Managing Radio Interference

Coexistence between broadcasting and mobile in the UHF TV band

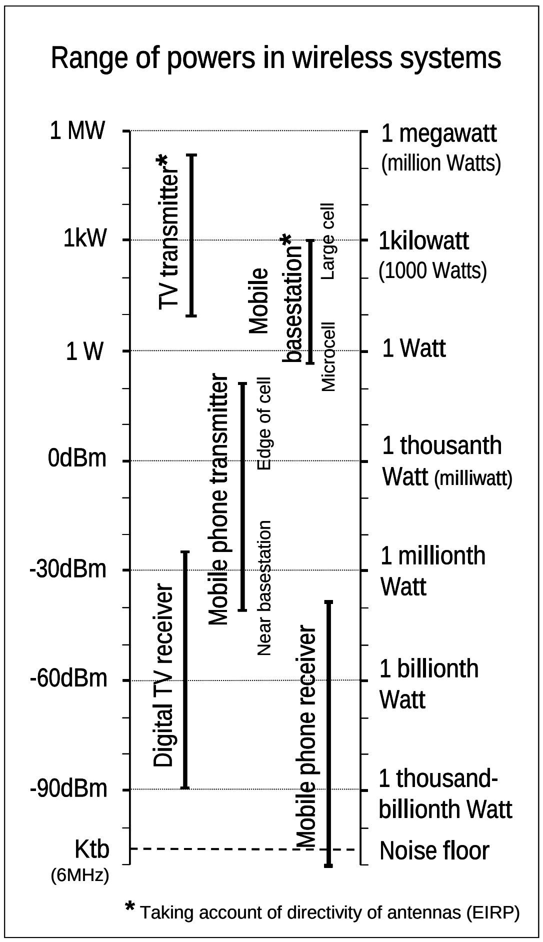
Summary

Radio signals are difficult to contain, both in space and in frequency. There is always the potential for transmissions from one wireless system to cause interference to other signals on neighbouring frequencies or at nearby locations. Broadcasters are rightly concerned to ensure that the introduction of mobile services within the digital dividend spectrum in the UHF band does not interfere with television reception, and mobile operators are equally concerned to ensure that this does not happen.

Over the last hundred years, many techniques have been developed to manage the interference between radio systems. Mobile systems will only be permitted to operate in the digital dividend spectrum once there is assurance that the frequencies that they will use and the techniques that they will employ to avoid interference will prevent interference to reception of broadcast television reception. This will be confirmed by technical studies conducted within CEPT.

Introduction

Radio waves are a form of electromagnetic radiation, just like visible light, infra-red or X-rays. Like visible light, they are difficult to constrain – they generally travel in straight lines from the transmitter, getting weaker as they spread out. Unlike light, they can penetrate walls and 'bend' around corners to some extent. Eventually they become reduced below the level of background radiation from the earth's surface (the thermal noise floor), and they can no longer be received. The level of this 'noise floor' is extremely low – many radio systems can successfully receive a signal that is at least a million billion times weaker than what was transmitted (see diagram).



Radio signals are characterised by the frequency on which they are transmitted. To receive a radio signal, it must be above both the noise floor and the level of any unwanted signals on the same frequency. These unwanted signals are called interference.

What causes interference?

Radio signals have a tendency to spill into other frequencies, and can then cause interference to other radio signals on those frequencies. There are technical ways to constrain a radio signal to its operating frequency and to limit this interference, and we have become much better at doing so with advances in technology. These have costs in terms of equipment price, energy efficiency and the ability of the equipment to operate on multiple frequencies.

The effect of these limitations is greatest when different signals are immediately adjacent in frequency. The traditional way to manage interference has therefore been to put small "guard bands" between different spectrum users, which are either left vacant or used less fully.

However, these guard bands reduce the overall efficiency of use of the spectrum. Today, spectrum regulators ensure that other techniques are used as far as possible to mitigate the effects of interference, to minimise this loss of usable spectrum.

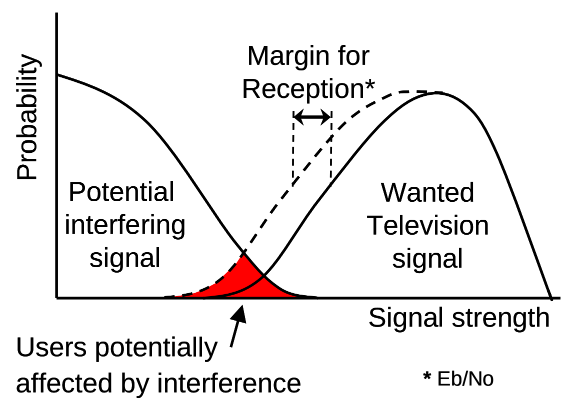
Managing interference is not only an issue between users but also for each individual spectrum user. Every frequency must be reused many times in different geographic areas. It is therefore necessary to predict how far these areas need to be separated to avoid transmissions in one area causing interference to users in another. Major spectrum users perform this analysis to make the most effective use of their spectrum, and regulators do so to ensure that licence holders do not interfere with each other. The European spectrum regulators are global leaders in this field, through their joint body CEPT, which has developed the world-leading SEAMCAT software tool for this purpose. The GE06 agreement for digital television broadcasting in Europe is basically a plan for deploying digital television transmitters without causing interference to the service areas of other transmitters.

