SOFTWARE GPS IN SB3500 PROCESSOR

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AGENDA

- GPS briefly
- Current technology
- Software GPS
- Implementation
- Performance
- Conclusions

GPS Briefly

- NAVSTAR
- 24 active satellites each time
- All synchronized
- 32 PN sequences
- 26600 Km altitude
- ~ 11 hrs period
- At most 11 satellites visible each time

Current Technology

- ASIC
- Time domain correlation
- Multiple independent channels
- Cost determined by number of channels
- 1 to 8 bits word length, most receivers 2 bits
- Fixed based band receiver algorithms

Software GPS

- Frequency domain correlation
- Variable number of channels based on SW resource allocation
- Different algorithms base on application, cost propagation conditions
- Standalone or assisted based upon application
- Accommodates any existing RF frontend

Software GPS

$$s(t) = \sum_{i=0}^{N_s-1} \sum_{n=-\infty}^{+\infty} \sum_{k=-\infty}^{+\infty} A_i d_i[k] g\left(t - k\frac{N_p}{f_i}\right) g\left(t - n\frac{1}{f_i}\right) \times$$

$$\times P_i[(n + n_i^{'})\% N_p] \cdot \cos(2\pi f_i t + \varphi_i)$$

$$g\left(t - k^{'}\frac{N_p}{f}\right) \cdot g\left(t - m\frac{1}{f}\right) \cdot \cos(2\pi f\ t)$$

$$- j \cdot g\left(t - k^{'}\frac{N_p}{f}\right) \cdot g\left(t - m\frac{1}{f}\right) \cdot \sin(2\pi f\ t)$$

Software GPS

$$\chi(t) = s(t)\cdot g\left(t - k^{'}\frac{N_p}{f}\right)\cdot g\left(t - m\frac{1}{f}\right)\times$$

$$\times\cos(2\pi f\ \ t) - s(t)\cdot j\cdot g\left(t - k^{'}\frac{N_p}{f}\right)\times$$

$$\times g\left(t - m\frac{1}{f}\right)\cdot\sin(2\pi f\ \ t) =$$

$$= \sum_{i=0}^{N_s-1}\sum_{n=-\infty}^{+\infty}\sum_{k=-\infty}^{+\infty}\xi_{i,k,n}\cdot g\left(t - k^{'}\frac{N_p}{f}\right)g\left(t - k\frac{N_p}{f_i}\right)\times$$

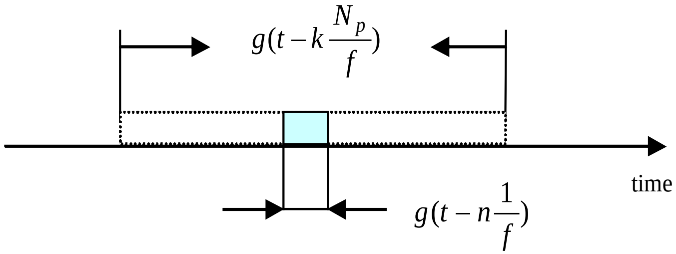
$$\times g\left(t - m\frac{1}{f}\right)g\left(t - n\frac{1}{f_i}\right)\cdot\cos(2\pi f_i t + \varphi_i)e^{-j2\pi ft}$$

$$\xi_{i,k,n} = A_i d_i[k]P_i[(n + n_i^{'})\%N_p]$$

$$g\left(t - k^{'}\frac{N_p}{f}\right)\cdot g\left(t - m\frac{1}{f}\right)\cdot g\left(t - k\frac{N_p}{f_i}\right)\cdot g\left(t - n\frac{1}{f_i}\right)$$

Software GPS

$$\chi(t) = \sum_{i=0}^{N_s-1} A_i d_i[k] P_i[(n+n_i^{'})\%N_p]\cdot g\left(t - n\frac{1}{\max(f, f_i)}\right)\times$$
$$\times\cos(2\pi f_i t + \varphi_i)\cdot e^{-j2\pi ft}$$



$$\int_{-\infty}^{+\infty}\chi(t)dt =$$

$$= \int_{n\cdot T}^{(n+1)\max(T,T_i)}\chi(t)dt =$$

$$= \int_{n\cdot T}^{(n+1)\cdot\max(T,T_i)} dt \sum_{i=0}^{N_s-1} A_i d_i[k] P_i[(n+n_i^{'})\%N_p]\cdot\cos(2\pi f_i t+\varphi_i)\cdot e^{-j2\pi ft} =$$

$$= \int_{n\cdot T}^{(n+1)\cdot\max(T,T_0)} dt \quad A_o d_0[k] P_0[(n+n_0^{'})\%N_p]\cdot\cos(2\pi f_0 t+\varphi_0)\cdot e^{-j2\pi ft} +$$

