

# ECE4723/6723 Embedded Systems

- 1 Embedded Computer Systems
  - 1.1 Embedded System Applications
    - 1.1.1 Embedded systems
    - 1.1.2 Low power
    - 1.1.3 Wireless
  - 1.2 Product lifecycle
  - 1.3 Product design process
    - 1.3.1 Requirements (including design requirements & metrics)
    - 1.3.2 Specifications
    - 1.3.3 Design (algorithm, architecture, detailed)
    - 1.3.4 Testing (unit, system)
    - 1.3.5 Deployment
    - 1.3.6 Maintenance
    - 1.3.7 Product design models
  - 1.4 Choosing a low-power microcomputer
- 2 Electronic Circuits
  - 2.1 Charge, current and KCL
  - 2.2 Energy
  - 2.3 Power
  - 2.4 Voltage and KVL
  - 2.5 Resistance and Ohm's Law
  - 2.6 Operational Amplifiers
  - 2.7 Diodes
  - 2.8 Bipolar Junction Transistors
- 3 CMOS Circuits
  - 3.1 Basic MOSFET Operation
  - 3.2 MOSFET Parameters
  - 3.3 Circuits models for CMOS timing
  - 3.4 CMOS Inverter
    - 3.4.1 Basic operation
    - 3.4.2 Threshold voltage and noise margins
    - 3.4.3 Switching characteristics
  - 3.5 Power dissipation in CMOS systems
    - 3.5.1 Static power (leakage)
    - 3.5.2 Charge/discharge power
    - 3.5.3 Short-circuit power
    - 3.5.4 CMOS system power dissipation
    - 3.5.5 Energy, power, and energy-delay
    - 3.5.6 Low-power CMOS circuit techniques
- 4 Energy Sources for LPESs
  - 4.1 The "Grid"
    - 4.1.1 Electric utilities
    - 4.1.2 Energy Star (US, Canada, EU, Japan, Taiwan, AUS, NZ)
  - 4.2 Chemical batteries
    - 4.2.1 Introduction
    - 4.2.2 Theory and metrics
    - 4.2.3 Primary
      - 4.2.3.1 Alkaline
      - 4.2.3.2 Lithium
      - 4.2.3.3 Zinc-air
      - 4.2.3.4 Silver oxide

- 4.2.4 Secondary
  - 4.2.4.1 Nickel metal hydride
  - 4.2.4.2 Nickel cadmium
  - 4.2.4.3 Lithium ion
  - 4.2.4.4 Lead acid
- 4.3 Fuel cells
- 4.4 Environmental and parasitic
  - 4.4.1 Thermal
  - 4.4.2 Mechanical
  - 4.4.3 Solar
  - 4.4.4 Wind
  - 4.4.5 Other electrical systems
- 5 CPUs for LPES (The Texas Instruments MSP430F2xx family)
  - 5.1 CPU core
    - 5.1.1 Instruction set
    - 5.1.2 Busses
    - 5.1.3 Memory
  - 5.2 Clocks
  - 5.3 Sleep modes
  - 5.4 Timers
  - 5.5 Interrupts and wake-up sources
  - 5.6 Low-power peripherals
- 6 Interfacing with LPES
  - 6.1 Inputs
    - 6.1.1 Switches
    - 6.1.2 Low-power switches
    - 6.1.3 Interfacing with 5V systems
  - 6.2 Outputs
    - 6.2.1 LEDs
    - 6.2.2 LCDs
    - 6.2.3 Motors
  - 6.3 Communications
    - 6.3.1 Synchronous
    - 6.3.2 Asynchronous
  - 6.4 Mixed-signal I/O
    - 6.4.1 ADCs
    - 6.4.2 DACs
    - 6.4.3 Signal conditioning
  - 6.5 Low-power peripheral functions
    - 6.5.1 On-die
    - 6.5.2 External devices
- 7 Software for LPES
  - 7.1 Programming LPESs
    - 7.1.1 Assembly language programming
    - 7.1.2 C language programming
    - 7.1.3 Assembly+C language programming
  - 7.2 LPES software design patterns
    - 7.2.1 Active processing architecture
    - 7.2.2 Reactive processing architecture
    - 7.2.3 Sleepy-drowsy processing architecture
  - 7.3 Software constructs for LPESs
    - 7.3.1 Software optimizations for LP operation
    - 7.3.2 Energy aware software development
  - 7.4 Real-time operating system concepts

- 7.4.1 Kernel
- 7.4.2 Tasks
- 7.4.3 Events
- 7.4.4 Semaphores
- 7.4.5 Messages
- 7.4.6 Other RTOS Services
- 8 Design Strategies for LPESs
  - 8.1 Finite charge
  - 8.2 Finite energy
  - 8.3 Power-performance trade offs
  - 8.4 Energy and power budget analysis