

INTRODUCTION

Congratulations on your choice of the MFJ-9402. We think you'll enjoy countless hours rag-chewing, chasing grids, contesting, and roving as you explore the fascinating world of VHF weak-signal communication. Please read this manual thoroughly before attempting to operate your unit. Here are some of the radio's features we think you'll like:

Easy to Operate: Just turn on and tune in! No microprocessor mumbo-jumbo to learn, and no complex commands to memorize.

Potent Signal: *Constant Current™* syllabic speech processing gives your signal 4-6 dB added punch to break pileups or climb above the noise.

Energy Efficient: All-analog circuitry uses minimal energy. Mountain top and rove on portable power, or operate from home with a small 2-Amp regulated supply.

Sensitive Receiver: A low-noise front-end and doubly-balanced mixer fight intermod, yet dig into band noise for weak signals. If the signal's there, you'll hear it!

Excellent Selectivity: Sharper selectivity *does* make a difference on VHF. Fight contest QRM and enjoy reduced passband noise with HF-style 2.3 kHz ladder filter.

Real S-Meter: Full-sized electromechanical meter displays subtle changes. Aim your beam with pin-point accuracy and give out signal reports that mean something!

Agile Tuning: Reduction-drive analog VFO lets you scan for signals quickly, then zero in smoothly without sudden rate shifts or stair-stepping. Ideal for fast-paced hunt-and-pounce operation during contests and band openings!

Amplifier Friendly: Built-in FET switch keys solid-state or tube amps. Output signal is tailored for most popular multi-mode "brick" amplifiers (call 800-647-1800 for the latest information on Mirage VHF-amplifier products).

Built to Last: Conservative design, premium FR-4 plate-through PC board, state-of-the-art SMD layout, handsome brushed-aluminum panel, and tough vinyl-clad case make for good looks and years of dependable service.

Optional MFJ-416 CW Module: Communicate with CW stations instantly--no need to switch modes, sidebands, or to fiddle with the RIT. Just grab the key and start sending. A must for snagging elusive grids, extra contest points, or auroral contacts!

At home or on the road, you'll enjoy superb two-meter performance with your MFJ-9402. Best of all, it's fully backed by MFJ's exclusive *NO MATTER WHAT™* one-year guarantee. If it breaks, we'll take care of it.

GENERAL DESCRIPTION

The MFJ-9402 is a compact and economical SSB transceiver designed especially for fixed or portable communication in the weak-signal segment of the two-meter band. Although normally configured for USB voice communication, the MFJ-9402 will also operate on CW with the addition of the MFJ-416 semi-QSK CW-adapter module. Energy-efficient analog circuitry conserves energy, while syllabic RF speech processing ensures on-air performance equal to larger and more powerful radios. Other features include a sharp HF-style crystal filter, built-in heavy-duty 3" speaker, analog mechanical S-meter, "ergonomic" operating controls, and a built-in phone jack for *walkman™* style stereo phones.

Typical Specifications

Receiver Section:

Frequency Coverage:..... 144.000-144.300 MHz
Receiver Type: Single-conversion superhet
Frequency Control:..... Crystal-heterodyne VFO, low-side injection
IF Frequency:..... 10 MHz
IF Selectivity: -6 dB @ 2.3 KHz
AGC: Audio-derived, 70-dB range
Sensitivity:..... MDS <.1 uV, S9 = 10 uV
AF Output:..... 500 mW speaker, 100 mW phones
Average Rx Current: 60-mA, (S-meter lamp disabled)

Transmitter Section:

RF Power Output:..... 7 watts PEP into 50 ohms*
VSWR Tolerance: 3:1 or greater
Peak Tx Current: 1.5 Amps (13.8 vdc)
Speech Enhancement: RF compression, syllabic rate
Spurious Attenuation:..... -60 dBc or better
CW Generation:..... A1 carrier, adjustable offset**
Mic Input: 600-Ohm dynamic, PTT

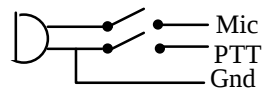
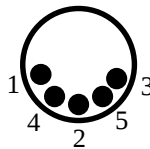
* Note that most "10-watt input" multi-mode solid-state amplifiers are spec'd for FM service and require significantly less than 10-watts for linear SSB operation.

