



CANADIAN BASIC AMATEUR RADIO EXAM PREPARATION

SECTION 3 C STATION ASSEMBLY, PRACTICE & SAFETY





**THIS COURSE IS BEING TAUGHT TO THE JULY 15, 2025 UPDATE
OF THE CANADIAN BASIC AMATEUR RADIO EXAM QUESTIONS.**

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B-003-001: HF STATION SETUP AND COMPONENTS

B-003-002: COMPONENTS AND FUNCTIONS IN AN FM TRANSMITTER

B-003-003: STAGES IN A SUPERHETERODYNE RECEIVER FOR FM

B-003-004: BASIC STRUCTURE AND OPERATION OF A CW TRANSMITTER

B-003-005: COMPONENTS IN AN SSB/CW RECEIVER

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**B-003-007: ROLE AND FUNCTIONS OF A SOUND CARD INTERFACE IN
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B-003-021: RF EXPOSURE SAFETY AT UHF/MICROWAVE FREQUENCIES

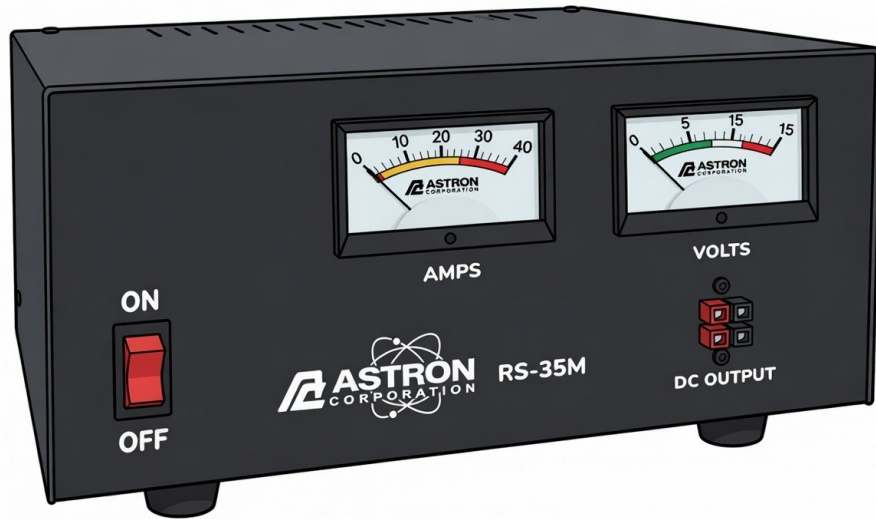




QUESTION SECTION B-003-001:

HF STATION SETUP AND COMPONENTS

B-003-001: HF STATION SETUP AND COMPONENTS



POWER SUPPLY

- A RELIABLE DC POWER SOURCE, TYPICALLY 13.8V AT HIGH AMPERAGE (EX: 20-35A FOR BASE STATIONS), CONVERTS AC MAINS TO STABLE DC TO POWER THE TRANSCEIVER AND ACCESSORIES.

B-003-001: HF STATION SETUP AND COMPONENTS



POWER SUPPLY

- ALTERNATIVELY, YOU CAN PROVIDE STATION POWER THROUGH A 12V BATTERY INSTEAD OF A POWER SUPPLY FOR OFF-GRID, PORTABLE OR EMERGENCIES.

B-003-001: HF STATION SETUP AND COMPONENTS



TRANSCEIVER (RADIO/RIG)

- THE CORE RADIO UNIT COMBINING TRANSMITTER AND RECEIVER FUNCTIONS, HANDLING HF/VHF/UHF BANDS WITH MODES LIKE SSB, CW, FM, AND DIGITAL. MODERN RIGS INCORPORATE WATERFALL DISPLAYS TO VISUALIZE THE RADIO SPECTRUM AND SIGNALS.

B-003-001: HF STATION SETUP AND COMPONENTS



LINEAR AMPLIFIER

- BOOSTS THE TRANSCEIVER'S OUTPUT POWER (EX: FROM 100W TO 1KW+), IMPROVING SIGNAL REACH FOR DX CONTACTS WHILE MAINTAINING SIGNAL LINEARITY TO AVOID DISTORTION.

B-003-001: HF STATION SETUP AND COMPONENTS



LOW PASS FILTER

- SUPPRESSES HARMONICS AND SPURIOUS EMISSIONS ABOVE THE OPERATING FREQUENCY TO COMPLY WITH REGULATIONS AND PREVENT INTERFERENCE.

B-003-001: HF STATION SETUP AND COMPONENTS



SWR BRIDGE/METER

- MEASURES STANDING WAVE RATIO TO ASSESS ANTENNA SYSTEM EFFICIENCY AND IMPEDANCE MATCH, HELPING TUNE FOR MINIMAL REFLECTED POWER.

B-003-001: HF STATION SETUP AND COMPONENTS



ANTENNA SWITCH

- **ALLOWS SELECTION BETWEEN MULTIPLE ANTENNAS OR SELECTING A DUMMY LOAD FOR TUNING.**

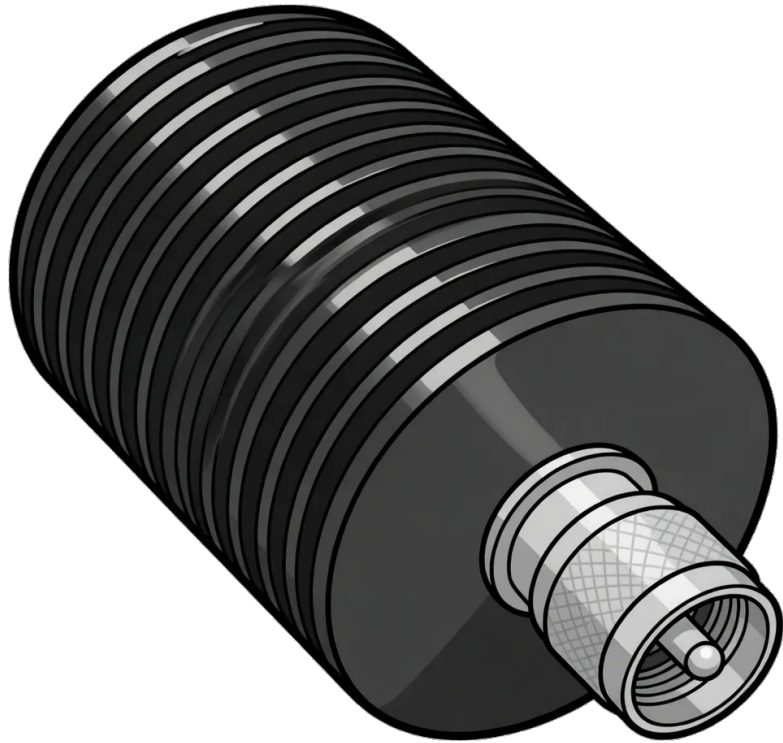
B-003-001: HF STATION SETUP AND COMPONENTS



ANTENNA TUNER

- MATCHES TRANSCEIVER IMPEDANCE (50 OHMS) TO THE ANTENNA/FEEDLINE FOR OPTIMAL POWER TRANSFER AND LOW SWR.

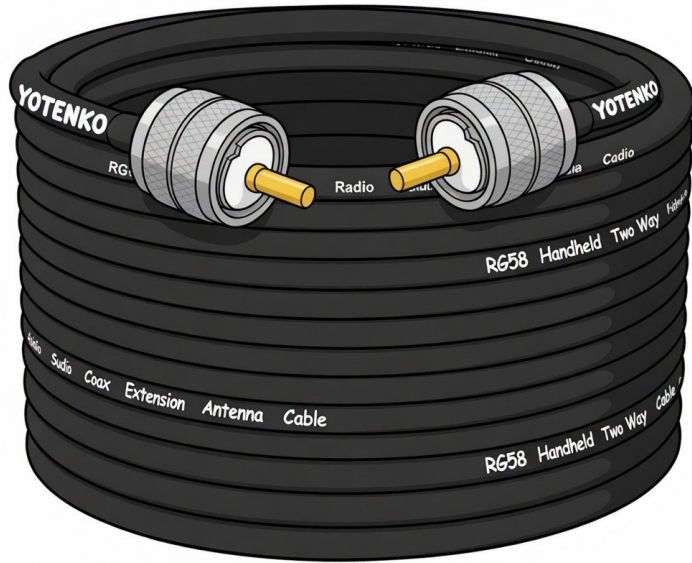
B-003-001: HF STATION SETUP AND COMPONENTS



DUMMY LOAD

- A NON-RADIATING RESISTOR (50 OHMS) ABSORBING RF ENERGY FOR SAFE TESTING OF TRANSMITTERS/AMPLIFIERS WITHOUT ON-AIR SIGNALS.

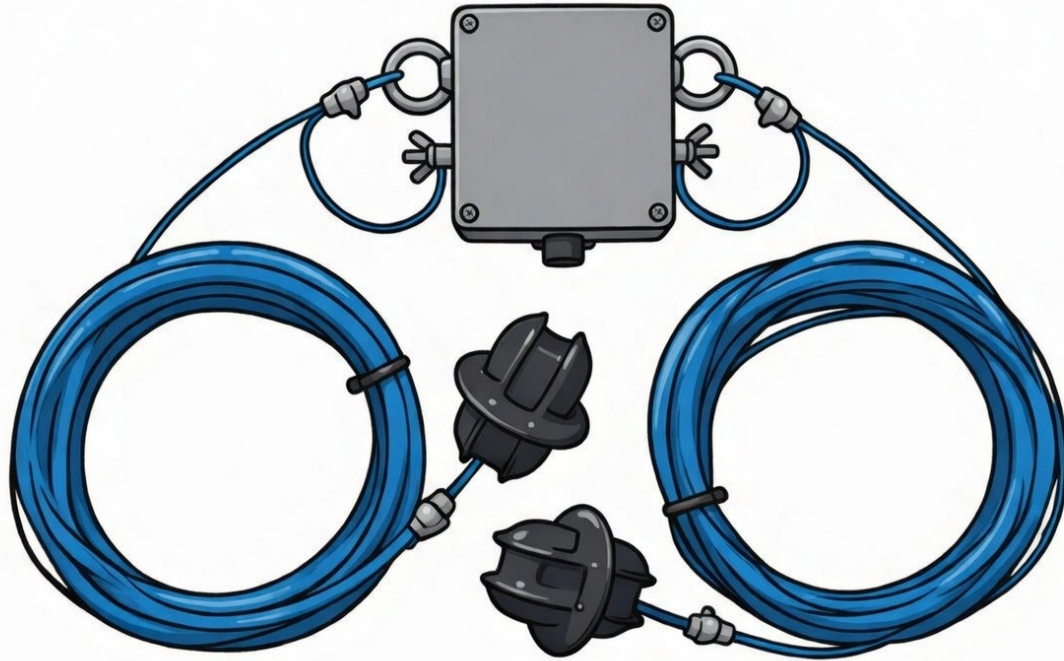
B-003-001: HF STATION SETUP AND COMPONENTS



FEEDLINE

- **THE CABLE THAT CONNECTS YOUR TRANSCEIVER (OR AMPLIFIER/TUNER) TO THE ANTENNA, CARRYING RF SIGNALS WITH MINIMAL LOSS WHILE SHIELDING AGAINST INTERFERENCE. MOST HAM RADIO SETUPS USE 50-OHM COAXIAL CABLE (COAX).**

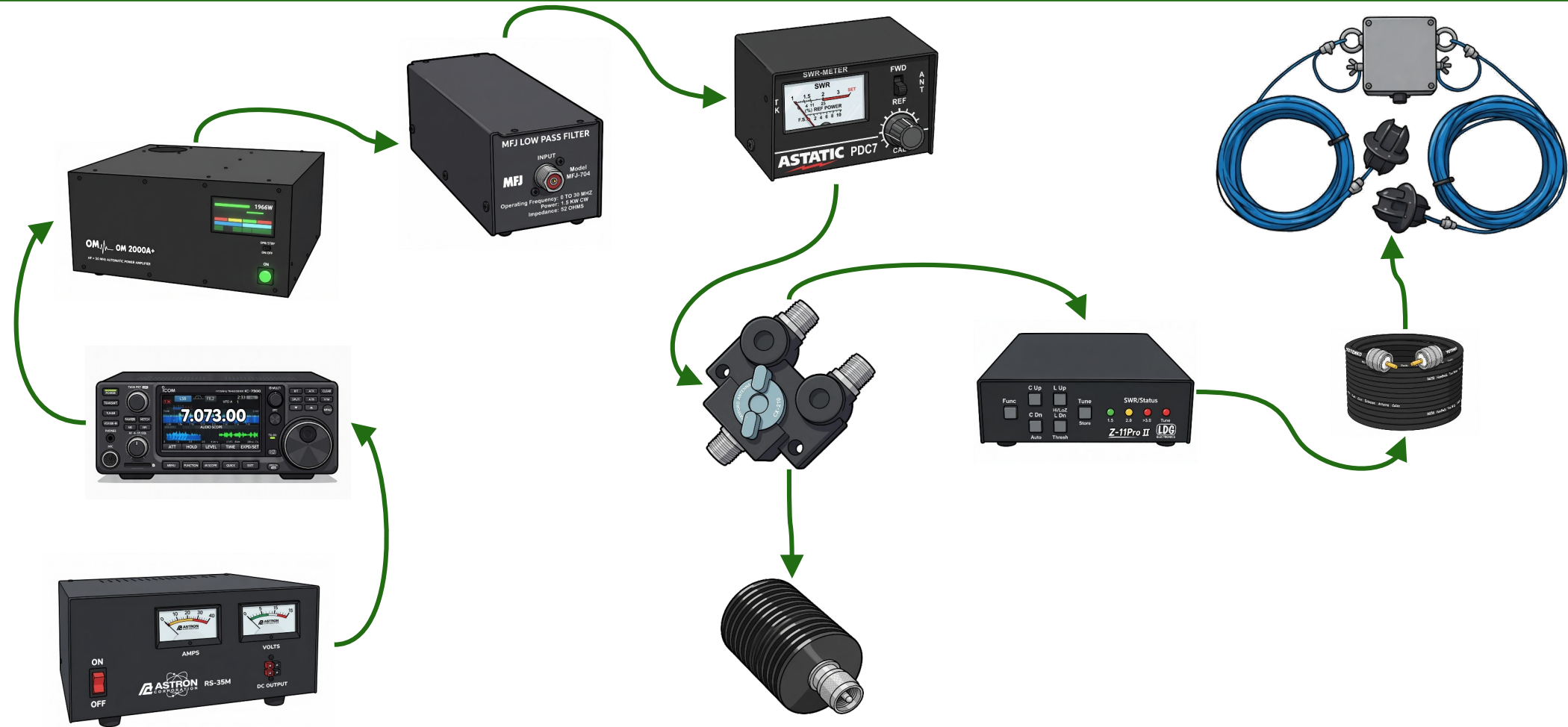
B-003-001: HF STATION SETUP AND COMPONENTS



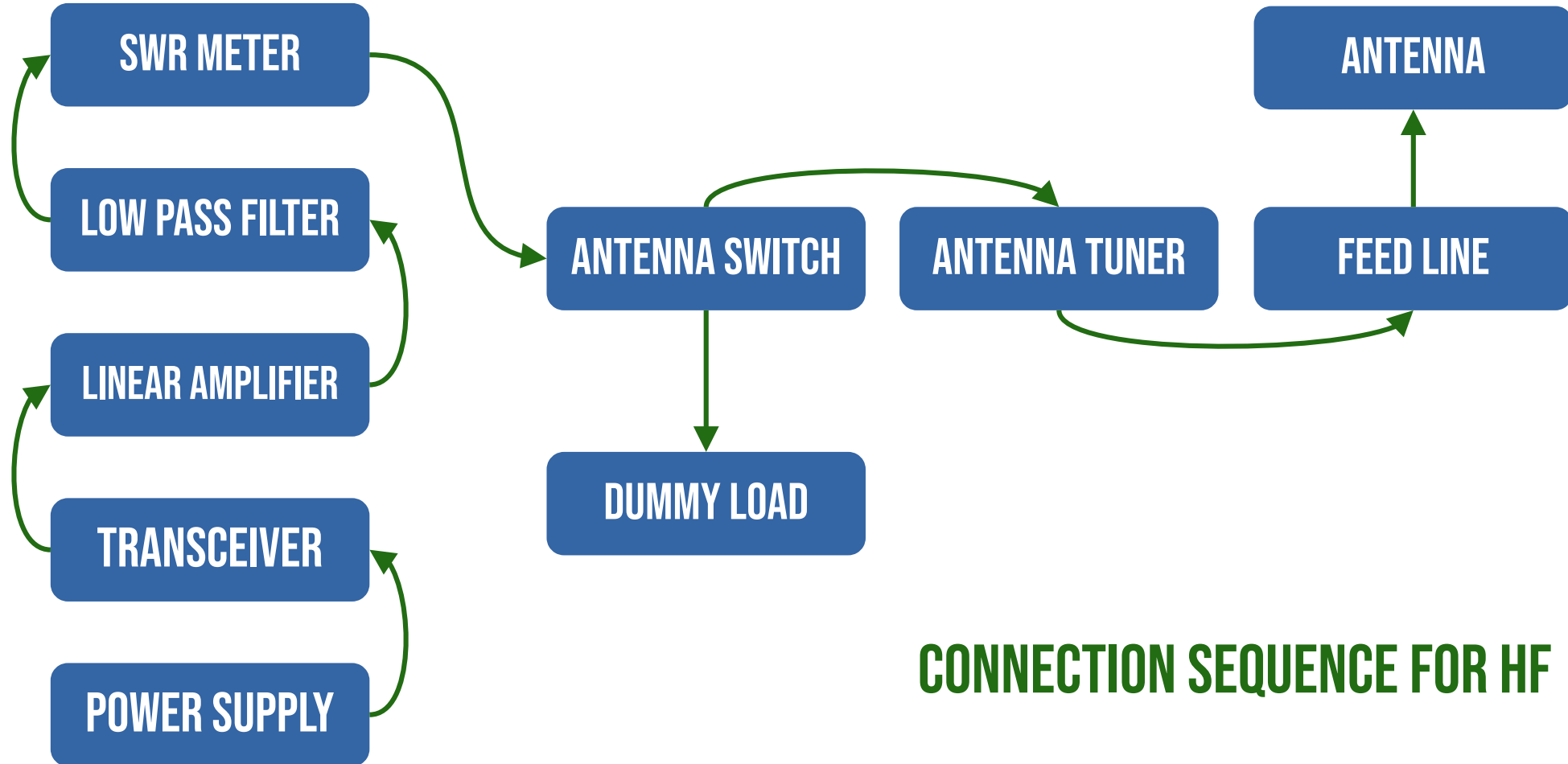
ANTENNA

- THE RADIATOR THAT CONVERTS ELECTRICAL RF ENERGY INTO ELECTROMAGNETIC WAVES (TRANSMIT) AND VICE VERSA (RECEIVE). PERFORMANCE DEPENDS ON DESIGN, HEIGHT, GROUND, ETC.
- DIPOLE ANTENNA SHOWN HERE.

B-003-001: HF STATION SETUP AND COMPONENTS



B-003-001: HF STATION SETUP AND COMPONENTS



CONNECTION SEQUENCE FOR HF

B-003-001: HF STATION SETUP AND COMPONENTS

LOW-PASS FILTER PLACEMENT AND PURPOSE

- A LOW-PASS FILTER (LPF) ATTENUATES FREQUENCIES ABOVE ITS CUT-OFF (TYPICALLY ~30-54 MHZ FOR HF), **REDUCING HARMONIC EMISSIONS** (MULTIPLES OF YOUR OPERATING FREQUENCY) THAT COULD CAUSE INTERFERENCE (EX: TO TV OR OTHER SERVICES).
- MODERN TRANSCEIVERS OFTEN HAVE BUILT-IN LPFS FOR BASIC HARMONIC REDUCTION. PLACEMENT IS CRITICAL: INSTALL THE LPF **AS CLOSE AS POSSIBLE** TO THE SOURCE OF HARMONICS (THE FINAL AMPLIFIER STAGE) TO CATCH SPURS BEFORE THEY REACH THE FEEDLINE, ANTENNA, OR EXTERNAL AMP.
 - WITHOUT EXTERNAL AMP: RIGHT AT TRANSCEIVER OUTPUT.
 - WITH EXTERNAL AMP: RIGHT AT AMP OUTPUT (AFTER THE AMP, WHICH CAN GENERATE ADDITIONAL HARMONICS).

B-003-001: HF STATION SETUP AND COMPONENTS

SWR METER AND MATCHING

- AN **SWR METER** (STANDING WAVE RATIO METER) MEASURES HOW WELL THE ANTENNA SYSTEM MATCHES THE TRANSMITTER'S OUTPUT IMPEDANCE (USUALLY 50 Ω). HIGH SWR INDICATES MISMATCH, CAUSING POWER LOSS, HEATING, OR POTENTIAL TRANSMITTER DAMAGE.
- **INSERT IT AFTER THE LPF** (SO IT SEES THE FILTERED/CLEAN SIGNAL) BUT BEFORE THE ATU OR ANTENNA SWITCH. IT HELPS TUNE THE ANTENNA OR ATU FOR MINIMUM SWR (IDEALLY 1:1 TO 2:1).

B-003-001: HF STATION SETUP AND COMPONENTS

ANTENNA TUNER AND OTHER ACCESSORIES

- AN **ANTENNA TUNER** (ATU OR "TRANSMATCH") MATCHES THE ANTENNA'S IMPEDANCE TO 50Ω , ALLOWING USE OF NON-RESONANT ANTENNAS OR MULTI-BAND OPERATION ON BANDS THE ANTENNA WASN'T DESIGNED FOR. IT OFTEN NEEDS READJUSTMENT WHEN CHANGING FREQUENCY OR BAND.
- OTHER KEY ACCESSORIES:
 - **DUMMY LOAD** — A NON-RADIATING 50Ω RESISTOR THAT DISSIPATES RF ENERGY SAFELY (USED FOR TESTING/TRANSMITTER CHECKS WITHOUT RADIATING).
 - **ANTENNA SWITCH** — SELECTS BETWEEN ANTENNAS, DUMMY LOAD, OR MULTIPLE FEEDS FOR CONVENIENCE/SAFETY.



QUESTION SECTION B-003-002:

COMPONENTS AND FUNCTIONS IN AN FM TRANSMITTER

B-003-002: COMPONENTS AND FUNCTIONS IN AN FM TRANSMITTER

ROLE OF THE MICROPHONE IN AN FM TRANSMITTER

- THE **MICROPHONE** CONVERTS SOUND WAVES (YOUR VOICE) INTO A VARYING ELECTRICAL AUDIO SIGNAL. THIS SIGNAL IS WEAK AND **NEEDS AMPLIFICATION** BEFORE IT CAN MODULATE THE TRANSMITTER.
- SOUND CREATES **PRESSURE VARIATIONS IN THE AIR** → THE MICROPHONE'S DIAPHRAGM VIBRATES → GENERATES A TINY ALTERNATING VOLTAGE (AUDIO SIGNAL) PROPORTIONAL TO THE SOUND.



