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PTNSS–2011–SC–024

DEVKIT8000 AND BECKHOFF CONTROLLER AS A COMPLETE CONTROL SYSTEM IN HYBRID VEHICLE

Abstract

Hybrid control system and visualization of the actual performance of the two different drives can be realized by PLC controller and SCADA system witch could be installed on simple computer with LCD display. The components and main idea of connecting PLC controller with the SCADA system and simple computer to control hybrid drive system will be implemented to prototype hybrid scooter. This scooter was built by Marcin Terelak and Ernest Ozga during their master studies on Wroclaw University of Technology few years ago. Hybrid vehicle is vehicle which combines a conventional propulsion system with an on-board rechargeable energy storage system to achieve better fuel economy than a conventional vehicle without being hampered by range from a charging unit like a battery electric vehicle, which uses batteries charged by an external source. Prototype hybrid scooter has a conventional engine (gasoline) as well as a four lithium-ion batteries and an electric motor, so that the wheels of the vehicle are driven by both an internal combustion engine and an electric motor. Authors showed in the article actual steering control system and parameters of prototype hybrid scooter and also the idea of implementation SCADA system, embedded single board computer and PLC controller to control hybrid drive in prototype scooter. Single-board computers (SBCs) means complete computers built on a single circuit board. Embedded Single Board Computers are much smaller than ATX motherboards, and provide an I/O mix more targeted to an industrial application such as on-board digital and analog I/O, on-board bootable flash so no hard drive is required. Information about single-board computers (DEVKIT8000) and implementation of this computer to control hybrid vehicles engines will be the showed in second part of this article. Programmable logic controller (PLC) as a microprocessor-based system that accepts input data from switches and sensors, processes that data by making decisions in accordance with a stored program, and then generates output signals to devices that perform a particular function based on the application. SCADA (Supervisory Control And Data Acquisition) is very flexible solution for example to choose between the parameters and driving modes in prototype hybrid scooter and also to show information from controller on touch panel.

Key words: *hybrid vehicle, hybrid scooter, DEVKIT8000, BECKHOFF controller, control system, SCADA, touch panel, single-board computer, new solutions, future, power control fuzzy logic, reducing of gas consumption, reducing of CO emissions.*

1. Introduction

A hybrid scooter is more expensive than a conventional scooter. In comparison with a conventional bike the hybrid scooter has the extra cost of an electric engine, steering control system and the battery's needed to store the electric energy. In spite of these costs, a hybrid electrical system makes sense, because you can combine the best properties of both engines. Besides that, the internal combustion engine in a conventional scooter works very inefficient. Only 18% of the generated energy is used to drive the wheel, all other energy goes to waste in shape of heat. In a gasoline scooter the combustion engine is much more powerful than required to drive the bike at a constant speed of say 75km/h. [1,3] This power is necessary to realize a good acceleration while taking off and in case of starting the engine. In most driving situations this engine operates inefficiently far below its capacity.

In a hybrid scooter the electric engine is responsible for providing the power necessary for acceleration. Because of this the internal combustion engine can be build smaller and more efficient. Moreover the combustion engine will only be used when needed. The combustion engine is stopped when the bike is running at low speed or standing still. It is started immediately when more energy is required.

An electric engine reduces the loss of energy dramatically because of its efficiency of 88 till 90%. This makes it possible to use the combustion

engine only at its most efficient point. When the combustion engine produces more energy than needed, it will be stored in the battery. Also energy is recovered while braking, by using the electric motor in reverse as a generator; energy is fed into the batteries.

Fig. 1. The prototype of Hybrid Scooter

2. Actual control system in our prototype hybrid scooter

The current control system in our hybrid scooter is constructed with three microprocessors: the microcontroller, the power controller and the electric controller [2,4].

The microcontroller is the main processor and is responsible for choosing the correct motor(s). At this moment, the microprocessors' decision for the correct engine is based on the present vehicle speed. The main rules are presented in figure no. 2.

Electric motor	from 0 till 20km/h
Internal Combustion Engine	from 20 till 40km/h
EM + ICE	above 40km/h

Fig. 2. The example of current rules

This controller is programmed with two different programs and gives the driver the possibility to choose between manual or automatic drive modes. Both these driving modes consist out of three possible hybrid settings: electric power, internal combustion engine power and hybrid power. If the driver selects the manual mode, needs to select which power mode, and so which motor(s), must be switched on. If the driver selects automatic mode, the microcontroller automatically switches ON or OFF the correct motor(s). To switch off ICE, the electric controller interrupts both the injection of gasoline, and the current needed for the ignition, by switching a relay. To switch off the electric motor, the microprocessor sends a signal to the power controller which interrupts the current flow towards the motor. At the moment, the choice for the correct motor(s) in automatic mode only depends on the vehicle speed registered by the front wheel hall sensor. The selected drive mode and hybrid setting is at all times shown by the digital display connected with the microprocessor. Due to these hybrid settings, various levels of acceleration and efficiency are possible. For example the scooter can run on a zero emission but much powerful less all-electric mode, or it can make use of both engines which boosts acceleration by 85%.

