



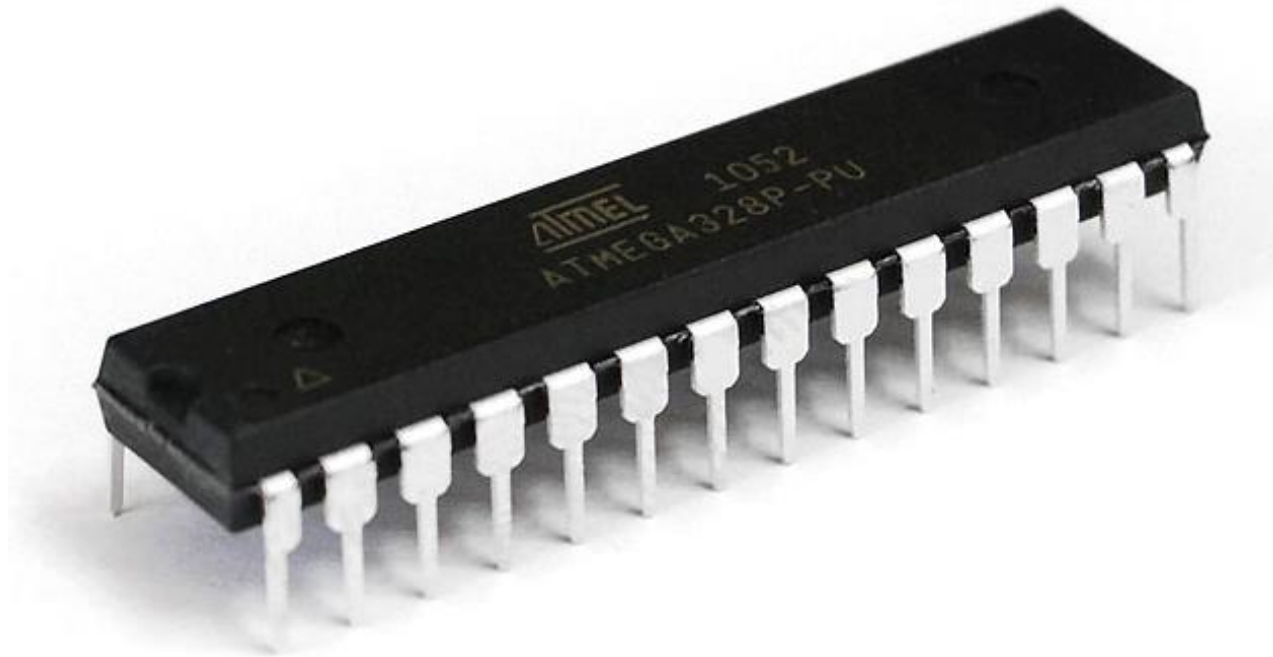
University of Dar es Salaam

Arduino Target Processor (ATmega 328)



