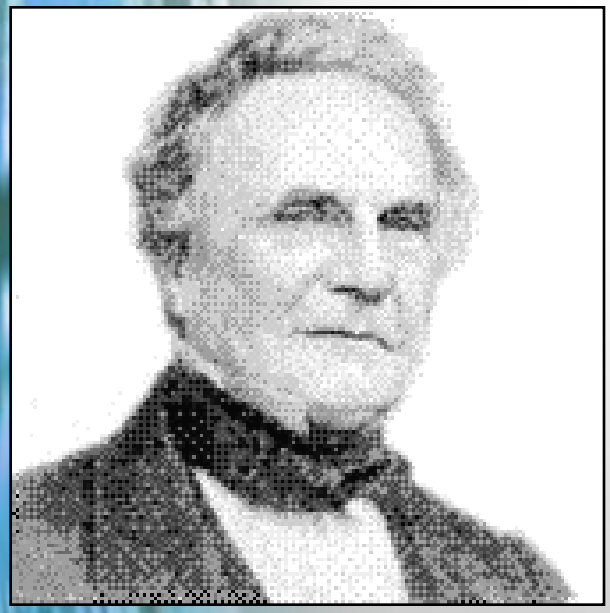
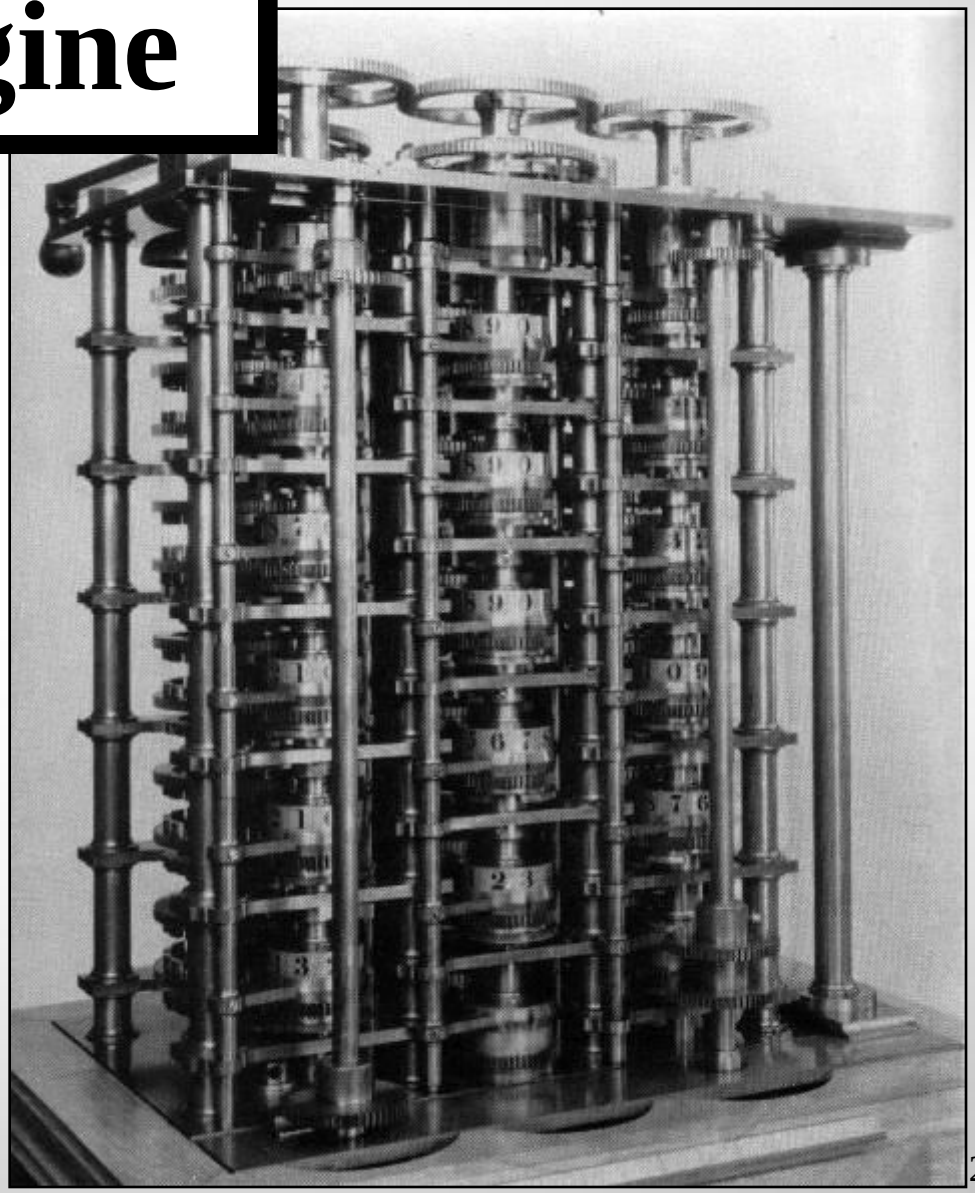
HEATHKIT™
EDUCATIONAL SYSTEMS

Unit 1

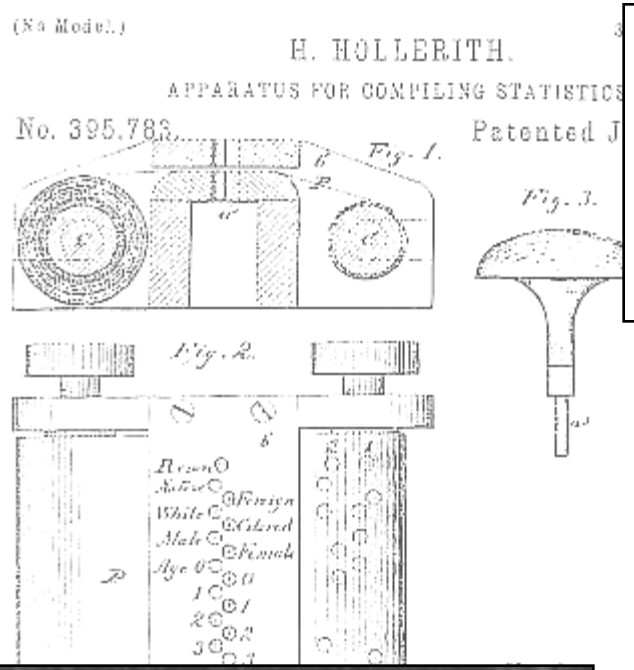
General Knowledge, CPUs, and Safety

Charles Babbage's Analytical Engine



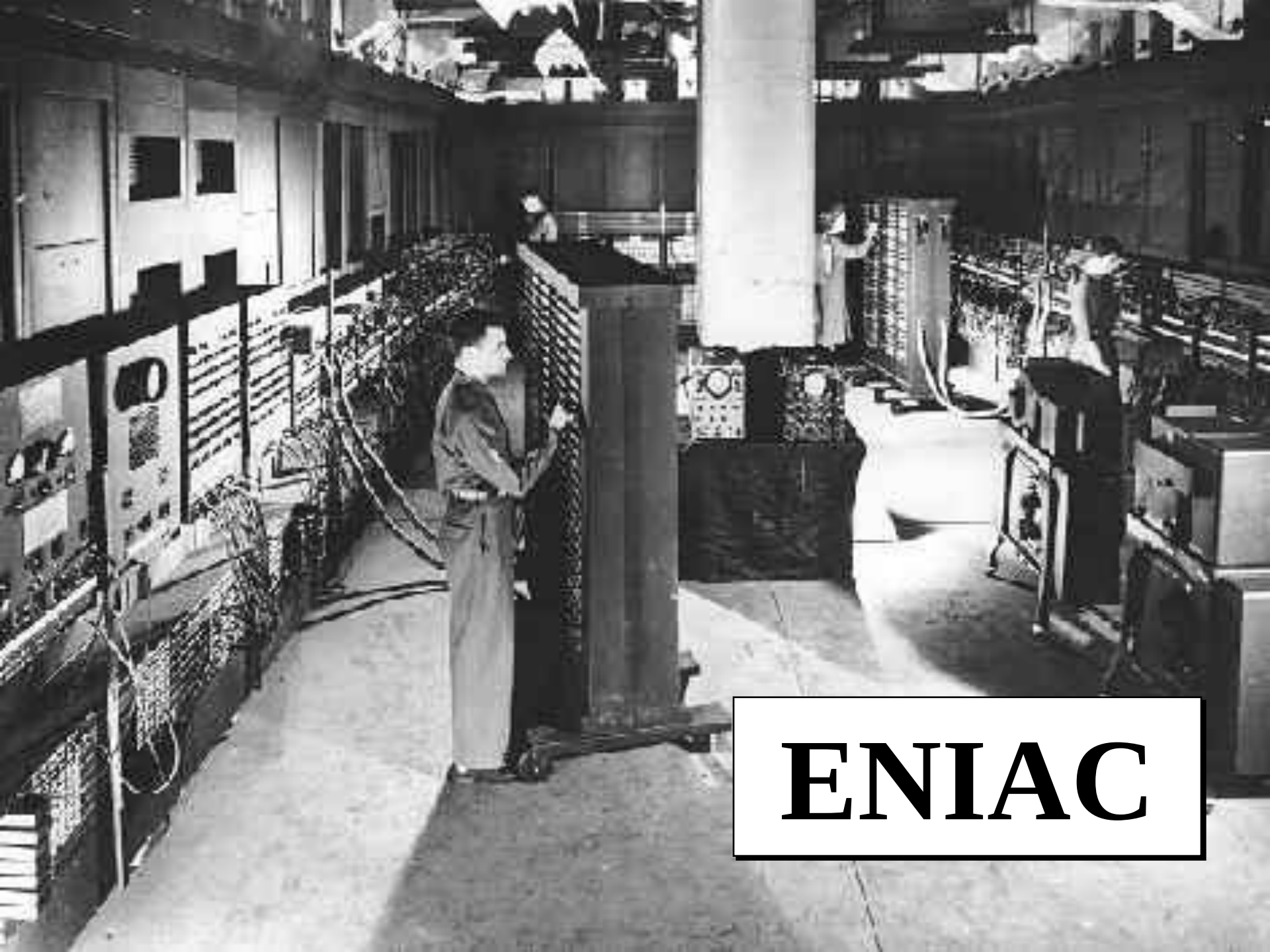


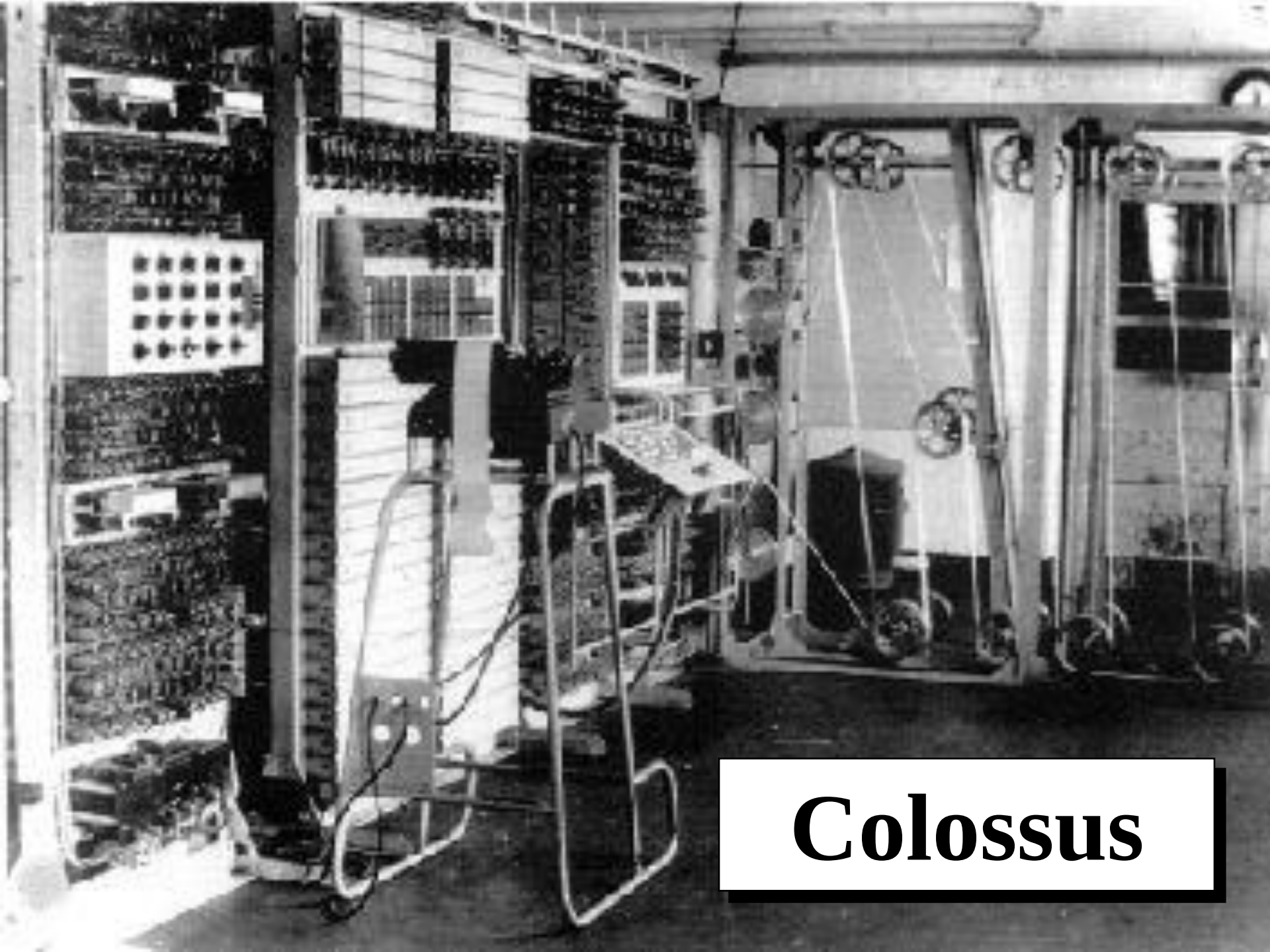
The Hollerith Machine



First Electronic Digital Computer

John Vincent Atanasoff


ENIAC


Colossus

Prior to the Personal Computer

- Computers were very large.
- Computers were very expensive.
- Computers were quite rare.

History of the PC

- Before the IBM PC - 1975 to 1981
- The IBM PC - 1981
- The IBM XT - 1983
- The IBM AT - 1984
- The IBM PS/2 - 1987
- Waning of IBM as the pace setter - 1987 to present

The First PC

- Generally considered the MITS Altair
- Introduced in January 1975
- Based on the 8080 Intel Processor
- Sold for $395 in kit form

Before the IBM PC, personal computers used:

- A variety of microprocessors
- Many different architectures
- A variety of operating systems

The IBM PC

- Introduced on August 12, 1981
- Used the Intel 8088 microprocessor
- Operated at 4.77 MHz
- No hard drive
- One or two *single-sided* floppy drives
- Used MS-DOS 1.0
- Introduced the 8-bit ISA bus

The IBM PC brought standardization

- Intel Microprocessors
- Microsoft Disk Operating System (MS-DOS)
- Architecture

The IBM XT

- Introduced in 1983
- Included a 10 MB hard drive
- Used MS-DOS 2.0
- 16-bit ISA Bus

The IBM AT

- Introduced in 1984
- Based on Intel's 80286 microprocessor
- Operated at 6 MHz
- 20 MB hard drive
- Used MS-DOS 3.0

The IBM PS/2

- Introduced in 1988
- IBM abandoned its own standard
- Microchannel replaces the ISA bus
- Introduced the VGA graphics standard
- New OS called OS/2 is DOS compatible, allows multitasking.

From 1981 to 1987

- IBM dominated the personal computer business
- IBM set the standards for:
  - Microprocessor used
  - Bus structure
  - Architecture
  - Video
  - Disk Drives

From 1987 to Present

- IBM's influence gradually waned
- Software standards set, largely, by Microsoft
  - MS-DOS
  - Windows 3.xx
  - Windows 95, 98, Me
  - Windows NT, 2000, XP
- Hardware standards set, largely, by Intel
  - Microprocessor, Chipset, Motherboard

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The Language of a Computer

The Telegraph

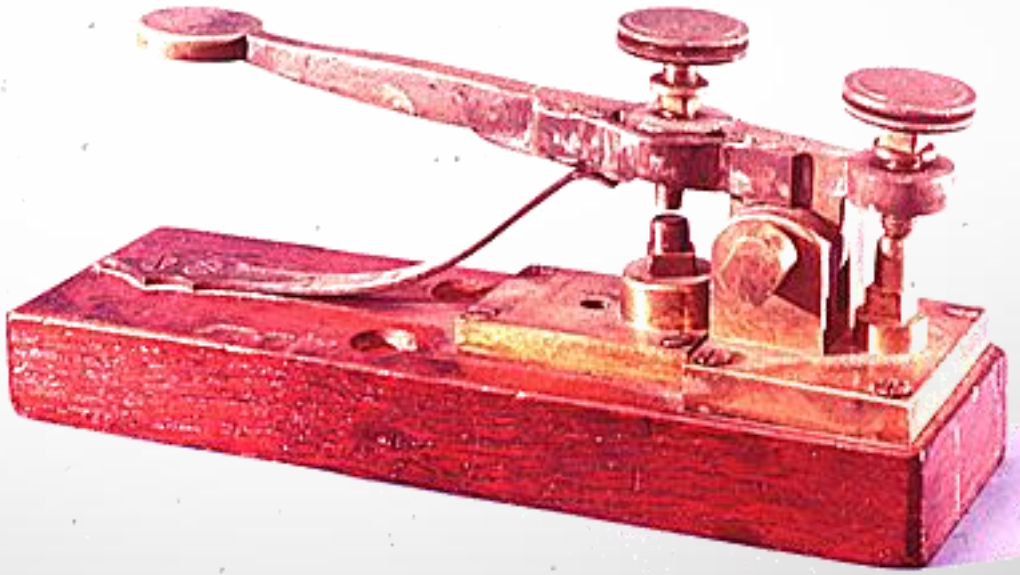
- Samuel F.B. Morse
- 1838

  A • –

  B – •••

  C – • – •

  D – ••



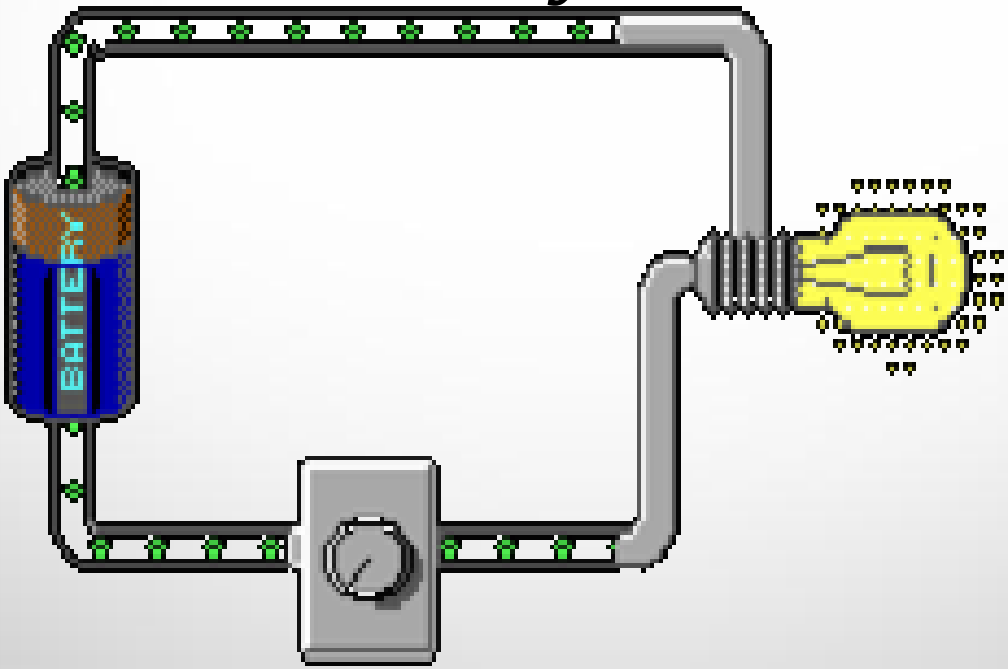
Analog vs. Digital

- Analog Signals vary over a continuous range
- Digital signals vary between two fixed levels

Analog vs. Digital

Analog Signals are

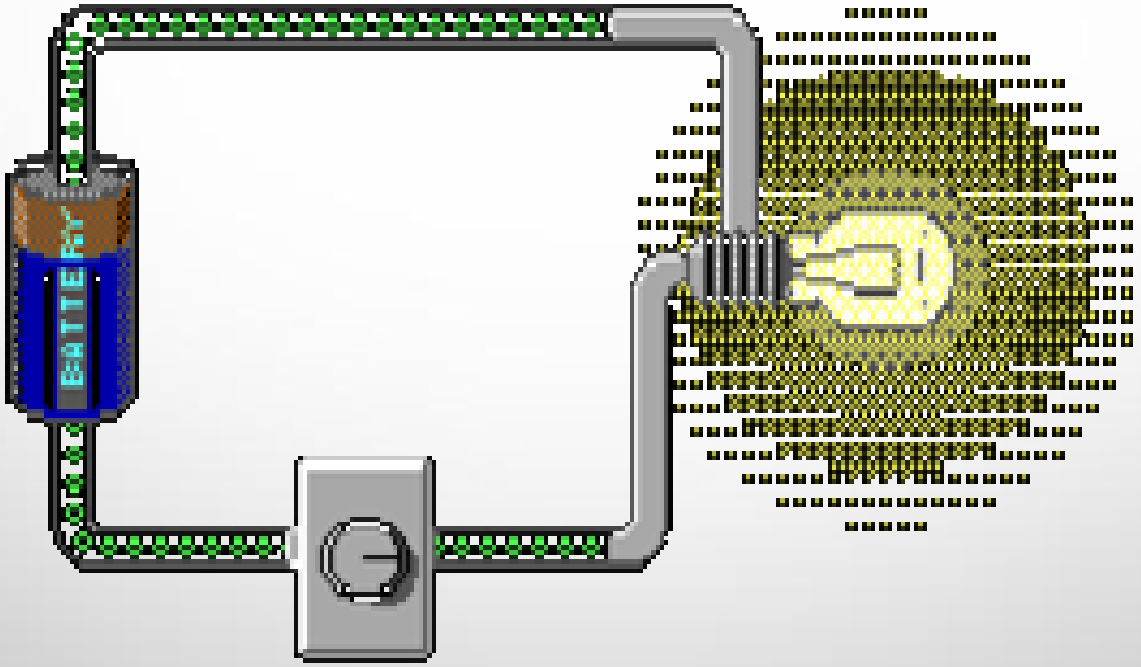
continuously variable



Analog vs. Digital

Analog Signals are

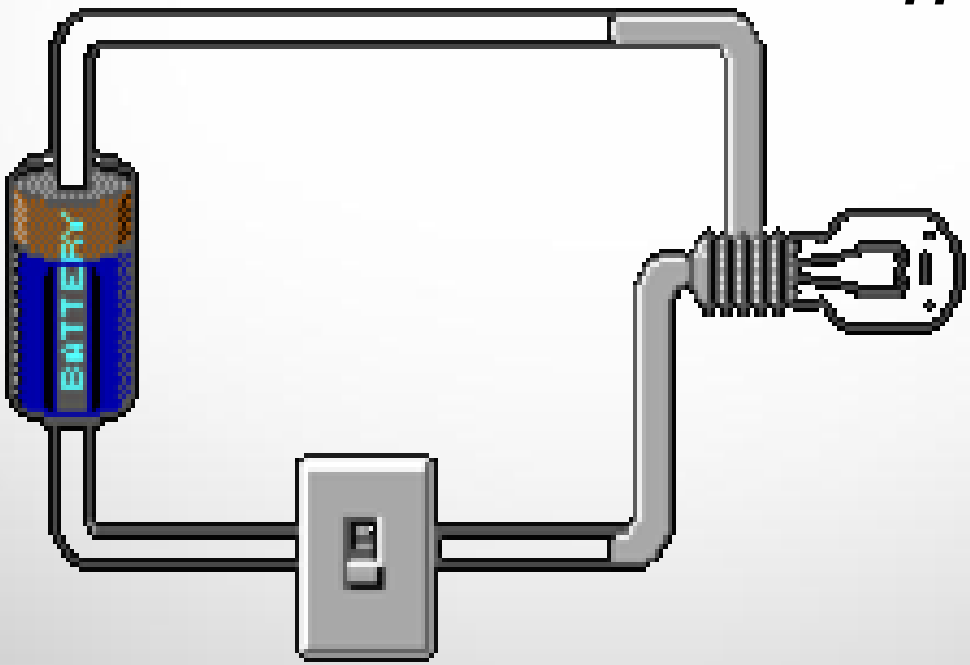
continuously variable



Analog vs. Digital

Digital Signals have

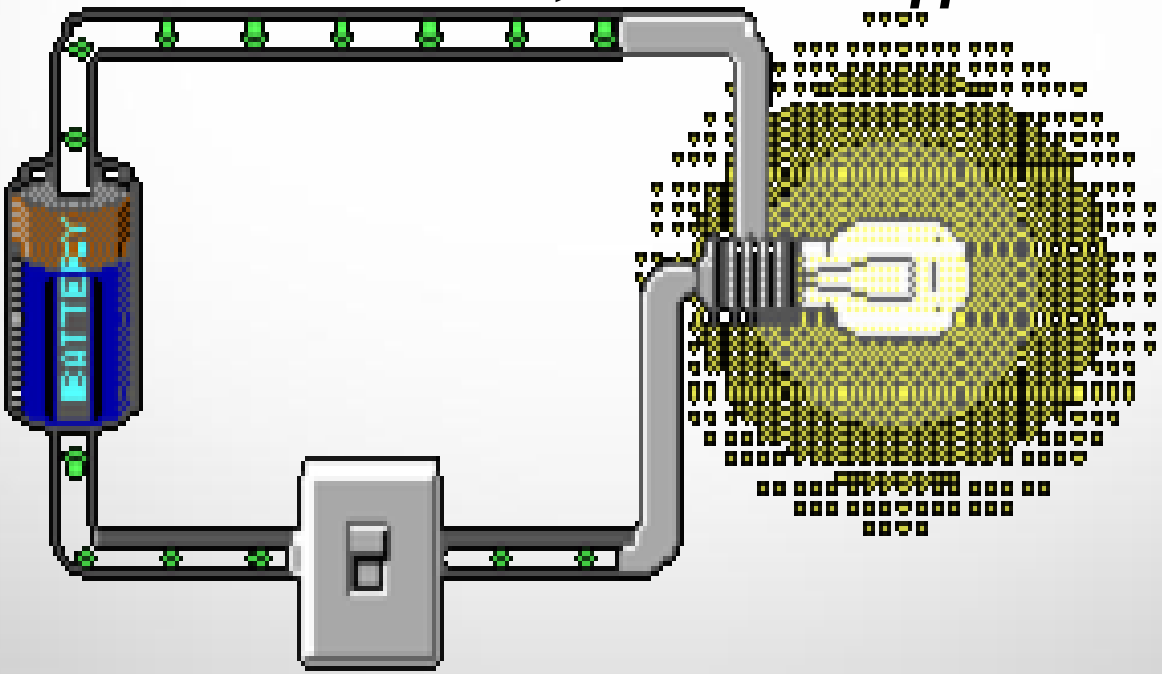
two levels; *on* or *off*



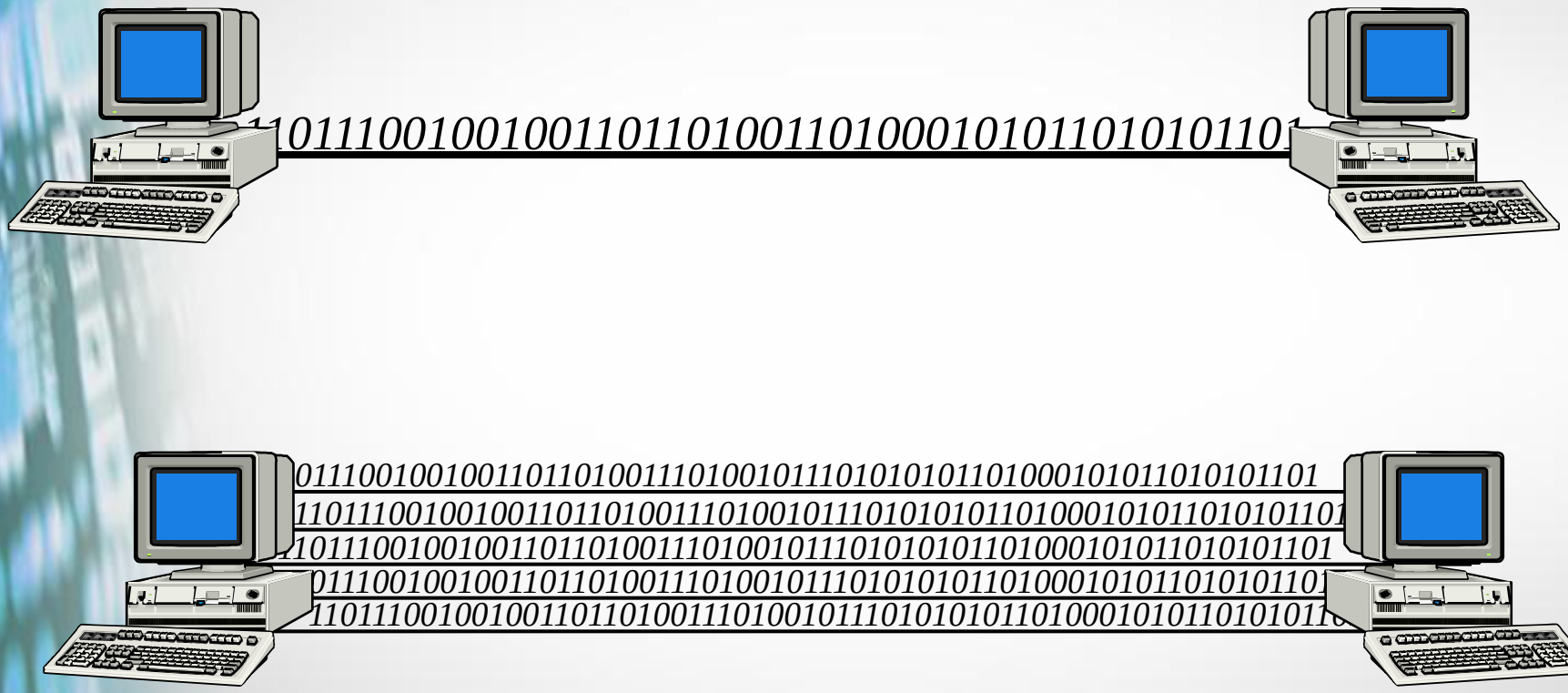
Analog vs. Digital

Digital Signals have

two levels; *on* or *off*



Parallel vs. Serial



Decimal Numbers

- 0,1,2,3,4,5,6,7,8,9
- called a “base 10” system

Binary

- Either 0 or 1
- Requires more digits than decimal for a given value
- **Bit**: single digit
- **Byte**: eight bits together
- **Word**: multiple bytes together

