Digital Design of A Monitoring System for the Power Drive Device of Vehicle

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Abstract: Researched on a monitoring system for one type of power drive device. Designed a mathematic model for monitoring and evaluating the status of power drive device based on data fusion theory, and developed the related software. Developed a database to manage the measured status data, and then developed an online built-in monitoring system which includes a displaying terminal, main controlling unit, vehicular parameters monitoring unit, engine monitoring unit and gear system monitoring unit. Such a monitoring system realizes automatic measuring and diagnosing the status of power drive device.

Introduction

Modern warfare puts forward greater demands on the level of automation and information of weaponry. Taking an example of the tank and armored vehicle, the United States, Britain, Russia, France and other developed countries have equipped or are developing with automated monitoring system that was able to detect in appropriate time, diagnose the state and fault of the subsystem and component.

Research on automation equipment monitoring technology has important economic and military significance. It is significant for keep good technical performance of equipment to develop online real-time monitoring system, predict and diagnose of potential failures, and remove the detected fault. Researched on one type of power drive device, we designed and developed an online automatic monitoring system, to complete the function for the power transmission unit, including state detection, state evaluation and fault diagnosis.

Configuration of the Monitoring System

The online monitoring system of the power drive device is a built-in automation equipment. As shown in Fig.1, the system includes a displaying terminal, main controlling unit, vehicular parameters monitoring unit, engine monitoring unit and gear system monitoring unit. Each module realizes information communication through CAN bus. The main controlling unit and each monitoring module is integrated with software, including data collection, analysis and processing, parameter monitoring, condition assessment and fault diagnosis.

The module functions as follows:

(1)The displaying termination displays the parameter values of the monitoring and the result of the assessment and diagnosis, which was installed in the cockpit, as shown in Fig.2. The driver completed the operation and monitoring tasks via terminal touch key.

(2)The main controlling unit can be installed in the cockpit, as shown in Fig.3, to achieve the control of CAN bus and the management of the monitoring nodes, each node parameter data and raw data are stored in the CF card. A monitoring diagnostic software is integrated in the main controlling unit, to complete the monitoring tasks of power drive device.

(3)The vehicular parameters monitoring unit connected with each vehicle instrument input plug via T-joint, and digitalize all vehicle instrument parameters which was monitor real-time and store timely by main controlling unit.

