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An Automated Telephone Billing System for Subscriber's Use

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ABSTRACT

An automated telephone billing system with user controller facilities, which is designed and constructed under this study, is to be employed at the subscriber-end. The system will provide metering of calls and a proper control mechanism at the subscriber's premises. The construction discussed in this study is aimed at Sri Lanka Telecom (SLT) landline subscribers and interfacing to other fixed operator lines has not been tested, and will not be appropriate for Private Branch Exchanges. Metering of call units is based on the concept of Subscriber Pulse Metering (SPM) provided by SLT. The owner, who has the authority to access system settings, can allow the other users to dial only pre-selected numbers; to block all unauthorized dialing. The system can be utilized only for domestic (national) customer dialed calls and is subjected for billing in the constructed system. However International Direct Dialing could be also made possible for customers having IDD facility with a slight modification to the program.

1. INTRODUCTION

Although the telephone, being the simplest device that links the global community, plays a major role in making human life easier, its usage is always attached with a considerable cost, especially with increasing rates. This makes people to be more concerned about the ways to control their telephone bills nowadays. Self-controlling of telephone bill could mean avoiding unnecessary usage of the telephone especially during peak hours, tracking the telephone usage and up-to-date bill, so that telephone usage can be managed properly to cut off undue cost. Unlike the typical fixed telephones, mobile phones with their integrated features provide information that could help to control the telephone usage. For example, it provides information on the duration of a progressing call, duration of calls received and dialed, call costs with breakdowns, where the timers and counters can be preset and also the prepaid credit can be managed through call register settings. And also the automated services offered by mobile phone service providers often enable their customers to be alert on the up-to-date bill. But in Sri Lanka, landline subscribers are not provided with these exact facilities; neither the service provider offer call management services nor there is a system to use as a self-controller.

In Sri Lanka, most of the communication centers use commercial telephone call-charge indicators (e.g. PEPTELLER-30A) [1] with the usage of the concept of Subscriber Pulse Metering (SPM) provided by Sri Lanka Telecom (SLT) for charging purposes. In other words they are using meter pulse detecting techniques for call metering for their charging purposes. However in general this facility is not utilized by home users, mainly due to the inappropriateness of those telephone call-charge indicators for

domestic usage since those are manufactured for commercial environment and those machines cost around Rs. 30,000. These are merely call charge indicators and are not for the purpose of managing telephone usage with the consent of the owner. Hence they are not suited for home use. However still there is no such product available in the Sri Lankan market for home users of landlines, although the need for such a product is there with the customers. Thus the ultimate aim of the intended system is not just to perform call metering or billing, but rather to provide a call management system or a self-controller for telephone bills, that indicates monthly bill based on SLT charges and restricts unauthorized use of the telephone by allowing only dialing of pre-selected numbers, blocking high costly calls during peak hours, etc. Also a great emphasis is placed upon the cost factor as this system is intended for home users. It will definitely be an issue for a normal SLT subscriber when purchasing a system similar to this, where subscriber will consider the provision of value for money.

An automated telephone billing system with user controller facilities, which is designed and constructed under this study, is to be employed at the subscriber-end. The said system will provide metering of calls and a proper control mechanism at the subscriber's premises. The construction discussed in this study is aimed at Sri Lanka Telecom (SLT) subscribers. Metering of call units is based on the concept of Subscriber Pulse Metering (SPM) provided by SLT. The similar methodology could be followed for the customers of other landline service providers in the country.

2. BACKGROUND

2.1. SLT Billing system

The billing cycle is from the first day to the last day of a given calendar month, with a billing period of one month. Depends on the type of the call, the charging is significantly different for each category. However for SLT subscribers, incoming calls are not charged. An outgoing call will be charged only when the called party answers the phone. SLT uses a unit based charging system where a meter will be used to measure the number of units utilized by an individual customer [2]. At the instant the called party answers, one unit is incremented in the meter, even though the call has not proceeded for the duration of one call unit.

The duration of a call unit varies upon the applicable time zone, which depends on the time band and the day on which the call is taken, and also varies upon the categorization of the call as Local or Long distance. The computation of the monthly charge will be based upon the total number of units utilized and the charges of operator assisted calls taken during the billing period of one month [2]. The consumption of call units is divided into four blocks with different unit charges applicable to each block of call units. A SLT subscriber is entitled to 200 call units that are free of charge for every billing cycle. However a monthly rental will be charged for the SLT customers regardless of their telephone usage.

