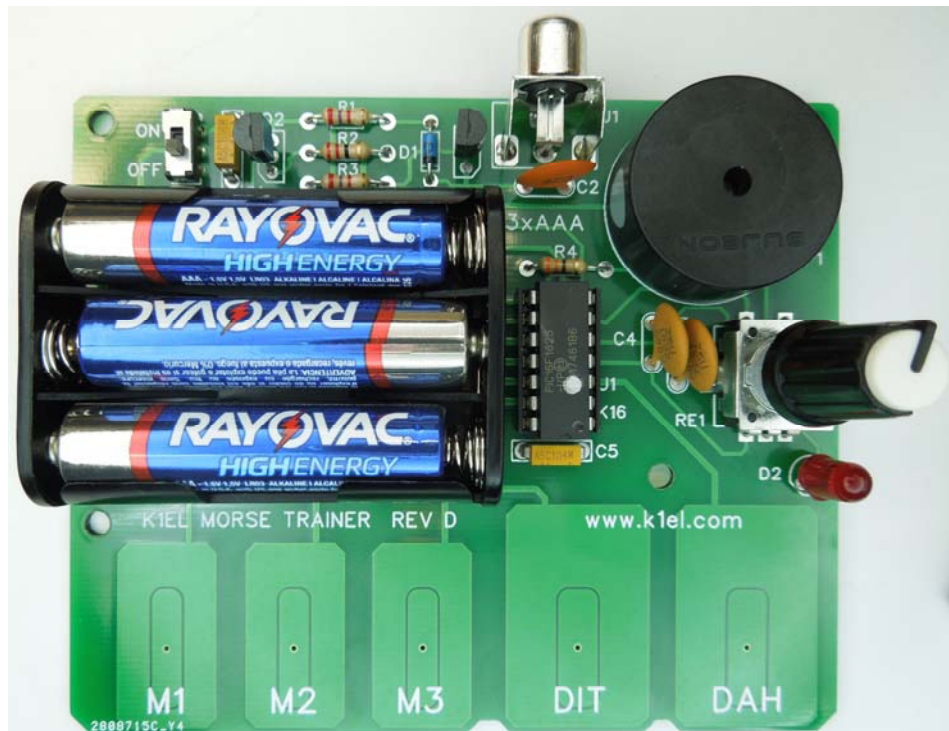


Morse Tutor Board

User Manual v 2.0



K1EL
HAM RADIO KITS

www.k1el.com

Morse Tutor Board (MTB) Features

- Keyer speed range: 5 - 99 WPM
- Touch sensitivity calibration function
- Dynamically allocated message memory
- Keying Modes: Bug, Ultimatic, Iambic A or B
- Rotary Encoder Speed control
- Adjustable Weighting: 25 to 75 %
- Paddle swap command
- Continuously adjustable Sidetone frequency
- Four Push-Pad user interface
- Two User Configurations each with callsign
- Low Power Consumption: 2 mA idle, 70 uA off
- Non-Volatile Message Memory: 232 letters in 10 Slots, dual banked, with embedded commands.
- Non-Slip Rubber Feet
- Beacon: Programmable interval: 1 to 99 seconds
- Integrated Touch Paddle
- 34 easy to use commands
- Supply Voltage Monitor
- Serial Number Generation
- Adjustable Letter Spacing: 25 to 75%
- Automatic letter space mode (Autospace)
- Sidetone Output: On board speaker
- Optional Key Output: Open collector (60V @120mA)
- Battery holder for three AAA cells
- Backspace supported on message entry
- Power on/off slide switch
- Easy access Rx and Tx practice modes
- Multiple MTBs can be networked together
- Message stacking
- Board Dimensions: 4.0" by 3.25"

Morse Tutor Description (MTB)

The MTB is a low cost, educational platform for learning and practicing Morse code. Everything the student needs; a set of touch paddles, electronic keyer, and code practice oscillator are all included in one easy to build printed circuit board. The MTB uses a special version of the K1EL K16 keyer controller which provides a wide range of features. Setup commands are directly entered on the paddles in Morse code. All settings and messages are stored in nonvolatile memory so that they are preserved when the keyer is turned off. The K16 keyer core has many original features not found in other keyers such as:

• Supply Voltage Monitoring

The MTB has a unique feature that is useful in battery powered applications. It continuously monitors the supply voltage and will provide an indication when battery voltage is low. Normally the MTB will respond with an **R** when entering command mode. If the battery voltage is approaching the minimum operating limit, it will respond with an **L** instead. This tells the operator that the batteries need to be replaced. The actual supply voltage can be read out in Morse by using the **V** command in the extended command set. (Page 16). The keyer will continue to operate until the battery voltage falls to approx. 2.7V.

• Dual User Configuration

The MTB provides storage for two complete configuration setups. For example, one setup could be used for contesting while the other for casual operating. When two operators share the same keyer, each user can have their own setup profile. The extended command **U** is provided to select one configuration or the other. All MTB settings are included in each profile including a stored callsign. (Page 16)

• Dual Message Banks

The MTB has two message banks of five slots plus two callsign slots. Total message storage is 232 bytes. While this does not seem like a lot of message space, since the MTB dynamically allocates message storage in memory, it turns out to be more than adequate for most users. It is very easy to swap message banks with the **E** command. This is the shortest command sequence and allows you to swap banks quickly. There is also a buffered message command **IE** that swaps message banks within a message. (Page 19)

• Stored Callsigns

Two special memory slots are provided to store a callsign for two users. These callsigns are programmed by using the callsign load command in the extended command set. A callsign is embedded in a message by using the **IM** buffered command. The callsign slot works like any other message slot; you can call other messages and embed commands, (Page 19)

• Wide range of embedded message commands

Please refer to the list on page 19.

- **Sidetone Frequency**

The MTB sidetone can be set to any frequency between 300 Hz and 2000Hz. (Z command, page 15)

- **Fast Message Interruption**

The MTB will stop a message immediately upon paddle press, stopping in mid-letter if need be.

- **Practice Modes**

Many practice options are supported. The user can select practice content by letter group so that easier letters can be mastered first followed by progressively more difficult groups. A very good random letter generator is provided which generates a varied, ever changing letter order. (G & P commands, Page 14)

- **Message Stacking**

Up to 10 messages can be queued to be sent in the order requested. Just press a sequence of up to 10 message pads and the MTB will play them in order.

- **Simplified Beacon Formatting**

This message is all that is required to setup a repeating 15 second beacon: **/B15 K1EL BCON**

- **Easy Beacon**

Any message slot can be turned into a beacon without having to add the special **/B** embedded command (page 19). The **B** command allows 'on the fly' beaoning without embedded commands. (Page 13)

- **Dit/Dah Ratio Control**

The timing of dits vs. dahs can be customized. A ratio of 1:3 is standard but this can be altered to suit different tastes. (Y command, Page 15).

- **Improved Cut Number Selection**

The MTB allows serial number cuts to be used for 0 and/or 9. (Extended commands N&T Page 16)

- **Tuning Duty Cycle Selection**

Tune can be set to generate either a 50% or 100% key down duty cycle. (V command, Page 15)

- **Contest Word Spacing**

The MTB allows a shorter inter-word spacing to be selected to speed up exchanges during contests. Standard word spacing is 7 dits while contest mode word spacing is 6 dits. (Extended C command, Page 16)

- **Full Time Speed Control**

The MTB responds to speed encoder changes without delay, even while sending messages.

- **Speed Control Range Setting**

The upper and lower limit of the speed control can be set by command. Two values are entered the lowest speed control setting followed by the highest speed control setting. (R command, Page 16)

- **Command Response Time Adjustment**

The MTB will enter command mode when the encoder pushbutton is pressed down for about 2 seconds. This may be too long for some operators so it can be shortened to 1.3 seconds. (F command, Page 16)

- **Touch Paddle Adjustment**

The MTB scans and adjusts paddle sensitivity automatically based on current conditions, however, due to process variations in PIC microcontrollers, a baseline calibration must be run once when the kit is complete. See page 10 for the procedure description.

Morse Tutor Functional Block Diagram

Figure 1 is a block diagram of the MTB. There's a power switch, five touch pads, a sidetone speaker, a rotary speed control/pushbutton, and a keying port with an RCA connector. The keying port can be used to connect two or more MTBs in a network configuration or to key a transceiver/transmitter. The pushbutton on the encoder is dual purpose; press and hold to enter commands, or a quick press to play a message. Touch keyer paddles and message pushbuttons are integrated into the MTB circuit board which allows very compact layout. The board is completely self contained, running on three standard AAA batteries. No other accessories are required to operate the MTB.

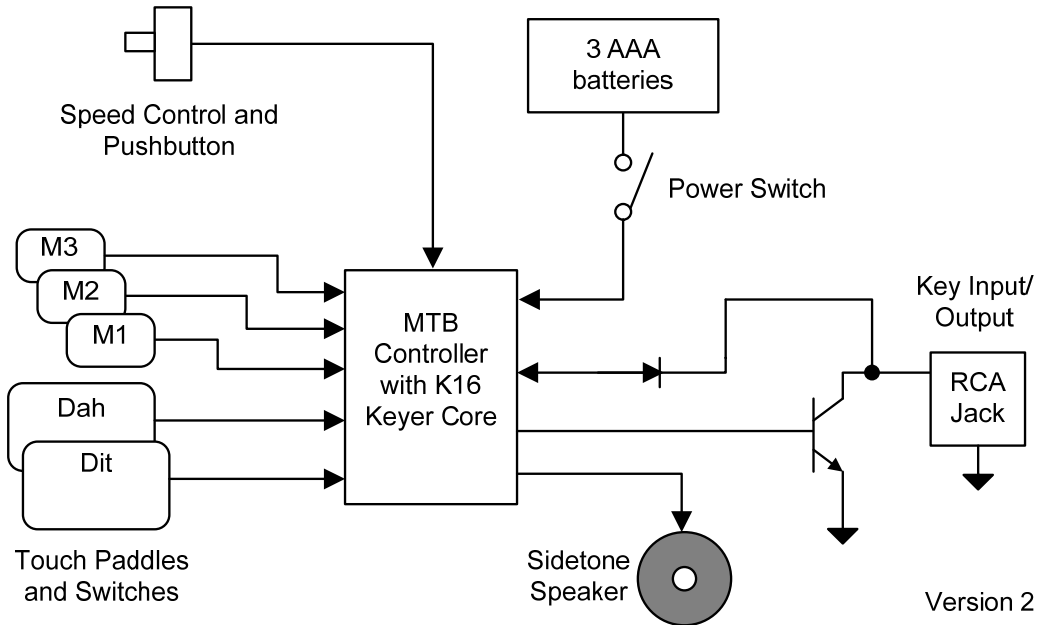


Figure 1 – Morse Tutor Block Diagram

Morse Tutor Board Kit

The MTB keyer kit consists of a single board with all through-hole components for easy assembly. It's a good idea to read through the assembly instructions before starting. Please follow the steps in the order presented for best results. Even if you are an experienced builder, we highly recommend reviewing the appendices A, B, and C at the end of this document for helpful assembly hints.

