How To: Setup and Use the Custom 3D LED-Cube Hardware

The LED Cube provided by the group Cub3D is a custom hardware project built from 10 meters of *WS2812b* LED strips at 30 LEDs per meter. The cube contains 294 LEDs, in a 7x7x6 configuration. Each of the six 7x7 'layers' of LEDs is connected independently to ground and power, however the data pins of each layer are chained together into one long (294 LED) controllable strip for ease of control off a single pin on the beaglebone. Each LED at max brightness will pull up to 60mA from a power supply, so all LEDs at once could pull max 17.64A - as a result we recommend finding a 20A power supply to leave some headroom. Additional circuit hardware will be required to step the 3.3v from the beaglebone to the required 5v for data input of the strips.

Note that this how-to guide covers strictly the hardware setup, and not the software control. For software control, we recommend using a PWM library, rolling your own implementation using the beaglebone's PRU, or using a WS2812b LED control library like LEDScape:
https://github.com/Yona-Appletree/LEDscape

Here's a video demo of the hardware in use, rendering a static teapot:
https://drive.google.com/open?id=1PcOXzEX4U4s69fLmechgCVudSOeDBFoy

Expected hardware

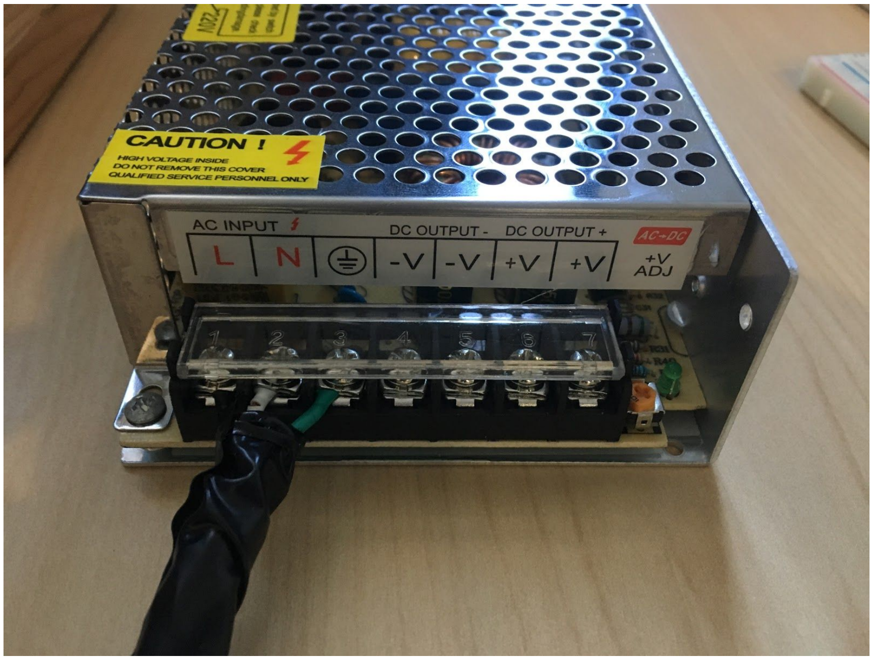
- The LED cube itself
- 5V, >20A power supply
- A 3.3v -> 5v level stepper, OR
- Two 10k resistors, an N-channel MOSFET, some wire, and a small breadboard
- A Beaglebone with desired LED control software installed and runnable.

