ECC Recommendation (11)06

Block Edge Mask Compliance Measurements for Base Stations

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INTRODUCTION

Block Edge Masks (BEM) are being developed as a new regulatory approach for the definition of a set of “common and minimal (least restrictive) technical conditions” optimised for, but not limited to, fixed/mobile communications networks. In this regulatory approach BEMs have been set into effect in order to provide a certain level of protection for wireless systems in adjacent frequency blocks and to reduce the necessity for coordination between the operators.

BEMs are not intended to replace or relax limits set in dedicated equipment standards, e.g. limits for spurious emissions. Those measurements are not in the scope of this document.

The purpose of this Recommendation is to provide a common measurement method which will enable CEPT administrations to verify BEM compliance in the field.

ECC RECOMMENDATION OF OCTOBER 2011 ON BLOCK EDGE MASK COMPLIANCE MEASUREMENTS FOR BASE STATIONS

"The European Conference of Postal and Telecommunications Administrations,

considering

a) that Block Edge Masks (BEM) are being developed as a new regulatory approach for the definition of a set of common and least restrictive technical conditions;

b) that in this approach a number of contiguous frequency blocks are assigned to network operators with usually no guard bands in between;

c) that in this approach it is up to the license holder to decide on the size of any internal guard band inside their block, if needed;

d) that Block Edge Masks have been set into effect in order to provide a certain level of protection for wireless systems in adjacent frequency blocks and to reduce the necessity for coordination between the operators;

e) that BEMs are not intended to replace or relax limits set in dedicated equipment standards, e.g. limits for spurious emissions;

f) that this Recommendation is not intended to replace any conformity assessment procedures;

g) that additional specific methods can be added to the Annexes to this Recommendation.

recommends

1. that the measurement principles described in Annex 1 should be used for the assessment of compliance with the provisions of all BEMs;

2. that the specific methods described in subsequent Annexes should be used for the assessment of compliance with the provisions of BEMs when applicable."

ANNEX 1: GENERAL CONSIDERATIONS FOR THE ASSESSMENT OF BLOCK EDGE MASKS

A1.1 INTRODUCTION

Block Edge Masks (BEM) are being developed as a new regulatory approach for the definition of a set of "common and minimal (least restrictive) technical conditions" optimised for, but not limited to, fixed/mobile communications networks. In this approach a number of contiguous frequency blocks are assigned to network operators, with usually no external guard bands in between. No decision is made by the regulatory body on which technology has to be used for the service, which channel bandwidths to be used, and so on. It is even up to the license holder to decide on the size of an optional internal guard band, if needed. This way the maximum freedom is granted the license holder to decide on how to make the best use of the spectrum.

In this regulatory approach Block Edge Masks have been set into effect in order to provide a certain level of protection for wireless systems in adjacent frequency blocks and to reduce the effort for coordination between the operators. BEMs are not intended to replace or relax limits set in dedicated equipment standards, e.g. limits for spurious emissions. Those measurements are not in the scope of this document.

A1.2 TERMS AND DEFINITIONS / LIST OF ABBREVIATIONS

Abbreviation	Explanation
WAPECS	Wireless Access Policy for Electronic Communication Services
EIRP	The Equivalent Isotropically Radiated Power of an antenna is the product of the antenna input power and the antenna gain, referenced to an isotropically radiating antenna, which does exist in theory only
TRP	The Total Radiated Power is used for defining the power limits of terminal stations. TRP is a measure of how much power the antenna actually radiates. The TRP is defined as the integral of the power transmitted in all directions over the entire radiation sphere. For a lossless isotropic antenna EIRP and TRP are equivalent. For a directional antenna EIRP in the direction of the main beam is (by definition) greater than the TRP
PAPR	The Peak-to-Average power ratio of a transmitter is the ratio of the peak value of the output power to its time-averaged value. In some literature this is also referred to as the crest factor.
RBW	In swept analysers the resolution bandwidth is the bandwidth of the measurement filter, usually referenced to the 3 dB points, which is used to sweep across the selected frequency range and to measure the signal power which passes the filter. In FFT analysers the RBW determines the FFT bin size or the smallest frequency step that can be resolved
OoB	In this document this abbreviation is used for the Out-of-Block signal power of a transmitter, i.e. the power density present outside the frequency block assigned to the network operator. It may not be mixed up with the out-of-band power of a transmitter, which describes the output power density outside the necessary bandwidth of an individual transmitter. The frequency range of an out-of-block measurement does not depend on the actual transmit frequency, but only on the edge frequencies of the assigned frequency block
DANL	The Displayed Average Noise Level of an analyser is the level of noise which the analyser will display with its input terminated and depends on the thermal noise of all components involved in the signal processing chain of the analyser. It is the absolute minimum signal power which can be measured under specific ideal conditions. The DANL is usually stated for a 1 Hz bandwidth, no input attenuation, active pre-

	amplifier and maximum amplification in the signal processing chain
OMC	The Operations and Maintenance Centre is the central location of a network operator where all important parameters of a network are supervised.

A1.3 BLOCK EDGE MASKS DEVELOPED IN CEPT DOCUMENTATION

BEMs were developed for the WAPECS bands, e.g. 790-862 MHz [4], 2500-2690 MHz [3, 5] and 3400-3800 MHz [1, 3]. The BEM consists of in-block and out-of-block (OoB) limits depending on frequency offset. The out-of-block component of the BEM consists of a baseline limit as well as transitional (or intermediate) limits, to be applied, where applicable, at the frequency boundary of an individual licensed spectrum block. These limits were derived using studies of appropriate compatibility and sharing scenarios between fixed/mobile communication networks and other applications in adjacent bands but in the same geographical area.

Base station:

The limits are expressed in EIRP or transmitter output power density. The assumed typical values for the antenna gain are 15 dBi for the 800 MHz range and 17 dBi for 2 GHz and 2.6 GHz bands. The in-block limit for FDD is suggested to be in the range up to 56-64 dBm/5MHz (EIRP). For unsynchronized TDD networks or at the transition to the FDD range, a 'restricted TDD block' may be required with significantly smaller in-block power.

Terminal station:

The terminal station may be a mobile, nomadic or fixed station. The power limits are specified as EIRP for fixed terminal stations and as TRP for mobile or nomadic terminal stations, e.g. handhelds. Note that there may be no BEM defined for terminal stations at all, or the limits may refer to the actual channel edge rather than the block edge.

