Electronic Control Air Brake System for High Speed Trains

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ABSTRACT
The aim of this implementation is to control the brake system for high speed trains. The existing system uses the mechanical braking method to control the speedy trains to avoid train collisions and accidents. The sensors and proportional valve functions are controlled by embedded systems. The brake instrument is interfaced to a pc which can automatically display the current position of the trains running condition. The system proposes the use of automatic electronic braking system with the presence of different types of sensors such as acceleration sensor and vibration sensor. The merits of the proposed system are automatic monitoring and require short duration to control the brake system.

Keywords – Train air brake; Embedded system; Proportional valve; SOC; Air pressure control.

1. INTRODUCTION
Nowadays locomotives ruin human world, most of the human accidents occur due to collision of vehicles and carelessness of humans. So, to avoid such accidents an automatic control system for brake rather than manual operation is required. When it comes to the normal heavy vehicles on road the accidents caused by them have ended in a very disastrous manner. So as far as the train is concerned with its linked carriages, the accidents and its results caused by its collision are normally out of imagination. Hence it is necessary to avoid the brake failure automatically which needs some interfacing with sensors that are controlled by a microcontroller.

The latest commercial vehicles and trailers are expected to work safely, economically and comfortably as well as being compatible throughout the fleet. We introduced EBS or electronically controlled braking system as a means to meet these demands. EBS is now fitted as standard to trains. The minimum requirement for train EBS is a 24v ISO 7638(5core) electric connector on the prime mover and preferably some form of anti-lock brakes.

With this basic requirement, an EBS trailer will outperform a normal ABS trailer in both response time and stopping distance. With EBS on the prime mover and an ISO 7638-1996 (7 core) connector, one gets the ultimate in braking.

The embedded controller is connected with a panel computer. This is equipped with a touch screen. The controller is the slave here. The controller uses the C++ programming language. The easy operation and high efficiency characteristics of the brake test instruments is possible with the help of server database. The proposed arrangement is a simple model and is easy to connect.

2. EXISTING SYSTEM
The system which is existing to avoid the brake failure uses the mechanical braking method. The mechanical braking method consists of valves, pipes and controlling cylinders. When a driver pulls the brake valve, the valve opens the brake pipe and controls the wheel by stopping the function cylinder valve. The triple valve as the name states contain three valves,

- Valve-1 charging air into the air tank ready to be used.
- Valve-2 is for applying brakes.
- Valve-3 releasing the brake (recharging the reservoir).

The cylinder valve contains the piston inside. The function of the piston is to compress the air and pressurise it through the air pipes. The air pipe is connected to a motor. Here the pressure from the air pipe is transformed into desired voltage level to run the motor. This transformation is performed by a transducer. But the disadvantages of the existing system are, it takes longer time for the detection of the pressure level in the pressure valves and manual checking is a must.

3. MODIFICATION
The proposed system avoids the brake failure using the automatic braking system rather than the manual monitoring. It can be achieved by detecting the pressure and acceleration rate using the corresponding sensors and monitors the controlled brake system by the PIC microcontroller interfaced with it. The advantages of proposed system to overcome the existing system are automatic detection of the valves and controlled the driving motor with it.

DRAWBACKS: The pressure valve requires much time to fill the pressure tank. The pressure levels greatly influences the brake system thus fails to meet the desired output.

4. SYSTEM DESCRIPTION
A. System Structure
The train air brake test instrument is a prototype instrument and its structure is as shown in Fig. 1. The air compressor and the air equipment in the train are connected with the prototype instrument. They are inturn connected with air pipes and air connectors. There are four different modules present in this instrument. They are supervisory computer, valves, pipes, and embedded systems. Component A in the diagram as shown contains air filter inorder to prevent litters filling in the valves. The pressure regulator is component B . The stabilization of the pressurized air from the compressor is possible with this component. The embedded system controls the solenoid valve and that is component C. The system fills air into the train air pipe. The total opening degree of the air exhaust channel is controlled by components E, F, G and they are the proportional air exhaust valves.

There are two air pipes- air pipe1 and air pipe2 connected to the prototype instrument. Air pipe1 is connected to the air compressor and air pipe2 is connected to train. According to the test condition the air flows in two directions in air pipe2. The solenoid valve C is opened and the air flows from air compressor to the train this instrument fills the train air equipment. The solenoid valve C closed and proportional valve E, F and F opened according to the test process to drain air from train to the atmosphere. This happens when the instrument test the status of the train’s air brake system. This design made the air pipes’ connection neat and easy to install. The train brake instrument includes the following components,

- Valves
- Pipes
- Embedded systems
- Solenoid valve drive interface
- Sensor signal conditioning amplifier
- Proportional valve drive interface
- LCD display, keyboard
- AC/DC power module
- Touch screen supervisory computer connected to the embedded system via a USB connection.

