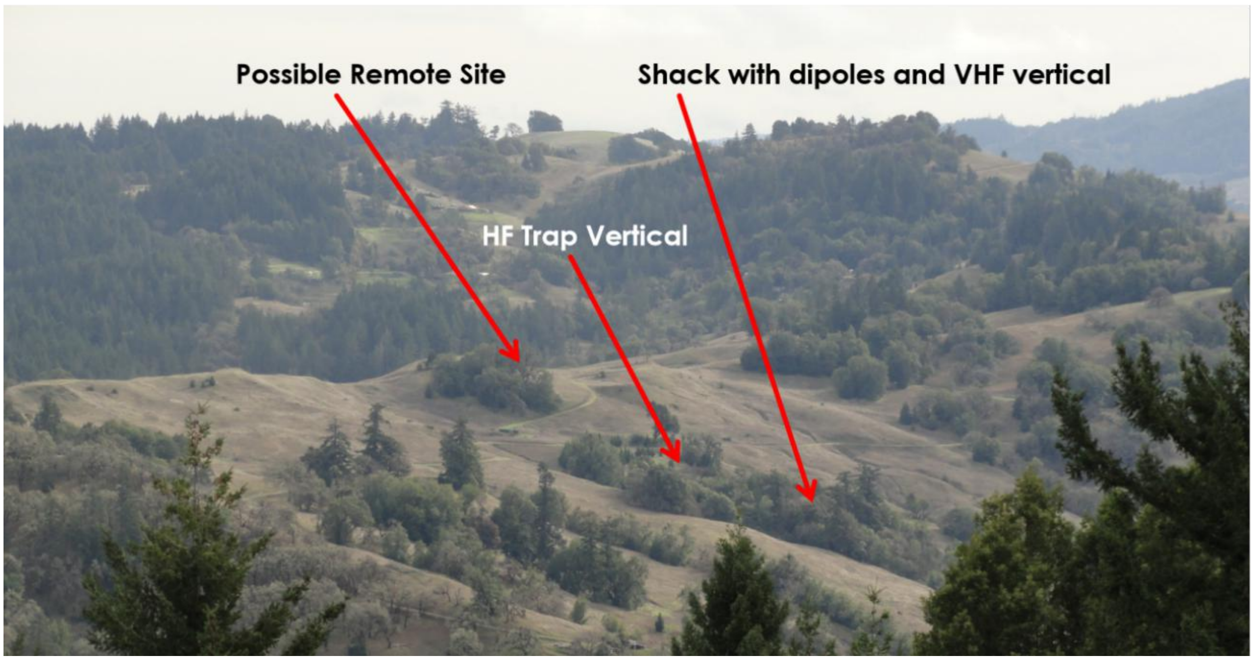
<u>Designing, Constructing and Operating a Solar Powered Remote Base Station</u>
Presented to the Technical Net, Dec 7, 2021, by Steve Turner, KJ6EIF

0. Why?

I built this station because my off-grid QTH is in a small, westward facing valley near the Pacific Ocean. I am surrounded on three sides by ridges hundreds of feet above me. I tried various dipole and vertical antenna configurations, but it was very difficult to work stations on three points of the compass on any band. I installed an HF trap dipole 60' above me and fed it with 300' of coax but it was still shadowed by the hills. My solution was to create a remote base station on the nearby ridge top, to lower the horizon relative to my antennas.

1. Possible Remote Site



Ridgetop Site negatives:

1/2 mile drive in bad weather

No power or internet

Small site, limits antennas, support structures, separation of antennas

Concerns of equipment being too close to antenna field

Potential benefits:

Site 300' above shack at 2100' elev.

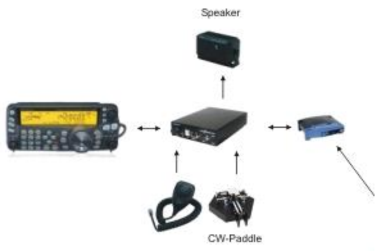
Line-of-site to shack

Lower RF horizon most directions

2. **Remote method:**

The RemoteRig system was suggested to me by Greg, WA6RQX, for simplicity. The equipment does not require a computer, has low power consumption (12v) and only required an IP interconnection between the body and the face-plate (Control panel) of my existing Yaesu FT-857 . The interconnection I selected was a Ubiquiti 5 gHz link.

