EDITION 8

R-Book

UK DIGITAL TELEVISION

DTG
THE CENTRE OF UK DIGITAL TV

Contents

Introduction

The first R-Book – a publication covering the installation of digital television receiving systems - was written in 2001 with the last update (R-Book 7) published in 2017. The 'R' stands for reception, although the original books also covered cabled distribution systems.

Since the first book, the television industry has undergone a technical transformation, including the migration from analogue services and the introduction of DVB-T2 transmission technology.

In parallel, demand for spectrum has increased at pace resulting in a range of new technologies and services operating at frequencies in and around those utilised by digital television.

For example, a major engineering exercise was recently completed to move all DTT transmissions out of the 700 MHz band and into the 470-694 MHz band to make way for mobile services. This required a widespread reorganisation of frequencies used by DTT.

In order to provide guidance on how these changes could impact digital television reception, the DTG and CAI have worked in partnership to bring the R-Book up to date. The aim is to support and prepare the installation industry with how to deal with the impact of spectrum changes on working practices, as well as practical advice on interference mitigation and the latest industry guidelines.

R-Book 8 retains this valuable information but also builds upon it with the following key updates:

- Details of the latest DTT frequency changes including the removal of COM7 and COM8 from UHF channels 55 and 56 and the impact on installations;
- A new section on the European IRS Certification Scheme (EICS) which provides independent testing assurance for DTT and satellite distribution equipment for MDUs;

Version	Date of issue	Comments
R-Book 8	20/04/2022	Draft V1
R-Book 8 Draft V2	26/04/2022	Updated section 2 added
R-Book 8 Draft V3	06/05/2022	Review by PB and AB
R-Book 8 Draft V4	16/05/2022	Review by PB and AB Addition of captions and cross-references
R-Book 8 Draft V5	17/05/2022	Removed text on frequencies below 470 MHz from the Ofcom Policies section as it is already included in the Increasing Demand for Spectrum section
R-Book 8 Draft V6	27/05/2022	Comments from CAI, RF Group, and Restore TV included

Section 1
Background of spectrum use

DTT viewing share strong

Free to air digital terrestrial TV (DTT) is still a popular television platform in the UK with 40% of homes using this as their primary source of TV[1]. It provides viewers with significant benefits including universal coverage and free to air services. This has become further enhanced, via an internet connection, by the availability of catch up and interactive services as well as ancillary screen, HD and PVR technology.

The latest **BARB** figures (Q4 2021) shows that total broadcaster[2] monthly viewing accounted for 68% of the **overall total**.

Ofcom has stated that it believes DTT is likely to retain a central role in the UK over the next decade, with DTT broadcasting continuing in 470-694 MHz until at least 2030, and probably longer[2]. As part of this, the UK government has given Ofcom permission to extend the multiplex licences for the Freeview DTT platform through to 2034. A suitable revocation clause is to be included in these licences to cover any circumstances arising, but that could not be used before 2030.

Therefore, the DTT industry continues to work to ensure it meets consumers' expectations until at least 2030.

Increasing demand for spectrum

The spectrum used by DTT has been under increasing pressure for use by other sectors due to the favourable propagation characteristics of these frequencies. This has led to a need for DTT receivers to work alongside other technologies operating in both adjacent and the same frequency bands and means that DTT installations will need to account for the potential of new technologies becoming sources of interference.

In addition, existing services such as Programme Making and Special Events (PMSE) require access to share DTT spectrum. The implications for installation practices are covered in Section 2 of this guide.

The list below highlights the new and existing technologies and services that utilise UHF spectrum and that are explained further in this guide:

- DTT services including local TV multiplexes
- 800 MHz mobile services
- 700 MHz mobile services
- Programme Making and Special Events (PMSE) equipment

In addition, existing services such as Programme Making and Special Events (PMSE) require access to share DTT spectrum. The implications for installation practices are covered in Section 2 of this guide.

1 Total broadcaster viewing – time spent watching linear broadcast channels and BVOD services, including live viewing, pre- and post-broadcast viewing and viewing to archive box-sets on a BVOD service. Viewing is reported across four screens (TV sets, tablets, PCs and smartphones). For tagged services, this includes any viewing streamed through something other than the home WiFi network.

2 UK position on UHF spectrum for WRC23

The list below highlights the new and existing technologies and services that utilise UHF spectrum and that are explained further in this guide:

- DTT services including local TV multiplexes
- 800 MHz mobile services
- 700 MHz mobile services
- Programme Making and Special Events (PMSE) equipment

DTT services

The DTT platform carries a wide range of TV channels. DTT transmitters broadcast a number of signals, called multiplexes, each of which contains multiple TV channels or radio services. Currently, the following multiplexes hold licences to broadcast on the DTT platform (updates can also be seen on the CAI website):

- Three Public Service Broadcasting (PSB) multiplexes – BBC and D3&4 provide these multiplexes. They broadcast from all of the transmitters in the DTT network and are available to around 98.5% of households. These multiplexes carry a range of PSB services, including the BBC's channels, ITV, ITV2, 3 and 4, Channel 4 and Channel 5. Two of the multiplexes carry Standard Definition (SD) channels only. One of the multiplexes carries the High Definition (HD) variants of some of the PSB channels.
- Three commercial multiplexes – these are licensed to Arqiva Services Limited and SDN. They broadcast from the largest 80 transmitters but not from small relay transmitters, achieving coverage of around 90% of households. These carry a wide range of channels including ITV 2+1, ITV 3+1 and ITV 4+1.
- Northern Ireland multiplex – one multiplex that broadcasts RTÉ and TG4 services from three transmitters and covers approximately 78% of households in Northern Ireland.
- Local television multiplexes – these broadcasts local TV services in over 30 locations across towns and cities in the UK. The general principle is that local TV is transmitted from the same mast as national services so that households do not need to re-position their aerial to receive it. Local TV is transmitted on channels 21-48 as per the national service but typically it is transmitted at about half the height of the main aerial due to the smaller coverage area required. It is also generally transmitted at a lower power compared to the national commercial and public service broadcast multiplexes but using a more robust transmission mode to compensate.
- Geographic interleaved spectrum multiplexes - two portions of spectrum that can be used to provide a DTT multiplex in Manchester and Cardiff. The service in Cardiff has not been launched.
- Interim multiplexes – In 2013 Ofcom awarded interleaved spectrum in the 600 MHz spectrum band (550-606 MHz) to Arqiva on an interim basis by granting a single licence for the establishment of two temporary DTT multiplexes (COM7 and COM8) using DVB-T2/MPEG4 technology. These multiplexes carried a range of HD and SD services and covered around 76% of households. However, COM8 which was transmitted on UHF channel 56 came off air on 22nd June 2020 and COM7 which was transmitted on UHF channel 55 came off air at the end of June 2022.

800 MHz mobile services

The increase in demand for spectrum saw former TV frequencies in the 800 MHz band (790-862 MHz, channels 61-68) auctioned to mobile operators in 2013. TV services using channels 61-68 were moved to lower channels to accommodate this change.

700 MHz mobile services

The 700 MHz band (694-790 MHz, channels 49-60) was auctioned to mobile operators in 2021. DTT services operating in channels 49-60 were moved to lower channels to accommodate this change and interim multiplexes COM7 and COM8 were closed.

Programme Making and Special Events equipment (PMSE)

PMSE equipment such as wireless microphones, in-ear monitors and wireless cameras has access to the same frequencies that DTT uses. Channel 38 (606-613 MHz) is exclusively for PMSE use for wireless microphones in the UK and is therefore not used for DTT. PMSE equipment can also use other DTT channels on a coordinated basis. Due to the managed process of allocating licences to PMSE equipment, the risk of interference between PMSE and DTT is minimal.

Frequencies below channel 21

The frequency bands immediately below DTT channel 21 are known as UHF1 and UHF2 and cover 410-470 MHz. This band is used for a wide range of services including business radio, Programme Making and Special Events (PMSE), emergency services, maritime and aeronautical services, licence exempt services and amateur radio.

These services are not expected to cause widespread coexistence problems for DTT; in other words, interference caused by them is expected to be rare.

Ofcom's announced policies and date – 700 MHz mobile services (694-790 MHz, channels 49-60)

Overview of 700 MHz mobile services

The 700 MHz band was identified as a potential candidate for mobile broadband spectrum due to the band's favourable propagation characteristics as well as the opportunity to allocate the same band to mobile services in many regions around the world. The advantage of having harmonised spectrum allocations will be a reduction in the cost of network and user equipment required to deliver mobile broadband services due to increased economies of scale. In addition, it will lead to improved consumer experience when roaming between different countries as it will be possible to use the same handset in multiple regions.

Key points associated with 700 MHz clearance:

- The change of use of the 700 MHz band (channels 49-60) to make it available for mobile services was confirmed at WRC 15;
- Clearance of 700 MHz frequencies ran from 2017 to 2020; The interim multiplexes known as COM7 and COM8 were temporarily moved into channels 55 and 56 from their original channels (31 to 37, excluding 36) during the clearance. This was to allow the 6 other main multiplexes currently using 700 MHz frequencies to be moved into channels 31 to 37 to clear the 700 MHz band. The interim multiplexes were then turned off by the end of June 2022 to make way for mobile use in channels 55 and 56.

Potential for 700 MHz mobile services interference

As was the case with 800 MHz coexistence, base station interference to DTT services could still occur at 700 MHz. The principal mechanism for interference is likely to be overload, particularly of amplified installations. Interference caused by uplink signals from mobile handsets could be more of a problem at

700 MHz than at 800 MHz due to handsets using frequencies close to DTT channel 48. These signals can be picked up by rooftop antennas and presented at the input to the receiver. The transmitted power from handsets is much lower than from base stations, but as handsets will generally be closer to TV aerials than base stations, there is potential for impact to DTT services.

As with 800 MHz interference, the use of 700 MHz band filters is one of the solutions available to mitigate issues. Additionally, Restore TV which was previously at800 is available to support viewers who experience DTT interference caused by mobile services.

The immediate impact of the 700 MHz clearance on DTT installations will be the choice of aerial installed. With any aerial installation expected to span years and possibly tens of years, future-proofing through selecting the correct aerial will help prevent issues when 700 MHz mobile services come in to service. Further details of the type of aerial to choose, in order to future proof installations as well as interference mitigation techniques, are given in Section 2 of this document.

Figure 1 *Example of picture failure caused by interference*

Legislative requirements for TV and satellite equipment

The Radio Equipment Directive (RED) is EU legislation designed to ensure that equipment sold in the EU meets minimum technical requirements and to encourage the use of common standards. Following Brexit, the UK has its own version called the Radio Equipment Regulations 2017 (RER). According to these Directives, products must demonstrate that they have met requirements for health and safety (H&S), electromagnetic compatibility (EMC), and spectral efficiency, i.e. radio performance prior to being placed on the market.

Examples of products that fall under RER are:

- **Broadcast receivers** e.g. TV receivers, DAB/DAB+/DRM/FM/AM radios
- **Amplifiers** such as loft and masthead amplifier for distribution of TV signals
- **Multiswitches and dSCRs**
- **Active antennas** such as indoor antenna for TV reception that contain amplifiers
- **Satellite receivers and LNBs**

Note: this list is not exhaustive and any products that intentionally emit or receive radio waves are required to demonstrate compliance to the RER.

How to demonstrate compliance to RER

In order for manufacturers to demonstrate their products have complied with RER they must test them against internationally agreed standards such as the ones listed below.

For some product types e.g. multiswitches, there are no agreed standards available. In cases like this the manufacturer must test their products using tests they see fit to demonstrate compliance, and then have these test reports signed off by a UK Approved Body (such as DTG Testing). The European IRS Certification Scheme (EICS), run by DTG and CAI (see section on EICS below) is an example of an test specification that could be used for demonstrating compliance in the absence of internationally agreed standards.

The following list shows examples of specifications for radio performance (H&S and EMC requirements also need to be met) and to which products they apply (these are freely available from the ETSI website):

- EN 303 340 – Digital Terrestrial TV Broadcast Receivers
- EN 303 354 – Amplifiers and active antennas for TV broadcast reception in domestic premises
- EN 303 372-1 Satellite earth stations and systems; satellite broadcast reception equipment; Part 1: Outdoor unit
- EN 303 372-2 Satellite earth stations and systems; satellite broadcast reception equipment; Part 2: Indoor unit

Market access for the UK - New product requirements for cyber security

In addition to the radio, EMC and H&S requirements, new cyber security requirements for network connectable products e.g. devices with Bluetooth, Wi-Fi, or ethernet connections will come into force in the UK over the next 2 years. Although the requirements don't apply directly to many of the components of a typical TV reception system, such signals may be fed into another system containing network connectable products as described above which must comply with the cyber security requirements.

As part of this, a new bill is being introduced called the Product Security and Telecommunications Infrastructure Bill (PSTI) which will stipulate that consumer IoT products must meet minimum cyber security requirements to be placed on the UK market. There is no specified date for when this will be introduced but it is currently going through parliamentary process which can be tracked here.

The market access requirements will be underpinned by a standard called ETSI EN 303 645 Cyber Security for Consumer Internet of Things: Baseline Requirements. DTG Testing has set up SafeShark, a test company to provide product testing against the EN 303 645 standard in preparation for the legislation. This is backed by certification from the British Standards Institute (BSI).

The European IRS Certification Scheme (EICS)

DTG Testing and CAI have launched a Europe-wide assurance scheme for TV and Satellite distribution equipment known as the European IRS Certification Scheme (EICS).

Experience has shown that problems do arise caused by factors such as communication and power support issues between different elements of the reception and distribution equipment. This leads to post installation call backs, increased support costs and ultimately unhappy customers.

The EICS scheme therefore aims to 'provide reassurance of end-to-end device compatibility, interoperability and robust RF performance within satellite and DTT distribution systems.'

The scheme has been developed through an industry collaboration of satellite and DTT platforms, major equipment manufacturers, and led by industry associations DTG and CAI. It consists of a test specification underpinned by international standards and a consumer-facing logo. Manufacturers of equipment such as receivers, dSCRs, multiswitches, fibre gateways, launch amplifiers and LNBs can display the logo on their products after successfully passing the required tests.

Supported by the leading retailers, the logo ensures a high quality of experience for the end customer. End-users, such as installers, specifiers, housing associations and platform operators can use the logo to recognise equipment that is compatible with all major satellite and TV services; and therefore interoperable with other EICS equipment.

