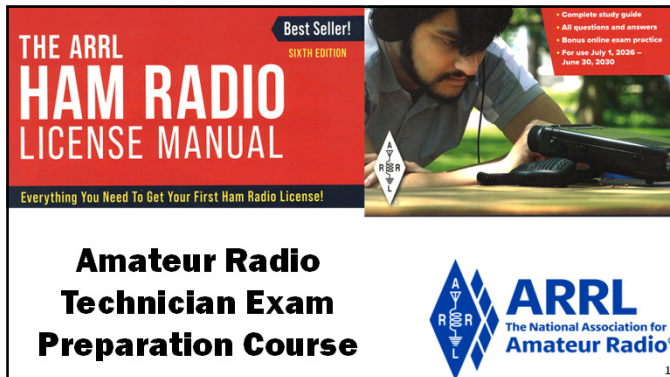




THE ARRL HAM RADIO LICENSE MANUAL
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Everything You Need To Get Your First Ham Radio License!

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Amateur Radio Technician Exam Preparation Course

ARRL
The National Association for Amateur Radio

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Amateur Radio Technician Exam Prep Course

Module 8
Operating Regulations

- 8.1 Control Operators
- 8.2 Identification
- 8.3 Interference
- 8.4 Third-party Communications
- 8.5 Remote and Automatic Operation
- 8.6 Prohibited Transmissions

2



Control Operators

- The **control operator** is a licensed operator who is responsible for making sure all FCC rules are followed
- The **control point** is wherever the control operator operates the transmitter
- The **station licensee** is responsible for designating the control operator
- All transmissions must be made under the supervision of a control operator
- The control point can be remotely located and connected by phone lines, the internet or a radio link

3



Privileges and Guest Operating

- A control operator may operate the station in any way permitted by the privileges of their license class
 - Regardless of the station owner's privileges
- You may allow another amateur to use your station (**guest operator**)
 - The guest may operate under your privileges as long as you're present
 - If you walk away, the guest may operate only under his/her privileges (if unlicensed, they have no privileges)
 - If you're the guest, and have a higher license class than the station owner, you may operate under your privileges
- Both the guest operator and station owner are responsible for proper operation of the station
- The control operator is responsible for the station's transmissions
- The station owner is responsible for limiting access to the station only to responsible licensees who will follow the FCC rules

4



Identification

- Your **call sign** is your identity on the air
- Identification rules apply at all times
- Unidentified transmissions (that is, no call sign) are not allowed
 - Exception ... controlling a model craft
- To make a short transmission to test an antenna or make adjustments to your radio, just state/send your call sign
 - Don't key the microphone and listen for the repeater's signal (**kerchunking**)
- Give your call sign at least once every **10 minutes** during a contact and when the communication is finished
- If you are using phone, you are required to **identify in English**, even if communicating in another language
 - FCC recommends the use of phonetics when you identify by voice
 - You may give call sign by CW when communicating by voice

5



Tactical Calls

- Tactical call signs** (or tactical IDs) help identify where a station is and what it is doing
- Can be used at any time, but are usually used in emergency and public service operation
- Allow consistent identification that streamlines communication based on function
- Regular identification rules apply ... give your FCC-assigned call sign **every 10 minutes** and at the end of the communication
- When a new operator takes over a tactical station, he/she gives their FCC-assigned call sign along with the tactical call

6

Self-Assigned Indicators

- When operating away from your home station, add information to your call sign so other stations are aware of your location
- FCC Part 97.119(c) says ...
 - One or more indicators may be included with the call sign. Each indicator must be separated from the call sign by the slant mark (/) or by any suitable word that denotes the slant mark. If an indicator is self-assigned, it must be included before, after, or both before and after, the call sign.
 - For example, on phone, KL7CC could identify as W3/KL7CC or KL7CC/W3, using "stroke," "slash" or "portable" between the indicator and the call sign.
 - Indicator may not conflict with some other indicator specified in the FCC rules, such as /KT, /AG and /AE (upgraded license class)
 - Indicator may not conflict with a prefix assigned to some other country



7

7

Test Transmissions

- Identification rules apply to on-the-air test transmissions
 - Call sign must be given once every 10 minutes and at the end of transmissions
- Keep test transmissions brief to ...
 - Avoid causing interference
 - Keep from occupying an otherwise useful frequency
- Usual method of identifying during a test transmission ...
 - Voice: Say *KØILP testing*
 - CW / Morse Code: Send *KØILP VVV*



8

8

PRACTICE QUESTIONS



9

9

When may an amateur station transmit without a control operator?

- When using automatic control, such as in the case of a repeater
- When the station licensee is away and another licensed amateur is using the station
- When the transmitting station is an auxiliary station
- Never



T1E01 D 97.7(a) 8-1

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10

Who must designate the station control operator?

- The station licensee
- The FCC
- The frequency coordinator
- Any licensed operator



T1E03 A 97.103(b) 8-1

11

11

What determines the transmitting frequency privileges of an amateur station?

- The frequency authorized by the frequency coordinator
- The frequencies printed on the license grant
- The highest class of operator license held by anyone on the premises
- The class of operator license held by the control operator



T1E04 D 97.103(b) 8-2

12

12

What is an amateur station's control point?