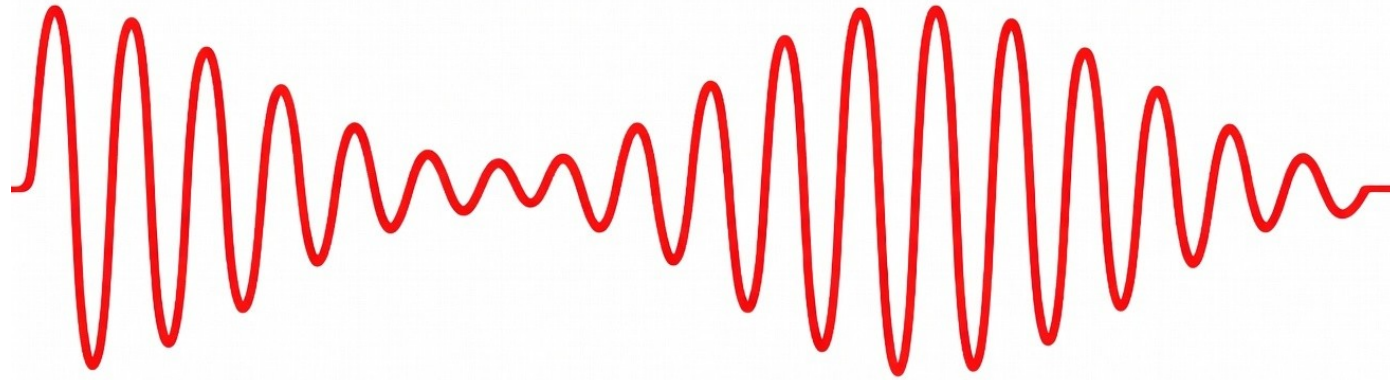
B-003-002: COMPONENTS AND FUNCTIONS IN AN FM TRANSMITTER

HOW FREQUENCY MODULATION (FM) OCCURS — THE MODULATOR STAGE

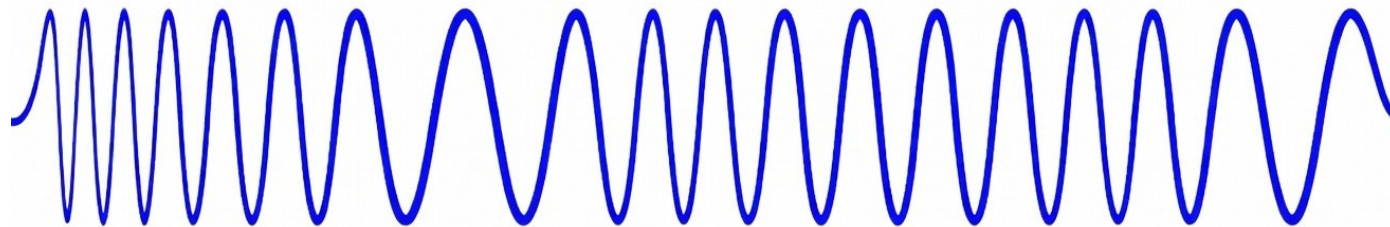
- IN FM, THE AUDIO SIGNAL FROM THE MICROPHONE (AFTER AMPLIFICATION) CHANGES (MODULATES) THE INSTANTANEOUS **FREQUENCY** OF THE CARRIER WAVE PRODUCED BY THE **OSCILLATOR**. LOUDER OR HIGHER-PITCHED SOUNDS CAUSE LARGER OR FASTER FREQUENCY SHIFTS.
- IN AM/SSB, THE OSCILLATOR RUNS AT A FIXED FREQUENCY, AND MODULATION CHANGES AMPLITUDE OR SIDEBANDS. IN CW, IT'S USUALLY UNMODULATED (JUST ON/OFF KEYING). IN FM, **THE MODULATOR DIRECTLY VARIES THE OSCILLATOR'S FREQUENCY** — THIS IS THE **DEFINING DIFFERENCE** FOR FM TRANSMISSION.

B-003-002: COMPONENTS AND FUNCTIONS IN AN FM TRANSMITTER

HOW FREQUENCY MODULATION (FM) OCCURS – THE MODULATOR STAGE



AM MODULATING
THE WAVE
AMPLITUDE



FM MODULATING
THE WAVE
FREQUENCY



B-003-002: COMPONENTS AND FUNCTIONS IN AN FM TRANSMITTER

FREQUENCY MULTIPLIER STAGE — REACHING THE OPERATING FREQUENCY

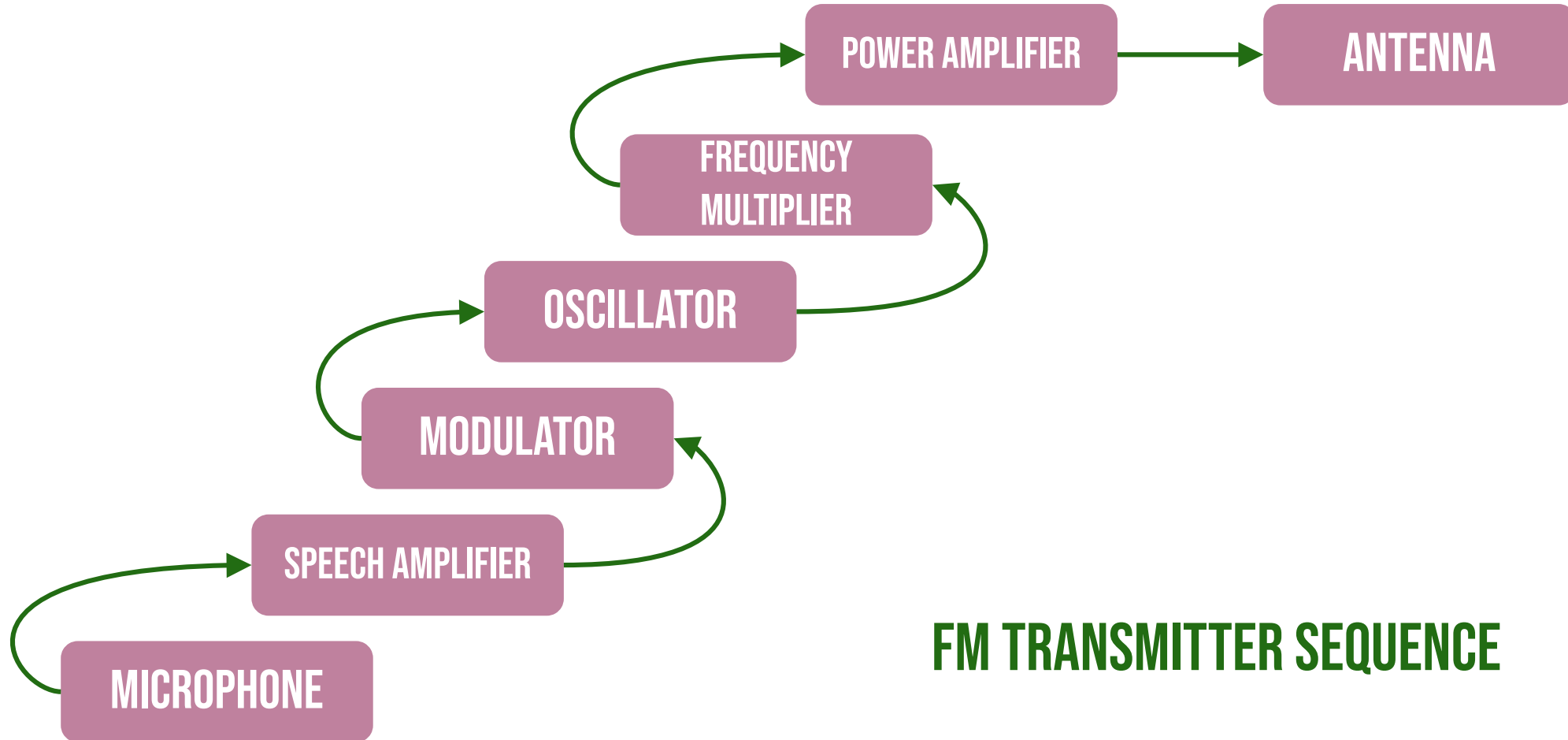
- THE INITIAL OSCILLATOR OFTEN RUNS AT A LOW FREQUENCY (FOR STABILITY). THE FREQUENCY MULTIPLIER MULTIPLIES THIS (EX: DOUBLES OR TRIPLES IT SEVERAL TIMES) TO REACH THE DESIRED TRANSMIT FREQUENCY (LIKE 2 M BAND ~144-148 MHZ). IMPORTANTLY, IT MULTIPLIES BOTH **THE CARRIER** AND THE DEVIATION, INCREASING MODULATION DEPTH.
- FREQUENCY MULTIPLIERS DELIBERATELY GENERATE AND SELECT **HARMONICS** **(MULTIPLES)** OF THE INPUT FREQUENCY. THESE HARMONICS BECOME THE NEW CARRIER — A "**USEFUL**" APPLICATION OF HARMONICS, UNLIKE UNWANTED ONES THAT CAUSE INTERFERENCE.

B-003-002: COMPONENTS AND FUNCTIONS IN AN FM TRANSMITTER

POWER AMPLIFIER — THE FINAL STAGE

- THE POWER AMPLIFIER (PA OR FINAL) BOOSTS THE LOW-POWER RF SIGNAL FROM THE MULTIPLIER TO THE FULL TRANSMIT POWER (EX: 5W, 50W, OR MORE).
- IT HANDLES THE HIGHEST CURRENT AND DISSIPATES THE MOST HEAT, SO IT CONSUMES THE MAJORITY OF DC INPUT POWER FROM THE SUPPLY.

B-003-002: COMPONENTS AND FUNCTIONS IN AN FM TRANSMITTER





QUESTION SECTION B-003-003:

STAGES IN A SUPERHETERODYNE RECEIVER FOR FM

B-003-003: STAGES IN A SUPERHETERODYNE RECEIVER FOR FM

THE FRONT-END: RF AMPLIFIER – FIRST STAGE AFTER THE ANTENNA

- THE RF (RADIO FREQUENCY) AMPLIFIER IS THE FIRST ACTIVE STAGE (**FRONT END**) AFTER THE ANTENNA. IT AMPLIFIES WEAK INCOMING SIGNALS WHILE ADDING AS LITTLE NOISE AS POSSIBLE.
- NOISE ADDED EARLY IN THE CHAIN GETS AMPLIFIED BY ALL LATER STAGES — SO THE **RF AMPLIFIER** (FRONT-END) NEEDS TO BE VERY LOW NOISE, ESPECIALLY ON VHF/UHF WHERE SIGNALS ARE OFTEN WEAK.

B-003-003: STAGES IN A SUPERHETERODYNE RECEIVER FOR FM

FREQUENCY CONVERSION: SETTING THE TUNE AND CREATING THE IF

- THE **LOCAL OSCILLATOR** (LO) **SETS THE RECEIVED FREQUENCY**. CHANGING ITS FREQUENCY CHANGES WHICH INCOMING SIGNAL GETS CONVERTED TO THE FIXED INTERMEDIATE FREQUENCY (IF) — THIS IS HOW YOU "TUNE" THE RADIO.
- THE **MIXER** COMBINES THE INCOMING RF SIGNAL WITH THE LO SIGNAL, PRODUCING SUM AND DIFFERENCE FREQUENCIES. THE DIFFERENCE (IF) IS FIXED (EX: 455 kHz FOR AM, 10.7 MHz FOR FM, OR 9 MHz/36 MHz IN MANY HF RIGS).

B-003-003: STAGES IN A SUPERHETERODYNE RECEIVER FOR FM

INTERMEDIATE FREQUENCY (IF) STAGES – SELECTIVITY AND GAIN

- THE **IF FILTER** (CRYSTAL, CERAMIC, OR MECHANICAL) IS SHARP AND FIXED-FREQUENCY. IT PASSES ONLY THE DESIRED SIGNAL'S BANDWIDTH WHILE **REJECTING** STRONG NEARBY STATIONS — THIS GIVES EXCELLENT SELECTIVITY.
- THE **IF AMPLIFIER** BOOSTS THE SIGNAL AFTER FILTERING TO A LEVEL STRONG ENOUGH FOR THE DETECTOR/DEMODULATOR TO WORK PROPERLY. IT PROVIDES MOST OF THE RECEIVER'S GAIN.

B-003-003: STAGES IN A SUPERHETERODYNE RECEIVER FOR FM

FM-SPECIFIC STAGES: LIMITER AND DISCRIMINATOR

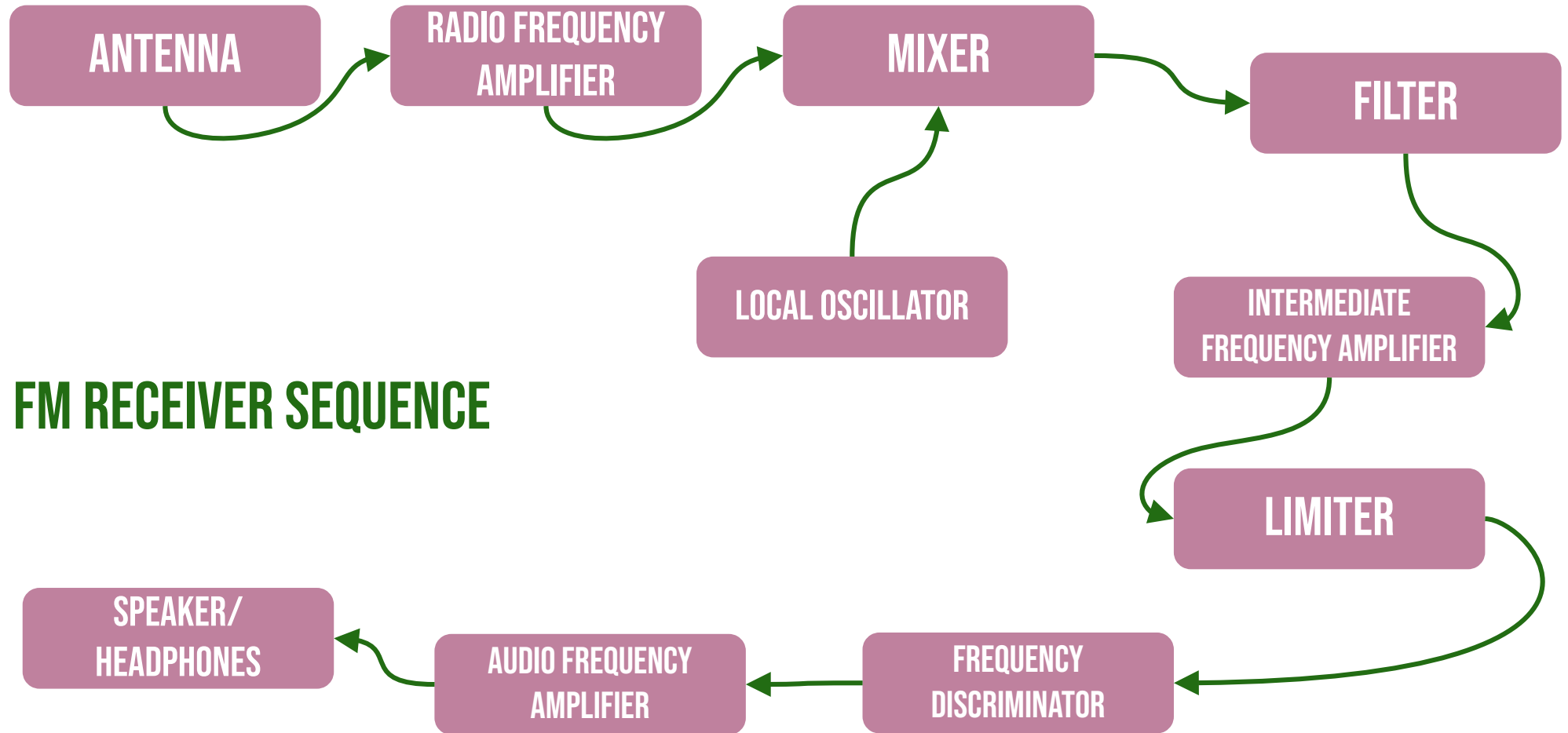
- FM CARRIES INFO IN FREQUENCY CHANGES, NOT AMPLITUDE. THE LIMITER CLIPS THE SIGNAL TO CONSTANT LEVEL (**REMOVES AMPLITUDE VARIATIONS**) STRIPPING OFF ANY AM NOISE OR FADING — THIS IS WHY FM IS NOISE-RESISTANT.
- THE **DISCRIMINATOR** (OR RATIO DETECTOR) **RECOVERS THE ORIGINAL AUDIO SIGNAL**. IT OUTPUTS VOLTAGE PROPORTIONAL TO FREQUENCY DEVIATION.

B-003-003: STAGES IN A SUPERHETERODYNE RECEIVER FOR FM

AUDIO STAGES – VOLUME AND SQUELCH

- THE **AF (AUDIO FREQUENCY) AMPLIFIER** BOOSTS THE DEMODULATED AUDIO TO DRIVE THE SPEAKER OR HEADPHONES. THE VOLUME POT ADJUSTS GAIN HERE.
- AF AMP HAS A **SQUELCH CIRCUIT** WHICH MUTES AUDIO WHEN NO SIGNAL (OR BELOW THRESHOLD) IS PRESENT, REDUCING NOISE BETWEEN TRANSMISSIONS. IT'S USUALLY IN THE AF CHAIN AFTER DETECTION.

B-003-003: STAGES IN A SUPERHETERODYNE RECEIVER FOR FM



FM RECEIVER SEQUENCE



QUESTION SECTION B-003-004:

BASIC STRUCTURE AND OPERATION OF A CW TRANSMITTER

B-003-004: BASIC STRUCTURE AND OPERATION OF A CW TRANSMITTER

THE OSCILLATOR – HEART OF THE CW TRANSMITTER

- **UNLIKE FM TRANSMITTERS (WHICH OFTEN USE A LOW-FREQUENCY OSCILLATOR + MULTIPLIERS), A BASIC CW TRANSMITTER GENERATES THE CARRIER DIRECTLY AT THE OPERATING FREQUENCY (EX: 7.040 MHz FOR 40M CW). THIS KEEPS THE DESIGN SIMPLE AND STABLE—NO FREQUENCY MULTIPLICATION NEEDED.**

B-003-004: BASIC STRUCTURE AND OPERATION OF A CW TRANSMITTER

POWER SUPPLY – DC EVERYWHERE

- IN A CW TRANSMITTER, **ALL STAGES RUN ON DC (DIRECT CURRENT)** FROM THE POWER SUPPLY. THE KEYING MODULATES THIS DC TO TURN THE RF CARRIER ON AND OFF—NO AC IS USED INTERNALLY.

B-003-004: BASIC STRUCTURE AND OPERATION OF A CW TRANSMITTER

DRIVER/BUFFER STAGE – KEEPING THE OSCILLATOR STABLE

- THE OSCILLATOR IS SENSITIVE—IF DIRECTLY CONNECTED TO THE POWER AMPLIFIER, **CHANGES IN LOAD** (ANTENNA TUNING, KEYING, TEMPERATURE) WOULD **"PULL" THE FREQUENCY**, CAUSING CHIRP OR INSTABILITY.
- THE DRIVER/BUFFER ISOLATES THE OSCILLATOR, PROVIDING CLEAN AMPLIFICATION WITHOUT AFFECTING IT.

B-003-004: BASIC STRUCTURE AND OPERATION OF A CW TRANSMITTER

KEYING – HOW MORSE CODE IS CREATED

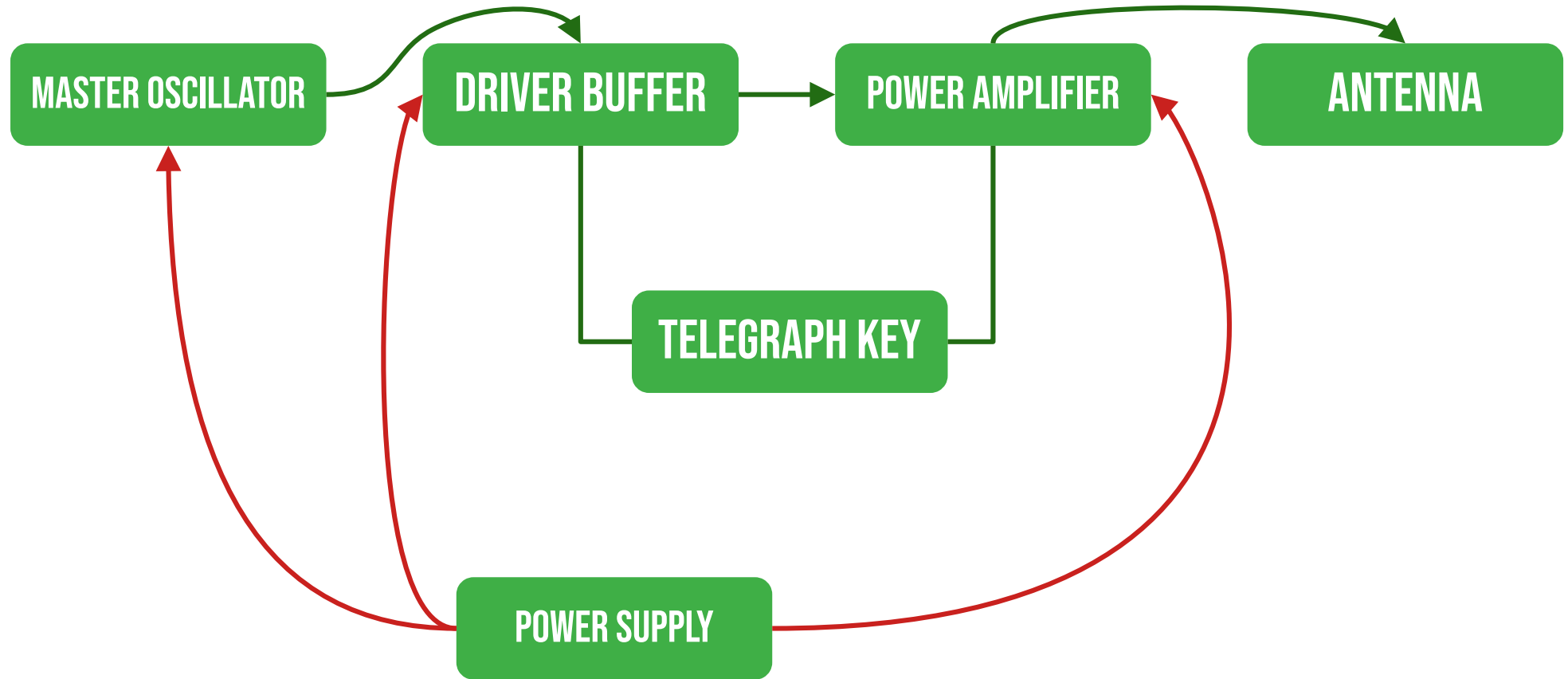
- PRESSING THE KEY ALLOWS DC TO FLOW TO THE OSCILLATOR, DRIVER, OR FINAL AMPLIFIER (DEPENDING ON DESIGN), TURNING THE RF CARRIER ON (KEY DOWN) OR OFF (KEY UP). THIS ON/OFF ACTION CREATES THE DOTS AND DASHES OF MORSE CODE BY **MODULATING AMPLITUDE**.
- KEYING INTERRUPTS THE CARRIER, PRODUCING THE CHARACTERISTIC CW SIGNAL (**SWITCHING THE CARRIER ON AND OFF**).

B-003-004: BASIC STRUCTURE AND OPERATION OF A CW TRANSMITTER

POWER AMPLIFIER – BOOSTING THE SIGNAL

- THE OSCILLATOR AND DRIVER PRODUCE ONLY A FEW MILLIWATTS TO WATTS. THE **POWER AMPLIFIER** (FINAL STAGE) BOOSTS THIS TO THE DESIRED LEVEL (EX: 5W QRP OR 100W FULL POWER) SO THE SIGNAL CAN TRAVEL FAR.

B-003-004: BASIC STRUCTURE AND OPERATION OF A CW TRANSMITTER



CW TRANSMITTER SEQUENCE



QUESTION SECTION B-003-005:

COMPONENTS IN AN SSB/CW RECEIVER

B-003-005: COMPONENTS IN AN SSB/CW RECEIVER

ANTENNA – THE STARTING POINT

- THE **ANTENNA** CAPTURES INCOMING RADIO WAVES (ELECTROMAGNETIC FIELDS) AND **CONVERTS THEM** INTO **ELECTRICAL CURRENTS** (RF ELECTRICAL SIGNALS) THAT THE RECEIVER CAN PROCESS. WITHOUT THIS CONVERSION, NO SIGNAL REACHES THE RADIO.

B-003-005: COMPONENTS IN AN SSB/CW RECEIVER

RF AMPLIFIER – BOOSTING WEAK SIGNALS

- INCOMING SIGNALS FROM THE ANTENNA ARE OFTEN VERY WEAK (MICROVOLTS). THE **RF AMPLIFIER** (FRONT-END STAGE) BOOSTS THESE SIGNALS EARLY IN THE CHAIN, IMPROVING THE RECEIVER'S ABILITY TO DETECT FAINT STATIONS WHILE ADDING MINIMAL NOISE.
- **IT INCREASES THE SENSITIVITY OF THE RECEIVER.**

B-003-005: COMPONENTS IN AN SSB/CW RECEIVER

FREQUENCY CONVERSION – FROM RF TO IF

- THE **MIXER** COMBINES THE INCOMING RF SIGNAL WITH A SIGNAL FROM THE LOCAL OSCILLATOR, PRODUCING SUM AND DIFFERENCE FREQUENCIES. THE DIFFERENCE IS THE FIXED **INTERMEDIATE FREQUENCY** (IF), WHERE MOST FILTERING AND AMPLIFICATION OCCUR.

B-003-005: COMPONENTS IN AN SSB/CW RECEIVER

FREQUENCY CONVERSION – FROM RF TO IF

- THE **LOCAL OSCILLATOR** (LO) GENERATES A TUNABLE SIGNAL. TUNING THE LO CHANGES WHICH RF FREQUENCY GETS CONVERTED TO **THE FIXED IF** (EX: 9 MHz OR 455 kHz), ALLOWING YOU TO SELECT STATIONS ACROSS THE BAND.

B-003-005: COMPONENTS IN AN SSB/CW RECEIVER

IF STAGES – SELECTIVITY AND GAIN

- THE **IF FILTER** (CRYSTAL, MECHANICAL, OR CERAMIC) IS SHARP AND FIXED AT THE IF FREQUENCY. IT PASSES THE DESIRED SIGNAL'S BANDWIDTH (EX: ~2.4–3 kHz FOR SSB/CW) WHILE REJECTING STRONG ADJACENT-CHANNEL INTERFERENCE—GIVING EXCELLENT **SELECTIVITY**.
- AFTER FILTERING, THE **IF AMPLIFIER** BOOSTS THE SIGNAL TO A LEVEL SUITABLE FOR DETECTION. IT SUPPLIES THE BULK OF THE RECEIVER'S OVERALL **GAIN** (AMPLIFICATION).

B-003-005: COMPONENTS IN AN SSB/CW RECEIVER

DETECTION – RECOVERING THE AUDIO (PRODUCT DETECTOR & BFO)

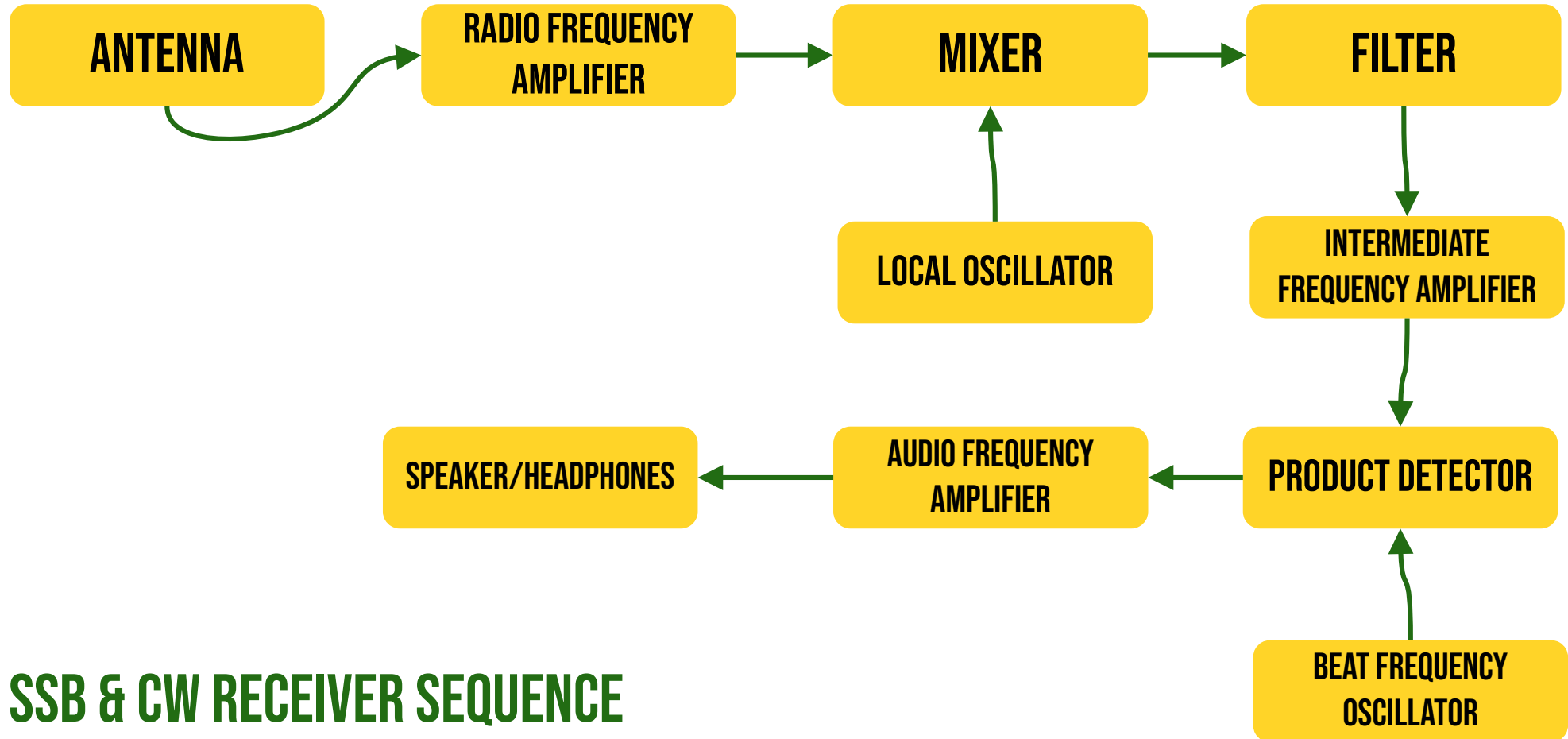
- THE **PRODUCT DETECTOR** MIXES THE IF SIGNAL WITH A CARRIER FROM THE BFO, PRODUCING SUM/DIFFERENCE PRODUCTS. FOR SSB, THIS RECONSTRUCTS THE ORIGINAL AUDIO; FOR CW, IT PRODUCES AN AUDIBLE TONE (EX: 700 Hz). (**RECOVERS THE TRANSMITTED MODULATION**)
- SSB SUPPRESSES THE CARRIER DURING TRANSMIT, SO THE RECEIVER MUST RE-INSERT IT. THE BFO PROVIDES A STABLE CARRIER AT THE EXACT IF FREQUENCY (OR OFFSET FOR CW TONE), WHICH THE PRODUCT DETECTOR USES TO DEMODULATE THE SIGNAL.

B-003-005: COMPONENTS IN AN SSB/CW RECEIVER

AUDIO STAGE – FINAL BOOST AND FILTERING

- AFTER DETECTION, THE AUDIO SIGNAL IS WEAK. THE **AF AMPLIFIER** BOOSTS IT TO DRIVE THE SPEAKER OR HEADPHONES AT COMFORTABLE VOLUME (**INCREASE THE LEVEL**).
- AN AUDIO BAND-PASS FILTER (EX: 300–3000 Hz) CAN BE PLACED IN THE **AF AMPLIFIER** STAGE TO FURTHER REDUCE NOISE OR IMPROVE INTELLIGIBILITY BY LIMITING BANDWIDTH.

B-003-005: COMPONENTS IN AN SSB/CW RECEIVER





QUESTION SECTION B-003-006:

ELEMENTS OF A SINGLE-SIDEBAND TRANSMITTER

B-003-006: ELEMENTS OF A SINGLE-SIDEBAND TRANSMITTER

GENERATING THE RF CARRIER – THE FIXED RF OSCILLATOR

- THE **FIXED RF OSCILLATOR** GENERATES A STABLE, UNMODULATED RF SIGNAL (**THE CARRIER**) AT A FREQUENCY CLOSE TO THE DESIRED OPERATING BAND (EX: NEAR 9 MHz IN MANY DESIGNS). THIS CARRIER IS ESSENTIAL FOR CREATING SIDEBANDS DURING MODULATION.

B-003-006: ELEMENTS OF A SINGLE-SIDEBAND TRANSMITTER

PREPARING THE AUDIO – SPEECH AMPLIFIER

- **MICROPHONE** OUTPUT IS TYPICALLY VERY WEAK (**LOW POWER OUTPUT**). THE **SPEECH AMPLIFIER BOOSTS** THIS LOW-LEVEL AUDIO TO A LEVEL SUITABLE FOR DRIVING THE BALANCED MODULATOR.

B-003-006: ELEMENTS OF A SINGLE-SIDEBAND TRANSMITTER

CREATING THE SIDEBANDS – BALANCED MODULATOR & FILTER

- THE **BALANCED MODULATOR** MIXES THE **AMPLIFIED AUDIO** WITH THE RF CARRIER FROM THE FIXED OSCILLATOR, PRODUCING UPPER AND LOWER SIDEBANDS (AND IDEALLY CANCELLING THE CARRIER). THIS SHIFTS THE VOICE FREQUENCIES (300–3000 Hz) UP TO THE RF RANGE.

B-003-006: ELEMENTS OF A SINGLE-SIDEBAND TRANSMITTER

CREATING THE SIDEBANDS – BALANCED MODULATOR & FILTER

- THE **BALANCED MODULATOR** PRODUCES BOTH UPPER AND LOWER SIDEBANDS. THE SHARP SIDEBAND FILTER (CRYSTAL OR MECHANICAL) **REMOVES ONE SIDEBAND** (AND ANY RESIDUAL CARRIER), LEAVING ONLY THE DESIRED SSB SIGNAL (USB OR LSB).

B-003-006: ELEMENTS OF A SINGLE-SIDEBAND TRANSMITTER

CREATING THE SIDEBANDS – BALANCED MODULATOR & FILTER

- THE **FILTER** OPERATES **NEAR THE FIXED RF OSCILLATOR FREQUENCY** PRECISELY CUTTING OFF ONE SIDEBAND WHILE PASSING THE OTHER WITH MINIMAL DISTORTION.

B-003-006: ELEMENTS OF A SINGLE-SIDEBAND TRANSMITTER

FREQUENCY CONVERSION – MOVING TO THE OPERATING BAND

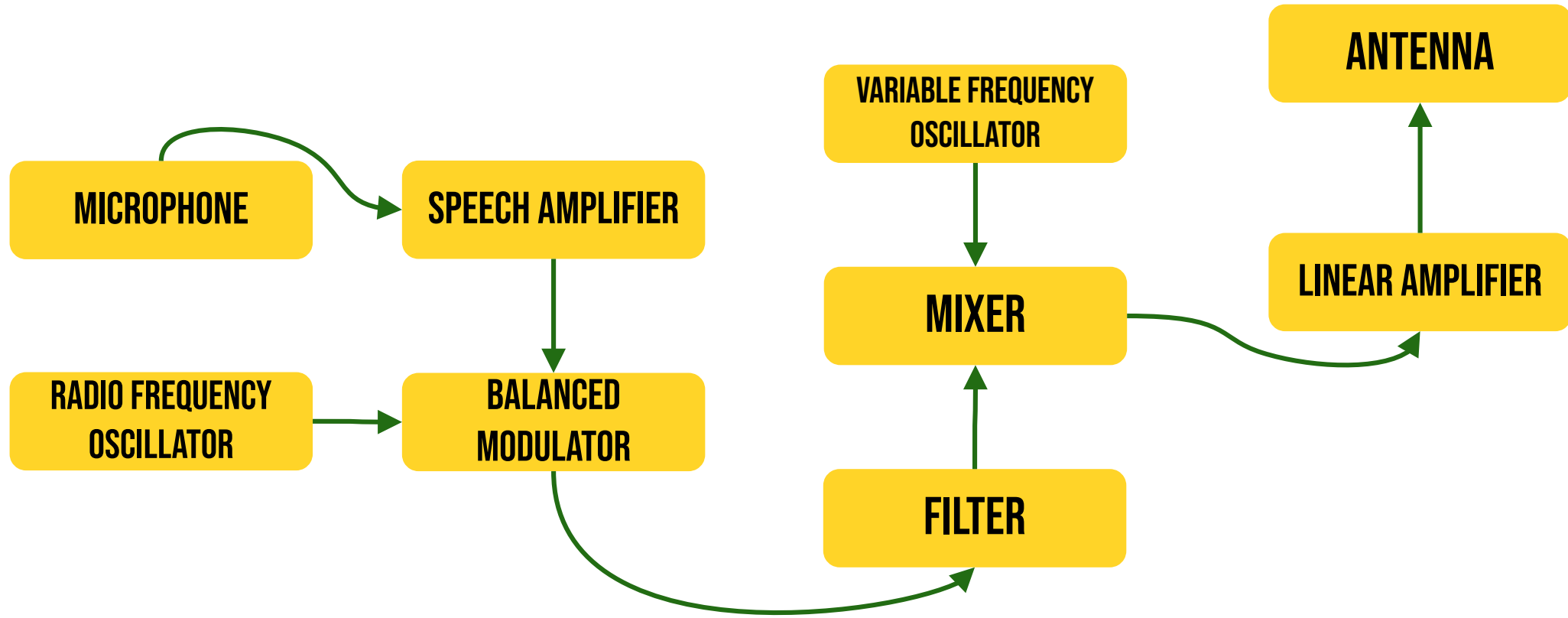
- THE **MIXER** COMBINES THE FILTERED SSB SIGNAL (AT THE FIXED IF-LIKE FREQUENCY) WITH A SIGNAL FROM THE VARIABLE FREQUENCY OSCILLATOR (VFO), SHIFTING IT TO THE DESIRED TRANSMIT FREQUENCY (EX: 14.200 MHz ON 20M).
- THE **VFO** GENERATES A TUNABLE SIGNAL THAT, WHEN MIXED WITH THE SSB SIGNAL, DETERMINES THE FINAL OUTPUT FREQUENCY. TUNING THE **VARIABLE FREQUENCY OSCILLATOR** MOVES YOUR TRANSMITTED SIGNAL ACROSS THE BAND.

B-003-006: ELEMENTS OF A SINGLE-SIDEBAND TRANSMITTER

FINAL STAGE – POWER AND PROTECTION

- THE **FINAL (POWER) AMPLIFIER** BOOSTS THE SSB SIGNAL TO FULL TRANSMIT POWER. IT OFTEN INCLUDES **SWR** PROTECTION (FOLDBACK OR SHUTDOWN) TO PREVENT DAMAGE FROM HIGH REFLECTED POWER CAUSED BY POOR ANTENNA MATCH.

B-003-006: ELEMENTS OF A SINGLE-SIDEBAND TRANSMITTER



SSB TRANSMITTER SEQUENCE



QUESTION SECTION B-003-007:
ROLE AND FUNCTIONS OF A SOUND CARD
INTERFACE IN COMPUTER-BASED
DIGITAL MODES

CORE PURPOSE OF THE SOUND CARD INTERFACE

- THE **SOUND CARD INTERFACE COUPLES** THE COMPUTER'S AUDIO SYSTEM AND THE TRANSCEIVER'S AUDIO IN/OUT JACKS. IT CARRIES RECEIVE AUDIO FROM THE RIG TO THE COMPUTER AND TRANSMIT AUDIO FROM THE COMPUTER TO THE RIG.

ANALOG-TO-DIGITAL AND DIGITAL-TO-ANALOG CONVERSION

- **THE TRANSCEIVER OUTPUTS ANALOG AUDIO (THE RECEIVED DIGITAL MODE TONES). THE SOUND CARD'S ANALOG-TO-DIGITAL CONVERTER (ADC) DIGITIZES THIS SO THE COMPUTER SOFTWARE CAN DECODE IT.**
- **THE COMPUTER GENERATES DIGITAL DATA THAT REPRESENTS THE TONES OR MODULATION FOR THE MODE. THE SOUND CARD'S DIGITAL-TO-ANALOG CONVERTER (DAC) TURNS THIS INTO ANALOG AUDIO TONES THAT THE TRANSCEIVER CAN MODULATE AND TRANSMIT.**

PTT CONTROL – SWITCHING TRANSMIT/RECEIVE

- **MANY INTERFACES INCLUDE A PTT (PUSH-TO-TALK) CIRCUIT. WHEN THE SOFTWARE WANTS TO TRANSMIT, IT SENDS A SIGNAL (VIA SERIAL PORT, VOX, OR CAT COMMAND) THROUGH THE INTERFACE TO KEY THE TRANSCEIVER. THIS AUTOMATES TRANSMIT/RECEIVE SWITCHING.**

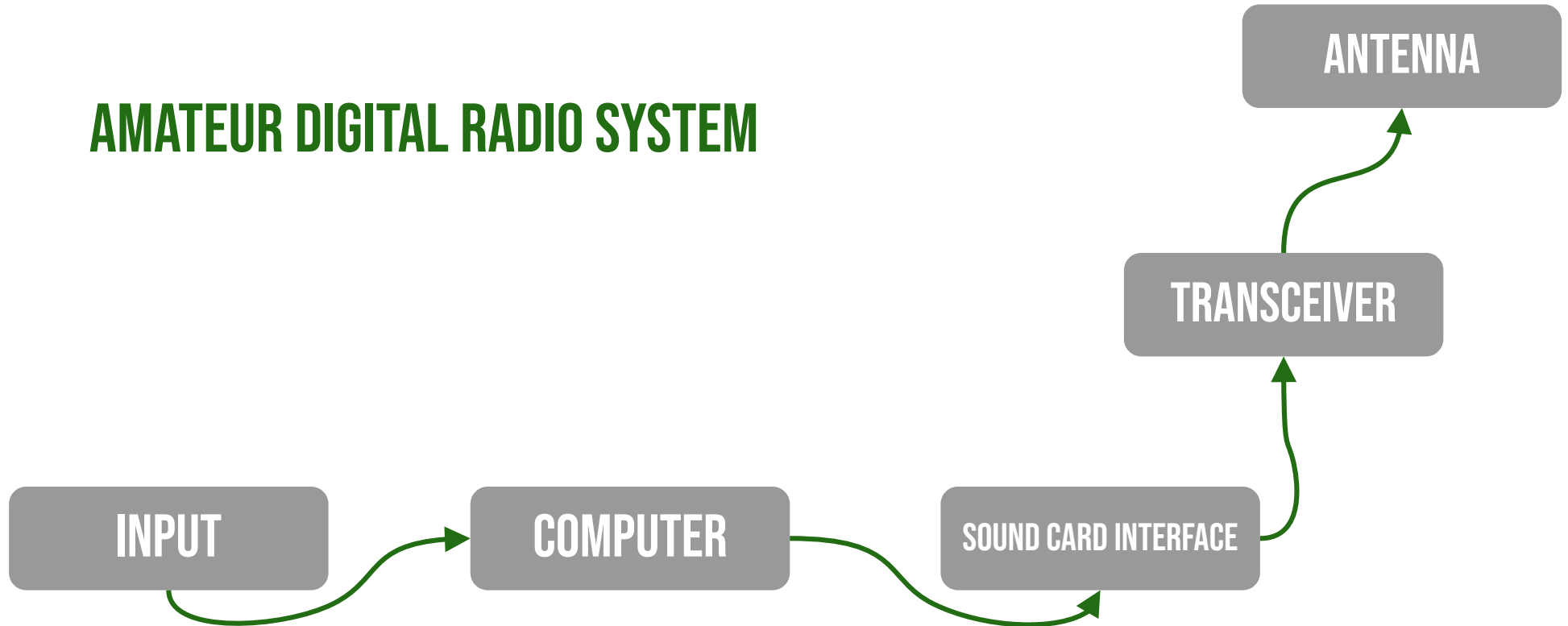
ISOLATION AND NOISE REDUCTION

- **COMPUTERS AND POWER SUPPLIES CAN INTRODUCE 60 Hz HUM, GROUND LOOPS, OR RFI INTO THE AUDIO PATH. ISOLATION TRANSFORMERS PROVIDE GALVANIC ISOLATION, BREAKING THE DIRECT ELECTRICAL CONNECTION AND ELIMINATING GROUND-LOOP NOISE (INTERFERENCE INTO THE TRANSMITTED SIGNALS).**

MODERN TRANSCEIVERS WITH BUILT-IN SOUND CARD FUNCTIONALITY

- **MOST MODERN RIGS HAVE BUILT-IN USB AUDIO CODECS. THE COMPUTER SEES THE RIG AS A SOUND CARD OVER USB—NO EXTERNAL INTERFACE NEEDED FOR AUDIO. PTT AND CAT CONTROL ARE ALSO HANDLED VIA THE SAME USB CONNECTIONS.**

AMATEUR DIGITAL RADIO SYSTEM





QUESTION SECTION B-003-008:

COMPONENTS AND PURPOSES IN A LINEAR POWER SUPPLY

B-003-008: COMPONENTS AND PURPOSES IN A LINEAR POWER SUPPLY

TRANSFORMER STAGE

- THE **TRANSFORMER STEPS DOWN** THE HIGH AC MAINS VOLTAGE (EX: 120V OR 240V) TO A LOWER AC VOLTAGE SUITABLE FOR THE RADIO EQUIPMENT.
- IT ALSO PROVIDES GALVANIC **ISOLATION** BETWEEN THE MAINS AND THE DC OUTPUT FOR SAFETY — IMPORTANT IN HAM SETUPS TO PREVENT SHOCKS OR GROUND LOOPS.

B-003-008: COMPONENTS AND PURPOSES IN A LINEAR POWER SUPPLY

RECTIFIER STAGE

- AFTER THE TRANSFORMER, THE LOWERED AC IS FED TO A RECTIFIER (USUALLY A BRIDGE RECTIFIER WITH FOUR DIODES). **THIS CHANGES THE ALTERNATING CURRENT** (WHICH FLOWS BOTH WAYS) **INTO DIRECT CURRENT** (ONE DIRECTION ONLY), BUT THE OUTPUT IS STILL PULSATING — NOT YET SMOOTH OR USABLE FOR MOST ELECTRONICS.

