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Automated Meter Reading System Based on BASIC Stamp2 Microcontroller

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ABSTRACT

Automated Meter Reading (AMR) systems are widely used all over the world. This study is aimed at designing and developing a new method for obtaining, displaying and sending the meter readings over 300 m distance. The proposed design is composed of three modules: Analog Meter, transmitter and receiver modules. The BASIC Stamp2 (BS2) microcontroller is used to display the received meter reading data on the Liquid Crystal Display (LCD) screen and initiate a connection to send the obtained meter reading data as Radio Frequency (RF) signal to the receiver module. The meter reading is displayed and saved in two LCDs and two Electrical Erasable Programmable Read Only Memories (EEPROMs), respectively, one before and one after transmission to assure the reliability of the transmitted meter reading. Based on the experimental study, we have identified that the meter reading was exactly received as it was captured. Furthermore, the proposed system is also capable of obtaining an accurate and efficient meter reading and providing reliable data for the staff-in-charge of the preparation of electrical consumption reports; it also eliminates wastage of time, tediousness and manual method of meter reading. The researchers have suggested further enhancements to the AMR System to include an extra useful application such as GSM chip that sends the data directly to database or connect the receiver module to that database to eliminate the need of a human interaction in obtaining the readings.

Key words: AMR system, BASIC Stamp2 microcontroller, liquid crystal display, meter, radio frequency signal

INTRODUCTION

With the rapid progress of mobile communications technology and the deepening reform of the electricity market, more and more information collection instruments are introduced into the market (Yuan, 2011; Jiang and Chi, 2000). Smart meters and sub-metering systems are widely used and support multifunctional applications, especially those modern types of electronic meters which includes microcontrollers (Rajakovic *et al*., 2009). This technology based systems are expected to become virtually a standard feature in buildings within the near future (Mak and Radford, 1995).

Traditional meter reading depends on manual reading on site at a fixed date, where the meter reading personnel goes from one house to another and manually copies the readings from the meters. This traditional method has many drawbacks and deficiencies (Kehe *et al*., 2010); the first and foremost of the drawbacks is the probability of inaccurate meter readings due to human errors, furthermore, the meter reading personnel would just provide an estimated consumption which is unacceptable and the next critical issue is the huge amount of time consumed by the manual meter reading process, because the meter reading personnel has to go to each and every house and has to spend significant amount of time in reading the meters (Tan *et al.*, 2007). Ultimately, the traditional meter reading approach is expensive, as the number of customers are rapidly increasing within the enormous development of residential housing estates, commercial premises, industries and etc. (Primicanta *et al.*, 2009).

On the other hand the Automated Meter Reading Systems (AMRS) have a lot of advantages and one of the most important benefits of AMRS is the ability to provide more accurate billing to individual users, in addition to real-time, low cost information collection and control for meter reading process. Such systems would decrease the working hours to complete the meter reading task (Fischer *et al.*, 2001).

Several studies have referred to strategic deployment of Automated Meter Reading (AMR) technology as an effective way to reduce cost, improve safety and increase customer satisfaction. The digital communication interface instruments are popularly employed for solving the meter reading problems, instead of manual reading meter. At present, even though more and more studies are focused on communication technologies on distribution automation (Delsing *et al.*, 2000), but the digital communication methods have been prioritized (Zhao *et al.*, 2005).

Generally the AMR communication networks are employed using a number of methods, including Power Line Carrier (PLC), telephone/Internet and short range radio frequency (Sridharan and Schulz, 2001). Of which, the former has drawn the attention as the AMR backhaul network as it does not need additional cables (Sivaneasan *et al.,* 2010). According to Soh and Kerk (2005), a hybrid of PLC AMR with a wireless technology network is the sole resort for addressing the reduction of tariff and capable of serving more-residential areas in countries like India and Singapore. Furthermore, Choi *et al.* (2008) have proposed the method of utilizing PLC as means for sending power, gas and water measurements to the consumers. Figure 1 illustrates the devices and various communication technologies of the PLC.

Of late, in a lot of countries the PLC has been employed for distributing broadband services, due to its reliability and suitability, as against other methods of communication and it even considered as cost effective method (Khalifa *et al.*, 2011).

Furthermore, a design layout for a telephone line AMR system has been proposed by Kim (2006). Additionally, Lee *et al.* (1996) have depicted an AMR system which employs the Public Switched Telephone Network (PSTN), however, it is mandatory to have a telephone line at each meter which is not practically possible, particularly in developing countries.

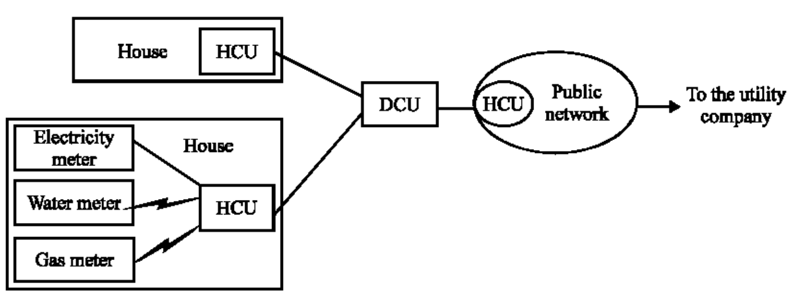

Fig. 1: IMR system diagram (Khalifa *et al.*, 2011)

In the era of Bluetooth technology, Koay *et al.* (2003) have proposed electricity meters equipped with Bluetooth modules, to facilitate wireless ambience for sending meter reading to a nearby PC. Even though Bluetooth is not trustworthy as an alternative to AMR, still it remains as a feasible solution in some specific conditions (for instance, at early deployments of AMR).

Consequently, the prevailing process needs to be improved to provide better services to the households. In this light, this study has responded to these problems by proposing an AMR system which presents simpler way of reading meters using RF module and BS2 microcontrollers. At any time, the AMR system gathers real-time data and transfers the information gathered to the BS2 microcontroller through RF transceivers technology. This enables an economical fast path for gathering metering data wirelessly.

MATERIALS AND METHODS

The proposed AMR system is composed of three modules: Analog meter, transmitter module and receiver module. The transmitter module consists of BS2 Microcontroller, RF transmitter, LCD and an Integrated Circuit (LM339 "Op-Amp" that is used as a Comparator). The receiver module consists of BS2 Microcontroller, RF receiver and LCD. The specifications and features of these devices are explained below:

BASIC Stamp2 microcontroller: The BASIC stamp is a single board computer, compromising of several components: PIC16C57-20/SS - a Microchip 2K 8-bit microcontroller programmed with the BASIC Stamp "Interpreter" that runs the Parallax BASIC Stamp code like a mini operating system; the 24LC16B EEPROM - a Microchip 2K EEPROM (electrically erasable programmable read-only memory) with a user-modifiable Read-only Memory (ROM) that can be reprogrammed with BASIC Stamp code; a 20 MHz resonator, to provide an accurate clock source for the BASIC Stamp; a voltage regulator and reset circuitry. As Fig. 2 shows, 24 I/O pins are available for peripherals.

