STELLARIS BASED PULSE WIDTH MODULATION

PRIYA STALIN1, R.G.BHARGAVI2, T.PRIYA3, T.SCINDIA4, B.K.SRUTHI5
Assistant Professor1, Student Scholar2,3,4,5, Department of Electronics & Communication Engineering, Sree Sastha Institute of Engineering & Technology

ABSTRACT
The aim of development of this project is towards providing efficient and simple method for controlling speed of DC motor using pulse width modulation technique. The electric drive system used in many industrial applications requires high performance reliability, variable speed due to ease of controllability. The speed of DC motor is very cruel in applications where precision and production are of essence. The modulation of pulse width is obtained using Stellaris. An improved PWM method for Stellaris is provided. Controlling the PWM duty cycle is equivalent to controlling the motor terminal voltage, which in turn adjusts directly the motor speed. This work is a practical one and high feasibility according to economic point of view and accuracy. In this work, development of hardware and software of the dc motor speed control system have been explained and illustrated. The desired objective is to achieve a system with the constant speed at any load condition. The advantages of this method can generate an output voltage with maximum current ratings of 2Ma, 4mA, 8mA to control the speed of DC Motor.

Keywords – Stellaris Micro Controller, Pulse Width Modulation (PWM), PIC Micro Controller, Code Composer Studio (CCS).

1. INTRODUCTION
Texas Instruments is the industry leader in bringing 32-bit capabilities and the full benefits of ARM® Cortex-M™ microcontrollers to the broadest reach of the microcontroller market. Now with over 200 compatible ARM Cortex-M Stellaris microcontrollers and over 30 Stellaris evaluation, development, and reference design kits, Stellaris fits the performance, integration, power, and price-point requirements of nearly any industrial application. The Stellaris family of microcontrollers—the first ARM Cortex-8 based controllers—brings high-performance 32-bit computing to cost-sensitive embedded microcontroller applications. 32-Bit RISC Performance-32-bit ARM Cortex-8 architecture optimized for small-footprint embedded applications System timer, providing a simple, 24-bit clear-on-write, decrementing, wrap-on-zero counter with a flexible control mechanism. Thumb-compatible Thumb-2-only instruction set processor core for high code density. Texas Instrument’s Stellaris family of microcontrollers provide designers a high performance ARM Cortex M-based architecture with a broad set of integration capabilities and a strong ecosystem of software and development tools. Targeting performance and flexibility, the stellaris architecture offers a 80 MHZ Cortex-M with FPU, a variety of integrated memories and multiple programmable GPIO. Stellaris devices offer consumers compelling cost effective solutions by integrating, Application-specific peripherals and providing a comprehensive library of software tools which minimize board costs and design-cycle time. Offering quicker time-to-market and cost savings, the Stellaris family of microcontrollers is the leading choice in high performance 32-bit applications. Stellaris with a Cortex-M offers a direct path to the strongest ecosystem of development tools, software and knowledge in the industry. Designers who migrate to Stellaris will benefit from great tools, small code footprint and outstanding performance. More importantly, designers can enter the ARM ecosystem with full confidence in a compatible road map from $1 to 1GHZ and you will never need to change architectures again.

2. STELLARIS LM4F120H5QR MICROCONTROLLER FEATURES
Stellaris uses ARM Cortex-M4F processor core. It performs 80 MHZ,100 DMIPS and it has 256 KB single-cycle flash memory with 32KB single-cycle SRAM. It has 2KB of EEPROM and internal ROM loaded with StellarisWare® software. In communication interfaces it provides Eight UARTs-Universal Asynchronous Receiver/Transmitter, Four Synchronous Serial Interface (SSI) modules, Four Inter-Integrated Circuit (I2C) modules with four transmission speeds including high-speed mode. And it also provides 2.0 A/B CAN controllers- Controller Area Network, 2.0 Device USB – Universal Serial Bus. In System Integration, Micro Direct Memory Access (μDMA) provides ARM® PrimeCell® 32-channel configurable μDMA controller. In General-Purpose Timer (GPTM) provides Six 16/32-bit GPTM blocks and six 32/64-bit Wide GPTM blocks. In Watchdog Timer (WDT) Two watchdog timers are provided, in Hibernation Module (HIB) Low-power battery-backup is used. And Six physical General-Purpose Input/output (GPIO) are used.