Morse Tutor Board Assembly

Morse Tutor Parts Inventory

U1	- K16 14 pin DIP IC (16F1825)
Q1,2	- 2N3904 NPN transistor or equivalent
R2	- 22Ω ¼ watt (red red black)
R1,3	- 2.7KΩ ¼ watt (red violet red)
R4	- 330Ω ¼ watt (orange orange brown)
C1,5	- .1 μF ceramic capacitor 104
C2,3,4	- .01 uF ceramic capacitor 103
D1	- BAT75 Schottky Diode

D2	- LED keying indicator
B1	- Battery Holder (3xAAA)
SP1	- Mini speaker
J1	- RCA keying connector
RE1	- Rotary Encoder
1 pc	- 14 Pin DIP Socket
1 pc	- Morse Tutor PC board
Misc	- 4 rubber feet

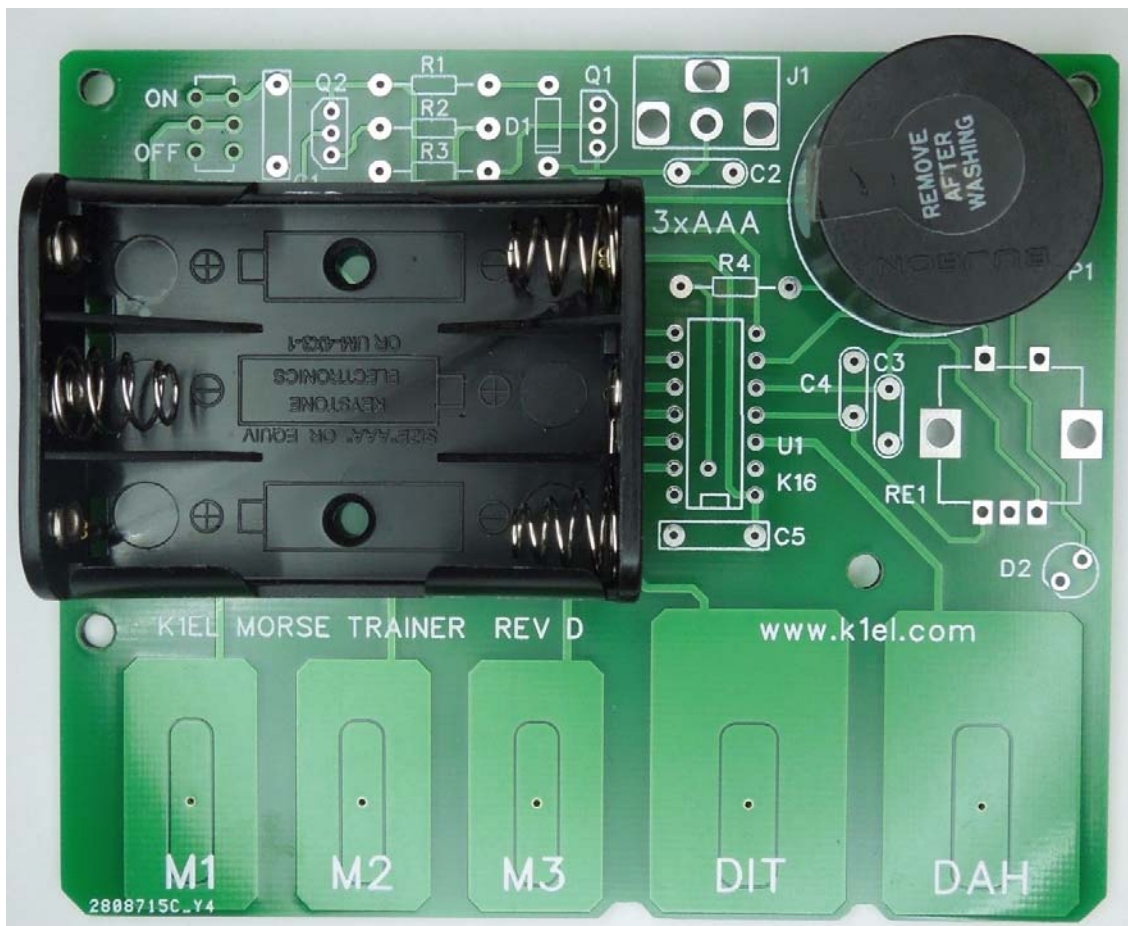


Figure 2 – Morse Tutor PC Board (MTB) as shipped

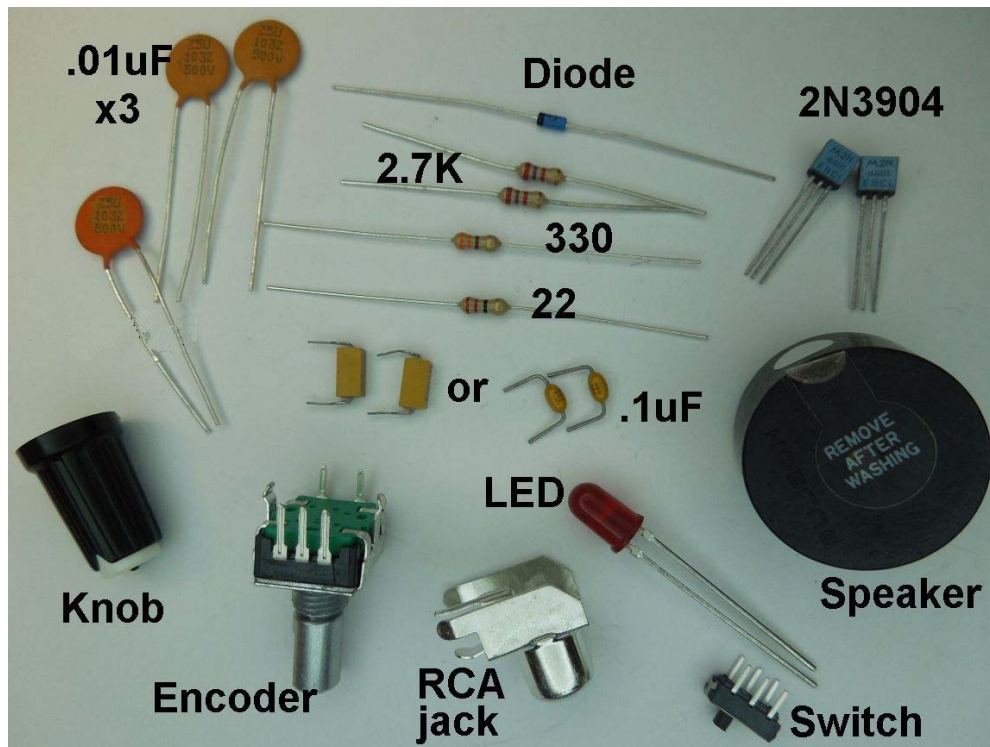


Figure 3 - MTB component identification

- ___ Start kit assembly by attaching the four stick-on rubber feet to the bottom side of the board:

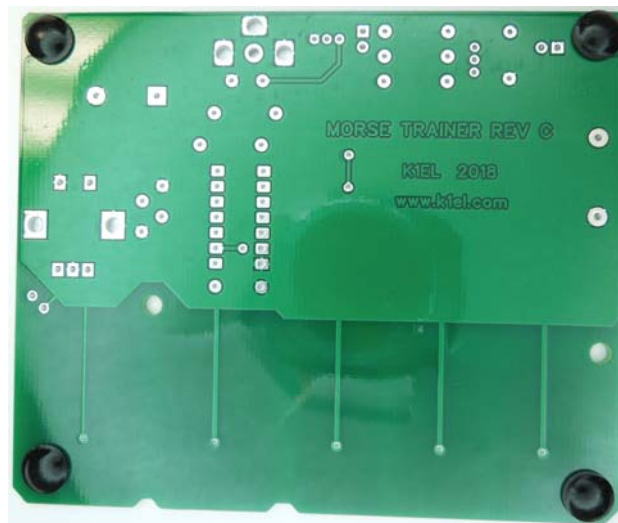


Figure 4 – Rubber feet in place

- ___ Using figure 5 on page 6, install and solder all four resistors. Color codes are listed in the parts inventory on page 5. Verifying resistor values with an ohmmeter before installing them is recommended
- ___ Install and solder two .1uF and three .01 uF capacitors. Use figure 3 as a guide.
- ___ Install diode D1 observing black polarity stripe. Use figure 3 as a guide.

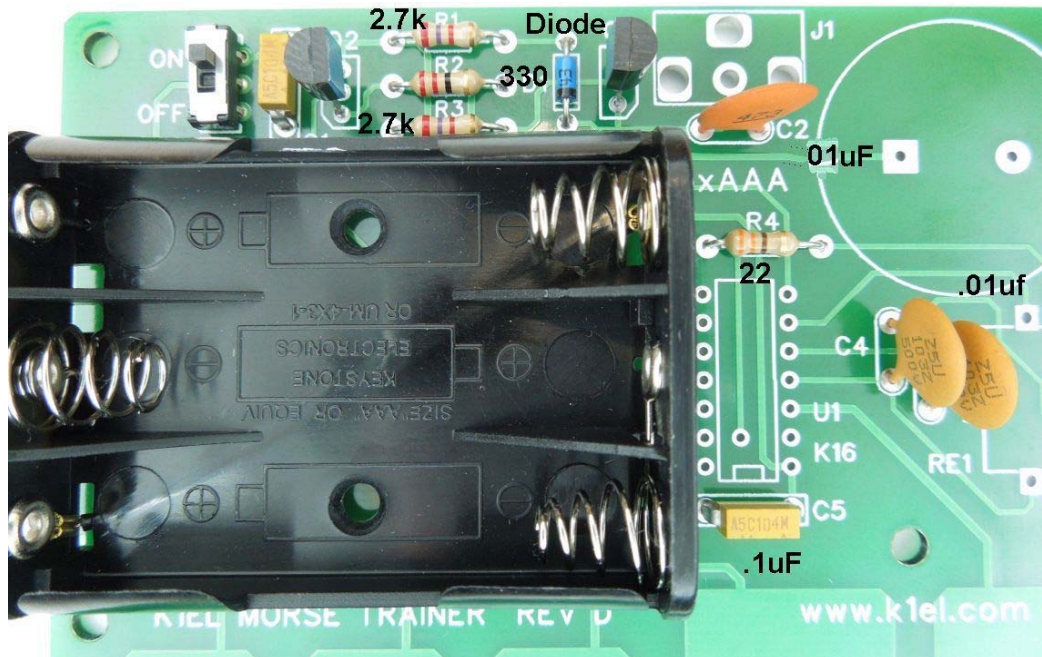


Figure 5 – Resistors, diode, and capacitors installed

- ___ Install the power on/off switch. Bend over two leads to hold the switch in place while you solder it.
- ___ Install the 14 pin DIP socket; orient the notch in the socket as shown in figure 7

