



Ofcom Site Engineering Code for Analogue Radio Broadcast Transmission Systems

Broadcasting - Radio

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Introduction

This Code is based on the provisions of the Broadcasting Act 1990 and the Broadcasting Act 1996, the Wireless Telegraphy Act 2006 and the Communications Act 2003. It applies to all analogue local and national Independent Radio services, Community Radio services, BBC services and restricted services, other than where exceptions are detailed herein.

Ofcom will amend and re-issue this code from time to time as it thinks appropriate; it will require compliance with the most recent code and subsequent variations thereto which it has published.

It will be the responsibility of Broadcasting Act and Wireless Telegraphy Act licence holders¹ to ensure compliance with the requirements of this code as applied to the technical characteristics set out in those licences, and to comply with any other specific requirement which may be notified by Ofcom from time to time. Each licensee shall nominate a person, or organisation with a nominated contact, as responsible for maintenance and operation of the transmission equipment; the licensees and all relevant employees and contractors thereof should be familiar with the contents of this code and able to secure compliance with it.

¹ The BBC's services are regulated by the BBC Trust and not licensed under the Broadcasting Act

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Scope, Tests and Inspections

1.1 Scope of Code

Ofcom is empowered to include conditions in licences which will enable it to supervise and enforce technical standards which apply to the service concerned. The areas where Ofcom considers itself to have responsibilities to require adherence to particular technical standards are those which relate to the efficient use of the radio spectrum, the protection of other broadcasters and users of the radio spectrum, and those circumstances where adherence to a particular transmission standard is believed better to serve the wider interests of the consumer. This latter consideration is particularly likely to apply in circumstances where competing standards are proposed for new or enhanced methods of transmission (either of the sound programme service or of additional services attached thereto). In general, however, Ofcom will not seek to impose technical standards which may otherwise be determined by licensees without prejudice to the position of their competitors.

1.2 Other Responsibilities

The conditions in this specification relate solely to the requirements of Ofcom. Compliance with these requirements does not absolve the licensee from general legal responsibilities outside the interest of Ofcom. These general requirements include:

- Compliance with the current Health and Safety at Work Act.
- Duties and liabilities imposed by Law by virtue of ownership, occupation or use of a building and surrounding land.
- Securing that operators and members of the public are not exposed to an electromagnetic field in excess of that recommended by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). For Band II VHF frequencies these limits are currently set at 2 Watts/m² for continuous exposure (> 6 mins), which equates to an electric field of 148.8 dB (μV/m). In the MF Band the worst case is at the top of the band, where the limit is set at 13.4 Watts/m² which equates to an electric field of 157 dB (μV/m).
- Compliance with EC Directive 1999/5/EC on radio equipment (the R&TTE Directive) as embodied by Statutory Instrument 2000 No. 730. This only applies to newly installed transmitters, which are required either to carry the appropriate **CE** stamp indicating compliance, or be accompanied by a bill of sale, indicating purchase prior to 8 April 2000, also the serial number and manufacturer's name, matching those on the equipment concerned.

Notwithstanding the generality of these responsibilities, Ofcom will reserve the right to refuse to undertake the tests referred to in 1.3 below, if it has reason to believe that any of these general responsibilities has not been adequately discharged. Ofcom may charge a fee for any additional expenses incurred for this reason.

1.3 Commissioning Tests and Subsequent Modifications

All transmission systems, other than those used by RSLs, require to be tested for compliance with this Code and associated WT. and B. Act licence conditions prior to coming into service, and to have permission granted by Ofcom to continue transmissions. If the licensee wishes these tests to be performed by Ofcom then they must book attendance at least 20 working days in advance of the desired commissioning date. If their system fails Ofcom compliance testing for reasons that might reasonably have been anticipated, and which cannot be rectified whilst Ofcom engineers are in attendance, Ofcom will postpone the tests and authority to transmit, until they can next attend site, and may charge the licensee for any additional visits.

Alternatively, licensees may opt to carry out their own commissioning tests or contract these out to a third party. They must advise Ofcom of this course of action at least 20 working days in advance of their intended commissioning date. Ofcom would then require documentary or electronic evidence of compliance within 5 working days of commissioning. If not forthcoming, or the results are not satisfactory, the transmitter in question will be required to be switched off and permission to transmit withheld until satisfactory evidence of compliance has been received and assessed.

