Arduino Electronic Load Version 6

**Introduction**

This project is a simple electronic load using the Arduino

**Conventions**

**Red Text**: A To-Be-Determined requirement. Color set by the Comments element type

[ ... ]: Future Feature. Color set by the Identifier element type

CAPITAL TEXT: Text to be replaced with product specific names

**Product Characteristics**

* Must Interface with serial monitor of Arduino
* Must incorporate a heat sink and a fan
* Must be portable
* Weight: 3 pounds
* Height (X): 4 in.
* Length (Y): 6 in.
* Width (Z): 6 in.
* Target Cost: Cheap. Equal to or less than $50.00
* Product Life Time Target: 5 years
* Operating Temperature: commercial temperature range

Arduino Electronic Load

**Feature List**

Arduino

Characteristics

* User interface with serial monitor
* User can set commands using serial monitor
* Command for measuring source voltage at any time
* Command for measuring temperature at any time
* Command for showing the display rate
* Command for changing the display rate
* Command for showing the log rate
* Command for changing the log rate
* Command for measuring current in a time interval
* Commands for starting and exiting (Turn on and off)
* Controls operation of fan
* Compares signal from temperature sensor to temperature limit set in program
* Turns on/off signal to fan depending on temperature of heat sink and temperature limit
* Sends signal to DAC to set current
* Receives signals for current, voltage, and temperature measurements
* Switches Overload Protection stage on or off
* Turns on/off signal to red LED depending on error condition

DUT (Device Under Test)

Characteristics

* Source
* Current can be drawn from the source
* Has a voltage across it that can be measured and provided to the user
* Output voltage: Up to 25V
* Output voltage: Up to 2A

Overload Protection

Characteristics

* Protects load from over current, over voltage, and overheating
* Cuts current from source for over current, over voltage, and overheating
* User is notified through serial monitor when heatsink is above temperature threshold
* User is notified through serial monitor when there is an over current or over voltage

Current Sink Driver

Characteristics

* Controls how much current passes through the Current Sink stage using a DAC connected to the Arduino

Current Sink

Characteristics

* Sinks current from the Device Under Test (source)
* Range: 0 – 2A
* Adjusts how much current passes through

Current Sensor

Characteristics

* Senses current from Current Sink stage; 30 mV/bit
* Max Current: 2A
* Accuracy: 5%

Temperature Sensor

Characteristics

* Senses temperature from heat sink
* Commercial temperature range
* Accuracy: 5%

Heat Sink

Characteristics

* Sinks the heat from the Current Sink stage
* Temperature rating of up to 100 degrees Celsius

Fan Driver

Characteristics

* Provides necessary power to drive the Fan

Fan

Characteristics

* Cools down heat sink and circuit board

LED

Characteristics

* Red LED
* Used to display overloading and error condition

Computer

Characteristics

* Uses Arduino serial monitor for display
* Displays current to be drawn from source, set by user
* Displays load current, source voltage, and temperature
* Logs load current and source voltage versus time

**Behavior Definition**

Product States

PROGRAM STARTUP

STANDBY

MEASUREMENT SETUP

DATA LOG

VOLTAGE OVERLOAD

CURRENT ERROR

* CURRENT OVERLOAD
* CURRENT MISMATCH

COOL DOWN

Detailed Behavior

PROGRAM STARTUP

1. Display welcome screen on serial monitor
2. Display instructions to user on how to use program on serial monitor

Initial State: STANDBY

EVENT: Entry

1. Send state message to serial monitor
2. Stop measurement
3. Set all values to zero
   1. Load is off

EVENT: Current value in mA or A is sent

1. Update setpoint current value
2. Display setpoint current value on serial monitor

EVENT: If voltage read is greater than 25V

1. Change state to VOLTAGE OVERLOAD

EVENT: Start command

1. Change state to MEASUREMENT SETUP

Initial State: MEASUREMENT SETUP

Update DAC value

Set DAC

EVENT: Entry

1. Display the up-to-date setpoint current on serial monitor
   1. If setpoint current is less than 3mA
      1. Display message to user “Current is below minimum measured amount”
      2. Display minimum measured current value (3mA)
2. Send state message to serial monitor
3. Display the up-to-date display rate on serial monitor
4. Start sample timer 1

EVENT: Current value in mA or A is sent

1. Update setpoint current value
2. Display setpoint current value on serial monitor
   1. If setpoint current is less than 3mA
      1. Display message to user “Current is below minimum measured amount”
      2. Display minimum measured current value (3mA)

EVENT: If voltage read is greater than 25V

1. Change state to VOLTAGE OVERLOAD

EVENT: If sense current is greater than 2A

1. Change state to CURRENT ERROR
   1. Change error state to CURRENT OVERLOAD

EVENT: If setpoint current does not equal sense current

1. Change state to CURRENT ERROR
2. Change error state to CURRENT MISMATCH

EVENT: If temperature read is greater than 100 °C

1. Display message “ERROR!”
2. Display message “Temperature is out of range!”
3. Change state to COOL DOWN

EVENT: Log data command

1. Change state to DATA LOG

EVENT: End command

1. Display “Ending measurement” on serial monitor
2. Display “Returning to STANDBY state” on serial monitor
3. Change state to STANDBY

EVENT: Sample timer 1 ends

1. Read current from current sensor
2. Display sense current on serial monitor
   1. If sense current is less than 3mA
      1. Display “Current is below minimum measured amount”
3. Read voltage from source
4. Display voltage read on serial monitor
5. Display all values in human readable form: Current: <current>

