CDMA2000 1xEV-DO Rel. B Non-Signaling Testing[1]
Application Note

Products:

- R&S®CMU200
- R&S®CMU-K88
- R&S®CMU-K839
- R&S®CMU-K849
- R&S®CMU-K859
- R&S®CMU-K869

Application Note

Robert Macketanz
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ROHDE&SCHWARZ

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1 Introduction

The R&S® CMU200 1xEV-DO Release B non-signaling testing application provides the means to allow users to perform RF measurements on a 1xEV-DO Rel. B access terminal in a mode that does not require any signaling. This allows the calibration and final tests of a Rel. B AT, according to the minimum performance standards with the R&S® CMU200.

2 Definitions

Throughout this document, a few particular expressions are used. In order to minimize possible confusion, we give here a short introduction to these.

- Signaling: mode of communication between tester (AN emulation) and device under test (AT) that involves protocol messages, and no special access to the AT.
- Non-Signaling: this describes an operation mode in which there are no protocol messages exchanged between AN and AT. Depending on the AT's implementation, this mode may require tools/interfaces from the AT's chipset vendor.

3 CDMA2000 1xEV-DO Release B Application

This application note describes the three most important measurements that are required to prove the conformity of an AT to a given performance specification for calibration and final test. These are

- Modulation quality measurement.
- Channel power over the full span of the active carriers in Rel. B.
- Conducted spurious emissions measurement.

Usual set-ups for Non-Signaling EVDO Rel. B tests require only the reverse link (from AT to AN) to be constituted of more than one carrier, while the forward link (AN to AT) is left as single carrier, identical to Rel. A tests.
Depending on the band classes to test, the R&S® CMU200 needs to be equipped with at least one of the software options CMU-K88 (in conjunction with hardware option CMU-B88), or any of CMU-K839, CMU-K849, CMU-K859, or CMU-K869. Also, for the generator part, the hardware options CMU-B83 Var. 12 with CMU-B88 or CMU-B83 Var. 22 with CMU-B89 need to be installed.
For the whole procedure, the R&S® CMU200 performs both forward link generation within the 1xEV-DO functional group and the reverse link measurements RF spectrum, or 1xEV-DO modulation analysis simultaneously. This is a mode that is available in remote operation of the instrument only.
As the R&S® CMU200 is used to perform different tasks from different functional groups in parallel in remote mode, the screen shots and pictures in this application note are for reference only.

3.1 Modulation Quality Measurement

The modulation quality measurement is conducted carrier-by-carrier.
Initially, the R&S® CMU200's generator should be set up. This requires the band class and RF channel to be set to the necessary values. (See figures 1, and 2)

