Analysis Methodology for Spectrum Sharing between Medical Implants and Digital Broadcasting

Haim Mazar (Madjar)

RF Spectrum Management and Engineering, ATDI, Warsaw; Poland (*not published yet at* EMC Europe 2016 Wroclaw)

h.mazar@atdi.com , mazar@ties.itu.int; http://mazar.atwebpages.com/

Abstract **— The classical RF sharing method relies on parameters that we may not know: EIRP of the interferer, distance to victim and challenging propagation losses. A pragmatic methodology is proposed: using field-strength (FS) to evaluate mutual interference between medical implants and digital broadcasting (TV and sound). To analyse interference to broadcasting, the calculated FS around the interfering implant is compared to the thresholds, required to ensure the protection of VHF T-DAB and V/UHF DVB-T. To evaluate interference to the medical-implant, the planning field-strengths (20 dB higher than interfering thresholds) of broadcasting are compared to the FS sensitivity (easily derived from power sensitivity) of the medical-implant. For the comparison, the RF sharing between the medical-implant and V/UHF digital broadcasting is calculated by the power and field-strength methods. To estimate the interference power from broadcasting stations, the free-space propagation model (20 log d/λ), and more representative model (35 log d/λ) are used. Free-space formula calculates the interference to digital broadcasting receivers, close to the medical-implant. The results by field-strengths are realistic and fruitful.**

Keywords — Antennas and propagation, DVB-T, EMC, field-strength, medical-implant, methodology, noise floor, protection levels, RFI, SRDs, T-DAB, thresholds.

I. INTRODUCTION

Radio services are vulnerable to interference. Medical-implants operating in the RF bands 174–216 MHz and 470–694 MHz may interfere (and may be interfered by) incumbent digital broadcasting sound (Terrestrial Digital Audio Broadcasting, T-DAB) and video (Digital V/UHF Video Broadcasting Terrestrial, DVB-T). The RF sharing and coexistence power-method calculates propagation loss to determine the minimum distance between the interfering transmitter and the victim, to avoid interference. Powers are analysed: minimal propagation loss (PL) PL (dB) = EIRP (dBm) - [Sensitivity (dBm) - C/I (dB)]. Threshold (sometimes called trigger) power levels of the RF power at the victim receiver are commonly used to establish the in-band coexistence and out of band compatibility. Common criteria for the protection of the victim system are based on the acceptable level of receiver sensitivity degradation, which determines, the allowed interference signal at the input to the victim receiver [1] section II: criterion to protect radio services. The power-method relies on parameters that we may not know (*eirp* and location of interferer) and propagation losses, that depend on topography, buildings and walls. This paper provides pragmatic methodology based on FS thresholds, without referring to transmitter's parameters (power and antenna gain toward the victim), the distance to the victim, nor attenuations due to topography, buildings and walls. After presenting the RF transmission and receiving parameters of the broadcasting and the medical-implant, the classical method calculates interference to the implant, and the proposed methodology calculates mutual interference by comparing the interfering to the thresholds' field-strengths. Tables summarise the results.

II. BROADCASTING: TX AND RX PARAMETERS

A. *Transmitting Parameters*

In Europe, in the 174–216 MHz band operate VHF TV channels 1 to 12, 7 MHz channel separation and T-DAB, 1.5 MHz bandwidth; in 470–694 MHz operate UHF TV channels 21 to 49, 8 MHz channel separation. Assuming antenna gain 12.5 (dBd), including feeder attenuation, *Table 1* specifies typical RF engineering parameters of V/UHF digital broadcasting transmitters (DVBT and TDAB), in rural and urban areas [2] Section 3 of Annex 3 and [3].

Table 1: Typical RF Parameters Broadcasting Transmitters

Power (W)		***erp* (W)**		***eirp* (W)**		**EIRP(dBm)**	
rural	urban	rural	urban	rural	urban	rural	city
2,000	20	35,000	350	58,000	580	77.6	57.6

B. *Receiving Parameters, Field-Strength*

Table 2 specifies the DVB-T2 VHF/UHF, minimum equivalent field-strength in dBμV/m for fixed reception *[4]* Table 2.10 and *[5]* Tables 3.3.1 and 3.3.2.

