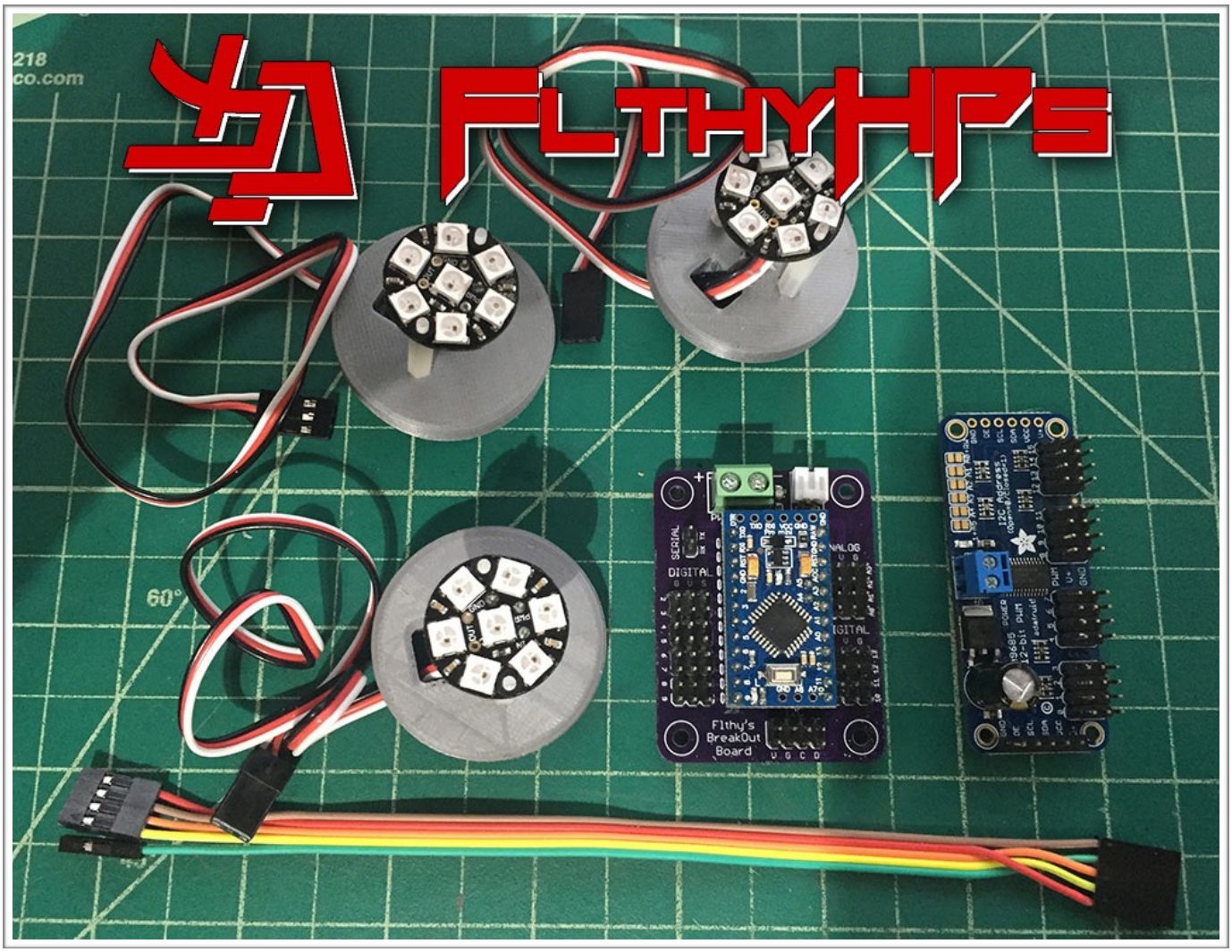
Guide to Using Your FlthyHPs

by Ryan Sondgeroth

flthymcnsty



2016

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What are the FlthyHPs

What do they do and Why you want a set!

This system and sketch combines the movement and display functions of each Holoprojector into a single easy to control sketch. Instead of using a single RGB like other HP systems, the FlthyHPs utilizes a 7 LED NeoPixel board inside each HP to produce a more life-like representation of a hologram projection.

Servo control of the system is handled by a Adafruit 16 Channel I2C Breakout board, giving increased flexibility over the I2C bus while providing significant current to safely run your HP servos.

This system also allows us to operate the HP Servos with NeoPixel LEDs from the same sketch, a problematic solutions when attempting to use the stock Arduino servo library with Adafruit's NeoPixel library. Big Happy Dude's Slow Servo Library is much better any way, Thanks Brad!

The system incorporates semi randomized auto twitch sequences for both the LEDs and Servos of each HP giving your droid the illusion of autonomy. In addition to these free running auto modes, the LED and Servo behavior can be controlled in unison or separately through a variety of sequences triggered via I2C and Serial communication protocols. To simplify control, the FlthyHP system allows you to control HP functionality by sending all HP commands to a single device.

