Building and Operating:          Mcount Morse code counter kit
                                                  from Jackson Harbor Press

Introduction:

The Mcount is a frequency counter with Morse code output.  It includes an on-board prescaler option to extend the counter range above the usual 50 MHz specified for PIC based counters.

General notes on building the Mcount kit

The integrated circuits (U1 and U3) are CMOS 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 the ICs.

One decision the builder should make before starting construction of the Mcount kit is how the project will be mounted in the case.  If the Mcount will be used standalone, a candy tin will work fine.  If the Mcount will be used as a digital dial in a QRP transceiver, it can probably fit into the case of the radio.

The kit is surface mount mainly due to the fact that the prescaler IC is  only easily available in a surface mount package (8 pin SO).  The passive components are small (1206 sized, 12 hundreths of an inch by 6 hundreths of an inch) but not too small.  The 5 volt regulator is a normal TO-92 leaded part.

The components should be inserted a few at a time, soldered in place and then clip the leads.  The pads and traces are small and delicate - a small tipped, low power (25 watts or less) soldering iron should be used.

The use of good quality desoldering braid or solder wick is suggested for cleaning up any short circuits between the IC leads.  The cheap stuff isn't worth the trouble.  I use the no-clean SODER WICK from Chemtronics, available from Digi-key.

Building the Mcount

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 include:

Input connector
metal case,   an Altoids or other candy tin will work fine
mounting hardware, 4-40 sized
piezo speaker
momentary switch
power switch
9V battery "snap" or other power connector

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 electrolytic cap is clearly marked for polarity - be sure to orient the negative stripe correctly per the parts placement diagram.  The yellow trimmer cap should be inserted with the flat side towards U3 (the middle of the board).  This will make it easier to adjust the capacitor since the exposed metal will be at ground potential. The ceramic capacitors are unmarked so keep them in the marked holders until ready to place them on the board.  The resistors are marked but you may need to use a magnifying glass to see the markings clearly.  On the top of the 8 pin SO prescaler IC a stripe is marked on the pin1+ pin 8 end of the device.  Pin 1 is undistinguished on the 74HC00 SOIC but when the marking on the part is readable, pin 1 and 14 are at the left end of the part.

step 3) 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 after soldering. I would recommend that the builder insert parts by their profile (or height) above the circuit board starting with the lowest and working up.

a)  C4, a .1 uF 1206 sized capacitor.  Be certain that you have the .1 uF cap and not one of the 1000 pF caps.  Place C4 as shown on the parts placement diagram, at the mid-lower right of the circuit board.  When the leads are centered on the traces, use something like a screwdriver, tweezers,  toothpick or some other hold-down to keep C4 in place.  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  pin, it's easier to move the part (if needed) with only one lead soldered.  If the other lead is OK, then solder it down to the board.  Use the solder wick to clean up any excess solder.

 Note:  C5, R2, R3, C2, U2 are only mounted if the optional prescaler was purchased

b)  C5, the other .1 uF capacitor.  Place C5 as shown on the parts placement diagram, to the below left  of  C4 and solder in place.

c)  R2, 820 ohm  1206 sized resistor (black, marked 821).  Place R2 as shown on the parts placement diagram, to the left  of  C5 and solder in place.

d) R3, 51 ohm 1206 sized resistor (black, marked 510). Place R3 as shown on the parts placement diagram, to the top left of R2 and solder in place.

e) C2, 1000 pF 1206 sized capacitor. Place C2 as shown on the parts placement diagram, to the right of R3 and solder in place.

f) U2, the SO packaged IC. place it down on the board per the diagram with the white striped end towards the top of the board. Adjust the leads until they all are aligned correctly with the pads on the board, then hold the part down while tack soldering one corner pin. Double check the alignment of the other pins and if they are OK, solder the rest of the pins down to the board. Don't worry if there are solder bridges, just use the solder wick to clean them up after you have soldered all the leads.

g) C3, 1000 pF 1206 sized capacitor. Place C3 as shown on the parts placement diagram, to the right of U2 and solder in place.

