

Products: CMD57/59, FSE, NRVD

Calibrating the CMD Output Level for BER

Application Note

The CMD 57/59 output level for BER measurement can be calibrated to high accuracy to match GSM 11.21, (with modulated signals and adjacent timeslots + 50 dB above the used timeslot) using a simple test setup containing an NRVD power meter and an FSE spectrum analyzer.



Contents

1 Overview.....	2
2 Principle of Calibration	3
3 Calibration Procedure.....	4
4 Changing the CMD EEPROM values.....	8
5 Level uncertainty calculation:	9
6 Ordering information	10

1 Overview

Specifications for Static Reference Sensitivity for the newest generation of GSM base station receivers are becoming more stringent, so that a correspondingly high BER level accuracy for the test instrument is very important. Using an FSE spectrum analyzer (option FSE-B22 required) together with an NRVD powermeter and an FSE-Z4 power sensor, the accuracy of the CMD 57 output level at output RF OUT 2 can be increased considerably. The calibration takes place at a higher output power level where it can be measured directly by the sensitive FSE spectrum analyzer. A precise external attenuator is used afterwards to achieve the required level range. The described method is used in CMD-U92 ("Special calibration for CMD57: Output Level -85 dBm to -91 dBm at 50 dBc adj. TS") and can also be used to recalibrate the CMD57 on site.

There are two Excel Sheets to download with this application note:

Use Excel Sheet No. 1 for convenient calculation of the mean level error of the CMD, dependent on the measured results.

Use Excel Sheet No. 2 for a uncertainty calculation of the CMD output level after calibrating according to this application note.

2 Principle of Calibration

Important: The CMD output level at RF OUT 2 is calibrated according to GSM 11.21 with a modulated signal and adjacent timeslot levels +50 dB above the used timeslot. This guarantees that the achieved level accuracy is really achieved when measuring Static BER sensitivity.

Principle of calibration:

1. Measure the output level at CMD OUT 2 at high level (-35 dBm) and a nonbursted signal (adjacent timeslots 0 dB) using an NRVD with an NRV-Z4 diode sensor to get a reference point with the highest possible accuracy.
2. Measure output level at CMD OUT 2 again at same conditions with an FSE, to obtain a correction factor.
3. Lower the output level of the CMD to -85 dBm, set the adjacent time slots to +50 dB and measure the used timeslot with the FSE. Only the FSE linearity error still contributes to the overall error (< 0.2 dB with option FSE-B22).

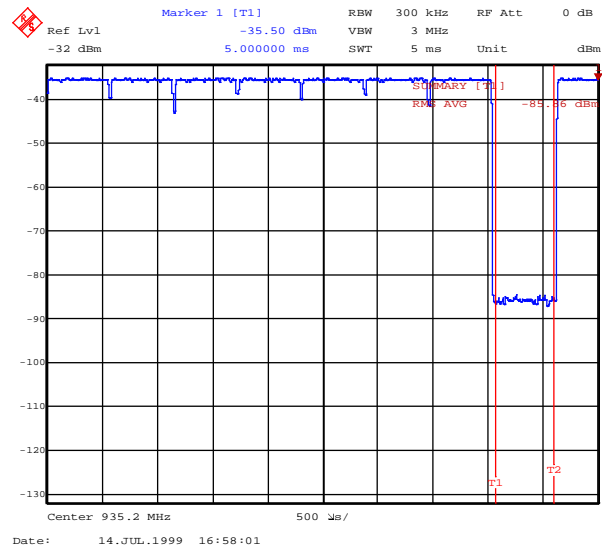


Fig. 1: Measuring the timeslot used with an FSE

4. Lower the output level of the CMD further to -91 dB in steps of 0.6 dB and note the measured values.
5. Measure the FSE noise level.
6. Correct all results by the FSE noise level and the correction factor from step 2 to get the absolute CMD BER output levels in the range of -85 dBm to -91 dBm.
7. Use the mean level error in the range -85 dBm to -91 dBm as the new calibration factor for the CMD (change the EEPROM value).
8. Using a precisely calibrated external attenuator at for example, 20 dB, the output level range can be shifted as required e.g. to the -105 dBm to -111 dBm range. A level uncertainty of <0.5 dB is achieved (expanded combined standard uncertainty with 95 % confidence level).