2.2. Subscriber pulse metering (SPM)

Subscriber pulse metering where the metering of telephone usage is carried out at the customer's premises. Subscriber's private metering equipment was first introduced in 1958 to coincide with the introduction of subscriber trunk dialing (STD). The intention was to allow subscribers to monitor the cost of telephone calls, by detecting the meter pulse [3]. Metering pulses were earlier derived from a Pulse Machine that produces pulses of 200 - 250 ms at varying time intervals, depending on the conversation time allowed for a call unit. These pulses operated subscribers' meters on the metering rack in the exchange [3]. At present, most exchanges have the option to send a 12 kHz/ 16 kHz signal (pulse) over the phone line to the customer's premises for each registration that is recorded by the customer's call metering circuitry located at the telephone exchange. This allows customers to calculate their call-charges with the use of a third-party hardware or software at the customer's premises to record these 12 kHz/ 16 kHz pulses.

SLT provides two types of facilities to drive the call-metering devices at the customer's premises named Battery reversal signal and metering pulse. The subscriber has to apply for the above facilities at an additional cost of Rs. 300/- per month [4]. The telephone company will send metering pulses to the customer through the phone line for each unit increment indicated during the call progress. In transmitting metering pulses, either 12 kHz or 16 kHz pulses will be transmitted depending on the type of the exchange used.

3. DESIGN AND METHODOLOGY

The block diagram in Figure 1 demonstrates the overall view of the automated telephone billing system with a user controller for the subscriber's use based on metering pulse technique. The functionality of the designed system is illustrated in Figure 2. The system is designed such a manner to operate only when the telephone is made off-hook to initiate an outgoing call. Therefore making the phone off-hook to answer an incoming call, alerted by ringing signal, will not provide the required condition for starting the main operation of the system.

However since the microcontroller unit has to be always on and lookout for the changes in the off/on hook condition of the telephone in order to start/end the system operations, the power should be always applied to the system. The system relies upon the metering pulses from the network for counting units and the increment of the system counter can be achieved when the signal from the metering pulse detector is fed into the microcontroller as an interrupt.

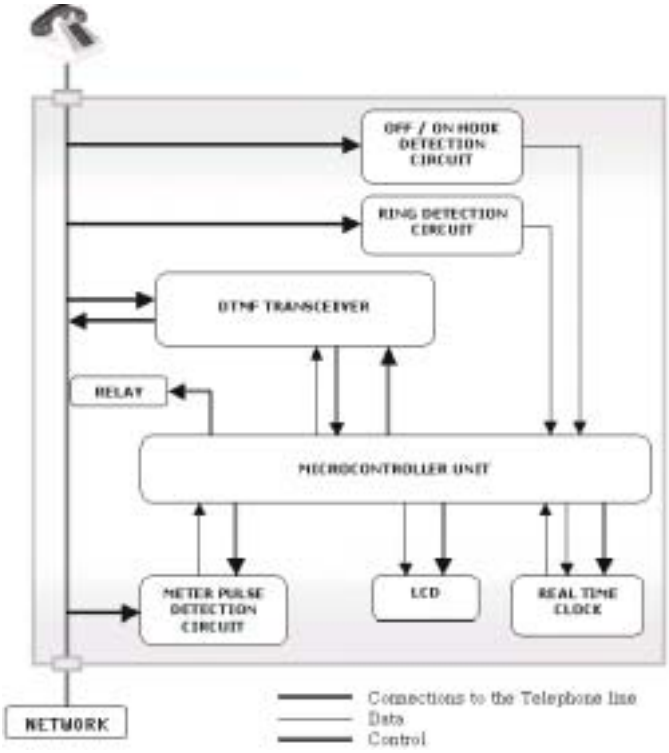

Figure 1: Block diagram of the automated telephone billing system with a user controller

4. CONSTRUCTION AND IMPLEMENTATION

There are seven major sub-circuit modules constructed and tested separately and later integrated to the main controller unit (constructed based on 18F458 PIC microcontroller [5]), which will act accordingly upon the signals received from the home telephone, network and the user.

