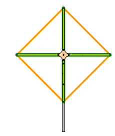
Reception of SAQ Transmissions at Cohoe Radio Observatory on 24 December 2019

Whitham D. Reeve

1. Introduction



On 24 December 2019 station SAQ in Grimeton, Sweden {SAQ} transmitted their annual commemorative Christmas Eve message in Morse code on a frequency of 17.2 kHz. This article describes my reception of those transmissions at Cohoe Radio Observatory in Alaska. The Alexanderson rotary transmitter usually transmits messages only two times per year – Alexanderson Day in mid-summer and Christmas Eve. The station also attempted to transmit a message on United Nations Day, 24 October 2019, but the transmitter could not be started. All transmissions are sponsored by the Alexander Association, of which I am a member.

Reception of a VLF signal over a distance of almost 7000 km is an interesting challenge to me. The reception at Cohoe Radio Observatory of the Christmas Eve event marks the third time I successfully received SAQ transmissions out of four attempts; I also received the Alexanderson Day transmissions on 1 July 2018 {Reeve18} and 30 June 2019 {Reeve19-1} but not on Christmas Eve 2018. I also have attempted to receive the SAQ transmissions at my Anchorage observatory, but the VLF radio frequency interference levels there are far too high.

2. Stations

Only brief station summaries are provided here. For more complete details, see {Reeve18}. The estimated radiated power from the SAQ station is around 8 kW. Cohoe Radio Observatory uses a relatively small, untuned, square loop antenna with 1.2 m diagonal length and effective height of 1.9 cm at 17.2 kHz, and a software defined radio (SDR) receiver. For the event described here, the loop plane was oriented north-south, very closely in line with the great circle propagation path.

As with the summer 2019 reception, I used the SDRPlay RSPduo receiver with SDRuno software. CRO is a remote site, so I used TeamViewer software to access the observatory PC a few days before the event and setup a signal I/Q recording schedule on SDRuno. At that time, I upgraded the software to the newest available v1.33. The receiver was set to the zero-IF (direct conversion) mode with 2 MHz sample rate and 8 decimation. This produces a 125 kHz wide received spectrum, the narrowest possible with the receiver-software combination.

3. Transmission and Reception

Startup and tuning of the SAQ transmitter commenced at 0730 UTC followed by the message transmissions at 0800 UTC (the corresponding local times at the SAQ station were 8:30 AM and 9:00 AM, respectively). The startup and message were recorded live at the SAQ station on {YouTube}. The messaging used Morse code, which I believe was produced by a preprinted paper tape and electromechanical reader.

Because of the local time difference between the SAQ station in Sweden and Cohoe Radio Observatory in Alaska, the transmissions were received at CRO late on 23 December (10:30PM local time for tune-up and 11:00PM for messaging). My preconfigured recording schedule covered a time period of 65 min from 0725 to 0830 UTC. This resulted in two WAV files, about 2.1 GB and 1.7 GB. The file sizes were too large to upload using the fixed 4G cellular internet connection at CRO, so I had to retrieve the data later. On 30 December I drove to Cohoe, transferred the data to a USB hard drive and returned to Anchorage. While at CRO I also did some routine station maintenance.

Playback and analysis of the recorded Wave files in SDRuno clearly shows an easily recognizable signal in the combined spectrum and waterfall display during tune-up (figure 1) and message transmission (figure 2). I could hear the Morse code characters, but I do not have the code reading skills to decode the message. However, I could make out the SAQ station ID after listening to the recording several times.

