Building a Beacon for 2401 MHz

Amateur radio operators who use weak-signal propagation on the microwave bands like having beacons available in order to determine whether or not a band opening is under way. Here W3HMS and K3VDB discuss theur 2401-MHz beacon project. Significant portions of this article also appeared in the *Proceedings* of the 2007 AMSAT-NA Space Symposium.

By John Jaminet,* W3HMS, and Charlie Heisler,† K3VDB

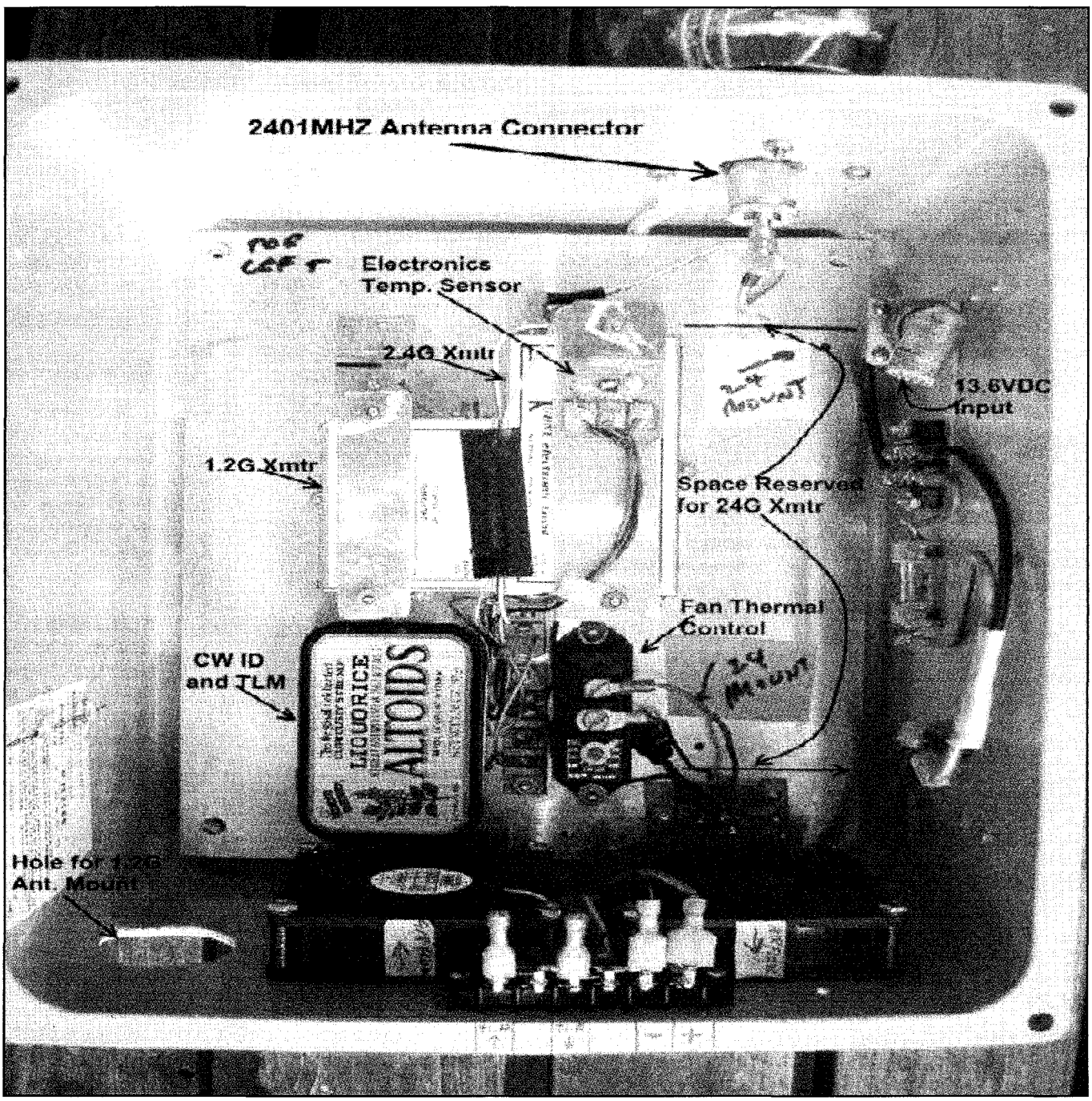

Photo A. Inside view of the beacon.

With no high-earth-orbit satellite to use as a signal source for quite some time, we thought a 24/7 beacon might be useful to folks around south-central Pennsylvania.

Overview

The microwave community makes extensive use of beacons for checking equipment equipment and propagation on all bands from 50 MHz to 24 GHz. Therefore, why not do the same for satellite users? Thus, we set about building a dual beacon for 1296.064 MHz horizontal polarization and 2401 MHz circular polarization, both in the same box.

The "we" in this case is Fred Lowe, W3MMV, Joe Lockbaum, WA3PTV, John Jaminet, W3HMS, and Charlie Heisler, K3VDB. We defined the tasks to be done and the purchases to be made and then shared the jobs among our group. I (W3HMS) have operated a Kuhne Electronics beacon on 10 GHz for about six years now and am so very pleased with the dependability of it, which is consistent with the company's other products that I use for contesting on VHF, UHF, and the microwave bands.

Technical Summary

The heart of the two beacons is the Kuhne Electronics of Germany "Bakensenders" for each band. Each was ordered with the frequency specified. Each uses F1 FSK keying in lieu of classic "make and brake" keying, as this promotes better short-term stability. The frequency will change a few kHz over time as the crystal ages.

W3MMV volunteered to fabricate "from scratch" the horizontally polarized Alfred Slot antenna for 23 cm. Likewise, K3VDB volunteered to fabricate the 13-cm circularly polarized Lindenblad antenna. The slot antenna gain is about 4 dB and the Lindenblad about 3 dB; both antennas are housed in radomes.

The 10-GHz experience told us that we wanted to use a WW2R keyer with telemetry so that we could remotely monitor the health of each beacon, keyed by the same keyer. We use two blowers both for air flow and dependability, and they are turned on and off by a thermostat set to about 80 degrees. All is mounted in a waterproof box designed for the electrical trade to house both beacons. The 23-cm antenna is below in the box and the 13-cm antenna is on top. A single coax cable feeds 13 VDC to the beacons. The 23-cm beacon has an output power of 1.5 watts and the 13-cm MHz beacon 1 watt.

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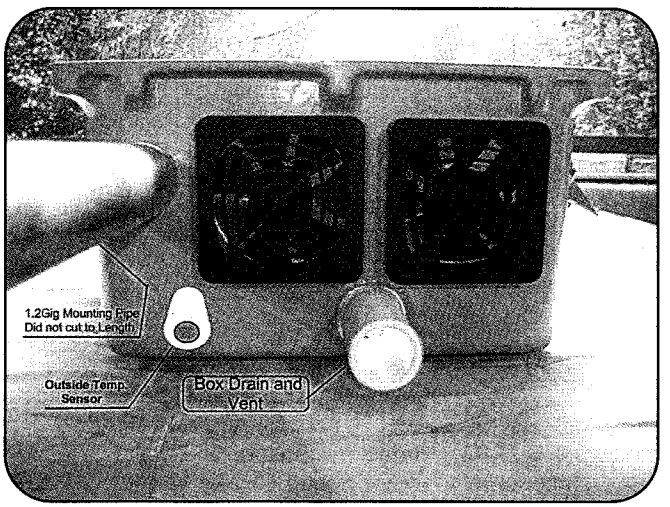

Photo B. Interior view of the beacon ready to install.

