Measurement of Power Ramps of GSM, DCS1800 and PCS1900 Signals with Spectrum Analyzers of the FSE Family

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Application Note 1EPAN18E

Subject to change

26 December 1995, Josef Wolf

Products:

FSEA 20/30, FSEB 20/30

ROHDE&SCHWARZ

Measured Quantities

TDMA communications systems like GSM, DCS 1800 or PCS 1900 make effective use of the frequency spectrum by assigning several subscribers to the same frequency channel. Each subscriber has access to one predefined time slot for transmitting information. With GSM eight subscribers share one frequency channel with a bandwidth of 200 kHz.

In order not to disturb the other users of the 200-kHz channel it has to be ensured that, for instance, a mobile sends in the assigned time slot only and that no power is emitted by the transmitter at other times. For this reason the transmitter power is practically switched off in the transmission intervals.

However, when the transmitter output power is switched off also components of the transient spectrum are emitted in addition to the modulation spectrum. The transient spectrum is the wider, the faster the transmitter power is switched on and off. In a borderline case of a fast-switching transmitter, the output spectrum becomes infinitely wide and decreases according to the formula

$$\frac{\sin(p \cdot f \cdot T)}{p \cdot f \cdot T}$$ starting at the center frequency,

where T = burst duration

f = frequency.

To avoid subscribers of other frequency channels being disturbed, the transmitter output power should be switched on and off as slowly as possible so that, as a consequence, the frequency of the transient spectrum is limited. However, the minimum steepness of the switching ramps is determined by the guard interval between the subscribers operating at the same frequency. Due to the marginal conditions - spurious emissions outside the assigned channel, time interval to adjacent time slots and the maximum permissible power during transmission intervals - a narrow tolerance mask is obtained for the rising and falling edge of the TDMA burst. With GSM this mask is specified by GSM Specs 11.10 for mobiles and 11.20 for base stations.

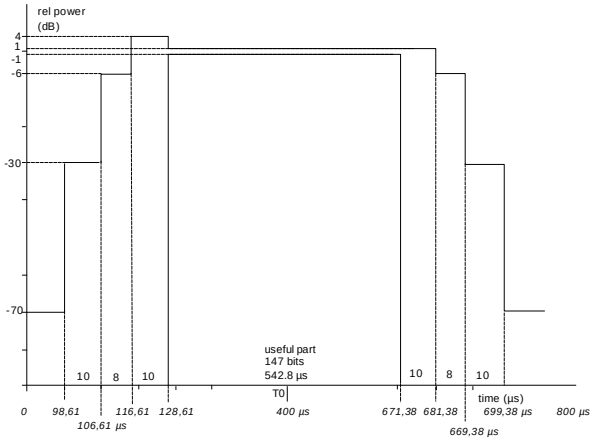

FIG. 1 Mask for GSM burst as specified by GSM 11.20

Compliance with this mask places high requirements on the transmitter and therefore also for the test equipment.

The dynamic range between burst power and off must be more than 70 dB. In order not to impair the ramps by transients of the resolution or video filter, a resolution bandwidth of 1 MHz and a video bandwidth of ≥1 MHz should be used. This places high demands on the noise figure of the spectrum analyser.

The upper limit line is maximal 4 dB above the nominal burst level, ie the set reference level is 4 B above the burst level. The displayed noise level must be more than 70 dB below the burst level. For an error <1 dB a level difference of 10 dB to the limit value is required. Thus the required dynamic range of 84 dB at a 1-MHz bandwidth is obtained.

The dynamic range of the spectrum analyzer is determined by the maximum mixer level and the noise figure. The maximum mixer level of all spectrum analyzers is -10 dBm. Consequently a noise floor of <-94 dBm is required in the spectrum analyzer. The corresponding noise figure is

NF = -174 dBm + 94 dB + 60 dB +2,5 dB

= **22.5 dB**,

where

-174 dBm = thermal noise power of 50-Ω resistor for 1-Hz bandwidth

-94 dBm = inherent noise of spectrum analyzer at 1-MHz bandwidth

60 dB = 10 x log (1 MHz/1 Hz); noise increase for 1-MHz referred to 1-Hz bandwidth

2.5 dB = correction factor for noise weighting by the log amplifier.