University of Dar es Salaam

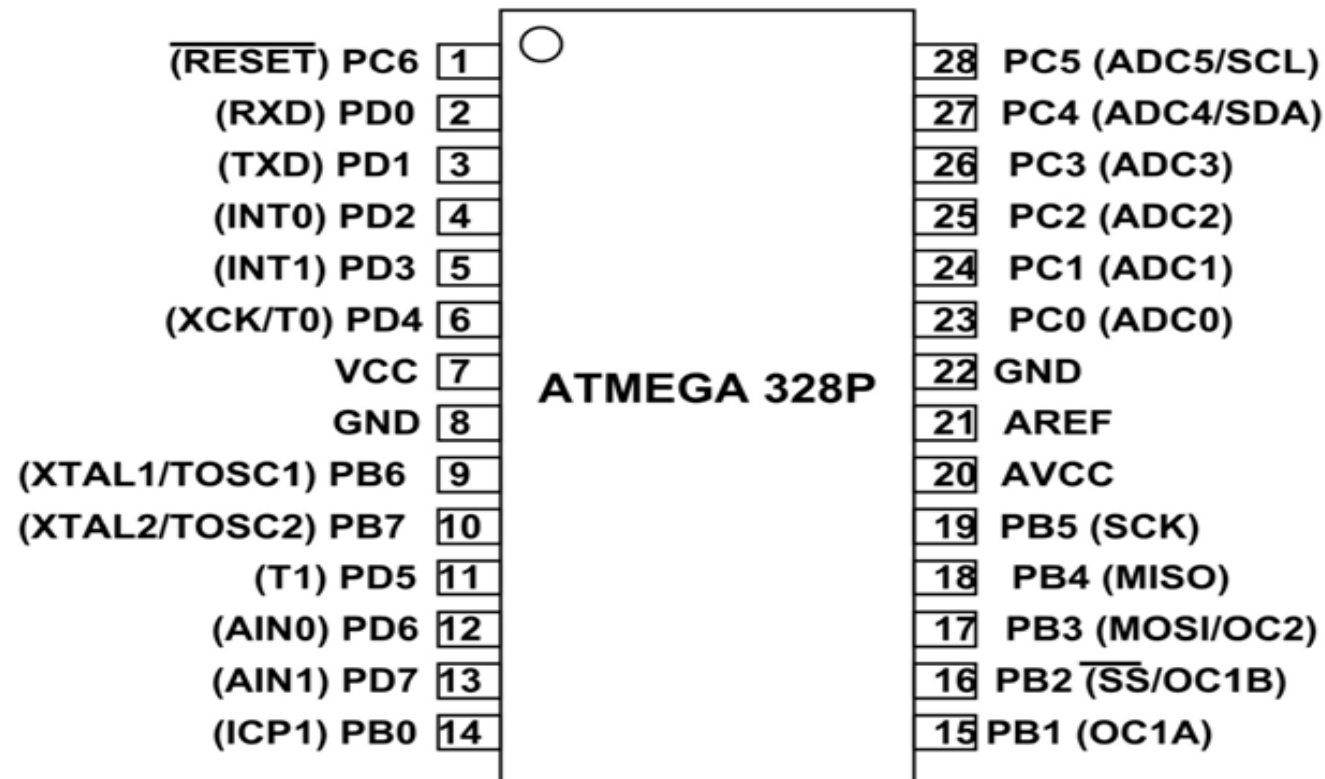
Physical structure





University of Dar es Salaam

Pinout Diagram





University of Dar es Salaam

- The ATmega328 is a low-power CMOS 8-bit microcontroller based on AVR enhanced RISC (Reduced Instruction Set Computer) architecture.
- In order to maximize performance and parallelism, it uses Harvard architecture.
- It belongs to AVR family of microcontrollers.
- AVR stands for Advanced Virtual RISC (RISC stands for Reduced Instructions Set Computers).
- AVR executes most of the instructions in single execution cycle, They consume less power and they can be designed to operate in different power saving modes.