** The MFJ-416 CW adapter is required for CW operation (\$39.95). Easy-to-install plug-in board provides semi-QSK operation and built-in sidetone.

QUICK-START OPERATING INSTRUCTIONS

- **Power Supply:** Use any well-regulated 13.8-V DC supply (1.5-amp or greater) or a suitably-rated 14-V battery pack. The MFJ-9402 will also run on 12-volts at slightly reduced RF output. Use a 5.5mm x 2.1 mm coaxial power plug *with the + lead attached to the center pin of the connector* (use Radio Shack 274-1569).
- **Microphone:** The MFJ-290 handheld microphone was especially selected for MFJ-9400-series radios, but virtually any 600-ohm dynamic mic will work if it has a 5-pin DIN connector wired as shown below (use RadioShack 274-003).

Pin 3 = PTT Line
Pin 4 = Mic Line
Pin 1,2,5 = Ground

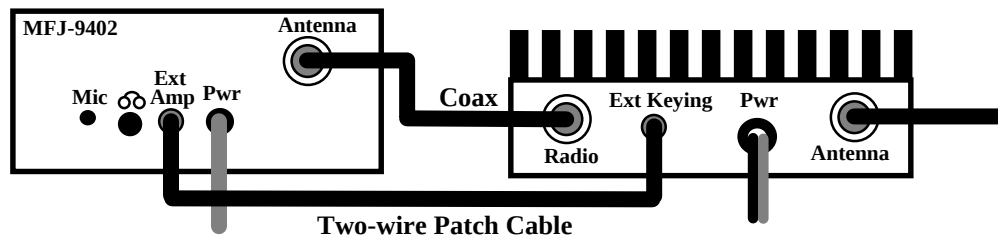


Important Note: The PTT switch must cut both mic line and PTT line during receive. Never use an amplified microphone--it will overdrive the speech processor.

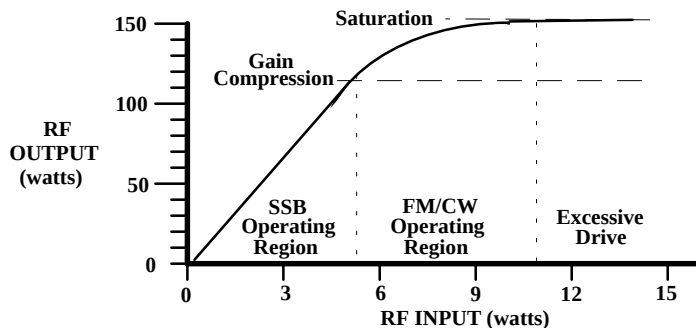
- **Antenna:** Use any horizontally polarized 2-meter antenna exhibiting a VSWR of 2:1 or less at 144.2 MHz. *Avoid antennas with unknown or high VSWR.* A simple dipole or omni-directional halo may be adequate for local contacts, but a 5-10 element directional yagi will yield vastly superior long-range performance and is strongly recommended (see antenna tips on page 5).
- **Speech Processor:** The MFJ-9402 features a built-in syllabic speech processor. For best results, hold the mic about 1-inch from your lips and speak normally. *Avoid close-talking or yelling.* The S-meter should deflect about 1/2-scale with normal speech. A *Mic Gain* trimpot is located on the rear panel. The factory-default gain setting is mid-range, or 12-o'clock.
- **External Power Amplifiers:** The MFJ-9402 is especially designed to compliment most popular 10-watt input 2-meter FM/SSB amplifiers. The *Ext Amp* jack provides ground-closure on transmit to key the amplifier. Be sure to follow *all* amplifier manufacturer's instructions closely and make any needed adjustments to avoid exceeding your amplifier's safe drive level on SSB. In many cases, SSB drive requirements will be significantly lower than those required for FM operation. See amplifier primer and drive-level adjustment instructions on page 4.
- **Receiver Preamplifiers:** If your external PA features a built-in GaAsFET preamp, try using it. If you observe an audible improvement in *signal-to-noise ratio* on weak signals and a desirable increase in overall sensitivity, you may wish to leave it in line. However, if it makes the background noise disproportionately louder than weak