- The location of the station's transmitting antenna
- The location of the station's transmitting apparatus
- The location at which the control operator function is performed
- The mailing address of the station licensee

T1E05 C 97.3(a)(14) 8-1

13

13

When, other than during an emergency, may a Technician class licensee be the control operator of a station operating in an Amateur Extra Class band segment?

- At no time
- When designated as the control operator by an Amateur Extra Class licensee
- As part of a multi-operator contest team
- When using a club station whose trustee holds an Amateur Extra Class license

T1E06 A 97.103(b) 8-2

14

14

When the control operator is not the station licensee, who is responsible for the proper operation of the station?

- All licensed amateurs who are present at the operation
- Only the station licensee
- Only the control operator
- The control operator and the station licensee

T1E07 D 97.103(a) 8-2

15

15

What is a control operator as defined in Part 97?

- The person speaking or otherwise communicating messages over an amateur station
- The person who is the licensee of an amateur station
- An amateur operator identified in the FCC database as responsible for transmissions and FCC rules compliance at a station license location
- An amateur operator designated by the licensee of a station to be responsible for transmissions and FCC rules compliance at that station

T1E11 D 97.103(a) 8-2

16

16

What do the FCC rules state regarding the use of a phonetic alphabet for station identification in the Amateur Radio Service?

- It is required when transmitting emergency messages
- It is encouraged when using phone emissions
- It is required when in contact with foreign stations
- All these choices are correct

T1A03 B 97.119(b)(2) 8-3

17

17

When may an amateur station transmit without identifying on the air?

- When the transmissions are of a brief nature to make station adjustments
- When the transmissions are unmodulated
- When the transmitted power level is below 0.1 watt
- When transmitting signals to control model craft

T1D11 D 97.119(a) 8-3

18

18

When are you required to transmit your assigned call sign?

- At the beginning of each contact, and every 10 minutes thereafter
- At least once during each transmission
- At least every 15 minutes during and at the end of a communication
- At least every 10 minutes during and at the end of a communication

T1F03 D 97.119(a) 8-3

19

19

What language must you use for identification when using a phone emission?

- Any language recognized by the United Nations
- Any language recognized by the ITU
- English
- English, French, or Spanish

T1F04 C 97.119(b)(2) 8-3

20

20

What method of call sign identification is required for a station transmitting phone signals?

- Send the call sign followed by the indicator RPT
- Send the call sign using a CW or phone emission
- Send the call sign followed by the indicator R
- Send the call sign using only a phone emission

T1F05 B 97.119(b)(2) 8-3

21

21

How often must you identify with your FCC-assigned call sign when using tactical call signs such as "Race Headquarters"?

- Never, the tactical call is sufficient
- Once every hour
- At least every 10 minutes during and at the end of a communication
- At the end of every transmission

T1F02 C 97.119 (a) 8-4

22

22

Which of the following self-assigned indicators are acceptable when using a phone transmission?

- KL7CC stroke W3
- KL7CC slant W3
- KL7CC slash W3
- All these choices are correct

T1F06 D 97.119(c) 8-4

23

23

What is an effective way to seek a call from any phone station when not using a repeater?

- Sign your call sign once, followed by the words "listening for a call;" if there is no answer, change the frequency and repeat
- Say "QTC," followed by "this is" and your call sign; if there is no answer, change the frequency and repeat
- Transmit an unmodulated carrier for approximately 10 seconds, followed by "this is" and your call sign, and pause to listen; repeat as necessary
- Repeat "CQ" a few times, followed by "this is," and your call sign, then pause to listen; repeat as necessary

T2A06 D 8-5

24

24

Interference

- Interference is caused by *noise* and by *signals*
- Interference from natural sources or unintentionally radiated signals from appliances, industrial equipment, and computing equipment is called *QRN*
- Interference from nearby signals is called *QRM*
- *Harmful interference* is a transmission signal that seriously degrades, obstructs, or interrupts communications of a regulated service
 - No one has an absolute right to any frequency
- *Willful interference* is intentionally creating harmful interference, and is never allowed

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25

Third-Party Communications

- Ham radio is frequently used to send messages on behalf of unlicensed persons or organizations
- Third-Party Communications definition: A message from an amateur station control operator to another amateur station control operator on behalf of another person ... the *other person* is the third party
- Rules change when signals cross international borders ... only certain countries allow third-party communications with US hams ... called *third-party agreements*
- List of countries with third-party agreements with the US is in Table 8.1 in your text

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26

Remote and Automatic Operation

- Stations such as repeaters and beacons operate without a human control operator present
 - Must be operated in compliance with FCC rules, no matter where the control point is located
- Local control — a control operator is physically present at the transmitter
- Remote operation — the control point is located away from the transmitter
 - Control operator operates the transmitter indirectly via some kind of *control link*
 - Control operator must be present at the control point during all transmission
- Automatic operation — the station operates under the control of devices and procedures that ensure compliance with FCC rules
 - Control operator is required, but need not be at the control point when the station is transmitting
 - Repeaters, beacons, space stations, and digipeaters (that relay messages) are allowed to be automatically controlled

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Responsibilities

- No matter what type of control is asserted, the station must operate in compliance with FCC rules at all times
- Repeater owners must install the necessary equipment and procedures for automatic control that ensures the repeater operates in compliance with FCC rules
- Even if a repeater is on remote control, repeater users are still responsible for proper operation via the repeater

