FCC Radio Certification

EMC
Radio
Telecom
Environmental
Product Safety
International Approvals
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Code of Federal Regulations (CFR) is the codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the Federal Government. It is divided into 50 titles that represent broad areas subject to Federal regulation. Each volume of the CFR is updated once each calendar year and is issued on a quarterly basis.

Title 1 (1CFR) - General Provisions
Title 2 (2CFR) - Grants and Agreements
Title 19 (19CFR) - Customs Duties
Title 32 (32CFR) - National Defense
Title 37 (37CFR) - Patents, Trademarks, and Copyrights
Title 47 (47CFR) - Telecommunication

Title 6 (6CFR) - Homeland Security
Title 10 (10CFR) - Energy
Title 21 (21CFR) - Food and Drugs
Title 34 (34CFR) - Education

47CFR CHAPTER I - FEDERAL COMMUNICATIONS COMMISSION
47CFR CHAPTER II - OFFICE OF SCIENCE AND TECHNOLOGY POLICY AND NATIONAL SECURITY COUNCIL
47CFR CHAPTER III - NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION, DEPARTMENT OF COMMERCE
- Federal Communications Commission (FCC) regulates the private sector telecommunications industry, in the public interest

- Establishes technical regulations for transmitters and other equipment to minimize their potential for causing interference to radio services

- Administers an authorization program to ensure that equipment reaching the market complies with the technical requirements
FCC Regulations Overview

- **Administrative Rules** - Contain general requirements applicable to all other rule sections
  - 47 CFR Parts 0, 1 and 2
  - Examples: application filing process, general description of required tests, confidentiality, etc

- **Radio Service Rules** - Contain specific user licensing and equipment authorization testing requirements
  - 47 CFR Part 15 - Unlicensed services
    - Part 15 subpart B - Unintentional radiators
    - Part 15 subparts C-H - Intentional radiators
    - Examples: Line conducted and radiated emission limits for specific products, occupied bandwidth masks, etc
  - 47 CFR Parts 22, 24, 25, 27, 90, 95, 101 etc - Licensed services
    - Examples: Output power and PSD, Spurious conducted and radiated emission limits for specific products, occupied bandwidth masks, etc
47CFR CHAPTER I:
FEDERAL COMMUNICATIONS COMMISSION

- 47CFR PART 1 - PRACTICE AND PROCEDURE
- 47CFR PART 2 - FREQUENCY ALLOCATIONS AND RADIO TREATY MATTERS; GENERAL RULES AND REGULATIONS
- 47CFR PART 15 - RADIO FREQUENCY DEVICES
- 47CFR PART 18 - INDUSTRIAL, SCIENTIFIC, AND MEDICAL EQUIPMENT
- 47CFR PART 22 - PUBLIC MOBILE SERVICES
- 47CFR PART 24 - PERSONAL COMMUNICATIONS SERVICES
- 47CFR PART 27 - MISCELLANEOUS WIRELESS COMMUNICATIONS SERVICES
- 47CFR PART 68 - CONNECTION OF TERMINAL EQUIPMENT TO THE TELEPHONE NETWORK
- 47CFR PART 73 - RADIO BROADCAST SERVICES
- 47CFR PART 90 - PRIVATE LAND MOBILE RADIO SERVICES
- 47CFR PART 95 - PERSONAL RADIO SERVICES
- 47CFR PART 101 - FIXED MICROWAVE SERVICES
No person shall sell, import, ship or lease (including advertising for sale) of any radio frequency device unless

- device has been authorized by the Commission and is properly identified and labelled as required by § 2.925
- device that is not required to have a grant of equipment authorization, but which must comply with the specified technical standards prior to use, such device also complies with all applicable administrative (including verification of the equipment or authorization under a Declaration of Conformity, where required), technical, labelling and identification requirements
Prior to equipment authorization or determination of compliance with the applicable technical requirements any RF device may be operated, but not marketed for:

- Compliance testing
- Demonstrations at a trade show and/or exhibition
- Evaluation of product performance for customer acceptability

Limitations for operation prior to authorization:

- Business, commercial, industrial, scientific, or medical location
- Excluding locations in a residential environment
- The relevant notice is displayed in a conspicuous location on, or immediately adjacent to, the device

**NOTICE:**
This device has not been authorized as required by the rules of the Federal Communications Commission. This device is not, and may not be, offered for sale or lease, or sold or leased, until authorization is obtained.
Equipment Authorization Procedures (47CFR Part 2 Subpart J)

- **Certification**
  - 47CFR Part 2 Subpart J § 2.907
  - FCC or TCB grant (approval)

- **Declaration of Conformity**
  - 47CFR Part 2 Subpart J § 2.906
  - Self approval using an accredited test laboratory

- **Verification**
  - 47CFR Part 2 Subpart J § 2.902
  - Self approval

Intentional radiators

Unintentional radiators

Time and money investments in the authorization process

Maximum

Minimum
Verification is a procedure where the manufacturer makes measurements or takes the necessary steps to ensure that the equipment complies with the appropriate technical standards.

Submittal of a sample unit or representative data to the Commission demonstrating compliance is not required unless specifically requested by the Commission pursuant to Section 2.957.

Examples of devices subject to Verification include, but are not limited to Industrial, Scientific and Medical (ISM) equipment; business Class A computer equipment; TV and FM receivers. Devices subject only to Verification shall be uniquely identified.
A DoC is a procedure where the responsible party as defined in Section 2.909, makes measurements or takes other necessary steps to ensure that the equipment complies with the appropriate technical standards.

Submittal of a sample unit or representative data to the Commission demonstrating compliance is not required unless specifically requested pursuant to Section 2.1076.

Examples of devices subject to DoC include, but are not limited to Class B personal computers and peripherals; CB receivers; TV interface devices. Devices subject to DoC shall be uniquely identified.

Devices must be tested by a test laboratory accredited by the National Voluntary Laboratory Accreditation Program (NVLAP); the American Association of Laboratory Accreditation (A2LA); or an accredited laboratory designated by the Commission.
Certification is an equipment authorization issued by the Commission or by a designated Telecommunications Certification Body (TCB) based on representations and test data submitted by the applicant.

Examples of devices subject to Certification which must be submitted to the Commission include, but are not limited to Ultra Wideband; Software Defined Radio; new technology.

Examples of devices subject to Certification which must be submitted to a TCB are Computers and Computer Peripherals.