Table 2: DVB-T2, min. Equivalent Field-Strength (dBμV/m)

VHF (shape fill)	
UHF (no background)	
Min. C/N (dB)	20
	20
Equivalent noise band width BW (MHz)	6.66
	7.77
Ant. gain relative to half dipole (dBd)	7
	11
Man-made noise (dB)	2
	0
Penetration loss (building or vehicle) (dB)	0
	0
Min. median equivalent field-strength (dBμV/m)	41.3
	48.2

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The assumptions are: 50% time and 50% locations; receiver's height 10 m for fixed reception and 1.5 m for other reception modes; frequency 200 MHz for VHF and 600 MHz for UHF, receiver noise figure 6 dB, feeder loss of 2 dB at VHF and 4 dB at UHF.

In order to set the broadcasting field-strengths triggers, indoor and outdoor, we refer to the minimal C/N 20 dB and minimal DVB-T median equivalent FS 41.3 dB(μV/m) at VHF, and 48.2 dB(μV/m) at UHF. Actually, the minimum median equivalent FS dB(μV/m) is the FS to be protected; the minimum median equivalent field-strength for planning is the actual field-strength, that broadcasters provide; the difference between the two values is usually the C/N 20 dB; these are the underlined values in *Table 2*.

Table 3 specifies the minimum median equivalent FS (dB(μV/m)) for digital sound [6] Recommendation ITU-R BS.1660 Table 1, [3] Table 5.2 and [4] Table 2.5.

Table 3: Field-Strength dB(μV/m) for Digital Sound

Frequency band (MHz)	**174–230**
Minimum equivalent FS (dB(μV/m))	35
Location percentage correction factor (50% to 99%) (dB)	13
Antenna height gain correction (dB)	10
Minimum median equivalent field-strength for planning (dB(μV/m))	<u>58</u>

Therefore, the minimal T-DAB median equivalent FS equals 58 dB(μV/m); this value will be used later.

C. *I/N of –20 dB Criterion to Protect Broadcasting*

The ITU Radio Regulations allocate RF bands to radiocommunications services such as broadcasting, land mobile, radio-location and satellite. The I/N ratio of –20 dB criterion protects these services from unintentional radiators and non-allocated emissions; e.g., [7] Rec. ITU-R BT.1895 *recommends* 2 "that the total interference at the receiver from all radiations and emissions without a corresponding frequency allocation in the Radio Regulations should not exceed 1% of the total receiving system noise power". 1% of the total receiving system noise power is I/N ratio of –20 dB. The European 70-03, [8] Annex 10 Note 1, specifies: a threshold of 35 dBμV/m is required to ensure the protection of a DAB receiver, located at 1.5m from interfering device. Interesting to note that the threshold 35 dBμV/m (this value is used later) is close to the 38 dBμV/m: 58 dBμV/m (see *Table 3*) Rx threshold, minus the C/I of 20 dB.

III. Medical-Implant Parameters

A. *Transmitting Parameters*

The total EIRP of the specific implant out of the body (taking into account power, antenna gain and body-loss) is only -50 dBm, 10 nW.

B. *Receiving Parameters*

Assuming 1 MHz BW and Noise figure of 7dB, the receiver's thermal noise equals -114 dBm + 7 dB= **-107 dBm**.

C. *Excessive Losses*

Excessive Losses (EL) such as man-made decrease the interference from and to the implant; body's attenuation decreases interference from implant; therefore, EL are most relevant for the sharing study. Total EL equal the fixed values V/UHF fading 10 dB, body attenuation 15 dB [9], and variable values for V/UHF man-made noise (MMN): 16 dB in VHF and 6 dB in UHF. *Table 4* lists the assumed EL [9] Rec. ITU-R P.372 Fig. 3.

Table 4: Excessive Losses in V/UHF

RF band (MHz)	**Fading + body**	**MMN (dB)**	**Total (dB)**
174–216	10 +15	16	41
470–694		6	31

D. *Thresholds Interfering Powers*

Supposing the same V/UHF receiver noise -107 dBm, and the excessive losses (EL) of *Table 4*, *Table 5* specifies the implant threshold interfering power *Pr*, derived from threshold power.

Table 5: Threshold of Implant interfering powers in V/UHF

Band (MHz)	**Rx**	**XL**	**Interfering Rx power**
VHF 174–216	-107(dBm)	41(dB)	-66 (dBm)
UHF 470–694		31(dB)	-76 (dBm)

IV. Power Method Analysing Sharing

A. *General and Defining Symbols*

References[1] [10] a and [11] served the ITU regional agreement GE-06 (RRC-06) to define interference thresholds, to protect the mobile and the fixed services from the digital TV, using the power-method, thermal noise and protection ratios. The interfering thresholds are calculated to estimate the interference distances.

