LTE and DVB-T Coexistence: A Simulation Study in the UHF Frequency Band

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Abstract: The introduction of new mobile services, mainly UMTS (Universal Mobile Telecommunications System) and LTE (Long Term Evolution), in the digital dividend portion of the UHF spectrum (from 790 MHz to 862 MHz), resulting from the digital switchover process, makes necessary the assessment of how much the interference of these signals impacts on QoS of existing DVB-T services, in particular when operating on adjacent bands. To this aim, in this paper an analysis of coexistence between broadcast television services and broadband mobile communication systems is carried out. It is based on the computation of specific parameters, such as the Protection Distance, evaluated in some specific operative scenarios. The goal of this analysis is to provide valuable inputs to operators, in deploying new mobile cellular networks in the above mentioned frequency band.

Key words: LTE (Long Term Evolution), DVB-T, protection distance, UHF Frequency band, digital dividend.

1. Introduction

The ever increasing spectrum demand for modern wireless communication systems is leading to an overall spectrum scarcity perception, forcing countries authorities to find not optimal solutions, from both an economic and an implementative point of view, in allocating new mobile services. In this context, as a consequence of the spectrum reframing process, the most likely designated frequency bands where the new services could operate will be the ones at present used by Universal Mobile Telecommunications System (UMTS) and Global System for Mobile Communications (GSM), as well as new bands at 2.6 GHz. Nevertheless, the best frequency band option to open up these services would be, definitely, the digital dividend portion of the UHF spectrum (from 790 MHz to 862 MHz), resulting from the Digital Switchover (DSO) process from analog to Digital Television (DTV) whose conclusion is expected by the end of 2012.

For both mobile operators and customers the benefits of carrying out this choice will be numerous including larger coverage areas and best penetration into buildings. All of this, of course, operating at the same radiated power or even lower.

During the last World Radio Conference (WRC-2007) was indicated to allocate the 790-862 MHz frequency band to mobile services in several world regions (see Fig. 1) [1].

Such position was supported also by main international radio communication organizations (European Conference of Postal and Telecommunications Administrations (CEPT), Federal Communications Commission (FCC), etc.).

However, in order to make these systems fully interoperable, the problem of coexistence between DVB-T (Digital Video Broadcasting-Terrestrial) channels, operating in the lower part of the UHF band...
(470-790 MHz) and signals of future mobile communication systems, operating in the above mentioned band, must be carefully analyzed and evaluated and the results of these studies should be taken into account in the implementation of the new broadband mobile networks.

The present work focuses on the above mentioned coexistence problem addressing, in particular, the interference impact on DVB-T signals and evaluating, for some reference scenarios, the Protection Distance ($d_P$) between Long Term Evolution (LTE) and DVB-T stations [2].

In particular, the paper, after a brief description of the UHF band regulatory aspects (Section 2), in Section 3, introduces the concept of Protection Distance and provides an analytical approach to estimate it. Section 4 summarizes the characteristics of wanted and interfering signals adopted in the simulation tool. Finally Section 5 reports the simulation results and Section 6 gives some concluding remarks.

2. UHF Band Regulatory Aspects

As previously mentioned, the switch off process will make possible to release the last portion of the UHF band V that ranging from 790 to 862 MHz (or from channel 61 to channel 69) to non broadcast services. CEPT, starting from the results of WRC-2007, stated that in this band could be implemented networks for mobile telecommunication systems in either Time Division Duplexing (TDD) or Frequency Division Duplexing (FDD) technique [3]. In case of TDD implementation (or mixed TDD/FDD) has been set a guard band of 7 MHz, between the UHF channel 60 (782-790 MHz) and the 13 blocks of 5 MHz (see Fig. 2) where will be transmitted radio mobile signals. This channelization meets the requirements of country authorities having problems of spectral harmonization with neighboring countries or that have already allocated part of the UHF band V to other services.

In case of using the FDD technique, two 30 MHz bands have been established: one for downlink and one for uplink communications, separated by a duplex gap of 11 MHz (see Fig. 3). Each of these bands is splitted into 6 blocks of 5 MHz. The downlink frequency band starts at 791 MHz, while the corresponding uplink frequency band starts at 832 MHz, with a resultant guard band of 41 MHz.

