OPEN LOOP SYSTEM

Then an Open-loop system, also referred to as non-feedback system, is a type of continuous control system in which the output has no influence or effect on the control action of the input signal. In other words, in an open-loop control system the output is neither measured nor “fed back” for comparison with the input.

Eg. Head Lights. Wiper Motor etc

CLOSED LOOP SYSTEM

A Closed-loop Control System, also known as a feedback control system is a control system which uses the concept of an open loop system as its forward path but has one or more feedback loops(hence its name) or paths between its output and its input.

EG: Reverse Sensor, Security And Warning Systems In automobiles

VEHICLE MOTION CONTROL

The application of electronics to vehicle motion control systems such as cruise control, tire slip control, ride control, antilock braking, and electronic power steering control.

Recall that the components of a control system include the plant, or system being controlled, and a sensor for measuring the plant variable being regulated. It also includes an electronic control system that receives inputs in the form oft the desired value of the regulated variable and the measured value of thatvariable from the sensor. The control system generates an error signal constituting the difference between the desired and actual values of this variable. It then generates an output from this error signal that drives an electromechanical actuator. The actuator controls the input to the plant in such a way that the regulated plant variable is moved toward the desired value .In the case of a cruise control, the variable being regulated is the vehicle speed. The driver manually sets the car speed at the desired value via the accelerator pedal. Upon reaching the desired speed the driver activates a momentary contact switch that sets that speed as the command input to the control system. From that point on, the cruise control system maintains speed automatically by operating the throttle via a throttle actuator. Theplant being controlled consists of the power train (i.e., engine and drive train), which drives the vehicle through the drive axles and wheels. The load on this plant includes friction and aerodynamic drag as well as a portion of the vehicle weight when the car is going up and down hills. The configuration for a typical automotive cruise control is shown in Figure 8.1. The momentary contact (push-button) switch that sets the command speed is denoted S1 in Figure 8.1. Also shown in this figure is adisable switch that completely disengages the cruise control system from the power supply such that throttle control reverts back to the accelerator pedal. This switch is denoted S2 in Figure 8.1 and is a safety feature. In an actual cruise control system the disable function can be activated in a variety of ways, including the master power switch for the cruise control system, and a brake pedal–activated switch that disables the cruise control any time that the brake pedal is moved from its rest position. The throttle actuator opens and closes the throttle in response to the error between the desired and actual speed.

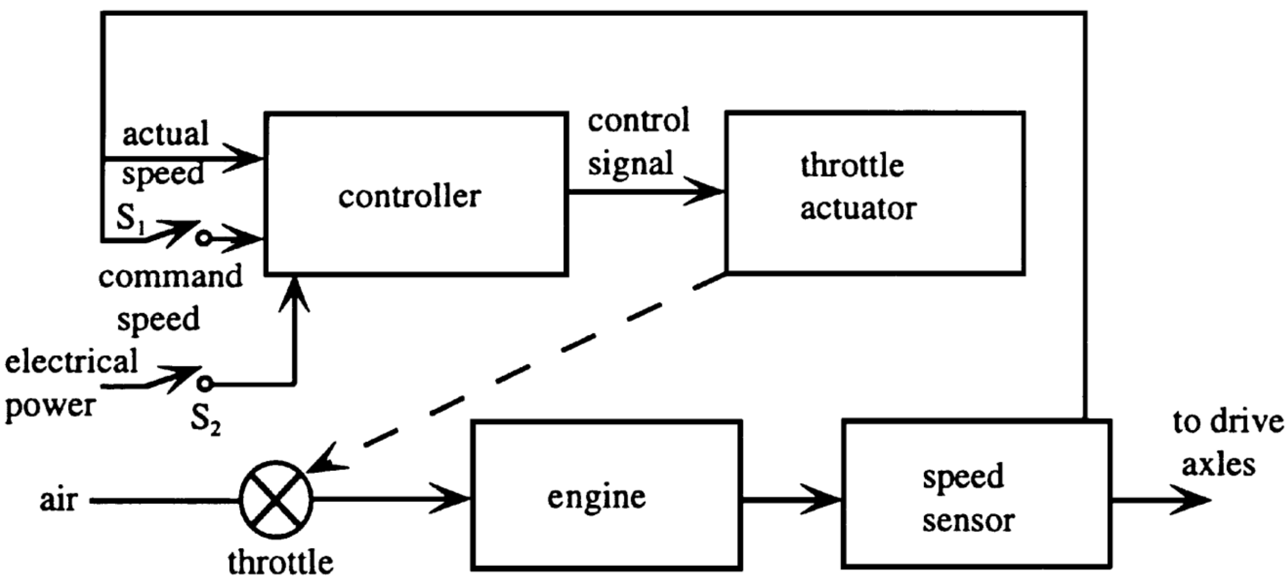


FIGURE. BLOCK DIAGRAM OF CRUISE CONTROL

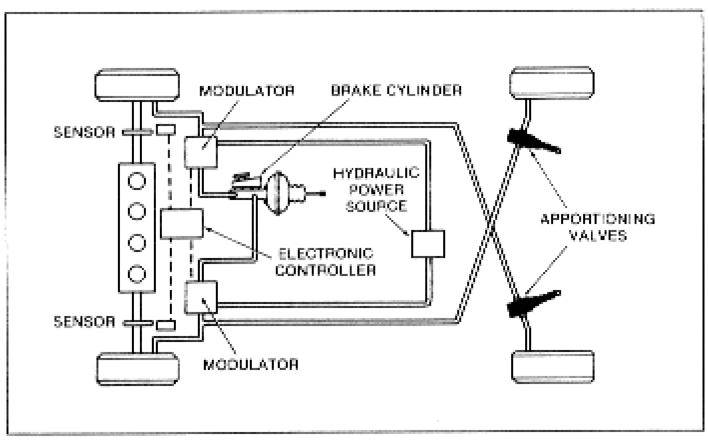
Whenever the actual speed is less than the desired speed the throttle opening is
increased by the actuator, which increases vehicle speed until the error is zero, atwhich point the throttle opening remains fixed until either a disturbance occursor the driver calls for a new desired speed.

A block diagram of a cruise control system is shown in Figure 8.2. In thecruise control depicted in this figure, a proportional integral (PI) controlstrategy has been assumed. However, there are many cruise control systems stillon the road today with proportional (P) controllers. Nevertheless, the PIcontroller is representative of good design for such a control system since it canreduce speed errors due to disturbances (such as hills) to zero. In this strategy an error e is formed by subtracting (electronically) the actual speed Va from the desired speed Vd:e = Vd – VaThe controller then electronically generates the actuator signal by combining a term proportional to the error (KPe) and a term proportional to the integral of

the error (that is,). The actuator signal u is a combination of these two terms. The throttle opening is proportional to the value of this actuator signal.

ANTILOCK BRAKING SYSTEM (ABS)

An anti-lock braking system or anti-skid braking system (ABS) is an automobile safety system that allows the wheels on a motor vehicle to maintain tractive contact with the road surface according to driver inputs while braking, preventing the wheels from locking up (ceasing rotation) and avoiding uncontrolled skidding. It is an automated system that uses the principles of threshold braking and cadence braking which were practiced by skillful drivers with previous generation braking systems. It does this at a much faster rate and with better control than a driver could manage.



