

## FEATURES

- Keyer speed range: 5 - 99 WPM
- HSCW: 1000, 1500, 2000, 3000, 4000 or 6000 lpm
- QRSS: 3, 6, 10, 12, 30, 60 second dits
- Non-Volatile Message Memory: 240 letters in twelve Slots/dual banked with embedded commands.
- Dynamically allocated message memory
- Backspace supported on message entry
- Keying Modes: Bug, Ultimatic, Iambic A or B
- Serial Number Generation
- Audio Frequency keying mode
- Adjustable Letter Spacing: 25 to 75%
- Adjustable Weighting: 25 to 75 %
- Automatic letterspace mode (Autospace)
- Adjustable Keying Compensation: 0 to 31 mSec
- Paddle swap command
- Beacon: Programmable interval: 1 to 99 seconds
- Sidetone Output: TTL Square wave, 100Ω output Z
- Continuously adjustable Sidetone frequency
- Keying output: TTL, high true when keyed
- Speed control potentiometer
- Push-button user interface
- 39 easy to use commands
- Operating Voltage: 2.5-5.0 VDC, built in oscillator
- Power Consumption: <1 ma active, <18 μA standby
- Supply Voltage Monitor
- Two User Configurations each with callsign
- Rx and Tx Practice Modes
- Ability to key two separate radios

### New Features for the K16

If you are familiar with the K12 keyer IC, you may be interested to find out what improvements and changes have been added to the K16. There are quite a few:

#### • Supply Voltage Monitoring

The K16 has a unique feature that is especially useful in battery powered applications. It is able to accurately monitor its supply voltage and provide an indication when battery voltage is low. Normally the K16 will respond with an **R** when entering command mode. If the battery voltage is approaching the minimum operating range, 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. See page 11.

#### • Dual User Configuration

The K16 provides space for two complete configuration setups. For example, one setup could be used for contesting while the other for casual operating. Or, when two operators share the same keyer, each one can tailor the keyer to their taste and store separate profiles. The extended command **U** is provided to select one configuration or the other. All K16 settings are included in each profile including a stored callsign.

#### • Stored Callsigns

A special memory slot is provided to store the operator's callsign. In fact there are two callsign slots provided, one for each user. The callsign is programmed by using a special callsign load command in the extended command set. The callsign can be embedded in a message with the **/M** buffered command. The callsign slot works like any other message slot, you can call other messages, embed commands, and there is no practical limit to the length of the string.

#### • Many new embedded message commands

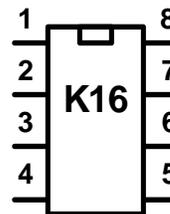
Please refer to page 14 for details.

## DESCRIPTION

The K16 is a single chip Morse code keyer with a wide range of features. It is implemented in a Microchip PIC12F1840 single chip microcontroller. A powerful keyer can be constructed using a K16 with a minimum number of components. Setup commands are directly entered on the paddles in Morse code. When not in use, the K16 will automatically enter a low power sleep mode so it can run off a battery for many months. All settings and messages are stored in nonvolatile memory so that if power is removed they are preserved. The K16 has many original features not found in other keyers.

Please Note: The K16 is not pin compatible with either the K10+, K12, or K14 I.C.s

**K16 Kit information can be found on Page 20**



Top View

- Pin 1: VCC
- Pin 2: Key Port 1 Output
- Pin 3: Sidetone/AF Out
- Pin 4: Right Paddle
- Pin 5: Key Port 2/PTT Output
- Pin 6: Switch Network
- Pin 7: Left Paddle
- Pin 8: Ground

- **Dual Message Banks**

The K16 has two message banks of six slots each for a total of 12 slots, not including two callsign slots. While this does not seem like a lot of messages, due to the K16's dynamic memory allocation scheme, it turns out to be more than adequate for most users. It is very easy to swap message banks with **E** command. This is the shortest command sequence and allows you to swap banks quickly. There is also a buffered message command that swaps message banks.

- **Sidetone Frequency**

In the K12 only a handful of sidetone frequencies could be selected. The K16 allows practically any frequency between 300 Hz and 2000Hz.

- **Fast Message Interruption**

The K12 waited until a letter was complete before checking for an abort request. The K16 will stop a message immediately upon paddle press, stopping in mid-letter if need be.

- **Practice Mode**

Both send and receive practice are included. The user can select practice content by letter group so that easy letters can be mastered first followed by progressively more difficult groups. A very good random letter generator is provided which generates varied, ever changing letter order.

- **Message Stacking**

Up to 10 messages can be queued to be sent in the order requested. The number of nested called messages has been increased as well.

- **Simplified Beacon Formatting**

In the K12 a **/Jn** command had to be placed at the end of a beacon string in order for the beacon to repeat. The K16 does not require this extra jump command as it is inferred. A K12 style beacons message like this:

**/B15 K1EL BCON/J1** can now be formatted as: **/B15 K1EL BCON**

- **Easy Beacon**

Any message slot can be turned into a beacon without having to add the special **/B** embedded command. The **B** command allows on the fly beaconing without embedded commands.

- **PTT Lead In and Tail Settings**

The K16 adopts the Winkeyer notion of PTT control. Both the lead in delay and tail delay can be specified in milliseconds as well as speed dependent hang delay for paddle operation.

- **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.

- **Improved Cut Number Selection**

The K16 allows serial number cuts to be used for 0, 9, both, or neither.

- **Tuning Duty Cycle Selection**

Tune can be set to generate either a 50% or 100% key down duty cycle.

- **Contest Word Spacing**

The K16 allows a shorter inter-word spacing to be selected. This is intended to speed up exchanges during contests. Standard word spacing is 7 dits while contest mode word spacing is 6 dits.

- **Keyer Lock**

The K16 can be locked by command and it will stay locked until both paddles are pressed at the same time for eight seconds. While locked, the K16 will ignore any input and stays in a very low power sleep mode. This is useful for traveling or to prevent "accidental" keying while connected to a radio. (page 16)

- **Fixed Speed Setting**

The K16 supports both a variable speed control and a fixed "favorite" speed setting. It is very easy to switch between them. The fixed speed setting is set by the **S** command.

- **Speed Pot Range Setting**

The upper and lower limit of the speed pot is set with a new extended command; **R** for range. Two values are entered the lowest speed pot setting followed by the highest speed pot setting.

- **Fast Speed Change Feature**

The speed can be incremented or decremented quickly by pressing and holding the command pushbutton and then tapping the paddles. Press left to decrease the speed or right to increase the speed. If you don't want to include a speed pot, this feature provides the same functionality. (page 14)

- **First Element Extension**

This is another command that is brought over from the Winkeyer command set. It allows the first dit or dah of a transmission to be elongated to allow for receive to transmit relay delay.

- **Command Response Time Adjustment**

The K16 will enter command mode when the command pushbutton is pressed for about 2 seconds. This may be too long for some operators. A new extended command **F** has been added that allows the delay to be shortened to about 1.3 seconds.

- **Full Time Speed Pot**

The K12 required a switch on the speed pot. The K16 can run the speed pot and four message push buttons on one single pin, no extra switches required.

### Typical Keyer Application

Figure 1 is a schematic of a minimum component count K16 keyer. It uses a single command pushbutton, a sidetone speaker and a single key output port. The command push-button provides access to command mode and one message. Of course, most users will want to take advantage of all K16 features and include message pushbuttons, a speed pot, and a sidetone driver. Hamcrafters offers a replacement kit for the popular K12-BAT/K12-EXT. The new kit is nearly identical to the older kits with the exception that it provides different message and speed pot wiring as required by the K16 IC. The K16-BAT and K16-EXT kits are described on pages 19 through 31 starting with a comparison chart.

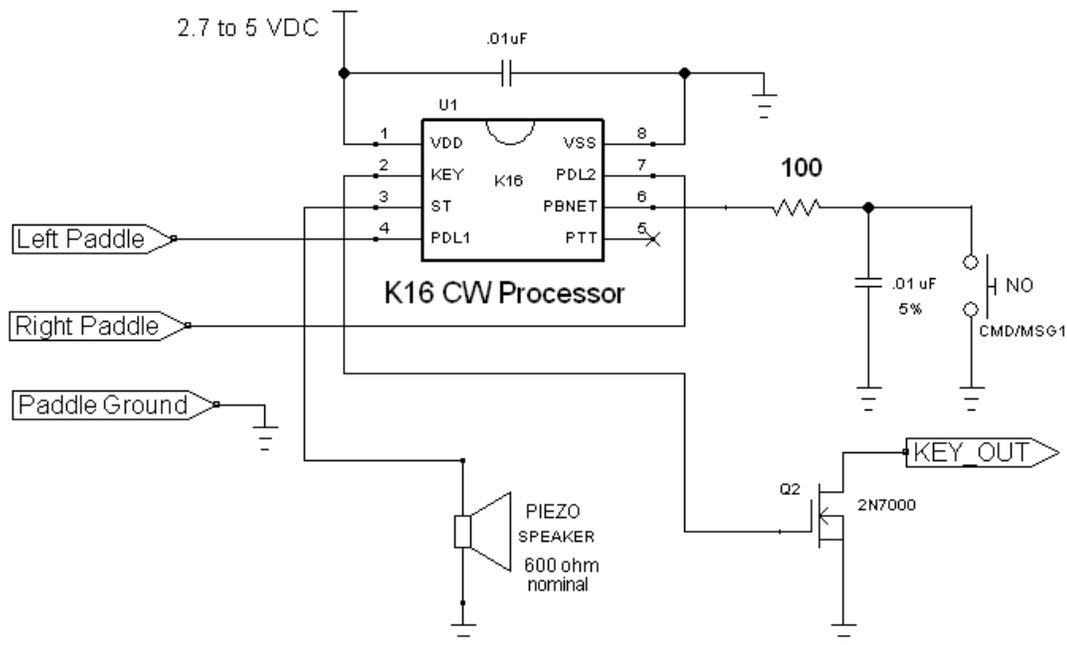


Figure 1 – Minimal Keyer

It is quite easy to design and build your own custom keyer using a K16 IC. Read through the following design considerations and then review the various K16 kit schematics starting on page 20.

## Keyer Construction

Layout is not critical; A K16 keyer could be constructed on a small piece of perf-board. Be sure to place a .01  $\mu\text{F}$  power supply bypass capacitor as close as possible to K16 pins 1 and 8. If using a supply greater than 5 volts, use a three terminal regulator such as an LM7805 to provide 5 volts for the K16. The K16 will also run fine at 3.3V. Use the interface shown in Figure 2 if you wish to drive a small speaker. If installing the K16 directly in a transceiver, the sidetone audio should be fed into the receiver's audio chain, it may be necessary to reduce the output level by using an attenuator network such as shown in Figure 3. Select R1 and R2 to give you the desired attenuation. The capacitor values were chosen to soften the sharp edges of the square wave output.

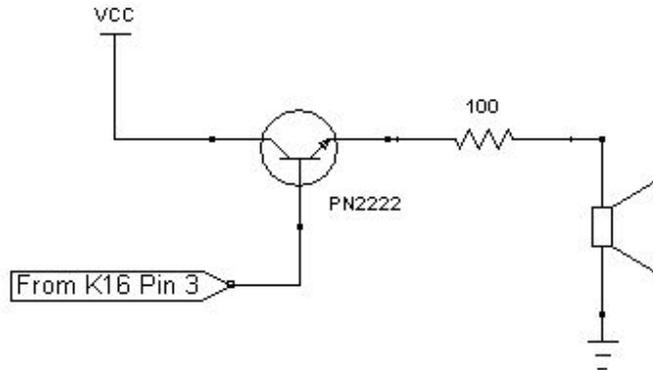


Figure 2 – Sidetone Speaker Driver

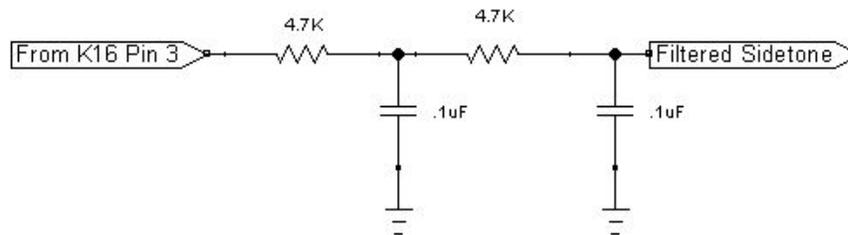


Figure 3 – Sidetone AF Filter

## Keying Considerations

K16 key outputs are high true, the KEY and PTT outputs go to a high state on key down. These outputs are capable of sourcing and sinking 20 milliamps. The highest voltage that the K16 can safely switch is  $V_{cc} + .6V$  which is an absolute maximum. A buffer stage between the keyer chip and a transmitter is highly recommended. A 2N7000 MOSFET transistor buffer is rated at 60 VDC with a max power dissipation of 350 mW. Reed relays or solid state relays are good solutions for keying voltages greater than 60 volts or negative keying voltages as found in vacuum tube transmitters employing grid block keying.

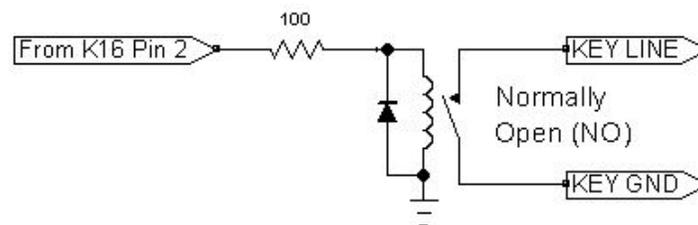


Figure 4 – Using a reed relay to key a transmitter

## Input Considerations

A paddle or command push-button input on the K16 is activated by pulling it to ground. Pull-ups for pins 4 and 7 are built into the K16 so external pull-up resistors on these pins are not required. A shunt .001 $\mu\text{F}$  capacitor is recommended on the paddle inputs to reduce RFI effects during transmit.

### Command and Message Push-buttons

The K16 requires at least one normally open push-button control, this switch is referred to as the command push-button and is connected to pin 6. It serves two functions, command entry and message record/playback. Three additional message push-buttons can be added to provide a total of four direct access messages. Be sure push-button switches that have contacts that are normally open (NO). Two additional messages are accessed by pressing two pushbuttons in a specific sequence, see page 14 for more info.

### Speed Pot

The speed pot is sensed by the same mechanism that reads pushbutton presses. This circuit is shown in Figure 4. The K16 continuously monitors the speed pot position and pushbutton matrix state. The value of the speed pot must be 10K ohms with a capacitor value of .01 uF. No other resistor values may be substituted. If a speed pot is not desired, simply replace it with a connection to ground.