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Prohibited Transmissions

- Four types of prohibited communications ...
 - Unidentified transmissions (no call sign)
 - False or deceptive signals (using someone else's call sign)
 - False distress or emergency signals
 - Obscene or indecent speech
- Regular communications that could reasonably be performed through some other radio service are prohibited (such as directing boat traffic that should be done on marine VHF channels)
- Communications in return for some kind of compensation is prohibited

29

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Business Communications

- No transmissions related to conducting your business or employer's activities are permitted
- You can order things over the air, as long as you don't do it regularly or as part of your normal income-making activities
- You can advertise equipment for sale as long as it pertains to Amateur Radio and it's not your regular business
- You cannot be paid for operating an amateur station
- One exception to business prohibition is that teachers may use ham radio as part of their classroom instruction
 - Must be incidental to their job and can't be the majority of their duties

30

30

Encrypted Transmissions

- Encoding that uses codes or ciphers to hide the meaning of the transmitted message is called **encryption**
 - Recovering the encrypted information is called **decryption**
- Amateurs **may not use** encryption techniques except for radio control and control transmissions to space stations

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31

Broadcasting and Retransmission

- **Broadcasting** consists of **one-way transmissions** intended for reception by the general public
- Hams may only broadcast when ...
 - Transmitting code practice
 - Communicating information bulletins for other amateurs
 - Necessary for emergency communications
- Hams are prohibited from assisting and participating in news gathering by broadcasting organizations
- Music can only be rebroadcast as part of an authorized rebroadcast of space station transmissions
- **Retransmitting** the signals of another station is prohibited, except when relaying messages or digital data from another station

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PRACTICE QUESTIONS

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Which of the following is prohibited?

- International communications on VHF bands and higher frequencies
- Willful or malicious interference
- Third-party traffic using digital modes
- All these choices are correct

T1A11 B 97.101 (d) 8-5

34

34

Which of the following is an example of automatic control?

- Repeater operation
- Controlling a station over the internet
- Using a computer or other device to send CW automatically
- Using a computer or other device to identify automatically

T1E08 A 2026-2030

35

35

Which of the following applies when two stations transmitting on the same frequency interfere with each other?

- The stations should negotiate continued use of the frequency
- Both stations should choose another frequency to avoid conflict
- Whichever station was on the frequency first has preemptive rights to the frequency
- Use subaudible tones so both stations can share the frequency

T2B08 A 8-5

36

36

Which of the following restrictions apply when a non-licensed person speaks to a foreign amateur radio station via a station under the control of an FCC-licensed amateur radio operator?

- The person must be a U.S. citizen
- The foreign station must be in a country with which the U.S. has a third-party agreement
- The licensed control operator must do the station identification
- All these choices are correct

T1F07 B 97.115(a)(2) 8-7

37

37

What is the definition of third-party communications?

- A message from a control operator to another amateur station control operator on behalf of another person
- Amateur radio communications where three stations are in communications with one another
- Operation when the transmitting equipment is licensed to a person other than the control operator
- Temporary authorization for an unlicensed person to transmit on the amateur bands for technical experiments

T1F08 A 97.3(a)(47) 8-7

38

38

Which amateur stations may be remotely controlled?

- Only repeater stations
- Only automatically controlled stations
- Only digital stations
- Any station

T1E09 D 97.109(c) 8-9

39

39

Which of the following is an example of remote control as defined in Part 97?

- A software defined radio (SDR)
- Operating the station over the internet
- Controlling a model aircraft, boat, or car by amateur radio
- Earth-Moon-Earth (EME) communication

T1E10 B 97.3(a)(39) 8-9

40

40

Who is accountable if a repeater inadvertently retransmits communications that violate the FCC rules?

- The control operator of the originating station
- The control operator of the repeater
- The owner of the repeater
- Both the originating station and the repeater owner

T1F10 A 97.205(g) 8-9

41

41

What, if any, are the restrictions concerning transmission of language that may be considered indecent or obscene?

- The FCC maintains a list of words that are not permitted to be used on amateur frequencies
- Any such language is prohibited
- The International Telecommunications Union (ITU) maintains a list of words that are not permitted to be used on amateur frequencies
- There is no such prohibition

T1D06 B 97.113(a)(4) 8-10

42

42

When may amateur radio operators use their stations to notify other amateurs of the availability of equipment for sale or trade?

- Never
- When the equipment is not the personal property of either the station licensee, or the control operator, or their close relatives
- When no profit is made on the sale
- When selling amateur radio equipment and not on a regular basis

T1D05 D 97.113(a)(3) (ii) 8-10

43

43

In which of the following circumstances may the control operator of an amateur station receive compensation for operating that station?

- When the communication is related to the sale of amateur equipment by the control operator's employer
- When the communication is a part of classroom instruction at an educational institution
- When the communication is made to obtain emergency information for a local broadcast station
- All these choices are correct

T1D08 B 97.113(a)(3) (iii) 8-10

44

44

When is it permissible to transmit messages encoded to obscure their meaning?

- Only when using a remote station during a contest
- Only when transmitting certain approved digital codes
- Only when transmitting control commands to space stations or model craft
- Never

T1D03 C 97.211(b), 97.215(b), 97.113(a)(4) 8-11

45

45

Under which of the following circumstances are one-way transmissions by an amateur station prohibited?