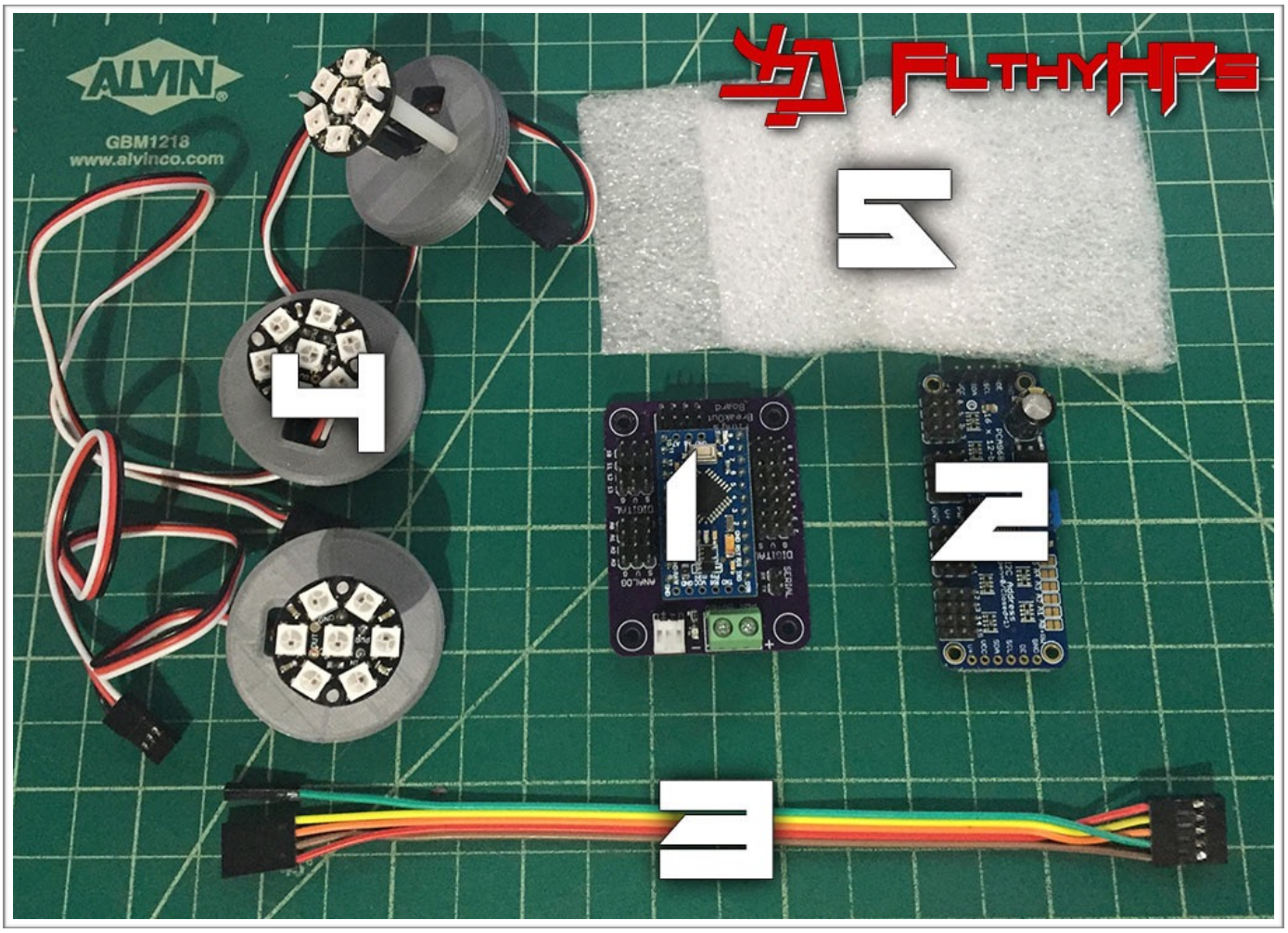
The most current version of this manual can be found at:
http://2geekswebdesign.com/FlthyHPs/Manual/

Rhyno45 is a Wanker, in case Ya'll didn't know!

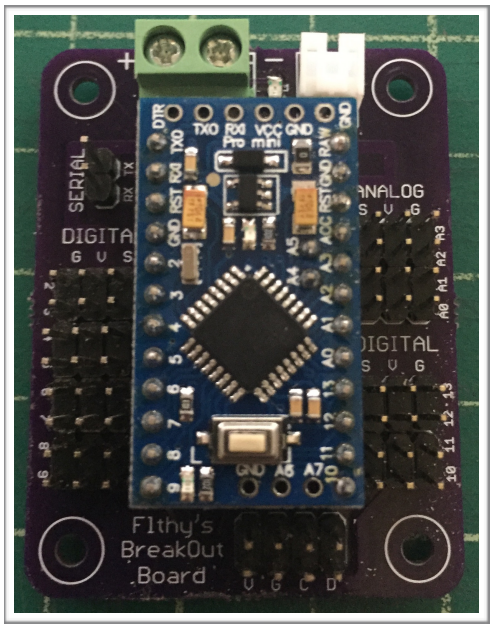
What's in the Kit

Below is a picture of the complete contents of your HP kit. Please make sure everything is included before you begin. A brief description of each part/assembly is included below.

Each system comes pretested and pre-installed with the current sketch and default settings.