Commissioning tests will be to ensure compliance with this specification and to ascertain that the stability of the equipment is such that the requirements therein should continue to be satisfied thereafter. Reference measurements taken will assist in the subsequent assessment of compliance.

Ofcom strongly advises licensees to ensure that, subsequent to permission being granted to transmit, test transmissions are made over a period of at least 2 weeks in advance of the on-air date, in order to facilitate identification and resolution of possible incompatibilities with other radio services.

No change to the transmitter, RF distribution system or aerials, that may affect radiated power levels or levels of spurious or harmonic emissions, is permitted without the explicit permission of Ofcom except where such change (i) is to use a reserve or temporary antenna or transmission system, the characteristics of which have previously been agreed with Ofcom; and (ii) is notified to Ofcom as soon as practicable after it is made. Other than where this is due to an unforeseen fault, at least 20 working days notice is required of any such work.

Where changes are made to programme input equipment (PIE) that are likely to increase modulation levels, then continued compliance with this code must be ensured. Where there is likely to be a significant change to modulation characteristics, Ofcom requires to be advised at or before the time of that change.

1.4 Documentation

At least 20 working days prior to commissioning tests referred to in section 1.3 above, the licensee is to furnish Ofcom with an accurate block diagram of the complete installation, also aerial horizontal radiation patterns in each active plane of polarisation, vertical radiation characteristics (Section 2.4 refers) and system gain calculations.

More detailed information concerning system design, equipment handbooks, and operating instructions for the setting-up and adjustment of the transmitter, should be available at reasonable notice, if requested by Ofcom staff.

1.5 Inspections and Monitoring

Ofcom reserves the right to have access to the transmitter installation from time to time to conduct inspections, and tests thereof, to verify continued compliance with this specification. Ofcom also reserves the right to conduct such other tests as it sees fit, including the remote measurement of the licensee's transmissions, without notification. Licensees should ensure that arrangements made with third parties facilitate these inspections and tests, by providing accompanied access.

Regardless of how recently or frequently Ofcom may have tested a transmission system, it is the licensee's responsibility to ensure, in context, adequate monitoring of critical transmission parameters, and to provide either for the signal to be switched off or to be transferred to a compliant system in the event of drift or other failure.

Section 2

Characteristics and Limits of Transmission: (VHF: 87.5 – 108 MHz): frequency modulation

2.1 Transmission Standard

Transmissions must be compliant with ITU-R Recommendation 450-3, adhering to certain options and additional provisions therein, as follows:

- i) The maximum frequency deviation applied to the radio-frequency carrier must not exceed ± 75 kHz by more than 5 positive-going or 5 negative going excursions in any 5 second period of programme service. Where an excursion above ± 75 kHz exceeds 10 msec duration, it shall be divided into discrete 10 msec periods (rounded up) and counted accordingly. Under no circumstances is the deviation to exceed ± 80 kHz other than by anomalous behaviour.

It is recognised that licensees may not be able to provide monitoring that is capable of continuously demonstrating that the above has been met. Thus, the means of satisfying these requirements shall include the insertion of limiters (or, if appropriate, audio processing equipment capable of the same function) at appropriate points in the programme input equipment of the transmitter. Such limiters should be installed as close along the signal path, as is practical, to the transmitter. Even where this is prior to the programme link to the transmitter (including off-air Band II signals for relaying) Ofcom will hold the licensee responsible for any breach of this code that may result from noise, instability, inherent characteristics, failure of, or interference to the programme distribution system. In addition to the above, in the event of failure of main or standby programme feed to the transmitter, its carrier should ideally be switched off, but in any event modulation should be removed until the programme feed is restored.

- ii) The pre-emphasis characteristic of the sound signal(s) must be identical to the admittance-frequency curve of a parallel resistance-capacitance circuit having a time constant of $50 \mu\text{s}$ ($\pm 2 \mu\text{s}$).
- iii) Where stereophonic programmes are to be transmitted, the GE Zenith Pilot-Tone System, as described in section 2.2 of ITU-R Recommendation 450-3, must be employed.
- iv) The amplitude modulation of the unmodulated carrier must not exceed 1% depth of modulation.
- v) Supplementary audio or data signals (other than where inaudibly embedded in, and integral to, the main audio modulation of mono and stereo-difference channels) should not be sent in addition to the main programme multiplex, other than as provided for under Section 2.9 below.

