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Company / organisation	UIC ERTMS/GSM-R OPERATORS GROUP	
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GSM-R RF filter requirements

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EVOLUTION SHEET

Version	Date	Modification
0.1	04-04-2014	Initial draft
0.2	14-05-2014	Update on filter slope and texts
0.3	03-06-2014	Update after discussion at UIC FWG meeting May 19-20.
0.4	10-9-2014	Measurement results updated and minimum filtering response explained
0.5	18-11-2014	Editorial changes
0.6	27-11-2014	UIC document number added
0.7	17-04-2015	Inclusion of review comments UIC FMG
0.8	06-08-2015	Final Drafting
0.9	22-10-2015	OG#58 comments
0.10	09-11-2015	FMG#24 review
0.11	18-11-2015	Change of front page format and footnote correcting clerical errors. Review by DS and RS.
0.12	19-11-2015	Remarks from DM
1.0.1	26-11-2015	Final draft for ERIG endorsement
1.0	26-11-2015	Final document

TABLE OF CONTENTS

1 Introduction

Due to the evolution of public land mobile network (PLMN) technologies, GSM-R radios in Europe will have to operate correctly in the presence of GSM, UMTS and LTE signals in the adjacent 900MHz frequency band. It has been demonstrated that the introduction of UMTS or LTE in the 900MHz band will increase the level of interference on GSM-R receivers, see e.g. ECC FM(13)134r1 Compatibility measurements GSM/UMTS/LTE vs. GSM-R.

The UIC recognized that, in order to coexist with such PLMNs, the performance of the GSM-R radios (Cab Radios, EDORs and handhelds) needs to be improved. To address this, the UIC has created Report O-8736 that defines the Radio Frequency (RF) environment in which these radios must operate, with full performance. UIC Report O-8736 was also the basis for further work in ETSI RT specifying the improved receiver standard ETSI TS 102 933 V2.1.1.

The purpose of this Document O-8760 is to specify the minimum performance of external filters that may be used together with existing GSM-R cab radios or EDORs, in order to meet EIRENE requirements in the presence of an RF environment as defined in the O-8736.

The present document only addresses the minimum filter response requirements. For other technical requirements please refer to the actual EIRENE FRS and SRS versions.

2 Radio Frequency performance

In order to reduce the impact of strong GSM, UMTS or LTE signals from public networks entering the receiver chain of a GSM-R Cab Radio or an EDOR, resulting potentially in blocking/intermodulation effect and leading to dropped calls, a minimum filter characteristic has been identified. This filter characteristics will allow improving the behaviour of all currently deployed types of GSM-R Cab Radios and EDORs that comply with the ETSI TS 145 005 (all versions) or ETSI TS 102 933 versions prior to v1.3.1 to the level defined in UIC Report O-8736.

Although the interference resistance of different GSM-R receiver brands and types will vary, it is thought to be cost effective to define only one type of filter. Furthermore, such differences most probably are of such a limited nature that the impact on the necessary filtering performance can be regarded as negligible.

The filter characteristics defined in section 2.1 below have been based on the following assumptions:

- Measurements (e.g. Ref 2) have demonstrated that LTE 5 MHz signals create a slightly higher interference level than UMTS 5MHz signals;
- CEPT report 41 defined the lowest centre frequency for a 5 MHz LTE carrier to be at 927,6 MHz

2.1 Filter characteristics

The RF filter shall meet the performance requirements stated in table 1. This filter selectivity curve is based on the E-UIC frequency band (uplink 873-880 MHz, downlink 918-925 MHz).

Frequency range (MHz)	Attenuation (dB)	Return Loss (dB rel. 50 ohms)
873.0 – 880,0	≤ 2.0	>15
918,0 – 924,8	≤ 2.0	>15
924.9	≤ 3.0	>12
925.4	≥ 15	Not applicable
926,0 – 960,0	≥ 30	Not applicable

Table 1 – Filter characteristics

3 Methodology for definition of the minimum filter response

The German regulatory authority BNetzA (Bundesnetzagentur) has performed measurements in August 2014 [Annex 7 of Ref 1: ECC FM(13)134r1 Compatibility measurements GSM/UMTS/LTE vs. GSM-R.] that combined a typical current generation GSM-R radio module with a prototype band rejection filter, which was developed to keep the filter as simple as possible.

