Guidelines for the use of Benchmarked Aerials

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An example the proposed 'mark'

Introduction

Background

The introduction of Digital Terrestrial Television (DTT) in the UK has presented a considerable challenge to the TV aerial industry. The characteristics of DTT, from a reception viewpoint, are significantly different to analogue TV and this makes it much more difficult to ensure that an aerial installation is satisfactory. In particular, the severity of most analogue reception problems such as marginal signal strength, co-channel interference, overloading of receivers/amplifiers, reflections from buildings, etc. can often be assessed by their effect on picture quality. In contrast, very little information on reception quality can be obtained in the same way for DTT and inappropriate aerials have often been installed.

The problem facing an installer is also compounded by the fact that satisfactory DTT reception is much more demanding of aerial performance and installation than is the case with analogue TV. A small degradation may be only just noticeable on an analogue TV picture, but with DTT it may make the difference between a picture and a blank screen.

The tolerance of analogue TV reception to aerial performance has also resulted in a significant quantity of inexpensive but poorly designed and manufactured products becoming available on the market. In most instances, these are unsuitable for satisfactory DTT reception. The lack of any recognised performance standards or existing approval process for domestic DTT aerials has therefore led the CAI and the DTG to introduce the Aerial Benchmarking Scheme.

Acknowledgements

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Benefits of aerial benchmarking

- The only way of ASSURING levels of PERFORMANCE for:
  - gain,
  - impedance match (return loss)
  - pattern (F/B, sidelobes, etc.)
  - cross-polar discrimination
  - rejection of pick-up on feeder

- INDEPENDENTLY tested by an accredited test lab
  - no need to rely on manufacturers' claims alone

- IMPULSE INTERFERENCE problems reduced by low feeder pick-up
  - yet performance data not generally available from manufacturers

- COMPARE different manufacturers' offerings more easily
  - no more confusion over dBi / dBd, differing frequency ranges or voltage/log scales on polar plots etc.

- Professional IMAGE of installer enhanced

- Constant REVIEW of all products granted the "mark"

- An INCENTIVE for manufacturers to improve products

- ONGOING development of standards
  - extensions planned to cover other types of aerial

- STANDARD 1 aerial performance consistent with coverage planning assumptions

- SUPPORTED both by industry and government bodies

Basis of the CAI/DTG Aerial Benchmarking Scheme

The basis of the scheme is to lay down minimum standards for the technical performance of domestic TV aerials based on the specific requirements for satisfactory DTT reception. It is not intended to address general quality issues, such as standard of construction, durability etc., which can largely be assessed by visual inspection and from practical experience. This benchmarking scheme covers aerials only. It does not cover the complete aerial installation, or installation practice.

Conformance to the minimum standards is determined by independent measurements against a technical performance specification. This has been compiled by an industry wide committee who will monitor the implementation of the scheme and agree any necessary changes to the detailed procedures, test methods, and specifications.

The scheme allows the measurements to be carried out by any test house that is able to demonstrate that it meets the required standards of measurement accuracy. The use of the "mark" will be authorised for specific products by the CAI, once the "pass" certificate and supporting documentation has been issued by the test house. Testing of random samples sold to installers or retailers will ensure ongoing conformance.

The Aerial Benchmarking Scheme is a purely voluntary arrangement within the industry and the DTG/CAI have no intention of seeking any form of mandatory status. It is however expected to be widely adopted, following the success of the CAI Cable Benchmarking Scheme. Reference may be made to specific types of CAI/DTG benchmarked aerials in manufacturers literature, purchasers' requirement specifications or supply contracts.

Benchmarked aerials should always be used in conjunction with good installation practice as laid down by the CAI Code of Practice (Ref. 1) and the recommendations in DTG R Book 2 (Ref. 2) The more relevant aspects are detailed under the section headed "Installation of benchmarked aerials" below.

Overview of the CAI/DTG Aerial Benchmarking Scheme

Types of aerial covered by the scheme

The benchmarking scheme currently covers the most common types of external domestic UHF TV aerials that are used for DTT reception. These include yagis, log-periodics and stacked dipole arrays (commonly known as billboards or grids). The inclusion of active aerials (i.e. with an integrated amplifier) is under detailed consideration and eventually the scheme may be extended to set-top aerials, DAB aerials and VHF/FM aerials.

Technical performance requirements

Within the scheme a number of minimum performance levels cater for the range of DTT reception conditions experienced in practice. Clearly a higher performance aerial is needed at the fringe of reception compared with that needed closer to the transmitter. The highest performance standard has been designated Standard 1. The basis of the specification for this standard is that it should provide adequate DTT reception at the edge of coverage, without the need for a masthead amplifier (assuming a downlead of 'normal' length). The minimum specification for Standard 1 is therefore consistent with the aerial performance assumptions that are used in the UK definition of DTT coverage (Ref. 3), on which the DTG Postcode Database is based.