signals, leave it off. Also, note that extra preamplification may degrade the radio's overload performance and IMD immunity when strong signals are near-by.

CONNECTING A MULTI-MODE AMP TO THE MFJ-9402



Drive Requirements: The "10-watt input" rating assigned VHF amps typically refers to FM operation. As illustrated below, SSB drive requirements may be substantially less because of the need to maintain *amplifier linearity*. Overdriving on SSB results in two types of interference-generating non-linearity. First, gain compression causes amplifier IMD performance to deteriorate rapidly, adding distortion to the audio and making your signal needlessly broad. Second, saturation causes flat-topping, a condition that clips the SSB waveform and produces severe splatter. On SSB, your amplifier should always be driven at levels below the point where significant gain compression begins.

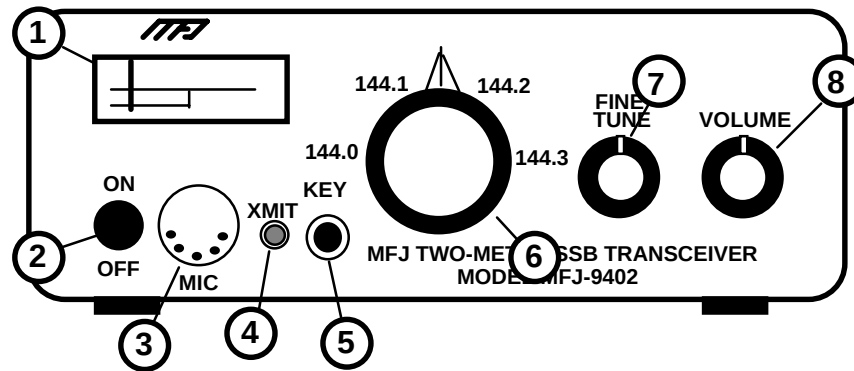


Input/Output Power Curve for a "Typical" 150-W VHF Amplifier

Setting Drive Level: As a rule-of-thumb, plan to run your VHF amp at $.66 \times$ full-rated FM output power. For example, if your brick is rated for 150 watts on FM, run it at 100 watts PEP on SSB ($.66 \times 150 = 99$). In most cases, this will keep your amp linear. The MFJ-9402 is normally adjusted for 7-watts PEP output. While this is right for some amps, it may overdrive others. If so, you may reduce drive by re-setting ALC trimpot R73 for the desired level (R73 is located near the antenna connection on the left-rear corner of the PC board--see Page-9 for trimpot locations). To monitor amplifier output, connect a *true peak-reading wattmeter* between the amp and a low-VSWR 50-ohm load (a good antenna will do). To generate a ALC-limited SSB signal, speak loudly into the microphone so the processing meter deflects vigorously. Adjust R73 until your amplifier delivers 66% of its full-rated FM output on the wattmeter. If you use an *average-reading wattmeter* (Bird 43, etc), note that the meter movement will read a lot lower--only about 40-50% of the PEP value with syllabic processing (or 40-50 Watts for a 150-W amp). Also, note that the transceiver's processor meter will read *higher* as you increase ALC

