EE4800-03
Embedded Systems Design

Lessons 16-18
Real World Design Issues

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

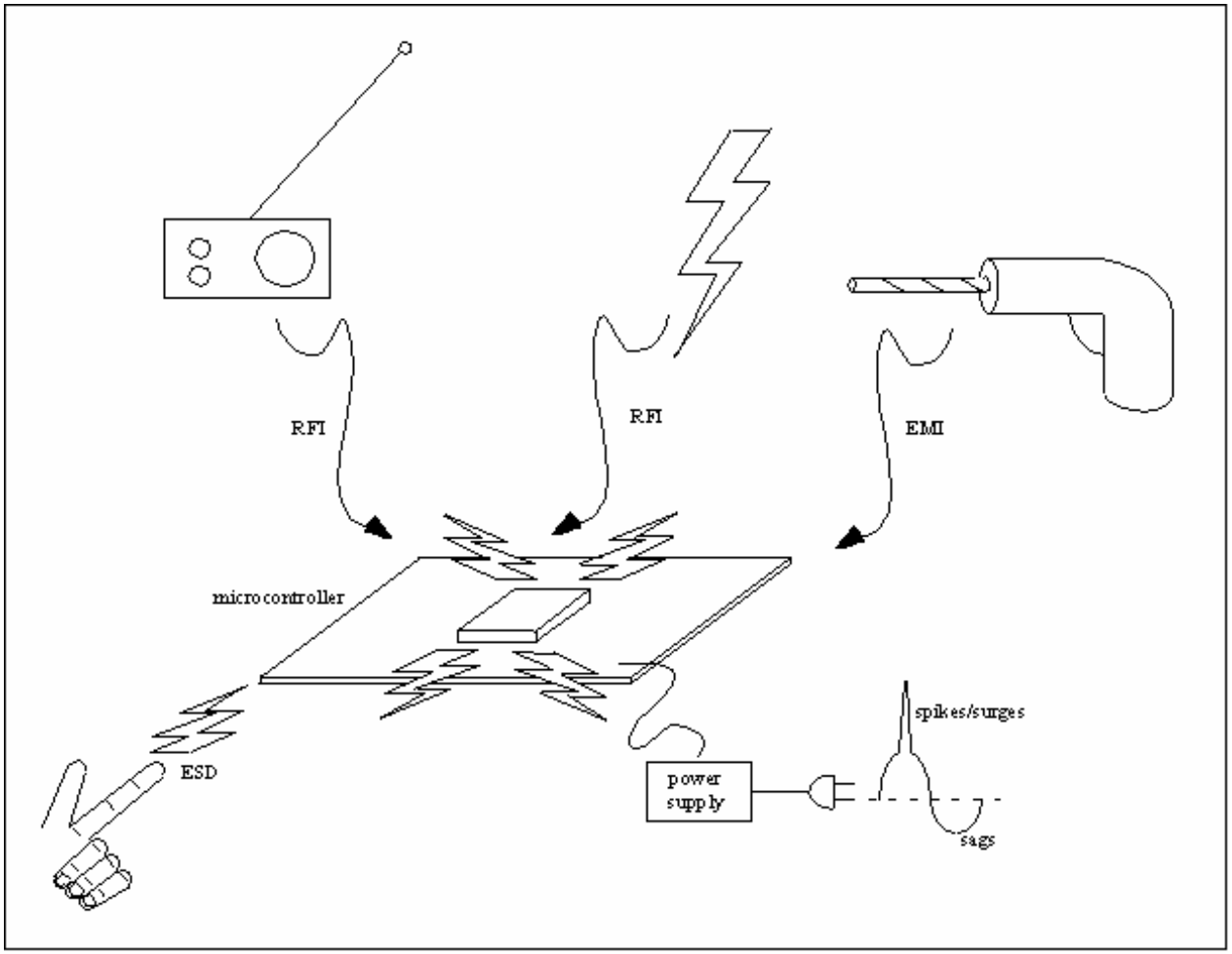
CMOS Characteristics

- 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

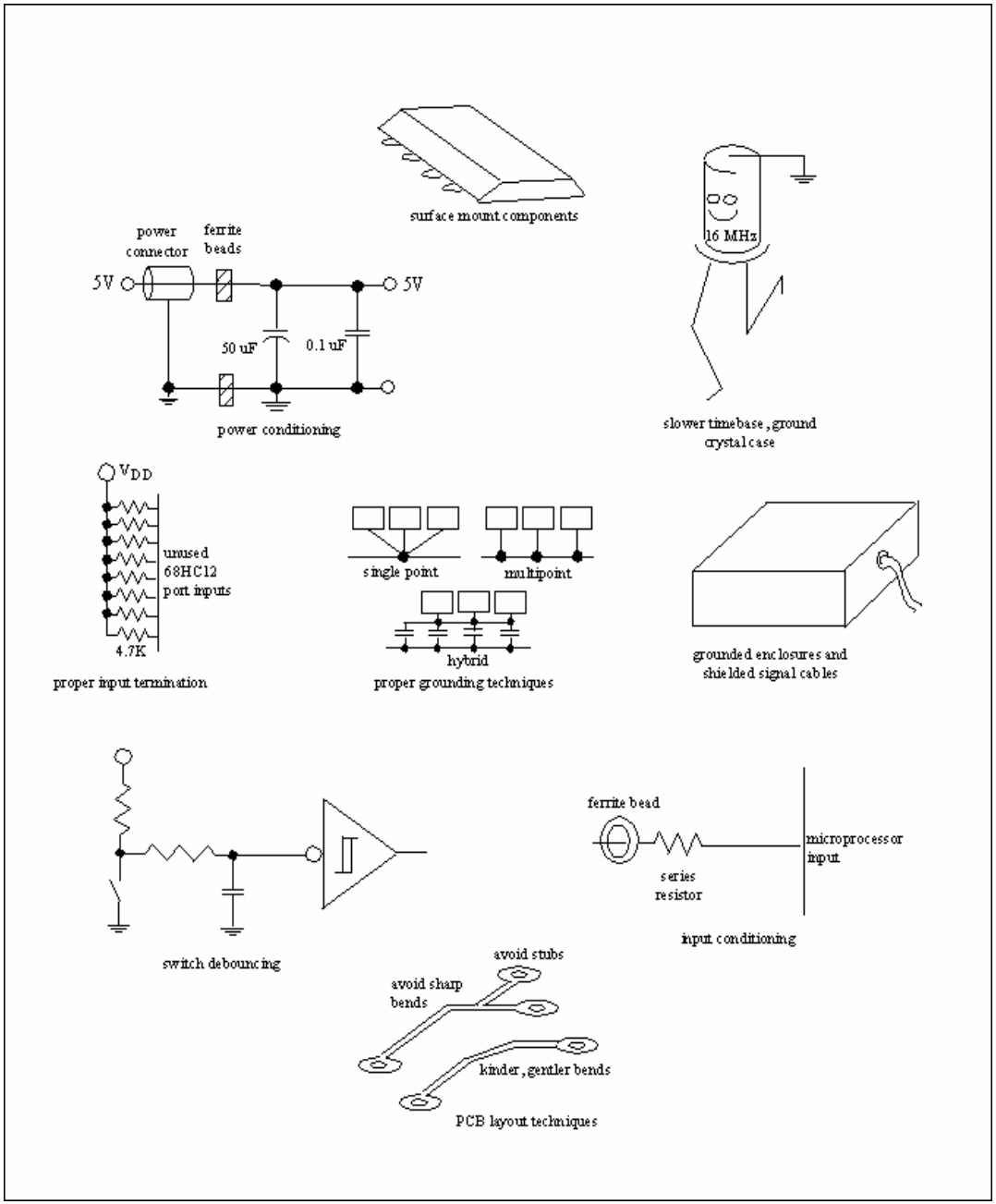
Noise Sources



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

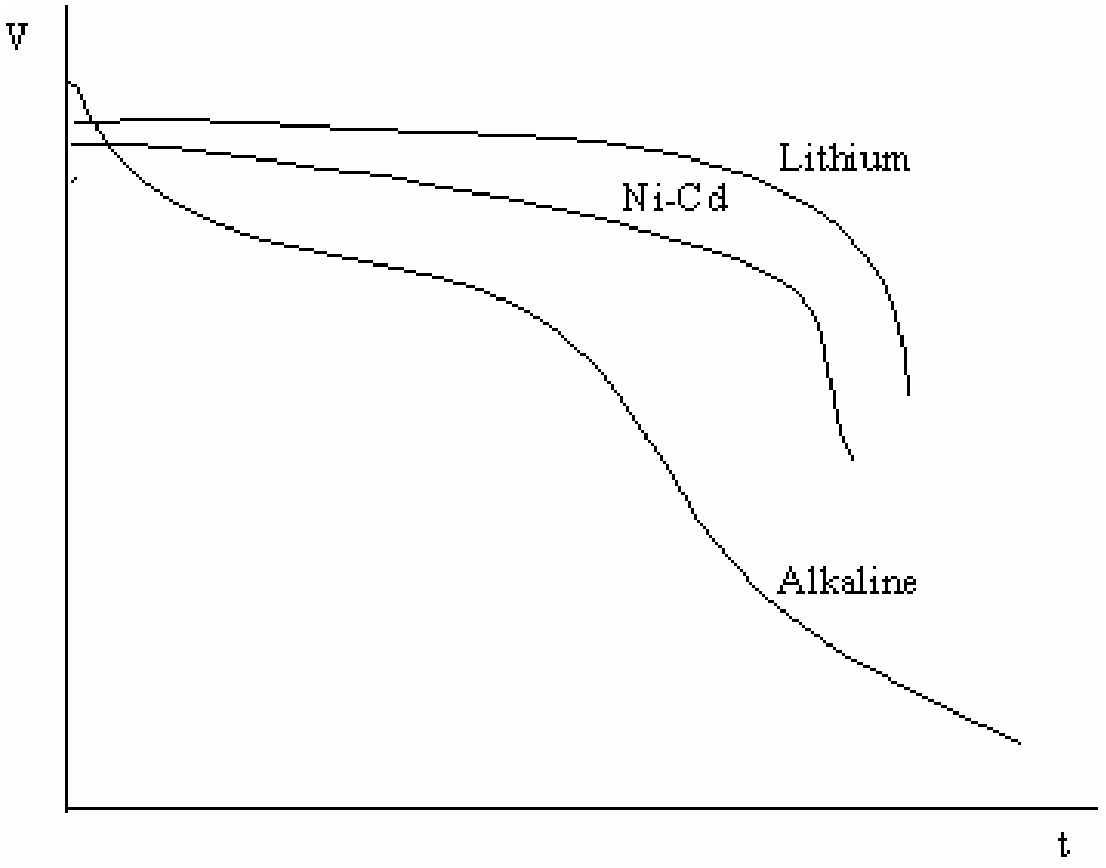
Power Management

Maximum Total Supply Current	Processor Operating Frequency 2 MHz	4 MHz	8 MHz
