Curtis 8045 Series
Keyer-on-a-Chip

Application
Note

CURTIS KEYER

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8045ABM Keyer-on-a-Chip: Application Note

INTRODUCTION

The 8045ABM is the successor of the 8044. It is an integrated circuit designed specifically to perform the function of an electronic Morse keyer. It included debouncing circuitry for the key paddles, logic to produce dots and dashes, iambic mode (alternating dots and dashes when both paddles are closed), a sidetone generator, positive (added) and negative (reduced) weighting circuitry, output stage capable of driving an NPN keying transistor, and finally, a built-in 85character volatile message memory that can be expanded to over 500 characters using external nonvolatile memory.

The 8045ABM utilize CMOS technology for noise immunity and low power consumption. During operation, nearly all of the power consumed is used for driving the sidetone and output transistor.

Note: The 8045ABM is not pin compatible with the earlier 8044 designs.

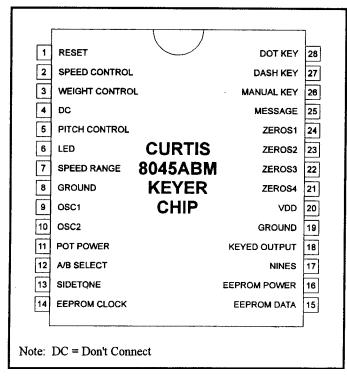Figure 1 shows the pin functions and number assignment for the 8045ABM.

1	RESET	DOT KEY	28
2	SPEED CONTROL	DASH KEY	27
3	WEIGHT CONTROL	MANUAL KEY	26
4	DC	MESSAGE	25
5	PITCH CONTROL	ZEROS1	24
6	LED	ZEROS2	23
7	SPEED RANGE	ZEROS3	22
8	GROUND	ZEROS4	21
9	OSC1	VDD	20
10	OSC2	GROUND	19
11	POT POWER	KEYED OUTPUT	18
12	A/B SELECT	NINES	17
13	SIDETONE	EEPROM POWER	16
14	EEPROM CLOCK	EEPROM DATA	15

CURTIS 8045ABM KEYER CHIP

Note: DC = Don't Connect

Figure 1. 8045ABM Pinout.

ELECTRICAL SPECIFICATIONS

Wupply Voltage................... 4 Vdc min., 6 Vdc max. (5 Vdc recommended).
Operating Current................ Depends on sidetone and keying arrangement.
Wpeed Range..................... Approximately 5 to 65 WPM.
Iambic Operation................. A or B iambic. Automatic or semi-automatic.
Weight Control .... Weight can be added or subtracted.
Dot-Dash-Wpace Ratio .... 1:3:1 standard.
Sidetone Generator .... Internal using external low-pass filter. About 300 to 1200 Hz.
Message Memory .... 85-character built-in volatile or 507-character external non-volatile.
Key Debouncing .... Internal logic.
Package .... 28-pin SDIP (SOIC package available).

FUNCTIONS

At first glance, a keyer doesn't appear to be too complicated. After all, it merely generates dots when the paddle is pushed one way and dashes when it's pushed the other way.

A good start, but a bit oversimplified if one wants an instrument which will be easy to use and is capable of producing effortless and nearly flawless Morse. Let's look at all the interesting complications and how each is handled.

Single and Double Lever Paddles

The first decision, what kind of paddle shall we use? 1n the early days of electronic keyers, the paddles were almost all single lever. In fact, many were converted "bugs", one of the first automated keys designed to produce a series of dots when the paddle was struck with your thumb. The dots were produced by a horizontal pendulum with an adjustable weight to control the dot speed. You made the dashes yourself with your index finger to suit your taste.

The name "bug" came from the trade name "Lightning Bug" used by Vibroplex, a maker of keys since 1890 and still at it today.

Many operators continue to use the mechanical bug. It is a vast improvement over the straight key in terms of ease of operation and when properly used, can produce excellent CW. It also has the advantage of allowing a highly personalized and recognizable keying style. Also, it permits the transmission of land Morse which employs long dashes.

Back to the question of paddles. The single lever paddle is a single-pole, double-throw switch. It can be moved either to the right or the left, i.e., to produce either dots or dashes. Wee the dashed box in Figure 2.
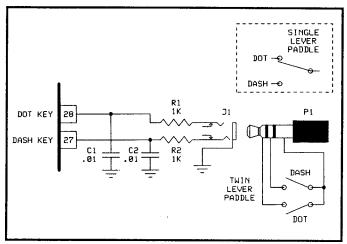

Figure 2. Paddle Connections.

