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Amateur Radio Exam Course — USA, Technician Class

FCC Element 2, Technician Class: one chapter for each of the 35 topic groups of the official NCVEC 2026-2030 question pool.

Author, contact and licence

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Commission's Rules

T1A Purpose of the service, the FCC and coordinators

Basis and purpose

Part 97 of the FCC rules lists the purposes of the Amateur Radio Service, among them **advancing skills in the technical and communication phases of the radio art**, emergency communications and international goodwill.

- The **FCC** regulates and enforces the rules of the Amateur Radio Service in the United States.
- **Willful or malicious interference** is prohibited.

Your license

- After the exam, you receive an **email from the FCC** with a link to download the license grant.
- The proof that a license has been issued is that it **appears in the FCC ULS database**.

Definitions and coordination

Term	Meaning
Space station	An amateur station more than 50 km above the Earth's surface
Propagation beacons on HF	Automatically controlled beacons on 10 m, 28.200 to 28.300 MHz
Frequency coordinator	Recommends repeater and auxiliary channels; a volunteer recognized by local amateurs , selected by the amateurs of the area whose stations are eligible to be repeater or auxiliary stations
RACES control operator	Besides an amateur license, needs certification of enrollment in a civil defense organization

- A **phonetic alphabet** is **encouraged** for station identification on phone.

Source: 47 CFR Part 97: §97.1, §97.3, §97.7, §97.23, §97.101, §97.119, §97.203, §97.407.

T1B Technician frequency privileges and power

HF privileges

Band	Technician segment	Modes
80 m	3.525 to 3.600 MHz	CW
40 m	7.025 to 7.125 MHz	CW
15 m	21.025 to 21.200 MHz	CW
10 m	28.000 to 28.300 MHz	CW, RTTY, data
10 m	28.300 to 28.500 MHz	CW, SSB phone

- On HF, Technicians have phone privileges on the **10-meter band only**.
- Maximum power in the HF segments: **200 W PEP**.

VHF and UHF

All amateur bands above 50 MHz, including:

Band	Frequencies
6 m	50 to 54 MHz (for example 52.525 MHz)
2 m	144 to 148 MHz (146.52 MHz is the national FM simplex calling frequency)
1.25 m	222 to 225 MHz
70 cm	420 to 450 MHz

- **CW only**: 50.0 to 50.1 MHz and 144.0 to 144.1 MHz.
- **SSB phone** is allowed in at least some segment of every band above 50 MHz.
- **Digital modes** such as FT8 are allowed on **10, 6 and 2 meters**.
- Maximum power above 30 MHz, except specific restrictions: **1,500 W PEP**.
- Any amateur with a **Technician license or higher** may contact the **International Space Station**.

Good practice and secondary bands

- Do not transmit exactly at a band or sub-band edge: allow for **calibration error**, **drift** and the **sidebands** of your signal.
- Where amateurs are **secondary**, you may find non-amateur stations and **must avoid interfering** with them.

Source: 47 CFR §97.301(a) and (e), §97.303, §97.305(c), §97.313; §97.207 (space stations).

T1C Licenses, call signs and renewal

License classes and term

- The FCC issues new **Technician, General and Amateur Extra** licenses.
- A license normally lasts **ten years**.
- You may request renewal up to **90 days before** expiration.
- After expiration there is a **two-year grace period** to renew, but you **may not transmit** until the license is renewed.
- After your first exam, you may transmit **as soon as your license grant appears in the ULS database**.
- If the FCC cannot reach you by **email**, your license may be **revoked or suspended**: keep your email address up to date.

Call signs

- A **Group D** call sign (Technician and General) has two letters, a digit and three letters, for example **KF1XXX**.
- **Any licensed amateur** may apply for a **vanity** call sign.

Operating away from home

- International communications must be **incidental to the purposes of the service or remarks of a personal character**.
- You may operate aboard a **US-documented vessel** with the **master's permission**.

Source: 47 CFR §97.5, §97.9, §97.11, §97.17, §97.19, §97.21, §97.23, §97.25, §97.117; 47 CFR §1.949.

T1D What may not be transmitted

Prohibited communications

- **Broadcasting**, that is, transmissions intended for the **general public**, is prohibited.
- Communications with a country whose administration has notified the **ITU** that it **objects** are prohibited.
- **Indecent or obscene** language is prohibited.
- Messages **encoded to obscure their meaning** are prohibited, except **control commands to space stations or model craft**.
- **Music** is prohibited, except when incidental to an authorized **retransmission of manned spacecraft** communications.

Exceptions

Situation	Allowed?
Telling other amateurs about amateur equipment you are selling , not on a regular basis	Yes
Compensation for communications that are part of classroom instruction at a school	Yes
Information for broadcasting or news gathering	Only when directly related to the immediate safety of human life or protection of property

One-way transmissions and identification

- An **auxiliary station** sends one-way transmissions, for example between a remote repeater receiver and the main repeater transmitter.
- Signals that **control model craft** may be sent without identification.
- **Test transmissions** must still **identify** the station.

Source: 47 CFR §97.3(a)(10), §97.111, §97.113, §97.119, §97.201, §97.211, §97.215.

T1E The control operator

- A **control operator** is the amateur designated by the station licensee to be responsible for the station's transmissions.
- A station may **never** transmit without a control operator.
- The **station licensee** designates the control operator.
- The **control point** is where the control operator function is performed.

Privileges and responsibility

- Transmitting privileges are set by the **license class of the control operator**, not of the station owner.
- A Technician may **never** (except in an emergency) be the control operator of a station operating in an **Amateur Extra-only** segment.
- When the control operator is not the licensee, **both** the control operator and the licensee are responsible.
- Through a satellite, any amateur allowed to transmit on the **uplink frequency** may be the control operator.

Types of control

Control	Example
Local	The operator at the station
Remote	Operating the station over the internet ; any station may be remotely controlled
Automatic	Repeater operation

Source: 47 CFR §97.3(a)(6), (13), (14), (39); §97.7, §97.103, §97.109, §97.205, §97.207, §97.301.

T1F Identification, third parties and station types

Identification

- Transmit your call sign **at least every 10 minutes** during a communication and **at the end** of it, even when using tactical call signs such as "Race Headquarters".
- On phone, identify in **English**, using **CW or phone**.
- Self-assigned indicators may be added with "**stroke**", "**slant**" or "**slash**" (KL7CC slash W3).

Third-party communications

- A **third-party** communication is a message from a control operator to another station's control operator **on behalf of another person**.
- A non-licensed person may only talk to a foreign station if the US has a **third-party agreement** with that country.

Station types

- A **repeater** simultaneously retransmits another amateur station's signal on a different channel.
- If a repeater retransmits a communication that breaks the rules, the **control operator of the originating station** is accountable.
- A **club station** license requires a club with **at least four members**.

Inspection

The licensee must make the station and its records available to an **FCC representative at any time** upon request.

Source: 47 CFR §97.3(a)(40), (47); §97.5(b)(2), §97.103(c), §97.115, §97.119, §97.205.

Operating Procedures

T2A Calling on the air

Repeaters and simplex

- **Simplex**: transmitting and receiving on the **same frequency**.
- **Repeater offset**: the difference between a repeater's **transmit and receive** frequencies.

Band	Common repeater offset
2 m	$\pm$ 600 kHz
70 cm	$\pm$ 5 MHz

- The national **FM simplex calling frequency** on 2 m is **146.520 MHz**.

