Automatic Braking System for Forward Collision Avoidance

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***Abstract*: The work presents an ultrasonic automatic braking system for forward collision avoidance with accelerator pedal disengagement mechanism. This system consists of ultrasonic sensors namely ultrasonic wave emitter and ultrasonic wave receiver. The ultrasonic wave emitter is provided in front portion of the car, producing and emitting ultrasonic waves in a predetermined distance in front of the car. Ultrasonic wave receiver is also provided in front portion of the car, receiving the reflected ultrasonic wave signal from the obstacle. The reflected wave (detection pulse) is measured to get the distance between vehicle and the obstacle. Then PIC microcontroller is used to control the servo motor based on detection pulse information, and the servo motor in turn automatically controls the braking of the car. The present work demonstrates the possible use of an accelerator pedal disengagement mechanism in this system, by which the accelerator pedal is automatically disengaged once the braking starts. Thus, even if the acceleration pedal is pressed the vehicle won't accelerate and this will prevent the collision. This solves the problem of safety in case the accelerator pedal is pressed when the vehicle is expected to brake.**

***Keywords*: Automatic Braking, Collision Detection, Accident, Road Safety, Vehicle Security**

1. Introduction

1.1 Background

Driving is a compulsory activity for most people. The number of vehicles is increasing day by day. It is produced tacked tightly and risk to accident. Nowadays, the numbers of accident is so high and uncertainly. Accident will occurs every time and everywhere and cause worst damage, serious injury and dead. These accidents are mostly cause by delay of the driver to hit the brake. To prevent the accidents caused by this delay, ultrasonic braking system is used in automobiles.

The main target of the ultrasonic braking system is that, cars should automatically brake when the sensors sense the obstacle. This is a technology for automobiles to sense an imminent forward collision with another vehicle or an obstacle, and to brake the car accordingly, which is done by the braking circuit. This system includes two ultrasonic sensors viz. ultrasonic wave emitter and ultrasonic wave receiver. The ultrasonic wave emitter provided in front portion of an automatic braking car, producing and emitting ultrasonic waves in a predetermined distance in front of the car. Ultrasonic wave receiver is also provided in front portion of the car, receiving the reflected ultrasonic wave signal from the obstacle. The reflected wave (detection pulse) is measured to get the distance between vehicle and the obstacle. Then PIC microcontroller is used to control the servo motor based on detection pulse information and the servo motor in turn automatically controls the braking of the car. Thus, this new system is designed to solve the problem where drivers may not be able to brake manually exactly at the required time, but the vehicle can still stop automatically by sensing the obstacles to avoid an accident.

1.2 Objective

To develop a safety car braking system using ultrasonic sensor to design a vehicle with less human attention to the driving

1.3 Scope Of Project

- To develop an ultrasonic sensor to detect the obstacle
- To process the output from the ultrasonic sensor to drive the servo motor as an actuator.

1.4 Methodology

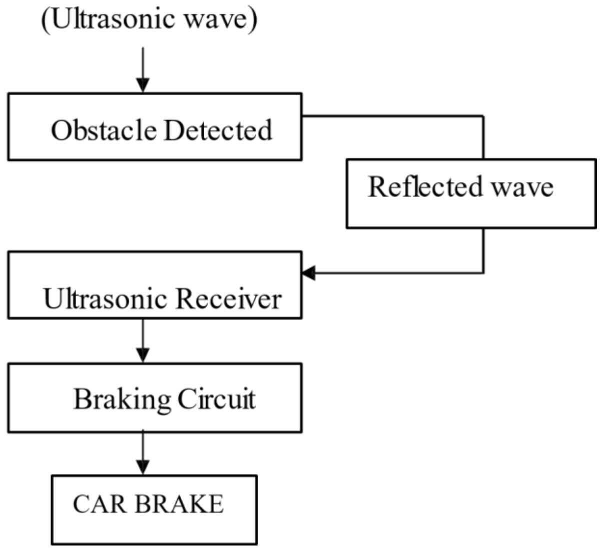

Figure 1.1 - Block Diagram of the System

1.5 Principal Components of Ultrasonic Braking System

- Sensor
- Transducer
- Ultrasonic Sensor
- Operational Amplifier and ADC
- Braking Circuit
- Servomotor

1.5.1 Sensor

A sensor is an electrical device that maps an environmental attribute to a quantitative measurement. Each sensor is based on transduction principle which is conversion of energy from one form to another form. There are two important terms related to any sensor:

- **Target Angle:** This term refers to the 'tilt response' limitations of a given sensor. Since the ultrasonic waves reflect off the target object, target angles indicate acceptable amounts of tilt for a given sensor.
- **Beam Spread:** This term refers to the maximum angular spread of the ultrasonic waves as they leave the transducer.

1.5.2 Transducer

A transducer is an energy conversion device which converts one form of energy into another. In the ultrasonic sensors they are used to convert electrical energy into ultrasonic energy and vice-versa. In this system piezoelectric transducers are used, which create ultrasonic vibration through use of piezoelectric materials such as certain forms of crystals or ceramic polymers. Their working is based on the piezoelectric effect. This effect refers to the voltage produced between surfaces of a solid, (non-conducting substance) when a mechanical stress is applied to it. Conversely, when a voltage is applied across surfaces of a solid that exhibits piezoelectric effect, the solid undergoes mechanical distortion.

1.5.3 Ultrasonic Sensor

Ultrasonic ranging and detecting devices use high frequency sound waves called ultrasonic waves to detect presence of an object and its range. Normal frequency range of human ear is roughly 20Hz to 20,000Hz. Ultrasonic sound waves are sound waves that are above the range of human ear, and thus have frequency above 20,000Hz. An ultrasonic sensor necessarily consists of a transducer for conversion of one form of energy to another, a housing enclosing the ultrasonic transducer and an electrical connection. These sensors are of two types:

- **Ultrasonic Transmitter –** Before transmit the ultrasonic wave, there is a part which is ultrasonic wave generator that function to generate ultrasonic wave. In that part, there is timing instruction means for generating an instruction signal for intermittently providing ultrasonic waves.

This signal will send to an ultrasonic wave generator for generating ultrasonic waves based on the instruction signal from said timing instruction means (transform electrical energy into sound wave). After ultrasonic wave was produced, ultrasonic transmitter transmits the ultrasonic waves toward a road surface to find out the obstacle. The range that obstacle detected is depends on the range of ultrasonic sensors that used.

- **Ultrasonic Receiver –** If the ultrasonic wave detects the obstacle, it will produce a reflected wave. An ultrasonic receiver is used for receiving the ultrasonic waves reflected from the road surface to generate a reception signal. There is ultrasonic transducer that will transform back the sound wave to electrical energy. This signal amplified by an amplifier. The amplified signal is compared with reference signal to detect components in the amplified signal due to obstacles on the road surface. The magnitude of the reference signal or the amplification factor of the amplifier is controlled to maintain a constant ratio between the average of the reference signal and the average of the amplified signal.

1.5.4 Operational Amplifier and ADC

An operational amplifier, usually referred to as op-amp, is a high gain voltage amplifier with differential inputs and a single output. The amplifier's differential inputs consist of an inverting input and a non-inverting input. The op-amp amplifies only the difference in the voltage between the two inputs called the 'differential input voltage'. The output voltage of the op- amp is controlled by feeding a fraction of output signal back to the inverting input. This is known as negative feedback. Due to the amplifier's high gain, the output voltage for any given input is only controlled by the negative feedback.

The amplified signal is a square pulse which is given to the ADC. ADC (Analog to Digital Converter) converts input analog signal to corresponding digital signal. The digital signal is given to the microcontroller.

1.5.5 Braking Circuit

The processed i.e. the amplified digital signal is sent to the braking circuit.

PIC (Peripheral Interface Controller) – The microcontroller used is PIC 16F84 which is 8-bit microcontroller. PIC microcontrollers are made by microchip technology. PICs are used in this system due to their low cost and wide availability. The numbers of instructions to perform a variety of operations vary from 35 instructions in low-end PICs to about 70 instructions in highend PICs. It is programmed by using C language.