SCHEMATIC DIAGRAM OF AN ABS SYSTEM

ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces; however, on loose gravel or snow-covered surfaces, ABS can significantly increase braking distance, although still improving vehicle control

Since initial widespread use in production cars, anti-lock braking systems have been improved considerably. Recent versions not only prevent wheel lock under braking, but also electronically control the front-to-rear brake bias. This function, depending on its specific capabilities and implementation, is known as electronic brakeforce distribution (EBD), traction control system, emergency brake assist, or electronic stability

he anti-lock brake controller is also known as the CAB (Controller Anti-lock Brake

Typically ABS includes a central electronic control unit (ECU), four wheel speed sensors, and at least two hydraulic valves within the brake hydraulics. The ECU constantly monitors the rotational speed of each wheel; if it detects a wheel rotating significantly slower than the others, a condition indicative of impending wheel lock, it actuates the valves to reduce hydraulic pressure to the brake at the affected wheel, thus reducing the braking force on that wheel; the wheel then turns faster. Conversely, if the ECU detects a wheel turning significantly faster than the others, brake hydraulic pressure to the wheel is increased so the braking force is reapplied, slowing down the wheel. This process is repeated continuously and can be detected by the driver via brake pedal pulsation. Some anti-lock systems can apply or release braking pressure 15 times per second.Because of this, the wheels of cars equipped with ABS are practically impossible to lock even during panic braking in extreme conditions.

The ECU is programmed to disregard differences in wheel rotative speed below a critical threshold, because when the car is turning, the two wheels towards the center of the curve turn slower than the outer two. For this same reason, a differential is used in virtually all roadgoing vehicles.

If a fault develops in any part of the ABS, a warning light will usually be illuminated on the vehicle instrument panel, and the ABS will be disabled until the fault is rectified.

Modern ABS applies individual brake pressure to all four wheels through a control system of hub-mounted sensors and a dedicated micro-controller. ABS is offered or comes standard on most road vehicles produced today and is the foundation for electronic stability control systems, which are rapidly increasing in popularity due to the vast reduction in price of vehicle electronics over the years.

Modern electronic stability control systems are an evolution of the ABS concept. Here, a minimum of two additional sensors are added to help the system work: these are asteering wheel angle sensor, and a gyroscopic sensor. The theory of operation is simple: when the gyroscopic sensor detects that the direction taken by the car does not coincide with what the steering wheel sensor reports, the ESC software will brake the necessary individual wheel(s) (up to three with the most sophisticated systems), so that the vehicle goes the way the driver intends. The steering wheel sensor also helps in the operation of Cornering Brake Control (CBC), since this will tell the ABS that wheels on the inside of the curve should brake more than wheels on the outside, and by how much.

ABS equipment may also be used to implement a traction control system (TCS) on acceleration of the vehicle. If, when accelerating, the tire loses traction, the ABS controller can detect the situation and take suitable action so that traction is regained. More sophisticated versions of this can also control throttle levels and brakes simultaneously.

The speed sensors of ABS are sometimes used in indirect tire pressure monitoring system (TPMS), which can detect under-inflation of tire(s) by difference in rotational speed of wheels.

COMPONENETS

There are four main components of ABS: wheel speed sensors, valves, a pump, and a controller.

Speed sensors

A speed sensor is used to determine the acceleration or deceleration of the wheel. These sensors use a magnet and a Hall effect sensor, or a toothed wheel and anelectromagnetic coil to generate a signal. The rotation of the wheel or differential induces a magnetic field around the sensor. The fluctuations of this magnetic field generate a voltage in the sensor. Since the voltage induced in the sensor is a result of the rotating wheel, this sensor can become inaccurate at slow speeds. The slower rotation of the wheel can cause inaccurate fluctuations in the magnetic field and thus cause inaccurate readings to the controller.

VALVES

There is a valve in the brake line of each brake controlled by the ABS. On some systems, the valve has three positions:

In position one, the valve is open; pressure from the master cylinder is passed right through to the brake.

In position two, the valve blocks the line, isolating that brake from the master cylinder. This prevents the pressure from rising further should the driver push the brake pedal harder.

In position three, the valve releases some of the pressure from the brake.

The majority of problems with the valve system occur due to clogged valves. When a valve is clogged it is unable to open, close, or change position. An inoperable valve will prevent the system from modulating the valves and controlling pressure supplied to the brakes.

