L2C GPS Signal Simulator

A. Sindhura [1,]
1. PG Scholar, Department of ECE,
Madanapalle Institute of technology and Science,
A.P, India

C. K. Hemanthalakshmi[2]
2. Assistant professor, Department of ECE,
Madanapalle Institute of Technology and Science,
A.P, India

N. Hemanth Kumar Reddy [3]
3. Head, Navigation section,
Communication Systems Group,
ISRO Satellite Centre,
Bangalore, India

Gaurangishay [4]
4. Navigation Section, Communication Systems Group,
ISRO Satellite Centre,
Bangalore, India

***Abstract:-* In our modern life the function of perfect and accurate time giving out is ordered to Global Positioning System (GPS) satellite navigation. GPS be designed to give coordinate location and time synchronization everywhere on the globe. In late worldwide situating framework signs L2C have another formative prospect; despite the fact that GPS was initially considered for utilization by the military in their missions, it has turned into a fundamental utility for various common and business applications. The vital target of modernizing GPS indicator is to create the general execution of the framework, as far as enhancing the precision giving better insusceptibility to RF interface and multipath and better air redresses. These are carried out by giving extra coded common indicators on numerous transporter frequencies, advanced regular citizen sign Examples-L2C, L5 and so forth.**

This project discusses the generation of L2C GPS signals using Xilinx FPGA. The L2C signal is the first fully accessible signal to join the legacy L1 C/A signal to serve dual frequency civil users. We have considered L2 frequency. Band as it is mainly used for commercial, civilisation and other purpose. Due to its imminent availability and modern code design L2C signals are having the better tracking and message threshold than L1C. more flexible RF/IF filter and signal processing options and lower chip rate than L5. Once L2C GPs signals are generated we can test the proper working of multichannel GPS receiverL2C is likely to be a widely used GPS signal. The board that has been used for the hardware implementation is virtex-5 FX130T (DAC board).RF layer having a transmission and receiving of 1227MHz. This will lead to the development of indigenous digital L2C GPS signal simulator using reconfigurations. Development of indigenous digital L2C GPS signal simulator using reconfigurations.

Key words: L2C data, GPS Signal, frame work.

INTRODUCTION:

GPS stands for Global Positioning System and it was started in the year 1973 by the US department of defense. It was made commercial for civil aviation in the early 1990's. GPS is a satellite based navigation system, which is used to find the position of an object across the earth by giving its coordinates. Currently GPS consists of 32 satellites of which 24 are for working and the rest eight are kept spare to replace any of these 24 satellites in case of malfunction or damage to them[1]. These 24 satellites revolve around the earth surface in six predetermined orbits each orbit having four satellites. The satellites are not placed equidistant in a given orbit. Each orbit makes an angle of 60° with the equator of the earth so as to complete total 360°. The orbital radius is 26560 km and time taken for one complete revolution is 11 hrs 57 mins and 57.26 secs .In this paper, GPS signals simulator using Xilinx fpga DAC board has been dealt. First the GPS signal has been explained followed by each and every module of GPS signal. Then each component has been built using Xilinx fpga and tested and finally complete GPS signal generator has been built and tested on hardware using Xilinx fpga fx130t DAC board.

GPS signs are grouped into two sorts:

They are

1. Course/obtaining (C/A) code
2. accuracy (P) code.

The true P code is scrambled by a Y code, so it is called as the P(y) code. At present, the C/A code is utilized for non military personnel applications while the P(y) code is held for military utilization. The GPS indicators are transmitted on two separate frequencies: L1 (1575.42 Mhz) and L2 (1227.6 Mhz). These frequencies are lucid with a 10.23 Mhz clock related as takes after

New Signal Availability:

The number of GPS navigation signals can be dramatically changed by development of L2C signal.

