SYS 595 Automotive Electronics

- Fall 96, CRN: 47221, Class at Ford
- Lecture notes on August 31, 2006

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Embedded System- Present and Future

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- What is an Embedded System (ES)
- What is Unique about the design goals for ES
- What does Real Time mean
- What are typical Embedded processors
- Intro to Microprocessors and Micro-controllers
- What Programming Languages are used in ES

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What is an Embedded System?

- Electronic devices that incorporate a computer (usually a microprocessor) within their implementation.
- A computer is used in such devices to simplify the system design and to provide flexibility.
- Often the user of the device is not even aware that a computer is present.

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Aerospace	Navigation systems, automatic landing systems, flight attitude controls, engine controls, space exploration (e.g., the Mars Pathfinder).
Automotive	Fuel injection control, passenger environmental controls, anti-lock braking systems, air bag controls, GPS mapping.
Children's Toys	Nintendo's "Game Boy", Mattel's "My Interactive Pooh", Tiger Electronic's "Furby".
Communi-cations	Satellites; network routers, switches, hubs.

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Computer Peripherals	Printers, scanners, keyboards, displays, modems, hard disk drives, CD-ROM drives.
Home	Dishwashers, microwave ovens, VCRs, televisions, stereos, fire/security alarm systems, lawn sprinkler controls, thermostats, cameras, clock radios, answering machines.
Industrial	Elevator controls, surveillance systems, robots.
Instrumen-tation	Data collection, oscilloscopes, signal generators, signal analyzers, power supplies.

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Medical	Imaging systems (e.g., XRAY, MRI, and ultrasound), patient monitors, heart pacers.
Office Automation	FAX machines, copiers, telephones, cash registers.
Personal	Personal Digital Assistants (PDAs), pagers, cell phones, wrist watches, video games, portable MP3 players, GPS.

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Embedded System Everywhere!

- Embedded processors account for 100% of worldwide microprocessor production!
- Embedded:desktop = 100:1
- 1999: #embedded processors in the home estimated at 40-50.

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Some More Embedded Systems

- Cell Phones, Pagers, TV, VCR, DVD Players, Digital Radios, Video Game Consol all contain embedded microprocessor
- A typical car may contain as many as 65 embedded microprocessors, controlling such tasks as antilock braking, climate control, engine control, audio system control, and airbag deployment
- Even PCs, which are designed around powerful CPUs such as the Intel Pentium III, contain embedded systems

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Product: Hunter Programmable Digital Thermostat.

Microprocessor: 4-bit

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Product:Vendo V-MAX 720 vending machine.

Microprocessor: 8-bit Motorola 68HC11.

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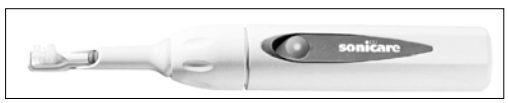
Product: Sonicare Plus toothbrush.

Microprocessor: 8-bit Zilog Z8.



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Product: Miele dishwashers.

Microprocessor: 8-bit Motorola 68HC05.

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Product: NASA's Mars Sojourner Rover.

Microprocessor: 8-bit Intel 80C85.

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Product: CoinCo USQ-712 coin changer.

Microprocessor: 8-bit Motorola 68HC912.

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Product: Garmin StreetPilot GPS Receiver.

Microprocessor: 16-bit.

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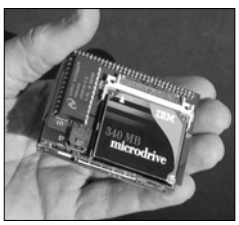

Product: TIQIT Computer's "Matchbox PC".

Microprocessor: 32-bit AMD Elan SC410.

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Product: Palm Vx handheld.

Microprocessor: 32-bit Motorola Dragonball EZ.

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Product: Motorola i1000plus iDEN Multi-Service Digital Phone.

Microprocessor: Motorola 32-bit MCORE.

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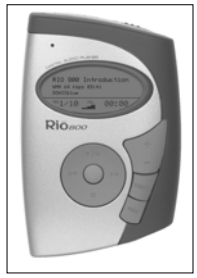

Product: Rio 800 MP3 Player.

Microprocessor: 32-bit RISC.

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Product: RCA RC5400P DVD player.

Microprocessor: 32-bit RISC.

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Product: IBM Research's Linux wrist watch prototype.

Microprocessor: 32-bit ARM RISC.

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Product: Sony Aibo ERS-110 Robotic Dog.

Microprocessor: 64-bit MIPS RISC.

