DEVELOPMENT OF A NEW LIGHTNING SURGE COUNTER WITH SMS SYSTEM

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ABSTRACT

This paper presents a new method to measure the number of lightning discharge currents to a specific place. The surge detector is composed of Rogowski coil and a Monostable multivibrator. In addition, serial communication is made in between the PC and detector using PIC microcontroller. The interface between the user, the program, PIC controller and modem to send a SMS is done via a computer program namely, VISUAL BASIC. Each part of the system is tested individually to ensure their right performance. Eventually, the whole system is tested together, which can satisfy the required performance of a lightning counter by registration of time, date and number of strikes and sending the data to a specified phone number as a SMS.

Key words: Keywords: Lightning; Lightning flash counter; Lightning protection; Rogowski coil; Monstable multivibrator; PIC microcontroller; SMS.

I. INTRODUCTION

Lightning is an atmospheric discharge of electricity accompanied by thunder, which typically occurs during thunderstorms, and sometimes during volcanic eruptions or dust storms [1]. In the atmospheric electrical discharge, a leader of a bolt of lightning can travel at speeds of 60,000 m/s (130,000 mph), and can reach temperatures approaching 30,000 °C (54,000 °F). This temperature is hot enough to fuse silica sand into glass channels known as fulgurites, which are normally hollow and can extend some distance into the ground [2-3]. Approximately 16 million lightning storms occur around the world every year [4]. L. S. Rose et al. [5] have studied some urban regions influencing warm-session cloud-to-ground lightning flashes and precipitation. Eight years of flashes and mean accumulated precipitation from the North American Regional Reanalysis model were mapped under seven wind speed and direction combinations derived from cluster analysis. R. B. Rodrigues et al. [6] have investigated cloud-to-ground activity over the continental territory of Portugal with data collected by the National Lightning Location System. They constructed an overall ground flash density map from the database, which contains the information of more than five years. Lightning has an affinity to strike high buildings, transmission towers, and communication towers as well as open ground. Lightning strikes may damage the internal domestic wiring systems, computer networks, telecommunication equipments as well as open ground. Hence, it is very important to know the effects of lightning discharges on those objects. The accumulation of lightning strike data assists in this aspect since a knowledge of the actual probability of lightning strikes is essential to determine the extent and the type of protection required. For an open ground, the propensity to high lightning activities can be avoided for future development of such buildings. Lightning has caused lots of damage including livestock. In order to avoid or minimize the impact of lightning strikes, it is important to know the quantity of the lightning discharge current through the existing down conductor of a high-risk structure. It is used to investigate how frequent lightning strikes a particular structure or object. Several works have been done to implement lightning strike counters since 1950. A first, so-called ground-flash counter was

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proposed by E. T. Pierce [4] and has been modified by R. H. Golde [7]. B. S. Sonde [8] proposed a method where a transistorized radiation field actuated flash counter was implemented. F. de la Rosa and R. Velazquez [9] have critically reviewed the available ground flash density measuring devices for the power industry. They also found that both lightning flash counters and lightning location systems normally offered a number of advantages to the power utilities. Still, there is a need for the development of surge detector devices with advanced equipment. In this paper, a surge detector device is built with a combination of a Rogowski coil and a Monostable multivibrator.

II. HARDWARE SYSTEM DESIGN

The structure of the proposed lightning flash counter is illustrated in Fig.1. This device is built with the combination of a Rogowski coil, triggering circuit (lightning detection), PIC microcontroller, serial communication interface and PC.

The electronic schematic of the whole system is shown in Fig. 2.

The transistor is on when the push button switch is closed and sends a triggering pulse to the monostable multivibrator. After that monostable multivibrator generates an impulse and the PIC detects this impulse. Then three LED will be on and at the same time the PIC sends a signal to the PC through the SCI. A Mobile phone then receives a SMS from the PC.

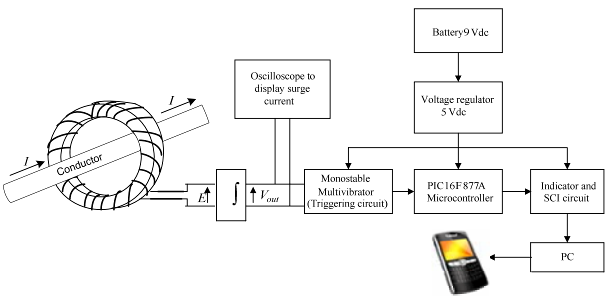


Fig. 1 Lightning flash counter with SMS data sender.

