Technical Description of a Compute S+ Module

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Introduction

This document is a general-purpose description of a Compute S+ Module for new members of the PrISUm Solar Car Club or other teams who are looking to use a similar design for their vehicle and want to learn about PrISUm's implementation.

Overview

The Compute S+ Module (Compute) is a general-purpose programmable circuit board designed by PrISUm Solar Car Club for use in their solar car (see Figure 1 and Figure 2). These are attached to separate specialized adapter boards throughout the car which provide an interface between this module and they physical world. For example, Motorboard connects the pedals at the driver's feet to a Compute, allowing the Compute to read how far each pedal is depressed and react accordingly. Each of these modules are connected to the others via the Central Area Network (CAN) protocol commonly used in vehicles ("CAN Specification Version 2.0"). This protocol allows each module to communicate with all other modules and make the vehicle move through combined collaboration.

The Compute S+ Module consists of several parts which can be separated into three main categories: The programmbale microcontroller used to control the module, power Filtering, CAN communication, and additions to aid in debugging.

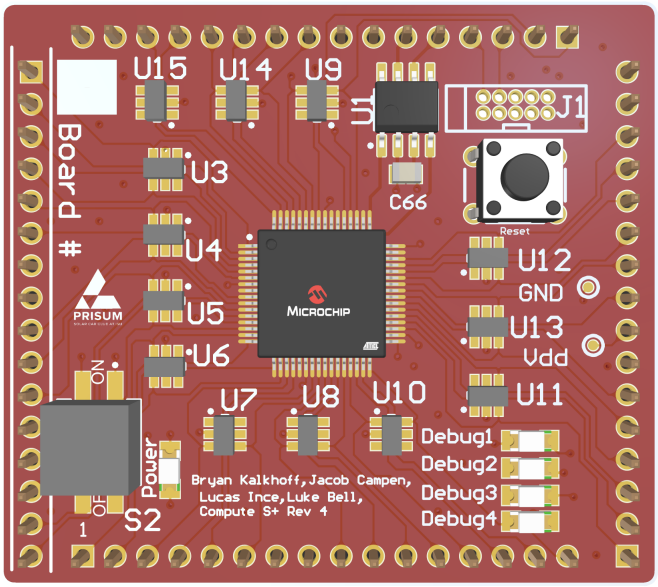

Figure 1: A 3D Render of the Front of a Compute S+ Module

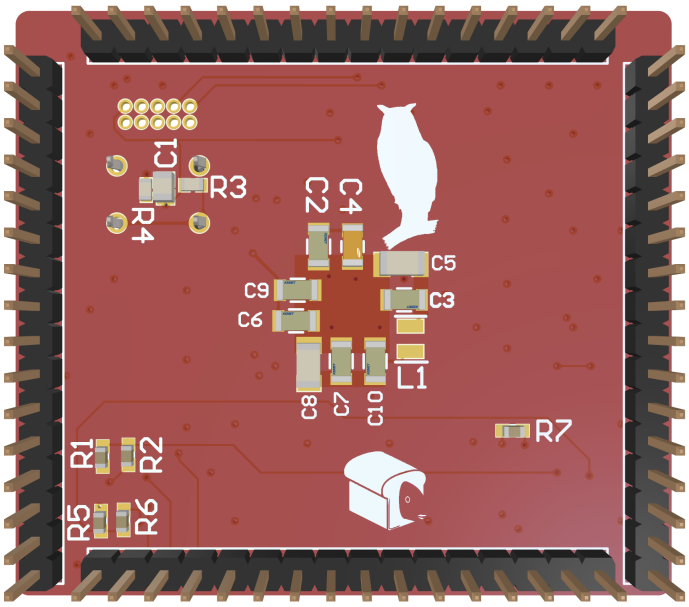

Figure 2: A 3D Render of the Back of a Compute S+ Module

Microcontroller

A microcontroller is an integrated circuit (IC) that runs a configurable program that recieves input from the physical world by reading the voltage at the pins on the outside of the IC (see highlighted portion of Figure 3) and responds by changing the voltage at those same pins.

The microcontroller in the center of the module (see Figure 3) is an ATSAMC21J18A general-purpose microcontroller produced by Microchip, formerly Atmel Corporation (”ATSAMC21J18A”). This specific microcontroller contains support for many common operations required in the vehicle’s operation including support for the CAN protocol. The microcontroller’s pins can be used in several different modes, some of the most common modes include General Purpose Input/Output (GPIO) and Analog/Digtial Conversion (ADC):

GPIO
Pins in GPIO mode act as simple switches that can be programmed to turn on or off at designated times or read a logical value (0 or 1) depending upon the voltage at the pin. These are commonly used for LEDs or buttons where the input or output can only be on or off (”SAM C20/C21 Family Data Sheet” 345-462).