Details of the scheme can be found **here**.

A list of products certified under the scheme can be found **here**.

Section 2
Installation practices

Introduction

This section provides an overview of typical DTT and satellite distribution equipment that's available as well as examples of typical scenarios for which they may be deployed. There is also an overview of technologies that could potentially cause interference to DTT and satellite services and the techniques that can be employed in order to mitigate the risk as far as possible.

Cases of interference can be very difficult to solve, especially when they are intermittent. It is particularly important to have a good understanding of interference in its many forms, and also the behaviour of receivers and amplifiers, if an installer is to be successful in resolving interference problems.

Consider the case of a receiving installation that has been working well. A mobile services base station is powered up nearby and provides sufficient interference to move the operating point of the receiver into the region close to failure (the cliff edge) - see Figure 15. By itself, this interference causes no impact on the picture, but now impulsive interference from passing traffic causes decoding errors, and the familiar blocking in the picture. The cause is the arrival of the base station, but the effect is that of impulsive interference from traffic. The installation engineer called to solve the problem goes looking for solutions to impulsive interference, whereas fitting a suitable filter to reduce the base station interference would restore the system to satisfactory operation.

Impulsive interference

Impulsive interference can originate from a wide range of sources, but most often from devices that generate sparks, either intentionally or otherwise. Typical sources include:

- Vehicle ignition systems, particularly motorcycles, which do not benefit from the metallic shielding that a car has;
- Light switches;
- Central heating thermostats, the suppression capacitors in these being notorious for becoming ineffective after a few years of use;
- Electric motors, particularly the type with brushes and a commutator; and
- Poorly maintained electric fences.

Impulsive interference typically has significant energy at all frequencies up to about 1 GHz, and lower TV channels are affected more than higher channels. DVB-T multiplexes tend to be affected more severely than DVB-T2.

Mitigating impulsive interference

Impulsive interference energy is spread across the whole TV band, so it affects all channels, but typically has a bigger effect on low frequency channels than high. The disruption it brings to TV services normally arises from the energy that falls in the same bandwidth as the wanted multiplex, and is known as co-channel interference, CCI. Therefore, filtering will have little effect, if any.

Impulsive interference most commonly gets into TV systems in the following ways:

- Through the aerial. If impulsive interference is being received via the aerial, the only option is to try re-positioning the aerial so that the path from the interference source is blocked, but the path from the wanted transmitter is not.
- From the downlead. Impulsive interference can induce currents that flow in the outer conductor of the downlead. If the downlead is of poor quality, some of these currents will leak into the interior of the cable instead of remaining on the outside. Furthermore, even if the downlead's screening is good, interference currents can travel up to the aerial, and if there is no balun, can enter the downlead at this point.
- Via the outlet plate or flylead. The quality and, in particular, the screening of outlet plates and fly leads are often extremely poor, allowing an entry point for impulsive interference. If interference is entering a reception system at this point, increasing the signal level delivered to the outlet plate will improve the signal–to-interference ratio, and may reduce actual disturbances to services.

Guideline: In cases of impulsive interference, make sure that the downlead uses cable that has been approved under the CAI's Cable Certification Scheme , the aerial has a balun , the outlet plate and fly lead are well-screened, and that an appropriately high level of signal is being delivered to the outlet. Persistent cases of impulsive interference should be reported to the **[Radio & Television Investigation Service](#)**.

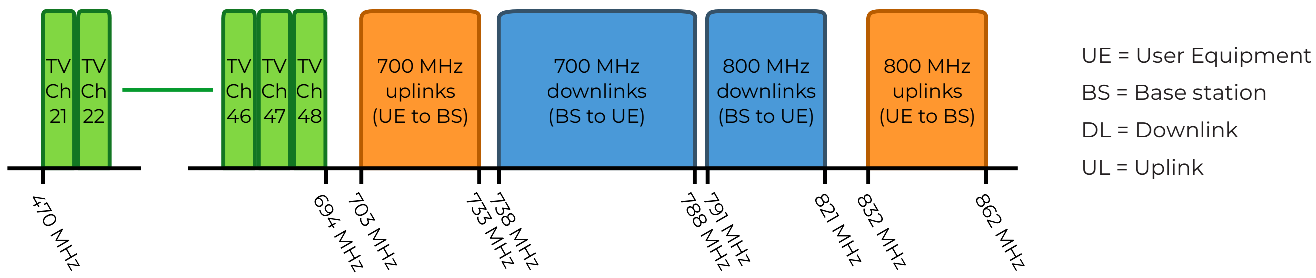

Figure 2 *UHF frequency allocations*

Mobile services interference

The term "mobile services" is used to describe both LTE, an abbreviation of Long Term Evolution, the fourth generation (4G) standard for high speed data communications for mobile phones, and for 5G, the fifth generation.
Mobile services can use a number of frequency bands, but the bands of most interest for TV receiving systems are the 700 MHz and 800 MHz bands, because these were used until recently for TV (channels 49-68).

Mobile base stations transmit in the downlink to user equipment such as mobile phones which in turn transmit to base stations in the uplink.

Since the closure of the temporary multiplex COM7 on channel 55 in June 2022, DTT broadcasting takes place only in the band 470-694 MHz (channels 21 to 48). Base stations (BS) for mobile services transmit to user equipment (UE), such as mobile phones, in the frequency blocks 738-788 MHz and 791-821 MHz. UE transmits back to the BS in the frequency blocks from 703-733 MHz and 832-862 MHz.

It is possible for UE to cause interference to TV receivers, typically by entering a leaky outlet plate or flylead, or if the handset is close to the receiver, by penetrating the receiver's screening. If this happens, the householder should be advised to move the handset away from the TV receiver. Replacement of the outlet plate and the flylead with well-screened versions should also help. Indoor set-top aerials are particularly vulnerable to interference from UE, especially aerials that have amplifiers built in and it is recommended to use rooftop aerials instead where possible.

The main problem for TV systems is usually emissions from BS rather than UE. If the BS happens to be in the same direction as the TV transmitter, a rooftop aerial can pick up an extremely strong signal due to the BS being relatively close.

Interference can occur on any or all channels, but the channels closest to the BS frequencies are the most susceptible.

Mitigating mobile interference

Following the 800 MHz auctions in 2012, at800 was formed in order to provide support for households whose Freeview services could be affected by the deployment of mobile services at 800 MHz, and that used Freeview as their primary TV service. at800 was funded by and represented the UK mobile operators operating mobile services in the UK at 800 MHz: EE, Virgin Media O2, Three and Vodafone.

To continue supporting the 4G rollout and to encompass the change of use of the 700 MHz band from broadcasting to mobile services, the at800 programme became the Restore TV programme. Help and support will be provided to those who may be affected by interference to TV reception due to new or upgraded base stations being deployed.

How Restore TV can help

If a household is experiencing new disruption to DTT services such as loss of sound, blocky or pixelated images or loss of some or all channels, then the advice to viewers is to contact Restore TV.

It will then assess whether the disruption might be due to mobile services at 700 MHz or 800 MHz, for example by checking if a new or upgraded mast has been recently activated in the area.

Restore TV will send a free filter to the property for the householder or property manager to fit. For installations with rooftop amplifiers, Restore TV can arrange for an approved weatherproof filter which should be installed by an accredited aerial engineer. If eligible, Restore TV may be able to arrange for a Restore TV engineer to visit their home. The engineer will test whether mobile signals are the cause of the interference and fit a filter to the TV system. If the viewer isn't eligible for a Restore TV engineer they will be directed to contact an accredited aerial engineer.

Guideline: Installers who believe that disruption to a DTT installation is caused by mobile service disruption should contact [Restore TV](). This is the advice even if the installer is able to rectify the issue so that cases of disruption can be tracked.

Restore TV: 0808 13 13 800. Calls from UK landlines and mobiles are free.
Opening hours: Monday - Saturday, 9am - 5pm. Closed Sunday and bank holidays. Opening hours are subject to change, see restoretv.uk/contact us for information

Mobile service filters

The main tool for reducing interference from a mobile service BS is a filter. The job of the filter is to selectively reduce the level of the interfering signal below the point where it is no longer affecting reception, while having the least possible effect on the TV multiplexes to be received.

Figure 3 shows the characteristic of a low pass filter, which offers more than 40dB of attenuation across the downlink bands (738-821 MHz). Note that in channel 48 (686-694 MHz) there is 2-3 dB of attenuation. Where reception is marginal and channel 48 is in use, care would need to be taken that this does not cause decoding of the signal on that channel to become unreliable. However, in the great majority of cases, a filter with this characteristic would have negligible effect on the wanted signals, while greatly suppressing interference.

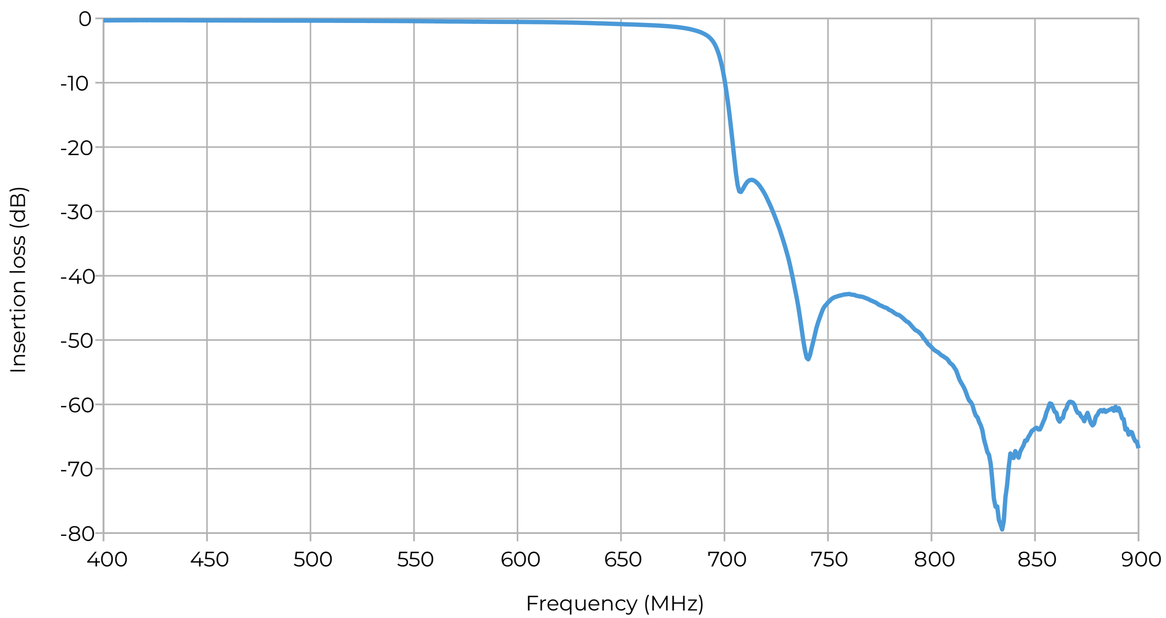

Figure 3 *Characteristic of a low pass filter designed to reduce interference from mobile services*

The impact of DTT amplifiers on interference from mobile services

Experience of interference from BSs for mobile services to date is that the great majority of affected systems are using some form of amplifier, and that interference to TV services can usually be prevented by using a suitable filter.

A filter must always be installed before any active component such as an amplifier. Amplifiers generate intermodulation products, which are unwanted signals that tend to cover a wide range of channels and will affect the DTT channels being received. (This is described in further detail in the Amplifiers section of this document.) Filtering cannot be used to remove interfering intermodulation products once they have been created; filtering must be introduced before the signal reaches any amplifier to prevent significant levels of intermodulation products being generated in the first place.

EN 303 354, the standard use to demonstrate compliance of TV amplifiers with certain requirements of the Radio Equipment Directive, specifies five classes of amplifier, four of which incorporate filtering to protect against interference from mobile services. These are listed in Table 1.

Now that TV transmissions are limited to the band 470-694 MHz, class 3 and 4 amplifiers are no longer suitable for new installations. However, many will have been installed when the 700 MHz band was still in use for TV, but as their filters do not cut off until around 790 MHz, they will be vulnerable to interference from mobile services in the 700 MHz band. Systems using these types of amplifier may require an external filter to be fitted to protect against interference between 703-790 MHz.

Class	Type and Use
0	Wideband from 470 MHz to 862 MHz. If used with signals from an aerial, it must be preceded by a filter to reduce the power of mobile phone and base station signals in the upper part of the band. Also used on systems with locally modulated signals that are carried on cable only (i.e. never radiated), and where these signals are in the 700 MHz and 800 MHz bands.
1	Passes signals from 470 MHz to 694 MHz. Intended for use after 700 MHz clearance.
2	Not used in the UK.
3	Passes signals from 470 MHz to 782 MHz. Intended for use after 800MHz clearance, but where channel 60 (782 MHz to 790 MHz) is not used.
4	Passes signals from 470 MHz to 790 MHz. Intended for use after 800MHz clearance, and where channel 60 is used.

Table 1 *DTT amplifier classifications and their use*

Note that launch amplifiers in communal aerial systems tend to be driven quite hard compared to other types of amplifier. They therefore tend to have the least capacity for handling LTE BS signals without generating harmful levels of intermodulation noise. This may mean that in some instances they will need a filter with higher than usual stopband attenuation.

Guideline: Mitigation steps in cases of interference from mobile services are to remove any unnecessary amplifiers, and where there is either no filter or a class 3 or 4 filter integrated into the amplifier design, to fit a filter before the input to any remaining amplifiers, or other active devices such as multiswitches.

Receivers

We have seen how amplifiers are an important source of problems in the presence of interference from mobile services, but we should also give some thought to how receivers themselves behave. After all, there are still plenty of installations where an aerial is connected via a download directly to a TV receiver, with no amplifiers or other components involved.

There are effectively three ways in which a receiver can be prevented from decoding what would otherwise be a perfectly good DTT signal:

1. Co-channel interference (CCI). This term is often applied to unwanted DTT signals from distant transmitters using the same channel, but in the case of interference from mobile services we are generally referring to the intermodulation noise generated in an amplifier, or more specifically the part of the intermodulation noise spectrum that is on the same channel as the wanted DTT signal. This intermodulation noise behaves like any other noise signal, and reduces the MER of the DTT signal. See the Amplifiers section for a description of the effects of noise;
2. Adjacent Channel Protection Ratio (ACPR). This is a measure of how much more powerful an interferer on a nearby channel can be, compared to the wanted DTT signal, before the receiver suffers with errors on the picture. See Figure 4.