Making contact

Situation	What to say
Calling a known station on a repeater	Their call sign, then yours
Answering a CQ	The other station's call sign, then yours
General call without a repeater	"CQ" a few times, "this is", your call sign, then pause to listen ; repeat as needed
Showing you are on a repeater and available	Your call sign followed by " listening "

- **CQ** means **calling any station**.
- A **band plan** is a **voluntary guideline** for using modes and activities within a band, beyond the FCC rules.

Source: NCVEC 2026-2030 Technician question pool (subelement T2).

T2B Repeater operation and digital voice

Accessing a repeater

- The **reverse** function lets you listen on the repeater's **input** frequency (to check whether simplex would work).
- **CTCSS** is a **sub-audible tone** sent with your voice to open the repeater's squelch; **DCS** is a digital code doing the same.
- If you can hear a repeater but cannot access it, check the **offset**, the **CTCSS tone** and the **DCS code**.
- **DTMF** signaling uses **two simultaneous audio tones** (the keypad).
- Audio dropping out on voice peaks: you are **talking too loudly** (overdeviation).
- A **linked repeater network** retransmits on all repeaters what one of them receives.

Digital voice (DMR)

Term	Meaning
Color code	An access code programmed in the transmitter to use a given DMR repeater
Talkgroup	An identifier that organizes traffic so that users only hear the group they want; join it by programming its ID

Courtesy and Q signals

- **Simplex channels** let nearby stations talk **without tying up a repeater**.
- If two stations interfere on the same frequency, they should **negotiate** its use.
- **Squelch** mutes the receiver when no signal is present.

Q signal	Meaning
QRM	Interference from other stations
QSY	Changing frequency

Source: NCVEC 2026-2030 Technician question pool (subelement T2).

T2C Nets, emergency communications and traffic

- The FCC Part 97 rules **always** apply to an amateur station.
- In situations involving the **immediate safety of human life or protection of property**, an operator may transmit outside their privileges.

Nets

- The **net control station** calls the net to order and directs the stations checking in.
- In a net, transmit **only when directed** by net control, unless you have an emergency.
- Spell unusual words with a **standard phonetic alphabet**.

Emergency organizations

Organization	What it is
ARES (Amateur Radio Emergency Service)	Licensed amateurs who have registered their qualifications and equipment for public service
RACES (Radio Amateur Civil Emergency Service)	A Part 97 service for civil defense communications; requires certification by a civil defense agency
Winlink	Relays messages using email addresses based on call signs

Traffic

- **Traffic** means **formal messages** exchanged by net stations.
- The **preamble** of a message holds the information needed to **track** it.
- The **check** is the number of **words** in the text.

Source: NCVEC 2026-2030 Technician question pool (subelement T2).

Radio Wave Propagation

T3A Fading, multipath and polarization

Multipath

- Moving a VHF antenna a few feet can change signal strength a lot: **multipath** signals cancel or reinforce.
- **Picket fencing** is the rapid flutter of mobile signals caused by multipath.
- Multipath **increases error rates** on data transmissions.
- If a building blocks a distant repeater, try a path that **reflects** your signal to it.

Polarization

- Long-distance **CW and SSB** on VHF and UHF normally use **horizontal** polarization.
- **Cross-polarization** on a line-of-sight path **reduces signal strength**.
- Signals propagated by the ionosphere are **elliptically polarized**: either vertical or horizontal antennas work.

Weather and terrain

Factor	Effect
Vegetation	Absorbs UHF and microwave signals
Precipitation	Reduces range at microwave frequencies
Fog or rain	Little effect on 10 m and 6 m

Ionospheric fading

The **ionosphere** reflects HF waves; irregular fading comes from signals arriving by **different paths** and combining at random.

Source: NCVEC 2026-2030 Technician question pool (subelement T3).

T3B Radio waves, wavelength and frequency ranges

The radio wave

- Two components: an **electric** field and a **magnetic** field, at **right angles**.
- **Polarization** is the orientation of the **electric** field.
- Radio waves travel at the **speed of light**, about **300,000,000 m/s**; **all frequencies** travel at the same speed.

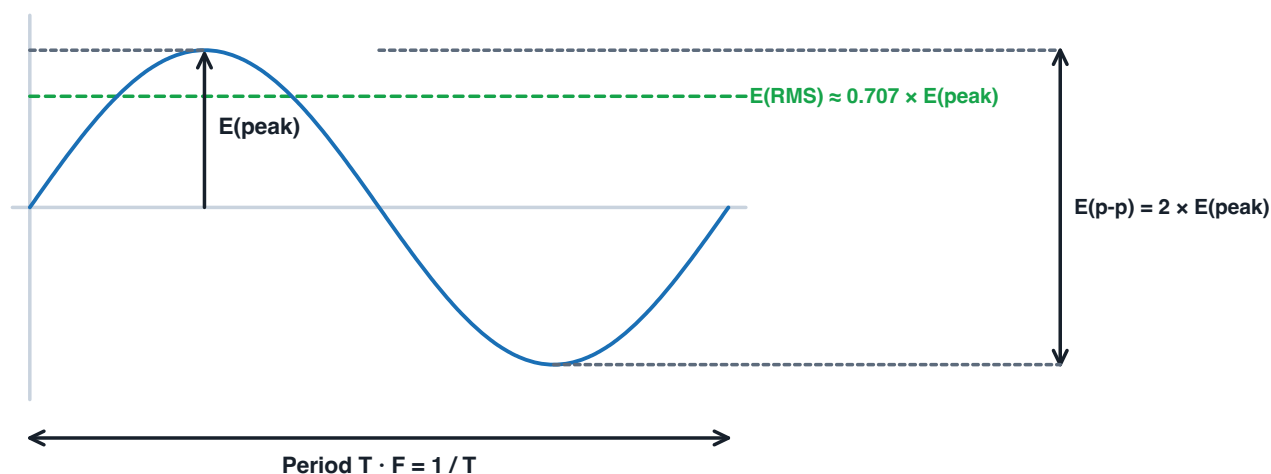
Wavelength

$$\lambda \text{ (m)} = \frac{300}{f \text{ (MHz)}}$$

- Wavelength gets **shorter** as frequency **increases**.
- Amateur bands are named by their approximate **wavelength in meters** (2 m: $300 / 146 \approx 2$ m).

Frequency ranges

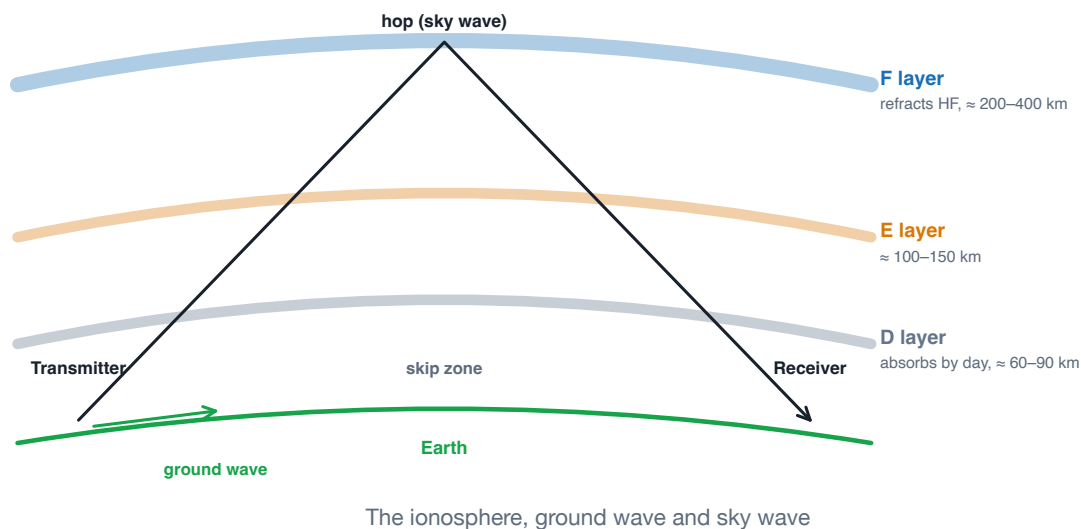
Range	Frequencies
HF	3 to 30 MHz
VHF	30 to 300 MHz
UHF	300 to 3,000 MHz



Sine wave: peak, RMS and period

Source: NCVEC 2026-2030 Technician question pool (subelement T3).

