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AX5051 Use in Compliance with ETSI EN 300 220-1

Introduction

All measurements are executed conducted. The measurements are performed on the AX5051 DVK2b module. It is not the aim to measure an antenna performance.

Devices are set up using the AXGen2–RadioLab software.

Identical results can be obtained for AX5151, AX5031, AX5131 and AX8052F151.

Receive

Receivers of ETSI EN 300 220–1 V2.4.1 (2012–05) Categories 2 or 3 can be built using AX5051. Please refer to the datasheet for the relevant sensitivity and blocking values.

Transmit

The following table lists output power levels for GFSK modulated signals that can pass ETSI EN 300 220–1 V2.4.1 (2012–05) as a function of the bitrate and the reference crystal frequency. In the following chapters of this application note, detailed measurements for 50 kbps GFSK using a 16 MHz crystal and 100 kbps GFSK using a 24 MHz crystal are presented.

Table 1. TYPICAL OUTPUT POWER LEVELS FOR GFSK, $h = 0.67$ MODULATED SIGNALS THAT CAN PASS ETSI EN 300 220–1 V2.4.1 (2012–05) IN THE FREQUENCY BAND 868.0 – 868.6 MHz (WIDE BAND)

Bitrate	Crystal Frequency	Typical Output Level
GFSK with $h = 0.67$		Passes ETSI EN 300 220–1 V2.4.1 (2012–05) in the frequency band 868.0 – 868.6 MHz (wide band)
50 kbps	16 MHz	14 dBm
100 kbps		8 dBm
200 kbps		5 dBm
100 kbps	24 MHz	14 dBm
200 kbps		12 dBm
300 kbps		7 dBm



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APPLICATION NOTE

Measurements

General

- Frequency Error ETSI EN 300 220–1 V2.4.1 (2012–05), Sub-clause 7.1

The frequency error of the AX5051 is given by the frequency error of the frequency source XTAL or TCXO.

ETSI EN 300 220–1 requirements are
 ± 100 ppm for 868 MHz wide band systems,
 ± 14.4 ppm for 868 MHz narrow band systems,
 ± 27 ppm for 433 MHz narrow band systems,
 ± 59 ppm for 169 MHz narrow band systems.

Narrow band refers to channel widths smaller ≤ 25 kHz.

EN 13 757–4 2005 which applies for wireless M–Bus devices, requires stricter frequency errors. 60 or 25 ppm for the center frequency.

Although this is all achievable with normal crystals, we do recommend use of a TCXO for optimal performance in narrow band systems.

868 MHz Wide Band, 100 kbps, GFSK

ETSI EN 300 220–1 V2.4.1 (2012–05), in frequency band 868.0 – 868.6 MHz.

- Setup

Table 2. SETUP FOR 868.3 MHz, 100 kbps, GFSK

Module	AX5051 DVK-2b V1.4 Module with 24 MHz XTAL Internal synthesizer loop filter
Measurement equipment	0.5 m RG-58 cable from SMA to R&S FSEB spectrum analyzer (Note 1)
Mainboard and debug adapter	DVK-2
Setup software	AXGen2-RadioLab V1.1
Carrier Frequency	868.3 MHz
Bit rate	100 kbps
Modulation	GFSK
FSK deviation ($f_{\text{mark}} - f_{\text{space}})/2$	$h=0.667$, 33.334 kHz
Changes to setup software default register settings	Set the parameter "Radio XTAL prestart time" in the Synchronous Timing Panel to 1.56 ms.
Changes to hardware default configuration	1. Use 24 MHz XTAL 2. Remove 100 nF capacitor from pin 26
Power level for which module meets ETSI EN 300 220-1 V2.4.1 (2012-05)	14 dBm (Notes 1 & 2)

1. Values presented are the spectrum analyzer readings. Cable losses are not compensated
2. The maximum power level for 868.3 MHz is 14 dB. The maximum power level of AX5051 is above the limit but can be programmed down to meet the limit. The Power level of AX5051 is very little dependent on supply voltage.

- Average Power ETSI EN 300 220-1 V2.4.1 (2012-05), Subclause 7.2

AX5051 is outputting CW for this measurement. The ETSI limit for the 868.0 – 868.6 MHz band is 25 mW

(14 dBm). Measured output for AX5051 is 13.8 dBm, all the following measurements were done at this power level.

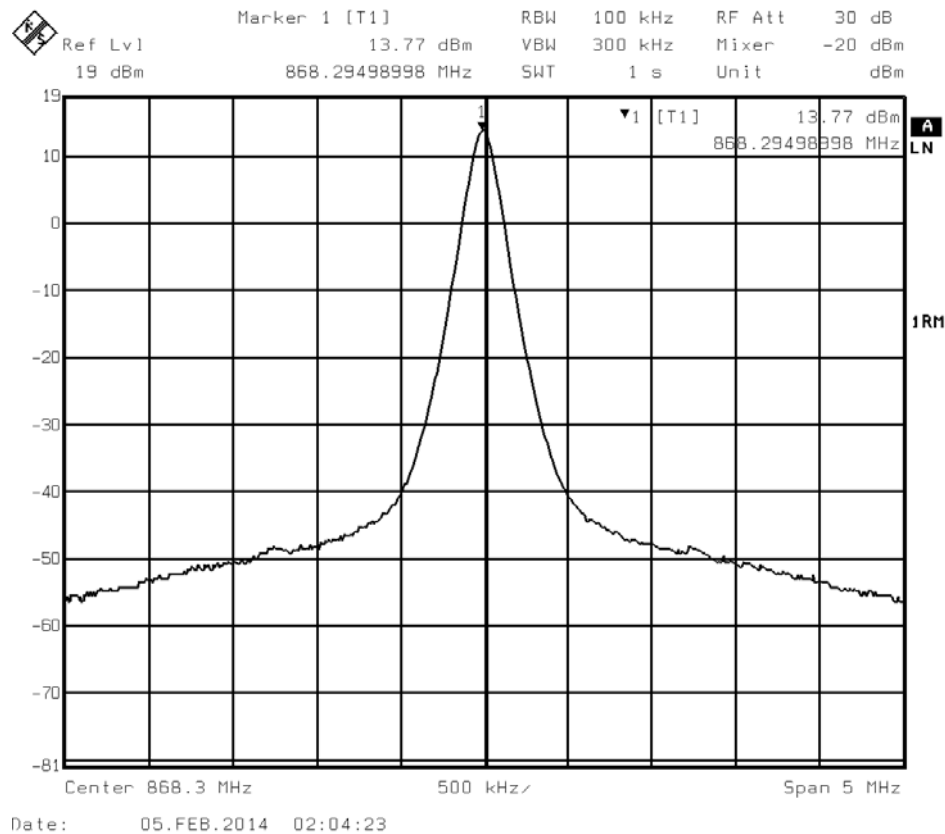


Figure 1. Transmit Spectrum, 868.3 MHz, CW

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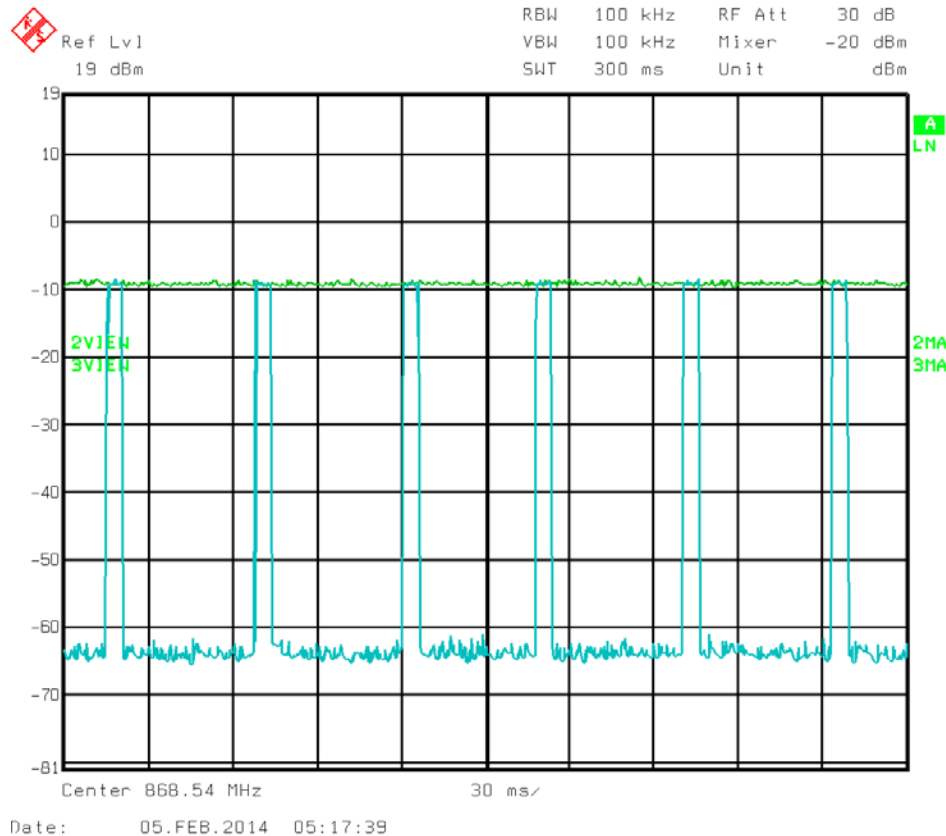
- Transient Power EN 300 220-1 V2.4.1 (2012-05), Subclause 7.5

The edges of the modulation bandwidth are $f_a = 868.44$ MHz and $f_b = 868.16$ MHz, see Figure 5. The following figures show measured Transient Power maximum levels for both On-Off operating mode (ETSI Step 1) and continuous operating mode (ETSI Step 2). Detector setting max

ETSI limits are either -36 dBm for On-Off operating mode or where this is not met, no more than 3 dB difference

between Step 1 and Step 2 measurements. It can be seen from Figure 3 and Figure 4, that this is met.

Note that crystals can vary in the start-up time required. If there are overshoots at the rising edge of the on-off operation then this is an indicator of a too short XTAL start-up time. In the RadioLab software this parameter can be set in the Synchronous Timing Panel in the field "Radio XTAL prestart time". That setting varies the XTAL start-up time for all duty-cycled modes, not only for synchronous timing!



The blue trace shows results for on-off operation (step 1), the green trace shows the reference measurement results for continuous transmission (step 2). Note that detector setting max peak is used.

Figure 2. Measurement for Transient Power at 240 kHz Distance from the Carrier Frequency

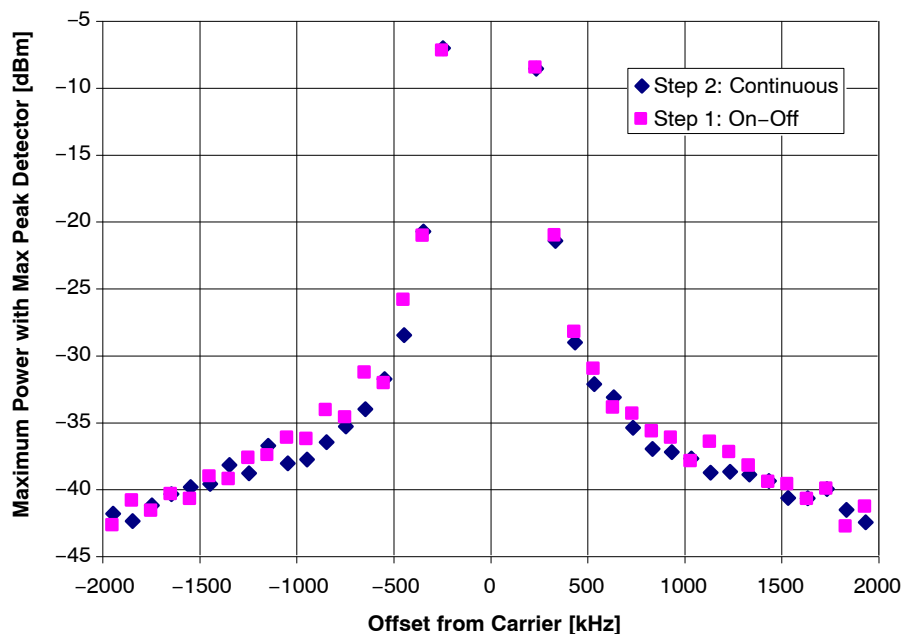


Figure 3. Measurement of Transient Power for Frequency Offsets $f_a + 100$ kHz and $f_b - 100$ kHz to ± 2 MHz Offset from Carrier. Note that Detector Setting Max Peak is used.

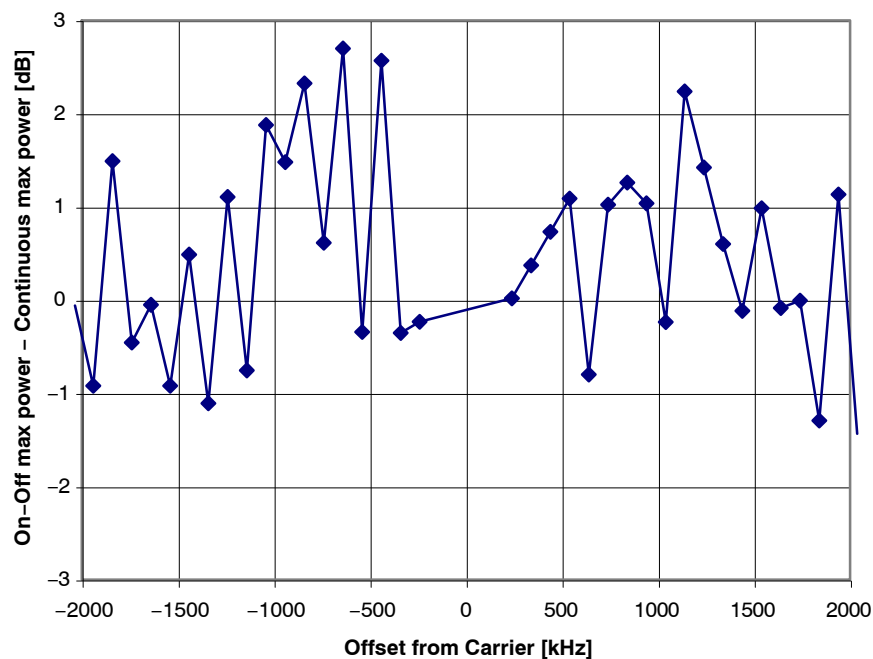


Figure 4. Difference between Transient Power Measurements Step1 and Step 2. Note that Detector Setting Max Peak is used.

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- Modulation Bandwidth EN 300 220-1 V2.4.1 (2012-05), Subclause 7.7

The following three plots show the modulated output at different resolution bandwidths with the corresponding ETSI limit lines.

Spectrum analyzer settings for all three measurements are:

- ♦ detector function: max peak
- ♦ trace: max hold

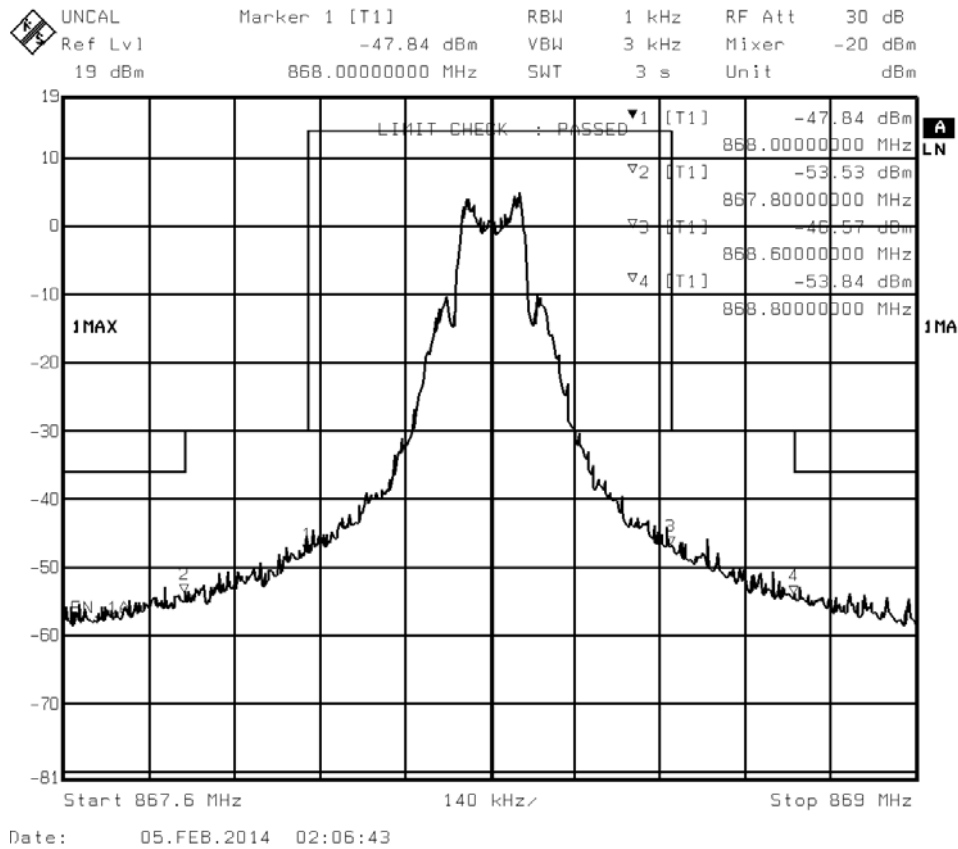


Figure 5. Transmit Spectrum, 868.3 MHz, GFSK, 100 kbps, $h = 0.667$, RBW = 1 kHz, Detector Max Peak, Trace Max Hold

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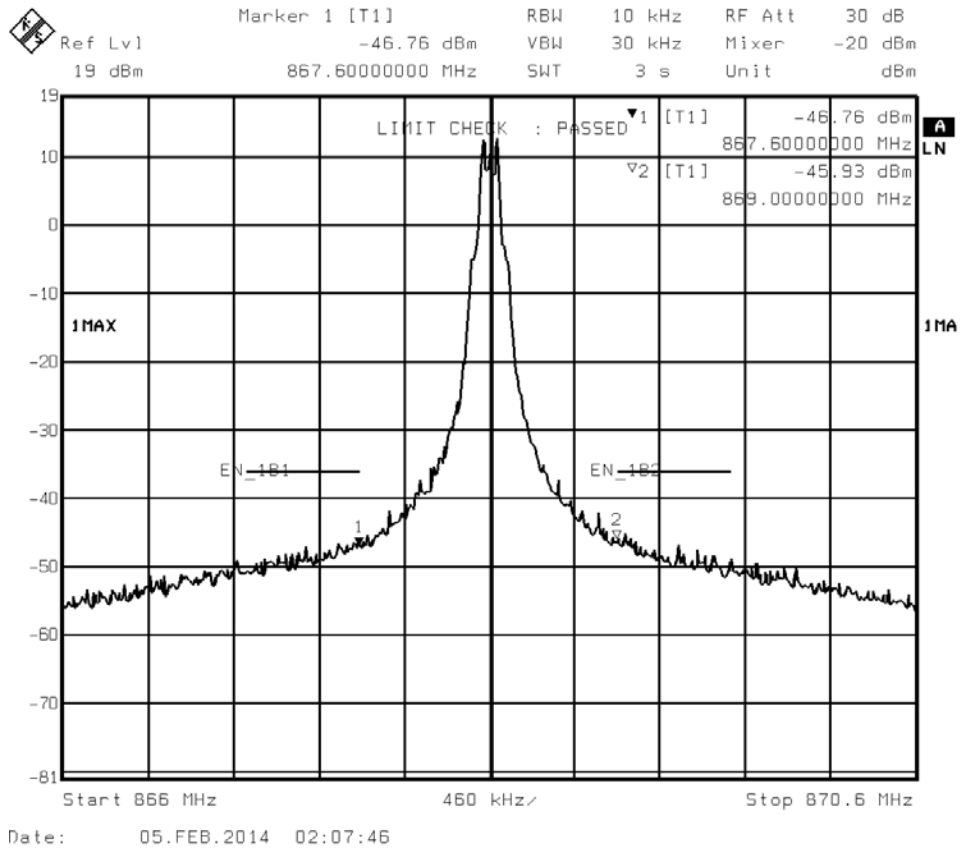