Another important processor installed on the scooter is the power controller. This controller arranges the current flow to the EM. The right amount of current depends on two signals: on one hand the voltage coming from the potentiometer in the throttle, on the other hand the voltage coming from the hall sensor in the rear wheel.

The third processor installed on the scooter is the electric controller. This controller is responsible for all the lights and their switches, the starting process, and the ignition. When a light is switched on, the controller is also responsible for the indication on the dashboard. When the start button is activated, the controller switches on the relay so current can flow from the battery on the right side of the scooter, towards the starter. This electronic controller also controls the ignition in both automatic and manual mode when ICE engine is turned on or turned off.

Next to these three microprocessors, there is also an extra module to control the current and voltage of the batteries. This control module was installed later on the scooter therefore it is integrated with the microcontroller.

The main controller is responsible for choosing the correct engine. The scooter can be run in one of three hybrid settings, allowing for various levels of acceleration or efficiency, and the scooter can also be run in a much less powerful all-electric mode. When used in concert with the gasoline engine, the electric engine boosts acceleration by 85%.

2.1. The hybrid drives modes, parameters and diagram of electric installation in prototype hybrid scooter.

In manual and automatic mode is possible to drive on: electric drive, internal combustion drive or hybrid drive.

Maximum speed of the scooter is depending from the mode, e.g.:

- electric drive – 40km/h
- internal comb. drive – 75km/h
- hybrid drive – 85km/h

Gas consumption:

- internal comb. drive –1,7L / 100km
- hybrid drive – 1,1L / 100km

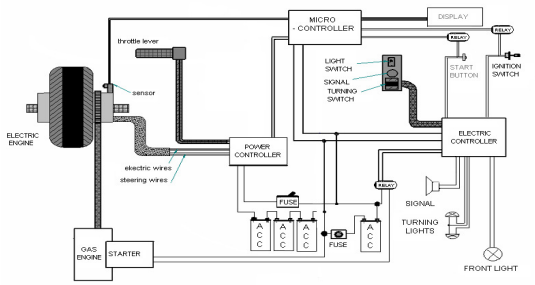

Fig. 3. The example of the electric installation

3. Single-board computer DEVKIT8000 as touch screen controller in hybrid scooter

Embest DevKit8000 Evaluation Kit (fig.4) is an ideal hardware and software platform for OMAP35x processor development, it is a complete development system accelerating time to market for OEMs building portable handheld, multimedia, medical instrument or embedded devices. The platform features an OMAP3530 Application Processor with supporting peripheral hardware and a production-quality Windows® Embedded CE 6.0 BSP; it can also run Linux 2.6.28 and Google Android OS and Angstrom (GPE). The DevKit8000 evaluation board and accessories are helpful for users to start designing different applications. User can display the system by using a 7"TFT LCD and Touch screen or using a DVI-D monitor with an HDMI to DVI-D cable. [5]

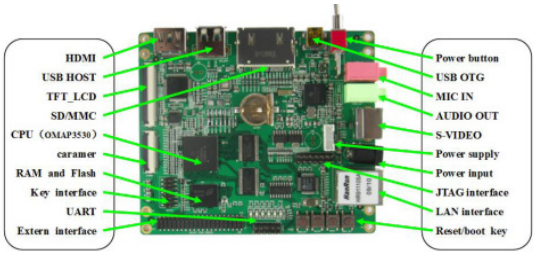

Fig.4. Hardware interface of DevKit8000

DevKit computer is cheaper than normal Touch Screen Operational Panel with e.g. Simatic MP 177 and also give us much more flexibility for futures solutions. Brand new computer is without any system and is necessary to prepare special image with system in CE version and install it.

3.1 Installation of Windows CE 6.0 Embedded on SD card

Before installation of WINCE we used HP Disk Storage Format Tool and formatted the SD card for FAT or FAT32 file system. Prepared image of Windows CE 6.0 (in Visual Studio 5.0) we copied on SD card. That way we have ready platform for implementation SCADA visualisation software. (fig. 5)

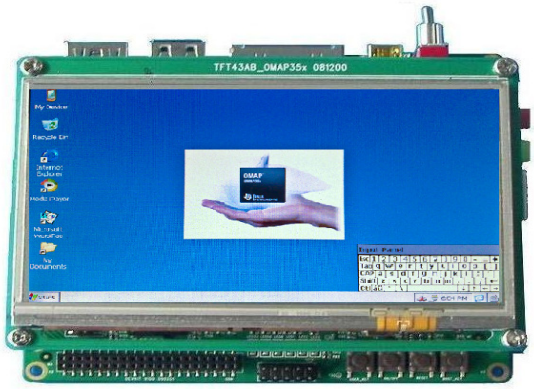

Fig.5. DevKit8000 with LCD touch panel.

