Introduction to Embedded Systems

Hardware Elements in the Embedded Systems

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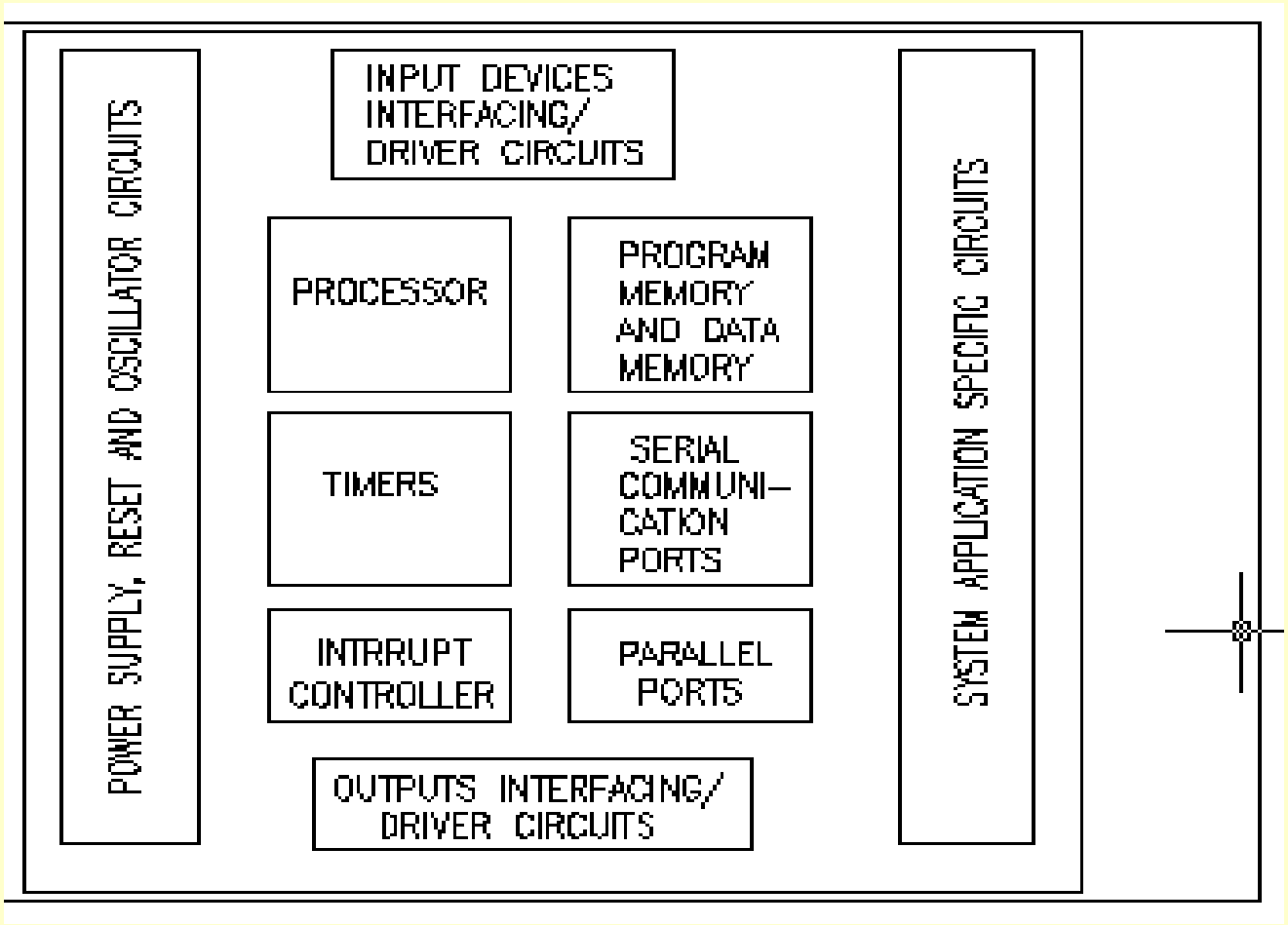
2. Basic Circuit Elements at the System

Typical Embedded System Hardware elements



Power Source and Managing the Power Dissipation and Consumption

- Most systems have a power supply of their own
- Embedded system operate in one of the following four operation ranges:

I. 5.0V ± 0.25V

II. 3.3V ± 0.3V

III. 2.0V ± 0.2V

IV. 1.5V ± 0.2V

Additionally, a 12V ± 0.2V supply is needed for a flash (a memory form used in digital cameras) or EEPROM

Contd…

- Flow of voltage in to the ES (chip) and the connections depend on the number of supply pins provided within the processor plus the pins in the associated chips and circuits

(i) Power Source

1. System own supply with separate supply- rails for the IOs, clock, basic processor and memory and analog units, or
2. Supply from a system to which the embedded system interfaces, for example in a network card, *or*
3. Charge pump concept used in a system of little power needs, for examples, in the mouse or contact-less smart card.