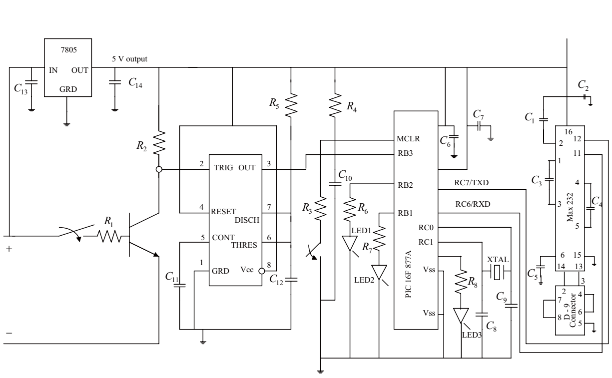


Fig. 2 Electronic schematic of the system.

2.1 Rogowski Coil

A Rogowski coil, named by Walter Rogowski, is an electrical device for measuring alternating current or high-speed current pulses as shown in Fig. 3.

It consists of a helical coil of wire with the lead from one end returning through the center of the coil to the other end, so that both terminals are at the same end of the coil. The inside and outside diameters and height of the Rogowski coil is . The whole assembly is then wrapped around the straight conductor whose current is to be measured. Since the voltage that is induced in the coil is proportional to the rate of change (derivative) of current in the straight conductor, the output of the Rogowski coil is usually connected to an electrical (or electronic) integrator circuit in order to provide an output signal that is proportional to the current. In this approach, one integrator block is used after the Rogowski coil. The purpose of placing an integrator with the Rogowski coil is to get its output in terms of induced voltage.

2.2 Lightning Detection Circuit

The basic principle of the lightning detection in this study is that whenever the lightning strikes a structure, the lightning current will be discharged to ground through an existing path (which is mostly a copper down conductor). By encircling the conductor with a Rogowski coil, the voltage will be induced at the output of the Rogowski coil. The induced voltage is then used to trigger the monostable multivibrator for generating a pulse. The monostable multivibrator actually acts as a pulse generator. It is responsive to any induced voltage from the Rogowski coil for generating a pulse with a constant amplitude and pulse width.

2.3 PIC Microcontroller

One of the core components in the electronic lightning counter circuit is the microcontroller. In this study, the microcontroller that is being used is the microchip microcontroller. As the lightning surge counter needs to be interfaced with a computer, a microcontroller that has in-built serial communication interface is needed. The PIC16F877A has 4 ports with 33 digital I/O pins. It has a wide range of operating voltages that vary from 2.0V to 5.5V.

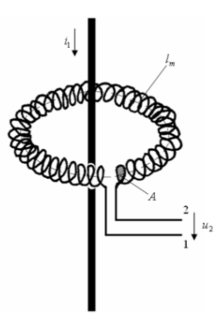


Fig. 3 Schematic of Rogowski coil.

The microcontroller used in this case is to accomplish two major tasks. Firstly, it is used to detect the changes at the monostable multivibrator output. Secondly, the microcontroller is used to send signal to the computer through the serial communication interface.

2.4 Serial Communication Interface

The universal synchronous asynchronous receiver transmitter module is one of the two serial I/O modules. USART is also known as a serial communication interface. The USART can be configured as a full-duplex asynchronous system that can communicate with peripheral devices such as CRT terminals and personal computers, or it can be configured as a half duplex synchronous system that can communicate with peripheral devices such as A/D or D/A integrated circuits, serial EEPROM, etc. In this study, the USART feature is used to transmit a signal to computer. The asynchronous mode is chosen.

III. VISUAL COMPUTER INTERFACE PROGRAM

A graphic user interface for this study is created and developed by using Microsoft Visual Basic 6.0. The GUI is an important element here, which is used to record and count each time whenever lightning strikes the particular structure. The graphic user interface is connected to a database which is created using Microsoft Access. The created database consists of two important columns. The first column is used to display how frequent lightning currents discharge through a conductor. The second column is used to record the date and time of each discharge.

As the GUI needs to communicate with external hardware, the electronic lightning counter in this study, the band rate and COMPORT for both the GUI and counter need to be matched. This is very important in order to setup a proper connection between the hardware and the software. Fig. 4 shows the graphic user interface for the lightning strike counter system.

3.1 AT Command

AT command is the command that is used to control the GSM modem or mobile phone to perform a task, for example sending a SMS or making a phone call. In this paper, AT command is only used to send out a SMS, and AT command plays an important role as the key advantage is to focus on the auto SMS function.

