A Prototype of a Device Control and Alarm Monitor System Based on The GSM Short Message Service and The AYR AT90S2313 Microcontroller

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Abstract

A Prototype of a Device Control and Alarm Monitor Based on the GSM Short Message Service and the AVR AT90s23i3 Microcontroller has been designed and implemented. The prototype consists of an AVR AT90s23l3 connected to the alarm circuitry and two cellular phones: one as a controller and the other as a transceiver. Whenever the status of the alarm changes, an SMS will be sent from the transceiver cellular phone to the controlling cellular phone. Alternatively, the controlling cellular phone can send an SMS querying the system about the status of the alarm. In response of this SMS, the microcontroller will check the alarm status, compose an SMS and send it through the transceiver cellular phone to the querying cellular phone.

Part of the design of the system involves designing the format of the SMS, in addition to the hardware design, and the programming of the microntroller. It is concluded that the system work we// *with the only predominat limitation being the availability and the signal strength of the GSM infrastructure, which limits the real-time nature of the system.*

Keywords

Microcontroller, Short-Messaging Services, Remote Control.

\. Introduction

The advancement of technologies has offered convenience to our lives. The world-wide availability and low-cost (hut not low quality) nature of the microcontroller technology has enabled the implementation of many circuits and changed the field of electronics. As Tsugio Makimoto, Sony corporate adviser, predicted, the next wave (1997-2007 is the reconfigurable electronics era) in elecironics had come into existence. Reconfigurable electronics (soft electronics) will be the norm (Hartenstein, 2002). Reconfiguable electronics is based on the FPGAs (Field-Programmable Gate Arrays) technology. However, in a developing country like Indonesia, microcontrollers are more popular than FPGAs due to their lower development cost. Therefore, programmable electronics is more popular than reconfigurable electronics.

Programmable electronics based on microcontrollers may be slower than FPGAs. but for some applications, it suffices.

The penetration of cellular phones in Indonesia has been dramatic, so much so that not only adults are in possession of one or many cellular phones, but also primary school children are carrying cellular phones to their schools. Short messaging services, as one of the many features of a modern cellular technology are more preferred than voice calls due to its low cost. It is known that voice calls are to corporate employees that SMS are to the youths and students.

This trend has open millions of opportunities for developing many applications based on the SMS technology, such as SMS banking, SMS-based polling, and even SMS-based voting. The Indonesian president has recently invited Indonesian citizens to send SMS containing criticism or suggestions to the president.

2. Short-Messaging Services (Sms)

SMS as one of the GSM (Global Systems for Mobile Communications) was introduced initially in 1990. SMS was developed and standardized by ETSI (European Telecommunication and Standard Institute). SMS enables the user to send a message consisting of 160 characters(using 7-bit encoding) or 140 characters (using 8-bit encoding). An SMS can be sent using a text mode or a PDU (Protocol Data Unit) mode (Le Bodic, 2002).

A text-mode SMS is the simplest of sending an SMS, but no picture nor ring tone can be inserted in the SMS content.

A PDU-mode SMS consists of hexadecimal octets (8-bit units) composing a maximum of 160 7-bit ASCII characters or 140 octets. In the PDU format, a 1-12 octet of Service Center Address, an octet of PDU type, and an octet of User Data Length are also specified, among other things (Siemens, 2001).

SMS is a store-and-forward system. SMS is not sent directly from the sending mobile equipment to the receiving mobile equipment, but is sent to the SMS Center first. This makes SMS not a real-time service. When the GSM network is busy at peak hours (such as at Saturday night or during Eid day when muslims in Indonesia are

sending each other SMS as a greeting card), the SMS will usually arrived delayed to the destination.