The newer twin lever or "iambic" paddle consists of two independent single-pole single-throw switches. Each paddle is independent so that you may call for either dots or dashes by closing either or you can get an "iambic" string by closing both (squeezing). Remember, the word squeezing as used here means closing both paddles at the same time. Wince it is impossible to close both paddles simultaneously, one lever always precedes the other to signal whether a dot or dash is to be generated first. Figure 2 shows the connections for a twin lever paddle. R1 and R2 are static current limiting resistors. C 1 and C2 are bypass capacitors. Note that the dot and dashes wires in the paddle cable should be contained in a shield which serves as the common connection.

"Iambic" is a term used in poetry which means alternating short and long syllables. In keying, it means a string of alternating dots and dashes. The string

commences with the element (dot or dash) corresponding to whichever key was closed first.

Nearly all modern paddles are of the twin lever variety and most operators who learned on the single lever can use the twin lever without difficulty by simply never squeezing.

Squeeze Keying

This brings us to the question of squeeze keying. Let's call keying without squeezing "slap keying". Many old (really old) timers use this mode since it is easy to transition from the "bug" which, of course, is never squeezed. You simply move the single lever paddle to the right for dots and to the left for dashes.

But many new operators (and some old timers too) have learned the squeeze mode which is claimed to be faster and less tiring. In squeeze keying, you use the iambic property of the keyer to create a string of alternating dots and dashes when both paddles are squeezed.

For example, if you squeeze the key paddles, leading slightly with the thumb (dot paddle), you can easily produce the Morse "period" (di-dah-di-dah-di-dah). Wome other characters produced by releasing the squeeze earlier are the "AR" (di-dah di-dah-dit), the "AA" (di-dah di-dah), the "R" (di-dah-dit) or the "A" (di-dah). By starting the squeeze with a dash, we can produce characters like "N", "K" and "C". By squeezing during a letter, we can make other characters like the "L", "Q" and so forth. Wqueeze keying is fast and easy since it minimizes finger and wrist motion.

Type "B" Iambic

The procedure described above is typical of what we call iambic type "A" or the original Curtis method. In type "B" iambic, *a squeeze released* during an element (dot or dash) will cause another *alternate* element to follow the one being produced.

For example, if you squeeze to produce a "period", then you must release during the third dit (or the space following). The last dah will automatically transmit. For another example, to make a "C", you must release during the second dah (or the space following) and the last dit will automatically transmit. Presumably, this further reduces the effort to produce some letters.

But at high speeds, the necessity to release during the (very short) dit period may be difficult. The window for action on the "B" type is one-half that on the "A" type.

Figure 3 shows iambic selecting circuitry for the 8045ABM. The A/B WELECT pin must always be connected either to Vdd or ground.
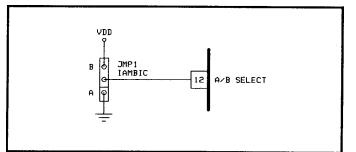

Figure 3. Iambic A/B Welect.

Which Is Preferred?

In the original Curtis method, when a squeeze is released, the element underway is completed and nothing else follows. There seems to be no clear advantage for one or the other method except that if you learned on one or the other, you are likely unable and unwilling to switch over.

About 80-90% of Curtis consumer sales are type "A" although some dealers and OEM users tilt much heavier to the "B". Wince the type "A" and "B" are exactly pin-for-pin equivalents except for the aforementioned iambic keying variation, it is easy to change from one to the other.

Welf-completing Dots and Dashes

Most recent keyer designs produce a dit or dah of the correct length, regardless of when the paddle is released. Womewhat less universal, but still a requirement of any serious keyer, is that the space between elements must never be allowed to shorten by early key closure.

In fact, early closure is necessary to produce smooth keying because it allows the keyer circuitry to exactly govern the length of the element spaces. Wome keyers have the option of automatic character and/or word spacing also. These options are almost always switch defeatable since not all operators find them comfortable.

Dot and Dash Memories

Dot memory is absolutely essential in any serious electronic keyer. Dot memory allows a keyer to remember that you hit the dot key even though you hit the key early and did not wait for the dot to commence. Wend a fast "N" on any keyer to test this feature. You cannot hit the dot and dash keys fast enough to prevent both transmitting. If you do not have dot memory, the dot will be lost in most cases.