AT command has been written and tested through the hyper terminal. Before the writing of AT command, the mobile has to be tested in order to determine which type of SMS mode it is supporting. The SMS mode is divided into two types: one is called PDU mode and the other one is called text mode. For PDU mode, the message content to be sent has to be converted to HEX code before sending is done. For text mode, a SMS can simply be in the alphabet format that can be written normally. There are also mobile phones that support both types of SMS modes. Therefore, it is easier if mobile phones that support both modes are used.

IV. HARDWARE BUILD

Initially, design works have been completed before the hardware construction. For the construction of the electronic lightning counter, the required components with its specifications are listed in Table 1.

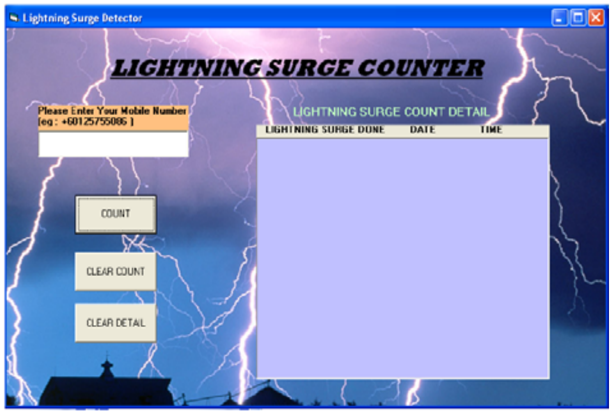


Fig. 4 GUI Interface for lightning counter.

Table 1 Component list.

Components/ Devices	Specification
SK40B	Starter kit
NPN Transistor	BC 546
Push Button	2 / 4 Pins continuity switch
LED	3mm Green, Red
C_{13}	Electrolytic 1.0μF, 50V
C_1, C_2, C_4, C_5, C_{10}	Ceramic 0.1μF
C_8, C_9	Ceramic 27pF
C_{14}	Electrolytic 10μF, 50V
C_{12}	Ceramic 0.01μF
R_2	8.2kΩ, ¼ watt
R_3	56Ω, ¼ watt
R_1	47kΩ, ¼ watt
R_5	10kΩ, ¼ watt
R_4	100Ω, ¼ watt
R_6, R_7, R_8	220Ω, ¼ watt
D-9 Connector	Female
MAX 232	Serial communication
PIC 16F877A	Microcontroller

The electronic counter is built on a strip board. The microcontroller used in this study is a four port microcontroller. Additional functions can be added to fully utilize the input/output pins. The SK40B starter kit is bought to be the basic circuit of the counter. The circuit is constructed and soldered on a strip board. Fig. 5 shows the complete prototype of the lightning counter.

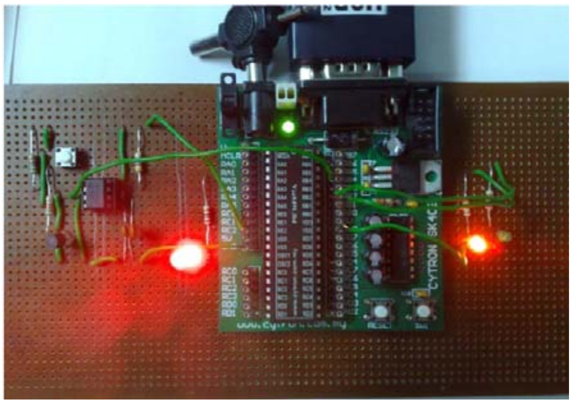
V. EXPERIMENTAL RESULTS

Upon the completion of the hardware construction and software development, the lightning surge counter needs to be tested for evaluation on the accuracy and stability of detecting, counting and sending a SMS. A few sets of tests are carried out to test and calibrate the lightning surge counter system. The tests can be divided into two groups: individual tests and overall tests. Under individual tests, every major part of the lightning counter is tested separately while for overall tests, the whole lightning counter system is also tested. The purpose of doing individual tests is to ensure the stability of every single circuit in this study. Besides, it can save time in troubleshooting. Upon the completion of the electronic counter, the electronic counter is put under two individual tests. The first individual test is used to test the accuracy and stability of the triggering circuit. For the testing, the base of the transistor in the electronic counter circuit that functions as a switch is connected to a 9 VDC battery supply through a push button and a resistor. Once the push button is pressed, the monostable multivibrator will generate an impulse waveform at its output, which is connected to the microcontroller. From Fig. 5(a), the functionality of the triggering circuit can be shown through the green LED (LED3).