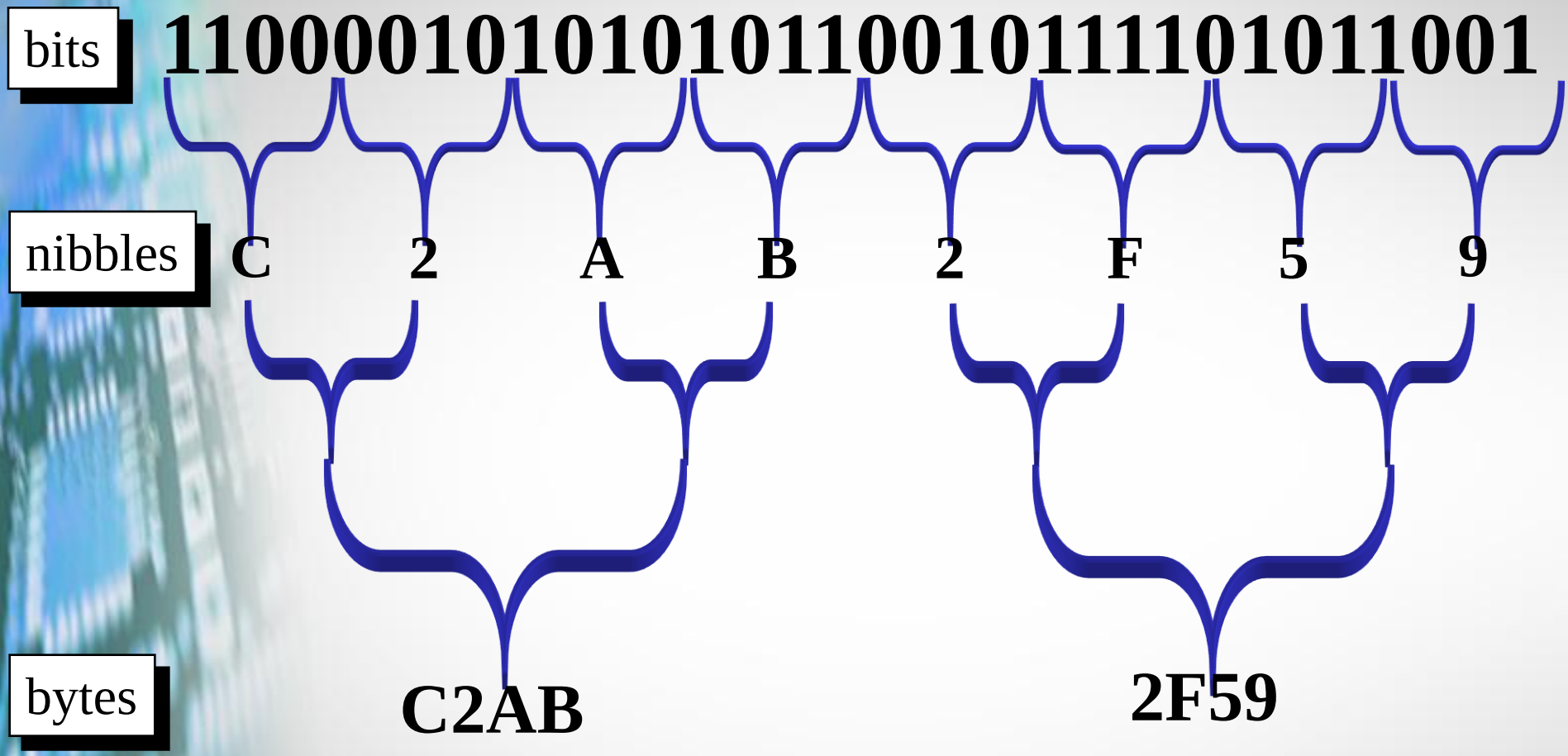
Binary

Position	8	7	6	5	4	3	2	1
Decimal value of a “1” in this position	128	64	32	16	8	4	2	1
Power of 2	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Hexadecimal

- 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F
- Called a “base 16” numbering system
- Requires fewer digits than decimal for a given value
- Primarily used to make binary easier

Decimal Number	Binary Number	Hex Number
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F
16	10000	10
17	10001	11
50,096	1100001110110000	C3B0


bits
1100001010101011001011110101011001
nibbles
C
2
A
B
2
F
5
9
bytes
C2AB
2F59

Identifying Numbers

- 330H is *Hex*
- 3F8 is *Hex*
- 256 is *Decimal*
- 1010 is *Binary*

menu

American Standard Code for Information Interchange (ASCII)

0 NUL	1 SOH	2 STX	3 ETX	4 EOT	5 ENQ	6 ACK	7 BEL
8 BS	9 HT	10 NL	11 VT	12 NP	13 CR	14 SO	15 SI
16 DLE	17 DC1	18 DC2	19 DC3	20 DC4	21 NAK	22 SYN	23 ETB
24 CAN	25 EM	26 SUB	27 ESC	28 FS	29 GS	30 RS	31 US
32 SP	33 !	34 "	35 #	36 $	37 %	38 &	39 '
40 (	41)	42 *	43 +	44 ,	45 -	46 .	47 /
48 0	49 1	50 2	51 3	52 4	53 5	54 6	55 7
56 8	57 9	58 :	59 ;	60 <	61 =	62 >	63 ?
64 @	65 A	66 B	67 C	68 D	69 E	70 F	71 G
72 H	73 I	74 J	75 K	76 L	77 M	78 N	79 O
80 P	81 Q	82 R	83 S	84 T	85 U	86 V	87 W
88 X	89 Y	90 Z	91 [	92 \	93]	94 ^	95 _
96 `	97 a	98 b	99 c	100 d	101 e	102 f	103 g
104 h	105 i	106 j	107 k	108 l	109 m	110 n	111 o
112 p	113 q	114 r	115 s	116 t	117 u	118 v	119 w
120 x	121 y	122 z	123 {	124 |	125 }	126 ~	127 DEL

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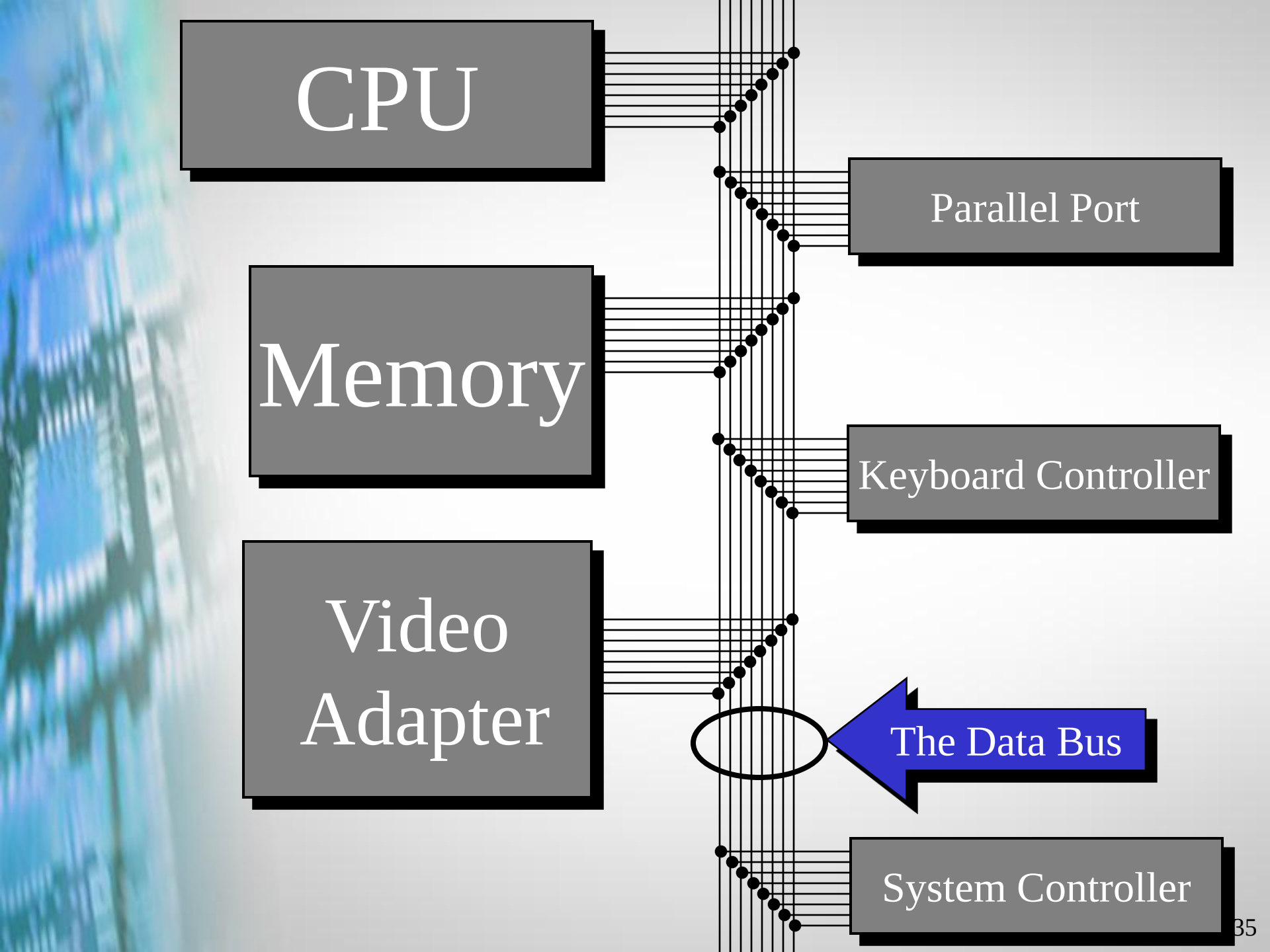
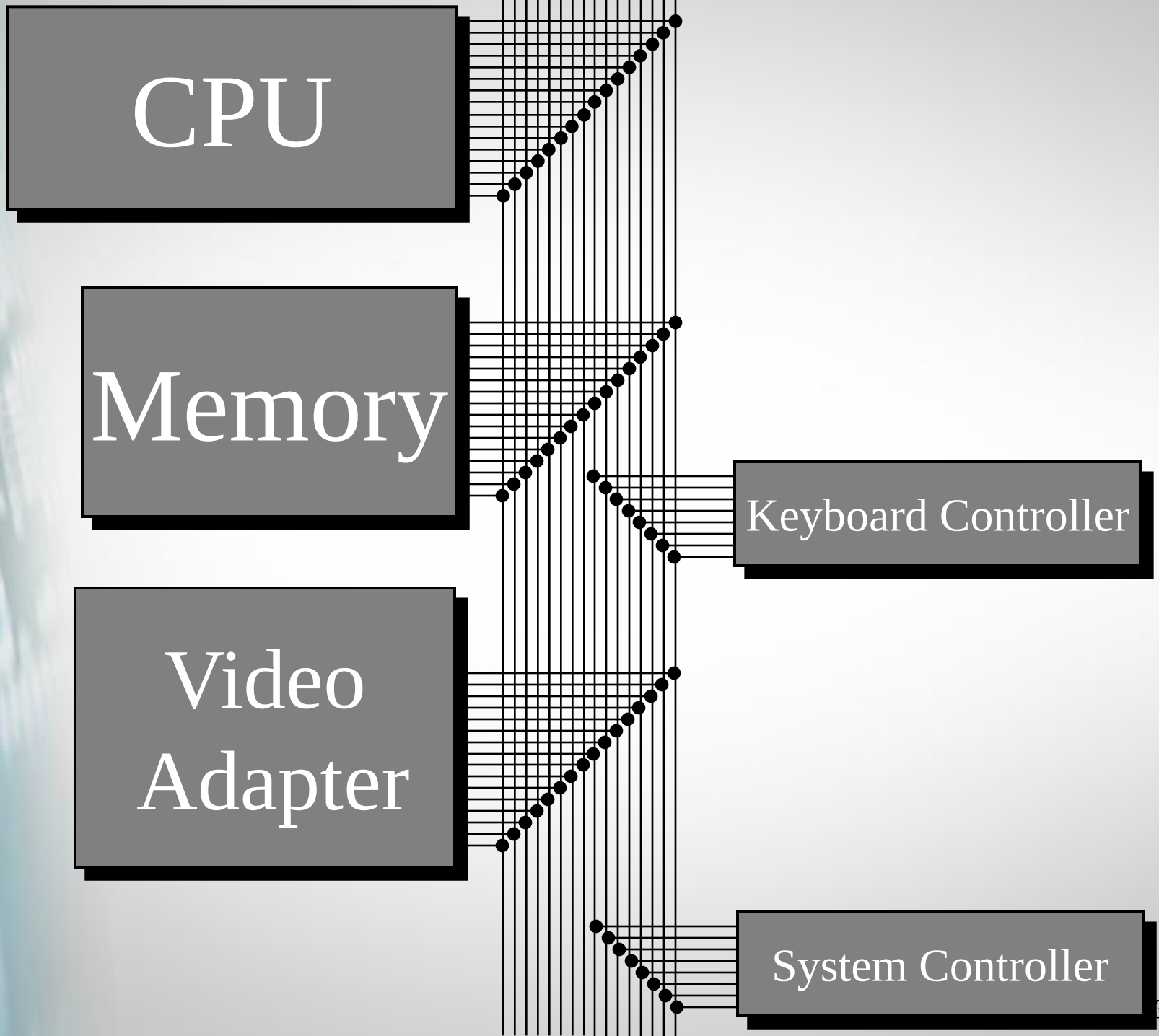
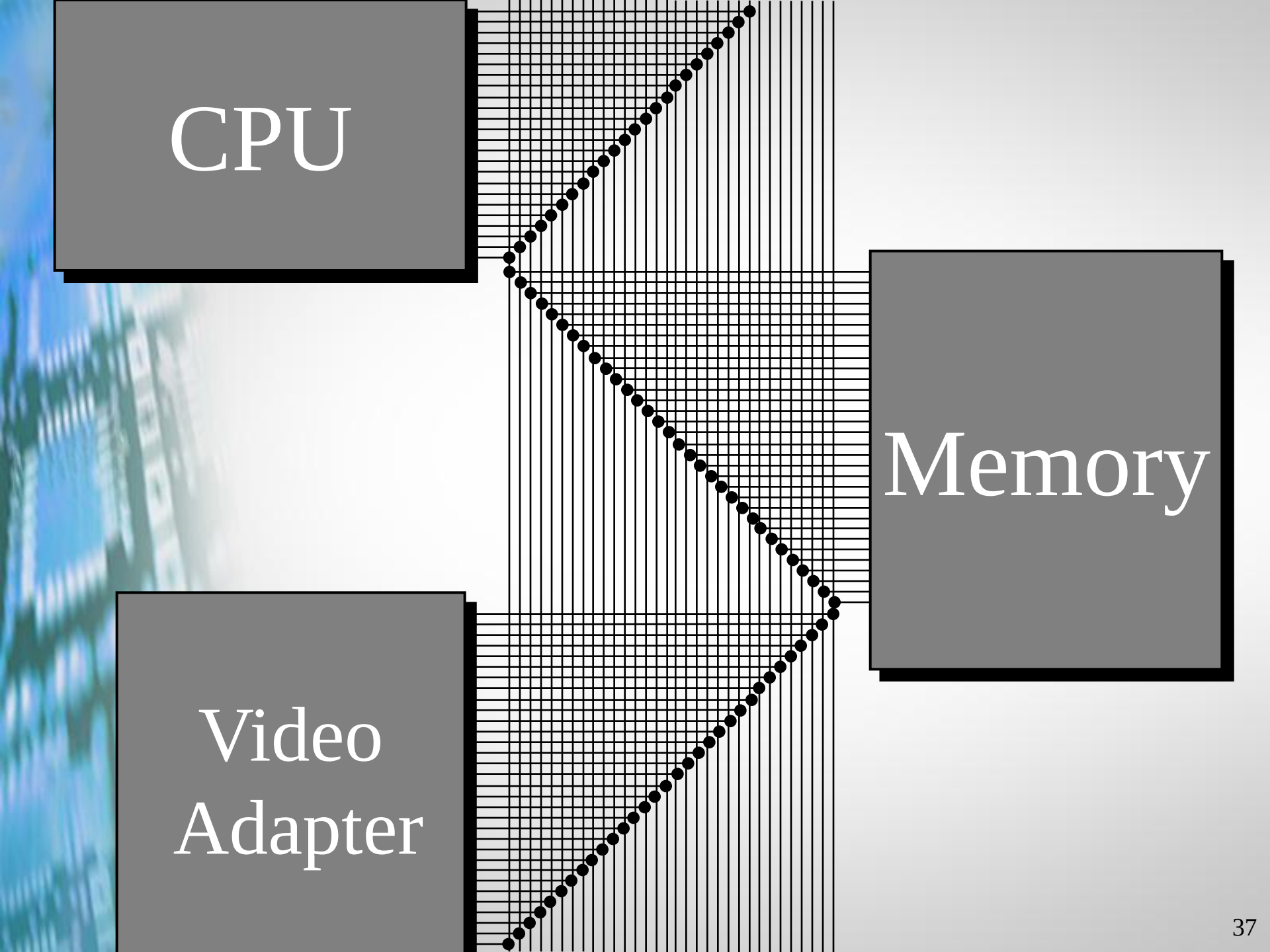
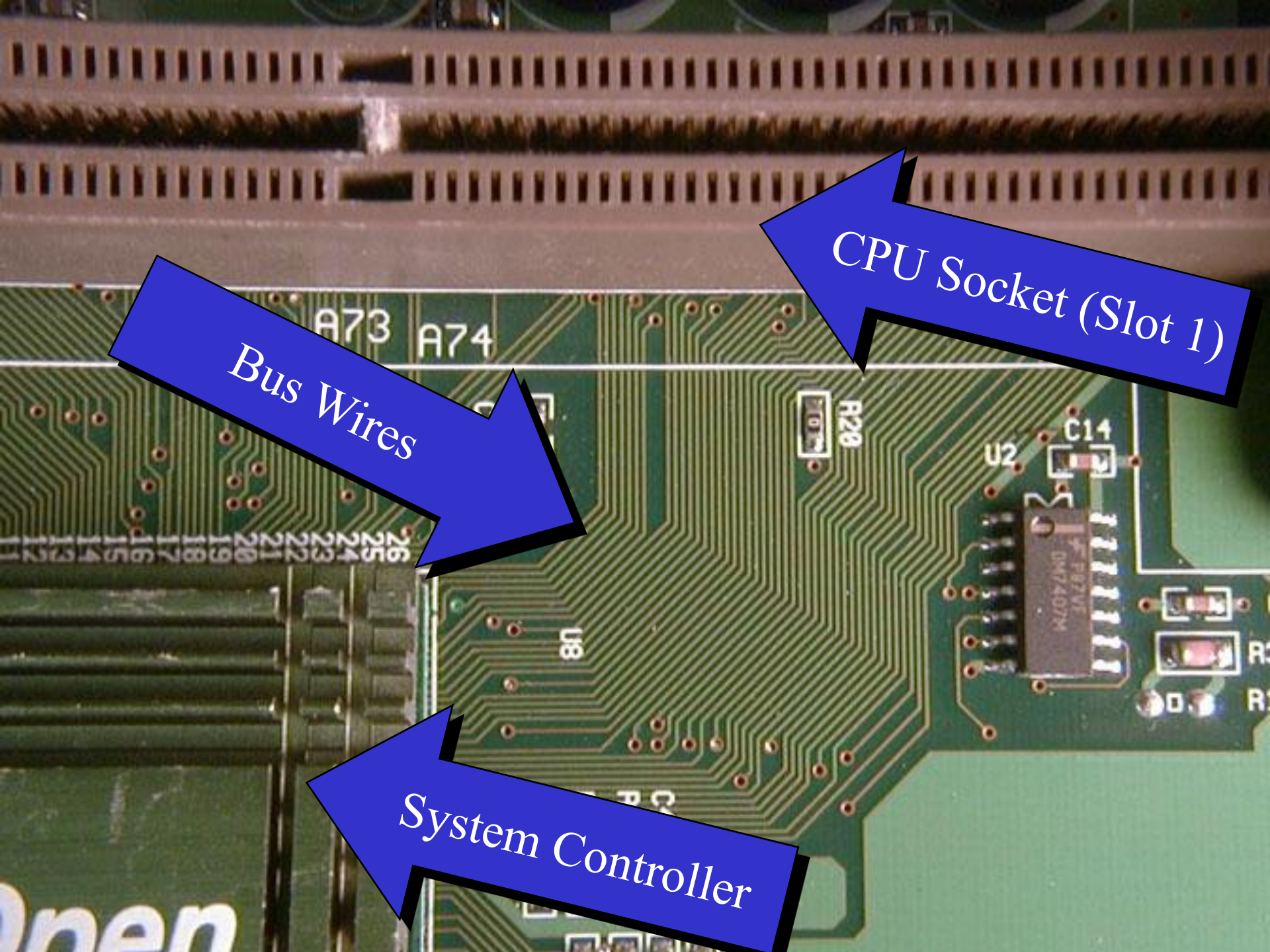
The Computer Bus


CPU
Memory
Video Adapter
Parallel Port
Keyboard Controller
The Data Bus
System Controller


CPU
Memory
Video Adapter
Keyboard Controller
System Controller


CPU
Memory
Video Adapter


CPU Socket (Slot 1)
Bus Wires
System Controller
A73
A74
R20
U2
C14
U8

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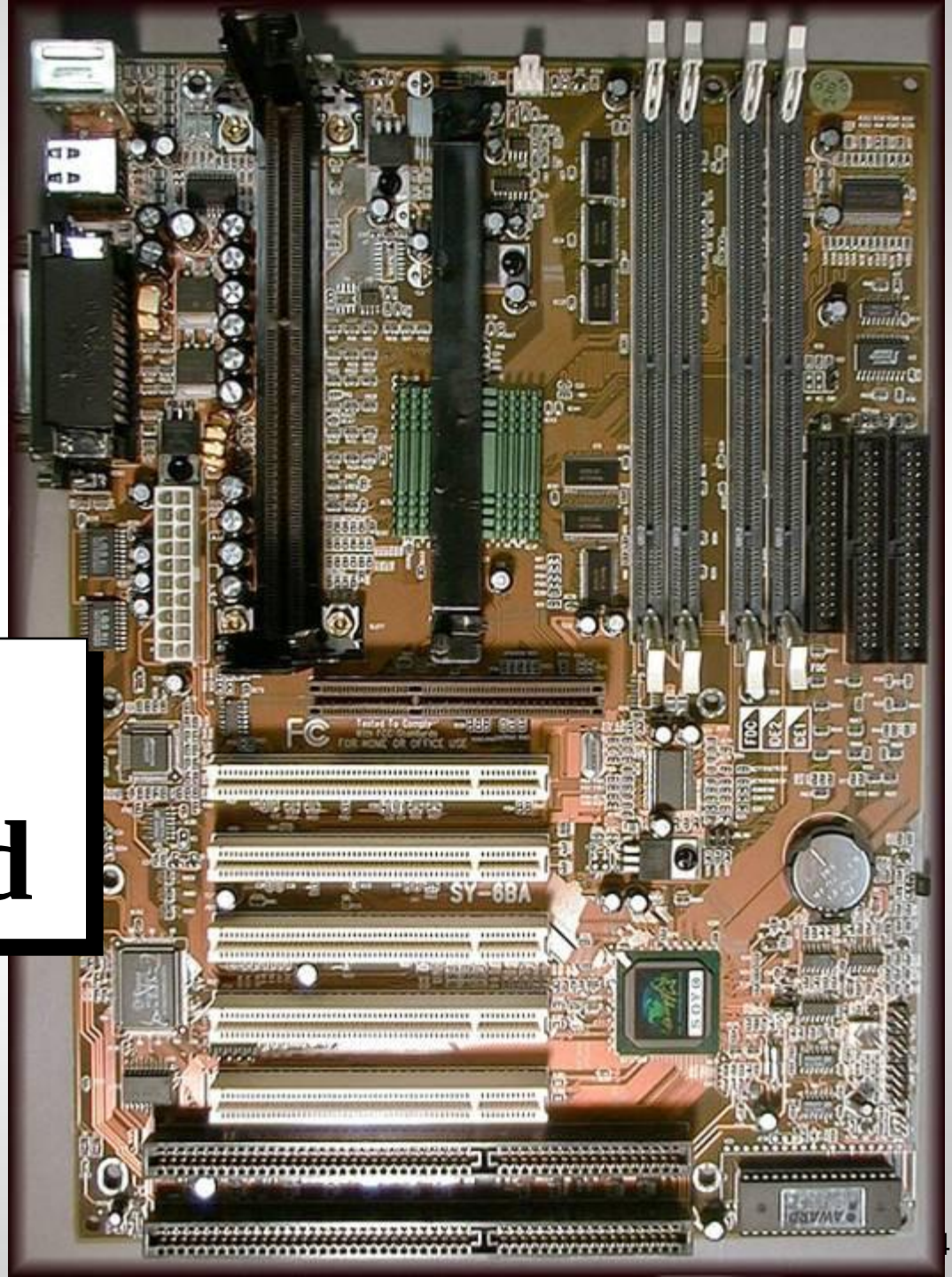
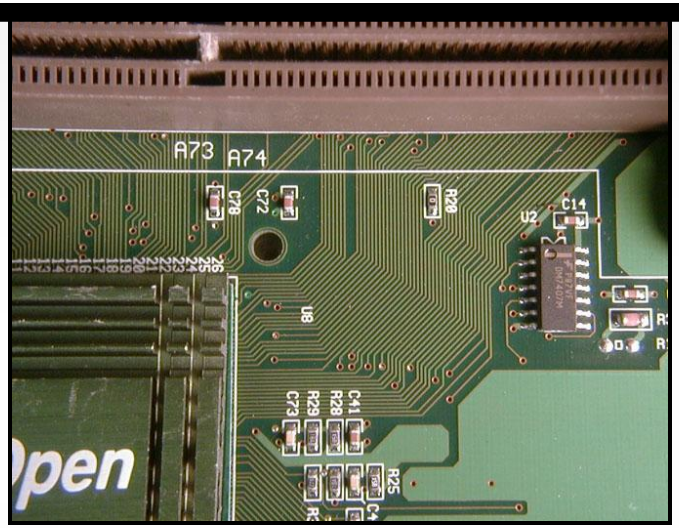
Computer Components

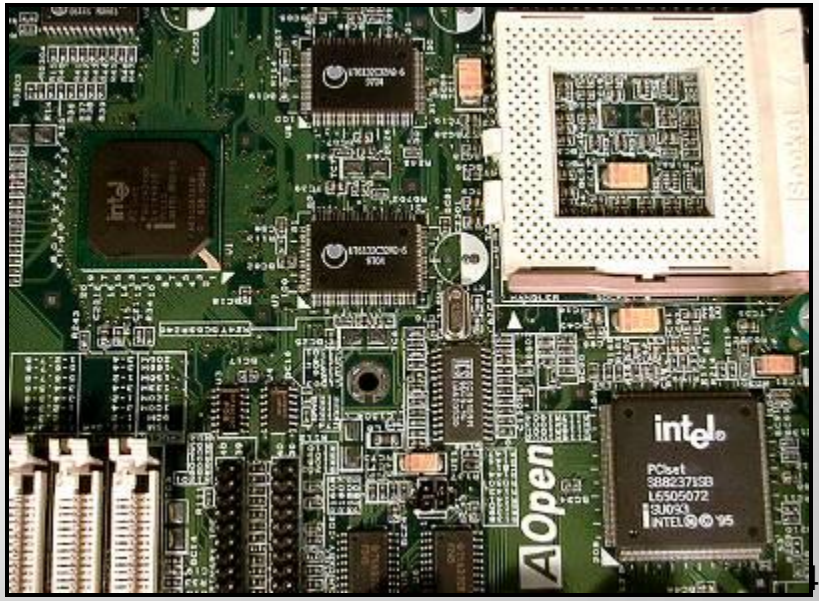
The Ultimate Processing Components

ATX Motherboard



Processing Components





Input Devices

Keyboards

Mice

Trackballs

J-mice

Biometric Scanner

Scanner

Microphone

CD-ROM

Touchpads

Output Devices

- Monitors
- Printers
  - Inkjet, Laser, Dot-matrix, Plotters
- Speakers

Input/Output Devices

- Floppy Drive
- Hard Drive
- Modem
- Network Interface Card
- CD-R/W
- Other Storage Media

Support Hardware

- Power Supply
- UPS
- Surge Arrestor
- Switch Box

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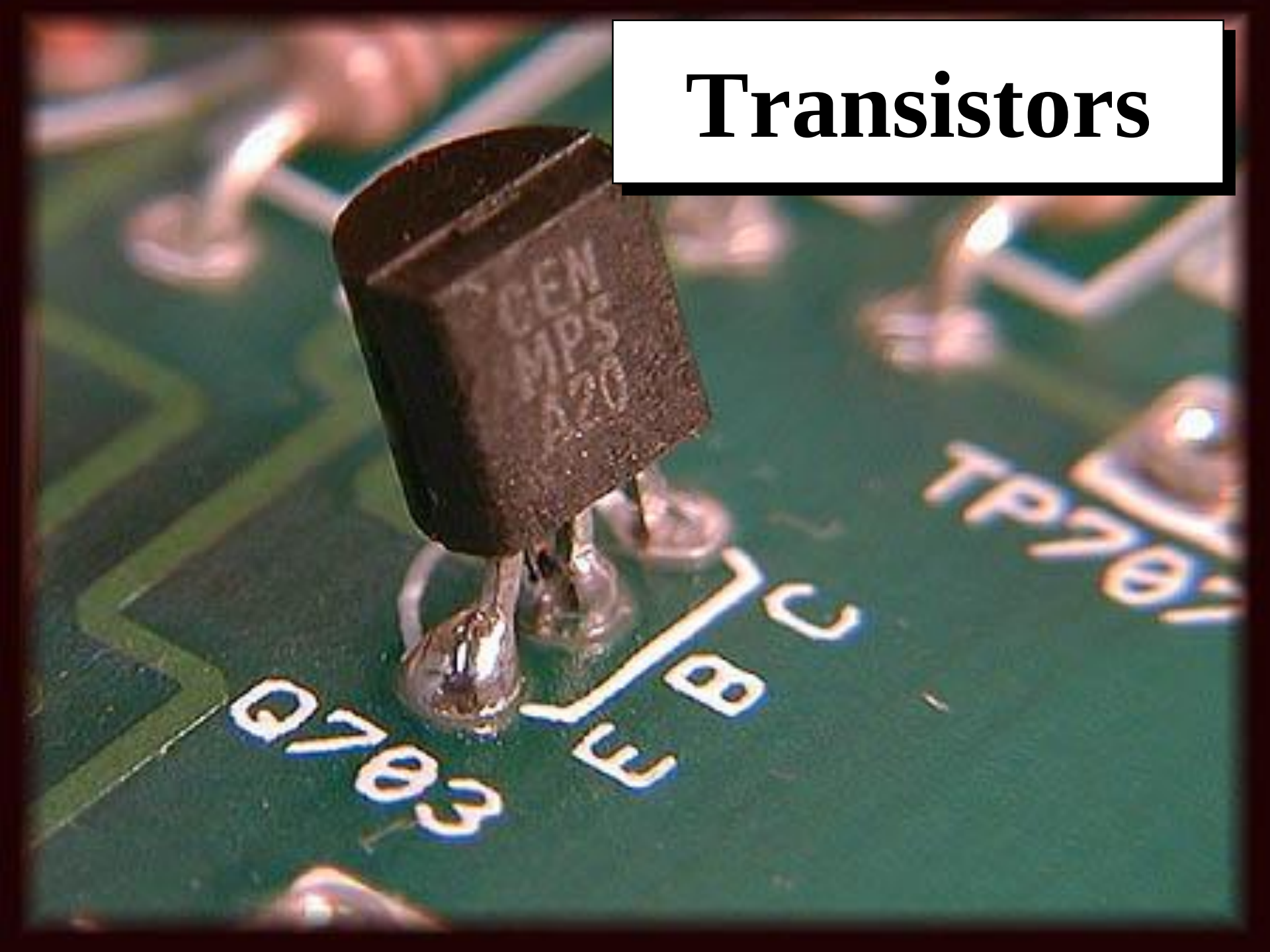
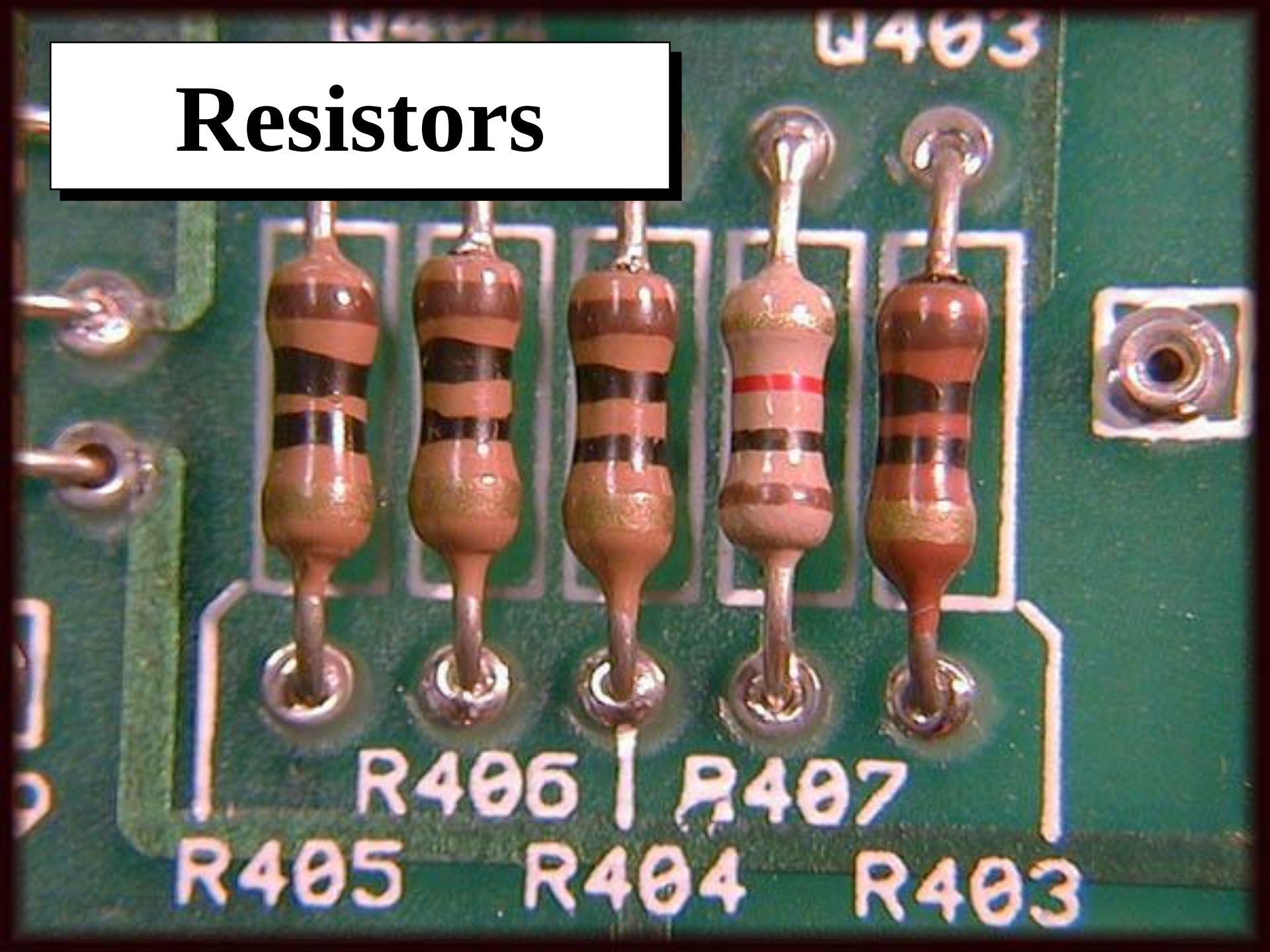
CPU Support Components



