

J2ME Based Bluetooth Portable Monitoring & Diagnosis System for Fuel Cell City Bus

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ABSTRACT

Under the background of the increasingly serious global energy crisis and environmental problems, governments and enterprises around the world have paid more attention to the development of a new generation of green energy. The fuel cell city bus has become a favorite choice for new energy vehicles due to its free emission, high energy conversion efficiency as well as long driving endurance. A fuel cell city bus consists of varied components, such as fuel cell stacks, power batteries, DC/DC converter, electronic motor and etc. A distributed control system is developed for the fuel cell bus which has been facing many challenges from complex electromagnetic environment, demands of on-line monitoring and diagnosis, wide working temperature range, energy dynamic optimization (EDO) ability and etc. In order to meet the requirements of the challenges, a series of novel electronic technologies has been successfully implemented in the control system of the fuel cell city bus. This paper presents a portable monitoring & diagnosis system via Bluetooth communication for the fuel cell city bus. The monitoring terminal could be a cell phone, PDA or any other smart mobile devices.

INTRODUCTION

With the environment showing signs of irreversible damage from fossil fuels and the fear that this conventional resource is running out in the near future, the pursuit of clean energy resource in the automobile industry has become graver and graver in recent decades. Fuel cell has been considered for transportation primarily because it's ability to increase vehicle energy efficiency and significantly reduce or eliminate air emissions. Compared to fossil energy, as a renewable energy source, hydrogen can be reproduced from different kinds of energy sources, such as solar energy, bio-energy, electric energy and etc. [1]

Proton Exchange Membrane Fuel Cells (PEMFC) feature simple compact stacks which do not have complex requirements with respect to fuel, oxidant and coolant supplies. PEM fuel cells deliver high power density and offer the advantages of low weight and volume, when compared to other fuel cells. PEM fuel cells operate at relatively low temperatures, around 80°C. Low temperature operation allows them to start quickly and results in less wear on system components and better durability. Therefore, PEM fuel cells are used primarily for automotive applications. [2]

In the last decade a variety of demonstration vehicles have been developed by the major car manufactures. DaimlerChrysler has been playing an important role in the research of fuel cell powered vehicles, as their prototype series has already reached the fifth generation. Manufactures such as Ford, GM, Toyota Nissan Honda and many others as well have made considerable progress in their efforts toward mass producing fuel cell cars in the near future. [3]

The State Key Lab of Automotive Safety and Energy at Tsinghua University has already started the research on the fuel cell vehicle since 2002, which mainly focuses on commercial vehicles. Under the support of China National 863 Hi-tech Research Program, the first Chinese fuel cell city bus was developed in 2004 by Tsinghua University and its partners. It is a hybrid vehicle combined a PEM fuel cell as main power and a battery as the auxiliary power unit. Until now a fleet of fuel cell buses has been grounded in sequence, one in the fleet is shown in Fig. 1. [4]

The power train configuration of the bus is shown in Fig. 2. The bus is driven by an AC motor, which has a rated power output of 100KW, a peak power output of 150KW, a maximal speed of 6000rpm and a maximal torque of 670Nm. A fuel cell with rated power of 65KW and an 80Ah power battery are equipped as the hybrid power source. The fuel cell stacks and battery are separated by

a DC-DC converter, which can regulate the power output of the fuel cell according to vehicle global energy management strategy.



Fig.1: A fuel cell city bus developed by Tsinghua Univ.

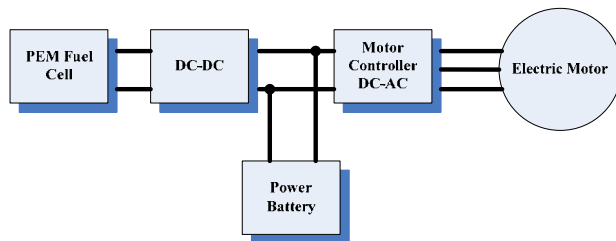


Fig.2: Power train configuration of the fuel cell city bus

For the complexity of the power train configuration, some working parameters are significant for diagnosis and security purpose, such as fuel cell output voltage and current, minimal cell voltage, hydrogen pressure, motor speed, SoC (State of Charge) of the power battery, working state of each device, error code and etc. Accordingly, in the development and demonstration process of the fuel cell city bus, some particular measurement devices are indispensable due to the speciality of fuel cell engine and electrified power train system. In order to procure the status of the vehicle power train especially the fuel cell engine rapidly and conveniently, a novel wireless portable on-line monitoring system based on J2ME (Java 2nd Micro Edition) and Bluetooth technology is implemented for the fuel cell city bus.