1. Arduino Pro Mini (5v 16MHz) on a Flthy Breakout Board.



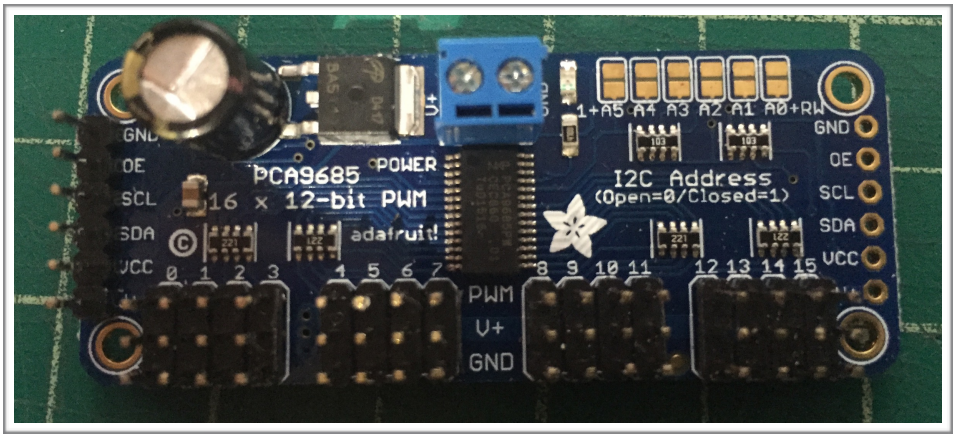
The Flthy Breakout Board is a custom designed PCB* which conveniently breaks out the digital and analog pins of the Arduino Pro Mini into easy to use connections. It also breaks out the Serial Tx/Rx and I2C Clock/Data pins. A screw terminal and JST-PH-2.0 connector are included, giving you a couple of choices for connecting your 5v power. There is a single SMD power LED on the board as well.

**The breakout board design is based on the publicly CADEagle files available on letsmakerobots.com.*

2. Adafruit 16 Channel I2C Servo Breakout board*

See product info at https://www.adafruit.com/product/815

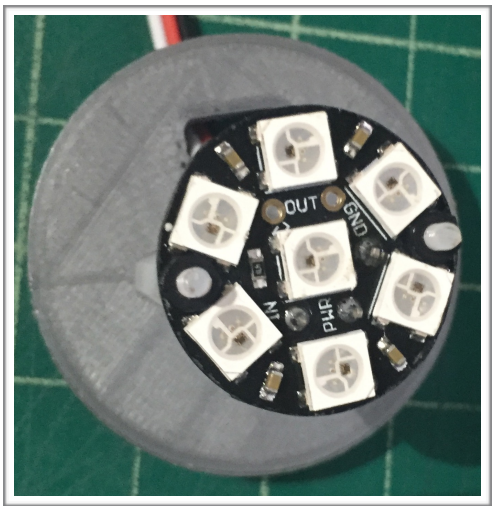
**Optional…Because some R2 Builders may not wish to articulate their HPs, some kits are available without this board.*



3. 5 Wire Jumper Cable

This pre-wired jumper cable is used to connect the Servo Breakout Board to the Arduino via the Flthy Breakout board.

4. HP LED Assemblies (Qty. 3)



Each assembly consists of a Adafruit NeoPixel Jewel 7 LED Board (https://www.adafruit.com/products/2226), mounted on a custom 3D printed backplate via M2 nylon standoffs and connected with a 30cm 3 wire lead.

The 3D printed back plates were designed to thread into the rear off the recent Pwrsrce aluminum halo-projector run. While not an absolutely perfect fit, they have been tested to work with BobC HPs as well.

The center hole comes tapped for an M4 patterned bolt.

5. 1/4" Micro Foam Packaging Wrap (Qty. 3)

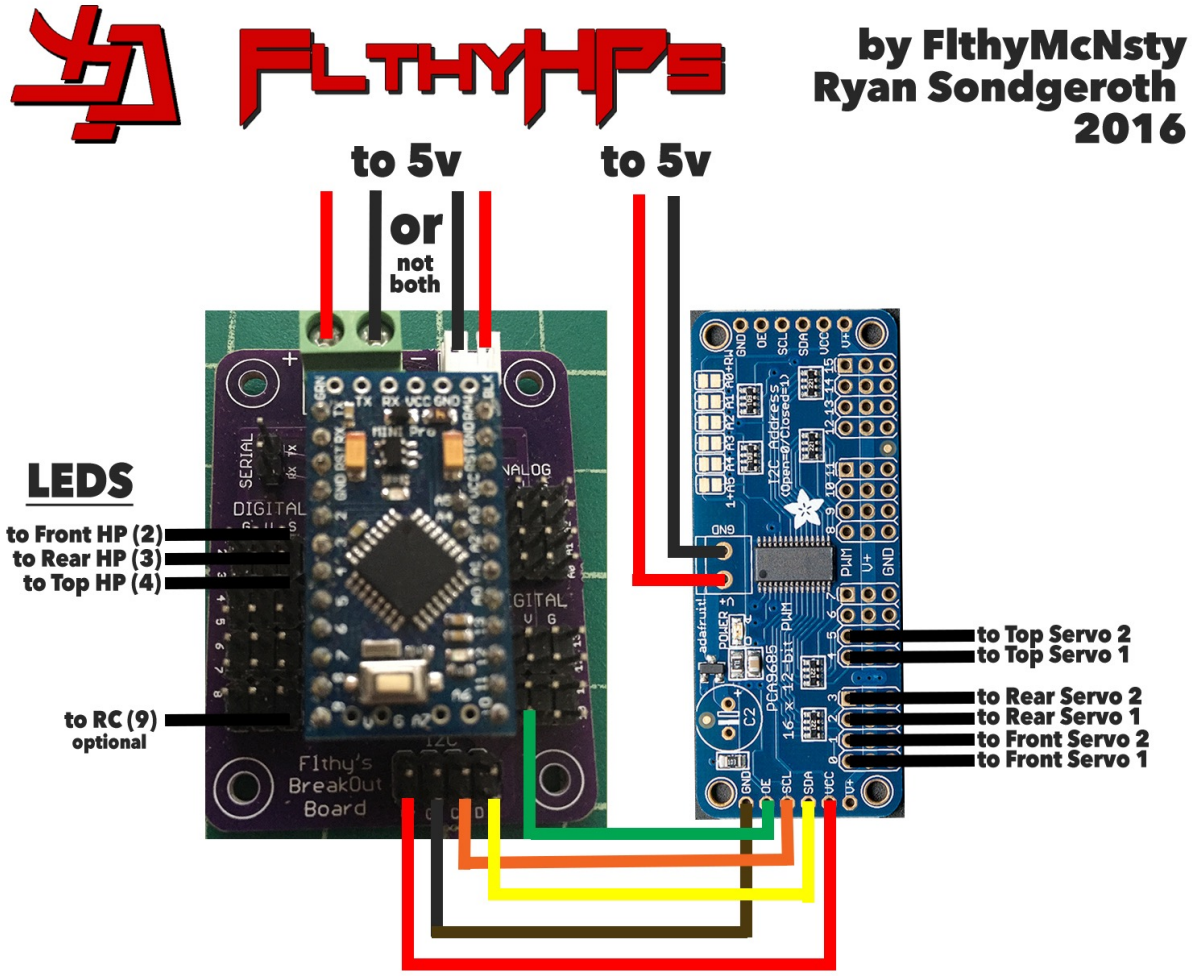
These 3 pieces can serve as a light diffuser between the HP's LEDs and its lens, just cut to size. They help blur the lines between the individual LEDs while maintaining a multicolor display. The foam construction also give the HP's light a unique texture when looking directly into the lens. (Which I don't recommend you do for long periods off time)

