VAHCS

VOICE ACTIVATED HOME CONTROL SYSTEM

Senior Project Report

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Abstract

VAHCS is a voice activated remote control that operates infra-red activated devices. This project consists of two subsystems: the voice activation subsystem that uses a Sensory Voice Direct II kit, and the IR sub-system uses the MircoPac Evaluation (EMAC) board. The EMAC board records the devices' existing IR sequences. A menu-interface, run on the Emac board, allows the user to record command words through the Voice Direct II, and to associate multiple IR commands to each of them. A recognized command word triggers the corresponding IR sequences to be recalled from memory and transmitted to the controlled devices.

Contents

Introduction:

The scope of this project is to create a voice activated system that remotely controls electronic appliances in a home. Figure 1 shows a block diagram of the system. The system will utilize two voice-recognition integrated chips which have the functionality to learn 15 separate commands each. The chips communicate through a hardware interface with an 80515 based-microcontroller. The microcontroller interprets an inputted voice signal which triggers a hardware device outputting the corresponding infrared (IR) signal. The microcontroller learns IR commands through a second IR hardware subsystem connected to the microcontroller.

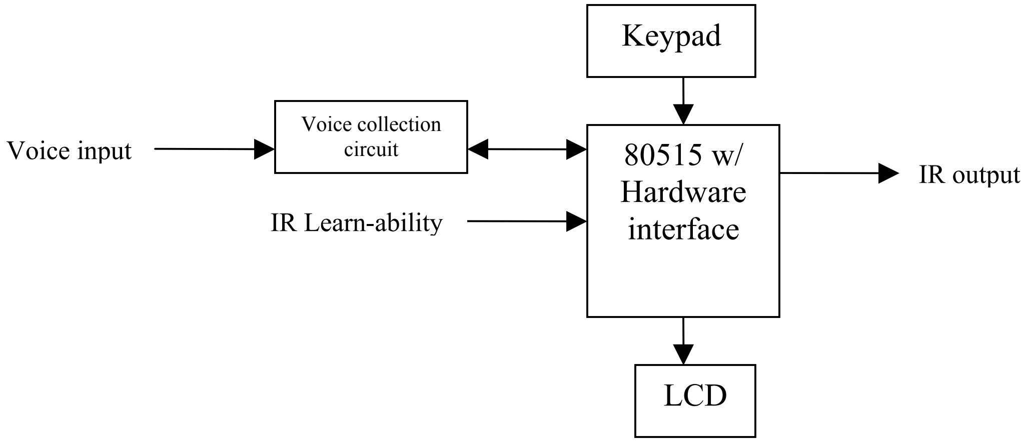


Fig. 1: *Block Diagram: Inputs: the operators voice command, a keypad, and IR collector. Outputs: an IR emitter, an LCD display.*

System Description:

The system consists of two systems or two sets of 15 possible commands, each labeled by a recorded system name or a trigger word. Once a system is named via the user interface, as to differentiate between different IR receivers, commands can be added (maximum of 15 per system). Each system name or command name has a maximum capacity of 2.5 seconds. Upon recording a new command via the user interface, the voice command number (1-15) is saved with its system number (1 or 2) and a series of five corresponding IR signal location in external memory. The user is then able to record up to five IR inputs for each voice command. This multiple IR capture allows for commands such as “channel 23” which requires IR output ‘2’ then ‘3’ followed by ‘Enter’. Once a command is entered under a named system, the VAHCS controller automatically enters a continuous listening mode, this is noted by a “*” in the bottom right of the LCD. This allows a user to say the trigger word (system name), followed by the entered command name at any time. If the trigger word and command word are recognized the microcontroller receives an 8-bit parallel input from the Voice Direct II collection circuit. This then references the five corresponding stored IR signals which are then output through the IR output hardware.

The hardware is composed of signal conditioning IR input and output circuitry. The input IR hardware reads, translates, and inputs an IR signal into the microcontroller. The output IR hardware translates and outputs the correct IR signal, by OOK (On/Off Keying) modulation, to the desired appliance.

Modes of Operation:

There are two primary modes of operation. The first family of modes refers listening for a command work and transmission of IR. Refer to Figure 2 for a diagram of the modes of operation in this family. The initial mode of this family is the *waiting for a command* mode. This refers to the system waiting for a voice command to be given. The system will remain primarily in this mode. Once a command is received it must be compared with those stored in memory, hence the second mode is called *the compare mode*. If the command is not in memory the system returns to the *waiting for command* mode. If the command is present in memory its associated IR command string is fetched from memory and transmitted to the controlled device.

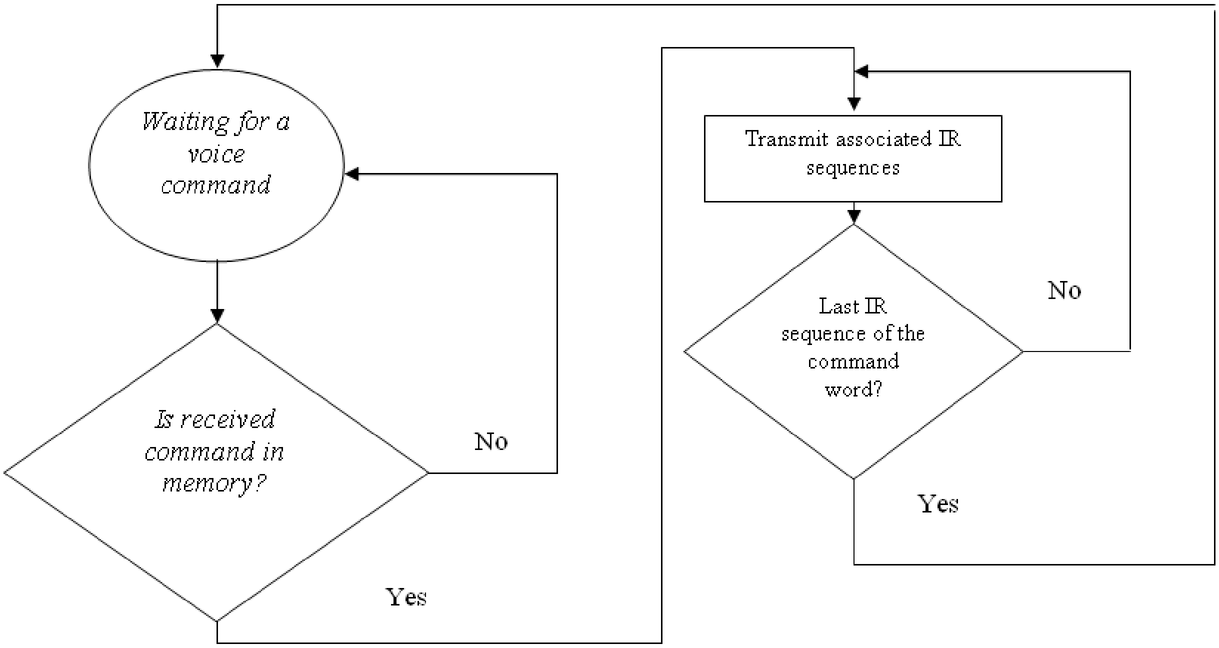

Waiting for a voice command
Is received command in memory?
No
Yes
Transmit associated IR sequences
Last IR sequence of the command word?
No
Yes

Fig. 2: *Diagram of the primary family of operational modes*

The second family of operational modes refers to the learn-ability of the system. This family is initiated by a user inputted key press. Refer to Figure 3 for a diagram of the learning family modes of operation. The first mode encountered by this system is the *voice learn mode*. It is in this mode that a voice command is stored in memory; this data will be used by the *normal function family* during the *compare mode*. The second mode entered during the *learn family* is the *capture IR* mode. This mode captures and equates IR commands to the voice commands previously learned. On completion of this mode the system returns to the *waiting for a command mode*.

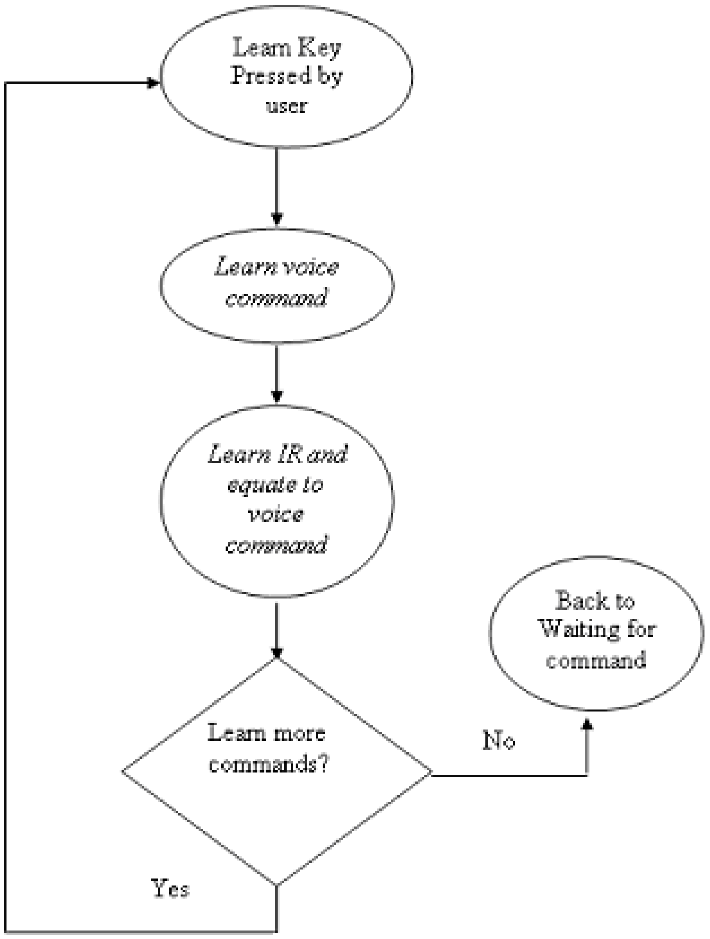

Learn Key Pressed by user
Learn voice command
Learn IR and equate to voice command
Back to Waiting for command
Learn more commands?
No
Yes

Fig. 3: *The learning family of operational modes (those in italics are modes)*

System Block Diagram:
Please refer to Figure 4 to identify all subsystems discussed.