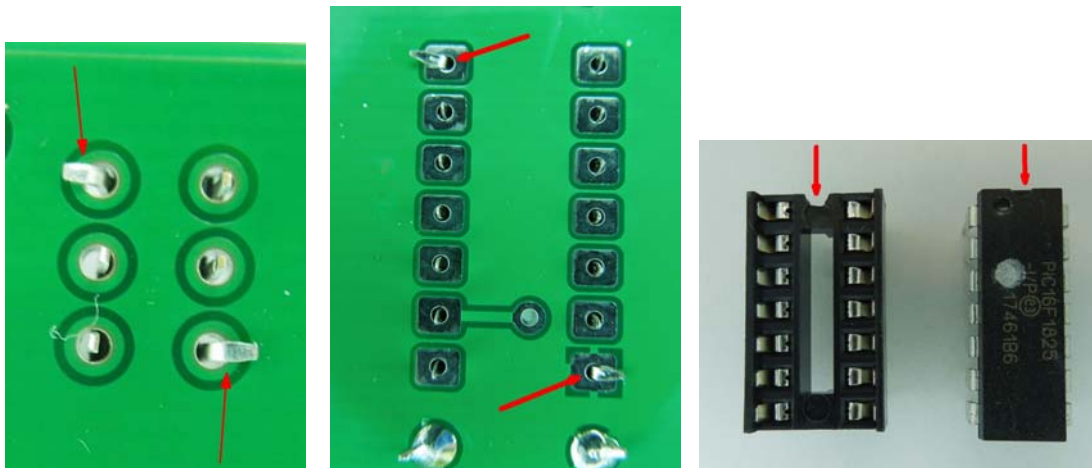


Figure 6 – Bend leads on switch and IC socket to hold them in place for soldering

Referring to figure 7:

- ___ Install transistors Q1 and Q2, align their flat sides with the silkscreen.
- ___ Install the speaker with the silver dot facing C2.
- ___ Install the LED with flat side as shown. If you are not sure which side that is, note that one of the LED's leads is slightly longer than the other, an arrow on figure 7 points to where that lead goes.

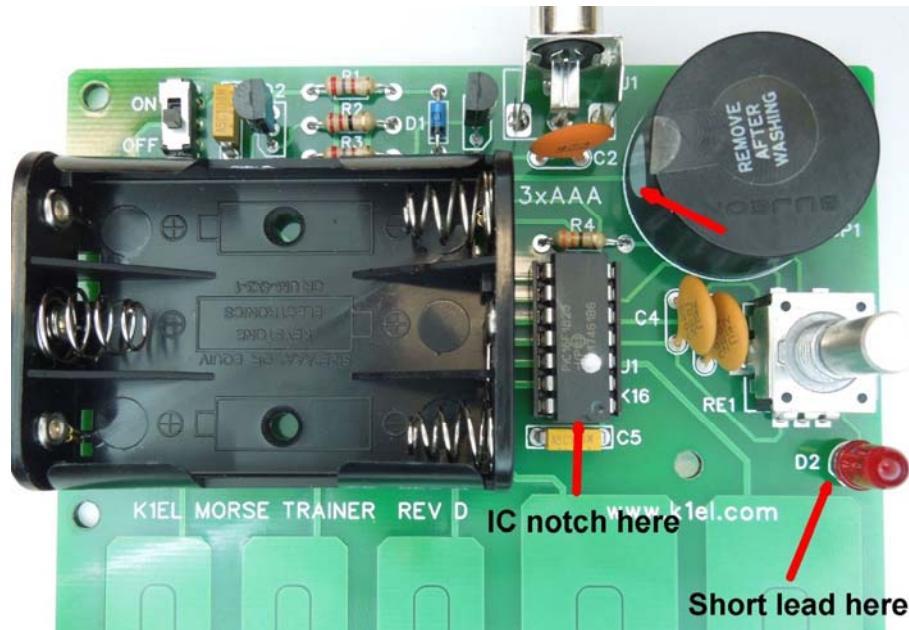


Figure 7 – Socket, 2 pin headers, Q1, Q2, speaker, and LED installed

- Snap the RCA connector into place and be sure it is fully seated into the board before soldering. It will take some extra heat to solder this part in so don't rush it. Be careful since the body of the RCA jack will get extremely hot while it's being soldered, so don't touch and avoid a painful burn. Once the connector is snapped in place it will stay there while you solder it.
- Now install the rotary encoder. Insure that the encoder is fully seated and its bottom flush with the surface of the PC board before soldering. You may have to tweak one or more of the five encoder leads to get the part to fit properly in the PCB holes. Double verify the leads before soldering.
- Be sure to remove the protective film cover from the speaker.
- Install U1 in its socket. You may need to straighten the IC's leads as shown in the lower left picture. Push just enough to bend but not crush the leads, using two hands helps. Once the leads are right press the IC into the socket as shown in the lower right picture. The red arrow shows where the IC's dot goes. The silver dot on the IC signifies that the part has been programmed.

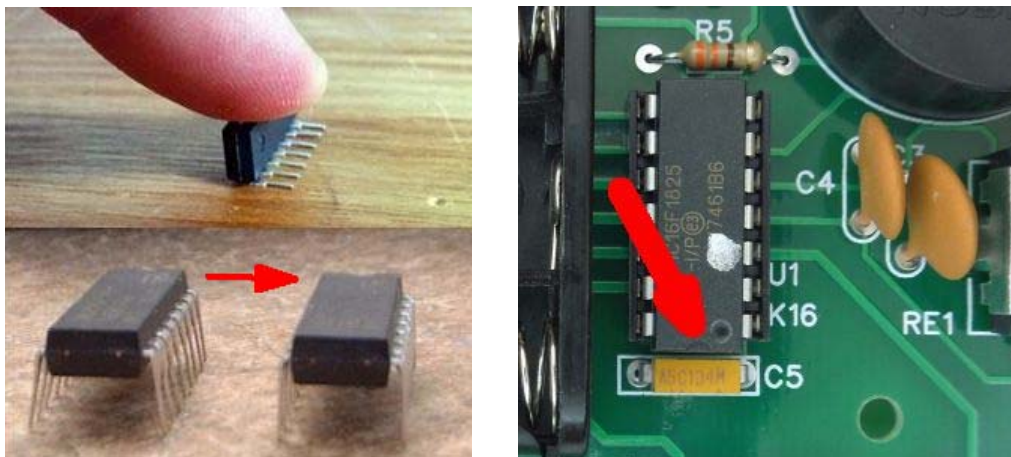


Figure 8 – Straighten leads on U1, then install in socket

- The last task is to push the plastic knob on the encoder shaft. The flat of the encoder shaft has to line up with the flat of the knob. You will have to push pretty hard to get this to go on all the way. We recommend putting something under the board below the encoder when pushing the knob in place to avoid flexing the PC board which could possibly break some copper traces.

This completes the assembly of the MTB board. Before continuing, carefully re-inspect your work. Please check that Q1, Q2, and U1 are placed correctly and that all parts were installed. Make sure that all solder connections have been made and that there are no solder shorts between pads. For reference, the completed assembly is shown here:

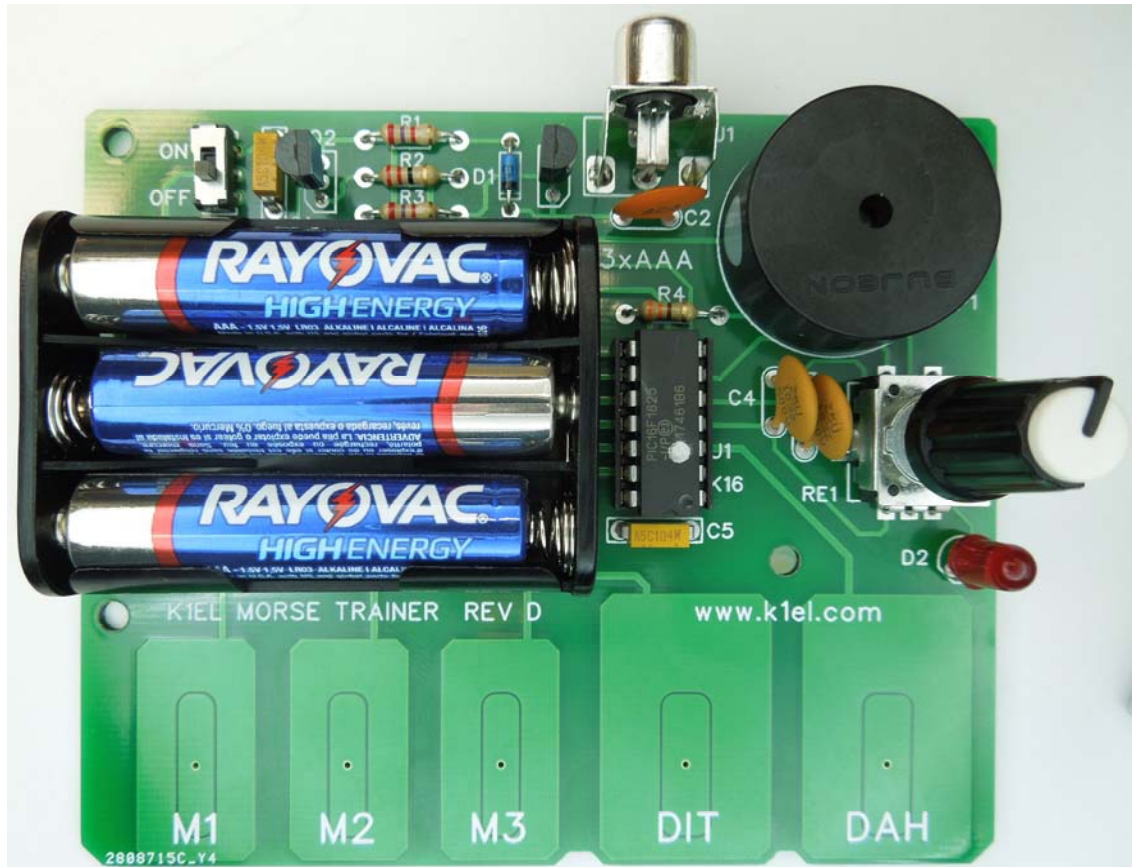


Figure 9 – Assembled Morse Tutor Board

MTB Test Procedure

The simplified drawing below is labeled to make it easy to identify MTB's main features. We will start by installing three AAA batteries in the holder paying attention to battery polarity.

