IJRSET February 2016 Volume 3, Issue 2 Pages: 10-20
ISSN 2394-739X
International Journal for Research in Science Engineering and Technology

DESIGNS AND CHALLENGES IN GPS RECIEVERS

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Abstract

The inspiration for this work is the development of the non-ongoing GPS beneficiary. It gives a brief measure of foundation data concerning the GPS signal and the navigational message structure. The equipment stage used in this work is investigated to represent its different capacities and assets. To comprehend the usage of securing and following on the WARP, the hypothesis and calculations behind these procedures are displayed. Using the calculations, the FPGA collector usage is spoken to in GPS. The different plans and difficulties are investigated to give an unmistakable comprehension of the multifaceted nature included with acquiring the GPS navigational message progressively. At last, the aftereffects of the collector are given suggestions for development of its capacities and future works.

Keywords: - [GLOBAL POSITIONING SYSTEM FPGA, RECEIVERS]

1. INTRODUCTION

The Global Positioning System (GPS) is intended to permit clients to decide their area in three measurements. The framework comprises of 32 unique satellites, each of which circles the Earth roughly once at regular intervals. The circles of the satellites have been set such that 6 satellites are in perspective at any given position on Earth. There are a few distinctive GPS transporters and information streams, however the main bearer and information stream used in this work is the non military personnel access sign, or C/A code. The non military personnel access signal or Coarse Acquisition (C/A) code is telecast on the L1 transporter at 1.57542 GHz. Every Broadcast message contains the satellite's orbital parameters (ephemerides), an Atmospheric remedy model, and an arrangement of coarse satellite situating parameters (almanac).The telecast message is comprised of the navigational bits. These navigational bits have an information rate of 50 Hz. The bits are adjusted onto the L1 bearer utilizing twofold stage shift Keying (BPSK) [4]. Since every Satellite is transmitting at the same recurrence and in the meantime, a code-division numerous entrance (CDMA) plan has been used to permit every satellite's message to be isolated from each other. In this CDMA plan, every satellite is given a particular double pseudorandom code. This pseudorandom code, or PRN code, is 1023 chips long. The code length is measured in chips rather than bits as every chip independently conveys no data. It is the whole code that really gives each navigational piece. For the situation that the navigational piece to be transmitted is a +1, the chip grouping is transmitted. For the situation that the navigational piece to be transmitted is a - 1, the one's supplement of

the chip succession is transmitted. No different examples are allowed. Every chip is transmitted at a rate of 1.023 MHz, thusly the code rehashes itself once every millisecond. The PRN code is increased with the BPSK tweaked transporter to create an immediate succession spread range (DSSS) signal. It is this last DSSS signal which is transmitted by the satellite and got on Earth.

GPS MESSAGE CHARACTERISTICS

A GPS recipient is intended to uproot the segments of the GPS sign to acquire the first navigational bits for every satellite. Once the navigational bits have been acquired from no less than 4 satellites, the recipient's position can be processed. While precise determination of client area is affirmation that the navigational message has been accurately acquired, computation of position directions is not required for such affirmation. At the point when just a solitary satellite is being followed, the structure of the navigational message can be used to confirm fruitful gathering. The navigational message is comprised of 5 sub outlines, each of which comprises of 10 words and every word comprises of 30 bits. Toward the start of every sub outline, a telemetry word (TLM) is transmitted. The start of each TLM is a 8-bit prelude, 1000 1011. It ought to be noticed that a following channel could bolt on to a 180 o stage moved duplicate of the navigational bits. On the off chance that this happens, the introduction would seem modified, as 0111 0100. Given the information rate of the navigational bits, this preface will happen once like clockwork. By analyzing the got navigational bits for this prelude, fruitful gathering of the navigational message can be guaranteed. Each word likewise contains a 6-bit equality. This is utilized to check for confused bits and serves as an auxiliary check to guarantee fruitful message gathering [4]. The remaining words in the navigational message change with every sub outline. In the event that a beneficiary is going to register position, this data is basic . Notwithstanding, just the TLM and HOW words are vital for a check of effective route message . The 6-bit equality present toward the end of the words gathering [is used to check for bit blunders in the got information. The equality mathematical statements, appeared in (2.1) through (2.6), are acquired from the GPS-SPS Specification .

2. RECIEVER ARCHITECTURE

The main component in a GPS collector is the RF front end, further point by point in segment . This comprises of the vital equipment to get and condition the GPS signal for digitization. It is generally made of a radio wire, enhancers, channels and a blender. Once the GPS sign is molded legitimately for digitization, a simple to-advanced converter, or ADC, tests the sign and gives computerized tests to encourage baseband advanced sign preparing. The baseband signal preparing components of a GPS beneficiary are the evacuation of both the C/A code (dispreading) and the bearer recurrence (down transformation) to extricate the information message. After acquiring the information message, the discovery of the introduction is performed and the start of the sub edge is gotten. The required baseband signal preparing is isolated into 3 separate, consecutive capacities: procurement, following, and navigational message interpreting. Obtaining, is the procedure by which the collector figures out which satellites are in perspective. It includes the down change of the digitized GPS sign to baseband and distinguishing proof of the obtained C/A code to figure out which satellite transmitted the sign. To down proselyte the sign, the transporter recurrence must be known. Because of the Doppler Effect bringing about a recurrence counterbalance on the L1 bearer, the genuine recurrence of the got transporter must be assessed. Realizing that the beneficiary is stationary and the Doppler

movement must be between ±5 KHz, a hunt can be performed over all conceivable transporter frequencies. Distinguishing proof of the C/A code includes examination of the gained C/A code to every one of the 32 conceivable C/A codes to recognize the satellite from which the sign began. Every satellite is persistently transmitting its particular code yet the start of the code is obscure. In this manner, the start of a square of information in the recipient does not as a matter of course relate to the start of the code. In this manner, the distinction in time between the start of the code and the information obstruct at the collector must be evaluated. This operation is finished using a cross connection between's the Received information piece and the first code. Since every code has a most extreme relationship just for zero slack, the code period of the recipient sign can be resolved. Consequently, in securing, both the C/A code stage and the bearer recurrence are assessed. Once both the bearer recurrence and code stage have been assessed, the qualities can be gone to following. Since satellites are in constant movement, the separation between any given satellite and the collector is alert. Besides, the bearer recurrence of the got sign is additionally always showing signs of change because of Doppler movements. In this way, once obtained, a satellite must be followed after some time to keep up synchronization with the privately created bearer and code imitations [4]. The following procedure is further depicted in area 6. Both the C/A code time arrangement and the bearer recurrence must be followed. To track the time arrangement of the C/A code, three neighborhood reproductions are produced for every C/A code. The variant that precisely coordinates the arrangement of the approaching C/A code is alluded to as brief. A somewhat propelled rendition, known as right on time, and a marginally postponed adaptation, known as late are additionally produced [4]. Relationship of the approaching sign with these three adaptations advises the collector if the code should be balanced, by how much, and in which course. This is expert in a postponement bolted circle (DLL), which processes the misalignment in time between the nearby duplicates of the code and creates a mistake sign to remedy the era of the neighborhood duplicates of the code. To track the transporter recurrence of the procured signal, stage bolted circles (PLL) or recurrence bolted circles (FLL) are frequently utilized [4]. In a PLL, the stage blunder between the neighborhood duplicate of the bearer and the got sign is utilized to make a mistake signal. On account of a FLL, the recurrence blunder between the nearby duplicate of the transporter and got sign is utilized as a part of the production of a mistake signal. In both cases, the mistake sign is then used to adjust the transporter generator, creating a more precise neighborhood duplicate of the bearer. Both PLLs and FLLs regularly utilize a Costas circle engineering, as it is the most widely recognized technique to track BPSK waveforms in GPS . In the Costas circle design, two duplicates of the transporter are created. The main duplicate created has the same stage as the got transporter, called the in-stage duplicate. The second duplicate created has a +90 stage movement to the in-stage bearer and is alluded to as the quad rature duplicate. In a following channel, input circles are utilized to create exact neighborhood duplicates of both the code and transporter for their expulsion from the approaching information. Once these two components have been expelled from the approaching information, the yield from following channel, the navigational bits, can be gotten. The last handling venture for this GPS recipient is affirmation that the navigational message has been effectively acquired, as point by point in segment 8. This is finished via hunting down the introduction of the TLM word and performing an equality check of the TLM

and HOW words. A relationship between's the navigational bits and the introduction delivers a greatest esteem every time the prelude happens in the got bits. The time between every event of the preface can then be measured. In the event that the preface happens at regular intervals, then effective gathering of the navigational message is confirmed. To facilitate guarantee that the message has been gotten effectively, without bit mistakes, an equality mind both the TLM and HOW words is performed. Both words contain a 6-bit equality which can be utilized to guarantee no bit blunders are available.