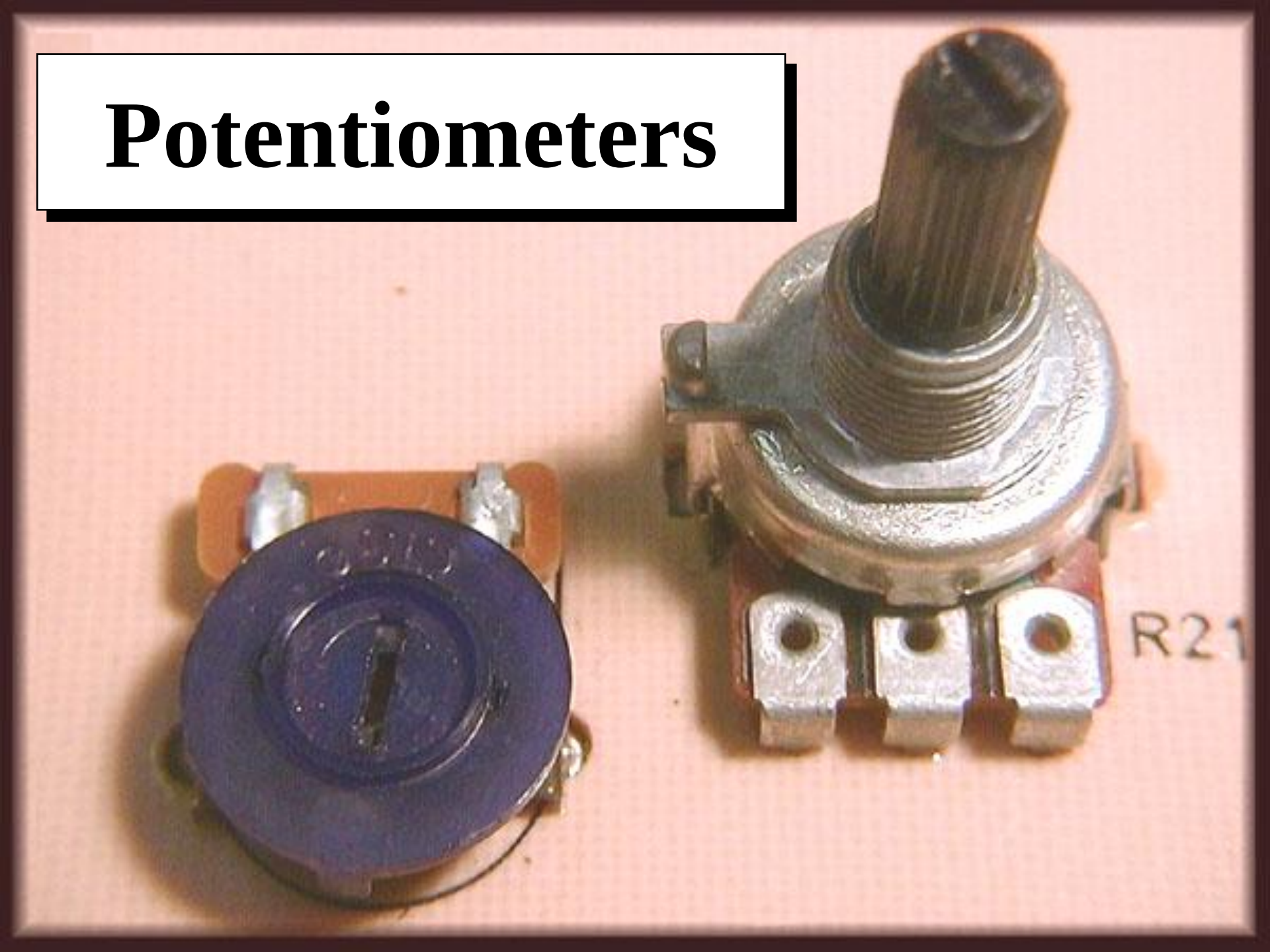
Transistors


Resistors
W403
R406
R407
R405
R404
R403

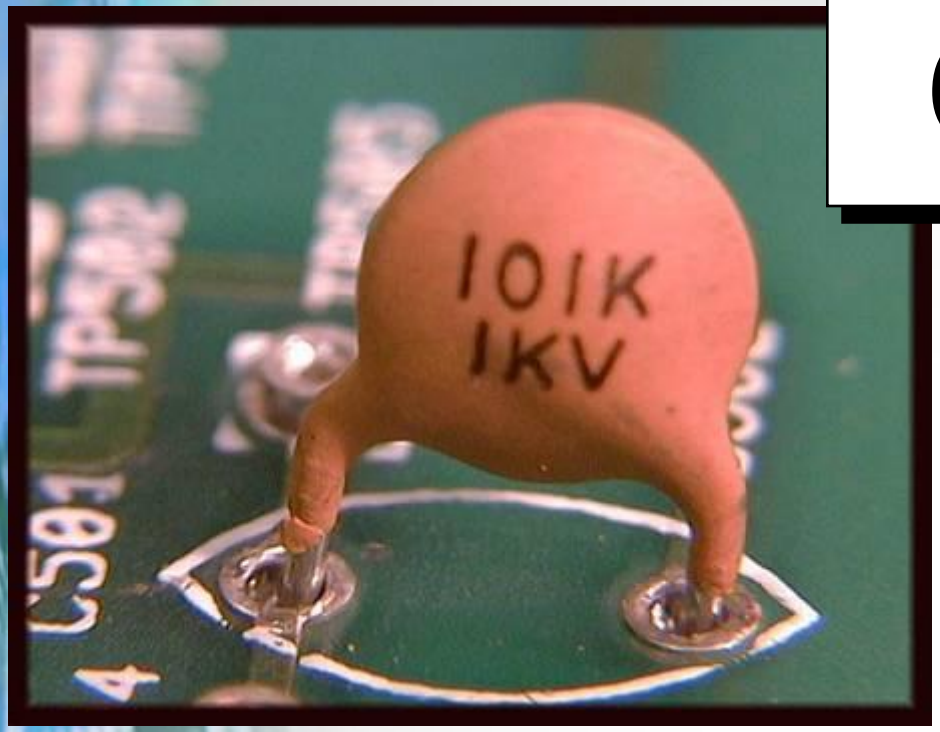
Color Codes

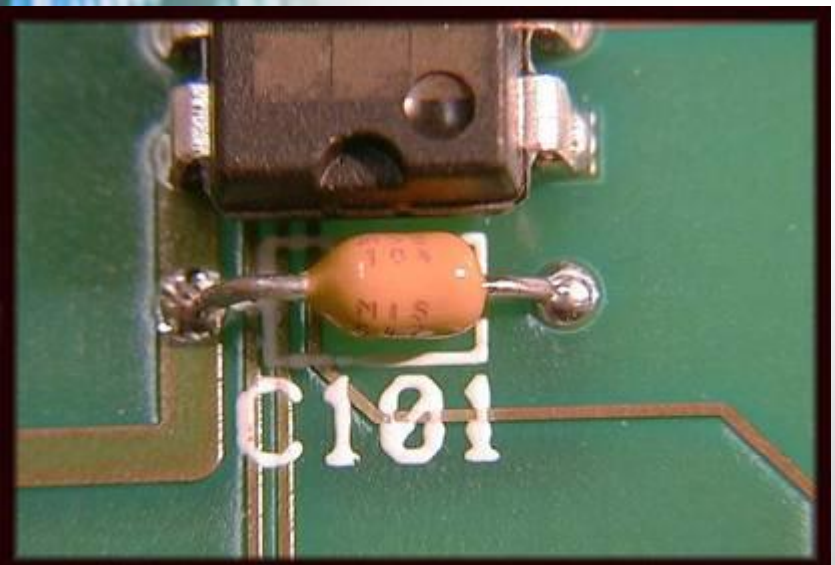
Color	First Band	Second Band	Third Band (optional)	Fourth Band (multiplier)	Tolerance Band
Black	0	0	0	1	
Brown	1	1	1	10	
Red	2	2	2	100	
Orange	3	3	3	1,000	
Yellow	4	4	4	10,000	
Green	5	5	5	100,000	
Blue	6	6	6	1,000,000	
Violet	7	7	7	(silver) .01	(silver) 10%
Gray	8	8	8	(gold) .1	(gold) 5%
White	9	9	9		(brown) 1%

Potentiometers

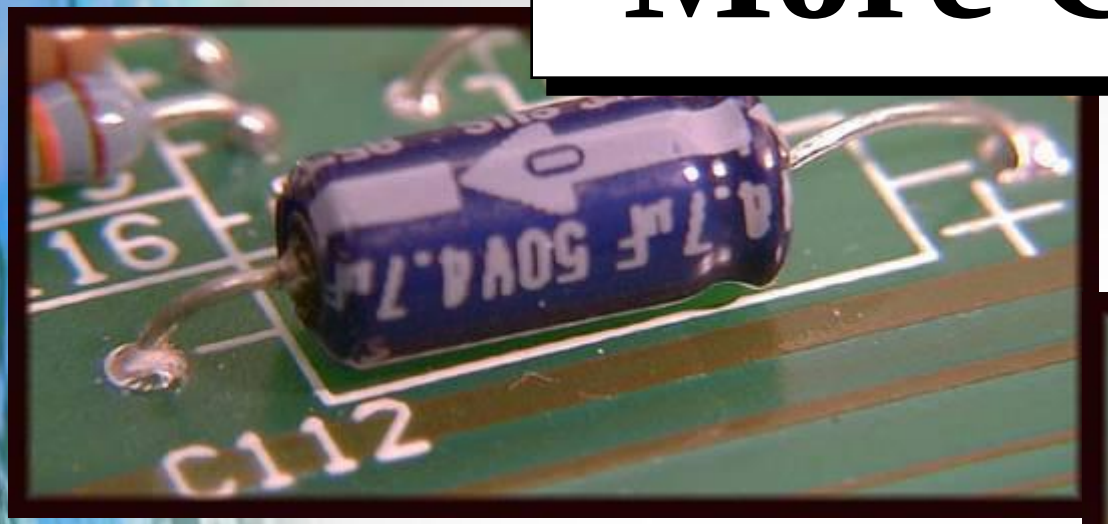


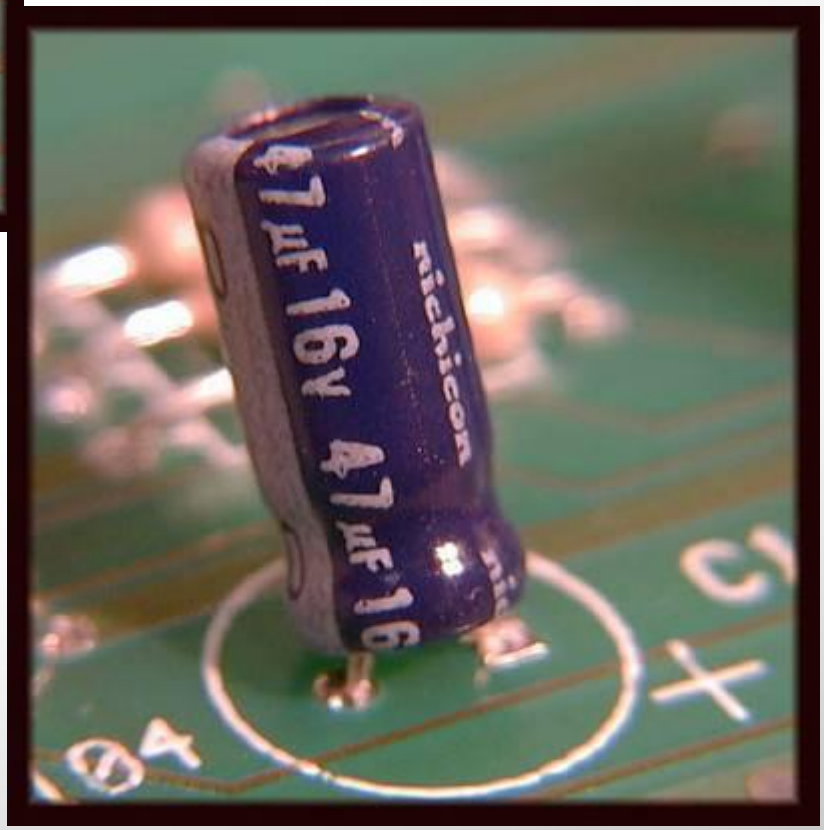
Capacitors

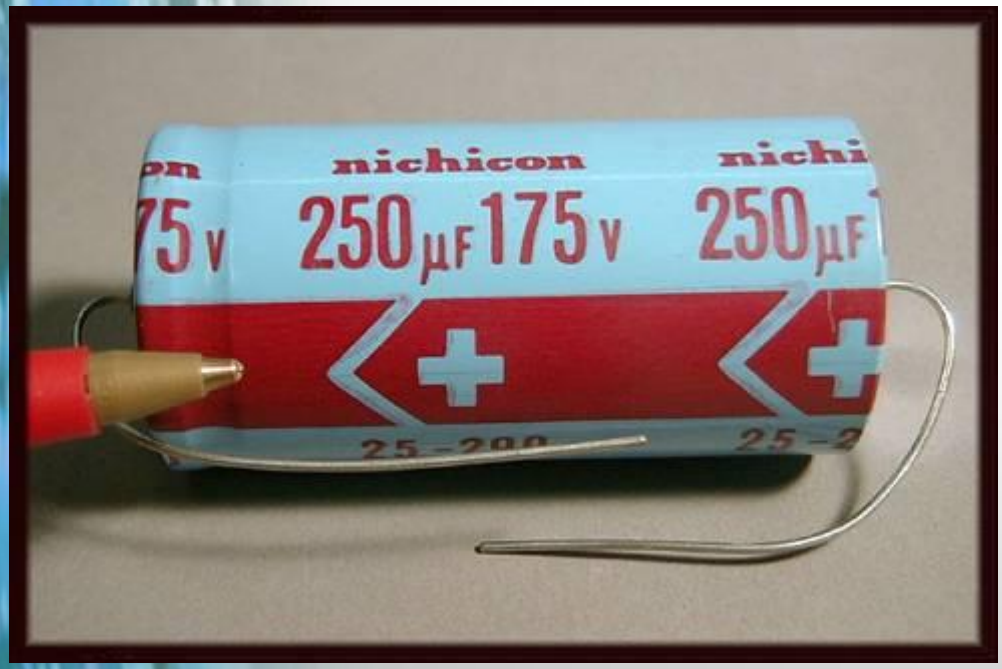




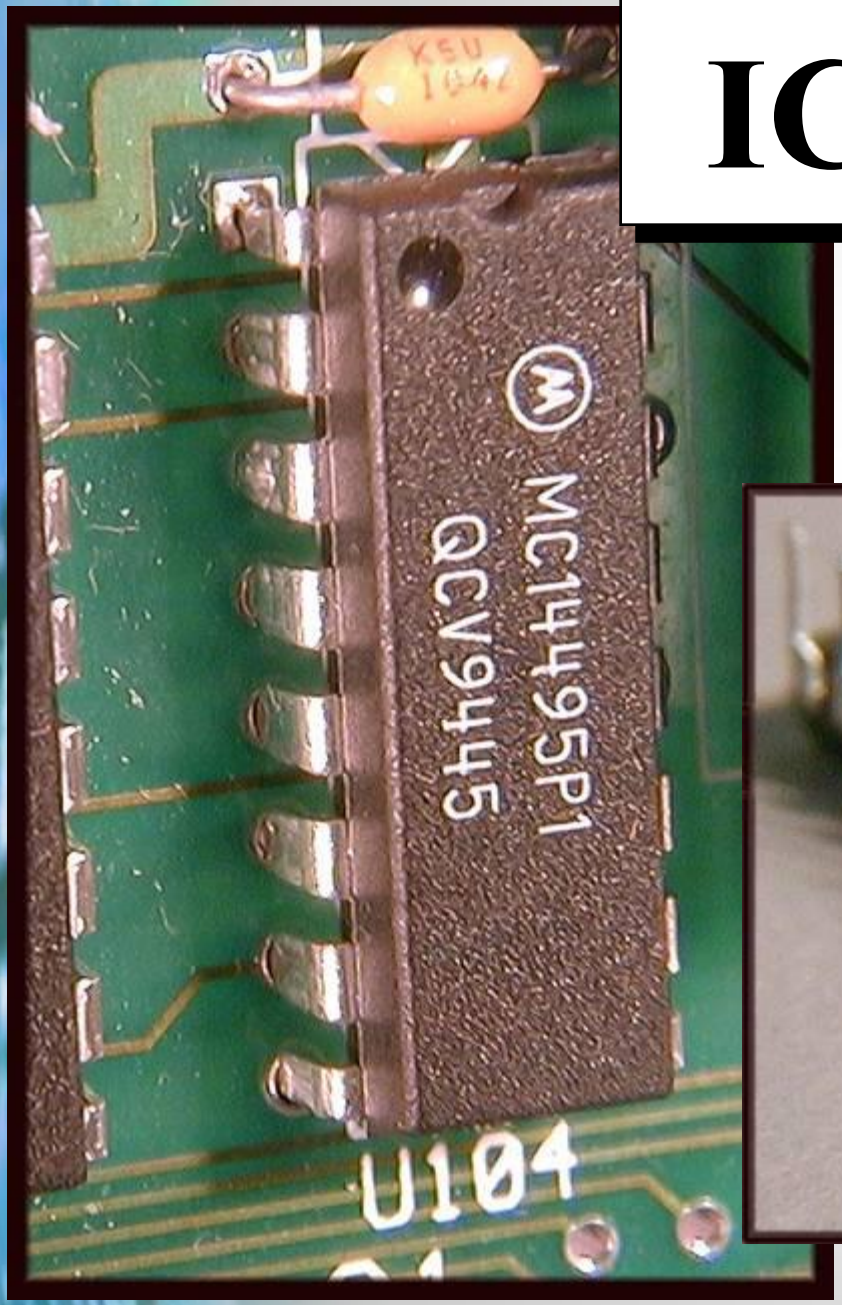
More Capacitors

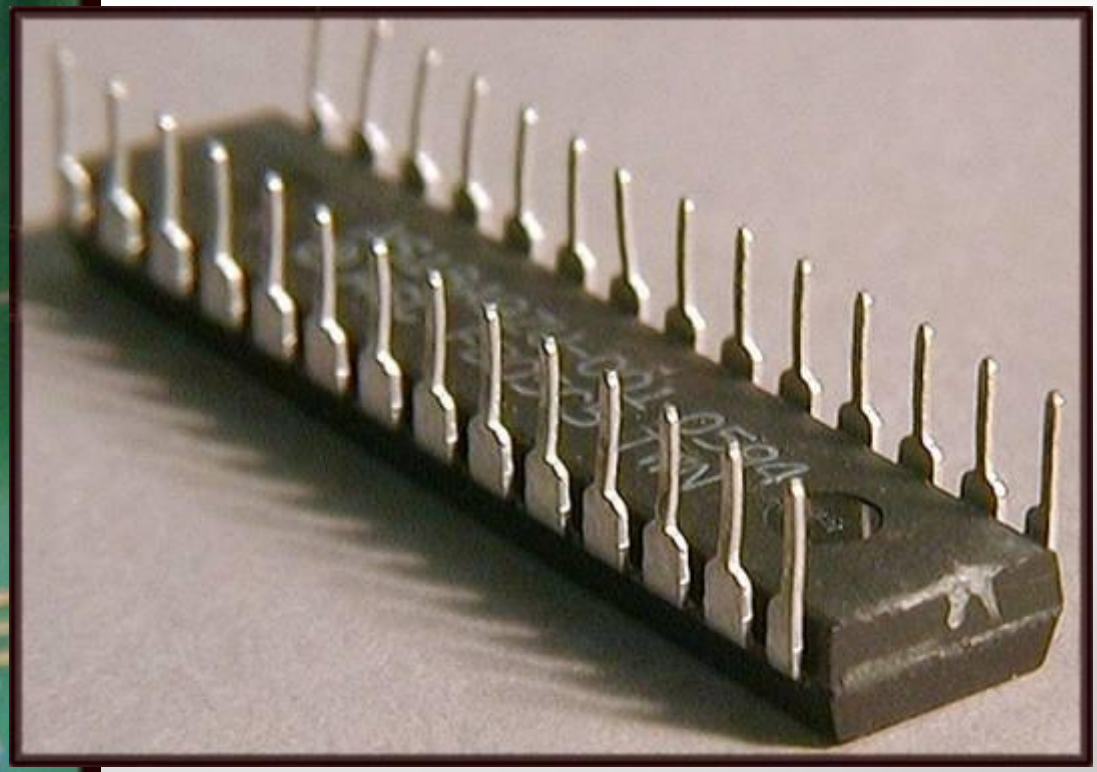




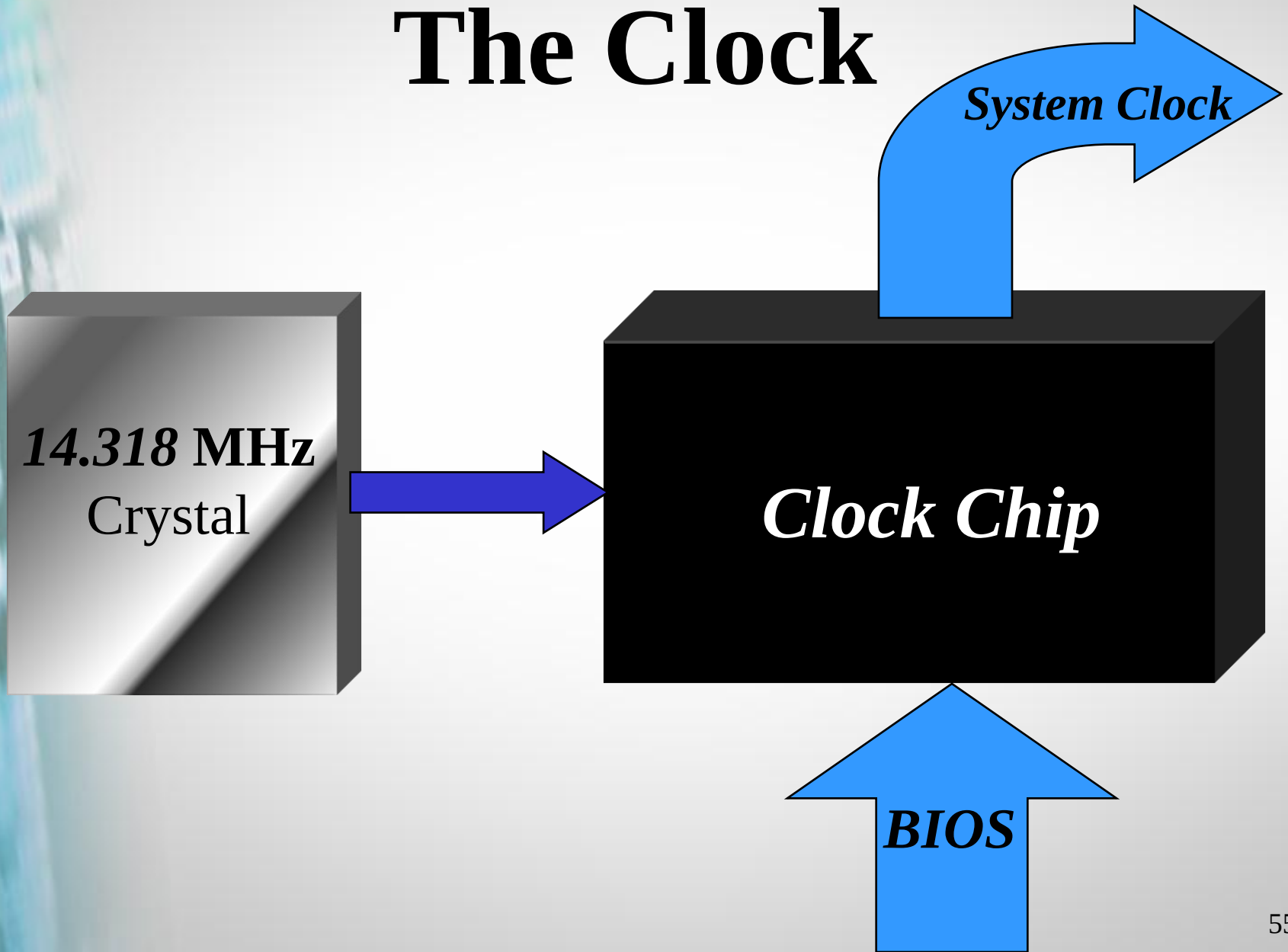


IC's - DIP style





The Clock



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The History of Processors

The First Microprocessor

- **4004** by Intel in 1971
- Designed as the core logic of a calculator
- Handled data 4 bits at a time
- Ran at 108 KHz
- 2300 transistors
- Memory: 640 bytes

8008

- Date Introduced April 1972
- Number of Transistors 3,500
- Internal Register Size 8-bits
- Data I/O Bus Width 8-bits
- Maximum Memory 16 KB
- Typical Speed 0.2 MHz

8080

- Date Introduced April 1974
- Number of Transistors 6000
- Int Register Size 8-bits
- Data I/O Bus Width 8-bits
- Maximum Memory 64 KB
- Typical Speed 2 MHz

8088

- Date Introduced June 1979
- Number of Transistors 29,000
- Int Register Size 16 bits
- Data I/O Bus Width 8 bits
- Maximum Memory 1 MB
- Typical Speed 8 MHz

The 8088 was used in the first IBM Personal Computer

80286

- Date Introduced May 1982
- Number of Transistors 134,000
- Int Register Size 16 bits
- Data I/O Bus Width 16 bits
- Maximum Memory 16 MB
- Typical Speed 12 MHz

80386

- Date Introduced Oct. 1985
- Number of Transistors 275,000
- Internal Register Size 32 bits
- Data I/O Bus Width 32 bits
- Maximum Memory 4 GB
- Typical Speed 16/20/25/33 MHz

80386sx

- Int Register Size 32-bits
- Data I/O Bus Width 16-bits
- Typical Speed 16/20/25/33 MHz

Math Coprocessors

- Fast circuits to perform floating point math
- For 8088 through 80386, a separate device
- As complicated as the CPU itself

CPU and Coprocessor

8088 → **8087**

80286 → **80287**

80386 → **80387**

80486

- Date Introduced — April 1989
- Transistors — 1,200,000
- Int Register Size — 32-bits
- Bus Width — 32-bits
- Max Memory — 4 GB
- Typical Speed — 66 MHz
- L1 Internal Cache — 8 KB
- Math Coprocessor — Internal

Internal Cache

- A small memory inside the CPU that runs at the same speed as the CPU
- Also called an L1 cache

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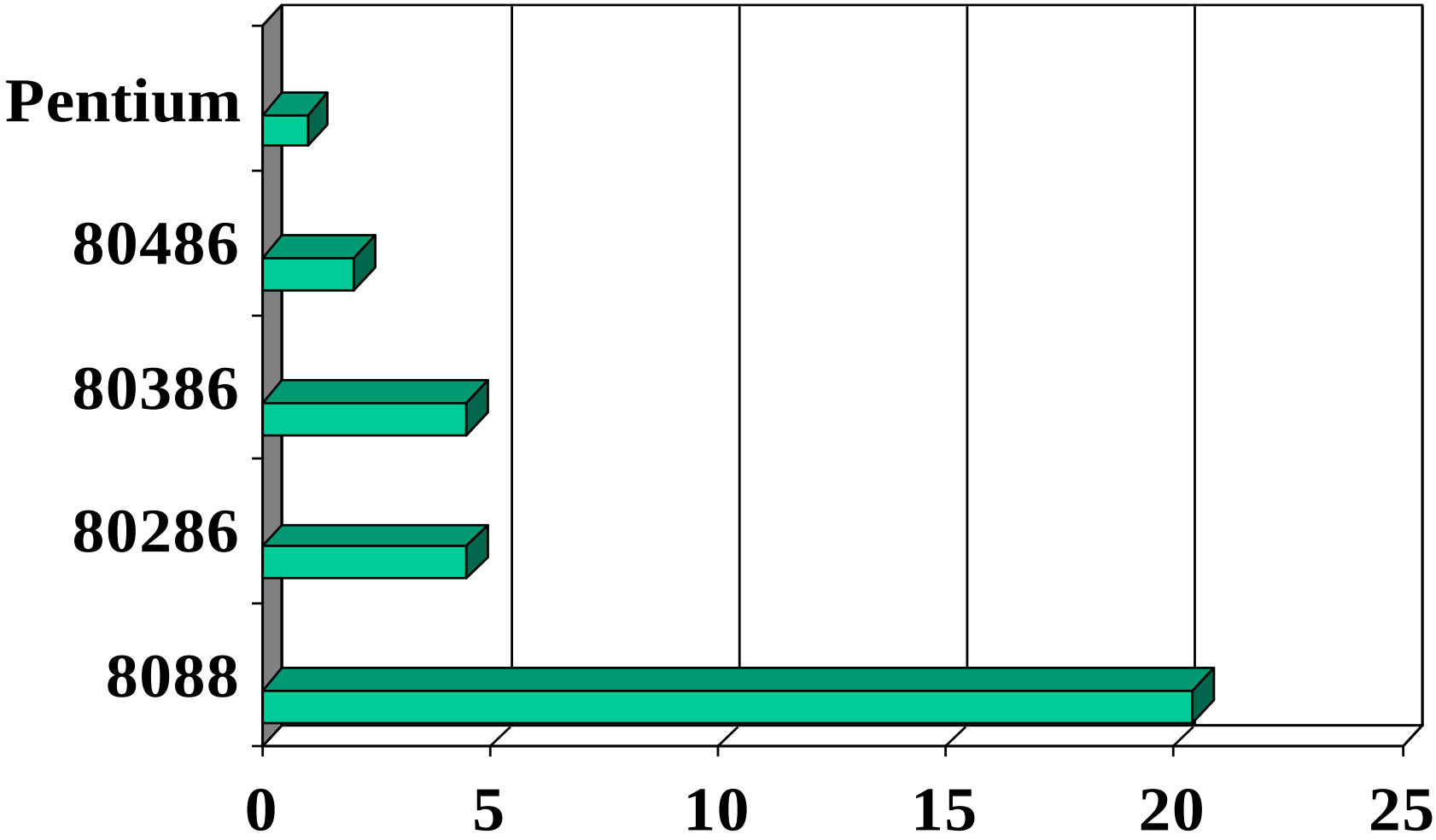
Today's CPU Standard

Pentium®

- Date Introduced March 1993
- Transistors 3,100,000
- Int Register Size 32-bits
- Data I/O Bus Width 64-bits
- Maximum Memory 4 GB
- Typical Speed 100 MHz
- L1 Internal Cache 2×8 KB
- Internal Coprocessor Yes

Number of clock cycles needed to execute a typical instruction




intel®
pentium®
A80502100 SY007
ICOMP® 2 #=90
L6503229-1033
INTEL©'92'93
Socket 7
HANDLER
SOCKET 4

