Building
and
Operating

The DC Beeper
from Jackson Harbor Press
A Morse code voltmeter / DC switch

The DC Beeper kit is a combination of a Morse code voltmeter with 20 mV resolution and a DC switch. The functions are accomplished using very little power. The DC switch can be actuated manually, automatically (to cutoff a connection to a battery below a certain voltage) or with a timer. The Morse voltmeter is read with a manual button press.

General notes on building the DC Beeper kit

U1, U2, Q1, Q2, Q3 and Q4 are all MOS devices. This means that they should be handled as little as possible to prevent static damage. The builder should use a grounding strap and anti-static mat if available or at the very least, work on a grounded metal surface and be sure to touch ground prior to touching these parts.

The pads and traces are small and delicate - a small tipped, low power (25 watts or less) soldering iron should be used.

Building the DC Beeper

Step 1) Get the parts together: All of the board mounted components have been supplied but you will still have to provide off-board items to fully implement the kit. These items are mentioned at the end of the kit parts list.

Step 2) Identify and orient the components: Most of the components should be fairly easy to identify and place, see the parts list and the parts placement diagram for descriptions. The orientation of the capacitor: C2 is especially important since it is a polarized (electrolytic) capacitor. C2 is a small yellow cap, the + side is marked on the slightly bumped out side of the cap. Be sure to match these polarity marks with the ones on the parts placement diagram and in the building procedure to follow.

Step 3) Form the leads, place and solder the components on the main circuit board: Use the parts placement diagram for information on the placement and orientation of the parts. Clip the leads of the parts after soldering.

a) 8 pin DIP socket - place it at the center of the board with the notch pointing up and solder in place.

b) R1, 10 k ohm resistor (brown, black, orange, gold). Place R1 as shown on the parts placement diagram, between the bottom edge of the DIP socket and the bottom edge of the circuit board and solder in place.

c) C1, .1 uF capacitor (marked 104, small yellow, .1" lead space). Place C1 as shown on the parts placement diagram, at the top of the DIP socket and solder in place.

d) C4, .1 uF capacitor (marked 104, small yellow, .1" lead space). Place C4 as shown on the parts placement diagram, at the top left corner of the circuit board and solder in place.

e) C3, .01 uF capacitor (marked 103, small yellow, .1" lead space). Place C4 as shown on the parts placement diagram, at the lower left corner of the circuit board and solder in place.

f) Q1, SMT MOSFET transistor (marked FR9120N). Place Q1 as shown on the parts placement diagram, at the right side of the circuit board. When the leads are centered on the traces, use something like a screwdriver or a toothpick to hold Q1 in place, another idea is to use an alligator clip to hold the transistor in place. Note that the "stub" lead located between the two formed legs on the MOSFET does NOT need to be soldered. Next, use a soldering iron to tack down one of the leads. Usually there is enough solder on both the board and part to allow this, if not, add a little extra solder to the tip of the iron and try again. Double check the lead alignment of the other two pins, it's easier to move the part (if needed) with only one lead soldered. If the other leads are OK, then solder them down to the board. Use solder wick to clean up any excess solder if necessary.

g) Q2, MOSFET transistor (marked 2n7000). Place Q2 as shown on the parts placement diagram, at the right of the DIP socket with the flat face right (towards Q1, soldered in the last step) and solder in place.

h) R3, 22 meg ohm resistor (red, red, blue, gold). Form the leads of R3 by bending one lead over 180 degrees to allow vertical mounting. Place R3 as shown on the parts placement diagram, at the top of Q2 (soldered in the last step) and solder in place.

i) Q3, MOSFET transistor (marked 2n7000). Place Q3 as shown on the parts placement diagram, at the left of the DIP socket with the flat face right (towards the DIP socket) and solder in place.

j) R5, 12 k ohm resistor (brown, red, orange, gold). Form the leads of R5 (a small, 1/8 watt resistor) by bending one lead over 180 degrees to allow vertical mounting. Place R5 as shown on the parts placement diagram, at the left of Q3 (soldered in the last step) and solder in place.