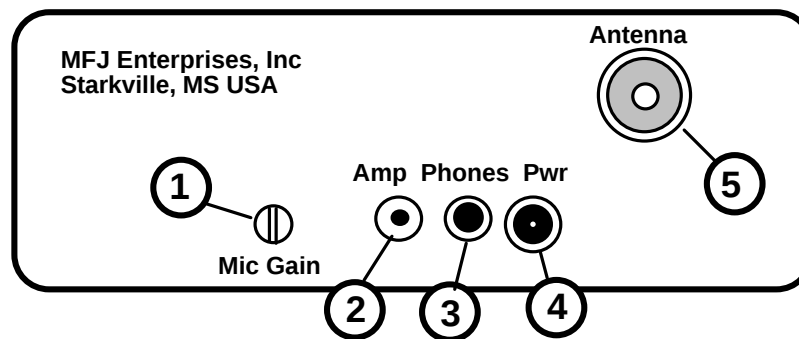
voltage and reduce power output. This is normal. Remember, if you overdrive your VHF amp on SSB, the signal won't get any louder--but it's guaranteed to get a lot broader!

MFJ-9402 CONTROL LOCATION AND FUNCTION



FRONT PANEL

- | | |
|-----------------------|--|
| 1. S-METER: | Measures signal strength on receive, ALC on transmit |
| 2. POWER: | Applies power to the radio. |
| 3. MIC: | 5-pin DIN connector for PTT microphone. |
| 4. XMIT LED: | Illuminates when transmitter is keyed. |
| 5. KEY: | 3.5mm mono key jack--used with MFJ-416 CW adapter. |
| 6. VFO TUNING: | Tunes in stations, indicates operating frequency. |
| 7. FINE TUNE: | Fine tune control to assist with precise SSB tuning. |
| 8. VOLUME: | Adjusts listening level. |



REAR PANEL

- | | |
|-----------------------|---|
| 1. MIC GAIN: | Adjusts transmitter audio level (normal setting 12:00). |
| 2. EXT AMP: | Keys linear amplifiers--closure to ground on transmit. |
| 3. PHONES: | 3.5mm mini-jack wired for stereo headphones |
| 4. POWER JACK: | 5.5mm OD, 2.1mm ID, [+] to center pin. |
| 5. ANTENNA: | SO-239 for standard 50-Ohm coaxial plug. |

TWO-METER ANTENNA SYSTEMS

While serious VHF DXers sometimes construct huge antenna systems, it's quite easy to achieve outstanding results with only a modest installation. Here are some tips for selecting antennas and getting top performance from your new VHF-SSB station:

- **Antenna Selection:** Before purchasing your antenna, first survey the site where you plan to install it. For a densely wooded area or location with nearby obstructions, consider mounting a smaller light-weight antenna as high as possible to get above RF-absorbing foliage and ground clutter. For open locations, a larger antenna (with more gain) mounted at a lower height may yield better results. Also, assess your "hardware" options. If you have a tower with a strong rotor available, a single long-boom antenna is probably the best choice. However, if you are restricted to a roof-top installation using TV hardware, a mid-size yagi--or a stacked array using two or more short-boom yagis--may make more sense. When starting out, even a single 5 to 10-element yagi on a good TV mast can yield very good results. Remember, VHF antenna systems are easy to expand and upgrade over time, so there's no need to do everything at once!
- **Feedline Routing:** For best performance, 2-meter yagis should be mounted as high and in the clear as possible. However, at 144 MHz, it's also important to factor in feedline loss. If you must add 50 additional feet of coax to gain only 10 feet in height, it may not be worth the trouble! Take time to plan out and measure feedline runs before making a final decision. Also, calculate your anticipated line loss using the data from coax-loss charts. Feedline attenuation greater than 1-2 dB will begin to make a discernible difference in your station's weak signal performance.
- **Coax Cable:** RG8X foam coax may be sufficient for short direct cable runs (no more than 50 feet). However, for longer runs, it really pays to install high-quality low-loss cable such as 9913--or a more-flexible equivalent. Be sure to seal exterior connectors against moisture with silicon compound or rubber tape--water incursion damages low-loss cables very rapidly. To reduce loss, avoid installing unessential in-line devices such as coax switches, barrel splices, and power meters. Also, use premium connectors, install them carefully, and avoid sharp bends or kinks in the feedline.
- **Rotor:** A light-duty TV rotor handles most small or mid-sized yagis, but long-boom arrays require the extra torque and breaking action of a "ham" rotor.
- **Safety:** Never install antennas where they can accidentally fall and contact power lines or residential entrance cables. For electrical-hazard protection, permanently ground the mast outside the building using a *ground system* with multiple rods. Also, *always* disconnect the feedline from the radio at the first sign of threatening weather (even nearby strikes may damage sensitive receiver circuitry). Finally, never install antennas alone. Make sure *someone* knows where you are and what you are doing so they can render assistance in the event of an unexpected problem or accident.