Examples of devices subject to Certification which may be submitted to either the Commission or to a TCB include, but are not limited to cell phones; RF Light; Microwave Oven; RC Transmitters; Family Radio; Telemetry Transmitters; Wireless Phones; Walkie Talkies.
### Equipment authorization of unintentional radiators (15.101)

<table>
<thead>
<tr>
<th>Type of device</th>
<th>Equipment authorization</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV and/or FM broadcast receiver</td>
<td>Verification</td>
</tr>
<tr>
<td>CB and/or Superregenerative receiver</td>
<td>DoC or Certification</td>
</tr>
<tr>
<td>Scanning receiver and/or Radar detectors</td>
<td>Certification</td>
</tr>
<tr>
<td>All other receivers subject to part 15</td>
<td>DoC or Certification</td>
</tr>
<tr>
<td>TV interface device</td>
<td>DoC or Certification</td>
</tr>
<tr>
<td>Cable system terminal device</td>
<td>DoC</td>
</tr>
<tr>
<td>Stand-alone cable input selector switch</td>
<td>Verification</td>
</tr>
<tr>
<td>Class B personal computers and peripherals</td>
<td>DoC or Certification</td>
</tr>
<tr>
<td>CPU boards and internal power supplies used with Class B personal computers</td>
<td>DoC or Certification</td>
</tr>
<tr>
<td>Class B personal computers assembled using authorized CPU boards or power supplies</td>
<td>DoC</td>
</tr>
<tr>
<td>Class B external switching power supplies and other Class B digital devices &amp; peripherals</td>
<td>Verification</td>
</tr>
<tr>
<td>Class A digital devices, peripherals &amp; external switching PSs</td>
<td>Verification</td>
</tr>
<tr>
<td>Access Broadband over Power Line (Access BPL)</td>
<td>Certification</td>
</tr>
<tr>
<td>All other devices</td>
<td>Verification</td>
</tr>
</tbody>
</table>
Verification and Declaration of Conformity approval steps:

1. **Product sample**
2. **Testing (in accredited lab for DoC)**
3. **Detailed test report**
4. **DoC**
5. **Product documentation**
6. **Mass production**
7. **Sales**
As a Responsible Party for this Declaration, we declare under our sole responsibility that the equipment complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Date and Signature:.................................
Clarification of name:..............................
Position of signatory:..............................
Company stamp:....................................

DoC shall be supplied with the product at the time of marketing or importation and shall be included in the user’s manual or attached as a separate sheet!
Certification steps

- Product sample
- Detailed test report
- Mass production
- Sales
- Testing in accredited lab
- Detailed product documentation
- FCC/TCB approval
FCC web resources

- **Rules and Regulations**

- **Federal Register**

- **Electronic Filing**
  - [https://fjallfoss.fcc.gov/eas/Eas731Welcome.do](https://fjallfoss.fcc.gov/eas/Eas731Welcome.do)

- **Equipment Authorization System (FCC ID search)**
  - [https://fjallfoss.fcc.gov/oetcf/eas/reports/GenericSearch.cfm](https://fjallfoss.fcc.gov/oetcf/eas/reports/GenericSearch.cfm)

- **Measurement Procedures**

- **Knowledge Database(KDB)**
  - [http://gullfoss2.fcc.gov/oetcf/kdb/](http://gullfoss2.fcc.gov/oetcf/kdb/)
FCC registration

- TCBs-FCC has appointed a number of test laboratories as telecommunications certification bodies (TCBs)
  https://fjallfoss.fcc.gov/oetcf/tcb/reports/TCBSearch.cfm

- Test Laboratories
  https://fjallfoss.fcc.gov/oetcf/eas/reports/TestFirmSearch.cfm

- Companies
  - FCC registration through the FCC's COMmission REgistration System (CORES)
  - Assign FCC Registration Number (FRN)
    https://fjallfoss.fcc.gov/coresWeb/publicHome.do
  - This number will be used to uniquely identify you in all transactions with the FCC
  - Assign Grantee code for FCC ID
    https://fjallfoss.fcc.gov/oetcf/eas/forms/GranteeRegistration.cfm
Application Package (2.1033)

- **Form 731**
- **13 Exhibits**
  - Identification label and location information
  - Attestation statements (Optional)
  - External photos
  - Block diagrams (For unlicensed only)
  - Schematics (RF portion)
  - Test report
  - Test setup photos
  - User's manual*
  - Internal photos*
  - Parts list and tune-up information (For licensed only)
  - RF exposure information (For licensed and 15.247, 15.407)
  - Operational description (Including DC voltage & current supplied to RF amplifier & Antenna description)
  - Cover letters (Request description, Registration number, Responsible)

- **Additional information**
  - Request for confidentiality (*-under permit but ask procedure)
  - Authorization letter
  - Letter for FCC’s Drug Compliance Statement
FCC identifier (FCC ID)

- **Grantee Code** - 3 characters alphanumeric string consisting of Arabic numerals, capital letters, or combination thereof representing the grantee/applicant
  - begins with an alphabetic character
  - does not contain the numbers one and/or zero
  - is assigned and displayed to the applicant during grantee registration

- **Equipment Product Code** - up to 14 characters alphanumeric string consisting of a series of Arabic numerals, capital letters or a combination thereof, and may include the dash or hyphen (-)
  - shall be one which has not been previously used in conjunction with the same grantee code and/or denied application

- **Example**: FCC ID XXX123
  - XXX—Grantee Code
  - 123—Equipment Product Code
Equipment classes

- The category or class of equipment assigned to the device submitted for approval for marketing
  - AMP - Amplifier
  - PCB - PCS Licensed Transmitter
  - PCE - PCS Licensed Transmitter held to ear
  - PCF - PCS Licensed Transmitter held to face
  - PCT - PCS Licensed Transmitter worn on body
  - TNB - Licensed Non-Broadcast Station Transmitter
  - TNE - Licensed Non-Broadcast Transmitter Held to Ear
  - TNF - Licensed Non-Broadcast Transmitter Held to Face
  - TNT - Licensed Non-Broadcast Transmitter Worn on Body
  - TBC - Licensed Broadcast Station Transmitter
  - LMS - Location & Monitoring Transmitter
  - Others
Type of emission (emission designator) = XXXXXYYYYYY

First section - The necessary bandwidth is expressed by three numerals and one letter, the letter occupies the position of the decimal point and represents the unit of bandwidth. The first character shall be neither zero nor K, M or G symbol.

Examples:
- 0.1 Hz = H100
- 12.5 kHz = 12K5
- 10 MHz = 10M0
- 5.65 GHz = 5G65

Second section - Is expressed by three characters: letter, numeral and letter:
- first symbol – type of modulation of the main carrier
- second symbol – nature of signal modulating the main carrier
- third symbol – type of information to be transmitted

Third section - Is expressed by two letters
- Fourth symbol – Details of signal(s)
- Fifth symbol – Nature of multiplexing
Emission designator example

Example: 20MOD1DEC

The necessary bandwidth is 20.0 MHz

D – Emission in which the main carrier is amplitude- and angle-modulated either simultaneously or in a pre-established sequence

1 – A single channel containing quantized or digital information without the use of a modulating sub-carrier

D – Data transmission, telemetry, telecommand

Third section- Is expressed by two letters

E – Multi-condition code in which each condition represents a signal element (of one or more bits)

C – Code-division multiplexing
Labeling requirements

- Shall be beared in a conspicuous location on the device
- Shall be of a type size large enough to be legible without the aid of magnification
- If the device is small size (less than a palm) this statement may be included in user manual instead of label
- Shall be permanently affixed to the equipment
- A software defined radio may be equipped with a means such as a user display screen to display the FCC identification
# Labeling guideline

