Embedded IRIG Generator Using Beaglebone

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Abstract – *In recent days, every industry has expanded its roots into the space industry. The ongoing research in the industry has produced very promising results. Embedded IRIG Generator Using beagle bone is one of those advancements. Inter-range instrumentation group timecodes, commonly known as IRIG timecode, are standard formats for transferring timing information. IRIG-B is the most used time code for synchronizing various devices. It is mostly used to synchronize rocket launch sequences between the payload and ground control. The commercial IRIG Generators are quite expensive. Beaglebone is an open-source, low-cost computer board. It contains a CPU and two Programmable Real-Time Units (PRU). These PRUs can be used to generate high precision timing signals. So, by utilizing them we have produced IRIG-B time code with high precision and good stability. We were able to generate a PWM signal with IRIG-B timecode embedded in it. This PWM Signal can be used to synchronize various devices and applications including rocker launches.*

Key Words: IRIG, PWM, Beaglebone, CPU, PRU.

1.INTRODUCTION

The growing complexity of industries such as aerospace, telemetry and broadcasting require devices with high precision at low cost. Many centuries have been spent by man for determination and measurement of time. Earliest references were the sun and the moon. (E.g.: Sundial). Invention of the Clock helped to process the methods of measuring and regulating time. The invention of the Time Code was a major step in this direction. Time Codes, which are in serial form, are used to transport time information from one point to another. Different time code formats have been developed over the years, by both commercial as well as military agencies. IRIG (Inter Range Instrumentation Group) codes have been in use for a long time in the industry. The commercial IRIG generators are quite costly and are not flexible enough. It is difficult to modify them for any custom applications.

There are various versions of IRIG time codes, but IRIG-B time code is the most used in the industry. RIG-B consists of 100 bits produced every second, 74 bits of which contain various time, date, time changes and time quality information of the time signal. Consisting of logic ones, zeros and position identifier bits, the time code provides a reliable method of transmitting time to synchronize power equipment devices. There are three functional groups of bits in the IRIG-B time code: Binary Coded Decimal (BCD), Control Functions (CF) and Straight Binary Seconds (SBS).

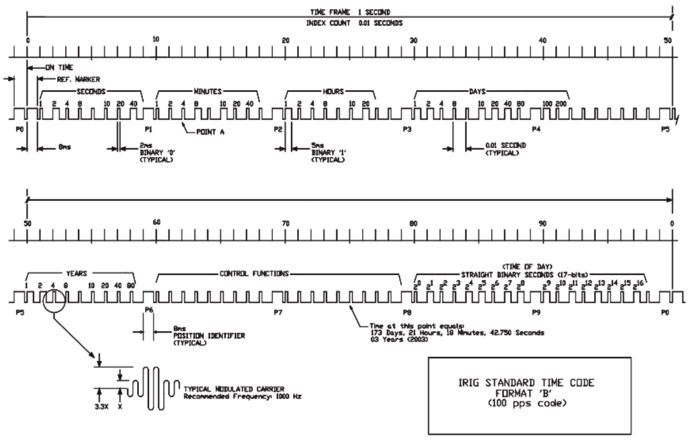

Figure 1 : Single frame of IRIG-B Time Code

Beaglebone black is a low-cost and high precision development board which can be used for generating various signals with high precision. With its ARM- Cortex A8 processor and unique Programmable Real-Time Units is ideally suited for applications which require precise timing signals and synchronization.

By utilizing the beagle bone in these time code generators, we can build the device tailored for custom applications. This approach reduces the budget requirements of timing applications and improves the flexibility of the system.

2. HARDWARE

The BeagleBone Black is a widely used single-board computer with low power consumption and high-performance hardware integration. It uses Texas Instruments Sitara AM3358BZCZ100 at 1GHz to meet the processing requirements of various tasks. ICH has 512MB DDRIII RAM and 4GB of onboard eMMC flash memory which are adequate for running applications and storing data. Networking includes a 10/100 Mbps Ethernet port, connectivity, USB 2. 0 host ports (2) for peripherals connectivity and an HDMI output port for display connectivity. The board contains 65 GPIO pins, seven analog inputs, and eight PWM outputs that allow for easy integration with other devices or processes in an external environment. Even more expansion capabilities are enabled by cape compatibility with Beaglebone and two

46-pin connectivity options, P8 and P9 headers. Furthermore, the Beaglebone Black has compatibility with multiple distributions of Linux, has a small form factor, and is appropriate for numerous applications including IoT, robotics, and automation applications as well as prototyping. The Beaglebone Black distinguishes itself with its unique feature: the Programmable Real-Time Units (PRUs). These PRUs are two 32-bit microcontrollers located in BeagleBone's system-on-chip and perform real-time processing in coordination with the ARM Cortex-A8 processor. Every PRU runs at 200 MHz and contains full access to the board I/O pins, enabling fine and low timing jitter control of external hardware and devices.

