What is a [Microwave] Beacon and Why Have One?

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I am in the process of building a 10 GHz amateur radio beacon for a site near me. Today I was asked “What does a beacon do?” That is an excellent question! It made me realize the advantages of a beacon might not be apparent to those who are not into microwave operating. I sensed an educational opportunity here.

What is a beacon?

First let’s establish what a beacon is. In its basic form a beacon is a low to moderate power transmitter, usually installed at a favorable site, that transmits a simple message continuously. The message usually consists of the beacon call sign and a 6-character “Maidenhead” grid square locator that indicates the approximate beacon location. Beacons often emit a steady carrier signal for 10 seconds or more between repeats of the message. This is useful for peaking directional antennas on the beacon signal.

The most common (and easiest to build) transmit CW, or Morse code. More advanced beacons may transmit a digital mode such as Q65 which can be heard further away, or even alternate back and forth between CW and digital.

Even more advanced beacons may contain a receiver. They can listen for you to transmit and either append a signal report for you to the next outgoing beacon message or spot you on the internet. The latter is often known as a “reverse beacon”.

A favorable site for microwaves (in amateur radio often meaning bands at or above 900 MHz) typically means an elevated spot such as a hill, tower or tall building. These can extend the useful range of a beacon, just as VHF/UHF repeaters, FM broadcast and TV stations often utilize favorable locations for the same reason. What is even more important than being in a high location is having a clear view of the horizon so that the signal doesn’t need to go through trees or other things that would attenuate (weaken) it.

Now that we know what a beacon is, we can talk about why we might desire one. Microwave beacons serve as tools to check and adjust antenna rotator calibration, provide a frequency reference, a propagation indicator and as a means to verify proper operation of our stations and ward off paranoia when we think our stations may be broken.

Antenna headings

To get the best range on microwaves, most people use high gain, highly directional antennas. Parabolic dish antennas in the 18 to 36 inch range are the most common on the 10 GHz band, also known as the 3 centimeter band, the latter referring to the approximate wavelength. These dishes have a beamwidth of two to four degrees so they need to be precisely aimed toward distant stations we hope to make contact with (or toward a common storm cell, but that is a topic for another time).

Because of this it is difficult to make “random” contacts over long distances by getting on and calling CQ as we might do on lower frequencies. The odds of someone far away who is in the pattern of our antenna having their antenna pointed directly at us are rather small. In addition, since most people are not fortunate enough to have a clear horizon from their home, much microwave operation is done with portable systems.

To overcome these challenges, microwave contacts are often facilitated by first establishing contact using some other means such as VHF radio, telephone, text message, online chat servers or other means. Then the two parties can point their microwave antennas at each other and try to make the contact. This implies that one needs to know exactly where their antenna is pointing. Rotators, especially the ones that allow more precise aiming, can have a nasty habit of getting out of calibration.

Having a beacon within “line of sight” or “brute force” range can be an aid to checking and adjusting rotator calibration. If I turn my antenna to peak the beacon signal, I can then check to see if the direction indicated by my antenna rotator matches the known heading to the beacon. For example, I know from plotting the path from the tower in my back yard at home to the tower on Stickney Hill where my beacon is to be installed that the bearing is precisely 347.26 degrees. If I turn my antenna to peak the beacon signal and my rotator does not indicate 347 degrees, then I know I need to calibrate it or at least I know how far off it is and in which direction.

Portable stations may need to calibrate headings each time they go out or move to another site. If they have calculated the bearing from each site to a local beacon, this can be an aid to finding directions or verifying that some other means of finding directions has given a correct calibration.

Frequency reference

Building microwave stations with precise frequency control can be considerably more complex and expensive than simpler setups that lack such precision. Since most contacts over long distances are prearranged, we also need to know how to find the frequency of the other station. Beacons can help with this.

Many beacons now employ means to precisely control their frequency so that they can serve as an accurate reference. For example, let’s say I have a beacon with a known precisely controlled frequency of 10,368.310 MHz but I tune it in and find that my radio says 10,368.322 MHz. Now I know that my radio is reading 12 kilohertz higher than the true frequency. If I have agreed to meet my QSO partner on 10,368.100 MHz, I now know that my radio will indicate 10,368.112 when I am on that frequency.

