Implementation Glonass Software Receiver

Rajkumar L. Biradar
Dept. of Electronics & Telematics, G.Narayanamma Institute of Tech & Science, Hyderabad, India

Abstract
The primary goal of the software receiver is to minimize the hardware used in a receiver. It permits to upgrade of the receiver easily to new signal structure and support other navigational systems (Example-GPS, Galileo, COMPASS, IRNSS…). It uses Analog-to-digital converter (ADC) to change the input radio frequency (RF) signals into digital data at the earliest possible stage in the receiver. In other words, the input signal is digitized as close to the antenna as possible. Once the signal is digitized, software-based digital signal processing will be used to obtain and process the digital signal. The steps involved in software receiver are acquisition, tracking, data decoding and navigation solution. The aim of the paper is to implement and develop a Time synchronous GLONASS software receiver in C language from the available software receiver in MATLAB language. Later it can be converted to assembly language for Black fin Processor.

Keywords
GLONASS, GPS, receiver, software, code.

I. Introduction
Fixed-point implementation has considerable improvement in the execution speed and decreases the power consumption. However, these improvements come at the cost of reduced dynamic range and accuracy of the variables, and extra programming effort.

Fixed-point numbers differ from floating- point numbers in that the decimal point is fixed (the position is known at the compile time). Many low-cost microprocessors only give hardware support for 16 bit integer numbers, and floating point operations have to be realized by the compiler. The use of 16 bit fractional arithmetic may allow fast computations with real numbers at the cost of lower precision and much more programming work and algorithm analysis. The Analog Devices 16 bit Black fin Processor family does not have hardware of FPU. This data type, called fract16, is a two's complement fixed-point number defined to be a 1.15 representation. The one integer bit is a sign bit and the other 15 bits are reserved for fractional bits. This helps us to represent data in the range of -1.0 to +0.99996948. The advantage of this data range is that the result of multiplying two numbers within the range produces a result that also is in the range. Thus, overflows are possible only when performing addition and subtraction. However, the applications that requires processor-intensive real-time signal processing, such as real-time audio processing, where the overhead of the floating-point emulation library is too great. For those applications, we convert floating-point algorithm to a fixed-point implementation where we need performance improvements.

II. Literature Survey

A. GPS (Global Positioning System)
Global Positioning System [1] is a space based satellite based Navigation system developed by US Department of Defense in 1970s and maintained by the US government, which provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. GPS was originally found for military use, later it served even for civilian applications such as surveying and navigation. The United States Global Positioning System (GPS) consists of up to 32 medium Earth orbit satellites in six different orbital planes, with the exact number of satellites varying as older satellites are retired and replaced. Operational since 1978 and globally available since 1994, GPS is currently the world's most utilized satellite navigation system; it is freely accessible to anyone with a GPS receiver [2].

B. Compass
China has indicated they intend to expand their regional navigation system called Beidou or Big Dipper, into a global navigation system by 2020 a program that has been called Compass in China's official news agency Xinhua. The Compass system is proposed to utilize 30 medium Earth orbit satellites and five geostationary satellites. A 12-satellite regional version is expected to be completed by 2012.

C. Galileo
The European Union and European Space Agency agreed in March 2002 to introduce own alternative to GPS, called the Galileo positioning system [3]. At an estimated cost of EUR 3.0 billion, the system of 30 MEO satellites was originally scheduled to be operational in 2010. The estimated year to become operational is 2014. The first experimental satellite was launched on 28 December 2005. Galileo is expected to be compatible with the modernized GPS system. The receivers will be able to combine the signals from both Galileo and GPS satellites to greatly increase the accuracy. Galileo is now not expected to be in full service until 2020 at the earliest and at a substantially higher cost.

D. IRNSS
The **Indian Regional Navigational Satellite System** (**IRNSS**) is an autonomous regional satellite navigation system being developed by Indian Space Research Organization (ISRO) which would be under the total control of government of India [4]. The government approved the project in May 2006, with the intention of the system to be completed and implemented by 2014. It will consist of a constellation of 7 navigational satellites. All the 7 satellites will be placed in the Geostationary orbit (GEO) to have a larger signal footprint and lower number of satellites to map the region. It is intended to provide an all-weather absolute position accuracy of better than 7.6 meters throughout India and within a region extending approximately 1,500 km around it. A goal of complete Indian control has been stated, with the space segment, ground segment and user receivers all being built in India.
Implementing acquisition of GLONASS receiver signal requires 3 main modules. They are
- C/A Code generation.
- DDS (Direct Digital Synthesizer).

- FFT.

These modules are implemented as follows.