ADC
Pins in ADC mode compare the voltage between two pins and give a number proportional to the difference between them. These are commonly used for measuring continuous values such as pedals (”SAM C20/C21 Family Data Sheet” 868-909).

These microcontrollers are programmed using C through the team’s software development system based on PlatformIO (*PlatformIO*).

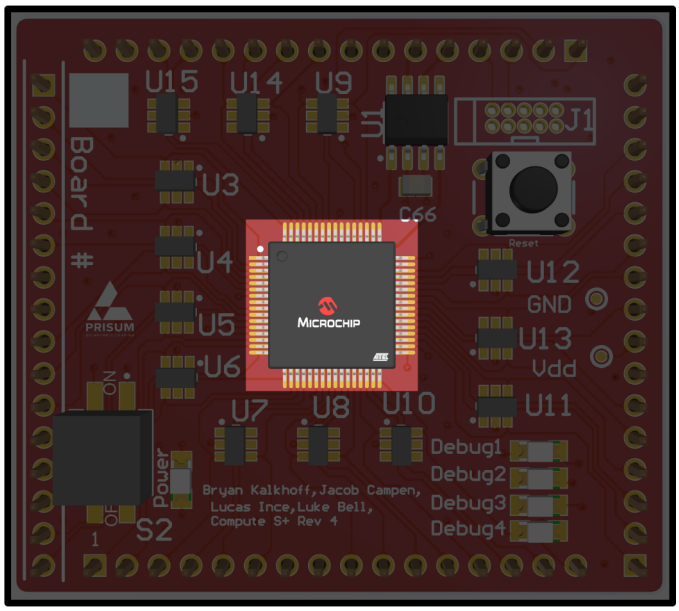

Figure 3: The ATSAMC21J18A Microcontroller

Power Filtering

The microcontroller requires 2.7V - 5.5V to operate which is supplied from the adapter board. To ensure the power supply is as consistent as possible, a few capacitors are added to the underside of the module (see Figure 4) which effectively reduce small variations in the supply voltage and make the microcontroller run more reliably.

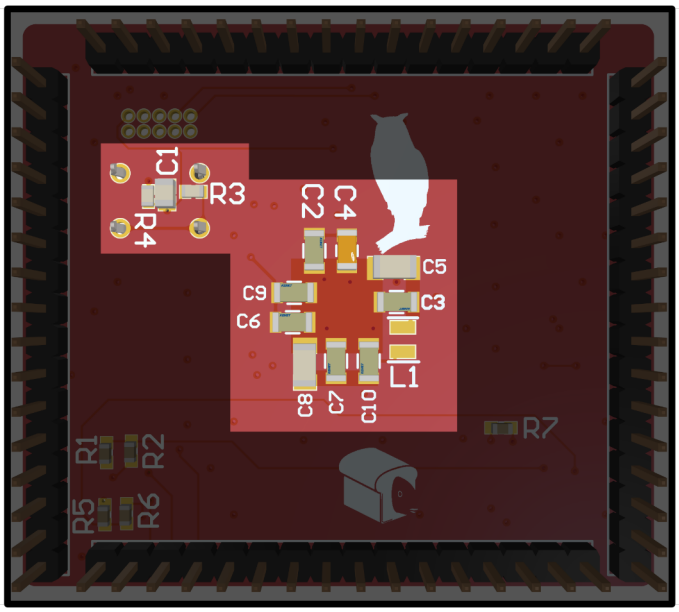

Figure 4: The Power Filtering Capacitors

CAN Transciever

The CAN Transciever is an IC that translates the signals transferred to and from the microcontroller into a differential pair suitable for transmission over long distances in a noisy environment. CAN signals are transmitted over a pair of wires where if the voltages are different, it's interpreted as a dominant bit, and if the voltages are the same, it's interpreted as a recessive bit. This form of transmission is known as a differential pair since the signal is conveyed solely through the difference between the pair of wires without any external reference and is especially useful in environments where external causes might change the voltage in the wire (especially common in vehicles while in motion). The wires are kept close together physically, so any external interference will affect both wires equally, causing the difference between the wires to stay consistent and the signal to be minimally distorted when it arrives at its destination.

The microcontroller is unable to process differential pairs directly, so a CAN Transciever is added between the main communication lines and the microcontroller to translate the differential pair into a signal form the microcontroller can process (see Figure 5). The specific CAN transciever in use in the Compute is the SN65HVD232DR produced by Texas Instruments ("SN65HVD23x 3.3-V CAN Bus Transceivers").

