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Electric Vehicle's Controller Control Strategy Based on Warm Standby and Its Reliability Analysis

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Abstract. Stand-alone control mechanism for electric vehicles has problems in reliability and security, a control strategy based on warm standby was proposed, when host engine failed, the standby engine would replace the host engine and take over the control tasks. Markov model was used to analysis the reliability of the warm standby system, and its performance was compared with stand-alone control system on reliability and security performance, the results show that reliability and security level of warm standby system is significantly higher than stand-alone control system.

Keywords: Warm standby; Markov model; Electric vehicle

1 Introduction

At present, the development trend of electric vehicles is tending to become more systematic, modular and safe, controller is the core of a control system as the drive unit, its reliability and security is directly related to the whole control system's continuous and stable running [1-2]. When vehicle controller uses stand-alone control mode, once the controller fails, the whole vehicle system will fall into a dangerous state [3], therefore, it needs to use a redundant fault-tolerant technology to design the processor's core components and other associated key components of the controller, This paper proposes up a safe and reliable control strategy for electric vehicle controllers' development, this strategy is based on a kind of warm standby hardware redundancy design.

2 Control Strategy Based on Warm Standby

Traditional warm standby control mode usually uses independent fault detection unit to detect fault [3], although fault detection unit has a high fault detection rate and low

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system resources occupancy rate, it needs additional CPU and detection circuitry, which greatly improve the system cost [4], once the fault detection unit is invalid, the system will fall into a dangerous state with unpredicted fault, at this time, system will be judged as fail [5]. The control strategy proposed in this paper removes the independent fault detection circuit based on traditional hot stand-by control mode, and it is replaced by adding heartbeat bus and control signal lines between host engine and standby engine.

3 Controller Implementation Based on Warm Standby

According to the warm standby control strategy, in consideration of system's functional, reliability and engineering design requirements, design the structure of controller's overall control strategy frame, it is shown in Figure 1.

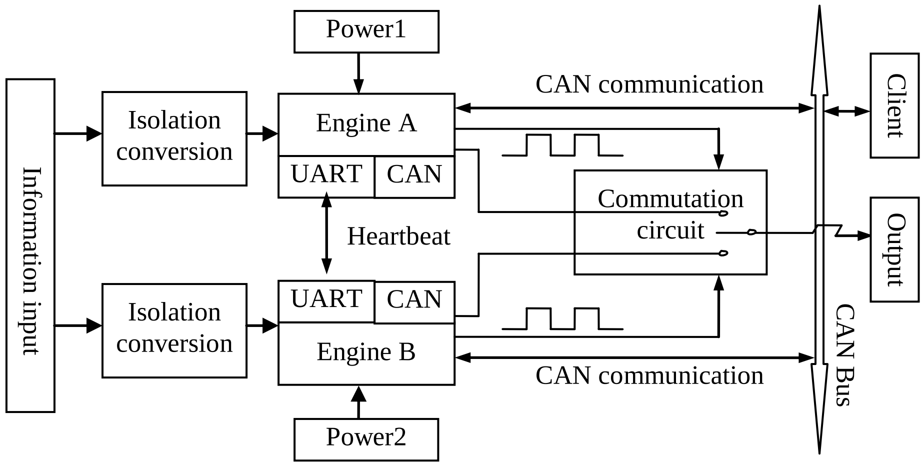

Fig. 1 Controller structure based on warm standby

3.1 Dual Engines

Dual engines consist of two same processors based on TI company's TMS320F28335DSP, after engine A and engine B are contemporarily powering, output dynamic square wave, switch circuit of engine who first outputs square wave will automatically fall to the host side through competition, the host will connect the output circuit and gain the control right, at this time, the dynamic square wave and output of the standby engine are invalid, square wave's period is regarded as the fault detection interval time, this period is set to be 200ms. When engine A and engine B are not powering at the same time, the former powering one will be the host engine, the other will be the standby engine.

