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Design and Simulation of Remotely Power Controller

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Abstract

Noting the benefits of power controlling in the industrial and related applications, this paper presents a remotely controlled power system to be used for alternating current (AC) and direct current (DC) loads. Remote controlling is achieved by transmitting a phone digit corresponding to the desired level of power from a Dual Tone Multi Frequency (DTMF) based fixed or mobile phone device. A receiver phone device receives the DTMF tones corresponding to the transmitted digit and the tones will be processed by the proposed multi stages electronic system that includes arrays of filters, buffers, decoder, and drive circuits to activate a suitable set of relays that control the power part of the system. The power part is represented by binary weighted resistance TRIAC based power circuit with the RC part of the circuit controlling the firing angle, which is directly related to the level of power selected by the remote user at the transmitting end. Transferred power analysis and simulation results based on NI-MULTISIM are presented. The strong agreement of the simulation results with the analysis reflects the effectiveness of the proposed electronic design.

Keywords— Load Power, Power Control, DTMF, Touch-Tone, Remote Control, Bandpass Filters, Dimmer, Binary Weighted Resistor

I. INTRODUCTION

In industrial, home application including remote rural applications, control of AC or DC power supplied to motors is important in order to attain flexible speed for a wide range of applications such as textile industry, grinding industry with different gauges depending upon the adjustable speed value, agricultural pumping systems and other similar applications [1], [2]. Specially designed AC voltage controller offers an ability to control power supplied to the house electrical devices such as fans, chandelier lamps and/or spot light [3]-[6]. In the field of solar tracking systems, the DC motors speed control is more important to have high flexibility of tracking the solar energy [7], [8].

In recent years, advances in technology have led to the development of remote controlling systems for electrical load power in different applications so as to facilitate the daily human service requirements such as remote door locking systems, remote controlling of electrical apparatus in offices and homes, remote operation of robotic systems, remote vehicular security systems, remote switching systems and other relevant applications, [9], [10]. More specifically, the use of Dual Tone Multi-Frequency (DTMF) technique is becoming predominant in various remote controlling applications [11]-[14]. A DTMF based remote controlling system is proposed in [9], [10] in order to control the switching states (ON/OFF) of remotely located agricultural pumps. In the designed system, a remotely located person, which could be a farmer will have the ability to press the keypad of the telephone handset (fixed or mobile) and can switch on or off water pumps located at the different locations. The simulation results of the proposed system showed the capability for controlling the switching states of the water pumping motors used for the irrigation. A DTMF decoder and controlling logic circuit are designed to control the working state of the pumps by issuing commands encoded as audio DTMF signals. The DTMF decoder and controlling circuit receives those remote commands and controls the switching states of the connected motor pump system.

In this paper, we present a new technique to remotely control the amount or level of transferred power form the source to any AC and/or DC load based on the DTMF signaling technique. A DTMF tone signal, which corresponds to a certain pressed digit from the keypad of the user phone device, is transmitted. At the receiving side, the received tone signal is processed through the stages of the designed electronic system to finally achieve the required level of power control based on the transmitted phone digit. The electronic system includes DTMF decoder, a logic controller and a system of relays that control the power circuit. The state of relays will be controlled based on the value of transmitted phone digit and the designed decoding circuit. The contacts of the relays control the equivalent resistance in the RC part of the power circuit based on the arrangement of the binary weighted resistors. The power circuit is a conventional dimmer circuit where the firing angle (equivalently the firing time) required to make the TRIAC (triode for alternating current) in the conduction state is determined based on the values of the connected resistor and capacitor (the RC part) of the dimmer circuit. The variation of the resistance value in RC circuit will lead to the control of the voltage supplied to the load, which is connected serially with the dimmer circuit. The voltage across the load is normally alternating current (AC) controlled voltage and hence a full wave bridge rectifier circuit is required to have direct current (DC) for DC loads like DC motors, which is suitable to control the motor speed.

The first part after the receiving phone device is a DTMF decoder, which is used to decode the tones corresponding to the dialled digits. Each digit of the telephone keypad is constructed from two DTMF frequencies (tones). Based on the standard set of DTMF frequencies, an analogue active filter is designed to decode the DTMF tones from easily available passive and active electronic components. After the decoding of the tones, a logic controller is designed to identify the exact transmitted phone digit corresponding to the transmitted DTMF tones. The analogue active filter based on operational amplifiers has s strong capability of selecting and recognizing the transmitted DTMF based phone digit that determines the desired level of power to be transferred to the connected load.

II. LOAD POWER ANALYSIS

Here, we focus on the transferred load power analysis and calculation for different firing angle, which controls the time the gate pulses are sent to the TRIAC in the dimmer control circuit. As shown in Fig. 1, the load is connected to the AC source with the TRIAC controlling dimmer circuit [3]-[6]. The input is a sinusoidal AC voltage $V(t) = V_p\sin(\omega_0 t)$, where V_p is the peak voltage, $\omega_0=2\pi f_0$, f_0: frequency of source voltage, $f_0 = 1/T$, T is the period of the input voltage.