L2C SIGNAL :

Two ranging codes are composed to form a L2C signal, one is L2 CM code and another one is L2 CL code[1]. The range of L2 CM code has a 10230 chips and time period is 20milliseconds and the range of L2 CL code has 767250 chips and time period is 1.5seconds.data is added to CM code with modulo-2 operation and the result of this modulo-2 operation is combined with CL code on a chip-by-chip basis by time-multiplexed operation. The being CM and CL codes are clocked at 511.5 kHz though the combined L2C code have a frequency of 1.023 MHz Code limits of CM and CL are adjusted and every CL period contains precisely 75 CM periods. This time multiplexed L2c arrangement regulates the L2 (1227.6 MHz) convolution encoder is utilized to transmit the information at 50 images for every second (the same image rate concerning L1 C/A code). Subsequently, every information image matches the CM time of 20 milliseconds. Figure 1 represents the L2c code structure over a CL code period. Not at all like other new GPS indicators, for example, is L5, L2c constrained to a solitary bi-stage indicator segment as opposed to two signs in quadrature as it must impart the L2 recurrence to the new military M-code and the legacy P (y) code. Rier (IS GPS 200 D, 2006). The first L2 CNAV information rate is 25 bits for every second except a half rate. Figure 2 outlines the CM code is joined together with CNAV information utilizing modulo-2 operation after that information is consolidated with CL code the resultant information is indicated.

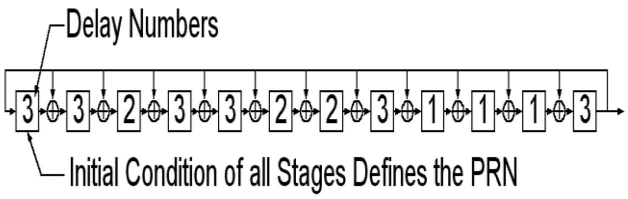

Figure.1.L2C code phase shift

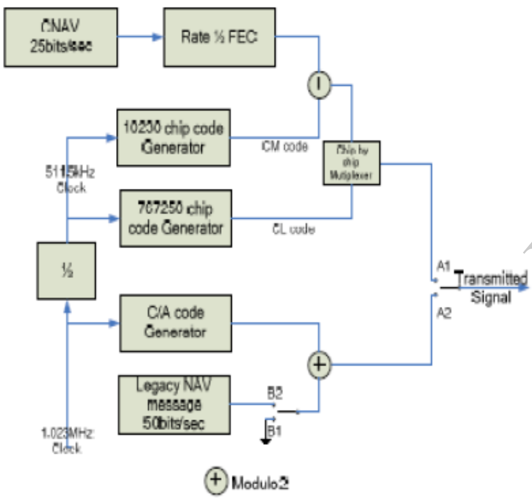

Figure.2. L2C code generation.

L2C NAVIGATION DATA (CNAV):

The L2C Navigation data stream contains the same data as normal GPS.Control segment allowed by the CNAV to signify the sequence and timing of each message component [2]. The components are 300 bit sub frames, each with a message type designator The CNAV data rate is 25bps, and symbol rate is 50sps with 1/2 rate Forward Error Correction (FEC) encoding. The CNAV and CM codes are added with modulo-2 operation.
The five sub frames or message types can be defined as

• Sub frame 1 or message type 1 contains an Ephemeris message data part 1
• Sub frame 2 or message type 2 contains an Ephemeris message part 2
• Sub frame 3 or message type 3 contains an Ionosphere, time biases, health bits, etc.
• Sub frame 4 or message type 4 contains an Almanac data of satellites.
• Sub frame 5 or message type 5 contains an Free form text message.

L2C GPS SIGNAL SIMULATOR

GPS reproduction gives a compelling and effective method for testing GPS recipients and the frameworks that depend on them by creating the same signs transmitted by GPS satellites, consequently GPS beneficiaries prepare the recreated indicators in precisely the same path as indicators from real satellites. A GPS test system gives control over the signs created over the worldwide the earth, with the goal that testing could be directed in controlled research facility conditions A GPS test system gives a better option than testing contrasted with utilizing real GPS motions as a part of a nature's turf. Dissimilar to live testing, testing with test systems gives full control of the mimicked satellite indicators and the recreated ecological conditions. With a GPS test system, clients can without much of a stretch create and run numerous distinctive situations for different sorts of tests, with complete control over:
Vehicle movement
Ecological conditions
Sign slips and errors