h) C1, 1000 pF 1206 sized capacitor. Place C1 as shown on the parts placement diagram, to the right of C5 and solder in place.

i) R1, 24k ohm 1206 sized resistor (black, marked 243). Place R1 as shown on the parts placement diagram, below C1 and solder in place.

j) U1, the 14 pin SO packaged IC. place it down on the board per the diagram with the pin 1 end towards the top of the board. Pin 1 is hard to identify with this part, but there is a Philips corporate logo on the pin 1 end of the part - when the part number can be read, pin 1 is the leftmost pin. Adjust the leads until they all are aligned correctly with the pads on the board, then hold the part down while tack soldering one corner pin. Double check the alignment of the other pins and if they are OK, solder the rest of the pins down to the board. Don't worry if there are solder bridges, just use the solder wick to clean them up after you have soldered all the leads.

k) DIP socket - should be inserted with the notch towards the top side of the board and soldered in place.

l) R5, 470 ohm resistor (yellow, violet, brown, gold). Insert to the right of the socket and solder in place and then trim the leads.

m) R4, 10k ohm resistor (brown, black, orange, gold). Insert to the left of the socket and solder in place and then trim the leads.

n) C6, 27 pF ceramic NPO disk capacitor (marked 27). Insert on the left side of the board and solder in place and then trim the leads.

o) C8, .1 uF ceramic capacitor (marked 104). Insert above the socket and solder in place and then trim the leads.

p) C9, .1 uF ceramic capacitor (marked 104). Insert at the top left of the board and solder in place and then trim the leads.

q) C7, 7-40 pF trimmer capacitor (yellow). Insert below and right of C9 with the flat side towards the socket and solder in place.

r) C10, 22 uF electrolytic capacitor Insert above C8 at the top of the board with the negative stripe side towards the right side of the board and solder in place and then trim the leads.

s) U4, the 78L05 5 volt regulator IC - place U4 to the right of C9 at the top edge of the board with the flat side of U4 towards the top of the board . Solder U4 in place and then trim the leads.

t) X1, the 4 MHz crystal - place X1 below the yellow trimmer cap. Solder X1 in place and trim the leads.

u) Connect the 9V battery snap (or other power input connector to the ground and +Vin holes on the top left side of the board, don't forget to add a power switch if necessary in series with the positive lead.

v) Connect the piezo speaker to the ground and piezo holes on the right of the socket (with the JHP supplied piezo, connect the black wire to ground, the red wire to the piezo board hole, the blue wire is unused).

w) Connect the switch to the ground and readout switch holes on the left side of the board.

x) If desired, solder the 3 jumper pin sockets to the board at the prescaler input, prescaler output and normal input holes. Then pieces of small solid wire can be used to jumper between the prescaler output and normal input OR from the input jack to the prescaler input OR from the input jack to the normal input. The pin sockets may need to be cut apart from each other with a diagonal cutter.

y) Connect the input and output signal jacks. You may want to just use a short piece of wire as an antenna for the prescaler input.

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 the integrated circuits, the electrolytic capacitor and the yellow trimmer cap. After

you are convinced that the board is OK, form the leads of U3 to fit in the socket, insert the U3 in the socket, being sure to follow the parts placement diagram for proper orientation (pin 1 indicated by a notch or dimple should be towards the top edge of the board. Then connect the board to a 9V battery using a VOM to measure the current used, current should be less than 15 mA with no input signal present, if it's larger, or if it's too low (should be over 2 ma) power down and re-check the board for shorts and polarity problems.

If the current is relatively low, power down and then place the board into the case. At any subsequent power up the Mcount should send an FB to let you know it is working.

The Mcount requires one adjustment, C7, the yellow trimmer capacitor should be adjusted so that the 4 MHz PIC oscillator is exactly on frequency. One way to do this is to use the C menu item described below. Another way is to use the Mcount to measure a known frequency source which been calibrated to a reference such as WWV.

