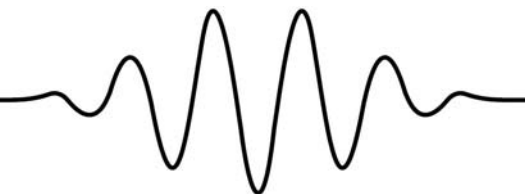




Radio Society of Great Britain

Advancing amateur radio since 1913



## Reference Data for use in the Full Level Examination

What next:

**Once your results arrive at RSGB HQ it will usually be processed after 6 working days have elapsed, then your official result will be posted to you and uploaded to the Ofcom system. Results are not available any sooner.**

**To obtain your licence please log on to the Ofcom website [www.ofcom.org.uk](http://www.ofcom.org.uk) and follow the online instructions.**

Queries:

**Invigilators are not permitted to explain or comment on questions but you may draw their attention to any question you believe is wrong. Please do that before you submit your answers to allow the question number to be noted.**

**You may also comment on any aspect of the examination, either to the invigilators or to the RSGB Examinations Office [exams@rsgb.org.uk](mailto:exams@rsgb.org.uk). All comments should be received within 5 days of the examination.**

**All comments are dealt with in strict confidence.**

## Section 2

### Terms, conditions and limitations

#### 1. Purpose

1(1) The Licensee shall ensure that the Radio Equipment is only used:

- (a) for the purpose of self-training in radio communications, including conducting technical investigations; and
- (b) as a leisure activity and not for commercial purposes of any kind.

1(2) The Licensee may use or permit the use of the Radio Equipment by a member of a User Service during any operation conducted by a User Service or during any exercise relating to such an operation in each case for the purpose of sending Messages on behalf of the User Service.

1(3) The Licensee may use the Radio Equipment to assist with communications in times of disaster or national or international emergency.

#### 2. Location

2(1) The Licensee may only operate the Radio Equipment in the United Kingdom (including its territorial seas) subject to sub-clauses (a) – (c):

- (a) Where this Licence is a Full Licence only, and unless it is a Full (Club) or Temporary Licence, the Licensee may operate the Radio Equipment from a Maritime Mobile location;
- (b) Where this Licence is a Full Licence only, and unless it is a Full (Club) or Temporary Licence, the Licensee may operate the Radio Equipment in countries which have implemented CEPT Recommendation T/R 61-01.
- (c) The Radio Equipment may not be established or used in any Aircraft or Airborne Vehicle.

2(2) The Licensee shall use the following appropriate Regional Secondary Locator after the United Kingdom Callsign prefix “G”, “M” or “2” as specified in Section 1, when identifying the Radio Equipment in accordance with Clause 13(1):

- (a) England - No Regional Secondary Locator;
- (b) Guernsey - “U”;
- (c) Isle of Man - “D”;
- (d) Jersey - “J”;
- (e) Northern Ireland - “I”;
- (f) Scotland - “M”;
- (g) Wales - “W”.

2(3) If the Callsign specified in Section 1 begins with the number “2”, the provisions of Clause 2(2) shall apply with the addition that when used in England, the Secondary Locator “E” shall be used.

#### 3. Operators and qualifications

3(1) Subject to Clauses 1(2), 3(2) and 3(3), the Licensee shall ensure that the Radio Equipment shall only be operated by the Licensee personally and by no other persons.

3(2) The Licensee may permit the operation of the Radio Equipment by a person who holds a current United Kingdom Amateur Radio Licence provided that any such operation of the Radio Equipment is carried out in the presence of and under the direct supervision of the Licensee and that such persons are made aware of, and of the requirement to comply with, the terms, conditions and limitations of this Licence.

3(3) Only where this Licence is a Full Licence or a Full (Club) Licence may the Licensee also permit the operation of the Radio Equipment:

- (a) by a person on a Recognised Foundation Training Course; or
- (b) by a non-UK person who holds a current radio amateur licence issued by any other country,
- (c) by any person:
  - I. who does not fall within Clause 3(3)(a) or (b);
  - II. whom the Licensee has reasonable grounds to believe is not a Disqualified Person; and
  - III. who holds a Radio Amateurs’ Examination Pass Certificate recognised by Ofcom.

provided that, in each case, any such operation of the Radio Equipment is carried out in the presence of and under the direct supervision of the Licensee and that such persons are made aware of, and of the requirement

to comply with, the terms, conditions and limitations of this Licence.

3(4) Only where this Licence is a Full Licence may the Licensee permit a non-licensed person to send a Message using the Radio Equipment provided that the Radio Equipment is operated by the Licensee.

3(5) Only where this Licence is a Full (Club) Licence issued to the Licensee for use on behalf of a Club, may the Licensee:

- (a) authorise any Club member who holds their own separate Full Licence to use and supervise the operation of the Radio Equipment on the Licensee's behalf under this Licence;
- (b) permit a non-licensed person to send a Message using the Radio Equipment provided the Radio Equipment is operated by the Licensee or by a Club member who holds their own separate Full Licence,

provided that, in each case, such persons are made aware of, and of the requirement to comply with, the terms, conditions and limitations of this Licence.

#### **4 Variation and revocation**

4(1) Subject to Clause 4(5), this Licence shall continue in force until revoked by Ofcom in accordance with Clause 4(2) or surrendered by the Licensee.

4(2) Pursuant to schedule 1, paragraph 8 of the Wireless Telegraphy Act 2006 (the "Act"), Ofcom may not revoke this Licence under schedule 1, paragraph 6 of the Act except:

- (a) at the request of, or with the consent of, the Licensee;
- (b) if there has been a breach of any of the terms, conditions or limitations of the Licence;
- (c) in accordance with schedule 1, paragraph 8(5) of the Act;
- (d) if it appears to Ofcom to be necessary or expedient to revoke the Licence for the purposes of complying with a direction by the Secretary of State given to Ofcom under section 5 of the Act;
- (e) for reasons related to the management of the radio spectrum, provided that in such cases the power to revoke may only be exercised after first giving reasonable notice to Licensees;
- (f) where this Licence is a Paper Licence, for failure by the Licensee to pay the Licence Fee on or before the date of issue of this Licence;
- (g) where this is a Full (Club) Licence, Ofcom is satisfied that the Licensee no longer represents the club; or
- (h) where the Licensee has been convicted of an offence under the Wireless Telegraphy Acts.

4(3) Where Ofcom exercises its power to revoke or vary the Licence in accordance with schedule 1, paragraph 6 of the Act, the Licensee shall be notified in writing, or by email, or by a general notice. Any general notices will be posted on the Ofcom website<sup>1</sup>.