The PRUs provide the greatest flexibility and efficiency in recent applications like industrial control, robotics, and real-time signal processing. Thanks to their tight coupling with the BeagleBone's environment, developers can delegate system management and reporting to the cape while leaving computations to the main processor.

The possibilities of PRUs are enabling developers to create custom real-time control algorithms, high speed data acquisition, and precise timing operations with the help of BeagleBone connectivity and data processing. This combination makes the BeagleBone Black the suitable platform for projects that need low latency of response and high speed and frequency in I/O operations.

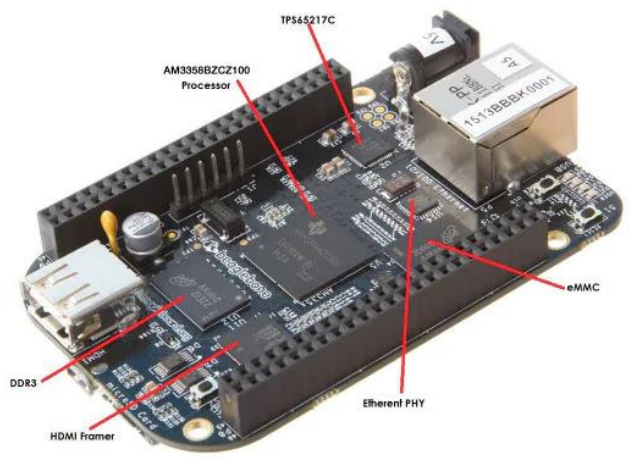

Figure 2 : Beagle Bone Black

3. IMPLEMENTATION

Before using BeagleBone Black for the first time, certain procedures have to be followed and these are quite easy to follow. Start by unpacking and assessing the parts where the key item should be the BeagleBone Black board and a USB cable. Connect the board to your computer with the USB cable or use a 5V direct current power supply. Power up the BeagleBone Black by connecting it to your computer using the USB cable through which both power and data will be transferred. For Windows users, download and install the required USB network and serial drivers from Beaglebone official site. Access the Beaglebone Black's web interface by navigating to its web interface. Finally, it is suggested to download the latest Debian image from the Beaglebone website and flash it onto the demo board to run the latest software and features.

We created a C program for this application. In the program we have utilized time and math header files for precise timing. It takes time and date as a input and count it back to zero second by second. Every second the board generates 100 pulses from its I/O pins.

The C program developed for this purpose for the Beaglebone Black board to generate the IRIG-B encoded PWM signal puts to affect the board's copious hardware and real time processing ability. The first step is to bring up the hardware interfaces required and program the PRUs for real time functionality. Through the integration of standard C libraries such as `<time. h>` and `<math. h>`, the program acquires the time and date from the system's clock before transforming these into the IRIG-B format After getting such data as BCD time, date, operational controls as well as straight binary seconds, the program produces 100 bits of data each second and these form the complete IRIG-B frame.

The program then uses the PRUs to create a PWM signal, within which the IRIG-B time code exists. It determines the pulse width at which a logic one, zero, and position identifier within the PWM signal is maintained, by modifying the so-called virtual pin descriptions that refer to the Beaglebone's physical I/O pins. Thus, by periodically setting the output to correspond to the converted time data, the program guarantees that the signal produced corresponds to the IRIG-B code. The PRUs are responsible for the real-time signal generation aspects thereby providing low latency and high accuracy while on the other end, operations such as fetching and converting of time information may be performed by the main ARM processor. Hence, the effective utilization of the Beaglebone's capabilities contributes to the successful generation of a high precision and stability IRIG-B encoded PWM signal that would be compatible to most time synchronizing applications.