The signal from the ADC is processed by the PIC microcontroller, and it gives an instruction as an output, based on the condition of the signal, to the servo motor. The signal received from the ADC is also displayed on the LCD display (which gives an audio-visual warning on the windshield in the driver's field of view), and it gives the distance between the front of the vehicle and the obstacle. The distance value at which automatic braking should start is already stored in the microcontroller. When the measured distance reaches this value, the PIC automatically sends the signal to the servo motor which in turn controls braking through mechanical arrangements.

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1.5.6 Servo Motor

The output of the PIC is the input of the servo motor. The servo motor allows for precise control of angular position, velocity and acceleration. It consists of a motor coupled to a sensor for position feedback. Thus, it is a closed loop mechanism that uses position feedback to control its motion and final position. The input to it is a signal, either analog or digital, representing the position commanded for the output shaft. The measured position of the output shaft is compared to the command position (the external input to the motor). If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction as needed, to bring the output shaft to the appropriate position. As the required position approaches, the error signal reduces to zero and the motor stops.

The output shaft of servo motor is capable of travelling somewhere around 180 degrees. A normal servo motor is used to control an angular motion between 0 and 180 degrees, and it is mechanically not capable of turning any farther due to a mechanical stop built on to the main output gear. The angle through which the output shaft of the servo motor need to travel is determined according to the nature of the signal given to the motor as input from the PIC.

The servo motor controls the braking through mechanical arrangements. This is done by using a pair of crossed helical gears and a grooved cylindrical component. The larger gear is mounted on the output shaft of the servo motor and the smaller is mounted on the master cylinder piston rod. Thus, when the output shaft of the servomotor and hence the larger gear rotates in say anticlockwise direction, the smaller gear and hence the master cylinder piston rod rotates in clockwise direction. Due to the groove on the cylindrical component translatory motion is also produced. This is due to a pin, one end of which is inserted in the groove and the other end is fixed rigidly to a support. Thus, a combination of translatory as well as rotary motion is produced. Hence, the fluid pressure is applied due to stretching out of the master cylinder piston (in the same manner as that of the brake pedal) thus resulting in braking of the car. The piston returns to the original position when the servo motor output shaft rotates in clockwise direction. Thus, the speed of the car reduces for clockwise rotation of the smaller gear (i.e. anticlockwise rotation of larger gear and hence the servo motor output shaft). Thus, the servo motor is used to control the brakes, when the PIC gives the signal to the servo motor, based upon the distance measured by means of sensors. This constitutes the braking circuit.

2. Review of Literature

2.1 Fundamentals of Sensors

In the broadest definition, a sensor is an object whose purpose is to detect events or changes in its environment, and then provide a corresponding output. A sensor is a type of transducer; sensors may provide various types of output, but typically use electrical or optical signals. For example, a thermocouple generates a known voltage (the output) in response to its temperature (the environment). A mercury-in-glass thermometer, similarly, converts measured temperature into expansion and contraction of a liquid, which can be read on a calibrated glass tube.

Sensors are used in everyday objects such as touch-sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base, besides innumerable applications of which most people are never aware. With advances in micro-machinery and easy-to-use micro controller platforms, the uses of sensors have expanded beyond the most traditional fields of temperature, pressure or flow measurement, for example into MARG sensors. Moreover, Analog sensors such as potentiometers and force-sensing resistors are still widely used. Applications include manufacturing and machinery, airplanes and aerospace, cars, medicine, and robotics.it is also included in our day-to-day life.

2.1.1 Ultrasonic Sensor

Ultrasonic ranging and detecting devices use high-frequency sound waves to detect the presence of an object and its range. The systems either measure the echo reflection of the sound from objects or detect the interruption of the sound beam as the objects pass between the transmitter and receiver.

An ultrasonic sensor typically utilizes a transducer that produces an electrical output in response to received ultrasonic energy. The normal frequency range for human hearing is roughly 20 to 20,000 hertz. Ultrasonic sound waves are sound waves that are above the range of human hearing and, thus, have a frequency above about 20,000 hertz. Any frequency above 20,000 hertz may be considered ultrasonic. Most industrial processes, including almost all source of friction, create some ultrasonic noise.

The ultrasonic transducer produces ultrasonic signals. These signals are propagated through a sensing medium and the same transducer can be used to detect returning signals. Ultrasonic sensors typically have a piezoelectric ceramic transducer that converts an excitation electrical signal into ultrasonic energy bursts. The energy bursts travel from the ultrasonic sensor, bounce off objects, and are returned toward the sensor as echoes. Transducers are devices that convert electrical energy to mechanical energy, or vice versa. The transducer converts received echoes into Analog electrical signals that are output from the transducer.

The piezoelectric effect refers to the voltage produced between surfaces of a solid dielectric (non-conducting substance) when a mechanical stress is applied to it. Conversely when a voltage is applied across certain surfaces of a solid that exhibits the piezoelectric effect, the solid undergoes a mechanical distortion. Such solids typically resonate within narrow frequency ranges. Piezoelectric materials are used in transducers, e.g., phonograph cartridges, microphones, and strain gauges that produce an electrical output from a mechanical input. They are also used in earphones and ultrasonic transmitters that produce a mechanical output from an electrical input.

Ultrasonic transducers operate to radiate ultrasonic waves through a medium such as air. Transducers generally create ultrasonic vibrations through the use of piezoelectric materials such as certain forms of crystal or ceramic polymers.

2.1.2 Ultrasonic Sensing and Control

Ultrasonic signals are like audible sound waves, except the frequencies are much higher. Our ultrasonic transducers have piezoelectric crystals which resonate to a desired frequency and convert electric energy into acoustic energy and vice versa. The illustration shows how sound waves, transmitted in the shape of a cone, are reflected from a target back to the transducer. An output signal is produced to perform some kind of indicating or control function. A minimum distance from the sensor is required to provide a time delay so that the "echoes" can be interpreted. Variables which can affect the operation of ultrasonic sensing include, target surface angle, reflective surface roughness or changes in temperature or humidity. The targets can have any kind of reflective form - even round objects.

2.2 Measurement Principle and Effective Use of Ultra Sonic Sensor

Ultrasonic sensor transmits ultrasonic waves from its sensor head and again receives the ultrasonic waves reflected from an object. By measuring the length of time from the transmission to reception of the sonic wave, it detects the position of the object. The ultrasonic transducer produces ultrasonic signal. These signals are propagated through a sensing medium and the same transducer can be used to detect returning signals. In most applications, the sensing medium is simply air. An ultrasonic sensor typically comprises at least one ultrasonic transducer which transforms electrical energy into sound and in reverse sound into electrical energy, a housing enclosing the ultrasonic transducer, an electrical connection and optionally, an electronic circuit for signal for signal processing also enclosed in the housing.

