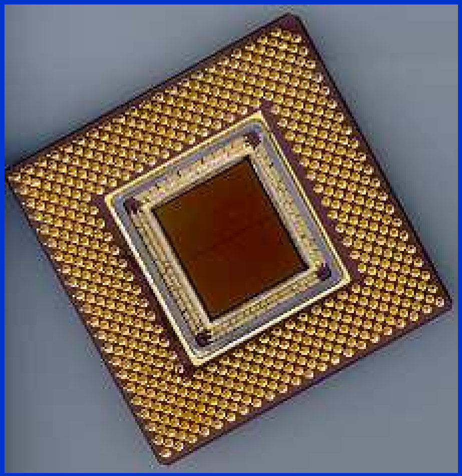


ECE 477 Digital Systems Senior Design Project

Module 5

Real-World Design Constraints and Product Packaging Considerations

Reference: *IEEE Spectrum*, January 2003

Instructional Objectives:

- **To gain a better understanding of the real-world constraints associated with a digital system design project**
- **To gain a better understanding of product packaging considerations**

Outline:

Real-world design constraints

Product packaging considerations

Real-World Design Constraints

- **Choice of logic family**
  - **voltage swing of outputs (relative to requirements of other inputs) = DCNM**
  - **current source/sink capability = Fan-out**
  - **speed of operation**
  - **power dissipation**
  - **functions available**
  - **price**
  - **others?**

Real-World Design Constraints

- Choice of supply voltage(s)
  - power dissipation (goes up as square of supply voltage)
  - some "functions" (e.g., a specific CODEC) are only available for certain supply voltages → possible need for level translation buffers (look for higher voltage tolerant input availability, e.g., 3.3 V part with "5 volt tolerant" inputs)
  - power supply complications (multiple voltage regulators, DC-DC converters, etc.)

Real-World Design Constraints

- **Choice of operating frequency(s)**
  - **power dissipation (increases linearly with operating frequency)**
  - **know difference between “static” and “dynamic” logic:**
    - **“static logic” can operate down to D.C. (i.e., no minimum clock rate)**
    - **“dynamic logic” requires a minimum clock rate**
  - **different parts of circuit may need to operate at different frequencies**
  - **some microcontrollers have PLL that allows convenient changing/programming clock frequency for different operating modes**

Real-World Design Constraints

- **Choice of IC package(s)**
  - **DIP (dual in-line package) – facilitates prototyping, but larger than necessary**
  - **surface mount – preferred for most components (prototyping is a challenge, but can be done and tools are available)**
  - **PLCC (plastic leadless chip carrier) – no longer very commonly used (fragile)**
  - **PGA (pin grid array) – hard to route on 2-layer board**
  - **BGA (ball grid array) – DON’T USE!!**

