A Telephone Based Wireless Remote Controller for Home Appliances

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***Abstract*— A telephone based wireless system for the remote operation of the home appliances is proposed. The telephone, acting as a remote controller, generates a DTMF signal corresponding to each dialed digit which is converted to a BCD code by the Telephone interface circuit. This is given as input to the transmitter module which is then used to control various home appliances through a receiver module. Data processing stages of the transmitter and receiver modules have been implemented using digital components, thereby avoiding possible use of conventional devices like monostable multivibrators. Due to the fully digital nature, the proposed design is less complex and hence the implementation is cost effective.**

I. Introduction

With the advancement in science and technology, human beings have developed a tendency to make their everyday life amply luxurious with the aid of technology. This has led to the development of many sophisticated gadgets and equipments that assist them partially/fully in their daily activities. Operating all such electronic/electrical instruments in a modern house might be difficult for the elderly as well as disabled people. Our primary motivation to build a simple and low cost system which remotely operates all the home appliances stems from this point. We integrate our system with a standard telephone set so that the telephone can be used for the dual purpose of telephony and remote controller for various home appliances.

The proposed system mainly consists of 3 modules, viz., telephone interface circuit, transmitter and receiver. The transmitter module is in turn made up of a digital data processing block and a wireless (infrared) transmitter block and the receiver module is made up of a wireless (infrared) receiver block, digital data processing block and a decoding block. In the scheme, a telephone receiver acts as a remote terminal to provide input Dual-Tone Multi-Frequency (DTMF) signals to the telephone interface circuit which converts them to corresponding 4 bit Binary Coded Decimal (BCD) codes. The transmitter generates an 8 bit frame using this BCD code to facilitate asynchronous communication. The receiver decodes the received signals after checking for any transmission errors (single bit) in the frame. These decoded bits act as control signals for the operation of home appliances.

The system employs an asynchronous type of communication [1] in which the transmitter and receiver clocks are independent. The receiver clock does not have any prior information regarding the phase of the transmitter clock [2]. This leads to the problem of choosing the correct sampling instants at the receiver [3]. Hence the data is transmitted in the form of frames instead of individual bits. Each such frame consists of start bits, information bits, and stop bits [1]. This is explained in detail in the subsequent sections.

When the system is idle, the data processing block of the transmitter gives constant logical high output. Since the transmitter consumes more power in transmitting logical high than logical low, the output of data processing block is negated before transmission to save power in the idle state. The receiver module also senses this and remains idle whenever the transmitter is transmitting continuous logical low. The reception of a start bit changes the state of the receiver from an idle to an active state. It then has to sample the remaining data bits in the frame at proper sampling instants. Most of the standard hardware schemes involve the use of monostable multivibrators at the receiver to recover the data bits following the start bit. The monostable multivibrators commonly rely on variable components such as resistance and capacitance values, as well as they often account for a major part of the propagation delays associated with the receiver. We have extended this treatment to a fully digital design that presents more challenging tasks including a digital output feedback. Moreover, use of all digital components in the data processing stages reduces the propagation delay considerably.

The complete design outline of all the modules of the proposed system is presented in Section II. Results and discussions are given in Section III. Finally, we present our conclusions in Section IV.

II. Design Outline

The block diagram of the proposed telephone based wireless remote control system is shown in Fig. 1. In the proposed system, the telephone set performs the dual functions of telephony and remotely controlling various devices. The remote control mode of the telephone can be activated by pressing '#' from the keypad of the telephone. After the desired tasks are accomplished, '#' should be pressed again to deactivate the control system. This is one of the functions of the telephone interface circuit, which is discussed next.

A. Telephone Interface Circuit

The telephone interface circuit integrates the designed system with the standard telephone system. As shown in Fig. 2, it basically performs the job of receiving the signals from the local loop and converting them to the standard digital signals in the BCD format. When any telephone button is pressed, a

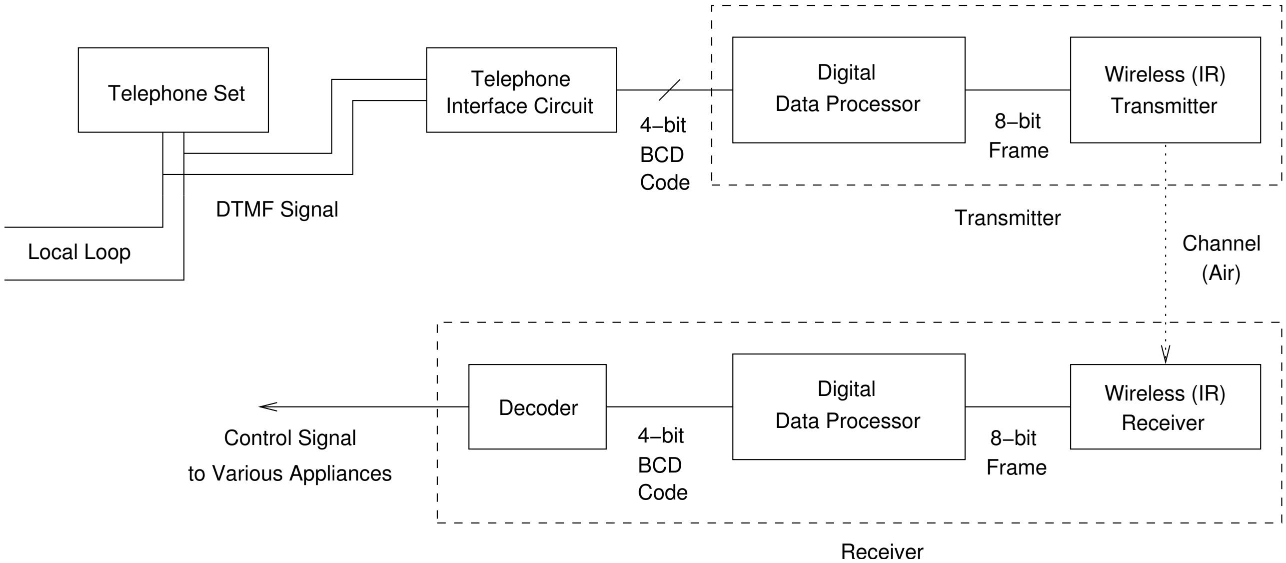

Fig. 1. Block diagram of the proposed telephone based wireless remote control system.

TABLE I
THE DUAL TONE FREQUENCIES AND THE BCD CODES ASSOCIATED WITH EACH DIALED DIGIT.

Dialed Number	Low Frequency	High Frequency	BCD Code
1	697	1209	0001
2	697	1336	0010
3	697	1477	0011
4	770	1209	0100
5	770	1336	0101
6	770	1477	0110
7	852	1209	0111
8	852	1336	1000
9	852	1477	1001
0	941	1336	1010
*	941	1209	1011
#	941	1477	1100
A	697	1633	1101
B	770	1633	1110
C	852	1633	1111
D	941	1633	0000

unique DTMF signal is produced for a short duration [4] which is converted to corresponding BCD code by a standard DTMF to BCD converter (KT-3170) [5]. The dual tone frequencies and the BCD codes associated with each dialed digit are shown in Table 1.

The system remains in the idle state until '#' button is pressed which sets the telephone to remote control mode. This mode remains activated until '#' button is pressed again. This is realized in the hardware by using the BCD code corresponding to '#' as the clock to toggle the J-K flip-flop (74112). The flip-flop output toggles whenever the '#' button is pressed and this is directly used to control the mode of operation of the telephone.

The DSO output of KT-3170 [5] is used to generate a start bit for the system as it is logical high whenever a received tone pair has been registered and the output latch is updated. As the latched 4-bit BCD code is directly available at the output of KT-3170, it is given as such to the data processing block of the transmitter. These data bits are then processed to facilitate asynchronous communication as explained below.

B. Transmitter

The 4-bit output of KT-3170 can not be directly transmitted as individual bits as the proposed system employs asynchronous mode of communication. The 4-bit BCD code is thus transmitted as frames for proper reception [1]. We have chosen an eight bit frame for our system which consists of a start bit followed by four data bits, a parity bit and two stop bits. Parity bit enables the system to detect any single bit error during transmission. Stop bits mark the ending of the frame. The frame is then transmitted using infrared (IR) transmitter.

As shown in Fig. 2, the transmitter mainly consists of two blocks which are explained below.

1) Fully Digital Data Processing Block: This block performs the function of converting individual bits to 8-bit frames in order to carry asynchronous communication. First bit of the frame is the start bit (taken as 0) which is generated when any of the buttons is pressed. The succeeding 4 bits are the data bits (BCD code) generated by the telephone interface circuit as explained before. Next bit is taken as parity check bit generated by XORing the first 5 bits of the frame. Last 2 bits, termed as stop bits, are taken as 1. Following the generation of the start bit, the data bits are loaded in the parallel to serial converter (74165) using a D-type flip-flop (7474) and the frame is transmitted serially.

2) IR Transmitter Block: This module transmits the frames generated in the previous section using an IR emitting diode. The data to be transmitted is modulated using Amplitude Shift Keying (ASK) with a carrier square wave of 38 kHz. The transmission range of the system is thus highly improved over the case when data is transmitted without modulation. As the data processing stage gives logical high output in the idle state, it is negated before transmission to save power. Thus, a logical low is actually transmitted whenever the system is in idle state.

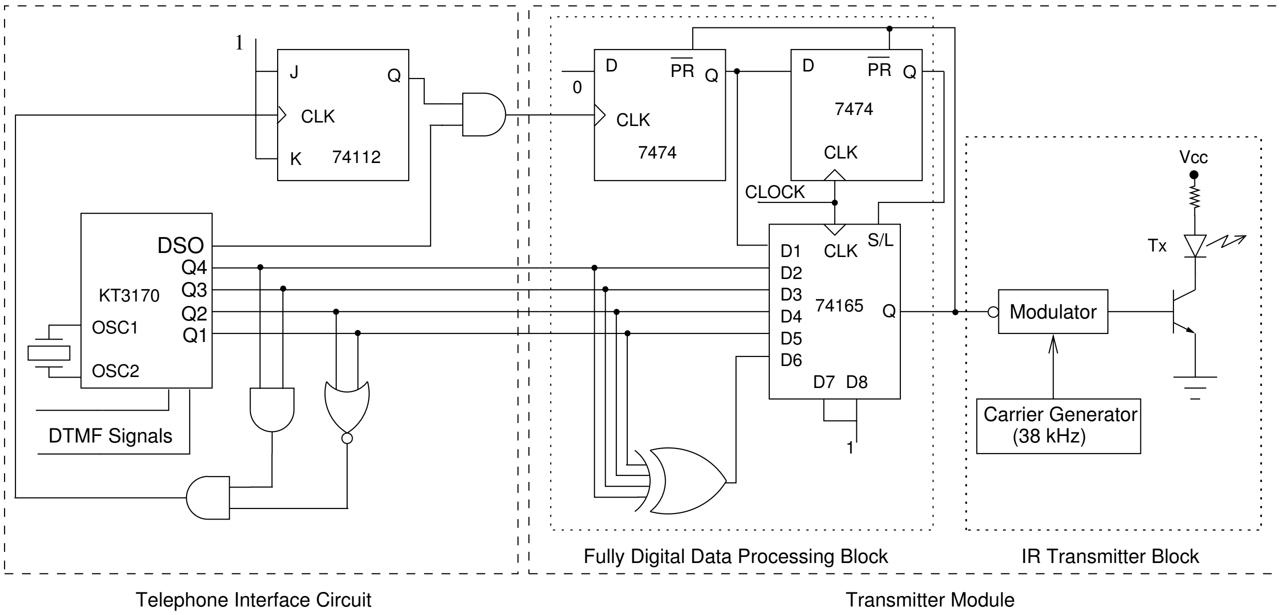

Fig. 2. Telephone interface and transmitter modules of the proposed system.

