SAQ Reception at Cohoe, Alaska on 30 June 2024

Whitham D. Reeve

Introduction: The very low frequency band (VLF, 3 – 30 kHz) is used mostly for military undersea naval communications, but it has non-military uses as well. Here, I report the commemorative transmissions on 17.2 kHz by the historic civilian station SAQ. The transmissions take place three or four times each year. I first attempted to receive them at Cohoe Radio Observatory on 1 July 2018 (Reeve18} and have successfully received almost all of them to date. SAQ uses its original *Alexanderson System* radio frequency alternator (rotary transmitter), which is operated and maintained at Grimeton in Sweden by the Alexander Grimeton Friendship Association. See {SAQ} for more information on the station.

This article describes the reception at Cohoe on 30 June 2024 of the Alexanderson Day transmissions commemorating the station's 100 year anniversary (the station and associated transmitter originally entered commercial service on 1 December 1924). The anniversary transmissions consisted of identical Morse code messages at 0900 and 1200 UTC; the duration of each transmission was almost 10 minutes.

Propagation path: SAQ is located on a true azimuth of 009° and a distance of 6900 km from Cohoe. The great circle path nearly passes over the Magnetic North Pole (figure 1). According to sea ice maps for June and July 2024 (https://nsidc.org/arcticseaicenews/2024/), the path from Grimeton was over open water to the northern coast of Greenland and over ice from there to the northern coast of Alaska. The remaining distance was over land to Cohoe.

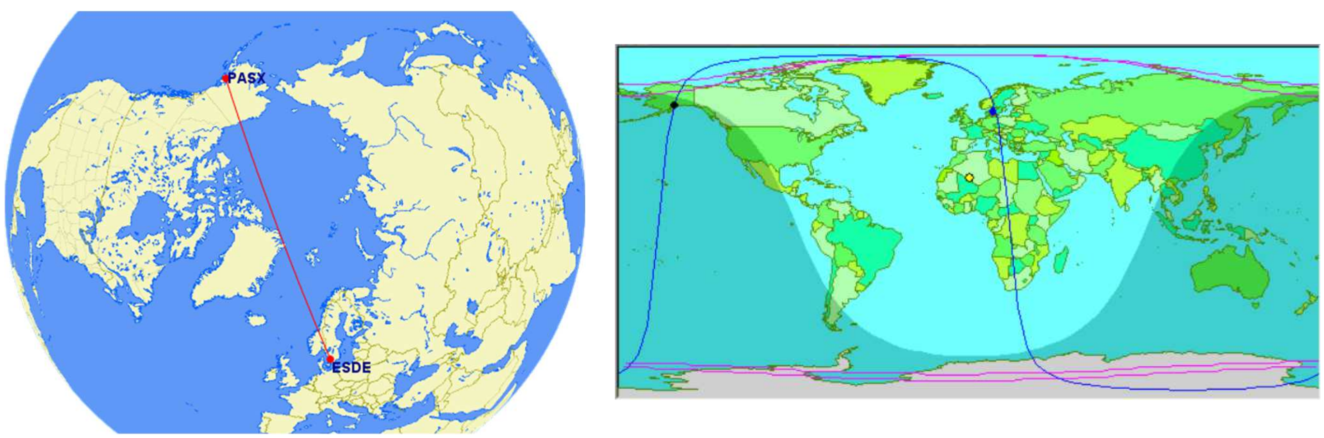

Figure 1 ~ Left: Map showing the great circle path between the airports nearest Cohoe and Grimeton. Image source: http://www.gcmap.com/mapui?P=PASX-esMT&MS=wls&DU=mi ; Right: Solar terminator map for 30 June 2024 at 0900. The short and long propagation paths are shown by the blue line and the Sun is the yellow circle over northwest Africa. It is seen that almost all of the path and the SAQ station were sunlit at 0900. Both stations and the path were sunlit for the later transmission at 1200, which may explain the slightly weaker received signal at that time. Image source: DXView

