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Research Article

Design and Construction of a Wireless Remotely Controlled Video Capturing Vehicle II

Nathan David[1], Nmerenu, Chima David[2], Nwosu, Chineze Benita[2], Ogbaga, Onome James[2], Abioye, Ayodeji Opeyemi[3*]

[1]Lecturer and Project Supervisor, Department of Electronic Engineering, Faculty of Engineering, University of Nigeria, Nsukka.

[2]Final Year (2013), Undergraduate Project, Department of Electronic Engineering, Faculty of Engineering, University of Nigeria, Nsukka.

[3]Department of Electrical and Electronic Engineering, School of Engineering and Engineering Technology, Modibbo Adama University of Technology (MAUTECH), Yola.

***Corresponding author**
Abioye, Ayodeji Opeyemi
Email: abioyeayo@yahoo.com

Abstract: The Video Capturing Vehicle (VCV) is a robotic video capturing vehicle with full ground mobility. The control of the robotic vehicle is achieved using Dual Tone Multi Frequency (DTMF) technique. The VCV is controlled by a Remote Control System (RCS) which consists of a Personal Computer (PC) with a Graphic User Interface (GUI) application interfaced via Universal Serial Bus (USB) to a DTMF generating circuit and an FM transmitting circuit that sends DTMF codes via Radio Frequency (RF) link to the VCV robot. The robotic vehicle consists of an FM receiver, a DTMF decoding circuit, a microcontroller circuit board and an Internet Protocol (IP) camera. Using the DTMF codes, the direction and motion of the VCV, as well as the viewing angle of the VCV's camera is controlled by the RCS. The robot while moving, simultaneously captures video feeds using the IP camera attached to it and sends captured video feeds via Wireless Local Area Network (WLAN) to which the PC at the RCS is initially connected to. The received video feed is displayed on the GUI. This system finds application in diverse areas such as surveillance, viewing of human inaccessible area, experimentation (monitoring health hazardous areas remotely), military applications as well as other industrial and security pursuits.
Keywords: Binary Coded Decimal (BCD), Dual Tone Multi Frequency (DTMF), Graphic User Interface (GUI), Internet Protocol (IP), Radio Frequency (RF), Universal Serial Bus (USB) Interfacing, Video Capturing Vehicle (VCV), Wireless Local Area Network (WLAN).

Prologue

This project is based on an earlier work published as "Design and Construction of a Wireless Remotely Controlled Video Capturing Vehicle" by David and Abioye [1]; and therefore serves as a continuation of that project.

INTRODUCTION

Project Objectives

This project was aimed at improving/modifying an existing VCV project. Focus was put on

- Modifying the USB control device to wirelessly communicate DTMF codes from the computer system to the VCV remotely located;
- Modifying, designing and developing the VCV circuit system to
- Receive DTMF tones through an FM receiver,
- Decode the tones into Binary Coded Decimal (BCD) codes using a decoder, and
- Interpret the BCD codes into desired motor controls using a microcontroller.
- Improving the mechanical structure to reduce weight and improve turning efficiency through the use of gears.

PROJECT OVERVIEW

The robot is a vehicle with an antenna, with an IP camera mounted on it. It is remotely controlled from a computer system as shown in the figure 1 above.

The computer system has a GUI application running on it for viewing the video feed (from the IP camera) as well as sending control signals to the control device through button clicks.

As control buttons are clicked on the GUI, control signals are generated and transmitted via RF link by the USB interfaced control transmission device.