OPERATING ON TWO METER SSB

Unlike the HF amateur bands, there is relatively little atmospheric background noise on 2-meter SSB to cover up extremely weak signals. Because of this benefit, even modestly-equipped stations can expect to communicate routinely over distances ranging from 75 to 150 miles without using repeaters or relying on band openings. Of course, when band openings do occur, the communication range may increase significantly. Here are some of the more common forms of 2-meter "skip":

Tropospheric Enhancement: Tropospheric bending, or "tropo", is the most common form of "lift" at 144 MHz. Tropo occurs when warm air overrides entrenched cold air, forming a thermal barrier aloft. Instead of passing into space, VHF radio waves duct along this barrier, extending communication well beyond 100 miles--to as much as 1000 miles or more. Watch for signs of tropo on VHF-TV, FM Broadcast, or two-meter FM.

Auroral Enhancement: "Aurora" most often appears in the early evening hours around the spring and fall equinox on days when the NBS K-index is over 4. Be sure to use CW on 2-meters. Unlike at 6-meters, SSB becomes too "buzzy" and distorted copy on the higher bands. Point your beam North and listen for DX up to 800 miles away.

Meteor Scatter: Random meteor bursts normally enhance distant signals for only a few seconds. However, during a shower or storm, meteors may hit frequently enough to support complete two-way exchanges of QSO information. This can yield fantastic DX. Watch your favorite magazine's VHF column for predicted meteor shower dates.

Sporadic E: Look for "E-skip" during June-July, and again in November-December--around the summer and winter solstice. E openings are much shorter and less frequent on 2-meters than on 6 and 10, but they are dramatic--yielding contacts of 1200 miles or more.

EME: Earth-Moon-Earth propagation involves bouncing SSB or CW signals off the moon to work world-wide DX. While you won't achieve 2-way "moon-bounce" with a 5-element yagi and 10 watts, many have done it on CW using only a 160-Watt brick and a single medium or long-boom yagi. Monitor the low edge of the band for EME activity when the moon is full and low on the horizon. You might be pleasantly surprised by what you'll hear--and work!

GRID SQUARES

On VHF SSB, the maidenhead world-wide grid locator system is used to identify approximate station location (see the U.S. map provided at the back of this manual). A typical QSO report might go, "You're 5-by-6 in Echo Mike 52". This means, "your Q5 signal is S-6 here in grid square EM52" (central Mississippi). VHF operators collect new "grids" the same way HF hams collect states and countries. Most VHF contest scores and

awards are based upon the grid locator system. Know your grid--you'll be asked for it often!

THEORY OF OPERATION

General: The MFJ-9402 is a 7-Watt USB voice transceiver covering 144.0-144.3 MHz. CW operation may be added with the addition of the MFJ-416 plug-in CW adapter.

Receiver: Bandpass filter L1/L2 pre-selects incoming 144 MHz signals prior to pre-amplification by Q1. U1 down-converts received signals to 10 MHz, where ladder filter Y1-Y6 sets a 2.3 kHz USB message-channel bandwidth. IF amplifier U2 boosts and levels the filtered SSB signal using audio-derived AGC. Product detector U3 self-injects 10-MHz LO and demodulates the USB signal, routing recovered audio to op-amp U4a for amplification. U4a drives AGC amp Q3/Q4 and AF-power amp U5. Switch Q2 selects between a slow AGC rate in receive mode and a fast (syllabic) ALC rate in transmit.