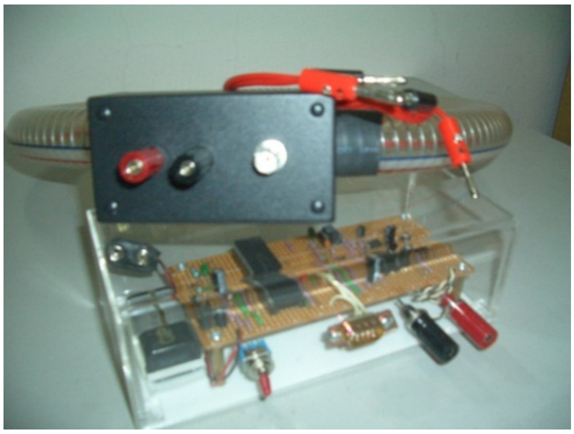
The second individual test is serial communication interface (SCI) individual test. The functionality of the serial transfer circuit is tested under this test. In order to perform the SCI individual test, Hyper Terminal in a Windows operating system is used. First, the electronic lightning counter is connected to the computer using a serial cable. A few steps need to be followed to set up the Hyper Terminal for the lightning counter. The Hyper Terminal is opened and the setup is completed as shown in Fig. 6. After assigning a name for the connection, a "Connect To" window will pop up, then the user should choose "connect using COM1". The following steps are filled in every criterion as shown in Figs. 6(a) and (b) respectively:

Once the push button is pressed, the microcontroller will send a signal to the computer through SCI and an letter "A" will appear at the Hyper Terminal. This indicates that the SCI can operate as well as expected.

The graphic user interface needs to be tested for its connectivity to the external hardware, which is the lightning surge counter. The same concept in doing the Hyper terminal test is applied here. The lightning counter is connected to the computer and the lightning counter graphic user interface is launched. Once the push button is pressed, the real time is recorded as shown in Fig. 7. This shows that the interface successfully received the signal sent by the PIC microcontroller. Experimental data for two tests are obtained by the lightning counter system on April 5, and April 15, 2006 at 1:25:00 pm and 10:50:08 pm respectively as shown in Fig. 7. Fig. 8 shows the voltage waveform of a lightning stroke which was captured on April 6, 2006 at 15:37:15 pm. After constant positive voltage, this voltage becomes negative first, negative for the subsequent stroke and the positive

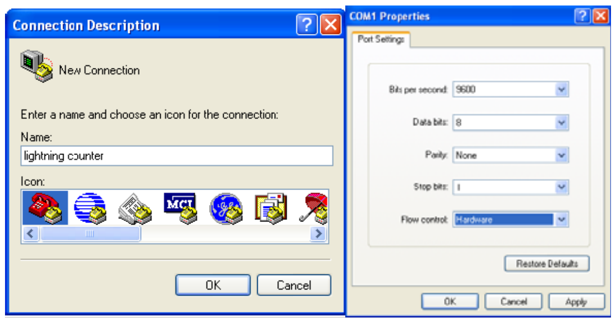


(a)



(b)

Fig. 5 Complete prototype of the lightning counter (a) detection board, (b) Rogowski coil with the detection board unit.



(a) (b)

Fig. 6 Hyper Terminal com port set up.

Fig. 7 Lightning information collected by implemented system.

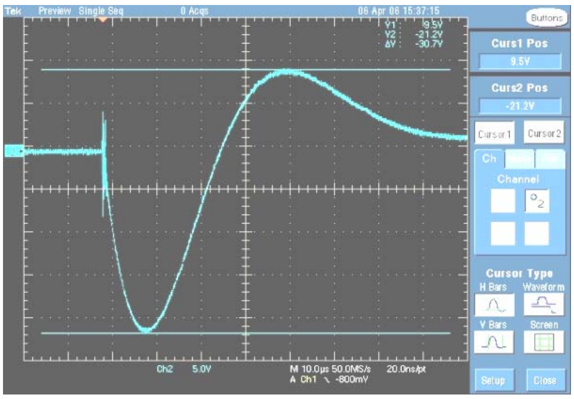


Fig. 8 Rogowski coil voltage invoked by 20 kV surge.

peak respectively. According to the waveform, this voltage consists of the inductive and resistive components. The inductive component is proportional to the current derivative, $\frac{di(t)}{dt}$ and the resistive component is proportional to the current, $i(t)$.

VI. CONCLUSION

In this paper, a low cost lightning counter is designed and constructed, which is able to detect and record the real time of each strike and send a SMS to a user. Experimental results have shown that the designed lightning surge counter is able to trigger the circuit, able to communicate with a computer and send out a SMS. The proposed lightning surge counter has solved some limitations faced by other designs, which are available nowadays. The first key advantage provided by this lightning counter is the ability to send data to a computer and record the date and time of each strike. As the counter is normally installed on the top of a structure, it is very important to have a good monitoring system towards the counter.

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