Electrical Safety

Electricity is the flow of electrons, which are one of the fundamental building blocks of all matter. A **conductor** is a material that permits the flow of electricity. An **insulator** is a material that inhibits the flow of electricity.

Voltage is the force of electricity caused by a difference in charge, or electrical potential, at two locations (this value is measured in volts, also called **potential** or **potential difference**). Volts has the abbreviation “V”. electricity flows to equalize potential. Electricity in the Americas and in Japan operate at 110 volts (actually, within a range of 90-135 V).

Current is the measure of the flow of electrons past a given point – essentially measuring the speed of electrons through the conductor (measured in amps, or amperes). For current to flow there must be a complete **circuit**, or path from the source, through any intervening devices, and back to the ground. A complete circuit is called **closed**, an incomplete circuit is called **open**.

Current that flows in a single direction at a constant voltage through a circuit is called **direct Current (DC)** (Batteries provide this sort of current, and it is the type required by most electronic components). Current that flows back and forth through a constantly varying voltage level is called **alternate current (AC)** (a building's electrical service is an AC system, and most household items require AC to operate). AC systems complete a full cycle – voltage change from zero, through the maximum voltage, minimum voltage, and back to zero – many times a second (in the United States, Canada, and elsewhere, AC operates at 60 cycles per second [60 **hertz**, or Hz]).

Resistance is a force that opposes the flow of DC through a conductor. **Impedance** is like resistance, but applies to AC instead. When resistance (or impedance) is present, electrical energy is converted to heat or some other form of energy. Resistance and impedance are measured in ohms (this is quantity is written using the Greek letter Omega [Ω]).

Electrical power, measured in **watts (W)**, is derived from quantity that you can calculate by multiplying the voltage by the current (when calculating electrical power, always use absolute values, change any negative values to positive for your calculation). Power supplies are rated according to the watts of electrical power they can supply. Electrical energy is electrical power delivered over time. For example, one **kilowatt-hour (kWh)** is the flow of one kilowatt (1000 W) delivered for a one-hour period (the average home in the U.S consumes about 800 kWh of electrical energy per month).

Examining the Characteristics of electricity

Electricity is the source of energy for electronic equipment, including personal computers. Electricity is dangerous (if you don't follow proper safety precautions, electricity could kill you).

Current, not voltage, is what causes the danger. A dangerous level of current is possible, even with low voltage sources, such as a 9 V battery.

The 1-10-100 rule states that you can fell 1 mA (1 milliamp, or 1/1000 amp) of current through your body, 10 mA is sufficient to make your muscles contract to the point where you can't let go of the power source, and 100 mA is sufficient to stop. This is a rule you should learn to respect.

Voltage, current, and resistance are related through the following formula:

$V = i * r$

in this formula, *V* is for Voltage in volts, *i* is the current in amps, and *r* is the resistance in ohms (Ω). At a given voltage, current increases as resistance drops. A dangerous level of current can be reached if resistance is reduced sufficiently.

The human body has resistance of about 500 KΩ (500,000 Ω). Death isn't likely if electricity passes from finger to finger through your body, along your arm, and so forth (however, your brain and heart are considerably more sensitive). Visit www.allaboutcircuits.com/vol_1/chpt_3/4.html for more detailed information about the resistance of the human body and dangers from electricity.

You should always follow common-sense safety precautions to avoid electric shock. These precautions include the following:

- don't touch exposed electrical contacts with any part of your skin
- touch only insulated handles and parts of tools, probes, cords, etc.
- leave covers on equipment, unless you need to access their internal components
- work one-handed. If you use only one hand, electricity is less likely to flow through your body (Specifically, your heart or head) and cause injury or death
- never insert anything into a wall outlet other than a power cord
- rings, watches, and jewelry can cause unintended contact with electrical components. Furthermore, these metallic items can increase the surface area that's in contact with an electrical source and thus lower your body's resistance. Remove jewelry and watches when working around electricity.
- Keep your hands clean and dry
- don't work with electricity in wet surroundings, especially on wet floors.

Considering electrical Safety

Electrostatic discharge (ESD) is a phenomenon that occurs when the charges on separated objects are unequal. From the perspective of a PC technician, the most interesting (and dangerous) aspect of ESD happens when statically charged objects are brought near each other.

Electrostatic discharges (the current flow) aren't dangerous to humans, even though the voltage in the system can measure in the range of thousands of volts (however, such discharges are potentially harmful to electronics). The microscopic wires and components that make up chips and other devices are very sensitive to even small amounts of current. To feel a static shock, you must experience a discharge of approximately 3,000 volts or more.

