**Introductory Description:**

If you drive, you must know that the difficult part of driving is to drive backward while backing up or parking. Because a driver can not see certain parts of the rear view from the driver seat, reverse driving has been troubling for many people. Hitting a pole can result in US$500-$1500 in damages to your vehicle while backing up your car just below 5 miles per hour. Moreover, small children sometimes are not possible to see from inside a car, especially when they are behind it. According to the data from the NSW Motor Accidents Authority, 17 children have been killed by reversing cars over the past three years. In fact, a friend of mine just hit a vehicle while backing up in a Western Washington University parking lot. Due to the facts above, a thought comes into my mind: I will design a Reversing Aid Sensor System (RASS) that will save lives and money.

The Reversing Aid Sensor System will save lives and money because it will detect objects that are behind the vehicle, and provides sound warnings and a distance readout. Moreover, the system will be designed for external installation: the sensors will be attached on the car rear lamp. This method will not require the user to make holes on a car, so the car appearance will be unchanged. The RASS will be easy and fast to install. It will let you overcome the blind spot of the rear view and guide you to drive in and out of a tight parking space.
General Description:

The Reversing Aid Sensor System will include a microcontroller unit (MCU), LED display, potentiometer, speaker, toggle switch, automobile power plug, and two ultrasonic sensors. Figure 1 depicts the major hardware of the RASS.

The ultrasonic sensors will be used to detect the distance from the vehicle to an object. After receiving the signals from the sensors, the microcontroller unit will output the ranging measurement in feet to the LED display and audible warning signals through the speaker. The rates and frequencies of the warning signals will be changed by the MCU depending on the distance between the vehicle and an object. The toggle switch will allow the driver to turn off the system when he/she doesn't need its assistance. The potentiometer will let users adjust the speaker volume according to their need. The RASS will consume power from the car battery.

Even though many similar products are in the market already, my Reversing Aid Sensor System will be a better choice to go with because the RASS will be installed externally. Since the device will not be activated through the shift stick of a vehicle, anyone will be able to install the RASS on his/her own. Besides, there will be another useful function in the device. By defining an absolute distance (15 feet behind the car) in the program code, the RASS will be activated if any object appears within the absolute distance. This feature will promote my RASS to another level: the RASS will warn a driver when another vehicle approaches his/her car on the road. The RASS will be suitable for all kinds of automobiles. After installing the system, you will enjoy the pleasure of driving ever after. Figure 2 illustrates a sketch of the overall assembled RASS prototype. The final product dimension will approximate be 3" high, 8" wide, and 5" deep, and the size of the ultrasonic sensor module will be 1.1" x 2.8" x 0.3".
Figure 1  System hardware

Figure 2  Sketch of Assembled device
Functional Description of Hardware:

The Reversing Aid Sensor System will include a M68HC912B32 microcontroller unit, 16 MHz crystal, 2-digit LED display, volume amplifier, toggle switch, reset circuit, power supply, and ultrasonic sensor module. Figure 3 depicts the block diagram of the hardware.

![Block diagram of the hardware](image)

Figure 3  Block diagram of the hardware
The Ultrasonic Sensor Module:

The ultrasonic sensor module will detect distance between the vehicle and an object. The sensor module will consist of an ultrasonic receiver and an ultrasonic transmitter. I will choose ultrasonic sensor because the sensor works well on broad area detection and non-contact distance measuring. Moreover, the ultrasonic sensor has unique advantages over conventional sensors. It measures and detects the distance to moving objects that can be any kind of shape, and it has a virtually unlimited maintenance-free life span. Also it is resistant to external disturbances such as vibration, so it can function properly when a vehicle is running on a bumpy road. The ultrasonic sensor is capable of distance measurement up to twenty feet accurately, and it is inexpensive compared to other sensors such as active optical sensors. A minimum distance (0.6 feet) between an object and the sensor is required to provide a time delay so that the echo can be interpreted.

