DESIGNS OF INPUT AND OUTPUT DRIVER CIRCUITS FOR 16-BIT ELECTRONIC CONTROL UNIT (ECU) AND DEVELOPMENT OF CONTROL STRATEGY FOR ECU USING THESE I/O DRIVER CIRCUITS

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Abstract

The rapid prototype based method for design process of control strategy of electronic control unit for input and output driver circuit for 16-bit Electronic Control Unit (ECU). This method saves time and cost for making of an electronic control unit board and uses the electronic control unit board having a type of microcontroller in which we can flash code many times for generation of control strategy. Based on the given circuit, development of control strategy for electronic control unit is done in microcontroller's supported IDE. Then, test and verify the developed code with the use of given input and output driver circuits for electronic control unit on test bench with virtual engine environment setup or in an actual vehicle. The whole process is associated with development of Engine Management System. In this paper the input and output driver circuit design is given for further development of control code for four wheeler vehicles. Using this technique the validation process of electronic control unit board is done on test bench setup or in actual vehicle.

Keywords- *Electronic Control Unit, Integrated Development Environment, Engine Management System, Manifold-air Pressure, Accelerator Pedal Position, Engine Coolant Temperature, Controller Area Network*

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1. INTRODUCTION

Electronic Control Unit Consists of input and output drivers circuits with communication devices as its peripherals. Those are used for controlling purpose for internal operation of electronic control unit. The main aim of the peripheral circuits for electronic control unit is to drive vehicle with greater accuracy on road condition for achieving better performance from vehicle. Testing of electronic control unit on bench is required because vehicle's engine contains dangerous liquids and harmful gases so the vehicle and electronic control unit may get damaged.

So, it necessary to test electronic control unit on test bench earlier and then set up it to actual vehicle. Therefore, the process of development of control code is done in the microcontroller's IDE and tested the same on test bench or in a vehicle.

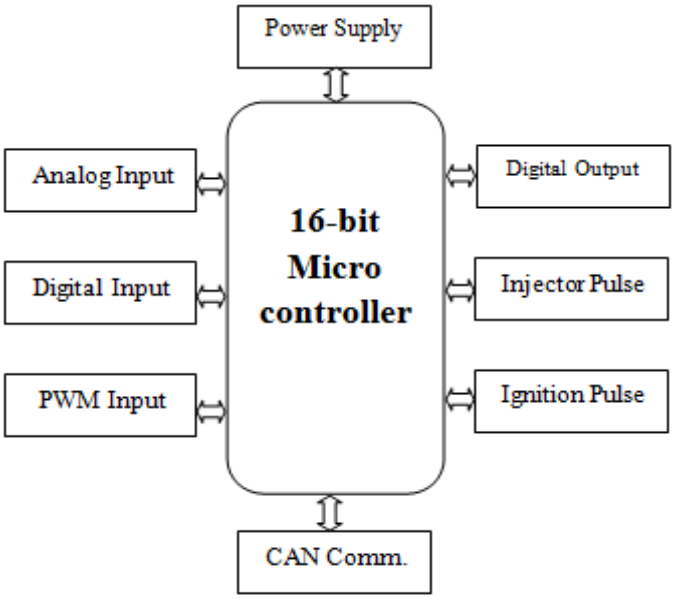

Fig 1: ECU input output circuit diagram

For above given process the circuit of input and output drivers of electronic control unit is required. For designing purpose peripheral circuits of electronic control units is done using circuit

tool drafting tool. Here in this paper the schematic for the input and output driver circuits of 16-bit Electronic Control Unit design is given using orcade capture tool.

An Electronic Control Unit consists of functional blocks:

- Microcontroller or microprocessor
- Power Supply Section
- Analog Inputs (continuously varying values)
- Digital Inputs (on/off type inputs)
- Frequency Inputs (vehicle speed input)
- Digital Outputs (on/off type output)
- Injector Driver Output
- Ignition Coil Driver Output

2. ANALOG INPUT CIRCUIT FOR ELECTRONIC CONTROL UNIT

An analog signal is a type of signal which represents continuously variable voltage and amplitude with respect to time is called as an analog signal. The analog inputs refer and receive the outcome from sensors. In other words an analog input senses the sensor information and feed them to the ECU using a supported voltage level of microcontroller. Typical analog inputs for ECU include accelerator pedal position sensor signal (APP), manifold-air pressure sensor signal (MAP), and engine coolant temperature sensor signal (coolant) etc. are referred as analog inputs. All analog inputs given here are supplied with 5V with reference to ground potential (zero/negative potential).

