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22 Meter Band Part 15 CW Beacon Kit

Just $25 with Free Shipping! (We ship to the USA Only)

Beacon kit: Tell us the Callsign / ID to send and then click Add to Cart, if ordering extra microcontrollers, put all the IDs here:

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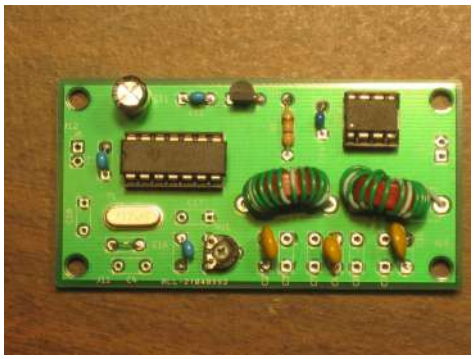

This kit is a sub-assembly, not a complete transmitter. You need to provide your own power supply, enclosure, RF connectors, coax, and antenna.

The kit includes the PCB and components, including a custom programmed microcontroller that will continuously transmit the ID / callsign of your choice, up to 8 characters, at about 13 wpm.

Small size - just 2 7/8 by 1 1/2 inches. Easy to build, just a few components, all through hole, no surface mount. Full instructions on this page, just keep reading!

When ordering, please specify what ID / callsign you wish to use, in the text field just before the Add to Cart button.

Please make it obvious what the ID of each is, or send a followup email to support@blackcatsystems.com

You can contact me via email prior to ordering with questions, or inquiries about longer messages.

If you would like to order an extra microcontroller along with your kit, you may do so for just $5. Please note that extra microcontrollers must be ordered with a kit, not by themselves: Add to Cart

Many 22m enthusiasts log reception of beacons on this message board:
https://www.hfunderground.com/board/index.php/board,35.0.html

Regulations concerning operation in the 22 meter band

This beacon kit will allow you to operate in the 22 meter band. Part 15 of the FCC regulations allows for unlicensed operation in the 13553-13567 kHz band:
Section 15.225(a): The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 microvolts/ meter at 30 meters.

Full text here: https://www.gpo.gov/fdsys/pkg/CFR-2011-title47-vol1/pdf/CFR-2011-title47-vol1-sec15-225.pdf

As it is difficult for hobbyists to perform these field strength measurements, W1TAG has done some calculations on the power levels into various antennas which meet this limits. I strongly suggest reading his entire paper, so you are aware of the methods he used, and you can stay within the generous field strength limits for this band.

In a nutshell, he calculated that the limits are 4.6 mW into a half wave dipole, or 2.3 mW into a quarter wave ground plane antenna. Assuming 50 ohm loads, these are 0.48 Vrms and 0.34 Vrms respectively. An oscilliscope

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HF Weather Fax
NAVTEX
Rad Map Tracker
SelCall Tone Gen
Sound Byte Control
SWBC Schedules
Wire Calc

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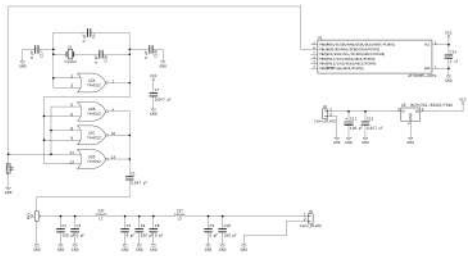
could be used to measure the output of your beacon, to verify compliance with the regulations. As always, it is up to you the operator to verify proper compliance with the field strength limits.

This beacon could also be used on the amateur bands, where these field strength limits do not exist. You would need to change the values of the coils and capacitors in the output filter (although only minor adjustments most likely for 20 meters). Note that other than on 10 meters, HF amateur beacons must be operated with a control operator. So you can not run it unattented continuously.