Power supply

- A power supply source or a charge pump is essential in every system
- Charge pumps – made up of a circuit of diode and capacitor that accumulate charge from the bus signals through which they connect or network to the host

Power Dissipation Management Element

1. Clever real-time programming by Wait and Stop instructions
2. Clever reduction of the clock rate during specific set of instructions
3. Optimizing the codes and the use of cache enable/disable

Clock Oscillator Circuit, Clocking Units

- Clock controls the time for executing an instruction
- After the power supply, the clock is the basic unit of a system
- A processor needs a clock oscillator circuit
- Clock controls the various clocking requirements of the CPU and the CPU machine cycles

(ii) Clock Oscillator Circuit, Clocking Units

1. Appropriate clock oscillator circuit
2. Real Time Clock*(System Clock) and Timers, which control the hardware and software

* RTC

System Timers and Real-time Clocks

- To schedule the various tasks and for real-time programming, an RTC or system clock is needed.
- Clock also drives the timers for various timing and counting needs in a system

(iii) Reset Circuit

1. Power-up Reset
2. External and Internal Reset
3. Watchdog timer timeout reset

(Ref: Section 1.3.4 pp.19 for details)

Reset

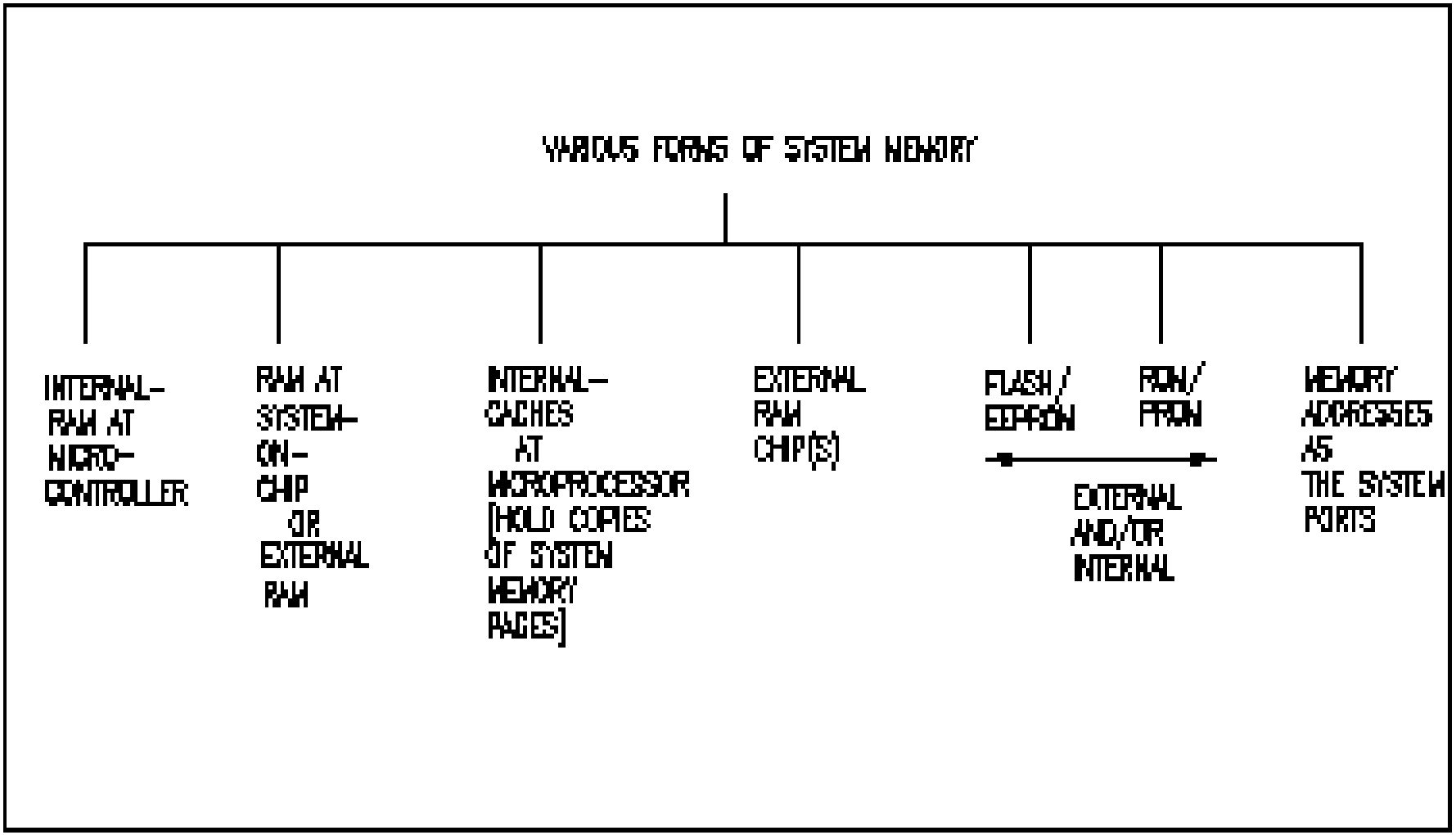
- When a program executes the program counter increments or changes. An important circuit that associates a system is its reset circuit that can change the program counter to a power-up default value.
- A program that is reset and runs on a power-up can be one of the following:

Reset

- i) A system program that executes from the beginning
- ii) A system boot-up program
- iii) A system initialization program

- The watchdog timer reset is a required feature in control applications (Page 12)

(iv) Memory


VARIOUS FORMS OF SYSTEM MEMORY
INTERNAL– RAM AT MICRO– CONTROLLER
RAM AT SYSTEM– ON– CHIP OR EXTERNAL RAM
INTERNAL– CACHES AT MICROPROCESSOR (HOLD COPIES OF SYSTEM MEMORY PAGES)
EXTERNAL RAM CHIP(S)
FLASH / EEPROM
RAM/ PROM
EXTERNAL AND/OR INTERNAL
MEMORY ADDRESSES AS THE SYSTEM PORTS

a. Functions Assigned to the ROM or EPROM

1. Storing Application program from where the processor fetches the instruction codes
2. Storing codes for system booting, initializing, Initial input data and Strings.
3. Storing Codes for RTOS. Pointers (addresses) of various service routines.

b. Functions Assigned to the Internal, External and Buffer RAM

1. Storing variables during program run,
2. Storing stacks,
3. Storing input or output buffers for example, for speech or image

c. Functions Assigned to the EEPROM or Flash

Storing non-volatile results of processing.

d. Functions Assigned to the Memory Sticks

Storing non-volatile database or results of processing for example. songs, images, videos,..

e. Functions Assigned to the Caches

1. Storing copies of the instructions, data and branch-transfer instructions in advance from external memories during their processing and
2. Storing temporarily the results in write back caches during fast processing

(v) Interrupts Handler

Interrupt Handling element for the external port interrupts, IO interrupts, timer and RTC interrupts, software interrupts and exceptions

(Ref: Section 1.3.7 pp.22 for details)

(vi) Linking Embedded System Hardware

Linking and interfacing circuit* for the Buses by using the appropriate multiplexers, and decoders, demultiplexers Interface the various system units

(Also called glue circuit, Ref: Section 1.3.13 pp.25 for details)

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3. IO Communication Unit

a. Communication Driver(s): Network Ethernet or serial driver to communicate with host embedded system Expansion Facility …

Serial Bus(es): For example, UART (512 kbaud/s), 1-wire CAN (33 kbps), Industrial I^2C (100kbps), SM I^2C Bus (100 kbps), SPI (100 kbps), Fault tolerant CAN (110 kbps), Serial Port (230 kbps), MicroWire (300 kbps), …

SCSI parallel (40 Mbps), Fast SCSI (8M to 80 Mbps) , Ultra SCSI-3 (8M to 160 Mbps), FireWire/IEEE 1394 (400 Mbps, 72 meter), High Speed USB 2.0 (480 Mbps, 25 meter)

Parallel Bus(es): PCI, PCI-X

b. Media IO Control Element

c. Keypad or Keyboard IO Interface
d. LCD Display System Interface
e. ADC – Single or Multi channel
f. DAC
g. Wireless LAB 802.11
h. Pulse Dialing Element
i. Modem
j. Bluetooth
k. Zigbee

Required Hardware Elements in a System

- *Refer Section 1.3.14 and Table 1.5 for examples of required elements in exemplary systems*

Summary

We learnt that the hardware elements after the processor(s) are:

Basic circuit elements: power source, clock, reset, timers, interrupt-handler, memories, glue circuit for the elements linking and interfacings, …

- IO communication elements: buses (serial and parallel), interfaces for the keypad, LCD display matrix, network interface, ADC, DAC, pulse dialer, modem … as per the application

End of the Lesson - 3