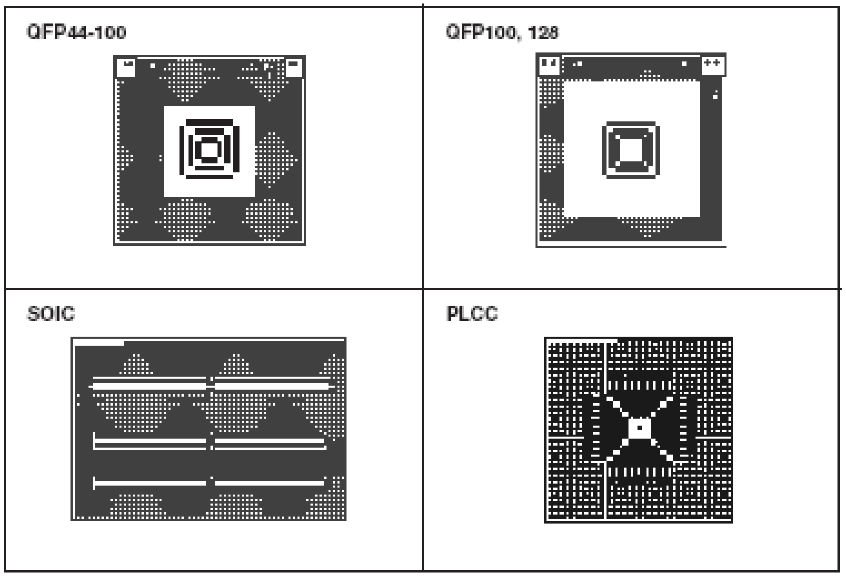
Real-World Design Constraints

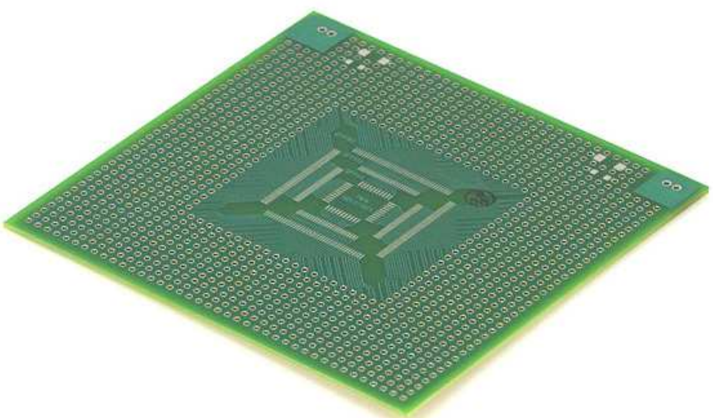
- Common packages:
  - **SOT##**: small outline transistor
  - **SO / SOIC**: small outline IC
  - **(T)SSOP**: (thin) shrink small outline package
  - **LQFP**: low quad flat pack
  - **TQFP**: thin quad flat pack
  - **QFN**: quad flat, no-lead (tricky – try to avoid)
  - **BGA:** ball grid array (do not use)
  - **CSP**: chip scale package (do not use)
- Also tricky: “exposed flags” (on bottom of IC)

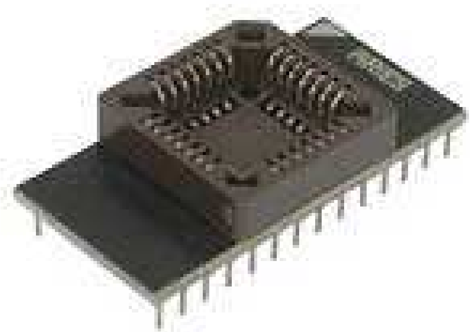
Some Prototyping Adapters

SMT Adapter Boards

Surface mount components are soldered to pads on boards. Traces extend from pads to prototyping holes on standard 0.1" x 0.1" (2.54mm x 2.54mm) grid. Individual leads can be monitored or other components can be added to evaluate performance of surface mount product. Saves time and prototyping cost. All boards made with FR4 laminate, and featuring ground plane on back side. Pad to pad spacing (pitch) is measured in mils (thousandths of inch).







The photo represents 16-pin version

The photo represents 20-pin version

Real-World Design Constraints

- **Choice of component manufacturer(s) and/or distributors**
  - **always a good idea to have more than one source/supplier (*steer clear of parts that are only available from a single distributor*)**
  - **some have better _______ than others…**
    - **documentation (steer clear of parts that have little/no <u>on-line</u> documentation)**
    - **support ("real people on real phones")**
    - **reliability ("dead on arrival parts")**
    - **price**
    - **development tools (look for 3rd party support)**
    - **generosity/promptness in sampling parts**

Real-World Design Constraints

- **Certification requirements**
  - **U/L** (anything that plugs in)
  - **FCC** – anything that communicates via RF or common carrier (TELCO)
  - **FCC** – anything that “accidentally” radiates RF (i.e., just about every product that incorporates a microcontroller)…can cause a MAJOR DELAY in product release
  - **Methods for reducing RF emissions**
    - packaging (shielding)
    - board layout (copper pour)
    - ferrite beads
    - minimize clock frequency (where possible)
    - reduce output pin drive (where possible)

Real-World Design Constraints

- Field upgrade/maintenance features
  – built-in self-test (BIST)
  – diagnostic mode
  – modular construction (where possible)
  – unique connectors for different cables ("idiot-proof" re-assembly)

Design Constraint Homework

- **Itemize your project's…**
  - **processing power requirements**
    - **ALU/data bus width/data types**
    - **address bus width/memory expandability**
    - **on-chip memory types/amounts (Flash/SRAM)**
    - **specialized instructions (e.g., multiply/divide)**
    - **MIPS/clock speed/instruction cycle count**
  - **on-chip peripheral requirements**
    - **Regular: PWM, ADC, SCI, SPI, TIM, RTI, IIC, USB**
    - **Network: CAN, ethernet**
  - **direct support requirements**
    - **external reset controller**
    - **crystal/resonator/oscillator module**