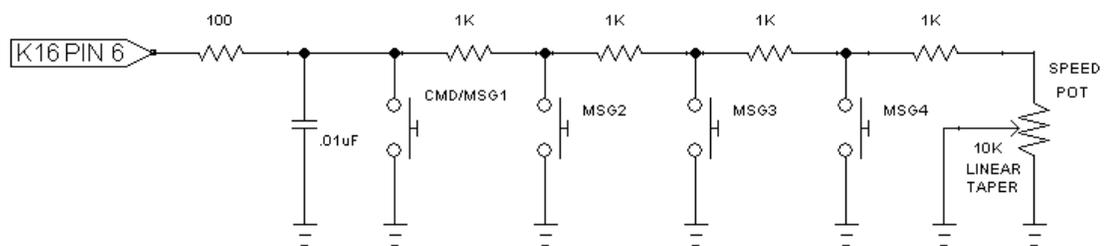


Figure 5 – Pushbutton Matrix (note that K16BK uses different values)

## Operating the K16 Keyer IC

Changes to the K16's configuration are made by entering values on the paddles. Before doing this, the K16 must be put into command mode.

### Command Mode

If the command push-button is pressed and held, the K16 will respond after about two seconds with the letter **R** in sidetone. This means the K16 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 K16 will prompt you with the letter **E** (for enter). When the K16 is in command mode, the KEY and PTT outputs are inactive. 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 K16 will respond with a question mark.

**Important Note !** When in command mode, transmitter keying is disabled and replies are sent in sidetone only. If sidetone was disabled with the **A** command it will be re-enabled automatically for 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 K16 will echo an **N** for "Not enabled" Likewise when a toggle command is turned on an **A** is echoed for en**A**bled.

### K16 Command List

<b>A</b> - Toggle sidetone on/off	<b>N</b> - Load 4 digit serial number
<b>B</b> - Easy Beacon	<b>O</b> - Swap keying output port
<b>C</b> - Set command speed in WPM	<b>P</b> - Start a Practice Session
<b>D</b> - Decrement serial number	<b>Q</b> - Query: Report current settings
<b>E</b> - Swap Message Banks	<b>R</b> - Review message without transmitting
<b>F</b> - Set Farnsworth Speed	<b>S</b> - Set Fixed Speed
<b>G</b> - Toggle Tune Duty Cycle 50/100%	<b>T</b> - Set PTT Tail Delay
<b>H</b> - Set PTT Hang Delay	<b>U</b> - Toggle Autospacing on/off
<b>I</b> - Set Letter Spacing	<b>V</b> - Set Keying compensation in mSec
<b>J</b> - Set Paddle sensitivity	<b>W</b> - Set Key Weight
<b>K</b> - Select keyer mode	<b>X</b> - Enter Extended Command
<b>L</b> - Set PTT Lead In Delay	<b>Y</b> - Set Dit/Dah Ratio
<b>M</b> - Toggle Transmit Mute on/off	<b>Z</b> - Select sidetone frequency
	<b>AA</b> - Tune command (di-dah-di-dah)

In the command descriptions below, the **[n]** or **[nn]** notation means that additional parameters must be entered on the paddles after the command. A letter displayed in **BOLD** is something you enter, **BOLD ITALIC** is the K16's response. **[pb]** means that the K16 will wait for you to press one of the message pushbuttons.

**A - Sidetone enable:** is toggled when this command is entered. Sidetone should be disabled when using a transceiver's built in sidetone generator. The K16 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 [m,dd] - Easy Beacon:** Any message slot 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 (1-6) and then prompted to enter a two digit beacon cycle time (1-99) in seconds. After the command is entered the beacon starts. A beacon is cancelled 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 beacon messages.

**C [nn] – Command WPM:** The K16 uses different speeds for command transactions and on air transmitting. Changes in transmit speed will not affect command speed. After the **C** command is issued, enter the speed in WPM. If the speed is valid, the K16 responds with an **R**, otherwise a **?** See the **S** command for details on setting transmit Morse speed.

**D - Decrement serial number** by 1, K16 responds with a **D**

**E - Swap message banks:** The K16 has two separate message banks, six messages in each. In response to this command, the K16 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 spacing between letters is at a 7 WPM rate. To disable Farnsworth mode, set it to zero. Note that Farnsworth is activated only when it is set faster than the current sending speed. Command response is **R** or **?**.

**G - 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 in transmitter finals and/or linear amplifier. An **A** is echoed when 50% is enabled, an **N** is echoed when set to 100%.

**H [n] - Set Transmit PTT Hang Delay Time:** Sets a PTT delay that is proportional to sending speed. The delay begins after paddle sending stops. You can select one of four delays:

HangTime = 0: wait 1 wordspace + 1 dit before ending PTT  
 HangTime = 1: wait 1 wordspace + 2 dits before ending PTT  
 HangTime = 2: wait 1 wordspace + 4 dits before ending PTT  
 HangTime = 3: wait 1 wordspace + 8 dits before ending PTT

After entering the command letter, you will be prompted with an **E** to enter the desired hang time as a number 0 to 3 as indicated in the table above. Hang delay is different than PTT tail delay in that it is proportional to code speed while PTT delay is primarily a fixed delay time. This frees you from having to change PTT delay every time you change sending speed. Command response is **R** or **?**.

**I [nn] - Set Letterspace Adjustment:** nn is a value 0 to 31, specifying an additional letterspace 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 K16 waits one dit time after a paddle press has been sensed before latching a second paddle press. This command allows this delay time to be adjusted longer or shorter than one dit. If the delay is set too short, the keyer may send unwanted dits or dahs, if there is too much delay it can make sending a bit more tedious. Using the formula provided below, delay time can be set greater or smaller than one dit time. The default value is 50 which specifies one dit time. A value of 99 doubles the delay time while a value of 25 halves the delay. Faster operators report a setting somewhat less than default has a nice feel. The command response is **R**. **If the paddle sensitivity is set to zero, both dit and dah paddle memories are disabled.** The delay is calculated with this formula:

$DELAY\_TIME = (nn \times DIT\_TIME) / 50$  where Switchpoint is a value between 01 and 99.

**K - Set Keying Mode:** There are six different keying modes supported by the K16: 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 [nn] - Set PTT Lead In Time** to a value between 0 and 99 milliseconds. See the Set PTT Lead/Tail description on page 7 for more information.

**M - Toggle transmit mute:** Mute transmit when you want to use the K16 as a Code Practice Oscillator (CPO) When muted, the K16 will send CW in sidetone only. In response to this command, the K16 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. **R** or **?** is the command response. 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.

**O - Swap Key Output Port:** Each time the **O** command is issued, the key port is toggled back and forth between key port 1 and key port 2. When port 1 is selected the K16 responds with a single dit and two dits are echoed when port 2 is selected. Note that port selection is only allowed when the PTT option is disabled. Normally Key port 2 is the K16's PTT output. If PTT is enabled, the command response will be an **X**. To disable PTT mode, use the extended command **P** which unlinks the PTT function and allows that port to be used as a second key output port. If you have two transceivers, you can swap radios without moving the keying cable.

**P [m,d] - Start Practice Mode:** A dual mode multi-level code practice program is built into the K16. There are two styles of practice, receive only and echo (receive/respond) practice. There are four levels of practice organized by easy to difficult letter groups. The four levels are:

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 syntax for entering a practice mode is:

**P m d** where m is R for receive or E for echo practice and d is a single digit 1 to 4 to select difficulty level.

**P R 2** selects Level 2 receive practice

**P E 4** selects Level 4 echo practice

Receive Practice Description: Random characters from the selected level are sent in groups of five. Practice will continue until the command pushbutton is pressed.

Echo Receive/Transmit Practice Description: The K16 will send a random character from the selected level and you must respond by echoing the character back on the paddles. If you get it right the K16 will repeat the first character followed by a new character. Now you must echo back both characters. The K16 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 K16 will respond with an **X** and start over with a new sequence of characters.

When you want to end practice, either respond with di-dah-di-dah or press the command pushbutton. By default practice will be sent on the active output key port, enable transmit mute (**M** command) to inhibit this.

**Q - Query K16 Current Settings:** K16 will respond with current settings sent in the following format:

**WPM** *is sent first*  
**N** *followed by Serial Number*  
**M** *followed by free msg memory space in letters available*  
**C** *followed by command WPM*  
**W** *followed by weight*  
**L** *followed by lead time*  
**T** *followed by tail time*  
**E** *followed by 1<sup>st</sup> extension (this parameter described in host mode section)*  
**V** *followed by key compensation*  
**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 pot min WPM*  
**T** *followed by speed pot max WPM*  
*firmware revision denoted by a single letter; A or B or C... etc.*

You can abort this command at any time after the first parameter is sent by pressing the Command and PB4 pushbuttons together or holding either the left or right paddle.

**R [pb] - Review a message without transmitting:** After the **R** command is entered the K16 will respond with an **E**. Press the message button of the message you wish to play. The message will be sent in sidetone only. If you try to play an empty slot, the K16 will respond with **MT**. Embedded commands will be sent as is without expansion. In other words /S10TEST will be sent as: **DAH-DI-DI-DAH-DIT 10TEST**

**S [nn] - Set Favorite Speed in WPM:** Enter a WPM value between 5 and 99. This speed is activated when the speed pot is turned fully counterclockwise. The speed pot will act normally above this setting. The minimum allowable WPM is 5 WPM, the maximum allowable WPM is 99. Response is an **R** or **?**

**T [nn] - Set PTT Tail Time:** The K16 provides a transmitter PTT output that can be used to switch a transmitter or linear amplifier over to transmit mode in advance of actual CW keying. You have control over the time delay between when PTT is asserted and when CW keying will start; this is lead-in delay. You also have control over how long the transmitter will stay in transmit after keying has stopped; this is tail delay. The tail delay is handled differently for CW sent by paddle and CW sent by message. Paddle delay is controlled by the Hang Time setting while message PTT delay is controlled by the Tail setting. The formula to calculate tail time is:

Tail Delay = Three Dit Times + (Tail Setting *times* 10 milliseconds)

Examples:

At 20 WPM, Tail set to 7, Tail Delay = (3x60)+(7x10) = 250 mSec  
 At 40 WPM, Tail set to 7, Tail Delay = (3x30)+(7x10) = 160 mSec  
 At 20 WPM, Tail set to 0, Tail Delay = (3x60)+(0x10) = 180 mSec  
 At 15 WPM, Tail set to 55, Tail Delay = (3x80)+(55x10) = 790 mSec

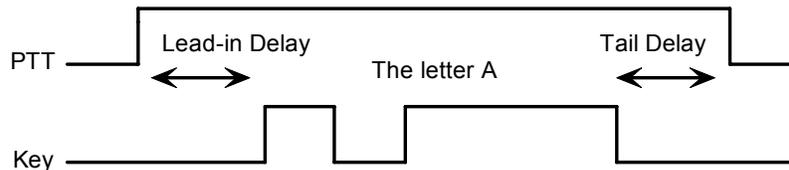


Figure 6 – PTT Lead-in and Tail Example

In general we want a very short tail time when sending messages and we want PTT to stay asserted between letters while sending with a paddle set. That's the reason the delay is dictated by two mechanisms. The command response is an **R** or **?**

**U - Toggle Autospace Mode Off and On:** When autospace is enabled, the K16 will automatically insert proper inter-letter space between letters. When the **U** command is issued, the K16 will respond with an **A** for autospace enabled or an **N** for autospace disabled.

Here is how autospace works: If you pause for more than one dit time between a dit or dah K16 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. K16 has a paddle event memory so that you can enter dits, dahs, or squeeze both during the inter-letter space and K16 will send them as they were entered. With a little practice, autospace will help you to send near perfect Morse.

**V [nn] - Keying Compensation:** allows a fixed amount of time to be added to the length of all dits and dahs. QSK keying on modern transceivers can cause shortening of these elements which is especially noticeable at high speeds. The K16 allows the length of the elements to be increased uniformly to compensate for this. The adjustments can be made in one-millisecond steps. The maximum adjustment is 31 mSecs. Key compensation is very similar to Weighting in that any adjustment added to the dits and dahs is subtracted from the spacing so the resulting speed is not changed. The difference between weighting and keying compensation is that compensation is independent of speed, so if 10 mSec of key compensation is selected, 10 mSec will be always be added regardless of speed. So be careful, using large values of keying compensation at high speeds may result in dits and dahs being run together with no spacing at all. The command response is an **R** or **?**

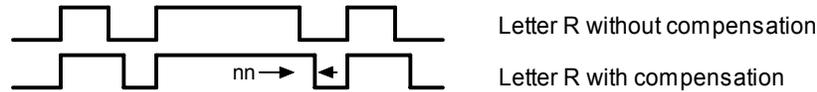


Figure 7 – Key Compensation

**W [nn] - Key Weighting:** can be adjusted in percentage from 25% to 75%. When set to 50 % the dit time is equal to the inter-element time, which 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. Reduction in 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. The command response is an **R** or **?**

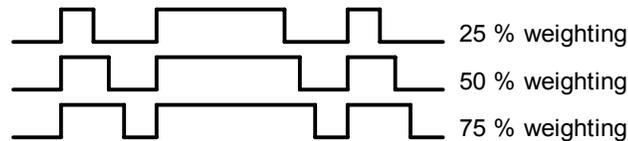


Figure 8 – Key Weighting

### X - Extended Keyer Commands

An additional set of commands are located in a sub menu. These commands are ones that are not entered very often so the additional paddle action is not a significant issue. Extended commands require two entries, an **X** followed by a sub command. Here is the procedure in detail:

Press and hold the command pushbutton and the K16 will respond with an **R**  
 Enter an **X** and the K16 will respond with an **E** (command request)  
 Enter desired Extended Command with additional parameters, if required.

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

**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:

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

The command response is an **R** or **?**

**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 nearly 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 command pushbutton will end this command and store the new sidetone frequency. Like all settings, use the Preserve Settings extended command to save the new sidetone setting in EEPROM.

**AA-** This command will key the transmitter for tuning. The K16 will stay in tune mode until either either paddle is pressed or CMD+PB4 is multi-pressed. (**AA** is the di-dah-di-dah prosign)

### Extended Command List

**A – Pushbutton Input Diagnostic:** is used to verify the correct operation of the switch network connected to K16 input pin 7. This design allows four switches and a potentiometer to share a single pin on the K16. The state of the network generates a unique numeric value which is then handled appropriately, either as a pushbutton press or speed pot change.

