Team 2
Solar Kiosk Project

Sponsored by:

Team Members:
Jakub Mazur - Manager
Eric Tarkleson – Presentation/Lab
Josh Wong - Webmaster
Ben Kershner – Document Preparation
Current Sensing

- Applications
- Pros Cons
- The Hall Effect
- Shunt Resistors
- Making your Data useful
- Questions
Applications

• Measuring Power Consumption
• Design for Safety
  – GFCIs, fuses, circuit breakers
• Temperature optimization
  – High current = hotter components
<table>
<thead>
<tr>
<th>Shunt Resistor</th>
<th>Hall Effect Sensor</th>
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<tbody>
<tr>
<td>- Low failure probability</td>
<td>- Isolated from current source</td>
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<tr>
<td>- Cheap</td>
<td>- Higher precision</td>
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<tr>
<td>- Wastes power</td>
<td>- More expensive</td>
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<td>- Limited sensing range</td>
<td>- Can be integrated into an IC device</td>
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<tr>
<td>- Requires additional voltage</td>
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<tr>
<td>measurements</td>
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Who is this Guy?

André-Marie Ampère (1775 –1836)

By 1800 scientists were wondering if electricity and magnetism were related. Ampère was one of the first to develop a technique for measuring electricity… essentially a compass with wire wrapped around it.

Electrodynamics → Electromagnetics, where studied at this time by: Faraday, Weber Thomson and Maxwell.
Shunt Resistor

\[ V = IR \]
The Hall Effect

- When there is a Magnetic field in the presence of a conductor a voltage is induced due to electron and hole drift
- Electron – negative charge carrier
- Hole – positive charge carrier
\[ F = q(E + v \times B) \]

**Hall Effect**

\[ q = +q \] for holes
\[ = -q \] for electrons

\[ F = qE \]
The Hall Effect - Math

- $V_{hall} = \frac{-I \cdot B}{d \cdot n \cdot e}$
- $R_{hall} = \frac{-1}{n \cdot e}$
- $I = \text{current}$
- $B = \text{Mag Flux Dens}$
- $d = \text{depth of plate}$
- $e = \text{electric charge}$
- $j = \text{current density}$
- $n = \text{charge carrier dens}$
- $r = \text{distance to center of wire}$
- $U_0 = 4 \cdot \pi \cdot 10^{-7}$

current through wire

$B_{field} = \frac{U_0 \cdot I_p}{(2 \cdot \pi \cdot r)}$

of wire
So what?

• We can use this to our advantage
• We can detect
  – B field
  – Current
  – Voltage
  – Charge drift velocity
• We can do this without having inline components (like a shunt resistor)
How do I handle this data?

• Many types of signals
  – Reference voltage (LEM sensors)
  – Voltage drop (Shunt resistor)
  – Parallel bus (Some ADCs)
  – Serial interface (Some ADCs, other ICs)
    • Traditional Serial Interface
    • I²C Bus
How do I handle this data?

• Sampling by digital ICs
  – Direct
  – Indirect
    • Intermediate ADC
• Direct
  – Built-in ADC on the PIC
    • Inaccuracies
  – Parallel
    • High Pin Count
Serial Buses

• Traditional UART/USART Serial
  – Typically one-to-one communication
  – Parity checking

• Serial Protocols
  – \( \text{I}^2\text{C} \)
    • Developed by Philips
    • 128 Devices on one bus
  – USB
    • Driver implementation