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TECHNICAL REPORT

RFID
Measurement methods for transmit spectrum using modern spectrum analysers

Reference

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Executive summary

The present document investigates methods for transmitter spectrum mask measurements and proposes a new method for measuring the transmitter spectrum mask for RFID interrogators.

New limits for the transmitter spectrum masks in the lower band and upper band utilizing the new proposed measurement method are calculated based on the current measurement limits.

1 Scope

The present document specifies technical characteristics and methods of measurements for Radio Frequency IDentification (RFID) devices used in the frequency ranges 865 MHz to 868 MHz and 915 MHz to 921 MHz. Power limits up to a maximum of 2 W e.r.p. are specified for this equipment in the frequency band 865 MHz to 868 MHz and up to a maximum of 4 W e.r.p. in the frequency band 915 MHz to 921 MHz.

NOTE: The term frequency band is typically used for reference to dedicated bands as described in CEPT ECC ERC Recommendation 70-03 [i.7], while frequency range is used in the other cases.

While ETSI EN 302 208 [i.2] covers a comprehensive set of technical characteristics and methods of measurements, the focus of the present document is on transmitter spectrum mask using modern spectrum analysers, and ETSI EN 302 208 [i.2] applies for all other aspects.

The types of equipment covered by the present document are as follows:

- fixed interrogators;
- portable interrogators.

The present document contains measurement methods to demonstrate that the specified radio equipment both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] CEPT ECC ERC Recommendation 74-01: "Unwanted emissions in the spurious domain", Approved 1998 Corrected 23 May 2022.

[i.2] ETSI EN 302 208 (V3.3.1): "Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W and in the band 915 MHz to 921 MHz with power levels up to 4 W; Harmonised Standard for access to radio spectrum".

[i.3] ETSI TS 136 101 (V8.3.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (3GPP TS 36.101 version 8.3.0 Release 8)".

[i.4] ISO/IEC 18000-63:2021: "Information technology - Radio frequency identification for item management - Part 63: Parameters for air interface communications at 860 MHz to 960 MHz Type C".

[i.5] ETSI EN 302 208 (V3.4.1): "Radio Frequency Identification Equipment operating in the band 865 MHz to 868 MHz with power levels up to 2 W and in the band 915 MHz to 921 MHz with power levels up to 4 W; Harmonised Standard for access to radio spectrum".

[i.6] Japan ARIB STD-T106 Version 1.1.

[i.7] CEPT ECC ERC Recommendation 70-03: "Relating to the use of Short Range Devices (SRD)", approved 1997 (Tromsø), Subsequent amendments 8 March 2024.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ISO/IEC 18000-63 [i.4] and the following apply:

Lower band: frequency band 865 MHz to 868 MHz according to CEPT ECC ERC Recommendation 70-03 [i.7]

Upper band: frequency band 915 MHz to 921 MHz according to CEPT ECC ERC Recommendation 70-03 [i.7]

3.2 Symbols

For the purposes of the present document, the symbols given in ISO/IEC 18000-63 [i.4] and the following apply:

S	sensitivity of the receiver
N_{TOT}	total noise
N_{OC}	interferer noise from other users
N_D	distortion noise
N_{th}	thermal noise

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ISO/IEC 18000-63 [i.4] and the following apply:

4G LTE	Fourth-generation Long-Term Evolution
ACLR	Adjacent Channel Leakage Ratio
BER	Bit Error Rate
BW	Bandwidth
DRM	Dense Reader Mode
DUT	Device Under Test
E-UTRA	Evolved Universal Terrestrial Radio Access
FFT	Fast Fourier Transform
LB	Lower Band
LTE	Long-Term Evolution
NF	Noise Figure
OFDM	Orthogonal Frequency Division Multiplexing
PSD	Power Spectral Density
QoS	Quality of Service
QPSK	Quadrature Phase Shift Keying
RBW	Resolution Band Width
SNR	Signal to Noise Ratio
UB	Upper Band
UHF	Ultra High Frequency

4 State of the art in current standards

4.1 Introduction

This clause is a summary of recherche and analysis of existing standards and similar documents and contains a proposal how in future transmit spectrum measurements could be done.

4.2 Background

4.2.1 ETSI EN 302 208

Certification according ETSI EN 302 208 [i.2] requires that devices meet the mask requirement for the frequency ranges 865 MHz to 868 MHz and 915 MHz to 921 MHz. The transmitter spectrum in the lower band is shown as an example in Figure 1.

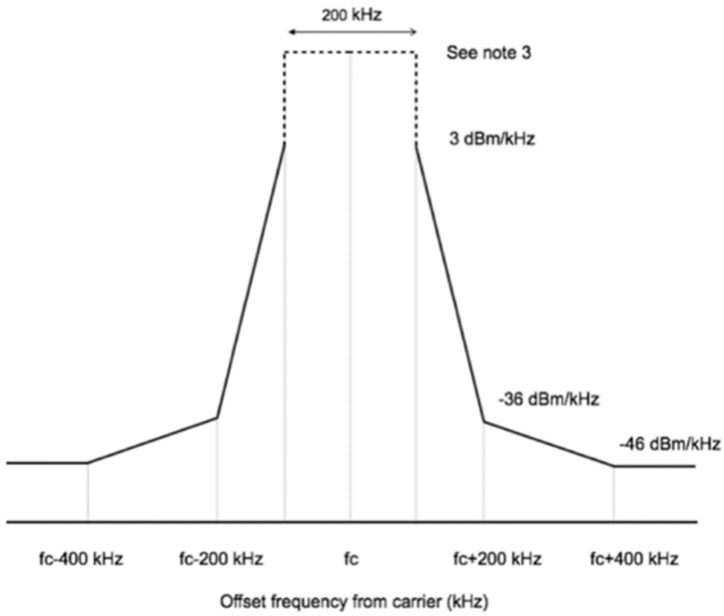


Figure 1: Spectrum mask for modulated signals in the lower band according to ETSI EN 302 208 [i.2], Figure 5

The above requirement was derived from CEPT ECC ERC REC 74-01 [i.1]. The current version is 23 May 2022 and as the document states that it should be reviewed every three years an update could be anticipated, if required.

The test requirements specify the waveform duty cycle and the spectrum analyser settings in detail:

a) Resolution bandwidth: 1 kHz.

b) Video bandwidth: Equal to the RBW.

c) Sweep Time: Auto.

d) Span: 1 MHz.

e) Trace mode: Maximum hold sufficient to capture all emissions.

f) Detection mode: Average.

The main reason for transmitter regulatory requirements is to maximize the spectral efficiency so that other users or applications can also share the spectrum. A user whose transmitter has significant leakage into adjacent frequencies would interfere with the operation of neighbouring users. If the interference is very large, the throughput of other applications would be harmed thus reducing overall capacity in the system.

4.2.2 Signal to Noise Ratio

All standards typically require a minimum Signal to Noise Ratio (SNR) or equivalently Bit Error Rate (BER) to sustain acceptable Quality of Service (QoS). For example, if a system uses QPSK modulation, the bit error rate for $AWGN$ channel is:

$$BER = Q\left(\sqrt{SNR}\right)$$

where $Q(.)$ is the standard Q function defined by:

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty exp\left(\frac{-u^2}{2}\right) du$$

Another common example is of BER dependent on SNR is OFDM modulation in a Raleigh fading channel, and the BER is given as:

$$BER = \frac{1}{2}\left(1 - \sqrt{\frac{\frac{L}{N} \times SNR}{2 + \frac{L}{N} \times SNR}}\right)$$

where L is the number of non-zero channel model coefficients for the Rayleigh fading channel and N is the number of FFT points for the OFDM. A standard BER curve versus SNR for OFDM is shown below in Figure 2.

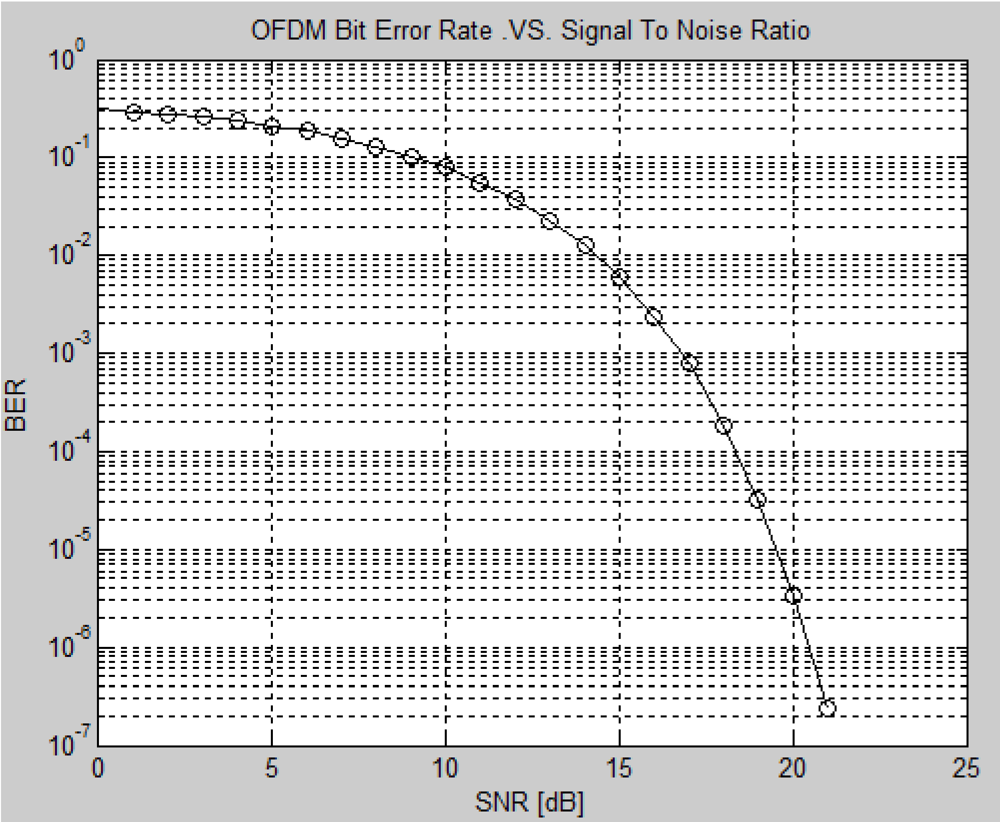


Figure 2: OFDM bit error rate

Relationships between a receiver's BER throughput performance and SNR is similarly established in most wireless technologies.

