474THz Beacon Tests 22/23 November 2006

The objective of this test was to establish if broad-beamwidth LED in its standard configuration, without a lens, could be used as a beacon for Digital Modes. The beacon was set up at the home of VK7ZIF and beamed in the general direction of VK7MO over a distance of 6.8 km. The main conclusions were:

- A broad beamwidth 300 milli-watt output LED beacon gives 100% decodes at night time and is around 20 to 25 dB and above the level necessary to decode on WSJT at a distance of 6.8 km.
- Signal to noise ratios drop by about 35 to 40 dB in strong sunlight such that decoding is not possible.

Equipment

1. VK7MO Mike's "Big Box"
   i. RX lens 400 x 340 mm

2. VK7ZIF Beacon
   i. 1 Watt Luxeon
   ii. No TX lens

Weather Data

128.45 MHz reported visibility beyond 10 km on both days

Locations

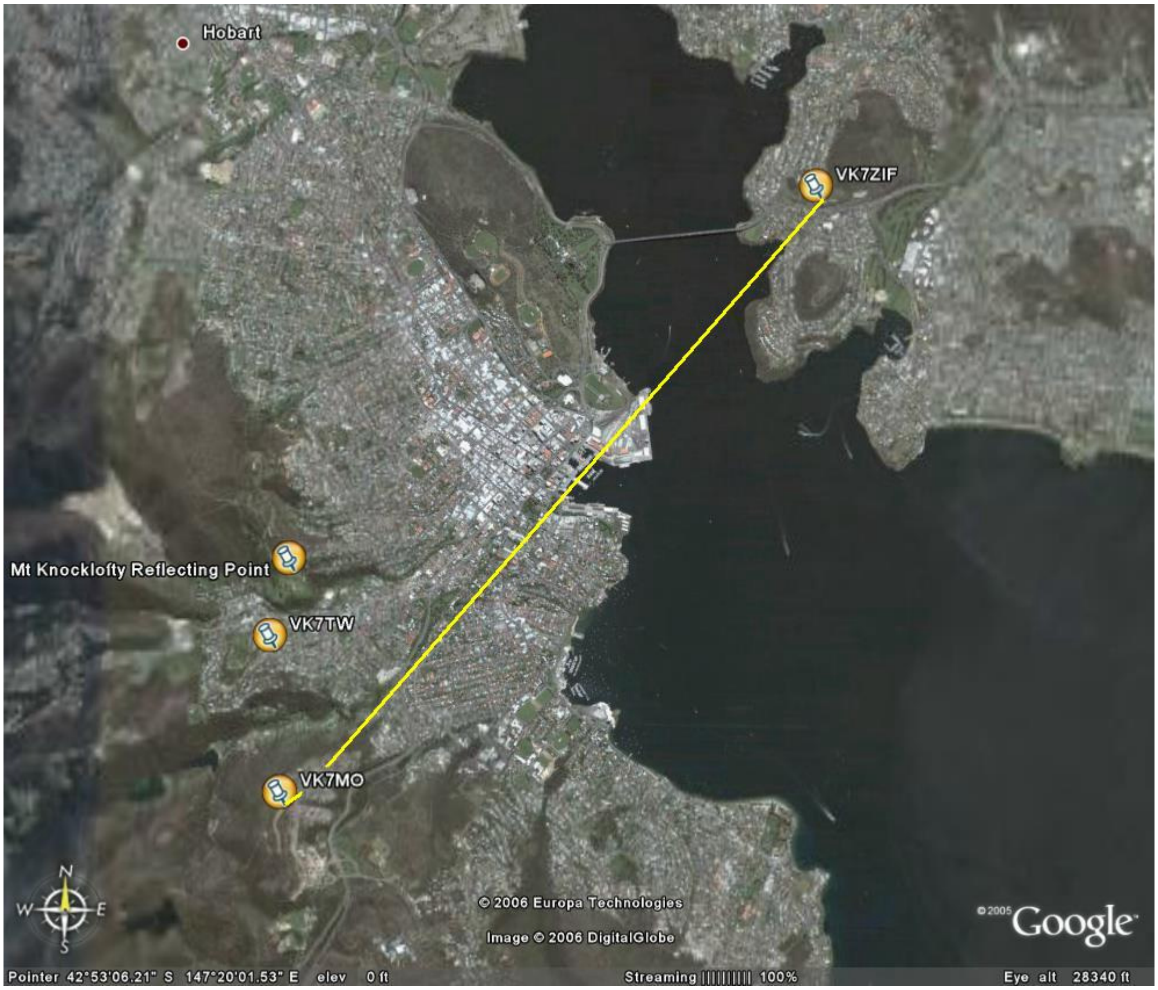
VK7MO
Latitude 42 Deg, 54 min, 28.60 secs South
Longitude 147 Deg, 18 min, 13.78 secs East

VK7ZIF
Latitude 42 Deg, 51 min, 40.83 secs South
Longitude147 deg, 21 min, 28.31 secs East

Distances to Between VK7MO and VK7ZIF

6.8 km

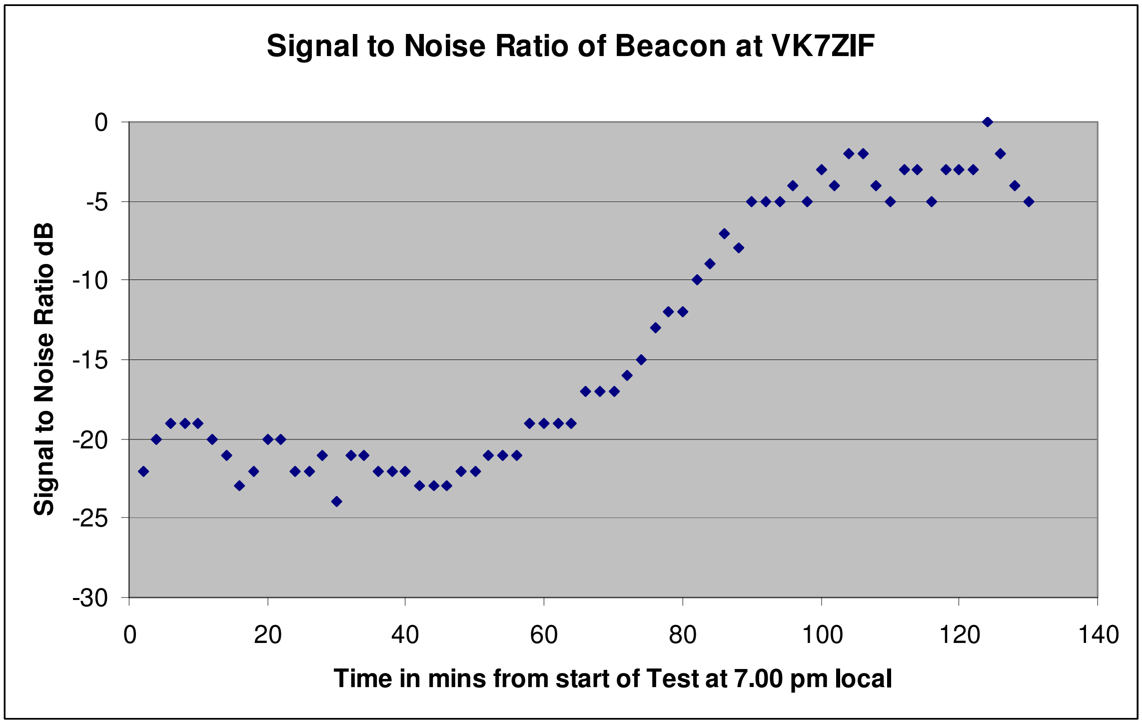
Path (Plan View)



Path (Slant View)

Results

100% copy was received as soon as the beacon was switched on. The following graph shows the signal to noise ratio at VK7MO.



At the start of the test there was still light in overcast conditions and the signal to noise ratio ranged from -19 dB to -24 dB. The graph shows signal to noise ratio improving from 50 mins to around 90 minutes which would have coincided with the on-set of twilight. Signal levels reached a plateau around -2 to -5 dB at 100 mins into the test which would coincide with the on-set of darkness. It should be noted that WSJT is not designed to operate at high signal levels and that for signals stronger than about -6 dB it tends compress and underestimates the actual signal strength. Thus the dark signal level could well have been stronger than zero dB and might have supported voice communications.

It is possible that the variability in signal levels was the result of leaves of trees that were very close to the path and possibly obscured it for part of the time.

