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Procedure to Investigate Radio Interference from the Operation of the Broadcasting Radio Equipment of Broadband Mobile Radio Communication Networks

(Methodical Procedure)

Published in connection with the preparation of Tender for granting the rights to use radio frequencies to provide a public communications network in the 700 MHz frequency band.

1. Introduction

The Czech Telecommunication Office (hereinafter referred to as “Office”) has prepared and published this methodical procedure in connection with the preparation of Tender for granting the rights to use radio frequencies to provide a public communications network in the 700 MHz frequency band. The document describes the procedure used to investigate complaints concerning radio reception interference from the operation of the broadcasting radio stations of the newly built mobile networks for broadband data transmission. This methodical procedure is a modified version of the procedure to investigate complaints concerning interference from the operation of broadcasting radio equipment (VRZ) of radio communication networks in the 800 MHz, 1800 MHz and 2600 MHz bands, issued in 2014. The modification accepts new frequency plans of the mobile networks and the networks for digital terrestrial TV broadcasting DTT (for the purpose of this document including both DVB-T and DVB-T2 standards). After the MFCN in the 700 MHz frequency band starts to operate, this methodology will be used to investigate interference with DTT reception from the operation of VRZ in the 700 MHz and 800 MHz frequency bands.

It can be expected, that the new operating mobile networks frequency band (700 MHz), similarly to the 800 MHz frequency band, will have the greatest problems with the TV signal reception interference in the UHF television band, i.e., in a frequency up to 694 MHz due to the operation of base stations (BS) of mobile networks in the 758–788 MHz (700 MHz) and 791–821 MHz f (800 MHz) bands, or due to operation of user terminals (ÚT) in the 703–733 MHz (700 MHz) and 832–862 MHz (800 MHz) bands. Although interference caused by the VRZ signals using higher frequency bands cannot be entirely excluded, such interferences will certainly be significantly less frequent, and the interference mechanism will be the same.

Based on experience with similar problems (in particular interference with TV reception by the signals of the LTE 800 MHz system BS), it can be expected that the vast majority of interferences will be caused by high levels of the mobile networks VRZ signals at the receiver input. Interference due to a failure to comply with the EMC-related parameters of the broadcasting radio equipment is quite exceptional today (mostly due to equipment defect). Therefore, the document describes the procedure to investigate interferences in cases of interference from strong signals of broadcasting radio equipment with television or radio signals on the receiving side due to:

- A low C/I separation – in this case the required protection ratio between the desired and interfering signal is not adhered to.
- Receivers blocking – due to a high level of the interfering signal, the receiver sensitivity is reduced, and cross-modulation created.
- Intermodulation products generated due to a high level of the interfering signal. According to the frequency position of the interfering signal(s) and desired signals (DTT), these intermodulation products can interfere with any DTT channel.

In practice, it is possible to expect cumulative occurrence of all the above-mentioned types of interference with the DTT signal.

Compared to the current situation, the introduction of the 700 MHz frequency band is expected to have the following pros and cons, which follow from the new MFCN frequency plan in the 700 MHz frequency band and the DTT network.

Pros:

1. Significantly greater frequency separation of the DTT band from BS MFCN band (64 MHz for the 700 MHz frequency band as opposed to 1 MHz for the 800 MHz frequency band) means TV receivers will become more resistant and the slope requirements for filters to suppress the MFCN 700 MHz networks signal will be substantially reduced.
2. In their specifications, new TV receivers (STB) are more resistant to interference from high-level signals outside the TV bands and with lower requirements for C/N separation.

Cons:

1. Due to the operation of additional mobile networks BS, the overall level (power) of the interfering signals at the TV receivers input (or, as the case may be, upstream active elements of the reception chain) will be increased – in many cases, 700 MHz and 800 MHz base stations will be located at the same site.
2. The frequency separation of the interfering signal (MFCN) and the signal subject to interference (DTT) will be substantially reduced for users' MFCN terminals– from 42 MHz (800 MHz) to 9 MHz (700 MHz).