k) R6, 68 k ohm resistor (blue, gray, orange, gold). Form the leads of R6 (a small, 1/8 watt resistor) by bending one lead over 180 degrees to allow vertical mounting. Place R6 as shown on the parts placement diagram, at the left of Q3 and above R5 (soldered in the last step) and solder in place.

l) Q4, MOSFET transistor (marked BSS92). Place Q4 as shown on the parts placement diagram, at the top left corner of the DIP socket with the flat face left (away from the DIP socket) and solder in place.

m) R2, 1 meg ohm resistor (brown, black, green, gold). Form the leads of R2 by bending one lead over 180 degrees to allow vertical mounting. Place R2 as shown on the parts placement diagram, to the left of Q4 (soldered in the last step) and solder in place.

n) R4, 5 k ohm trim pot (blue and white trim pot marked 53C). Place R4 as shown on the parts placement diagram, to the left of R2 (soldered in the last step) and solder in place.

o) U2, Seiko 3V regulator (marked S812C30A). Place U2 as shown on the parts placement diagram, above of R2 (soldered in step m) with the flat face oriented towards R2 and solder in place.

p) C2, 2.2 uF yellow Tantalum capacitor. Place C2 as shown on the parts placement diagram, to the right of U2 (soldered in the last step) with the positive, bumped out side towards U2 and solder in place.

q) Solder the 9V battery snap (or other power input connector) to the ground and +Vin holes at the top left corner of the board. Positive (red) lead soldered to the top hole, the negative (black) lead soldered to the hole below the red lead, don't forget to add a power switch and/or fuse if necessary in series with the positive lead.

r) Solder the piezo speaker to the holes at the bottom right of U1, one wire to pin 5 of U1 and the other wire to ground.

s) Solder the switch to the holes at the bottom left of U1, one wire to R1 and the other wire to ground.

Step 4) Check the board: Before proceeding, take the time to check the top (mostly) and the bottom of the board for solder bridges. Use the parts placement and bottom view diagrams as a guide to visually check for these shorts. It may help to clean the flux from the board and then use a strong light in conjunction with a magnifying glass to see these problems. Also, double check the orientation of the critical components such as U1, U2, the transistors and the electrolytic cap C2. Here are some quick measurements that can be made to confirm that the board is working correctly:

Attach the negative lead of a DVM to ground, then use the positive lead to measure the resistance at the 8 pins of the open U1 IC socket.:

pin	resistance measurement
1	increasing megohms as the capacitors charge
2	infinity
3	about 12 k
4	increasing megohms as the capacitors charge
5	infinity
6	infinity
7	infinity
8	0

Next, try applying power (9 volts were applied for this test)

pin	voltage measurement
1	3.0
2	climbing voltage
3	1.3 (will vary per R4 trim pot position and state of pin 2)
4	3.0
5	climbing voltage
6	climbing voltage
7	climbing voltage
8	0

After you are convinced that the board is OK, form the leads of U1 (the 8 pin DIP PIC IC) and insert it into the 8 pin socket with pin 1 oriented towards the top edge of the board as shown on the parts placement diagram. Then connect the board to a battery or power supply using a VOM to measure the current used, current should be about .5 mA when first connected (during the FB) and then decrease into the microamp range, jumping up every couple of seconds into the tens of microamps. If it's much larger, power down and re-check the board for shorts and polarity problems.

Voltage measurements with the PIC inserted into the socket and power at 9 volts

pin	voltage measurement
1	3.0
2	0 (this will momentarily jump up every few seconds)
3	15 mV (will vary per R4 trim pot position and will jump up to 44 mV every few seconds)
4	3.0
5	0
6	3.0
7	3.0
8	0

If the DC Beeper is working correctly, the next step is to calibrate the voltage reading. Use a DVM to read the battery voltage, if using an adjustable power supply, adjust the voltage until the DVM reads to an even 20 mV (for example: 13.80 volts) because the DC Beeper has a resolution of 20 mV. Adjust R4 and readout the voltage with the DC Beeper until the DC Beeper agrees with the DVM.