   ACPR differs significantly between types of receivers and with the number of channels separating the interferer (mobile services) and the victim (DTT). ACPR is usually a laboratory measurement made under controlled conditions and free from other sources of degradation, such as multipath, co-channel DTT interference, impulsive interference, etc. However, it gives a useful indication of the resilience of the receiver to strong signals on nearby channels.

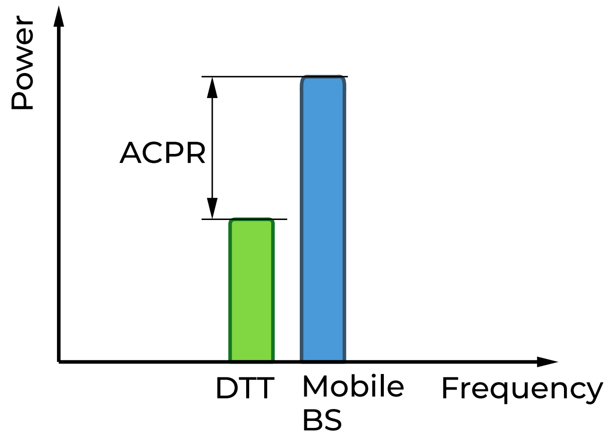

Figure 4 *ACPR is the difference in level between the interferer and the victim when the victim signal just begins to fail.*

3. Blocking. If a signal on a nearby channel is powerful enough, it will cause the receiver not to be able to decode a DTT signal at any level. The receiver is then said to be blocked (but this should not be confused with blocking on the picture, when the edges of blocks of pixels become visible).

For a receiver to work reliably, ALL the following conditions at the receiver input must be met:

- The wanted DTT signal must be within the operating range of the receiver, and must have a MER significantly greater than the threshold (cliff edge) value;
- Any intermodulation noise that is co-channel with the wanted DTT signal must be sufficiently low in level as to avoid significantly degrading the MER of the wanted DTT signal;
- Any interferer e.g. LTE or other DTT signal must not exceed the DTT receiver's ACPR; and
- Any interferer e.g. LTE or other DTT signal must not cause the DTT receiver to block.

Under laboratory conditions, receivers will normally operate satisfactorily with less than 30 dBμV of signal. However, in most domestic installations, a considerably higher level of signal is required to overcome degradation due, for example, to multipath, impulsive and other interference. Up to a point, as the signal level applied to the receiver increases, disturbance to services can decrease.
For reliable reception, the levels and MER of signals presented to the receiver should meet the requirements shown in Table 2.

It is important to recognise that:

- using an amplifier to raise the signal levels into the recommended ranges may make the system more vulnerable to interference;
- the minimum levels stated have been arrived at empirically, and other organisations may recommend lower levels;
- signals over 74 dBμV may cause overload, especially on older receivers; and
- operating receivers with MER values lower than recommended may cause increased occurrences of disturbances to pictures and sound.

Guideline: In the absence of adjacent channel interference, e.g. from mobile services, ensuring that signals delivered to outlets meet the criteria in Table 2 should ensure that receivers perform well.

Mode	Used by multiplex	Minimum level	Maximum level	Minimum MER
DVB-T 64QAM 2/3	PSB1 PSB2	45 dBμV	74 dBμV	23 dB
DVB-T 64QAM 3/4	COM4 COM5 COM6	48 dBμV	74 dBμV	23 dB
DVB-T2 256QAM 2/3	PSB3	44 dBμV	74 dBμV	26 dB

Table 2 *Recommended signal level ranges and MER values for regional multiplexes (excludes local TV)*
Source: CAI Codes of Practice

Aerials

An aerial is intended to capture TV signals from a particular transmitter, and convert them from electromagnetic waves in space to electrical signals in a coaxial cable. However, the aerial must also provide a given degree of rejection of signals coming from other directions. If this rejection is insufficient, and the interferer is a co-channel TV signal, the C/I (carrier to interference ratio, which in this case is much the same as MER or C/N), may be lower than desirable. This may result in more frequent disturbances to services than if the aerial gave a high level of rejection.

Aerial groups

When the TV networks were first planned, attempts were made to keep channels in one coverage area from being spread across the available spectrum to a greater extent than necessary. Although this worked in many cases, there were some transmitters where it was necessary to spread out the channels used across much of the band, to avoid interference from and to transmitters in neighbouring coverage areas.

Aerial designers found that the broader the bandwidth of an aerial, the lower is its gain. High gain was often needed, especially towards the edge of coverage and where the path from the transmitter was blocked by terrain, vegetation or buildings. In many instances, a wideband aerial that covered all the channels from 21-68 simply did not have enough gain, and so the idea of aerial groups was developed.

Group W covered the whole UHF broadcast band, but all the other groups, A, B, C/D, E, K and T, each covered only part of the whole band, and so were able to have higher gain for the same number of elements.

Guideline With mobile services now using the 700 MHz and 800 MHz bands (channels 49 to 68) and broadcasting limited to channels 21 to 48, Groups B, C/D, E, W and T are not normally recommended for installation. With most aerial types, gain falls quite rapidly above the intended frequency range, so avoiding using aerials specified for channels higher than 48 should give some protection against interference from mobile services. Therefore Group K aerials are generally recommended. Note however that the gain of log periodic aerials does not fall as rapidly as most other types, so the protection offered against interference from mobile services is reduced.

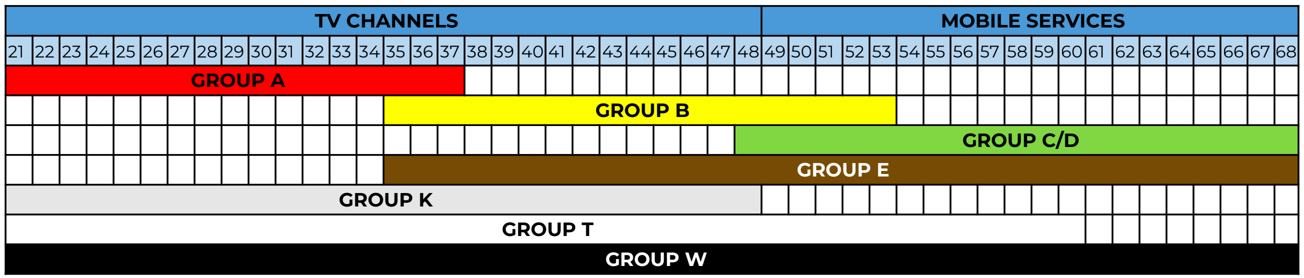

Figure 5 *Aerial groups*

CAI's Aerial Certification Scheme

This scheme lays down the minimum standards for the technical performance of UHF TV aerials based on the specific requirements for satisfactory digital terrestrial TV (DTT) reception.

Certified Aerials are categorised into two standards:

- Standard F is for reception in 'Fringe' or low signal strength areas.
- Standard S is for reception in 'Standard' or good signal strength areas.

Aerial polar pattern

An aerial's polar pattern is a diagram showing how the aerial's gain varies with direction. Ideally, aerials would accept signals only from the forward direction, and would completely reject all signals from other directions. In practice, aerials will to some extent accept signals coming from directions other than the forward direction.

Figure 6 shows the polar pattern of a well-designed Yagi aerial (data courtesy of Blake UK Ltd), and there are two main features to note:

- The gain either side of the forward direction (upwards in Figure 6) makes what is known as the main lobe. As the number of elements in the aerial increases, so the gain in the centre of the main lobe increases and the width of the main lobe decreases. The angular width of the main lobe, normally between the points 3dB below maximum gain, is often specified by the manufacturer. In this example, the gain falls by 3 dB from maximum at roughly 30° from the forward direction, and is said to have a 60° beamwidth.
- In this example, the gain outside the main lobe is always more than 24 dB below the forward gain.

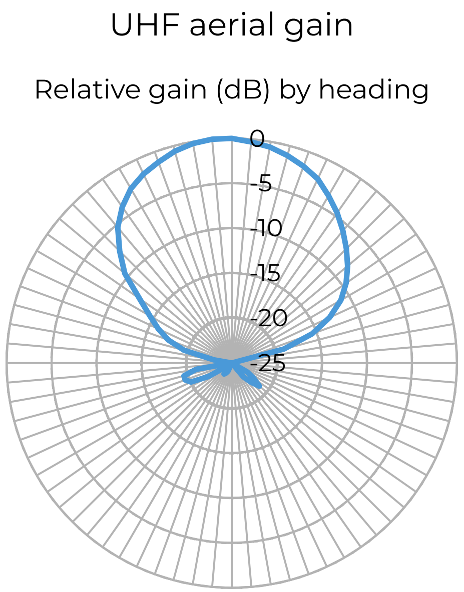

Figure 6 *a polar pattern of a well-designed Yagi aerial*

In some locations, signal levels from transmitters in other areas can be quite strong, and if they are on the same channel as the wanted signals, can cause harmful interference. The aerial is the only means of separating co-channel signals from different directions, so attention must be paid to the polar pattern of the receiving aerial. Outside the main lobe, we want the gain to be as low as possible, so that signals from unwanted co-channel transmitters cause the minimum of interference. If the interference is coming from a direction within the main lobe of a low gain aerial, using a high gain aerial with a narrower main lobe may be necessary.

Unfortunately, some contract aerials have particularly poor patterns, with rather high gains outside the main lobe (also known as off-axis gain). These should be avoided, and CAI certified aerials used wherever possible. This certification ensures that off-axis gain is kept low.

Log periodic aerials are characterised by having a wideband response, with lower gain than a Yagi of comparable size, but particularly low off-axis gain. The main lobe tends to be fairly wide. In areas where the signal strength is high and good rejection of signals arriving outside the main lobe is required, a log periodic aerial can make an effective solution, although its frequency response in the forward direction generally offers little rejection of signals from mobile services.

Aerial gain and frequency response

Aerial gain is a measure of how much signal the aerial produces at its terminals when correctly pointed towards a transmission of given signal strength. The frequency response is a measure of how the gain varies with frequency.

For aerials based on the Yagi, the gain increases with the number of elements the aerial has. The gain decreases with increasing bandwidth: a wideband aerial has lower gain than a narrowband aerial. The gain also tends to rises with frequency, and then drops rapidly just above the highest channel it is intended to work on, as illustrated in Figure 7.

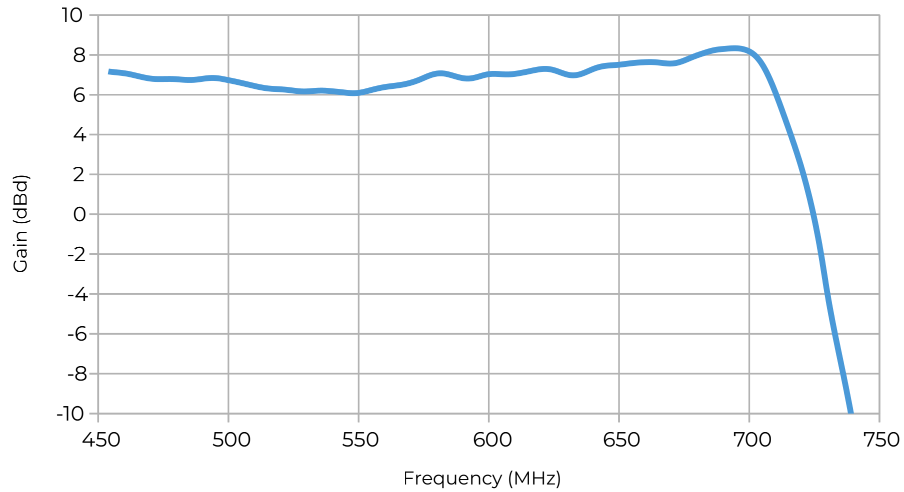

Figure 7 *An example of the gain of a Yagi aerial against frequency*

Aerial polarisation

Generally speaking, main transmitters radiate horizontally polarised signals, and relay transmitters radiate vertically polarised signals, although there are some exceptions to this, such as Rowridge, which radiates both horizontal and vertical components.

In principle, a receiving aerial with its elements horizontal will only respond to horizontally polarised transmissions, and will completely ignore vertically polarised signals. In practice this isolation is not perfect, but there will be a large loss of signal if the aerial's polarisation is not matched to the transmission's polarisation.

Polarisation is another tool that frequency planners can use to control interference and use the spectrum efficiently. It is therefore important for a receiving aerial to meet minimum polarisation requirements.

Baluns

Most receiving aerial designs by their nature tend to produce a balanced output, where as one terminal goes up in voltage, the other terminal goes down by the same amount. Coaxial cable is naturally unbalanced, with the outer conductor staying at the same potential while the inner conductor carries the signal voltage.

A balun, which is short for balanced to unbalanced transformer, ensures that the aerial sees a balanced connection from the coax, and the coax sees an unbalanced connection from the aerial. This will help prevent interfering signals that are received on the outer of the coax from travelling up to the aerial, where without a balun the signal can get onto the inside of the coax. This is another reason to use a certified aerial, as they all have baluns. An exception is log periodic aerials where baluns are intrinsic to the design.

Amplifiers

Amplifiers of various types are widely used in aerial systems to boost (increase) signal levels. However, they should be used with care as inappropriate use of amplifiers can badly degrade the quality of signals, or in extreme cases can prevent receivers from operating at all. In this section we look at amplifiers in more detail, and then go on to look at specific cases of masthead amplifiers and launch amplifiers.

All amplifiers have two main limitations that the system designer and the installer should be aware of:

- **Noise:** All amplifiers add noise to a signal. It is impossible to improve the MER of a signal by passing it through an amplifier. After all, both the carrier and the noise components of the input signal will be amplified by the same amount, and the amplifier will also add a little noise, so the C/N will be degraded.