4(4) Ofcom reserves the right to publish the Callsign of the Licensee if the Licence is revoked.

4(5) Ofcom may revoke this Licence five years after the later of:

- (a) the date on which the Licensee last notifies Ofcom that the Licensee wishes to amend any of the details set out in Section 1 of the Licence; or
- (b) the date on which the Licensee last confirms to Ofcom that the details set out in Section 1 of the Licence are still valid.<sup>2</sup>

4(6) In relation to the following bands:

- (a) 2310 to 2350 MHz;
- (b) 2390 to 2400 MHz; and
- (c) 3400 to 3410 MHz.

Ofcom may vary this licence for reasons related to interference management after first giving reasonable notice of three months.

#### **5 Modification, restriction and closedown**

5(1) A person authorised by Ofcom may require the Radio Equipment, or any part thereof, to be modified or restricted in use, or temporarily or permanently closed down with immediate effect if, in the reasonable opinion of the person authorised by Ofcom:

- (a) a breach of this Licence has occurred; and/or

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<sup>1</sup> [www.ofcom.org.uk](http://www.ofcom.org.uk)

<sup>2</sup> For guidance please refer to note (i) to this Licence.

- (b) the use of the Radio Equipment is causing or contributing to Undue Interference to the authorised use of other radio equipment.

5(2) Ofcom may require the Radio Equipment to be modified or restricted in use, or temporarily closed down either immediately or on the expiry of such period as may be specified in the event of a national or local state of emergency being declared. Ofcom may only exercise this power after a written notice is served on the Licensee or a general notice is published. Any general notices will be posted on the Ofcom website.

5(3) When operating the Radio Equipment from a Maritime Mobile location, the Licensee shall cease to operate the Radio Equipment on the demand of the Vessel's master.

## 6 Changes

6(1) This Licence is personal to the Licensee and may not be transferred.

6(2) The Licensee must give immediate notice to Ofcom either in writing or by means of Ofcom's on-line licensing system of any change to the Licensee's name, Main Station Address (or mailing address if different) from that recorded in this Licence.

6(3) By no later than five years after the date of issue of this Licence, unless during that five year period the Licensee has given notice to Ofcom of any change to any of the Licensee's details as set out in Section 1 of the Licence in accordance with Clause 6(2), the Licensee must confirm to Ofcom that the details set out in Section 1 of this Licence remain current and accurate. The Licensee must make a further confirmation to Ofcom once every five years from the later of:

- (a) the date on which the Licensee last confirms to Ofcom that the details set out in Section 1 of this Licence remain current and accurate; and
- (b) the date on which the Licensee last gives notice to Ofcom of any change to the Licensee's details in accordance with Clause 6(2),

unless during that five year period the Licensee has already given notice to Ofcom of a change to any of the Licensee's details set out in Section 1 in accordance with Clause 6(2), in which case the subsequent five year period will be calculated from the date on which the Licensee gave that notice. Failure to do so may lead to the revocation of this Licence in accordance with Clause 4(5).

## 7 Equipment

7(1) The Licensee shall ensure that:

- (a) the emitted frequency of the apparatus comprised in the Radio Equipment is as stable and as free from Unwanted Emissions as the state of technical development for amateur radio apparatus reasonably permits; and
- (b) whatever class of emission is in use, the bandwidth occupied by the emission is such that not more than 1% of the mean power of the transmission falls outside the nominal modulated carrier bandwidth<sup>3</sup>.

7(2) Where this Licence is a Foundation Licence, the Licensee shall only use commercially available Radio Equipment which satisfies IR 2028. Foundation Licence holders may also use Radio Equipment constructed using commercially available kits which satisfy IR 2028.

7(3) Notwithstanding any other terms of this Licence, the Licensee shall ensure that the Radio Equipment is designed, constructed, maintained and used so that its use does not cause any Undue Interference to any wireless telegraphy.

7(4) If any Undue Interference to wireless telegraphy is caused by the radiation of Unwanted Emissions from the Radio Equipment, then the Licensee shall suppress the Unwanted Emissions to the degree satisfactory to Ofcom.

7(5) The Licensee shall conduct tests from time to time to ensure that the requirements set out in this Clause 7 are met.

7(6) In order to reduce the likelihood of causing Undue Interference, the Licensee shall ensure that the Radio Equipment is capable of receiving Messages on the same frequencies and with the same classes of emission in use for the transmission of Messages by the Radio Equipment.

## 8 Access and inspection

8(1) The Licensee shall permit any person authorised by Ofcom:

- (a) to inspect the Licence; and

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<sup>3</sup> Please refer to note (a) to this Licence.

(b) to have access to the Radio Equipment for the purposes of inspection, examination and testing, at any and all reasonable times or, when in the reasonable opinion of that person an urgent situation exists, at any time to ensure that the Radio Equipment is being used in accordance with the terms of this Licence.

## 9 Limitations

9(1) Each of the limitations set out in this Clause 9 are without prejudice to the provisions of Clause 1 of this Licence.

9(2) When operating the Radio Equipment the Licensee shall:

- (a) only use the frequency bands specified in Schedule 1, subject to the limitations set out in that Schedule;
- (b) only use a power level relating to those frequency bands which does not exceed the maximum power level specified in Schedule 1; and
- (c) take account of any other limitations set out in Schedule 1 which apply to the class of Licence held by the Licensee.

9(3) Before operating the Radio Equipment on a Vessel, the Licensee shall install, use or make changes to the Radio Equipment only with the written permission of the Vessel's Master.

9(4) Whilst operating the Radio Equipment on a Vessel, the Licensee shall observe radio silence on the advice of the Vessel's Master.

9(5) When the Licensee operates the Radio Equipment on a Vessel in international waters, use of the radio spectrum shall continue to be made in accordance with Schedule 1, except that the Licensee shall use only those frequency bands which, in accordance with the Radio Regulations, have an allocation to the amateur service in the International Telecommunication Union (ITU) region being visited.

9(6) The Licensee may receive Messages from an overseas amateur or from a UK Amateur duly authorised by Ofcom on a frequency band not specified in Schedule 1 but the Licensee may only transmit on a band specified in Schedule 1 which is authorised under Clause 9(2).

9(7) The Licensee shall comply with all relevant statutory enactments including, without limitation, the Wireless Telegraphy Acts.