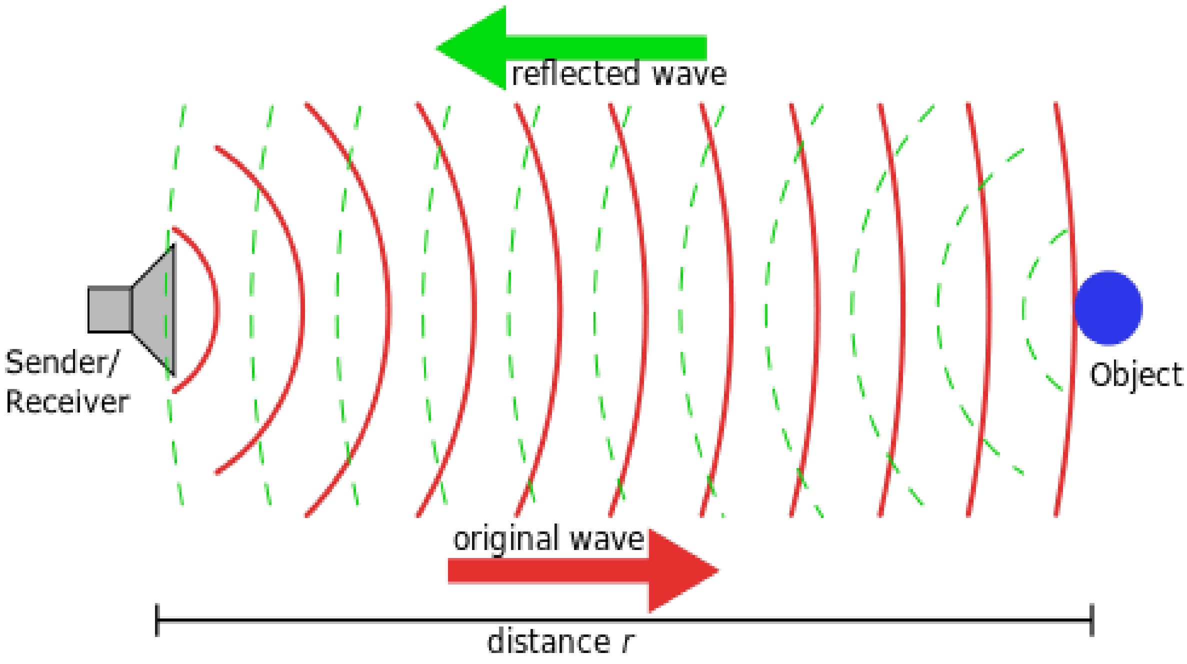


Figure 2.1 - Basic Ultrasonic Operation

2.3 Advantages of Ultrasonic Sensors

Ultrasonic have a lot of advantages for using in real application. The advantages of ultrasonic sensor are:

- Discrete distances to moving objects can be detected and measured.
- Less affected by target materials and surfaces, and not affected by colour. Solid-state units have virtually unlimited, maintenance free life. Ultrasonic can detect small objects over long operating distances.
- Resistance to external disturbances such as vibration, infrared radiation, ambient noise, and EMI radiation.
- Measures and detects distances to moving objects. • Impervious to target materials, surface and colour.
- Solid-state units have virtually unlimited, maintenance free lifespan.
- Detects small objects over long operating distance.
- Ultrasonic sensors are not affected by dust, dirt or high moisture environments.

2.4 Disadvantages of Ultrasonic Sensors

Some disadvantages of ultrasonic sensor are:

- Overheating of a wave emitter precludes the energy of ultrasonic waves emitted there from being enhanced to a practical level.
- Interference between the projected waves and the reflected waves takes place, and development of standing waves provides adverse effects.
- It is impossible to discern between reflected waves from the road surface and reflected waves from other places or objects.

2.5 Target Angle and Beam Spread

This term refers to the "tilt response" limitations of a given sensor. Since ultrasonic sound waves reflect off the target object, target angles indicate acceptable amounts of tilt for a given sensor. This term is defined as the area in which a round wand will be sensed if passed through the target area. This is the maximum spreading of the ultrasonic sound as it leaves the transducer.

2.6 Effect of Environmental factors on Ultrasonic sensor

There are many factors present in the environment which can affect the working of ultrasonic sensor. They are:

2.6.1 Temperature

The velocity of sound in air is 13,044 inches/s at 0 ^{0}C, it is directly proportional to air temperature. As the ambient air temperature increases, the speed of sound also increases. Therefore if a fixed target produces an echo after a certain time delay, and if the temperature drops, the measured time for the echo to return increases, even though the target has not moved.

This happens because the speed of sound decreases, returning an echo more slowly than at the previous, warmer temperature. If varying ambient temperatures are expected in a specific application, compensation in the system for the change in sound speed is recommended.

2.6.2 Air Turbulence and Convection Current

A particular temperature problem is posed by convection currents that contain many bands of varying temperature. If these bands pass between the sensor and the target, they will abruptly change the speed of sound while present. No type of temperature compensation (either temperature measurement or reference target) will provide complete high-resolution correction at all times under these circumstances. In some applications it may be desirable to install shielding around the sound beam to reduce or eliminate variations due to convection currents. Averaging the return times from a number of echoes will also help reduce the random effect of convection.

2.6.3 Atmospheric Pressure

Normal changes in atmospheric pressure will have little effect on measurement accuracy. Reliable operation will deteriorates however, in areas of unusually low air pressure, approaching a vacuum.

2.6.4 Humidity

Humidity does not significantly affect the operation of an ultrasonic measuring system. Changes in humidity do have a slight effect, however, on the absorption of sound. If the humidity produces condensation, sensors designed to operate when wet must be used.

2.6.5 Acoustic Interference

Special consideration must be given to environments that contain background noise in the ultrasonic frequency spectrum. For example, air forced through a nozzle, such as air jets used for cleaning machines, generates a whistling sound with harmonics in the ultrasonic range. When in close proximity to a sensor, whether directed at the sensor or not, ultrasonic noise at or around the sensor's frequency may affect system operation. Typically, the level of background noise is lower at higher frequencies, and narrower beam angles work best in areas with a high ultrasonic background noise level. Often a baffle around the noise source will eliminate the problem. Because each application differs, testing for interference is suggested.

2.7 Sensor's Target Considerations

For detecting a target, the ultrasonic sensor takes into consideration the various properties of the target. They are:

2.7.1 Composition

Nearly all targets reflect ultrasonic sound and therefore produce an echo that can be detected. Some textured materials produce a weaker echo, reducing the maximum effective sensing range. The reflectivity of an object is often a function of frequency. Lower frequencies can have reduced reflections from some porous targets, while higher frequencies reflect well from most target materials. Precise performance specifications can often be determined only through experimentation.

2.7.2 Shape

A target of virtually any shape can be detected ultrasonically if sufficient echo returns to the sensor. Targets that are smooth, flat, and perpendicular to the sensor's beam produce stronger echoes than irregularly shaped targets. A larger target relative to sound wavelength will produce a stronger echo than a smaller target until the target is larger than approximately 10 wavelengths across. Therefore, smaller targets are better detected with higher frequency sound. In some applications a specific target shape such as a sphere, cylinder, or internal cube corner can solve alignment problems between the sensor and the target.

2.7.3 Target Orientation

To produce the strongest echoes, the sensor's beam should be pointed toward the target. If a smooth, flat target is inclined off perpendicular, some of the echo is deflected away from the sensor and the strength of the echo is reduced. Targets that are smaller than the spot diameter of the transducer beam can usually be inclined more than larger targets. Sensors with larger beam angles will generally produce stronger echoes from flat targets that are not perpendicular to the axis of the sound beam. Sound waves striking a target with a coarse, irregular surface will diffuse and reflect in many directions. Some of the reflected energy may return to the sensor as a weak but measurable echo. As always, target suitability must be evaluated for each application.

2.8 Servo Operation

The servo motor has some control circuits and a potentiometer (a variable resistor) that is connected to the output shaft. In the picture above, the pot can be seen on the right side of the circuit board. This pot allows the control circuitry to monitor the current angle of the servo motor. If the shaft is at the correct angle, then the motor shuts off. If the circuit finds that the angle is not correct, it will turn the motor the correct robots direction until the angle is correct. The output shaft of the servo is capable of traveling somewhere around 180 degrees. Usually, it is somewhere in the 210 degree range, but it varies by manufacturer. A normal servo is used to control an angular motion of between 0 and 180 degrees. A normal servo is mechanically not capable of turning any farther due to a mechanical stop built on to the main output gear.

The amount of power applied to the motor is proportional to the distance it needs to travel. So, if the shaft needs to turn a large distance, the motor will run at full speed. If it needs to turn only a small amount, the motor will run at a slower speed. This is called proportional control.

The control wire is used to communicate the angle. The angle is determined by the duration of a pulse that is applied to the control wire. This is called Pulse Coded Modulation. The servo expects to see a pulse every 20 milliseconds (.02 seconds). The length of the pulse will determine how far the motor turns. A 1.5 millisecond pulse, for example, will make the motor turn to the 90 degree position (often called the neutral position). If the pulse is shorter than 1.5 millisecond, then the motor will turn the shaft to closer to 0 degrees. If the pulse is longer than 1.5 ms, the shaft turns closer to 180 degrees.