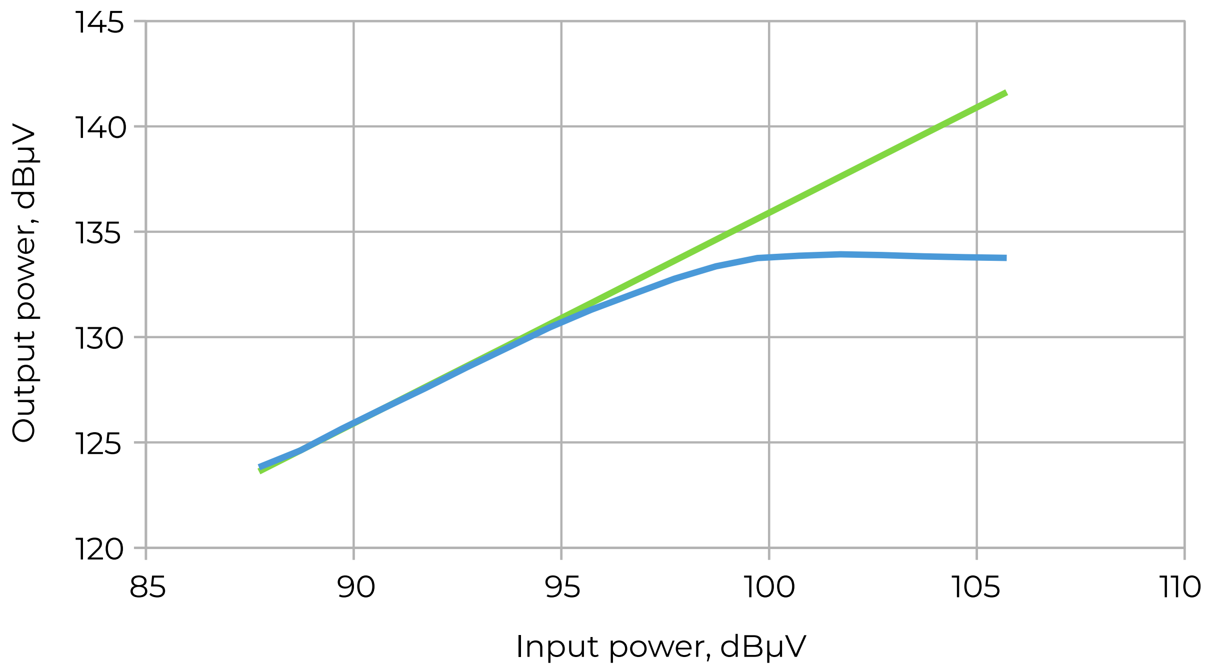

Figure 8 *Power gain for an ideal amplifier (green trace) and a real amplifier (blue trace)*

- **Non-linearity:** An ideal amplifier amplifies all signals by the same amount, irrespective of their amplitudes. This is represented by the straight line on the graph in Figure 8, which shows that the output signal always increases uniformly with the input signal.

A real amplifier behaves quite like an ideal amplifier when input signal levels are small, but as input signal levels increase, the output does not increase as much as it should. Finally, as the input increases further still, the output does not change at all. This deviation from the ideal is usually known as non-linearity, and it has some very important characteristics.

Non-linearity has the undesirable property of generating signals that were not present at the input of the amplifier. These new unwanted signals are known as intermodulation products, and where the wanted signals are DTT multiplexes, the intermodulation products look and behave very much like noise.

Figure 9 shows a single multiplex before it has passed through an amplifier. Figure 10 shows the same multiplex after it has passed through an amplifier at a level that generates significant intermodulation noise. The multiplex now appears to be sitting on a pedestal of noise which extends either side of the channel occupied by the multiplex. As a result, the MER of this multiplex was degraded to about 20 dB by this amplifier. This figure roughly corresponds with the ratio of the signal power to the intermodulation noise at the edge of the channel.

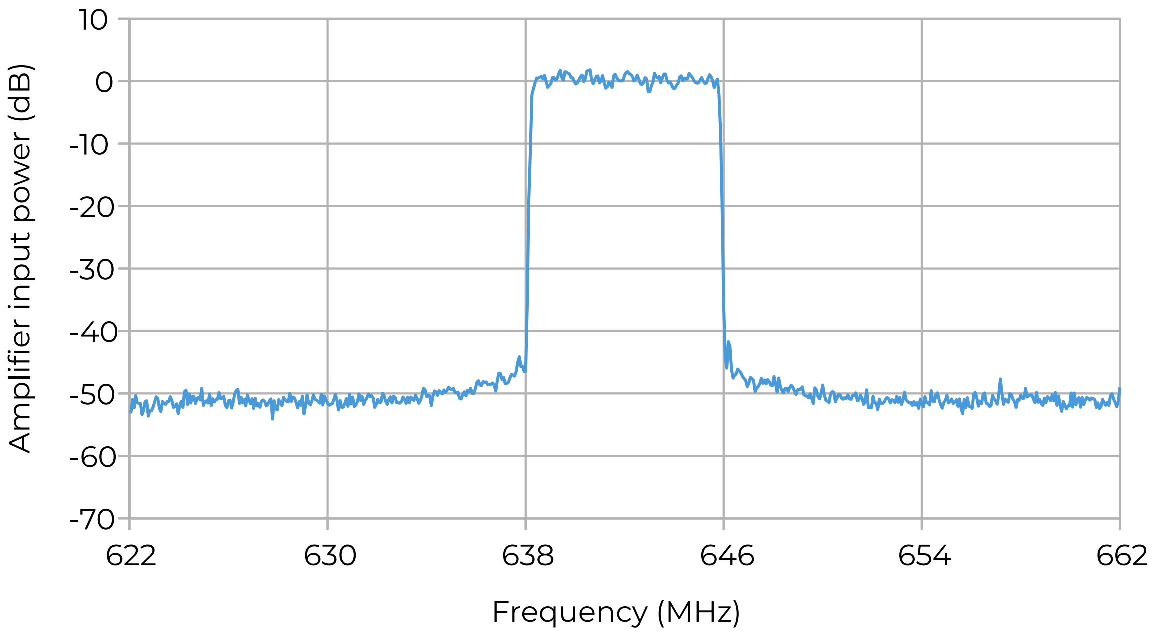

Figure 9 *DTT multiplex before passing through an amplifier*

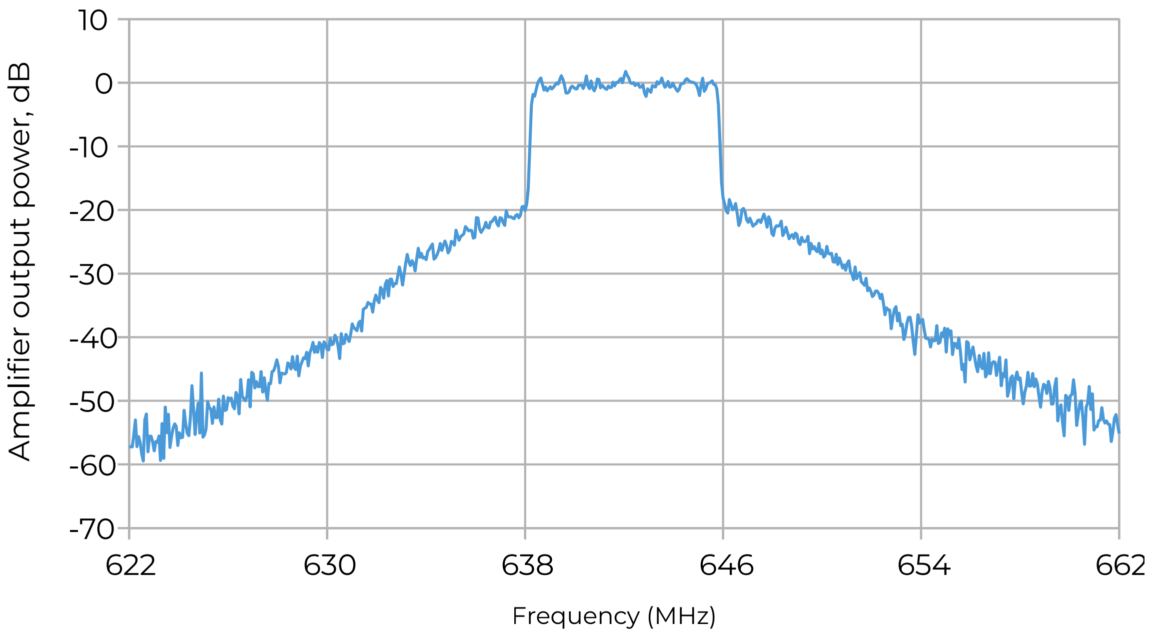

Figure 10 *DTT multiplex before and after passing through an amplifier*

Fortunately, the level of intermodulation noise is strongly dependent on the level of the signal in the amplifier. If the input signal is reduced by 3 dB then the intermodulation noise will be reduced by about three times as much, about 9 dB.

This means that reducing the input signal by 3 dB will reduce its level at the output by slightly less than 3 dB, but its MER will increase by about 6 dB due to the much bigger fall in intermodulation noise level. In a well-designed amplifier, the intermodulation should mainly be generated in the output stage. Therefore, reducing the amplifier's gain should reduce intermodulation in the same way as reducing the amplifier's input signals.

Guideline: if an amplifier is generating too much intermodulation noise, reduce the amplifier's gain, or reduce the level of signal at the input. Although this will reduce the signal level at the output, it will increase the MER at the output.

Non-linearity of an amplifier is the principal factor in mobile services causing disruption to TV reception. Over-driving an amplifier with high levels of interference generates intermodulation noise that can completely swamp the TV signals, preventing decoding.
There are two ways of avoiding this:

1. Fit a low pass filter to reduce the levels of the interference signals;
2. Use an amplifier with better linearity.

To illustrate this, measurements were made on two amplifiers. Both amplifiers met the requirements of the Radio Equipment Regulations, one (amplifier A) by a small margin, and the other (amplifier B) by a much larger margin. In both cases, a set of off-air signals was applied to the amplifier, together with a signal representing mobile services interference, which could be varied in level. The

MER of one of the off-air signals was recorded as the level of the interferer was increased, and the results are shown in Figure 12.

Amplifier A gave the results in blue. The horizontal axis, which shows the relative level of the interference, has been set to 0 dB at an MER of 23 dB for this amplifier. The orange line shows the results for amplifier B, and it can be seen that this amplifier tolerates 10 dB more interference before it too degrades the signal quality to an MER of 23 dB.

The most rugged systems will use both of these techniques: filtering to reduce interference levels, and an amplifier with particularly good linearity.

Guideline: for the best resilience to interference from mobile services, fit a filter with a high level of rejection in the 700 MHz and 800 MHz bands, and use an amplifier with particularly good linearity.

Masthead amplifiers

The need for masthead amplifiers has reduced considerably since digital switchover, due to the increase in transmitter powers that could be achieved once the analogue services had been removed. Unless masthead amplifiers are needed for a specific reason, such as unusually large losses due to long cable runs, splitters, etc., they should not be used, as they will increase the vulnerability to interference (see section on interference mitigation).

Guideline: avoid the use of masthead amplifiers unless they are absolutely necessary.

A masthead amplifier should normally only be used to overcome a loss by having a gain just a little greater than the loss, and it should always be located ahead of the loss. For example, imagine a case where there is 10 dB of feeder

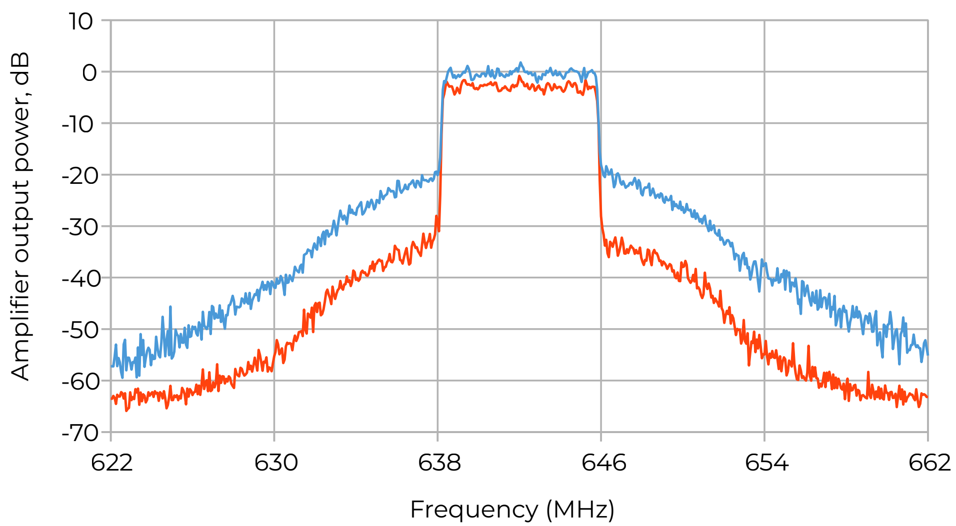

Figure 11 *Reducing the signal power by 3 dB reduces the intermodulation power by approximately 9 dB*

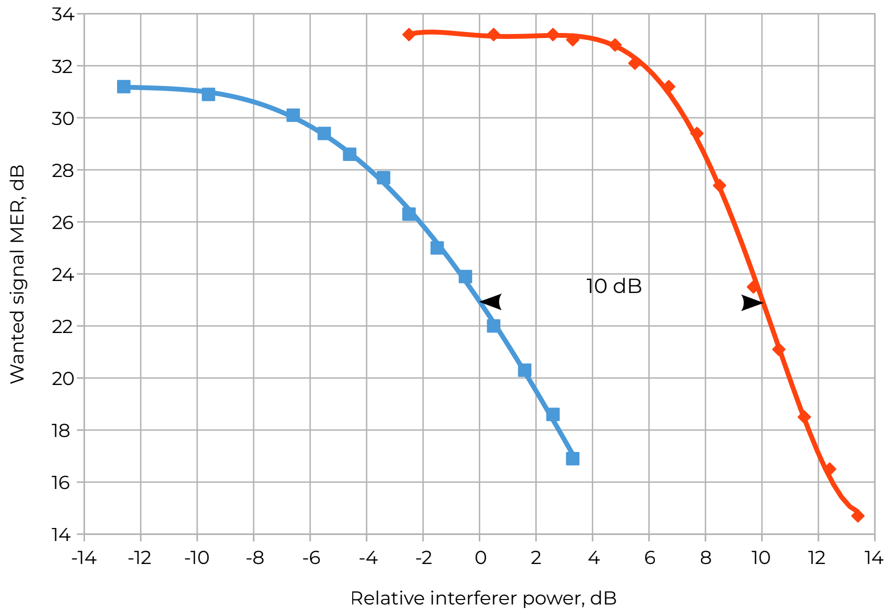

Figure 12 *Difference in amplifier tolerance to overload*

loss between an aerial and a TV receiver. In Figure 13 an amplifier with a gain of 14 dB and a noise figure of 2 dB has been installed before the lossy feeder, and in Figure 14, it has been installed after the feeder. Let us say that the signal at the aerial terminals has a C/N of 30 dB. What is the difference between installing the amplifier as shown in Figure 13 compared to Figure 14?