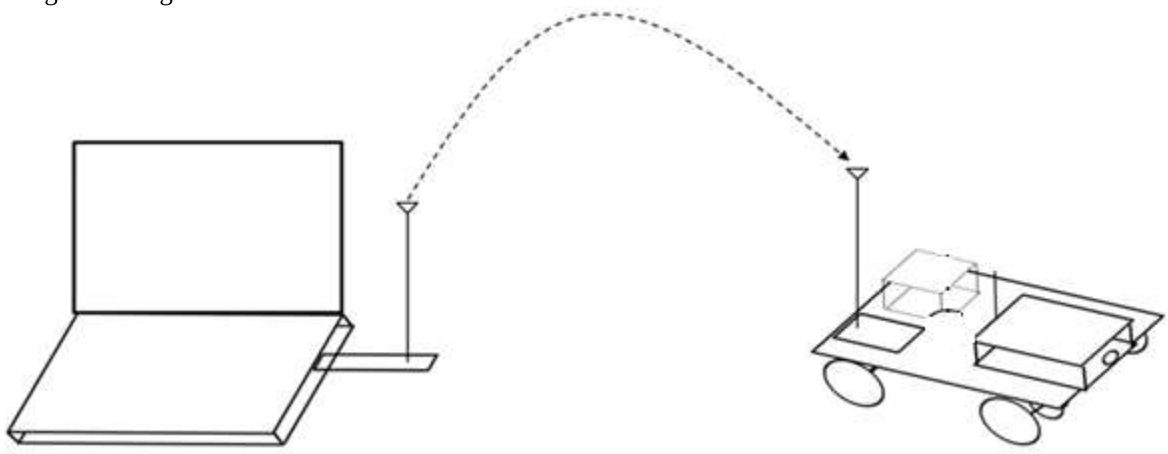

Figure 1: Graphical representation of VCV project

The modification brought here was that the control signals generated are now DTMF tones as against ordinary low frequency signals previously generated.

These control signals are received by the RF receiver at the VCV, decoded into BCD codes using a DTMF-BCD decoder and the microcontroller on the vehicle's circuit board interprets each BCD code received and executes the motor control by sending appropriate signals to the motor drivers.

The IP camera on the robot is preconfigured to broadcast a wireless Local Area Network (LAN). The computer system which runs the control GUI application has an in-built Wi-Fi Module for wireless LAN communication with the IP camera.

Video feeds are sent via WLAN from the IP camera on the VCV to the PC remotely situated and control signals are sent via RF link to the VCV from the PC at the remote location. This is illustrated in the block diagram of the VCV project shown in figure 2 below.

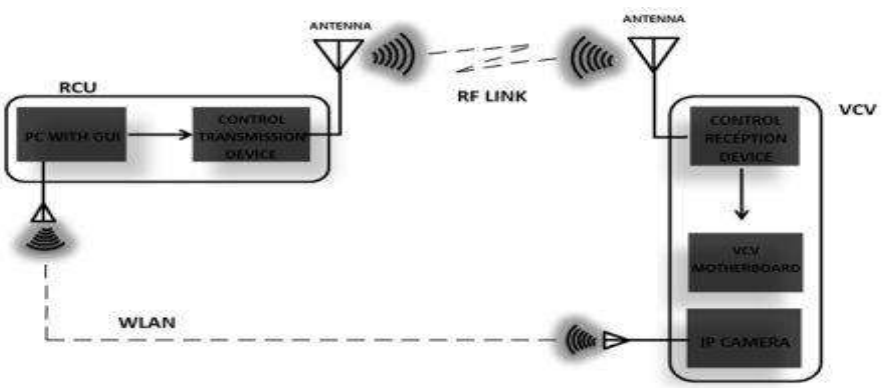

Figure 2: Block Diagram describing the Wireless Remotely Controlled VCV Project

Thus the computer system controls the vehicle and captures the video feeds from the vehicle wirelessly from a remote location with the range of the video feed capture being the standard 100m radius for WLANs and that of the control signals depending on the efficiency of the RF systems.

The project was modified to use DTMF technique as control signals generated because once successfully generated and transmitted, DTMF tones are far easily received and decoded as there are standard DTMF decoders available and this would reduce the complexity of writing codes to monitor and decoded frequency signals using microcontroller as was first used.

PROJECT AREA AND APPLICATION AREA

The VCV robot is a mechanical device that is controlled electronically. It falls under robotics which is a sub-field of Mechatronics which combines 2 main fields of Engineering; Mechanical Engineering and Electronic Engineering.

