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MFJ-8631 220-MHz Packet Only™ Data Radio

Congratulations on your choice of the MFJ-8631 Packet Only Data Radio. Please read this manual thoroughly before attempting to operate your unit. Let's begin with a look at some useful MFJ-8631 Features:

FEATURES

Packet-Only Performance: The MFJ-8631 is designed from the ground up for packet. This means you'll get uncompromising performance at all data rates--on AFSK or FSK--for a fraction of what you'd pay for a converted voice radio.

Cool Running: The MFJ-8631 draws only 25 mA on receive, and less than 1 A on transmit. Run it 24 hours a day, 365 days a year. It's perfect for unattended backbone links in your network.

Sensitive: Motorola-IC based receiver circuitry recovers data from weak signals for better throughput and fewer collisions.

Made-For-Data Filters: Optimize your receiver for wide 9600-baud signals or narrow 1200-baud signals. No other radio does this!

Rugged 3-Watt Transmitter: MRF-227 PA provides plenty of power to get the job done without consuming needless energy.

Clean Unsquelched Data Output: The MFJ-8631 uses a wide-response DC-coupled line driver rather than a speaker amp for flawless signal recovery.

Note: Your TNC must have a DCD (Data Carrier Detect) circuit in order to work with radios that have unsquelched AFSK output.

Lightning-Fast TXD: Set TXD low! PIN-diode switching, continuous-running receiver, and crystal control deliver ultra-fast switching.

Twin Modulators: Varactor-modulation for true-FM at 9600 baud and reactance modulation for mic-level signals at 1200 baud provide ultra-clean FSK and AFSK.

Simple Setup: The MFJ-8631 is compatible with virtually any DCD-equipped TNC-2 modem.

Easy To Rechannel: Run your MFJ-8631 with supplied crystals on 223.7 MHz, or order custom crystals for the channel of your choice. Simple step-by-step instructions illustrate how to exchange crystals and set them on-frequency with a counter.

The Right Tool For The Job: Your MFJ-8631 was designed from scratch for fast, clean packet communication and nothing else! You can look forward to years of hands-off service.

TECHNICAL SPECIFICATIONS (Typical Unit):

Receiver:
Frequency Coverage.....216-230 MHz
Sensitivity..... 0.5 µV for 12 dB SINAD
Image Rejection.....-45 dB or better
1st IF..... 10.7 MHz
2nd IF..... 455 KHz
1st LO..... Crystal , 71`Mhz 3rd overtone
2nd LO..... 10.245 MHz
Selectivity.....-6 dB at 20 KHz (data-passband filter)
AFSK Output..... 0dBm@ 3.0-KHz deviation
Current Drain.....25 mA

Transmitter:
Frequency Control.....Crystal, 18-MHz x 12
FSK/AFSK Input level.....100 mV p-p @ 1200 baud, .5 V p-p @ 9600
Deviation..... 0-10 KHz, adjustable at TNC
RF Power Output.....>3 Watts into 50 Ohms
VSWR Tolerance.....3:1 Max.
Current Drain.....1.0 Amp @ 13.8 Volts