For the communication between the running program and pins, we have used a concept called pin descriptors. These pin descriptors are the virtual locations of the hardware pins on the Beaglebone. If we change the value of the file at the location, then the physical output of the pin is also changed. As we know the time is converted into BCD Format i.e., as every second passes the entire time, date and control information is converted into its respective time frame and that time frame is given as the PWM output at the described pin.

4. RESULTS

We have successfully generated IRIG-B encoded PWM signal from the I/O pin of Beaglebone Black.

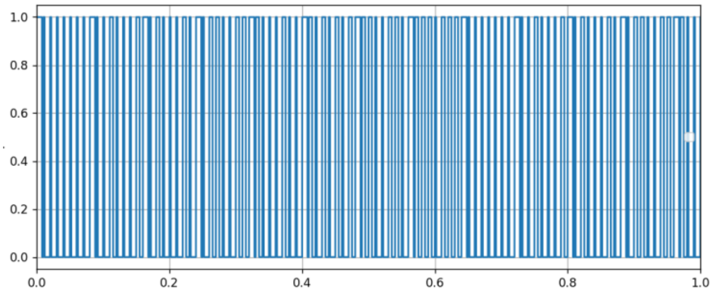

Figure 3 : Single Frame of IRIG-B

The above figure shows the single frame of IRIG-B with three different types of pulse width.

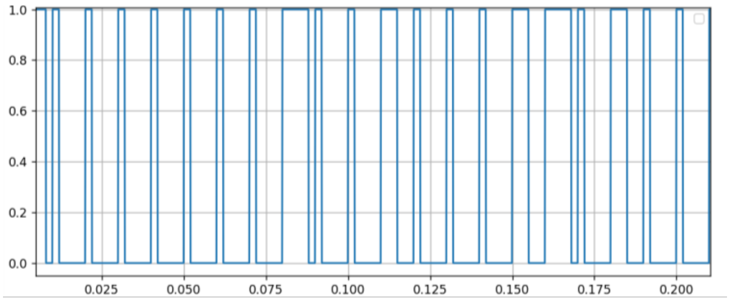

Figure 4 : Zoomed version of Frame of IRIG-B

The above figure gives a clear idea of the frame and different pulse width.

5. CONCLUSION

The specific objectives of the proposed system have been achieved as the generation of IRIG-B time code frames is possible with accurate timing and high stability. As a result of the system being built on the Beaglebone Black's powerful hardware and real time abilities, this system is operationally effective and accurate. This not only fulfils the present day need for synchronization in various applications but also provides a better and credible solution for time tracking.

Nevertheless, the scope of this system is much greater than what has been described above. The system may be used to solve more complicated and challenging problems with additional enhancements and modifications of the given system. For instance, it can be incorporated in highly technical space-based programs to establish harmonization of the complicated rocket firings and payload management systems. Further, they add flexibility and cost-efficient character due to which they are useful for other lines of business-like telecommunications, broadcasting, power grid, and industrial applications particularly where references to time are significant.

The usage of this system can cause an enhanced decrease in the cost of timing applications and rocket launches. Thus, young and small firms and startups can decide to invest in aerospace and other technologically sophisticated industries, meaning that access to such technology is widespread and innovation is encouraged. In this way, with the help of this system, those who dream about an aerospace division for their companies could make the dream come true and start new explorations, research, and developments in the space domain or other precise connected branches.

6. APPLICATIONS

The use of Beaglebone to generate IRIG standard is useful in aerospace and rocket launch where timing of the various subsystems in relation to the payload and the ground control must be synchronized. Also, it is significant in the automation of power grid and substation since it enables synchronization of devices, which is crucial in description of the operations and faults in power grids. In addition to satellite communication, broadcasting and telecommunication also use IRIG-B signals to synchronize their operations and make them precise thus improving the efficiency of these structures.

7. FUTURE SCOPE

The next steps for this project will be directed on utilizing adopted strategies for solving much more complicated problems in more critical contexts like auto-car driving and advancing robotics where precise timing can make a critical difference. Due to easiness of manipulation and low price, Beaglebone can be used in further extensions of the above-mentioned industrial automation processes, scientific research, and even transportation systems that are commonly used in any field that may require strict synchronization of the time. Perhaps, its integration into IoT and AI-based systems will expand opportunities for real-time data processing and making decision in various industries with technology improvement.

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