The reason of this choice is to protect the DVB-T broadcast signal transmitted on 60 UHF channel from interference produced by the uplink transmission of
mobile ECN (Electronic Communication Networks) terminals, which represents a critical aspect for DVB-T receiving systems. From this point of view, the adoption of the above mentioned frequency allocation determines a 41 MHz virtual guard band. In addition, the remaining 11 MHz duplex gap could be exploited by other unspecified services.

3. Protection Distance Concept and Evaluation Approach

In fixed and mobile cellular networks the interference between uplink and downlink transmissions, among different operators serving the same geographical area and operating in adjacent channels, can generate extremely high noise due to inadequate filtering, unwanted modulation products, improper tuning, or poor frequency control, in either the reference channel or the interfering channel, or both. However, setting an appropriate distance between the victim and the interfering system can help to mitigate these undesired effects.

In this section the Protection Distance \(d_P\) concept between LTE and DVB-T stations will be introduced. The \(d_P\) parameter is defined as the minimum distance between an LTE (Base Station (BS) or User Equipment (UE)) antenna and a DVB-T receiving antenna in order to make the interference effects at the DVB-T front-end acceptable in terms of quality of service.

Recommendation ITU-R SM.337-5 provides a general method to evaluate the spatial distance between an interfering and a victim antenna for radio systems, as well as their frequency separation in order to bind the interfering signal under an acceptable power level [4]. According to this method, to evaluate \(d_P\), in addition to the selection of the adopted radio propagation model (Gaussian, Rayleigh, etc.), the following physical parameters must be taken into account:
- power and spectral distribution of the desired signal at the receiver or the signal that would otherwise be received without interference;
- power and spectral distribution of the interfering signal at the receiver;
- path loss contribution to signal attenuation;
- characteristics of the receiver (noise figure, demodulation technique).

The basic scenario that we take into consideration (see Fig. 4 for an example) analyzes the case of a desired DVB-T signal received at the antenna with power \(P_d\), which is interfered by a signal, with power \(P_r\), emitted by a mobile system (ECN LTE for example) on a carrier at distance \(\Delta f\) from the DVB-T carrier frequency and adding, on the desired signal (exclusively in the reference channel of the receiver), an interfering signal with power level equal to \(P_i\) (see Fig. 5).

The power \(P_i\) depends on two kinds of factors: the spectral one and the spatial one.
3.1 Spectral Factor

The spectral factor depends on the power density spectrum of the interfering signal and the frequency response of the receiver. It is expressed by the Off-Channel Rejection factor \( OCR(\Delta f) \), which represents an index of selectivity of the receiver:

\[
OCR(\Delta f) = -10 \log_{10} \left( \frac{\int_{-\infty}^{+\infty} P(f) |H(f + \Delta f)|^2 df}{\int_{-\infty}^{+\infty} P(f) df} \right)
\]  

(1)

In this expression,

- \( P(f) \) is the power density spectrum of the interfering signal;
- \( H(f) \) is the frequency response of the DVB-T receiver in RF band;
- \( \Delta f \) is the difference between the carrier frequencies of the interfering and the desired signals.

3.2 Spatial Factor

The spatial factor depends on the antennas distance between the victim receiver system and the interfering one, the propagation model chosen and the statistical distribution of the signal, and is expressed by the Path Loss \( L_p \). If the diffraction propagation model (see the worst case reported in the Recommendation ITU-R SM337-5[4]) is adopted, \( L_p \) is given by:

\[
L_p = L_{FS} - L_{dif/FS}
\]
\[ L_{FS} = 32.44 + 20 \log_{10} f_{MHz} + 20 \log_{10} d_{iv} - G_T - G_R \tag{2} \]

where:

- \( L_{FS} \) is the attenuation due to free space (dB);
- \( L_{DIF,FS} \) is the attenuation due to diffraction (dB), and is usually a negative term;
- \( d_{iv} \) is the distance between the interfering and the victim antennas, and is expressed in km.

Our goal in this work is to evaluate how the above mentioned factors affect the interfering power, and consequently calculate \( d_P \).

In the following a brief description of the approach adopted to calculate the Protection Distance of the DVB-T signal in presence of an interfering radio mobile signal (BS and UE) is given.