Instrumentation: The Cohoe instrumentation consisted of a shop-built, rotatable, passive, untuned, square loop antenna with 1.2 m diagonal dimension described at {Loop} and {Cohoe}, a shielded twisted pair transmission line and an SDRPlay *SDRduo* software defined radio (SDR) receiver with *SDRuno* software. The antenna was rotated to 000° true azimuth. The SDR sampling rate was set to 2 MHz with 32X decimation, giving an effective rate (and maximum displayed spectrum width) of 62.5 kHz. The receiver was set to the Zero IF (ZIF) mode with the local oscillator (LO) set to 31 kHz. The software was scheduled beforehand to record the receiver I-Q data streams for later analysis because the transmissions were to take place at 1 am and 4 am local Alaska Daylight Time. The recorded data were retrieved several hours later and then played back to produce the spectrum waterfall displays shown below.

<u>Spectrum waterfall displays</u>: The following screenshots (figure 2) were taken from the recorded I-Q data streams. The timestamps shown in the waterfalls are actual. No FFT averaging was used.

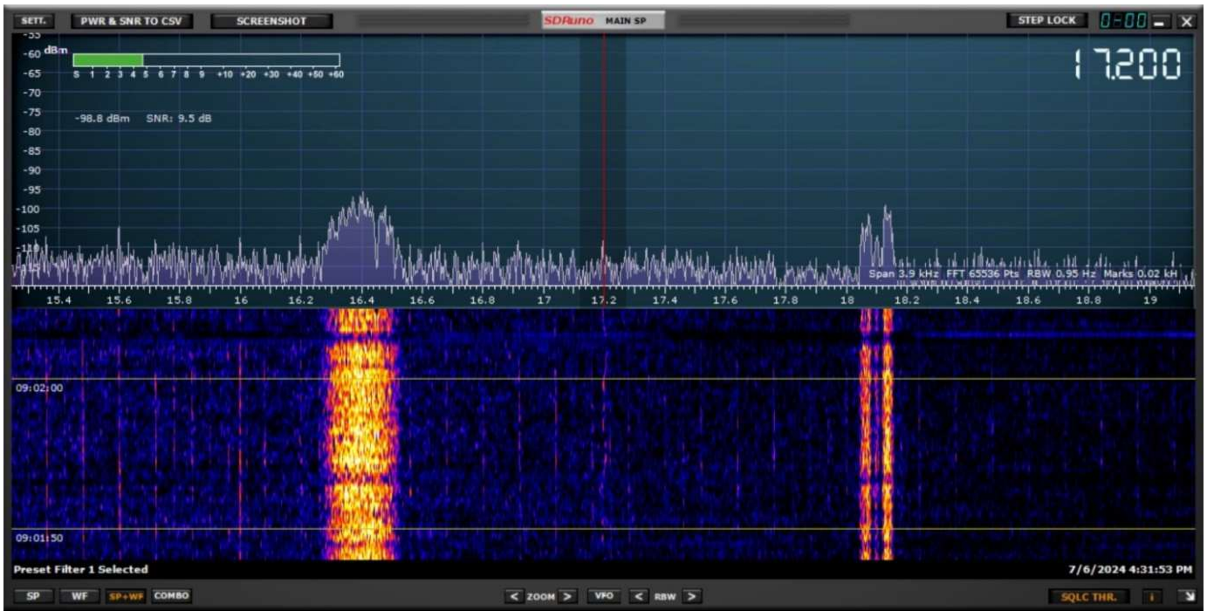

Figure 2.a ~ Waterfall spectra from 15.3 to 19.1 kHz with the SAQ signal at 17.2 kHz in the middle. Relative received signal power level is shown in dB on the left-vertical scale and frequency in kHz is shown along the middle-horizontal scale. The signal is very weak and indiscernible in the spectra but visible in the waterfall. The vertical lines in the waterfall are powerline harmonics at 120 Hz intervals. The brighter signal on the left is the Norwegian VLF station JXN at 16.4 kHz and the two signals to the right centered on 18.1 kHz are thought to be a Russian VLF station.