A1.4 MEASUREMENT PRINCIPLE

Basically measuring compliance of a transmitter to a given block edge mask can be compared to measuring a transmitter spectrum mask. The difference is that the transmitter may be actually operating on any system channel within the assigned frequency block. Usually it can be assumed, that the most critical case is a transmitter operating on the lowest or highest system channel within its block. The block edge mask applies to both edges of the assigned frequency block. As usually both edges cannot be measured the same time, in most cases two measurements are necessary.

For the assessment a standard spectrum analyser may be used setting centre frequency and span in such a way, that the relevant frequency span covered by the block edge mask is displayed. The actual transmitter frequency is not relevant here. Usually the RBW is set according to the transmitter's system bandwidth, observing relevant standards, e.g. ETSI EN 302 326-2 [2].

A1.4.1 Reference Level and dynamic range

The assessment of block edge masks usually requires a high dynamic range and high sensitivity. Sensitivity may be increased by (manually) switching off any input attenuator and switching on a preamplifier (internal or external). However, it is very important to avoid any overloading of the analyser, observing especially bandwidth and PAPR of the signal under test (for details see section A.1.5).

A1.4.2 Increasing dynamic range

The usable dynamic range of most modern spectrum analysers is limited to about 70 dB. Often higher dynamic ranges are stated for very small RBWs as a result of increased sensitivity with small filters. But this is true only for discrete spectral components. Most digital techniques (e.g. all QAM derivates) will produce a noise-like continuous spectrum resulting in the above mentioned limited dynamic range.

Most block edge masks require a dynamic range of about 100 dB or more. To increase the dynamic range of the spectrum analyser the in band-transmission of the transmitter under test has to be attenuated. This may be done using a bandpass-filter tuned to the adjacent frequency block or using a bandstop-filter tuned to the actual transmitter in-band signal. The achieved gain in dynamic range depends on stopband attenuation and sharpness of the used filter. The bandwidth of the filter has to be matched to the relevant adjacent block frequency range of the mask or the bandwidth of the in-band signal, respectively.

The received signal is passed through the filter. As the in-block signal is being attenuated the reference level and input attenuation of the analyser can be decreased, thus improving sensitivity and overall dynamic range. Using the input attenuator the transmitter’s signal is levelled in such a way, that the total input power doesn’t overload the analyser and at the same time the displayed signal level stays well above the DANL for all relevant frequencies.

The filtered spectrum is measured and stored in numerical format (e.g. csv format) for post-processing.

In a second step the input signal is being disconnected. A tracking generator is being connected to the filter input. Using a suitable generator level the amplitude response of the filter is measured and again stored for post-processing.

In a third step the analyser input is terminated and DANL is measured and stored.

In post-processing the measured spectrum is corrected by the frequency dependent filter attenuation and plotted along with the block edge mask. Eventually the block edge mask has to be renormalized to the used RBW. The system’s sensitivity may be plotted along with the result.

A1.4.3 Normalisation

The BEM may be defined either channelized for a certain channel bandwidth or contiguous with a certain reference bandwidth.

In case of a channelized BEM the assessment may be done using a receiver with a suitable channel filter bandwidth tuned and stepped to the relevant channels defined, or using an analyser set to a RBW chosen according to [2] and sweeping over the defined channel. The signal power for all spectral components has to be integrated over the channel; i.e. a channel power measurement, as available on most state of the art spectrum analysers. A re-normalization of the BEM is not necessary.

In case of a contiguous BEM the assessment is done using a conventional sweep over the relevant frequency range. However, the BEM may be referenced to a bandwidth not suitable for the measurement; e.g. too broad. In this case the RBW of the analyser is chosen according to [2].

Because of the noise-like spectral density distribution of nowadays digital modulation schemes the measured signal power is reduced according to $10 \bullet \log\left(\frac{BW_{Sig}}{RBW}\right)$; where BW_{Sig} = signal bandwidth and RBW = analysis bandwidth. Therefore the BEM has to be re-normalized as well according to

$$A_X^* = A_X - 10 \bullet \log\left(\frac{BW_{\mathrm{Re}\,f}}{RBW}\right)$$

where A_X^* = amplitude of re-normalized BEM at frequency point X

A_X = amplitude of original BEM at frequency point X

$BW_{\mathrm{Re}\,f}$ = reference bandwidth of the original BEM

RBW = analysis bandwidth.

Note: In the (unlikely) case a transmitter does produce discrete spectral components in its OoB domain, those discrete components may exceed the re-normalized BEM by a factor of

$$10 \bullet \left(\log\left(\frac{BW_{\mathrm{Re}\,f}}{RBW} \right) - \log(N) \right); \text{ where}$$

N= number of discrete spectral lines present within a window of size $BW_{\mathrm{Re}\,f}$.

A1.4.4 Absolute vs. relative defined masks

Block Edge Masks may be defined with absolute power or power density limits or alternatively with power limits relative to the transmitter in-block power. Those masks based on relative limits may be assessed using conducted or radiated measurements. However, the received signal-to-noise ratio has to be higher than the dynamic range introduced by the mask definition. This in turn requires the use of a high-gain antenna, highly sensitive analyser and preamplifier. Also the mobile measurement equipment, which is usually car-based, has to be placed in the direct vicinity of the transmitting antenna and within its main lobe. Although radiated measurements are often desirable, for practical reasons they may often not be possible. Some practical considerations are given in section A1.5.7.

The assessment of block edge masks with absolute power limits should be done using a conducted measurement directly at the transmitter output. Although a radiated measurement is possible in principle it's not recommended, as it will introduce a number of additional uncertainties (e.g. measurement distance). Especially in the case of a BEM based on transmitter output power or output power density for a radiated measurement the knowledge of certain parameters is necessary, which can be acquired only on-site; i.e. feeder loss and antenna gain.

A1.5 PRACTICAL CONSIDERATIONS

The realisation of the measurement principle as described in section A1.4 is relatively straightforward for those systems with non-bursted and constant output power for such block edge masks with constant reference bandwidth and when performing the measurement at the transmitter output. Those systems may be found mainly in broadcasting (unidirectional) radio systems. However, specific characteristics of many mobile communication systems will require special prerequisites, some of which will be detailed in the following sections.