<table>
<thead>
<tr>
<th>Equipment Authorization</th>
<th>FCC Rule Section(s)</th>
<th>Label:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verification and Certification</td>
<td>§15.19(a)(1) Receivers associated with the operation of a licensed radio service</td>
<td>This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.</td>
</tr>
<tr>
<td></td>
<td>§15.19(a)(2) A stand-alone cable input selector switch</td>
<td>This device is verified to comply with Part 15 of the FCC Rules for use with cable television service.</td>
</tr>
<tr>
<td></td>
<td>§15.19(a)(3) All other devices shall bear the following statement :</td>
<td>This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.</td>
</tr>
<tr>
<td>Additional For Verification Only</td>
<td>§2.954 Devices must be labelled with a unique identifier</td>
<td>The identification format shall not be confused with the FCC ID label for certification</td>
</tr>
<tr>
<td>Additional Labelling For Certification Only</td>
<td>§2.925(a) Each equipment shall bear: FCC Identifier as specified in Section 2.926. The FCC Identifier shall be preceded by the term FCC ID in capital letters on a single line</td>
<td>Example: <strong>FCC ID AAAAXXX</strong>  AAA=3 Character Grantee Code  XXX=Unique Equipment Product Code (up to 14 characters)  Shall be of a type size large enough to be legible without the aid of magnification</td>
</tr>
<tr>
<td>Declaration of Conformity</td>
<td>§15.19(b)(1)(i) Products subject to authorization under a Declaration of Conformity shall be labelled as follows:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>§15.19(b)(1)(ii) If a personal computer is authorized based on assembly using separately authorized components:</td>
<td></td>
</tr>
</tbody>
</table>
**Class A:**
- equipment suitable for use in all establishments other than domestic
- equipment not directly connected to a low voltage power supply network which supplies buildings used for domestic purposes
- equipment which satisfies the class A limits but not the class B limits
- usually operating instruction shall contain warning: This is a class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures

**Class B:**
- equipment suitable for use in establishments directly connected to a low voltage lower supply network which supplies buildings used for domestic purposes
- equipment suitable for use in domestic establishments

*The domestic environment is an environment where the use of broadcast radio and television receivers may be expected within a distance of 10 m of the apparatus concerned.*
Class A NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Class B NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
— Reorient or relocate the receiving antenna
— Increase the separation between the equipment and receiver
— Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
— Consult the dealer or an experienced radio/TV technician for help
§ 15.21 Information to user
Changes or modifications not expressly approved by the party responsible for compliance could void the user’s authority to operate the equipment.

§ 15.27 Special accessories
Where special accessories, such as shielded cables and/or special connectors, are required to enable an unintentional or intentional radiator to comply with the emission limits in this part, the equipment must be marketed with, i.e., shipped and sold with, those special accessories.

§ 15.19 Labelling requirements
When the device is so small or for such use that it is not practicable to place the required statement on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed, however, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.
Application Submission

- **FCC submission**
  - The application begins with the form 731, after which attachments are submitted
  - The Web site automatically provides a fee form 159. Fees can be paid on-line via credit card or by mail using a hard copy of the form
  - Reviews take about 1 month

- **TCB submission**
  - The same application package
  - The application supply depends on the specific TCB
  - Reviews take about 2 weeks
FCC Test Procedure

- **Unlicensed Radio Service Equipment - Part 15**
  - ANSI C63.4-2003 or ANSI C63.4-2009: American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

- **Licensed Radio Service Equipment - Parts 22, 24, 27, 90, 101**
  - ANSI/TIA-603-C-2004: Land Mobile FM or PM Communications Equipment Measurement and Performance Standards
For equipment operating in the authorized radio services, measurements are required as specified:

- 2.1046—RF power output
- 2.1047—Modulation characteristics
- 2.1049—Occupied bandwidth
- 2.1051—Spurious emissions at antenna terminals
- 2.1053—Field strength of spurious radiation
- 2.1055—Frequency stability
- 2.1057—Frequency spectrum to be investigated
- 2.1091—RF exposure evaluation: mobile devices
- 2.1093—RF exposure evaluation: portable devices
2.1046—RF power output

- Conducted measurement at antenna terminal
- Transmitter shall be terminated with a load equal to antenna nominal impedance
- May be expressed in terms of EIRP or ERP
- Power spectral density is limited for some applications
- Substitution measurements required for transmitters equipped with integral antenna
- Peak, average or true RMS depends on the specific section rules
- Measurement BW must be wider than EBW

\[
\text{ERP} / \text{EIRP} (W) = \text{RF power (dBm)} + \text{Antenna Gain (dBd / dBi)}
\]
Power and Voltage in decibels

Decibel is a logarithm of ratio and is dimensionless $\text{dB} = 10 \times \log (\text{RATIO})$

Decibel allows to see small and large signals on the same scale - extends dynamic range

**Power:**

$$P(\text{dBm}) = 10 \times \log \left( \frac{P_{\text{measured}}(\text{mW})}{1(\text{mW})} \right)$$

**Voltage:**

$$V(\text{dB}\mu\text{V}) = 20 \times \log \left( \frac{V_{\text{measured}}(\mu\text{V})}{1(\mu\text{V})} \right)$$

**MF Effective Radiated Power:**

$$\text{ERP}(W) = \left(8 \times \mu_0 \times \pi^3\right) \times \left(N \times I(A) \times A(m^2) \times f^2(Hz)\right)^2 \times \frac{3 \times c^3(m/s)}{1}$$
2.1047—Modulation characteristics

- **Emission mask requirements**
  - Reference level (0 dBC) adjustment
    - Unmodulated carrier
    - Total RF power
    - Modulated carrier
  - The same detector as for reference power measurement (0 dBC)
  - Measurements bandwidth

- **Band edge limitation**
  - Radiated or conducted depends on the specific section rules
  - Band/block/channel edges
  - Measurements bandwidth
2.1049—Occupied bandwidth

- **Type of Bandwidth**
  - 99% power bandwidth
  - 26 dBc
  - 20 dBc
  - 6 dBc

- **Reference level (0 dBc) adjustment**
  - Unmodulated carrier
  - Total RF power
  - Modulated carrier

- **Measurements bandwidth about 1% of the EBW**

- **Peak detector**

- **Single sweep or MAX HOLD function depends on the specific section rules**
2.1051—Spurious emissions at antenna terminals

- Transmitter shall be terminated with a load equal to antenna nominal impedance
- Detector function
- Measurement BW
- Sweep time for pulse modulated and/or fast changed signals
- Wide range measurement

**Diagram:**

```
EUT -> Attenuator -> Spectrum Analyzer
```
2.1053—Field strength of spurious radiation

- Transmitter shall be terminated with a load equal to antenna nominal impedance
- Requires substitution measurement of power
- Detector function
- Measurement BW
- Sweep time for pulse modulated and/or fast changed signals
- Wide range measurement
**Power to field strength conversion**

If transmitter output power is $P$ in Watts, the transmitter numeric antenna gain is $G$ in times, transmitter to measuring antenna distance is $d$ in meters:

$$ P_t = \frac{E^2 \times d^2}{30 \times G} $$

$$ E = \frac{\sqrt{30 \times G \times P_t}}{d} $$

After conversion in logarithmic units will obtain:

$$ P_t[dBm] = E[\mu mV/m] + 20 \log d[m] - G[dBi] - 104.77 $$

For $d=3m$ and $G=0$ dBi will get EIRP:

$$ P_t[dBm] = E[\mu mV/m] + 20 \log 3 - 0 - 104.77 = E[\mu mV/m] - 95.23 \text{ dB} $$