The ultrasonic sensor module will communicate with the microcontroller unit. The module will have two inputs and one output. The transmit sensor will be connected to Port T (pin PT0) and it will send out an ultrasonic sound wave when receiving a signal from the MCU. The receive sensor will be connected to Port T (pin PT1) and it will send out a signal to the MCU when receiving the ultrasonic sound wave that bounces back from an object. The module will be also connected to Port P (pin PP0). The MCU will generate 40 kHz frequency through this pin to the module to drive the transmit sensor.

M68HC912B32 Microcontroller Unit:

The M68HC912B32 MCU will be operated by a 16 MHz oscillator (8 MHz bus frequency) in single-chip mode. It will calculate distance between the vehicle and an object. It will also output the distance measurement and audio warning.
The microcontroller unit will generate 40 kHz frequency through Port P (pin PP0) to drive the ultrasonic transmitter. At this point, the MCU will start counting time until receiving the returning wave from the ultrasonic receiver through Port T (pin PT1). The distance will be calculated by determining the time between the raising edges of transmitted and received signals (phase shift). The MCU will output the range measurement to the LED display. Port A (pins PA0-6) and Port B (pins PB0-1) will provide 9 I/O lines to control the LED. The MCU will also output warning signals through Port P (pins PP1-3) to the volume amplifier. The frequencies and rates of the warning signals will be changed depend on the distance between the vehicle and an object. The pulse-width modulation (PWM) will be used to generate the different frequencies. The frequency outputs are described as follows:

- 625 Hz through PP1 for 15 to 10 feet
- 1250 Hz through PP2 for 9 to 5 feet
- 2500 Hz through PP3 for 4 to 1 feet

The main program will be stored in the 32k bytes of Flash EEPROM, which can execute the program at high speed and keep the program when the power is off. The 1k bytes of RAM will be used for storing temporary variable stacks from the sensor sampling and the time loop.

*Reset Circuit (refer to Branden Le & Daniel Dorker's Web Control System):*

The reset circuit will reset the microcontroller unit whenever the supply voltage drops below approximately 4.59V. To prevent unintentional resets, the signal will be pulled high by a resistor. The circuit input will be connected to the 5V voltage source (the
output of the voltage regulator), and the circuit output will be connected to the /RESET, pin 32, of the MCU.

Crystal Circuit (refer to Branden Le & Daniel Dorker's Web Control System):

The crystal circuit will utilize the microcontroller unit common XTAL connection. The 16 MHz crystal will be connected in parallel with a resistor to the Crystal Driver (XTAL), pin 34, and the External Clock Input (EXTAL), pin 33, of the MCU. Each of the crystal pins will be also connected to ground through two capacitors.

LED display:

The detecting range of the Reversing Aid Sensor System will be defined between 15 feet to 1 foot at the resolution of one foot. Therefore, a 2-digit LED will be needed in order to display the distance of 15, 14, 13…3, 2, 1 feet. Because the most-digit will only go to 1 and two decimal points will not be displayed, only 9 connections of the LED will be used. The LED display will be connected to Port A (pins PA0-6) and Port B (pins PB0-1) of the microcontroller unit.

Volume Amplifier:

After determining the distance between the vehicle and an object, the microcontroller unit will output an audible warning signal through the volume amplifier. The volume amplifier will output sound at the different rates and frequencies depending on the range between the vehicle and an object. The pulse-width module will be used to
generate the different frequencies. The volume amplifier will be connected to Port P (pins PP1-3) of the microcontroller unit.

*Power Supply:*

By using an automobile power plug, a car battery will be used to supply power to the microcontroller unit. A car battery is not a stable voltage source because its voltage output jumps between 12 VDC to 14 VDC. Hence, the input voltage to the MCU will be regulated to 5 VDC by a voltage regulator.

**Software requirement and description:**

The software for the Reversing Aid Sensor System will be written in either assembly language or C language. The program will contain several modules that include: Timer, Signal, Range, Display, and Alarm module. The functions of the modules are described as follows:

Timer Module: This module will count time.

Signal Module: This module will monitor the signals that are transmitted and received by the ultrasonic sensor module.

Sensor Module: This module will drive the ultrasonic transmit sensor.

Range Module: This module will calculate the distance between the vehicle and an object.

Display Module: This module will display the distance measurement.