The task *off/on hook detector unit* [6] is to provide a signal to the microcontroller unit on the states of the host telephone. The *ring detector* circuit [6] is constructed to alert the system of an incoming call, where the system will not respond for the off-hook signal during the ring alert. The *relay circuit* is constructed to perform as a switch that disconnects and connects the telephone line to the network upon the signals received from the microcontroller unit. The application circuit given in the MT8889C transceiver datasheet [7] is used as a *DTMF transceiver circuit*. In designing the PCB, the decoupling capacitor (100 nF ±10%) is placed close to the device and ground loops are avoided with the objective of optimizing the transceiver performance by keeping noise on the supply rails to a minimum.

DS1742 – Nonvolatile Timekeeping RAM is used as the *real time clock (RTC) circuit*. Since the clock accuracy is affected by the electrical environment, action has been taken to place the RTC in the lowest level EMI section of the PCB layout as per the instructions in the datasheet [8].

Therefore a separate PCB is designed for the *RTC unit* together with the two 74LS273 ICs [9] to minimize the possible electromagnetic interference. The *display unit* is constructed using a HD44780U LCD module [10].

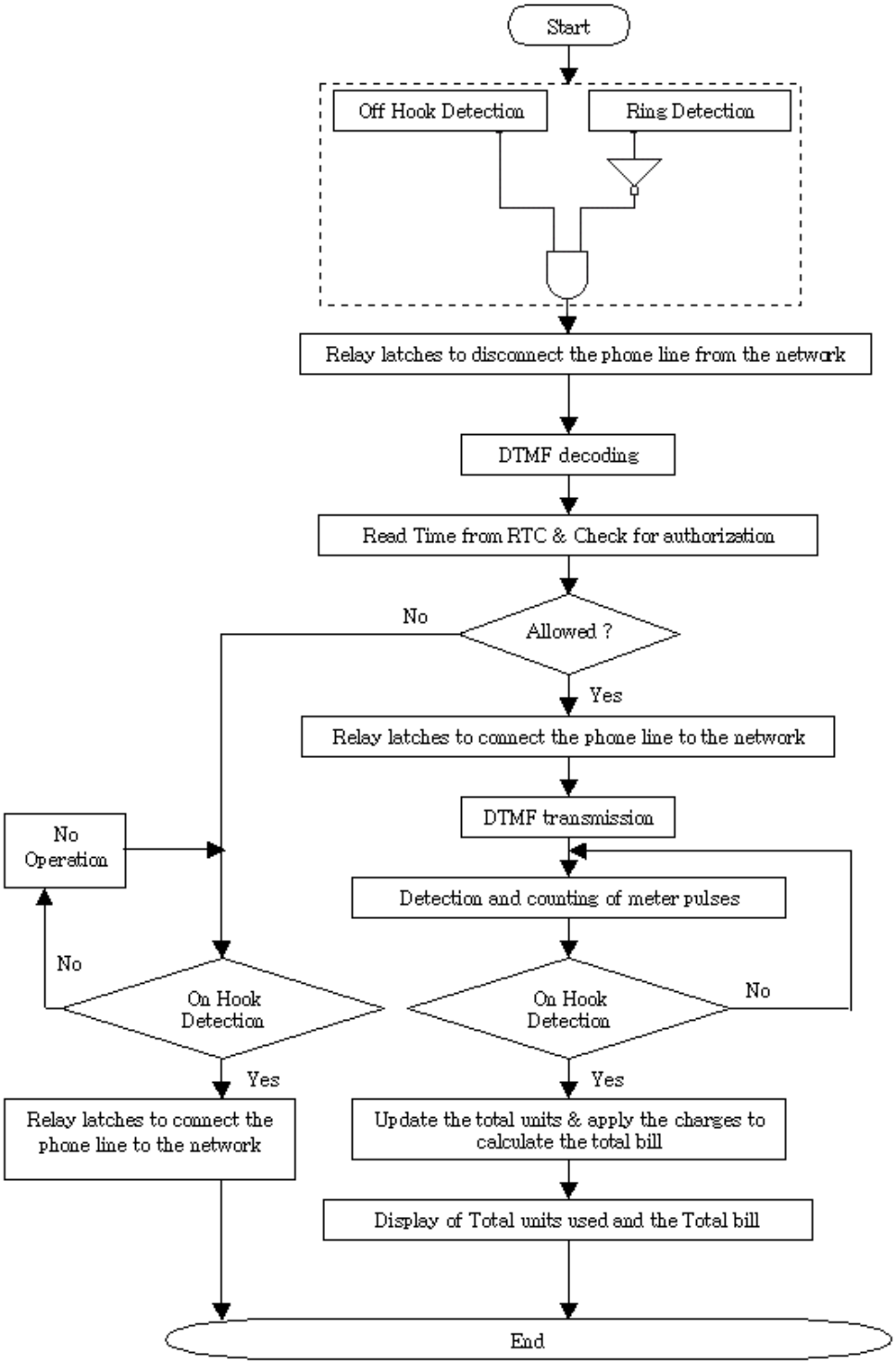

Figure 2: Methodology followed in the design of the system

Meter pulse detection circuit is constructed using an integrated circuit (CMX631A) which has the inbuilt subscriber pulse metering (SPM) detector [11]. Figure 3 shows the circuit diagram of the meter pulse detector circuit. The CMX631A is a low-power, system-selectable SPM detector that indicates the presence of either 12 kHz or 16 kHz telephone call-charge frequencies on a telephone line.

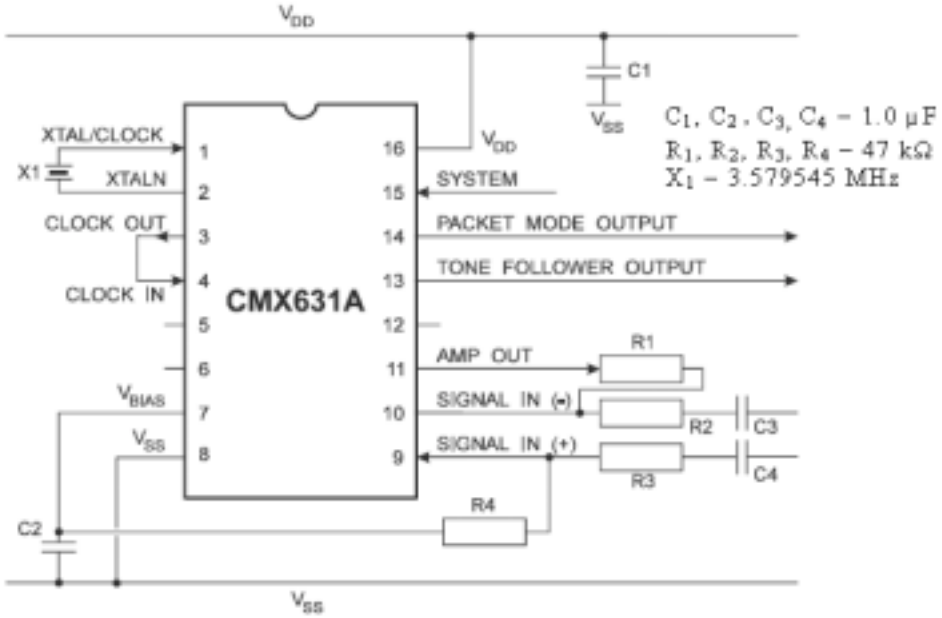

Figure 3: Meter Pulse Detector circuit

5. DISCUSSION AND CONCLUSION