For Analog Support it has Two 12-bit ADC modules with a maximum sample rate and Two independent integrated analog comparator controller. It also provides 16 Digital Comparators and One JTAG module with integrated ARM Serial wire Debug (SWD). The used LM4F120h5QR device comes in 64 pin package and industrial operating range is -40°C to 85°C.
2.1 Electrical Characteristics

2.1.1 MAXIMUM RATINGS

The maximum ratings are the limits to which the device can be subjected without permanently damaging the device. Device reliability may be adversely affected by exposure to absolute-maximum ratings for extended periods.

*The device is not guaranteed to operate properly at the maximum ratings.*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parameter Name</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD</td>
<td>VDD supply voltage</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>VDDA</td>
<td>VDDA supply voltage</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>VBAT</td>
<td>VBAT battery supply voltage</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>VIN_GPIO</td>
<td>Input voltage on GPIOs, regardless of whether the microcontroller is powered</td>
<td>-0.3</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>Input voltage for PB0 and PB1 when configured as GPIO</td>
<td>-0.3</td>
<td>VDD + 0.3</td>
</tr>
<tr>
<td>IGPIOMAX</td>
<td>Maximum current per output pin</td>
<td>-</td>
<td>25</td>
</tr>
<tr>
<td>INON</td>
<td>Maximum current into or out of a non-power, non-GPIO, non-XOSCl pin when the microcontroller is unpowered</td>
<td>-</td>
<td>pending</td>
</tr>
</tbody>
</table>

2.1.2 RECOMMENDED RATINGS

For special high-current applications, the GPIO output buffers may be used with the following restrictions. With the GPIO pins configured as 8-mA output drivers, a total of four GPIO outputs may be used to sink current loads up to 18-mA each. At 18-mA sink current loading, the VDD value is specified as 1.2V. The high current GPIO package pins must be selected such that there are only a maximum of two per side of the physical package with the total number of high-current GPIO outputs not exceeding four for the entire package.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parameter Name</th>
<th>Min</th>
<th>Nom</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD</td>
<td>VDD supply voltage</td>
<td>2.97</td>
<td>3.3</td>
<td>3.63</td>
<td>V</td>
</tr>
<tr>
<td>VDDA</td>
<td>VDDA supply voltage</td>
<td>2.97</td>
<td>3.3</td>
<td>3.63</td>
<td>V</td>
</tr>
<tr>
<td>VDDC</td>
<td>VDDC supply voltage</td>
<td>1.08</td>
<td>1.2</td>
<td>1.32</td>
<td>V</td>
</tr>
<tr>
<td>VSH</td>
<td>GPIO high-level input voltage</td>
<td>0.6 * VDD</td>
<td>-</td>
<td>VDD</td>
<td>V</td>
</tr>
<tr>
<td>VIL</td>
<td>GPIO low-level input voltage</td>
<td>0</td>
<td>-</td>
<td>0.35 * VDD</td>
<td>V</td>
</tr>
</tbody>
</table>

2.2 HARDWARE DESCRIPTION

2.2.1 Power Management:

*Power Supplies*

The Stellaris LaunchPad can be powered from one of two power sources:

- On-board Stellaris ICDI USB cable (Debug, Default)
• USB device cable (Device)
The POWER SELECT switch (SW3) is used to select one of the two power sources. Select only one source at a time.

Hibernate
The Stellaris LaunchPad provides an external 32.768-kHz crystal (Y1) as the clock source for the LM4F120H5QR Hibernate module clock source. The current draw while in Hibernate mode can be measured by making some minor adjustments to the Stellaris LaunchPad. The conditions that can generate a wake signal to the Hibernate module on the Stellaris LaunchPad are waking on a Real-time Clock (RTC) match and/or waking on assertion of the WAKE pin. The second user switch (SW2) is connected to the WAKE pin on the microcontroller. The WAKE pin, as well as the VDD and HIB pins, are easily accessible through breakout pads on the Stellaris LaunchPad. See the appended schematics for details. There is no external battery source on the Stellaris LaunchPad Hibernate module, which means the VDD3ON power control mechanism should be used.
This mechanism uses internal switches to remove power from the Cortex-M4F processor as well as to most analog and digital functions while retaining I/O pin power. To measure the Hibernate mode current or the Run mode current, the VDD jumper that connects the 3.3V pin and the MCU_PWR pin must be removed. See the complete schematics (appended to this document) for details on these pins and component locations. An ammeter should then be placed between the 3.3 V pin and the MCU_PWR pin to measure IDD (or IHB_VDD3ON). The LM4F120H5QR microcontroller uses VDD as its power source during VDD3ON Hibernate mode, so IDD is the Hibernate mode (VDD3ON mode) current. This measurement can also be taken during run mode, which measures IDD the microcontroller running current.

