ISSN 2250-3153

Validation Process and Development of Control Strategy of Electronic Control Unit for Injector and Ignition coil Drivers

Mansi K. Ajudia*, Prof. Dr. Mahesh T. Kolte, Mr. Prasanta Sarkar*****

*Department of Electronics & Telecommunication, M.E. 2nd Year (E&TC), M.I.T College of Engineering Pune
**Department of Electronics & Telecommunication, H.O.D (E&TC), M.I.T College of Engineering Pune
***TTL Pvt. Ltd., Pune
University of Pune, India
mansiajudia@gmail.com, mahesh.kolte@mitcoe.edu.in

Abstract- This paper is based on Electronic Control Unit (ECU)'s validation process for Input (crank signal) and Output Drivers (injector and ignition coil signals) characteristics. Because of the code flashed on ECU using IDE for particular microcontroller that controls the injector driver and ignition driver pulses respectively. Based on the given PWM Input signal(crank signal) it will give injector and ignition pulses , which is used to obtain ECUs best result using generated and flashed code on microcontroller on virtual environment setup. Hardware-in-loop setup is act as a virtual engine setup, which gives the input sensor signals to ECU for their best performance under test on bench or in lab testing.

Index Terms- Electronic Control Unit, Hardware in loop setup, pulse width modulated signal, integrated development environment.

I. Introduction

Rigorous testing of Electronic control unit is necessary since engine contains ignitable liquids and human lives will be put at danger if something goes mistaken. If nothing goes mistaken then also it is compulsory that the engine works well. Electronic control units are costlier and also the human lives are involved, for this reason ECU's are tested prior on test bench and then ECU's will be put in the actual Vehicle.

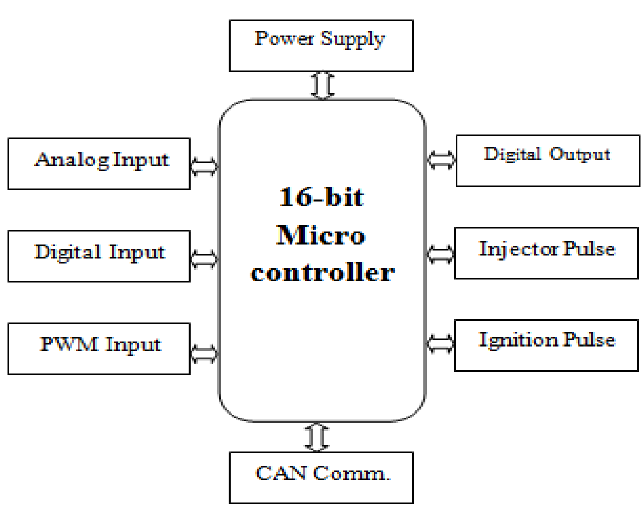


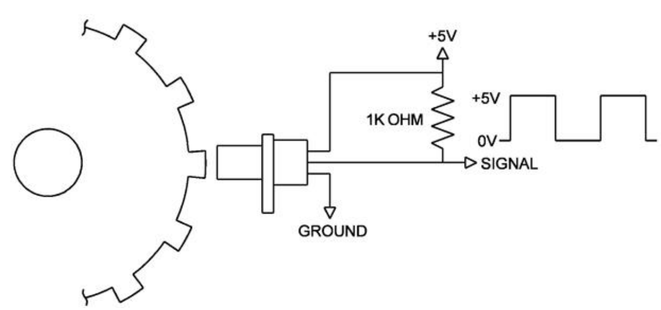
Figure 1: ECU input output diagram

II. Crankshaft Position Sensor (engine speed) Frequency Input:

In an internal combustion engine, an electronic device used is a crankshaft position sensor which keeps an eye on the arrangement or rotational speed of the crankshaft. The engine management system http://en.wikipedia.org/wiki/Engine_management_system uses this information to control ignition system timing and engine's other parameters. Electronic crank sensors were available earlier; the distributor has to physically regulate a timing mark on the engine.

The crank sensor and a camshaft position sensor both are used combinable to observe the functionality between the pistons and valves inside the engine, this is mainly central in engines with the variable valve timing. Whole mechanism is used to synchronise a four stroke engine starting, and also allows the management system to know when the fuel is injected inside it. For measurement of engine speed in terms of revolution per minute, this method is primary and commonly used for engine management system.

Now a days, this sensor is the most important sensor and used widely in 4-wheeler vehicle. Whenever this sensor fails, there may be a probability that the engine will not start or may cut out during running mode.



ISSN 2250-3153

Figure 2: Mechanism of crank wheel for 4-wheeler vehicle.

2.1 LOCATION OF CRANKSHAFT POSITION SENSOR

Crank shaft position sensor is also known as Engine Speed Sensor or Crank Sensor. This sensor is mounted in an installation bore in the engine housing as shown in figure below.

