

CAI/AB/DOC02 - Joint CAI / DTG Aerial Benchmarking	
Standards	BS 5640:I, II 1978 and ITU-R. BT.419-3 1992
Page: 1 of 35	Procedure and Benchmark Manual
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Introduction

1. *Basis for Benchmarking*

For the reception of Digital Terrestrial Television (DTT) signals in the UK, there is a requirement that the receiving aerials are designed and manufactured to a minimum industry standard.

It is felt that due to the high level of analogue signals in comparison to the lower digital signals, that the correct aerial has not always been fitted. This has been mainly prevalent in fringe reception areas where DTT reception issues have invariably been improved with the installation of a correct aerial.

The Confederation of Aerial Industries and the Digital Television Group have therefore decided that an approval process is required to ensure that aerials conform to a minimum standard. The benchmark specification is to determine the characteristics of an aerial required to obtain stable DTT reception. It does not alter the basic requirements of aerial design but highlights important parameters so that satisfactory DTT reception may be achieved.

Aerials that have been approved will display a CAI Benchmark Logo [™], and CAI Registration/Certification number on all packaging, for aerials individually bagged the same information must appear on the antenna assembly instructions for each aerial, confirming that the required standard has been passed.



It has been noted that this benchmark is not a legal requirement but a recommendation. Experience in the industry has indicated that it will be to the industry's advantage to supply equipment to this recommendation.

The standards BS 5640:1, II 1978 and ITU-R. BT.419-3 have been used as a guide in setting the specification.

The benchmark is to set the minimum performance required for various standards of aerial. It does not cover ease of assembly, durability and installation. The Confederation of Aerial Industries issues a **Code of Practice for the installation of aerials/antennas and receiving equipment in the single dwelling unit** and it is essential that this code be followed.

The scheme was launched in April 2003 and has now been adopted by over 16 manufacturing companies and in excess of 135 CAI certificates have been issued.

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2. *Testing*

The test procedures listed in this document will be able to be repeated by any UKAS approved test house or European equivalent standard. The CAI/DTG have approved a test house for manufacturers to use but this does not mean that this is the only test house that can be used.

The tests must however be carried out by an independent test house with UKAS 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 the electrical characteristics set out in this manual. 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.

Details of the CAI/DTG test house can be found in the appendix, together with a sample test certificate and a details list of the uncertainty budgets per test.

The test house will issue a conformity certificate (1st page of the test report) to manufacturers. For details on obtaining a CAI benchmark certification please refer to the **CAI Guidelines on Process for Product Testing**.

3. *Auditing Procedure*

Once a product has received CAI certification, then the CAI Inspectorate will acquire random samples from either the manufacturer or a distributor/retailer during the course of the normal CAI inspection process.

Details of this procedure together with timeframes for discrepancies can be found in the **CAI Guidelines on Process for Product Testing**.

Any previously benchmarked aerial that have received modifications that could affect the “active” electrical characteristics **must** be submitted for re-test.

If the manufacturer has the BSEN ISO9001: 2008 standard of quality then the product review period is eighteen months but if the manufacturer cannot provide evidence of an approved quality management system then the frequency is every twelve months.

4. *Training*

The CAI and DTG feel that it is essential that all installation engineers carry out an approved installation course so that they are aware of the particular aerial and cable requirements of DTT.

This benchmark is to determine the aerial characteristics required to obtain stable DTT reception. It does not alter the basic requirements of aerial design but highlights important sections so that satisfactory reception of DTT may be given. An aerial that meets these requirements will enable an aerial installer and specifier to be sure that the product being used is to the required standard and as such is likely to give good performance tied in with a total installation to the required standards. The result will be reduced call back and a guarantee for the customer.

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The installation of a particular aerial does not in itself guarantee satisfactory reception. This will depend on local conditions and the requirements of the customer.

5. *Implementation*

Initial tests were undertaken in April and May 2003. The initial batch of products were certified in June 2003 to all submitting manufacturers.

Since then, testing is at the discretion of the manufacturer and the appropriate test house.

6. *Enhancements*

The manual issue 12 and associated procedures were the first approved issue for the benchmarking of UHF external aerials for the UK market place.

In 2012 the specification was revised to consider LTE (Long Term Evolution).

It is possible to extend the Benchmarking to include Set Top Aerials, aerials with integral amplified dipoles (Active Dipoles), DAB aerials and VHF/FM aerials.

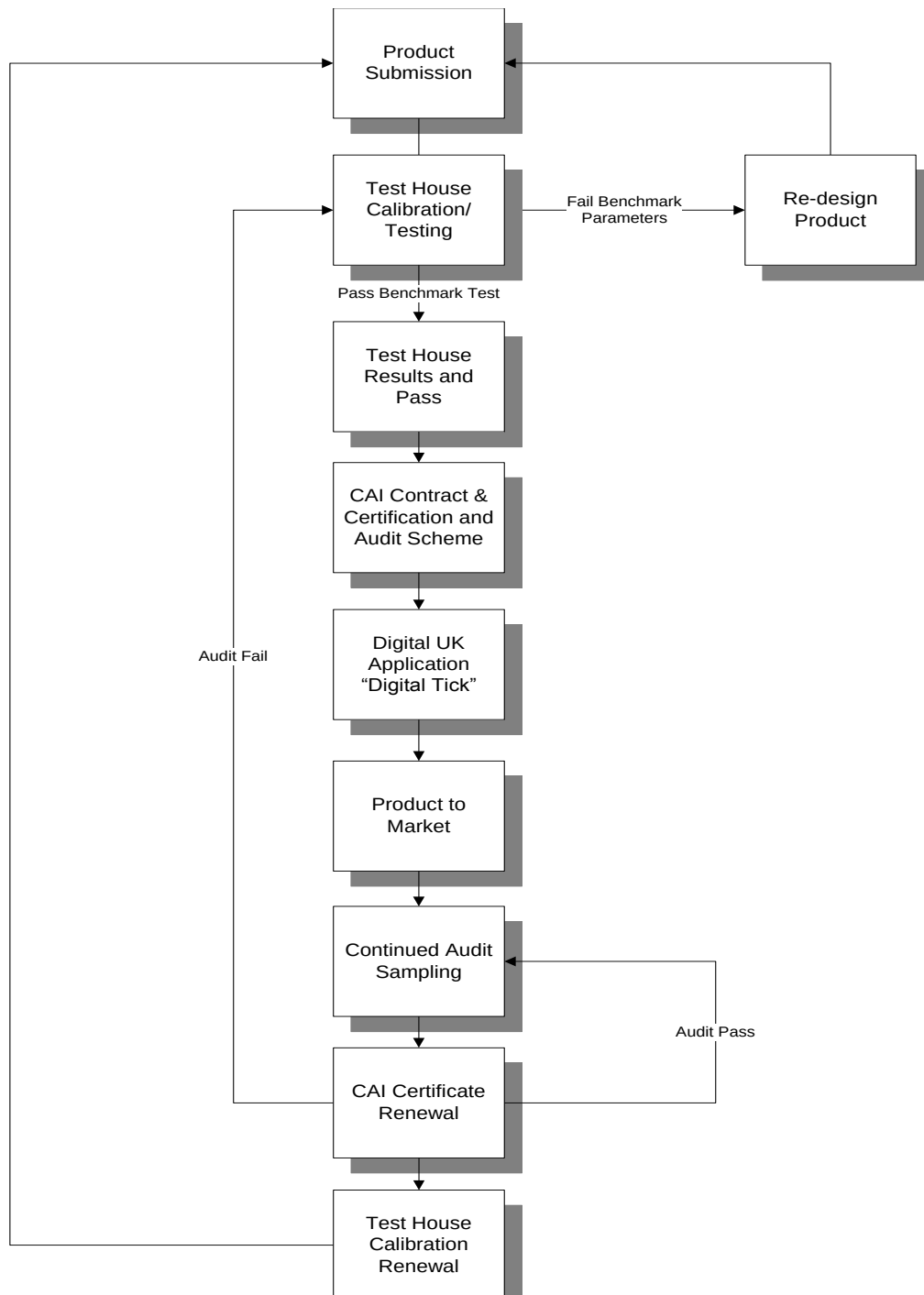
The Benchmarking System is reviewed on an on-going development basis at various meetings, sub meetings and after further aerial testing. The CAI test UKAS approved house findings are the bases for the initial levels; developments and enhancements to the testing procedures and site may influence these initial settings as a commitment to on-going improvement of the benchmarking procedure.