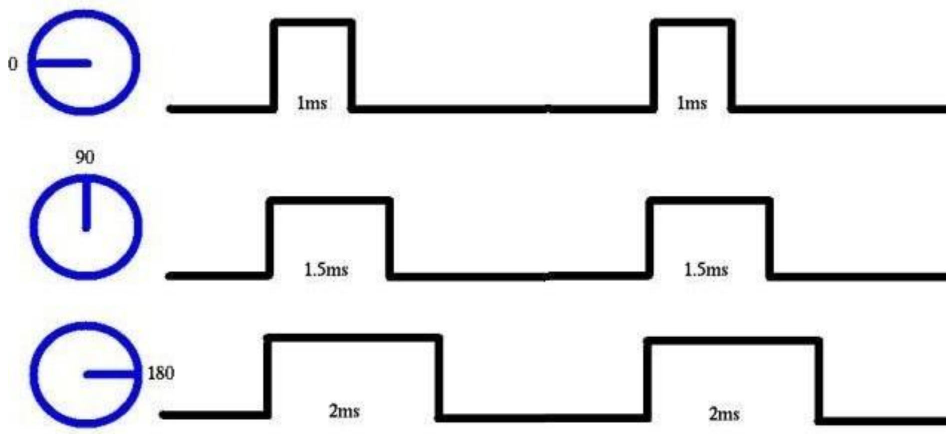


Figure 2.2 - Servo Motor Movement Timing

From the figure above, the duration of the pulse dictates the angle of the output shaft (shown as the blue circle with the arrow). Note that the times here are illustrative and the actual timings depend on the motor manufacturer. The principle, however, is the same.

2.9 Arduino

Arduino is a software company, project, and user community that designs and manufactures computer open-source hardware, open-source software, and microcontroller-based kits for building digital devices and interactive objects that can sense and control physical devices.

The project is based on microcontroller board designs, produced by several vendors, using various microcontrollers. These systems provide sets of digital and Analog I/O pins that can interface to various expansion boards (termed shields) and other circuits. The boards feature serial communication interfaces, including Universal Serial Bus (USB) on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on a programming language named Processing, which also supports the languages C and C++.

The first Arduino was introduced in 2005, aiming to provide a low cost, easy way for novices and professionals to create devices that interact with their environment using sensor and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

Arduino boards are available commercially in preassembled form, or as do-it-yourself kits. The hardware design specifications are openly available, allowing the Arduino boards to be produced by anyone.

3. Accelerator Disengagement Mechanism

3.1 Drawing of the mechanism

The drawing of Accelerator disengagement mechanism is as:

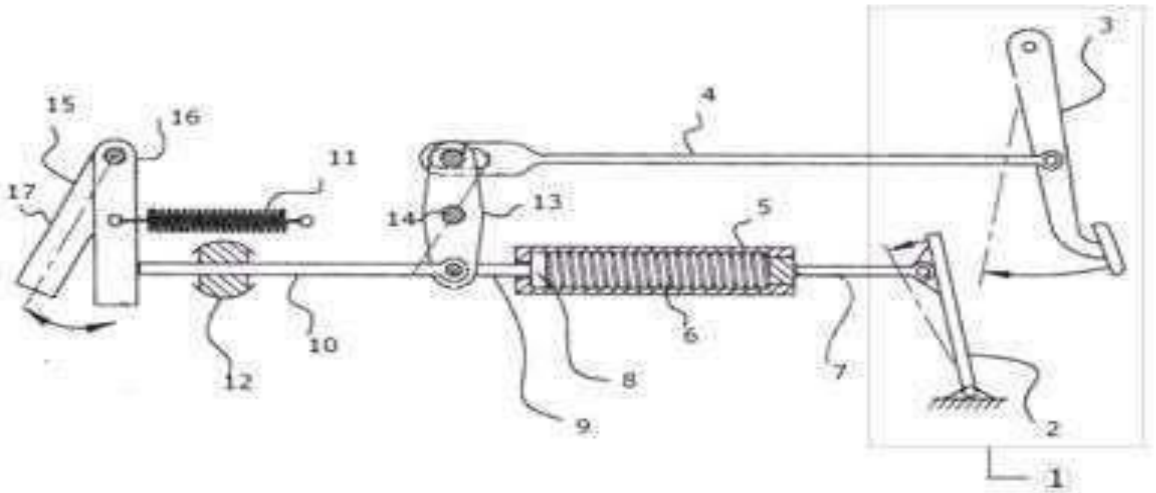


Figure 3.1 - Accelerator Disengagement Mechanism

3.1.1 Components in the Mechanism

The following list of numbers corresponds to a particular element of the system:

1. Brake Pedal and Accelerator Pedal Assembly

2. Accelerator Pedal
3. Brake Pedal
4. Connecting Rod
5. Spring Housing
6. First Spring
7. First Pushrod
8. Piston
9. Second Pushrod
10. Third Pushrod
11. Second Spring
12. Bushing
13. Lever
14. Fixed Axis
15. Engine Control Lever
16. First/Disengaged Position of Engine Control Lever
17. Second/Engaged Position of Engine Control Lever

Accelerator is operatively connected to an engine control lever that moves between an engaged and a disengaged position. When the accelerator is pressed, the engine control lever moves to the engaged position to accelerate the vehicle. When the accelerator is not pressed, the engine control lever moves to the disengaged position so the vehicle does not accelerate. An accelerator pedal disengagement mechanism moves the engine control lever to the disengaged position when the brake pedal is pushed, which prevents the accelerator pedal from causing the engine control lever to move to the engaged position when both the accelerator pedal and brake pedal are pressed. Thus, the system prevents the accelerator pedal and brake pedal from simultaneously fighting each other.

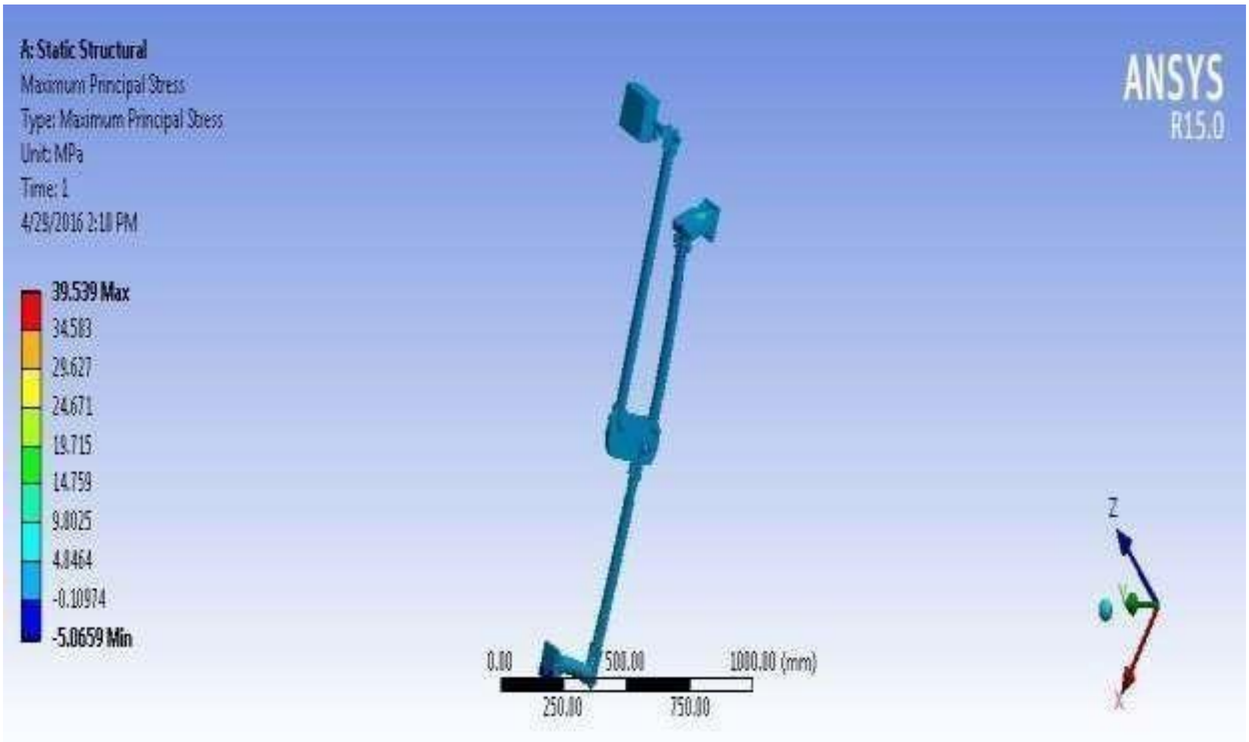
The combined brake pedal and accelerator pedal assembly comprises of an accelerator pedal, a brake pedal and an accelerator pedal disengagement mechanism which is controlled by the brake pedal. If the brake pedal is pressed, this mechanism allows the accelerator pedal to be disengaged, if the accelerator pedal is pressed simultaneously. The accelerator pedal disengagement mechanism causes the throttle to return to the idle position and also physically blocks the accelerator from being pressed.