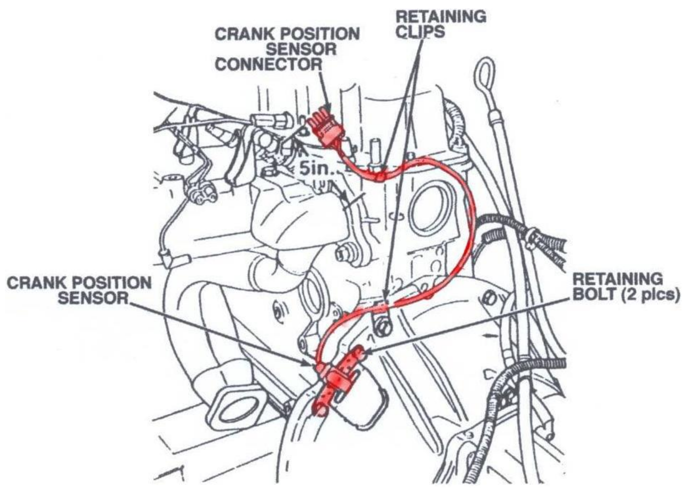


Figure 3: Location for crank shaft position sensor in 4-wheeler vehicle.

The crankshaft position sensor decides the situation and/or revolution per minute (RPM) of the crank wheel because this is its main aim. Inside engine management system, engine control units make use of the information comes from and to the sensor to control the engines parameters such as ignition period and fuel injection period. For the starting up of a four stroke engine, this is very important phenomenal.

III. FUEL INJECTOR

Figure 4: Fuel Injector for 4-wheeler vehicle.

The venture effect of a converging-diverging nozzle to transfer the pressure energy of a motion based fluid to speed energy which is responsible for creation of a low pressure region that puts in and entrains a suction fluid this technique is used pumps is known as an injector or ejector. Velocity reduction and the assorted fluid expansion is achieved after passing it all the way through esophagus of injector. Conversation of speed energy back into force energy, this result is achieved while recompressing the mixed fluids. The motion based fluid can be in form of liquid, vapor or any other gas form.

Figure 5: Location of fuel injector in 4-wheeler vehicle.

3.1 TECHNICAL PRINCIPLE OF OPERATION FOR FUEL INJECTORS IN 4-WHEELER VEHICLE.

Fuel Injectors are the actuators which control the fuel to be injected. The amount of fuel delivered by the fuel injector is determined electronically in accordance with the air flow in such a way as to minimize pollutants in the exhaust gas. ECU provides drive signal to injector (normally closed valve) to open and remain in open condition (pulse width-ms) depending upon the engine operating conditions (speed/load). Also the pulse width is compensated for low battery voltage condition. The concept of Sequential injection means when ECU provides drive signal to each injector spray separately at the end of compression process.

IV. IGNITION COIL

The ignition coil in 4-wheeler vehicle may be attached to the fender or engine inside the distributor cap. It converts the signal into the volt charge and can be tested either on or off the vehicle.

Figure 6: Ignition coil for 4-wheeler vehicle.

An ignition coil sometimes called as an induction coil in a vehicle's ignition arrangement. Their main function is to amplify the battery's voltage to a required level of voltage to produce an electric spark with the intention of ignites or burns fuel in the spark plugs. Their main function is to amplify or produces the battery's 12 volts to thousands of volts. To convert the storage battery of 12 volts to the thousands of volts required to generate the spark within spark plugs ignition coils are used in 4-wheeler vehicle. It works as a storage device and its main function is to storage of energy. Conversion of the high voltage that comes from the battery into current which the spark plugs necessitate to fire for this purpose ignition coils are used. An induction coil which is nothing but an ignition coils with the purpose of changing current as of a battery into the high-voltage current required by spark plugs in an internal-combustion engine. It handles and receives a small amount of electrical voltage from the battery and ladders up the low and quot prime and quot voltage and amplifies it into a big range of voltage and gives it to the spark plugs through the distributor.

4.1 TECHNICAL PRINCIPLE OF OPERATION FOR IGNITION COIL IN 4-WHEELER VEHICLE.

The induction coil operates according to the laws of induction. The unit consist of two magnetically Coupled copper coils (primary and secondary windings). Energy is stored in the primary winding's magnetic field by allowing a current to flow through the primary circuit switched by the power stage. At the firing point current flow is interrupted which induces secondary voltage in the coil's secondary winding. The ignition coil has two high voltage terminal one for waste spark and the other for the ignition spark.

4.2 LOCATION OF IGNITION COIL

The ignition coil assembly is mounted on engine cylinder head cover as shown in figure.