These measurements demonstrated that this prototype filter gave almost the required performance value derived from the UIC Report 0-8736. UIC Report 0-8736 defines that a cab radio or EDOR should tolerate a level of -10 dBm for an LTE signal of 5 MHz bandwidth when referred to the train rooftop antenna.

In the ETSI work for TS 102 933 V2.1.1 this level was interpreted to mean that improved GSM-R cab radio modules shall tolerate an LTE signal of 5 MHz bandwidth at a level of -13 dBm at the radio module connector, when the LTE carrier center frequency is at 927,6 MHz

The Bundesnetzagentur measurements showed that the blocking performance of a GSM-R radio module plus the prototype filter was significantly improved. The combination was capable of handling an LTE signal of 5 MHz bandwidth of -14 dBm, i.e. only 1 dB lower than the defined performance.

4 Minimum Filter response requirements

From these measurement results, the UIC minimum filtering response requirement has been identified as described below.

Figure 1 shows the following:

- The red line is the filtering response of the prototype filter;
- The blue line is the spectrum of a 5MHz LTE signal at a center frequency of 927,6 MHz The total power of this signal is -13 dBm and at the picture shows power levels measured in 10 kHz resolution bandwidth;
- The green line shows the remaining interfering power level after filtering. The level of this can be calculated by integration over its nominal bandwidth and the resulting total power is -33,6 dBm.

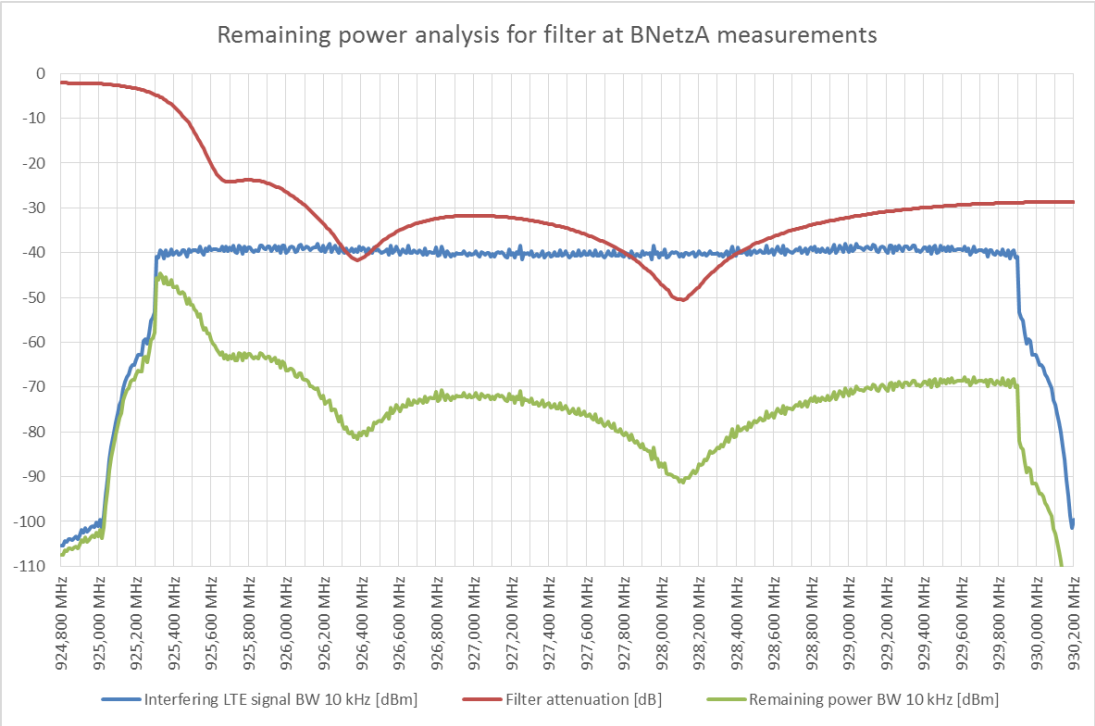

Figure 1. Remaining power analysis for BNetzA measurements where integrated remaining power is -33,6 dBm (green line)

The following analysis calculates the remaining power using the minimum filtering response as defined in chapter 4 above. The total remaining power can be calculated following the same approach as with figure 1 above, and the result is -37,9 dBm.