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Future Trends in Embedded System Design

- **Higher Integration**
  - **Microprocessor** : An integrated circuit forms the CPU for embedded controller and uses external circuitry too (E.g. Pentium, AMD K6)
  - **Micro-controller** : A microprocessor plus additional peripheral support devices integrated into a single package (E.g. Motorola Coldfire)
  - **System-on-Chip (SOC)** : A microprocessor plus additional peripheral support devices integrated into a single chip (E.g. Intel StrongARM)
  - **Core based SOC** : Reusable Intellectual Property (IP) circuits or cores are pre-designed and pre-verified functional units (E.g. ARM, PowerPC, DSP)

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Trends in Embedded System Design

- **Hardware and Software Co-Design**
  - **In the past** : Hardware and Software were separate. Lack of a unified hardware-software representation, which leads to difficulties in verifying the entire system, and hence to incompatibilities across the HW/SW boundary
  - **At Present** : Tools available for designing system in a unified framework, with a unified hardware-software representation, so as to prejudice neither hardware nor software implementation

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Trends in Embedded System Design

- **Design Flow Maturity**
  - Better tools for High Level Language Translation
  - Formal verification, synthesis, and simulation of finite state systems (VIS)
    - System level HW-SW Co-simulation is a way to give designers feedback on their design choices
    - Design Partitioning
    - Hardware and Software Synthesis

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Typical Hardware

Hardware:

- 8 bit Processor or Microcontroller – intel 8051, Motorola 6805, Hitachi…
- 16 bit Processor or Microcontroller – intel 80251, Motorola 68HC12, 68000 ..
- 32 bit Processor or Microcontroller – intel Pentium, Motorola 68332, MP 555
- DSP fixed Point processor- TI 5X, 6871..
- DSP floating Point Processor- TI C4X, 6X..
- DRAM, EPROM, Flash, SRAM- memory
- Field Programmable Gate Array - FPGA – An Array of Logic Gates - Xilinx

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Typical Software

Software:

RTOS- Real Time Operating System

- Windows CE
- Linux- RT Linux
- Code Composer Studio (normally in DSPs)
- Palm OS
- VxWorks
- pSOS

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Software: Languages

- C,
- C++
- Java
- Assembly
- ADA

Tools

- UML
- IDE – Integrated Development Environment

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➢ **Automotive Embedded Systems**

- Transmission Controller
- Engine Controller
- Chasis Controller
- Environment Control Unit
- Power Steering Controller
- Entertainment Control Unit
- Torque Controller
- CAN network Analysis

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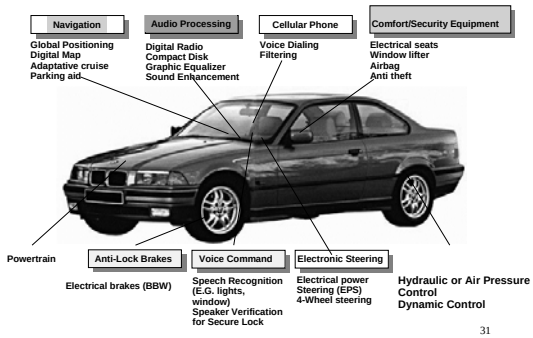
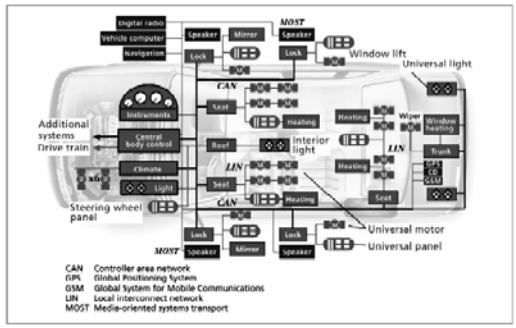
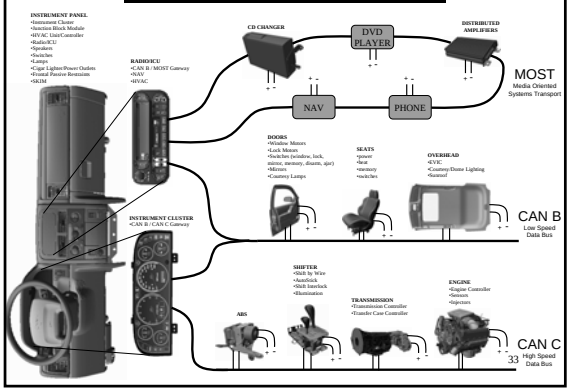
Automotive Embedded Applications



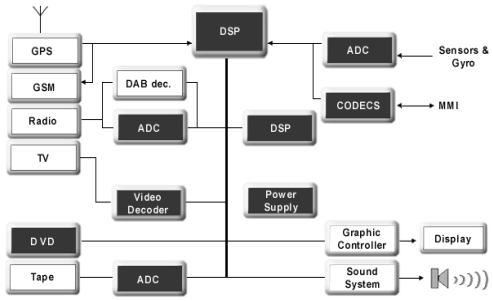


Future Electronic Architecture



Object Layer - Message Filtering - Message and Status Handling
Transfer Layer - Fault Confinement - Error Detection and Signaling - Message Validation - Acknowledgment - Arbitration - Message Framing - Transfer Rate and Timing
Physical Layer - Signal Level and Bit Representation - Transmission Medium

Car Multimedia



Design Goal: Reliability

- Mission Critical
- Life-Threatening
- 24/7/365
- Can't reboot!

Design Goal: Performance

- Multitasking and Scheduling
- Optimized I/O ➔ Assembly Language
- Limits, Inaccuracies of Fixed Precision

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Design Goal: Cost

- Consumer Market: Minimize Manufacturing Cost.
- Fast Time to Market Required
- No chance for future modification.

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What is a Real-Time System?

- Real-time systems must process events before the deadline.
- Events occurring on external inputs cause other events to occur as outputs.
- Minimizing response time is usually a primary objective, or otherwise the entire system may fail to operate properly.

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Hard/Soft Real-Time Systems

- **Soft Real-Time System**
  - Compute output response as fast as possible, but no specific deadlines that must be met.
- **Hard Real-Time System**
  - Output response must be computed by specified deadline or system fails.

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Multi-Tasking and Concurrency

- Most real-time systems are also embedded systems w/several inputs and outputs and multiple events occurring independently.
- Separating tasks simplifies programming, but requires somehow switching back and forth among the three task (*multi-tasking*).
- *Concurrency* is the appearance of simultaneous execution of multiple tasks.

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Three Concurrent Tasks Within a Programmable Thermostat

```
/* Monitor Temperature */
do forever {
    measure temp ;
    if (temp < setting)
        start furnace ;
    else if (temp >
            setting + delta)
        stop furnace ;
}
```

```
/* Monitor Time of Day */
do forever {
    measure time ;
    if (6:00am)
        setting = 72°F ;
    else if (11:00pm)
        setting = 60°F ;
}
```

```
/* Monitor Keypad */
do forever {
    check keypad ;
    if (raise temp)
        setting++ ;
    else if (lower temp)
        setting-- ;
}
```

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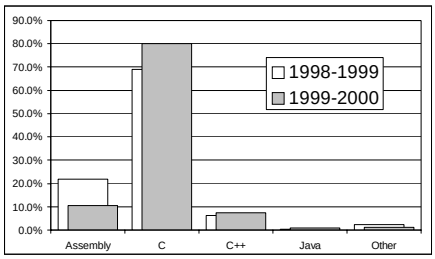
Programming Languages Used in New Embedded Designs



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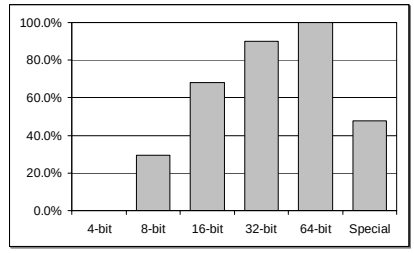
Use of Real-Time Kernels in New Embedded Designs.



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Examples of Embedded Real-Time Software.

Property	*FAX Machine*	*CD Player*
Microprocessor:	16-bit	8-bit
Number of Threads:	6	9
Read-Write Memory (RAM):	2048 Bytes	512 Bytes
Total RAM Actually Used:	1346 Bytes (66%)	384 Bytes (75%)
Amount Used by Kernel:	250 Bytes (19%)	146 Bytes (38%)
Read-Only Memory (ROM):	32.0 KB	32.0 KB
Total ROM Actually Used:	28.8 KB (90%)	17.8 KB (56%)
Amount Used by Kernel:	2.5 KB (8.7%)	2.3 KB (13%)

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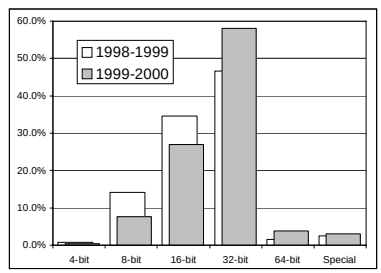
Processor Types Used in New Embedded Designs



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More on Future of

Embedded Systems

•New and Novel Embedded Applications- e.g. Electric Power Steering, Refrigerator connected to internet….