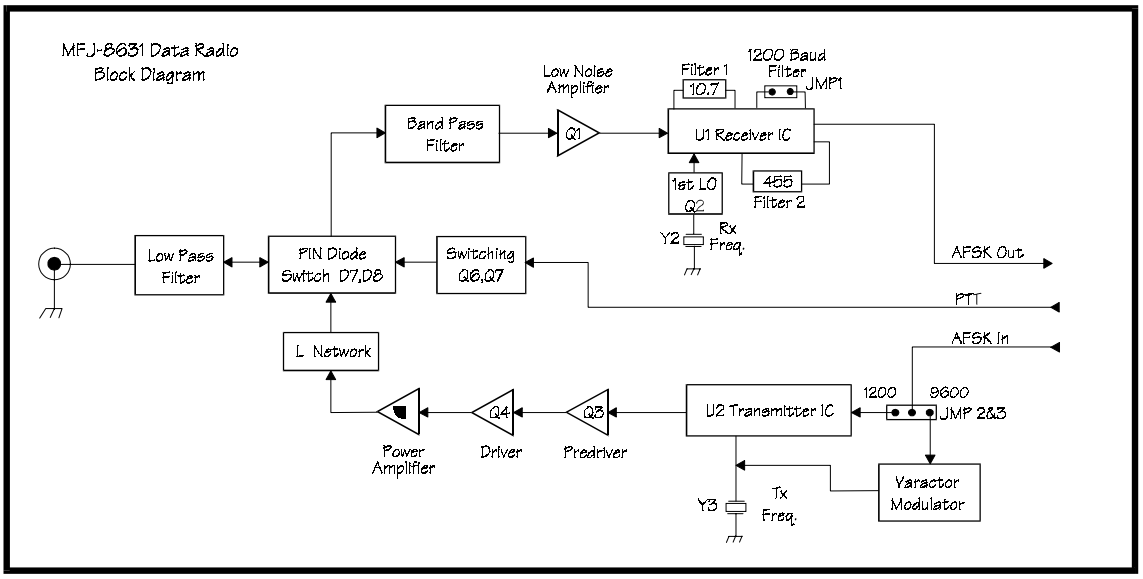


Figure 1
Block Diagram of MFJ-8631 Data Transceiver

SIMPLIFIED TECHNICAL DESCRIPTION:

Your MFJ-8631 was especially designed for packet-only operation. MFJ has eliminated costly circuitry you don't need--things like squelch, repeater offsets, PL tones, DTMF pad, PLL synthesis, memory, and the speaker-amplifier. At the same time, we engineered in essential packet circuits like true-FM direct modulation, unsquelched AFSK, PIN-diode switching, data-passband IF filtering, and a tailored 0-Vu DC-coupled line driver to ensure top-notch performance. There are no user-adjustable controls to set incorrectly, and the MFJ-8631 works with most popular DCD-equipped TNCs.

MFJ-8631 TECHNICAL DESCRIPTION:

General:
The MFJ-8631 is a dedicated-channel 220-MHz FM-AFSK transceiver designed for use with ***DCD equipped*** TNC-2 style modems at data-rates through 9600 baud.

Receiver:
Referring to Figure 1, incoming signals are preselected by the lowpass and bandpass filters. Low-noise preamp Q1 enhances weak signal performance. U1 is a monolithic dual-conversion narrowband-FM receiver IC that provides all mixer, IF amplification, limiting, and audio functions. The 1st-LO, Q2, is an external 3rd-overtone oscillator-tripler and the 2nd LO is built into U1. U1 and Q2 remain powered during transmit to ensure seamless RX recovery and self-monitoring capability. IF passband filtering is provided by ceramic filters FL1 (10.7 MHz) and FL2 (455 KHz). FL2 is a 20-KHz data-bandwidth filter which supports 9600 baud operation. Discriminator output is looped to U1's auxiliary op-amp which is configured as a DC-coupled AFSK line driver. Gain is set to provide 0-dBm AFSK output into a 600-Ohm load for approximately 3.0 KHz deviation. A jumper configures the line driver feedback loop for HF noise reduction at 1200 baud AFSK reception. Test points at the 1st-LO, RSSI, and DISC outputs facilitate alignment.

Transmitter:
FM signals are generated by monolithic FM-transmitter IC U2. Frequency control is provided by 18-MHz crystal Y3 (oscillator/modulator output is multiplied by three successive stages to 220 MHz). 1200-baud AFSK is fed directly to the IC's reactance modulator. 9600-baud FSK is fed through a varactor modulator for true-FM modulation. Pre-driver Q3 and Driver Q4 operate in class AB and use tuned bifilar 4:1 interstage transformers to facilitate matching and bandpass filtering. The PA stage (Q5) is a conventional class-C amplifier with a tuned-L network and pi-section low-pass filter to provide Z-matching and harmonic suppression.

T/R Switching:
RF switching is executed by PIN diodes D8 (receive path) and D7 (transmit path). DC switching is executed by Q6, Q7. Supply voltage to U1 is regulated at 5 volts, and voltage to U2 is regulated at 8 Volts. The 1st-LO voltage is regulated at 6.8 Volts. Receiver chip U1 remains powered during transmit for seamless T/R switching characteristic. MFJ-8631 is designed to operate from 13.8-Volt @ 1-Amp.