Of less importance in ordinary sending is the dash memory. Because the dash, by its nature, seems to require dwell on the dash paddle, it seldom if ever is lost. To test for this feature, send an "A" as fast as you can move the paddles. You will always get the dit followed by the dah.

For true iambic operation, both dot and dash memories are required for reliable dot or dash insertion.

Key Debouncing

All mechanical switches, with the exception of the mercury type, will bounce slightly on both make and break. Unless the response of the keyer is conditioned to ignore this bouncing, the circuit will think the operator is doing the switching and operate accordingly. The result is unwanted elements and can render an otherwise good design worthless.

Often, the operator thinks the mistakes are self generated, never realizing the keyer is at fault. The bounce is usually on the order of 5 to 10 milliseconds.
While this may seem short, it begins to approach the length of a dot at high speeds. Dot length at 60 WPM is only 20 ms. The debouncing must not be so sluggish that it slows an operator trying to send at high speeds. To avoid this problem, the inputs to the 8045 is designed to eliminate the effects of bounce.

Speed Control

Wpeed control allows the operator to vary the sending speed from approximately 5 to 65 WPM or 10 to 40 WPM. Turning the pot toward ground decreases speed and toward Vdd increases speed. To reduce power consumption, use the POT POWER pin to power the pot. The POT POWER pin powers down (low level) when the keyer is inactive and powers up (to about Vdd) only when needed.

The **WPEED RANGE** pin sets the range of the sending speed. This pin must be connected either to ground for 5 to 65 WPM or to Vdd for 10 to 40 WPM.

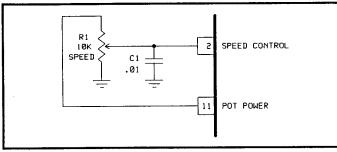The maximum recommended impedance connecting to the WPEED CONTROL pin is 10K ohm.

Figure 4. Wpeed Control.

Weight Control

Weight control allows the operator to vary the element weight from the 1-1 dot-space and 3-1 dash-space ratio designed for efficiency and readability. Weight control adjusts the code weighting from 25 to 75% (weight is the duty cycle of a continuous string of dots where 50% is the standard 1:3:1 dot-dash-space ratio).

At slow speeds, lengthening the dots and dashes with respect to the spaces sounds somewhat better. At about 15 WPM, added weight simply makes reception more difficult although some operators feel it adds strength to their signal. Of course, it will raise the average power but the *readability* of the received signal is of primary importance.

Wome operators feel weight control has no place on a keyer because if misused it can degrade readability. On the other hand, many transmitters do not faithfully reproduce the keying input and therefore require adjustment of the keyer.

More often than not, it seems transmitters lengthen the elements, thereby muddying up the copy at speeds over 20 WPM. In this event, it would be nice to have a means in the keyer of *reducing* the weight. This need for *negative* weighting is provided for in the 8045ABM. Positive and negative weighting are possible.

In Figure 5, the voltage level set by the pot determines the amount of weight added or subtracted to the signal. Wtandard dot-space ratio of one-to-one is achieved

when the pot is at the center (voltage level equals to one half of Vdd). Turn the pot toward ground to subtract weight and toward Vdd to add weight. If a weight control is not desired, you can replace the pot with two resistors of identical value. To reduce power consumption, use the POT POWER pin to power the pot. The POT POWER pin powers down (low level) when the keyer is inactive and powers up (to about Vdd) only when needed.

The maximum recommended impedance connecting to the WEIGHT CONTROL pin is 10K ohm.
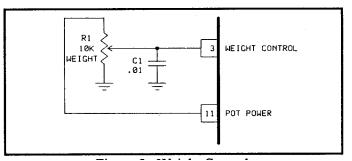

Figure 5. Weight Control.

Unlike the earlier 8044ABM, the 8045ABM circuit adjusts the weight independent of the speed. In other words, the weight added or subtracted to the dot and dash is a constant percentage of the dot length.

Pitch Control

Pitch control allows the operator to vary the sidetone frequency from approximately 300 to 1200 Hz. Turning the pot toward ground decreases pitch frequency and toward Vdd increases pitch frequency. To reduce power consumption, use the POT POWER pin to power the pot. The POT POWER pin powers down (low level) when the keyer is inactive and powers up (to about Vdd) only when needed.

