DLP SLA 3D Printer

Control System & Electronics

The printer control system consists of an Arduino Uno, an A4988 driver board, and the LC4500-UV. The user controls the printer from a PC using the LC4500_GUI-PEM and the Arduino's serial monitor. The A4988 drives the stepper motor which moves the vat/projector assembly along the Z-axis. After the projector has been configured with the correct pattern sequence using the GUI, the serial monitor is used to configure the printer hardware and to start printing.

The Arduino Uno

The Arduino Uno provides the highest-level control of the printer by running software which drives both the A4988 and the LC4500-UV by sending synchronized signals to both devices based on user input. The Arduino can be fully powered and run with a single USB cable connected to the PC. Along the top of the board are a number of headers which the software configures for digital logic output. These headers can be easily wired to the header pins on the A4988 driver, and to connector J7 on the LC4500-UV. The Arduino also outputs 5V power, which is used to power the A4988 driver.

Once the software has been uploaded onto the Arduino, it begins to run when the board is powered. To interact with the board, connect it to a PC over USB and run Arduino.exe (Arduino must be installed on the PC). Using the tools menu, ensure the port is connected to the Arduino, then open the serial monitor (Ctrl+Shift+M). This window displays all serial output from the program and provides a channel for user input.

Arduino Software Guide

The Arduino software provides a simple interface which is used to setup and start the printer. At startup, the program displays its internal settings for reference. The optimal values for these settings have been determined through prototype testing and are hard-coded into the software. These values may only be changed by editing the source code, which is not recommended. These parameters are as follows:

- Layer thickness = 0.40 mm
- Exposed curing time = 3.00 seconds
- Peeling distance = 0.60 mm
- Peeling/prep time = 40.00 seconds

As one of the goals for this prototype is to increase the speed of 3D prints, great care has been taken to reduce the time required to cure and to peel each layer. The resin requires 3 seconds of UV exposure to cure fully. The limiting factor for peeling is the specifications of the lead screw and the capabilities of the hardware. This prototype uses a lead screw which must turn 25 full steps to achieve a vertical rise or fall of 1 mm. The hardware can only process one full step per second. Using a peeling distance of 0.6 mm, the vat/projector setup must first lower 0.6 mm to peel, then raise 0.2 mm to be in place for the next layer. The net displacement is 0.4mm, equal to the height of one layer. The total distance traveled is

0.8mm at 25 steps/mm and 1 second/step, so the total peeling/prep time = 20 seconds. The total time required to print = the number of layers * 23 seconds.

After displaying the internal settings, the software prompts the user for the number of layers to be printed. This is the only value that the user may change, and it must be set correctly for each print. This value should be set to the number of PNG files created by the slicer software. Once this value has been set, the user has the option to change it or to start printing.

As the printer prints, the Arduino software displays information about the status of the layer currently being printed, including an estimate of the time remaining. A print job may be paused or aborted between layers; however, note that this may have disastrous cosmetic or structural consequences. Once printing concludes, another print may be started at any time. If printing a new design, be sure to set the number of layers and use the correct pattern sequence.

The A4988 Driver

The A4988 driver board controls the stepper motor and has 16 total pins, comprising 8 logical inputs, 2 sets of power inputs, and 4 outputs which drive a single motor, as follows:

- Direction – controls the direction of movement of the motor.
- Step – causes motor to move one step.
- Sleep – puts board to sleep, minimizing power usage. Held high by a pullup resistor.
- Reset – resets motor and step size. Needs to be set high when running the motor.
- MS3, MS2, MS1 – these pins work in conjunction to set the step size.
- Enable – enables the motor to run. Held low by a pulldown resistor.
- VDD/GND – 5V power for board logic.
- VMOT/GND – motor power (up to 35V).
- 1A, 1B, 2A, 2B – these pins drive the motor.

Each of the logical inputs and the 5V power supply are connected to Arduino outputs. Pins 1A, 1B, 2A, and 2B must be wired to a connector (Digi-key 455-1162 ND) which attaches to the step motor. VMOT must be powered by an external power supply which must not exceed 35V and 2A. The A4988 must have a heat sink attached to prevent overheating.

The LC4500-UV

The LC4500-UV displays UV patterns in sync with motor movement, with each pattern corresponding to a single build layer of the print. These patterns should be sent to the projector as a single pattern sequence, with solid black patterns inserted between each cure pattern, including the first and last patterns in the sequence. The black patterns will be displayed during the peeling and vertical movement stages of printing. The Arduino sends a trigger signal to pin 4 of connector J7 on the LC4500-UV. The projector advances to the next pattern in the sequence on rising edges of the trigger signal. Thus, the pattern sequence must be setup for external (+) trigger mode and must already be running before the print job is started.

Running the Printer

To print an object, follow these steps:

- Ensure that all components are connected properly as shown in the schematic.
- Power on the LC4500-UV and connect to the PC via USB or Ethernet, using the LC4500_GUI-PEM. For more information, refer to the LC4500 User's Guides.
- Power on the Arduino Uno by connecting it to the PC via USB. Open the serial monitor.
- Verify that the external power supply is set to the proper levels, then power it on.
- Create a pattern sequence (or use a saved solution) and send it to the LC4500-UV using the GUI, abiding by the parameters outlined above. Start the pattern sequence.
- Use the serial monitor to configure the print settings and start the print job, as described above.
- Do not disturb any of the electronic or structural components while printing is in progress.