NNODUKA C. ERUCHALU

# 80188 MP3 JUKEBOX PROJECT (EE/CS 52)

CALTECH

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# USER MANUAL

# 80C188 MP3 Jukebox Project

# User Manual

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## General Safety Summary

To avoid fire, personal injury, or even worse total destruction of the jukebox:

**Use Proper Power Cord.** Use only the power cord specified for this project and certified for use in the U.S.A. This power supply should be stable to avoid erratic behaviors of the jukebox.

**Connect and Disconnect Properly.** Do not just pull out the power cord, speakers, the hard disk connector or a compact flash card, from their corresponding connections on the board. This could break solder joints, destroy the connectors or break the board.
Also it has been noticed that it is best to plug in all peripherals, turn them all on, and then finally turn on the circuit board's power supply.

**Observe the Red LED.** The Red LED has been installed as an instant check for shorts between Vcc and Ground. If this Red LED is not turned on and the power supply is turned on, immediately turn off the power supply, flip the board over and check for shorts. Potential shorts will be the bypass capacitor leads**.**

**Avoid Operating In Messy Environment.** This could lead to alien fragments getting stuck in places underneath the board and potentially cause serious problems (like shorting Vcc and Ground).

**Avoid Exposed Circuitry.** This really applies to the bottom of the board. There is no base plate so be careful not to touch the bottom as this could hurt you and potentially create unwanted shorts and capacitances.

**Do Not Operate With Suspected Failures.** If you suspect there is damage to this product, have it inspected by a qualified past EE5x student, preferably the maker of this particular board, Nnoduka C. Eruchalu.

**Do Not Operate at Extreme Temperatures.** Room temperature is best. It is easiest to appreciate listening to good music at decent temperatures.

**Handle Jukebox with Caution.** Do not move it around in quick and jerky motions, and store it in a safe box.

**Keep Out of the Reach of Children.** But do not deprive them of the joy of listening to good quality music.

**Do Not Remove Covers.** Be especially careful of the tape over the ROM. This is a UV EPROM, so it is there to prevent the ROM from getting its data erased/corrupted.

**Do Not Operate in Wet/Damp Conditions.**

**Keep Jukebox Clean and Dry.**

## Initial Setup

Below is an image of the bare jukebox board without any external peripherals.

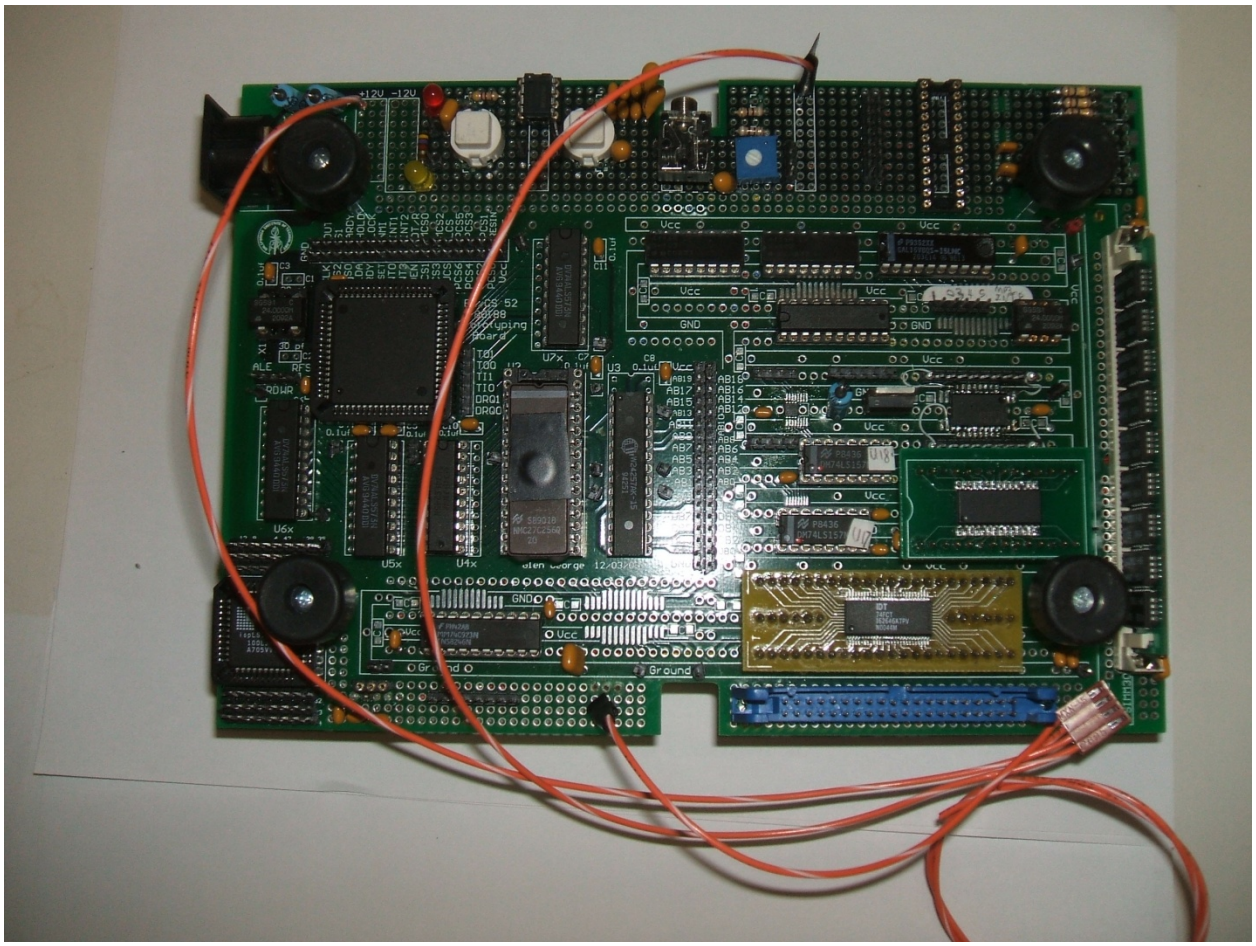


Figure 1- Jukebox without any external peripherals

The sequence in which the necessary peripherals are placed unto the board does not matter. What is important is that all the power supplies are left turned off till the user has the board fully setup and is ready to use the jukebox. The peripherals needed for full operation are:

- The LCD
- The Keypad
- The IR Control Unit (Remote Control and Receiver Board)
- The Speakers.

Setting up each of these will be explained below and with pictures to make it easier to see how it should be done.

**Connecting the LCD**

Below is a picture of the 40 x 2 LCD used on this project, with its connector cable.

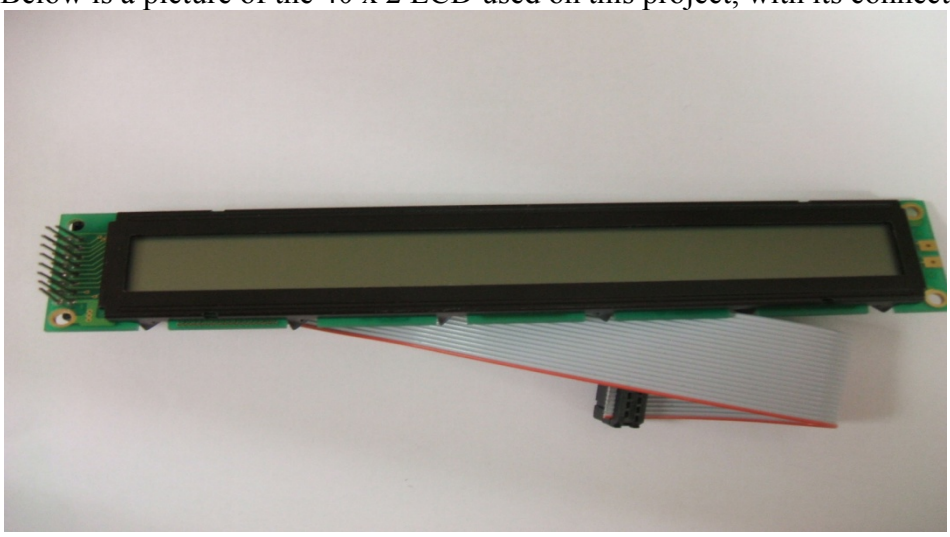


Figure 2- LCD with connector cable

On the top right corner of the board layout, there is a box labeled "L1- LCD connector". That is where the connector cable fits and below is a picture of this connector.

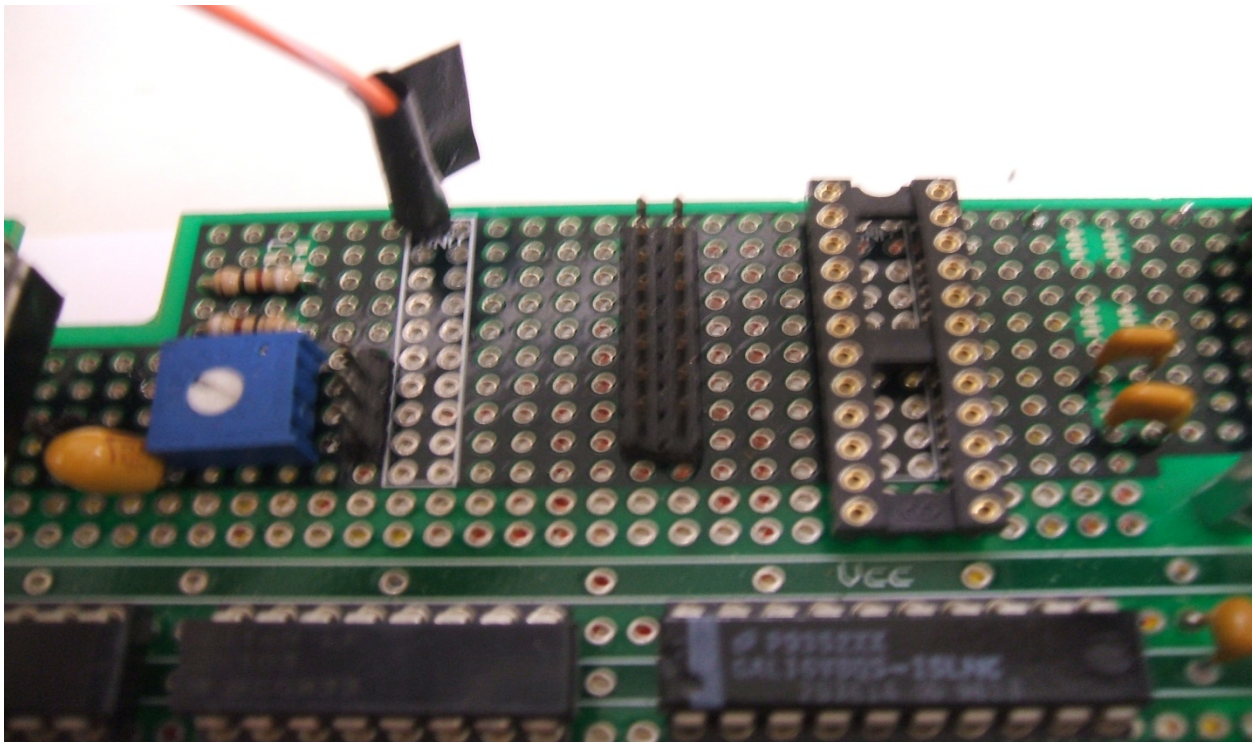



Figure 3- L1- LCD Connector

It will be noticed that this is an 8 x 2 pin connector, while the connector cable is designed for a 10 x 2 connector. This simply means that 2 rows of the connector cable are not hooked up to anything. To hook up the connector cable properly, simply line up the bottom of the actual 8 x 2 connector with the red line of the connector cable. That way the two unused rows of the

connector cable should be the top two rows, which if the user observes closely are not connected to any LCD pin. Below are pictures demonstrating this connection of the LCD connector cable.