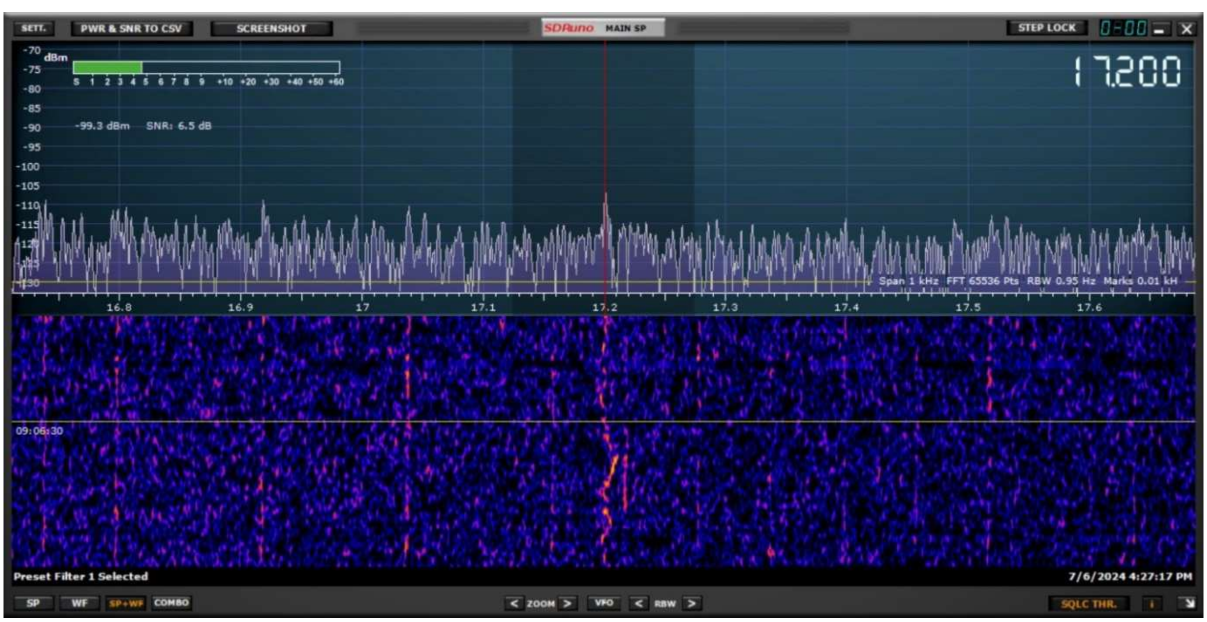

Figure 2.b ~ The displayed frequency range has been reduced to show 16.7 to 17.7 kHz. The SAQ signal near the middle is very weak but visible in the spectra and in the waterfall along with powerline harmonics at 120 Hz intervals. Rapid frequency drifts of around 5 Hz are visible just before the timestamp at 0906:30.