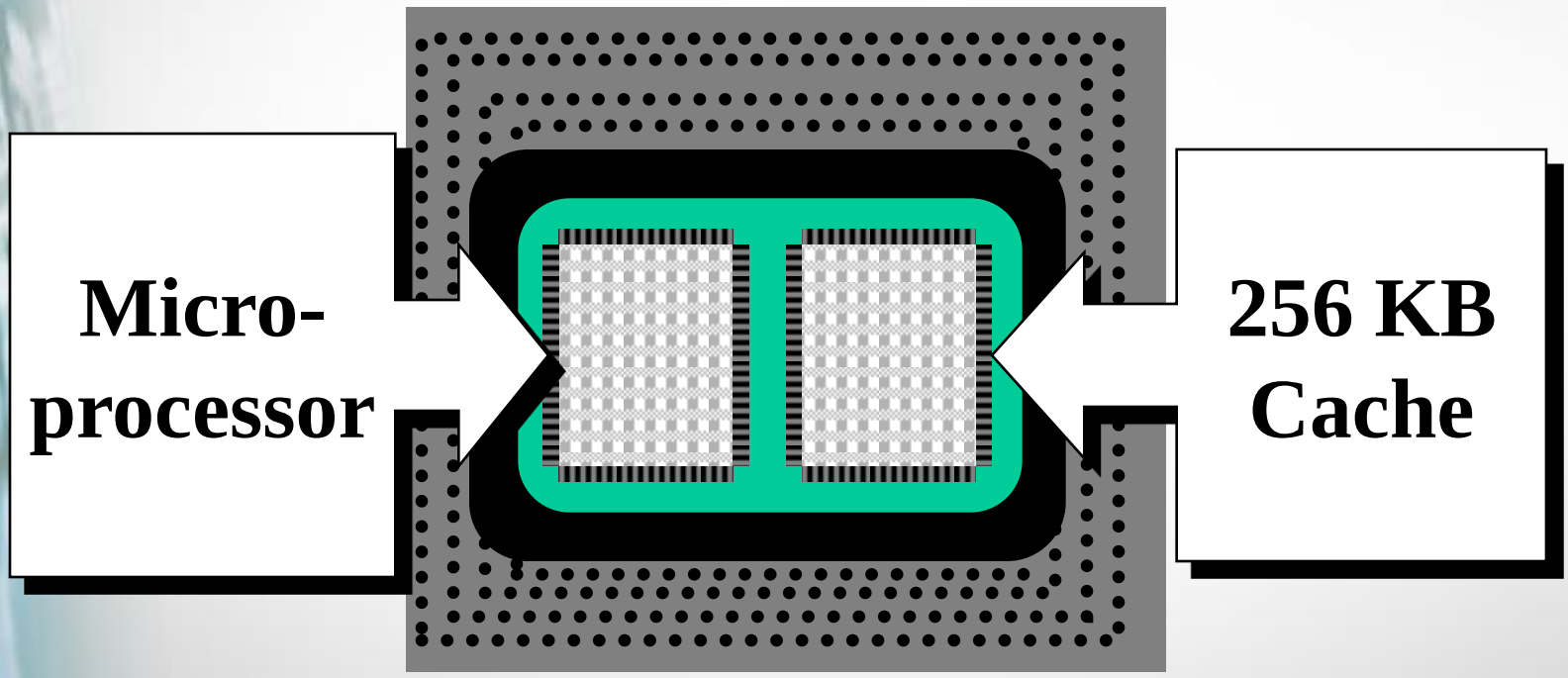
Pentium MMX

- Date Introduced January 1997
- Transistors 4,100,000
- Internal Register Size 32 bits
- Data I/O Bus Width 64 bits
- Maximum Memory 4 GB
- Typical Speed 200 MHz
- L1 Internal Cache 2×16 KB
- Math Coprocessor Yes
- MMX Instructions Yes

Pentium Pro®

- Date Introduced — November 1995
- Transistors — 5,500,000
- Internal Register Size — 32 bits
- Data I/O Bus Width — 64 bits
- Maximum Memory — 64 GB
- Typical Speed — 200 MHz
- L1 Internal Cache — 2×8 KB
- Math Coprocessor — Yes
- L2 Cache — 256 KB

Pentium Pro®

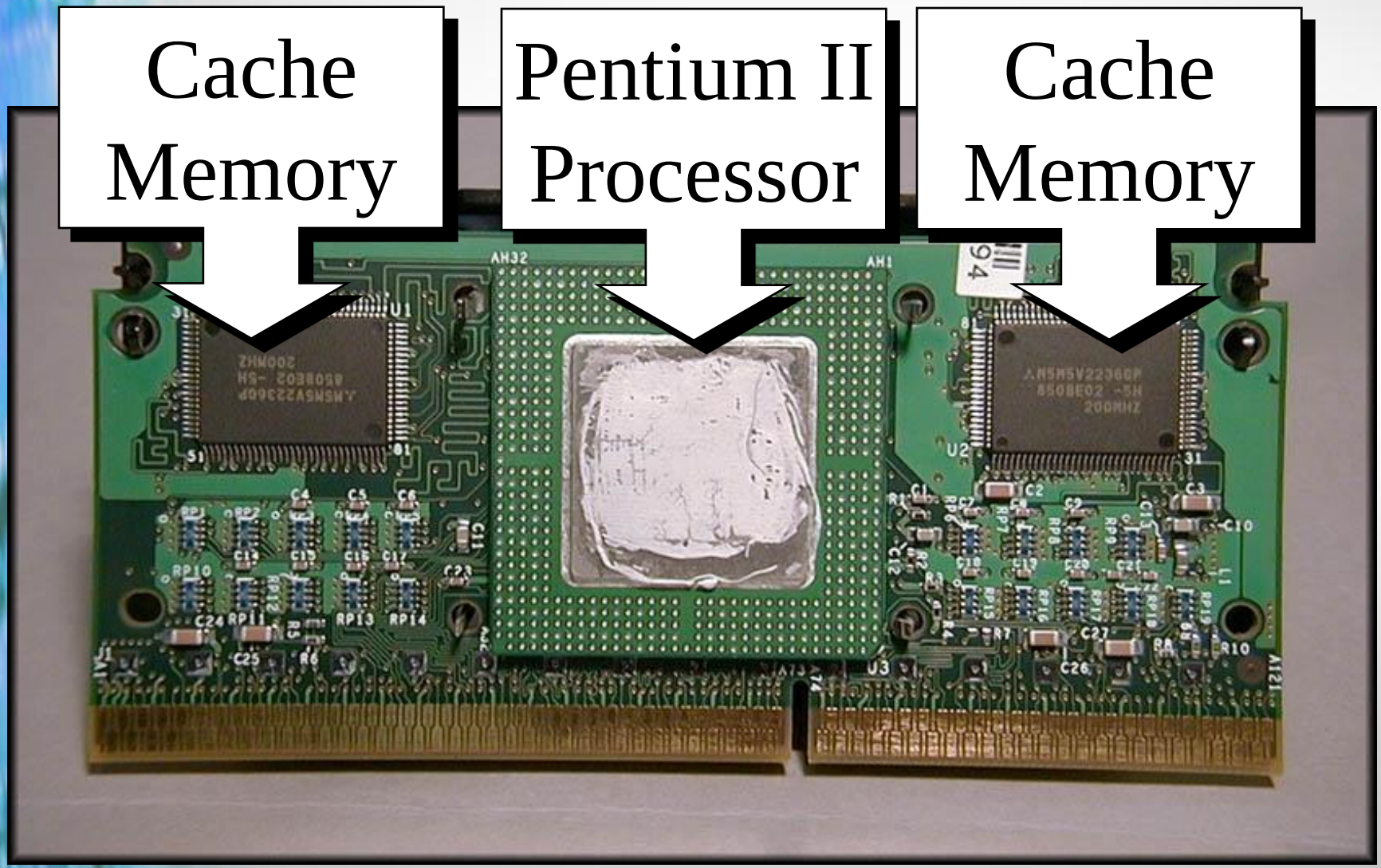


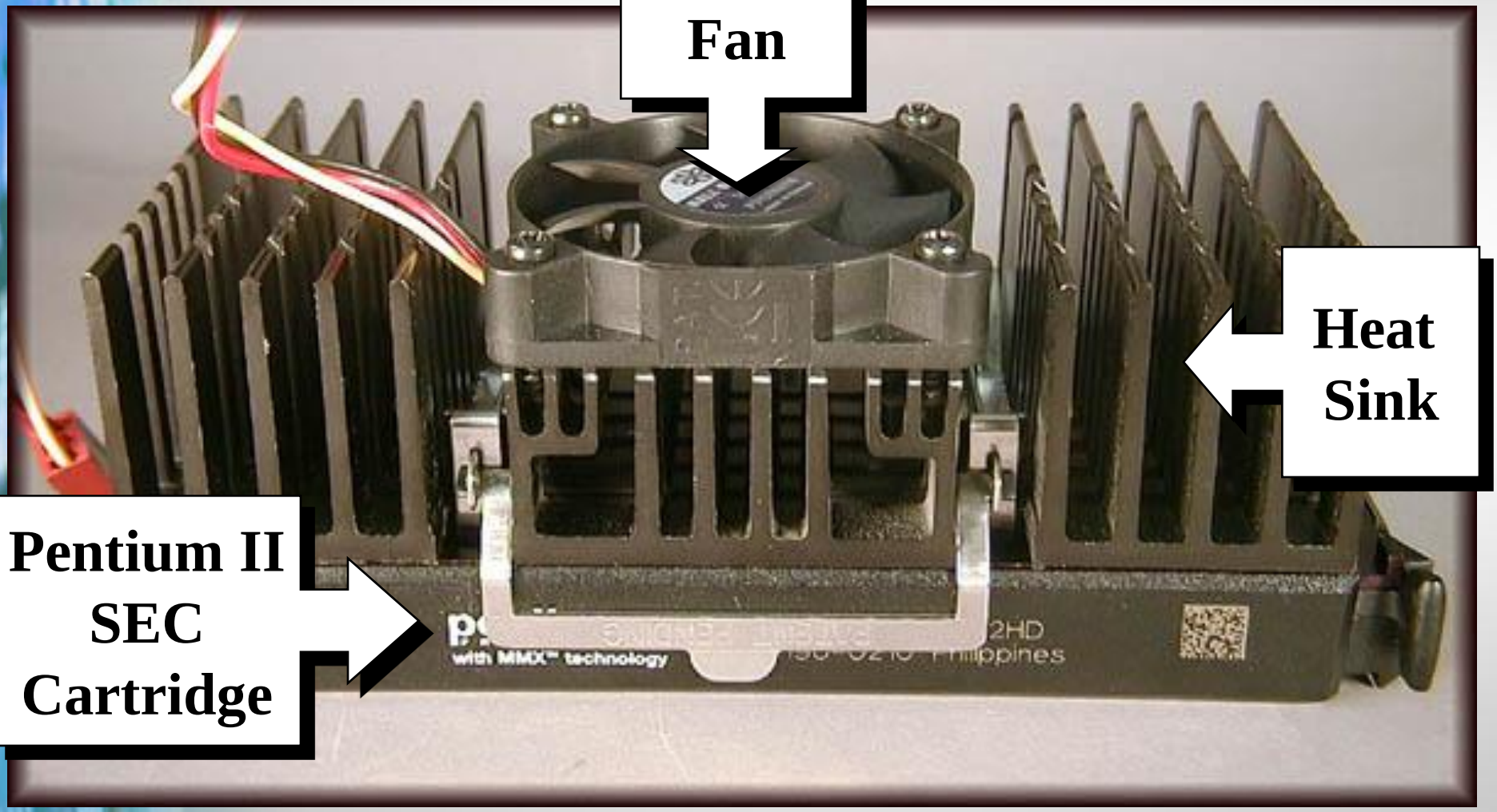
Pentium II®

- Date Introduced May 1997
- Number of Transistors 7,500,000
- Int Register Size 32 bits
- Data I/O Bus Width 64 bits
- Maximum Memory 64 GB
- Typical Speed 300 MHz
- L1 Internal Cache 2×16 KB
- Math Coprocessor Yes
- L2 Cache 512 KB

Pentium II Single Edge Contact (SEC) Cartridge

Internal View (Front)



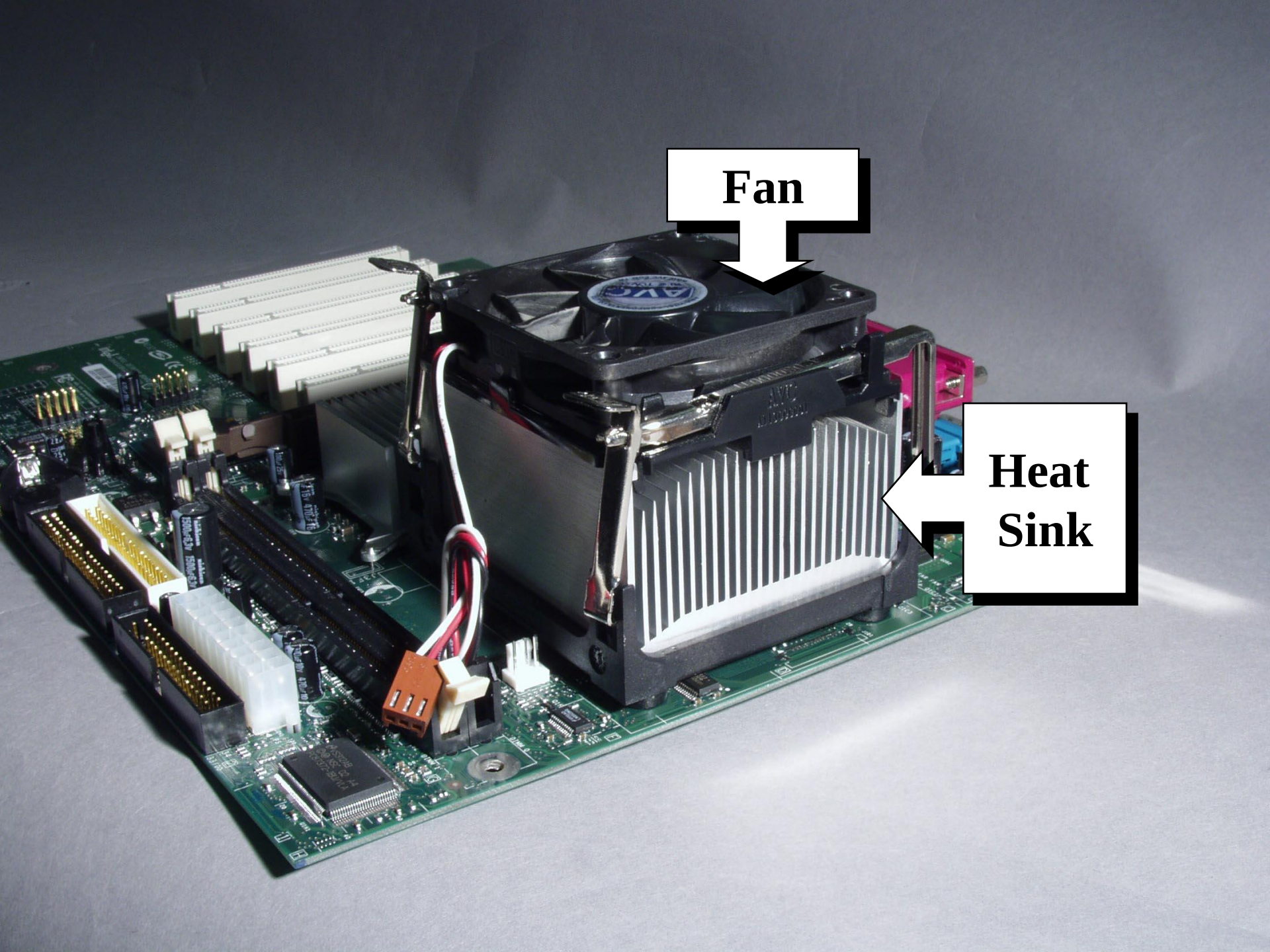

Fan
Heat Sink
Pentium II SEC Cartridge
with MMX™ technology

Pentium III ®

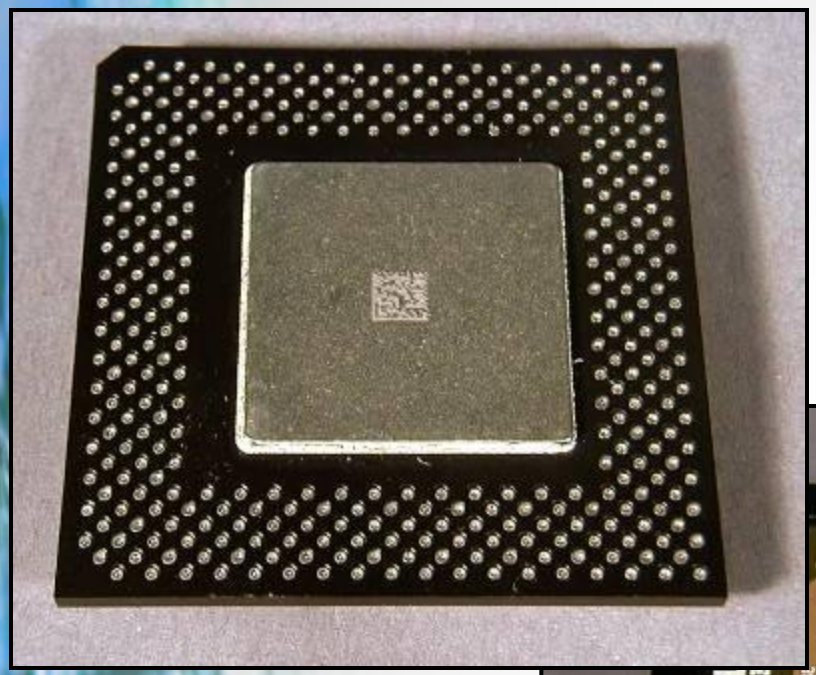
- 0.25 Micron Technology
- 450 MHz to 1.4 GHz
- 1.8V core voltage
- Dissipates less heat
- Supports multi-processing

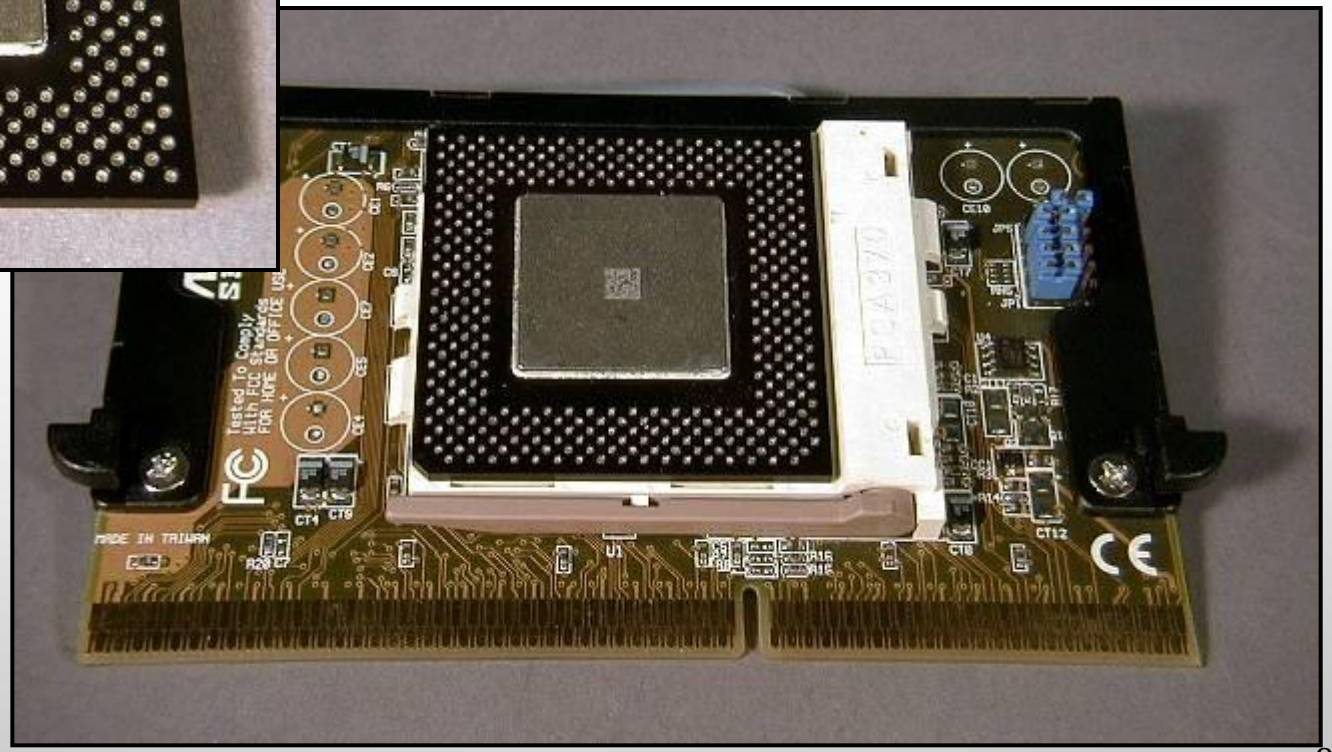
Pentium 4 ®

- 0.18, 0.13, 0.09 Micron Technology
- 1.3 GHz to 4 GHz and higher
- 1 V to 1.8 V core voltage
- Dissipates lots of heat (up to 100 W)
- Supports multi-processing

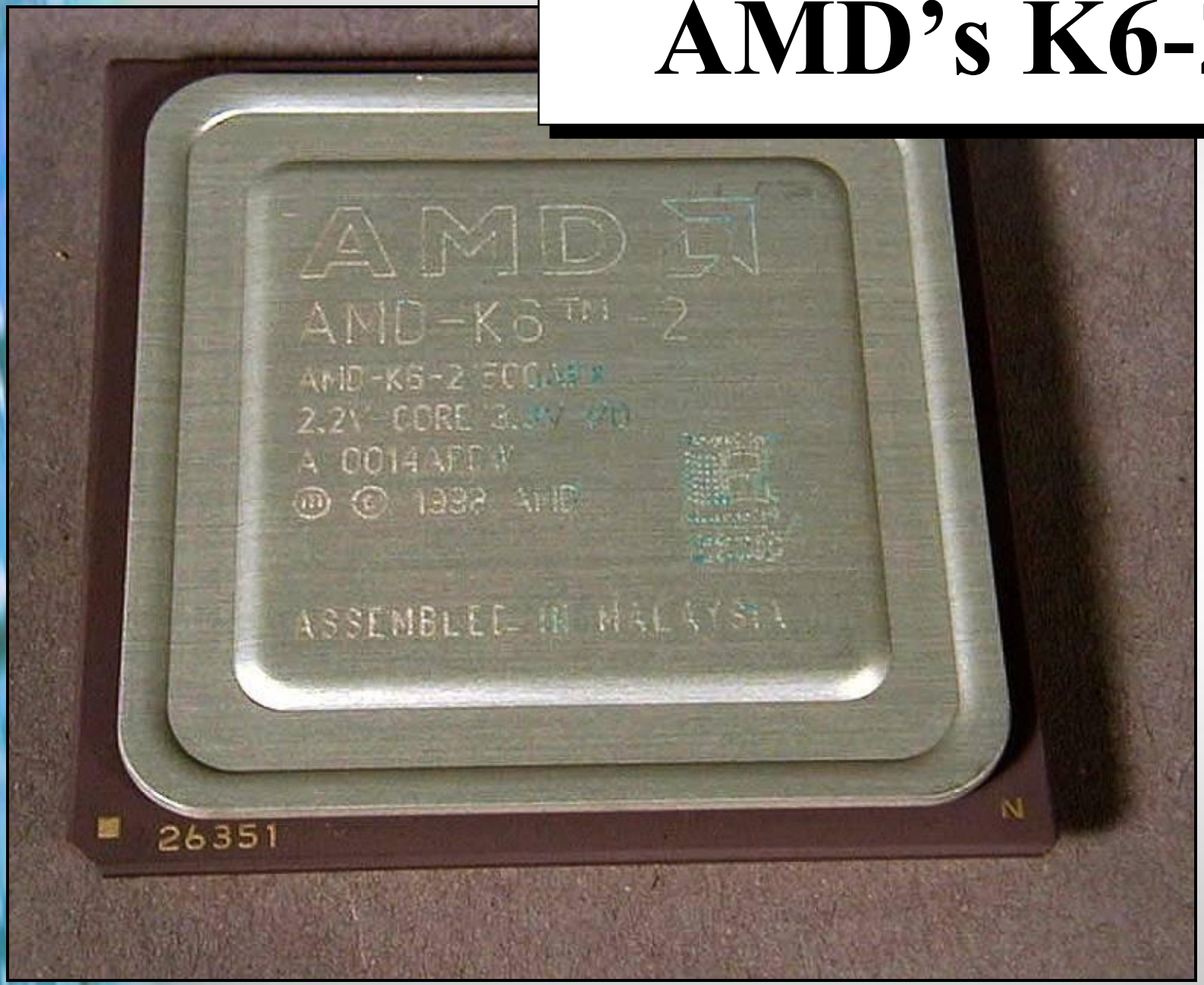

Fan
Heat
Sink

Celeron




Tested To Comply
With FCC Standards
FOR HOME OR OFFICE USE
MADE IN TAIWAN

AMD's K6-2

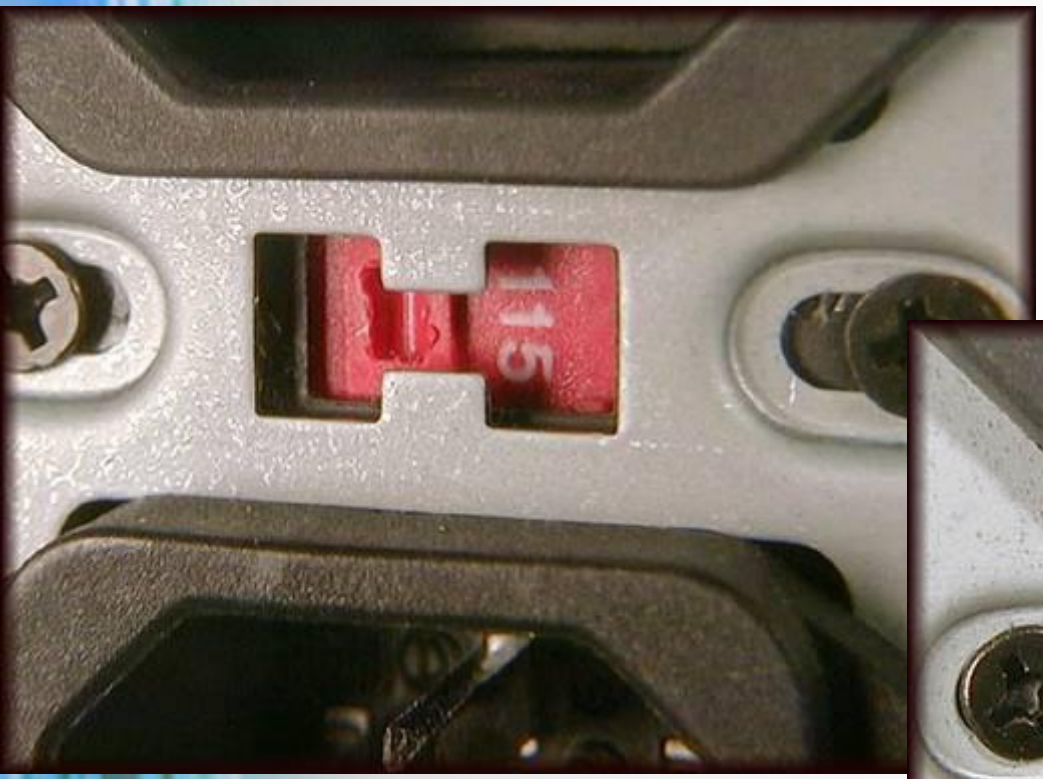


HEATHKIT™
EDUCATIONAL SYSTEMS

Power and Connectors

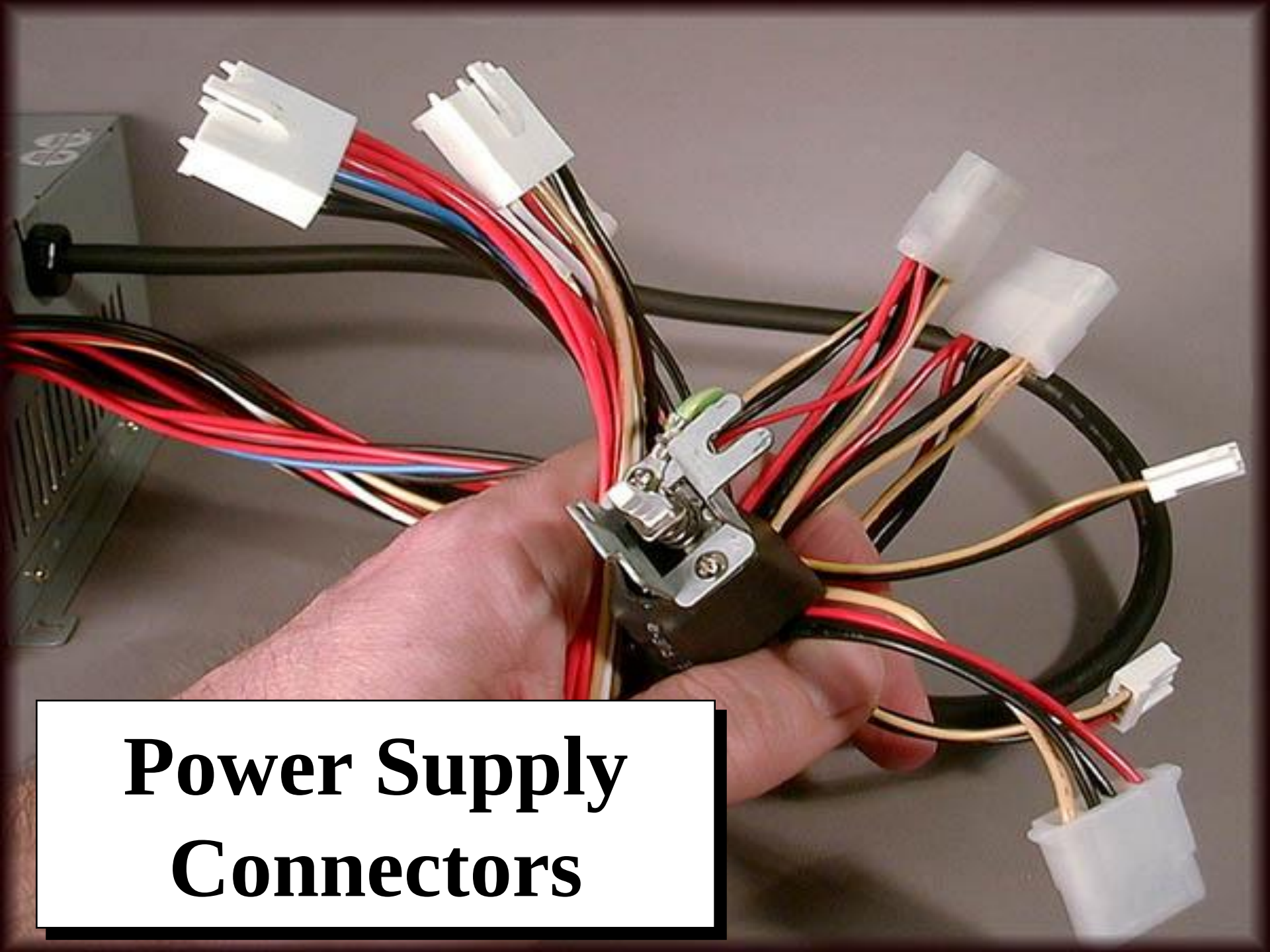

Standard Power
Supply

Power Selection Switch



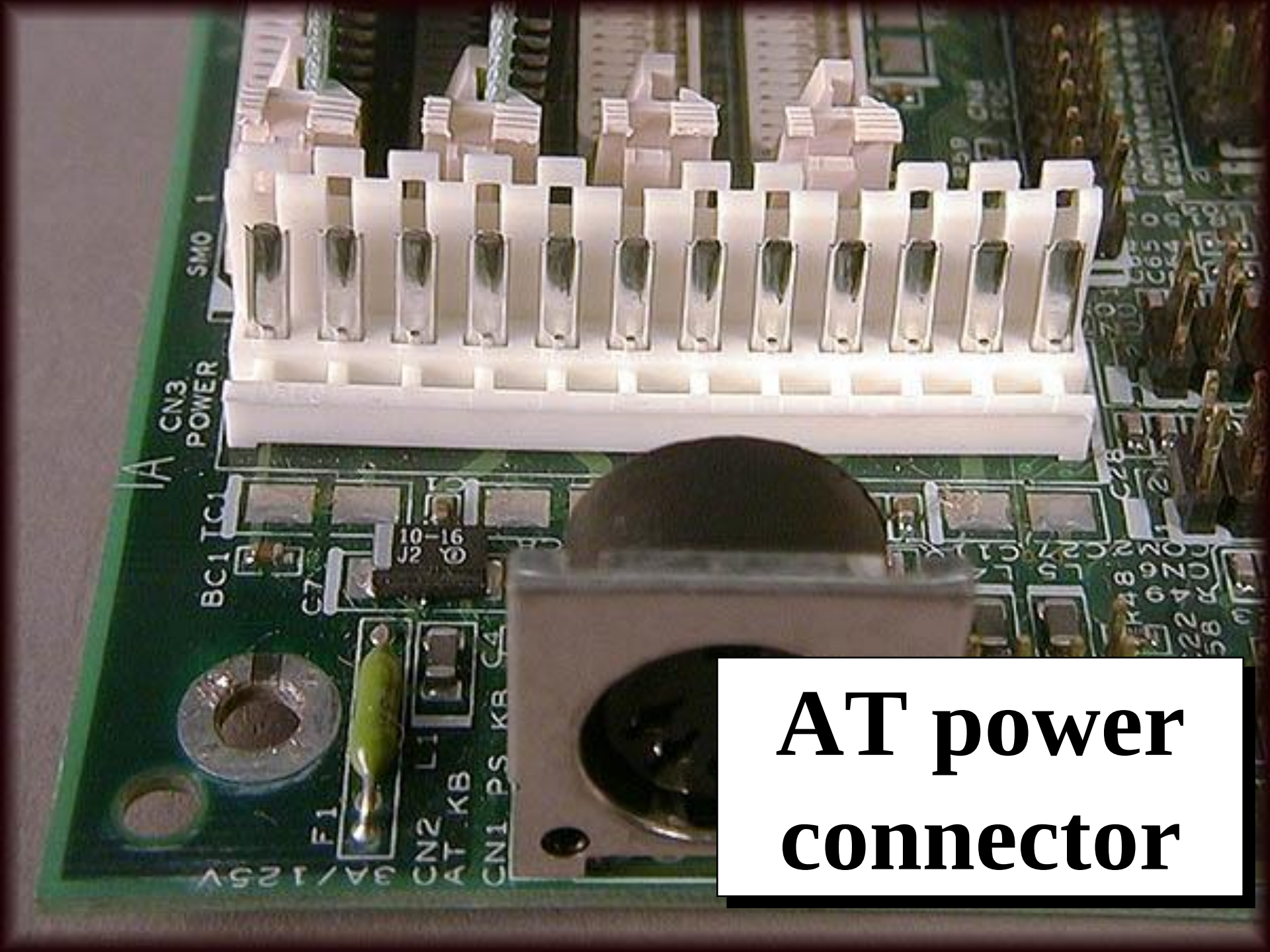
WARNING!