3.TheAVRAT90S2313

The AT90s2313 is an 8-bit microcontroller based on the Reduced Instruction Set Computer (RISC) architecture. It also uses the low-power technology. It consists of 32x8-bit registers connected directly to the Arithmetic and Logic Unit (ALU). Provided with the AT90s2313 are a 2 Kbytes flash memory with an in-system programmable capability, a 128 bytes SRAM (Static Random Access Memory), a 128 bytes in-system programmable EEPROM data memory, and a programming key for securing the data and program in the EEPROM. There are two kinds of AT90s2313: one running at a maximum of 4 MHz crystal oscillator and powered by 2,7-6 volt, and the other running at a maximum of 10 MHz crystal oscillator and powered by 4 - 6 volt. There can also be other peripherals attached to the AT90s2313 such as an 8-bit or a 16-bit timer/counter, an analog comparator, a watchdog timer with an on-chip oscillator, an SPI serial interface, and a full-duplex UART (ATMEL, 2002).

4. Literature Search

Remote control systems based on a microcontroller and the Short-Messaging Service have been published by (Vasilis, 2003) and (Istiyanto and Efendy, 2004). (Vasilis, 2003) uses the AYR AT90s23l3 but uses Erricson TlOs, TI8, or T28 as the cellular phone. (Istiyanto and Efendy, 2004) uses the AT89C52 and tests their system on a number of series of Sony Erricson and Siemens. AT89C52 is simpler and cost lower than the AT90s2313. However, both (Vasilis, 2003) and (Istiyanto and Efendy, 2004) systems control only a set of LEDs {Light-Emitting Diodes) which requires simple circuitry to control. The system reported in this paper controls electric bulbs, which requires more complicated circuitry, such as the utilization of a set of relays.

5. The Description of the System

The control and monitor device needs two cellular phones: one as a transceiver, dan the other as a controller. The main component of the system is an AT90s2313 which serves as the "brain" of the system. A photograph of the implemented system is illustrated in Figure 1. As shown in the Figure, the system is powered using a battery, and uses a Siemens cellular phone. This product has been chosen due to the simplicity of design and ease of programming using the Hayes AT command set since Siemens uses the M-bus (Siemens, 2001). Pictured in the figure is also a temperature sensor which is not reported in this paper, because the temperature sensor is part of another experiment using the same prototype.

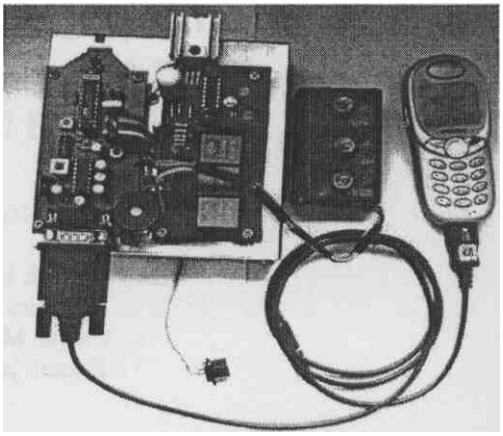

Figure 1 **A photograph of the implemented system**

The schematics for the system is depicted in Figure 2. Figure 2 only illustrate the microcontroller part. The part of the circuitry that controls the alarm and the lamps are not shown.

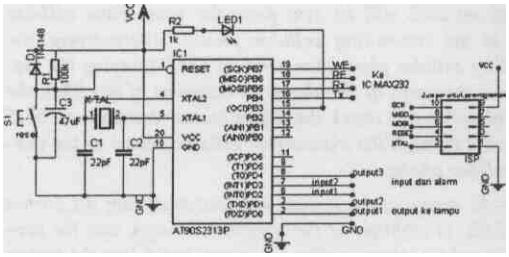

Figure 2 The main schematics **of the** system with an AT90s2313

The communication between the microcontroller and the cellular phone requires an RS-232 interface which serves to convert the CMOS TTL output voltage of the microcontroller (0-5 volt) into a voltage of+/- 12 volt. The converter uses the MAX232 converter 1C (Dallas Semiconductor, 2004), as illustrated in Figure 3. The connection of MAX232 to the cellular phone uses the data cable through the RS-232 serial port. The data cable serves to adapt the output voltage of the system with the working voltage of the cellular phone which is less than 5 volt.