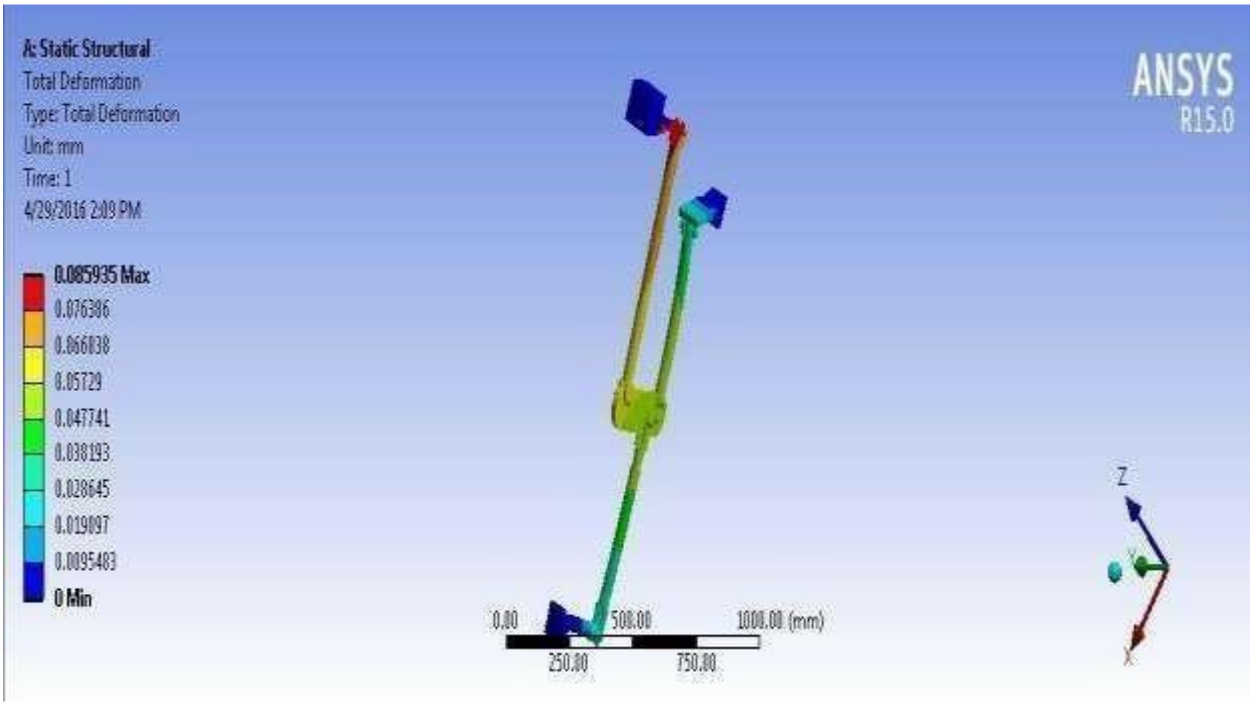
The accelerator pedal is connected to one end of the first pushrod. The other end of the first pushrod is attached to a first spring in a spring housing. The first spring pushes on a piston.

The piston is connected to a second pushrod, which is generally attached perpendicular to the lever. The lever is pivoted about a fixed axis. The brake pedal is connected to one end of the connecting rod. The other end of the connecting rod is attached to the lever as shown in the figure. When the accelerator is pushed, the lever moves to the first position, which corresponds to the accelerator functioning to accelerate the vehicle. When the brake pedal is pressed, the lever moves to the second position, which corresponds to the accelerator not functioning to accelerate the vehicle.

A third pushrod is also attached perpendicular to the lever (opposite to the second pushrod) as shown in the figure. Its movement is constrained in a single plane by a bushing. The third pushrod connects with the bottom end of an engine control lever. The engine control lever causes the engine to accelerate. The engine control lever can pivot between an engaged position and a disengaged position. The engine control lever is biased in the disengaged position by a second spring. When the accelerator is pushed, the lever pushes the third pushrod. The third pushrod pivots the engine control lever to the engaged position. When the driver stops pressing on the accelerator, the lever moves back to the initial position and the engine control lever returns to the disengaged position.

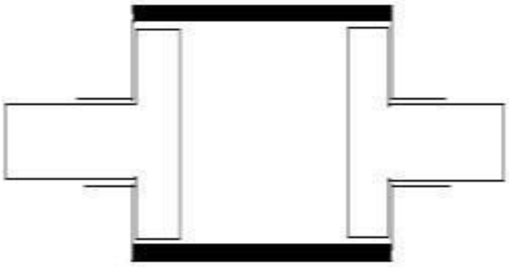
3.2 Analysis of the Mechanism





3.3 Proposed Improvement in the System

- One major problem with the above proposed model is the sudden jerk given to the accelerator pedal when the servo motor comes into play. This happens because as soon as the SCU senses a potential threat, it gives signals to the servo to disengage the pedal immediately.
- The second problem is with the SCU. Since as soon as the speed of car rises and any obstacle comes in the front, the system disengages the accelerator pedal and no further acceleration can be achieved. This possesses a problem in case the driver wants to overtake.



4. Sensing and Controlling Unit

The Sensing and Controlling unit, is that part of this system which senses the object or obstruction in front of the car, measures the distance and the approaching velocity and then sends necessary signals to the servo motor and hence to the Automatic Braking Unit. Its components consist of Arduino as a microcontroller, Servo motor, Ultrasonic Transducer and a power source to keep the system running. The Arduino is coded by a software called Arduino 1.6, a language promoted by the company of the same name, which acts as a free source coding, just like Android.

4.1 Components of Sensing and Controlling Unit (SCU)

4.1.1 Arduino Uno

The Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 Analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.. You can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform.

The structure of Arduino is its disadvantage as well. During building a project you have to make its size as small as possible. But with the big structures of Arduino we have to stick with big sized PCB's. If you are working on a small micro-controller like ATmega8 you can easily make your PCB as small as possible.