For many systems several of the following aspects will have to be addressed in order to execute a trustworthy measurement. Therefore every block edge mask assessment has to be preceded by a detailed analysis of the signal characteristics of the radio system under test.

A1.5.1 Switchable input attenuator / preamplifier

As described in section A1.4.2 the input attenuator is needed to optimize the input signal level to the analyser's dynamic range. If the dynamic range of the analyser is only a few dB higher than the dynamic range given by the BEM the analyser's internal switchable attenuator may be too coarse (e.g. 10 dB steps). In this case an external switchable attenuator with smaller steps is required.

Especially when doing measurements via the air interface the available signal power may be too low to apply the necessary attenuation; the signal may drop below DANL on some frequencies. In this case a higher gain antenna and/or a low noise preamplifier may be needed. Special care has to be taken that the preamplifier is not being overloaded. This means the drive of the amplifier should stay well below its 1 dB compression point. A high intercept point is needed to avoid intermodulation.

A1.5.2 Bursted signals

Doing a conventional sweep over a bursted signal with RMS detector will result in false readings, as for every sweep point the RMS value is calculated from a number of *on burst* and *off burst* samples. So the reading will be too low depending on the (usually random) ratio of *ON* and *OFF* samples. To overcome this issue one has to make sure, that samples are only taken during active burst times. This can be accomplished using the gated sweep mode, available on most modern spectrum analysers.

In gated sweep mode samples are only taken when the detected input power is above a certain level. The RF detector is usually located directly behind the first filter stage of the analyser, thus isn't affected by the RBW. However, the bandwidth of the first filter often is only slightly broader than the widest RBW of the analyser. As block edge mask measurements may be commenced at a large offset from the actual signal's RF frequency, the trigger might not be fired.

On the other hand on analysers with a special (broad) filter for the RF detector the trigger might be fired erroneously by another transmitter nearby. In this case an external selective trigger source tuned to the transmitter's frequency is needed.

The trigger source might be a second analyser in zero span modes. The analyser is tuned to the actual centre frequency of the transmitter under test, choosing an appropriate RBW. The Sweep time is set according to the burst duration. The video trigger is used to stabilize the display and has to reliably trigger on the bursts only.

The trigger output is being fed to the trigger input of the measuring analyser and used as external trigger for the gated trigger mode. Now the block edge mask can be reliably assessed in the relevant frequency range as described in section A1.4.

A1.5.3 Signals with PAPR > 0 dB

Most wireless systems employ modulation schemes, which not only use phase but also amplitude modulation (e.g. all QAM derivates). The resulting transmitter output signal has a PAPR > 0 dB (see definition in section A1.2), the actual value of which depending on the actual data sequence being sent. As the peak power of such signals can be much higher than the RMS power there is the risk of overloading the analyser's input without noticing it. Reference level and input attenuation have to be set according to the peak power, not the usually stated RMS power of the transmitter. The same applies to a preamplifier being used for measurements via the air interface. The received peak power has to stay well below the input 1 dB compression point of the amplifier.

In case the modulation bit patterns are not statistically even distributed over time the PAPR may vary during bursts or from burst to burst, adversely affecting the measurement. In this case the relevant standards may define special test models and one may have to activate the test model for the highest PAPR. This of course requires cooperation of the network operator and is accompanied with a service interruption, which may pose an additional threat in implementing the measurement.

A1.5.4 Power Reference

Some telecommunication systems transmit a fixed bit pattern in a certain part of a burst (e.g. a preamble) at the beginning of every burst. This part of the burst usually has a fixed and often the highest output power within the burst. The standard may define this part as the power reference, instead of the RMS power averaged over the complete burst. On those systems it is necessary to limit the BEM measurement to the preamble part of the burst.

A1.5.5 Power Control

In CDMA based systems the actual output power varies with the number of active code channels. The usage of code channels is highly dynamic. As the output power density spectrum in the out of band domain usually can be assumed to be dependent of the actual transmitter's drive, the BEM of a CDMA transmitter cannot be assessed in normal operating mode of the transmitter under test. Again a special test mode (referred to as test models in various standards) has to be activated to achieve a maximum and constant output power.

OFDM systems on the other hand may use sub-channelizing (OFDMA). With this mode of operation groups of OFDM subcarriers may be assigned dynamically to a dedicated client and switched off completely when not needed. Power control may also be applied individually to groups of subcarriers, again resulting in a highly dynamic non-constant below maximum output power of the transmitter. One has to check whether the technology used by the transmitter under test uses some kind of preamble with all OFDM carriers switched to maximum power. This preamble may be used for the assessment. Otherwise a suitable test signal or test mode has to be activated in the transmitter to assess the BEM.

A1.5.6 Assessing customer (client) equipment

Most BEMs are defined for base stations. However, if a BEM is defined also for the terminal equipment, they have to be assessed, too. Unlike base station equipment the terminals usually do not output any signal until a valid base station signal is received. During assembly and test the manufacturer uses a special test interface to put the transmitter in a test mode for rapidly testing the transmitter. However, this interface is usually not available after final assembly. Therefore a valid base station signal has to be made available to the terminal equipment so that it starts transmitting.

This may be done using a signal generator with programmable IQ modulator. But with most telecommunication standards a sophisticated terminal tester will be necessary, which is able to communicate bi-directionally with the terminal. Those testers are rarely available at radio monitoring services and are expensive. Therefore it might be easier to test the terminal in a real network.

A directional coupler may be connected between antenna and terminal equipment to access the transmit signal without interrupting the RF conversation between base station and terminal equipment.

However, as today's radio interfaces are often highly dynamic (frequency, power, modulation schemes and so on), in-depth knowledge of the respective radio interface is necessary in order to achieve stable and defined conditions. To give an example: In order to rule out power control of the terminal equipment one may connect a switchable attenuator between antenna and transmitter and drive the radio connection to the lowest possible level resulting in base station and terminal station both using the highest available transmit power.

A1.5.7 Radiated measurements

When performing radiated measurements the most critical part is to get enough field strength for the measurement. Furthermore in the case of BEMs with absolute (power) limits one has to ensure to precisely measure the *correct* field strength. To accomplish this it is important to position the receiving antenna within the main beam of the transmit antenna in respect to azimuth, elevation, geographical position, antenna height and polarisation. Note that many terrestrial mobile communications networks use 45° polarisation. Satellite links often use circular polarisation.