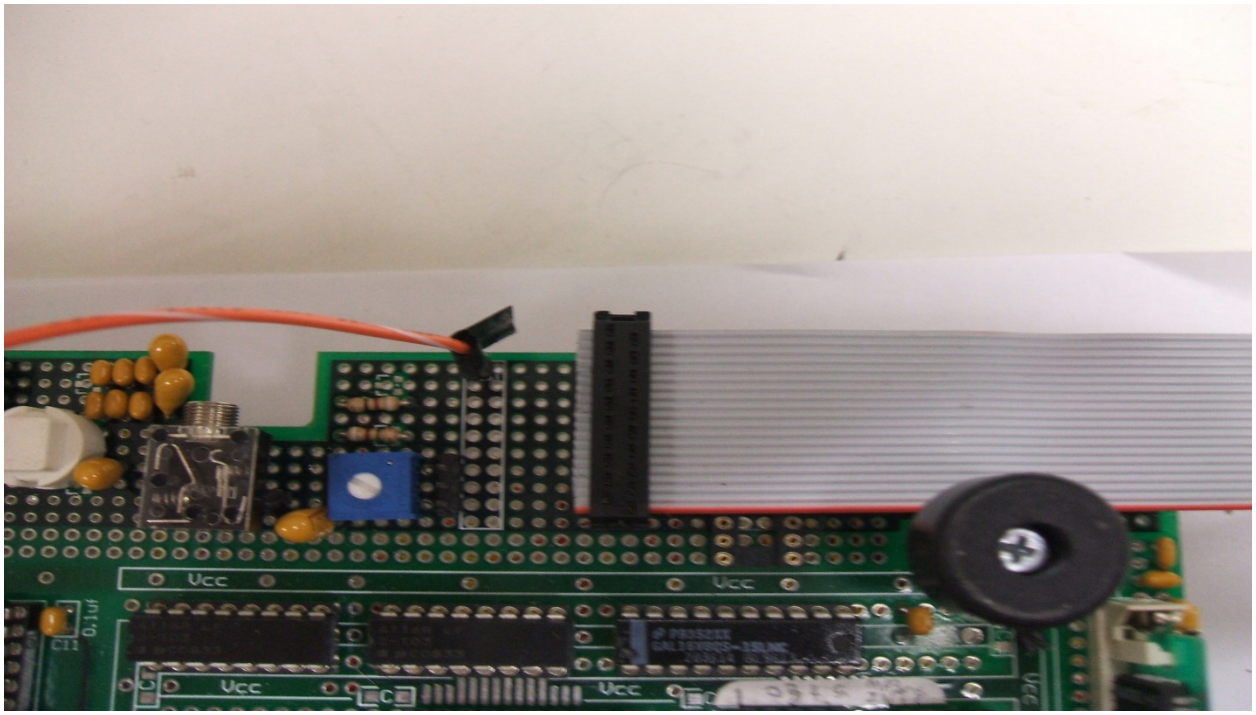



Figure 4- How to connect the LCD Connector Cable, Zoomed In

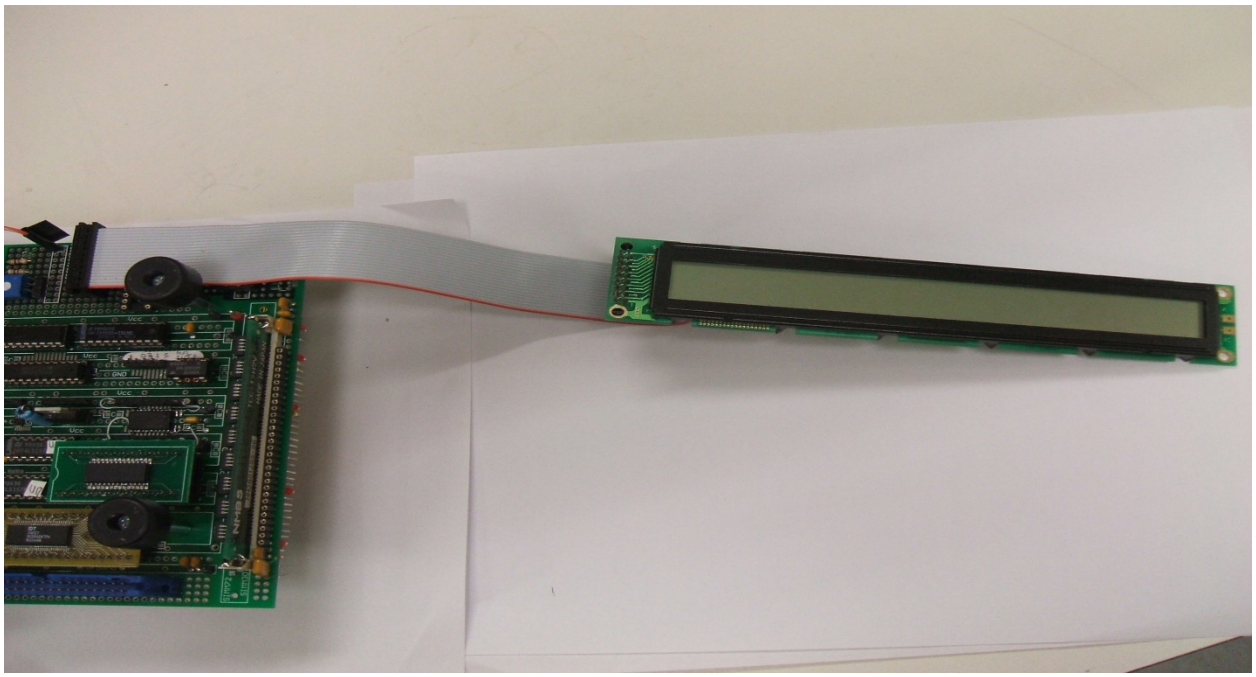


Figure 5- How to connect the LCD Connector Cable, Zoomed Out

With the LCD connected, it can now be balanced on the top two stands. This can be done over or underneath the orange connector cables going across the board. Below is a picture demonstrating placing the LCD over the orange connector cables, so as to get a full view of the LCD.

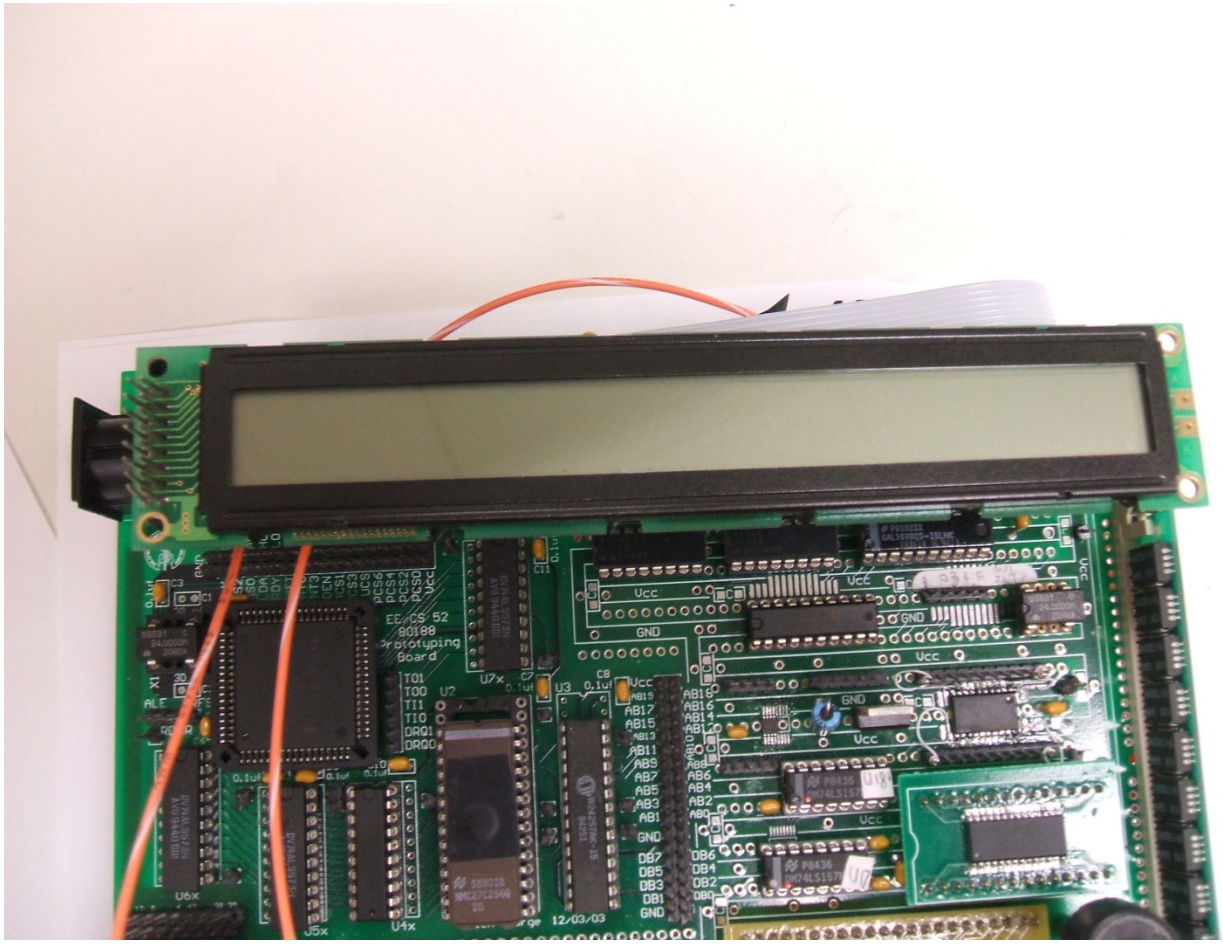



Figure 6- Connected and Mounted LCD

## Connecting the Keypad

Below is a picture of the 4 x 4 keypad used in this project, with its connector cable.

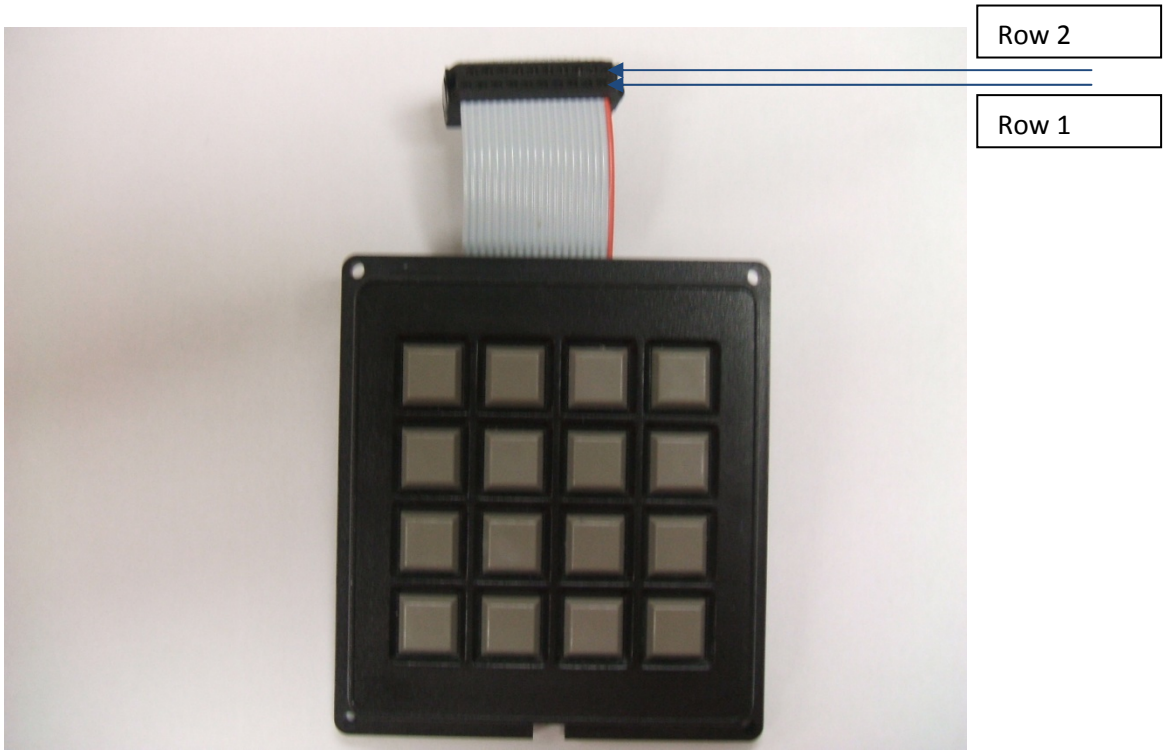



Figure 7- Keypad with its Connector

On the bottom left corner of the board layout, there is a box labeled “K1- Keypad connector”. That is where the connector cable fits and below is a picture of this connector.