III. C/A Code Generation

In GLONASS we use 9 bit shift register for generating C/A code as discussed in chapter two. It is implemented in C language using for loop for generating 512 bits code.9 bits are loaded with -1 values.4th bit and 8th bit out of 9 bits shift register stored in temporary variable.

In output (pointercatable) variable is stored with 7th bit of register. Later bits are shifter and again loop are repeated till 512 bits are generated. The main purpose of generating C/A code is remove C/A code from incoming satellite signal so that data can extracted.

Pseudo code for CA code generation:

```
#include"complexMath.h"
#include"basic.h"
#include "settings.h"
void glonass_generateCAcode(SETTINGS *p2Settings,
Word8 *p2CaCodeTable)
{
        Word16 i;
        Word8 reg[9]={-1,-1,-1,-1,-1,-1,-1,-1,-1},j,temp;
        for(i=0;i<511;i++)
        {
                temp=reg[4]*reg[8];
                *p2CaCodeTable++=-reg[6];
                for(j=8;j>=1;j--)
                reg[j]=reg[j-1];
                                reg[0]=temp;
        }
}

void glonass_generateLocalCaCode(SETTINGS *p2Settings,
COMPLEX *p2LocalCaCode, Word8 *p2CaCodeTable)
{
        Word16 samplesPerCode,i,s;
        Word16 ts,tc;
        Word16 stepsize=523; //2^14
        Word16 codeValueIndex;
        Word8 LocalCode[1600];
        samplesPerCode = 1600;
   for (i=0;i<samplesPerCode;i++)
      {
codeValueIndex =(stepsize*i)>>14;            LocalCode[
i]=p2CaCodeTable[codeValueIndex];
        p2LocalCaCode[i].Real
=p2CaCodeTable[codeValueIndex];
        p2LocalCaCode[i].Imag = 0;
        }
        for (i=samplesPerCode;i<16384; i++)

        {
                p2LocalCaCode[i].Real = 0;
                p2LocalCaCode[i].Imag = 0;
        }
}
```

GLONASS satellites generate C/A code having 511 chips/ms with a clock rate of 511kcps, this code repeats every 1ms, and each group of 511 chips represents one C/A code and is same for every satellite. In our case GLONASS satellite generated signal is down converted into Intermediate frequency which is sampled at a rate of 16MHz sampling frequency through A/D converter, resulting signal is required to process for acquisition and tracking a satellite generated signal. But here we are observing 511 chips of C/A code for different sampling frequencies and its spectrum of C/A code.

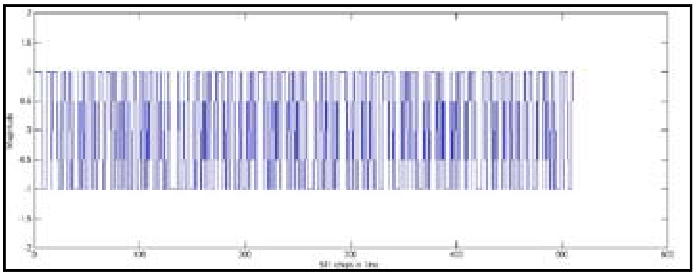

Fig.1: 511 chips of C/A code in MATLAB

The generated 511 chips code from linear feedback shift register is shown in below Figure 1. The generated C/A code consist within 1ms, which consist one set of C/A code at sampling frequency of 0.511MHz shown in below via by expressing C/A code vs. Time

$$\frac{1}{sampling\ frequency} \times (0\text{: code length -1})$$

× (0: code length -1)

IV. Generation of Local carrier using DDS

For removing the carrier from the incoming signal we need to multiply the signal with the carrier that is locally generated. To generate the local carrier we are using the method called as Direct Digital Synthesis (DDS). Direct digital synthesis (DDS) is a method of producing an analog waveform—usually a sine wave—by generating a time-varying signal in digital form and then performing a digital-to-analog conversion. Because operations within a DDS device are primarily digital, it can offer fast switching between output frequencies, fine frequency resolution, and operation over a broad spectrum of frequencies. With advances in design and process technology, today's DDS devices are very compact and draw little power.

The main function for DDS is void DDS_SINE(COMPLEX *p2LOCALCARRIER)

DDS_SINE is called from main function to generate local carrier with input p2LOCALCARRIER.In this various variables are declared and this values are fixed.