B-003-008: COMPONENTS AND PURPOSES IN A LINEAR POWER SUPPLY

FILTER STAGE

- **LARGE ELECTROLYTIC CAPACITORS (AND SOMETIMES INDUCTORS) FORM THE FILTER. THEY STORE CHARGE DURING VOLTAGE PEAKS AND RELEASE IT DURING TROUGHS, GREATLY REDUCING RIPPLE AND PRODUCING A STEADIER (BUT STILL SOMEWHAT VARYING) DC VOLTAGE. THIS "SMOOTHED" DC IS THE UNREGULATED INPUT TO THE NEXT STAGE.**

B-003-008: COMPONENTS AND PURPOSES IN A LINEAR POWER SUPPLY

REGULATOR STAGE

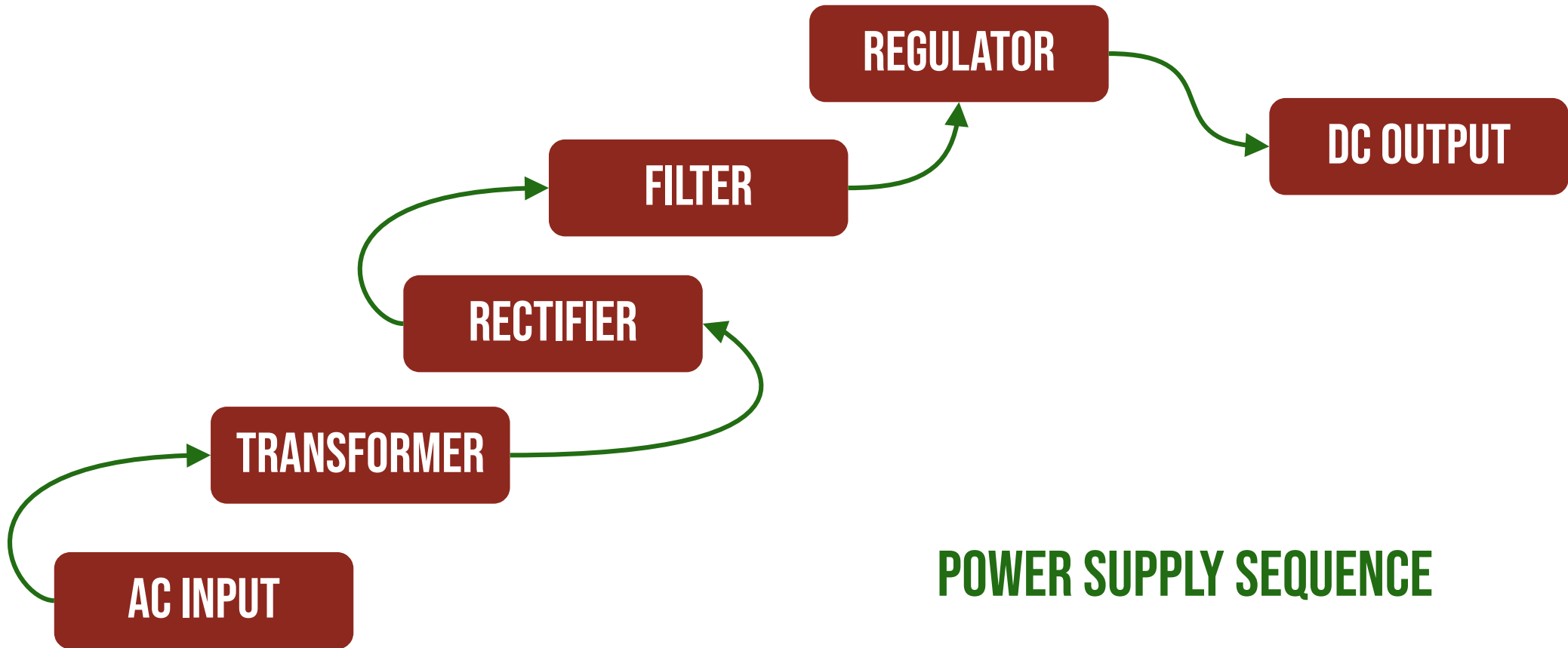
- THE **REGULATOR** MAINTAINS A CONSTANT OUTPUT VOLTAGE DESPITE CHANGES IN LOAD CURRENT (EX: WHEN YOUR TRANSCEIVER KEYS UP AND DRAWS MORE POWER) OR SMALL INPUT VARIATIONS.
- LINEAR REGULATORS "DROP" EXCESS VOLTAGE AS HEAT , WHICH IS WHY THEY ARE LESS EFFICIENT THAN SWITCHING SUPPLIES BUT PRODUCE VERY CLEAN, LOW-NOISE DC — IDEAL FOR SENSITIVE RADIO CIRCUITS.
- BECAUSE THE REGULATOR DISSIPATES SIGNIFICANT POWER AS HEAT (ESPECIALLY AT HIGHER CURRENTS OR WHEN THERE'S A LARGE VOLTAGE DROP), IT ALMOST ALWAYS NEEDS A **HEAT SINK**. POOR HEATSINKING CAN CAUSE THERMAL SHUTDOWN OR FAILURE — A COMMON ISSUE IN HOMEBREW OR OLDER HAM GEAR.

B-003-008: COMPONENTS AND PURPOSES IN A LINEAR POWER SUPPLY

REGULATOR STAGE

- **OVERVOLTAGE PROTECTION** (CROWBAR CIRCUITS, FUSES, OR SHUTDOWN CIRCUITRY) SENSES **THE FINAL REGULATED OUTPUT**.
- IF VOLTAGE EXCEEDS SAFE LIMITS (EX: REGULATOR FAILURE), IT PROTECTS CONNECTED EQUIPMENT LIKE YOUR TRANSCEIVER FROM DAMAGE.

B-003-008: COMPONENTS AND PURPOSES IN A LINEAR POWER SUPPLY





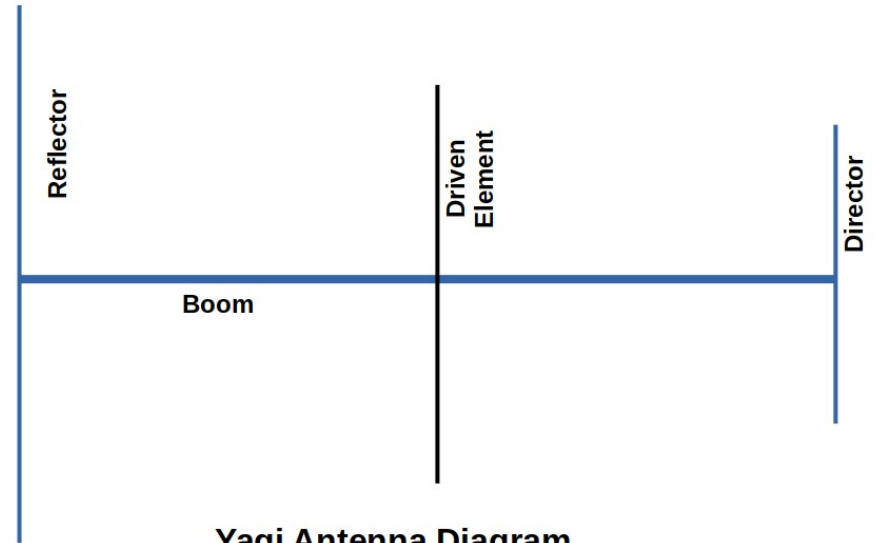
QUESTION SECTION B-003-009:
STRUCTURE OF A 3-ELEMENT YAGI
ANTENNA

B-003-009: STRUCTURE OF A 3-ELEMENT YAGI ANTENNA

ANATOMY OF A 3-ELEMENT YAGI ANTENNA

- A 3-ELEMENT YAGI HAS FOUR MAIN COMPONENTS: ONE MECHANICAL SUPPORT (**BOOM**) AND **THREE RADIATING ELEMENTS**. THE ELEMENTS ARE PARALLEL METAL RODS (OR TUBES/WIRES) MOUNTED PERPENDICULAR TO THE CENTRAL SUPPORT. THE ANTENNA IS DIRECTIONAL – IT HAS A MAIN LOBE OF GAIN IN THE FORWARD DIRECTION (TOWARD THE DIRECTOR) AND A BACK LOBE TOWARD THE REFLECTOR.
- THE TYPICAL ORDER FROM BACK TO FRONT (DIRECTION OF MAXIMUM RADIATION):
 - **REFLECTOR** (LONGEST ELEMENT, BEHIND THE DRIVEN)
 - **DRIVEN** ELEMENT (MIDDLE, FED BY COAX)
 - **DIRECTOR** (SHORTEST ELEMENT, IN FRONT)

B-003-009: STRUCTURE OF A 3-ELEMENT YAGI ANTENNA



Yagi Antenna Diagram

B-003-009: STRUCTURE OF A 3-ELEMENT YAGI ANTENNA

THE BOOM

- THE **BOOM** IS THE LONG HORIZONTAL (OR SOMETIMES VERTICAL) STRUCTURAL MEMBER THAT **PROVIDES MECHANICAL SUPPORT** AND HOLDS ALL THE ELEMENTS IN PLACE AT THE CORRECT SPACING AND ALIGNMENT. IT'S USUALLY MADE OF ALUMINUM TUBING, PVC (FOR LIGHTER/HOMEBREW VHF ANTENNAS), OR FIBERGLASS.
- IT PROVIDES RIGIDITY AND KEEPS THE ELEMENTS PARALLEL AND PROPERLY SPACED — CRITICAL FOR GOOD PERFORMANCE. WITHOUT A STRONG BOOM, THE ANTENNA SAGS OR TWISTS IN WIND, RUINING ITS PATTERN AND SWR.

B-003-009: STRUCTURE OF A 3-ELEMENT YAGI ANTENNA

THE REFLECTOR

- THE **REFLECTOR** (**LONGEST ELEMENT**) IS THE REARMOST ELEMENT (FARTHEST FROM THE DIRECTION YOU WANT TO TRANSMIT/RECEIVE). IT IS SLIGHTLY LONGER THAN A HALF-WAVELENGTH AT THE OPERATING FREQUENCY (TYPICALLY ABOUT 5% LONGER THAN THE DRIVEN ELEMENT).
- ITS JOB IS TO REFLECT RADIO WAVES FORWARD, INCREASING GAIN IN THE FORWARD DIRECTION AND REDUCING RADIATION BACKWARD. THINK OF IT AS A "MIRROR" THAT HELPS FOCUS THE ENERGY

B-003-009: STRUCTURE OF A 3-ELEMENT YAGI ANTENNA

THE DIRECTOR

- THE **DIRECTOR** (**SHORTEST ELEMENT**) IS THE FRONTMOST ELEMENT (CLOSEST TO THE TARGET DIRECTION). **IT IS THE SHORTEST** — USUALLY ABOUT 5% SHORTER THAN THE DRIVEN ELEMENT.
- IT HELPS "PULL" OR DIRECT THE RADIO WAVES FORWARD, FURTHER SHARPENING THE BEAM AND ADDING FORWARD GAIN. MORE DIRECTORS (IN LONGER YAGIS) INCREASE GAIN EVEN MORE, BUT IN A BASIC 3-ELEMENT DESIGN, THERE'S JUST ONE.

B-003-009: STRUCTURE OF A 3-ELEMENT YAGI ANTENNA

THE DRIVEN ELEMENT

- THE **DRIVEN ELEMENT** IS THE MIDDLE ONE — **THE ONLY ELEMENT DIRECTLY CONNECTED TO THE FEEDLINE (COAX)**. IT'S USUALLY CLOSE TO A HALF-WAVELENGTH LONG (RESONANT) AND ACTS LIKE A SIMPLE DIPOLE: IT RADIATES (TRANSMIT) OR INTERCEPTS (RECEIVE) THE RF ENERGY.
- THE REFLECTOR AND DIRECTOR ARE PARASITIC — THEY AREN'T FED DIRECTLY BUT INTERACT ELECTROMAGNETICALLY WITH THE DRIVEN ELEMENT TO CREATE DIRECTIVITY AND GAIN.



QUESTION SECTION B-003-010:

RECEIVER PERFORMANCE METRICS AND

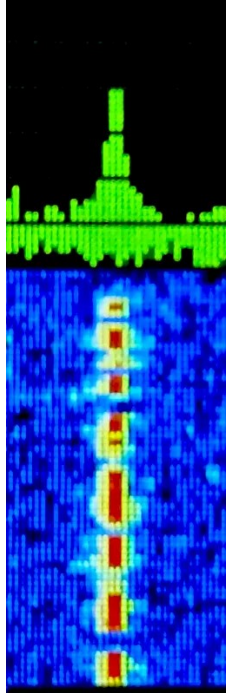
FEATURES

B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES

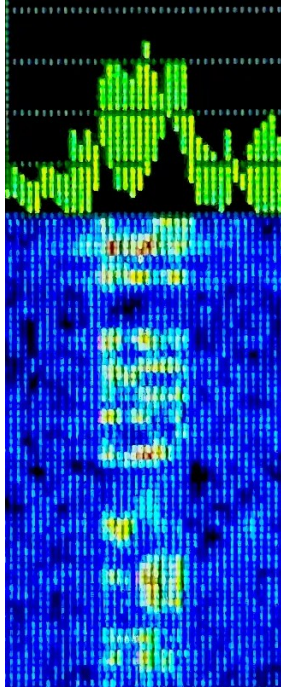
EMISSION MODES & BANDWIDTH

- **CW** (MORSE CODE) **USES THE NARROWEST BANDWIDTH** (100–500 Hz, OFTEN ~150 Hz TYPICAL).
 - **SSB** VOICE IS NEXT (2.4–3 kHz FOR GOOD INTELLIGIBILITY).
 - **FM VOICE IS WIDEST** (~10–15 kHz OR MORE, DEPENDING ON DEVIATION).
- NARROWER MODES ARE MORE SPECTRUM-EFFICIENT AND BETTER FOR WEAK SIGNALS OR CROWDED BANDS — KEY FOR HF DX.**

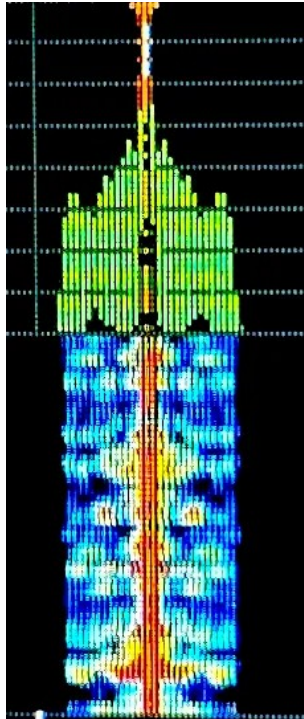
B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES



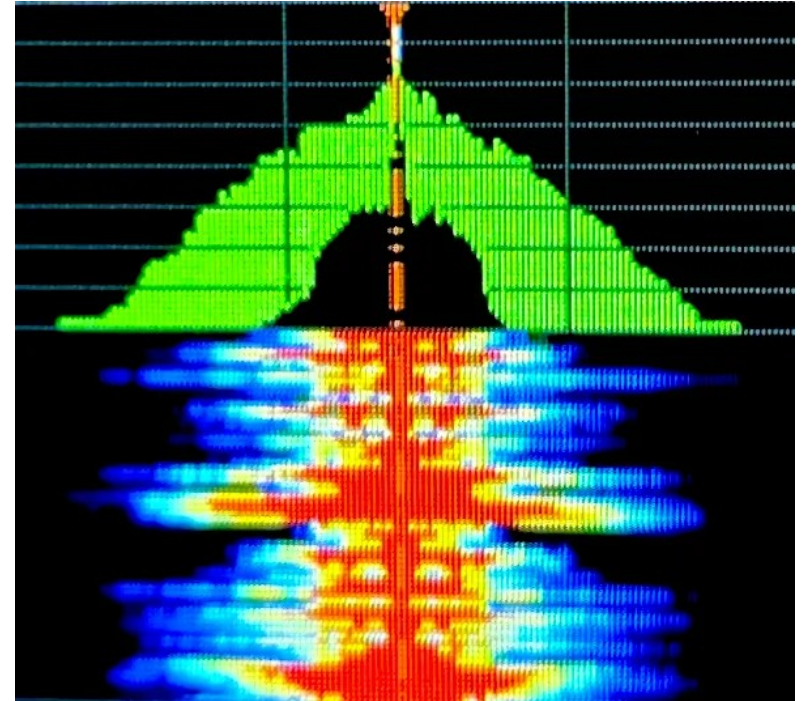
**CW
SIGNAL**



**SSB
SIGNAL**



**AM
SIGNAL**



**FM
SIGNAL**

B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES

RECEIVER SENSITIVITY

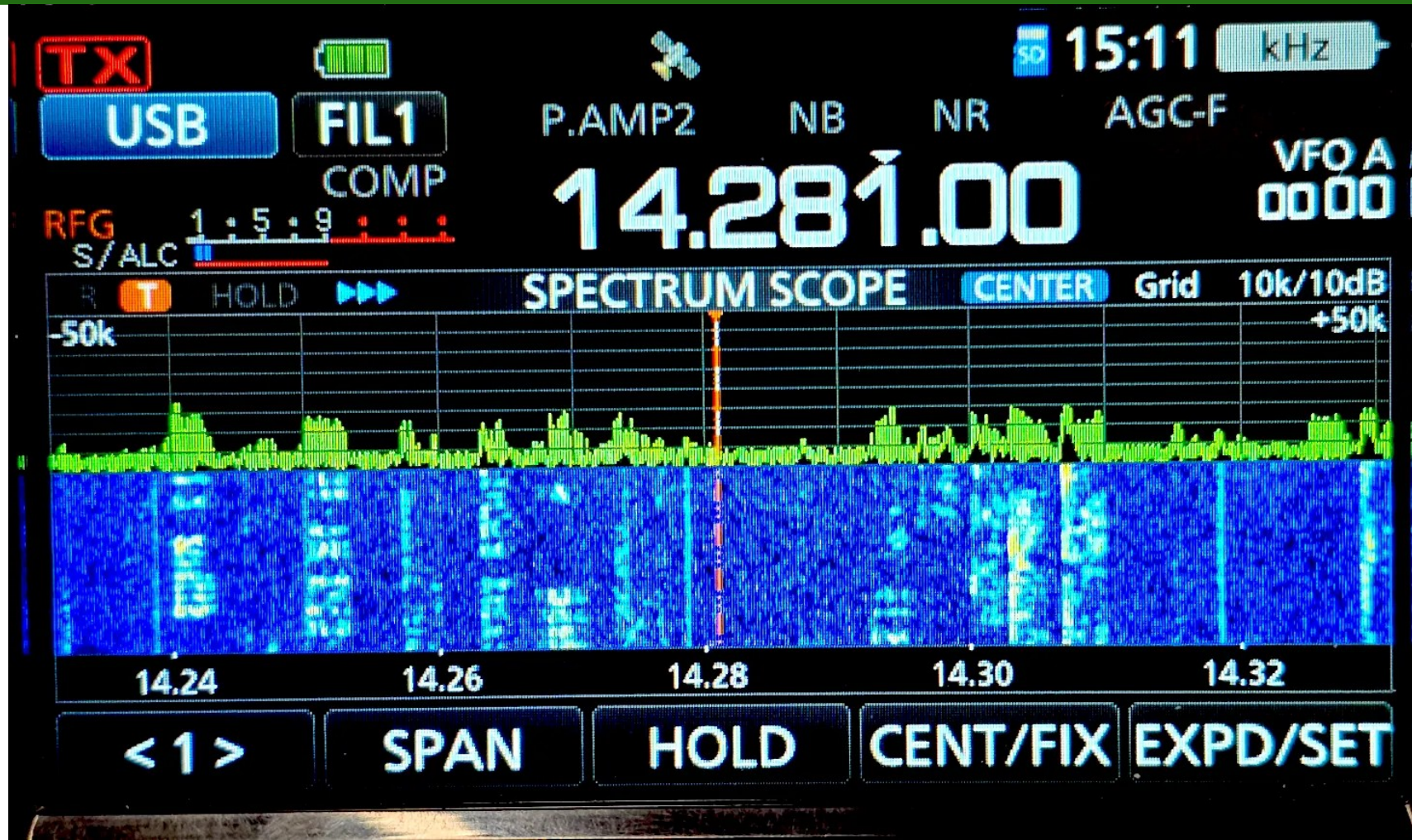
- **SENSITIVITY** IS USUALLY QUOTED AS THE **MINIMUM RF INPUT SIGNAL FOR A SPECIFIC SIGNAL-TO-NOISE RATIO (SNR)**
- **LOWER NUMBER = BETTER SENSITIVITY (WEAKER SIGNALS DETECTABLE).**
- **IN PRACTICE, IT'S OFTEN MEASURED FOR 10 dB SNR IN A STANDARD BANDWIDTH.**

B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES

WATERFALL DISPLAY (SPECTROGRAM)

- MODERN SDR RECEIVERS SHOW A WATERFALL: HORIZONTAL AXIS = **FREQUENCY**, VERTICAL = TIME (SCROLLING DOWN), COLOR/BRIGHTNESS = **AMPLITUDE** (SIGNAL STRENGTH).
- YOU SPOT SIGNALS BY THEIR POSITION (FREQUENCY) AND BRIGHTNESS (HOW STRONG), MAKING IT EASY TO FIND AND TUNE TO WEAK OR BUSY SIGNALS.

B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES

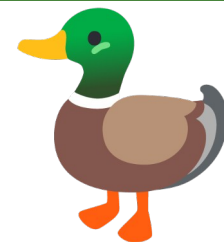


B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES

AUTOMATIC GAIN CONTROL (AGC)

- **AGC** AUTOMATICALLY ADJUSTS RECEIVER GAIN TO KEEP AUDIO OUTPUT LEVEL FAIRLY CONSTANT — WEAK SIGNALS GET BOOSTED, STRONG ONES ATTENUATED.
- **PREVENTS BLASTING LOUD SIGNALS OR LOSING WEAK ONES IN FADING** (COMMON ON HF). FAST/SLOW AGC SETTINGS HELP: FAST FOR QUICK FADING, SLOW FOR STEADY SIGNALS.
- **LIMITS THE CHANGE IN VOLUME DUE TO LARGE SIGNAL STRENGTH VARIATIONS**

B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES



TUNING ACCURACY REQUIREMENTS

- **SSB** (ESPECIALLY VOICE) SOUNDS DISTORTED OR MUFFLED IF OFF-FREQUENCY BY EVEN 100-200 Hz — VOICES BECOME DONALD DUCK-LIKE!
- CW AND FM ARE MORE FORGIVING; AM SOMEWHAT. PRECISE TUNING (**WITHIN 100 Hz**) IS ESSENTIAL FOR SSB ON HF.

B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES

SUPERHETERODYNE RECEIVER TUNING

- B-003-010-006 — A SUPERHETERODYNE RECEIVER HAS AN INTERMEDIATE FREQUENCY (IF) OF 455 kHz. THE LOCAL OSCILLATOR RUNS ABOVE THE OPERATING FREQUENCY. TO WHICH FREQUENCY SHOULD IT BE TUNED TO RECEIVE A SIGNAL ON 3.54 MHz? **ANSWER: 3.995 MHz**
- IN **SUPERHET RECEIVERS** WITH HIGH-SIDE LO INJECTION ($LO > \text{SIGNAL FREQ}$),
 $LO = \text{SIGNAL FREQ} + IF$. SO: $3.54 \text{ MHz} + 0.455 \text{ MHz} = 3.995 \text{ MHz}$.
- THE MIXER PRODUCES THE DIFFERENCE (IF) FOR FILTERING/AMPLIFICATION. COMMON IN MANY CLASSIC RADIOS.