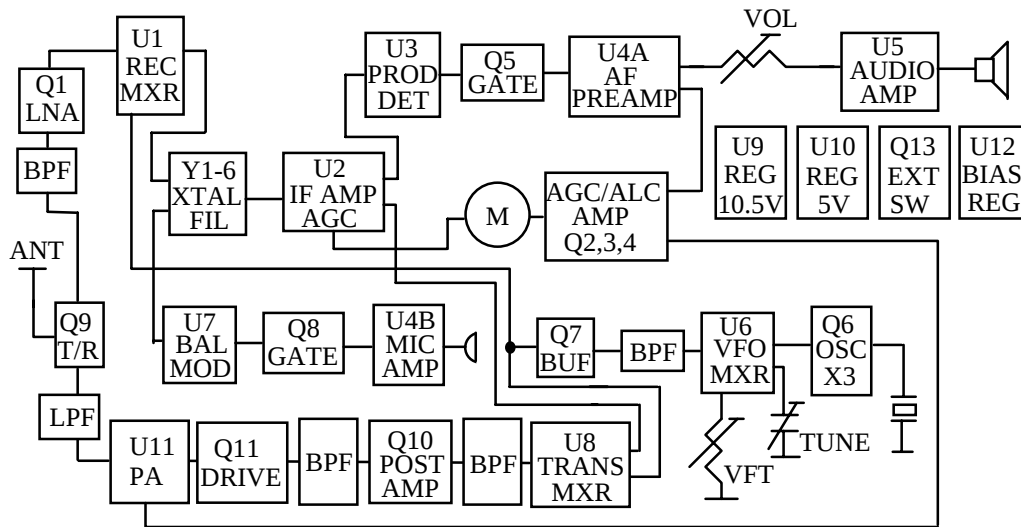
Transmitter: Mic-amp U4b and BFO U3 drive balanced modulator U7. DSB output is routed to IF filter Y1-Y6, which strips the unwanted sideband and shapes audio response. U2 then amplifies and levels the 10-MHz USB IF signal using RF-derived ALC. Transmit mixer U8 combines IF and VFO signals, and the 144 MHz product is selected by filter L9/10. RF amplifier Q10 boosts this signal prior to additional filtering at L11/12. Driver MMIC Q11 boosts RF level to +5 dBm PEP for final amplification. PA stage U11, a 2-stage linear RF-power module, delivers approximately 7-watts PEP on SSB and 5-8 watts CW. Output is fed through a half-wave harmonic filter at L13/14 and routed to T/R relay K1. During transmit, PTT switch Q9 drives T/R relay K1.

Mixing VFO: Mixer U6 combines an internally-generated 6-MHz VFO signal with 128-MHz LO generated by crystal-oscillator/tripler Q6. The mixer's 134-MHz product is selected at L6/L7 and fed to buffer Q7. The output of Q7 is filtered at L8 and level-corrected for driving U1 and U8.

Regulation and Protection: Adjustable monolithic regulator U9 sets Vcc at 10.25 volts for most of the radio's low-level stages. Regulator U10 supplies 5 Volts to the mixing VFO, and U12 biases the PA module on during transmit. A crowbar at D10 protects circuitry from accidental reverse-polarity damage.

Amplifier Keying: FET switch Q13 provides ground-path closure for keying an external linear amplifier when the transceiver is in transmit mode.

