

2. ATmega328P Hardware & Memory Architecture

A. Memory Map

The ATmega328P memory map provides information on how the Microcontroller Unit (MCU) uses memory. Here is the address division:

Category	Address	Size	Description
General Purpose Registers	0x0000 - 0x001F	32 x 8 bit	Registers R0 - R31
I/O Registers	0x0020 - 0x005F	64 x 8 bit	Accessible via IN / OUT instructions
Extended I/O Registers	0x0060 - 0x00FF	160 x 8 bit	Additional I/O registers
Internal SRAM	0x0100 - 0x08FF	2048 x 8 bit	Internal data memory

B. General Purpose Working Registers (GPR)

The AVR architecture has **32 general-purpose registers** labeled **R0** through **R31**. These registers function as temporary storage for data during processing and are directly connected to the ALU (Arithmetic Logic Unit).

Register Division:

Group	Registers	Characteristics
Lower Registers	R0 - R15	Limited functionality. Cannot store immediate values directly (cannot use LDI instruction).
Upper Registers	R16 - R31	More flexible. Can work with immediate data, allowing direct storage of bytes or words.

Pointer Registers:

The last six registers (R26 through R31) can be combined into 16-bit pointers for indirect memory addressing:

Pointer Name	Low Register	High Register	Function
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X Register	R26 (XL)	R27 (XH)	Pointer for memory access
Y Register	R28 (YL)	R29 (YH)	Pointer for memory access
Z Register	R30 (ZL)	R31 (ZH)	Pointer for memory & flash access

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