But, don't try to use another counter to measure the 4 Mhz PIC clock frequency. for one thing, this is almost impossible to do since the PIC in the Mcount is usually "sleeping" (the 4 MHz clock is turned off). Also, even if the PIC clock is operating (such as in the calibrate mode), the added capacitance of a counter probe to the crystal oscillator will change the frequency observed. It's much better to measure the calibrate output on the piezo pin when in the C mode or to use the Mcount and another accurate counter to both measure the same frequency at the same time and adjust the Mcount yellow capacitor until the Mcount "display" agrees with the other counter.

Operation:

To read the frequency, press and release (PAR) the switch. Mcount will then send a dit-dit to indicate the start of the gate period and follow by sending the frequency after the gate period is complete. Note that a dah is sent to separate the MHz digits from the kHz digits (two dahs are sent when cut numbers are used) and a dit is sent to separate the kHz digits and the Hz digits.

If desired, the frequency play can be stopped after the current character with a switch PAR.

The Mcount uses a one switch action/menu system. To perform an action (mainly reading out the frequency, but also moving between menu items and killing a frequency play) a PAR will perform the action. To enter a menu or change a menu item, press and hold (PAH) the switch for 2 seconds and release the switch when the piezo sends a response. In general, N means the item is oN, F means the item is oFf.

To change the current setting, PAH the switch until the Mcount sends the next setting.

PAR the switch to skip to the next menu item.

If the switch is unpressed for about 12 seconds, the Mcount will exit the menu and go to sleep.

As the menus are very long, one quick way to exit the menu is to power cycle the Mcount, (turn off the power and then turn it back on again). The settings are saved in eeprom so are unaffected when the power is turned off.

One easy way to confirm operation of the Mcount (if you have the optional prescaler)is to connect the prescaler input to some wire and then key an HT or FRS radio and see what the counter reads.

Default settings are provided for all menu items. If required, the Mcount can be reset to the defaults by:
1) powering the Mcount down.
2) press and hold the switch
3) power up the Mcount
4) release the switch when FB is sent

| Switch Menu item | Default | Option |
|---|---|---|
| L  (Long gate time) | N (oN) | F (oFf) sets the gate time to .1 second |
| S  (Speed set) | 15 wpm | 18, 20, 25, 30, 35, 5, 7, 10, 13 wpm, |
| P  (Prescale "display" option) | F (oFf) | N (oN)  turns on the prescale "display" |
| SS  (Sidetone Set) | 440 Hz | 494, 523, 587, 659, 698, 784, 880, 988, 1046, 247, 262, 294, 330, 349, 392 Hz |
| DL  (Display Low order digit) | 1 | 2, 3, 4, 5, 6, 7, 1 |
| DH  (Display High order digit) | 8 | 7, 6, 5, 4, 3, 2, 1, 8 |
| CN (Cut Numbers option) | F (oFf) | N (oN) turns on cut number play |
| CA  (calibrate counter, exit with power off) | | L sent before entering loop |

| O  (Offset mode) | F (oFf) | P, M, B, F |
|---|---|---|
| I HM  (IF set, Hundred Megahertz digit) | 0 | 0 - 9 |
| TM  (Ten Megahertz digit set) | 0 | 0 - 9 |
| M  (Megahertz digit set) | 9 | 0 - 9 |
| HK  (Hundred Kilohertz digit set) | 0 | 0 - 9 |
| TK  (Ten Kilohertz digit set) | 0 | 0 - 9 |
| K (Kilohertz digit set) | 0 | 0 - 9 |
| H (Hundred hertz digit set) | 5 | 0 - 9 |
| T  (Ten hertz digit set) | 4 | 0 - 9 |

L - after the Switch button is held for 2 seconds, the Mcount will send L and then it will send the current setting either N for oN or F for oFf.  LN refers to the Long gate time of 1 second which allows the Mcount to measure to a resolution of 1 Hz.  LF refers to a gate time of 0.1 second which has a resolution of 10 Hz.  Note that when any of the Offset modes are in use, Mcount will automatically be switched to the shorter 0.1 second gate time.