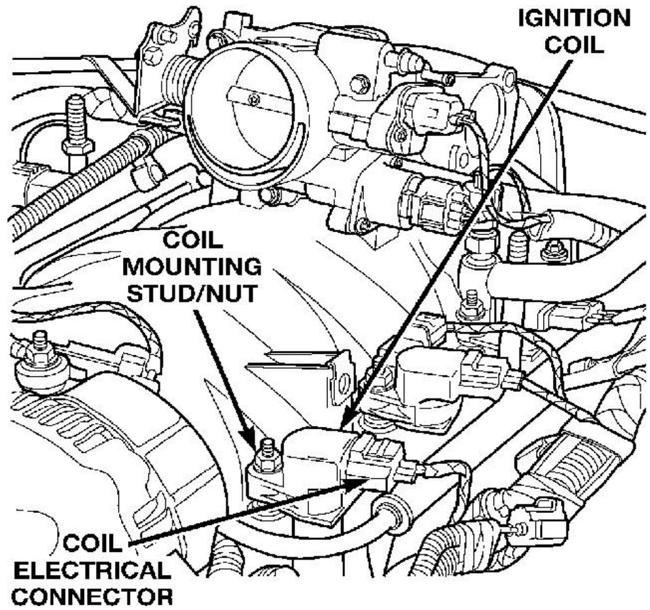


Figure 7: Location of Ignition Coil in 4-wheeler vehicle.

Ignition Coil generates the high voltage spark for ignition. The spark timing is decided by ECU based on various inputs like crank shaft position.

V. EXPERIMENT AND RESULTS

According to developed code for frequency input (crankshaft position input) for ECU from ECU's IDE, it will perform some action.

```
** ===========================================================
** Event : Cap1_OnCapture (module Events)
**
** Component : Cap1 [Capture]
** Description :
** This event is called on capturing of Timer/Counter actual
** value (only when the component is enabled - <Enable> and the
** events are enabled - <EnableEvent>.This event is available
** only if a <interrupt service/event> is enabled.
** Parameters : None
** Returns : Nothing
** ===========================================================
*/

void Cap1_OnCapture(void)
{
/* Write your code here ... */
char i;
unsigned long Total_time_ticks = 0 ;
Cap1_GetCaptureValue(&New_Count);
Cap1_Reset();
/* Increment the teeth counter every time you enter crank isr*/
u8_Int_cran_cou_teeth++;
/* store the capture register value to indicate the ticks when following
edge of teeth occurs.*/
u16_Int_Cran_TickDiff_Array[u8_Int_cran_cou_teeth-1] = New_Count;
if(u8_Int_cran_cou_teeth>2){
if( u16_Int_Cran_TickDiff_Array[u8_Int_cran_cou_teeth-1] >=
(3 * u16_Int_Cran_TickDiff_Array[u8_Int_cran_cou_teeth-2]/2))
{ //Missing Pulse
for(i=1;i< u8_Int_cran_cou_teeth;i++){
Total_time_ticks = Total_time_ticks + u16_Int_Cran_TickDiff_Array[i];
}
RPM = 60000000/Total_time_ticks;
mip_engine_rpm = RPM;
u32_vEngineRpm_couRaw = RPM;
//angle to time domain
if(float_vInjOnAngle>135)
{
u32_Int_Cran_Tic_InjectionOnTicks =((Total_time_ticks *
```

```
((float_vInjOnAngle - 135)/360))*5);
}
else
{
u32_Int_Cran_Tic_InjectionOnTicks =((Total_time_ticks *
((float_vInjOnAngle + 225)/360)*5);
}
mff_injector_pulse_width = 2;
/* millisecs to ticks conversion for 1MHZ clock */
u16_Int_Inje_ms_InjectionPulseWidthTicks =((mff_injector_pulse_width/2)*5000);
if( float_vCoilOffAngle > 60)
{
float_vCoilOffAngle = 60;
}
else if(float_vCoilOffAngle < (-10))
{
float_vCoilOffAngle=(-10);
}

/*Convert the angular domain to time domain*/
u32_Int_Cran_Tic_IgnitionOffAngle = ((Total_time_ticks *((360-(225 +
(float_vCoilOffAngle))))/360)*5);
u16_Int_Igni_Tic_DwellTicks = u16_Int_Igni_Tic_DwellTime*5000;//
u32_Int_Cran_Tic_IgnitionOnAngle = u32_Int_Cran_Tic_IgnitionOffAngle
- u16_Int_Igni_Tic_DwellTicks;

IGN_Timer_SetPeriodTicks32(u32_Int_Cran_Tic_IgnitionOnAngle);
u8_Int_Igni_Fla_SparkIsOn = 0;
INJ_Timer_SetPeriodTicks32(u32_Int_Cran_Tic_InjectionOnTicks);
u8_Int_Inje_Fla_InjectorsAreOn = 0;
INJ_Timer_Enable();
IGN_Timer_Enable();
u8_Int_cran_cou_teeth = 1;
}
}
}
```