2. General principles

a) Limit values of the protection ratios (PR), overloading threshold (Oth), and other parameters, as indicated below, apply to networks:

- desired DVB-T signal, version 64 QAM, 8k, CR=1/2 … 7/8
- desired DVB-T signal, version 256 QAM, 32k ext., CR=1/2 … 5/6
- interference signal of MFCN base stations (other than section 3.3.3)

b) Where other systems are used, the parameters will be determined in accordance with their respective specifications.
c) Submissions reporting interference with radio reception from MFCN signal are investigated by the Office, mainly by its regional branches. The Office decides on the following process in accordance with the Electronic Communications Act. The operator of the interfering equipment may work independently on removing the interference in cooperation with the parties submitting the reports or with the local authorities.

3. Procedure to investigate interference with individual radio and TV reception

3.1 *General investigation procedures*

a) Subjective evaluation is performed on the complaint submitter's reception equipment (pursuant to Decree No. 163/2008 Coll.) to find out whether there is any interference. If no interference occurs, only measurements according to paragraph b) will be performed for later investigation, if any.
b) The level of a desired signal (TV signal) and interfering signal (MFCN signal) will be measured on the receiving equipment.
c) The level of the desired signal is assessed according to ČSN EN 60728-1 standard. In simple distribution systems without active elements, a minimum DTT signal level of 40 dBµV is admissible at the receiver input, which is a sufficient reserve with respect to the receivers sensitivity, based on the required sensitivity thereof:

-82.0 dBm = 27.0 dBµV@75Ω for CR = 1/2

-79.7 dBm = 29.3 dBμV@75Ω for CR = 3/5
-78.2 dBm = 30.8 dBμV@75Ω for CR = 2/3
-76.2 dBm = 32.8 dBμV@75Ω for CR = 3/4
-74.7 dBm = 34.3 dBμV@75Ω for CR = 4/5
-73.9 dBm = 35.1 dBμV@75Ω for CR = 5/6
-72.9 dBm = 36.1 dBμV@75Ω for CR = 7/8

d) As for the MFCN signal, the total power in the entire frequency block(s) is measured at the maximum BS load of at least 80% (the required BS load will be provided by the operator upon the Office's request).
e) The protection ratio value (PR) at the TV receiver input will be based on the measured values of the signal subject to interference (DTT) and the interference signal (MFCN) using the following formula:

$$PR = U_{DTT} - U_{MFCN} \quad [dB], [dB\mu V], [dB\mu V]$$

f) If necessary, the electromagnetic field intensity of both signals will be measured (using a measuring antenna with polarization corresponding to the interference signal polarization), if possible in the area near the reception antenna of the equipment exposed to the interference. If it is not possible to ensure objective measurement of the electromagnetic field intensity (it is not possible to measure at a location equivalent to the location of the receiving antenna of the system subject to interference), the electromagnetic field intensity of the interfering signal will be calculated using a free-space method according to EIRP and distance of the system subject to interference from the MFCN BS.
g) To assess objectively whether interference occurs as a result of the MFCN BS operation, it is necessary to assess the state when the BS is switched off, especially if the requirements for protection ratio and overloading threshold are met.
h) Upon suspected interference due to failure to respect the technical parameters (EIRP, BEM) of the MFCN base station, an indicative measurement will be performed in the measuring vehicle and, depending on the results, further measurements will be performed directly at the broadcasting radio equipment output.
i) The minimum electromagnetic field intensity of a desired signal of the FM and T-DAB radio transmitters is defined in Decree No. 22/2011 Coll. The minimum electromagnetic field intensity of the DTT signal for the purpose of this document is defined in the following table.