For $d=3m$ and $G=0$ dBd (2.12 dBi) will get ERP:

$$ P_t[dBm] = E[\mu mV/m] + 20 \log 3 - 2.12 - 104.77 = E[\mu mV/m] - 97.35 \text{ dB} $$

The following equation shall be used to calculate spurious emission limit expressed as attenuation versus carrier output power:

$$ \text{Spurious limit [dBm]} = P[\text{dBm}] - (43 + 10 \times \log P[W]) = P[\text{dBm}] - \left( 43 + 10 \times \log \left\{ \frac{P[mW]}{1000} \right\} \right) $$

As $10 \log P(mW)=P(\text{dBm})$ and $10 \log 1000=30\text{ dB}$ will obtain:

$$ \text{Spurious limit [dBm]} = P[\text{dBm}] - (43 + P[\text{dBm}] - 10 \times \log 1000) = -13[\text{dBm}] $$
Equivalent Isotropically Radiated Power: 
EIRP = P (dBm) + G (dBi)

- **P** - Tx power at antenna connector
- **G** - Tx antenna gain
- **E** - Field strength
- **CL** - Cable loss
- **AF** - Antenna factor
- **r** - Test distance

**E- field**: 
E (dBµV/m) = \( V_{\text{receiver}} \) (dBµV) + AF (dB/m)

For test distance \( r = 3 \text{m} \):

\[ P_t [\text{dBm}] = E[\text{dB} \mu \text{V/m}] - 95.23 \text{ dB} \]
Substitution power measurements

Measure E-field:
\[ E (\text{dB} \mu \text{V/m}) = V (\text{dB} \mu \text{V}) + AF (\text{dB/m}) \]

Transmitter under test

Substitute transmitter under test by calibrated antenna connected to a signal generator under the same set-up at the receive side

\[ \text{EIRP(dBm)} = \text{Pgen(dBm)} - CL(\text{dB}) + AG(\text{dBi}) \]

Substitution power measurement setup

Adjust signal generator output power to measure the same E-field at the same frequency
1. Set up transmitter under test pointed to the receive antenna
2. Adjust antenna height to the maximum readings
3. Rotate the turn table throughout 360° to find out the maximum readings
4. Fine adjust antenna height to the maximum readings
5. Record the measured field strength
1. Substitute transmitter under test with reference antenna connected to a signal generator
2. Set signal generator to the same frequency
3. Adjust signal generator to measure the same field strength as produced by transmitter under test
4. Adjust antenna height to the maximum readings
5. Fine adjust signal generator to measure the same field strength as produced by transmitter under test
6. Calculate EIRP
2.1055—Frequency stability

- From -30° to +50° centigrade for most of equipment
- Each 10 degrees upon temperature stabilization
- The lower temperature limit, 0° centigrade and +30° centigrade with no primary power applied
- Transmitter may cease to operate at extreme temperatures
- From a cold start to frequency stabilization within the applicable tolerance
- Vary primary supply voltage from 85 to 115 percent of the nominal
- For hand carried, battery powered equipment, reduce primary supply voltage to the specified battery operating end point
- Voltage shall be measured at the input to the cable normally provided with the equipment
- At least frequency determining and stabilizing portions need be tested for large scale transmitters

Diagram:

- Variable power supply
- Voltmeter
- Temperature chamber
- EUT
- Attenuator
- Spectrum Analyzer
2.1057—Frequency spectrum to be investigated

- **From lowest radio frequency signal generated in the equipment, without going below 9 kHz**

- **Up to at least:**
  - For EUT operates below 10 GHz: to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower
  - For EUT operates at or above 10 GHz and below 30 GHz: to the 5th harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower
  - If the equipment operates at or above 30 GHz: to the 5th harmonic of the highest fundamental frequency or to 200 GHz, whichever is lower

- **Measurements above 40 GHz shall be performed using a minimum resolution bandwidth of 1 MHz**

- **The amplitude of spurious emissions which are attenuated more than 20 dB below the limit need not be reported**

- **Particular attention to harmonics, subharmonics and image frequencies**
A mobile device is a transmitter designed to be used in other than fixed locations and the expected separation distance of at least 20 centimeters is normally maintained.

Fixed location means that the device is physically secured at one location and is not able to be easily moved to another.

Transmitting devices that can be easily re-located by consumers are considered to be mobile devices if they meet the 20 centimeter separation requirement.

Licensed services authorized under part 22 subpart H, parts 24, 25, 26, 27, 80, 90 and Unlicensed personal communication devices, millimeter wave devices and NII devices authorized under §§ 15.253, 15.255, and 15.257, and subparts D and E of part 15 of this chapter are subject to RF exposure evaluation prior to equipment authorization or use:

- if operates at 1.5 GHz or below and ERP is 1.5 W
- if operates above 1.5 GHz and ERP is 3 W or more
Portable device is a transmitter to be used so that the radiating structure(s) is/are within 20 centimeters of the body of the user.

Licensed services that authorized under subpart H of part 22 of this chapter, parts 24, 25, 26, 27, 80 and 90, subparts H and I of part 95 and Unlicensed personal communication service, NII devices and millimeter wave devices authorized under subparts D and E, 15.253, 15.255 and 15.257 are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use.

Portable devices must be evaluated using the specific FCC test procedures, and the SAR measurement techniques of OET Bulletin 65 Supplement C 01-01 and IEEE Std 1528-2003.
SAR considerations for portable devices

- **SAR** is a measure of the rate of energy absorption inside tissues.

- When the maximum transmitter and antenna output power are \( \leq \frac{60}{f(\text{GHz})} \) (mW), SAR evaluation is typically not required for FCC or TCB approval.

- Unless excluded by specific FCC test procedures, portable devices with output power > \( \frac{60}{f(\text{GHz})} \) mW shall include SAR data for equipment approval. The FCC Laboratory may be contacted if SAR is expected to be very low, especially for devices below 300 MHz, to determine if SAR evaluation is necessary.

- For multiple transmitters, the effects of overlapping SAR distributions can be minimized if antennas are deployed at least 5 cm apart.
### § 2.106 Table of Frequency Allocations - example

