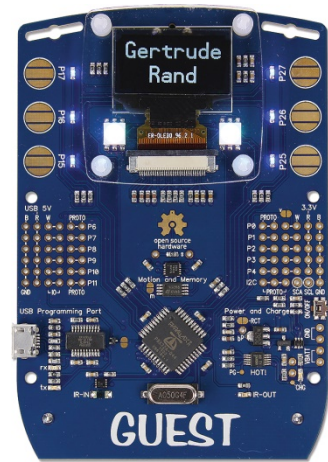


## Hackable Electronic Badge

**Guest (blue, #20000); Staff (white, #20100); Speaker (black, #20200)**

Energize your events by using the Badges to store and distribute schedules, identify participants, share contact info, and play interactive games. In educational environments, Badges encourage hands-on activities, creativity, and collaboration while studying electronics and programming.

Hack your Badge! Use our open-source programming tools and example code in C, Spin, and Propeller Assembly to try out a variety of example programs that use all of the Badge's features, and let your Badge share contact information with other Badges. For software and example code downloads, visit [www.parallax.com/badge](http://www.parallax.com/badge).



### Features

- Propeller 8-core microcontroller, 64 KB EEPROM and 5 MHz crystal oscillator
- 128 x 64 OLED display
- 3-axis accelerometer ( $\pm 1.5$  g) for orientation and motion detection
- Two-way infrared communication
- Two super-bright, tri-color RGB LEDs
- Six passive touch-buttons with status LEDs, plus 1 special OSHW logo touch-button
- Stereo audio and composite video out
- USB port for programming and charging
- Convenient on/off push switch
- 3.6 V Li-ion battery included (#752-00011)
- On-board battery charger, management, and charging disable functions
- Two mini prototyping areas, with access to I2C, 11 I/O's, 3.3V, 5V-USB and battery voltage
- Replaceable and user-customizable display covers
- Six mounting points plus lanyard slots; lanyard included

### Key Specifications

- Voltage requirements: USB 5V standard, or 3.7 VDC rechargeable Li-ion battery (included)
- Communication: USB for programming and charging
- Programming current: 40 mA typical
- Charging current: USB host 90 mA max, USB charger 540 mA max
- Dimensions: 4 x 2.75 in (102 x 70 mm)
- Operating temp range: 32 to 158 °F (0 to +70 °C)

### Application Ideas

- Interactive ID Badge for conferences, hackathons, and maker spaces
- Interactive lessons in programming, cyber security, and information diffusion in the classroom
- Research and experimentation with parallel processing and social communication
- Robot control panel, using onboard multicore processor, OLED display, accelerometer and buttons
- Develop portable games or interactive quizzes

## Quick Start Guide

Your Badge comes complete with a rechargeable battery, lanyard, and pre-loaded code that will demonstrate some of the built-in features. Let's get started!

### Installing the Battery

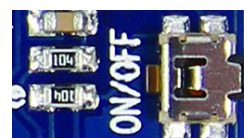
- Only use a 3.7 V, 800 mAh rechargeable Li-ion battery; one is included with your Badge.
- Match the plus (+) symbols on the battery and the back of the Badge and insert.



**CAUTION!** DO NOT PUT THE BATTERY IN BACKWARDS! IT COULD DAMAGE YOUR BADGE!

### Running the Test Code

- Press the on/off button on the right hand side of the Badge.
- Follow the prompts on the Badge's screen to demonstrate its features.



### Wearing your Badge

- Attach the included lanyard by clipping each end to a slot in the top of the Badge.
- Wear the badge around your neck, but heed the cautions below to prevent short circuits!



**CAUTION!** Do not wear the Badge with conductive materials such as metallic cloth, metal jewelry or buttons, or additional lanyards, that may short out against the Badge PCB. Protect the Badge from your skin, moisture, fluids, lotions, and static discharge from the environment. Parallax Inc. is not responsible for damage to people or objects caused by electrically connecting with your badge.

### Stashing your Badge

- Turn off the Badge using the pushbutton on the right-side edge of the board.
- If you are going to pack your Badge in a toolbox, backpack, or purse, put the Badge back its original bubble envelope with the lanyard left out. This will protect your Badge from scratches and from making contact with conductive items.