Table 1. Minimum electromagnetic field intensity of the DTT signal

TV channel	$E_{min.}$	TV channel	$E_{min.}$
-	[dBμV/m]	-	[dBμV/m]
21 - 23	46	32 - 39	48
24 - 31	47	40 - 48	49

The above stated values are applicable to the Rice distribution model (fixed reception), CR = 2/3. For other DTT system options, an adjustment needs to be added with respect to the used code ratio CR; k = -4.7 dB (1/2); -1.9 dB (3/5); 2.3 dB (3/4); 3.9 dB (4/5); 4.5 dB (7/8) and 4.7 dB (5/6).

The electromagnetic field intensities are based on the planning criteria for DTT networks for $E_{min.}$ = 46 dBμV@650 MHz.

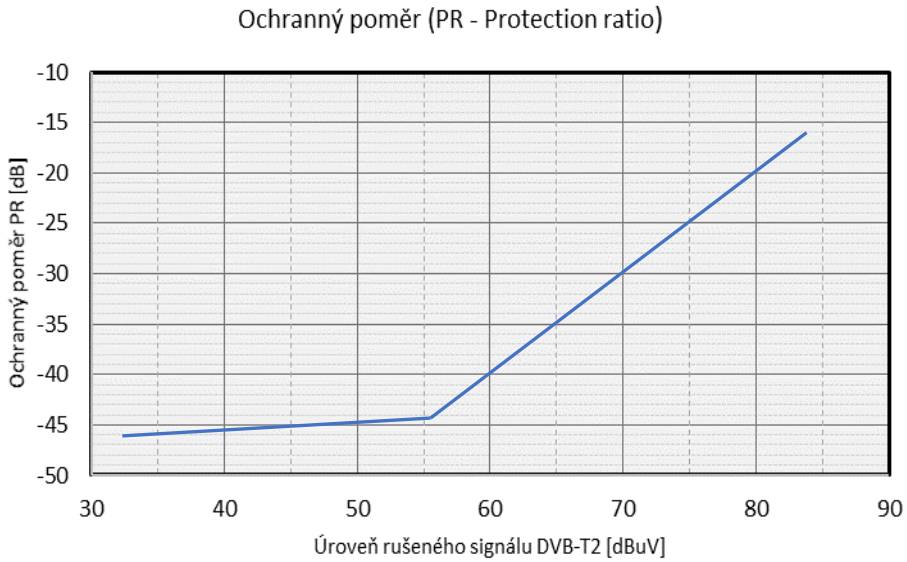
j) The reception equipment is assessed for:

- Suitability of the selected solution for television and radio reception (use of antennas, boosters and passive elements in the distribution of television and radio signals);
- Levels of the desired and interfering signal at the individual points of the reception system subject to interference as necessary and according to the system configuration;
- Suitability of using the selected elements (including, but not limited to, boosters and their gain), conformity declaration of the active elements.

3.*2* *The Office will reject the complaint*

a) If defects in the reception equipment are found or in case of unsuitable solution thereof.
b) In case the electromagnetic field intensity of the desired signal is lower than the value necessary for good-quality reception (according to Table 1 in section 3.1 i).
c) If there is interference from MFCN signal and the required protection ratio (PR) is adhered to at the receiver input according to Chart 1.
d) If there is an interference and the input level of the MFCN interference signals does not exceed the value of the overloading threshold (Oth), i.e., -9 dBm (100 dBµV@75Ω), and, at the same time, the PR value is adhered to.
e) In case an active reception antenna is used inside a building.
f) If the electromagnetic field intensity of the interfering MFCN base station signal measured at the site of the signal subject to interference ≤ 125 dBµV/m, provided that the interfering signal enters the reception equipment outside the antenna lead-in conductors, i.e., directly into the receiver or other active elements.

Should the Office reject a complaint, the operator of the equipment subject to interference shall bear the costs of the protection measures.



(1) Chart showing the dependence between the protection ratio (PR) at the level of the DTT signal subject to interference.

