Building and Operating: Mcount2 Morse code counter kit
from Jackson Harbor Press

Introduction:

The Mcount2 is a frequency counter with Morse code output. It replaces the original Mcount which had an on-board prescaler option. The Mcount2 also eliminates the use of surface mount parts. The Jackson Harbor Press Prescaler kit can be used to add counting capability above 50 MHz.

General notes on building the Mcount2 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 Mcount2 kit is how the project will be mounted in the case. If the Mcount2 will be used standalone, a candy tin will work fine. If the Mcount2 will be used as a digital dial in a QRP transceiver, it can probably fit into the case of the radio.

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 Mcount2

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.

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) 14 pin DIP socket (for U1). Insert the socket as shown on the parts placement diagram at the bottom right of the board with the notch (pin 1 end) of the socket to the right and solder in place.

b) 8 pin DIP socket (for U3) – Insert the socket as shown on the parts placement diagram at the top right of the board with the notch (pin 1 end) towards the top edge of the board and solder in place.

c) C4, a .1 uF ceramic capacitor (marked 104). Insert C4 as shown on the parts placement diagram, to the left of U1, solder in place and then trim the leads.

d) C1, a .01 uF ceramic capacitor (marked 103). Insert C1 as shown on the parts placement diagram, above C4, solder in placeand then trim the leads.

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

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

g) 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.

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

i) C9, .1 uF ceramic capacitor (marked 104). Note that there is a mistake on the circuit board, ideally C9 should be connected from the input of the 78L05 regulator to ground so the builder can elect to do this by soldering it on the bottom side of the board if desired. However this isn't critical so C9 can be placed as shown and the circuit will function OK. Insert at the top left of the board and solder in place and then trim the leads

j) D1, 1n5817 or 1n5818 or 1n5819 Schottky diode, bend the lead on the cathode (banded) end of the diode around 180 degrees until both leads are about .1" apart. Insert at the top left of the board, next to C9 with the cathode end lead away from C9. When you are certain of the correct polarity, solder in place and trim the leads. D1 is used as a reverse polarity protection diode, so the anode must be connected to the C9 and the cathode (banded end) must be connected to the 78L05 regulator or the kit will not work.

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

l) R1, 27k ohm resistor (red, violet, orange, gold). Bend on lead of R1 around 180 degrees until both leads are about .1" apart. Place R1 as shown on the parts placement diagram, above U1 and solder in place.

m) 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.

n) U4, the 78L05 5 volt regulator IC - place U4 to the right of D1 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.

o) X1, the 4 MHz crystal - place X1 to the right of the yellow trimmer cap (C7). Solder X1 in place and trim the leads. The case of X1 can be grounded with a small piece of wire soldered between the case and the ground trace to the left of X1.

p) 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.

q) 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).

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

s) Connect the input signal jack.

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. Similarly, form the leads of U1 and insert it into the 14 pin socket with pin 1 oriented to the right 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 Mcount2 should send an FB to let you know it is working.

The Mcount2 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 Mcount2 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 Mcount2 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 Mcount2 and another accurate counter to both measure the same frequency at the same time and adjust the Mcount2 yellow capacitor until the Mcount2 "display" agrees with the other counter.

Operation:

To read the frequency, press and release (PAR) the switch. Mcount2 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 Mcount2 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 Mcount2 sends the next setting.

PAR the switch to skip to the next menu item.

If the switch is unpressed for about 12 seconds, the Mcount2 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 Mcount2, (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.

Default settings are provided for all menu items. If required, the Mcount2 can be reset to the defaults by:
1) powering the Mcount2 down.
2) press and hold the switch
3) power up the Mcount2
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	18, 20, 25, 30, 35, 5, 7, 10, 13 wpm,
P (Prescale “display” option)	F (oFf)	N (oN) turns on the prescale “display”
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 Mcount2 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 Mcount2 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, Mcount2 will automatically be switched to the shorter 0.1 second gate time.

S - after the L menu item, Mcount2 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, Mcount2 will “wraparound” to 5 wpm.

P - after the S menu item, Mcount2 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.

The Mcount2 menu items DL and DH are used to limit the number of digits sent by the Mcount2 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.

DL - after the P menu item, Mcount2 will enter the Display Low digit set menu item DL. When the Mcount2 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, Mcount2 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, Mcount2 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, Mcount2 will "wraparound" back to 8.

CN - after the DH menu item, Mcount2 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, Mcount2 will play CA for CAlibrate. If the switch is PAH, Mcount2 will send an L and then enter an infinite loop, the only way to exit this is to turn off the Mcount2. While in the infinite loop the Mcount2 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 adjuisted 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, Mcount2 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, Mcount2 will "wraparound" back to F. Plus indicates that Mcount2 will display a frequency derived by adding the measured frequency to the IF frequency set in the following menu item. Minus indicates that Mcount2 will display a frequency derived by subtracting the IF frequency set in the following menu item from the measured frequency. Backwards indicates that Mcount2 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 Mcount2 is used as a digital dial in a QRP or other ham radio. When using the Mcount2 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, Mcount2 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. Mcount2 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 Mcount2 (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 Mcount2 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 27k 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. Since the gate is in a normal DIP socket, it is easy to replace it with a 74HC132 NAND gate with hysteresis

If the normal input is used above 50 MHz, the Mcount2 will NOT output a frequency, use a prescaler for frequencies greater than 50 MHz.

Modification ideas:

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

2) an ON/OFF switch: especially if you are using a 9V battery as a power source, it won't last long connected to the Mcount2. 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.

3) 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:

jacksonharbor@att.net

Thanks for choosing the Mcount2 kit and best regards,

Chuck Olson, WB9KZY

List of parts included with the Mcount2 kit

Ref	marking	Description
C1	103	.01 uf multilayer ceramic .1" lead space cap
C2 and C3 are not used		
C4	104	.1 uf multilayer ceramic .1" lead space cap
C5 is not used		
C6	27	27 pf, NPO ceramic radial capacitor, .1” lead space
C7		yellow, 7-40 pF ceramic trimmer capacitor
C8	104	.1 uf multilayer ceramic .1" lead space cap
C9	104	.1 uf multilayer ceramic .1" lead space cap
C10	22 uF	22 uF electrolytic capacitor
D1		1n5817/18/19 Schottky diode
R1	red-violet-orange-gold	27 k ohm, 1/4 watt resistor
R2 & R3 are not used		
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 DIP, quad NAND gate
U2 is not used		
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)
		circuit board

Items you’ll need to provide to complete the Mcount2 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)

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