$$+ \int_{n\cdot T}^{(n+1)\cdot\max(T,T_1)} dt \quad A_1 d_1[k] P_1[(n+n_1^{'})\%N_p]\cdot\cos(2\pi f_1 t+\varphi_1)\cdot e^{-j2\pi ft} + \ldots$$

$$+ \int_{n\cdot T}^{(n+1)\cdot\max(T,T_{N_s-1})} dt \quad A_{N_s-1} d_{N_s-1}[k] P_{N_{s-1}}[(n+n_{N_s-1}^{'})\%N_p]\times$$

$$\times\cos(2\pi f_{N_s-1} t+\varphi_{N_s-1})\cdot e^{-j2\pi ft} \qquad (4)$$

Software GPS

$$D_i(k, n+n_i^{'}) \int_{nT}^{(n+1)\cdot\max(T,T_i)} dt \cdot \cos(2\pi f_i t + \varphi_i) \cdot e^{-j2\pi ft} =$$

$$D_i(k, n+n_i^{'}) \cos\varphi_i \int_{n\cdot T}^{(n+1)\cdot\max(T,T_i)} dt \cdot \cos(2\pi f_i t) \cdot e^{-j2\pi ft} -$$

$$- D_i(k, n+n_i^{'}) \sin\varphi_i \times$$

$$\times \int_{n\cdot T}^{(n+1)\cdot\max(T,T_i)} dt \cdot \sin(2\pi f_i t) \cdot e^{-j2\pi ft} =$$

$$= D_i(k, n+n_i^{'}) \cos\varphi_i \int_0^T dt \cdot \cos(2\pi f_i t) \cdot e^{-j2\pi ft} -$$

$$- D_i(k, n+n_i^{'}) \sin\varphi_i \int_0^T dt \cdot \sin(2\pi f_i t) \cdot e^{-j2\pi ft} +$$

$$+ D_i(k, n+n_i^{'}) \cos\varphi_i \int_T^{T_i} dt \cdot \cos(2\pi f_i t) \cdot e^{-j2\pi ft} -$$

$$- D_i(k, n+n_i^{'}) \sin\varphi_i \int_T^{T_i} dt \cdot \sin(2\pi f_i t) \cdot e^{-j2\pi ft} =$$

Software GPS

$$E_i = D_i(k, n + n_i^{'}) \cos\varphi_i \int_T^{T_i} dt \cdot \cos(2\pi f_i t) \cdot e^{-j2\pi ft} -$$

$$- D_i(k, n + n_i^{'}) \sin\varphi_i \int_T^{T_i} dt \cdot \sin(2\pi f_i t) \cdot e^{-j2\pi ft}$$

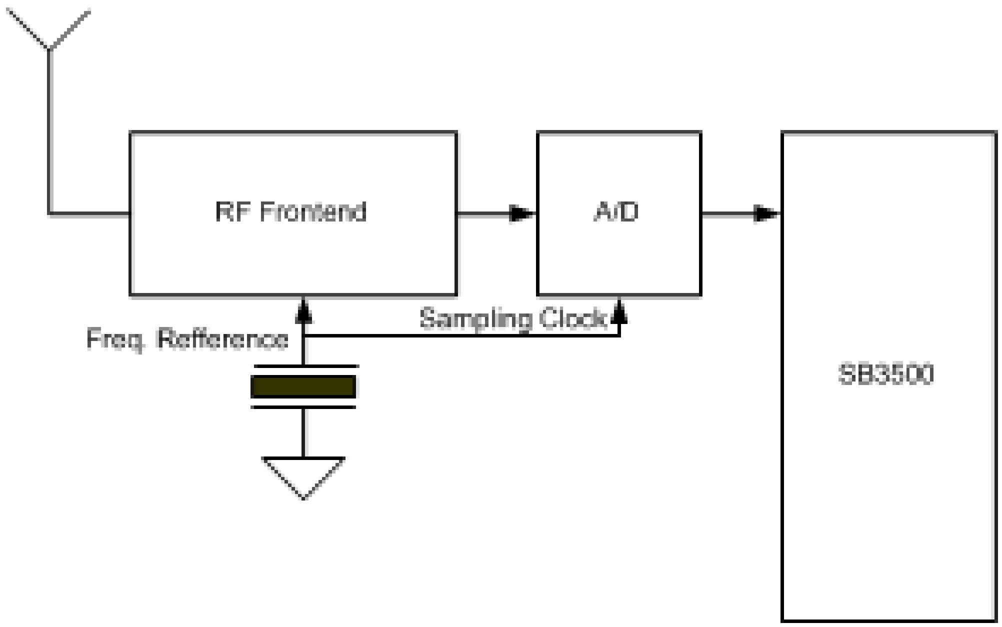
$$= \frac{D_i(k, n + n_i^{'}) \cos\varphi_i}{2} \delta(f - f_i) +$$

$$j \frac{D_i(k, n + n_i^{'}) \sin\varphi_i}{2} \delta(f - f_i) + E_i \qquad (5)$$