- Announcements of upcoming ham radio operating events
- Broadcasting
- International Morse Code Practice
- Telecommand or transmissions of telemetry

T1D02 B 97.113(b), 97.111(b) 8-11

46

46

Under what conditions is an amateur station authorized to transmit music using a phone emission?

- When incidental to an authorized retransmission of manned spacecraft communications
- When the music produces no spurious emissions
- When transmissions are limited to less than three minutes per hour
- When the music is transmitted above 1280 MHz

T1D04 A 97.113(a)(4), 97.113(c) 8-11

47

47

Which of the following is required when making on-the-air test transmissions?

- Identify the transmitting station
- Conduct tests only between 10 p.m. and 6 a.m. local time
- Notify the FCC of the transmissions
- All these choices are correct

T1D12 A 2026-2030

48

48

Which of the following is an example of an auxiliary station?

- A station sending one-way transmissions between a remote repeater receiver and the main repeater transmitter
- A backup radio for emergency use in case the main station radio fails
- A station used in the Military Auxiliary Radio System for linking government and amateur stations in a digital network
- A second station utilized in multi-operator contest stations

T1D07 A 97.113(d) 8-11

49

49

When may amateur stations transmit information in support of broadcasting, program production, or news gathering, assuming no other means is available?

- When such communications are directly related to the immediate safety of human life or protection of property
- When broadcasting communications to or from the space shuttle
- Where non-commercial programming is gathered and supplied exclusively to the National Public Radio network
- Never

T1D09 A 97.113(5)(b) 8-11

50

50

When must the station licensee make the station and the station records available for inspection?

- At any time ten days after notification by the FCC of such an inspection
- At any time upon request by an FCC representative
- At any time after a written notification by the FCC of such inspection
- Only when presented with a valid warrant by an FCC official or government agent

T1F01 B 2026-2030

51

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How does the FCC define broadcasting for the Amateur Radio Service?

- Two-way transmissions by amateur stations
- Any transmission made by the licensed station
- Transmission of messages directed only to amateur operators
- Transmissions intended for reception by the general public

T1D10 D 97.3(a)(10) 8-11

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END OF MODULE 8



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Amateur Radio Technician Exam Prep Course

Module 9
 Safety

9.1 Electrical Safety
 9.2 Managing RF in Your Station
 9.3 RF Interference (RFI)
 9.4 RF Exposure
 9.5 Mechanical Safety

2

Electrical Injuries

- Electrical current through the body can disrupt the electrical function of cells
 - Can cause involuntary muscle contractions
 - Large currents can burn the skin and heat tissue

Table 9.1
Effects of Electric Current in the Human Body

Current	Reaction
Below 1 milliamperes	Generally not perceptible
1 milliamperes	Faint tingle
5 milliamperes	Slight shock felt; not painful but disturbing. Average individual can let go. Strong involuntary reactions can lead to other injuries.
6-25 milliamperes (women)	Painful shock, loss of muscular control; the "freezing current" or "can't let-go" range.
9-30 milliamperes (men)	
50-150 milliamperes	Extreme pain, respiratory arrest, severe muscular contractions. Death is possible.
1000-4300 milliamperes	Rhythmic pumping action of the heart ceases. Muscular contraction and nerve damage occur; death likely.
10,000 milliamperes	Cardiac arrest, severe burns; death probable

3

Avoiding Electrical Hazards

- Safety tips for working with power **ON**
 - Keep one hand in your pocket
 - Wear insulating shoes
 - Never bypass a safety interlock during testing
 - Make sure capacitors are discharged
 - Keep metal objects clear of storage battery terminals
 - Avoid working on equipment with the battery connected
 - Remove unnecessary jewelry from your hands
 - Avoid working alone

4

AC Safety Grounding

- The **safety ground** is a connection to the power system's ground reference connection in your main electrical service box
- The ground connection causes a fuse or circuit breaker to remove power from the equipment
- Grounding guidelines ...
 - Use three-wire power cords and plugs
 - Make sure all equipment has a connection to the ground
 - Use ground fault circuit interrupter (GFCI) circuit breakers/outlets
 - Verify AC wiring is done properly
 - Never replace a fuse or circuit breaker with one of a larger size
 - Don't overload single outlets

5

AC Safety Grounding (cont.)

- When wiring circuits, be sure to follow the US standard ...
 - Hot — black wire (occasionally red)
 - Neutral — white wire
 - Safety or equipment ground — green
- Use cable and wire sufficiently rated for the expected current load
- Use the proper size fuses and circuit breakers
- Be sure fuses or circuit breakers are installed in series with the hot conductor or conductors

Table 9.2
Current-Carrying Capability of Some Common Wire Sizes

Copper Wire Size (AWG)	Allowable Current (A)	Max Fuse or Circuit Breaker (A)
6	55	50
8	40	40
10	30	30
12	25 (20) ¹	20
14	20 (15) ¹	15

¹The National Electrical Code limits the fuse or circuit breaker size (and as such, the maximum allowable circuit load current) to 15 A for #14 AWG copper wire and to 20 A for #12 AWG copper wire conductors.