<u>Subsystem</u>**:** 80515 u-Processor, LCD, Keypad & External Memory (EMAC board)
This hardware package contains the LCD and keyboard. The microprocessor is also embedded on this board. The LCD and keyboard all communicate with the microprocessor via a pre-programmed signal processing function. The first input to this subsystem is the IR TTL level pulses received from the IR Receiver. The second input is from the voice activation chip. The Voice Direct II signal locations are transmitted to the EMAC board by way of Parallel 8-bit input.

The first output of the EMAC board is TTL level pulses to the IR transmitter. IR codes are stored in memory located on the PUI board. When this subsystem gets a command from the Voice Direct II to transmit the IR codes, TTL pulses (representing the IR codes) are sent to the IR transmitter. The second output of the EMAC board is a series of TTL level pulses to control the Sensory Voice Direct II subsystem. These signals will request the Voice Direct II to learn a new word, listen for a previously learned word, or to erase the words stored in memory.

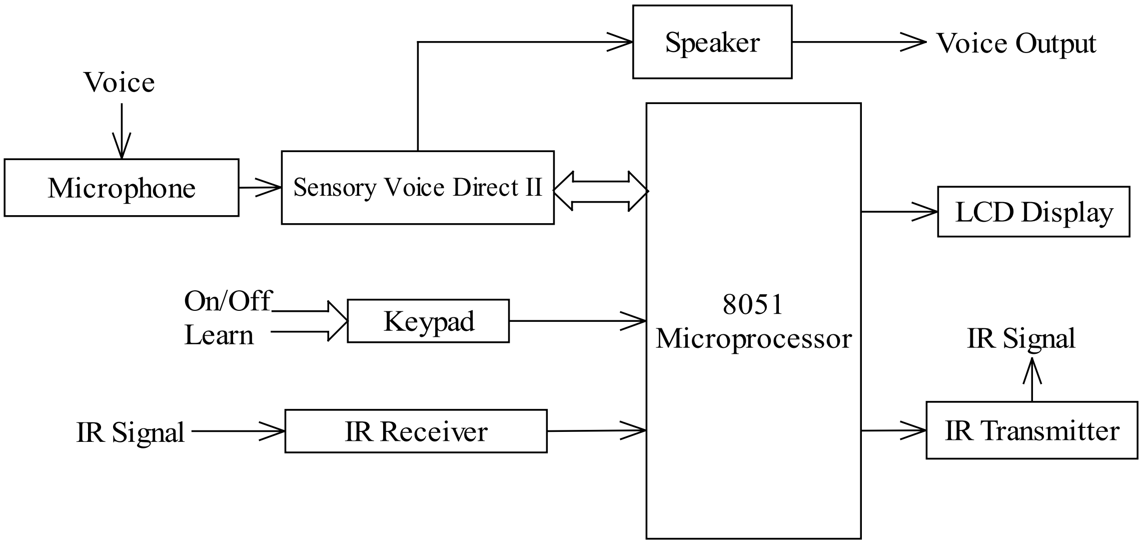


Fig. 4. *Complete system level block diagram.*

Subsystem: IR Receiver

The IR receiver has two purposes. The first task is the retrieval of IR signals passed to it via an IR transmitter (from a remote control.) These signals are made up of photons. The second task of this subsystem is to demodulate the received IR signal. This means that the receiver will transform a 38 kHz sine wave into a low state output and the absence of that sine wave into a high state output. Since the sine wave will vary in frequency (dependant on manufacturer of the remote control) it may be necessary to include 3 or 4 different receivers to demodulate the different frequencies.

Subsystem: IR Transmitter

The IR transmitter will output modulated IR codes. These IR codes will be in the form of photons and electromagnetic waves. The input of this system is received from the EMAC board. The input signal will be in the form of TTL level pulses.

Subsystem: Sensory Voice Direct II (VDII) Voice Activation Chip

The input of this subsystem comes from an onboard microphone; the millivolt level signal (from the microphone) is in the form of a voltage waveform representing a spoken word. This subsystem decodes a 2.5 second recorded signal or template and compares it with previously recorded templates stored by the VDII. This subsystem is controlled by a series of input pins on a bus from the EMAC board. The pins float high (+ 3.4[V]) and are pulled low (GND) for a duration of 105[ms] to trigger different operations. Operations include: record system name, record command name, stop recording, begin listening, stop listening, and delete system memory.

The first output of this subsystem is a preprogrammed user interface which requests the user to record words. The subsystem also has preprogrammed notifications such as a beep for recognition of a spoken word and "memory erased" for the delete stored operation. The second output of this subsystem is to the EMAC board. This is a parallel TTL level 8-bit output that identifies the memory location of a recognized word.

Subsystem: Microphone

The input of this subsystem is audio waves. These waves need to be clearly spoken words to be correct signals for the overall system. This subsystem transforms these audio waves into voltage waves which are received by the Voice Direct II chip.

Subsystem**:** Speaker

The input of this subsystem is an analog voltage wave that carriers a spoken word. The output of this subsystem is a spoken word in the form of sound waves.

Both the Microphone and Speaker are embedded in the voice Direct II

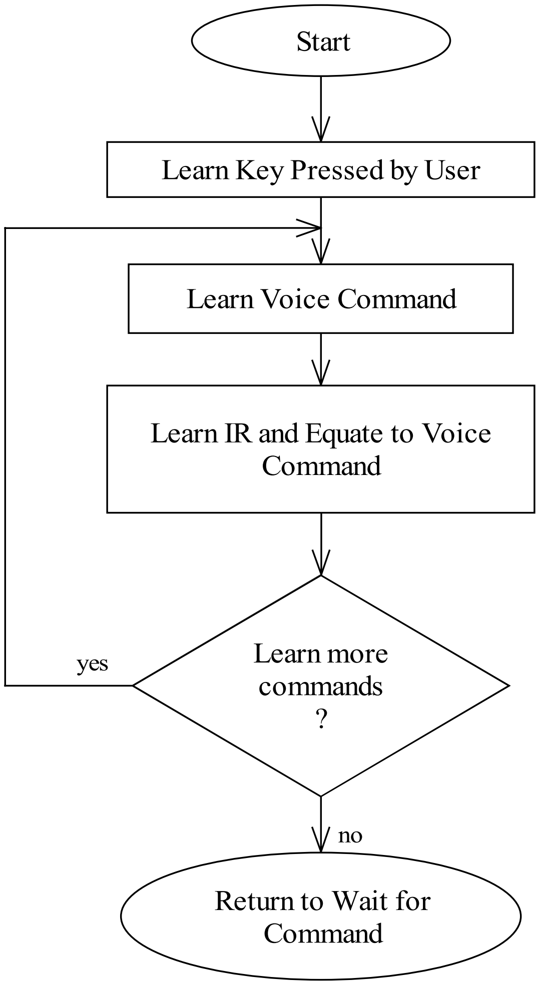

Start
Learn Key Pressed by User
Learn Voice Command
Learn IR and Equate to Voice Command
Learn more commands ?
yes
no
Return to Wait for Command

Fig. 5a *The Logic of IR capture.*

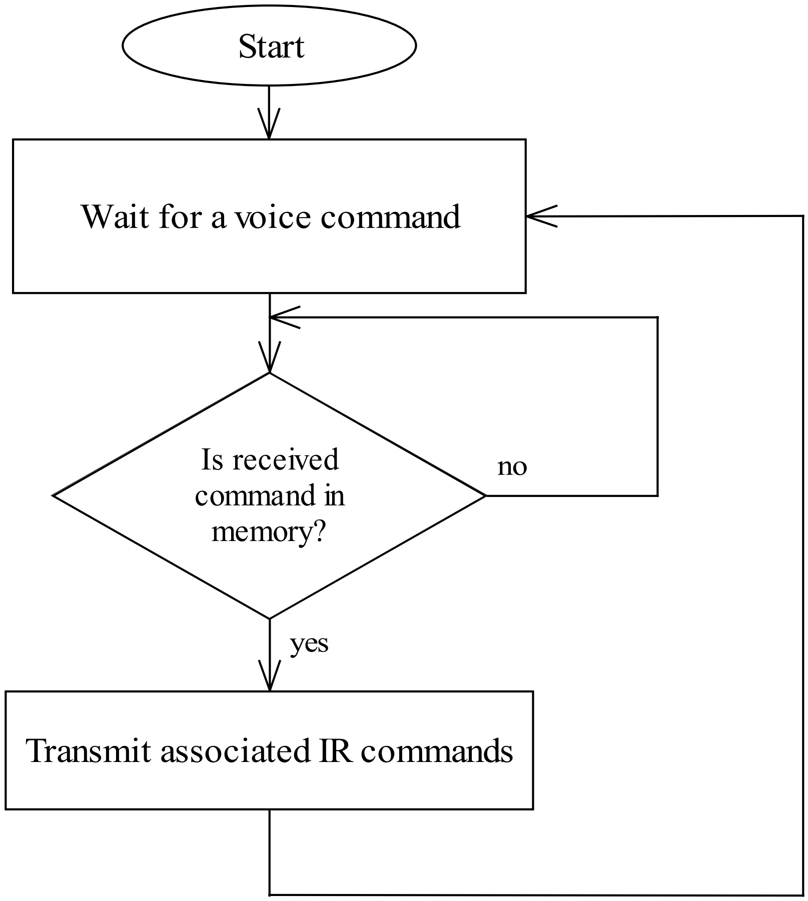
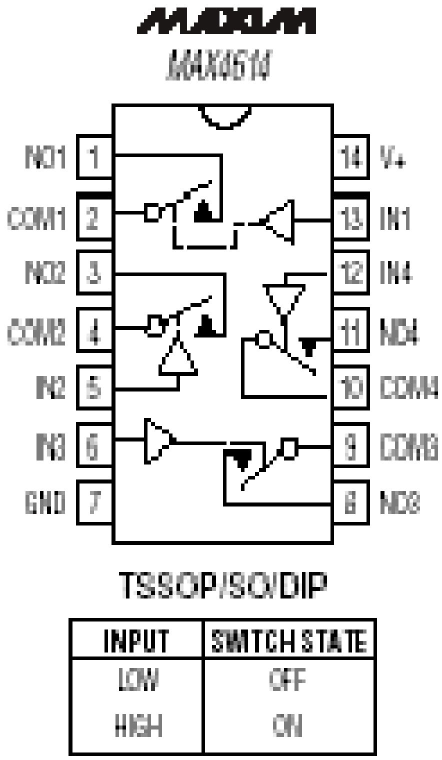