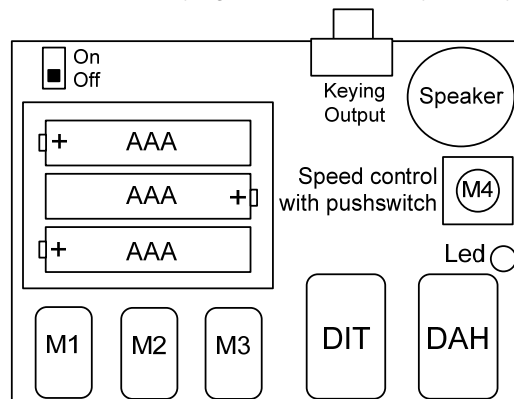


Figure 10 - MTB Components

Baseline Calibration

First, we need to run a baseline calibration to compensate for process variations in the PIC microcontroller:

1. Press and hold the encoder pushbutton down while you turn power switch to the on position.
2. The keyer will send **AR** (di-dah-di-dah-dit) followed by an **L** (di-dah-di-dit)
3. Immediately release the encoder PB.
4. Press the left (DIT) paddle with your index finger and wait for the keyer to send an **R** (di-dah-dit)
5. Then press the right (DAH) paddle until the keyer sends an **SK** (di-di-di-dah-di-dah) followed by the normal start up **R**.

After calibration, you should find that pressing the DIT or DAH pads will cause the keyer to automatically send a stream of Morse dits or dahs over the sidetone speaker. If you press both pads, the keyer will send alternating dits and dahs. The keying LED should light at the same time as audio sidetone. Turning the encoder will alter the sending speed; clockwise faster, counter clockwise slower.

Test command mode by pushing and holding the encoder button down until the keyer responds with an **R**. Release the button and after a few seconds the keyer will respond with a **?** (di-di-dah-dah-di-dit) A quick press on any of the three message pads (M1, M2, and M3) will cause the keyer to send an **MT** (dah-dah dah) which signifies that the message slot is eMpTy. We will cover message loading on page 18 and commands on page 13. The keying output can be tested with an ohmmeter, you'll see continuity from RCA center pin to shield when pressing the paddles, be sure to connect the black lead to the shield.

Output Keying Considerations

The MTB is intended to be used primarily as a tool to learn and practice Morse standalone or with others over a local CW network. To use it in network mode, simply connect it to another MTB with an RCA to RCA cable. Now you can communicate back and forth in Morse. This is a great way to simulate on air QSOs to learn both Morse and amateur radio CW operating procedures. Alternatively, the MTB can key a transceiver. It will safely switch keying voltages up to 60 V which should work with all modern transceivers. You will need a cable adapter to go from the MTB's RCA to your transceiver's 1/8 or 1/4 inch plug.

Important Note: The MTB will not key vacuum tube type transmitters !!

Safety considerations

For safety's sake, do not touch or probe the output connector pins while connected to a transceiver.

ESD Considerations

The MTB touch pads have ESD protection resident inside the K16 controller IC. However, the safety margin can be increased by applying a layer of plastic tape to the paddles. You will have to re-run the baseline calibration to compensate for this physical change to the paddles.

Where do I go from here ?

The following is a simple checklist to help you get started with your MTB. As you become familiar with it, you'll also want to explore the many options that you can use to customize the operation of your MTB.

- Be sure to Calibrate your board using the **MTB Test Procedure** on page 10.
- Set your keyer's speed to a comfortable level using the rotary control knob and practice sending Morse Code with your MTB until you are comfortable using it.
- Read the **Command Mode** section (page 13) to learn how to program your MTB before proceeding to the following steps.
- Program the **Rotary Push Button (M4), M1, M2, and M3** buttons with your call sign, CQ sequence, a signal report, or another set of messages that you want to use (page 18).
- Consider setting your **Farnsworth Speed** (page 13) to something that is comfortable for you. Using Farnsworth mode will cause the keyer to set the *dits* and *dahs* for individual characters at a higher speed and the keyer will use the speed that you set by the rotary control knob to set the time between characters to a slower rate. Farnsworth mode is a good way to practice learning Morse Code. 15 – 20 WPM Farnsworth Speed is a good place to begin.
- Try out the **Practice Modes** (page 16)
- If you accidentally put the MTB into an undesired state, you can always **Restore Factory Defaults** (page 20) to reset your configuration and start again

MTB Schematic Diagram

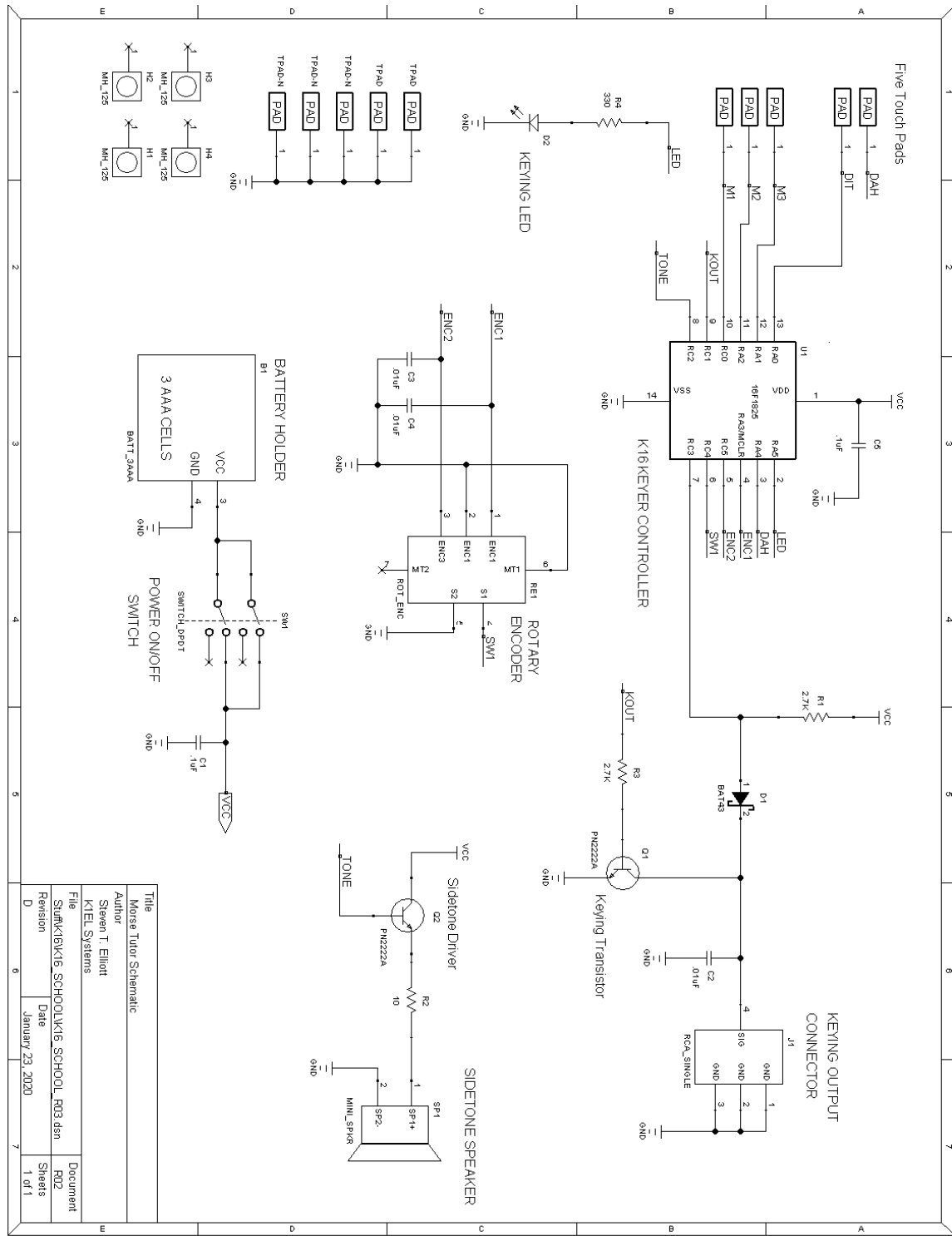


Figure 11 – Morse Tutor Board Schematic

Operating the MTB Keyer

Command Mode

Normally a novice Morse student will not need to make any changes to MTB settings other than change speed which is done by turning the speed control. As the student improves, they will want to experiment and learn more about the MTB. We recommend reading through the MTB tutorial on Page 22 before returning to the detailed command descriptions outlined here.

Changes to the MTB's configuration are made by entering values on the paddles. Before doing this, the MTB must be put into command mode. If the encoder push-button (PB) is pressed down and held, the MTB will respond after about two seconds with the letter **R** (di-dah-dit) in sidetone. This means the MTB is ready to accept a command. Simply enter the command letter in Morse on the paddles and the command will be executed. Some commands require additional parameters. In this case, the MTB will prompt you with the letter **E** (for enter). When the MTB is in command mode, the KEY and PTT outputs are de-activated. All commands provide some sort of feedback to tell you if the command was understood and executed properly. If an illegal command or parameter is entered, the MTB will respond with a question mark (di-di-dah-dah-di-dit). **NOTE:** If you press the encoder PB and it answers with an **L**, this means the batteries are low and should be replaced soon.

Important Note ! In command mode, transmitter keying is disabled and replies are sent in sidetone only. If sidetone had been disabled with the **A** command, it will be re-enabled temporarily during command mode.

Command Toggles – Many settings such as Paddle Swap and Transmit Mute have just two states, on or off. These settings are turned on or off like a toggle switch. Issuing the command will change the state back and forth between off and on. When a toggle command is turned off, the MTB will echo an **N** for “Not enabled” Likewise when a toggle command is turned on an **A** is echoed for en**A**bled.

MTB Command List

In the following command descriptions, the letter displayed in **BOLD** is the command and **BOLD ITALIC** is MTB response. **[pb]** means that the MTB will wait for you to press one of the message pushbuttons.