T3C Propagation beyond the horizon



HF versus VHF/UHF

- **Long-distance ionospheric propagation** is far more common on **HF**.
- UHF signals are usually **not propagated by the ionosphere**, so simplex UHF is rarely heard beyond the radio horizon.
- The radio horizon is farther than the visual horizon because the **atmosphere refracts** radio waves slightly.

Unusual VHF/UHF modes

Mode	Feature
Sporadic E	Occasional strong signals on 10, 6 and 2 m from beyond the horizon
Tropospheric ducting	Regular contacts out to about 300 miles ; caused by temperature inversions
Meteor scatter	Best on 6 m
Auroral backscatter	Signals distorted , with a raspy sound
Knife-edge diffraction	Lets signals pass beyond obstructions

The F region and sunspots

- At the peak of the sunspot cycle, **6 and 10 m** can open for long distance via the F region.
- On 10 m, the best time is **from dawn to shortly after sunset** during high sunspot activity.

Source: NCVEC 2026-2030 Technician question pool (subelement T3).

Amateur Radio Practices

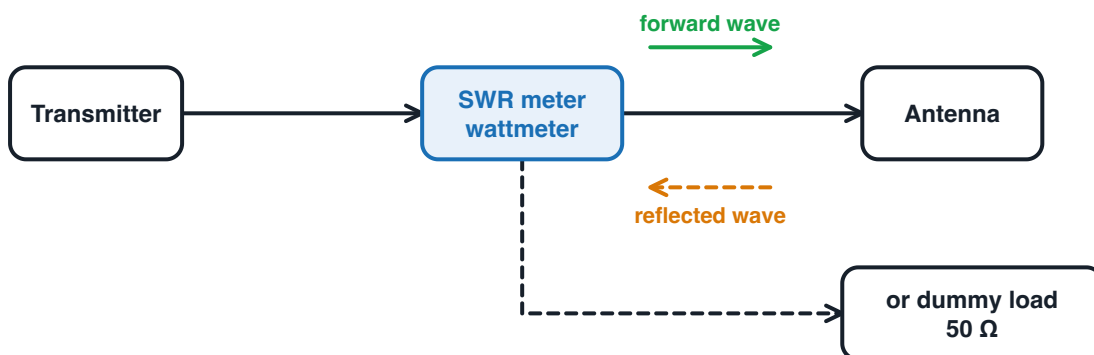
T4A Setting up the station

Power

- A 50 W mobile FM transceiver needs about **13.8 V at 12 A**.
- Use **short, heavy-gauge** wires for DC power, to **minimize voltage drop** when transmitting.
- In a vehicle, connect the negative lead to the **battery chassis ground** at the 12 V battery.
- Battery run time: the **ampere-hour rating divided by the average current** (a 20 Ah battery at 4 A average lasts about 5 hours).

Measuring

- An **RF power meter** goes **in the feed line**, between the transmitter and the antenna.
- Choose an **SWR meter** for the **frequency and power** you will use.



SWR = 1: antenna perfectly matched, no reflected wave

Measuring SWR and power

Digital modes

- The computer-radio interface carries **receive audio, transmit audio and transmitter keying (PTT)**.
- For FT8, the transceiver's audio input and output go to the **computer's audio output and input** (for example the transceiver speaker to the computer's "line in").
- A **hotspot** connects nearby digital transceivers to a **digital voice or data network**.

Other

- For RF bonding, a **flat copper strap** is preferred.
- An **electronic keyer** helps you send Morse code manually.

Source: NCVEC 2026-2030 Technician question pool (subelement T4).

T4B Operating controls

Tuning

- Enter the frequency with the **keypad** or the **VFO knob**.
- **Scanning** tunes through a range of frequencies to check for activity.
- If an SSB station's voice pitch sounds too high or too low, adjust the **RIT** (clarifier).
- An FM signal received slightly **off frequency** sounds **distorted**.

Squelch and filters

- To hear a **weak FM** signal, set the squelch so the audio is **on all the time**.
- Choosing a **filter bandwidth** that matches the mode reduces noise and interference.
- For SSB, a **2400 Hz** filter gives the best signal-to-noise ratio.

Microphone

Too much **microphone gain** on SSB gives **distorted audio**.

Digital voice

System	What to set
DMR	A code plug : configuration data to access repeaters and talkgroups; select a group by its ID code
D-STAR	Your call sign , before transmitting

Source: NCVEC 2026-2030 Technician question pool (subelement T4).

Electrical Principles

T5A Electrical basics

Quantity	Unit	What it is
Current	Ampere	The flow of electrons
Voltage	Volt	The difference that causes electron flow
Power	Watt	The rate at which energy is used
Frequency	Hertz	The number of complete cycles per second

- **Alternating current** alternates between positive and negative directions.
- Metals conduct well because they have many **free electrons**; **glass** is a good insulator.
- **Resistance** opposes every kind of current: DC, AC and RF.

Source: NCVEC 2026-2030 Technician question pool (subelement T5).

T5B Units, prefixes and decibels

Prefixes

Prefix	Factor	Examples
Giga (G)	1,000,000,000	2,425 MHz = 2.425 GHz
Mega (M)	1,000,000	1,500,000 Hz = 1,500 kHz = 1.5 MHz
Kilo (k)	1,000	1 kV = 1,000 V; 28,400 kHz = 28.400 MHz; 3.525 MHz = 3,525 kHz
Milli (m)	1/1,000	1.5 A = 1,500 mA; 3,000 mA = 3 A; 500 mW = 0.5 W
Micro (μ)	1/1,000,000	1 μ V = one millionth of a volt
Pico (p)	1/1,000,000,000,000	1,000,000 pF = 1 μ F

Decibels

Change	Decibels
Power $\times$ 2 (5 W $\rightarrow$ 10 W)	+3 dB
Power $\div$ 4 (12 W $\rightarrow$ 3 W)	-6 dB
Power $\times$ 10 (20 W $\rightarrow$ 200 W)	+10 dB

Source: NCVEC 2026-2030 Technician question pool (subelement T5).