At around 20 minutes into the test Rex returned home and could not see the beacon by eye or even when using a high power spotting scope. After darkness Rex could still not see the beacon by eye but could just detect it with a high power spotting scope as a weak dancing ring of light about 5 meters across (judging from the lighted window at the front of Ian's house). This dancing ring faded in and out which might be due to the leaves of trees obscuring it. Possibly the dancing ring is a function of scintillations due to multi-path propagation.

Attenuation Tests

After completing the test results graphed above Rex tried attenuating the signal by blocking of the receiving lens and found that with a slot of 1.5 cm high and 9 cm wide across the lens signals were reduced down to around -26 dB and that a further reduction to 1.5 cm by 4.5 cm wide reduced signal levels to between -29 and -31 dB.

Assuming the slot across the lens represents a reasonably linear reduction in intensity in proportion to area the attenuation should have been as follows compared to the full lens of 340 mm x 400 mm:

15 mm x 90 mm   20 dB attenuation
15 mm x 45 mm   23 db attenuation

The signal level reductions were as follow:

20 dB attenuator -4 dB reduction with attenuation to -26 dB or 22 dB change
23 dB attenuator -4 dB reduction with attenuation to -30 dB or 26 dB change

Thus it is concluded that the strip attenuators are within a few dB of the measured change and can reasonably be used for performance measurements.

Lens Gains

Chris VK3AML advises that one can estimate the gain of the lenses on the basis of the size of the lens in relation to the blur spot. For the larger and better quality lenses he estimates the blur spot at 1 mm and for the small and poorer quality lens he estimates the blur spot at 1.5 mm. Applying these figures gives the following gains:

Mike's Big Box	Lens Height	Lens Width	Lens Area	Blur Spot	Blur Spot	**Gain**
	mm	mm	sq mm	mm	area sq mm	**dB**
TX Lens	400	340	136000	1	1	**51.3**
RX Lens	400	340	136000	1	1	**51.3**
Mike's Yellow Box						
TX Lens	180	150	27000	1.5	2.25	**40.8**
RX Lens	180	250	45000	1.5	2.25	**43.0**
Mike's Green Box						
TX Lens	170	140	23800	1.5	2.25	**40.2**
RX Lens	235	185	43475	1.5	2.25	**42.9**
Justins Big Box						
TX Lens	400	400	160000	1	1	**52.0**
RX Lens	400	400	160000	1	1	**52.0**

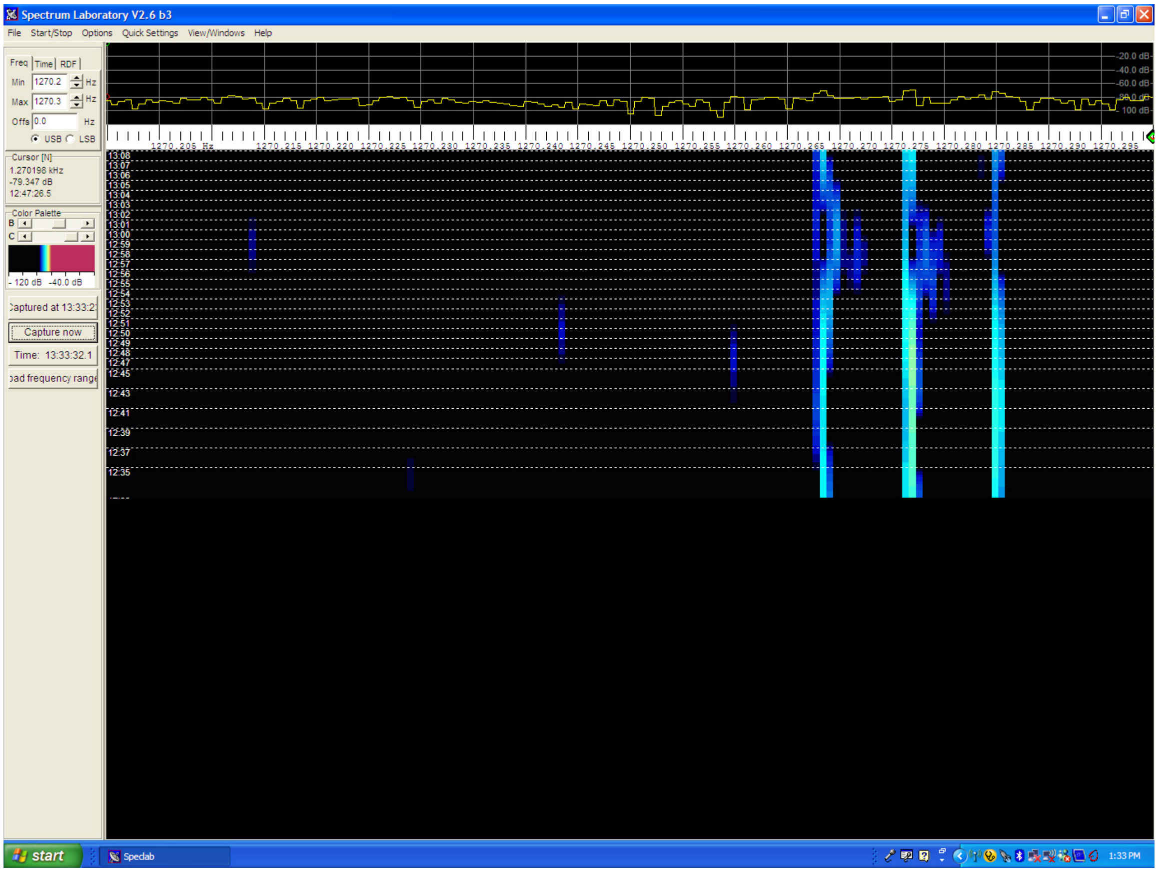
If we assume the use of one of the smaller 40 dB gain lenses and allow for a further 20 dB attenuation that was found still allowed 100% decodes then this path has 60 dB to spare. If one of the larger lenses was used at the VK7ZIF end then the path has 70 dB to spare.