- DeltaTheta=45036, which is calculated by2*Pi*frequency*Ts. where frequency is GLONASS signal frequency and Ts is sampling time.
- DeltaBinTheta =201 which is calculated 2*pi/FFT length.
- DDSBIN=0 whereDDSBIN value is initialized with zero.
- DDSBIN2= DDSBIN+NincrementsMin;Nincrements
- BinTheta=DDSBIN* DeltaBinTheta;
- p2LOCALCARRIER[SampleNumber].Real=SineTable[DDSBIN2]>>1+SineTable[DDSBIN]>>1;

Output of DDS in mat lab:

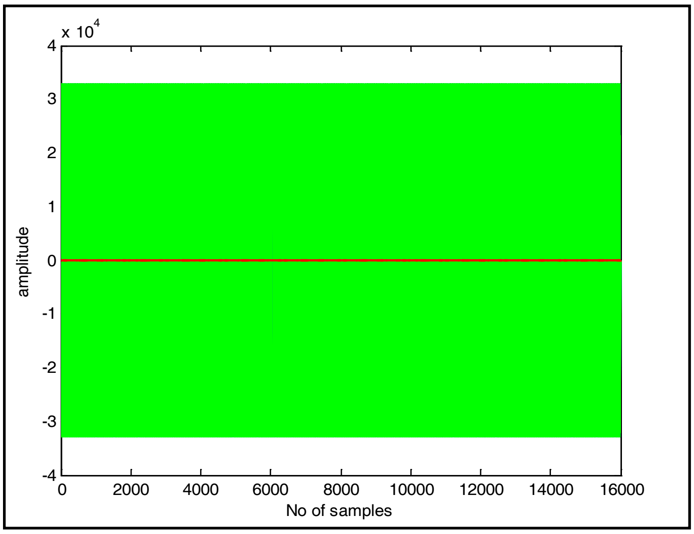

Fig. 2: DDS spectrum

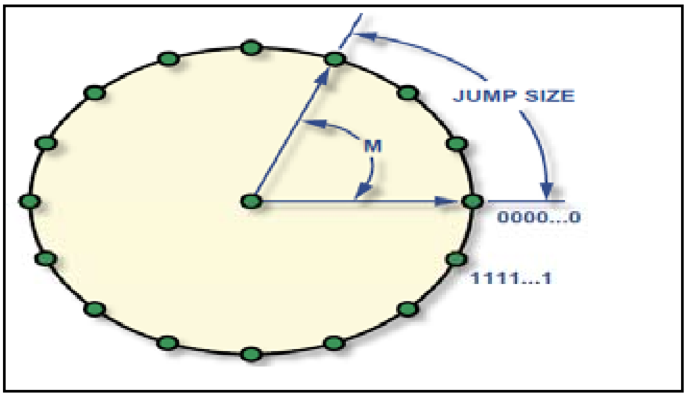

Fig. 3: DDS phase wheel
Where M= theta
JUMP SIZE=delta theta used in DDS code.

V. FFT Algorithm

A fast Fourier transform (FFT) is an algorithm to compute the discrete Fourier transform (DFT) and it's inverse. Fourier analysis converts time (or space) to frequency and vice versa. The fast Fourier transform (FFT) is a discrete Fourier transform algorithm which reduces the number of computations needed for N points from $2N^2$ to 2NlogN.

In code for acquisition we calculate FFT in two modules. First is bit reverse and FFT.In bit reverse we transform original data into reverse array by applying bit reverse function. This makes the mathematical calculations of the second part easy. The second part processes the FFT in N*log2(N) operations.

To C/A code when we have applied FFT or DFT, it will convert C/A code from time domain to frequency domain, because in frequency domain we can easily analyze the spectrum of C/A code which is shown in below figure. Here the sampling frequency is 0.511MHz. So C/A code sampled at 0.511MHz; it generates 511kcps means 511chips/ms so each sample takes 1 kHz frequency resolution.

$$\frac{\text{Sampling frequency}}{511} \times (0\text{: code length} -1) = \frac{0.511\text{MHz}}{511} \times (0{:}510)$$

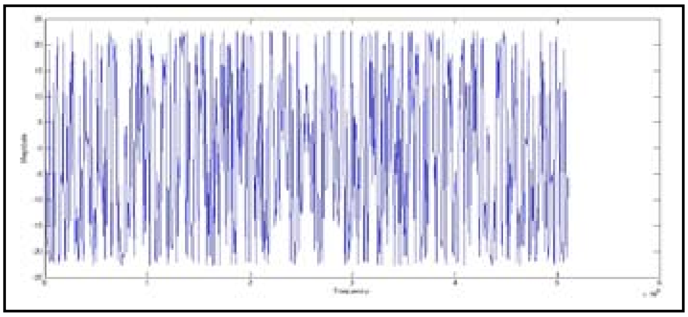

Fig. 4: FFT Spectrum of 511 chips CA code in MATLAB

To the above spectrum of C/A code when we applied the absolute of FFT or DFT, the magnitude of all samples having same value that has been shown in below figure.