T5C Capacitance, inductance, impedance and power

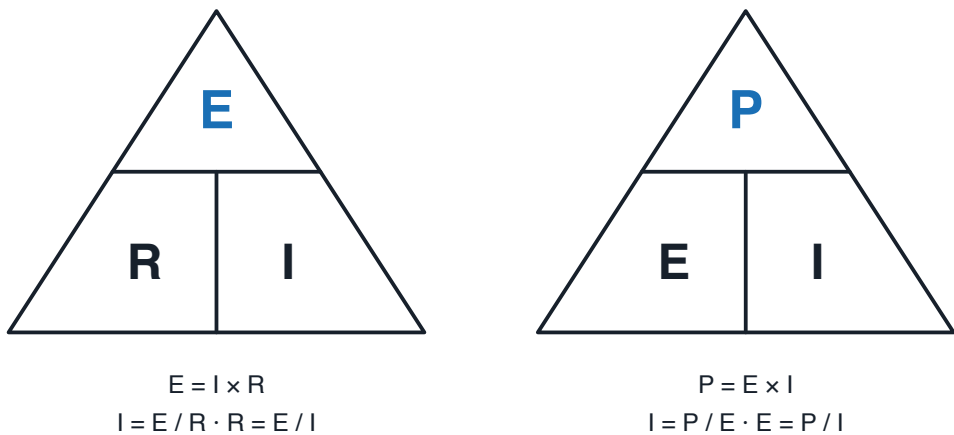
Property	Stores energy in	Unit
Capacitance	An electric field	Farad
Inductance	A magnetic field	Henry
Impedance	— (the opposition to AC current)	Ohm

- Abbreviations: **kHz** for kilohertz, **MHz** for megahertz.

Power

$$P = I \times E$$

Data	Result
13.8 V and 10 A	138 W
12 V and 2.5 A	30 W
120 W at 12 V	$I = 120 / 12 = 10 \text{ A}$



Ohm's law and power triangles

Source: NCVEC 2026-2030 Technician question pool (subelement T5).

T5D Ohm's law and series or parallel circuits

$E = I \times R$ $I = \frac{E}{R}$ $R = \frac{E}{I}$

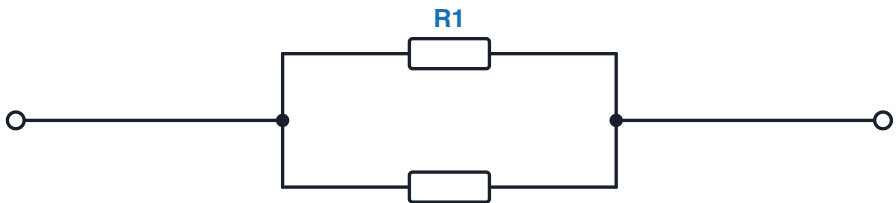
Data	Calculation
3 A at 90 V	$R = 90/3 = 30\ \Omega$
12 V, 1.5 A	$R = 8\ \Omega$
4 A from 12 V	$R = 3\ \Omega$
120 V across 80 Ω	$I = 1.5\text{ A}$
200 V across 100 Ω	$I = 2\text{ A}$
240 V across 24 Ω	$I = 10\text{ A}$
0.5 A through 2 Ω	$E = 1\text{ V}$
1 A through 10 Ω	$E = 10\text{ V}$
2 A through 10 Ω	$E = 20\text{ V}$

Series and parallel

Circuit	Always the same through or across all components
Series	The current
Parallel	The voltage



Series: $R = R1 + R2 + R3$



Parallel: $1/R = 1/R1 + 1/R2$ (two: $R1 \cdot R2 / (R1 + R2)$)

Resistors in series and in parallel

Source: NCVEC 2026-2030 Technician question pool (subelement T5).

Electronic and Electrical Components

T6A Basic components

Component	Feature
Resistor	Opposes the flow of current
Potentiometer	A variable resistance , often used as a volume control
Capacitor	Conductive surfaces separated by an insulator ; stores energy in an electric field
Inductor	Usually a coil of wire ; stores energy in a magnetic field
SPST switch	Single pole, single throw: one circuit, on or off (component 3 of figure T-2)
SPDT switch	Switches one circuit between two others

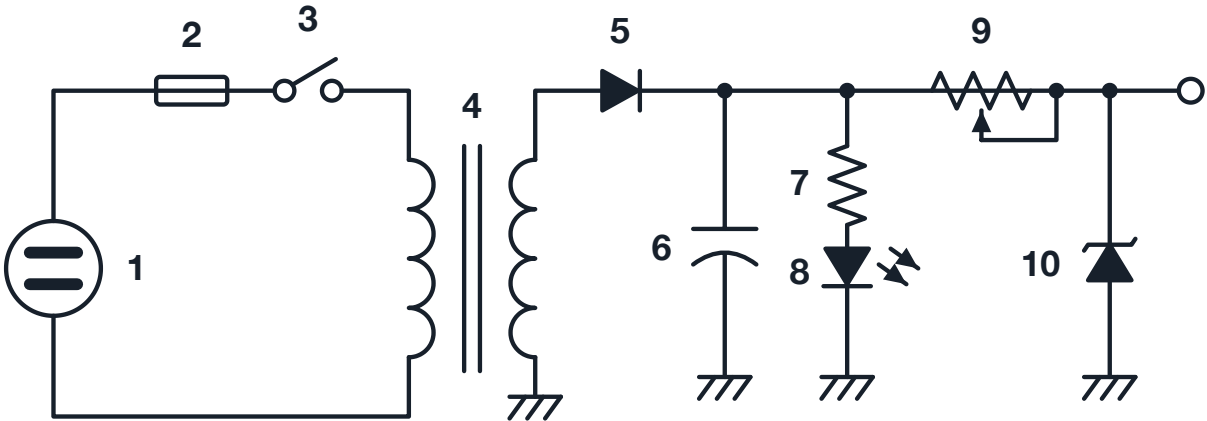


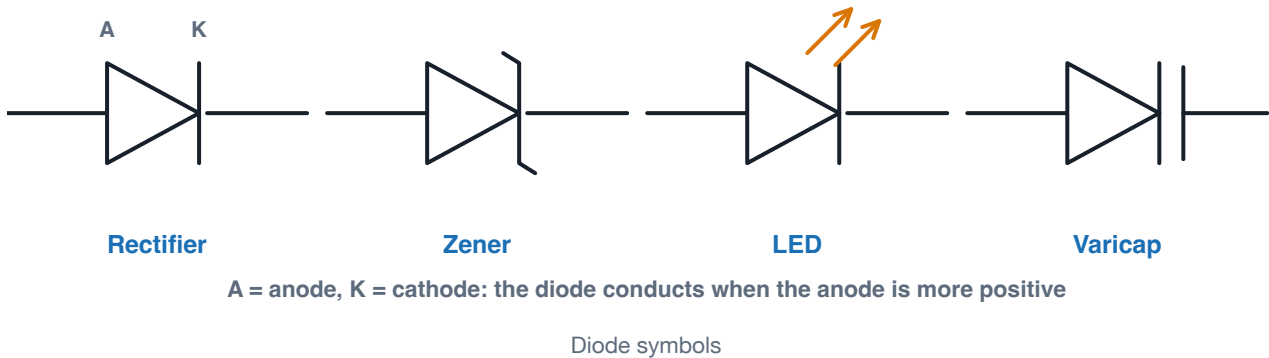
Figure T-2

Batteries

Chemistry	Rechargeable?
Nickel-metal hydride, lithium-ion, lead-acid	Yes
Carbon-zinc	No

Source: NCVEC 2026-2030 Technician question pool (subelement T6).