The values shown in the chart apply to the TV receiver input and the system option with CR = 2/3, Rice distribution model (fixed reception). For other DTT options, PR must be adjusted according to the CR value used:

		DVB-T	DVB-T2
Option CR = 1/2 :	$PR_{1/2}$ =	$PR_{2/3}$ - 2.3 dB	$PR_{2/3}$ - 4.7 dB

CR = 3/5 :	$PR_{3/5}$ =	--	$PR_{2/3}$ - 1.8 dB
CR = 3/4 :	$PR_{3/4}$ =	$PR_{2/3}$ + 1.7 dB	$PR_{2/3}$ + 2.3 dB
CR = 4/5 :	$PR_{4/5}$ =	--	$PR_{2/3}$ + 3.9 dB
CR = 5/6 :	$PR_{5/6}$ =	$PR_{2/3}$ + 3.2 dB	$PR_{2/3}$ + 4.6 dB
CR = 7/8 :	$PR_{7/8}$ =	$PR_{2/3}$ + 4.2 dB	--

Notes:

- *In the case of an interfering MFCN signal, it is the total power of the signal(s) at the DTT receiver input with the maximum BS load of at least 80%;*
- *The overloading of the active elements of the receiving equipment is caused by the total power of the interfering vf signal; the difference for the options CR 1/2 - CR 5/6 is ambiguous and is not taken into account in the overloading threshold value (Oth);*
- *The values shown in the PR chart and the calculation of Oth are based on the documents of ITU-R, ECC and foreign sources, including the results of measurements done on a limited number of TV receivers.*

3.3 *The protection measures shall be paid for by the interfering equipment operator*

If the Office finds the interference complaint justified, i.e., no defects are found in the receiving equipment and the interference is caused by the operation of broadcasting radio equipment in the MFCN network.

The assessment of the reception equipment EMC must be differentiated according to its configuration.

3.3.1 *Passive distribution of radio and TV signals*

The operator of the interfering equipment shall bear the costs of the protection measures taken with respect to the distribution of the received signals without active elements:

a) If the protection ratio value (PR), as indicated in Chart 1, is not adhered to due to the interfering signal.
b) If the interfering signal exceeds the overloading threshold value ($\Sigma P_{MFCN} \geq$ -9 dBm)
c) If the electromagnetic field intensity of the interfering signal measured at the site of reception subject to interference (for TV receivers) is $E \geq 125$ dBµV/m and the interfering signal enters the reception equipment outside the antenna lead-in conductors (ČSN EN 55020 standard).
d) If the Office finds the complaint justified.

3.3.2 *Distribution of radio and TV signals with active elements*

Where active elements (boosters) are included in the reception route, the Office shall use the following procedure to assess whether the costs for the protection measures should be borne by the interfering equipment operator:

A) The booster has an input connector, commonly available for measurement

In this case, the levels of both the desired and interfering signals are measured – section 3.1(b) and (c) above. The measured values are compared with those indicated by the manufacturer (the maximum output level, gain in the UHF band). If the interfering signal overloads the booster or (with the booster in a linear mode) causes the protection ratio at the receiver input to decrease below the limit value shown in Chart 1, the costs for the

protection measures (filter at the booster input, attenuation at the booster input) must be borne by the MFCN operator.

B) <u>The booster is located directly at the antenna (without an accessible input port)</u>

In this case, the assessment must be based on the electromagnetic fields intensities of both signals (DTT and MFCN) measured as close to the reception antenna as possible, and on the given parameters of the antenna pre-booster (if known).

As frequent use of pre-boosters with unknown parameters can be expected, it is necessary, for the basic assessment, to rely on average values of pre-booster parameters:

Antenna gain	:	12 dB	
Booster gain	:	15 dB	(sufficient to cover normal distribution attenuation with usual passive elements)
Maximum output level	:	107 dBµV	for the overloading threshold (IP_{1dB})
Maximum input level	:	92 dBµV	

The relevant electromagnetic field intensity of the interfering signal can be determined based on the above stated values of antenna gain and maximum input level:

$E_{interfering}$	:	105 dBµV/m	(758–821 MHz)

These values are only indicative. Should interference occur with this configuration of the receiving system, it is necessary to prefer the use of an external booster (outside the antenna box) with a primary filter eliminating the interfering signal.

