International Journal of Engineering Research and General Science Volume 3, Issue 3, May-June, 2015
ISSN 2091-2730

# Ultrasonic Braking-To Prevent Accidents in Vehicles and in Industries

Sakthi Kumar Arul Prakash,
Department of Mechatronics Engineering,
Kumaraguru College of Technology, Coimbatore-641049.
sakthikap77@gmail.com, Ph. No: +91 9944114624
(An autonomous institute affiliated to Anna University, Chennai)

**Abstract:** Vehicles in road and material handling systems' in industries are a great boon to humans as it vividly reduces effort put in to accomplish any work. How well we use them and how much benefits we yield from these is a question. Lately, newspapers and reports have baffled us with huge information on accident issues. Accidents caused due to the use of vehicles in road are primarily caused due to rash driving, drink and drive, hand phone driving, loss of concentration due to psychological feelings.etc. In industrial environments accidents happen due to improper material handling systems. As technology keeps improvising, effort has to be put into safety of humans as well; accidents do happen just at the spur of the moment, but we do have the capacity to prevent them if not avoid them. This paper brings to light a novel idea which can save lives and prevent accidents. Basically, a simple mechanism is involved. Ultrasonic instrumentation can be readily exploited, coupled with a microcontroller for a feel of feedback, to effectively provide braking power to the different transportation agents we use.

**Keywords:** Ultrasonic Transducer, Electro Hydraulic Proportional valve, Spool, Cylinder, Brake, Arduino.

## Introduction:

Vision is the most important sense needed for a safe driving. It is shown that 50% information of the road is lost during driving using hand phones. Drink and drive causes blurred vision. Depression causes concentration to be elsewhere. All these reasons are what causes 80% of the road accidents and also industrial accidents. The death toll records a near 50,000 deaths and 1.1 million crashes every year. Hence it is very important to safely brake the vehicles. It is always not possible to prevent these accidents from occurring, but technology can be upgraded to reduce the above number.

Ultrasonic braking is the new idea being proposed in this paper. This project when employed in real time can save a lot of lives and material.

## Components Required and Working:

The idea is simple. A vehicle is taken up and ultrasonic transducers are implanted at the front side and on the left and right sides of the vehicle. The ultrasonic transducer (TR mic+) here refers to both the transmitter and the receiver. The output of this is connected to a microcontroller (Arduino UNO). The Arduino requires only a 5V power supply. The use of Arduino is not mandatory and it depends upon the type of application it is used for. The output from the Arduino in the form of electrical signal in range of (4mA-20mA) is coupled to the solenoid of a proportional direction control hydraulic valve.

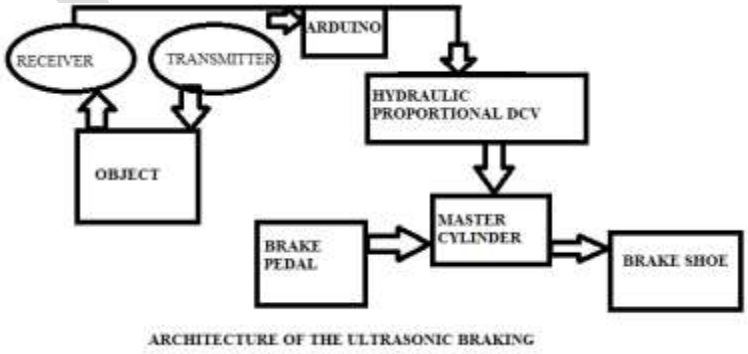


*Figure 38: ARCHITECTURE*

The hydraulic proportional direction control valve along with an accumulator is connected to the master cylinder in the vehicle. The master cylinder is a part of the hydraulic circuit that makes up the braking circuit in the vehicles.

