Update to "A Simple Beacon System"

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Background

I presented an article in the Proceedings of Microwave Update 1991 which described "A Simple Beacon System". That article has been further published as chapter 3-1 of the recently released ARRL Microwave Projects Book. The article elaborates on beacon basics and describes the general design used to place beacons on several HF, VHF and microwave bands which could be easily extended to other bands. I continued placing additional beacons in service until mid 1994, culminating in operation of continuous beacon transmitters on all *eleven* bands from "10 meters to 10 GHz". Having now relocated 1200 km east, all station activities including the beacons are being reestablished. This paper describes and elaborates on the evolution of the system and the design concepts and techniques involved, in hopes that additional beacons might be encouraged in desirable and appropriate areas. The background which was elaborated upon in the original paper has not changed; therefore, this paper concentrates on technical aspects of the system. Despite the microwave emphasis of the conference and proceedings, I am continuing to describe briefly all bands so as to maintain the entire chronology in one document.

Evolution

A band by band description of each of the eleven beacon transmitters best describes the system components as well as the process in which they evolved. Some parts of the basic system remained unchanged during the more than three years of operation. Most notably, the keyer, which identified reliably more than 3 million times. As more transmitters and power amplifiers were added, the +12 volt supply was increased to a single 35 amp unit.

On ten meters, the system remains unchanged from the original paging transmitter exciter. The dipole antenna failed due to metal fatigue from wind vibration. It was rebuilt with additional reinforcement. Even with only a few inches of radiating element remaining, it was still receivable weakly at 14 km. The IARU Region 1 beacon coordinator has requested shifting away from 28.250 MHz to alleviate congestion on this popular band.

The six meter transmitter, a surplus GE FM exciter board, has proven reliable also. A Henry Radio commercial 15 watt amplifier was purchased at a hamfest to liberate the Mirage A1015. The antenna, a Cush Craft Trik-Stik dipole has been reliable but will be replaced with the more omnidirectional M^2 Sqloop when placed back in service. Also, the 50.070 spot is overpopulated in the FM17 vicinity, necessitating a small shift in frequency (thanks to W3OTC for advice).

The two meter transmitter, an RF Concepts FM exciter board, also is unchanged. Various amplifiers have been tried, up to a Mirage B1016 (100 watts out!). The two meter beacon is back in service temporarily from my new QTH in FM17kn. The amplifier is now a Santec unit producing 30 watts. The original home-brew squalo has been replaced with an M^2 Sqloop. Even with the antenna only 5 meters above ground amongst tall trees, the beacon is heard at 300 km range.

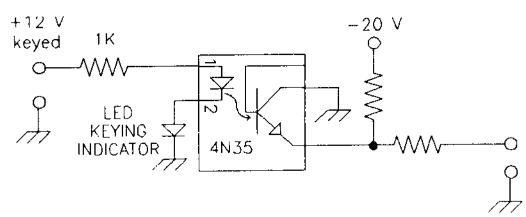
The 222 MHz beacon is still the same minimal GLB FM transmitter sans audio components. A Mirage amplifier of unknown pedigree provides about 6 watts out to a homebrew squalo. No other changes have been made. Plans include repackaging the transmitter board along with the two meter beacon transmitter to make for better space efficiency.

The 432 beacon is unchanged from the original GE FM exciter and hybrid amplifier put together by W4HHK. The antenna was a simple dipole (well, actually half a dipole after the wind blew away the "cold" side). Plans are to obtain one of the M^2 Sqloops now available for 432 (note to M^2: you skipped 222).

The 903 and 1296 beacons are very similar and are packaged together in a minimum height rack enclosure. They both use "no-tune" weak signal boards from Downeast Microwave. Each board has an added hybrid amplifier to bring the power up to the watt plus range. Antennas are both alford slots with Superflex feedlines. The frequency stability needs to be improved. Since both units use oscillators in the 100 MHz range, the oscillator and temperature control circuitry from a Frequency West PLO "brick" can be used to replace the on board oscillator for vastly improved stability. This is an excellent use for "bricks" with bad cavity oscillators or multipliers.

