

## FER Measurements on CDMA Mobile Radios with AWGN and Fading

Application Note 1MA05\_2E

Products:

**Signal Generator SMIQ**  
**Digital Radiocommunication Tester CMD80**

Subject to change - Detlev Liebl 07-98

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## 1. Overview

The receiver quality of CDMA mobile radios to standard IS-95 is determined by measuring the frame error rate of signals loaded with AWGN.

The test method and parameters are defined by standard IS-98. Section 9.3.4 specifies frame error rate measurements with AWGN also under conditions of fading.

The required tests can be carried out conveniently with a combination of Vector Signal Generator SMIQ with option NDSIM (Noise Generator and Distortion Simulator) and option Fading Simulator and Digital Radiocommunication Tester CMD80 with option I/Q MODULATOR OUTPUTS.

## 2. Principle of Operation

Fig. 1 shows the test setup in accordance with chapter 12 of IS-98. (The signal names correspond to the symbols used by the standard.)

A channel simulator generates multipath signal  $\hat{I}_{or}$  from the TX output signal  $I_{or}$  of the base station. Additionally, signal  $I_{oc}$  from an AWGN generator is

fed into the signal path to simulate occupancy of the radio channel.

For the tests to IS-98,  $I_{or}$  and  $I_{oc}$  are set in accordance with table specifications such that the useful level  $I_{or}$  is higher than the interference level  $I_{oc}$  by a predefined value.

In the subsequent frame error rate measurements, the ratio of the level components of the pilot and traffic channels is slightly varied relative to the total power of signal  $I_{or}$ . Measurements are performed at different bit rates.

The mobile radio is set to the loopback mode for these tests. The base station at the same time operates as a frame error rate meter.

In this application, CMD80 acts as a base station. SMIQ (with options SMIQ-B14 Fading Simulator and SMIQ-B17 Noise Generator and Distortion Simulator) generates both the stipulated multipath signal  $\hat{I}_{or}$  and the AWGN signal  $I_{oc}$  and combines them into signal  $I_o$  at its output.

The fading profiles required by standard IS-98 can be called on SMIQ at a keystroke from a list of preprogrammed standards. Moreover, the preprogrammed profiles can be edited as required to create user-specific multipath profiles.

