Abstract— Driving in traffic has become cumbersome especially in cities like Mumbai, the sheer number of cars on the road along with the disorganized system has made driving even more difficult and hence we come up with a solution to end all these woes.

AUTO DRIVE which will henceforth be referred to as Auto-d is a traffic assist solution. In simple words it refers to semi-autonomous control of a vehicle by an on-board computer in traffic conditions.

Our system involves partial automation of a car in terms of accelerator, clutch brake and transmission coupled with inputs from the sensors (ultrasonic and radar sensors) around the car which would enable the system to start from rest and accelerate gradually till the preset distance from the leading car.

EXECUTION:
The accelerator, brake and clutch are coupled with prime movers which can be controlled by the microcontroller and calibrated accordingly to achieve precise car motion via accurate pedal movement. Based on the sensor outputs we can control the accelerator and control the car to move by that exact distance.

COMENCEMENT OF AUTO-D:
In the auto-d mode the driver is initially prompted to shift the car to the first gear the clutch is automatically floored when the gear has been engaged clutch is slowly released and the car accelerates to a speed decided by the microcontroller based on the inputs given to it by the sensors.

After engine revs up to a predetermined rpm user is prompted once again to shift to the second gear the vehicle behaves in a similar way however attaining higher speeds at lower rpm. Thus throughout auto-d the car always tries to attain the speed of the vehicle in front of it also ensuring a certain minimum distances between itself and the vehicle in front. During auto-d however if the speed of the car is reduced to zero the above procedure is repeated.

DISABLING OF AUTO-D:
If however the engine does rev up to a higher predetermined value user is prompted to shift to a higher gear and auto-d disengages itself and complete control of the vehicle is transferred to the user.

PRACTICAL REALIZATION:

- PRIME MOVERS: For precise motion of the pedals, we have a choice of actuators including high torque Stepper Motors and Linear Actuators.
- SENSORS: We incorporate Radar and Ultra-sonic sensors as a source of primary feedback to the control system.
- SECONDARY FEEDBACK: To get proper feedback regarding the RPM of the engine and the vehicle speed, we have the following sensors
  1. Speed sensors & RPM sensors.
  2. Pedal position sensors.

INTRODUCTION
Auto-d relieves the driver of all the pressure of driving in traffic conditions as the driver does not need to repetitively floor the clutch, accelerate and then slow down again. Imagine if the car drove itself and the driver would only assist with minimal interference.

Automatic gear transmission is a very common feature in today’s world but one big disadvantage of auto transmission is its low fuel efficiency under extreme conditions. Auto-d is a step ahead of the automatic gear shift.

The concept of a commercial car driving by itself is not one that is easily comprehensible but it is one that can be achieved. But before we can explain how we can practically achieve it we will run you through the features of the system.

FEATURES:
1. The most innovative aspect of Auto-d is its TRAFFIC SOLUTION.
2. Auto-d can be easily extended to improve performance at mid-speeds where the car can be preprogrammed to accelerate at a specified rate ensuring maximum efficiency.
3. Collision avoidance system and auto braking override in case of sudden obstacles can improve safety.
4. The driver can also be prompted about blind-spots during overtaking and lane changing.

PRACTICAL REALIZATION:

- PRIME MOVERS: For precise motion of the pedals, to achieve we have 3 options:
1. Linear actuators.
2. Stepper motors.
3. Combination of the above two.

- **SENSORS**: To know the accurate position of the cars or obstacles around the vehicle, we have the following sensors.
  1. 24 GHz Radar sensors.
  2. Ultrasonic sensors.

- **FEEDBACK CONTROL**: To get proper feedback regarding the RPM of the engine and the vehicle speed, we have the following sensors
  1. Speed sensors & RPM sensors.
     a. Shaft Encoder sensor
     b. Hall Effect Sensor
     c. Doppler Radar Sensor
  2. Pedal position sensors.

**ACTUATORS/PRIME MOVERS**

**LINEAR ACTUATORS**

**CHOICE OF THE LINEAR ACTUATOR**

Electromechanical Linear actuators function to convert rotary motion of a motor into reciprocating motion of a shaft. It is this shaft that will be causing or producing the desired effect. We will be using electromechanical linear actuators as opposed to hydraulic actuators as the latter have very large response time, in addition to the extra cost of designing an hydraulic system including master cylinder, the hydraulic lines etc. Moreover, this system cannot be controlled by a microcontroller requires manual control, an example of this, the braking system or the clutch system adopted in many recent cars. Electromechanical linear actuators however provide us with a lot more flexibility when we talk of controlling the same using microcontrollers; they provide good speed to load ratios as well and are quite economical.

