The Development of GPRS Based Speed Regulator for DC Motor

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Abstract— **In this study, the establishment of a control platform for DC motor has been carried out with a personal digital assistant (PDA) using GPRS (General Packet Radio Service). The man-machine interface is achieved with embedded Visual Studio 2005 which includes the Pocket PC 2003, Smartphone 2003 and Windows CE 5.0 software applications. The protocol of application server was created by using basic principles of GPRS control, the client software was performed and the real time torque and speed control of DC motor was realized on a monitor system written on C# language and prepared without using any additional equipment. It was observed that the GPRS protocol used in system control provided many advantages in both time and cost.**

Keywords- GPRS; PDA; speed and torque control; real-time monitoring

I. INTRODUCTION

Owing to the rapid developments in the technology, the studies carried out for remote control of devices and systems have particularly gained speed. Different kinds of methods have been used to meet the system requirements like starting/stopping and monitoring an installed system including the determination of critical cases and realization of the necessary interventions [1]. One of these methods is the remote control system realized via PDA (Personal Digital Assistant) using GPRS (General Packet Radio Service) protocol. There are so many studies using this method in the literature. A GPRS based real time data-acquisition system is presented in [2]. Reference [1] carries out an establishment of a monitoring control system by a PDA, a wireless device server, a set of PLC, a servomotor and its driver. A wireless remote monitoring system based on GPRS is presented in [3]. In other works, some examples of remote monitoring system via on GPRS were carried out [4, 5].

DC motor becomes popular in various applications because of its high efficiency, high power factors, high torque and good controllability [6] features; especially they have been widely used in speed control systems which need high control requirements [7-9].

PI and PID controller methods are widely used for speed regulation in the industrial applications [10, 11]. There are so many case studies in the literature in which PID control strategy has been used [6-8, 12, 13]. A control strategy of fuzzy algorithm combining with PID control for DC motor speed regulating system is presented in [14].

In this study; the remote control of DC motor which has become an integral part of any system controlled remotely and preferred for especially small scale applications, was purposed. The control of the system was carried out via a Pocket PC using internet based GPRS system and a monitoring screen of which control interface was developed by using C# language.

PID method was preferred for controlling purposes. It was aimed that the communication of the system could be provided without any control distance constraint and PDA of which application is increasing day by day, was used as a communication channel. By using a PDA and a client code, the operating parameters of DC motor can be easily monitored via the designed driver circuit and RS232 data transfer cable and the time-based operating graphs of the motor can be investigated.

II. GPRS BASED MONITORING SYSTEM

GPRS (General Packet Radio Service) is a packet based mobile communication service which serves uninterrupted internet connection for pocket telephone and mobile device users over Global System for Mobile Communications (GSM) [5]. Besides, GPRS has high transmit efficiency so that it can assemble eight time interval mostly in theory, it can provide 171.2 kb/s bandwidth [4].

The possible applications for GPRS can spread from communication possibilities on a laptop to special applications with low transmission. In the past, some PC applications were used with GSM data services, but nowadays they became much more economical via GPRS. Furthermore, they have created a wide market for the applications realizing infrequent data transfer of small scale data amounts. Robot control mechanisms are important part of web-based control applications [15-16]. There are many electrical devices that can take advantage of these communication possibilities. The idea of installing a GPRS transmitter on the device is to show periodic statistical error notifications and intervention alarms. In order to provide fast process, the system access time and data rate should be high enough. A presentation of the applications to be realized via GPRS is given in Fig.1.

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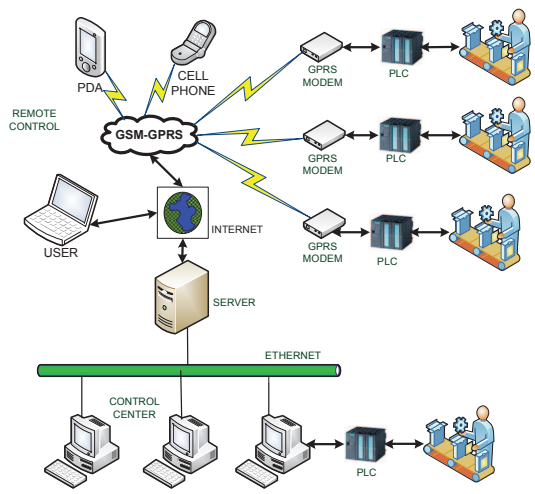

Figure 1. System control applications via GPRS

Besides high speed data handling technique, GPRS has many aspects, such as vast coverage, great data transmission quantity, low running expense, fast switching on, real-time on line, charging on flow and so on. And it has unapproachable predominance for remote paroxysmal real time data transmission.

Mobiles can be used as a client in mobile-based control systems as well as computers. The application software in the mobile connects to the web page in the internet by using packet-switched radio services. The process in the field can be easily monitored and controlled from remote or local points through mobile based control system which is independent from a local computer or a computer connected to the internet [2-4].

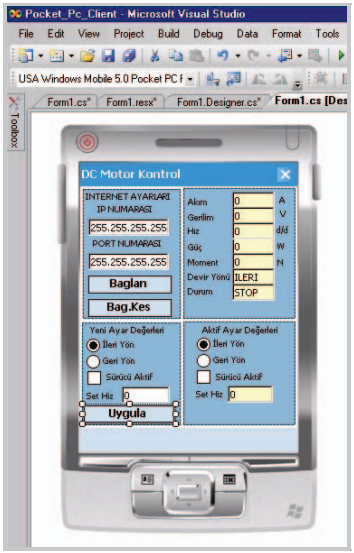

Figure 2. A PDA application developed with Visual Studio 2005 platform

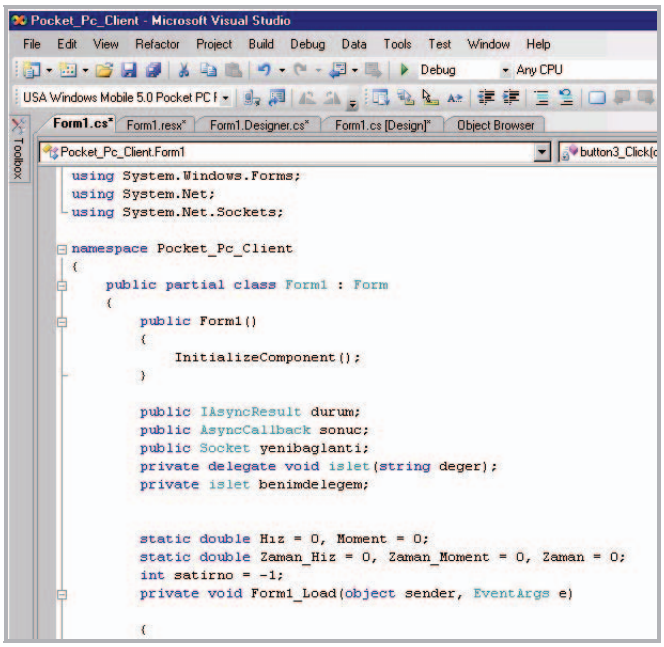

Figure 3. Visual Studio 2005 Smart Device PDA application – Programming Interface

With the effective use of programming techniques, advanced control software can be developed. Microsoft Visual Studio and Java Platform are the most effective platforms preferred for developing PDA applications. In the developed application, Visual Studio 2005 platform was preferred. As shown in Fig.2 and Fig.3, it is possible to develop applications for different kinds of device and hardware via GPRS by the help of such platforms.

III. System Design

The system and its design which is aiming real-time control of DC motor through an internet-based monitoring system will be covered in two major groups:

- Hardware design
- Software design

A. Hardware Design

The interaction of all components used in the system design is shown in Fig.4. The flow chart and hardware block diagram are drawn together in order to provide a clear and comprehensible function for the hardware.

According to the general block diagram given in Fig.4, it is possible to arrange the basic devices used in internet based control of DC motor as follows:

- Supply circuit (power supply circuits consisting of four transformers of +5V-15V designed for 220 V, 10 A power supply),
- Measurement circuit,
- Programming and control circuit (in which PIC18F452 is used),

- Monitoring system,
- MOSFET driver circuit (designed with IR2110 MOSFET driver integrated circuits),
- H-Bridge control circuit (in which IRFP250 200V, 33A MOSFET is used),
- RS232 communication protocol [2, 3-5].