PUMP

The pump in the ABS is used to restore the pressure to the hydraulic brakes after the valves have released it. A signal from the controller will release the valve at the detection of wheel slip. After a valve release the pressure supplied from the user, the pump is used to restore a desired amount of pressure to the braking system. The controller will modulate the pumps status in order to provide the desired amount of pressure and reduce slipping.

CONTROLLER

The controller is an ECU type unit in the car which receives information from each individual wheel speed sensor, in turn if a wheel loses traction the signal is sent to the controller, the controller will then limit the brake force (EBD) and activate the ABS modulator which actuates the braking valves on and off.

POWER STEERING SYSTEMS

In automobiles, **power steering** (also **power assisted steering (PAS)** or **steering assist system**) helps drivers steer by augmenting steering effort of the steering wheel.

Hydraulic or electric actuators add controlled energy to the steering mechanism, so the driver can provide less effort to turn the steered wheels when driving at typical speeds, and reduce considerably the physical effort necessary to turn the wheels when a vehicle is stopped or moving slowly. Power steering can also be engineered to provide some artificial feedback of forces acting on the steered wheels.

Representative power steering systems for cars augment steering effort via an actuator, a hydraulic cylinder that is part of a servo system. These systems have a direct mechanical connection between the steering wheel and the linkage that steers the wheels. This means that power-steering system failure (to augment effort) still permits the vehicle to be steered using manual effort alone.

Other power steering systems (such as those in the largest off-road construction vehicles) have no direct mechanical connection to the steering linkage; they require electrical power. Systems of this kind, with no mechanical connection, are sometimes called "drive by wire" or "steer by wire", by analogy with aviation's "fly-by-wire". In this context, "wire" refers to electrical cables that carry power and data, not thin-wire-rope mechanical control cables.

In other power steering systems, electric motors provide the assistance instead of hydraulic systems. As with hydraulic types, power to the actuator (motor, in this case) is controlled by the rest of the power-steering system.

Some construction vehicles have a two-part frame with a rugged hinge in the middle; this hinge allows the front and rear axles to become non-parallel to steer the vehicle. Opposing hydraulic cylinders move the halves of the frame relative to each other to steer.

Electric power assisted steering (**EPS**/**EPAS**) or **motor-driven power steering** (**MDPS**)

This system uses an electric motor to assist the driver of a vehicle. Sensors detect the position and torque of the steering column, and a computer module applies assistive torque via the motor, which connects to either the steering gear or steering column. This allows varying amounts of assistance to be applied depending on driving conditions. Engineers can therefore tailor steering-gear response to variable-rate and variable-damping suspension systems, optimizing ride, handling, and steering for each vehicle. On Fiat group cars the amount of assistance can be regulated using a button named "CITY" that switches between two different assist curves, while most other EPS systems have variable assist. These give more assistance as the vehicle slows down, and less at faster speeds.

A mechanical linkage between the steering wheel and the steering gear is retained in EPAS. In the event of component failure or power failure that causes a failure to provide assistance, the mechanical linkage serves as a back-up. When EPAS fails, the driver encounters a situation where heavy effort is required to steer. This heavy effort is similar to that of an inoperative hydraulic steering assist system. Depending on the driving situation, driving skill and strength of the driver, steering assist loss may or may not lead to a crash. The difficulty of steering with inoperative power steering is compounded by the choice of steering ratios in assisted steering gears vs. fully manual. NHTSA has assisted car manufacturers, such as Ford, with recalling EPAS systems prone to failure.

Electric systems have an advantage in fuel efficiency because there is no belt-driven hydraulic pump constantly running, whether assistance is required or not, and this is a major reason for their introduction. Another major advantage is the elimination of a belt-driven engine accessory, and several high-pressure hydraulic hoses between the hydraulic pump, mounted on the engine, and the steering gear, mounted on the chassis. This greatly simplifies manufacturing and maintenance. By incorporating electronic stability control electric power steering systems can instantly vary torque assist levels to aid the driver in corrective maneuvers.

