

# Components

- [CPU](#)
- [Supplemental Reading for CPU architecture](#)
- [RAM](#)
- [Motherboards](#)
- [Physical Storage: Hard Drives](#)
- [Supplemental Reading for Data Storage](#)
- [Power Supplies](#)
- [Supplemental reading: Power Supplies](#)
- [Mobile Devices](#)
- [Batteries and Charging Systems](#)
- [Supplemental Readings for Batteries and Charging Systems](#)
- [Peripherals and Ports](#)
- [Supplemental Reading on Connector Types](#)
- [Supplemental reading Cables \( remind admin to download and rehost the pdfs linked \)](#)
- [Supplemental Reading for Projectors](#)
- [BIOS](#)
- [Ben: Skills of IT professionals](#)
- [Putting it All Together: Installing The Processor](#)
- [Putting it All Together: Adding Graphics and Other Peripherals.](#)
- [Mobile Device Repair](#)
- [Mobile Display Types](#)
- [One program, many futures](#)

# CPU

If someone asked you, calculate the square root of 5,000,439,493 would you do the math by hand? Unless you really love tedious math problems, you'd probably use a calculator. What about binary? Well, you probably wouldn't calculate binary by hand either. There's actually a very powerful calculator right inside of your computer, that process binary for us. We've already discussed this in calculator in detail. Do you know what it is? It's our CPU, the brain of our computer. In this video, we'll cover the more practical aspects of the CPU. Remember that transition book that I talked about in an earlier lesson? The CPU uses this to translate and perform functions on our data. This translation book is called an instruction set, which is literally just a list of instructions that our CPU is able to run. Functions like adding, subtracting, copying data are all instructions that our CPU can carry out. Every single program on your computer, while extremely complex, is broken down into very small and simple instructions found in our instruction set. Instruction sets are hard-coded into our CPU so different CPU manufacturers may use different instruction sets, but they generally perform the same functions. It's like how car manufacturers build their engines differently, but they all get the same job done. You probably worked with computer hardware as an IT support specialist, replacing failed hard disks, upgrading RAM modules, and installing video cards. You need to be aware of what's out there. You've probably heard of a few popular CPU manufacturers or chipsets, like Intel, AMD, and Qualcomm. These CPU manufacturers use different product names to differentiate their processes. Like Intel Core i7, AMD Athlon, Snapdragon 810, Apple A8, and more. Now when you hear these terms, you'll know what they mean. Each of these CPU manufacturers have their strengths and weaknesses. If you're interested in learning more about why some CPUs are more popular than others, you can check out the next supplemental reading. When you select your CPU, you need to make sure it's compatible with your motherboard, the circuit board that connects all your components together, heads up. You can't just buy a bunch of parts and expect them to work together there are different ways of CPUs fit on motherboards using different sockets. Your CPU might have lots of tiny pins that are either stick out or have contact points that look like dots. Depending on your motherboard, you need to make sure these CPUs fit correctly in the socket. There are currently two major types of CPU sockets; Land Grid Array, also known as LGA, and Pin Grid Array, also known as PGA. In an LGA socket, like this one, there are pins that stick out of the motherboard. The socket size may vary, so always make sure your CPU and socket are compatible beforehand. When you purchase a CPU or motherboard, they'll tell you right on the box what type of socket it has. Make sure your CPU and motherboards socket also both match. If it's not listed on the box, you can go to the manufacturer's website where you usually list what types of CPUs are compatible with the motherboard. The other type of socket is the PGA socket, where the pins are located on the processor itself. When we installed our CPU, we need to do a few things to it to keep it cool. Since it does a lot of work, it's prone to overheating. We have to make sure to include a heat sink too which takes the heat from our CPU and dissipates it through a fan or another medium.

There's one last thing I want to call out about CPUs. If you purchase the CPU, you'll see that it has either a 32-bit or 64-bit architecture. What does that mean? Well, we know we can process eight

bits in binary now, imagine how we can process with 32 or even 64 bits. CPUs that have 32-bit or 64-bit architecture are just specifying how much data they can efficiently handle. For now, the main takeaway is that the CPU is one of the most important parts of the computer so we have to make sure it's compatible with all other components and can perform well for our computing needs.

# Supplemental Reading for CPU architecture

To learn more about the differences between **32-bit and 64-bit CPU architecture**, click [here](#) for microsofts explanation and [here](#) for the wikipedia article.