When we talk about the specifications of the actuator we talk about the following criteria
- stroke length
- thrust
- dimensions
- actuator speed
- response time
- current, speed to load characteristics

Let us talk about each of the above mentioned criteria, now when we talk about stroke length we are talking about the maximum displace required to move either of the three pedals namely clutch, brake and accelerator. The clutch has maximum displacement of 4” for a point 8cm from the hinge, the brake and accelerator have about 2” and 3” respectively these would vary from car to car hence we would have to customize and integrate a limit switch to each of the actuator that we will be using.

Second is the thrust, now this varies drastically from pedal to pedal, the force required to move the clutch pedal is a compound force in the sense it requires about 30kg-cm to floor the clutch and about 25kg-cm to keep it there now these forces that we talk about are at the pad that means if we talk about the force that would be required at 8cm from the hinge would be 2 times as much we should safely use an actuator that provides a thrust of 1000N or 100kg-cm force .this we do as the actuator nears its upper limit speed decreases drastically, hence we should ensure that the load is about 70% of the thrust that is actually provided by the actuator. Hence for the brake and the accelerator we may as well use an actuator with the same load characteristics.

The other criteria are response time and the speed; these will be taken care of in the interfacing section and will be paid attention to in the algorithm. As shown in the datasheets the actuators that we will be using sink minimum current of 3A thus appropriate relays and or drivers will be required when we interface these actuators.

**MOUNTING OF THE ACTUATORS**

The linear actuators are to be mounted as shown parallel to the shaft of the steering wheel at an appropriate angle of approximately 30 degrees to the horizontal, thus point of contact should be established at about 8cm from the hinge of the pedal. As we will be using forked ends for the actuators, pedal shafts would easily come back into the fork after the manual control of the vehicle, thus a sturdy iron frame would be required in the cavity as shown for clamping the linear actuators firmly.

![Figure 1: Movement of pedals using linear actuators](image)

**INTERFACING THE ACTUATORS**

As shown in the block diagram linear actuators will be controlled using the microcontroller unit via a driver. firstly the current requirements of the linear actuators are very high,
and they require a 12V dc supply voltage hence the driving element is of an essence, we could use drivers like L298 or L293D for the same as we have very high current sourcing capabilities as well as very low response times as opposed to relays which essentially use mechanical switching for the same.

**Figure 2** interfacing of linear actuators with the microcontroller

**STEPPER MOTORS**

The other option that we have for prime movers is Stepper motors.

In Auto-d, our main objective is to obtain precise motion of pedals i.e. accelerator, brake and clutch. This precise motion will decide the state of the car and enable the driver with partial computer control.

Stepper motors present us with the option of having precise angle of rotation of the motor shafts. They are usually low torque motors; however the motor torque can be increased with the help of speed reduction gear heads.

**PRACTICAL REALIZATION**

Stepper motors are connected to the car pedals i.e. accelerator, brake and clutch. Hence, we are able to achieve precise pedal motion via precise control of the stepper motors. This precise motion is obtained due to appropriate pulses given to the motor. These pulses are obtained after processing the available sensor outputs. The torque required to achieve pedal motion is very high. Thus we connect stepper motors to appropriate speed reduction gear heads so as to achieve high torque. This however reduces the motor speed.

**MAJOR CONSIDERATIONS**

- **Space constraints:** Since the space available near the pedal area is considerably less, we must use very small sized stepper motors.
- **Mechanical coupling:** The stepper motor shaft is coupled to the pedals via pulley and cables. This arrangement may introduce errors in the system thus decreasing the efficiency and reliability of the system.

**Figure 4** stepper motor MTS3a

One of the stepper motors that we found in our survey was MTS3a. It is quite small in size with dimensions 36dia X 21(mm). This small size will not cause any problem with reference to the space constraints as mentioned above. It has a step angle of rotation equal to 7.5°. Torque provided by this motor is around 130 gm-cm. This motor is available at Mech-Tex Mfg. Co, Mulund, Mumbai.

**REDUCTION GEARHEAD**

1. **CALCULATIONS :**
   - Our system requires torque as high as 50 kg-cm.
   - Available torque = 100 gm.cm = 0.1 kg.cm.
   - Therefore, reduction ratio is 500.
   - Such a reduction ratio will cause the step angle to reduce to 7.5/500 = 0.015 degrees.

2. **CONSIDERING GEAR EFFICIENCY :**

   Here however we need to consider the gear efficiency which will give us the maximum required torque. Referring the data sheets of the reduction gear heads, we are in a position to find out the actual reduction ratio required for 50 kg.cm torque. This turns out to be 1800. On the basis of the above calculations we choose an appropriate reduction gear head, GB4.