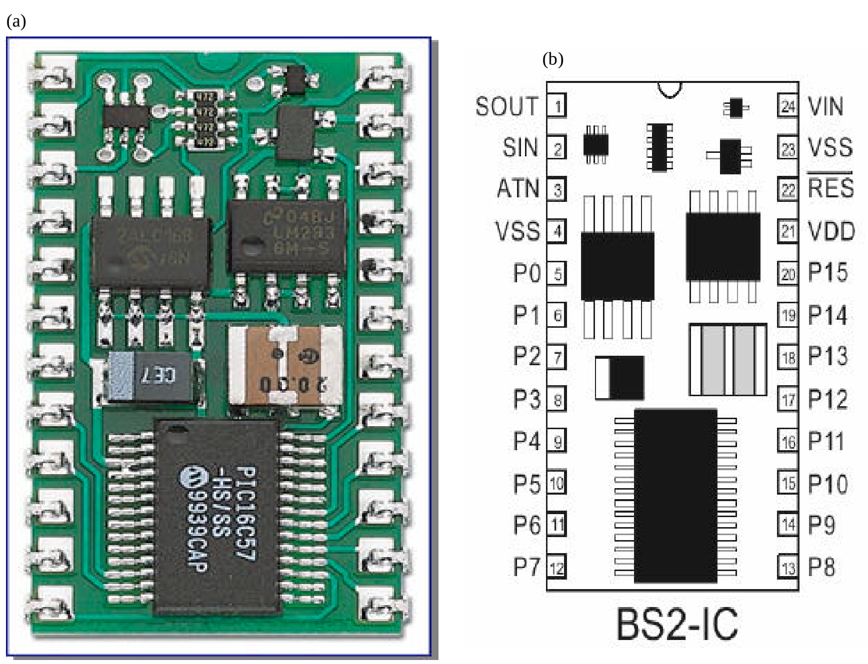

Fig. 2(a-b): BASIC Stamp2 (BS2) microcontroller

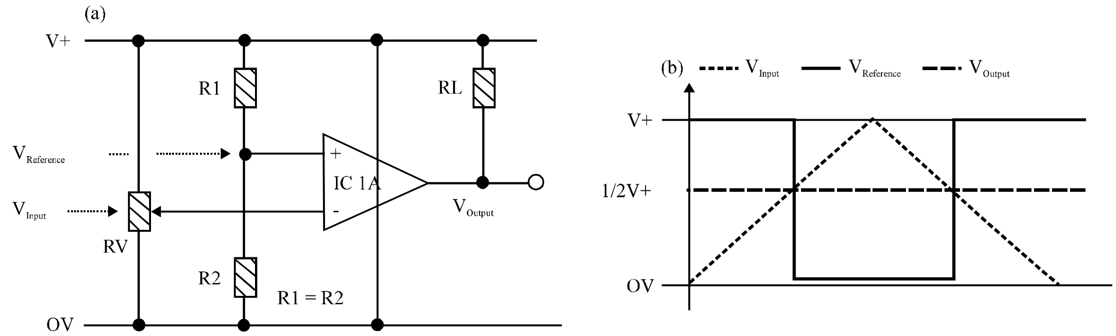

Fig. 3(a-b): BASIC comparator operation circuit A, (a) Comparator with positive reference voltage and (b) Input, output and reference voltage

PBASIC is a term refers to the programming language used for writing code for the BASIC Stamp microcontrollers created by Parallax, Inc. The language was employed to bring ease of use to the microcontroller and embedded processor world. After the code is written it is tokenized and loaded into an EEPROM on the microcontroller. These tokens are fetched by the microcontroller and used to generate instructions for the processor. However, in the proposed AMR system, PBASIC is used to control and monitor the RF module, LCD screen and store the obtained data from the meter in the EEPROM (Lindsay, 2005).

Comparator–LM339 IC: This Integrated Circuit-LM339 is called as Low Power Low Voltage Offset Quad Comparator which is used to trigger the Microcontroller whenever a whole revolution is made inside the meter. The comparator is used to compare the signals from the photo-resistor that is placed inside the meter and the generated reference signal using the voltage divider rule. The normal voltage signal from the photo-resistor is approximately 4 V when it is not facing the LED. Once the LED is aligned with the photo-resistor, the voltage drops to 1.7 V. Based on those readings, the reference signal has the value of 2.1 V. When the photo-resistor get more light from the LED, its value will be lower than the reference which will generate a positive signal '1' in the output, otherwise, the output is '0'. Figure 3 shows the basic operation of the comparator based on circuit A with positive voltage reference whereas, Fig. 4 shows the basic operation of the comparator based on circuit B with negative voltage reference.

Radio frequency module: This module is produced by Parallax and it is compatible with the BASIC Stamp 2 Microcontroller. It is used in pairs, transmitter and receiver. It is used to send the data obtained from the transmitter module to the receiver module. It is capable of establishing a connection within the 300 feet range. To initialize the two modules, the TR/TX parameter needs to be put to '1' for sender and '0' for the receiver and then a command is used to initialize the connection. Once the initialization phase is done, transmission of data begins. A handshaking phase is initiated, before sending the data and the receiver waits for a special code, in order to start receiving the data. The RF module is capable of sending 9600 bits per second (bps). Figure 5 represents the physical illustration of the RF Transceiver that shows its parameters and the connection type needed.