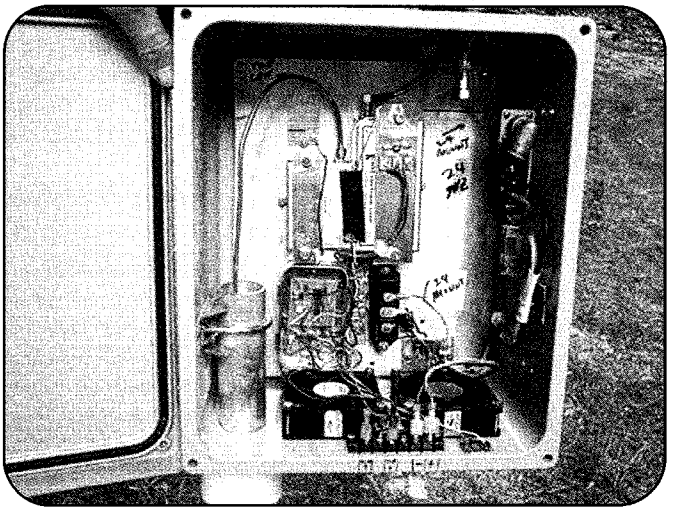

Photo C. Bottom view of the beacon showing the 23-cm antenna on the left.

Telemetry (TLM)

The TLM has four positions of information. It was designed, built, and the PIC programmed by Doug Robinson, G4FRE/WW2R, in Texas. All the details are available on his website: <http://g4fre.com/radio.htm>. In the past, W3HMS and WA3PTV have used several of Doug's keyers for various functions, all with superb results. The keyer with telemetry is called an "Intelligent Keyer," and it is viewable on his site under this title with schematic. Doug programs your desired message at purchase time. It is possible to send any TLM sensor value that can be expressed in the range 0–5 VDC.

Beacon Message

We decided we wanted to send the following message: W3HZU/B W3HZU/B FN10PA FN10PA QSL TO W3HMS@AOL.COM, followed by the telemetry in four groups of three numbers, such as: 056 049 234 032. The message would then recycle. The telemetry consists of the DC bus voltage, the temperature from the thermometer mounted on the beacon transmit cover, the status of the vent fans, and the temperature outside the beacon.

DC Bus Voltage: The DC voltage on the beacon bus is calculated by a formula a bit too complex to do in your head, but easy to define in an EXCEL spreadsheet for common values. Let's say you copy the first group number 056. That number is equal to 12.60 VDC at the beacons.

Thermometer: The second set of three numbers is the thermometer mounted on the beacon transmitter cover. One half of the temperature in degrees Fahrenheit is sent in CW. As an example, 049 is sent, so 049 × 2 = 98 °F. The thermometer is the reasonably priced LM34DZ.

Vent Fans: If the two vent fans are on, the numbers are more like 231 than 000, as the latter indicates the fans are off. The

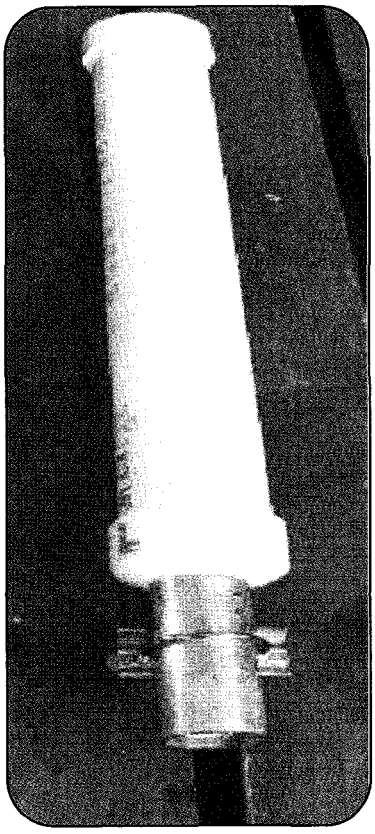

Photo D. The 1.2-GHz antenna.

fans cycle on and off about every six minutes at an outside temperature of 70 °F.

Outside Temperature: The temperature outside the beacon is sent as defined above for beacon temperature.