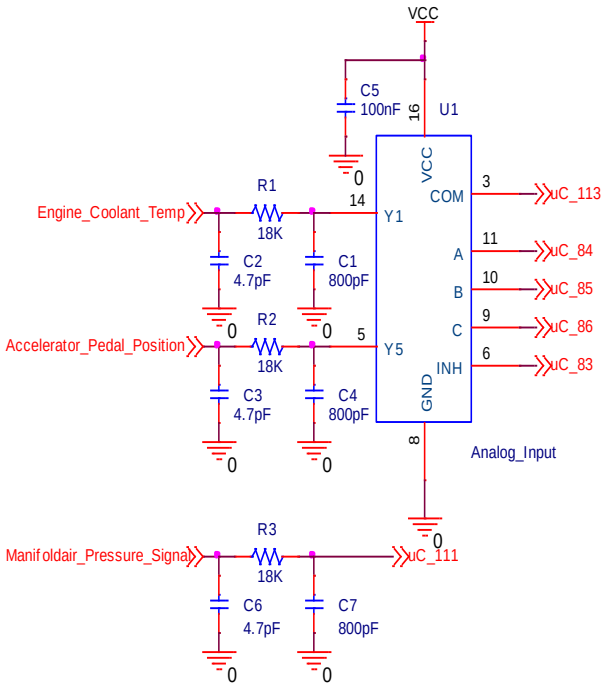

Fig 2: Analog I/P Circuit for 16-bit ECU

3. DIGITAL INPUT CIRCUIT FOR ELECTRONIC CONTROL UNIT

A digital input signal is a type of signal that represents two voltage levels first is high and second is low. The digital signals are having two states for representation and transition of data. The digital input provides the on/off (triggered) type data input to the ECU for its operation. Typically the on/off switch input (toggle switches) are given as a reference for digital inputs of electronic control unit. All digital inputs are preconfigured with internal pull up resistors which can be preconfigured or set during the programming of ECU to convene particular environment. All digital inputs are feed with 5V supply with respect to Ground. The digital signal is not having continuously variable value like analog signals. The two state values of digital inputs have been expressed in various ways like high/low, on/ off, 0/1.

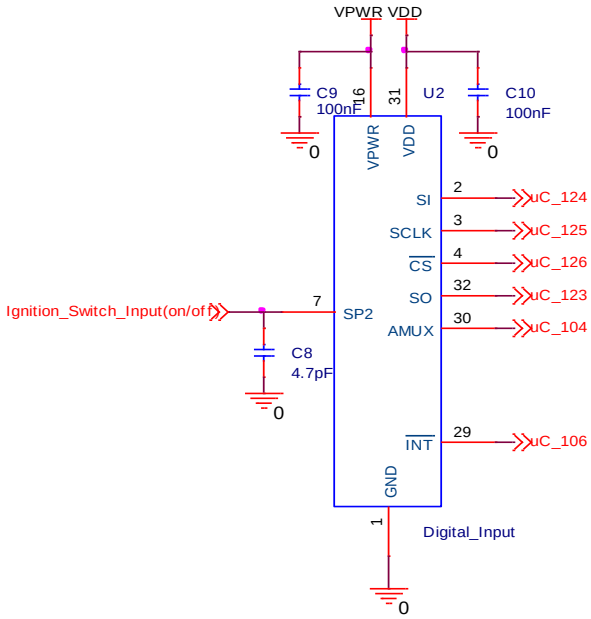

Fig 3: Digital I/P Circuit for 16-bit ECU

4. DIGITAL OUTPUT DRIVER CIRCUIT FOR ELECTRONIC CONTROL UNIT

The Low-side Switch and Low-side Drive outputs are used to control the low side of relay coils and other devices. These outputs current on the low-side (zero potential), they are constantly attached to the negative potential a zero potential region of circuit. An example of a Low-side Switch output enabling an external relay.

