Tracking loop in the IITB NAVIC SOC

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1 The tracking loop used in the IITB NAVIC SOC

The process of tracking in the IITB NAVIC SOC consists of the following flow of activity.

```
for each satellite S do {
  // F=carrier frequency
  // P=carrier phase
  // C=code delay
  // OK=1 if acquired, else 0
  F,P,C,OK := Acquire(S)
  CP := C           // initial prompt phase
  CE := C - CHIP/2  // initial early phase
  CL := C + CHIP/2  // initial late phase
  if(OK) {
    do {
       // in-phase and quadrature correlations
       // for prompt, early and late code delays,
       // using the carrier frequency F and phase P.
       Ip,Qp,Ie,Qe,Il,Ql :=
           ComputeCorrelations(S,F,P,CP,CE,CL);
       // Freq, phase, prompt, early, late code phases.
       F,P,CP,CE,CL :=
           RunTrackingLoop(Ip,Qp,Ie,Qe,Il,Ql,F,P,CP,CE,CL);
    } while S track not lost;
  }
} while TrackNotLost(S);
```

The inner loop is executed every 1 ms. Let $T = 0.001$ secods. The tracking loop is responsible for computing the updated values of

- Carrier frequency F.
- Carrier phase P.
- Data code phase CP (hence CE, CL).

given the results of correlation computation based on the previous values of F,P,CP.

We use f to denote the carrier frequency, ϕ to denote the carrier phase, and $\Delta_E, \Delta_P, \Delta_L$ to denote the data code phases CE, CP, CL shown above. The tracking loop actually consists of three loops, a frequency locked loop (FLL) to update f, a phase locked loop (PLL) to update ϕ, and a delay-locked loop (DLL) to update Δ_P. Let the current index of the inner loop execution be k (we start with $k = 1$)..

The FLL and PLL use an error value computed using the following discriminator.

$$\theta(k) \;=\; \tan^{-1}(Ip(k)/Qp(k)) \tag{1}$$

The FLL is described by the following equation:

$$f(k+1) = ((0.055 \times 2 * \Pi * T) \times \theta(k)) \;+\; f(k) \tag{2}$$

The PLL is described by the following equations:

$$\begin{aligned}
\phi_R(k+1) &= \phi_R(k) \;+\; (f(k) \times 2 \times \Pi \times T) \\
\phi_{accum}(k+1) &= \phi_{accum}(k) \;+\; (0.75 \times \theta(k)) \\
\phi(k+1) &= \phi_{accum}(k+1) + \phi_R(k+1)
\end{aligned}$$

Together the FLL and DLL determine the values of f and ϕ to be used in the next correlation set.

The DLL uses the following discriminator:

$$\begin{aligned}
E(k) &= I_e(k)^2 + Q_e(k)^2 \\
L(k) &= I_l(k)^2 + Q_l(k)^2 \\
\psi(k) &= (E(k) - L(k))/(E(k) + L(k))
\end{aligned}$$

Based on the discriminator $\psi(k)$, the next value of the prompt code phase is calculated using the following.

$$\begin{aligned}
h(k+1) &= (0.9 \times \psi(k)) + (0.1 \times h(k)) \\
P(k+1) &= P(k) + ((h(k) > 0)? -1 : 1)
\end{aligned}$$

- It is assumed that $h(1) = \phi_R(1) = \phi_{accum}(1) = 0$.
- Note that the tracking loop is entirely described by software.