ECET 270

Mini Team Project

Hardware Design Notes

The design of the mini team project for ECET 270 is a common anode RGB LED strip driver board. The design features open source hardware and software, allowing the user to configure whatever they want with hardware provided on the board. The board also features:

* The popular Atmel ATmega328p series microcontroller with 11 GPIO (as well as other pin specific function pins) broken out for use with external circuitry
* A standard ISP header
* External 16 MHz crystal oscillator
* Power supply regulation and filtering, three pushbuttons with hardware
* Standard DC power jack
* Audio-reactive LED driving
* 3 active low pushbuttons with hardware debouncing
* Reset pushbutton
* 3 high power N-Channel MOSFETs
* +12V, +5V, and +2.5V supplies

The operation of the board can be broken up into six distinct sections; the power section, the microcontroller, the audio signal processing, the power driver, the breakout, and the user inputs.

The power section is comprised of the DC power input jack as well as the 7805 regulator and associated supply filtering capacitors. The capacitors decouple AC signals from the supply line to create a clean +12Vdc and +5Vdc supply output. Additionally, the 7805 helps protect the sensitive digital electronics from overheating, overcurrent, and reverse voltage.

The microcontroller section is comprised of the ATmega328p microcontroller, its bypass capacitors, active low reset switch, ISP header, and external 16 MHz crystal oscillator. While the bypass capacitors and ISP header are all fairly standard, an external reset switch and oscillator were both chosen to allow the user of the device more flexibility in what they wanted to do with the design. The crystal oscillator provides highly accurate timing, allowing the device to communicate over fairly quick serial interfaces without an issue. Additionally, in the board layout, care was taken to ensure bypass capacitors were in close proximity to the supply pins, and that the traces from the oscillator were routed to the same length to reduce errors due to propagation delay.

The audio signaling section consists mainly of the MSGEQ-7 series bandpass filter with combined analog and digital serial output. This chip is driven by an external RC oscillator connected to pin 8 allowing it to effectively communicate with a microcontroller. The chip will sample audio, amplify it, filter it, and assign it a spot in a serial buffer. A strobe from a microcontroller will then tell this chip to output its values in the buffer (typically line level). The controller can use an onboard ADC to convert these analog voltages into usable digital values. The MSGEQ-7 also produces a 2.5 Vdc signal ground for use when interfacing it with AC audio signals. This allows the whole device to operate on single supply and simplify the design..

The power driver section consists of three IRF510 N-Channel MOSFETs connected to the microcontroller and an external breakout for LED strip connection. These MOSFETs were chosen due to their line-level turn on gate to source voltage (<5V), as well as their ability to switch more amps than a typical 5m 60LED strip demands. This allows the user to use this device with more than just one LED strip – providing that the user’s power supply can handle the amount of current their LEDs draw. High value pullup resistors are used at the gate of each MOSFET to prevent accidental turn on during a high-z state of a microcontroller pin.

The breakout section consists of all unused pins from the microcontroller as well as a regulated +5V supply. This section is designed to allow the user maximum flexibility to configure their driver board the way they want it. Not only are there 11 GPIO pins, but the functionality of a UART, 5 ADCs, a TWI/I2C bus, and a SPI bus is all included.

The push button section allows the user to configure three push buttons to interface with the microcontroller and add further functionality to the project. These pushbuttons all feature hardware debouncing, as well as pullup resistors.

Finally, the design as a whole was designed with manufacturability and prototyping in mind. The design has been done in the popular EDA software EagleCAD and gerber files can be generated allowing PCB fabrication. Additionally, most all passive components are 0805 size, and are generally the same thing (10k resistors and 100nF capacitors). This helps bring down the cost as it is cheaper to get 3 10k resistors (in bulk) than it is to get 1 10k and 1 22k resistor. The 0805 size means all passive components are fairly easy to solder by hand, without taking up too much valuable board space. The board features four mounting holes allowing the design to be encased, or put onto a substrate. All headers are designed to 0.1” pitch, a standard size that accommodates most breadboards and prototyping perfboards. Finally, the high current PCB traces have been widened to accommodate more current without overheating, the pads of the high power devices have been expanded and have more thermal mass (copper on both sides of the board with extra vias) to allow greater thermal transfer to the ambient air.

Before full-scale production testing must be done on a small batch of boards (prototypes) to determine maximum voltage and current characteristics, as well as determine and fix the problems that arise from use in the real world. A variety of test cases will be formed to meet EMC as well as other standards, and the power supply would be sold separately/built by another company to avoid the costs of UL certification.