B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES

EFFECT OF TOO NARROW BANDWIDTH

- **TOO NARROW A FILTER** CUTS OFF SIDEBANDS OR AUDIO COMPONENTS – **LOSS OF INFORMATION.**
- **SSB SOUNDS TINNY/MUFFLED, FM DISTORTED, CW MAY LOSE KEYING CHARACTERISTICS.**
- **ALWAYS MATCH BANDWIDTH TO THE MODE FOR BEST INTELLIGIBILITY.**

B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES

THIRD MAIN RECEIVER PERFORMANCE INDICATOR

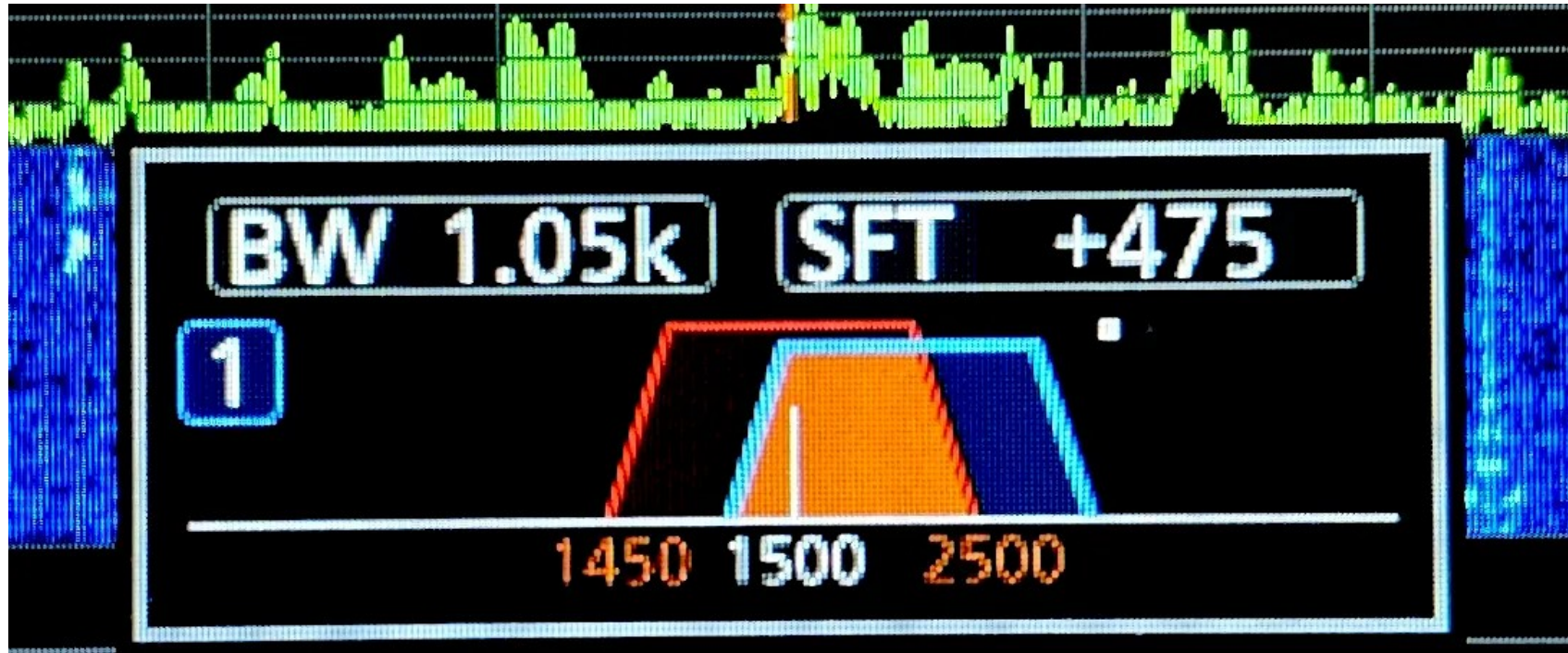
- SENSITIVITY, SELECTIVITY & **DYNAMIC RANGE**
- DYNAMIC RANGE MEASURES HOW WELL THE RECEIVER HANDLES BOTH **VERY WEAK** AND **VERY STRONG SIGNALS** WITHOUT DISTORTION.
- HIGH DYNAMIC RANGE IS CRUCIAL IN CROWDED BANDS WITH STRONG NEARBY SIGNALS — PREVENTS DESENSITIZATION OR SPURIOUS PRODUCTS.

B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES

CHOOSING THE RIGHT FILTER

- **SSB** VOICE NEEDS **~2.4 kHz** (STANDARD FOR COMMUNICATIONS-QUALITY AUDIO, PASSES ~300–2700 Hz).
- **CW** IN HEAVY QRM: NARROWEST (**250 Hz**) REJECTS INTERFERENCE BEST.
- **OPTIMUM CW** FILTER CENTER: AROUND 800 HZ (**750–850 Hz** RANGE) — COMFORTABLE PITCH FOR MOST OPERATORS, GOOD FOR PEAKING WEAK SIGNALS. NARROW FILTERS SHARPEN COPY IN CONTESTS OR PILEUPS.

B-003-010: RECEIVER PERFORMANCE METRICS AND FEATURES





QUESTION SECTION B-003-011:

CW AND AM TRANSMITTER CHARACTERISTICS

B-003-011: CW AND AM TRANSMITTER CHARACTERISTICS



CW TRANSMITTER CHIRP & STABILITY

- **CHIRP** IS A NOTICEABLE **FREQUENCY SHIFT** (UP OR DOWN) DURING KEY-DOWN IN CW — CAUSED BY SUDDEN LOAD CHANGES PULLING THE OSCILLATOR WHEN THE TRANSMITTER KEYS UP (EX: VOLTAGE SAG UNDER CURRENT DRAW).
- IT MAKES CLEAN COPY HARDER, ESPECIALLY AT HIGHER POWER. PREVENT IT WITH STIFF, **WELL-REGULATED POWER SUPPLIES** (GOOD FILTERING, LOW RIPPLE, STABLE VOLTAGE) AND SOMETIMES KEYING THE DRIVER STAGES SOFTLY.

B-003-011: CW AND AM TRANSMITTER CHARACTERISTICS



VARIABLE FREQUENCY OSCILLATOR (VFO) IN CW TRANSMITTERS

- EARLY CW RIGS USED **FIXED** CRYSTAL OSCILLATORS — YOU COULD ONLY TRANSMIT ON CRYSTAL FREQUENCIES.
- A VFO LETS YOU TUNE CONTINUOUSLY ACROSS THE BAND (GREAT FOR FINDING CLEAR SPOTS).
- MODERN RIGS USE SYNTHESIZED VFOS, BUT THE PRINCIPLE IS THE SAME: **FLEXIBILITY** OVER CRYSTAL-LIMITED OPERATION.

B-003-011: CW AND AM TRANSMITTER CHARACTERISTICS

TRANSMITTER STABILITY REQUIREMENT

- **STABILITY PREVENTS DRIFT (SLOW FREQUENCY CHANGES FROM TEMPERATURE, VOLTAGE, OR MECHANICAL VIBRATION). DRIFT RUINS CONTACTS — ESPECIALLY IN CW OR NARROW MODES. USE GOOD SHIELDING, TEMPERATURE COMPENSATION, RIGID MOUNTING, AND REGULATED SUPPLIES.**

B-003-011: CW AND AM TRANSMITTER CHARACTERISTICS

TRANSMITTER EFFICIENCY & POWER LOSS

- B-003-011-010 — THE DC POWER TO THE FINAL STAGE OF YOUR TRANSMITTER IS 200 WATTS AND THE RF OUTPUT IS 125 WATTS. WHAT HAS HAPPENED TO THE REST OF THE POWER? **ANSWER: IT HAS BEEN DISSIPATED AS HEAT**



B-003-011: CW AND AM TRANSMITTER CHARACTERISTICS

AMPLITUDE MODULATION (AM) BASICS

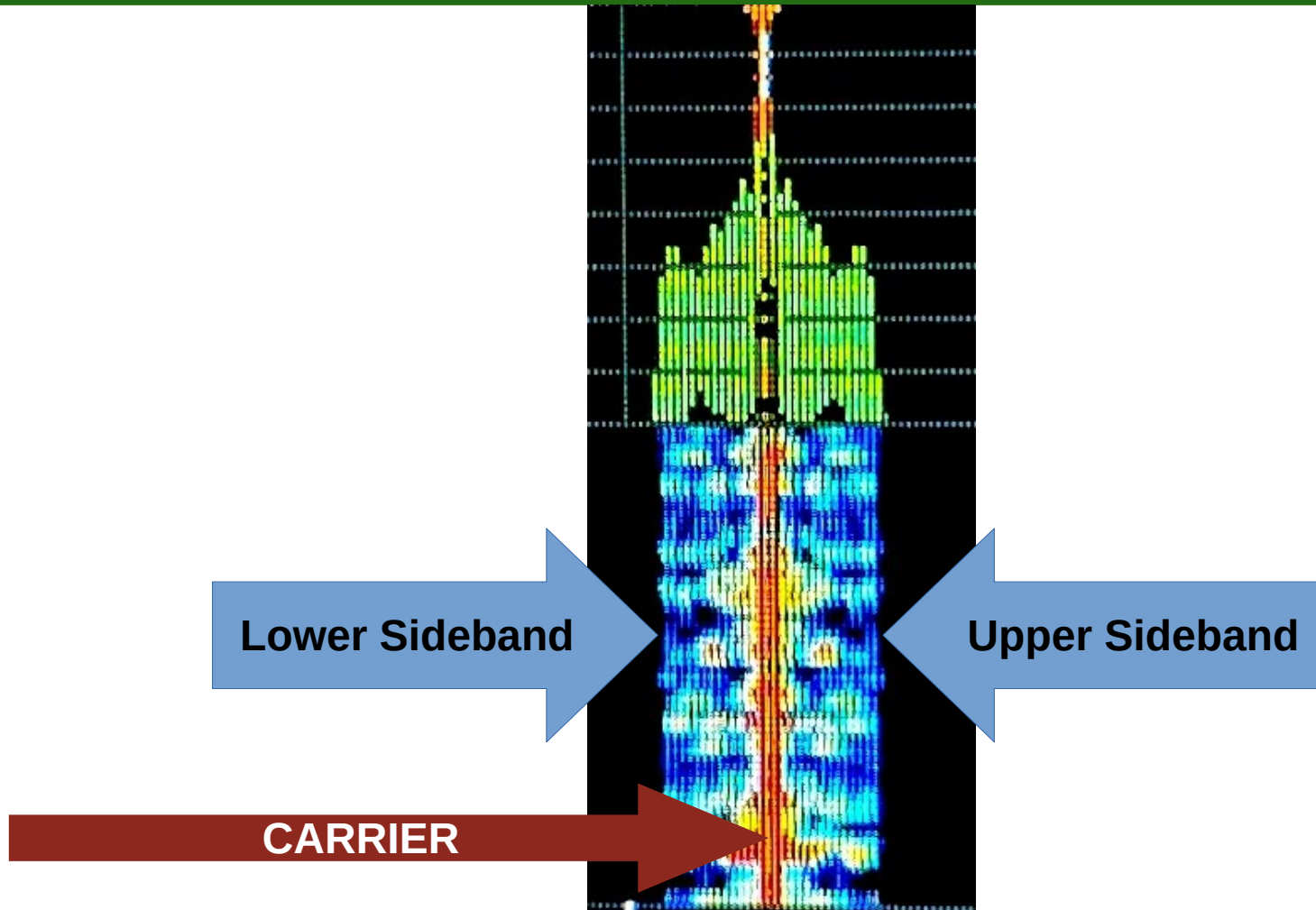
- **AM** VARIES THE **CARRIER AMPLITUDE** IN PROPORTION TO THE AUDIO SIGNAL (VOICE, TONE). THE ENVELOPE FOLLOWS THE AUDIO WAVEFORM — THAT'S HOW THE INFORMATION IS CARRIED.
- **CW** IS ON-OFF (**INTERRUPTED**) KEYING OF A CONSTANT-AMPLITUDE CARRIER (NO AMPLITUDE VARIATION DURING KEY-DOWN). CONTRAST THIS WITH AM, WHERE AMPLITUDE CHANGES CONTINUOUSLY WITH AUDIO.

B-003-011: CW AND AM TRANSMITTER CHARACTERISTICS

AM BANDWIDTH & SIDEBANDS

- FOR VOICE UP TO 3 KHZ, THE UPPER SIDEBAND (CARRIER FREQ + 0-3 KHZ) AND LOWER SIDEBAND (CARRIER FREQ - 0-3 KHZ) EACH TAKE 3 KHZ, PLUS THE CARRIER — TOTAL OCCUPIED BANDWIDTH $\approx$ 6 KHZ [CARRIER + TWO SIDEBANDS].
- THIS IS DOUBLE SSB'S $\sim$ 3 KHZ, WHICH IS WHY AM USES MORE SPECTRUM.

B-003-011: CW AND AM TRANSMITTER CHARACTERISTICS





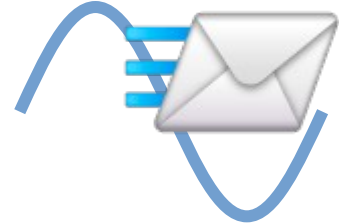
QUESTION SECTION B-003-012:

OPERATION OF SSB TRANSMITTERS

B-003-012: OPERATION OF SSB TRANSMITTERS

COMMON SSB OPERATING MISTAKES & INTERFERENCE

- HIGH MIC GAIN OR EXCESSIVE SPEECH PROCESSING (COMPRESSION) OVERDRIVES THE TRANSMITTER, CAUSING **SPLATTER** — BROAD SPURIOUS EMISSIONS THAT INTERFERE WITH ADJACENT FREQUENCIES. THIS IS "DIRTY" SSB AND A MAJOR ETIQUETTE VIOLATION.
- OVERMODULATION FLATTENS PEAKS, INTRODUCES **DISTORTION** (GARBLED AUDIO), AND SPREADS THE SIGNAL BEYOND NORMAL **BANDWIDTH** — MORE SPLATTER AND **INTERFERENCE TO OTHER STATIONS**.



PEAK ENVELOPE POWER (PEP)

- PEP MEASURES THE MAXIMUM POWER OUTPUT DURING VOICE PEAKS (AT **THE ENVELOPE CREST**). SSB TRANSMITTERS ARE RATED IN PEP (EX: "100W PEP") — NOT AVERAGE POWER, WHICH IS MUCH LOWER FOR VOICE.



SSB BANDWIDTH & LINEARITY REQUIREMENT

- TYPICAL **SSB** VOICE OCCUPIES **~2-3 kHz** (AUDIO RANGE ~300-2700 Hz), HALF OF AM'S 6 kHz — EFFICIENT FOR HF.
- NON-LINEAR AMPS DISTORT THE VARYING ENVELOPE, MAKING SSB AUDIO GARBLED (**VOICE BECOME UNINTELLIGIBLE**). LINEAR AMPS PRESERVE THE SHAPE FOR CLEAN DEMODULATION.

B-003-012: OPERATION OF SSB TRANSMITTERS



CARRIER SUPPRESSION ADVANTAGE

- IN SUPPRESSED-CARRIER SSB, NO POWER IS WASTED ON THE USELESS CARRIER — **ALL POWER GOES TO INFORMATION-CARRYING SIDEBANDS**, INCREASING EFFICIENCY AND RANGE FOR THE SAME TRANSMITTER CAPABILITY.

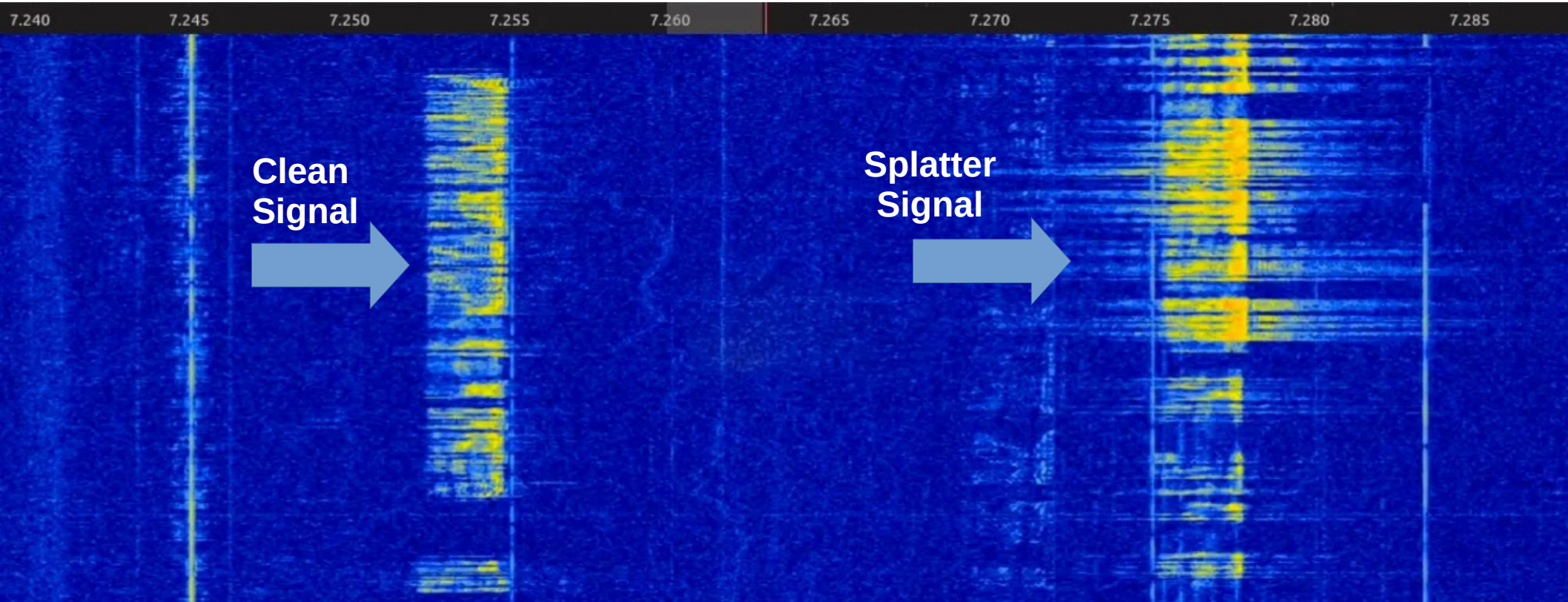
B-003-012: OPERATION OF SSB TRANSMITTERS



PROPER MIC GAIN / ALC ADJUSTMENT

- SET **MIC GAIN** SO ALC (AUTOMATIC LEVEL CONTROL) DEFLECTS ON **VOICE PEAKS BUT DOESN'T PIN OR EXCEED THE MARKED LIMIT** (OFTEN HALF TO FULL SCALE). THIS **PREVENTS OVERDRIVE** WHILE MAXIMIZING CLEAN POWER.
- ALC REDUCES GAIN AUTOMATICALLY ON PEAKS TO KEEP THE SIGNAL LINEAR AND CLEAN — ESSENTIAL PROTECTION AGAINST SPLATTER.

B-003-012: OPERATION OF SSB TRANSMITTERS



© Kevin Loughin YouTube: New Ham Tips - Splatter. What is it? Why is it bad? How to avoid it.

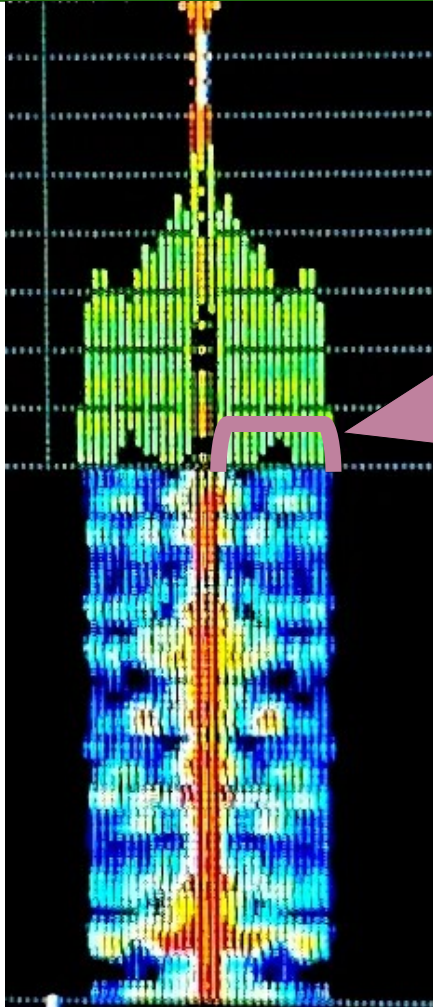
B-003-012: OPERATION OF SSB TRANSMITTERS

SSB GENERATION & FREQUENCY EXAMPLE

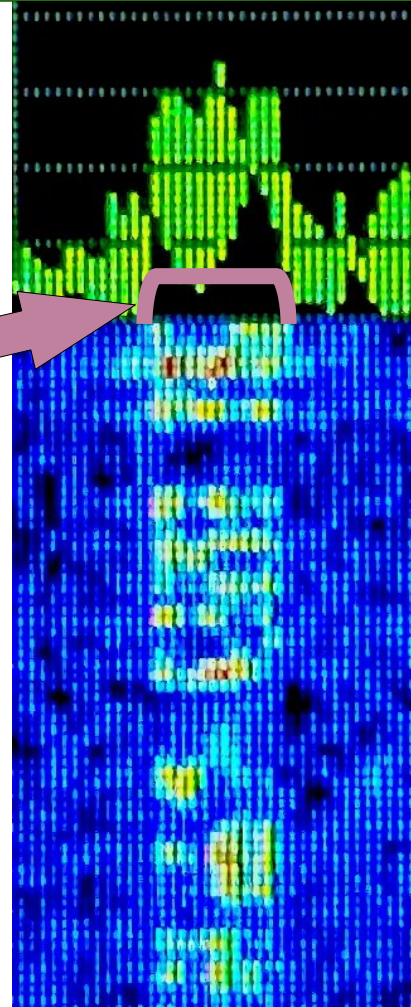
- THE **BALANCED MODULATOR** MIXES AUDIO WITH RF CARRIER, CANCELLING THE CARRIER (**SUPPRESSED-CARRIER**) AND **PRODUCING BOTH SIDEBANDS**. A FILTER THEN REMOVES ONE SIDEBAND FOR SSB.
- FOR **LSB**, THE SIDEBAND IS BELOW THE SUPPRESSED CARRIER FREQUENCY. A 1000 Hz TONE PRODUCES ENERGY AT CARRIER. $1000 \text{ Hz} = 7100 \text{ KHz} - 1 \text{ kHz} = \mathbf{7099 \text{ kHz}}$. (USB WOULD BE 7101 KHz.)

B-003-012: OPERATION OF SSB TRANSMITTERS

AM
SIGNAL



SSB
SIGNAL





QUESTION SECTION B-003-013:

FM TRANSMITTER AND RECEIVER BEHAVIOURS

B-003-013: FM TRANSMITTER AND RECEIVER BEHAVIOURS

FM RECEIVER NOISE & QUIET OPERATION

- WITHOUT A CARRIER, THE **FM RECEIVER'S HIGH-GAIN RF/IF STAGES** AMPLIFY THERMAL NOISE, WHICH THE DISCRIMINATOR (FM DETECTOR) INTERPRETS AS RANDOM FREQUENCY SWINGS — PRODUCING LOUD WHITE NOISE (HISS). A STRONG INCOMING FM SIGNAL "QUIETS" THIS NOISE VIA THE CAPTURE EFFECT AND LIMITER ACTION.
- **CAPTURE EFFECT** (OR CAPTURE RATIO) MEANS **THE STRONGER SIGNAL SUPPRESSES THE WEAKER ONE** ALMOST COMPLETELY — GREAT FOR REPEATERS (NO HETERODYNES), BUT YOU LOSE THE WEAKER STATION ENTIRELY IF IT'S JUST A FEW DB DOWN.

B-003-013: FM TRANSMITTER AND RECEIVER BEHAVIOURS

DEVIATION & MODULATION BASICS

- **DEVIATION** IS THE PEAK **FREQUENCY SHIFT FROM THE CARRIER** (EX: ± 5 kHz). LOUDER AUDIO OR HIGHER PEAKS CAUSE WIDER SWINGS; FREQUENCY (NOT AMPLITUDE) CARRIES THE INFORMATION.
- **PHASE MODULATION** (PM) VARIES PHASE, WHICH IS MATHEMATICALLY EQUIVALENT TO FM FOR AUDIO FREQUENCIES **IS CLOSEST TO FREQUENCY MODULATION**.
- **IF YOUR FM MIC FAILED**, THE FM TRANSMITTER WOULD PRODUCE A STEADY **UNMODULATED CARRIER** (LIKE CW BUT ON FM FREQ). IT WOULD KEY THE REPEATER BUT TRANSMIT SILENCE (OR NOISE IF PL TONE IS USED).

B-003-013: FM TRANSMITTER AND RECEIVER BEHAVIOURS

FM BANDWIDTH & PRACTICAL CONSEQUENCES

- B-003-013-006 — WHAT IS THE APPROXIMATE BANDWIDTH OF A FREQUENCY MODULATED SIGNAL USING 5 KHZ DEVIATION? **ANSWER: BETWEEN 10 KHZ AND 20 KHZ**
- B-003-013-002 — YOU ARE USING AN FM REPEATER CONFIGURED FOR 5 KHZ DEVIATION, BUT YOUR TRANSMITTER IS SET TO 2.5 KHZ DEVIATION. WHAT IS THE CONSEQUENCE? **ANSWER: YOUR AUDIO WILL BE LOW**
- B-003-013-010 — SEVERAL STATIONS REPORT THAT YOUR FM TRANSMISSION IS LOUD AND DISTORTED, BUT ON FREQUENCY. WHICH OF THE FOLLOWING IS THE MOST PROBABLE CAUSE OF THE DISTORTION? **ANSWER: SPEAKING TOO LOUDLY INTO THE MICROPHONE**

B-003-013: FM TRANSMITTER AND RECEIVER BEHAVIOURS



"TALK ACROSS THE MIC, NOT INTO IT."