Operation Notes: General notes on using the switch to control the kit: The switch can be pressed and released (PAR) OR pressed and held for two seconds (PAH). This allows the single switch to work both as a way of reading the battery voltage and turning on and off but also allows it to set the various parameters in the menus.

Generally, PAR is used for actions: send the voltage measurement. PAH is used for settings: change the speed. Note that the voltage readout is delayed by about 1 second after releasing the switch. This allows the switch to be double pressed (think the Morse letter I) to turn off the output (a short beep will be heard after turning off the output).

Powerup: Immediately after powerup the DC Beeper will send an FB through the sidetone to signal correct operation. If you don't hear the FB, power down the kit, then press and hold the switch for 5 seconds to discharge the bypass capacitors, then try powering up again.

The output will be on at powerup. To turn off the output, press and release the switch twice in a row within one second. To turn on the output and also readout the voltage, press and release the switch once. After the switch is released, the DC Beeper will wait a second (looking for the second off PAR) and then after the second is over, the voltage will be sent in Morse code. Note that the DC Beeper sends a D for the decimal point.

Operation: Normally the DC Beeper will be in a power down or "sleep" mode to save power. Approximately every 2.3 seconds, the DC Beeper will wake up, read the battery voltage (+Vin) and then compare this voltage to the pre-programmed trip level. If the voltage is less than the trip level (and if the output was turned on), the DC Beeper will turn off the output. The DC Beeper will then send a short beep to indicate the trip and will keep beeping every 2.3 seconds until the battery voltage exceeds the untrip (hysteresis) level programmed. The output will then be turned back on.

Also, if the timer has been turned on, the DC Beeper will compare the elapsed time to the timeout value IF the output is currently on. When the elapsed time exceeds the programmed limit (multiples of about 10 minutes) the DC Beeper will turn off the output. To turn on the output and restart the timer, PAR the switch (the voltage will then also be sent in Morse code).

To enter the menu, press and hold the switch for 2 seconds until you hear the Sxx (where xx is the current speed), then release the switch. Note that while in the menu at any point, if you wait more than about 13 seconds, the DC Beeper will automatically exit the menu and enter the power down mode.

The menu settings are stored in EEPROM and will be retained even if the power is disconnected. To restore the default settings:

1) disconnect the battery
2) press and hold the switch
3) turn on the power
4) release the switch when FB is sent

Switch menu (PAR switch to advance to the next menu item)

	Menu item	PAH switch
S xx	Morse speed (XX) default is 15 WPM	increase the Morse speed by 1 step
TO aa	Time Out on/off , default off	toggle the current setting
DM x	Delay Multiple, default 1	increase the delay multiple by 1
TRxxDxx	voltage trip level, default setting is 12D00	Set a new trip level
UxxDxx	voltage untrip level, default setting is 12D90	Set a new untrip level

Sxx: - after an initial 2 second switch press the DC Beeper will enter the Speed set menu item S. The default speed is 15 wpm. The user can select any speed from 5 to 35 wpm in the 10 step (ARRL) sequence (5, 7.5, 10, 13, 15, 18, 20, 25, 30 and 35 wpm). To increase to the next speed in the sequence, PAH the switch for two seconds until the DC Beeper responds with S 18 (or whatever the next speed value is). After 35 wpm, DC Beeper will “wraparound” to 5 wpm. If the switch is held down, the DC Beeper will step through the incrementing speeds - when the desired speed is reached, release the switch.

TO - Time Out: The DC Beeper contains a rough timer with a basic period of about 10 minutes. The timer is off by default. To enable this timer, PAH the switch. The DC Beeper will then send TO ON to signify that the timer is now on. To toggle the timer off, PAH the switch again, the DC Beeper will then send TO OFF. To skip to the next menu item, PAR the switch. When the timer period is complete, the DC Beeper will turn off the output and also emit a short beep. This timer allows the DC Beeper to function as a battery saver.

