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Construction of Remote Controlled Window Blind

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Abstract:
In the advent of rapid technological growth, the need for remote control facilities to be incorporated in household devices is essential to enable humans perform their household task using high performance machines to make life more comfortable and easy. To this end, the idea of a wireless remote controlled window was conceived and implemented. The construction entails using the 433 MHz radio frequency transmitter/receiver module to perform the basic windows operation such as opening and closing of window blinds as well as raising and dropping of the blind placed in offices and homes. Results of test carried out on the device showed control of the window blinds through motor drivers to move the window blinds in forward and reverse order. The construction was tested and functioned well. The realizable working distance between the remote and receiver achieved was 10.66m.

Keywords: Window blind, Transmitter module, Receiver module, Motor, Electronic device.

1. INTRODUCTION

The optimum utilization of daylight, maintenance of proper indoor lighting intensity and glare protection are some of the challenges that need to be solved to ensure a comfortable ambience at homes and offices. This, with the rapid progress or growth of the electronics industry and the non-stop development of people's living standard, has created an insatiable search for automated, smart and suitable control systems in virtually every sphere of human existence. This led to the invention of lots of home automated and remote controlled house-hold appliances. One of such new house-hold device is automated window blinds. Window blinds are material coverings used by people for regulating amount of light (daylight), air flow in and out of a room or apartment. These window coverings or blinds come in a wide variety of types and shapes, and can be located inside, outside or within the envelope of a building. Thus, a remote controlled window blind is a blind controlled using a remote control instead of the usual manual control. Window blinds are of great importance in modern buildings as its position and operation affects the amount and distribution of daylight entering a building as well as all forms of thermal transfer. Nowadays, people have to worry about when to close and open windows. Hence, a lot of people are not able to adjust the window to be opened or closed when they are not around the window. This is even more worrisome for the elderly, sick and disabled who may find it difficult to control these blinds to their convenience. This causes lots of heat, moisture and solar light damage to stuffs inside the rooms. This implies the need for a more convenient and flexible method of control for window blinds so that daylight intensity, humidity and temperature of a room or apartment can be controlled by all. This will give a high level of user convenience in terms of heat protection and glare related problems. Although, automatic control of window blinds is rapidly becoming a house-hold device due to the rapid growth of the electronics industries, the efficiency and flexibility of these automated windows or blinds is still low due to the lack of some specialized control mechanisms which this construction seeks to incorporate. Most of the commercially automated windows blind or curtains make use of a host of sensors with which it determines whether or not to open or close. This implies that the desire, health status and preference of the end user of the home or apartment are not taken into consideration. This renders such automated window blinds un-ideal and ineffective as the end user has no control over the window blinds of the apartment. One of such means through which this can be achieved is remote control. Amit (2015) provided the design and implementation of automatic window blind by using manual button operation to clean the board. The design made use of mechanical gear such as chain or gear socket to move the window blind in forward and reverse order. The use of buttons to operate the blind has some disadvantages like the operator standing in front to operate the window blind, which is almost like manually operating it. Santosh (2014) implemented another method which made use of two DC motors to move the window blind in horizontal and in vertical axis. The design incorporated an IR receiver or four limit switches to detect the boundaries of the blind. This automatic window blind operates in two moves. In the first move, the first DC motor was used to control the up or down movement of the blind while the second DC motor was used to control the open/close operation of the blind. Carelin and Jacob, (2011) presented a technology to control a home appliance using Zigbee module and GSM module. The design implemented a GSM and zig-bee module that was interfaced to the controller to operate it through User registered mobile. A different and new method for automatic operation was proposed and implemented by Santosh (2014) which was Android based app to control the motor operation for the window blind. An Android Bluetooth app which was in mobile phone was connected to the controller with some interfacing and through this interfacing, the operation of the motor was controlled. The curtain was controlled by the wireless remote control. This activated the motor on the command given by the remote device which starts the curtains moving from the one location to other based on the pressed key. The motor speed was dependent on the weight of the curtain. Chen *et al* (2009) presented the venetian blind control using fuzzy neural network for indoor day lighting. Solar powered smart blind system was proposed by Herrera *et al*, (2009). Kim *et al* (2007) conducted an extensive experimental study to evaluate the environmental performance of automated venetian blind. As the Microcontroller Unit (MCU) is currently popular in designing various automatic and autonomous systems, the design uses the Arduino microcontroller unit for designing the motion control system of the window blind. This paper thus reports our device construction which is tailored towards improving electronic window blinds by incorporating a wireless radio frequency (RF) control with which the window blind can be better controlled.

2.0 MATERIALS

Materials used in the construction of the remote controlled window blind are shown in Table 1

Table.1. Materials used for the construction.