There are two ways to prevent problems from static electricity:

- prevent the buildup of static charges
- prevent discharges, or discharge the charge safely

to reduce the buildup of static charges, follow these tips:

- don't shuffle your feet as you walk
- increase the humidity in the room or building - static charges dissipate before growing large if the humidity level is sufficiently high
- keep yourself grounded as you work and move around. Use the tools found in a typical ESD kit, such as wrist straps (shown in Exhibit 3-1) and mats. You and the components you're servicing can remain connected to ground so that charges can't buildup
- wear cotton clothing, which is less likely to generate static charges than are many synthetic materials.
- Remove carpeting from rooms where you service computers and from computer rooms

- use an air ionization system to build up an opposite, thus neutralizing, charge in the air.

If a charge differential does buildup, you can follow these tips to reduce the likelihood of damage from static discharges:

- equalize the charge safely. Unplug the equipment, then touch a metal portion of the chassis.
- If you must move around as you work, keep yourself grounded (with an antistatic wrist strap) so that charges can't build up.

To prevent damaging discharge from occurring, you need to be at equal charge potential with the device you are servicing (not equal charge with ground). If there's a fault in the building's wiring system, full wall current could be flowing through the ground wire (you could be injured or get killed if you came into contact with the ground).

An ESD toolkit includes tools that you can use to prevent buildup of charge differentials and to equalize them safely.

Exhibit 3-1: An antistatic (ESD) wrist strap

electrostatic discharge isn't typically a problem when the computer case is closed. The biggest problems arise when you have the computer's case open and are working with internal components.

The typical component that you find inside a computer case include:

- primary circuit board (the motherboard)
- hard drive

- power supply
- adapter cards
- wires and connectors

Such components shown in Exhibit 3-2

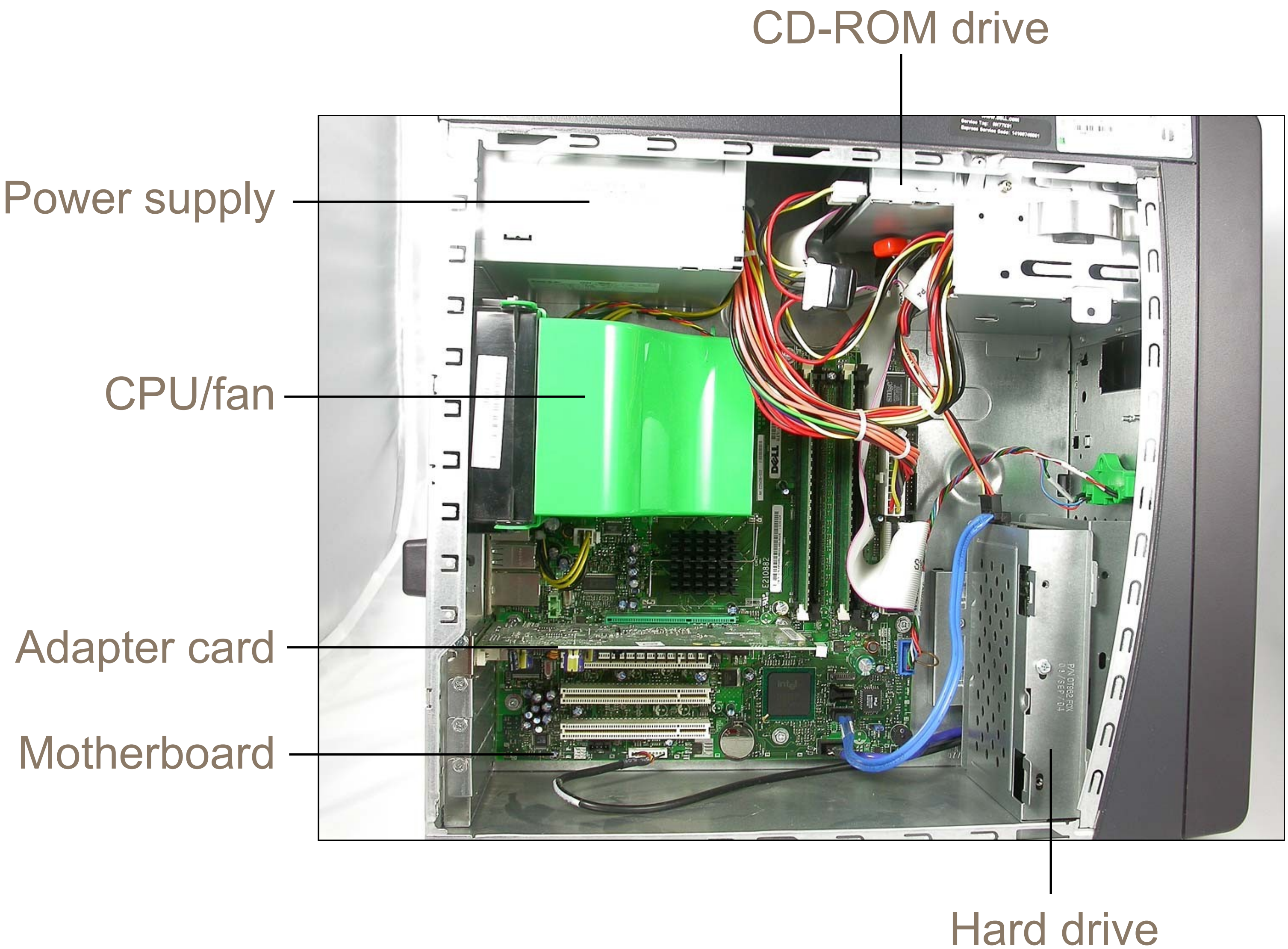

Exhibit 3-2: Internal Components of a typical computer

Computer cases come in a variety of styles, all of which provide some means to access the internal components. Older cases are held closed with screws, typically three per side, newer cases use slide latches or push-button clips that require no tools and make opening the case much easier. These clips are shown in Exhibit 3-3.