The DTT coverage definition assumes the use of an aerial with increasing forward gain with rising frequency. Standard 1 has therefore been defined separately for each of the standard aerial groups, including wideband (Group 'W'). It should be noted that Standard 1 represents a high gain aerial and, whereas some of the higher performance group aerials on the market may meet this standard, it is unlikely that wideband versions will. There are two other standards that have also been defined for group aerials, including wideband. These are Standard 2 (The intermediate standard) and Standard 3 (The minimum standard), which many existing types of yagi aerial should be capable of meeting. A further category, known as Standard 4, is intended for situations where a wideband aerial with performance better than Standard 3 is needed. Log-periodic aerials should be capable of meeting Standard 4.

Choosing the most appropriate aerial standard.

The DTG Postcode Database gives an indication of whether DTT coverage is likely to be available in a given location, but it is based on predictions rather than measurements. Since the database cannot account for local obstructions, a site survey is normally the best way of determining reception conditions.

It is recommended that a benchmarked aerial be used for reception surveys, as the gain being achieved on each channel is likely to be known with much more certainty. A Standard 4 aerial may often be a good choice for this, particularly when there is any doubt as to which transmitter provides the best coverage at any given location.

The signal levels, and other indications of reception conditions, obtained from the survey aerial can then be used to determine which aerial standard is most appropriate for the particular circumstances. This can be done by comparing the performance of the survey aerial with that of the various standards of benchmarked aerials using the details in the following section. For example, a Standard 2 wideband aerial may be preferable to a Standard 4 product in the Sandy Heath service area as the DTT multiplexes are on higher frequencies than the analogue services and so may benefit from the extra gain provided.

The performance range within each standard has been kept relatively small, but there will still be some variation between individual products. In some cases, a manufacturer may have two different products in the same standard. For example, one might be a high gain Yagi that just meets the minimum requirements for Standard 2 and the other might be of higher performance but not sufficient to achieve Standard 1. Having chosen the appropriate standard, the installer should therefore bear this possibility in mind when making a choice of product.

Electrical performance expected of benchmarked aerials

This section explains the relevance of each aerial performance parameter and gives details of the minimum requirements for each of the four aerial standards. Further information on the requirements for satisfactory DTT reception can be found in References 1 and 2, mentioned above.

Forward Gain

This is usually the most important technical performance parameter. Insufficient level at the receiver can either result in a failure to decode, or make reception vulnerable to impulse interference. Equally, too high a level of the analogue signals can cause overloading and the generation of intermodulation products, which reduces the decoding margin. The choice of which aerial standard to use is therefore primarily determined by the gain needed to achieve the recommended minimum DTT input level of 45 dBµV. The minimum gain (in dBd) for each type of aerial standard is shown in the table below:

AERIAL STANDARD	GROUP 'A' (CH21-37)	GROUP 'B' (CH35-53)	GROUP 'CD' (CH48-68)	GROUP 'E' (CH35-68)		GROUP 'K' (CH21-48)		GROUP 'W' (CH21-68)		
				CHANNEL 35-47	CHANNEL 48-68	CHANNEL 21-36	CHANNEL 37-48	CHANNEL 21-36	CHANNEL 37-52	CHANNEL 53-68
1	10	11	12	11	12	10	11	10	11	12
2	7.5	8.5	10	8.5	10	7.5	8.5	7	8.5	10
3	6	7	8	7	8	6	7	5	7	8
4	Not applicable							7	7	7

Note that 2.15 dB must be added to the above figures to give the gain in dBi.

Return Loss Ratio

Return loss ratio, or return loss, is a measure of the extent to which an aerial is matched to the system characteristic impedance (75 Ω in the case of domestic TV aerial systems) The main effect of mismatch on DTT reception is usually to introduce a small amount of additional signal loss. Note however that this is already included in the gain figure, and so it is not an additional loss. An aerial with a poor return loss, used in conjunction with the poor load match typical of domestic receivers, set-top boxes etc., results in ripples on the amplitude/frequency response. This can have the effect of reducing the decoding margin.

The minimum return loss for each aerial standard is shown in the table below:

AERIAL STANDARD	GROUP 'A'	GROUP 'B'	GROUP 'CD'	GROUP 'E'	GROUP 'K'	GROUP 'W'
1	8 dB	8 dB	8 dB	7 dB	7 dB	6 dB
2	8 dB	8 dB	8 dB	7 dB	7 dB	6 dB
3	8 dB	8 dB	8 dB	7 dB	7 dB	6 dB
4	Not applicable					6 dB