The Electronic Engineering aspect involved software development, computer interfacing, wireless communication, and powering and control of the robot; while the Mechanical Engineering aspect involved the structure design, material selection, fabrication of structure and mechanics.

This system finds application in diverse areas such as surveillance, viewing of human inaccessible area, military applications and other industrial and security purposes

THE VIDEO CAPTURING VEHICLE

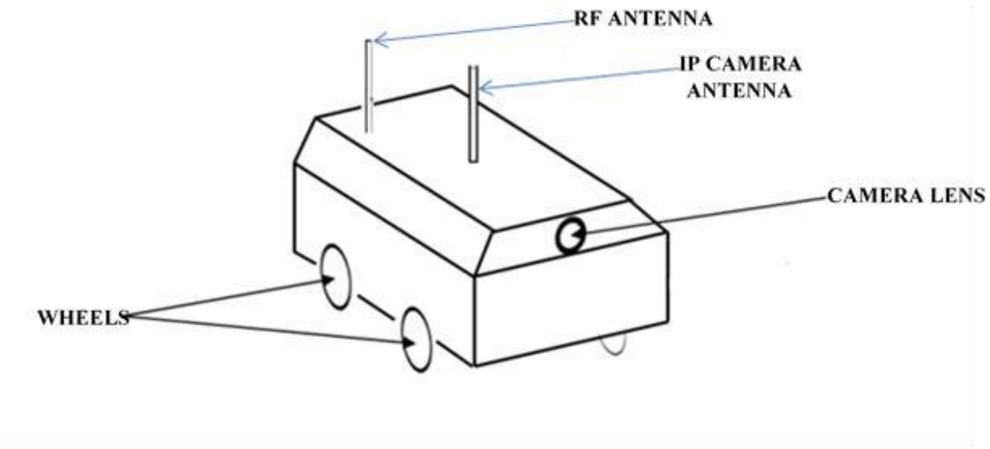

Figure 3: The features of the Video Capturing Vehicle Modified

After modifying the VCV structure, figure 3 above shows the new features of the VCV. The vehicle is now driven by the 2 back wheels while the 2 front wheels are used for direction control. The 2 back wheels are propelled by a DC motor and they move the VCV forward or backward while the 2 front wheels are propelled by a stepper motor which gives the controller the control over the angle or degree of turn (steering), after a turn is made, the back wheels will be required to push the VCV in the direction of steer after which the front wheels will be steered to the other direction to keep the VCV straight. The RF antenna receives control signals from the RCS while the IP camera antenna sends captured video feeds to the RCS during operation.

THE REMOTE CONTROL SYSTEM

The Remote Control System for the modified VCV consists of a PC and the Control Transmission Device modified for the project. The VCV computer application is required to be installed on the PC. The modified Control Transmission Device is a USB interface device connected to the PC, which receives commands from the VCV computer application via the USB port, and encodes this data into DTMF tones which is used to modulate the transmitter.

DESIGN MODIFICATIONS AND IMPLEMENTATION

DESIGN AND MODIFICATIONS

The block diagram in figure 2 describes the entire VCV project. It demonstrates the overall features of the whole project concept showing 2 main parts, the RCS and the VCV. Modifications were carried out within the 2 parts.

The block diagram of the RCS is illustrated in figure 4 which shows 2 main blocks, the PC and GUI application as a single block and the control transmission device as the other. Modifications were only carried out within the control transmission device.