After the Extended **A** command is issued, the numeric pushbutton network value will be sent in Morse sidetone. For proper operation the input values must fall within the following ranges:

Command PB .....	0 to 7	PB 4 .....	32 to 44
PB 2 .....	8 to 17	Speed Pot .....	56 to 160 (approx)
PB 3 .....	18 to 31		

The K16 will remain in this diagnostic state until power is cycled. Note that the readings on a K16-BK will be different, contact K1EL for more information.

**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.

**E[nn] - First Element Extension:** Forces the first dit or dah of a transmission to be elongated to allow for receive to transmit delay. Enter a value between 0 and 99 mSecs for nn. Response is an **R** or **?**

**F - Toggle Fast Command Response Time:** Normally the K16 will enter command mode when the command pushbutton is pressed 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. K16 will respond with an **A** for fast response or an **N** for normal response.

**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.

**P - Toggle PTT Mode:** The user can choose whether to use PTT while keying. This is a toggle command and after it is entered, the K16 will respond with an **A** for PTT enabled, or **N** for PTT disabled. Please note that when PTT is enabled, the key output port is locked on port 1. If the toggle output port command is issued the K16 will respond with an **X** to indicate that PTT is enabled and swap is not allowed.

**R [nn nn] - Set Speed Pot minimum and maximum:** After the command is entered the K16 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, if the minimum value is less than 5 WPM. Maximum WPM allowed is 99. The command response is an **R** or **?**

**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 K16 provides two complete user configurations, each with a unique callsign. Both message banks are available to both users. This allows a universal set of messages to be created that will work with either user. 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 K16 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):** K16 will respond with a letter **A** to signify when paddle swap is enabled and an **N** when turned off.

### PTT Functionality

K16's PTT output is normally used to control an accessory device in addition to normal CW transmitter keying. In most cases this device is a linear amplifier but it could be an antenna relay or the PTT input of a transmitter. In all of these cases there are delay requirements that must be met to insure that the accessory device is switched on before transmission begins and is held on until transmission completes. This prevents damage to the accessory device due to hot switching. The K16 provides three independent PTT delays to meet this requirement; Lead In, Tail, and Hang Delay.

Lead-In delay initiates a keying event. PTT will be asserted first and then, after the Lead-In delay expires, the key output will be asserted. Lead-In can be set to a value from 0 to 990 milliseconds in 10 millisecond steps (0 to 99).

Tail Delay specifies the amount of time PTT will be released after Key is released. Like Lead-In delay, it is adjustable from zero to 990 milliseconds in 10 millisecond steps. Tail delay is the sum of two delays, Tail setting times 10 milliseconds plus three dit times.

Tail Delay = Three Dit Times + (Tail Setting *times* 10 milliseconds) *note: one dit time = (1200/WPM) mSec*

Examples:

At 20 WPM, Tail set to 7, Tail Delay =  $(3 \times 60) + (7 \times 10) = 250$  mSec

At 40 WPM, Tail set to 7, Tail Delay =  $(3 \times 30) + (7 \times 10) = 160$  mSec

At 20 WPM, Tail set to 0, Tail Delay =  $(3 \times 60) + (0 \times 10) = 180$  mSec

At 15 WPM, Tail set to 55, Tail Delay =  $(3 \times 80) + (55 \times 10) = 790$  mSec

In setting tail delay it is desirable to set the delay long enough to prevent hot switching. The K16 will hold PTT between letters for messages and then PTT will timeout after the last letter of a message is sent.

For paddle sending, most ops want PTT to be held just long enough to prevent drop out between letters. An issue arises in that Tail delay is not solely proportional to sending speed. This is problematic when someone sets a comfortable tail delay at a slow speed and then increases the speed to a much faster rate. At the faster rate, the tail delay will hold too long after keying stops. Alternatively, if a comfortable delay is set at a faster WPM rate, PTT will then drop out between letters at a slower speed. Since it is very time consuming to constantly adjust the tail delay with sending speed, a different delay method is used for paddle sending, namely Hang Time.

Hang Time is adjustable in four steps and is measured only in wordspace and dit times rather than fixed milliseconds. This means that the delay will track sending speed. In other words it will decrease automatically as sending speed increases and vice versa. The four settings for Hang Time are:

HangTime = 0: wait 1 wordspace + 1 dit before ending paddle insertion

HangTime = 1: wait 1 wordspace + 2 dits before ending paddle insertion

HangTime = 2: wait 1 wordspace + 4 dits before ending paddle insertion

HangTime = 3: wait 1 wordspace + 8 dits before ending paddle insertion

To sum up, Tail delay is set to provide just enough delay to prevent hot switching for machine sent CW while hang delay is designed to hold PTT between letters independent of sending speed. PTT will automatically be held between machine sent letters and words but will drop out quickly after a message has been sent as long as there is no trailing wordspace. When entering a message be sure to end the message with the di-dah-di-dah (**AA**) character to prevent the K16 from automatically appending a wordspace.

### Shortcuts and Speed Ups

A goal for the K16 design was to streamline command entry, here are some notable improvements:

Faster Command responses – K16 uses an **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 **S U N** instead of **S 2 9**

These are the command cuts used in the K16: 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 K16 will figure out that it's a single digit. For example instead of entering **T 0 7** you can simply enter **T 7**.

K16 will respond with an **E** or **I** when swapping users, message banks, or output port. 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 command button till you get an R then simply press the message button you want to load. To stop load mode, either press the command button or enter di-dah-di-dah. This technique is used for the review command also.

Fast Tune Mode – Press and hold pushbutton 4 and then press the command button to start tune. Press the command button to end tune.

Fast Speed change – Press the command button and then press left paddle to decrement and right paddle to increment WPM speed. The K16 echoes a single dit to signify that the command was accepted. This is very useful for keyer setups that don't include a speed pot.

Fast Command Response – If you think the K16 takes too long to respond to the command button, enable fast command reply mode which halves the delay time. This is the extended command **F**.

Command Prompts – The K16 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 K16 will respond with an **E** to let you know it is waiting for the value.

### Speed Potentiometer Functionality

An optional speed pot can be added to the resistor network on K16 pin 6 to allow adjustment of sending speed. For the interface to work properly, a 10K linear taper potentiometer must be used. Turning the speed control will change the speed and update the WPM rate with minimal lag. The entire sweep of the speed pot is called the speed pot range and it can be modified with the extended **R** command which sets the upper and lower speed limits. This allows you to tailor the speed control to an area that you prefer. The minimum value is 5 WPM and the maximum is 99 WPM. You can determine the current speed control setting with the **Q** (query) command. Turning the speed pot fully counterclockwise will select the fixed "favorite" speed. (see **S** command) If you want to set an exact speed, the easiest way to do this is to turn the speed control fully counter clockwise and set the fixed speed to whatever you want using the **S** command.

### Message Functionality

Messages are loaded by holding the command button until the K16 responds with an **R**, and then pressing the message pushbutton of the memory slot you wish to enter. When K16 is ready to accept a new message it will respond with an **E**. If you wait too long, K16 will respond with a **?** and you will have to start over. Since only four pushbuttons are provided, messages 5 and 6 are accessed by pressing two pushbuttons in the following sequence after the **R** is echoed:

Press and hold either message button 2 or 3. (for message 5 or 6 respectively)  
Press the command pushbutton.  
Release both push buttons.

Message 5 and 6 can be played in a similar manner by first pressing and holding pushbutton 2 or 3, then pressing the command pushbutton, and finally releasing both. Don't forget that there are also two separate message banks each containing six slots bringing the total number of unique messages to 12.

After the K16 responds with an **E**, enter a new message 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 K16 will respond with an **E** to signify a word space insertion. You can force a wordspace insertion by entering 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 command pushbutton and K16 will backspace through the letters that have been entered. When you reach the position you want, release the button and new letters can then be added starting at that position. If the message memory becomes full while entering a message, K16 will stop further loading, respond with an **F**, and then return K16 back to non-command mode. When a new message has been completely entered, press the command push-button, or enter di-dah-di-dah (**AA**), and K16 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 the control with a / (**DN**) and it will not be acted on as a control code: **/IM /IG /AA**

Usually when you finish a message, the K16 will append a wordspace before you have a chance to press the command pushbutton. There are cases when you do not want a wordspace at the end, especially if you are using PTT to key an amplifier. This is because K16 will hold PTT during that added wordspace. The best way around this is to end a message with the di-dah-di-dah (**AA**) control code inserted immediately after the last letter in the message. This will terminate the message without a trailing word space.

If you are having problems loading messages into the K16, 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 K16 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 K16 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 explicitly. To abort a message, press the command and PB4 pushbuttons together or press and hold one of the paddles and K16 will stop transmission immediately. The reason you can't stop a message with a single command press is that the K16 interprets this as a request to stack message 1, in other words, play message 1 after the current message completes.

### Gap (Extra Space) Insertion

In messages, K16 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**IG**O**IG**M**IG**O makes it easier to copy. To insert a **IG** prosign in a message without translating it to a gap, enter it as **/IG**.

### Word Space Insertion

In messages, K16 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

As previously mentioned above, you can trigger message 5 and 6 directly with the following sequence:

- 1) Press and hold PB2 for message 5 or PB3 for message 6
- 2) Press the command PB (you now have two PBs pressed)
- 3) Now release both pushbuttons and selected message will play.

### Quick Tune Command

If you use the sequence outlined above but start with PB4 instead, tune mode is turned on. This keys your transmitter until you press either paddle or PB1+PB4 at the same time. Use the **G** command to select either a 100% or 50% tune duty cycle.

### Quick Serial Number Decrement

Sometimes during contest operation, a serial number has to be reissued. Since the serial number is automatically incremented when it's played, we need a way to decrement the serial number. This can be done by using the **D** paddle command. After the serial number is decremented, K16 echoes a single dit.

There is another way to decrement a serial number, that is with a **/D** command embedded in a message. A message can be built that decrements the serial number before sending it. For example the following two messages can be created:

Message 1: 5NN /N QSL ?

Message 2: /D/N QSL ?

Message 1 is played as the initial exchange and if the serial number needs to be resent, message 2 would be used. The second message pre-decrements the serial number before sending it. Both of these messages leave the serial number incremented after it is sent. Here is a way to send the serial number twice in one message:

**Message 3:** /N/D /N

### Message Stacking

Some users like to load small message fragments and then play multiple copies by stacking them. For example instead of loading the message 5NN 5NN 5NN, enter 5NN in the slot and then just stack the number of repeats. So if you want to send three 5NN press the PB three times. For this to work correctly, you need to add a workspace at the end of 5NN. To do that, enter the message and then just wait for the K16 to send a dit telling you it auto appended a workspace. If you didn't do this it would come out like this 5NN5NN5NN. You can also do this by adding the **IM** workspace command.

### Fast Speed Change Feature

The sending speed can be changed in 1 WPM increments by holding the command push-button and then pressing either the dit or dah paddle. You must press a paddle before the normal command mode time-out occurs. Once in fast change mode it will stay there until the command push-button is released. A dit is sent each time the speed is incremented or decremented. If you wish to use the fast speed feature when you have a speed pot connected, be sure to turn the pot fully counterclockwise to force the K16 into fixed speed mode which ignores the speed pot setting.

## 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

<b>/Bnn</b>	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.		
<b>/Cn</b>	Call message in slot n (1-6), return and resume current message.		
<b>/D</b>	Decrement serial number.		
<b>/E</b>	Toggle message banks		
<b>/Hn</b>	Set HSCW speed. See table below for determining n.		
<b>/Inn</b>	Increase letterspacing within a message, nn is a value from 0 to 31 percent times 2.		
<b>/Knn</b>	Key transmitter for nn seconds. (nn=00 to 99)		
<b>/M</b>	Play user callsign.		
<b>/N</b>	Play Serial Number with auto post increment.		
<b>/On</b>	Select key output port; 1 for port 1 or 2 for port 2.		
<b>/P</b>	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 (2-6) or 3) Press the cmd PB to cancel.		
<b>/Q</b>	Set QRSS speed. See table below for determining n.		
<b>/Snn</b>	Set a speed change within a message. (nn=WPM, 5 to 99)		
<b>/Un</b>	Turn PTT on or off. PTT is turned on when n = 1 and off when n=0.		
<b>/V</b>	Send the current voltage in Morse, useful for beacons.		
<b>/Wnn</b>	Wait for nn seconds. (nn=00 to 99)		
<b>/Xn</b>	Cancel speed override, for example cancel HSCW, QRSS, or /Snn speed.		
<b>/Yn</b>	Force a relative speed change up. Add n to the current WPM. n=(0-9)		
<b>/Zn</b>	Force a relative speed change down. Subtract n from the current WPM. n=(0-9)		
<b>/1</b>	Jump to message 1	<b>/2</b>	Jump to message 2
<b>/3</b>	Jump to message 3	<b>/4</b>	Jump to message 4
<b>/5</b>	Jump to message 5	<b>/6</b>	Jump to message 6
<b>AA</b>	End message load immediately	<b>(DI-DAH-DI-DAH)</b>	
<b>IG</b>	Insert ½ letterspace pad	<b>(DI-DI-DAH-DAH-DIT)</b>	
<b>IM</b>	Insert wordspace pad	<b>(DI-DI-DAH-DAH)</b>	

### Rate Table

n	HSCW Rate	QRSS Rate
0	1000 lpm (200 wpm)	3 sec dit
1	1500 lpm (300 wpm)	6 sec dit
2	2000 lpm (400 wpm)	10 sec dit
3	3000 lpm (600 wpm)	12 sec dit
4	4000 lpm (800 wpm)	30 sec dit
5	6000 lpm (1200 wpm)	60 sec dit

### 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

**/H2CQ CQ DE K1EL K1EL K1EL/S15 DE K1EL** will send 1<sup>st</sup> part at 1500 lpm and the 2<sup>nd</sup> at 15 WPM

**CQ CQ CQ DE K1//10TMT//00 K** will send message with 20% extra space in TMT. A more manageable way of doing this would be to load **K1//10TMT//00** 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.

**/Q2EL /1** will continuously send EL at QRSS10 speed (this message is in slot 1). Avoid inserting a space between the QRSS command and the start of text: **/Q2 EL** unless you want a long delay at start of message.