### 3.3 Approach Adopted to Calculate \( d_P \)

Taking into account the minimum Carrier to Noise (C/N) ratio (\( CNR_{\text{min}} \)) required for a DVB-T signal good quality reception and the two mentioned factors, for each value of power level \( P_d \) it is possible to calculate the correspondent maximum interfering power \( P_i \) that does not cause critical interference on the DVB-T signal (\( P_i^* \)). In general, the interfering power is calculated by the formula [4]:

\[ P_i = P_t + G_r - L_p - OCR(\Delta f) \approx P_t + G_r - OCR(\Delta f) \tag{3} \]

where \( P_t \) is the EIRP (Effective Isotropic Radiated Power) (dBW) of the interfering transmitter, \( G_r \) is the receiver antenna gain (dBi) and \( P_r = P_t - L_p \) is the power level of interfering signal (dBW) at the receiver.

According to the expression (3) the interfering power depends on the power \( P_r \), which is function of the distance between the antenna transmitting the interfering signal and the antenna of the victim system (DVB-T), but also by the carrier frequency offset \( \Delta f \).

As evidentiated in Fig. 5, \( P_i \) is the portion of the mobile signal spectral power causing interference on the DVB-T signal. It represents the co-channel or adjacent channel interference depending whether the frequency offset \( \Delta f \) is null or equal to one (or more) channel spacing.

Once the values of \( P_d \) and \( CNR_{\text{min}} \) are fixed, the maximum allowable interfering power \( P_i^* \), in the DVB-T signal bandwidth, can be calculated as reported in expression (4).

\[ \frac{P_d}{(N + P_i^*)} \geq CNR_{\text{min}} = \frac{S_x}{N} \]

\[ P_i \leq N(\frac{P_d}{S_x} - 1) = \frac{(P_d - S_x)}{CNR_{\text{min}}} = P_i^* \tag{4} \]

According to expression (4), in order to not have a clear degradation of TV signal quality, the expression \( P_i \approx P_i^* \) should be fulfilled.

Using the value \( P_i^* \) in expression (3), it is possible to extrapolate the \( L_p \) parameter and, consequently, the distance \( d_{iv} \) from expression (2) that, in this case, is equivalent to \( d_P \). To empirically evaluate a solution of the above mentioned expression, a simulation software has been implemented using MATLAB tool.

### 4. DVB-T and Broadband Mobile Systems Signal Characteristics Used in the Simulation

#### 4.1 LTE Signal

LTE systems, in this simulation study, are the interferer sources and are assumed to transmit on a 5 MHz bandwidth channel [5]. Transmitting antennas of BS and UE systems are supposed to be at a height of 30 m and 1.5 m respectively. Being unable to get the spectra effective numerical representation of the interfering signals, the power density spectrum of LTE signals have been approximated using the spectrum Block Emission Masks (BEM) reported on the ETSI (European Telecommunications Standards Institute) recommendations ETSI TS 136 104 V8.7.0 for LTE base stations (see Table 1) and ETSI TS 136 521-1 V8.3.1 for LTE UE (see Table 2) [6, 7].

#### 4.2 DVB-T Signal

As earlier mentioned, DVB-T is the victim signal in this simulation analysis.
Table 1  LTE BS (5 MHz): Spectrum emission mask.

<table>
<thead>
<tr>
<th>Frequency offset of measurement filter -3 dB point, Δf</th>
<th>Frequency offset of measurement filter centre frequency, f_offset</th>
<th>Minimum requirement</th>
<th>Measurement bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 MHz ≤ Δf &lt; 5 MHz</td>
<td>0.05 MHz ≤ f_offset &lt; 5.05 MHz</td>
<td>-7 dBm - ( \frac{7}{5} \left( \frac{f_{offset}}{MHz} - 0.05 \right) ) dB</td>
<td>100 kHz</td>
</tr>
<tr>
<td>5 MHz ≤ Δf &lt; 10 MHz</td>
<td>5.05 MHz ≤ f_offset &lt; 10.05 MHz</td>
<td>-14 dBm</td>
<td>100 kHz</td>
</tr>
<tr>
<td>10 MHz ≤ Δf ≤ Δf_max</td>
<td>10.05 MHz ≤ f_offset &lt; f_offsetmax</td>
<td>-13 dBm</td>
<td>100 kHz</td>
</tr>
</tbody>
</table>

Table 2  LTE UE (5 MHz): Spectrum emission mask.