Start
Wait for a voice command
Is received command in memory?
no
yes
Transmit associated IR commands

Fig. 5b *The Logic of capture IR transmit.*

Design Equations and Calculations

Voice Recognition

The Voice Direct II (VDII) chip is mainly controlled by three input pins: TRIG-TRAIN (J1-08), TRAIN (J1-04), RECOG (J1-06). When powered these ports float at a TTL level high = 3.4 V, and are active high. The pins are activated via user inputs to the EMAC controlled user interface. Activated consists of a 105 ms +5 V output from a corresponding EMAC port. This output is connected to a CMOS switch in a MAX4614 quad-CMOS chip, pin-outs are shown in Figure 6. The EMAC outputs to the MAX4614 chips to the VDII inputs are shown in Figure 7. The EMAC outputs correspond to the INX ports on the MAX4614, the VDII inputs correspond to the COMX ports and the NOX ports are connected to ground. Therefore when EMAC output is activated the CMOS switch pulls the VDII floating HIGH input LOW for approximately 105 ms, before returning it HIGH activating the rising-edge triggered VDII input pin. A sample scope reading of the EMAC output and VDII input is show in Figure 8.



INPUT	SWITCH STATE
LOW	OFF
HIGH	ON

Fig. 6: *The Pin-outs for the Maxim 4614 CMOS chip bank.*

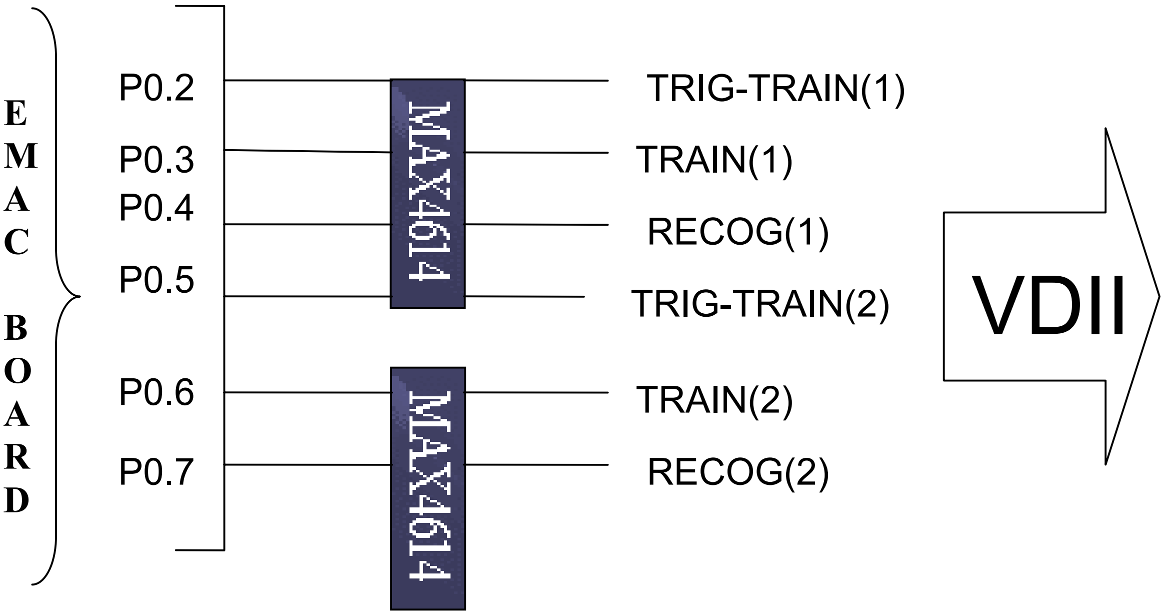


Fig. 7: *Emac pin-outs to CMOS switch to VDII inputs.*

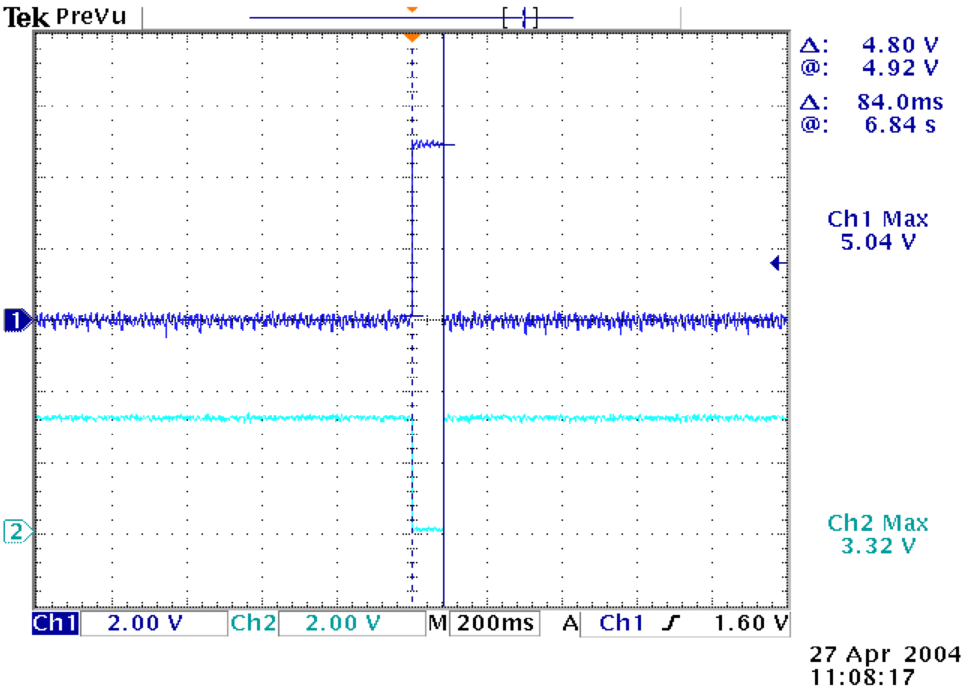


Fig. 8: *Sample output: Channel 1 – output from EMAC; Channel 2 – input to VDII*

IR software design equations

The IR subsystem requires a timer driven interrupt every 100 µs in order to capture and transmit IR sequences. Timer 0 generates an interrupt every time it overflows. The timer 0 register will be loaded with a value from which the counter will start counting. Once the timer goes from FFh to 00 the overflow interrupt will occur.

Each count takes 1.08 µs, therefore 92 counts are needed. The overflow requires a count so 91 counts is needed.

255-91=164, 164 is the reload value which translates to A4h.

The IR subsystem takes 720 samples per IR sequence. Therefore, a counter must be programmed to count up to 720. Individually registers can only count to 255, therefore two registers are required. Register 2 must overflow 3 times to count up to 720. One the first overflow it is reloaded with 0, on the second overflow it is reloaded with 23h. A second register is used to count the overflows.

255+255+x=720
x=210
255-210=40
255+255+(255-40)=720

Modulator hardware design

The IR transmitter is an LED. This LED has a maximum current of 100 mA, therefore the maximum current the design allowed through was 76 mA.

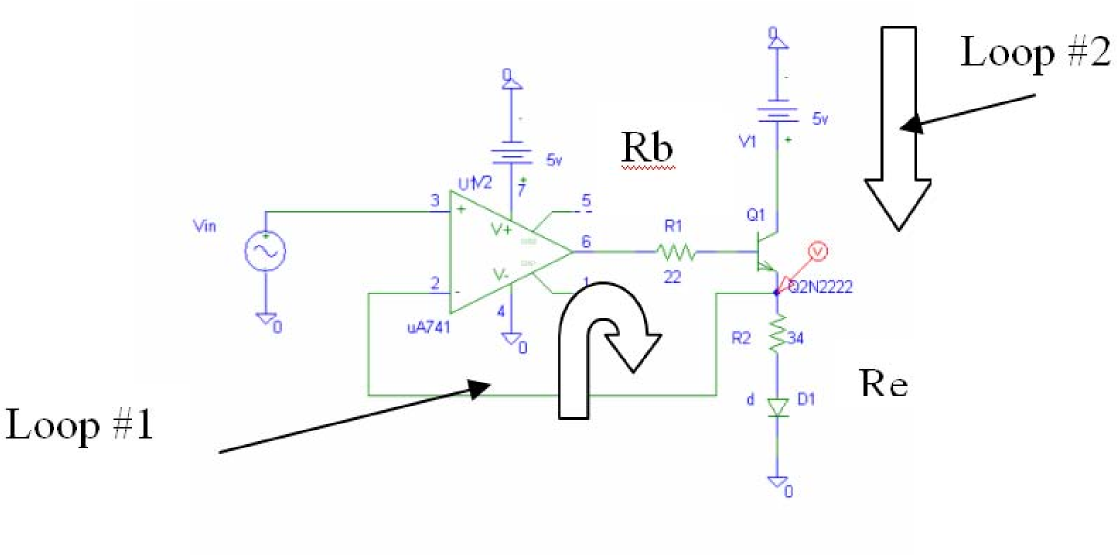


Fig. 9: *The circuit for the IR modulator, this circuit is included to fully explain the design equations of the modulator.*

The OP-AMP saturates at 4.3 V.