**/B10K1EL BCON/W2/VVOLTS** sends K1EL BCON, wait 2 secs, send XrXX VOLTS repeat every 10 secs

**SOM/E/C3/E/U1/W5/U0/S50K1EL//1/XEOM** Send SOM, swap to msg bank 2, call msg 3, swap back to msg bank 1, turn PTT on for 5 seconds, change speed to 50 WPM and send K1EL/1, cancel 50WPM send EOM.

## Save Settings

K16 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 command PB until the **R** and enter an **X** followed by an **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 User Defaults (Warm Restart)

It's possible that a command could get entered by accident and put the K16 into an undesired state. An easy way to restore user default settings is to power off and on. Another way is to press and hold the command pushbutton and keep holding after the **R** is sent. After an additional 5 seconds, **OE** will be sent signifying that a warm reboot has occurred which reloaded the user default settings.

## Restore Factory Defaults

If you want to restore the K16 to original "factory" settings hold the command pushbutton down and wait for the **OE** to be sent. Then before releasing the pushbutton, press and hold both paddles closed. Now when you release the pushbutton, the K16 will send a **C** signifying a cold reboot which erases all settings and messages and then restores factory settings.

Factory Defaults are:

Fixed WPM: 15	Command WPM: 15	Sidetone: 800Hz	Weight: No adjustment
KeyComp: 0	Interchar Spacing: Normal	SampleAdjust: None	KeyMode: Iambic B
Sidetone: On	Autospace: Off	OutputMode: KEY/PTT	Serial Number: 0001
TX Mute: Off	User: 1	Message Bank: 1	Messages: All Erased
Speed Pot Min: 5	Speed Pot Max: 35	First Extension: 0	Farnsworth: Off
Dit/Dah Ratio: 1:3	Sidetone: On	Tune Duty Cycle: 100%	Extra Letterspace: None

## Sleep Mode

The K16 utilizes the automatic sleep mode of the PIC CPU. If there is no activity, the K16 will go into low power sleep mode and draw about 20  $\mu$ A of DC current. When either the paddles or push-button(s) is pressed, the chip wakes up and goes into active mode drawing about 1 ma in idle and about 10ma while actively sending. After the paddle or push-button is serviced the K16 goes back to sleep after a few seconds. The K16 will not go into sleep mode while transmitting a message or actively running a beacon.

## Keyer Lock and Extreme Low Power Sleep

A lock feature is provided to disable paddle input and message pushbuttons. This is useful when you want to pack up a battery powered keyer and insure that it stays off with batteries still connected. It is also handy to lock the keyer paddles to keep little hands from sending "messages". While the keyer is locked it is held in low power shutdown mode. To lock the keyer, press the command pushbutton, wait for the **R**, and then enter a period (di-dah-di-dah-di-dah). The K16 will respond with an **L** to let you know it is now in a locked state. To unlock the keyer, press and hold the both paddles closed for about 5 seconds and the K16 will wake up and send an **R**. This is a very reliable lock mechanism because once the paddles are removed there is no possible way to accidentally unlock the K16, the pushbuttons are ignored.

The very nice side effect of Lock Mode is that the K16 is placed in a very low power sleep mode, if you want to stretch battery life as long as possible, lock the K16 when you are not using it for an extended period of time.

## K16 Command Cheat sheet

## Immediate Command List

- |                                    |  |
|------------------------------------|--|
| A - Toggle sidetone on/off         | N - Load 4 digit serial number             |
| B - Easy Beacon                    | O - Swap keying output port                |
| C - Set command speed in WPM       | P - Start Practice Mode                    |
| D - Decrement serial number        | Q - Query: Report current settings         |
| E - Swap Message Banks             | R - Review message without transmitting    |
| F - Set Farnsworth Speed           | S - Set Fixed Speed in WPM                 |
| G - Toggle Tune Duty Cycle 50/100% | T - Set PTT Tail Delay                     |
| H - Set PTT Hang Delay             | U - Toggle Autospacing on/off              |
| I - Set Letter Spacing             | V - Set Keying compensation in mSec        |
| J - Set Paddle sensitivity         | W - Set Key Weight                         |
| K - Select keyer mode              | X - Enter Extended Command                 |
| L - Set PTT Lead In Delay          | Y - Set Dit/Dah Ratio                      |
| M - Toggle Transmit Mute on/off    | Z - Select sidetone frequency              |
|                                    | AA - Key output for tuning (di-dah-di-dah) |

## Extended Command List

- |                                   |                                    |
|-----------------------------------|------------------------------------|
| A - Analog Input Diagnostic       | R - Set Speed Pot Min and Max WPM  |
| C - Toggle Contest Spacing        | S - Save Settings in EEPROM        |
| E - First Element Extension       | T - Toggle Number 0 Cut            |
| F - Toggle Fast Cmd Response Time | U - Swap Users                     |
| M - Load Callsign                 | V - Voltage Readout                |
| N - Toggle Number 9 Cut           | X - Exchange dit/dah inputs (Swap) |
| P - Toggle PTT Mode               |                                    |

## Embedded Message Command List

- |  |  |
|--|--|
| /Bnn - Set a beacon cycle time               | /Un - Turn PTT On/Off (n=0 or 1)           |
| /Cn - Call message (n=1-6)                   | /V - Send Voltage reading in Morse         |
| /D - Decrement Serial Number                 | /Wnn - Wait for nn seconds (n=0-99)        |
| /E - Swap message banks                      | /X - Cancel speed override                 |
| /Hn - Set HSCW Speed (n=0-5)                 | /Yn - Relative WPM change up (n=0-9)       |
| /Ann - Set Alternate Letterspacing (n=0-31)  | /Zn - Relative WPM change down (n=0-9)     |
| /Knn - Key down for nn seconds (n=0-99)      | /1 - Jump to message 1                     |
| /M - Play user callsign                      | /2 - Jump to message 2                     |
| /N - Play Serial Number                      | /3 - Jump to message 3                     |
| /On - Select Key Output Port (n=0 or 1)      | /4 - Jump to message 4                     |
| /P - Pause and Wait for Paddle               | /5 - Jump to message 5                     |
| /Qn - Set QRSS Speed (n=0-5)                 | /6 - Jump to message 6                     |
| /Snn - Set Sending speed in WPM (n=0-99)     | <u>AA</u> - End message load               |
| <u>IM</u> - Insert Wordspace (DI-DI-DAH-DAH) | <u>IG</u> - Insert Gap (DI-DI-DAH-DAH-DIT) |

Rate Table for H and Q Commands

n	HSCW Rate	QRSS Rate
0	1000 lpm (200 wpm)	3 sec dit
1	1500 lpm (300 wpm)	6 sec dit
2	2000 lpm (400 wpm)	10 sec dit
3	3000 lpm (600 wpm)	12 sec dit
4	4000 lpm (800 wpm)	30 sec dit
5	6000 lpm (1200 wpm)	60 sec dit

To send a message with a / use two of them. Example: K1XYZ//1

## K16 Tutorial

- 1) Power up: After power is applied, the K16 will output the letter **R** to let you know it's ready. Pressing the paddle keys will generate dits and dahs both in sidetone and keyed output.
- 2) Command Entry: A command cheat sheet can be found on page 18. There are three command types, immediate, extended, and embedded message. The first commands to look at are immediate commands. Press the command pushbutton (CMD) until the K16 answers with an **R**. Then without hesitation enter an immediate command letter on the paddles. Try the **Z** command which allows the sidetone frequency to be changed. The K16 will output a continuous tone and you can adjust the frequency by pressing the paddles. When you are finished, press CMD to return to normal operation. If the K16 does not understand a command or you are too late to enter a command the K16 will respond with a question mark. Some commands require additional parameters, a good example is setting the command speed. Press CMD, wait for the **R**, and then enter **C**. The K16 will respond with an **E** telling you it's waiting for you to enter something. Enter a 1 followed by a 0. Try it again but this time use a **T** for the zero. This is a handy shortcut. You have changed the command entry speed to 10 WPM. If this is too slow, repeat the command with a more comfortable speed.
- 3) Change Keyer Mode: Enter the **K** command and the K16 will prompt you for desired keying mode. For example **A** for Iambic A, **B** for Iambic B... the full list is on page 7. The K16 will respond with an **R** to let you know it acknowledged the command. The sample adjust command **J** adjusts the paddle sensitivity to home in on the way you want the paddles to respond. By setting sample adjust to zero you can disable the dit and dah paddle memories. Weighting, Keying compensation, and letterspace are a few other ways to adjust the way Morse is generated.
- 4) Since we have more commands than letters in the alphabet, we added extended commands. They work just like immediate commands with the exception that you have to enter two letters. A useful extended command is the 'save settings' command **S**. Press CMD to get an **R** and in response enter an **X** for extended command followed by an **S** for save. The K16 saves settings in nonvolatile memory so that when you power down and back up your preferred settings are preserved. Messages are automatically saved in memory when entered but settings have to be preserved using the Save command. It works this way since most users may want to change settings temporarily but always want to go back to their favorite settings when they are done. It's easy to restore default settings, just press and hold CMD until you get the **R** and keep holding until the K16 responds with an **OE** for warm start. This means that your default settings have been restored. Another interesting extended command is **V** which tells the K16 to report the current keyer supply voltage. It plays it in this form: **4r35** which in this case is 4.35 volts.
- 5) Now let's play with messages. Review the procedure for message loading on page 13. The K16 has two great features associated with message loading. The first is backspace, if you make a mistake while entering a message just hold CMD down and the K16 will back up letter by letter. The second is non-fixed 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. Now we will load a message into slot 1. Press and hold CMD until the **R** and then release and then momentarily press CMD again and release. This tells the K16 you want to load a message into slot 1. You can load any other slot in the same manner, just press a different pushbutton. The K16 responds with an **E** to let you know it is ready to accept the message. On the paddles enter: **/S10SLOW /S25FAST**. ( / is the DN prosign DAH-DI-DI-DAH-DIT) This message has two embedded commands which will change the speed while the message is playing. **SLOW** at 10 WPM and **FAST** at 25 WPM. Note that after playing this message the operating speed will be returned to the initial starting speed.
- 6) It's easy to compose a beacon command: In msg slot 2 enter: **/B60/K05 BCON DE K1EL NH** This will key down for 5 seconds, send **BCON DE K1EL NH** and repeat every 60 seconds. To cancel a beacon simply press CMD; K16 will stop the loop and return to normal operation.
- 7) Next we will test out serial numbering. First enter a starting serial number using the **N** command. You need to enter all four digits including leading zeroes. You may want to select the way K16 will send 0s and 9s in a serial number. Use the two extended commands **N** and **T** for that (see page 11). Here is an example of a message that will play a serial number incorporating the **/P** pause command: **CQ DE K1EL/P UR NR /N QSL?/P**. This message will send CQ and then pause to let

you listen for a reply. If no reply, hit the msg PB to repeat the CQ. If there was a reply, enter the station's callsign and the K16 will send the serial number and pause again. If the station needs a repeat of the callsign press 2 to play this message in slot 2: **UR NR /D/N QSL ?** Since the serial number is incremented after an **/N** command you need to pre-decrement it with **/D** to send the original number. The **/P** command is a three-way branch, 1st branch: paddle something to continue, 2nd branch: hit a msg button (other than CMD PB), 3rd branch: hit the CMD PB to cancel the message. Since MSG1 = CMD PB you can't use slot one as a 2nd branch choice.

- 8) The K16 supports two alternate sending modes. They are selected by putting embedded commands in the message. QRSS is extremely slow CW for VLF operation, while HSCW is extremely fast CW typically used for QSOs via meteor scatter. Here are examples of each: QRSS: **/K10/ Q2EL/2** Key down for 10 seconds followed by **EL** at QRSS6 rate, repeat. HSCW: **/H3K1EL K1EL K1EL K1EL K1EL K1EL K1EL /1** Callsign is repeated at 3000 LPM
- 9) There are three K16 output modes.
  - 1) Normal mode: Keying output on pin 2 and sidetone on pin 3.
  - 2) AFSK mode using PTT: Pin 5 keys the transmitter while pin 3 provides a keyed tone to feed into a microphone. Filtering is usually required to process the K16's square wave output.
  - 3) External Oscillator mode: Used mainly for HSCW. K16 pin 2 keys an external, crystal based, tone oscillator. This provides very stable and accurate audio frequencies,

### K16 Kits available from K1EL

In the following sections, four different K16 kits will be described. Each one can be purchased from K1EL at a reasonable price. Full kit assembly and hook up instructions are included in each kit section. Here is a table that compares the four kits.

### K16 Kit Comparison

Feature	K16-BAT	K16-EXT	K16-EMB	K16-BK
On board battery	Yes, 3-LR44	No	No	Yes, 3-AAA
On board regulator	No	Yes	Yes	No
Power supply voltage	4.5V	7-13V	7-13V	4.5V
K16 Operating voltage	2.7-4.5V	5.0V	5.0V	2.7-4.5V
Pushbutton interface	Yes, 4PB	Yes, 4PB	Yes, 4PB	Yes, 5PB
Speed pot interface	Yes	Yes	Yes	On board SP
On board speed pot	No	No	No	Yes
On board speaker	Yes	Yes	No	Yes
On board output jack	No	No	No	Yes
Ext. Speaker driver circuit	No	No	Yes	No
Filtered AF output	No	Yes, 1 pole	Yes, 2 pole	No
Number of Outputs	1 Key	1 Key	1 Key, 1 PTT	1 Key, 1 PTT
Board Size	2.0" x 1.6"	2.0" x 1.25"	2.0" x 1.5"	3.5" x 3.0"
Keyer I.C.	K16	K16	K16	K16-BK
Mounting Holes	3 x .125"	3 x .125"	2 x .125"	4 x .125"
Front panel mount	No	No	Yes	No



K16-BAT



K16-EXT



K16-EMB



K16-BIG

### K16-BAT Kit

This kit consists of a printed circuit board, sidetone speaker, keying output driver, and a multiple pushbutton interface. The kit is internally powered by an array of three LR44 or SR44 1.5V board batteries.

### K16-BAT Parts Inventory

U1	-	K16 8 pin DIP IC
Q1	-	2N7000 Transistor TO92
R1	-	4.7K $\Omega$ 1/4 watt (yellow violet red)
R2	-	100 $\Omega$ 1/4 watt (brown black brown)
R3, 4,	-	1.0K $\Omega$ 1/4 watt (brown black red)
R5, 6	-	" "
R7	-	10 $\Omega$ 1/4 watt (brown black black)
B1, 2, 3-	-	LR44 Battery holder

C1, 2, 5	-	.001 uF ceramic capacitor 102
C3	-	.01 uF ceramic capacitor 103
C4	-	.01 uF blue 5% cap
1 pc	-	8 Pin DIP Socket
1 pc	-	K16BAT PC board
3 pc	-	LR44 batteries
SP1	-	Mini speaker

### K16-BAT PCB Assembly

Please review Appendices A through C before starting the kit for general kit assembly advice. The K16-BAT picture on page 21 is invaluable for part placement help.