CONNECTING TO YOUR MFJ-8631:

Power Supply:
The MFJ-8631 will operate from any well-filtered DC power source delivering 13.8 Volts at 1 Amp. The MFJ-4110 wall-adapter supply is a light-weight voltage-regulated unit especially suited for powering the MFJ-8631. "CB" type supplies or battery packs capable of 1-A output will also work (anticipate lower RF output when using a 12-volt source). The MJF-8631 accepts a standard 5.5mm x 2.1mm coaxial-type power plug (Radio Shack 274-1569). Connect the (+) or red lead to the center pin, and connect the (-) or black lead to the outer sleeve. Use a 2 amp fastblow fuse with any power supply other than the MFJ-4110. Your MFJ-8631 features "crowbar" protection to prevent damage from incorrect power supply polarity. If power leads are accidentally reversed, the crowbar-diode conducts and immediately opens the radio's line fuse, cutting off power (for line-fuse replacement instructions, see the Appendix).

Antenna:
For best packet performance, use a high-quality antenna adjusted for minimum VSWR at your operating frequency. Omni-directional types--like the MFJ-1740 1/4-wave ground plane or MFJ-1752 5/8-wave ground plane should provide good local coverage. For point-to-point communication--especially at 9600-baud--install a directional yagi antenna. Be sure to feed it with high-quality low-loss coax such as 9913, and keep the cable run as short as possible. In many cases, a lower antenna fed with good cable will outperform a higher antenna fed with lossy cable. To cut line losses to a minimum, avoid adding unnecessary in-line connectors, power meters, and coax switches.

TNC Connection:
The MFJ-8631 plugs directly into any MFJ TNC starting with the MFJ-1270B. Any other DCD equipped TNC, such as the PK-96 and many others, will also work with this data radio. Use a 5-pin DIN-to-5-pin DIN cable, MFJ-5100, for connection to MFJ TNCs or the PK-96.

Caution: *Not All TNCs have DCD (Data Carrier Detect) circuitry, and your MFJ-8631 --which has an unsquelched output---will not work with those TNCs.*

Pin	Function
1	AFSK IN (100 mV pp / 500 mV pp)
2	GND
3	PTT (ground or logic-low for TX activation)
4	AFSK OUT (2.2 V pp max into 600 Ohms)
5	N.C.

RFI:
After completing initial adjustments, always reinstall the covers on your MFJ-8631 and TNC. Without shielding, the receiver may be swamped with RF interference generated by microprocessors in the computer and TNC. For added RFI protection, many veteran packet operators recommend installing ferrite RFI chokes on interconnect and power cables--and keeping the radio as far as possible from the TNC and computer. The MFJ-701 RFI kit provides 4 snap-on chokes for this purpose, along with instructions. Snap-on RFI chokes are also available at Radio Shack (273-104 and 273-105).

SELECTING BAUD RATE:

Receiver Filter:
The MFJ-8631 receiver features a special noise-reduction filter to enhance 1200-baud operation. When running at 1200-baud, this filter improves weak-signal performance. To activate the 1200-baud noise-reduction filter, install a shorting plug at JMP-1 (this plug must always be removed when operating at 9600-baud). See figure 3 on page 8 for placement of the jumpers on the pc board.

Transmitting:
Your MFJ-8631 has two FM modulators. One is a sensitive reactance modulator designed for mic-level 1200-baud TX-AFSK signals. The other is a "true-FM" varactor modulator designed for line-level 9600-baud TX-FSK. See figure 3 on page 8 for placement of the jumpers on the pc board.

For 1200-baud AFSK operation, set JMP-2 and JMP-3 in the reactance modulator positions (jumper plugs on the left-hand and center pins of each header).

For 9600-baud operation, set JMP-2 and JMP-3 in the varactor modulator positions (jumper plugs go on the center and right-hand pins of the headers).

If your TNC has a high-level output setting for 1200 baud TX-AFSK (usually set via a jumper inside the TNC), you may use the varactor modulator at both data rates.

IMPORTANT NOTE: Always recalibrate the MFJ-8631 transmitter oscillator for frequency (L6) after switching modulators (see calibration, page 9). Also, make sure JMP-1 is removed before attempting to receive 9600-baud signals.

TRANSMITTER DEVIATION:

Setting Deviation:
The MFJ-8631 has no internal deviation control. Deviation is adjusted via the AFSK output level control on your TNC (consult your TNC manual for specifics). If you don't have access to a FM deviation meter, you can set deviation by measuring the peak-to-peak AFSK signal output from your TNC:

With jumpers in the reactance modulator (1200-baud) jumper positions, a 100 mV p-p sine wave should produce approximately 3-KHz deviation.

With jumpers in the varactor modulator (9600-baud) jumper positions, a 500 mV p-p sine wave should produce approximately 3-KHz deviation.