### Recharging the Battery

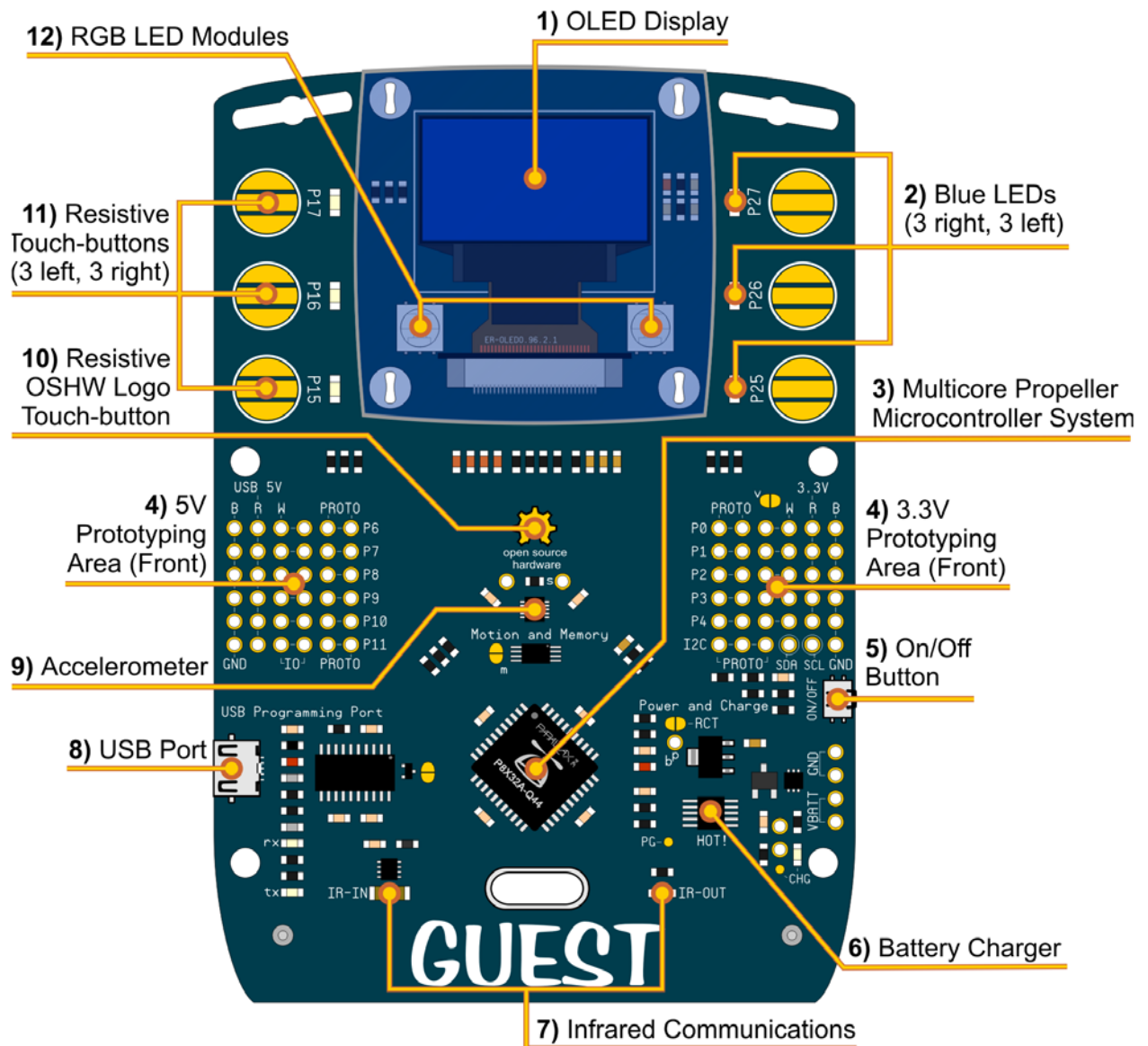
- To recharge the battery included with your Badge, connect the Badge to a USB port or USB charger with a standard USB Micro B cable (Parallax #805-00016).
- If you are using an external battery charger, follow the manufacturer's instructions.
- For using batteries other than the one included with your Badge, see sections (14) Battery on page 9, and (15) Battery Type Select on page 10.

