IRNSS Receiver

Group number 17

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Abstract

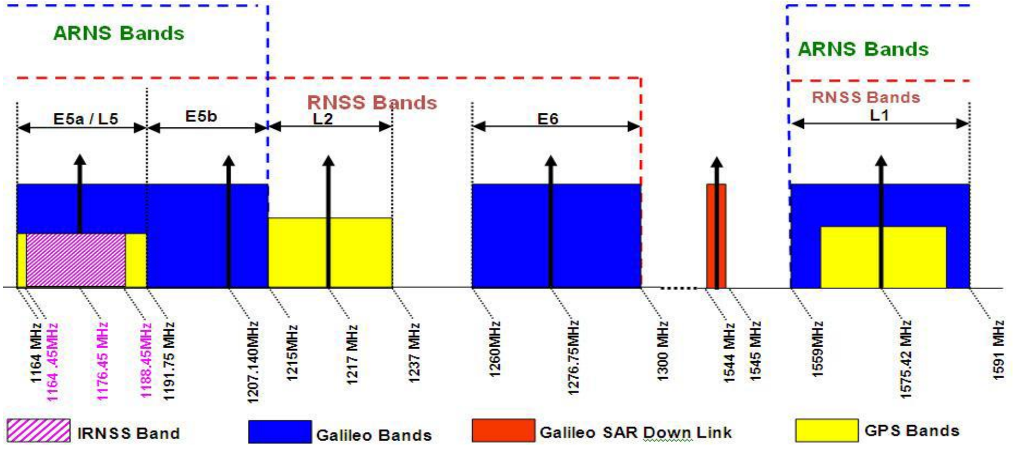
The Indian Regional Navigation Satellite System(IRNSS) project was approved by the Indian Government in May 2006 when the Indian military was denied access to the Global Positioning System(GPS) during the Kargil War. Seven satellites were subsequently launched which gave the capability of accurately determining location within India as well as in a region extending up to 1500 km from its boundary. However, receiver modules currently available in market are very expensive making them very unpopular. We aim to develop a cheaper alternative for the RF front end of the receiver circuit for the IRNSS L5 band centred at 1176.45 MHz.

Project Description:

Background and Motivation

The IRNSS, also popularly known as NAVIC(**NAV**igation with **I**ndian **C**onstellation) coined by PM Modi, provides two levels of services namely, the 'standard positioning service' open for public use and a 'restricted service'(encrypted) for the military and other authorised users. The SPS signal is modulated by a 1 MHz BPSK signal, while the Precision service uses BOC(5,2). The satellites transmit dual NAVIC signals centred on the L5(1176.45 MHz) and S band (2492.08 MHz). Unlike GPS, the Indian model isn't affected by atmospheric disturbances and assesses the difference in delay of two frequencies. Hence it is more accurate than GPS.

Last year, our seniors successfully built an S-band receiver but they didn't implement it on a single PCB. In this project, we wish to design a single PCB receiver for L5 band containing all subsystems. The L5 band is translated to the L1 band and then a GPS chip is used for further processing. The received signal power is around –154dBW in the L5 band. To efficiently extract the desired signal in the presence of –130 dBW noise is a challenge. We would need to obtain a gain of 100 dB from our front-end to get output power in the order of mW. Moreover, IRNSS L5-band faces interference from GPS and Galileo signals which needs to be dealt with appropriately.



Applications

IRNSS has both commercial and strategic applications. It caters to the needs of civil aviation and for positioning, navigation and timing. With the complete system in place, the armed forces will be able to find their position accurately in the battleground and direct ammunition and missiles deep into enemy territory. It will provide time-location coordinates on land, sea and air which will be of immense help during disaster management.

Goal and Specifications

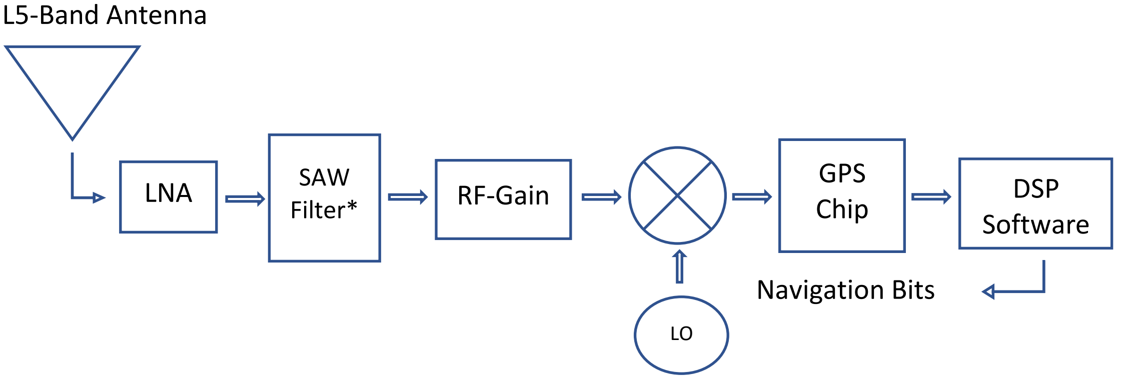
We wish to obtain the navigation bits as the final output of our receiver which will be subsequently processed digitally to obtain precise location and time.

