VHF/UHF Go-Box and Base Station

Jay Taft, K1EHZ

Over time my VHF/UHF go-box has been re-configured according to changes in technology, communication requirements, and operating preferences. As I thought about updating it again, I looked at online sources such as shack-in-a-box.com to decide how to balance the inevitable trade-offs. I wanted to use it both as a base station at home and as a portable station for ARES.

Capabilities. I had in mind maximum flexibility for voice, NBEMS, Winlink, cross-band repeater, and remote computer access through a raspberry pi in the go-box. I also planned to use a laptop computer connected directly to the SignaLink for a Winlink RMS gateway or digital repeater. A GPS receiver for the raspberry pi provides accurate time and position reporting by Winlink. A Byonics TT4 provides position reporting by 2m APRS.

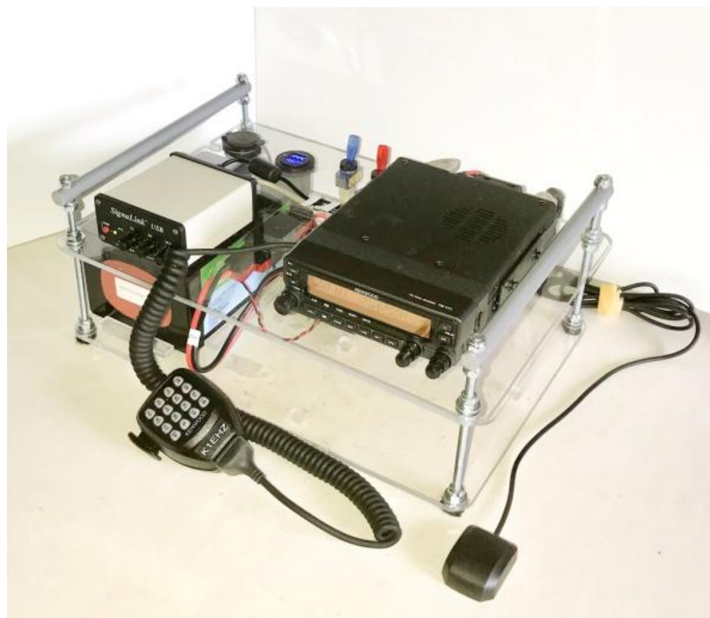
Equipment On-hand. A major consideration was using items on-hand as much as possible. I had a Kenwood TM-V71A transceiver (3.6 pounds) and a SignaLink for digital modes from the previous go-box. A Byonics TT4 TNC and GPS receiver for APRS was available and was added towards the end of the project. I had a Pelican 1450 case (5.5 pounds) from another project. There was also a raspberry pi computer with an early version DRAWS hat (nwdigitalradio.com) sitting around unused. These became the core components. Coaxial dipole antenna, folding 100w solar panel, and other on-hand accessories formed the portable kit.

Power. The previous go-box had both a 12v power supply and a heavy 17Ah SLA battery for backup. I explored using a higher capacity LiFePO4 battery with a small charger to eliminate the 12v power supply. LiFePO4 batteries maintain voltage until nearly discharged, and have overall energy efficiency approaching 90%, compared to SLA batteries at about 70%. A 20Ah SLA cost $40 and weighs about 13 pounds. LiFePO4 batteries are said to sustain about 7 times as many charge-discharge cycles as SLA batteries. The long-term cost of 7 SLA batteries would be about $280. The 20Ah LiFePO4 battery with charger is half the weight of the SLA. I settled on a Bioenno 20Ah battery (5.5 pounds, $193) with a compatible 14.6v 4A charger (1 pound, $25).

Case Integrity. The second consideration was whether or not to make holes in the case for antenna and power connections. I decided to maintain case integrity and keep connections inside, since the lid has to be open to operate anyway. This approach has a nice benefit. With no connections to the case, the assembly can be lifted out easily for use as a base station at home.

Radio Configuration. Two tiers would be needed to fit everything in the case, so the third consideration was whether to separate the control head from the radio, placing the main radio on the lower tier and the control head on the upper tier. Putting the radio on the lower tier creates additional wiring, audio, and cooling issues. The simpler approach is mounting the radio on the upper tier.

Construction. For the interior platforms I decided on acrylic which is easily cut and drilled with my woodworking tools. I chose a 18” x 24” x 0.22” sheet ($30) from the local home center which is enough for two tiers with some left over to practice drilling. I used the foam liner from the Pelican case lid as a pattern to cut the acrylic. The case is slightly tapered so the upper tier was cut first, and then the lower tier was cut slightly smaller. Edges were trimmed and corners rounded to fit snuggly in the case.



The tiers were connected at each corner with 1/4-20 zinc-plated bolts 6” long. The 6” bolts just fit the case depth preventing the assembly from shifting when the lid is closed. For initial construction I used regular 1/4-20 nuts for easy adjusting while figuring out exact equipment placement and distance between tiers. For final assembly I used 1/4-20 nuts with nylon locking inserts (boltdepot.com, 100 for $3) and washers at all acrylic contact points.