B-003-013: FM TRANSMITTER AND RECEIVER BEHAVIOURS

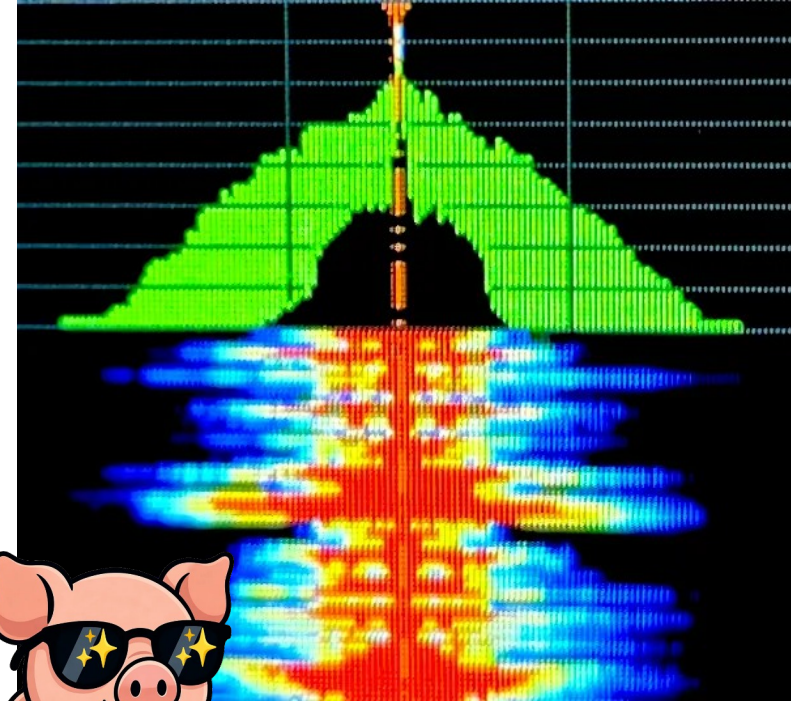
ADVANTAGES OF FM FOR VHF/UHF

- FM'S CONSTANT AMPLITUDE + LIMITER/DISCRIMINATOR COMBO REJECTS AMPLITUDE NOISE (STATIC, IGNITION, ETC.).
- ONCE ABOVE THRESHOLD (~QUIETING), **SNR IMPROVES DRAMATICALLY** — CLEARER AUDIO THAN AM/SSB AT FRINGE SIGNALS.
- **GOOD SIGNAL-TO-NOISE RATIO AT LOW RF SIGNAL LEVELS**

B-003-013: FM TRANSMITTER AND RECEIVER BEHAVIOURS

WHY NO FM BELOW 28 MHZ?

- **FM'S WIDE BANDWIDTH** (10-20 kHz) DOESN'T FIT HF BANDPLANS OR REGULATIONS (EX:3 kHz MAX ON MANY HF ALLOCATIONS).
- **FM BANDWIDTH EXCEEDS LIMITS IN THE REGULATIONS**
- **SSB (2-3 kHz) AND CW ARE MORE SPECTRUM-EFFICIENT FOR LONG-DISTANCE HF.**



FM: BANDWIDTH HAWG!



QUESTION SECTION B-003-014:

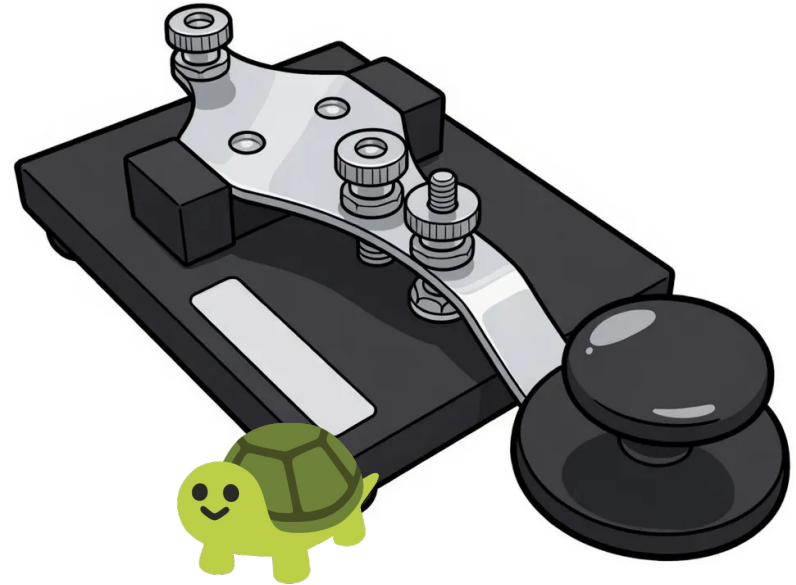
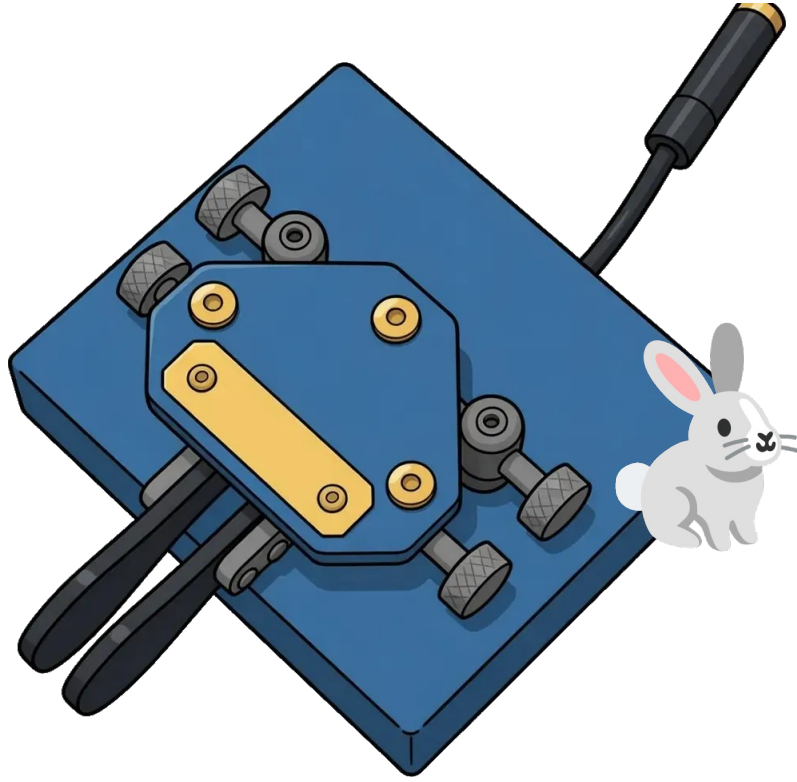
STATION ACCESSORIES AND CONTROLS

B-003-014: STATION ACCESSORIES AND CONTROLS

CW KEYING WITH ELECTRONIC KEYERS

- AN **ELECTRONIC KEYS** (OFTEN BUILT INTO TRANSCEIVERS OR EXTERNAL) USES TIMING CIRCUITS TO ENSURE **PERFECT 1:3 DIT:DAH RATIO AND PROPER SPACING** — NO MORE "SLOPPY" HAND-KEYED CODE.
- WITH A PADDLE (SINGLE OR DUAL IAMBIC), YOU TAP FOR DITS/DAHS; THE KEYS AUTO-GENERATES STRINGS (SQUEEZE FOR FASTER SENDING). ADJUST SPEED/WEIGHT/RATIO FOR PERSONAL STYLE — ESSENTIAL FOR READABLE CW AT HIGHER SPEEDS.

B-003-014: STATION ACCESSORIES AND CONTROLS



B-003-014: STATION ACCESSORIES AND CONTROLS

MICROPHONE SETUP & SPEECH PROCESSING FOR SSB

- ALWAYS **SET MIC GAIN FIRST** (WITH ALC MONITORING) TO AVOID OVERDRIVE/SPLATTER. SPEAK NORMALLY; PEAKS SHOULD KICK ALC BUT NOT PIN IT.
- **SPEECH PROCESSING** (COMPRESSION) REDUCES DYNAMIC RANGE — QUIET PARTS BOOSTED, PEAKS LIMITED — **RAISING AVERAGE POWER** (MORE "PUNCH" FOR WEAK-SIGNAL WORK) WHILE KEEPING PEAKS AT 100% MODULATION. RESULT: BETTER COPY THROUGH NOISE/FADING, WITHOUT DISTORTION IF ADJUSTED PROPERLY. (**IMPROVES SIGNAL INTELLIGIBILITY**)

B-003-014: STATION ACCESSORIES AND CONTROLS

NOISE MANAGEMENT CIRCUITS

- **DIGITAL SIGNAL PROCESSING** (DSP) **NOISE REDUCTION** SAMPLES THE AUDIO, MODELS NOISE PATTERNS, AND SUBTRACTS THEM — EFFECTIVE ON STEADY HISS/STATIC. IT HAS ADJUSTABLE LEVELS; OVER-USE CAN MAKE AUDIO "WATERY."
- **NOISE BLANKER** DETECTS SHARP PULSES (IGNITION, POWER-LINE ARCS, STATIC CRASHES, **SHORT-DURATION IMPULSE-TYPE NOISES**) AND MUTES RECEIVER FOR MICROSECONDS — BLANKS THE NOISE WITHOUT LOSING MUCH SIGNAL. WIDE/NARROW MODES FOR DIFFERENT PULSE WIDTHS; GREAT FOR MOBILE HF OR NOISY ENVIRONMENTS

B-003-014: STATION ACCESSORIES AND CONTROLS

TRANSMIT/RECEIVE SWITCHING & VOX

- **TR SWITCHING** (OR PIN DIODES IN MODERN RIGS) PROTECTS RECEIVER DURING TRANSMIT AND **ENABLES ONE ANTENNA TO BE USED FOR BOTH TRANSMITTING AND RECEIVING** — FAST SWITCHING PREVENTS HOT-SWITCHING DAMAGE.
- **VOX** (VOICE OPERATED EXCHANGE/TRANSMIT) SENSES AUDIO FROM THE MIC, **KEYS PTT AUTOMATICALLY**. HANDS-FREE FOR MOBILE, DIGITAL MODES, OR RAGCHEWS.

B-003-014: STATION ACCESSORIES AND CONTROLS





QUESTION SECTION B-003-015:

DIGITAL COMMUNICATION MODES AND

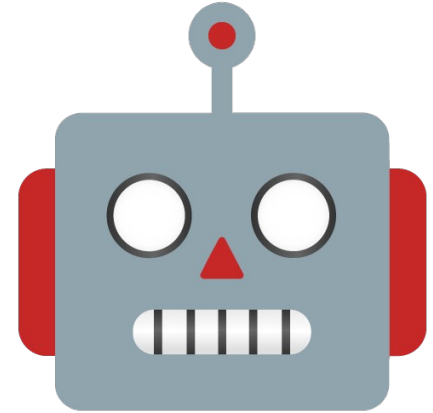
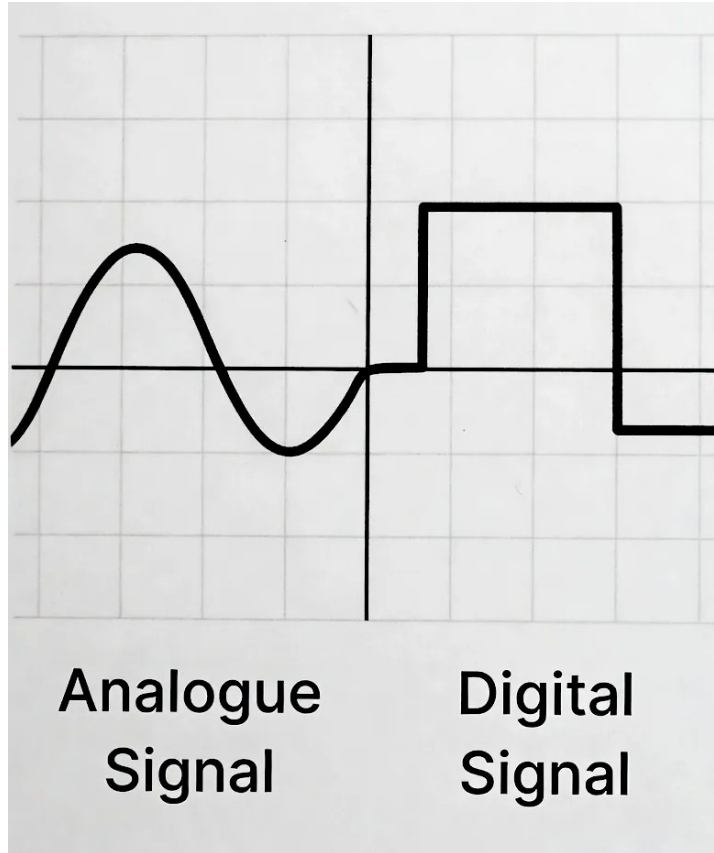
SYSTEMS

B-003-015: DIGITAL COMMUNICATION MODES AND SYSTEMS

DIGITAL VS. ANALOG FUNDAMENTALS

- **ANALOG SIGNALS** (VOICE, PHOTOS) ARE CONTINUOUS WAVEFORMS. **DIGITAL CONVERTS** THEM VIA SAMPLING/QUANTIZATION INTO BINARY BITS (0s/1s AT **DISCRETE PRE-AGREED VALUES**).
- ONCE DIGITAL, VOICE (VOIP-LIKE), IMAGES (SSTV, FAX), TEXT, OR TELEMETRY CAN ALL BE SENT AS ERROR-CHECKED PACKETS — THE SAME WAY COMPUTERS SEND FILES.

B-003-015: DIGITAL COMMUNICATION MODES AND SYSTEMS



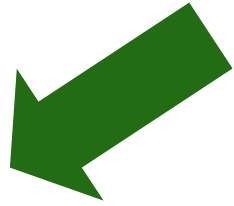
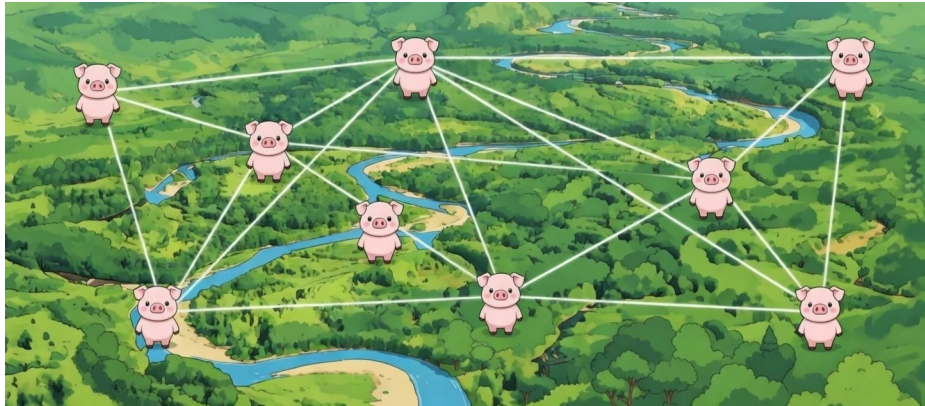
B-003-015: DIGITAL COMMUNICATION MODES AND SYSTEMS

PACKET RADIO & NETWORKING

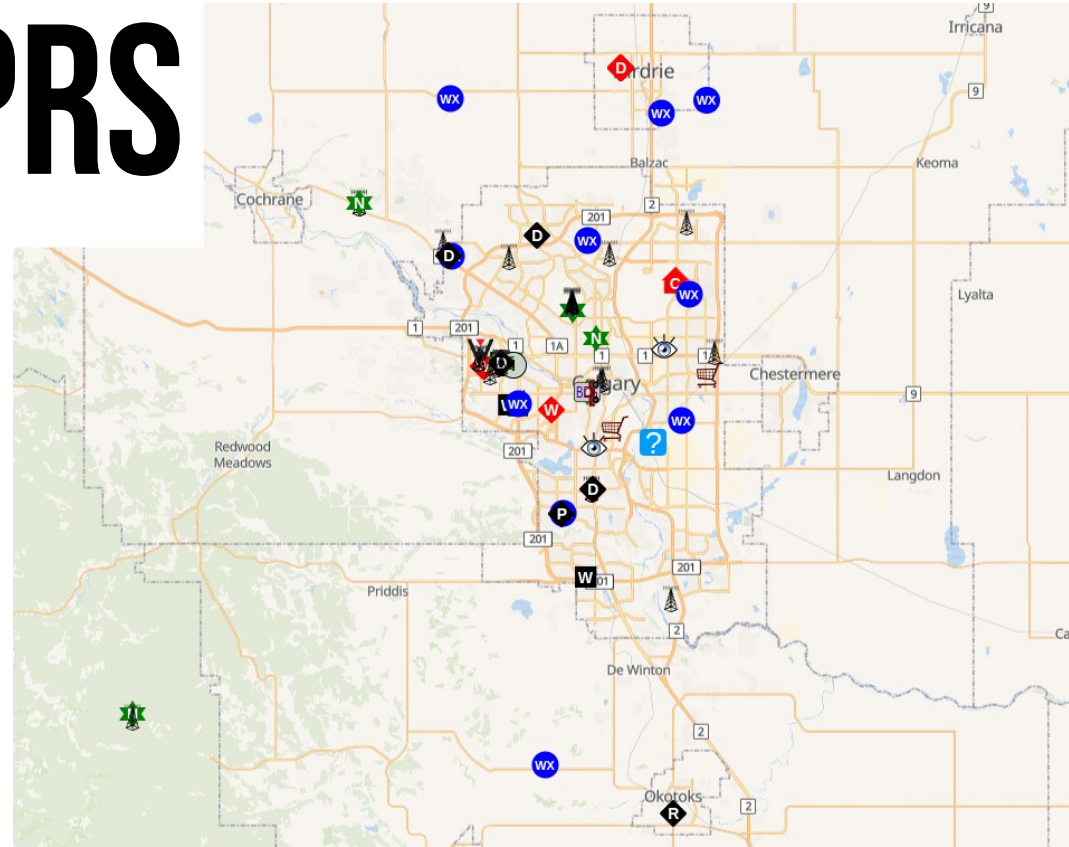
- A **DIGIPEATER** (DIGITAL REPEATER) **HEARS PACKETS**, CHECKS ADDRESSES, **AND RETRANSMITS** IF DESTINED FURTHER.
- **NETWORKS** CHAIN STATIONS/DIGIPEATERS FOR MULTI-HOP PATHS.
- **ARQ** (AUTOMATIC REPEAT REQUEST) **REQUESTS RETRANSMITS ON ERRORS** — ENSURES MESSAGES ARRIVE OR FAIL NOTIFIED — IDEAL FOR EMERGENCY TRAFFIC (EX: ARES/RACES FORMS, WINLINK EMAIL).

B-003-015: DIGITAL COMMUNICATION MODES AND SYSTEMS

“MESH”



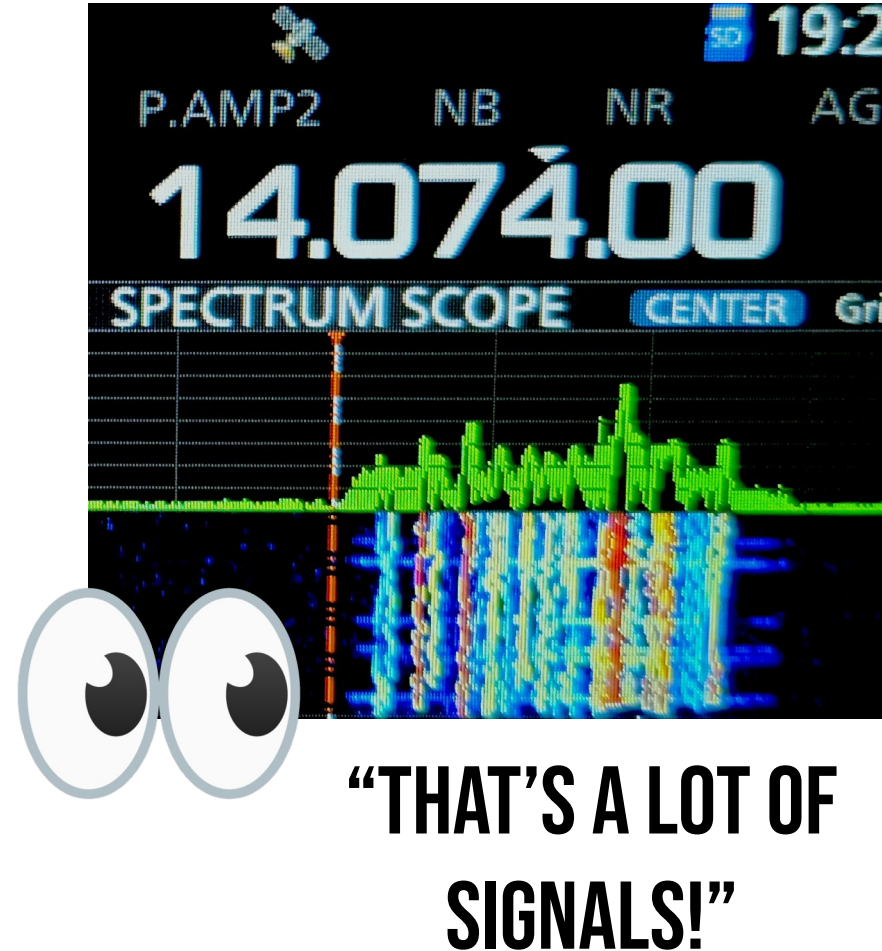
APRS



B-003-015: DIGITAL COMMUNICATION MODES AND SYSTEMS

MODERN WEAK-SIGNAL DIGITAL MODES (FT8)

- FT8 IS A DIGITAL MODE AND USES ONLY ~50 HZ BANDWIDTH PER SIGNAL. MULTI-TONE FSK, FORWARD ERROR CORRECTION (FEC), AND 15-SECOND CYCLES — PACKS 50+ QSOs INTO 2-3 KHZ WHERE SSB FITS ONE.
- EXCELS AT -20 TO -24 DB SNR (2500 Hz BANDWIDTH) — ENABLES WEAK-SIGNAL DX ON POOR BANDS.



B-003-015: DIGITAL COMMUNICATION MODES AND SYSTEMS

RTTY SPACING & DIGITAL TRANSMIT BEST PRACTICES

- RTTY A DIGITAL MODE (45 BAUD, 170 HZ SHIFT) OCCUPIES ~250-300 Hz TOTAL. CENTRE-TO-CENTRE SPACING OF **250-500 Hz** AVOIDS OVERLAP — LISTEN FIRST, CHECK WATERFALL FOR CLEAR SPOT.
- **SOUND-CARD MODES** (FT8, PSK31, RTTY) FEED AUDIO TO RIG'S SSB INPUT. TOO HIGH LEVEL OVERDRIVES — CAUSES **SPLATTER** (BROAD SPURIOUS EMISSIONS). BEST CHECK: HAVE **A NEARBY HAM** MONITOR YOUR WATERFALL/SIGNAL REPORT — AIM FOR ALC BARELY MOVING OR NONE.



QUESTION SECTION B-003-016:

BATTERY TYPES CHARACTERISTICS

AND CONFIGURATIONS

B-003-016: BATTERY TYPES CHARACTERISTICS AND CONFIGURATIONS

BASIC BATTERY CONCEPTS & SOURCES OF EMF

- A **BATTERY** PROVIDES DC EMF (**ELECTROMOTIVE FORCE**) VIA CHEMICAL REACTIONS
- **~12 V** NOMINAL FOR CAR AND HAM RADIO
- ALWAYS IDENTIFY + (POSITIVE/RED) AND - (NEGATIVE/BLACK) TERMINALS TO AVOID REVERSE POLARITY DAMAGE TO RIGS.
- **NEVER SHORT A LITHIUM ION BATTERY!**



B-003-016: BATTERY TYPES CHARACTERISTICS AND CONFIGURATIONS

RECHARGEABLE VS. NON-RECHARGEABLE BATTERIES

- **STORAGE BATTERIES** LIKE LEAD-ACID, NIMH, OR LITHIUM-ION RECHARGE HUNDREDS/THOUSANDS OF TIMES (**REPEATEDLY**).
- **ALKALINE** ARE PRIMARY (SINGLE-USE) — NIMH OFFERS SIMILAR VOLTAGE/SIZE BUT REUSABLE FOR HTS, FLASHLIGHTS, OR ACCESSORIES.



B-003-016: BATTERY TYPES CHARACTERISTICS AND CONFIGURATIONS

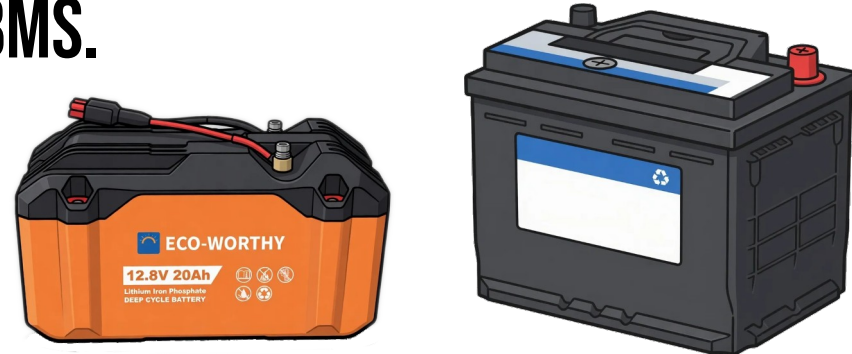
VOLTAGE DROP & CAPACITY BASICS

- **INTERNAL RESISTANCE** CAUSES VOLTAGE SAG UNDER LOAD (EX: HIGH-CURRENT TRANSMIT). CAPACITY IN AMPERE-HOURS (AH) ASSUMES A STANDARD DISCHARGE RATE (EX: C/20).
- **HIGHER CURRENT SHORTENS RUNTIME** — IMPORTANT FOR SIZING BATTERIES FOR PORTABLE RIGS.

B-003-016: BATTERY TYPES CHARACTERISTICS AND CONFIGURATIONS

LITHIUM VS. LEAD-ACID FOR PORTABLE OPERATION

- **LITHIUM-ION** (LIFEPO4 COMMON IN HAM) OFFERS 2-3× ENERGY DENSITY (WH/KG) VS. LEAD-ACID. **HIGH BATTERY CAPACITY PER KILOGRAM.**
- LIGHTER FOR FIELD DAYS, POTA/SOTA, OR GO-KITS.
- ALSO DEEPER SAFE DISCHARGE AND LONGER CYCLE LIFE, THOUGH MORE EXPENSIVE AND NEEDS PROPER CHARGING/BMS.

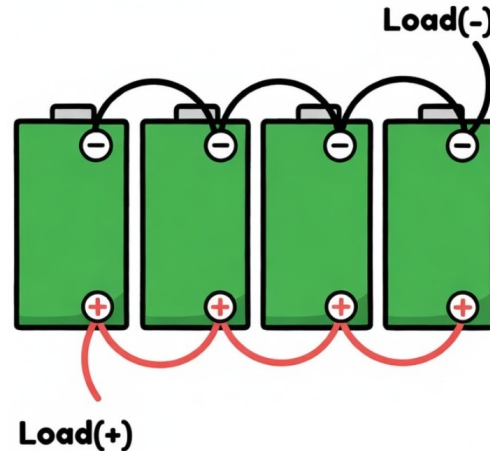


B-003-016: BATTERY TYPES CHARACTERISTICS AND CONFIGURATIONS

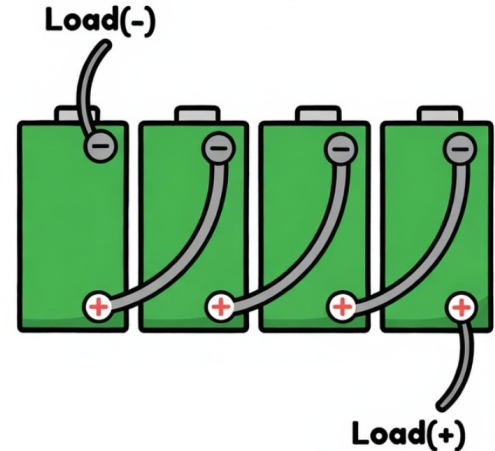
SERIES & PARALLEL CONNECTIONS

- **PARALLEL**: SAME VOLTAGE, DOUBLE CAPACITY.
- **SERIES**: SAME CAPACITY, DOUBLE VOLTAGE.
- USE IDENTICAL BATTERIES
- SAME AGE/TYPE
- MISMATCH CAUSES IMBALANCE/DAMAGE.

Connection In **Parallel**



Connection In **Series**





QUESTION SECTION B-003-017:

POWER SUPPLY DESIGN AND INSTALLATION FOR TRANSCEIVERS

B-003-017: POWER SUPPLY DESIGN AND INSTALLATION FOR TRANSCEIVERS

SIMPLE DC SUPPLIES & CW CHIRP

- **UNREGULATED POWER SUPPLIES SAG UNDER KEY-DOWN LOAD (VOLTAGE DROPS FROM NO-LOAD TO FULL CURRENT). CW OSCILLATORS PULL FREQUENCY WITH VOLTAGE CHANGES → CHIRP (UNWANTED UPWARD/DOWNWARD SHIFT PER DIT/DAH). ADD REGULATION OR STIFF FILTERING FOR CLEAN CW.**
- **IF YOU HAVE HUM (60/120 HZ FROM AC MAINS) IT USUALLY MEANS POOR FILTERING/RECTIFICATION IN THE POWER SUPPLY — RIPPLE MODULATES RF OUTPUT. CHECK ELECTROLYTIC CAPS FIRST (DRIED OUT = HUM), THEN RECTIFIER DIODES.**

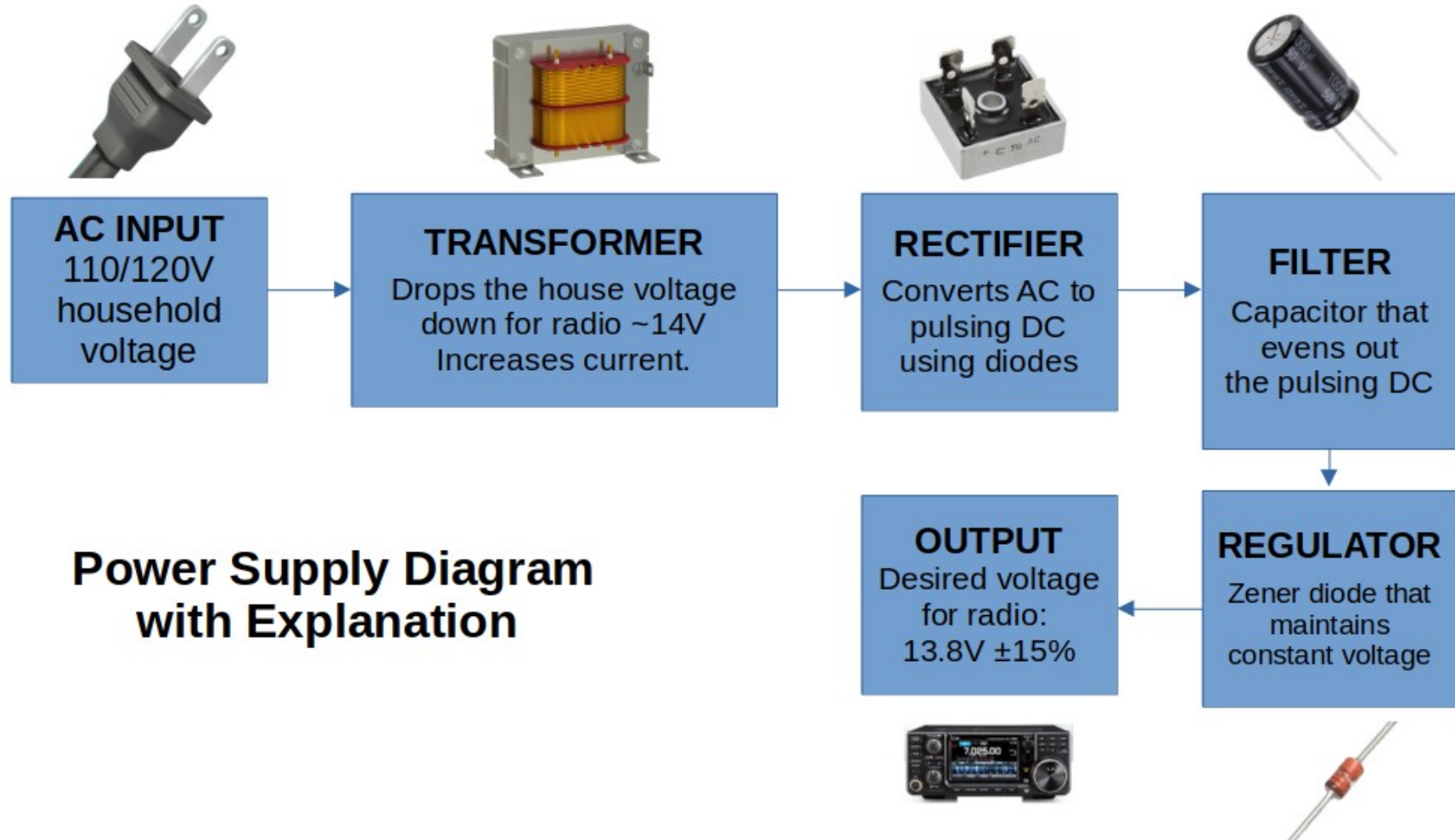
B-003-017: POWER SUPPLY DESIGN AND INSTALLATION FOR TRANSCEIVERS

BASIC POWER SUPPLY FUNCTION

- **POWER SUPPLIES** CONVERT HOUSEHOLD AC (**120 V** SINGLE-PHASE OR **240 V** FOR HEAVY LOADS) TO STABLE DC (EX: 13.8V NOMINAL FOR HAM GEAR). LINEAR OR SWITCHING TYPES; BOTH USE TRANSFORMER (OR EQUIVALENT), RECTIFICATION, FILTERING, AND OFTEN REGULATION.



B-003-017: POWER SUPPLY DESIGN AND INSTALLATION FOR TRANSCEIVERS



B-003-017: POWER SUPPLY DESIGN AND INSTALLATION FOR TRANSCEIVERS

CHOOSING A 13.8 V SUPPLY FOR TRANSCEIVERS

- B-003-017-003 — WHEN SELECTING A 13.8V DC POWER SUPPLY FOR A TRANSCEIVER, WHAT DESIGN SPECIFICATION IS MOST IMPORTANT? **ANSWER: OUTPUT CURRENT CAPABILITY**
- TRANSCEIVERS DRAW HIGH CURRENT ON TRANSMIT (EX: 20-25A FOR 100W HF). SUPPLY MUST HANDLE PEAK LOAD WITHOUT VOLTAGE DROP OR SHUTDOWN — CHECK RATING (EX: 30A CONTINUOUS) > RIG'S MAX DRAW.

B-003-017: POWER SUPPLY DESIGN AND INSTALLATION FOR TRANSCEIVERS

LINEAR VS. SWITCHING POWER SUPPLIES

- **LINEAR SUPPLIES** DISSIPATE EXCESS VOLTAGE AS HEAT — QUIET (NO SWITCHING HARMONICS) BUT BULKY/HEAVY/INEFFICIENT.
- **SWITCHING SUPPLIES** ARE COMPACT/LIGHT/EFFICIENT BUT CAN GENERATE RFI (BIRDIES) UNLESS WELL-FILTERED — MANY HAM-GRADE SWITCHERS INCLUDE NOISE OFFSET OR BETTER SHIELDING.

B-003-017: POWER SUPPLY DESIGN AND INSTALLATION FOR TRANSCEIVERS

DC POWER SUPPLIES



LINEAR:

- 60% OR LESS EFFICIENCY
- LARGE & HEAVY TRANSFORMER
 - LOW NOISE
- FAST RESPONSE TIMES
 - PHYSICALLY LARGE
- LOTS OF HEAT DISSIPATION

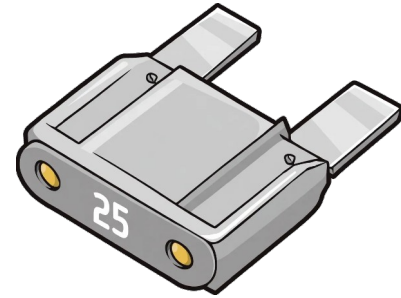


SWITCHING:

- 80% OR MORE EFFICIENCY
- SMALLER TRANSFORMER
- NOISE FROM SWITCHING
- SLOW RESPONSE TIMES
 - COMPACT & LIGHT
- LOWER HEAT DISSIPATION

B-003-017: POWER SUPPLY DESIGN AND INSTALLATION FOR TRANSCEIVERS

MOBILE INSTALLATION WIRING & SAFETY



- **FUSE CLOSE TO BATTERY POSITIVE** PROTECTS WIRING FROM SHORTS (EX: CHAFED CABLE) — IF FUSED AT RADIO END, **SHORTED WIRE COULD MELT/BURN BEFORE FUSE BLOWS.** 
- **USE AUTOMOTIVE BLADE OR ANL FUSE RATED FOR RIG CURRENT + MARGIN.**

B-003-017: POWER SUPPLY DESIGN AND INSTALLATION FOR TRANSCEIVERS

MOBILE INSTALLATION WIRING & SAFETY

- **HEAVY WIRE** (EX: #10 AWG OR THICKER) REDUCES RESISTANCE
- B-003-017-009 — YOUR TRANSCEIVER'S USER GUIDE SUGGESTS LIMITING THE VOLTAGE DROP TO 0.5 VOLTS AND THE VEHICLE BATTERY IS 3 METRES AWAY. GIVEN THE LOSSES LISTED BELOW AT THE REQUIRED CURRENT OF 22 AMPERES, WHICH MINIMUM WIRE GAUGE MUST YOU USE? **ANSWER: NUMBER 10, 0.07 V PER METRE**
- $\text{DROP} = 0.07 \text{ V/M} \times 6\text{M} = 0.42 \text{ V}$



QUESTION SECTION B-003-018:
STATION SECURITY MEASURES AND
ELECTRICAL HAZARDS

PREVENTING UNAUTHORIZED USE OF YOUR STATION

- **HOME:** KEY SWITCH ON MAIN AC LINE (OR DC SUPPLY) PREVENTS POWERING UP — BETTER THAN PASSWORDS OR LOCKS ALONE.
- **MOBILE:** DETACH MIC (COMMON ON HANDHELDS OR CONTROL HEADS) — QUICK, EFFECTIVE DETERRENT AGAINST CASUAL MISUSE OR THEFT.



VEHICLE BATTERY ELECTRICAL HAZARD

- **CAR STARTER BATTERIES** DELIVER HUNDREDS/THOUSANDS OF AMPS IF **SHORTED** — CAN MELT TOOLS, START FIRES, OR CAUSE EXPLOSIONS (HYDROGEN GAS). ALWAYS FUSE POSITIVE LEAD NEAR BATTERY, USE EYE PROTECTION, AND AVOID METAL JEWELRY/TOOLS NEAR TERMINALS DURING MOBILE INSTALLS.



B-003-018: STATION SECURITY MEASURES AND ELECTRICAL HAZARDS

HIGH-VOLTAGE POWER SUPPLY SAFETY FEATURES

- **INTERLOCK SWITCH (OR MICROSWITCH) KILLS POWER WHEN LID OPENS — STANDARD IN AMPS WITH PLATE VOLTAGES >1 KV.**
- **NEVER BYPASS — LETHAL RISK INSIDE (CAPACITORS STORE CHARGE EVEN UNPLUGGED).**



B-003-018: STATION SECURITY MEASURES AND ELECTRICAL HAZARDS

HUMAN BODY RESPONSE TO ELECTRIC CURRENT

- B-003-018-005 — WHAT IS THE MINIMUM ELECTRICAL CURRENT THAT CAN BE FATAL TO THE HUMAN BODY? **ANSWER: 20 MILLIAMPERES**
- B-003-018-006 — WHICH BODY ORGAN CAN BE FATALLY AFFECTED BY A VERY SMALL AMOUNT OF ELECTRICAL CURRENT? **ANSWER: THE HEART**
- B-003-018-007 — WHAT IS THE LOWEST VOLTAGE THAT IS USUALLY CONSIDERED HAZARDOUS TO HUMANS? **ANSWER: 30**
- 20 MA ACROSS CHEST CAN INDUCE VENTRICULAR FIBRILLATION (HEART STOPS PUMPING EFFECTIVELY). AS LOW AS 30V CAN DRIVE FATAL CURRENT THROUGH SKIN (WET SKIN LOWERS RESISTANCE). RESPECT ALL VOLTAGES >30V AS HAZARDOUS — ESPECIALLY DC IN MOBILES OR AC IN SUPPLIES.



B-003-018: STATION SECURITY MEASURES AND ELECTRICAL HAZARDS

EMERGENCY RESPONSE TO ELECTRICAL BURNS/SHOCKS

- B-003-018-008 — WHAT SHOULD YOU DO IF YOU DISCOVER SOMEONE WHO IS BEING BURNED BY HIGH VOLTAGE? ANSWER: **TURN OFF THE POWER, CALL FOR EMERGENCY HELP AND PROVIDE FIRST AID IF NEEDED**
- B-003-018-009 — WHAT IS THE SAFEST METHOD TO REMOVE AN UNCONSCIOUS PERSON FROM CONTACT WITH A HIGH-VOLTAGE SOURCE? ANSWER: **DE-ENERGIZE THE POWER SOURCE BEFORE TOUCHING THE PERSON**
- **FIRST RULE: DO NOT TOUCH LIVE VICTIM — CURRENT CAN PASS THROUGH YOU.** KILL POWER FIRST (BREAKER, UNPLUG, OR SWITCH), THEN CALL EMERGENCY (911), CHECK ABCS (AIRWAY/BREATHING/CIRCULATION), START CPR IF NO PULSE/BREATHING, TREAT BURNS WITH COOL WATER (NO ICE).



B-003-018: STATION SECURITY MEASURES AND ELECTRICAL HAZARDS

SAFE TROUBLESHOOTING PRACTICES

- WHEN DEALING WITH ELECTRICITY/POWER SUPPLIES, **ALWAYS DISCONNECT POWER/UNPLUG** AND **WAIT FOR CAPACITORS TO DISCHARGE** (USE BLEEDER RESISTORS OR SAFE DISCHARGE TOOL). LIVE TROUBLESHOOTING RISKS SHOCK, BURNS, OR ARC FLASH — ONLY EXPERTS WITH PROPER TOOLS/PPE SHOULD DO IT.





QUESTION SECTION B-003-019:

GROUNDING PRACTICES AND SAFETY

IN STATIONS

B-003-019: GROUNDING PRACTICES AND SAFETY IN STATIONS

STATION GROUNDING & SINGLE-POINT PRACTICE

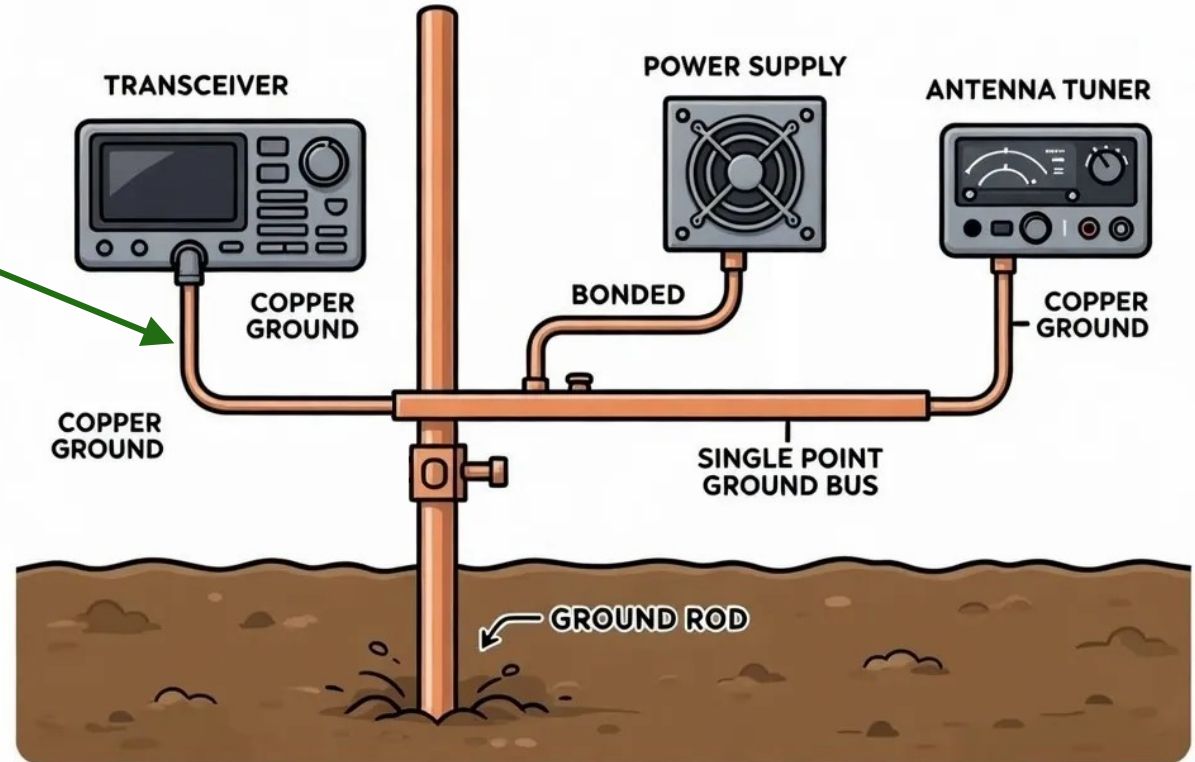
- **GROUND** ALL METAL CHASSIS/RACKS (TRANSCIVER, AMP, TUNER, POWER SUPPLY) TO **ONE COMMON SINGLE-POINT GROUND** (BUS BAR OR PLATE). **THIS EQUALIZES POTENTIALS** — NO SHOCK FROM TOUCHING DIFFERENT PIECES DURING FAULTS.
- **BOND ALL GROUNDS** (STATION ROD, UTILITY ENTRANCE, ANTENNA MAST) WITH HEAVY WIRE (#6 AWG COPPER MIN). LIGHTNING CURRENT FLOWS SAFELY TO EARTH WITHOUT CREATING HUGE VOLTAGE STEPS BETWEEN POINTS — REDUCES SIDE-FLASH OR EQUIPMENT DAMAGE.