The first point to note is that the signal level presented to the receiver will be the same in both cases. There is 10 dB of loss and 14 dB of gain, so there will be 4 dB of end-to-end gain irrespective of the order in which the gain and loss occur.

Table 3 shows that there is a large difference of MER between the two cases: putting the amplifier before the feeder loss gives an MER value of 27 dB, which for UK DTT modes represents a good quality of signal, while putting the amplifier after the feeder loss gives an MER value of 18 dB, which is close to the point of failure. This is why we have masthead amplifiers!

Note that the term feeder loss used here should include losses from passive components such as splitters. For example, a four-way passive splitter with about 20m of type 100 cable in any one path could have a total loss of around 10 dB at UHF.

Guideline: if an installation needs a masthead amplifier, use one with the lowest gain consistent with adequate performance in order to minimise the risk of overload from mobile services, place it as close to the aerial as possible, and place it ahead of any significant losses from feeders, passive splitters, etc. If one is not already integrated into the amplifier design, installing an appropriate filter before the amplifier will reduce vulnerability to interference from mobile services

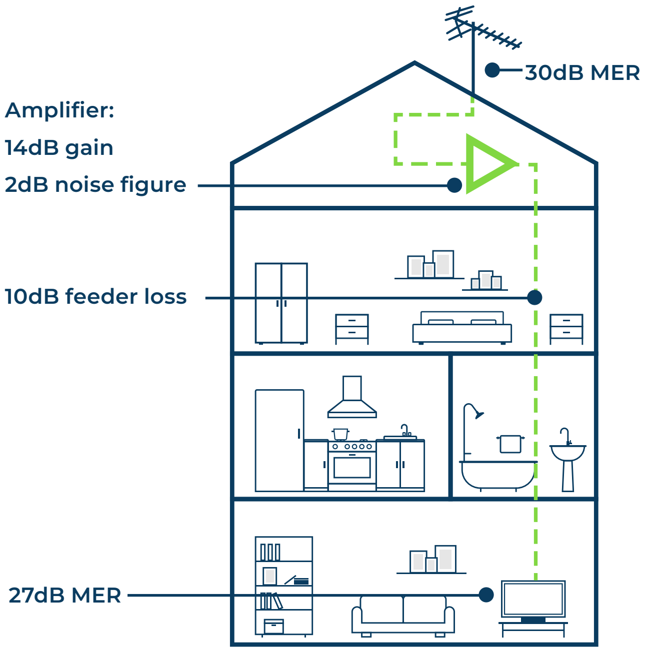

Figure 13 *the amplifier is before the loss*

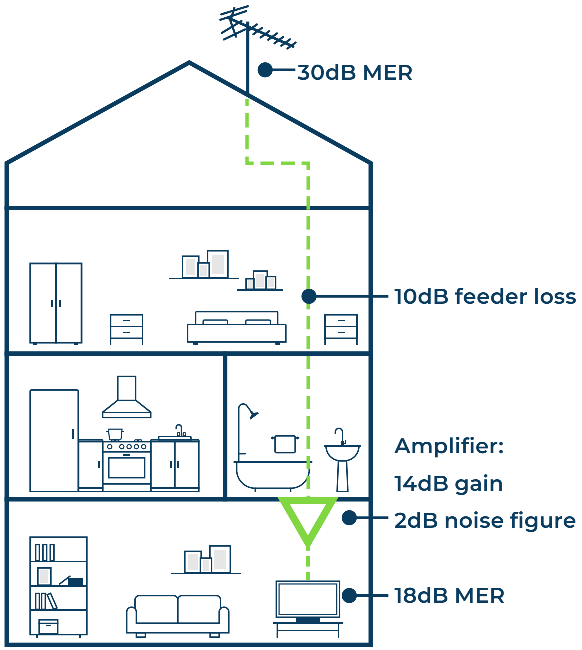

Figure 14 *the amplifier is after the loss*

	MER at the aerial	MER at the TV receiver
Amplifier before feeder loss	30 dB	27dB
Amplifier after feeder loss	30 dB	18dB

Table 3 *MER for the two cases in Figures 13 and 14*

Distribution amplifiers

The term “distribution amplifier” is used to include loft amplifiers, set-back amplifiers and launch amplifiers. There is no clear distinction between distribution amplifiers and masthead amplifiers; in fact masthead amplifiers with multiple outputs could be said to be distribution amplifiers. As described previously, all amplifiers introduce noise and are non-linear, and distribution amplifiers are no exception.

Launch amplifiers

Launch amplifiers generally are capable of producing the highest signal power of any of these amplifier types, so we will concentrate mainly on these.

Launch amplifiers are also the most expensive type of amplifier, with the price rising in relation to the output power capability. In an IRS or a MATV system, a balance must be found between the amount of signal power that must be launched into the distribution network, the amount of intermodulation noise that can be tolerated, how hard the amplifier can be driven, and hence the size and cost of the amplifier.

In principle, the same process applies in the current all-digital environment as in the days of analogue. For the analogue world, manufacturers rated their amplifiers for two vision carriers, and a formula could be applied which gave the amount that the channel power had to be reduced, according to the number of channels in use. This power reduction is most widely known as de-rating, or sometimes as back-off.

For example, if an amplifier is rated by the manufacturer at 116 dBμV, and it is to be used with five channels, the de-rating can be calculated like this:

- de-rating = 10log(N-1) dB, where N is the number of channels.
- de-rating = 10log(5-1) = 6 dB

This means that the carriers can each be operated at 116 - 6 = 110 dBμV at the amplifier output, assuming they are all received at equal level.

Number of channels	De-rating (dB)
2	0
3	3
4	4.8
5	6

Table 4 *De-rating figures for numbers of equal power multiplexes*

Analogue TV was particularly susceptible to annoying patterning on pictures arising from intermodulation, and this level of de rating ensured that intermodulation remained sufficiently low that no patterning was visible. Operating analogue carriers above this level would risk visible patterning appearing on pictures.

In the digital world, we need a slightly different approach, for two main reasons:

- DTT is not susceptible to patterning on the picture.
- Intermodulation generated by DTT signals in a non-linear amplifier behaves like noise.

It is important to bear in mind how digital signals fail as the quality of the signal decreases. DTT has a failure threshold, sometimes called the digital cliff, below which it is impossible to decode pictures, sound or any other service carried in the multiplex, such as the programme guide. For simplicity these will be referred to collectively as pictures.

Just above this threshold is a region where pictures can be decoded, but it takes only a very small disturbance to cause errors in the picture, such as freeze-frames and blocks errors. As we move away from the threshold, increasing the quality of the signal, the likelihood of disturbances decreases until we reach a region where disturbances are so rare that we can say they do not happen. It is clear that we should avoid operating close to the threshold.

The CAI's Code of Practice for MDUs makes recommendations for MER values at both the aerial and outlet plates on a system, and these are summarised in Table 5.

Multiplex Mode	Minimum MER at any outlet, dB
DVB-T QPSK 3/4	17
DVB-T 64QAM 2/3	23
DVB-T 64QAM 3/4	23
DVB-T2 QPSK 2/3	17
DVB-T2 256QAM 2/3	26

Table 5 *Minimum MER values at aerials and outlets, recommended in the CAI's Code of Practice for MDUs*

The values of MER given in Table 5 have been determined to ensure that in normal operation the signal is well above the threshold, and clear of the zone in which disturbances are likely. This has implications for how launch amplifiers should be operated.

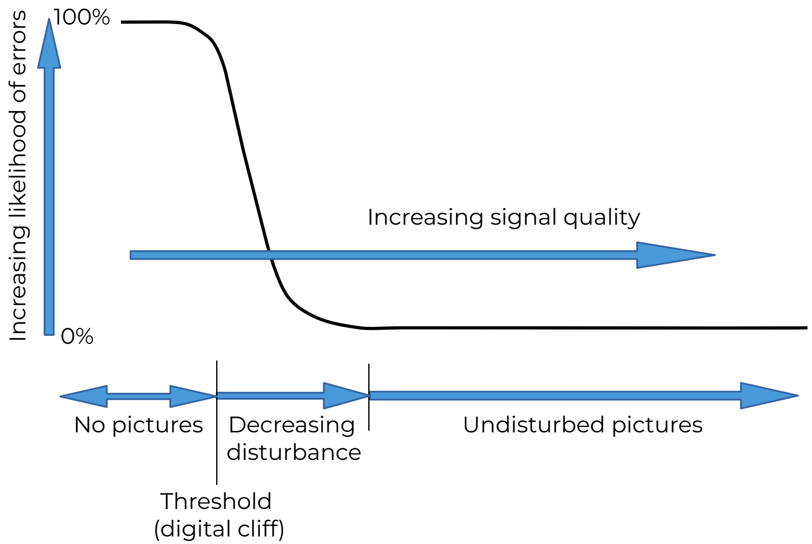

Figure 15 *Illustrating the DTT threshold (digital cliff) and the operating region for undisturbed services.*

A DVB-T2 256QAM signal being received off the aerial at 30 dB MER has to be delivered to outlets at no worse than 26 dB MER, allowing a total of 4 dB of MER degradation. Assuming we allow half of this degradation is caused by the amplifier, it can be shown that the amplifier must degrade perfect signals to no worse than 32.3 dB MER.

Some tests have been carried out on a small number of amplifiers to see if it is possible to define the maximum drive level for an amplifier, given the MER target and the manufacturer's amplifier rating. Unfortunately it was found that the results vary significantly from one amplifier model to another, so no straightforward rule has emerged. However, on the few models of amplifier tested, it seems that using the analogue de-rating formula gives a safe estimate of the usable power level, but perhaps this is not quite as cost effective as it might be.

Measurements

It should be clear from discussions of signal levels and interference elsewhere in this guide that measurements of signal level and signal quality are of great importance to ensure that any terrestrial TV system, no matter how simple or complicated, works effectively. The installer should therefore be equipped with a meter that measures signal level and MER, and ideally is able to display the spectrum of TV signals as well as frequencies outside the TV band in order to assess the level of interference from mobile services.

Signal level

Signal level is a straightforward measurement of the strength of a signal. Meters are normally calibrated for use with digital signals occupying an 8 MHz channel, which is why an analogue-only meter is no longer of use in a digital-only environment. The unit of measurement is usually dBμV. Using dB (decibels) means that for every drop of 10 dB, the power of the signal is reduced by a factor of ten. For example, a 20 dB drop means that the power has gone down by a factor of 100, and a 30 dB drop means it has gone down by a factor of 1000. Using dB allows a wide range of signal powers to be displayed at the same time.

Recommended signal levels at outlets are given in Table 5.

Carrier to noise ratio, C/N or CNR

C/N is a measure of the ratio of the signal power in a channel to the noise power in the same channel, and is fundamental to the operation of a receiver: the C/N must be over a certain minimum value for the receiver to work at all. C/N is normally expressed in dB.

The main problem with C/N is that it is not possible with a spectrum analyser to see the noise present in a channel without switching off the TV signal, which is not normally possible. An estimate of the noise level may be found by measuring the noise in an unoccupied nearby channel, but this cannot take account of variations in frequency response between channels, and co-channel interference (which usually behaves like noise). Modulation error ratio (MER) is a better measurement.

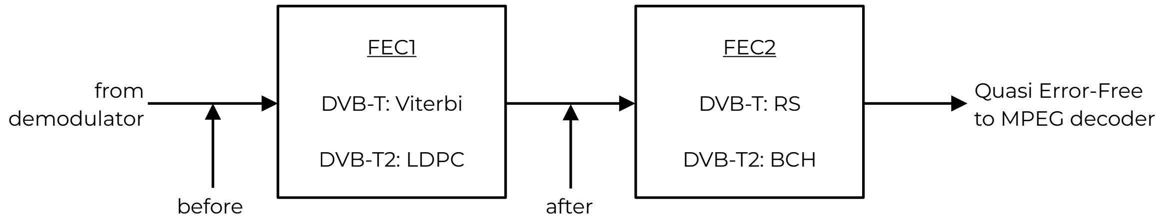

Figure 16 *Receiver error correction (FEC) processes*

Modulation error ratio, MER

MER is a measurement of how much a signal deviates from the ideal. It includes transmitter distortions, co-channel interference and noise, and all of these are combined into one signal as if they were all sources of noise. By measuring the power of the signal, and then the effective power of all the degradations, the MER can be calculated. Note that if the transmitter distortions are small, as is normally the case with main transmitters, MER is effectively the same as C/N.

MER is normally averaged over a period of about a second, so it is of limited use with transient interference, such as impulsive interference, because its duration is significantly shorter than the averaging period.

Bit error ratio, BER

BER is a measure of the number of errors in the received data stream. We need to be careful to understand exactly where the BER is being measured, because receivers contain mechanisms to correct errors, known as FEC (Forward Error Correction). Of course, normally pictures and sound should be delivered without any errors, a condition known as Quasi Error-Free, QEF.

The error correction processes in a receiver are as shown in Figure 16. The data bit-stream coming off the demodulator is fed to two successive error correction processes, FEC1 and FEC2, which under normal conditions will effectively eliminate all data errors. BER measurements are usually made before or after FEC1; after FEC2 there should be virtually no errors to measure.

In DVB-T systems, the FEC1 process is named after its inventor, Viterbi. You may hear references to BER being measured before or after Viterbi. Sometimes these are called bBER and aBER (before-BER and after-BER). The target maximum value for BER before Viterbi is 2 x 10-4, sometimes written as 2E-4.

DVB-T2 systems use a much more powerful FEC1 process known as LDPC (Low Density Parity Check). This makes using BER measurements somewhat more difficult, as the post-LDPC BER is very low, even for quite high values of pre-LDPC BER.

