Welcome to the Real World!
- what keeps paper designs from working -

• CMOS Characteristics
• Noise
• Defensive Programming Techniques
• Power conditioning and management
CMOS Characteristics

• Handling guidelines:
  – Use grounded wrist strap when handling CMOS devices
  – Keep CMOS devices in original container until use
  – Use grounded test bench
  – Use grounded soldering tip
  – Do not remove/replace CMOS device in circuit when power is applied
CMOS Characteristics

• Design guidelines
  – Properly terminate unused inputs
    • Resistor (4.7K) to power or ground
  – Use series resistors when connecting PCBs
  – Use CMOS devices within specified parameter envelope
Noise Sources

- Electrostatic discharge (ESD) - static electricity
- Radio frequency interference (RFI) - undesired RF energy
- Electromagnetic interference (EMI) - varying magnetic fields emanating from electromechanical devices (motors)
- Sag - decrease in input AC
- Surge - sudden increase in input AC
Noise Sources

- RFI
- EMI
- spikes/surges
- power supply
- sags
- microcontroller
- ESD
Reducing noise susceptibility

- Printed circuit boards should have well filtered power supply inputs
  - Provide ferrite-bead feed-throughs
  - 50 uF capacitor between power and ground -- mount close to beads
    - low frequency noise
  - 0.1 to 0.01 uF capacitor to bypass mid to upper frequency noise
- Provide bypass capacitors on every IC
  - 0.01 uF capacitor between IC supply and ground pin
- Provide ferrite-bead feed-throughs at signal inputs and output
- Provide separate power feed to each IC row
- Provide short ground return paths with large ground planes
- Properly terminate unused IC inputs
- Every other conductor in ribbon cable should be grounded
- Enclose system processor in a well-grounded metal box
Noise Minimization Techniques
Terminating Unused Inputs

• Input impedance is very high on unused input pins
• If not connected, the input can oscillate or float to midsupply level
• Oscillation can couple noise to power supply
• Terminate unused input pins by pulling up (or down) via a resistor -- 4.7 Kohm
Noise Testing Techniques

• Low-cost prototype testing techniques for noise emission and susceptibility
  – Tune TV to Channel 2 with no cable connection
    • Picture is AM and affected by RFI
  – Use high-power videotape bulk eraser
  – Move your hand in close proximity to circuit under operation -- circuit should remain stable
Defensive Programming Techniques

• Effective software techniques to minimize noise effects
  – Detects faulty algorithm execution
  – Provides some level of fault recovery
Defensive Programming Techniques

• Refresh port pins: periodically update DDRx registers and port output values

• Polling: Poll input pin for some time (50 ms) to insure valid input rather than spurious signal

• Token Passing: Insures correct execution of algorithm.
  – Designate token collection memory location
  – As algorithm executed, place tokens at site in numerical order
  – As new portion is entered, insure previous numerically ordered tokens are in place
Defensive Programming Techniques

- Unused memory: place “SWI”, Software Interrupt instructions, in unused memory space
- COP watchdog timer - COPRST:
  - Strategically place:
    COPRST = 0x55:
    COPRST = 0xAA;
    command pairs throughout algorithm
  - This resets COP timer
  - If command sequence not sent properly, software is “stuck” and reset will be generated
Power Management

• Design parameters required for embedded control system:
  – supply voltages
  – current drain
  – operational life expectancy for battery supply
  – temperature of operating environment
## Power Management

<table>
<thead>
<tr>
<th>Processor Operating Frequency</th>
<th>2 MHz</th>
<th>4 MHz</th>
<th>8 MHz</th>
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<tbody>
<tr>
<td><strong>Maximum Total Supply Current</strong></td>
<td></td>
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<td></td>
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<tr>
<td>Run:</td>
<td></td>
<td></td>
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<tr>
<td>- Single-chip Mode</td>
<td>15 mA</td>
<td>25 mA</td>
<td>45 mA</td>
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<tr>
<td>- Expanded Mode</td>
<td>25 mA</td>
<td>45 mA</td>
<td>70 mA</td>
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<tr>
<td>Wait: (All peripheral functions shut down)</td>
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<td></td>
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<tr>
<td>- Single-chip Mode</td>
<td>1.5 mA</td>
<td>3 mA</td>
<td>5 mA</td>
</tr>
<tr>
<td>- Expanded Mode</td>
<td>4 mA</td>
<td>7 mA</td>
<td>10 mA</td>
</tr>
<tr>
<td>Stop:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Single-chip Mode, no clocks</td>
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<td></td>
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<tr>
<td>- 40 to +85</td>
<td>10 uA</td>
<td>10 uA</td>
<td>10 uA</td>
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<tr>
<td>- +85 to +105</td>
<td>25 uA</td>
<td>25 uA</td>
<td>25 uA</td>
</tr>
<tr>
<td>- +105 to +125</td>
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## Power Management

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<tr>
<th>Type</th>
<th>Alkaline</th>
<th>Nickel-Cadmium</th>
<th>Lithium</th>
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<tr>
<td></td>
<td>Non-rechargeable</td>
<td>Rechargeable</td>
<td>Non-rechargeable</td>
</tr>
<tr>
<td>Size</td>
<td>Voltage</td>
<td>Capacity</td>
<td>Voltage</td>
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<tr>
<td>D</td>
<td>1.5 V</td>
<td>15,000 mA-hr</td>
<td>1.2 V</td>
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<tr>
<td>C</td>
<td>1.5 V</td>
<td>7,000 mA-hr</td>
<td>1.2 V</td>
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<tr>
<td>AA</td>
<td>1.5 V</td>
<td>2,250 mA-hr</td>
<td>1.2 V</td>
</tr>
<tr>
<td>AAA</td>
<td>1.5 V</td>
<td>1,000 mA-hr</td>
<td>1.2 V</td>
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<tr>
<td>N</td>
<td>1.5 V</td>
<td>650 mA-hr</td>
<td>1.2 V</td>
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<tr>
<td>9V transistor</td>
<td>9.0 V</td>
<td>550 mA-hr</td>
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</tr>
<tr>
<td>6V lantern</td>
<td>6.0 V</td>
<td>11,000 mA-hr</td>
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