**Overall Objectives**

**Historical and Economic Perspective**

*Unlocking the Phase Lock Loop – Part 1*

* First PLL proposed by French scientist de Bellescize in 1932 (Also credited with coherent demodulation)
* PLL used for:
  + Carrier synchronization
  + Carrier recovery
  + Frequency division and multiplication
  + Demodulation
* PLL can be either Digital or Analog
  + Phase Detector: Analog or Digital Multiplier
  + Loop Filter: Analog or Digital Filter (Differential equation/Difference equation)
  + Local oscillator: VCO/NCO/DDS

*Design and Implementation of Costas Loop Based on FPGA*

* Costas loop performs phase coherent suppressed carrier reconstruction and synchronous data detection

**Candidate Solutions**

*Unlocking the Phase Lock Loop – Part 1*

* + If then the VCO/NCO is locked in phase with the received signal
  + Units of is volts/radian

*Practical Costas Loop Design*

* + When the Costas Loop is locked
  + When the Costas loop is tracking
* Classical PLL have trouble tracking onto a BPSK signal that is reversing by 180 degrees. The reason is because the loop begins tracking in one direction and then the 180 degree reversal cause it to start tracking in the opposite direction. Conversely, the addition the of the quadrature branch allows it to track and lock onto a BPSK modulated signal.

**Proposed Solution Concept**

**Major Design and Implementation Challenges**

**Implications of Project Success**

**Needs Requirement**

* PLL Loop BW must be greater than the received baseband frequency, 1200bps, otherwise baseband information will be attenuated and lost.
* PLL Loop filter must have a -3dB cutoff frequency of 2400hz in order to attenuate double frequency component from phase detector
* PLL must be a third order type 2 feedback system in order to provide Doppler shift correction.
  + A0-16 LEO-AMSAT provides approximately an 8 minute window from line of sight (LOS) to peak altitude (16 minutes from horizon to horizon). At a downlink frequency of 437.025 MHz, the Doppler shift is +/-10.1 kHz from the downlink frequency. The resulting time rate change of frequency is approximated to 21 KHz/sec.
* Channel filter (BPF) must have a broad enough BW to pass the baseband information, but narrow enough to remove as much noise as possible.