2.2 Spectral Occupancy

ITU-R Recommendation 412-7 makes certain assumptions concerning the level of modulating signal power and peak deviation levels, in defining protection levels intended for use in FM Sound Broadcasting. Ofcom will continue to control spectral occupancy by limiting peak deviation levels in accordance with Section 2.1 rather than by the introduction of a spectral 'mask', however licensees should make every reasonable endeavour to restrict the levels of energy radiated at frequencies up to and including ± 150 kHz of the rest carrier frequency, known as the 'necessary bandwidth' required for the modulation process. In order to manage the transition between 'necessary' and 'out-of-band' emissions Ofcom will use the following technique for measuring emissions at that transition, under programme modulation conditions:

The carrier power level against which emissions will be compared is assessed by setting a spectrum analyser with Resolution Bandwidth (RBW) and Video Bandwidth (VBW) to 300 kHz, and frequency span to 500 kHz centred on the rest carrier frequency. The peak level is noted and the analyser reference level is set to that. The RBW and VBW are then reduced to 3 kHz and the relative levels are noted at ± 150 kHz. These should not exceed those specified in Section 2.3 following.

2.3 Spurious and Harmonic Emissions

With the transmitter operating at any power up to its specified power level into its designed load impedance, the level of any spurious or harmonic emissions measured downstream of all filters and combiners, above 100 kHz but excluding the range within ± 150 kHz of the rest carrier frequency (this being the necessary bandwidth for modulation – Section 2.2), must not exceed the following limits:

- a value 40dB below the unmodulated carrier power for transmitter power < 250mW;
- a power of 25 μ W for transmitter power < 25w and \geq 250mW;
- a value 60dB below the unmodulated carrier power for transmitter power < 1 kW and \geq 25w;
- a power of 1mW for transmitter power \geq 1kW;

and in the band 118-137 MHz:

- a power of 25 μ W for transmitter power < 7.9kW and \geq 250mW;
- a value 85dB below the unmodulated carrier power for transmitter power \geq 7.9kW;

also, in the band 108-118 MHz, the level of such emissions must not exceed a value below the unmodulated carrier power of:

- 40dB, for transmitter power < -6dBW (250mW);
- [46 + erp in dBW]dB for erp < 30dBW; where erp refers to total mixed effective radiated power.
- XdB for erp < 48dBW and \geq 30dBW, where, $X = 76 + 9[\text{erp in dBW} - 30]/18$;
- 85dB for erp \geq 48dBW

Without prejudice to the generality of the above provisions, nor to the other provisions of this code, Ofcom may also require the licensee to secure particular measures for the suppression of certain effects which arise in combination with other radio transmissions, including:

- i) the radiation of intermodulation products generated within shared aerial and feeder systems, or aerial systems mounted on the same or neighbouring mast structures;
- ii) the re-radiation of other transmissions from nearby aerials.

Ofcom will make reasonable endeavours to predict such effects in so far as these effects are:

- i) generated in conjunction with other broadcast transmissions in the VHF band (87.5-108 MHz), and;
- ii) liable to interfere with aeronautical navigation services in the band 108 - 137 MHz;

but even in this category such effects may not always be revealed by theoretical predictions prior to the commencement of the licensee's transmissions and subsequent changes may therefore need to be made.

It may occur at multi-user sites that whilst a newly installed transmitter provides one of the frequencies contributing to the generation of an intermodulation product, it is not the one radiating that product at unsatisfactory levels. Licensees are to ensure that the requirements of this section, and any additional suppression that may be notified by Ofcom, are met throughout the licence period, including when other new services are introduced. They should check their output at intervals appropriate to the quality of output filtering employed, and the 'reverse intermodulation' performance of their transmitter. Whatever the site configuration, licensees are strongly encouraged to fit band-pass filters to increase the confidence level that their RF output characteristics will remain compliant.

2.4 Antenna Design

In the assessment of broadcast compatibility with aircraft communications and navigation systems, relatively coarse assumptions are made concerning broadcast antenna design and expected vertical radiation patterns, related to ERP as follows:

<u>Total Mixed ERP</u> <u>(dBW)</u>	<u>Aperture</u> <u>(λ)</u>	<u>VRP 90° Elevation</u> <u>(dB)</u>
ERP \geq 44	8	\geq 14
37 \leq ERP < 44	4	\geq 14
30 \leq ERP < 37	2	\geq 14
ERP < 30	1	\geq 8

Although these assumptions are increasingly at odds with current usage, it is not possible to modify aeronautical databases and analysis software to account for every

antenna design, so Ofcom has sought to provide a workable interpretation of compliance, as follows:

The achieved VRP will be taken as the worst-case (least) restriction within a cone defined by 80° elevation on all azimuthal bearings, referred to the maximum ERP in azimuth in whichever is the greater plane of polarisation. Where maximum ERP is the same in each polarisation the maximum ERP for these purposes will be taken to be the maximum/plane +1dB.

If it is proposed to use an antenna system that may not comply then design must be notified to Ofcom at least 4 months in advance of commissioning, to allow further compatibility checks to be performed. It is possible that antenna re-design may be the only solution, but in any event the maximum VRP shortfall that Ofcom will allow is 4dB. Where an exemption is made, the shortfall will be recorded and added to the required aeronautical suppression levels specified in Section 2.3.

2.5 Field Strengths Close to the Transmitter Site

Licensees should ideally choose a site and antenna design that do not cause unacceptably high field levels within adjacent accommodation where members of the public are likely to be tuned to Band II frequencies, as some receivers may be affected by 'blocking'. A set of researched field strength limits has been adopted by Ofcom whereby a transmitter whose radiated output exceeds these limits could cause 'blocking', albeit to a small percentage of receivers. Field strengths below these levels are in any case considered acceptable, whatever effects may be produced within inferior equipments. The catchment areas are defined as follows:

"Beyond 200m from the base of the mast where the field strengths attributable to the new antenna exceeds 100dB ($\mu\text{V}/\text{m}$) in the horizontally polarised plane, or 110dB ($\mu\text{V}/\text{m}$) in the vertically polarised plane; and closer than 200m from the base of the mast, where levels exceed 110dB($\mu\text{V}/\text{m}$) in the horizontal plane or 120dB($\mu\text{V}/\text{m}$) in the vertical ."

In the event of reception complaints from listeners to other services, arising within a year of, and as a consequence of the introduction of transmissions which do not respect the limits defined above, the relevant licensee(s) will be required to resolve, at their own expense and to the reasonable satisfaction of the complainant, any such 'blocking' problem that (i) results from the above limits being exceeded at the location in question, and (ii) causes unacceptable interference to reception of a Band II frequency within its protected service area. This may require receiver aerial modification, the addition of suitable screening or filtering of the input of the receiver in question, or its outright replacement.

Licensees will be expected to make any assessment of their aerial system in respect of 'blocking' at an early stage of project design. In the event that Ofcom is required to make its own assessment this will be based on a theoretical free-space analysis of horizontal and vertical radiation patterns in each polarisation, of the antenna and the associated supporting mast structure. It will not take account of any building or other clutter effects impinging on the path between the antenna and the receiver in question. Ofcom's determination in respect of reasonableness of listener complaint and licensee remedial action will be final.

Where an oncoming service increases levels that were previously in excess of the above limits, that licensee will only be responsible for resolution of those 'blocking' problems that can be proved not to be evident in the absence of the latest transmissions.

2.6 Efficient Implementation of Cleared Transmission Parameters

The technical characteristics of the transmissions as radiated should fulfil a reasonable proportion of the characteristics permitted under the relevant licence (where these represent maxima), and where “reasonable” includes that some account is taken of practical circumstances applying at each transmitter site (e.g. practicable antenna location and design). This transmission should be maintained other than for periods of technical failure or maintenance requirements, the duration of which should not be unreasonably protracted.

Unless otherwise described in the relevant licence, the radiated powers should not be at levels less than -6dB with respect to permitted maxima, over significant portions of the horizontal arc from the transmitter site, unless the portions of arc concerned lead only towards areas of low population density (at the time of acceptance), or towards nearby terrain which would in any case obstruct effective propagation beyond the achieved limit of coverage.