<table>
<thead>
<tr>
<th>Spectrum emission limit (dBm)/Channel bandwidth</th>
<th>Δf_{OOB} (MHz)</th>
<th>1.4 MHz</th>
<th>3.0 MHz</th>
<th>5 MHz</th>
<th>10 MHz</th>
<th>15 MHz</th>
<th>20 MHz</th>
<th>Measurement bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>± 0-1</td>
<td>-10</td>
<td>-13</td>
<td>-15</td>
<td>-18</td>
<td>-20</td>
<td>-21</td>
<td>30 kHz</td>
<td></td>
</tr>
<tr>
<td>± 1-2.5</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>1 MHz</td>
<td></td>
</tr>
<tr>
<td>±2.5-2.8</td>
<td>-25</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>1 MHz</td>
<td></td>
</tr>
<tr>
<td>± 2.8-5</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>1 MHz</td>
<td></td>
</tr>
<tr>
<td>± 5-6</td>
<td>-25</td>
<td>-13</td>
<td>-13</td>
<td>-13</td>
<td>-13</td>
<td>-13</td>
<td>1 MHz</td>
<td></td>
</tr>
<tr>
<td>± 6-10</td>
<td>-25</td>
<td>-13</td>
<td>-13</td>
<td>-13</td>
<td>-13</td>
<td>-13</td>
<td>1 MHz</td>
<td></td>
</tr>
</tbody>
</table>

A DVB-T receiver is characterized by several parameters (see Table 3), including receiver sensitivity (S_r) and the minimum C/N ratio (CNR_{min}) required for a DVB-T signal good quality reception. Table 4 provides a list of values for CNR_{min} extracted from the ETSI EN 300 744 V 1.6.1 rec. [8].

Concerning the modulation scheme, taking into account of the high computational time, in this work only two different configurations have been considered. The first one, more robust to interferences, operating with 8 k carriers, modulated 16QAM 2/3, assuming a Gaussian channel model and an SNR_{min} = 11.4dB (DVB-T-1 configuration); the second one, a little more sensible, operating with 8k carriers, modulated 64QAM 2/3, assuming a Gaussian channel model and an SNR_{min} = 16.7dB (DVB-T-2 configuration).

The DVB-T receiver is assumed to operate with an ideal receive filter H(f) and have a sensitivity S_r = -77.2 dBm [9].

5. Simulation Results for Protection Distance

In the simulation tests two propagation scenarios have been considered (see [10]):
Table 4  \textit{CNR}_{\text{min}} \text{ for a DVB-T system.}

\begin{table}[h]
\begin{tabular}{|c|c|c|c|c|c|c|c|c|}
\hline
Constellation & Code rate & Gaussian channel (AWGN) & Ricean channel (F1) & Rayleigh channel (P1) & $\Delta{T}_{U}=1/4$ & $\Delta{T}_{U}=1/8$ & $\Delta{T}_{U}=1/16$ & $\Delta{T}_{U}=1/32$ \\
\hline
QPSK & 1/2 & 3.5 & 4.1 & 5.9 & 4.98 & 5.53 & 5.85 & 6.03 \\
QPSK & 2/3 & 5.3 & 6.1 & 9.6 & 6.64 & 7.37 & 7.81 & 8.04 \\
QPSK & 3/4 & 6.3 & 7.2 & 12.4 & 7.46 & 8.29 & 8.78 & 9.05 \\
QPSK & 5/6 & 7.3 & 8.5 & 15.6 & 8.29 & 9.22 & 9.76 & 10.05 \\
QPSK & 7/8 & 7.9 & 9.2 & 17.5 & 8.71 & 9.68 & 10.25 & 10.56 \\
\hline
16-QAM & 1/2 & 9.3 & 9.8 & 11.8 & 9.95 & 11.06 & 11.71 & 12.06 \\
16-QAM & 2/3 & 11.4 & 12.1 & 15.3 & 13.27 & 14.75 & 15.61 & 16.09 \\
\hline
64-QAM & 1/2 & 13.8 & 14.3 & 16.4 & 14.93 & 16.59 & 17.56 & 18.10 \\
64-QAM & 2/3 & 16.7 & 17.3 & 20.3 & 19.91 & 22.12 & 23.42 & 24.13 \\
64-QAM & 5/6 & 19.4 & 20.4 & 26.2 & 24.88 & 27.65 & 29.27 & 30.16 \\
64-QAM & 7/8 & 20.2 & 21.3 & 28.6 & 26.13 & 29.03 & 30.74 & 31.67 \\
\hline
\end{tabular}
\caption{\textit{CNR}_{\text{min}} \text{ for a DVB-T system.}}
\end{table}

Note 1. Quasi Error Free (QEF) means less than one uncorrected error event per hour, corresponding to BER = 10^{-11} at the input of the MPEG-2 demultiplexer.