HFE is assumed to be 50. This in the minimum value, if it is higher more current will pass through the LED, this is ok because the design is 24 mA away from max current of the LED. There is a 1.2 voltage drop across the LED. A Vce of .3 is assumed to be the limit of the active region of the transistor.

Doing a KVL around loop #1 yields:

$-4.3 + Rb(Ib)+.7+Re(Ib+Ic)+1.2=0$

Doing KVL around loop #2 yields:

$-5 +.3+Re(Ib+Ic)+1.2=0$

$.076=Ic+Ib$

$Ic=50*Ib$

$Ib=.0015mA$

$Re=67\Omega$

$Rb=34\Omega$

However, values are not standard; therefore both resistors will be 47Ω.

Circuit Diagrams:

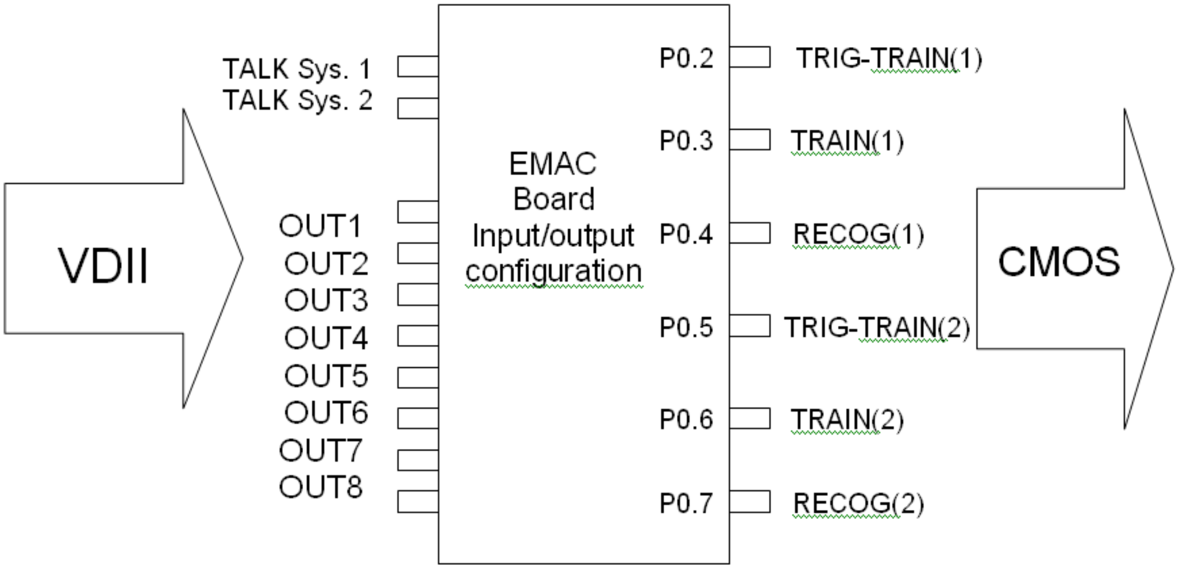


Fig. 10: *EMAC control of Voice Direct II boards*.

The EMAC control of the VDII is shown in Figure 10. The three main inputs to the two VDII boards are shown entering the MAX4614 or CMOS switches. The inputs to the EMAC board are the two talk signals and the 8-bit parallel input, which is shared by the two VDII boards. As the parallel input to the EMAC is active HIGH so the inputs must be ORed together, knowing only one will input at a specific time.

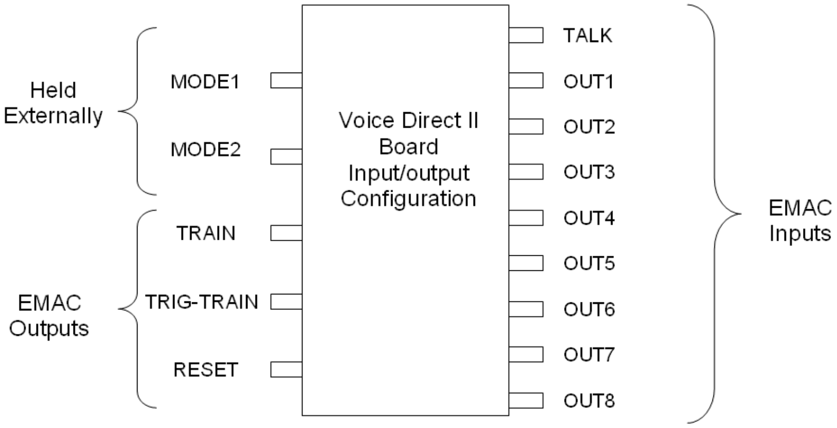
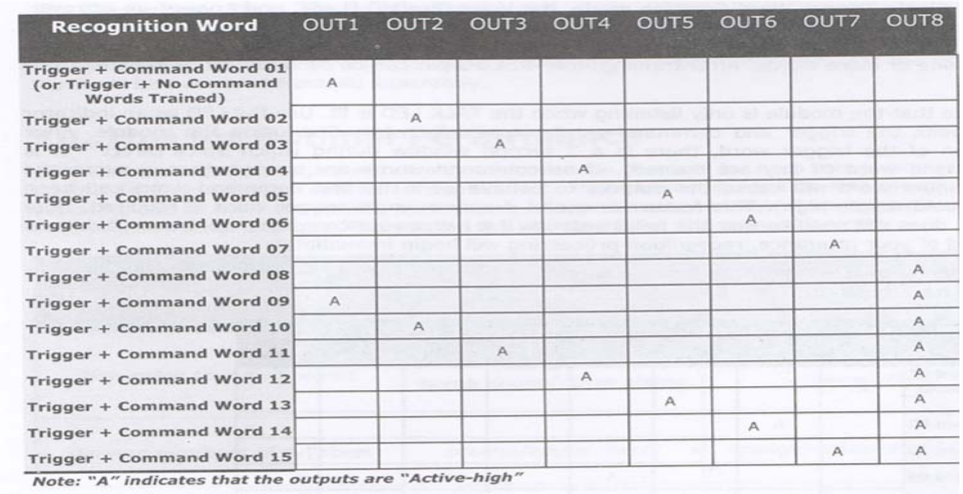


Fig. 11: *Voice Direct II I/O configuration*

Then Voice Direct II boards have five main inputs and nine main outputs as shown above in Figure 11. For the VAHCS application only single trigger continuous listening mode is utilized, MODE1 is held to GND and MODE2 floats TTL HIGH. The TRAIN, TRIG-TRAIN and RESET pins float TTL HIGH and are pulled low by EMAC controlled CMOS switches. The TALK output is TTL HIGH and remains high while the board is listening. The pins OUT1-8 form an 8-bit parallel output to the EMAC which is active TTL HIGH. The possible configuration for the 8-bit parallel output is shown in Figure 12.



Recognition Word	OUT1	OUT2	OUT3	OUT4	OUT5	OUT6	OUT7	OUT8
Trigger + Command Word 01 (or Trigger + No Command Words Trained)	A							
Trigger + Command Word 02		A						
Trigger + Command Word 03			A					
Trigger + Command Word 04				A				
Trigger + Command Word 05					A			
Trigger + Command Word 06						A		
Trigger + Command Word 07							A	
Trigger + Command Word 08								A
Trigger + Command Word 09	A							A
Trigger + Command Word 10		A						A
Trigger + Command Word 11			A					A
Trigger + Command Word 12				A				A
Trigger + Command Word 13					A			A
Trigger + Command Word 14						A		A
Trigger + Command Word 15							A	A

Note: "A" indicates that the outputs are "Active-high"

Fig. 12: *Possible 8-bit outputs for a system commands 1 – 15.*

The IR modulator is a current amplifier. The voltage that is applied to the input of the OP-AMP is the theoretical voltage on the emitter in this design. The input voltage of the OP-AMP is switched between ground and a carrier wave consisting of a 38 KHz triangle wave. Ideally the carrier frequency should be a sine wave; however the voltage controlled oscillator selected does not output a sine wave. A triangle wave, which the VCO outputs, works correctly in so far as an receiver will react correctly to the signal.

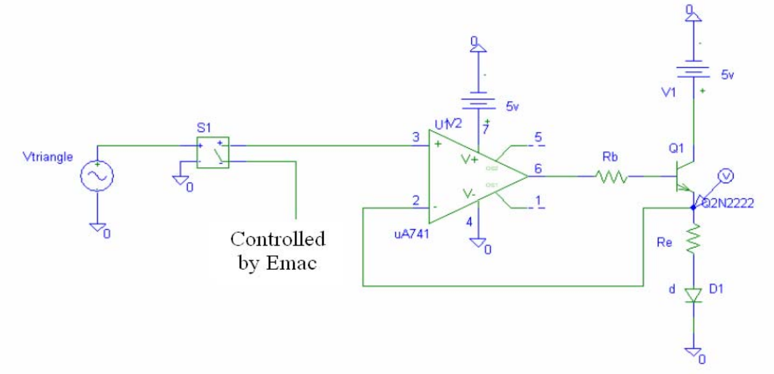


Fig. 13: *The modulator circuit. A high on the EMAC board output pin will cause this circuit to output IR light with its intensity modulated to a 38 KHz triangle wave. A low on the output pin will cause this circuit to emit no IR light.*

Computer Simulations:

Pspice was utilized in the design of the modulator. The peak desired current through the LED in the circuit show in Figure 13 is 76 mA. The simulation plot shows the specification of current through the LED was met.

