

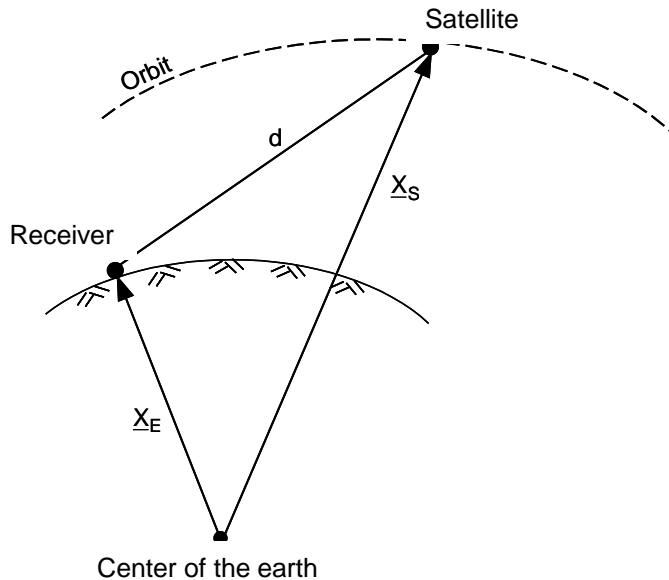


Lab 4:

Kinematic GNSS Measurements



Main Principle



- Coordinates of satellite are known X_S
- d measurements are made by evaluating the transit-time between satellite and receiver
- Measurements of distances d to different satellites
→ d defines a sphere surface around X_S
- X_E is the intersection point of 3 spheres
(but: 4 satellites are needed in consideration of clock error)

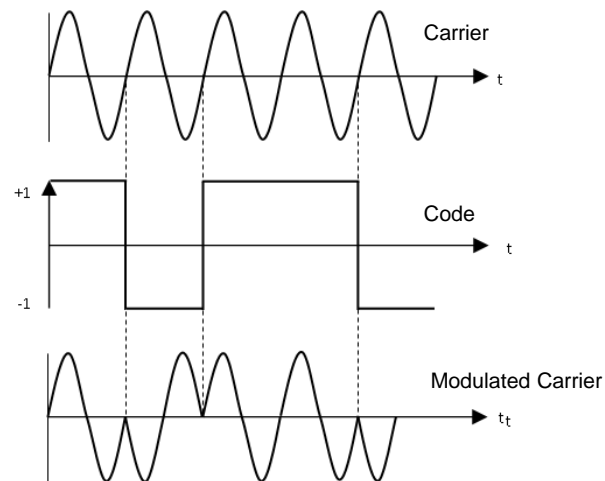
Signals

Carrier waves

L1 : $154 \times 10.23 \text{ MHz} = 1575.42 \text{ MHz}$ 19.05 cm

L2 : $120 \times 10.23 \text{ MHz} = 1227.60 \text{ MHz}$ 24.45 cm

Codes



C/A-Code: course acquisition code on L1
 Periode 1 msec
 $f = f_0/10 = 1.023 \text{ MHz}$ 293.1 m
 Noise (1%) of $\lambda \Rightarrow 3 \text{ m}$

P-Code: precise code on L1 und L2
 Period 267 days (7 days per satellite)
 $f = f_0 = 10.23 \text{ MHz}$ 29.31 m
 Noise (1%) of $\lambda \Rightarrow 0.3 \text{ m}$

Data

- Phase modulation on L1 and L2
- Likewise sequence of +1 and -1
- Contains information about satellite's clock and position/ orbit
- 1500 bit at 50 bit/sec



Signal Processing

Code observations: measurements of pseudo ranges, falsification of distance by receiver's clock error

Observation equation:

$$\rho_{rs} + v_{rs} = \sqrt{(X_s - X_r)^2 + (Y_s - Y_r)^2 + (Z_s - Z_r)^2} - c \cdot \delta T_r$$

ρ_{rs} - Pseudo Range between receiver and satellite

v_{rs} - Correction

c - Speed of light

δT_r - Receiver's clock error (difference between receiver clock and GPS system time)

4 unknowns: X_r Y_r Z_r $\delta T_r \rightarrow$ at least 4 observations are needed



Signal Processing

Phase observations:

Observation equation:

$$\rho_{rs} + v_{rs} = N \cdot \lambda + \frac{\lambda}{2\pi} \cdot \Delta\Phi_i = \sqrt{(X_s - X_r)^2 + (Y_s - Y_r)^2 + (Z_s - Z_r)^2} - c \cdot \delta T_r$$

λ - carrier wave length

N - ambiguities, unknown number of full wavelengths

$\Delta\Phi_i = \Phi^R - \Phi_i^S$ - measured phase difference for satellite i

$\Delta\phi_i(t_0) + \Delta\Delta\phi_i(t_0, t_1) + \Delta\Delta\phi_i(t_1, t_2) + \dots + \Delta\Delta\phi_i(t_{n-1}, t_n) = \Delta\Phi_i(t_n)$ Permanent satellite tracking and summation of phase differences.
 N is unaltered, but unknown!

2 problems:

- unknown ambiguity N for each satellite
- cycle slips at tracking (loss of ambiguities)

solution:

- long observation times
- usage of more than 4 satellites
- usage of linear combinations of L1 and L2



Equipment

Leica Viva GS15



Phase Observations

U-Blox



Code Observations



Task

One member of each group has to join the test drives with the IIGS bus on the “Cannstatter Wasen”. One member of each group has to do the data readout after testdrives.

The collected data should be processed as follows:

- Calculation of the distance between the two antennas on the bus' roof
- Comparison of the calculated distances between the antennas with the “reference baseline” and plot of the differences for each epoch
- Plot of the driven trajectories for both GNSS receivers (in geodetic coordinate system $\lambda[^\circ], \varphi[^\circ], h[m]$)
- Calculation of the velocities for both receivers and their presentation in figures
- Plot of height differences between the two receivers
- Discussion on the results under following aspects:
 - code solution
 - phase solution
 - shadowing areas



Measurement drives with the IIGS bus



Source: Google Earth

