Mini Power Supply project

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## Motivation

Wanted to build a power supply with

* dual unregulated,
* dual adjustable regulated
* fixed 5V for TTL and
* a 100 Hz clock (mains derived)

The main side can be replaced with a battery pack resulting in a kid safe device. The device includes an Arduino component to provide measure and display volts, amps and clock outputs in as close as possible to real time.

## Arduino Capabilities

The Arduino voltage range of zero to 3,3V for a 1024 (10 bit) with a resolution of 3.22e-3 V per ADC step. This is suitable for an ADC for both volts (resistive divider) and current (linear hall effect devices).

For the negative rails, an inverting unity gain op amp is used, both for the fact that Arduino won’t deal with a negative voltage and that the multiplexer used won’t take a bigger voltage than the Vcc/Vss Gnd/Vdd without damaging the component.

The module also has voltage regulators that can be used to power up the sensor chips.

## Clock Biasing

Using Ohms law, a current that generates approx. 0.7 volt when 6 volts is applied. Start with an assumed current of 1mA (1E-3A) the Rb is approximately 700 Ohms, from an E96 series closest is 698 Ohm

The larger value is derived from summing current per Kirchhoff’s law and from the transistor curve a saturation is attained at 50uA (5e-5A) then we have

## Sensing Current

The use of a milliohm range shunt was considered, which brings voltage drops after regulator chips. To reduce or eliminate the drop, it was decided to find Hall effect sensors for this circuit. An effective shunt on each rail this power supply has would lead to a resistance of:

That small voltage requires additional components to amplify the signal into a suitable range for the ADC with a complexity of using a differential amplifier configuration. Amplification of the signal to get a reasonable 0 to 100% of the ADC would require a gain of 300, along with any and all noise on the rails, increasing measurement uncertainties.

The Allegro ACS70331EOLCTR-2P5U3 has a 3V3 supply and a range of +/- 2.5A for an almost full swing from the middle of the rail voltage to indicate plus or minus flow. Given this is a 200mA transformer, the swing is under 10% of the range, and requires amplification around the mid voltage

A single Amplifier using mid-rail voltage is expected to provide a gain of approx. 10 times to give a reasonable value to the Arduino ADC. Only one is required after the MUX reducing chip count and complexity of the board.

### Current Scaling

With 5 current sources, the chip count will put space and costs into the design. Mitigation is derived from multiplexing the analog signals into a signal processing chain, based on this analysis:

1. Voltage is centered on Vcc/2 (1.65Volts)
2. Current sensitivity is 2.5A but we can only get 200mA out of the transformer, < 10% of scale
3. Allegro spec the device @400mV/A, 80mV based on 200mA.

This can be scaled up by a factor of 10 by:

* Buffer the 1.65 source with an op amp.
* Diff amp to subtract the offset with a gain of 15-20.
* Unity gain inverting summing of diff output and 1.65V source
* Use the remaining Op Amp to buffer the voltage dividers after the MUX

### Block Diagram

I Sense Mux

1.65V Ref

Diff Amp

1.65V Buffer

Sum Amp

ADC

### Notes

Its not ideal to be sensing under 10% of scale, and the case for a milliohm shunt has already been thought through.

## Voltage Sensing

Sensing the voltage as close as possible to the output pins delivers optimal measurement without resorting to external wires. The resistors to provide an approximate 1/3 output at minimal current and reasonable cost are 20K and 10K 0.1% stand-alone resistors (SMD). The total uncertainty of this combination is:

= 0.14%

To negate the issue from the negative rails, an inverting unity gain amplifier is used with only two for the entire supply.

## Noise Reduction

To reduce noise from the Arduino, mains and attached circuitry, 0.1uF suppression caps are distributed into each chip’s inputs, outputs and power rails. Board design runs tracks on top and bottom at right angles to reduce capacitive and inductive coupling, plus there is a large ground plane on each layer.

## Schematic

The schematic breaks the circuit into modules and re-usable hierarchical sheets. Modules are:

* Unregulated Power
* Dual Adjustable Regulator
* 5V and Clock
* Sensor and Mux

Within Sensor and Mux the re-usable items are:

* Current Sensor
* Voltage Divider and output
* Unity Inverting Gain Amplifier

Wiring between sensor and Mux was chosen for the least chaotic routing of the tracks.

The nano, OLED and controls produce the most noise in the projects schema.