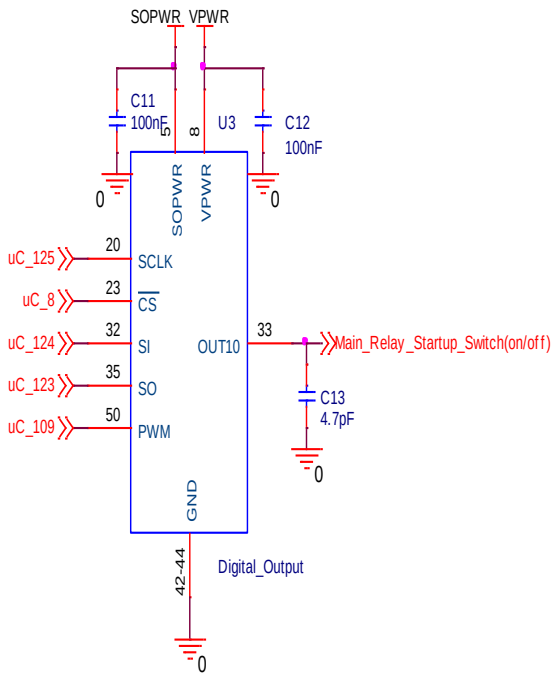

Fig 4: Digital O/P Circuit for 16-bit ECU

The low-side driver switch outputs are selected as low voltage and current range probably the ranges are 2A which indicates low value, 5A which indicates medium value, or 10A which indicates high value with respect to their current conducting capabilities. The only care must be taken to make sure that the devices related with the ECU, which do not exceed the ratings of their respective outputs.

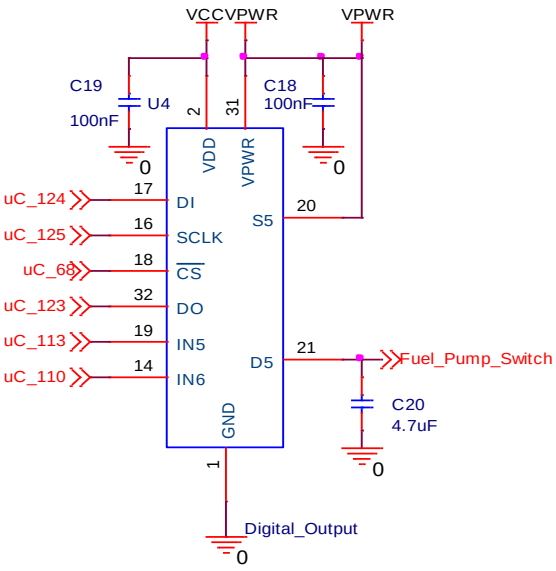

Fig 5: Digital O/P Circuit for 16-bit ECU

5. FREQUENCY INPUT CIRCUIT FOR ELECTRONIC CONTROL UNIT

The Electronic Control unit senses the input signal coming from variable reluctance sensor (VR); these inputs are being used to provide trigger sensor information to the ECU. These is used in many other applications, typically these are uses include in Cam-shaft/Crank-shaft Position/Vehicle Speed Sensors and wheel speed sensors.