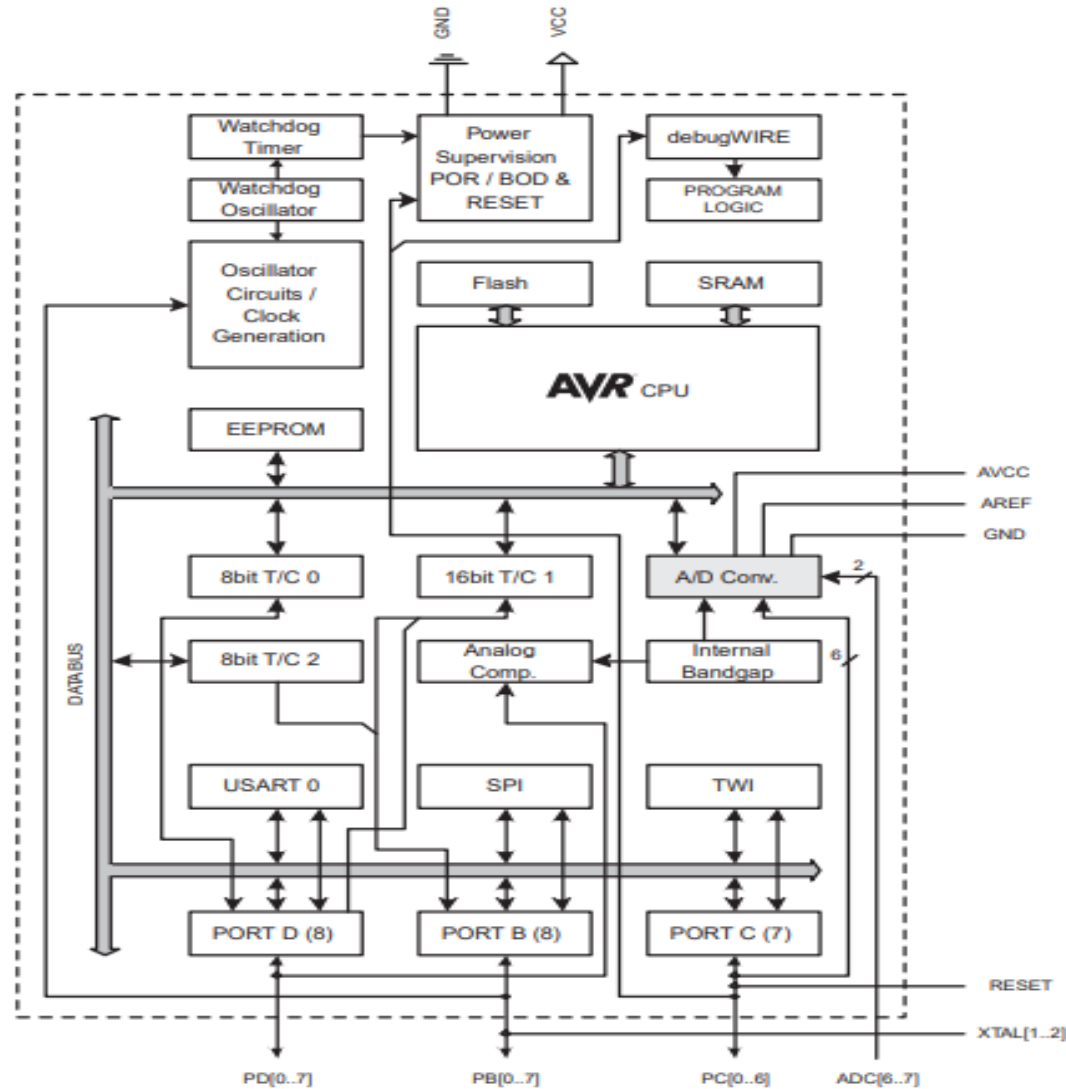


ATMEGA 328 ARCHITECTURE

- Simply, Arduino's processor uses the Harvard architecture where the program code and program data have separate memory.
- It consists of two memory namely **Flash memory (program memory)** and **Data memory**.
- The code is stored in the flash memory, whereas the data is stored in the data memory.
- The Harvard architecture allows more than one memory transaction simultaneously through the use of two memory spaces.



University of Dar es Salaam





University of Dar es Salaam

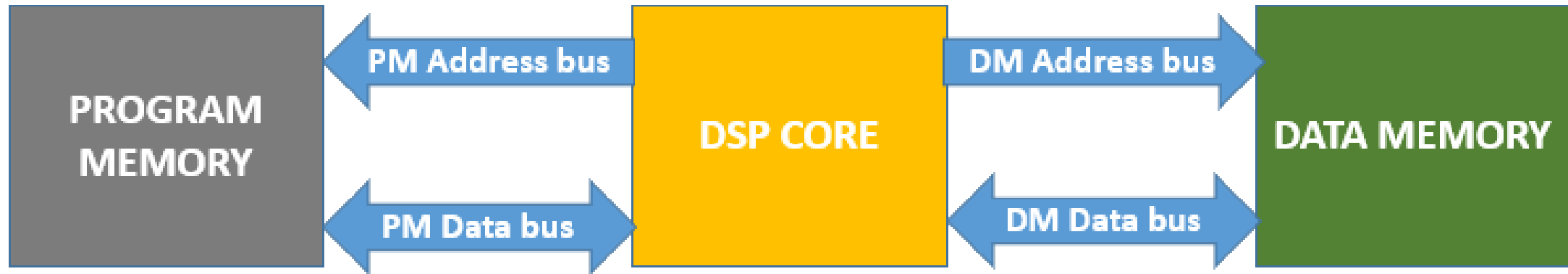
ATMEGA 328 Architecture cont...

