User Settable G-switch

Seal Team Seven
Team Members

- Sean Vanharen (manager)
- Tom Larter (document prep)
- Frank Doherty (webmaster)
- DJ Eaton (presentation prep)
- Xiao Xu (lab coordinator)
- Facilitator
  - Dr. Dean Aslam
- Sponsor
  - Greg Hoshal at Instrumented Sensor Technology, Inc.
Agenda

- Background
- Problem
  - General
  - Requirements
- Solution Statement
- Circuit Structure
- DIP switch design
- Product Choices
- Code Flow Chart
- Relay Choices
- Risk Analysis
  - Durability
  - Pros & Cons
- Budget
- Summary
- References
- Questions
Background

• Instrumented Sensors and Technology

• Shock, Vibration, Temperature and Humidity Sensor Recorders.
• Motion Master, Self contained sensor/Recorder measures and records 6-Axis Roll, Pitch & Yaw.
• Shock-Timer for shipment monitoring.

• Worked with NASA, Mythbusters, and the US Armed Forces
General Problem

- **Heavy Machinery (Industry)**
  - Out of control/destructive oscillation
  - Earthquake/destructive weather

- **Shipping**
  - Cargo monitoring
  - Damage from shock and vibration

- **Vehicles**
  - Collisions
  - Abrupt braking/swerving
Requirements

- Operate from DC to 100Hz
- Mode setting selected via DIP switch
- RMS and peak detection modes
- Must work with 125V/10A relay
- Battery powered (6 months) or wall powered
- No larger than 12 cubic inches
- Screw terminal strip for relay connections
# G-level Setting Requirements

<table>
<thead>
<tr>
<th>Peak Mode</th>
<th>RMS Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>.25g</td>
<td>.0625g</td>
</tr>
<tr>
<td>.50g</td>
<td>.125g</td>
</tr>
<tr>
<td>1g</td>
<td>.25g</td>
</tr>
<tr>
<td>2g</td>
<td>.50g</td>
</tr>
<tr>
<td>4g</td>
<td>1g</td>
</tr>
<tr>
<td>6g</td>
<td>2g</td>
</tr>
</tbody>
</table>
Solution

• User-settable g-switch
  • Small, self-contained
  • Can be mounted on a machine/building/package
  • Will trip a relay necessary to cut off power/start a control procedure
  • Visually indicates a tripped or un-tripped state
Circuit Structure

- BMA250 Accelerometer
  - Sensor
  - Low Pass Filter
  - Gain
  - ADC Converter

- MSP430G2 Microcontroller
  - Red LED
  - Green LED
  - Output Relay 2
  - Output Relay 1

- DIP Switch
- Reset Switch
## DIP Switch Truth Table

<table>
<thead>
<tr>
<th>DIP setting</th>
<th>Detection mode</th>
<th>Trip level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td>Peak</td>
<td>.25g</td>
</tr>
<tr>
<td>0001</td>
<td>Peak</td>
<td>.50g</td>
</tr>
<tr>
<td>0010</td>
<td>Peak</td>
<td>.75g</td>
</tr>
<tr>
<td>0011</td>
<td>Peak</td>
<td>1g</td>
</tr>
<tr>
<td>0100</td>
<td>Peak</td>
<td>1.5g</td>
</tr>
<tr>
<td>0101</td>
<td>Peak</td>
<td>2g</td>
</tr>
<tr>
<td>0110</td>
<td>Peak</td>
<td>4g</td>
</tr>
<tr>
<td>0111</td>
<td>Peak</td>
<td>6g</td>
</tr>
<tr>
<td>1000</td>
<td>RMS</td>
<td>.0625g</td>
</tr>
<tr>
<td>1001</td>
<td>RMS</td>
<td>.125g</td>
</tr>
<tr>
<td>1010</td>
<td>RMS</td>
<td>.15g</td>
</tr>
<tr>
<td>1011</td>
<td>RMS</td>
<td>.25g</td>
</tr>
<tr>
<td>1100</td>
<td>RMS</td>
<td>.50g</td>
</tr>
<tr>
<td>1101</td>
<td>RMS</td>
<td>.75g</td>
</tr>
<tr>
<td>1110</td>
<td>RMS</td>
<td>1g</td>
</tr>
<tr>
<td>1111</td>
<td>RMS</td>
<td>2g</td>
</tr>
</tbody>
</table>
BMA250 Bosch Triaxial Accelerometer

- Made by Bosch Sensortec
- X Y and Z triaxial acceleration sensor
- Desired Gforce measurement range
- Digital Output
- 8Hz – 1kHz Settable bandwidth with built-in filter
- 3.91 mg resolution
- Ultra Small Package – 2mm x 2mm, 0.95 mm height
- Ultra Low power – 7µA in Low power mode, 0.5µA in suspend mode
- High shock survivability
MSP430G2 Microcontroller

• Low cost, easy to use (Programmable in C)
• Large support base online by TI and user community
• Can do all functions desired (RMS calculation, Peak Detection)
• Up to 16MHz internal frequency with 32kHz Crystal Clock
• Ultra Low power – 0.5µA Standby mode, 220µA at 1MHz

TI Launchpad Development Board

• Low cost
• USB Connection and DIP sockets for easy prototyping
Start

Close Relay 1
Open Relay 2

Read Value from Accelerator and from dip switch

Check Accelerometer against User setting

Accelerator value is under limit
Blink Green LED

Microcontroller tripped
Open Relay 1
Close Relay 2

Blink Red LED

No Action
Delay

Reset Switch Pressed
Issues to still overcome

Relay choices

**Solid State Relay**
- Lower Minimum latching current
- Faster Switching Time
- Longer life span
- No bouncing, cleaner operation
- Less effected by environment
- Can design on-board relay

**Mechanical Relay**
- Better Fail Safe
- Cheap
- More diverse/accessible
Risk Analysis and Concerns

• Very durable, hazardous conditions
  • Heat
  • Vibrations
  • Dirt
• Low Power Consumption
  • 6 month battery life
• Portable
  • Easy to install and take apart
Pros and Cons

- Low Power Consumption
- Cheap
- Set and Forget
- Easy to Use
- Small design

- Limited space for additional batteries
- Durable enough
## Budget

<table>
<thead>
<tr>
<th>Part</th>
<th>Cost</th>
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<tbody>
<tr>
<td>2 Bosch Sensortec Accelerometer</td>
<td>$7.08</td>
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<tr>
<td>3-Axis Digital Accelerometer PCB – BMA 250</td>
<td>$10.00</td>
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<tr>
<td>TI Launchpad Experimenter</td>
<td>$4.30</td>
</tr>
<tr>
<td>Relay and MOSFET</td>
<td>$40.00*</td>
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<tr>
<td>DIP Switch</td>
<td>(from lab) $0.00</td>
</tr>
<tr>
<td>PCB</td>
<td>$33.00*</td>
</tr>
<tr>
<td>Power Supply</td>
<td>$10.00*</td>
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<tr>
<td><strong>CURRENT TOTAL:</strong></td>
<td><strong>$104.38</strong></td>
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* Estimation
Conclusion

- Problem Statement
- Solution Statement
- Block Diagram
- DIP switch design
- Relay Choices
- Risk Management
- Pros v Cons
- Budget
Technical Roles

- Software Development
  - Xiao
  - David
- Circuit and PCB Design
  - Tom
- Assembly and Testing
  - Frank
  - Sean
QUESTIONS?
References

- http://www.4pcb.com/33-each-pcbs.html
- http://www.ti.com/
- http://www.bosch.us/content/language1/html/index.htm
- http://www.isthq.com/