6

Lightning Protection

- Lightning protection is intended to provide fire protection for your home
- Starting at your antennas, all towers, masts, and antenna mounts should be grounded according to local building and electrical codes
- Connections are made at the tower base through a large-diameter wire to a ground rod
- Ground connections should be as short and direct as possible — avoid sharp bends
- Use lightning arrestors grounded to a common plate that is in turn connected to a nearby external ground
- All ground rods and earth connections must be bonded together with heavy wire

7

PRACTICE QUESTIONS

8

What health hazard is posed by electrical current flowing through the body?

- It may cause injury by heating body tissue
- It may disrupt the electrical functions of cells
- It may cause involuntary muscle contractions
- All these choices are correct

T0A02 D 9-2

9

What hazard exists in a power supply immediately after turning it off?

- Circulating currents in the dc filter
- Leakage flux in the power transformer
- Voltage transients from kickback diodes
- Charge stored in filter capacitors

T0A11 D 9-2

10

In the United States, what circuit does black wire insulation indicate in a three-wire 120 V AC cable?

- Neutral
- Hot
- Equipment ground
- Negative

T0A03 B 9-4

11

What is a good way to guard against electrical shock at your station?

- Use three-wire cords and plugs for all AC powered equipment
- Connect all AC powered station equipment to a common safety ground
- Ensure all capacitors used for high-voltage DC are fully discharged before working inside equipment
- All these choices are correct

T0A06 D 9-4

12

Where should a fuse or circuit breaker be installed in a 120V AC power circuit?

- In series with the hot conductor only
- In series with the hot and neutral conductors
- In parallel with the hot conductor only
- In parallel with the hot and neutral conductors

T0A08 A 9-4

13

13

Where should a lightning arrester be installed in a coaxial feed line?

- At the output connector of a transceiver
- At the antenna feed point
- At the AC power service panel
- On a grounded panel near where feed lines enter the building

T0A07 D 9-5

14

14

What should be done to all external ground rods or earth connections?

- Waterproof them with silicone caulk or electrical tape
- Keep them as far apart as possible
- Bond them together with heavy wire or conductive strap
- Tune them for resonance on the lowest frequency of operation

T0A09 C 9-5

15

15

Which of the following is good practice when installing ground wires on a tower for lightning protection?

- Put a drip loop in the ground connection to prevent water damage to the ground system
- Make sure all ground wire bends are right angles
- Ensure that connections are short and direct
- All these choices are correct

T0B01 C 9-5

16

16

Which of the following is true when installing grounding conductors used for lightning protection?

- Use only non-insulated wire
- Wires must be carefully routed with precise right-angle bends
- Sharp bends must be avoided
- Common grounds must be avoided

T0B10 C 9-5

17

17

Which of the following establishes grounding requirements for an amateur radio tower or antenna?

- FCC Part 97 rules
- Local electrical codes
- FAA tower lighting regulations
- UL recommended practices

T0B11 B 9-5

18

18

Managing RF in Your Station

- Your station wiring, feed lines, power connections, and other cables all pick up RF from your transmitted signal
- It is not practical to “ground” RF current in the same way as for AC power and lightning protection
- Best approach is to **bond** all of the equipment together
 - Keeps all of your equipment at the same voltage so that RF current does not flow between the different pieces
- RF current on cables and enclosures can cause audio distortion, erratic operation of computer equipment, and even RF “burns”
- “RF feedback” via a microphone cable can cause distorted transmitted audio

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19

Bonding Tips

- Bond all metal equipment enclosures to a common RF ground bus
- Use short, wide conductors such as copper flashing or strap or heavy solid wire
 - Solid strap is best because it presents the lowest impedance to RF
- Keep all connections, straps and wires as short and direct as possible
- Connect the ground bus to your AC safety ground and any earth connections
- See Figure 9.2 in text

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20

RF Interference (RFI) and Filters

- Interference between appliances and ham radio is called **radio frequency interference** (RFI)
- Filters are used to ...
 - Prevent unwanted signals from being radiated
 - Keep unwanted signals from being received
- AC power line filters keep RF signals from passing into or out of equipment via the hot and neutral conductors of the AC power connection
 - They reject all signals with frequencies greater than a few kHz
- Ferrite chokes are also used to reduce RF current on the outside of shielded audio, microphone, and computer cables.

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21

Filters (cont.)

Ferrite — The RFI Buster

One of the most useful materials in dealing with RFI is the ferrite core. Ferrite is a ceramic magnetic material — you may have used ferrite magnets. The type of ferrite used for RFI suppression is specially designed to absorb RF energy over a broad frequency range, such as HF or VHF. Ferrite is available in many different mixes of slightly different composition that absorb best in a particular range.

One popular form of ferrite is the snap-core shown in the figure. The actual ferrite is a rectangular block with a large hole in it, sawn in half. A plastic case with a snap holds the two pieces together. This allows cords or cables to be wound on the core even if they already have connectors attached, such as power cords or video cables.

Ferrite is available as round cores (toroids), rods and beads shown in Figure 9.4. Wires or cables are then wound on or passed through the ferrite forms. Beads are made large enough that they can be slipped over coaxial cables and secured with tape or a locking wire-tie. A wire or cable wound on such a ferrite core forms an RF choke.



Figure 9.4 — Ferrite is a ceramic magnetic material used to make choke filters for RFI suppression. It is available in many different forms: rings (toroids), rods, and beads. Cables can be passed through or wound on these cores to prevent RF signals from flowing along their outside surfaces.

