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DESIGN OF RF DOWN CONVERTER FOR IRNSS USER RECEIVER

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ABSTRACT

This paper demonstrates the design of RF front end down converter for IRNSS user receiver. Here the IRNSS frequency L5 (1176.45 MHz), S1 (2492.028 MHz) and GPS (1575.42 MHz) are down converted to a common Intermediate frequency (IF) 72.221 MHz. The Down Converter proposed here is interfaced between the antenna and Base Band Card, for down converting and pre-conditioning the Radio-Frequency signal. A prototype of the design is successfully used in finding the user position with an accuracy of 0.5 meter.

KEYWORDS: Indian Regional Navigation Satellite System (IRNSS), Radio Frequency (RF), Down Converter (DC) and Intermediate Frequency (IF).

INTRODUCTION

The IRNSS is an autonomous regional satellite navigation system being developed by the Indian Space Research organization (ISRO), which would be under complete control of Indian Government. The requirement of such a navigation system is driven by the fact that access to foreign government-controlled global navigation satellite system is not guaranteed in hostile situation. The IRNSS would provide two services, first Standard Positioning Service (SPS) for all users and the restricted service for authorized user (such as military) [1].

Like any other Global Navigation Satellite System (GNSS), IRNSS will have three main systems namely

- The Space Segment
- The Control Segment
- The user segment

The user segment in case of IRNSS consists of a receiver capable of receiving signals at L5, S1 and L1 frequency, down convert them to base band and then process them to calculate the position, velocity and time solution. This is officially the 1st IRNSS user receiver being developed by Accord software and system, Banglore, India.

DESIGN OF RF DOWN CONVERTER

IRNSS User Receiver Down Converter is expected to receive and down convert the transmitted signals from IRNSS and GPS satellite. Since the incoming signal level is very low, down conversion stages have to provide sufficient gain to drive the ADC. A backend processor shall be used for further processing of IF signal and derive the navigation information as well as the precision clock. Input reference of 10 MHz signal is used to derive highly stabilized local oscillator signal. Figure 5 shows the block diagram of RF down converter.

The down converter will receive RF signal, which are IRNSS L5 (1176.45 MHz), S1 (2492.028 MHz) and L1 C\A (1575.42 MHz) frequencies from the active antenna. These signals are fed to wide band front end LNA. The LNA amplifies the combined RF signal available from the active antenna. Then the signal is split into two channels using 1:2 splitters, one for IRNSS and another for GPS. The IRNSS signal is passed to Ceramic diplexer having pass band at 1176 MHz and 2492 MHz to separate the L5 and S1 signals. It also provides the required image rejection while at the same time reducing the close-to-band spurious mixing products. Subsequently, signals are fed to RF amplifier as shown in the Figure 5. These signals are then down converted to an IF by a mixer that is integrated with synthesizer. Here the LO injected, Low-side injection [2].

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$F_{if} = F_{rf} – F_{lo}$

F_{if} - Intermediate Frequency
F_{rf}- Radio Frequency
F_{lo}-Local generated Frequency

Now the down converted signals are at an intermediate frequency 72.221 MHz. The IF frequency at 72.221 MHz is amplified, then filtered using a SAW (surface wave acoustic) filter which prevents the LO leakage and its harmonics. A VGC is used to provide a stable output to the Base band card. The output of the DC is at 72.221 MHz, 0dBm, 50 ohms, which is feed to Analog to Digital Converter (ADC) of Base band Card.

Similarly, the GPS signal is fed to 1575.42 MHz BPF to remove out of band components and also to remove image frequency. Then the signals are fed to another LNA. Subsequently, the amplified signal (L1) is down converted to an IF by the mixer that is integrated with synthesizer. Then the down converted signal is at intermediate frequency 72.221 MHz are amplified, filtered (SAW) and fed to VGC to provide a stable output to the Base band card. The output of the DC is at 72.221 MHz, 0dBm, 50 ohms, which is feed to ADC of Base band Card.

