GPS Signal Description

1. The baseband signal **transmited** by the satellite is given as

$$S(t) = S_{PPS}(t) + jS_{SPS}(t) \tag{1}$$

- $S_{SPS}(t) = \sum_{i=-\infty}^{\infty} c_{sps}(|i|_{L\_sps}).d([i]_{CD\_sps}).rect_{T_{c,sps}}(t - iT_{c,sps})$ — Standard Positioning Service
- $S_{PPS}(t) = \sum_{i=-\infty}^{\infty} c_{pps}(|i|_{L\_pps}).d([i]_{CD\_pps}).rect_{T_{c,pps}}(t - iT_{c,pps})$ —- Precision Positioning Service

2. Let $x_{in}[n]$ be the incoming signal at the **receiver** end and is given as

$$x_{in}[n] = A(t)s_T(t - \tau(t))e^{j(2\pi f_D(t)t + \phi(t))}|_{t=nT_s} + n(t)|_{t=nT_s} \tag{2}$$

where

- $A(t)$ is Amplitude
- $s_T(t)$ is Complex baseband signal
- $\tau(t)$ is code delay(time varying)
- $f_D(t)$ is Doppler shift(time varying)
- $\phi(t)$ is carrier phase shift(time varying)
- $n(t)$ is Random noise with zero mean
- T_s is Sampling period
- f_s is Sampling frequency

Pseudo code for GPS Signal Acquisition

1.1 Functions for computing the PRN codes of GPS satellite

1. (a) g1_lfsr(out)
    - state = 0x3FF
    - **For i**=0 to **i**=1022
        - out[**i**] = (state $\gg$ 9) & 0x1
        - new_bit = ((state $\gg$ 9) $\oplus$ (state $\gg$ 2)) & 0x1
        - state = ((state $\ll$ 1) | new_bit) & 0x3FF

   (b) g2_lfsr(tap0,tap1,out)
    - state = 0x3FF
    - tap0 = tap0-1
    - tap1 = tap1-1
    - **For i**=0 to **i**=1022
        - out[**i**] = ((state $\gg$ tap0) $\oplus$ (state $\gg$ tap1)) & 0x1
        - new_bit = ((state $\gg$ 9) $\oplus$ (state $\gg$ 8) $\oplus$ (state $\gg$ 7) $\oplus$ (state $\gg$ 5) $\oplus$ (state $\gg$ 2) $\oplus$ (state $\gg$ 1)) & 0x1
        - state = ((state $\ll$ 1) | new_bit) & 0x3FF

   (c) combine_g1_g2(g1,g2,out)
    - **For i**=0 to **i**=1022
        - out[**i**] = g1[**i**] $\oplus$ g2[**i**]

1.2 Main function

1. Capture 2ms samples of incoming signal $x_{in}[n]$
2. PRN Code frequency f_c is 1.023Mhz
3. Sampling frequency f_s s 2.048Mhz
4. The number of samples **N** for 1ms is 2048

5. Static array SVs[64] = [2, 6, 3, 7, 4, 8, 5, 9, 1, 9, 2,10, 1, 8, 2, 9, 3,10, 2, 3, 3, 4, 5, 6, 6, 7, 7, 8, 8, 9, 9,10, 1, 4, 2, 5, 3, 6, 4, 7, 5, 8, 6, 9, 1, 3, 4, 6, 5, 7, 6, 8, 7, 9, 8,10, 1, 6, 2, 7, 3, 8, 4, 9]
6. Static array g1[1023]
7. static array g2[32][1023]
8. Call the function g1_lfsr(g1)
9. k=0
10. visibility = 0
11. **For sv**=01 to **sv**=32:
    - i tap0 = SVs[k++]
    - ii tap1 = SVs[k++]
    - iii Call the function g2_lfsr(tap0,tap1,g2[**sv**])
    - iv Call the fumction combine_g1_g2(g1,g2,gold_code)
    - v **For i** = 0 to **i** = 1022
        - if gold_code[i] > 0
            - gold_code[i] = -1
        - else
            - gold_code[i] = 1
    - vi **For i** = 0 to **i** = N-1
        - $p_{sv}[\mathbf{i}]$ = gold_code[$\mathbf{i}.\frac{f_c}{f_s}$]
    - vii Compute correlation between $x_{in}[n]$ and $p_{\mathbf{sv}}[n]$, for n= 0,1,2....,N-1

$$z_{\mathbf{sv}}[n] = \sum_{m=0}^{N-1} p_{\mathbf{sv}}[m] x_{in}[n+m] \tag{3}$$

    - viii max_element = 0
    - ix max_index = 0
    - x **For i** = 0 to **i** = N-1
        - $z_{\mathbf{sv}}[\mathbf{i}] = \{\mathrm{Re}(z_{\mathbf{sv}}[\mathbf{i}])\}^2$.
        - if $(z_{\mathbf{sv}}[\mathbf{i}] > max\_element)$
            - max_element = $z_{\mathbf{sv}}[\mathbf{i}]$
            - max_index = **i**
    - xi if max_element > ϑ && (visibility < 4)
        - visibility = visibility+1
        - Code phase $\hat{\tau}_{\mathbf{sv}}$ = max_index
        - **For i** = 0 to **i** = N-1
            - x[**i**] = $x_{in}[\mathbf{i} + \hat{\tau}_{\mathbf{sv}}]$
        - max_of_max=0
        - **for** $f_D = f_{min}$ to $f_D = f_{max}$ in f_{step} steps:
            - Shift the signal $x[n]$ by f_D

$$x_{sh}[n] = x[n] \cdot e^{-j2\pi f_D n T_s} \tag{4}$$

            - Apply FFT to $x_{sh}[n] \longrightarrow X_{sh}[k]$
            - Compute conjugate of FFT of $p_{\mathbf{sv}}[n] = P^*_{\mathbf{sv}}[k]$
            - Multiply $X_{sh}[k]$ and $P^*_{\mathbf{sv}}[k]$.

$$Y[k] = X_{sh}[k] \cdot P^*_{\mathbf{sv}}[k] \tag{5}$$

            - Compute IFFT for $Y[k]$

$$R_{\mathbf{sv}}[n] = IFFT_k\{Y[k]\} \tag{6}$$

            - max_value = $R_{\mathbf{sv}}[0]$

- max_fd = 0
- **For i** = 0 to **i** = N-1
  - $R_{\mathbf{sv}}[\mathbf{i}] = \{\mathrm{Re}(R_{\mathbf{sv}}[\mathbf{i}])\}^2$.
  - if $(R_{\mathbf{sv}}[\mathbf{i}] > max\_value)$ && $(R_{\mathbf{sv}}[\mathbf{i}] > max\_of\_max)$
    - max_value = $R_{\mathbf{sv}}[\mathbf{i}]$
    - max_fd = **i**
- max_of_max = max_value

- Doppler Frequency offset f_{sv_D} = max_fd

xii else if visibility ≥ 4

- break

xiii else

- continue

- **end for**