Comparison with Empress Towers Reflected Path

The total distance from VK7MO to VK7TW is 6.4 km on the reflected path which is similar to the 6.8 km for this path. The reflected path produced signal levels of -14 dB at VK7MO with a 41 dB Txing lens and the same 1 watt TXer. The direct path with no lens produced signal level of around -4 dB. Thus the additional loss in using reflection is around 51 dB.

Midday Daylight Tests

A further test the next day around midday in overcast conditions produced no evidence of signals on WSJT. In order to see if a signal could be detected Spectrum Lab was employed with a bandwidth of 0.7 milli-Hz. At this very narrow bandwidth the integration time is around 20 minutes. Interestingly after 20 minutes a signal did show up about 10 dB above the noise with sidebands around 8 milli-Hz ether side (see screen shot below). These sidebands correspond to the frequency of WSJT transmissions of one every 120 seconds or 8.3 milli-seconds which gives reasonable confirmation that the signal is in fact deriving from VK7ZIF. There is some evidence of signal fading and frequency spreading at this bandwidth although much of the time the optical path copes well with a sub milli-Hz bandwidth.



The screen shot shows a Spectrum Lab spectrum of the signal in a 0.7 milli-Hz bandwidth with sidebands 8 milli-Hz either side.

0.7 milli-Hz bandwidth compares to reported WSJT signals in a 2.5 KHz passband which is a difference of 35 dB in noise power. Thus a 10 dB signal to noise ratio in a 0.7 milli-Hz bandwidth should produce a WSJT signal around -25 dB and the WSJT signals should have been detectable. This leads one to wonder if conditions improved after the switch to 0.7 milli-Hz bandwidth. After a longer period of monitoring it was noted that the 0.7 milli-Hz bandwidth signals had in fact dropped to close to zero dB confirming some variability in conditions. At zero dB this would produce a -35 dB WSJT signal that could not be detected. Sufficient to say that in midday conditions is seems WSJT is only around 5 to 8 dB too weak to be detected but that it might be possible in conditions such as when the sky is heavily clouded. Thus a longer test is worthwhile to see if decodes can be achieved.

