Microprocessors and Micro-controllers

Class 3

8085 System Bus

Typical system uses a number of buses, collection of wires, which transmit binary numbers, one bit per wire. A typical microprocessor communicates with memory and other devices (input and output) using three buses: Address Bus, Data Bus and Control Bus.

Address Bus

- The 16-bit Address Bus consists of 16 wires. A 16 bit binary number allows 2^{16} different numbers, or 65,536 (=64 KB) different numbers. Because memory consists of boxes, each with a unique address, the size of the address bus determines the size of memory, which can be used. So a 16-bit address bus can access 64K different locations in the RAM.
- To communicate with memory the microprocessor sends an address on the address bus, eg 0000000000000011 (3 in decimal), to the memory. The memory then selects box number 3 for reading or writing data.
- Address bus is unidirectional, i.e. numbers can only be sent from microprocessor to memory, not the other way.

> ***Q: If you have a memory chip of size 256 kilobytes (256 x 1024 x 8 bits), how many wires does the address bus need, in order to be able to specify an address in this memory? Note that the memory is organized in groups of 8 bits per location, therefore, how many locations must you be able to specify?***
>
> *To Address 256 KB memory locations, we can calculate 256 KB = 2^18 bytes.*
> *A computer is generally made in byte-addressable format, i.e., one bit in a logical address can be used to denote 1 Byte of physical memory address.*
>
> *Thus, if we go by byte addressable format, we get -->log (base 2) 2^18 = 18.*
>
> *Thus, 18 bits are needed for the logical address to be specified.*
> *Therefore 18 physical wires could be used to create the bus.*

Data Bus

- Data Bus carries 'data', in binary form, between **µP** and other external units, such as memory. It has a typical size of 8 or 16 bits.
- The Data Bus typically consists of 8 wires. Therefore, 2^8 combinations of binary digits. Data bus is used to transmit "data", i.e. information, results of arithmetic operation, etc, between memory and the microprocessor.
- Bus is bi-directional. If it is only 8 bits wide, then largest number is 11111111 (255 in decimal). Therefore, larger number have to be broken down into chunks of 255. This slows microprocessor.

- Data Bus also carries instructions from memory to the microprocessor. Size of the bus therefore limits the number of possible instructions to 256, each specified by a separate number.

Control Bus

- Control Bus are various lines which have specific functions for coordinating and controlling **µP** operations.
- e.g. Read and Write lines carries a single binary digit to Controls whether memory is being 'written to' (data stored in memory) or 'read from' (data taken out of memory).
- It may also include clock line(s) for timing/synchronizing, 'interrupts', 'reset' etc. Typically **µP** has 10 control lines and it cannot function correctly without these vital control signals.
- Modern day microprocessors, like 80386, 80486 have much larger buses. Typically 16 or 32 bit buses, which allow larger number of instructions, more memory location, and faster arithmetic.
- Micro-controllers are organized along same lines, except that the buses may all be internal because micro-controllers have memory etc inside the chip.
- In the microprocessor the three buses are external to the chip (except for the internal data bus). In case of external buses, the chip connects to the buses via buffers, which are simply an electronic connection between external bus and the internal data bus.

History of Microprocessor

MP	Introduction	Data Bus	Address Bus
4004	1971	4	8
8008	1972	8	8
8080	1974	8	16
8085	1977	8	16
8086	1978	16	20
80186	1982	16	20
80286	1983	16	24
80386	1986	32	32
80486	1989	32	32
Pentium	1993 onwards	32	
Core solo	2006	32	
Dual Core	2006	32	
Core 2 Duo	2006	32	
Core to Quad	2008	32	
I3,i5,i7	2010	64	

- The figure above shows how the size of the data bus and the address bus has improved, in terms of number of bits, so as to increase the performance of microprocessors, since its inception in 1971, till date.