Holders of this Benchmarking Manual are registered and any revisions are appropriately recorded.

Further investigations in relation to mechanical stability were undertaken, but due to the cost of independent testing it was considered prohibitive.

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Procedures and Processes



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Confidentiality

The results of all tests are confidential between the test house and the submitting manufacturer.

The conclusion of a pass or fail and relevant evidence will be passed to the submitting manufacturer from the Test House.

Accreditation with a CAI certificate will only be given once the CAI have been informed of a pass with appropriate Test House certification and dimension drawings from the submitting manufacturer and subject to the payment of the certification fee.

The Test House will retain the results and documentation, including dimension drawings and photography.

The CAI will retain manufacturer dimension drawings.

Commercial confidentiality **will** be respected.

Manual Control

This manual will only be issued as directed by the Benchmarking Committee Chairman.

Distribution of issue 9 is via the CAI/DTG to all interested parties. Distribution of Issue 12, revision 1 is to the aerial benchmarking group and includes minor amendments to the levels and Feeder Pickup Measurement including uncertainties for final comment before being distributed to other interested parties. Subsequent issues and revisions are to be distributed by the CAI.

The benchmarking auditor is responsible for the administration and control.

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Controlled Manual Distribution

Les Hampson	CAI Vice Chairman & Technical Committee Chairman
Tim Jenks	CAI Senior Executive
Robert Oliver	Benchmarking Committee Chairman
Kevin Dawson	CAI Assessment & Training Executive
David Knight	National Physical Laboratory
Bev Walker	CAI Secretary
Paul Blake	Blake UK (Manual Control)

Manual Status

Issue No.	Date of Issue
1	6th December 2001 (Draft)
2	20th December 2001 (Draft-Amendment Number 1)
3	14th January 2002 (Draft-Amendment Number 2)
4	28th January 2002 (Draft-Amendment Number 3)
5	1st March, Martin Turner, changes
6	11th May 2002 (Draft-Amended)
7	29th May 2002 (Draft-Amended)
8	1st October 2002 (sub. Committee Meeting)
9	30th October 2002 (Final committee amendments)
10	15th November 2002 (Type 4 added)
11	22nd February 2003 (FPU added, uncertainties confirmed)
12	11th April 2003 (FPU/Polar levels amended, appendix added with FPU procedures)
13	17th April 2003 (General Distribution)
14	22nd June 2011 (Directivity template changes & updated for incorporate CAI AERIAL BENCHMARK AGREEMENT)

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Definitions

OPERATING FREQUENCY RANGE: Spectrum between maximum and minimum frequencies of particular aerial group.

GROUP A: Minimum 470 MHz Maximum 606 MHz, Centre frequency 538 MHz.

GROUP B: Minimum 582 MHz Maximum 734 MHz, Centre frequency 658 MHz.

GROUP CD: Minimum 686 MHz Maximum 854 MHz, Centre frequency 770 MHz.

GROUP E: Minimum 582 MHz Maximum 854 MHz, Centre frequency 718 MHz.

GROUP K: Minimum 470 MHz Maximum 694 MHz, Centre frequency 582 MHz

GROUP T: Minimum 470 MHz Maximum 790MHz, Centre frequency 630MHz

GROUP W (Wideband): Minimum 470 MHz Maximum 854 MHz, Centre frequency 658MHz.

Standard 1 Aerial: (Highest Standard)

Standard 2 Aerial: (Intermediate Standard)

Standard 3 Aerial: (Minimum Accepted Standard)

Standard 4 Aerial: (Log periodic aerial Standard)

Standard F Aerial: (LTE) (Fringe)

Standard S Aerial: (LTE) (Standard)

Polarisation: Horizontally Mounted Aerial or a Vertically Mounted Aerial.

Forward Gain dBd: Reference to a Half Wave Dipole.

Forward Gain dBi: Reference to an Isotropic Source.

Note: 2.15dB must be added to Forward Gain dBd to allow a direct comparison to dBi.

Dimension drawing: Documentary evidence of the “Active” parts of an aerial. Clearly showing construction details of all physical dimensions, spacings and tolerances of the director elements and driven element.

“Active” parts: An active part of an aerial is one, which contributes to the electrical performance of an aerial. E.g. director elements, driven element or balun. Non “active” parts would include plastic parts and clamping arrangements if not used as circuit connections in the aerial design. Where clarification is required the sub-group will confirm the classification.

Tolerance: Maximum tolerance to be +/- 3mm. (For auditing purposes)

Active Dipole: A dipole with a built in amplifier.