The Signal to Noise Ratio (SNR) is the average signal power to average noise power:

$$SNR = \frac{E[S^2]}{E[N^2]}$$

where $E[S^2]$ is the average signal power and $E[N^2]$ is the average noise power. Often the noise power is computed as the Power Spectral Density (PSD) over the channel bandwidth of the receiver. Using thermal noise as an example, the logarithmic referred to input thermal noise power, N_{th}, normalized to one milliwatt is:

$$N_{th} = -174 + NF + 10 \times \log_{10} BW$$

where NF is the noise figure of the receiver in dB and BW is the receiver bandwidth in Hertz. For example, a 4G LTE receiver has an effective bandwidth 4,5 MHz, excluding guard bands. If the Noise Figure (NF) of the 4G LTE receiver is 10 dB, then the input referred thermal noise is:

$$N_{th} = -174 + 10 + 10 \times log_{10} 4{,}5\ MHz = -97{,}4\ dBm$$

Thermal noise is a type of noise that impacts SNR, and interference from others in the same bandwidth can also be considered as a noise, N_{OC}. With these two types of noise sources, the total noise, N_{TOT}, that impacts SNR is linear sum:

$$N_{TOT} = N_{th} + N_{OC}$$

Noise ultimately limits the performance of receivers, and in particular, interference from other users, N_{OC}, should be viewed as integration over the receive channel bandwidth instead of power spectrum density mask. Clause 4.2.3 highlights other standards as examples that define transmitter requirements for power in a channel bandwidth.

4.2.3 Transmitter requirements in other standards

Many regulatory agencies and industry standards define the transmitter requirements as the average spectral leakage over adjacent frequencies. A case in point is the Japan regulatory requirement [i.6] which specifies the adjacent channel leakage ratio as shown in Figure 3.

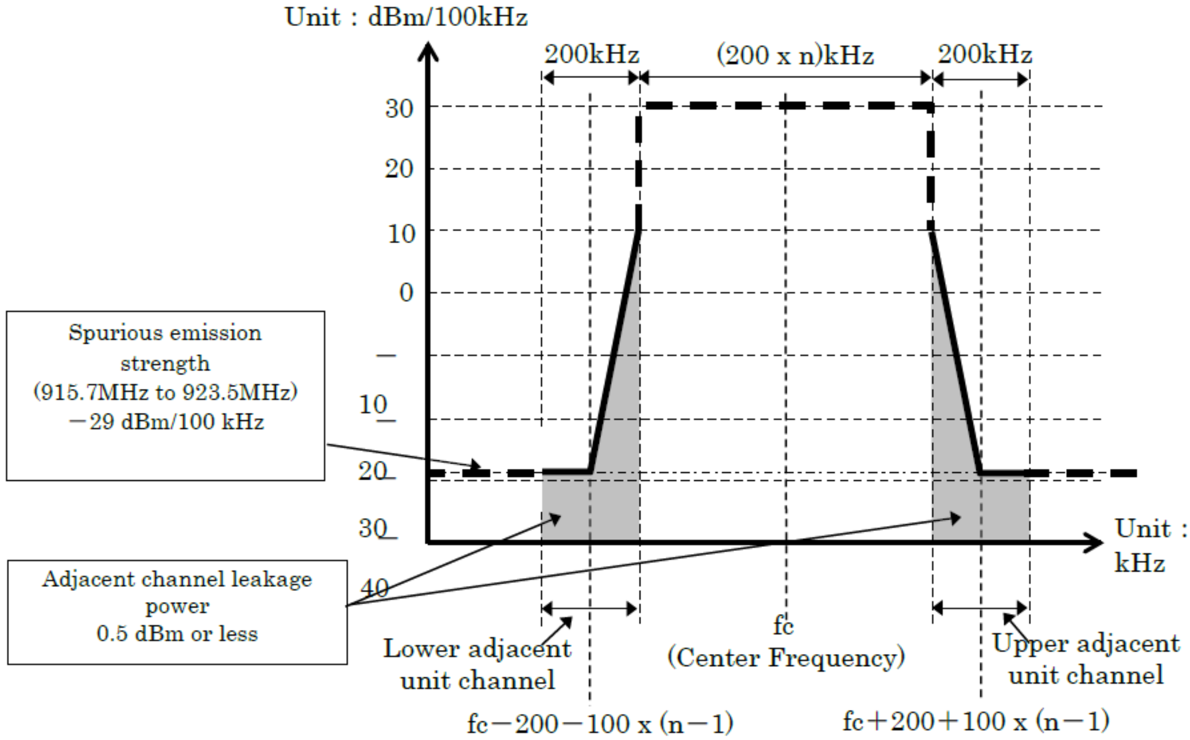


Figure 3: Japan mask requirements

ETSI TS 136 101 [i.3] also specifies the adjacent channel requirement using the average leakage power. This protects other users from interference. In ETSI TS 136 101 [i.3] the power is integrated over the channel BW and is averaged.