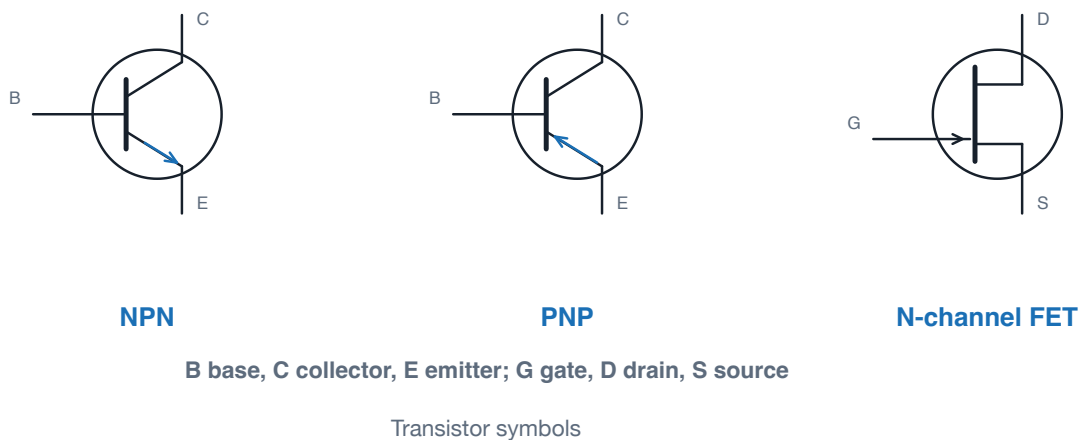
T6B Semiconductors



Diodes

- A **diode** lets current flow in **one direction only**.
- Its electrodes are the **anode** and the **cathode**; the cathode is often marked with a **stripe**.
- Its **forward voltage drop** is lower in some types than in others.
- An **LED** emits light when **forward current** flows.

Transistors



- A transistor is made of **three regions** of semiconductor material; it can work as an **electronic switch** and provide **power gain**.
- Bipolar junction transistor electrodes: **emitter, base, collector**.
- **FET** stands for **field-effect transistor**: its electrodes are **gate, drain and source**.

Gain

Gain is the output signal relative to the input signal: **voltage, current or power**.

Source: NCVEC 2026-2030 Technician question pool (subelement T6).

T6C Reading schematics

A **schematic** is an electrical diagram drawn with standard symbols. It accurately shows the **component connections**, not their physical layout.

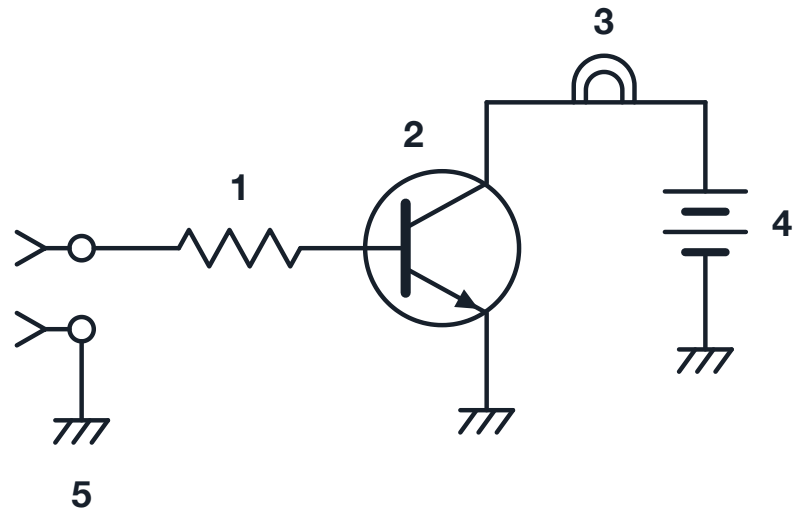


Figure T-1

Figure T-1	Component
1	Resistor
2	Transistor
3	Lamp
4	Battery

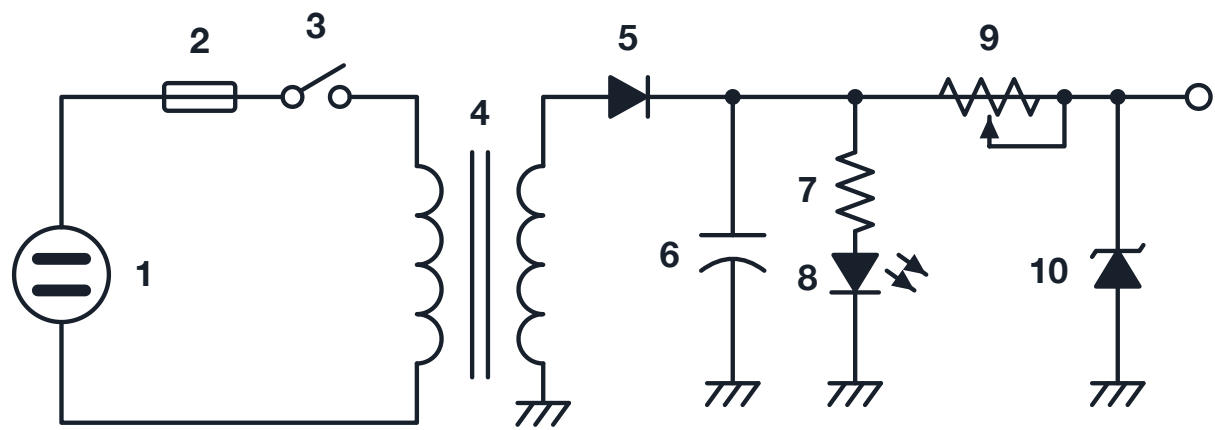


Figure T-2

Figure T-2	Component
3	Single-pole single-throw switch
4	Transformer
6	Capacitor

Figure T-2	Component
8	Light-emitting diode
9	Variable resistor

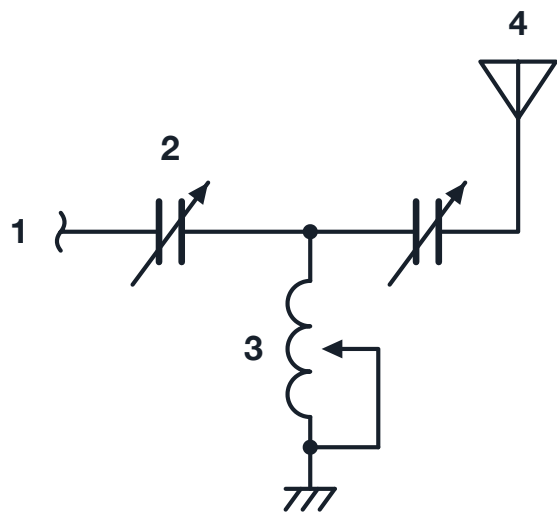


Figure T-3

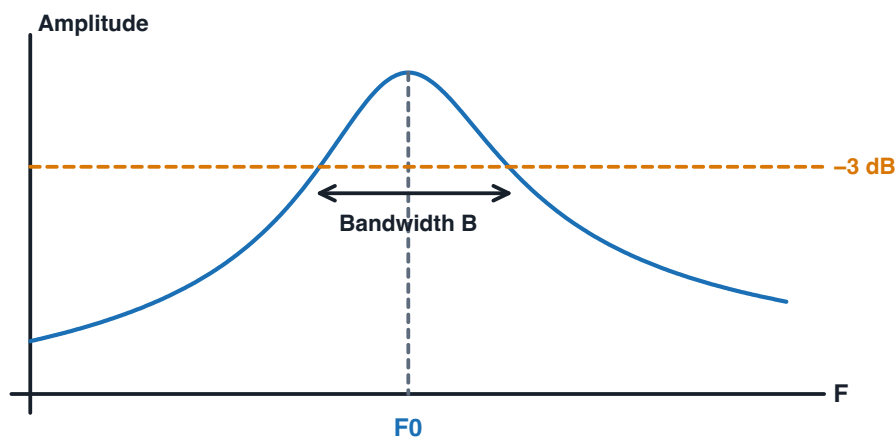
Figure T-3	Component
3	Variable inductor
4	Antenna

Source: NCVEC 2026-2030 Technician question pool (subelement T6).

