

Embedded systems

- there are many times an IBM-PC is an overkill solution
- an IBM-PC is a general purpose computer, sometimes a more specific computer is cost effective
- a specific computer executing a specific operating system might be the solution and in a minimal case we might choose to use an embedded operating system
 - or embedded system if we include the application

Characteristics of an embedded system

- these systems can be tiny
 - could be < 1KBytes

- only use software which you need
 - for example many times it is possible to implement an embedded system using no interrupts
 - choice, it might be
 - easier to implement
 - guarantee a hard realtime performance for time critical applications

Case examples: embedded systems built using the ATmega328p

- we will look at building a basic computer running a tiny embedded system
 - flashing LED program

- many, many other examples in which the ATmega328p can be used
 - network on/off switch
 - cruise controller for an electric bicycle
 - amplifier controller
 - tiny web server and LCD panel
 - Arduino!

Why use ATmega processors?

- support within gcc is mature (it has supported ATmega microprocessors for about two decades)
 - the ATmega series of microprocessors have very similar instructions
- harvard risc architecture

Atmel ATMega series of microprocessors

- the number of components to make a minimal system is tiny
- they are also extremely easy to interface to peripherals
 - A->D, D->A, pwm (servo and motor control) etc
 - multiple hardware timers etc

Atmel 328p

- is an 8-bit AVR RISC-based microcontroller (some of its features include):
 - 32KB flash memory
 - 1024B EEPROM, 2KB SRAM

- 23 general purpose I/O lines
 - 32 general purpose working registers
 - three flexible timer/counters with compare modes
 - internal/external interrupts, a 6-channel 10-bit A/D converter
 - programmable watchdog timer with internal oscillator
 - 2 PWM channels (ie control two servos) in hardware

- many features omitted for sake of brevity

Simple computer flashing a LED with the ATmega328p



Code for the flashing LED


```
MODULE flashled ;

PROCEDURE Turn (on: BOOLEAN) ;
BEGIN
    IF on
    THEN
        (* turn LED on *)
        ASM VOLATILE ("cbi 8,5");
    ELSE
        (* turn LED off *)
        ASM VOLATILE ("sbi 8,5");
    END
END Turn ;

(*
    InitLed - initialize pin 0 as an output
*)

PROCEDURE InitLed ;
BEGIN
    ASM VOLATILE ("sbi 7,5")
END InitLed ;
```



Code for the flashing LED



```
CONST
    Delay = 400 ;

VAR
    i, j: CARDINAL ;
```

Code for the flashing LED



```
BEGIN
  InitLed ;
  Turn(FALSE) ;
  LOOP
    FOR i := 0 TO Delay DO
      FOR j := 0 TO Delay DO
        ASM VOLATILE ("nop")
      END
    END ;
    Turn(TRUE) ;
    FOR i := 0 TO Delay DO
      FOR j := 0 TO Delay DO
        ASM VOLATILE ("nop")
      END
    END ;
    Turn(FALSE)
  END
END flashed.
```

Cruise controller for an electric bicycle

- uses PWM device to control the power delivered to the electric motor
- uses a A to D device to take input from the throttle (potentiometer)
- uses several output pins to control status LEDs
- uses input pins for wheel movement sensing
- due to the hardware support inside the Atmega328p the software is extremely simple
 - no need for interrupt service routines
 - no need for separate processes

Amplifier control embedded system

- uses the Atmega328p to
 - turn on the +-12v power
 - turn on the +-9v power
 - connect the speakers after 2 seconds (speaker protection)
 - uses the A to D device to take input from a potentiometer to select input source

Amplifier control embedded system

- uses input lines to detect push button
 - three pulses turns it off
 - two pulses turns off the speakers
 - one pulse resets the power save timer

- software is a simple C program which controls hardware directly

Conclusion

- embedded systems come in many sizes and the examples given here are tiny applications
- embedded systems might range up to and including the Linux kernel (with various scheduling and device driver changes)