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Frequency Allocations</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>890-942 FIXED</td>
<td>Mobile except aeronautical mobile 5.317A</td>
<td></td>
</tr>
<tr>
<td>902-928 FIXED</td>
<td>Amateur Mobile except aeronautical mobile 5.325A</td>
<td></td>
</tr>
<tr>
<td>928-942 FIXED</td>
<td>Mobile except aeronautical mobile 5.317A</td>
<td></td>
</tr>
<tr>
<td>932-935 FIXED</td>
<td>Mobile except aeronautical mobile 5.325A</td>
<td></td>
</tr>
<tr>
<td>935-940 FIXED</td>
<td>Mobile except aeronautical mobile 5.325A</td>
<td></td>
</tr>
<tr>
<td>940-941 FIXED</td>
<td>Mobile except aeronautical mobile 5.325A</td>
<td></td>
</tr>
<tr>
<td>941-946 AERONAUTICAL MOBILE</td>
<td>Mobile</td>
<td>Public Mobile (22)</td>
</tr>
<tr>
<td>946-951 FIXED</td>
<td>LAND MOBILE</td>
<td>Private Land Mobile (90)</td>
</tr>
<tr>
<td>951-902 FIXED</td>
<td>MOBILE</td>
<td>Personal Communications (24)</td>
</tr>
<tr>
<td>902-915 FIXED</td>
<td>MOBILE</td>
<td>ISM Equipment (18)</td>
</tr>
<tr>
<td>915-928 FIXED</td>
<td>MOBILE</td>
<td>Private Land Mobile (90)</td>
</tr>
<tr>
<td>928-932 FIXED</td>
<td>MOBILE</td>
<td>Amateur (97)</td>
</tr>
<tr>
<td>932-935 FIXED</td>
<td>MOBILE</td>
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<td>Private Land Mobile (90)</td>
</tr>
<tr>
<td>951-902 FIXED</td>
<td>MOBILE</td>
<td>Personal Communications (24)</td>
</tr>
</tbody>
</table>

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<tr>
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<td>Private Land Mobile (90)</td>
</tr>
<tr>
<td>951-902 FIXED</td>
<td>MOBILE</td>
<td>Personal Communications (24)</td>
</tr>
</tbody>
</table>
### Parts 22, 24, 27 most useful frequency bands

#### PART 22—PUBLIC MOBILE SERVICES

<table>
<thead>
<tr>
<th>Mobile operation</th>
<th>454.025-459.65MHz, 152.03-158.07MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellular Radiotelephone Service:</td>
<td>824-849MHz, 869-894MHz</td>
</tr>
</tbody>
</table>

#### PART 24 - Personal communications service

<table>
<thead>
<tr>
<th>Narrowband PCS</th>
<th>901-902, 930-931, 940-941</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadband PCS</td>
<td>1850-1890, 1930-1970, 2130-2150, 2180-2200</td>
</tr>
<tr>
<td>UTAM Unlicensed PCS</td>
<td>1910-1930</td>
</tr>
</tbody>
</table>

#### PART 27 – Miscellaneous wireless communication services

<table>
<thead>
<tr>
<th>Miscellaneous</th>
<th>2305-2320, 2345-2360</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miscellaneous</td>
<td>746-764, 776-794</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>698-746</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1390-1392</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1392-1395</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1432-1435</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1670-1675</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1710-1755, 2110-2155, 2160-2180</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>2495-2690</td>
</tr>
</tbody>
</table>
## PART 90 –PRIVATE LAND MOBILE RADIO SERVICES

<table>
<thead>
<tr>
<th>Service Type</th>
<th>Frequency Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control stations (UHF-TV sharing)</td>
<td>470-512</td>
</tr>
<tr>
<td>Mobile and portable transmitters</td>
<td>150-170</td>
</tr>
<tr>
<td>Location and Monitoring Service (LMS)</td>
<td>150-170, 902-928</td>
</tr>
<tr>
<td>Dedicated Short-Range Communications Services</td>
<td>5850-5925</td>
</tr>
<tr>
<td>Cellular systems &amp; paging</td>
<td>806-824, 851-869, 896-901, 935-940, 929-930</td>
</tr>
<tr>
<td>One way paging</td>
<td>929-930</td>
</tr>
<tr>
<td>Base, mobile or fixed (repeater) transmissions</td>
<td>764-776</td>
</tr>
<tr>
<td>Mobile or fixed (control) transmissions</td>
<td>794-806</td>
</tr>
<tr>
<td>Point to point links</td>
<td>4940-4990</td>
</tr>
<tr>
<td>Wireless Broadband</td>
<td>3650-3700</td>
</tr>
</tbody>
</table>
General requirements under Part 15 subpart C

- **15.203 Antenna requirements** – the use of a standard antenna connector is not allowed except for professionally installed transmitters
  - integral antenna
  - unique coupling
  - professional installation

- **15.204 External radio frequency power amplifiers and antenna modifications** - External amplifiers are not permitted for part 15 transmitters unless it is authorized and marketed as a part of a system

- **15.205 Restricted bands of operation** - restricted band for fundamental emission and exempt devices

- **15.207 Conducted limits** – conducted emission limits for intentional radiators powered from A.C mains - class A and B, applicable always at the mains power connection

- **15.209 Radiated emission limits; general requirements** - RE limits for unwanted emissions from a intentional radiators, class B limits only

- **15.215 Bandwidth; general requirements** - The 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated
<table>
<thead>
<tr>
<th><strong>Part 15 sections</strong></th>
<th><strong>Typical applications</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>15.209 Radiated emission limits; general requirements</td>
<td>Any complying with limits 15.209 at carrier outside restricted bands of 15.205</td>
</tr>
<tr>
<td>15.225 Operation within the band 13.110–14.010 MHz</td>
<td>Any, RF ID, Acess control</td>
</tr>
<tr>
<td>15.227 Operation within the band 26.96–27.28 MHz</td>
<td>Any, RF ID, Acess control</td>
</tr>
<tr>
<td>15.231 Periodic operation in the band 40.66–40.70 MHz and above 70 MHz</td>
<td>Periodic Transmissions, Alarm system, RCs</td>
</tr>
<tr>
<td>15.240 Operation in the band 433.5–434.5 MHz</td>
<td>RF ID of commercial shipping containers</td>
</tr>
<tr>
<td>15.245 Operation within the bands 902–928 MHz, 2435–2465 MHz, 5785–5815 MHz, 10500–10550 MHz, and 24075–24175 MHz</td>
<td>Field disturbance sensors, excluding perimeter protection systems</td>
</tr>
<tr>
<td>15.247 Operation within the bands 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz</td>
<td>Spread spectrum intentional radiators FHSS, DTS</td>
</tr>
<tr>
<td>15.249 Operation within the bands 902–928 MHz, 2400–2483.5 MHz, 5725–5875 MHz, and 24.0–24.25GHz</td>
<td>Any</td>
</tr>
<tr>
<td>15.253 Operation within the bands 46.7–46.9 GHz and 76.0–77.0 GHz</td>
<td>Vehicle-mounted field disturbance sensors used as vehicle radar</td>
</tr>
<tr>
<td>15.401 U-NII devices that operate at 5.15–5.35 GHz, 5.47–5.725 GHz and 5.725–5.825 GHz bands.</td>
<td>Access point’s for 802.11a</td>
</tr>
</tbody>
</table>
Some bands, fully or partially, may appear multiple times under different sections depending on the specific application

<table>
<thead>
<tr>
<th>Section</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.231</td>
<td>Periodic Transmissions, Intermittent Control Signals</td>
</tr>
<tr>
<td>15.243</td>
<td>Measurements of Characteristics of a Material</td>
</tr>
<tr>
<td>15.245</td>
<td>Field Disturbance Sensors</td>
</tr>
<tr>
<td>15.247</td>
<td>Spread Spectrum Transmitters</td>
</tr>
<tr>
<td>15.249</td>
<td>Any</td>
</tr>
</tbody>
</table>
### Technical requirements under Part 15.209