## 10 Unattended and remote control operation

10(1) The Licensee may conduct Unattended Operation of Radio Equipment provided that any such operation is consistent with the terms of this Licence. Additional restrictions which apply to the Unattended Operation of Beacons are specified in Schedule 2 to this Licence.

10(2) Subject to Clause 10(3), the Licensee may also conduct Remote Control Operation of Radio Equipment (including, for the avoidance of doubt, Beacons) provided that any such operation is consistent with the terms of this Licence.

10(3) This Clause 10 does not permit the Licensee to install Radio Equipment capable of Remote Control Operation for general unsupervised use by other Amateurs.

10(4) Any communication links<sup>4</sup> used to control the Radio Equipment or to carry Messages to or from the Radio Equipment in accordance with Clause 10(2) must be adequately secure so as to ensure compliance with Clause 3 of this Licence. Any security measures must be consistent with Clause 11(2) of this Licence.

10(5) The use of any such communication links referred to in Clause 10(4) must be failsafe such that any failure will not result in unintended transmissions or any transmissions of a type not permitted by this Licence.

10(6) If this Licence is a Foundation Licence or an Intermediate Licence, and the Licensee wishes to establish communication links to operate the Radio Equipment in accordance with Clause 10(4), then the Licensee may only do so using wireless communication links and the Licensee may only use the amateur band allocations detailed in Schedule 1<sup>6</sup> to operate those links. Any such communications links shall be subject to a maximum power level of 500 mW pep e.r.p.

10(7) Only where this Licence is a Full Licence, Full (Reciprocal) Licence, Full (Temporary Reciprocal) Licence or a Full (Club) Licence, the Licensee may make use of any communications links (including, for the avoidance of doubt, the amateur band allocations detailed in Schedule 1<sup>5</sup>) to establish the wireless communication links referred to in Clause 10(4).

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<sup>4</sup> Please refer to note (f) to this Licence

<sup>5</sup> Please refer to note (g) to this Licence

## 11 Messages

11(1) The Licensee shall be permitted to use the Radio Equipment to discuss any topics of mutual interest with other Amateurs, and to seek to receive and impart any information and any ideas<sup>6</sup>.

11(2) Unless the Radio Equipment is being used for the purposes of clauses 1(2) or 1(3) in the UK:

- (a) Messages sent from the station shall only be addressed to other Amateurs or to the stations of those Amateurs;
- (b) Messages sent from the station shall not be encrypted for the purposes of rendering the Message unintelligible to other radio spectrum users.

11(3) The Licensee may use codes and abbreviations for communications as long as they do not obscure or confuse the meaning of the Message.

11(4) The Licensee shall not send Messages (whether directly or for onwards transmission by another station) for general reception other than:

- (a) initial calls; or
- (b) to groups or networks ("nets") of three or more Amateurs as long as communication is first established separately with at least one Amateur in any such group;
- (c) Messages transmitted via a mailbox or bulletin board for reception by Amateurs.

## 12 Log

12(1) For the purposes of any interference investigation, to determine compliance with the terms, conditions and limitations of this Licence, or for any other matter concerning the enforcement of any relevant legislation, the Licensee shall at the request of a person authorised by Ofcom, keep a permanent record (a "log") of such matters concerning the operation of the Radio Equipment, over such period, and in such form, as the authorised person may require.

12(2) When operating the Radio Equipment from a Vessel, the Licensee shall, at the request of the Vessel's master, keep a log of such matters concerning the operation of the Radio Equipment as the master may require.

## 13 Identification

13(1) The Licensee, or, if this Licence is a Full Licence, then any other authorised person who uses the Radio Equipment, shall ensure that:

- (a) the station is clearly identifiable at all times;
- (b) the Callsign is transmitted as frequently as is practicable during transmissions, unless the specific requirements of Note (g) to the Notes to Schedule 1 of this Licence apply; and
- (c) the Callsign is given in voice or other appropriate format consistent with the mode of operation.

## 14 Recorded or retransmitted Messages

14(1) The Licensee may record and retransmit Messages addressed to the Licensee received from other Amateurs:

- (a) with whom the Licensee is in direct communication; or
- (b) which are intended for retransmission to a specified Amateur.

14(2) When recording and retransmitting the Message of another Amateur, if the Licensee also records and retransmits the Callsign of that Amateur, then the Licensee shall transmit the Callsign in such a way that the origin of the Message and the origin of the retransmission are clear.

## 15 Fees

The Licensee shall pay to Ofcom the relevant sums as provided in section 12 of the Wireless Telegraphy Act 2006 and the regulations made thereunder.

## 16 Operation by the Licensee in CEPT countries

16(1) Where the Licensee is authorised to operate abroad in accordance with Clause 2(1)(b), the Licensee shall:

- (a) comply with the requirements applicable to the use of wireless telegraphy apparatus at the location of operation in the host country;

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<sup>6</sup> Please refer to note (h) to this Licence.

- (b) present this Licence upon request to the relevant supervisory authorities in the host country;
- (c) unless instructed otherwise by the host country, use the Callsign specified in Section 1 of this Licence after the appropriate host country Callsign prefix.

## 17 Interpretation

17(1) In this Licence, unless the context otherwise requires:

- (a) "Act" means the Wireless Telegraphy Act 2006;
- (b) "Alternative Address" means a fixed postal address in the United Kingdom other than the Main Station Address;
- (c) "Aircraft" and "Airborne Vehicles" includes full size and models and also includes balloons whether tethered or free;
- (d) "Amateur" means a holder of a United Kingdom Amateur Radio Licence;
- (e) "Beacon" means automatic transmitting only Radio Equipment which is operated by the Licensee in accordance with Clause 10 and Schedule 2 of this Licence;
- (f) "Callsign" means the unique group of alphanumeric characters specified in Section 1 of this Licence and used to identify the Radio Equipment in accordance with ITU Radio Regulations;
- (g) "CEPT" means the European Conference of Postal and Telecommunications Administrations;
- (h) "Club" means an amateur radio club;
- (i) "Disqualified Person" means any person:
  - I. whose United Kingdom Amateur Radio Licence is currently revoked or varied as a result of revocation action;
  - II. whose last application for a United Kingdom Amateur Radio Licence was refused as a result of revocation action; or
  - III. who, in the last six months, has been convicted of an offence under the Wireless Telegraphy Acts.
- (j) "Foundation Licence" means a Licence issued to an Amateur who is the holder of a Radio Amateurs' Examination Pass Certificate which confirms that the holder has achieved the appropriate level of competence required by Ofcom to be issued with a Foundation Licence;
- (k) "Full Licence" means a Licence issued to an Amateur who is the holder of a Radio Amateurs' Examination Pass Certificate which confirms that the holder has achieved the appropriate level of competence required by Ofcom to be issued with a Full Licence;
- (l) "Full (Club) Licence" means a Licence issued to an Amateur who is the holder of a separate Full Licence and who represents a Club;
- (m) "Full (Reciprocal) Licence" means a Licence issued to an Amateur who holds a Harmonised Amateur Radio Examination Certificate which confirms that the holder has achieved the appropriate level of competence required by Ofcom to be issued with a Full (Reciprocal) Licence;
- (n) "Full (Temporary Reciprocal) Licence" means a licence issued to an Amateur who holds an amateur radio Licence issued by a foreign (non-UK) administration recognised by Ofcom and which confirms that the holder has achieved the appropriate level of competence required by Ofcom to be issued with a Full (Temporary Reciprocal) Licence;
- (o) "Harmonised Amateur Radio Examination Certificate" means a certificate issued by a non-UK licensing administration as evidence that the holder has achieved a specified level of qualification consistent with the requirements of CEPT Recommendation T/R 61-02;
- (p) "Inspect" means examine and test;
- (q) "Intermediate Licence" means a licence issued to an Amateur who is the holder of a Radio Amateurs' Examination Pass Certificate which confirms that the holder has achieved the appropriate level of competence required by Ofcom to be issued with an Intermediate Licence;
- (r) "Licence Fee" means the licence fee payable by the Licensee to Ofcom only where this Licence is a Paper Licence;
- (s) "Licensee" means the holder of this Licence named in Section 1 of the Licence;
- (t) "Main Station Address" means the main station address stated in Section 1 of this Licence;
- (u) "Maritime Mobile" means the Radio Equipment is located on any Vessel at Sea;
- (v) "Message" means a signal which conveys information to or from Radio Equipment operated by an Amateur in accordance with a United Kingdom Amateur Radio Licence;
- (w) "Mobile" means the Radio Equipment is located in the United Kingdom:
  - I. in or on any vehicle or conveyance;
  - II. on the person of the Licensee where the Licensee is a pedestrian; or
  - III. on any Vessel on Inland Waters;
- (x) "Modifier" means the applicable Regional Secondary Locator and may also include a suffix in accordance with note (d) to this Licence;
- (y) "Ofcom" means the Office of Communications;

- (aa) "Paper Licence" means a Licence that is issued to the Licensee in paper form by Ofcom;
- (bb) "Radio Amateurs' Examination Pass Certificate" means an original certificate issued by an examination body which is recognised by Ofcom which confirms that that person named on the certificate has achieved the level of competence required to hold either a Full, Intermediate or Foundation United Kingdom Amateur Radio Licence;
- (cc) "Radio Equipment" has the meaning given to it in Section 1 of this Licence;
- (dd) "Recognised Foundation Training Course" means a training course which, if successfully completed, will lead to the person attending the course being issued with a Radio Amateurs' Examination Pass Certificate which confirms that that person has achieved the level of competence required by Ofcom to be issued with a Foundation Licence;
- (ee) "Regional Secondary Locator" means a letter used by the Licensee to convey the location of the Radio Equipment in accordance with Clause 2(2) and note (c) to this Licence;
- (ff) "Remote Control Operation" means Unattended Operation but where the Radio Equipment is operated by remote control, that is, where the Licensee has the ability to control the Radio Equipment from a different location to that where the Radio Equipment is located;
- (gg) "Secretary of State" means the Secretary of State for Trade and Industry;
- (hh) "Telecommunication Convention" and "Radio Regulations" mean the International Telecommunication Convention and the Radio Regulations annexed thereto and include any Convention or Regulation which may from time to time be enacted or brought into force in substitution for, in amendment of, or in addition to, the Telecommunication Convention or Radio Regulations;
- (ii) "Temporary Licence" means a Licence which is issued to a radio amateur who is already licensed by a foreign (non-UK) licensing administration and who wishes to operate on a temporary basis in the UK. A UK Callsign will not be issued with a Temporary Licence;
- (jj) "Temporary Location" means a fixed location in the United Kingdom which is not the Main Station Address or an Alternative Address;
- (ll) "Unattended Operation" means the operation of Radio Equipment by the Licensee when the Licensee is in a different location to that where the Radio Equipment is located;
- (mm) "Undue Interference" shall have the meaning given by Section 115 of the Act;
- (nn) "United Kingdom" means the United Kingdom of Great Britain and Northern Ireland, the Channel Islands and the Isle of Man;
- (oo) "United Kingdom Amateur Radio Licence" means a Full, Intermediate, Foundation, Full (Reciprocal), Full (Temporary Reciprocal), or Full (Club) Amateur Radio Licence;
- (pp) "Unwanted Emissions" means spurious emissions and out-of-band emissions as defined in the Radio Regulations;
- (qq) "User Service" means the British Red Cross, St John Ambulance, the St Andrew's Ambulance Association, the Women's Royal Voluntary Service, the Salvation Army, any Government Department, any 'Category 1' responder, and any Category 2 responder as defined in the Civil Contingencies Act 2004;
- (rr) "Vessel" means any floating structure which is capable of being manned;
- (ss) "Vessel at Sea" means a Vessel operating on the seaward side of the low-water line along the coastline as marked on large scale charts officially recognised by the relevant coastal state;
- (tt) "Vessel on Inland Waters" means a Vessel operating on the landward side of the low-water line along the coastline as marked on large scale charts officially recognised by the relevant coastal state; and
- (uu) "Wireless Telegraphy Acts" means the Wireless Telegraphy Act 2006 and the Wireless Telegraphy (Content of Transmission) Regulations 1988 as either of them have been or may be amended from time to time.

17(2) The Licence consists of Section 1 and Section 2 (which includes Schedule 1 and Schedule 2) together with the notes thereto, as any of them may be varied from time to time.

17(3) The headings in this Licence are for ease of reference only and shall not affect the interpretation of the Licence.

17(4) To the extent that they do not conflict with or are not inconsistent with any of the Clauses herein, the notes to the Schedules and the notes to the Licence are binding on the Licensee.

17(5) The Interpretation Act 1978 shall apply to this Licence as it applies to an Act of Parliament.



## Notes to the licence

(a) The bandwidths of emissions should be such as to ensure the most efficient utilisation of the spectrum. In general this requires that bandwidths be kept at the lowest values which technology and the nature of the service permit. Where bandwidth-expansion techniques are used, the minimum spectral power density consistent with efficient spectrum utilisation should be employed.