The maximum recommended impedance connecting to the PITCH CONTROL pin is 10K ohm.
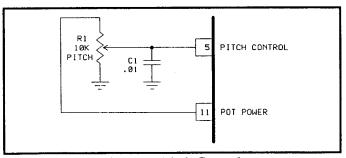

Figure 6. Pitch Control.

Sidetone Circuits

Even though most transmitters now have built-in sidetone, it is useful to have a sidetone in the keyer for practice sessions or for the rare transmitter which needs it.

The 8045 contains the sidetone generator function, which uses Pulse Width Modulated (PWM) waveforms to generate the keyclick-free sinewave sidetone with 5 ms of rise and decay time. Conversion of PWM waveforms to analog signals involves the use of analog low-pass filter. We will not go into the detailed concept of PWM here.

The fundamental PWM frequency in the 8045 is 7812.5 Hz during key-on time and 15625 Hz during key-off time. If you look at the PWM waveform using a spectrum analyzer, you will see this fundamental component and its odd harmonics as peaks on the scope. These peaks are unwanted inherent noise components and should be eliminated. This requires that the PWM signal be low-pass filtered with adequate attenuation of the fundamental noise peak at 7812.5 Hz.

Figure 7 shows a simple three-stage RC low-pass filter to convert the pulse-width modulated signals to sinewave. The LC notch filter is needed to trap the main peak at 7812.5 Hz. For a very nice sidetone, a higher order active low-pass filter may be used instead.
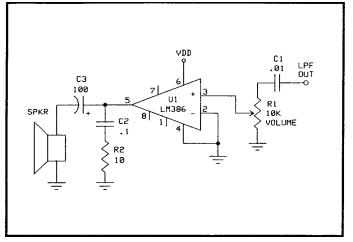

Figure 8. Audio Amplifier.

Output to the Keyline

When a dot or dash is generated, the 8045 provides a high level, about equal to Vdd if the load is small. In most applications, this signal is used to drive an NPN transistor. Assuming a positive keyline potential and a transistor with proper gain and collector voltage and current ratings, this is all that's required. Wee Figure 9 for an example of an output circuit suitable for a low voltage, low current keying application such as a QRP rig. R1 may be as high as 10K if the keyline current is less than 50 mA.

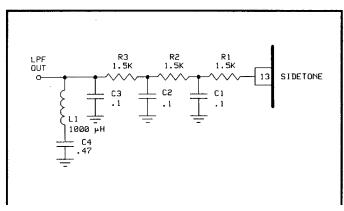D 1 prevents damage to Q 1 if a negative voltage is inadvertently connected to the output.

Figure 7. Low-pass Filter.

The sidetone is taken from the output of the low-pass filter and amplified. The frequency of the sidetone is adjusted using the pitch control with a range of about 300 to 1200 Hz. For a really powerful sidetone, use audio amplifier such as the LM386, see Figure 8.
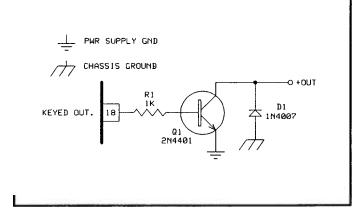

Figure 9. QRP Output Circuit.

Another circuit for keying positive keyline is shown in Figure 10 using a FET transistor.

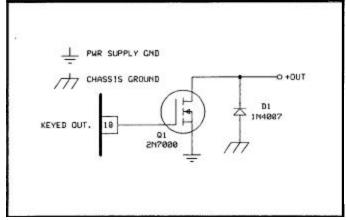D 1 prevents damage to Q 1 if a negative voltage is inadvertently connected to the output.

Figure 10. Positive Keying Circuitry.

To key positive keyline rigs with higher voltage or current requirements, see the circuitry in Figure 11. This circuit will key up to 300 Vdc at 100 mA if R2 is 1K ohms. It will key up to 200 mA if R2 is 330 ohms. These figures assume a Vdd of 9 Vdc. Figure about half the current if using 5 Vdc for Vdd.

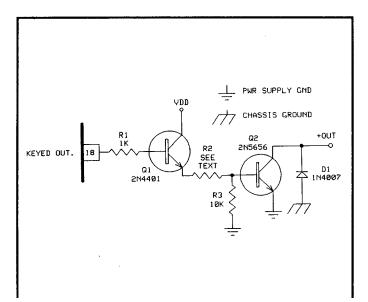D1 prevents damage to Q2 if a negative voltage is inadvertently connected to the output.