Italic non-capital letters express the numeric symbols (e.g., *p* for power and *g* for antenna gain); *Italic* capital letters (e.g., *P* and *G*) indicate the dB notation. Enclosed the parameters' definitions, in the two methods:

PL: Propagation Loss (dB)
XL: Excessive Loss (dB)
F: receiver noise figure (dB)
B: bandwidth (BW) of Transmitter (MHz)

[1] Based mainly on Authors' contributions to ITU-R in 2002 to 2006; see http://mazar.atwebpages.com/ContributionstoITU.html

BW_{comp}: BW compensation for different Tx and victim BW
g_i: receiver antenna gain (numeral)
G_r: receiver ant gain (dBi)
L_F: antenna cable feeder loss (dB)
f: reference frequency (MHz)
P_r: power trigger level at victim (dBm), including G_r
E_r: field-strength level at victim (dBμV/m)
c: velocity of light ~ $3x10^8$ m/s

B. Interference to Implant from Broadcasting, by Power

Based on *Table 5*, the implant's threshold interfering powers in VHF and UHF equal -81 dBm and -91 dBm, respectively. The T-DAB and implant use a similar bandwidth BW; as the DVB-T signal is wider than the implant's 1 MHz bandwidth, only part of it (7 MHz at VHF, and 8 MHz at UHF) enters the medical-implant. We assume that all T-DAB (about 1.5 MHz) signal interferes, and the interfering V/UHF TV signal is attenuated by 9 dB (~10log7, ~10log8). The minimal propagation loss to avoid interference equals:

$$PL(\mathrm{dB}) = P_{tx}(dBm) - BW_{comp} - (-81(dBm)) + Gr(dBi) \quad (1)$$

- for T-DAB, VHF, BW_{comp}= 0

$$PL(\mathrm{dB}) = P_{tx}(dBm) + 81dBm - 5dBi = P_{tx}(dBm) - (-76dBm) \quad (2)$$

- for DVB-T VHF, BW_{comp}= 9 dB:

$$PL(\mathrm{dB}) = P_{tx}(dBm) - 9dB + 81dBm - 5dBi = P_{tx}(dBm) - (-67dBm) \quad (3)$$

- for DVB-T UHF, BW_{comp}= 9 dB:

$$PL(\mathrm{dB}) = P_{tx}(dBm) - 9dB + 91dBm - 5dBi = P_{tx}(dBm) - (-77dBm) \quad (4)$$

a) Free- Space Propagation

The free-space loss at 200 MHz (wavelength 1.5 m) for 1 meter is about **18.5 dB**. Therefore, (2) can be rewritten:

- for T-DAB, VHF, BW_{comp}= 0

$$PL(\mathrm{dB}) = P_{tx}(dBm) + 76 = 18.5 + 20\log d(\mathrm{m}) \quad ;$$

thus, the minimal free-space T-DAB separation-distance is:

$$20\log d(\mathrm{m}) = P_{tx}(dBm) + 76 - 18.5 = P_{tx}(dBm) + 57.5 \quad (5)$$

- for DVB-T VHF, BW_{comp}= 9 dB, (3) can be rewritten:

$$20\log d(\mathrm{m}) = P_{tx}(dBm) + 67 - 18.5 = P_{tx}(dBm) + 48.5 \quad (6)$$

- for DVB-T UHF, BW_{comp}= 9 dB.

The free-space loss at 600 MHz (wavelength 0.5 m) for 1 meter is **28 dB**. Therefore, (4) can be rewritten:

$$28 + 20\log d(m) = P_{tx}(dBm) + 77 \quad (7)$$

thus, the minimal **UHF** TV separation-distance equals:

$$20\log d(\mathrm{m}) = P_{tx}(dBm) + 49 \quad (8)$$

Following (5), a digital **VHF** T-DAB of circa P_{tx} 57 dBm (500 W), (see *Table 1*), the minimal distance-separation equals: $20\log d(\mathrm{m}) = 57 + 57.5 = 114.5$.

Therefore, d(m)=$10^{114.5/20}$=530,884m; **530.9 km**.

Following (6), a digital **VHF** TV of P_{tx} 57.6 dBm (about 500 W), the minimal distance-separation equals $20\log d(\mathrm{m}) = 57 + 48.5 = 105.5$, therefore,

d(m)=$10^{105.5/20}$=188,364 m; **188.4 km**.

