

CN531C Global Navigation Satellite System (GNSS) Receiver Design (6.0 CEUs)

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Prerequisite: Some knowledge of mathematics, RF circuit design, analog and digital signal processing and GNSS (i.e., CN505C) will be useful.

Intended Audience: Design and development engineers, academic researchers, scientists, educators, and managers interested in the area of satellite navigation, particularly with respect to the design and implementation of GNSS receivers, software radio research platforms, or GNSS signal processors. The course is more advanced than a simple overview, and will get into more detailed implementation-centric topics.

Course Overview: This course is designed to be a two-part sequence covering the design and practical implementation of GNSS receivers using the latest developments in radio frequency (RF) and digital signal processing technologies. The material covered will be applicable to a wide range of GNSS user equipment from instrumentation-quality reference receivers through aviation-grade, military, and low-power consumer-grade single chip devices. Part 1 (Morning Session) covers the design of GNSS RF front-ends starting from the low-noise amplifier (LNA) through to the analog-to-digital converter (ADC). Part 2 (Afternoon Session) covers digital signal processing techniques from sample correlation through range measurement computation, and the implementation of these techniques using hardware, software, or reconfigurable logic (i.e. FPGA) processors. The course material is approached with both the theoretical and practical perspective, using case studies of actual GNSS receivers developed by the instructor as well as an overview of the latest commercially available GNSS chipsets. The major topics include:

Morning Session:

- Overview of received GNSS signals: Link budget, signal structure, power spectrum, spreading codes, auto and cross correlation properties, thermal noise, and system noise figure.
- GNSS front-end architectures: Single versus dual conversion, analog versus digital downconversion, direct RF sampling.
- Frequency planning and control: Image frequencies, bandwidth and filter selection, reference clock types and parameters, PLL synthesizers, phase noise, and cost-performance tradeoffs.
- RF/IF components: Parameters important to GNSS signal processing; component selection guidelines for amplifiers, filters, mixers and oscillators.
- Implementation intricacies: Factors affecting the end performance of GNSS receivers such as component-induced multipath, crosstalk, and power supply isolation.

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- Sampling subsystem: ADC specifications, impact of sampling resolution and jitter, automatic gain control, dynamic range considerations.
- GNSS front-end design techniques and case studies
 - Modular design using connectorized components
 - PCB-level design using discrete RF components
 - Commercial GNSS MMICs for portable electronics

Afternoon Session:

- Overview of received GNSS signals: Signal structures of GPS L1-C/A, L2C, and L5 and Galileo E1. BPSK, BOC, and other proposed modernized signal modulations and properties.
- Signal correlation: Time, frequency, and transform-domain techniques. The complementary nature of time-domain and frequency-domain processing. Coherent versus non-coherent integration. Advanced correlator architectures for multipath mitigation and signal quality/deformation monitoring (SQM, SDM).
- Processing complexity: Methods for reducing complexity for realtime implementation. Performance impact due to reduced numerical precision.
- Signal Acquisition: Acquisition threshold statistics, search algorithms, fast acquisition techniques
- Acquisition-to-tracking transition: Acquisition verification, bit synchronization, and false-lock detection techniques.
- Tracking: FLL, PLL and DLL, loop tightening/transitioning techniques, noise bandwidth, tracking performance, block (batch) processing and open-loop tracking techniques.
- Measurement computation: Navigation databit extraction and decoding, TOT and TOR counters, pseudorange and carrier-phase measurements, carrier-smoothed code.
- Implementation techniques and platforms (including case studies):
 - Matlab®-based non-realtime algorithms
 - Bitwise software algorithms for general-purpose microprocessors
 - FPGA-based processing engines and design overview
 - Commercial GPS processor chipsets

Course Topic Tailoring: GNSS Solutions can tailor the above course outline to meet your special needs or market. We can provide you more or less emphasis in specific areas, add or subtract topic areas. Feel free to [contact us](#) and discuss options for your course outline to maximize your benefit. Be sure to include any requested modifications when you [request a quote](#).

Handout Booklet: A booklet of the slide material presented will be provided. One Handout Booklet will be provided per student. The Handout Booklet will be professionally spiral bound with clear protective vinyl on the front and back cover (clear on front, navy blue on back). References will be provided on slides, as appropriate, and a reference list of significant material will be provided. Color will be provided on a limited basis where it is needed for clarity. This information will be copyrighted by the author and cannot be reproduced without the written permission of the author or GNSS

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Solutions if associated with this course. All color and/or password protected slide copies may be requested at additional cost.

Reference List: A reference list will be provided as part of the note package to allow the interested attendee to obtain additional information. Additionally, an acronym list will be provided.

Location: On-site at the Government and/or contractor facility. A local commercial location can be arranged by GNSS Solutions if requested.

Host Responsibilities:

Facilities: Room, restrooms, seats, chairs, etc.
Refreshment access or provided (coffee, soda, snacks, etc.)
Scheduling of students and fund coordination.
LCD projector with screen and white/chalkboard (or equivalent).
No audio or video taping of the presentation is allowed.
GNSS Solutions can provide the above items with proper coordination.

Day Schedule: The class room shall be available no later than 07:30 on class day, with presentation beginning at 08:30. A 15 min break will be scheduled every hour. One hour for lunch will be scheduled. The course will end at 16:30 every day. A total of 6 hrs of presentation time will occur each day. Different start, stop, break, and duration times can be accommodated.

Scheduling: A lead time of at least 4 weeks shall be used to schedule the course. A 10% deposited is required when ordering the course.

Rescheduling or Cancellation: Once the course has been ordered, the course can be rescheduled or canceled but fees may occur. The amount of these fees can be negotiated at the time of course rescheduling or cancellation. Generally, non-recoverable expenses (e.g., travel costs) may be forfeited in the event the course is rescheduled. If the course is cancelled, a 10% cancellation fee will apply.

Request a Quote: Please include the dates, location, number of attendees, and any exceptions, tailoring or special requests in your [request for quote](#).