### Hacking your Badge

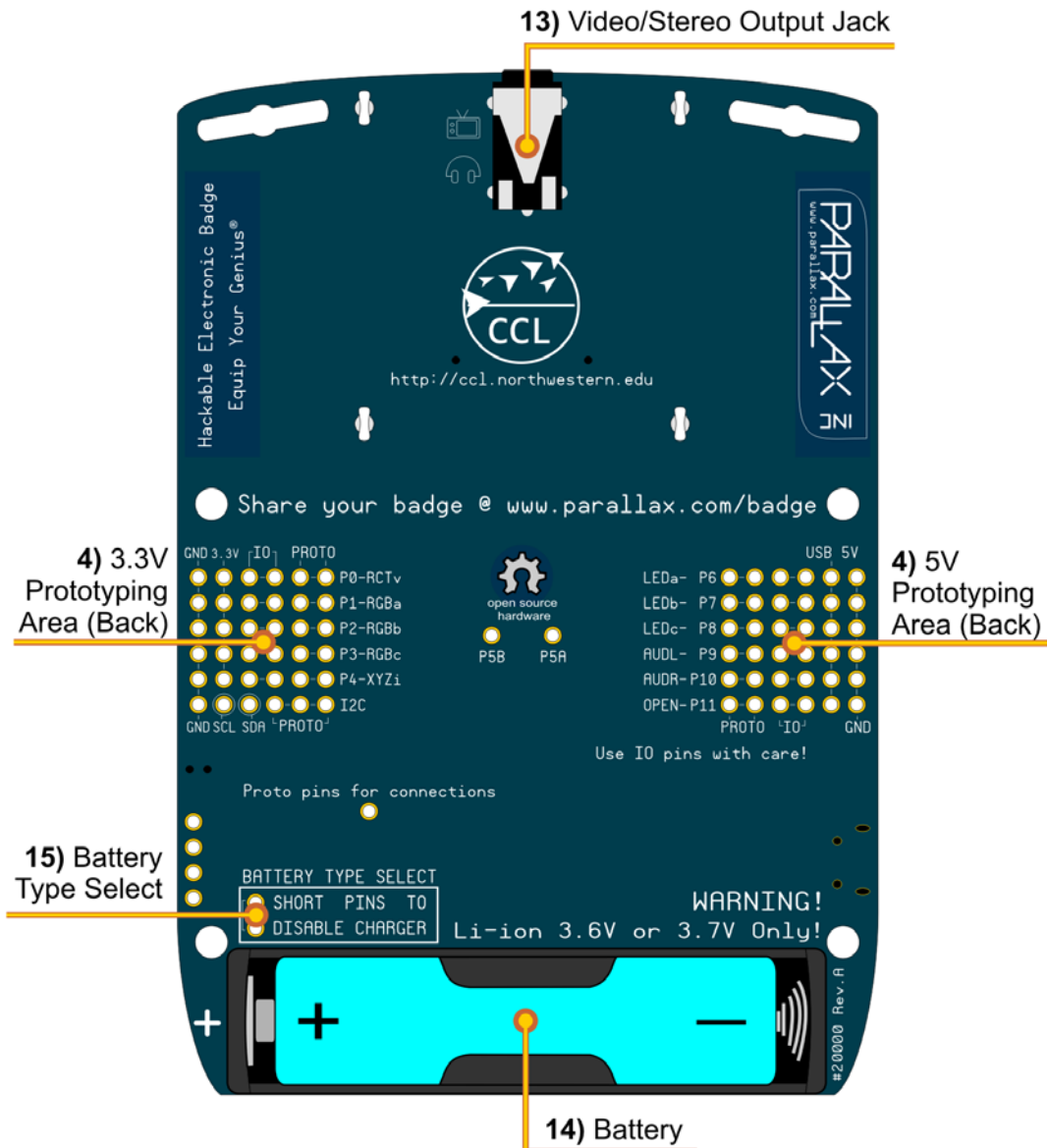
- Read through the remainder of this guide to learn more about all of your Badge's features.
- Programming your Badge requires a USB Micro B Cable (Parallax #805-00016).
- Find free software, example code, tutorials, and open-source files: [www.parallax.com/badge](http://www.parallax.com/badge)