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22

Interference from Amateur Transmissions

- The most common causes of RFI from your transmissions are **fundamental overload**, **harmonics**, and **spurious emissions**
- Very strong signals may overwhelm a receiver's ability to reject them
 - This is called **fundamental overload**
- Consumer equipment is often unable to reject strong signals outside the bands it is intended to receive
- A **high-pass filter** can be connected at antenna input of FM & TV receivers to reject strong lower-frequency signals from amateur HF signals
- **Broadcast-reject filters** attenuate signals from nearby AM, FM, or TV broadcast stations

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23

Harmonics, Spurious Emissions & Leakage

- Every transmitter's RF output signal contains weak **harmonics** of the desired output signal and other **spurious emissions** that can cause interference to nearby equipment
- A **low-pass** or **band-pass filter** can be installed at the transmitter's connection to the antenna feed line to prevent harmonics
- **Leakage** is another source of interference
- The most common cause of leakage is faulty coaxial connectors on the cable feed line
 - Be sure the connectors are installed correctly and attached tightly

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Good Practices in Your Station

- Regardless of the source, you can reduce or eliminate much interference by making sure your own station follows good amateur practices for grounding and filtering
 - Make sure your station is in good working order with appropriate grounding, filtering, and good quality connections
 - Use shielded wire and shielded cables to prevent coupling with unwanted signals and undesired radiation ... be sure to connect the shield properly
 - Eliminate interference to your own home appliances and televisions first

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RFI and Neighbors

- Start by making sure it's really your transmissions that are causing the problem
- Offer to help determine the nature of interference
- If you're the recipient of the RFI ...
 - Make sure your station meets the standards of good amateur practices
 - Offer to help determine the source of interference
 - You may have to politely explain to the neighbor that FCC rules prohibit them from using a device that causes harmful interference
 - Be diplomatic in dealing with your neighbors

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PRACTICE QUESTIONS

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Which of the following conductors is preferred for bonding at RF?

- Copper braid removed from coaxial cable
- Copper-clad steel wire
- Twisted-pair cable
- Flat copper strap

T4A08 D 9-6

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Which of the following can eliminate distorted voice transmissions?

- Adding extra feedline to the antenna to lower SWR
- Turning the radio on and off to reset the computer-controlled circuitry
- Adding a clip-on ferrite "choke" to the microphone cable to prevent the transmitted signal from feeding back into the transmitter
- Turning the squelch control fully clockwise to prevent the transmitted signal from triggering the squelch circuit

T7B11 C 9-6

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Which of the following might be the cause of low RF power output from a solid-state transceiver?

- Poor amplifier noise figure
- Poor amplifier linearity
- Low SWR
- High SWR

T7B04 D 9-7

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Which of the following can cause radio frequency interference?

- Fundamental overload
- Harmonics
- Spurious emissions
- All these choices are correct

T7B03 D 9-8

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What would cause a broadcast AM or FM radio to receive an amateur radio transmission unintentionally?

- The receiver is unable to reject strong signals outside the AM or FM band
- The microphone gain of the transmitter is turned up too high
- The audio amplifier of the transmitter is overloaded
- The deviation of an FM transmitter is set too low

T7B02 A 9-8

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Which of the following might reduce interference by an amateur station to a non-amateur over-the-air radio receiver?

- Block the amateur signal with a filter at the antenna input of the affected receiver
- Block the interfering signal with a filter on the amateur transmitter
- Switch the transmitter from FM to SSB
- Switch the transmitter to a narrow-band mode

T7B05 A 9-8

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Which of the following can reduce interference to a 2-meter band transceiver from a nearby commercial FM station?

- Installing an RF preamplifier
- Using double-shielded coaxial cable
- Installing bypass capacitors on the microphone cable
- Installing a band-reject filter

T7B07 D 9-8

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What should be the first step to resolve non-fiber optic cable TV interference caused by your amateur radio transmission?

- Add a low-pass filter to the TV antenna input
- Add a high-pass filter to the TV antenna input
- Add a preamplifier to the TV antenna input
- Be sure all TV feed line coaxial connectors are installed properly

T7B09 D 9-10

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Which of the following is a reason to use shielded wire?

- To decrease the resistance of DC power connections
- To increase the current carrying capability of the wire
- To prevent coupling of unwanted signals to or from the wire
- To reduce receiver overload

T6D03 C 9-9

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Which of the following actions should you take if a neighbor tells you that your station's transmissions are interfering with their radio or TV reception?

- Make sure that your station is functioning properly and that it does not cause interference to your own radio or television when it is tuned to the same channel
- Immediately turn off your transmitter and contact the nearest FCC office for assistance
- Install a harmonic doubler on the output of your transmitter and tune it until the interference is eliminated
- All these choices are correct

T7B06 A 9-9

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What should you do if something in a neighbor's home is causing harmful interference to your amateur station?