S/N	Components		Quantity	Unit
1	Resistors	R1	1	10KΩ
		R2	1	100kΩ
2	Capacitors	C1	1	2200uF
		C2	1	1uF
		C3 – C4	3	22pF
3	integrated Circuit	U8	1	7024
4		U5 and U9	3	7805
		U3	1	L297
		U2 and U7	2	L298
		HT12H	1	
		U1	1	PIC16F87A
5	Diodes	BR1	1	IN4007
	Crystal	X1	1	MHz
		D2-D3 (Zenner)	2	3V3
6	Miscellaneous	BR1	1	IN5408
		TR1	1	220/24V step-down
	Push button		4	
	9V battery		1	
	Mps4 Stepper	M49SP	2	

2.1 Method: The block diagram of the remote controlled window blind is shown below in Figure 1. It consists of power supply unit, remote transmitter unit, receiver unit, oscillatory unit, control unit and output unit.

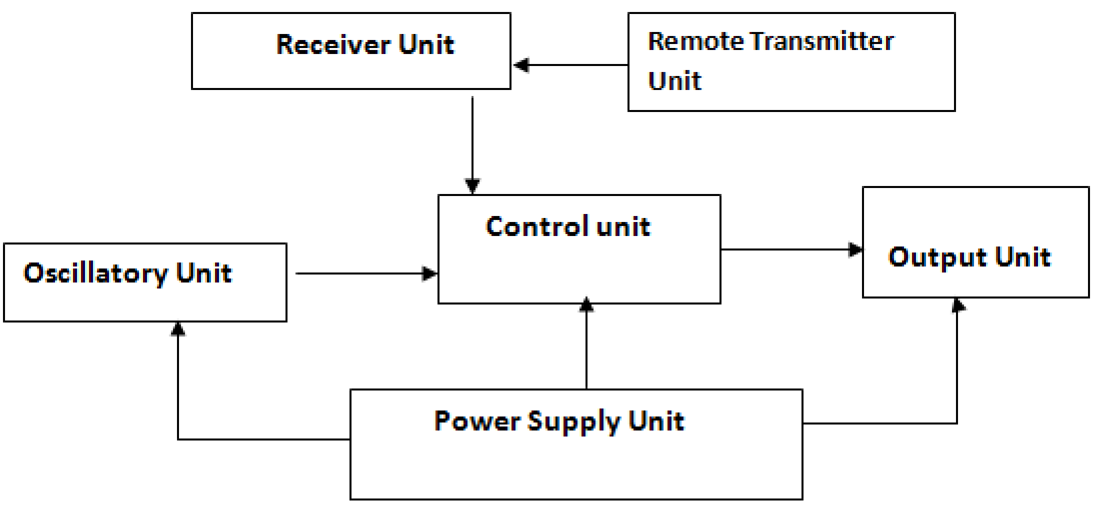

Figure.1. Block Diagram of Remote Controlled window blind

2.2 Circuit Layout: The circuit layout of the remote controlled window blind is shown in Figure 2

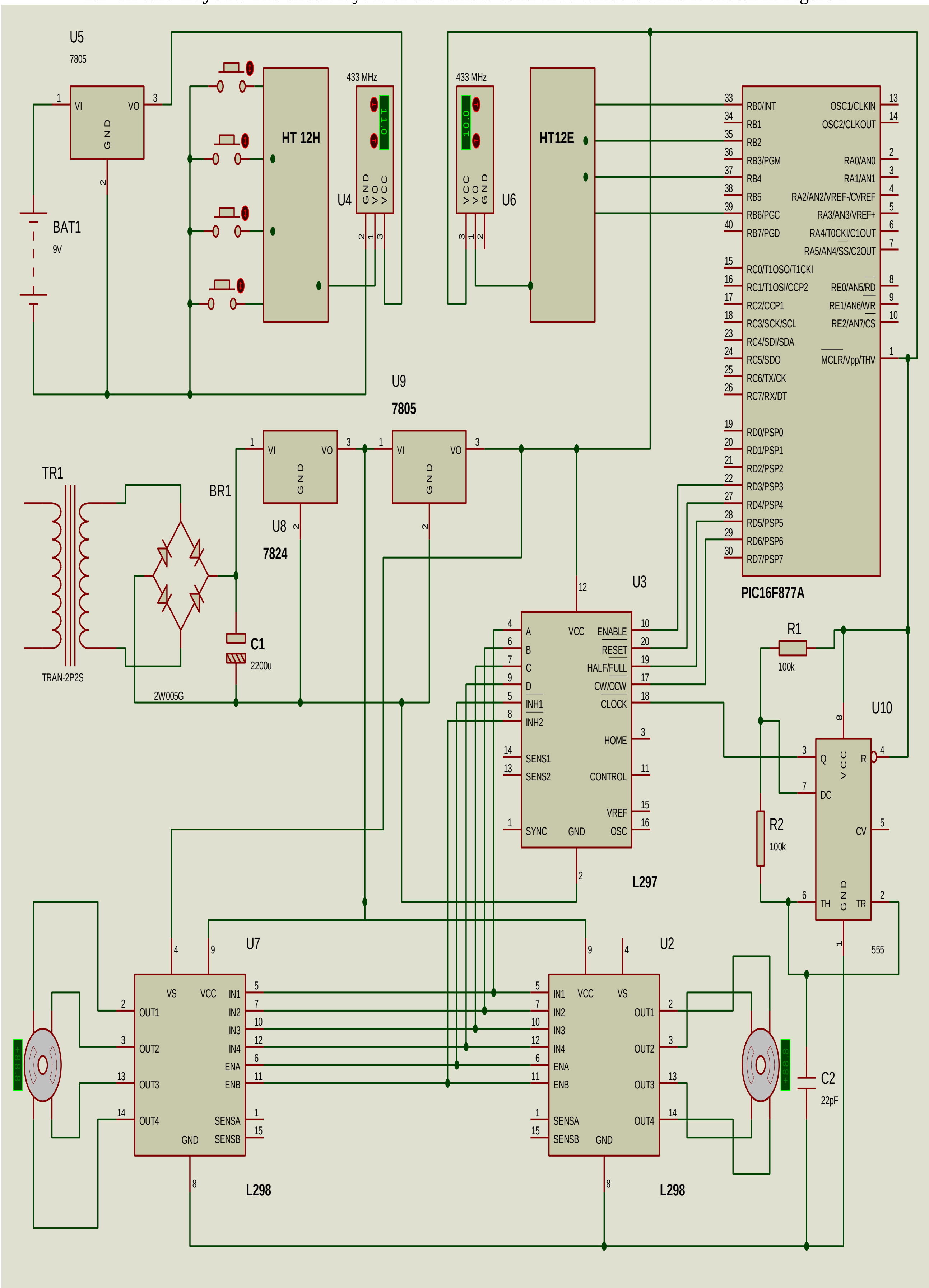

