MULTI-PHOTO DIODE RECEIVER TEST RESULTS

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During October/November 2007 we have been developing and testing various multi-photo diode receivers and also conducted non-line of site tests with these units. The objective of the multi-photo diode receiver is to pick up more light from dispersed sources as applies with cloud bounce and particle scatter. Justin, VK7TW, has been undertaking tests with a low light source under his house and will report on these results separately. While there are some testing issues still to be resolved our indicative results are:

1. By the use of the KA7OEI pre-amplifier circuit we have achieved an improvement of 20 to 25 dB in performance over the VK7MJ circuit.
2. By using multiple photo-diodes the performance improvement compared to a single photo-diode is further improved approximately as follows:
    a. 4 photo-diodes 5 dB
    b. 7 photo-diodes 7 dB
    c. 35 photo-diodes 14 dB

In summary the results of non-line-of-sight tests with the 35 diode unit are:

1. On a short path of 1.2 km cloud bounce signals have improved dramatically such that voice communication is now well out of the noise with the following giving an example:

http://reast.asn.au/soundfiles/Cloudbounce_VK7MO_TH_VK7TW_SH_20071008.mp3

2. JT65a signals have now been copied at up to -14 dB over a 27 km non-line-of-sight path between VK7MO to VK7DY's QTHs.

Multi-Photo Diode Receiver

The receiver uses an array of BPW34 photodiodes mounted on Vero board and spaced as close as practical. The photodiodes are at the focal point of a 550 mm focal length 400x320 mm Fresnel Lens. The spacing of the photodiode causes a spot pattern with a total beamwidth of around 5 degrees which is within the beamwidth of the 60 Luxeon transmitter we are using. Each BPW34 feeds a separate 2N5457 FET. The vero board is drilled so that the connection between the FET and the photodiode is in air. Up to 7 FETs in parallel feed from the same constant current source as per the KA7OEI circuit. The constant current source is increase by reducing resistor R5 to 22 ohms. For the larger 35 diode array the outputs of groups of 6 diodes each with their own constant current sources are summed with an op amp summer. The filtering transistor Q4 in the KA7OEI circuit was removed as it did not provide sufficient current and the unit fed from a GEL cell to reduce AC hum. An Op-Amp low frequency cut-off filter was added after U1A in the KA7OEI circuit to reduce both induced hum and hum deriving from light sources. Even so it was found that induced hum was still a problem due to the rather large opening necessary to allow light to pass to the multi-photodiode array. This was reduced by shielding around the opening to the diodes with a tin can.

The 35 photodiode array comprises 6 x 6 photodiodes with one in the middle being used for a separate single diode reference to measure relative performance improvement.

It was hoped that with multiple photodiodes the signal would add coherently and the noise incoherently such that for each doubling of the number of diodes there would be an improvement of 1.5 dB. Thus the expected improvements were as follows compared to the measured improvement.

Number of Photodiodes	Expected Improvement based on 1.5 dB per Doubling dB	3 dB per Doubling dB	Measured Improvement dB
1	0.00	0.00	0
4	3.01	6.02	5
7	4.23	8.45	7
35	7.72	15.44	14

It is seen that the measured improvement is almost 3 dB per doubling and thus more than expected for reasons we cannot explain. Now these tests are based on darkroom type conditions so external noise should not be a factor. In practice it is likely the external noise generated from city light will be the dominating factor and that the improvement might be somewhat less.

Voice Frequency Tests on Short Cloud bounce Path of 1.2 meters

These tests were conducted on an evening with good cloud cover over a 1.2 Km path between the QTHs of VK7MO and VK7TW. Elevations at both ends of around 70 degrees produced maximum signal strength. The signal to noise ratios have not been measured but as indicated on the example (see above URL), would typically produce a 5/9 report. There is some high frequency hiss that could probably be removed by improved filtering.

JT65 Tests over a 27 km Path

These tests were carried out between the QTHs of VK7MO and VK7DY on the evenings of 1, 2 and 3 November with the following results:

1 November 2007: Scattered clouds with stars visible giving an estimated 75% cloud cover. Signals were quite consistent varying from -14 to -18 dB. Maximum signal strength when beaming as close as possible to the horizon – 3 degrees at VK7MO and 8 degrees at VK7DY

2 November 2007: Heavy cloud with no stars visible giving and estimated 100% cloud cover. Again signals were quite consistent varying from -14 to -18. Again maximum signal strength when beaming as close as possible to the horizon.

3 November 2007: Initially heavy cloud cover with no stars visible, misty and frequent rain showers. No evidence of signal on WSJT but a weak signal varying from below the noise up to 8 dB above the noise showed up on Spectran in a bandwidth of 0.084 Hz. A figure of 8 dB in 0.084 Hz bandwidth is equivalent to about -38 dB on the WSJT scale in 2.5 kHz bandwidth and as WSJT rarely decodes at better than -30 dB this was as expected undetectable. Later rain cleared and stars showed through in patches giving and estimated cloud cover of 70%. Signal levels peaked at 20 dB above the noise in 0.084 Hz bandwidth on Spectran. This is equivalent to -26 dB on the WSJT scale. WSJT gave decodes from a best of -24 dB to at worst being undetectable. Again we beamed as close as possible to the horizon.

4 November 2007: VK7DY reported heavy cloud cover and no stars with a low cloud ceiling. Signals varied from -19 dB to -31 dB and became weaker as the test progressed. Towards the end of the Test VK7DY reported light rain which may be the reason for the weakening of the signal.

At the distance of 27 km cloud appears within a few degrees of the horizon and it is difficult to determine if signals are via cloud bounce or via particle bounce. Certainly the rather steady signal levels on the first two nights suggests particle scatter rather than cloud bounce, but it is possible that at longer distances the effects of clouds average out giving a more consistent signal. The fact that signals dropped off on 3 and 4 November is most likely due to increased absorption due to mist and rain.

CONCLUSION

The use of multi-photodiode arrays behind large Fresnel lens does give significant performance improvement for cloud bounce and possibly particle scatter. A 35 photodiode array provides around a 14 dB improvement in dark room conditions compared to a single photodiode.