© 2014 IJIRT | Volume 1 Issue 6 | ISSN : 2349-6002

INTEL MICROPROCESSOR 8086

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***Abstract-* A microprocessor incorporates the functions of a computer's central processing unit (CPU) on a single integrated circuit (IC), or at most a few integrated circuits. Intel 8085 is a 8-bit microprocessor introduced by Intel in 1977 and Intel 8086 is a 16-bit microprocessor chip designed by Intel between early 1976 and mid-1978. The 8086 gave rise to the X86 architecture which eventually turned out as Intel's most successful line of processors. This paper aims to summarize the details 8086 microprocessor.**

***Index Terms-* Microprocessor, single integrated chip(IC)**

I. INTRODUCTION

A **microprocessor** incorporates the functions of a computer's central processing unit (CPU) on a single integrated circuit (IC), or at most a few integrated circuits. All modern CPUs are microprocessors making the micro- prefix redundant. The microprocessor is a multipurpose, programmable device that accepts digital data as input, processes it according to instructions stored in its memory, and provides results as output. It is an example of sequential digital logic, as it has internal memory. Microprocessors operate on numbers and symbols represented in the binary numeral system. The **Intel 8085** ("eighty-eighty-five") is an 8-bit microprocessor introduced by Intel in 1977. It was backward binary compatible with the more-famous Intel 8080 (only adding a few minor instructions) but required less supporting hardware, thus allowing simpler and less expensive microcomputer systems to be built. The "5" in the model number came from the fact that the 8085 requires only a +5-Volt (V) power supply by using depletion mode transistors, rather than requiring the +5 V, −5 V and +12 V supplies the 8080 needed. This is similar to the competing Z80 (also 8080-derived) introduced the year before. These processors were sometimes used in computers running the CP/M operating system.

The Intel 8085 required at least an external ROM and RAM and an 8 bit address latch (both latches combined in the Intel 8755 2Kx8 EPROM / 2x8 I/O, Intel 8155 256-byte RAM and 22 I/O and 14 bit programmable Timer/Counter) so cannot technically be called a microcontroller.

Both designs (8080/8085) were eclipsed for desktop computers by the compatible Zilog Z80, which took over most of the CP/M computer market as well as taking a share of the booming home computer market in the early-to-mid-1980s.

The 8085 had a long life as a controller. Once designed into such products as the DEC tape controller and the VT100 video terminal in the late 1970s, it served for new production throughout the life span of those products.

The 8086 ("eighty-eighty-six", also called iAPX 86) is a 16-bit microprocessor chip designed by Intel between early 1976 and mid-1978, when it was released. The Intel 8088, released in 1979, was a slightly modified chip with an external 8-bit data bus (allowing the use of cheaper and fewer supporting ICs), and is notable as the processor used in the original IBM PC design, including the widespread version called IBM PC XT. The 8086 gave rise to the x86 architecture which eventually turned out as Intel's most successful line of processors.

II. HISTORY

Background

In 1972, Intel launched the 8008, the first 8-bit microprocessor. It implemented an instruction set designed by Data point Corporation with programmable CRT terminals in mind that also proved to be fairly general purpose. The device needed several additional ICs to produce a functional computer, in part due to it being packaged in a small 18-pin "memory-package", which ruled out the use of a separate address bus (Intel was primarily a DRAM manufacturer at the time).

Two years later, Intel launched the 8080, employing the new 40-pin DIL packages originally developed for calculator ICs to enable a separate address bus. It had an extended instruction set that was source- (not binary-) compatible with the 8008 and also included some 16-bit instructions to make programming easier. The 8080 device, often described as the first truly useful microprocessor, was eventually replaced by the depletion-load based 8085 (1977) which could cope with a single 5V power supply instead of the three different operating voltages of earlier chip. Other well-known 8-bit microprocessors that emerged during these years were Motorola 6800 (1974), General Instrument PIC16X (1975), MOS Technology 6502 (1975), Zilog Z80 (1976), and Motorola 6809 (1978).

III. DETAILS

Buses and Operation: All internal registers, as well as internal and external data buses, were 16 bits wide, firmly establishing the "16-bit microprocessor" identity of the 8086. A 20-bit external address bus gave a 1 MB physical address space (2^{20} = 1,048,576). This address space was addressed by means of internal 'segmentation'. The data bus was multiplexed with the address bus in order to fit a standard 40-pin dual in-line package. 16-bit I/O addresses meant 64 KB of separate I/O space (2^{16} = 65,536). The maximum linear address space was limited to 64 KB, simply because internal registers were only 16 bits wide. Programming over 64 KB boundaries involved adjusting segment registers (see below) and remained so until the 80386 introduced wider (32 bits) main registers (the memory management hardware in the 286 did not help in this regard, as registers were still 16 bits).

Some of the control pins, which carry essential signals for all external operations, had more than one function depending upon whether the device was operated inmin or max mode. The former was intended for small single processor systems while the latter was for medium or large systems, using more than one processor.

Registers and Instruction: The 8086 has eight more or less general 16-bit registers (including the stack pointer but excluding the instruction pointer, flag register and segment registers). Four of them, AX, BX, CX, DX, could also be accessed as twice as many 8-bit registers (see figure) while the other four, BP, SI, DI, SP, were 16-bit only.

Due to a compact encoding inspired by 8-bit processors, most instructions were one-address or two-address operations which means that the result was stored in one of the operands. At most one of the operands could be in memory, but this memory operand could also be the destination, while the other operand, the source, could be either register or immediate. A single memory location could also often be used as both source and destination which, among other factors, further contributed to acode density comparable to (and often better than) most eight bit machines.

