Courses

Course 452A: Navigation Receiver Signal Processing: Advanced Baseband Processing for High Performance GPS Receivers

On-site only

New configuration of our previously offered Course 442!

Quotes:

"Thanks much. Your course offerings have proven to be extremely useful from a technical (as well as networking) perspective. Phil is an excellent resource."
Pete Ryan
Honeywell

"Phil Ward is a very knowledgeable instructor who explains things very clearly. I recommend this course for anyone needing an introduction to GPS receiver design."
Ernest Ohlmeyer
Naval Surface Warfare Ctr.

"I am moving into the area of receiver processing and this course has given me a good understanding of the signal processing aspects."
Kevin J. Neigum
Rockwell Collins

"This course will help in analyzing problems brought to CIGTIF concerning GPS anomalies."
Jim Killian
AMCOMP,
Holloman AFB

"This course has given me, in detail, a fundamental understanding of the building blocks required for GPS signal processing. This course will help me better understand the design decisions faced in building a GPS receiver."
George Kalaydjian
Canadian Marconi Company

"This course will help me understand and solve many GPS receiver problems. It gave me the knowledge I needed about the operability of GPS; way beyond the everyday GPS knowledge that a typical user has obtained. It gets the student into the nuts and bolts of the system."
Michael Bailey
NAWC-WD China Lake

Time	Monday	Tuesday	Wednesday	Thursday
8:30 9:45 11:00	*Mr. Phillip Ward, Navward GPS Consulting* **GPS Signal Characteristics** Satellite signal modulation Frequencies and modulation format GPS satellite signal structure GPS signal structure for L1 GPS code mixing with data GPS L1 carrier modulation **Satellite Code Generators** Direct sequence PRN code generation Code phase assignments and initial code sequences for C/A and P-code C/A-code generator P-code generator GPS code generator polynomials and initial states **Satellite Signal Power and Antenna Array** Satellite signal power levels; minimum received GPS signal power levels L1 and L2 navigation satellite signal power budgets GPS satellite helix array gain pattern Satellite to user geometry and path loss equations Satellite signal power budget GPS satellite antenna relative power patterns	**Baseband Signal Processing** Phase alignment; predetection integrate/dump intervals with SV data transition boundaries Carrier aiding of code loop Scale factors for carrier aided code External aiding Digital frequency synthesizer block diagram, output waveforms, and synthesizer design **Carrier Tracking Loops** Carrier tracking loops Generic GPS rcvr carrier trk loop block diagram Phase lock loops Common phase lock loop discriminators Costas loops, and common discriminators Comparison of Costas PLL discriminators I, Q phasor diagram depicting true phase error between replica and incoming carrier phase **Frequency Lock Loops (FLL's)** Frequency lock loop discriminators; compar. I, Q phasor diagram: true frequency error **Code Tracking Loops:** Generic GPS receiver code tracking loop Common delay lock loop discriminators Comparison of delay lock loop discriminators Code correlation processes for 3 code phases; 1/2 chip early, etc. Code discriminator output versus replica code offset	**Measurement Errors and Tracking Thresholds III** Total PLL tracking loop measurement error and thresholds Total PLL jitter for third-order carrier loop plot Jerk stress thresholds for third-order PLL FLL tracking loop measurement errors **Measurement Errors and Tracking Thresholds IV** FLL thermal noise jitter plot Jerk stress thresholds for second order FLL Code tracking loop measurement errors DLL jitter plots **Tightly-coupled and Vector (Ultra-tightly Coupled) Tracking Loops** Synergism between GPS and various GPS/inertial architectures Inertial systems leading to tightly-coupled configurations Issues in a tightly-coupled configuration Vector tracking (ultra-tightly coupled) loop configurations Ultra-tightly coupled vs. tightly coupled configuration	*Mr. Logan Scott, LS Consulting* **Signal Acquisition I** 2-Dimensional C/A-code search pattern Probability density functions for a binary decision; probability of false alarm, false dismissal, detection and correct dismissal The Generalized Marcum's Q-function Taxonomy of search detectors Example of fixed dwell time detector: M of N search detector **Signal Acquisition II** Probability of detection for M of N search algorithm Example of variable dwell time detector: Tong search detector Probability of detection for Tong search algorithm **Miscellaneous Important Baseband Functions** Bit & symbol synchronization Reading the current signal's 50 bps data stream Interleaving and convolutional encoding; reading future signal's data C/No meter design & performance Phaselock detector design
12:00	*Lunch is on your own*			
1:30 2:45 4:00 5:00	**Autocorrelation Functions and Power Spectral Densities** GPS signal power spectrum Autocorrelation function power spectrum of a rectangular pulse, a random binary code, a maximum length PN code and its line spectrum Autocorrelation function, spectrum, and power ratios for a typical C/A-code Normalized and simplified autocorrelation function typical C/A and P(Y)-codes Comparisons between C/A-code and P(Y)-code autocorrelation Power spectrum of L1 P(Y)-codes and C/A-codes from a GPS signal generator L2 P(Y)-codes and L1 C/A-codes from a GPS signal generator showing line spectra Cross-correlator functions & code division multiple access performance C/A maximum cross-correlation power **Receiver Noise** Carrier to noise power ratio - C/N_0 Generalized model of a GPS receiver - computing G/T G/T model equation formulation Deriving C/N_0 from G/T model equation C/N_0 versus received signal level **GPS Satellite Signal Tracking** Signal tracking overview Receiver code and carrier tracking Generic digital receiver block & channel diagram Generic baseband processor code and carrier tracking loops block diagram Predetection integration	**Receiver Tracking Loops** Loop filter Block diagrams of first, second, and third order analog loop filters Loop filter characteristics Block diagram of analog, digital boxcar and digital bilinear transform integrators Block diagrams of 2 FLL-assisted PLL filters Loop filter parameter design example **Measurement Errors and Tracking Thresholds I** PLL tracking loop measurement errors PLL thermal noise PLL thermal noise jitter plot Vibration-induced oscillator phase noise **Measurement Errors and Tracking Thresholds II** Allan deviation oscillator phase noise Allan deviation jitter in L1 second order PLL Dynamic stress error Reference oscillator acceleration stress error	**Formation of Pseudorange, Delta Pseudorange and Integrated Doppler I** Pseudorange definition and measurement Relationship of satellite transmit time to pseudorange measurements Relationship between PRN code generator and code accumulator Measurement time skew Maintaining and getting measurement from the code accumulator Synchronizing the code accumulator to the C/A-code and P-code **Formation of Pseudorange, Delta Pseudorange and Integrated Doppler II** Code setter and code generator block diagram C/A-code and P-code setup Count states for 3,749th and 3,750th cycles of X1A in first X1 cycle of week PN code states corresponding to final two and reset count states Count states for 3,749th and 3,750th cycles of X1A in last X1 cycle of week **Formation of Pseudorange, Delta Pseudorange and Integrated Doppler III** Flowchart of P-code setter algorithm Obtaining transmit time from the C/A-code GPS C/A-code timing relations Example of bit sync error in C/A-code measurements Delta PRN & integrated Doppler measurements **Workshop**	

