ELEC 464 : Microcomputer System Design
Fall 1995

Introduction to Microprocessor Systems

The Microprocessor System

A *microprocessor* is an integrated circuit (IC) that contains all of the logic components of a computer except for memory and input/output (I/O) devices. This course is mainly concerned with connecting memory and I/O ("interface") devices to a microprocessor chip so as to form a complete *microcomputer* system.

Exercise: An ad in computer magazine describes a computer system as having a "486DX2-66 CPU, 4 MB RAM, and 540 MB HD". What parts of the microcomputer system do these specifications refer to?

For various reasons, memory and I/O devices can seldom be connected directly to the microprocessor. The logic required to interface the CPU (microprocessor) to the I/O and memory devices is often called *glue logic*. A large part of this course is devoted to the design of such digital circuits.

The amount of additional logic varies from none in the case of *microcontrollers* (microprocessors that contain on-chip memory and i/o devices) to interfaces that are as complex as the microprocessor itself.

Buses

A *bus* is a related group of signals. Microprocessor systems involve many types of buses. At the lowest level the address and data pins on the CPU chip itself form the *processor bus*. Many microprocessor systems also allow for expansion by using a *system bus* that allow peripherals and memory to be placed on physically separate PC cards. Peripherals external to the computer (such as disk drives) are connected to computer system using a *peripheral bus* such as the SCSI (Small Computer Systems Interface) bus.

These buses are often further divided into smaller buses. For example, the processor bus usually contains a data bus and an address bus.

Exercise: The same ad talks about "PCI motherboard, EIDE hard drive, plus serial, parallel and game ports." What types of buses do these refer to? How about the VME bus? the "address" bus?

Common Interface Circuits

This section lists some of the more common functions required to interface the microprocessor and its peripheral chips. We will cover these functions in more detail later in the course.

Clocks

Microprocessors use a fixed frequency

clock to synchronize the operation of their internal logic. This clock signal is usually generated by a quartz-crystal controlled oscillator.

Reset Circuit

The processor must be initialized to a known state when power is first applied or when the system "crashes." Most microprocessors require external circuits to detect the power-on condition or external resets.

Buffers

In complex systems the microprocessor pins must supply (or sink) more current than the microprocessor chip's electrical specifications allow. Special ICs called *buffers, bus drivers* or *transceivers* are used as a "buffer" between the microprocessor and the rest of the circuitry.

Address Decoders

Since microprocessors can usually address more memory than an individual memory chips contains, there has to be external logic to select the appropriate memory chip for a given address. This logic is called address decoding.

Latches

Microprocessors often reduce the number of pins required on the chip by using the same pin for two purposes, such as using the same pin alternately as part of the address bus and then as part of the data bus. An external chip (a latch) is required to temporarily hold the address bus value.

DRAM Refresh

Dynamic RAM (a particular type of read/write Random-Access Memory) stores data as electric charge in a capacitor. DRAM requires that every memory cell's contents be "refreshed" periodically by recharging the capacitor. The circuitry to do this can be quite complex.

Cache Memory

Many modern microprocessors are able to access RAM memory faster than inexpensive RAM devices can be read or written. Fast auxilliary memories called cache memories are used to store the contents frequently used memory locations and therefore improve the overall performance of the system.

Wait State Generators

Memory and I/O devices often access their data more slowly than the processor needs it. Special circuits are required to force the processor to "wait" one or more clock cycles until the memory or I/O device is ready to be read or written.

Interrupt Controllers

Devices that require immediate attention can interrupt a program's normal flow of control by forcing low an *interrupt* pin on the microprocessor. When a system has several sources of interrupts it is useful to be able to distinguish between them and to ensure that higher-priority interrupts are recognized first.

Bus Arbitration

Buses in relatively complex systems such as PCs are often shared between the microprocessor and peripherals. This DMA (Direct Memory Access) arrangement allows peripherals to directly access memory or other peripherals on the bus. Special logic is required to ensure that only one device uses the bus at the same time.

Exercise: A PC is composed of a motherboard containing the microprocessor, and two plug-in PCB (printed circuit board) cards, one a memory card and the other a high-performance SCSI i/o card. Which of the above circuits would we likely find on each card?