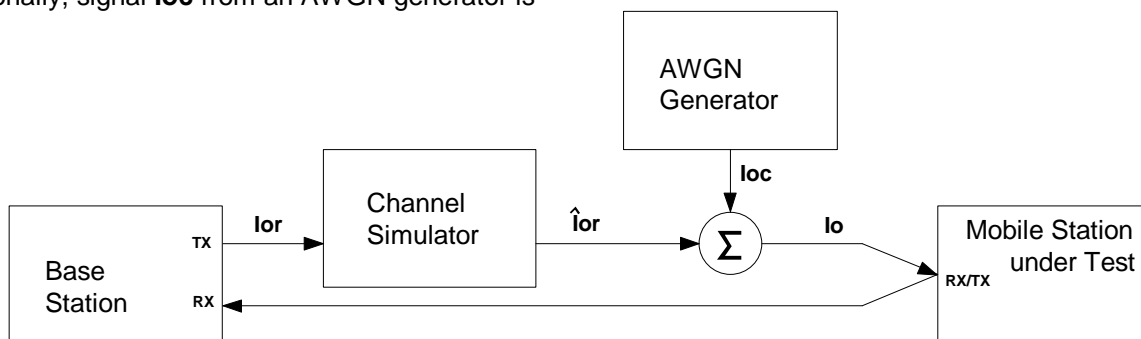
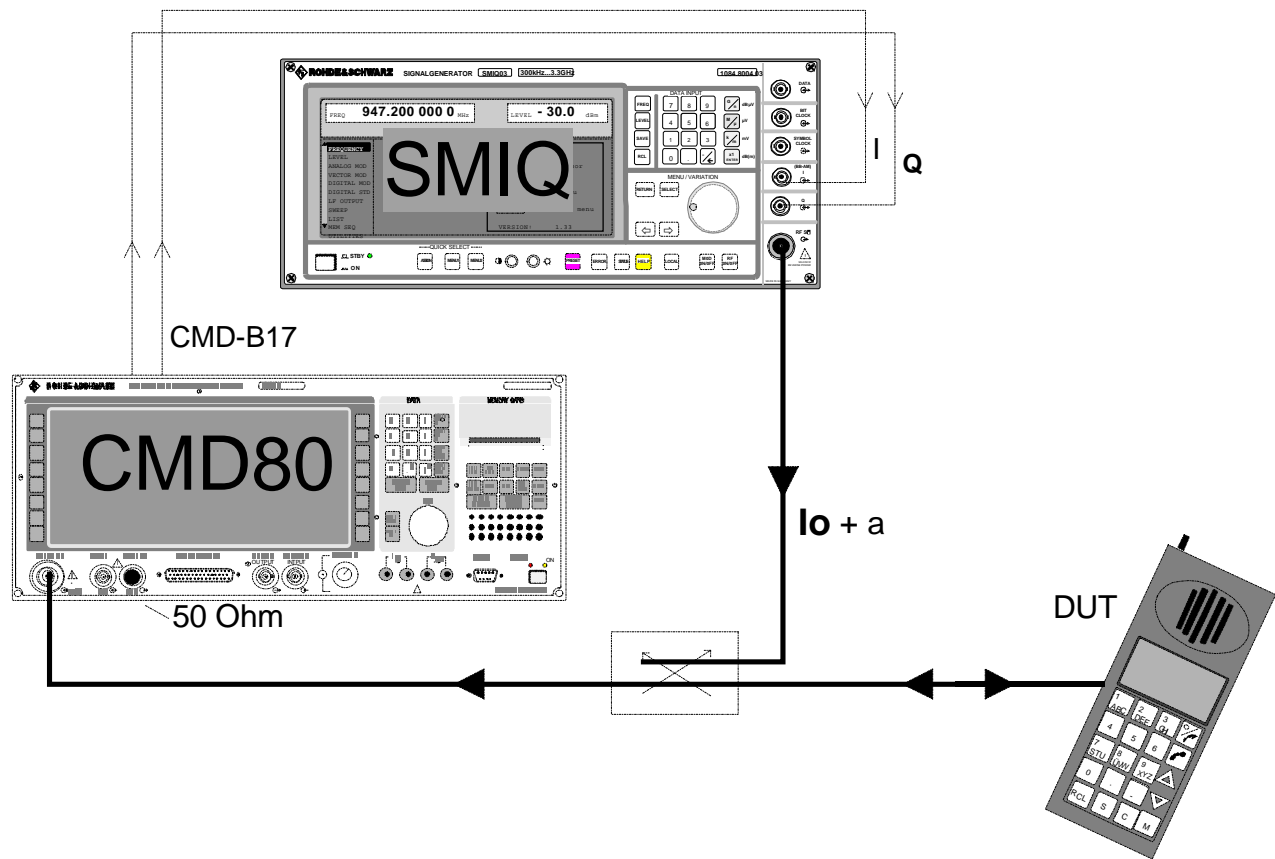


Fig. 1: Block diagram of test setup for FER measurements



2: Test setup for FER measurements with CMD80 and SMIQ

Fig.

### 3. Test Setup

Connect SMIQ and CMD80 in a setup as shown in Fig. 2. For the RF paths (shown by thick lines), low-loss coaxial cables with tight shielding have to be used. The (DUT) is not yet needed and is to be connected later.

In contrast to the setup shown in Fig. 1, the output signal of the measurement system is not derived from the RF signal  $I_{or}$  of the base station but from the baseband signals I and Q provided by option CMD-B17.

Connect IQ1 with the Q input and IQ2 with the I input of SMIQ. Use shielded 50  $\Omega$  cables of exactly the same length in either case.

The RF signal of the CMD80 output stage is not needed and therefore taken to output RF OUT2 (see Presettings, section 4). A 50  $\Omega$  RF termination

must be connected to output RF OUT2 to avoid interference being picked up by the test system.

The RF IN / OUT N connector of CMD80 is only used as an input.

The Tx signal  $I_o$  generated by SMIQ is fed to the DUT via a directional coupler. The insertion loss of the coupler is determined and compensated during measurements using correction factors (see section 5).

If option CMD-B3 (Reference Frequency Inputs/Outputs) is fitted, the frequencies of CMD80 and SMIQ can be phase-locked. This might improve long term stability. To this end, connect the 10 MHz reference connectors of the two instruments with each other. CMD80 is the source; SMIQ is switched to an external reference.

