INDUSTRIAL AUTOMATION

R2 SERIES OPERATORS MANUAL

Electronics Section

Model R2-X2 eXperimental Model

Cover artwork by John Jongsma

Droid Electronics (Dome)

The R2 series droids have a myriad of electronic devices tucked under the dome. Examples include front and rear logics, control of the periscope and life-form scanner lifting devices, holo-projector movement, PSI lights, control of the pie panels and lower dome panels, pan and tilt of cameras behind the radar eye, activation of the “fire extinguisher” and much more. Inside the dome the micro controller rules. Almost all of these devices use a micro controller in one form or another to perform their function. Many of the devices while different follow one of 2 basic patterns for their operation so I will cover those basic constructions and leave it to the droid builder to come up with variations on those themes for their own droids.

Front Logics:

The original R2 in the movies used fiber optic wires that were positioned behind each light of the front logic. A spinning wheel with a hole pattern cut in it was used to turn the individual lights on and off by blocking or allowing light through the optical wire. Today however that has been replaced with LED lights and a micro controller to turn the individual LEDs on and off. A small circuit board with a PIC micro controller is mounted behind the front logics. A 12 V power supply is used to run the LEDs and the micro controller. The original LED based front logics were designed and programmed by Dave Everett the founder of the R2-D2 builders club. Part run was done by Jason Kotecki, Ben Lewitt & Bruce Maley.

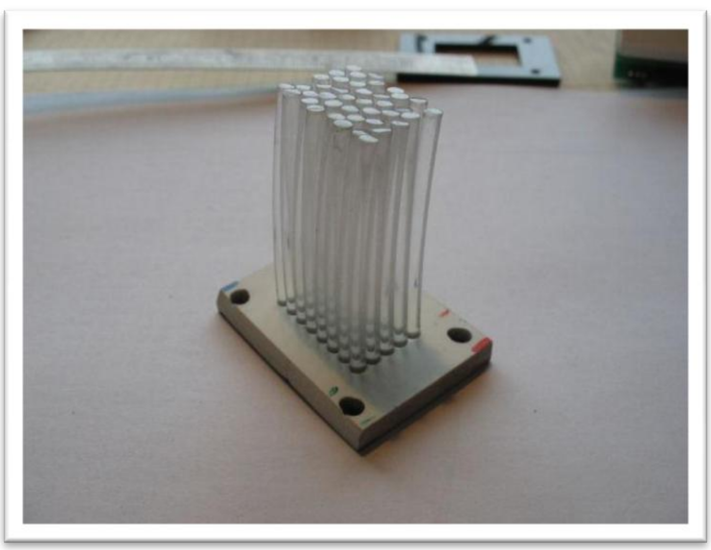


Figure 1: Front logics - using fiber optics

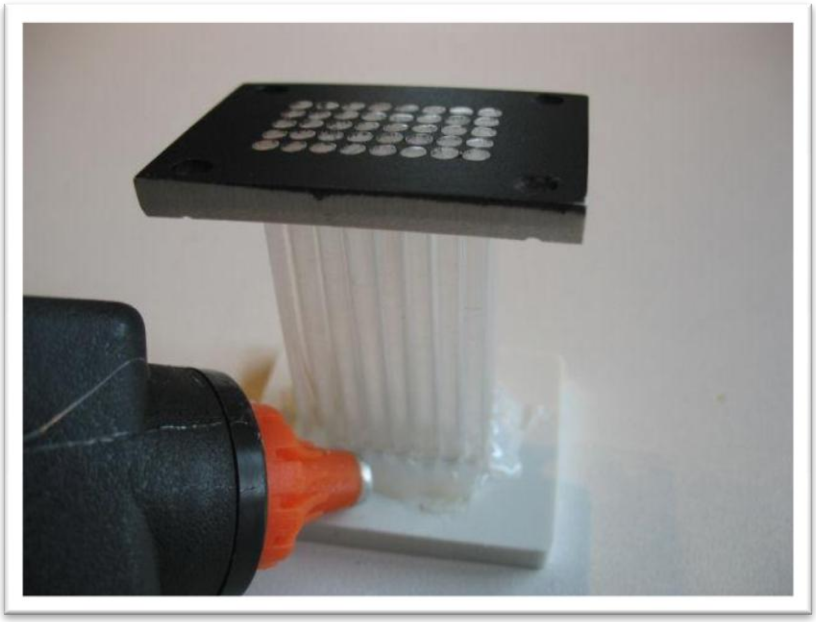


Figure 2: Front logics - fiber optics with bezel

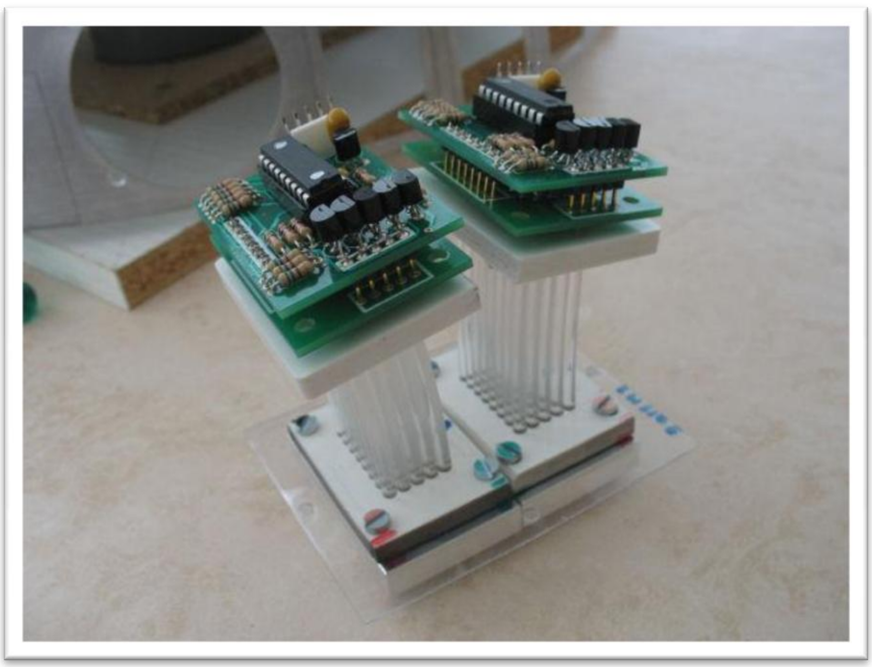


Figure 3: Front logics - LEDs & fiber optic

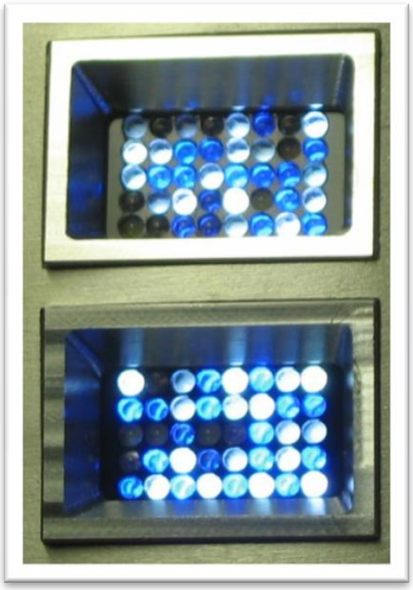


Figure 4: Front Logics LEDs lit up

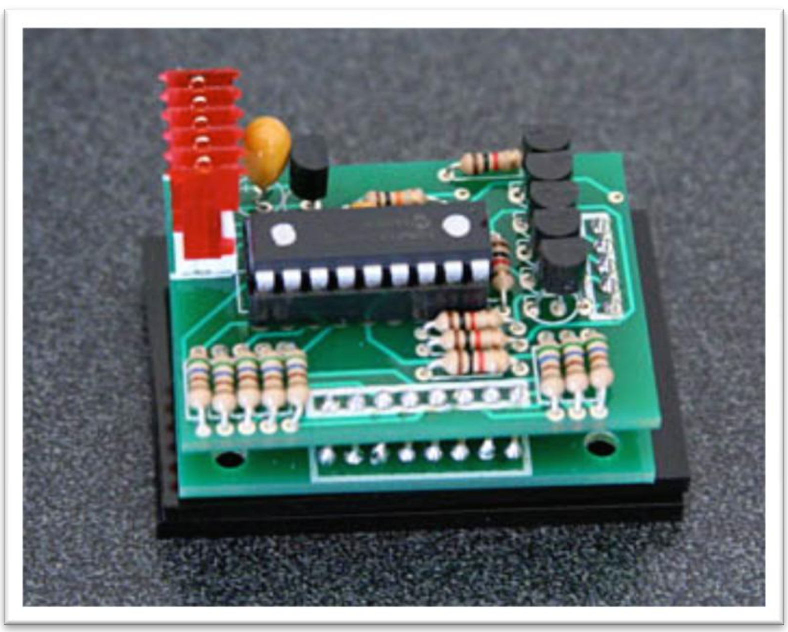


Figure 5: Front logics PIC micro controller and circuit board

Rear Logics:

The rear logics are constructed in a similar way to the front logics. LED lights are used for the display and a PIC micro controller is used to turn the individual LED lights on and off. The circuit board used for the rear logics is an electronic kit called the PIC flasher and it can be purchased from a number of different online electronics stores.

The form factor of the rear logics is longer than the front logics and therefore the design of the board that the LEDS are soldered to is different. The nature of running strings of LED lights is such that the voltage across each LED needs to be kept constant. If a singles voltage was applied to a string of LEDS the first ones in the string would be brighter that the ones near the end of the string. This is because each LED light is a diode that has some resistance to it. As more and more LEDs are added to the string the resistance of each of the LEDs lovers the voltage for the LEDS further down the chain and thus they glow lees bright. This problem is solved by first breaking up all of the LEDs into 4 separately powered strings. The each string has resistors of different values added along the chain of LEDs to control the voltage across the LEDs. This allows all of the LEDS to glow with very close to the same brightness. However, it should be noted that different color LEDS have different internal resistance. This causes the voltage to change depending on the color and number of LEDs used in any specific string. The specification of the resistors used for the rear logics is meant to compensate for this difference in the number and color of the LEDs used.

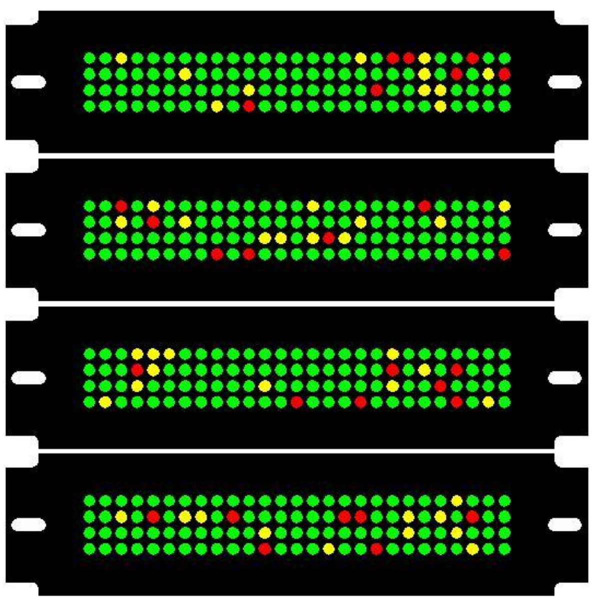


Figure 6: Rear logics color pattern

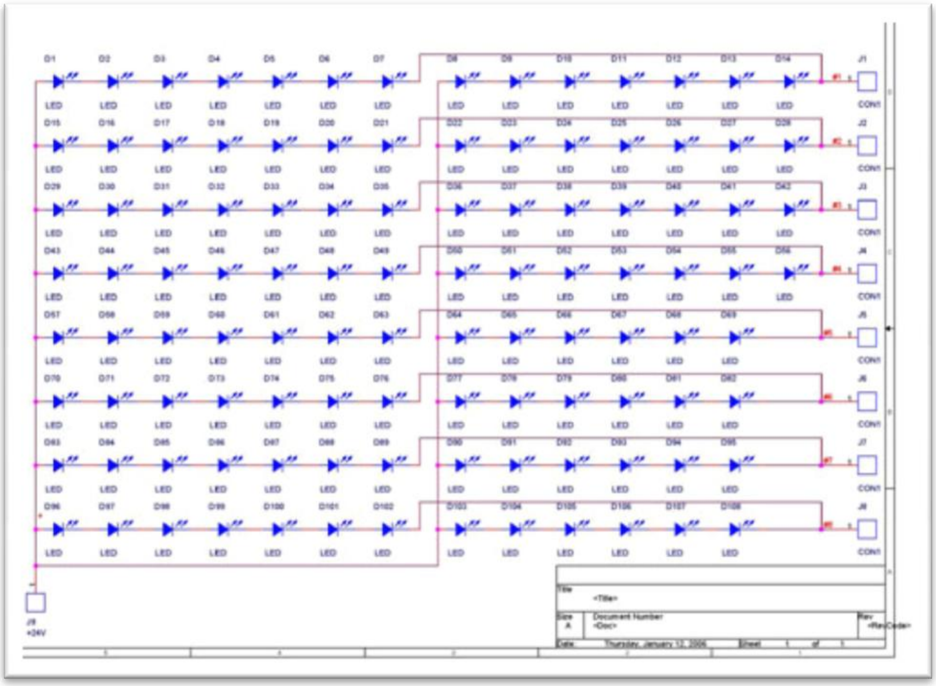


Figure 7: Rear logics schema

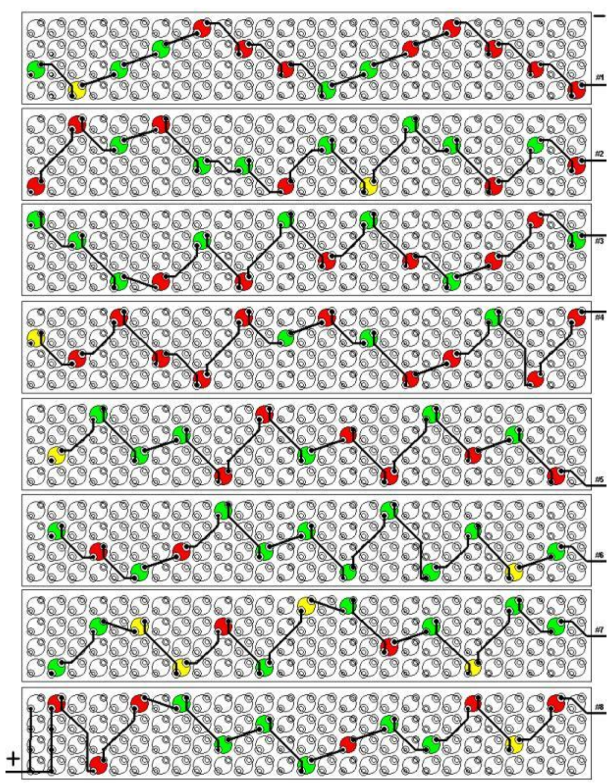


Figure 8: Rear logics LED wire pattern

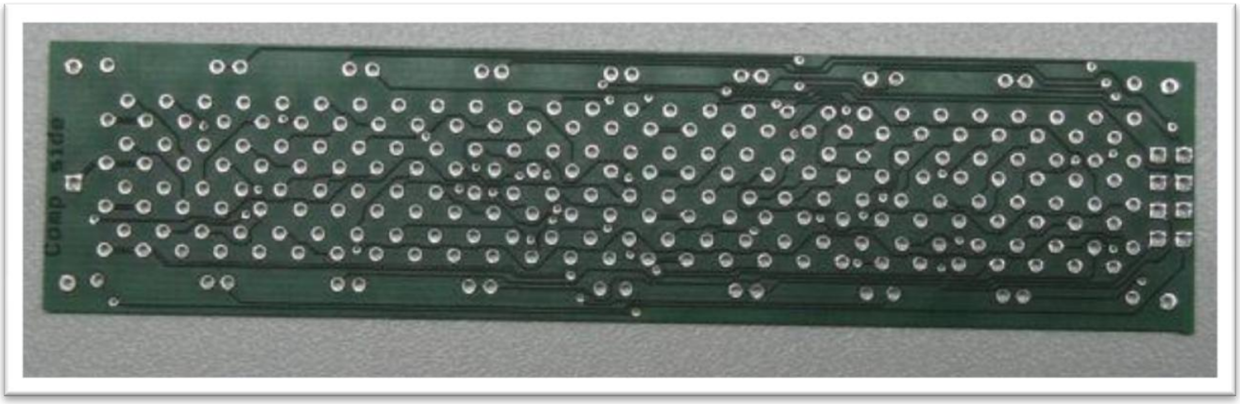


Figure 9: Rear logics printed circuit board

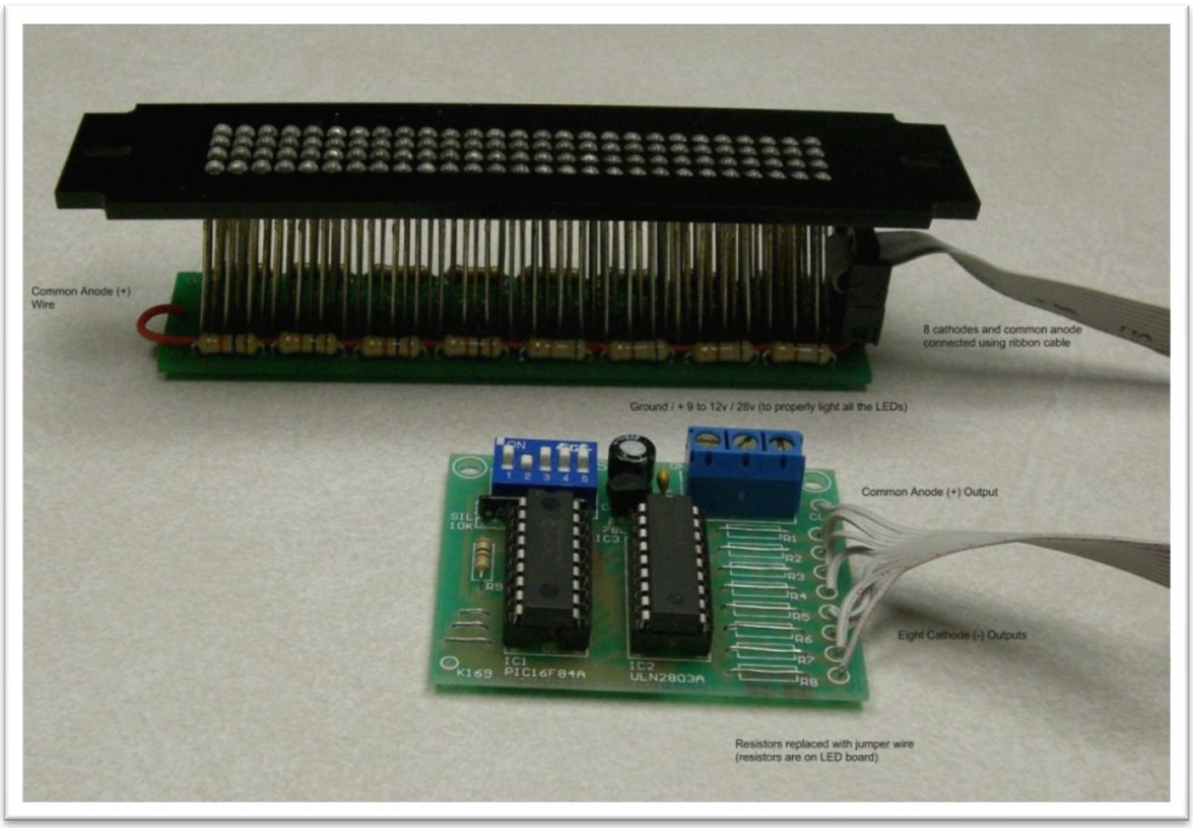


Figure 10: Logics - Rear electronics with bezel – beautiful work!

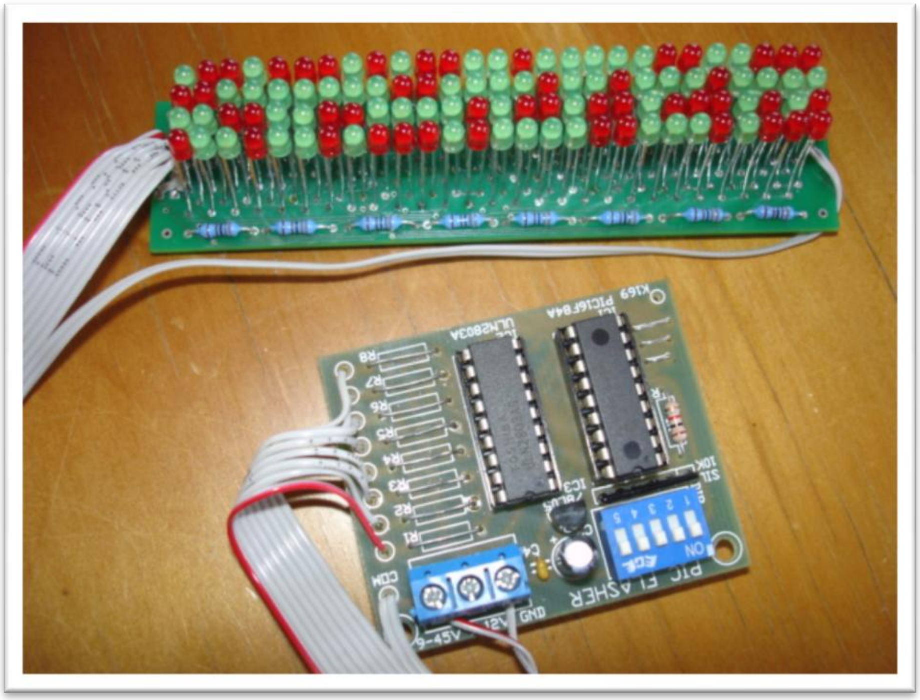


Figure 11: Logics Rear electronics without the cover bezel – another beautiful job

PSI Lights (Process State Indicators):

The PSI lights are a simple 2 LED flasher that alternates the LED lights. There are 2 PSI lights in the dome and each has 2 different colored LED lights. The lights are placed behind a milky white round circle and give off a diffuse glow that alternates from side to side with different colors. These simple 2 LED flasher kits are available from many different online electronics stores.

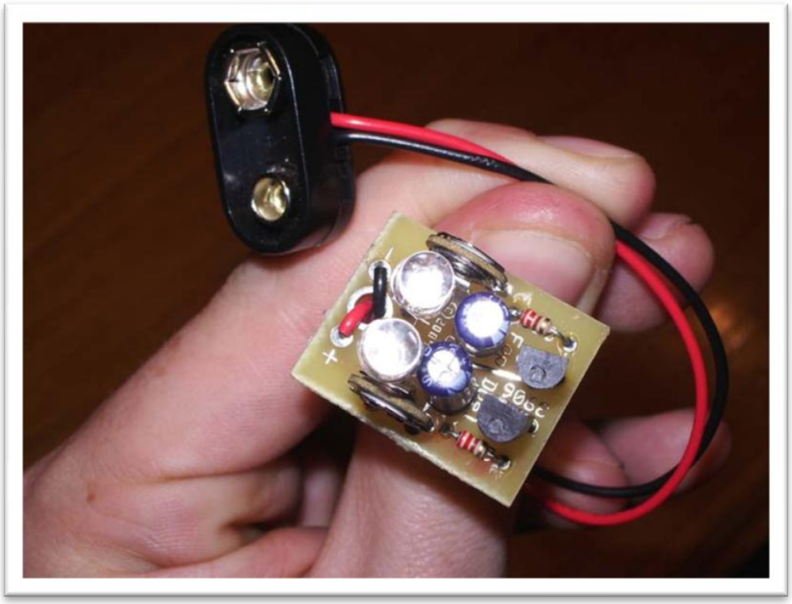


Figure 12: Simple electronic LED flasher for PSI lights

A part supplier from the R2 Builders cub offer a more advanced version of the PSI lights that does a better job of simulating the left and right switch and glow of the R2 used in the movies.

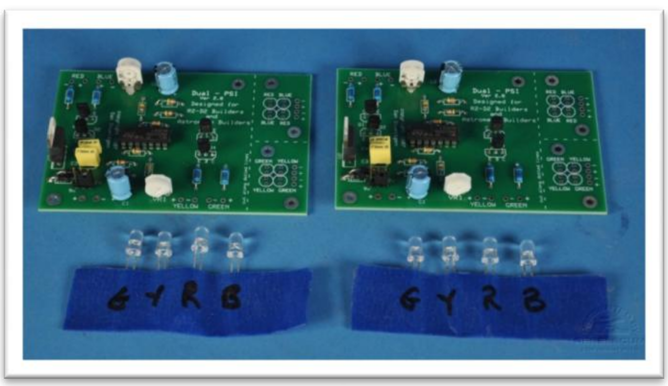


Figure 13: R2 Builders dual PSI circuit boards – Dan S.

In addition to the individual front and rear logic displays and PSI lights there is an integrated display system called the J.E.D.I. display. This system incorporates the front and rear logics and the PSI lights into a single micro controlled system. It also provides a display readout for display information about what the system is doing. The J.E.D.I. display system also allows the user to control the displays via joystick movements on the RC transmitter. One further advantage of the J.D.E.I system is that it lets the user write their own Jawa scripts to control the system displays.

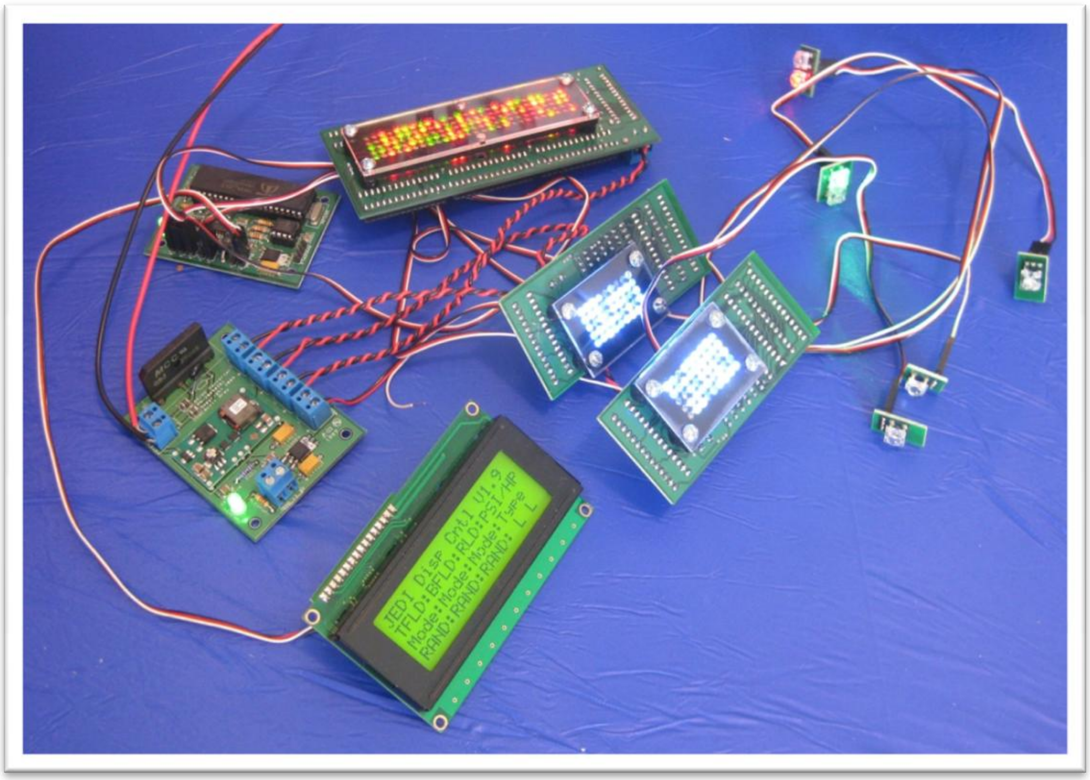


Figure 14: J.E.D.I. display integrate system - front & rear logics and PSI lights

Power Distribution:

R2 series droids use a number of different electronic devices and not all of them require the same voltage. Many R2 units have a main 12V power supply but need a way to provide power to a number of different devices that take 5, 6 or 9 volts. The power distribution board offers a solution to this problem. It has a main input of 12 volts and uses voltage regulators to step down the voltage to allow other devices to be powered by the 12 volt source. The voltage regulators used by the power distribution board are linear type which are very efficient at stepping down the voltage without wasting energy in the form of heat. Some energy is lost but by using this type of voltage regulator it is kept to a minimum.

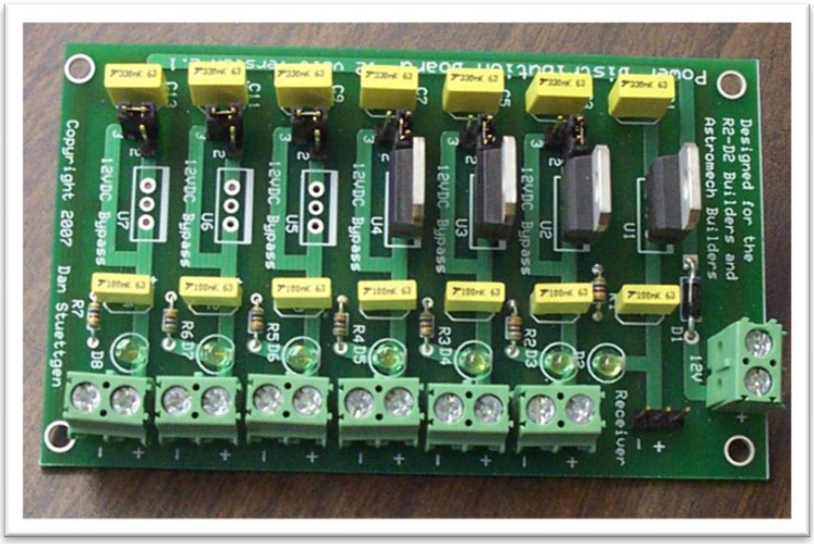
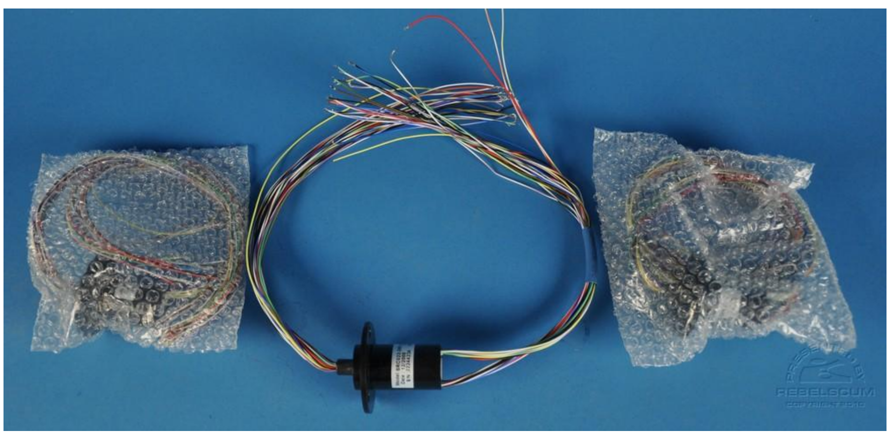


Figure 15: Power distribution board **- Photo by: Dan Stuettgen**

Slip Rings:

Slip rings are used to transfer both power and electrical control signals from the body where most main power supplies are located to the dome while allowing the dome to rotate.



Periscope Lifter Control Circuit:

Lifter mechanisms use limit switches on each end of the motion to stop the motor. The wiring of the limit switches along with a double pole double throw relay causes the motor to reverse direction when the lifter reaches each end of the motion. This allows a single button on a RF remote to signal the periscope to move up or down.

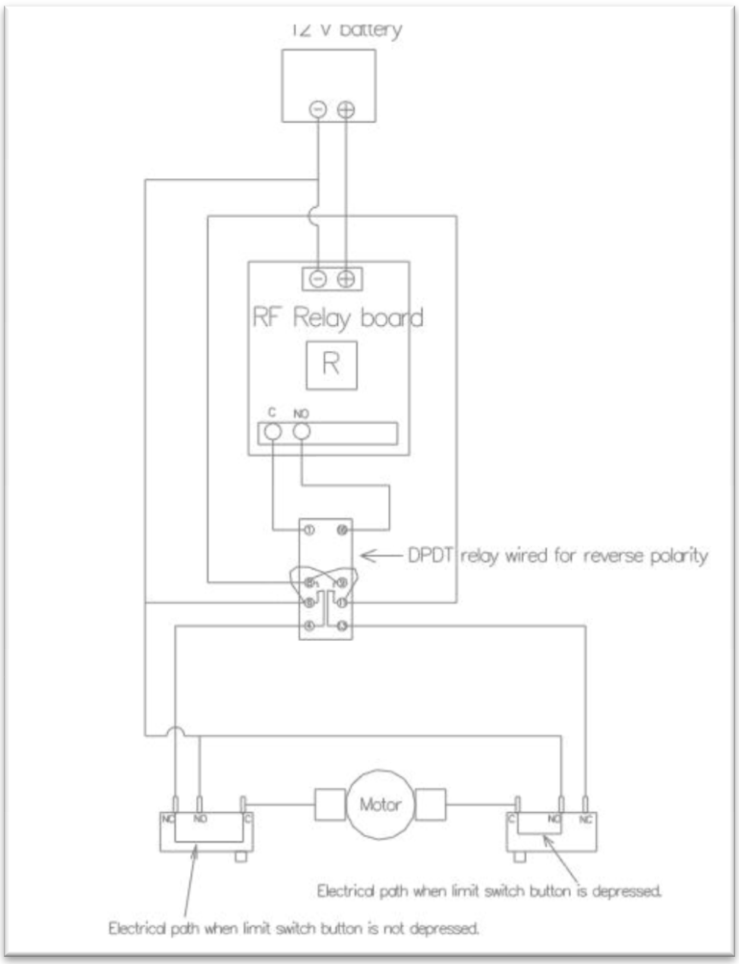


Figure 16: Periscope lifter wire diagram **- by: Blake Mann**

Droid Electronics (Body)

Electronic Panel Mounts:

The R2-X2 eXperimental Astromech droid has a stock JAG 4 frame that has been modified to allow all of the droids electronics to be mounted on removable panels. Removable panels provide access to the droids internal components by simply removing a panel. Once removed from the droid body any component on the panel can easily be replaced or repaired. When repair work is complete the panel is simply slid back into place. The panels are designed to slide in and out of the droid on magnetic rails and once the connectors mounted on the bottom of the panels are seated all the necessary electrical and electronic connections are established to the internal power supplies and the electromechanical components of the droid. The panels were designed to group the electronics of the major systems together. Therefore, there are 3 major panels and several sub panels. The three major panels contain the electronics for the drive system, the audio system and the animatronics system. Several of the sub panels have components mounted on them for the electrical charging system while 2 other sub panels have additional speakers on them which are part of the audio system. These speaker sub panels have been moved off of the main audio system panel to provide optimal placement for projecting sound.

Figure 17: JAG 4 frame with electronic panels mounts – **Photo by: Blake Mann**

Audio Systems:

Many droid builders use the CFII or CFIII sound boards for the R2 audio. CF stands for Compact Flash since it uses a Compact Flash card to stores the audio files. The CFIII is an audio player that gives you an all-in-one system as well as a platform to program the sound board called ASC Basic. The basic CFIII gives you an audio player, a stereo amplifier, and a built in Basic compiler. All you need to supply is the speakers. However if you want to be able to remotely trigger more than just 8 sounds you can add on the Contact Sense 8 or 24 expansion boards that mount directly to the CFIII main board. The Contact Sense (8 or 24) gives you an additional 8 or 24 contacts you can use to trigger sounds to play. To trigger the sounds a 12 ch RF relay board is used. The program inside the CFIII memory interprets what contact is being closed and performs some function according to how it is programmed. You will find the source code for a CFIII basic program in the Appendix of this manual.

While this is a good system there are some draw backs to using the CFIII. First it is a fairly large board especially when you add the Contact Sense add on module. Space is at a premium inside an Astromech droid. However, if you don’t have a lot of other electronics inside your droid there will be plenty of space. Secondly the ACS Basic programming environment is good but not great. Since their main job is not as a software compiler company it lacks some of the features of other Basic based systems such as a Picaxe, Arduino, or Basic Stamp. If you are only playing sounds though it is certainly sufficient to accomplish that. The third disadvantage and this may be the biggest one is that it is fairly expensive. Of course “expensive” is a relative word so I leave it to you to decide if it fits in your budget.

There are alternatives to the CFIII sound board. Alex Kung and Murray Jones developed an inexpensive substitute for the CFIII using the VMusic2 MP3 player. The system they developed uses a Picaxe micro controller to control the VMusic2 player. By adding a 12 ch RF remote and a stereo amplifier you have a full sound system at about 1/3 the cost of the CFIII. One nice feature of the VMusic2 player is that it uses a USB thumb drive to store the music files. This makes it almost universally compatible with all PCs and Macs for copying sounds files.

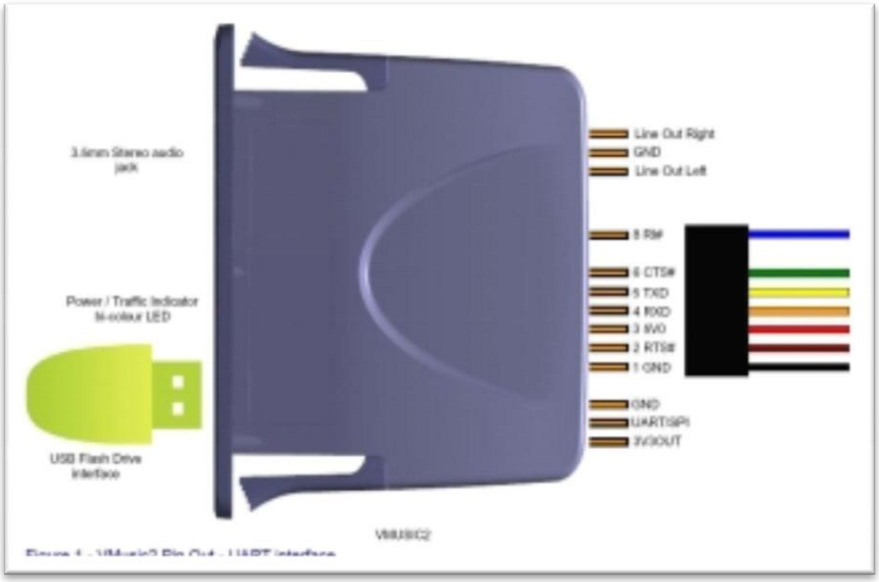


Figure 18: VMusic2 Pin-out diagram

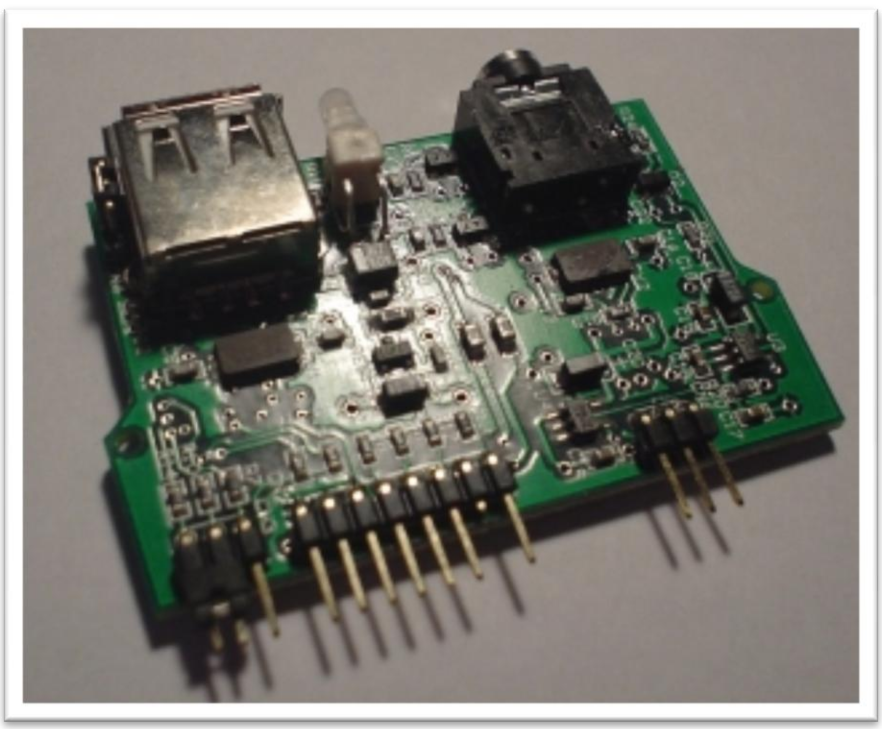


Figure 19: VMusic2 circuit board

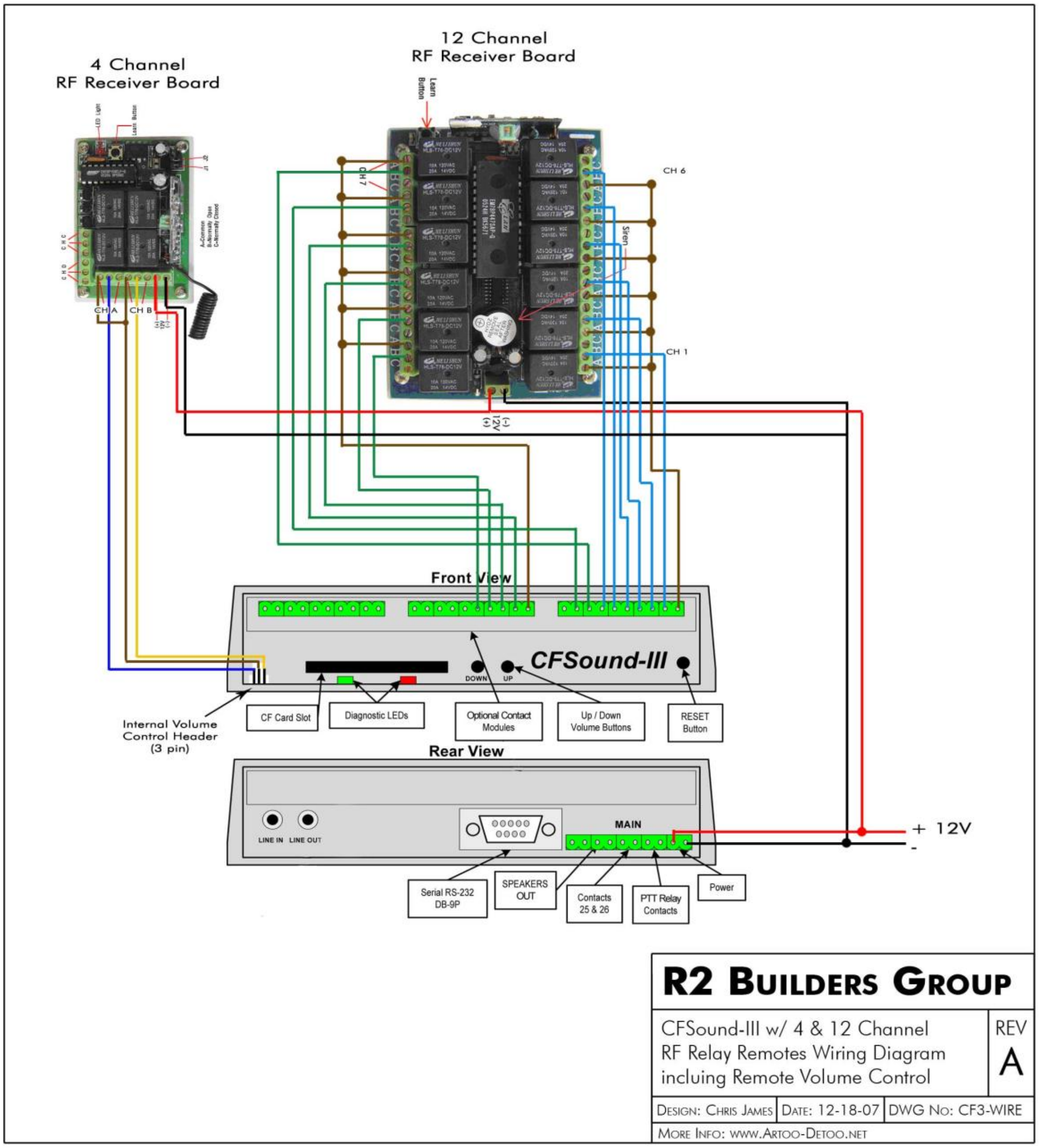


Figure 20: CFIII Wire diagram with 12 ch RF remote – **Diagram by: Chris James**

R2-X2 eXperimental Audio Panel:

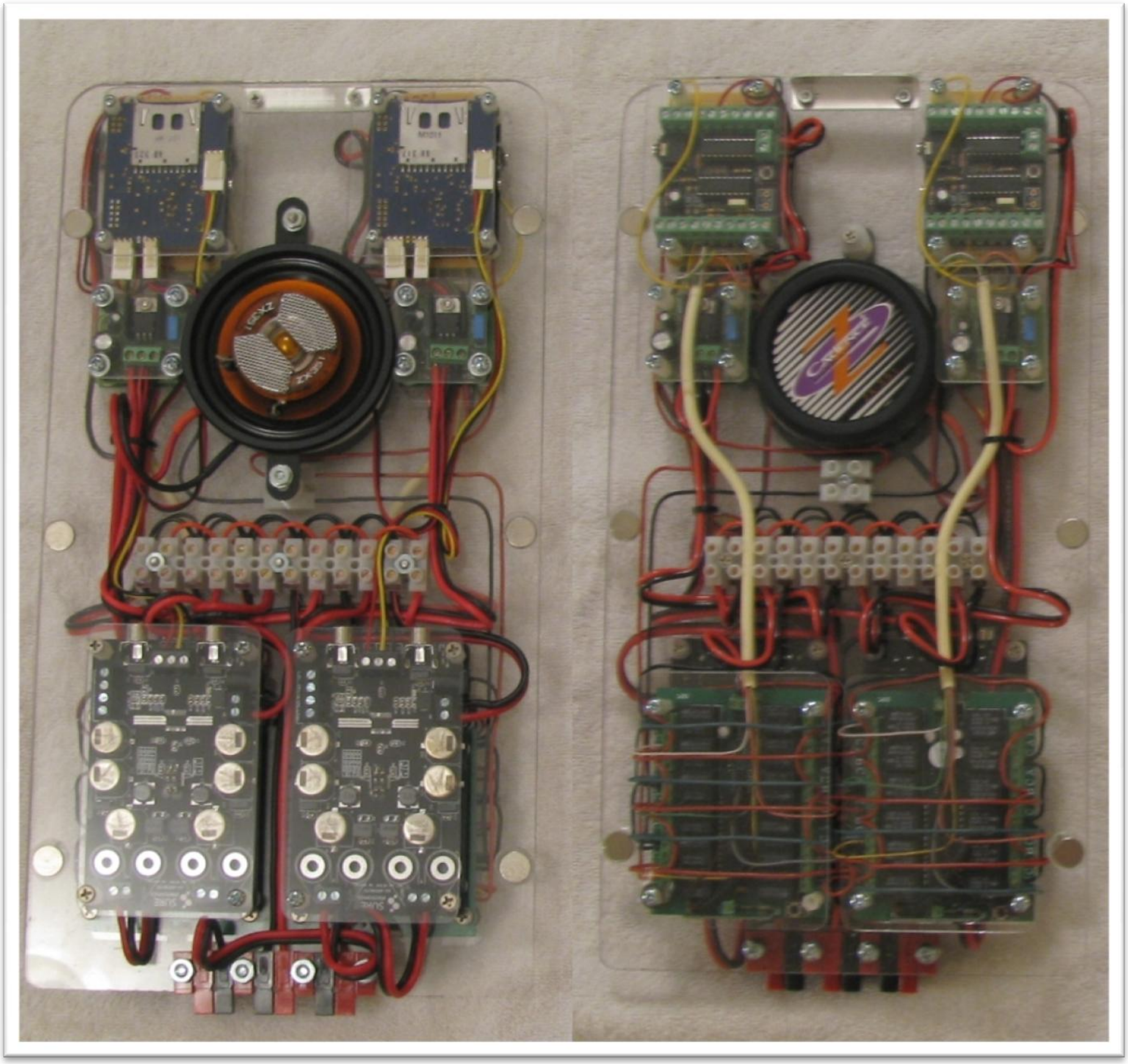


Figure 21: Audio system panel front & back **- Photo by: Blake Mann**

All of the audio electronics are mounted on a single Plexiglas panel that comprises 2 complete and self-contained audio systems with the exception of 2 – 5" speakers that are mounted behind the side vents for better sound projection.

Figure 22: Audio system speaker panels **- Photo by: Blake Mann**

The panel is mounted in the droid by sliding it in from the top of the droid while the dome is removed. The panel slides in on L shaped aluminum rails mounted to the droid's frame. The L shaped rails prevent the panel from moving side to side and neodymium magnets embedded into the Plexiglas panel prevent it from falling forward. On the bottom of the Plexiglas panel are mounted Anderson Power Pole electrical connectors that mate with corresponding connectors mounted in a cross member at the bottom of the rails. When the panel is slid into place all of the electrical and electronic connections are established with the droids internal power source as well as to the additional speakers mounted behind the side vents.

System Design:

The sound system design is based on the work of Alex Kung and Murray Jones who developed an inexpensive sound system that could be used in place of the more expensive CFIII Sound board. The R2-X2 eXperimental sound system works in a very similar way to the system they constructed. However, the sound system in the R2-X2 droid replaces the stereo amplifier used by Alex and Murray with a Class D amplifier and also replaces the VMusic2 player with a Rouge Robotics Micro MP3 player. The other components are identical to the Alex and Murray system. The software that runs the remote control of the audio system has been replaced with new software written by Blake Mann.

The older style stereo amplifier of the Alex and Murray system was replaced with a more efficient Class D stereo amplifier. Class D amplifiers use much less energy and produce very little heat. This means they do not require a bulky heat sink as do the older style stereo amplifiers. The Rouge Robotics Micro MP3 play was chosen to replace the VMusic2 player for its form factor, its compactness and the fact that it uses an SD card rather than a USB drive to store the sound files. The SD card is even smaller than a USB solid state drive and adds virtually no size to the unit when in place. With the VMusic2 the USB drive extends out of the unit and adds additional space requirements.

The R2-X2 sound system actually consists of 2 completely independent audio player systems. Having 2 separate player systems allows the droid to play both theme music and voice sound files simultaneously. The speaker for playing the voice sounds is mounted directly on the sound system panel and projects the voice sounds from behind the front vents. This is a single speaker that receives a mono signal as stereo is not required for voice sounds. The speakers that play theme music are mounted behind the side vents receive a stereo sound signal from the amplifier to provide full stereo sound that is required for theme music such a movie sound tracks. The remote controls of the audio systems are programmed so that each remote control can operate both sound systems simultaneously. Therefore two operators can control the droid sounds if necessary.

Components of the sound system:

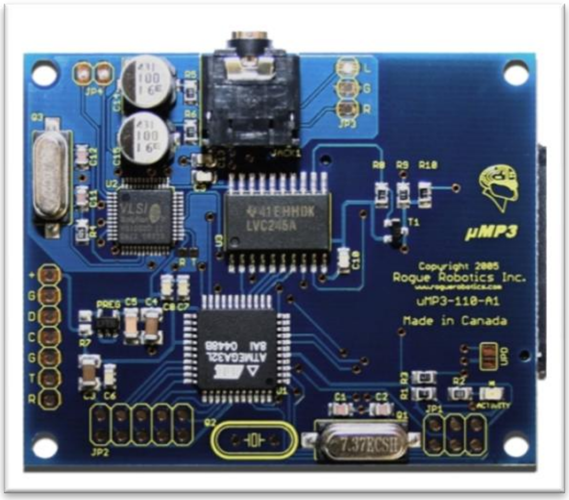


Figure 23: Rouge Robotic Micro MP3 players

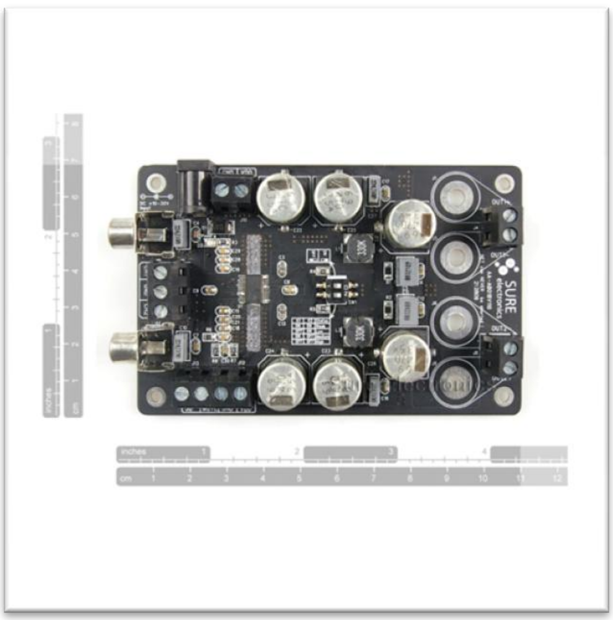


Figure 24: Class D stereo amplifiers

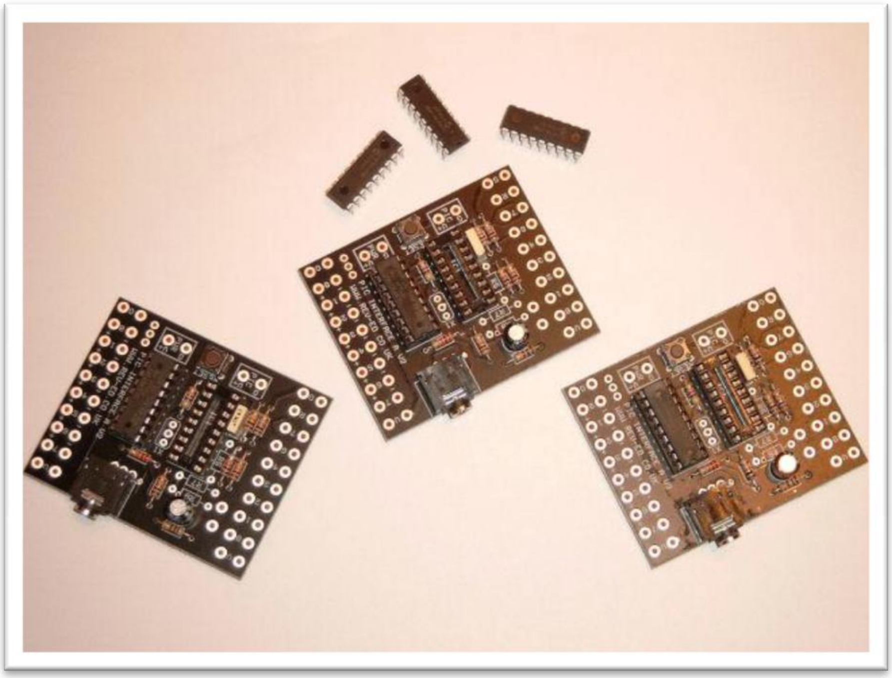


Figure 25: Picaxe 18X micro controller boards

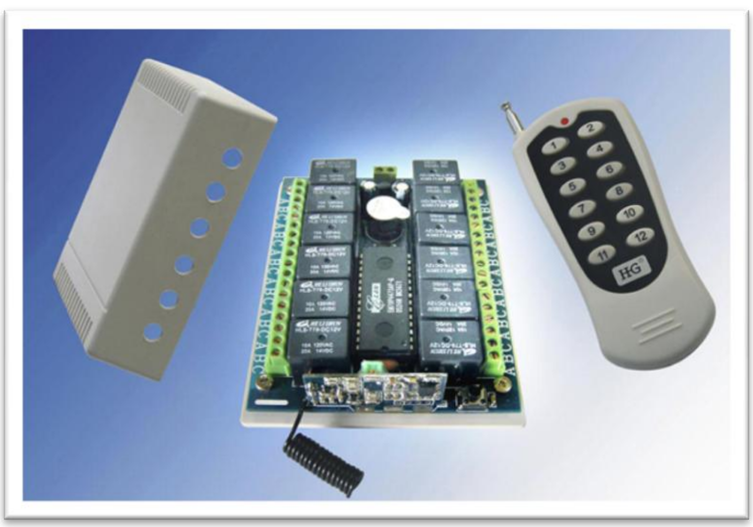


Figure 26: 12 channel RF remote relay boards

Figure 27: 5V voltage regulators

Figure 28: Five inch mid range speaker

Figure 29: 3.5” speaker

Audio System Power:

The audio system panel has a main power buss bar that connects to the internal 12 volt power source when the panel is inserted into the droid. All of the audio electronics draw power from the main 12 volt buss bar. The 4 12V → 5V voltage regulators step down the voltage to 5V to run the 2 Picaxe micro controller boards and the 2 Rouge Robotics Micro MP3 players. The stereo amplifiers and the 12 channel RF relay boards draw power directly from the 12V buss bar.

System Operation:

The sounds stored on the SD cards are triggered to play by using the 12 channel RF relay boards. Each relay boards come with a 12 button remote control. Each button on the remote control when pressed will trigger a relay on the board to close. When the relay closes it creates a completed circuit path which is used to send a signal to the Picaxe Micro controller that a specific relay (1 of the 12) has been triggered. The software in the Picaxe Micro controller is program to perform a different function when each specific relay is triggered. That function may be to play a sound file or change “modes” of the sound system or to increase or decrease the volume of the sound system. When the Picaxe Micro controller receives the signal that a relay has been closed it performs its function. Assuming that function is to play a sound the Picaxe Micro controller sends a signal to the Rogue Robotics Micro MP3 play to play a sound. The Rogue Robotics Micro MP3 player then begins playing the specified sound. However, the signal that is produced by the Micro MP3 player is too small to be used directly by the speakers so the signal is sent to the Class D stereo amplifiers first. The Stereo amplifier amplifies the sound signal and passed the amplified signal on to the speakers so the sound can be heard.

Audio System Setup Notes:

1. In order to initiate a sound to be played the Picaxe will be connected to a 12 ch RF relay board. The 12 ch RF relay board has a remote control with 12 button on it and each button triggers one relay. Each relay when triggered will be used to send a signal to the Picaxe to execute some function which in turn will cause the uMP3 player to play a sound or do something else like increase or decrease the volume or change modes of the system. The first issue you will face when using the Picaxe 18x to run the Micro-MP3 player is that the Picaxe only has 5 inputs to work with. It would be nice if it had 12 inputs since then the sound system functions could be mapped 1 to 1 with the 12 ch RF board. In other words each relay on the 12 ch RF board would have a single function that was executed by the VMusic2 or uMP3 players. Still this would probably not be enough for what we would like to do and in the end and we would have to go with a "Mode" system. A mode system is where pushing a specified button on the RF remote causes the "mode" of the buttons to change and therefore have a different function. By using the "mode" system we can have as many functions as we want even if we have just 5 inputs on the Picaxe to work with. Therefore, that's what this program will do. We will have a mode button that will cause the mode of the sound system to change and in each different mode the buttons will do something different. If you read the documentation of the Picaxe (which is downloadable from the website) you will find that the inputs you have to work with are inputs numbered 0, 1, 2, 6, & 7. See the accompanying image to locate these specific inputs on your Picaxe 18x board.

2. Both the VMusic2 and the uMP3 players work nearly the same way. Each requires 3 inputs to make them work. The 3 inputs to the players are outputs from the Picaxe 18x board. Actually, only one of the outputs from the Picaxe is an actual output the other 2 are GND and V. The actual output from the Picaxe board we will use is output 4. This output from the Picaxe gets connected to the connection point labeled R (Receive) on the uMP3. The other 2 wires from the Picaxe and going to the uMP3 are the G and V. On the uMP3 player side these 2 wires get attached to the 2 connections labeled T & G (Transmit, Ground). V from the Picaxe connects to T on the uMP3 and G from the Picaxe connects to GND on the uMP3. The uMP3 and the VMusic2 also require a 5V power supply. The (+ -) of the 5V power supply get attached to the 2 connections labeled PWR or (G, +).

3. There are 3 outputs from the uMP3 player to the stereo amplifier. These connections carry the sound signals produced by the uMP3 player to the amplifier before being output to the speakers. There is one wire for each sound channel (left & right) and one ground wire.

4. Since the Picaxe only has 5 inputs to work with only 5 of the 12 button on the 12ch RF relay will be used. How you wire your 12 ch RF relay board to the Picaxe will determine which buttons will perform functions on your sound system. I chose buttons 1, 3, 5 & 7 (a vertical column of buttons) on the left side of the remote. To determine how to wire your 12 ch RF relay to a specific set of buttons see the accompanying image of the 12 ch RF relay board which shows which relays map to the remote control buttons. I had a very specific reason for choosing buttons 1,3,5 & 7. I have 2 completely separate sound systems and I wanted each remote control to be able to control both sound systems. I therefore also have buttons 2, 4, 6 & 8 wired to the 2nd 12 ch RF relay board for the second sound system. This gives me 2 vertical columns of buttons to work the different sound systems. Left column works sound system 1 and the right column works sound system 2. Buttons 11 & 12 are not used by either system.

5. What we want the program to do:

Button (1 & 2): These buttons will cycle through a series of 10 sound files. Each push of the button should play the next sound in the series and then begin repeating the same sounds after all 10 have been played. We can use a mode to have multiple lists of 10 sounds to cycle through.

Button (3 & 4): A second button will play random sounds at random times. Push this button and the system will operate on its own playing random sounds from a list of 10 sounds are random intervals. Again the mode will determine the list of sounds that will be randomly played.

Button (5 & 6): These will be our mode buttons. Each press will change the mode of the sound system. To start we will have 4 different modes but this can easily be expanded later. It might be nice to have R2 repeat a sound x times to indicates the mode number the sound system is in just in case we lose track.

Button (7 & 8): These will be volume down buttons

Button (9 & 10): These will be volume up buttons

Animatronics System Panel:

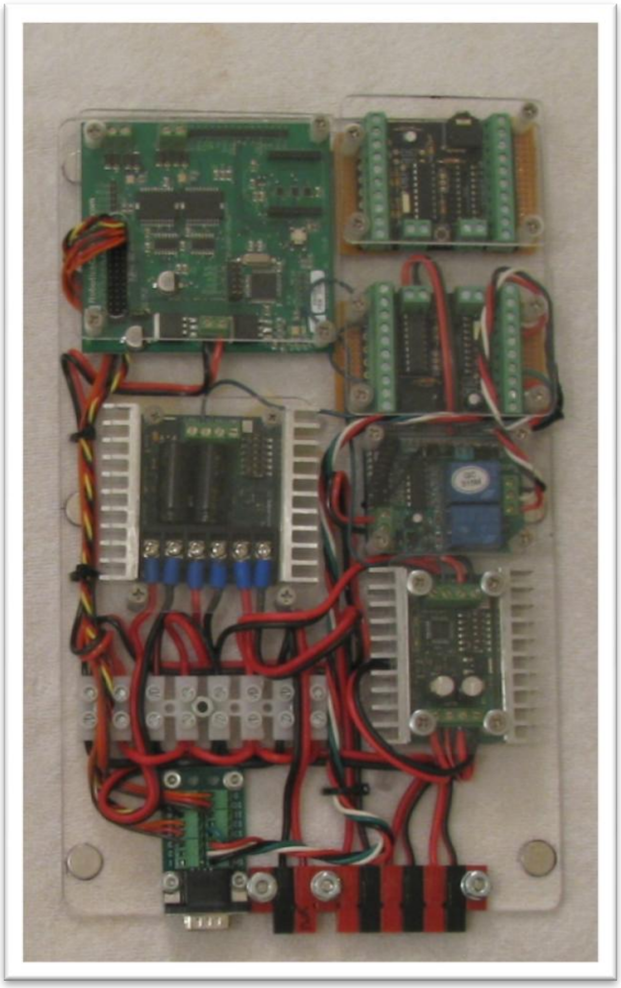


Figure 30: Animatronics system panel **- Photo by: Blake Mann**

The animatronics panel is mounted in the droid by sliding it in from the top of the droid while the dome is removed. Just like the audio system panel the panel slides in on L shaped aluminum rails mounted to the droid's frame. The L shaped rails prevent the panel from moving side to side and neodymium magnets embedded into the Plexiglas panel prevent it from falling forward. On the bottom of the Plexiglas panel are mounted Anderson Power Pole electrical connectors that mate with corresponding connectors mounted in a cross member at the bottom of the rails. When the panel is fixed in place all of the electrical and electronic connections are established with the droids internal power source. The animatronics panel also has a 15 pin sub D connector that electrically connects servos mounted in the body to the Picaxe 18X Micro controller and the Serializer boards on the animatronics panel.

Components of the animatronics system:

(2) - Revolution Education - Picaxe 18x Micro controllers

(1) - Robotics Connection - Serializer Robot Controller

(1) - 2 channel RF relay

(1) - Dimension Engineering - 2 X 25A Sabertooth motor speed controller

(1) - Dimension Engineering - 25 A SyRen motor speed controller.

System Design:

The animatronics panel has all of the electronic components mounted on it that control the droids movements, except the drive system which is a separate system panel. The 2 channel RF relay is the receiver that is used to trigger the 2-3-2 motions. Each channel triggers a one way transition 2-3 or 3-2. The 2 x 25A Sabertooth motor speed controller is used to power the linear actuators for the 2-3-2 transitions. The single channel 25A SyRen motor speed controller is used to power the center motor the moves the center foot up and down during the 2-3-2 transitions. One of the Picaxe 18x Micro controller contains the programmed logic for coordinating the movements of the center foot motor and the linear actuators during the 2-3-2 transitions.

The second Picaxe Micro controller contains programmed logic to operate different servos based on either sensor feedback or when an external signal is received from an RF source. The Picaxe Micro controllers may also operate servos based on a timed cycle or even at random intervals.

Drive System Panel:

Figure 31: DX5e 5-channel transmitter and receiver

Most droids are “driven” by an operator using an RC (Radio Control) transmitter that sends radio frequency signals to the RC receiver mounted inside the droid. The receiver inside the droid directs the motor speed controller(s) to run the motors either forward or backward and at a specific speed. Typically a joystick is used to send the direction of motion and speed to the receiver inside the droid. The electronics in the transmitter and receiver interpret the direction and speed information and cause the motors to move the droid accordingly. However, with the explosion of electronic devices that have become available in the last 5 years several other avenues for controlling droid motion have been explored by builders. Some of the new methods for controlling a droid include using a Wii controller or an iPhone or iPad. While these new methods offer additional flexibility in the form factor of the controller the basic principle remains the same which is an operator is remotely controlling the droid.

Micro Controllers:

The area of robotics has also grown a great deal in the past 5-10 years. Developing systems for the electronic control of mechanical devices has become greatly simplified by the popularity of micro controllers and personal computers - PCs. Micro controllers are everywhere. They are in cars, mobile phones, computers, radios, smoke detectors, washing machines, iPods and the list go on and on. You can think of a micro controller as a computer on a chip. It basically has everything your desktop computer has like a CPU, storage memory, RAM memory, registers but it lacks an interface such as a keyboard and monitor. The lack of an interface is simply because the micro controller is pre-programmed to do what it needs to do before it is inserted into a device like a microwave oven. However, some devices may give you an interface to work with the micro controller. For example the microwave oven has buttons to set the time and intensity of cooking.

If you are a droid builder or a programmer you can purchase or build your own device to interface with the micro controller. Typically these devices are called programmers. You use them to hook a micro controller to your desktop computers keyboard and monitor so that you can write and upload the program to the micro controller's memory yourself. The great thing about micro controllers is that they are CHEAP and using some programming languages like BASIC they are easy to program as well. If you couple this with a simple electronics board like a Picaxe or Arduino or Basic Stamp you now have an easy way to mechanize mechanical components based on the programming logic in a micro controller. Sensors like IR or sonar can also be easily hooked to the electronics board and therefore your mechanical devices can "react" to sensor data like light, sound, heat, vibration, G-force etc. Droid builders take great advantage of the micro controller in developing the animatronics of their droids.

Micro Controllers vs. PC CPUs:

The Picaxe Micro controllers are an ideal solution for programming very specific movements or movements based on sensor feedback. Examples of this would be random rotation movement of the dome or holo-projectors. Other examples might be to turn on a holo-projector lamp in response to low ambient light or to turn the dome if an obstacle is too close to a holo-projector (like a hand). These types of programmed motion are well suited to micro controllers that only deal with a few specific tasks or a few simple tasks. For more involved motion requirements much more computing power is required and therefore a different solution is employed. The Serializer board is an electronics board that can communicate with an external computer that has much more computing power than a micro controller. But even more important than the Serializer's ability to communicate wirelessly with a PC is that it is designed to be programmable using the latest software development environment from Microsoft. Microsoft has developed the Robotics Studio environment for writing robotics software on the PC. This environment leverages the object oriented structure of the .Net framework. This is a giant step forward for robotics development since now the underlying foundation for writing robotics software is already built into the environment. Now the software developer can concentrate on writing the logic of the motion without having to deal with the specific and extremely technical requirements of robotic software. And all of this can be accomplished with a standard and completely object oriented language like C#.

While it is possible to install a more powerful computer that could perform these more complex computations inside the droid itself this would require a significant additional power source to run the computer as well as add weight to the droid. The current solution in the R2-X2 eXperiment model is to communicate with an external computer via an XBee communication module using the ZigBee wireless communications protocol. This allows the Serializer board to send sensor information from different sensors mounted on the droid to an external computer(s) and receive back computed vales based on the sensor information. The external computer can run very complex programmed algorithms that allow the droid to perform complex motions. An example would be to allow the droid to navigate around a room without bumping into obstacles. This type of movement requires a lot of computing power to interpret sensor data from one or several types of sensors such as sonar sensors, IR sensors or image data from cameras mounted on the droid. The R2-X2 droid is equipped with a Serializer board and an XBee communications module to wirelessly communicate with another computer.

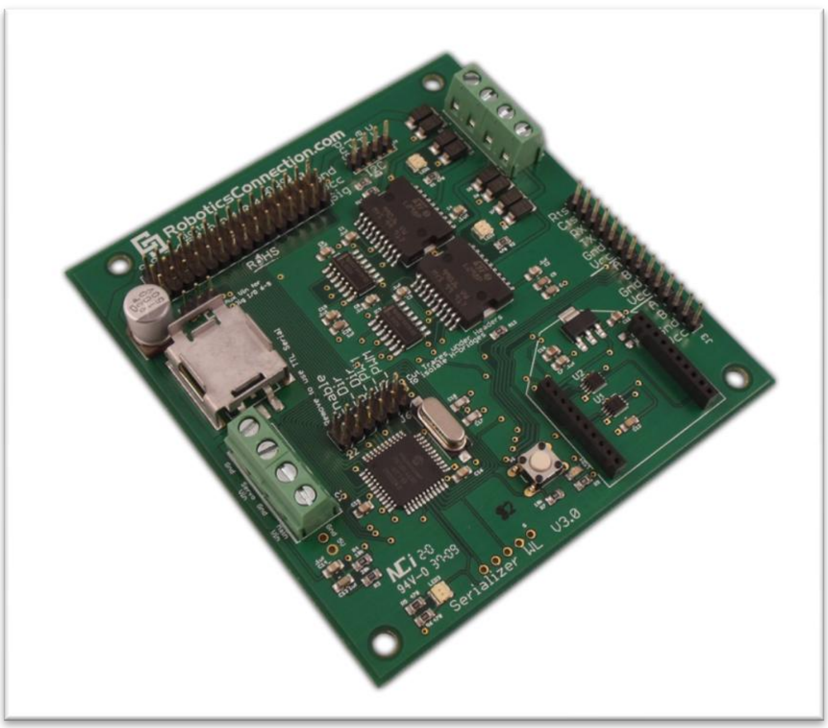


Figure 32: Serializer robot controller

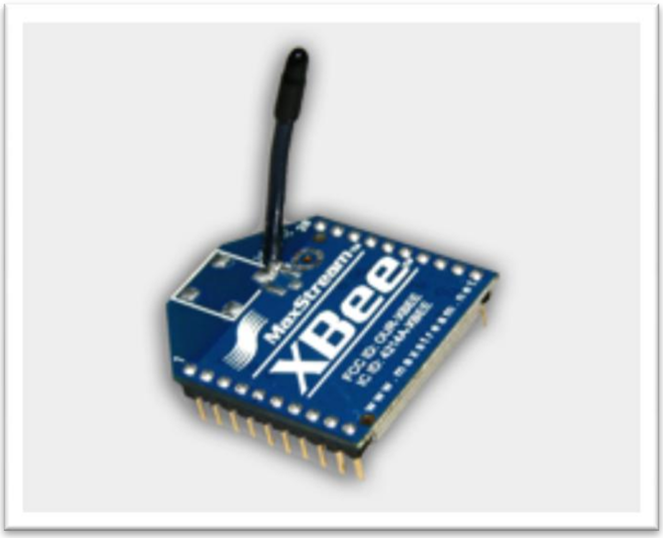


Figure 33: XBee communication module

Components of the Drive System:

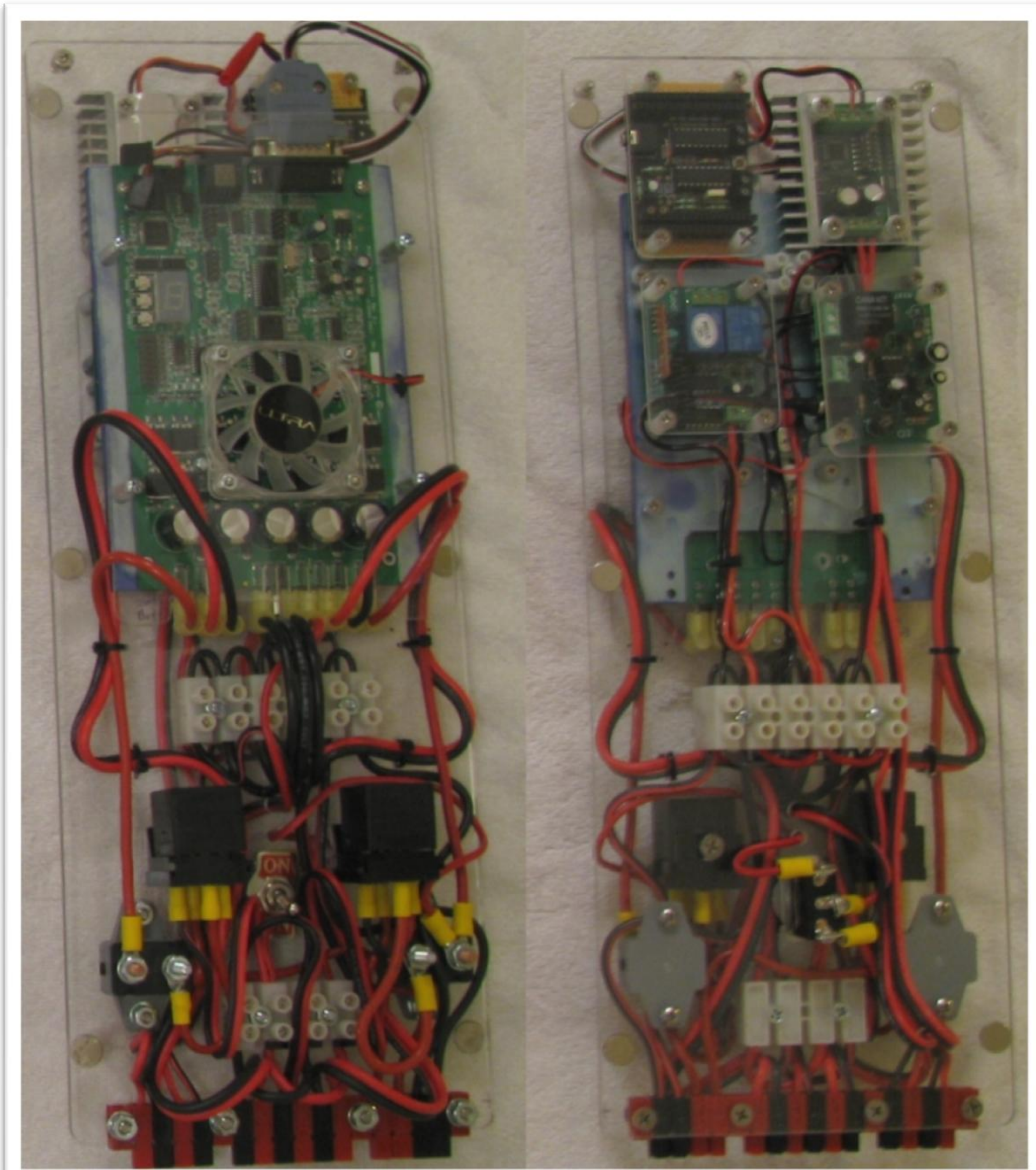


Figure 34: Drive system panel front & back **- Photo by: Blake Mann**

The drive system panel is mounted in the droid by inserting it in from the back of the droid. The panel mounts on L shaped aluminum rails mounted to the droid's frame. The L shaped rails prevent the panel from moving side to side and neodymium magnets embedded into the Plexiglas panel prevent it from falling forward. On the bottom of the

Plexiglas panel are mounted Anderson Power Pole electrical connectors that mate with corresponding connectors mounted in a cross member at the bottom of the rails. When the panel is mounted all of the electrical connections are established with the droids internal power source and the external relays that are part of the charging system.

Components of the drive system:

(1) - Roboteq AX-3500motor speed controller

(2) - 40 AMP manual reset circuit breakers

(1) - Revolution Education - Picaxe 18x Micro controller

(1) - 2 channel RF relay

(1) - Dimension Engineering - 25 A SyRen motor speed controller

(1) - 555 timer module

(1) - BR6000 DSM DuaLink 6-Channel Bot Receiver

(2) - 40A relays (See Electrical Section)

System Design:

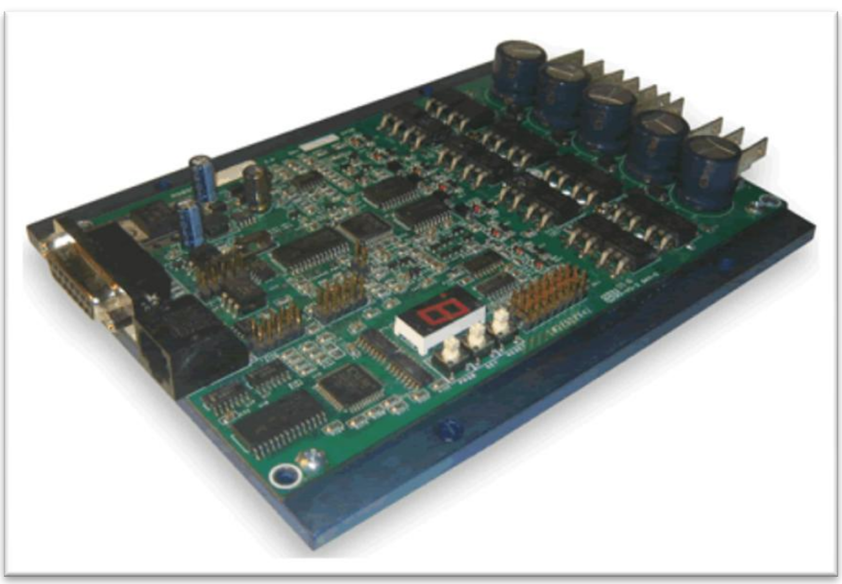


Figure 35: Roboteq AX-3500BP dual motor speed controller

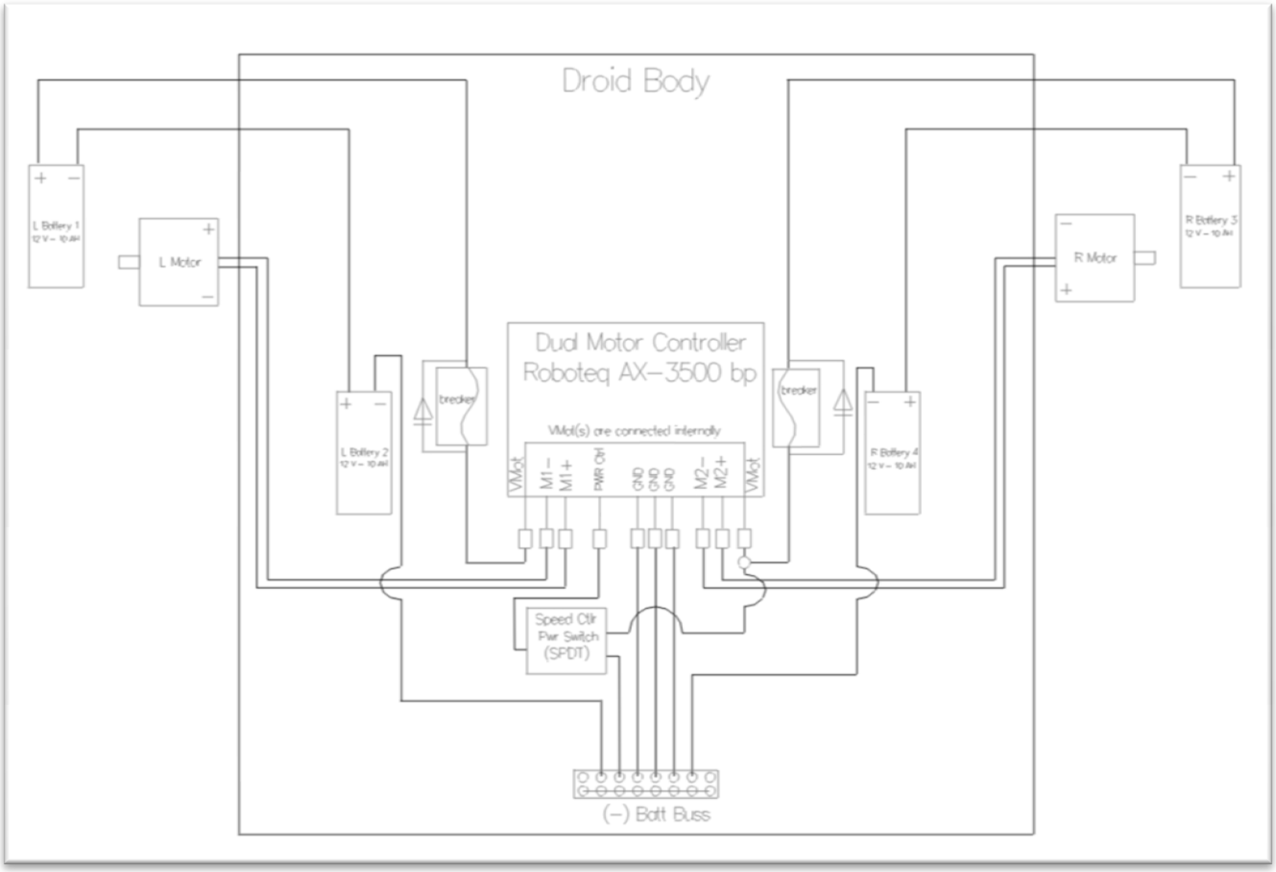


Figure 36: Roboteq AX-3500BP wire diagram **– Drawing by: Blake Mann**

The main component of the drive system panel is the Roboteq AX-3500BP motor speed controller. This is a 60 Amp per channel max dual motor speed controller that controls the two foot drive motors. The motor speed controller receives an RC signal from the BR6000 DSM RC receiver which is controlled by a DX5e 5-Channel full range radio control transmitter. The AX-3500BP has an aluminum heat sink that the actual circuit board is mounted to. Due to the high amperage the foot motors draw the MOSFET on the speed controller do get hot under heavy use and the heat sink helps to absorb and distribute the heat. In addition the R2-X2 eXperimental model has a fan mounted just above the MOSFETs on the motor speed controller. There is a heat sensor mounted to the back side of the aluminum heat sink just behind the MOSFETs. If the temperature of the heat sink reaches 120 degrees Fahrenheit the 555 timer module will turn on the fan for 5 minutes and then shut off. If the temperature of the heat sink is still about 120 degrees the fan will continue to stay on for 5 minute intervals until the temperature of the heat sink drops below 120 degrees.

Two 40 Amp circuit breakers are mounted on the Drive panel and wired in-line with the foot motors. If the amperage draw is too high the circuit breakers will break the circuit and cause the droid to stop. This will prevent damage of the wiring or the circuitry of the motor speed controller. Once tripped the circuit breakers need to be manually reset by simply pushing the reset button.

The Dome drive motor is controlled by the 25 A SyRen motor speed controller mounted on the back of the drive system panel. Although the dome rotation may be considered part of the animatronics of the droid it is controlled via the DX5e 5-Channel radio control transmitter and therefore needs to be located near the BR6000 DSM RC receiver. Since the RC receiver is required for the AX-3500, it makes mounting the dome drive motor controller on the drive system panel the ideal choice. The Picaxe 18x Micro controller is also capable of controlling the dome drive motor and it contains software to randomly rotate the dome or to rotate the dome in response to sonar senor data.

2-3-2 Elecronics:

The R2-X2 eXperimental 2-3-2 electronics design uses a PicAxe 18x project board and 2 SyRen motor speed controllers to control all of the start and stop motor motions for the 2-3-2 action. It also uses 3 opto-electrical switches to sense the position of the center foot. The motion of the shoulder rotation and leg pin actuator motors are triggered by the position and direction of movement of the center foot using opto-electrical switches. The start of the 2 cycles (2->3 & 3->2) are triggered by two different buttons of an RF relay remote. By using motor speed controllers I can easily adjust the power I want to apply to each motor thus affecting its speed and therefore its timing. I need to do timing adjustments to fine tune the motions I can easily do it by simply changing a single number in the software. In fact I can even change the speed of the motors while it is in motion giving me infinite adjustability to the whole mechanism.

Dimension Engineering has built into their motor speed controllers a way to control them from a micro controller. They call it the simplified serial mode and basically the micro controller hooks up to the speed controller with a single TX wire and sends 1 byte of data that contains the speed and direction you want to set. You can continually send new bytes of data thus continually adjusting the speed of the motor.

Below is the Picaxe software I was able to write and successfully test on my 2-3-2 mock up. It is surprisingly short in fact almost a trivial amount of code. I'm certain this could also be done using one of the other micro controllers I mentioned before if you like one of them better than the Picaxe. The SyRen motor speed controller will accept input from any of these systems as long as the baud rate is correct. The communications protocol for talking to the SyRen speed controller is 8N1 – that is 8 data bits, No parity, 1 stop bit.

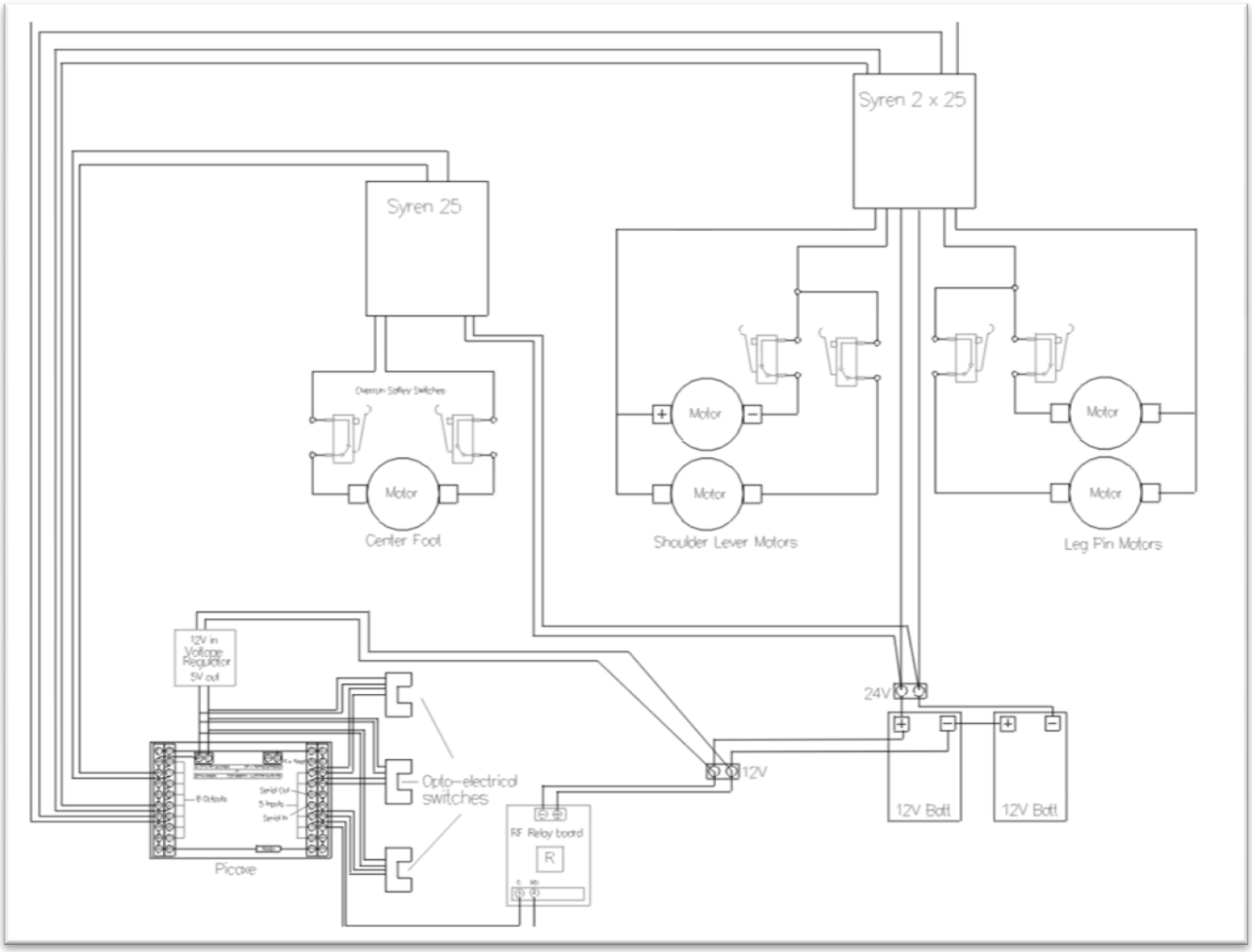


Figure 37: 2-3-2 Wire diagram **- Drawing by: Blake Mann**

2-3-2 Programming Code Logic:

2-3 transition:

1. RF relay triggers the beginning of the 2-3 transition program.
2. Center foot begins travels down until center foot reaches the floor.
3. Center foot reaching the floor triggers the shoulders to begin rotating to completion.
4. Center foot moves to fully extended position.
5. 1/10 second later ankle pin begin retracting to fully retracted position.

6. Once center foot reaches full extension the center foot locking mechanism triggers to lock it in place (if lock is required) 2→3 transition complete.

3-2 transition:

1. RF relay triggers the beginning of the 3-2 transition program.
2. Center foot locking mechanism (if lock is required) unlocks the center foot.
3. Center foot begins retracting to a position where it just touches the floor.
4. Simultaneously with (3) shoulders begin rotating to upright position
5. Simultaneously with (3) the ankle pin begins extension to fully extended position.
6. Center foot retracts into body 3→2 transition complete.

The actual eXperimental Picaxe 18x source code for the 2-3-2 system is listed in the Appendix C of the manual.