Setting up the hardware

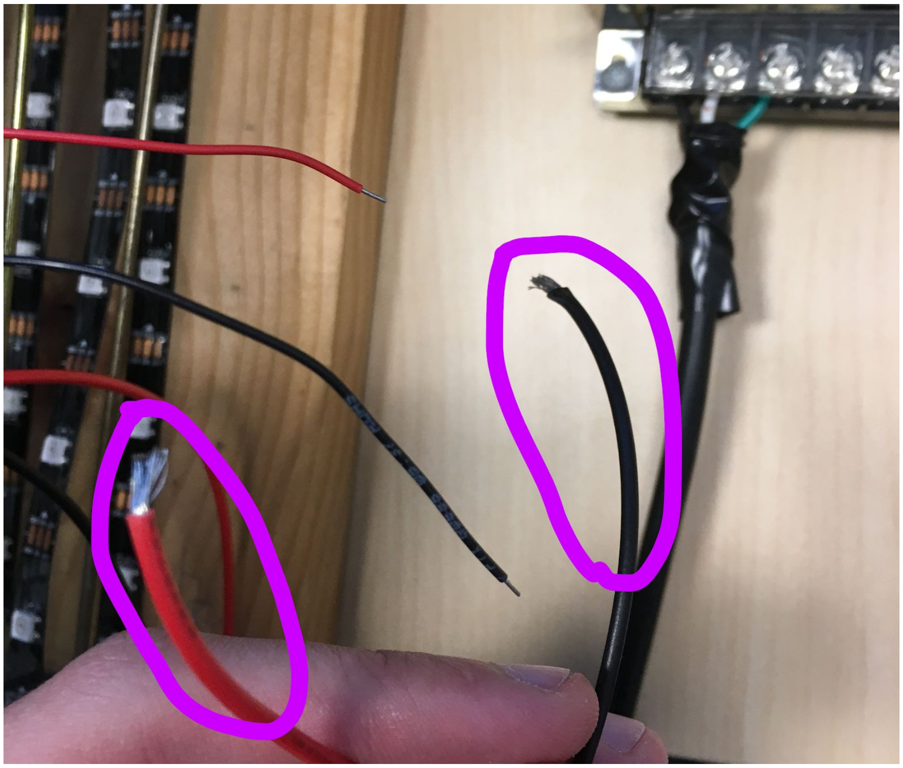
The hardware setup for the LED Cube is meant to be as simple as possible; as such, there are only three wires coming from the cube. The following instructions assume you have setup a level stepper, either purchased one (YMMV) or created as described in the **Level Stepper Circuit Wiring** section.

Follow the below steps to complete the wiring setup:

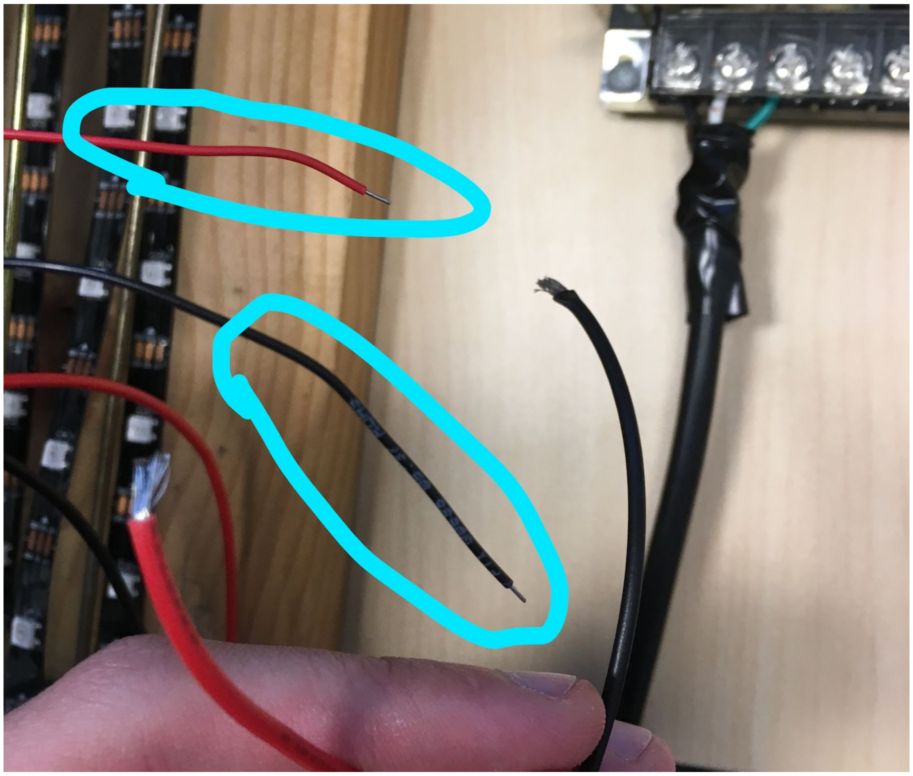
1. Grab the power supply and place it near the LED Cube's input wires. It should have a wiring setup that looks like the following:



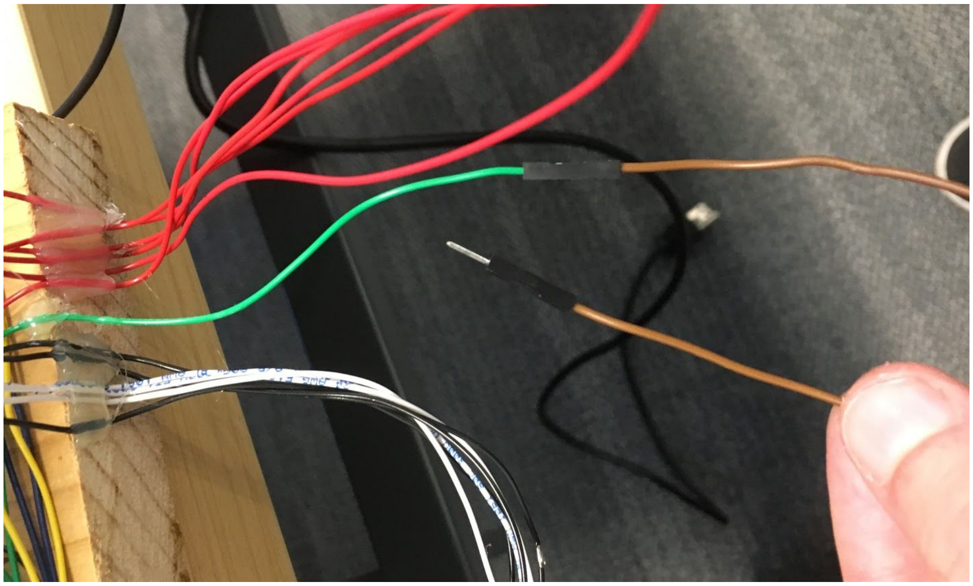
2. The LED Cube should have one large red and one large black wire extending from a bundle of wires. These are the higher-gauge wires that supply the full 5v/20A power to the LED Cube. Connect/screw these wires to the power supply's -V and +V terminals; say, the large black wire should be connected to terminal 5 and the large red wire should be connected to terminal 7.



3. Now, connect the small red and small black wires from the LED Cube to the **+** and **-** rails on the breadboard. These are connected to the power supply's 5v/GND wires, and thus will ensure a common ground and 5v supply is passed to the level stepper.