Figure 6. Transmit Spectrum, 868.3 MHz, GFSK, 100 kbps, $h = 0.667$, RBW = 10 kHz, Detector Max Peak, Trace Max Hold

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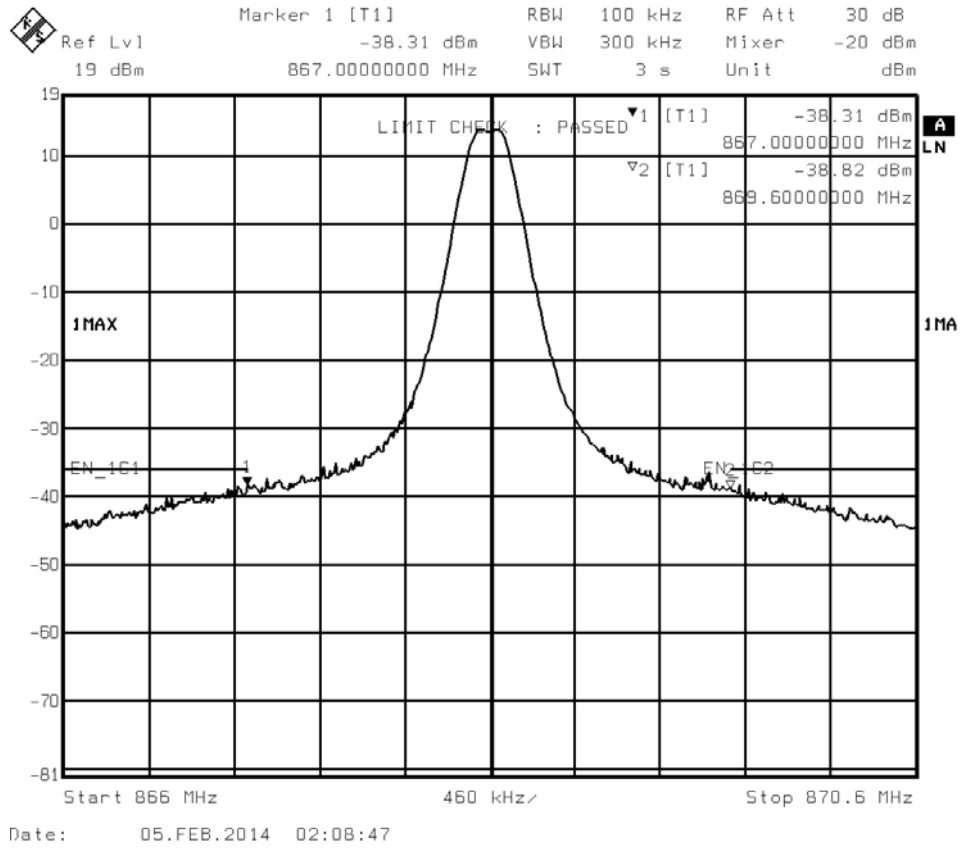


Figure 7. Transmit Spectrum, 868.3 MHz, GFSK, 100 kbps, $h = 0.667$, RBW = 100 kHz, Detector Max Peak, Trace Max Hold

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- Unwanted Emissions in Spurious Domains
EN 300 220-1 V2.4.1 (2012-05), Subclause 7.8
Unwanted emissions are shown for the most critical cases.

470 – 862 MHz

From 470 – 862 MHz the ETSI limit is –54 dBm for an RBW of 100 kHz. The highest measured spur is –60.7 dBm.

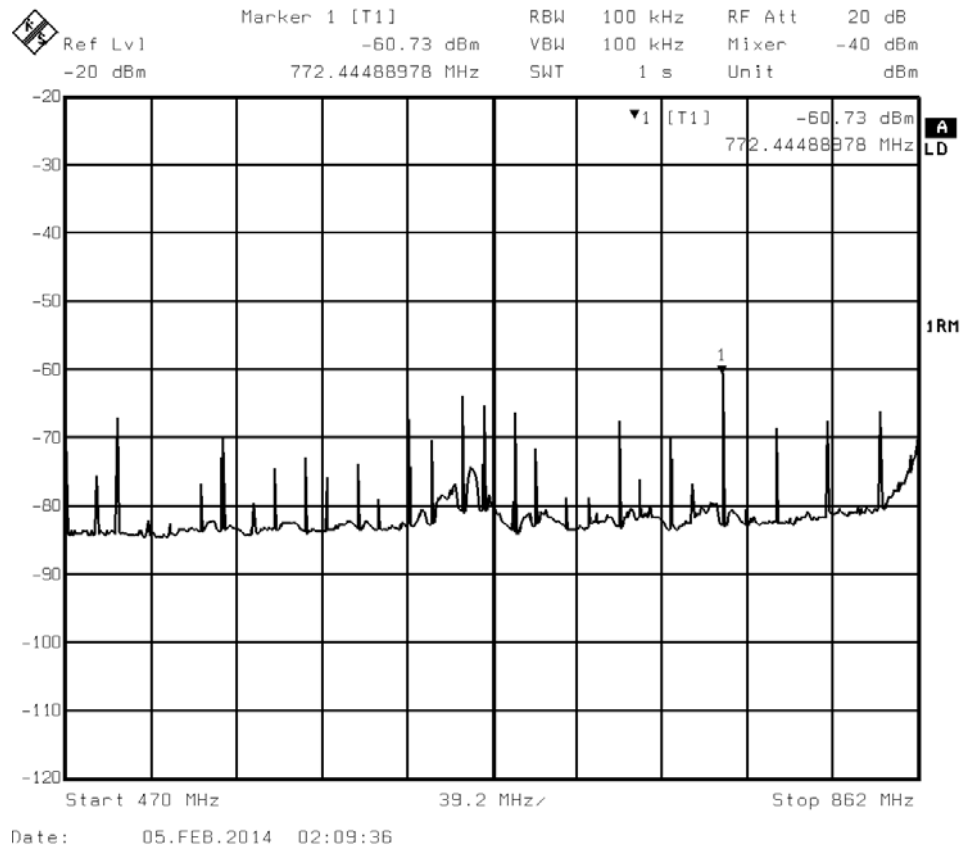


Figure 8. Spurious Emission 470 – 862 MHz

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Harmonics

Above 1 GHz the ETSI limit is -30 dBm for an RBW of 1 MHz. Here the harmonics of the wanted signal are most critical, but below -36 dBm.

