Short Delayed Echoes Continue To Amaze

By Gene Greneker, K4MOG

On the afternoon of January 7, 2013, between 2:20 PM and 3:00 PM Eastern Standard Time, I heard short delayed echoes while calling CQ using CW on 18.090 MHz. I have heard short delayed echoes before on 80 meters CW, and reported one incident in the June 2007, issue of QST [1]. Both short and long delayed echoes have been reported by numerous amateurs, and there is a body of literature that discusses the source of these events, so there is nothing new about short delayed echoes right? Wrong!

When I heard the short delayed echo, I started keying specific patterns of 'dits' to excite the echoes for recording and later analysis. Each time a dit was sent, a 700 Hz short delayed echo return could be heard, given that my receive frequency was off-set 700 Hz higher than my transmit frequency. Now the interesting part! Every fourth dit in the sequence, there were two echoes present, one at the fundamental return frequency of 700 Hz and the second at approximately 1,420 Hz, slightly more than twice the fundamental echo frequency. Dits were sent at half second intervals then at other spacings over the next 40 minutes. An analysis was performed on the recorded data which produced the totally unexplainable results which follow, but first an analysis of one of many of the short delayed echoes that was recorded and analyzed.

Figure 1 shows a time domain signal event time line. Moving from the left to the right of the figure, receiver noise alone occurs between starting time 0 to approximately 60 milliseconds along the time line (bottom).

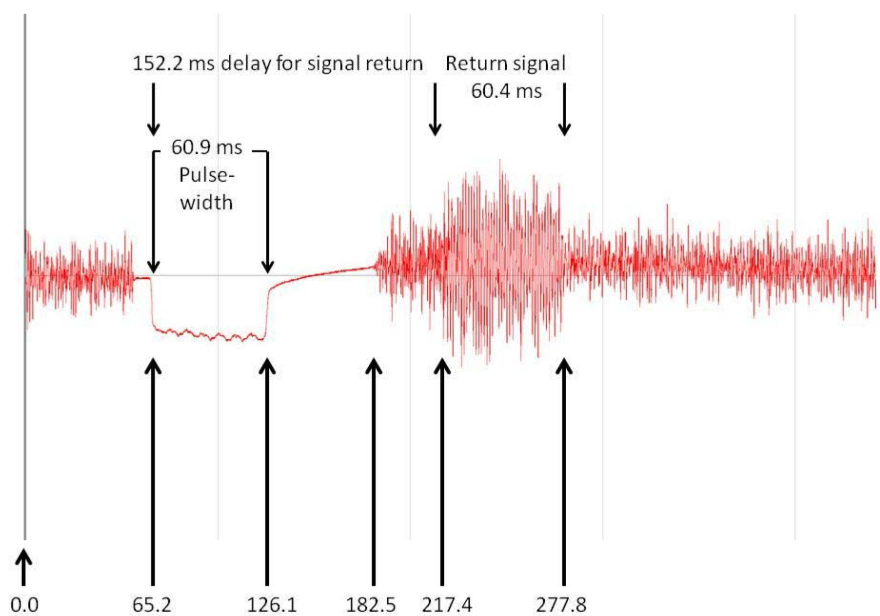

Figure 1. Time line of one of the keying events and the time relationship between events.

At approximately 60 milliseconds the transceiver is keyed with a dit causing 5 milliseconds of no receiver noise followed by a negative excursion of the base line that lasts from 65.2 milliseconds to 126.1 milliseconds. This event marks the transmission of the dit that is 60.9 milliseconds in duration.

Moving further left from 126.1 to 182.5 milliseconds along the baseline, the transceiver is recovering from the transmit mode back to the receive mode after transmitting the dit. The receiver is back on at 182.5 milliseconds. At 217.4 milliseconds, the return pulse (short delayed echo) starts, and it ends after 277.8 milliseconds. Referring to the event times shown above the baseline, the transmitted pulse width was approximately 60.9 milliseconds. The length of the returned pulse (echo) was measured as 60.4 milliseconds which is very close to the measured transmitted pulse width of 60.9 milliseconds. The slight difference of .5 milliseconds occurs because the echo has associated noise, and picking the start and end times by eye with this noise present is not exact.