Virtually any calibrated oscilloscope will allow you to make this measurement. Connect your scope probe to PIN-1 on the 5-pin DIN jack at either the TNC or radio end (look for the TX-AFSK line if your TNC uses a different type of jack). Use the CALIBRATE function on your TNC to generate a test-tone.

Figure 2
Monitoring Incoming and Outgoing Signals with a Scope

Two-Way Deviation Monitoring:
In addition to monitoring TNC output at pin 5, you may also monitor both incoming and outgoing Packet signals passing through your station by connecting an oscilloscope to the RX-AFSK line at pin-4. RX-AFSK also appears at the "monitor" or "speaker" jack on most TNCs. Use 1-V/div V-sens and 1-ms/div H-time base. To set TX deviation while monitoring RX-AFSK, first note the waveform height of average off-air signals (2.2 V p-p--or 0-Vu--is typical for 3-KHz deviation with 9600-baud filter set *off*). Next, key the MFJ-8631 transmitter via the CALIBRATE function on your TNC--and adjust TNC output (TX-AFSK) for a waveform of about the same height.

Confirming Deviation:
If a node in your area uses the X-1J2 version of theNET, you may take advantage of that station's built-in deviation meter to confirm the accuracy of your setting. Anytime you experience consistent difficulty connecting with local stations, you should suspect improper deviation level as a possible cause.

ORDERING CRYSTALS:

You may order crystals for other channels factory-direct. Specifications are:

Receiver Crystal:

$$\text{XTAL Freq.} = \frac{\text{Operating Freq.} - 10.7\ \text{MHz}}{3}$$

TYPE.....	3rd overtone (70-MHrange)
TOLERANCE.....	.003% Commercial Standard
TEMPERATURE.....	26-Degrees C (room temperature)
LOAD.....	Series
CASE.....	HC-25U or FM-2

Transmitter Crystal:

$$\text{XTAL Freq.} = \frac{\text{Operating Freq.}}{12}$$

TYPE.....	Fundamental Mode (18-MHz range)
TOLERANCE.....	.003% Commercial Standard
TEMPERATURE.....	26-Degrees C (room temperature)
LOAD.....	32 pF, Parallel
CASE.....	HC-25U or FM-2

Crystals for the MFJ-8631 may be ordered directly from:

JAN Crystals
P.O. Box 06017, 2341 Crystal Drive
Fort Myers, FL 33906-6017
Telephone (800) 526-9825, FAX (813) 936-3750

When ordering from JAN, simply tell the sales person that you wish to order a pair of crystals for the MFJ-8631Data Radio and give the ***operating frequency*** in MHz. JAN has complete MFJ-8631 crystal specifications on file in their ordering system and no additional information is required. Alternatively, you may purchase crystals from:

International Crystal Manufacturing Co., Inc. (ICM)
P.O. Box 26330, 701 W. Sheridan
Oklahoma City, OK 73123-0330
Telephone: (405) 236-3741, FAX (405) 235-1904

For receiver crystals, order 476270-CRYSTAL FREQ (not the operating freq.)
For transmitter crystals, order 434275-CRYSTAL FREQ (not the operating freq.)
JAN and ICM both welcome telephone orders and accept MasterCard or Visa.

INSTALLING CRYSTALS:

To install new crystals in your MFJ-8631, refer to the diagram below:

[ ] Remove the MFJ-8631 cabinet lid (one screw on each side of the cabinet).
[ ] Locate and pull the existing transmit crystal (Y3) from its socket.
[ ] Carefully plug the new transmit crystal in its place.
[ ] Locate and pull the existing receive crystal (Y2) from its socket.
[ ] Carefully plug the new receive crystal in its place.

Figure 3
Crystal Locations and Calibration Adjustment Points.

For future reference, label your pull-out crystals for operating frequency and store them in a safe place.

Anytime you install new crystals, you must readjust L4 and L6 for exact frequency calibration on the new channel (see page 9). Do not attempt to operate your radio until this calibration procedure has been completed.

CRYSTAL OSCILLATOR CALIBRATION:

Transmit Oscillator:
To measure the exact operating frequency of the MFJ-8631 transmitter, monitor the radio's RF output signal with a digital frequency counter. To obtain a usable signal sample, place the counter's pickup antenna near the MFJ-8631 PA section--or install a sampling tap in the coax line leading to your dummy load. To obtain a carrier, use the CALIBRATE function on your TNC--or short pin-3 of the data jack (PTT Line) to ground to key your transmitter's PTT line. Refer to Figure 3 on page 8 for specific locations on the pc board.

