Design and Development of IRNSS User Receiver Using GSM

[1]Rachan Nachappa M, [2]G Shashibhushan

[1,2]Sir MVIT Bengaluru

Abstract—This paper presents about the design and development of Indian Regional Navigation Satellite System (IRNSS),with an functional name of NAVIC is an autonomous regional positioning system which is developed by Indian Space Research Organization (ISRO) similar to Global Navigation Satellite Systems (GNSS) that provides accurate real-time positioning and timing services. The work is focused on development of miniaturized NAVIC user receiver of the previous prototype produced. Based on the requirement of Space Application Centre (SAC)-1SRO, TATA POWER SED takes initiative in developing the receiver using GSM module with small form factor and also reduced power consumption.

Keywords —Global Navigation Satellite Systems (GNSS), Indian Space Research Organization (ISRO) Space Application Centre (SAC), Indian Regional Navigation Satellite System (IRNSS), Geo-stationary orbit (GEO), Geo-synchronous orbit (GSO). Miniaturized NavIC User Receivers

I. INTRODUCTION

Indian Regional Navigation Satellite System (IRNSS) is ISRO'S proposal for building an independent and regional satellite navigation system which is based on a constellation of two satellites GEO and GSO.The two satellites are located in different orbital planes with an inclination of 29º. One of main importance of user receiver is for finding the position of the user using NAVIC satellite signals.SAC is responsible for development of user receiver using GSM module.

The technology for this is positioned based on ZYNQ FPGA device. For vast applications like vehical tracking, vessel tracking etc small form factor, low power and low cost receiver is needed. A Prototyping unit has already been developed by SAC for these kinds of receivers. The centre of attention is to develop hardware with small form factor. In accordance with different applications, hardware with different kinds is required. The inclusion of GSM/GPRS module in the hardware is mainly for GSM connectivity.

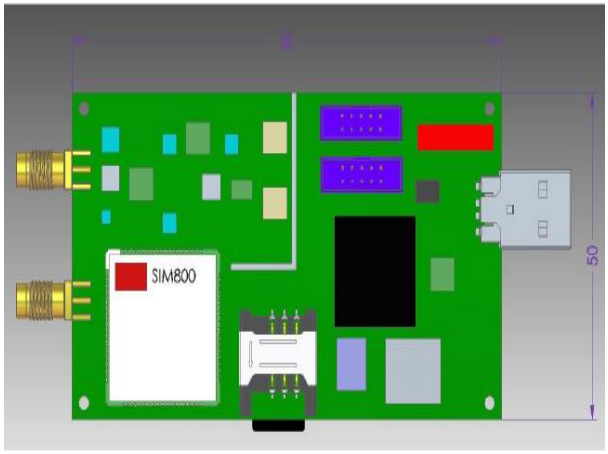

Fig.1. PCB front view of NAVIC user receiver with GSM

Functional Requirements

The User Receiver card will supports following functional Requirements

1. The receiver will be compact, low cost, low power and works on standard interface like USB.

2. The receiver has a provision to transmit text messages besides navigation messages.

3. Total hardware should operate on single DC supply of 5V and all necessary supplies to be derived on card. The card should also have an option to connect to battery.

4. JTAG interface and QSPI boot options for configuration.

5. Cards / Modules are designed for continuous operation

6. Cards / Modules will perform without any performance degradation at an altitude up to 3000 meters above mean sea level.

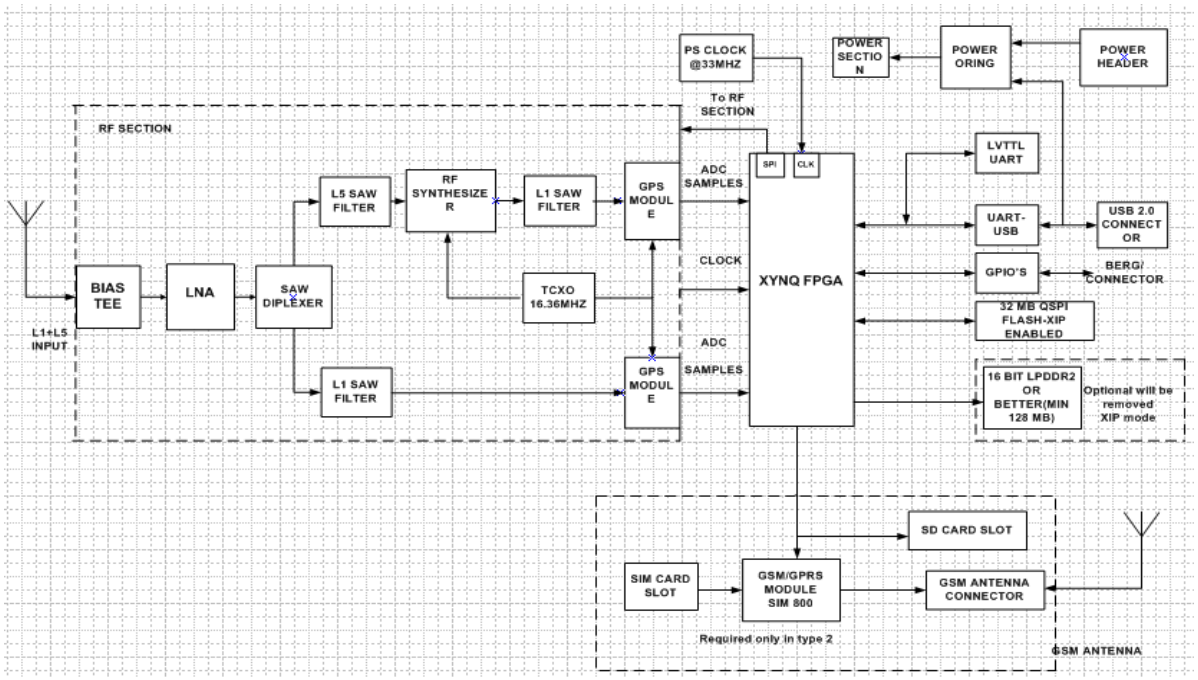

Fig.2. IRNSS user receiver with GSM

BIAS TEE: This is chosen for setting the DC bias point of the antenna without disturbing the other components. This acts as a diplexer where one port is used to set the bias and other port will pass signals but by blocking the biasing levels.

LNA: It is a low noise amplifier with high performance. It operates between +2.7 V to +3.6 V which is low power single-supply operation. It provides approximately 20dBi power gain in the frequency range of 5MHz to 4000 MHz. For L1 band the highest gain is 28.5 dBi.

SPLITTER: The splitter is designed using discrete components for separating L5 band signals from L1 band signals of IRNSS.

SAW DIPLEXER: It is used for any navigation system applications using L1, L2 & L5 GPS bands. For each band it can function as band pass filter and it can also split one path into three or it can also combine the band back. Its main function is to isolate and reject the unwanted band signals coming inside the hardware. Its package dimension is 5*5*1.7mm and it can mount easily on PCB.

SAW FILTER: The main function of Saw filter is to reject all out of band signals other than L5 band (1176.45 MHz +/- 12 MHz) and L1 band (1575.42 MHz +/- 10 MHz).

RF SYNTHESIZER: it is used as an up converter from L5 to L1 and given as input to GPS module. It is used as frequency conversion devices. It operates within the frequency range of 85MHz to 2700MHz. RF Synthesizer operates in full duplex mode. It consist of fractional-n phased locked loop (pll) synthesizer, voltage controlled oscillator (vco) and either one or two high linearity mixers. Current consumption is very low which one of the features.

TCXO: it is a crystal type of oscillator which acts like a clock. it is a SMD type so that it can be directly mounted on the target PCB. It sends the signals from GPS module and transfers to RF synthesizer. The signals can be high or low. It operates at a temperature range of -30℃ to -85℃.its operating voltage ranges from 1.8 V ~ 3.3 V.

GPS MODULE: GPS module is used as a universal RF down convertor. This module is used for 2 bit-ADC sampling of GPS signals as well as L1 up converted IRNSS signals. Through SPI interface this module shall be pre-configured by ZYNQ FPGA. This device can receive any kind of information from GPS satellite and can calculate its geographical location more accurately.

GPIO'S: It is mainly used to provide extra configuration or connectivity purposes.it is called general purpose input output

Pin is like an interface which has no predefined purpose and it can go unused by default.

LPDDR: It is called low power double data rate which is used mainly for storing the temporary memory.it has an active low chip select (CS) and clock will enable the signal CKE.