Hooking Up Your HPs

What Wires Go Where?

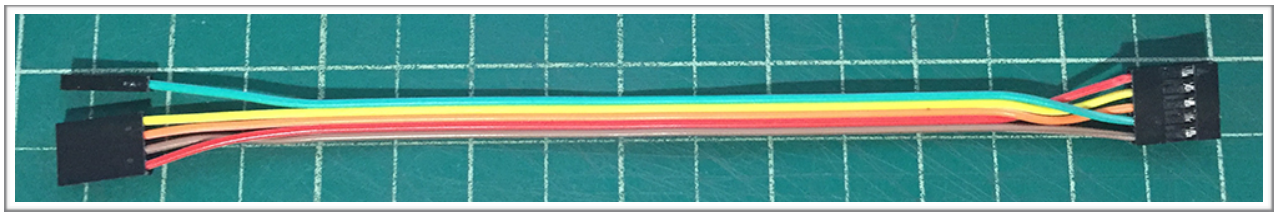
Wiring Diagram

The wiring for this system is pretty straight forward. Both boards take 5v with the servos and LEDs attached as shown.



Arduino Sketch Located at:
http://2geekswebdesign.com/FlthyHPs/Sketches/

Pay special attention to the wiring between the Arduino breakout board and the servo breakout board. The servo breakout board uses a different pin layout than the standardized I2C pin layout used by other systems created by R2 Builders. Incorrectly connecting the servo board can result in damage. In order to help prevent this occurrence, each kit is provided with a 5 wire jumper cable (pictured below) which has been rearranged into the correct wiring pattern with each wire matching the color used in the wiring diagram above.



Understanding the Sketch Settings

Explanation of User Definable Settings in the Code

I keep the most current versions of my FlthyHP sketch freely available on my web server at: http://2geekswebdesign.com/FlthyHPs/Sketches

For those who use my sketch and feel you may have a way to improve upon it, please share your ideas and thoughts with me. Together we can continue to improve our droids.

As you review the sketch, you will see I have broken out a number of settings into user definable variables in order to let each user tweak the system to their specific needs. Below is a complete list of each of these variables with a brief explanation of its function and purpose.

1. I2C Address of the System

Since each device on the I2C bus can and must be assigned its own unique address, this variable allows you to do so. An I2C address of 25 has been standardized for other HP devices so I used it as well. It can be changed with the following variable. Please note that it is set using the hexadecimal equivalent of the address's decimal value.

```
byte I2CAddress = 0x19;  // 25 in Hexadecimal
```

2. I2C Address of the Servo Board

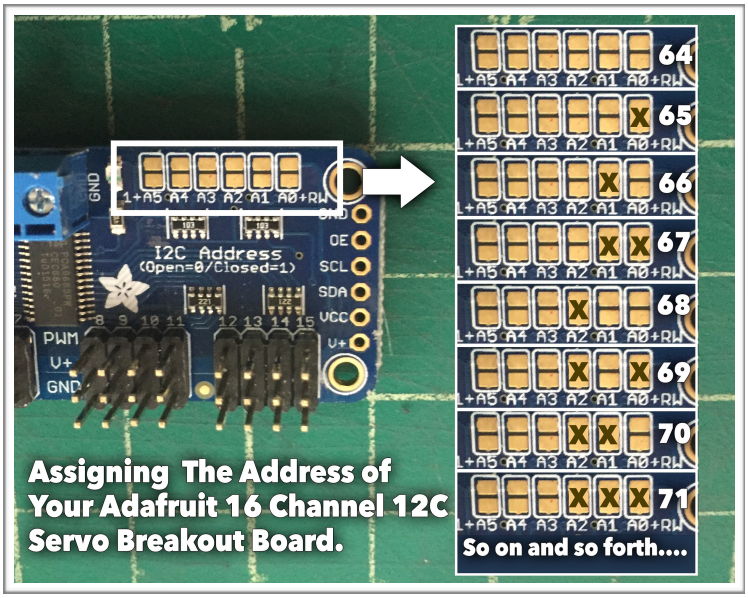
Similarly, we need to set a unique 12C address for the Adafruit Servo Breakout Board.