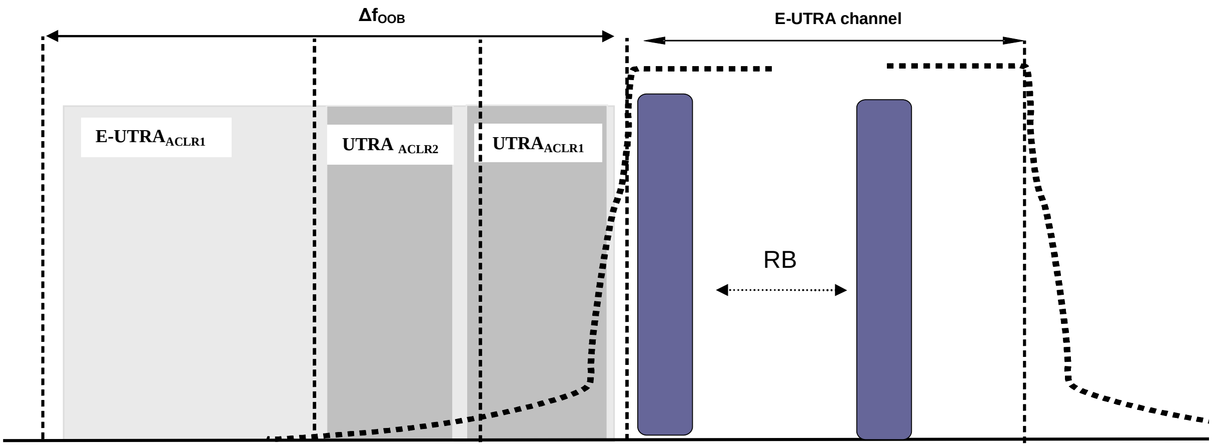


Figure 4: LTE ACLR (power in dBm over frequency)

The requirement for Adjacent Channel Leakage Ratio (ACLR) is -30 dBc in the adjacent channel and is progressively more stringent for frequency channels with higher offsets. Table 1 shows the specified limits at different offsets.

Table 1: LTE ACLR

	Channel bandwidth / E-UTRA$_{ACLR1}$ / measurement bandwidth					
	1,4 MHz	**3,0 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**
E-UTRA$_{ACLR1}$	30 dB	30 dB	30 dB	30 dB	30 dB	30 dB
E-UTRA channel Measurement bandwidth			4,5 MHz	9,0 MHz	13,5 MHz	18 MHz

The same principle applies to RFID technology in the ISO/IEC 18000-63 [i.4] air interface. There are two masks specified based on the reader density in the environment. The more stringent of the two is the dense reader mode mask.

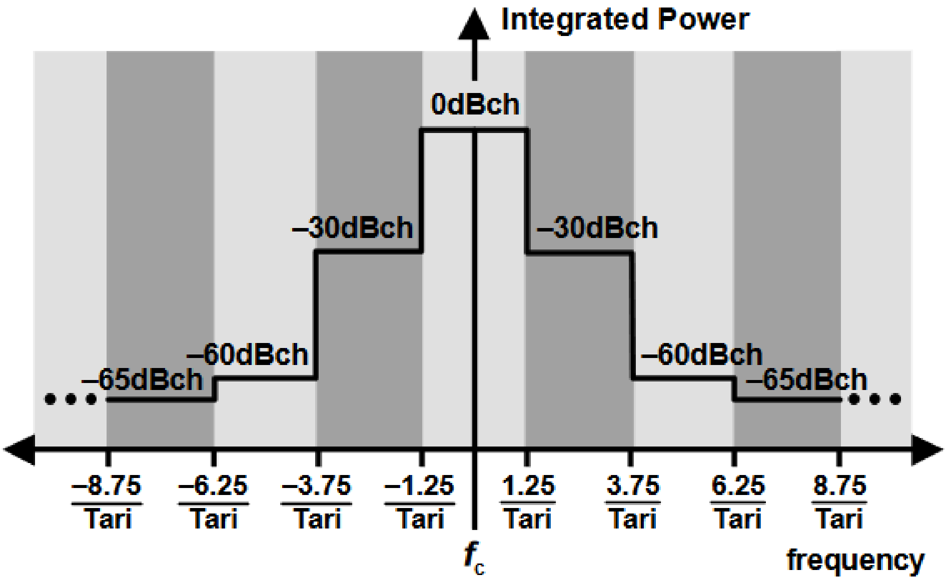


Figure 5: Gen2 Dense Reader Mode (DRM) mask

The similarity of the adjacent channel power to LTE is noteworthy. The methodology used is similar to other standards where the power is integrated over a channel bandwidth.