Circuit details

Below is the schematic. Click on it to view full sized:



Parts List:

Ref	Value	
C1	0.047 uF	(or 0.1 uF)
C2	100 pF	
C6	220 pF	
C7	0.047 uF	(or 0.1 uF)
C10	100 pF	
C11	100 uF	
C12	0.047 uF	(or 0.1 uF)
C14	1 uF	
L1	15 turns on T50-2 toroid	
L2	15 turns on T50-2 toroid	
R1	470K resistor	
RV1	1K trimmer potentiometer	
U1	ATTINY85-20PU	
U2	74HC02	
U3	MCP1702-5002E/TO92	
Y1	HC49 crystal 13.560 MHz	

U1 is an ATTiny85 microcontroller. It has a built in oscillator. Output PB1 (pin 5) is used to key the transmitter on and off. Inverted polarity is used, a logic 0 (low output) turns on the transmitter, a high output turns it off.

Resistor R1 pulls the output line low, should U1 not be installed. This allows the beacon to continuously transmit a carrier, for testing and measurement purposes.

U2, an 74HC02, is the oscillator and amplifier. The first gate is the oscillator, which always runs. There are four optional capacitors that may be installed in conjucntion with the crystal Y1:
C4 is in parallel with Y1
C16 is in series with Y1
C17 and C18 go from one lead of TY1 to ground

C16 can be used to slightly pull Y1 to a higher frequency. If it is not used, a short (jumper) must be installed.

C4, C16, and C17 can be used to pull Y1 to a lower frequency. If not used, they are left open.

Without any of the capacitors installed, Y1 tends to run at around 13563 or 13564 kHz, the exact value depends on the particular crystal, construction, temperature, voltage, the phase of the moon...

The other three gates of U2 are connected in parallel and are a low power amplifier. They are controlled by the PB1 output from U1, which allows keying the transmitter.

The output from U2 is capacitively coupled to trimmer resistor RV1, which is used to set the desired output level. RV1 can be replaced with a jumper, for full power output, say on a ham band.

Following this is a low pass filter, to attenuate harmonics, and provide some impedance matching to the antenna. Note that all of the capacitors are not used. Extra footprints are provided, in parallel, should the user wish to adjust the filter characteristics, and need to use two or three capacitors in parallel to obtain the desired total capacitance.

The output is at pin 1 of J5.

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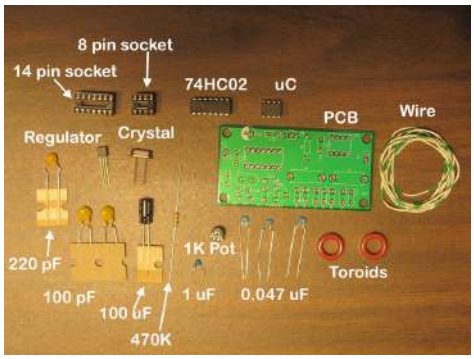
DC power is applied to pin 1 of J6. Up to 12 volts may be applied, which is regulated to 5 volts by U3. The beacon can also be operated at a lower voltage, from roughly 3.5 to 5 volts, by installd a jumper in place of U3. This allows operation from a small solar panel / battery setup.

Current consumption varies with the voltage, message length, etc. With 5 volts of DC power, it generally runs around 10 mA average. Somewhat less at 3.7 volts. I have been able to continuously run the beacon powered by the solar cell / battery from a small solar powered garden light.

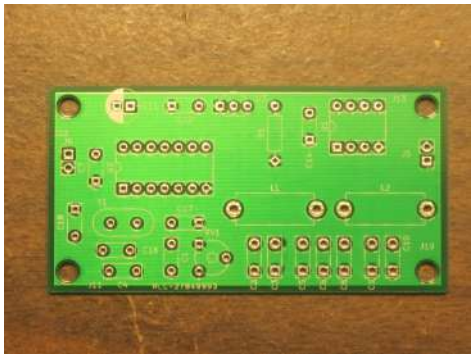
Assembly Instructions

Note: While it is believed that the assembly details and schematic are correct, there is always the possibility for a typo. If you believe this is the case, or have any questions, please contact me prior to assembly, to verify the correct steps. I want to you succeed!