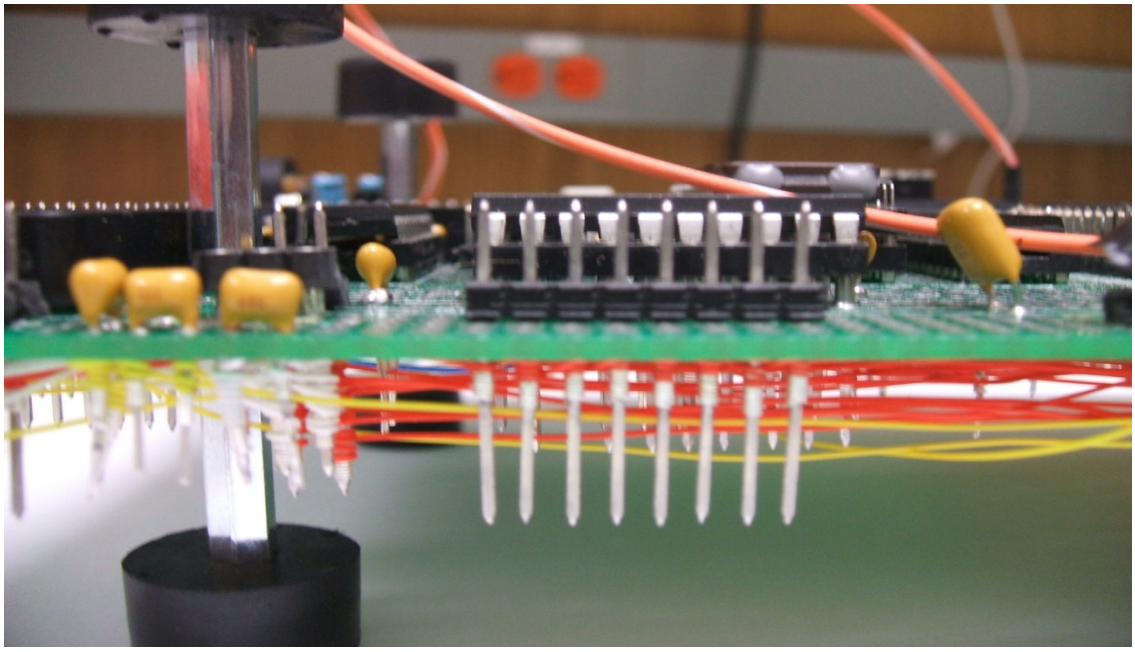


Figure 8- Keypad Connector

It will be noticed that this is a 1 x 8 connector while the connector cable is designed for a 2 x 10 connector. This simply means that only 1 row of the connector cable is used, and on that 1 row only 2 slots are not used. To hook up the connector cable properly, simply line up the right end of the connector with the red line of the connector cable, and use Row 1 as labeled in Figure 7. That way the two unused slots of Row 1 are on the leftmost end of the keypad's connector end. Below is a picture demonstrating this connection of the Keypad Connector Cable.

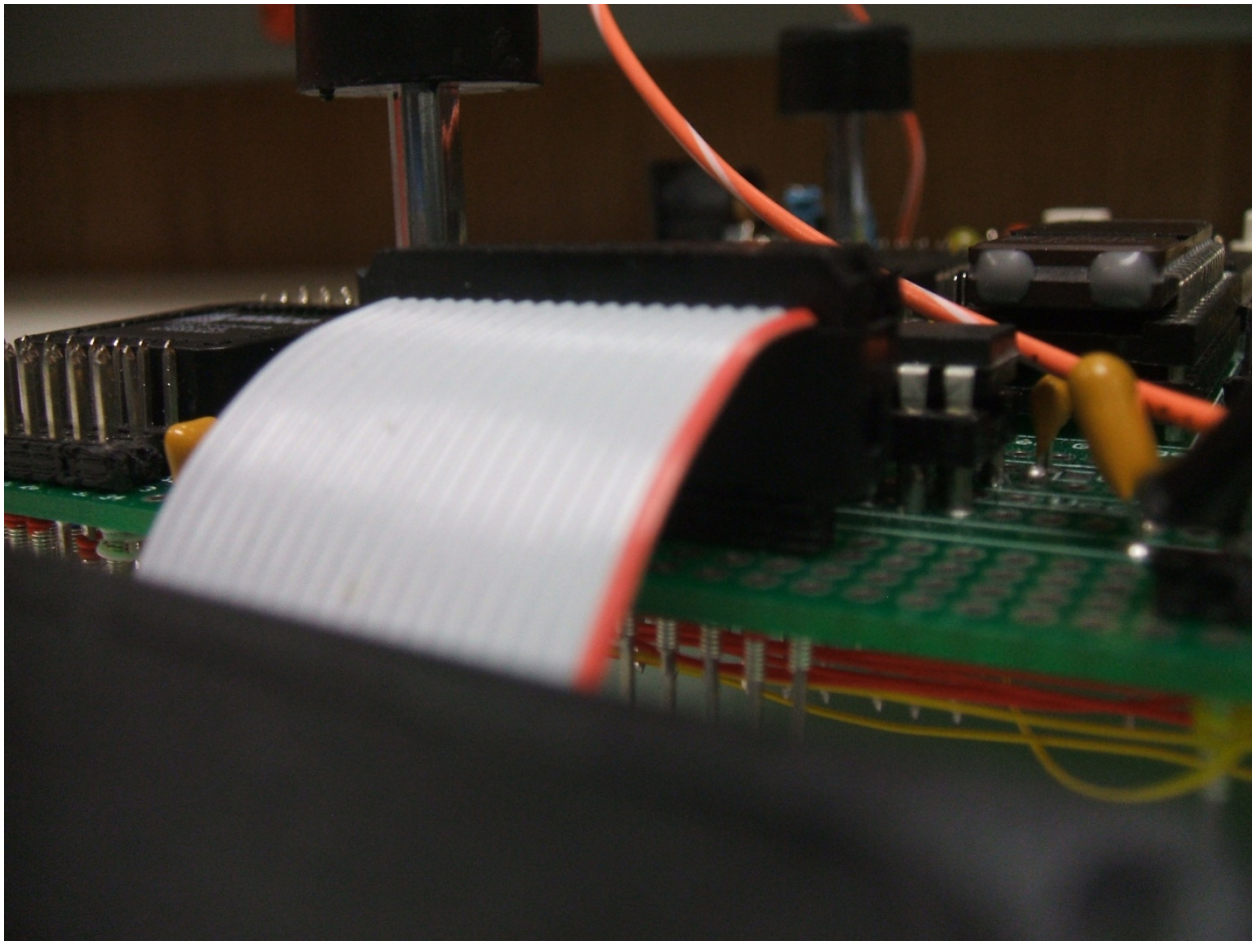


**Figure 9- How to connect the Keypad Connector Cable**

**Connecting the IR Control Unit (Remote Control and Receiver Board)**

Below is a picture of the IR Remote Control and the IR Receiver Board.

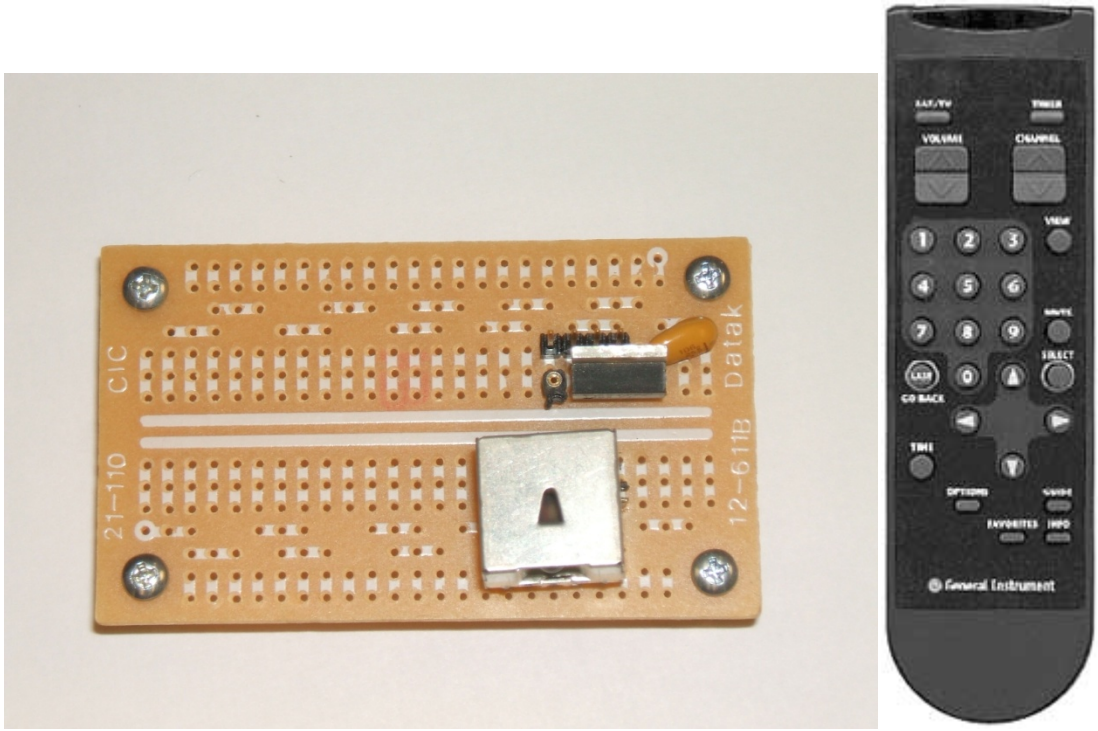



Figure 10- IR Receiver Board and IR Remote Control

Looking back at Figure 1, there is a 4-pin orange connector cable lying across the board. On the top right of the IR controller board Layout, there is a box labeled “Connector to MP3 B.” This is where the 4-pin orange connector from the main mp3 board is attached to the IR controller board.

Below is a close-up picture of this connector on the IR controller board.

