Lab 3- Power Supplies

Chapter 18

Upgrading and Repairing PCs

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The Power Supply

- The basic function of the power supply is to convert the electrical power available at the wall socket to that which the computer circuitry can use.
- The power supply in a conventional desktop system is designed to convert either 120V (nominal) 60Hz AC (alternating current) or 240V (nominal) 50Hz AC power into +3.3V, +5V, and +12V DC (direct current) power.
- Some power supplies require you to switch between the two input ranges, whereas others auto-switch.

Voltage Rails

- The PSU normally supplies +3.3V, +5V, and +12V to the system.
- These voltages are often called rails, referring to the fact that although there are multiple wires carrying a specific voltage, they are normally tied to a single rail (or tap) in the PSU.
- The digital electronic components and circuits in the system (motherboard, adapter cards, and disk drive logic boards) typically use the +3.3V or +5V power, and the motors (disk drive motors and any fans) use the +12V power.
- In addition, voltage regulators on the motherboard or in other components convert these standard voltages to others as necessary.

Table 18.1 Voltage Rail Usage in a PC

Rail	Devices Powered
+3.3V	Chipsets, some DIMMs, PCI/AGP/PCIe cards, miscellaneous chips
+5V	Disk drive logic, low-voltage motors, SIMMs, PCI/AGP/ISA cards, voltage regulators, miscellaneous chips
+12V	Motors, high-output voltage regulators, AGP/PCIe cards

SIMM = Single Inline Memory Module
DIMM = Dual Inline Memory Module
PCI = Peripheral Component Interconnect
PCIe = PCI Express
AGP = Accellerated Graphics Port
ISA = Industry Standard Architecture

Voltage Regulators

- The power supply must deliver a good, steady supply of DC power so the system can operate properly.
- Devices that run on voltages other than these directly must then be indirectly powered through onboard voltage regulators, which take the 5V or 12V from the power supply and convert that to the lower voltages required by various components.

Voltage Regulators

- For example, older DDR (double data rate) dual inline memory modules (DIMMs) and Rambus inline memory modules (RIMMs) require 2.5V, whereas DDR2 and DDR3 DIMMs require 1.8V and 1.5V.
- These voltages are supplied by simple onboard regulators.
- Processors also require a variety of voltages (as low as 1.3V or less) that are supplied by a sophisticated voltage regulator module (VRM) that is either built into or plugged into the motherboard.

Negative DC Voltages

- If you look at a specification sheet for a typical PC power supply, you can see that the supply generates not only +3.3V, +5V, and +12V, but also –12V and possibly –5V.
- If present, the –5V is simply routed to the ISA bus on pin B5 so any ISA cards can use it, even though very few ever have.
- However, as an example, the analog data separator circuits found in older floppy controllers did use –5V.
- The motherboard logic typically doesn't use –12V either; however, it might be used in some board designs for serial port or local area network (LAN) circuits.

Negative DC Voltages

- Although older serial port circuits used +/–12V outputs, today most run only on +3.3V or +5V.
- The main function of the +12V power is to run disk drive motors as well as the higher-output processor voltage regulators in some of the newer boards.
- The +12V supply is used by any cooling fans in the system.
- Portable systems can use fans that run on +5V or even +3.3V.

PS_ON Signal

- Systems with modern form factors based on the ATX standards include another special signal.
- This feature, called PS_ON, can turn the power supply *on* or *off* via software.
- It is sometimes known as the *soft-power feature.*
- PS_ON is most evident when you use it with an operating system (OS) such as Windows.
- When you shut down a PC from the Start menu, Windows automatically turns off the computer after it completes the OS shutdown sequence.
- A system without this feature only displays a message that it's safe or ready for you to shut down the computer manually.

The Power Good Signal

- The power supply actually prevents the computer from starting up until all the power supply voltages are within the proper ranges.
- The power supply completes internal checks and tests before allowing the system to start.
- If the tests are successful, the power supply sends a special signal to the motherboard called Power_Good.
- This signal must be continuously present for the system to run.
- Therefore, when the power supply can't maintain outputs within regulation tolerance, the Power_Good signal is withdrawn (goes low) and forces the system to reset.
- The system does not restart until the Power_Good signal returns.

Power Supply Form Factors

- The shape and general physical layout of a component is called the form factor.
- When designing a PC, the engineers can choose to use one of the popular standard PSU form factors, or they can elect to build their own custom design.
- In the PC market, IBM originally defined the form factor standards, and everybody else copied them.
- All the popular PC power supply form factors up through 1995 were based on one of three IBM models, including the PC/XT, AT, and PS/2 Model 30.

Power Supply Form Factors

- Intel defined a new power supply form factor in 1995 with the introduction of the ATX form factor.
- The names of some of the power supply form factors seem to be the same as those of motherboard form factors.
- The power supply form factor relates more to the system chassis (case) than to the motherboard.
- That is because all the form factors use one of only two main types of connector designs: either AT or ATX.

Power Supply Form Factors

- All the modern power supply form factors include same connectors and therefore are capable of plugging into the same motherboards.
- No matter what the form factor of the motherboard (ATX, BTX, or any of the smaller variants of either), virtually any of the modern industry-standard power supplies will plug in.
- Plugging the power supply connectors into the motherboard is one thing.
- But for the power supply to work in the system, it must physically fit inside the chassis or case—and that is what the different modern power supply form factors are all about.