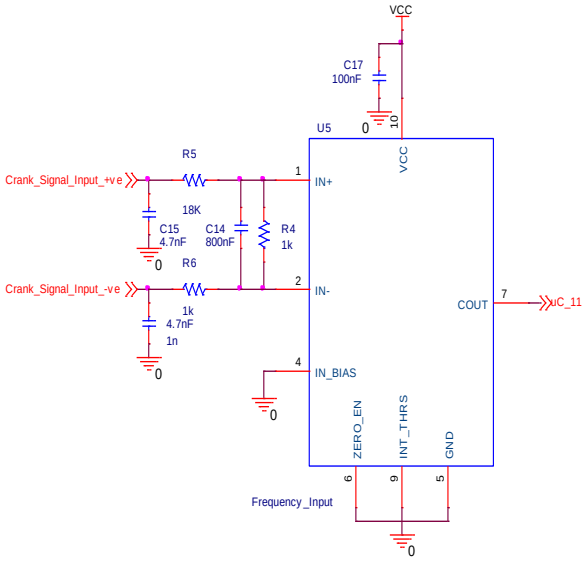

Fig 6: Frequency I/P Circuit for 16-bit ECU

6. INJECTOR AND IGNITION COIL DRIVER CIRCUIT FOR ELECTRONIC CONTROL UNIT

Injectors are driven with the help of output signal, which is coming from ECU having lower voltage range. Supply of 12 V feed to injectors, which is coming from main power relay of vehicle. High impedance or low impedance injectors can be used with engine lab controllers without the need for higher value resistors. Similarly, Ignition coils are driven with the help of output signal, which is coming from the ECU and having lower voltage range. So, many different types of ignition characteristics are supported, such as Multi-Sequential, Multi-Wasted Spark, Single, Distributor coil and many more. In multi-coil package, the spark gap is used which supports a igniters pack, which are supplied by the positive 12V main relay signal from the main power relay of vehicle for driving purpose of vehicle successfully on the running condition.

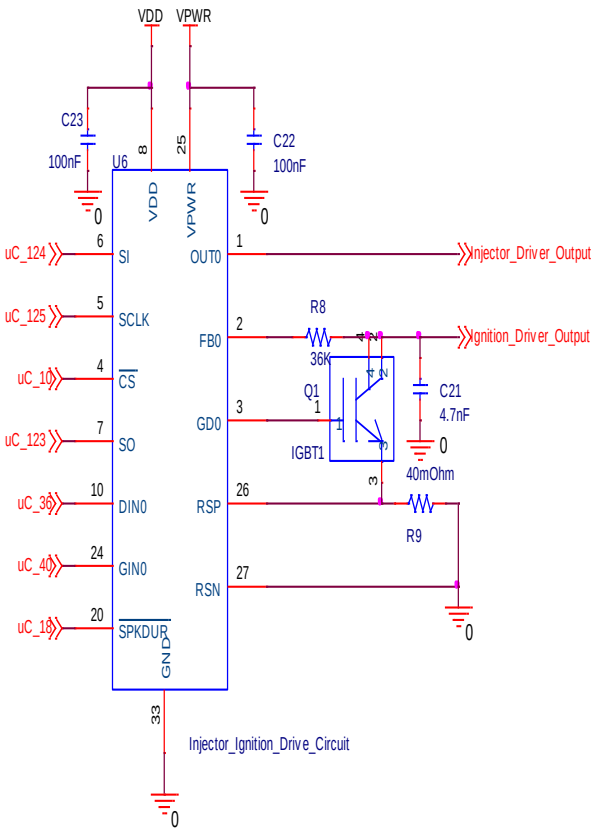

Fig 7: Injector and Ignition Coil Circuit for 16-bit ECU

7. CONTROLLER AREA NETWORK (CAN) CIRCUIT FOR ELECTRONIC CONTROL UNIT

The Can Bus is used to control and communicate with Can devices on the vehicle. To control the air pollution and emission of harmful which are produced by today's automotive industry, the automotive industry has developed multiple electronic systems. Those main functions are to improve pollution and fuel consumption. Those systems having more complication that's why those required the data exchange among them, therefore they required so many hard-wired connections for performance of dedicated lines for signal operations. The CAN Communication protocol gives the complete solution path for its function. With, the help of CAN, microcontrollers, vehicle sensors and output directed actuators communicate or interact with each other devices in the given node network, in real(synchronized)-time, with a speed of up to 1Mbit/second, over a two wire cable serial (ongoing) data bus.