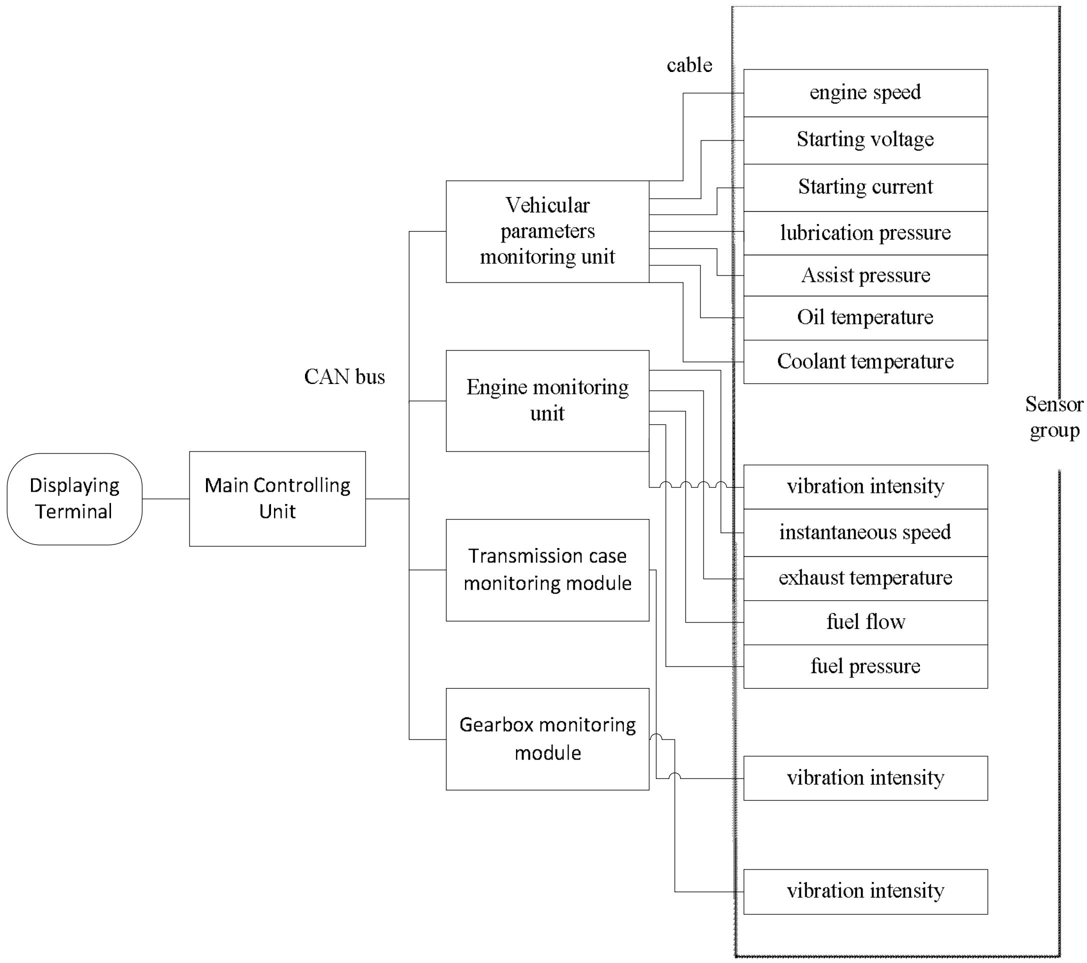


Fig.1 Monitoring system schematic diagram

Fig.2 Displaying terminal

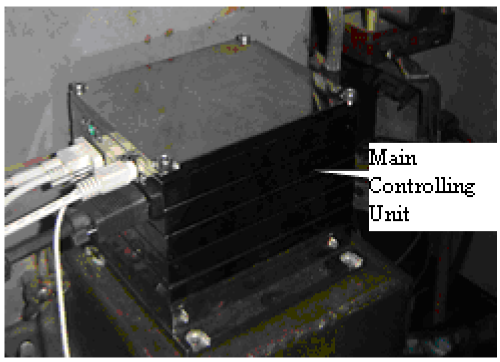


Fig.3 Main controlling unit

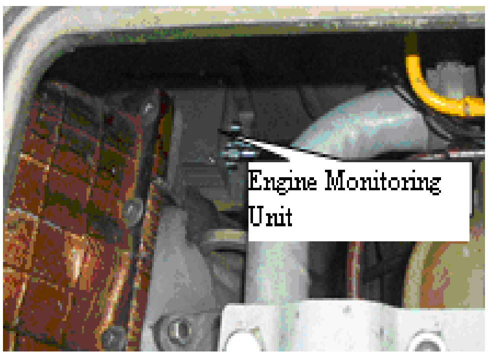


Fig.4 Engine monitoring unit

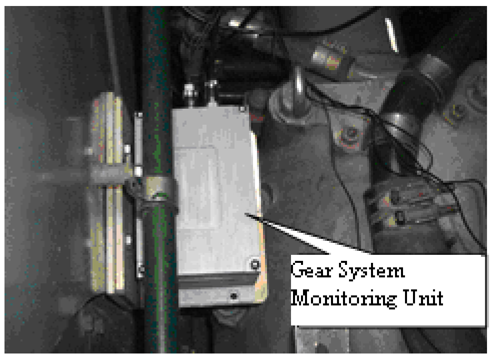


Fig.5 Gear system monitoring unit

(4) The engine monitoring unit was installed in the power compartment, and was responsible for collecting the engine speed, the body vibration, exhaust temperature, fuel flow and pressure signals,

calculating vibration strength, acceleration time, deceleration time, speed fluctuation and other parameters, which can monitor abnormal engine vibration, fuel supply system status and engine wear, work balance and lack of cylinder failure.

