University of Notre Dame

Low Level Design

Team Baja

Jung Whan (Stephen) Kim, Patrick Whalen, Michael Manno, Matt Creehan
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1 SYSTEM REQUIREMENTS

The Notre Dame Baja team is a Baja car design team staffed with Notre Dame students that designs and races their own Baja vehicle against other colleges around the country. These competitions consist of a variety of scoring areas, including dynamic events, such as hill climbs and maneuverability events, and static events, such as design evaluations and presentations. Historically the Notre Dame team has performed very well, finishing 32nd out of 118 teams in 2012 at their annual competition in Peoria, Illinois. The team is shooting for a top-10 finish this summer at the competition in Peoria, Illinois.

In order to help them achieve that goal, Team Baja is building an electrical system for the vehicle to track and display vehicle data. The electrical system will display rpm, velocity, and lap time to the driver, and will also be capable of storing speed, rpm, GPS, as well as lap data to a removable SD card. The data can then be opened in excel for quick and easy analysis.

In addition to the stated features above, the module must also be able to operate flawlessly in the imperfect conditions that occur during a normal Baja race. Mud, vibrations, high speeds, and high temperatures all must be tolerable for the device. Below in Table 1.1 is a summary of the system features.

Table 1.1 System Requirements

SYSTEM REQUIREMENTS
Physical
System must fit within the Baja car in a spot where driver can access it System must be easily viewable from the driver during use System must have port for SD Card that is accessible to the user but can be locked tightly during a competition System must have three physical buttons: ON/OFF, STOP, and LAP that are spaced appropriately to prevent driver from accidentally hitting the wrong button
Operating Environment
System must be protected from potential mud splashes System must be susceptible to significant bumps and vibrations System must be susceptible to fast speeds and quick changes of direction
Features
Screen must display rpm, speed, and lap time to driver Driver must be able to record lap time by hitting LAP button System must be able to save rpm, GPS, speed, and lap data to an SD card

2 SUBSYSTEM REQUIREMENTS

2.1 POWER SUPPLY

The system we construct will use the pic32mx795 microcontroller. This system will be powered with V_{dd} of 3.3V, which will be used to power the GPS module and SD cards. The screen and rpm sensor(s) will require 5V, which will be provided by either a separate battery or derived from the car battery depending on what the Mechanical Engineering team decides for their electrical system.

2.2 GPS MODULE

The GPS module will be a critical piece of our system and will be responsible for providing velocity, latitude, longitude, and time data. This module will communicate with the pic32 through a UART connection and can be powered with 3.3V from the board. The module provides updated information every second and sends NMEA strings to the microcontroller through the UART ports. This data will then be sent to the screen and SD card when applicable. Data will be parsed and printed to the screen through the screen's SPI interface and to the SD card through its SPI interface using the Microchip MDD library. The GPS module that will be used is the MEDIATEK-3329 66-channel GPS engine board.

2.3 RPM SENSORS

The RPM sensors will be another critical component of the system, as they will be responsible for providing both engine and wheel rpm information. This information will be stored to the SD card, and displayed to the driver as appropriate. This module will operate using a Hall Effect sensor and an op amp comparator. The Hall Effect sensor outputs 2.5V without the presence of a magnetic field, and a slightly higher voltage when a magnet is nearby. An operational amplifier comparator will then be used to turn these differences into a logical signal, to be inputted into the microcontroller. The hall effect sensor will be powered with 5V from the car power supply, and the operational amplifier will draw its voltages (2.55V Vin(-), GND, and 3.3V V_{cc}) from the board. A collar with magnets will be placed on the wheel and engine axels, with the Hall Effect sensor nearby to read when the magnet passes. Using the time between magnet passes, the microcontroller will be able to calculate wheel and engine RPM.