FSEA guarantees a noise indication of <-145 dBm for a 10-MHz bandwidth, -150 dBm being typical. Consequently, for a 1-MHz bandwidth the guaranteed noise floor is <-95 dBm, the typical value being -100 dBm.

Spectrum analyzers with a higher noise figure often use a 300-kHz bandwidth instead of 1 MHz to reduce the noise floor below the specified limit. In this case the burst ramp is slowed down so that the reference to the limit values is only qualitative. The difference between the two measurements can be clearly seen in FIG. 2: the rising edge of a GSM burst is shown for a 1-MHz and a 300-kHz resolution bandwidth.

For a bandwidth of 300 kHz the burst edge is determined by the resolution filter.

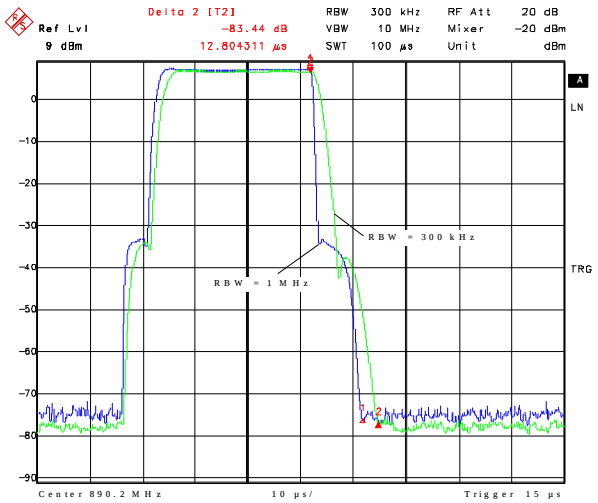

FIG. 2 Rising and falling edge of a GSM burst measured at a 300-kHz and 1-MHz bandwidth. The center part of the burst is blanked by the gap sweep function.

Measurement with FSE

In the example below the burst of a GSM transmitter is measured on uplink channel 1:

Note: A signal generator with GSM modulation capabilities and pulse shaping, eg R&S Signal Generator SME may be used as a transmitter.

1. Display of timing characteristic

- Press [**PRESET**] key to bring the FSE to its basic setting.
- Connect the transmitter output to the RF input. Make sure that the transmitter power does not exceed 30 dBm. If this is the case connect a power attenuator between transmitter output and RF input. In the display this attenuation can be corrected by entering a level offset.

  [**REF**: REF LEVEL OFFSET: nn dB]
  nn = attenuator value
- Set FSE center frequency to the channel frequency, in this case 890.2 MHz. [**CENTER**: 890.2 MHz].
- Set a reference level which is approx. 10 dB higher than the expected transmitter output level [**REF**: {*transmitter level + 10*} dB]
  Set input attenuator for low-noise operation [ATTEN AUTO LOW NOISE].
- Select time display [**SPAN**: ZEROSPAN]
- Set a resolution and a video bandwidth of 1 MHz [**COUPLING**: RBW MANUAL: 1 MHz: VBW MANUAL: 1 MHz].

*Note: If the measurement is performed after a **PRESET,** RBW = 1 MHz and VBW = 1 MHz is automatically set when the zero span is switched on.*

- Select a sweep time of 800 µs: [**COUPLING**: SWEEPTIME MANUAL: 800 µs]
- Set triggering to video [**TRIGGER**: VIDEO] and a trigger level of 75% by means of the spinwheel or by entering a numeric value.

The result is a still display of burst characteristics of the GSM signal.

2. Shifting the GSM burst to the display center

With the above settings made, the burst starts at the display edge and ends at 70% of the X axis. For shifting the burst to the display center, FSE offers a pretrigger via the gap sweep.

- [**SWEEP**] key
- [GAP SWEEP ON]
- [GAP SWEEP SETTINGS: PRETRIGGER: 128 µs]

The burst is now roughly in the center of the display. By varying the pretrigger using the spinwheel it can be exactly centered.

3. Optimizing the dynamic range

The dynamic range in the measurement of a GSM burst is at its maximum when the highest

permissible level is applied to the input mixer, as in this case the inherent noise is at its minimum. The maximum level is applied to the mixer when the RF attenuation at a preset reference level is reduced to minimum.