Clocking:
The Stellaris LaunchPad uses a 16.0-MHz crystal (Y2) to complete the LM4F120H5QR microcontroller main internal clock circuit. An internal PLL, configured in software, multiplies this clock to higher frequencies for core and peripheral timing. The Hibernation module is clocked from an external 32.768-KHz crystal (Y1).

Reset:
The RESET signal into the LM4F120H5QR microcontroller connects to the RESET switch and to the Stellaris ICDI circuit for a debugger-controlled reset. External reset is asserted (active low) under any of three conditions:
• Power-on reset (filtered by an R-C network)
• RESET switch held down
• By the Stellaris ICDI circuit when instructed by the debugger (this capability is optional, and may not be supported by all debuggers)

2.2.2 STELLARIS IN-CIRCUIT DEBUG INTERFACE (ICDI):
The Stellaris LaunchPad evaluation board comes with an on-board Stellaris In-Circuit Debug Interface (ICDI). The Stellaris ICDI allows for the programming and debug of the LM4F120H5QR using the LM Flash Programmer and/or any of the supported tool chains. Note that the Stellaris ICDI supports only JTAG debugging. An external debug interface can be connected for Serial Wire Debug (SWD) and SWO.

2.2.3 General-Purpose Input/Outputs (GPIOs): The GPIO module is composed of six physical GPIO blocks, each corresponding to an individual GPIO port (Port A, Port B, Port C, Port D, Port E, Port F). The GPIO module supports up to 43 programmable input/output pins, depending on the peripherals being used. The GPIO module has the following features:
Up to 43 GPIOs, depending on configuration and highly flexible pin muxing allows use as GPIO or one of several peripheral functions. 5-V-tolerant in input configuration. Two means of port access: either Advanced High-Performance Bus (AHB) with better back-to-back access performance, or the legacy Advanced Peripheral Bus (APB) for backwards-compatibility with existing code for Ports A-G. Fast toggle capable of a change every clock cycle for ports on AHB, every two clock cycles for ports on APB. Programmable control for GPIO interrupts
– Interrupt generation masking.
– Edge-triggered on rising, falling, or both.
– Level-sensitive on High or Low values.

Bit masking in both read and write operations through address lines and can be used to initiate an ADC sample sequence or a µDMA transfer. Pin state can be retained during Hibernate mode and Pins configured as digital inputs are Schmitt-triggered. Programmable control for GPIO pad configuration are Weak pull-up or pull-down resistors, 2-mA, 4-mA, and 8-mA pad drive for digital communication; up to four pads can sink 18-mA for high-current applications. Slew rate control for 8-mA pad drive, Open drain enables, Digital input enables.
3. STELLARIS LAUNCHPAD

- ARM® Cortex™-M4F
- 32-pin 60 MHz LM4F120H5QR
- On-board USB ICDI (In-Circuit Debug Interface)
- Micro AB USB Device port
- Device/ICDI power switch
- BoosterPack XL pinout also supports existing BoosterPacks
- 2 user pushbuttons
- Reset button
- 3 user LEDs (1 tri-color device)
- Current measurement test points
- 10 MHz Main Oscillator crystal
- 32kHz Real Time Clock crystal
- 3.3V regulator
- Support for multiple IDES:

4. PIN DESCRIPTION

In LM4F120H5QR, upto 43 GPIO with programmable control for GPIO interrupts and pad configurations, and highly flexible pin muxing. Two 12 bit Analog-to-Digital converters (ADC) with 12 analog input channels.