DM - Delay Multiplier: The Delay Multiplier menu item allows the user to specify the number of approximate 10 minute periods to wait before turning off the output. The possibilities are 1, 2, 3, 6 or 12 for 10, 20, 30, 60 or 120 minutes of delay time. The delay multiplier is 1 (one) by default, resulting in a 10 minute approximate delay. To increase the multiplier, PAH the switch. The DC Beeper will then send DM 2 to signify that the delay multiplier is now 2. Increasing the delay multiplier above 12 will “wraparound” back to a delay multiplier of 1. To skip to the next menu item, PAR the switch. If the switch is held down, the DC Beeper will step through the incrementing delay multipliers - when the desired multiplier is reached, release the switch.

TR xxDxx (Voltage trip level): The voltage trip level defaults to the 12D00 (or 12.0 volts) level read out when the menu is entered. The DC Beeper will measure the battery voltage approximately every 2.3 seconds and then compare that measurement to the trip level. If the battery voltage is below the trip level, the DC Beeper will turn off the output and then start sending a series of beeps each 2.3 seconds to signify that the trip has happened. Clear the trip by increasing the battery voltage (by re-charging or replacing the battery) above the untrip level.

To change the trip level, PAH the switch for two seconds until you hear the DC Beeper play: T 1 which means that the tens digit of the trip value is now 1 (ten volts). To change the tens digit to a 0 (zero volts), PAH the switch until the DC Beeper sends: T 0. To revert the tens digit back to a 1 (ten volts), PAH the switch until the DC Beeper sends T 1. To skip to the ones digit set, PAR the switch.

The DC Beeper will then play: O 2 which means that the ones digit of the trip value is now 2 volts. To increase the ones digit to a 3 (three volts), PAH the switch until the DC Beeper sends: O 3. The ones value can be increased digit by digit until after 9, the DC Beeper will wrap the ones around to 0. To skip to the tenths digit set, PAR the switch.

The DC Beeper will then play: D 0 which means that the Decimal (tenths) digit of the trip value is now 0.0 volts. To increase the decimal (tenths) digit to a 1 (point one volts), PAH the switch until the DC Beeper sends:

D 1. The decimal (tenths) value can be increased digit by digit until after 9, the DC Beeper will wrap the decimal (tenths) around to 0. To skip to the hundredths digit set, PAR the switch.

The DC Beeper will then play: H 0 which means that the hundredths digit of the trip value is now .00 volts. To increase the hundredths digit to a 2 (point zero two volts, the DC Beeper has a 20 mV resolution so the hundredths must be incremented by 2), PAH the switch until the DC Beeper sends: H 2. The hundredths value can be increased by two hundredths until after 8, the DC Beeper will wrap the hundredths around to 0. To skip to the next menu item and write the new trip value to eeprom, PAR the switch. Note that if one of the digit set menus times out (no button activity in 13 seconds) the DC Beeper will exit the routine WITHOUT changing the trip value.

<u>U xxDxx ("Untrip" voltage level):</u> The voltage "untrip" level defaults to the 12D90 (or 12.9 volts) level read out when the U menu is entered. After a trip has happened, the DC Beeper will continue to measure the battery voltage approximately every 2.3 seconds but then it will compare that measurement to the untrip level. If the battery voltage is below the untrip level, the DC Beeper will continue sending a series of beeps each 2.3 seconds to signify that the trip has happened. Clear the trip by increasing the battery voltage (by re-charging or replacing the battery) above the untrip level. The idea of the untrip (hysteresis) test after a trip is to prevent an oscillation condition where the voltage of the battery will increase when the output is switched off and clear the beep sends. So normally the untrip value should be set well above the trip value or any alarm beeping of the DC Beeper will be cleared immediately and the output will get turned on).

To change the untrip level, PAH the switch for two seconds until you hear the DC Beeper play: T 1 which means that the tens digit of the untrip value is now 1 (ten) volts. To change the tens digit to a 0 (zero volts), PAH the switch until the DC Beeper sends: T 0. To revert the tens digit back to a 1 (10 volts), PAH the switch until the DC Beeper send T 1. To skip to the ones digit set, PAR the switch.

The DC Beeper will then play: O 2 which means that the ones digit of the untrip value is now 2 volts. To increase the ones digit to a 3 (three volts), PAH the switch until the DC Beeper sends: O 3. The ones value can be increased digit by digit until after 9, the DC Beeper will wrap the ones around to 0. To skip to the tenths digit set, PAR the switch.