2.7 Transmitter Carrier Frequency

The rest RF Carrier frequency must remain within ± 2 kHz of the value specified in the WT Act Licence.

The transmitter mean RF carrier frequency must not vary by more than ± 200 Hz under any modulation condition up to peak permitted deviation.

In some cases, notably where synchronous operation of more than one co-frequency transmitter is implemented, more stringent limits may be specified in the appropriate licence technical annex.

2.8 Programme Material

Programme material must comprise analogue audio signals confined to the nominal frequency range 0 to 15 kHz. The transmission of encrypted signals is not permitted, other than as may be detailed in the appropriate licence technical annex.

The definition of a merely "nominal" range is in recognition of the practical difficulty of testing compliance with a given filter characteristic of a variable gain device such as a compressor/limiter, which is where such filtering is usually applied. The interpretation of the term "nominal" in this case shall be at the sole discretion of Ofcom.

2.9 Supplementary Signals (RDS, Additional Services and Control/Monitoring Functions)

No supplementary subcarrier systems other than those conforming to the RDS specification IEC 62106 are currently permitted.²

Where the RDS system is implemented, all information transmitted must be accurate with respect to its content and timing. Dynamic alteration of the PS Name (scrolling) is not permitted. For those services licensed under the Broadcasting Act, the

² The BBC has an in-house subcarrier system used for telemetry purposes which is exempt from this provision.

Programme Identification (PI), Programme Service (PS) Name, and any other features that Ofcom may deem to be necessary, must be as specified in Part II of the Annex to the B. Act licence. Further, for Broadcasting Act licensees, transmission of the Traffic Programme (TP) flag unless dynamic control of the Traffic Announcement (TA) flag is available and in current use is not permitted³.

The allocation of PI codes and control of certain other RDS features are of necessity made centrally by Ofcom, in co-operation with the BBC.

The maximum allowable level of deviation of the main carrier by the RDS sub-carrier is ± 4 kHz,⁴ with a nominal level of 2 kHz and 3 kHz where TMC is transmitted

Ofcom may, in due course, review the possibility of permitting other subcarrier systems also to be transmitted. This will require the definition of conditions which are adequate to secure protection from interference to adjacent and second-adjacent services. The provisions of ITU-R Rec. 450-3 in this respect may not of themselves provide adequate protection in all cases.

³ The BBC use EON and as such transmit a TA flag without the TP flag

⁴ The INR-1 licence (AN001) is subject to a separate provision specified in its licence

Section 3

Characteristics and Limits of Transmission: (MF: 531 kHz to 1602 kHz): amplitude modulation

3.1 Transmission Standard

The transmissions must use amplitude modulation, suitable for conventional envelope detection by receivers. In the event of asymmetric modulation being present, the maximum permitted EMRP will be reduced to ensure that peak levels are not exceeded.

The carrier must not be modulated beyond 100%. The means of achieving this shall include the insertion of a limiter at an appropriate point in the programme input equipment of the transmitter. Such limiters should be installed as close along the signal path, as is practical, to the transmitter. Even where this is prior to the programme link to the transmitter Ofcom will hold the licensee responsible for any breach of this code that may result from noise, failure of, or interference to the programme distribution system. In addition to the above, in the event of failure of main or standby programme feed to the transmitter, the carrier should ideally be switched off, but at the least modulation should be removed until the programme feed is restored.

3.2 Spectral Occupancy

Sidebands must not exceed a level with respect to the steady state carrier, of:

- 20dB for sideband components more than ± 7.5 kHz from nominal carrier frequency.
- 40dB for sideband components more than ± 9 kHz from nominal carrier frequency.

These limitations are to be achieved by the use of audio low-pass filters.

3.3 Spurious and Harmonic Emissions

With the transmitter operating at any level up to that required to radiate the maximum EMRP as specified in the WT. Act Licence, into its designed load impedance or into the aerial system, the power of any spurious or harmonic emission must not exceed a level 40dB below carrier. Compliance may be assessed off-air, taking advantage of the added filtering effect of the aerial's own tuned characteristics.