EQUIP IN SHACK	5gHz LINK	EQUIP @ REMOTE SITE

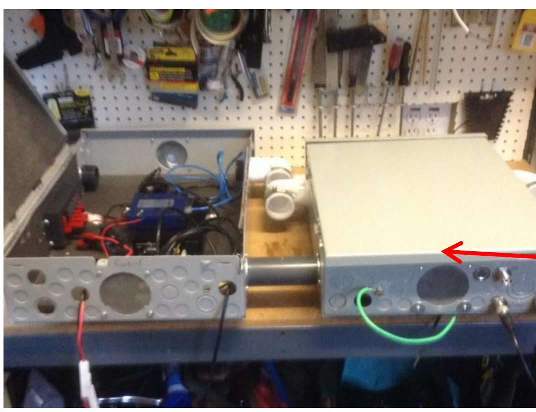


Control panel, mic, spkr, RemoteRig

RemoteRig rcvr, radio body

3. Creating an Electronics-friendly space:

I needed protection from the elements for the radio, the electronic equipment required to produce power, control and operate the radio equipment, and other accessories. The space would need to provide protection from moisture, extreme temperatures, and critters. I was also concerned with protection from the RF fields of the antennas, which are in close proximity and noise generated by adjacent electronic equipment.



I chose to use electrical service entrance boxes as enclosures.

The metal boxes are weatherproof, strong and provide electromagnetic shielding. I thermally insulated them with carpeting to moderate the inside temperature and prevent cold weather sweating. I mounted the equipment using hardware and velcro.

I installed ferrite cores on all connecting cables to hopefully prevent noise transmission due to their close proximity. All the components inside are individually fused. I was initially concerned with humidity and extreme temperatures so I installed thermostatically controlled fans and heating elements in each box. After three years time, they have proved an unnecessary precaution.

4. The structure:

The posts are lengths of chain link fence top rail and are anchored in concrete and bolted to the sides of the battery box.

The battery box contains 2) 110 amp/hr deep cycle batteries, fuses, a power meter, and disconnects.

The PVC 90s you see near the top of both equipment boxes are air vents protected with window screen. I partially plug them in winter to retain the heat generated by the equipment.

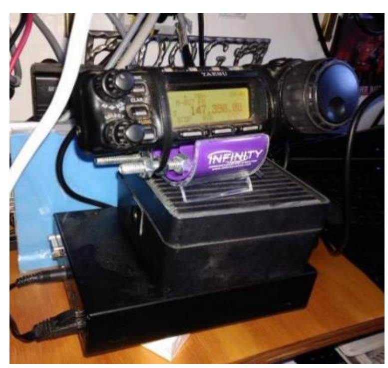
This is the initial installation with 2) 50 watt solar panels. The Ubiquiti down-link is not shown.

The left box contains the IP switch, RemoteRig receiver, solar charge controller, thermostats, a fused power distribution terminal strip and a power-over-ethernet (POE) inserter to power the downlink. All the external wiring and coax is encased in flexible coduit to the extent possible.

The right box contains the Yaesu FT-857 body. The low interconnecting metal pipe houses the radio's control cabling and power. The two barrel connectors passing through the bottom of the box provide antenna outputs. There is just enough room inside the box to use a ratcheting screwdriver to remove the radio body when necessary.

The original boxes opened upwards which became very inconvenient once the structure was install in the concrete footings. Soon after I removed them and re-installed the components in larger service boxes with sideways hinged doors to make maintenance easier.

5. Shack controls



Back in the shack, the Yaesu FT-857 face plate, sits atop a speaker. Both are powered by the RemoteRig below them, along with the microphone, not shown. The RemoteRig connects to the router which powers the Ubiqiti up-link outside All the controls of the radio function normally, as if connected directly to the body of the radio. The Yaesu face plate displays the remote system voltage.

6. Ridgetop Solar power budget

This initial setup had a continuous 1.05 amp (14 watt) draw on standby, with the radio off. When the radio power is on and monitoring, the site consumes a continuous 2.9 amps (39 watts), without the previously mentioned heating elements (20 watts) or cooling fans (9 watts). Transmitting draws 24 amps (326 watts) when key-down.

Thus, 25 amps are consumed daily on standby, and 2 more amps, per hour, monitoring. If the radio was monitoring 4 hours per day, and the transmitter was keyed for a total of 30 minutes, the total daily draw would be 48 amp/hours of consumption, over 650 watts.

The battery box contains two 110 amp/hr deep-cycle batteries. Limiting power consumption to no more than 70% of charge, extends battery life, but limits available power to 66 amp/hrs per day.

The initial solar panels were rated at 100 watts, 2-50 watt panels @ 17.5 volts. I used a 10 amp Pulse Width Modulation (PWM) charge controller (80% efficient). Typically the system would provide a maximum of 4-5 amps per hr of charge, depending on sunshine. This was very marginal, especially during the short days in winter, so I limited my operating hours and manually disconnect the load during extended winter storms to prevent damage to the batteries.