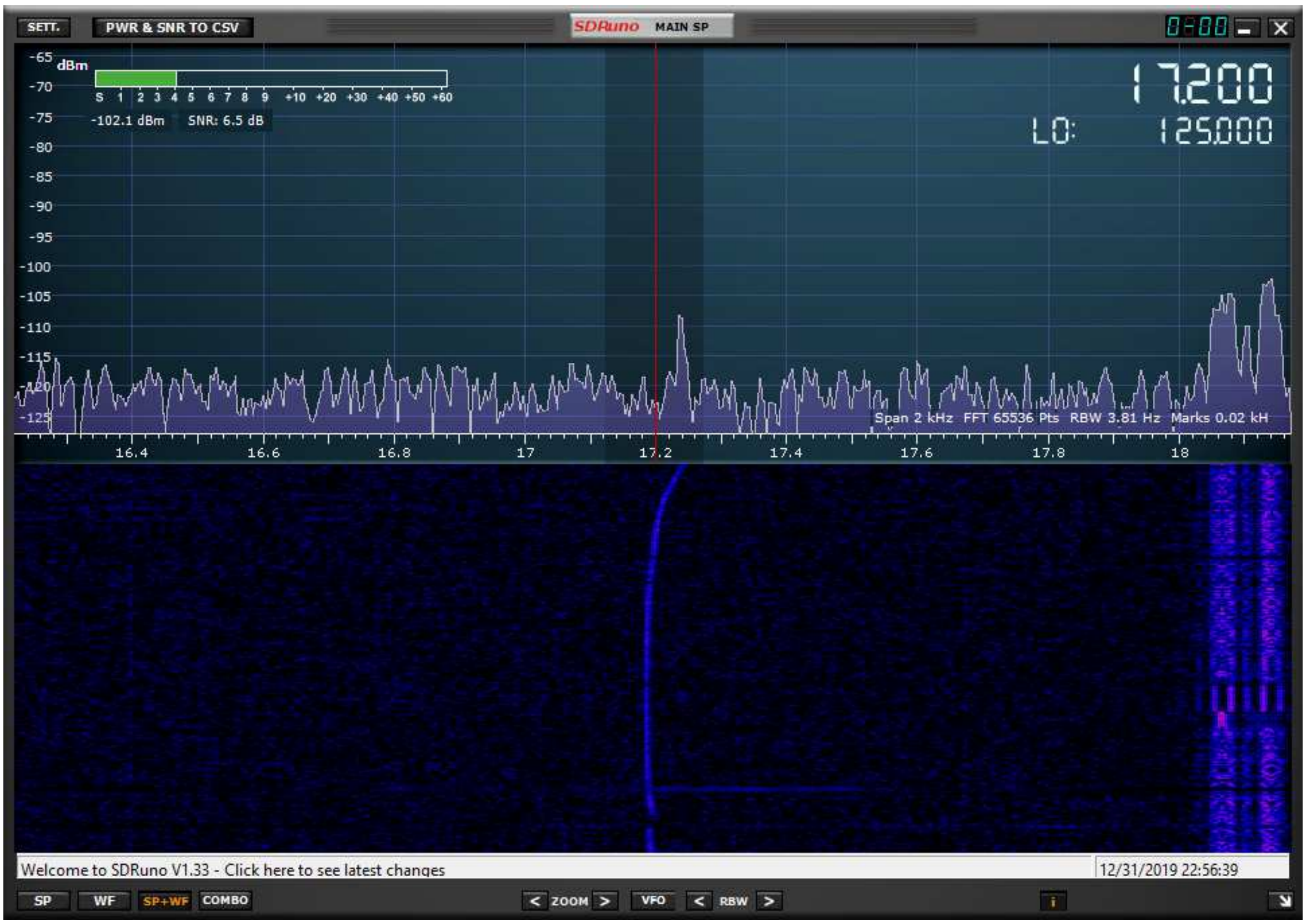


Figure 1 ~ Screenshot of SDRuno spectrum and waterfall combination during SAQ transmitter tune-up as received at Cohoe Radio Observatory. The horizontal scale in the middle of the image shows a 2 kHz frequency span centered at 17.2 kHz. Tick marks on the frequency scale are at 20 Hz intervals and the resolution bandwidth is 3.81 Hz. The vertical scale on the left of the spectra plot is received power labeled dBm but, in this case, actually is a relative scale in dB (the receiver gain is not calibrated in the WAV files from which this image was produced). The red vertical cursor is set to the center frequency. As seen in the waterfall portion of the image, the SAQ signal starts very close to the correct frequency but then drifts rapidly to about 40 Hz high when this screenshot was captured. Several "key-down" transmissions like this were made before actual Morse characters were sent. The SAQ carrier peak is about 10 dB above the noise peaks. The signals on the right centered at 18.2 kHz are believed to be from a Russian VLF station.