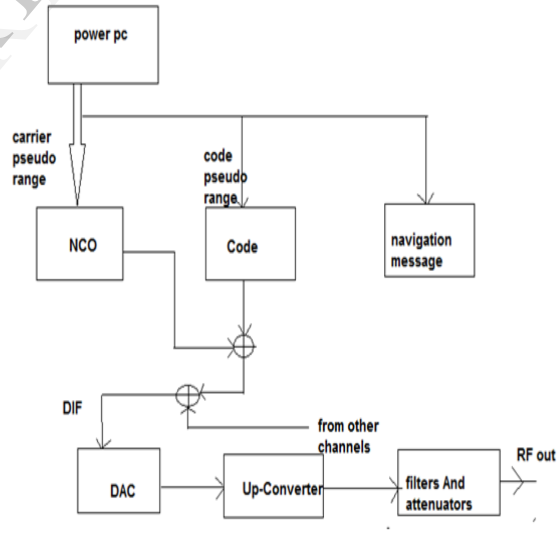

Figure.3. GPS Simulator

A signal is completely generated on an intermediate frequency(IF) in the digital part(FPGA) and then it is converted to analog signal and up-converted to an RF[3]. The carrier is generated by a numerically controlled oscillator. Together with a code and navigation message, it creates a digitized intermediate frequency signal(DIF).It is summed with DIF signals from other channels and then goes through digital to analog converter(DAC) and become an intermediate frequency signal with its further path no different from an analog simulator Satellite transmitters for future and modernized current GNSS may move to digital signal generation as well ,because it allows more flexibility. Also the transmitter in the case of digital design can easily be reprogrammed on the fly to provide a different signal structure. Other advantages of a digital simulator are high quality, low aging and high predictability. They also provide an easy high frequency resolution.

DIF SIGNAL GENERATOR:

A single channel simulator should be able to provide

1. Control over signal power with a required range
2. Control of the Doppler shift.
3. An enable navigation message.

RF SIGNAL GENERATOR:

1. Digital to analog converter.
2. Up converter.

FPGA kit:

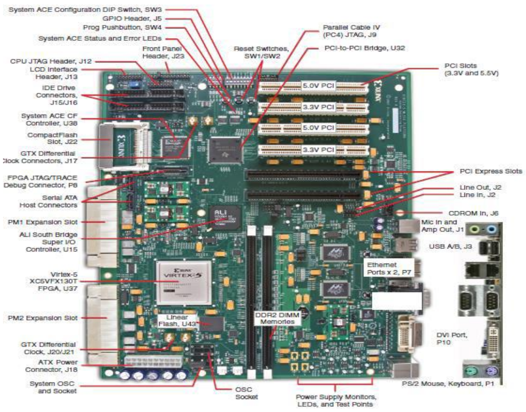

Figura.4.ML510 DAC board

We used the ML510 development board to implement and verify our design. The main reason for selection of ML510 development platform was the accessibility of a rich set of features with good software support, high reliability and availability of Virtex-5 series FPGAs with space grade quality as well.

ML510 DEVELOPMENT PLATFORM :

The ML510 board offers designers a versatile Virtex-5 FX platform for rapid prototyping and system verification[7]. In addition to the more than 30,000 logic cells, over 2,400 kb of block RAM, dual IBM PowerPC 505 (PPC405) processors, and Rocket IO transceivers available in the FPGA, the ML510 provides an onboard Ethernet MAC PHY, DDR memory, multiple PCI bus slots, and standard front panel interface ports within an ATX form factor motherboard. An integrated System ACE Compact Flash (CF) controller is deployed to perform board bring-up and to load applications from the Compact Flash card. A block diagram of the Virtex-5 board platform is as given below, followed by a snap of the actual board. Next, the architectural description of the virtex-5 family is described.

The next section gives the information of the software tools we used.