Like MER measurements, BER measurements are averaged over periods of time that allow enough errors to be counted to make the measurement meaningful. For low values of BER, the time required can be several seconds. So BER measurements are also of limited use for short duration interference.

Noise margin

Noise margin is a measure of how far the MER is above the failure threshold, or digital cliff. The failure threshold varies between the various modes of both DVB-T and DVB-T2 signals (e.g. the mode used for local TV transmissions has a threshold about 10 dB lower than the other multiplexes), so this is a useful indication that the operating point is not close to failure.

Satellite reception and distribution

The reception and distribution of satellite TV signals requires quite different techniques to those used for terrestrial television. The main reasons for this are:

- Satellite signals are very weak in comparison to terrestrial. They are transmitted with lower power than terrestrial TV, and the signals have to travel over 24,000 miles from the satellite to reach us.
- Satellite signals use much higher frequencies than terrestrial. Terrestrial TV uses frequencies in the range 470 MHz to 694 MHz, whereas satellite TV signals use the frequency range from 10,700 MHz to 12,750 MHz.
- Satellite TV signals are able to use a much wider range of frequencies than terrestrial TV. Terrestrial TV has 224 MHz of bandwidth, whereas satellite TV has a bandwidth of 2,050 MHz – which it is able to use twice through use of horizontal and vertical polarisation, making an effective bandwidth of 4,100 MHz.

As receiver technology has developed, so too have the requirements for signal distribution. In this section we will look at legacy systems, in use in the great majority of reception systems, and also at the more recent wideband LNBs, and single cable router (SCR) systems.

Satellite reception

In common with terrestrial transmissions, satellite signals are transmitted in individual multiplexes. Each individual multiplex has its own transmitter hardware on the satellite, known as a transponder. The transponder's task is to receive signals sent up from an uplink earth station, and to re-transmit these signals back down to earth. The satellite's transmit dish aims the transponder's power at the territory required to be covered by the signal, for example the UK, or the whole of western Europe. If the transmitter power is spread over a relatively small area such as the UK, then the signal on the ground will be stronger than if it is distributed over a wider area.

Satellite signals are affected by moisture in the air in the form of cloud or rain. Heavy rainfall can cause several dB of attenuation of the signal, and in addition to this loss of signal power, there will also be an increase in the noise level in the system, both of which will degrade the signal to noise ratio in the receiver. Rainfall statistics are known from many years of measurements (although climate change may affect the statistics), and can be used to calculate the availability, usually expressed as the percentage of a year that the signal can be received by a particular receiving installation. This will depend on many factors, including: satellite signal power, geographic location, receiving dish size, LNB noise figure, modulation and FEC (forward error correction) rate. Calculations that take account of all these factors are known as a link budget, and can be quite complex. However, for most broadcast applications, it is normally sufficient to use a recommended dish size, as all the link budget calculations will have been done by the satellite operator.

Recommendations for satellite signal conditions at outlet plates

The Confederation of Aerial Industries recommends the following signal conditions should be met at outlets on a communal aerial system:

Minimum signal level	52 dBμV
Maximum signal level	77 dBμV
Minimum MER	11 dB

Table 6 *Recommended satellite signal conditions at outlet plates*

The signal conditions in Table 6 are also appropriate for satellite receiving systems in single occupier properties. The important factors are:

- The signal levels are sufficiently high to ensure that there is negligible degradation of the C/N or MER;
- The signal levels are not high enough to cause the receiver to overload;
- The MER is high enough to ensure a high level of availability of the signals during all but the most severe rain fades.

Downlink frequencies

The spectrum from 10,700 MHz to 12,750 MHz can be filled with multiplexes, as illustrated in Figure 17. (Figure 17 is illustrative, and may not show the correct number of transponders, which may vary from one satellite to another. Furthermore, signal power levels may vary somewhat from one multiplex to another.) The satellite actually uses this range of frequencies twice: once with a set of signals that are horizontally polarised, and then again with another set of signals that are vertically polarised. In a single receive dish on the ground, the two sets of signals can be received simultaneously, and if the dish is aligned correctly, the two sets of signals will not interfere with each other to any significant extent.

Why IF frequencies are used

Signals at the frequencies transmitted by the satellite would suffer a high degree of attenuation in a typical coaxial cable, and must be moved to a lower frequency range for the use of coaxial cables to become practical over useful distances. A good location in the spectrum to move them to would be just above the UHF TV band; in this way, UHF TV signals and satellite signals could be carried on the same cable with no mutual interference. However, moving the whole satellite band so that it began at 950 MHz would still leave the top of the band at 3,000 MHz, where cable attenuation is still quite high. Splitting the satellite band into two parts (sub-bands), known as Low Band (10,700 MHz to 11,700 MHz) and High Band (11,700 MHz to 12,750 MHz) has been standardised; the range of frequencies that the signals are moved to is 950 MHz to 2,150 MHz, which is known as the satellite IF (intermediated frequency) band. Splitting into Low Band and High Band results in four sets of signals (four sub-bands) that can be carried in the satellite IF: vertically polarised High Band and Low Band, and horizontally polarised High Band and Low Band.

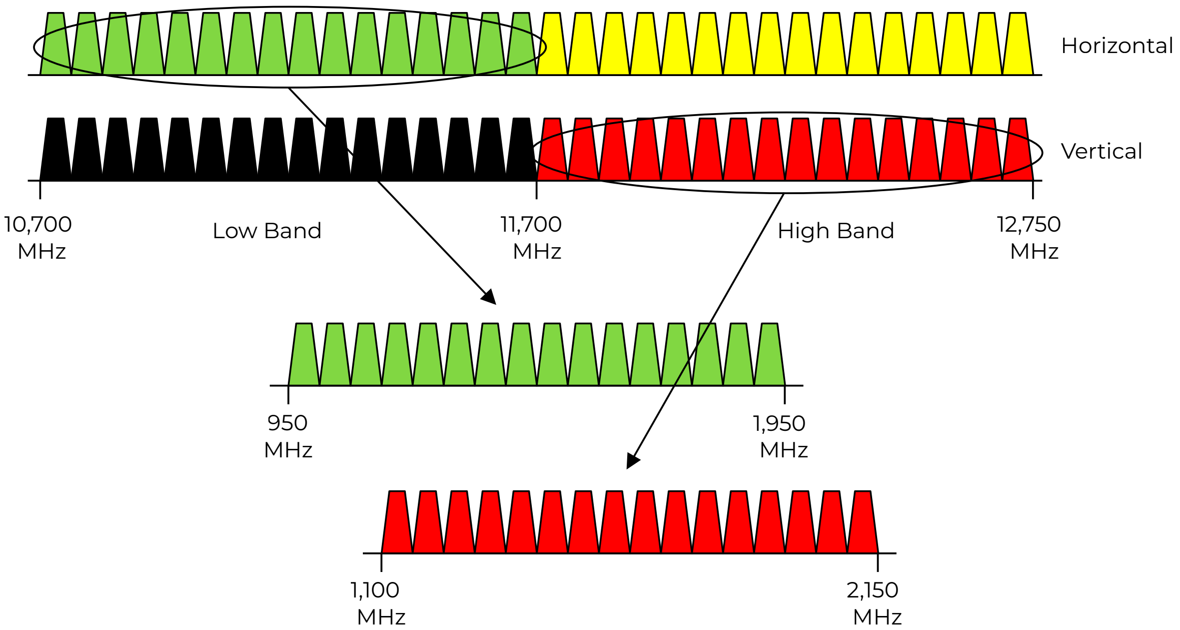

Figure 17 *an LNB converts an entire band of frequencies to the satellite intermediate frequency (IF)*

Low Noise Block downconverters (LNBs)

The required frequency shifts and selection of vertical or horizontal polarisation take place in the LNB (Low Noise Block downconverter), which is normally located at the feed point of the receiving dish, and is integrated with the feed that gathers in the signals that have been brought to a focus by the curved reflector of the dish.

For a domestic installation where the LNB is connected directly to each satellite receiver's tuner using a single coaxial cable, there has to be a means for each tuner independently to tell the LNB which of the four possible sub-bands to supply. It would also be convenient for the receiver to supply power to the LNB using the same coaxial cable. These requirements are met using tone and voltage signalling. Each tuner supplies current to the LNB at either 13 volts or 18 volts; this powers the LNB and tells the LNB that vertical polarisation (13 volts) or horizontal polarisation (18 volts) is required. The tuner also can send a 22 kHz tone to the LNB on the same cable. If the tone is present, the LNB selects High Band, and if the tone is absent, the LNB selects Low Band.

The frequency shift that is applied to signals in the LNB is controlled by an oscillator (sometimes called a local oscillator, because it is located in the LNB). A signal coming into the LNB will be shifted to a frequency that is the difference between the incoming signal's frequency and the oscillator frequency. The choice of whether to shift the High Band or the Low Band into the satellite IF band is made by switching the oscillator frequency, normally at either 9,750 MHz or 10,600 MHz. For example, if a signal from the satellite is received on 10,750 MHz, and the oscillator is at 9,750 MHz, then the incoming signal will be found at 1,000 MHz on the LNB's output.

When there is switching in the LNB, the LNB's output cannot be used for more than one receiver. This is because two receivers sharing one feed from the LNB may need to see different sub-bands, so the tone and voltage commands from the two receivers may conflict with each other; further, there is only capacity in the satellite IF for one of the four sub-bands at a time. Note that a PVR (Personal Video Recorder) that allows recording of one programme while watching another is effectively two separate receivers as it has two independent tuners. Each tuner must be connected directly to its own output on an LNB. To enable PVRs or other arrangements of multiple receivers all to use the same dish, LNBs with multiple outputs are available: a Quad LNB has four switched outputs, and an Octo LNB has eight switched outputs.

There are two types of LNB that have four outputs, and these are known as Quad and Quattro. Quad LNBs provide four switched outputs as described above, each of which can individually be controlled by tone and voltage signalling. In contrast, Quattro LNBs provide four un-switched outputs, one for each of the four sub-bands. Normally, a Quattro LNB is used in communal systems.

Communal systems

While an Octo LNB might appear to make a simple and inexpensive way of getting satellite signals to up to four flats, with two cables per flat, most systems are also required to carry terrestrial TV signals, and often FM and DAB radio. This is best achieved with a combination of a Quattro LNB and a multiswitch in a configuration known as an IRS (Integrated Reception System).

A multiswitch connects to all four satellite sub-bands simultaneously, each one on a separate cable. It also connects to terrestrial TV and radio signals; often these have to be combined externally onto one cable. The number of outputs on a switch varies from one model to another, typically from four to thirty-two. Each output carries the full set of terrestrial signals, together with one of the four satellite sub-bands, depending on the tone and voltage signalling that it is sent by the satellite receiver. As far as any satellite receiver is concerned, a multiswitch behaves in the same way as an LNB.

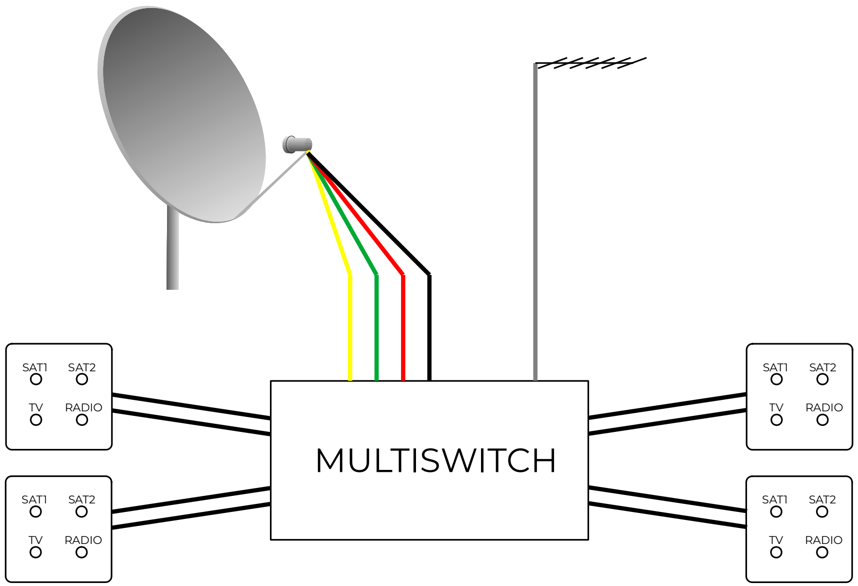

Figure 18 *An example of a multiswitch being used in an IRS to feed four flats*

The type of IRS shown in Figure 18 is known as a 5-wire IRS, because it has four cables from a satellite dish and a further one carrying terrestrial signals (UHF TV, FM, DAB, for example). It is quite common for systems to be built that carry the signals from more than one satellite network (e.g. Astra, Hot Bird). An IRS providing access to two satellite networks would be known as a 9-wire system, as it would have two sets of four satellite signal cables together with the terrestrial signal cable.

It is important that the four satellite signal inputs on the multiswitch are connected to the correct set of satellite signals, or the receiver will not see the signals that it is expecting. To help avoid confusion, the cables carrying these signals should be colour coded as follows:

Cable colour	Signals
Yellow	Horizontal High Band (HH)
Green	Horizontal Low Band (HL)
Red	Vertical High Band (VH)
Black	Vertical Low Band (VL)
White	VHF + UHF

Table 7 *Colour coding for multiswitch input cables*

It is common to install two cables (often referred to as “drop cables”) from the multiswitch to each flat, so that a personal video recorder (PVR) can be used. When two cables are used, the outlet plate in the flat should have four sockets (a quad plate): two for satellite, one for terrestrial TV, and one for radio (FM and DAB). The four sockets and two drop cables are connected via a triplexer behind the face plate, which filters the signals so that each type of signal appears only on the appropriate socket.

Single cable router, SCR

While the use of two cables per flat has been widely adopted, this is not able to satisfy the requirements of residents wanting to operate more than a single PVR, for example to have an additional receiver in another room. SCR addresses this problem by allowing multiple satellite receivers to operate on a single cable.

In the conventional IRS (sometimes referred to as “legacy IRS”) described above, the LNB converts each of the four satellite sub-bands to the satellite IF, and the multiswitch routes the whole of the appropriate sub-band to the satellite receiver’s tuner(s), responding to the tone and voltage signalling received by the multiswitch. With SCR, each tuner is allocated a unique channel on its cable, and the multiswitch routes the single desired multiplex into that channel. The channels used by receivers are known as user bands.