## Description

### Front



## Back



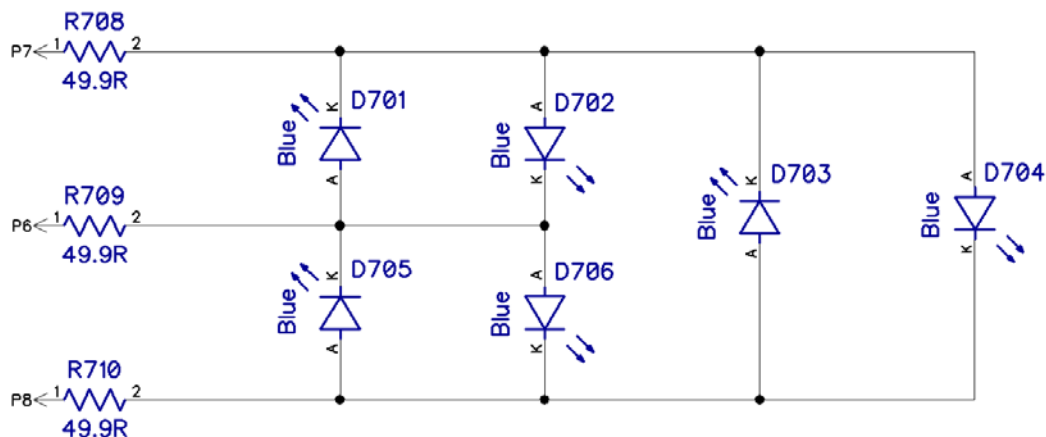
## (1) OLED Display

The 0.96" OLED screen features a high-contrast graphics display with 128x64 pixels. Pixels are white on a dark background. The screen has a built in SSD1306 display driver, which the Propeller controls directly by SPI protocol on pins P18 through P22.

(Marie Gertrude Rand Ferree (October 29, 1886 – June 30, 1970) was an American research scientist who is known for her extensive body of work about color perception.)

## (2) Blue LEDs

The Badge includes a blue LED beside each of the 6 round touch pads. Instead of using 6 I/O, or an extra multi-channel led driver component, these LEDs are controlled by Charlieplexing ([Charlieplexing](https://en.wikipedia.org/wiki/Charlieplexing): <https://en.wikipedia.org/wiki/Charlieplexing>.)



Charlieplexing is a technique that allows for control of more LEDs with fewer I/O pins by taking advantage of the one-way current flow properties of diodes (including Light Emitting Diodes), along with the tri-state properties of the Propeller I/O pins. It also saves battery power!

This image is taken from the actual Badge schematic, and represents a typical Charlieplex layout. Each Propeller I/O pin (labeled here P6 through P8) can be in any of 3 user-controlled states: HIGH (3.3 V output), LOW (0 V output), or INPUT (does not output anything, like a closed door). And, LEDs will only allow current to flow from the positive Anode (A) side to the negative Cathode (K) side; the "Forward direction."

Now, imagine if we set P6 to INPUT, P7 to HIGH, and P8 to LOW. Which LED will light? The answer can only be D704, as that is the only LED positioned in such a way to allow the current flow from P7 to P8.

This lookup table shows the required state of the Propeller I/O pins to illuminate each LED:

	P6	P7	P8
LED D701 (by P17 button)	HIGH	LOW	INPUT
LED D702 (by P16 button)	LOW	HIGH	INPUT
LED D703 (by P15 button)	INPUT	LOW	HIGH
LED D704 (by P27 button)	INPUT	HIGH	LOW
LED D705 (by P26 button)	LOW	INPUT	HIGH
LED D706 (by P25 button)	HIGH	INPUT	LOW

So this is all good... We can light one LED at a time! But how do we light more LEDs simultaneously, like in the Badge demo code?

The answer is that we don't actually light the LEDs simultaneously. We switch them on and off fast enough to trick the human eye into believing they are on simultaneously.

When Propeller code switches each LED on and off at least 50 times a second (50 Hz), flickering should not be noticeable and the LEDs will appear to be permanently on. (For the Propeller this switching speed is no problem as each I/O could switch faster than 5 MHz.)

This explains that low-power benefit. Each LED consumes approximately 10mA when lit. If all the LEDs were continuously powered on together, they could consume 60 mA together. But, with Charlieplexing we only light one LED at a time, so total current consumption at any instant in time remains only 10 mA!

### (3) Multicore Propeller Microcontroller System

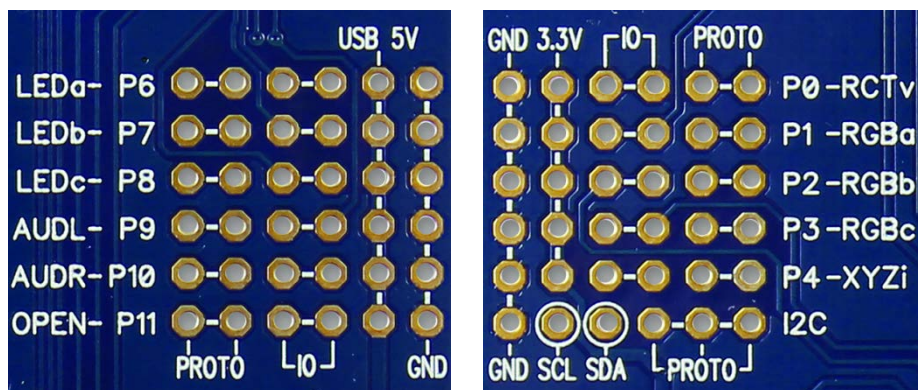
- 8-core Propeller microcontroller
- 64 KB I2C EEPROM for non-volatile program and data storage
- 3.3 V, 250 mA voltage regulator
- 5.00 MHz crystal oscillator