ZYNQ FPGA:

IRNSS User Receiver module is integrated with Xilinx Zynq-7000 SoC. The Baseband section consists of Xilinx's ZYNQ 7000 series .the device consists of FPGA fabrics and two Cortex A9 ARM processors. It has QSPI flash, UART to USB converter. Both RF sections are configured through FPGA over SPI lines. The 2-bit ADC samples are captured in FPGA section at16.369MHz clock from both GPS module ICs.

SIM 800: It is mainly used for transmitting of voice, SMS and data which is a GSM/GPRS module. It has low power consumption operating in the quad band 850/900/1800/1900 MHz which supports - CS-1, CS-2, CS-3 and CS-4, GPRS coding schemes and is connected to ZYNQ FPGA through RS232. some of its features include Bluetooth, FM, real time clock (RTC), and SIM card interface and embedded AT support. Jamming detection, audio recording, e-mail, MMS, echo cancellation, noise suppression, FTP/HTTP, TTS .When operating in sleep mode, the module can still receive paging message and SMS. It consumes very low current as low as 0.7 mA. The GSM antenna port is given for SIM800 and it is named as GSM_ANT. GSM is mainly used for communication between the two devices. To communicate it requires SIM CARD.

I. PROPOSED SYSTEM

In the previous published papers IRNSS user receivers are designed using L5 and S bands. But in this existing system the receiver is designed for two RF bands viz.L5 frequency and L1 frequency, L5 frequency which is NavIC Frequency and L1 frequency which is GPS frequency. A Common phase centered dual band patch antenna is connected to two RF inputs of the board which receives the signals from the satellite. A suitable bias tee is chosen which receives the input signal from the antenna at the desired frequency bands. Bias tee is used for setting the DC bias point of the antenna without disturbing the other components.Then the signals is passed via LNA which is a low noise amplifier where the signals get amplified and then passed on to a saw diplexer block which uses GPS bands L1, L2 and L5. Saw diplexer will isolate and rejects the undesirable signals that are coming in. The splitter is designed with the usage of discrete components for separation Of L5 band signals from L1 band signals of IRNSS. For GPS, L1 RF front end is available which takes L1 frequency input and gives ADC samples. It has in built down converter and amplifier to provide required gain including AGC.RF synthesizer is used as a up converter to convert from L5 to L1 and given as an input to GPS module. A TCXO and clock buffer is used to provide reference clock to all three RFICs.

III. SOFTWARE/TOOLS USED

ORCAD Tool

OrCAD is a proprietary software tool suite which is used mainly for electronic design automation (EDA). This software is mainly used in electronic based designing by electronic design engineers and electronic technicians to create electronic schematics, circuit designing and electronic prints for manufacturing printed circuit boards. The name OrCAD reflects the company and its software's origins Oregon + CAD. OrCAD was first introduced in 1985 by John Durbetaki, Ken and Keith Seymour as "OrCAD Systems Corporation" in Hillsboro, Oregon. The company became a supplier of desktop electronic design automation (EDA) software. OrCAD software tool is a suite of products for EDA, and it also includes a schematic editor (Capture), a circuit simulator (PSpice) and a PCB designer which is used for the designing purposes.

ORCAD CAPTURE

OrCAD Capture is a schematic capture application, and part of the OrCAD circuit design suite.it is mainly used as schematic design solutions for documenting and creating electrical circuits. For today's product creation OrCAD capture will provide the best environment with fast, easy circuit capture, supporting engineering process with high integrated flows. It also The powerful, tightly integrated PCB design technologies include schematic capture, librarian tools, PCB editing and routing (PCB Editor), Constraint Manager, signal integrity (included in Professional), auto routing (included in Professional), and optional mixed-signal circuit simulation. Capture can also export a hardware description of the circuit schematic to Verilog or VHDL, and net lists to circuit board designers such as OrCAD Layout, Allegro, and others. Capture includes a component information system (CIS), that links component package footprint data or simulation behavior data, with the circuit symbol in the schematic. Capture includes a TCL/TK scripting functionality that allows users to write scripts that allow customization and automation. Any task performed via the GUI may be automated by scripts.