B-003-019: GROUNDING PRACTICES AND SAFETY IN STATIONS



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HAM RADIO GROUNDING SYSTEM

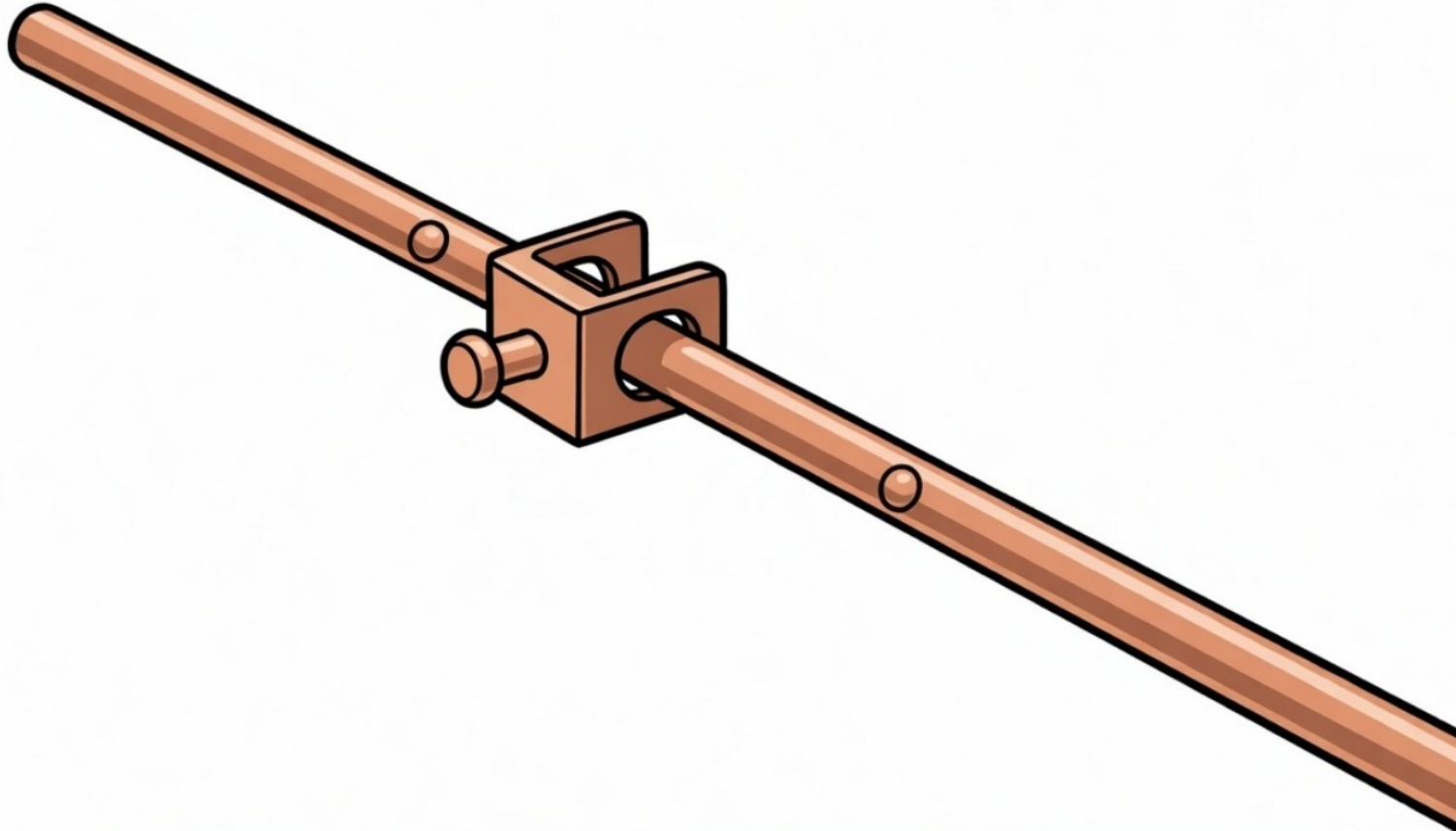


All equipment bonded to a common single point ground for safety and performance.

GROUND ROD MATERIALS

- **COPPER-CLAD STEEL RODS** (TYPICALLY 8 FT × 5/8" OR 1/2")
COMBINE LOW-RESISTANCE COPPER SURFACE WITH STRONG STEEL
CORE — DURABLE, CORROSION-RESISTANT, CODE-COMPLIANT
(NEC/CANADIAN ELECTRICAL CODE). AVOID PLAIN STEEL (RUSTS)
OR PURE COPPER (SOFT/BENDS).

B-003-019: GROUNDING PRACTICES AND SAFETY IN STATIONS



B-003-019: GROUNDING PRACTICES AND SAFETY IN STATIONS

RF GROUNDING ISSUES

- B-003-019-007 — YOUR THIRD-FLOOR STATION HAS A GROUND WIRE RUNNING 10 METRES DOWN TO A GROUND ROD. YOU GET AN RF BURN WHEN YOU TOUCH YOUR HF TRANSCEIVER WHILE TRANSMITTING. WHAT IS THE LIKELY CAUSE? **ANSWER: THE GROUND WIRE HAS HIGH IMPEDANCE ON YOUR OPERATING FREQUENCY**
- LONG GROUND WIRES ACT AS **INDUCTORS** AT HF FREQUENCIES — **HIGH RF IMPEDANCE PREVENTS EFFECTIVE RF RETURN PATH**. RF "FLOATS" ON CHASSIS → BURNS WHEN TOUCHED. USE SHORT, WIDE STRAPS/BONDING FOR RF GROUND (SEPARATE FROM DC/ELECTRICAL GROUND IF NEEDED); ADD RF CHOKE OR FERRITE ON FEEDLINE.

B-003-019: GROUNDING PRACTICES AND SAFETY IN STATIONS

AC MAINS GROUNDING PROTECTION

- B-003-019-006 — WHERE SHOULD THE GREEN WIRE IN A THREE-WIRE AC LINE CORD BE CONNECTED IN A POWER SUPPLY? **ANSWER: TO THE CHASSIS**
- B-003-019-010 — ON MAINS-OPERATED POWER SUPPLIES, THE GROUND WIRE OF THE AC LINE IS CONNECTED TO THE POWER SUPPLY CHASSIS. WHAT PROTECTION DOES THIS PROVIDE IF A FAULT OCCURS IN THE POWER SUPPLY? **ANSWER: ENSURES THE CHASSIS DOES NOT BECOME ENERGIZED**
- GREEN GROUND WIRE BONDS CHASSIS TO EARTH VIA OUTLET — IF HOT WIRE SHORTS TO CHASSIS, FAULT CURRENT FLOWS TO GROUND, TRIPPING BREAKER/GFCI. PREVENTS "HOT CHASSIS" SHOCK HAZARD.

B-003-019: GROUNDING PRACTICES AND SAFETY IN STATIONS

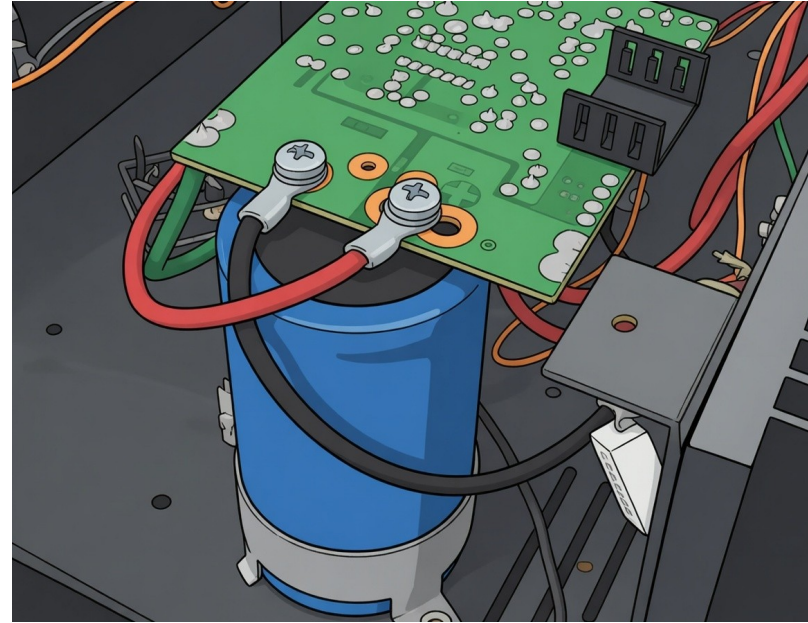
FUSE & CAPACITOR SAFETY

- B-003-019-003 — WHY SHOULD YOU NEVER USE A FUSE WITH A HIGHER CURRENT RATING THAN SPECIFIED? **ANSWER: A FAULT MAY CAUSE PERMANENT DAMAGE, INCLUDING A FIRE** 
- A HIGHER-RATED FUSE DOESN'T BLOW FAST ENOUGH ON OVERLOAD — WIRING/COMPONENTS OVERHEAT, MELT INSULATION, OR IGNITE. ALWAYS MATCH SPEC (EX: 5A FUSE FOR 5A CIRCUIT)

B-003-019: GROUNDING PRACTICES AND SAFETY IN STATIONS

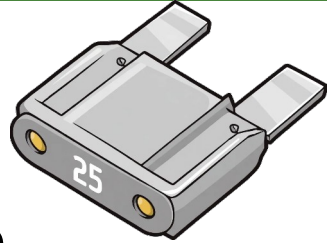
FUSE & CAPACITOR SAFETY

- B-003-019-005 — YOU NEED TO WORK ON A POWER SUPPLY THAT HAS BEEN TAKEN OFFLINE. WHAT IS THE FIRST THING YOU SHOULD DO ONCE THE CABINET IS OPEN? **ANSWER: DISCHARGE THE FILTER CAPACITORS**
- B-003-019-009 — WHAT IS A SAFE METHOD TO DISCHARGE POWER SUPPLY FILTER CAPACITORS? **ANSWER: USE AN INSULATED SHORTING STICK WITH AN INLINE RESISTOR**
- LARGE ELECTROLYTICS STORE LETHAL CHARGE (HUNDREDS OF VOLTS) EVEN UNPLUGGED. DISCHARGE WITH INSULATED TOOL + SERIES RESISTOR (LIMITS CURRENT/SPARK) — PROBE + TO GROUND, WAIT, VERIFY ZERO VOLTS WITH MULTIMETER.



B-003-019: GROUNDING PRACTICES AND SAFETY IN STATIONS

FUSE VOLTAGE RATING



- **B-003-019-011 — WHY DO FUSES HAVE A VOLTAGE RATING?**

ANSWER: TO SPECIFY THE VOLTAGE THAT CAN BE INTERRUPTED WITHOUT ARCING

- **AFTER BLOWING, FUSE MUST WITHSTAND SYSTEM VOLTAGE WITHOUT RE-ARCING ACROSS GAP. USE AT LEAST LINE VOLTAGE RATING (EX: 250V FUSE FOR 120/240V MAINS).**



QUESTION SECTION B-003-020:

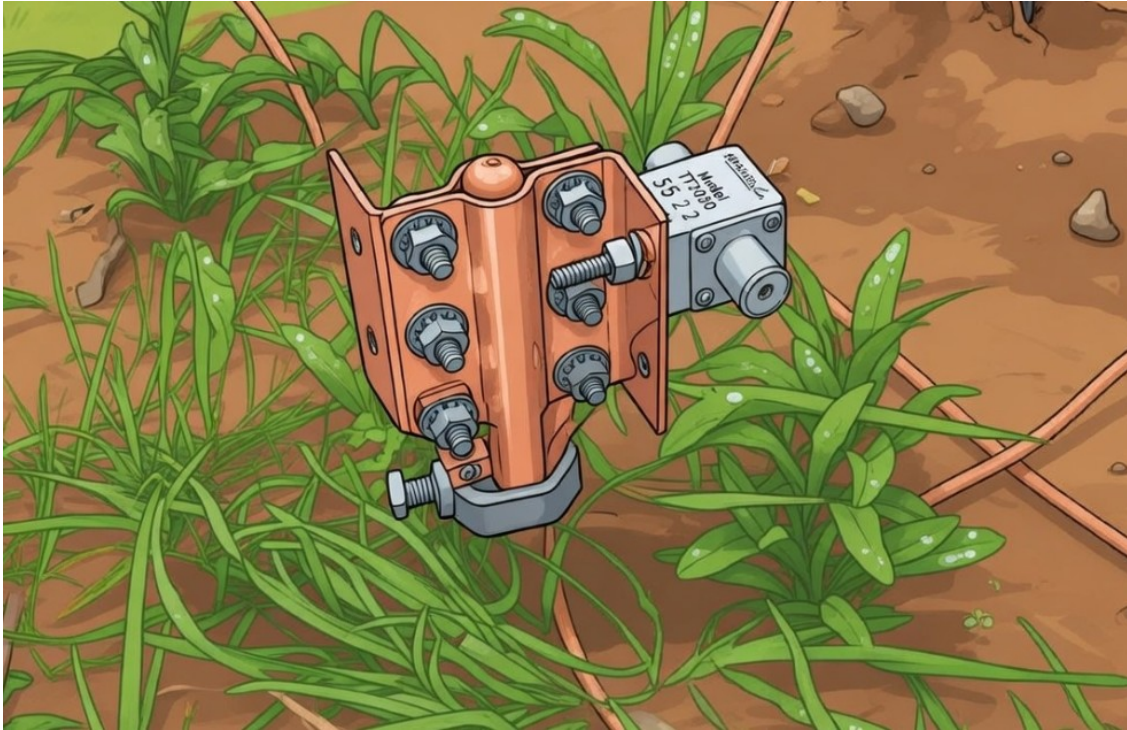
LIGHTNING PROTECTION AND TOWER/ANTENNA SAFETY

B-003-020: LIGHTNING PROTECTION AND TOWER/ANTENNA SAFETY

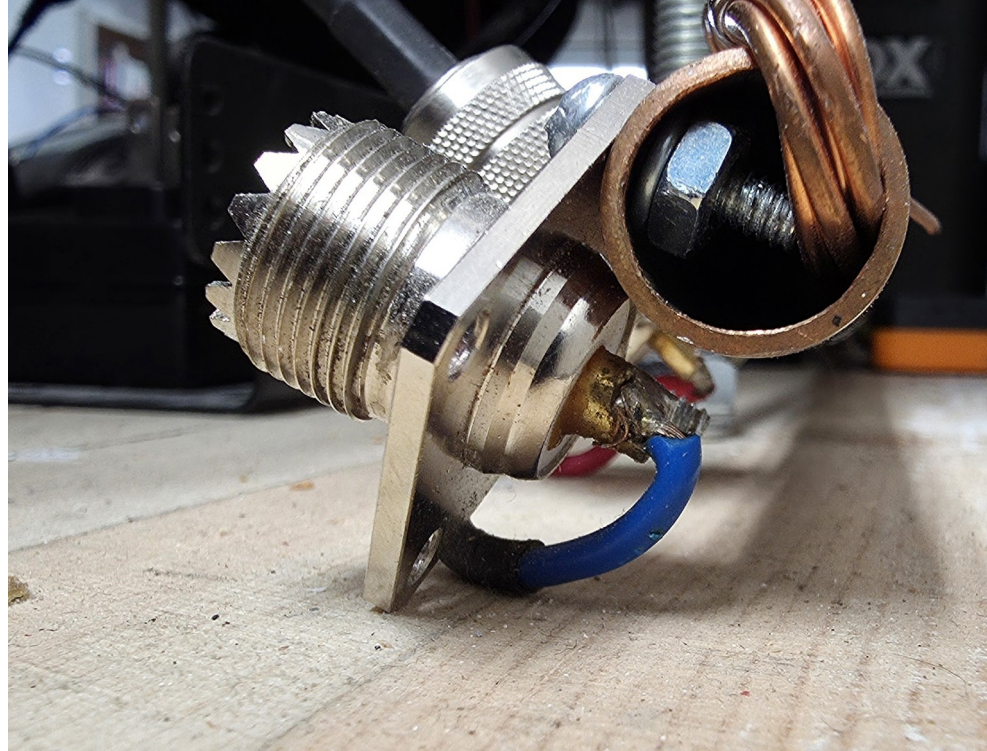
LIGHTNING PROTECTION FOR ANTENNAS & STATION

- **LIGHTNING SEEKS THE LOWEST-RESISTANCE PATH TO GROUND.** GROUNDING COAX/ROTATOR CABLES (VIA ARRESTORS OR DIRECT BONDS) WHEN OFF-AIR GIVES SURGES A SAFE PATH OUTSIDE THE BUILDING. SURGE PROTECTORS MUST BE **MOUNTED OUTSIDE NEAR THE GROUND ROD** FOR SHORTEST DIVERSION PATH. ULTIMATE PROTECTION: FULLY DISCONNECT COAX, ROTATOR CABLES, AND AC POWER DURING STORMS OR LONG ABSENCES — NO PATH FOR ENERGY INTO THE SHACK.

B-003-020: LIGHTNING PROTECTION AND TOWER/ANTENNA SAFETY



B-003-020: LIGHTNING PROTECTION AND TOWER/ANTENNA SAFETY



ANTENNA COAX GROUNDING WHEN NOT IN USE – SHORTED SO-239 TO STATION GROUND

TOWER & FALL SAFETY

- TOWER WORK REQUIRES **FULL-BODY HARNESS**, LANYARD, POSITIONING BELT, AND HELMET (CSA/ANSI APPROVED). FALL ARREST LIMITS IMPACT FORCE AND PREVENTS FREE FALL. GROUND CREW WEARS **HARD HATS** — TOOLS/BOLTS DROPPED FROM HEIGHT CAN CAUSE SERIOUS INJURY.

B-003-020: LIGHTNING PROTECTION AND TOWER/ANTENNA SAFETY



ANTENNA HEIGHT & RF BURN PREVENTION



- **RF BURNS** OCCUR FROM HIGH RF CURRENT/VOLTAGE ON ANTENNAS/FEEDLINES DURING TRANSMIT — SKIN CONTACT CAUSES LOCALIZED HEATING (LIKE A MICROWAVE BURN). KEEP HORIZONTAL WIRES/FEEDLINES (ESPECIALLY OPEN-WIRE LADDER LINE) **HIGH AND INACCESSIBLE**. USE WARNING SIGNS/LABELS IN HIGH-RF AREAS.



**RF BURNS
ARE
NASTY!**

B-003-020: LIGHTNING PROTECTION AND TOWER/ANTENNA SAFETY

PRE-REPAIR & GROUND-MOUNTED ANTENNA PRECAUTIONS

- ALWAYS **KILL TRANSMITTER POWER AND DISCONNECT COAX** BEFORE CLIMBING OR WORKING ON ANY ANTENNA — ACCIDENTAL KEY-UP CAUSES RF BURNS OR SHOCK.
- GROUND-MOUNTED VERTICALS (EX: QUARTER-WAVE WITH RADIALS) HAVE HIGH RF CURRENT NEAR THE BASE — FENCE OFF, MARK, OR ROPE OFF THE AREA TO **KEEP PEOPLE/PETS AWAY DURING OPERATION.**



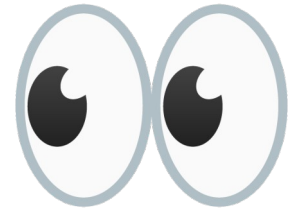
QUESTION SECTION B-003-021:

RF EXPOSURE SAFETY AT UHF/MICROWAVE FREQUENCIES

B-003-021: RF EXPOSURE SAFETY AT UHF/MICROWAVE FREQUENCIES

UHF/MICROWAVE SPECIFIC SAFETY

- UHF (300 MHz+) AND MICROWAVE (GHz) FREQUENCIES PENETRATE LESS DEEPLY BUT FOCUS ENERGY — **EYES ARE ESPECIALLY VULNERABLE** (LENS/CORNEA HEATING CAN CAUSE CATARACTS). NEVER LOOK INTO A TRANSMITTING HORN/PARABOLIC DISH; **MOUNT ANTENNAS HIGH/INACCESSIBLE DURING TX.**
- UHF AMPS CAN PRODUCE HIGH POWER IN SMALL SPACES — **LOCK OUT/TAG OUT POWER**, DISCHARGE CAPS, AND VERIFY NO RF BEFORE OPENING SHIELDING TO AVOID ACCIDENTAL EXPOSURE OR SHOCK.



B-003-021: RF EXPOSURE SAFETY AT UHF/MICROWAVE FREQUENCIES

HANDHELD TRANSCEIVER (HT) SAFETY

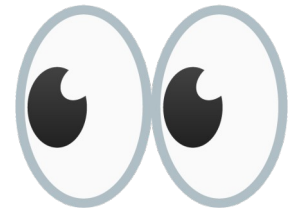
- HTs ON VHF/UHF (2M/70CM) HAVE ANTENNAS CLOSE DURING USE
 - HOLD RADIO VERTICALLY, ANTENNA OUTWARD/**AWAY FROM HEAD**/BODY/OTHERS TO MINIMIZE SAR (SPECIFIC ABSORPTION RATE).
- USE SPEAKER-MIC OR HEADSET FOR LONGER TX.



RF ENERGY EFFECTS ON TISSUE

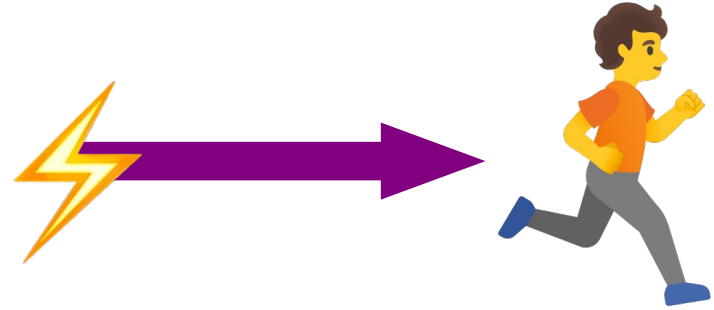


- RF IS NON-IONIZING BUT CAUSES **DIELECTRIC HEATING** (LIKE A MICROWAVE OVEN) – TISSUE ABSORBS ENERGY, RAISING TEMPERATURE. **EYES** (LOW BLOOD FLOW, NO COOLING) ARE MOST AT RISK FOR CATARACTS FROM PROLONGED EXPOSURE.



B-003-021: RF EXPOSURE SAFETY AT UHF/MICROWAVE FREQUENCIES

POWER DENSITY & DISTANCE (INVERSE SQUARE LAW)

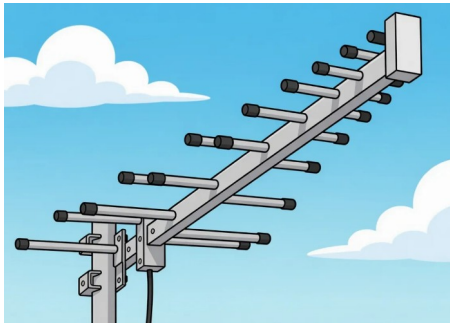


- RF INTENSITY DROPS OFF RAPIDLY WITH DISTANCE.
- DOUBLING YOUR DISTANCE FROM THE ANTENNA REDUCES EXPOSURE TO JUST ONE-QUARTER OF WHAT IT WAS.
- B-003-021-008 — HOW DOES THE POWER DENSITY OF AN ELECTROMAGNETIC WAVE CHANGE AS IT PROPAGATES AWAY FROM AN ANTENNA IN FREE SPACE? **ANSWER: IT DECREASES AS THE SQUARE OF THE DISTANCE**

B-003-021: RF EXPOSURE SAFETY AT UHF/MICROWAVE FREQUENCIES

INDOOR & DIRECTIONAL ANTENNA PRECAUTIONS

- **INDOOR ANTENNAS (ATTIC LOOPS, DIPOLES) CONCENTRATE RF INDOORS — PLACE THEM **AWAY FROM BEDROOMS/LIVING AREAS.****
- **HIGH-GAIN BEAMS (YAGIS) FOCUS ENERGY FORWARD — ELEVATE ABOVE ROOFS/NEIGHBOURS TO **AVOID DIRECTING MAIN LOBE AT PEOPLE.****



B-003-021: RF EXPOSURE SAFETY AT UHF/MICROWAVE FREQUENCIES

GENERAL ANTENNA HEIGHT & CONTACT PREVENTION

- **ELEVATE DIPOLES (AND ANY WIRE ANTENNA) HIGH — PREVENTS RF BURNS FROM TOUCHING DURING TX (HIGH VOLTAGE AT ENDS/CENTER) AND REDUCES GROUND-LEVEL EXPOSURE.**





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