<table>
<thead>
<tr>
<th>Frequency, MHz</th>
<th>Radiated emission limit, dB($\mu$V/m)</th>
<th>Antenna type</th>
<th>Detector type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3 m</td>
<td>RBW</td>
<td></td>
</tr>
<tr>
<td>0.009 – 0.090</td>
<td>128.5 - 108.5**</td>
<td>200Hz</td>
<td>Loop</td>
</tr>
<tr>
<td>0.090 – 0.110</td>
<td>108.5 - 106.8**</td>
<td>200Hz</td>
<td>Loop</td>
</tr>
<tr>
<td>0.110 – 0.490</td>
<td>106.8 - 93.8**</td>
<td>9kHz</td>
<td>Loop</td>
</tr>
<tr>
<td>0.490 – 1.705</td>
<td>73.8 - 63.0**</td>
<td>9kHz</td>
<td>Loop</td>
</tr>
<tr>
<td>1.705 – 30.0</td>
<td>69.5</td>
<td>9kHz</td>
<td>Loop</td>
</tr>
<tr>
<td>30 - 88</td>
<td>40.0</td>
<td>120kHz</td>
<td>Biconilog</td>
</tr>
<tr>
<td>88 - 216</td>
<td>43.5</td>
<td>120kHz</td>
<td>Biconilog</td>
</tr>
<tr>
<td>216 - 960</td>
<td>46.0</td>
<td>120kHz</td>
<td>Biconilog</td>
</tr>
<tr>
<td>960 - 1000</td>
<td>54.0</td>
<td>120kHz</td>
<td>Biconilog</td>
</tr>
<tr>
<td>Above 1000</td>
<td>54.0</td>
<td>1MHz</td>
<td>Horn</td>
</tr>
</tbody>
</table>

**FCC requires measurement up to the 10th harmonic**

**Inverse linear extrapolation factor:**
\[
\text{Lim}_{\text{new}} = \text{Lim} + 20 \log(D/D_{\text{new}})
\]

**Square Inverse linear extrapolation factor:**
\[
\text{Lim}_{\text{new}} = \text{Lim} + 40 \log(D/D_{\text{new}})
\]
### Technical requirements sections 15.225 & 15.227

<table>
<thead>
<tr>
<th>Tests</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transmitter parameters section 225 (13.110–14.010 MHz)</strong></td>
<td></td>
</tr>
<tr>
<td>In band radiated emissions (spectrum mask)</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Out of band radiated emissions</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Frequency tolerance</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Band edges</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Conducted emissions</td>
<td>All transmitters</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tests</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transmitter parameters section 227 (26.96-27.28MHz)</strong></td>
<td></td>
</tr>
<tr>
<td>In band radiated emissions</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Out of band radiated emissions</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Band edges</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Conducted emissions</td>
<td>All transmitters</td>
</tr>
</tbody>
</table>
## Technical requirements section 15.231

<table>
<thead>
<tr>
<th>Tests</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter parameters (40.66–40.70 MHz and above 70 MHz)</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Periodic operation requirements</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Field strength of emissions</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Occupied bandwidth</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Antenna requirements</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Conducted emissions</td>
<td>All transmitters</td>
</tr>
</tbody>
</table>
## Technical requirements sections 15.245 & 15.249

<table>
<thead>
<tr>
<th>Tests</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>(902–928MHz, 2435–2465MHz, 5785–5815MHz, 10500–10550MHz and 24075–24175MHz)</em></td>
<td>All transmitters</td>
</tr>
<tr>
<td>Field strength of emissions</td>
<td></td>
</tr>
<tr>
<td>Band edge emissions</td>
<td></td>
</tr>
<tr>
<td>Antenna requirements</td>
<td></td>
</tr>
<tr>
<td>Conducted emissions</td>
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<table>
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<tr>
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<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>(902–928MHz, 2400–2483.5MHz, 5725–5875MHz and 24.0–24.25GHz)</em></td>
<td>All transmitters</td>
</tr>
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<td></td>
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<tr>
<td>Band edge emissions</td>
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</tr>
<tr>
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<tr>
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</tbody>
</table>
## Technical requirements section 15.247

<table>
<thead>
<tr>
<th>Tests</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>(902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz)</td>
<td></td>
</tr>
<tr>
<td>6dB bandwidth</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Peak output power</td>
<td>All transmitters</td>
</tr>
<tr>
<td>RF exposure</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Conducted spurious emissions</td>
<td>Transmitters with RF connector</td>
</tr>
<tr>
<td>Radiated spurious emissions</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Peak spectral power density</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Antenna requirements</td>
<td>All transmitters</td>
</tr>
<tr>
<td>Conducted emissions</td>
<td>All transmitters</td>
</tr>
</tbody>
</table>
Field strength limits according to FCC

The out of band emissions shall be attenuated at least 20 dBc as measured in any 100 kHz BW. For average power measurements the minimum required attenuation is 30 dBc.

Emissions that fall into restricted bands per FCC 15.205 must comply with 15.209 limits.

<table>
<thead>
<tr>
<th>Frequency, MHz</th>
<th>Limit 15.247</th>
<th>20dBc</th>
<th>Limit 15.209</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVG</td>
<td>2.31-2.39 GHz</td>
<td></td>
<td>2.4-2.4835 GHz</td>
</tr>
<tr>
<td>Restricted band</td>
<td>2.4-2.4835 GHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted band</td>
<td>2.4835-2.5 GHz</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The out of band emissions shall be attenuated at least 20 dBc as measured in any 100 kHz BW. For average power measurements the minimum required attenuation is 30 dBc.
Field strength limits according to FCC

The out of band emissions shall not exceed -27 dBm/MHz EIRP as measured in any 1 MHz BW under the same measurements settings used to measure the Tx power of fundamental

Emissions that fall into restricted bands per FCC 15.205 must comply with 15.209 limits.

<table>
<thead>
<tr>
<th>Frequency, MHz</th>
<th>Limit, dB(µV/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AVG</td>
</tr>
<tr>
<td></td>
<td>Peak</td>
</tr>
<tr>
<td></td>
<td>Quasi-Peak</td>
</tr>
</tbody>
</table>

Restricted bands
- 4.5-5.15 GHz
- 5.15-5.35 GHz
- 5.35-5.46 GHz

Limit 15.407
Limit 15.209
Averaging types for Part 15 measurements

- **Power average (True RMS detector)**
- **EMC average detector**

- **Averaging of pulse modulated signals within time window (100 ms per FCC 15.35)** - Measured with peak detector + average factor:
  
  \[
  \text{Average factor} = 20 \times \log\left(\frac{\text{Tx ON}}{\text{Tx period}}\right) \text{ or } \\
  \text{Average factor} = 20 \times \log\left(\frac{\text{Tx ON}}{100 \text{ ms}}\right)
  \]

- **Averaging signals other than pulse modulated within time window (100 ms per FCC 15.35)** - Measured with peak detector and VBW = 10 Hz

- **Averaging of wideband (noise-like) modulated signals according to FCC 15.247 within time window (100 ms per FCC 15.35)** - Measured with peak detector and VBW = 10 Hz at modified for continuous transmission sample + average factor due to the actual duty cycle under the maximum payload:
  
  \[
  \text{Average factor} = 20 \times \log\left(\frac{\text{Tx ON}}{100 \text{ ms}}\right)
  \]
Averaging according to FCC 15.35 and other sections