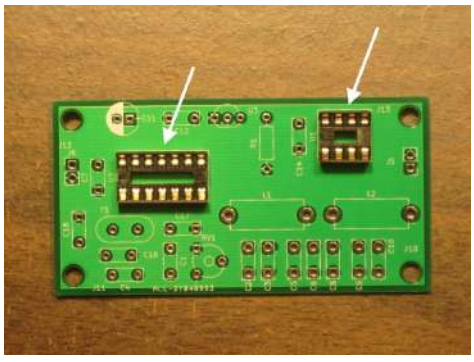
Below is a photo of all the components. Click to view it, as well as the other photos, to full sized. Familiarize yourself with each part, to avoid assembly errors.



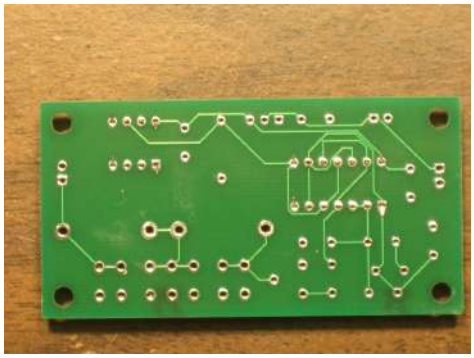
Here's the PCB, we'll start assembly. Below will be a series of photos with each assembly step. Solder at each step:



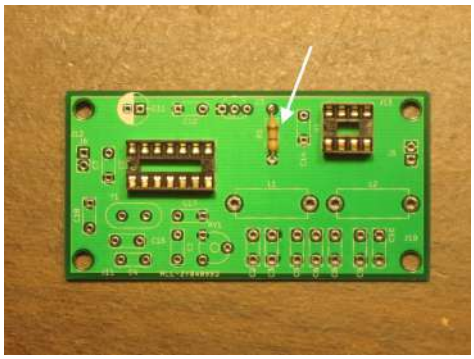
First install the 8 and 14 pin IC sockets:



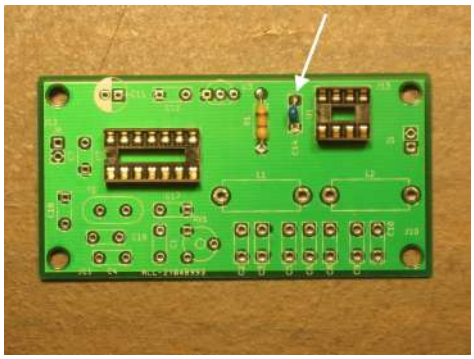
I find it is easy to secure them before soldering by carefully bending the corner pins of each socket. Be sure to not bend the pin onto an adjacent track with a different signal, to avoid shorts. Then solder:



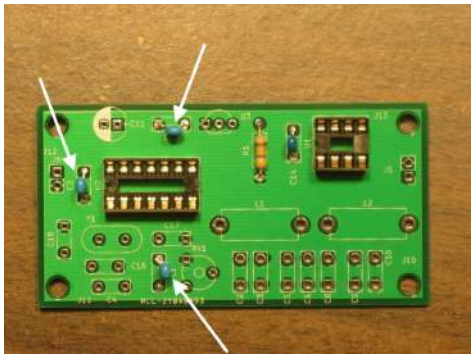
Then install the 470K resistor (R1, Yellow / Violet / Yellow bands), save the cut leads, you may need them as jumper wires in a later step:



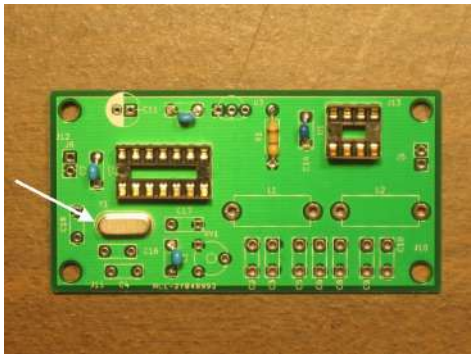
Then install the 1 uF (C14, marked 104) capacitor, you may need them as jumper wires in a later step. There is only one capacitor of this value, and it is a slightly different color than the 0.047 uF caps:



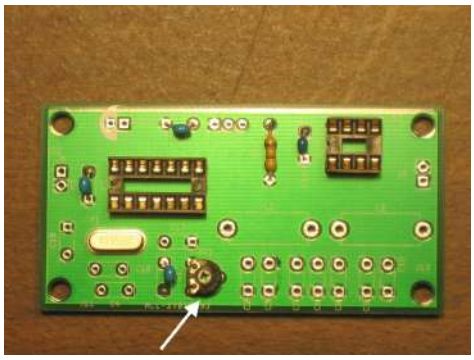
Next install the three 0.047 uF (or 0.1 uF, depending on what I have to ship) capacitors (C1, C7, C12, marked 473), save the cut leads, you may need them as jumper wires in a later step:



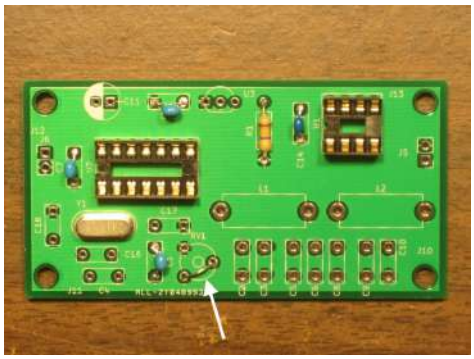
Next install the crystal (Y1). Try to get it flush with the PCB, to avoid movement, which can affect the frequency:



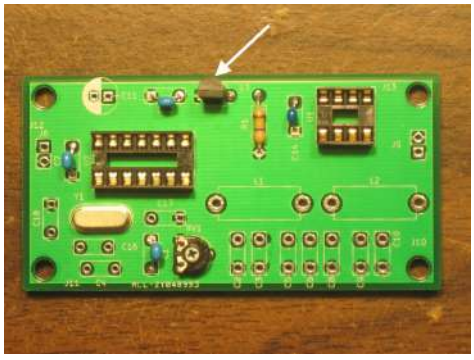
Now you have a choice. The beacon kit includes a 1K potentiometer / pot (RV1) which can be used to reduce the output power, to stay within the Part 15 field strength limits. You can install the pot, or you can install a jumper wire. You might prefer the jumper wire if you are using the beacon on the ham band, where you want to transmit at the highest possible power. If you wish to install the pot, do so as shown below:



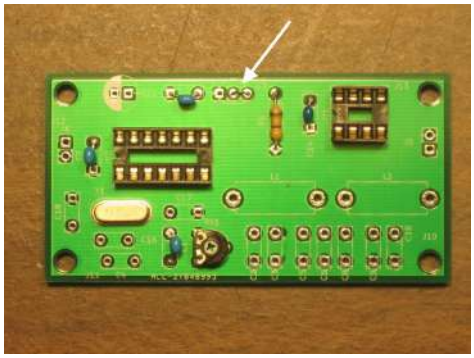
If you prefer the jumper, install as shown below:



Now you have another choice. The beacon kit includes a 5 volt regulator (U3). If you are going to power the beacon off of a power supply that is greater than 5 volts, say a large solar panel or a DC supply, then you need to install the regulator, otherwise the ICs will be damaged. If you wish to install the regulator, do so as shown below. Be sure to install it with the correct orientation, or it could be damaged, as well as the other ICs:

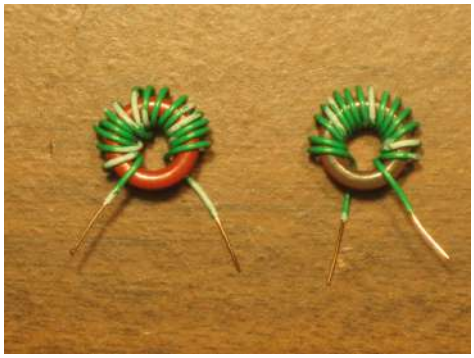


If you prefer the jumper, install as shown below:

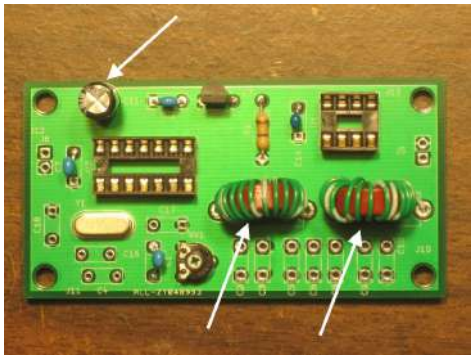


Next the two toroid coils (L1, L2) need to be wound for the low pass filter. Insulated hookup wire is provided. While it is common to use enameled (magnet) wire, it is tedious to sand and strip off the enamel, hookup wire works just as well for this application, and is easier to use.

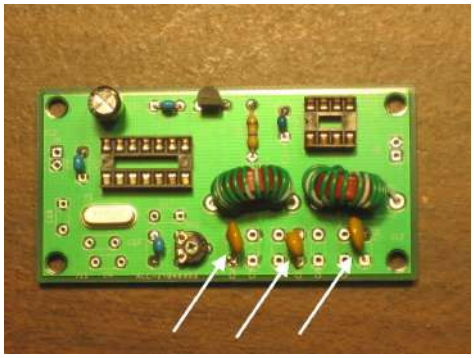
Each coil has 15 turns of wire. Try to be neat, but as this is being used for a filter, it is not critial that each coil be exactly the same or perfect. Strip off some insulation at the end of each wire:



Install the two coils, as well as the 100 uF electrolytic capacitor (C11). Note that the capacitor is polarized and must be installed with the correct orientation. The coils are not polarized, of course:



Next install the three filter capacitors. Note that there are two 100 pF capacitors (C2, C10, marked 101) and one 220 pF capacitor (C6, marked 221), install them correctly:

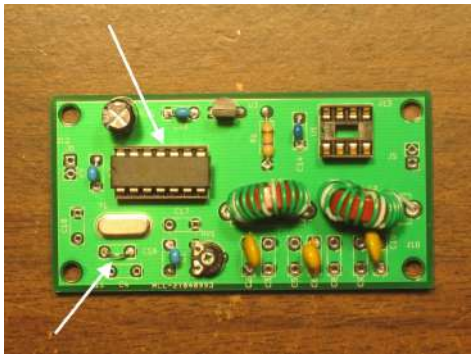


The beacon kit has provisions for four capacitors in the oscillator circuit, which can be used to "pull" the crystal slightly, to shift it to a different frequency. The amount of pull varies based on which capacitors are used, their values, and the particular crystal. A few low pF ceramic capacitors are included, none, one or more of which can be optionally used, if desired. No exact instructions are provided for their use, as it is up to each operator to decide what amount of pull, if any, they wish to use. And this will vary from unit to unit, based on stray capacitance and performance of the other various components. Trial and error is needed here. You won't want to install them until after you have completed all the other steps and are powering up the board for the first time. (If you don't install anything now for C16, even a short, remember to put something there when you power up, or it won't oscillate!)

The beacon usually works fine without any capacitors, and ends up around 13563 or 13564 kHz. Capacitor C16 is in series with the crystal, and can be used to slightly increase the frequency. If you do not wish to install C16, then you must install a jumper in place of it.

If you do not wish to use the other capacitors, C4, C17, and C18, then just leave them empty.

Also be sure to install 74HC02 IC (U2), after this step:



At this point, you are ready to power up your beacon! You can leave U1, the microcontroller, uninstalled for the first tests. With it not installed, the beacon will continuously transmit, which makes it easy to make adjustments and measurements.