3. ANTENNA/LNA

The interface between the radio wire and the WARP board is known as the RF front end. The recurrence of the GPS L1 Carrier is 1.57542GHz, out of reach for the simple board. Extra equipment is required to interface the simple board with the GPS L1 signal. Because of the wide assortment of RF front closures which are practical for getting GPS flags, the radio wire, enhancer and channel depicted in Thompson et al. will be viewed as a beginning stage for the interfacing of the GPS sign to the WARP [1]. The reception apparatus used was a GPSRSSMA recieving wire. This dynamic reception apparatus gave roughly 28 dB of addition. A 58529A band pass channel from Symmetri com gave another 20 dB of increase before the down converter. A fundamental square outline of the recipient can be seen , a more definite depiction of the reception apparatus and the bandpass channel is accessible in Thompson et al. [1].

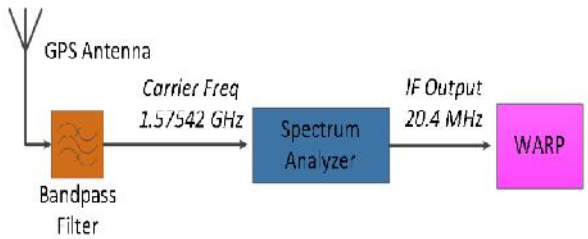


Figure 1. Receiver front-end block diagram

4. DOWNCONVERTER

The interface between the RF front end and the simple board is a down converter which blends the L1 bearer at or close baseband for A/D change. Once the sign has been down changed over, it should be gone through an intensifier to scale the sign properly for digitization. An exquisite answer for the prerequisite of a down converter and addition speaker is the utilization of a range analyzer. By setting the range analyzer's range to 0 Hz, its inside recurrence to L1, and arranging the increase appropriately, it will deliver a down changed over sign at its moderate recurrence (IF) yield. In this recipient, a Rohde and Schwarz FSG Spectrum Analyzer was utilized to deliver a Down changed over sign from the RF front end at 20.4 MHz.

4.1 Clock Rate Selection

Making a specimen rate of 6.25 MHz is conceivable by first oversampling the ADC at a higher clock recurrence and after that performing downsampling on the subsequent information. The coveted clock rate of 6.25 MHz is difficult to deliver with the FPGA. Following the reference clock gave to the FPGA is 40 MHz, the advanced check modules in the FPGA would be not able blend this low recurrence [20]. Notwithstanding, if the ADC clock is been 37.5 MHz, this recurrence is much closer to the reference and can be orchestrated with the FPGA's computerized clock modules [20]. Along these lines, the ADC clock was set to keep running at 37.5 MHz and the subsequent information is then crushed by a component of 6 to deliver the fancied specimen rate. This procedure is outlined by Fig. 4.4.

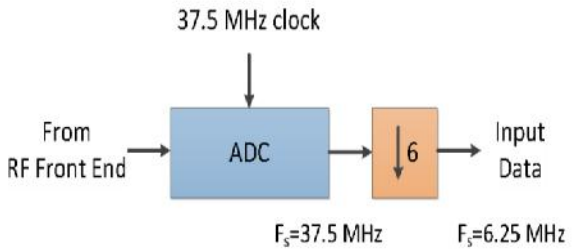


Figure 2. ADC sample rate block diagram

The clock rate decided for the FPGA's frameworks, primarily, the PLB transport clock, was chosen to be as quick as could reasonably be expected while as yet keeping up fruitful timing conclusion. Amid production of the FPGA picture, the Xilinx ISE devices must perform a timing investigation of the FPGA outline. In the event that the clock rate of a FPGA outline surpasses the inactivity of the components in the FPGA, the configuration won't work effectively and an unsuccessful timing conclusion happens. The other FPGA frameworks, for the most part pre-constructed components, similar to Ethernet availability and DDR2 memory have maximum points of confinement on their info timekeepers which can't be surpassed. To make the interface between the different FPGA frameworks proficient, a typical clock was decided for every one of them. Besides, the PLB clock ought to be a different of the ADC clock so that synchronization between approaching specimens and the rest of the GPS calculation is basic. Given these requirements, the PLB clock was been 75 MHz. This permits the GPS calculation to keep running at an element of 12 speedier than the example clock rate, while as yet having the capacity to close the timing requirements of the prebuilt components. At long last, the clock rate of the processor is prescribed to be a number several of the PLB clock. The processor clock was been 150 MHz. Speedier clock rates were attempted, yet neglected to meet timing requirements amid outline arrangement.