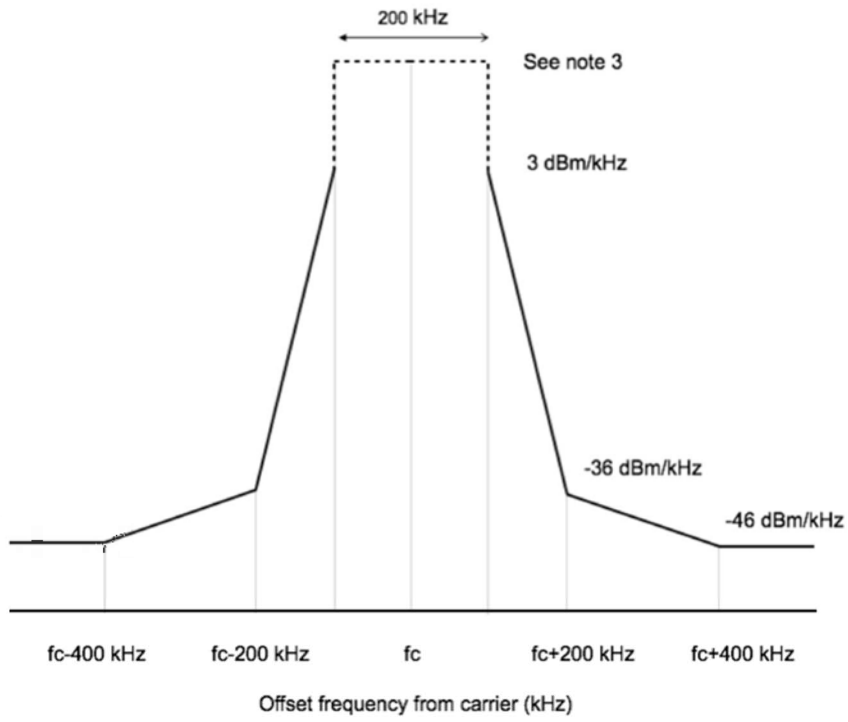
5 Transmitter spectrum mask measurements using modern spectrum analyser devices

5.1 General

Regulatory and industry standards specify the transmit mask in terms of adjacent channel power at different offsets especially in the vicinity of the transmit region. In particular the adjacent channel requirements across regions are integrated over the channel bandwidth and is an average power measurement. A peak hold measurement captures transient responses of very short duration and places undue burden on the DUT with minor effect on the victim receiver. Therefore, it is the proposition of ETSI ERM TG34 to accommodate advancements in measurement techniques using modern spectrum analyser devices and to adopt a transmit mask that measures the adjacent channel power accordingly.

5.2 Current ETSI EN 302 208 mask

Figure 6 shows the spectrum mask for modulated signals in the lower as in ETSI EN 302 208 [i.2] and [i.5].



NOTE 1: Where fc is the centre frequency of the carrier transmitted by the interrogator applicable over the frequency range fc ± 500 kHz.
NOTE 2: All limits are shown with reference to a resolution bandwidth of 1 kHz.
NOTE 3: Measurements in the frequency range fc ± 100 kHz shall be made in accordance with clauses 4.3.3 and 5.5.3.
NOTE 4: This figure considers the spurious emissions limits as of table 2.

Figure 6: Transmitter spectrum mask for the lower band according ETSI EN 302 208 [i.2] and [i.5] Figure 5

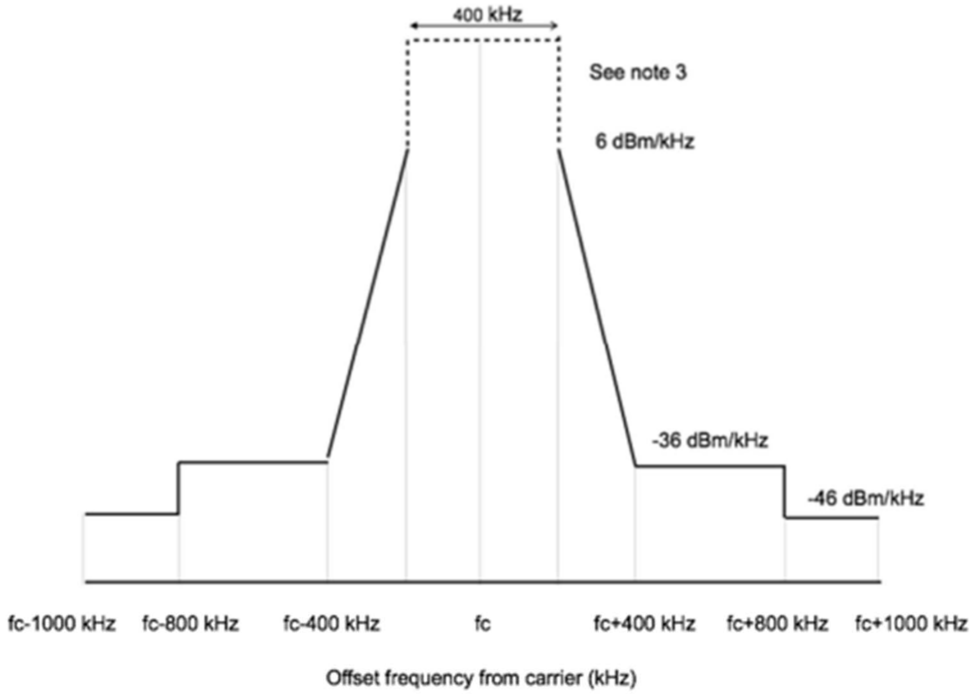
Using the spectrum mask in Figure 6, Annex A derives the equivalent channel power for adjacent channels centred at ±200 kHz and the (alternate) adjacent channels centred at ±400 kHz in the lower band. Table 2 summarizes the results from Annex A for the lower band, and Table 2 specifies the new transmitter spectrum mask limits, which are derived from ETSI EN 302 208 [i.2] and [i.5] as shown in Figure 6.

Table 2: Transmitter spectrum mask for modulated signals in the lower band

Frequency offset	Integration BW	Adjacent channel power (linear)	Adjacent channel power (log)
0 ± 100 kHz	200 kHz	2 000 mW	33 dBm
+200 ± 100 kHz -200 ± 100kHz	200 kHz	23,2 mW	13,7 dBm
+400 ± 100 kHz -400 ± 100kHz	200 kHz	7,2 μW	-21,4 dBm
+600 ± 100 kHz (note 1) -600 ± 100 kHz (note 1)	200 kHz	5,0 μW	-23,0 dBm (note 2)

NOTE 1: This row is for reference only since the offset frequencies are outside of the spectrum mask.
NOTE 2: $-23\ dBm/400kHz = -46\ dBm/kHz + 10 \cdot \log\{200kHz/1kHz\}$.

Figure 7 shows the spectrum mask for modulated signals in the upper band as in ETSI EN 302 208 [i.2] and [i.5].



NOTE 1: Where fc is the centre frequency of the carrier transmitted by the interrogator applicable over the frequency range fc ± 1 000 kHz.
NOTE 2: All limits are shown with reference to a resolution bandwidth of 1 kHz.
NOTE 3: Measurements in the frequency range fc ± 200 kHz shall be made in accordance with clauses 4.3.3 and 5.5.3.
NOTE 4: This figure considers the spurious emissions limits as of table 2.

Figure 7: Transmitter spectrum mask for the upper band according to ETSI EN 302 208 [i.2] and [i.5], Figure 6

Using the spectrum mask in Figure 7, Annex A derives the equivalent channel power for adjacent channels centred at ±400 kHz and the (alternate) adjacent channels centred at ±800 kHz in the upper band. Table 3 summarizes the results from Annex A for the upper band, and Table 3 specifies the new transmitter spectrum mask limits, which are derived from ETSI EN 302 208 [i.2] and [i.5] as shown in Figure 7.

Table 3: Transmitter spectrum mask for modulated signals in the upper band

Frequency offset	Integration BW	Adjacent channel power (linear)	Adjacent channel power (log)
0 kHz	400 kHz	4 000 mW	36 dBm
+400 ± 200 kHz -400 ± 200 kHz	400 kHz	84,4 mW	19,3 dBm
+800 ± 200 kHz -800 ± 200 kHz	400 kHz	55,0 μW	-12,6 dBm
+1200 ± 200 kHz (note 1) -1200 ± 200 kHz (note 1)	400 kHz	10,0 μW	-20,0 dBm (note 2)
NOTE 1: This row is for reference only since the offset frequencies are outside of the spectrum mask. NOTE 2: $-20\ dBm/400kHz = -46\ dBm/kHz\ +\ 10 \cdot \log\{400kHz/1kHz\}$.			

Annex A: Derivation of Adjacent Channel Power from Spectrum Mask

A.1 Adjacent Channel Power in Lower Band

To derive the linear adjacent channel power at $\pm 200\ kHz$ in the lower band, the power from $100\ kHz$ to $300\ kHz$ is integrated in two parts by the offset frequency, f_{off}:

$$Power_{mW}(100\ kHz\ to\ 300\ kHz) = \int_{100\ kHz}^{200\ kHz} PowerA_{mW}(f_{of}) \cdot df_{off} + \int_{200\ kHz}^{300\ kHz} PowerB_{mW}(f_{of}) \cdot df_{off}$$

The spectral mask of Figure 6 is a spectral power density normalized to $1kHz$ bandwidth, and the two linear spectral power density functions, $PowerA_{mW/kHz}(\cdot)$ and $PowerB_{mW/kHz}(\cdot)$, depend on the offset frequency and their logarithmic spectral power density, $PowerA_{dBm/kHz}(\cdot)$ and $PowerB_{dBm/kHz}(\cdot)$, respectively:

$$PowerA_{mW/kHz}(f_{off}) = 10^{PowerA_{dBm/kHz}(f_{off})/10} \cdot mW/kHz$$

and:

$$PowerB_{mW/kHz}(f_{off}) = 10^{PowerB_{dBm/kHz}(f_{off})/10} \cdot mW/kHz$$

From observing Figure 6, the frequency and power boundaries of the logarithmic spectral power density are:

$$PowerA_{dBm/kHz}(f_{of} = 100\ kHz) = 3\ dBm/kHz$$

$$PowerA_{dBm/kHz}(f_{off} = 200\ kHz) = PowerB_{dBm/kHz}(f_{off} = 200\ kHz) = -36\ dBm/kHz$$

$$PowerB_{dBm/kHz}(f_{off} = 300\ kHz) =$$
$$-36\ dBm/kHz - (300\ kHz - 200\ kHz)\frac{-36\ dBm/kHz - 46\ dBm/kHz}{200\ kHz} = -41\ dBm/kHz$$

And as seen in Figure 6, the logarithmic power density is linear between the boundaries, so the two logarithmic power densities are:

$$PowerA_{dBm/kHz}(f_{off}) = 3\ dBm/kHz - (f_{off} - 100\ kHz)\frac{39\ dB/kHz}{100\ kHz}$$

$$PowerB_{dBm/kHz}(f_{off}) = -36\ dBm/kHz - (f_{off} - 200\ kHz)\frac{5\ dB/kHz}{100\ kHz}$$

Since the logarithmic power and linear spectral power densities are in $1\ kHz$ increments, the linear power can be summed in $1\ kHz$ increments to integrate and determine the adjacent channel power:

$$Power_{mW}(100\ kHz\ to\ 300\ kHz) = \sum_{\substack{100\ kHz \\ \text{step } 1\ kHz}}^{200\ kHz} PowerA_{mW}(f_{off}) + \sum_{\substack{200\ kHz \\ \text{step } 1\ kHz}}^{300\ kHz} PowerB_{mW}(f_{off})$$

Substituting the logarithmic power densities and eliminating some of the dimensional units, the linear power of the adjacent channels centred at $\pm 200kHz$ for the lower band is:

$$Power_{mW}(100\ kHz\ to\ 300\ kHz) =$$

$$\sum_{\substack{100\ kHz \\ \text{step } 1\ kHz}}^{200\ kHz} 10\hat{}\left\{\left[3 - 39 \cdot \frac{(f_{off} - 100\ kHz)}{100\ kHz}\right]/10\right\} + \sum_{\substack{200\ kHz \\ \text{step } 1\ kHz}}^{300\ kHz} 10\hat{}\left\{\left[-36 - 5 \cdot \frac{(f_{off} - 200\ kHz)}{100\ kHz}\right]/10\right\}$$

And the logarithmic power of the adjacent channels centred at $\pm 200\ kHz$ for the lower band is:

$$Power_{dBm}(100\ kHz\ to\ 300\ kHz) = 10 \cdot \log_{10}\{Power_{mW}(100\ kHz\ to\ 300\ kHz)\}$$

Using integer frequency indexes to calculate the logarithmic power for adjacent channel power at $\pm 200\ kHz$ in the lower band:

$$Power_{dBm}(100\ kHz\ to\ 300\ kHz) = 10 \cdot \log_{10}\left\{\sum_{0}^{100} 10^{\frac{x_i}{10}} + \sum_{0}^{100} 10^{\frac{y_k}{10}}\right\}$$

where the integer frequency index, i, for the first summation is bounded by $0 \leq i \leq 100$ and relates to the offset frequency $i = f_{off} + 100$, and x_i:

$$x_i = 3 - \frac{39}{100} i$$

and a second integer frequency index, k where $0 \leq k \leq 100$, for the second summation is also bounded by k where $0 \leq k \leq 100$ and relates to the offset frequency $k = f_{off} + 200$, and y_k:

$$y_k = -36 - \frac{5}{100} k$$

And by using the frequencies indexes to compute the adjacent channel power centred at $\pm 200 kHz$ in the lower band, the power is:

$$Power_{dBm}(100\ kHz\ to\ 300\ kHz) = 13{,}7\ dBm$$

In a similar approach, the linear power for adjacent channels centred at $\pm 400\ kHz$ in the lower band is:

$$Power_{mW}(300\ kHz\ to\ 500\ kHz) = \sum_{\substack{300\ kHz \\ \text{step } 1\ kHz}}^{400\ kHz} 10\text{^}\left\{\left[-41 - 5 \cdot \frac{(f_{off} - 300\ kHz)}{100\ kHz}\right]/10\right\} + \sum_{\substack{400\ kHz \\ \text{step } 1\ kHz}}^{500\ kHz} 10\text{^}\{-46/10\}$$

Using one integer frequency index simplifies calculation of the logarithmic power for adjacent channel power at $\pm 400\ kHz$ in the lower band:

$$Power_{dBm}(300\ kHz\ to\ 500\ kHz) = 10 \cdot \log_{10}\left\{\sum_{0}^{100} 10^{\frac{x_i}{10}} + \sum_{0}^{100} 10^{\frac{-46}{10}}\right\}$$

where the integer frequency index, i where $0 \leq i \leq 100$, for the first summation relates to the offset frequency $i = f_{off} + 300$, and x_i:

$$x_i = -41 - \frac{5}{100} i$$

And by using one frequency index to compute the adjacent channel power centred at $\pm 400\ kHz$ in the upper band, the power is:

$$Power_{dBm}(300\ kHz\ to\ 500\ kHz) = -21{,}4\ dBm$$

A.2 Adjacent Channel Power in Upper Band

To derive the linear adjacent channel power at $\pm 400\ kHz$ in the upper band, the power from $200k\ Hz$ to $600\ kHz$ is integrated in two parts by the offset frequency, f_{off}:

$$Power_{mW}(200kHz\ to\ 600kHz) = \int_{200kHz}^{400kHz} PowerA_{mW}(f_{of}) \cdot df_{off} + \int_{400kHz}^{600kHz} PowerB_{mW}(f_{of}) \cdot df_{off}$$

The spectral mask of Figure 7 is a spectral power density normalized to $1kHz$ bandwidth, and the two linear spectral power density functions, $PowerA_{mW/kHz}(\cdot)$ and $PowerB_{mW/kHz}(\cdot)$, depend on the offset frequency and their logarithmic spectral power density, $PowerA_{dBm/kHz}(\cdot)$ and $PowerB_{dBm/kHz}(\cdot)$, respectively:

$$PowerA_{mW/kHz}(f_{off}) = 10^{PowerA_{dBm/kHz}(f_{off})/10} \cdot mW/kHz$$

and:

$$PowerB_{mW/kHz}(f_{off}) = 10^{PowerB_{dBm/kHz}(f_{off})/10} \cdot mW/kHz$$

From observing Figure 7, the frequency and power boundaries of the logarithmic spectral power density are:

$$PowerA_{dBm/kHz}(f_{off} = 200\ kHz) = 6\ dBm/kHz$$

$$PowerA_{dBm/kHz}(f_{of} = 400\ kHz) = PowerB_{dBm/kHz}(f_{of} = 400\ kHz) = -36\ dBm/kHz$$

$$PowerB_{dBm/kHz}(f_{off} = 600\ kHz) = -36\ dBm/kHz$$

And as seen in Figure 7, the logarithmic power density is linear between the boundaries, so the two logarithmic power densities are:

$$PowerA_{dBm/kHz}(f_{off}) = 6\ dBm/kHz - (f_{off} - 200\ kHz)\frac{42\ dB/kHz}{200\ kHz}$$

$$PowerB_{dBm/kHz}(f_{off}) = -36\ dBm/kHz$$

Since the logarithmic power and linear spectral power densities are in $1\ kHz$ increments, the linear power can be summed in $1kHz$ increments to integrate and determine the adjacent channel power:

$$Power_{mW}(100\ kHz\ to\ 300\ kHz) = \sum_{\substack{200\ kHz \\ \text{step } 1\ kHz}}^{400\ kHz} PowerA_{mW}(f_{off}) + \sum_{\substack{400\ kHz \\ \text{step } 1\ kHz}}^{600\ kHz} PowerB_{mW}(f_{off})$$

Substituting the logarithmic power densities and eliminating some of the dimensional units, the linear power of the adjacent channels centred at $\pm 400kHz$ for the upper band is:

$$Power_{mW}(200\ kHz\ to\ 600\ kHz) = \sum_{\substack{200\ kHz \\ \text{step } 1\ kHz}}^{400\ kHz} 10\hat{}\left\{\left[6 - 42 \cdot \frac{(f_{off} - 200\ kHz)}{200\ kHz}\right]/10\right\} + \sum_{\substack{400\ kHz \\ \text{step } 1\ kHz}}^{600\ kHz} 10\hat{}\{-36/10\}$$

And the logarithmic power of the adjacent channels centred at $\pm 400\ kHz$ for the upper band is:

$$Power_{dBm}(200\ kHz\ to\ 600\ kHz) = 10 \cdot \log_{10}\{Power_{mW}(200\ kHz\ to\ 600\ kHz)\}$$

Using integer frequency indexes to calculate the logarithmic power for adjacent channel power at $\pm 200kHz$ in the upper band, in a similar manner to the lower band and using an integer frequency index to simplify calculation of the logarithmic power for adjacent channel power at $\pm 400\ kHz$ in the upper band:

$$Power_{dBm}(200\ kHz\ to\ 600\ kHz) = 10 \cdot \log_{10}\left\{\sum_{0}^{200} 10^{\frac{x_i}{10}} + \sum_{0}^{200} 10^{\frac{-36}{10}}\right\}$$

where the integer frequency index, i where $0 \leq i \leq 200$, for the first summation relates to the offset frequency $i = f_{off} + 200$, and x_i:

$$x_i = 6 - \frac{42}{200}$$

And by using the frequency index to compute the adjacent channel power centred at $\pm 400\ kHz$ in the upper band, the power is:

$$Power_{dBm}(200\ kHz\ to\ 600\ kHz) = 19{,}3\ dBm$$

The logarithmic power for adjacent channel power at $\pm 800\ kHz$ in the upper band is:

$$Power_{dBm}(600\ kHz\ to\ 1\ 000\ kHz) = 10 \cdot \log_{10}\left\{\sum_{0}^{200} 10^{\frac{-36}{10}} + \sum_{0}^{200} 10^{\frac{-46}{10}}\right\}$$

And by calculating the adjacent channel power centred at $\pm 800\ kHz$ in the upper band, the power is:

$$Power_{dBm}(600\ kHz\ to\ 1\ 000\ kHz) = -12{,}6\ dBm$$

Annex B: Bibliography

- GS1® EPC™: "Radio-Frequency Identity Protocols Generation-2 UHF RFID, Specification for RFID Air interface, Protocol for Communications at 860-960 MHz".

Annex C: Change history

Date	Version	Information about changes
2023-05	0.0.1	Initial
2023-09	0.0.2	Early draft
2023-12	0.0.3	Stable draft
2024-04	1.1.1	First published version

History

Document history		
V1.1.1	April 2024	Publication