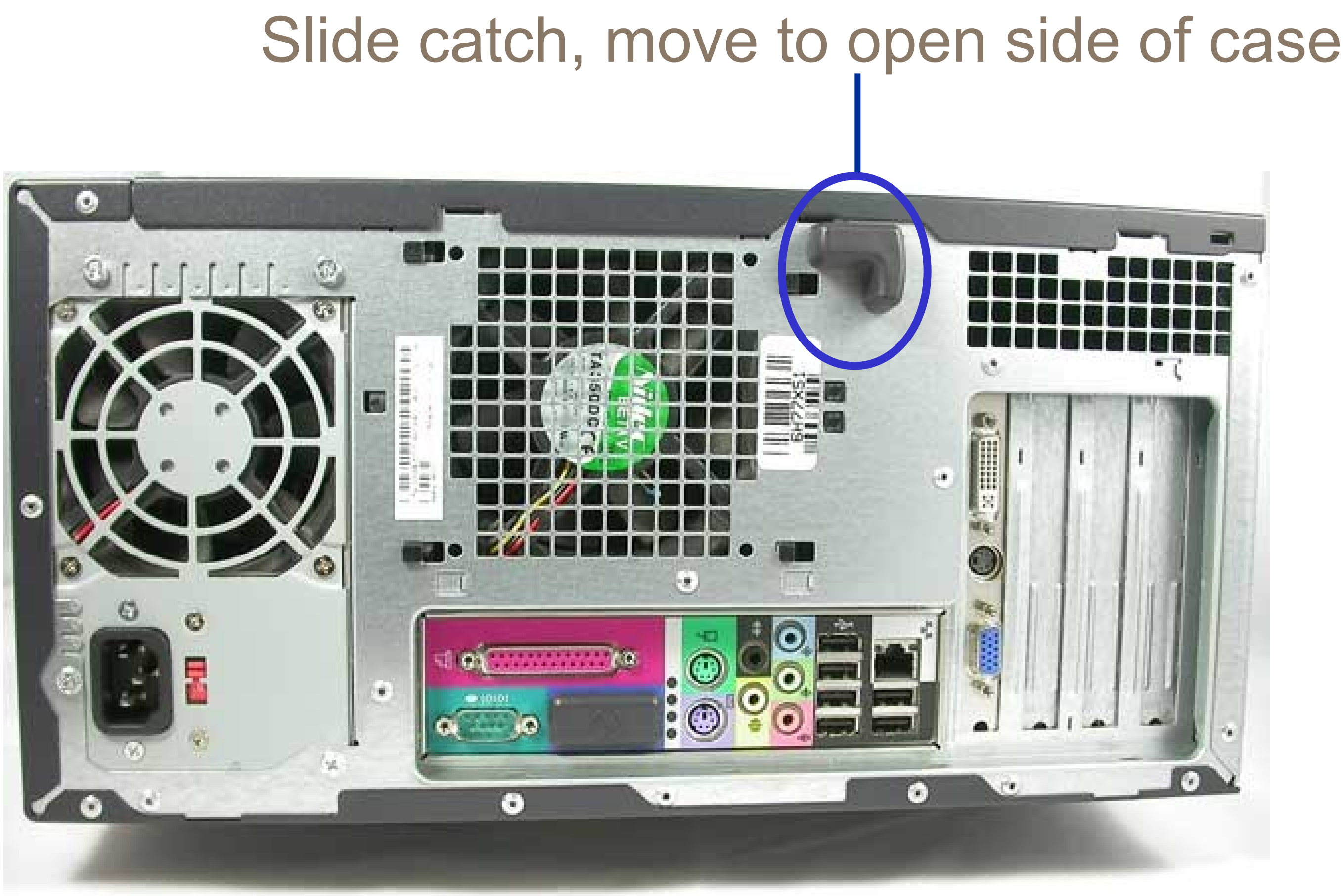

Exhibit 3-3: Typical slide latch used to secure a case

When removed, one side exposes the internal components, while the other side reveals the underside of the main circuit board. You usually tell which side to open by looking at the connectors extending through the back of the computer. You typically open the side opposite the rows of connectors, as show in exhibit 3-4 .

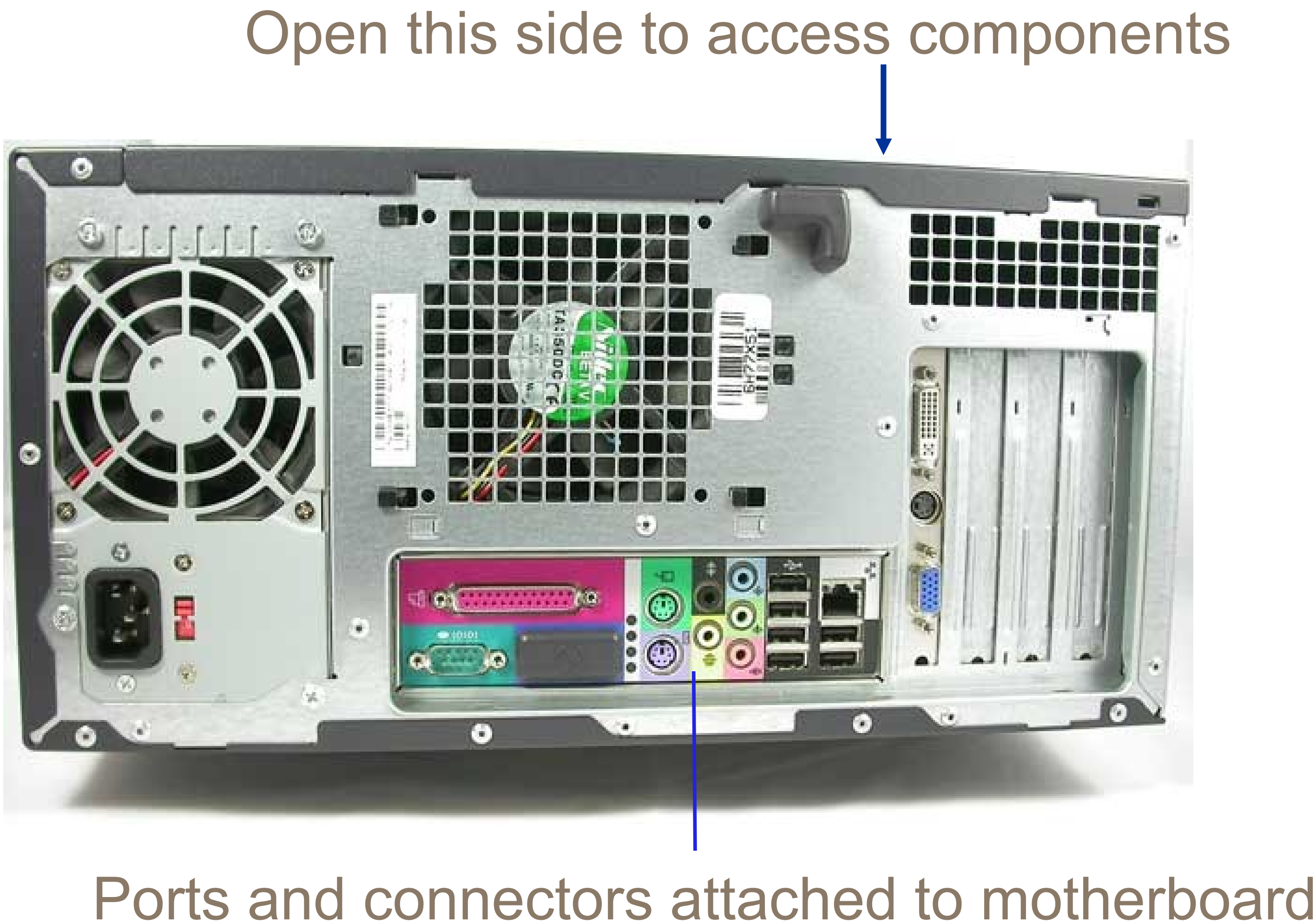

Exhibit 3-4: Typically, you open the side opposite the port connectors

Most modern computer cases include a removable front cover. Typically, the front cover is held in place with snap-clips and one or more alignment posts. These posts and clips are shown in Exhibit 3-5.