The 13 cm beacon transmitter is still based on an AN/GRC-144 multiplier amplifier assembly putting 4 watts into an alford slot. The frequency determining components have been improved. To provide proportional temperature control of the oscillator, a Frequency West PLO "brick" was modified to bring out the 96 MHz oscillator through the MOD BNC connector. This is tripled in an MMIC stage to the 288 MHz needed to drive the surplus assembly. The original oscillator was in a separate Thermos bottle. The new design allowed repackaging everything into one rack panel space.

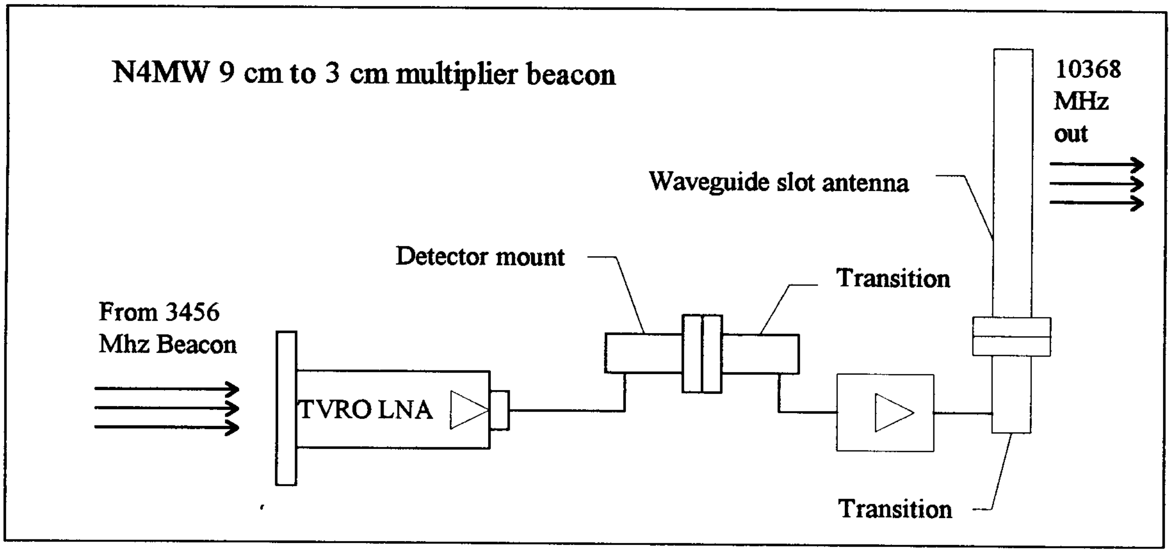
The 9 cm beacon is also based on an unmodified Frequency West "brick" with output on 3456 MHz. These units are not intended to be keyed as required for CW service. When first placed in beacon service, the unit was FSK modulated by varying the power supply voltage slightly, resulting in "rubbery" but useable FSK. Phase two involved use of a PIN diode modulator (an HP 330001D) to modulate the output to a 35 dB depth, sufficient to perceive as CW, although the -22 dBm backwave was just receivable 14 km away. KH6CP/1 came to the rescue with the gift of an Avantek 100 mw amplifier, which boosted the power a bit and allowed good CW keying of the amplifier power supply voltage, the classic master oscillator/power amplifier (MOPA) of my novice days. Serendipitously, gain of the amplifier was sufficient to allow location of the frequency source in the equipment cabinet rather that at the antenna. The antenna is an alford slot made from copper water pipe. The entire amplifier/antenna assembly is inside of a PVC drain pipe radome.



Pin Modulator Keying Circuit

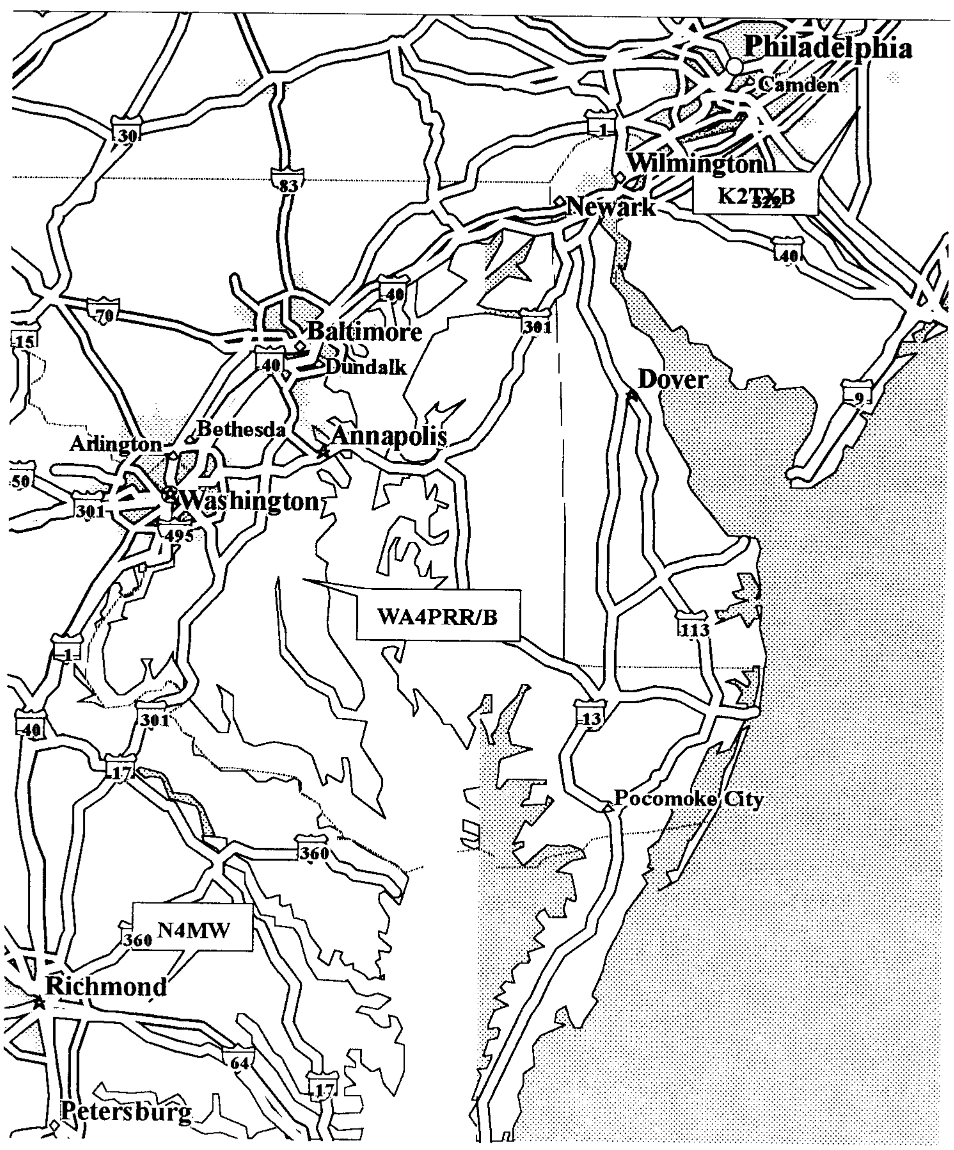
The 6 cm beacon uses another ubiquitous "brick" remoted in the equipment cabinet. An FET TWT replacement with around 2 watts out is located at the antenna. The positive supply voltage is keyed for good CW. The negative supply is left on at all times to maintain bias on the FETs. To insure that positive voltage is never applied without negative first being applied, a simple relay powered from the negative supply is included to enable the positive keyed voltage. To be extra careful, the relay gets its negative voltage from an extra conductor which runs all the way to the remote mounted amplifier/antenna assembly, separate from the wire carrying the negative bias voltage. This helps assure that a broken wire will not fry the FETs. The alternative is to build the fail-safe relay close to the amplifier, but I wanted to keep it in the equipment cabinet. The antenna is a waveguide slot in WR-137. Like the 9 cm amplifier/antenna, the entire assembly is inside of a PVC drain pipe radome.

And finally, the 3 cm beacon is somewhat bizarre in concept. The entire beacon is built into a NEMA watertight enclosure. A 4 GHz waveguide to N connector transition serves to pick up a sample of the 9 cm beacon transmitter output over the airspace between the beacon enclosures, about 0.5 m. The sample is amplified 50 dB using a small Avantek amplifier (A TVRO LNA would do the same job as both). The amplifier output is fed to a garden variety HP diode detector mount with a WR-90 waveguide flange. This triples the frequency into the 3 cm band. The 10 Ghz signal is then amplified to the 35 mw level in an Avantek surplus amplifier, which outputs to a 24 slot waveguide antenna through a WR-90 waveguide section, which serves as a high pass filter. This beacon was receivable over a 69 km path. It went into service just prior to shutting everything down to move, so there was not enough time to continue range testing.



