Introduction

Welcome to the world of effortless CW. With the MFJ-403 you will have a professional sounding fist in no time! Whether you are a Novice or seasoned Extra, the MFJ-403 Pocket CW Keyer has the features you have been waiting for! Novices will appreciate the preset power-up defaults for plug-and-play operation. Extras will enjoy the advanced features: Weight control from 25 to 75%, Iambic A and B operation, automatic or semi-automatic operation, full dot and dash memories, and immediate front-panel speed control from 5 to 60 WPM (words per minute). The built-in sidetone generator and speaker are ideal for CW practice sessions or for radios lacking a CW sidetone.

The MFJ-403 keyer is compatible with any modern transceiver or QRP transmitter using positive keying. The 50-volt at 100-mA keying permits the use of many early vintage cathode-keyed transmitters. Its small size and battery operation are ideal for QRP or Field Day activities! CW has never been so enjoyable or effortless!

A state-of-the-art PIC12C671 microprocessor is the heart of the keyer! Learn the basics behind embedded controllers, and how they are revolutionizing the electronics field. The powerful PIC device permits advanced settings to be entered from the keyer paddles, using Morse characters! Powered by a common 9-volt transistor radio battery, the keyer is ready for action wherever you are! The microprocessor even senses inactivity. Leave it sitting and the keyer goes into a battery conserving sleep mode!

Operating Instructions

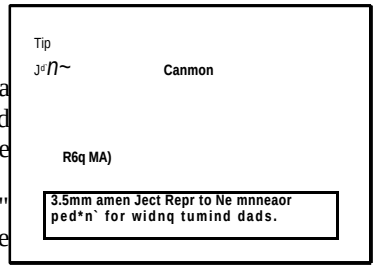
Dits, daps, dots and dashes? Beginners often think of CW characters as being composed of strings of dots and dashes, the visual image conveyed when viewing Morse CW characters on the printed page. Experienced CW operators tend to think of CW characters as *a sound,* and hear *dahs* instead of dashes, and *dits* instead of dots when listening to CW characters. Both terms will be used interchangeably in the following text.

Determining Keyer speed: Hold the dash lever and count the number of dashes generated in a five-second period. The number of dashes roughly equals your CW sending speed.

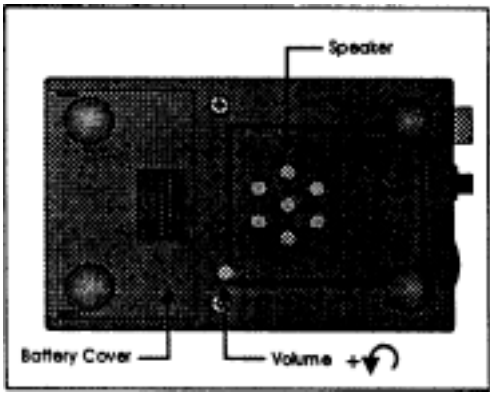
Power requirements: The keyer is designed to operate from a 9-volt DC battery source. An alkaline battery will give long service, but always remember to turn the keyer power switch off when the keyer is not being used.

Keyer paddles: Most popular paddles will work well with the MFJ-403. Full enjoyment of the MFJ-403 's features requires paddles that are capable of

iambic operation. We recommend the MFJ iambic **paddles as being a good** value. Iambic paddles can be recognized by the totally **independent operation** of the *Dit* (or "Dot") and *Dah* (or "Dash") paddles. Some CW operators refer to iambic paddles as "squeeze paddles".



The paddles should be equipped with a three-wire interconnecting cable terminated in a 3.5mm stereo jack. Miniature shielded and balanced microphone cable is ideal for this. The common return is connected to the longest "ring" (shaft) of the stereo jack. The *Dah* paddle connection is made to the jack terminal for the smaller insulated ring. The *Dit* paddle is connected to the jack tip connection. If your paddles are equipped with a '/," stereo jack, a suitable stereo adapter is available at most electronic or HI-FI shops. Reversed paddle wiring can be corrected by a function entry, more on this later. The paddles arc connected to the Paddle jack on the MFJ-403.



Linear controls: There are two linear controls. A Volume control, accessed from the bottom of the unit, sets the sidetone monitoring level. Use a small flat-head screwdriver and rotate right to decrease volume. The second control, OFF/Speed knob, sets the CW speed over a range of 5 to 60 WPM. Speed is one of the most frequently adjusted parts of your keyer.