Voltage: <voltage>

1. Reset sample timer 1

Initial State: DATA LOG

EVENT: Entry

1. Send state message to serial monitor
2. Display the up-to-date log rate on serial monitor
3. Start sample timer 2

EVENT: If voltage read is greater than 25V

1. Change state to VOLTAGE OVERLOAD

EVENT: If sense current is greater than 3A

1. Change state to CURRENT ERROR
   1. Change error state to CURRENT OVERLOAD

EVENT: If setpoint current does not equal sense current

1. Change state to CURRENT ERROR
2. Change error state to CURRENT MISMATCH

EVENT: If temperature read is greater than 65 °C

1. Display message “ERROR!”
2. Display message “Temperature is out of range!”
3. Change state to COOL DOWN

EVENT: End command

1. Stop sample timer 2
2. Reset sample timer 2
3. Display “Ending measurement” on serial monitor
4. Display “Returning to STANDBY state” on serial monitor
5. Change state to STANDBY

EVENT: Sample timer 2 ends

1. Read current from current sensor
2. Display sense current on serial monitor
   1. If sense current is less than 3mA
      1. Display “Current is below minimum measured amount”
3. Read voltage from source
4. Display voltage read on serial monitor
5. Display time elapsed on serial monitor
6. All values are displayed in csv format separated by commas: Time, current, voltage

<time>, <current>, <voltage>

Initial State: VOLTAGE OVERLOAD

EVENT: Entry

1. Send state message to serial monitor
2. Turn LED on
3. Turn Overload Protection on
4. Inform user that voltage is too high
5. Inform user to lower voltage to less than or equal to 25V
6. Display read voltage on serial monitor

EVENT: Sample timer 1 ends

1. Read voltage from source
2. Display voltage read on serial monitor
3. Reset sample timer 1

EVENT: If voltage read is less than or equal to 25V

1. Turn Overload Protection off
2. Turn LED off
3. Display message “The voltage is in suitable range”
4. Display message “Returning to STANDBY state”
5. Stop sample timer 1
6. Reset sample timer 1
7. Change state to STANDBY

Initial State: CURRENT ERROR

EVENT: entry

1. Turn LED on
2. If error state equals CURRENT OVERLOAD
   1. Send error state message to serial monitor
   2. Turn on Overload Protection
   3. Inform user that the sense current is too high
3. If error state equals CURRENT MISMATCH
   1. Send error state message to serial monitor
   2. Inform user that there is a difference between setpoint and sense currents
   3. If the up-to-date set point current is less than 3mA
      1. Change setpoint current to 3mA
      2. Update DAC value
      3. Set DAC

Initial State: CURRENT OVERLOAD

EVENT: entry

1. Inform user to lower the setpoint current and then test it
2. Display the up-to-date setpoint current

EVENT: Test current command

1. If setpoint current is less than 3mA
   1. Inform user to enter a setpoint current greater than or equal to 3mA
2. If setpoint current is less than or equal to 2A and greater than or equal to 3mA
   1. Turn Overload Protection off
   2. Update DAC value
   3. Set DAC
   4. Read current from current sensor
   5. Display sense current to user
3. If sense current is less than or equal to 2A
   1. Turn LED off
   2. Display “The sense current is in suitable range”
   3. Display “Returning to STANDBY state”
   4. Change state to STANDBY
4. If sense current is greater than 2A
   1. Turn Overload Protection on
   2. Inform user that the current is still too high
   3. Inform user to lower setpoint current and test it again

EVENT: Current value in mA or A is sent

1. Update setpoint current value
2. Display setpoint current value on serial monitor

EVENT: Sample timer 1 ends

1. Display setpoint current value on serial monitor
2. Reset sample timer 1

Initial State: CURRENT MISMATCH

Update DAC value

Set DAC

EVENT: Entry

1. Inform user to lower setpoint current
2. Display up-to-date setpoint current
3. Display up-to-date sense current

EVENT: If setpoint current equals sense current

1. Turn off LED
2. Inform user that setpoint and sense current values match
3. Display “Returning to STANDBY state”
4. Change state to STANDBY

EVENT: Current value in mA or A is sent

1. If Setpoint current value is greater than or equal to 3mA
   1. Update setpoint current value
   2. Display setpoint current value on serial monitor
   3. Update DAC value
   4. Set DAC
2. If setpoint current value is less than 3mA
   1. Inform user to enter a setpoint current greater than or equal to 3mA

EVENT: Sample timer 1 ends

1. Display setpoint current value on serial monitor
2. Read current from current sensor
3. Display sense current on serial monitor
4. Reset sample timer 1

Initial State: COOL DOWN

EVENT: entry

1. Send state message to serial monitor
2. Turn LED on
3. Turn Overload Protection on
4. Turn Fan on
5. Inform user that heat sink will cool down until temperature reaches 25 °C
6. Read temperature from temperature sensor
7. Display temperature read on serial monitor

EVENT: Sample timer 1 ends

1. Read temperature from temperature sensor
2. Display temperature read on serial monitor

EVENT: If Temperature read is equal to 25 °C

1. Turn Overload Protection off
2. Turn LED off
3. Display “Temperature is in suitable range”
4. Display “Returning to STANDBY state”
5. Change state to STANDBY

**Interface List**

Arduino <--> Computer

Characteristics

* Serial monitor based

Command Definition

|  |  |
| --- | --- |
| **Command** | **Description** |
| help | Displays commands that can be used by the user |
| start | Starts the measurement of current and voltage |
| set current | Set the setpoint current in A or mA |
| log data | Logs the current and voltage with a time stamp using a log rate |
| read temperature | Reads the current temperature of the heat sink |
| read voltage | Reads the current voltage of the source |
| set displayrate | Set the rate at which the current and voltage are displayed on the screen during the measurement |
| show displayrate | Displays the current display rate |
| set lograte | Set the log rate when logging current and voltage with a time stamp |
| show lograte | Displays the current log rate |
| end | Ends the measurement |

Security

Regulation

Mechanical