

Throttle by Wire using Embedded Environment

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ABSTRACT: In recent year's the automotive electronics plays important role in the automobile industry .Throttle by wire is the important technique under Drive by Wire. It plays very important role in emission, control, Safety of automobiles .It's looks simple problem but position control of the throttle valve quite difficult due to its application constraints and system characteristics .The main function of the throttle is to regulate the air inflow to change the engine's power and so vehicle acceleration .So the system consist of Electronic throttle and Accelerator pedal with inbuilt position sensor. It's application of closed loop system.

KEYWORDS: Arduino, TPS, APP sensor, PID controller, Communication Protocol

I. INTRODUCTION

In past several decades the motor vehicle has undergone several transformations with respect to automotive electronics. Drive by Wire is vibrant topic in the automotive electronics. Throttle by Wire (TBW) is one of the interesting topic under Drive by Wire methods. The traditional method of throttle driving is fully mechanical process, So TBW is effort to make it automated with the use of electronic control unit (ECU). As throttle is consist of butterfly spindle /shaft which help to rotate the valve. And position of valve can be controlled by the accelerator movement. In traditional mechanical way the throttle valve movement is connected to the mechanical cable which is connected with the accelerator. So by pressing the accelerator, the stress is applied on the mechanical cable which will control the position of the valve. For TBW, the requirement of Electronic Throttle Body (ETB) is used which is consist of Throttle Position Sensor (TPS) which senses the position of throttle valve. TPS is angular position sensor which senses the position of throttle valve. By obtaining the position of throttle is input to ECU and angular position of accelerator pedal position (APP) sensor is also used for this purpose. As this process is open loop system which unstable system. The main aim of this prototype is obtain stable output system. For that purpose use of PID (proportional integral derivative) technique is very useful to obtain stable output of the system. The output of PID controller will be converted into PWM wave which will drive the DC motor shaft which is connected to throttle valve of the Electronic Throttle Body. The DC motor of throttle is driven by the driver circuit which consist of H - bridge circuitry. It is used to drive the motor in forward and reverse direction with change in the direction of current from the transistors. At time two transistors are on from different vertical line so by combining it looks like H. It is used for the current amplification purpose which cannot be provided by microcontroller output.

II. GENERAL SPECIFICATIONS

System specification

The system consist main part

1. Electronics Throttle body (ETB) with consist of Throttle Position sensor (TPS) and DC motor.
2. Accelerator Pedal Position sensor
3. H-bridge drive circuit i.e. MD -10 C
4. Arduino MEGA

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1. Electronic Throttle Body (ETB): The main part of the throttle by wire is ETB which consist of Throttle position sensor and DC motor to drive the shaft of valve of throttle. It is part of Maruti Suzuki Celerio so it is manufactured by the MARUTI Company and they have not provided any data sheet. The throttle position sensor which consist of two main signal sensors i.e. TPS MAIN and TPS SUB. TPS MAIN is used to monitor the actual position of throttle and TPS SUB is use for the testing purpose ETB as application of ETB is used for crucial purpose so that testing of the sensor becomes very necessary. it gives the analog signal which is given to the microcontroller .controller will convert this value into digital value with its in built ADC.ETB consists of 6 pins which are as follows :

- a. TPS MAIN
- b. TPS SUB
- c. MOTOR Positive
- d. MOTOR Negative
- e. 5 volt
- f. GND

The MOTOR Positive and MOTOR Negative are used to drive the DC motor which control the movement of the shaft of throttle.



Figure 1: Electronic Throttle Body

2 .Accelerator Paddle Position (APP) sensor: The accelerator paddle position (APP) sensor is used to obtain the exact position of accelerator which will be set point of our system .It is manufactured by BOSCH. APP sensor is using angular position sensor with help variable potentiometer. It gives the analog output. The APP sensor which consist of two main signal sensors i.e. APP MAIN and APP SUB.APP MAIN is used to monitor the actual position of throttle and APP SUB is use for the testing purpose as application of APP is used for crucial purpose so that testing of the sensor becomes very necessary. The APP sensor consist of 6 pins which are as follows :

- a. APP MAIN
- b. APP SUB
- c. 5 volt
- d. GND (zero volt reference)
- e. 5 volt
- f. GND (zero volt reference)



Figure 2: Accelerator Pedal Position sensor

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3. DRIVER CIRCUIT (MD 10C): H-bridge driver is simple circuit, containing four switching element with the load at centre is like H like configuration. The switching element (Q1, Q4) are bipolar or FET transistors. The diode (D1, D4) are called catch diodes and are usually of a schotkey type. The top end of the bridge is connected to a power supply and the bottom end is grounded.