I also had a ThinkTank lid organizer from a photography case that I wanted to incorporate for holding a writing pad, pens and pencils, and other accessories. The organizer is intended for inside the lid, but it didn’t fit depth-wise with the equipment installed. I mounted it on the outside using the provided tape supplemented with heavy duty Velcro. Hopefully it will last if I am not too rough on it.

Layout. With the radio on the upper tier and the battery below, it made sense to place power wiring on the underside of the upper tier. This facilitates assembly as well as separating the tiers when necessary. Three small strips of acrylic were glued to the lower tier at the two ends and inner side of the battery to prevent shifting. The upper tier is snugged down on the top of the battery just enough to stabilize the battery without bending the acrylic sheets. This arrangement leaves enough space between the tiers to accommodate the raspberry pi, battery charger, cables, and coaxial dipole antenna.

The photos show equipment placement. The radio is secured with aluminum brackets cut from right-angle stock. The SignaLink, raspberry pi, and GPS receiver are fastened with Velcro. The mic hanger is fastened with 6-32 machine screws and nuts with nylon locking inserts. It is oriented with the prongs pointing forward so the mic is secure when the case is carried by the handle. Powerpole connections are made with a 6-position block secured to the underside of the upper tier, below the mic, with Velcro. The radio and the RPi are powered from the 12v powerpole block.

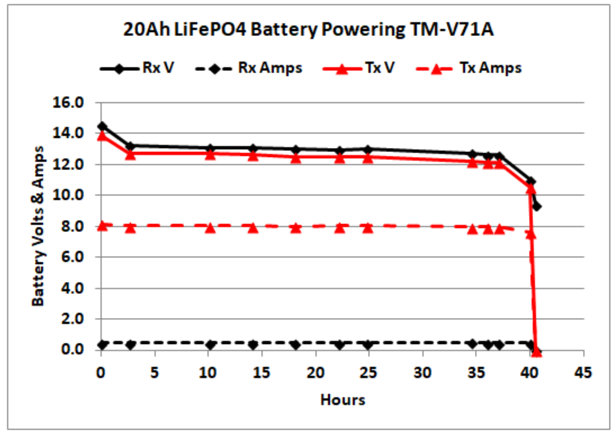
The battery charging connector passes through a slot in the left side of the top tier. The power cable for the radio and the cable from the raspberry pi to the SignaLink pass through a slot in the back of the top tier. The 2-position powerpole port on top can be used for additional connections and for charging the battery with a solar panel. The red automotive toggle switch is the master power switch for the system. There is a 20 amp fuse in line from the battery + to the switch. The blue toggle switch controls the volt-amp meter.

One small challenge was making a short cable connecting the SignaLink to the radio. I cut one end from a long cable with 6-pin mini-din connectors on each end. I attached an RJ-45 plug, in what was intended to be a standard cable for the TM-V71A radio. Although I studied the pin-outs at both ends, the RJ-45 configuration was wrong and the cable didn't work. A second try was a slight improvement but not 100% successful. So as not to shorten the cable any further, I re-arranged the jumpers in the SignaLink to correct the configuration. Not totally satisfying but practical.

When the interior assembly was finished, I realized there was space for handles. I found a piece of PVC rod, left over from an antenna project, long enough for 2 handles. I stuck small squares of loop fabric from Velcro scraps to the bolt heads on the bottom of the assembly to minimize sliding and scratching when the assembly is used out of the case. I also added stick-on plastic feet under the battery and elsewhere on the bottom to minimize sagging of the acrylic over time.

Actual Battery Capacity. The TM-V71A consumes 0.5A on receive, 8A on high transmit power (50w), 4A on medium (10w) and 2.7A on low (5w) into a dummy load.

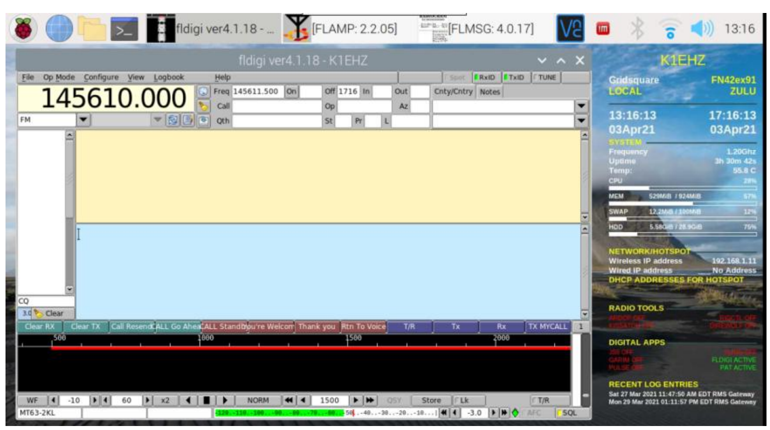
Typically the system would be operated on mains with the 4A charger connected. On battery alone it lasted almost 40 hours on receive at 0.5A/hr with short periodic transmissions on high power (see graph). These results confirm that 20Ah are available from the Bioenno battery.