Run:			
- Single-chip Mode	15 mA	25 mA	45 mA
- Expanded Mode	25 mA	45 mA	70 mA
Wait: (All peripheral functions shut down)			
- Single-chip Mode	1.5 mA	3 mA	5 mA
- Expanded Mode	4 mA	7 mA	10 mA
Stop:			
- Single-chip Mode, no clocks			
- 40 to +85	10 uA	10 uA	10 uA
+85 to +105	25 uA	25 uA	25 uA
+105 to +125	50 uA	50 uA	50 uA

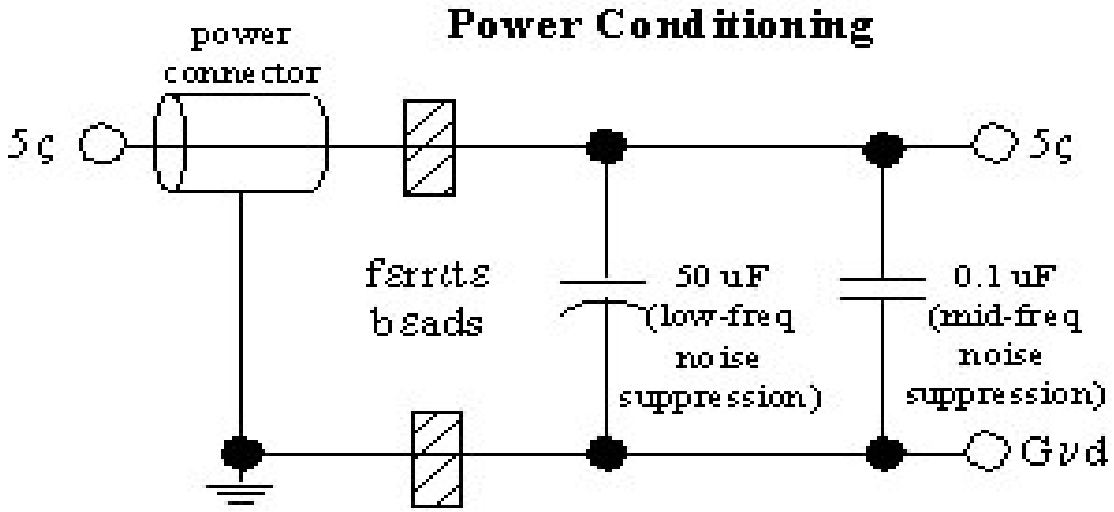
Power Management

	Alkaline		Nickel-Cadmium		Lithium	
Type	Non-rechargeable		Rechargeable		Non-rechargeable	
Size	Voltage	Capacity	Voltage	Capacity	Voltage	Capacity
D	1.5 V	15,000 mA-hr	1.2 V	1,200 mA-hr	3.6 V	16,500 mA-hr
C	1.5 V	7,000 mA-hr	1.2 V	1,200 mA-hr	3.6 V	7,200 mA-hr
AA	1.5 V	2,250 mA-hr	1.2 V	500 mA-hr	3.6 V	2,100 mA-hr
AAA	1.5 V	1,000 mA-hr	1.2 V	180 mA-hr	---	---
N	1.5 V	650 mA-hr	1.2 V	150 mA-hr	---	---
9V transistor	9.0 V	550 mA-hr	---	---	---	---
6V lantern	6.0 V	11,000 mA-hr	---	---	---	---

Power Management



Power Management



Power Management