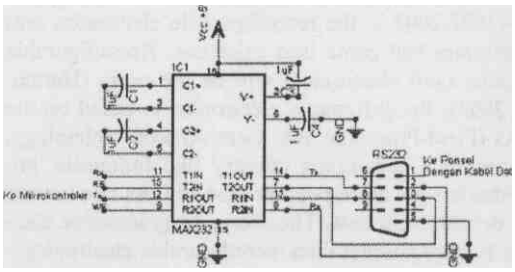

Figure 3 Schematics of the RS-232 Interface

The system has two main functions which are monitoring the status of the alarm and controlling (setting on/off) of a lamp or other electrical devices. Up to three devices can be controlled in the current design, marked

A, B, and C. The monitoring and the controlling can be done by sending an SMS with a certain format. Whenever the status of the alarm changes, the microcontroller will automatically command the transceiver cellular phone to send an SMS containing the status of the alarm to a preset cellular phone number.

The microcontroller will check the presence of a new SMS every minute. This is done by executing an AT command "AT+CMGR=1". If there is a new SMS, the content of the SMS will be compared to predefined keywords. If there is a match, the microcontroller will execute the command mentioned in the SMS content. On completion of the reading of the SMS, whether there is a match or mismatch of the SMS content with the keyword, the SMS will be deleted by executing another AT command "AT+CMGD=r.

The format of the SMS is illustrated in Table 1.

Table I Formal of the SMS content

N	Keyword	Function
1.	ALARM1	Querying the status of alarm 1
2,	ALARM2	Querying the status of alarm 2
3.	ABC1	Setting the lamps A, B, C on
4.	ABCO	Setting all lamps off
5.	Al	Setting the lamp A on
6.	Bl	Setting the lamp B on
7.	Cl	Setting the lamp C on
8.	ABI	Setting both the lamps A and B
9.	AC1	Setting both the lamps A and C
10,	BC1	Setting both the lamps B and C on

To save the cost of sending SMS, another mode of format has been provided. One of the examples for this format is "A I YYZZx". AI is a command to put the lamp A on and YYZZ is a set of numbers expressing a time duration in hours; YY means the time to start putting the lamp A on, and ZZ is the time to switch the lamp A off. The character x is a sentinel, just like '\0' is a character in the C programming language to indicate the end of a string of characters. As an example is the SMS containing "A I 0304x" which is a command to the microcontroller to switch the A lamp on at 03:00 and to pul the lamp A off at 04:00. The microcontroller checks the timer every minute. This is actually done by allowing the timerl to interrupt the microcontroller every minute. If the timerl does not interrupt, the microcontroller checks the status of the input.

The character 'x' in the content of the SMS is a necessity imposed by the simplicity of the parser of the SMS content. A more sophisticated parser may not require the presence of the character 'x'. However, the more sophisticated the parser, the more complicated is the program that the microcontroller has to handle. The more complicated the program, the more memory that the microcontroller has to provide. This necessitate the presence of an external memory.

The presence of the character 'x' will also enable a more complicated SMS content, such as "Al 010204070910" which means that the lamp A will be put on at 01:00, off at 02:00, on again at 04:00, off again at 07:00, on again at 09:00, and finally off at 10:00. Without such a command, the operational cost of the system will be high because to do such commands we will need eight SMS, instead of one.

6. Limitations of the System

The system has been tested and performed well. However, there are some limitations, such as

1. The system can only function within the reach of a GSM operator
2. When another SMS arrives, while the microcontroller is reading a previous SMS, the arriving SMS may get deleted before being read.
3. Because the system is powered using a battery, the system will cease to operate when the power of the battery is low.

7. Conclusion and **Future Work**

In spite of the limitations, the system has been shown to work well as expected. A mechanism should be devised to replace the battery when the power is low. An AT command can be used to check the level of the battery power, and an SMS will be sent to notify a nearby technician to replace the battery. Work is still being carried out to replace the sending of SMS by the controlling cellular phone with the sending of a missed call signal to save the operating cost of the system.

To prevent the incoming SMS from unintentional deletion, a programming trick may be used. However, this may complicate the programming task.

It is concluded that the limitation is predominantly the availability and signal strength of the GSM infrastructure. The other limitations can still be dealt with.

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