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Development and Study of Hardware in Loop Simulation

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ABSTRACT:- With the development of electronic control technology and the improvement of diesel engine performance, diesel engine control system has become more complicated. The complication of diesel engine threatens stability and endurance life of system, which make development and test of electronic system increasingly heavy. Emulation technique, especially hardware in loop simulation (HILS) will make the development and test of electronic system more flexible and simple.

Hardware in Loop Simulation system (HILS) is a platform for external ECU development and test. This system uses the diesel engine mathematical model to compute and simulate signals related to target ECU on special condition in real time and constitutes a closed-loop development and test system with target ECU, which will help people develop and test a target ECU under laboratory conditions. HILS system can test software, hardware and control strategy of target ECU and accomplish some experiments that are impossible or difficult to accomplish under laboratory conditions, such as critical testing, fault simulation and so on, which can reduce developing costs and period and improve security of system developing.

Keywords:- Hardware In Loop. Simulation. Electronic control system. ECU

I. PRESENT DEVELOPMENT OF HILS

1. Present development abroad

Abroad, study on HILS begins quite early and develops more mature. And HILS has played an important role in industrial production and manufacturing and has become a irreplaceable tool.

U.Varchmin Professor of Blanc grandstand industrial university in Germany developed a HILS for ECU, called MOSIG. Compared with traditional bench test, this HILS system can test ECU effectively served as a tool for ECU development and test. ADI company, America, develop a hardware system, called Simsystem, for real-time dynamic simulation. This hardware system is based on VME system, and it uses Motorola PowerPC processor as high performance simulation CPU. High running performance and VME backboard are supported by PowerPC processor, which enable this hardware system apply to high speed real-time simulation. Simsystem can be programmed by C and Fortran language, and it also can use Simulink and SystemBuild to build simulation model.

DSPACEGmbh company,Germany, developed a platform, called dSPACE software and hardware system, for real-time developing and testing, which supports hardware control and simulation with Simulink in the earliest. DSPACE is suitable for rapid prototyping of ECU, HILS system, automatic code generation of production grade and virtual system test. Hardware system of DSPACE, includes ECU and I/O port, has high arithmetic speed. And software system of DSPACE can generate, download and debug code, which can develop, test and achieve control strategy. Abroad, DSPACE has been widely used in automotive, electric locomotive, robot, aerospace and industrial control area.

2. Present development at home

In domestic, study on HILS system begins quite late. But, in recent years, great advances have been made from original manual operation to automatic system, and the intelligent system is on the way.

HengRun scientific and technical corporation developed an integrated platform for control system. This integrated platform builds rapid prototyping to download all-digital simulation model directly to real-time emulation device and to accomplish system united via connecting to real device and test device for different hardware target with commercial grade real-time IPC.

Harbin Engineering University developed a simulation model of supercharged diesel engine and speed regulating system and carried out Hardware-In-Loop simulation via DSPACE platform. Beijing Institute of Technology build a HILS platform of ECU and conducted Hardware-In-Loop test experiment for single cylinder diesel with DSPACE. WuXi fuel injection equipment research institute China FAW Group developed ECU HILS of high pressure common rail diesel engine by MATLAB/SIMULINK and MicroAutoBox of DSPACE company. Shanghai Jiaotong University and Dalian University of Technology developed Real-time simulation processor and data acquisition Card based on single chip, and developed some monitoring softwares by LabView and VisualC++.

II. STUDY AND APPLICATION OF HILS ON HIGH PRESSURE COMMON RAIL DIESEL ENGINE ECU TEST AND DEVELOPMENT

HILS system of high pressure common rail diesel engine ECU consists of hardware system and software system. Hardware system consists of target ECU, emulation ECU and PC. The software system consists of human-computer interaction interface and emulation model.