Note 2. Net bit rates are given after the Reed-Solomon decoder.

received at the fixed rooftop receiving antenna front-end.

The value $P_d = -70$ dBm corresponds roughly to the power of the DVB-T signal to the edge of the DVB-T transmitter macrocell (in an urban environment is about 28 km).

Note that, as reported in Section 2, the FDD duplexing solution for 790-862 MHz UHF frequency band guarantees an effective virtual guard band (42 MHz) between UHF DVB-T channel 60 and LTE UE first block FDD uplink. For this reason, in this work has been analyzed only the TDD duplexing technique case study for LTE UE and FDD duplexing technique case study for LTE BS network implementation, as possible worst cases.

5.1 LTE UE Interfering

It should be underlined that, when a mobile network operator needs of using a TDD duplexing technique and have to transmit in a channel adjacent to the UHF DVB-T channel 60, the UE transmitter signal should be compliant to the LTE signal emission mask specified in the CEPT Report 30 (see Fig. 6).

In this case, simulating the worst case (that is when the DVB-T receiving antenna is at the edge of the cell coverage of the transmitter and the signal is 64QAM modulated), it results that the protection distance between the LTE-UE and the antenna of the DVB-T terminal fixed roof is in the order of just a few meters.

This result is possible as a consequence of the blocking mask severe requirements recommended by CEPT for the LTE-UE signal. In fact, as it is shown in Fig. 6, a quite consistent guard band (7 MHz) between the upper edge of the UHF channel 60 and the lower edge of the first available LTE channel (797-802 MHz) has been fixed. In addition, the out of band emission limit for LTE signal for frequencies below 790 MHz is equal to -74 dBm, that is very close to the sensitivity level of a DVB-T receiver (about -77 dBm).

5.2 LTE BS Interfering

A different result is obtained when the DVB-T receiving antenna is interfered by an LTE Base Station, using FDD duplexing technique. In the considered
simulation tests, the LTE BS can transmit a signal in a frequency band adjacent to the UHF channel 60. In this case the LTE BS signal must be compliant with the constraints imposed by the CEPT recommendation, reported in Table 5, where out-of-band emissions are subject to significant restrictions.

In Fig. 7 the emission mask of an LTE BS 5 MHz signal (EIRP: 43dBm/5MHz) is shown in case the protection of UHF channel 60 is required (case A in Table 5).

In Figs. 8-11 are reported the power of an interfering LTE BS antenna as a function of its distance (in meters) from fixed roof DVB-T antenna and considering Fig. 6 CEPT mask for a LTE UE (TDD) 5 MHz signal adjacent to UHF 60 channel.

### Table 5  Baseline requirements—BS BEM OUT-OF-BLOCK EIRP limits over frequencies occupied by broadcasting.

<table>
<thead>
<tr>
<th>Case</th>
<th>Frequency range of out-of-block emissions</th>
<th>Condition on base station in-block E.I.R.P., $P_{EIRP}$ (dBm/10 MHz)</th>
<th>Maximum mean out-of-block E.I.R.P., $P_{out}$ (dBm)</th>
<th>Measurement bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>For DTT frequencies where broadcasting is protected</td>
<td>$P \geq 59$ dBm, $36 \leq P &lt; 59$ dBm, $P &lt; 36$ dBm</td>
<td>$0 \text{ dBm}$, $P-59 \text{ dB}$, $P-23 \text{ dB}$</td>
<td>$8 \text{ MHz}$</td>
</tr>
<tr>
<td>B</td>
<td>For DTT frequencies where broadcasting is subject to an intermediate level of protection</td>
<td>$P \geq 59$ dBm, $36 \leq P &lt; 59$ dBm, $P &lt; 36$ dBm</td>
<td>$10 \text{ dBm}$, $P-49 \text{ dB}$, $P-13 \text{ dB}$</td>
<td>$8 \text{ MHz}$</td>
</tr>
<tr>
<td>C</td>
<td>For DTT frequencies where broadcasting is not protected</td>
<td>No condition</td>
<td>$22 \text{ dBm}$</td>
<td>$8 \text{ MHz}$</td>
</tr>
</tbody>
</table>
different received powers (in dBm) and DVB-T signal modulation formats, calculated for both the large and small urban environment. In each graph the dotted line indicates the maximum interference level of LTE signal power acceptable at DVB-T front-end antenna.