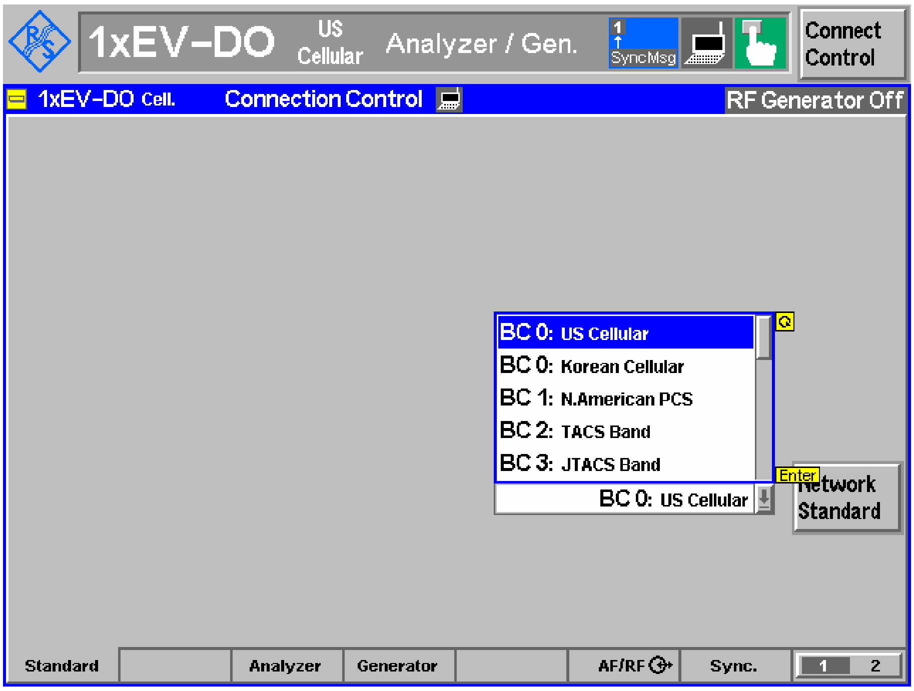

Figure 1: Band class selection

The modulation quality measurement of the separate reverse link carriers of the AT's signal is then conducted carrier-by-carrier. This can be achieved by tuning the receiver RF frequency of the R&S® CMU200 to the desired frequency.
Please note that the frequency editor in the R&S® CMU200 will auto-correct the frequency to the nearest CDMA RF channel (or channel number equivalent, if the frequency chosen is outside the channel table) in the current selected band class. This means that if one wants to measure a carrier whose center frequency is not exactly on a CDMA channel, the frequency offset setting of the CMU must be utilized.
Please see Figure 3 as an example: the desired frequency is 1.0 GHz, which may be achieved with the R&S® CMU200 by setting the RF frequency to 999.9900 MHz and adding an additional frequency offset of 10 kHz.

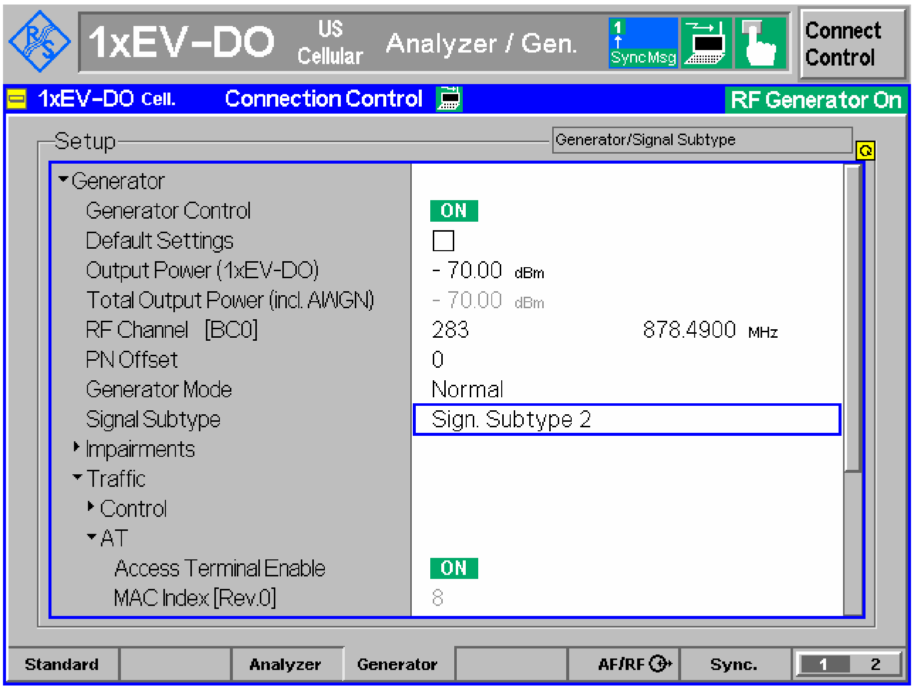

Figure 2: Configuration of the generator

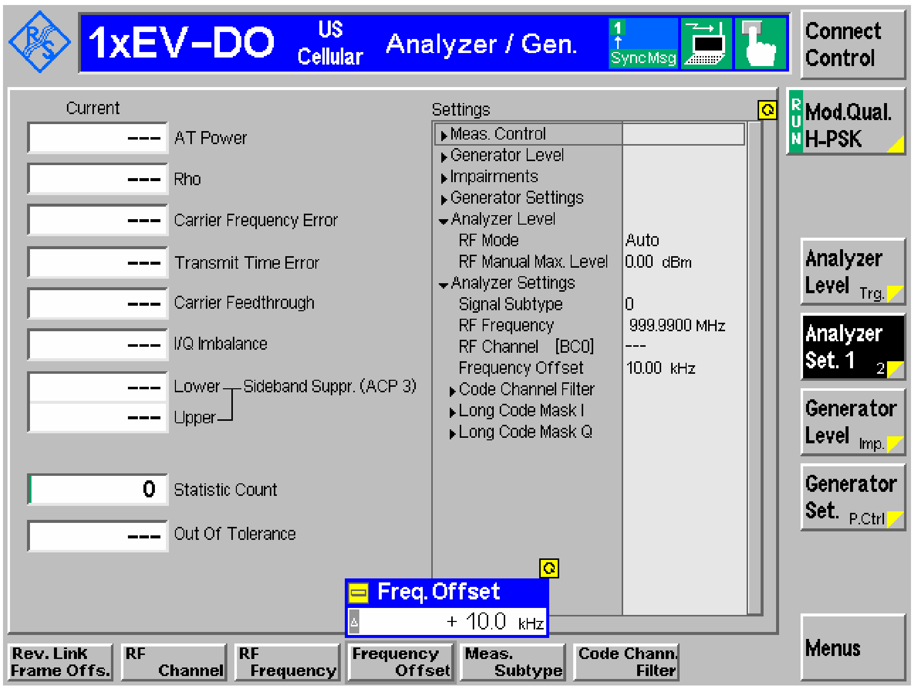

Figure 3: Frequency setting

The measurement screen in Figure 3 also shows the type of measurement necessary to conduct the modulation quality measurement. In detail, the results of interest are