S  - after the L menu item, Mcount 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 code practice sequence.  PAH the switch to increase to the next speed in the sequence.  After 35 wpm, Mcount will "wraparound" to 5 wpm.

P  - after the S menu item, Mcount will enter the Prescale on/off menu item P.  The default setting  is prescaler oFf or PF.  The user can turn on the Prescaler display mode with a PAH of the switch or PAR to the next item.  Note that this menu item just moves the dah separating the MHz digits from the kHz digits and the dit separating the kHz digits and the Hz digits one digit to the left.  It does not electrically turn on the prescaler IC, that will always be on if it is installed..

The Mcount menu items DL and DH are used to limit the number of digits sent by the Mcount when it is being used as a digital dial for a QRP rig or possibly when it is being used to match components like crystals by measuring an oscillator frequency.  Hopefully this saves the user time when either the upper or lower digits are always the same or aren't of interest.

SS  - after the P menu item, Mcount will enter the Sidetone Set menu item SS. The currently programmed sidetone frequency will then be sent (keydown).  The user can select any of 16 sidetone frequencies: 494, 523, 587, 659, 698, 784, 880, 988, 1046, 247, 262, 294, 330, 349, 392 and the default 440 Hz.  PAH the switch to increase the sidetone frequency to the next tone in the sequence.  After 1046 Hz, Mcount will "wraparound" to 247 Hz.  The tones are approximately equal to the notes of the musical scale from B3 to C6.

DL  - after the SS menu item, Mcount will enter the Display Low digit set menu item DL.  When the Mcount sends a frequency, the first digit sent (leftmost) is numbered as 8.  The last or rightmost digit is numbered as 1 The default setting  for Display Low digit is 1 sent as DL1 .  The user can change DL, increasing it by 1 digit (moving the last digit played one digit left) with a PAH of the switch.  When the digits exceed 7, Mcount will "wraparound" back to 1.  Yes, it is possible to setup a nonsense situation where the rightmost digit is higher in number than the leftmost digit and thus nothing is sent (other than the starting dit).  Also note that the digits not sent when DL is increased are truncated, no rounding is performed on the digits being sent.

DH  - after the DL menu item, Mcount will enter the Display High digit set menu item DH. The default setting  for Display High digit is 8 sent as DH8 .  The user can change DH, decreasing it by 1 digit (moving the first digit played one digit right) with a PAH of the switch.  When the digit goes  below 1, Mcount will "wraparound" back to 8.

CN  - after the DH menu item, Mcount will enter the CN for Cut Numbers menu item.  The default setting  is Cut Numbers  oFf or CNF.  The user can turn on the Cut Numbers display mode  (CNN) with a PAH of the switch.  PAR the switch  to proceed to  the next menu item or wait 12 seconds to exit the menu.  The Cut Numbers are shorter versions of the normal Morse numbers where letters are substituted for the longer numbers.  Here is the  Cut Number table:

number  cut number
0        T
1        A
2        U
3        W
4        V
5        S
6        B
7        G

8          D

9          N

   Note that this menu item also changes  the dah separating the MHz digits from the kHz digits to a dahdah to distinguish between that and a zero (T)

CA  -  after the CN menu item, Mcount will play CA for CAlibrate.  If the switch is PAH, Mcount will send an L and then enter an infinite loop, the only way to exit this is to turn off the Mcount.  While in the infinite loop the Mcount will output a 250 kHz signal on the piezo output.  The user will probably want to disconnect the piezo during calibrate since the capacitance of the piezo will distort the output waveform so that it is unusable.  The user can then either measure the 250 kHz signal with another calibrated counter or use it as a crystal calibrator against a signal source such as WWV.  The yellow variable capacitor can be adjusted until the oscillator is zerobeat the harmonics of the 250 kHz signal against WWV at 5, 10 or 15 MHz or until the other calibrated counter reads 250 kHz.