Although the degree of generality of most registers was much greater than in the 8080 or 8085, it was still fairly low compared to the typical contemporary minicomputer, and registers were also sometimes used implicitly by instructions. While perfectly sensible for the assembly programmer, this made register allocation for compilers more complicated compared to more regular 16- and 32-bit processors such as the PDP-11, VAX, 68000, 32016 etc. On the other hand, it was more regular and orthogonal than ubiquitous but rather minimalistic 8-bit microprocessors such as the 6502, 6800, 6809, 8085, MCS-48, 8051 and other contemporary accumulator based machines. It was significantly easier to construct an efficient code generator for the 8086 design.

Another factor for this was that the 8086 also introduced some new instructions (not present in the 8080 and 8085) to better support stack based high level programming languages such as Pascal and PL/M; some of the more useful ones were push mem-op, and retsize, supporting the "pascal calling convention" directly. (Several others, such as push immed and enter, would be added in the subsequent 80186, 80286, and 80386 processors.)

The 8086 had a 64 KB of 8-bit (or alternatively 32 K-word of 16-bit) I/O space. A 64 KB (one segment) stack growing towards lower addresses is supported in hardware; 2-byte words are pushed to the stack and the stack top is pointed to by SS:SP. There are 256 interrupts, which can be invoked by both hardware and software. The interrupts can cascade, using the stack to store the return addresses.

Flags: 8086 has a 16-bit flags register. Nine of these condition code flags are active, and indicate the current state of the processor: Carry flag (CF), Parity flag (PF), Auxiliary carry flag (AF), Zero flag (ZF), Sign flag (SF), Trap flag (TF), Interrupt flag (IF), Direction flag (DF), and Overflow flag (OF).

Segmentation: There are also four 16-bit segment registers (see figure) that allow the 8086 CPU to access one megabyte of memory in an unusual way. Rather than concatenating the segment register with the address register, as in most processors whose address space exceeded their register size, the 8086 shifts the 16-bit segment only four bits left before adding it to the 16-bit offset (16×segment + offset), therefore producing a 20-bit external (or effective or physical) address from the 32-bit segment:offset pair. As a result, each external address can be referred to by $2^{12} = 4096$ different segment:offset pairs.

Although considered complicated and cumbersome by many programmers, this scheme also has advantages; a small program (less than 64 KB) can be loaded starting at a fixed offset (such as 0000) in its own segment, avoiding the need for relocation, with at most 15 bytes of alignment waste.

Compilers for the 8086-family commonly support two types of pointer, near and far. Near pointers are 16-bit offsets implicitly associated with the program's code or data segment and so can be used only within parts of a program small enough to fit in one segment. Far pointers are 32-bit segment offset pairs resolving to 20-bit external addresses. Some compilers also support huge pointers, which are like far pointers except that pointer arithmetic on a huge pointer treats it as a linear 20-bit pointer, while pointer arithmetic on a far pointer wraps around within its 16-bit offset without touching the segment part of the address.

IV. PERFORMANCE

Although partly shadowed by other design choices in this particular chip, the multiplexed address and data buses limited performance slightly; transfers of 16-bit or 8-bit quantities were done in a four-clock memory access cycle, which was faster on 16-bit, although slower on 8-bit quantities, compared to many contemporary 8-bit based CPUs. As instructions varied from one to six bytes, fetch and execution were made concurrent and decoupled into separate units (as it remains in today's x86 processors): The bus interface unitfed the instruction stream to the execution unit through a 6-byte prefetch queue (a form of loosely coupled pipelining), speeding up operations on registers and immediates, while memory operations unfortunately became slower (four years later, this performance problem was fixed with the 80186 and 80286). However, the full (instead of partial) 16-bit architecture with a full width ALU meant that 16-bit arithmetic instructions could now be performed with a single ALU cycle (instead of two, via internal carry, as in the 8080 and 8085), speeding up such instructions considerably.

V. HARDWARE MODEL

The 8086 and 8088 support two hardware modes: maximum mode and minimum mode. Maximum mode is for large applications such as multiprocessing and is also required to support the 8087 coprocessor. The mode is usually hard-wired into the circuit and cannot be changed by software. Specifically, pin #33 (MN/MX) is either wired to voltage or to ground to determine the mode. Changing the state of pin #33 changes the function of certain other pins, most of which have to do with how the CPU handles the (local) bus. The IBM PC and PC/XT use an Intel 8088 running in maximum mode, which allows the CPU to work with an optional 8087 coprocessor installed in the math coprocessor socket on the PC or PC/XT mainboard. (The PC and PC/XT may require Max mode for other reasons, such as perhaps to support the DMA controller.)

VI. FEATURES

- 8086 is a 16bit processor. It’s ALU, internal registers works with 16bit binary word
- 8086 has a 16bit data bus. It can read or write data to a memory/port either 16bits or 8 bit at a time
- 8086 has a 20bit address bus which means, it can address upto 220 = 1MB memory location
- Frequency range of 8086 is 6-10 MHz

VII. FLOATING POINT

The 8086/8088 could be connected to a mathematical coprocessor to add hardware/microcode-based floating point performance. The Intel 8087 was the standard math coprocessor for the 8086 and 8088, operating on 80-bit numbers. Manufacturers like Cyrix (8087-compatible) and Weitek (non 8087-compatible) eventually came up with high performance floating point co-processors that competed with the 8087 as well as with the subsequent, higher performing Intel 80387.

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