## 4. Presettings

### General:

The presettings described in this section must be carried out only once for a complete series of measurements. The presettings are for

- selecting the desired network and configuring the RF paths on **CMD80** and
- setting the frequency, level, AWGN bandwidth and the fading profile on **SMIQ**.

The following entries are also the presettings for the determination of corrections factors, which is described in the next section.

### Settings on **CMD80**:

All settings on CMD80 are started from the default configuration, which is activated by pressing the RESET key.

Sequence of keys to be pressed:

**RESET** (hardkey) and **ALL DATA**

Select network:

**NETWORK, US CELLULAR** or **PCS**

Configure output RF OUT2 as TX output:

**CONFIG MENU**

**RF CONNECT / EXT ATTEN,**

**RF IN / RF OUT2**

Return to basic menu with:

**MENU HOME**

Switch CMD80 to:

**MANUAL TEST**

The **CDMA MANUAL TEST** menu will come up.

**In the MANUAL TEST menu, select the PREFERRED RATE SET stipulated for the first test.**

From the channel number N (**BS SIGNAL, RF CHANNEL**) shown in the MANUAL TEST menu, calculate the frequency for SMIQ according to the following formulas:

for **US CELLULAR**:

1 < N < 799: (0.03N + 870) MHz or  
 990 < N < 1023: (0.03(N-1023) + 870) MHz

for **US PCS**:

0 <= N <= 1199: (0.05N+1930) MHz

### Example:

**RF CHANNEL 283** (US CELLULAR)

----> **878.49 MHz**

### Settings on **SMIQ**:

The settings on SMIQ are likewise started from the default configuration.

Press:

**PRESET**, then **FREQUENCY**

Enter the carrier frequency calculated above in MHz.

Set the level to a preliminary value:

**LEVEL** ----> **-30 dBm**

Further settings on SMIQ:

**VECTOR MOD, STATE, ON**

As a result, SMIQ will be modulated by I/Q signals of CMD80.

Set the bandwidth of the AWGN generator of SMIQ to 2.46 MHz:

**NOISE / DIST, SYSTEM BW** 2.46MHz

The AWGN generator should be deactivated.

Select the necessary fading profile:

**FADING SIM, STANDARD, eg CDMA 8**

Fading should be deactivated.

### Selectable fading profiles on SMIQ:

Channel simulator configuration / IS-98	SMIQ profile
1 (case 1, 4)	CDMA8
3 (case 2, 5)	CDMA30
4 (case 3, 6)	CDMA100

If you use the 10 MHz reference from CMD80, select the following on SMIQ:

**UTILITIES, REF OSC, SOURCE, EXT.**

## 5. Determination of Correction Factors

### General

The level value displayed on SMIQ refers to the maximum voltage at the I/Q modulation inputs. Because of the high crest factor of the CDMA signal, the rms value of the amplitudes of the I/Q lines is approx. 10 dB below the maximum permissible peak value at the I/Q inputs. With vector modulation, therefore, the prospective output level of SMIQ is likewise approx. 10 dB below the level displayed on SMIQ. The signal is further attenuated by the directional coupler and the cables used.

Correction value **a** is to compensate for the effect of these three factors.

To determine correction value **a**, the actual level of a CDMA signal is measured at the test point and the difference between the level displayed on SMIQ and the measured level is determined.

Correction value **a** is to be added to the value specified by standard IS-98 when making the **LEVEL** entry on SMIQ in FER measurements, so that the actual **lor** is obtained at the test point.

The second correction value, **d**, is to compensate for the facts that the **CARRIER / NOISE RATIO** value entered on SMIQ for the AWGN generator refers to the rms value displayed on SMIQ and that the prescribed measurement bandwidth must be smaller than the noise bandwidth.

Correction value **d** is determined by measuring the actual level of an AWGN signal at the test point and forming the difference between the result of this measurement and the CDMA level measured when determining correction value **a**.

Correction value **d** is to be added to the value specified by standard IS-98 when making the **CARRIER / NOISE RATIO** entry on SMIQ in FER measurements, so that the actual **loc** is obtained at the test point.

### Procedure

A sufficient warm-up period is to be allowed for the instruments used. First, make a calibration on SMIQ (see SMIQ operating manual, section 2.20.9).

Connect a spectrum analyzer instead of the DUT. The spectrum analyzer should be capable of measuring rms power across a bandwidth of 1.23 MHz (R&S recommendation: FSE).

Make sure that measurements are made exactly at the point where the DUT will be connected later.