Sidetone operation: The sidetone is the tone keyed by the CW keyer. This permits you to monitor your keying and provides the aural "feedback" to assist in sending good CW. Many transceivers already provide for internal CW sidetone monitoring. If your transmitter does not have built-in sidetone monitoring provisions, the MFJ-403 will generate a sidetone for you. A builtin speaker lets you monitor the CW sidetone. Adjust the Volume control to a comfortable listening level.

Default initial status: As soon as power is supplied and the MFJ-403 is turned on, the unit is ready for operation. A microprocessor program "subroutine" loads several operating parameters into the keyer at power up. These parameters are based on standard operating practices; many of them may be

changed to suit your preferences-more on this later. Commands entered via the Function switch are cleared when the power is removed.

Initially, the keyer assumes standard paddle wiring. This means the *dit key* connects to the tip and *dah* key connects to the ring of the 3.5 nom jack. Iambic operation is set to mode A. The sidetone frequency is set to 727 Hz. The CW weight is set to 50%, yielding the standard 1:3 *dit* to *dah* ratio. The keyer is in the automatic mode.

If CW operation is a new experience for you, consider running the keyer in its basic power-up configuration until you become comfortable with its feel and operation. Feel free to learn the more advanced features at your own pace.

Default settings at power on:

1. Automatic
2. Iambic A
3. Standard paddle wiring (tip = dot, ring = dash) 4.
727 Hz sidetone
5. Standard weight (50%, dot-dash-space ratio of 1:3:1)

Transmitter keying: The keyer output is through the Key Out jack, (RCA phono jack). You will need a cable connecting the keyer and the CW keying jack of your radio. The operation instructions for your set should show what sort of connector you need and its location on your radio. Many modern transceivers use RCA phono jacks for connecting accessories. In those cases, ready-made cables for home entertainment devices may be used between the MFJ-403 and radio.

Keyer output specs: The keyer is designed for *positive keying output*. Most modern solid-state transceivers and QRP transmitters meet this requirement. Always check the owner's manual before attaching the keyer to a radio. The MFJ-403 will key positive voltages to a 50 Vdc maximum and current to a 100 mA maximum. Exceeding these limits may damage the keying transistor Ql.

Use with vintage sets: Early tube transmitters and hybrid transceivers may not be compatible with the MFJ-403. If the transmitter uses grid-block keying (a negative key voltage), it cannot be used with the MFJ-403. An example of a
grid-block keyed transmitter is the Heathkit DX60. Check the ARRL handbooks for circuits designed to adapt keyers to grid-block keying.

Vintage novice transmitters commonly used cathode keying, a combination of high current and high voltage. The Heathkit DX40 used cathode keying, for example. In general, most cathode-keyed transmitters are compatible with the MFJ-403 keying circuit, so long as the 50 Vdc and 100 mA limits are not exceeded.

Dot and dash memories and Iambic keying: The dot and dash memories make sending CW easier. The memory allows the user to key a dot before the completion of a dash, and vice-versa. This feature maybe checked by setting the keyer to the lowest speed and tapping first the dash lever and then the dot lever before the completion of the dash. The keyer will generate *a dash-dot* with perfect spacing. Test the dash memory in a similar manner. First, depress the dot lever, hold, quickly tap the dash lever, and release. The keyer will send the dot followed by the dash, again with perfect spacing.

Iambic paddles allow both paddles (or levers) to be depressed at the same time. Depressing (squeezing) both paddles simultaneously will generate a continuous stream of alternating dots and dashes. The paddle that initially contacts the spacer determines whether a dot or dash occurs first. CW characters such as C, **K, Q** and R are very easy to generate with iambic paddles.

*Power-off **reminder:*** As a reminder to turn off the MFJ-403, the keyer is programmed to key **"ON ON ON"** (dah-dale-dah dah-dit) after 30 minutes of nonuse. It will then key this every five minutes for the next 30 minutes. After this time, the keyer goes into sleep mode to conserve battery usage. However, other electronic components in the keyer still consume power. Therefore, turn off the keyer to completely prevent battery from going dead.

Special Functions

Note: All programmable special functions are lost when the MFJ-403 is turned off. The default settings are restored at power on.

