Instrument Cluster Display

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Presentation Outline

- Introduction and Motivation
- Features
  - Temperature Sensing
  - LCD Display
  - Fahrenheit/Celsius Selection
  - RGB LED temperature scale
  - Ultrasonic distance sensing and alarm
- Conclusions and Recommendations

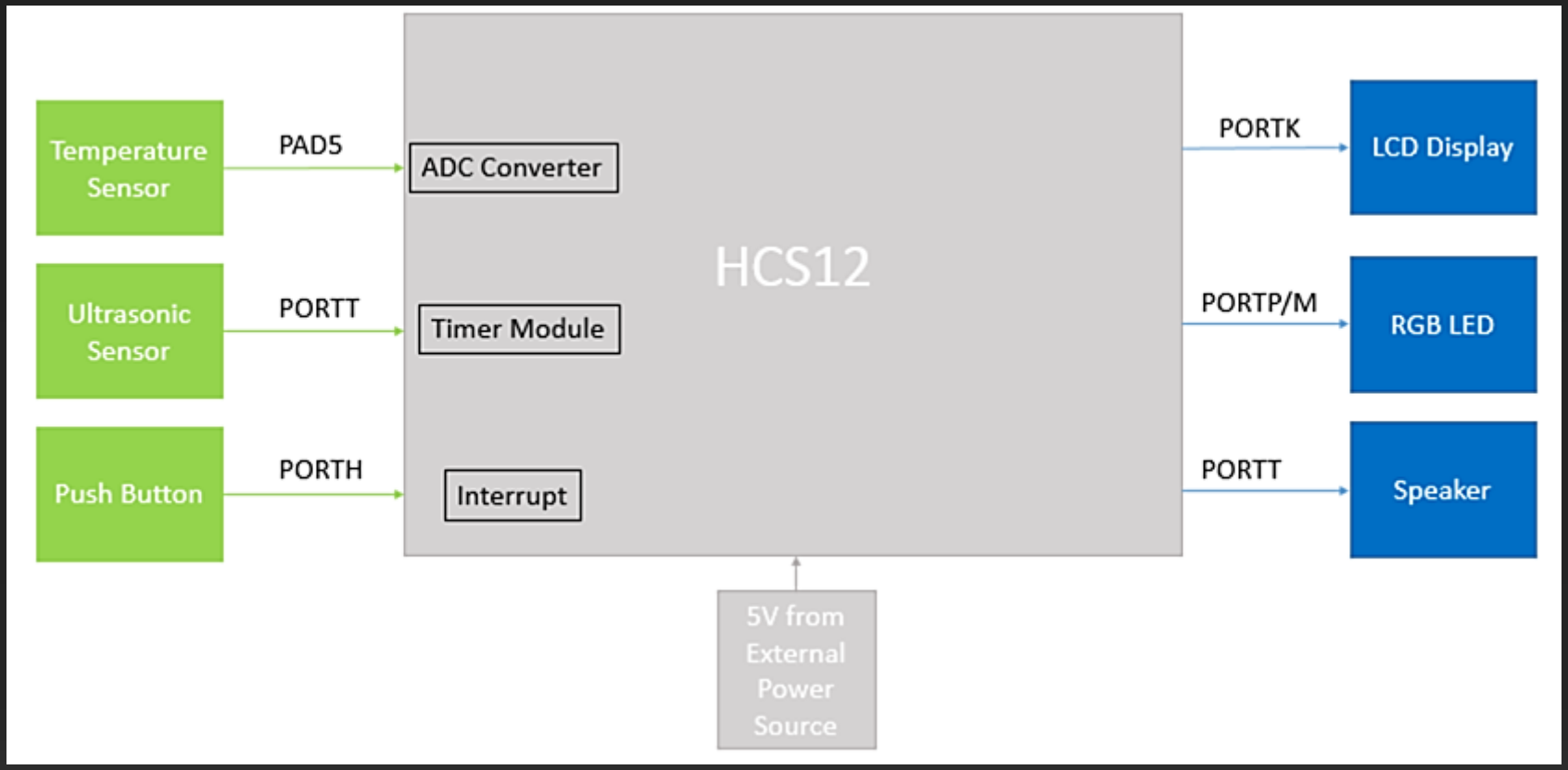
Project Introduction

- Vehicle electronics system simulator
- Dragon12 board provides easy system simulator
- Automotive driver information systems
  - Temperature monitor
  - Icy conditions warning LED
  - Ultrasonic parking proximity sensors

Motivation

- In-vehicle testing is expensive
  - Vehicle cost
  - Insurance
  - Fuel
- Fulfill a need for a development platform
  - Dragon12 board is portable and has small footprint

Features Walk-Through



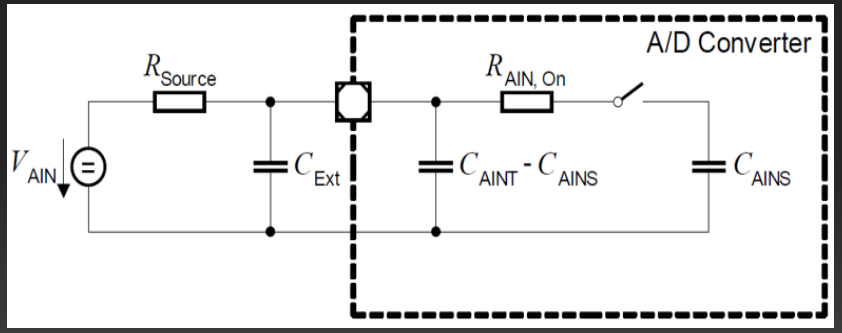
Temperature Sensing

- Many vehicle “features” use internal and/or external temperature
  - Climate Control
  - Weather warnings

- TI LM45 Sensor
  - On-board 0°C to 100°C but with HW modification can read -20°C to 100°C
    - Not used in this project due to the need for another voltage rail which was not in scope
  - MCU reads ADC signal from the sensor at a ~200ms rate

ADC Setup

- 2MHz ADC Clock
- Sample Hold Time set to 4 clock periods (2us) for extra confidence due to no timing constraints in this project
  - Target is 5tau based on the RC time constant calculated to reach 99% of the target voltage
  - LM45 does not have significant source resistance (not in datasheet) which means the charge share time is small (<400ns) which equates to 2us being enough time for proper accuracy



LCD Display

- Clear display needed for pleasant visual
- Hitachi HD44780
  - 16mm x 63mm display
  - Many fonts available along with text sizes
  - 4bit or 8bit data mode
- PORTK is used to control the display
  - 2 line, 5x7 font selected
  - 4bit data is used by sending the upper 4 bits first than the lower 4 bits (2 transfers)
    - This reduces the number of connections to the MCU
  - Mode pins are used to command display and write data to the display using the same 4 connections to the MCU (total of 7 connections)

Fahrenheit/Celsius Toggle

- Vehicles in North America need both F/C compatibility
- A push button is used to toggle a flag
  - If Celsius, display Celsius
  - If Fahrenheit, run the Celsius temp through the function (9/5)*temp+32, then display that value
- PORTH interrupt, called when the button is pressed, is used to toggle the flag

RGB LED Temperature Scale

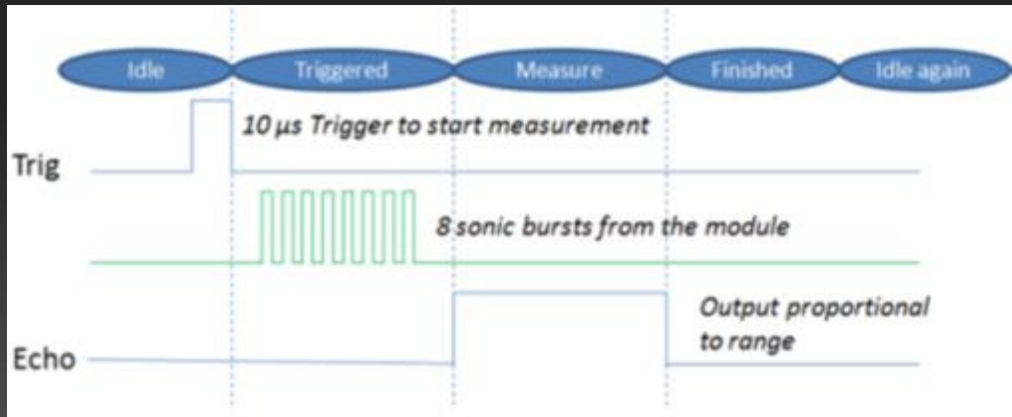
- Qualitative temperature indication
- Could warn driver of icy conditions
- RGB LED is connected to PWM ports 4, 5, and 6
- Varying the proportion of each color provides a continuous appearance
- Red when hot, Blue when cold, green mixed in to avoid purple (diagram)

RGB LED Temperature Scale, continued

- Integer math made the task more difficult
- PWM Duty Cycle 0-255
- Temperature min~0degC, Tmax~50degC
- Use of ADC counts not feasible because of temp sensor range (Only 1V change for 0degC-100degC)
- Qualitative indicator only

Ultrasonic Distance Sensor

- Used in industry to alert driver of obstacles at low speed
- The code uses an output compare register to trigger the HC-SR04 sensor's measurement routine
- The sensor requires one trigger pulse longer than 10uS and listens for the return signal.
- Device returns pulse with length corresponding to distance



Ultrasonic Distance Sensor, continued

- Distance corresponds to a frequency
  - Higher frequency indicates a closer object distance
- HC-SR04 sensor operates consistently in the 3cm to 3 meter range
- PP5, the 5th PWM port is wired to both the buzzer and the RGB LED
  - RGB LED chosen to use PWM
  - Speaker has selectable input
- As objects approach the sensor, the speaker pitch rises

Conclusions

- Could serve as the basis for a commercial test-bench
- Code written in functions to allow processor portability
- Temperature sensor could be replaced with any analog sensor- many automotive applications
- Ultrasonic sensor could be optimized to accommodate longer distances
- Project provided a great learning experience in C code, assembly, and microcontroller usage

Recommendations

- Temperature Sensor
  - Choose a sensor that has full automotive range -40°C to 125°C without HW modifications
    - Save external component cost
- LCD Display
  - Choose a display that uses less MCU pins which would communicate through SPI for example
    - Save MCU Cost
  - Ability to dim the display
- Temperature Warning
  - Choose a display to allow for snowflakes for cold and a thermometer for heat instead of RGB
  - Ability for user to change temperature limits/scale
- Ultrasonic Sensor
  - Select a sensor with an optimized sampling speed to ensure safety in high speed situations
  - Optimize circuit, implementing an op-amp to expand effective sensing to longer distances