- Rho (waveform quality).
- Carrier frequency error.
- Transmit time error.

This requires the measurement to be operated in triggered mode, which can be either "Internal" or "External". "Internal" means that the trigger is taken from the R&S® CMU200's generator timing reference. For "External", a trigger signal needs to be supplied to the R&S® CMU200 via the AUX 3 port on the front of the instrument. Please see Figure 4.

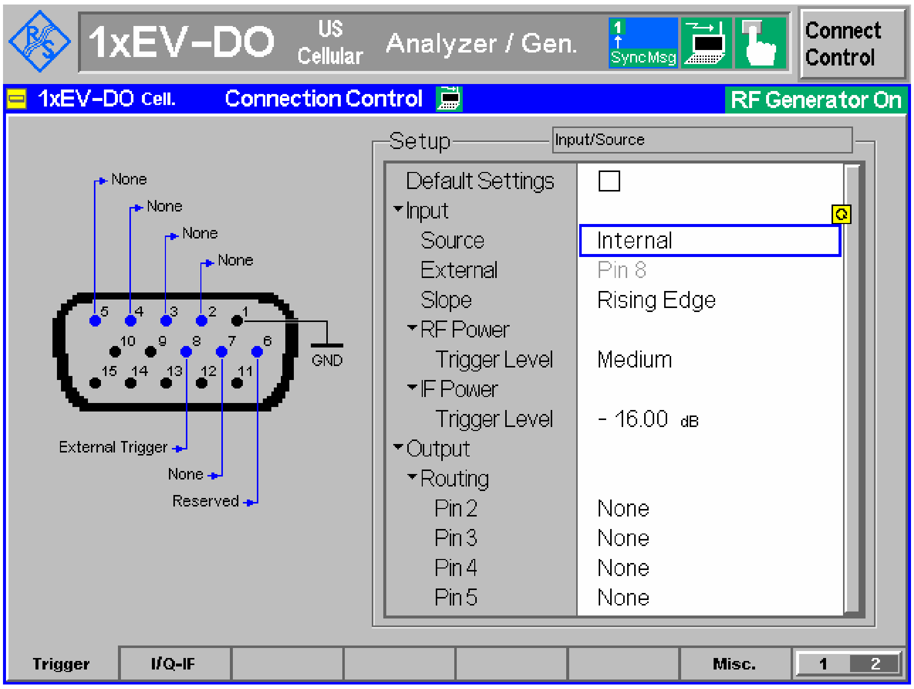

Figure 4: Trigger settings

3.2 Channel power over the full span of occupied carriers in Rel. B

This measurement is performed using the RF functional group of the R&S® CMU200. The application note 1CM55 describes in detail how to set up a wideband power meter using the sweep capability of RF spectrum functionality in the R&S® CMU200.
For example, consider a 1xEV-DO signal that utilizes a signal bandwidth of approximately 5 MHz. The bandwidth of the intermediate frequency stage of the R&S® CMU200 is not wide enough for this signal without significant losses on both sides of the spectrum. However, by utilizing the frequency sweep capabilities of the RF functional group within the R&S® CMU200, it is possible with minimal additional calculations to examine signals of considerably larger bandwidths.
In the case of the 1xEV-DO Rel. B channel power power measurement, the spectrum analyzer used in the "RF Non-Signaling" functional group is used. The measurement is based on the following settings:

- Center frequency set to the center carrier of the 1xEV-DO reverse signal.
- Span 5.6 MHz. The R&S® CMU200 evaluates 560 sample points, which results in frequency step of 10 kHz between two adjacent points.
- Resolution bandwidth (RBW) 100 kHz.
- RMS detector.