Figure.2. Circuit layout of Remote Controlled window blind

2.3 Stage by Stage Analysis of Circuit

2.3.1 Power Supply Unit: This unit is used to convert ac voltage from commercial mains (PHCN) supply to a low dc voltage suitable for powering the bipolar stepper motors and other electronics in the system. It consists of a 1500mA power transformer that step down the 220V AC mains to about 24volts as shown below in Figure 3

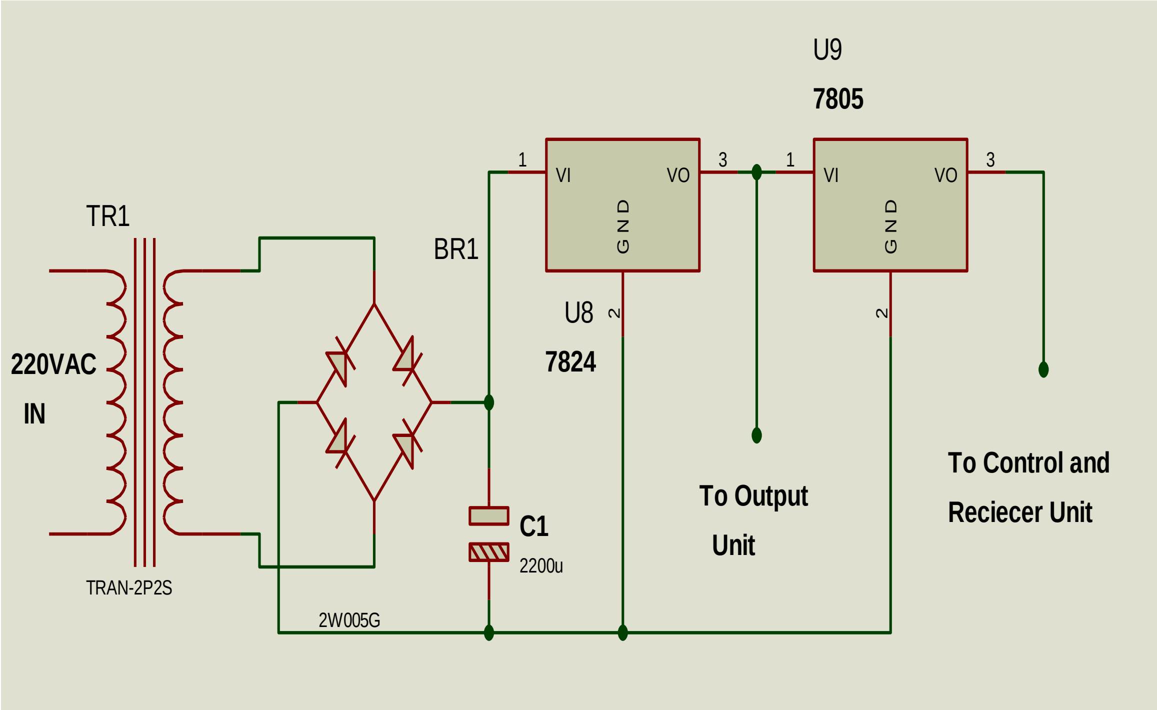

Figure.3. Circuit Diagram of Power Supply Unit

The 24V output from the secondary of the transformer was rectified using IN4001 diodes and then passed to the 7824 and 7805 voltage regulator IC which was used to set the output voltages to 5V. Capacitor C1 was used to filter out AC components from the rectified DC voltage while the 7824 voltage regulator was used to produce the 24VDC voltage required by the bipolar stepper motors in the output unit.