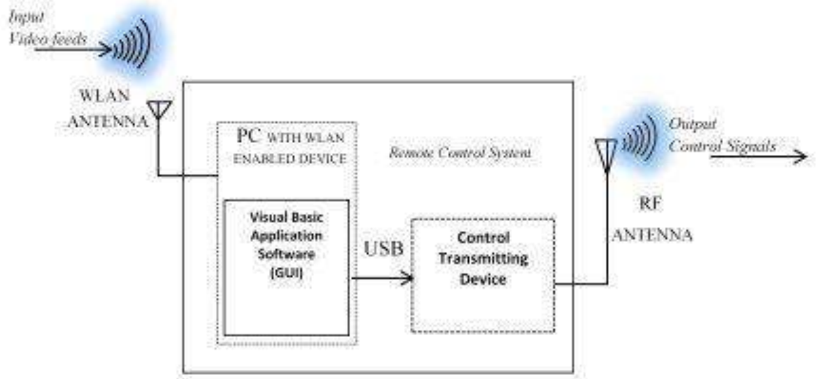

Figure 4: Block diagram describing the Remote Control System

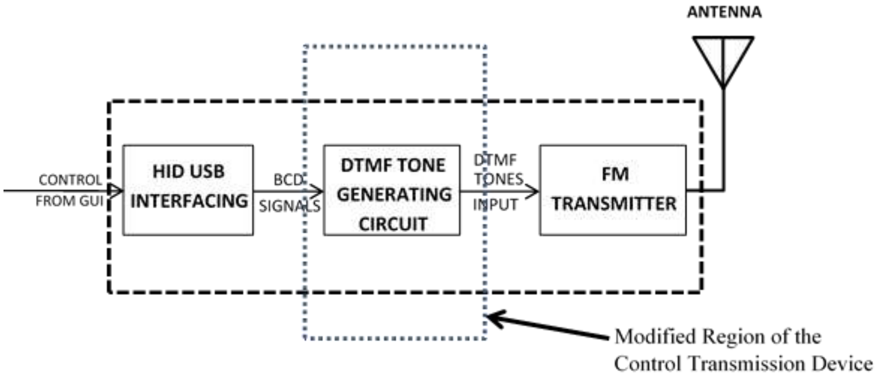

Figure 5: Block Diagram of the Control Transmission Device indicating where modifications were made

Figure 5 above indicates where modifications were made within the control transmission device. The frequency generated to modulate the FM transmitter is no longer carried out by the USB interfacing microcontroller; instead the BCD output from the microcontroller is fed into a DTMF encoding module to generate DTMF tones to uniquely identify each control signal.

Modifications made at the VCV end of the project were:

- To include a DTMF decoding module after the FM receiving module to properly decode each received tone back to the original BCD code initially encoded.
- To provide a new microcontroller circuit board to control the motors using BCD signals instead of decoding frequency of signal received based on interrupts before taking action.
- To incorporate some degree of control into the angle of view of the IP camera

REASONS FOR MODIFICATIONS

These DTMF modifications were carried out because it was discovered that after transmitting a particular signal frequency without DTMF, the microcontroller at the VCV did not receive the exact number of interrupts expected for a particular frequency as observed, in that the action executed sometimes was different from the signal transmitted. This was due to noise and interference, although a range was provided for, sometimes the range got exceeded.

Also the view of the camera was observed to be fixed and could only view the legs of people and objects since the bot was simply a small vehicle.

IMPLEMENTATION

Applying the modifications to the design was done in a step-wise manner; this gave us the chance to evaluate and improve our modifications along the way.

MODIFICATIONS AT THE RCS

Incorporating the DTMF encoding module into the control transmission device at the RCS was done using the block diagram in figure 6 below. Each BCD signal output from the USB interfacing microcontroller PIC 18F2550 is decoded by a BCD to decimal decoder 74HC154 to produce a single output with decimal value as shown in table 1; each output is used to switch a transistor in an array of transistors arranged in the manner of a keypad. Each transistor switched, connects the pins needed to encode appropriately DTMF tones corresponding to the decimal value of the BCD signal received from the USB microcontroller as shown in table 2 using a DTMF generating IC UM91214A which uses a keypad facility to generate DTMF tones in tone dialing circuits as shown in Figure 7.

Figure 6: Block diagram showing level 3 description of how the control DTMF tones are generated

Any tone produced at each button clicked on the GUI was now used to modulate the carrier of the FM transmitter on the control transmission device. This worked perfectly as the tones were heard on the speaker of an FM transistor radio tuned to the FM transmitter on the control transmitting device at the RCS.