Raspberry Pi. The raspberry pi computer (Model 3B+) has a DRAWS hat which includes a 12v to 5v converter, a real-time clock, a GPS chip, and a quality sound card for 1200 baud and 9600 baud packet. The DRAWS aluminum case helps with RF shielding. At present, the 12v to 5v converter is being used for power. As my linux skills improve I plan to take advantage of more DRAWS capability. For now I am using the excellent Build-a-Pi software package assembled by Jason Oleham KM4ACK (https://github.com/km4ack/pi-build). It contains a variety of programs such as a hotspot, NBEMS software suite, and Pat Winlink with VHF packet and HF ARDOP modes. Many video tutorials are available to help get the system going.

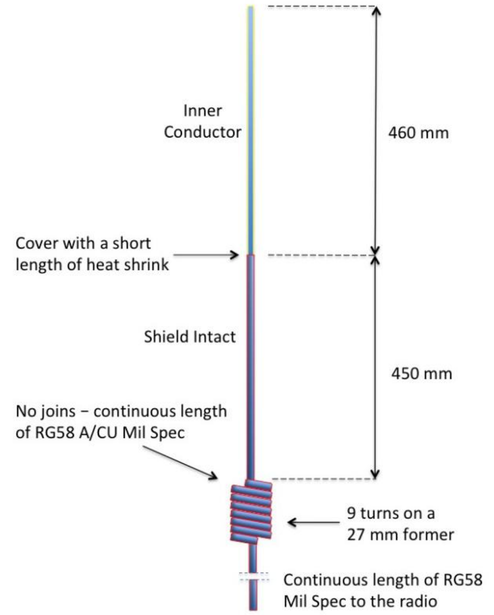
GPS. Small GPS dongles work outdoors. A GPS receiver with a low noise amplifier (LNA) provides greater sensitivity and a cable for placement flexibility. Alternatively, GPS data from a smart phone can be streamed to the raspberry pi with an appropriate app. Online videos by Jason Oleham KM4ACK cover many of these topics. After considering the possibilities, I decided on an LNA receiver.

Remote Access. I use a laptop computer to access programs through the raspberry pi's built-in wifi/hotspot. The VNC remote access program that comes with the raspberry pi OS is used on the home network and the hotspot (https://www.realvnc.com/en/connect/download/viewer/). TeamViewer (https://www.teamviewer.com/en-us/) or NoMachine (https://www.nomachine.com/) are used for access from



beyond the home network. The laptop is connected directly to the SignaLink to use Winlink programs not available on the raspberry pi OS.

Portable Antenna. I made a roll-up coaxial dipole from 20' of RG-58 that was lying around (VK1AD design at https://vk1nam.wordpress.com/2018/02/10/portable-2m-144-mhz-coaxial-dipole-antenna/). Similar to the illustration, the balun was formed by winding 9 turns of the coax on a 1" OD PVC pipe 3" long, starting 18" from the point where the center conductor emerges from the shield. SWR on 2m is 1.2 to 1.4 across the band.



2m 144.2 MHz ½ wave Coaxial Dipole VK1AD

Testing. In addition to testing the battery capacity, I tested the go-box in the loft over the garage near a south-facing window. A 100w fold-up solar panel was placed on the ground below. The coaxial dipole was suspended from a rafter. I accessed the go-box over wifi from the house. Using 5w, I checked Winlink email several times a day through an RMS packet gateway 9 miles away. I also participated in ARES NBEMS simplex training nets using up to 50w.

The coaxial dipole was tested by transmitting NBEMS mode MT63-2KL with 5w over an 11-mile path. Signal to noise ratio at the receiving end was +18 on 2m and +16 on 70cm. A test on 70cm through a repeater 20 miles away was also successful. Although the coaxial dipole is cut for 2m, it works on the 70cm third harmonic. Many thanks to Steve Nelson WA1EYF and Ken Geddes N1KWG for assisting with on-air evaluations.

Summary. The assembly works well on the base station antenna at home. Combined with a laptop computer, coaxial dipole antenna, and compact 100w solar panel, it provides a lot of flexibility as a portable station for ARES. The raspberry pi can be accessed remotely by computer, tablet or smartphone. A Byonics TT4 TNC was added for APRS at the end of the project. The go-box came together using mostly existing equipment and accessories, plus a battery upgrade. Battery charger and coaxial dipole antenna store nicely between the tiers. The final go-box is a compact 17" x 13" x 8" outside dimensions, and weighs a manageable 23 pounds.