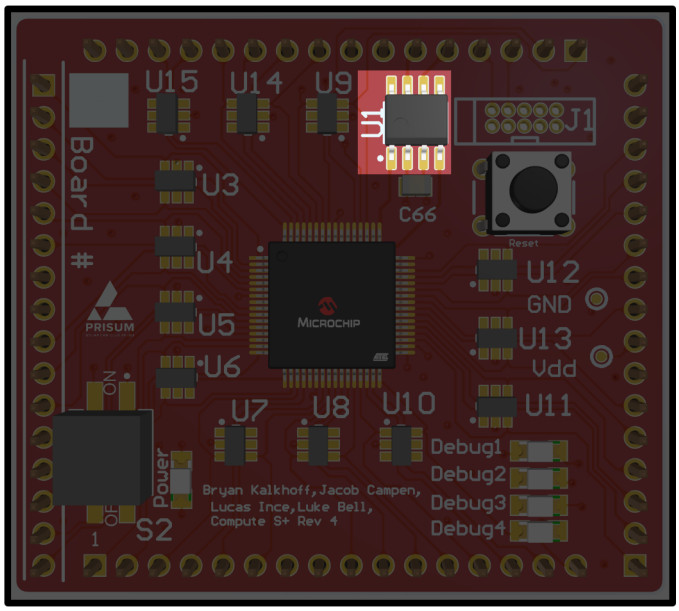

Figure 5: The CAN Transciever

Debugging Additions

When programming these modules, it is often difficult to determine what state the program is in or what is happening internally since there is no display or other method of user interaction. Instead, there are four LEDs to indicate the program's status to the user and one debug port which allows for both programming and inspection of the microcontroller's internal behavior while running (see Figure 6). While these are not critical to the performance of the module once programmed, they are extremely useful when trying to program it correctly.

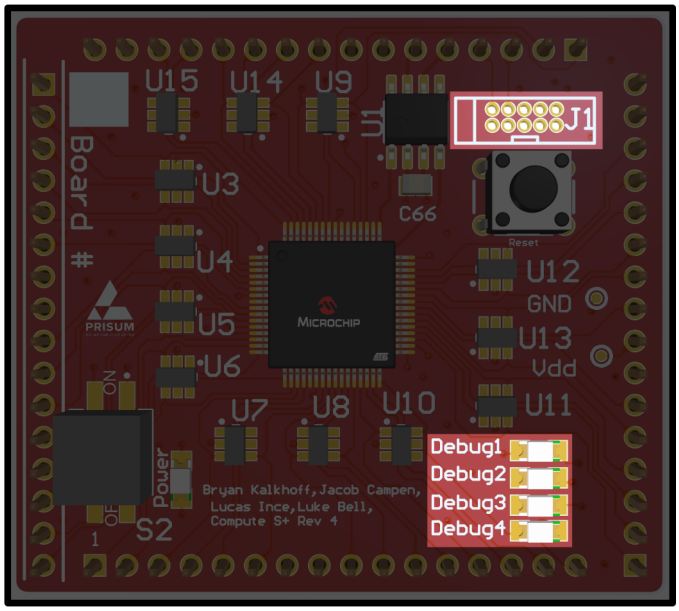

Figure 6: The Debug LEDs and Port

Conclusion

The microcontroller relies on the power filtering system for stable power, communicates with other boards using the CAN protocol through the CAN Transciever, informs the user via the debug LEDs, and is programmable via the debug port. This fairly simple board is extremely powerful given the variety of programs which can be made and the different adapter boards they can be attached to. The car currently contains approximately 8 Compute S+ Modules throughout the vehicle in constant communication with each other to create the mind which makes the car run.

Works Cited

”ATSAMC21J18A.” *Microchip,* www.microchip.com/en-us/product/ATSAMC21J18A. Accessed 9 March 2022.

”CAN Specification Version 2.0.” *Robert Bosch GmbH,* esd.cs.ucr.edu/webres/can20.pdf. Accessed 9 March 2022.

PlatformIO. Version 5.2.5, PlatformIO Labs, platformio.org. Accessed 9 March 2022.

”SAM C20/C21 Family Data Sheet.” *Microchip,* ww1.microchip.com/downloads/aemDocuments/documents/MCU32/ProductDocuments/DataSheets/SAM-C20-C21-Family-Data-Sheet-DS60001479J.pdf. Accessed 9 March 2022.

”SN65HVD23x 3.3-V CAN Bus Transceivers.” *Texas Instruments,* www.ti.com/lit/ds/symlink/sn65hvd232.pdf. Accessed 9 March 2022.