SYSTEM DESCRIPTION

The power train control system of the bus is distributed, which consists of fuel cell engine MS (Management System), electric motor MS, DC-DC MS, power-battery MS and Hydrogen Supply MS. Different kinds of microprocessors are embedded into each control node according to the complexity of control tasks, enabling the nodes to manage their own components and system independently. These control sub-systems are connected by CAN (Control Area Networks) bus and centralizedly governed by a Vehicle Control Unit (VCU), as shown as Fig. 3.

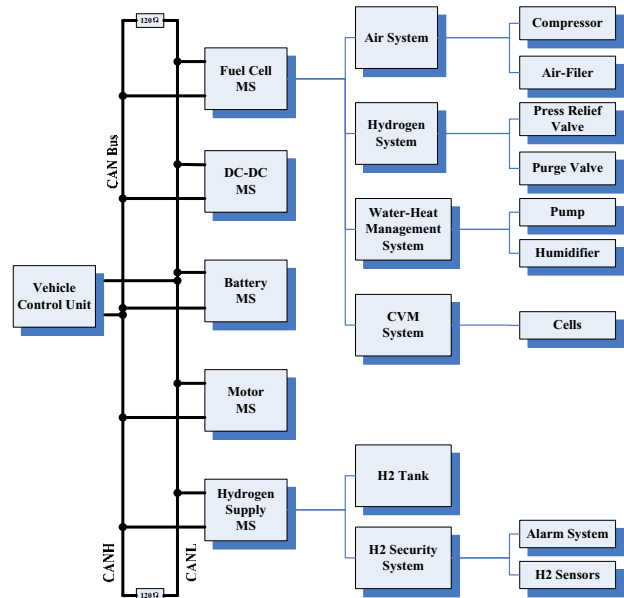


Fig.3: Power train control system configuration

The controller area networks were first developed by Robert Bosch in 1986 for use in automobiles, which is documented in ISO 11898 (for applications up to 1 Mbps) and ISO 11519 (for applications up to 125 Kbps). Equipped with an array of sensors, the network is able to monitor the systems that the automobile depends on. CAN is kind of a serial bus network of microcontrollers that connects devices, sensors and actuators in a system or sub-system for real-time control applications. There is no addressing scheme used in controller area networks, as in the sense of conventional addressing in networks (such as Ethernet). Rather, messages are broadcast to all the nodes in the network using an identifier unique to the network. Based on the identifier, the individual nodes decide whether or not to process the message and also determine the priority of the message in terms of competition for bus access. This method allows for uninterrupted transmission when a collision is detected, unlike Ethernets that will stop transmission when collision detection. The arbitration process of CAN networks is shown in Fig.4. [5]

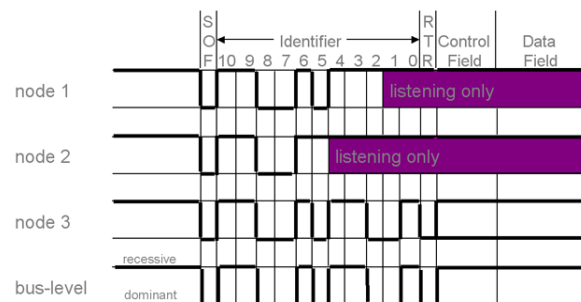


Fig.4: CAN notes arbitration process [6]

Since all of significant data supervised by each sub-control node can be gathered via CAN bus, a traditional monitoring and diagnosis solution is based on only the CAN networks, a PC or laptop is chosen as monitoring terminal device. This method has some disadvantages as below:

- For the monitoring via CAN bus a PC or laptop is necessary because almost all of the CAN interface applications only runs on the Windows or Linux platform. It's very inconvenient to set up a PC working environment inside a vehicle during the road test.
- An inverter has to be equipped to the vehicle to provide a 220V AC power source for PC or Laptop battery recharging.
- The remote monitoring and diagnosis is hard to achieve due to there is not a common network for PC or laptop in most urban and suburb area.
- The placement of monitoring devices is restricted as long as the connection must be created through a twisted-pair cable to in-vehicle CAN networks.