2.3.2 Remote Transmitter Unit: The remote control unit was used to control the up/down and open/close movement of the window blind when the four (4) buttons on the remote were depressed. It consists of the popular HT 12H encoder IC and a 433 MHz radio frequency transmitter module. The 433MHz transmitter has its corresponding receiver pair that can receive and decode any signal radiated out by the transmitter unit as radio waves. The encoder IC is required to generate a code that corresponds to the particular button on its input that is activated. This generated code is then applied to the data input of the 433 MHz transmitter for transmission (Figure 4).

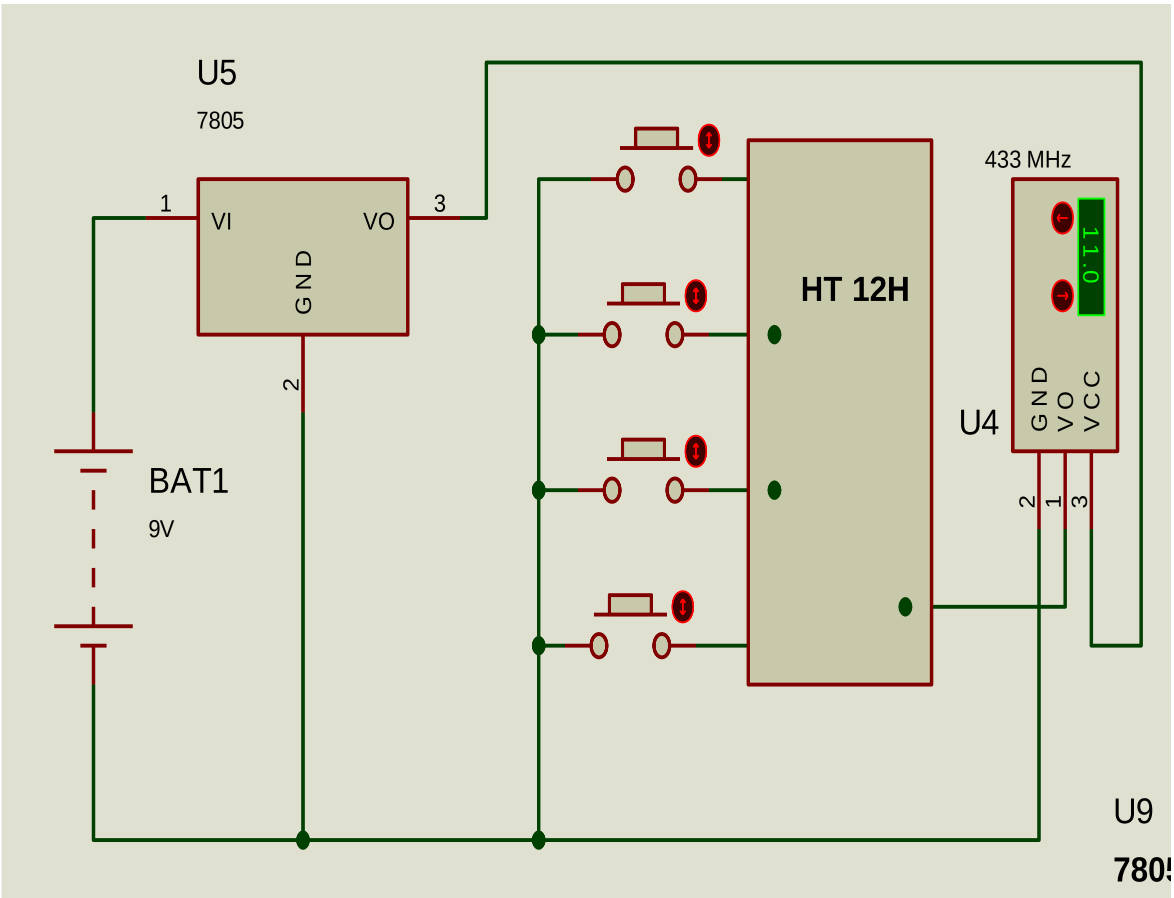

Figure.4. Circuit Diagram of Remote Transmitter Unit

2.3.3 433 MHz Receiver Unit:

This unit consist of the radio frequency receiver module that receives and decodes the transmitted radio wave signal before applying the decode signals to the control unit for proper signal conditioning (Figure 5).

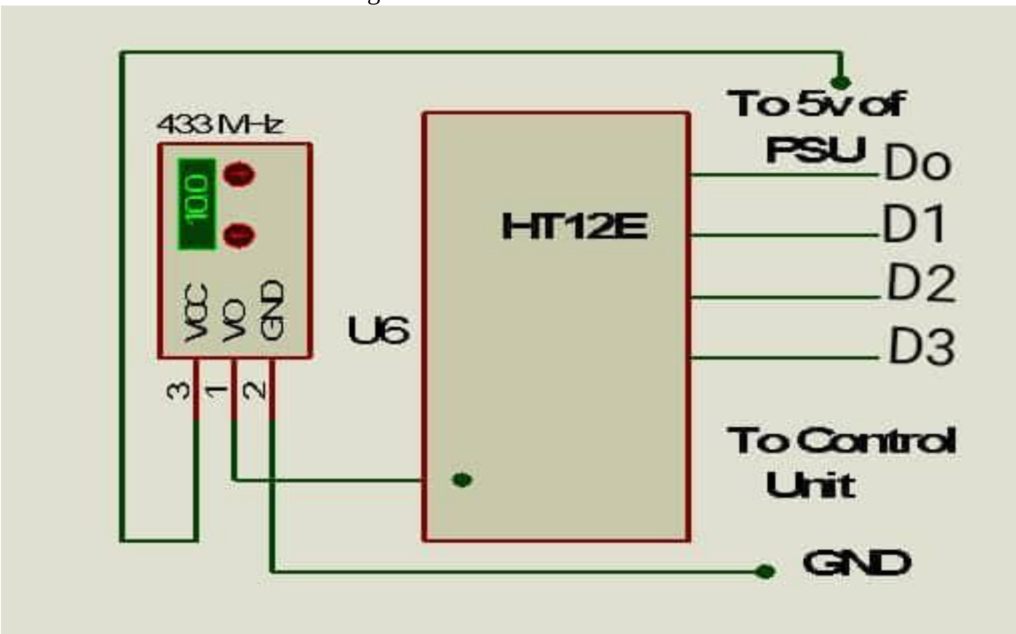

Figure.5. Circuit Diagram of 433MHz Receiver Module

In Figure 5, the output of the 433MHz module is coupled to the data input of the decoder IC (HT12E). This effectively decodes the incoming pulses from the 433 MHz receiver module before setting the corresponding output D0 – D3. The outputs D0 – D3 are then applied to the microcontroller inputs RB0, RB2, RB4 and RB6.

2.3.4 Oscillatory Unit

The oscillatory unit is used to generate the low frequency square wave signal (step clock) that is required by the stepper motors and it consists of the popular 555 timer IC wired in the Astable mode of operation as shown in Figure 6.

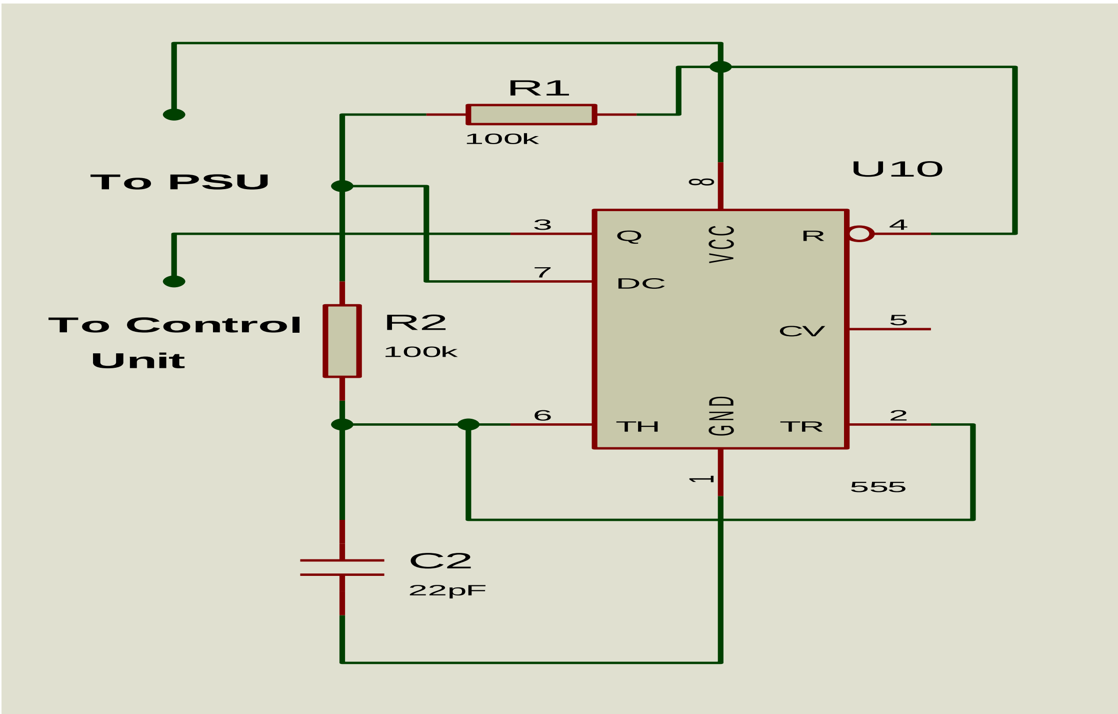

Figure .6. Circuit Diagram of Oscillatory Unit

The frequency of the 555 timer IC configured as an Astable multivibrator is related to:

$$F = \frac{1.49}{(R_A + 2R_B) * C} \qquad (1)$$

Where:

F = Frequency (in Hz)

R_A = Resistance between pin 7 and Vcc (R1)

R_B = Resistance between pin 6 and 7 (R2)

C_2 = Capacitance between pin 6 and GND (in farad)

C_2 is the capacitor connected between pin 2, 6 and GND while R_2 is connected between Pin 2, 6 and 7 to Vcc of the 555 timer IC. To obtain the frequency of oscillation, a 1µf capacitor and 1kΩ was arbitrarily chosen for C_3 and R_1 while the value of R_2 was chosen to be 100kΩ.

$$F = \frac{1.49}{(10k) * 0.000001}$$

$$F = \frac{1.49}{10k * 0.000001}$$

F = 149 Hz
The 555 timer was configured in the Astable mode. The square wave signal from the oscillator unit was applied to pin 30 of the microcontroller and the step input of the L297 IC.

2.3.5 Control Unit

The control unit consists of the PIC 16F877A microcontroller. A microcontroller often abbreviated MCU is a single computer chip integrated circuit that executes a user program normally for the purpose of controlling some devices, hence the name microcontroller. Microcontroller includes several thousands of transistors stored into one chip, with addition of external peripherals such as memory, Input-output lines and timers built into it. The PIC16F877A which belongs to a class of 8-bit microcontrollers of RISC architecture and its pin out is shown in Figure 7. Its features are shown in Table 2. Figure 8 depicts the circuit connections of the control unit.