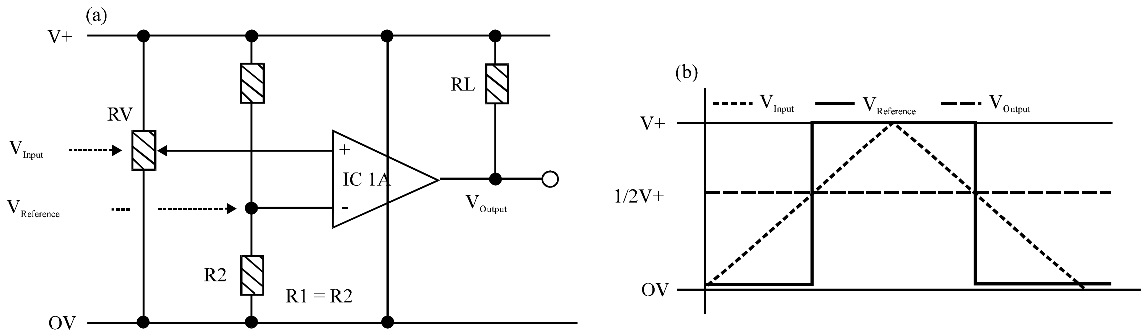

Fig. 4(a-b): BASIC comparator operation circuit B, (a) Comparator with negative reference voltage and (b) Input, output and reference voltage

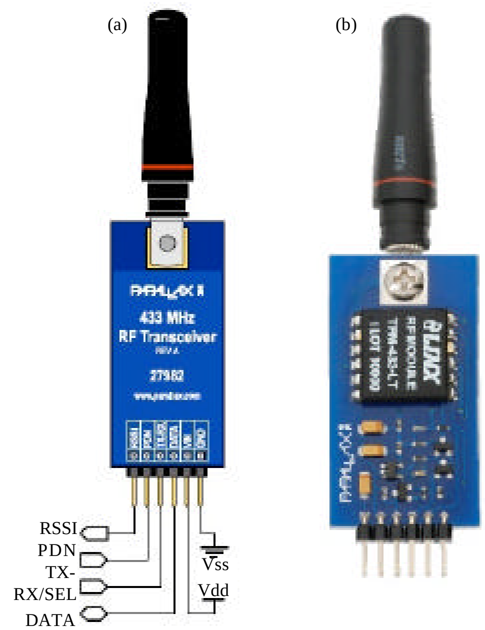

Fig. 5(a-b): Physical illustration of RF transceiver

Liquid crystal display (LCD): Figure 6a illustrates the LCD, where the obtained meter reading is displayed. Two LCDs are used in each process; one is attached to the sender module and the other one to the receiver module. The reason of having two LCDs is to verify the accuracy and reliability of the RF modules. The LCDs have specific commands that control the way the displaying. Figure 6b shows the diagram of connection used for the LCD screen. It uses a serial input to receive the commands and data from the Microcontroller.

Analog meter: The Analog meter as shown in Fig. 7 is the module used by the Ministry of Electricity and Water in the Kingdom of Bahrain and some other countries to indicate the consumption of the electricity by each household. It is customized in order to obtain the reading, a hole is made in the rotating plate and an LED is installed in the lower part

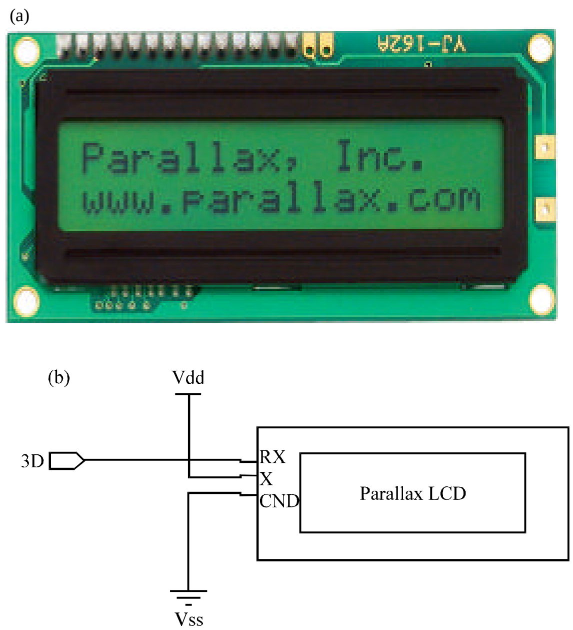

Fig. 6(a-b): (a) Physical LCD screen and (b) Connection used for the LCD screen

Fig. 7: Analog meter

of the plate while a photo-resistor is installed in the upper part. When the plate rotates and the hole gets aligned with the LED and photo-resistor, the counter is increased by one.

System structure and installation: The proposed AMR system was conceptualized using the block diagram as shown in Fig. 8. The Analog meter module is used to get the watts hour reading that is consumed by the electrical loads. The transmitter module converts the captured analog

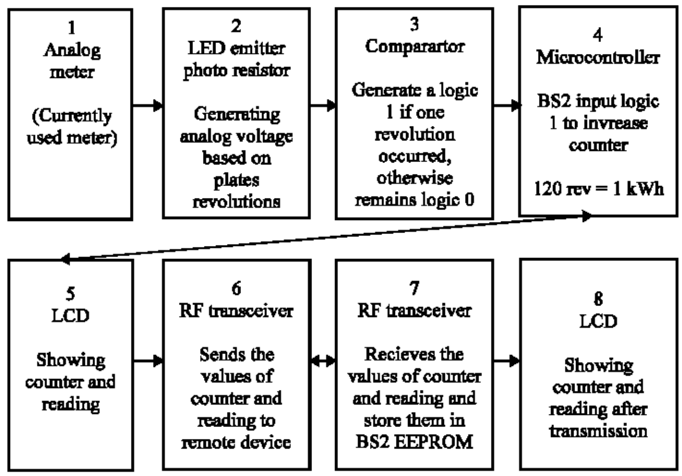

Fig. 8: Block diagram of the proposed AMR system

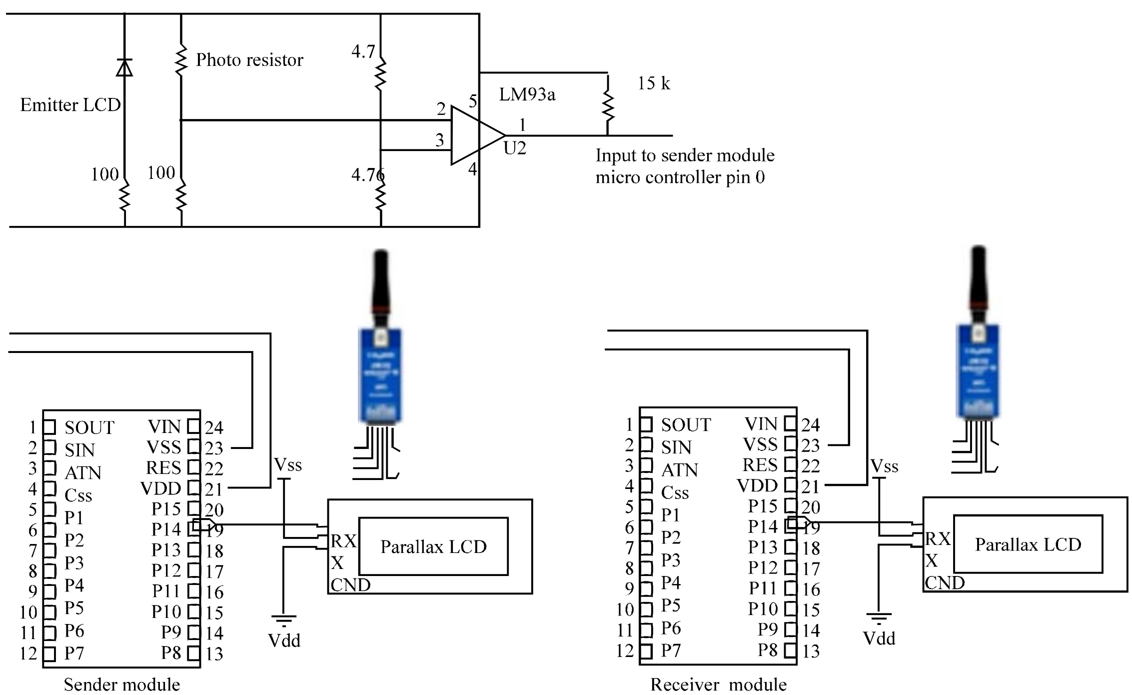

Fig. 9: Schematic diagram

data to digital form, displays it on LCD and sends it to the receiver module through radio frequency. The receiver module is used to retrieve the reading from the meter by initializing RF connection with the sender module, transmitting the reading value and displaying it on LCD.