Hazardous voltages contained within this power supply, not user serviceable. Return to service center for repair.

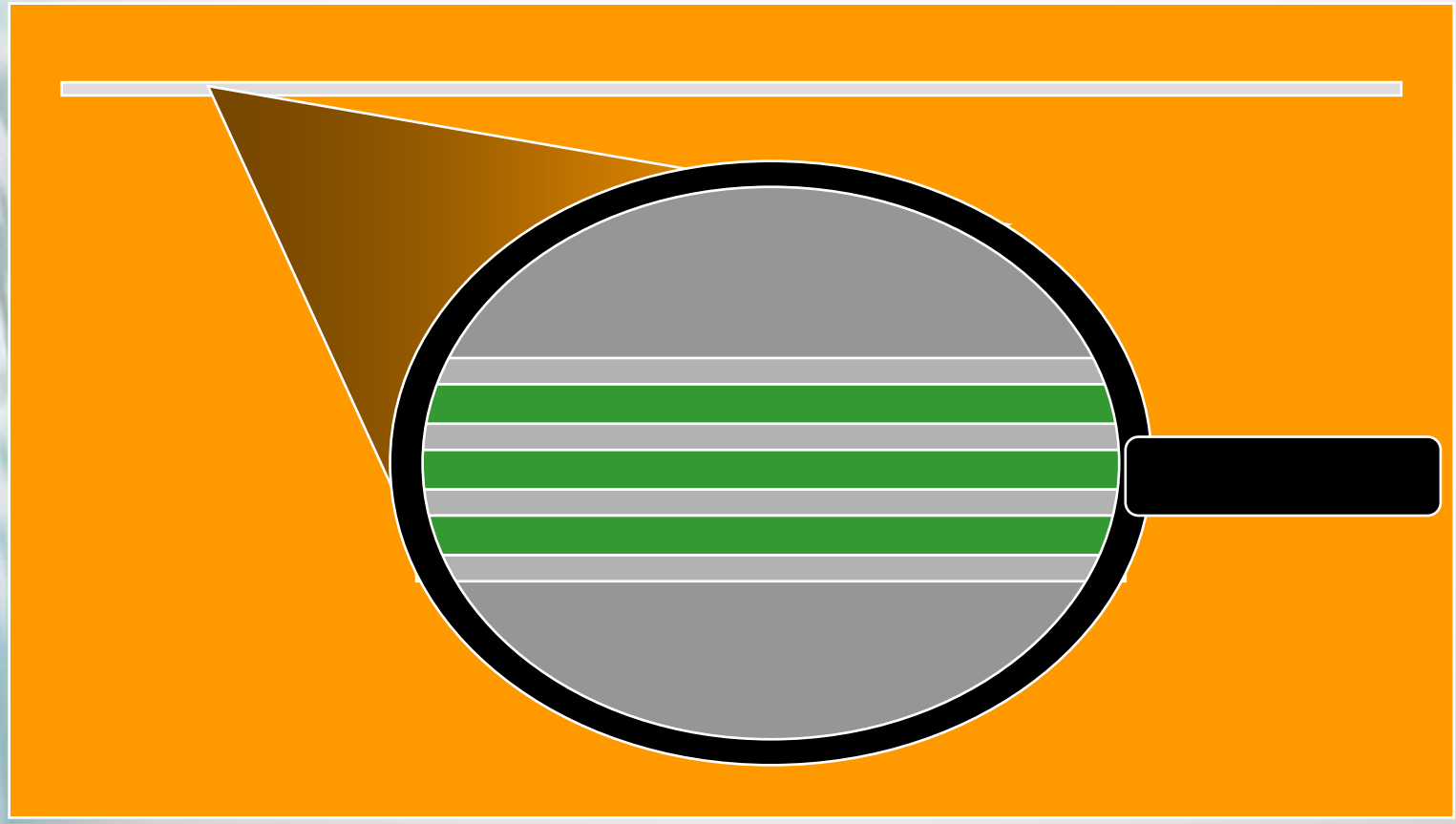

Power Supply
Connectors

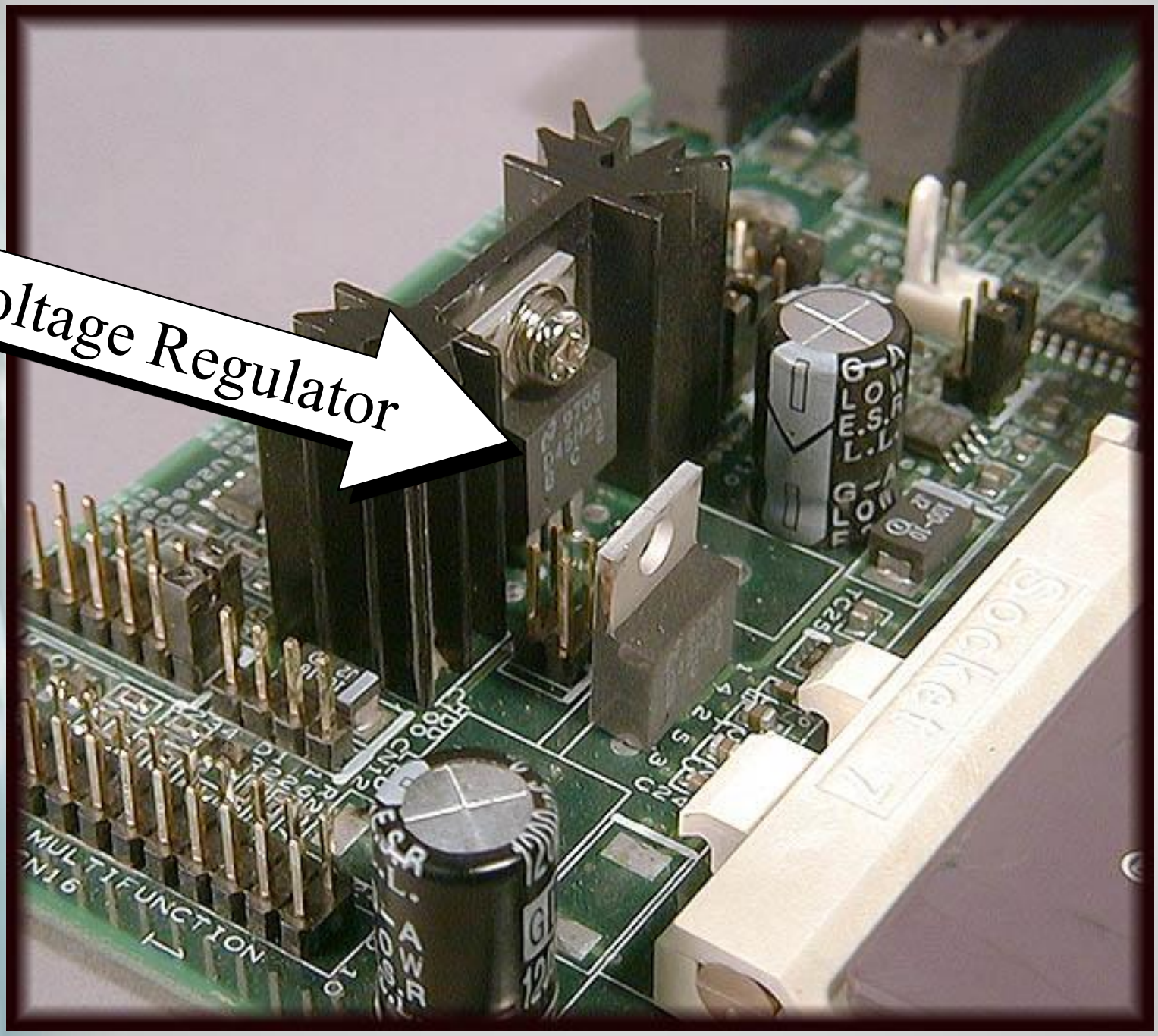
Power Supply Output Voltages AT-Type

- +5 Volts
- +12 Volts
- -12 Volts
- -5 Volts

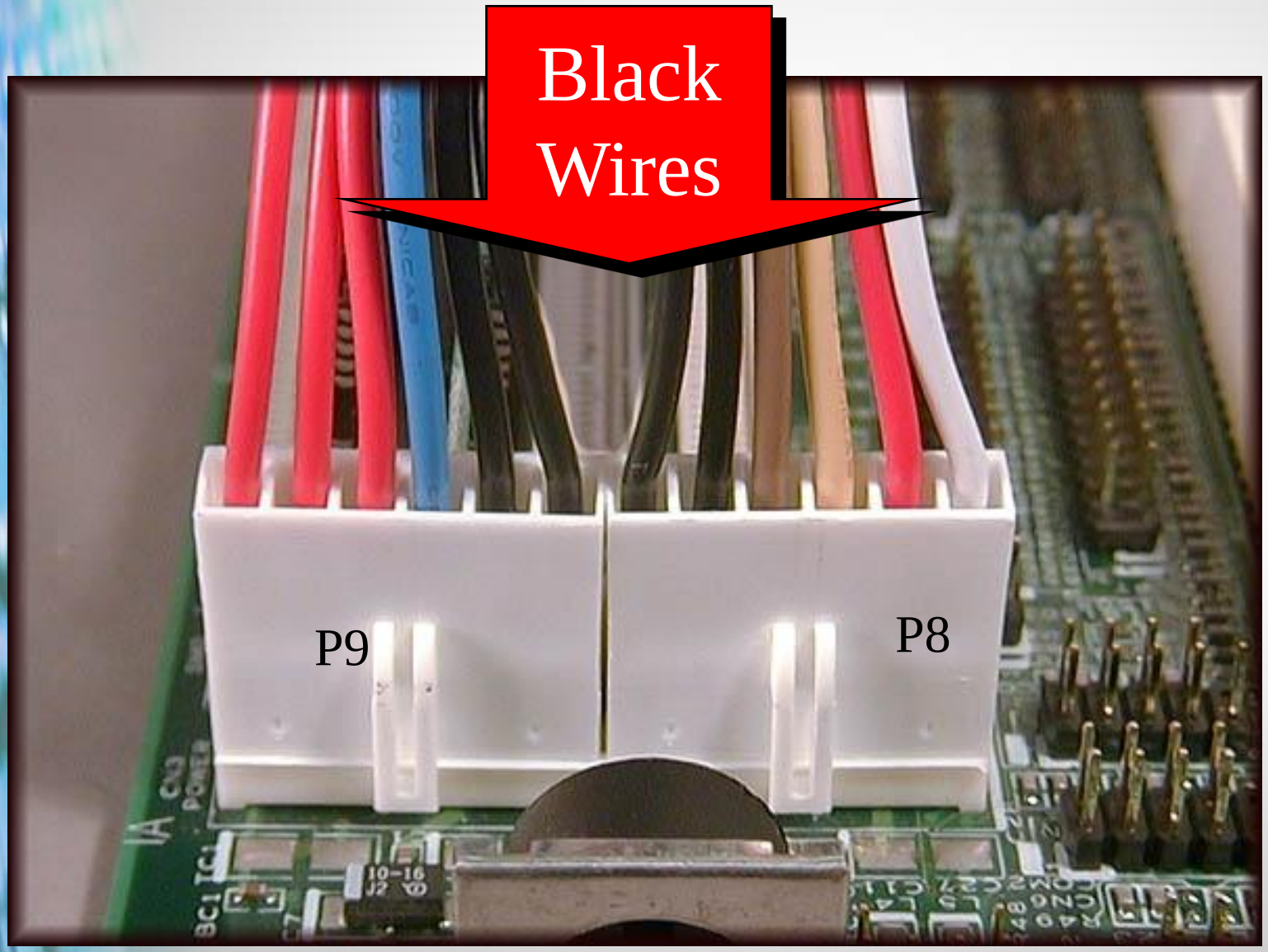

AT power
connector

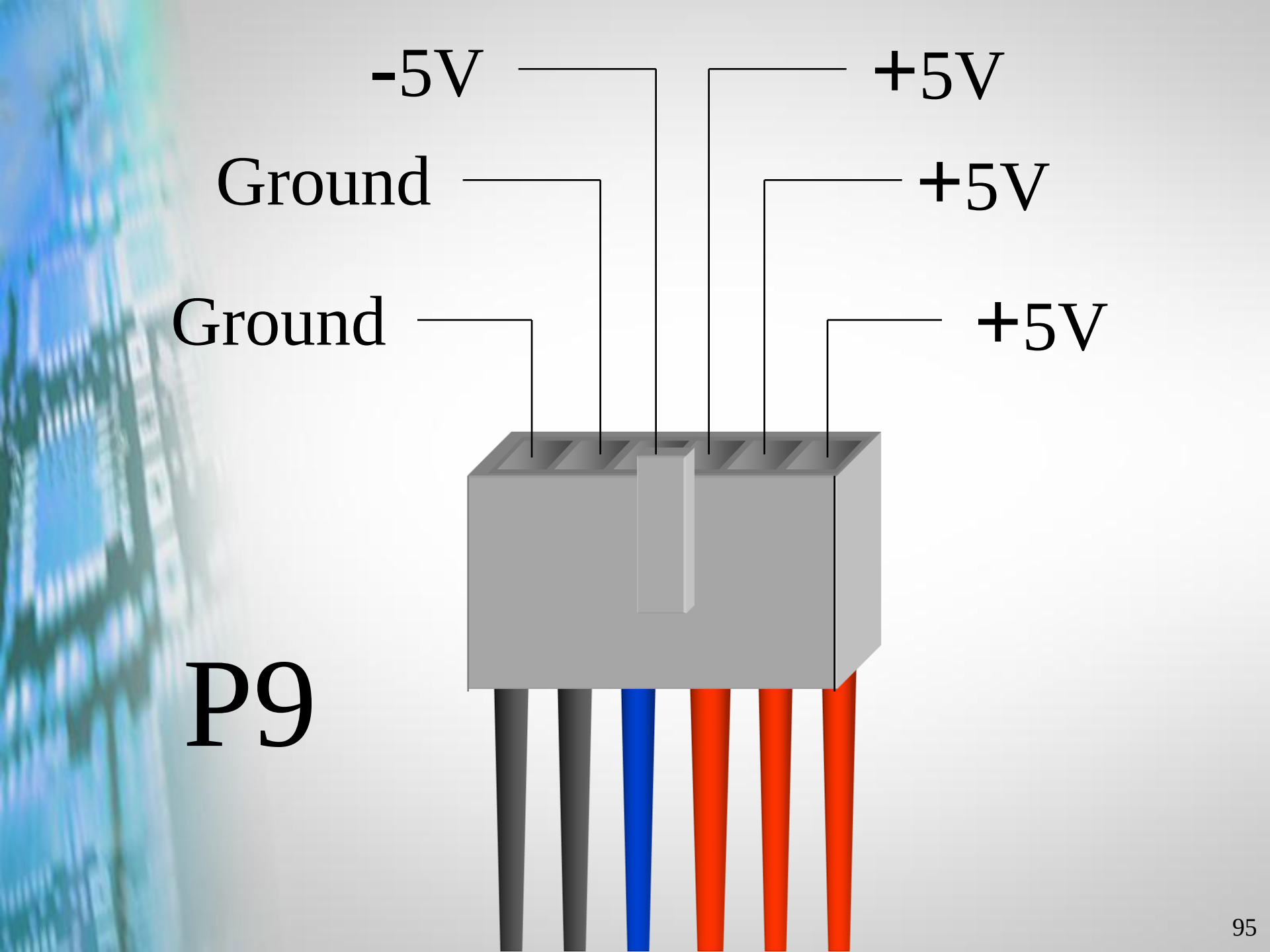
Edge View of Motherboard

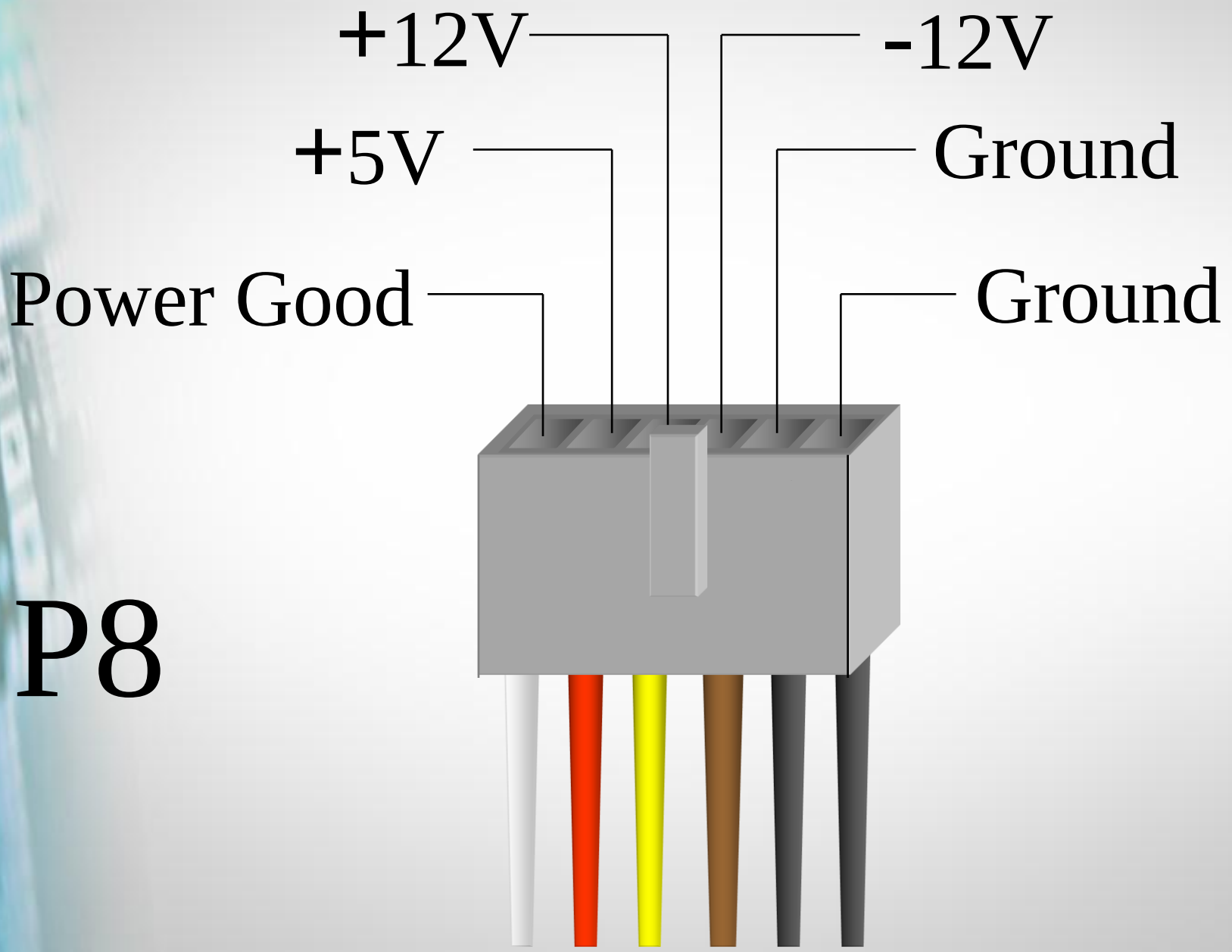



Voltage Regulator
MULTIFUNCTION
CN16

Motherboard Power Connectors



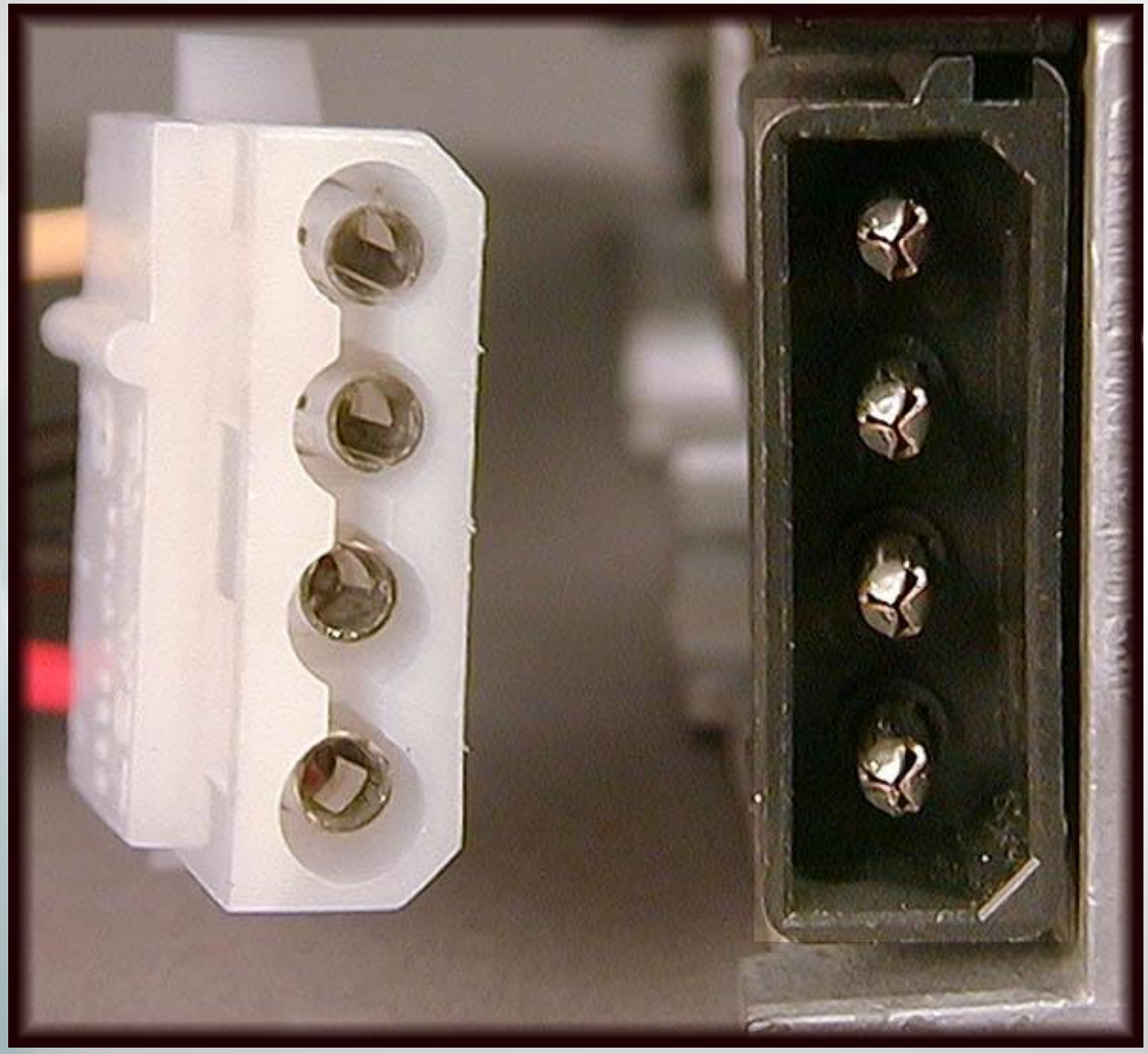

-5V
+5V
Ground
+5V
Ground
+5V
P9


+12V
-12V
+5V
Ground
Power Good
Ground
P8

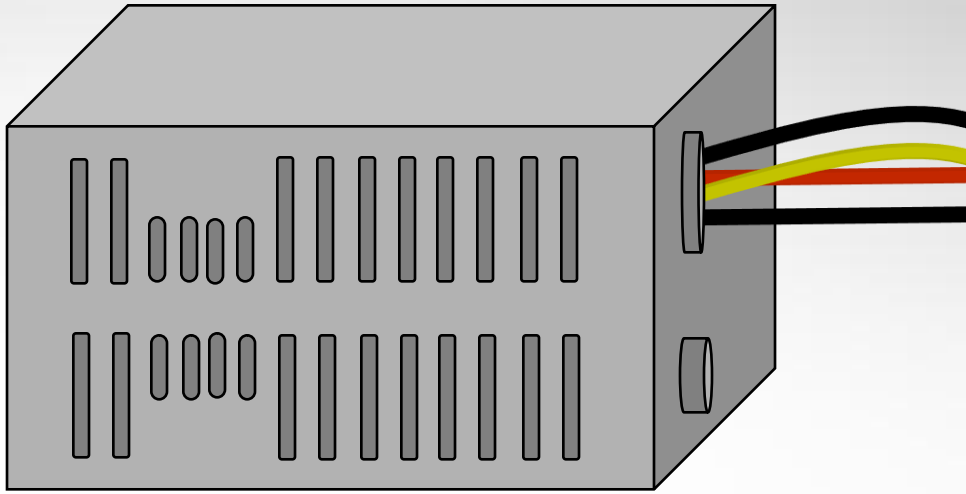
The *Power Good* Signal

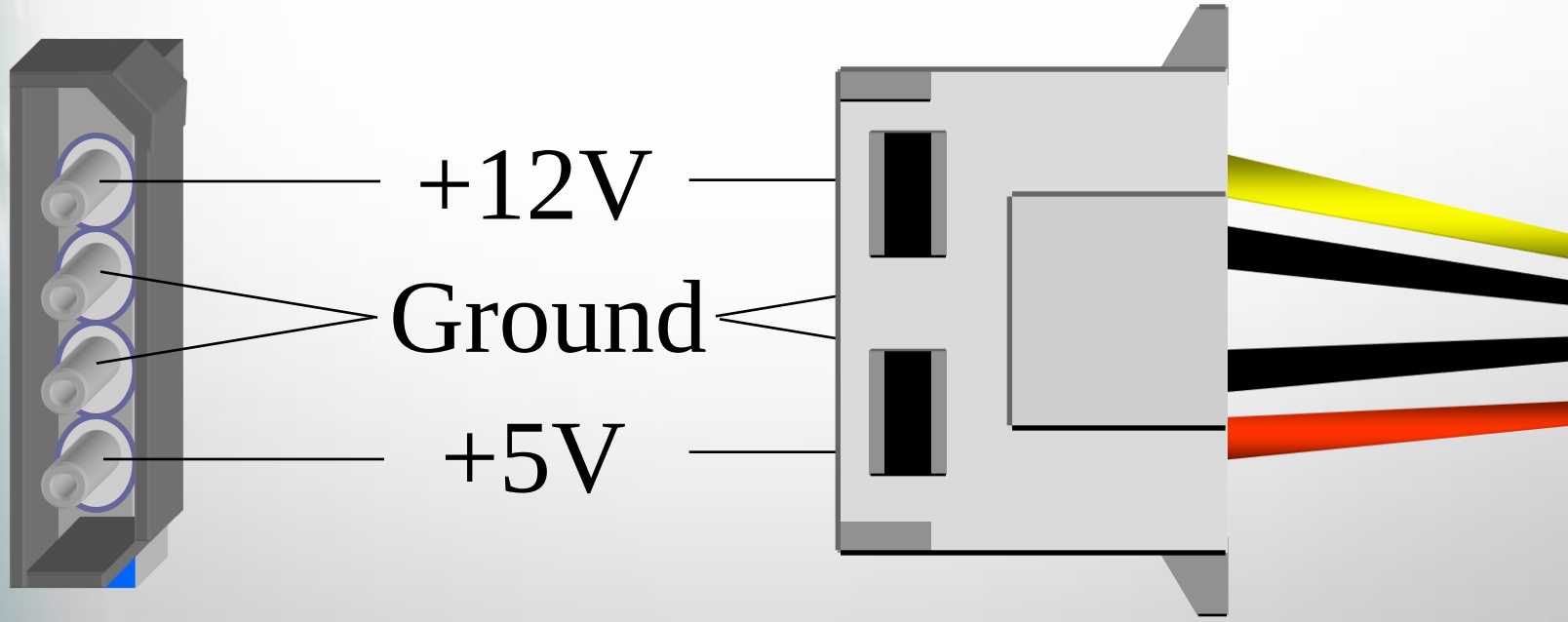
- +5 Volt signal generated by the power supply
- Indicates that the power supply passed its self test and its output has stabilized
- Occurs within first 0.5 seconds
- Prevents system from running under bad or unstable power conditions

Large Molex Connector

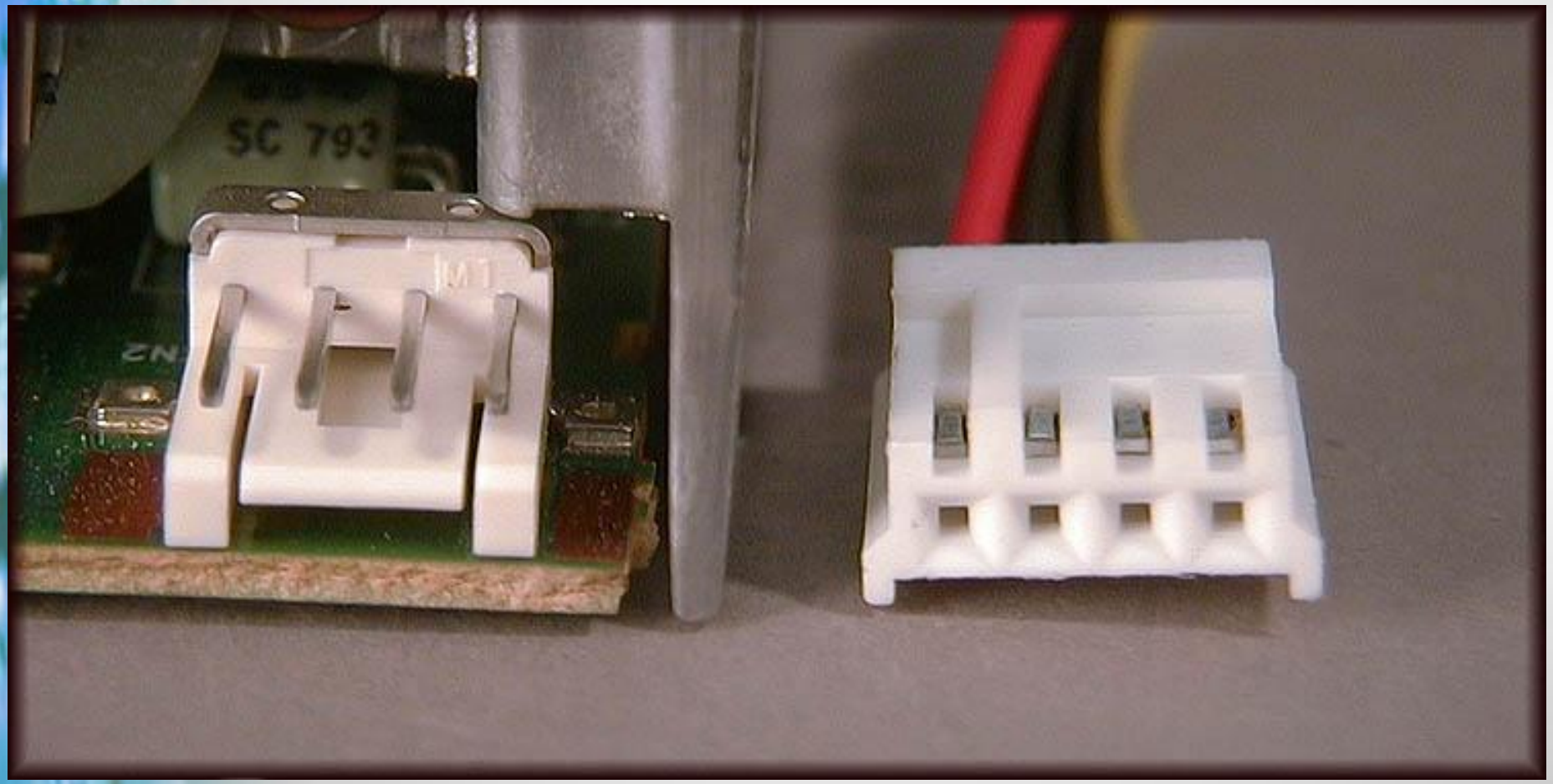


4-Pin Molex Connector

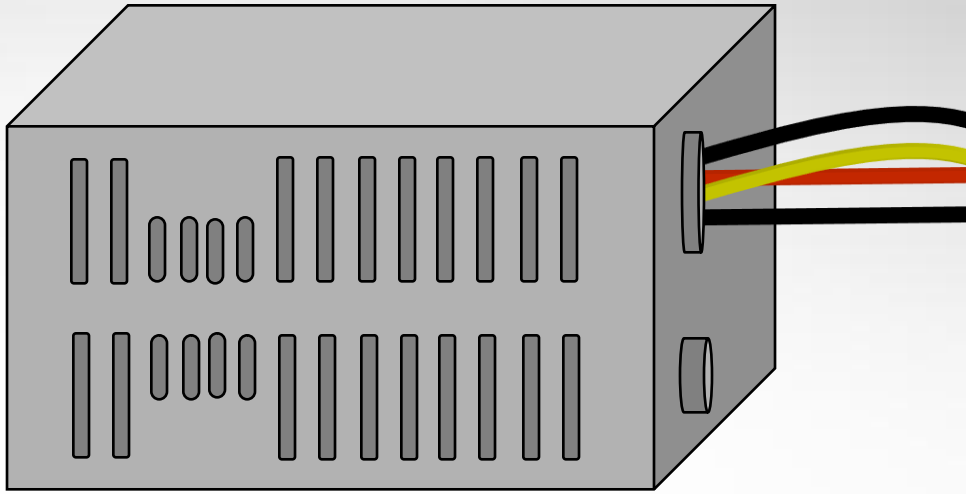


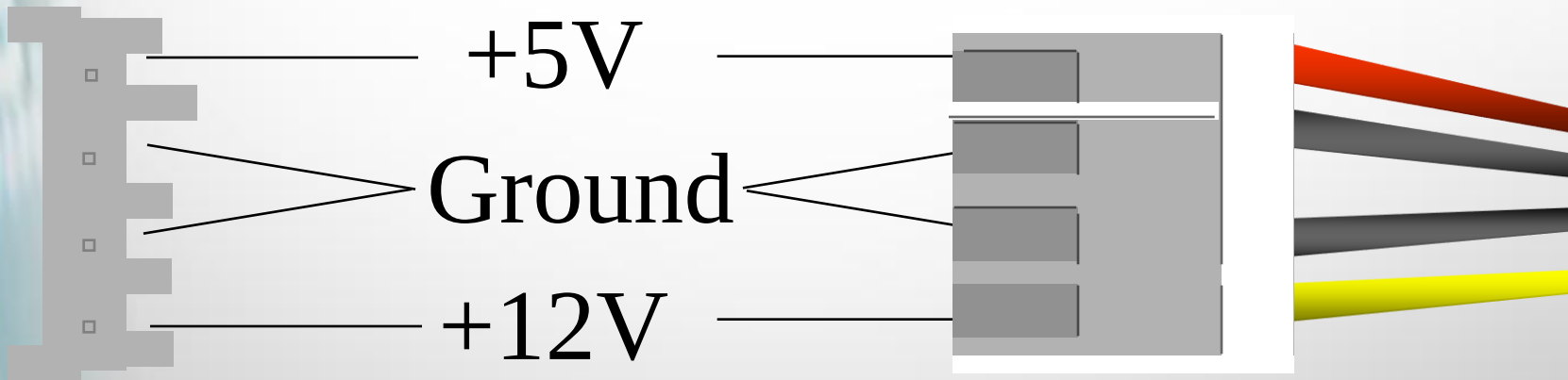


Berg Connector

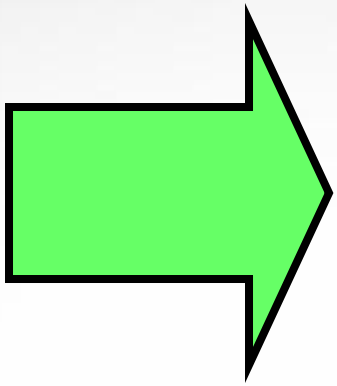


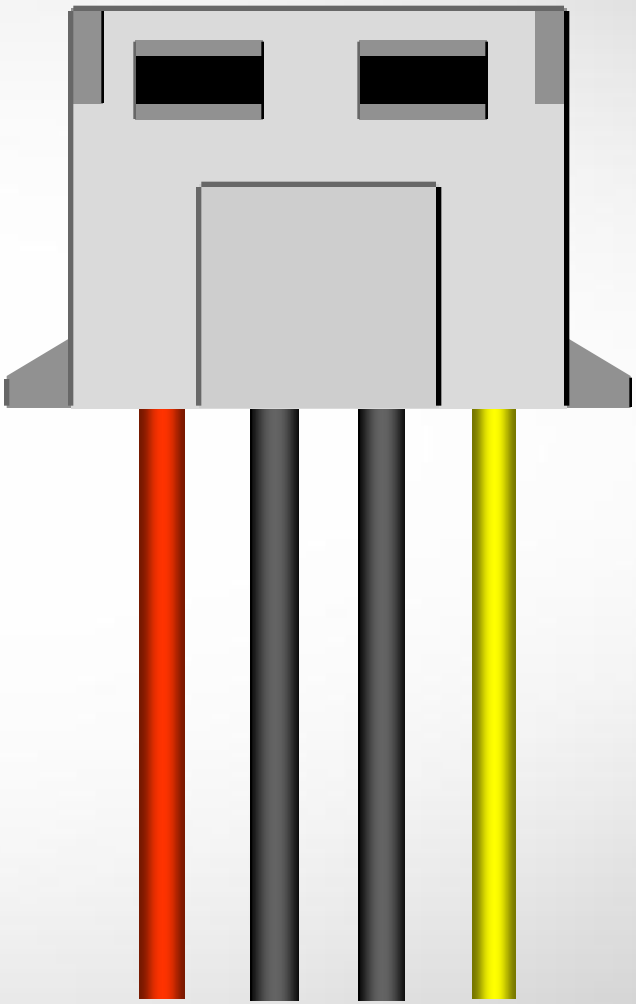
4-Pin Berg Connector



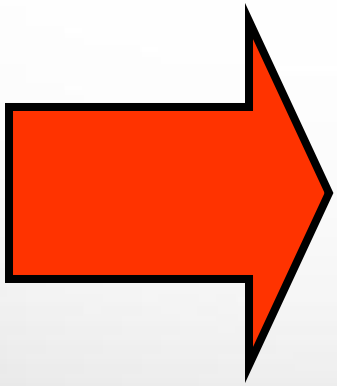


Grasp the connector by the shell…





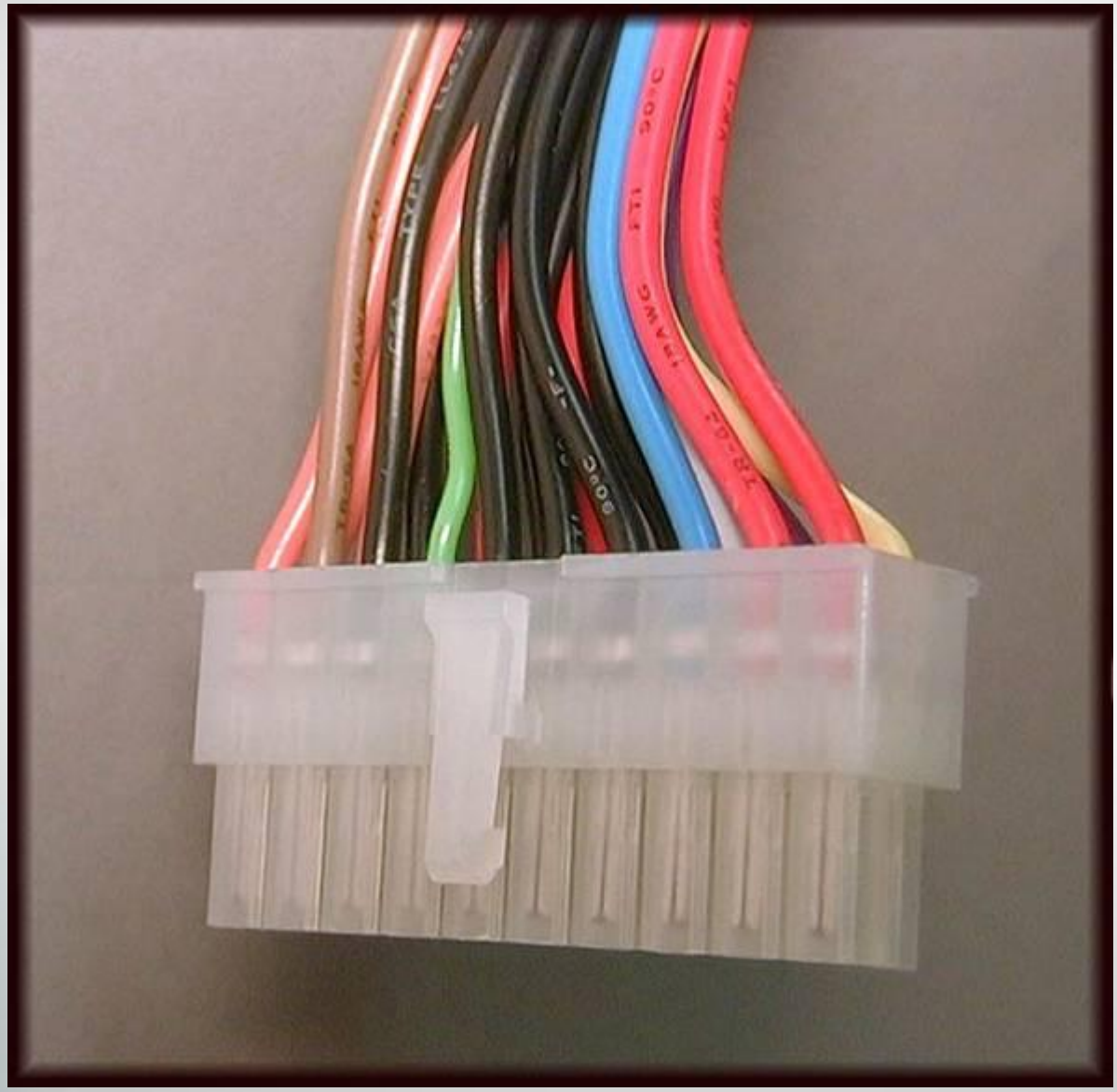
never by the leads



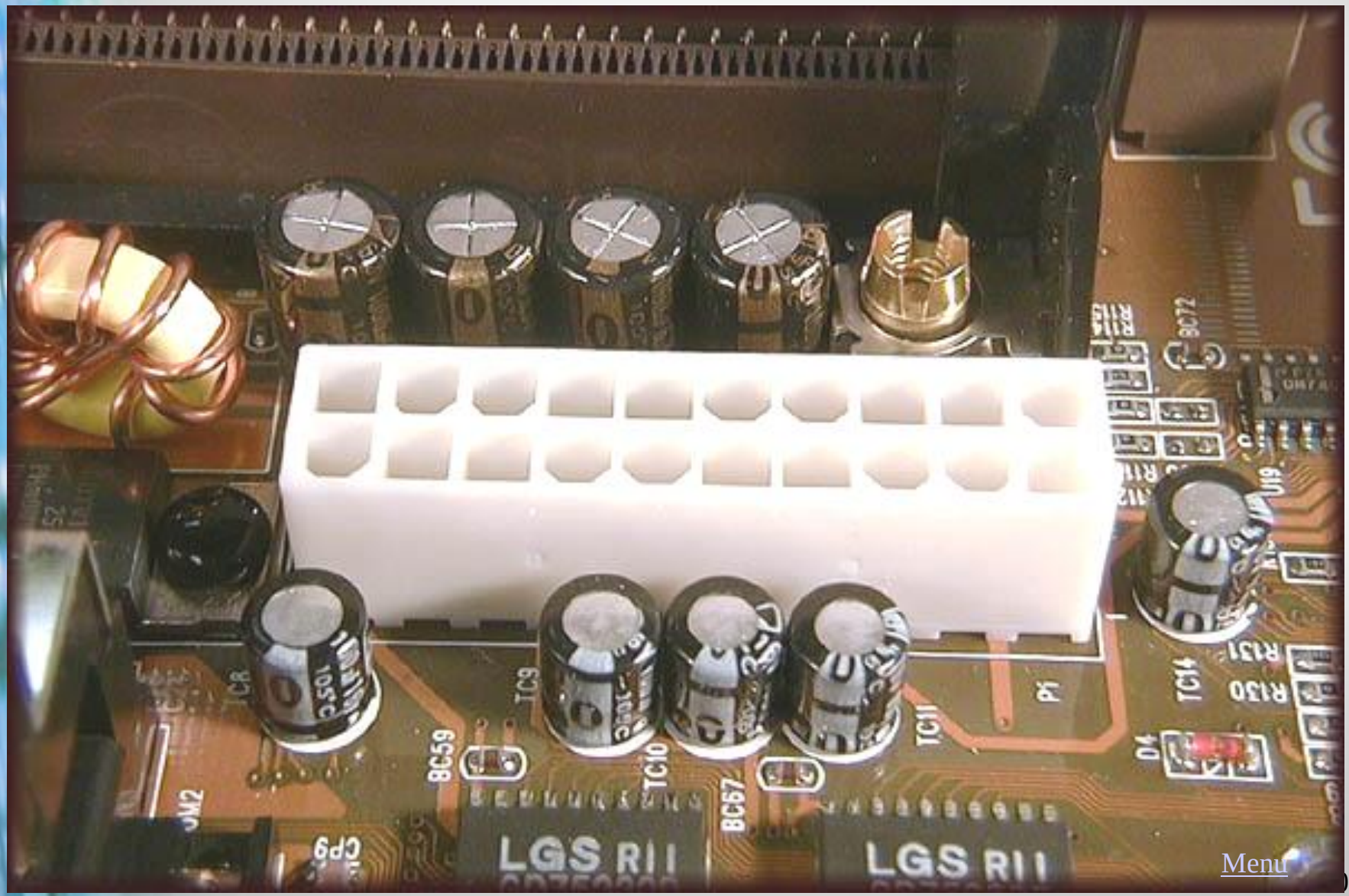
Power Supply Output Voltages ATX-Type

- +5 Volts
- +12 Volts
- -12 Volts
- -5 Volts
- +3.3 Volts

ATX Power Connector



ATX Power Connector



Menu

HEATHKIT™
EDUCATIONAL SYSTEMS

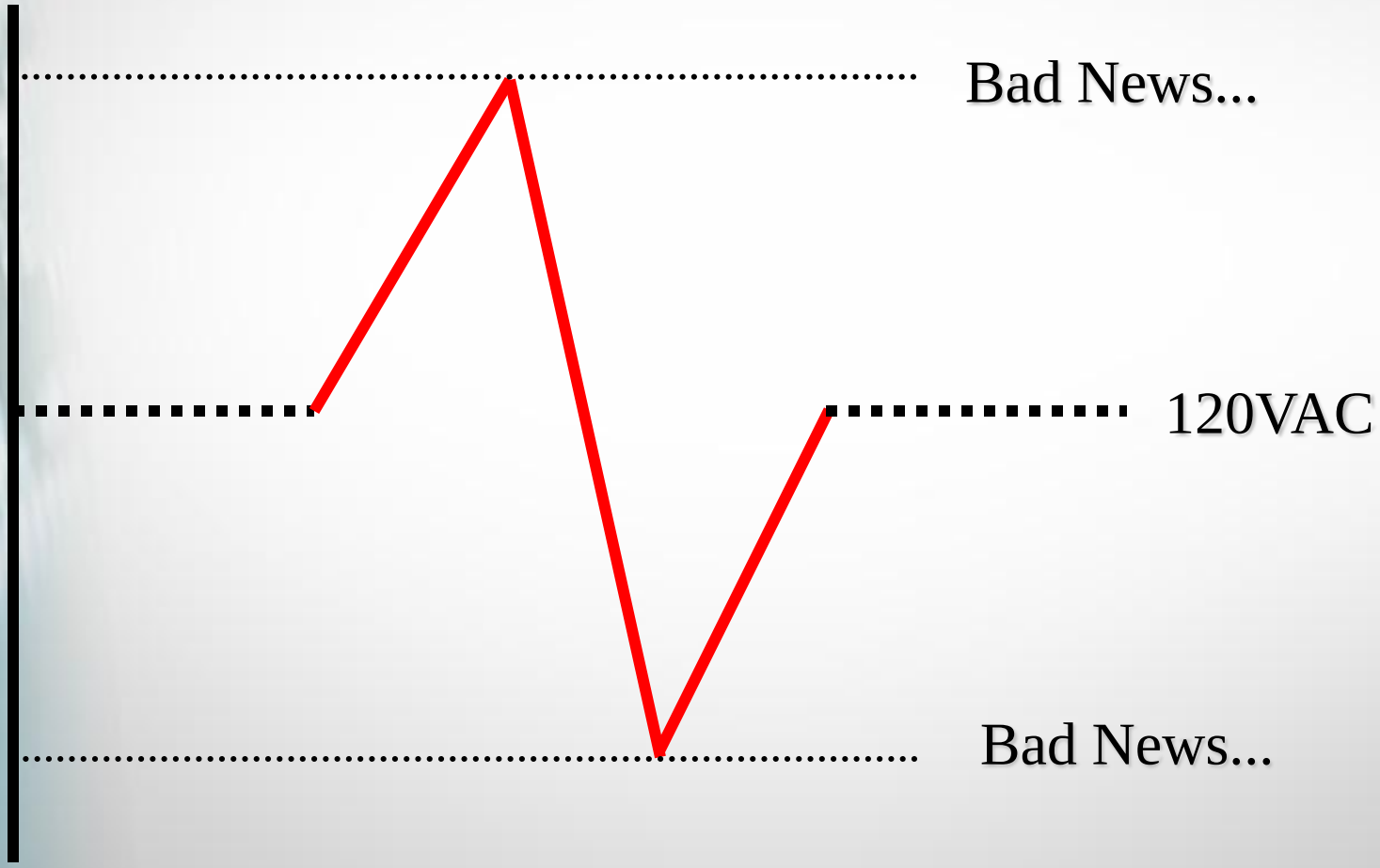
When Things go Wrong!

The Power Supply

- Don’t fix it
- Don’t open it
- It isn’t worth it!
- Only use UL or CSA approved supplies

Check Fan Operation

Power Surges and Sags are both serious problems...

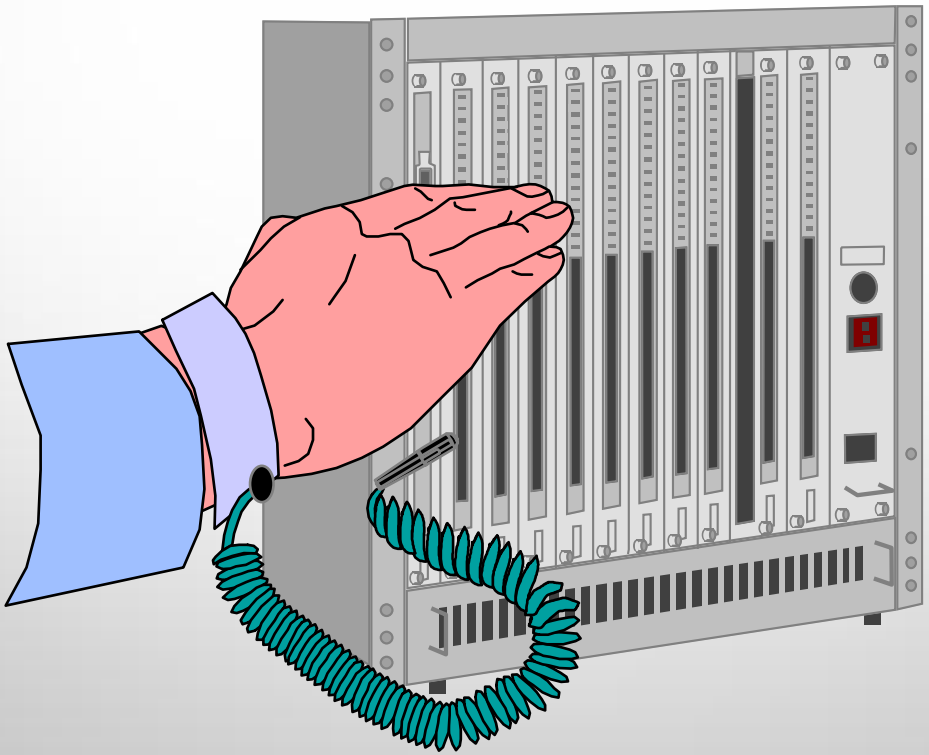


HEATHKIT™
EDUCATIONAL SYSTEMS

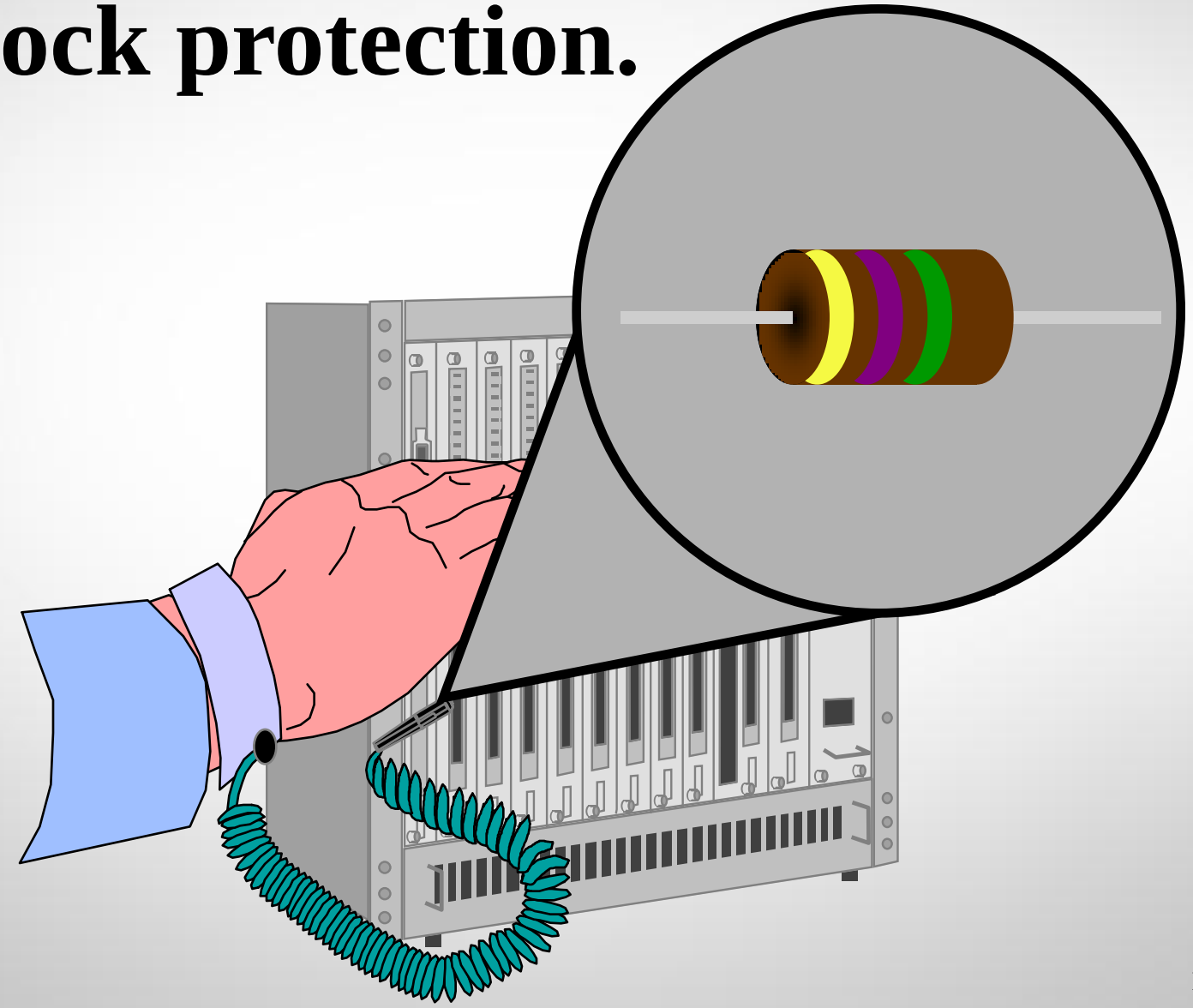
Static Electricity and the Computer

Your greatest enemy when working in the computer is Electrostatic Discharge or ESD.

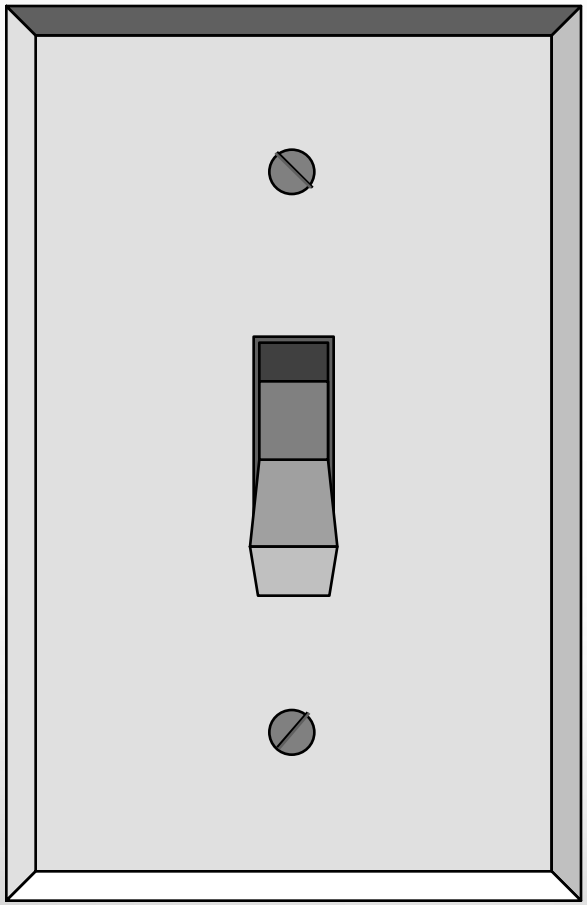
Your best defense against ESD is the anti-static wrist strap.



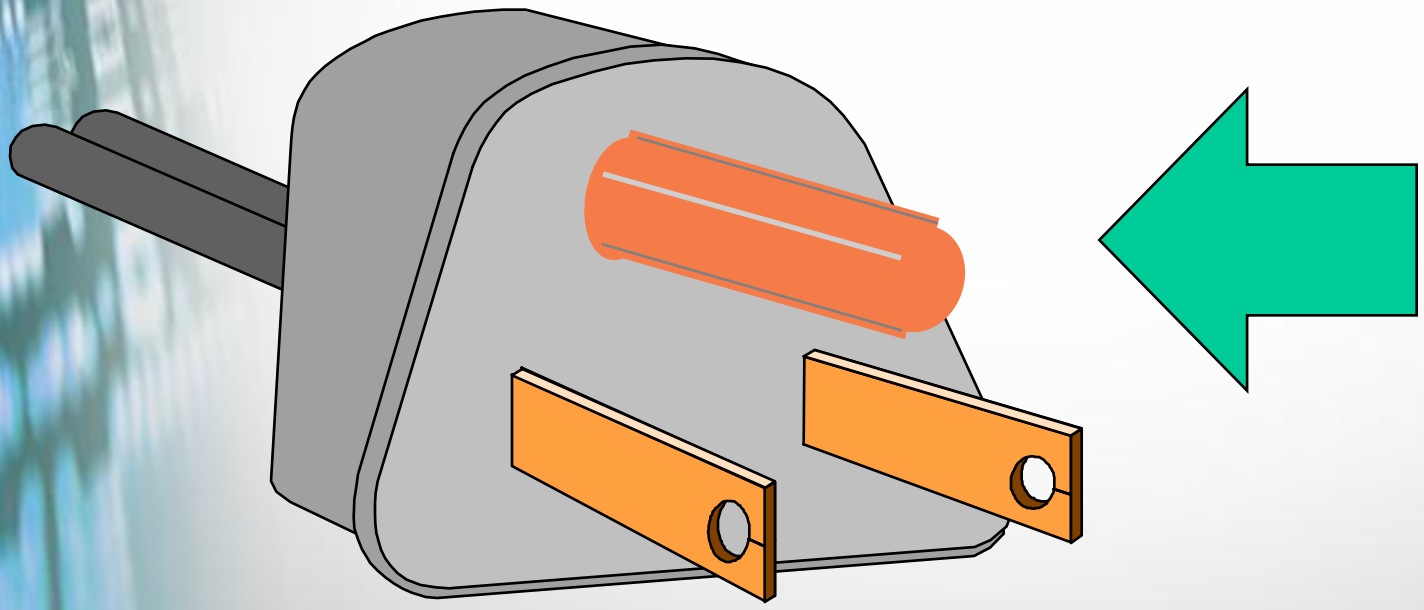
An internal resistor provides shock protection.



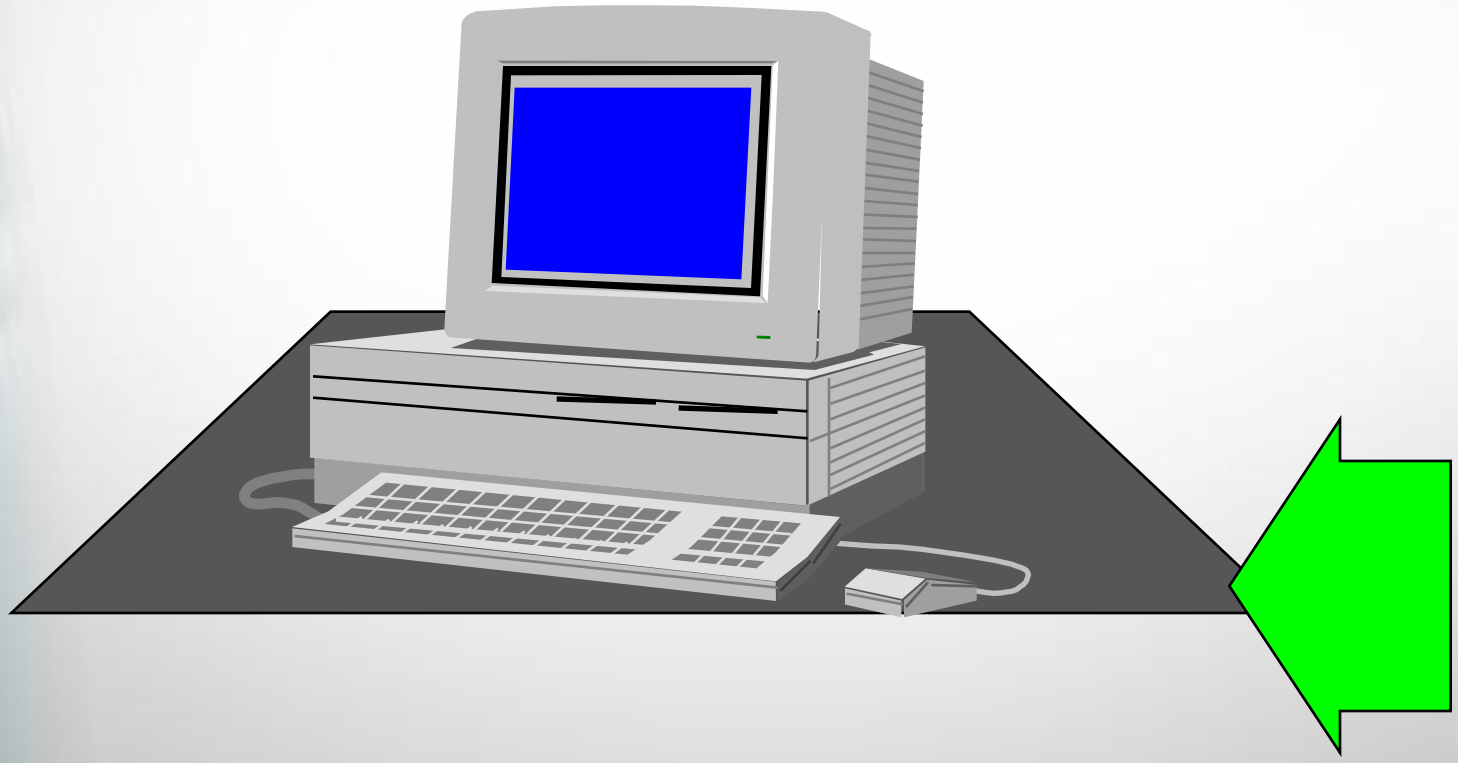
Switch off power at the computer and at the workbench...



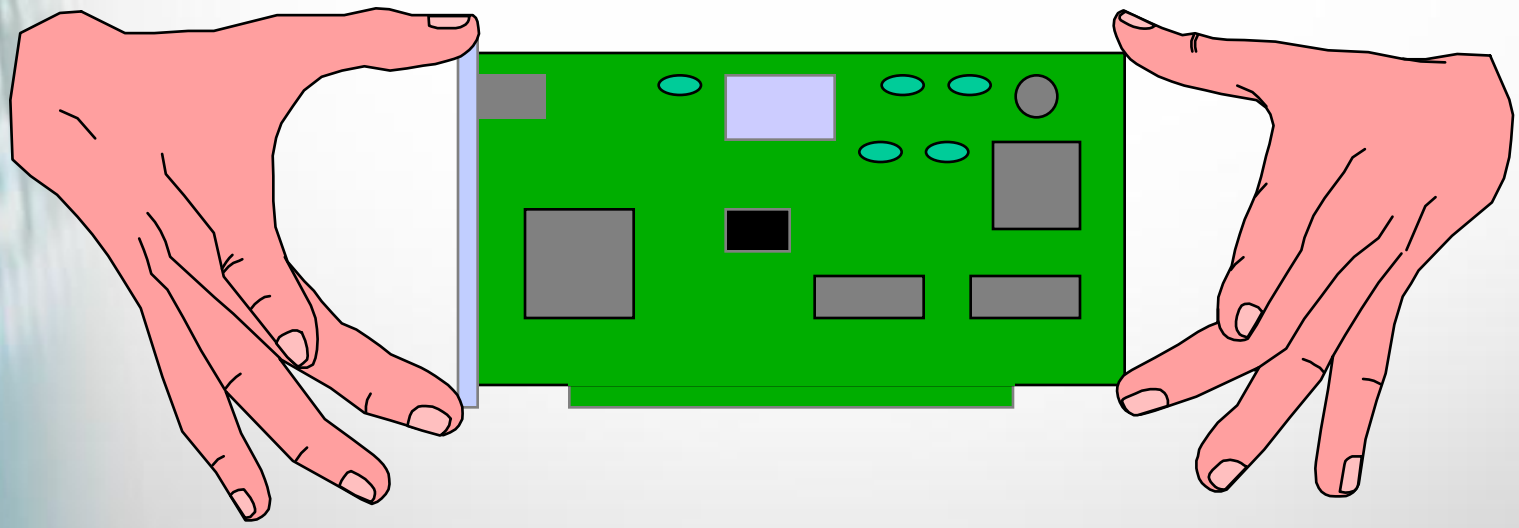
...but leave the computer plugged in.



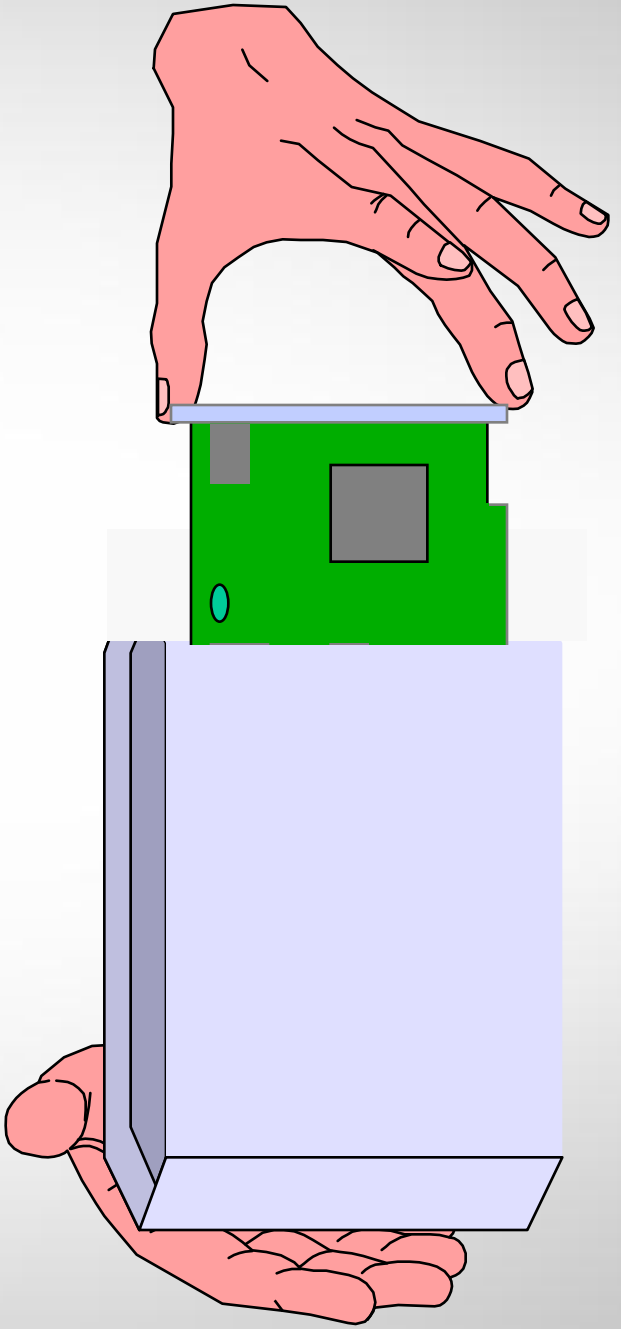
Use anti-static mats on the workbench and floor.



Hold Circuit Boards by their edges



Store Circuit Boards in Anti-static Bags.



General Safety Tips

- Look for UL or CSA labels
- Be careful around fans
- Watch for sharp edges
- Double-check the power before removing or replacing anything

The Power Supply

- Don’t fix it
- Don’t open it
- It isn’t worth it!
- Only use UL or CSA approved supplies

Respect... not fear.

HEATHKIT™
EDUCATIONAL SYSTEMS

Disassembling and Reassembling a Computer

Why Disassemble the Computer?

- To upgrade.
- To repair.
- To add to it.

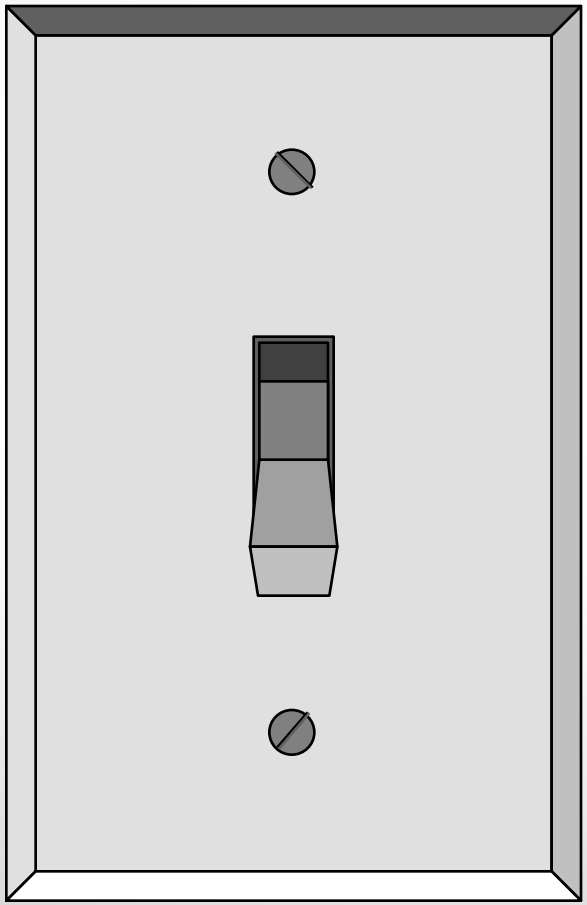
The three most important things to remember when disassembling a computer are:

- Document
- Document
- Document!

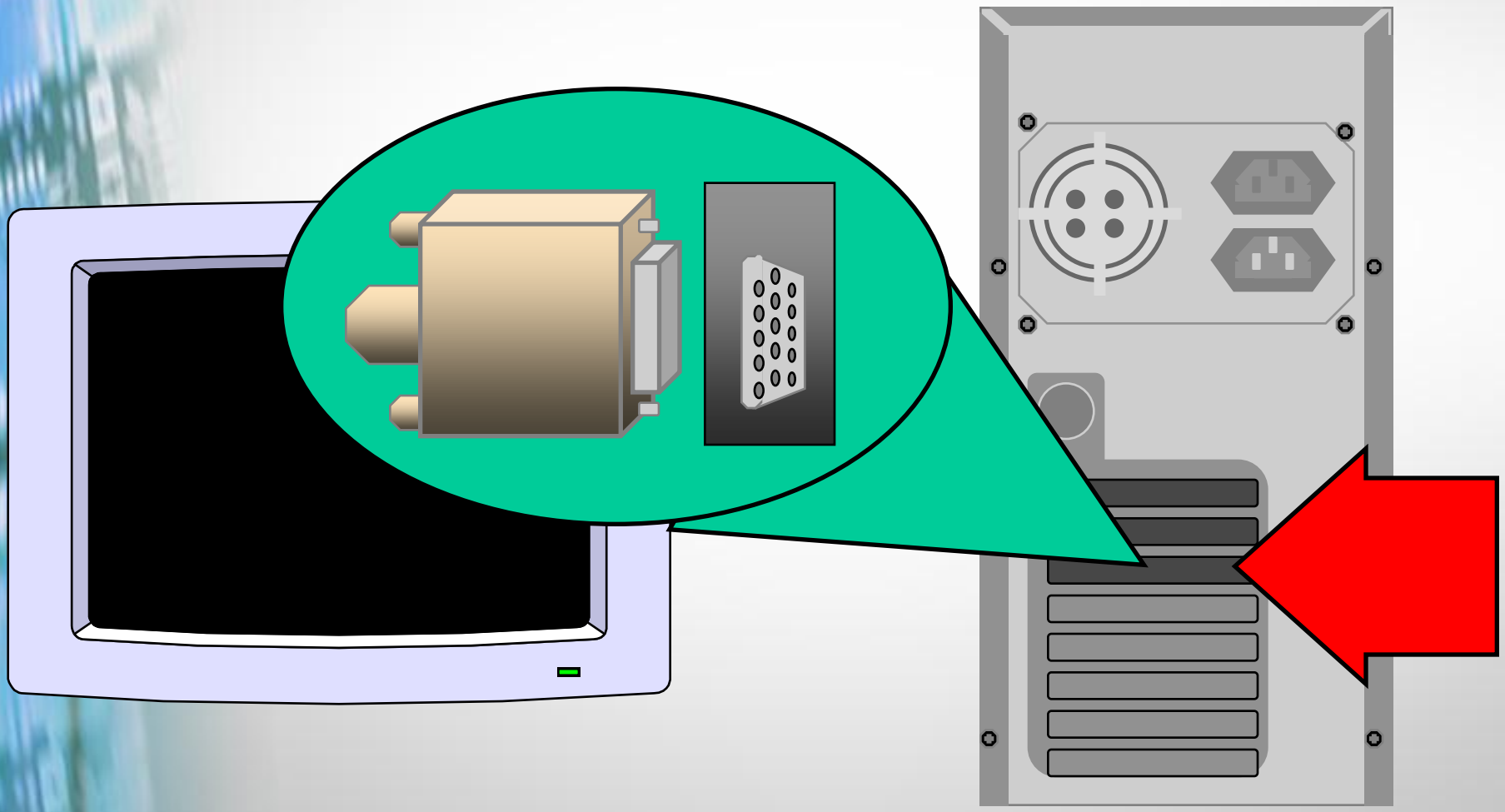
Document

- Where cards are located.
- How cables are routed.
- Orientation of cables and connectors.
- Hardware used to secure each component.
- Anything else that might cause confusion when reassembling.

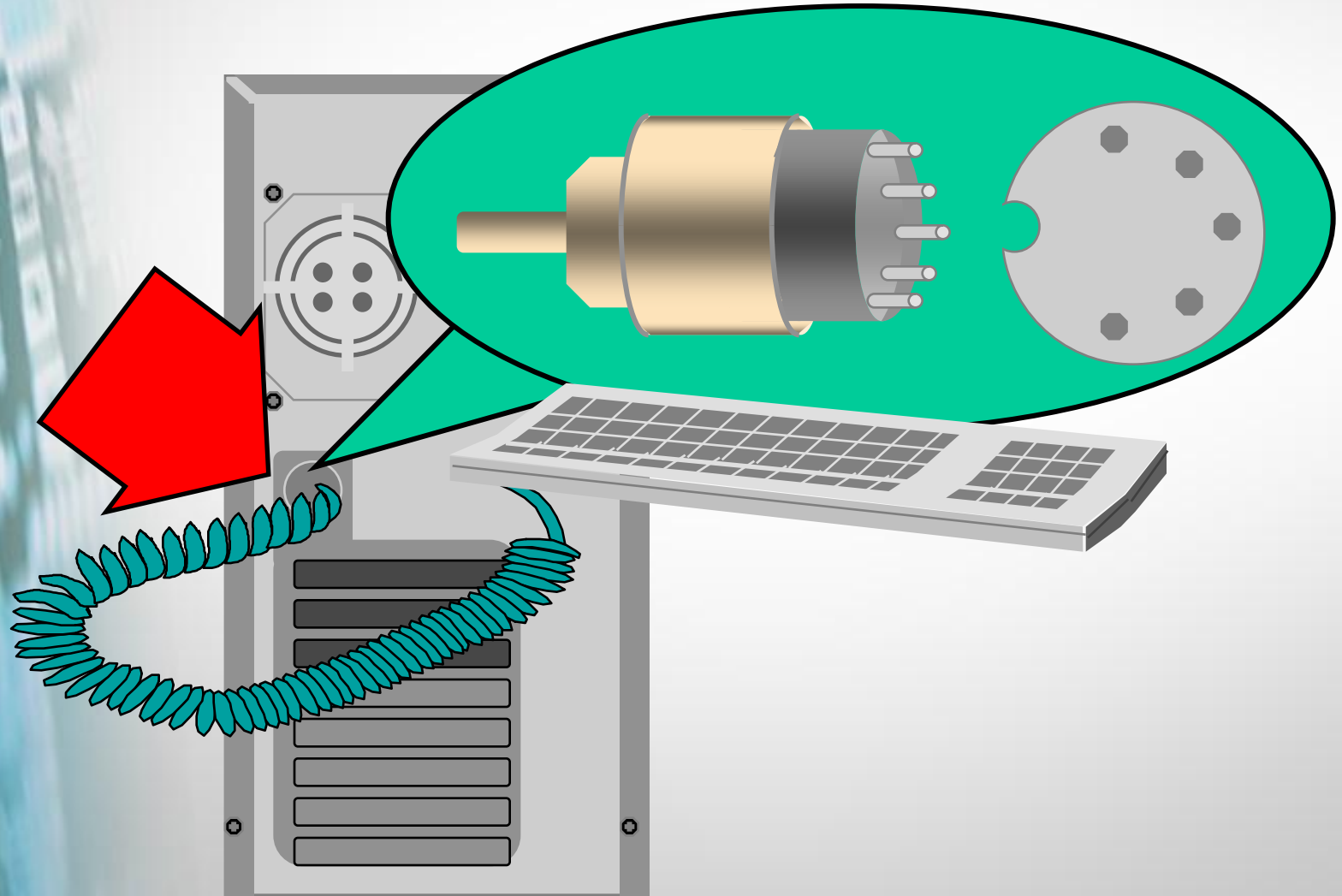
Turn off power to the computer and everything connected to it.



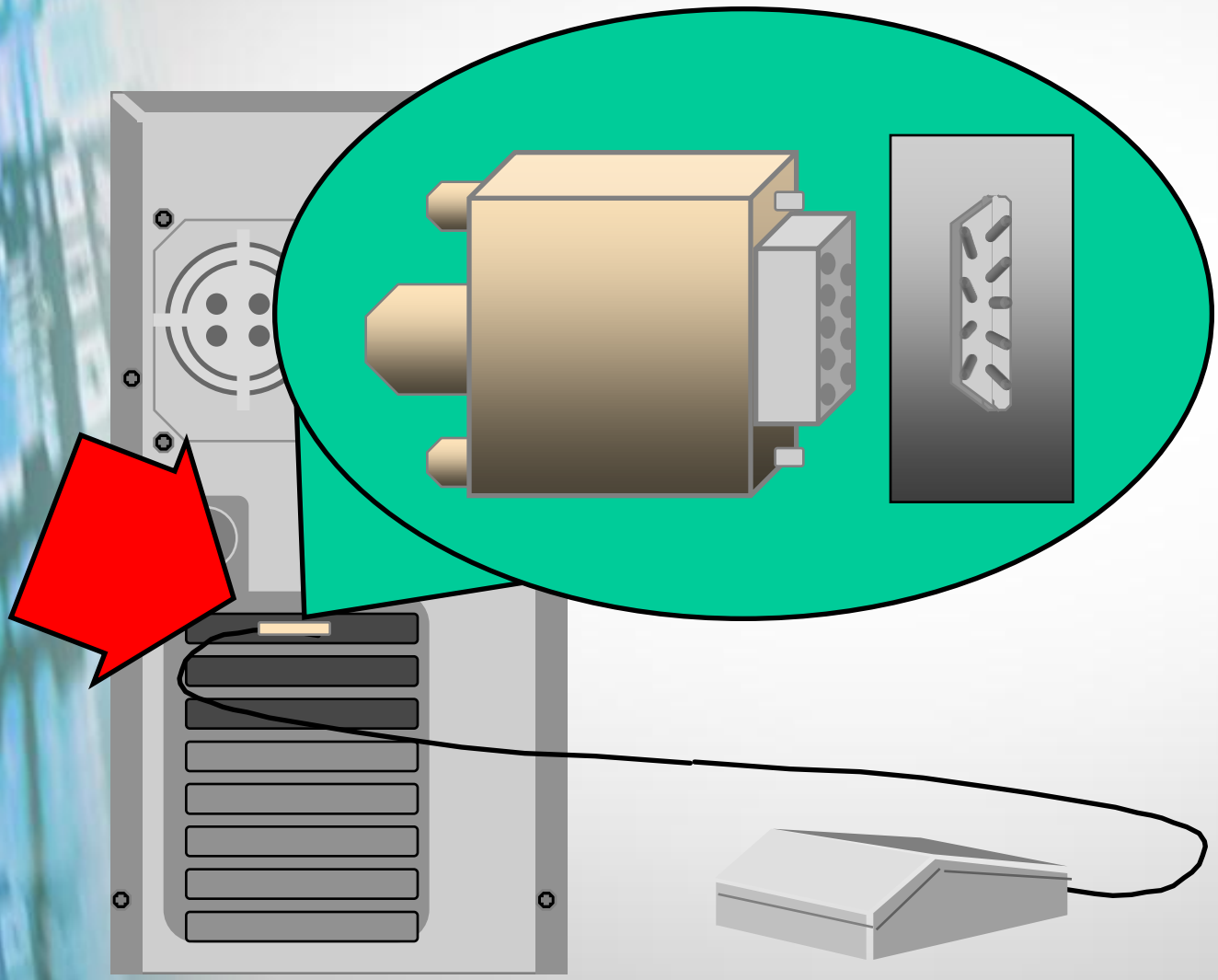
Disconnect the monitor and set it aside.



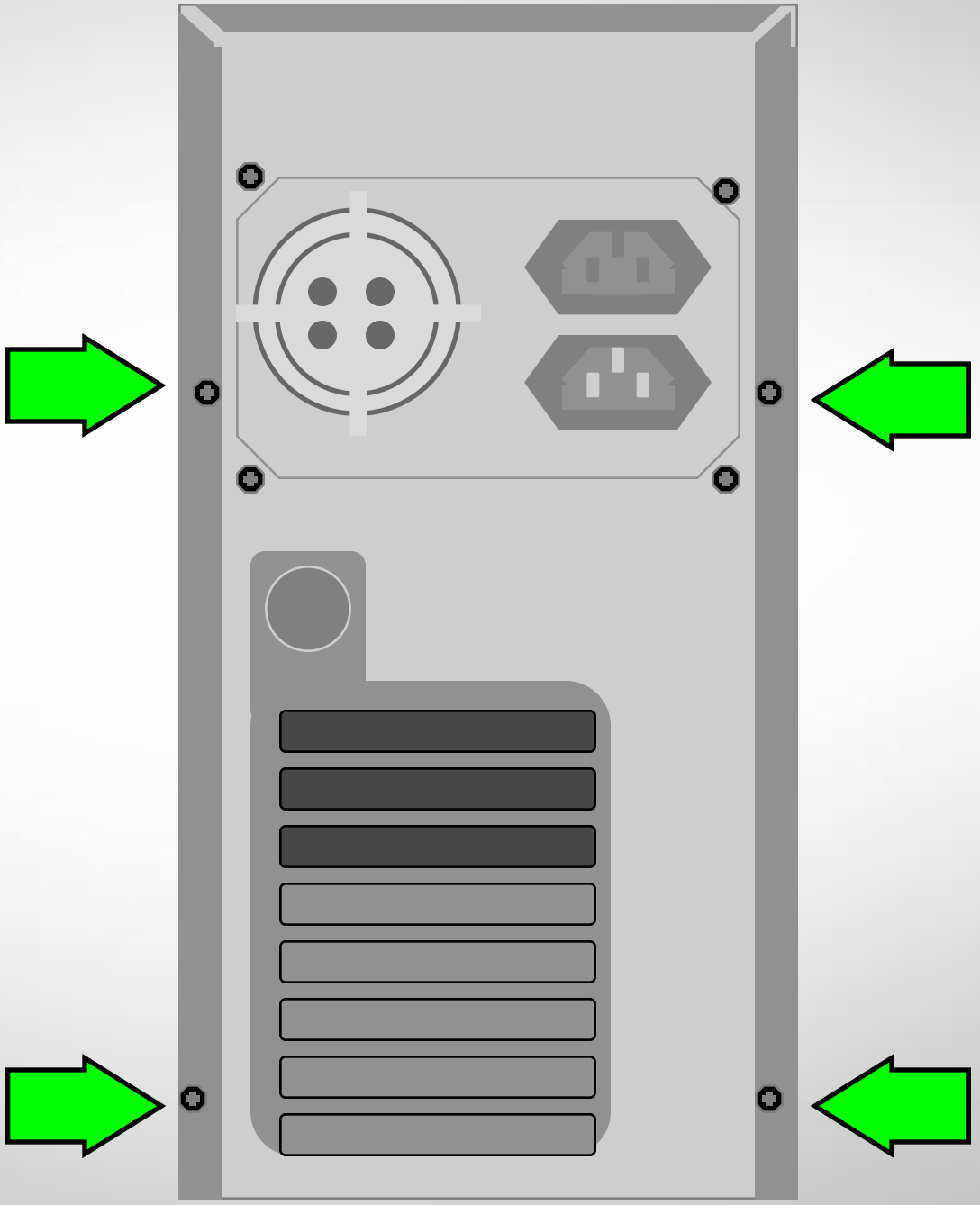
Disconnect the keyboard and set it aside.



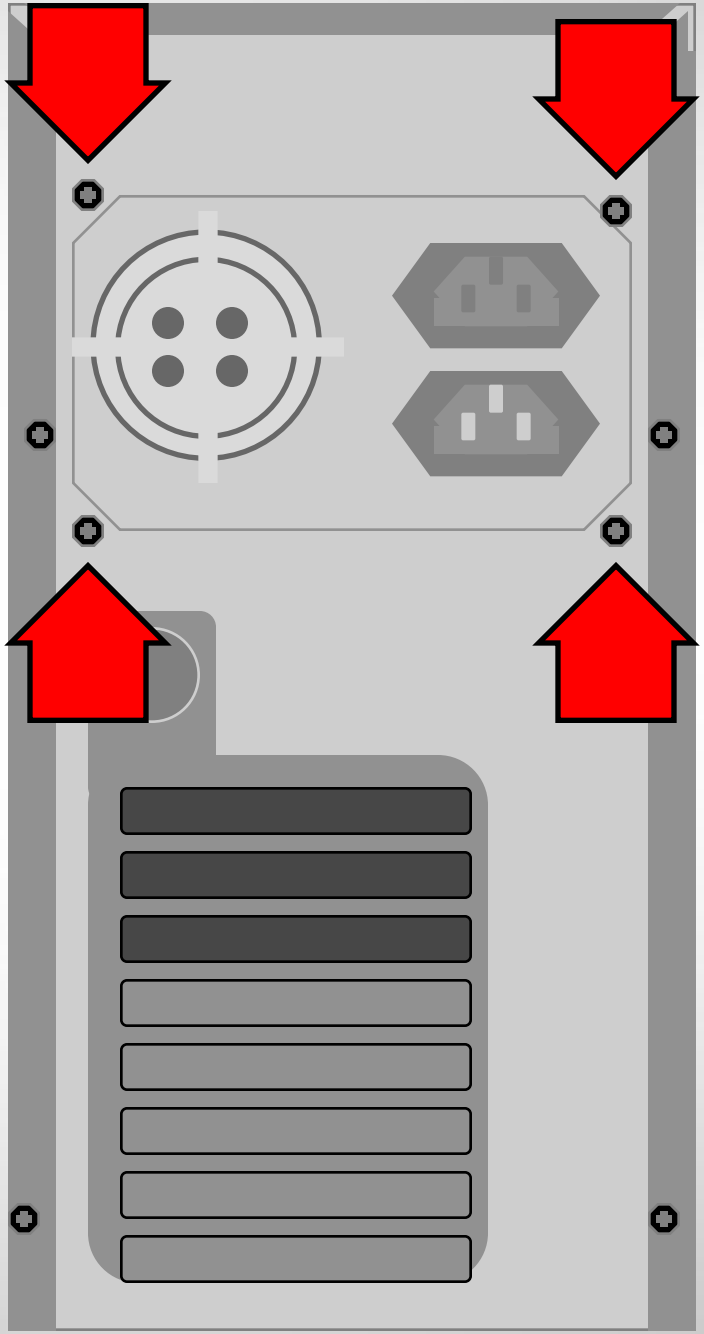
Disconnect the mouse and set it aside.

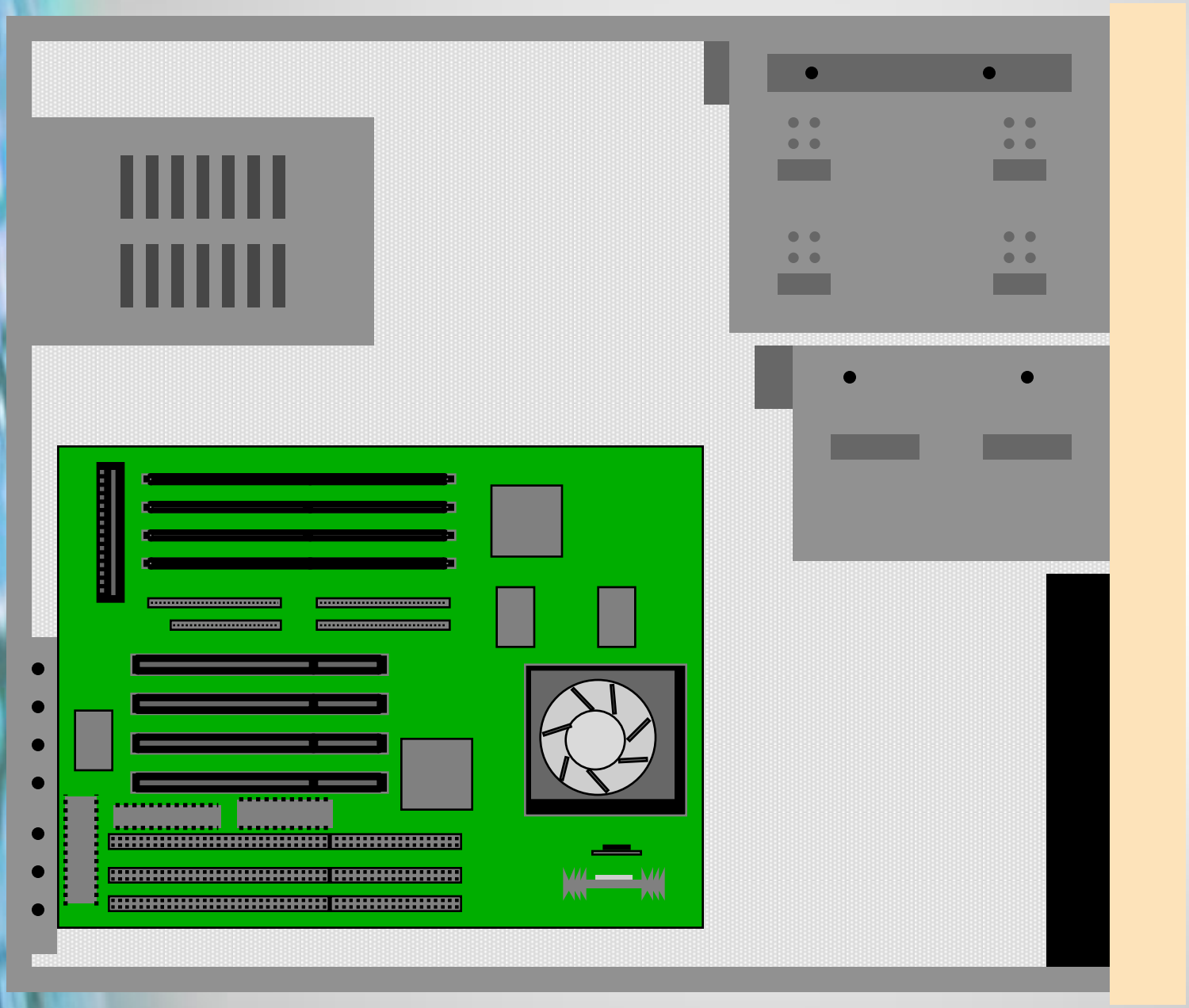


Remove these screws...

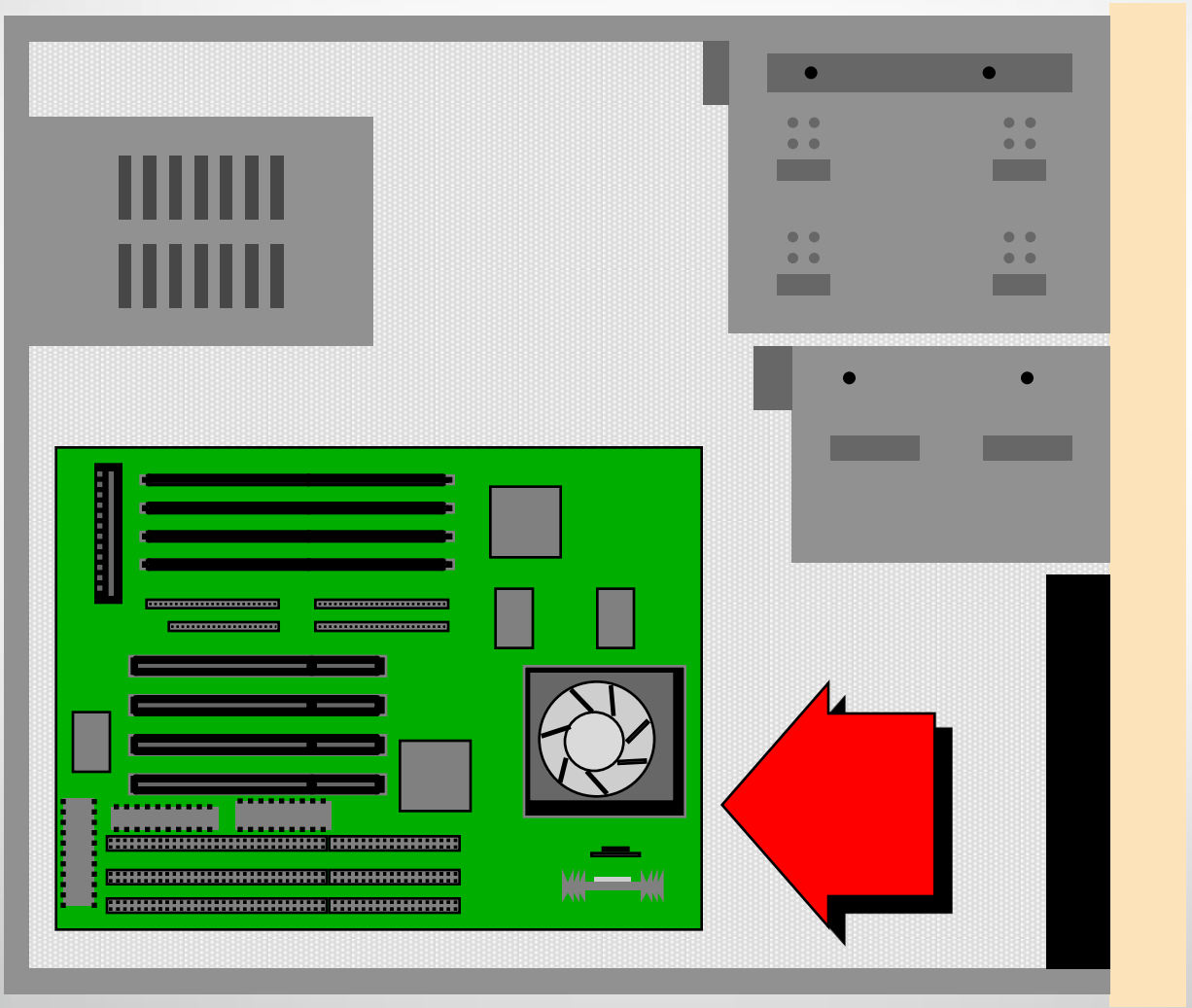


... not these.



