DECODING OF ALTERNATING CODES USING FAST FOURIER TRANSFORMS

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ABSTRACT

One of the most used pulse codes at many incoherent scatter radars is the alternating code. It has proven to be very robust and the same code provides good ion line data at many altitude ranges. The altitude resolution of the codes can be increased by sampling the received signal at a higher rate than the code bit length, for targets with relatively small scale heights, such as the ionospheric E-region. This technique can also be utilised for the longer ranges, where the correlation times are a few bit lengths. One drawback of alternating codes, is that the target has to stay constant over the cycle of codes, but by using the oversample technique, the number of codes can stay relatively low, and still produce good estimates with high enough resolutions. Normally, the total cycle is at a sub second level.

Alternating codes are mainly used for incoherent scatter ion line measurements as the bandwidths are relatively low, making the decoding process simple enough for normal correlators to do all calculations, either in hardware of software. The codes have also been used for plasma lines, but the bandwidths used have been rather low. With the strong dependence on plasma line frequency on electron density, the filter bank technique have mostly been utilised. This makes the observations of lower value as it only provides signal at a few altitudes.

In this paper we present a decoding technique based on fast Fourier transforms, enabling spectra with large received bandwidths with high range and spectral resolutions. The FFT routines have been developed to large speeds over the years, and with those this technique provides a fast decoding process even when using very large sample rates relative to the code bit lengths.

The technique works with a window put onto the sample stream corresponding to the code and then a normal FFT on the filtered data is performed. This produces, after going through all codes, spectra at specified range intervals. The spectra has then contribution from scatter from the whole pulse length. However, the ambiguities of low range resolution parts can be removed with sets of short undecoded transforms. The third step is to do a more normal decoding at low frequency resolution. This can then be added to the high frequency resolution spectra, producing spectra with a range resolution corresponding to the code bit length. The technique can be used for any spectral width, also for normal ion line data, with calculation speeds orders of magnitude higher than normal time domain decoding. However, the range resolution is never better than the code bit length.

A detailed description of the technique will be presented. The first measurements using this technique have been carried out at EISCAT and we will show the results. We will also discuss the properties of the technique, and in particular the plasma line measurements will benefit from it.