A - Sidetone enable is a toggle command. Sidetone should be disabled when using a transceiver's built in sidetone. The MTB will acknowledge this command by responding with an **A or N**. Note: If sidetone is disabled, it will be temporarily re-enabled when entering command mode.

B [n,dd] - Easy Beacon: Any message in the current bank can be repeated at a specified rate. After entering **B**, the user is prompted to enter a single digit message number **n** (1-6) and then prompted to enter a two digit beacon cycle time **dd** in seconds (01-99). A beacon can be interrupted by hitting either paddle. The beacon is timed from start of beacon to start of next beacon. For example if you set a delay time of 10 seconds, the beacon will start every 10 seconds regardless how long the message is. If the message is longer than delay time, then there will be no gap between messages.

C [nn] – Command WPM: The MTB uses different speeds for command transactions and keyed transmit. Changes in transmit speed will not affect command speed. After the **C** command is issued enter the speed **nn** in WPM (05-99). If the speed is valid the MTB responds with an **R**, otherwise a **?** See the **S** command for details on setting transmit Morse speed.

D - Decrement serial number by 1, MTB responds with an **E**

E - Swap message banks: The MTB has two separate message banks, six messages each. In response to this command, the MTB will respond with an **E** for bank one or an **I** for bank two.

F [nn] - Set Farnsworth Speed: This is used primarily for code practice. Letters are sent at the Farnsworth speed while maintaining the default code speed. For example, if Farnsworth is set to 25 WPM and the operating speed is set to 7 WPM, individual letters will be sent at 25 WPM while the spacing between letters remains at a 7 WPM rate. To disable Farnsworth mode, set it to zero.

G[n] – Start Letter Group Practice: n = E, I, S, or H. This is just one of the practice modes that the MTB supports. A full description of both practice modes can be found on Page 16.

I[nn] – Set Letterspace Adjustment: nn is a value 0 to 31 that specifies an additional letterspace delay to be applied between letters. Multiply nn by two to arrive at the actual adjustment percentage. For example a value of 7 applies 14% additional letterspace between letters. The maximum adjustment is 62%.

J [nn] - Paddle Sample Delay: Normally the MTB waits one dit time after a paddle press has been sensed before latching a second paddle press. The **J** command allows this delay time to be adjusted. Shorter delays can result in the keyer sending unwanted dits or dahs while a longer delay will slow you down. The value of nn can range from 01 to 99 with a default value of 50 which specifies one dit time. A value of 99 doubles the delay time while a value of 25 halves the delay. A value of 55-60 gives a more relaxed feel. **If the paddle sensitivity is set to zero, both dit and dah paddle memories are disabled.** The delay, which tracks sending speed, is calculated with this formula:

DELAY_TIME = (nn×DIT_TIME)/50 where nn is a value between 01 and 99.

K - Set Keying Mode: There are six different keying modes supported by the MTB: Iambic mode A, Iambic mode B, Straight Key/Bug, Ultimatic, Dit priority mode, and Dah priority mode. In either Iambic mode, alternating dits and dahs are sent while both paddles are held closed. In mode B an extra alternate dit or dah is sent after both paddles are released. In straight key/bug mode a dah paddle press will key the transmitter for as long as the paddle is pressed and dits will be generated automatically when the dit paddle is pressed. In Ultimatic mode when both paddles are pressed the keyer will send a continuous stream of *whichever paddle was last pressed. Hold dah then press dit->sends dits. Hold dit then press dah -> dahs are sent.* Ultimatic dit and dah priority mode will generate dits and dahs automatically in response to single paddle presses, but when both paddles are pressed either dit or dah has priority.

After the **K** command is issued the current mode is set by entering a single letter:

Iambic B:	Enter B
Iambic A:	Enter A
Ultimatic:	Enter U
Straight Key:	Enter S (This is also the Bug setting)
Dit Priority:	Enter E (Ultimatic with dits always taking priority when both pressed)
Dah Priority:	Enter T (Ultimatic with dahs always taking priority when both pressed)

L – Enable/Disable LED: This is a toggle command which controls whether the LED is turned on with keying output. In response to this command, the MTB will echo an **A** when LED enable is turned on and an **N** when LED enable is turned off.

M – Mute Transmit: This is a toggle command which turns keying output on and off. When muted, the MTB will send Morse in sidetone only. In response to this command, the MTB will echo an **A** when mute is turned on and an **N** when mute is turned off.

N [nnnn] - Load 4 Digit Serial Number: All four digits must be entered including leading zeroes. The serial number is played by inserting a play message token **N** into a message. The serial number is automatically incremented after playing. See *Embedded Command* section for more details.

P[n] – Start Echo Practice: n = E, I, S, or H. This is just one of the practice modes that the MTB supports. A full description of both practice modes can be found on Page 16.

Q - Query MTB Current Settings: MTB will respond with current settings sent in the following format:

WPM	current operating speed is sent first
N	followed by Serial Number
M	followed by free msg memory space available in letter count
C	followed by command WPM
W	followed by weight
F	followed by Farnsworth WPM
I	followed by letterspace adjustment
J	followed by paddle Sample Adjust
Y	followed by dit/dah ratio
B	followed by speed control min WPM
T	followed by speed control max WPM
REV	followed by K16-PS firmware revision denoted by a single letter; A or B or C... etc.

The Morse readout can be stopped by holding either the left or right paddle until the listing stops.

R [pb] – Review a message without transmitting: After the **R** command is entered the MTB will respond with an **E**. You then press the slot you wish to play (M1-M5). The contents will be sent in sidetone only. An empty slot will play as **MT**. Embedded commands will be sent as entered which is very helpful for debugging messages. In other words /S10TEST will be sent as DAH-DI-DI-DAH-DIT S10TEST

S [nn] - Set Morse Speed in WPM: The value **nn** is entered in WPM (05-99). This sets the speed encoder to the selected speed. If you enter a value above or below the speed control range it's ignored.

U - Toggle Autospace Mode Off and On: When autospace is enabled, the MTB will automatically force correct inter-letter space between letters. When the **U** command is issued, the MTB will respond with an **A** for autospace enabled or an **N** for autospace disabled.

This is how autospace works: If you pause for more than one dit time between a dit or dah MTB will interpret this as a letter-space and will not allow the next the next dit or dah to be started until the proper letter-space time has been met. The normal letter-space is 3 dits however this can be increased by using the **I** command. MTB has a paddle event memory so that you can enter dits, dahs, or squeeze both during the inter-letter space and MTB will send them as they were entered. With a little practice, autospace will help you to send near perfect Morse.

V - Toggle 50% tune duty cycle: The default tune duty cycle is 100% key down. This command allows either 100% or 50% duty cycle to be selected. Some folks prefer a 50% tuning duty cycle to reduce power dissipation thereby protecting transmitter finals and/or a linear amplifier. An **A** is echoed when 50% is enabled, an **N** is echoed when set to 100%

W[nn] – Key Weighting: Can be adjusted in percentage from 25% to 75%. When set to 50% weighting is normal. Values less than 50 reduce weighting while values greater than 50 increase weighting. Note that weighting does not affect sending speed because any increase in keyed time is subtracted from spacing time. Reduced weighting results in a thinner sound while increased weighting results in a heavier sound. Since weighting tracks speed, a given weighting will sound the same at all speeds.

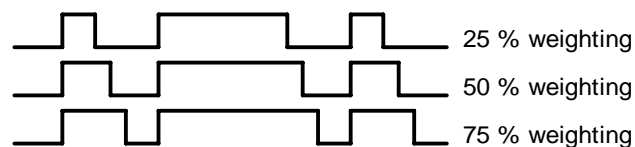


Figure 12 – Key Weighting

X – Extended Keyer Commands

An additional set of commands is located in a sub menu for settings that are not changed very often. Extended commands require two entries, an **X** followed by a sub command.

A list of extended commands is provided in the next section on Page 16.

Y [nn] - Set Dit/Dah Ratio: **nn** ranges from 33 to 66. Entering **Y 50** sets the standard 1:3 ratio. For example a value of **33** selects a dit/dah ratio of 1:2 while a value of **66** selects 1:4. The ratio formula is:

$$\text{Ratio of 1:N where } N = (nn * 3) / 50 \quad \text{example } nn = 40 \quad \text{give a ratio of } 1:((40*3)/50) = 1:2.4$$

Z - Change Sidetone Frequency: After this command is entered the sidetone oscillator will be keyed at a steady rate with transmit muted. Pressing the paddles will raise or lower the frequency. The range varies continuously from 300 Hz at the low end to 2000Hz on the high end. It takes a while to sweep through the whole range. Pressing the encoder pushbutton down will end this command and store the new sidetone frequency. Use the Preserve Settings extended command to store the setting in EEPROM.

Extended Command List

An additional set of commands is located in a sub menu. Extended commands require two entries, an **X** followed by a sub command. This is the Extended Command procedure in detail:

Press and hold the rotary encoder down and the MTB will respond with an **R**

Enter an **X** and the MTB will respond with an **E** (command request)

Enter desired Extended Command with additional parameters, if required.

C - Toggle Contest Spacing: When contest spacing is enabled, word space is set to 6 dit times as opposed to the normal 7 dit times. An **A** is sent when CT space is enabled, an **N** is sent when it is turned off.

F - Toggle Fast Command Response Time: Normally the MTB will enter command mode when the encoder pushbutton is pressed down for 2 seconds. This may be too long for some operators. When fast response is enabled, the delay time is reduced to 1.3 seconds.

M - Load Callsign: Use this command to load a stored callsign. It works just like a message entry and the destination is the currently enabled user slot. Each user slot has one unique callsign. Since the callsign is treated like any other message, embedded commands can be included if desired. The only way to play back a callsign is by embedding the **/M** command in a message.

N - Select Cut Number for number 9: When enabled, an N will be substituted for the number nine when sending a serial number. Command response: an A is sent when enabled, an N is sent when disabled.

R [nn nn] - Set Speed Control minimum and maximum: The MTB will prompt for two values, the minimum WPM and the maximum WPM. An error will be flagged if the minimum value entered is greater than the maximum or if the minimum value is less than 5 WPM. Maximum WPM allowed is **99**.

S - Preserve Settings in EEPROM: will respond with a letter **R** to signify that settings were saved successfully.

T - Select Cut Number for Zero: When enabled, a T will be substituted for the number zero when sending a serial number. An **A** response means this cut is enabled, an **N** response means it is disabled.