3.4 Transmitter Carrier Frequency

The carrier frequency is to remain within ± 10 Hz of the nominal value specified in the WT Act Licence.

Where synchronous operation of more than one co-frequency transmitter is implemented the limit is ± 1 Hz of the nominal value specified in the WT Act Licence

3.5 Programme Material

Unless otherwise specified in the licence, programme material shall comprise analogue audio signals confined to the nominal frequency range (-3dB) 0 to 6 kHz. The transmission of data signals, or any encrypted signals, is not permitted, other than may be detailed in Part II of the Annex to the B. Act Licence.

The definition of a merely "nominal" range is in recognition of the practical difficulty of testing compliance with a given filter characteristic of a variable gain device with such as a compressor/limiter, which is where such filtering is usually applied. The interpretation of the term "nominal" in this case shall be at the sole discretion of Ofcom.

3.6 Supplementary Signals

No phase or frequency modulation of the carrier is permitted.

Section 4

Transmitter Equipment

4.1 Access to Adjustments

The licensee should take all appropriate precautions necessary to protect access to any controls and adjustments which, if maladjusted, might result in transgression of the requirements of this specification or the station characteristics given in the WT Act Licence. Depending on the licensee's assessment of the threat, measures might include: control of entry; physical protection of adjustments; requirement for and control of special adjustment tools; or in the case of software-controlled devices, appropriate control of access codes.

4.2 Metering and Monitoring

The transmitter must incorporate a suitable meter indicating, or uniquely related to, the RF output power. Also, for all VHF transmitters other than those used for RSLs, a calibrated bi-directional monitor point must be provided, presented as a fixed BNC or N Type coaxial 50Ω connector, fed via a suitable coupling mechanism from the transmitter RF output, downstream of all filters and combiners. A buffered monitor point, presented either as a fixed BNC coaxial connector, or as a fixed audio line jack socket, must be provided, fed via a suitable coupling mechanism from the feed to the modulator input.

These provisions are to facilitate regulatory checks respectively of output power (by reference to the meter) and spectral content (by reference to the monitor points) without, if possible, interrupting the programme service. Nevertheless, Ofcom reserves the right to take any transmitter out of service at 15 minutes notice and without compensation to inspect any adjustments internal to the equipment. These provisions apply to both the main and standby systems

4.3 Feeder Arrangements and Performance

It should be possible (by switching or by an easy change of connection) for a single transmitter or either of two (main and standby) to be tested individually into a dummy load provided by the licensee.

In the case of VHF transmissions, the transmitting aerial must be matched to the characteristic impedance of its RF feeder cable to provide a reflected signal power of no greater than -14dB presented to the transmitter RF output. This performance must be achieved over a bandwidth of at least ± 150 kHz relative to the unmodulated carrier frequency.

In the case of MF transmissions, the transmitter should be capable of meeting the requirements of this Code and of the licence, when transmitting into an aerial whose return loss is ≥ 20 dB at the carrier frequency, and ≥ 10 dB at ± 6 kHz from the carrier frequency.

As with the above provision 4.2, these requirements are intended to facilitate regulatory checks to be undertaken with the minimum of disruption. Particularly, these provisions should enable certain fault conditions and installation deficiencies to be identified more easily. The requirements for feeder performance are to ensure

that a useful correlation will exist between measurements taken of transmitters when they are, and are not radiating.

4.4 Environmental and Reliability Requirements

Compliance with the above requirements must be achieved over all the ranges of ambient temperature and relative humidity to which the equipment is likely to be exposed.

Such compliance should also apply to variations in the range +6% to -10% of the nominal value of the power supply, these being the limits permitted for either the mains or locally sourced supplies.

These requirements are included to give reasonable confidence that commissioning checks will adequately cover a range of circumstances external to the equipment itself.

The licensee should apply sound engineering practice throughout, including that:

- i) The transmitter should be designed such that it will not suffer damage when operated continuously with the RF output connector either open or short-circuited.
- ii) Precautions should be taken to prevent switching or commutation spikes from being radiated or superimposed upon the incoming supply.
- iii) Sufficient space should be provided adjacent to transmission equipment (under cover) for location of the test equipment required to prove compliance with this code of practice.