The delay period between echo transmission and reception was 152.2 milliseconds. This propagation delay time is slightly longer than a trip around the Earth or a trip half way around the Earth and back (approximately 138 milliseconds). When my earlier report on the 80 meter short delayed echo observations appeared in the June issue of QST, 2007, several amateurs responded in QST's March 2009, Technical Correspondence, and provided several possible explanations regarding the source of these echoes with longer delays than a signal going around the Earth [2]. One explanation for an echo with a delay time greater than approximately 138 to 140 milliseconds is that the signal is trapped along a magnetic field line of the Earth. Perhaps these readers are correct, but what is the mechanism that generates a short delayed echo, at both the fundamental frequency and approximately double the frequency of the fundamental, and why did this combination occur no more often than 2.5 seconds?

Figure 2 shows a spectrogram of 15 of the 60 recorded dits that produced short delayed echoes during the 2:25 PM data collection. The Spectrogram transforms the time domain signal, shown previously in figure 1, into a frequency domain plot. The Spectrogram displays the frequency of the received signal along the Y axis (ordinate) and increasing time is shown from left to right along the X axis (abscissa). The amplitude of the signal is shown in false color, blue being low amplitude and red being highest amplitude.

Starting at the far left of figure 2, the first event shown is the 60.9 millisecond dit, and the transmission period is depicted as a dark blue line vertical indicating no signal because the receiver is off during dit transmission. Moving from left to right, when the receiver is switched back on, there is a field of green which is the receiver noise. The red rectangle that appears at approximately 700 Hz along the Y axis is the return of the short delayed echo. The return echo appears at approximately 700 Hz on the Y (frequency) axis because of the receiver's 700 Hz off-set. There is a second echo shown as a red rectangle and it appears at approximately 1.420 KHz on the Y axis. It is the origin of this 1,420 Hz short delayed echo that is the mystery to be solved.