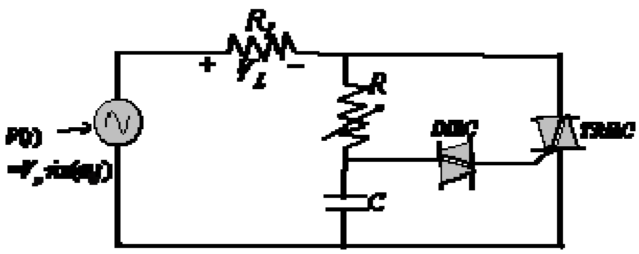

Fig. 1: TRIAC based dimmer circuit

When the capacitor is charged to a voltage level equal to the break down voltage of the DIAC, the DIAC conducts creating a gate pulse current that in turn makes the TRIAC to be fully conducting as a result, the voltage across the load becomes the same as the input source voltage ($V_L(t) = V(t)$). The point where the TRIAC starts to be fully conducting when observing over one period of the input signal is called the firing angle or the firing time (t_0) as shown in Fig. 2. The firing angle is controlled by the product of the value of the resistance and the capacitance *(RC)*. The load voltage is approximately zero before the firing time since the TRIAC isn't conducting and almost negligible current passes through the load. Let us examine the average power delivered to the load over one period of the input signal. The power delivered or transferred to the load is given by:

$$P_L = \frac{V_{rms}^2}{R_L} = I_{rms}^2 R_L \qquad (1)$$

Where V_{rms} is the root means square (rms) value of the input voltage, $V(t)$.

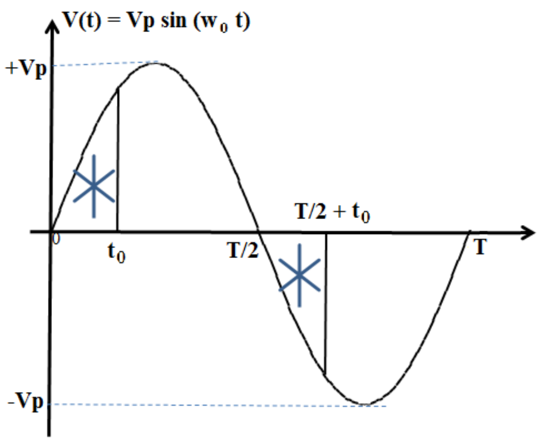

Fig. 2: AC load voltage through over one period of the input signal

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T V^2(t)dt} = \sqrt{\frac{1}{T}\int_0^T \left(V_p^2 \sin^2(\omega_0 t)\right)dt} \qquad (2)$$

$$\frac{1}{T}\int_0^T \left(V_p^2 \sin^2(\omega_0 t)\right)dt = \frac{V_p^2}{2T}\int_0^T \left(1-\cos(2\omega_0 t)\right)dt$$

$$= \frac{V_p^2}{2T}\int_0^T dt - \frac{V_p^2}{2T}\int_0^T \cos(2\omega_0 t)dt$$

$$V_{rms}^2 = \frac{V_p^2}{2T}\int_0^T dt - \frac{V_p^2}{2T}\int_0^T \cos(2\omega_0 t)dt =$$

$$\frac{V_p^2}{2T}\left(\int_{t_0}^{\frac{T}{2}} dt + \int_{\frac{T}{2}+t_0}^{T} dt\right) - \frac{V_p^2}{2T}\left(\int_{t_0}^{\frac{T}{2}} \cos(2\omega_0 t)dt + \int_{\frac{T}{2}+t_0}^{T} \cos(2\omega_0 t)dt\right)$$

$$V_{rms}^2 = \frac{V_p^2}{2T}\left(t\Big|_{t_0}^{\frac{T}{2}} + t\Big|_{\frac{T}{2}+t_0}^{T}\right) - \frac{V_p^2}{2T}\left(\frac{\sin(2\omega_0 t)}{2\omega_0}\Big|_{t_0}^{\frac{T}{2}} + \frac{\sin(2\omega_0 t)}{2\omega_0}\Big|_{\frac{T}{2}+t_0}^{T}\right)$$

$$= \frac{V_p^2}{2T}\left(\tfrac{T}{2} - t_0 + \tfrac{T}{2} - t_0\right) - \frac{V_p^2}{2T}\left(\begin{array}{l}\frac{1}{2\omega_0}\left(\sin(\omega_0 T) - \sin(2\omega_0 t_0)\right) \\ + \frac{1}{2\omega_0}\left(\sin(2\omega_0 T) - \sin(\omega_0 T + 2\omega_0 t_0)\right)\end{array}\right)$$

From trigonometry, we have the following simplifications

$\sin(\omega_0 T) = \sin(\frac{2\pi}{T}T) = \sin(2\pi) = 0$ and

$\sin(2\omega_0 T) = \sin(\frac{4\pi}{T}T) = \sin(4\pi) = 0$

$\sin(\omega_0 T + 2\omega_0 t_0) = \sin(2\pi + 2\omega_0 t_0) = \sin(2\omega_0 t_0)$

$$V_{rms}^2 = \frac{V_p^2}{2T}\left(2\left(\frac{T}{2} - t_0\right) + \frac{1}{\omega_0}\sin(2\omega_0 t_0)\right) = \frac{V_p^2}{2T}\left(2\left(\frac{T}{2} - t_0\right) + \frac{T}{2\pi}\sin\left(\frac{4\pi t_0}{T}\right)\right)$$

Let $\alpha_0 = \omega_0 t_0 = \dfrac{2\pi}{T} t_0$

$$V_{rms}^2 = \frac{V_p^2}{2T}\left(T - 2t_0 + \frac{T}{2\pi}\sin(\frac{4\pi t_0}{T})\right)$$

$$V_{rms}^2 = \frac{V_p^2}{2}\left(1 - \frac{2t_0}{T} + \frac{1}{2\pi}\sin(\frac{4\pi t_0}{T})\right) \quad (2)$$

$$V_{rms}^2 = \frac{V_p^2}{2}\left(1 - \frac{\alpha_0}{\pi} + \frac{1}{2\pi}\sin(2\alpha_0)\right) \quad (3)$$

The square of the rms value of the load voltage is given by (2) or (3) in terms of the firing time (t_0) or the firing angle (α_0) respectively. Table 1 shows different values of V_{rms} for different cases of firing time or firing angle.

Table 1: Load voltage, V_{rms} for different firing angles

Firing time, t_0	0	$T/12$	$T/8$
Firing angle, α_0	0	$\pi/6=30^0$	$\pi/4=45^0$
V_{rms}	$\frac{V_p}{\sqrt{2}} = 0.707V_p$	$\frac{V_p}{\sqrt{2}}\sqrt{\frac{5}{6}+\frac{\sqrt{3}}{4\pi}} = 0.6968V_p$	$\frac{V_p}{\sqrt{2}}\sqrt{\frac{3}{4}+\frac{1}{2\pi}} = 0.6742V_p$
V_{rms}^2	$\frac{V_p^2}{2}$	$0.4856V_p^2$	$0.4546V_p^2$
Firing time, t_0	$T/6$	$T/4$	$T/3$
Firing angle, α_0	$\pi/3=60^0$	$\pi/2=90^0$	$2\pi/3=120^0$
V_{rms}	$\frac{V_p}{\sqrt{2}}\sqrt{\frac{2}{3}+\frac{\sqrt{3}}{4\pi}} = 0.6342V_p$	$\frac{V_p}{2} = 0.5V_p$	$\frac{V_p}{\sqrt{2}}\sqrt{\frac{1}{3}-\frac{\sqrt{3}}{4\pi}} = 0.3127V_p$
V_{rms}^2	$0.4022V_p^2$	$\frac{V_p^2}{4}$	$0.0978V_p^2$

III. SYSTEM MODEL

In addition to the transmitter side (fixed or mobile phone), the proposed system in the receiver side includes a receiver phone (fixed or mobile), DTMF decoder and Logic Controller and dimmer circuit with set of relays. The relays state will be controlled by the transmitted digits decoded by the DTMF decoder. The contacts of relays in the dimmer circuit determine or control the total value of the resistor *R* in the *RC* branch of the dimmer circuit. Binary weighted sub-resistors are selected to make up the total resistance *R*, and the relay contacts are arranged to select or deselect the sub-resistors in order to achieve different levels of transferred power to the AC and/or DC load. Fig. 3 shows the main block diagram of the receiving end showing the proposed system including all main parts.

At the transmitter side, the user will send the DTMF control signal by first dialing the receiver mobile or fixed phone. After the answering mode is completed, the user will send appropriate digit coded as DTMF tone commands to switch on/off the relay contacts that control the connection and disconnection of the sub-resistors to the overall dimmer circuit. The received DTMF tone command will be decoded by an appropriate DTMF decoder circuit designed from analogue active filter. After the decoding step, a logic controller is designed to identify the exact transmitted phone digit corresponding to the transmitted DTMF tone. A related relay will be changing its switching state corresponding to the transmitted digit. The electronic design of the proposed work is done by the NI-MULTISIM software.

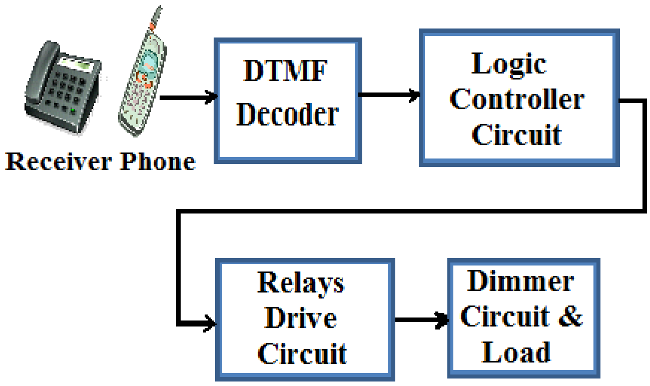

Fig. 3: Main block diagram of the proposed system

IV. DTMF SIGNALLING

The telephone keypad includes 16 digits, and each digit keypad is represented by two simultaneous tones selected from a two sets of frequencies. One set contains a low frequencies (697 Hz, 770 Hz, 852 Hz, 941 Hz) while second set contains a high frequencies (1209 Hz, 1336 Hz, 1477 Hz, 1633 Hz) as shown in Fig. 4. When we press a digit or symbol on the phone keypad, a sinusoid signal, which is a sum of the lower frequency (f_L) and the higher frequency (f_H) is generated. Therefore, the DTMF tone signal generated is given by:

$$x(t) = A\sin(2\pi f_L t) + B\sin(2\pi f_H t) \tag{4}$$

Where *A* & *B* are the amplitude of the each frequency sinusoid.

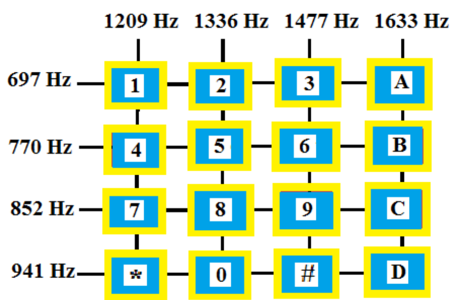

Fig. 4: The DTMF tones generated from a keypad

The transmitted DTMF tone from a transmitting phone station is received at the receiving station and be identified by a suitable DTMF decoder circuit. In our previous work [9], [10], we focused on the implementation of the DTMF decoder using analog electronic circuits. In that work, we presented the designed circuit of each stage of the overall decoder supported by experimental test and results for the different stages of the overall proposed design. From (4), the DTMF tone signal is the sum of two sinusoid frequencies that will be received through the phone device at the receiver side. From [10], the received dual tone signal of the transmitted digit “0” is $V_{"0"}(t) = V_{941}(t) + V_{1336}(t)$ as shown in Fig. 5, which is a sum of the 941 Hz and 1336 Hz signals. This signal will be the input to the decoder stage represented by an array of bandpass filters (BPF) one for each frequency. The filters array represents the first stage of the DTMF decoder as shown in detailed block diagram of the proposed system in Fig. 6.

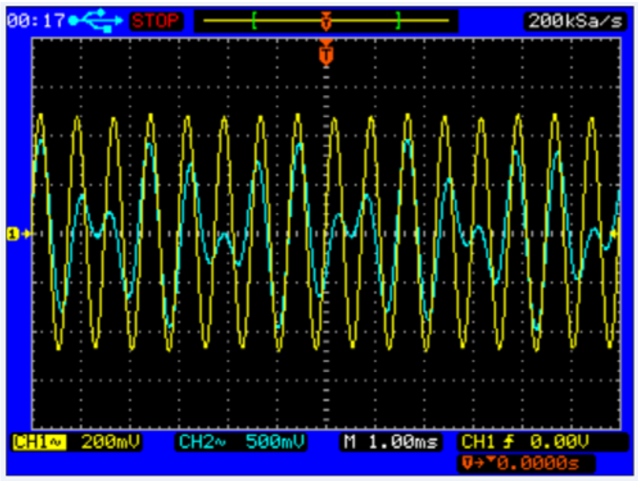

Fig. 5: The DTMF tone corresponding to the digit “0” at the input of the BPF filters array, Channel 1 of Oscilloscope (CH1, Yellow color-1336 Hz) and Channel 2 of Oscilloscope (CH2, Blue color- 941 Hz + 1336 Hz) [10].

The DTMF decoder circuit is able to identify the individual DTMF tone signals. We used a four-pole active band pass filter based on the four-pole bandpass filter that can be designed from a cascade or series connection of two identical two-pole topologies. Fig. 7 shows a fourth order Butterworth active bandpass filter where the parameters are selected to have resonance or maximum gain at a frequency of 1477 Hz, and the capacitor and resistance values can be determined using the design steps as mentioned in [9], [10], [15], [16] which is one of the eight DTMF frequencies. We will have eight fourth order bandpass filters corresponding to the eight DTMF frequencies.

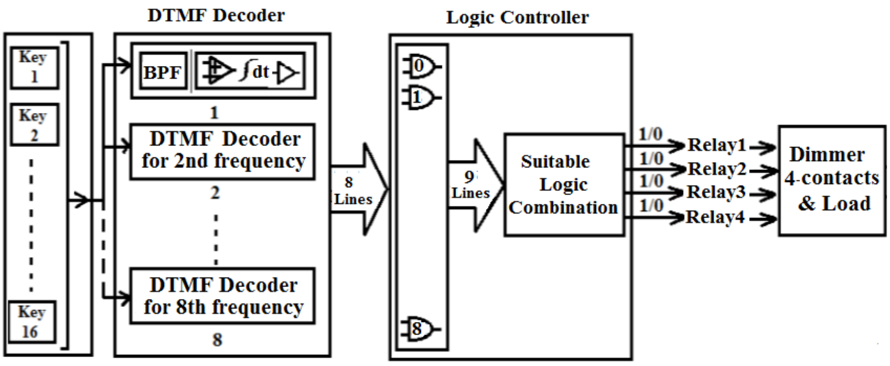

Fig. 6: The details of the proposed system including DTMF decoder stages

The values of the components for Fig. 7 are determined for bandwidth, B = 100 Hz (quality factor, Q =100/941), $C_{11} = C_{12} = C_{13} = C_{14} = C$ =100 nF and overall gain of A_m =2.

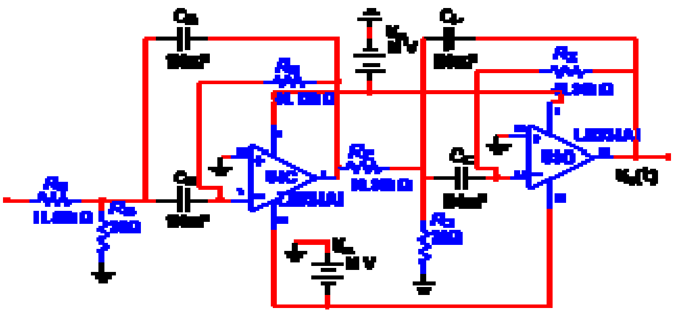

Fig. 7: Fourth order topology active bandpass filter (component values are for mid or center frequency, f_m =1477 Hz) [x2], [x3].

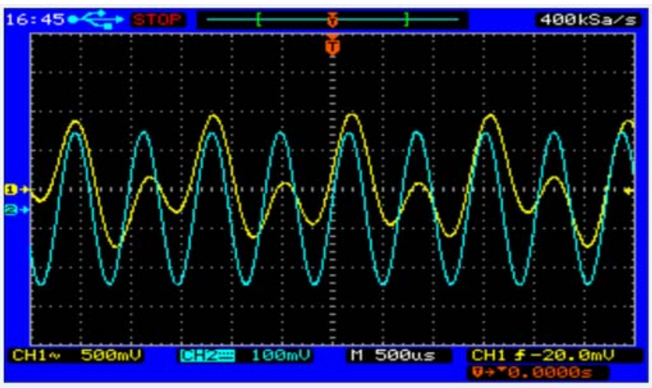

Fig. 8: Output of the bandpass filter of center frequency f_m =1477 Hz for DTMF tone input signal corresponding to digit "3" (yellow color:- input signal of 697 Hz + 1477 Hz & blue color:- output signal of 1477 Hz) [10].