3 Calibration Procedure

Note: The following calibration procedure is valid to calibrate the M channels for GSM900/1800/1900

Necessary instruments:

FSEA(B/M)20(30) Spectrum Analyzer with FSE-B22

NRVD Power Meter with NRV-Z4

Test Setup:

Connect Pin 25 (BITCLK) with Pin 27 (USERTRIGGER) of the CMD multifunction connector to trigger the CMD in Manual Test Mode without having a GSM Signal at its input.

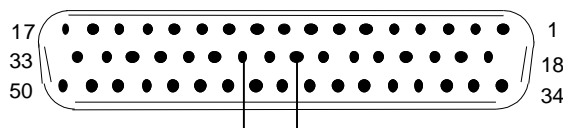


Fig. 2: Pin bridging of the 50-pin MULTIFUNCTION connector of the CMD (Option CMD-B6 required)

Either the NRV-Z4 or the FSE is connected directly to the CMD RF OUT 2 connector via cable.

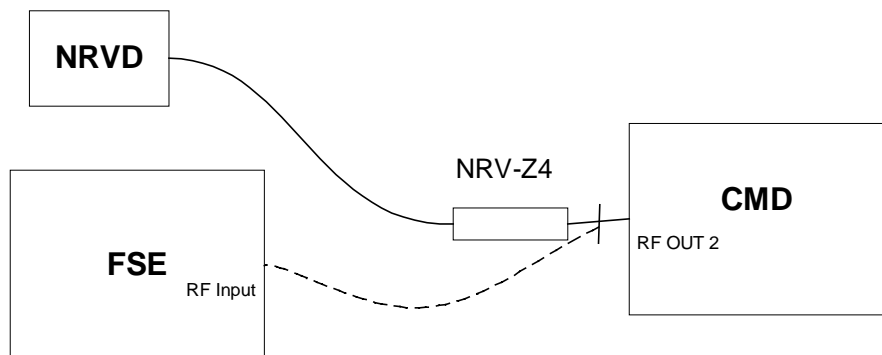


Fig. 3: Schematic diagram of calibration test setup

Calibration Procedure:

Note: Conventions:

Cursive fat capitals mean pressing an instrument hardkey eg. **RESET**

Cursive normal capitals mean pressing an instrument softkey eg. **DETECTOR RMS**

Operation steps are separated by a colon.

Comments are shown in normal letters inside brackets (...).

Calibrating CMD BER Level

For easy result calculating use the appending Excel Sheet No.1 and the operating descriptions in rectangular brackets [...].

1. Determine absolute power at CMD level -35 dBm in non-bursted mode, using NRVD

➤ Connect the NRV-Z4 Power Sensor to CMD Output 2

➤ CMD Setting:

RESET: ALL DATA

NETWORK TYPE: GSM 1800 (or GSM 1900 or GSM900)

CONFIG MENU: CONNECT EXT: ATTEN: RF IN1/RF OUT2

MENU UP↑: OTHER: AUTO RANGING: OFF

MENU UP↑: BER TEST: USED TS -35 dBm: UNUSED TIMESLOT 0 dB:HOLD OFF 100000 ms

(During hold off time the output level is stable)

MENU HOME

MANUAL TEST: TCH RF CHANNEL 699 (for GSM1900: TCH RF CHANNEL 661, for GSM900: TCH RF CHANNEL 37): MODE TIMING REFERENCE EXT. TRIGGER TRY TO SYNC

Wait about 10 sec until the Traffic channel menu comes up.

SPEECH MODE: PSR 2E16-1

BER TEST: CONT: BER MEAS.

(The CMD sends an unbursted PRBS modulated GSM Signal with -35 dBm).

➤ Measure the power with NRVD (PNRVD) and note it down.

[Enter NRVD reading in cell B3 of Excel Sheet]

2. Measure power with FSE in non-bursted mode

➤ Connect the FSE to CMD output 2 instead of the NRV-Z4.