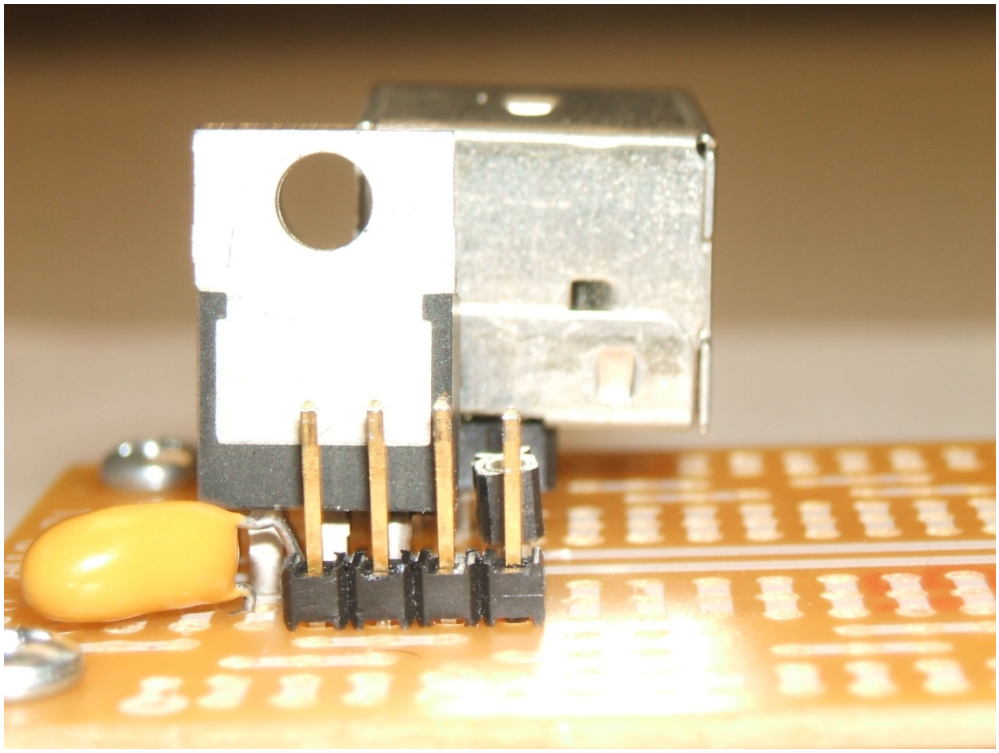


Figure 11- Close-up picture of Connector on IR Controller Board

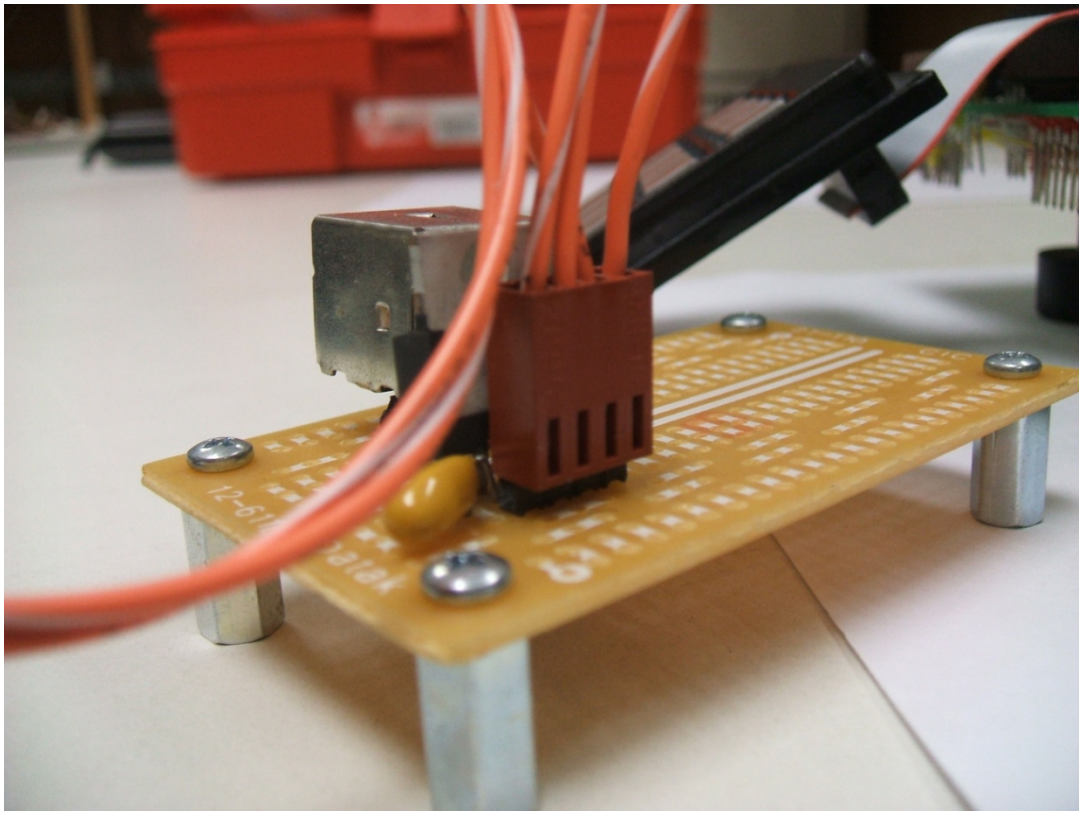


Figure 12- How to Connect to the IR Controller Board

To connect the Main MP3 Jukebox board to the IR Controller board, simply connect the orange 4-pin connector cable to the 4-pin connector on the IR Controller board. It is important that the orientation is not messed up. The proper orientation is as shown in Figure 12 on the previous page. When connected, the user should be able to see the four slots of the connector which expose the metal within the connector, by simply looking at the back of the IR Controller board as shown in Figure 12.

After having gone over the connection of the Keypad and IR Control Unit, below is a picture of the board with the complete Control Unit (Keypad and IR Control Unit).

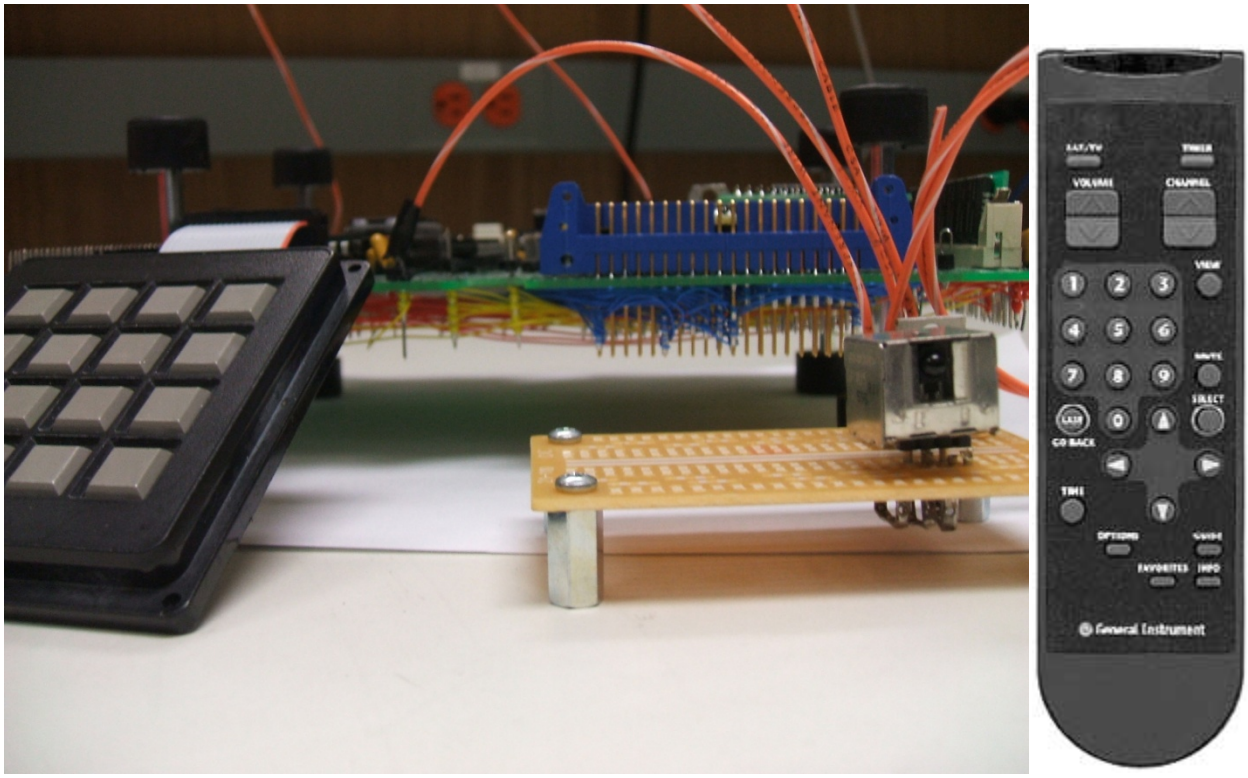



Figure 13- Complete Control Unit (keypad and IR Control Unit)

**Connecting the Hard Disk/Compact Flash Memory Card**

The system is designed to be used with a FAT formatted hard drive or Compact Flash memory card. Compact Flash memory cards are easier to use as the user does not have to connect an external power supply to the card. The IDE interface on the board has been designed to send power from the board to the Compact Flash Card. Note however that if the user decides to use a hard drive, the user has to power up the hard drive using an external power supply.
Below is a picture of a Compact Flash Memory Card that can be used with the project.

Figure 14- Compact Flash Memory Card

On the bottom right of the MP3 board layout, there is a box labeled “U12 – IDE Interface Connector”. That is where the Compact Flash fits or the connector cable from the hard drive fits. On the next page is a picture of this connector.

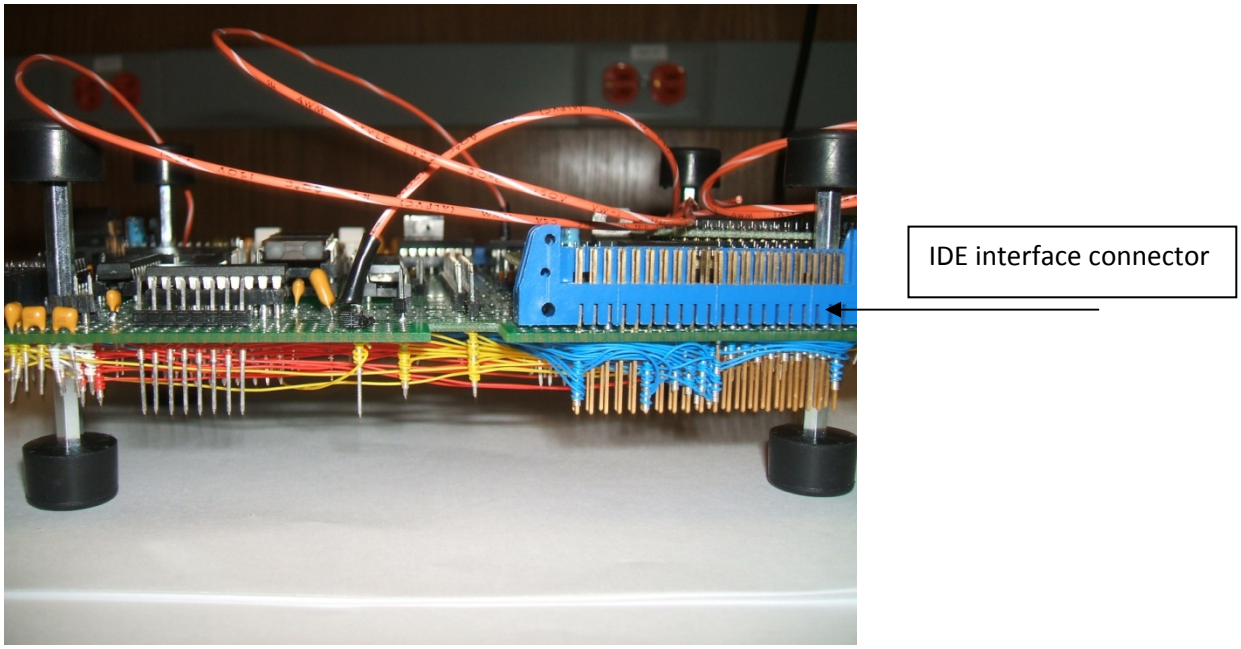



Figure 15- U12- IDE Interface Connector

Considering the above view the front view (as has been assumed all the while in this manual), then from the top view the pinout of the IDE interface connector is drawn below. It is done relative to its position on the board (the darker line) from top view.

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 39 | 37 | 35 | 33 | 31 | 29 | 27 | 25 | 23 | 21 | 19 | 17 | 15 | 13 | 11 | 9 | 7 | 5 | 3 | 1 |
| 40 | 38 | 36 | 34 | 32 | 30 | 28 | 26 | 24 | 22 | 20 | 18 | 16 | 14 | 12 | 10 | 8 | 6 | 4 | 2 |

With this pinout in mind it should be easy to connect a Hard Drive Connector Cable as pin 20 is supposed to be the keypin. So be careful when using a Hard Drive Connector Cable, there has to be a slot for pin 20 on the cable end that fits on the board. Pin 20 is to be left on the board for compatibility with the Compact Flash Card. On the next page is a picture of a Compact Flash Card carefully placed in the IDE interface connector, making sure to line up the pins properly, because in some cases, like this one the compact flash card is narrower than the IDE interface connector so it is easy to place the card a pin off and this could lead to disastrous consequences.