Fig. 8 shows the output of the active bandpass filter shown in Fig. 7 when the DTMF signal for digit "**3"** is passed through the bandpass filter (yellow-colored graph), which has a center frequency f_m = 1477 Hz. It clearly shows that the circuit filters the input DTMF tone corresponding to the digit "**3**" and produces the sinusoid signal of frequency 1477 Hz at its output (blue-colored graph). Similarly, Fig. 9 shows the output of the active bandpass filter designed for a center frequency of f_m = 697 Hz when the DTMF signal for digit "**3"** is an input signal to the filter. It clearly shows that the circuit filters the input DTMF tone corresponding to the digit "**3**" and produces the sinusoid signal of frequency 697 Hz at its output (blue-colored graph). Therefore, the two active bandpass filters (center frequency f_m =697 Hz and f_m =1477 Hz) together are used to recognize or decode that the dialed digit is "**digit 3**".

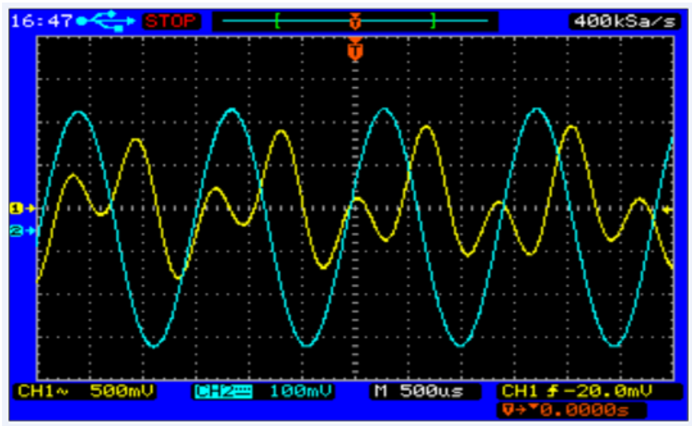

Fig. 9: Output of the bandppass filter of center frequency f_m =697 Hz for DTMF tone input signal corresponding to digit 3 (yellow color:- input signal 697 Hz + 1477 Hz & blue color:- output signal of 697 Hz) [10].

The filters design accuracy can be noted by looking the output of the filters when a DTMF tone signal different from the center frequency is an input to the filter. For example, Fig. 10 shows the output of the bandpass filter with center frequency f_m =1477 Hz when an input DTMF tone signal corresponding to digit "7" (852 Hz + 1209 Hz) is an input to the filter. Clearly, the output signal (blue color) is significantly attenuated by the filter and hence weak amplitude and as a result no recognition of the digit 7 for this particular filter.

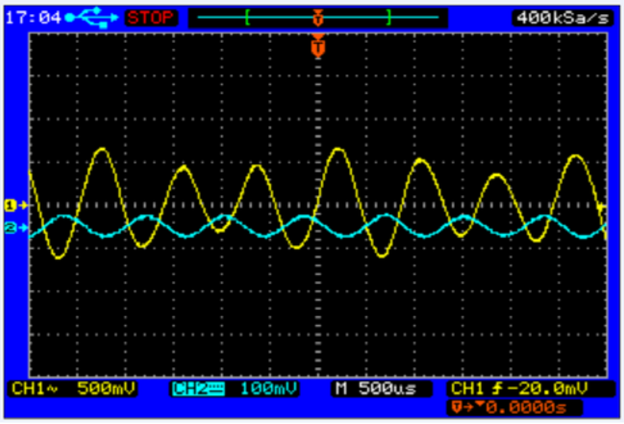

Fig. 10: Output of the bandpass filter of center frequency f_m =1477 Hz for DTMF tone input signal corresponding to digit 7 (yellow color:- input signal 852 Hz + 1209 Hz & blue color:- output signal of the filter) [10].

The next stage of the decoder circuit is eight similar circuits with each circuit be a cascaded connection of a comparator, integrator and buffer circuit. The total function of each circuit is producing an output voltage with low or high level (Logic 0 or logic 1) based on the amplitude of the input signal, which is originally the output signal of each filter. The bandpass filter circuit as shown in Fig. 7 is designed to attenuate other DTMF frequencies that are different from the center or the resonance frequency and therefore there will be very small amplitude signal at the output for the frequencies different from the resonant frequency. Fig. 11 shows the comparator circuit, followed by the integrator *RC* circuit, buffer logic gate with indicator lamp for indicating the detection of the DTMF frequency. The potentiometer is set for a reference voltage of approximately 0.15 V and the comparator gives an output voltage of 15 V (HIGH) when the output of the bandpass filer is above 0.15 V and an output voltage of -15V (LOW) when the bandpass output voltage is less than the 0.15 V.

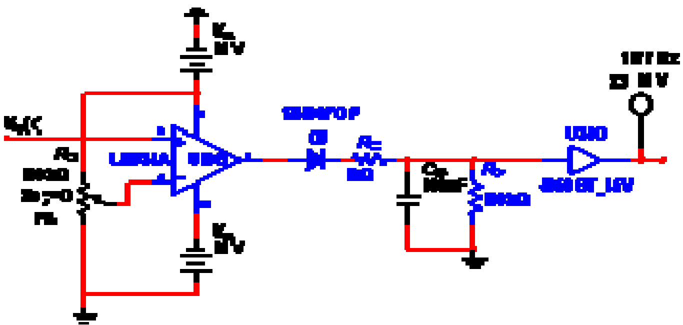

Fig. 11: A comparator, integrator and buffer circuit [10]

V. LOGIC CONTROLLER CIRCUIT

We have shown the possibility of complete detection and recognition of the DTMF frequencies using the designed DTMF decoder circuit. We get a “logic 1” if a DTMF frequency is recognized and a “logic 0” if a DTMF frequency isn’t detected or recognized by the decoder electronic circuit. The logic controller controls the four relays in the dimmer circuit. When digit “0” is pressed or transmitted from the transmitter, it leads to reset of all the relays making no gate pulse reaches to the gate of the included TRIAC in the dimmer. The load voltage and power will be null in this case. When digit “1” is transmitted, it leads to activation of only relay 1 and pulse signal reaches the TRIAC gate to make it conducting and the dimmer circuit allows lower voltage or power to be delivered to the load. Depending upon the proposed design, the load voltage and power will be increased from minimum value when “*digit* 1” is pressed to maximum value when digit “8” is pressed. When a particular relay is switched on, it remains in switched on state unless it is switched off by another transmitted digit. Therefore, there is a need of tracking the state of the relays and hence a requirement not only a combinational but also a sequential circuit [8], [9].

Four sequential circuits represented by four J-K flip flops are required to the continuity of the state of relays working condition. Depending on the truth table of J-K flip flop as shown in table 2, the design of the four sequential circuits started by the whole truth table which includes the details of the input terminals (J, K) of each flip flop:

Table 2: Truth table of the J-K Flip Flop

JK FLIP FLOP		
J_1	K_1	$Q_1(t+1)$
0	0	No change
0	1	SWITCH OFF
1	0	SWITCH ON
1	1	Toggle

Table 3 explains the desired sequence of relays working states considering the input terminals of flip flops to have the desired steps of binary increments which will lead to have increment of the load voltage and load power.

Table 3: Desired relay switching sequence corresponding to transmitted phone digits, JK flip flops, and load voltage/power steps

Transmitted Digit	**Relay 1**			**Relay 2**			**Relay 3**			**Relay 4**			**Volt/ Power Step**
	R1	**J1**	**K1**	**R2**	**J2**	**K2**	**R3**	**J3**	**K3**	**R4**	**J4**	**K4**	
Digit “0” A	**0**	0	1	**0**	0	1	**0**	0	1	**0**	0	1	Zero Value
Digit “1” B	**1**	1	0	**0**	0	1	**0**	0	1	**0**	0	1	Min.
Digit “2” C	**1**	1	0	**0**	0	1	**0**	0	1	**1**	1	0	Increment
Digit “3” D	**1**	1	0	**0**	0	1	**1**	1	0	**0**	0	1	Increment
Digit “4” E	**1**	1	0	**0**	0	1	**1**	1	0	**1**	1	0	Increment
Digit “5” F	**1**	1	0	**1**	1	0	**0**	0	1	**0**	0	1	Increment
Digit “6” G	**1**	1	0	**1**	1	0	**0**	0	1	**1**	1	0	Increment
Digit “7” H	**1**	1	0	**1**	1	0	**1**	1	0	**0**	0	1	Increment
Digit “8” I	**1**	1	0	**1**	1	0	**1**	1	0	**1**	1	0	Max.

Eight lines enter the proposed digital controller circuit with each line be logic level “0” or “1” depending on the recognition of eight DTMF frequencies by the previous decoder circuit. The output lines of the logic controller represent the activated logic lines for 4-relays. The function of the digital controller is executing the requirements of Table 3. The controller design includes two internal stages, first one to recognize the digits (0, 1, 2, 3, 4, 5, 6, 7, and 8) from the input logic levels of the DTMF frequencies; this stage is done by a set of nine AND gates (2-inputs) as shown in Fig. 12. The design of the second stage of the logic controller depends on the truth table requirements shown in Table 2 and Table 3. The derived logic equations for the J, K inputs of each flip flop explain the details of the second stage. Fig. 13 shows the details of the circuit diagram regarding the first part of the second stage to activate the first relay while the other three relays; relay2, relay3, and relay 4 have different inputs according to the below logic equations:

$J1 = B + C + D + E + F + G + H + I$

$K1 = A$

$J2 = F + G + H + I$

$K2 = A + B + C + D + E$

$J3 = D + E + H + I$

$K3 = A + B + C + F + G$

$J4 = C + E + G + I$

$K4 = A + B + D + F + H$

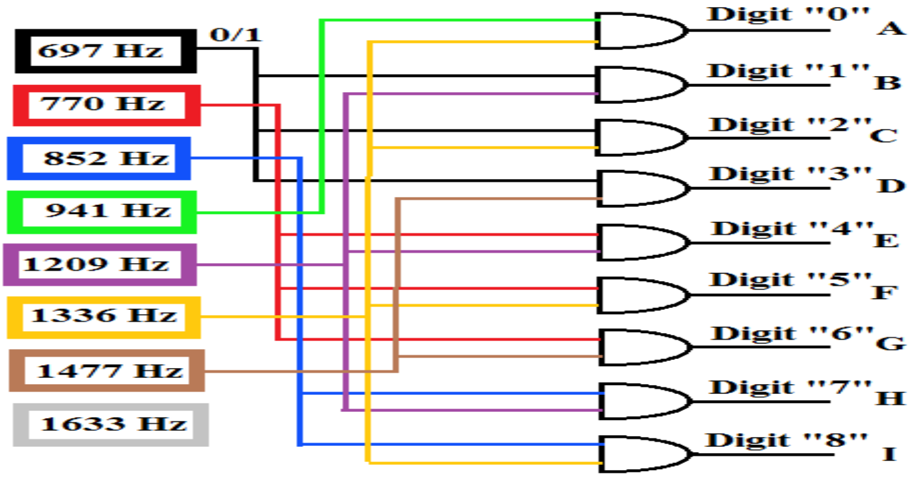

Fig. 12: First stage of the logic controller circuit

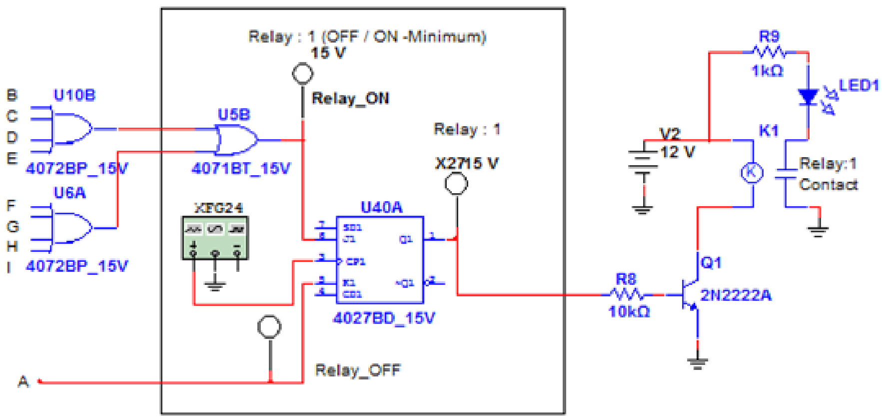

Fig. 13: First part of the second stage of the logic controller circuit according to the logic equations

VI. EIGHT STEPS DIMMER CIRCUIT

The relay contacts control the total resistance value of the resistor of RC circuit in the dimmer through connecting and disconnecting the contacts across binary weighted serial four resistors (R1=1 kΩ, R6= 320 kΩ, R2=160 kΩ, R5=80 KΩ). Fig. 14 shows the proposed and simulated dimmer circuit to remotely control the AC load voltage and power, while Fig. 15 show the proposed dimmer circuit for the DC load:

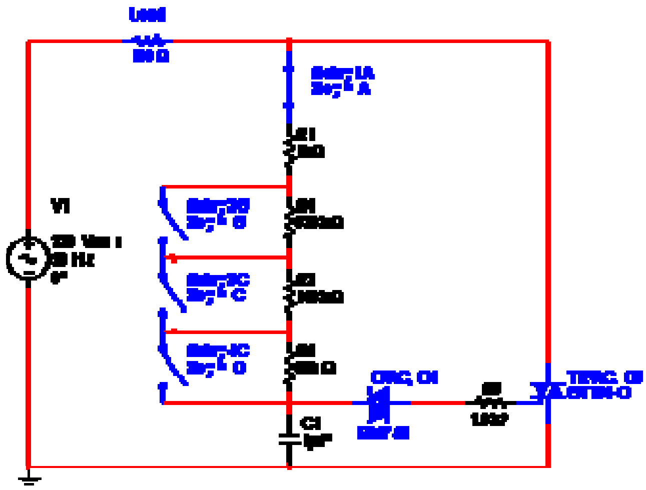

Fig. 14: Dimmer Circuit for controlling voltage/power delivered to AC load.

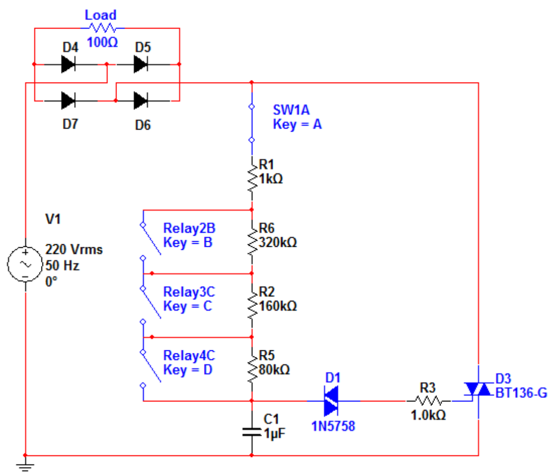

Fig. 15: Dimmer Circuit for controlling voltage/power delivered DC load.

Figures Fig. 16, and Fig. 17 show the AC and DC load voltage waveforms when as an example digit "4" is pressed and transmitted (blue wave is input AC supply waveform, while red wave is the load voltage)

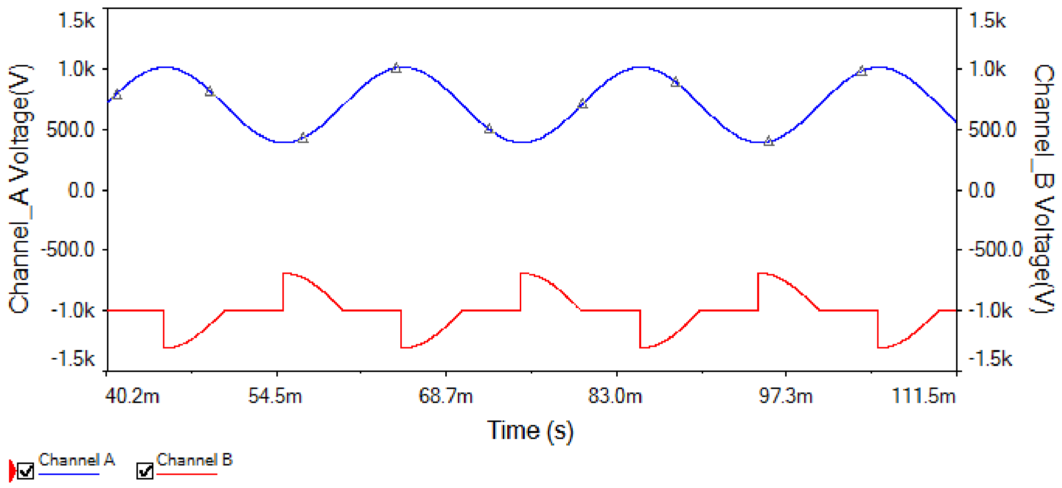

Fig. 16: AC load voltage when digit "4" pressed and transmitted

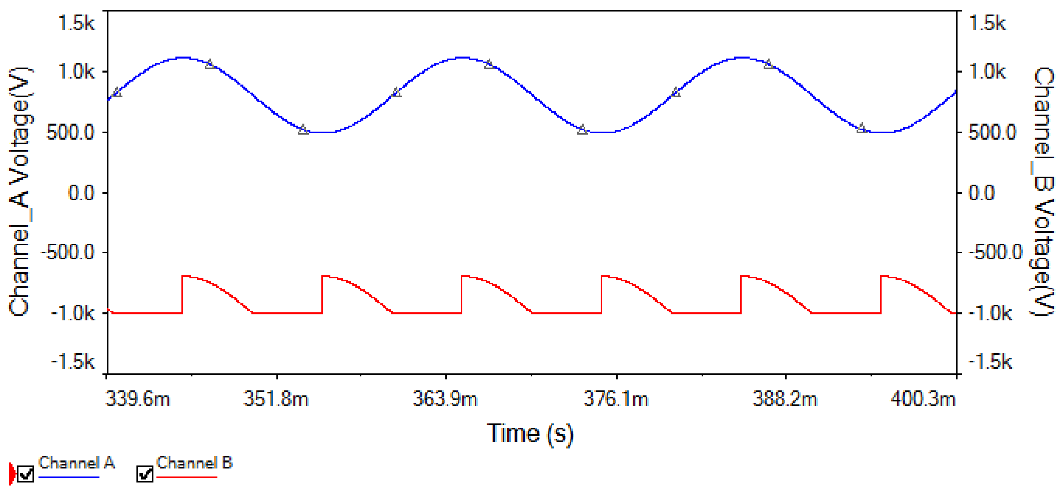

Fig. 17: DC load voltage when digit "4" pressed and transmitted

Table 5, and Table 6 show the details of relay states, the total resistance values, firing time, firing angles, AC/DC load voltages, load power for the different phone digit transmission cases. The measured voltages are in agreement with the theoretical analysis results given in (2) and (3).

Table 5: Total resistance values, firing time, firing angles for different phone digits:

Pressed Digit	Rly 1	Rly 2	Rly 3	Rly 4	Total Res. R_{at} (kΩ)	Firing Time (msec)	Firing Angle
"0"	0	0	0	0	Open Circuit	--	--
"1"	1	0	0	0	561	7.463	134.3^{o}
"2"	1	0	0	1	481	6.53	117.5^{o}
"3"	1	0	1	0	401	5.69	102.4^{o}
"4"	1	0	1	1	321	4.944	88.99^{o}
"5"	1	1	0	0	241	4.104	73.87^{o}
"6"	1	1	0	1	161	3.265	58.77^{o}
"7"	1	1	1	0	81	2.332	41.98^{o}
"8"	1	1	1	1	1	0.2239	4.03^{o}

Table 6: AC and DC Load voltage and power for different phone digits:

Pressed Digit	AC-Load Volt (V)	AC-Load Power (W)	DC-Load Volt (V)	DC-Load Power (W)
"0"	0	0	0	0
"1"	66.08	39.01	28.53	38.57
"2"	101.85	95.69	52.37	94.84
"3"	131.62	161.92	76.22	160.66
"4"	157.18	240.37	100.1	239.52
"5"	179.03	321.16	123.94	318.97
"6"	197.16	405.18	147.82	383.49
"7"	211.12	442.92	171.62	439.97
"8"	218.92	475.87	195.07	472.54

Fig. 18 shows the AC and DC load powers for different pressed digits. It is clear from the figure that power controlling can be achieved with capability of having different values (steps) of transferred power through adjusting the connected serial resistors in RC branch of dimmer power controlling circuit.

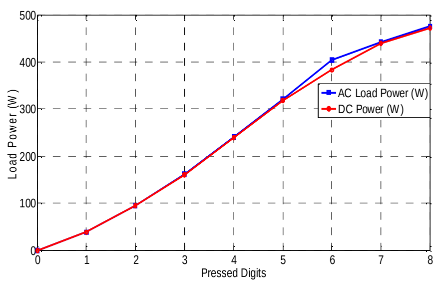

Fig. 18: AC and DC load powers for different pressed digits

VII. CONCLUSIONSTHIS

This study shows a power controlling system with the details of the proposed electronic design, power analysis, and simulation results for remotely controlling power delivered to AC and/or DC electrical load. Firstly, the system uses the communication network where there is transmitting and receiving of digits from the DTMF based phone devices. Secondly, a new electronic design is proposed to decode DTMF frequencies at the receiving side and thirdly a power controlling circuit is designed and the simulation results show that load power controlling is achieved with high accuracy. The presented deign of multi-step dimmer power control circuit offers flexibility in the selection of the desired delivered power to the load through suitable selection of the values of the serial resistors in the RC branch of the dimmer circuit. The proposed methodology can be adopted for other remotely controlled systems. The overall electronic design is done by using national instrument NI-MULTSIM simulation software.

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