Table 1: A table showing each control button and corresponding unique logic signal

Button- Click	BCD output	DECIMAL VALUE
Forward	0001	1
Backward	0010	2
Right	0011	3
Left	0100	4
A (Camera up)	0101	5
B (Camera down)	0110	6

Table 2: A table showing the keypad interfacing logic with the corresponding DTMF Tone produced by the IC chip and how we used it.

Control Function	Decimal value	DTMF Row and Column Combination	UM91214 Chip Pin connection	DTMF TONE GENERATED
Forward	1	Row1, Col 1	Pin13 and Pin 10	697 Hz + 1209 Hz
Backward	2	Row1, Col 2	Pin13 and Pin 11	697 Hz + 1336 Hz
Right	3	Row1, Col 3	Pin13 and Pin 12	697 Hz + 1477 Hz
Left	4	Row2, Col 1	Pin14 and Pin 10	770 Hz + 1209 Hz
A	5	Row2, Col 2	Pin14 and Pin 11	770 Hz + 1336 Hz
B	6	Row2, Col 3	Pin14 and Pin 12	770 Hz + 1477 Hz
Test	0	Row4, Col 2	Pin16 and Pin 11	941 Hz + 1336 Hz

	Column 1	Column 2	Column 3	
Row 1	1	2	3	697Hz
Row 2	4	5	6	770Hz
Row 3	7	8	9	852Hz
Row 4	*	0	#	941Hz
	1209Hz	1336Hz	1477Hz	

Figure 7: Showing DTMF frequencies for rows and columns used in tone dialing

MODIFICATIONS AT THE VCV

The DTMF-BCD decoder MT8870 was used to decode each DTMF tone received via FM receiver into BCD codes which are inputs to the microcontroller on the VCV motherboard. The motherboard now uses PIC16F877A, as its microcontroller. This microcontroller is responsible for the processing of the received DTMF decoded signal which is now in BCD and sending control signals to execute the required function such as motion of VCV or camera view control. The microcontroller is the brain of the VCV motherboard.

Two L293Ds, a push-pull four channel driver were used to interface one bipolar stepper motor and two DC motors to the microcontroller for controlling the front wheels (stepper motor for direction steering), back wheels (DC motor for forward and reverse motion) and camera view adjust(DC motor for tilting camera up or down) respectively. The microcontroller sends in the drive patterns to the appropriate driver IC. The PIC 16F877A was programmed using micro C programming Language, a variant of C programming Language. The flow chart that was used to develop the firmware for the VCV version 2 is shown in figure 8 below.