The Propeller provides the 64 KB EEPROM's I2C clock through I/O pin P28, and communicates with its I2C data line through I/O pin P29. The EEPROM's lower 32 KB contains the program image that the Propeller loads on reset. The upper 32 KB can be used for non-volatile data storage. The Propeller microcontroller can multiply the 5.0 MHz crystal oscillator signal by up to 16x for a system clock frequency of 80 MHz.

### (4) Prototyping Areas

The Badge features two mini prototyping areas for users to add their own circuits! The labels on the bottom of the Badge include short pin names to help identify each IO pin. The holes are spaced at 0.1" pitch, suitable for standard 0.1" headers (#451-04001) or sockets for easy experimentation. Or, you may solder components or cables directly to the board.

#### Prototyping Areas - Back



The white bars between the through-holes indicate that those holes are electrically joined. Each row has ground (GND), supply voltage (3.3V or USB 5V), pair of holes connected to the I/O pin labeled at the end of the row, and a pair of connected holes labeled "PROTO". The PROTO holes simplify the building of new circuits, as is demonstrated in the PROJECTS section below.



With the exception of P11, which does not have any other function on the Badge, the other IO pins are dual function. That is they are already connected to certain features on the Badge, as well as being available on the prototype area. These should therefore be used with care, and the user does have the option of cutting traces if certain Badge features are not required in-place of using a custom add-on!

For example: P9 is also connected to the audio left channel (AUDL) at the 3.5mm jack socket. You should refer to the schematic diagram for full details of each connection and any additional on-board components, such as pull-up, pull-down or series resistors.

The last row labeled "I2C" is also an exception. This provides access to an I2C bus, which is connected to the Propeller at P28 (I2C SCL) and P29 (I2C SDA). This last row has ground (GND), SCL, SDA, followed by 3 connected "PROTO" holes. The I2C bus is also connected to the Badge EEPROM and ACCELEROMETER, and can support additional user devices. Both the I2C SCL and SDA connections are pulled up to 3.3 V using 2.2 k $\Omega$  resistors included on the Badge.

### (5) On/Off Button

Press the pushbutton on the right side of the Badge once to switch on, press again to switch off. When you use this button to power off and on the Badge, the Propeller will reset then reload and restart its program from EEPROM. During power-off state, the battery can still be charged if a USB cable is connected. This will be indicated by the blue charge-status (CHG) led.



**TIP!** To help with debugging, the screen state will persist when the Badge is turned off with a USB cable connected.

### (6) Battery Charger Circuit

The Badge has a built-in battery charge management circuit which is specially designed for Li-ion batteries. When a suitable power source is connected to the USB port, charging will start and stop automatically as required. The Badge will charge automatically whether it is switched on or off. The maximum charge rate is 90 mA (8 hours) while connected to a computer USB port, or up to 540 mA (2.5 hours) while connected to a dedicated USB power supply. While charging, the blue charge-status led (CHG) will turn on. See sections (14) Battery on page 9, and (15) Battery Type Select on page 10 for important information.



**CAUTION!** THE BATTERY CHARGER CIRCUIT MAY GET HOT WHILE RECHARGING YOUR BATTERY!

### (7) Infrared Communications

The infrared transmitter is directly driven by Propeller I/O pin P24. It should be modulated at 36 kHz to work with the Infrared Receiver. It can also work with modulation schemes for other receivers. Use it to transmit to other Badges or to various infrared receivers such as TVs, cameras, LCD shutter glasses, and printers.

The infrared receiver, connected to Propeller I/O pin P23, includes a built-in 33 k $\Omega$  pull-up resistor and drives the I/O pin low when it receives a signal. It can receive signals from devices that transmit an infrared signal modulated at 36 kHz, including signals from the Infrared Transmitter on the same Badge, on another Badge, or from many TV and camera remotes.

