Light Transmissions - Particulate/Water Vapour Bounce Tests

By Rex Moncur VK7MO and Justin Giles-Clark VK7TW

Since improving the performance of VK7MO's 30 "Copy Luxeon" transmitter to a 60 actual Luxeon transmitter and possibly more efficient lenses, the output has been increased by around 18 dB. VK7TW has improved his receiver by around 4 dB by using a 350mm high quality reflecting mirror in place of a 400x400 mm Fresnel lens. The new transmitter/receiver combination has dramatically improved the performance for cloud bounce such that it is no longer necessary to have clouds and signals averaging -19 dB on the WSJT scale have been measured over a 5.3 km path on a clear night. At the time of the tests (evening of 22 August 2007) stars were clearly visible with no sign of clouds so it is postulated that the light was being reflected from either water vapour or some particulate matter in the air.

IMPROVED MULTI-LED TRANSMITTER

Early in 2007 VK7MO constructed a 30 LED transmitter (Fig 1) based on cheaper "Copy Luxeons" which are available in Australia from the electronics supply company JAYCAR. This unit provided good performance for cloud bounce with WSJT signals being record at -9 dB referenced to the noise in 2.5 kHz bandwidth over the 5.3 km path from VK7MO's QTH at Tolmans Hill to the Radio and Electronics Association of Southern Tasmania (REAST) club rooms site at Queen's Domain in Hobart. The transmitter unit uses separate small lenses available from JAYCAR and specified as "narrow beam". A major problem with the "Copy Luxeons" is that they are constructed with two chips and thus produce two spots when focused through a lens producing a oval shaped beam roughly 10 by 20 degrees.

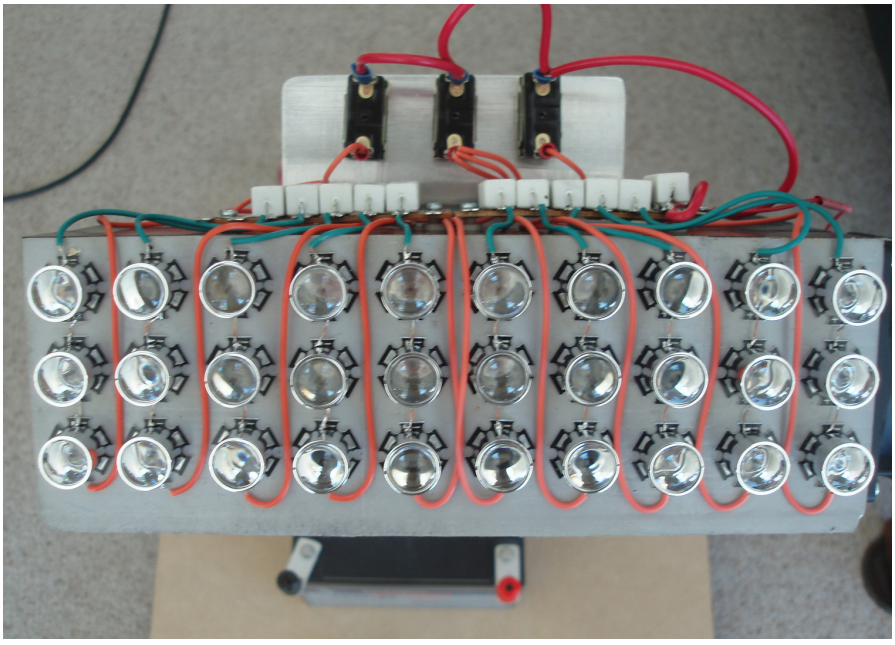

Figure 1: 30 Copy Luxeon Transmitter

It was felt that 3 dB gain could be achieved by going to actual Luxeons which use a single chip and that there might be a few more dB gain due to increased efficiency of the Luxeons combined with more efficient lenses that are specifically designed for Luxeons. The Luxeons chosen were the high output Red units specified at 140 lumens – type LXHL-LD3C. The lenses were 5 degree divergence L2OP005. In quantities of 50 the Luxeons can be purchased from Canada for much less than the "Copy Luxeons". Such a unit was constructed with 2 bays of 30 Luxeons (Fig 2) driven by an IRF-1405 FET switch.