For the purpose of this document all ‘Forward Gain’ figures are quoted in dBd i.e. gain versus a half wave dipole as defined in BS5640.

Uncertainties: Uncertainties are based on nominal values.

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Assembly Procedures

When performing the assembly of an aerial for the purpose of performing any of the benchmark tests, the submitting manufacturer will provide the following:

1. Two aerials assembled, complete with all fixings.
2. A 3-metre length of **CAI benchmarked cable** fitted to the aerial. For clarity the 3 metre length of coax cable does not include cables which are an integrated part of the submitted product (e.g. Log Periodic feeder cable, phased array cables running to the combiner). Therefore the connection point for the 3m cable to the aerial represents the same connection point the installer would use on an installation.
3. Termination using 'F' type crimp on connector.
4. Documentation as described below.

The aerials may be broken down for the purpose of shipment and storage with the cable connected, part routed and then coiled whilst waiting testing.

Two identical aerials are required to ensure complete traceability.

Where the aerial has the option of different methods of mounting the product. (e.g. Back or cradle mount) then aerial must be tested using all fixings provided by the manufacturer.

The CAI cable benchmark standard RNE678/100 has been selected to ensure full continuity of tests. The attenuation details of the 3-metre length of cable are used as part of the necessary cable measurement calculations. The cable route is securely fastened to the aerial, mounting system and mast section in line with the manufacturer's preferred method.

Full documentation and photographic evidence of the aerial's construction and the cable route taken for the test is to be made. This will allow complete repeatability.

Instructions for the purpose of testing only are to be provided to the CAI/DTG Test House, confirming both final assembly and fixing instructions. These instructions must include details of integral parts of the balun connections, internal cable routing/termination and internal splitter/combiners.

The submitting manufacturer's dimension drawings are also to be included stating all dimensions, construction details and tolerances. Details are also required of the method of mounting and alternative methods, where applicable.

This must be strictly adhered to for conformity.

Discrepancies found within any manufacturer's assembly procedures or dimension drawings or differences in the two submission aerials will be reported to the submitting manufacturer immediately.

These procedures are to be listed in a quantifiable way.

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Coaxial Cable Connections

Scope

This procedure defines the methods adopted for the identification of examination and assessment status of an aerial's cable connection.

Procedure

1. Ensure that the inner and outer coaxial cable core termination points on the dipole connection are a minimum of 3mm and no more than 20mm apart. (If the installer prepares the coaxial cable correctly this distance will prevent any short circuits.)
2. This section is not applicable to F type terminations.

Final Pass Stage

AERIAL STANDARD	INNER/OUTER DISTANCE CHECK REQUIRED
1	YES
2	YES
3	YES
4	YES
F	YES
S	YES

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Tilting Mechanism

Scope

This procedure defines the methods adopted for the identification of examination and assessment status of an aerials tilting mechanism.

Procedure

1. The chart below illustrates the aerial types that will require a tilting mechanism.

AERIAL STANDARD	REQUIRED
1	YES
2	YES
3	NO
4	NO
F	YES
S	NO

Final Pass Stage

The tilting method must incline the aerial from a level plane up to a minimum of 15 degrees. Level of Accuracy is +/- 2 degrees.

An aerial that is designated to have a tilting method, and found not to have one will fail this stage of the benchmark.

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Electrical Characteristics: Forward Gain

Scope

This procedure defines the methods adopted for the identification of examination and assessment status of forward gain.

Procedure

1. Uncertainty to be 1dB and within 95% confidence.
2. Forward gain to be measured in line with the Substitution method outlined in BS5640 Page 2, Section 3.2.1. (IEC page 9)
3. Produce a graphical representation, showing full frequency response of the aerial.
4. A graph, showing the response of the aerial when horizontally polarised must be produced.

Final Pass Stage

The information in the charts below should be taken as the minimum value of forward gain within the designated operating frequency range of the specific aerial standard i.e. 1, 2, 3 or 4.

Aerial Groups – Gain in dBd

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

There should not be any variation in forward gain exceeding 2dB per 8MHz of operating frequency range.

Where aerial groups overlap e.g. (E, K and WB) the required gain is apportioned into groups of channels as indicated in the table.

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Electrical Characteristics: Return Loss Ratio

Scope

This procedure defines the methods adopted for the identification of examination and assessment status of return loss.

Procedure

1. Uncertainty to be 1dB and within 95% confidence.
2. In line with Return Loss Ratio (RLR) BS 5640:I Section 3.17
3. Produce a graphical representation, ensuring that the defined aerial group centre frequencies are shown at all times.

Final Pass Stage

The information in the chart below should be taken as the minimum value of return loss ratio within the designated operating frequency range of the specific aerial type i.e. 1,2 or 3.

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

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Electrical Characteristics: Directivity

Scope

This procedure defines the methods adopted for the identification of examination and assessment status of directivity.

Procedure

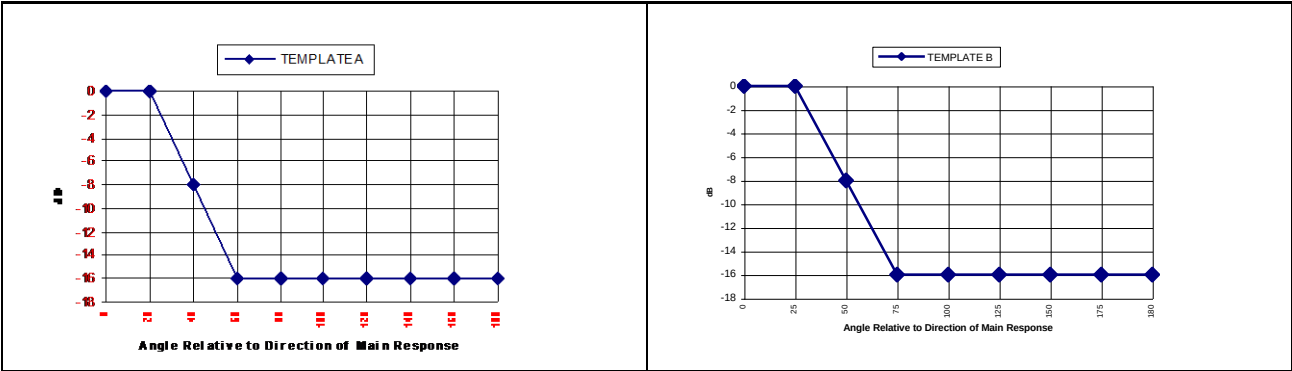
1. Uncertainty to be 2dB and within 95% confidence.
2. This test must be BS 5640:I Section 3.5, BS5640: II Section 4.1. Page 4 (IEC page 13) and ITU-R. BT.419-3.
3. Produce linear or logarithmic plots, with the aerial horizontally polarised, for each of the frequencies listed in the table below.