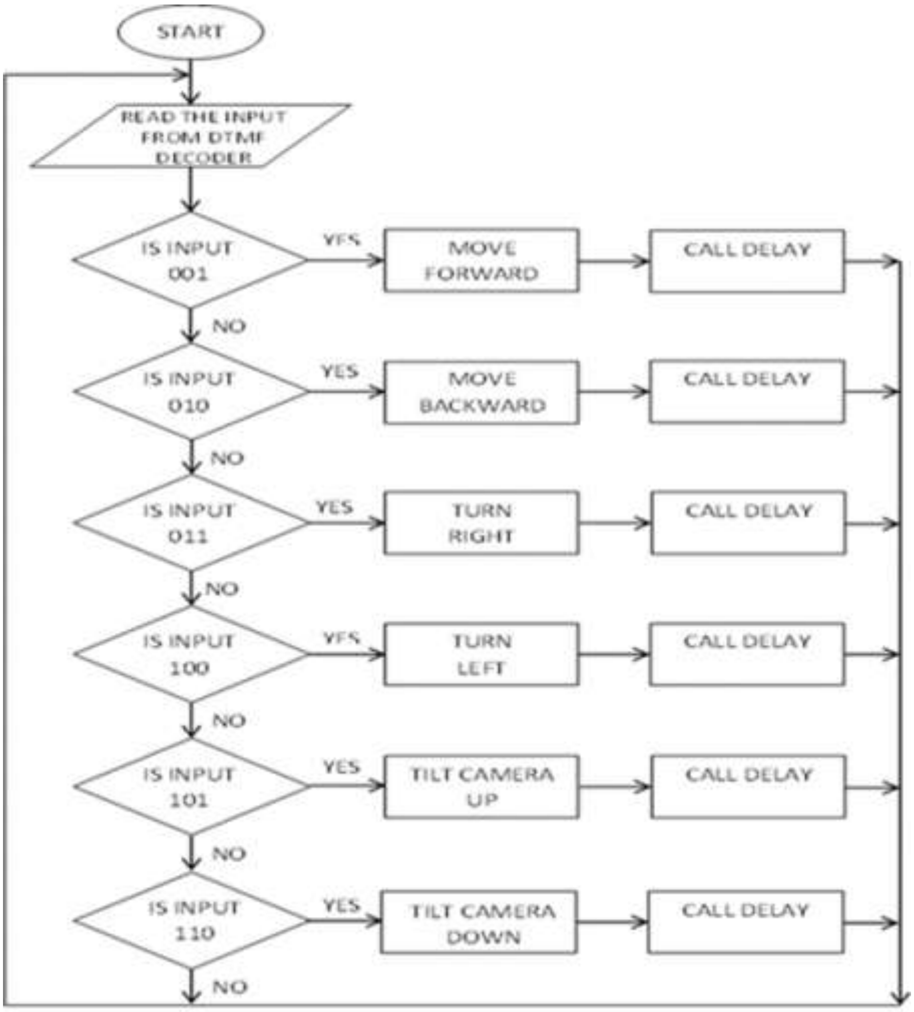

Figure 8: Flowchart describing the VCV firmware Algorithm

PROJECT RESOURCES

Modification of the VCV project was successfully achieved through consultation of various textbooks, projects [1], theses, and other online materials as well as through the help of our supervisor, lecturers, friends and online forums as have been referenced in the project write up. [2-10]

CONCLUSION

The Wireless Remotely Controlled Video Capturing Vehicle is a robotic vehicle with full ground mobility and video capturing ability. It is modified and now controlled using DTMF tones generated remotely from Remote Control System which consists of a computer application (GUI) running on a PC and a USB interfaced control transmission device. The robotic vehicle receives and obeys control commands via RF link as well as sends video feeds captured via WLAN to the PC at the RCS.

This system finds application areas such as surveillance, viewing of human inaccessible area, experimentation (monitoring health hazardous areas remotely), military applications as well as other industrial and security purposes.

LIMITATIONS

The range of RF communication between the VCV and the RCS was found to be too small. This was due to the inefficiency of the RF circuits we built which was as a result of time constraints and little experience with RF circuits.

This led us to make provision for the use of a mobile phone for the purpose of demonstration. The VCV now has an earphone connector which connects to mobile phone. The mobile phone is set to automatic answer; when the phone is called and the phone answers the call, DTMF tones can be sent to the VCV from the calling phone. Using this, the VCV can be controlled wirelessly via the GSM network while still sending video feeds to the PC via WLAN.

RECOMMENDATIONS

Practical lectures in the area of RF communication circuits should be provided for students, especially in the area of RF remote control systems both short and long ranged. Mechatronics projects should be encouraged as a collaborative effort of both mechanical and electronic engineering students. This would

improve the efficiency of the students and reduce time constraint issues.
This project is recommended for further research.