The crankshaft position sensor senses the PWM signal (frequency input) from the engine of vehicle. According to the detected input signal, it will generate the injector and ignition pulse after some time respectively. If the Crank sensor is of 36 teethes, it will gives crank signal of 36 teethes. With, reference to the crank pulse and generated code for the ECU for injection pulse. It will give injection pulse after >135 degrees and <225 degrees with reference to the crank pulse, which is of 360 degrees. This process indicates the successful injection of fuel inside the engine, this result is reflects from the generated code for microcontroller. And after >60 degrees or < (-10) degrees it will give ignition pulse with reference to the crank signal as per generated code for ECU in their IDE. These results are shown in given figure:

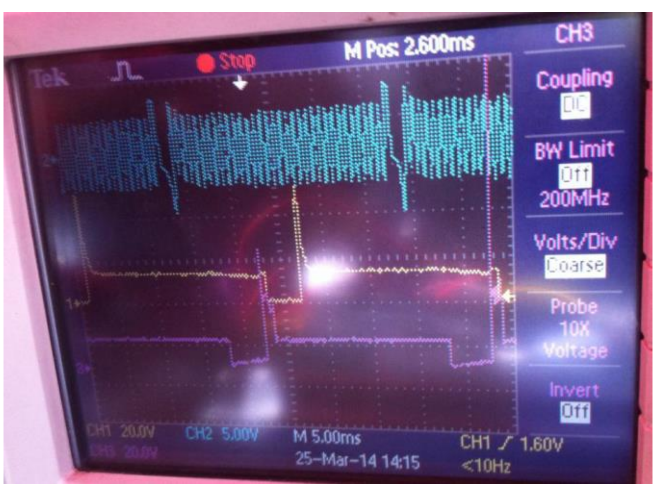


Figure 8: Results of crank input and injector and ignition coil driver pulse in oscilloscope.

Here in given figure 8, the results of crank input, injector driver output and ignition coil driver output are given respectively in form of pulses. These pulses are taken from oscilloscope, which determines the proper working of ECU in test bench, in virtual engine setup and in a vehicle.

(1.) Frequency Input (crank input) Signal
(2.) Frequency Output (injector pulse) Signal
(3.) Frequency Output (ignition pulse) Signal

VI. Conclusion

For validation process of ECU, the prefect working of crank shaft sensor input and injector and ignition driver output is required for ECU's accurate operation on bench testing or in a virtual environment on PC or in a vehicle. This paper is based on working process of crank sensor input, injector driver and ignition coil driver in 4-wheeler vehicle and also gives their location in vehicle. For ECU's validation process perfect angular operation are required for injector and ignition coil driver, this paper gives the angular position and its working based on the generated code for crank input, injector driver and ignition coil driver with microcontroller from their IDE. The results are shown here is in form of oscilloscope results, which are the standard results for ECU and their working process.

References

[1] F. Barghi, A.A. Safavi, *"An Intelligent Control Policy for Fuel Injection Control of SI Engines (Case Study: CNG Engine),"* INES 2011, 15th International Conference on Intelligent Engineering Systems, Poprad, Slovakia, June 23–25, 2011.

[2] Jie Zeng, Liyan Zhang, Feng Kong, Xigeng Song, *"Development of 32-bit Universal Electronic Control Unit UECU32 for Automotive Application,"* IEEE ICARCV, 2006.

[3] A.Cebi, L. Guvenc, M. Demirci, C. Kaplan Karadeniz, K. Kanar, E. Guraslan, *"A Low Cost, Portable Engine Electronic Control Unit Hardware-in-the-loop Test System,"* IEEE ISIE, Dubrovnik, Croatia, 2005.

[4] Feng Huizong, Cen Ming, Zhang Yu, Jiang Jianchun, Dai Huasheng, *"A Weak Coupled Calibration System Architecture for Electronic Control Unit,"* IEEE Vehicle Power and Propulsion Conference (VPPC), September 3-5, China, 2008.

[5] Liu Sh.h.,WANG. Z.Y., REN J., *"Development of compressed natural gas/diesel dual-fuel turbo-charged compression ignition engine,"* Proc. IMechE vol.217 PartD: J. Automobile engineering:839-845

[6] AUTOSAR Technical overview, R3.0, *Rev.0001*, November, 2007.

[7] AUTOSAR Specification of PWM Driver, *R3.0*, Rev.0001, October 2007.

[8] Woong-Jae Won, Jangkyung Son, Gwangmin Park, Daehyun Kum, Seonghun Lee, "*Design and Implementation Procedure of the AUTOSAR I/O Driver Cluster,"* ICROS-SICE International Joint Conference, Fukuoka International Congress Centre, Japan, August 18-21, 2009