	Aerial Standard 1	Aerial Standard 2	Aerial Standard 3	Aerial Standard 4
GROUP 'A' AERIAL	470MHz 538MHz 606MHz	470MHz 538MHz 606MHz	470MHz 538MHz 606MHz	N/A
GROUP 'B' AERIAL	582MHz 658MHz 734MHz	582MHz 658MHz 734MHz	582MHz 658MHz 734MHz	N/A
GROUP 'CD' AERIAL	686MHz 770MHz 854MHz	686MHz 770MHz 854MHz	686MHz 770MHz 854MHz	N/A
GROUP 'E' AERIAL	582MHz 718MHz 854MHz	582MHz 718MHz 854MHz	582MHz 718MHz 854MHz	N/A
GROUP 'K' AERIAL	470MHz 582MHz 694MHz	470MHz 582MHz 694MHz	470MHz 582MHz 694MHz	N/A
GROUP 'W' AERIAL	470MHz 658MHz 854MHz	470MHz 658MHz 854MHz	470MHz 658MHz 854MHz	470MHz 658MHz 854MHz
GROUP T AERIAL	Aerial Standard F	Aerial Standard S		

Final Pass Stage

Aerial Standard	GROUP 'A'	GROUP 'B'	GROUP 'CD'	GROUP 'E'	GROUP 'K'	GROUP 'W'
1	TEMPLATE A	TEMPLATE A	TEMPLATE A	TEMPLATE A	TEMPLATE A	TEMPLATE A
2	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B
3	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B
4	Not applicable					TEMPLATE B

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Electrical Characteristics: Cross-Polar Protection

Scope

This procedure defines the methods adopted for the identification of examination and assessment status of Cross Polar Protection.

Procedure

1. Uncertainty to be 1dB and within 95% confidence.
2. Produce a graphical representation, showing full frequency response of the aerial.
3. Test must be carried out in accordance with BS BS5640 Page 3,Section 3.5. (IEC page 11)
4. A graph, showing the response of the aerial when horizontally mounted must be produced.

Final Pass Stage

Aerial Standard	GROUP 'A'	GROUP 'B'	GROUP 'CD'	GROUP 'E'	GROUP 'K'	GROUP 'W'
1	15dB	15dB	15dB	15dB	15dB	15dB
2	15dB	15dB	15dB	15dB	15dB	15dB
3	15dB	15dB	15dB	15dB	15dB	15dB
4	Not applicable					15dB

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Electrical Characteristics: Feeder Pickup

Scope

This procedure defines the methods adopted for the identification of examination and assessment status of Feeder Pickup.

Procedure

1. Uncertainty to be 2dB and within 95% confidence.
2. Produce a graphical representation, showing full frequency response of the aerial.
3. Test must be carried out in accordance with Feeder Pickup Measurement Procedure (Date: 11 April 2003, Issue 2) Author: A. Wade
4. A graph, showing the response of the aerial must be produced.

Final Pass Stage

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

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Appendix A

Submission Documents

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AERIAL BENCHMARKING PRODUCT SUBMISSION FORM

Measurement Service: EF1000

NPL Reference:

Test date:

(NPL use)

Your company details	
Company name:	
Company address (to appear on front page of benchmark report):	
Contact name:	
Tel. No. :	e-mail :
Invoicing address (if different from above):	

Your aerial details (PLEASE TICK BOX)						
Std 1	☐	Std 2	☐	Std 3	☐	Std 4 ☐ Tilt mechanism? (Yes / No)
Full aerial name to appear on benchmark report:						
Manufacturer:			Model:			
Part No. or Version :						
Operating frequency band designation :						

Has this aerial been tested previously :	YES / NO	Cert Reference & Date :	
Do you wish NPL to return the aerals after testing?		YES / NO*	
(Unwanted aerals will be sent for recycling at NPL)			

If there are special measurement requirements, please give details here: (e.g. Do you require a certificate for the best pass standard achieved)
--

CHECK LIST FOR SUBMISSION

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CHECK LIST FOR SUBMISSION									
Mast fixings		3m cable terminated with F-type		Assembly Instructions		Cable layout Instructions		Dimension Drawings	

Please send completed form by return e-mail or to NPL Fax No.: +44 (0)20 8943 7176, and include a copy of this form with the aerial when it is sent to NPL for testing. If you have previous calibration results or data, it may be helpful to supply this with the aerial.

Issue: 7

April 2011

The test will be conducted in accordance with the CAI Benchmark Guidelines (“Guidelines”) pursuant to NPL terms and conditions. Once testing is complete and you have been notified of a pass, the CAI will require you to enter into a contract with them and comply with the Guidelines before they will issue you with a Benchmark certificate and permit you to use the Benchmark logo.

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Contact Details

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2) CAI/DTG Approved Test house is the National Physical Laboratory (NPL).

Technical Enquiries to:

Mr David Knight

Tel: 020 8943 6860
Email: david.knight@npl.co.uk
Website: www.npl.co.uk

Administration contact to:

Mr Tahir Maqba

Email: tahir.maqba@npl.co.uk

G1-A6
National Physical Laboratory
Hampton Road
TEDDINGTON
Middlesex
TW11 OLW

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Price Matrix Per Aerial

Stage Of Scheme	Service Provider	Frequency	Cost
Product Submission: Initial Testing and Conformity Certification	NPL	Initial Submission Only	£ 700 + £ 370 = £ 1,070
CAI Certification and Audit Scheme	CAI	Initial Submission Only	£ 200 CAI Member / £ 450 Non Member
Digital UK Logo Authorisation	Digital UK	Initial Submission Only for 1 st Product ONLY	Free of charge
CAI Certificate Renewal	CAI	1 x Review period (e.g. ISO registered 18 months and non-ISO 12 months)	£ 250 CAI Member / £ 450 Non Member
Re-Test Submission: Test House Calibration (Gain & Polar Pattern only)	NPL	3 x Review periods (e.g. ISO registered 3 x 18 months = 4.5 years and non-ISO registered 3 x 12 = 3 years)	£ 780

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Prices and Details of the CAI/DTG Test House: NPL.