(5)The gear system monitoring unit collected gear unit vibration signal, calculated vibration intensity, monitored abnormal wear, gear and bearing fault condition of gear unit by threshold method.

Design of Monitoring Parameters System

This paper developed the monitoring parameters system of the power drive device, as shown in Table1. These parameters reflect abnormal engine vibration, fuel supply system state, the cylinder piston group wear, work balance, lack of cylinder failure, driveline wear, failure of gear and bearing from different aspects. The monitoring module is respond of collecting signals, analyzing and calculating characteristic parameters, then send the corresponding parameters into main controlling unit via CAN bus. At last the main controlling unit completes the monitoring tasks.

Table 1 The monitored signals, parameters and sensors

module	Sensor type	Monitored signals	Function
Engine monitoring module	Magnetoelectric tachometric transducer	instantaneous speed	engine speed fluctuation, acceleration ability
	Turbine flow transducer	fuel flow	Oil supply system state
	Liquid pressure pick-up	fuel pressure	
	thermocouple	exhaust temperature	Combustion state
	Vibration sensor	vibration intensity	Engine's abnormal vibration
Transmission case monitoring module	Vibration sensor	vibration intensity	Transmission case's abnormal vibration
Gearbox monitoring module	Vibration sensor	vibration intensity	Gearbox's abnormal vibration
Duty parameter monitoring module	Vehicle sensor	engine speed	As a reference standard
		Starting voltage	Monitor condition of storage battery, generate alarm signal in abnormal state
		Starting current	
		Lubrication pressure	generate alarm signal in abnormal state
		Assist pressure	generate alarm signal in abnormal state
		Oil temperature	generate alarm signal in abnormal state
		Coolant temperature	generate alarm signal in abnormal state

Design of Condition Monitoring Model

Framework of the Model

The gear system monitoring unit was given priority to monitor abnormal vibration when we establish the system model. Due to its complexity and importance, the engine not only monitors the abnormal state, but also assesses its technical state. The model framework is shown in Fig.6.

Assessment Model of Engine Condition

Engine vibration, fuel consumption, speed and other characteristics of information reflect the change of engine wear, burning, working balance from different aspect. Using data fusion method can integrate the different characteristics of information technology state of the engine effectively, and improve the rate of correct diagnosis.

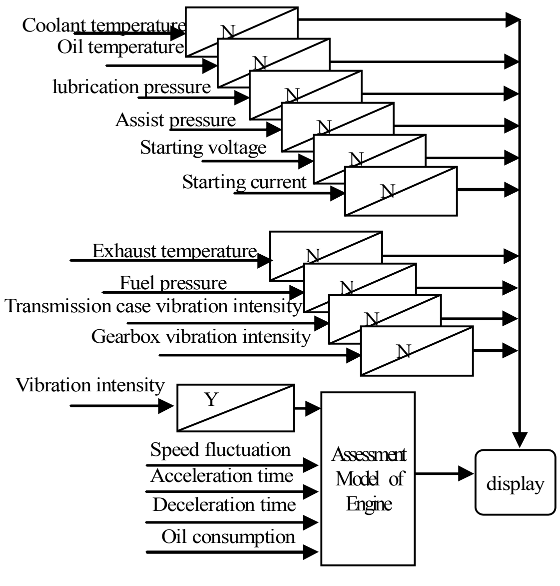
Artificial neural network is a very effective information fusion method, and has had a wide range of applications in various fields. This paper used three-layers BP network model to develop the engine technical condition evaluation model, as shown in Fig.7. There are 5 input layer neurons, respectively are speed fluctuation, acceleration time, deceleration time, fuel consumption and vibration intensity of engine. There are 10 hidden layer neurons and 5 output layer neurons in the neural network, which represent five technology states. The output value is 1 or 0.