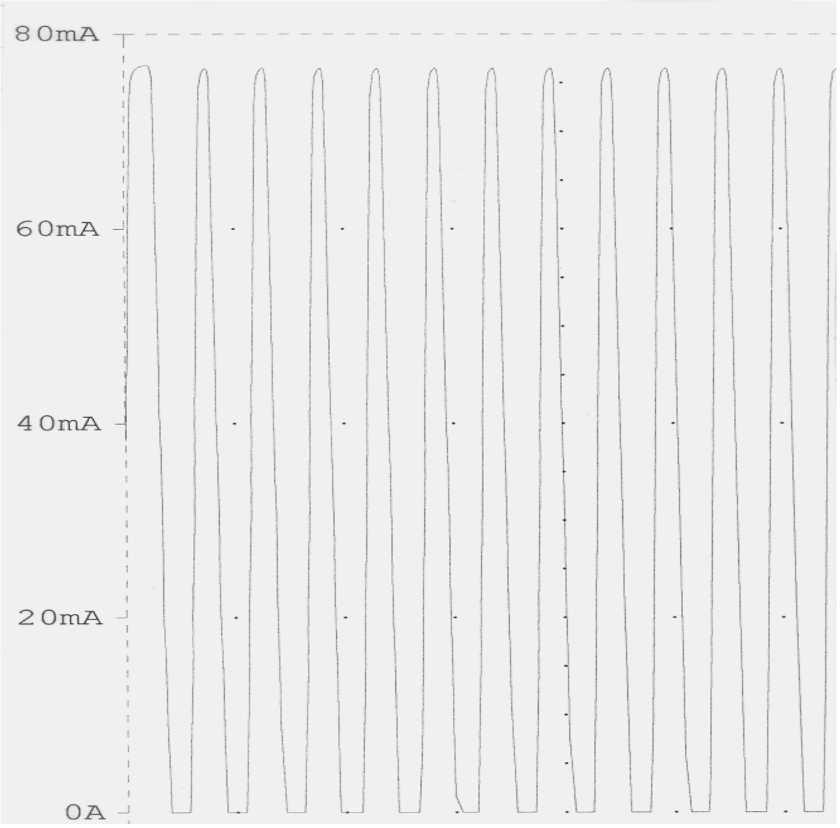


Fig. 14: *The Pspice simulation of the circuit in fig 14-1 . Note the peak current is at 76 mA.*

Program Flow Charts:

User Interface

The EMAC controlled user interface is divided up into three main options: New System, New Command, and Delete System. The flow chart for this user interface is shown in Figure 15. Each option stems from an opening menu, shown at the top of the flow chart. This menu allows the user to select a ‘1’ for the new command or new system options or a ‘2’ for the delete system option. The user must then press ‘E’ after their selection to enter or activate the selection. The menus also allow for a ‘B’ input for backspace, and any input that is not a 1 or a 2 is shown to be “invalid input. . .” and the user is returned to the opening menu. Also shown in the opening menu is a listening signal, once a command has been stored in either system a “*” appears in the bottom left corner of the opening menu to show listening mode has been entered.

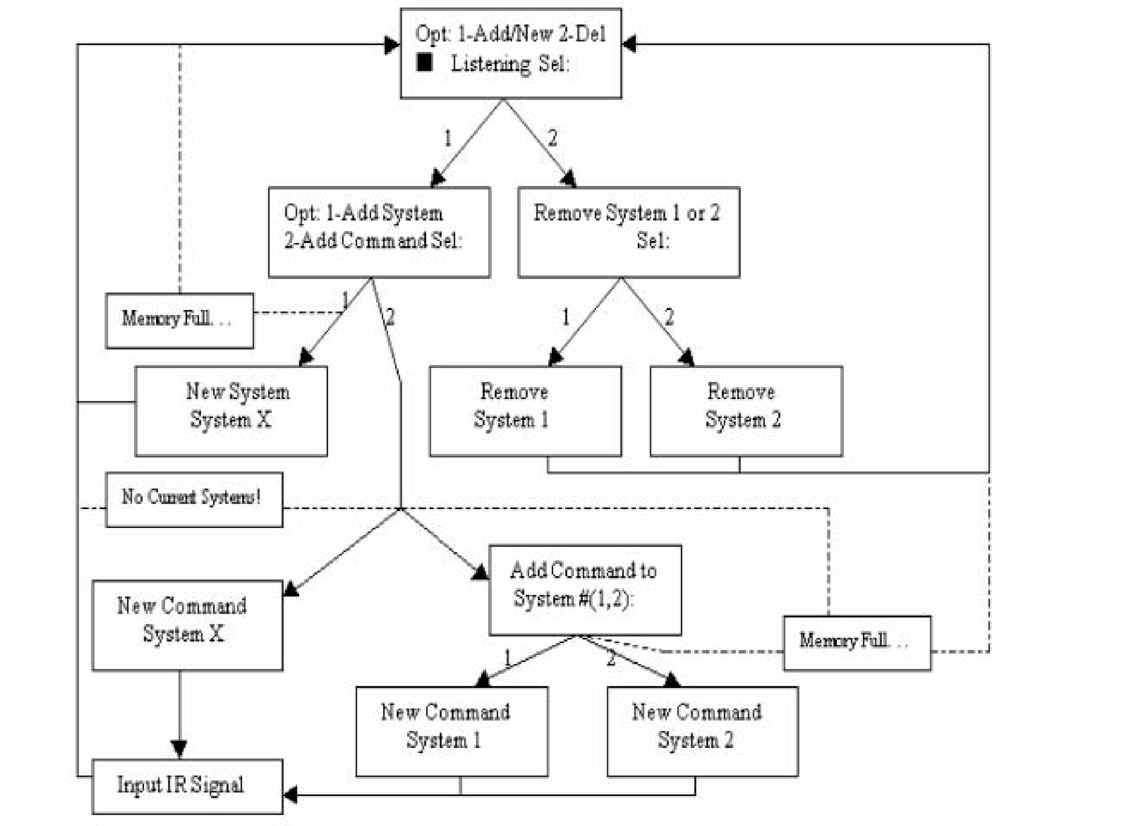


Fig. 15: *Overall user interface flow-chart.*

<u>New System Option:</u>

The new system option is called when, from the opening menu, the user inputs a 1 followed by an 'E', opening the Add System/Add Command menu, followed by the input of another 1 and another 'E'. This tells the user interface that another system is desired. The VAHCS device is setup with the knowledge that there are only two VDII boards attached, and therefore only two systems can exist at one time. As the command for a new system is received the program checks the current # of systems. If there are no systems, system 1 is then activated by triggering EMAC P1.2, TRIG-TRAIN(1). If only system 1 or system 2 is active then the other is activated and the user is notified of the new system number. This is again done by trigger EMAC P1.2 (TRIG-TRAIN(1)) or P1.5 (TRIG-TRAIN(2)). If both systems are already active then the user is notified, "Memory full. . ." for a duration of 1.8 seconds before being returned to the opening menu.

If a system is activated, that is the TRIG-TRAIN pin is triggered, then the VDII for the specified system enters trigger-word record mode. The user is notified by the LCD, "new system, system X" (duration 1.8 seconds) as to which system is recording, and then the LCD returns to the opening menu. The user is then asked to, "say word 1," the name of the system is spoken, the VDII then asks the user to, "repeat," and the user repeats the name of the system. If the trigger-word or system name is correctly stated then the VDII beeps acknowledging a successful record.

If the two words don't match or there is too much background noise the user may be asked to rerecord word 1. If a word is not successfully recorded in three attempts the VDII returns to an idle state. If this occurs the user must delete the system, run through the process of adding a new system and rerecord the system name.

New Command Option:

The new command option is called when, from the opening menu, the user inputs a 1 followed by an 'E', opening the Add System/Add Command menu, followed by the input of a 2 and an 'E'. This tells the user interface that another command is desired. At this point the user interface checks the number of systems currently active. If no systems are active the LCD shows an error, "no current systems," (duration 1.8 seconds) and returns the user to the opening menu. If only one system exists, the user interface identifies this system and automatically notifies the user which system the command is being added to, "New Command System X." At the same time the corresponding EMAC output is triggered: either p1.3 (TRAIN(1) system 1), or p1.6 (TRAIN(2) system 2). If both systems exist then the user is brought to a third window, "add command to System #(1,2): ." The user is allowed to choose the desired system name or trigger word under which they wish their command to be recorded. Once a system is identified and triggered, via EMAC p1.3 (system 1) or p1.6 (system 2), the corresponding VDII prompts the user to "say word X." X is the command number (1 -15), once 15 commands are saved both the LCD and the VDII notify the user that system memory is full. The user then records the command name and repeats it for storage purposes. Once a command name is successfully stored, the VDII asks, "say word (X+1)," after the statement is finished press any key on the keypad to exit the VDII from command name record mode. The VDII should beep if correctly exited. The button push also activates the continuous listening mode of the system corresponding to the newly input command by triggering either p1.4 (RECOG(1) system 1) or p1.7 (RECOG(2) system 2).

If the IR system was integrated into the user interface then the IR record would be called after the VDII command name record mode was correctly exited. This would allow the user to input IR commands corresponding to the saved voice command. After the user is done recording IR, the VDII would then enter continuous listening mode and the user interface would return to the opening menu.

Delete system option:

The delete system option is called when, from the opening menu, the user inputs a 2 followed by an 'E'. This tells the user interface that a system is to be deleted and a second menu is shown. This asks the user, "Remove system 1 or 2," and the user has the choice to input a 1 or a 2 followed by an 'E'. Once the user selects a system the user interface checks the number of commands in the system. If there are 1 or more commands the system is in continuous listening mode and must exit this before erasing the system memory. This is done by triggering the TRAIN input for that system: either p1.3 (TRAIN(1) system 1), or p1.6 (TRAIN(2) system 2). Once the system is idle both the TRAIN and RECOG pins of the desired system are triggered simultaneously. This would be either both EMAC outputs p1.3 and p1.4 (system 1) or EMAC outputs p1.6 and p1.7 (system 2). Once this is done, the user is notified by the LCD output

"Remove System X," (duration 1.8 seconds) and a voice saying, "memory erased." After this the user is returned to the opening menu.