CAI TESTING, QUOTATION PRICE LIST – 2011

Note: NPL does not discriminate between CAI members and non-members. Our price structure applies to the testing only; the CAI may charge different rates for final certification.

1	Initial testing (gain & pattern): Test of TV aerials in accordance with CAI Benchmarking scheme. Measurements provided are forward gain and E-plane polar pattern. Manufacturer will be contacted upon failure to decide whether further testing is required. Costs apply only to testing performed to point of fail. It is possible that a lower pass standard may be offered if the aerial does not pass the standard on the submission form.	£700 per aerial
2	Complete testing and certification: Perform the remaining 3 tests and produce final report.	£370 per aerial
3	Aerial retest: Aerials subject to retesting are only required to pass gain and pattern, within the uncertainty of the measuring system.	£780 per aerial
4	Site visit: Customers may prefer a site visit to witness the test. This may involve some experimentation to solve issues with the aerial. The daily rate includes one benchmark report, and any additional reports incur an extra cost.	£1125 per day (plus £250 per additional pass certificate)

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Appendix B

Method of Measurement for Feeder Pickup

Document Status

11th April 2003 – second draft release.

(24th February 2003 – first draft release for discussion.)

Introduction

Feeder pickup

The term '**feeder pickup**' refers to the tendency for the feeder cable of a receiving antenna system to act to some extent as an antenna itself. Signals picked up on the feeder can be coupled into the wanted signal path, thereby reaching the receiver. Although significant feeder pickup can result from the use of poorly screened coaxial cable, the coupling mechanism that we are concerned with here is that in which the connection between the driven element(s) of the antenna and a well-screened feeder allows RF current flowing on the outside of the outer conductor of a coaxial feeder (common-mode current) to enter the wanted signal path. Where the driven element is a balanced structure, such as a half-wave dipole, some form of balance-to-unbalance transformer ('balun') is required to suppress this coupling.

Feeder pickup is usually an unwanted characteristic of an antenna system and can introduce a number of undesirable effects, for example unpredictable modification of the antenna's radiation pattern ('polar diagram') and degradation of its cross-polar discrimination.

Feeder pickup can also lead to raised levels of interference. In particular, interference radiated from sources close to the feeder may, if feeder pickup rejection is inadequate, reach the receiver at a much higher level than if it were picked-up by the antenna alone.

Feeder pickup and DTT

In the context of digital terrestrial television (DTT) reception this is of concern because of the susceptibility of DVB-T systems to electrical impulse interference. Feeder pickup on the antenna system provides a route whereby impulse interference from household electrical equipment can reach the receiver at levels high enough to cause disturbances to viewing and listening. TV antenna feeders ('downleads') often run close to mains wiring, providing a mechanism for close coupling of such conducted interference

Aerial benchmarking

The CAI / DTG aerial benchmarking standard therefore includes requirements for minimum standards of *feeder pickup rejection* performance in order to reduce the risk of undue impulse interference.

This document specifies the measurement method to be used for determining feeder pickup rejection (FPU rejection) as part of the benchmarking test suite. The measurement is based on the use of the ferrite *absorbing clamp* to inject a common mode signal onto the feeder of the antenna under test (AUT). The absorbing clamp is a standard piece of equipment used for EMC measurements and is described in CISPR publication 16-1.

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Definition

FPU rejection is defined for a single-frequency signal. The FPU rejection of an antenna will, in general, vary with frequency across the antenna's bandwidth. Thus the FPU rejection measurement results for an antenna will take the form of a set of data representing FPU rejection versus frequency – typically in the form of a frequency response plot.

FPU rejection is defined as the ratio, expressed in decibels, of the signal level injected onto the feeder of an antenna under test (AUT) using the absorbing clamp to the signal level measured at a receiver connected to the AUT via a length of well-screened coaxial cable, when measured according to the procedure in section 3 of this document. The signal levels referred to are determined after allowing for the calibrated coupling loss of the absorbing clamp and the attenuation of the coaxial cable.

Measurement Method

Test site requirements

Measurement of FPU rejection is carried out on a suitable outdoor test site complying with the following requirements:

- The ground shall be substantially level.
- There shall be no significant obstructions within a cylinder of radius 3 m, with its axis vertical and centred on the position of the AUT and extending upwards from ground level to a height of at least 10 m; in particular there must be no overhead metallic wires, cables or pipes, etc. passing within the cylinder at any height above 1.2 m above ground level.

Equipment requirements

The following equipment is required:

- A table or structure of height 1 m ($\pm$ 50 mm) for supporting the absorbing clamp; this shall be made of non-conductive material, e.g. timber. The length of the support shall be sufficient to allow the absorbing clamp to be moved along the feeder by at least half a wavelength at the lowest frequency of interest (320 mm at 470 MHz). Details of a suitable support are given in Fig. 1.
- A support 'mast' for the antenna under test; this is made from non-conductive material and is supported by the table referred to above. Suitable means shall be devised to attach the AUT at the specified height – examples of attachment of rear mounted and cradle mounted antennas are illustrated in Fig. 2. The mast shall be capable of being rotated about its vertical axis.
- An absorbing clamp in accordance with CISPR publication 16-1 (BS 727).
- Frequency response (insertion loss) measuring equipment covering at least the frequency range 470 - 854 MHz and comprising a suitable source and receiver – e.g. a spectrum analyser with tracking generator, or a network analyser. N.B. owing to the risk of off-air interference being picked-up by the AUT, the measuring receiver must be selective – i.e. the use of equipment which employs wideband diode detectors (as found in some types of scalar network analyser) is not permitted.
- 75 Ω test cable for connecting AUT to receiver; this shall be a 4.8 mm size drop cable to BS EN 50117-2 and shall be of a type approved under the CAI cable benchmarking scheme.
- 50 Ω test cable for connecting signal source to absorbing clamp.
- 50 - 75 Ω matching pads, and other coaxial adapters and sundry items as required.

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The absorbing clamp and frequency response measuring equipment shall be calibrated by an accredited test house, with calibration data traceable to national standards.

Test set-up

The essential details of the test set-up are shown in Fig. 3. The 75 Ω test cable connected to the AUT shall be routed in accordance with the antenna manufacturer's instructions, or may consist of the 'tail' supplied with the antenna for the forward gain and other measurements. Care must be taken to route the cable vertically down the support mast and through the absorbing clamp in a manner which makes the measurements repeatable.

Where a connection is required between a tail supplied with the AUT and the test cable to the receiver, this shall be made with a Type-F back-to-back coupler with a return loss of not less than 20 dB at the highest test frequency. Alternatively a 50 - 75 Ω matching pad may be inserted at this point, the remainder of the cable run to the receiver then being 50 Ω .

Note that measurements are normally taken with the E-plane of the AUT at right-angles to the antenna cable (this is to minimise any direct pickup of radiation from the cable by the antenna). The output level from the signal source should be kept to a minimum, consistent with obtaining sufficient signal-to-noise ratio in the measurement. A level of 0 dBm (into the 50 Ω test cable) will generally be found satisfactory.

Where the AUT is an active antenna, line-power at the appropriate voltage is injected into the antenna cable using a suitable 75 Ω bias tee. The latter should exhibit return losses of not less than 20 dB at the highest test frequency.

Measurement procedure

Calibration

To determine the FPU rejection of the AUT, the losses in the measurement set-up must be 'calibrated out' ('normalised'). This can be done in a number of ways and the best method will depend on the type of test equipment being used and whether the raw measurement data is being automatically post-processed in software. This procedure, therefore, does not prescribe any specific method of calibration. The following additional notes may be helpful:

- The losses of the test cables may be measured separately and included in a results calculation; alternatively the loss of the two cables together may be taken out by use of a 'response calibration' or 'normalisation' facility in the test equipment. Care must be taken however to ensure that cable losses are measured under well-matched conditions and that the losses of attenuator and/or matching pads are properly accounted for.
- The loss of the absorbing clamp is obtained from its calibration data. N.B. the value required is the absolute loss (nominally 17 dB) and not the correction value ($\pm$ deviation from 17 dB) which is sometimes given on calibration certificates. The clamp loss may either be included in a results calculation or be entered as a 'amplitude correction table' in the test receiver.

Measurement

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A measurement consists of collecting one or more 'sweeps' of insertion loss readings, and may be taken as either a number of discrete frequency points, or as sampled data from a continuous sweep. In either case the frequency interval between readings shall not exceed 4 MHz. Averaging may be used to reduce the effect of noise.

Before taking measurements it shall be verified that the antenna is not directly picking up radiation from the feeder. This is done by rotating the support mast by up to 90° in each direction whilst observing the insertion loss readings. Any significant change indicates the presence of direct pickup and in this case the mast should be rotated to minimise the indicated RF level (maximum insertion loss), otherwise return it to the orthogonal E-plane position.

The absorbing clamp is moved along the support table in order to maximise the indicated RF level (minimum insertion loss). Usually this occurs with the clamp close to the antenna mast.

For each recorded frequency point the FPU rejection is calculated as follows:

FPU rejection = measured insertion loss - sum of all losses in test set-up.

Measured data points where the results are clearly being affected by off-air interference pickup by the AUT (e.g. from a local TV transmitter) may be ignored and replaced by interpolated data.

END OF PROCEDURE

Diagrams Figs. 1 & 2 to follow.

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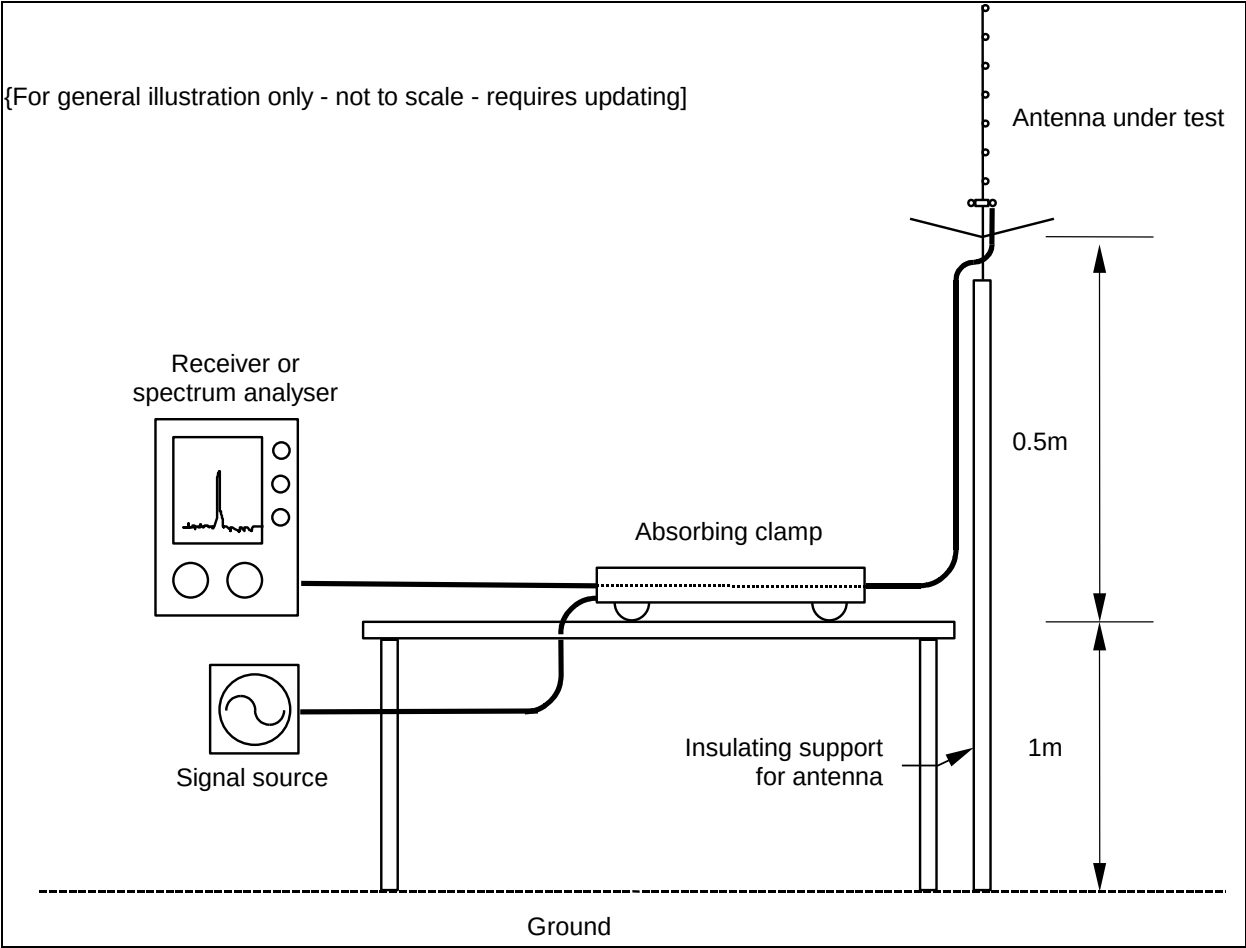


Fig. 3 – Measurement set-up
[Sketch from earlier publication to indicate general nature of test set-up only.]