Following (8), for a digital **UHF** TV of P_{tx} = 57.6 dBm (about 500 W), (see Table 1), the minimal separation distance equals

$20\log d(\mathrm{m}) = 57 + 49 = 106$.

Therefore, d (m)= $10^{106/20}$= 199,526 m= **199.5 km**.

The detailed analysis refers to the worst-case. As there is not Line of Sight and free-space propagation between the interferer and implant, at long distances, another model is needed.

b) Non Free- Space Propagation

The simplistic $10^{3.5}$ (35 log d/λ) propagation loss model is used, instead of the free-space 10^2 (20 log d/λ). The propagation losses (in dB) relative to free-space, for specific range, are multiplied by 35/20=1.75: at 200 MHz (wavelength 1.5 m) for 1 meter, PL is 32.3 dB; and the loss at 600 MHz (wavelength 0.5 m) for 1 meter is 49 dB. Using the same equations as for the free-space, but multiplying properly by 3.5, we get for-

- VHF **T-DAB** of about P_{tx} 57 dBm (500 W), (see *Table 1*), the minimal distance-separation: $35\log d(\mathrm{m}) = 57 + 43.7 = 100.7$ and d(m)=$10^{100.7/35}$=**754 m**;
- **VHF TV** of P_{tx} 57.6 dBm (~500 W), (see Table 1), the minimal distance-separation: $35\log d(\mathrm{m}) = 57 + 34.7 = 91.7$ and d(m)=$10^{91.7/35}$=**417 m**;
- **UHF TV** of P_{tx} 57.6 dBm (~500 W), (see Table 1), the minimal distance-separation: $35\log d(\mathrm{m}) = 57 + 28 = 85$ Therefore, d(m)=$10^{85/35}$=**268 m**.

c) Summerising Interference to Implant, by Power

Table 6 summarizes the interference to the implant. Power-method is used to calculate the distance, beyond which, the implant is not interfered, applying two propagation models.

Table 6: Interference to Implant; power-method

Threat	**T-DAB**	**DVB-T**	
Band	**VHF**		**UHF**
Interfering BW (MHz)	1.5	7	8
Threshold implant (dBm)[a]	-76		-86
BW compensation (dB)	0	9	
Implant reference (dBm)	-76	-67	-77
Distance separation, to avoid interference (m)			
20logd/λ model	530,900	188,400	199,500
35logd/λ model	754	417	268

[a] Including -5dBi, *Gr*

As the existing interference thresholds to T-DAB and DVB-T are in field-strength dB(μV/m), this section didn't include interference study by the power-method, from the implant to the digital broadcasting.

V. Field-Srength Method for coexistence

A. Using Power and FS units in different RF services

The minimum median parameters for planning broadcasting are always recommended by field-strength (dBμV/m). It is not the case for the fixed and mobile services, where the units of planning parameters are in power (dBm). However, also for land mobile and fixed service, the coordination between countries (and between operators) is based solely on FS values, for preferential and non-preferential frequencies [13], as the FS is easier to monitor: administrative measurements are carried out at a height of 3 m above ground, with a half-wave dipole antenna of gain 2.1 dBi.

Since the broadcasting thresholds are in field-strength (FS), it is logical to evaluate interference from implant to T-DAB and DVB-T in the FS domain, and not to transfer the Rx broadcasting protected values, to the power domain. The result is the minimal distance of the implant to broadcasting receiver.

B. Converting received power to field-strength

As the interference threshold to implant is in power (dBm), there is a need to convert it to field-strength dB(μV/m), in order to calculate properly interference, by the field-strength method. The Poynting Vector relates field-strength and *eirp* in free-space conditions: $\frac{eirp}{4\pi d^2} = \frac{e^2}{120\pi}$; FS equals: $e = \frac{\sqrt{30 \times eirp}}{d}$.