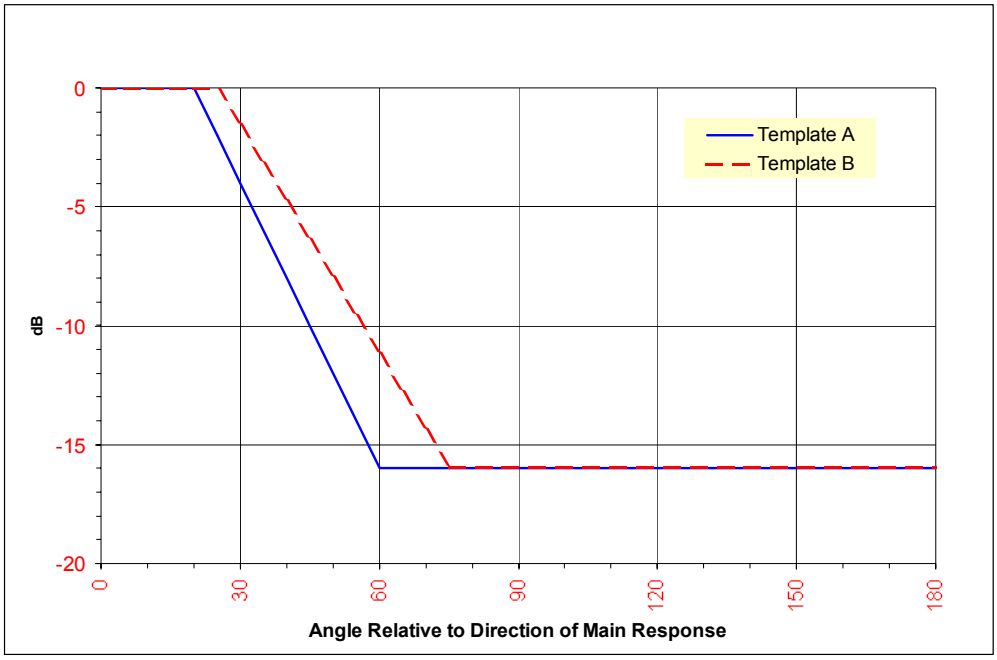
Note that the higher the return loss, the lower the actual signal loss.

Cross-Polar Protection

DTT transmissions, like those of analogue TV, use either horizontal or vertical polarisation. The types of aerial commonly used for TV reception inherently have a fairly high degree of cross-polar protection and therefore reject any co-channel interference of the opposite polarisation. This fact has been used in the planning of DTT coverage to make the best use of the UHF spectrum. Hence if a sufficient level of cross-polar protection is not achieved by a particular aerial, its use could reduce the decoding margin or in extreme cases render DTT reception impossible. This problem can occur continuously, if the interfering station is relatively close, or only for short periods of time if the interfering station is at a long distance. DTT coverage planning is based on a cross-polar protection of 15 dB, which is not particularly difficult to achieve in practice providing care is taken with aerial downlead routing (See section on installation) The figure of 15 dB is therefore used as a minimum requirement for all four aerial standards.

Directivity

Good aerial directivity has the benefit of reducing the level of interfering signals on any bearing with a minimum separation to that of the wanted signal. It is therefore a more onerous requirement than just the simple front-to-back ratio often quoted by manufacturers. It is relied upon by the DTT spectrum planners to reduce the effect of co-channel interference. Hence similar problems to those mentioned in connection with cross-polar protection can occur if the assumed directivity is not achieved in practice. In general, the higher the gain of an aerial, the narrower the forward beam and therefore the better the directivity. However, the difficulty of obtaining high gain over a wide bandwidth, especially for a wideband yagi aerial, means that sidelobes may appear at certain frequencies and so reduce the directivity. The directivity assumed for DTT planning purposes is based on an ITU-R Recommendation (Ref. 4) that requires a reduction in gain of 16 dB over a wide arc. This is shown as Template A on the chart overleaf.



The ITU-R Recommendation is not however appropriate for lower gain aerials and so a slightly relaxed version of the template has been used for Standard 2 and 3 aerials in Groups E, K and W, and also for Standard 4 aerials. This is shown as Template B on the same chart.

These templates, and the associated tests, have been specified for horizontal polarisation (E-plane) only, in order to reduce the complexity and cost of testing. (Although aerial directivity is generally slightly worse for vertical polarisation, this is only used for a relatively small percentage of the overall coverage.)

Feeder Pickup Rejection

This aerial performance parameter, which is not very critical for UHF analogue TV, is particularly important for satisfactory DTT reception. This is because poor feeder pickup rejection can lead to any impulse interference that is picked up on the outer of the downlead being transferred to the inner, via the aerial termination arrangements. It is a common cause of impulse interference from domestic appliances getting into the STB or iDTV, especially after the most frequent cause (poor downlead screening) has been eliminated by the use of CAI benchmarked cable.

It is unlikely that any balanced aerial will pass this test unless some form of balance to unbalance transformation is incorporated in the design. Any type of aerial that requires the coax outer to be directly connected to one side of the dipole element will almost certainly fail to meet the requirement. The minimum amount of feeder pickup rejection for each aerial standard is shown in the table overleaf.