- Work with your neighbor to identify the offending device
- Politely inform your neighbor that FCC rules prohibit the use of devices that cause interference
- Make sure your station meets the standards of good amateur practice
- All these choices are correct

T7B08 D 9-10

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RF Exposure

- With its relatively low frequency, RF energy is *non-ionizing radiation*
- RF radiation is not the same as ionizing radiation from radioactivity because the energy in signals at radio frequencies is far too low to cause an electron to leave an atom (can't cause genetic damage)
- Per FCC rules the station licensee is responsible for ensuring that no one is exposed to RF energy above the FCC exposure limits
- Heating as a result of exposure to RF fields is caused by the body absorbing RF energy
- Absorption varies with frequency because the body absorbs more RF energy at some frequencies than others
- RF burns can be eliminated by proper bonding techniques or by preventing access to an antenna

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Exposure Limits

Controlled Exposure (6-Minute Average)	
Frequency Range (MHz)	Power Density (mW/cm ²)
0.3-3.0	(100)*
3.0-30	(900/f)*
30-300	1.0
300-1500	f/300
1500-100,000	5
Uncontrolled Exposure (30-Minute Average)	
Frequency Range (MHz)	Magnetic Field Power Density (mW/cm ²)
0.3-1.34	(100)*
1.34-30	(180/f)*
30-300	0.2
300-1500	f/1500
1500-100,000	1.0

f = frequency in MHz

* = Plane-wave equivalent power density

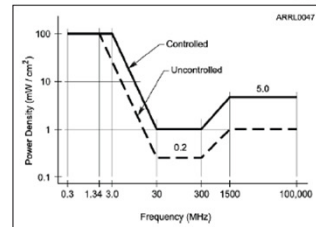


Figure 9.5 — Maximum Permissible Exposure (MPE) limits vary with frequency because the body responds differently to energy at different frequencies. The controlled and uncontrolled limits refer to the environment in which people are exposed to the RF energy.

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Exposure Limits (refer to previous slide)

- People in *controlled environments* are aware of their exposure and can take the necessary steps to minimize it
- People in *uncontrolled environments* are not aware of their exposure, (areas open to the general public or your neighbor's property)
- Frequencies at which the body has the highest absorption rate are from 30 to 1500 MHz (see graph)

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Averaging and Duty Cycle

- MPE limits are based on averages, not peak exposure, allowing exposure to be averaged over fixed time intervals
- Transmitters only generate RF for a fraction of the time they operate (only when transmitting ... they receive or sit idle the remaining time)
 - This lowers the *duty cycle* of the emissions ... the ratio of the transmitted signal's on-the-air time to the total operating time
- Duty cycle must be considered when evaluating exposure
- *Because the signal is only present for about ½ the time (50% duty cycle), the signal power can be twice as high and still have the same average power as transmitting continuously with a duty cycle of 100%*

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Evaluating Exposure

- All fixed stations must perform an exposure evaluation ... three ways of making this evaluation ...
 - Use the techniques outlined in the FCC's OET (Office of Engineering Technology) Bulletin 65
 - Measure the power density of your transmissions
 - Make computer models of your station
- You only need to re-evaluate if you change equipment in your station that affects average output power
- The following web page lists resources that make the job a lot easier (<http://www.arrl.org/fcc-rf-exposure-regulations-the-station-evaluation>)
 - You'll need information on the RF signal's frequency and power level, distance from the antenna and the antenna's radiation pattern

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Exposure Safety Measures

- Locate antennas away from where people can get close to them
- Raise the antenna
- Avoid pointing beam antennas where people are likely to be
- Use a lower gain antenna to reduce radiated power density or reduce transmitter power
- Limit the average power of your transmissions
- Place mobile antennas on the roof or trunk of the car (maximizes shielding)
- Use a remote microphone to hold a handheld transceiver away from your head

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PRACTICE QUESTIONS

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What type of radiation are radio signals?

- Gamma radiation
- Ionizing radiation
- Alpha radiation
- Non-ionizing radiation

T0C01 D 9-11

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Why do exposure limits vary with frequency?

- Lower frequency RF fields have more energy than higher frequency fields
- Lower frequency RF fields do not penetrate the human body
- Higher frequency RF fields are transient in nature
- The human body absorbs more RF energy at some frequencies than at others

T0C05 D 9-11

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What hazard is created by touching an antenna during a transmission?

- Electrocutation
- RF burn to skin
- Exposure to ionizing radiation
- All these choices are correct

T0C07 B 9-11

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How does RF radiation differ from ionizing radiation (radioactivity)?

- RF radiation does not have sufficient energy to cause chemical changes in cells and damage DNA
- RF radiation can only be detected with an RF dosimeter
- RF radiation is limited in range to a few feet
- RF radiation is perfectly safe

T0C12 A 9-11

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Who is responsible for ensuring that no person is exposed to RF energy above the FCC exposure limits?

- The FCC
- The station licensee
- Anyone who is near an antenna
- The local zoning board

T0C13 B 9-11

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Which of the following bands has the lowest maximum permissible exposure for RF safety?

- 3.5 MHz
- 50 MHz
- 440 MHz
- 1296 MHz

T0C02 B 9-12

51

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How does the allowable power density for RF safety change if duty cycle changes from 100 percent to 50 percent?

- It increases by a factor of 3
- It decreases by 50 percent
- It increases by a factor of 2
- There is no adjustment allowed for lower duty cycle

T0C03 C 9-13

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Why is duty cycle one of the factors used to determine safe RF radiation exposure levels?