Beacons that don't have precise frequency control can be useful in a similar way. One practice is to agree to try a QSO on some frequency relative to the beacon, for example "200 kHz below the beacon frequency". If both stations attempting a QSO can hear the beacon, this works even if the beacon frequency is imprecise or drifting.

Thus a beacon can help those with less elaborate and less costly stations enjoy more success on the microwave bands.

Encouraging newcomers

Building a receiving system for microwave bands is often far less costly than building a full station capable of transmitting. This is especially true on 10 GHz where if one already has a computer of some sort and a 12 to 18 volt power source, a receiving setup can be constructed using a satellite TV LNB ($25 or less shipped) and low cost software defined receiver that covers UHF (some under $30 shipped). I wrote an article on how to do that.[1]

It may be easier for people to spend the money and time to build a listening setup if they know there is a beacon constantly transmitting for them to listen for. This is not too different from being a shortwave listener before deciding to get an amateur radio license. What is the point? Perhaps just reassurance that it truly is possible to hear microwave signals. Or perhaps to experience and become fascinated by microwave signals and propagation phenomena.

I have a temporary, very low power beacon at the Stickney Hill site, 5.6 miles from my house. I can hear its signal direct despite many compromises such as an indoor antenna on the beacon and several trees in the way. When a rain shower passes between me and the beacon, I can either hear its signal direct (clear CW tone) and via rain scatter (spread frequency hiss) at the same time, or if the rain is intense enough I might even lose the direct signal and only hear the rain propagated signal.

Characteristics of the rain scattered signal can be very different from one storm to another and even from moment to moment as a storm passes through. This may not be everyone's cup of tea but some may find it fascinating and become more interested in microwave operating. Come winter, I expect I will hear similar yet different effects from snow scatter of the signal.

At this point I am still just starting out on microwaves. I don't live in an ideal location. I am in a valley and was very concerned that I might not be able to hear signals or get a signal out of here. I am fortunate to have towers tall enough to get over the trees. I have built a low cost 10 GHz receiver and placed a 76cm dish on one of my towers. On the very first day I had this system up, I had several hours of rain scatter signals from beacons in Vermont and Quebec at distances of 195 and 260 miles. I *can* hear signals!

I have been hearing those as well as another Vermont beacon and one in Massachusetts quite frequently on rain scatter. I can hear one of the Vermont beacons at 195 miles most of the time without rain scatter. It is very weak and seldom readable in terms of actually being able to copy the CW but the mere fact

1 http://n1bug.com/10ghz/Low-Cost-10GHz-Receiver.pdf

that I can hear something from that distance over a path that is severely blocked by mountains is encouraging.

That beacon runs 800 milliwatts to an omnidirectional antenna. A typical 10 GHz station with two or three watts and a dish having 15 to 20 dB more gain than the beacon would surely be easily workable at any time, so even though the beacon is too weak to copy, hearing it at all gives me valuable information.

I am very grateful for these beacons. They are greatly encouraging me and providing a means to learn more about microwave propagation first hand while I continue to work toward building a full station.

Propagation indicator

Beacons can serve as indicators that a particular area is workable at a given time. Since most microwave contacts are prearranged and many operators need to head out to a portable operating site, one might wonder when to make these attempts. Hearing a beacon near some of those stations or in a location that gives you reason to think you might have propagation to an area at a given time can serve as an indication that now would be a good time to try.

Equipment testing

Suppose you have packed your station out to some portable site, set up and tried to make a contact but you didn't hear the other station. You might wonder if propagation simply wasn't there or if you have a problem with your equipment. If there is a beacon close enough to your location that you can be certain you should hear it, listening for the beacon can help to answer that question.

Of course, advanced beacons with receiving capability can go further and allow testing our transmitters as well, but these beacons are much more complicated and costly to build. There are few of these around.

As we have seen, beacons can be very useful. I personally believe the presence of beacons can be a critical aid in encouraging people to try something new, increasing activity on our microwave bands and encouraging the spread of activity into new geographical areas. If I'd had a beacon nearby I could have tried a very simple receiving setup and started to gain experience much sooner, without the need to put a dish on one of my tall towers. And – perhaps more importantly – without the need to first build the beacon myself!