The first electric power steering system appeared on the Suzuki Cervo in 1988.The system has been applied by various automobile manufacturers.

ENGINE CRANKING SYSTEM

The starting system provides a method of rotating (cranking) the vehicle's internal combustion engine (ice) to begin the combustion cycle. In early vehicles, this was done by the use of a hand-crank handle. Modern vehicles use an electric starter motor that draws its electrical power from the vehicle's battery . The starter is designed to work for short periods of time and must crank the engine at sufficient speed in order for it to start. Modern starting systems are very effective provided that they, and the battery, are well maintained.

The starting/cranking system consists of the battery, high- and low-amperage wires, a solenoid, a starter motor assembly ring gear, and the ignition switch. On pcm activated starting systems, there is also the pcm, a relay, and all of the related sensors that feed information to the pcm. A control circuit determines when and if the cranking circuit will function.

The control circuit starts sometimes with a fuse, the ignition switch (or pcm circuitry), the starter relay, a safety switch, and/or a combination relay/starter solenoid. All vehicles equipped with an automatic transmission use a neutral safety switch or a similar device, and many vehicles equipped with a manual transmission have a clutch safety switch.

An on-board computer (pcm) and a security system may also determine if and when the starting system will function.

During the cranking process, two actions occur. The pinion of the starter motor engages with the flywheel ring gear, and the starter motor then rotates to turn over, or crank, the engine. The starter motor is an electric motor mounted on the engine block or transmission. It is typically powered by the 12-volt storage battery, although some hybrid vehicles use the high-voltage battery to operate the starter motor. It is designed to have high turning effort (torque) at low speeds. The starter cables are the heaviest in the vehicle since they carry the high currentneeded by the starter motor. The starter motor causes the engine flywheel and crankshaft to rotate from a resting position and keeps them turning until the engine fires and runs on its own.

ACCELERATION ENRICHMENT

During periods of heavy engine load such as during hard acceleration, fuel control is adjusted to provide an enriched air/fuel ratio to maximize engine torque and neglect fuel economy and emissions. This condition of enrichment is permitted within the regulations of the EPA as it is only a temporary condition. It is well recognized that hard acceleration is occasionally required for maneuvering in certain situations and is, in fact, related at times to safety. The computer detects this condition by reading the throttle angle sensor voltage. High throttle angle corresponds to heavy engine load and is an indication that heavy acceleration is called for by the driver. In some vehicles a switch is provided to detect wide open throttle. The fuel system controller responds by increasing the pulse duration of the fuel injector signal for the duration of the heavy load. This enrichment enables the engine to operate with a torque greater than that allowed when emissions and fuel economy are controlled. Enrichment of the air/fuel ratio to about 12:1 is sometimes used.

DECELERATION LEANING

During periods of light engine load and high RPM such as during coasting or hard deceleration, the engine operates with a very lean air/fuel ratio to reduce excess emissions of HC and CO. Deceleration is indicated by a sudden decrease in throttle angle or by closure of a switch when the throttle is closed (depending on the particular vehicle configuration). When these conditions are detected by the control computer, it computes a decrease in the pulse duration of the fuel injector signal. The fuel may even be turned off completely for very heavy deceleration.

IDLE SPEED CONTROL

Idle speed control is used by some manufacturers to prevent engine stall during idle. The goal is to allow the engine to idle at as low an RPM as possible,yet keep the engine from running rough and stalling when power-consuming accessories, such as air conditioning compressors and alternators, turn on.