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Appendix C

Further Reading/References

Title	Author
Aerials with CAI Benchmark status	CAI
Guidelines for the use of Benchmarked Aerials	Doug Fisher (DTG)
CAI Guidelines on Process for Product Testing	CAI
Code of Practice for the installation of television aerials	CAI
CAI AERIAL BENCHMARK AGREEMENT (CAI & Applicant)	CAI
CONTRACT FOR SERVICES (Test House & Applicant)	CAI/NPL

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Appendix D

Assumptions

- 1 Aerial Standard – “S” : New Aerial Standard for “Standard reception areas , within coverage. (Low Gain)”
- 2 Aerial Standard – “F” : New Aerial Standard for “Fringe reception areas, on edge or outside of coverage. (High gain)”
- 3 Aerial Group “A” : New Group per Andy Wade document but taking PSME into consideration. Channels 21-39
- 4 Aerial Group “T” : New Group per Andy Wade document. Channels 21-60
- 5 No consideration for the “H” group per Andy Wade document due to the final confirmation of mid-band use.
- 6 No special consideration Log-periodics.
- 7 New Out-of-band Gain Parameters to be added to the Forward Gain Test. *These figures need some practical testing for feasibility WITHOUT in-line filtering*
- 8 New Polar plot Template C for Directivity – per discussions at forum
- 9 Max Gain Measurement fna Polar Plot to be considered at channel 57 and not 60 – to allow Peak gain and then reduce for out-of-band rejection in the LTE bands.
- 10 Currently no consideration for in-built LTE filters for aerials for this specification. This is under consideration.

A) Coaxial Cable Connections (Existing)

AERIAL STANDARD	INNER/OUTER DISTANCE CHECK REQUIRED
1	YES
2	YES
3	YES
4	YES

Coaxial Cable Connections (New)

AERIAL STANDARD	INNER/OUTER DISTANCE CHECK REQUIRED
S	YES
F	YES

B) Tilting Mechanism (Existing)

AERIAL STANDARD	REQUIRED
1	YES
2	YES
3	NO
4	NO

Tilting Mechanism (New)

AERIAL STANDARD	REQUIRED
S	NO
F	YES

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C) Electrical Characteristics: Forward Gain (Existing)

Aerial Groups – Gain in dBd

AERIAL STANDARD	GROUP 'A' (CH21-37)	GROUP 'B' (CH48-68)	GROUP 'CD' (CH48-68)	GROUP 'E' (CH35-68)		GROUP 'K' (CH21-48)		GROUP 'W' (CH21-68)		
				CH 35- 47	CH 48- 68	CH 21- 36	CH 37- 48	CH 21-36	CH 37-52	CH 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

Electrical Characteristics: Forward Gain (New)

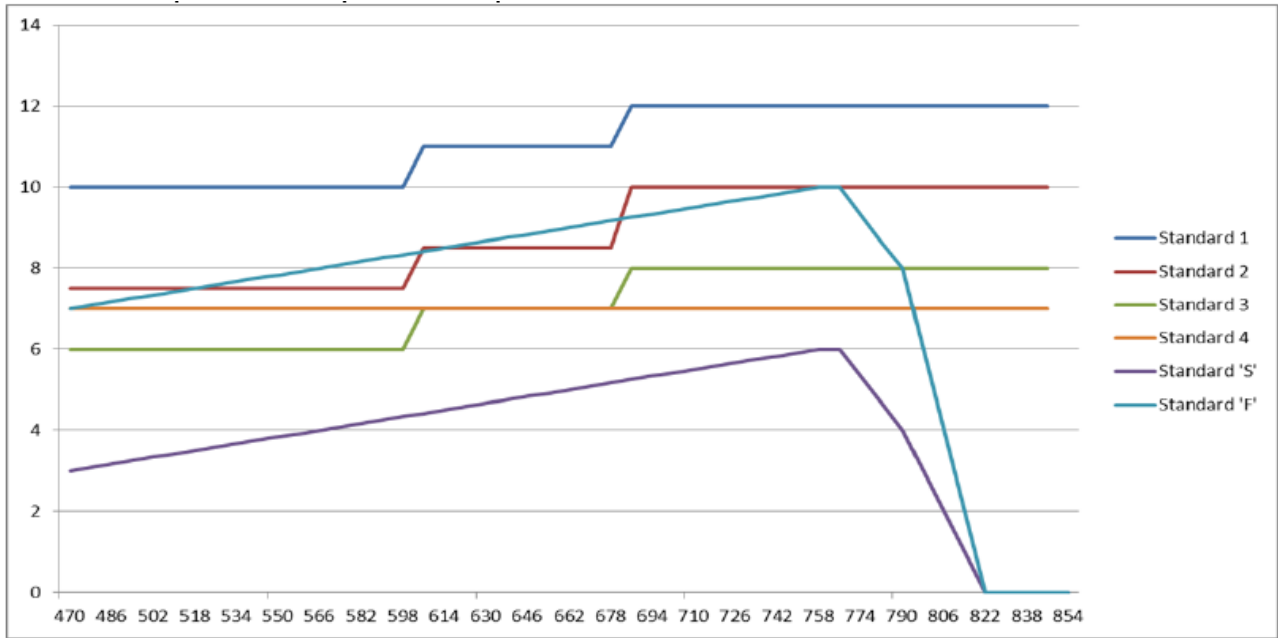
AERIAL STANDARD	GROUP 'A' (CH21- 37)	GROUP 'T' (CH21-60)			
		CH 21- 36	CH 37- 52	CH 53- 57	CH 60
S	6	3	5	6	4
F	10	7	9	10	8

Electrical Characteristics: Out-Of-Band Forward Gain Rejection (New*)

AERIAL STANDARD	GROUP 'A' (CH60- 68)	GROUP 'T' (CH65- 68)
S	<=0	<=0
F	<=0	<=0

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Note the gain drop from channel 60 to out-of-band channel 65 must NOT cross the line more than once. E.g. To prevent out-of-band spiking in the LTE bands and to ensure a smooth gain reduction.