4.2 Serial-Search Algorithm

The initial phase in getting the GPS message is to perform procurement. This procedure will assess the code stage and Doppler recurrence counterbalance of the transporter for a particular satellite vehicle number (SVN). Since this recipient is performing a "cool begin", where no past data about the satellite is known, each code stage and each Doppler counterbalance must be sought. There are three understood systems utilized for securing of a GPS signal – serial inquiry, parallel recurrence space pursuit, and parallel code space seek obtaining [26] [27]. The serial inquiry strategy regularly includes connections of the got C/A code with bit-adjusted variants of known C/A codes. The parallel recurrence space look and the parallel code space seek utilize the Fourier Transform in recurrence space or code space, individually, and are characteristically parallel methodologies. The serial pursuit using so as to obtain technique can likewise be parallelized various connections, testing a few code bit arrangements in the meantime [26]. For this work, the serial inquiry calculation was chosen due to its usage effortlessness. As opposed to the parallel recurrence and parallel code space approaches, no execution of the Fourier Transform is required in this procurement philosophy. The serial-look calculation requires just duplicate and collect operations which are effortlessly actualized by a FPGA. While an ideal opportunity to finish procurement can be diminished by executing a parallelized approach with different correlators, just a solitary correlator is actualized in this work. The code stage being looked alludes to the time arrangement of the beneficiary's information with the satellite's spreading code.

Following the satellite is continually transmitting the spreading code, when the recipient starts gathering information, the start of the code grouping is obscure. The spreading code has a high connection esteem just when it is adjusted impeccably so as to itself. Utilizing this property, a nearby duplicate of the spreading code can be produced which begins at different stages in the chip arrangement, from 0 to 1022. In the serial inquiry calculation, the code stage is generally sought in 0.5 chip steps [2]. The privately produced duplicate of the code can be associated with the approaching

information and if the got code is splendidly adjusted to the created code, the greatness of the connection will be expansive. On the off chance that the codes are misaligned, the extent of the connection will be little. By setting a particular edge to demonstrate an effective relationship, the code stage can be assessed. Notwithstanding the code stage, the bearer recurrence should likewise be assessed. The ostensible bearer recurrence worth is resolved from the recurrence of the L1 transporter (1.57542 GHz) and any downconversion to a middle of the road recurrence (IF). A neighborhood duplicate of the bearer must be created and expelled from the got signal. As expressed in segment 2.2, the bearer can encounter a Doppler movement of ±5 KHz. Along these lines, a pursuit is performed ±5 KHz from the ostensible estimation of the transporter. While assessing the recurrence of the bearer, the period of the got transporter is additionally obscure. While producing a nearby duplicate of the bearer, both an in-stage duplicate (I) and a quadrature duplicate (Q) are required. The Q-transporter is +90 out of stage with the I-bearer. By researching the sign force on both the I-regulated arm and the Q-tweaked arm, the sign force is ensured to be caught. A square outline of the serial-seek calculation is shown in Fig. This framework works by attempting every last conceivable code stage and Doppler recurrence until the satellite is found. A solitary emphasis of this calculation relates to a hunt over a solitary code stage and a solitary Doppler counterbalance.

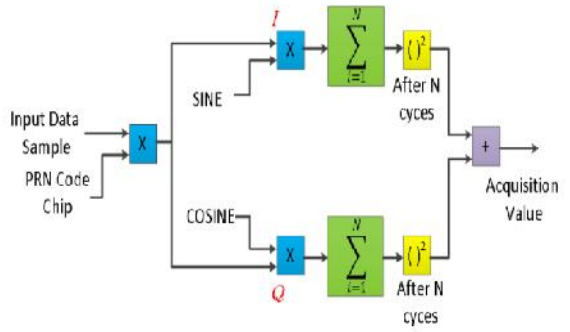
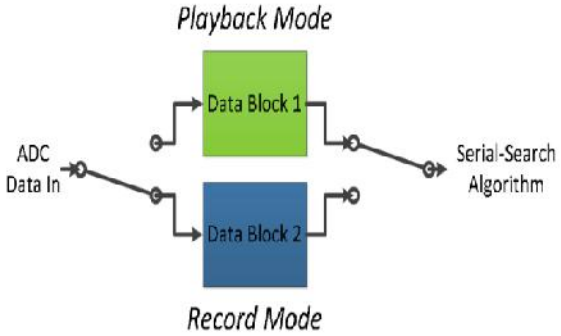


