Satellite Communication Systems 21/22

Lab Instructions Short Recap

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General Instructions

- The baseband signal should be saved as I/Q samples in a `.bin` file; the sampling rate should be kept as parameter;
- All the other outputs should be in `.txt`/`.csv` format;
- No restriction on the programming language! ;
- You will be asked to deliver the code and a short report: in the latter, you will have to report the **high level** description of your code, discuss your design choices and report figures that proving that your block works as expected.
- Consider the instructions minimum requirements: you are encouraged to propose, discuss and implement improvements!

Acronyms

CRC Cyclic Redundancy code.

PRN Pseudo Random Noise.

SV Space Vehicle.

0.1 Message Structure

Field	Length	Content
Sync Pattern	10 bits	0101100000
SV ID	6 bits	SV ID from settings
Message ID	4 bit	Message Sequential ID starting from 0
Message Body	70 bit (30 bit)	Message to be TX in ASCII 7-bit format. For the transmission from ground to satellites consider the shorter 30 bit format with ACK/NACK, followed by random bits.
CRC	24 bit	CRC, only for Message ID and Message Body. Check GAL ICD for details.
Tail	6 bit	000000

0.2 Signal Structure

Modulation	BOC(1,1)
Chip Rate	1.023 MHz (as Galileo OS E1 and GPS L1)
PRN	GAL E1 PRNs; The PRN sequence is associated to the transmitter/receiver SV ID

1 Orbital Propagator

TASK: Taking in input satellite position and velocity, receiver position, simulation duration, time granularity (orbit sampling) computes for each instant, observables (i.e., code delay, Doppler frequency, etc.), pseudoranges and free space path-loss. All the input coordinates are in an inertial frame, analogous to ECI for Earth communications.
INPUT: `settings.ini`
OUTPUT: observables, pseudoranges, free space path-loss

2 Satellite Transmitter

TASK: Compute I/Q samples of the signal to be transmitted from the SV to the ground. More in detail, you have to read a chunk of message to be transmitted and, by using the observables computed from the previous block, compute the actual signal; use a BOC(1,1) modulation; PRN from GAL E1 (4092 chips) with 1.023 MHz chip rate. Consider the symbol rate as a variable multiple of the PRN duration (e.g. in GAL E1 you have one symbol per PRN; in GPS L1 one symbol lasts for 20 ms). Model the channel as an AWGN channel with a flag, false if no noise is added).
INPUT: `settings.ini`, observables, pseudoranges, path-loss
OUTPUT: binary signal

3 User Receiver

TASK: process the I/Q samples and try to retrieve the transmitted message. In particular you are expected to process the signal (acquisition and tracking) and decode the message. Finally, verify the content using the CRC.
INPUT: `settings.ini`, binary signal
OUTPUT: message, ACK/NACK

4 User Transmitter

TASK: Compute I/Q samples of the signal to be transmitted from the ground to the satellite. Assume that the transmission can start immediately after the reception of the signal. As for the satellite transmitter you have to use a BOC(1,1) modulation; PRN from GAL E1 (4092 chips) with 1.023 MHz chip rate. As before pick the same PRN of the satellite receiver (i.e. if you have to transmit to the SV 5, use the fifth PRN of the GAL ICD). Keep the same message structure of the transmitter: the message will be filled with either 0 if the previous message was trasnmitted 0's or 1's. Model the channel as an AWGN channel with a flag, false if no noise is added).
INPUT: `settings.ini`, ACK/NACK.
OUTPUT: binary signal

5 Satellite Receiver

TASK: you have to process the I/Q samples and verify if the first messages was ACK or NACK by the ground receiver. In particular you have to, process the signal (acquisition and tracking) and decode the content of the message. Finally, verify its correctness by using the CRC.
INPUT: `settings.ini`, binary signal
OUTPUT: message, ACK/NACK

References

[1] Galileo Signal-In-Space Interface Control Document *SIS ICD*, https://www.gsc-europa.eu/sites/default/files/sites/all/files/Galileo_OS_SIS_ICD_v2.0.pdf.

[2] GPS Interface Control Document *SIS ICD*, https://www.gps.gov/technical/icwg/IS-GPS-200M.pdf.