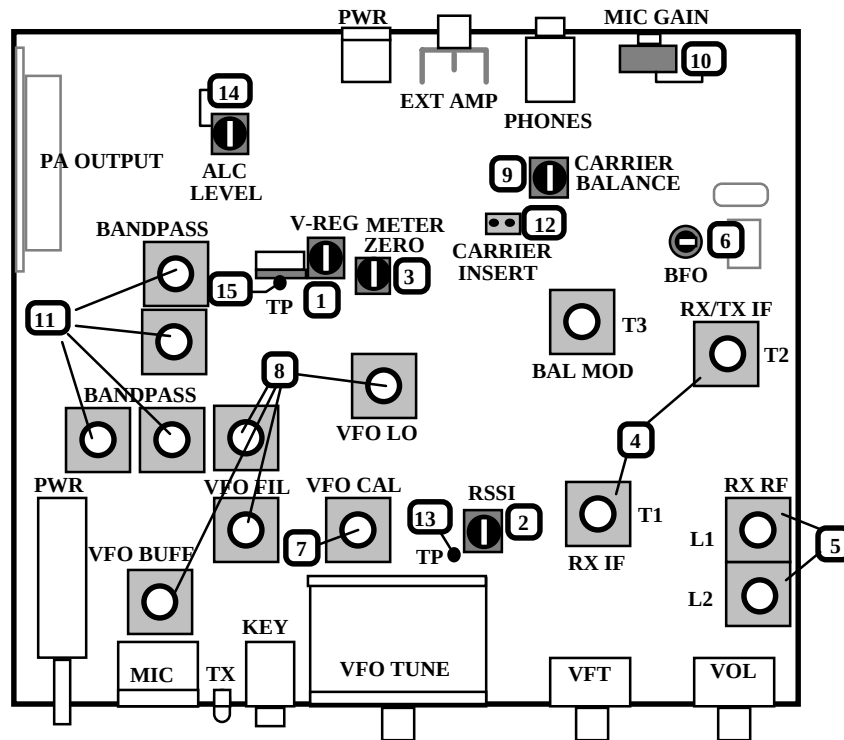
MFJ-416 CW Adapter (optional): On initial key contact, RC-timed switching establishes semi-QSK operation by activating the PTT line and re-biasing the radio's fine-tune varactor for CW offset (offset is adjustable). To generate CW characters, additional switching unbalances SSB modulator U7--forcing it to generate A1 carrier. Switching also powers a built-in 2.8-kHz sounder to provide sidetone (internal sidetone may be defeated when using a keyer with sidetone).

BLOCK DIAGRAM, MFJ-9402 TWO-METER SSB TRANSCEIVER**MFJ-9402 Internal Adjustments: (see pictorial on page 9)**

- [1] **Voltage Regulator:** Adjust V-REG trimpot for 10.25V on tab of U9 [15].
- [2] **RSSI Threshold:** Adjust AGC trimpot for 4.3 V at RSSI test point [13].
- [3] **Meter Zero:** Adjust M-ZERO trimpot for zero meter reading w/o signal.
- [4] **IF Transformers:** Peak IF cans T1,T2 for best receiver sensitivity.
- [5] **RF Transformers:** Peak RF coils L1,L2 for best receiver sensitivity.
- [6] **BFO:** Set BFO trimcap so skirt peak corresponds with 600-Hz beat note.*
- [7] **VFO Cal:** Tune signal generator and VFO to 144.200 MHz, set L3 for zero beat.
- [8] **Mixing VFO:** Peak L5,L6,L7,L8 for best receiver sensitivity.
- [9] **Carrier Balance:** Set BAL trimpot for minimum carrier.
- [10] **Mic Gain:** Set trimpot to preference--12-o'clock position is factory default.
- [11] **Transmitter Bandpass Filters:** Install a shorting plug at [12] to insert carrier, and turn ALC trimpot [14] clockwise to disable ALC line. The meter should not move on TX. Key mic and peak L9,L10,L11,L12 for maximum output on a RF Wattmeter. After aligning, remove shorting plug and restore ALC trimpot to previous setting.
- [12] **Carrier Insert:** Shorting plug location to insert carrier for tuning driver trimpots.
- [13] **RSSI Test Point:** Used when setting RSSI trimpot [2].
- [14] **ALC Level:** Key mic and speak, adjust ALC trimpot for 1/2-scale meter deflection.
- [15] **V-REG Test Point:** Set V-REG trimpot [1] for 10.25-V on regulator tab.