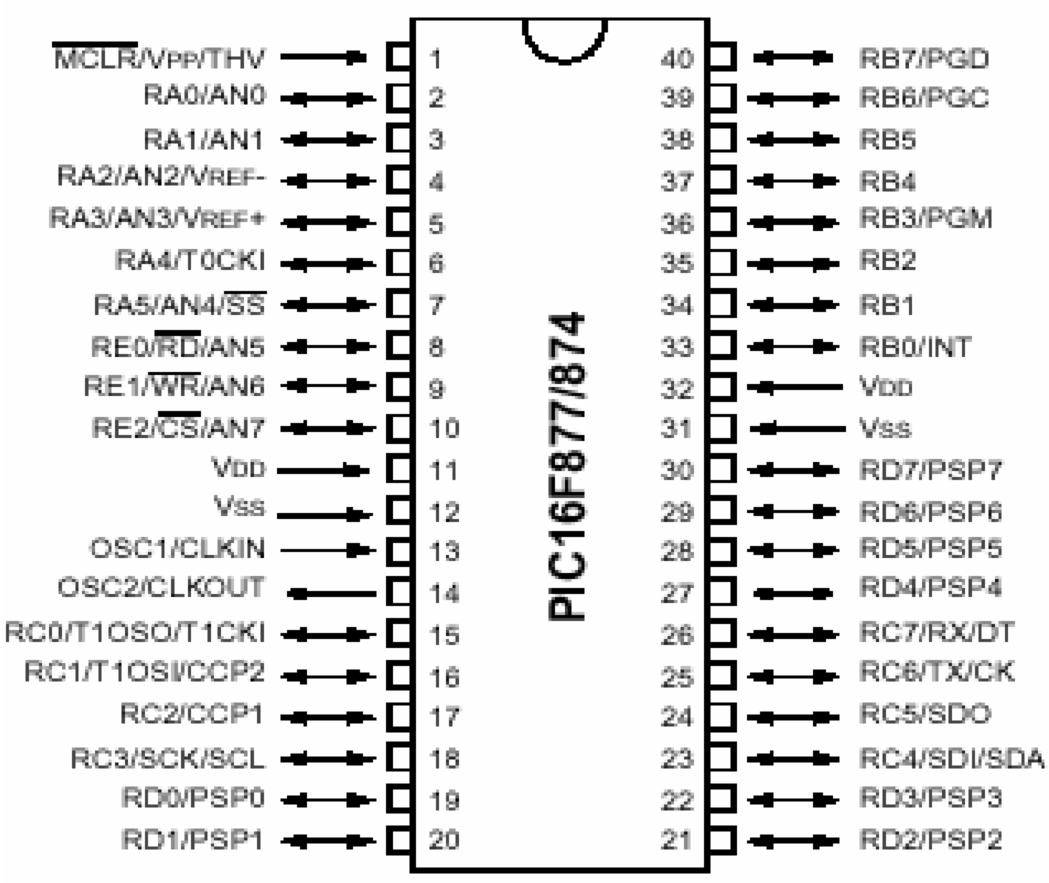

Figure.7. Pin Out of the PIC16F877A

Table .2. Features of PIC16F877A

Key Features	PIC16F877A
Operating Frequency	DC-20 MHz
RSETs (Delays)	POR, BOR, WDT
FLASH Program Memory (14-Bit Words)	8K
Data Memory (Bytes(	368
EEPROM Data Memory	256
Interrupts	14
I/O Ports	PORTS A,B,C,D,E
Timers	3
Capture, Compare and PWM Modules	2
Serial Communications	MSSP, USART
Parallel Communications	PSP
10-Bit Analogue-to-Digital Module	8-Input Channels
Instruction Set	35 Instructions

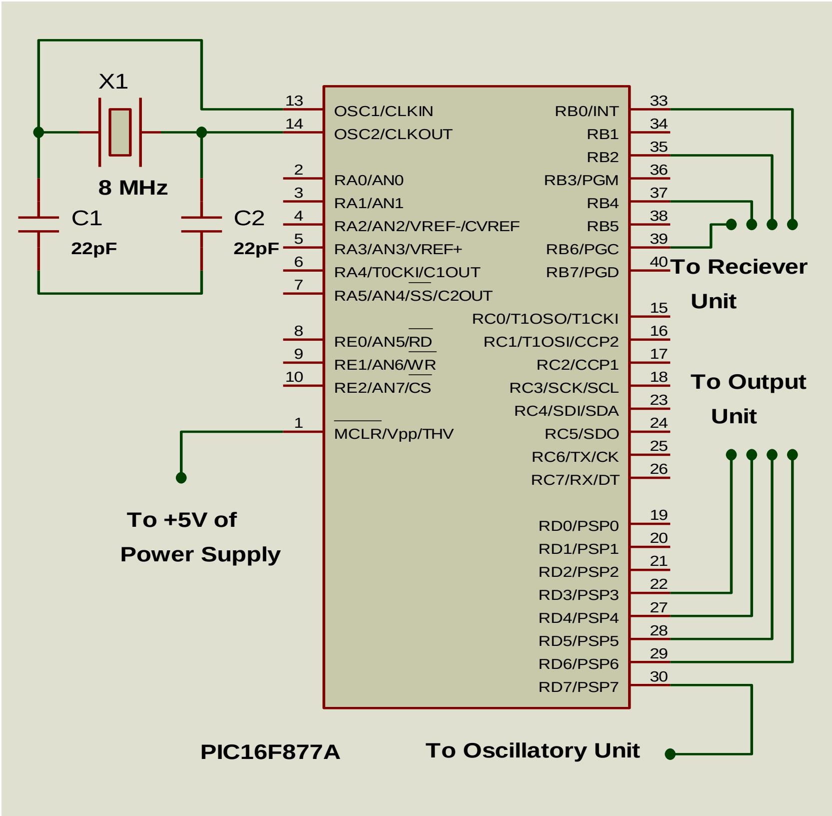

Figure.8. Circuit connections of Control Unit

From figure 8 schematic, pins 22 (RD3) to (RD5) are connected to the output unit while pin 30 (RD7) is connected to the oscillatory. Under program control, the PIC16F877A continuously monitors its input pins RB0, RB2, RB4 and RB6 to determine which of the buttons on the remote is active. Once the active button has been detected, control signals are then sent to the output unit which actuates the corresponding motor to turn as long as that button is depressed.

2.3.6 Output Unit

The output unit (Figure 9) consists of two bipolar stepper motors, an integrated stepper motor driver IC (L297) and two power drivers IC (L298). The L297 integrates all the control circuitry required to control bipolar and unipolar stepper motors. Used with a dual bridge driver such as the L298N, the L297 forms a complete microprocessor-to-bipolar stepper motor interface. The L298N and L293E contain two bridge drive stages, each controlled by two TTL-level logic inputs and a TTL-level enable input. In addition, the emitter connections of the lower transistors are brought out to external terminals to allow the connection of current sensing resistors. For the L298N, innovative ion-implanted high voltage/high current technology was used, allowing it to handle effective powers up to 160W (46V supply, 2A per bridge). A separate 5V logic supply input is provided to reduce dissipation and to allow direct connection to the L297 or other control logic.