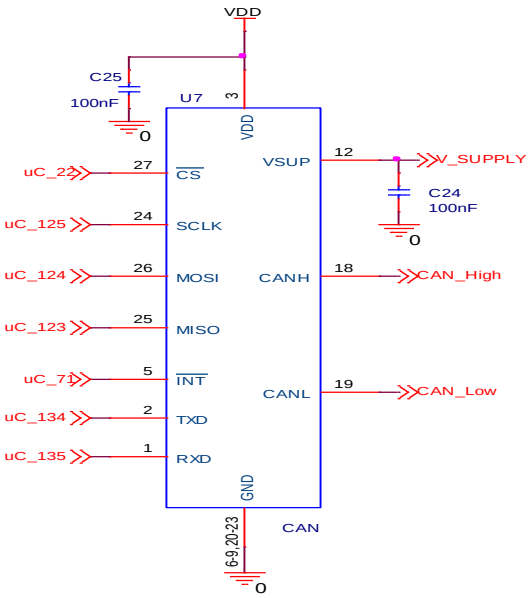

Fig 8: Controller Area Network Circuit for 16-bit ECU

8. EXPERIMENT AND RESULTS

Procedure for Generating the Control Algorithm for input and output driver circuits of 16-bit Electronic Control Unit (ECU) in the microcontroller's given Integrated Development Environment (IDE) using the input and output driver circuit and pin mapping of input and output driver circuits with using above given figures for input and output driver circuits.

```
/************** read analog I/ps **************************/
  A_HC4851_SetVal();
  B_HC4851_ClrVal();
  C_HC4851_SetVal();

  AD1_Measure(1);      //Measure Accelerator pedal signal
  AD1_GetValue8(Analog_values);
  Acc_Pedal_Signal = Analog_values[2];

  A_HC4851_SetVal();
  B_HC4851_ClrVal();
  C_HC4851_ClrVal();

  AD1_Measure(1);      //Measure Engine Coolant temp signal
  AD1_GetValue8(Analog_values);
  Eng_Coolant_Temp_Signal = Analog_values[2];
  u32_vECT_couRaw = Eng_Coolant_Temp_Signal;

  MAP_Signal =  Analog_values[0]; //Measure Manifold air pressure signal

  /************** end of read analog I/ps********************/
  /************** read digital I/p ******************/
```

```
read break switch i/p
   if(!MC33972_vRead_IP(Rd_Buffer)){
    if((Rd_Buffer[0]&0x01)){//if ignition on

     // MC33999B_MainRelay_SetVal(); //switch on main relay
      MC33999B_MainRelay_ClrVal();
              FuelPump_ClrVal();
        } else {

    //  MC33999B_MainRelay_ClrVal(); //switch off main relay
     MC33999B_MainRelay_SetVal();
             FuelPump_SetVal();
    }    }
/*************** end of read digital I/p *****************/
```

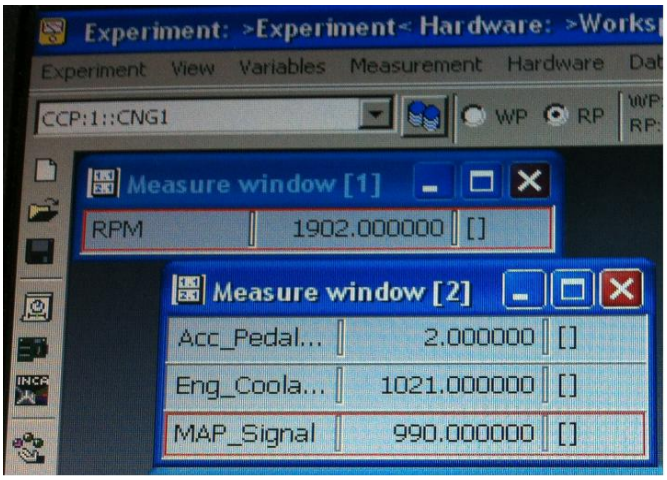

Fig 9: Results of ECU Variables in INCA Window

In the given figure the results of ECU inputs are shown. This result shows the variable value in the software tool for ECU variables and its parameters.

9. CONCLUSIONS

The actual development process of electronic control unit board takes much time and cost. For solution of these difficulties we can use such type of microcontroller based ECU board in which we can use a controller which supports the flash programmable memory. Therefore, we can easily do flashing of code on microcontroller of ECU board. This technique is very useful because we can get many applications as per our desired code. By, using this method, development process of control code increases the code flexibility, efficiency, reuse ability and reliability in case of testing or validation process for Electronic Control Unit on test bench, on virtual environment PC setup and in a vehicle.

This process is initial and essential for testing purpose of automotive electronic circuits on test bed setup. This is the best example of component based Electronic Control Unit design method. With using this method we can develop a code for input and output driver circuits for ECU.

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