There are many ways to reduce interference

- Increase the physical separation between the transmitter and receiver.
- Increase the frequency separation between them.
- Increase the strength of the wanted signal.
- Reduce or minimise the power of the unwanted signal.
- Improve the quality of the transmitted signal so that less of it spills into neighbouring channels.
- Improve the performance of the receiver, so that it is able to reject strong signals on neighbouring frequencies.
- Insert a frequency-selective filter between the receiver and its antenna, to reject strong signals on neighbouring frequencies.
- Modify the shape of the signal radiated by a transmitter, so that it is reduced in the direction of the affected receiver.

Managing interference between systems

Everybody has experienced the variability of broadcast radio reception or mobile phone coverage. No wireless system can guarantee to provide a service to every user, whatever their location, for 100% of the time. They are therefore planned to provide a defined grade of service for a certain proportion of users (or locations) and percentage of time.



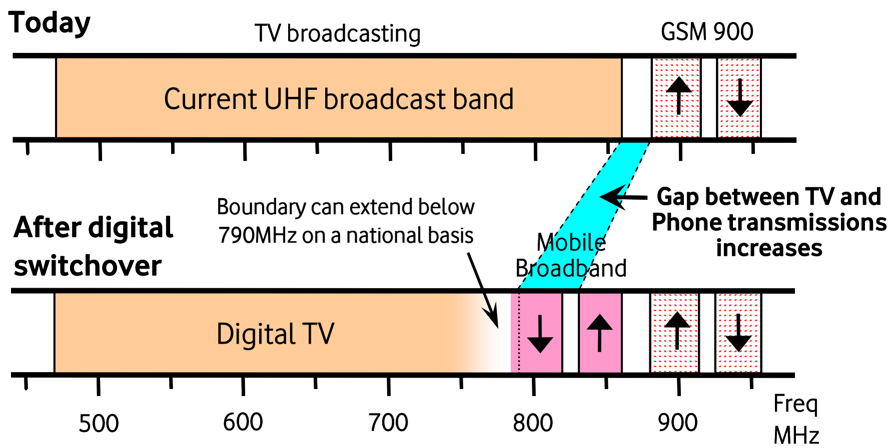
Interference occurs when an interfering signal exceeds a margin below the level of a wanted signal. Interference mainly affects the users with weak signals, and even then, the interference will exceed this margin in only a small proportion of cases. Interference that exceeds this criterion is known as "harmful interference" in EU.

For a new service to be introduced in the radio spectrum, it must be demonstrated that it does not cause harmful interference to existing users that have rights to protection from interference. This means that there should not be any significant change in the overall grade of service to existing spectrum users.

Co-existence in the UHF TV band

Mobile operators are among the most intensive users of the radio spectrum. They have narrow frequency bands shared between several operators, and some of the neighbouring bands are heavily used. They therefore have considerable experience in managing interference. In contrast, the UHF TV band is very wide, with generally only one broadcast transmission operator[1]. Broadcasting was the first widespread use of the UHF band. Broadcasters have therefore needed less experience in managing interference between different users on neighbouring frequencies.

Mobile services generally use separate frequency ranges for basestations and handsets to transmit in, called the downlink and uplink bands. The transmissions from handsets have more potential to cause interference to broadcast reception, because they can be used close to television sets with indoor antennas. It is therefore expected that the mobile frequencies will be arranged so that the uplink band is furthest from the television channels[2].



Note that the minimum frequency separation will be greater than at present if mobile uses digital dividend spectrum as envisaged[3]. The risk of interference will therefore be no greater than today – and probably less[4]. Furthermore, most broadcast networks use different frequencies for the same "multiplex" in neighbouring areas, to avoid one transmitter causing interference to viewers receiving signals from another. The highest DVB-T frequency will therefore only be used in around one sixth of a country, and typically there will be several unused TV channels between the top channel in use and any mobile services.

The downlink transmissions from the mobile network will come from basestation antennas at the top of a mast. This is similar to the configuration of a broadcast network, so the interference to TV sets from mobile transmitters is unlikely to be substantially different to broadcasting. Advances in technology make it possible for these transmissions to spill less into neighbouring channels (i.e. the broadcast spectrum) than for the existing mobile bands.

Any interference would therefore be limited to a small area around a basestation and to areas where the television signal is weak. If this situation arises, a small booster for the television signals can be installed at the basestation, to increase the signal strength of television reception within this area.

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[1] In countries with more than one broadcast transmission operator, they coordinate very closely.

[2] This arrangement is called a bandplan. This bandplan for the digital dividend spectrum has the uplink and downlink bands in the opposite order to the GSM900 band and almost all existing mobile bands. This would double the separation to a minimum of 38 MHz between the top TV channel and transmissions from terminals, compared with the current 18MHz separation between the highest TV (channel 69) and the 900 MHz GSM (GSM 900) uplink band.

[3] This reversal of duplex direction has the incidental benefit that the mobile uplink band is close to the GSM 900 uplink band. This avoids interference between terminals in these two bands and simplifies the manufacture of multi-band terminals.

[4] It is possible under some circumstances for transmissions to cause interference on multiples of the transmission frequency, called harmonics. For the mobile bandplan envisaged for the digital dividend spectrum, the harmonics fall in frequency bands where they are unlikely to cause any interference to the services in these bands.

If necessary, a guardband can be placed between the mobile and broadcasting spectrum.

These techniques will prevent the vast majority of cases of interference. However, if a few stubborn cases remain, these can be simply resolved by fitting a small filter costing a few Euros in the antenna cable of affected television receivers. This technique was used successfully in UK during the introduction of the fifth analogue television channel (Channel 5), to resolve a similar interference problem.