Architecture and Applications of Software GPS Receiver

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GPS Overview

- GPS provides the position, velocity, and timing information that enabled many applications we use in our daily life.
- It includes precision agriculture, land transportation, maritime, mapping, surveying and aviation etc.
GPS Receiver Architecture

Antenna

Front End → Acquisition → Tracking → Navigation

ASIC

Micro Processor

Hardware Software

* ASIC (Application Specific Integrated Circuit)
Software GPS Receiver Architecture

Antenna

ASIC

Front End

MICROPROCESSOR

Acquisition → Tracking → Navigation

Hardware

Software
Why Software GPS Receiver?

- A generic signal processing research platform for all kind of Global Navigation Satellite Systems
- Multiple systems in single device
- Easy to reprogram for any specific environment, like:
  - Multipath mitigation
  - Weak signal acquisition and tracking
  - Interference mitigation
- Easy to reconfigure for modern GPS signals
Why Software GPS Receiver?

- Easy FPGA implementation
- Receiver performance trade off analysis
- Passive microwave signal (GPS – 1.5 GHz) analysis for soil moisture and water boundary
- Using aided navigation minimizing the data latency issue.
- Post processing of field data
Algorithm Flow in Software GPS Receiver

Front End
- Down Convert
- ADC

Acquisition
- Initial Code Phase
- Coarse Frequency

Tracking
- Track Code Phase (DLL)
- Track Frequency (PLL)
- Navigation Bits

Navigation
- Decoding
- Pseudorange
- Position
- Velocity
Steps in Software GPS Receiver

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<td>User Position and Velocity</td>
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Front End

• Incoming signal is down converted
• Signal is digitized
• Buffering in any storage media
Acquisition

- Find if a certain satellite is visible?
- If YES then find the code phase and frequency of incoming signal
# Acquisition Method

<table>
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<th>Conventional GPS Receiver</th>
<th>Software GPS Receiver</th>
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<td>Conventional receiver uses correlation method, resulting less efficient computing and requiring more time to search a satellite.</td>
<td>Software GPS receiver uses DFT (Discrete Fourier Transform), resulting efficient computing and requiring less time to search a satellite.</td>
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DFT Based Acquisition

Schematic representation of FFT based acquisition
Tracking

- Initial Code Phase
- Delay Lock Loop (DLL)
- Phase Lock Loop (PLL)
- Initial Frequency
- Storage
- Navigation Bits

- Demodulate Navigation bits
- Track variations in the carrier Doppler and code offset due to line of sight dynamics for efficient demodulation of navigation bits
Delay Lock Loop (DLL)
Carrier Tracking Loop

Costas Phase Lock Loop
Complete Tracking Loop
Matlab Demonstration

Front End  Acquisition  Tracking
Digitized GPS Signal

Real GPS data (2 bits quantization)

FFT of Real GPS signal

Time Domain

Frequency Domain
Acquisition Results
Tracking Result

In-phase prompt code correlator output

Navigation bit transitions

Time (msec)
Applications

- Low cost navigation solution
- In depth understanding of GPS signal structure and processing
- Modular implementation, so that every module can be independently replaced with an alternative algorithm
- Platform for evaluating novel algorithms for
  - Multipath mitigation
  - Weak signal acquisition and tracking
  - Interference management
- All type of GNSS receiver in a single unit
Thanks for your attention

www.suparco.gov.pk

Reference: