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An Innovative Technique in Switching Electrical Appliances: An Omni-Directional RF Remote Control Switch Mechanism

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Abstract: Remote control systems for electrical appliances over the years have adopted the infra-red mechanism where the user is expected to point the controller towards the appliance before operation. This requires the user not only to be in the line of sight of the appliance but in close proximity to the appliance. The technique presented in this study is an omni-directional remote control system, which utilizes a Radio Frequency (RF) transmitter and receiver system. The piezoelectric crystal oscillator used in the implementation of the system operates at a frequency of 84 MHz. It is an especially accurate form of electronic oscillator. The modulated signal is transmitted to the receiver in the RF band. The receiver, incorporated into the appliances sends the signal to the logic unit. Through, the help of timer and digital counter ICs the relays receive signals to switch the appliance on or off as required. An operational distance of 35 m was realized.

Key words: Omni-directional, crystal oscillator, radio frequency, switch, proximity, controller

INTRODUCTION

Switching is a fundamental and necessary control action in the operation of engineering appliances, gadgets, machines and systems. One of the major functions of a switch is to put equipment and devices on or off. This has often been done either manually or by the use of infra-red remote control systems. Infra-red remote is constrained and limited in application due to two major reasons. It is unidirectional, as the user is expected to point the remote controller towards the appliance before operation, thus requiring the user to be in line of sight of the appliance. Secondary, the user must be in close proximity to the appliance. Thus, is not only discomforting, it could be irritating. The problem of direction is surely overcome by the use of RF remote control switching mechanism, as switching can be done at any position as long as the controller is within the coverage area of the RF mechanism. In an effort to predictably control engineering devices, equipment and machineries, Beccuti *et al*. (2009), Correa *et al*. (2009), Kouro *et al*. (2009), Lai and Yeh (2009) and Lezana *et al*. (2009) used predictive controllers in power converters and switched-mode power supplies while, researchers like Bolognami *et al*. (2009), Cortes *et al*. (2009), Drobnic *et al*. (2009), Geyer *et al*. (2009), Miranda *et al*. (2009) and Papafotiou *et al*. (2009) worked on the predictive control of UPS (Uninterruptible Power Supply), AC and DC drives. Hyodo *et al*. (2009), Kubo *et al*. (2009), Mehta and Bandyopadhyay (2009) and Ying-Shich *et al*. (2009) examined the frequency-shaped sliding mode control using output sampled measurements and using FPGA technology and multitateral control schemes for motion control. The RF remote control system can predictably be used to switch an appliance on/off; select channels; forward; reverse and play disc and perform sundy other compatible functions.

MATERIALS AND METHODS

Design of the remote controller: The crystal oscillator used in the construction of the transmitter is especially, an accurate and stable form of electronic oscillator.

It is made of piezoelectric material and operates at a frequency of 84 MHz, thus provide stable clock signals for the digital integrated circuit and stabilize the frequency of the radio transmitter (Fig. 1).

The inductance of the inductor used in the transmitter is obtained from Eq. 1:

$$f = \frac{1}{2\Pi\sqrt{LC}} \qquad L = \frac{1}{4\Pi^2 f^2 C} \tag{1}$$

Choosing C = 50 pF, then

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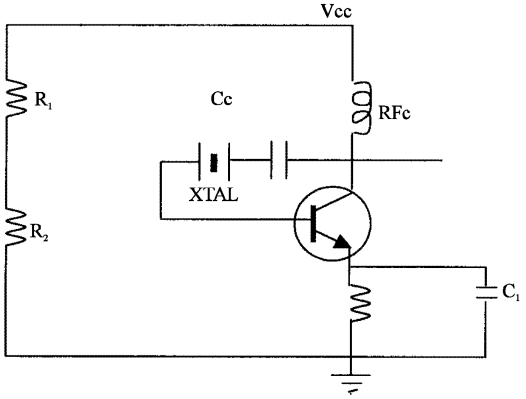

Fig. 1: Crystal-control oscillator using crystal in series feedback path

$$L = \frac{1}{4\Pi^2(84\times10^6)^2\times50\times10^{-12}}$$
$$= 7.1779\times10^{-8}H$$
$$= 0.07178\mu H$$

To determine the number of turns of the coil that will give this inductance, a wire of SWG 20 was chosen and wound with a diameter of ¼ inch (6.35 mm) and 2 mm in length.

Let,

A = Cross sectional area of coil
D = Diameter of coil = 6.35 mm
d = Thickness of wire = 1 mm

$$A = \frac{\Pi}{4}(D+d)^2 = \frac{\Pi}{4}(6.35+1)^2$$
$$= 42.43\times10^{-6}m^2$$

$$\text{Recall } L = L = \sqrt{\frac{\mu_o\mu_r N^2}{1}}\times A \quad (2)$$

Where:

L = Inductance of coil
μ_o = Permittivity of free space (44Π×10^{-7} H/m)
μ_r = Relative permittivity of air = 1
N = Number of turns

Rearranging Eq. 2:

$$N = \frac{L\times\ell}{\mu_o\mu_r A}$$
$$= \frac{7.178\times10^{-8}\times2\times10^{-3}}{4\Pi\times10^{-7}\times1\times42.43\times10^{-6}} \quad (3)$$
$$= \frac{1.4356\times10^{-10}}{5.33175\times10^{-17}} = \frac{14.356}{5.33175} = 2.69$$
$$\approx 3\text{turns.}$$

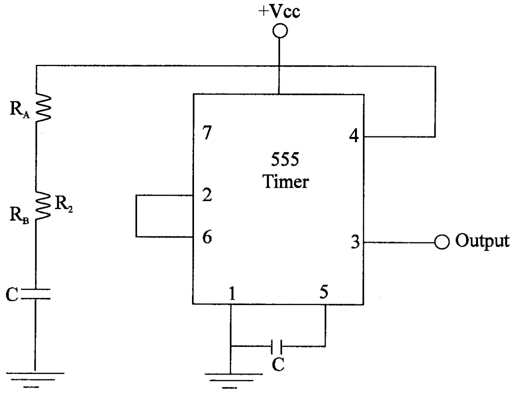

Fig. 2: 555 IC timer

Timer circuit: The 555 timer IC comprising linear comparators and digital flipflops was used in the astable multivibrator mode (Fig. 2).

External capacitor and resistors were used to set the timing interval of the output signal. The time interval is calculated from the equations:

$$T_{high} = 0.693\ (R_A + R_B)C \quad (4)$$

$$T_{Low} = 0.693\ R_BC \quad (5)$$

The total period is:

$$T_{total} = T_{high} + T_{Low} \quad (6)$$

The frequency of the astable circuit is:

$$f = 1/T \quad (7)$$

The following values were used:

$R_A = R_B = 47$ kΩ
C = 0.1 µf
$V_{cc} = 6$ v

Thus, applying Eq. 4-7:

$$T_{high} = 0.693\ (47k+47k)\ (0\text{-}1\times10$$
$$= 6.51Ms$$
$$T_{Low} = 0.693(47\times10^3)(0.1\times10^{-6}) = 3.26\ ms$$

$$T = T_{high} + T_{low} = 9.77\ ms$$

Frequency of the astable circuit:

$$f = 1/T = 102\ HZ$$

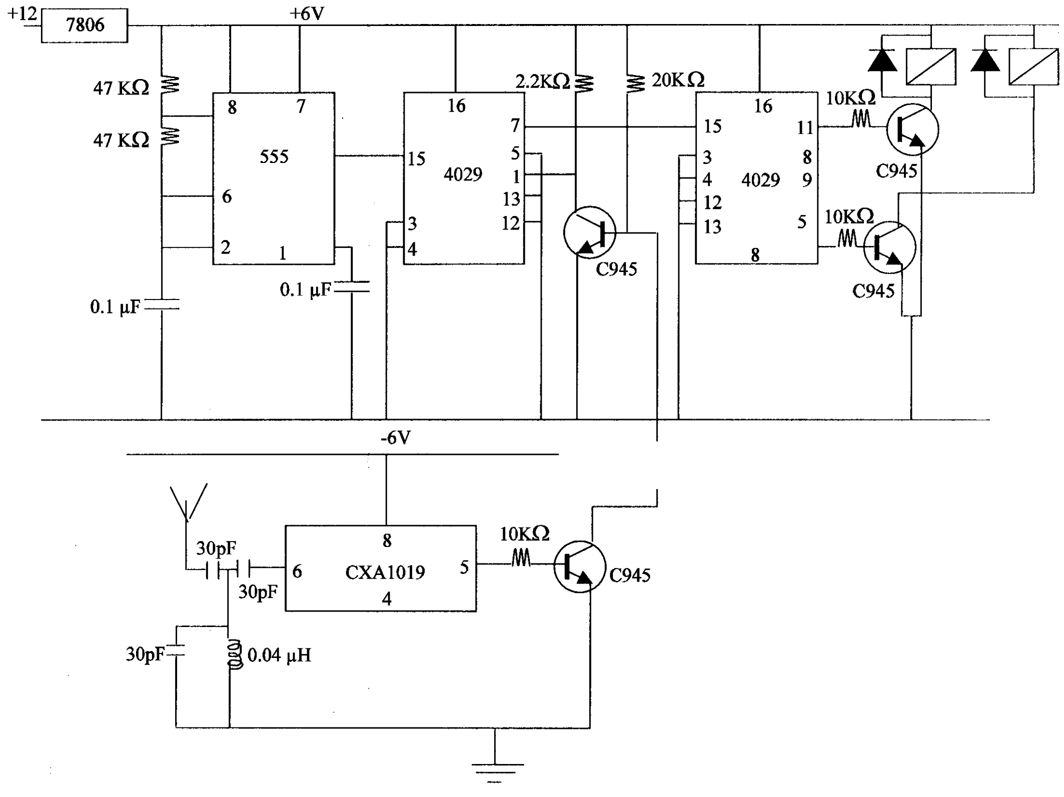

Fig. 3: Receiver logic unit

Receiver: The integrated circuit used is the miniaturized FM radio chip CSA 1019. It is a complete FM circuit and contains all the necessary circuitry in constructing an FM receiver.

The choice of transistor that will operate with the tank circuit to generate the required carrier frequency is based on the following parameters:

- It must have sufficient gain to sustain oscillation
- It must be capable of producing phase reversal of input signal (180° phase oscillation)

An NPN transistor (C945) with a minimum gain of 120 was chosen for the oscillator circuit to be biased in the common emitter mode.

The condition for oscillation generation in a positive feedback system states that:

$$(1\text{-}B\ A_0) = 0 \tag{8}$$

Where:

B = Feedback factor, determined by N_1/N_2

A_0 = Voltage gain

$$A_0 = h_{fe}\ R_c/h_{is} \tag{9}$$

h_{fe} = Gain of transistor = 120

R_c = $2\Pi fL$

h_{is} = The input impedance with output shorted

Thus,

$$B = N_1/N_2 = 1/3$$

$$R_c = 2\pi fL = 2\pi\times 84\times 10^6\times 7.1779\times 10^{-8} = 37.89\Omega$$
$$A_0 = 120\times 37.89/1500 = 3$$

Hence,

$$(1\text{-}BA_0) = (1\text{-}1/3\times 3) = 0$$

The condition for oscillation generation is satisfied. It is thus, a positive feedback signal generator.

Power supply: The power supply was designed to supply 3V DC to the transmitter. A 220/12 V step down transformer with a bridge rectifier was employed. A 25 V/220 µF shunt-connected smoothing capacitor was used.

The output was fed toa 6V DC regulator (7806) to assure a steady DC supply of 6V. The receiver and transmitter circuit diagrams are shown, respectively in Fig. 3 and 4.

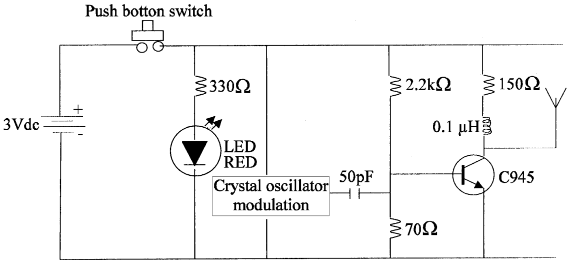

Fig. 4: Transmitter circuit diagram (remote control)

RESULTS AND DISCUSSION

After fabrication, the device was tested to determine the frequency of transmission, the range of reception as well as the sensitivity and selectivity of the receiver. The transmission frequency was determined using a digital frequency tuner and the signal was received at 84 MHz. To determine the range of transmission, an appliance was connected to the receiver and logic unit. The effective range was 35 m. The sensitivity and selectivity of the receiver were tested by varying the frequency of a variable gang tuner and different stations were selected. The reception was stable at 84 MHz.

CONCLUSION

A low-cost ommi-directional RF remote controller for switching electrical appliances has been built, tested and found effective and functional. It is sensitive and selective and the transmission frequency of 84 MHz is outside the commercial frequency band.

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