Unlike our Arduino based control board, the Servo Breakout board is only capable of using an I2C address in the range between 64 and 126. The specific address the board uses can be set using the set of 6 solder pads located on the top of the PCB. By default the board has an address of 64, and no changes are needed if you are not using the same board elsewhere on the I2C bus or have assigned another device with this address.

However, if you do need to make changes to the boards address you can do so by using the solder pads to select a new address value. To do so, you simply place a bead of soldier across the gap in the requisite pad pairs.

The address value is determined just as you would using binary as show in this image.

Once you have set your Servo board's address, you will then need to change this address in the Sketch. It can be changed with the following variable. Again, please note that it is set using the hexadecimal equivalent of the address's decimal value.




```
byte ServoI2CAddress = 0x40;  // 64 in Hexidecmal
```

If there is no need to reassign the Servo board's address, the default value in the sketch can be left as is.

3. HP LED Pin Assignment

This variable allows you to set which of the Arduino's digital pins are used to connect each of the 3 LED displays. The first value being the front HP, the second the rear HP and the third the top HP. Under most situations, the default values can be left unchanged.

```
int LEDpins[3]   = {2,3,4};   // {Front, Rear, Top}
```

4. Servo Board Pin Assignment

This variable allows you to set which of the Servo breakout board's pins are used to connect each of the 6 servos. The first value pair being for the front HP, the second value pair for the rear HP and the third pair for the top HP. Under most situations, the default values can be left unchanged.

```
int HPpins[3][2] = {{0,1},{2,3},{4,5}};   // Front HP Pins, Rear HP Pins, Top HP Pins
```

Important: *It is recommended that you remain consistent with how you orient your HP mounts and control system so that the two servos for each HP are positioned in a similar manner with the others. Likewise, pin assignments/servo connection should be consistent as well between the HPs. This will help keep their behavior during movements consistent.*

5. Output Enable (OE) Pin Assignment

The servo breakout board is equipped with Output Enabled (OE) capabilities. Output Enable is used to disable/enable power to the servos between movements by pulling the OE pin on the servo break outboard to LOW. This is used to minimize the unnecessary and unwanted hum/noise often heard when a servo fails to reach it's exact destination after a movement command is executed. Under most situations, the default value can be left unchanged.

```
int oepin = 10;
```

6. Enable/Disable OE

In some rare cases* you may wish to not use the Output Enable capabilities. You can disable OE by setting the following variable to 0.

```
int enableOE = 1;    //  0 = Disabled; 1 = Enabled;
```

** The only reasons you would want to disable this is if…*

1. *You wish to use an additional micro-controller to send servo control commands via the Adafruit library.*
2. *You want to use additional servos on the same servo breakout board as your HP servos.*

Neither scenario is recommended because the increased complexity it introduces far outweighs the costs savings of not purchasing an additional servo board.

7. RC Input Pin Assignment

This variable allows you to set the digital pin used to feed a single RC input into the system to be read when the system's RC function has been triggered via Serial or I2C command. The RC function allows you to move a selected HP up or down using one of your controllers sticks. At this time the system only supports movement on a single axis and its use is completely optional. Under most situations, the default values can be left unchanged.

```
int RCpin = 9;
```

8. RC Pulse Width Range

Since RC controllers/PWM sources are different, this variable allows you to set a min and max pulse width value to map to the end positions of the up/down axis of movement. Which value corresponds with up and which corresponds with down is dependent on your specific set up so you may need to switch the order of the two values.

```
int RCRange[2] = {1250, 1750};     // {Min, Max}
```

9. LED Brightness

If you need to adjust the brightness of your LEDs, simply change the value of the following variable. It accepts a range from 0-255. The higher the brightness, the more power the system requires.

```
#define BRIGHT 100
```

10. Enable/Disable LED & Servo Auto Twitch

Each HP can be set independently from each other to twitch its servos and LEDs automatically at various intervals to give your droid a sense of autonomy. Furthermore, the servos and LEDs of a single HP can be set to twitch independently from each other as well. This auto twitch behavior can be enabled/disabled using the following variables. Enabled = 1, Disabled = 0

```
int enableTwitchFLED  = 1; //Front LED
int enableTwitchFHP   = 1; //Front Servo
int enableTwitchRLED  = 1; //Rear LED
int enableTwitchRHP   = 1; //Rear Servo
int enableTwitchTLED  = 1; //Top LED
int enableTwitchTHP   = 1; //Top Servo
```

11. LED & Servo Auto Twitch Interval Ranges

The length between twitches can be adjusted by using these values to select the range (min, max) in seconds to randomly select the next auto twitch interval. This helps give the illusion these displays & movements are totally autonomous as the interval between the same HP twitching will randomly change each time. First value is the min, and the second value is the max time in seconds.

```
unsigned int FLEDTwitchInterval[2] = {240,360};  // (4-6m) Front HP Led Twitches
unsigned int RLEDTwitchInterval[2] = {300,420};  // (5-7m) Rear HP Led Twitches
unsigned int TLEDTwitchInterval[2] = {300,420};  // (5-7m) Top HP Led Twitches

unsigned int FHPTwitchInterval[2] = {60,120};  // (1-2m) Front HP Servo Twitches
unsigned int RHPTwitchInterval[2] = {60,180};  // (1-3m) Rear HP Servo Twitches
unsigned int THPTwitchInterval[2] = {60,180};  // (1-3m) Top HP Servo Twitches
```

Since R2-D2 is seen in the films to move his HPs often yet rarely projects from them, the default settings have the servo twitch occurring more often than the LED twitch.