(b) When telephony is used, the letters of the Callsign may be confirmed phonetically by the pronouncement of well-known words of which the initial letters are the same as those in the Callsign. It is recommended that the phonetic alphabet contained in Appendix 14 of the Radio Regulations be used:

<b>A</b>	Alpha	<b>J</b>	Juliet	<b>S</b>	Sierra
<b>B</b>	Bravo	<b>K</b>	Kilo	<b>T</b>	Tango
<b>C</b>	Charlie	<b>L</b>	Lima	<b>U</b>	Uniform
<b>D</b>	Delta	<b>M</b>	Mike	<b>V</b>	Victor
<b>E</b>	Echo	<b>N</b>	November	<b>W</b>	Whiskey
<b>F</b>	Foxtrot	<b>O</b>	Oscar	<b>X</b>	X-ray
<b>G</b>	Golf	<b>P</b>	Papa	<b>Y</b>	Yankee
<b>H</b>	Hotel	<b>Q</b>	Quebec	<b>Z</b>	Zulu
<b>I</b>	India	<b>R</b>	Romeo		

(c) If the Radio Equipment is used solely by a Club then the following Regional Secondary Locators may be used instead of those described in Clause 2(2.):

- |                  |       |                     |       |
|------------------|-------|---------------------|-------|
| I. England       | - "X" | V. Northern Ireland | - "N" |
| II. Guernsey     | - "P" | VI. Scotland        | - "S" |
| III. Isle of Man | - "T" | VII. Wales          | - "C" |
| IV. Jersey       | - "H" |                     |       |

(d) When operating at locations other than the Main Station Address, it is recommended that the following suffixes be used:

- I. If the Licensee operates the Radio Equipment at an Alternative Address, the Licensee may use the suffix "/A" with the Callsign;
- II. If the Licensee operates the Radio Equipment at a Temporary Location, the Licensee may use the suffix "/P" with the Callsign;
- III. If the Licensee operates the Radio Equipment from a Mobile location, the Licensee may use the suffix "/M" with the Callsign;
- IV. If the Licensee operates the Radio Equipment from a Maritime Mobile location, the Licensee may use the suffix "/MM" with the Callsign

(e) When the location of the Radio Equipment is given, it is recommended that one of the following location identifiers be used:

- I. the full postcode;
- II. latitude and longitude in degrees and minutes;
- III. National Grid Reference correct to six figures;
- IV. International Amateur Radio Union (IARU) locator to six characters; or
- V. the address or other geographical description correct to 5 km.

(f) When considering the use of communication links referred to in Clause 10(4) of this Licence, it is the Licensee's responsibility to ensure that the Licensee is duly authorised to use the communications link for this purpose. When considering the use of public communications links, it is the Licensee's responsibility to ensure that any such use would be consistent with the terms and conditions of the service provider.

(g) When considering the use of the amateur band allocations detailed in Schedule 1 to establish the communication links referred to in Clause 10(4) of this Licence, the Licensee should only use band allocations above 30 MHz to establish these communications links.

(h) The Wireless Telegraphy (Content of Transmission) Regulations 1988 make it an offence to use any station for wireless telegraphy or any wireless telegraphy apparatus to send a message, communication or other matter in whatever form that is grossly offensive or of an indecent, obscene or menacing character.

(i) In order to avoid the Licence being revoked, by no later than five years after the date of issue of this Licence, the Licensee must either notify Ofcom of a change of the Licensee's details in Section 1 of the Licence or confirm to Ofcom that the details set out in Section 1 of the Licence are still valid. Unless the Licensee makes a further notification or confirmation to Ofcom once every five years from the last date of notification or confirmation, then the Licence will be revoked.

# Schedule 1

Where this Licence is either a Full Licence, a Full (Reciprocal) Licence, a Full (Temporary Reciprocal) Licence or a Full (Club) Licence, the Licensee shall only be permitted to operate the Radio Equipment using the frequency bands and power levels set out in Table C of this Schedule 1.

**Table C**

Full Licence Parameters

Frequency Bands (in MHz)	Status of allocations in UK to the Amateur Service	Status of allocations in UK to the Amateur Satellite Service	Maximum Peak Envelope Power level in Watts (and dB relative to 1 Watt)
0.1357-0.1378	Secondary. Available on the basis of non-interference to other services inside or outside the UK.	Not allocated	1W (0 dBW) e.r.p.
0.472 - 0.479 (subject to note (f))	Secondary	Not allocated	Subject to note (f), 5W (7 dBW) e.i.r.p.
1.810-1.830	Primary. Available on the basis of non-interference to other services outside the UK	Not allocated	400W (26 dBW)
1.830-1.850	Primary	Not allocated	400W (26 dBW)
1.850-2.000	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	32W (15 dBW)
3.500-3.800	Primary. Shared with other services	Not allocated	400W (26 dBW)
5.2585 – 5.264 (subject to note (g))	Secondary. Available on the basis of non-interference to other services inside the UK	Not allocated	100 W (20dBW)
5.276 – 5.284 (subject to note (g))	Secondary. Available on the basis of non-interference to other services inside the UK	Not allocated	100 W (20dBW)
5.2885 – 5.292 (subject to note (g))	Secondary. Available on the basis of non-interference to other services inside the UK	Not allocated	100 W (20dBW)
5.298 - 5.307 (subject to note (g))	Secondary. Available on the basis of non-interference to other services inside the UK	Not allocated	100 W (20dBW)
5.313 – 5.323 (subject to note (g))	Secondary. Available on the basis of non-interference to other services inside the UK	Not allocated	100 W (20dBW)
5.333 – 5.338 (subject to note (g))	Secondary. Available on the basis of non-interference to other services inside the UK	Not allocated	100 W (20dBW)
5.354 – 5.358 (subject to note (g))	Secondary. Available on the basis of non-interference to other services inside the UK	Not allocated	100 W (20dBW)
5.362 – 5.3745 (subject to note (g))	Secondary. Available on the basis of non-interference to other services inside the UK	Not allocated	100 W (20dBW)
5.378 – 5.382 (subject to note (g))	Secondary. Available on the basis of non-interference to other services inside the UK	Not allocated	100 W (20dBW)
5.395 – 5.4015 (subject to note (g))	Secondary. Available on the basis of non-interference to other services inside the UK	Not allocated	100 W (20dBW)
5.4035 – 5.4065 (subject to note (g))	Secondary. Available on the basis of non-interference to other services inside the UK	Not allocated	100 W (20dBW)
7.000-7.100	Primary	Primary	400W (26 dBW)
7.100-7.200	Primary.	Not allocated	400W (26 dBW)
10.100-10.150	Secondary	Not allocated	400W (26 dBW)
14.000-14.250	Primary	Primary	400W (26 dBW)
14.250-14.350	Primary	Not allocated	400W (26 dBW)
18.068-18.168	Primary	Primary	400W (26 dBW)
21.000-21.450	Primary	Primary	400W (26 dBW)
24.890-24.990	Primary	Primary	400W (26 dBW)
28.000-29.700	Primary	Primary	400W (26 dBW)
50.00-51.00	Primary. Available on the basis of non-interference to other services outside the UK	Not allocated	400W (26 dBW)
51.00-52.00	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	100W (20 dBW)
70.00-70.50	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	160W (22 dBW)
144.0-146.0	Primary	Primary	400W (26 dBW)
430.0-431.0	Secondary	Not allocated	40W (16 dBW) e.r.p.