Design Constraint Homework

- Itemize your project's…
  - external interfacing requirements
    - number/type (input/output) of port pins
    - port pin expansion (external shift register)
    - data direction register support
    - current drive capability (programmability)
    - output voltage swing
    - input voltage tolerance
    - input pin pull-up/down (programmability)
  - power consumption constraints
    - battery powered (rechargeable?)
    - supply voltage(s)
    - voltage regulation requirements
    - current requirements

Design Constraint Homework

- **Once you have determined your project's microcontroller-related constraints, pick <u>at least</u> two candidate parts that match your system requirements as closely as possible**
- **In your discussion, describe how the microcontroller-related design constraints guided the selection, comparison, and evaluation of the candidate parts**
- **The ultimate goal is to match (as closely as possible) your project's requirements with the capabilities and resources available on the microcontroller chosen**
- **Repeat this procedure for any other MAJOR components needed (e.g., MP3 decoder)**

Packaging Considerations

- Based on the *IEEE Spectrum* article, what are some of the most important packaging considerations for “handheld” devices?
  - size (fit in pocket)
  - weight
  - cost
  - shape (ergonomic)
  - durability
  - battery life
  - upgradeability
  - storage capacity
  - style
  - features
  - display size
  - font size
  - button size
  - GUI
  - intuitive operation
  - wireless I/F

Packaging Considerations

- **What is the relationship between packaging and marketability?**
  - **ratio of screen size to overall size (want screen size to be as large as possible)**
  - **buttons large enough to be pressed by normal people (or, icons on touch screen large enough to see and differentiate among)**
  - **match of technical capability to intended audience (“personality target”) – e.g., better if cell phone “put to ear” (vs. use of earbuds)**
  - **“feature creep” dilemma – marginal multi-purpose device (does lots of things, none very well) *or* high-performance single-purpose (does single thing well…simple, reliable, long battery life)**

Packaging Considerations

- **Examples of "feature creep"**
  - **watch with web browser (Bill Gate's SPOT)**
    http://news.bbc.co.uk/2/hi/business/2487787.stm
  - **net-enabled toaster**
    http://www.reghardware.com/2008/09/11/wacky_toaster/
  - **others?**

- **Opinion:** ***At some point, designers and manufacturers need to come to grips with the fact that: (a) "smaller" and "better" are not necessarily synonyms, and (b) not every home appliance benefits from being on-line.***

Packaging Considerations

- “Desktop” products
  - power supply/line connection
    - wall wart or in-line transformer
    - internal supply/normal A.C. power cord
  - cabinet material and size/shape/color
  - keypad/display size/type
  - ventilation requirements
  - line-of-sight requirements (IR remote control)
  - interface cable requirements
    - phone-line jack
    - network cable jack
    - game controller jack

Packaging Considerations

- **“Desktop” products (continued)**
  - **wireless RF/network requirements**
    - **antenna size/placement/orientation**
    - **effective operating range**
    - **half vs. full duplex operation**
- **“Mobile” (robot) products**
  - **power supply**
    - **batteries (rechargeable)**
    - **“fuel gauge”**
    - **intelligent charging (speed/convenience)**
  - **weight/inertia/size**
  - **material (metal, plastic, composite) and shape/color**
  - **motor type (BDC, BLDC, stepper), feedback**

Packaging Considerations

- "Mobile" (robot) products (continued)
  - sensor requirements
    - IR obstacle detection (where mounted)
    - ultrasonic distance sensing (where mounted)
    - digital compass
    - accelerometer
    - GPS
  - wireless RF/network requirements
    - antenna size/placement/orientation
    - effective operating range
    - half vs. full duplex operation

Packaging Design Homework

- Analyze similar existing products
  - illustration and description of packaging used
  - discussion of positive and negative aspects of the product's packaging
  - aspects of the commercial product's packaging you plan to copy or adapt
  - aspects of your project's packaging that are unique (or that differentiate it from the commercial product under consideration)

Packaging Design Homework

- Develop a set of specifications for your design project's packaging
  - detailed <u>scale</u> CAD drawing illustrating size and shape
  - construction materials list
  - any special tooling requirements
  - <u>estimates</u> of packaging weight and cost
- PCB footprint layout (based on major components selected in Homework #3)
- Underlying principle to keep in mind: "This is an ECE course, not an ME course!"