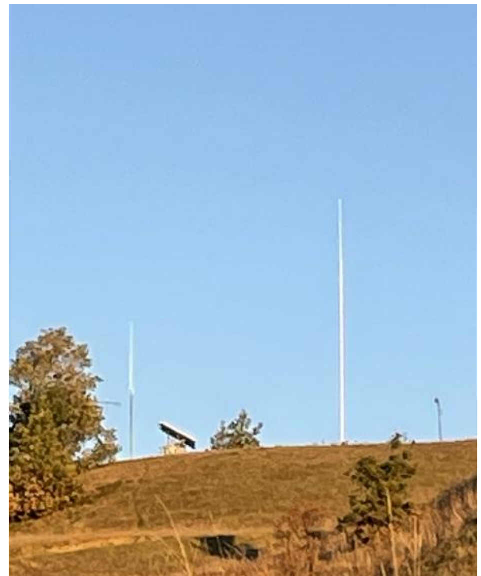
7. 2019 Power Upgrade:

To increase the available power and more rapidly recover from deep discharges, I replaced the 50w panels with two, 175w @ 44 volt panels, wired in series, and installed a 100 volt/30 amp Maximum Power Point Tracking (MPPT) charge controller. These are contained in a third service box, one of the originals boxes, recycled.

An MPPT controller is 97% efficient and works by using higher voltage solar panels, and continuously compares the available panel voltage and power to the current battery state-of-charge. The charger continuously converts the solar power to the optimum battery charging voltage and current. This optimization occurs thousands of times per minute. This is especially valuable on dark or cloudy days. The other advantage of the upgrade is the ability to rapidly re-charge the batteries during breaks in winter clouds.

To increase the performance of the station, I installed a voltage booster, which constantly maintains 13.8 volts to the radio. Previously, I would see the battery voltage drop below 12 volts after just a few minutes of transmission. A mobile radio's output power drops dramatically when the input voltage falls below 13.6v. With the booster, that is no longer a problem.

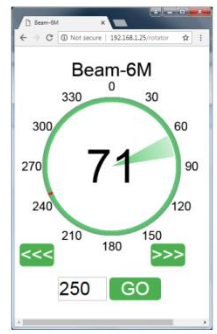
8. **Antennas:**



The station currently has one HF and two VHF/UHF antennas.

The HF antenna is a ground mounted, 40 meter 1/4 wavelength vertical with 30 buried radials. I buried the radials to assure that no high voltage sparks would be created on this grassy hilltop. The edge of the radial field is only three feet from the equipment structure, initially a concern. The coax is underground in conduit with a ferrite core choke at 33’ from the antenna. The antenna works well on both the 40m and 15m bands.

The primary VHF/UHF antenna is a Diamond 2 meter/70 centimenter dual-band collinear , mounted 12’ above ground.



There is also an 11 element, 2 meter yagi mounted 10’ above ground, steered by a modified, app-controlled, TV antenna rotor operating on 12 volts, designed by AF6SA. The yagi is not currently connected since there is only one VHF/UHF output on the FT-857.

9. Remote Antenna Switching:

I am currently equipping a fourth service box with four dc powered coaxial switches and a webswitch containing five ip actuated relays. With this configuration I will be able to use an app on my phone to remotely switch between 6 different antennas, 3 HF and 3 VHF/UHF. The remaining 3 web relays will be available for future use.

With these switches I will be able to add antennas for more hf bands to take advantage of the improving solar propagation. With the added VHF and UHF antenna capacity I will add a specially designed antenna group to broaden my coverage of the north coast and install some horizontally polarized antennas so I can try Single Sideband and CW on the 2m and 70cm bands.

10. Remote Base Performance:

I have been extremely pleased with the results of this project. I have gained some basic knowledge of internet protocols and solar energy technology. I have enjoyed puzzling out the engineering challenges faced along the way and have many ideas to further enhance the station.

My reception and contact range has increased on all my currently active bands. My reception on VHF is often better than I want and I have had to enable Tone Controlled Squelch on many local repeater channels to reduce interference from Sacramento Valley and Bay area repeaters.

As the sunspot cycle has increased, the 40m antenna has been able to reach several other states and continents.

11. Lessons Learned:

Don't over-engineer!

You will need more room for cabling than you think!

Incremental improvement is progress. Don't hesitate because you cannot build it all at once!

Experiment, learn and HAVE FUN!!

Disclaimer

I'm not an engineer, ham radio is my hobby. Everything I think I know, I learned from others, so any mistakes are my own. Please let me know if I am mis-speaking about anything.

Steve Turner, KJ6EIF