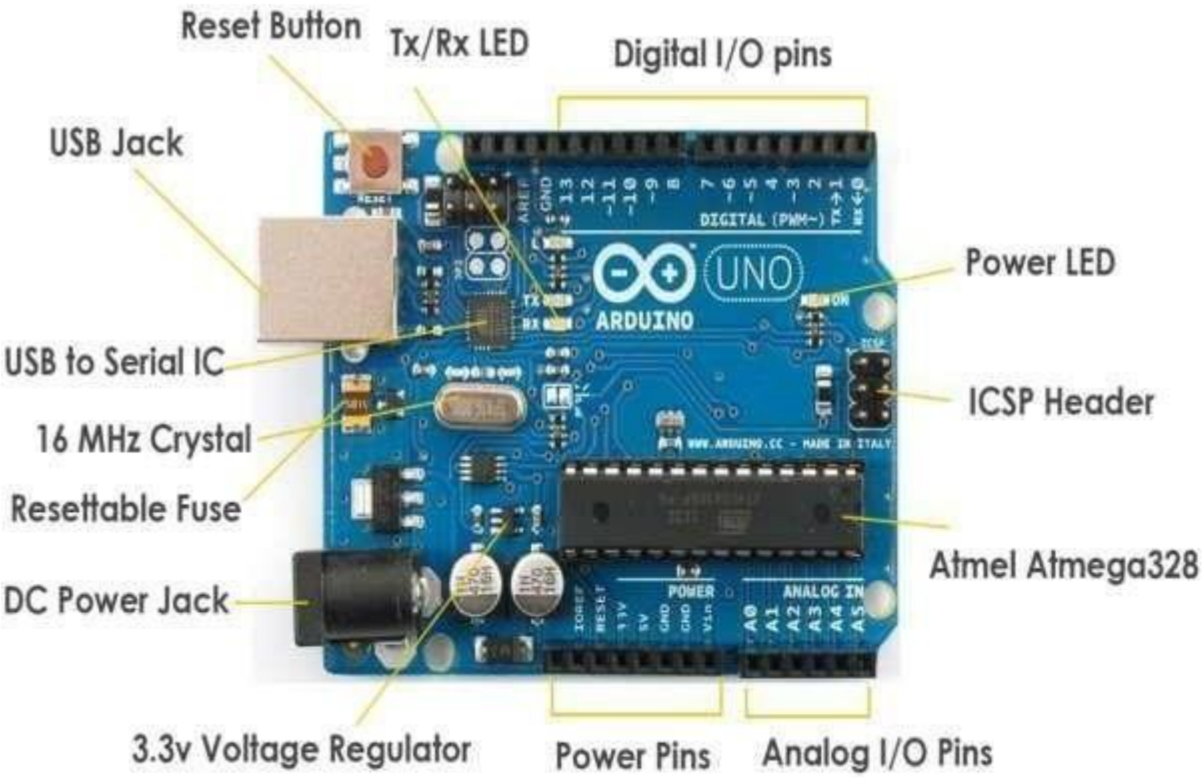


Figure 4.1 - Arduino Uno Layout

Table 4.1 - Technical Specification of Arduino Uno

Microcontroller	ATmega328P
Operating Voltage	5 V
Input Voltage (recommended)	7-12 V
Input Voltage (limit)	6-20 V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by boot-loader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an ACto-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm centrepositive plug into the board's power jack. Leads from a battery can be inserted in the GND and VIN pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The power pins are as follows:

- **V IN:** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5 V:** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
- **3.3 V:** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND:** Ground pins.

Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode(), digital Write(), and digital Read() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins have specialized functions:

- **Serial:** 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts:** 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt( ) function for details.
- **PWM:** 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analog Write( ) function.
- **SPI:** 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.
- **LED:** 13. There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

4.1.2 Ultrasonic Transducer

Ultrasonic transducers are transducers that convert ultrasound waves to electrical signals or vice versa. Those that both transmit and receive may also be called ultrasound transceivers; many ultrasound sensors besides being sensors are indeed transceivers because they can both sense and transmit. These devices work on a principle similar to that of transducers used in radar and sonar systems, which evaluate attributes of a target by interpreting the echoes from radio or sound waves, respectively. Active ultrasonic sensors generate high-frequency sound waves and evaluate the echo which is received back by the sensor, measuring the time interval between sending the signal and receiving the echo to determine the distance to an object. Passive ultrasonic sensors are basically microphones that detect ultrasonic noise that is present under certain conditions, convert it to an electrical signal, and report it to a computer.

Ultrasonic probes and ultrasonic baths are used to apply sound energy to agitate particles in a wide range of laboratory applications. An ultrasonic transducer is a device that converts AC into ultrasound, as well as the reverse, sound into AC. In ultrasonic, the term typically refers to piezoelectric transducers or capacitive transducers. Piezoelectric crystals change size and shape when a voltage is applied; AC voltage makes them oscillate at the same frequency and produce ultrasonic sound. Capacitive transducers use electrostatic fields between a conductive diaphragm and a backing plate.

The beam pattern of a transducer can be determined by the active transducer area and shape, the ultrasound wavelength, and the sound velocity of the propagation medium. The diagrams show the sound fields of an unfocused and a focusing ultrasonic transducer in water, plainly at differing energy levels.

Since piezoelectric materials generate a voltage when force is applied to them, they can also work as ultrasonic detectors. Some systems use separate transmitters and receivers, while others combine both functions into a single piezoelectric transceiver. Ultrasound transmitters can also use non-piezoelectric principles such as magnetostriction. Materials with this property change size slightly when exposed to a magnetic field, and make practical transducers.

A capacitor ("condenser") microphone has a thin diaphragm that responds to ultrasound waves. Changes in the electric field between the diaphragm and a closely spaced backing plate convert sound signals to electric currents, which can be amplified.

Ultrasonic sensors are widely used in cars as parking sensors to aid the driver in reversing into parking spaces. They are being tested for a number of other automotive uses including ultrasonic people detection and assisting in autonomous UAV navigation.

Figure 4.2 (a)

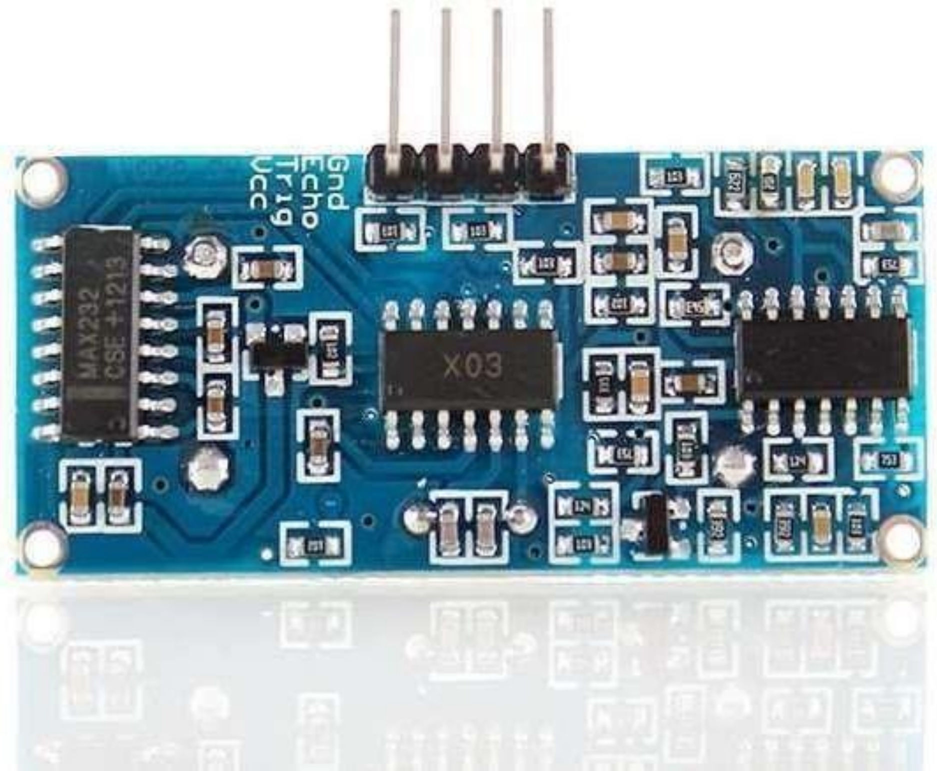


Figure 4.2 (b)

Figure 4.2 (a) and (b) Ultrasonic Transducer HC-SR04 (Front and Back view) Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit.

The basic principle of work:
- Using IO trigger for at least 10us high level signal,
- The Module automatically sends eight 40 kHz and detect whether there is a pulse signal back.
- IF the signal back, through high level , time of high output IO duration is the time from sending ultrasonic to returning. Test distance = (high level time * velocity of sound (340M/S) / 2.

Wire connecting direct as following:
- 5V Supply
- Trigger Pulse Input
- Echo Pulse Output
- 0V Ground

Table 4.2 - Specification of Ultrasonic Transducer HC-SR04

Working Voltage	DC 5V
Working Current	15 mA
Working Frequency	40 Hz
Max Range	4 m
Min Range	2 cm
Measuring Angle	15 degree
Trigger Input Signal	10 uS TTL pulse
Echo Output Signal	Input TTL lever signal and the range in proportion
Dimension	45 * 20 * 15 mm

Timing Diagram

The Timing diagram is shown below. You only need to supply a short 10uS pulse to the trigger input to start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion .You can calculate the range through the time interval between sending trigger signal and receiving echo signal.

Formula:
µS / 58 = centimetres or µS / 148 =inch;
Or
The range = high level time * velocity (340M/S) / 2

It is always suggested to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal.