$$\frac{\text{Sampling frequency}}{\text{Cacode length}} \times (0\text{: Cacode length} -1) = \frac{0.511\text{MHz}}{511} \times (0{:}511-1)$$

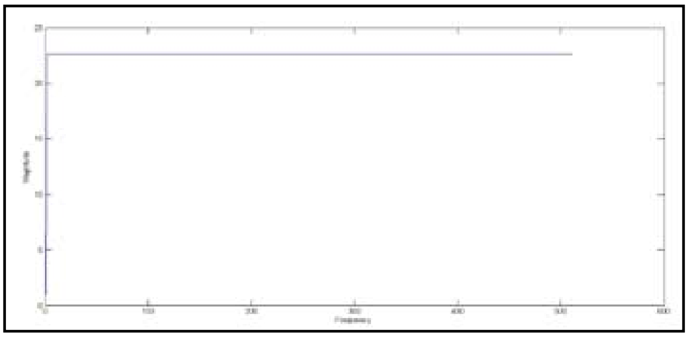

Fig.5: Correlation FFT Spectrum of 511 chips CA code

Sampling frequency can be defined as a discrete time signal generated from a continuous signal or converting a continuous time signal in to discrete time signal.

After sampling C/A code of 0.511MHz to 16MHz,

Sampling time (t_s) = 6.25×10^{-8}sec

Chip duration (t_c) = 1.95×10^{-6}sec

To the above C/A code, when we applied DFT or FFT to 16MHz sampled c/a code, the spectrum of c/a code shown in below figure here. The transmitted c/a code is having main lobe and several side lobes because of sampling frequency is very high compare to its code frequency

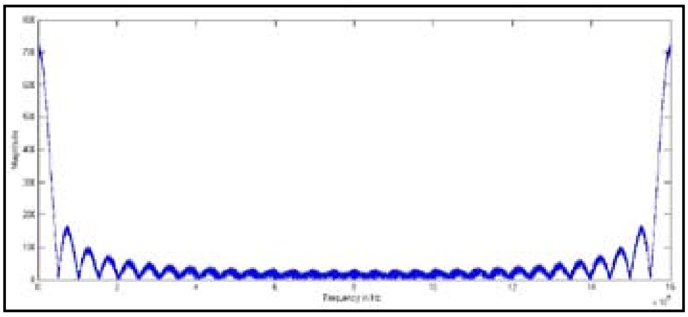

Fig. 6.6: Spectrum of 16MHz sampled C/A code

VI. Conclusion and Future Scope

Global Navigation Satellite System has a wide research area and can be implemented in various real time applications. In this project focused for the implementation of Acquisition and Tracking algorithms in Microsoft Visual Studio by taking the reference from the MATLAB code. In this development process first the MATLAB code was studied, and it has been converted

ISSN : 2347 - 8446 (Online)
ISSN : 2347 - 9817 (Print)

into C.

The goal of this work is to develop a C code for Acquisition and Tracking of GLONASS Software Receiver. The base band processing of GLONASS software receiver includes acquisition; tracking and additional decoding algorithms to compute receiver position for every millisecond. Here the acquisition is performed by using FFT search method and estimated code phase, carrier frequency values. After acquisition process completed, the estimated parameters are fed into the input of the tracking module. In this module two tracking loops have been introduced and utilized to produce exact carrier and code for the demodulation of navigation data bits in the incoming signal. The results obtained in MATLAB and C-code for Acquisition and Tracking algorithms are in agreement.

References

[1]. Yuying Zheng and Xi'an. "A Software-based Frequency Domain Parallel Acquisition Algorithm for GPS Signal" in 2010 IEEE, China.

[2]. A. J. Van Dierendonck, B. W. Parkinson and J. J. Spilker, Jr, Eds.Washington, "GPS Receivers, in Global Positioning System":Theory and Application, DC: Amer. Inst.

[3]. Bao, J. and Tsui, Y. . Fundamentals of Global Positioning System Receivers: a Software Approach. John Wiley & Sons, Inc., pp. 133.

[4]. Rao, K.N.Suryanarayana "Indian Regional Navigation Satellite System(IRNSS)," Second Meeting of the United Nations International Committee on Global Navigation Satellite System(ICG),Banglore,India,September 4-7,2007.

[5]. Bartenev, V., Kosenko, V. E., Zvonar, V. D. and Chebotaryov, V. E. (2005). Space vehicle GLONASS-M.Peculiarities of goal designing. 10th International Conference on System Analysis, Controlling and Navigation, Eupatoria, 3–10 July.

[6]. ophia Y. Zheng "Signal acquisition and Tracking for A Software GPS Receiver" February, 2005 Blacksburg, Virginia.