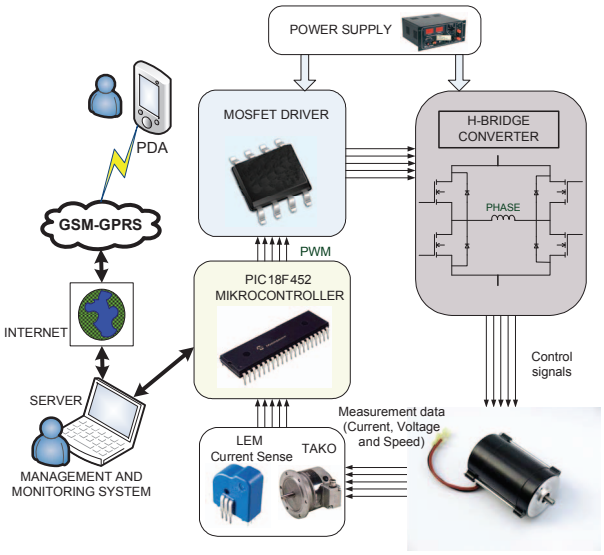

Figure 4. Hardware block and system flow diagram

B. *Software Design*

Three different interface programs was realized by using Visual Studio 2005 in order to monitor the data obtained during system operation and send data to the micro controller when required. The realized interfaces can be grouped as follows:

- Server interface,
- Mobile (PDA) [1] client interface.

Visual Studio 2005 platform is the most effective platform used for developing PDA programs in addition to interface developing. As seen in Fig.2, it is possible to create advanced control applications via Pocket PC 2003, Smartphone 2003 and Windows CE 5.0 software under Smart Device Applications tab. Windows CE 5.0 software was preferred for the developed PDA application.

IV. EXPERIMENTAL STUDIES

The experiments carried out in the study have several phases. Before mentioning the experiments, obtained results and the differences between the results, it is better to have a look at test bed. The devices used during the experiments rather than the ones mentioned before are as follows:

- Two shunt wound DC motor, 1 kW LM brand, 200 V and 5.75 A (one of the motor was used as a generator),
- One taco generator (sensitivity of 2.5V for 1000 rpm),
- One 220 V, 10 A DE LORENZO DL1013 T2 brand external power supply,
- One CISCO brand wireless modem,
- 1kW serial DC load,
- Measurement devices.

The following figures show the test bed and the devices used in test bed.

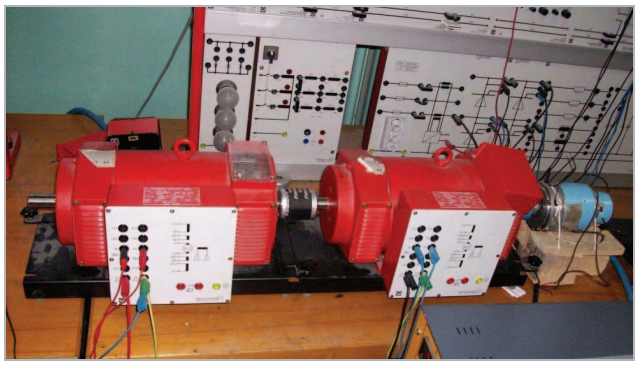

Figure 5. 1 kW LM brand DC motor and taco generator

Figure 6. Laptop used as a server during the tests and PDA mobile as client

The tests carried out in order to prove the practicability and effectiveness of the system designed consist of 2 steps:

- In the first test, the PWM ratio is kept constant (%80) and the motor is loaded up to its nominal load (I=5A). And then the resulting current, power, speed and moment variations are obtained on server and client sides.
- During the last test, PID control of the DC motor is realized and the resulting current, power, speed and moment variations are obtained on server side.

A. *The Experiments Realized at a Constant PWM (%80)*

On the developed interface, 100% PWM ratios refer to the number “1024” digitally. That means for 80% PWM value, we have to set “Set Speed” field as “818”. Once the necessary

adjustments are completed, 1 kW load is connected to the motor ends and increased gradually. And the moment and speed values related to the current are recorded on Table 1. In this experiment, the operating graphs obtained from server side are shown in Fig.7 and the screen shot obtained from PDA mobile is shown in Fig.8.