In logarithmic terms, in standard units:

$$E = 20\log e = 20\log\frac{\sqrt{30\times eirp}}{d} = 14.8 + EIRP - 20\log d \qquad (9)$$

The vector power-density $\frac{e^2}{120\pi}$ is transferred to the numeric power by scalar product '·', with the effective antenna area $\frac{g_r\lambda^2}{4\pi}$ to get:

$$p_r = \frac{e^2}{120\pi}\cdot\frac{g_r\lambda^2}{4\pi} = \frac{e^2}{120\pi}\cdot\frac{g_r c^2}{4\pi f^2} \qquad (10)$$

In logarithmic terms, in standard units: $P_r\left(\text{dBW}\right) = E\left(\text{dB V/m}\right) + G_r\left(\text{dBi}\right) - 20\ log\ f\left(\text{MHz}\right) + 12.8$

Rearranging (10), FS is calculated from the received power with G_r gain as follows:

$$E\ \left(\text{dB V/m}\right) = 20\ log\ e\left(\text{V/m}\right) = P_r\left(\text{dBW}\right) - 12.78 - G_r\left(\text{dBi}\right) + 20log\ f\left(\text{MHz}\right)$$

Using E dB(μV/m) and P_r dBm:

E dB(μV/m)-120 =P_r (dBm)-30-12.8-G_r (dBi)+20log f (MHz), we get:

$$E\ \left(\text{dB μV/m}\right) = 77.2 + P_r\left(\text{dBm}\right) - G_r\left(\text{dBi}\right) + 20log\ f\left(\text{MHz}\right) \qquad (11)$$

C. Interference to Implant, by Field-Strength

a) In-Band Interference from Digital Broadcasting

Assuming implant G_r =-5 (dBi), and f=200 MHz for VHF and f=600MHz for UHF, we may transfer to FS the thresholds interfering power, in VHF -81 dBm and in UHF -91 dBm using (11):

$$E\left(\text{dB μV/m}\right) = 77.2\text{-}81\left(\text{dBm}\right) + 5(\text{dBi}) + 20log200\left(\text{MHz}\right) = 77.2\text{-}76 + 46\text{=}47.2\left(\text{dB μV/m}\right)$$

$$E\left(\text{dB μV/m}\right) = 77.2\text{-}91\left(\text{dBm}\right) + 5(\text{dBi}) + 20log600\left(\text{MHz}\right) = 77.2\text{-}86 + 55.6\text{=}46.8\left(\text{dB μV/m}\right)$$

Disregarding where is the interferer, the EIRP of the transmission and the propagation model, but aware that we already took into account the fading and man-made, the interfering signal to the implant outside the body should not exceed in VHF 47.2 dBμV/m and in UHF 46.8 dBμV/m.

Following, the minimal C/N 20.0 dB and minimal DVB-T median equivalent field-strength 41.3 dB(μV/m) at VHF, and 48.2 dB(μV/m) in UHF, the planning DVB-T FS is 20 dB above median equivalent field-strength, and equals at: VHF TV 41.3 + 20 = 61.3 dB(μV/m), for T-DAB, 58 dB(μV/m) see next; for UHF TV: 48.2 + 20 = 68.2 dB(μV/m).

b) Interference from digital Broadcasting to Implant

Assuming that the implant operates at an operating T-DAB channel, and that T-DAB doesn't operate in adjacent channels (it penetrates to the implant only in one channel), we refer to the minimal T-DAB median equivalent FS 58 dB(μV/m) at VHF; see *Table 3*. Assuming the broadcasting operators provide satisfactory signal even indoor, as all the T-DAB signal enters to the victim implant, T-DAB Interference to Signal (I/S) is 58-47.2=10.8 dB, above threshold. Regarding interference from TV broadcasting, only part (-9dB) of the V/UHF signal enters to the implant:

- VHF TV is 61.3 - 9 - 47.2=5.1 dB, above threshold;
- UHF TV is 68.2 – 9 - 46.8=12.4 dB, above threshold.

These are the interfering values to the implant by digital broadcasting T-DAB and V/UHF TV.

c) Summerising Table, Interferences to Implant

Table 7 summarizes the interference to the implant, using the FS method. The 'sensitivity' power is -107 dBm; taking into account -5 dBi (decreasing the susceptibility of the Rx by 5 dB) at V/UHF implant antenna (Tx and **Rx**) gain, excessive losses (different in VHF and UHF), the threshold interfering powers are -66 dBm in VHF and -76 dBm in UHF. The equivalent implant FS are at VHF 62.2 dBμV/m and at UHF 61.8 dBμV/m.