The train air brake test prototype experiment with its field application is shown in the Fig 2. The air compressor station connected to the instrument with a standard air pipe to acquire compressed air source. A short air pipe through an angle cock valve is connected to the train’s air system. This in turn is connected with the instrument. After the air pipes are connected, the air test operator power on the instrument and use the touch screen on the supervisory panel computer to start the test procedure. There are five kinds of test tasks designed in this instrument which are air filling test, air leakage test, brake sensitivity test, brake stable test and emergency brake performance test. When the operator starts a procedure the supervisory computer send a compiled instruction string to the embedded system via USB. Then the embedded system control the valves to process the test task to generate a predetermined testing air pressure curve and record the process value of the air pressure sensor. At the same time the field air pressure value is send to the supervisory computer and stored in the database. After the test process the operator can display the air pressure curves and the proportional air exhaust valves.

The module makes use of SOC, (system on chip) embedded system. The database loaded in the pc gives necessary information about the train. The PIC microcontroller uses the port that supports the ADC system. This port can provide and update the information regarding the speed details of the train. The PIC is programmed in such a way that depending on the number of bits the ADC can support, the reference value is fixed. the reference value is taken as the threshold level. The simulation result is designed in such a way that when the train is in normal running condition the output displayed is “The train is running” and when the speed of the train exceeds the threshold value it displays a command “the train is over speed”. Automatically the voltage given to the motor is limited. This in turn slows down the force exerted by the wheels and the train slows down.

B. Air Components Configuration

The air components configuration and installation is shown as Fig. 3. Air filter A is essential to avoid the dust and water flow from air compressor to the instrument’s valves. Valve B is an air pressure regulator which can ensure the pressure of source air to be stable. Valve D is a drain solenoid valve which is added after the optimization design of the air system because the high speed proportional valves cannot be closed tightly without air leakage. The air pressure sensor is installed between the air filling valve C and air drain valve D. In this structure the air pressure sensor can be used both in the air filling and air drain test process. Furthermore there are two manometers installed on the instrument’s dashboard for inspection convenient. The connections of the manometers are using quick connect pipes.

C. PIC microcontroller

The PIC microcontrollers have variety of choices and are affordable. The cost of 8-bit is$0.41 and 32-bit is $6.00. The power consumption is very low.
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As shown in Fig. 2, the instrument is fixed in a movable chassis with wheels which made it convenient to move from one rail platform to another in the train test center.

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Fig. 3.1-3. Plot of Eqs. (3.1-8) and (3.1-9) for the vibration of a viscously damped system.

Acceleration Sensing

- Piezoelectric accelerometer
- Nonservo lower cutoff frequency (0.1–1 Hz for 5%)
- Light, compact size (miniatuere accelerometer weighing 0.7 g available)
- Measurement range up to ± 500 g
- Less expensive than capacitive accelerometer
- Sensitivity typically from 5–100 mw/g
- Broad frequency bandwidth (typically 0.2–5 kHz)
- Operating temperature: −10 to 150°C
The schematic representation and the corresponding outputs are listed above. The controller is logically programmed in such a way that with reference to the ADC values the command of either the train is running or is over speed can be analysed. Here we make of a 16 bit controller whose word length is approximated to be around 2536. The reference value cannot have such a larger word length hence for easy estimation we take it as 2536/51 = 16.

The program logic is that the ADC values from both the sensors when it goes greater than the reference values the command will be displayed on the screen automatically the speed of the motor can be controlled finally the motor is brought to stop condition.

ADC requires only pulse width modulation (PWM). The corresponding changes in the pulse position is also varied. This is according to the concept that wider the pulse greater will be the speed of the motor. As the pulse width reduces the speed of the motor comes down. With the help of the PC interfaced to the system it gets easier to monitor all the changes.

CONCLUSION

The EBS (electronic control air brake system) for high speed trains provides advantage by establishing some sophistication in monitoring and controlling the system without any manual power. Thus embedded systems proves its excellence in all models related to automation and this project can be quoted as one of its best example.

REFERENCES