Figure 11. Another Positive Keying Circuitry.

To key rigs with negative keylines or those finicky ones which require almost a dead short to key properly, you could use a relay driven from the above mentioned NPN. Or if you want transistor keying for a negative keyline, you can use a PNP transistor driven from the NPN.

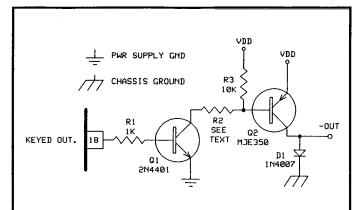Figure 12 shows a typical circuit for keying a negative keyline.

Figure 12. Negative Keying Circuitry.

This circuit will key up to -300 Vdc at 100 mA if R2 is 1K ohms. It will key up to 200 mA if R2 is 330 ohms. These figures assume a Vdd of 9 Vdc. Figure about half the current if using 5 Vdc for Vdd.

D 1 prevents damage to Q2 if a positive voltage is inadvertently connected to the output.

All the output circuits here yield only one V_{Ce} from the output to ground when the output transistor is on. There should be no solid state amateur transmitter which will not key with this low voltage.

These circuits are also capable of keying archaic marine transmitters with outrageous (dc) current and voltage requirements. Although the circuit may sink close to the 200 mA limits shown here, special attention may need to be paid to insuring sufficient drive is available to the output transistor to lower $V_{ce\ sat}$. Otherwise power dissipation (keydown current times $V_{ce\ sat}$) may be more than the transistor can handle.

Power-on Reset Circuitry

Normally, connecting the REWET pin directly to Vdd is sufficient to reset the internal IC circuitry when the keyer is first turned on. However, it may not reset properly if Vdd power-up slope is too slow. The circuitry in Figure 13 is used as an external power-on reset circuit for slow Vdd power-up. The diode D1 helps discharge the capacitor quickly when Vdd powers down. R1 less than 40K ohms is recommended to make sure the voltage drop across it is minimum to prevent malfunction of the IC. R2 of 100 to 1K ohms will limit any current flowing into the REWET pin from the external capacitor C 1 in the event of REWET pin breakdown due to Electrostatic Discharge (ESD).
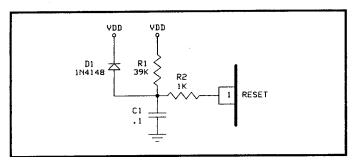
Figure 13. External Power Up Circuitry.

Oscillator Circuitry

A crystal must be connected to the OSC1 and OSC2 pins to establish oscillation for the IC to function, as shown in Figure 14. The crystal frequency must be 4 MHz and the value of the capacitors C 1 and C2 must be in the range of 15 to 33 pF. Higher capacitance increases the stability of oscillator but also increases the start-up time. These values are for design guidance only. Wince each crystal has its own characteristics, the user should consult the crystal manufacturer for appropriate values. For Vdd greater than 4.5 volts, C 1 and C2 of about 30 pF is recommended.
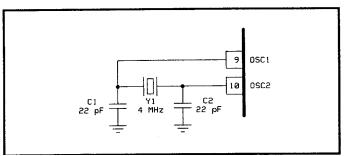

Figure 14. Crystal Oscillator Circuitry.

Connecting a Straight Key

Connecting a straight or manual key to the 8045ABM is more straightforward than the 8044 series. A manual key is simply connected to the MANUAL KEY pin as shown in Figure 15. R1 is a static current limiting resistor.
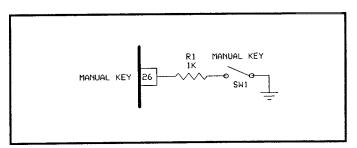

Figure 15. Manual Key Connection.

Message Memory

The 8045ABM has a built-in volatile memory of 85 units for storing a message for playback. Each normal character uses one unit of memory; only the rarely used 7-, 8- and 9-element (dots and dashes) characters require two units of memory. Characters with more than nine elements are ignored. Wince the memory is volatile, its content is erased when the keyer's power is turned off. If you want to preserve the memory content during power down, read the section titled "Nonvolatile Memory" on page 9.