Objectives

- To provide technical professionals with an in-depth understanding of GPS signal structures, receiver signal processing techniques, receiver system tradeoffs and how the processing techniques perform in a variety of environments. These include outdoor and indoor regions that are jamming, spoofing & multipath impaired.
- To provide a practical approach to receiver design and analysis from a conceptual perspective. This course focuses on advanced baseband acquisition, tracking and signal processing for high performance receivers.

Prerequisites

- Electrical Engineering degree or equivalent experience required.
- *Course 356* or equivalent professional experience recommended.
- Understanding of basic GPS operation, signal structure and signal processing techniques is desirable.

Instructors:

Mr. Phillip Ward

Mr. Logan Scott

Who Should Attend

- Engineers, system analysts and others who require in-depth knowledge of GPS receiver technology for the purpose of building, modifying, or designing receivers.
- User equipment (UE) designers and integrators.

Materials You Will Keep

- A notebook including all materials presented in course.
- Navtech's CD-ROM containing a variety of GPS references.
- A voucher for the following text, or substitute of your choice:
  - ***Understanding GPS Principles and Applications***, Elliott Kaplan, Editor, Artech House, Inc., 1997. The course addresses much of the material in Mr. Ward's chapter in this book, and expands upon it. The attendee therefore leaves with very complete documentation.