Frequency Bands (in MHz)	Status of allocations in UK to the Amateur Service	Status of allocations in UK to the Amateur Satellite Service	Maximum Peak Envelope Power level in Watts (and dB relative to 1 Watt)
431.0-432.0	Secondary. Not available for use; within 100km radius of Charing Cross, London (51°30'30"N,00°07'4"W)	Not allocated	40W (16 dBW) e.r.p.
432.0-435.0	Secondary	Not allocated	400W (26 dBW)
435.0-438.0	Secondary	Secondary	400W (26 dBW)
438.0-440.0	Secondary	Not allocated	400W (26 dBW)
1240-1260	Secondary	Not allocated	400W (26 dBW)
1260-1270	Secondary	Secondary. Earth to space only	400W (26 dBW)
1270-1325	Secondary	Not allocated	400W (26 dBW)
2310-2350	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	400W (26 dBW)
2390-2400	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	400W (26 dBW)
2400-2450	Secondary. Users must accept interference from ISM users.	Secondary. Users must accept interference from ISM users.	400W (26 dBW)
3400-3410	Secondary. Available on the basis of non-interference to other services inside or outside the UK	Not allocated	400W (26 dBW)
5650-5670	Secondary	Secondary. Earth to space only	400W (26 dBW)
5670-5680	Secondary	Not allocated	400W (26 dBW)
5755-5765	Secondary. Users must accept interference from ISM users	Not allocated	400W (26 dBW)
5820-5830	Secondary. Users must accept interference from ISM users	Not allocated	400W (26 dBW)
5830-5850	Secondary. Users must accept interference from ISM users	Secondary. Users must accept interference from ISM users. Space to Earth only.	400W (26 dBW)
10000-10125	Secondary	Not allocated	400W (26 dBW)
10225-10450	Secondary	Not allocated	400W (26 dBW)
10450-10475	Secondary	Secondary	400W (26 dBW)
10475-10500	Not allocated	Secondary	400W (26 dBW)
24000-24050	Primary. Users must accept interference from ISM users	Primary. Users must accept interference from ISM users	400W (26 dBW)
24050-24150	Secondary. May only be used with the written consent of Ofcom. Users must accept interference from ISM users	Not allocated	400W (26 dBW)
24150-24250	Secondary	Not allocated	400W (26 dBW)
47000-47200	Primary	Primary	400W (26 dBW)
75500-75875	Secondary	Secondary	400W (26 dBW)
75875-76000	Primary	Primary	400W (26 dBW)
76000-77500	Secondary	Secondary	400W (26 dBW)
77500-78000	Primary	Primary	400W (26 dBW)
78000-79000	Secondary	Secondary	400W (26 dBW)
79000-81000	Secondary	Secondary	400W (26 dBW)
122250-123000	Secondary	Not allocated	400W (26 dBW)
134000-136000	Primary	Primary	400W (26 dBW)
136000-141000	Secondary	Secondary	400W (26 dBW)
241000-248000	Secondary	Secondary	400W (26 dBW)
248000-250000	Primary	Primary	400W (26 dBW)

## Notes to Schedule 1

- (a) dBW is the power level in dB relative to one Watt.
- (b) Peak envelope power is the average power supplied to the antenna by a transmitter during one radio frequency cycle at the crest of the modulation envelope taken under normal operating conditions.
- (c) Effective radiated power (e.r.p.) (in a given direction) is the product of the power supplied to the antenna and its gain relative to a half-wave dipole in a given direction.
- (d) ISM is an abbreviation for industrial, scientific and medical applications.
- (e) In all frequency bands, high intensities of radio frequency radiation may be harmful and safety precautions should be taken. Advice concerning safe levels of exposure to radio frequency radiation is provided by Public Health England.

continued overleaf

(f) Where Radio Equipment is being used in the 0.472 - 0.479 MHz band, the following specific terms and conditions will also apply:

- (i) Where the Equipment is used within 800 kilometres of any border of any of the countries listed below, the maximum power level must not exceed 1 Watt eirp.  
Algeria, Saudi Arabia, Azerbaijan, Bahrain, Belarus, China, Comoros, Djibouti, Egypt, United Arab Emirates, the Russian Federation, Iran (Islamic Republic of), Iraq, Jordan, Kazakhstan, Kuwait, Lebanon, Libya, Morocco, Mauritania, Oman, Uzbekistan, Qatar, Syrian Arab Republic, Kyrgyzstan, Somalia, Sudan, Tunisia, Ukraine and Yemen
- (ii) Any use of the Station in another country is subject to the laws of that country;
- (iii) The Station must not cause interference to and may not claim protection from other wireless telegraphy or electronic equipment;
- (iv) In particular, the Radio Equipment must not cause interference to stations operating in the aeronautical radio navigation service or on 490 kHz in the Maritime Mobile service;
- (v) If the Licensee is notified that the Radio Equipment is causing interference to the services described in (iv) above, the Licensee must close down the Equipment and not use it until it can be used without causing such interference.