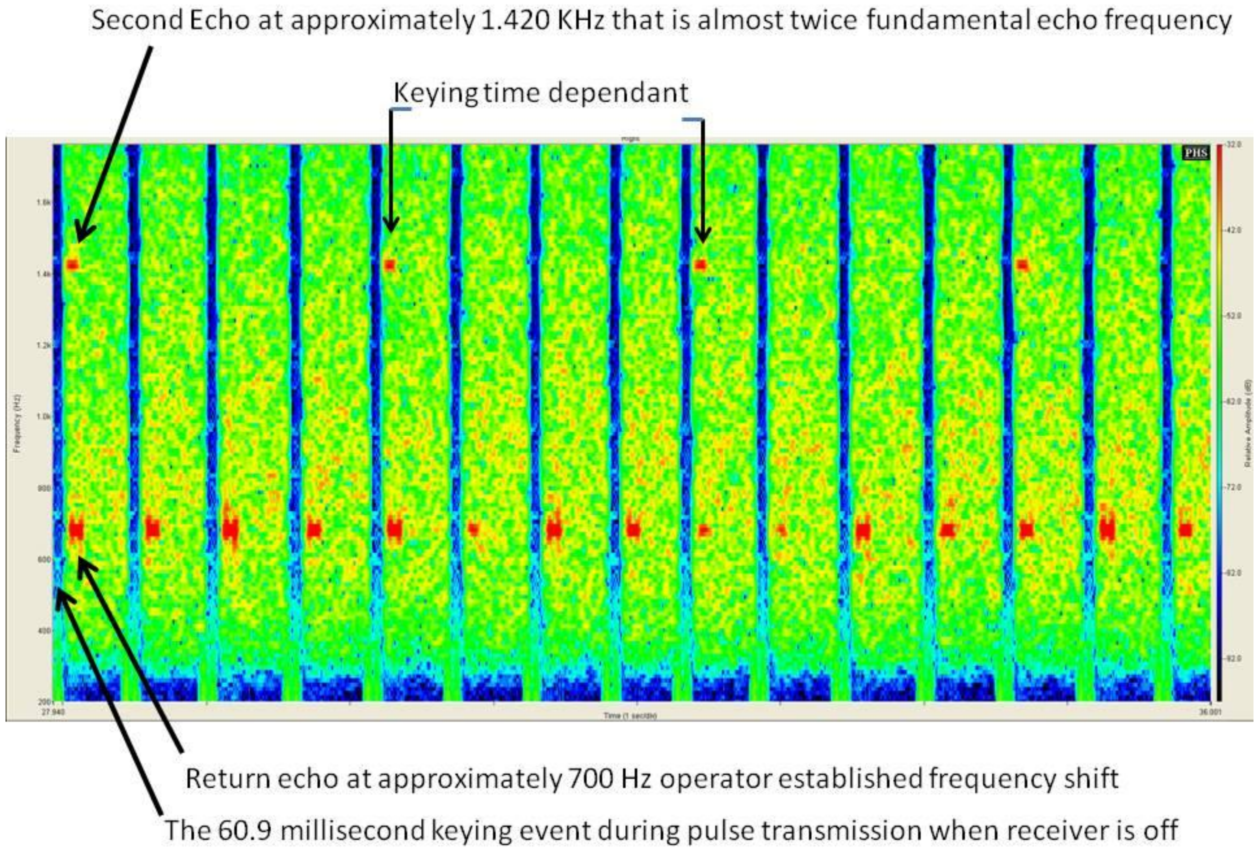

Figure 2. Spectrogram showing time and frequency of all received information.

The data in the example spectrogram was recorded between 2:25 and 2:27 PM on January 7, 2013. Only 15 dit events are shown in figure 2, but a total of 38 are part of the recorded data. An analysis of that recorded data shows the average time between dits was approximately .66 seconds. At this spacing between dits the 1,420 Hz short delayed signal occurred approximately once every 2.64 seconds. It was found to be the general case that the first dit in a test run always triggered the 1,420 Hz echo. Another recording was made at approximately 2:58 PM. The dit rate was increased to one every .29 seconds to provide more dits between the occurrences of the 1,420 Hz echo (increased resolution). A total of 44 short delay events were analyzed when the higher speed keying was used, and it was found that the 1,420 Hz echo occurred on the first dit and then was not repeated again before 2.5 seconds after a previous occurrence. In summary, the data shows that the first dit would always trigger the 1,420 Hz echo, but 2.5 seconds must pass before another 1,420 Hz echo could be triggered. Thus, it was the total elapsed time between dits that was important, not the number of dits transmitted.

The station set-up at the time of the observations was a Yaesu FT DX 5000 transceiver with full break-in enabled (recovery delay minimum) and the automatic gain control (AGC) off. All digital audio processing/filtering was off and the 3,000 Hz bandpass filter was used in the CW mode. Low noise amplifier 2 was turned on for maximum receiver sensitivity. The linear amplifier was the ETO 91B running 1 KW output into a double Zepp antenna cut for 40 meters, but tuned for 18.090 MHz. The axis of Zepp alignment was north/south, however the radiation pattern has not been analyzed when it is operated on 18.090 MHz. The antenna was tuned with a Johnson KW matchbox and the Zepp was fed with 450 Ohm feedline. The recording software was SpectraPlus© Professional Edition, version 5.0 marketed by Pioneer Hill Software. The Spectra software allows post processing analysis in the time domain, frequency domain, and variants of the frequency domain processing. The Spectra software provides very accurate timing cursors to be used to determine both times between events and event occurrence times. The station location is 33^0 56’ 21.01” north and 84^0 39’ 06.81” west.

So what theories may explain these observations? The frequency of the higher frequency echo shown on the spectrogram is slightly more than twice the frequency of the fundamental short delayed echo which, without other information, might indicate the frequency shifted 1,420 Hz echo is a second harmonic generated by the spectrogram processing or even something in the digital processor of the FT DX 5000. Remember, the higher frequency event occurs the first dit and then only after an elapsed time of 2.5 seconds after the previous 1,420 Hz event. If this phenomena was caused by a digital signal processing anomaly it should occur every dit. Most important, the author has listened to the time domain recording. The fundamental 700 Hz return can be heard following each dit and the 1,420 Hz echo can be heard 2.5 seconds after a previous 1,420 Hz echo. The author also repeated the test sequence 5 hours later when the band was dead using the same exact set-up used to record the 700 and 1,420 short delayed echoes. There was no fundamental short delayed echo at 700 Hz and no 1,420 Hz echo present 5 hours later, just receiver noise after a dit. There is no doubt that the echo was a propagation related event.