Set vector I = {1,2,3,4,5} to represent the technical status "perfect, good, middle, bad, worse" .The values of output neuron are:

$$O_k = s(i,k) = \begin{cases} 0 & i \neq k \\ 1 & i = k \end{cases} \tag{1}$$

Where *k* represent the number of output layer neuron, and *i* represent the state value. The excitation functions of hidden layer and output layer are used S-type function as the following:

$$f_j(x) = 1/(1+e^{-x}) \tag{2}$$



In the above, Y means exceed the alarm limit, N means not

Fig.6 Framework of the monitoring model

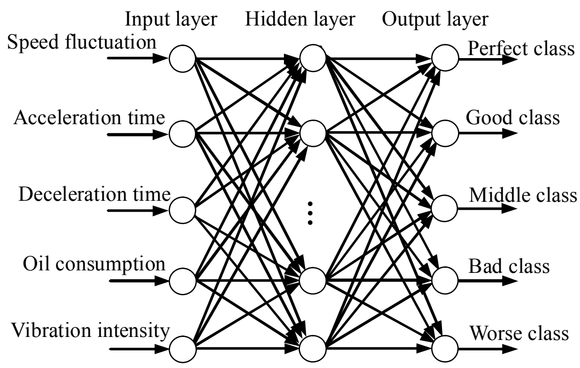


Fig. 7 The structure of BP network model

Management of the Measured Data

This paper developed an ACCESS database for the storage and management of monitoring data to facilitate the management of data, because the monitoring system has many parameters and the ability to continuous long-term monitoring, the amount of data is large. The result of parameter measurement, calibration information and setting information are stored in the database. Users can browse the historical monitoring data and technical status in a query form and call the technical state to analysis the database data trend.

The system initialized three databases, "System Settings Database", "Equipment Using database" and "Test Results database". Where Parameters Settings Database is used to store the setting of system, the calibration value of parameters and other data related to inner system; Equipment Using database only has one table about using equipment, where adds the relevant equipment using time, the name of test results database and other information related to the index when it Is open every time; Test results database constitute of working parameters database table and the state parameter table. Form a database named by the date of starting equipment when using vehicle every time.

Information Communication Based on CAN Bus

Design of CAN Bus Transceiver Circuit

Monitoring system adopts C8051F040 microcontroller with Controller Area Network (CAN), uses CAN protocol to achieve serial communication. CAN contains a CAN Core, Message RAM (independent of the CIP-51's RAM), message processing state machines and control registers. But Silicon Labs CAN is a protocol controller without providing physical layer drivers (transceiver), so it must be connected with CAN bus transceiver to communicate with external.

The system adopts the PCA82C250CAN bus transceiver which was the port of CAN protocol controller and the physical bus. The device provides differential transmit capability to the bus and differential receive capability to the CAN controller.

CAN Bus Protocol

Monitoring system realize the interconnection of information via CAN bus. CAN cards located in the main controlling unit and CAN controllers located in each module ensures reliable transmission of information, while it must establish and improve the application layer protocol in order to ensure the various parameters of the information is correctly identified, classified, storage. The protocol of communication uses "ID + data" format to combine a form of a message, where the data is three bytes, and each message frame is 40 bits (5 bytes).

The number of message combinations (7 bits) starts with 1, marking the type of information, as shown in Table 2.

Table 2 Information and Number

number	Information type	Information description
1	Fault information	DTC described fault information
2	General parameters	Parameter information obtained by each module's calculation
3	Vehicular information code	Vehicular information collected by module
4	Status information code	Module monitoring results
5	Configuration information	Main controlling unit modify the configuration of each module by bus, transmit configuration word through this message
6	Self-test status information	Module self-test result

Conclusion

The built-in monitoring system is able to inform the technical condition of the Power Drive Device timely, generate alarm signal in the event of abnormal state, which benefits driver to master technical state of equipment, abnormal state can be disposed timely to avoid equipment damage. Monitoring results are also beneficial for command staff to schedule and use the vehicle reasonable, and are an important role on command and management, maintenance and security of equipment.

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