16-bit

In computer architecture, **16-bit** integers, memory addresses, or other data units are those that are 16 bits (2 octets) wide. Also, 16-bit CPU and ALU architectures are those that are based on registers, address buses, or data buses of that size. 16-bit microcomputers are computers in which 16-bit microprocessors were the norm.

A 16-bit register can store 2^{16} different values. The signed range of integer values that can be stored in 16 bits is −32,768 (-1×2^{15}) through 32,767 ($2^{15} - 1$); the unsigned range is 0 through 65,535 ($2^{16} - 1$). Since 2^{16} is 65,536, a processor with 16-bit memory addresses can directly access 64 KB (65,536 bytes) of byte-addressable memory. If a system uses segmentation with 16-bit segment offsets, more can be accessed.

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16-bit architecture

The MIT Whirlwind (c. 1951)[1][2] was quite possibly the first-ever 16-bit computer. Other early (c. 1965–70) 16-bit computers include the IBM 1130,[3] the HP 2100,[4] the Data General Nova,[5] and the DEC PDP-11.[6] Early (c. 1973–75) multi-chip 16-bit microprocessors include the National Semiconductor IMP-16 and the Western Digital MCP-1600. Early (c. 1975–76) single-chip 16-bit microprocessors include the Panafacom MN1610,[7][8] National Semiconductor PACE, the HP BPC, and the TI TMS9900. Other notable 16-bit processors include the Intel 8086, the Intel 80286, the WDC 65C816, and the Zilog Z8000. The Intel 8088 was binary compatible with the Intel 8086, and was 16-bit in that its registers were 16 bits wide, and arithmetic instructions could operate on 16-bit quantities, even though its external bus was 8 bits wide.

A 16-bit integer can store 2^{16} (or 65,536) distinct values. In an unsigned representation, these values are the integers between 0 and 65,535; using two's complement, possible values range from −32,768 to 32,767. Hence, a processor with 16-bit memory addresses can directly access 64 KB of byte-addressable memory.

16-bit processors have been almost entirely supplanted in the personal computer industry, and are used less than 32-bit (or 8-bit) CPUs in embedded applications.

16/32-bit Motorola 68000 and Intel 386SX

The Motorola 68000 is sometimes called *16-bit* because its internal and external data buses were 16 bits wide; however, it could be considered a 32-bit processor in that the general purpose registers were 32 bits wide and most arithmetic instructions supported 32-bit arithmetic. The 68000 was a microcoded processor with three internal 16-bit ALUs. Only 24 bits of the program counter (PC) were available on original DIP packages, with up to 16 megabytes of addressable RAM. 68000 software is 32-bit in nature and forward-

compatible with other 32-bit processors in the same family.[9] The 68008 was a version of the 68000 with 8-bit external data path and 1 megabyte addressing for the 48-pin DIP version and 4 megabyte for the 52-pin PLCC version. Several Apple Inc. Macintosh models; e.g., LC series, used 32-bit 68020 and 68030 processors on a 16-bit data bus to save cost.

Similar analysis applies to Intel's 80286 CPU replacement called the 386SX which is a 32-bit processor with 32-bit ALU and internal 32-bit data paths with a 16-bit external bus and 24-bit addressing of the processor it replaced.

Intel 16-bit memory models

Just as there are multiple data models for 64-bit architectures, the 16-bit Intel architecture allows for different memory models—ways to access a particular memory location. The reason for using a specific memory model is the size of the assembler instructions or required storage for pointers. Compilers of the 16-bit era generally had the following type-width characteristic:

16-bit data model

Data model	short	int	long	Pointers
IP16L32 (near)	16	16	32	16
I16LP32 (far)	16	16	32	32

Tiny
> Code and data will be in the same segment (especially, the registers CS, DS, ES, SS will point to the same segment); *near* (16-bit) pointers are always used. Code, data and stack together cannot exceed 64 KB.

Small
> Code and data will be in different segments, and near pointers are always used. There will be 64 KB of space for code and 64 KB for data/stack.

Medium
> Code pointers will use *far* pointers (16:16 bit), enabling access to 1 MB. Data pointers remain to be of the near type.

Compact
> Data pointers will use far and code will use near pointers.

Large/huge
> Code and data pointers will be far.[10]

16-bit application

In the context of IBM PC compatible and Wintel platforms, a 16-bit application is any software written for MS-DOS, OS/2 1.x or early versions of Microsoft Windows which originally ran on the 16-bit Intel 8088 and Intel 80286 microprocessors. Such applications used a 20-bit or 24-bit segment or selector-offset address representation to extend the range of addressable memory locations beyond what was possible using only 16-bit addresses. Programs containing more than 2^{16} bytes (65,536 bytes) of instructions and data therefore required special instructions to switch between their 64-kilobyte segments, increasing the complexity of programming 16-bit applications.

List of 16-bit CPUs

- Angstrem
  - 1801 series CPU
- Data General
  - Nova
  - Eclipse

- Digital Equipment Corporation
  - PDP-11 (for LSI-11, see Western Digital, below)
    - DEC J-11
    - DEC T-11
- EnSilica
  - eSi-1600

- Ferranti
  - Ferranti F100-L
  - Ferranti F200-L
- Freescale
  - Freescale 68HC12
  - Freescale 68HC16
- General Instrument
  - CP1600
- Hewlett-Packard
  - HP 21xx/2000/1000/98xx/BPC
  - HP 3000
- Honeywell
  - Honeywell Level 6/DPS 6
- IBM
  - 1130/1800
  - System/7
  - Series/1
  - System/36
- Infineon
  - XE166 family
  - C166 family
  - C167 family
  - XC2000
- Intel
  - Intel 8086/Intel 8088
  - Intel 80186/Intel 80188
  - Intel 80286
  - Intel MCS-96
- Lockheed
  - MAC-16
- Motorola
  - Motorola 68000 (32-bit registers, 16-bit bus)
  - Motorola 68010 (32-bit registers, 16-bit bus)
- National Semiconductor
  - IMP-16
  - PACE/INS8900
- NEC
  - V20/V30
- Renesas
  - Renesas M16C (16-bit registers, 24-bit address space)
- Ricoh
  - Ricoh 5A22 (WDC 65816 clone used in SNES)
- Texas Instruments
  - Texas Instruments TMS9900
  - TI MSP430
- Western Design Center
  - WDC 65816/65802
- Western Digital
  - MCP-1600 (used in the DEC LSI-11)
- Xerox
  - Alto
- Zilog
  - Zilog Z8000

See also

- Microprocessor: 16-bit designs
- Influence of the IBM PC on the personal computer market: Before the IBM PC's introduction
- 74181 (key component of some early 16-bit and other CPUs)
- Audio bit depth – as 16-bit is the most common bit depth used, e.g. on CD audio.

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