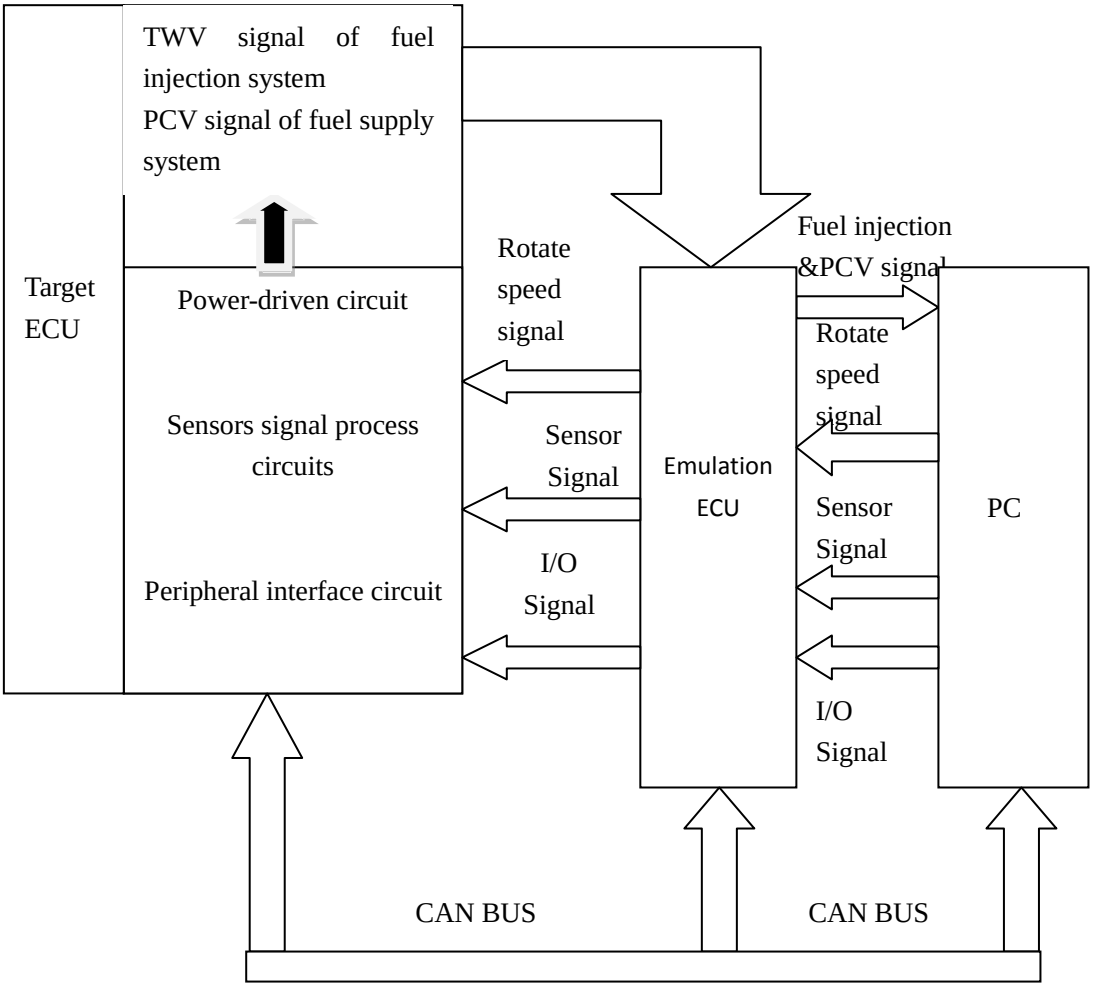
Target ECU is actual use and test needed ECU. It includes drive circuit of injector, PCV power driving circuit, sensors signal process circuits, CPU and external interface circuits and so on. Target ECU, emulation ECU and PC make up a closed-loop simulation system together.

Emulation ECU is CPU of HILS system. It can figure out the rotation speed signal, sensor signal and I/O signal related to diesel engine operating condition according to real-time mathematical model of diesel engine in PC and transmit these signals to target ECU. At the same time, Emulation ECU samples injection signal (includes fuel injection pulse width signal and fuel injection advance angle signal) and PCV signal (includes PCVON and PCVOFF) transmitted from target ECU and transmits these signals to PC to implement signal feedback of ECU via can bus.

PC system of HILS consists of PC and can bus port. The main function is figuring out signals, such as rotation speed signal, sensor signal and I/O signal, the parameters diesel engine needed, according to real-time mathematical model of diesel engine and then transmitting these signals to emulation ECU via can bus. When emulation ECU gets these signals, it will be converted to corresponding voltage analog signals via Digital to Analog Converter (DAC) and transmits to target ECU. The other main function of PC system of HILS is receipting operating condition feedback signals transmitted from emulation ECU.