Automatic mode: Early telegraphers used a mechanical device called a bug to send high-speed code. The bug would automatically send a string of *dits* when the dot paddle was depressed and held. However, the bugs did not generate strings of dashes, the dash had to be depressed once to generate each individual "dah". The MFJ-403 normally operates in the fully automatic mode, but it may be set for "semi-automatic" operation. This causes it to emulate the sound and feel of a mechanical bug.

Iambic mode: Select mode A or B, whichever you prefer. Type A is the default mode. When you release a squeeze during an element (dot or dash), it just finishes the element in progress and does *not* produce a following alternate element. On the other hand, type *B* adds the opposite element. For example, in Type A Iambic, a squeeze release during the "dah" in the letter "A" will produce "di-dah" (A). In Type *B* Iambic, a squeeze release during the "dah" in the letter "A" will produce "di-dah-dit" (R).

Reverse: This reverses the sense of the left and right paddles. It is useful when both left and right-handed operators share the paddle.

Sidetone frequency: The default sidetone is about 727 Hz. The sidetone may be programmed from 300 to 1000 Hz to suit individual tastes.

Weight: A 1:3 ratio between dits and dabs is considered optimum. Some operators prefer slightly different ratios; and the MFJ-403 weight is adjustable from 25 to 75% to suit those preferences. The power-on default is 50%, or 1:3.

Using the Function switch: The Function switch customizes the keyer to your preferences. To set or change a setting, depress the Function switch. The keyer acknowledges by sending the Morse character for the letter "F" *(di-didah-dit).*

Enter keyer functions via the keyer paddles. If you enter an invalid character, the keyer responds with two beeps. *A* single beep acknowledges a valid entry. Entering multiple functions at one time is not permissible. That is, each function must be individually entered, preceded by pressing the Function button. The transmitter key line disables during programming, except the "X" and "Y" functions. The function mode maybe exited at any time by pressing the Function switch. The keyer confirms the exit with two beeps.

Command Character	Function
A	Automatic. Toggles between automatic and semi-automatic mode.
I#	Iambic. Sets Iambic mode A or B, where # represents A or B.
R	Reverse. Reverses the sense of the dot and dash paddles.
T	Tone. Dash paddle raises the sidetone frequency. Dot paddle lowers. Both paddles together exit. The speaker sounds an alternating series of dots and dashes to assist in setting the desired sidetone frequency.
W##	Weight. ## represents weight value between 25 and 75 percent.
X	Carrier Tune (Xmit). Gives continuous key-down for adjusting transmitter or antenna tuner. Tapping either paddle exits tune mode and releases the key line.
Y	Pulse Tune. Gives a string of dots for adjusting transmitter or antenna tuner. Tapping either paddle exits tune mode and releases the key line.

c

Troubleshooting

Keyer dead: Dead battery. Make sure the OFF/Speed knob is ON.

Sidetone distorted, erratic operation: Weak battery. RF is getting into keyer. To remedy RF, use shielded leads.

Cannot enter function mode: Make sure to firmly depress the Function button.

Keyer gives error beeps on function entry: Invalid command prefix or suffix. Code characters must be perfectly formed, with proper timing.

Theory of Operation and Specifications

Theory of operation:

The MFJ-403 features the powerful PICI2C671 microcontroller. This tiny eight-pin integrated circuit contains the programming and basic power of a microprocessor chip. CW speed is set via R1, a 10K-ohm potentiometer, which controls the voltage input to pin 7 of U1 (PIC chip). Pin 7 is an analog-todigital input for the PIC processor. Programming subroutines scan the digitized setting of R1, and adjust the speed accordingly.

The PIC chip also senses keyer paddle activation. All dot-and-dash memories, Iambic operations, sidetone generation, and sidetone frequency are under the control of the PIC12C671 device.

IC U3 is a low-power 5-Vdc regulator IC. It regulates power to the PIC controller at 5 volts. U2 is a linear audio amplifier IC. It amplifies the sidetone signal from the processor, and is powered directly from the 9-volt battery. Transistor Q1 is a silicon-gate TMOS switching FET, and is used to key the transmitter. The maximum FET ratings are 50 Vdc at 100 mA.