O  -  after the C menu item, Mcount will enter the Offset mode set menu item O. The default setting  for Offset modet is oFf sent as OF .  The user can change O, cycling through the 4 possible modes (oFf, Plus, Minus, Backwards) with a PAH of the switch.  When the digit goes  past B, Mcount will "wraparound" back to F.  Plus indicates that Mcount will display a frequency derived by adding the measured frequency to the IF frequency set in the following menu item.  Minus indicates that Mcount will display a frequency derived by subtracting the IF frequency set in the following menu item from the measured frequency.  Backwards indicates that Mcount will display a frequency derived by subtracting the measured frequency from the IF frequency set in the following menu item.  Note that if the P, M or B selections are made, the L menu item will be set oFf to a 0.1 second gate time.  This was done to allow quick checks of frequency when the Mcount is used as a digital dial in a QRP or other ham radio.  When using the Mcount as a digital dial it'll be necessary to connect the normal input to the output of the rig VFO.  With some QRP rigs such as the OHR100a, this will be quite easy as a buffered source of the VFO is brought out to a connector on the back panel of the rig.  With other rigs, the user may need to get out the schematic and find the best place to tap into the VFO.  An additional buffer amplifier may be needed for best results.

I  HM  -  after the O menu item, Mcount will enter the offset frequency set menu item I  HM. The default setting  for the first digit (Hundred Megahertz)  is 0 sent as HM0 .  The user can change HM, cycling through the the digits 0 to 9 with a PAH of the switch.  A PAR will advance to the TM (Ten Megahertz), M (Megahertz), HK (Hundred Kilohertz), TK (Ten Kilohertz), K (Kilohertz), H (Hundred hertz) and finally T (Ten hertz).  Each of these digits are set in the same way, increasing from 0 through 9  with a PAH of the switch.  Mcount is preset to a frequency of 00900054 for my OHR100a 40 meter rig.  Generally, the offset frequency is roughly equal to the IF (Intermediate Frequency) of the QRP rig in question modified by the audio offset frequency setting of the QRP rig.  One way to calculate the correct IF frequency is to tune the rig to a station of known frequency such as W1AW.  Then measure the VFO frequency of the rig using the Mcount (offset mode OFF).  Then using a little arithmetic, the IF frequency can be calculated by either adding the known station frequency to the VFO frequency or by subtracting them in either of the two ways.  The manual for the  QRP rig should provide the details on which mixing scheme is used.  A direct conversion rig may just require a small audio (usually less than 1000 Hz) offset while a superhet rig will usually be a number hundreds of kilohertz or above.

Gotchas:

The normal input of the Mcount uses a 74HC00 NAND gate as what I think of as a conformable oscillator.  Without a significant input, the gate can oscillate at a rate determined by the 24k ohm feedback resistor and the stray capacitance of the circuit.  One consequence of using a regular NAND gate is that it doesn't work well with low frequency  (audio) sine wave signals because the slowly rising/falling waveforms can cause multiple transitions on the output of the NAND gate as the signal passes through the switching threshold of the gate.  If the gate were a normal DIP in a socket, it would be easy to replace it with a 74HC132 NAND gate with hysteresis, but since the Mcount uses an SMT part, any use of the Mcount at audio should probably be done with an external amplifier that can change the input signal into a fast rise/fall time square wave.

If the normal input is used above 50 MHz, the Mcount will NOT output a frequency, use the prescaler input for frequencies greater than 50 MHz.

For the prescaler, please note that the input 50 ohm resistor is only 1/4 watt, so don't connect the Mcount prescaler input directly to a high power source of RF.

It is normal for the prescaler to output a frequency when the input is unconnected.  My prescaler does this at roughly 20 Mhz.  If this bothers you, Earl, N8ERO, suggested this fix for the standalone prescaler kit which uses the same prescaler IC, add a 100 k ohm resistor across capacitor C3. This results in slightly lower sensitivity for the prescaler.

Modification ideas:

1)  A series diode from the power switch to the circuit board will prevent reverse polarity problems which could easily damage U4, the 5 Volt regulator.  I like to use the BAT42 or 1n5817 Schottky diodes for this as they have a low forward voltage drop.