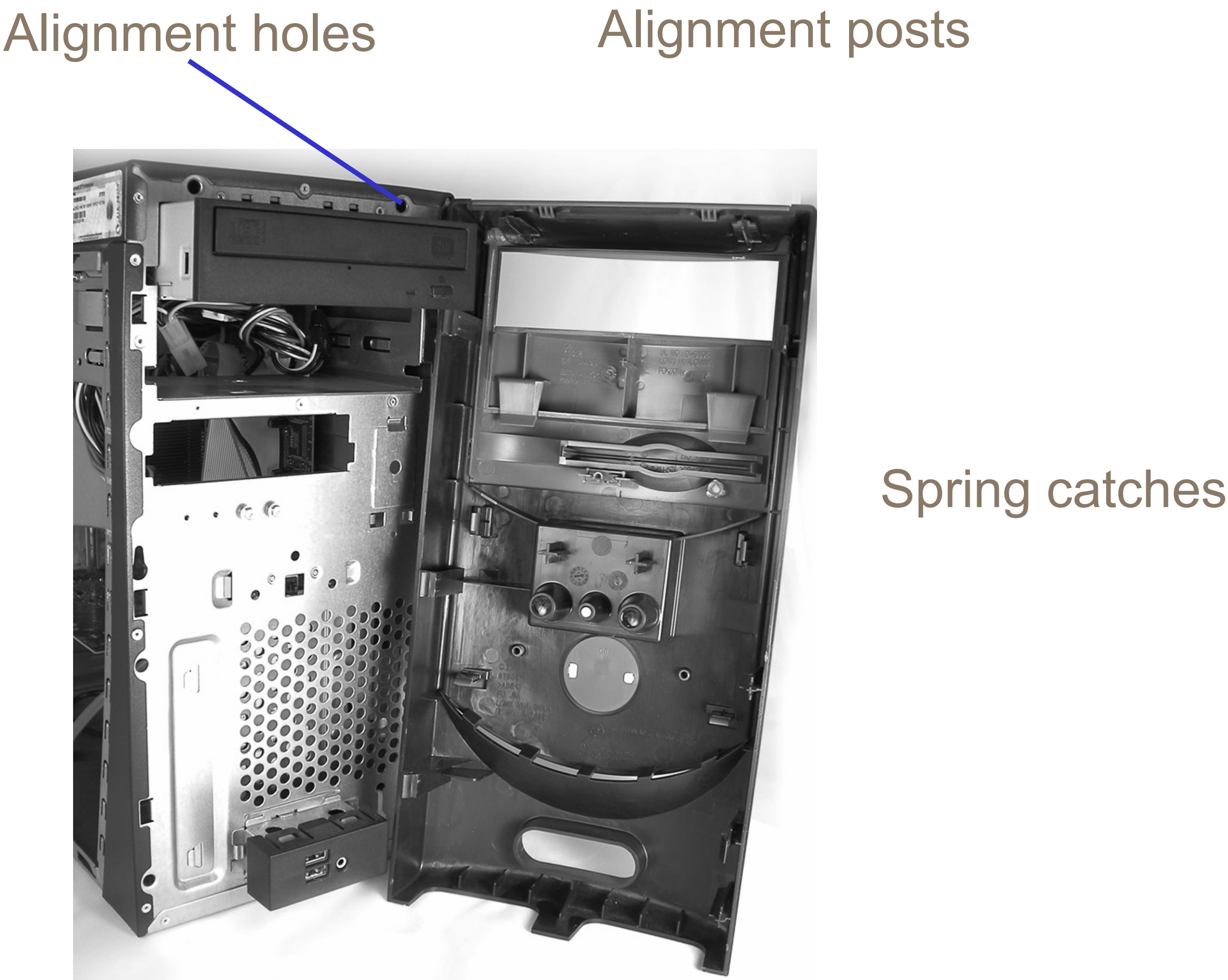

Exhibit 3-5: Front-cover alignment and catch mechanisms

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