[ ] Key the PTT line and check for a stable counter reading.
[ ] Using an insulated tuning wand, adjust L6 to the exact operating frequency.
[ ] Key and unkey the transmitter a couple of times to confirm setting.

Receiver Oscillator:
Your MFJ-8631 has a unique built-in feature that allows you adjust the receiver oscillator by using the *calibrated* MFJ-8631 transmitter signal as a reference. You'll need a accurate DC voltmeter (or DVM) and an insulated tuning wand for this adjustment. Refer to Figure-3 for locations on the pc board:

[ ] Locate DISC-TP (discriminator test point) in front of the radio's data jack.
[ ] Set up voltmeter to measure DC readings in the 3-volt range.
[ ] Connect the voltmeter to DISC-TP.
[ ] Key the transmitter on.
[ ] Adjust L4 for a DISC-TP reading of 2.35 volts.

The MFJ-8631 is now calibrated to transmit and receive on the same frequency.

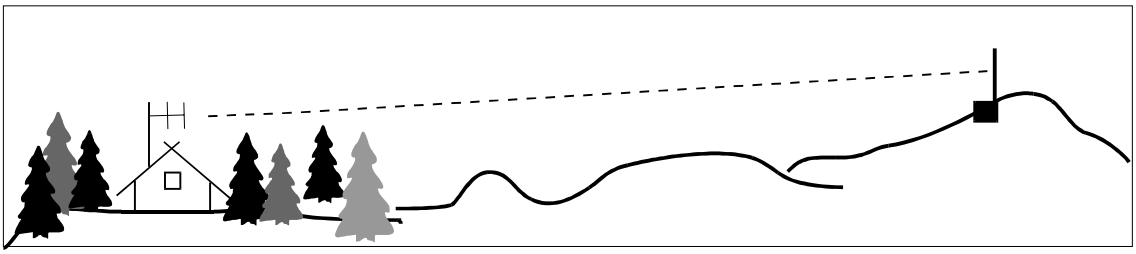
To calibrate your MFJ-8631 receiver for a frequency different than the transmitter (i.e. for split-channel operation), you may use a 220-mhz HT for your signal source. First, connect a dummy load to the HT antenna jack (a 47-Ohm 1/4-W resistor is okay). Set your HT for low-power simplex operation and dial in the desired calibration frequency. Now, follow the procedure above, substituting the HT as your signal source--and setting L4 for 2.35 volts at DISC-TP.

MORE ABOUT 9600-BAUD FSK PACKET SIGNALS:

The familiar "braaap" generated by 1200-baud packet signals is a combination of 1200 and 2200-Hz sine-wave tones beating together. Although the information being conveyed by these tones is digital, the transmission system itself is *analog* and falls within the range of normal speech. Unlike 1200-baud packet, 9600-baud signals are transmitted *digitally* by binary FSK. To understand how this works, suppose you set your radio at 223.7 MHz with the modem adjusted for 3-KHz deviation. Anytime the TNC sends a 1, the transmitter should flip 1.5 KHz high in frequency to generate a carrier at 223.7015 MHz. When the TNC sends 0, the transmitter should flop 1.5 KHz low to generate a carrier at 223.6985 MHz. This is called FSK-FM (frequency-shift keyed FM), and there are no analog tones involved--only a rapid switching back and forth between binary states. In fact, 9600-baud signals sound more like white noise rather than tones when monitored on a conventional FM receiver. Data signals of this type require significantly more bandwidth than normal speech. Extended low-frequency response is needed to sustain prolonged strings of 1s or 0s, and extended high-frequency response is needed to provide a fast rise time when the signal changes state. This is why true 9600-baud receivers require wide IF filters and a special RX-FSK output circuit--and why transmitters often use "direct-FM" modulators especially adapted for binary FSK.

SENDING AND RECEIVING 9600-BAUD DATA:

Although 9600 baud packet is much faster than 1200 baud, it is also much less forgiving of marginal signal paths. For solid throughput, you'll need about 5-6 dB more signal strength to overcome wideband noise generated the receiver's extra-wide IF and audio passbands. You'll also need a direct signal path--free from multi-path reflections--because 9600-baud signals are extremely vulnerable to phase shift errors. Finally, your transmitter and receiver must be accurately adjusted to frequency--and the transmit deviation set for the correct shift.