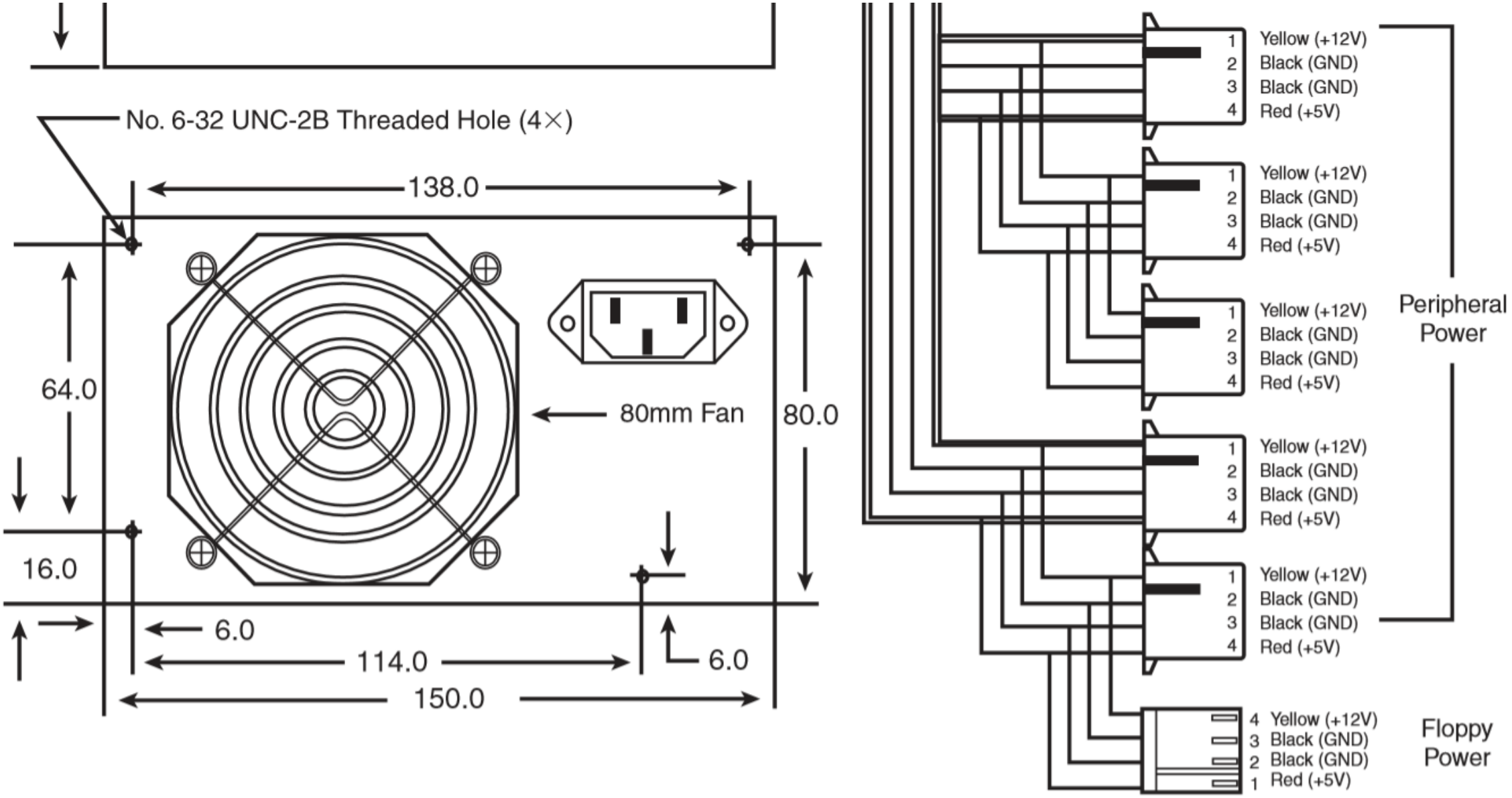
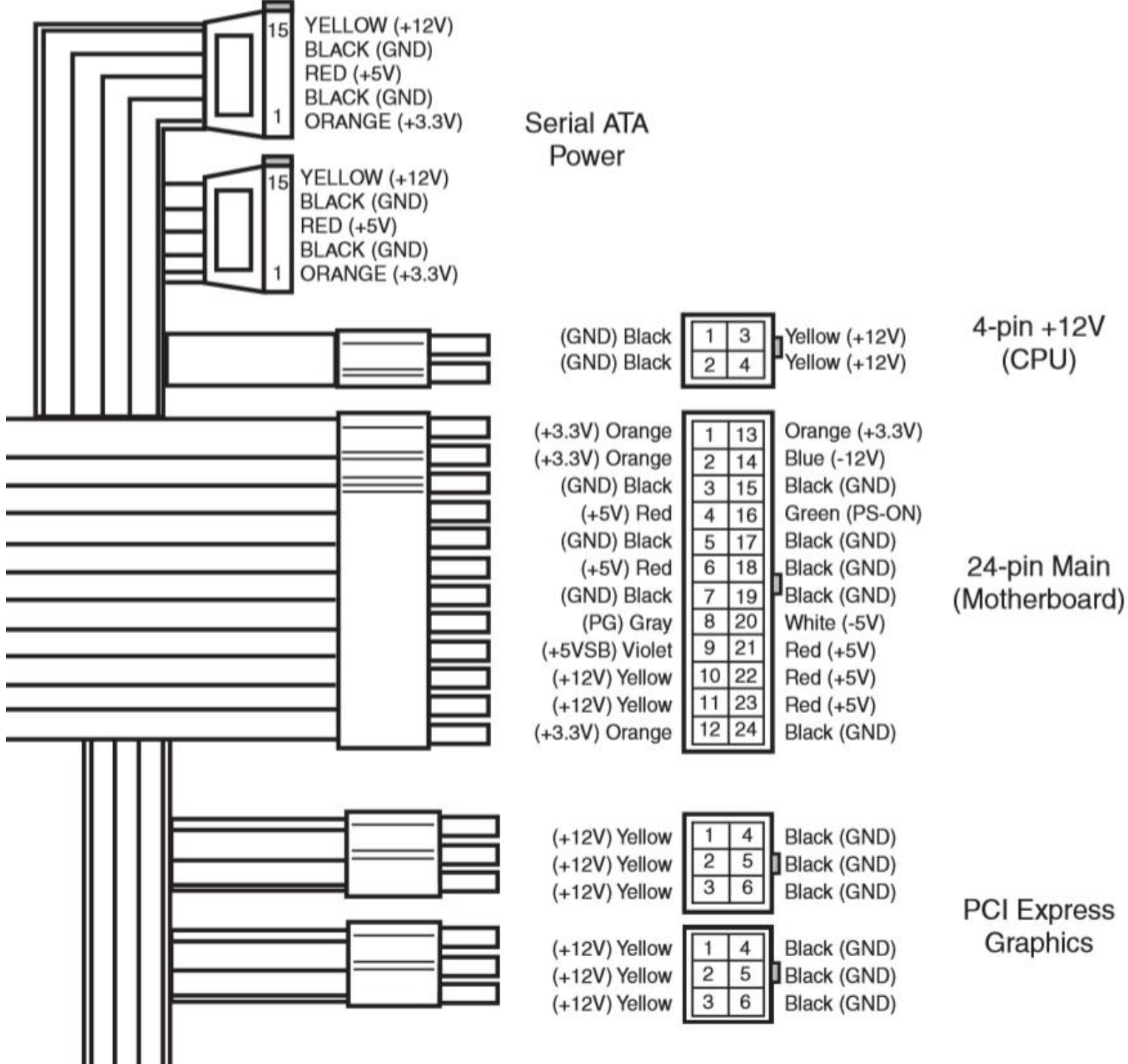


Figure 18.1 ATX12V 2.x form factor power supply with 24-pin main, 4-pin +12V, and optional PCI Express Graphics connectors.


15
1
YELLOW (+12V)
BLACK (GND)
RED (+5V)
BLACK (GND)
ORANGE (+3.3V)
Serial ATA Power
15
1
YELLOW (+12V)
BLACK (GND)
RED (+5V)
BLACK (GND)
ORANGE (+3.3V)
(GND) Black
(GND) Black
1 3
2 4
Yellow (+12V)
Yellow (+12V)
4-pin +12V (CPU)
(+3.3V) Orange
(+3.3V) Orange
(GND) Black
(+5V) Red
(GND) Black
(+5V) Red
(GND) Black
(PG) Gray
(+5VSB) Violet
(+12V) Yellow
(+12V) Yellow
(+3.3V) Orange
1 13
2 14
3 15
4 16
5 17
6 18
7 19
8 20
9 21
10 22
11 23
12 24
Orange (+3.3V)
Blue (-12V)
Black (GND)
Green (PS-ON)
Black (GND)
Black (GND)
Black (GND)
White (-5V)
Red (+5V)
Red (+5V)
Red (+5V)
Black (GND)
24-pin Main (Motherboard)
(+12V) Yellow
(+12V) Yellow
(+12V) Yellow
1 4
2 5
3 6
Black (GND)
Black (GND)
Black (GND)
(+12V) Yellow
(+12V) Yellow
(+12V) Yellow
1 4
2 5
3 6
Black (GND)
Black (GND)
Black (GND)
PCI Express Graphics

Power Switches

- Three main types of power switches are used on PCs.
  - Front panel motherboard-controlled switch (ATX and newer)
  - Front panel power supply AC switch (AT/LPX; obsolete)
  - Integral power supply AC switch (PC/XT/AT; obsolete)

Power Switches: ATX and Newer

- All ATX and newer power supplies that employ the 20- or 24-pin motherboard connector use the PS_ON signal to power up the system.
- The power supply runs in standby mode when plugged in with the system off.
- The PS_ON signal is routed from the power supply through the motherboard to a low-voltage momentary contact DC switch on the front panel.
- The power supply's on or off status is toggled by the PS_ON signal received on the ATX Main power connector.
- This is called a soft-off switch.
- PS_ON is an active low signal.

