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()

```
    state = 0x3FF
    Declare an array out[1023]
    for i=0 to i=1022
        out[i] = (state ≫ 9) & 0x1
        new_bit = ((state ≫ 9) ⊕ (state ≫ 2)) & 0x1
        state = ((state ≪ 1) | new_bit) & 0x3FF
    end for
return out
```

(b) g2_lfsr(tap0,tap1)

```
    state = 0x3FF
    Declare an array out[1023]
    tap0 = tap0-1
    tap1 = tap1-1
    for i=0 to i=1022
        out[i] = ((state ≫ tap0) ⊕ (state ≫ tap1)) & 0x1
        new_bit = ((state ≫ 9) ⊕ (state ≫ 8) ⊕ (state ≫ 7) ⊕ (state ≫ 5) ⊕ (state ≫ 2) ⊕ (state ≫ 1)) & 0x1
        state = ((state ≪ 1) | new_bit) & 0x3FF
    end for
return out
```

(c) combine_g1_g2(g1,g2)

```
    declare out[1023]
    for i=0 to i=1022
        out[i] = g1[i] ⊕ g2[i]
    end for
return out
```

1.2 Main function

1. PRN Code frequency f_c is 1.023Mhz
2. Sampling frequency f_s is 2.048Mhz
3. The number of samples **N** for 1ms is 2048

   /* Array to store Phase selector values for 32 satellites - 2 values per satellite*/

4. 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]
5. Static array g1[1023]
6. static array g2[32][1023]
7. g1 = g1_lfsr() /* Fucntion call */
8. k=0
9. visibile_satellites = 0
10. **for sv**=01 to **sv**=32:

    /* Generating PRN code */

    i tap0 = SVs[k++]
    ii tap1 = SVs[k++]
    iii g2[**sv**] = g2_lfsr(tap0,tap1) /* Fucntion call */
    iv gold_code = combine_g1_g2(g1,g2) /* Fucntion call */
    v **For i** = 0 to **i** = 1022
        if gold_code[i] > 0
            gold_code[i] = -1
        else
            gold_code[i] = 1
    /* Upsampling the PRN code */
    vi **for i** = 0 to **i** = N-1
        $p_{sv}[\mathbf{i}]$ = gold_code[$\mathbf{i}.\frac{fc}{fs}$]
    vii **for** i = 0 to i = N-1
        c[**sv**][i] = p_{sv}[i]

    end for

11. Calculate received signal power using the formula

    $P_x = 0$

    for i=0 to N-1

    $$P_x = P_x + |x_{in}[i]|^2$$

12. The power of incoming signal should be $P_x > \vartheta$

    $$\vartheta = \frac{\sum_{n=1}^{4} X_i}{4}$$

    X_i represents Signal powers at gain ={0,27,47} and noise

13. Capture 2ms samples of incoming signal $x_{in}[n]$
14. max_values[5] = {0}
15. max_row_indices[5] = {0}
16. max_indices[5] = {0}

17. **for sv**=01 to **sv**=32

    max = 0

    max_index = 0

    for n = 0 to n = N-1

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

    $z_{\mathbf{sv}}[\mathbf{n}] = \{\mathrm{Re}(z_{\mathbf{sv}}[\mathbf{n}])\}^2$

    if $z_{\mathbf{sv}}[\mathbf{n}] >$ max

    max = $z_{\mathbf{sv}}[\mathbf{n}]$

    max_index = n

    end for

    for i = 0 to i = 4

    if max > max_values[i]

    for j = 4 to j = i-1

    j = j-1

    max_values[j] = max_values[j-1]

    max_row_indices[j] = max_row_indices[j-1]

    max_indices[j] = max_indices[j-1]

    end for

    max_values[i] = max

    max_row_indices[i] = **sv**

    max_indices[i] = max_index

    break the loop

    end if

    end for

    end for

18. **for** sv = 0 to sv = 4

    Code phase $\hat{\tau}_{\mathbf{sv}}$ = max_indices[sv]

    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

    $$x_{sh}[n] = x[n] \cdot e^{-j2\pi f_D n T_s} \tag{3}$$

    Apply FFT to $x_{sh}[n] \longrightarrow X_{sh}[k]$

    for n = 0 to n = N-1

    $P^*_{\mathbf{sv}}[n]$ = c[**max_row_indices[sv]**][n]

    Compute conjugate of FFT of $p_{\mathbf{sv}}[n] = P^*_{\mathbf{sv}}[k]$

    Multiply $X_{sh}[k]$ and $P^*_{\mathbf{sv}}[k]$.

    $$Y[k] = X_{sh}[k] \cdot P^*_{\mathbf{sv}}[k] \tag{4}$$

    Compute IFFT for $Y[k]$

    $$R_{\mathbf{sv}}[n] = IFFT_k\{Y[k]\} \tag{5}$$

    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