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LTE 800 Low pass filter

Second subsequent report by the German TV-Platform concerning the compatibility of broadcasting and mobile telephony in the UHF frequency band

1. Initial situation

Within the digital dividend process, the UHF frequency range of 790 MHz to 862 MHz (800 MHz range) previously assigned to broadcasting was assigned to mobile telephony applications. Now, the primary objective of this frequency range is to provide wireless broadband connections for Internet access in such areas where there is none or insufficient wired infrastructure. When reassigning the 800 MHz range, the Bundesnetzagentur (German Federal Network Agency) mandated the mobile operators to first cover rural areas without internet access before extending the new services to metropolitan areas.

The selling of the frequencies in the 790 MHz to 862 MHz range was performed as an auction; bids were accepted from Telefonica Deutschland (O2), Telekom Deutschland and Vodafone and all three providers will be running the latest generation of mobile telephony (4G). This is LTE (long term evolution), that will also be used in the 1.8 GHz and 2.6. GHz frequency bands. In order to prevent misunderstanding in this report, the use of the 800 MHz band is called LTE800.

For LTE800, the following frequency use applies:

<u>Downlink</u> i.e. base station transmission to LTE800 end device: **791 MHz to 821 MHz**

<u>Uplink</u>: i.e. LTE800 end device transmission to base station: **832 MHz to 862 MHz**

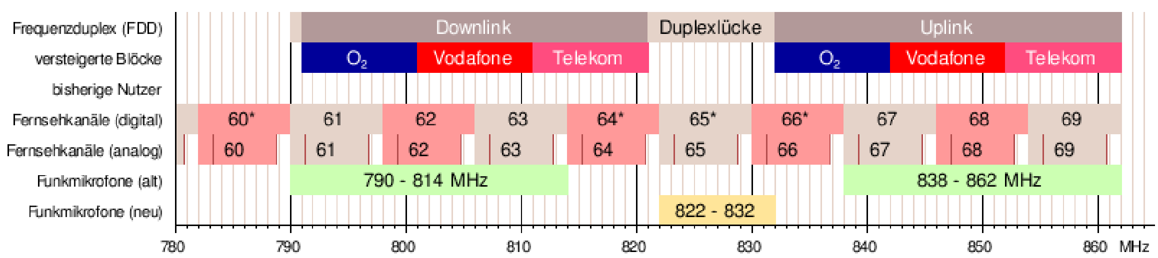

Figure 1: Result of the frequency auction from May, 2010

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The range of 30 MHz each are divided into three blocks of 10 MHz, whereby each of the aforementioned mobile telephony providers has been assigned one block. The spacing between downlink and uplink always is 41 MHz, i.e. the end devices of the provider that has been assigned the 791 MHz to 801 MHz block will transmit within the 832 MHz to 842 MHz range.
The 790 MHz to 791 MHz and 821 MHz to 832 MHz frequency ranges serve as guard bands from the broadcast frequency range up to 790 MHz, as well as a guard band between downlink and uplink. In the preparation of the auction, several studies had recommended to use wider guard bands in order to limit possible interferences from the start.

2. Problem regarding DVB-T

DVB-T digital terrestrial television was originally designed to be able to use simple means to provide uncomplicated terrestrial reception virtually everywhere ("Überallfernsehen"). The technical design of the DVB-T devices and appropriate accessories (particularly antennas) was carried out based on the assumption that operation would be within a broadcast band in which – apart from strong neighbouring broadcast signals – there were no further strong HF signals within close frequency or physical proximity. With the introduction of LTE800 in the UHF broadcast band V (790-862 MHz), that situation will change radically.
High frequency transmissions from LTE base stations and LTE end devices can generally have an effect on the television reception of the entire UHF band, where only the frequency range below 790 MHz is still available for television applications. DVB-T reception disturbance becomes noticeable in the form of image and sound dropouts or blocking, right through to complete blackout.
All DVB-T reception devices and antennas that are already in the market – particularly active antennas – continue to receive all signals up to 862 MHz. This means that LTE800 signals are received unattenuated at the antenna input of the receiver or the antenna amplifier. This can cause interference in various ways to the DVB-T reception, the extent of which is dependent on the tuner concept in use, as well as on concrete signal conditions in terms of volume and frequency.
The reasons for interference of DVB-T reception are manifold and they arise primarily from:

- too high LTE signals in comparison to the wanted DVB-T signals i.e. the receiver is not capable of clear differentiation
- too high absolute disturbance level i.e. the receiver or the preamplifier (in particular in active antennas) is overloaded;
- intermodulation of several signals and superpositioning of the mixed products with the actual DVB-T signals to be received; "several signals" in this case can be LTE signals as well as DVB-T signals.

Interference of the DVB-T reception can also be caused by direct radiation of LTE800 signals into the housing of DVB-T receivers. The probability of such radiation can only be reduced by increased shielding measures to an appropriate level – both to the receivers as well as to all cables and plugs . In case of existing devices, such retrofitting can either not be performed at all or only in most unusual environment. New (future) DVB-T receivers could of course be manufactured with better shielding performance which would however increase their cost and – assuming justifiable expenses – would only improve radiation resistance in relative terms against current levels and not in absolute terms.

3. The implementation of filter technology

3.1 Ideal filters

The task of an *ideal* LTE800 low pass filter is to allow all frequencies up to 790 MHz to pass without influence on the DVB-T signals to be received, while completely blocking all frequencies above 791 MHz. To achieve a *real* filter solution, an insertion loss of less than 1 dB must be assumed in respect of the passband, while the stopband attenuation can be between 30 dB to 50 dB. Attenuation below 790 MHz can effectively lead to a reduction of the reception area as weak signals (that can still be received) are becoming even weaker.

On the other hand it should be considered that modern receivers – particularly in flatscreen televisions – are often fitted with multinorm tuners, i.e. they are capable of receiving several DVB signals e.g. DVB-T and DVB-C. Any LTE800 filter as described above would then also significantly limit the frequency range for DVB-C reception.

Thus solutions must be sought that:

a)ensure the aforementioned requirements in respect of the interference-free reception of DVB-T;

b) concurrently attenuate LTE signals as strongly as possible up to 862 MHz and also beyond that in perspective and

c) at the same time do not limit the reception area for DVB-C in multinorm devices.

It is required to provide appropriate filters at reasonable cost in relation to the tuner and in compact size.

3.2 Limitations with real filters

Real filters always have a certain attenuation in the passband; the so-called insertion loss. As this affects the receptivity of DVB-T or can significantly increase the costs of these networks within the scope of new planning of DVB-T/T2 networks, the value to be demanded is clearly below 1 dB.

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The second important parameter is the attenuation of such filter within the stopband. From several studies - e.g. from the British regulator Ofcom- this results in a minimum required attenuation of at least 30 dB.

What is particularly critical is the slope steepness of the filter. This is the transition between the passband and the stopband. i.e. how quickly that filter - based upon a minimum insertion loss - can reach a certain stopband attenuation. Assuming a stopband attenuation of 30 dB, then given the frequency gap of 1 MHz between the end of the passband (790 MHz) and start of the stopband (791 MHz) a slope steepness of 30 dB/MHz would be required.

Filters may, after all. not cause any distortion of signals in the time range across the whole bandwidth (group delay).

4. Solution approaches

Low pass filters can be fundamentally realized with passive components or with active filter circuits (with power supply). In both cases they are functionally placed in front of the antenna inputs to DVB-T receivers.

In the case of passive components there are many realisation opportunities e.g. using discrete components (coils, capacitors) and taking advantage of certain physical effects (e.g. surface acoustic wave filters, SAW).