➤ FSE Setting:

PRESET

LEVEL REF: -32 dBm: ATTEN MAN: 0 dB

FREQUENCY CENTER: 1747.6 MHz (with GSM1900: 1880 MHz, with GSM900: 897.4 MHz): ZERO SPAN

COUPLING: RES BW MANUAL: 300 kHz: VIDEO BW MANUAL: 3 MHz

TRACE 1: DETECTOR RMS

MARKER SEARCH: SUM MKR ON

(The summary marker "RMS of Trace 1" is shown now inside the grid. It calculates the numeric RMS Value of the shown trace 1).

SUMMARY MARKER↓: AVERAGE ON: SWEEP COUNT 30

SWEEP: 5 ms: SINGLE SWEEP

Calibrating CMD BER Level

(When pressing SINGLE SWEEP the FSE builds the average RMS value of the trace over 30 Sweeps).

The difference between the Summary Marker RMS reading and the NRVD reading as a correction factor for use in step 8.

[Enter the Summary Marker RMS reading in cell C3 of the Excel sheet, the difference is calculated automatically in cell D3].

3. Measure power of the timeslot used at -85 dBm with + 50 dB power in the adjacent timeslots

- Change the CMD setting to:

USED TIMESLOT -85 dBm: UNUSED TIMESLOT 50 dB

(The CMD sends a bursted signal where the unused timeslots are + 50 dB above the used timeslot)

- Change the FSE setting:

TRIGGER VIDEO: LEVEL 82% (-50 dBm)

(Set the FSE to video trigger to get a stable signal).

DLINES: TIME LINE 1: 4.1 ms: TIME LINE 2: 4.6 ms

MARKER SEARCH: SEARCH LIMITS ON

SINGLE SWEEP

(The FSE calculates the average RMS value between the Time Lines 1 and 2; the power of the used timeslots)

- Note down the Summary Marker RMS reading.

[Enter the reading in cell B11 of Excel sheet].

4. Measure the power of the used timeslot down to -91 dBm with +50 dB power in the adjacent timeslots

- Reduce the CMD level (Used Timeslot) stepwise by -0.6 dB to -91 dB. Press SINGLE SWEEP on the FSE at every step, and note the Summary Marker RMS readings.

[Enter FSE readings in columns B12 to B21 of the Excel sheet]

5. Measure FSE input noise, to correct the measured CMD levels later.

- CMD SETTING:

USED TIMESLOT. -148 dBm (minimum value)

UNUSED TIMESLOT: 0 dB

- FSE SETTING:

TRIGGER: FREE RUN

MARKER SEARCH: SEARCH LIMITS OFF

SINGLE SWEEP

- Note down the FSE Summary Marker RMS reading.

[Enter the Summary Marker RMS reading in cell C8 of the Excel sheet]

Calibrating CMD BER Level

6. Correct the powers measured measured at the 11 different levels by the FSE measured noise power (convert dBm's to watts, subtract noise power in watt, and reconvert results to dBm's).

[Noise correction is done automatically by the Excel sheet in columns D11 to D21]

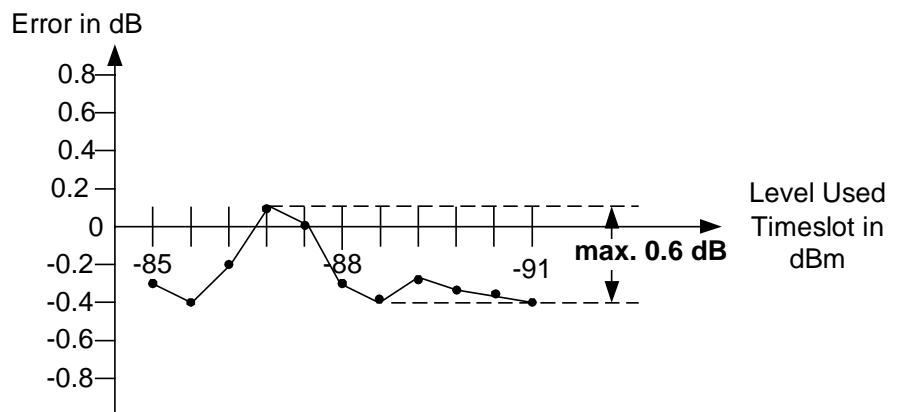
7. Correct again the values obtained in step 7 by the correction factor from step 2 to get the real power of the used timeslots.