To do so set the reference level to approx. 5 dB above the displayed signal level [REF: {*signal level + 5*} dB].

Now set the minimum RF attenuation (RF Att) for the entered reference level (Ref LvL). The minimum is attained when the following applies:

-20 dBm < (Ref Lvl - RF Att) ≤ -10 dBm,

ie the mixer level is between -10 dBm and -20 dBm.

[**REF**: ATTEN MANUAL: nn dB]

The GSM burst is now displayed with a maximum dynamic range.

4. Displaying the tolerance mask

With the aid of the limit lines function of the FSE, tolerance masks can be defined and displayed. A line may be inserted for the upper or the lower limit value. With the monitoring function switched on FSE signals

"*LIMIT CHECK:Passed*" when the values are within the set limit and " *LIMIT CHECK:Failed*" when limits are exceeded.

Defining the limit values:

- Press [**LIMITS**] key.
- [NEW LIMIT LINE: NAME] softkey: enter name, domain, scaling, unit and limit and, if required, a comment for the lower or upper limit value as defined in the tables below.
- [VALUES] softkey: enter points for the lower or upper limit values as specified in the tables below.
- [SAVE LIMIT LINE] softkey: the limit line is stored on the FSE hard disk under the respective name.

Lower limit value:

Name:	GSM_NBL
Domain:	time
Unit:	dB
X scaling:	relative
Y scaling:	relative
Limit:	lower

Time	Limit
-271.38 µs	-100 dB
-271.38 µs	-1 dB
271.38 µs	-1 dB
271.38 µs	-100 dB

Upper limit value:

Name:	GSM_NBU
Domain:	time
Unit:	dB
X scaling:	relative
Y scaling:	relative
Limit:	upper

Time	Limit
-1000 µs	-70 dB
-299.39 µs	-70 dB
-299.39 µs	-30 dB
-289.39 µs	-30 dB
-289.39 µs	-6 dB
-281.39 µs	-6 dB
-281.39 µs	+4 dB
-271.39 µs	+4 dB
-271.39 µs	+1 dB
281.38 µs	+1 dB
281.38 µs	-6 dB
289.38 µs	-6 dB
289.38 µs	-30 dB
299.38 µs	-30 dB
299.38 µs	-70 dB
1000 µs	-70 dB

Limit lines are defined in relation to the reference point/transition from bit 13 to 14 of the midamble so that times at the left of the reference point are negative and times at the right positive.

Activating limit lines:

- Press [**LIMITS**] key.
- Press [SELECT LIMIT LINE] softkey.
- Set cursor to GSM_NBL.
- Select limit line with ENTER.
- Set cursor to GSM_NBU.
- Select limit line with ENTER.

  Selected limit lines are marked with √ at the left display edge.
  For an automatic check whether measured values are within the set limits, a the limit check function can be activated for each line. To do so select ON under LIMIT CHECK in the table.
- Press the [**CLR**] twice. The limit line table is closed.

Note: Relative is selected for the scaling of limit lines in the X and Y direction.

X direction: X scaling relative, ie times are displayed with reference to the time displayed at the left screen edge.

Y direction: unit dB, Y scaling relative, ie the limit level is selected with reference to the top level line in the diagram (= Ref Level).

Matching limit lines to the burst

The displayed limit line is in relation to the reference points on the screen. To ensure optimum matching to the measured burst, the line is positioned on the burst using the X and the Y offset function. The best way for accurately positioning the line is to switch on the 20-dB level range prior to the adjustment.

- [**RANGE**] key, [LOG 20 dB] softkey
- [**LIMITS**] key, [X OFFSET: 400 µs] softkey; the mask is shifted to the display center (X offset = 0.5 x sweep time).
- [Y OFFSET] softkey; using the spinwheel shift the limit line on the level axis so that the horizontal part of the measured curve is in the center of the ±1-dB tolerance band defined by the limit values.
- [X OFFSET] softkey; using the spinwheel shift the limit line on the time axis so that the edges of the burst lie within the tolerance band.
- Select the required level display range by pressing the [**RANGE**] key again.

The GSM burst is now displayed within the tolerance mask (FIG. 3).

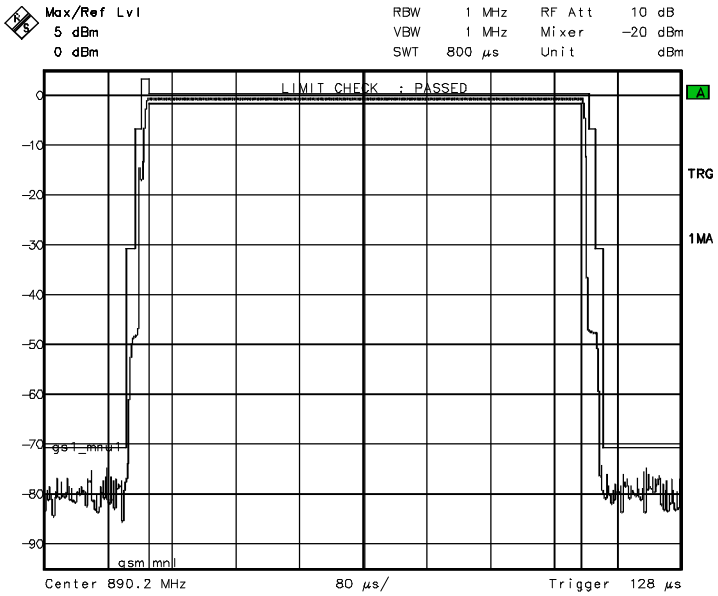

FIG. 3 Display of complete burst of a GSM mobile with tolerance masks

If only the burst ramps are to be examined, they may be expanded by inserting a gap in the burst center.

- [**SWEEP**: GAP SWEEP SETTINGS:
  GAP LENGTH: 500 µs,
  TRG TO GAP TIME: 22 µs]
- [SWEEPTIME: 300 µs

During the measurement, the 500-µs gap in the center of the burst is ignored. FSE displays 150 µs at the left and the right of the gap.

(Left: pretrigger + trigger to gap time
= 128 µs + 22 µs = 150 µs;

Right: sweep time -(pretrigger + trigger to gap time = 300 µs -150 µs = 150 µs)

The limit lines are adapted as required to the new scales (FIG. 4).

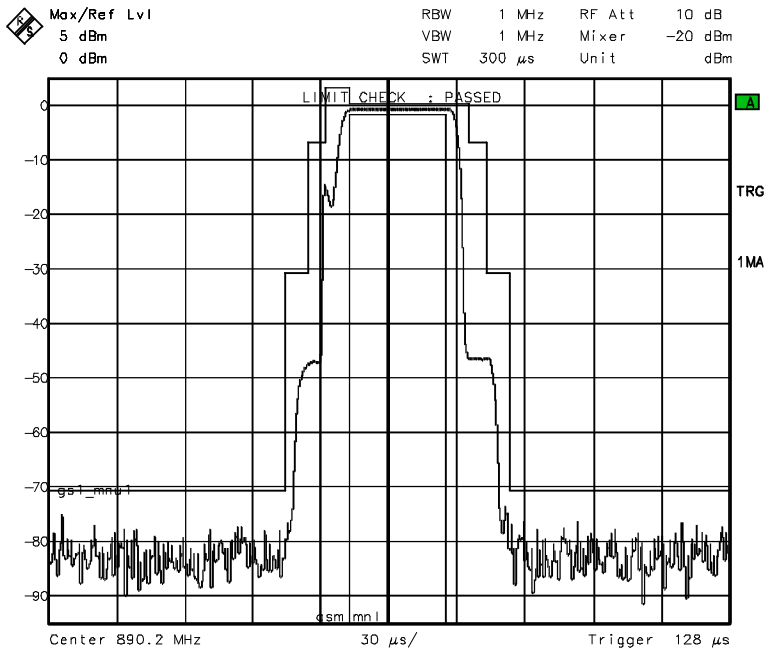

FIG. 4 High-resolution display of rising and falling burst edges of a GSM mobile as selected on the FSE. By inserting a gap in the burst center only the edges are displayed.

Note:

Limit lines as described in the application can be displayed from firmware version 1.30 onwards. The firmware version used in the FSE may be queried with [**INFO**: FIRMWARE VERSION].

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