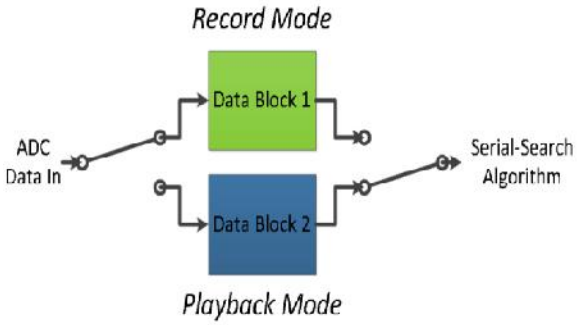
Figure 3. Serial-search block diagram

4.3 Ping-pong buffers

The buffering plan works with two separate buffers. One cushion is put into "record mode". In this mode, it is associated with a location counter determined by the example clock (or a down tested duplicate of the FPGA clock to coordinate the specimen clock speed and stage) and its information data associated with the ADC. Its yield is not utilized. The other cradle is in "playback mode" and the cushion is associated with a location counter running at the FPGA clock speed. Its information would be detached, and its yield would be encouraging the serial-look calculation. When one support has filled, the both buffers must swap their states instantly. In the event that there is any postponement in swapping the inputs of the two buffers, information tests could be lost.



Figuer 4. Ping-pong buffering system at time t



Figuer 5. Ping-pong buffering system at time t+2ms

In this figure, information square 2 is in "record" mode and is getting tests from the ADC at a rate of 6.25 MHz. Information square 1 is in "playback" mode and is giving information to the serial-seek calculation at

the FPGA clock rate of 75 MHz. Fig. demonstrates the status of the buffers 2 ms after Fig. This figure demonstrates that information square 1 is currently in "record" mode while information piece 2 is in "playback" mode. The measure of every cradle is specifically identified with the reconciliation time required by the serial-look calculation. On the off chance that the cushion is 1 ms, sufficiently long information can be given by a solitary support to perform a solitary emphasis (one code stage, one doppler counterbalance) of the calculation. Be that as it may, in gathering just 1 ms of information, the bit move times are obscure. It is conceivable that a bit move could happen in the 1 ms of assembled information, skewing the aftereffects of securing. Rather, it is alluring to gather 2ms of information in every cradle, ensuring that 1 ms of information without a bit move has been gotten. At the wanted example rate of 6.25 MHz, 2 ms of information will required the capacity of 12500 specimens. Each 32-bit word in memory just stores one 4-bit test, requiring that every cushion involve 12500 expressions of memory (around 50 kB).

4.4 Interpreting the Results

The size squared yield esteem got from the serial-seek calculation is gone from the FPGA to processor to decide the practicality of the code stage and Doppler assessments got amid the procurement process. This extent must be more prominent than or equivalent to a limit for the appraisals to be esteemed right. On account of this collector, the limit level was resolved experimentally in the accompanying way. Test information was gathered from the RF front end and prepared by a current programming characterized GPS collector accessible in Borre et al. This recipient can give the right code stage and Doppler balance for a given information set. This information set was then go through a Matlab reproduction of the calculation executed in the WARP-based beneficiary. Sizes for right and off base assessments of satellites' sign parameters were watched and an estimation of 9,000,000 was picked as a feasible edge level. This limit strikes an even harmony between getting a false discovery and missing a frail sign. To guarantee that this limit is reasonable, two other information sets were gathered and prepared, with comparative results. The calculation utilized for assessing the limit was gotten from the Tong Detector depicted in Kaplan , and is represented in Fig. 5.12. The first Tong locator sets the edge used by approximating the root-mean-square commotion of the framework. This is finished by passing past size squared qualities through a recursive lowpass channel . In the framework executed in this work, the edge used was discovered experimentally and utilized as a steady. The rest of the Tong Detector depicted in Kaplan is actualized in the WARP-based collector]. The limit assessment calculation is executed totally in the processor. The extent squared worth portrayed in segment is sent out from the FPGA to the Processor over the PLB design. . This limit assessment calculation does not acknowledge a solitary fruitful keep running of the obtaining process; rather, the processor's edge calculation requests an effective estimation of a satellite's parameters 6 times before a fruitful lock is announced. For every Doppler recurrence/code stage to be pursuit, a counter it instated to an estimation of 2. This introductory estimation of the counter and the quantity of accomplishments was browsed the depiction gave by Kaplan . On the off chance that the extent squared worth surpasses the edge, the counter is increased. In the event that the edge is not met, the counter is decremented. Should the counter achieve 0, the quest for a particular code stage and Doppler recurrence is ended. At the point when the counter achieves 6, an effective securing is pronounced and the beneficiary proceeds onward to following.

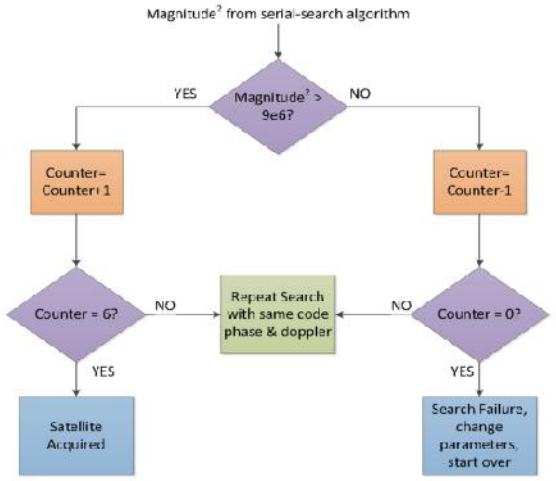


Figure 6. Magnitude form

5. Top Level

The top level of the collector comprises of the securing framework in , the following framework in , the information quantizer framework in , and the memory mapped registers that are Needed for the whole recipient Which are appeared in. The System Generator And EDK Processor Blocks in Fig. are a piece of any center intended to be appended to the PLB. The System Generator Block is in charge of keeping up gadget specifics for arrangement, while the EDK Processor Block is in charge of instantiating the memory-map for all PLB components. through the Simulink model used to make a custom with the obtaining calculation, and the following calculation, While the reasons of a large number of squares are clarified here, a complete depiction of the usefulness of every piece is accessible in the System Generator Reference Manual [21]. This recipient was implicit layers, with complex parts embodied inside of subsystem pieces. The subsystem squares are demonstrated with different hues.

6. RESULTS VISUAL INSPECTION

The estimations of the six aggregators and two circle discriminators were put away in DDR2 memory amid following. Once the fancied number of following circle emphasess had been accomplished, the processor could send these qualities over an Ethernet association with the host PC using the Ethernet association nitty gritty in segment 3.7 for resulting handling in Matlab. In an effectively bolted following circle, the navigational bits will be acquired by analyzing the estimation of the in-stage brief aggregator. There is a speedy visual watch that can be performed on a plot of the in-stage brief collector to figure out whether the following circle has been fruitful. A plot of this information ought to have sharp piece moves once every 20 tests. Subsequent to the navigational bits have an information rate of 50 Hz and the following circles are overhauled at rate of 1000 Hz, each navigational piece is spoken to by 20 information focuses from the following circle. Fig. 8.1 demonstrates the information acquired from the following circle in-stage brief arm, as it was following information from PRN 19. A visual examination demonstrates the normal qualities of a substantial navigational message. There are sharp moves from positive qualities to negative qualities happening at 20 point interims. While this visual review is not solid confirmation the following circle was fruitful, it is the initial phase in assessing collector execution.

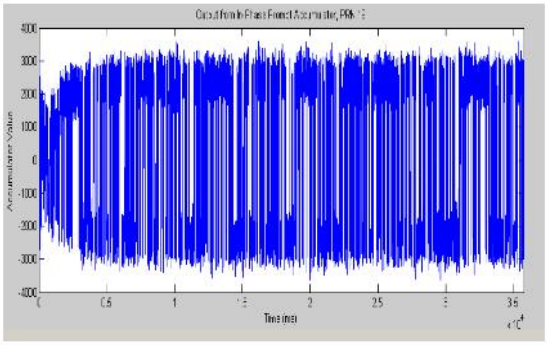


Figure. 7 Output from in-phase, prompt accumulator on PRN 19

Notwithstanding outwardly reviewing the navigational information got, the yield from the code circle and transporter circle

discriminators is likewise outwardly examined. It demonstrates the mistake in the code circle and bearer circle, individually. At the point when the following circle is simply starting, the mistake in both circles is entirely expansive, yet as time proceeds with, this blunder is enormously diminished. When the following circle has been working for 0.5 ms, the vast majority of the blunder in the code and bearer circles has been uprooted. In the event that the following framework was not able lock onto the navigational message, the blunder from the transporter and code circles would not rot after some time.