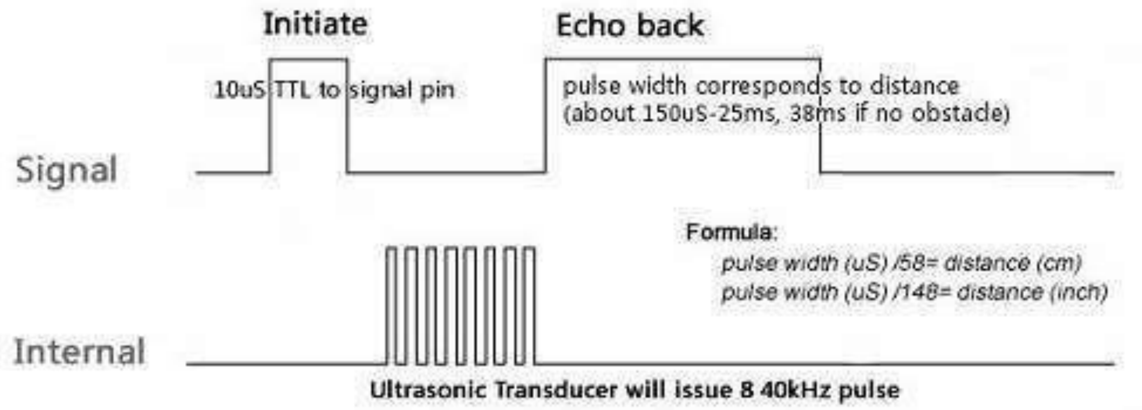


Figure 4.3 Timing diagram for the Ultrasonic Transducer HC-SR04

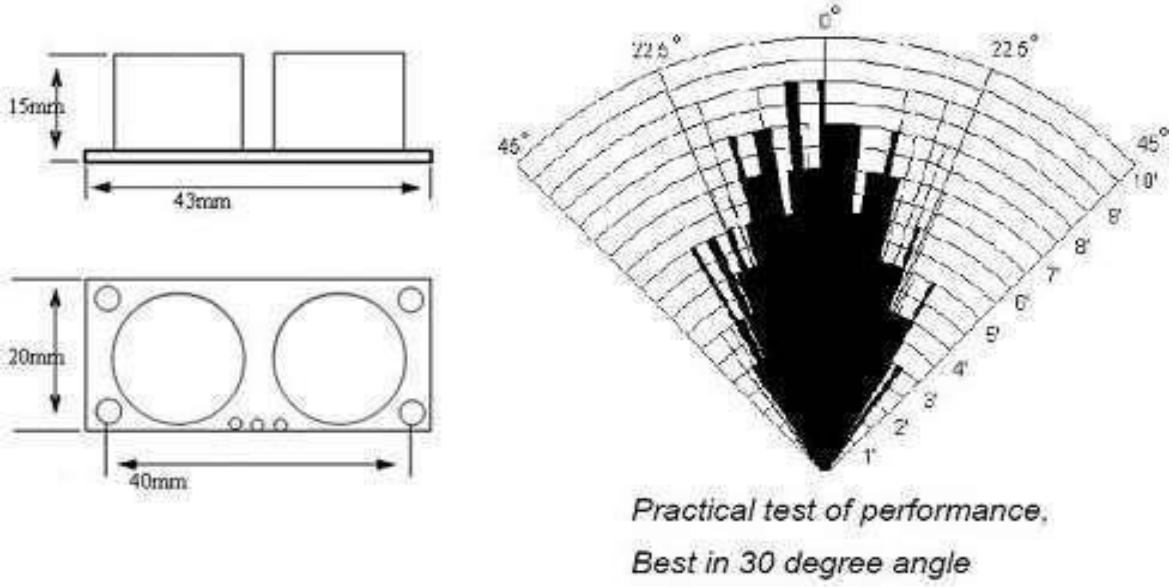


Figure 4.4 - Target Angle Range Test of Ultrasonic Transducer

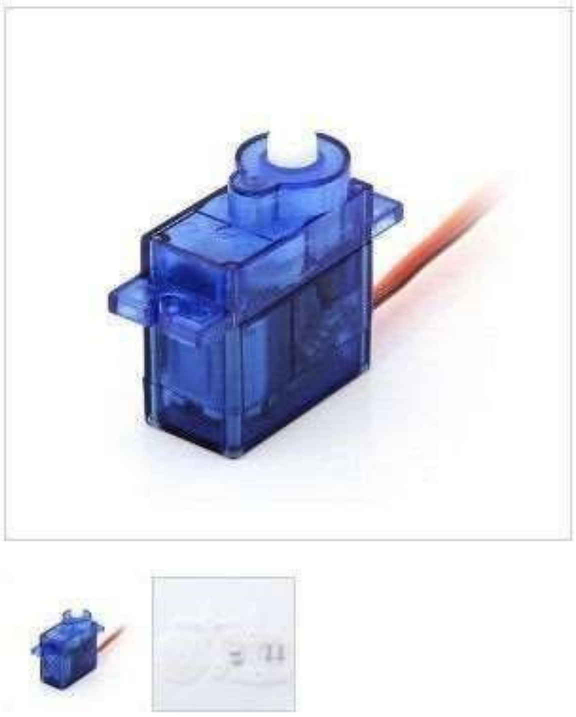
4.1.3 Servo Motor

A servo system mainly consists of three basic components - a controlled device, a output sensor, a feedback system. This is an automatic closed loop control system. Here instead of controlling a device by applying the variable input signal, the device is controlled by a feedback signal generated by comparing output signal and reference input signal. When reference input signal or command signal is applied to the system, it is compared with output reference signal of the system produced by output sensor, and a third signal produced by a feedback system.

This third signal acts as an input signal of controlled device. This input signal to the device presents as long as there is a logical difference between reference input signal and the output signal of the system. After the device achieves its desired output, there will be no longer the logical difference between reference input signal and reference output signal of the system.

Then, the third signal produced by comparing theses above said signals will not remain enough to operate the device further and to produce a further output of the system until the next reference input signal or command signal is applied to the system. Hence, the primary task of a servomechanism is to maintain the output of a system at the desired value in the presence of disturbances.

A servo motor is basically a DC motor (in some special cases it is AC motor) along with some other special purpose components that make a DC motor a servo. In a servo unit, you will find a small DC motor, a potentiometer, gear arrangement and an intelligent circuitry. The intelligent circuitry along with the potentiometer makes the servo to rotate according to our wishes. As we know, a small DC motor will rotate with high speed but the torque generated by its rotation will not be enough to move even a light load. This is where the gear system inside a servomechanism comes into the picture. The gear mechanism will take high input speed of the motor (fast) and at the output, we will get an output speed which is slower than original input speed but more practical and widely applicable.



Micro 0.12sec/60degree 1.3kg.cm Analog Servo FS90

Date: Mar 8, 2013 Go Back

SKU:	FS90
Dimensions:	23.2 × 12.5 × 22 mm
Weight:	9 g
Operating Speed :	0.12sec/60degree (4.8V) 0.10sec/60degree (6V)
Stall Torque :	1.3kg.cm/18.09oz.in(4.8V)
Operating Voltage :	4.8V~6V
Control System :	Analog
Direction :	CCW
Operating Angle :	120degree
Required Pulse :	900us-2100us
Bearing Type :	None
Gear Type :	Plastic
Motor Type :	Metal
Connector Wire Length :	20 cm

Table 4.3 - Specification of Servo Motor

4.1.4 Arduino 1.6 Software

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on processing and other open-source software. This software can be used with any Arduino board.