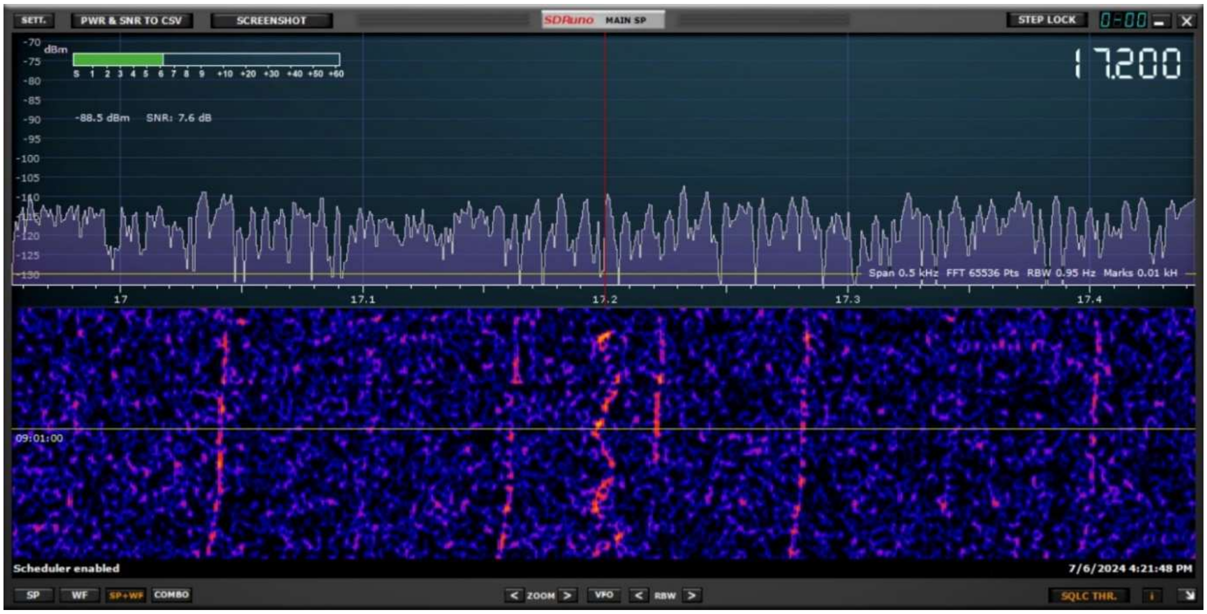

Figure 2.c ~ The waterfall spectra range has been changed to show the range 16.95 to 17.45 kHz. The SAQ signal is clearly visible near the middle of the waterfall but its associated spectrum is indiscernible at the time of this screenshot. Rapid frequency drifts of around 10 Hz are visible for the duration of the waterfall (about 15 s).