The distance to the transmit antenna should be smaller than the distance at which the transmit antenna beam will touch ground and thereby free-space propagation can also be assumed. This will eliminate uncertainties introduced by ground reflections. Furthermore it is necessary to avoid any reflections caused by nearby buildings, trees or anything alike. Such reflections may cause frequency-selective distortion. Check the received signal using a spectrum analyser for any distortion.

On the other hand the distance must be sufficient to ensure far-field conditions. For transmit antennas with apertures being large compared to the wavelength, the far-field region is commonly taken to exist at distances greater than

$$d \geq \frac{2D^2}{\lambda}$$

where d = distance from transmit antenna
D = largest dimension (aperture) of the transmit antenna
λ = wavelength

Special care has to be taken to avoid overloading the analyser by strong nearby transmitters. Even when using a highly directive receiving antenna the analyser may be overloaded by other transmitters, which may be located on or near the building of the base station under test. Therefore a pre-measurement over a wide frequency range should be performed. A band pass filter may be used to improve the strong signal immunity of the measurement setup.

A1.5.8 Uncertainty in BEM Measurement

As with all kinds of measurement the assessment of block edge masks is subject to a number of uncertainties, which have to be taken into account. Uncertainties include but are not limited to level uncertainty of the analyser / receiver, uncertainties in cable loss and filter amplitude response.

Administrations implementing this recommendation should evaluate and express uncertainties of their individual measurement equipment according to the general rules established by JCGM 100:2008 [7] or ETSI TR 100 028-1 and TR 100 028-2: “Uncertainties in the measurement of mobile radio equipment characteristics” (Parts 1 and 2) [8].

ANNEX 2: ASSESSMENT OF THE BLOCK EDGE MASK FOR BROADBAND WIRELESS ACCESS (BWA) CENTRAL STATIONS (CS) WITHIN THE FREQUENCY BAND 3400-3800 MHZ USING IEEE 802.16 TRANSMITTERS

A2.1 INTRODUCTION

This supplement describes the assessment of block edge masks for BWA CS transmitters within the frequency band 3400-3800 MHz and operating in accordance to standard IEEE 802.16 [6] using the Wireless MAN-OFDM or Wireless MAN-OFDMA air interfaces.

Those interfaces are based on OFDM modulation and designed for NLOS operation in frequency bands below 11 GHz. Supported modulations of the OFDM subcarriers includes BPSK, QPSK, and QAM. Channel bandwidths can be chosen flexibly between 1.25 MHz and the allocated block size by the operator. FDD and TDD duplexing is allowed.

The transmission has a burst structure with modulation scheme, power and number of active OFDM carriers being variable, even within a single burst.

A2.2 BLOCK EDGE MASK FOR CENTRAL STATIONS

ECC/REC/(04)05 [1] defines the relevant technical conditions for central stations (CS). Those conditions include a maximum in-block EIRP spectral density of 53 dBm/MHz. It is assumed that the total transmitter output power does not exceed 43 dBm. The actual CS EIRP spectral density limit may be adjusted by administrations.

The out-of-block emissions of a CS are limited by the BEM.

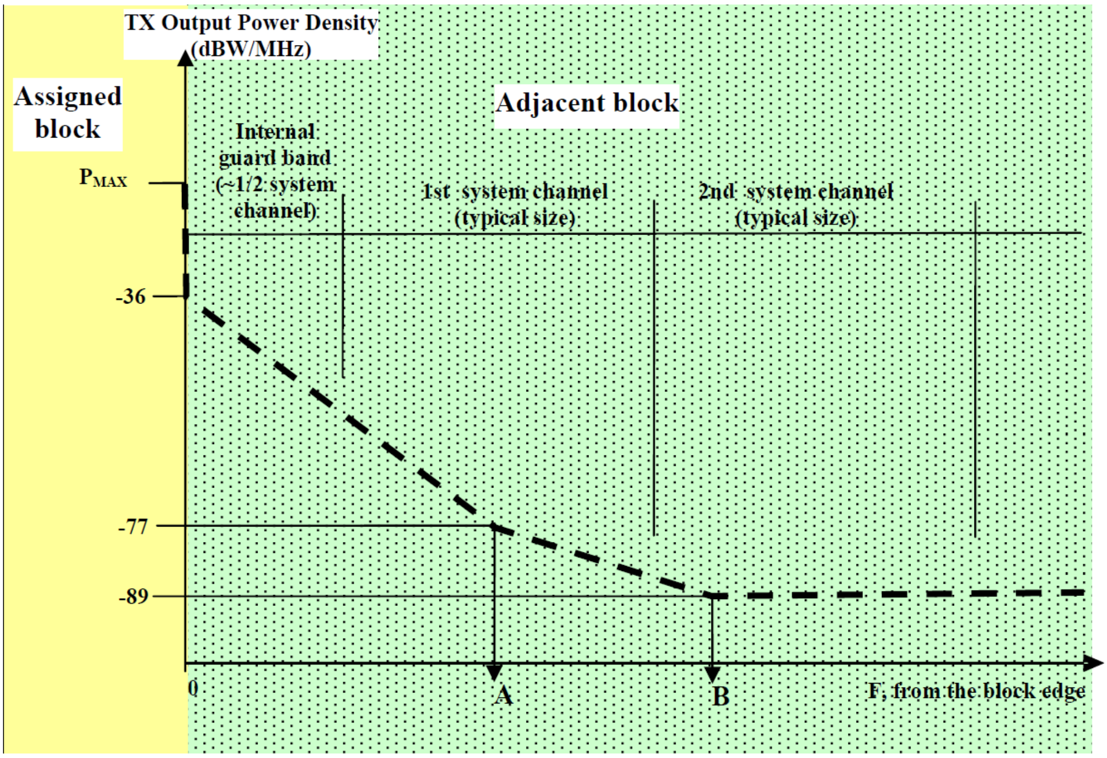

Figure 1: CS BEM as of ECC Rec. (04)05

The BEM consists of three sections: The baseline level is -59 dBm/MHz and is valid for frequencies being away from the block edge more than 35% of the size of the assigned block (point B). The two inner sections realize the transition from the in-block limit to the baseline level. The first section of the BEM starts at -6 dBm/MHz and linearly decreases to -47 dBm/MHz at point A, which is away from the block edge 20% of the size of the assigned block. In section 2 (frequencies between points A and B) the limit decreases from -47 dBm/MHz to the baseline level.