- In the Harvard architecture the un-occupied data memory cannot be used by instructions and the free instructions cannot be used by data.
- Memory dedicated to each unit has to be balanced carefully.
- Harvard architecture is primarily for small embedded systems and signal processing.
- A Harvard architecture system can be thus faster for a given circuit complexity because instruction fetches and data access do not contend for a single memory pathway.
- Also the Harvard architecture has distinct code and data address spaces meaning address zero is not the same as data address zero.



University of Dar es Salaam

Harvard Architecture block diagram





University of Dar es Salaam

AVR microcontrollers categories

- There are three categories namely TinyAVR, MegaAVR and XMegaAVR
- MegaAVR are the most popular ones having good amount of memory (upto 256KB), higher number of inbuilt peripherals and suitable from moderate to complex applications.
- The naming convention of the AVR is such that, taking ATmega328, the "AT" stands for ATMEL the manufacturer, the "mega" means that the microcontroller belong to the MegaAVR category and "32" signify the memory of the microcontroller which is 32KB and the "8" signify the system type which is 8-bit



University of Dar es Salaam

Arduino UNO ATmega328 Features

- The operating voltage ranges from 1.8V to 5.5V (normally it operates in a range of 3.3V to 5.5V)
- Many arduino boards operate at 5V but some of the newer cards operates at 3.3V.
- It is an 8 – bit and 28 pins AVR microcontroller, 32KB of flash memory, 1KB of EEPROM, 2KB of SRAM, 8 pins for ADC operations, 3 built-in timers (2 are 8-bit timers, 1 is a 16-bit timer) and 6 PWM pins.
- It has both general purpose registers and special purpose registers.



University of Dar es Salaam

- An electronic register is a form of memory that uses a series of flip flops to store the individual bits of a binary word.
- The general purpose registers do not have side effects, they can be used by most instructions. One can do arithmetics with them, use them for memory addresses and so on.
- Special purpose registers can only be used for certain purposes and only by certain instructions.
- A timer is a control device that outputs a signal at a present time after an input signal is received.
- A counter is a device which stores the number of times a particular event or process has occurred (often in relationship to a clock).



University of Dar es Salaam

ATMega328P and Arduino Uno Pin Mapping

Arduino function			Arduino function		
reset	(PCINT14/RESET) PC6	1	28	PC5 (ADC5/SCL/PCINT13)	analog input 5
digital pin 0 (RX)	(PCINT16/RXD) PD0	2	27	PC4 (ADC4/SDA/PCINT12)	analog input 4
digital pin 1 (TX)	(PCINT17/TXD) PD1	3	26	PC3 (ADC3/PCINT11)	analog input 3
digital pin 2	(PCINT18/INT0) PD2	4	25	PC2 (ADC2/PCINT10)	analog input 2
digital pin 3 (PWM)	(PCINT19/OC2B/INT1) PD3	5	24	PC1 (ADC1/PCINT9)	analog input 1
digital pin 4	(PCINT20/XCK/T0) PD4	6	23	PC0 (ADC0/PCINT8)	analog input 0
VCC	VCC	7	22	GND	GND
GND	GND	8	21	AREF	analog reference
crystal	(PCINT6/XTAL1/TOSC1) PB6	9	20	AVCC	VCC
crystal	(PCINT7/XTAL2/TOSC2) PB7	10	19	PB5 (SCK/PCINT5)	digital pin 13
digital pin 5 (PWM)	(PCINT21/OC0B/T1) PD5	11	18	PB4 (MISO/PCINT4)	digital pin 12
digital pin 6 (PWM)	(PCINT22/OC0A/AIN0) PD6	12	17	PB3 (MOSI/OC2A/PCINT3)	digital pin 11 (PWM)
digital pin 7	(PCINT23/AIN1) PD7	13	16	PB2 (SS/OC1B/PCINT2)	digital pin 10 (PWM)
digital pin 8	(PCINT0/CLKO/ICP1) PB0	14	15	PB1 (OC1A/PCINT1)	digital pin 9 (PWM)

Digital Pins 11, 12 & 13 are used by the ICSP header for MOSI, MISO, SCK connections (Atmega168 pins 17, 18 & 19). Avoid low-impedance loads on these pins when using the ICSP header.



University of Dar es Salaam