If the IR system was integrated, all IR captured signals for the selected system would be erased before returning the user to the opening menu.

Recognized Voice:

Once a command is saved under a system heading in the user interface, continuous listening mode is activated. This allows the user at any time they are not in the recording process, to recall that command. As there are two systems and one set of parallel inputs to the EMAC the user interface must identify the system transmitting. This is done by monitoring the talk signals of the two voice direct II chips. As shown in Figure 17, when monitoring the TALK signal if a word is recognized there is a low of at least 176 ms. As shown in Figure 16. If the EMAC senses a low longer then 176 ms it saves the input system number to a global variable as to know the source of a possible 8-bit parallel input. If an 8-bit parallel input is received, the input is translated to a hex value and the IR memory locations are recalled as shown in Figure 18.

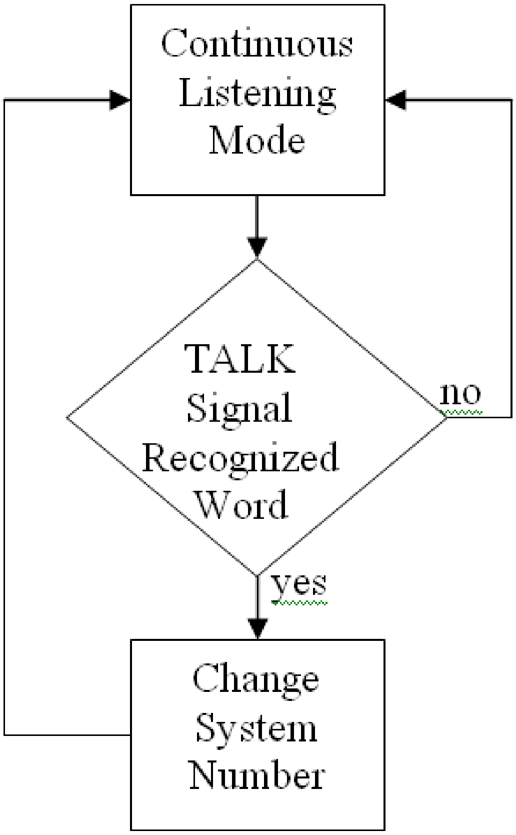


Fig. 16: *Flow-chart for system input identification. The EMAC monitors the TALK signal until a word is recognized. Once recognized the system number is saved and it returns to continuous listening mode.*

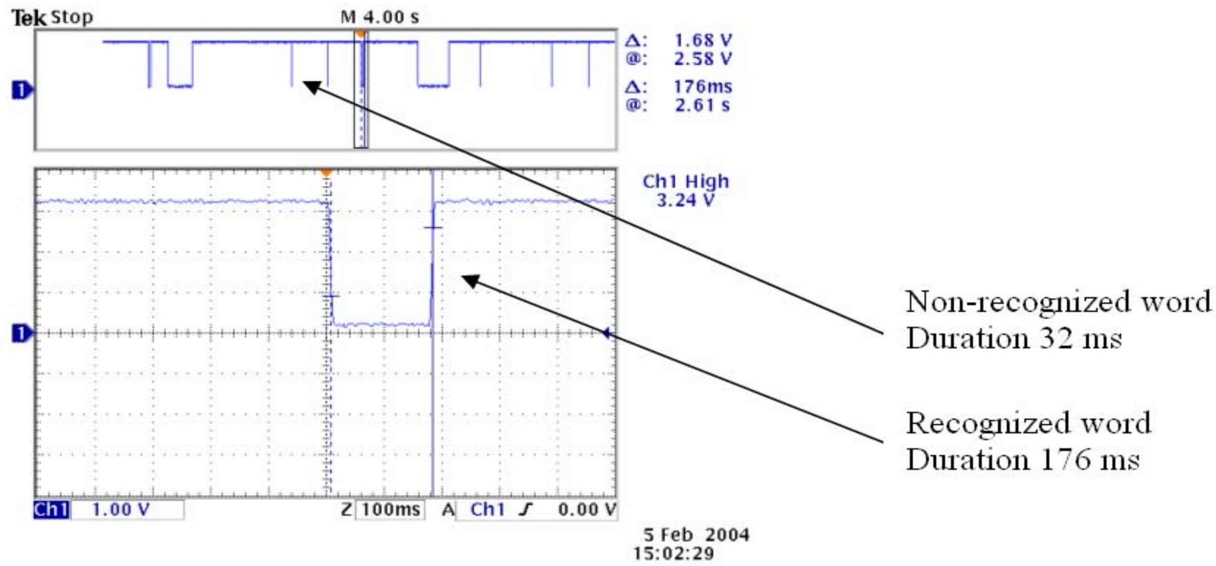


Fig. 17: *The talk signal is monitored for a recognized word or TTL low for longer then 176 ms.*

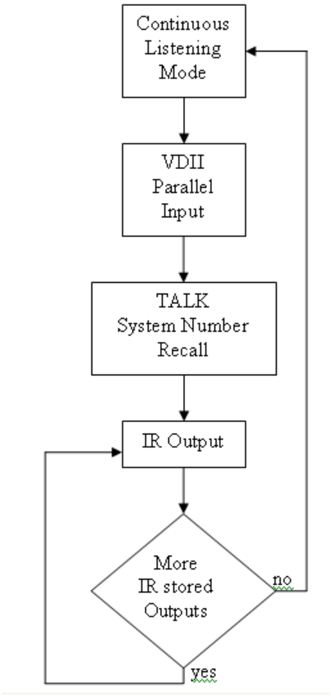


Fig. 18: *Parallel input Flow chart: Parallel input to the EMAC is received, the system source is recalled, then the IR is output and the system is returned to continuous listening mode.*