The costs of the protection measures should be borne by the interfering equipment operator :

a) If the interfering signal exceeds the permitted maximum output level of the booster (given by the manufacturer).
b) If the protection ratio value (PR) according to Chart 1 is not adhered to at the booster output.
c) If the electromagnetic field intensity of the interfering signal measured by an antenna with polarization corresponding to the polarization of the interfering signal in the area of the receiving antenna is higher than 105 dBµV/m.
d) If the Office finds the complaint justified.

3.3.3 *Interference with TV reception signal caused by operation of MFCN user terminals.*

If the DTT signal reception is interfered with by the operation of MFCN user terminals (ÚT) , a procedure pursuant to Section 100 of the Electronic Communications Act will apply. It can be expected that in most cases the interfering user terminal operator is the same as the one of the receiving equipment subject to interference, and distance separation will be a sufficient protection measure. This type of interference is discussed in detail in the documents of ITU-R, ECC and many international organizations (e.g., OFCOM). In the vast majority, the interfering signal will not enter the TV receiver through an antenna, but through a cover or through an imperfect coaxial cable. This phenomenon has to be taken into account when investigating the interference.

3.3.4 *Interference with TV reception signal from abroad*

a) In the event of interference with the reception of foreign DTT signals, the procedure shall be the same as in the case of interference with national signals.

b) If the foreign signal meets the quality requirements (electromagnetic field intensity, signal quality) according to the criteria defined above and interference from MFCN signal occurs, the costs of the protection measures shall be borne by the MFCN operator.

3.4 *Evaluation of the time course when interference occurs*

a) When assessing the interference in terms of the time course from starting the operation of the equipment subject to interference and the interfering equipment, the Office follows Section 100 of the Electronic Communications Act.
b) If possible under current legislation, this procedure shall not apply to the protection of reception against interference with DTT networks put to operation after starting the operation of the mobile networks in the 700 MHz frequency band.

4. Procedure to investigate interference with communal TV antenna and TV cable wiring systems

4.1 *Crosstalk interference over the antenna (main station interference)*

Interference with the electronic communication networks via a line (communal TV antenna and TV cable wiring systems) shall be addressed similarly to the case of interference with individual reception, taking into account the specific characteristics of these systems. Professional installation can be assumed.

a) Measurements can be taken at different points of the system to consider the place where the interference occurs.
b) When investigating the communal TV antenna and TV cable wiring systems, it is necessary to thoroughly investigate the need to use pre-boosters and reduce their gain to an essential minimum. Mostly, the interference can be eliminated by including selective elements before the first active element of the system.

The costs of the protection measures shall be borne by the interfering equipment operator if the interference signal level exceeds the maximum permitted output level of the pre-booster and other active elements of the distribution system determined by the specification of the elements used, or if the required protection ratio value according to Chart 1 is not achieved in the subscriber outlets because of the interfering signal**.**

4.2 *Crosstalk interference over the distribution system*

ČSN EN 50083-8 standard can be applied when assessing crosstalk interference over the distribution system caused by broadcasting radio equipment of the mobile networks where the specified external system resistance (EMC for networks) is E = 106 dBμV/m in the 0.15 – 3,000 MHz frequency band.

a) The distribution operator shall take necessary protection measures, if the distribution is interfered with by MFCN signal and distribution signals with the same frequency are directly interfered with. Frequencies 694 - 862 MHz are reserved, as a priority, for radio communication services.
b) If the mobile networks operators consider it useful, they can use the website of the Council for Radio and Television Broadcasting (www.rrtv.cz – list of operators of broadcasting via cable systems) to look up the operators of TV cable wiring systems and request information on the locations of the main TV cable wiring stations.