2)  For the normal input: an external FET input circuit will increase the input impedance of the normal input of the counter.

3)  A double pole switch can be used to select either the prescaler output or an external input for the normal input of the counter. Alternatively, the supplied pin sockets can be used with pieces of solid wire to either jumper between the normal input and the prescaler output or to connect the normal input directly to the circuit being measured.

4)  an ON/OFF switch: especially if you are using a 9V battery as a power source, it won't last long connected to the Mcount.  One other idea would be to use a battery saver circuit such as the kit of the same name from Jackson Harbor Press.  If the kit is being used without the prescaler, a lower power regulator such as the LM2936 might also be used to minimize standby power, this type of regulator will require a different cap at C10, a 2.2 uF, 16 V tantalum.cap is what I usually use.

5)  For the Prescaler input:  an input amplifier - if the sensitivity of the Mcount is not high enough, for your application, one of the new 50 ohm, MMIC super wide band amplifiers might be appropriate, connected to the prescaler input of the Mcount.

6)  For possibly better stability of the PIC 4 Mhz oscillator and maybe an easier adjustment, the yellow variable cap (C7) could be replaced by a parallel combination of a smaller value variable cap and a parallel NPO cap (mounted in the two holes next to C8).

Please feel free to email with any questions, comments, suggestion or problems with this kit.  My email address is:

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Thanks for choosing the Mcount kit and best regards,

Chuck Olson, WB9KZY                                             Copyright 2005 by Charles J. Olson

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List of parts included with the Mcount kit

| Ref | marking | Description |
| ----- | ----------- | ----------------- |
| C1 | | 1206 sized 1000 pF multi-layer ceramic capacitor |
| C2 | | 1206 sized 1000 pF multi-layer ceramic capacitor (for optional prescaler) |
| C3 | | 1206 sized 1000 pF multi-layer ceramic capacitor (for optional prescaler) |
| C4 | | 1206 sized .1 uF multi-layer ceramic capacitor |
| C5 | | 1206 sized .1 uF multi-layer ceramic capacitor (for optional prescaler) |
| C6 | 27 | 27 pf, NPO ceramic radial capacitor, .1" lead space |
| C7 | | yellow, 7-40 pF ceramic trimmer capacitor |
| C8 | .1M or 104 | .1 uf multilayer ceramic .1" lead space cap |
| C9 | .1M or 104 | .1 uf multilayer ceramic .1" lead space cap |
| C10 | 22 uF | 22 uF electrolytic capacitor |
| R1 | 243 | 24 k ohm, 1206 sized resistor |
| R2 | 821 | 820 ohm, 1206 sized resistor   (for optional prescaler) |
| R3 | 510 | 51 ohm, 1206 sized resistor   (for optional prescaler) |
| R4 | brown, black,orange, gold | 10 k ohms 1/4 watt resistor |
| R5 | yellow, violet, brown, gold | 470 ohms 1/4 watt resistor |
| U1 | 74HC00 | 14 pin SO, quad NAND gate |
| U2 | 12080 | MC12080. 8 pin SO, ECL prescaler   (for optional prescaler) |
| U3 | 12F629 | 8 pin DIP, programmed PIC microcontroller |
| U4 | 78L05 | TO-92, 5 Volt regulator, 3 pin |
| X1 | 4.00 | 4 Mhz, HC-49 crystal |
| | | 8 pin machined pin socket (for  U3) |
| | | 3 pin sockets for the prescaler input & out and normal input |
| | | circuit board |

Items you'll need to provide to complete the Mcount kit

| | Metal case (an Altoids tin is fine) |
| --- | --- |
| | Misc. 4-40 sized mounting hardware |
| | 9V battery snap connector OR other power connector |
| SW | SPST momentary readout switch |
| | input connector, RCA jack |
| | solder, wire, good quality desoldering braid |
| | piezo speaker |
| | power switch (optional but recommended for 9V battery users) |