Underlying software system is running in PC served as one part of HILS. It consists of human-computer interaction interface and emulation model. We need create a friendly human-computer interaction interface to realize real-time operating condition of target ECU monitoring and displaying. Real-time mathematical model of diesel engine should be set up in PC to compute signals the target ECU needed. Also, underlying software should ensure can bus communications of PC, target ECU and emulation ECU. At the same time, underlying software should save data timely so that experimenters can check the data when necessary.

Schematic diagram of HILS is shown in diagram 1.



When this system works, an established real-time mathematical model of diesel engine in PC figures out some signals diesel engine needs, includes rotation speed signal, sensor signal and I/O signal, and transmits these signals to emulation ECU. These signals are digital signals created by PC system. Rotation speed signal is transmitted to emulation ECU to generate crank shaft speed signal and CMP camshaft position signal. CMP camshaft position signal is used to determine phase angle of diesel engine and the crank shaft speed signal is used to measure diesel engine speed. They must have strict timing sequence and phase angle relation. And they are the basis of injection timing and PCV of target ECU.

Emulation ECU converts sensor signals transmitted from PC system into corresponding voltage signal via D/A converter (DAC) embedded in HILS and transmits to target ECU. Sensor signals target ECU needs includes water temperature signal, oil temperature signal, common rail fuel pressure signal, throttle position signal, environment temperature signal, intake air temperature signal and boost pressure signal and so on. Because of rapid change of actual signal and actual driving condition, DAC module must have higher respond speed and response frequency to enable output signal keep up with the change of throttle position signal.

Target ECU figures out the injection timing signal and PCV signal and transmits it to emulation ECU after target ECU got the relative signal transmitted from emulation ECU. When emulation ECU gets these two signals, convert it into digital signals from responding voltage signals via A/D converter module and transmitting to PC system. Real-time mathematical model of diesel engine in PC figures out the fuel delivery per cycle to enable real-time mathematical model of diesel engine work normally. Real-time mathematical model of diesel engine

figures out rotation speed signal, sensor signal and I/O signal the next circle.

III. CONCLUSION

1. The wide use of HILS on the development of automobile control system is a profound breakthrough for traditional experiment methods. HILS system provides a platform for the test and assessment of automobile control system via the establishment of HILS system. It shortens the period of developing control system, improves the designing level of control system, saves resources and reduces the experiment cost. And it plays a very important role in developing a automobile control system.

2. We should pay attention to key technology during the use of HILS system, which includes three main aspects. The first aspect is that real-time mathematical emulation model should ensure validity and timeliness for different objective function or evaluation parameters; The second aspect is that precise control to system relies on different control method for different complexity and control aim of prototype system; The third is that MATLAB/Simulink can bring us convenience to accomplish the establishment of real-time mathematical emulation model.

REFERENCE

[1]. Bin Zhuo, QiHua Liu. Fuel injection and electronic control of gasoline engine[M].BeiJing: China Machine Press,2001:127-130.

[2]. HangBo Tang,WenChun Tan. Hardware design of HILS of diesel engine high pressure common rail ECU[J]: Vehicle engine,2005,02(1)1-5.

[3]. BinXuan Li, Feng Wu.Design of HILS of diesel engine ECU[J]: Journal of Zhejiang University,2002,03(2)1-6.

[4]. WenChun Tan,HangBo Tan.HILS design of high pressure common rail ECU of diesel engine[J]: Journal of Shanghai Jiaotong University,2004,10(10):1-5.

[5]. Hui Zhu,LiQing Wang. Study on HILS of diesel engine ECU[J]: Transactions of Csice,1998,16(4):389-398.

[6]. ShiTao Yu.HILS of electronic unit pump(EUP)[J]: Transactions of the Chinese Society for Agricultural Machinery,2006,12(12):1-5.

[7]. Jiguang Yue,Yanchao Dong. HILS study of automobile engine models[J]: System Simulation Technology,2008,04(2):1-5.

[8]. Renping Shao. Machinery System Dynamics[M].Beijing: China Machine Press,2005.

[9]. Jie Zhang. HILS study of high pressure common rail of diesel engine[D]: Huazhong University of Science and Technology.2007:15-17.

[10]. Tao Xu, BoTao Wang. Development of hardware test system of electronic control diesel engine ECU[J]: Diesel Engine Press,2007(4):6-10.