Install the resistors first, R1 through R7. Color codes noted above.

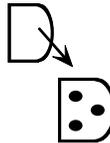
Install the 8 pin DIP socket, locating the index mark in the socket to match the PCB silkscreen.

Install Caps: C1 through C5

Install battery clips B1, B2 and B3.

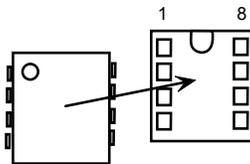
Install and solder the mini speaker, SP1, orient the plus side of the speaker into the square hole.

Install Q1, making sure you match the transistor to the silkscreen:



### K16-BAT Test Procedure

Install U1, carefully aligning pin one as shown in this diagram:

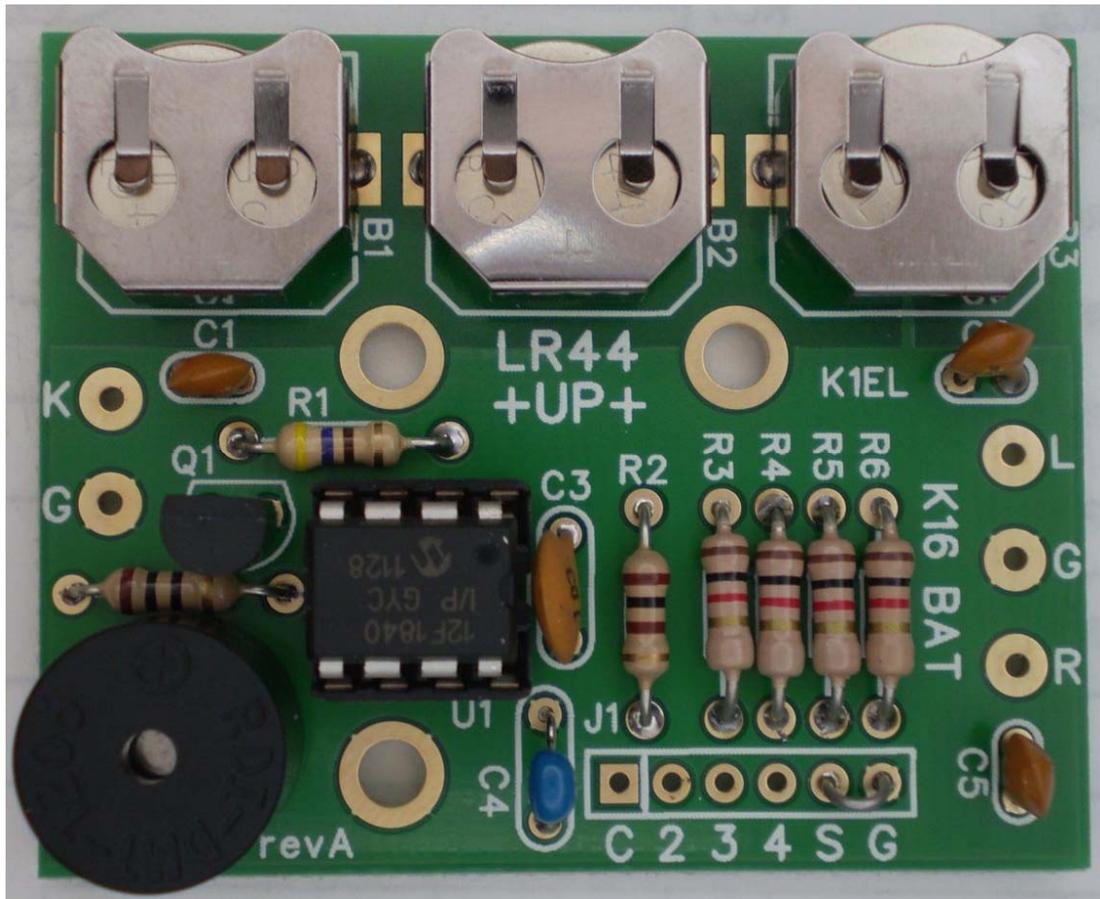


Install the three LR44 batteries making sure you put all three of them in with the plus side facing up. (see picture on page x) Upon installing the third battery you should hear one "R" (di-dah-dit) in Morse from the speaker. Use a piece of jumper wire to ground the L and/or R points on the PCB and you should hear dits and dahs. Momentarily connect each message pad (C, 2, 3, 4) to ground point and the keyer will send MT. If you hold C at ground, the keyer will send an R followed by a question mark.

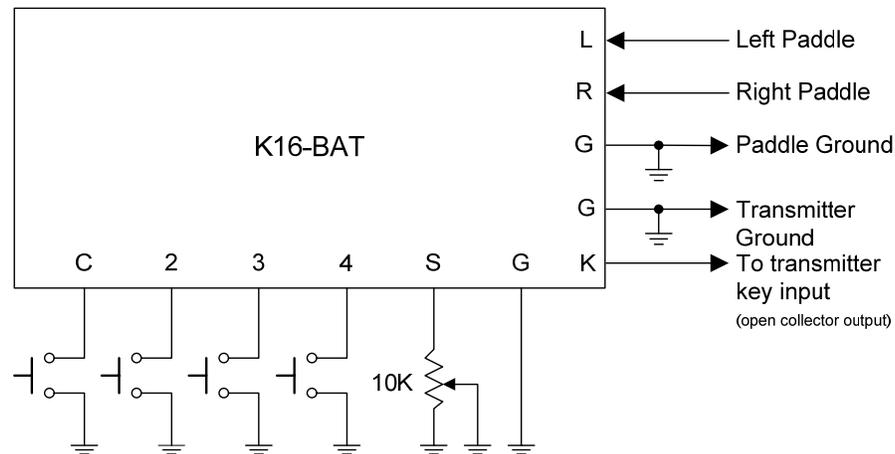
If you don't get any of these tests to work carefully check the board for mis-wires or solder shorts.

Now you can finish wiring up the paddle, keying, and push button connections. The K16 can be installed directly in an enclosure of your choosing.

K16-BAT Assembled PCB



Assembled K16-BAT



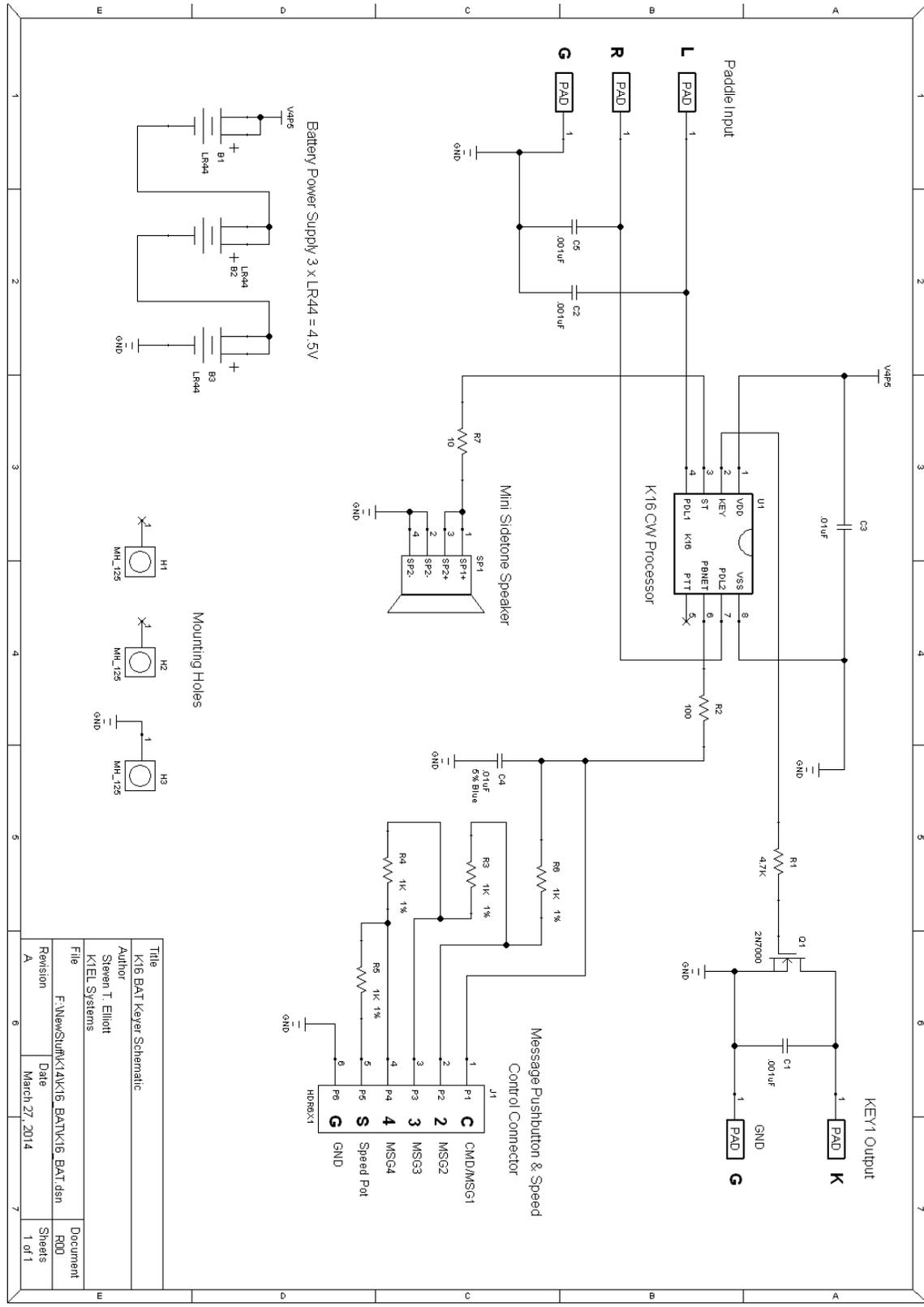
**K16-BAT Hook Up Diagram**

This is a diagram illustrating the various connections to the K16-BAT. Note that there are various options available. Not all pushbuttons are required; the K16-BAT will work fine with a single pushbutton tied to the command (C) input. Alternatively 2, 3, or 4 pushbuttons can be connected. The more pushbuttons, the more messages can be accessed. A speed pot is not a requirement, if you don't want to use one simply tie the S input to ground, this will tell the K16 to operate in fixed speed mode. The speed then is changed using either the S command or by the Paddle Fast Speed Change feature.

An on board speaker provides sidetone for the K16-BAT. There is no provision for external audio.

The key output is open collector which means it acts as a switch to ground. The key output would be directly connected to a transmitter keying input. Beware that this keying output can only switch voltages up to 60V DC. It is not capable of directly keying a vacuum tube transmitter which uses grid blocking or cathode keying.

K16-BAT Kit Schematic



Title		K16 BAT Keyer Schematic	
Author		Steven T. Elliott	
File		F:\NewStuff\K14\K16_BAT\K16_BAT.dsn	
Revision		Date	
A	March 27, 2014	Document	
		RJD	
		Sheets	
		1 of 1	

### K16-EXT Kit

This kit consists of a printed circuit board, paddle interface, keying output driver, sidetone audio speaker, and a multiple pushbutton interface. The kit can be powered of any DC supply that provides a voltage between 8 and 12 volts which is fed to an on board voltage regulator.

An on-board circuit is provided to attenuate and filter the sidetone output to allow it to be fed directly into a transceiver's audio chain in embedded applications (PCB board pad A). This allows the K16-EXT's command sidetone to be heard in the transceiver's speaker output.

### K16-EXT Parts Inventory

U1	- K16 8 pin DIP IC
VR1	- LM78L05 5.0V regulator TO92
Q1	- 2N7000 MOSFET TO92
R1	- 100 $\Omega$ 1/8 watt (brown black brown)
R4, 5,	- 1.0K $\Omega$ 1/8 watt 1% (brown black red)
R6, 7	" "
R3	- 4.7K $\Omega$ 1/8 watt (yellow violet red)
R2	- Reference Page 29
SP1	- Mini speaker

C8	- .01 $\mu$ F blue 5% multi-layer cap
C1, 6	- .01 $\mu$ F ceramic capacitor 103
C2, 4, 7	- .001 $\mu$ F ceramic capacitor 102
C3	- .1 $\mu$ F ceramic capacitor 104
C5	- 3.3 $\mu$ F electrolytic capacitor
1 pc	- 8 Pin DIP Socket
1 pc	- K16 EXT PC board

### K16-EXT PCB Assembly

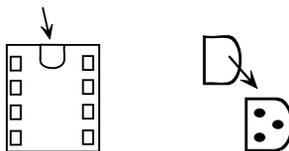
Please review Appendices A through C before starting the kit for general kit assembly advice. The K16-BAT picture on page 21 is invaluable for part placement help. A DMM or multimeter is helpful.

A picture of an assembled K16-EXT board is presented on page 25, use that as a guide for placing parts. Install the resistors first, R1 through R7. Color codes are noted above.

Install capacitors: C1 through C8, Note that C8 (.01 $\mu$ F) is blue in color and is different than C1 and C6.

**Observe polarity on C5:** Long lead goes in the plus hole.

Install the 8 pin DIP socket, locate the index mark to match the PCB silkscreen. (see picture below)



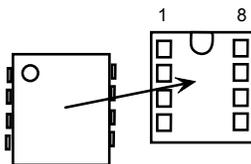
Now install VR1. Carefully form the leads so they will line up with the PCB holes in such a way that the flat side of the TO92 package lines up with the silk screen as shown above, solder in place.

Install and solder the mini speaker SP1. The speaker is enabled by installing J1. If you are going to route the sidetone to an external audio amplifier do not install J1.

### K16-EXT Test Procedure

Apply power to the V+ and GND pads, 9V is recommended. Using a voltmeter, measure the voltage between pins 1 and 8 on the U1 socket and you should read 5 volts. Turn power off.

