Dynamic Headlight
Leveling System

Hardware Description

Glenn Denton

Western Washington University

05/04/2010
Introduction

The Dynamic Headlight Leveling System implements automotive headlight leveling in the vertical axis in response to the car's change in level in order to provide the driver with the best possible view ahead, while avoiding headlight glare for other motorists. Two modules are used to accomplish this task, the Control Module, and the Headlight Module. These modules communicate over the vehicle's high speed Controller Area Network. Leveling is accomplished with the use of an accelerometer to measure the car's change in level, and a dial connected to a potentiometer to allow the driver to change the desired level for the system to maintain. These functions are contained in the Control Module, which will make all decisions regarding level. This information is transmitted to the Headlight Module, which will control the level with a stepper motor connected to the automobile's headlights.

Control Module

Microcontroller

The control module is run by a Freescale 9S12DP512. Among the considerations for this choice are the relatively large size of RAM, necessary for the DSP operations performed by the MCU, suitability of 9S12 MCU's in automotive applications, and the integral MSCAN module. The RAM requirement is a particular concern as all signal processing takes place in the CPU for enhanced configurability. The 9S12DP family meets this requirement comfortably with 14 kbytes of RAM along with 512 kbytes of ROM. The 9S12DP512 makes use of a 16 MHz crystal and the aid of the integral PLL to run its bus at 24 MHz. Also used are the CAN1 port for external communications, SPI0 for the accelerometer, and ATD00 for the potentiometer that is the driver input. The additional four CAN ports are available for future feature expansion, for example sending acceleration data to other vehicle systems.

Debugger interfaces are supplied for both modules through a 6 pin jumper to the microcontroller to facilitate any necessary bug fixes after the product is released.

Power Supply

Most of the components, including the MCU’s, and CAN transceivers require +5 volts. To this end a National Semiconductor LM2931T voltage regulator is used. It is plugged directly into the 12 V supply from the car. This setup can supply in excess of 100 mA, which comfortably meets the power requirements for these components.

The accelerometer used in the control module requires a voltage between +2.4 and +3.6 volts. To power this, a Fairchild FAN2500S33X is included. This provides a fixed output of +3.3 volts.

Low Voltage Detection

The 9S12DP512, unlike the 9S12C family, does not have integrated low voltage detection circuitry. To rectify this an MC34154P low voltage detection IC is tied to the Reset_L pin of the 9S12DP512. A 10 kOhm pullup resistor is used due to the open drain output of the MC34154P.
Accelerometer

The accelerometer used in the control module unit is the Freescale MMA7455L. This accelerometer provides selectable sensitivities of +/- 2/4/8 g, and up to 10 bits of resolution. It interfaces through four wire SPI, three wire SPI, or I2C. The control module makes use of the three wire SPI interface through SPI0, reducing the cost in converting logic levels between the +3.3 volts of the MMA7455L and the +5 volts of the MCU. Communication is through a Texas Instruments TXS0101DRL bidirectional logic level converter for the accelerometers slave in/slave out pin. The chip select, and clock pins use schottky diode clamp circuits as these signals are not bidirectional.

When run above 3 volts, the MMA7455L can interface through the SPI at up to 8 MHz clock frequency. In this case it will be run at 6 MHz due to the SPI module on the 9S12 only being capable of dividing its 24 MHz bus clock in multiples of 2.

Driver Interface

The sole interface available to the driver is through a 10 kOhm potentiometer from +5 volts to ground hooked into the analog to digital converter on the 9S12DP512. The potentiometer is run trough a single pole low pass filter set to 1.6 kHz to minimize undesired noise to the circuit. The circuit is the hooked into the ATD00 pin on the microcontroller.

The ATD circuitry of the microcontroller is hooked into the +5 volts and the analog ground planes of the module's printed circuit board.

CAN Transceiver

Both of the Freescale 9S12 MCU's have integral CAN controllers, but still require CAN transceivers in order to drive the CANH and CANL differential signals of a CAN bus, and convert these signals to TX and RX signals for the CAN controller. This system will make use of NXP Semiconductor PCA82C250 transceivers. These are high speed CAN transceivers that meet all the the specifications for ISO 11898 standards for the Controller Area Network hardware layer. The control module uses the CAN1 port for communication with the headlight module.

Headlight Module

Microcontroller

The headlight module makes use of a 9S12C128 from Freescale Semiconductor. This part is selected for being one of the lower cost microcontrollers with an integrated CAN controller module. It has 4kbytes of RAM and 128kbytes of ROM available. An 8 MHz crystal is used as reference for the internal PLL to convert up to 24 MHz for the bus clock. Peripherals to this module are the CAN bus connection through the MSCAN controller, PWM0, and several ports to control the stepper motor driver.
**Power Supply**

The power supply used by the headlight control module MCU and motor driver I/O is the same LM2931T as used by the control module.

The Motor Driver has two voltage inputs, a logic level input for its MCU interface and a +9 volt to +30 volt input for the motor load. The logic input is connected to the +5 volt supply from the LM2931T, and the load supply is tied to the vehicle's +12 volt supply for the stepper motor in parallel with a 47 uF electrolytic filtering capacitor.

**Stepper Motor and Driver**

The headlight controller module uses an Allegro MicroSystems A3967LSB bipolar micro-stepping driver. This IC uses +5 volts from the regulator as reference for its logic IO, and the +12 volts from the car's supply to drive the motor. It can supply up to 750 mA of current to the attached motor. It has integrated micro-stepping functionality, and requires only a pulse to control a single step. In addition it has a sleep function to turn off drive to the motor, allowing for a significant decrease in power consumption when the motor is not being stepped. The driver is directly connected to a 12 volt bipolar stepper motor.

The Pulse Width Modulator used to supply the pulse train to the stepper driver operates through PWM0, routed through PTT0. Sleep_L puts the driver to sleep, and is tied to a 10 kOhm pullup and PTT1. MS1 and MS2 pins control the size of each step taken per pulse. Both pins are tied to 10 kOhm pullups and are controlled by PTT2 and PTT3 respectively. The direction pin, DIR, is tied directly to PTT4.

**CAN Transceiver**

The headlight module uses the same NXP PCA82C250 CAN transceiver as is used by the control module. It is connected through the only CAN port available on the 9S12C128.