Select an rms detector on the spectrum analyzer. Set the center frequency to the SMIQ frequency and the bandwidth to 1.23 MHz.

With the presettings made in accordance to section 4, the test system consisting of CMD80 and SMIQ supplies a suitable CDMA signal.

Make the following settings on **SMIQ**:

**NOISE / DIST, STATE, ON**

**CARRIER / NOISE** 0 dB

**SYSTEM BW** 2.46 MHz

### Determination of correction value **a**:

Make the following settings on SMIQ:

**UTILITIES, DIAG, C/N MEAS, MODE..., CARRIER**

As a result, only the CDMA signal **lor** will be output.

Measure the rms level (of CDMA signal) with spectrum analyzer.

Calculate the correction factor **a** by forming the difference between the value displayed on SMIQ and the value measured with spectrum analyzer.

### Example:

Level displayed on SMIQ -30 dBm

Level measured (CDMA carrier) -58.9 dBm

$$\text{-----> } \mathbf{a} = 28.9 \text{ dB}$$

### Determination of correction value **d**:

Make the following settings on SMIQ:

**UTILITIES, DIAG, C/N MEAS, MODE..., NOISE**

As a result, only the AWGN signal **loc** will be output.

Measure the rms level (of AWGN signal) with spectrum analyzer.

Calculate the correction value **d** by forming the difference between the level measured here and the level measured above:

$$d = \text{measured value (AWGN)} - \text{measured value (CDMA carrier)}$$

### Example:

Level displayed on SMIQ -30 dBm

Level measured (AWGN) -52.7 dBm

Level measured (CDMA carrier) -58.9 dBm

-----> d = 6.2 dB

Switch SMIQ back to:

UTILITIES, DIAG, C/N MEAS, MODE..., CARRIER+NOISE

and set:

NOISE / DIST, STATE, OFF

Remove the spectrum analyzer and connect the DUT.

### 6. Link Setup to DUT

The level at the DUT should be at least -70 dBm. If necessary, adapt the SMIQ level accordingly.

On CMD80, proceed in the same way as for FER measurements without SMIQ.

Switch CMD80 to MANUAL TEST.

Switch the mobile on and wait for registration. Then set up radio link to the mobile with:

CALL TO MOBILE for MS Loopback tests

CMD80 goes to the

CDMA MANUAL TEST CALL ESTABLISHED menu.

Frame error rate measurements are receiver measurements. Press softkey:

RECEIVER QUALITY

The RECEIVER QUALITY menu will come up.

### 7. Setting of Test Parameters

For tests to section 9.3.4 of IS-98, the following parameters are to be set on CMD80:

TOTAL POWER, TRAFFIC and PILOT LEVEL, DATA RATE

The following parameters are to be set on SMIQ:

LEVEL, CARRIER / NOISE RATIO, FADING STANDARD.

Settings on CMD80:

In the RECEIVER QUALITY menu, press hardkey:

CONFIG

The RECEIVER QUALITY CONFIGURATION menu will come up. Here, various parameter sets can be selected by softkeys: SENSITIVITY, DYN. RANGE, CURRENT SIGNAL LEVEL, USER DEFINED 1 and USER DEFINED 2.

For user-defined settings, select:

USER DEFINED 1 or USER DEFINED 2

The level entries to be made on CMD80 are calculated from the individual levels defined in the test specifications:

TOTAL POWER Ior = loc + Ior / loc

Example:

(IS-98, section 9.3.4, table 9.3.4.2-1, test 1):

loc = -63 dBm

Ior / loc = 8 dB

TOTAL POWER = -55 dBm

NOTE:

Although Ior is in this test setup supplied by SMIQ alone, the correct TOTAL POWER value must be set also on CMD80 because the receiver sensitivity of CMD80 automatically adjusts to the transmitter level selected on this unit. If TOTAL POWER is reduced too much, the level expectancy of the RX input increases, which may lead to underdrive of the receiver and thus produce an additional error.

TRAFFIC LEVEL = Traffic Ec / Ior + Corr

Correction value Corr compensates for the fact that CMD80 automatically lowers the traffic channel component by 3 dB each time the data rate is halved.