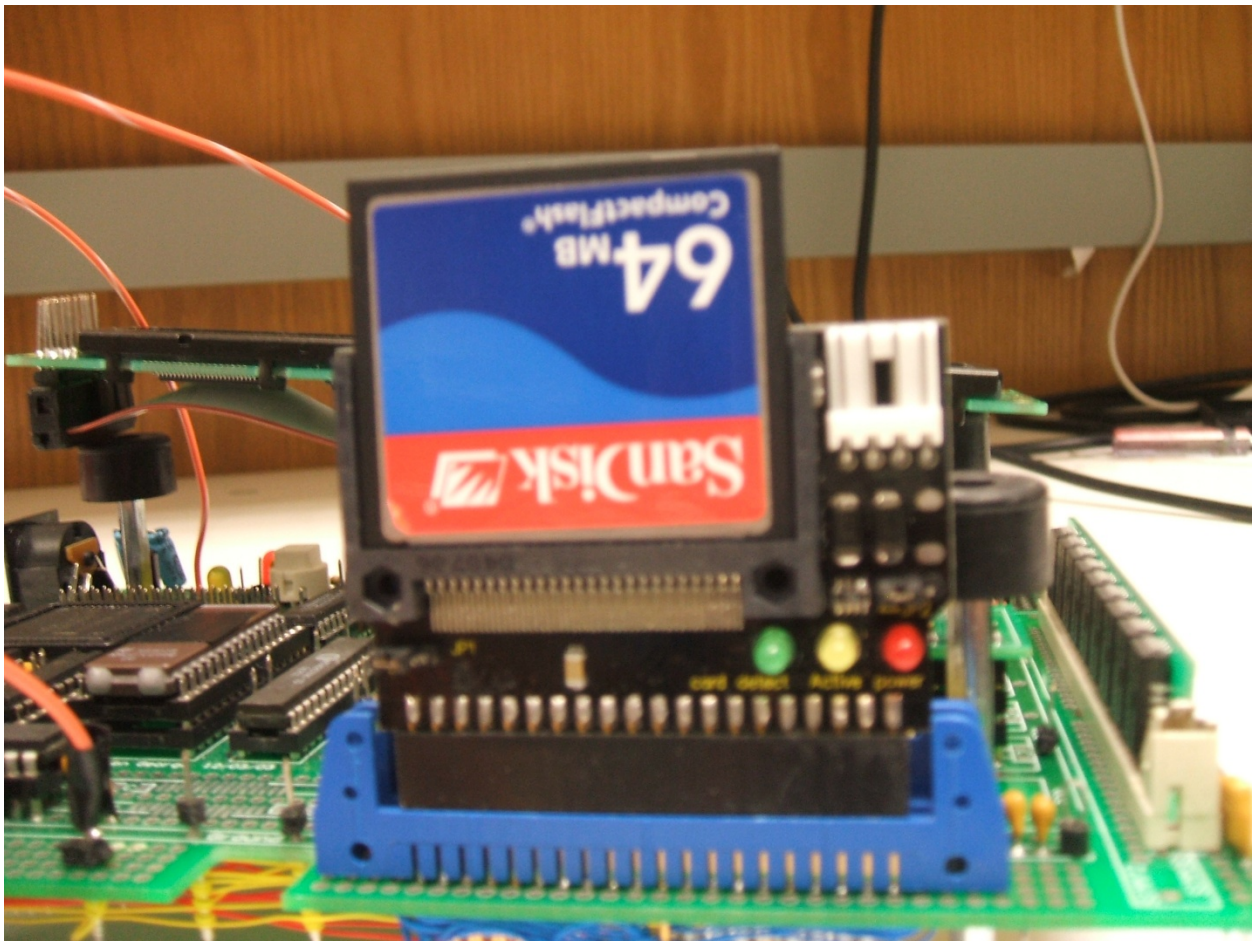



**Figure 16- Compact Flash Card mounted on IDE interface connector**

**Connecting the Speakers**

The ideal speaker set to use will be that will a TRS connector. Note that in order to not destroy the on-board VS1011E audio codec, the speakers should be powered up before the MP3 board is. This is so that the board will not try to drive the speakers. Headphones could also be used in place of speakers, but speakers are preferred. The TRS connector cable from the speakers go into the audio jack on the top –middle of the board (as depicted on the MP3 board layout). Below is an image showing how the speaker's TRS connector cable fits into the on-board audio jack.

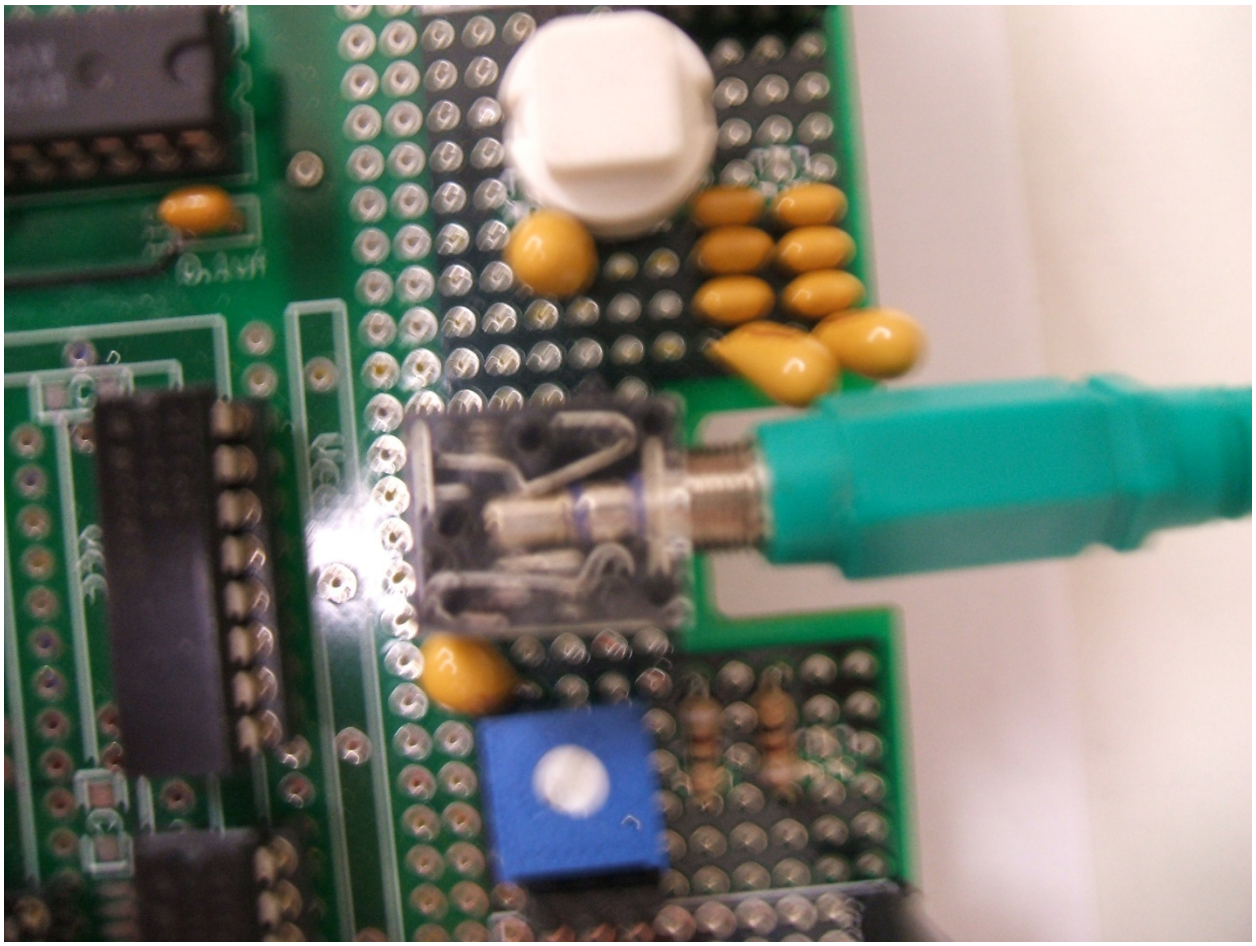


Figure 17- Connecting speakers to the board

**Connecting the Power**

This should be connected to the board last. This is because you should turn on the MP3 board last. Ideally, the user should use a power supply which has its own light source to tell the user when the power supply is on. This MP3 Jukebox should be powered by an Elpac or compatible power supply, which fits into the 5-pin DIN connector on the top left of the board. Below is a sample of the best option power supply (one with a light indicating on/off status)

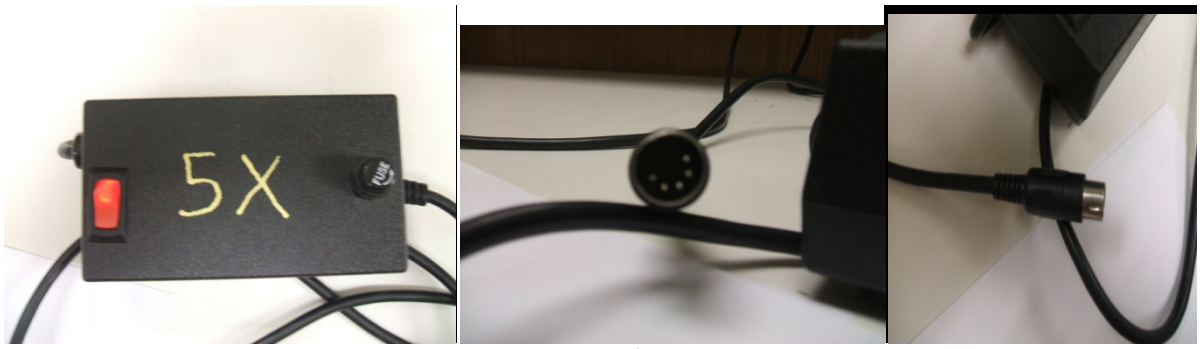



Figure 18- Elpac power supply with a light source to indicate on/off status

Below is an image of the power supply plugged into the 5-pin DIN connector of the board.

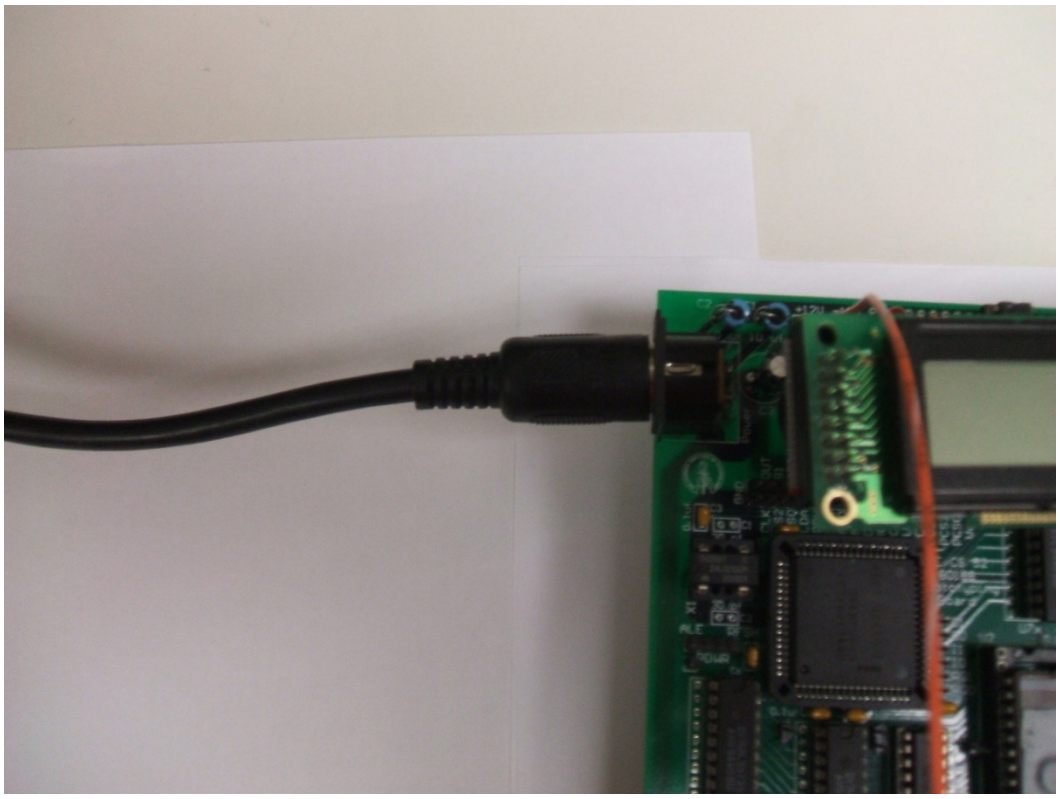


Figure 19- Power Supply plugged into MP3 board's 5-pin DIN connector

## Final Setup

With all the peripherals attached, below is an image of what the final setup should look like