Course 452B: **Navigation Receiver Signal Processing:**

GPS & Galileo New Signals, Signal Processing & Performance Capabilities

On-site only

Courses

This new course is based on the successful presentation of Tutorials *310A & 310B: The New Military and Civil Signals I & II* prior to the ION GPS 2002 conference in Portland, Oregon. The curriculum has been extended to 1.5 days to allow more time to expand on the topics covered.

Time	Thursday	Friday
8:30		Mr. Scott **L2 and L5 Civil Signal Structures** Signal structures and specifications Tracking Loop Design & Performance Use of the "data free" channel to enhance threshold performance
9:45		**Multipath Mitigation Techniques** Why multipath is becoming a more important error source Narrow spacing correlator Strobe correlator Early gate tracking
11:00		**Anti-Jam Capabilities of the P(Y), C/A & M-code Signals (Part 1)** The Betz equation for computing baseband C/N_0 Processing gain for BOC signals Comparative performance against a variety of jammer types Split spectrum tracking & acquisition
12:00	*Lunch is on your own*	
1:30	Mr. Logan Scott *LS Consulting* **GPS & Galileo New Signals Overview** Frequency allocations & spectral characteristics Deployment schedules and resulting capabilities The European Galileo Program	**Anti-Jam Capabilities of the P(Y), C/A & M-code Signals (Part 2)** Spot beam (area coverage) plans and implications Basics of ground mobile signal propagation Predicting received jamming strength Anti-jamming performance for the ground mobile user Prospects for civil signal denial
2:45	**Basics of BOC Modulation & Tracking (Part 1)** BOC signal structure and generation M-Code characteristics and design criteria Galileo signal characteristics	**Advanced Signal Acquisition** FFT & massive correlator approaches Direct P(Y) acquisition and M-code assisted acquisition Operation in indoor/impaired signal environments
4:00	**Basics of BOC Modulation & Tracking (Part 2)** BOC tracking loop design False code lock detection & correction Pseudorange tracking accuracy	**Miscellaneous Topics** Combined GPS/Galileo performance Interplex modulation; keeping the signal constellation circular Summary of principal elements of course Question & answer session Comments and conclusion
5:00		

Quotes (from ION GPS 2002 tutorial version):

"Outstanding knowledge. Answered every question easily and with skill... I'm not an EE by trade but I understood most of the class. I like the discussion of anti-jam capability. I like the practical examples and solutions to issues like M-code vs. multipath."
David Holz

"Excellent graphs of DTI and spectrum plots to show very complex subject matter."
Edmund Burke

"Excellent overall. CD ROM with key reference papers and info is brilliant and greatly appreciated."
Name withheld

"The content of this tutorial is on a high level which is really appreciated. It is of high value for engineers."
Name withheld

"Excellent course. Excellent instructor."
Name withheld

"Navtech should charge double for this course. The technical content is way above the typical Navtech course. The CD ROM is most valuable as a resource and additional training aid."
Phil Ward
Navward Consulting

Objectives

- To provide a detailed understanding of the features and operational characteristics for the new GPS & GALILEO signals, both military and civil, and address techniques for processing these multiple signals to exploit their significantly improved performance capabilities as they become available.

Prerequisites

- Basic understanding of GPS, as in *Course 122*, required.
- Understanding of basic GPS operation, signal structure and signal processing techniques, as in *Course 452A*, or equivalent professional experience is desirable.

Instructor: Mr. Logan Scott

Who Should Attend

- Engineers, system analysts and others who require in-depth knowledge of GPS receiver technology for the purpose of specifying, building, modifying, or designing receivers.
- User equipment (UE) designers and integrators.

Materials You Will Keep

- A notebook which includes all materials presented in course.
- Navtech's CD-ROM containing a variety of GPS references, specifications, and technical papers.

Revised and Updated Course Under Construction
- the next course to take after 452!
Refer to our web site for details (www.GPSetc.com)

Course 499:

Advanced GPS Receiver Architectures and Design:

LSI Hardware, Software, Tightly Coupled Integrations and Modern Processing Techniques for Stand-Alone and Embedded Receivers

Objectives

- To provide the engineering professional with an in-depth understanding of the various facets of advanced GPS receiver operation, system architectures, and hardware implementations.
- To address the integration of GPS with other sensors and in tightly coupled configurations
- To address architectural options and alternatives for next generation receivers
- To provide performance comparisons of chip sets, boards and development tools
- To carry out, demonstrate and critique a chip level design