Figure 18.16 ATX power switch.

Power Switches: PC/XT/AT and LPX

- The earliest systems had power switches integrated or built directly into the power supply, which turned the main AC power to the system on and off.

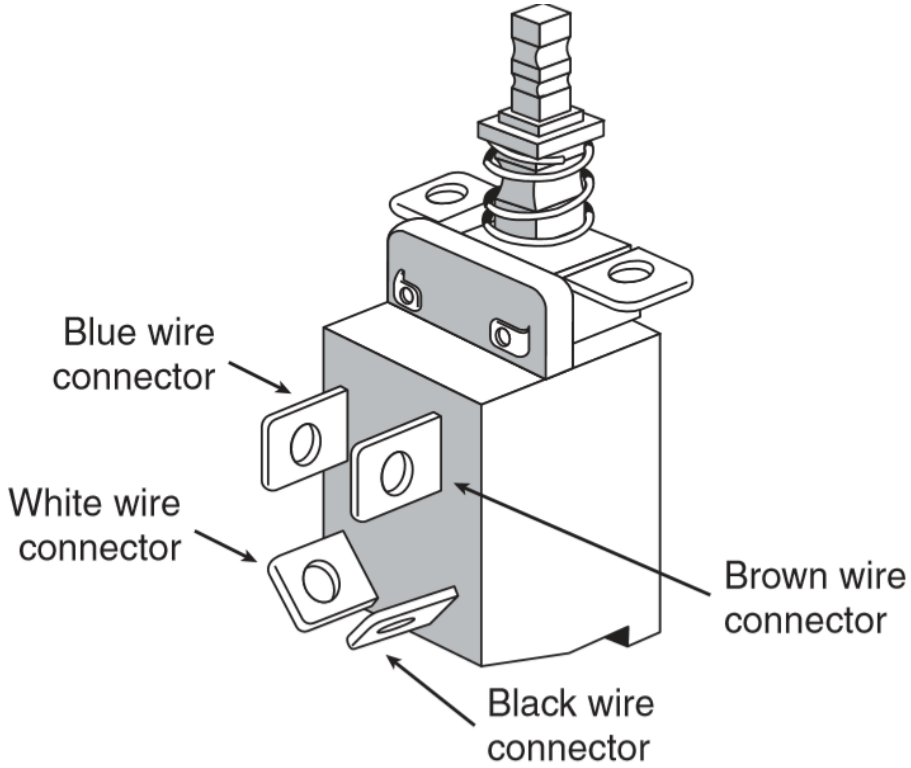


Figure 18.17 Power supply remote pushbutton switch connections.

AT/LPX Power Supply Connectors

Motherboard Power Connectors

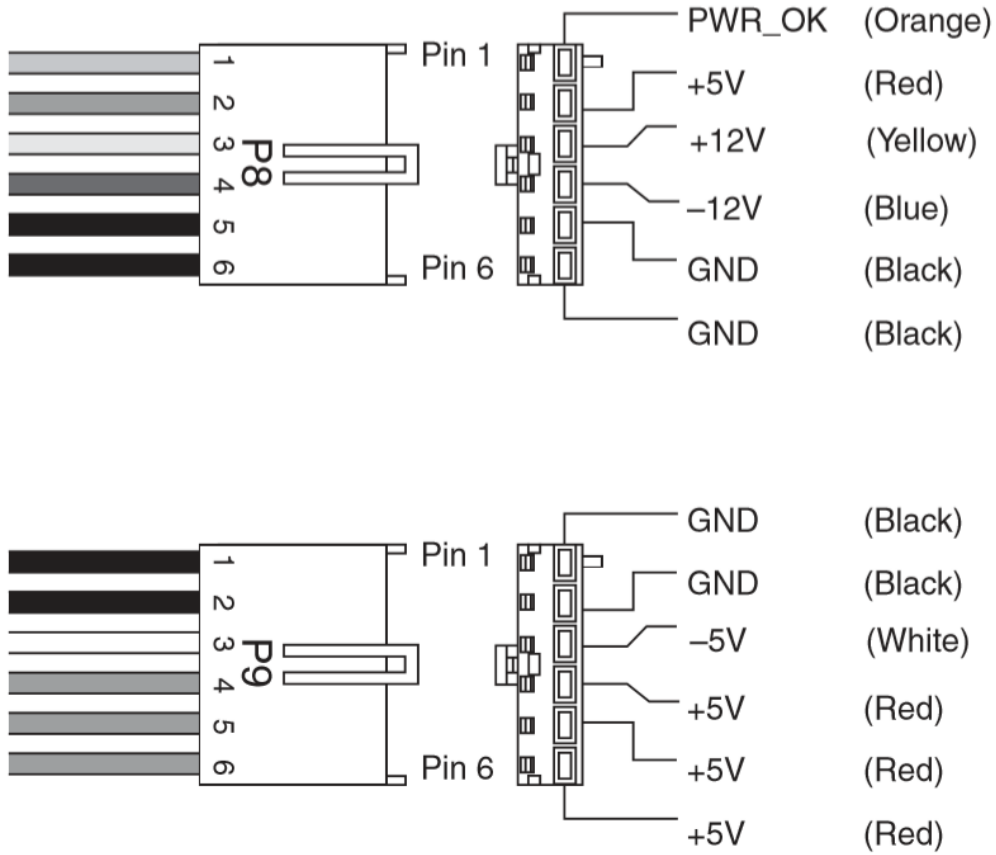


Figure 18.18 AT/LPX main P8/P9 (also called P1/P2) power connectors, side and terminal end view.

Motherboard Power Connectors

ATX and ATX12V Motherboard Power Connectors

- Power supplies conforming to the original ATX and ATX12V 1.x form factor standards or variations thereof use the following three motherboard power connectors:
  - 20-pin main power connector
  - 6-pin auxiliary power connector
  - 4-pin +12V power connector

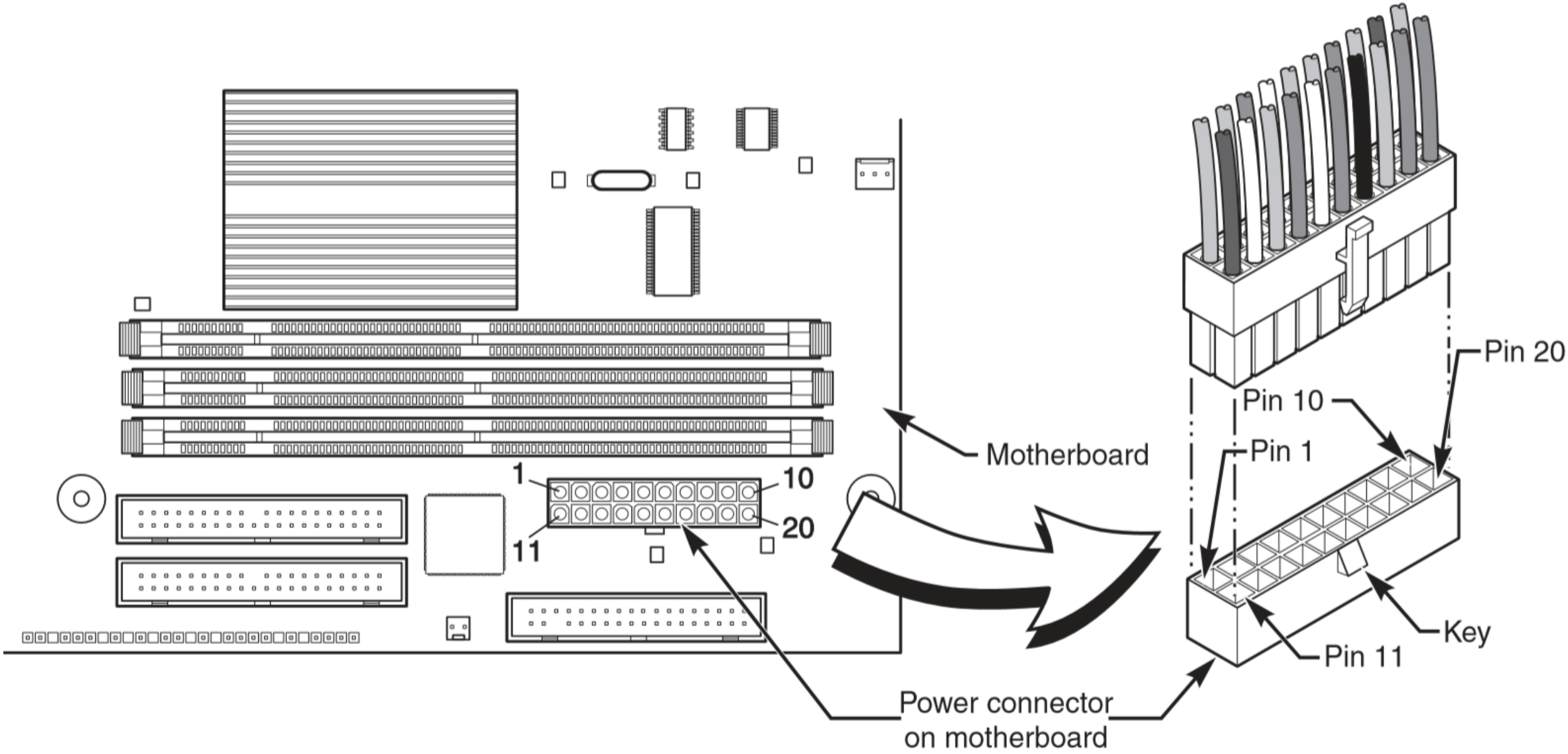


Figure 18.20 ATX 20-pin motherboard main power connector, perspective view.

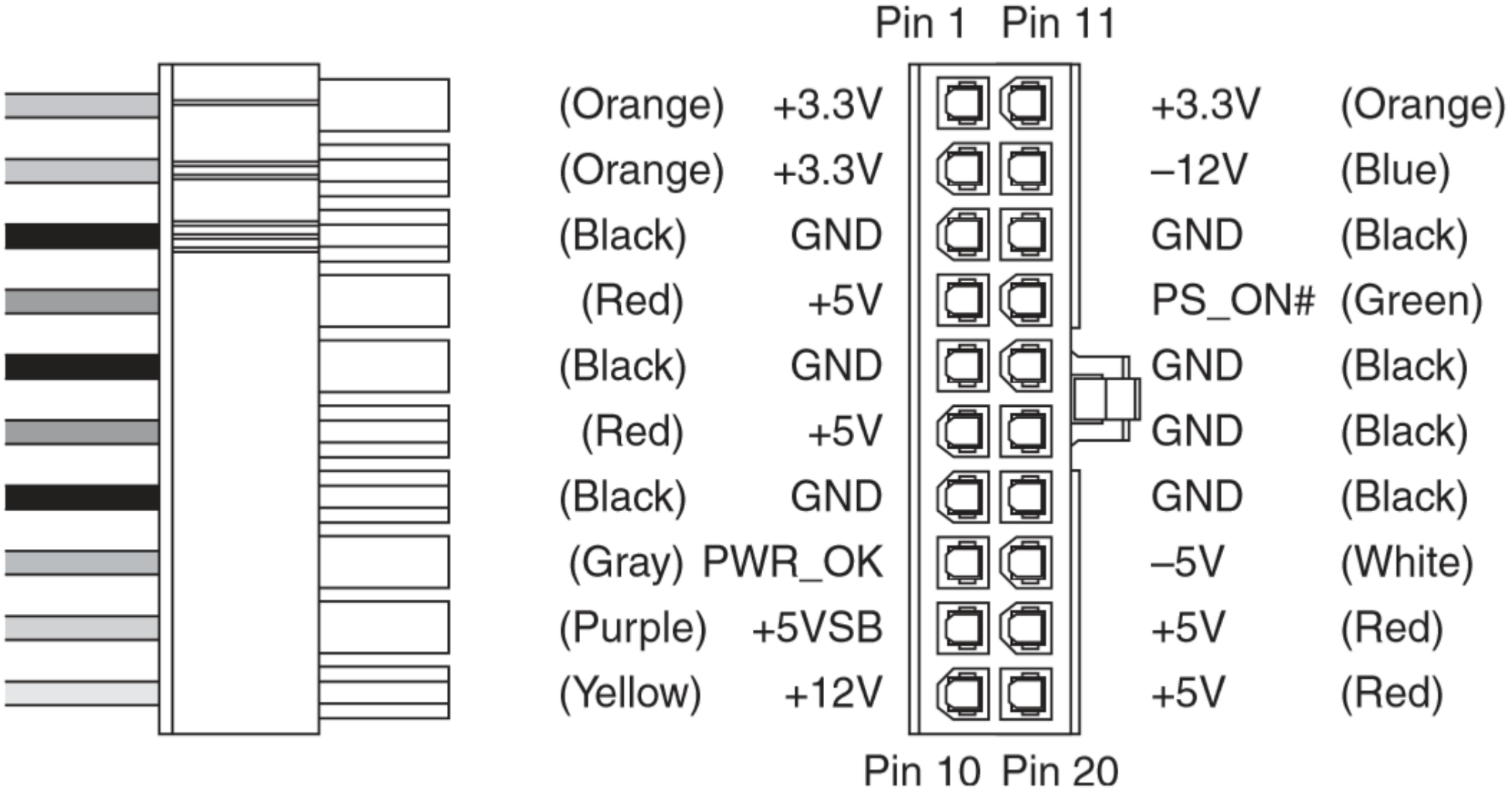


Figure 18.21 ATX 20-pin main power connector, side and terminal end view.

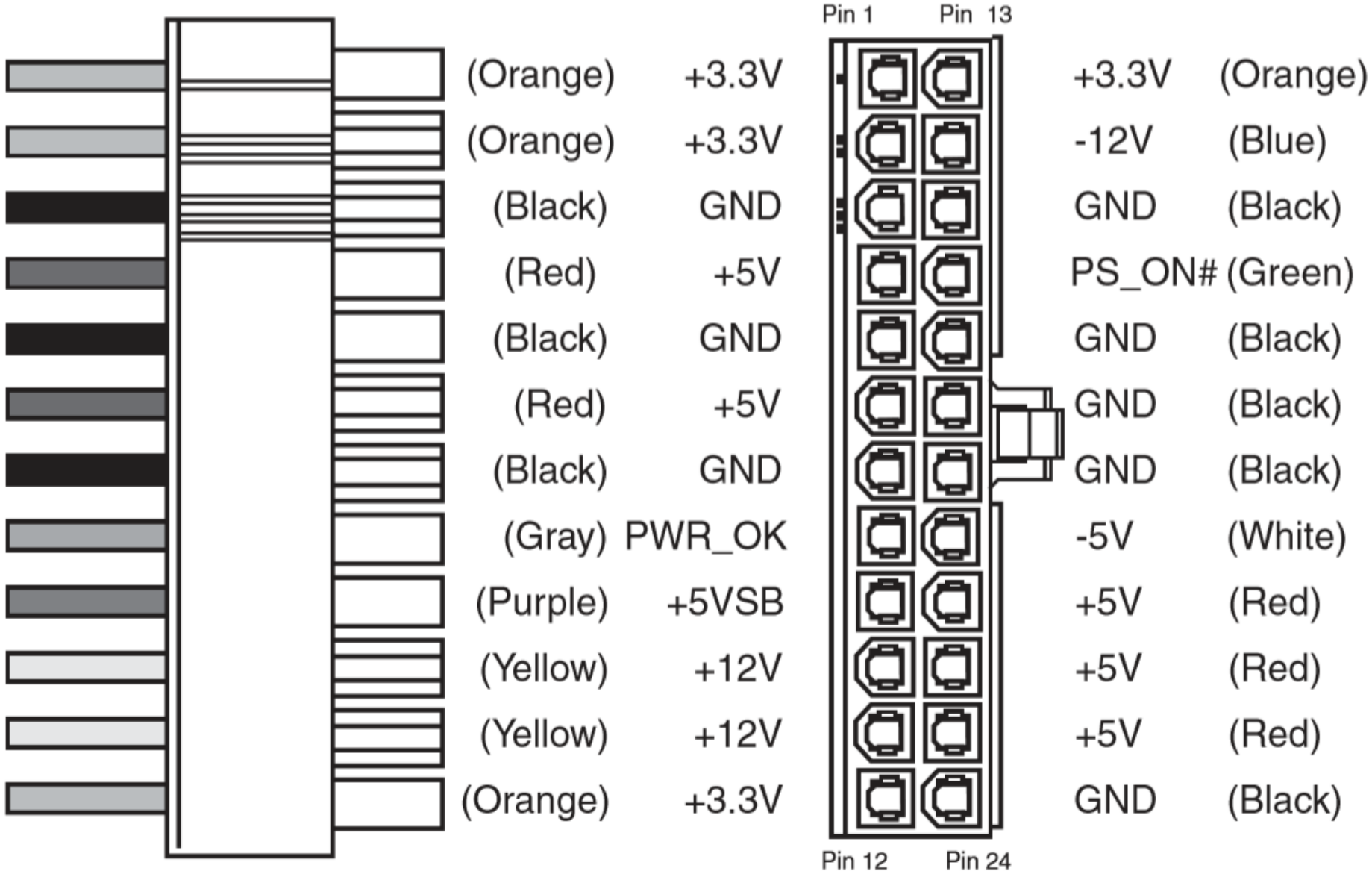


Figure 18.23 ATX12V 2.x 24-pin main power connector.

Motherboard Power Connectors

Four-Pin +12V CPU Power Connector

- To augment the supply of +12V power to the motherboard, Intel created a new ATX12V power supply specification.
- This added a third power connector, called the +12V connector, specifically to supply additional +12V power to the board.

Figure 18.24 +12V 4-pin CPU power connector, side and terminal end view.

Motherboard Power Connectors

Peripheral to 4-Pin +12V CPU Power Adapters

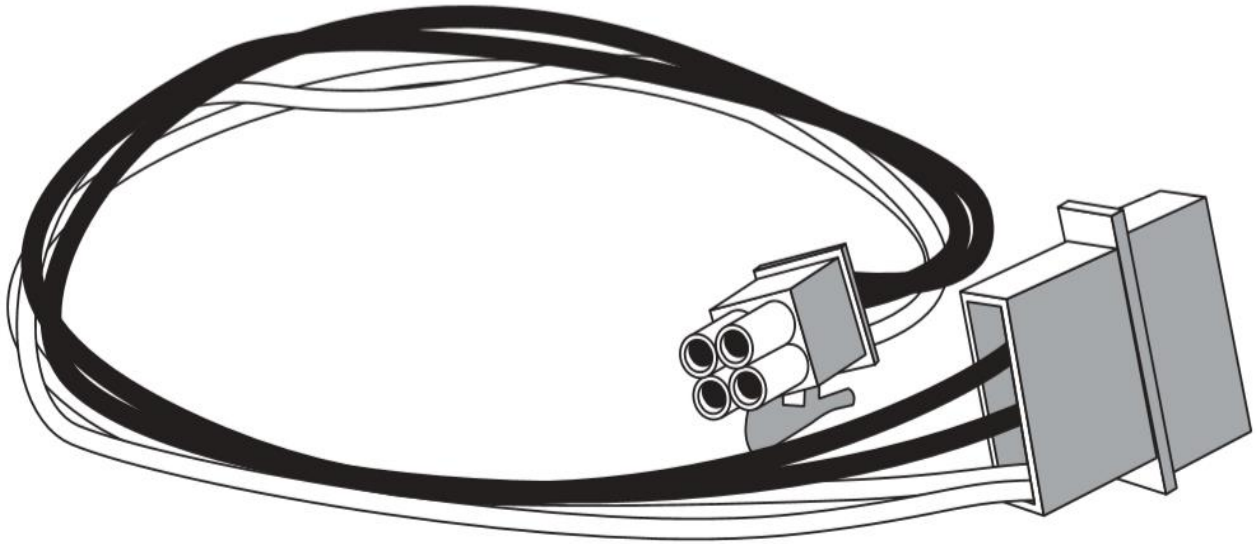


Figure 18.25 Peripheral to +12V power adapter.

Motherboard Power Connectors

Backward and Forward Compatibility

- What happens if you purchase a new power supply that has a 24-pin main power connector but your motherboard has only a 20-pin main power socket?
- Likewise, what if you purchase a new motherboard that has a 24pin main power socket but your power supply has only a 20-pin main power connector?
- There are adapters that can convert a 24-pin connector to a 20-pin type, and the other way around, but surprisingly these adapters are not usually necessary.

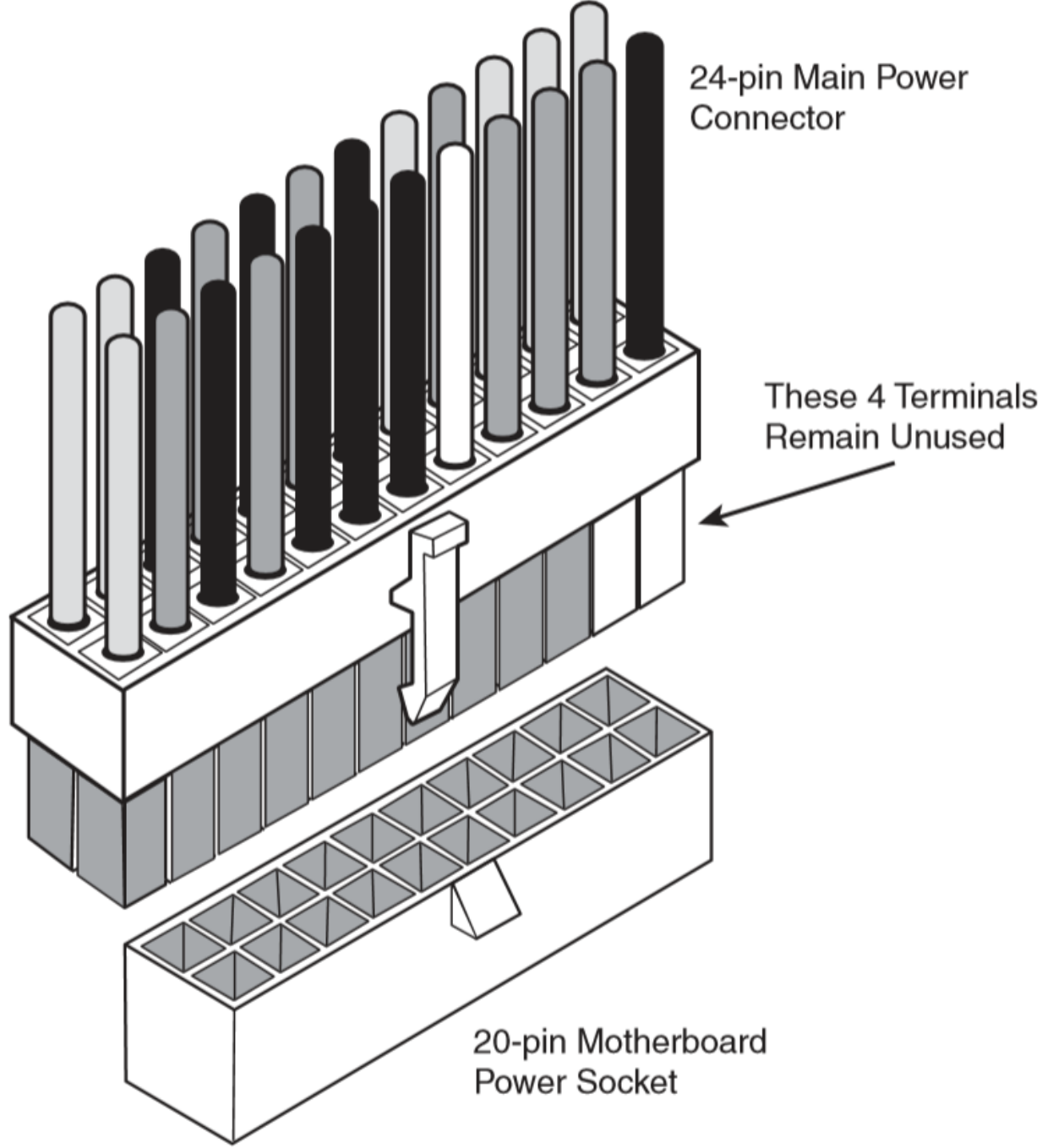


Figure 18.28 Connecting a 24-pin main power connector to a 20-pin motherboard socket.

Additional Power Connectors

Peripheral Power Connectors

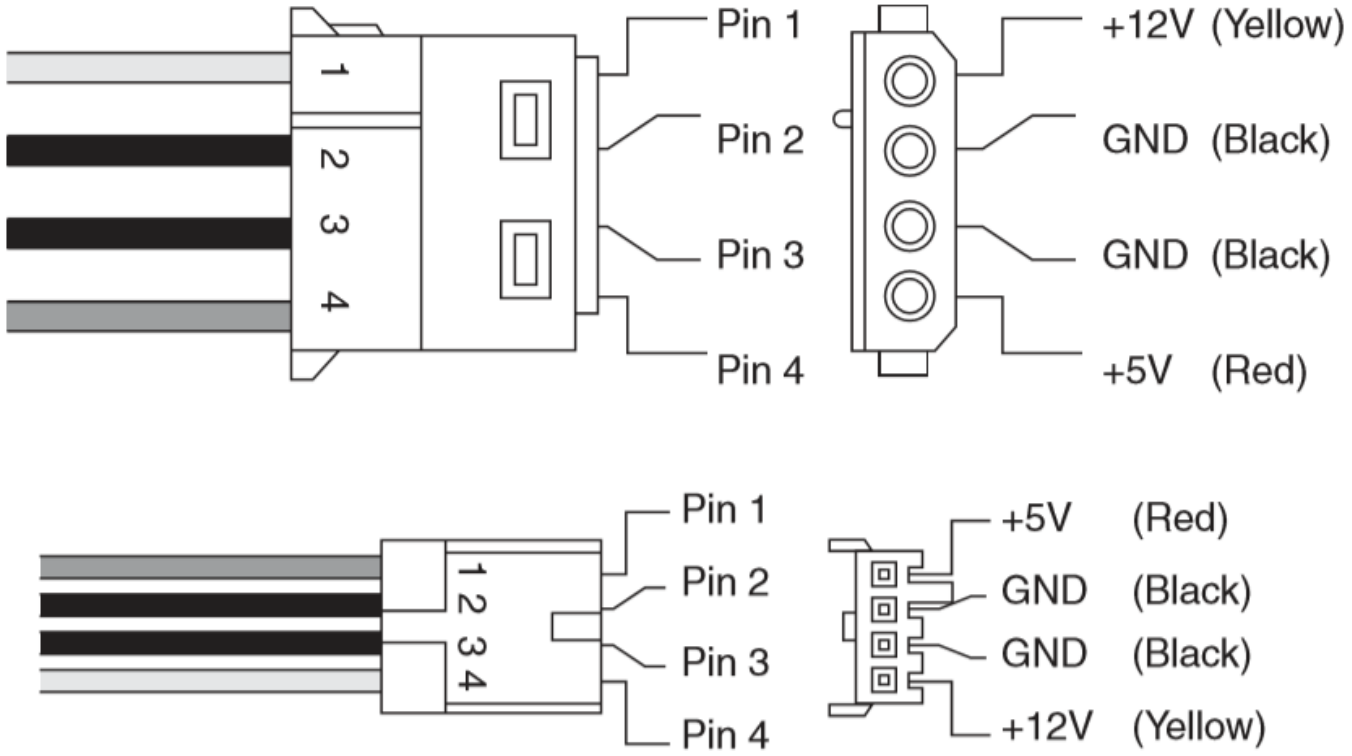


Figure 18.30 Peripheral and floppy power connectors.

Additional Power Connectors

Serial ATA Power Connectors

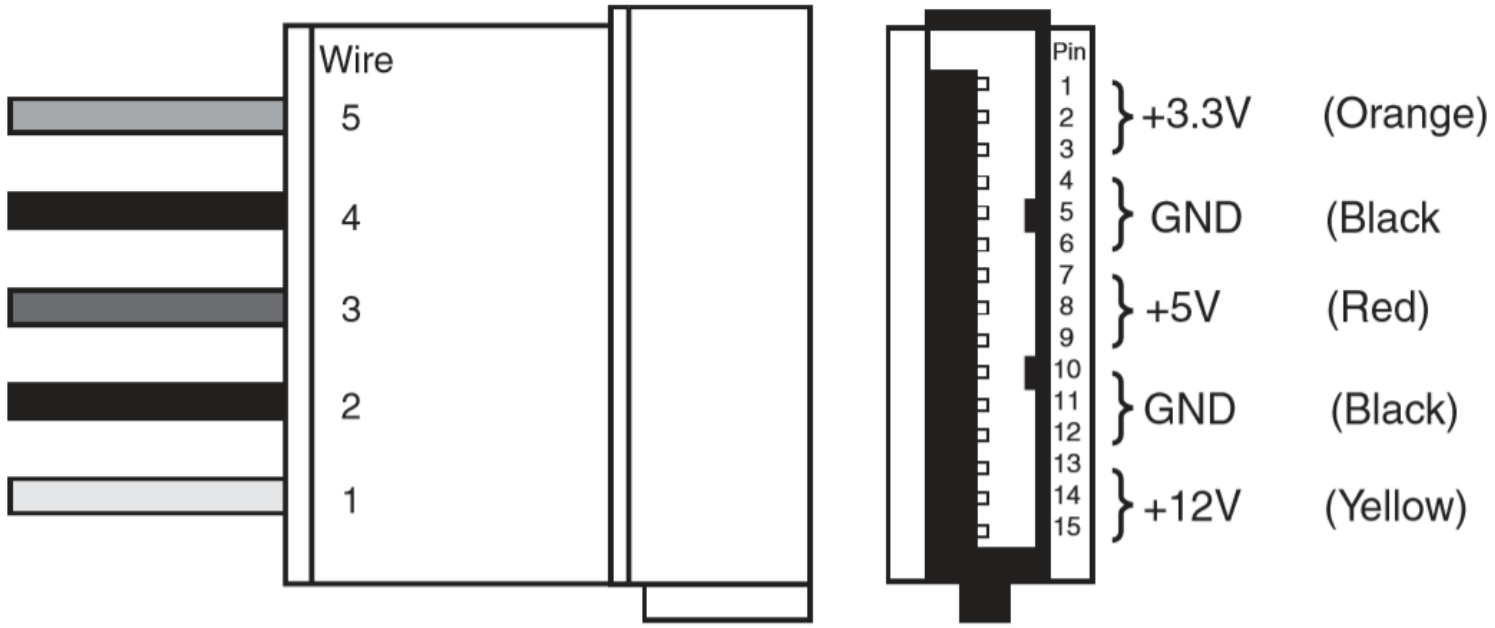


Figure 18.31 A SATA power connector.

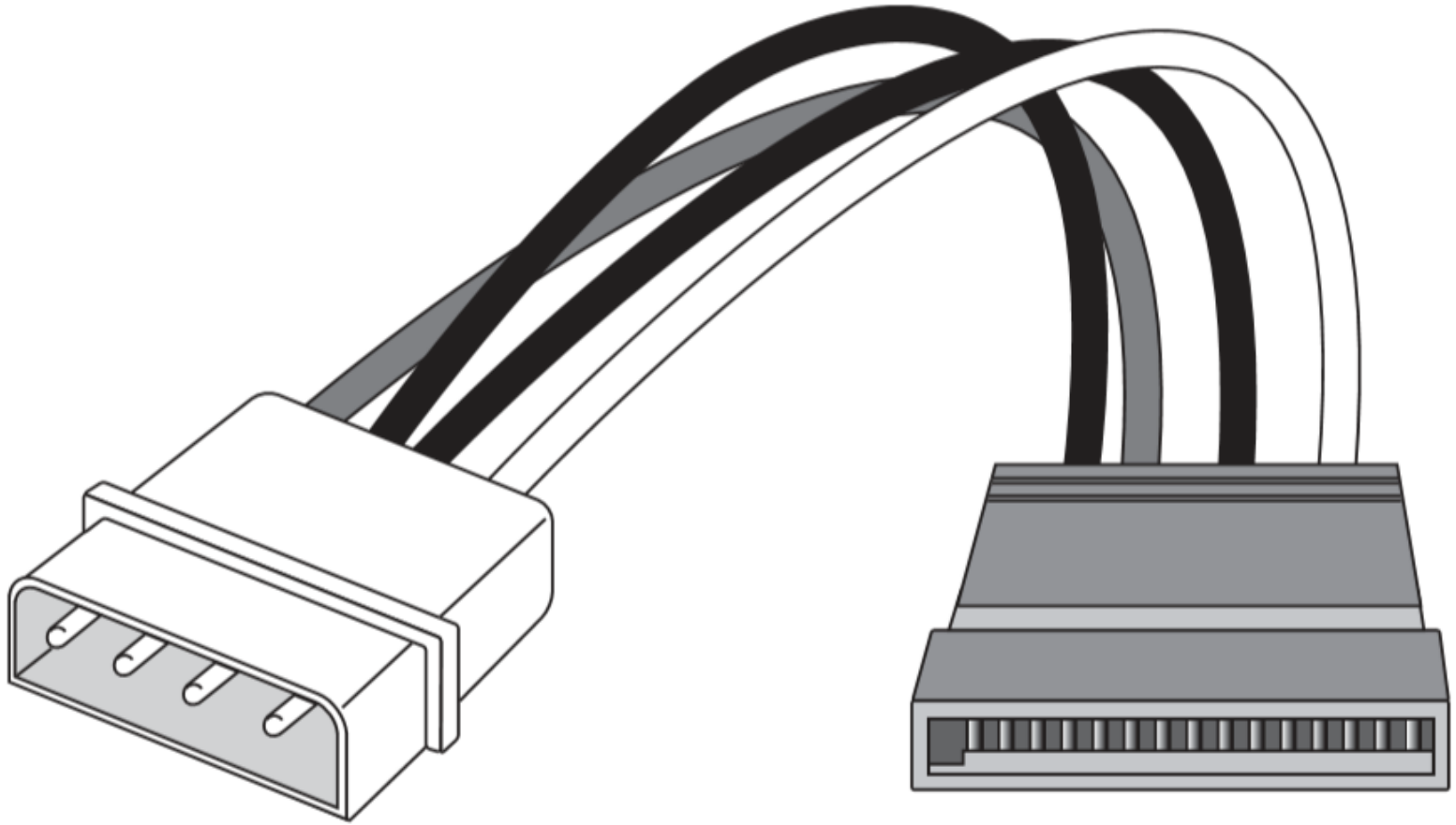


Figure 18.32 A peripheral-to-SATA power adapter.

Power Supply Specifications

- **Mean Time Between Failures (MTBF) or Mean Time To Failure (MTTF):** the average interval, in hours, that the power supply is expected to operate before failing.
- **Input Range (or Operating Range):** The range of voltages that the power supply is prepared to accept from the AC power source (110 V or 220 V).
- **Peak Inrush Current:** The greatest amount of current drawn by the power supply at a given moment immediately after it is turned on, expressed in terms of amps at a particular voltage.
- **Hold-Up Time:** The amount of time (in milliseconds) that a power supply can maintain output within the specified voltage ranges after a loss of input power.

Power Supply Specifications

- **Maximum Load Current:** The largest amount of current (in amps) that safely can be delivered through a particular output.
- **Minimum Load Current:** The smallest amount of current (in amps) that must be drawn from a particular output for that output to function.
- **Efficiency:** The ratio of power input to power output, expressed in terms of a percentage.

Table 18.26 Power Consumption Calculation

Component	Power Usage	Comments
Motherboard	50W–75W	Depends on the number of integrated components.
Processor	25W–150W	For each physical processor (not cores). Most are 50W–100W.
RAM	5W–15W	For each module (DIMM).
Integrated video	5W–15W	Integrated into the North Bridge chip.
Discrete video card	25W–300W	For each video card.
PCI card	5W–15W	For each nonvideo card.
PCIe card	10W–25W	For each nonvideo card.
Hard disk drive	15W–30W	For each drive. Power use increased during startup.
Optical drive	15W–35W	For each drive.
Cooling fan	3W–5W	For each fan.
USB/FireWire	2W–5W	For each used port.

Power Supply Troubleshooting

- The following is a list of PC problems that often are related to the power supply:
  - Any power-on or system startup failures or lockups
  - Spontaneous rebooting or intermittent lockups during normal operation
  - Intermittent parity check or other memory-type errors
  - Hard disk and fan simultaneously failing to spin (no +12V)
  - Overheating due to fan failure
  - Small brownouts that cause the system to reset
  - Electric shocks felt on the system case or connectors
  - Slight static discharges that disrupt system operation

Measuring Voltage

- A **digital multimeter** (DMM) is a test tool used to measure two or more electrical values—principally voltage (volts), current (amps) and resistance (ohms).

Back Probing

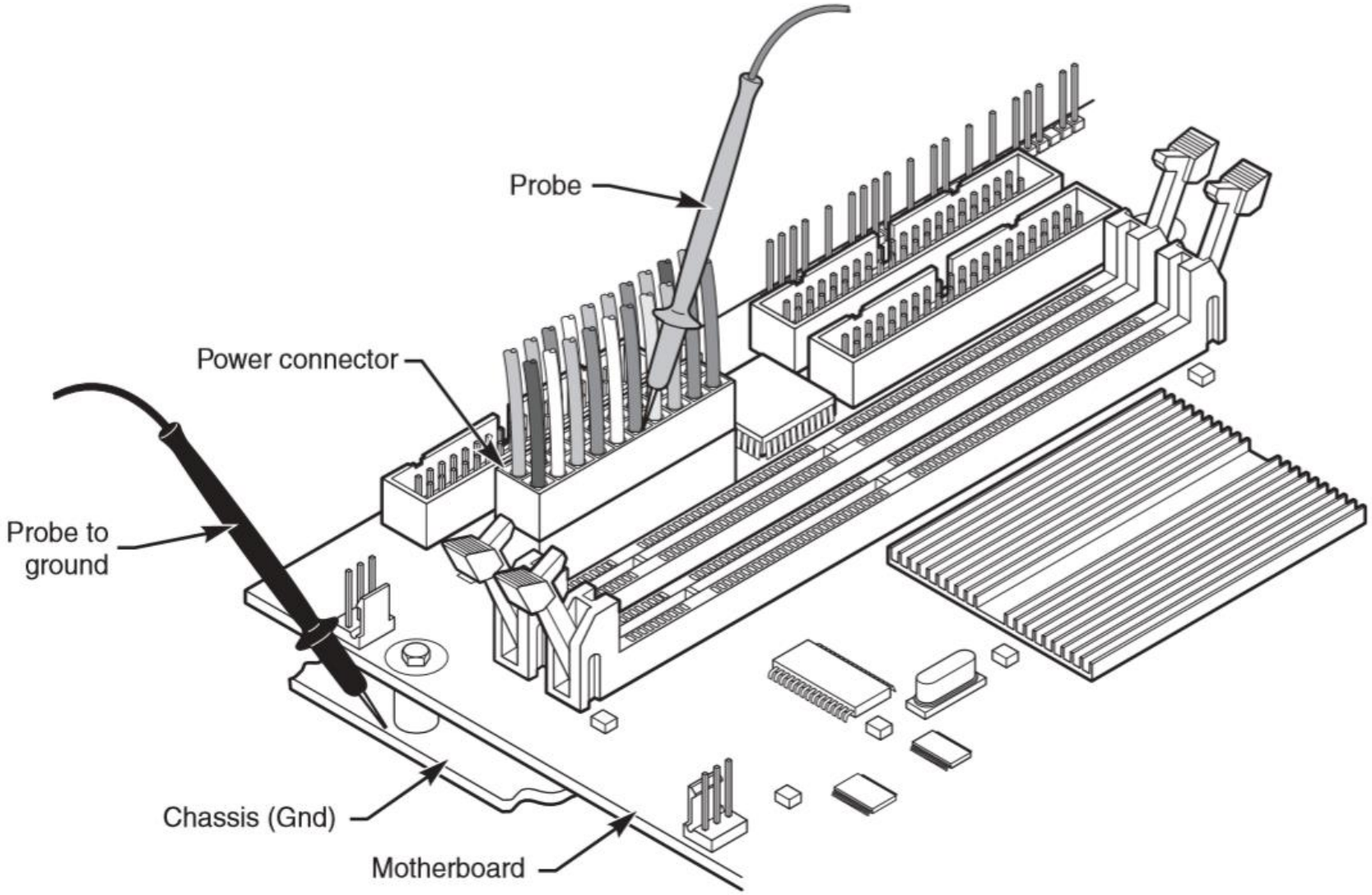


Figure 18.39 Back probing the power supply connectors.

Table 18.30 Voltage Ranges

	Loose Tolerance		Tight Tolerance	
Desired Voltage	**Min. –10%**	**Max. (+8%)**	**Min. (–5%)**	**Max. (+5%)**
+3.3V	2.97V	3.63V	3.135V	3.465V
+/–5.0V	4.5V	5.4V	4.75V	5.25V
+/–12.0V	10.8V	12.9V	11.4V	12.6V

Signal	Minimum	Maximum
Power_Good (+5V)	3.0V	6.0V