Specifications:

Voltage requirements	Internal 9-volt transistor battery
Keyer speed	Typically 5 to 60 WPM
Sidetone level	50-mW max., adjustable internal trimpot
Sidetone frequency	727 Hz default, adjustable 300 to 1000 Hz
Keying limits	Positive keying. 50 volts at 100 mA max
CW generation	Iambic A or B, Automatic or Semi-automatic
Memory	Dot Dash memory
Weight	50% default, adjustable 25 to 75 percent

Morse Code Character Set

A	di-dah	• –	N	dah-dit	– •
B	dah-di-di-dit	– • • •	O	dah-dah-dah	– – –
C	dah-di-dah-dit	– • – •	P	di-dah-dah-dit	• – – •
D	dah-di-dit	– • •	Q	dah-dah-di-dah	– – • –
E	dit	•	R	di-dah-dit	• – •
F	di-di-dah-dit	• • – •	S	di-di-dit	• • •
G	dah-dah-dit	– – •	T	dah	–
H	di-di-di-dit	• • • •	U	di-di-dah	• • –
I	di-dit	• •	V	di-di-di-dah	• • • –
J	di-dah-dah-dah	• – – –	W	di-dah-dah	• – –
K	dah-di-dah	– • –	X	dah-di-di-dah	– • • –
L	di-dah-di-dit	• – • •	Y	dah-di-dah-dah	– • – –
M	dah-dah	– –	Z	dah-dah-di-dit	– – • •

1	di-dah-dah-dah-dah	• – – – –	6	dah-di-di-di-dit	– • • • •
2	di-di-dah-dah-dah	• • – – –	7	dah-dah-di-di-dit	– – • • •
3	di-di-di-dah-dah	• • • – –	8	dah-dah-dah-di-dit	– – – • •
4	di-di-di-di-dah	• • • • –	9	dah-dah-dah-dah-dit	– – – – •
5	di-di-di-di-dit	• • • • •	0	dah-dah-dah-dah-dah	– – – – –

Period	[.]	di-dah-di-dah-di-dah	• – • – • –	$\overline{AAA}$
Comma	[,]	dah-dah-di-di-dah-dah	– – • • – –	$\overline{MIM}$
Question Mark or Request for Repetition	[?]	di-di-dah-dah-di-dit	• • – – • •	$\overline{IMI}$
Fraction Bar	[/]	dah-di-di-dah-dit	– • • – •	$\overline{DN}$
End of Message or Cross	[+]	di-dah-di-dah-dit	• – • – •	$\overline{AR}$
End of Work		di-di-di-dah-di-dah	• • • – • –	$\overline{SK}$
Double Dash, Pause or Break	[=]	dah-di-di-di-dah	– • • • –	$\overline{BT}$
Semicolon	[;]	dah-di-dah-di-dah-dit	– • – • – •	$\overline{KR}$
Colon	[:]	dah-dah-dah-di-di-dit	– – – • • •	$\overline{OS}$
Apostrophe	[']	di-dah-dah-dah-dah-dit	• – – – – •	$\overline{WG}$
Quotation Mark	["]	di-dah-di-di-dah-dit	• – • • – •	$\overline{AF}$
Hyphen or Dash	[-]	dah-di-di-di-di-dah	– • • • • –	$\overline{DU}$
Underline	[_]	di-di-dah-dah-di-dah	• • – – • –	$\overline{IQ}$
Dollar Sign	[$]	di-di-di-dah-di-di-dah	• • • – • • –	$\overline{SX}$
Left Parenthesis	[(]	dah-di-dah-dah-dit	– • – – •	$\overline{KN}$
Right Parenthesis	[)]	dah-di-dah-dah-di-dah	– • – – • –	$\overline{KK}$
Wait		di-dah-di-di-dit	• – • • •	$\overline{AS}$
Understood		di-di-di-dah-dit	• • • – •	$\overline{SN}$
Starting Signal		dah-di-dah-di-dah	– • – • –	$\overline{KA}$
Error		di-di-di-di-di-di-di-dit	• • • • • • • •	$\overline{HH}$
Paragraph	[¶]	di-dah-di-dah-di-dit	• – • – • •	$\overline{AL}$
Invitation to Transmit		dah-di-dah	– • –	K

1. FCC test requirement consists the 26 letters, the 10 numerals, the period, the comma, the question mark, AIF , SK, M end W

Schematic