4.2 Circuit Diagram for the Connection

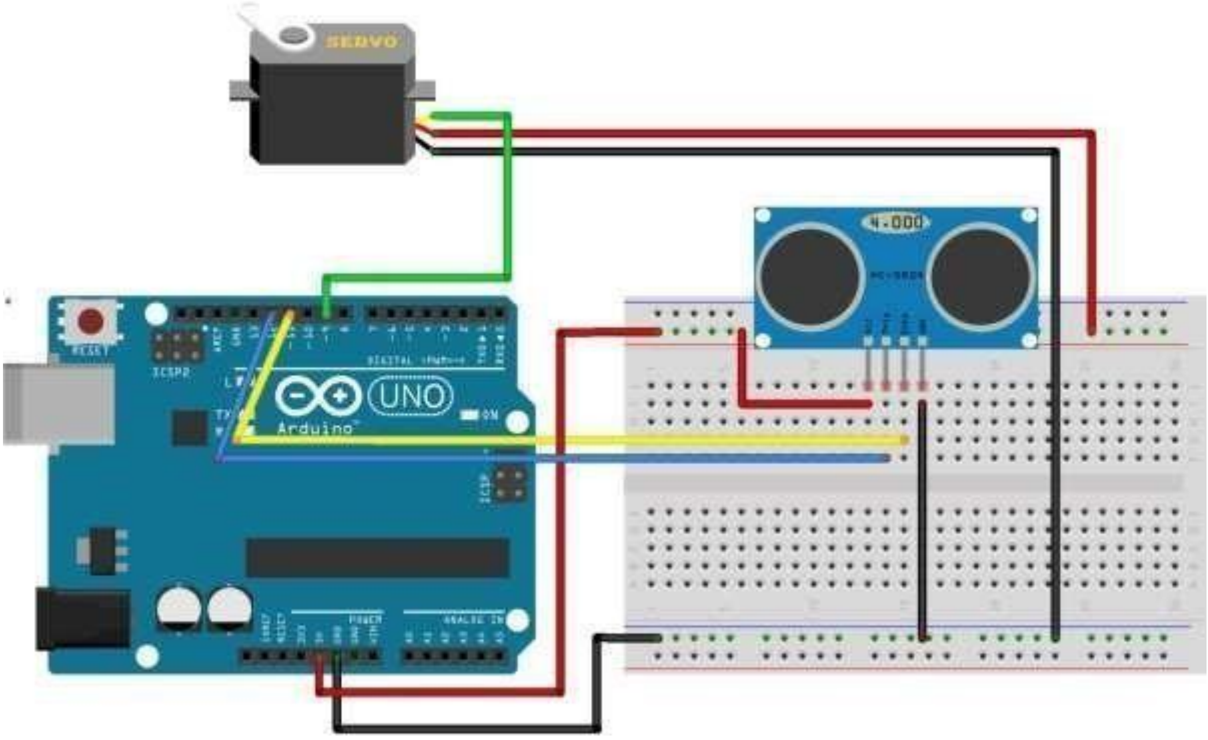


Figure 4.5 - Circuit Diagram of Connection

4.3 Code for Object Detection and Signal Processing

```
int trigPin = 11; //Trig - green Jumper int

echoPin = 12; //Echo - yellow Jumper

long duration, cm, inches;

#include <Servo.h> Servo myservo;

int val = 0;
int degree = 0;

void setup() {
        myservo.attach(9);

        //Serial Port begin
        Serial.begin(9600);

        //Define inputs and outputs
        pinMode(trigPin, OUTPUT);
        pinMode(echoPin, INPUT);
}

void loop() {
        // The sensor is triggered by a HIGH pulse of 10 or more microseconds.

        // Give a short LOW pulse beforehand to ensure a clean HIGH pulse:
        digitalWrite(trigPin, LOW);

        delayMicroseconds(5);
        digitalWrite(trigPin, HIGH);
        delayMicroseconds(10);
        digitalWrite(trigPin, LOW);

        // Read the signal from the sensor:
```

```
    // a HIGH pulse whose duration is the time (in microseconds)
    // from the sending the ping to the reception of its echo off of an object.
    pinMode(echoPin, INPUT);
    duration = pulseIn(echoPin, HIGH);

    // convert the time into a distance
    cm = (duration / 2) / 29.1;
    inches = (duration / 2) / 74;

    Serial.print(inches);
    Serial.print("in, ");
    Serial.print(cm);
    Serial.print("cm");
    Serial.println();

    val = (inches * 2.54) + cm;
    Serial.println(val);

    if(val < 30) {
        degree = 180;
        myservo.write(degree);
        delay(100);
        degree = 0;
    }

    if(val > 30) {
        degree = -180;
        myservo.write(degree);
        delay(100);
        degree = 0;
    }

    delay(25);
    degree = 0;
}
```

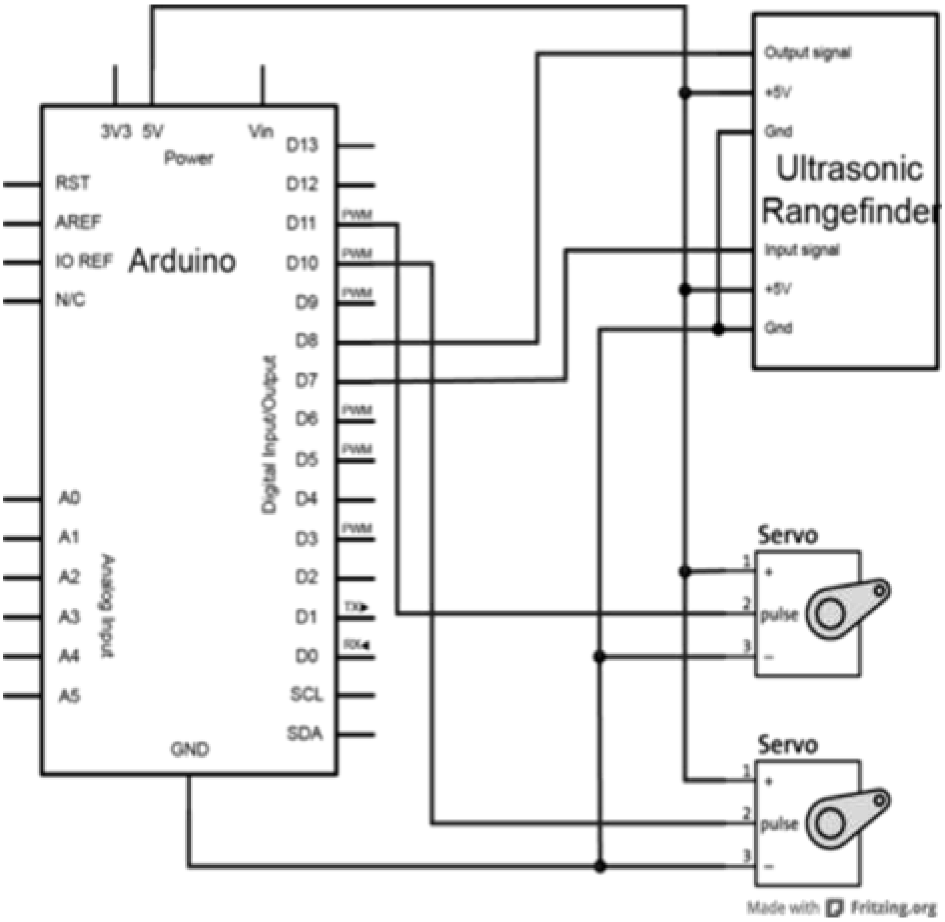


Figure 4.6 - Electronic Circuit

5. Summary and Conclusions

This was a proposed idea for final year project that presents an ultrasonic automatic braking system for forward collision avoidance with accelerator pedal disengagement mechanism. This system consists of ultrasonic sensors namely ultrasonic wave emitter and ultrasonic wave receiver. The ultrasonic wave emitter is provided in front portion of the car, producing and emitting ultrasonic waves in a predetermined distance in front of the car.

Ultrasonic wave receiver is also provided in front portion of the car, receiving the reflected ultrasonic wave signal from the obstacle. The reflected wave (detection pulse) is measured to get the distance between vehicle and the obstacle. Then PIC microcontroller is used to control the servo motor based on detection pulse information, and the servo motor in turn automatically controls the braking of the car. This abstract demonstrates the possible use of an accelerator pedal disengagement mechanism in this system, by which the accelerator pedal is automatically disengaged once the braking starts. Thus, even if the acceleration pedal is pressed the vehicle won't accelerate and this will prevent the collision. This solves the problem of safety in case the accelerator pedal is pressed when the vehicle is expected to brake.

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