5. Interference with other services

a) Interference with the operation of other electronic communications services shall be investigated by the Office in a standard manner pursuant to the Electronic Communications Act.
b) To protect the radio direction finders within the automated spectrum monitoring system of the Office, the electromagnetic field intensity of the MFCN signal at the monitoring station locations specified in section 6 thereof must not exceed 105 dBμV/m in the station antenna area.
The list of the stations is provided in section 6 (Table).

6. List of monitoring stations for the protection according to point 5b)

type	name	location	coordinates	
			LAT	LON
SNMS	České Budějovice	Lišov	49 N 01 09,91	14 E 34 57,88
SNMS	Plzeň	Doubravka	49 N 44 42,54	13 E 26 06,81
SNMS	Karlovy Vary	Horní Slavkov	50 N 08 15,12	12 E 43 45,11
SNMS	Ústí nad Labem	Osek	50 N 38 48,31	13 E 38 30,80
SNMS	Liberec	Rudolfov	50 N 47 20,30	15 E 06 21,50
SNMS	Hradec Králové	Poběžovice u Holic	50 N 06 07,10	15 E 59 46,00
SNMS	Jihlava	Větrný Jeníkov	49 N 27 46,00	15 E 30 26,90
SNMS	Brno	Diváky	48 N 58 17,50	16 E 46 29,40
SNMS	Ostrava	Prašivá	49 N 38 06,41	18 E 29 58,14
SNZS	Praha (city of Prague)	Praha - Lysolaje	50 N 07 36,06	14 E 23 05,09
SOMS	Karlovice	Karlovice	49 N 23 51,34	17 E 31 02,21
SOMS	Tehov	Tehov	49 N 58 16,00	14 E 42 15,00
SOMS	Brno (city of Brno)	Brno - Lesná	49 N 13 57,38	16 E 57 02,03

SNMS - stationary monitoring station unattended
SNZS - stationary direction finding station unattended
SOMS - stationary monitoring station unattended

7. List of abbreviations

EIRP equivalent isotropic radiated power
EMC electromagnetic compatibility
ECC Electronic Communications Committee (body of CEPT - European Conference of Postal and Telecommunications Administrations)
BEM block edge mask – edge mask of undesired radiation outside the allocated frequency block in the out-of-band broadcasting
BS MFCN base station – in the LTE system known as eNode B
C/I quotient between the desired signal (DTT) and the interfering signal (LTE)
DTT digital terrestrial TV broadcasting in DVB-T standard (the currently used variant in CZ with the following parameters: 8k OFDM mode, 64 QAM modulation, code ratio 2/3, 3/4, 5/6 or 7/8) and digital terrestrial TV broadcasting in DVB-T2 standard (the currently used variant in CZ with the following parameters 32k OFDM mode, 256 QAM modulation, code ratio 1/2, 3/5, 2/3, 3/4, 4/5 or 5/6)
ITU-R International Telecommunication Union – Radiocommunication sector
IP_{1dB} the output power level at which the gain decreases 1 dB from an ideal and theoretical response – this value is used to determine a transition of an active device to non-linear mode
LTE mobile cellular network, following the GSM ⇒ EDGE ⇒ UMTS standards, providing higher transmission speeds
MFCN electronic communication network

Oth	overload threshold – max. power (normally related to the input of an active device, related to the input of TV receiver in this case) which does not invoke non-linearity (blocking, production of intermodulation products, cross-modulation)
PR	protection ratio – the smallest difference between the power (power level) of useful and interfering signal (dB) which still does not cause harmful interference at noticeable level; $PR = P_{užit.} - P_{ruš.}$
STA	communal TV antenna, HS – main station
TKR	TV cable wiring
ÚT	user terminal
VRZ	broadcasting radio equipment

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