The remote data monitoring and diagnostic technology is originally applied in the medical area. Since last decade, in order to improve the reliability and safeness of some life support devices, such as an artificial heart, some continuous monitoring system were developed [15, 16]. Afterwards these technologies have been widely used in the other health-care project and research program. These devices continuously monitor vital signs and context information of patients, diagnose and analyze the health status and acute events, provide user feedback and provide access to clinical and professional expertise if required.[4,8,17, 18].

The motivation of this paper is to provide a similar portable wireless monitoring terminal which is very convenient for remote data monitoring and diagnosis on the fuel cell bus. The combination of two types of wireless communication technology makes it possible to implement a portable monitoring & diagnosis system based on the smart phone or PDA, one is Bluetooth for short-range communication and another is mobile cellular networks for world-wide connection.

Bluetooth is a universal short-range low-power radio protocol operating in the industrial, automotive, scientific, and medical frequency band. Bluetooth technology was designed primarily to support simple wireless networking of personal consumer devices and peripherals, including cell phones, PDAs, and wireless headsets. Wireless signals transmitted with Bluetooth cover short distances, typically up to 10 meters by Bluetooth class 2 and 100 meters by Bluetooth class 1. It allows both data and voice connections, with a nominal maximum data of 723 Kbps by Bluetooth 1.2 version and 3 Mbps by Bluetooth 2.0 + EDR (Enhanced Data Rate) version, as shown in Table 1. The modulation for Bluetooth technique is Gaussian frequency-shift keying, with transmission at a rate of 1M symbol/s on one of 79 channels with 1-MHz spacing in the 2.402-2.480GHz band. Bluetooth uses a spread-spectrum frequency hopping connection with a

rate of 1600 hops/s and its radio transceivers are categorized in three power classes, as shown in Table 2. [8]

A cellular network is a radio network made up of a number of radio cells each served by a fixed transmitter. The most common example of a cellular network is a cell phone network. With the evolution of cellular networks from the second generation such as GSM, to GPRS and enhanced data rate for global evolution, more applications can be designed for next-generation mobile tele-solutions. GPRS represents an enhancement of GSM. GPRS provides a maximum theoretical speed of up to 171.2 kb/s with all eight time slots available, as shown in Table 3. [8]

Version	Data Rate
Version 1.2	723 Kbps
Version 2.0 + EDR	3 Mbps
WiMedia Alliance (proposed)	53-480 Mbps

Table 1. Bluetooth transmission data rate [7]

Class	Maximum Permitted Power	Range (approximate)
Class 1	100 mW (20 dBm)	~ 100 meters
Class 2	2.5 mW (4 dBm)	~ 10 meters
Class 3	1 mW (0 dBm)	~1 meter

Table 2. Bluetooth communication coverage [7]

Technology	Maximum Theoretical Data Rate	Freq. Spectrum (MHz)
GSM	9.6 Kbps	900/1800/1900
GPRS	171.2 Kbps	900/1800/1900
3G	2 Mbps	1885~2200

Table 3. Cellular networks transmission data rate [7]

A prototype system structure is shown in Fig. 5: A Bluetooth 2.0 + EDR module is embedded into the VCU of the bus. All significant data of vehicle, such as fuel cell output voltage and current, minimal cell voltage, hydrogen pressure, motor speed, SoC (State of Charge) of the power battery, working state of each device, error code and etc., can be measured by each distributed control sub-system and gathered to the VCU via CAN bus. As a gateway between CAN and Bluetooth networks, VCU transmits the data to the cell phone via a secure Bluetooth connection according to the predefined