Table 7: Interference to Implant; FS method

Threat	**TDAB**	**DVB-T**	
Band	**VHF**		**UHF**
Interfering bandwidth (MHz)	1.5	7	8
Satisfactory signal (dB(μV/m))	58	61.3	68.2
Bandwidth compensation dB	0	9	
Implant reference (dB(μV/m))	47.2		46.8
Interference level[a] (dB)	10.8	5.1	12.4

[a] How many dBs above implant threshold

D. Interference to Broadcasting, by Field-Strength[2]

a) Field-Strengt around the Implant

Equation (9) calculates in free-space conditions the FS (V/m) around the TV station transmitting *eirp* (W). For other units, the field-strength equation expressed logarithmically looks:

$$E(\text{dB μV/m}) = 14.8 + 120 + EIRP\text{-}20logd = 134.8 + EIRP(\text{dBW})\text{-}20\ logd(\text{m}) \qquad (12)$$

Using dBm and dBμV/m units, to calculate E:

[2] There is method, to analyse interference to TV by power-density

$EIRP(\text{dBm})=E(\text{dB}\mu\text{V/m})+20\ log d(\text{m})\text{-}104.8$.

$$E(\text{dB}\mu\text{V/m})=EIRP(\text{dBm})-20\ log d(\text{m})+104.8 \quad (13)$$

Note that the FS level around the implant doesn't depend on frequency; only when transferring FS to power, the power value depends on RF; see (10).

b) Interference to T-DAB

For implant's EIRP= -50 dBm, (13) provides the field-strength, 1.5 m. (see [8] Annex 10 Note 1) from implant:

$$E(\text{dB}\mu\text{V/m})\text{=-50-20 } log 1.5+104.8=51(\text{dB}\mu\text{V/m})$$

Thus, at 1.5 m. we exceed by 16 dB, the allowed 35 dBμV/m. Therefore, assuming free-space attenuation, implant may interfere $1.5\text{x}10^{16/20}$= **9.5 m** from DAB receiver. As the person using the implant is aware and may tolerate its own DAB interference, the signal to the neighbor is attenuated by 8 dB, building penetration loss [3] Table 4.3. Thus, the interference is only 16-8= 8dB, and the new free-space distance is $1.5\text{x}10^{8/20}$= **3.8 m**.

c) Interference to V/UHF DVB-T

Using the underlined values in *Table 2*, the interfering FS from the implant should not exceed for TV VHF **41.3** dB(μV/m), and for TV UHF **48.2** dB(μV/m). Assuming in-band interference, and all implant signal enters to the TV Rx, using (13), for EIRP –50 dBm, the interfering free-space field-thresholds equals: $E(\text{dB}\mu\text{V/m})\text{=-50(dBm)-20 } log d(\text{m})+104.8$ and the separation-distance equals:

$$20\ log d(\text{m})\text{=104.8-50-}E(\text{dB }\mu\text{V/m})=54.8\text{-}E(\text{dB }\mu\text{V/m}) \quad (14)$$

As the interfering FS from the implant should not exceed, for VHF **41.3** dB(μV/m), $20\ log d(\text{m})\text{=54.8-41.3}=13.5$; *d*=**4.7 m**. For UHF **48.2** dB(μV/m), $20\ log d(\text{m})\text{=54.8-48.2}=6.6$, and *d*=**2.1 m**.

d) Summerising Interference to Digital Broadcasting

To protect digital broadcasting, these are FS thresholds that implant' FS emission should not exceed:

- for T-DAB, **35** dBμV/m;
- for DVB-T VHF **41.3** dB(μV/m);
- for DVB-T UHF **48.2** dB(μV/m).

Table 8 summarizes interference from the implant.

Table 8: Interference from Implant

Victim	**TDAB**	**DVB-T**	
Band	**VHF**		**UHF**
Threshold signal (dB(μV/m))	35	41.3	48.2
Separation-distance (m.)	2.5 [a.] –9.5	4.7	2.1

[a.] 2.5 m. includes building penetration loss

Important to notice that the person using the implant is aware and may tolerate interference at home, to its own equipment.

VI. Summary

A pragmatic field-strength methodology has been proposed. It is contrasted to the classic power analysis. The results are proved effective and fruitful, to evaluate RF sharing between medical device and digital broadcasting. The FS method is a powerful tool and can be used in many RFI scenarios, mainly, to protect broadcasting (video, sound and data). The power and the FS methods provide different results to coexistence; power analysis offers distance-separation from digital broadcasting to avoid interference to the implant. To evaluate interference to the implant, the FS method compares the planned (for satisfactory service) field-strength of the digital broadcasting, to the protected threshold of the implant.

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