VOICE OVER CLOUD OPTICAL COMMUNICATION

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On 12 September we completed one way tests of voice communication using cloud bounce over a 1.1 km, path peaking 5/3 and over a 5.3 km path peaking 5/1. Recordings of these tests are at the following URLs:

1.1 km path:
http://reast.asn.au/soundfiles/CloudbounceVK7MO_TH_VK7TW_SH_20070912.mp3

5.3 km path:
http://reast.asn.au/soundfiles/Cloudbounce_VK7MO_TH_VK7TW_QD_20070912.mp3

BACKGROUND

VK7MO has constructed a pulse width modulator for his 60 Luxeon array to allow the use of voice in AM mode while switching the FETs hard on and off to limit losses. Switching is done at 14.3 KHz with the pulse width being as a function of the magnitude of the audio frequency to produce AM. A diode clipper is used to prevent over modulation and the audio is filtered at a design cut-off frequency of 3.5 KHz to prevent aliasing effects.

VK7TW has re-built his KA7OEI pre-amp and mounted it on his 355 mm mirror dish. The rebuild was to reduce the physical area of the preamp shadowing the light on the dish. While tests have not been conducted, from previous results it is expected that the Mirror dish would produce around a 4 dB gain over a 400x400 mm lens.

Over all system improvements comprise:

- 30 copy Luxeon array to 60 Luxeon array +18 dB
- VK7MJ pre-amp to KA7OEI pre-amp + 12 dB
- 400 x 400 mm Fresnel Lens to 355 mm round Mirror Lens +4 dB

Estimated overall improvement in system performance +34 dB

VOICE TESTS

The cloud height was not measured but seemed to be somewhat lower than the top of Mt Wellington during the day. This would imply something less than 1000 meters above the transmitting and receiving locations. Relative Humidity varied from 85 to 87% for the period of the tests.

Initial tests were conducted over a 5.3 km path from the Radio and Electronics Association of Southern Tasmania (REAST) clubroom site at Queens Domain to the QTH of VK7MO at Tolmans Hill. Signals were first optimised using a tone with the maximum signal level occurring with VK7MO beaming at 25 degrees and VK7TW beaming around 10 degrees. These angles are consistent with a cloud height above the stations of a little less than 1000 meters. Tone signals peaked at around 35 dB above the noise in 2.7Hz bandwidth giving the equivalent of +5 dB above the noise in 2.5KHz bandwidth which is equivalent to the requirement for voice communication. Voice signals were barely detectable but unknown information was transferred. The voice signal was heavily masked by interference arising from harmonics of AC mains frequency that we assume came from lights in the vicinity of the REAST clubhouse. After processing the signal using the program Audacity to reduce the lower harmonics signals were readable at 5/1 on the RS scale as can been determined from the URL listed above.

In order to reduce the effects of mains frequency light interference the receiving station was transferred to VK7TWs home QTH reducing the path length to 1.1 km. At this location mains frequency interference was negligible and signal levels somewhat greater giving readily readable voice communication at 5/3 on the RS scale.

TONE TESTS OF PULSE WIDTH MODULATOR

From the spectrograms of the voice tests it was apparent the voice bandwidth was being limited to about 700 Hz. While this limitation did not appear to affect intelligibility tests were conducted to see if we could determine the cause of this bandwidth limitation and whether it was real. For the purposes of the tests one bay of 30 Luxeons was driven by the square wave tones normally used for WSJT and the other bay by the pulse width modulator. By choosing slightly different tones we could directly compare the performance between both methods of modulation at the same average current to the Luxeons. The results were as follows:

Tone Frequency	Square Wave Modulation	Pulse Width Modulation
400 Hz	-33 dB	-21 dB
950 Hz	-31 dB	-30 dB
3000 Hz	-47 dB	-50 dB

Both methods of modulation give similar performance at medium voice frequencies of 950 Hz but both show a drop-off of around 20 dB from 950 Hz to 3000 Hz. The drop-off could be due to a range of factors such as the low-pass 3.5 KHz filter in the transmitter of or the drop-off of the KA7OEI pre-amp.

The surprising thing is why the Pulse width modulator does some 10 dB better at 400 Hz. One might expect that for the same average current the Pulse Width Modulator which approximates a sine wave and thus has most energy in the fundamental one would get around a 2 dB improvement on a square wave which wastes energy in the harmonics and thus the small improvement of the Pulse width Modulation at 950 Hz is explainable. But why over 10 dB improvement at lower frequencies? All this will require investigation as if we can in fact achieve the 10 dB improvement of the Pulse Width Modulator over the full voice frequency range there seems to be significant potential for improvement in system performance.

CONCLUSIONS

These preliminary tests demonstrate the potential of a LUXEON array used in conjunction with the KAOEI circuit for voice communications with cloud bounce. There may be the opportunity for further improvements if we can find the reasons for the major changes in performance over the voice frequency spectrum.