U - Swap Users: The MTB provides two complete user configurations, each with a unique callsign. Messages are shared between users. For example a message like CQ CQ CQ DE /M /M K will send the selected user's callsign. In response to this command a single dit is echoed when user 1 is selected and two dits when user 2 is selected.

V - Voltage Readout: The MTB will measure the current supply voltage and send it in Morse sidetone. For example a voltage of 4.52 will be sent as **4R52** with the r indicating the decimal point.

X - Toggle paddle swap (Exchange dit/dah inputs): MTB will respond with a letter **A** to signify when paddle swap is enabled and an **N** when turned off.

Practice Modes

A dual mode, multi-level code practice program is built into the MTB. The two modes are random letter groups and receive/respond practice. There are four levels of practice, organized by level of difficulty:

Level 1: E T A N I M W S G D U K O R

Level 2: C Q P J F B V Y H X Z L including level 1

Level 3: 1 2 3 4 5 6 7 8 9 0 including level 1 & 2

Level 4: ? / , . AR SK BT AS including level 1 & 2 & 3

The random letter group practice command is **G**. After you enter the command, the MTB will reply with an **E** which is your cue to enter the level. Enter 1, 2, 3, or 4 dits to specify the level 1, 2, 3, or 4.

After you enter the level, random characters from the selected level are sent in groups of five with each group separated by two spaces. The WPM speed can be changed at any time with the speed encoder. To end this practice mode, press the encoder pushbutton down.

The receive/respond practice command is **P**. The level is entered just like the **G** command described above. Enter **P**, MTB responds with **E**, you enter the level; **E**, **I**, **S**, or **H**. (1 dit, 2 dits, 3 dits, or 4 dits).

After you enter the level, the MTB will send a random character from the selected level. You will respond by echoing that character on the paddles. If you get it right the MTB will repeat the first character followed by a new character. Now you must echo both characters. The MTB will continue to add characters until a set of five characters has been completed successfully. After that it will start over with a new set. If you miss a character the MTB will respond with an **X** and start over with a new sequence of characters.

When you want to end this practice mode, either respond with di-dah-di-dah or press the encoder pushbutton down. The MTB will respond by sending SK.

In both **G** and **P** modes, practice will be sent on the output key port. If you want to listen to sidetone only; either disconnect the keying output cable or issue the transmit mute command **M**.

The speed encoder can be changed at any time but only takes effect between sequences.

Shortcuts and Speed Ups

The MTB design goal was to streamline command entry, here are some notable improvements:

Fast Command responses – MTB uses **A** for positive responses instead of an **R** or **Y**

Cut Numbers on Command Entry – When entering numeric values use cut numbers to save time. For example when changing the command speed to 19 WPM, use **C A N** instead of **C 1 9**
These are the command cuts used in the MTB: T=0, A=1, U=2, V=3, 4=4, 5=5, 6=6, B=7, D=8, N=9

Single digit number entry – If you are entering a parameter that usually requires two digits but you only need to enter one, just enter the single digit and the MTB will figure out that there is only one. For example instead of entering **T 0 7** you can simply enter **T 7**.

MTB will respond with an **E** or **I** when swapping users, message banks, or output ports. Think of it as a single dit for 1 and a double dit for 2. This is much faster than responding with a Morse 1 or 2.

Fast Message Entry – Just press the rotary encoder down till you get an **R** then simply press the message button you want to load. To stop load mode, either press the encoder down or enter di-dah-di-dah.

Fast Tune Mode – Press and hold all three message pads (M1, M2, M3) to start tune. Press either the dit or dah pad to end tune.

Fast Command Response – If you think the MTB takes too long to respond to an encoder press, enable fast command reply mode which halves the delay time. (Extended command **F**)

Command Prompts – The MTB will respond to commands that require additional input with an **E**. The **E** stands for “Entry Required” and is fast and efficient. For example if you enter the Weight command **W**, the MTB will respond with an **E** to let you know it is waiting for the value.

The default command speed of the MTB is 10 WPM. If this is too slow or too fast, it can be set to a different speed with the **C** command. Be sure to save your new default with the **X S** command.

Speed Encoder Configuration

Turning the speed control will change the Morse WPM rate with minimal lag. The entire sweep of the speed control is called the range and it can be modified with the extended **R** command which sets the upper and lower speed control limits. This allows you to tailor the speed control to an area that you prefer. The minimum acceptable value for speed bottom is 5 WPM and the maximum is 99 WPM. The default range for the speed control is 5 to 25 WPM. If you need to set an exact speed; use the **S** command (see page 15).

To find out what speed the MTB is set to, run the query command **Q**. This will send a list of settings in sidetone. The first number sent is the current speed. Hold either paddle down to stop the rest of the list.

Message Functionality

Messages are loaded by first pushing the rotary encoder button down until MTB responds with an **R**, and then pressing the message pad M1, M2, M3, or encoder PB (M4) to select the memory slot you wish to enter. When MTB is ready to accept a new message it will respond with an **E**. If you wait too long, MTB will respond with a **?** and you will have to start over.

When a slot has been selected and the MTB responds with an **E**, a new message is entered directly on the paddles at a steady rate, making sure to leave proper space between letters. To insert a word space simply pause for longer than a word space and MTB will respond with an **E** to signify a word space insertion. You can force a wordspace insertion by entering di-di-dah-dah (**IM**). This allows you to put a wordspace at the beginning of a message or insert more than one wordspace in a row. A ½ letterspace pad character can be inserted by entering di-di-dah-dah-dit (**IG**).

If a mistake is made while entering a message, press and hold the rotary encoder pushbutton down and MTB will backspace through the letters that have been entered. When you reach the position where you want to stop, release the encoder and new letters can then be added starting at that position. If the message memory becomes full while entering a message, MTB will stop further loading, respond with an **F**, and end message entry. When a new message has been completely entered, press the encoder pushbutton, or enter di-dah-di-dah (**AA**), and MTB will respond with an **R** to signify that the message was accepted and stored. There are 232 letters in message memory that can be distributed in any way between 14 message slots. The length of the individual message slots is not fixed. This means, for example, you could have one message of 80 characters, one message with 5 characters, and a third with 10 characters and still have 141 locations left to split among the remaining three slots. Keep in mind that each word space occupies one memory location.

What if you want to insert one of the message controls (**IM**, **IG**, **AA**) into a message ? Simply precede them with a / (**DN**) and it will not be acted on as a control code.

Usually when you want to finish a message, MTB will usually append a wordspace before you have a chance to press the encoder pushbutton down. If you are chaining two messages together, you may not want a wordspace at the end. The best way around this is to end a message with di-dah-di-dah (**AA**). This will terminate the message without a trailing word space.

If you are having problems loading messages into MTB, make sure you leave adequate space between letters and are not sending much faster or slower than current command speed. If, for example, you enter an **A** followed by a **T** and end up with a **W**, you are not allowing enough space between letters. It's a fine line though because if you allow too much space MTB will interpret that as an intentional pause and insert a word space. Temporarily lowering the command speed (see command **C**) can help while you learn how the process works.

To play a message back, simply press the desired message button, release, and that message will be sent. If you press a pushbutton that does not have a message loaded, the MTB will respond with an **MT**, short for eMpTy. If you want to review the message without keying the transmitter, use the **R** (review) command. Note that review will ignore control codes and send them as entered, this is useful when debugging embedded commands. To abort a message, press and hold one of the paddles and MTB will stop transmission immediately.

Gap (Extra Space) Insertion

In messages, MTB interprets the **IG** prosign (di-di-dah-dah-dit) as a ½ dit delay time. The **IG** character can be included in a text string to add extra emphasis to similar sounding sequences. An example is W1OMO, sending it as W1**IGOIGMIGO** makes it easier to copy. To insert an **IG** prosign in a message without translating it to a gap, enter it as **/IG**.

Word Space Insertion

In messages, MTB interprets the **IM** prosign (di-di-dah-dah) as a 7 dit wordspace delay time. The **IM** character can be included to add a small amount of delay and is easier to use than a delay command. To insert an **IM** prosign in a message without translating it to a wordspace, enter it as **/IM**.

'Two Press' Message Button Functionality or Message 5 Access

You can load or play message five by pressing M1 and M3 simultaneously.

Embedded Message Command List

It is an easy procedure to embed commands in a message. The format is the fraction bar **DN** (D and N sent together as one letter) followed by the desired command letter. If you want to insert the DN prosign into a message but don't want it to be interpreted as a command simply enter DN twice.

Example: **K1EL/1** would be entered as **K1EL//1**

Embedded message command table

/Bnn	Set a beacon cycle time of nn seconds (nn=00 to 99). Put this at the beginning of a message to set the beacon period.		
/Cn	Call message in slot n (1-5), return and resume current message.		
/D	Decrement serial number.		
/E	Toggle message banks		
/Inn	Increase letterspacing within a message, nn is a value from 0 to 31 percent times 2.		
/Knn	Key transmitter for nn seconds. (nn=00 to 99)		
/M	Play user callsign.		
/N	Play Serial Number with auto post increment.		
/P	Pause and wait for paddle entry and then continue after one word space time. The pause is ended three ways 1) paddle entry 2) Press a msg PB (1-5) or 3) Press the encoder PB to cancel.		
/Snn	Set a speed change within a message. (nn=WPM, 5 to 99)		
/V	Send the current voltage in Morse, useful for beacons.		
/Wnn	Wait for nn seconds. (nn=00 to 99)		
/Xn	Cancel speed override, for example cancel HSCW, QRSS, or /Snn speed.		
/Yn	Force a relative speed change up. Add n to the current WPM. n=(0-9)		
/Zn	Force a relative speed change down. Subtract n from the current WPM. n=(0-9)		
/1	Jump to message 1 (M1)	/2	Jump to message 2 (M2)
/3	Jump to message 3 (M3)	/4	Jump to message 4 (PB)
/5	Jump to message 5 (M5)		
<u>AA</u>	End message load immediately	(DI-DAH-DI-DAH)	
<u>IG</u>	Insert ½ letterspace pad	(DI-DI-DAH-DAH-DIT)	
<u>IM</u>	Insert wordspace pad	(DI-DI-DAH-DAH)	

Embedded Command Examples:

/B60BCON DE K1EL BEDFORD NH will send BCON DE K1EL BEDFORD NH every 60 seconds
UR RST IS /P QSL will pause to allow the user to enter the RST then resume automatically
/K05 /W10 VVV DE K1EL will key down for 5 secs, wait 10 secs, and then send VVV DE K1EL
CQ CQ CQ DE /M /M /M will send a 3x3 CQ using the user callsign
CQ CQ CQ DE K1//10TMT//100 K will send message with 20% extra space in TMT. A more manageable way of doing this would be to load **K1//10TMT//100** in the callsign slot to get this spacing any time /M is used.
CQ CQ CQ DE /Z4K1EL K1EL K1EL/Y4 K send the callsigns 4 WPM slower then return to normal WPM.
QTH IS /E/C1/E NAME IS STEVE Will play the QTH from message bank 1 and then return for the name.
/B10K1EL BCON/W2/VVOLTS sends K1EL BCON, wait 2 secs, send XrXX VOLTS repeat every 10 secs
SOM/E/C3/E/S50K1EL//1/XEOM Send SOM, swap to msg bank 2, call msg 3, swap back to msg bank 1, change speed to 50 WPM and send K1EL/1, cancel 50WPM send EOM.