I first received the SAQ tuning signal at 0742, about 8 minutes after the transmitter was started – the delay presumably due to the time needed to accelerate the transmitter's heavy rotary components to operating speed and stabilize. The transmissions were almost continuous from that time to 0804 when my reception ended. The received signal levels throughout the 22 min period were very stable. I filed an online reception report on the Alexander Association website on 30 December after listening to and analyzing the recorded WAV files.

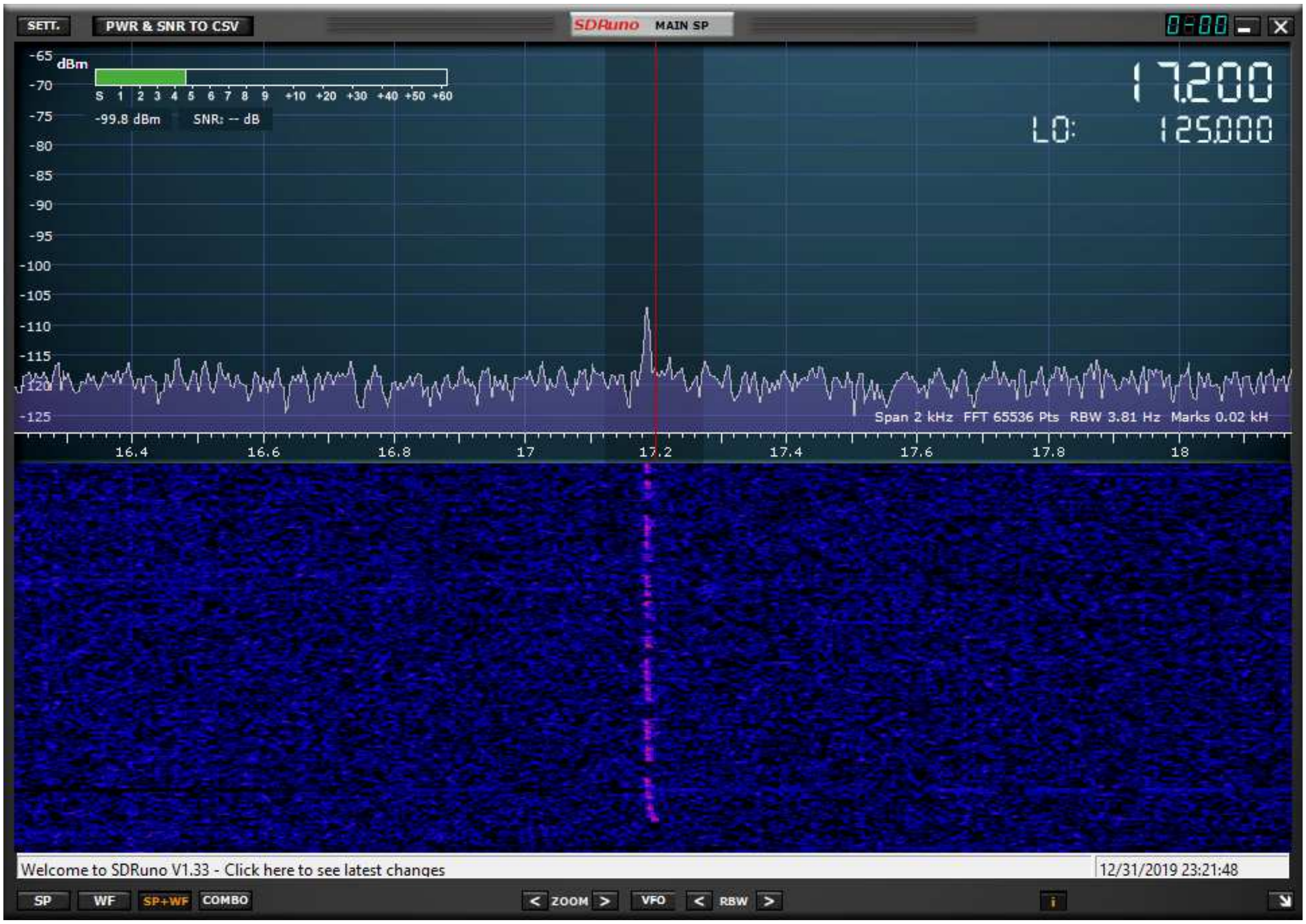


Figure 2 ~ Screenshot of SDRuno starting at the beginning of the message transmission. The receiver settings are the same as the previous figure except that the contrast in the waterfall has been increased and appears grainier. The SAQ signal starts very close to the correct frequency as seen at the bottom of the waterfall but then rapidly drifts to about 15 Hz low when this screenshot was captured. The individual Morse digits are almost readable. The message transmission lasted about 4 min. Note that the 18.2 kHz signals seen in the previous figure are absent.

---

4. Discussion

<u>Received frequency</u>: The CRO is unheated during winter and on the night of the Christmas Eve SAQ transmissions, both the observatory inside and outside temperatures were –8 °C (+18 °F). I believe this affected the receiver oscillator because the message signal frequencies indicated on the received spectrum plots were consistently about 15 Hz low. I noted small frequency errors in previous SAQ transmissions during the summer but never this large.

Propagation: The great circle propagation path from station SAQ to Cohoe Radio Observatory is about 6870 km and passes over the North Pole. During December, much of the path is over frozen surface regions and, at the time of the transmissions, in almost complete darkness (figure 3). Sunrise at the SAQ station was only a few minutes before the message transmissions at 0800 UTC (the ionosphere above the site would have been illuminated earlier).