Performance

The beacon entered into service at a temporary site on June 6, 2007. Initial tests from the W3MMV QTH confirmed good operation, but the signal was weak at any real distance. K3VDB was able to obtain temporary permission to mount the beacons at a height of about 1130 FAS on a tower in Red Lion, Pennsylvania, grid square FM19qv.

The beacon signs W3HZU and FN10PA, as that is the ultimate destination on the 200-foot tower at about the 150-foot level. We have had excellent reports on the 23-cm beacon out to about 100 miles. The 2401-MHz beacon has been heard at about 75 miles. The Weak Signal Group has asked why not 2304 MHz, and we explained the needs of satellite operators at 2401 MHz. An Excel spreadsheet has been developed by K3VDB to record telemetry data in a scientific manner and is available on request.

Cost

These beacons are quality instruments and as such are not cheap! We will be happy to discuss this aspect with serious prospective builders.

The Particulars

The frequency of the 1.2-GHz beacon is 1296.079 MHz. The frequency of the 2.4-GHz beacon is 2401.00 MHz. The voltage at the power supply is 13.79 VDC. The voltage at the beacon is 13.67 VDC at 1.38 amps. The 1.2-GHz antenna is an Alford Slot, ~4 dB gain, horizontal in the PVC radome. The 2.4-GHz antenna is a Lindenblad, ~3 dB gain, right-hand circular polarization in the glass radome. The 1.2-GHz beacon's output is ~1.5 watts. The 2.4-GHz beacon's output is ~1.0 watts. *(Note: ~ indicates about, or to the best of our knowledge.)*

Some Temperature Observations

With an outside temperature of ~90 °F, the electronics temperature is ~108 °F with the fans on. At this temperature, the 2.4-GHz frequency is ~2401.00 MHz. At ~70 °F the fans cycle on and off about every six minutes. The electronics temperature lowers about 4–5 degrees when the fans come on. At this temperature the 2.4-GHz frequency is ~2400.998 MHz.

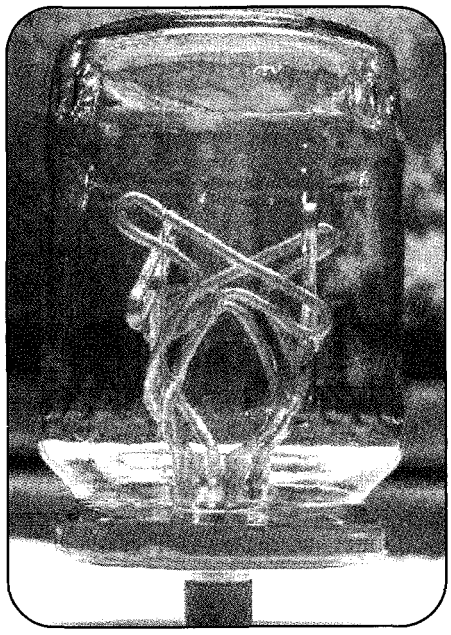

Photo E. The 2.4-GHz antenna.

The ID and Telemetry

The AFSK CW ID and Telemetry (TLM) message is: W3HZU/B (two times) FN10pa (two times) QSL to W3HMS @aol.com **XXXXXXXXXXXX**. Then there is ~14 seconds of key down; then it repeats. The "Xs" are beacon TLM numbers reporting beacon health. They are to be read in groups of three. The first group indicates power-supply volts, To decode the numbers, you would divide it by 51.2 then multiply by 11.283. The second group is the electronics temperature. Multiply this number by 2. The third group indicates whether the fans are on or off. Any number around 250 indicates that the fans are on; below 250 indicates that the fans are off. The fourth group is outside temperature. Multiply this number by 2 to get outside temperature. An MS Excel Spreadsheet is available for decoding the TLM.

Summary

We have included photos of the complete beacon package with the two antennas. Signal reports are welcomed. For further information and technical details, please e-mail Charlie Heisler, K3VDB, at <k3vdb@amsat.org>, or John Jaminet, W3HMS, at <w3hms@aol.com>.