## **(8) USB Port**

The USB Micro B connector serves several functions:

- Load programs from the computer into the Propeller microcontroller
- Run-time serial-over-USB communication with a terminal,
- Supply 5 V power input from a computer or portable USB boost charger (You may power the badge via USB with or without a battery installed.)

The USB Port is input current-limited to between 450 mA and 500 mA. This prevents any unexpected responses from USB 2.0 ports to current draws from motors, wiring mistakes, etc. For charging, the USB Port is current limited to 100 mA when connected to a computer, or 540 mA when connected directly to a USB charger.

## **(9) Accelerometer**

The 3-axis accelerometer ([Freescale](#) MMA7660FC) senses motion up to  $\pm 1.5$  g. It is connected to the common I2C bus on P28 & P29. An interrupt signal on P4 can be user-programmed to change state in certain conditions, such as tap and shake detection, or for a change in orientation. To configure the interrupt output, refer to the MMA7660FC datasheet settings IPP (open-drain / push-pull) and IAH (active high / active low). Data rate is configurable from 1 to 120 samples per second.

## **(10) Resistive OSHW logo Touch-button**

The Open Source Hardware Logo is a fancy version of the other resistive touch-buttons, described below in more detail. This one is connected to P5 through a 100 k $\Omega$  ESD protection resistor. For future customization, the 100 k $\Omega$  resistor has unused plated through-holes on either side of it. They are marked P5A and P5B on the back of the Badge, and marked with an S (for source) on the front of the Badge at the side which is connected to the Open Source logo.

## **(11) Resistive Touch-buttons**

P15 through P17 and P25 through P27 are connected to resistive touch-buttons. Each button is a signal pad with ground pads on either side, and connected through a 100 k $\Omega$  ESD protection resistor to the I/O pin. When the buttons are not in use, they will not load the I/O pins. When touched, they will add negligible resistive loading.

To read the state of a button, set its I/O pin to a high output, immediately switch it to an input, and then measure the amount of time before the I/O pin falls low. If nothing is touching the pad, the parasitic capacitance of the I/O pin and the PCB will hold the input high for several milliseconds. Alternately, instead of measuring the fall time, measure the input state 1 millisecond after the pin was switched to an input.

## **(12) RGB LED modules**

The Badge has two RGB LED modules (D801, D802) located either side of the OLED display, and connected to the Propeller I/O pins P1 through P3. Each of these RGB LEDs contains three individual LEDs (Red, Green, Blue), and by illuminating these in certain combinations it is possible to make many colors appear.



Two RGB LED modules made of three LEDs each gives us a total of 6 LEDs — A perfect number for Charlieplexing just like the 6 blue LEDs. Here is the lookup table which shows the required state of the Propeller I/O pins to illuminate each RGB LED:

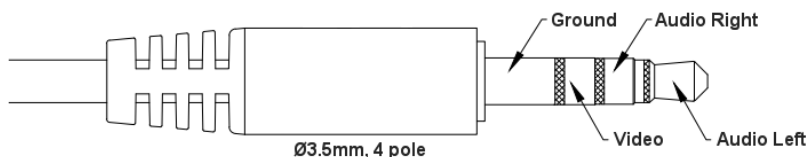
	P1	P2	P3
LEFT RGB LED D801 (red)	INPUT	LOW	HIGH
LEFT RGB LED D801 (green)	HIGH	LOW	INPUT
LEFT RGB LED D801 (blue)	HIGH	INPUT	LOW
RIGHT RGB LED D802 (red)	INPUT	HIGH	LOW
RIGHT RGB LED D802 (green)	LOW	HIGH	INPUT
RIGHT RGB LED D802 (blue)	LOW	INPUT	HIGH

### (13) Video and Stereo Output Jack

This convenient port provides stereo audio output for speech synthesis, music, and other audio applications. I/O pins P9 (left channel) and P10 (right channel) are hardwired to the output jack as well as the mini prototyping area, and can drive headphones, ear-buds, speakers with built-in amplifiers, or line-level inputs. Propeller microcontroller applications that display data and graphics on devices with composite video inputs are also possible, such as projectors and televisions. The signals are all line-level signals with a 75  $\Omega$  impedance.

The jack socket is compatible with both TRS (audio only) and TRRS (audio and video) cables with the following pin-outs:


- TRS (audio): Tip = left-channel audio, Ring = right-channel audio, Sleeve = ground return path.
- TRRS (audio and video): Tip = left-channel audio, Outer ring = right-channel audio, Inner ring = video, Sleeve = ground return path.



Warning! Not every AV cable is the same! Check carefully that you use a cable matching this diagram! One option available is the Parts Express B0007V6JCK, available from Amazon.

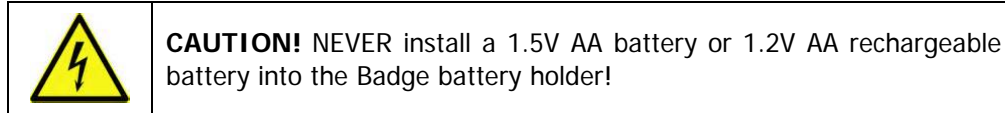
### (14) Battery

The Badge comes with a rechargeable 3.7 V 800 mAH Li-ion battery. This battery includes a special protection circuit to help prevent under-voltage, over-voltage and over-current conditions. Although this helps to prevent potential damage from shorting out of the battery, the user must also take common-sense precautions to prevent short circuits, shocks, or burns.

	<p><b>CAUTION!</b> Do not wear the Badge with conductive materials such as metallic cloth, metal jewelry or buttons, or additional lanyards, which may short out against the Badge PCB. Protect the Badge from your skin, moisture, fluids, lotions, and static discharge from the environment. Parallax Inc. is not responsible for damage to people or objects caused by electrically connecting with your badge.</p>
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### Rechargeable Battery Specifications

- Parallax part number: #752-00011
- Type: 14500 Rechargeable Lithium ion Battery AA 800 mAh 3.7 V
- Continuous discharge current: 250 mA
- Peak discharge current: 500 mA
- Discharge cut off voltage: 3.0V - 3.2V range

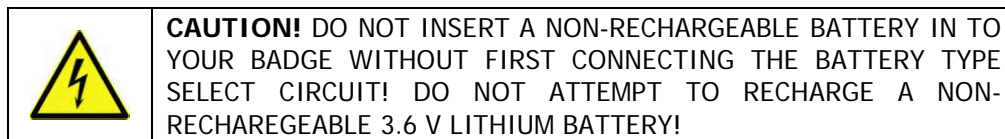


### (15) Battery Type Select

The Badge designed to operate from a single 14500 size Li-ion battery; a 3.7 V rechargeable Li-ion battery is included. To use the Badge with a non-rechargeable 3.6 V battery (NOT included), you MUST first disable the Badge's battery charger circuit. The Badge's battery charger circuitry can be disabled by joining together the two pins in the Battery Type Select box on the back of the board.



If you intend to swap between battery types often, you may solder a standard 0.1" pin header #451-04001 into the "Battery Type Select" holes, and use a 2-Pin Jumper #452-00009 to set the battery type.