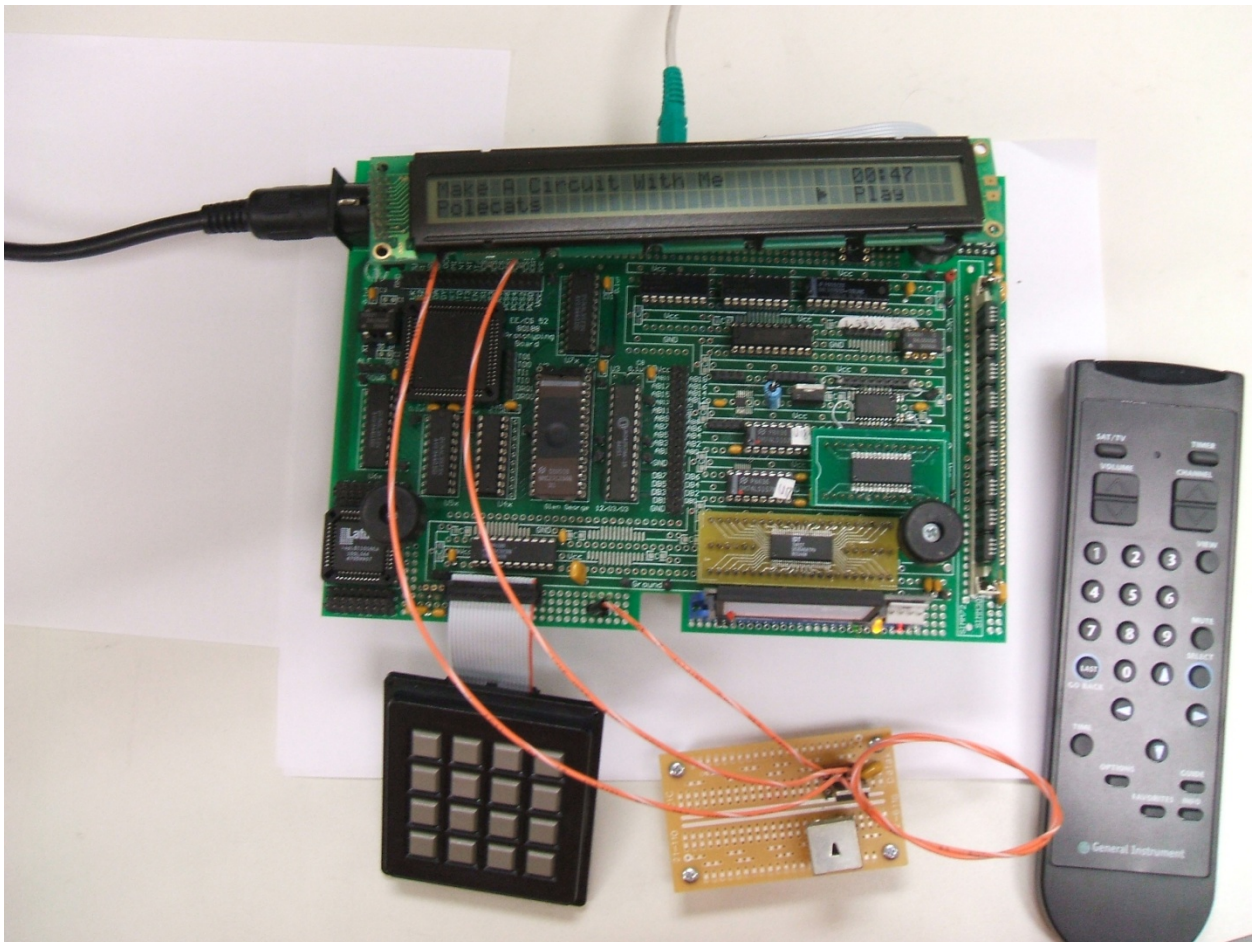



Figure 20- Final Setup of MP3 Jukebox

## Controlling and Operating the Jukebox

This section deals with the Inputs, outputs, and user interface of the MP3 Jukebox project.

**Inputs:**
Below is a table with the input devices and their descriptions

| Input Device | Description |
|---|---|
| 16-key keypad | This is a 4 by 4 keypad and the user has the option of using this keypad to perform the multiple MP3 Jukebox operations. A detailed description of these operations as well as a more detailed description of the keypad is given later. |
| IR Remote Control | This is a 29 button remote control and will have the same functions as the keypad. The user has to use either this or the keypad to control the Jukebox. A more detailed description of the IR Remote Control is given later. |

**Outputs:**
Below is a table with the output device and its description

| Output Device | Description |
|---|---|
| LCD Display | It is a 40 by 2 display. That is it has 2 rows of 40 character lengths.<br><br>The display shows the current system status and the status of the currently selected track. A more detailed description of the LCD Display is given later. |
| Audio Jack | Connected to speakers to output the playing music |

**User Interface:**

The user interface's important components are the 16-key keypad, a 29-button IR remote control and the display. As explained in the outputs section, the display shows the user current useful information about the system.

The most important components of the user interface are the 16-key keypad and the IR Remote Control and so they shall be explained in detail with reference to the display when necessary.

<u>The Keypad:</u>

It should be noted that on this keypad, only one button should be pressed at a time. Simultaneous multiple key presses will result in strange results. Thus the system will consider illegal keypad presses, and act as it deems fit. This will be undesirable so avoid it.

The design of the keypad is illustrated:

| | | | |
|---|---|---|---|
| Track Up | Track Down | Play/ Pause | Repeat Play |
| Fast Forward | Reverse | Stop | UNUSED |
| UNUSED | UNUSED | UNUSED | UNUSED |
| UNUSED | UNUSED | UNUSED | UNUSED |

The IR Remote Control:

It should be noted that on this remote control, only one button should be pressed at a time. Simultaneous multiple button presses will result in strange results. Thus the system will consider illegal keypad presses, and act as it deems fit. This will be undesirable so avoid it.

Also this remote control unit is very sensitive so be cautious and press buttons swiftly or the unit will auto repeat assume it has received multiple of the same key press and this could be problematic (as will be discussed below).

Below is a picture of the remote control:

Below is a table mapping the buttons, by their button labels to their corresponding functions.

| **Remote Control Label** | **Corresponding Jukebox Function** |
|---|---|
| 1 | <Track Up> |
| 2 | <Track Down> |
| 3 | <Play> |
| 4 | <Repeat Play> |
| 5 | <Fast Forward> |
| 6 | <Reverse> |
| 7 | <Stop> |
| Every other button | UNUSED |

The LCD Display

For ease of reference in describing the 40 x 2 (40 characters by 2 rows) LCD in this user manual, the characters on each row will be referred to by indices numbered from 0 to 39.

On the top row:
The first 30 characters (0 to 29) are used to display the track title,
Characters 30 to 31 are blank
Characters 32 to 36 are used to display the time remaining on the currently playing track (in minutes: seconds), or the total time for the songs in the current playlist which has not yet been entered.

On the bottom row:
The first 20 characters (0 to 19) are used to display the artist name
Characters 19 to 28 are blank
Characters 29 to 39 are used as a current system status indicator for the current operation (play, reverse, etc.). This status indicator is done symbolically as well as with text.

Example Display:
_____Track Name_____ __:__
_____Artist Name_____ __Status_

A very important part of this Display is the current system status display. The system status (mode) is one of:

| **Status** | **Description** | **Corresponding LCD Display** |
|---|---|---|
| Idle | The system is doing nothing, waiting for input. | '□□ Idle ' |
| Play | A track is being played. | '► Play ' |
| Repeat Play | A track is being repeatedly played. | '► Play ' |
| Fast Forward | A track is being fast forwarded. | '►► FastFwd ' |
| Reverse | A track is being reversed. | '◄◄ Reverse ' |
| Pause | A track is being paused. | '▌▌ Pause ' |

User Interface Functions Descriptions

The table below describes each key on the keypad or the IR remote control, and the actions that result from pressing the key (or button, but will be generally referred to as key):

| Key | Description |
|---|---|
| <Track Up> | This key makes the system go to the previous track in the current playlist and reset to the start of that track. When it gets to the first track in the playlist it saturates there.<br><br>If this key is pressed once and held down (thus being continually pressed) it is considered as multiple key presses. Thus there is auto repeat.<br><br>This key can only be pressed when the system is in the Idle state, and so the status indicator is still that for Idle: '□□ Idle '. |
| <Track Down> | This key makes the system go to the next track in the current playlist and reset to the start of that track. When it gets to the last track in the playlist it saturates there.<br><br>If this key is pressed once and held down (thus being continually pressed) it is considered as multiple key presses. Thus there is auto repeat.<br><br>This key can only be pressed when the system is in the Idle state, and so the status indicator is still that for Idle: '□□ Idle '. |
| <Play/Pause> | If the current track is a song, this key plays the current track from the current position on the track. When the end of the track is reached or the <Stop> key is pressed, playing stops and the track is reset to the start of the track. If the current track is a playlist, this key makes that playlist the current playlist.<br><br>If this key is pressed while the system is "playing" the system pauses until this key is pressed again (and the system continues playing) or until the Stop key is pressed, and the system goes into an Idle State.<br><br>If this key is pressed once and held down (thus being continually pressed) there is auto repeat which is bad because it means the user rapidly toggles between Play and Pause. Thus only screeches are heard if any sound at all.<br><br>This key can be pressed when the system is in any mode.<br><br>When this key is pressed initially and the system is in a Play mode the status indicator becomes: '► Play '<br>When the key is pressed again and the system is in a Pause mode the |

| | |
|---|---|
| | status indicator becomes: '❚❚ Pause ' |
| <Repeat Play> | This key makes the system play the current track repeatedly from the current position on the track. When the end of the track is reached the system resets to the beginning of the track and continues playing. This obviously only works if the current track is a song and not a playlist.<br><br>If this key is pressed once and held down (thus being continually pressed) there is auto repeat and the system simply continues repeat playing<br><br>This key is effective when the system is in any mode except Pause.<br><br>When this key is pressed and the system is playing the status indicator becomes: '► Play ' |
| <Fast Forward> | This key makes the system fast forward the current track. This moves the current position on the track forward, faster than normal play (at least a factor of two faster), without playing the track. The track may then be played from this position with <Play> or <Repeat Play>.<br><br>Fast Forwarding stops when the end of the track is reached or the <Stop> key or the <Fast Forward> key is pressed. Again it is obvious that this only has meaning if the current track is a song and not a playlist.<br><br>If this key is pressed once and held down (thus being continually pressed) there is auto repeat which will be bad because the system will toggle between Fast Forward and Idle and nothing gets done.<br><br>This key can be pressed and be effective when the system is in any mode except Pause.<br><br>When this key is pressed and the system is fast forwarding the status indicator becomes: '►► FastFwd'. |
| <Reverse> | This key makes the system rewind the current track. This moves the current position on the track backward, faster than normal play (by at least a factor of two faster), without playing the track. The track may then be played from this position with <Play> or <Repeat Play>.<br><br>Reversing stops when the start of the track is reached or the <Stop> key or the <Reverse> key is pressed.<br><br>If this key is pressed once and held down (thus being continually pressed) there is auto repeat which will be bad because the system will toggle between Reverse and Idle and nothing gets done.<br><br>This key can be pressed and be effective when the system is in any |

| | |
|---|---|
| | mode except Pause.<br><br>When this key is pressed and the system is reversing the status indicator becomes: '◀◀ Reverse'. |
| <Stop> | This key makes the system stop the current action. If no operation is currently active on the system, this key resets the current track to the start of the track or the current playlist to the start of the playlist.<br><br>If this key is pressed once and held down (thus being continually pressed) there is auto repeat and the system keeps on being Idle, which makes continual pressing seem rather pointless.<br><br>This key can be pressed when the system is in any mode.<br><br>When this key is pressed the status indicator becomes: '□□ Idle ' |
| UNUSED | NO FUNCTION |

Note that when a key with an associated action is pressed, the display messages (song, artist, and time) are updated appropriately to give current information, and the status indicator is changed to the corresponding message as described earlier.

User Interface Functions Summary:

On power up (boot up), the system starts in the Idle state with all tracks available for playing. At this point the user can move to any track with <Track Up> or <Track Down> and begin playing that track. When tracks are played, the track status display is updated to show the total time the track has left in playing time.