As shown in Fig. 9, the AMR system depends on the change of analog voltage reading obtained from reflection of the LED emitter on the photo-resistor, when the plate hole falls between the two components. This analog change is converted to a logical '1' pulse by using the LM339 Dual Comparator. The pulse is fed into PIN 0 of the BS2 microcontroller, calculated and saved in the EEPROM.

Fig. 10: Analog meter with transmitter module

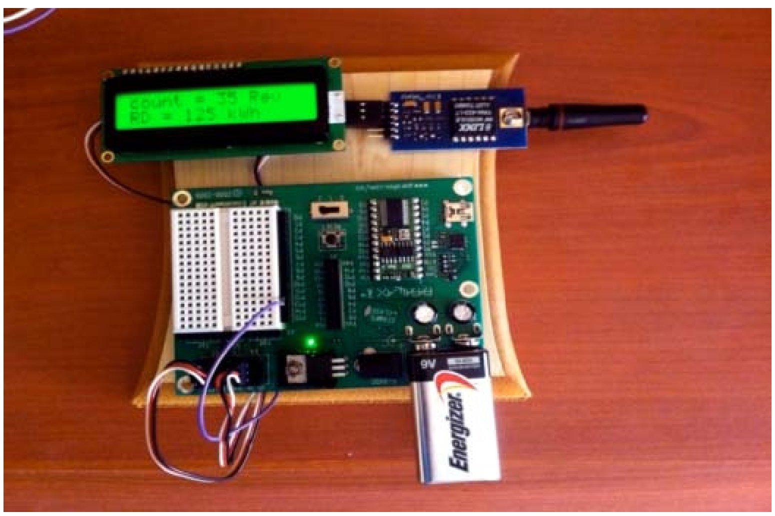

Fig. 11: Receiver module

Figure 10 shows the AMR system design, including an analog meter with transmitter module and Fig. 11 shows the receiver module.

RESULTS AND DISCUSSION

To begin with, by employing short range RF in the proposed AMR system, the consumers can be facilitated with to low-power RF facility. As against the Power Line Carrier (PLC), the proposed system is cost effective and inexpensive. Even though the RF has been employed in AMR systems in a lot of countries, still they offer very limited services; moreover, the proposed AMR system lacks direct interaction with an online database which can be enhanced by the future researchers.

The proposed AMR system starts functioning when the attached transmitter module gets the pulses from the Analog meter. Every Analog meter has its own ID that is stored in the EEPROM which provides a unique identification of the meter. The analog data obtained from the meter come in pulses which are generated by a photo-resistor that gives a consistent analog voltage reading. Once the reading value is changed after the meter revolves once, the photo-resistor is hit by the LED light and there will be a drop in the voltage reading which increases the counter by one. The meter specification states that 120 rev = 1 kWh, this difference in the voltage reading is the technique beyond obtaining a signal compatible with the BS2 Microcontroller specifications. Then, the signal which is converted into digital by using a Comparator (LM339) is sent to the BS2 Parallax Microcontroller. However, the Comparator (LM339) gives the signal that makes the Microcontroller able to count the revolutions made by the meter. The Microcontroller displays the received reading on the LCD and initiates a connection to send the obtained meter reading data as RF signal to the receiver module, thus once the reading is transferred, the data is automatically displayed on the receiver module LCD screen. The meter reading is displayed in two LCDs; one before and one after transmission, to make sure the reliability of the transmitted meter reading. Meter readings are received and stored in a database 300 feet away from the meter where the transmitter module is located, it is observed when the receiver module is over 200 meters away, the meter readings still can be received accurately with slight delay.

CONCLUSION

The proposed AMR system is considered new approach to obtain readings from the regular Analog meters, also to display it on LCD screens as well as sending to a receiver module located at 300 feet away. It offers a fast and reliable capture of meter readings and it would ensure accurate generation of electrical consumption reports, such as bills. The capability of fast and easy capturing of meter reading also lessens the need for manpower in obtaining manual reading. In future, the AMR system can be connected to an on-line database to provide a real-time transfer and processing of data. This would also enable the users to ensure the accuracy of all reports provided to the households.

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