The correction values Corr and the data rates assigned to FULL, HALF QUARTER and EIGHTH under DATA RATE on CMD80 are shown in the following table:

Rate Set 1	Rate Set 2	Corr	DATA RATE
9600 bps	14400 bps	0 dB	FULL
4800 bps	7200 bps	3 dB	HALF
2400 bps	3600 bps	6 dB	QUARTER
1200 bps	1800 bps	9 dB	EIGHTH

Example:

(IS-98, section 9.3.4, table 9.3.4.2-1, test 1):

Traffic Ec / Ior = -16.1 dB

**DATA RATE** = FULL

**Corr** = 0

**TRAFFIC LEVEL** = -16.1 dB

**PILOT LEVEL** = Pilot Ec / Ior

Example:

(IS-98, section 9.3.4, table 9.3.4.2-1, test 1)

Pilot Ec / Ior = -7 dB

**PILOT LEVEL** = -7 dB

The AWGN of CMD80 must be switched off.

To return to the **RECEIVER QUALITY** measurement menu, press **MENU UP** hardkey.

Settings on SMIQ:

Now the **LEVEL** for the first measurement is to be set on **SMIQ**.

To determine the correct value, add the correction value **a** measured in accordance with section 5.2. to the TOTAL POWER value set on CMD80:

**LEVEL** = TOTAL POWER + a

Example:

(IS-98, section 9.3.4, table 9.3.4.2-1, test 1)

**TOTAL POWER** = -55 dBm

**a** = 28.9 dB

**LEVEL** = -26.1 dBm

Then set the **Ioc** level for the AWGN generator.

To determine the correct value, add the correction value **d** measured in accordance with section 5.2. to  $\hat{I}or / Ioc$  of IS-98:

**CARRIER / NOISE RATIO** =  $\hat{I}or / Ioc + d$

Example:

(IS-98, section 9.3.4, table 9.3.4.2-1, test 1)

$\hat{I}or / Ioc$  = 8 dB

**d** = 6.2 dB

**CARRIER / NOISE RATIO** = 14.2 dB

## 8. Measurement

On **SMIQ**, switch on the AWGN generator and, if required, fading:

**NOISE / DIST, STATE ON**

**FADING SIM, CONFIGURATION, STATE ON**

On **CMD80**, press the softkey your parameter setting is stored behind in the **RECEIVER QUALITY** menu, ie:

**USER DEFINED 1** or **USER DEFINED 2**

The FER measurement is started. Any measurement values exceeding tolerance limits are displayed in inverse video during the measurement if the maximum error rates specified by the standard were entered before as limit values in the USER DEFINED configuration.

A measurement can be stopped by pressing the CONFIG hardkey or the softkey that started the measurement (in the above example USER DEFINED 1).

NOTE:

**Any changes to the TOTAL POWER  $\hat{I}or$**  must always be made on both SMIQ and CMD80 (as described above) since the RX sensitivity of CMD80 is dependent on the set TOTAL POWER.

Any changes to the **TRAFFIC** or **PILOT** components with the TOTAL POWER  $\hat{I}or$  remaining unchanged are to be made on CMD80 only. These relative changes are correctly transferred to the corresponding components of the I and Q baseband signals and thus to the SMIQ output signal.

Any frequency changes must be made on both CMD80 and SMIQ.

The Minimum Standards for IS-98 require a high accuracy for the Traffic **Eb / Nt value** calculated from the test parameters.

With the correction values **a** and **d** determined carefully in accordance to chapter 5.2, and the test parameters corrected as described, a long term accuracy better than +/- 0.2 dB can be achieved (at room temperature, after warm-up period).

## 9. References

The terms used in this application note are derived from the following standards:

- TIA/EIA/IS-95
- TIA/EIA/IS-98-A

Further references:

- Lüttich, F.: Fading simulator and signal generator in one unit. News from Rohde & Schwarz No. 155, p. 9

## 10. Ordering Information for Instruments and Options Used

Digital Radiocommunication Tester CMD80 must be fitted with option CMD-B17, Vector Signal Generator SMIQ with options SMIQ-B14 and SMIQ-B17.

Vector Signal Generator	SMIQ	1084.8004.02
Fading Simulator	SMIQB14	1085.4002.02
NDSIM	SMIQB17	1104.9000.02
Digital Radiocommunication Tester	CMD80	1050.9008.84
I/Q Modulator Outputs	CMD-B17	1099.3003.02
Spectrum Analyzer	FSEA30	1065.6000.30

Note: the above information is valid from software version

⇒ 2.1A for CMD80

⇒ 3.66 for SMIQ



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