AERIAL STANDARD	GROUP 'A'	GROUP 'B'	GROUP 'CD'	GROUP 'E'	GROUP 'K'	GROUP 'W'
1	15 dB	15 dB	18 dB	12 dB	12 dB	12 dB
2	12 dB	12 dB	15 dB	10 dB	10 dB	9 dB
3	10 dB	10 dB	12 dB	8 dB	8 dB	7 dB
4	Not applicable					20 dB

It will be seen from the table above that the requirement is gradually relaxed going from Standard 1 to Standard 3. This assumes that lower gain aerials are only used when much higher field strengths are present and so the required degree of protection from impulse interference is lower. The higher levels specified for Standard 4 are consistent with the performance achievable with a log-periodic aerial.

Note that the associated test procedure, although based on a standard EMC absorbing clamp (Ref. 5), has had to be developed specifically for this application.

Installation of benchmarked aerials

It is obviously important not to compromise the benefits of using benchmarked aerials by lack of attention to good DTT installation practice. This is particularly important for the reduction of impulse interference. The use of a benchmarked aerial with good feeder pickup protection needs to be supported, in particular, by the use of CAI benchmarked cable. Unscreened outlet plates and poor quality flyleads should not be used. Cable joints should be avoided wherever possible and when necessary should only use connectors intended for the purpose. All passive accessories should comply with the screening factor requirements of BS EN 50083-2.

Another important point to bear in mind is that almost all aerial performance parameters can be worsened to some degree by unsuitable routing of the downlead in the vicinity of the aerial feed point and/or directors. Manufacturers' instructions, where provided, should always be followed explicitly in this respect.

The process of benchmarking

The overall process is defined in detail in the CAI/DTG Procedure and Benchmark Manual (Ref. 6). There are three basic stages to the process, as described briefly below.

Testing

Manufacturers wishing to obtain authority to display the 'mark' are required to submit sample aerials for testing. This sample must be supplied assembled complete with all fixings. It must also be connected to a 3 metre 'tail' of CAI RNE678/100 benchmarked cable and accompanied by the specified documentation to ensure repeatability of testing.

The tests are largely based on the measurement methods specified in BS 5640/ IEC 60597 (Ref. 7). They must be carried out by an independent test house that has government accreditation providing traceability of measurements to national standards, in order to ensure the integrity of the benchmarking scheme. Accreditation must include (in Bands IV and V) antenna factor/gain, return loss, frequency and attenuation with associated uncertainties consistent with the limits for each aerial parameter set out in the benchmarking manual. Within the UK, this accreditation is carried out solely by UKAS (United Kingdom Accreditation Service). Additionally, the test house must provide the CAI/DTG with a detailed uncertainty budget showing how the required limits for each aerial parameter are achieved. The detailed results of all tests are confidential between the manufacturer and the test house.

Marking

Once the CAI has been informed of a pass from the test house with appropriate certification and production drawings, the manufacturer will be authorised to use the 'mark' for the specified product(s). The mark will also denote the Standard to which the aerial has passed.

An example of the mark is illustrated on the front page of this document

Auditing procedure

Random samples of products that carry the 'mark' will be regularly inspected by the CAI against the previously submitted production drawings. These samples will be obtained through the normal aerial supply chain and not directly from the manufacturer. Any modifications made that could affect the electrical characteristics will result in the need for retesting.

A one-month grace period will be given before any 'mark' is suspended. The minimum period between such product inspections will be 18 months for companies with the BS EN IS09002: 1994 or BS EN ISO9001: 2000 quality standard and 12 months otherwise.

References

Reference 1
"CAI Code of Practice for the Installation of Terrestrial and Satellite TV Reception Systems" October 2000.

Reference 2
DTG R-Book 2 "Installing Digital Terrestrial Television Domestic Systems" October 2002 Edition.

Reference 3
Digital Terrestrial Television Frequency Planning Project "Technical Parameters and Planning Algorithms" Document Number JPP/MB/1, Version 1.0, 10th August, 2001.

Reference 4
ITU-R Recommendation BT.419-3 "Directivity and Polarisation Discrimination of Antennas in the Reception of Television Broadcasting".

Reference 5
CISPR 16-1 (BS 727) " Specification for radio disturbance and immunity measuring apparatus and methods - Part 1: Radio disturbance and immunity measuring apparatus".

Reference 6
CAI/DTG "Procedure and Benchmarking Manual" Issue 12, Revision 1, 17th April 2003.

Reference 7
BS 5640:Part 2: 1978, IEC 60597-2: 1977 "Aerials for the reception of sound and television broadcasting in the frequency range 30 MHz to 1 GHz: Methods of measurement of electrical performance parameters".