This set-up finds use during times when the driver looses contact with the road or is not in a state to apply the brakes. The UT transducers constantly keeps sensing the objects in its path of transmission and based on the set distance and output, it proportionally activates the solenoid of the hydraulic proportional direction control valve. A pictorial representation of the working is illustrated above. (Figure 38). The machined lap spool moves allowing the fluid to flow to the brakes to brake the vehicle. The sensors at both sides are used to calculate the distance and alert the driver in case there is a case of a possible vehicle collision. This in coming times can be used to also assist the driver in steering left or right during a collision.

**About Ultrasonic Transducers and why:**

After light, the next fastest medium of energy transport would be the sound energy. Factually, we all know that sound streaks through air at a velocity of 330 meters per second. Ultrasonic sensors find use in many different applications. These operate at a frequency which is not audible to the normal human ear ;( i.e. >20 kHz). They are the backbone of RADAR and SONAR. These find extensive use in military applications, where it is very important to track enemy movements and their inbound activities into our country. Ultrasonic sensors have definitely diversified functions including "detection" of what you cannot see, "measurement" of length, thickness and amount, and "destruction" of objects. They have many uses in medicine as well as in other various advanced technologies including electronics, chemicals and construction.

Ultrasonic sensors perform dual action as in being able to send and receive signals. Medical use of ultrasonics are used in scanning of internal organs- finding defects.etc. Its applications do not end here. They are used in industries to perform NDT (Non Destructive Testing) and in instrument calibration, measuring dimensions .etc.

This technology has gained much appraisal due to the fact that in UT sensors the output value is linear with the distance between the sensor and the target; sensor response is not dependent on the colours, transparency of objects, optical reflection properties, or by the surface texture of the object; these sensors are designed for contact-free detection; sensors with digital (ON/OFF) outputs have excellent repeat sensing accuracy; accurate detection even of small objects; ultrasonic sensors can work in critical conditions such as dirt and dust; they are available in cuboid or cylinder forms, which is better for a freedom design.

## Specifications of the involved UTs' along with the focal distance:

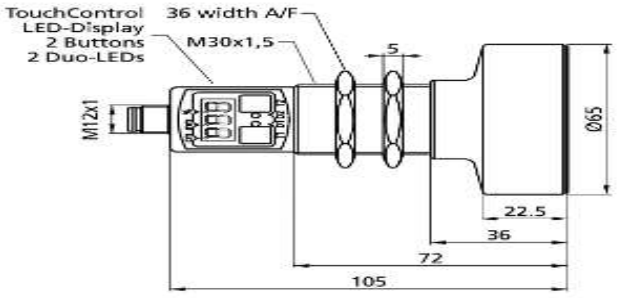


*Figure 39: Ultrasonic Transducer Cross-Section*

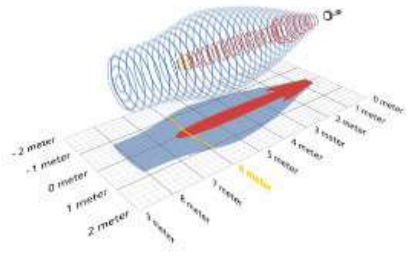

*Figure 40: Detection Zone*

The transducer being employed is designed and built by TR industries. The name of it is called TR mic+600. It has a minimum operating distance of 60mm or in other words called the blind zone. The maximum operating range rises up to 6 metres Figure 39: Ultrasonic Transducer Cross-Section Figure 40: Detection Zone). It has a transducer frequency of 80 kHz. It is made up of brass sleeve, nickel-plated, plastic parts, PBT, TPU, polyurethane foam, epoxy resin with glass contents. It has a response time of 240ms, a resolution of 0.18mm and a switching frequency lesser than 2 Hz. It requires a 9-18V DC supply. This transducer has an internal temperature compensation feature as well.