(g) Where Radio Equipment is being used in the 5 MHz band, the following specific terms and conditions will also apply:

- (i) When operating double sideband, the maximum bandwidth shall not exceed 6kHz;
- (ii) Notwithstanding the maximum peak envelope power expressed in the table, above, the maximum radiated power must not exceed 200 Watts eirp;
- (iii) The antenna height shall not exceed 20 metres above ground level;
- (iv) The Licensee must not cause interference to the use made of the 5 MHz band by the Ministry of Defence ("MoD") and must close down any apparatus that operates in the 5 MHz band if he or she becomes aware that such use is causing undue interference to the MoD's use of the band;
- (v) Communication may be established with military or military cadet organisations by transmitting and receiving only in the 5 MHz band;
- (vi) Particular care must be taken to ensure radiation does not take place outside the specified frequencies within the 5 MHz band;
- (vii) Where the Licensee intends to operate within a "net" (a network), the Licensee shall observe the following requirements in relation to the transmission of his or her Callsign:
  - (a) The Licensee shall transmit the station Callsign when he first joins the net and on leaving it;
  - (b) subject to sub-clause (c) below, whilst participating in the net, the Licensee shall not be required to transmit the station Callsign when making contact with other participants;
  - (c) where the Licensee's transmissions have been other than in speech mode for at least fifteen minutes, the Licensee shall transmit his call sign when next he transmits speech.
- (viii) The Licensee shall operate the Station only at the Main Station Address or at a Temporary Location within the United Kingdom.
- (ix) At a Temporary Location within the UK, the Licensee shall give the location of the Station every 30 minutes to an accuracy of at least 5km by a generally used identifier as indicated in Note (e) to the "Notes to the licence";
- (x) The Licensee shall only operate the Station to the extent that the Licensee can be contacted on a telephone which is located in close proximity to the Station.
- (xi) In this footnote, "the 5 MHz band" means the radio spectrum between 5.2585 MHz and 5.4065 MHz

## Schedule 2

### Additional restrictions which apply to the Unattended Operation of Beacons

Frequencies	Full Licence, Full (Reciprocal) Licence, Full (Temporary Reciprocal) Licence, Full (Club) Licence	Intermediate Licence	Foundation Licence
1.960 MHz	(1)	(1)	Not allocated
3.510 MHz -3.543 MHz	(1)	Not allocated	Not allocated
3.553 MHz - 3.600 MHz	(1)	Not allocated	Not allocated
28.000 MHz - 28.100 MHz	Not within 50 km of NGR SK 985640 (1)	Not allocated	Not allocated
28.100 MHz - 28.500 MHz	Not within 50 km of NGR SK 985640 (1)	Not within 50 km of NGR SK 985640 (1)	Not allocated
28.500 MHz – 29.700 MHz	Not within 50 km of NGR SK 985640 (1)	Not allocated	Not allocated
70.000 MHz - 70.500 MHz		Not allocated	Not allocated
144.000 MHz - 146.000 MHz	Not within 50 km of NGR TA 012869 (1) (2)	Not allocated	Not allocated
1298 – 1299 MHz	Not in N. Ireland and not within 50 km of NGR SS 206127 and NGR SE 202577	Not in N. Ireland and not within 50 km of NGR SS 206127 and NGR SE 202577	Not allocated
2310.0000 MHz - 2310.4125 MHz	Not within 50 km of NGR SS 206127 and NGR SE 202577	Not allocated	Not allocated
2310.4125 MHz - 2350.0000 MHz		Not allocated	Not allocated
2390 MHz - 2392 MHz		Not allocated	Not allocated
2392 MHz - 2450 MHz	Not within 50 km of NGR SS 206127 and NGR SE 202577	Not allocated	Not allocated
3400 MHz - 3410 MHz		Not allocated	Not allocated
5650 MHz - 5670 MHz		Not allocated	Not allocated
5670 MHz - 5680 MHz	Not within 50 km of NGR SS 206127 and NGR SE 202577	Not allocated	Not allocated
5755 MHz - 5765 MHz		Not allocated	Not allocated
5820 MHz - 5850 MHz		Not allocated	Not allocated
10000 MHz – 10125 MHz	Not within 50 km of NGR SO 916223, SS 206127, NGR SK 985640 and NGR SE 202577	Not within 50 km of NGR SS 206127, NGR SK 985640 or NGR SE 202577	Not allocated
10400 MHz – 10475 MHz			Not allocated
24000 MHz – 24050 MHz	Not within 50 km of NGR SK 985640 and NGR SE 202577	Not allocated	Not allocated
47000 MHz – 47200 MHz	Not within 50 km of NGR SK 985640 and NGR SE 202577	Not allocated	Not allocated

### Notes to additional restrictions which apply to the unattended operation of beacons

(1) May only be used for the purpose of direction finding competitions. The Beacon must transmit the Callsign of the Licensee in accordance with Clause 13 of this Licence and it must be possible to switch the Beacon off within two hours of a demand to close down by a person authorised by Ofcom.

(2) It is permissible to transmit positional information using automatic position reporting software on a spot frequency of 144.800 MHz at any one temporary location not within 50 km of NGR TA 012869. The maximum permitted period of unattended operation is 30 minutes.

### Notes to schedule 2

(a) The Unattended Operation of Beacons is only permitted within the frequency bands:

- I. Which are listed in the first column of Schedule 2; or
- II. which are above 75500 MHz and are listed in the first column of Schedule 1 providing that such operation is not within 50 km of NGR SK 985640 and NGR SE 202577.

(b) Beacons may operate with a maximum power level of 25 W e.r.p. pep.



# Radio Society of Great Britain

## Full Licence Amateur Radio Band Plans

### For Examination use only

5 MHz (60m)	Available Bandwidth	UK Usage
5258.5 - 5264.0 kHz	5.5 kHz	5262 kHz - CW QRP Centre of Activity
5276.0 - 5284.0	8 kHz	5278.5 kHz - may be used for UK emergency comms traffic
5288.5 - 5292.0	3.5 kHz	Beacons on 5290 kHz (Note-2)
5298.0 - 5307.0	9 kHz	
5313.0 - 5323.0	10 kHz	5317 kHz - AM 6kHz max. bandwidth
5333.0 - 5338.0	5 kHz	
5354.0 - 5358.0	4 kHz	Within WRC-15 Band
5362.0 - 5374.5	12.5 kHz	Partly within WRC-15 band, WSPR
5378.0 - 5382.0	4 kHz	
5395.0 - 5401.5	6.5 kHz	
5403.5 - 5406.5	3 kHz	

**Unless indicated, usage is all-modes (necessary bandwidth to be within channel limits)**

**Note 1:** Upper Sideband is recommended for SSB activity.  
**Note 2:** Activity should avoid interference to the experimental beacons on 5290 kHz  
**Note 3:** Amplitude Modulation is permitted with a maximum bandwidth of 6kHz, on frequencies with at least 6kHz available width  
**Note 4:** Contacts within the UK should avoid the WRC-15 band (5351.5 - 5366.5 kHz) if possible

**LICENCE NOTES:** Full Licensees only Secondary User: 100W max  
 Note that specific conditions regarding operating, transmission bandwidth, power and antennas are specified in the Licence.