The <Stop> key will stop any operation and return the system to the idle state. Additionally, other keys will stop the current operation and start a new operation to allow rapid switching between modes. The allowed keys under each mode (system status) and their actions are given below.

| **Mode** | **Recognized Keys** | **Description of Action** |
|---|---|---|
| Idle | <Stop> | resets to the start of the current track or playlist |
| | <Play> | begin playing the current track or move into the current playlist depending on whether the current selection is a song or playlist |
| | <Repeat Play> | begin repeatedly playing the current track if the current selection is a song |
| | <Fast Forward> | fast forward the current track if the current selection is a song |
| | <Reverse> | reverse the current track if the current selection is a song |
| | <Track Down> | go to the start of the next track or playlist |
| | <Track Up> | go to the start of the previous track or playlist |
| Play | <Stop> | stop playing and reset to the start of the track |
| | <Play> | pause playing at the current position |
| | <Repeat Play> | continue playing, but now repeat from the start of the track when get to the end of the track |
| | <Fast Forward> | stop playing and start fast forwarding the track from the current position |
| | <Reverse> | stop playing and start reversing the track from the current position |
| Repeat Play | <Stop> | stop playing and reset to the start of the track |
| | <Play> | continue playing, but stop when get to the end of the track |
| | <Fast Forward> | stop playing and start fast forwarding from the current position |
| | <Reverse> | stop playing and start reversing from the current position |
| Fast Forward | <Stop> | stop fast forwarding (do not reset to the start of the track) |
| | <Play> | begin playing from the current position |
| | <Repeat Play> | begin repeatedly playing from the current position and when the end of the track is reached, repeat from the start of the track |
| | <Fast Forward> | stop fast forwarding (same as <Stop>) |

| | | |
|---|---|---|
| | <Reverse> | start reversing from the current position |
| Reverse | <Stop> | stop reversing (do not reset to the start of the track) |
| | <Play> | begin playing from the current position |
| | <Repeat Play> | begin repeatedly playing from the current position and when the end of the track is reached, repeat from the start of the track |
| | <Fast Forward> | start fast forwarding from the current position |
| | <Reverse> | stop reversing (same as <Stop>) |
| Pause | <Stop> | stop playing and reset to the start of the track |
| | <Play> | continue playing from the current position |

Example Images

At this point it will be nice to put some sample images of the system displaying different statuses.

Figure 21- Idle Status

Figure 22- Play Status

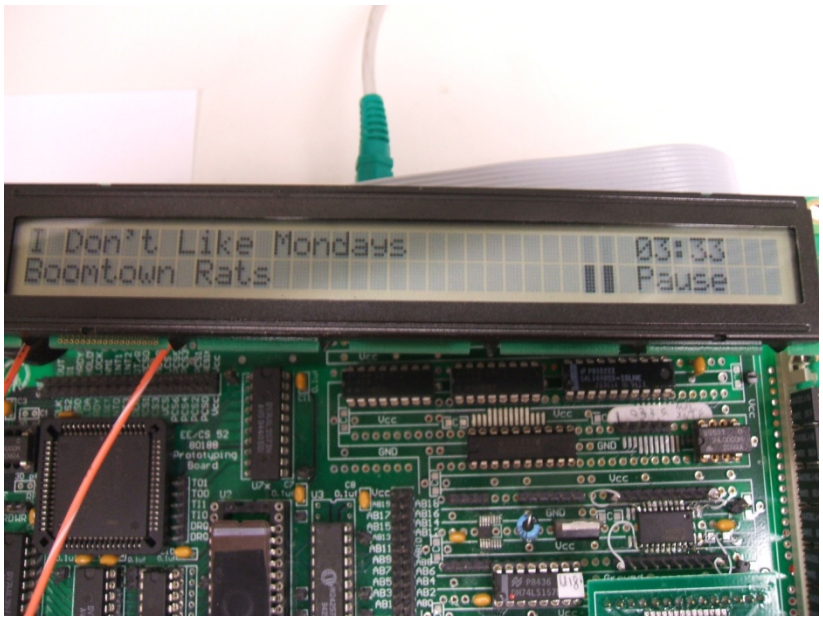


Figure 23- Pause Status

Figure 24- Fast Forward Status

Figure 25- Reverse Status

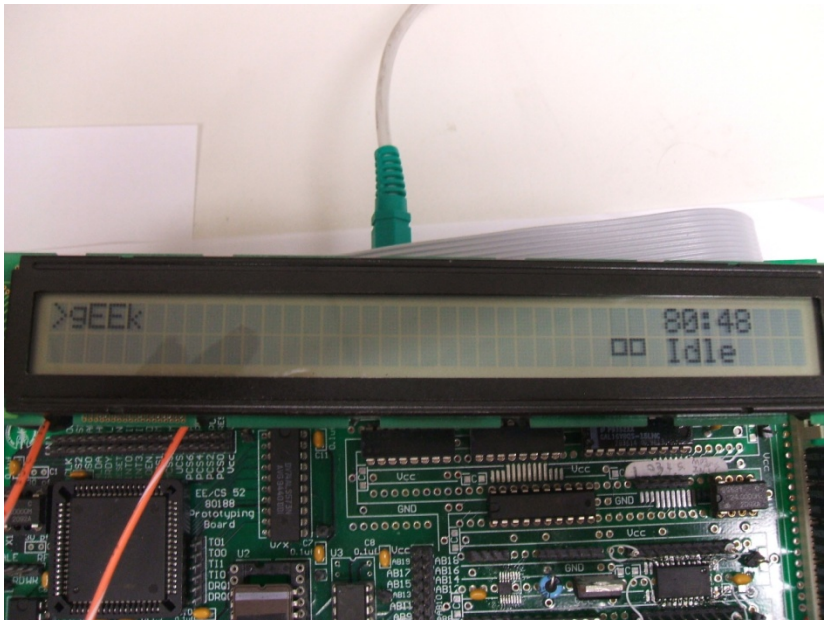


Figure 26- Displaying a playlist and the total time of the songs in it.

## Transporting the Jukebox

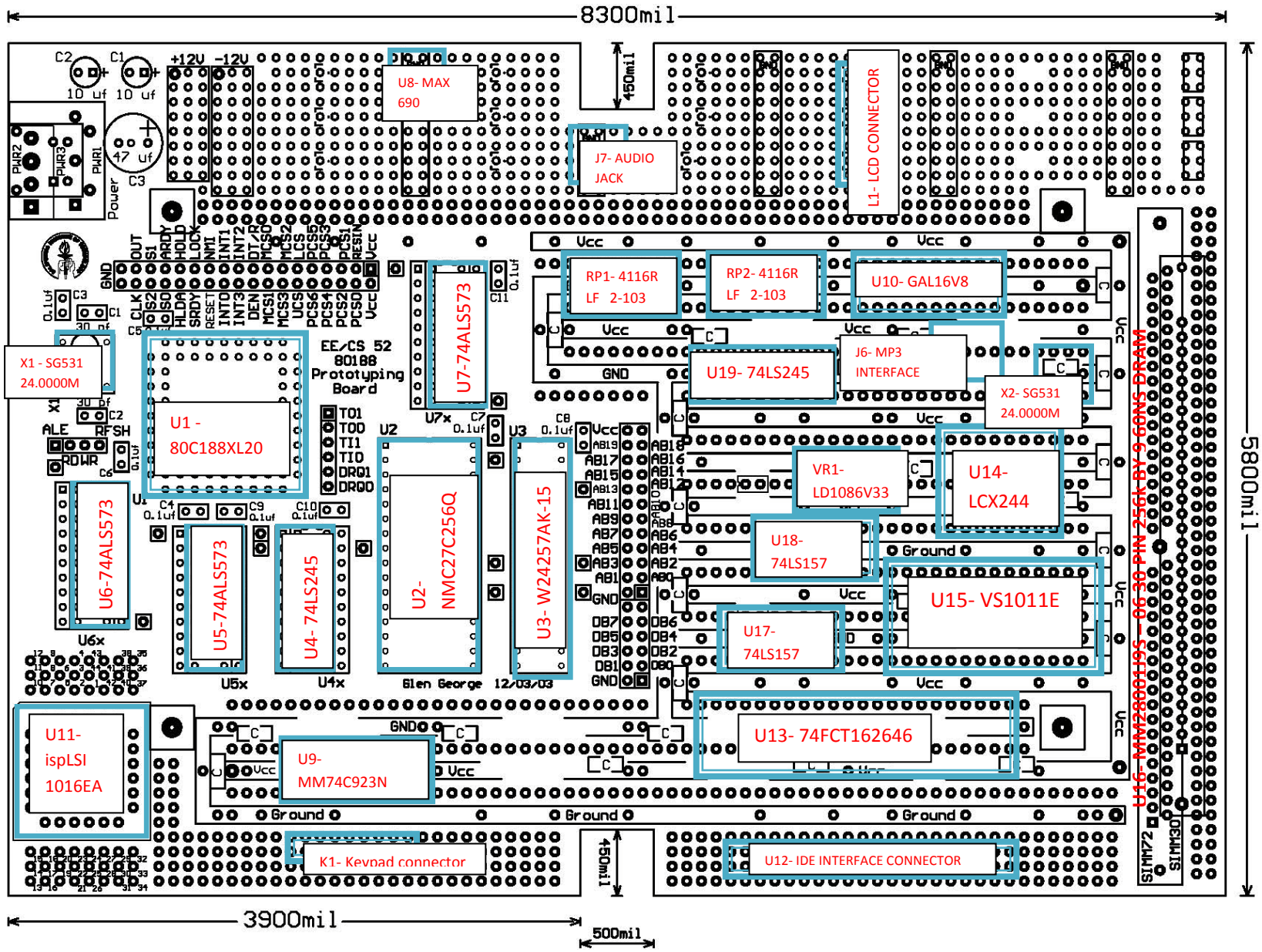
It is best to transport the jukebox in a box of its own. A cardboard box is good enough. Just be sure that the base of the box is somewhat fortified, so as to avoid the unfortunate event that the board fell out and possibly got smashed.

Before Transporting the jukebox be sure to dismantle it and keep the external peripherals in a separate box.

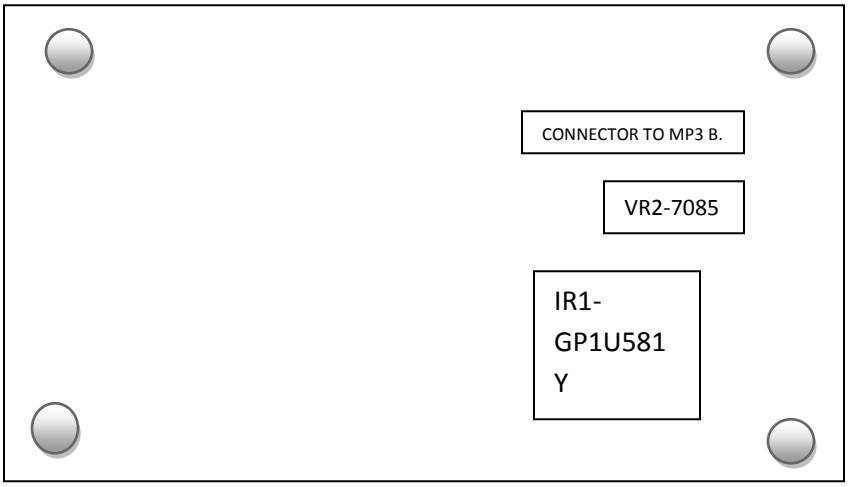
# BOARD LAYOUTS

-MP3 Jukebox Main Board Layout

-MP3 Jukebox IR Controller Board Layout


8300mil
5800mil
3900mil
500mil
450mil
U8- MAX 690
J7- AUDIO JACK
L1- LCD CONNECTOR
RP1- 4116R LF 2-103
RP2- 4116R LF 2-103
U10- GAL16V8
U19- 74LS245
J6- MP3 INTERFACE
X2- SG531 24.0000M
X1 - SG531 24.0000M
U1 - 80C188XL20
EE/CS 52 80188 Prototyping Board
U7-74ALS573
U6-74ALS573
U5-74ALS573
U4- 74LS245
U2- NMC27C256Q
U3- W24257AK-15
VR1- LD1086V33
U14- LCX244
U18- 74LS157
U17- 74LS157
U15- VS1011E
U13- 74FCT162646
U11- ispLSI 1016EA
U9- MM74C923N
K1- Keypad connector
U12- IDE INTERFACE CONNECTOR
U16- MM28001HS - 86-30 PIN 256K BY 9 60NS DRAM
Glen George 12/03/03