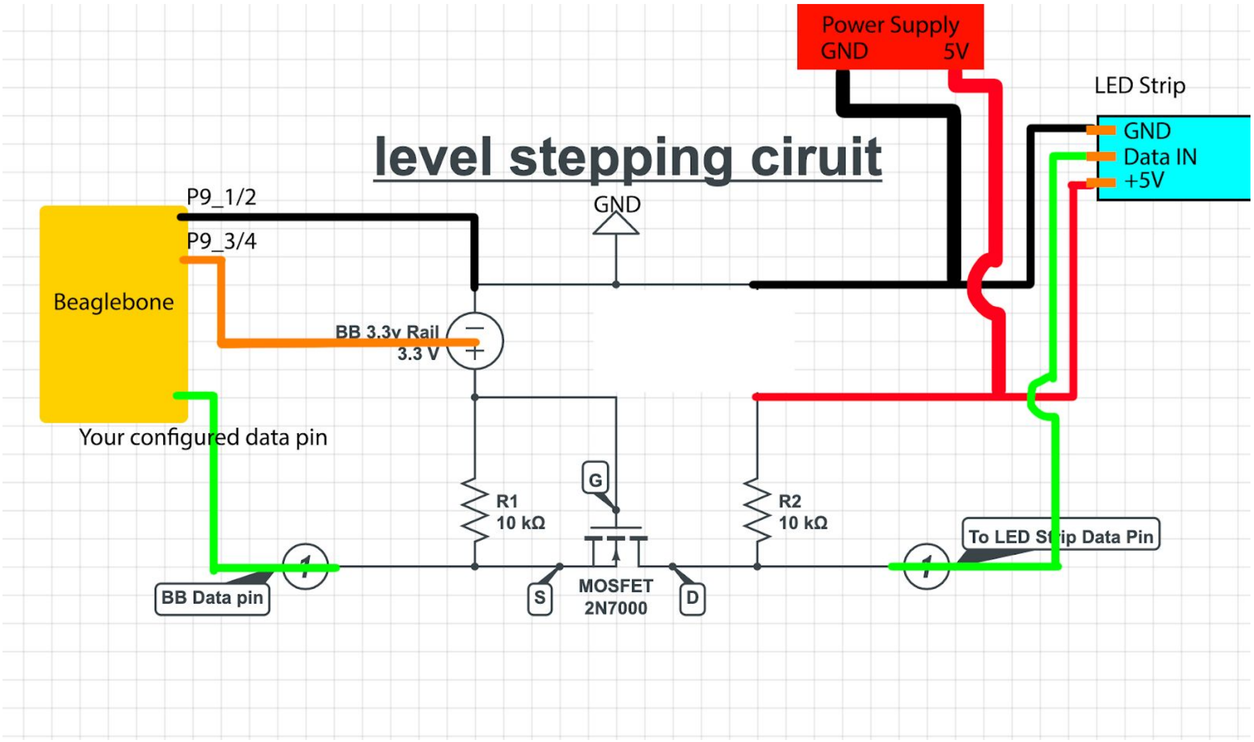


4. The cube and power supply should now be connected to each other and to the breadboard through those two sets of 5v/GND wires. There is one more connection - the LED Strip **Data** wire. All 294 LEDs are controlled through this single wire -- connect it to the output (high side) of the level stepper.



5. Finally, we need to connect the beaglebone's pins to our setup. First, connect a GND pin on the beaglebone to the **GND** (-) rail on the breadboard. On the beaglebone green, these are P9_1 and P9_2.
6. Connect the 3.3v rail on the BB to the 3.3v side of the level stepper. On the beaglebone green, this rail is on P9_3 and P9_4.
7. Connect the data pin you're using to the input (low side) of the level stepper. In our case, this was P8_8.
8. Run your software controlling software - the LEDs should light up! To test, we recommend setting up LEDscape (mentioned above) and running their precompiled *./run-ledscape* test program.

Your final setup should look something like this diagram:



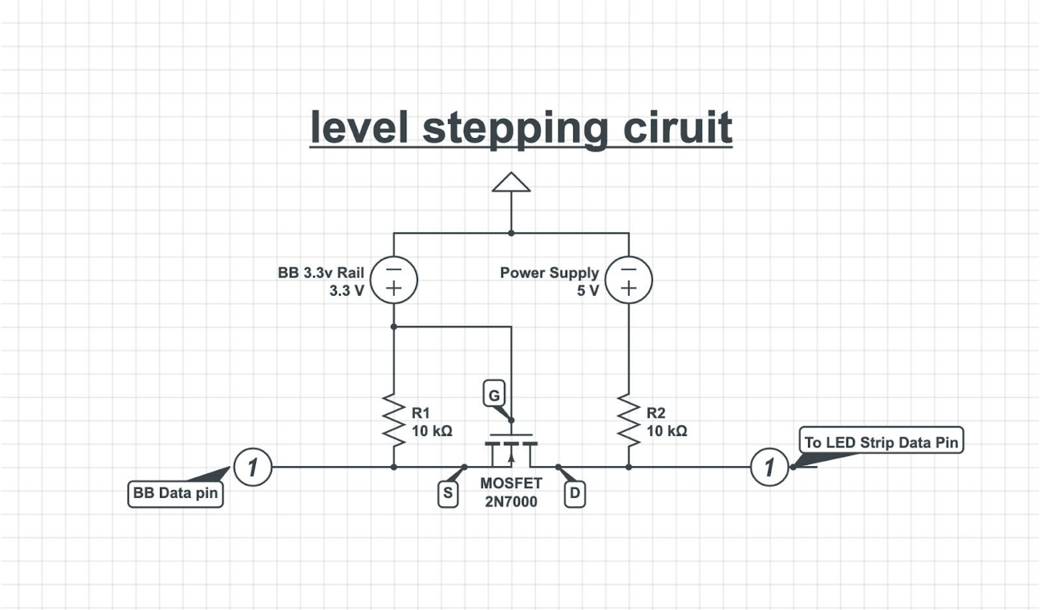
Troubleshooting

- **My driving software is running, but the LEDs won't turn on!**
    - You may have not connected the power supply to the board and cube correctly.
        - Ensure that the 5v output of the supply is connected to **both** the 5V input on the LED cube and the 5v input of the level stepper. These should already be pre-soldered together unless changes have been made.
        - Ensure the GND output of the supply is connected to **both** the GND input of the strip and the GND of the beaglebone - if you do not connect these together the reference voltages will likely mismatch!

        - Ensure the data input pin of the Cube is connected to the high side of the level stepper.
    - You may have not connected the beaglebone to the breadboard correctly.
        - Ensure that the GND connection of the beaglebone is connected to the GND connection of the LED Cube and the power supply.
        - Ensure the 3.3v rail of the beaglebone is connected to the 3.3v input of the level stepper.
        - Ensure the datapin you're intending to use is connected to the level stepper's low side. Note that if using LEDscape, output pins of the test program should be at least all pins between P8_7 and P8_12 (consult the tool's README).
        - If using LEDscape as a library where you control it yourself, be aware the pins on the beaglebone don't match with the pin ids in the program. For example, the 'strip' (pin) at index 26 corresponds to P8_8 in our tests.
    - When in doubt, the LEDscape library we used is confirmed working with the test program. Please try setting up and using that to conclude if its a software or hardware issue.
- **Updating the LEDs is too slow!**
    - The raw delays of updating 294 LEDs in a series as a single strip is not that long; you should be able to achieve 100-120fps. It's likely that most of your time spent is in whatever is generating the LED colors, or you have a bug somewhere.
    - In our case, we opted to use double buffering (per suggestions in LEDscape) where you generate the next frame while waiting for the LEDs to update the previous frame. This means you're spending compute time during the time when you'd otherwise have to wait for LEDs to update!
- **The LEDs on the cube are flickering!**
    - Due to the digital nature of the PWM signals sent by the BB to the strips, any flickering is likely due to noise in the 5v/ground inputs on the cube, as these are used as references for the data signal.
    - We experienced a very significant amount of flickering early in our project, but found a solution - by soldering the 5v and ground wires together rather than independently connecting each layer to the breadboard, it created a more reliable connection - the flickering went away after doing so.
    - If you still experience flickering, ensure the data pin has a good connection to the breadboard.

Level Stepper Circuit

The circuit comes from this site: http://www.hobbytronics.co.uk/mosfet-voltage-level-converter
We recommend using a similarly spec'd N-Channel MOSFET to the 2N7000, we used a BS170. It will convert the voltage signals at 3.3v from the BB's data pin to the 5v required for the LED strip's data pin.



If you've implemented this circuit correctly, it should look something like this on a breadboard: