Digital Logic Design

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KESL
Kookmin Univ. Embedded System Lab

Welcome!!

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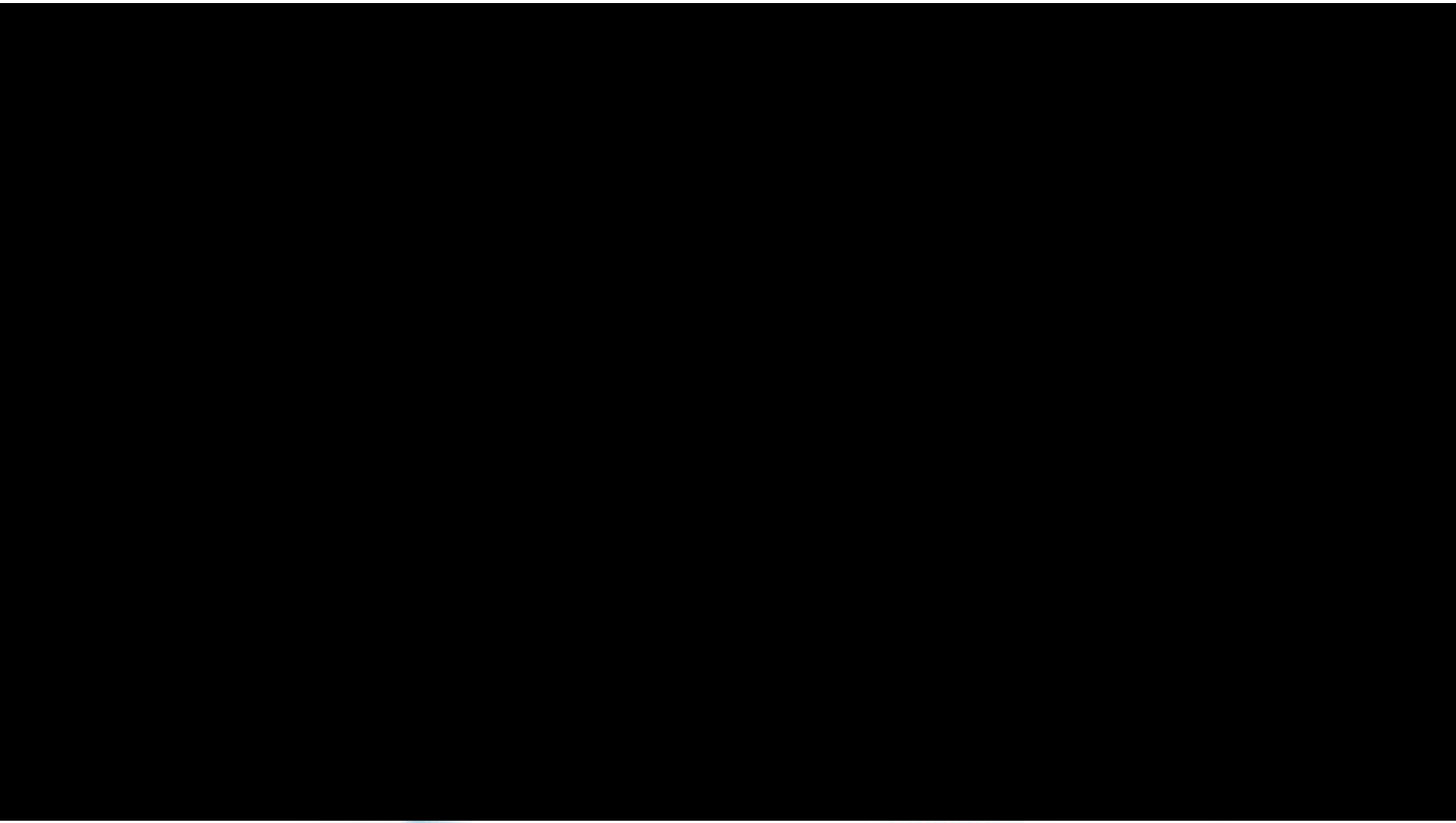
  - TBD

What We Learn?



What We Learn?

How Computer Works?

How Computer Works?

And How to Design It?

What We Learn?

40 years of the microprocessor

The Inquirer looks back at the most significant microprocessor developments that have shaped the IT industry

1970s

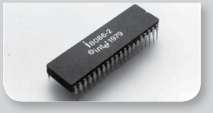
1971 Intel 4004
Developed to drive calculators, the 4004 was a 4-bit chip with **2,300 transistors** and clocked at 740KHz

1972 Intel 8008
The first 8-bit processor, the 8008 had an address space of 16KB and was clocked at 500KHz up to 800KHz

1974 Intel 8080
The 8080 was a significant step up, boasting a clock speed of 2MHz and able to address 64KB memory. Early desktop computers used this chip and the CP/M operating system

1975 MOS 6502
MOS Technology introduced the 6502 as a rival chip to the 8080. It powered such notable systems as the Apple II, Commodore PET and BBC Micro

1976 Zilog Z80
Zilog was founded by ex-Intel engineers who created a compatible but superior chip to the 8080. The Z80 powered many CP/M machines, plus home computers like the ZX Spectrum



1978 Intel 8086
Famous as the first x86 chip, the 8086 was also Intel's first 16-bit chip with about **29,000 transistors** and was clocked initially at 4.77MHz

1979 Intel 8088
A less costly version of the 8086, the 8088 used an 8-bit data bus and was the chip used in the IBM PC, forerunner of today's PC industry

1979 Motorola 68000
Intended to leapfrog rival processors, the 68000 was a 16-bit design but with 32-bit expansion in mind. It powered early Apple Macs and the first Sun Unix workstations

1980s

1982 Intel 80286
The 80286 was a high-performance upgrade of the 8086, and used by IBM in the PC-AT. First clocked at 6MHz, later versions ran up to 25MHz. The 286 had a 16MB address space and **134,000 transistors**

1985 Intel 80386
Intel's first 32-bit chip, the 386 had **275,000 transistors** – over 100 times that of the 4004. Versions of the 386 eventually reached 40MHz

1985
Acorn ARM produced as co-processor for BBC Micro
Seeking a new chip to power future business computers, the makers of the BBC Micro decided to build their own, calling it the Acorn RISC Machine (ARM)

1987 Sun SPARC
Like Acorn, Sun was looking for a new chip and decided to create its own. The Sparc architecture is still used today in Sun (now Oracle) systems, and supercomputers

1989 Intel 80486
A higher performance version of the 386, Intel's 486 was the first x86 chip with over **1 million transistors (1.2 million).** It was also the first with an on-chip cache and floating point unit

1990s

1990 IBM RS/6000 introduces Power chips
IBM experimented with RISC chips in the 1970s, and this bore fruit with the RS/6000 workstation in 1990. The processor later developed into the Power chip used by IBM and Apple

Acorn sets up ARM as a separate company to develop ARM chips

1993 Intel Pentium
The Pentium was a radical overhaul of Intel's x86 line, introducing superscalar processing. Starting at 60MHz but eventually reaching 300MHz, the Pentium had **3,100,000 transistors**

1995 Intel Pentium Pro
Developed as a high-performance chip, the Pentium Pro introduced out-of-order execution and L2 cache inside the same package. This line later morphed into the Xeon line

1996 AMD K5
AMD had been manufacturing Intel chips under licence for years, but the K5 was its first in-house design, intended to compete with the Pentium

1996 DEC StrongARM
Digital Equipment Corporation (DEC) developed this family of ARM-based chips, which was used in several PDAs. StrongARM was later sold to Intel

1997 Intel Pentium II
Based on the Pentium Pro, the Pentium II had **7,500,000 transistors** and shipped in a cartridge enclosure that also held L2 cache. Clock speed ranged from 233MHz up to 450MHz

1999 Intel Pentium III
An updated Pentium II, the Pentium III was the first to feature Intel's SSE instructions and featured clock speeds from 400MHz up to 1.4GHz

1999 AMD Athlon
The AMD Athlon was the firm's first processor that could beat Intel on performance. Starting at 500MHz, a later version was the first x86 chip to hit 1GHz and had **22 million transistors**

2000s

2000 Intel Pentium 4
Another major redesign, the Pentium 4 introduced Intel's Netburst architecture. It was clocked at 1.4GHz initially, rising to 3.8GHz, and had **42 million transistors**

2001 Intel Itanium
Developed by Intel and HP, Itanium is a 64-bit non-x86 architecture developed for parallelism and aimed at enterprise servers. The Itanium family has not been a great success

2002 Intel XScale ARM
To follow up the StrongARM line, Intel developed the XScale ARM chips, which powered many PDAs for years. However, Intel later sold off XScale to Marvell in 2006.

2002 TI Omap ARM
TI became one of the largest makers of system-on-a-chip devices for smartphones and PDAs with the Omap family, combining an ARM CPU with circuitry such as GSM processors

2003 Intel Pentium-M (Centrino)
The Pentium-M was designed specifically for laptops, and formed the core of Intel's first Centrino platform. It had **77 million transistors** and was clocked from 900MHz

2005 Intel Pentium-D
Intel introduced its first dual-core chips in 2005, starting with the Pentium Extreme Edition. The Pentium D was the first mainstream desktop chip to follow suit

2006 AMD acquires ATI
AMD bought up ATI, announcing ambitious plans to combine its x86 processors with ATI's graphics processors

2006 Intel Xeon 5300
Intel's first quad-core chips were the Xeon 5300 line for workstations and servers. Actually two dual-core dies joined together, these have a total of **582 million transistors**

2008 Qualcomm SnapDragon ARM
Wireless technology firm Qualcomm started producing high-performance smartphone chips based on the ARM architecture. SnapDragon is clocked at 1GHz and has **200 million transistors**

2011 Intel Core i3,i5, i7
Intel's latest chips, based on the Sandy Bridge architecture. The desktop processors have up to eight cores on a single chip and up to **995 million transistors**

2011 AMD Fusion chips
The Fusion line combines multiple CPU cores on a single chip along with ATI GPU cores, with the first chips having up to **1.45 billion transistors**

2011 ARM announces ARMv8 64-bit architecture
ARM unveils its specifications for future 64-bit chips. Although some years away, products based on ARMv8 could have as many as 128 cores

New Programming Languages?

```
        clk:        in std_logic;
        rst:        in std_logic;

        -- inputs
        data_in:    in std_logic_vector (DATA_W-1
        load:       in std_logic;
        en:         in std_logic;

        data_out:   out std_logic_vector (DATA_W-
        done:       out std_logic
    );
end component;

signal load_vec : std_logic_vector (TIMERS-1 down

begin
```

VHDL

```
    demux: process(load_sel, load)
    begin
        -- set all to 0
        load_vec <= (others => '0');
        -- Set load signal to the addressed timer
        load_vec(to_integer(unsigned(load_sel)))
    end process;
```

vs

```
17  localparam S2 = 2'b11;
18  localparam S3 = 2'b10;
19
20  reg [1:0] pState, nState;
21
22  always @ (pState, start, stop, increment)
23  begin
24      case (pState)
25          S0:begin
26              if (start == 1'b0 && increment == 1'b0)
27                  nState = S0;
28              else if (increment == 1'b1 && start == 1'b0)
29                  nState = S2;
30              else
31                  nState = S1;
32              end
33          S1:
34          begin
35              if (stop == 1'b1)
36                  nState = S0;
37              else
38                  nState = S1;
39           end
40          S2:
41              nState = S3;
42          S3:
43          begin
44              if (increment == 1'b1)
45                  nState = S3;
```

Verilog

Roadmap

시스템 분야 주요 진출 직무

- 반도체 소프트웨어 (삼성전자, SK 하이닉스, 텔레칩스 등)
- 자동차 소프트웨어 (현대기아자동차 및 계열사)
- 외국계 시스템 분야 기업 (퀄컴 코리아, 인텔 코리아, 브로드컴 등)