Frequency modulation

![Graph of frequency modulation with averaging window 100 ms and charge-discharge characteristic of VBW=10 Hz]

P_{AVR} = P_{AVR \text{ measured}}

Charge-discharge characteristic of VBW=10 Hz

Digital modulation with duty cycle

P_{AVR} = P_{PEAK} + 20 \log \left( \sum \text{Tx ON within 100ms window} / 100 \text{ ms} \right)

P_{AVR} = P_{AVR \text{ measured}} + 20 \log \left( \sum \text{Tx ON within 100ms window} / 100 \text{ ms} \right)

Averaging with VBW=10 Hz

Averaging with VBW=10 Hz (Peaks)

Averaging with VBW=1/\text{Tx ON}

Averaging with VBW=10 Hz (Averaging window 100 ms)
Average measurements according to FCC 15.247

Averaging with VBW=10 Hz

Averaging with VBW=1/Tx ON
Averaging with VBW=10 Hz

Averaging with VBW=1/Tx ON
Averaging with VBW=10 Hz

Averaging window 100 ms

\[ P_{AVR} = P_{AVR \, measured} + 20 \log \left( \frac{\Sigma \text{Tx ON} \, within \, 100ms \, window}{100 \, ms} \right) \]
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An intentional radiator may be operated only with the antenna with which it is authorized

- If an antenna is marketed with the intentional radiator, it shall be of a type which is authorized with the intentional radiator

An intentional radiator may be authorized with multiple antenna types

- The antenna type, as used in this paragraph, refers to antennas that have similar in-band and out-of-band radiation patterns
- Compliance testing shall be performed using the highest gain antenna for each type of antenna to be certified with the intentional radiator. During this testing, the intentional radiator shall be operated at its maximum available output power level
- Manufacturers shall supply a list of acceptable antenna types with the application for equipment authorization of the intentional radiator
- Any antenna that is of the same type and of equal or less directional gain as an antenna that is authorized with the intentional radiator may be marketed with, and used with, that intentional radiator. No retesting of this system configuration is required. The marketing or use of a system configuration that employs an antenna of a different type, or that operates at a higher gain, than the antenna authorized with the intentional radiator is not permitted unless the procedures specified in § 2.1043 of this chapter are followed
No person shall sell, import, ship or lease (including advertising for sale) of any external radio frequency power amplifier or amplifier kit intended for use with a part 15 intentional radiator unless

- A transmission system consisting of an intentional radiator, an external radio frequency power amplifier, and an antenna is authorized as a system, it must always be marketed as a complete system and must always be used in the configuration in which it was authorized.
- An external radio frequency power amplifier or amplifier kit shall be marketed only with the system configuration with which it was approved and not as a separate product.
- An external radio frequency power amplifier may be marketed for individual sale provided it is intended for use in conjunction with a transmitter that operates in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands pursuant to § 15.247 of this part or a transmitter that operates in the 5.725–5.825 GHz band pursuant to § 15.407 of this part. The amplifier must be of a design such that it can only be connected as part of a system in which it has been previously authorized. The output power of such an amplifier must not exceed the maximum permitted output power of its associated transmitter.
- The outside packaging and user manual for external radio frequency power amplifiers must include notification that the amplifier can be used only in a system which it has obtained authorization identified by FCC Identifier.
Modular approval overview

- **Module-like transmitter device:**
  - Peripheral to a host and typically plugged into an externally accessible standard bus on the host
  - Modular approval is not required but can be used

- **Single modular transmitter (modular approval, MA) device:**
  - Completely self-contained transmitter device typically incorporated into another product, host, or device
  - Per 15.101(b) the *receiver portion* of a transmitter module requires either Verification or no equipment authorization (unless a scanning receiver)

- **Non-modular-approval device:**
  - Stand-alone finished-product complete transmitter
  - Consult FCC in case module approval is requested

- **Multi-transmitter product:**
  - May have mix of modular-approval and non-modular-approval component devices, or only all of one or the other
  - Associated equipment – marketed or operated with other FCC IDs
Modular transmitters (15.212)

- Modular approval allows to build new devices with same transmitter in multiple hosts without the need for re-Certification of the transmitter
  - Part 15 Unlicensed Transmitter Modules (Small Entity Compliance Guide) (DA 08-314):

- Modular approval must be requested
  - Provide a cover letter requesting modular approval and addressing in detail compliance with the modular requirements
  - Mark Form-731 with appropriate modular approval type

- Limited single or split module requirements are described in 15.212(b)
- A single or split module approval meets all the requirements without limits
- A limited single or limited split modular transmitter may be granted if it does not meet single or split modular requirements listed in 15.212(a) and if compliance can be demonstrated under the operating conditions in which the transmitter will be used (e.g. grant conditions are needed for compliance)
Modular approval requirements

- Completely self-contained RF transmitter
- RF portion shall be shielded
- Buffered modulation/data inputs
- Integral power supply regulation
- The antenna must either be permanently attached or employ a “unique” antenna coupler, professional installation provision is not applicable to modules
- Must be tested in a stand-alone configuration (must not be inside another device)
- AC or DC power lines and data input/output lines must not contain ferrites, unless they will be marketed with the module
- The length of these lines shall be the length typical of actual use or, if that length is unknown, at least 10 cm
- Any accessories connected for testing shall be unmodified and commercially available
- Permanently affixed label or electronic display of FCC ID
- RF exposure requirements
For RF exposure compliance considerations, a portable modular transmitter is considered limited (single or split) if compliance must be demonstrated in a specific host such as for SAR

- Mobile and fixed modular approval devices are not considered limited, unless limited to a specific host or particular product configurations

For a Part 15 limited single or split module, the manufacturer must state how control of the end product into which the module will be installed will be maintained such that full compliance of the end product is always assured
Licensed Modular Transmitters

- Licensed modules are not subject to 15.212 rules, however applications for licensed modules are permitted:
  - The grantee is required to provide to other parties (OEM) and end users, clear documented instructions including all the conditions for installing and using the module. These instructions are required in the exhibit attachments for certification approval.
  - The applicant can use the guidelines for unlicensed modules for good engineering practice, except that split modular approvals or limited split modular approvals are not permitted for licensed modular devices.
  - The licensed module must have a FCC ID label on the module itself. The FCC ID label must be visible, a second label must be placed on the outside of the device that contains the following text: Contains FCC ID: bzzzzzzz.
  - The Grantee is responsible for compliance.
  - Licensed modular grant requirements: The maximum antenna gain to ensure compliance with rules, such as EMC (e.g. EIRP, PPSD limits) or RF exposure requirements, shall be listed on the grant.
Limited Licensed Modular Transmitters

- For a licensed limited single module, the manufacturer must state how control of the end product into which the module will be installed will be maintained such that full compliance of the end product is always assured.

- A license modular approval is designated as “limited” when compliance is demonstrated in a particular product configuration. For example, it may be installed in a specific host for demonstrating compliance for EMC, SAR or HAC requirements.

- A single licensed modular approval is one that is not limited (similar to unlicensed modular approvals).