The control mode selection logic switches to idle speed control when the throttle angle reaches its zero (completely closed) position and engine RPMfalls below a minimum value, and when the vehicle is stationary. Idle speed is controlled by using an electronically controlled throttle bypass valve (Figure 7.7a) that allows air to flow around the throttle plate and produces the same effect as if the throttle had been slightly opened. There are various schemes for operating a valve to introduce bypass air for idle control. One relatively common method for controlling the idle speed bypass air uses a special type of motor called a *stepper motor*. A stepper motormoves in fixed angular increments when activated by pulses on its two sets of windings (i.e., open or close). Such a motor can be operated in either direction by supplying

pulses inthe proper phase to the windings. This is advantageeous for idle speed control since the controller can very precisely position the idle bypass valve by sending the proper number of pulses of the correct phasing.
The engine control computer can know precisely the position of the valve in a number of ways. In one way the computer can send sufficient pulses to completely close the valve when the ignition is first switched on. Then it can send open pulses (phased to open the valve) to a specified (known) position block diagram of a simplified idle speed control system is shown in Figure. Idle speed is detected by the RPM sensor, and the speed is adjusted to maintain a constant idle RPM. The computer receives digital on/off status inputs from several power-consuming devices attached to the engine, such as the air conditioner clutch switch, park–neutral switch, and the battery charge indicator. These inputs indicate the load that is applied to the engine during idle. When the engine is not idling, the idle speed control valve may be completely closed so that the throttle plate has total control of intake air. During periods of deceleration leaning, the idle speed valve may be opened to provide extra air to increase the air/fuel ratio in order to reduce HC emissions.

DISTRIBUTOR LESS IGNITIONS SYSTEM

Fig. 1: Typical distributorless ignition schematic

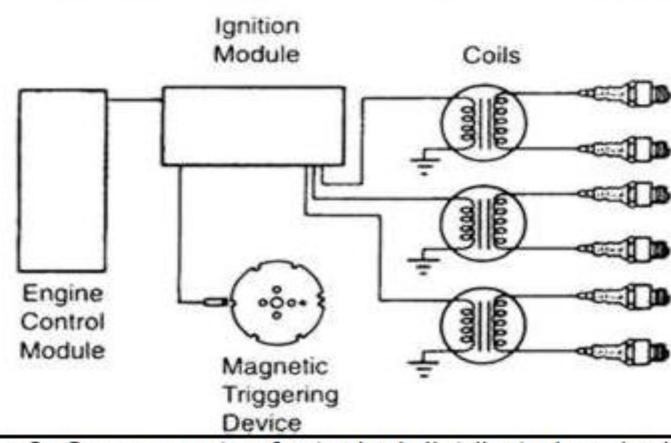
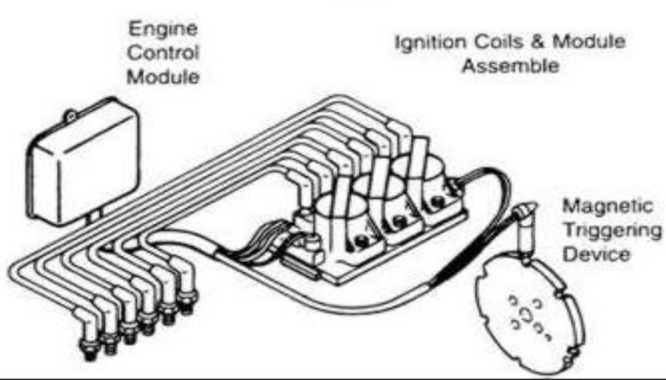


Fig. 2: Components of a typical distributorless ignition system



Some popular systems use one ignition coil per two cylinders. This type of system is often known as the waste spark distribution method. In this system, each cylinder is paired with the cylinder opposite it in the firing order (usually 1-4, 2-3 on 4-cylinder engines or 1-4, 2-5, 3-6 on V6 engines). The ends of each coil secondary leads are attached to spark plugs for the paired opposites. These two plugs are on companion cylinders, cylinders that are at Top Dead Center (TDC) at the same time. But, they are paired oppsites, because they are always at opposing ends of the 4 stroke engine cycle. When one is at TDC of the compression stroke, the other is at TDC of the exhaust stroke. The one that is on compression is said to be the event cylinder and one on the exhaust stroke, the waste cylinder. When the coil discharges, both plugs fire at the same time to complete the series circuit.