Figure 16 shown the connections necessary for using the message feature of the 8045. R2 is a static current limiting resistor.
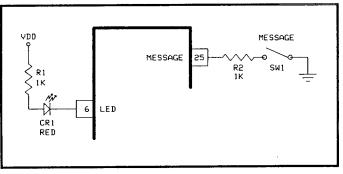

Figure 16. LED and Message Wwitch Connections.

The Message switch is used to record and play your message. To record a message, press and hold the Message switch until the keyer plays "GO" (dah-dah-dit dah-dah-dah) in Morse code and the LED flashes. You may now key in the message of your choice. As you pause after each word, the keyer will play a "W" (didah-dah) over the sidetone speaker to show that it is inserting a word break (uses one unit of memory). If you make a mistake entering a word, you can back up over it by briefly pressing and releasing the Message switch. The keyer will erase the last word, then play the word before it (if any) to let you know where you stopped. If deleting the first word of the message, the keyer will play "GO" instead. At the end of your message, press and hold the Message switch until the keyer sends an end of message character "+" (di-dah-didah-dit) and the LED stops flashing. When there are ten or less units of memory in the message remaining, the LED will flash faster to let you know the memory is running low. If you try to save more characters than you have memory, the keyer will automatically end your message and send you an end of message character.

To play the message, momentarily press the Message switch. On-going message can be stopped by tapping either paddle or pressing the Message switch.

The **WPEED** CONTROL, the WEIGHT CONTROL, the PITCH CONTROL and the KEYED OUTPUT pins are disabled during message recording.

Note: A straight or manual key cannot be used to record the message.

Embedded Commands:

While in the message recording mode you may use embedded commands for special features. To use an embedded command simply store the multi-character command code within your message.

Embedded Command	Represents
/D	Decrement—decrements the serial number. Serial number 0001 will wrap-around to 9999, skipping 0000 since it is not used. This feature allows a serial number to be sent twice in a message. Example: UR RST 559 559 SN /N /D SN /N
/G#	Gap—inserts a gap of # standard intra-character spaces into the message, where # is a digit in the range of 1 to 9 (0 can be used but not practical). Invalid numeral code will automatically default to zero. This command is used to exaggerate inter-character and word spacing.
/L	Loop—creates a message loop (message repeat). Note that any character recorded after "/L" will not be sent. Example: BEACON AA5CS 5 W /L
/N	Number—inserts a contest serial number, in the range of 001 to 9999, into the message. Only three digits are sent for numbers less than 1000--use leading zeros when appropriate. The serial number is automatically post-incremented each time it is sent (9999 will wrap-around to 0001). Example: YOU ARE CONTACT NR /N
/Pmmss	Pause—inserts a timed pause of *mm* minutes and *ss* seconds into the message. Four numbers must follow "/P". Invalid numeral code will automatically default to zero. Pauses greater than 99 minutes and 99 seconds are obtained by using consecutive commands that total the desired value. Example: TIMEOUT 1 HOUR /P6000 TIMEOUT 1.5 MIN /P0090 TIMEOUT 1 HR 40 MIN 39 SEC /P9999 TIMEOUT 2 HOURS /P6000/P6000
/R	Resume—suspends message playback to allow insertion of paddle entry. Once paddle sending is finished, press the Message switch again to continue the message.
/S	Space—inserts an extra standard word space into the message. This command yields the same result as "/G7" but uses one less unit of memory.
//	Slash character—stores the slash character "/" into the message.

Werial Number

A serial number in the range of 001 to 9999 can be inserted into the message. The ZEROS's and NINEW pins control the way zeroes and nines in the serial number are sent. Only three digits are sent for numbers less than 1000--use leading zeros when appropriate. The serial number is automatically post-incremented each time it is sent. Werial number 9999 will wraparound to 0001, skipping 0000 since it is not used.

The serial number is stored in volatile memory. If external *non-volatile* memory *is not* used, the serial number will reset to 0001 when the keyer powers on. 1f you want to preserve the serial number during power down, read the "Non-volatile Memory" section.

If a different serial number is desired, it must be programmed during power up. To initialize the serial number, press and hold the Message switch while turning the power on until the keyer plays "GO" (dahdah-dit dah-dah-dah) and the LED flashes. You must then enter *four* numbers in Morse code for a valid serial number, most-significant digit first (invalid numeral code will automatically convert to zero). All numbers must be in the proper Morse code format. For example, the number "1" must be "dit-dah-dah-dahdah" and the number "0" must be "dah-dah-dah-dahdah". When four numbers are entered, the keyer will automatically send an end of message character "+" (didah-di-dah-dit). The keyer then resumes with normal operation when the LED stops flashing. The serial number can be set from 0000 to 9999 (0000 will automatically convert to 0001).