Example for an assigned block size of 21 MHz:

- Point A is at block edge ± 4.2 MHz, resulting in a gradient in section 1 of -9.76 dBm/MHz;
- Point B is at block edge ± 7.35 MHz, resulting in a gradient in section 2 of -3.8 dBm/MHz.

Note that the BEM is defined in absolute transmitter output power density and does not depend on actual transmitter output power.

A2.3 PREREQUISITES

It is recommended to perform a conducted measurement at the transmitter output port. This avoids any additional measurement uncertainty resulting from uncertainties in CS antenna gain, feeder loss and free space loss.

Based on a maximum transmitter output power of 43 dBm and a baseline level of -59 dBm/MHz the necessary dynamic range of the measurement equipment is > 102 dB. As the assessment of the BEM cannot be performed using the normalization bandwidth of 1 MHz, the BEM has to be re-normalized to a narrower measurement bandwidth (RBW). This again increases the necessary dynamic range by a factor of 1/RBW; where RBW is given in MHz. As the needed dynamic range is far above the dynamic range offered by state of the art spectrum analysers, the dynamic range of the measurement equipment has to be increased using the method described in section A1.4.2.

As the CS antenna has to be disconnected for the measurement, care has to be taken to correctly terminate the CS transmitter. As the CS will be transmitting into the stop band of the filter, it will not present the correct impedance to the transmitter. Two alternatives are recommended:

1. Connection of a directional coupler in-line between transmitter output and antenna. The coupling factor should be in the range of 20 … 30 dB. The measuring setup will be connected to the coupled port.
2. Connection of a 20 … 30 dB power attenuator between transmitter output and input of the measurement setup (the filter).

The coupling factor or attenuation may be matched to the stopband attenuation of the used filter for optimized measuring sensitivity.

With either alternative the transmit power level will be reduced to a level suitable for the measurement setup while providing adequate impedance matching to the CS transmitter output. Alternative 1 has the additional benefit that the antenna can be left connected during the measurement and service interruptions are reduced to a minimum. Note that the sensitivity of the measuring setup will be degraded by the amount of in-line attenuation.

An IEEE 802.16-2009 [6] frame (which is one RF burst to be measured) always starts with a preamble, followed by a frame control header (FCH) and a number of data bursts. The data bursts may use BPSK, QPSK, 16-QAM or 64-QAM, each with code rate ½ or ¾. The FCH is always transmitted using BPSK-½ and the preamble uses a fixed constellation pattern. Because of this frame structure the output power is not constant within a frame, especially when using QAM. Additionally the preamble is power boosted by 3 dB to improve synchronization. As a result the preamble is the part of the frame with the highest and constant RMS power.

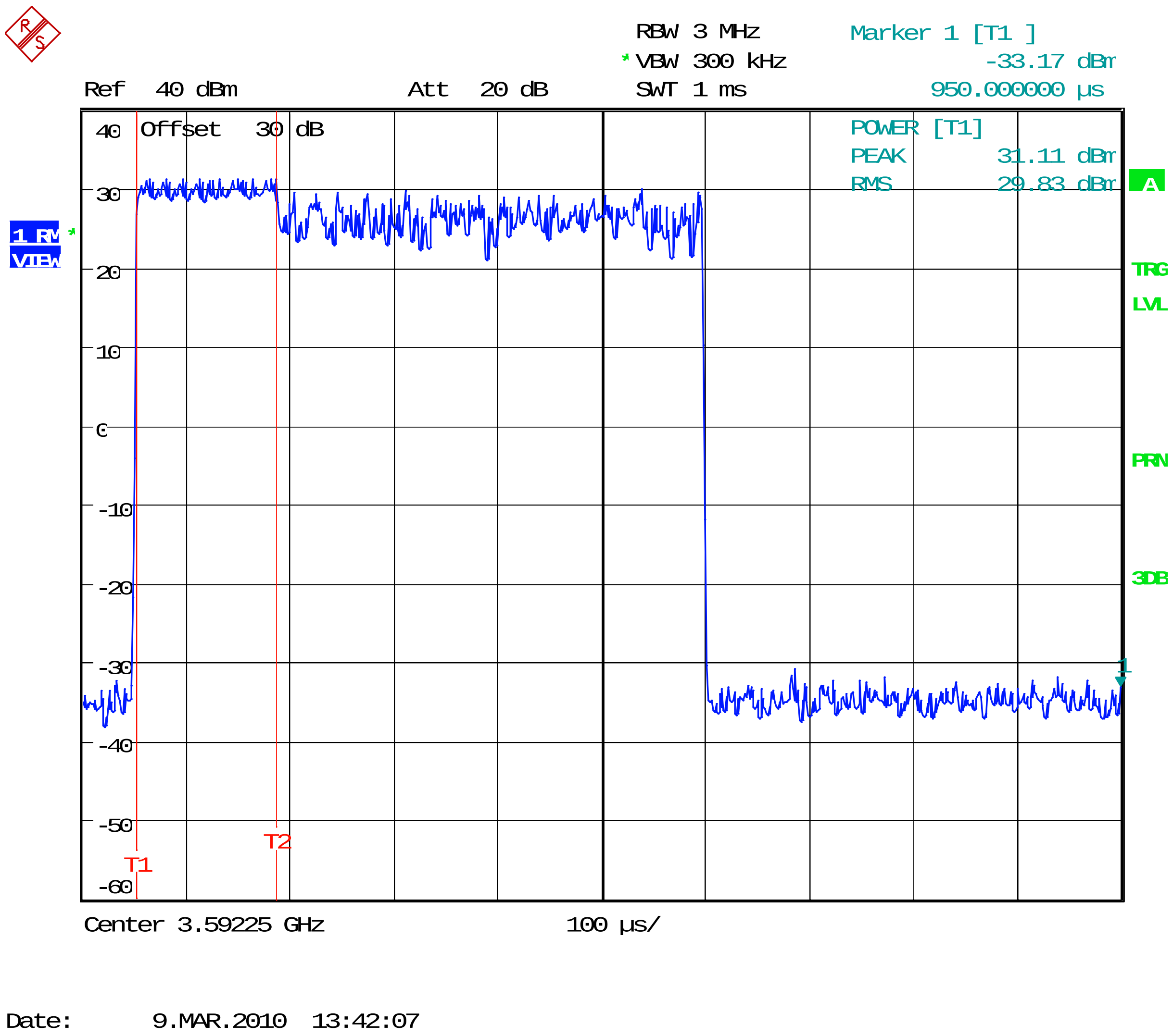

Figure 2: RF burst of IEEE 802.16 CS [6]