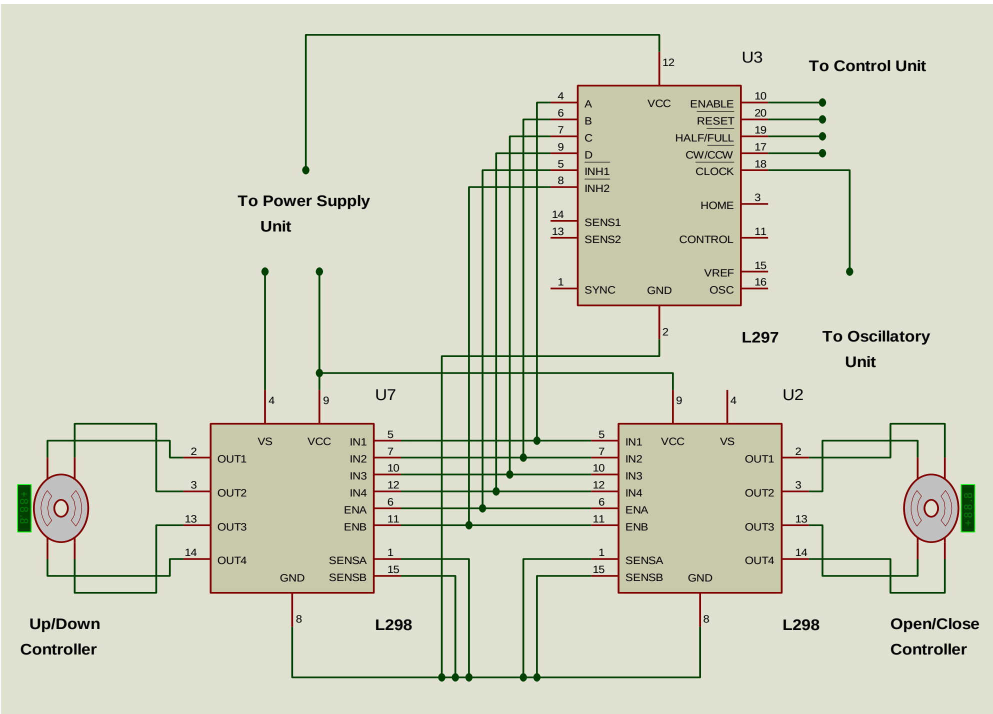

Figure.9. Circuit connections of Output Unit

The heart of the L297 block is a block called the translator which generates suitable phase sequences for half step, one-phase-on full step and two-phase-on full step operation. This block is controlled by two mode inputs – direction (CW/ CCW) and HALF/ FULL – and a step clock which advances the translator from one step to the next. Four outputs are provided by the translator for subsequent processing by the output logic block. Internally, the translator consists of a 3-bit counter plus some combinational logic which generates a basic eight-step grey code sequence. All three drive sequences can be generated easily from this master sequence. This state sequence corresponds directly to full step mode, selected by a low level on the HALF/ FULL input. The stepper motor used was the M49SP 7.5 degree bipolar stepper motor designed for an operating voltage of about 21.6V - 26.5V. It is a small stepper motor suitable for a large range of applications. It is mainly used in Air conditioner Louver, small cooling/heating fans etc. This stepper motor can be used for bi-directional purposes. Figures 10 and 11 show the constructed window blind in close and open operation respectively.

Figure.10. Constructed window blind in close operation.

Figure.11. Constructed window blind in open operation.

3.0 Tests: T

he system was tested as a whole by plugging the power cord for 22OV AC input into a wall socket with AC supply from commercial power supply while "no" button on the remote control was depressed. However, the main aim of the test was to see if the system could continue to function properly as designed by opening/closing the window blind (i.e. raising/ lowering the window blind) when there is electricity supply. To this end, the opening/closing feature of the system was first tested by depressing the close/open button on the remote while the system was observed. Subsequently, the raising/lowering feature of the system was then tested by depressing the raise/drop function button on the remote control while the system was observed.

3.1 Results

The result of tests carried out on the entire system using buttons on the remote control is tabulated in Table 3.

Table.3. Test results for constructed remote controlled blind

S/N	Remote Button	Operation of Window Blind
1	Open/Close	Opening and Closing of blind
2	Up/Down	Upward/Downward movement of blind

4. DISCUSSION

Results from test carried out on the constructed remote controlled window blind showed that the device was able to open/close the blind when the open/close button on the remote controls button was depressed. Similarly, test carried out on the system also showed the system was able to raise/lower the blind when the raise/lower button on the remote controls button was depressed. The control of the window blind was fully wireless as there was no manual intervention and this shows that the system respond as designed. The realizable working distance between the remote and receiver achieved was 10.66m. However, the distance achieved (10.66m) is acceptable for any practical purpose. At a distance of more than 10.66m, ambient background noise becomes a major factor affecting reliability of the transmitter and receiver circuits.

5. CONCLUSION

In order to eliminate human intervention as well as introduce some speed and flexibility in the operation of household window blinds, the remote controlled window blind system was constructed. It could move the window blind up/down or open/close when the control buttons on the remote controls are depressed. Such a facility will enable home owners to conveniently control their window blinds even at midnight from the comfort and safety of their bedrooms or anywhere within the premises of the house.

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