Reference for the LO generation is either from external 10 MHz source or internal source. External clock source is given high priority over internal source. The frequency plan of the DC is tabulated below

Table 1: Frequency Plan

Freq.	RF (MHz)	LO (MHz)	IF (MHz)	Reference (MHz)
L5	1176.45	1104.229	72.221	10
S1	2492.028	2419.807	72.221	10
L1	1575.42	1503.199	72.221	10

TEST RESULT

Small signal gain is given in Table 2

Table 2: Small signal gain

Freq. Band	Input power level (dBm)	Input Freq. (MHz)	Output power level (dBm)	Gain (dB)
L5	-110	1176.45	-1.35	108.65
S1	-110	2492.028	-9.24	-100.76
L1	-110	1575.75	-5.78	-104.22

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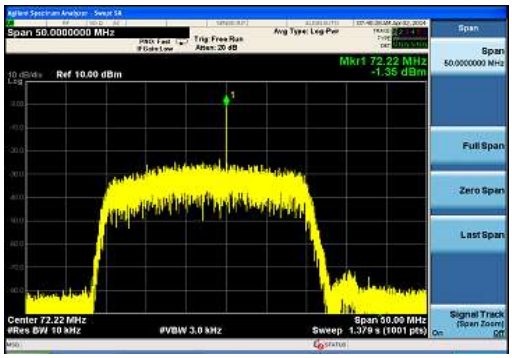

Figure 1: L5 IF

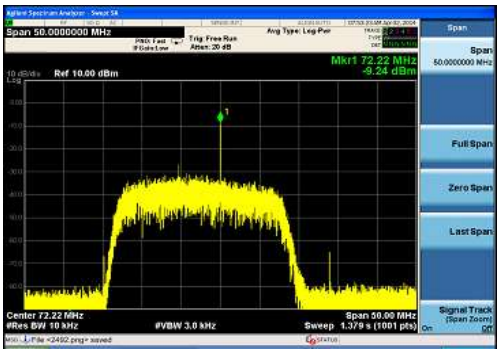

Figure 2: L1 IF

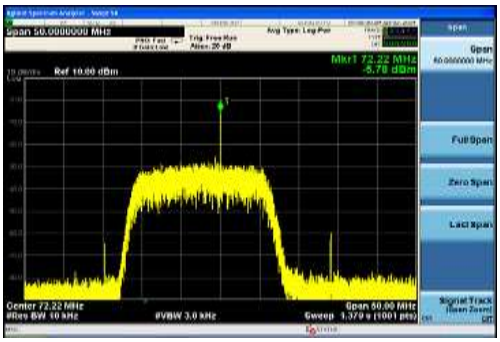

Figure 3: S1 IF

Figure 4: IRNSS User Receiver RF down converter Module

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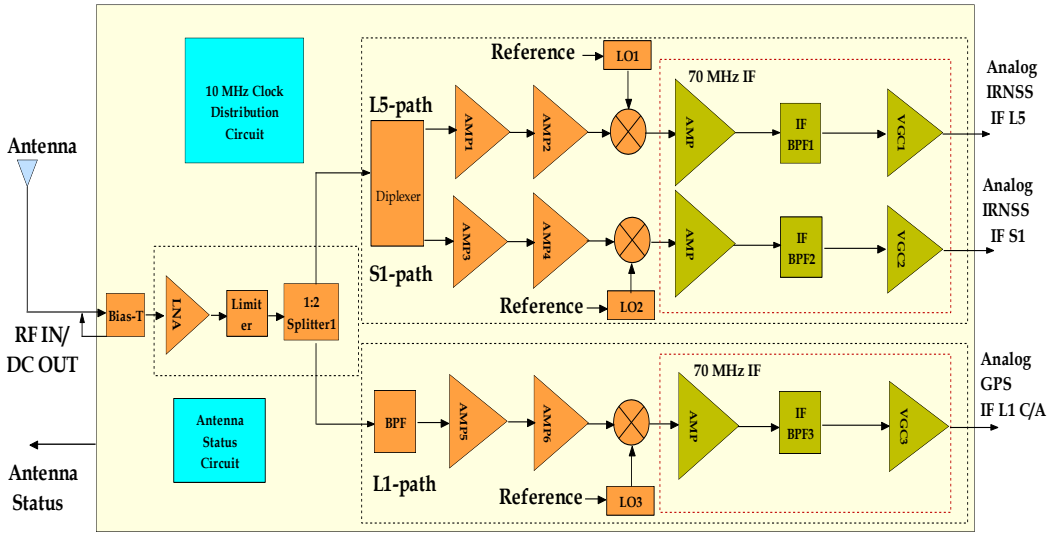

Figure 5 Block Diagram of IRNSS User Receiver RF Down Converter

CONCLUSION

A prototype of front end RF down converter for IRNSS user receiver is successfully used in finding the user position with an accuracy of 0.5 meter. The frame extraction from navigation message, decryption, pseudorange calculation, user position, and velocity and time solution is done at base band card. In the coming days the IRNSS down converter will be available as SoC.

The IRNSS is going to play a very important role in the development of the country and its defence application battlefield management, secure communication, and surveying etc.

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