Zeros and Nines:

The zeros and nines in the serial number can be set up to send in different ways. The leading zeros can be sent as "0" (dah-dah-dah-dah-dah), "0" (dah-dah-dah), "T" (dah) or not at all; the other zeros can be sent as "0", "O" or "T"; and the nines can be sent as "9" (dah-dahdah-dah-dit) or "N" (dah-dit). The ZEROS's and NINEW pins are used to configure how the zeros and nines in the serial number are sent. This is summarized in the table shown below.

Figure 17 shows zeros and nines circuitry for the 8045ABM. The ZEROS's and NINEW pins must always be connected either to Vdd or ground; however, connection to Vdd for the ZEROS's pins is not necessary because there are internal pull-up to Vdd on these pins.
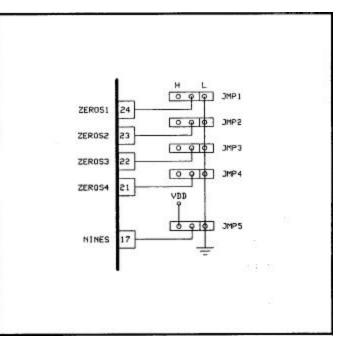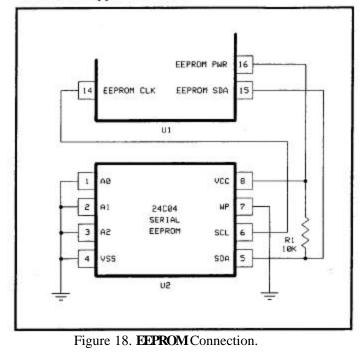

Figure 17. Zeros and Nines Connections.

ZEROS1 pin	ZEROS2 pin	Leading Zeros
Ground	Ground	none
Ground	Vdd	0
Vdd	Ground	O
Vdd	Vdd	T
ZEROS3 pin	**ZEROS4 pin**	**Other Zeros**
Ground	Ground	0
Ground	Vdd	0
Vdd	Ground	O
Vdd	Vdd	T
	NINES pin	**Nines**
	Ground	9
	Vdd	N

* The ZEROS's pins have internal pull-up to Vdd.

Non-volatile Memory

The built-in volatile memory can be replaced and expanded using an external 24C04 serial **EEPROM,** a non-volatile memory IC that does not require battery backup to preserve the recorded message. When nonvolatile memory is used, the serial number and the message are preserved even when the power to the keyer is disconnected. Also, the message memory capacity is increased to 507 units. If the serial number is changed during message playback, it is updated in the non-volatile memory when the message is finished. Therefore, the serial number is set to the same one as before when power on. If a different serial number is desired, it must be programmed during power up.

Figure 18 shows how to connect the EEPROM to the 8045. To reduce power consumption, power to the EEPROM is supplied by the EEPROM POWER pin, which powers up to Vdd when the non-volatile memory is accessed. The EEPROM's address pins A0, A1 and A2 must be connected to ground. RI serves as a pullup resistor for the open drain output SDA pin.

Figure 18. **EEPROM** Connection.

Simplest Possible Keyed Circuit

[riving only a solid state transmitter with a positive voltage keyline. An A/B jumper is included however he A/B SELECT pin could be wired either to Vdd or ;round if only A or B iambic (but not both) will be used. The Message switch and the LED can be omitted f the message memory will not be used.

'arts List for Simplest Possible Keyed

;1,C2,C3,C4,C5,	22 pF
C6,C7 ,8	0.01 ugh 10
;R1	ugh LED
)1 1	1N4007
2	Paddle Jack
MP I	RCA jack
	3 x 0.01" header
	2N7000 FET
	10K ohm pot
	10K ohm, 1/4 watt
	1K ohm, 1/4 watt
R4,R5,R6,R7	Latching switch
WW2	Momentary switch
U1 Y1	8045ABM keyer IC
	4 MHz crystal

Figure 19 shows the minimum number of parts for a very basic keyer. The keyer has no weight control, no sidetone generator and an output circuit capable of

Figure 19. Simplest Possible Keyer Circuit.