Alarm Module: This module will output audio signals to warn the driver if an object is close to the vehicle.
**User Interface Description:**

The user interface will include a 2-digit LED display, potentiometer, and toggle switch (Figure 4). The toggle switch will allow a driver to turn off the system when he/she doesn't need its assistance. The potentiometer will let users adjust the speaker volume according to their need. The LED display will indicate the distance in feet between the vehicle and an object. The digits of the LED will be determined by the biggest number that will be displayed, which will be 15. I will define 15 feet to be the maximum distance output number because it is about the length of a car.

![Figure 4 The user interface layout](image)

**Development Plan:**

During this Christmas break, I will develop a rough draft program code in assembly language. When the winter quarter starts, I will audit ETec 454 class, which focuses on writing C language to operate embedded system. As the class goes on, I will develop a rough draft program code in C language. Depending on the progress of two code developments, I will decide which code to use for my final product.

Along with the software development, I will also start building the hardware. This project success will revolve around the sensor signals sampling and the warning signals
output. I hope to accomplish the development in these two areas at the end of the winter quarter. A breakdown of tasks to be complete is described as follows:

Christmas break:

Week 1: Develop Timer and Signal module in assembly language.
Week 2: Develop Sensor and Range module in assembly language.
Week 3: Develop Display and Alarm module in assembly language.

Winter quarter:

Week 1: Study C language along with the class.
Week 2: Develop the power supply circuit.
Week 3: At this point I should have all the hardware I need.
Week 4: Test and modify the ultrasonic sensor module.
Week 5: Test and modify the ultrasonic sensor module.
Week 6: Test and modify the ultrasonic sensor module.
Week 7: Develop Timer module.
Week 8: Develop Timer module.
Week 9: Develop Signal module.
Week 10: Develop Signal module.
Week 11: Develop Range module.
Week 12: Implement the sensor module with the MCU.

Spring quarter:

Week 1: Develop Display module.
Week 2: Implement the LED display with the MCU.
Week 3: Develop Alarm module.
Week 4: Implement the volume amplifier circuit with the MCU.

Week 5: Project design review.

Week 6: System testing and trouble shooting.

Week 7: System testing and trouble shooting.

Week 8: Organize the hardware into a prototype.

Week 9: Set up for the demonstration.

Week 10: Project demonstration.

Development Hardware and software:

The Reversing Aid Sensor System will be developed in Western Washington University's ETEC lab, room 340. This lab contains all the development hardware and software for the project. Development hardware will consist of a digital multimeter, oscilloscope, solder iron, debug 12, M68HC912B32 microcontroller unit, and personal computer. Development software will include Codewright, Noral, Microsoft Office, and Pspice.

Demonstration Prototype:

The Reversing Aid Sensor System prototype will be a standalone device. The construction of the prototype will include a M68HC912B32 microcontroller unit, 16 MHz crystal, 2-digit LED display, toggle switch, potentiometer, speaker, power supply, and internal circuits in an enclosure. The ultrasonic sensor module will be connected to the MCU through long wires.
The Reversing Aid Sensor System prototype will be demonstrated with a roller chair. The device itself will be secured on the right handle of the chair, and the sensor module will be attached on the back of the chair during the demonstration. Furthermore, I will tape the floor at every foot. People will actually “drive” the chair and compare the LED readout with the distance between the chair and an object. Driver will experience how the RASS shows them exact distance between the car and an object behind, and then avoid damaging the vehicle.

**Electrical Specifications:**

*Project specification:*

- Resolution: 1 foot
- Range: 1 to 15 feet
- Sensor: broad angle detection
- Sampling rate: 67 mS
- Speaker frequency range: 625 ~ 2500 Hz
- Volume level range: 58 ~ 74 dB

*Power requirements:*

- 12 VDC car battery
- Total worst-case power dissipation: 3.9 W

*Special environmental requirements:*

- Operating temperature range: -80° F to +135° F
- Shock proof (Final Product)
- Water Proof Sensor (Final Product)
### Preliminary Parts List:

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<tr>
<th>Description</th>
<th>Part number</th>
<th>Source</th>
<th>Price ($)</th>
<th>Power Dissipation (max)</th>
<th>Lead Time</th>
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