Generally, a carefully-aimed yagi will provide better signal quieting and less multi-path than omni-directional antennas. If you install the MFJ-8631 in a backbone at a remote site, please remember it is a $120 amateur radio product and not a $5000 commercial repeater! Avoid high-IMD locations if you can, or be prepared to provide additional receiver filtering to reduce the effects of intermod and desensing from nearby transmitters. Also, avoid use in unheated buildings; the MFJ-8631 does not have a built-in crystal oven to maintain its operating frequency over a wide temperature range. Finally, make certain your transmitter is not interfering with commercial services sharing the site. Setting up a node for 9600 takes a little more care, but once you are "up and running", you can sit back and watch massive files pump through in a matter of seconds!

IN CASE OF DIFFICULTY:

Many equipment problems can be traced to simple setup errors or minor malfunctions that are easily corrected. Before contacting the MFJ factory for help, please take a few minutes to read through the list of symptoms below and check out all appropriate suggestions. If the problem persists, refer to the technical assistance section in the Appendix.

1. Unable To Copy Off-Air Signals:
[ ] Improper TNC setup (consult TNC manual and double-check setup).
[ ] Defective antenna or interconnect cables (check for shorts, opens, etc.).
[ ] TNC or computer RFI (install cabinet covers, check cable shields).
[ ] Wrong crystal installed at Y2 (RX crystal should be in the 70-MHz range).
[ ] 1200-baud filter on, blocking 9600-baud reception (remove JMP-1).

2. Unable To Connect:
[ ] Transmitter or receiver off-frequency (see crystal-oscillator calibration).
[ ] Incorrect deviation (see FM-deviation adjustment).
[ ] Trying to copy 9600-baud data with AFSK filter on. (Remove JMP-1).
[ ] Using wrong modulator (consult manual, check JMP-2, JMP-3).
[ ] Insufficient signal strength (check antenna orientation).
[ ] Node overloaded with traffic (wait for things to quiet down).

3. Transmitter Erratic Or Inoperative:
[ ] Insufficient power source (check voltage of power supply under load).
[ ] Wrong crystal installed at Y3 (crystal should be in the 18-MHz range).
[ ] High-VSWR antenna (check antenna with bridge -- should be 2:1 or less).
[ ] Transmitter locked out because TNC is not equipped with a DCD circuit.

IMPORTANT OPERATOR NOTES:

Your MFJ-8631 is specially designed to work with TNCs that are DCD equipped. If your TNC does not have data carrier detect circuitry, it will read the MFJ-8631's unsquelched audio as an incoming signal and will not allow the data radio to transmit.

Your MFJ-8631 is not VSWR protected and will not tolerate prolonged operation into high-VSWR antennas. Most commercial antenna installations provide a VSWR or 1.5:1 or less, and this is a good rule of thumb to follow for VHF amateur installations. Also, do not retune RF circuits in your MFJ-8631; this should only be done at the factory by a trained technician with access to correct procedures and instrumentation. MFJ cannot be held responsible for the on-air performance of radios subjected to unapproved tampering.

Finally, the MFJ-8631 is not FCC type accepted for commercial radio service and is intended solely for amateur use. Do not attempt to adapt this unit for commercial applications, and always test for interference to other radio services when using the MFJ-8631 in amateur service at a shared commercial site.

APPENDIX

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 *the Technical Service* Department 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 Rd., Starkville, MS., 39759. If you have access to a FAX machine, then you can FAX us a description of your problem. Our FAX number is: **601-323-6551**.

You can also send technical email to MFJ Enterprises at the address shown below. The address must be in all lower case letters. The email is answered every morning and you will receive an answer to your question the day we receive and read the message.

techinfo@mfjenterprises.com

Try to give as much information about your problem as possible. If necessary, send a description of your problem, an explanation of exactly how you are using your unit, and a description of your station setup.

Replacing the Fuse Link

The MFJ-8631 has a thin foil trace on the pc board that acts as a line fuse. This trace connects power to the rest of the circuitry and may "burn out" under certain conditions (such as when the MFJ-8631 is subjected to a reversed polarity power.)

If your Data Radio does not operate and you suspect that the line fuse is broken follow these steps:

1. Remove the cover and inspect the fuse line. It may be necessary to test the fuse for continuity.

2. If the line is broken replace it with a length of #32 wire of approximately the same length. You may optionally replace the line with a heavier gauge of wire and protect the unit with a 2 amp fastblow fuse.

3. Replace the cover and screws.

SCHEMATIC