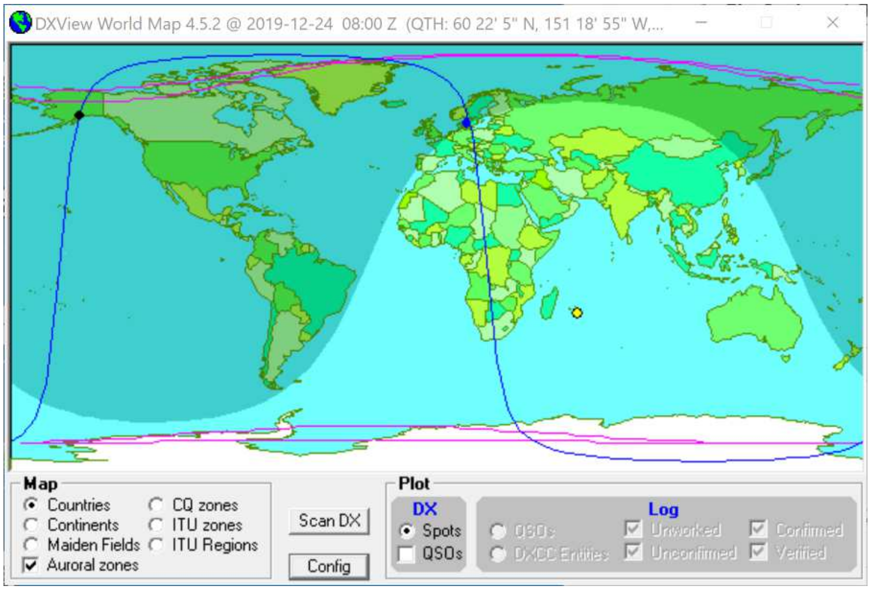


Figure 3 ~ Solar terminator map showing the great circle propagation path (blue line) between CRO in Alaska and SAQ in Sweden at 0800 UTC. The station locations are indicated by blue dots. Local times at the stations are 11:00 PM (23 December) at CRO and 9:00 AM (24 December) at SAQ. The short propagation path is through nighttime regions. The Sun's location is indicated by the yellow circle just east of Madagascar, and the auroral zones are indicated by magenta lines near the upper and lower edges of the map. This image was produced from DXView, a component of the DXLab software {DXLab}.

The Earth-ionosphere waveguide is responsible for long distance propagation of low incidence angle VLF radio waves (see {Reeve19-2}). The ionosphere's D-region is sufficiently conductive and is the upper boundary for the waveguide, both day and night. Earth's surface (land, ice and open water) is the lower boundary. The daytime D-region height ranges from about 60 to 75 km and the nighttime height ranges from about 75 to 95 km. The electron density in the D-region sharply decreases at sunset and is equivalent to an increase in region height and decrease in propagation phase velocity. Conversely, the electron density sharply increases at sunrise and is equivalent to a decrease in height and increase in phase velocity. The height change from day to night is in the range 15 to 20 km, or close to one wavelength at 17.2 kHz.

Transpolar VLF propagation encounters steep magnetic field lines compared to lower latitudes and, thus, the effects of Earth's magnetic field on propagation can be quite different. Solar phenomena can produce geomagnetic storms that add to the complexity and lead to large changes in the polar ionosphere. However, the Christmas Eve 2019 event occurred near the solar cycle minimum with a very quiet Sun, and no unusual propagation phenomena were noted during the short period of the transmissions.