* Resetting BFO will change audio characteristics, also may unbalance carrier.

** If CAR BAL alone doesn't produce -40dBc null, interactively adjust BAL and T3.

PICTORIAL DIAGRAM -- INTERNAL ADJUSTMENT LOCATIONS

IMPORTANT WARNING: The tune-up information provided in this manual does not constitute a step-by-step guide for aligning the MFJ-9402. *If you lack the test equipment, experience, and skills to align VHF SSB transceivers, do not attempt to make these adjustments on your own!* Far better to contact the MFJ factory for assistance. Mis-alignment may cause permanent damage to your unit or may result in interference to other radio services in violation of FCC rules. MFJ cannot be held responsible for the performance of radios that have been improperly tampered with or mis-adjusted.

TECHNICAL ASSISTANCE

If you have any problem with this unit first check the appropriate section of this manual. If the manual does not reference your problem or your problem is not solved by reading the manual, you may call *MFJ Technical Service* at **601-323-0549** or the *MFJ Factory* at **601-323-5869**. You will be best helped if you have your unit, manual and all information on your station handy so you can answer any questions the technicians may ask.

You can also send questions by mail to MFJ Enterprises, Inc., 300 Industrial Park Road, Starkville, MS 39759; by Facsimile (FAX) to 601-323-6551; or by email to techinfo@mfjenterprises.com. Send a complete description of your problem, an

explanation of exactly how you are using your unit, and a complete description of your station.

TROUBLESHOOTING GUIDE

Radio does not power up: Check power plug, power lead, and power supply. Also, check reverse-polarity protection fuse (etched on the pc board next to power jack J3). If open, install a 3-A pig-tail fuse above the pc fuse using the holes at each end.

No signals received: Check antenna and feedline for breaks or shorts.

Spurious signals received: Look for interference from nearby computers, modems, TVs, cordless phones, or other devices that may emit spurious 144-MHz signals.

Erratic transmit: Check antenna VSWR. Also, check battery or power supply voltage. If supply drops below 12V under load, the radio's regulator will "drop out" and operation will become erratic. If you operate from a 12-V battery, reduce the V-REG trimpot for 10.0 Volts to ensure regulation (measure on U9 regulator tab).

High meter deflection on transmit, low RF output: ALC voltage may be set incorrectly--or--the antenna impedance may be much higher than the specified 50 ohms. Check for a open feedline or for excessive VSWR. If okay, adjust R73 for mid-scale deflection into a 50-ohm dummy load with normal speech.

Splatter, low meter deflection: ALC voltage (trimpot R73) may be incorrectly set--or--antenna load impedance may be much lower than the specified 50 ohms. Look for a shorted feedline or excessive VSWR. If okay, adjust R73 for mid-scale deflection into a 50-ohm load with normal speech.

S-meter does not return to zero: Confirm V-REG (R78) is set for 10.25V on tab of U9 and AGC threshold (R11) is set for 4.3V at RSSI test point (w/o signal). When both voltage are set, adjust the Meter Zero trimpot (R17) for zero meter deflection.

Poor carrier suppression: Connect radio to a dummy load and turn the Mic Gain trimpot (R52) fully off. Monitor your operating frequency with a two-meter receiver--a FM-HT or scanner will work for checking unmodulated carrier. Key the MFJ-9402 PTT switch carefully adjust Carrier Balance trimpot (R57) for minimum signal in the monitor. If you cannot obtain a minimum of -40dBc suppression, detune T3 slightly and re-try.

Low or distorted transmit audio: Check to see if the mic gain is set too low. Also, make sure you are using a 600-Ohm low-Z dynamic microphone.

Excessive background noise or hum on signal: Mic gain may be set too high for ambient noise conditions. Also, the dynamic mic element may be too close to a large

power supply transformer or electric motor. Move mic away and see if hum disappears.

SCHEMATIC

U.S. GRID-LOCATOR MAP