SCR vs. dSCR

There have been two generations of SCR devices. First generation devices used analogue techniques, including typically SAW filtering, to separate the user bands. These devices are limited to a maximum of eight user bands per cable, and in practice normally only use up to four. Second generation devices use digital filtering techniques internally, and enable up to thirty-two user bands to be provided, but in practice this is normally limited to sixteen. Second generation devices are distinguished from first generation devices by the prefix d (dSCR), where the d indicates that digital techniques are used in the signal processing. Note that this has nothing to do with the satellite signals being digital; both SCR and dSCR should be capable of handling any signal format, analogue or digital.

First generation devices conform to BS EN 50494:2007, “Satellite signal distribution over a single coaxial cable in single dwelling installations” (which has extensions for use in MDUs), and second generation devices conform to BS EN 50607:2015, “Satellite signal distribution over a single coaxial cable. Second generation.” EN 50607 is quite similar to EN 50494, the main differences being the introduction of a number of extensions, for example to allow a greater number of user bands. In fact, EN 50607 systems are backwards compatible with EN 50494 receivers. However, while Sky’s proprietary dSCR system is similar to EN 50607, it differs in a number of ways, so that Sky receivers will only operate with distribution systems where the multiswitches are able to implement Sky’s specific system.

An SCR multiswitch is significantly more complex than a conventional multiswitch, and needs to be able to exchange information with the receivers about the user bands that will be used, the multiplex that is required, and so on. The data exchange uses DiSEqC™, an openly available standard created by Eutelsat. DiSEqC™ is effectively an extension of the tone and voltage signalling described in the LNB section of this report above. The 22 kHz tone is pulsed on and off in two different ways to represent the 1s and 0s of a binary message. This is a relatively slow data transmission method; a 5-byte message takes about 67 milliseconds to send. This is why the number of bytes in a message is kept to a minimum.

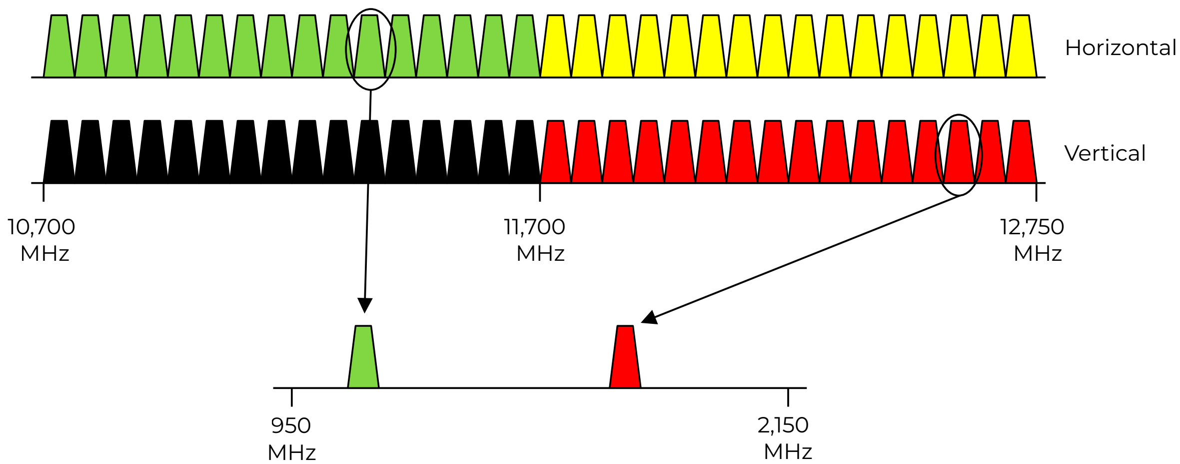

Figure 19 *SCR operation with two receivers using two user bands on the same cable*

The Sky Q receiver

The Sky Q receiver range has multiple tuners inside the box, and is able to operate with a full range of services using either one dSCR-fed cable or two wideband signal cables. The main receiver is connected to the incoming feed from the dish or communal system, and is intended to act as a hub or gateway. Secondary receivers in the same home are fed via Wi-Fi or Ethernet from the main receiver and do not use any direct satellite feeds

The main receiver can operate in either of two modes:

- Wideband mode (sometimes called full band capture), where the LNB provides signals on two cables;
- dSCR mode (shown on the receiver's set-up page as SCR), normally for communal systems, where the signal format must be in Sky's variant of the dSCR mode on a single cable.

Wideband mode

As discussed above, a conventional satellite receiving system will produce four sub-bands, all of which use the frequency range 950-2150 MHz. In a system using a wideband LNB, there are only two cables, each carrying a new wider satellite IF range: 290- 2340 MHz. The whole vertically polarised signal band is converted down to this new IF range and carried on one cable, while the whole of the horizontally polarised signal band is converted down and carried on the other cable - seeFigure 20. The LNB's conversion oscillator frequency is 10.41 GHz.

In a wideband system, all signals from one satellite location are present on the two cables, and no switching of signals on the cables is required. The receiver feeds these signals internally to all the tuners, which can operate independently and access any required multiplex on the satellite platform.

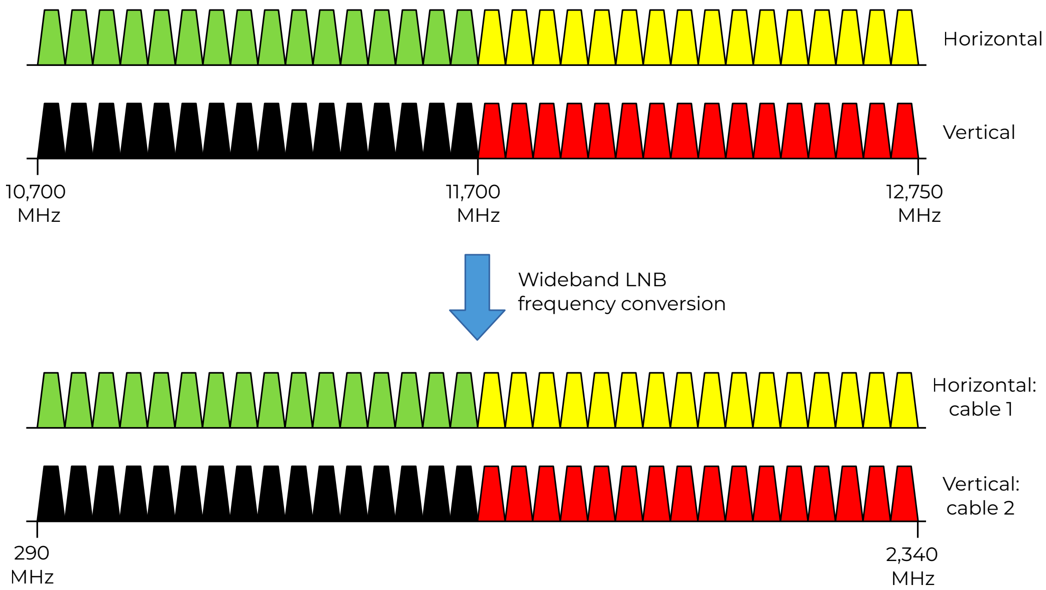

Figure 20 *a wideband LNB converts the whole of each polarisation to a new, wider IF range*

Wideband systems are normally intended for use in individual households equipped with their own dish, but some equipment is now available that allows the use of wideband LNBs in communal systems. In these systems, the cable colouring convention shown in the next table should be used:

Cable colour	Signals
Black	Vertical polarisation, satellite 1
Green	Horizontal polarisation, satellite 1
Red	Vertical polarisation, satellite 2
Yellow	Horizontal polarisation, satellite 2
White	Terrestrial

Table 8 *Cable colour coding for multiswitches with wideband inputs*

When using wideband systems it is no longer possible to carry terrestrial TV signals on the same cable as satellite, because wideband systems use frequencies down to 290 MHz. Furthermore, wideband systems cannot use outlet plates that contain diplexers or triplexers, as the satellite sockets are filtered to prevent passing signals below 950 MHz.

dSCR mode

Connecting a Sky Q receiver to a communal system requires that the system is able to provide signals that are compliant with Sky's variant of dSCR. Sky Q receivers will not operate either with the Sky's variant of SCR or conventional (legacy) systems.

Up to sixteen user bands can be operated on a single cable, each providing independent access to any of the multiplexes on the platform. In the Sky system, the user bands are at predetermined frequencies, as shown in the table.

User Band	Centre frequency
UB3	1680 MHz
UB9	1280 MHz
UB11	1380 MHz
UB14	1480 MHz
UB15	980 MHz
UB16	1030 MHz
UB17	1080 MHz
UB18	1130 MHz
UB19	1530 MHz
UB20	1580 MHz
UB21	1630 MHz
UB22	1730 MHz
UB23	1780 MHz
UB24	1830 MHz
UB25	1880 MHz
UB26	1930 MHz

Table 9 *User bands and their frequencies for the Sky Q system*

Note that UB3, UB9, UB11 and UB14 are not normally used by Sky Q receivers as these channels are close to those used by legacy (SCR) PVRs.

Smart splitters

Sometimes it is convenient to run more than one satellite receiver from a single dSCR feed. Two Sky Q receivers should not share the same dSCR feed, since a single receiver may use most of the available channels. However, a single dSCR feed can be used for one Sky Q receiver and a legacy PVR.

Any receivers on the same cable may initiate communications with the dSCR multiswitch. Receivers have no awareness of what any other receiver is about to do, so there is a small probability that two receivers will each try to send a DiSEqC™ message at the same time. The resulting collision will cause both messages to fail to be received correctly by the multiswitch.

Both EN 50494 and EN 50607 describe methods of detecting failures due to collisions, and a means of recovering from such a failure. Unfortunately, older satellite receivers may not fully support these standards, so an external device known as a smart splitter may be used. A smart splitter is an active device that intercepts DiSEqC™ messages from receivers, and if two arrive together, it adjusts the relative timing of the messages so that they no longer collide, as illustrated in Figure 21.

Interference into satellite systems

Since mobile phone handsets and base stations operate in frequencies that are within the standard satellite IF range and mobile phone handsets are likely to be operated from time to time in fairly close proximity to receiving equipment and cabling, it is important that appropriate quality materials and workmanship are used. Cables qualified under the CAI Cable Certification Scheme should be used, as these will provide a specified minimum level of screening. Only crimped or self-install F connectors should be used, fitted to the cable in accordance with the manufacturer's specifications, and tightened onto the F socket to the required torque (i.e. not left finger tight). Further information about recommended installation practices and interference mitigation can be found in the CAI's Codes of Practice.

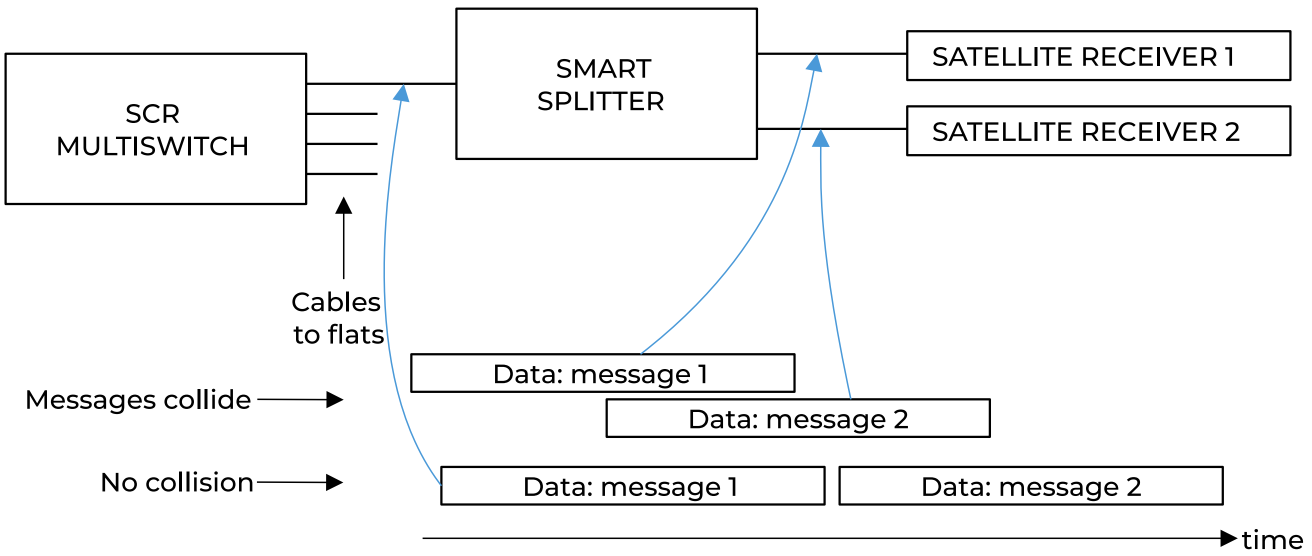

Figure 21 *Use of a Smart Splitter to avoid DiSEqC™ collisions between messages from receivers to the multiswitch*

Optical fibres

In recent years, the use of optical fibres for carriage of TV signals has become commercially viable, mainly due to the availability of inexpensive laser devices that have a sufficiently large modulation bandwidth to be able to carry a full set of terrestrial and satellite TV signals.

The major advantage of optical fibre is its very low loss compared to cable. Fibres can offer a loss as low as 0.2 dB per kilometre. In contrast loss for type 100 coaxial copper cables at the top end of the standard satellite IF band is 30 dB per 100 metres. Fibre optic systems are clearly most suited to systems with signal runs in excess of about 100 metres.

Optical fibres offer these additional advantages:

- The loss of a fibre is independent of the signal frequency, so unlike with copper coaxial cable, equalisation is not required;
- The diameter of a sleeved single fibre is typically less than half that of a copper coaxial cable;
- The fibre can provide electrical isolation between the two ends, eliminating problems arising from unequal earth potentials.

However, there are disadvantages too:

- Making joints and fitting connectors requires relatively expensive equipment;
- There is a need for scrupulous cleanliness when making connections. The tiniest amounts of dirt in a connector can cause a big increase in loss;
- A sharp bend in a fibre can cause increased loss.