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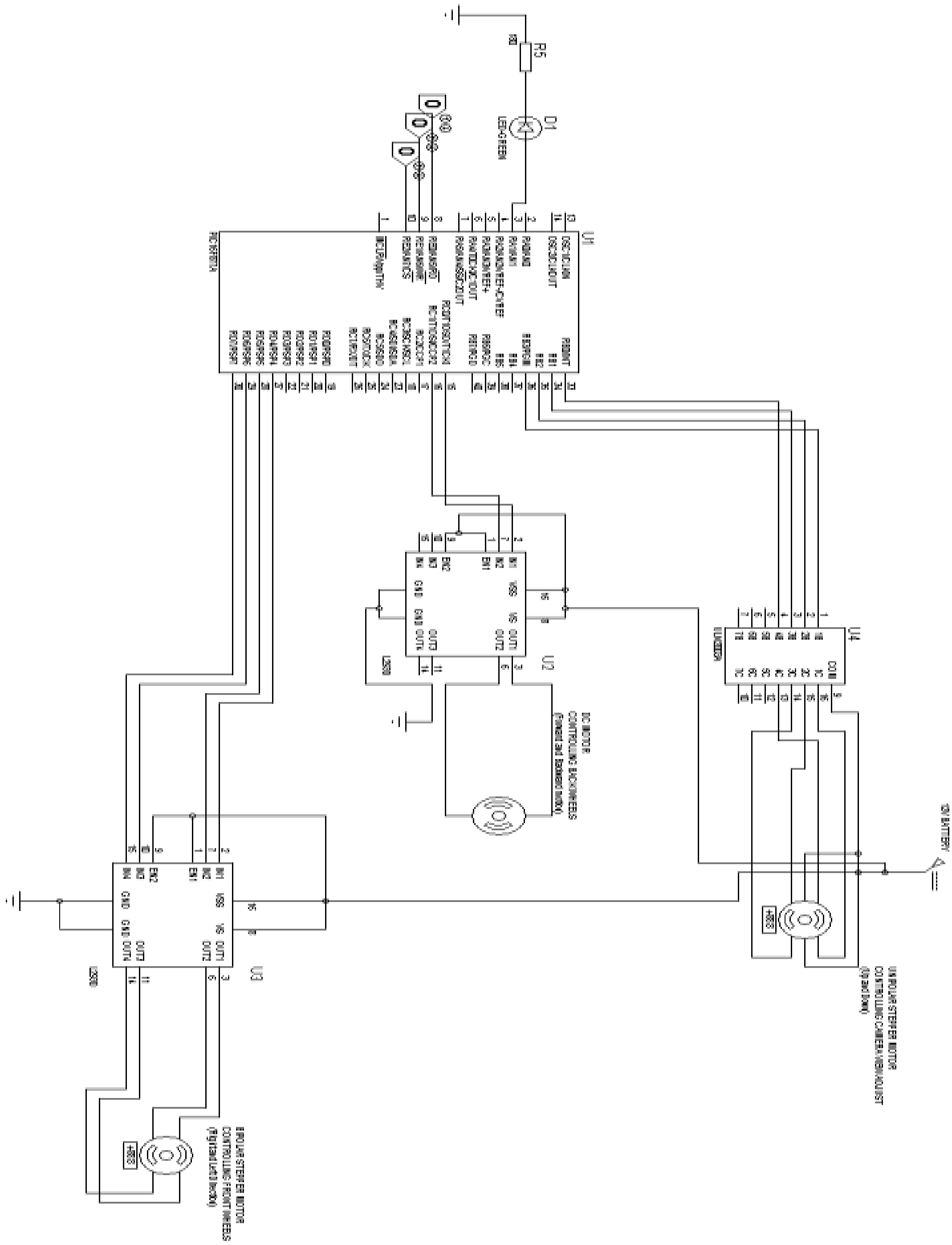
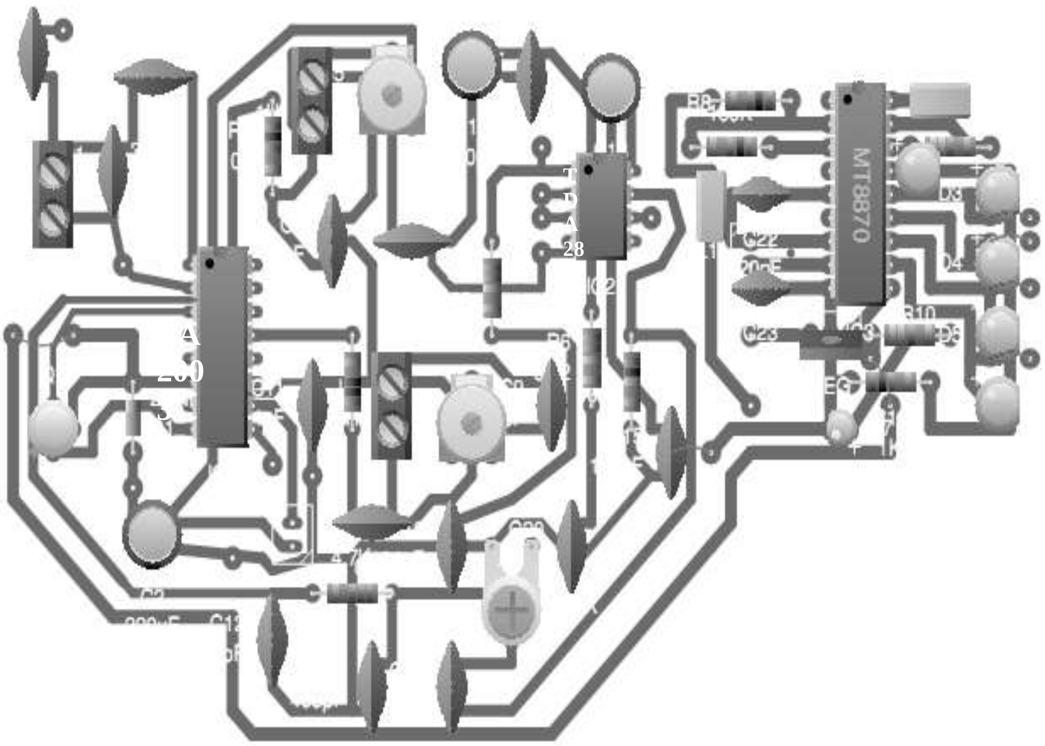
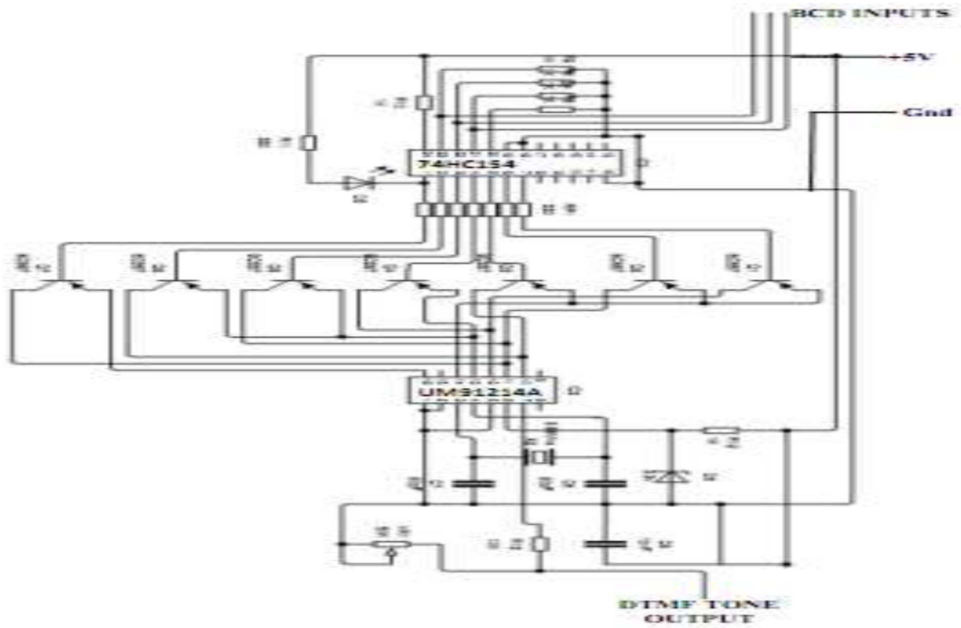


CIRCUIT DIAGRAMS OF DESIGN MODIFICATIONS
VCV MAIN CONTROL CIRCUIT BOARD



FM RECEIVER AND DTMF DECODING CIRCUIT (PCB VERSION)



DTMF GENERATING CIRCUIT USING BCD SIGNAL INPUTS

VCV before modifications

VCV before modifications

VCV top view

VCV side view

Control Transmission Device connected to PC (with GUI application running) via USB

VCV bot structure yet to be assembled

PICTURES