Other developments and plans

Also constructed was yet another 3 cm beacon for range testing purposes. It consists of a Frequency West source retuned for 10368 MHz output of about 20 mw. It was discovered that the output of an electronic keyer (such as the Morse-Machine by AEA) could be directly attached to the XTAL test point on the source to impart decent, narrow FSK modulation. FSK has the advantage of providing a steady, unwavering signal level for peaking antennas, etc. A narrow cw filter can be used to single out the mark frequency to identify a weak received FSK signal of unknown origin (if you are fortunate enough to find one on 10 Ghz). The source with attached waveguide slot antenna are mounted on a round plate on top of a CDE style rotator lower mast clamp assembly. A weather cover consisting of a "beehive" plastic TVRO feed cover is Ty-Wrapped to the round plate. The assembly is simply clamped on top of any convenient mast pipe or lag bolted to a vertical wall structure. A dedicated keyer could be built into the weatherproof enclosure if desired. The physical configuration of this style beacon lends itself to rapid redeployment. At the time of this writing, WA4PRR is placing this beacon on the air at a site in southeastern Maryland (FM18qq). The map inset shows that the beacon location is 131 km from my new QTH and 211 km from K2TXB in FN20, whom I hope to work on 10 GHz eventually. This is an example of siting a beacon to assist in acheiving a specific goal, with continuing benefit to others in the region.



The two meter beacon has been placed in operation at the new QTH temporarily until a suitable remote site has been located. In this case, remote means far enough away to not adversly affect normal station operation due to overloading. Of course, other stations must be considered also in choosing a site. For the VHF beacons, a site maybe 10 km or more distant is desireable. For the microwave beacons, a clear horizon is most important, but a reasonable seperation is also sought.

Although perhaps somewhat distant to assure constant reception at my QTH, I have entered into discussion about placing beacons at a mountaintop location in an adjoining grid. This would most likely start with 5760, then spread to the higher and lower microwave bands. This type of deployment would make best use of existing transmitters in serving the most stations. Hopefully, by the time this is published, some action will have occurred.

Meanwhile, I still plan to implement a Richmond area set of beacons from a remote site. Previously, unused control features of a collocated FM repeater were used to turn the beacons on and off if required. Control of the beacons must now be accomplished by independent means. A dedicated receiver will now be employed. A commercial DTMF decoder provides for on/off control, along with expandability if other functions become desirable. I intend to make use of the WB2OXJ "Ultimate IDer", a reprogrammable, dedicated microprocessor controlled keyer described in a recent QST article. This keyer is available in a convenient, high quality kit form for $30. A common "AT" computer keyboard is used to program the message, which can be repeated continuously at various code speeds. This keyer has the advantage that no EEPROM burner is needed to set up or change the message. It also consumes very little current, only a few milliamperes, which may be important in some situations (solar power). One disavantage is that no provision is made for programming a long dash, typically used for level measuement and equipment tweaking using a beacon as a signal source. A series of Ø characters can be used to approximate a long dash. The extreme convenience of programming this type of keyer makes it easier to use a more complex beacon message, including changeable information on frequencies and EIRP levels, etc. For my next generation beacon system, I plan to incorporate the new keyer, keying fanout circuitry, a control receiver and the control DTMF decoder into a common rack chassis.

Summary

Some scattered points to be noted from the above discussion:

- Using a little ingenuity and perseverance, available surplus and what-have-you can be integrated into a beacon system.
- Templates for construction of the waveguide slot antennas are available from the author for a WR-137 slot antenna for 5760 Mhz and a range of slot antennas in WR-75 and WR-90 for 10368 MHz.
- PVC pipe radomes can protect microwave beacon active equipment and antennas.
- Antennas can be fabricated with simple hand tools for all bands or obtained commercially for lower bands.
- Frequency West sources can be used directly or adapted to provide stabile frequency sources on all microwave bands.
- Keying of Frequency West sources can be accomplished in a variety of ways.
- The WB2OXJ "Ultimate IDer" keyer provides a convenient source of Morse.