Install U1, carefully aligning pin one as shown in this diagram:

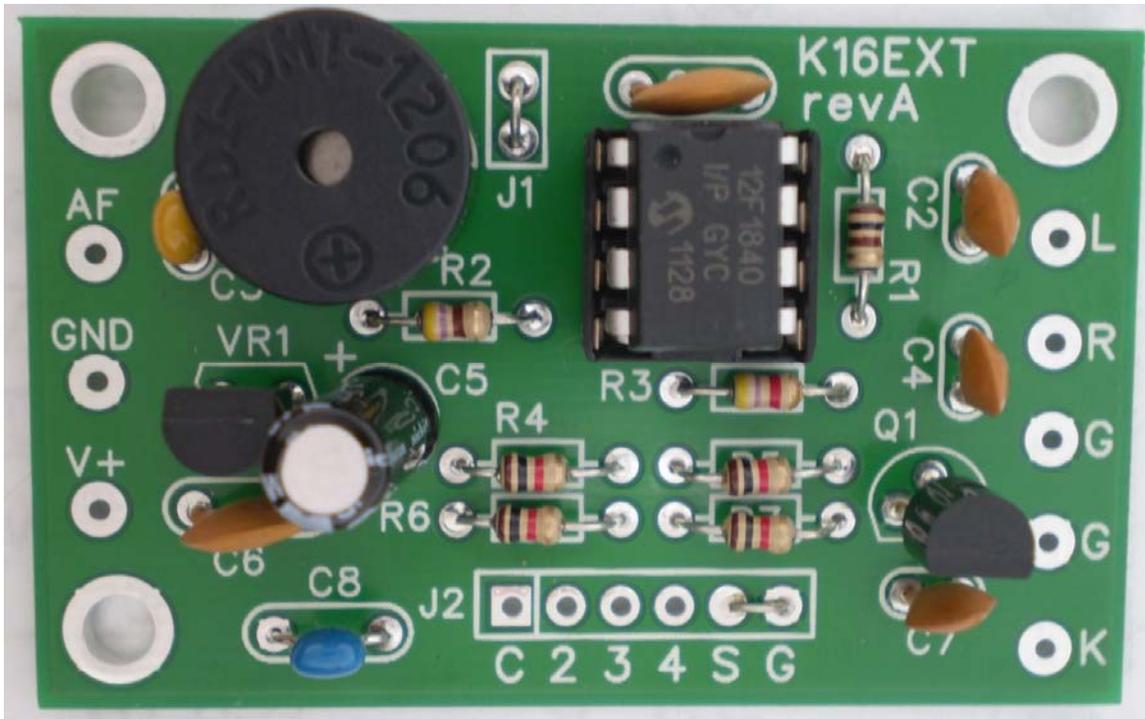


Reapply power battery and you should hear one "R" (di-dah-dit) in Morse from the speaker. Use a piece of jumper wire to ground the L and/or R points on the PCB and you should hear dits and dahs. Hold the C point to ground and you'll hear an "R" followed by ?. If you momentarily ground C, 2, 3, or 4 the keyer will send MT (empty message slot).

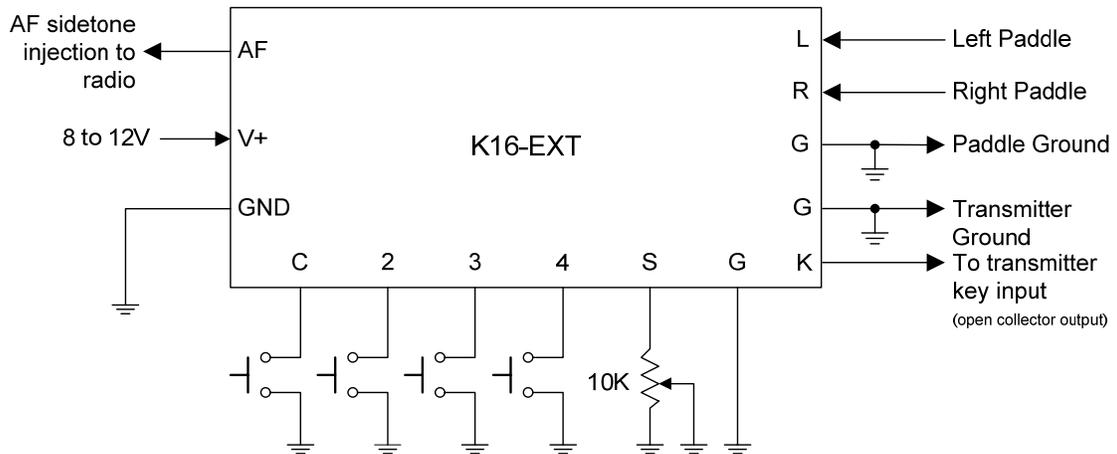
If you don't get any of these tests to work carefully check the board for mis-wires or solder shorts.

Now refer to the next page to finish wiring up the paddle, keying, speed pot, and push button connections. The K16 can be installed directly in your transceiver or in an enclosure of your choosing.

**K16-EXT Assembled PCB**



**Assembled K16-EXT**



**K16-EXT Hook Up Diagram**

This is a diagram illustrating the various connections to the K16-EXT kit. Note that there are various options available. Not all pushbuttons are required; the K16-EXT will work fine with a single pushbutton tied to the command (C) input. Alternatively, 2, 3, or 4 pushbuttons can be connected. The more pushbuttons, the more messages can be accessed. A speed pot is not a requirement, if you don't want to use one simply tie the S input to ground, this will tell the K16 to operate in fixed speed mode. The speed then is changed using either the S command or by the Paddle Fast Speed Change feature.

The key output is open collector which means it acts as a switch to ground. The key output can be directly connected to a transmitter key input. Beware that the Key output can only switch voltages up to 60V DC. It is not capable of directly keying a vacuum tube transmitter which uses grid blocking or cathode keying.

### **K16-EXT Sidetone Options**

There are two sidetone audio output options. The first is an onboard piezo speaker which is enabled by populating J1.

If you are embedding the K16-EXT into a radio, a convenient way to deal with sidetone is to inject it into the radio's AF chain. This means you don't have to provide a separate sidetone speaker and can easily control the sidetone's volume with the radio's AF gain control. To go this route, leave J1 out and tailor the on board attenuation and low pass filter (R2, C3) to provide the desired audio level to your radio. A .1 uF capacitor is a good universal value for C3 while the selection of R2 is governed by the input impedance of the circuit you are driving as well as the signal level desired. The best solution is to have the K16 sidetone level closely match the radio's audio level and this will take some experimentation. If the radio already has an internal sidetone generator you probably want to disable the K16's transmit sidetone by using the **A** command. This will not inhibit the K16's command sidetone so you will still be able to invoke keyer commands.



## K16-EMB Kit

This K16-EMB kit is designed to fit inside of an existing CW transceiver. It has a paddle connector that is used to mount the keyer board on the radio's front or rear panel. Since CW sidetone is injected into the radio's audio chain, there is no need for an on board sidetone speaker. A single pushbutton is required to enter keyer commands. More pushbuttons can be added, up to four total, to provide message triggering. The kit consists of a printed circuit board, paddle interface, keying output driver, sidetone audio interface, a multiple pushbutton interface, and a 5.0V voltage regulator.

An on-board circuit is provided to attenuate and filter the keyer's square wave output to allow it to be fed directly into a transceiver's audio chain. (PCB board pad A). This allows the K16-EMB's command sidetone to be heard in the transceiver's speaker output. The radio's existing sidetone would be used for normal transmit sidetone.

### K16-EMB Parts Inventory

U1	- K16 8 pin DIP IC	R6	- 2.2K $\Omega$ 1/8 watt (red red red)
VR1	- LM78L05 5.0V regulator TO92	R7	- See chart on page
Q1, Q2	- 2N7000 MOSFET TO92	C6	- .01 uF blue 5% multi-layer cap 103
Q3	- PN2222A	C1, 4	- .01 uF ceramic capacitor 103
R3	- 100 $\Omega$ 1/8 watt (brown black brown)	C2, 3,	- .001 uF ceramic capacitor 102
R9, 10	- 1.0K $\Omega$ 1/8 watt 1% (brown black red)	C7, 8	- " "
R11,12	- " "	C9, 10	- .1 $\mu$ F ceramic capacitor 104
R1,2,	- 4.7K $\Omega$ 1/8 watt (yellow violet red)	C5	- 3.3 $\mu$ F electrolytic capacitor
R4, 5	- " "	1 pc	- 8 Pin DIP Socket
J1	- Paddle Connector	1 pc	- K16 EMB PC board

### K16-EMB Kit Assembly

Please review Appendices A through C before starting the kit for general kit assembly advice. The K16-EMB picture on page 30 is invaluable for part placement help.

A picture of an assembled K16-EXT board is presented on page 29, use it as a guide for placing parts.

The first thing to consider is the value of R7 which determines the sidetone audio output level. This will require some experimenting to get the level to work with your audio chain. The chart below shows typical levels into a 5K $\Omega$  load. These four values are included with the kit, it's possible you may need a different value. We suggest leaving R7 out for now and revisiting it when you have the keyer connected to the radio.

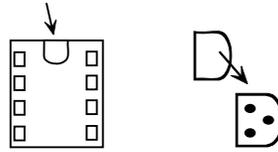
R7 Value	Sidetone level peak to peak
4.7K $\Omega$	900 mV
10K $\Omega$	500 mV
22K $\Omega$	250 mV
47K $\Omega$	125 mV

Install R1 through R12, leaving R7 out for now. Color codes are noted above.

Install capacitors: C1 through C10, Note that C6 (.01uF) is blue in color and is different than C1, C4.

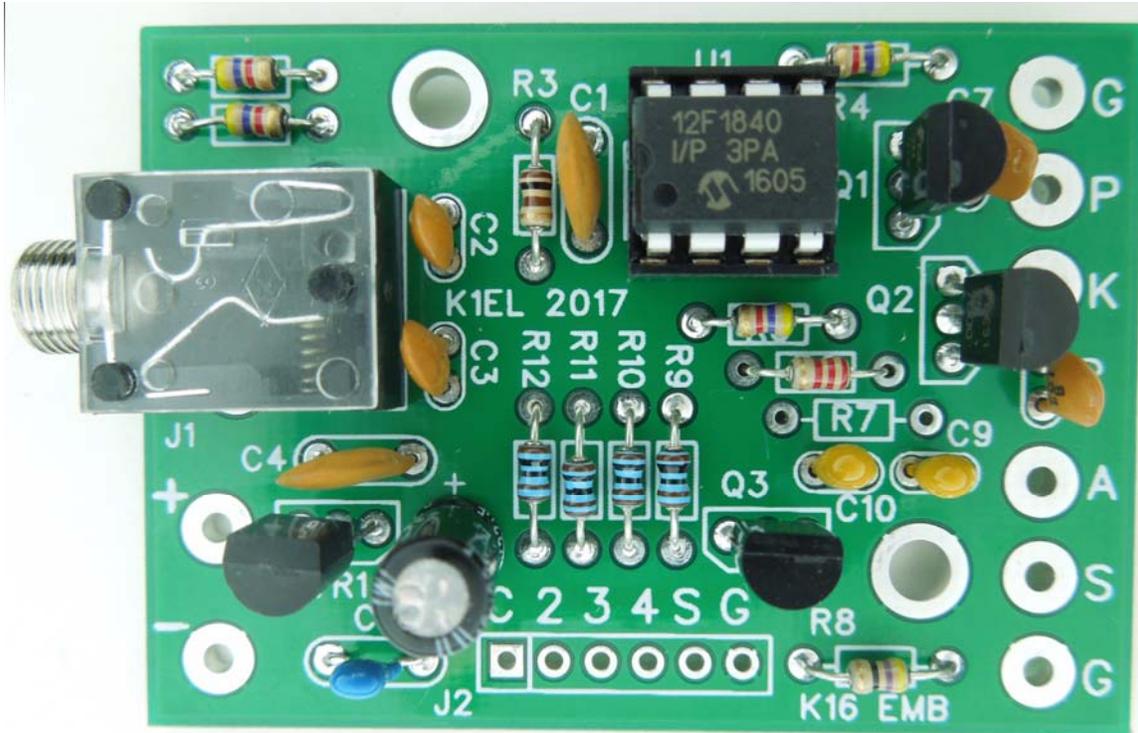
**Observe polarity on C5:** Long lead goes in the plus hole.

Install the 8 pin DIP socket, locating the index mark in the socket to match the PCB silkscreen.



Now install VR1, Q1, Q2, and Q3. Carefully form the leads so they will line up with the PCB holes in such a way that the flat side of the TO92 package lines up with the silk screen as shown above, solder in place.

Install and solder the paddle connector J1.

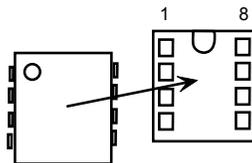


Assembled K16-EMB

### K16-EMB Test Procedure

You will need a DVM or volt/ohmmeter to test out the K16-EMB board. Apply power to the V+ and GND pads, 9V is recommended. Measure the voltage between pins 1 and 8 on the U1 socket and you should read 5 volts. Turn power off.

Install U1, carefully aligning pin one as shown in this diagram:

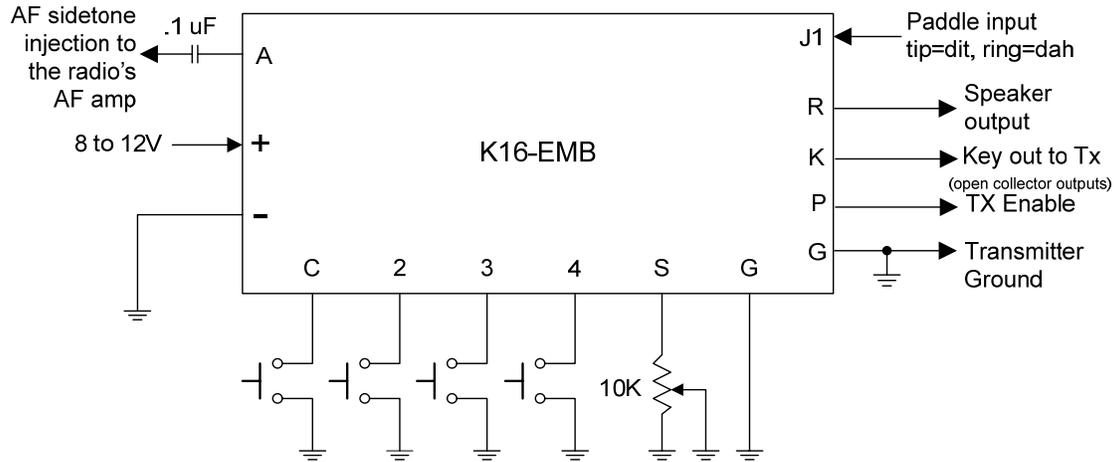


It is a little tricky to test operation since the board does not have a sidetone speaker. You can get around this by attaching a small speaker to the S and G pads. If you don't have a speaker, temporarily attach DVM leads to the K and G pads and set it for reading ohms, 10K scale is fine.