As a consequence, $d_p$ results from the intersection of the dotted line with the curve correspondent to the type of environment under observation. For example, $d_p$ value for a large and a small urban environment, in presence of a 16QAM DVB-T signal with -60dBm power level received at the fixed rooftop receiving antenna front-end, is respectively equal to 15 meters and 6 meters.

For completeness, Tables 6 and 7 summarize the results obtained respectively in large urban and small urban environment scenarios.
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Fig. 9  DVB-T 16QAM ($P_d = -70$ dBm).

Fig. 10  DVB-T 64QAM ($P_d = -60$ dBm).

Fig. 11  DVB-T 16QAM ($P_d = -60$ dBm).
Finally, Fig. 12 has been plotted Protection Distance values in function of the DVB-T signal power received at fixed roof antenna for both signal modulation formats (64QAM and 16QAM) and type of propagation environment (large and small urban environment).

6. Conclusions

In the present work the problem of coexistence of DVB-T and LTE mobile communication systems operating in the UHF frequency band has been analyzed.

A simulation software tool has been employed to determine the Protection Distance parameter $d_P$ in fixed reception environment, in presence of LTE interfering signals originating from base station and user equipment.

According to the obtained results, reported in the above mentioned tables, it is expected that, in presence of an LTE BS interference signal operating with FDD duplexing technique, the Protection Distance decreases as the power signal strength $P_d$ received at DVB-T antenna increases, for both the considered modulation schemes. In fact, the modulation format of DVB-T signal significantly affects the value of Protection Distance, since the required signal to noise ratio for a proper decoding in 64QAM modulation scheme is greater than the 16QAM modulation one. This trend is even more evident in presence of large urban environment.

It should be noted finally, despite the overestimation of the results, the great value of the Protection Distance required in the large urban environment scenario at the edge of DVB-T macrocell (-70 dBm) with 64QAM modulation scheme.

This criticism highlights the fact that the exclusive use of the BEM is not enough to solve the problem of interference from adjacent channels (especially at the edges of the DVB-T cell) and that it is necessary, as suggested in Refs. [9, 11-12], the use of mitigation techniques to be adopted in addition to the above blocking edge mask.

### Table 6 Large urban environment.

<table>
<thead>
<tr>
<th>$P_d$ (dBm)</th>
<th>Modulation</th>
<th>Protection Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-70 dBm</td>
<td>64 QAM</td>
<td>543 m</td>
</tr>
<tr>
<td>-70 dBm</td>
<td>16 QAM</td>
<td>172 m</td>
</tr>
<tr>
<td>-60 dBm</td>
<td>64 QAM</td>
<td>49 m</td>
</tr>
<tr>
<td>-60 dBm</td>
<td>16 QAM</td>
<td>15 m</td>
</tr>
</tbody>
</table>

### Table 7 Small urban environment.

<table>
<thead>
<tr>
<th>$P_d$ (dBm)</th>
<th>Modulation</th>
<th>Protection Distance (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-70 dBm</td>
<td>64 QAM</td>
<td>222 m</td>
</tr>
<tr>
<td>-70 dBm</td>
<td>16 QAM</td>
<td>67 m</td>
</tr>
<tr>
<td>-60 dBm</td>
<td>64 QAM</td>
<td>49 m</td>
</tr>
<tr>
<td>-60 dBm</td>
<td>16 QAM</td>
<td>6 m</td>
</tr>
</tbody>
</table>

Fig. 12 Protection distance—simulation results.
On the contrary, the results obtained in presence of an LTE UE interference signal operating with TDD duplexing technique, have shown a very little impact on DVB-T. In fact, the interfering power becomes relevant only when $d_p$ values are around the range of 1 meter.

It is important to highlight that these results have been obtained through an estimation calculation process since, in the implementation of the simulation tool, the spectrum of the interfering signals has been approximated with the correspondent block emission spectrum mask and the RF filter at the receiver DVB-T set-top-box has been approximated with an ideal one.

Nevertheless, the extensive use of the proposed approach in different application scenarios could help to provide valuable inputs into the design and implementation of new cellular networks in the UHF band.

References

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