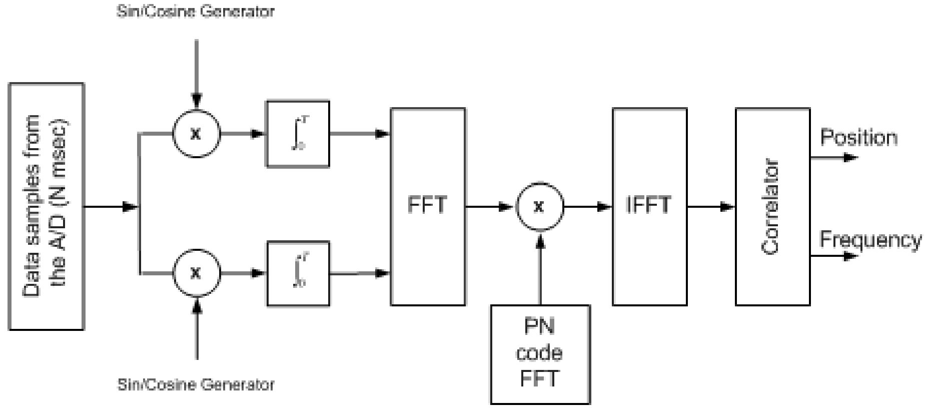
$$\sum_{i=0}^{N_s - 1} \int_{-\infty}^{+\infty} \chi(t) dt = \sum_{i=0}^{N_s - 1} \frac{D_i(k, n + n_i^{'}) \cos\varphi_i}{2} \delta(f - f_i) +$$

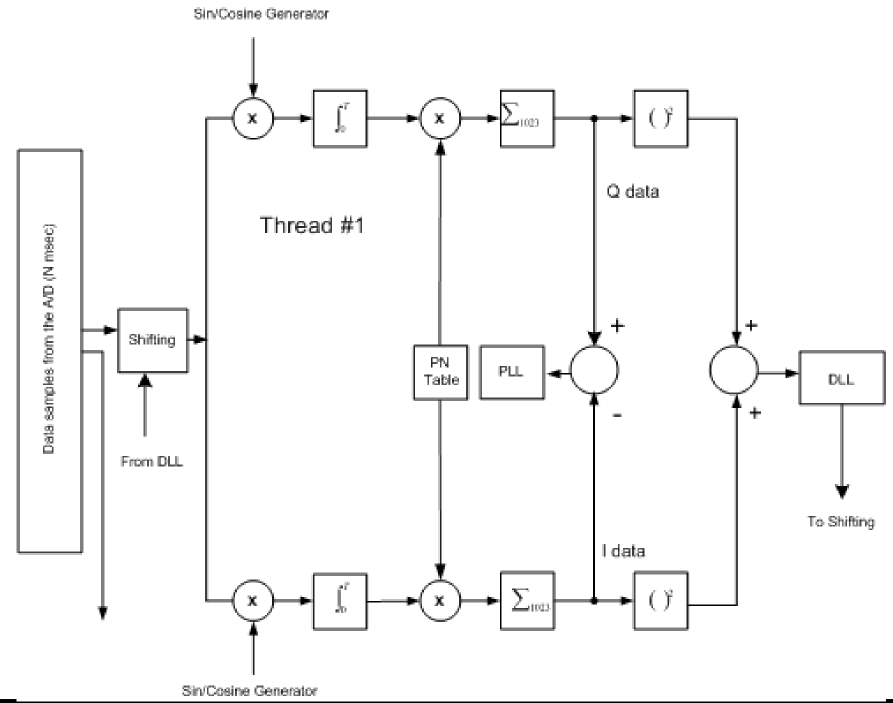
$$+ j \frac{D_i(k, n + n_i^{'}) \sin\varphi_i}{2} \delta(f - f_i) \sum_{i=0}^{N_s - 1} E_i \qquad (6)$$

Implementation



Implementation





Performance

Tested in the lab using the 12-channel Spirent 4500 as well as in the field.

- Full sky-search in under 2s, locating up to 12 satellites.
- Decode the ephemeris and get a first fix in a worst case of 36s.
- positioning precision of less then 10 meters with the decoded ephemeris data and less then 3 meters with precise ephemeris.
- -147dBm total receiver sensitivity with 18dBi active antenna

Conclusions

Thank you for your attention!