The most important feature of an UT is that it works in a multiplex and avoids cross interference. By avoiding cross-interference it will be able to transmit and receive only its signals. The UT has a housing whose material is also specified above. The UT is attached at the front vehicle bonnet and also along the sides in between the doors and very much out of sight. The UT continuously transmits and receives signal and feeds in the data to the user as well as to the arduino UNO to control the braking and steering of the car. This paper strictly focuses only on the braking part of the UT. The beam angle of the UT is very important, it specifies the area coverage as given in Figure 41: Beam Angle of UT. The beam angle of TR mic+ is $60^0$.

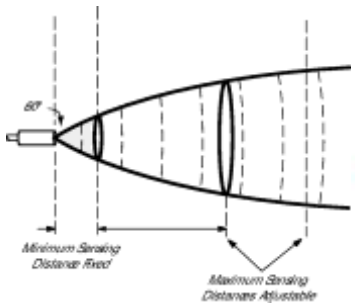


*Figure 41: Beam Angle of UT*


*Figure 42: Arduino UNO Pin Configuration*

## The Brain of the set-up:

The Arduino Uno (Figure 41: Beam Angle of UT Figure 42: Arduino UNO Pin Configuration) is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. The ATmega328 has 32 KB. It also has 2 KB of SRAM and 1 KB of EEPROM. It has an operating voltage of 5 volts, but the recommended input voltage to power UNO is from 7-12V DC; which can be supplied from the vehicle itself.

We require 4 jumper wires to connect the TR-mic+600 ultrasonic transducer to Arduino UNO. One wire connects the VCC pin to the 5V supply pin, second one gets the Arduino GND connected to the GND pin, the third one connects to the digital pin 12 with TRG pin (TRIGGER) and the last one connects the ECHO pin to the Arduino digital pin 11.

## The Role of the Hydraulic Proportional DCV and its detail:

A hydraulic proportional valve is a control valve that actuates an output (direction, pressure, flow) that is proportional to an electronic control input. The output force exerted by the armature of a DC solenoid depends on the current flowing through it. This principle is utilized in the design of a proportional DC solenoid in which the force exerted by the armature is proportional to the current flowing and is independent of the armature over the working range of the solenoid.

There are two types of special valves namely; the hydraulic proportional valve which gets actuated with the help of a proportional solenoid and the servo valves which are widely known for their extremely fine precision in working and excellent frequency response; these are actuated with the help of torque motors. All standard solenoids have no intermediate positions; rather they are always at one end or the other of the solenoid stroke. The magnetic flux attempts to drive the plunger to its fully closed position when the coil is energized. The force developed by the solenoid is a function of square of the solenoid current and inverse function of square of the air gap. The result is that the force increases as the air gap closes as well as when the current increases.

