Data Description and Target Sounder Signals

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Given are I/Q data with both sounder signals, interferers, and noise. In this document, the data format is described and target sounder signals are outlined.

Data Format

I/Q data is given in binary files as pairs of 16-bit integers in chronological order. For each pair, the first value represents the in-phase (I or real) signal value and the second value represents the quadrature (Q or imaginary) value. Both the center frequency and center frequency is in the file name, where the 2nd to last number delimited by '-' represents the center frequency in kHz and the last number is the sampling frequency in kHz. The first value delimited by '-' is a unique tag (or unique name) corresponding to a single sounding. For example the file, "Sounding001-12000-20000.bin" is for a sounding tagged as "Sounding001", has a center frequency of 12,000 kHz, and is sampled at 20,000 kHz.

Provide data will be one of two types of bandwidth, full-rate and base-banded.

Full-Rate Data

Full rate data is the primary focus of the PINS challenge. These data have a bandwidth of 10 to 25 MHz, covering a large portion of the HF spectrum. Within these data are soundings that can span frequencies as wide as the file bandwidth. A sounding can be found in a single full-rate data file.

Base-Banded Lite Data

For primarily training purposes, base-banded data will also be provided. These files are pre-tuned and narrow-banded at the sounder's transmit frequency at several times throughout the sounder's sweep. Because sounders sweep through a wide range of frequencies, a single sounding is broken up into several files centered at frequencies along the sounder's sweep. The file name convention is common between the full-rate data and the base-banded data. Like the full-rate data, both the center frequency and sampling frequency is in the file name, again, where the 2nd to last number delimited by '-' represents the center frequency in kHz and the last number is the sampling frequency in kHz.

Target Sounding Types

While there are several sounding signal types that exist, the PINS challenge will initially focus on two types of signals, linear sweep soundings and 16-chip complementary coded pulses.

Linear sweep sounding

The transmission for this target signal is described mathematically as

$$lss(t) = A \cdot \cos\left(2\pi \cdot \left(f_0 t + \frac{kt^2}{2}\right) + \phi_0\right),$$

Where t is time, A is an arbitrary signal amplitude, f_0 is the starting frequency, k is the frequency sweep rate, and ϕ_0 is an arbitrary initial phase. The instantaneous frequency of the transmitter, which we denote as $f_{tx}(t)$, is simply the derivative of the phase,

$$f_{tx}(t) = \frac{d\phi}{dt} = f_0 + kt,$$

which describes a linearly increasing frequency. Within this PINS challenge, frequency-sweep rates are confined to only being positive and span from 50 to 200 kHz per second. Note that for full-rate data, the sounding start times relative to the beginning of the file is generally non-zero, and it is part of the challenge to determine both the sweep rate and sounding start time of the sounding in order to process an ionogram.

16-chip Complementary Phase-Coded Pulse Sounding

In the initial stage of the PINS challenge, we also focus on 16-chip Complementary Phase-Coded Pulse Soundings. The parameter space is defined as follows:

- Complementary phase code pairs (strictly in the following order):
  - [+1, +1, -1, +1, +1, +1, +1, -1, -1, +1, +1, +1, -1, +1, -1, -1]
  - [-1, -1, +1, -1, -1, -1, -1, +1, -1, +1, +1, +1, -1, +1, -1, -1]
- Chip Baud Rate: 30 kHz
- Interpulse Period: 5 or 10 millisecond
- Number of pulses per frequency: 16, 32, 64, or 128
- Frequency step size: 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, or 100 kHz per step
- Polarization: O-mode only or O/X-mode
- 180 degrees phase shifting between code pairs: Enabled or Disabled

For polarization, O-mode only, the sounder transmit a circularly-polarized signal that primarily excites the O-mode polarization making polarization discrimination easier. However, note that X-mode polarization may be weakly present.

For polarization, O/X-mode, coded pulse pairs alternate between O-mode transmissions and X-mode transmissions. In this mode, the following 4 pulses (2 complementary codes x 2 polarizations) are repeated:

1. Complementary Pair, O-mode
2. Complementary Pair, X-mode

Typically, O and X modes are processed separately. Power leakage between polarizations may be present.

For sounding with 180 degrees phase shifting enabled (used to mitigate coherent interferers), phase codes are shifted by 180 degrees per phase code pair within each polarization, separately. To be specific, for polarization, O-mode only, and 180 degrees phase shift enabled, the following 4 pulses (2 complementary codes x 2 phase shifts) are repeated:

1. Complementary Pair, O-mode
2. Complementary Pair, O-mode, 180 degrees phase shift

For the transmissions with O/X-mode polarization and 180 degrees phase shifting the order of transmission is repeated as follows:

1. Complementary Pair, O-mode
2. Complementary Pair, X-mode
3. Complementary Pair, O-mode, 180 degrees phase shift
4. Complementary Pair, X-mode, 180 degrees phase shift

which is a repeated sequence of 8 pulses (2 complementary codes x 2 polarizations x 2 phase shifts).