The basic operating mode of an H-bridge is fairly simple: if Q1 and Q4 are turned on, the left lead of the motor will be connected to power supply while the right lead is connected to ground .Current starts flowing through the motor which energises the motor in the forward direction and motor shafts start spinning .If Q2 and Q3 are turned on, the reverse will happen, the motor gets energized in the reverse direction, and the shaft will start spinning backwards.

In a bridge, you should never ever close both Q1 and Q2(or Q3 and Q4) at the same time .If you did that ,you just have created a really low resistance path between power and ground , effectively short circuit will occur.MD 10 C is used to drive high current brushed DC motor up to 13 A continuously. It offers faster response time and eliminates the wear and tear of the mechanical relay.

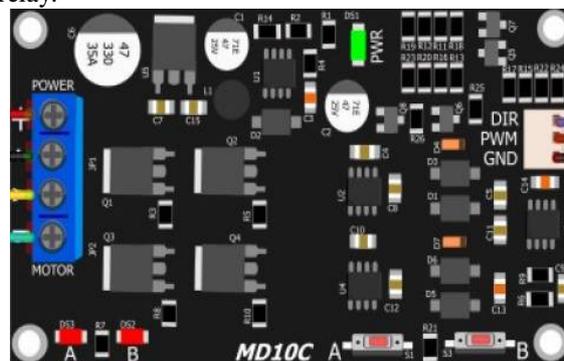


Figure 3: H-Bridge driver circuit(MD10C)

4 Arduino: It is microcontroller board contains on board power supply, USB port to communicate with PC and ATMEGA 2560.It is open source as hardware is reasonably priced and software is free. It supports simplified version of C/C++.It requires basic knowledge of C. The board consist of 2560 microcontroller. Its operating voltage is 5V.Its operating frequency will be 16 MHz . As its maximum output current per input output pin is 20mA. The board is very user friendly board which have 56 digital Input/output and 16 analog input pins.

III. PID CONTROLLER

The Proportional Integral Derivative (PID) is widely used method to achieve and process set point (*SP*). There are three primary component to know about PID control loop .Each component is prefixed with a gain constant, and when added together, give you the instantaneous control value that you use to drive your system .Generally we are generating the voltage to control your system which makes the system stable. The current state of your system i.e. called the process variable (*PV*). The set point is corresponding to the state you wish your *PV* to reach. So our ultimate aim is to drive our system so that *SP* is equal to *PV*.

$$u(t) = Mv(t) = k_p e(t) + k_i \int_0^t e(\tau) d\tau + k_d \frac{d}{dt} e(t) \quad (1)$$

Where the error (*e(t)*) is *SP* – *PV*.

The constant k_p, k_i, k_d are used to set sign and contribution gain of each part of this equation. *e(t)* is proportional to “error” corresponding to *SP* – *PV*. The variable *t* is corresponds to the current time in our system , τ is variable of integration.The proportional portion of the equation takes into account how far away our *PV* is from our *SP*. The differential part takes into account how fast we are moving (if we move to fast near our *SP* , we will over shoot), and can be used to reduce the proportional portion if we are moving too fast, or speed us up if we are experiencing resistance despite our proportional contribution. The integral part of the equation takes into account how long we have

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been off of the set point, contributing more to our output the longer we are missing the *SP*. This is important because our **P** and **D** contributions will typically lead our *PV* to sag slightly above or below our *SP* variable.

In our system the set point (*SP*) is output of APP sensor i.e. we want throttle valve position at that point and the output from the TPS sensor is used as *PV* for the system. The tuning of the PID controller is very important method in the PID controller. We have used trial and error method to determine the value of k_p, k_i, k_d by consider their effect on the system as given in the table.

Table 1: Effect of PID controller on Closed loop System

Symbol	Rise time	Overshoot	Settling time	Steady state error
k_p	decreases	increases	Small change	Decrease
k_i	Decreases	Increases	Increase	Eliminated
k_d	Small change	Decrease	Decrease	Small change

IV. RESULT

The complete setup enables us to operate the throttle valve with the help of input of accelerator pedal sensor with the help of PID controller by using single board computer. The mechanical linkage is eliminated. In the image we can observe the result. In the first image shows fully closed throttle which is the start condition of throttle which is slightly tilted. The second image is partially open which is will provide increase in the speed of vehicle. The third image is fully closed which will have highest speed of vehicle.



Figure 4: Setup of ETB

V. CONCLUSION

The Throttle by Wire is one of the critical system of modern vehicle system. It requires finely tuned system which ensures the proper function of engine which controls the torque and acceleration of vehicle. It is obtained with the help of PID controller using On Chip Microcontroller board. Preliminary results of the system are obtained using certain values of the throttle performance by certain values of PID gains. However further work is required in order to fine tuning of controller .and achieve better performance of the throttle responses.

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