•New Technology- e.g. RFID, Bluetooth, DSP, FPGA

•Low Power, Small Size- e.g.Integration of multifunctions Cell phone, organizer, music, internet, eBook

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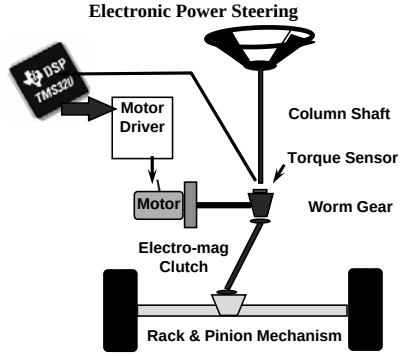
Electronic Power Steering



Setup as in an Automobile

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What is RFID

- RFID is an area of automatic identification that has quietly been gaining momentum in recent years and is now being seen as a radical means of enhancing data handling processes, complimentary in many ways to other data capture technologies such bar coding.

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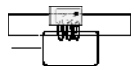
- Inductive Coupling



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Propagation Coupling

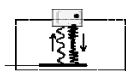

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Table 1. Frequency Bands and Applications

- Frequency BandCharacteristicsTypical Applications

Low 100-500 kHzShort to medium read range
-Inexpensive
-low reading speed- for Access control

Animal identification, Inventory control, Car immobiliserIntermediate
10-15 MHzShort to medium read range
potentially inexpensive
medium reading speedAccess control

Smart cardsHigh
850-950 MHz
2.4-5.8 GHzLong read range
High reading speed
Line of sight required

ExpensiveRailroad car monitoring
Toll collection systems

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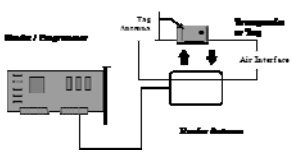
RFID system component



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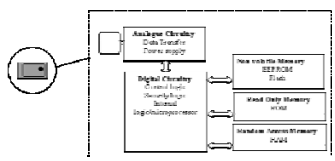
RFID System Transponder



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Case Study- Farmington Library

- Farmington Library has 74000 sqft with many books, CDs, Magazines, videos, paperbacks, reference books etc.
- A 14 digit barcode is printed using SATO CL480 thermal transfer printer on a white film label with library name and logo. It is affixed on the RFID tag on the inside of the book cover.

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Case Study- continued

- RFID reader connected to Library Computer System. The tag is turned off.
- When the book passes through the exit reader, the inventory data base is updated with “title of the book, to whom issued, date, and due date etc”.
- 30 to 40% faster to check out or verify.
- Inventory of books is easy. Just walk around the shelf with RFID wand, and the inventory is done.

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Applications

Principal areas of application for RFID that can be currently identified include:

- Transportation and logistics
- Manufacturing and Processing
- Security

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Applications- Continued

A range of miscellaneous applications may also be distinguished, some of which are steadily growing in terms of application numbers. They include:

- Animal tagging
- Waste management
- Time and attendance
- Postal tracking
- Airline baggage reconciliation
- Road toll management

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Some of the more prominent specific applications include:

Some of the more prominent specific applications include:

- Electronic article surveillance - clothing retail outlets being typical.
- Protection of valuable equipment against theft, unauthorised removal or asset management.
- Controlled access to vehicles, parking areas and fuel facilities - depot facilities being typical.
- Automated toll collection for roads and bridges - since the 1980s, electronic Road-Pricing (ERP) systems have been used in Hong Kong.
- Controlled access of personnel to secure or hazardous locations.

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•Time and attendance - to replace conventional "slot card" time keeping systems.

•Animal husbandry - for identification in support of individualised feeding programmes.

•Automatic identification of tools in numerically controlled machines - to facilitate condition monitoring of tools, for use in managing tool usage and minimising waste due to excessive machine tool wear.

•Identification of product variants and process control in flexible manufacture systems.

•Sport time recording

•Electronic monitoring of offenders at home

•Vehicle anti-theft systems and car immobiliser

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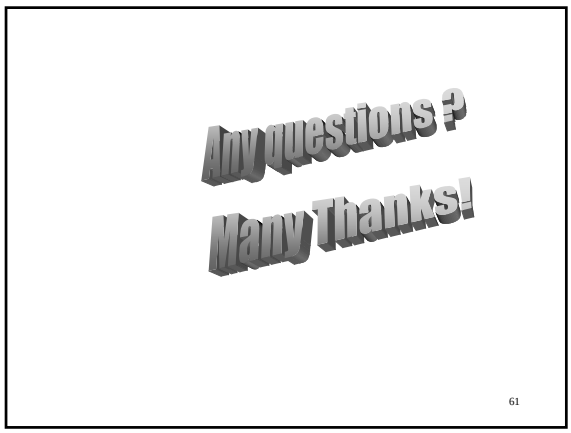
Any questions ?
Many Thanks!
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