C. Receiver

The receiver also has 2 working states, viz., idle and active. It remains in the idle state until it detects a start bit. It then receives the frame starting from the start bit and checks for a single bit error. If error is detected, no action is taken and the information has to be transmitted again by the user. The received data bits are then decoded which act as control signals for the operation of various appliances.

As is evident from Fig.3, receiver circuit can be subdivided into 3 blocks which are explained below.

1) IR Receiver Block: This block receives the transmitted frames and converts the signal back to Transistor Transistor Logic (TTL) levels. A standard 38 kHz IR receiver (TSOP 1738) [6] is used for this purpose.

2) Sampling Clock Generator: The main function of this block is to generate a sampling instant at approximately the middle of the transmitted bit interval. The start bit activates this block and loads counter 1 (4-bit up-counter) with value ‘0’. The clock frequency of this counter is 16 times the bit rate. When the output of this counter changes from 7 to 8, the most significant bit changes from ‘0’ to ‘1’ and this rising edge is used as the sampling instant for the data. Start bit also loads the counter 2 (4-bit down-counter) with the frame size i.e., 8. When this reaches the value ‘0’, the whole block is disabled and is reactivated only when next start bit arrives.

3) Data Sampler and Decoder: The serial input data is sampled according to the sampling instant generated in the previous stage and is converted to parallel form using serial to parallel converter (74164). This data is then checked for any 1-bit errors by XORing the bits. If error is found, no action is taken and the data has to be retransmitted. If no errors are found, the data is decoded using 4-16 decoder (74154) and the signal is given to the appliance for the completion of the corresponding task.

III. Results and Discussions

The proposed system has been fully implemented and successfully tested in the standard telephone local loop. The transmitter, kept near the telephone set, taps the DTMF signal from the local loop and transmits the corresponding data frame wirelessly. This signal is received by the receiver installed at the switch board. It decodes the data and takes the corresponding action.

At least ten control signals, corresponding to each digit from 0 to 9, can be generated using a standard telephone set. The transmitter was previously implemented without a modulator where the IR LED was kept ON for transmitting logical high and OFF for transmitting logical low. This limited the distance between the transmitter and receiver to a maximum of 30 cms for proper reception. The range of the wireless system has increased to several meters after modulating the data using 38 kHz square wave. This range also depends on the current flowing through the infrared diode which has to be properly tuned to maximize the range.

A standard TSOP 1738 receiver is used in the proposed system, which requires a minimum burst length of 10 cycles for proper detection. This puts an upper limit on the data rate supported by our system which is practically observed to be 2.8 kbps [5].

The IR transmitter is highly directional and requires the receiver to be in line of sight of the transmitter. The reception angle of the receiver is observed to decrease with increasing distance between the transmitter and receiver. This is because of the fact that the power is not uniformly distributed and is concentrated in narrow transmission angle. Moreover, the signal power reduces when the distance between the transmitter and the receiver is increased. So, the receiver has to be highly aligned with transmitter when operating at some substantial distance from it. This problem is of not much concern for our system because the transmitter and receiver, being static in