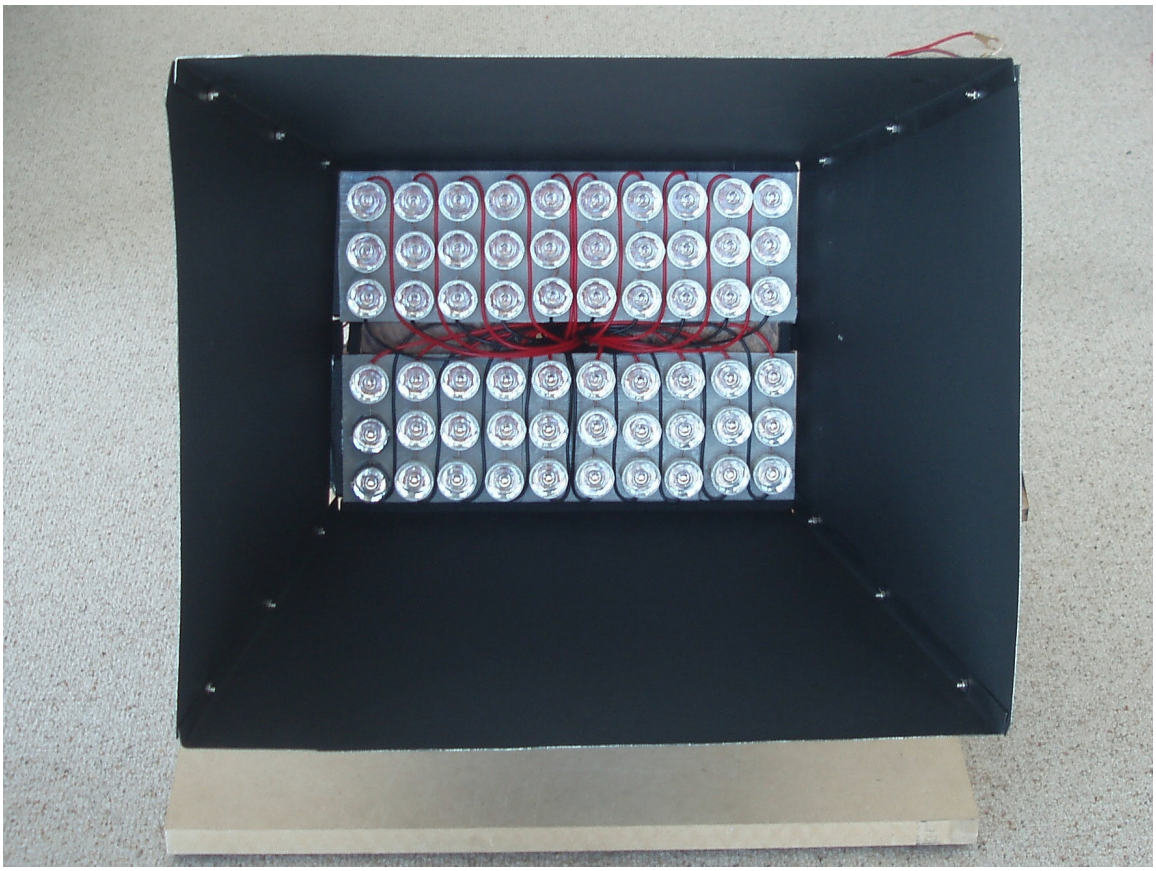

Figure 2: 60 Luxeon Transmitter

MIRROR RECEIVER

Figure 3 shows VK7TW's receiver which is based on a BPW34 with a VK7MJ pre-amplifier circuit in a mirror dish that originally came from an X-Ray machine. This receiver gives around 4 dB improvement in performance over VK7TW's standard receiver based on a 400mm x 400 mm Fresnel lens and the same pre-amp and detector. It is also easier to align due to an apparent wider beamwidth.

Figure 3: Mirror Receiver

INITIAL TESTS

Initial tests were conducted by beaming both the 30 “Copy Luxeon” and 60 Luxeon units at clouds and receiving the backscattered signal on the other side of VK7MO’s house. These tests showed around an 18 dB improvement in performance with the new 60 Luxeon unit. For these tests one transmitter was set up at 1269 Hz and the other on 1275 Hz. These measurements were made using the waterfall program Spectrum Lab which includes a data logger and allows one to log the signal level continuously on separate frequencies.

Tests were also made to measure the improvement between using a single bay of 30 Luxeons and 2 bays giving 60 Luxeons by using the 30 copy Luxeon unit as a reference. While it was expected that there should be close to a 3 dB improvement the measured improvement was 6 dB.

Further tests were then conducted over a 1.2 km path to VK7TW’s QTH using the waterfall program Spectran to measure levels. On this occasion no clouds were present but there seemed to be a haze when looking at the stars. While Spectran is a little more difficult for accurate measurements the signal levels again showed an improvement of around 18 dB with the new transmitter.

CLOUD FREE TESTS OVER 5.3 KM PATH

These tests were conducted between VK7MO's QTH and the REAST Clubrooms with VK7TW's Mirror Receiver at the REAST site. The sky was clear with the moon and stars clearly visible and just a hint of haze. Relative humidity, as measured at the Hobart Met office, varied from 71 to 74% over the period of the test. Decoded signals for the test period were as follows:

```
095100  6  -20 -0.7    8  3 *     VK7TW VK7MO QE37         1  10
095300  1  -31        10  3   RO
095500  6  -20 -0.7    8  3 *     VK7TW VK7MO QE37         1  10
095700  7  -19 -0.7    8  3 *     VK7TW VK7MO QE37         1  10
095900  7  -19 -0.8    8  3 *     VK7TW VK7MO QE37         1  10
100100  6  -19 -0.7    8  3 *     VK7TW VK7MO QE37         1  10
100300  8  -19 -0.6    8  3 *     VK7TW VK7MO QE37         1  10
100500  7  -20 -0.7    8  3 *     VK7TW VK7MO QE37         1  10
100700  8  -19 -0.7    8  3 *     VK7TW VK7MO QE37         1  10
100900  9  -19 -0.8    8  3 *     VK7TW VK7MO QE37         1  10
101100  9  -20 -0.8    8  3 *     VK7TW VK7MO QE37         1  10
101300  0  -25  8.2    8 11
101500  3  -25 -0.7    8  3 *     VK7TW VK7MO QE37         0   9
101700  0  -30 -0.8    8 11
101900  3  -25 -0.8    8  3 *     VK7TW VK7MO QE37         0  10
102100  3  -26 -0.9    8  3 *     VK7TW VK7MO QE37         0  10
102300  3  -24 -0.8    8  3 *     VK7TW VK7MO QE37         0   9
102500  3  -26 -0.6    8  3 *     VK7TW VK7MO QE37         0  10
102700  0  -26 -0.7    8  3
102900  2  -25 -0.8    8  3 *     VK7TW VK7MO QE37         0  10
103100  2  -25 -0.8    8  3 *     VK7TW VK7MO QE37      ?  0   4
```

At first both bays (60 Luxeons) were used with the signal level being around -19 dB on the WSJT scale. Then from time 101100 one bay was switched off giving 30 luxeons and the signal level dropped 6 dB to around -25 dB. There were four missed decodes at signal levels at which one would expect WSJT to decode. The reason appears to be that the transmitting computer was 8 Hz off frequency as shown by the 8 Hz DF in the 5th column in the above table. This will be corrected for future tests.

Figure 4 shows the variation in signal level for valid decodes. It is seen there is around a 6 dB drop with the reduction to half the power in going to one bay.

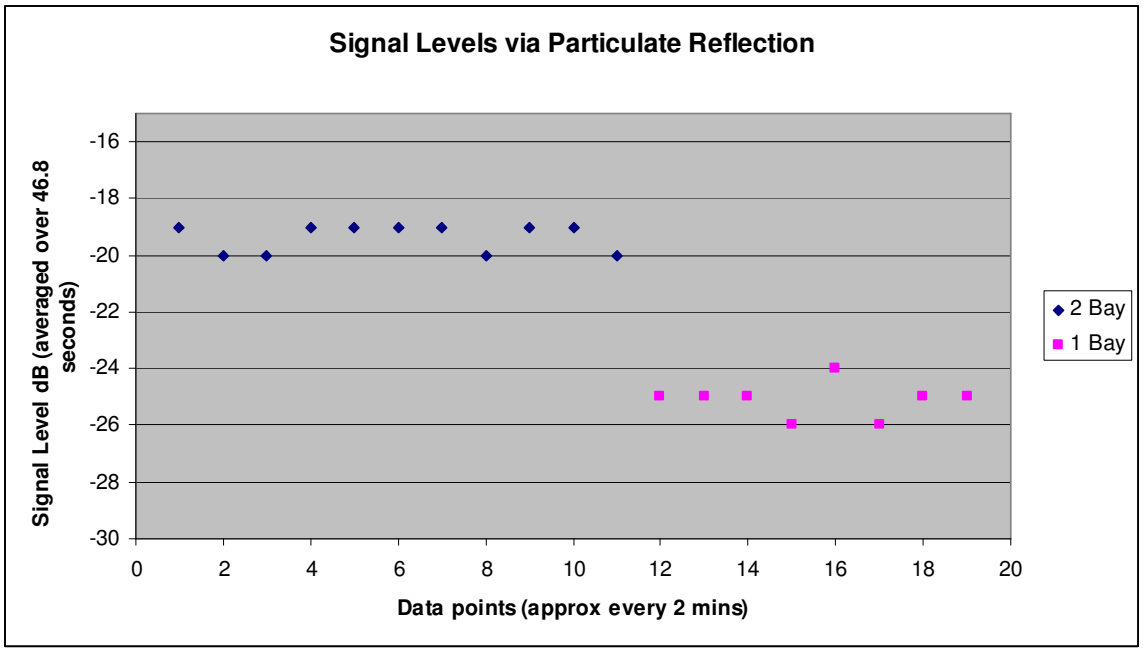

Figure 4: Graph of signal levels during "clear sky bounce" tests

Interestingly, the signal levels vary less than plus and minus one dB for a constant transmitter power. This is in contrast to cloud bounce where signal can vary 10 dB and more from one transmission to the next.

CONCLUSIONS

The new transmitter has improved performance by around 18 dB and the mirror receiver by a further 4 dB giving a total system improvement of around 22 dB. At this level optical bounce is seen to be possible with clear skys although much more extensive testing is required to determine how signal levels vary with different atmospheric conditions and whether signals are being reflected from water vapour/haze or particulate. A surprising issue is why signal levels improved 6 dB for a 3 dB increase in power – this needs further investigation and explanation. Nevertheless it is good to get "more" rather than "less" than one would expect.