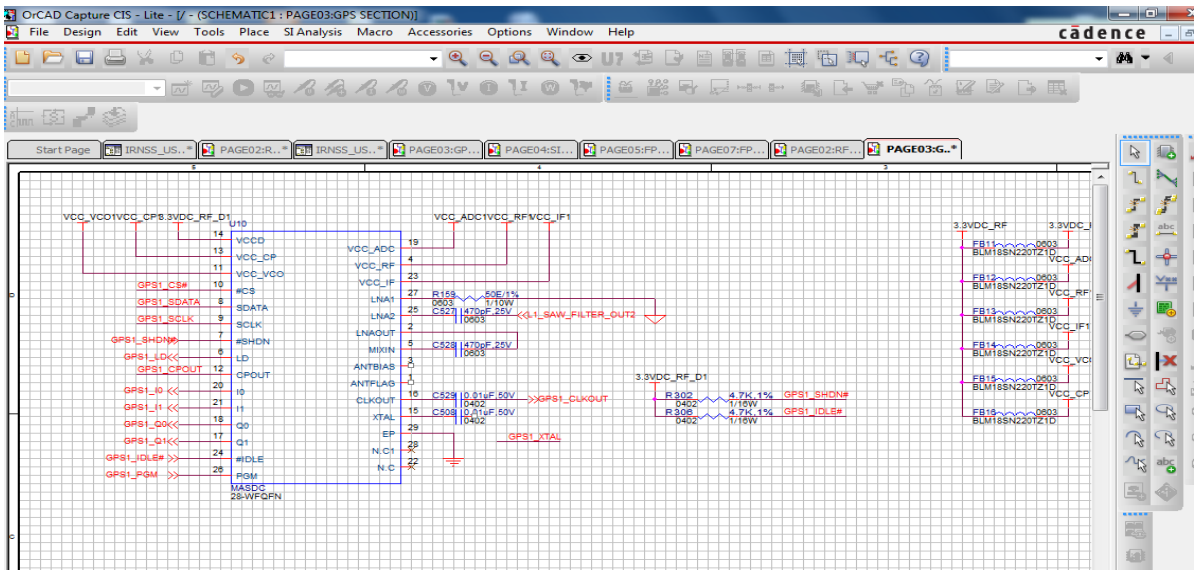

Fig.3. schematic showing orcad

VISIO SOFTWARE

Microsoft visio is a diagramming and vector graphics application and is part of the Microsoft Office family. A few new features have been added such as one-step connectivity with Excel data, information rights management (IRM) protection for Visio files, modernized shapes for office layout, detailed shapes for site plans, updated shapes for floor plans, modern shapes for home plans, IEEE compliant shapes for electrical diagrams, new range of starter diagrams, and new themes for the Visio interface. Communicate complex information simply. With Visio Standard 2016 and Visio Professional 2016, you can streamline your data and ideas, and create custom diagrams that make your vision easy to share, and easy for others to understand. Whether you're a department manager, a project manager, an IT expert or developing processes and protocols, Microsoft Visio can help you organize your thoughts, your data, your findings and designs – and communicate your vision at a glance. By using Microsoft Visio 2013 Viewer, Visio users can freely distribute Visio drawings to team members, partners, customers, or others, even if the recipients do not have Visio installed on their computers. For creating 3D map diagrams Visio software can be used. It works well for simple maps that you might print on a brochure or campus directory.

IV. PARAMETERS USED

Parameter plays a very important role in designing the receiver hardware circuit. The following parameters are considered in the design of IRNSS user receiver.

NO OF CHANNELS	19 channels
RF INPUT SIGNALS	L5: 1176.45+-12MHz L1: 1575.42+-10MHz
TCXO	16.369MHz or based on RF Parts
FPGA	Xilinx ZYNQ 7000 series
MEMORY	Minimum128MB,16bit LPDDR2 or better Compatible with ZYNQ processor and 32MB QSPI Flash
CLOCK	33.33 MHz for Processor section
GSM MODULE	Sim800 or equivalent
POWER SUPPLY	5 V from USB port / Power Header
OPERATING TEMP	0 to 50oC
UART	2 Pin LVTTL to interface directly at LVTTL level

Table.1. Parameters used

V. RESULT

User Receivers of NavIC positioning services with small form factor and reduced power consumption using GSM module is developed and the information received from satellite is seen in the computer which can be driven from USB.

VI. CONCLUSION

A new hardware platform is developed for IRNSS User Receiver with GSM and the receiver is designed for two

RF bands.L5 frequency, which is NavIC frequency and L1 frequency which is GPS frequency. GSM/GPRS module is included for transmission of voice, SMS and data with low

power consumption and also for GPRS connectivity for tracking the location of the vehicle and for finding user position using NavIC satellites signals.

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