When querying the RF functional group's spectrum analyzer results, the values of the individual measurement points are returned as absolute power values in “dBm”. The integration over the individual sample points yields the raw power over the bandwidth (span) which needs a correction factor to be applied with some straightforward math (see [2] for an in-depth discussion of the application of spectrum analysis):
The principle of the measurement is to integrate the partial powers across the individual frequency bands. Real rectangular filters, which have no attenuation within their bandwidth but an extremely high attenuation outside, exhibit a very unfavorable transient response. Instead, Gaussian filters are widely used in signal processing of digital modulation modes.
The R&S® CMU200 uses a sophisticated version of this type of filter within the spectrum analyzer function. When the noise bandwidth of a Gaussian filter is compared with that of a rectangular filter of the same bandwidth, the result of the Gaussian filter is 6.5% higher than that of the rectangular one. As a consequence, the power readings from the CMU operated in spectrum mode with Gaussian filters need to be compensated by 6.5% when the result values are to be interpreted for the application of rectangular filters.
In reference to the settings above, the resolution bandwidth is 10 times the step width between the individual measurement points, so the samples are integrated 10 times over each partial area.
Now, when applying both parts, the Gaussian correction and the oversampling factor, the total correction value sums up to 10.65.
The code in Example 1 is an example how to integrate and apply the correction factor to obtain a single channel power result from a RF spectrum sweep measurement.
The preconditions for this code example are

- The RF sweep measurement has been configured, as mentioned above, with
  - Span = 5.6 MHz.
  - RBW = 100 kHz.

  - RMS detector.
- The function's parameter iResults is a CStringArray containing the single sweep results as strings.

```
static const int CMU200_spectrum_measure_point = 560;

// ... other code ...

// input parameters:
// - iResults:          string array of result values (dBm)
// return value:
// - total channel power [dBm]
double integrate_measurement_points( CStringArray& iResults )
{
  double SumLevelmW    = 0.0; // Sum of the 560 sweep result values
  double AbsLevelmW    = 0.0;

  // sum up the RF spectrum sweep result values in mW
  // and apply correction factor
  for( int i = 0; i < CMU200_spectrum_measure_point; i++ )
    {
      AbsLevelmW = pow( 10, atof( iResults[ i ] ) / 10.0 );
      SumLevelmW += ( AbsLevelmW / 10.65 );
    }

  // convert to dBm and return
  return ( 10.0 * log10( SumLevelmW ) );
 }
```

Example 1: Code snippet for calculating the channel power

Please note that for 1xEV-DO, this type of measurement cannot be done when the reverse data rate is varying. In this case, the AT's reverse power will vary with the data rate, thus giving at least questionable results.
If the reverse link carriers are not adjacent, but spaced farther apart, the calculation of the channel power result must be adapted according to the necessary span of the spectrum measurement. Typically, it would be recommended to operate the RF spectrum measurement with a span setting that is at least 1MHz wider than the outer edges of the signal to measure.

3.3 Conducted spurious emissions measurement

There are two approaches to perform the conducted spurious emission measurement with the R&S® CMU200:

- On a carrier-by-carrier basis using the ACP measurement contained in the non-signaling 1xEV-DO functionality of the R&S® CMU200.
  With this approach, the controlling software does not need to perform any post-processing, and is required only to establish a minimal set-up, at the cost of a slower performance. As this is not recommended, this application note concentrates on the other approach.
- A one-shot measurement using the R&S® CMU200's RF spectrum functionality with a bit of post-processing. This approach performs the fastest, but needs some careful calculations being performed on the controller.

Although theoretically the ACP measurement in the R&S® CMU200's 1xEV-DO non-signaling functionality could be used on a carrier-by-carrier basis, a more performance-optimized way is described here. For this, the RF spectrum measurement of the R&S® CMU200 is used to perform the conducted spurious emissions measurement. Here, similar to the total channel power (see page 7) a frequency sweep is performed, and the result post-processed to obtain the desired single results.
For simplicity of understanding, it is assumed that the channel setup for the AT's signal to evaluate is the same as in the measurement of the total channel power earlier in this document. As the resolution bandwidth for the sideband channel power measurement is defined to be 30 kHz (see [1], section 4.4), for this measurement, the resolution bandwidth of the RF spectrum measurement also needs to be set to 30 kHz. Consequently, the calculation for the correction factor for integrating needs to be adapted:

- Span = 5.6 MHz.
- RBW = 30 kHz.
- Number of result points = 560, frequency step between sampling points = 10 kHz.
- Correction for Gaussian filter = 6.5%.
- Correction for oversampling = RBW / frequency step between sampling points = 3.

→ Total correction: = Correction for oversampling
+ Correction for Gaussian filter = 3.65.