We wish to achieve this functionality by using the small-sized and efficient GPS chip by feeding it the required signal(L5) in L1 band(on which it is designed to operate) after up-conversion.

We aim to come up with the design on a single PCB.

Technical design:

Block Diagram



*SAW filter may or may not be used based on whether high (LO > RF) or low-side injection (LO < RF) is used.

Alternative solution

One could make the complete RF chain by directly down converting to baseband, instead of making use of GPS chip where we translate the signals to L1 band. This needs to be followed by an appropriate ADC for getting the raw bits.

We aim to receive the navigation bits from L5 band using GPS chip since it is small, has low noise figure and has a high gain from mixer to ADC output stage (around 100dB).

Functional description of components

1) *Antenna* - The antenna should have centre frequency of 1176.45 MHz. For efficient transfer of received energy to the receiver, the antenna needs to have a VSWR of less than 2.3 dB and bandwidth of 24 MHz around the centre frequency of L5 band. The antenna axial ratio should not exceed 2.0 dB.

2) *LNA* – The low-noise amplifier(LNA), frequently found in radio systems, can amplify a very low-power signal (by around 20 dB) without significantly distorting the signal-to-noise-ratio(SNR). The significance of an LNA at the front-end of a RF receiver is justified by the Friis formula for noise. The LNA should be the first block placed after the antenna, due to which its high gain will reduce the noise figure of the complete chain to the following formula (higher terms will be negligible).

$$F_{receiver} = F_{LNA} + \frac{(F_{rest} - 1)}{G_{LNA}}$$

The noise figure of the system can be improved by having a large gain in the LNA.

3) *SAW filter* - To improve the selectivity and the image frequency rejection of the system a SAW front-end filter is placed between antenna and the receiver. Furthermore, the problem of receiver blocking and saturation in subsystems by powerful out-of-band interfering signals is strongly reduced.

4) *RF gain* - To meet the requirement imposed by the mixer, we may need to provide the necessary amplification.

5) *Mixer* – It is used for up converting the L5 band (1176.45 MHz) to the L1 band (1575.42 MHz) which is subsequently sent to the L1 band GPS chip.

6) *GPS Chip* - It down-converts the received signal to an Intermediate frequency, which is then sampled through an ADC and the raw bits thus obtained are sent for processing to a software through a serial interface.

Summary: The antenna receives L5 band signal, which is amplified by LNA. Then the SAW filter suppresses the out of band noises. After that, the mixer translates the signal to the L1 band. The GPS chip does the further processing. Output of GPS is sent to computer for processing, through serial interface.

Design Testing

We expect to test all the components using VNA, which shows the frequency response. The final design's output will be sent to the software for DSP. We expect to get navigation bits. We plan to make the design modular to ease testing of individual components.

Project plan

Division of work

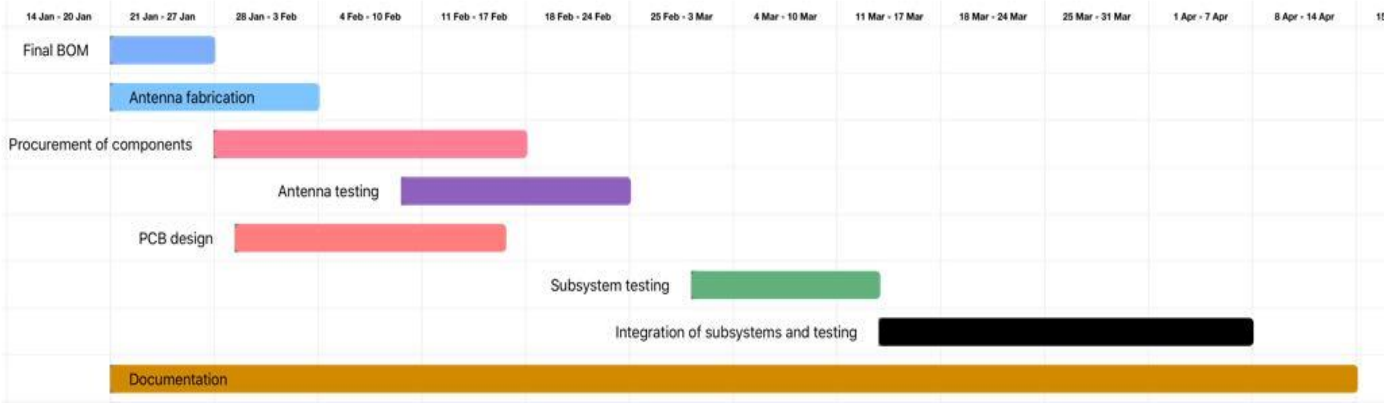
Varun : Antenna Design and testing, LNA and SAW filter selection

Aditya : PCB Design and soldering, GPS receiver selection

Theja : Power board, Mixer and PLL selection

Each member shall test his respective subsystem. The final integration and testing of final PCB will be done together.

Gantt chart



Deliverables

Evaluation 2 :

- Demo of working of individual subsystems.

Evaluation 3 :

- Demo of navigation bits reception*

*A group of seniors are currently working on the software part of the receiver. We would be able to demonstrate the reception of navigation bits provided they develop the software. We would otherwise use appropriate test signals (to be decided later) to test the front end.