L2 UP-CONVERTER :

Since L1 and L2C signals have similar power levels, same code chipping rate and thus the same spectral width, an L2C front-end can be almost identical to the L1 front-end except that it needs to work with a different carrier frequency thus requiring a modification to the filters and mixers of the L1 front-end. However, another approach for designing the L2C RF front-end is to shift the L2-band to the L1 frequency and then process the L2C signals with a L1 front-end[9]. The approach taken for this spectrum translation is to filter the L2-band, up-convert it to the L1 frequency and then feed it to an L1 RF front-end, such as suggested in Ledvina, et al. (2005). The up-conversion is accomplished by mixing the L2 signal with a signal whose frequency equals the difference between L1 and L2 frequencies i.e. 347.82 MHz Followed by the Mini Circuits matching transformer (TCM4-6T) to provide the appropriate power level for the mixing signal and Mini-Circuits MCA1-24 double balanced mixer for spectrum translation. On the other side of the up-converter, the L2 signal is filtered by a 20 MHz wide L2.

L2C ADVANTAGES

The civilian GPS signals have a more advantages. L1 has the lowest ionospheric refraction error, L5 has the highest power and also is in an Aeronautical Radio Navigation Service (ARNS) band, and L2C has the best cross correlation performance. The slower (compared to any other GPS signal) clock rates of individual CM and CL codes will reduce the power consumption without affecting the code measurement accuracy if carrier-to-code loop aiding and advance gated multipath mitigation techniques are considered. While the L2C power devoted to the data channel is half the total, its data recovery threshold performance is 5 dB better than C/A. This is because the Forward Error Correction (FEC) applied to navigation data offers 5dB gain in the data recovery thresholds and cutting the data rate in half, i.e. from 50 Hz (bits per second) in L1 C/A to 25 Hz in the L2C signal improves data recovery threshold another 3 dB. Hence even after the initial 3 dB loss due to power split between the data and pilot channel, the data recovery threshold is 5 dB better. Also, the longer L2C codes are expected to offer better cross-correlation performance than the 1 millisecond long C/A code. Other key signal parameters of L1 and L2C are compared in Table.1, indicating that after a long history with only the L1 C/A civil signal, L2C is an entirely different signal and must be dealt with care. At this point, it is worth mentioning that most of the L2C advantages only manifest themselves once the signal is acquired. The L2C acquisition, however, will suffer the effects of having longer codes, having a time multiplexed signal structure and being 1.5 dB weaker than the L1 signal[5][6].

Signal	L1	L2C	
Min.received power(dBw)	-158.5	-160	
Ranging code	C/A	CM	CL
Chipping rate(MHz)	1.023	0.5115	0.5115
Code period(Chips)	1023	10230	767250
Code period(ms)	1	20	1500
Navigation data rate (Hz)	50	25	-
FEC	NO	Yes	No

Table.1

Summary of advantages are getting better navigation accuracy, provided that an easy to track signal, Provided that improved immunity to RF interface and multipath and improved atmospheric correction. Using vertex5 fx130t (DAC) board because in that FPGA is having embedded processor power pc. since FPGA is having embedded processor, no need to use separate processor on board, it makes complete design compact, more flexible and cost effective.

IMPLIMENTATION RESULTS:

The algorithm is implemented in Xilinx Virtex-5 FX130T FPGA in ML510 development board. This FPGA is the commercial equivalent of the space qualified. Figure 5 specifies the snap shot of chip scope output of the L2C simulator.