Spectrum analyzer settings for all three measurements are:

- ♦ detector function: max peak
- ♦ trace: max hold

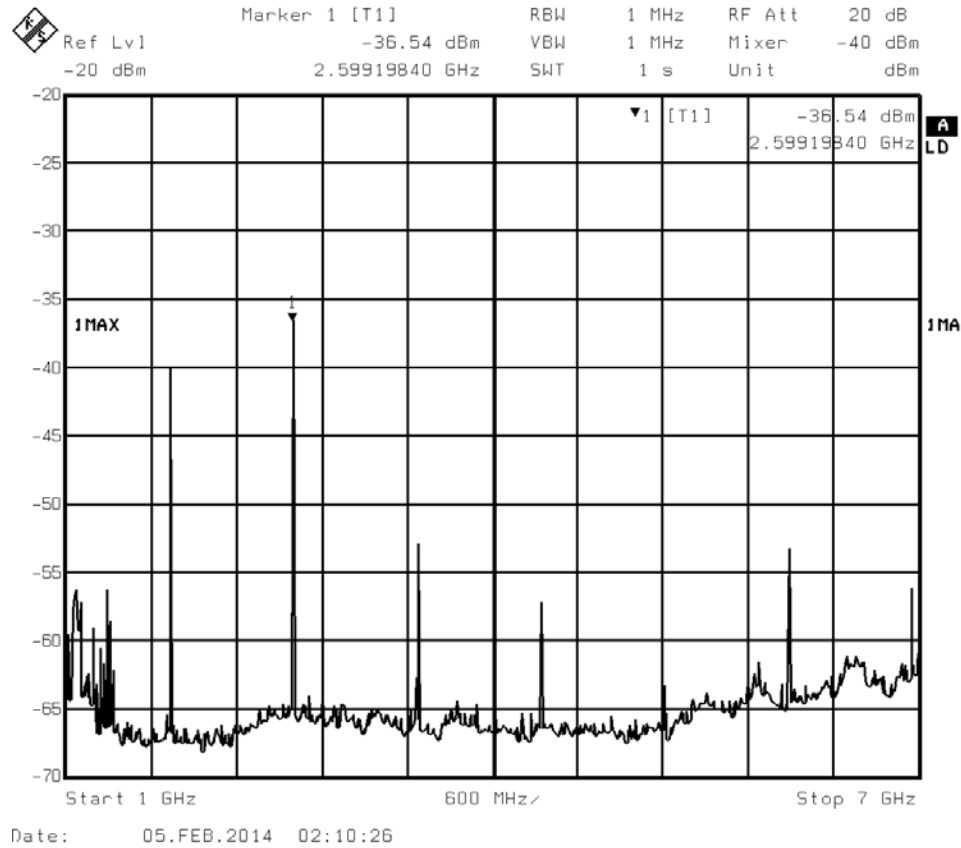


Figure 9. Spurious Emission above 1 GHz, Detector Max Peak, Trace Max Hold

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868 MHz Wide Band, 50 kbps, GFSK

ETSI EN 300 220-1 V2.4.1 (2012-05), in frequency band 868.0 – 868.6 MHz.

• Setup

Table 3. SETUP FOR 868.3 MHz, 50 kbps, GFSK

Module	AX5051 DVK-2b V1.4 Module with 16 MHz XTAL Internal synthesizer loop filter
Measurement equipment	0.5 m RG-58 cable from SMA to R&S FSEB spectrum analyzer (Note 1)
Mainboard and debug adapter	DVK-2
Setup software	AXGen2-RadioLab V1.1
Carrier Frequency	868.3 MHz
Bit rate	50 kbps
Modulation	GFSK
FSK deviation ($f_{\text{mark}} - f_{\text{space}})/2$	$h=0.667$, 16.667 kHz
Changes to setup software default register settings	Set the parameter "Radio XTAL prestart time" in the Synchronous Timing Panel to 1.56 ms.
Changes to hardware default configuration	Remove 100 nF capacitor from pin 26
Power level for which module meets ETSI EN 300 220-1 V2.4.1 (2012-05)	14 dBm (Notes 1 & 2)

- Values presented are the spectrum analyzer readings. Cable losses are not compensated
- The maximum power level for 868.3 MHz is 14 dB. The maximum power level of AX5051 is above the limit but can be programmed down to meet the limit. The Power level of AX5051 is very little dependent on supply voltage.

- Average Power ETSI EN 300 220-1 V2.4.1 (2012-05),
Subclause 7.2

AX5051 is outputting CW for this measurement. The ETSI limit for the 868.0 – 868.6 MHz band is 25 mW

(14 dBm). Measured output for AX5051 is 13.8 dBm, all the following measurements were done at this power level.

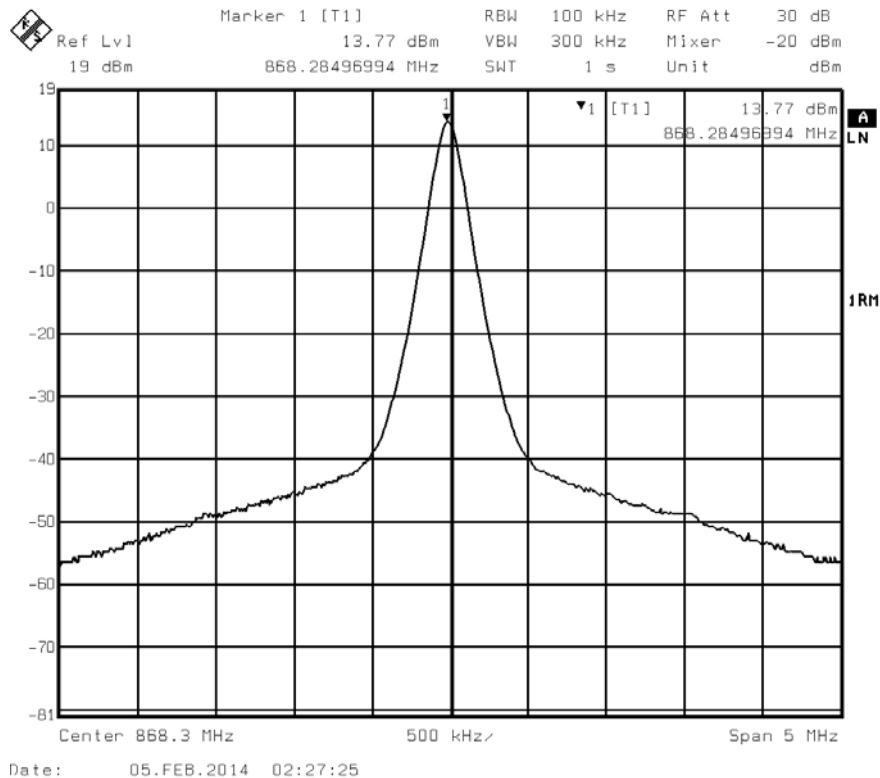


Figure 10. Transmit Spectrum, 868.3 MHz, CW

- Transient Power EN 300 220-1 V2.4.1 (2012-05), Subclause 7.5

The edges of the modulation bandwidth are $f_a = 868.4$ MHz and $f_b = 868.2$ MHz, see Figure 13. The following figures show measured Transient Power maximum levels for both On-Off operating mode (ETSI Step 1) and continuous operating mode (ETSI Step 2). Detector setting max

ETSI limits are either -36 dBm for On-Off operating mode or where this is not met, no more than 3 dB difference between Step 1 and Step 2 measurements. It can be seen from Figure 11 and Figure 12, that this is met.