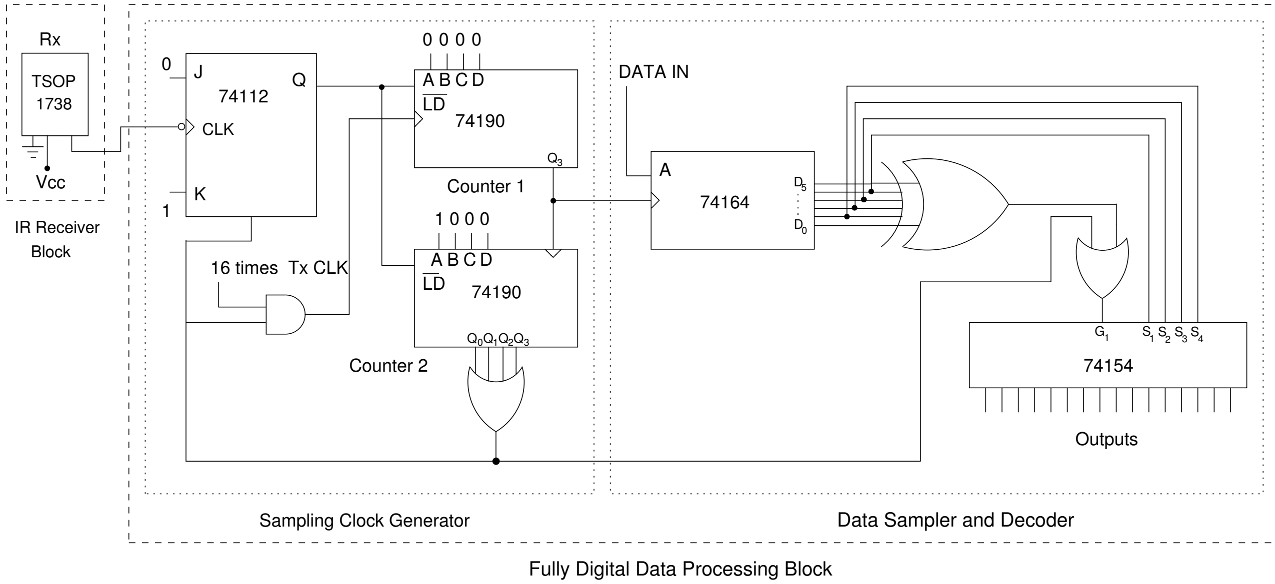

Fig. 3. Receiver module of the proposed system.

nature, can be properly aligned at the time of installation.

The data processing blocks of both the transmitter and the receiver are fully digital in nature. This comprehensively reduces the propagation delays involved and increases the rate at which data can be processed in these blocks. Though, data rate is not very important in the present application but this feature makes the design of our data processing blocks suitable for high data rate applications which are commonly seen in wired communication.

IV. Conclusions

A wireless system has been proposed to operate the home appliances remotely using a standard telephone set. This has been successfully tested and is found to be working satisfactorily within a distance of 10 meters. The telephone receiver performs a dual-function of telephony and remotely controlling various devices with the help of its '#' button on the keypad. The telephone interface circuit is easily integrated with the standard local loop thus avoiding any changes in the telephone set. Hence, the proposed system is compatible with any type of telephone working on standard local loop. The system employs asynchronous mode of communication which avoids the need to synchronize the transmitter and receiver clocks, thus making our system less complex and hence cost effective. The proposed fully digital innovative design of the data processing blocks reduces the propagation delay and makes them useful for even high data rate applications. Moreover, the system is capable of detecting the single bit errors occuring during transmission. The proposed system can be used in a wide range of practical applications such as speed control of motors, switching of appliances, control of robots, etc. The above discussed characteristics like simple design, high practical utility and easy installation makes our system highly marketable.

References

[1] Gorry Fairhurst. Asynchronous Communication [Online]. Available: http://www.erg.abdn.ac.uk/users/gorry/course/phy-pages/async.html.

[2] D. Comer, *Computer Networks and Internets with Internet Applications*. Upper Saddle River, NJ: Prentice-Hall, 2004.

[3] A. Subramanian, V. P. S. Makh and A. Mitra, "A New Digital Transceiver Circuit for Asynchronous Communication", *Enformatika Trans.*, vol. 8, pp. 237-241, Oct. 2005.

[4] DTMF Background [Online]. Available: http://www.ece.utexas.edu/∼mason/codesign/dtmf.html.

[5] Samsung Electronics Datasheet. KT3170 Low Power DTMF Receiver [Online]. Available: http://www.ortodoxism.ro/datasheets/SamsungElectronic/mXuusvq.pdf.

[6] Vishay Semiconductors Datasheet. Photo Modules for PCM Remote Control Systems [Online]. Available: http://www.vishay.com/docs/82030/82030.pdf.