These characteristics make it necessary to limit the gate open time of the gated trigger to *start of frame* (plus settling time of the resolution filter) until *end of preamble*. The preamble always has the length of two OFDM symbols and can be calculated from the OFDM symbol parameters as stated in [6], section A2.1

More easily the preamble length can be derived by displaying one RF burst in zero span modes as shown in the Figure above. The preamble now can easily be distinguished from the data part by the 3 dB power boost and the low PAPR. It has been marked with T1 and T2 in the example.

A2.4 MEASUREMENT SETUP

The following equipment is needed for the conducted measurement:

- **Power attenuator** or **(uni-) directional coupler:** Needed to terminate the transmitter output and to reduce the power level to a value which can safely be handled by the filter. The attenuation or coupling ratio should be at least 10 dB, usually 20 … 30 dB is useful.
- **Bandpass or bandstop filter:** Needed to suppress the main transmitter signal while bypassing the OoB domain. The needed attenuation depends on the used analyser and is usually about 40 dB on the transmitter's frequency and should be much less than 10 dB in the assessed frequency range. The resulting steepness can become quite large, especially with transmitters operating near an edge of the assigned frequency block. The attenuated in-block transmission has to be strong enough for the gated trigger to reliably work! Therefore a bandstop filter is preferably used.

- **Spectrum Analyser:** A model with high dynamic range, good sensitivity, RMS detection and gated sweep capability is needed. Usually an analyser with a DANL <-150 dBm/MHz is adequate. Depending on the available (bandpass or bandstop) filter and the margin in sensitivity a switchable input attenuator with step size ≤5 dB is desirable.
- **Signal Generator:** Needed to measure the amplitude response of the filter. It may be built into the analyser or external, but has to be tracked by the analyser.
- **Computer:** Used for post-processing of the data and result display. Additionally the computer may be used for automation of the procedure.

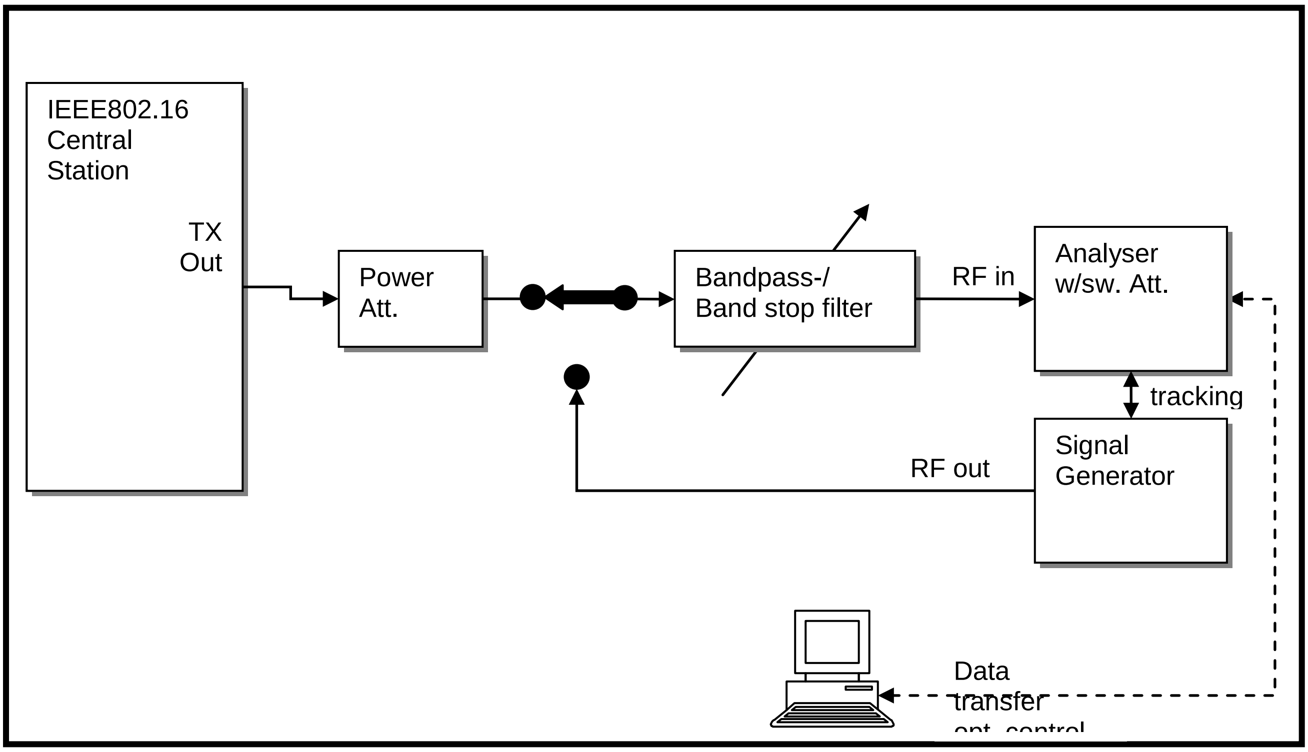

Figure 3: Example of a typical conducted measurement setup

A2.5 MEASUREMENT PROCEDURE

As the measurement is performed at the transmitter output, cooperation of the network operator is necessary. After shutting down the transmitter (locally or via the operator’s Operations Management Centre) the power attenuator (see section A2.3) is connected to the transmitter output and the transmitter is powered up again.

It is recommended to start with some initial measurements to register the actual transmitter frequency, bandwidth, power, framing and compare those parameters to the technical standard for which the transmitter was claimed to comply with.