For further remarks and a spectrum analyzer picture illustrating the measurement setup see the chapter on transient power for 100 kbps GFSK.

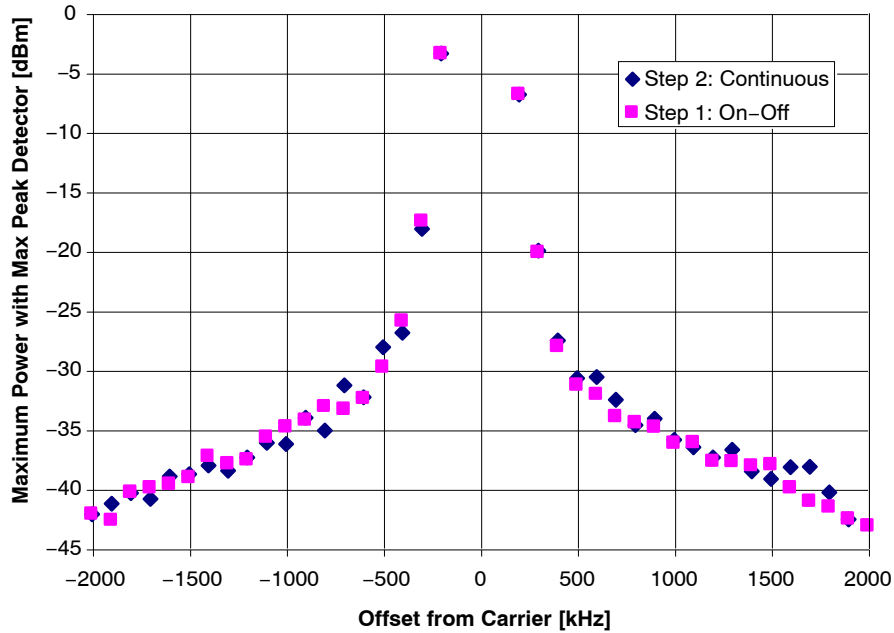


Figure 11. Measurement of Transient Power for Frequency Offsets $f_a + 100$ kHz and $f_b - 100$ kHz to ± 2 MHz Offset from Carrier. Note that Detector Setting Max Peak is used.

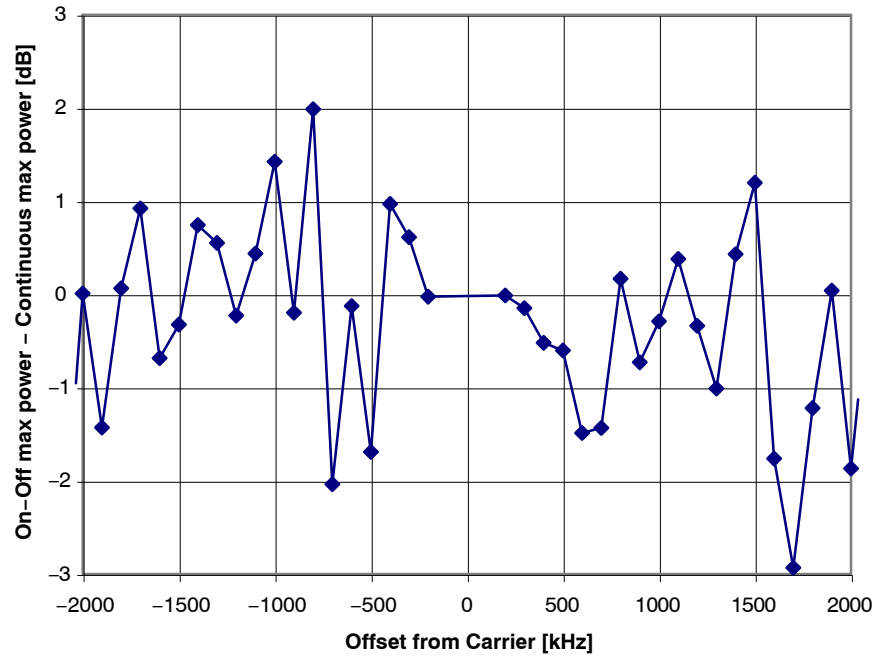


Figure 12. Difference between Transient Power Measurements Step1 and Step 2. Note that Detector Setting Max Peak is used.

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- Modulation Bandwidth

EN 300 220-1 V2.4.1 (2012-05), Subclause 7.7

The following three plots show the modulated output at different resolution bandwidths with the corresponding ETSI limit lines.

Spectrum analyzer settings for all three measurements are:

- ♦ detector function: max peak
- ♦ trace: max hold

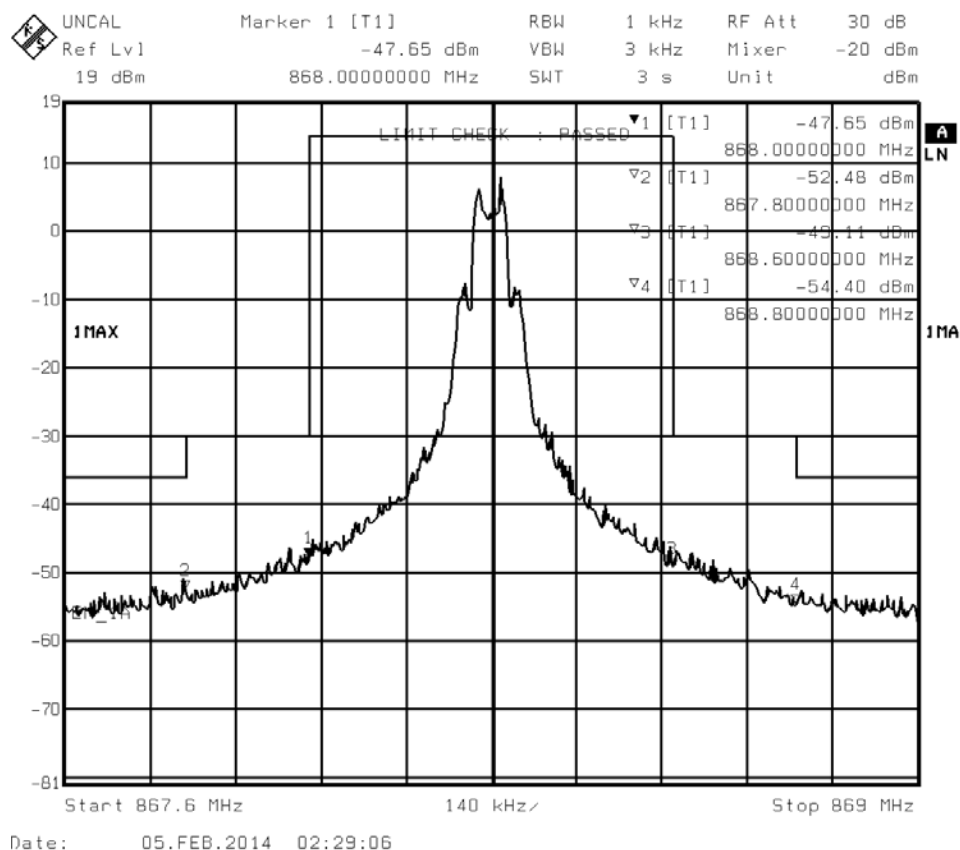


Figure 13. Transmit Spectrum, 868.3 MHz, GFSK, 50 kbps, $h = 0.667$, RBW = 1 kHz, Detector Max Peak, Trace Max Hold

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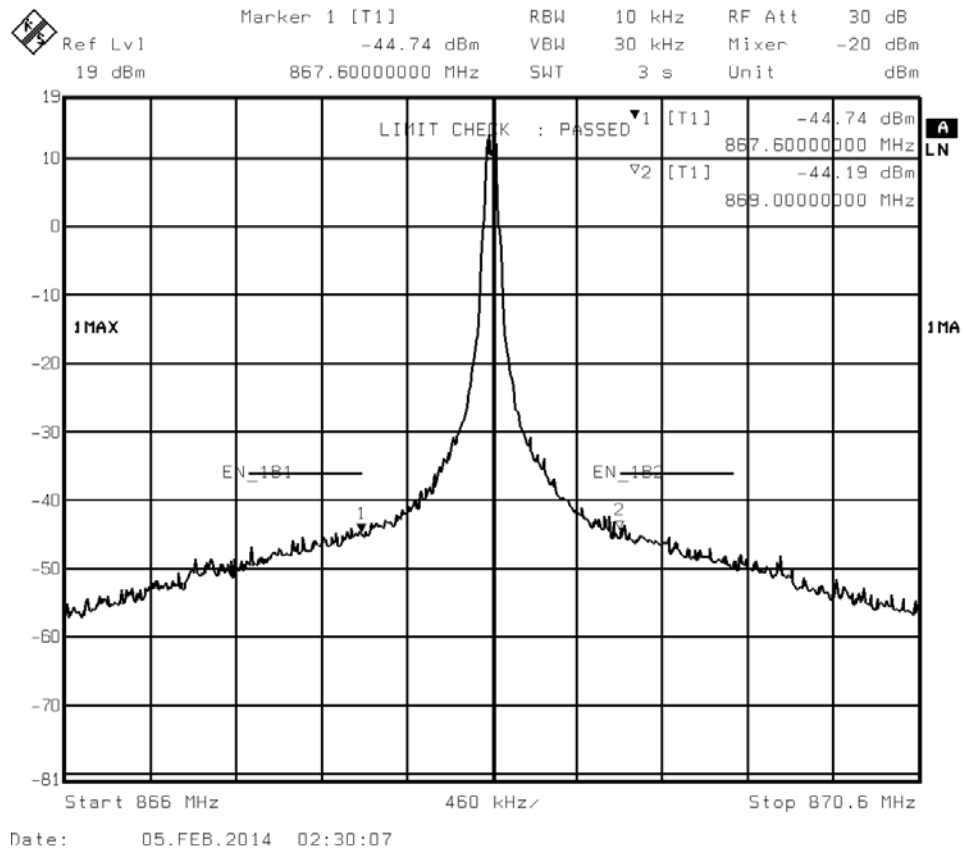


Figure 14. Transmit Spectrum, 868.3 MHz, GFSK, 50 kbps, $h = 0.667$, RBW = 10 kHz, Detector Max Peak, Trace Max Hold

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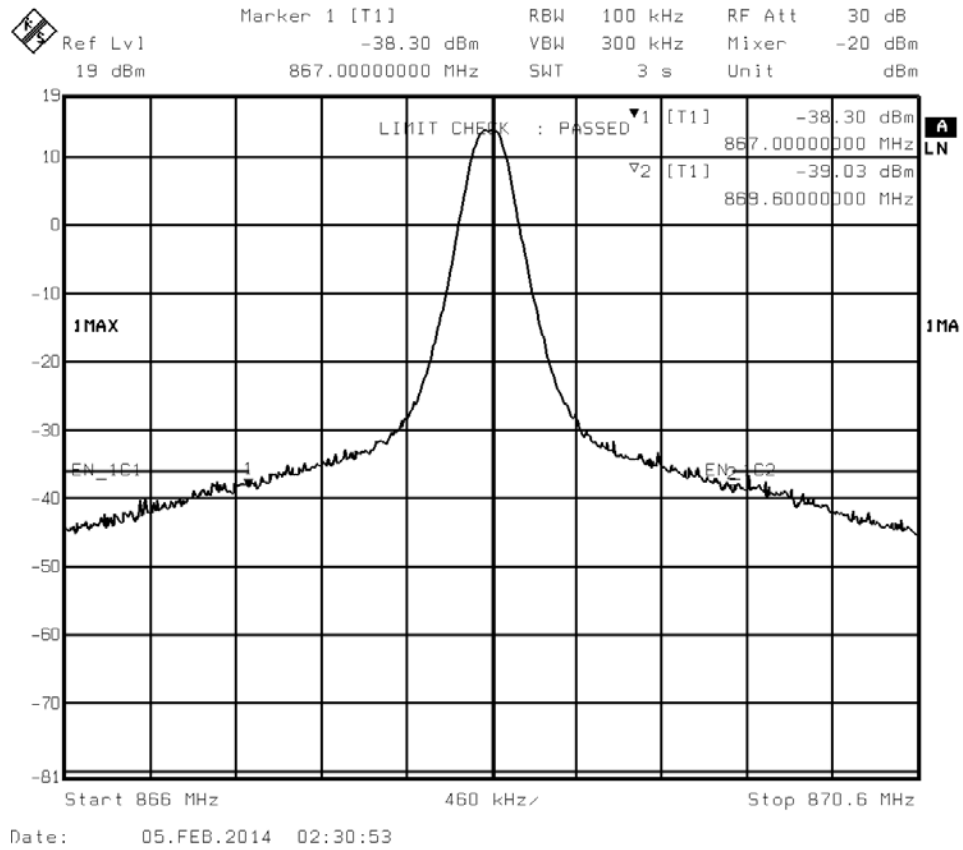


Figure 15. Transmit Spectrum, 868.3 MHz, GFSK, 50 kbps, $h = 0.667$, RBW = 50 kHz, Detector Max Peak, Trace Max Hold

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- Unwanted Emissions in Spurious Domains
EN 300 220-1 V2.4.1 (2012-05), Subclause 7.8
Unwanted emissions are shown for the most critical cases.