12. LED & Servo Auto Twitch Runtime Ranges

In addition to the interval between LED twitches, you can also set the duration the LEDs remain illuminated when executed. This too helps give the illusion these displays are totally autonomous as they operate for a different length of time each time a twitch is executed. First value is the min, and the second value is the max time in seconds.

```
unsigned int FLEDTwitchRunInterval[2] = {5,25};  // (5-25s) Front LED Runtime
unsigned int RLEDTwitchRunInterval[2] = {5,25};  // (5-25s) Rear LED Runtime
unsigned int TLEDTwitchRunInterval[2] = {5,25};  // (5-25s) Top LED Runtime
```

13. Servo Speed Range

The servo speed range can be set setting the min and max speed settings via the variable below. Values are in ms with lower values resulting in faster servo movement. By using a range, the servos will not always move at the same speed giving the subtle illusion that each movement is purposeful and unique.

```
const int SERVO_SPEED[2] = {150, 400};
```

14. Preset HP Servo Position Coordinates

The following settings can be confusing so I made every effort here to explain them at length.

Since each Builder's droid is assembled differently, we found using position coordinates generated randomly on the fly was problematic due to the occasional servo movement attempting to travel beyond the outer cowl path. Therefore we use a set of 6 position pairs for each HP, set to ensure they lie within a freely accessible position. These coordinates consist of the servo position of each servo using its pulse width value in microseconds. I suggest using a pair of servo testers with a digital display to find these position pairs while the HPs are mounted in the dome.

The first coordinate pair in each row references the DOWN position of the HP, the second pair is the CENTER position, and the 3rd pair the UP position. The three remaining pairs are auxiliary positions picked from an position free from obstructed servo travel.

Random twitch movement is then chosen to randomly travel between these 6 safe points minimizing the chance of the movement being impeded causing excessive and unpleasant servo noise. First value in each pair is the pulse width of Servo 1 and second is pulse width of Servo 2.

Important: *The following values are unique to my HP Control setup and are only used as place holders. They will not work as intended in your set up without first finding your own position values and entering them below. Likewise, your values will not work in another builders set up.* There is simply to many variables involved in how HPs are mounted to create a global set of positions that work between droids.

```
int HPpos[3][6][2] = {{{1492,1964},   // Front HP Down
                       {1492,1565},   // Front HP Center
                       {1492,1218},   // Front HP Up
                       {1281,1443},   // Front HP Aux
                       {1692,1757},   // Front HP Aux
                       {1255,1940}},  // Front HP Aux
                      {{1601, 1084},   // Rear HP Down
                       {1437,1537},    // Rear HP Center
```

```
  {1385,1954},    // Rear HP Up
  {1343,1406},    // Rear Aux
  {1633,1764},    // Rear Aux
  {1803,1283}},  // Rear Aux
 {{1547,1038},    // Top HP Down
  {1431,1395},   // Top HP Center
  {1473,1793},   // Top HP Up
  {1633,1737},   // Top Aux
  {1324,1200},   // Top Aux
  {1677,1151}}}; // Top Aux
```

Basic Positioning*:

If you would rather do things the simple way, you can set the Basic Position mode below. This will use the Center, Min and Max pulse width values set in the HPposBasic array. These are based on the assumed default center value of a normal servo so it is important that your servo linkage is installed in a manner where the center servo position corresponds with the orientation you want your HP to be at when centered.

```
int enableBasicHP = 1;   // 0 - Disabled, 1 - Enabled, Basic Servo Positioning
int HPposBasic[2][3] {{1500,1300,1700},   // {Center, Min, Max} Servo 1
                      {1500,1300,1700}};  // {Center, Min, Max} Servo 2
```

** enabled by default on new kits in order to increase their plug and playability.*

Important: *If you disassemble your HPs and servo linkage after setting custom Pre-Set values or custom Basic Position values, you will most likely need to recheck and reset them as the chances of reinstalling them exactly the same way is approximately 3,720 to 1.*

I also suggest once you measure your position values, you maintain a backup list of those values separate from your saved sketch. There is a couple of reasons for this, the most important being in the event you need to reinstall the default sketch, or I release an updated version you wish to use, this backup list will keep you from needing to measure your position values again. No one likes to have to mess with dome wiring after it has been neatly ran.

RC mode requires preset position coordinates to work well, so you must have enableBasicHP set to 0 and the HPpos array set with your specific values.

15. Default Color Settings

These settings allow you to set the default colors for the Auto Twitch/Leia and Short Circuit Sequences respectively. Currently, there is a choice of 8 basic colors you can use when setting these defaults.

Basic Color Integer Values
0 = Off (Black}
1 = Red
2 = Yellow
3 = Green
4 = Cyan (Aqua)
5 = Blue
6 = Magenta
7 = Orange
8 = White

Simply use the integer value from the color list above in each of the two default color variables below.

```
int defaultColor = 5;    //  Blue, Used in Twitch and Leia sequences
int shortColor   = 7;    // Orange, Used as Hue in ShortCircuit sequence.
```

The few times we see R2-D2 use his projector in the films, the Holograms projected had a blue tint to them, we selected blue as the default color to closely resemble this behavior. We also chose it because MKelly and Ripcord were whiney little girls about it. :-)

I2C/Serial Command Structure

How to Make Your HPs Do Some Unique Things

Command Structure

Most of the commands available to to you over I2C or Serial communication come in the form of a 4-5 character alphanumeric string . This string uses a well defined composition utilizing the following structure:

DT##C

D *- the HP designator; used to select the specific HP you wish to send the command to.*

Value Options: F - Front HP
R - Rear HP
T - Top HP
A - All 3 HPs

T *- the Sequence Type;*

Value Options: 0 - LED Function
1- Servo Function

*- the Sequence Value (including leading zero);*

LED Sequences
*Value Options: 01 - Leia Sequence, Random shades of blue to mimic Leia Hologram**
02 - Color Projector Sequence, Like Leia above using color command value
03 - Dim Pulse Sequence, Color slowly pulses on and off
04 - Cycle Sequence, using color command value
05 - Short Circuit, Led flashes on and off with interval slowing over time
06 - Toggles Color, Simply sets LEDs to solid color value.
*07 - Rainbow Sequence**
*98 - Clears LED, Disables Auto LED Sequence**
*99 - Clears LED, Enables Auto LED Sequence**
** Color Value Below Unneeded, Therefore Ignored, Can Be Omitted From Command String*

Servo Sequences
Value Options: 01 - Sends HP to the Center Position
02 - Sends HP to the Down Position
03 - Sends HP to the Up Position
04 - Enables RC Control on HP
98 - Disables Auto HP Twitch
99 - Enables Auto HP Twitch

C - Color Value;

Value Options: *0 - Off (Black}*
1 - Red
2 - Yellow
3 - Green
4 - Cyan (Aqua)
5 - Blue
6 - Magenta
7 - Orange
8 - White

Some Simple Examples:

"R0063" - This toggles the Rear HP LEDs to Green (R/0/06/3)
"F0036" - This pulses the front HP LEDs in Magenta (F/0/03/6)
"T007" - This starts the Rainbow sequence in the Top HP LEDs. (T/0/07)
"A098" - This clears the LEDs in all 3 HPs and disables the LED auto twitch mode. (A/0/98)
"F103" - This sends the Front HP to the UP position. (F/1/03)
"A101" - This sends all three HPs to the center position. (A/1/01)
"R104" - This enables RC mode on the rear HP. (R/1/04)
"T199" - This enables the Servo auto twitch mode. (T/1/99)

Important: *Command strings sent via Serial communication require the addition of a carriage return character (\r) to the end of the command string. So the command string "R0063" from the examples above, would become "R0063\r" when using serial communication. This carriage return character lets the system know it has reached the end of a command.*

I2C communication does not require this extra character.

Special Sequence Commands

The commands sent using the structure outlined in the last section only allow you to control either the LEDs or the Servos using any given command. There are times when you would like to use a single command to trigger several different behaviors of both types at once without needing to stack commands. Therefore we use special or "S"-series commands that combine a number of individual type functions and behaviors into a single complex sequence.

Currently we only have 3 of these special commands:

"S1" - Leia Mode: Front HP moves to down position, Leia LED Sequence begins, and the other two HPs are disabled.

*"S8" - Clear and Disable: Clear all LEDs, Disable Auto Servo and LED Twitch. Used to quickly **stop** all HP functions.*

*"S9" - Clear and Enable: Clear all LEDs, Enable Auto Servo and LED Twitch. Used to quickly **reset** all HP functions.*

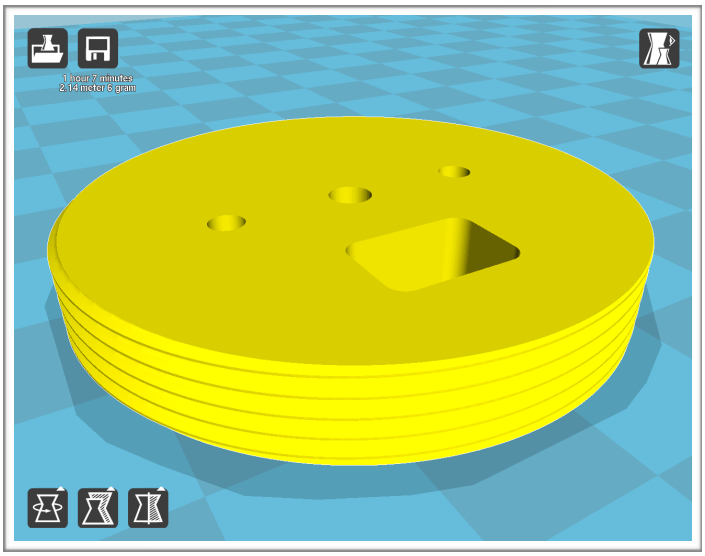
Replacement Back Plug

In the event you need to print a replacement rear plug due to damage or loss, the model file can be found at: http://2geekswebdesign.com/FlthyHPs/Rear_Plug.

***Important:** I have some tips for getting the best results when printing this plug.*

First, if the model renders incredibly small in your 3d printing software, the units used are incorrect. Just scale the size up by a factor of 25.4.

Second, before printing, orient the plug so that the holes with the bevelled and recessed edges face down towards the build plate. This will insure the edge that must thread into the HP is printed cleanly.



