# Analogue Radio Technical Code

Published 17 June 2024

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## Section

# 1. Introduction

1.1 This Analogue Radio Technical Code[1] 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 commercial radio services, community radio services, BBC radio services and restricted services, other than where exceptions are detailed herein.

1.2 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.

1.3 It will be the responsibility of Broadcasting Act and Wireless Telegraphy Act licence holders[2] 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.

## Other responsibilities

1.4 The conditions in this Code relate solely to the requirements that Ofcom places on analogue radio licensees under their Broadcasting Act Licences and associated Wireless Telegraphy Act licences[3]. Compliance with these requirements does not absolve the licensee from other legal responsibilities in areas such as (but not limited to) electromagnetic field exposure, electromagnetic compatibility, and compliance with the general requirements of the 2003 Communications Act which are outside the explicit scope of broadcast licences; particularly in respect of Part 2, Chapter 1 (Electronic Communications Networks and Services).

[1] The Analogue Radio Technical Code was previously known as the Ofcom Site Engineering Code for Analogue Radio Broadcast Transmission Systems, and may be referred to as such in licences.
[2] The BBC's services are not licensed under the Broadcasting Act. Instead they must comply with an operating licence issued by Ofcom, that applies to the services listed in Schedule 1 of the BBC Agreement. Ofcom issues a licence under the Wireless Telegraphy Act 2006 to authorise the BBC's use of spectrum to transmit those services.
[3] Wireless Telegraphy Act licences only in the case of the BBC's services.

# 2. Tests and Inspections

## Commissioning Tests and Subsequent Modifications

2.1 All transmission systems, other than those used by Restricted Service Licences issued for the purpose of serving an event, require to be tested for compliance with this Code and associated Wireless Telegraphy and Broadcasting Act licence conditions.

2.2 Tests will need to be carried out by or on behalf of the licensee before it is permitted to transmit to air from any given transmitter. The licensee must hold a suitable Wireless Telegraphy Act licence for any on-air tests to be carried out. The test results and associated evidence of compliance with licence conditions must be provided to Ofcom within five working days of the transmitter coming on-air, and should provide a reasonable confidence level that transmissions will remain compliant after commissioning.

2.3 Ofcom reserves the right to conduct its own tests on-site before giving permission to transmit, or at any time thereafter. If such tests are deemed by Ofcom to be necessary because of inadequacies or ambiguities in the evidence supplied by the licensee, then a fee will be payable to Ofcom at its sole discretion.

2.4 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.

2.5 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 by email to broadcastradioeng@ofcom.org.uk.

2.6 Ofcom will normally communicate with the licensee's prime contact as notified to us. We will deal with delegated contractors or other parties working on the licensee's behalf, although will copy any communication that Ofcom has with those parties to the licensee's prime contact. It is therefore important that licensees ensure Ofcom is notified of any changes to the licensee's prime contact details by sending any updates to broadcast.licensing@ofcom.org.uk

## Documentation

2.7 At least 20 working days prior to commissioning tests referred to in section 2.2 above, the licensee must provide Ofcom with an accurate block diagram of the complete installation, also aerial horizontal radiation patterns in each active plane of polarisation, vertical radiation characteristics (Sections 3.11 – 3.13 refers) and system gain calculations.

2.8 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.

## Inspections and Monitoring

2.9 Ofcom reserves the right to have access to the transmitter installation from time to time to conduct inspections and tests 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.

2.10 Regardless of how recently or frequently Ofcom may have tested a transmission system, it is the licensee's responsibility to ensure 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.

# 3. Characteristics and Limits of Transmission for FM radio services (87.5 – 108 MHz)

## Transmission standard

3.1 Transmissions must be compliant with ITU-R Recommendation BS.450-4[4], 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 millisecond duration, it shall be divided into discrete 10 millisecond periods (rounded up) and counted accordingly. Under no circumstances is the deviation to exceed ±80 kHz other than by anomalous behaviour.

3.2 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 µs (+ 2 µs).

iii) Where stereophonic programmes are to be transmitted, the GE Zenith Pilot-Tone System, as described in section 2.2 of ITU-R Recommendation ITU-R BS.450-4, 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 Sections 3.28 to 3.31 below.

[4] https://www.itu.int/rec/R-REC-BS.450/en

# Spectral Occupancy

3.3 ITU-R Recommendation 412-9[5] 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 Sections 3.1 and 3.2 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:

3.4 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.

3.5 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 3.6 following.

# Spurious and Harmonic Emissions

3.6 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 3.3), must not exceed the following limits:

**Table 1: Permitted levels of spurious or harmonic emissions**

| Transmitter power | Maximum permitted level of spurious or harmonic emissions |
|---|---|
| Less than 250 mW | 40 dB below unmodulated carrier power |
| Greater than or equal to 250 mW and less than 25 W | 25 µW |
| Greater than or equal to 25 W and less than 1 kW | 60 dB below unmodulated carrier power |
| Greater than or equal to 1 kW | 1 mW |

[5] https://www.itu.int/rec/R-REC-BS.412/en

**Table 2: Specific requirements for emissions in the band 118 - 137 MHz**

| Transmitter power | Maximum permitted level of spurious or harmonic emissions |
|---|---|
| Greater than or equal to 250 mW and less than 7.9 kW | 25 µW |
| Greater than or equal to 7.9 kW | 85 dB below unmodulated carrier power |

**Table 3: Specific requirements for emissions in the band 108 - 118 MHz**

| Transmitter power | Maximum permitted level of spurious or harmonic emissions |
|---|---|
| Less than 250 mW | 40 dB below unmodulated carrier power |
| Greater than or equal to 250 mW and less than 1 kW | [46 + ERP[6] in dBW] dB below unmodulated carrier power |
| Greater than or equal to 1kW and less than 63kW | [76 + 9 x (ERP in dBW – 30) / 18] dB below unmodulated carrier power |
| Greater than or equal to 63kW | 85 dB below unmodulated carrier power |

3.7 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.

3.8 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 II (87.5 - 108 MHz), and;
ii) liable to interfere with aeronautical navigation services in the band 108 - 137 MHz

3.9 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.

3.10 At multi-user sites a newly installed transmitter may provide one of the frequencies contributing to the generation of an intermodulation product, although may not be the one radiating that product at an unsatisfactory level. Licensees must 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 appropriate intervals. Whatever the site configuration,

[6] ERP is the total mixed effective radiated power

licensees are strongly encouraged to fit band-pass filters to increase the confidence level that their RF output characteristics will remain compliant.

## Antenna Design

3.11 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:

**Table 4: Expected antenna vertical pattern characteristics**

| Total Mixed ERP (dBW) | Aperture (λ) | VRP 90° Elevation (dB) |
|---|---|---|
| ERP ≥ 44 | 8 | ≥14 |
| 37 ≤ ERP < 44 | 4 | ≥14 |
| 30 ≤ ERP < 37 | 2 | ≥14 |
| ERP<30 | 1 | ≥8 |

3.12 Ofcom will interpret licensees' 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 the maximum ERP is the same in each polarisation the maximum ERP for these purposes will be taken to be the maximum/plane +1dB.

3.13 If it is proposed to use an antenna system that may not comply then the 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 Tables 2 and 3.

## Field Strengths Close to the Transmitter Site

3.14 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 100 dBµV/m in the horizontally polarised plane, or 110 dBµV/m in the vertically polarised plane; and closer than 200 m from the base of the mast, where levels exceed 110 dBµV/m in the horizontal plane or 120 dBµV/m in the vertical."

3.15 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 licensed 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.

3.16 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.

3.17 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.

## Transmission parameter implementation and resilience

3.18 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.

3.19 Unless otherwise described in the relevant licence, the radiated powers should not be at levels less than –6 dB 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.

3.20 It is important that licensees pay attention to the infrastructure they deploy to provide their service, and have in place plans for dealing with equipment breakdowns or failures of other infrastructure, so as to avoid prolonged loss of service.

3.21 Licensees should consider the technical resilience of their service, and to have in place service continuity plans that are proportionate to the service they are providing.

3.22 Licensees will not be required to report on their plans or show how they test implementation of those plans, although Ofcom may ask for details and evidence in the course of any investigation that may follow a prolonged failure.

## Transmitter Carrier Frequency

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

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

3.25 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.

## Programme Material

3.26 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.

3.27 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.

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

3.28 No supplementary subcarrier systems other than those conforming to the RDS specification IEC 62106 are permitted[7].

3.29 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 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 Broadcasting 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 permitted[8].

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

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

[7] The BBC use EON and as such transmit a TA flag without the TP flag.
[8] The INR-1 licence (AN001) is subject to a separate provision specified in its licence.

# 4. Characteristics and Limits of Transmission for AM radio services (531 – 1602 kHz)

## Transmission Standard

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

4.2 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.

## Spectral Occupancy

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

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

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

4.5 Exceptions to the above limits may be agreed with Ofcom on a case-by-case basis.

## Spurious and Harmonic Emissions

4.6 With the transmitter operating at any level up to that required to radiate the maximum EMRP as specified in the Wireless Telegraphy 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 40 dB below carrier. Compliance may be assessed off-air, taking advantage of the added filtering effect of the aerial's own tuned characteristics.

## Transmitter Carrier Frequency

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

4.8 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.

## Programme Material

4.9 Unless otherwise specified in the licence, programme material shall comprise analogue audio signals confined to the nominal frequency range (-3 dB) 0 to 6 kHz. Ofcom may on a case-by-case basis consider proposals from licensees to operate transmitters with audio signals that have a wider audio bandwidth. Should any such proposal be agreed by Ofcom, the amended parameters will be recorded in the relevant Wireless Telegraphy Act licence.

4.10 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 Broadcasting Act Licence

4.11 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.

## 4.6 Supplementary Signals

4.12 No phase or frequency modulation of the carrier is permitted.

# 5. Transmitter Equipment

## Access to controls and adjustments

5.1 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.

## Metering and Monitoring

5.2 The transmitter must incorporate a suitable meter indicating, or uniquely related to, the RF output power. Also, for all Band II transmitters whose output is combined with other services to feed a common antenna system, a calibrated bi-directional monitor point must be provided, presented as a fixed BNC or N Type coaxial 50 Ω connector, fed via a suitable coupling mechanism from the transmitter RF output, downstream of all filters and combiners.

5.3 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.

## Feeder Arrangements and Performance

5.4 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.

5.5 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.

5.6 As with the above provisions 5.2 and 5.3, 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.

## Environmental and Reliability Requirements

5.7 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.

## Electromagnetic fields

5.8 All transmitter equipment operating at powers above 10 watts EIRP (effective isotropic radiated power) must – as a condition of the service's Wireless Telegraphy Act licence – comply with international guidelines on electromagnetic field (EMF) emissions for the protection of the general public. These guidelines have been issued by ICNIRP (the International Commission on Non-Ionizing Radiation Protection). More guidance on EMF requirements is available on the Ofcom website at https://www.ofcom.org.uk/manage-your-licence/emf.