R2D2 Construction

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1 DISCLAIMER

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2 OVERVIEW

The purpose of this document is to provide the reader with a guideline on how I approached building the R2D2 robot. My R2D2 has the following features:

- Dome Rotation
- Projection
- Front and Rear PSI LED's
- Front and Rear Logic Boards
- LED Holoprojectors
- Audio
- Wireless Ethernet communication to an existing Lost in Space robot
- The R2D2 is stationary and does not have motorization for the legs

3 SUPPLIERS

The information below contains an itemized list of the components that I purchased for the R2D2 robot and where I obtained each component.

3.1 R2D2 Unfinished Shell & Components

The R2D2 shell and the structural components were purchased as an assembly from Manny of Sci-Fi Collectibles, LLC. Manny also sells various prop on items on eBay. He is eBay member "propsandtoys". His email address is propcollectibles@gmail.com. Since Manny lives with a few hours from my location, he delivered the R2D2 to my location for a small fee. For me, this was preferable since shipping damage would not be an issue and his delivery fee was much less than UPS. When Manny delivered the R2D2 unit, he spent some time going over the components with me. Based on this interaction and the quality of his work, I would order from him again.

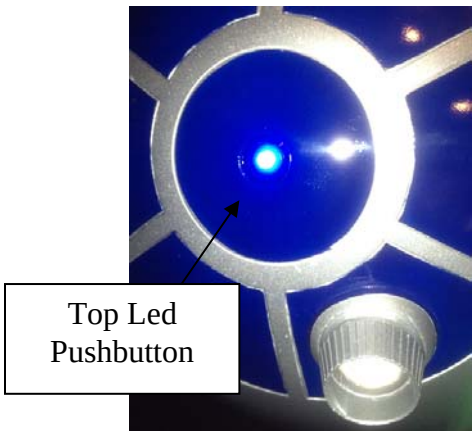
The R2D2 unit that Manny supplied was top notch and a well thought out design.

Manufacturer	Purchased	Description	Part #	Qty
Sci-Fi Collectibles, LLC	Sci-Fi Collectibles, LLC s	R2D2 Assembly with Center Leg.		1
Sci-Fi Collectibles, LLC	Sci-Fi Collectibles, LLC	Front and rear PSI LED boards. Front and rear Holoprojector boards. The electronics come with a power adapter and a remote control.		1

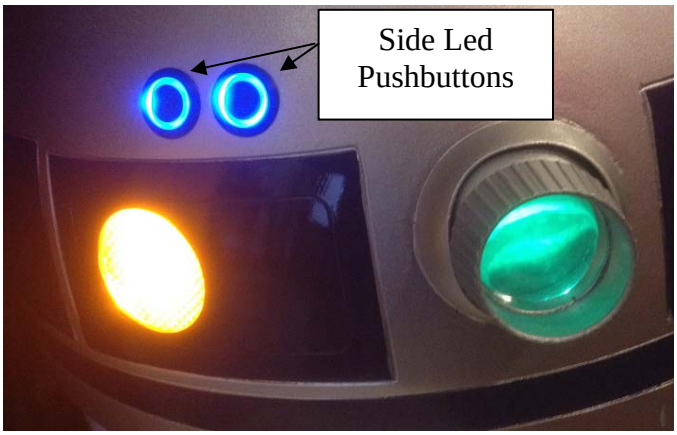
3.2 Dome Bump / Dome Top Pushbuttons

The Dome Bumps were included with the R2D2 assembly. I changed the included plastic dome bumps to blue ring illuminated switches since my R2D2 was going to have dome rotation, projection, and audio. I use the switches as a means to initiate different shows. I placed a single LED dot switch on the center top of the dome and (2) ring switches on the side of the dome.

Manufacturer	Purchased	Description	Part #	Qty
Performance PCS.com	Performance PCS.com	22mm Dome Bump replacement switches (blue LED ring)	VSW-BK-RING-BL	2
Performance PCS.com	Performance PCS.com	22mm Dome Bump replacement switches (blue LED dot)	VSW-BK-DOT-BL	1



Top Pushbutton

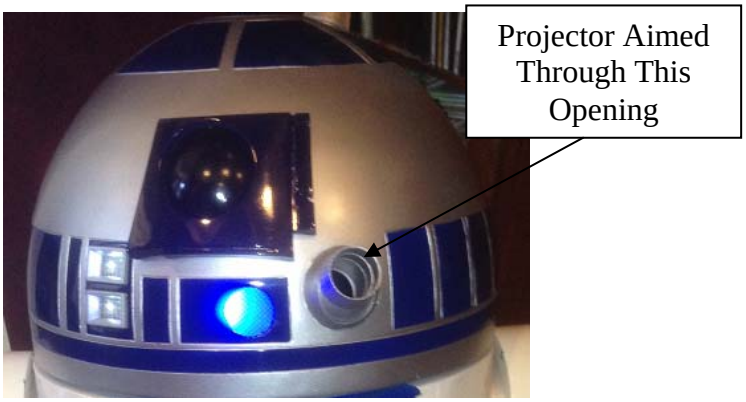


Side Pushbuttons

3.3 Projector

Manufacturer	Purchased	Description	Part #	Qty
HP	Amazon.com	HP AX325AA Notebook Portable LED Projector		1

The projector is a small LED based projector that utilizes a VGA input. The projector is pointed out of the holoprojector located near the radar eye.



Dome Projector Location

3.4 Wireless Ethernet

Manufacturer	Purchased	Description	Part #	Qty
Linksys	Amazon.com	Dual-Band N 4 Port Entertainment Bridge	WES610N	1

3.5 Triggerable Digital Video Player

I am using the digital video player for all audio and video playback. The device has VGA and composite video out. It also contains line level audio left/right out via RCA jacks. The audio is connected to amplified speakers located in the R2D2. The video is connected via VGA to the HP projector. All of the audio/video files reside on an SD card. The player has 7 inputs that can be triggered via individual contact closures. Each input can trigger an audio or video file. Since some of my "shows" do not utilize video, I simply create an audio file utilizing "Audacity" and play the audio file with the player.

Manufacturer	Purchased	Description	Part #	Qty
FrightProps, LLC	FrightProps.com	Playback Audio and Video stored on Unit.	1003-720P-T1	1

3.6 Speakers

Manufacturer	Purchased	Description	Part #	Qty
-	Staples	Amplified Computer Speakers		1

3.7 PLC (Programmable Logic Controller)

Manufacturer	Purchased	Description	Part #	Qty
Rockwell Automation	Rexell Consolidated	MicroLogix 1400	1766-L32BWA	1

3.8 Dome Rotation Stepper Drive & Motor

Manufacturer	Purchased	Description	Part #	Qty
AutomationDirect	AutomationDirect.com	Stepper Drive	STP-DRV-4850	1
AutomationDirect	AutomationDirect.com	Stepper Motor, 434 Oz-In	STP-MTR-34066	1
AutomationDirect	AutomationDirect.com	Drive to Motor Cable	STP-EXT-020	1

3.9 Stepper Drive Motor Hub

Manufacturer	Purchased	Description	Part #	Qty
ServoCity	ServoCity.com	1/2 inch x 0.770 inch Set Screw Hub	H250-770	1

The hub is used to mount the motor shaft to the gear provided by Andy Schwartz.

3.10 Lazy Susan Bearing

Manufacturer	Purchased	Description	Part #	Qty
Lee Valley	Lee Valley	17-3/8" Lazy Susan Bearing	12K6817	1

The R2D2 unit was provided with a Lazy Susan bearing for dome rotation. The bearing provided with the R2D2 unit was only slightly different in size to the one listed above. The only reason I changed the bearing is due to the fact that the gear shown below is drilled to fit the bearing above exactly.

3.11 Lazy Susan Gear

Manufacturer	Purchased	Description	Part #	Qty
Andy Schwartz	Andy Schwartz	18” Laser Cut Waist Gear	FR-04	1

3.12 Connectors

Manufacturer	Purchased	Description	Part #	Qty
Zip Port	AutomationDirect.com	Insert 16B 16 Pole Male Screw Terminal	ZP-MC16B-1-MS016	1
Zip Port	AutomationDirect.com	Insert 16B 16 Pole Female Screw Terminal	ZP-MC16B-1-FS016	1
Zip Port	AutomationDirect.com	Hood 16B Side Entry Pg21 Metal	ZP-MC16B-2-SSW21M	1
Zip Port	AutomationDirect.com	Coupler 16B Pg21 Metal	ZP-MC16B-2-SCP21M	1

The connectors are used to remove the Dome quickly by disconnecting the wiring for the lights, power, etc.

3.13 Power Entry

Manufacturer	Purchased	Description	Part #	Qty
TE Connectivity	AlliedElec.com	Module, Power Entry, PEM, Unfiltered, 6Amp	6VM1S	1
Volex Power Cords	AlliedElec.com	Power Cord; 10 A; 5-15P/C13; 18/3 SVT; Unshielded; 7ft 6in.	17250 10 B1	1

This part is the socket and switch for plugging the R2D2 into the wall.

3.14 Power Supply

Manufacturer	Purchased	Description	Part #	Qty
Rhino	AutomationDirect.com	24 VDC Industrial Power Supply.	PSB24-120	1

The power supply is used for the stepper motor and to provide input power for the dome bump switches.

3.15 Relays

Manufacturer	Purchased	Description	Part #	Qty
-	AutomationDirect.com	Cube Relay 15A DPDT 24VDC Coil Led Indicator Test Pushbutton	782-2C-24D	2
-	AutomationDirect.com	Relay Socket	782-2C-SKT	2

The relays are used to switch the voltage for control of the douser and to remove power from the projector 5 minutes after a show is complete.

3.16 Acrylic Cabochons and Spheres

Manufacturer	Purchased	Description	Part #	Qty
Tap Plastics	Tapplastics.com	Acrylic Cabochon 1 ½ in	24729	2
Tap Plastics	Tapplastics.com	Acrylic Circle (0.118 in thick x 2 in dia)	01902	2

Cabochons were provided as part of the unit. Since the cabochons that were provided had a hazy finish, I purchased the new cabochons from tapplastics.com. The new cabochons were crystal clear and allowed me to clearly project LED light through them.

4 Stepper Drive/Motor

The dome rotation is controlled via a stepper motor connected to a stepper drive. The stepper drive is an AutomationDirect STP-DRV-4850 that is connected to an AutomationDirect STP-MTR-34066 stepper motor.

The stepper drive is connected to the Allen-Bradley MicroLogix 1400 PLC via a serial cable that comes with the stepper drive. The PLC sends commands to the stepper drive such as position, velocity, accel, and decel. I discovered that the PLC will not always communicate to the stepper drive after a PLC power up was initiated but it would always talk via the software tool for the drive. To figure this out, I connected the drive to the software tool and monitored the communications between the software and the drive. What I discovered is that there a few undocumented commands that must be initially sent that make the communication work every time. The following text commands must be sent one time during the initial communication between the drive and the PLC.

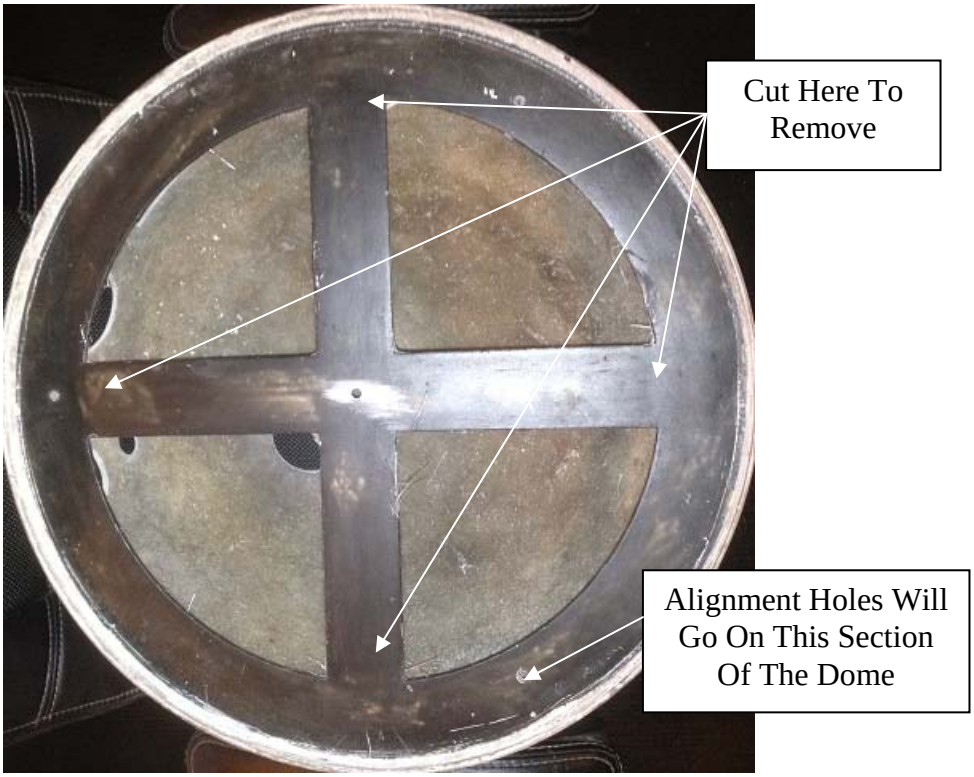
- QT
- HRCM
- SK
- CM21

The stepper drive requires a power supply to provide power to the drive and the motor circuit. Since I am using the STP-MTR-34066 stepper motor, the PSB24-120 power supply was utilized that you can also be purchased from AutomationDirect.com. To reduce current when the motor is not turning and to allow manual positioning of the dome before a sequence starts, I have configured the motor to have no idle current 2 seconds after the last move.

When a show is started, I set the position to 0 via a software command, this is like a manual home of the dome. Therefore, having the motor current at 0 allows me to physically rotate the dome to the desired start position so the dome can have any home (0) position desired.

5 Dome

As shown below, the dome has a fiberglass cross brace installed. To avoid clearance issues and allow easy access, I removed the cross piece using a jigsaw.

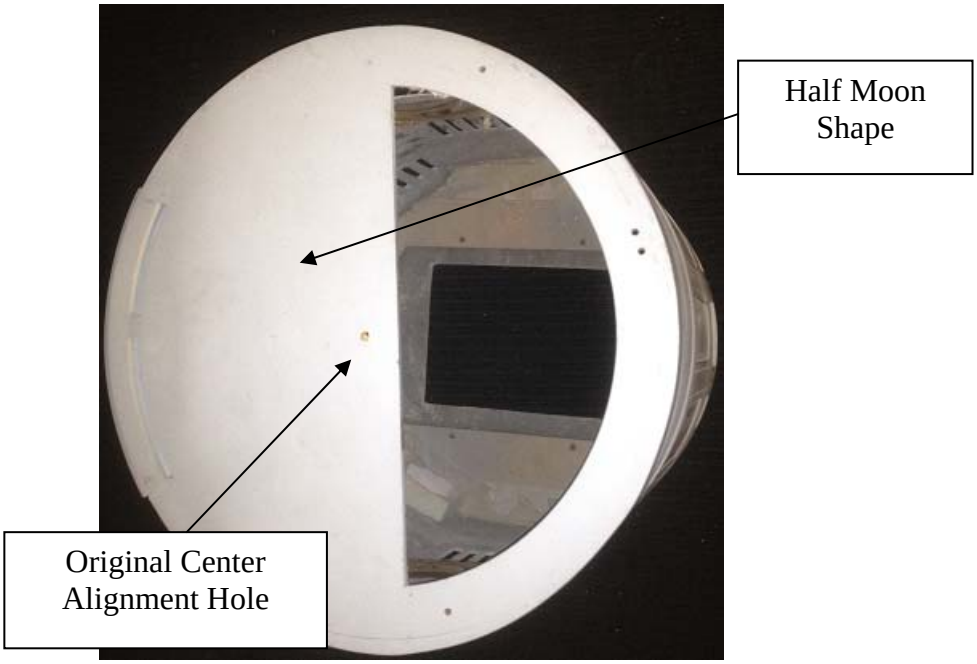


Dome Bottom View

Once I removed the cross brace, I installed a piece of flat aluminum stock to act as a support for the projector.

6 Body

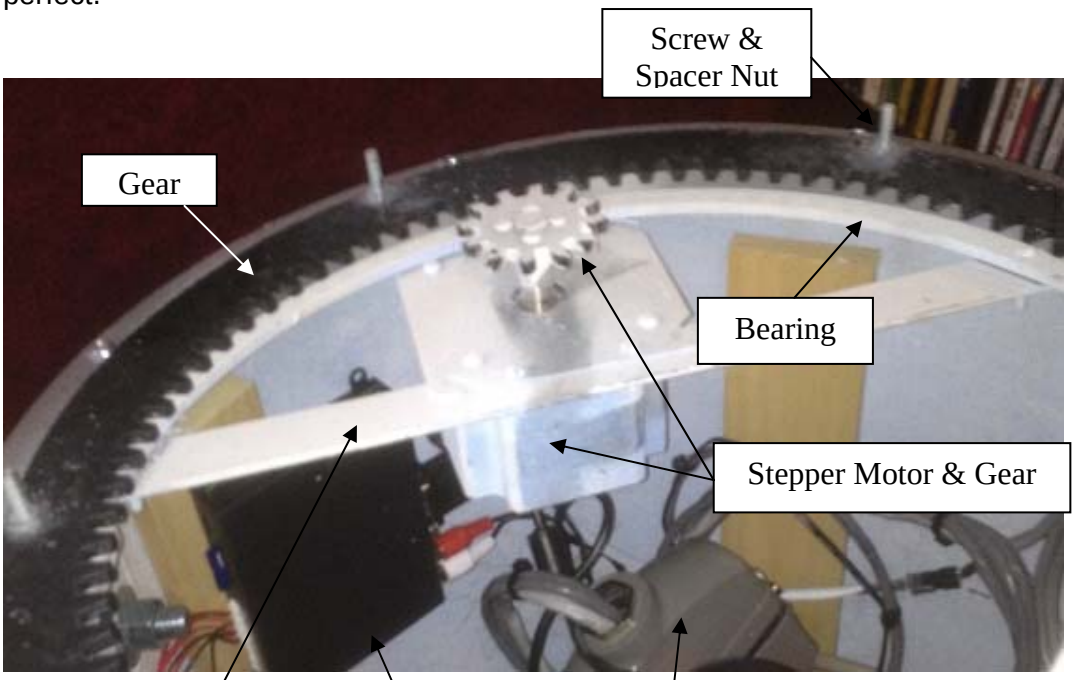
As shown below, the body has a plywood/fiberglass half moon shaped piece installed along the top of the body. The piece was used for center alignment of the included original Lazy Susan bearing. Since my dome will be automated as well as wanting easy access to the interior of the body for installing control equipment, I removed the half moon shaped piece with a jigsaw.



Body Top View

7 Rotation

The bearing and gear were installed as shown in the following picture. The screws are purposely long to allow the dome to slide over the screws for alignment and to keep the dome in the desired position. I simply attached the gear to the bearing with nuts. Dome alignment holes were drilled to the width of the nut to keep the dome to body clearance correct. The gear is 1/8" think and the amount of clearance with the gear installed is perfect.



Gears/Motor View

As can be seen above, I mounted the motor on an electrical cover that you can get at Home Depot. I mounted the electrical cover between the body and a piece of flat aluminum strip that I also obtained from Home Depot.

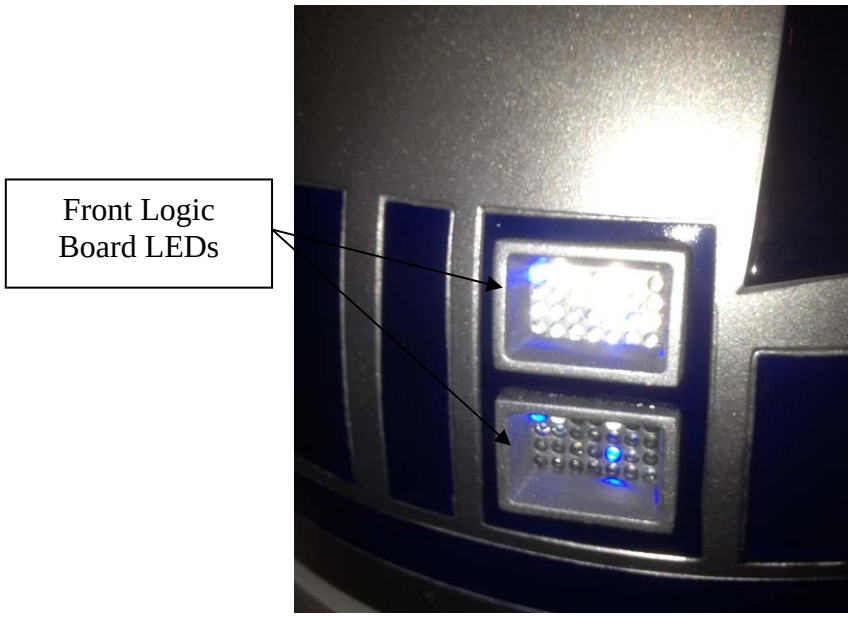
I glued some ½ inch wood strips to the inside of the body to allow mounting of the video player and amplified speakers. I used Quick Grab glue that you can get in caulk sized tubes at Home Depot.

(6) Screws and spacer nuts are used to secure the Lazy Susan and gear. The screw/Nut assembly also aligns with holes made in the dome for alignment and spacing.

8 Logic & PSI Lights

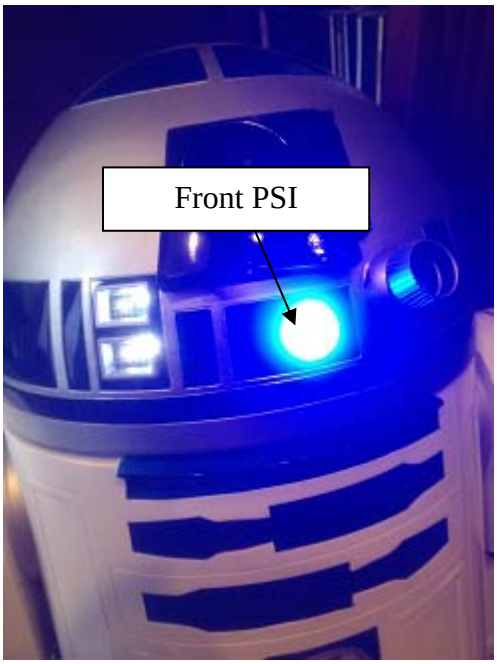
I purchased the electronics for the PSI lights and front/rear logic boards from Manny. The electronics include a remote control so the lights can be controlled via the remote. A 12 VDC adapter is included that provides power to the lights. In a nutshell, the remote switches 12 VDC power to the light circuits to allow them to operate.

The pictures below illustrate the effect of the PSI and logic board lights.

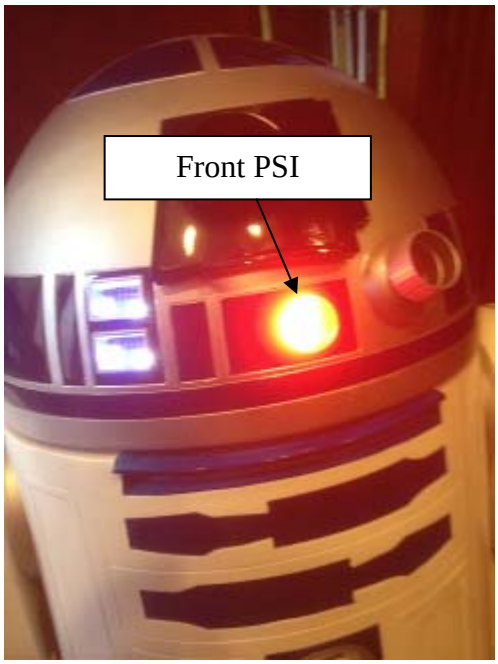


Front Logic Boards

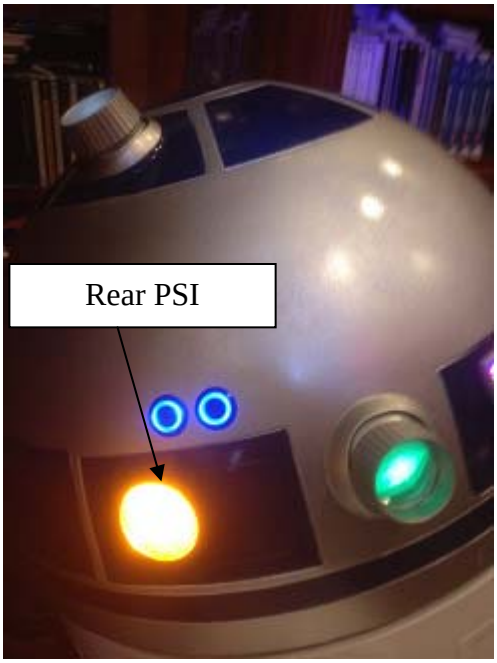
Rear Logic Board



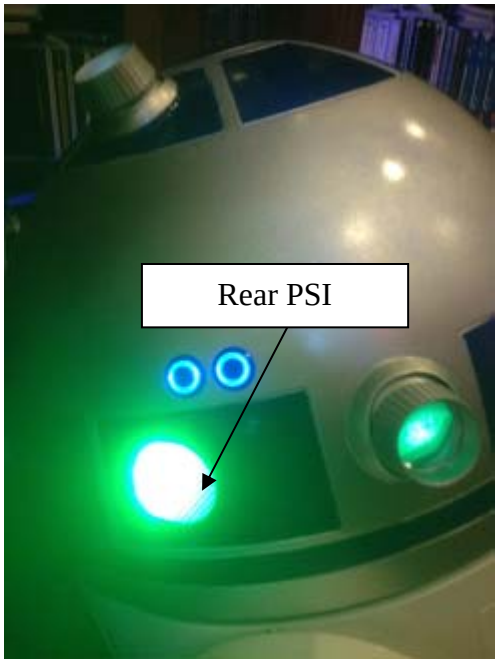
Front PSI (Blue)



Front PSI (Red)



Rear PSI Light (Yellow)

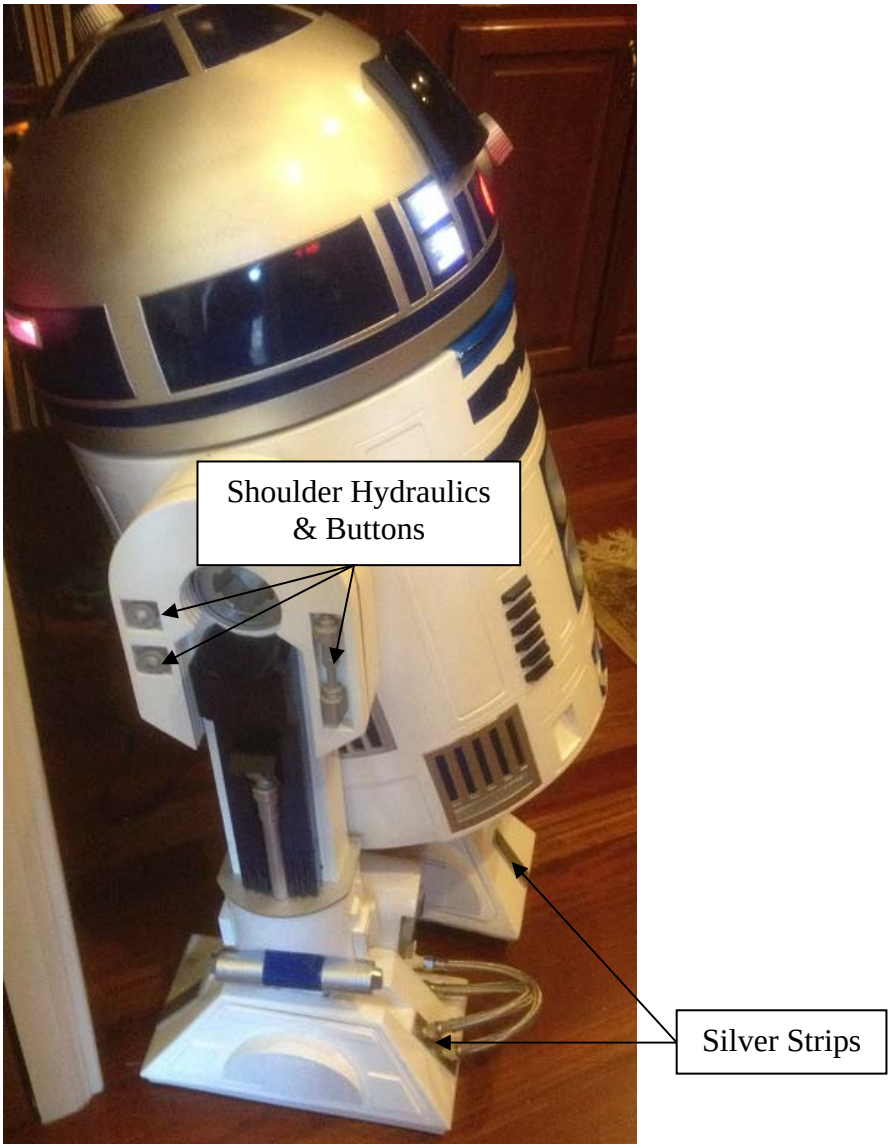


Rear PSI Light (Green)

The pictures above illustrate the PSI lights. The lights make a sweeping change between Blue/Red (front) and Yellow/Green (back). Diffused pieces of acrylic are included to mount the PSI LED assemblies behind. I added a clear acrylic circle to each PSI hole that was glued to the opening. I placed the included diffusers behind the clear acrylic circles.

9 Miscellaneous

The battery hoses and connectors are included as part of the system provided by Manny. The silver strips shown on the feet were not included. I cut, glued, and painted aluminum flat stock from Home Depot to provide this detail. One of the things I liked about the design is that components such as the shoulder hydraulics and shoulder buttons attach via magnets. This detail makes painting a simpler process. The legs are assembled in sections that allow for easy painting due to the color separation of the sections. Since my R2D2 was to be a static unit, I applied small roller wheels to the inside of the feet to allow easy movement.



10 Paint

I painted the R2D2 using the following colors:

Quantity	Description	Usage	Purchased
2	Dupli-Color BSP202 Brilliant Silver Metallic Paint Shop Finish System - 32 oz.	Dome, Dome Parts, Shoulder Hydraulics, Shoulder Buttons, Shoulder Cap, Etc.	Advanced Auto
3	Dupli-Color BSP201 Championship White Paint Shop Finish System - 32 oz.	Body, Legs, Feet, Dome	Advanced Auto
2	Dupli-Color BSP300 Clear Coat Paint Shop Finish System - 32 oz.	Body, Legs, Feet, Dome	Advanced Auto
1	Dupli-Color B92B Nighthawk Black Pearl Spray Can	Radar Eye	Advanced Auto
4	Dupli-Color Metalcast MC201 Blue Anodized Spray Can	Blue Parts	Advanced Auto

The Body Shop Dupli-Color paint is just pour and spray. Since I am not a painter, this seemed like the best solution since I was not getting satisfactory results with the spray cans for the body (white) and dome (silver). The color looks good and it really is a no fuss solution that is easy to apply. After spraying the color, I let everything cure for a week and sprayed the clear. Be sure to lower the air pressure when spraying the clear. With it too high, you will get a rough finish.

I painted the R2D2 using the following equipment:

Quantity	Description	Usage	Purchased
1	Campbell Hausfeld 8 Gallon Air Compressor	Torso, Tread Section, Radar *Note: The compressor cycled often since the tank is undersized for spraying*	Home Depot
1	Central Pneumatic Spray Gun Filter	Attach to spray gun to remove contaminants before they reach the spray gun	Harbor Freight
2	Central Pneumatic 20 ounce disposable paint spray gun cups	Comes with 5 in each package	Harbor Freight
1	Central Pneumatic Professional Automotive HVLP Spray Gun Kit	Spray guns – comes with 2 guns (large and small).	Harbor Freight
Several	Tack Cloths	Wipe down parts prior to spraying	Home Depot
1	Acetone	To clean spray gun when I finished spraying each day	Home Depot

I do not plan on embarking in a career that involves painting so I just went the inexpensive route and bought the Harbor Freight stuff. I wanted the spray gun to last for the entire painting process. It worked just fine so I guess even a blind squirrel gets a nut sometimes. If I was to spray often, I would probably get a bigger air tank and better sprayer.

11 Control

The R2D2 robot is controlled via an Allen-Bradley MicroLogix 1400 PLC. The dome motor is an AutomationDirect stepper motor. The stepper motor is controlled by an AutomationDirect stepper drive. The stepper drive allows for serial control. Therefore the MicroLogix PLC sends target positions, velocity, accel, and decel values to the stepper drive for each commanded dome motion.

The sound and video is triggered by the MicroLogix 1400 PLC to a FrightProps digital video player. The interface between the PLC and the FrightProps unit is via the Allen-Bradley MicroLogix 1400 PLC outputs (dry contact closures).

The Dome bumps on the R2D2 were replaced with 22mm illuminated pushbuttons. The pushbuttons are used to initiate R2D2 shows. The LED's for the pushbuttons are wired to the PLC outputs and flash for 3 seconds when a pushbutton is pressed. The pushbutton inputs are also wired to the PLC. The remaining (2) holoprojectors each have a 24 VDC LED located behind the cabochon to emit light from the holoprojectors

12 Dome Pushbutton Operation

12.1 Top Pushbutton

The Top pushbutton is used to initiate a short audio only show. The top pushbutton was added and located on the circle at the very top of the dome. Once the pushbutton is pressed, the LED ring on the pushbutton changes from solid on to flashing for (3) seconds. After (3) seconds, the LED ring illuminates in a solid fashion. Once the (3) second start timer has expired, A contact output for the PLC closes for 1 second to trigger the short audio only file on the FrightProps, LLC player. At the same time, the PLC initiates a series of dome rotations.

12.2 Left/Right Dome Bump Pushbuttons

The Left and Right Dome Bump pushbuttons are used to initiate a short video show. Once the desired pushbutton is pressed, the LED ring on the pushbutton changes from solid on to flashing for (3) seconds. After (3) seconds, the LED ring illuminates in a solid on fashion. Once the (3) second start timer has expired, A contact output for the PLC closes for 1 second to trigger the short video show file based on the pushbutton that was pressed. At the same time, the PLC initiates a series of dome rotations. The video file that is triggered is composed of a black screen with R2D2 audio beeps for the first (20) seconds. The remaining portions of the video file include clips from the Family Guy Star Wars episode. The PLC turns on the projector immediately and opens a douser that covers the holoprojector (20) seconds after the (3) second start timer has expired. Since the audio is embedded into the playback file, the audio can be heard through the onboard amplified speakers connected to the audio/video player.

The douser is used to block the video from being displayed during the 20 seconds of dome rotation. A douser was incorporated since the projector displays an HP logo on power-up and I did not want the Logo to appear to the viewing public.