3.2 Heartbeat Communication

Independent fault detection unit is replaced by adding heartbeat communication bus and outputted dynamic square wave between dual engines, fault detection work is completed by double engines coordinately. If standby engine detects the host engine fails, then standby engine sends conversion signal to host engine, host engine start the appropriate wrong judgment mechanism to judge whether the running host engine is failing, if it is true, then stop the square wave output and the switching circuit automatically falls to the side of standby engine, standby engine will gain the control right; if host engine detects the standby engine fails, host engine sends notification signal to standby engine, standby engine confirms its fault through self-test program and cut the square wave output to avoid false switching.

4 Reliability Analysis of Warm Standby System

Assume that failure rate is λ , scale factor that unit failure causes dangerous output is α , fault detection rate is c , common cause failure factor is β , define the states of dual computer hot stand-by system as follows:

State 0: host and standby engine are all working properly, system is working properly; State 1: single engine working state 1, host or standby engine appears the detected normal failure. State 2: single engine working state 2, standby engine appears the undetected normal failure. State 3: System's fault - safety state; State 4: System's fault - danger state. The Markov state transition [5-6] diagram is shown in Figure2.

Set $\lambda = 1.39 \times 10^{-5}$, $\beta = 0.085$, $c = 0.85$, $\alpha = 0.2$, and set the system's running time to be ranging from 0h to 3×10^{4} h, use MATLAB to do the simulation experiments, the comparison curves are shown as Figure 3. and Figure 4.

It can be seen from the figures above that dual computer hot standby system has obvious advantages comparing with stand-alone system on reliability and security. However, as the extension of the device service time, two kinds of systems' reliability and security are all decreasing, but the decreasing rate of dual computer hot stand-by system is lower than stand-alone system.

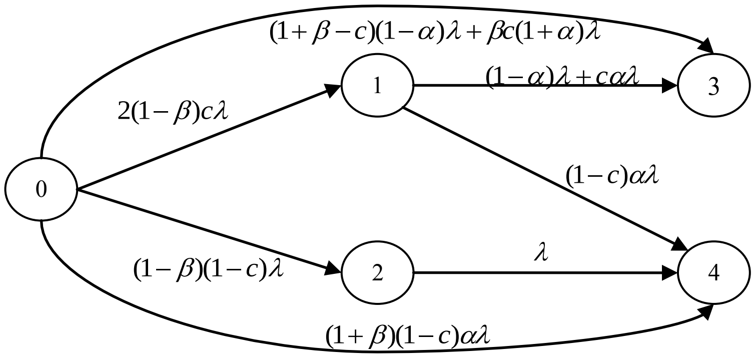

Fig. 2 State transition diagram of dual computer hot stand-by system

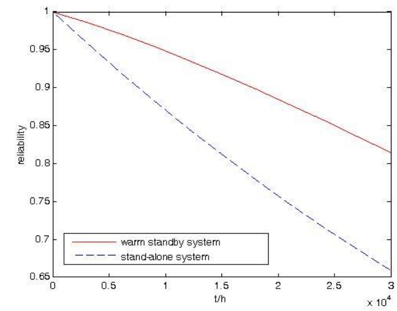

Fig. 3 Reliability comparison curves

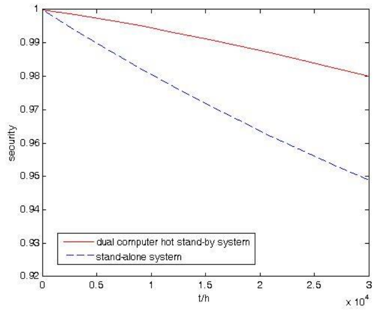

Fig. 4 Security comparison curves

5 Conclusions

This paper proposes up an electric vehicle controller control strategy based on warm standby system, and use heartbeat communication mode to replace the independent fault detection unit, it can solve that whole system will fail once the host engine is invalid. Experiments show that warm standby system has a higher reliability and security than stand-alone system, and as the extension of the device service time, this advantage is reflected more obvious.

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