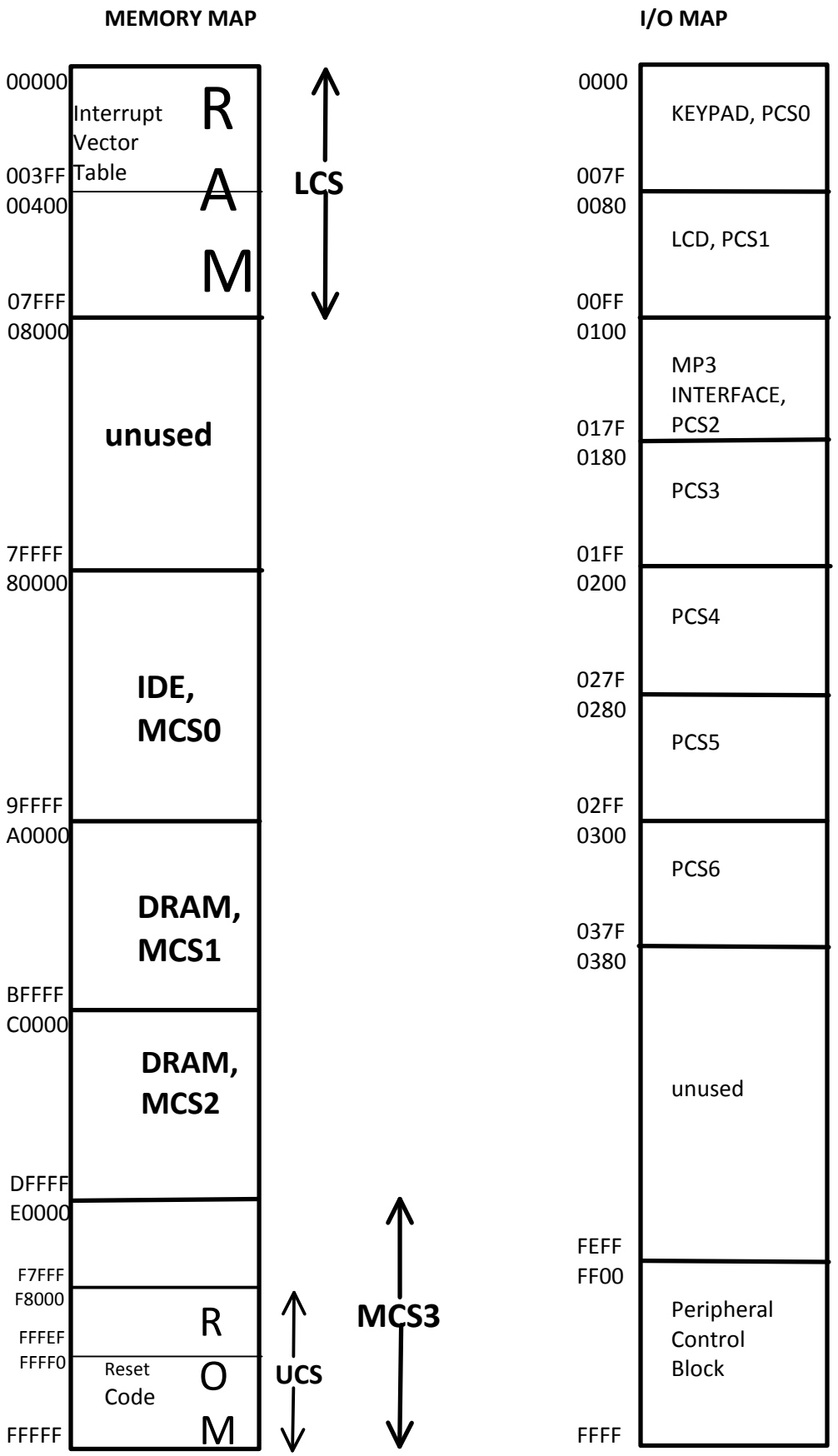
# IR Controller Board Layout



# 80188 MP3 Jukebox Memory Maps

# 80188 MP3 JukeBox Memory Map

Tuesday, April 07, 2009
11:16 PM



# 80188 MP3 Jukebox Project Functional Specification

# 80C188 MP3 Jukebox Project
# Functional Specification

**Description:**
The MP3 Jukebox is a microprocessor-based system which is capable of playing MP3 files stored on a FAT formatted hard drive or Compact memory card. The user has the ability to recall and play any MP3 recording on the hard drive or memory card.

**Global Variables:**
None.

**Inputs:**
Below is a table with the input devices and their descriptions

| Input Device | Description |
|---|---|
| 16-key keypad | This is a 4 by 4 keypad and it will be the main component of the user interface along with the display. The user will use this keypad to perform the multiple MP3 Jukebox operations. A detailed description is given in the "User Interface" section. |
| IR Remote Control | This is a 29 button remote control and will have the same functions as the keypad. |

**Outputs:**
Below is a table with the output devices and their descriptions

| Output Device | Description |
|---|---|
| LCD Display | It is a 40 by 2 display. That is it has 2 rows of 40 character lengths.<br><br>For ease of reference in describing the LCD in this functional specification, the characters on each row will be referred to by indices numbered from 0 to 39.<br><br>On the top row:<br>The first 30 characters (0 to 29) are used to display the track title,<br>Characters 30 to 31 are blank<br>Characters 32 to 36 are used to display the time remaining on the track currently playing track (in minutes: seconds), or the total time for the songs in the current playlist which has not yet been entered.<br><br>On the bottom row:<br>The first 20 characters (0 to 19) are used to display the artist name<br>Characters 19 to 28 are blank<br>Characters 29 to 39 are used as a status indicator for the current operation (play, reverse, etc.). |

| | |
|---|---|
| | Example:<br>_____Track Name_____ __:__<br>_____Artist Name_____ __Status_ |
| Audio Jack | Connected to speakers to output the playing music |

**User Interface:**
The user interface is made up of the 16-key keypad, a 29-button IR remote control and the display. As explained in the outputs section, the display shows the user current useful information about the system.

The most important components of the user interface are the 16-key keypad and the IR Remote Control and so they shall be explained in detail with reference to the display when necessary.

<u>The Keypad:</u>
It should be noted that on this keypad, only one button should be pressed at a time. Simultaneous multiple key presses will result in strange results. Thus the system will consider illegal keypad presses, and act as it deems fit. This will be undesirable so avoid it.

The design of the keypad is illustrated:

| | | | |
|---|---|---|---|
| Track Up | Track Down | Play/ Pause | Repeat Play |
| Fast Forward | Reverse | Stop | UNUSED |
| UNUSED | UNUSED | UNUSED | UNUSED |
| UNUSED | UNUSED | UNUSED | UNUSED |

The IR Remote Control:

It should be noted that on this remote control, only one button should be pressed at a time. Simultaneous multiple button presses will result in strange results. Thus the system will consider illegal keypad presses, and act as it deems fit. This will be undesirable so avoid it.

Also this remote control unit is very sensitive so be cautious and press buttons swiftly or the unit will auto repeat assume it has received multiple of the same key press and this could be problematic (as will be discussed below).

Below is a picture of the remote control:

Below is a table mapping the buttons, by their button labels to their corresponding functions.

| **Remote Control Label** | **Corresponding JukeBox Function** |
|---|---|
| 1 | <Track Up> |
| 2 | <Track Down> |
| 3 | <Play> |
| 4 | <Repeat Play> |
| 5 | <Fast Forward> |
| 6 | <Reverse> |
| 7 | <Stop> |
| Every other button | UNUSED |

Keypad and IR Remote Control

The table below describes each key on the keypad or the IR remote control, and the actions that result from pressing the key (or button, but will be generally referred to as key):

| Key | Description |
|---|---|
| <Track Up> | This key makes the system go to the previous track in the current playlist and reset to the start of that track. When it gets to the first track in the playlist it saturates there.<br><br>If this key is pressed once and held down (thus being continually pressed) it is considered as multiple key presses. Thus there is auto repeat.<br><br>This key can only be pressed when the system is in the Idle state, and so the status indicator is still that for Idle: '□□ Idle ’. |
| <Track Down> | This key makes the system go to the next track in the current playlist and reset to the start of that track. When it gets to the last track in the playlist it saturates there.<br><br>If this key is pressed once and held down (thus being continually pressed) it is considered as multiple key presses. Thus there is auto repeat.<br><br>This key can only be pressed when the system is in the Idle state, and so the status indicator is still that for Idle: '□□ Idle ’. |
| <Play/Pause> | If the current track is a song, this key plays the current track from the current position on the track. When the end of the track is reached or the <Stop> key is pressed, playing stops and the track is reset to the start of the track. If the current track is a playlist, this key makes that playlist the current playlist.<br><br>If this key is pressed while the system is "playing" the system pauses until this key is pressed again (and the system continues playing) or until the Stop key is pressed, and the system goes into an Idle State.<br><br>If this key is pressed once and held down (thus being continually pressed) there is auto repeat which is bad because it means the user rapidly toggles between Play and Pause. Thus only screeches are heard if any sound at all.<br><br>This key can be pressed when the system is in any mode.<br><br>When this key is pressed initially the status indicator becomes: |

| | |
|---|---|
| | '► Play '<br>When the key is pressed again the status indicator becomes:<br>'❚❚ Pause ' |
| <Repeat Play> | This key makes the system play the current track repeatedly from the current position on the track. When the end of the track is reached the system resets to the beginning of the track and continues playing. This obviously only works if the current track is a song and not a playlist.<br><br>If this key is pressed once and held down (thus being continually pressed) there is auto repeat and the system simply continues repeat playing<br><br>This key is effective when the system is in any mode except Pause.<br><br>When this key is pressed and the system is playing the status indicator becomes: '► Play ' |
| <Fast Forward> | This key makes the system fast forward the current track. This moves the current position on the track forward, faster than normal play (at least a factor of two faster), without playing the track. The track may then be played from this position with <Play> or <Repeat Play>.<br><br>Fast Forwarding stops when the end of the track is reached or the <Stop> key or the <Fast Forward> key is pressed. Again it is obvious that this only has meaning if the current track is a song and not a playlist.<br><br>If this key is pressed once and held down (thus being continually pressed) there is auto repeat which will be bad because the system will toggle between Fast Forward and Idle and nothing gets done.<br><br>This key can be pressed and be effective when the system is in any mode except Pause.<br><br>When this key is pressed and the system is fast forwarding the status indicator becomes: '►► FastFwd'. |
| <Reverse> | This key makes the system rewind the current track. This moves the current position on the track backward, faster than normal play (by at least a factor of two faster), without playing the track. The track may then be played from this position with <Play> or <Repeat Play>.<br><br>Reversing stops when the start of the track is reached or the <Stop> key or the <Reverse> key is pressed.<br><br>If this key is pressed once and held down (thus being continually pressed) there is auto repeat which will be bad because the system will toggle between Reverse and Idle and nothing gets done. |

| | |
|---|---|
| | This key can be pressed and be effective when the system is in any mode except Pause.<br><br>When this key is pressed and the system is fast forwarding the status indicator becomes: '◀◀ Reverse'. |
| <Stop> | This key makes the system stop the current action. If no operation is currently active on the system, this key resets the current track to the start of the track or the current playlist to the start of the playlist.<br><br>If this key is pressed once and held down (thus being continually pressed) there is auto repeat and the system keeps on being Idle, which makes continual pressing seem rather pointless.<br><br>This key can be pressed when the system is in any mode.<br><br>When this key is pressed the status indicator becomes: '□□ Idle ' |
| UNUSED | NO FUNCTION |

Note that when a key with an associated action is pressed, the display messages (song, artist, and time) are updated appropriately to give current information, and the status indicator is changed to the corresponding message as described earlier.

**Error Handling:**
The keypad and IR remote control have been designed for simple use, so if the user presses more than one button at a time, the user should expect unpredictable results. Also if the user presses a key/button that is not being used, the key press is ignored.

If the MP3 Jukebox suddenly loses power while playing when it is restarted it does not continue from where it was. It is instead reset to idle and waits for user input.

**Algorithms:**
No algorithms really.

**Data Structures:**
None.

**Limitations:**
The basic system is not capable of recording or storing MP3 files (the hard drive or memory card must be pre-recorded).

**Known Bugs:**
None.

**Special Notes:**
Don’t mess with the software or hardware without fully reading and understanding the ‘excellent’ documentation.