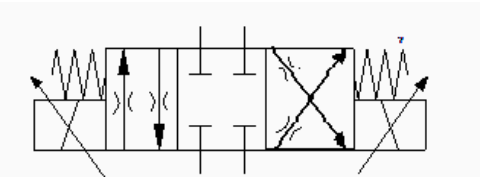

*Figure 43: 4/3 Electro-Hydraulic Proportional DCV Symbol*

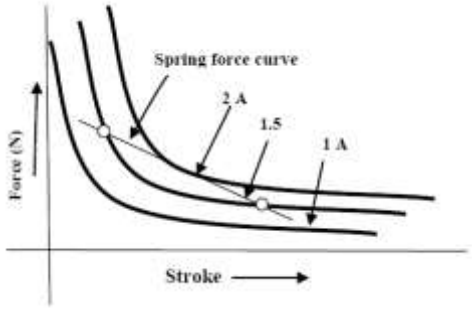


*Figure 44: Force vs. stroke displacement curve for various amperages*

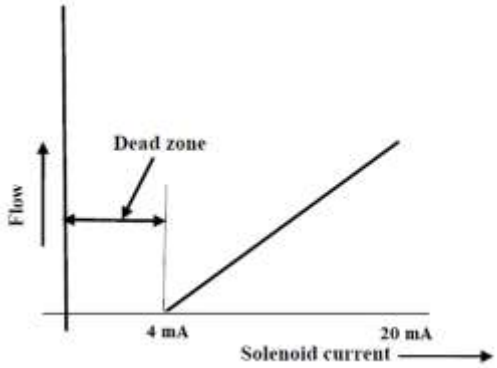


*Figure 45: Overlapped spool (flow vs. solenoid current)*

Figure 43: 4/3 Electro-Hydraulic Proportional DCV Symbol Figure 44: Force vs. stroke displacement curve for various amperages, shows the basic symbol of the 4/3 electro hydraulic proportional valve that is going to be used in our system. There are different variations to the physique of the valve and we can easily customize it as per the application requirement. Apart from the configuration of the valve, the design of the spool inside the valve is an important criterion.

Spool is the control element inside the valve, it is machined as per the type of usage required. The flow from the valve is proportional to the current flowing through the solenoid. Because of the difficulties in manufacturing a zero lap spool, overlapped spools are used in proportional spool valves. This means that the spool has to move a distance equal to the overlap before any flow occurs through the valve, giving rise to a dead zone as shown in Figure 45: Overlapped spool (flow vs. solenoid current). The various types of spools' available in market are underlapped, overlapped and zero lapped. An illustration of them is given below in Figure 46: Types of spools.

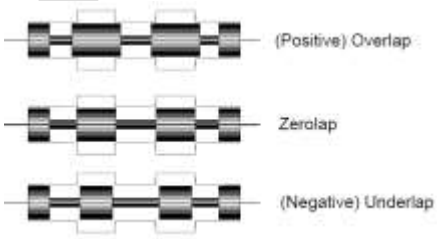


*Figure 46: Types of spools*


*Figure 47: Spool Notching*

The next parameter for an effective spool is the notches machined on the spool. Notches are used to gradually increase the application of pressure rather at a single blow. This is a very important parameter as it affects the comfort and convenience of passengers or basically the people who are travelling. They help in providing a controlled flow rate of the fluid as the orifice is progressively is opened up. It also determines the maximum flow rate of the valve and reduces the pulsations caused by the fluids due to sudden movement.