472 kHz (600m)	Necessary Bandwidth	UK Usage
IARU Region-1 does not have a formal band plan for this allocation, but has a usage recommendation (Note-1)		
472-479kHz (Note-2)	500	CW, QRSS and narrow-band digital modes (Note-1)

**Note-1:** Usage recommendation: - 472-475 kHz CW-only 200Hz max BW, 475-479 kHz - CW & Digimodes  
**Note-2:** It should be emphasised that this band is available on a non-interference basis to existing services. UK amateurs should be aware that some overseas stations may be restricted in their use of transmit frequency in order avoid interference to nearby radionavigation service Non-Directional Beacons  
**LICENCE NOTES:** Amateur Service Secondary User. Full Licensees only - 5 Watts eirp maximum. Note that specific conditions regarding this band are specified by the Licence Schedule notes.

**R.R. 5.80B** The use of the frequency band 472-479 kHz in Algeria, Saudi Arabia, Azerbaijan, Bahrain, Belarus, China, Comoros, Djibouti, Egypt, United Arab Emirates, the Russian Federation, Iraq, Jordan, Kazakhstan, Kuwait, Lebanon, Libya, Mauritania, Oman, Uzbekistan, Qatar, Syrian Arab Republic, Kyrgyzstan, Somalia, Sudan, Tunisia and Yemen is limited to the maritime mobile and aeronautical radionavigation services. The amateur service shall not be used in the above-mentioned countries in this frequency band, and this should be taken into account by the countries authorizing such use. (WRC 12)

## Notes to the bandplans

**Necessary bandwidth:** For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

**All Modes:** CW, SSB and those modes listed as Centres of Activity, plus AM. Consideration should be given to adjacent channel users.

**Image Modes:** Any analogue or digital image modes within the appropriate bandwidth, for example SSTV and FAX.

**Narrowband Modes:** All modes using up to 500Hz bandwidth, including CW, RTTY, PSK, etc.

**Digimodes:** Any digital mode used within the appropriate bandwidth, for example RTTY, PSK, MT63, etc.

**Sideband usage:** Below 10MHz use lower sideband (LSB), above 10MHz use upper sideband (USB). Note the lowest dial settings for LSB Voice modes are 1843, 3603 and 7043kHz on 160, 80 and 40m. Note that on (5MHz) USB is used.

**Amplitude Modulation (AM):** AM with a bandwidth greater than 2.7kHz is acceptable in the All Modes segments provided users consider adjacent channel activity when selecting operating frequencies (Davos 2005).

**Extended SSB (eSSB):** Extended SSB (eSSB) is only acceptable in the All Modes segments provided users consider adjacent channel activity when selecting operating frequencies.

**Digital Voice (DV):** Users of Digital Voice (DV) should check that the channel is not in use by other modes (CT08\_C5\_Rec20).

**FM Repeater & Gateway Access:** CTCSS Access is recommended. Toneburst access is being withdrawn in line with IARU-R1 recommendations.

**MGM:** Machine Generated Modes indicates those transmission modes relying fully on computer processing such as RTTY, AMTOR, PSK31, JTxx, FSK441 and the like. This does not include Digital Voice (DV) or Digital Data (DD).

**WSPR:** Above 30MHz, WSPR frequencies in the band plan are the centre of the transmitted frequency (not the suppressed carrier frequency or the VFO dial setting).

# Formula sheet

This formula sheet may be used to answer any question.

$R_T = R_1 + R_2 + R_3$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	$V = IR$
$V_{out} = V_{in} \left( \frac{R_2}{R_1 + R_2} \right)$	$P = VI = \frac{V^2}{R} = I^2R$	$V_{rms} = \frac{V_{peak}}{\sqrt{2}}$
$C = \frac{Q}{V}$	$C = \frac{kA}{d}$ where $k = \epsilon_0 \epsilon_r$	
$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$	$C_T = C_1 + C_2 + C_3$	$X_C = \frac{1}{2\pi fC}$
$L_T = L_1 + L_2 + L_3$	$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2}$	$X_L = 2\pi fL$
$Z = \sqrt{R^2 + X^2}$	$V_T = \sqrt{V_R^2 + V_C^2}$ (or $V_L^2$ )	$f = \frac{1}{2\pi\sqrt{LC}}$
$t = \frac{1}{f}$	$\tau = CR$	$\tau = \frac{L}{R}$
$Q = \frac{2\pi fL}{R}$ or $\frac{1}{2\pi fCR}$	$Q = \frac{f_c}{f_U - f_L} = \frac{\text{centre frequency}}{\text{bandwidth}}$	$R_D = \frac{L}{CR}$
$Q = 2\pi fCR_D$		
$V_s = V_p \left( \frac{N_s}{N_p} \right)$	$I_p = I_s \left( \frac{N_s}{N_p} \right)$	$Z_p = Z_s \left( \frac{N_p}{N_s} \right)^2$
$I_C = \beta I_B$	$f_{step} = \frac{f_{crystal}}{A}$	$f_{out} = f_{crystal} \frac{N}{A}$
$c = 3 \times 10^8 \text{ m/s}$	Gain (loss) = $10 \text{Log}_{10} \left( \frac{\text{power out}}{\text{power in}} \right)$ dB	$SWR = \frac{V_{max}}{V_{min}} = \frac{V_f + V_r}{V_f - V_r}$
$v = f\lambda$	Gain (loss) = $20 \text{Log}_{10} \left( \frac{\text{voltage out}}{\text{voltage in}} \right)$ dB	$Z_0^2 = Z_{in} \times Z_{out}$
$E = \frac{7\sqrt{erp}}{d}$	erp = power $\times$ gain (linear)	bw = $2(AF_{max} + \Delta f)$
Return Loss = $10 \text{Log}_{10} \left( \frac{\text{Incident Power}}{\text{Reflected Power}} \right)$ dB		
Gain = $10 \text{Log}_{10} \left( \frac{\text{Power from Yagi}}{\text{Power from dipole}} \right)$ dBd	Gain = $10 \text{Log}_{10} \left( \frac{\text{Power from Yagi}}{\text{Power from isotropic}} \right)$ dBi	