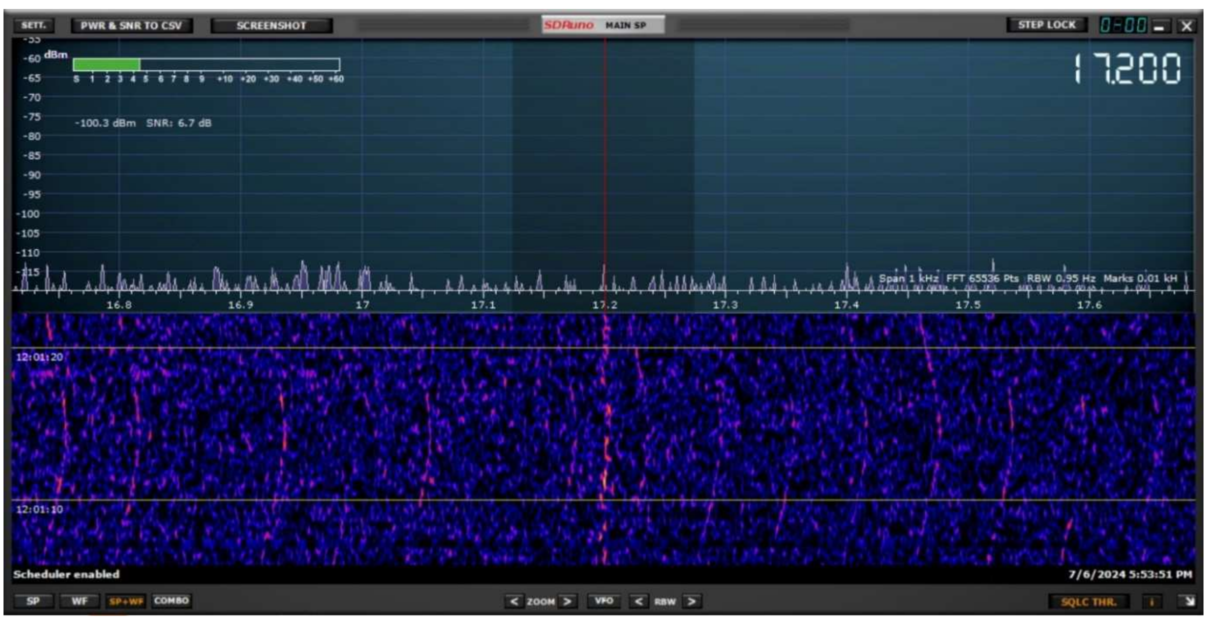

Figure 2.d ~ This display shows the second transmission at 1201 with a displayed frequency range from 16.7 to 17.7 kHz. The SAQ signal is much more stable than the first transmission a few hours earlier but is slightly weaker.

<u>Discussion</u>: The durations of the transmissions were 9 min 20 s for the transmission at 0900 and 9 min 15 s at 1200. The first transmission showed some frequency instability with rapid fluctuations between 17.200 kHz and 17.210 kHz (spectrum resolution bandwidth was 0.95 Hz); the second transmission was more stable. All waterfalls show powerline harmonics at 120 Hz intervals but none of the harmonics fell on 17.2 kHz.

The received signal levels for both transmissions on 30 June 2024 were very weak but the carriers were clearly visible in the spectrum waterfalls. The second transmission at 1200 was marginally weaker than the first one at 0900. I could hear the demodulated CW only occasionally above the background noise during each transmission but it was never clear enough to decode.

A first-order estimate of the receiver input signal power at Cohoe was made for the Alexanderson Day transmissions in 2018 {Reeve18}. That estimation method was based on a couple broad conditions: 1) Whether the path was on the day or nightside of Earth; and 2) Whether the path was over land or water. Both conditions were the same in 2018 and 2024. However, the sunspot cycle was near minimum in 2018 and near maximum in 2024, and the estimation did not specifically account for any effects that the sunspot cycle might have on propagation and the signal level.

The estimated receiver input signal power in 2018 was –112 dBm. It is seen from the above spectrograms that the 6 year old estimate was close to actual in 2024. However, the displayed noise floor during the 2018 transmissions was 10 – 15 dB lower and the demodulated signals were more readable. I also successfully received the SAQ transmissions on Alexanderson Day in 2019 {Reeve19}, very close to the solar cycle minimum. The signal levels were about 8 – 10 dB higher but still reasonably close to the first order estimate made the year before. The noise floor in 2019 was about 7 – 8 dB lower than in 2024 but not as low as in 2018.

In addition to the possible solar cycle effects, there may be other reasons for the differences in the noise floors in 2018, 2019 and 2024. In particular, powerline noise and other local noise sources at Cohoe are known to change on both short and long time scales and may have contributed to the differences.

The signals received at Cohoe from SAQ were much stronger during the UN Day commemorative transmissions on 24 October 2023. The SAQ signals presumably followed the same physical path over the North Pole to Cohoe as they did in 2024 (VLF signals do not necessarily follow great circle paths), so the main variable, in this simple first-order comparison, is whether the path was sunlit or dark. During the October 2023 transmissions, the propagation path was almost entirely dark as opposed to almost entirely sunlit during the June 2024 transmissions. VLF signals experience more absorption loss on sunlit paths because of the increased ionization in the lower ionosphere, so the received signal levels usually are lower, possibly explaining the weaker signals in 2024 compared to 2023.

References:

{Cohoe} Reeve, W., VLF-LF Loop Antenna Installation at Cohoe Radio Observatory: https://reeve.com/Documents/Articles%20Papers/Reeve_CohoeVLFLoopAntenna.pdf

{Loop} Reeve, W., Square VLF Loop Antenna, 1.2 m Diagonal ~ Mechanical and Electrical Characteristics and Construction Details: https://reeve.com/Documents/Articles%20Papers/Reeve_SquareLoopAntenna1.2m.pdf

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

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

{SAQ} The Alexander Association, Grimeton SAQ veteran radio friends: https://alexander.n.se/?lang=en