[Is done automatically by the Excel sheet in columns E11 to E21]

8. Draw a graph of measured level error against level -85 dBm to -91 dBm and check whether the PK to PK error is < 0,6 dB.

[When using the Excel sheet, check the value of I22 < 0.6 dB]

Example: Picture 4: How to check Pk-Pk error



Note: If the Pk to Pk error is > 0.6 dB the CMD is faulty and has to be repaired by an R&S Service facility.

9. Calculate mean level error (calibration factor for the CMD)

$$\text{Mean Level Error} = (\text{Error max} + \text{Error min})/2$$

The mean level error is the new calibration factor for the CMD.

[Mean level error/calibration factor error is calculated automatically by the Excel sheet in cell J22]

Example:

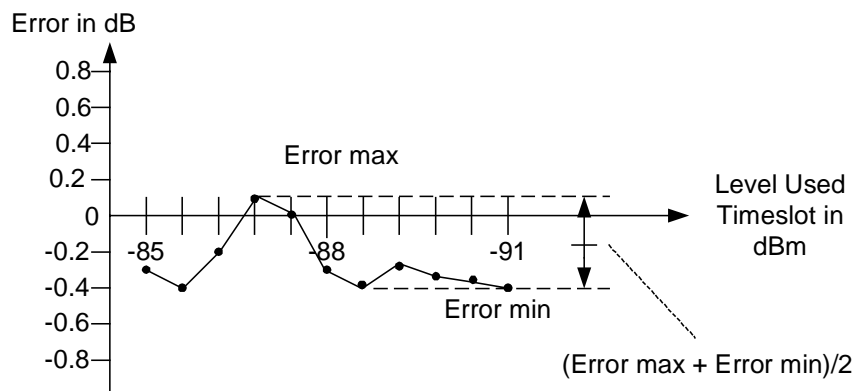


Fig. 4: How to determine mean level error

Calibrating CMD BER Level

$E_{max} = 0.1 \text{ dB}$, $E_{min} = -0.4 \text{ dB}$, mean level error = $(0.1 \text{ dB} - 0.4 \text{ dB})/2 = -0.15 \text{ dB}$

Mean level error (calibration factor for CMD) = -0.15 dB

	A	B	C	D	E	F	G	H	I	J
1	Set CMD Level Used TS	Indication NRVD @ 35 dBm CW / dBm (Example)	Indication FSE @ 35 dBm CW / dBm (Example)	Correction factor FSE /dB						
2										
3	-35.0	-35.2	-35.5	-0.3						
4										
5										
6	Set CMD Level Used TS	Indication FSE @ -85 to -91 dbm/dbm (Example)	Measured FSE Input Noise Power / dBm (Example)	Indication of FSE @ -85 to -91 dBm/dBm corrected by FSE input noise	TO NRVD indication corrected indication of FSE @ -85 to -91 dBm/dBm	Error of CMD RF OUT 2 / dB	Error M_{max} /dB	Error M_{min} /dB	(Error M_{max} - Error M_{min})/dB	Mean Level Error / Calibration Factor /dB
7										
8										
9										
10										
11	-85.0	-85.55		-85.60	-85.30	-0.30				
12	-85.6	-86.24		-86.30	-86.00	-0.40				
13	-86.2	-86.64		-86.70	-86.40	-0.20				
14	-86.8	-86.93		-87.00	-86.70	0.10				
15	-87.4	-87.62		-87.70	-87.40	0.00				
16	-88.0	-88.50		-88.60	-88.30	-0.30				
17	-88.6	-89.18		-89.30	-89.00	-0.40				
18	-89.2	-89.70		-89.83	-89.53	-0.33				
19	-89.8	-90.30		-90.45	-90.15	-0.35				
20	-90.4	-90.90		-91.07	-90.77	-0.37				
21	-91.0	-91.50		-91.70	-91.40	-0.40				
22							0.10	-0.40	0.50	-0.15

Excel Sheet No. 1: How to calculate the mean level error of the CMD automatically depending on the measured results

4 Changing the CMD EEPROM Values

The level uncertainty of the CMD RF OUT 2 output can be reduced directly by correcting the internal EEPROM values by the mean level error. As an alternative to this, the correction could be done externally in a controller.