Quick Tune Command

If you press all three message pads, M1, M2, and M3, tune mode is turned on. This keys your transmitter until you press one of the paddle pads. Use the **G** command to select either 100% or 50% tune duty cycle.

Quick Serial Number Decrement

During contest operation, it's not unusual that a serial number has to be repeated. Since the serial number is automatically incremented when it's played, we need an fast way to decrement the serial number. This can be done by holding down the encoder PB and pressing either the dit or dah paddle. As a signal that the MTB has decremented the serial number, it will echo a single dit in sidetone.

A serial number decrement command **D** is provided (see page 13) but this is not used very often.

There is a third way to decrement a serial number, that is with a **/D** command embedded in a message. A message can be built that pre-decrements the serial number before sending it. This may be the best way to deal with serial numbers in a contest. For example the following two messages can be created:

Message 1: 5NN /N QSL ?

Message 2: /D/N QSL ?

Message 1 is the initial exchange, if the serial number needs to be resent, message 2 would be sent. This message pre-decrements the serial number before sending it. Both of these messages leave the serial number incremented after it is sent.

Message 3 will send the same serial number twice in one message.

Message 3: /N/D /N

Power On and Off

Even though the MTB's idle current is low, about 2 mA, it will run down a set of alkaline batteries in about three weeks. For this reason the MTB has a power on/off switch. The silkscreen on the board shows which switch position is off. When you turn the MTB off, it will lose any settings that you made by entering paddle commands **unless** you stored the settings with the **S** command. Read the **Preserve Settings** section below.

Since it is easy to forget to turn the keyer off, a "snoring LED" indication will start after the keyer has been inactive for about 5 minutes. The LED will slowly cycle on and off to let you know the MTB is still on. Snoring will stop as soon as you press a paddle pad, message pad, or press/turn the rotary encoder.

Preserve Settings

MTB setting changes are not automatically copied into permanent storage. That means the settings will be lost if power is cycled. To save the settings permanently, use extended **S** command. Press and hold the encoder down PB until the **R** and enter an **X** followed by a **S**. This will save current settings in nonvolatile memory so that all settings will be retained on power cycling. Note that messages are always saved directly into nonvolatile memory so the **S** command is not required to preserve messages.

Restore Factory Defaults

If you want to restore the MTB to original "factory" settings, turn the MTB off, press both paddles, and then turn the MTB on. After about 2 seconds, release both paddles and the MTB will send a **C** signifying a cold reboot. This erases all settings and messages and then restores factory settings. Baseline paddle calibration is not changed by a cold reboot.

Factory Defaults are:

Fixed WPM: 15	Command WPM: 10	Sidetone: 700Hz	Weight: No adjustment
Sidetone: On	Interchar Spacing: Normal	SampleAdjust: None	KeyMode: Iambic B
TX Mute: Off	Autospace: Off	Extra Letterspace: None	Serial Number: 0001
Dit/Dah Ratio: 1:3	User: 1	Message Bank: 1	Messages: All Erased
Speed Ctl Min: 5	Speed Ctl Max: 25	Farnsworth: Off	Tune Duty Cycle: 100%

MTB Command Cheat sheet

Immediate Command List:

A	-	Toggle sidetone on/off	N	-	Load 4 digit serial number
B	-	Easy beacon	P	-	Receive/Resend practice
C	-	Set command speed	Q	-	Query: Report current settings
D	-	Decrement serial number	R	-	Review message with transmit muted
E	-	Swap message banks	S	-	Set WPM speed
F	-	Set Farnsworth Speed	U	-	Toggle autospace on/off
G	-	Letter Group Practice	V	-	Toggle tune duty cycle
I	-	Set Inter-letterspacing	W	-	Set keying weight
J	-	Set paddle sensitivity	X	-	Enter extended command mode
K	-	Select keyer mode	Y	-	Set Dit/Dah ratio
M	-	Toggle transmit muting	Z	-	Select sidetone frequency
<u>AA</u>	-	Set tune on			

Extended Command List

A	-	Analog input diagnostic	R	-	Set speed control Range (min max)
C	-	Toggle contest spacing	S	-	Preserve settings in EEPROM
F	-	Toggle fast command response	T	-	Toggle number 0 cut
M	-	Load callsign	U	-	Swap Users
N	-	Toggle number 9 Cut	V	-	Voltage readout in Morse
O	-	Set output mode	X	-	Swap paddle inputs (left to right)

Embedded Message Command List

<u>/Bnn</u>	-	Set a beacon cycle time	<u>/V</u>	-	Send voltage reading in Morse
<u>/Cn</u>	-	Call message (n=1-6)	<u>/Wnn</u>	-	Wait for nn seconds (n=0-99)
<u>/D</u>	-	Decrement serial number	<u>/X</u>	-	Cancel speed override
<u>/E</u>	-	Swap message banks	<u>/Yn</u>	-	Relative WPM change up (n=0-9)
<u>/Ann</u>	-	Set alternate letterspacing (n=0-31)	<u>/Zn</u>	-	Relative WPM change down (n=0-9)
<u>/Knn</u>	-	Key down for nn seconds (n=0-99)	<u>/1</u>	-	Jump to message 1
<u>/M</u>	-	Play user callsign	<u>/2</u>	-	Jump to message 2
<u>/N</u>	-	Play serial number	<u>/3</u>	-	Jump to message 3
<u>/P</u>	-	Pause and wait for paddle	<u>/4</u>	-	Jump to message 4
<u>/Snn</u>	-	Set sending speed in WPM (n=0-99)	<u>/5</u>	-	Jump to message 5
<u>IM</u>	-	Insert wordspace (DI-DI-DAH-DAH)	<u>/6</u>	-	Jump to message 6
			<u>AA</u>	-	End message load
			<u>IG</u>	-	Insert Gap (DI-DI-DAH-DAH-DIT)

MTB Tutorial

Start with power on:

Slide the power on/off switch to the on position and the MTB will send the letter **R** to let you know it's ready. Touching the paddle pads will generate dits and dahs both in sidetone and keyed output. If you press any of the message pads, the MTB will send an **MT** meaning the message slot is eMpTy. Even though the keyer uses a small amount of power when idle, be sure to turn the keyer off when not in use to prolong battery life. This is done by pushing down on the encoder until the keyer responds with an **R** followed by a **K**.

Command Entry:

A command cheat sheet can be found on page 20. There are three command types, immediate, extended, and embedded message. The first commands to look at are the immediate commands.

Immediate Command Entry:

Pushing down on the encoder PB encoder is the way to activate command mode. Press and hold until the MTB answers with an **R**. Then, without hesitation, release the encoder PB, and enter an immediate command letter on the paddle pads. Try the **Z** command which allows the sidetone frequency to be changed. The MTB will output a continuous tone and you can adjust the frequency by touching the paddle pads. When you are finished, press the encoder PB to return to normal operation.

If the MTB does not understand a command, or you are too late in entering a command, it will respond with a question mark.

Some commands require additional parameters; a good example is setting the command speed. Press the encoder PB, wait for the **R**, and then enter **C**. The MTB will respond with an **E** telling you it's waiting for you to enter the new speed in WPM. Enter a 1 followed by a 0. You have changed the command entry speed to 10 WPM. Re-issue the command but this time use a **T** for the zero (**1T**). This is a handy shortcut. If this command speed is too fast or slow for you, repeat the command with a more comfortable speed.

Change Keyer Mode:

If you enter the **K** command, the MTB will prompt you for a keying mode. **A** sets Iambic A while **B** sets Iambic B, there are many other choices, all covered on page 12. No matter what mode you set, the MTB will respond with an **A** to let you know it acknowledged the command or **?** if an illegal mode was entered.

Other keying parameter commands:

The sample adjust command **J** adjusts the paddle timing to respond the way you prefer. (a value of 55 will come close to another well known keyer). Setting sample adjust to zero will disable the dit and dah paddle memories. Weighting and letterspace are a few other ways to adjust the way Morse is generated. These commands are covered in detail on pages 11 through 14.

Entering Extended Commands:

The command set is expanded by using Extended Commands. These commands work just like immediate commands with the exception that you have to enter two letters. An often used extended command is the 'save settings' command **S**. Press the encoder PB, wait for the **R**, and in response enter an **X** for extended command, wait for the **E**, then enter **S** for save. The MTB will save the current settings to nonvolatile memory so that when you power off and on, your custom settings are preserved. Messages are automatically saved in memory when entered but settings have to be saved by the Save command. It works this way since most users make temporary changes settings but always want to go back to their favorite settings when they are done. It's easy to restore default settings, just turn the MTB off and then back on again. Another interesting extended command is **V** which tells the MTB to report the current keyer supply voltage. It plays it in this form: **4r35** which in this case is 4.35 volts.

Messages:

Now let's enter some messages. Review the procedure for message loading on page 18. The MTB has two unique features associated with message loading. The first is backspace, if you make a mistake while entering a message, just hold the encoder PB and the MTB will back up letter by letter. Just release the encoder PB when you are done backing up. The second feature is a variable message slot size; if you only use two bytes in slot one, only two bytes of message memory are used up, not an entire slot.

To start, we will load a message into slot 1. Press and hold the encoder PB, wait for the **R**, release the PB, and then momentarily press M1. This tells the MTB you want to load a message into slot 1. The MTB responds with an **E** to let you know it is ready to accept the message. On the paddles enter **CQ CQ TEST**.

Pause after entering the first CQ and a word space will be inserted. You will hear a dit in sidetone when this happens. To end the message entry, either enter **AA** (DI-DAH-DI-DAH) or press the Encoder PB. Now when you press M1 your message will be sent. Note that M4 is selected by pressing the encoder PB and Message 5 is accessed by pressing M1 and M3 at the same time.