Current studies in DVB indicate that filters with the aforementioned requirements are not workable. This is particularly because the slope steepness of filters that are cost-effective and can be manufactured with relatively moderate dimensions has a maximum steepness of 10 dB/MHz. The British regulator Ofcom comes to similar results in its current field test[1]. Here, interference from LTE broadcasts could be reduced in the frequency ranges of 801 MHz to 811 MHz and 811 MHz to 821 MHz, but in respect of the first block of 791 MHz to 801 MHz, this was not quite successful. This was subsequently also confirming measurements of the Heinrich Hertz Institute in its report to BMWi 2009 concerning the necessity for a protection band between LTE800 and terrestrial broadcasting. The HHI concluded here that due to the technical capabilities of filters, a protection band of at least 10 MHz would be required.

At present, there are practically no usable (effective) LTE low pass filters available on the market. Often their insertion loss is much too high, even in the channels to be received, so that the inclusion can lead to reduced reception. Even if this insertion loss only applies to channels that cannot be received for the time being at the particular location, this could change in the near future e.g. in the case of new DVB-T2 services such as HDTV, increased program offering and mobile applications.

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[1] ERA Technology Report 2010-0026 2 Ofcom 2221/PCFT/R/1.2

5. Outlook

Fundamentally, filters could contribute towards reducing the risk of LTE800/DVB-T interference for existing devices. Their use would, however, be strongly dependent upon the individual interference scenario and would just be one of several possibilities.

It should be taken into consideration that existing devices (DVB-T receivers, active antennas etc.) cannot be effectively retrofitted. There is currently no technology in view that could enable the realization of such filters. There will be situations where filters can be retrofitted but these would have to be individually adapted to a concrete reception situation at the appropriate location. In this respect it is not an economically feasible solution.

The currently very popular active room antennas are generally of no further use in the event of interference. In some cases, a reduction of the interference risk will only be possible with reduction of the output at the LTE base station or a modification of its antennas. In particular at short distance, the risk of interference between LTE-800 end devices and DVB-T receivers increases rapidly.

In total, it must be expected that a reduction of the risk of interferences by using filters will not be achieved.

Apart from the aforementioned problem of fundamental availability of appropriate filters, the question of time is essential in the case of DVB-T receivers. Such devices may only be brought to market with modified specification after an appropriate standardisation has been concluded. As of today a closing date for this process is not foreseeable.

Apart from this it can also be expected that such devices will only be produced when a real market demand exists. In this respect, it should particularly be noted that the digital dividend in Europe is introduced with different timing i.e. in many countries the reception of DVB-T signals in the respective channels 61 to 69 will still be possible in 2012 or even 2013. This applies in particular to such important markets as Great Britain, Spain or Poland. In Italy, there are no plans at the moment to introduce LTE 800.

Either way, there will be additional costs arising and it not yet clear by whom they will be covered. The tracing of the causes of radio communications interferencies is the responsibility of the Bundesnetzagentur and in particular their testing and measuring departments. It is therefore important that interference is communicated to the Bundesnetzagentur , since it is a case of radio communications interference. It is only in this way that it can be made responsible for costs to be borne by third parties – specifically the mobile network providers – who could then, given proof, be traced as the responsible party. The national hotline of the Bundesnetzagentur for radio communications interference is: 01803 / 23 23 23[2].

6. Summary and conclusions

With this report presented at IFA 2011, the German TV-Platform continues its contribution to the possible interference problems between LTE 800 and DVB-T. Following the compatibility reports in 2009 and 2010, the filter solutions hoped for are at the centre of the discussion this time. Irrational expectations of non-existent "wonder filters" are not supported by technical reality and the legend that receivers will become more robust to these interferences "by themselves" can also be filed within the category of wishful thinking.

The discussion between the market participants should much more be rendered objective by this document and methods identified to find improvement of the situation by means of partnership on equal terms. Using add-on filters alone will not remedy potential interference. This applies to integrated televisions and settop boxes and even more so to portable and mobile receivers, to say nothing of the million of factory installed automotive receivers with active window antennas.

[2] Landline call charges 9 ct/min; mobile call charges 42 ct/min max. This service number is accessible 24 hours per day. The website of the Federal Network Agency points out that measures required from it to clarify radio communications interference are free of charge to the person who has communicated the interference.

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