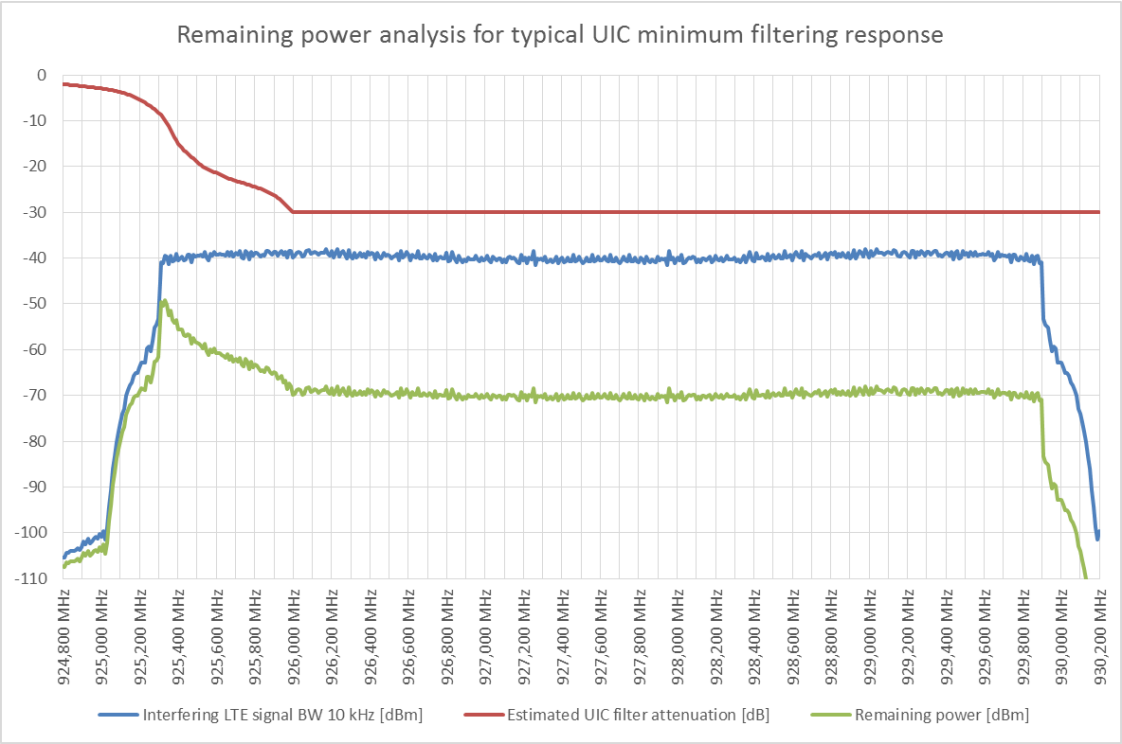

Figure 2. Remaining power analysis for minimum filtering response where integrated remaining power is -37,9 dBm (green line)

From the results as above we can see that with the UIC recommended minimum filtering response the remaining power is 4,3 dB lower (i.e. better) than the measured performance using the prototype filter, which was 1 dB lower than the defined performance. With this 4.3 dB improvement, it can be assumed that interference sensitive radio modules are able to achieve the performance level defined in UIC Report O-8736 (5MHz LTE at level -13 dBm at connector of GSM-R radio module).

5 References

Ref	Name	Source	Date
1	ECC FM(13)134r1 Compatibility measurements GSM/UMTS/LTE vs. GSM-R	Bundesnetzagentur	23 September 2013, revision 1 of 27 October 2014
2	UIC O-8736, version 1.0	UIC	March 2014
3	ETSI TS 102 933 V2.1.1	ETSI	23-06-2015
4	EIRENE FRS v7.4.0	UIC	27-04-2014
5	EIRENE SRS v15.4.0	UIC	31-03-2014
6	CEPT Report 41 Compatibility between LTE and WiMAX operating within the bands 880-915 MHz / 925-960 MHz and 1710-1785 MHz / 1805-1880 MHz (900/1800 MHz bands)and systems operating in adjacent bands	CEPT / ECC	12 November 2010