5. PWM IN STELLARIS

Each instance of a Stellaris PWM module provides up to four instances of a PWM generator block, and an output control block. Each generator block has two PWM output signals, which can be operated independently or as a pair of signals with dead band delays inserted. Each generator block also has an interrupt output and a trigger output. The control block determines the polarity of the PWM signals and which signals are passed through to the pins.

Some of the features of the Stellaris PWM module are:
- Up to four generator blocks, each containing
  - One 16-bit down or up/down counter
  - Two comparators
  - PWM generator
  - Dead band generator
  - Control block
  - PWM output enable
  - Output polarity control
  - Synchronization
  - Fault handling
  - Interrupt status

5.1 METHODOLOGY

A power supply provides a voltage input to the Stellaris. Clock signal is set to the required frequency using oscillator. This clock input is given to the timer to set the duty cycle. A comparator is used to compare the given
signal and it is transferred to the PWM generator. Output from this PWM is used to control the speed of the motor.

6. SOFTWARE
6.1 CODE COMPOSER STUDIO :
Code Composer Studio™ (CCStudio) is an integrated development environment (IDE) for Texas Instruments (TI) embedded processor families. CCStudio comprises a suite of tools used to develop and debug embedded applications. It includes compilers for each of TI’s device families, source code editor, project build environment, debugger, profiler, simulators, real-time operating system and many other features.

6.1.1 CCS FEATURES
Resource Explorer
The Resource Explorer provides quick access to common tasks such as creating new projects as well as enabling users to browse through extensive examples provided as part of Control SUITE, StellarisWare and others.

SYS/BIOS
SYS/BIOS is an advanced, real-time operating system for use in a wide range of TI digital signal processors (DSP), ARM microprocessors, and microcontrollers. It is designed for use in embedded applications that need real-time scheduling, synchronization, and instrumentation. It provides multi-tasking, hardware abstraction, and memory management. SYS/BIOS is royalty free and is included with Code Composer Studio.

Linux/AndroidDebug
Code Composer Studio supports both run mode debug and stop mode debug of Linux/Android applications. In run mode debug, it is possible to debug one or more processes. To accomplish this CCStudio launches a GDB debugger to control the target side agent (a GDB server process). The GDB server launches or attaches to the process to be debugged and accepts instructions from the host side over a serial or TCP/IP connection. The kernel remains active during the debug session. In the stop mode debug, CCStudio halts the processor using a JTAG emulator.

7. APPLICATIONS
The Stellaris LM4F series of ARM Cortex-M4 microcontrollers provides top performance and advanced integration. The product family is positioned for cost-conscious applications requiring significant control processing and connectivity capabilities such as: Low power, hand-held smart devices, Gaming equipment, Home and commercial site monitoring and control, Motion control, Medical instrumentation, Test and measurement equipment, Factory automation, Fire and security, Smart Energy/Smart Grid solutions, Intelligent lighting control and Transportation. Motion control covers a wide range of applications. Whether controlling a motor is the sole purpose of the application, or only part of it, Stellaris MCUs feature sophisticated hardware to support control of all types of motors, including high-speed motion control PWMs, QEIs, fast ADCs, and multiple timers. Additionally, with plenty of processor speed, generous memory options, a highly deterministic core, and multiple communication types, Stellaris is ideal for simultaneously handling sophisticated motion control, such as TI’s InstaSPIN technologies, and high-speed communications.

CONCLUSION
The microcontroller based speed control of dc motor has been introduced. Controlling a DC motor through PWM techniques using an Stellaris microcontroller is proposed. The system will be made user friendly so that anybody can operate the system without any trouble. Knowing the condition the user can change the amount of load if necessary.

REFERENCES
4. file:///F:/PROJECT/Hands%20On%20Review%20%20Texas%20Instruments%E2%80%99%20Stellaris%20ARM%20Cortex-M4%20LaunchPad%20Eval%20Board%E2%80%944.99!!!%20%20sort%20of%29%20%20Steve%20Leibson.htm
5. http://electrodesigns.net/blog/pic32-vs-stellaris/
6. file:///F:/PROJECT/Lab%20%20Pulse%20Width%20Modulation%2028PWM%29%20using%20PowerPC%20Embedded%20Lab.htm
7. file:///F:/PROJECT/ccstudio.htm