### Mystery Pads!

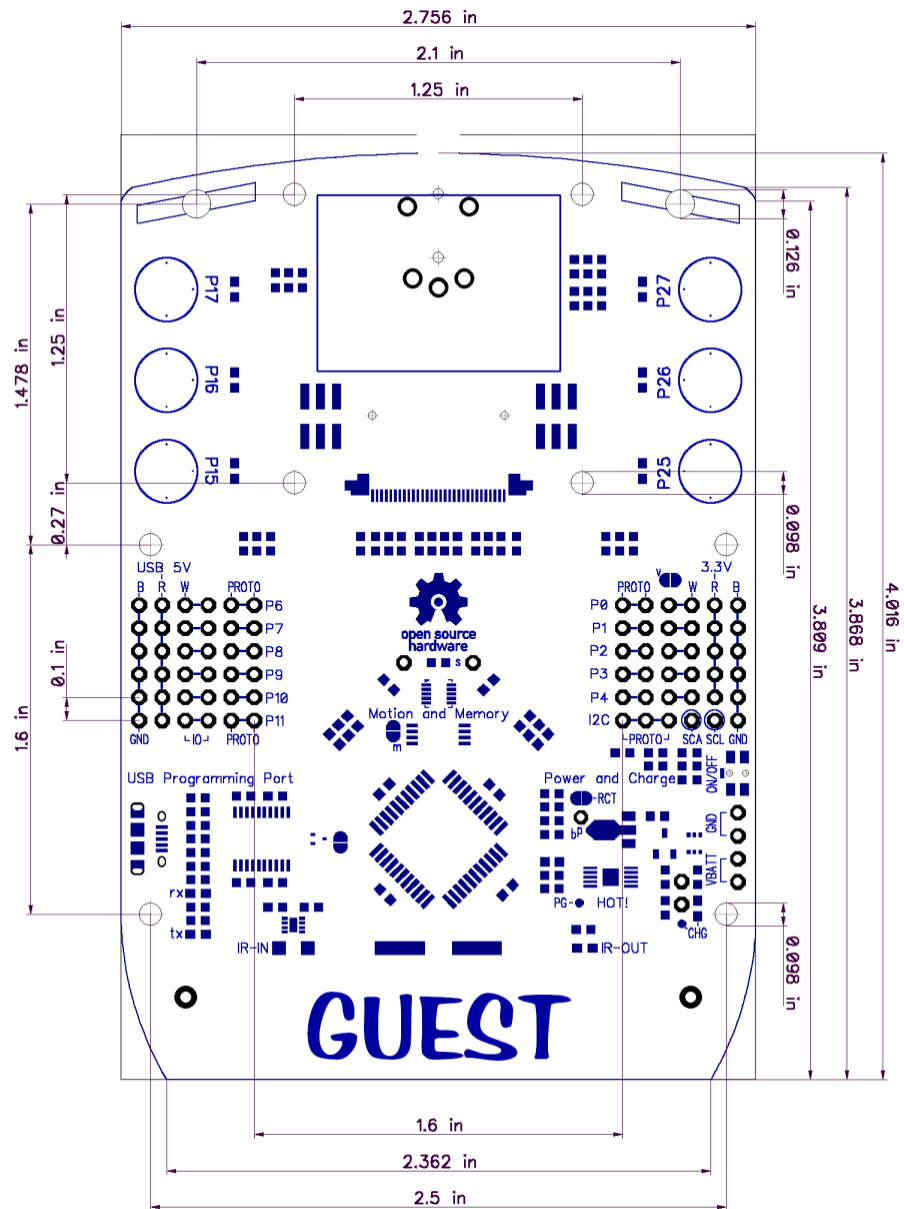
No open source Badge would be complete without some mystery pads! In no particular order:

- Egg-shape to left of Propeller — touch with a metal object to short the pads and reset the Propeller.
- Thru-hole marked "bP" below the "Power and Charge" label — Battery Potential (Voltage).
- Egg-shape marked "RCT" — RCTime input to Propeller from the battery. Cut the trace between the eggshells to measure a different voltage/
- Egg-shape marked "m" beside the motion sensor — connects to the motion INT; cut the trace if not required.
- Egg shape marked "v" above the prototype area — connects to the RCTime voltage level on the Propeller side. Cut this egg-trace to provide more PROTO pins!
- Through holes marked P5A, P5B and "s" — experiment with parallel resistor values at the open source Hardware logo. Do different values affect performance?
- PG pad below charger — Power Good status, Low (FET on) indicates the input voltage is above UVLO and the OUT (battery) voltage.
- CHG pad below charger — Charge Status, Low (FET on) indicates charging and Open Drain (FET off) indicates no Charging or Charge complete.

## Propeller I/O Pin Assignments

I/O Pin	Prototyping Area Label	Function
P0	RCTv	RC Time input to Propeller, to monitor battery voltage
P1	RGBa	Tri-color RGB LEDs - port A
P2	RGBb	Tri-color RGB LEDs - port B
P3	RGBc	Tri-color RGB LEDs - port C
P4	XYZi	Accelerometer interrupt
P5		OpenSource Hardware logo resistive touch-button
P6	LEDa	Touch pad LEDs - port A
P7	LEDb	Touch pad LEDs - port B
P8	LEDc	Touch pad LEDs - port C
P9	AUDL	Audio output left channel
P10	AUDR	Audio output right channel
P11	OPEN	Unused IO pin, for user expansion
P12 - P14		Composite Video output to 3.5mm AV jack
P15 - P17		Resistive touch-buttons on front-left side of Badge
P18		OLED display CS# (SPI active-low chip select)
P19		OLED display RES# (low to reset display)
P20		OLED display C/D# (Command / Data select)
P21		OLED display SCLK (SPI clock)
P22		OLED display SDIN (SPI data in)
P23		IR IN (Infrared receiver)
P24		IR OUT (Infrared transmitter)
P25 - P27		Resistive touch-buttons on front-right side of Badge
P28	I2C SCL	EEPROM / Accelerometer / I2C clock
P29	I2C SDA	EEPROM / Accelerometer / I2C data
P30		TX (USB programming / terminal)
P31		RX (USB programming / terminal)

## Dimensions



## Revision History

Version 1.0: Original release

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