Since the polarity of the primary and the secondary windings are fixed, one plug always fires in a forward direction and the other in reverse. This is different than a conventional system firing all plugs the same direction each time. Because of the demand for additional energy; the coil design, saturation time and primary current flow are also different. This redesign of the system allows higher energy to be available from the distributorless coils, greater than 40 kilovolts at all rpm ranges.

The Direct Ignition System (DIS) uses either a magnetic crankshaft sensor, camshaft position sensor, or both, to determine crankshaft position and engine speed. This signal is sent to the ignition control module or engine control module which then energizes the appropriate coil.

The advantages of no distributor in theory is:

- No timing adjustments
- No distributor cap and rotor
- No moving parts to wear out
- No distributor to accumulate moisture and cause starting problems
- No distributor to drive thus providing less engine drag

The major components of a distributorless ignition are:

- ECU or Engine Control Unit
- ICU or Ignition Control Unit
- Magnetic Triggering Device such as the Crankshaft Position Sensor and the Camshaft Position Sensor
- Coil Packs

EXHAUST EMISSION CONTROL ENGINEERING.

Detailed Report of this topic is given in the following Web Address

www.technology.matthey.com/pdf/157-162-pmr-oct03.pdf

ON BOARD DIAGNOSTIC SYSTEM

On-board diagnostics (OBD) is an automotive term referring to a vehicle's self-diagnostic and reporting capability. OBD systems give the vehicle owner or repair technician access to the status of the various vehicle subsystems. The amount of diagnostic information available via OBD has varied widely since its introduction in the early 1980s versions of on-board vehicle computers. Early versions of OBD would simply illuminate a malfunction indicator light or "idiot light" if a problem was detected but would not provide any information as to the nature of the problem. Modern OBD implementations use a standardized digital communications port to provide real-time data in addition to a standardized series of diagnostic trouble codes, or DTCs, which allow one to rapidly identify and remedy malfunctions within the vehicle.

EOBD

The EOBD (European On Board Diagnostics) regulations are the European equivalent of OBD-II, and apply to all passenger cars of category M1 (with no more than 8 passenger seats and a Gross Vehicle Weight rating of 2500 kg or less) first registered within EU member states since January 1, 2001 for petrol (gasoline) engine cars and since January 1, 2004 for diesel engine cars

For newly introduced models, the regulation dates applied a year earlier – January 1, 2000 for petrol and January 1, 2003 for diesel.
For passenger cars with a Gross Vehicle Weight rating of greater than 2500 kg and for light commercial vehicles, the regulation dates applied from January 1, 2002 for petrol models, and January 1, 2007 for diesel models.

The technical implementation of EOBD is essentially the same as OBD-II, with the same SAE J1962 diagnostic link connector and signal protocols being used.

With Euro V and Euro VI emission standards, EOBD emission thresholds will be lower than previous Euro III and IV.

EOBD fault codes

Each of the EOBD fault codes consists of five characters: a letter, followed by four numbers. The letter refers to the system being interrogated e.g. Pxxxx would refer to the powertrain system. The next character would be a 0 if complies to the EOBD standard. So it should look like P0xxx.

The next character would refer to the sub system.

P00xx – Fuel and air metering and auxiliary emission controls.

P01xx – Fuel and air metering.

P02xx – Fuel and air metering (injector circuit).

P03xx – Ignition system or misfire.

P04xx – Auxiliary emissions controls.

P05xx – Vehicle speed controls and idle control system.

P06xx – Computer output circuit.

P07xx – Transmission.

P08xx – Transmission.

Refer Class Notes for the following topics.
Components for electronic engine management,
Electronic management of chassis system,
Electronic dashboard instruments, and integrated engine control systems,