A fibre distribution system is typically structured as shown in Figure 22. At the headend, the terrestrial and satellite signals are combined and modulated onto the laserin the RF to optical converter. There is normally a need for some processing of terrestrial signals to control signal levels,

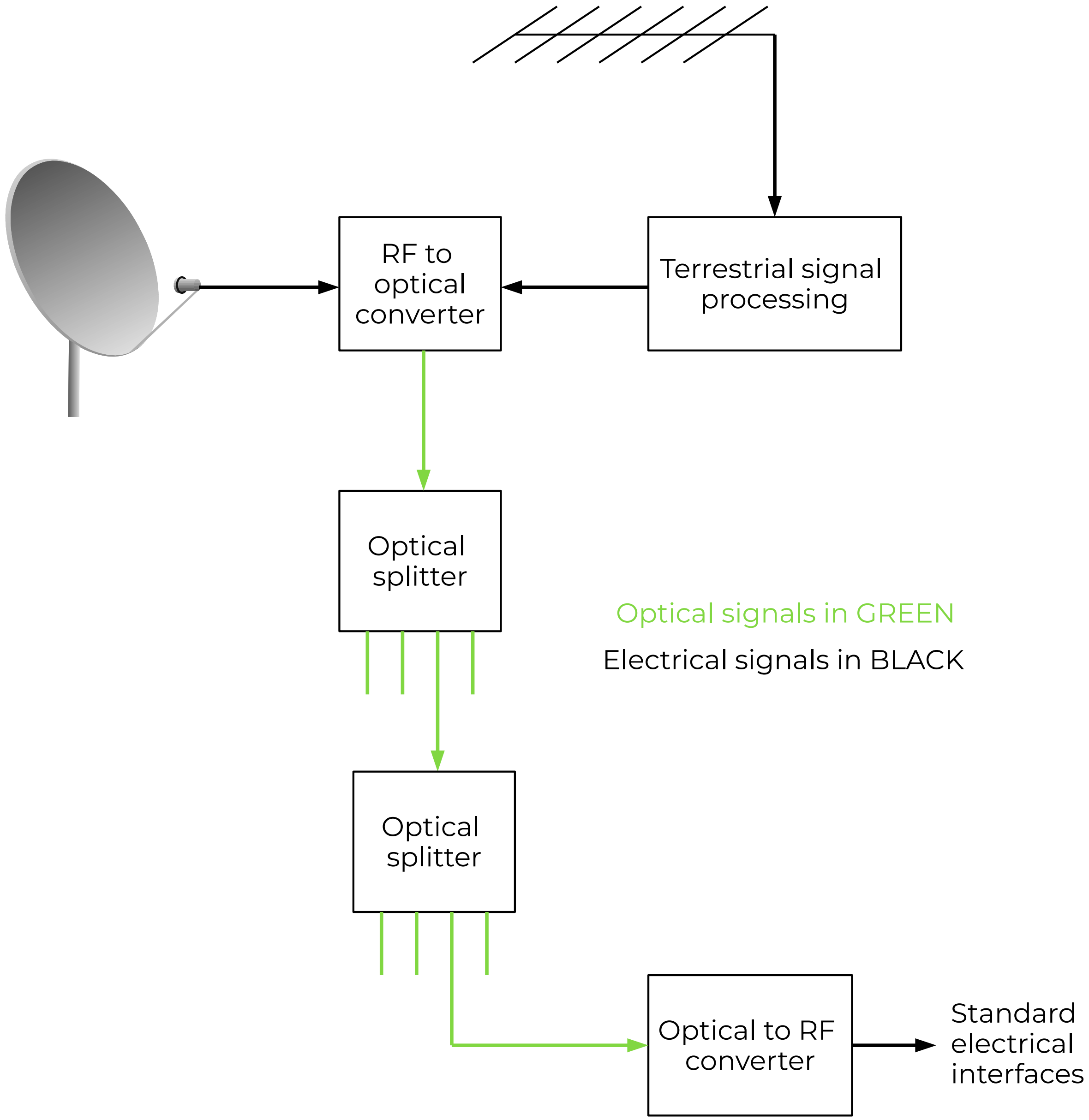

Figure 22 *the structure of a typical fibre optic distribution system*

and also to ensure that only the desired multiplexes are admitted, and that all interference, especially from mobile services in the 700 MHz and 800 MHz bands, is excluded.

The distribution network comprises an arrangement of fibres and optical splitters, not dissimilar to coaxial cable distribution networks found in many MATV systems. Each optical splitter introduces some power loss; for example, a 4-way splitter would introduce about 7 dB loss. The manufacturer will specify the maximum permissible loss across the distribution network, and this will limit the number of homes that can be fed from a single source without optical amplification.

When the fibre enters the home, it terminates on a optical to RF converter. These are available with a number of different output configurations, such as Quad, Quattro, SCR and dSCR. Once the signals are back in the electrical domain, they can be used with other IRS equipment; for example, a Quattro optical to RF converter can be used with a multiswitch, and a dSCR optical to RF converter can be used with a Sky Q receiver.

Optical to RF converters are typically powered either by a receiver or by an external power supply.

About us

About the DTG

The DTG is the UK collaboration centre for innovation in digital media technology, underpinning the free-to-air platforms Freeview, Freesat and YouView and supporting the development of Sky, Virgin Media, BT, TalkTalk, Connect TV and VuTV.

It has been central to the distribution of TV in the UK for nearly two decades and is currently embracing the convergence of content and networks across industries to focus on the efficient delivery of video to all screens - mobile, tablet and TV, in all formats - standard, high and 4k definitions and beyond.

The DTG is currently supporting the next generation of digital TV and related technologies though its work in the following areas: the delivery of video to mobile devices; television on tablets; spectrum coexistence management; TV white space; home networking; accessibility, and the UK UHD Forum.

About the CAI

The CAI is the recognised body for the aerial and satellite industry. The CAI is committed to raising Standards within the industry and the criteria for membership are extremely high.

CAI Members only employ qualified personnel whose work is monitored by an Inspector. If a CAI Member is undergoing inspection, it may be that the CAI Inspector will wish to accompany them to view their installing capabilities. This would be at no extra charge to the customer. It is however, within the rights of the customer to refuse the installation to be inspected.

All CAI Members guarantee their installations for a minimum of 12 months. In addition to this, the CAI undertakes to back-up this guarantee with its own 12-month guarantee, for domestic installations only.

This means that should a CAI Member fail to honour their 12-month guarantee on a domestic installation, the consumer can seek redress via the CAI. Provided that the problems are within the realms of the original guarantee, the CAI will arrange to have the work corrected - at no extra cost to the consumer.

All Members are required to work to the exacting standards laid down in the CAI's Codes of Practice.

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Definitions and abbreviations

ACPR: Adjacent Channel Protection Ratio
This is a measure of how much more powerful an interferer on a nearby channel can be compared to the wanted DTT signal before the receiver suffers with errors on the picture

BER: Bit Error Ratio
BER is a measure of the number of errors in the received data stream

BS: Base Station
BS is the term used to define the equipment and towers in mobile networks e.g. 4G or 5G, which transmit and receive to and from mobile handset equipment (user equipment - see UE)

CCI: Co Channel Interference
This term is often applied to unwanted DTT signals from distant transmitters using the same channel as the wanted DTT signal, but in the case of mobile interference we generally are referring to the intermodulation noise generated in an amplifier, or more specifically the part of the intermodulation noise that is on the same channel as the wanted DTT signal

C/N or CNR: Carrier to Noise Ratio
C/N is a measure of the ratio of the signal power in a channel to the noise power in the same channel, and is fundamental to the operation of the receiver. The C/N must be over a certain value for the receiver to work at all. C/N is normally expressed in dB.

Coexistence
This term is used to define the ability of different technologies to operate simultaneously without causing harmful interference to one another

dSCR: Digital Single Cable Router
This is a mechanism for allowing multiple satellite receivers to operate on a single cable. dSCRs use digital signal processing techniques in comparison to SCRs which use analogue signal processing

DTT: Digital Terrestrial TV
Digital TV broadcast entirely over land-based circuits i.e. not satellite or cable

DVB-T: Digital Video Broadcasting - Terrestrial
DVB-T is a standard for the broadcast transmission of digital terrestrial TV which was first published by the European consortium DVB in 1997 and first broadcast in the UK in 1998

DVB-T2 Digital Video Broadcasting - Terrestrial Second Generation
DVB-T2 is an extension to the DVB-T standard which offers improvements over DVB-T such as increased capacity and robustness to impulsive interference. DVB-T2 is used to transmit HD services in the UK

HDTV: High Defintion TV
High definition TV is broacast using DVB-T2 transmission technology in the UK and provides a higher resolution than standard definition

Impulsive interference
Impulsive interference can originate from a wide range of sources but most often from devices that generate sparks, either intentionally or otherwise

IPTV: Internet Protocol TV
A system in which TV services are delivered using the internet

IRS: Integrated Reception System
IRS are cabled distribution systems designed to deliver FM radio signals, Digital Audio Broadcasting (DAB), analogue and DTT signals, and satellite services

LNB: Low Noise Block Downconverter
An LNB receives microwave signals from a satellite dish and converts them to lower frequencies in order to send the signal to a receiver

Local TV
TV services transmitted to towns and cities across the UK. They are transmitted on channels 21 to 30 and 39 to 48 as per national services but typically it is transmitted at about half the height of the main aerial due to the smaller coverage area required

LTE: Long Term Evolution
LTE refers to Long Term Evolution which is a standard for wireless communication for mobile phones and data terminals. It is one of the technologies along with HSPA+ and WIMAX that was allowed by the ITU to be classified as 4G technology.

MATV: Master Antenna TV
MATV systems supply signals from a single aerial system to a number of receivers and are principally used to distribute terrestrial TV and radio received off-air

MER: Modulation Error Ratio
MER is a measurement of how much a signal deviates from the ideal

Optical to RF converter
A device that converts optical signals to standard electrical RF signals

PMSE: Programme Making and Special Events
PMSE is a term used to denote equipment that is used to support broadcast news gathering, theatrical productions and special events such as culture events, concerts, sports events, and conferences. Examples of such equipment are wireless microphones and in-ear monitors

PVR: Personal Video Recorder
An interactive TV recording device

RED: Radio Equipment Directive
RED replaced the Radio & Telecommunication Terminal equipment Directive from June 2014. The aim of both directives is to ensure that products sold in the EU meet minimum technical requirements and to encourage harmonisation of spectrum use. The RED introduced new requirements which meant that broadcast receivers will have to meet requirements for efficient and effective use of spectrum

RER: Radio Equipment Regulations
Following Brexit the UK has its own equivalent of the RED called the RER

RF to Optical converter
A device that converts standard RF electrical signals to optical

SCR: Single Cable Router
This is a mechanism for allowing multiple satellite receivers to operate on a single cable - see also dSCR

SDTV: Standard Definition TV
SDTV is a television system that uses a resolution that is not considered to be high definition

UE: User Equipment
UE is used to define the mobile handsets or other mobile equipment which can transmit and receive to and from mobile phone networks such as 4G and 5G

Appendices

Key guidelines

1) Aerial installation: DTT channels 49-60 (700 MHz band) have been cleared for use by mobile service. Aerial types need to be chosen accordingly.

DTT channels now operate up to channel 48 meaning the best option is to fit a group K aerial, provided these have sufficient gain. Then all available channels can be received, and some rejection of mobile signals is also achieved. Section 2 of this document provides an overview of aerial groups and the frequencies they cover.

2) Mobile services in 700 MHz: With more mobile networks rolling out across the UK there is a small chance of disruption to free to view services such as Freeview, YouView, BT and TalkTalk.

Installers who believe that disruption to a DTT installation is caused by mobile interference should contact Restore TV. This is the advice even if the installer is able to rectify the issue so that all cases of interference can be followed up.

Restore TV contact centre: 0808 13 13 800

3) Amplification that is no longer required increases the chances of mobile interference.

Mobile interference mitigation steps are:

- Remove any unnecessary amplifiers; and
- where there is either no filter or a class 3 or 4 filter integrated into the amplifier design, to fit a filter before the input to any remaining amplifiers, or other active devices such as multiswitches.

4) The need for masthead amplifiers has significantly reduced since digital switchover.

Do not use masthead amplifiers unless they are absolutely necessary.

5) If an installation does need a masthead amplifier, the following steps are recommended:

- Place it as close to the aerial as possible;
- Place it ahead of any significant losses from feeders, passive splitters, etc.;
- Install an appropriate filter before the amplifier (if a filter is not part of the amplifier design) to reduce vulnerability to interference from e.g. mobile services; and
- Use an amplifier with the lowest gain consistent with adequate performance in order to minimise the risk of overload from mobile services.

6) Mitigating the impact of amplifier overload.

If an amplifier is generating too much intermodulation noise due to overloading by strong signal levels, reduce the level of signal at the input, or reduce the amplifier's gain. Although this will reduce the signal level at the output, it will increase the MER at the output.

7) Steps to reduce impulsive interference include making sure:

- The downlead uses cable that has been approved under the **CAI's Cable Certification Scheme**;
- The aerial has a balun (note: baluns are intrinsic to the design of log periodic aerials);
- The outlet plate and fly lead are well screened; and
- An appropriately high level of signal is being delivered to the outlet.

Persistent cases of impulsive interference should be reported to the **Radio & Television Investigation Service**.

8) In the absence of adjacent channel interference e.g. from mobile services, ensure that DTT signal levels at outlet plates meet the criteria below in order for receivers to perform well:

Mode	Used by multiplex	Minimum level	Maximum level	Minimum MER
DVB-T 64QAM 2/3	PSB1 PSB2	45 dBµV	74 dBµV	23 dB
DVB-T 64QAM 3/4	COM4 COM5 COM6	48 dBµV	74 dBµV	23 dB
DVB-T2 256QAM 2/3	PSB3	44 dBµV	74 dBµV	26 dB

Note: these figures are taken from CAI codes of practise COP 1 for single dwelling units and COP 2 for multi dwelling and commercial units

UK DTT frequencies

DTT Channel	Centre frequency (MHz)
21	474
22	482
23	490
24	498
25	506
26	514
27	522
28	530
29	538
30	546
31	554
32	562
33	570
34	578
35	586
36	594
37	692
38	610
39	618
40	626
41	634
42	642
43	650
44	658
45	666
46	674
47	682
48	690

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