**Figure 5** reduction gear head GB4

**KEY FEATURES**
- Reduction ratio: 1800
- Dimensions: 78 x 72 x 19 (mm)
- Gear Torque: 100 kg.cm
- Lateral Torque: 80 kg.cm

**COMBINATION:**
MTS3a and GB4 = MTS3a4

Thus the combination can be used to achieve highly precise motion of the pedals thus enabling us to have better control over the car.

**PRIMARY FEEDBACK**

**RADAR SENSORS:**

**DRIVER ASSISTANCE SENSORS**

Assistance systems can help reduce stress and improve safety by monitoring traffic conditions and warning drivers of potential dangers. The auto-drive system unites a number of such automotive assistance systems.

**SHORT RANGE RADAR SENSORS**

Radar sensors involve emission of electromagnetic waves in the gigahertz range. The reflection or echo of these waves is then analyzed. On this basis, it is possible to calculate the range and speed of the object reflecting the waves (radio detection and ranging).

We plan to use 24 GHz Ultra Wide Band short range radar sensors. Almost all objects being good reflectors of radio waves, as long as the obstacle is a solid one it can be detected, irrespective of lighting conditions or weather conditions. Such sensors have a range of around 30m.

**ADVANTAGES OF RADAR OVER OTHER SENSORS:**

- Rapid Detection of Multiple Objects
- Provides quick information on both stationary and moving objects
- Detection Range from 20 cm to 30 m
- Functional in Adverse Weather Conditions (e.g., Rain, Snow, Fog, etc.)
- UWB provides ability to distinguish closely spaced objects

For this purpose the car is fitted with two types of sensors:
- Short Range Radar
- Ultrasonic Sensors.

The RADAR sensors are fitted in the grill of the car while the ULTRASONIC sensors are fitted at various points on the chassis.

The various sensor systems and the areas they scan all complement one another. This new system can control the car fully automatically at low speeds of between zero and 50 km/h. This is made possible by the software that checks the data from all sensors at millisecond intervals in order to verify that their readings do not contradict a model of the vehicle environment. The sensors have registered a vehicle in front that is driving at a certain speed, the model tells the system that the vehicle will probably continue to travel at that speed. Because the system knows its own speed, it can calculate where the vehicle in front should be by the time of the next reading, which in turn is compared with the new sensor data. In this way, the system can determine the precise position of the vehicle in front and therefore ensure that it remains at a safe distance.

The driver will have the option of overriding the system or completely deactivating it when it is not in use.
• Shorter wavelengths (e.g. IR, LIDAR) can have significant problems with Fog and other vision degrading weather (i.e. snow) Radar may have problems in ‘extreme’ rain or snow, but the scenario can be detected.

**KEY PARAMETERS THAT CHARACTERISE THE 24GHz RADAR SENSOR:**

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<th>Parameter</th>
<th>Value</th>
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<td>Azimuth 3 db beamwidth (sensor)</td>
<td>~40 deg</td>
</tr>
<tr>
<td>Elevation 3db beamwidth (sensor)</td>
<td>~15 deg</td>
</tr>
<tr>
<td>Range accuracy</td>
<td>+/- 5 cm typical</td>
</tr>
<tr>
<td>Bearing accuracy (point target)</td>
<td>+/- 5 deg typical</td>
</tr>
<tr>
<td>Sensor network local interface</td>
<td>Private can 2.0b 500kb</td>
</tr>
<tr>
<td>Power supply (sensors)</td>
<td>Vehicle power</td>
</tr>
<tr>
<td>Power consumption (sensors)</td>
<td>&lt; 5 w each</td>
</tr>
<tr>
<td>Operating temperature</td>
<td>-40 to + 85 deg c</td>
</tr>
<tr>
<td>Sensor size (cm)</td>
<td>9.5 x 6.3 x 2.1</td>
</tr>
</tbody>
</table>

**LOCATION:**
In front of the car, inside the grill.

**INTERFACING:**
The RADARBOARD 2/30 provided by NEOBOTIX can be interfaced with the auto-drive system. The Radar Board 2/30 is based on a 24 GHz radar sensor with preamplifier and a controller board with amplifier, signal conditioning, dsPIC30F5011 microcontroller and communication interfaces.

**SOFTWARE**

The software is running on a powerful 16 bit 20 MIPS/ 30 MIPS CPU of type dsPIC30F5011 from Microchip. Radar sensor data are continuously acquired, amplified and evaluated by the microcontroller. So the user may request the current position and velocity data by CAN or RS-232 anytime.

Information transmitted are:
• objects positions
• velocities
• directions of motion

The current status of the radar sensor data is displayed by LEDs mounted on the board. Using the RS 232 the sensor can now be interfaced to the auto-drive system i.e. to a microcontroller (e.g., ATMEGA128/32). The information from the sensor can be sampled by the system as and when required.

**ULTRA SONIC SENSORS**

**LOCATION:** On the periphery of the car. Mounted to detect adjacent obstacles including cars, pedestrians, road blocks.
• Two sensors mounted on the front beside the radar sensor to detect vehicles trying to cut-in.
• Two sensors at the back to detect vehicles while changing lanes.
• Two sensors on either side to detect adjacent vehicles.

We are using LV-MaxSonar -EZ1 High Performance Sonar Range Finder from MAXBOTIX.

**FEATURES:**
• Continuously variable gain for beam control and side lobe suppression
• Object detection includes zero range objects
• 2.5V to 5.5V supply with 2mA typical current draw
• Readings can occur up to every 50mS, (20-Hz rate)
• Free run operation can continually measure and output range information
• Triggered operation provides the range reading as desired
• All interfaces are active simultaneously
• Serial, 0 to Vcc
• 9600Baud, 81N
• Analog, (Vcc/512) / inch
• Pulse width, (147uS/inch)
• Learns ring down pattern when commanded to start ranging
• The interface output formats included are pulse width output, analog voltage output, and serial digital output.

ADVANTAGES:

• Very low cost sonar ranger
• Reliable and stable range data
• Sensor dead zone virtually gone
• Lowest power range
• Quality beam characteristics
• Mounting holes provided on the circuit board
• Very low power ranger, excellent for multiple sensor or battery based systems
• Can be triggered externally or internally
• Sensor reports the range reading directly, frees up user processor
• Fast measurement cycle
• User can choose any of the three sensor outputs

CIRCUIT:

Figure 10 PIN CONFIGURATION OF THE LV-MaxSonar-EZ1

• GND - Return for the DC power supply. GND (& Vcc) must be ripple and noise free for best operation.
• +5V – Vcc – Operates on 2.5V - 5.5V. Recommended current capability of 3mA for 5V, and 2mA for 3V.
• TX – When the *BW pin is held high the TX output sends a single pulse, suitable for low noise chaining (no serial data).

*Brown dot parts: When BW pin is held high the TX output sends a single pulse, suitable for low noise chaining (no serial data).
• RX – This pin is internally pulled high. The EZ1™ will continually measure range and output if the RX pin is left unconnected or held high. If held low the EZ1 will stop ranging. Bring high 20uS or more for range reading.
- **AN** – Outputs analog voltage with a scaling factor of \( \frac{V_{cc}}{512} \) per inch. A supply of 5V yields \(~9.8\text{mV/in.}\) and 3.3V yields \(~6.4\text{mV/in.}\). The output is buffered and corresponds to the most recent range data.
- **PW** – This pin outputs a pulse width representation of range. To calculate distance use the scale factor of 147\(\mu\)S per inch.
- **BW** – *Leave open or hold low for serial output on the TX output.*
  *Brown dot parts:* When BW pin is held high the TX output sends a pulse (instead of serial data), suitable for low noise chaining.

**INTERFACING:**

Each of the ultrasonic sensors are connected to the auto-drive system through a buffer. It is then connected to the onboard ADC of the auto-drive system’s central microcontroller.(eg, ATMEGA 128/32).

**SPEED AND RPM SENSORS**

Necessity: It is necessary for us to know the speed of our vehicle in order for us to determine the exact amount of acceleration required during Autodrive. This is achieved by the use of speed sensors. Similarly we must provide the driver information regarding the engine R.P.M to indicate to the driver when he/she has to change the gear in autodrive mode. This is achieved by the use of R.P.M sensors

<table>
<thead>
<tr>
<th>Application</th>
<th>Sensor Type</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Shaft Encoder</td>
<td>Hall Effect Sensor</td>
</tr>
<tr>
<td>Speed Sensing</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>R.P.M Sensing</td>
<td>√</td>
<td>√</td>
</tr>
</tbody>
</table>

**SHAFT ENCODER**

**BASIC WORKING:**

This instrument displays the speed of the vehicle in kmph. An opaque disc is mounted on the spindle attached to the front wheel of the vehicle. The disc has ten equidistant holes on its periphery. On one side of the disc an infrared LED is fixed and on the opposite side of the disc, in line with the IR LED, a phototransistor is mounted. IC LM324 is wired as a comparator.

When a hole appears between the IR LED and phototransistor, the phototransistor conducts. Hence the voltage at collector of the phototransistor and inverting input of LM324 go ‘low’, and thus output of LM324 becomes logic ‘high’. So rotation of the speedometer cable results in a pulse (square wave) at the output of LM324. The frequency of this waveform is proportional to the speed.

**HALL EFFECT SENSOR**

**BASIC WORKING:**

A Hall Effect sensor is a transducer that varies its output voltage in response to changes in magnetic field. Hall sensors are used for proximity switching, positioning, speed detection, and current sensing applications.

In its simplest form, the sensor operates as an analogue transducer, directly returning a voltage. With a known magnetic field, its distance from the Hall plate can be determined. Using groups of sensors, the relative position of the magnet can be deduced.

Electricity carried through a conductor will produce a magnetic field that varies with current, and a Hall sensor can be used to measure the current without interrupting the circuit. Typically, the sensor is integrated with a wound core or permanent magnet that surrounds the conductor to be measured.

Frequently, a Hall sensor is combined with circuitry that allows the device to act in a digital (on/off) mode, and may be called a switch in this configuration.

Hall sensors are commonly used to time the speed of wheels and shafts, such as for internal combustion engine ignition timing or tachometers.
Figure 12 hall effect sensor

Figure 13 working of hall effect sensor

Figure 14 interfacing of Hall Effect sensor with microcontroller

In the Figure above, an Atmel AVR AT90S2313 microcontroller is used to take inputs from the Hall Effect sensor. The Hall Effect sensor attaches to the vehicle near its periphery and a fixed distance from the wheels axle. When the wheel rotates, a permanent magnet attached to the wheel causes the sensor to generate a short pulse for each rotation of the wheel. This is used for measurement of speed. Similarly a sensor mounted near a rotating gear within the engine can be used to measure R.P.M. The pulses rising edge is used to generate a high priority interrupt. The microcontroller calculates the elapsed time between two interrupts, computes the speed and distance travelled. The distance travelled between two clock pulses is $2\pi R$, where $R$ is the radius of the wheel. Thus the speed of the vehicle is obtained by dividing the distance by time.

Figure 15 Timing diagram of a Hall Effect gear tooth sensor

Hall Effect Sensors are provided by the following companies (please open the datasheet as specified with the name from the folder DATASHEETS)

1. Sensoronix (datasheet8)
2. Gill Sensors (datasheet9)
3. Allegro Sensors

A list of Allegro Sensors is given at the end.
Non-contact speed measurement using the Delta speed sensor is achieved through the use of Doppler Radar. Doppler radar is named after the Doppler principle, which explains the frequency shift associated with energy waves reflected by or emanated from a moving body. A familiar example of a Doppler shift is the change in pitch when a car passes by - higher in pitch as the car approaches, lower in pitch as it leaves.

In the case of the Delta speed sensor, a Ka band radar signal is transmitted at a specific frequency by the sensor, reflects off of a target (or targets) and returns to the sensor (see Figure 1). If either the sensor or the target are moving relative to one another, the signal will be shifted in frequency when it returns to the sensor. This shift in frequency allows measurement of the relative velocity between the sensor and target.

The fundamental Doppler frequency shift is given by:

\[
F_d = 2 \times \frac{\nu}{c} \times \frac{V}{c} \times \cos \theta
\]

where:
- \(F_d\) = Doppler Shift, \(c\) = speed of light in Hz
- \(\nu\) = velocity in mph
- \(V\) = offset angle of sensor relative to direction of target motion

For the Delta speed sensor, the Doppler shift is 105.799 ± 0.298 Hz / mph (65.74074 ± 0.185185 Hz/kph). The Delta speed sensor's output is a square wave which is 100 Hz per mph (62.138 Hz per kph).

**CORRECTION FOR OFFSET ANGLE**

As shown by the Doppler frequency shift equation, any offset angle (see Figure 1) between the center of the radar beam and target direction of travel will introduce a factor of cosine \(\theta\) into the measured speed. This means that the output of the sensor must be corrected by dividing it by the cosine of the offset angle as shown in this example:

**Case 1:** Sensor Output: 2600 Hz
Offset Angle, \(\theta = 30\)

Actual velocity = \(\frac{(2600 \text{ Hz} / (100 \text{ Hz/mph}))}{\cos 30°} = 30.02 \text{ mph}\)

**Case 2:** Sensor Output 2600 Hz
Offset Angle, \(\theta = 31\)

Actual velocity = \(\frac{(2600 \text{ Hz} / (100 \text{ Hz/mph}))}{\cos 31°} = 30.33 \text{ mph}\)

Also shown by this example, changes in offset angle influence speed measurement. It is recommended that the angle be known to at least 1° to maintain an uncertainty of 1 to 2% for a target in the center of the beam. Because the value of the cosine changes rapidly for offset angles about 45°, these angles are not recommended.

The radar beam diverges about 6° from center resulting in a roughly conical shaped beam (think of it like the beam of a flashlight). In the case of a target passing a fixes sensor, this geometry can introduce what is termed cosine error into the speed measurement. This happens because targets at one edge of the beam are at a different offset angle than in the center of the beam. For small offset angles, the cosine change from one edge of the beam to the other is small and so the cosine error is minimal. For larger offset angles, the change is more significant. In the case of vehicle ground speed measurements where the sensor is used to measure the speed of a surface relative to the sensor, cosine error generally produces a steady bias.

**SIGNAL STRENGTH AND MULTIPLE TARGETS**

The Delta speed sensor includes a signal processing algorithm that determines the strength of return signal from the target. If the signal is strong enough, the output is turned on, and the sensor is said to be “locked”. Because different targets reflect different amounts of the radar energy back to the sensor, the sensor will lock at different distances from the target depending on such factors as the size, material and orientation.

In general, large targets reflect more energy, and the sensor will be able to distinguish them at a greater distance. Highly reflective targets, such as metal, will reflect more energy than materials like wood or plastic. If the target is a large flat, reflective surface, it will reflect a large amount of energy back to the sensor if it is oriented perpendicular to the beam, but much less energy if it is at an angle.

A useful analogy for deciding the amount of reflection in many cases is to think of the sensor as a flashlight. If the target surface would reflect a large amount of light back to the sensor, it is probable that it will return a strong signal. (Remember, however, that radar energy is at a different wavelength than visible light and the analogy will not work in some cases!)

The sensor receives reflected energy from all possible targets within the radar beam. If any of the targets are moving,
it will cause a Doppler shift, possibly causing a false measurement if it is not the desired target. For this reason, it is important to consider the beam geometry, particularly the divergence angle, and make sure that the sensor cannot “see” non-targets.

APPLICATION ON RADAR SENSORS

Using Non-Contact Speed Sensing to Measure Vehicle Ground Speed

Figure 17 Speed Sensor Mounting Diagram (not to scale)

Measuring vehicle ground speed is a straight-forward application of the Delta Non-Contact Speed Sensor. As shown in Figure One, the sensor can be mounted on a vehicle, pointed toward the ground and used to measure the speed of the vehicle relative to the ground. The sensor may pointed either forward or backward.

An advantage of using a non-contact speed sensor over other methods such as measuring wheel rotation is that the speed measurement is not affected by such factors as wheel slip, allowing a better measurement of true ground speed.

Figure 18 Vehicle Ground Speed (Miles per Hour)

The data in Figure Two clearly show such features as gear shifting, acceleration, coasting and braking. In this test, the vehicle was driven over an asphalt surface, but the sensor may be used on other surfaces such as gravel or dirt.

OFFSET ANGLE

The offset angle shown in Figure One is the nominal offset angle. This is the angle between the center axis of the radar beam and the horizontal in the vertical plane. Because of factors involving geometry and relative strengths of the return signal from the ground ahead of and behind the center axis of the radar beam, the effective offset angle will differ from the nominal and requires a correction.

Table One shows the results of testing conducted to determine the effective offset angles using the speed sensor on vehicles driven over asphalt. To use the table, replace the nominal offset angle actually used by the corresponding effective offset angle when correcting for the offset angle. (See Application Note 1000, Fundamentals of Non-Contact Speed Measurement Using Doppler Radar.) For convenience, the cosine of the effective offset angle is also given in the table.

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<th>Effective Offset Angle (degrees)</th>
<th>Cosine Effective Offset Angle</th>
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<th>Effective Offset Angle (degrees)</th>
<th>Cosine Effective Offset Angle</th>
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<td>43.47</td>
<td>0.7258</td>
</tr>
<tr>
<td>31</td>
<td>32.74</td>
<td>0.8411</td>
<td>44</td>
<td>44.39</td>
<td>0.7146</td>
</tr>
<tr>
<td>32</td>
<td>33.60</td>
<td>0.8329</td>
<td>45</td>
<td>45.32</td>
<td>0.7031</td>
</tr>
</tbody>
</table>

The particular choice of nominal offset angle involves a tradeoff between several factors. Placing the sensor at a steeper angle increases signal strength and reduces the field of view of the sensor so that it does not see non-targets such as other vehicles. On the other hand, a steeper angle also increases sensitivity of the sensor to vertical motions and may introduce more variation in the vehicle ground speed measurement because of pitching of the vehicle on its suspension.

The accuracy of the speed measurement using this method of offset angle correction depends on the accuracy to which the offset angle is known. For instance, with a 30º offset angle, a 1º uncertainty in offset angle can cause a 1 - 2% uncertainty in the speed measurement. If greater accuracy is required, the sensor can be calibrated by other methods such as distance comparison achieved by recording the number of pulses received from the sensor while the vehicles travels over a fixed distance.
The sensor should be aligned parallel to the direction of vehicle travel so that there is no horizontal offset angle. It is also important to consider factors such as suspension pitching, vibration, and dust or water spray when choosing a mounting location for the sensor. For example, a forward-pointing sensor may be indicated for applications where dust or water spray is expected at the rear of the vehicle which might interfere with the radar beam. The sensor should be mounted on a rigid location located away from engine vibration. Some suspension pitching is evident in Figure Two, where the vehicle under test was, in fact, driven over bumps and had a stiff suspension. These effects could be removed, if desired, by post-processing to smooth the data. If these factors are taken into consideration, however, measurements of vehicle ground speed can be made for a wide variety of applications.

**PEDAL MOTION SENSORS**

In our AUTO-D car, it becomes very necessary to sense the motion of the pedals i.e. accelerator, brake and clutch. This sensing of the pedal position helps in knowing the exact state of the car and thus one can further control the pedals through the ‘Prime Movers’.

These sensors will thus work as a FEEDBACK MECHANISM in controlling the pedal position. We have found out two sensing techniques that can be used for this feedback mechanism the details about which are specified below.

These techniques are:

1. Inductive sensing (non contact)- GILL TECHNOLOGIES
2. Light position sensing (non contact)- POSITEK TECHNOLOGY

**Gill Sensors**

**BASIC INTRODUCION**

This sensor utilizes a base which is 60 mm long over which an activator will move. The position of the activator is indicated at the output in various ways (analog, digital, ASCII)

**FROM THE MANUFACTURERS**

The 60mm Blade Sensor accurately senses the linear or angular position of a metallic ‘activator’ mounted away from the face of the sensor. The unique non-contact two-part design utilizes Gill’s patented inductive technology to provide a reliable, accurate output that will not deteriorate through use.

Small, light and robust, the sensor is fully electronic with on-board processing. The supplied software facilitates a fully configurable measurement range. Output signals are provided in three different formats and diagnostic information is given to assist in system fail-safe functionality.

**KEY FEATURES**

- Non-Contact
- No Moving Sensor Parts
- Up to 60mm Linear Measurement
- Up to 90˚ Angular Measurement
- Fully Configurable Range
- Analogue/Digital Output
- Unlimited Mechanical Life
- Submersible

**PRACTICAL REALISATION:**

**MECHANICAL INTERFACING**

The activator will be mounted onto the PEDALS. Now the movement of the pedals will result in the movement of the activator on the base plate. This will directly give the present position of the pedal.

**ELECTRICAL COUPLING**

This sensor can be given supply in the range of 4.8V to 30V DC. The output that we will get will depend on the input voltage. Means if the input is 5V the output will also be in the range of 5V.

**ADVANTAGES**

1. No contact involved.
2. Unlimited mechanical life
3. No moving sensor parts.

**DISADVANTAGES**

1. The output format is not directly compatible with processor thus signal processing might be required.
2. The mechanical interfacing becomes a little cumbersome

**POSITEK TECHNOLOGY**

**BASIC IDEA**

Positek position transducers need no contact between the moving components and therefore have a very long life.
Positek has developed a new technology that overcame the disadvantages normally associated with inductive technology (bulkiness, poor length to stroke ratio and the need for special magnetic materials).

Positek's PIPS® position sensor is an inductive based, high performance displacement sensor, which has an excellent record in the industrial market for providing good performance, robustness, durability and cost.

The PIPS® technology, utilising Positek's patented ASIC has three derivatives: LIPS® linear, RIPS® rotary and TIPS® tilt position sensors. Each of these is a totally self-contained unit, allowing the customer to install and interface it with his control or monitoring system.

Key features are robustness, accuracy, ease of use and compactness. Positek's displacement transducers have the simplicity of a potentiometer with the life of an LVDT/RVDT.

OVERVIEW (FROM MANUFACTURERS)

The P111 LIPS® (Linear Inductive Position Sensor) is a rugged, heavy duty version of the P101 with a significantly stronger 1/2” pushrod. The P111 is particularly well suited to applications where vibration is an issue or where the requirement is for a long travel sensor, horizontally mounted and supported by rod eyes.

It remains an affordable, durable, high accuracy linear sensor designed for industrial and scientific feedback applications. The highly compact and space efficient unit is responsive along almost all of its length.

Like all Positek sensors the P111 provides a linear output that is proportional to the displacement. Each unit is supplied calibrated to the exact travel required by the customer, the P111 is available with any travel from 50mm to 600mm, for example, if your application requires 10” (254 mm) measurement then Positek will manufacture the sensor specifically for this length. The mechanical length and calibration will be set up for 254 mm.