Embedded Message Commands

Follow the procedure you learned in the previous paragraphs and enter the following message in slot 2:

/S10SLOW /S25FAST where / is the DN prosign (DAH-DI-DI-DAH-DIT)

The letter(s) following a **DN** are the embedded command. This message has two embedded speed change commands which happen while the message is playing: **SLOW** will be sent at 10 WPM and **FAST** at 25 WPM. (make sure to not allow a space to be inserted between **DN** and **S**) After this message ends, the operating speed will be returned to what it was before the message was sent.

Embedded Beacon Command: It's easy to compose a beacon command. First, we will load msg slot 2.

/B60/K05 BCON DE K1EL NH

Press M2 to start the beacon. A 5 second key down is sent first followed by **BCON DE K1EL NH**.

/B60 specifies that the beacon will be repeated every 60 seconds. To cancel a beacon simply press the encoder PB and MTB will stop the loop and respond with an **X** to let you know the beacon was cancelled.

More embedded commands with Serial Numbers:

Next we will test out serial numbering. First enter a starting serial number using the immediate **N** command. You need to enter all four digits including leading zeroes. A serial number is sent by inserting the **/N** embedded command in a message. You may want to specify the way MTB will send 0s and 9s in a serial number through the use of the extended commands **N** and **T**. (see page 24).

Here is an example of a message that will play a serial number incorporating the **/P** pause command:

In slot 1 enter: **CQ DE K1EL/P UR NR /N QSL?/P.**

In slot 2 enter: **UR NR /D/N QSL ?**

Pressing M1 will send CQ and then pause to let you listen for a reply. If there is no reply, hit M1 to repeat the CQ. If there was a reply, enter the station's callsign and the MTB will send the serial number and pause again. If the station needs a repeat of the callsign, press M2. Since the serial number is incremented after the **/N** command, you need to pre-decrement it with **/D** to send the repeat the serial number.

In software terms, the **/P** command is a three-way branch: First branch: *paddle something to continue*, Second branch: *hit a msg button (other than the encoder PB)*, Third branch: *hit the encoder PB to cancel the message*. Since M4 = Encoder PB you can't use slot four as a second branch choice.

Manual Revision History

v1.0	Initial Release for Rev B board	9/1/2018
v1.1	Update for Rev C board	9/17/2018
v2.0	Updates for the new Rev D board	1/18/2020

MTB F/W Revisions

Rev A	– First Release	9/1/2018
Rev B	– Updates to support Rev D H/W	10/20/2020

Watch the K1EL Website for latest updates and new product offerings: <http://www.k1el.com>

Appendix A - Kit Construction Hints

1. Find a good workspace.

It is essential that you have a good place to work on your kit,

You will need room to spread out your parts and have access to tools. Good lighting and ventilation is essential. A magnifying glass or visor is highly recommended.

2. Have the proper tools.

At a bare minimum you will need:

Small side cutters, flush cutters are a plus.

Small needle nosed pliers

Small flat blade & Philips head screw drivers

A good quality, 40-60Watt, temperature controlled Soldering Iron. The price has come down on these lately, look for a [Weller WLC100 40W](#) soldering station it has adjustable power control for under \$40.

3. Read the Instructions First.

Read through the assembly instructions completely and have everything on hand before you start. Inventory the kit parts and make sure you have ALL of them.

4. Follow the assembly instructions in order.

Although not always obvious, the order in which parts are added to a board is important and should be followed. Sometimes sections are installed and tested in order or there could be a mechanical consideration.

5. Keep your Workplace Clean and Orderly.

Nothing spoils a kit building experience more than lost parts. Second to that is stray bits of dirt and metal that get into a printed circuit board assembly. Our PC boards are nicely plated and accept solder easily. There is no need to clean the board with steel wool before starting. A good rosin core solder will work fine, avoid organic core unless you have the capability to clean the board after assembly. Lead free solder is recommended for obvious health reasons.

6. Take your time.

There is no need to rush, enjoy the process and the end result will be much better. Moving too quickly or working when you are tired often leads to big mistakes which could be difficult if not impossible to fix.

Appendix B - A Note About Safety

Burns to your skin can be very painful and can lead to serious injury.

Burns to your eyes can be catastrophic.

Toxic fumes can cause serious harm.

Flying objects such as wire ends etc. can cause painful and serious injuries.

When building your kit please remember that Soldering Irons and Solder are used at High Temperatures !

Soldering Irons can remain hot for many minutes after being turned off. Never touch the tip to see if it is hot. Touch the tip to a wet pad to test for temperature.

Wear safety glasses to protect your eyes from flying objects.

Appendix C - Soldering Basics

1. Insert component leads into PCB holes and bend them back slightly to hold the part in place. You can either trim the lead now or wait till after the joint is soldered. I usually install several parts at one time and then solder and trim multiple leads.
2. Place a hot and clean iron tip against both the lead and pad as in Fig. C1.

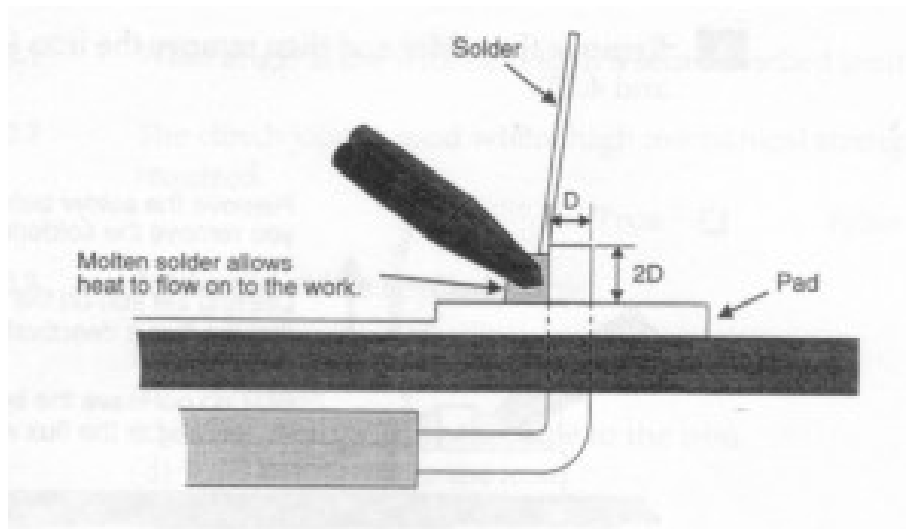


Fig. C1 - Form a heat bridge

3. Create a heat bridge between the lead, the PCB pad and the iron by placing a small amount of solder on the tip.
4. Apply solder around the outside edge of the pad as in Fig. C2. If the pad and lead are at the correct temperature, the solder will flow around the connection.

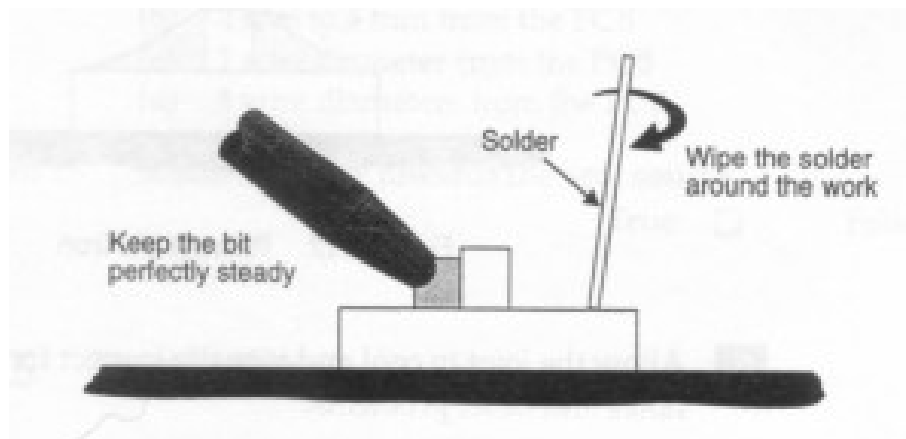


Fig. C2 - Spread solder around the work

5. Remove the solder and then remove the iron.

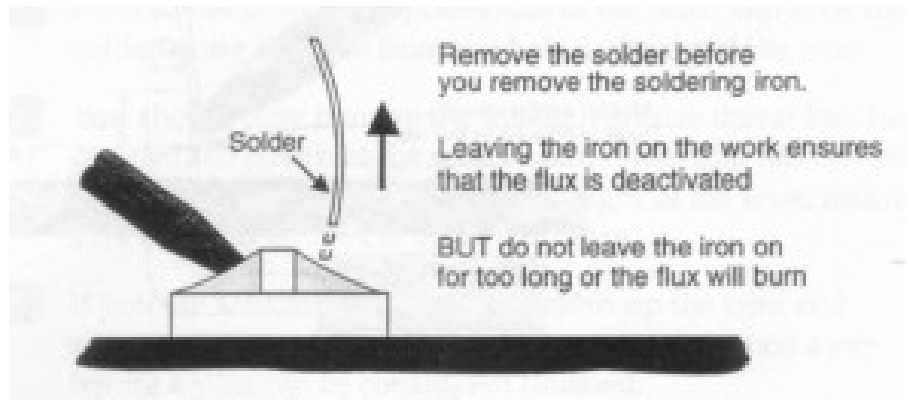


Fig C3 - Remove the solder

6. Allow the joint to cool and visually inspect for defects or other problems. You should have a solder joint with a bright shiny finish and a profile like that shown in the middle picture below. Make sure you use enough heat so that solder flows around both the lead and pad. A good connection will always look like a tent, if it looks like a round ball, then odds are, the solder did not bond to the PCB pad.

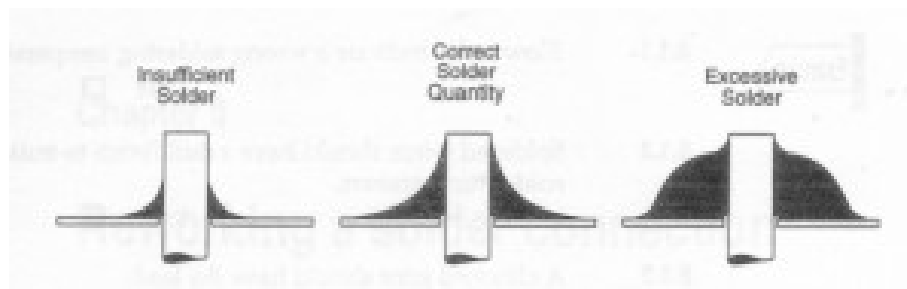


Fig. C4 - Solder quantity comparison

7. To avoid cold solder joints, do not move the board or component lead while the solder is cooling. Keep your iron tip clean, contamination can cause poor solder joints.

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