T6D Component functions

Device	Function
Rectifier	Changes alternating current into a varying direct current
Relay	An electrically controlled switch
Regulator	Controls the voltage from a power supply
Transformer	Changes 120 V AC to a lower AC voltage
Meter	Displays an electrical quantity as a numeric value
LED	A common visual indicator
Integrated circuit	Several semiconductors and other components in one package
Shielded wire	Prevents coupling of unwanted signals to or from the wire

- In figure T-1, the transistor (component 2) **controls the flow of current**.
- An **inductor and a capacitor**, in series or in parallel, form a **resonant** (tuned) circuit.



$Q = F_0 / B$: the higher the Q, the narrower the curve

Resonance curve

Source: NCVEC 2026-2030 Technician question pool (subelement T6).

Practical Circuits

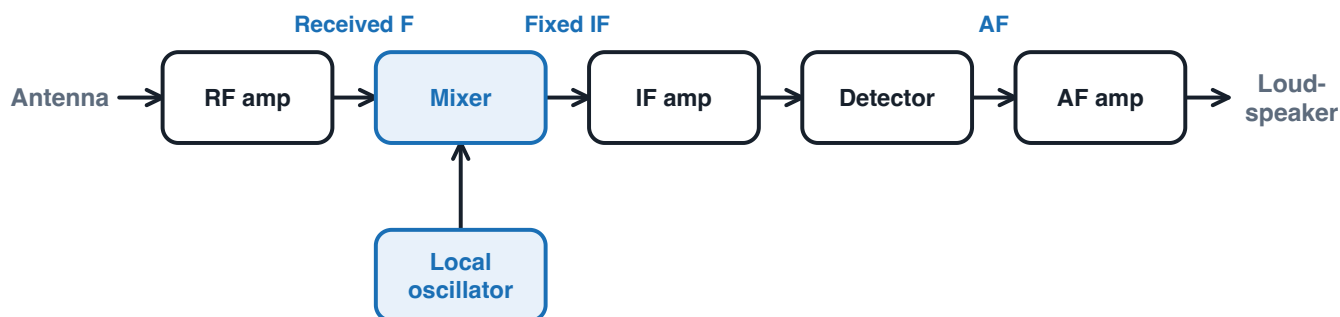
T7A Station equipment

Term	Meaning
Transceiver	A receiver and a transmitter combined
Oscillator	Generates a signal at a specific frequency
Mixer	Converts a signal from one frequency to another
Modulation	Combining speech with an RF carrier
Transverter	Converts a transceiver's RF input and output to another band
RF power amplifier	Added to a transceiver's output to increase power
VFO	Sets the receive and transmit frequency
PTT input	Switches to transmit when grounded

- On some VHF amplifiers, an SSB or CW-FM switch sets the amplifier for **proper operation in the selected mode**.

Receiver performance

Term	Meaning
Sensitivity	The ability to detect a signal
Selectivity	The ability to discriminate between signals



Superheterodyne receiver

Source: NCVEC 2026-2030 Technician question pool (subelement T7).

T7B Interference and troubleshooting

Causes of interference

- **Fundamental overload, harmonics** and **spurious emissions** can all cause RF interference.
- A broadcast radio picks up an amateur signal when it **cannot reject strong signals** outside its band.

Helping your neighbors

- If a neighbor reports interference, first make sure your station works properly and does **not interfere with your own radio or TV**.
- A **filter at the antenna input** of the affected receiver can block your signal.
- For cable TV interference (not fiber), first check that **all coaxial connectors** are installed properly.
- If a device in a neighbor's home interferes with you: work with the neighbor to **identify the device**, and politely explain that FCC rules prohibit devices that cause interference.
- A **band-reject filter** reduces interference to a 2 m transceiver from a nearby commercial FM station.

Your own signal

Problem	Cause or fix
FM over-deviation	Talk farther from the microphone
Distorted audio through a repeater	Off frequency, speaking too loudly, or a bad location
Distorted voice from RF feedback	A clip-on ferrite choke on the microphone cable
Low output from a solid-state transceiver	High SWR

Source: NCVEC 2026-2030 Technician question pool (subelement T7).

T7C Dummy loads, SWR and coaxial cable

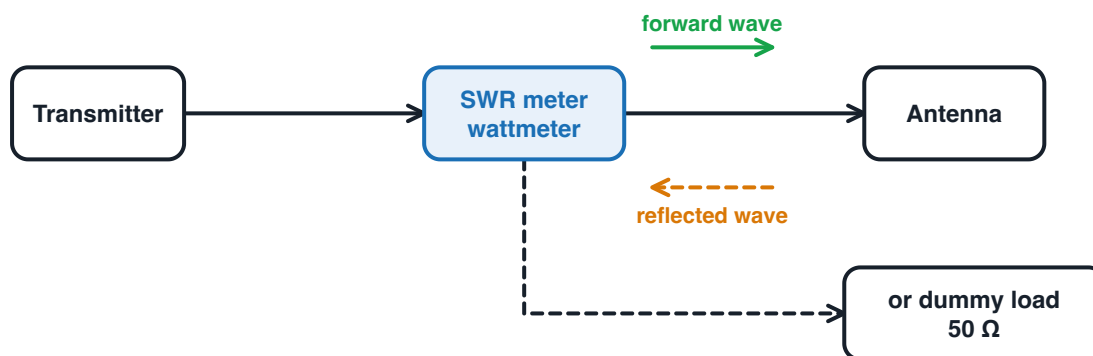
Dummy load

- Lets you **test without transmitting over the air**.
- A **50 Ω non-inductive resistor** on a heat sink.

SWR

Reading	Meaning
1:1	Perfect match between antenna and feed line
4:1	Impedance mismatch

- Measured with a **directional wattmeter** (SWR meter); an **antenna analyzer** shows whether the antenna is resonant at the desired frequency.
- Solid-state transmitters **reduce power** as SWR rises, to **protect the output transistors**.
- Power lost in a feed line is **converted into heat**.



SWR = 1: antenna perfectly matched, no reflected wave

Measuring SWR and power

Coaxial cable

- **Moisture** causes coax failure; a jacket resistant to **ultraviolet light** keeps water out.
- **Foam dielectric** cable has **less loss** per foot than solid dielectric.

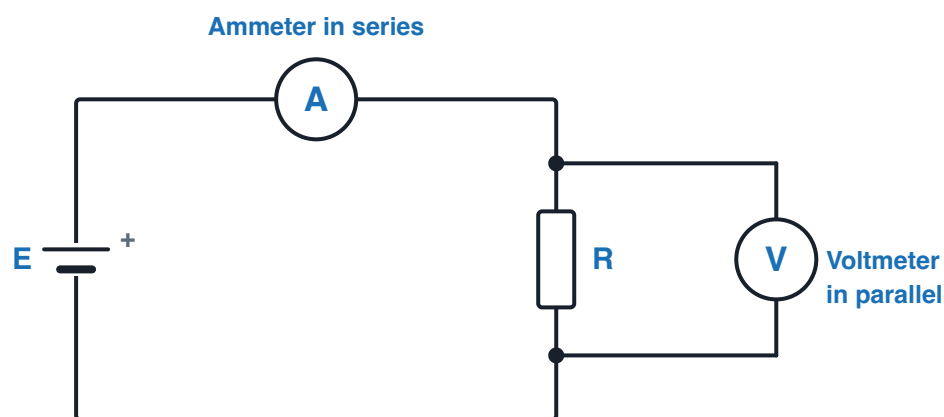
Source: NCVEC 2026-2030 Technician question pool (subelement T7).