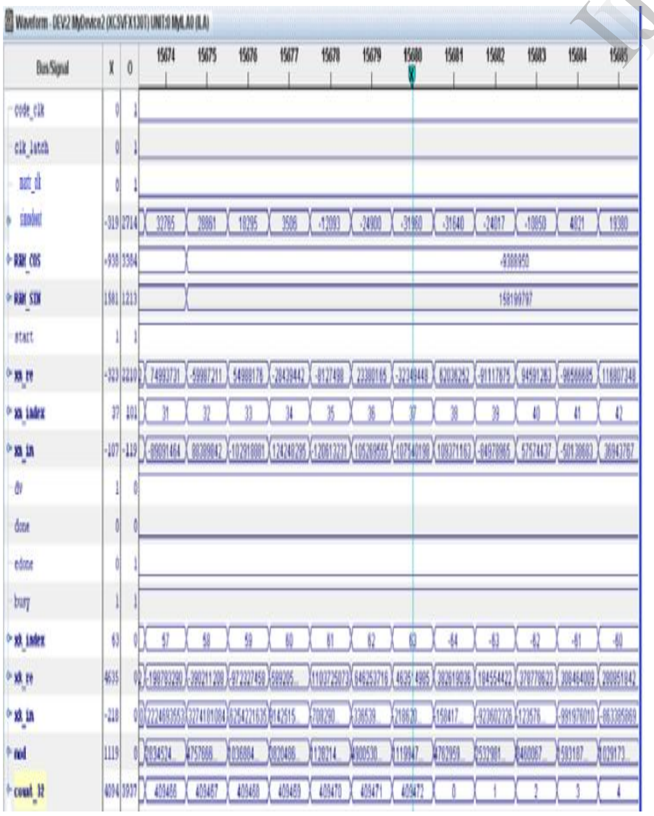

Figure.5. Chip scope output

CONCLUSION

This paper discusses the generation of L2C GPS signals using Xilinx FPGA. The modernized GPS signals, especially the L2Csignal, will have wider civilian market. Although the new modernization of GPS has been declared, the most GPS receivers do not have ability of the receiving new signals. The research and implementation of the modernized GPS signals have an extensive applications prospect, which can provide a strong support for the engineering application. The L2C signal is the first fully accessible signal to join the legacy L1 C/A signal to serve dual frequency civil users. We have considered L2 frequency band as it is mainly used for commercial, civilisation and other purpose. Due to its imminent availability and modern code design L2C is likely to be a widely used GPS signal. L2c signals are having the better tracking and message threshold than L1C, more flexible RF/IF filter and signal processing options and lower chip rate than L5. Once L2C GPs signals are generated we can test the proper working of multichannel GPS receiver. The board that has been used for the hardware implementation is virtex-5 FX130T (DAC board).RF layer having a transmission and receiving of 1227MHz. This will lead to the development of indigenous digital L2C GPS signal simulator using reconfigurations. The Results will shown on the hard ware is effective and reliable and it is simple and intuitional which can provide a strong support for the engineering civil and commercial applications.

REFERENCES

1. "The Modernized L2 Civil Signal", *GPS World*, September 2001
2. EGNOS is the European Geostationary Navigation Overlay Service, similar to WAAS in the U.S. (http://www.esa.int/EGNOS/)
3. MSAS is the MTSAT Satellite-based Augmentation System, similar to WAAS in the U.S.(http://www.mlit.go.jp/koku/ats/e/serv/next/01.html)
4. LAAS is the Local Area Augmentation System being designed to support high precision landings and airport surface navigation. (http://gps.faa.gov/Programs/LAAS/laas.htm)
5. NDGPS is the Nationwide DGPS extension of the Coast Guard Beacon DGPS service throughout the U.S. (http://www.navcen.uscg.gov/dgps/ndgps/).
6 "Low-CostCycloneFPGAs",2009a,Available: http://www.altera.com/products/devices/cyclone/cyc-index.jsp)
7. "Stratix FPGA: Low Power, High Performance", 2009b, Available: (http://www.altera.com/products/devices/stratix-fpgas/stratix/stratix/stx-index.jsp)
8 ."Quartus II Subscription Edition Software", 2009c, Available: (http://www.altera.com/products/software/quartus-ii/subscription-edition/qts-se-index.html)
9. Analog-Devices, "The ADF4360-8: An integrated integer-N synthesizer and voltage controlled oscillator (VCO)", 2009, Available: (http://www.analog.com/en/rfif-components/pll-synthesizersvcos/adf4360-8/products/product.html)
10. Stansell.T,―L2CSTechnicalDescription‖,2001,availableat http://www.navcen.uscg.gov.gps/modernization/industryday.html.
11. Scharf L. L. and B. Friedlander, "Matched subspace detectors", *IEEE Transactions on Signal Processing*, vol. 42(8), 1994, pp. 2146 – 2157.
12. Virtex-5 documentation pdf available at www.xilinx.com.