Thirdly, when using Hatchbox brand 1.75mm PLA filament on my Printrbot Metal Plus, I have achieved good results using the following print setting. Maybe you will too.

Layer Height: 0.1mm
Shell Thickness: 1.2mm
Bottom Thickness: 1.2mm
Fill Density: 30%
Print Speed: 40mm/s
Print Temp: 210C
Bed Temp: 50C
Flow: 100%

Nozzle Size: 0.4mm
Retraction Speed: 45mm/s
Retraction Distance 4.5mm
Initial Layer Thickness: 0.3mm
Initial line width: 100%
Bottom Layer Speed: 35mm/s
Cooling Fan: Enabled

Once printed, you will need to manually tap the center hole for M4 pattern bolt. The two mounting holes for the Adafruit Jewel LED board will most likely need slightly enlarged with a drill accommodate M2 sized screws.

To assemble, I use 2-M2 Nylon Screws (cut to length), 2-M2 20mm male/female Nylon standoffs. and 2- M2 Nylon nuts to mount the NeoPixel Jewel to the Back plug.

Finding Your Preset Servo Position Coordinates

As mentioned previously in the explanation of the sketch's HP position variable array, this system works best when we provide a complete set of 6 predetermined coordinate pairs per HP corresponding to specific position, namely the Down, Center, and Up positions along with 3 additional auxiliary positions.

I have found the easiest way to do the is to use a set of servo testers with digital displays. These servo testers will allow us to manually move each HP into the various positions and then quickly gather the two pulse width values in microseconds that make up each coordinate pair.

I used a pair of G.T. Power Digital Servo Performance testers to gather my coordinates pretty quickly once my HPs were mounted in my dome and the control linkage installed. A pair of these can be purchased for less than $50 from Banggood here:

http://www.banggood.com/G_T_Power-Digital-Servo-Performance-Tester-p-999251.html

Before you begin, I must make it clear your HPs need to be mounted with servo plates/linkage in place. These values are dependent on a number of variables and removing your HPs or their linkage you will more than likely require you to perform this process again.

First, take a piece of masking tape or a stick on label and number your two servo testers "1" and "2". This ensures the values gathered aren't mixed up. Tester "1" will always provide the first value in the coordinate pair, and tester "2" will provide the second value.

Next, locate the two servos for your first HP. (It is probably most efficient to start with the Front HP.) Plug one of the servos into Tester "1" and the other servo into Tester "2".

Remember the orientation of the servos in relation to how they are mounted in the dome along with which tester you connected to them. You want to maintain the spacial relationship when moving on to the other two HPs. This will help keep things consistent.

Using the up/down and menu/enter keys on each servo tester, you will want to select “Analog”->”LN Mode”->”Extend”. This will take you to a screen that reads “PULSE” with a 4 digit number followed by “US” (which stands for microseconds). You may have also noticed that once you reached this screen, the HP servos moved a bit, that is because you can now control the PWM values being sent to each servo.

Use the “Adjust” knob on each servo tester to move its respective servo. Using both in unison will allow you to move the HP to specific positions. Feel free to mess around and get a feel for it.

Once you are ready to collect your position coordinates, move the HP to the location you would like to assign as the Down position. Once you are happy with the HP’s orientation, record the value shown on the screen of tester “1” followed by the value seen on tester “2”. You now have collected your first position coordinate pair.

Repeat this process to determine the coordinates for the HP’s Center and Up positions. Once these first 3 coordinates are completed, you will then need to collect coordinates for the 3 auxiliary positions. These positions can be anywhere you wish as long as they lie safely in the range of motion of your HP. These are used to provide random movements different than the standard Down/Center/Up positions, but with the added benefit of being safe from impeding movement which could cause excessive noise or binding.

After collecting these last three auxiliary position coordinates, you have a complete set of positions for this particular HP and you can move on to the next, repeating the process.

Once you have completed collecting your position data for all three HPs, you will need to add them to the HPpos variable array in your custom copy of the FlthyHP Arduino sketch.

As suggested before, I strongly suggest you also save these values separately from your sketch. That way if you ever need to reinstall the sketch or a new version of the sketch is released, you don't need to go through these steps again.

It is probably a good idea to occasionally recollect this data as things get pulled on and tweaked in a manner that can gradually throw your alignment off in one direction or the other. Think of it as a sort of regular maintenance need of Artoo.

Build it Yourself

Open Source/Hardware Because Sharing is Caring

I believe that by freely sharing my hardware design files, Arduino sketch, and 3d models in the spirit of open hardware and software, we can continue to build better droids.

I will continue to host all current digital files for this system online at the following location: http://www.2geekswebdesign.com/FlthyHPs/

**The only file I currently don't have is the EagleCad BRD file for the Arduino Pro Mini Breakout Board because I accidentally deleted it after submitting it to Oshpark for initial fabrication . However, it is shared at Oshpark so you can order it from them at: https://oshpark.com/shared_projects/aIzj6gSL*

The Rules

These files are shared for personal use only. You may not offer/sell a system using my design in part or whole without my express permission.

I offer no warranty or liability for those choosing to built their own from the files provided. Doing so requires a basic familiarity with soldering small SMD components, the knowledge to install an Arduino sketch, and use/access to a 3D printer. If you don't have these skills or know someone who is willing to help you learn, I advise not attempting this build. I simply don't have the time each day to answer questions regarding the prerequisite skill sets needed to accomplish this build.

Thus…I offer complete assembled and tested systems for those not wishing to construct their own!