- It affects the average exposure to radiation
- It affects the peak exposure to radiation
- It takes into account the antenna feed line loss
- It takes into account the thermal effects of the final amplifier

T0C10 A 9-13

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What is the definition of duty cycle during the averaging time for RF exposure?

- The difference between the lowest and highest power output of a transmitter
- The difference between the PEP and the average power output of a transmitter
- The percentage of time that a transmitter is transmitting
- The percentage of time that a transmitter is not transmitting

T0C11 C 9-13

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What factors affect the RF exposure of people near an amateur station antenna?

- Frequency and power level of the RF field
- Distance from the antenna to a person
- Radiation pattern of the antenna
- All these choices are correct

T0C04 D 9-14

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Which of the following is an acceptable method to determine whether your station complies with FCC RF exposure regulations?

- By calculation based on FCC OET Bulletin 65
- By calculation based on computer modeling
- By measurement of field strength using calibrated equipment
- All these choices are correct

T0C06 D 9-14

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How can you make sure your station stays in compliance with RF safety regulations?

- By informing the FCC of any changes made in your station
- By re-evaluating the station whenever an item in the transmitter or antenna system is changed
- By making sure your antennas have low SWR
- By using only Underwriter Laboratories approved transmitting equipment

T0C09 B 9-14

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Which of the following is a safety hazard of a 12-volt storage battery that lacks internal protection circuitry?

- Touching both terminals with your hands can cause electrical shock
- Shorting the terminals can cause burns, fire, or an explosion
- RF emissions from a nearby transmitter can cause the electrolyte to emit poison gas
- All these choices are correct

T0A01 B 2026-2030

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Which of the following actions can reduce exposure to RF radiation?

- Relocate antennas
- Relocate the transmitter
- Increase the duty cycle
- All these choices are correct

T0C08 A 9-14

59

59

Mechanical Safety ... Antennas & Supports

- Make sure your plans satisfy any local zoning codes or covenants or restrictions in your deed or lease
- Place all antennas and feed lines well clear of power lines
- A good guideline is to separate the antenna from the nearest power line by 150% of total height of tower or mast plus antenna
 - A minimum of 10 feet of clearance during a fall is required
- Never attach an antenna or guy wire to a utility pole
- Grounding rules for antennas and supports must be followed according to your local electrical code
- Towers should be grounded with separate 8-foot long ground rods for each tower leg, bonded to the tower and each other
- Place a safety wire through any turnbuckles used to tension guy lines (prevents loosening due to vibration and twisting)

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Tower Work and Climbing Safety

- Climbers and ground crew should wear appropriate protective gear any time work is under way on the tower
- Be sure to get sufficient training on safe tower climbing techniques before beginning, use appropriate tie-off to the tower at all times, and always wear an approved climbing harness
- Never climb a crank-up tower supported only by the cable that supports the sections
- Double-check all climbing belts and lanyards before climbing
- Make sure all ropes and load-bearing hardware are in good condition before placing them in service
- Use a gin pole so that you do not have to hoist things directly
- Double-check the latest weather report
- Avoid climbing alone

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PRACTICE QUESTIONS

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Which of the following is an important safety precaution to observe when putting up an antenna tower?

- Wear a ground strap connected to your wrist at all times
- Insulate the base of the tower to avoid lightning strikes
- Look for and stay clear of any overhead electrical wires
- All these choices are correct

T0B04 C 9-17

63

What is the purpose of a safety wire through a turnbuckle used to tension guy lines?

- Secure the guy line if the turnbuckle breaks
- Prevent loosening of the turnbuckle from vibration
- Provide a ground path for lightning strikes
- Provide an ability to measure for proper tensioning

T0B05 B 9-17

64

What is the minimum safe distance from a power line to allow when installing an antenna?

- Add the height of the antenna to the height of the power line and multiply by a factor of 1.5
- The height of the power line above ground
- 1/2 wavelength at the operating frequency
- Enough so that if the antenna falls, no part of it can come within 10 feet of the power wires

T0B06 D 9-17

65

Which is a proper grounding method for a tower?

- A single four-foot ground rod, driven into the ground no more than 12 inches from the base
- A ferrite-core RF choke connected between the tower and ground
- A connection between the tower base and a cold-water pipe
- Separate eight-foot ground rods for each tower leg, bonded to the tower and each other

T0B08 D 9-17

66

Why should you avoid attaching an antenna to a utility pole?

- The antenna will not work properly because of induced voltages
- The antenna may unbalance the power transformer, causing power fluctuations
- The antenna could contact high-voltage power lines
- All these choices are correct

T0B09 C 9-17

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What is required when climbing an antenna tower?

- Have sufficient training on safe tower climbing techniques
- Use appropriate tie-off to the tower at all times
- Always wear an approved climbing harness
- All these choices are correct

T0B02 D 9-19

68

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Under what circumstances is it safe to climb a tower without a helper or observer?

- When no electrical work is being performed
- When no mechanical work is being performed
- When the work being done is not more than 20 feet above the ground
- Never

T0B03 D 9-19

69

69

Which of the following is an important safety rule to remember when using a crank-up tower?

- This type of tower must never be painted
- This type of tower must never be grounded
- This type of tower must not be climbed unless it is retracted, or mechanical safety locking devices have been installed
- All these choices are correct

T0B07 C 9-19

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END OF MODULE 9



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