phone when the call is released, and also at the tester.

```
1:SIGN:STAT?
```

If required, the generator of the R&S CMU200 can be switched off.

```
1:PROC:SIGN:ACT SOFF
```

This routine changes slightly if the call setup in AMPS was initiated by a handoff “with fallback”. In this case, the tester and mobile phone will revert to the original network. Initially, the sequence is exactly the same as for “without fallback”.

```
1:SIGN:STAT?
```

```
1:PROC:SIGN:ACT CREL
```

Unlike the case described above, however, we now have to address the function group to which the phone reverts, i.e. an appropriate function group for cdmaOne, cdma2000 or TDMA IS 136.

Testing of AMPS Phones

3:SIGN:STAT?

3:PROC:SIGN:ACT SOFF

Finally, the result of the test is given in the test report. The call release test is considered as “passed” if the call state reverts to the synchronized state “REG” in the predefined time. In the case of call release from the mobile phone, it is important to note that the time required by the user to operate the phone must also be included in the time criterion.

Call Release Test:			passed	✓
--------------------	--	--	--------	---

26 Test End

Finally, it is recommended to end the test sequence with “Test End”. Under this test item, the CMUgo “autosave” functions (if activated) can be used for the test report. More detailed information can be found in the CMUgo manual.



27 Additional Information

Please send any comments or suggestions concerning this application note to TM-Applications@rsd.rohde-schwarz.com.

28 Ordering Information

Radio Communication Tester		
CMU200	Base unit	1100.0008.02
CMU-B21 ⁽¹⁾	Versatile signalling unit	1100.5200.02
CMU-B21v14 ⁽¹⁾	Universal signalling unit	1100.5200.14
CMU-B54v14 ⁽¹⁾	Signalling module for AMPS, TDMA, GSM	1150.2604.14
CMU-B41	Audio generator and analyzer	1100.5300.02
CMU-K29	SW option for analog AMPS	1115.6807.02

⁽¹⁾ CMU-B21 or CMU-B21v14 with CMU-B54v14 is required.



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