## Braking Circuit:

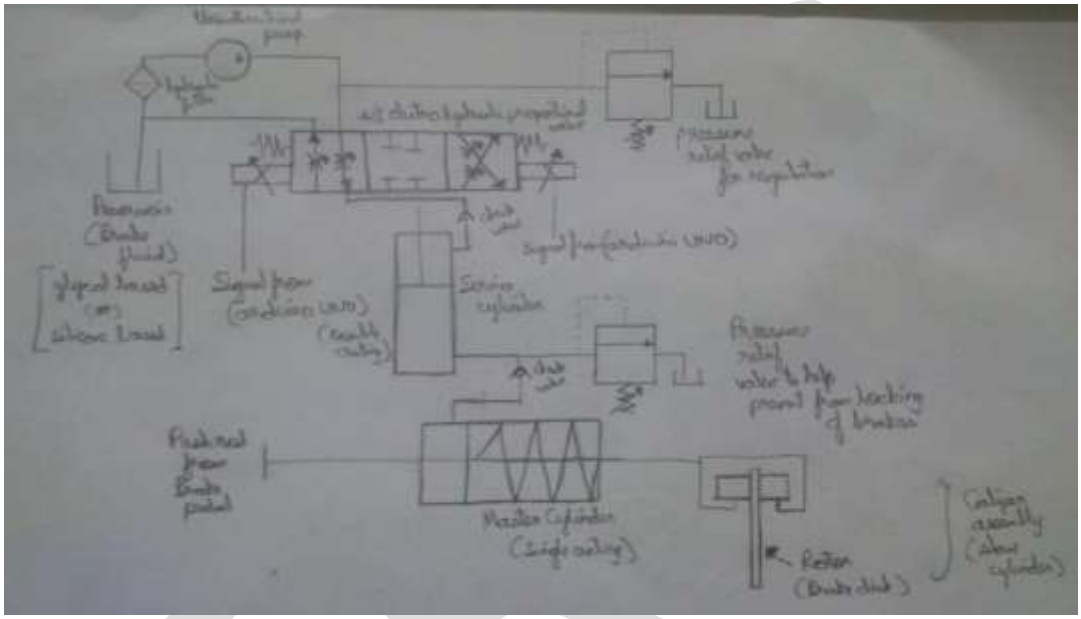


*Figure 48: Braking Circuit*

It all comes down to this circuit (Figure 48: Braking Circuit), the heart of this paper. The components required to make up this circuit includes, a reservoir containing brake fluid (silicone or glycol based), a filter to remove the foreign particles if any from the fluid. A uni-directional pump (external gear pump or lobe pump or balanced vane pump as these are heavy duty pumps), 4/3 electro hydraulic proportional DCV, two pressure relief valves (one for the pressure regulation into the service cylinder (double acting) and the other to avoid skidding during the locking of the tyres while high pressure braking); the skid removing relief valve can also be coupled along with an ABS module. This is not in the scope of this paper. A brake pedal, one single acting and 2:1 master cylinder. Actually both the double acting and the single acting cylinders in the circuit are in the above ratio. The electro hydraulic proportional valve is highly effective in cases of this ratio usage. The caliper assembly consists of two pistons which apply pressure on the rotor (disk) upon either the pressing of the brake pedal or detection from the UT. This system can be attached to all the rotors in any vehicle and works in co-ordination with both the disc type and drum type brakes.

## The Duo Working:

The system works while the normal pedal is pressed and also through the detection sensed by the UT. The Arduino is programmed to take up analog values of 4mA for a distance of 6 metres and the solenoid signal value increases by 1mA for every 33 cm neared; finally comes to a dead stop for a distance of 0.75m from the target for a signal value of 20mA. The sensors at the side are programmed to alert the user when it detects a target as close as 20cm at the sides. Check valves are provided in the circuit so that when the brake pedal is pressed, the fluid is made to enter only the master cylinder and not enter the service cylinder in any case. But both systems can be made to work simultaneously

## Conclusion and a futuristic focus:

Thus, we've come to the end of the paper, the proposed system will save a lot of lives, reduce road dangers and most importantly be an even more efficient system. This paper can be further improvised by looking into detail the ABS system and also including a steering assist based on ultrasonic transduction.

## REFERENCES:

[1] B. Besch, "Introduction to Electro-hydraulic Proportional and Servo Valves."
[2] J. S. Cundiff, "Fluid Power Circuits and," pp. 1–41, 2001.
[3] F. P. Circuits, "CHAPTER 12 Fluid Power Circuits and Controls , John Introduction Types of Proportional Valves," pp. 1–20, 2001.
[4] W. H. Y. Driving, W. Using, C. Phones, and I. S. Risky, "Understanding the distracted brain," *Natl. Saf. Counc.*, no. April, 2012.
[5] W. A. Brakes, "Air Brakes," pp. 153–202.
[6] M. Aurelius and R. Emperor, "Chapter 18 : Brakes and Clutches Brake and Clutch Types," 2014.
[7] P. Valiant, "Lecture 22," pp. 1–6, 2005.
[8] C. Vol and H. Park, "Ultrasonic Sensors," vol. 105.
[9] H. S. Mill and T. H. Mill, "The Hot Rolling Process," *Finishing*.
[10] B. a R. Psi, "CAVITY PRESSURE Proportional Control Valves."
[11] S. Copsey, N. Christie, and L. Drupsteen, *A review of accidents and injuries to road transport drivers. European Agency for Safety and Health at Work (EU-OSHA)*. 2011.
[12] T. R. Electronic, "mic + ultrasonic sensors."
[1]–[12]