470 – 862 MHz

From 470 – 862 MHz the ETSI limit is –54 dBm for an RBW of 100 kHz. The highest measured spur is –64.9 dBm.

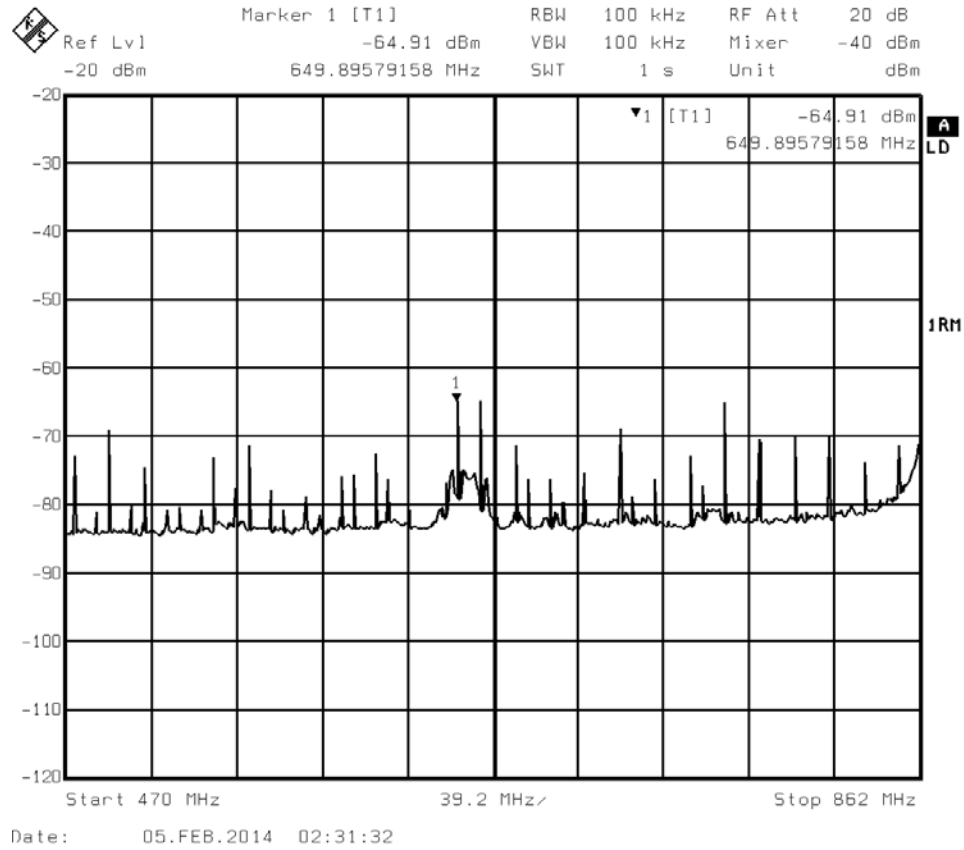


Figure 16. Spurious Emission 470 – 862 MHz

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Harmonics

Above 1 GHz the ETSI limit is -30 dBm for an RBW of 1 MHz. Here the harmonics of the wanted signal are most critical, but below -35 dBm.

Spectrum analyzer settings for all three measurements are:

- ◆ detector function: max peak
- ◆ trace: max hold

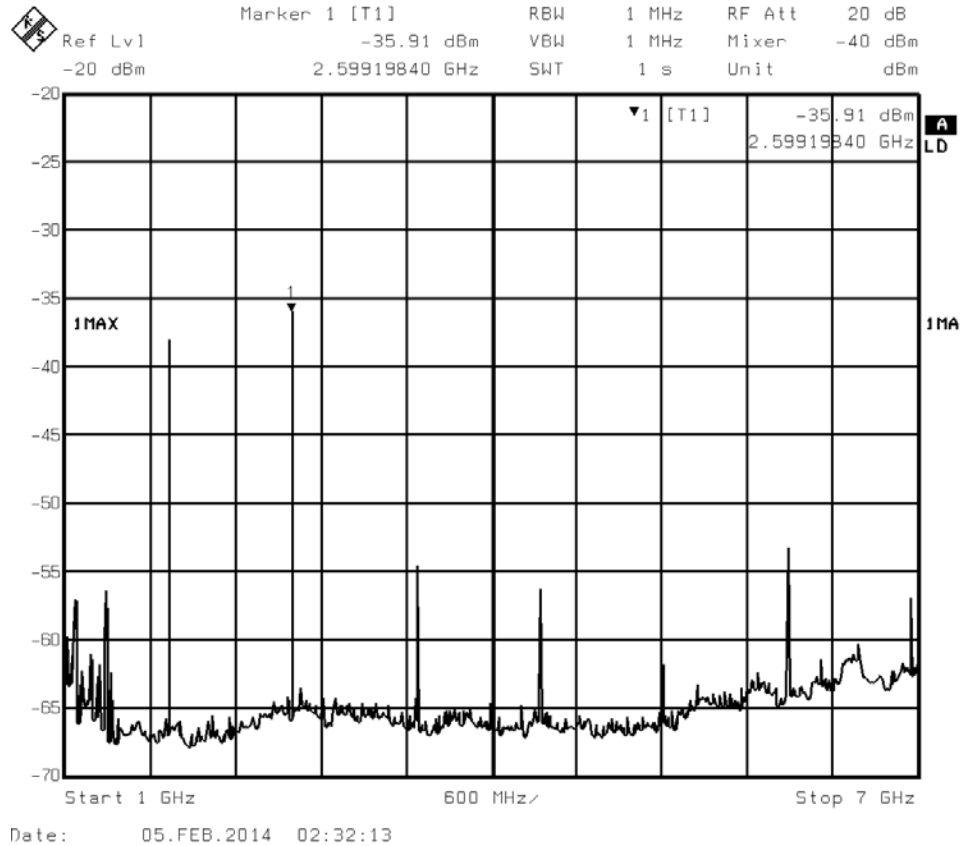


Figure 17. Spurious Emission above 1 GHz, Detector Max Peak, Trace Max Hold

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