In this example, to obtain the measurement result for each of the locations selected for spurious emission tests, three sample points for each side band location need to be integrated.
The code in Example 2 shows how to integrate and apply the correction factor to get the relative channel power @ 30 kHz at an arbitrary offset frequency to the center frequency of the sweep.
The preconditions for this code example are:

- The RF sweep measurement has been configured, as mentioned above, with
  - Span = 5.6 MHz.
  - Resolution bandwidth (RBW) = 30 kHz.
  - RMS detector.
- The function's argument `iResults` is a CStringArray containing the single sweep results as strings.
- The parameter offset frequency (`iFrequencyOffset`) does not exceed the interval [-2.8 MHz – 10kHz, +2.8 Mhz – 10kHz][2].

[2] In order not to read outside the bounds of the result string array, the upper and lower bounds of the frequency interval are to be excluded.

```
// ... other code ...

// input parameters:
// - iResults:           string array of result values [dBm])
// - iFrequencyOffset:   offset (in Hz) for the ACP point, in reference
//                       to the center frequency of the sweep
// - iTotalChPower:      power value in dBm over the occupied carriers,
//                       default = 0.0 (yields absolute return value
[dBm])
// return value:
// - channel power [dB] relative to the given iTotalPower
double integrate_ACP_points( CStringArray& iResults
                            , const int iFrequencyOffset
                            , const double iTotalChPower = 0.0 )
{
  double SumLevelmW    = 0.0; // Sum of the sweep result values
  double AbsLevelmW    = 0.0;

  // sum up the RF spectrum sweep result values in mW for the given
  // ofset frequency and apply correction factor
  for(int i=0; i < 3; i++)
    {
      int ArrayPos = ( iFrequencyOffset / 10 ) + ( i - 1 );
      AbsLevelmW = pow( 10, atof( iResults[ArrayPos] ) / 10.0 );
      SumLevelmW += ( AbsLevelmW / 3.65 );
    }

  // convert to dBm, subtract from iTotaLpower and return
```

Example 2: Code snippet for calculating the adjacent channel power

Please note that if the absolute power value @ 30 kHz is needed, the default parameter `iTotalChPower` should be omitted when calling the function `integrate_ACP_points()`. The result value's unit will be (absolute) [dBm] then instead of [dB] relative to the input parameter `iTotalChPower`.

3.4 Conclusion and general recipe

A general approach and recipe to measure the parameters in question could look like this

- Set up the R&S® CMU200 with the test fixture for the AT to be tested.
- Make sure that the external attenuation settings are proper. If the test is to be performed in several bands, it is advised to use the frequency dependent attenuation capability of the R&S® CMU200.

- Set up the forward link generator of the 1xEV-DO functionality of the R&S® CMU200, enable the generator output.
- Perform a RF channel measurement as described in section “Channel power over the full span of occupied carriers in Rel. B” on page 7.
- Configure and perform the adjacent channel power measurement, using the RF spectrum functionality.
- Execute the modulation quality measurement carrier-by-carrier.

Any implementation of this recipe needs to be aware that the generation of 1xEV-DO the forward link and the execution of any measurement in parallel are only available in remote operation *of the R&S® CMU200.*
For test purposes, the R&S® CMU200 allows the enabling of a special “Remote Debug Mode”, where the instrument, although fully controllable via the GUI, behaves as if operated over the remote control interface. For a more detailed description of this mode, please refer to the R&S® CMU200 reference manual.

4 Literature

[1] Recommended Minimum Performance Standard for cdma2000 High Rate Packet Data Access Terminal (3GPP2 C.P0033-B)
[2] Christoph Rauscher: Fundamentals of Spectrum Analysis (ISBN: 978-3-939873-01-15) – see http://www.books.rohde-schwarz.com/

5 Revision history

Revison history for this application note		
Date	**Author**	**Change**
04/28/2009	Robert Macketanz	Ready for publication
06/25/2009	Robert Macketanz	Small corrrections

About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

Regional contact

Europe, Africa, Middle East
+49 1805 12 42 42* or +49 89 4129 137 74
customersupport@rohde-schwarz.com

North America
1-888-TEST-RSA (1-888-837-8772)
customer.support@rsa.rohde-schwarz.com

Latin America
+1-410-910-7988
customersupport.la@rohde-schwarz.com

Asia/Pacific
+65 65 13 04 88
customersupport.asia@rohde-schwarz.com

Certified Quality System
ISO 9001
DQS REG. NO 1954 QM

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DQS REG. NO 1954 UM

Rohde & Schwarz GmbH & Co. KG
Mühldorfstraße 15 | D - 81671 München
Phone + 49 89 4129 - 0 | Fax + 49 89 4129 – 13777

www.rohde-schwarz.com