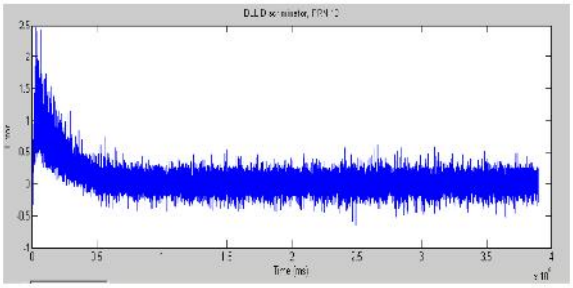


Figure 8. Output from the code loop discriminator on PRN 19

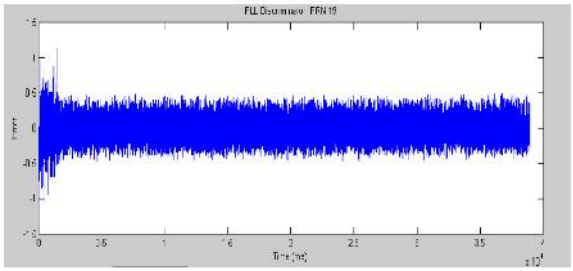


Figure 9. Output from the carrier loop discriminator on PRN 19

A superior perspective of the following circle expelling mistake from the framework can been seen in . These figures indicate just the initial 5000 ms of the following circle. Toward the start of the circle the yield of the in-stage brief arm, appeared in Fig. 8.4, does not display the attributes of navigational bits. It is not until approx. 1500 ms into the operation of the following circle that the navigational bits get to be evident. It demonstrates the more terrible case blunder in the code circle happening around 500 ms. The blunder has been lessened by around half at time 1500 ms. Fig. 8.6 demonstrates the more regrettable case mistake in the bearer circle is at time 0 ms. From time 0 ms to time 1500ms, the biggest measure of clamor is available in the blunder signal due the FLL discriminator and the more extensive circle transfer speed channels. After time 1500 ms, the last move is made in the bearer circle to the PLL discriminator with the most thin circle channel transmission capacity. Therefore, the commotion in the blunder signals reductions essentially.

7. FUTURE IMPROVEMENTS

The WARP equipment has been appeared in this work to be a skilled stage for continuous programming characterized GPS advancement. The most troublesome test related in working with the WARP is creating with the Xilinx instrument set. Every rendition of the Xilinx FPGA devices is exceptionally disparate from the past form and can be hard to learn. Further confusing the matter, a great part of the WARP Repository was composed around adaptation 10.1 of the Xilinx device set. This rendition was ended by Xilinx even before this work began. Working with an obsolete toolset can further hamper the decreasing so as to learn process industrial facility support for the device, including unsteadiness issues, and exhibiting deficient or non-working segments. Close to the season of finishing this work, Rice University has been attempting to overhaul a lot of their Repository to the more up to date Xilinx Tools. These upgrades have not been tried with the design portrayed in this work. For best execution, any future work in using the WARP for GPS ought to make utilization of the most recent Xilinx devices.

CONCLUSIONS

The receiver described in this work is capable of obtaining the navigational message from a single GPS satellite in real-time. The serial search algorithm is a straightforward approach to performing the process of

Acquisition. While this algorithm is time consuming, its simplicity is well-suited to the high-speed signal processing capabilities of an FPGA. Since the processor is governing Acquisition, otherwise necessary complex state machines can be avoided in the FPGA, saving logic elements. In the process of Tracking, a combination of FLL and PLL track the carrier, while a DLL tracks the code. Once again, the processor governs Tracking, preventing the need for complex state machines in the FPGA. Furthermore, by utilizing the DDR2 memory module on the WARP, large quantities of navigational data can be saved for future processing. Finally, the WARP's Ethernet connection is utilized to export the data to Matlab to post-process the data, confirming that the GPS navigational message was successfully received.

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