Simulink GPS Receiver

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Objective: This project aims to make the inner functions of a GPS receiver clearly visible through the use of graphical programming in Simulink.

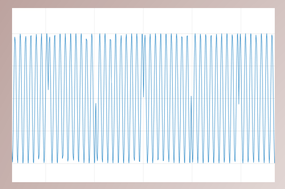
GPS SIGNAL – L1

L1 Frequency -1575.42 MHz (9.207MHz at IF).

Code Division Multiple Access – Different sequence spreading codes at same frequency.

C/A Code – Binary sequence used to encode satellite data to distinguish different sources.

BPSK Modulation- Modulating encoded data causes 180° phase shift in carrier.



BPSK Modulated Signal from Generator

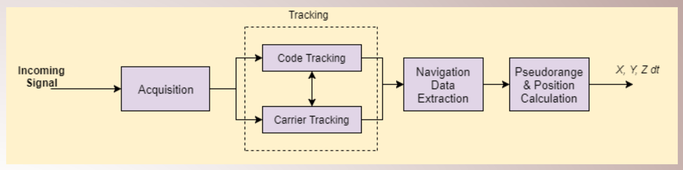
RECEIVER OVERVIEW

Acquisition

Identify in-range satellites at correct code phase and frequency shift.

Tracking

Track changes due to Doppler shift, allowing for coherent demodulation.



Navigation Data Extraction

Identify and align navigation data frames to extract information.

Pseudo-range & Position

Use information from a minimum of 4 satellites to calculate receiver position.

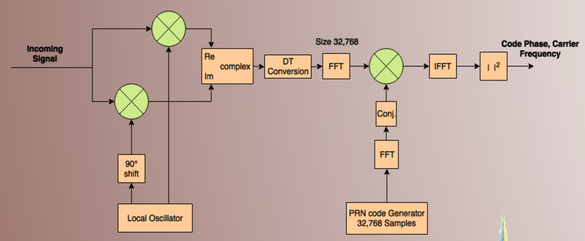
SIGNAL ACQUISITION

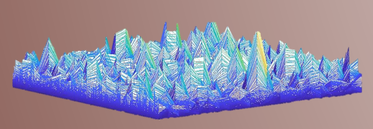
Parallel Code Phase Search Algorithm

Searches through 21 possible carrier frequencies per PRN code.

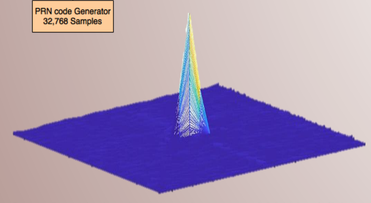
Use of FFT eliminates the need to search through 1023 possible code phases per PRN code.

Correlation values are used to identify visible satellites and signal characteristics.





Cross Correlation Results when PRN is not visible



Cross Correlation Results when tested PRN is visible

SIGNAL TRACKING

Demodulation is performed by multiplying the incoming signal with a locally generated carrier and C/A code. The local values must be aligned with the incoming signals values. Two tracking loops are combined and implemented to monitor deviations in the incoming signal. Three versions of the C/A code are produced (Early, Prompt, Late) each spaced half a chip apart.

Delay Locked Loop:

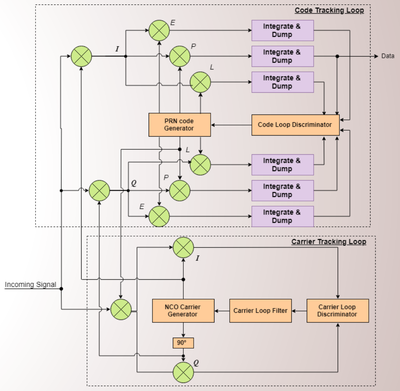
$$\epsilon = \frac{\sqrt{(I_E^2+Q_E^2)}-\sqrt{(I_L^2+Q_L^2)}}{\sqrt{(I_E^2+Q_E^2)}+\sqrt{(I_L^2+Q_L^2)}}$$

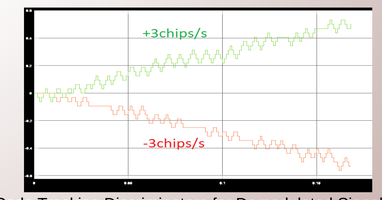
Tracks changes to the C/A code phase; Discriminator error output is used to shift the generated code, ensuring proper alignment.

Costas Phase Locked Loop:

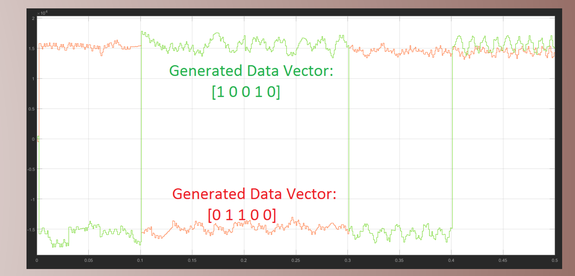
$$\epsilon = tan^{-1}\left(\frac{Q_P}{I_P}\right)$$

Tracks changes to frequency caused by Doppler shift; Discriminator output is a directly used to adjust the frequency of the locally generated oscillator. An IIR filter smooths this error term, minimizing oscillation and overshoot, providing stable demodulated data.

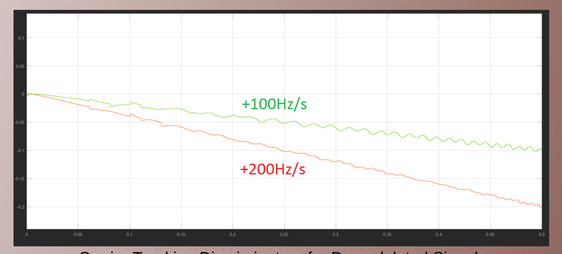




Code Tracking Discriminators for Demodulated Signals



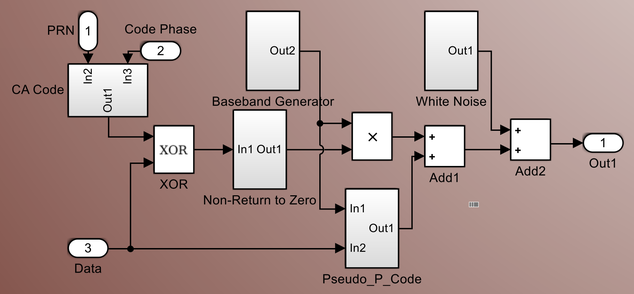
Demodulated Data From Collection of Signals



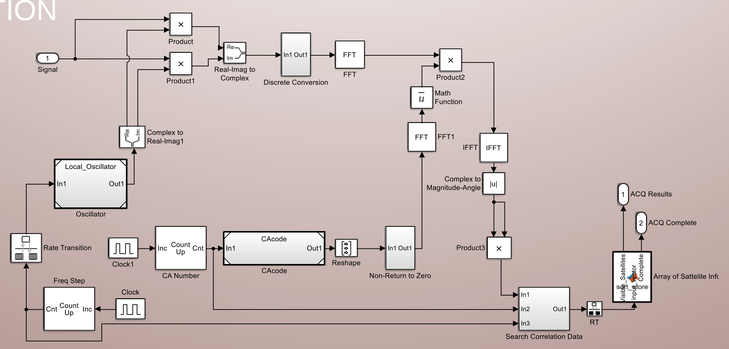
Carrier Tracking Discriminators for Demodulated Signals

SIMULINK MODELS

SIGNAL GENERATOR



ACQUISITION LOOP



COMBINED CARRIER + CODE TRACKING LOOP