Was someone ‘playing’ with me by sending a frequency shifted dit every 2.5 seconds? Figure 2 shows that the 1,420 Hz signal occurs within a very narrow window of time after the dit, regardless of the repetition rate of the dits. A detailed analysis of three separate recordings made over a time period of almost 40 minutes, shows that it would be extremely difficult for another operator to insert a keying event with the precision required to duplicate the results that were observed over the time span of the three recordings. In addition, another operator would have had to been ready to send a dit without knowing when I would start sending. It is safe to say this observation is not the result of someone “playing”. This may not be the case if a transponder was being triggered.

Over the horizon backscatter (OTH-B) radars may sometimes use a high frequency (HF) transponder to provide the OTH-B radar with a return signal from a known geographic location. The OTH-B transmits a pulse; the transponder receives the signal and then transmits a pulse back to the radar. The transponder may or may not reply every transmitted pulse. Could I have triggered an OTH-B transponder on 18.090 MHz? While highly unlikely, the OTH-B transponder theory is best left to be answered by someone who is more familiar with OTH-B radar than the author. Also, would the response from a transponder be 720 Hz (1,420-700 offset = 720Hz shift) higher than the transmitter frequency?

The echo delay of approximately 2.5 seconds agrees with the Earth Moon path delay. The Naval Observatory records show that the Moon was at an altitude of minus 7.9 degrees, and an Azimuth 252.3 degrees, as viewed from Atlanta, GA on January 7, 2013, at 2:30 PM, Eastern Standard Time. The Moon was 7.9 degrees below the optical horizon referenced to the transmitting antenna.

Was the frequency up shifted 720 Hz short delayed echo a result of an ionosphere or magnetosphere effect? When an Electromagnetic signal propagates through a plasma medium such as the ionosphere or along a magnetic field line in plasma, strange things can happen, especially when the magnetic field lines of the Earth are aligned in such a way to capture the signal. What related plasma effects would produce a discrete frequency shift of 720 Hz? Once triggered, could the plasma or associated particles require 2.5 seconds to realign before it could repeat the 720Hz up shifted echo?

In summary, there are three fundamental questions being asked: 1) What is the mechanism that delays the echo; 2) how would the short delayed echo frequency be shifted 720 Hz above the transmitted frequency, and 3), why can the frequency shifted echo be generated no faster than once every 2.5 seconds? More important, are these 3 factors a clue to the origin of the frequency shifted echoes? An attempt was made to duplicate the event over the past 12 months creating a delay in publication of this report. No frequency shifted echoes, with a minimum re-occurrence time of 2.5 seconds, have been observed during the intervening period.

Eric Nichols, KL7AJ, who is familiar with ionosphere and magnetosphere effects, published an article in the February, 2013, issue of QST urging amateurs to report their observations [3]. He points out that, “Most of the universe interacts with radio in one way or another”. He further states, “As radio amateurs, we have access to unbelievable wonders of nature that very few “civilians” can even dream of. We have a vast unexplored playground”. Hopefully, by publishing these observations, someone else who shares the same playground can readily identify the origins of the frequency shifted short delayed echoes that require 2.5 seconds to retrigger.

References

1. Greneker, E. F., The Ultimate DX: An Around the Earth Path , Technical Correspondence, QST, June 2007, pp 72-73.

2. Ewing, Martin and Holm, Sverre, Technical Correspondence, QST, March, 2009, pp. 53-54.

3. Nichols, E. P., Amateur Radio Science, QST, February, 2013, p. 77.

About the Author

Gene Greneker holds an Extra Class license, and was licensed as K4MOG in January, 1957 as a novice at age 14. He holds a BS degree from Georgia State University and an MS degree from the Georgia Institute of Technology. He worked in the field of radar research at the Georgia Tech Research Institute (GTRI) for 33 years before retiring as a Principal Research Scientist. He served as the CEO of RADAR Flashlight, LLC, for 8 years after his retirement. He is a senior member of IEEE, holds seven patents, and has authored over 90 publications. His interest in amateur radio includes working DX, weak signal propagation studies, and remote sensing using electromagnetic waves. The author can be contacted at k4mog@bellsouth.net.