4. Programmable logic controller CX1010 as control module in hybrid vehicle

The CX1010 CPU module (fig. 6) is the basic module of the CX system. It comprises the CPU and the internal flash memory in two implementation levels and offers the option to operate an additional memory medium in Compact Flash format II. An Ethernet interface is also part of the basic configuration. All other CX family components can be connected via the PC/104 interface that is available on both sides. The CPU module can be equipped with different hardware and software options: the operating system can be Windows CE or Windows Embedded Standard.

The basic configuration of the CX1010 includes a 64 MB Compact Flash card. The TwinCAT automation software transforms a CX1010 system into a powerful PLC and Motion Control system that can be operated with or without visualisation. Further system interfaces or field bus connections can be added to the basic CPU module. [6]

That controller will be a very good platform for our operating system also for future implementation fuzzy logic rules to control hybrid drive.

Fig.6. Programmable logic controller CX1010

5. Implementation Fuzzy logic control system to prototype hybrid scooter.

To achieve a good result in modelling and simulation fuzzy logic control for the whole driving system consisting of electric motor, IC engine and batteries must be converted into an appropriate simplified mathematical model that can be used to simulate different driving situations. [2]

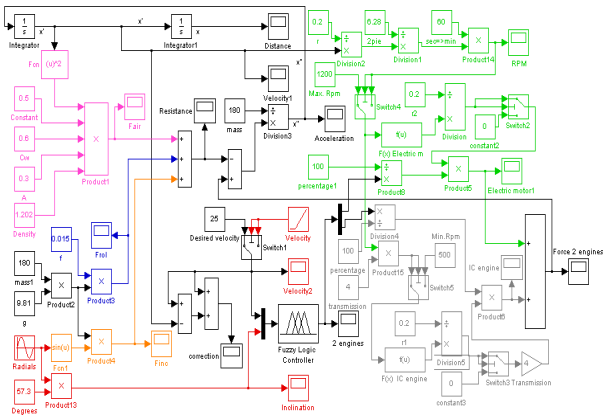

Fig.7. Physical simulation model

These simulations offer us the possibility to evaluate and adapt the fuzzy logic controller, and to modify all components of the system. Next to this, they can also be used to realize a better custom of energy from the two engines.
Finally, a simulation model can be seen as a never ending process which can always be enlarged and further developed in later stadiums of its genesis.

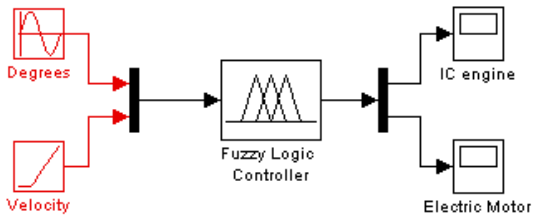

Fig.8. FIS integrated in the fuzzy logic controller

6. The Supervisory Control And Data Acquisition - SCADA

SCADA is a category of software application program for parameters control, the gathering of data in real time and to control equipment and conditions. [7]
This system includes hardware and software components. The hardware gathers and feeds data into a computer that has SCADA software installed. SCADA also records and logs all events into a file stored on a hard disk or sends them to a printer. SCADA warns when conditions become hazardous by sounding alarms. Below (fig 7.) is presented how easy we can prepare the control panel for hybrid vehicle. All designed components (e.g.: tachometer, battery level indicator, ratio of active drive mode, switch to change active mode and other…) will be showed on Touch Screen Panel connected to DevKit8000 single-board computer and easy available for operator.

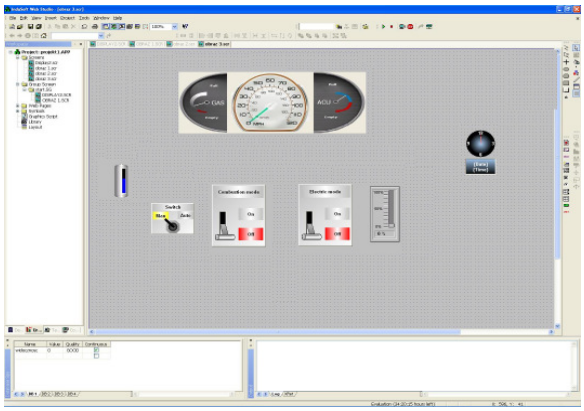

Fig.9. Indusoft Web Studio - SCADA .

7. Conclusions

By Ethernet connection is possible to connect single board computer (e.g. DevKit8000) and PLC controller (e.g. CX1010) and build good platform for control all signals and parameters in hybrid vehicle like in presented scooter, as well as to have good base for new implementations in the future. This platform will by prepared as plug-in device. It means that will be enough to connect one plug to hybrid scooter in our University Laboratory and take the control of all parameters and signals in prototype hybrid scooter. That will be the good solution for students to check how important is to have good parameters to achieve good results with reduction of gas consumption, increase of vehicle range (in electric mode) and reduce of CO_2 emission to atmosphere.

Nomenclature/*Skróty i oznaczenia*

SCADA The Supervisory Control And Data Acquisition
PLC Programmable Logic Controller
OEM Original Equipment Manufacturer
ICE Internal Combustion Engine

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