D) Electrical Characteristics: Return Loss Ratio (Existing)

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

E) Electrical Characteristics: Return Loss Ratio

Do not perform this test as part of the new process

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F) Electrical Characteristics: Directivity (Existing)

	Aerial Standard 1	Aerial Standard 2	Aerial Standard 3	Aerial Standard 4
GROUP 'A' AERIAL	470MHz 538MHz 606MHz	470MHz 538MHz 606MHz	470MHz 538MHz 606MHz	N/A
GROUP 'B' AERIAL	582MHz 658MHz 734MHz	582MHz 658MHz 734MHz	582MHz 658MHz 734MHz	N/A
GROUP 'CD' AERIAL	686MHz 770MHz 854MHz	686MHz 770MHz 854MHz	686MHz 770MHz 854MHz	N/A
GROUP 'E' AERIAL	582MHz 718MHz 854MHz	582MHz 718MHz 854MHz	582MHz 718MHz 854MHz	N/A
GROUP 'K' AERIAL	470MHz 582MHz 694MHz	470MHz 582MHz 694MHz	470MHz 582MHz 694MHz	N/A
GROUP 'W' AERIAL	470MHz 658MHz 854MHz	470MHz 658MHz 854MHz	470MHz 658MHz 854MHz	470MHz 658MHz 854MHz

Aerial Standard	GROUP 'A'	GROUP 'B'	GROUP 'CD'	GROUP 'E'	GROUP 'K'	GROUP 'W'
1	TEMPLATE A	TEMPLATE A	TEMPLATE A	TEMPLATE A	TEMPLATE A	TEMPLATE A
2	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B
3	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B	TEMPLATE B
4	Not applicable					TEMPLATE B

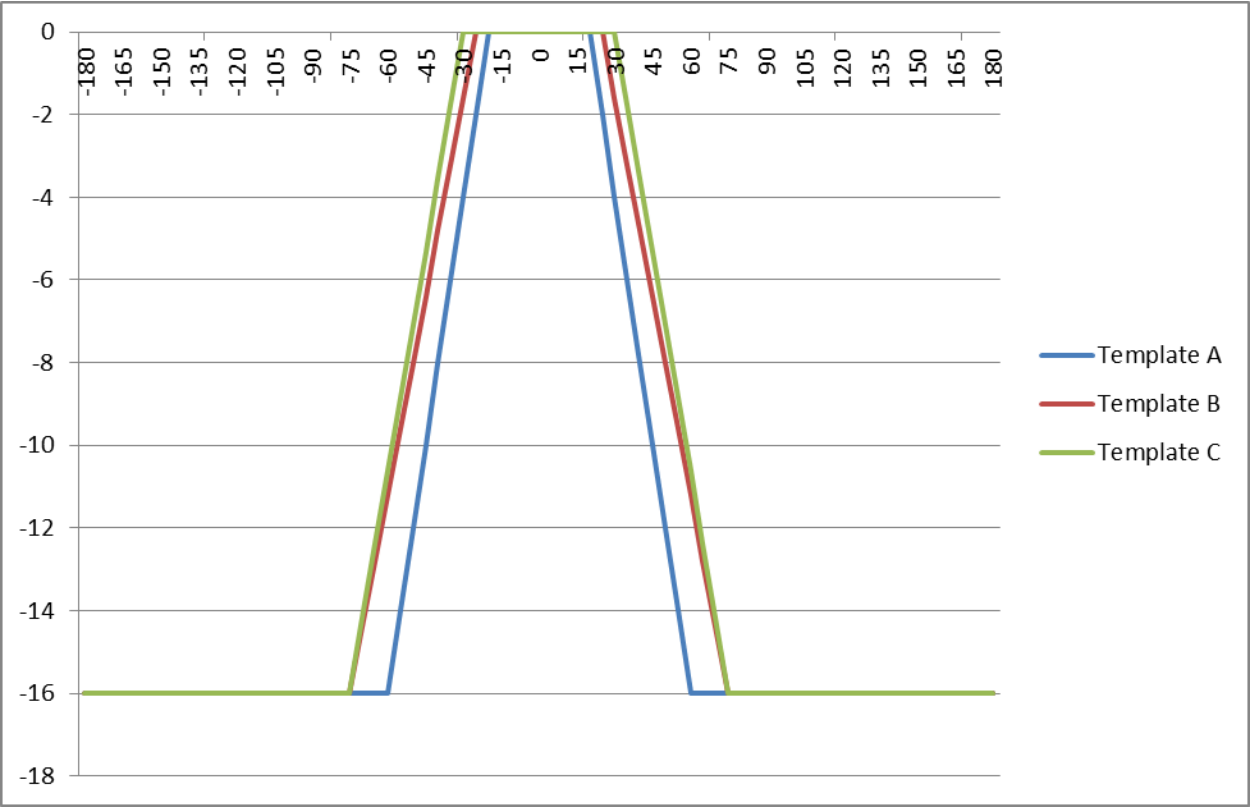
Electrical Characteristics: Directivity (New)

	Aerial Standard S	Aerial Standard F
Group 'A' Aerial	470MHz 630MHz 606MHz	470MHz 630MHz 606MHz
Group 'T' Aerial	470MHz 630MHz 766MHz***	470MHz 630MHz 766MHz***

Aerial Standard	Group 'A'	Group 'T' (Lower & Mid Frequency)	Group 'T'*** (Upper Frequency)
S	TEMPLATE B	TEMPLATE C	TEMPLATE A
F	TEMPLATE A	TEMPLATE B	TEMPLATE A

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Electrical Characteristics: Directivity (Templates A,B & Amended Template C)



G) Electrical Characteristics: Cross-Polar Protection (Existing)

Aerial Standard	GROUP 'A'	GROUP 'B'	GROUP 'CD'	GROUP 'E'	GROUP 'K'	GROUP 'W'
1	15dB	15dB	15dB	15dB	15dB	15dB
2	15dB	15dB	15dB	15dB	15dB	15dB
3	15dB	15dB	15dB	15dB	15dB	15dB
4	Not applicable					15dB

Electrical Characteristics: Cross-Polar Protection (New)

Aerial Standard	Group 'A'	Group 'T'
S	16dB	16dB
F	16dB	16dB

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H) Electrical Characteristics: Feeder Pickup (Existing)

Aerial Standard	GROUP 'A'	GROUP 'B'	GROUP 'CD'	GROUP 'E'	GROUP 'K'	GROUP 'W'
1	15dB	15dB	18dB	12dB	12dB	12dB
2	12dB	12dB	15dB	15dB	15dB	15dB
3	15dB	15dB	15dB	15dB	15dB	15dB
4	Not applicable					15dB