IR Capture

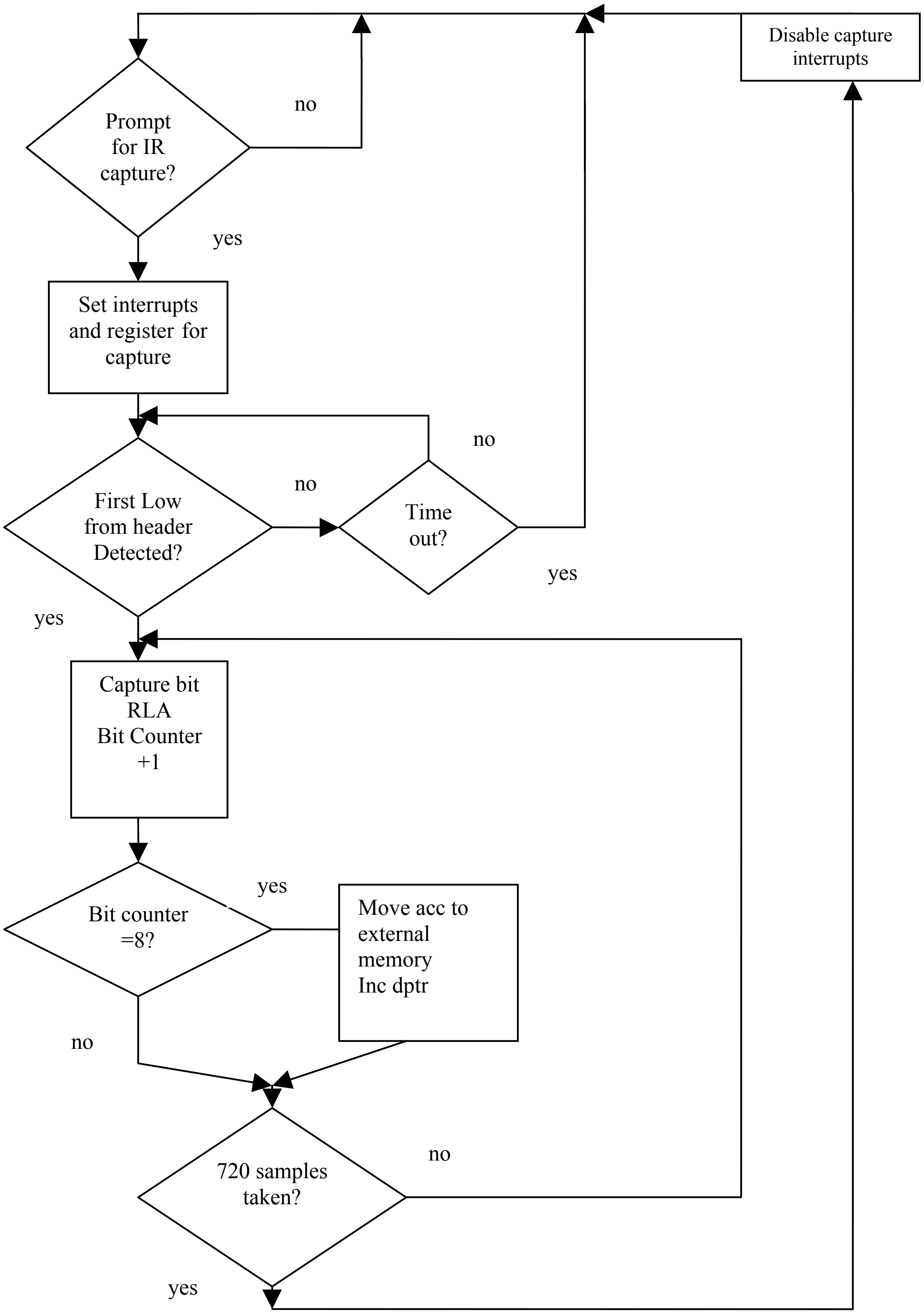


Fig. 19: *Full logic of IR capture*

IR Transmit

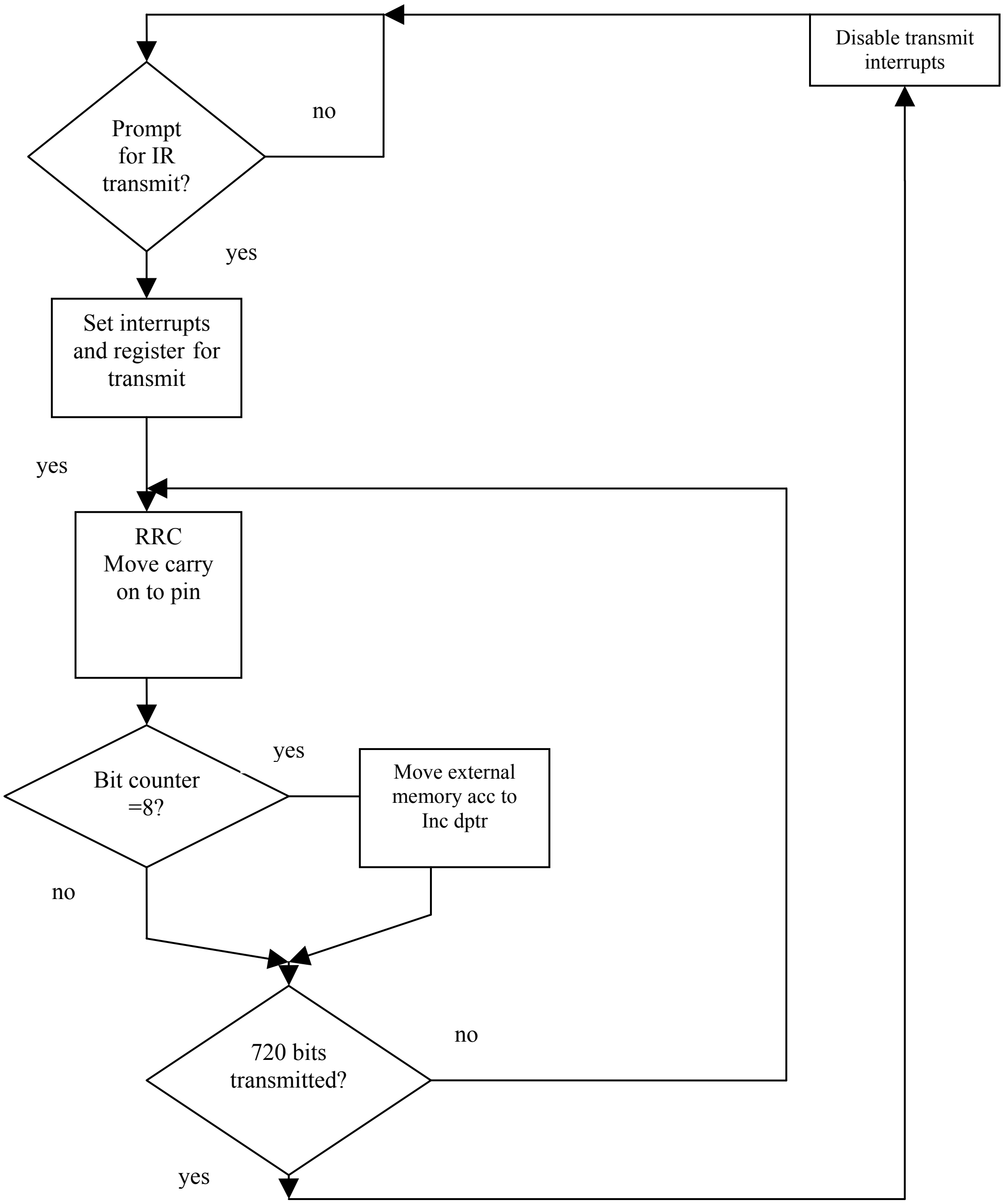

Disable transmit interrupts
no
Prompt for IR transmit?
yes
Set interrupts and register for transmit
yes
RRC Move carry on to pin
yes
Bit counter =8?
Move external memory acc to Inc dptr
no
no
720 bits transmitted?
yes

Fig. 20: *Full logic of IR Transmit*

Analysis of Results:

IR Subsystem Capture
The task of the IR subsystem is to capture/transmit IR on a prompt from the EMAC board. A capture command activates a subroutine which cues the user to shoot the IR code he wishes to capture at the onboard IR receiver. Upon completing the capture the LCD informs the user the signal was captured. If the user does not send an IR signal at the receiver in 7 seconds the program will return to the main loop.

The capture routine recognizes the IR signal when it receives a low (0 volts) from the receiver for the first time. It then records the signal for 72 ms, taking samples every 100 µs. This equates to 720 samples per IR sequence. Figure 21 illustrates the required logic low header to begin the capturing.

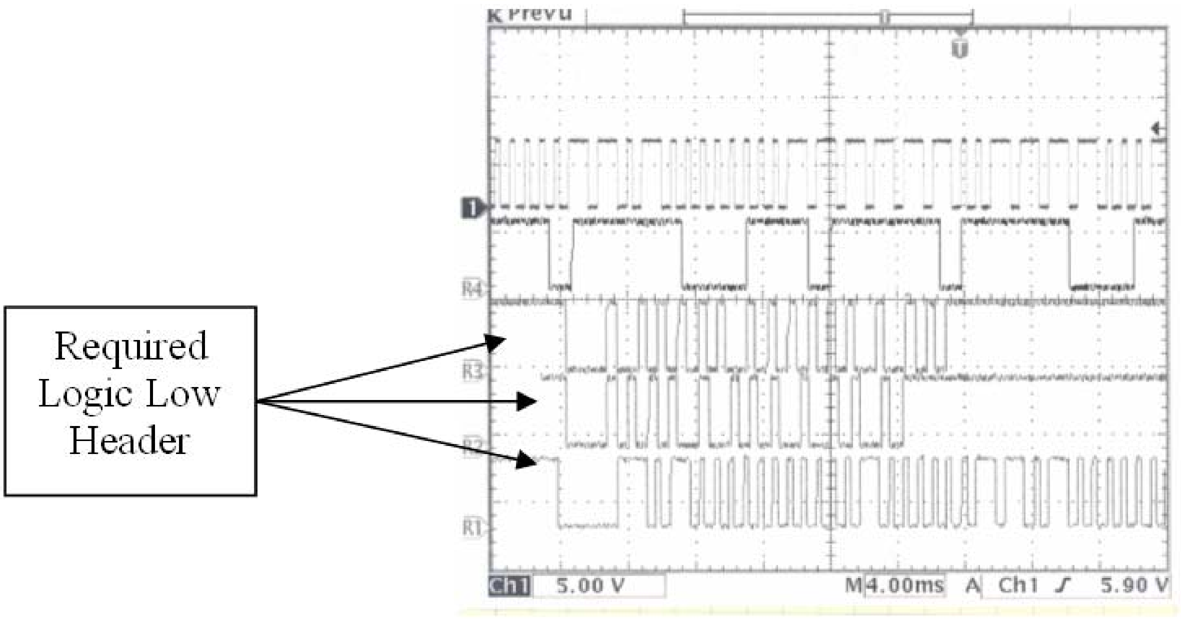
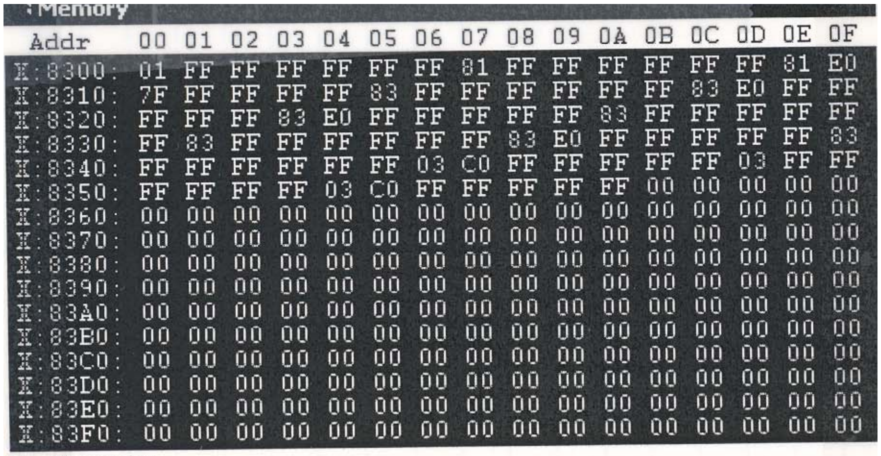

Required Logic Low Header

Fig. 21: *displays scope traces of various IR sequences. Note the low logic header present in the last three signals*

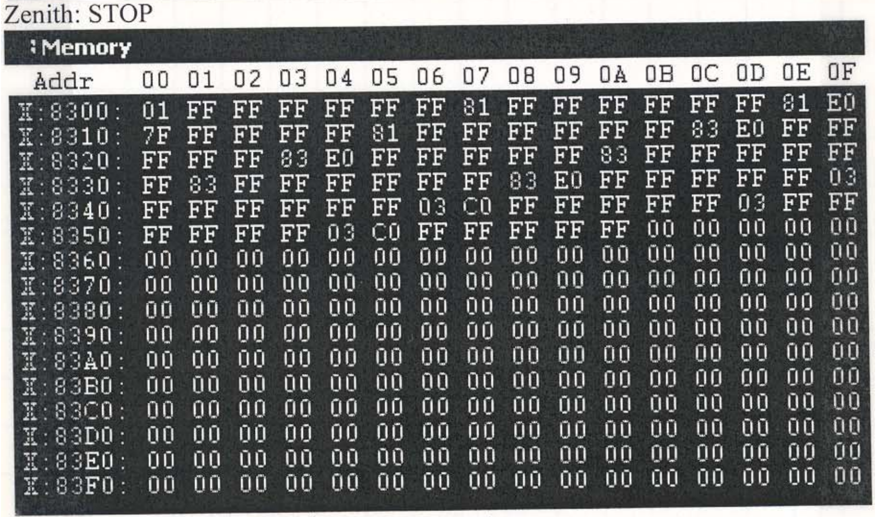
The IR sequences are stored as bits in external memory. The recording begins at 8400h of external memory. This is due to the program using The command Rotate Left Carry is used to capture each bit and save it to the accumulator which then can by moved to external memory.