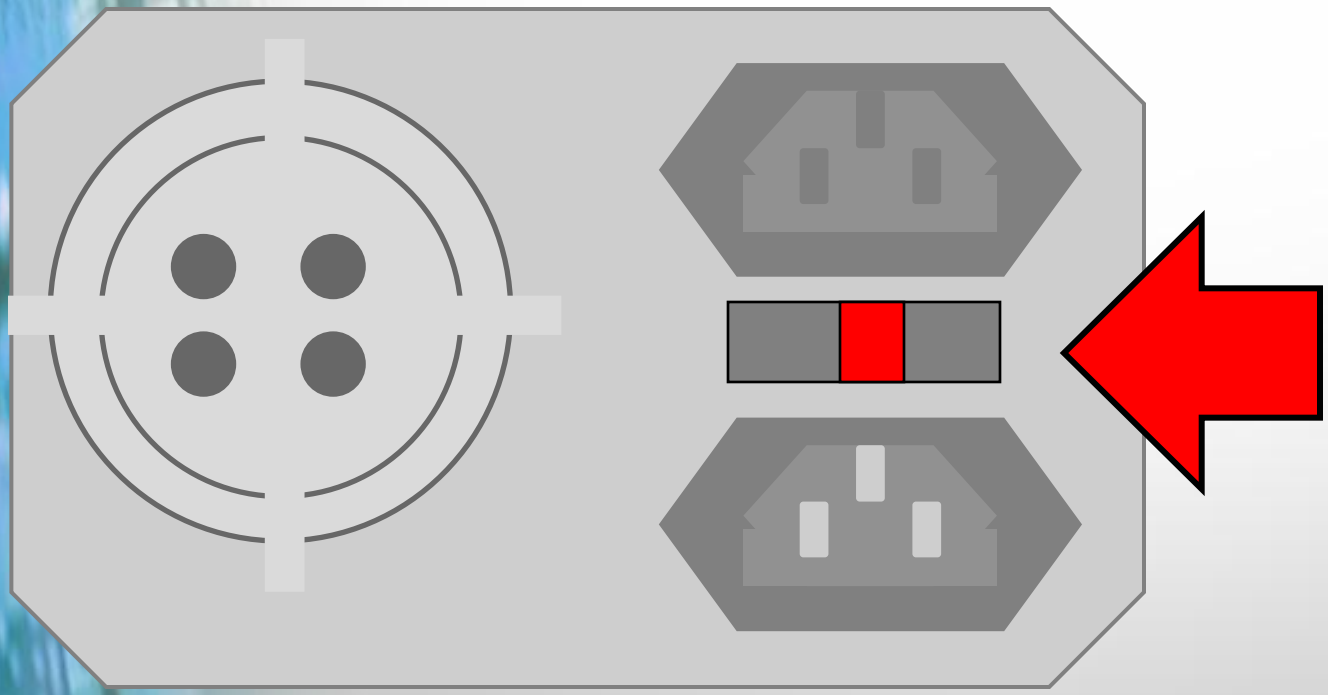


The Motherboard



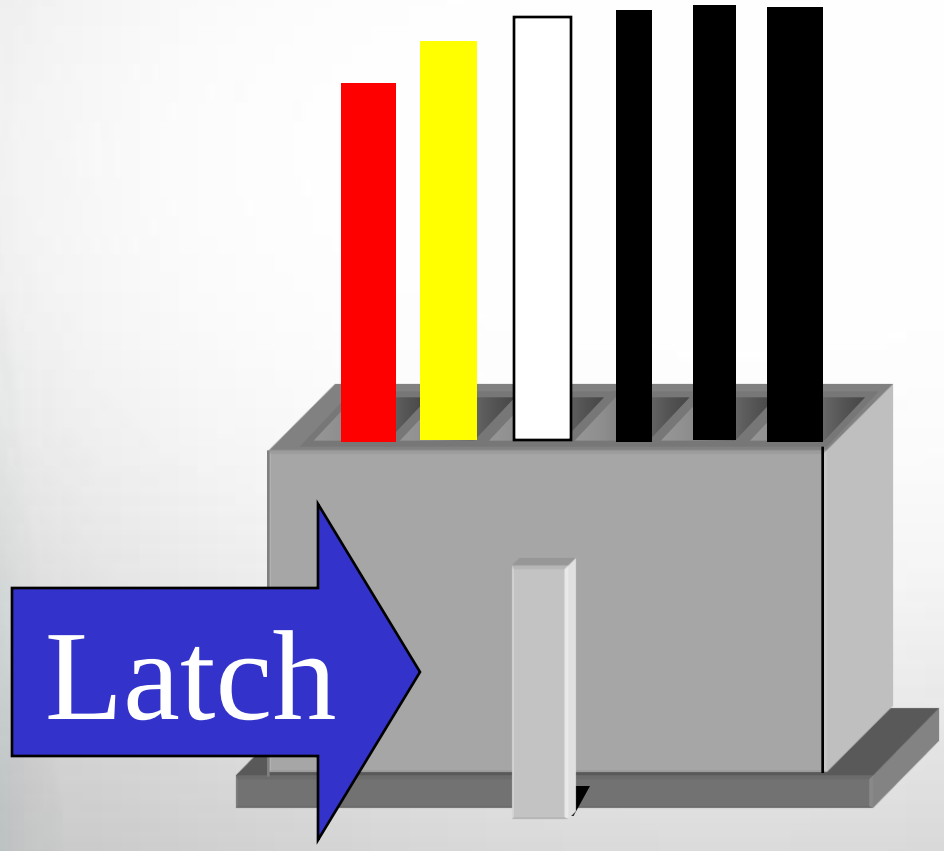
Power Supply Input Voltage

- 100 to 125 VAC @ 60 Hz
- 200 to 250VAC @ 50 Hz

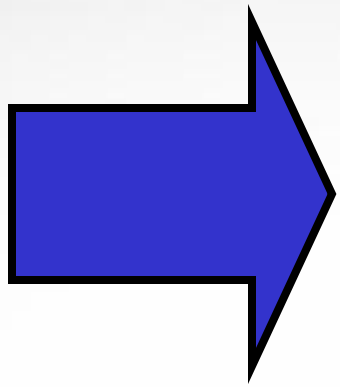


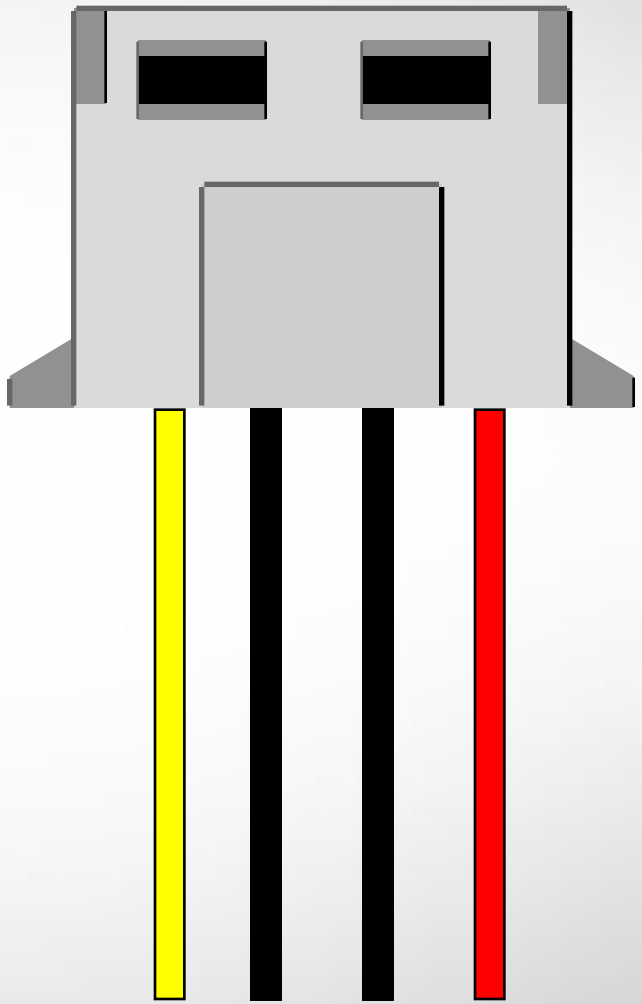
Switch Selectable

Some connectors are held in place by a latch.

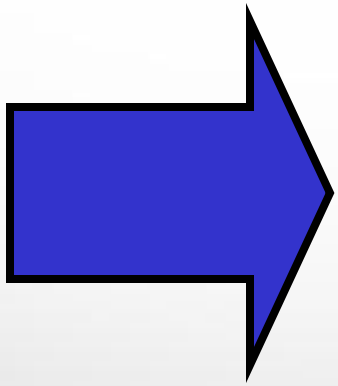


Grasp the connector by the shell…

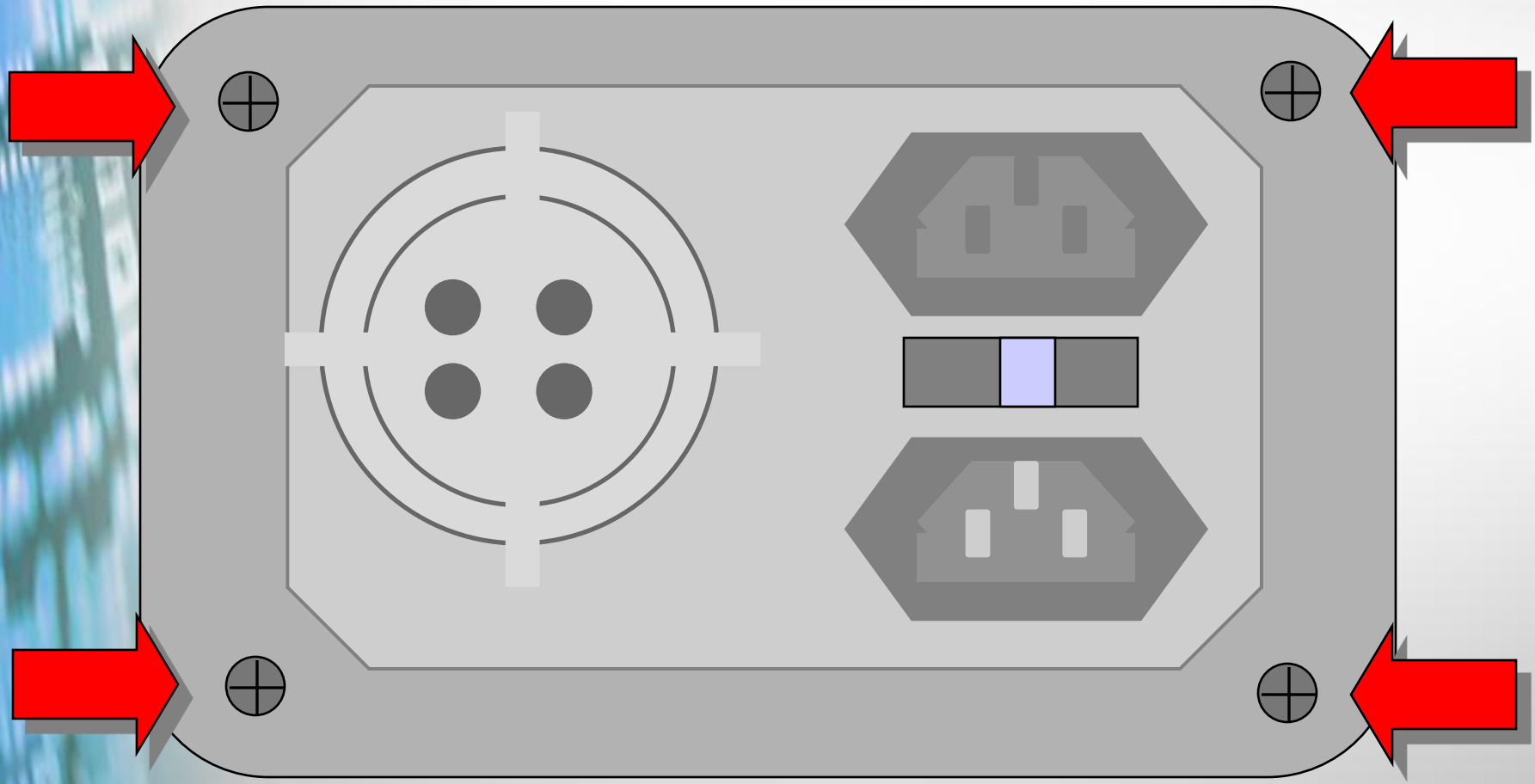




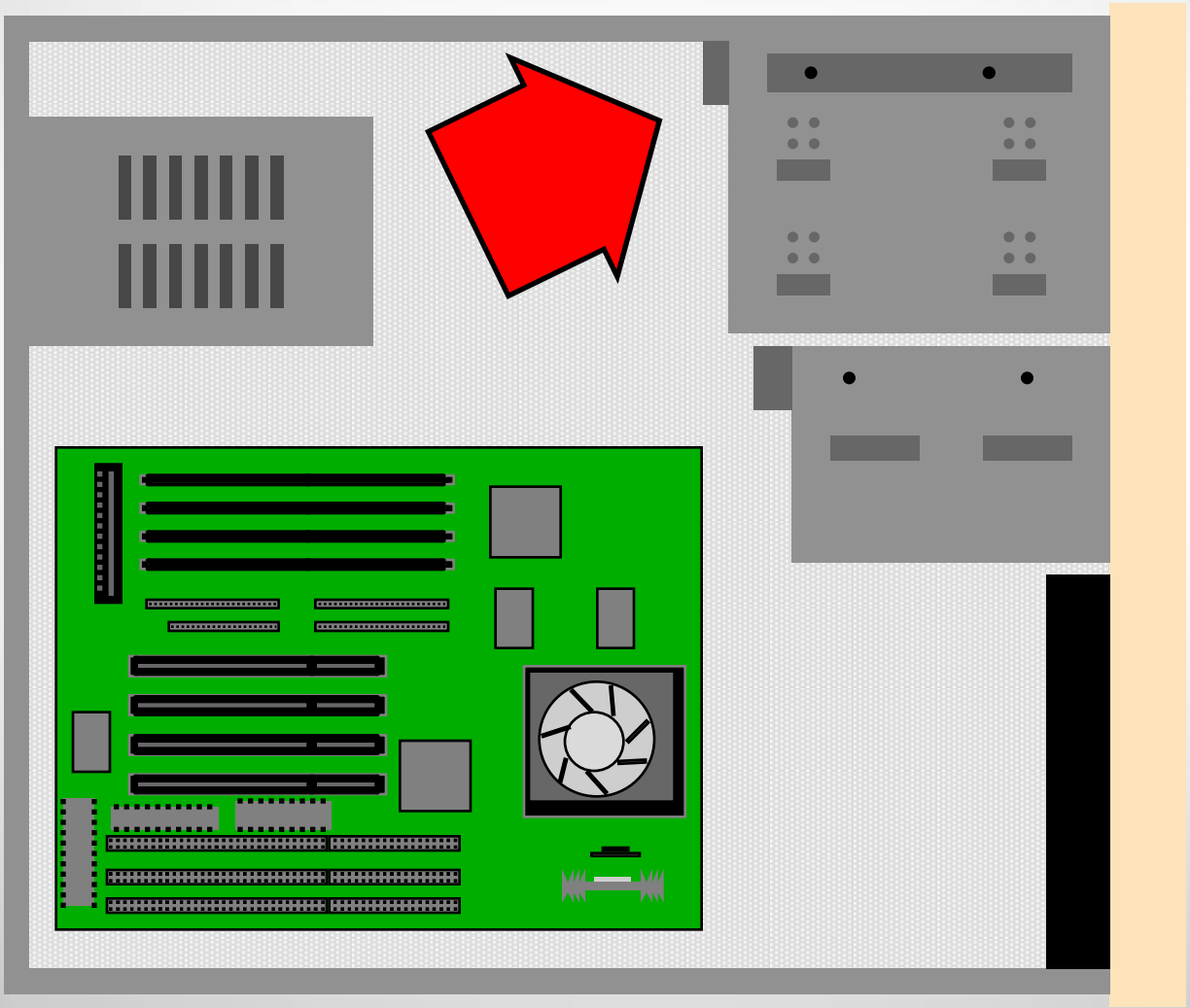
…never by the leads.



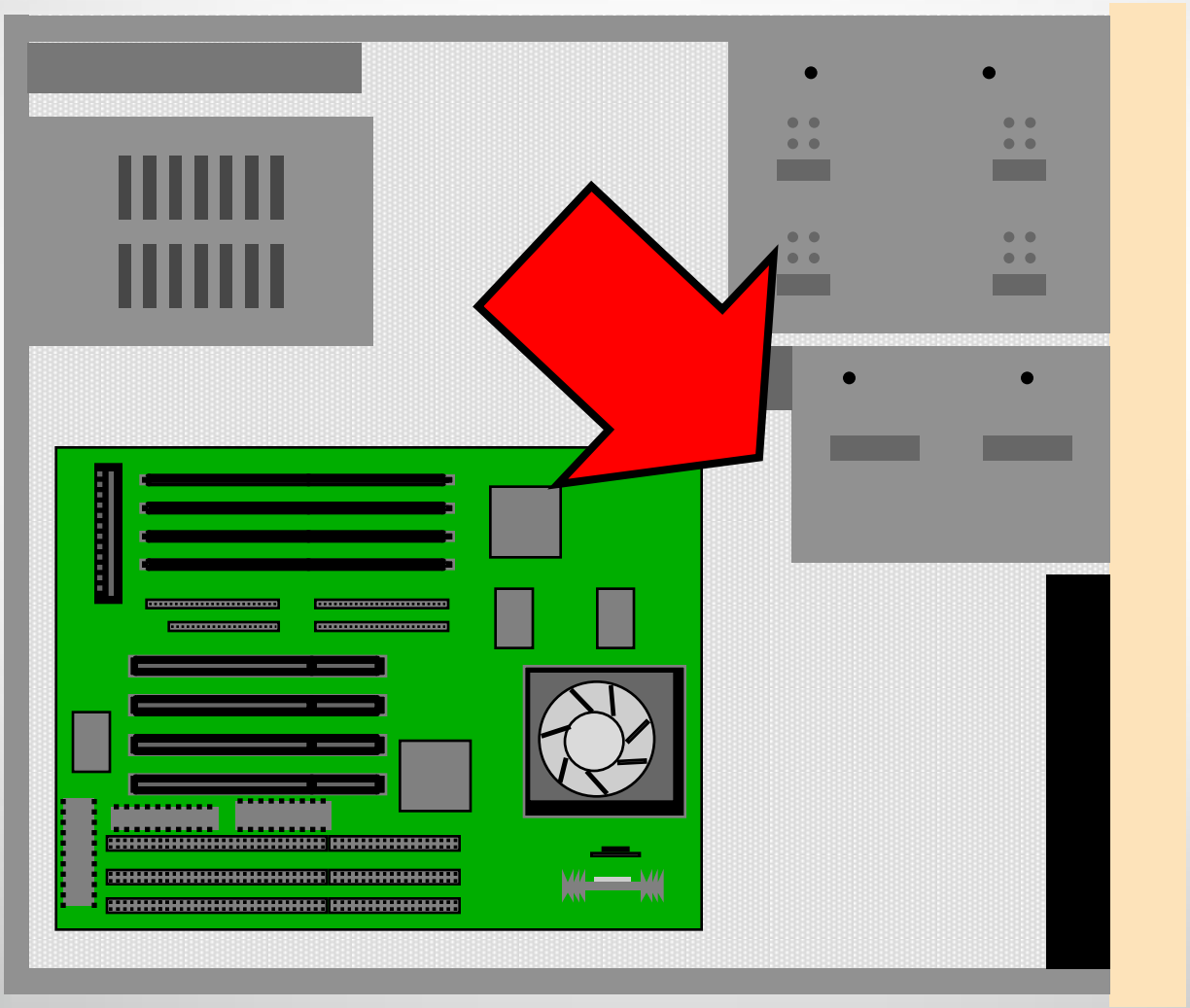
The Power Supply is held in place by four screws.



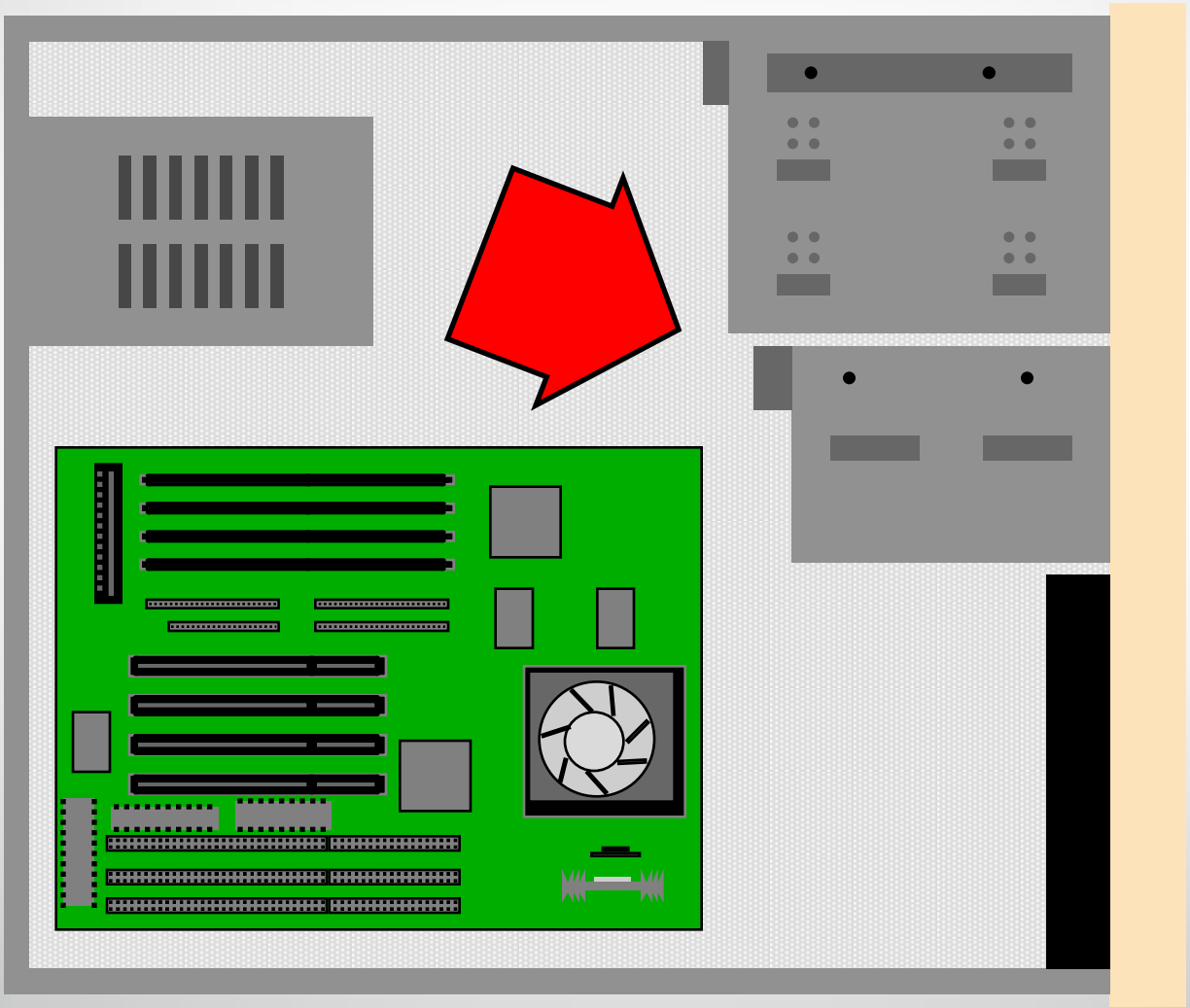
The Hard Drive may be located here ...

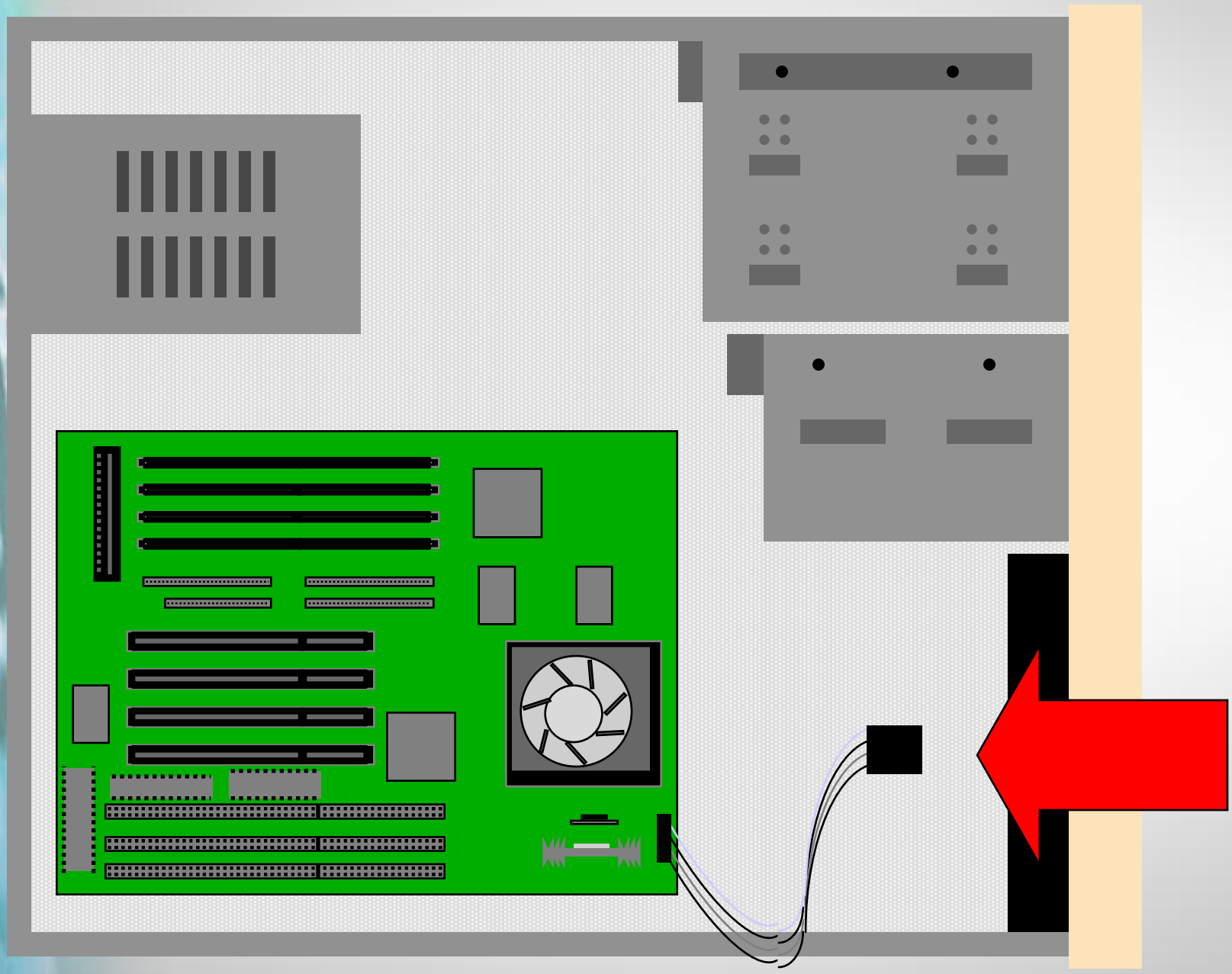


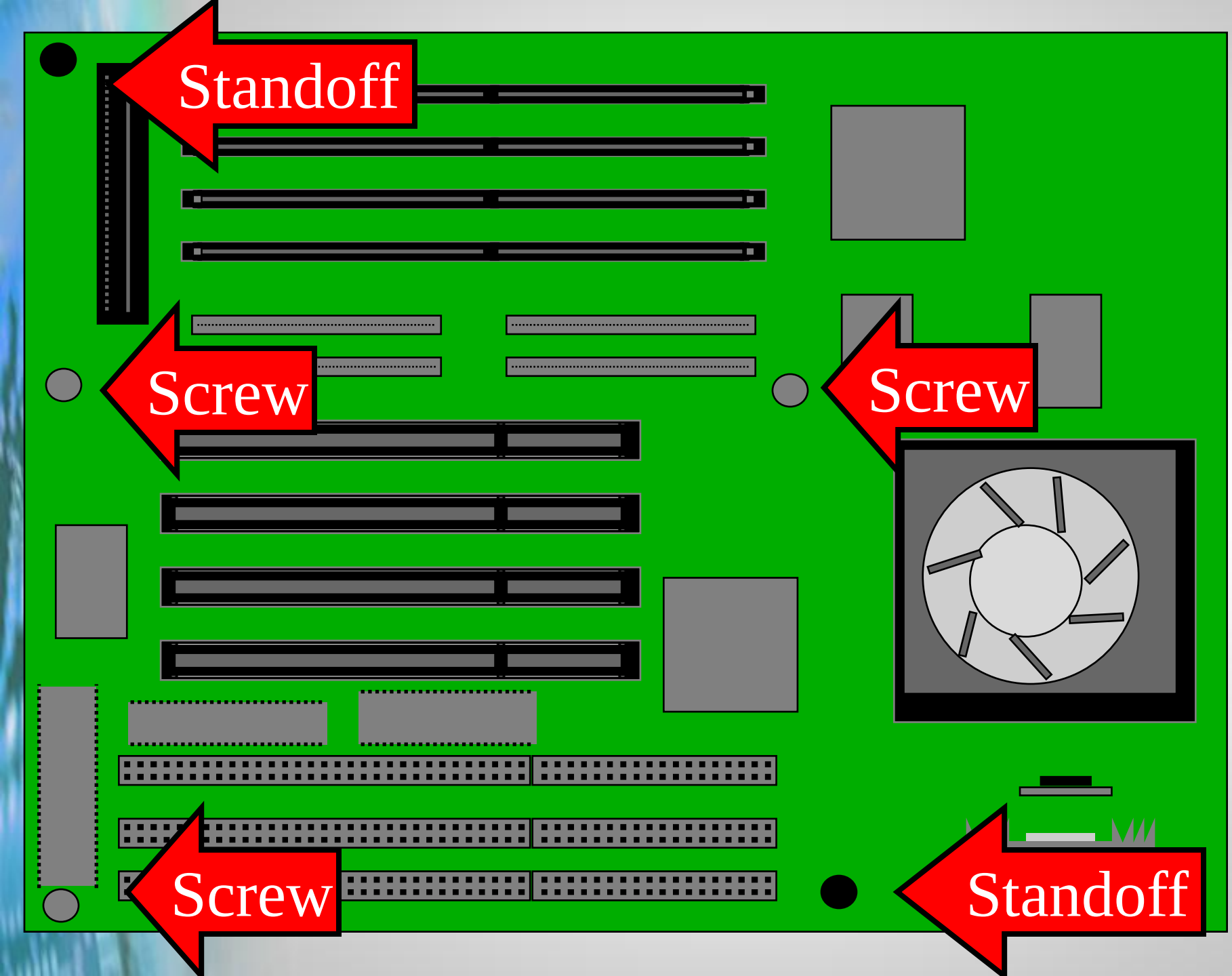
… Or here.



The Floppy Drive






Standoff
Screw
Screw
Screw
Standoff

Keep these tips in mind

- Document everything.
- Shut off power.
- Protect against ESD.
- Grasp connectors by shells-not leads.
- Never use force.
- Release latches on connectors.
- Rock boards end to end.