T7D Meters and soldering

Meters

Measurement	Instrument	Connection
Voltage (electric potential)	Voltmeter	In parallel
Current	Ammeter	In series
Resistance	Ohmmeter: applies a small current and measures the resulting voltage	Circuit not powered

- A **multimeter** measures voltage and resistance (and current).
- Measuring voltage on the **resistance setting** can damage a multimeter.
- Across a large discharged capacitor, an ohmmeter shows resistance **increasing with time**.



Ammeter: very low internal resistance; voltmeter: very high

Connecting a voltmeter and an ammeter

Soldering

- Never use **acid-core solder** for electronics.
- A **cold** tin-lead joint has a **rough or lumpy** surface.

Source: NCVEC 2026-2030 Technician question pool (subelement T7).

Signals and Emissions

T8A Modulation and bandwidth

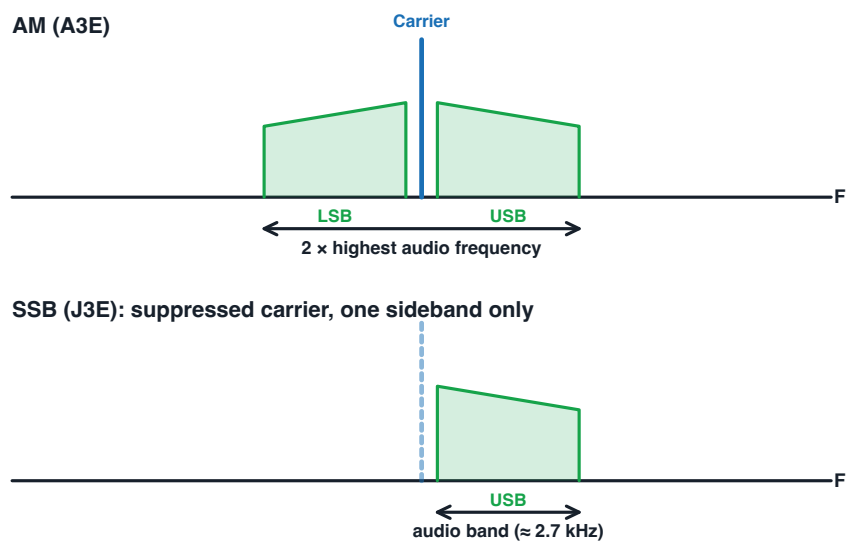
Which mode where?

Mode	Use
SSB (a form of AM)	Long-distance, weak-signal voice on VHF and UHF; upper sideband on 10 m, VHF and UHF
FM or PM	VHF/UHF voice repeaters and packet radio
CW	The narrowest signal

Bandwidths

Signal	Approximate bandwidth
CW	150 Hz
SSB voice	3 kHz
FM voice on VHF repeaters	10 to 15 kHz
AM fast-scan TV	About 6 MHz

- SSB has a **narrower bandwidth** than FM.
- A drawback of FM: **only one signal** can be received at a time (capture effect).



AM and SSB spectrum

Source: NCVEC 2026-2030 Technician question pool (subelement T8).

T8B Amateur satellites

Beacons and telemetry

- A **satellite beacon** transmits **status information**: the **health and status** of the satellite (telemetry).
- **Anyone** may receive telemetry from an amateur satellite.

Tracking

- A tracking program uses the **Keplerian elements** as input.
- It gives the satellite's real-time track, the **time, azimuth and elevation** of each pass, and the **Doppler-shifted** frequency.
- **Doppler shift** is the change in frequency caused by the **relative motion** between the satellite and the station.
- A **LEO** satellite (low Earth orbit) goes round in about **100 minutes**.
- **Spin fading** comes from the **rotation** of the satellite and its antennas.

Operating

- Satellites use **SSB, FM and CW/data**.
- **U/V mode**: uplink on **70 cm**, downlink on **2 m**.
- Too much uplink power **blocks access** for other users: on a linear transponder, your downlink signal should be about **as strong as the beacon**.

Source: NCVEC 2026-2030 Technician question pool (subelement T8).

T8C Operating activities and internet linking

On the air

- **Radio direction finding** locates noise sources or jamming; a hidden transmitter hunt needs a **directional antenna**.
- **Contesting** means contacting as many stations as possible in a set time; send **only the minimum** information: identification and the exchange.
- A **grid locator** is a letter-number designator for a geographic location.

Internet linking

System	What it is
VoIP	Voice over the internet using digital techniques
IRLP	Connects repeaters and other amateur systems via the internet; accessed over the air with DTMF tones
EchoLink	Lets a station transmit through a repeater without a radio ; you must register your call sign and prove your license
Gateway	An amateur station that connects other stations to the internet

Source: NCVEC 2026-2030 Technician question pool (subelement T8).

T8D Digital modes

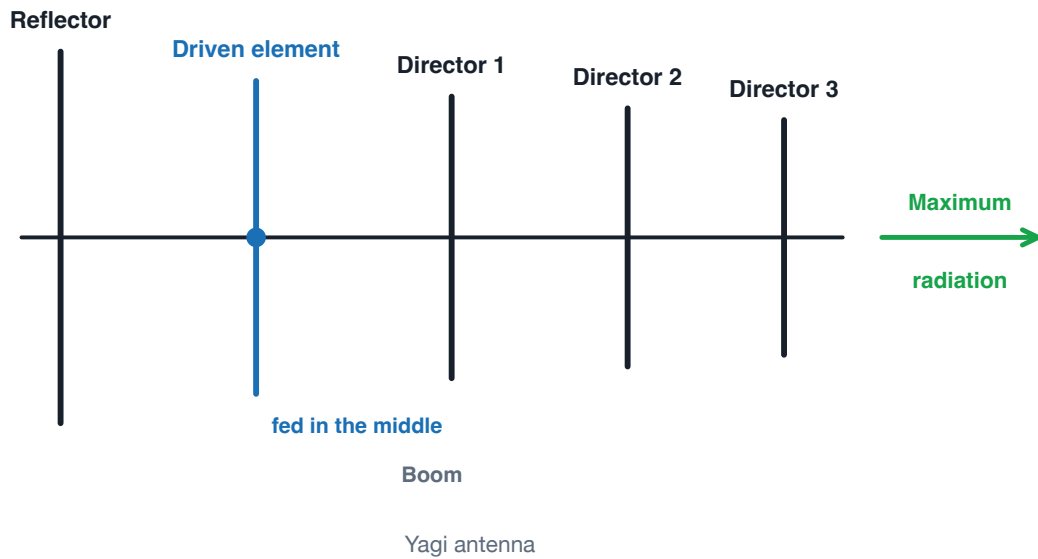
Mode	Description
CW	Another name for Morse code
FT8	A digital mode for low signal-to-noise operation (WSJT-X, which also handles EME, beacons and meteor scatter)
PSK	Phase shift keying
Packet radio	Includes a header with the destination call sign, a checksum for error detection and ARQ
APRS	Sends GPS position, text messages and weather data ; real-time tactical communications with a map of stations
DMR	Time-multiplexes two digital voice signals on one 12.5 kHz repeater channel
Mesh network	An amateur data network on commercial Wi-Fi equipment with modified firmware
NTSC	An analog fast-scan color TV signal

- Packet radio, IEEE 802.11 and FT8 are all digital modes.
- **ARQ**: the receiving station detects errors and **requests a retransmission**.