Figure 22 displays various captured IR sequences stored in memory. The first two captures prove the system's consistency. The IR sequences capture in both is the same command; as such it should be the same data string, which it is.



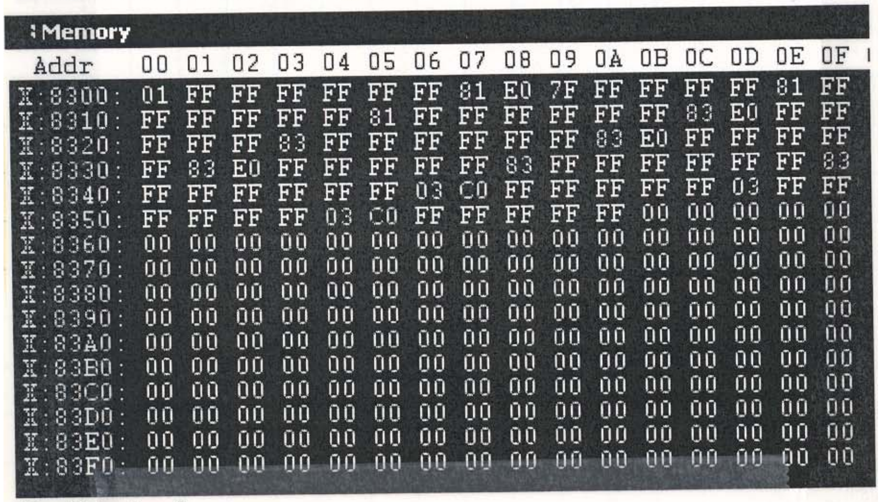
```
Memory
Addr     00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
X:8300:  01 FF FF FF FF FF FF 81 FF FF FF FF FF FF 81 E0
X:8310:  7F FF FF FF FF 83 FF FF FF FF FF FF 83 E0 FF FF
X:8320:  FF FF FF 83 E0 FF FF FF FF FF 83 FF FF FF FF FF
X:8330:  FF 83 FF FF FF FF FF FF 83 E0 FF FF FF FF FF 83
X:8340:  FF FF FF FF FF FF 03 C0 FF FF FF FF FF 03 FF FF
X:8350:  FF FF FF FF 03 C0 FF FF FF FF FF 00 00 00 00 00
X:8360:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:8370:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:8380:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:8390:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83A0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83B0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83C0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83D0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83E0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83F0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

Zenith: STOP



```
Memory
Addr     00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
X:8300:  01 FF FF FF FF FF FF 81 FF FF FF FF FF FF 81 E0
X:8310:  7F FF FF FF FF 81 FF FF FF FF FF FF 83 E0 FF FF
X:8320:  FF FF FF 83 E0 FF FF FF FF FF 83 FF FF FF FF FF
X:8330:  FF 83 FF FF FF FF FF FF 83 E0 FF FF FF FF FF 03
X:8340:  FF FF FF FF FF FF 03 C0 FF FF FF FF FF 03 FF FF
X:8350:  FF FF FF FF 03 C0 FF FF FF FF FF 00 00 00 00 00
X:8360:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:8370:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:8380:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:8390:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83A0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83B0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83C0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83D0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83E0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83F0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

Zenith: STOP included to show accuate capture



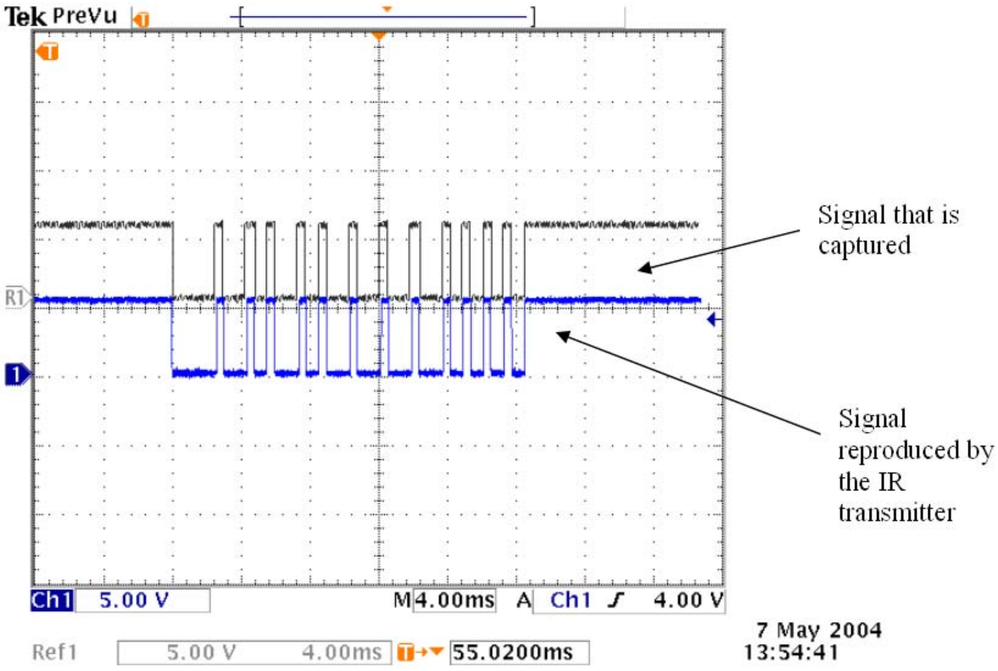
```
Memory
Addr     00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
X:8300:  01 FF FF FF FF FF FF 81 E0 7F FF FF FF FF 81 FF
X:8310:  FF FF FF FF FF 81 FF FF FF FF FF FF 83 E0 FF FF
X:8320:  FF FF FF 83 FF FF FF FF FF FF 83 E0 FF FF FF FF
X:8330:  FF 83 E0 FF FF FF FF FF 83 FF FF FF FF FF FF 83
X:8340:  FF FF FF FF FF FF 03 C0 FF FF FF FF FF 03 FF FF
X:8350:  FF FF FF FF 03 C0 FF FF FF FF FF 00 00 00 00 00
X:8360:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:8370:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:8380:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:8390:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83A0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83B0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83C0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83D0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83E0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
X:83F0:  00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
```

Zenith button 2

Fig. 22: *5 captured IR sequences, note the first two are identical, proving the consistency of the capture subroutine.*

IR subsystem transmit

The transmission subsystem is operational as well. Figure 23 illustrates the original IR sequence seen by system. The reproduced trace is identical to the trace which was taken directly from the IR receiver. The transmitter/modulator create signals which are recognized by the system's IR demodulator, however the IR receivers on devices will not recognized the commands. This problem is probably due to the limitation of the modulator, which may not produce enough IR light intensity.



Signal that is captured

Signal reproduced by the IR transmitter

Fig. 23: *The input and output of an IR sequences. Note the two traces are identical.*

IR Modulator

The modulator is operational. There is some concern due to the fact the 741 OP-AMP can not reach its power supplies and thus decreases the effective range of the IR transmitter. This glitch can be solved with a higher quality OP-AMP such as an MC33074. It was found that a triangle wave works as a carrier. This is an important fact as the VCO will only output a tri-angle wave. Please refer to Figure 13 for the diagram of the modulator circuit.

IR Receiver

A Vishay TSOP1130 IR receiver is used as the IR receiver and demodulator. There was no design work that was needed in integrating this hardware to the system. In the presence of IR light that has its intensity modulated with a triangle wave this chip gives zero volts on its output pin. In the presence of no modulated light it gives five volts on its output pin.

Conclusions:

IR Subsystem

The IR capture is operational. The system is able to input most IR sequences correctly into its memory (those without the low logic header are not able to be captured). The transmission subsystem works as well. The modulator works and it will work better with a superior OP-AMP driving the transistor. Therefore the IR subsystem is complete.

Voice Recognition

The user interface that controls the VDII operates fully. Users are able to use the add system, add command, and delete system options. The EMAC does not currently recognize the TALK signals and cannot receive the 8-bit parallel input. IR system integration would be the next step after TALK and 8-bit input reception.

Standards and Patents:

A patent search was done at the United States Patent webpage; a device almost identical was found. If we were to sell this we would need to contact Mr. William Stuart Bush of California.

An abstract of this system is included

A wireless, programmable, sound-activated and voice-operated ***remote control*** *transmitter can be used to add hands-free speech control operation to a plurality of remotely controlled appliances manufactured by various manufacturers, each of which is normally controlled with one or more signals from an associated* ***remote control*** *transmitter. The system may be pre-programmed with a universal library of codes for controlling various appliance categories and appliances produced by various manufacturers within each category. The system may also be programmed using the controlled appliances'* ***remote control*** *transmitters and one or more operators' spoken commands. Once programming is complete, there is no need for the operator to manually operate the system, allowing true hands-free voice control of the remotely controlled products. Voice commands are organized into a plurality of linked recognition vocabulary sets, each representing a subset of the complete voice command vocabulary available. These subsets are structured in a fashion that is intuitive to the user because the structure is consistent with controlled appliance operation. As such, the system allows a user to easily navigate via voice commands between recognition sets to attain access to the intended voice commands.*

United States Patent 6,397,186