The DC Beeper will then play: T 9 which means that the tenths digit of the untrip value is now 0.9 volts. To wrap the tenths digit to a 0 (point zero volts), PAH the switch until the DC Beeper sends: T 0. The tenths value can be increased digit by digit until after 9, the DC Beeper will wrap the tenths around to 0. To skip to the hundredths digit set, PAR the switch.

The DC Beeper will then play: H 0 which means that the hundredths digit of the untrip value is now .00 volts. To increase the hundredths digit to a 2 (remember that the hundredths digit is always a multiple of 2 due to the 20 mV resolution of the DC Beeper), PAH the switch until the DC Beeper sends: H 2. The hundredths value can be increased by two hundredths until after 8, the DC Beeper will wrap the hundredths around to 0. To exit the menu and write the new untrip value to eeprom, PAR the switch. Note that if one of the digit set menus times out (no button activity in 13 seconds) the DC Beeper will exit the routine WITHOUT changing the trip value.

<u>Modification ideas:</u>

1) If desired, the output transistor doesn't have to be used. The DC Beeper can just be connected to the battery and used strictly as a voltmeter.

2) Change the surface mount p channel MOSFET output transistor switch to a through hole TO-220 p-channel MOSFET transistor with a lower on-resistance. The IRFR9010 supplied with the kit is rated at 5.3 A and 50V with a typical on-resistance of 0.35 ohms. So, at a current of 1A, the drop across the transistor would be about 0.35 volts. A more expensive TO-220 P channel MOSFET transistor would have a lower resistance and thus a lower voltage drop when switching higher currents. Note that the three holes below Q1 can be used to connect to most P channel MOSFETs in the TO-220 package.

3) Increase the input impedance of the voltmeter by using an external amplifier (op-amp connected as a voltage follower, connect the minus input to the output and the plus input to the voltage to be measured, then connect the op-amp output to the 5k pot, removing the BSS92 connection. This would also allow the measurement of voltages lower than the regulator supply voltage (3 volts). Note that the op-amp should be a low offset, rail-to-rail type for best results.

4) Add a momentary switch between pin 6 of the PIC (via the unused pad between the ground lead to the piezo and the surface mount MOSFET) and ground. A PAR of this switch will readout the voltage, turn on the output and if the timer is enabled, start an approximately 1 minute long delay.

Please feel free to email with any questions, comments, suggestions or problems with the DC Beeper kit. Email to: `jacksonharbor@att.net`

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DC BEEPER parts list

Qty.	Ref.	Part Name	Description
1	U1	12F675	DC BEEPER 8 pin PIC DIP chip
1	U2	Seiko 3V reg.	S812C30A TO-92 3V regulator
1	Q1	SMT MOSFET	IRFR9010 Surface mount p channel MOSFET
2	Q2,3	2n7000	TO-92 n channel MOSFET
1	Q4	BSS92	TO-92 p channel MOSFET
2	C1,4	.1 uf	.1” lead space, radial multi-layer ceramic capacitor
1	C3	.01 uf	.1” lead space, radial multi-layer ceramic capacitor
1	C2	2.2 uf	Tantalum capacitor
1	R1	10 K ohm	Brown black orange gold - 1/4 watt carbon film resistor
1	R2	1 meg ohm	Brown black green gold - 1/4 watt carbon film resistor
1	R3	22 meg ohm	Red red blue gold - 1/4 watt carbon film resistor
1	R4	5 k ohm trim pot	53C blue & white cermet trimmer resistor
1	R5	12 k ohm	Brown, red, orange, gold - 1/8 watt carbon film resistor
1	R6	68 k ohm	Blue, gray, orange, gold - 1/8 watt carbon film resistor
1	-	socket	8 pin DIP socket
1	-	PCB	DC BEEPER circuit board

The following items are ***NOT*** included with the kit:

1	9V snap or other battery connector
1	Piezo transducer (high impedance speaker)
1	normally open, momentary SPST switch

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