To accomplish this analyser is connected to the output of the power attenuator (without the bandpass filter for now). Observe the considerations given in section A1.5.

The analyser should be set to RMS detection and the reference level be adjusted to the input power. One might also want to enter the level offset of the power attenuator to get true level readings for the transmitter output.

Now is a good point to switch to zero span mode and find out the parameters for the gated sweep, i.e. gate offset, gate length and IF trigger power level. Remember to set RBW according to the signal bandwidth.

Afterwards switch back to spectrum display and choose the RBW according to the precautions given in section A1.4.3, e.g. 100 kHz. Activate gated sweep using the parameters registered in zero span. One should now see the RMS transmitter output spectrum for the preamble. An example is given in Figure 4:

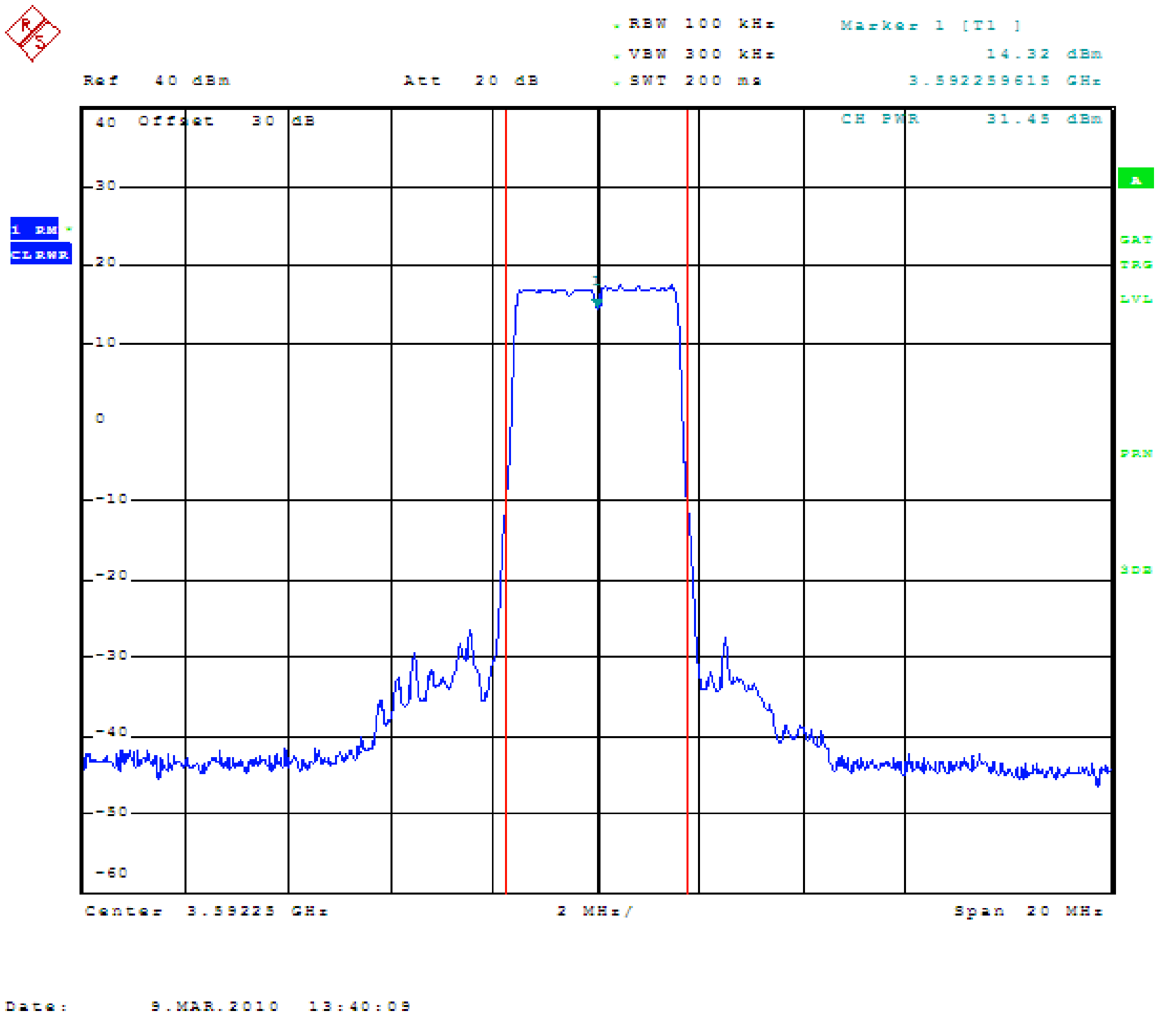

Figure 4: Typical CS output spectrum

Now the filter is connected in-line as shown in the above Figure and tuned in such a way that the transmitter's in-block transmission is sufficiently suppressed while maintaining minimal attenuation in the OoB domain. It might be favourable to prealign the filter using the tracking generator.

The reference level can now be reduced by the amount of achieved extra attenuation. If the filter is sufficiently steep one should now be able to achieve the maximum sensitivity of the analyser. It may be necessary to readjust the IF power level of the gated trigger.

Now Start and Stop frequency can be set to the desired OoB frequencies. When measuring the lower BEM the Stop frequency equals the assigned block edge frequency; for the upper BEM it's the Start frequency. The Span should be chosen adequately for the block size; e.g. 20 MHz for an assigned block size of 21 MHz. Now the BEM measurement is finally accomplished using the method as explained in section A1.4.2.

An example BEM measurement is shown in the Figure below.

The raw data have to be compensated for the filter response and the power attenuator or coupling ratio of the directional coupler (if not taken into account as *Level Offset*). The results are plotted along with the (re-normalised) BEM.