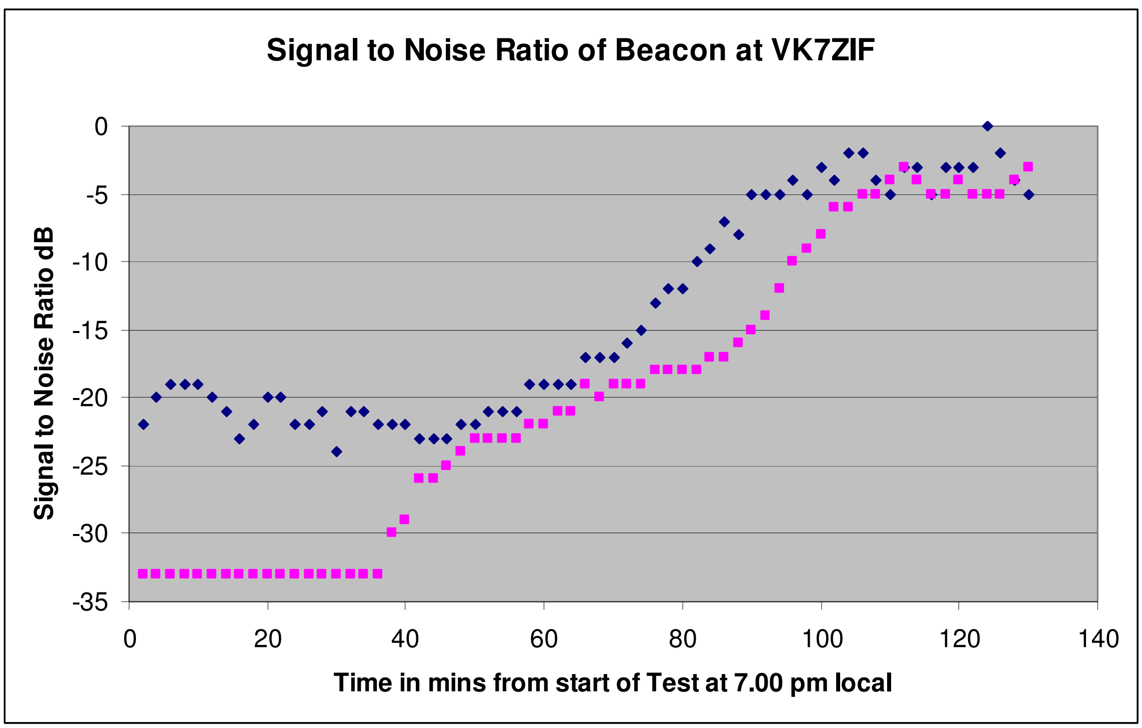
During the day the overcast conditions gradually gave way to periods of bright sunlight and signal levels even in 0.7 milli-Hz bandwidth faded at times to be undetectable.

Even as sunset approached the Eastern Shore around Ian’s home was bathed in bright sunlight and signals remained weak in 0.7 milli-Hz bandwidth with no decodes on WSJT.

As soon as the sun set (even with good twilight) on the Eastern Shore at Ian's home WSJT commenced decoding. The local time was 7:40 pm some 40 minutes later than the night before when decoding had commenced at 7:00 pm at the time the beacon was switched on in overcast conditions. It appears from these tests that system performance drops to around -35 or -40 dB on the WSJT scale when the RXer is looking at the Eastern Shore in bright sunlight compare to around -4 dB in darkness. So we can conclude the reduction in system performance due to bright sunlight is around 35 dB. We can also conclude that in order for WSJT to decode in bright sunlight we need another 10 dB or so in system performance which could be achieved by a small lens and in conjunction with a 3 watt Luxeon. Some arrangement that maintained good beamwidth in the horizontal plane but restricted the beamwidth in the vertical plane should allow sufficient gain to all daylight operation of a beacon.

On this second night the beacon was visible during twilight and did not show the dancing loop effect but rather more compact scattered dots of light no more than a meter apart – presumable the result of more stable weather conditions producing less scintillation.

The signal levels from the 7:00 pm some 40 minuted before WSJT started to decode until complete darkness are recorded in the graph below in pink. For this second evening the sky was mostly clear compared to overcast the night before as recorded the night earlier on 22 November in Blue for comparison. The main difference between the two nights is that there were useful signal levels prior to sunset on the 22 which is presumably due to the fact that sunlight at Ian's home was lower as it was an overcast day.



Blue data is for 22 November during overcast conditions and Pink data for 23 November when there was bright sunlight prior to sunset which occurred at around 38 minutes into the test

The next screen shot shows the signal in 0.7 milli-Hz bandwidth with annotations on sunlight conditions. Note the sidebands spaced 8 milli-Hz apart in line with the Pulse Repetition Rate of the TX period of 120 seconds.