Caution: The following procedure is recommended only for qualified service personnel!

1. Start the CMD in DOS mode:
Switch on the CMD and Press Ctrl-Alt-E after the first beep.
2. Move to the subdirectory C:\SERVICE and start the tool EEPROM.
3. Go to entry "Select new EEPROM", select "Path correction" and "Save to file" (the last entry in the menu).
4. Exit the tool, change to subdirectory C:\SERVICE\DATA and select "EDIT CA.DAT".
5. In the table CA02 change the values for mean level error:
GSM 900 = 900 MHz
GSM 1800 = 1750 MHz
GSM 1900 = 1850 MHz and 1900 MHz
Example:
Mean level error = +0.3 dB, original entry is -0.2 --> new value is -0.2 + (+0.3) = +0.1).
6. Save the file and exit the editor.
7. Move back to the subdirectory C:\SERVICE and enter „EEPROM -h -e“.
8. Select the menu entry "READ FROM FILE" and select "PATH CORRECTION"

Calibrating CMD BER Level

9. Exit the program and answer the queries with "yes".
10. Switch off the CMD to set the new correction data.

5 Level Uncertainty Calculation:

The level uncertainty of the CMD 57 BER Level output is calculated as follows. The calculation is according to ETSI ETR 028 "Radio Equipment and Systems; Uncertainties in the measurement of mobile radio equipment characteristics Part 1". Using a precise external attenuator, for example 20 dB ($SWR \leq 1.1$), a level uncertainty of less than 0,5 dB over a calibration interval of 1 year can be achieved in the level range for example -105 dBm to -111 dBm.

	A	B	C	D
		Data	Interim Results	Standard Uncertainty ETSI in dB
1				
2				
3	Uncertainty due to Powermeter			
4	at Level in dBm	-35	3.162E-07	
5			+	
6	Noise in pW (with Filter No. 9)	40	4.00E-11	
7	Standard Uncertainty			0.0003
8				
9	Zero Error in pW (rectangular distribution)	50	0.00069	
10	Standard Uncertainty			0.0004
11				
12	Calibration Uncertainty in dB (2σ)	0.07		
13	Standard Uncertainty			0.0350
14				
15	Linearity Error in % Power (2σ)	0.7		
16	Standard Uncertainty			0.0152
17				
18	Temp. Effect 18°-28° in % Power (1σ)	0.3		
19	Standard Uncertainty			0.0130
20				
21	Powermeter Acc. in % Power (rectangular distribution)	0.3		
22	Standard Uncertainty.			0.0075
23				
24	Sum Uncertainty Powermeter			0.0410
25				
26	Uncertainty due to mismatch:			
27	VSWR RFOUT2 of CMD	1.5		
28	VSWR Power Sensor	1.1		
29	Standard Uncertainty in dB			0.0586
30				
31	Uncertainty due to Linearity Error of FSE			
32	Linearity Error FSE in dB with FSE-B22 (rect. distribution)	0.2		
33	Standard Uncertainty in dB			0.1155
34				
35	Uncertainty due to permissible Linearity Error of CMD in dB (rectangular distribution)	0.3		
36	Standard Uncertainty			0.1732
37				
38	Uncertainty of CMD level due to temperature			
39	dB/15°K (rectangular distribution)	0.1		
40	Standard Uncertainty			0.0577
41				
42	Uncertainty due to ageing of CMD level			
43	in dB per 12 months (rectangular distribution)	0.1		
44	Standard Uncertainty			0.0577
45				
46	Combined Standard Uncertainty in dB			0.2348
47				
48	Expanded Combined Standard Uncertainty in dB with 95% Confidence (2σ)			0.4695

Excel Sheet No. 2: Error uncertainty calculation according to ETSI ETR 028

6 Ordering Information

Communication Tester

CMD 57	GSM900/GSM1800	1050.9008.57
CMD 59	GSM1900	1050.9008.59

Power Meter

NRVD		1065.6000.20
NRV-Z4 Power Sensor	20 mW, 6 GHz	1065.6000.20

Spectrum Analyzer

FSEA20	9 kHz to 3.5 GHz	1065.6000.20
FSEA30	20 Hz to 3.5 GHz	1065.6000.30
FSE-B22		1106.3480.02