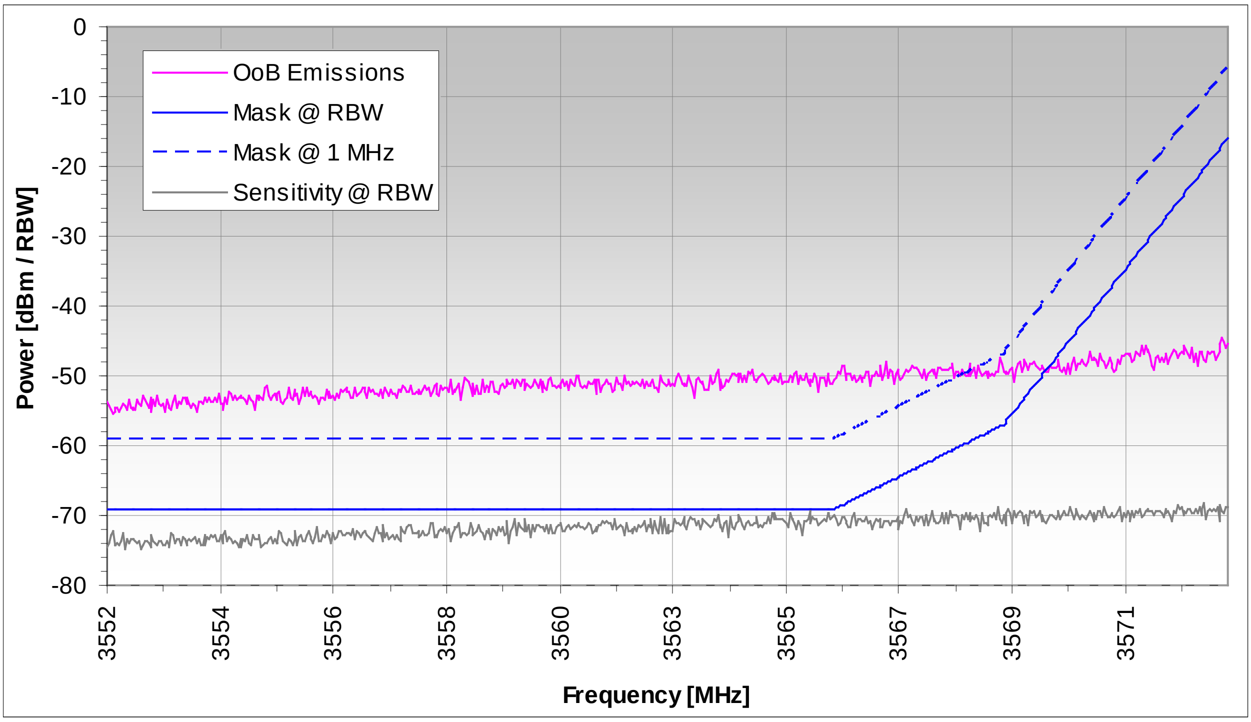

Figure 5: Example of measurement of OoB emissions of a CS

The diagram above shows the OoB emission of the transmitter (in purple), the re-normalized BEM in blue ("Mask @ RBW"), the original BEM ("Mask @ 1 MHz") referenced to 1 MHz as a blue dashed line and the system sensitivity in grey. The original BEM is only needed in case the OoB emission includes single discrete spectral components (see section A1.4.3). In the above example only the re-normalized BEM is relevant for the assessment. The assigned block for the transmitter under test is 3573 … 3594 MHz and the assessment were done in the lower adjacent block. The centre frequency of the wanted emission was 3592.25 MHz.

The measurement was made at a central station of a live IEEE 802.16-2009 [6] network referenced to the BEM as defined in ECC/REC/(04)05 [1].

A2.6 SPECIAL RECOMMENDATIONS REGARDING SYSTEM SENSITIVITY

The sensitivity is a key parameter of every spectrum analyser and is usually stated as DANL. However, the sensitivity will be degraded by the selected resolution bandwidth, the power attenuator or the directive coupler, the unwanted passband attention of the filter, the analyser's switchable attenuator (if needed) and the amplification of its internal signal chain; the latter one being depended of the reference level setting. This is why the analyser has to have a low DANL, although the rather relaxed limits of the BEM itself don't call for high sensitivity on the first view.

To give an example assumes an analyser with a DANL of **-155 dBm/Hz**. This value will be degraded as follows:

+50 dB	RBW = 100 kHz
+30 dB	power attenuator at transmitter output
+ 4 dB	passband attenuation of used band stop filter, frequency-dependend

———

-71 dBm.

The example measurement setup will end up with an effective system sensitivity of **-71 dBm**, which is barely good enough for the given BEM. Things will get even worse, if the analyser isn't operated with its maximum internal amplification. The amplification will be reduced on most analysers with reference levels above about -30 dBm (critical reference level). So a bandpass filter has to be selected that allows the reference level be kept on or below the critical reference level.

Additionally in the example above a "bad" filter with broad and flat amplitude response was used. This filter was just good enough, because the actual transmitter's frequency was sufficiently far away from the block edge.

Therefore it is important to plot the effective system sensitivity along with the measurement result to ensure the system sensitivity was sufficient. The raw data for the system sensitivity have to undergo the same compensation as the measurement data itself. As can be seen in Figure 5: the most critical point in respect to system sensitivity is the frequency with the lowest offset to the block edge, where the mask reaches the baseline level; i.e. point B in BEM definition see Figure 1:.

ANNEX 3: LIST OF REFERENCE

This annex contains the list of relevant reference documents.

[1] ECC/REC/(04)05: Guidelines for Accommodation and Assignment of Multipoint Fixed Wireless Systems in frequency bands 3.4-3.6 GHz and 3.6-3.8 GHz
[2] ETSI EN 302 326-2: Fixed Radio Systems; Multipoint Equipment and Antennas; Part 2: Harmonized EN covering the essential requirements of article 3.2 of the R&TTE directive for digital multipoint radio equipment
[3] CEPT Report 19: Report from CEPT to the European Commission in response to the Mandate to develop least restrictive technical conditions for frequency bands addressed in the context of WAPECS
[4] CEPT Report 30: Report from CEPT to the European Commission in response to the Mandate on "The identification of common and minimal (least restrictive) technical conditions for 790 - 862 MHz for the digital dividend in the European Union"
[5] ECC Report 131: Derivation of a block edge mask (BEM) for terminal stations in the 2.6 GHz frequency band (2500-2690 MHz)
[6] IEEE 802.16-2009: IEEE Standard for Local and metropolitan area networks
Part 16: Air Interface for Broadband Wireless Access Systems
[7] JCGM 100:2008: Evaluation of measurement data - Guide to the expression of uncertainty in measurement.
[8] ETSI TR 100 028-1 and TR 100 028-2: Electromagnetic and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics (Parts 1 and 2).