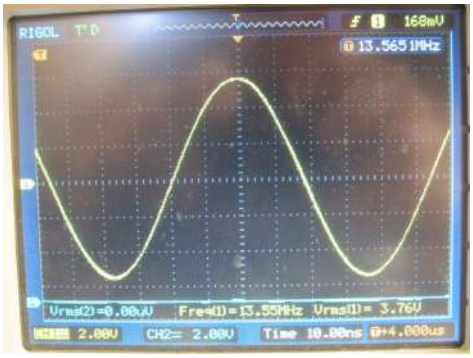
You may wish to temporarily remove U2 the first time you apply power, to make sure the voltages are correct. Apply power to J6. Note that the square pin closest to the J6 text is positive, and the other pin is ground. Do not apply more than 12 volts (5 volts if you did not install the regulator IC) and observe the correct polarity!

With a voltmeter, double check that you have the corect voltage on U1, you should measure 5 volts (or less if you did not install the regulator and are using a lower voltage power supply) between pins 8 (positive) and 4 (ground). If this is not the case, stop at this point, and locate the construction error. Do not install ICs if you have move than 5 volts, or they will be destroyed.

Assuming this voltage check passes, remove power, install U2, and apply power again. With a nearby receiver, you should hear a carrier somewhere close to 13560 kHz, probably a few kHz higher. You may need to install a short piece of wire as an antenna at J5, the output is the square pin.

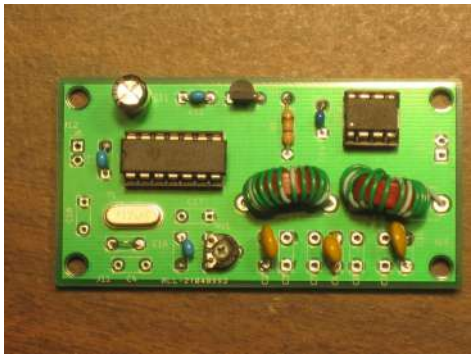
If you do not hear anything, you should double check your construction. An oscilliscope will be useful to check that the oscillator stage of U2 is correctly operating.

With an oscilliscope connected to the output pin at J5, a nice sine wave should be observed:



A 50+/- ohm resistor can be placed across the two pins of J5 to simulate an antenna, and adjustments made to RV1 to set the desired power level. I'm including a 56 ohm resistor you can use for testing purposes if you wish.

Next, remove power, and install the microcontroller (U1). Re-apply power, and your beacon should start transmitting your message!



A dipole antenna can be connected directly to the two pins at J5. If you have a balun, it can be used as well.

Notes and Troubleshooting

Sometimes the 74HC02 oscillator will not start without some load capacitance. I've included an envelope with six small capacitors, two each of 3.3 pF, 6 pF, and 10 pF (or close to those values, depending on what I have on hand). These can be used to alleviate this, as well as tune your oscillator. Usually a small capacitor in C18 will get it to start, you can just place a capacitor in without soldering, and see if that does the trick, then solder when happy. Likewise you can play around with capacitors in places C4 and C17 as well, to adjust your output frequency. This is also useful if you are running multiple beacons and want them on different frequencies. Again you can often place capacitors in the footprints before soldering them, while deciding which combinations work best for your application. Then solder when finished. You can of course use your own capacitors if you wish, or even trimmer cap(s).

It's perfectly normal to hear an extra dot or dash when the beacon first powers up, before the microcontroller software is running.

RV1 sets the output to the antenna, full clockwise is maximum power. Be sure to dial it down to stay within Part 15 limits!

Because the oscillator is always running, you can locally hear it, even when the beacon is not keying on. This is especially noticable if no antenna is connected to the beacon board. The output of the oscillator is much weaker than the final output, and will not be heard remotely (unless reception conditions are exceptional!)

The oscillator frequency is voltage sensitive. It's normal for it to vary slightly as the output gates switch on and off. The onboard voltage regulator helps to reduce the power supply voltage shift when keying. If you are not using the regulator, be sure your power supply is fairly well regulated. Usually a battery, such as those in solar lights, is stable enough so the frequency shift when keying is minimal.

Customer comments:

- Thanks again for a quality, easy to build kit. - KE8DNU

Email your comments and questions to info@blackcatsystems.com

Last February 3, 2019