- Mark Form-731 with appropriate modular approval type.
Permissive Change Policies

- Describes the modifications that may be made to an RF device without new authorization
  - Antenna changes
  - PCB and Hardware changes
  - Enclosure changes
  - Software changes
  - Miscellaneous changes
- Define the three different types of permissive changes
- Identify when a permissive change (PC) filing is required
- New FCC ID and a new equipment authorization application to the FCC required for the following changes (2.1043(a)):
  - Frequency multiplication stages
  - Basic modulator circuit
  - Maximum power or field strength ratings
  - Basic frequency determining and stabilizing circuitry (including clock and data rates)
Permissive changes classes

- Class I permissive change includes those modifications which do not degrade the characteristics reported.
- Class II permissive change includes those modifications which degrade the performance characteristics as reported however still meet the minimum requirements of the applicable rules.
- Class III permissive change includes modifications to the software of a software defined radio transmitter that change the frequency range, modulation type or maximum output power (either radiated or conducted) outside the parameters previously approved, or that change the circumstances under which the transmitter operates in accordance with FCC rules.

Class I and Class II permissive changes may only be made by the holder of the grant of certification.
Class I and II permissive changes

- **Class I permissive change** includes those modifications which do not degrade the characteristics reported
  - No filing with the Commission is required for a Class I permissive change

- **Class II permissive change** includes those modifications which degrade the performance characteristics as reported however still meet the minimum requirements of the applicable rules
  - When a Class II permissive change is made by the grantee, the grantee shall supply the Commission with complete information and the results of tests of the characteristics affected
  - The modified equipment shall not be marketed under the existing grant of certification prior to acknowledgement by FCC
Class III permissive change includes software defined radio (SDR)

- The grantee shall supply FCC with a description of the changes and test results showing that the equipment complies with the applicable rules with the new software loaded, including compliance with the applicable RF exposure requirements.
- The modified software shall not be loaded into the equipment, and the equipment shall not be marketed with the modified software under the existing grant, prior to acknowledgement by FCC.
- Class III changes are permitted only for equipment in which no Class II changes have been made.

**NOTE TO PARAGRAPH (b)(3):** Any software change that degrades spurious and out-of-band emissions would be considered a change in frequency or modulation and would require a Class III permissive change or new equipment authorization application.
Antenna changes for unlicensed services

- **Equivalent-type Part 15 antennas**
  - Additional equivalent antennas allowed without new authorization
    - Exception: UNII devices with DFS - a PC is required for lower antenna gain than previously approved for DFS
    - Exception: Portable devices - SAR levels should be evaluated for PC, either Class I or Class II must be filed
  - Additional equivalent antennas must be of the same type (e.g. yagi, dish, etc.) and must be of equal or less gain
  - Must have similar in band and out of band characteristics

- **New-type Part 15 antennas**
  - New antenna type, or higher gain, requires a Class II PC unless doesn’t contradict 2.1043(a) requirements for maximum power
  - A unique connector or professional installation required (15.203)
Antenna changes for licensed services

- Antenna replacement for licensed service transmitters
  - May be changed without an authorization request if
    - RF exposure comply with the original grant conditions
    - Maximum ERP/EIRP comply with the original grant conditions
  - Otherwise, an equipment authorization application is required
  - An integral antenna requirement (e.g. GMRS, FRS transmitters, etc.) means that the antenna is not user replaceable, or is not removable- antenna changes require retest and application submission
PCB and HW changes that require a new FCC ID

- Changes described in Section 2.1043(a) that result in a non-electrically equivalent device
- Different internal active hardware components (e.g. amplifiers and crystals) that result in different radio parameters (e.g. output power, frequency)
- Adding or subtracting an on-board amplifier component
- Depopulated versions of a transmitter require authorization under separate FCC IDs for each version
- Minor circuitry for non-transmitter portions (such as receiver or peripheral circuits) can be depopulated, and may be approved under one FCC ID
PCB and HW permissive changes

- **Part substitution - electrically identical parts may be substituted**
  - PC of Class I or Class II required

- **Transmitter chip replacements are considered a Class II permissive change under the following conditions:**
  - The new chip is pin for pin compatible
  - The new chip has the same function as the old chip, from an external perspective - internal frequencies may differ
  - No change in radio parameters has occurred
  - The same conditions apply when a small area (approximately the same as the chip) of the PCB is replaced with an equivalent chip
Enclosure changes

- For non-modular approved devices, only minor changes to an enclosure are allowed with a permissive change.
- If the basic functionality and intended usage are not the same, a new FCC ID is required.
  - For example, approval of a desktop and tower computer under the same FCC ID, or a laptop and desktop under the same FCC ID, is not permissible.
Software only changes

- Additional frequencies may be added
  - Additional frequencies are allowed with a Class II PC if
    - No hardware changes have been made
    - There is no increase in output power on new frequencies
    - The Equipment Class remains the same
    - RF exposure changes must be addressed
    - Only the Original Equipment Manufacturer may implement the new frequencies
    - There are no other changes that require new FCC ID
  - End user software implementation for new frequencies is not allowed unless the device was approved as a software-defined radio (Class III PC)

- Additional data rates (both higher and lower rates) under existing modulations that are consistent with a Form 731 line item/emission designator, may be either a Class I or Class II PC, depending on emissions

- A Class II permissive change is required if degradation occurs; otherwise a Class I PC is acceptable
Miscellaneous changes

- A new FCC ID required for the following changes
  - A non-modular to modular approval change
  - A change from a full modular approval to a Limited Modular Approval (LMA)
  - A change from a software defined radio (SDR) to a non-SDR or vice versa
  - Equipment Class changes, except for SDR devices
  - Modulation function disabled by parts removing

- Changes in antenna, and/or key radiating or metallic structures for portable devices require SAR evaluation
  - Class I or Class II permissive change is required
Transmitters operation supplied for tests

- **Conditions**
  - Transmitter supplied for the tests shall be a representative type of a production version

- **Output power**
  - Transmitter shall deliver maximum achievable output power
  - The power measured during the tests is declared as a maximum allowable power in FCC Grant
  - Transmitter adjusted to produce the nominal output power plus tolerance following tuning procedure shall be provided for tests
  - Transmitter sample, which yields maximum output power within batch, shall be provided for testing if output power is fixed

- **Operating frequency**
  - Lowest, highest and middle band frequency

- **Modulating (baseband) signal**
  - Transmitter shall be able to produce each type of modulation it supports
  - Unmodulated carrier is useful for frequency tolerance tests

- **Data rate**
  - Minimum and Maximum

- **Duty cycle**
  - Maximum available under normal conditions
  - Continuous transmission (100% DC) of modulated carrier
  - Transmitters operated intermittent shall be modified to provide repetitive transmission, preferably at least 20 Hz repetition rate
Market Surveillance

- The market surveillance program complements equipment authorization process
  - Complaints about non-compliant equipment from the public
  - Referrals from Enforcement Bureau
  - Random samples of a group of equipment to determine compliance for select product areas

- Audit and compliance evaluation of TCB issued grants
  - Post grant verification program
  - Sample tests increased from 2% to 5% of the total number of grants issued in 2009
Thank you, for your attention!

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