Source: NCVEC 2026-2030 Technician question pool (subelement T8).

Antennas and Feed Lines

T9A Antenna basics

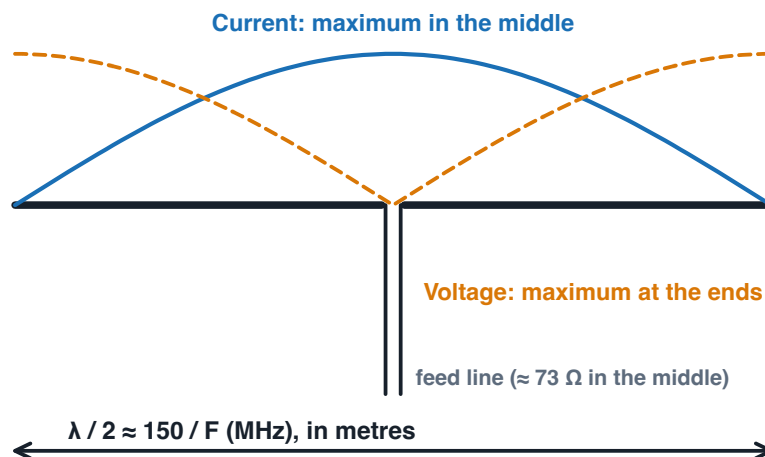


Definitions

- A **beam** antenna **concentrates** signals in one direction; the **Yagi** has the most gain among simple antennas.
- **Gain** is the increase in signal strength in a given direction compared with a **reference antenna**.
- **Polarization** is the orientation of the **electric field**.
- **Loading**: making an antenna **electrically longer** by inserting **inductors**.

Length and resonance

- **Shortening** a dipole **raises** its resonant frequency.
- A **19-inch** vertical on 2 m is a resonant **quarter wave**.
- A half-wave dipole radiates most strongly **broadside**.



Half-wave dipole: current and voltage

Mobile and handheld antennas

- The short flexible antenna of a handheld has **low efficiency**.
- Inside a vehicle without an outside antenna, the signal is **weakened by the metal body** (shielding).
- A **5/8-wave** whip has **more gain** than a 1/4 wave for VHF/UHF mobile.

Source: NCVEC 2026-2030 Technician question pool (subelement T9).

T9B Feed lines, connectors and SWR

Coaxial cable

- The most common impedance is **50 Ω** ; coax is popular because it is **easy to use** with few installation constraints.
- Loss **increases with frequency**. **RG-213** has less loss than RG-58; **air-insulated hardline** has the lowest loss.
- Sources of loss: **water** in connectors, **high SWR**, **many connectors**.

Connectors

Connector	Use
PL-259	Common at HF and VHF
Type N	Best above 400 MHz
BNC	Low power and test gear

Tape outdoor connectors (PL-259, BNC, N) carefully for weather protection.

SWR and matching

- **SWR** measures how well a load is **matched** to a transmission line.
- **Erratic SWR**: a **loose connection** in the antenna or feed line.
- An **antenna tuner** matches the antenna system impedance to the transceiver's output impedance.

Source: NCVEC 2026-2030 Technician question pool (subelement T9).

Safety

T0A Electrical safety

Current and the body

Current through the body may **heat tissue**, **disrupt the electrical functions of cells** and cause **involuntary muscle contractions**.

Mains wiring and fuses

- In US 120 V AC cable, the **black** wire is the **hot** conductor.
- A fuse or circuit breaker goes **in series with the hot conductor only**; it **removes power** in case of overload.
- Never replace a 5 A fuse with a 20 A fuse: excessive current could cause a **fire**.

Protecting yourself

- Use **three-wire cords** and plugs, connect all equipment to a **common safety ground**, and **discharge** high-voltage capacitors before working.
- Right after a power supply is turned off, **filter capacitors** can still hold a charge.
- For high voltages, use a voltmeter and leads **rated** for those voltages.

Batteries

- Shorting the terminals of an unprotected 12 V battery can cause **burns, fire or an explosion**.
- Charging or discharging it too fast causes **overheating or out-gassing**.

Lightning

- Install the **lightning arrester** on a **grounded panel** where feed lines enter the building.
- **Bond** all ground rods together with heavy wire or strap.

Source: NCVEC 2026-2030 Technician question pool (subelement T0).

T0B Towers and antenna installation

Climbing

- Get **training**, wear an **approved climbing harness**, and stay **tied off** at all times.
- **Never** climb without a helper or observer.
- A **crank-up** tower must not be climbed unless retracted or fitted with mechanical safety locks.
- A **safety wire** through a turnbuckle keeps it from **loosening** with vibration.

Power lines

- Stay clear of **overhead power lines**.
- Leave enough distance that if the antenna falls, no part comes within **10 feet** of the power wires.
- Never attach an antenna to a **utility pole**: it could touch high-voltage lines.

Grounding

- Lightning ground connections must be **short and direct, without sharp bends**.
- A tower is grounded with **separate eight-foot ground rods** for each leg, bonded to the tower and to each other.
- Grounding requirements come from **local electrical codes**.

Source: NCVET 2026-2030 Technician question pool (subelement T0).

T0C RF exposure

What RF radiation is

- Radio signals are **non-ionizing** radiation: they do not have enough energy to cause chemical changes in cells or damage DNA.
- Touching an antenna while transmitting can cause an **RF burn**.

Exposure limits

- Limits vary with frequency because the body **absorbs more RF** at some frequencies; of the amateur bands, **50 MHz** has the lowest maximum permissible exposure.
- Exposure depends on **frequency and power**, **distance** from the antenna and the antenna's **radiation pattern**.
- **Duty cycle** is the percentage of time a transmitter is transmitting; it affects the **average** exposure. Going from 100% to 50% duty cycle **doubles** the allowable power density.

Compliance

- Evaluate your station **by calculation** (FCC OET Bulletin 65 or computer modeling) or **by measurement** with calibrated equipment.
- **Re-evaluate** whenever you change the transmitter or antenna system.
- To reduce exposure, **relocate antennas**.
- The **station licensee** is responsible for making sure nobody is exposed above the FCC limits.

Source: NCVEC 2026-2030 Technician question pool (subelement T0).

Formulas

The formulas used in the Technician question pool.

Electricity

Quantity	Formula
Ohm's law	$E = I \times R; I = \frac{E}{R}; R = \frac{E}{I}$
Power	$P = I \times E$
Battery run time	Ampere-hours ÷ average current (hours)

Waves

Quantity	Formula
Wavelength (meters)	$\lambda = \frac{300}{f \text{ (MHz)}}$
Quarter-wave vertical (inches)	About 19 inches on 2 meters

Decibels

dB	Power ratio
3	× 2
6	× 4
10	× 10

Prefixes

Prefix	Factor
G (giga)	1,000,000,000
M (mega)	1,000,000
k (kilo)	1,000
m (milli)	0.001
μ (micro)	0.000 001
p (pico)	0.000 000 000 001

Source: NCVEC 2026-2030 Technician question pool.

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