Received signal levels: When the solar terminator crosses the propagation path, large variations in the received signal level can occur due to waveguide mode conversion and interference at the transition. For the SAQ signal reception at CRO on Christmas Eve (close to the Winter Solstice), the propagation was almost entirely through nighttime regions with no solar terminator crossings. These characteristics along with the lack of other propagation phenomena contributed to the relatively stable received signal levels that were observed.

5. References and Weblinks

{Reeve18} Reeve, W., Reception of SAQ Transmissions at Cohoe Radio Observatory in Alaska USA on 1 July 2018, 2018, available at: http://www.reeve.com/Documents/Articles%20Papers/Reeve_SAQ-Jul2018.pdf

{Reeve19-1} Reeve, W., Reception of SAQ Transmissions at Cohoe Radio Observatory on 30 June 2019, 2019, available at: http://www.reeve.com/Documents/Articles%20Papers/Reeve_SAQ-Jun2019.pdf

{Reeve19-2} Reeve, W., Monitoring Low Frequency Propagation with a Software Defined Radio Receiver: Part I ~ Propagation Concepts, 2019, available at: http://www.reeve.com/Documents/Articles%20Papers/Propagation/Reeve_LFProp-ConceptsP1.pdf

{SAQ} https://alexander.n.se/successful-christmas-transmission/?lang=en

{YouTube} https://www.youtube.com/watch?v=-zPfm6PtaNo

Author - Whitham Reeve is a contributing editor for the SARA journal, Radio Astronomy. He obtained B.S. and M.S. degrees in Electrical Engineering at University of Alaska Fairbanks, USA. He worked as a professional engineer and engineering firm owner/operator in the airline and telecommunications industries for more than 40 years and now manufactures electronic equipment used in radio astronomy. He has lived in Anchorage, Alaska his entire life. Email contact: whitreeve@gmail.com

Document Information
Author: Whitham D. Reeve

Revisions: 0.0 (Original draft started, 30 Dec 2019)
0.1 (Added images, 01 Jan 2020)
0.2 (Completed 1st draft, 02 Jan 2020)
0.3 (Distribution, 04 Jan 2020)

Word count: 1724
File size (bytes): 1071616