2.4 DISPLAY SCREEN / INTERFACE

For the Baja driver to interface with the electrical system, the system will have a display screen to provide valuable data as well as three buttons for the user to control the device. The screen used will be a TFT display as part of the VM800B43A module made by FTDI Chip. This system will communicate with the pic32 through an SPI interface. When the system is on, this screen will display velocity data from the GPS module as well as engine rpm data from the rpm sensors. Lap time will be displayed but will not begin to run until the user presses the “lap” button. Once the user presses “lap,” lap time will start increasing and will continue to increase until it is recorded on the SD card and set back to 00:00:00 when the user presses the “lap” button a second time. Once “lap” is pressed for the first time, the device will create two CSV file on the SD card and will begin saving data to that file. GPS and rpm data will be saved to the file every second when received from the sensors. Lap data, since it does not occur in predictable periods, will be stored in local memory and saved once the “stop” button occurs. All data storage will end when the “stop” button is pressed, at which time the system will go back to simply displaying speed and rpm data. In addition to those three buttons, there will be a “power” button for turning the system on and off. It is very important that these buttons (as well as the screen) are accessible to the driver, yet are designed to that they cannot be disabled by mud from the competition and will not accidentally trigger due to vibrations. The “power” and “stop” buttons will likely be on the backside of the device so as not to be mistaken for the “lap” button which will be placed on the front of the device for easy access for the driver.

2.5 SD CARD

A very important part of this electrical system is the ability for Baja members to be able to store data for analysis. The SD card module is responsible for providing this storage. When the system is powered on and the user presses the “lab” button for the first time, rpm data from the rpm sensors as well as lap data from the “lap” button and GPS, time, and velocity data from the GPS module will all be saved to the SD card. Each time “lab” is pressed from the system’s initial operating state, a new file on the SD card will be created, so that each run or race can be saved in different files. This data storage will continue until the “stop” button is pressed. While being used the SD card will be inaccessible from the outside of the system and will be held in place by the latch that seals it in. Once data collection is over, however, the user can open the latch and remove the SD card to upload his or her CSV files onto a computer. The SD card used will be a standard SanDisk 512mb SD card. It will be connected to the board through

SPI and will be formatted with a FAT file system using Microchip's MDD library for interfacing with SD cards.

2.6 SYSTEM OVERVIEW

Table 2.1 below summarizes the various subsystems and their respective requirements. Below that in Figure 2.1 is a diagram that describes the various states of the system as well as how it responds to different user inputs in each state.

Table 2.1 Subsystem Requirements

SUBSYSTEM REQUIREMENTS
Power
System must provide 5V to power screen and rpm sensors
3.3V must be supplied to the pic32, GPS, and SD card
GPS Module
Module must supply GPS data to the SD card every second when applicable Module must provide time data every second to card when applicable Module must provide velocity data to the screen every second and to the SD card when applicable
RPM Sensor
Sensor must provide data for engine rpm to the screen every second and to the SD card when called for Sensor must provide data for wheel rpm to the SD card when needed
Display/Interface
Display must clearly show vehicle speed, rpm, and lap data to the user User must be able to power device on/off with POWER button Interface must have a LAP and STOP buttons for user to decide when to start and stop recording data to SD card User must be able to record when a lap has elapsed for saving to SD card by pressing a LAP button after the lap counter has started running
SD CARD
System must store GPS latitude/longitude, velocity, and time from GPS module to CSV file on SD card when prompted by user System must also save rpm data from rpm sensors when prompted by user System must save lap times when prompted by user

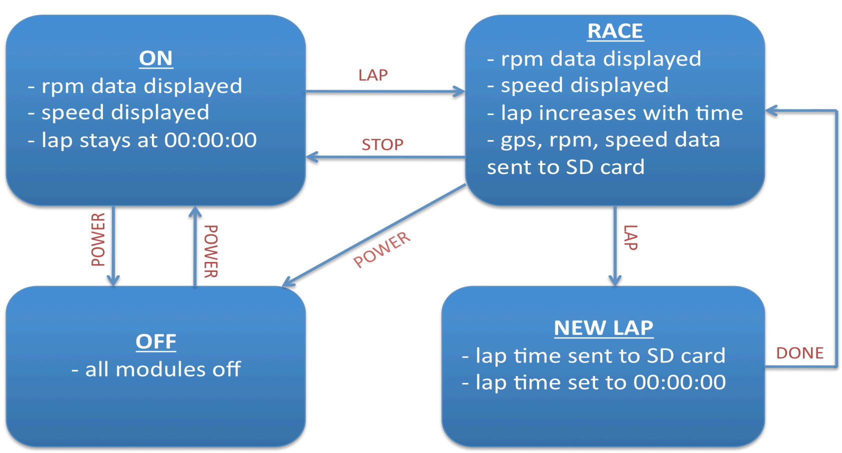

Figure 2.1 System State Diagram