Turn power back on and you should hear an R in your temporary speaker. Now insert a paddle into J1 and press the left and right paddles and you will hear dits and dahs in sidetone or see movement on the

DVM. These next steps apply to the temporary speaker case only. Hold the leftmost pushbutton down until you hear an "R" followed by ? That tests that you can enter command mode. Momentarily press the remaining four pushbuttons and the keyer will send MT (empty message slot) in sidetone.

If you don't get any of these tests to work carefully check the board for mis-wires or solder shorts. Refer to the images of the solder side and silkscreen to aid in your debugging.



**K16-EMB Hook Up Diagram**

Above is a diagram illustrating the various connections to the K16-EMB kit. Note that there are various options available. Not all pushbuttons are required; the K16-EMB will work fine with a single pushbutton tied to the command (C) input. Alternatively, 2, 3, or 4 pushbuttons can be connected. The more pushbuttons, the more messages can be accessed. A speed pot is not a requirement, if you don't want to use one simply tie the S input to ground, this will tell the K16 to operate in fixed speed mode. The speed then is changed using either the S command or by the Paddle Fast Speed Change feature.

The key and transmit enable outputs are open collector which means they acts as a switch to ground. The key output can be directly connected to a transmitter key input. Beware that the Key output can only switch voltages up to 60V DC. It is not capable of directly keying a vacuum tube transmitter that uses grid blocking or cathode keying.

### K16-EMB Sidetone Options

The first option is a speaker driver output which can drive a low impedance speaker directly.

The second is audio injection. If you are embedding the K16-EMB into a radio, a convenient way to deal with sidetone is to inject it into the radio's AF chain. This means you don't have to provide a separate sidetone speaker and can easily control the sidetone's volume with the radio's AF gain control. To go this route, select R7 to provide the desired audio level to your radio. Four values are provided with the kit. However, it may be necessary to increase the resistor value to lower the sidetone amplitude even more. The best solution is to have the K16 sidetone level closely match the radio's audio level and this will take some experimentation. We recommend that you capacitively couple the sidetone audio, a .1uF is a good choice. If the radio already has an internal sidetone generator you should disable the K16's transmit sidetone by using the A command. This will not inhibit the K16's command sidetone so you will still be able to invoke keyer commands.



## K16 Big Keyer (K16-BK) Kit

This K16 kit is an entire keyer on a single board. Connectors, controls, and battery power are all contained on the board, no external wiring is required. This kit goes together fast and the test procedure is easy. Five message pushbuttons are provided along with a speed control. Paddle, key, and PTT connectors are at the rear of the board.

A fairly large sidetone speaker is used which provides louder sidetone volume at lower volumes than other K1EL keyer kits. The K16-BK uses a special version of the K16 keyer IC that supports five message pushbuttons along with a lower frequency sidetone frequency default. Other than that the function of the K16 is identical to all other K16s.

As a bonus, the K16-BK uses a solid state keying relay offering a wide range of keying options.

### K16-BK Parts Inventory

U1	- K16 8 pin DIP IC
U2	- AQW210 or AQW280 SSR
Q1	- PN2222A or 2N4401
R1, 2	- 470 1/8 watt (yellow violet brown)
R3	- 100Ω 1/8 watt (brown black brown)
R4	- 10Ω 1/8 watt (brown black black)
R5, 6,	- 1.5 KΩ 1/8 watt 1% (brown green red)
R7, 8, 9	“ “ “
R10, 11	- 4.7K 1/8 watt (yellow violet red)
2 pc	- 8 Pin DIP Socket
1 pc	- K16 BK PC board

C4	- .0047 uF 5% cap blue 472
C3,8	- .01 uF ceramic capacitor 103
C5, 6	- .001 uF cap blue <b>500V</b> 102
C1, 2	- .001 uF ceramic capacitor 102
C7	- 22 or 33 μF electrolytic capacitor
RP1	- 10K potentiometer
J1	- Paddle connector
J2	- Dual RCA connector
SP1	- Sidetone speaker
One double sided adhesive foam square which may be pre-attached to the battery holder.	

### K16-BK PCB Assembly

The picture on the next page will help you put components in the correct places. Please read the accompanying text carefully.

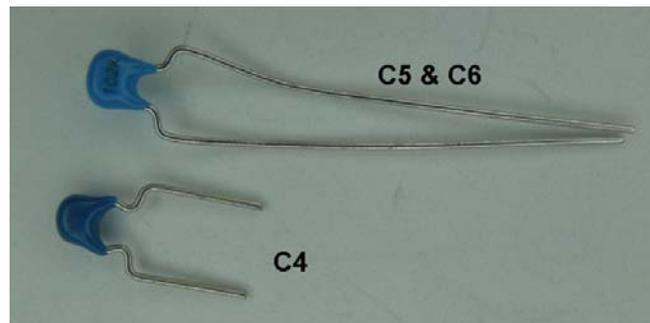
Referring to Parts Inventory above, make sure you have all the parts before starting to assemble the kit.

#### Capacitor identification:

C5 and C6 are blue .001 uF ceramic caps caps marked 102.

C4 is a .0047uF ceramic, also blue, but is marked 472

To avoid confusion, note that C4 is a darker blue while C5 & C6 have longer leads.



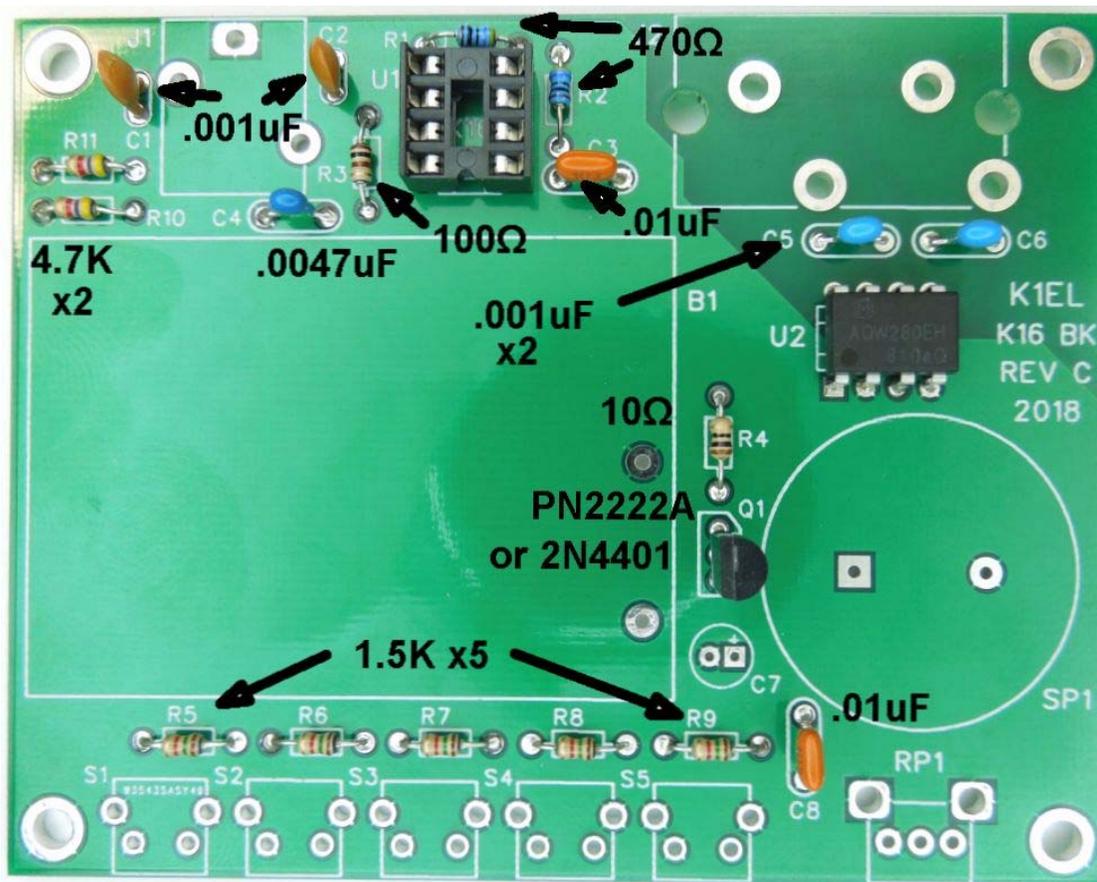
We highly recommend reading through appendices A, B, and C at the end of this document. Even if you are experienced builder it's a good idea to review standard practices before you start. A well built kit not only looks good, it will function properly for many years.

Start assembly with the resistors R1 through R11. The color codes on these 1/8 watt resistors can be difficult to read so use an ohmmeter (DMM) to verify the values before you install them. After soldering, trim the leads as close to the board as possible this applies to all leaded components in the kit.

Install capacitors C1-C6. Note that C1, C2, C5 and C6 are all .001 uF capacitors but C1 and C2 have .1" lead spacing while C5 and C6 have .2" lead spacing. They are all blue in color and look similar to each other. Review the picture on page 33 to be sure to put all of these capacitors in the right place.

Install the 8 pin DIP socket at location U1, orient the index mark in the socket to match the PCB silkscreen. Install U2 in the same manner.

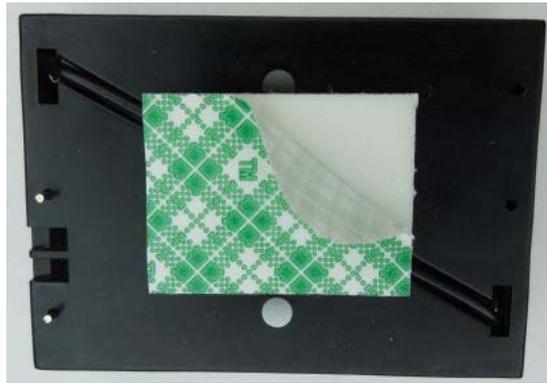
Now install Q1, this may be a PN2222A or 2N4401. Carefully form the leads so they will line up with the PCB holes and that the flat side of the TO92 package lines up with the silk screen as shown below.



First phase K16-BK assembly complete with values shown



If this hasn't been done already, remove the film from one side of the double sided foam tape and attach it to the battery holder as shown. Then peel back the film in preparation for installation in the PC board.

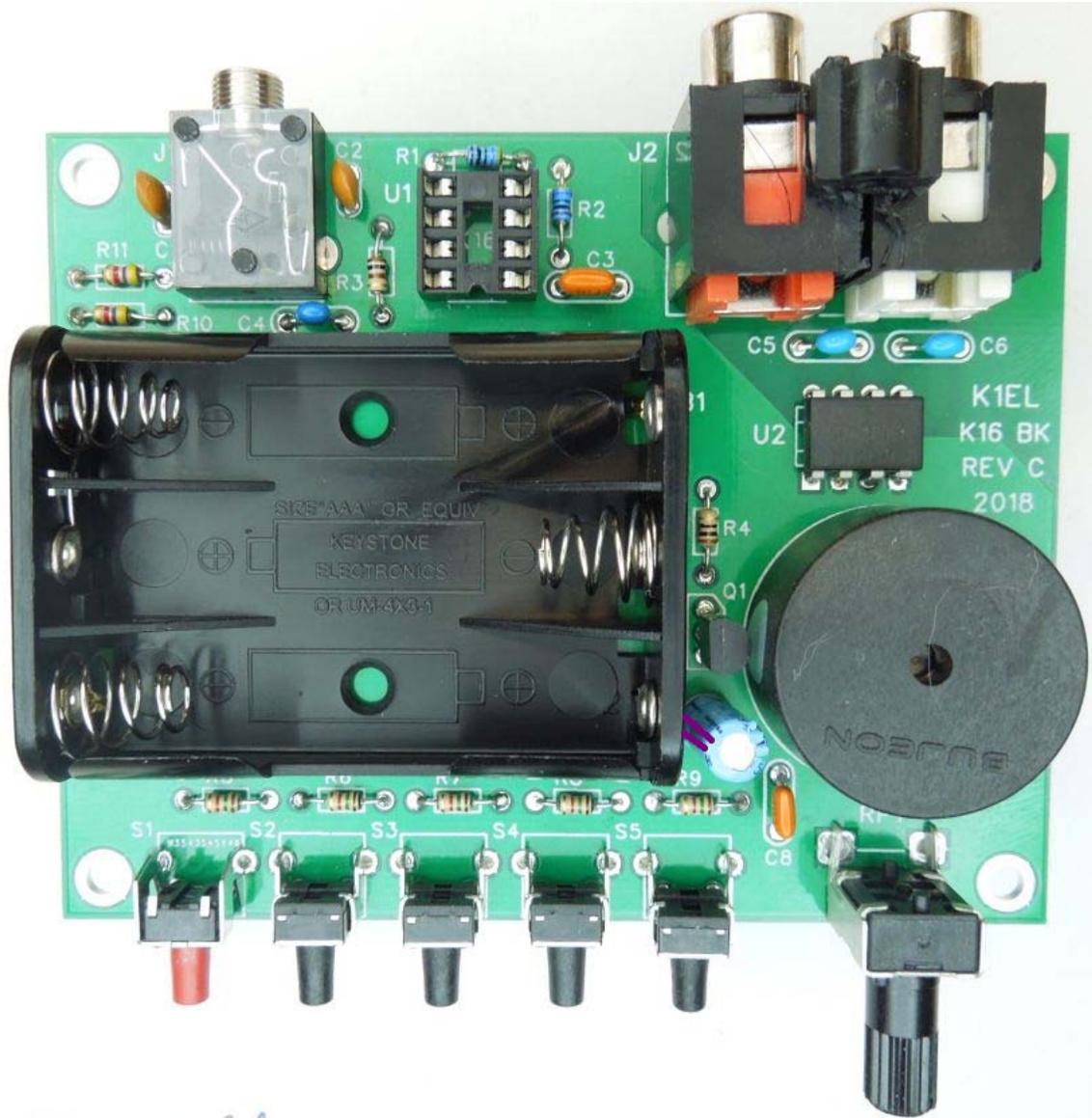


Double sided tape attached to bottom of battery holder

Carefully insert the battery leads into the board and make sure the holder is aligned with the silkscreen as you press the holder in place. Go slow here, the double sided tape is nearly impossible to remove once it is set. Now solder the leads in place.

Install the speed control at position RP1. Make sure you get the 3 leads and two bracket pins into the board without bending one over. You may have to straighten the bracket pins to get it to fit. Before soldering, make sure the control is fully seated into the board.

You may find that the dual RCA jack is a snug fit, it may take some extra pressure to get it to snap in place.

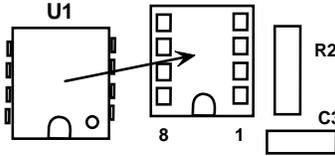


Completed K16-BK with battery holder and speed pot in place

### K16-BK Test Procedure

Install three AAA batteries into the battery holder. Measure the voltage between pins 1 and 8 of U1's socket and you should read about 4.5 volts. Pin 1 will be positive in respect to pin 8. Remove one battery.

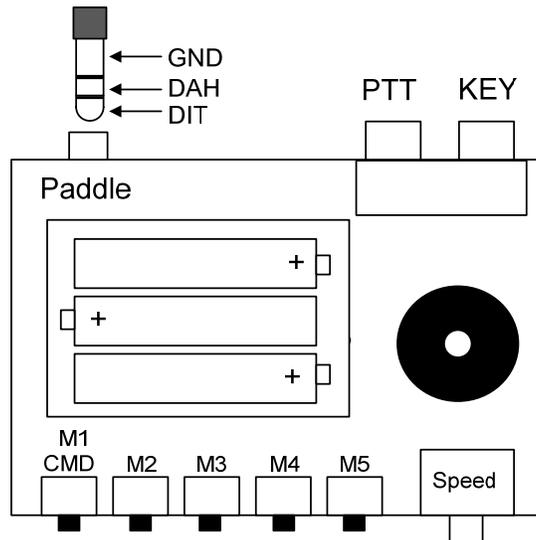
Install U1, carefully aligning pin one as shown in this diagram:



Reinstall the battery and you should hear one R (di-dah-dit) in Morse from the speaker. Hold the left most pushbutton (command) closed until you hear an "R" followed by a question mark. If you momentarily press any of the pushbuttons, the keyer will send MT telling you that the message slot is empty.

If you don't get any of these tests to work carefully check the board for mis-wires or solder shorts.

### Using the K16-BK



**K16-BK Hook Up Diagram**

Since the K16-BK automatically goes into power down sleep when not being used, a power on/off switch is not required. It only draws about 70 uA in sleep mode so a set of good alkaline batteries will last over one year. A keyer lock feature allows you disable the paddle and pushbutton switched for travel or storage. This is covered on page 17.

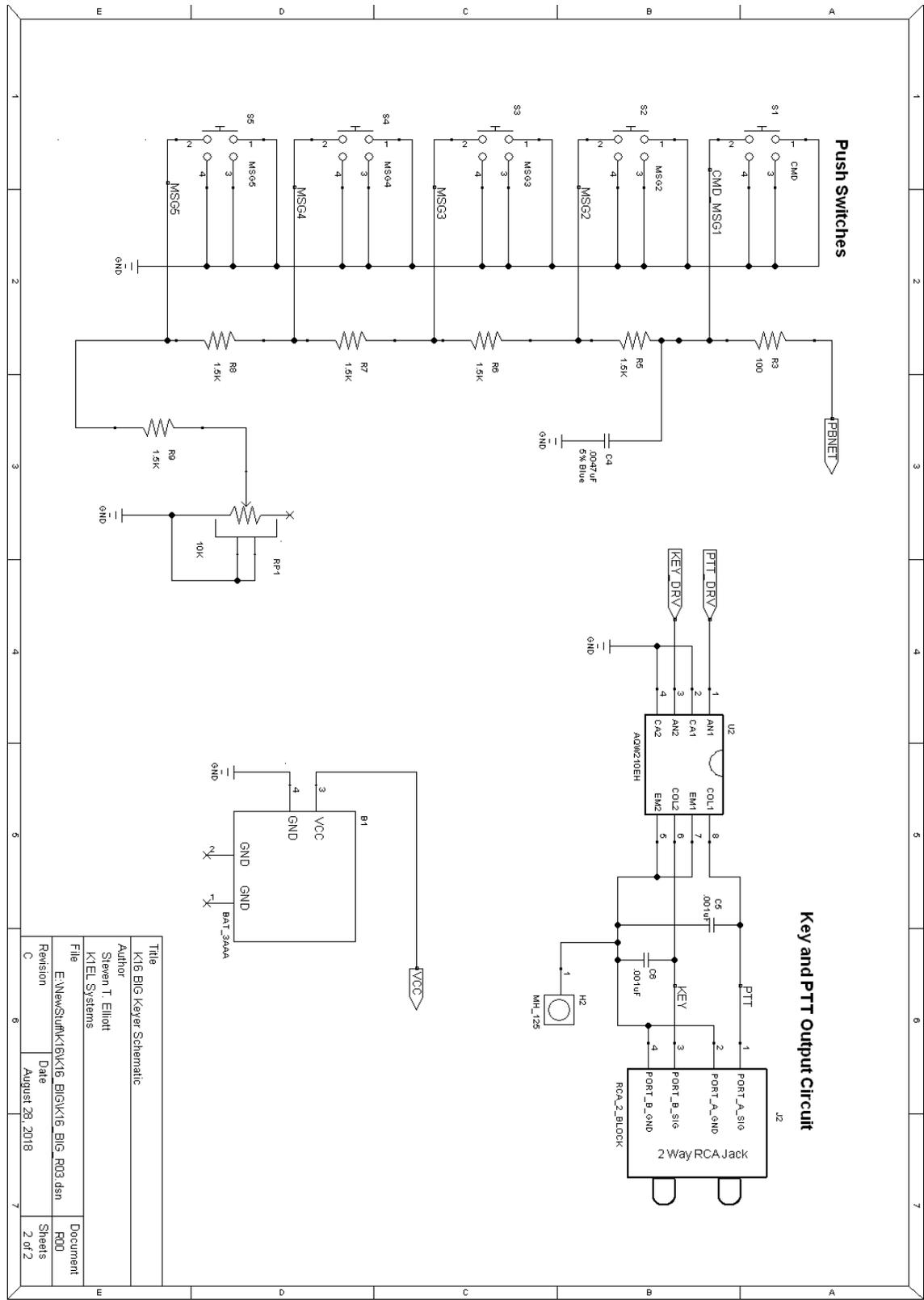
To connect a paddle to the K16 you need an 1/8" stereo connector wired as shown above. This is a standard so odds are your paddle already has this. One exception may be that you have a 1/4" plug instead. In that case the best solution is a stereo 1/8" to 1/4" adapter.

As mentioned previously, the Key and PTT outputs act as simple switches to ground. In the majority of setups, you will only use the Key output and ignore the PTT connection. A typical keying cable would have an RCA plug on one end and 1/4" phone plug on the other since most transceivers use a 1/4" keying input. Note that you will need to run the transceiver in straight key mode to use any external keyer. We recommend testing your radio configuration with a straight key to be sure it is setup correctly before you hook up your keyer. One other note is that some radios want a stereo keying plug with no connection to the ring. So to be safe a universal keying cable should be stereo.

The key and PTT outputs provide a high degree of electrical isolation (5000V) and switch positive and negative voltages up to 350 volts at 125 mA. So they work well for keying vacuum tube transmitters that use grid block keying. Please check the transmitter's manual before plugging the K16-BK in to be absolutely sure the keyer will work to the specified keying voltage and current.

The five pushbuttons on the front are used to configure the keyer and also trigger messages. The left most pushbutton is a combination command and message trigger input. Press and hold that pushbutton and after a couple of seconds the keyer will respond with an R to let you know it is in command mode. The first part of this manual, starting on page 6, covers the commands and capabilities of the K16.





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## Support and Warranty

A K16 kit is fully warranted to the original purchaser against defects in materials and workmanship for one year after purchase. This warranty does not cover damage caused by accident, improper care, or lightning damage. Please contact us before returning your K16 kit for repair and we will issue an RMA. Please submit questions by e-mail to [k1el.kitsinfo@gmail.com](mailto:k1el.kitsinfo@gmail.com)

Watch our website for latest updates and new products: <http://www.k1el.com>

**While every effort has been made to insure that the K16 kit designs are as complete and accurate as possible it is still possible to cause equipment damage or incur personal injury if:**

- 1) A K16 kit is not used as intended.
- 2) A K16 kit is connected incorrectly.
- 3) Safety guidelines outlined in this document are not followed.
- 4) A K16 kit is modified in any way.

**K1EL cannot be held responsible in these or other similar events.**

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

## Revision History

- 4-20-2014 – Revision A.2  
K16 Chip Rev C,  
K16-BAT and K16-EXT Rev A
- 7-09-2014 – Revision A.3  
Minor typo corrections, speed pot is 10K not 5K.
- 3-17-2015 – Revision A.4  
Added description for the Tune Command (AA)
- 3-07-2016 – Revision A.5  
Minor typo corrections
- 12-11-2016 – Revision A.6  
Updated Fig 4
- 12-1-2017 – Revision A.7  
Added K16-BK and K16-EMB kits
- 3-30-2018 – Revision A.8  
Corrected errors in K16-BK assembly instructions
- 5-8-2018 – Revision A.9  
C4 in K16-BK is a .0047uF not .01uF
- 6-13-2018 – Revision A.10  
Minor K16 command documentation corrections
- 5-5-2019 – Revision A.11  
Corrected K16-BK IC placement diagram

## 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.

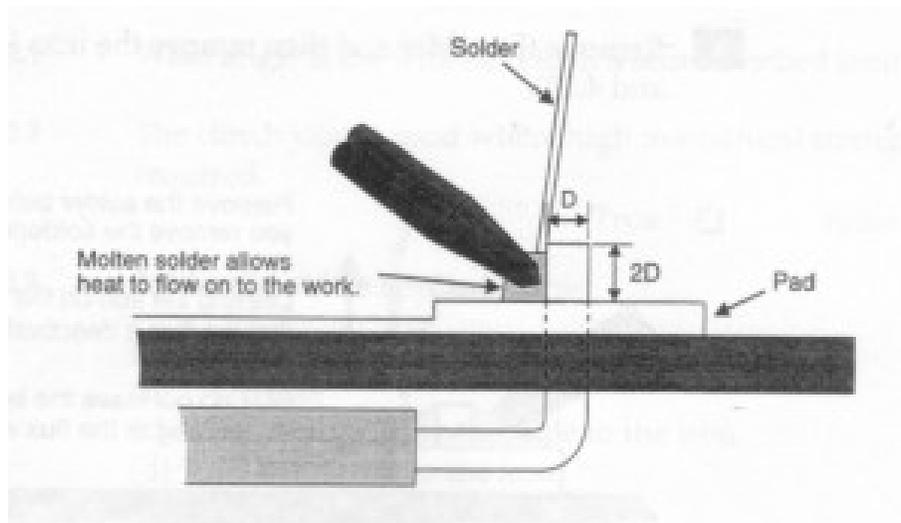


Fig. C1 - Form a heat bridge

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.

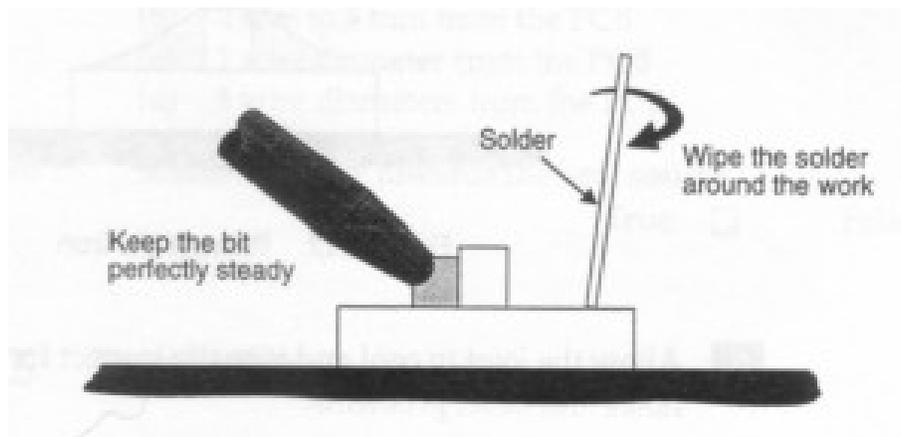


Fig. C2 - Spread solder around the work

5. Remove the solder and then remove the iron.

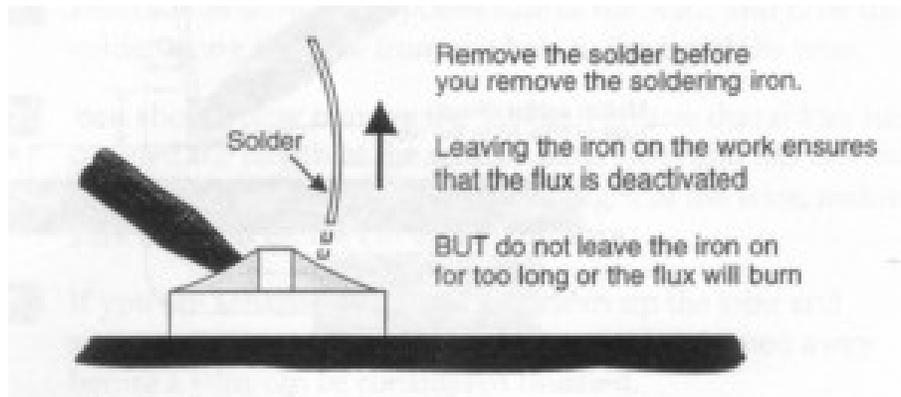


Fig C3 - Remove the solder

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.

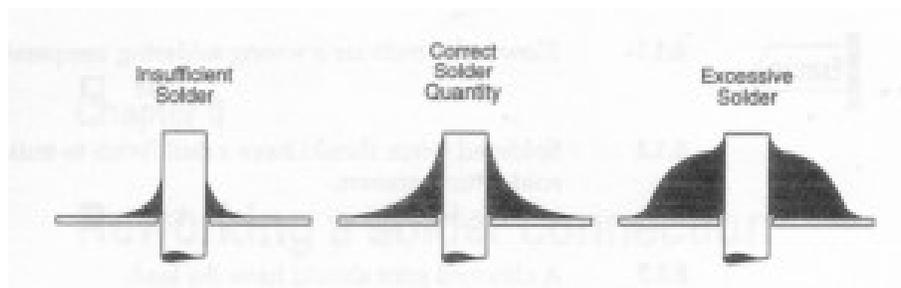


Fig. C4 - Solder quantity comparison

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.