An automated telephone billing system with user controller facilities is designed and constructed, to be employed at the subscriber-end. The said system will provide metering of calls and a proper control mechanism at the subscriber's premises. The construction is aimed at Sri Lanka Telecom (SLT) subscribers. Metering of call units is based on the concept of Subscriber Pulse Metering (SPM) provided by SLT. The metering pulse detection technique is identified as the most effective and efficient method for a telephone billing system, where updating of only call unit charge for each block of call unit is necessary if any changes occur in those values.

The functionality of the automated telephone billing system is illustrated in Figure 2 and can be explained as follows. The system is designed in such a manner to operate only when the telephone is made off-hook to initiate an outgoing call. The microcontroller unit keeps on the lookout for the changes in the off/on hook condition of the telephone in order to start/end the system operations. Thus the power should be always applied to the system. Until the condition for the start-up is met, the system is having a parallel connection to the telephone line, where following the necessary condition (phone made off-hook without the presence of ringing), the phone line should be temporally disconnected from the network. This disconnection will force the user to dial via system, in which only the allowed numbers will be re-generated and transmitted to the network after the connection between the telephone and the network is re-established. In case of dialing a number that is not allowed by the system, the connection between the

telephone and the network will not be re-established until the receiver is placed back on the hook switch. This ensures the blocking of unauthorized outgoing calls. The system relies upon the metering pulses from the network for counting units and the increment of the system counter can be achieved when the signal from the metering pulse detector is fed into the microcontroller as an interrupt. When the system senses on-hook condition of the telephone when terminating the outgoing call, the microcontroller unit will update the total number of units and accordingly apply the charges to produce the total bill up-to-date for the current billing period.