The sensor is very robust, the body and push rod are made from stainless steel for good environmental resistance and service life. This product is well suited to OEM customers looking for good sensor performance in arduous applications such as industrial machinery where cost is important. Overall performance, repeatability and stability are outstanding over a wide temperature range. The sensor is easy to install with mounting options that include M8 rod eye bearings and body clamps. The push rod is normally supplied captive but can be supplied free if required. The push rod is supplied with either; M8 rod end, M8 female thread or with a dome end.

The P111 is sealed to either IP65/IP67 depending on which connector/cable option. The sensor has fully integrated EMC protection.

KEY FEATURES-

- Non-contacting inductive technology to eliminate wear
- Travel set to customer’s requirement
- Compact and self-contained
- High durability and reliability
- High accuracy and stability
- Sealing to IP65/IP67 as required

GEAR POSITION SENSING USING BUMP SWITCHES

In this mechanism we use bump switches to sense in which gear the car is in. the gear in which the car is an essential part of the feedback control loop. Hence this requires accurate sensing of the gear engaged. As shown in the diagram as the gear is engaged it triggers a bump switch hence effectively the control system knows which gear the car is in. the advantage of using this mechanism is that it is quite accurate, easy to construct, and does not requires any internal modifications as compared to the other mechanisms.

GEAR POSITION SENSING AT THE GEAR BOX

Gear position sensing can also be done using gill non contact position sensors, however these have to be adopted in the gear
box itself, thus they require a lot of internal modifications related to the gear box, and secondly these sensors are quite expensive. The mechanism mentioned above using bump switches is hence more preferable.

**THE ALGORITHM**

The user starts by putting the car in NEUTRAL first and then pressing the AUTO-D push button.

After that the following will be checked:

- If speed $\geq$ 30kmph; Auto-D will not engage itself.
- If speed $< 30$kmph; Auto –D engages itself.

**AUTO – D ENGAGED**

The clutch is floored the moment AUTO-D is engaged.

The following parameters will be continuously checked and depending on that decisions will be taken. This is done as follows:

- Speed of car = X
- Distance between the our car and the closest vehicle in front of it = D
- Relative Speed = $R = \text{Speed of our car}(X) - \text{the speed of the closest vehicle in front}(Y)$
- Engine RPM = E

Depending on the inputs that are read initially, the following cases can be assumed.

**CASE 1**

- X = 0
- R = 0
- a) D $\leq$ 2 meters
   - This means that the speed of our vehicle is 0 and the car in front of it has stopped. Thus the System engages itself but no action will be taken on the vehicle.

- b) D>2 meters:
   - This means that although both the vehicles are stationary there is quite a large distance between the vehicles. In this case our vehicle will accelerate to reach a particle velocity and then decelerate such that it stops 2 meters behind the vehicle in front i.e. the vehicle will accelerate till it covers a distance of (D-2)/2 and then decelerate the same amount. The exact acceleration will depend upon the maximum safe velocity which can be attained in the limited distance.

**CASE 2**

- X = 0
- R $<$ 0

System indicates to the user to engage the first gear (the clutch is already floored the moment the system was engaged)

After the first gear is properly engaged (the indication is given by the Gear sensors) the car will start accelerating depending on the formula

$$v^2 = u^2 + 2as$$

Where,

- $v$= (speed of the closest car)
- $u$= x (speed of our vehicle)
- $a$= accelerating force required
- $s$= D-2

After the engine revs up to a PREDETERMINED RPM user is indicated to engage next gear. This happens till distance between your car and the closest vehicle ahead is a safe 7 meters, or, the gear presently engaged is third.

In the later case AUTO-D will indicate the User to take over the control of the car manually.

**CASE 3**

- X $\neq$ 0

1) R = 0
   - a) D>5
      - In this case our vehicle accelerates till it reaches a distance of 4 meters from the vehicle in front then it decelerates such that R=0 again at D=2.

   - b) D<5
      - In that case, Acceleration= 0
      - Now depending on the value of x the user is indicated to engage the appropriate gear.

2) R$\neq$0
   - In this case the car accelerates or decelerates (depending on the relative speed) till it attains a relative velocity =0 and D=2. The amount of acceleration is given by

$$v^2 = u^2 + 2as$$

Where,

- $v$= y (speed of the closest car)
- $u$= x (speed of our vehicle)
- $a$= accelerating force required
- $s$= D-2

**REFERENCES:**

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   http://www.gillsensors.co.uk.

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Figure 21 movement of pedals using linear actuators

Figure 22 movement of pedals using stepper motors

Figure 23 interfacing of linear actuators with the microcontroller

Figure 24 interfacing of Hall Effect sensor with microcontroller

P111 LIPS® (Linear Inductive Position Sensor)