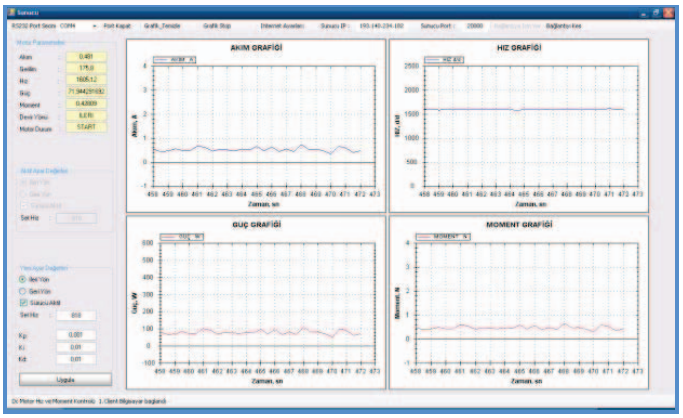

Figure 7. The operating graphs obtained on server side while the motor is unloaded (PWM=%80)

Figure 8. Screen shot obtained from PDA mobile

TABLE I. OPERATING VALUES OF THE MOTOR AT CONSTANT PWM RATIO

PWM Ratio (%)	Current (A)	Voltage (V)	Speed (rpm)	Moment (Nm)
80	0.4	175.8	1596	0.53
80	1.43	175.8	1461	1.27
80	3	175.8	1322	2.58
80	4.14	175.8	1254	3.73
80	5.3	175.8	1235	4.59

B. The Realization of PWM Control

The microprocessor reads the rotation direction and rotation and speed of DC motor from the PC by communicating through serial port. At the same time it also reads the real speed data of the motor from the taco generator and executes the embedded PID algorithm. As seen in Fig.9, PID algorithm always tries to keep the speed at 1000 rpm as the motor is loaded periodically. It shows that the interaction between the designed interface and the driver circuit is quite fine and the selected P-I-D parameters are judicious.

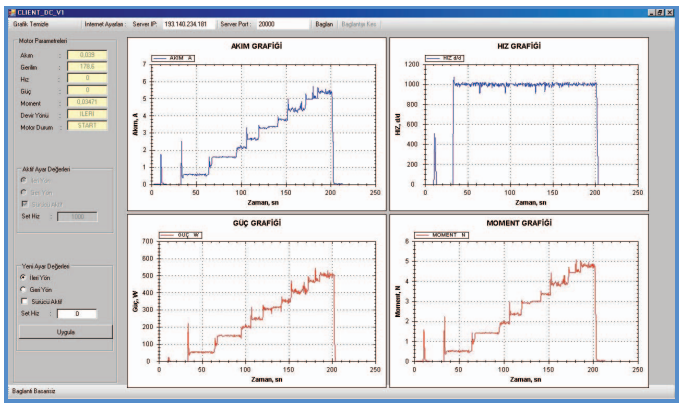

Figure 9. Operating graphs of the motor running on PID algorithm

V. CONCLUSION

In this study, the establishment of the control platform has been carried out with a personal digital assistant (PDA) and a server laptop using GPRS (General Packet Radio Service). The protocol of application server was created by using basic principles of GPRS control, the client software was performed and the real time torque and speed control of DC motor was realized on a monitor system written on C# language and prepared without using any additional equipment. So, a small scale monitoring system was developed by taking account the improvements that the today's technology brings and the conveniences of remote control system was testified within several experiments. It was observed that the GPRS protocol used in system control provided many advantages in both time and cost. The obtained graphical results clearly reveal the reliability and effectiveness of the system. The results also show that low cost, secure and reliable packet-switched radio services and the emerging wireless systems can play an important role in preferring such systems.

As a result of all these studies, the objective system can be recommended for any household or indusrial machine that can be remotely controlled. Next to this, our research prototype can be transferred to industrial level. For instance, the integration of these communication modules and interfaces extended with sensors in machines could allow their manufacturers to undertake preventive maintenance or on-time control. They could remotely check the "health" of a machine and send the required technical staff to repair the problems even before the workers reported them. So, the design of a protocol catered for wireless communication together with the optimizations has been succesfully studied for the feasibility of achieving real-time control of remote devices by means of GPRS.

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