The owner, who has the authority to access system settings, can allow the other users to dial only pre-selected numbers; to block all unauthorized dialing. For this process the owner should use the telephone keypad to communicate with the system and where appropriate the output will be displayed through the LCD.

Limitations and augmentations to the system

The system can be utilized only for domestic (national) customer dialed calls and is subjected to billing in the constructed system. However International Direct Dialing could be also made possible for customers having IDD facility with a slight modification to the program, but the billing will be rather complex with international country bands, time bands and promotional offer rates.

The system can only be interfaced with the direct telephone line of SLT. Interfacing to other fixed operator lines have not been tested, and the system will not be appropriate for Private Branch Exchanges.

As future enhancements, a system that operates through both metering pulses and line reversal signal can be constructed. However the additional charge paid to the SLT (Rs. 300/- per month) will not be changed. However the construction of a system for line reversal signal will cost more than a system for metering pulse detection, due to complexity of the program, due to the addition of internal timers and sufficient protection to the system to protect the ICs used when the polarity is being reversed. A system could be extended to even other fixed line service providers such as *Suntel* and *Lanka Bell*. This will involve detailed analysis of respective billing systems and services provided to the target customer group.

Through enhancing the program flexibility, by increasing the capacity of the memory and using a display with more lines, the breakdown of the bill could be easily displayed and can be stored for future use. Further the flexibility and the user friendliness of the system can be very much increased. By using a technique to use telephone keypad to generate characters in the alphabet, as well as many features could be added like phone books. However if the system is to be used in the communication centers as call charge indicators, addition of a receipts printing unit, user programmable charging system and a sophisticated booth display unit will be essential, therefore it will make a reproduction of the typical call charge indicators in communication centers. So we don't have any intention to introduce the above system for communication centers.

Associated problems in future developments

Although no market research has been carried out, the use of the system will force the SLT subscriber to obtain metering pulse facility by incurring an additional cost of Rs. 300/- per month in addition to the monthly rental and initial cost of the product. Therefore for a customer with an average use of telephone, this will bring about an additional burden on monthly telephone bill, where as customers with unnecessarily high telephone usage can use this product to control their telephone bill. Therefore the decision relies upon the customer's need that will be determined by the significance in controlling the telephone usage and thus the monthly bill.

Not all exchanges are capable of providing all the additional facilities to the total volume of customers. For example when considering the provision of CLI facility, only a limited number of customers are be provided with this facility in some exchanges such as FETEX, hence limiting the capacity to cover the demand. This is due to the limitations in the software used by some of the exchanges. The situation is same for the metering pulse facility as well. Due to the above reason and as well as other reasons like increase in customer complaints if the bill produced by the system in the customer's premises being not inline with SLT bill (However it can be argued that if the customer's system has proven results for accuracy, customer complaints regarding bills will be reduced) the SLT will be reluctant to permit the system, without updating its capacity to provide facilities to its customers. Futher it should always be noted that it is not possible to use the information obtained through the call metering systems used at customer's site to dispute the official telephone bill provided by SLT.

REFERENCES

1. PEPTELLER-30A User Manual, PEP Infotec Pvt. Ltd., 2001.
2. Sri Lanka Telecom www.slt.lk (03rd December 2004)
3. The Telecommunications Heritage Group, www.thg.org.uk (03rd December 2004).
4. Metering pulse application form, SM/SUB/1/94, Sri Lanka Telecom.
5. Microchip Technology Inc., www.microchip.com (07th January 2005).
6. TS117 – Multifunction Telecom Switch datasheet, Clare Inc., 2000.
7. MT8889C DTMF Transceiver with Adaptive Micro Interface datasheet, Zarlink Semiconductor Inc., 2003.
8. DS1742 Y2KC Nonvolatile Timekeeping RAM datasheet, Dallas Semiconductor.
9. 74LS273 Octal D-type Positive-edge-triggered Flip-Flops(with Clear) datasheet, Hitachi Semiconductor.
10. HD44780U Dot Matrix Liquid Crystal Display Controller/Driver datasheet, Hitachi Semiconductor.
11. CMX631A Low Voltage SPM Detector datasheet, Consumer Microcircuits Limited, May 1998.