# RAM

0:01

Let's talk about RAM, our computers short-term memory. We use RAM to store data that we want to access quickly. This data changes all the time so it isn't permanent. Almost all RAM is volatile, which means that once we power off our machines, the data stored in RAM is cleared. Remember that our computer is comprised of programs. To run a program, we need to make a copy of it in RAM so our CPU can process it. When you see a new phone or laptop that says it has 16 gigs of RAM, that means it can run up to 16 gigs of programs, meaning you can run lots of programs at the same time, when you type the document, you're using RAM. If you've ever had the misfortune of working on an important presentation or paper and losing power, you know the feeling you get when all of the work you've done is lost. It's a total bummer, this happens to anything with RAM, even video games. Have you ever gone on a long campaign without saving, then right as you get to a safe point, the power goes off on the console and all the progress you've made is lost forever? It's not fun at all. You spend the next hour or so deciding whether or not just to rage quit the game completely and start all over from scratch. Not that this happened to me or anything that was just a friend. Anyway, all of this happens because RAM clears its data when powered off. There are lots of types of RAM, and the one that's commonly found in computers is DRAM or dynamic random-access memory. When 1 or 0 is sent to DRAM, it stores each bit in a microscopic capacitor, this is either charged or discharged, represented by 1 or a 0. These semiconductors are put into chips that are on the RAM and store our data. They're also different types of memory sticks that DRAM chips can be put on. The more modern DIMM sticks which usually stands for Dual Inline Memory Module have different sizes of pins on them. I should call out, we don't really buy RAM based on the number of DRAM chips they have, they're labeled by the capacity of RAM on a stick, like an eight-gig stick of RAM. After DRAM was created, RAM manufacturers built something called SD RAM which stands for synchronous dram. This type of RAM is synchronized to our system's clock speed, allowing quicker processing of data. In today's system, we use another type of RAM called double data rate SDRAM or DDR SDRAM for short. Most people refer to this RAM as DDR, even shorter. There are lots of iterations of DDR, from DDR1, DDR2, DDR3, and now, DDR4. DDR is faster, takes up less power, and has a large capacity than earlier SD RAM versions. The latest version DDR4 is the fastest type of short-term memory currently available for your computer, and faster RAM means that programs can be run faster and that more programs can run at the same time. Keep in mind that any RAM sticks you use need a compatible motherboard with a different number of pins aligned with the motherboard RAM slots.

Just like with the CPU, make sure that your motherboard is compatible with any RAM sticks that you buy. Up Next, we'll take a deep dive into motherboards.

# Motherboards

The motherboard, the foundation that holds our computer together. It lets us expand our computers functionality by adding expansion cards. It routes power from the power supply, and it allows the different parts of the computer to communicate with each other. In short, it's a total boss. Every motherboard has a few key characteristics. First is the chipset, which decides how components talk to each other on our machine. The chipset on motherboards is made up of two chips. One is called the Northbridge that interconnects stuff like RAM and video cards. The other chip is the Southbridge, which maintains our IO or input-output controllers, like hard drives and USB devices, that input and output data. In some modern CPUs, the Northbridge has been directly integrated into the CPU so there isn't a separate Northbridge chip set. The chipset is a key component of our motherboard that allows us to manage data between our CPU, RAM, and peripherals. Peripherals are the external devices we connect to our computer, like a mouse, keyboard, and the monitor. In addition to the chipsets, motherboards have another key characteristic which allows the use of expansion slots. Expansion slots also give us the ability to increase the functionality of our computer. If you wanted to upgrade your graphics card, you could purchase one and just install it on your motherboard through the expansion slot. The standard for an expansion bus today is the PCI Express or Peripheral Component Interconnect express. A PCIe bus looks like a slot on the motherboard and a PCIe base expansion card looks like a smallest circuit board. The last component of motherboards that we'll discuss is form factor. There are different size of motherboards that are available today. These sizes of form factors determine the amount of stuff we can put in it and the amount of space we'll have. The most common form factor for motherboards is ATX, which stands for Advanced Technology Extended. ATX actually comes in different sizes too. In desktops, you'll commonly see full-sized ATXs. If you don't want to use an ATX form factor, you could use an IT or information technology extended form factor. These are much smaller than ATX boards. For example, the Intel NUC uses a variation of the ATX board, which comes in three board sizes; mini ITX, nano ITX, and pico ITX. When building your computer, you will need to keep in mind what type of form factor you want. Do you want to build something small that can't handle as much workload, or do you want a powerhouse workstation that you can add lots of functionality to? The form factor will also play a role into what expansion slots you might want to use. Understanding motherboards and their characteristics can be a big plus one fixing hardware issues since things like the type of RAM module or processes socket are dependent on the kind of motherboard they need to fit into. Let's say you're responding to a ticket for a user who's having video problems, you don't want to make it all the way to their desk only to realize the graphics card you bought as a replacement doesn't fit the motherboard their computer uses.

# Physical Storage: Hard Drives

Before we get into computer storage, we need to fill in some gaps. I'm referring to things like gigabytes, bits, etc. But we actually haven't talked at all about what those metrics mean. Sorry, I got a gigabit ahead of myself. As you might have guessed, these terms refer to data sizes. The smallest unit of a data storage is a bit. A bit can store one binary digit, so it can store a one or a zero. The next largest unit of storage is called a byte, which is comprised of eight bits. A single byte can hold a letter, number or symbol. The next largest unit is referred to as a KB bite. But we typically use the term kilobyte. A kilobyte is made up of 1,024 bytes. Here's a quick data conversion chart. How much does 500 gigabyte even mean? Let's take a look at the size of an average music file, which is about three megabytes. On a 500 gigabyte machine, that's approximately 165,000 music files. That's a lot of music. We saw all of our computers data on our hard drive, which allows us to store our programs, music, pictures, etc. Have you ever had an issue with your computer and lost all the data that was on your hard drive? Yeah, me too. It was the worst. This actually happens a lot and you'll probably encounter it as an IT support specialist. Make sure you backup your data to be safe. This means you should copy or save your data somewhere else just in case something goes wrong and your hard drive crashes. That way, you won't lose all your data. There are two basic hard drive types used today. Hard describes or HDDs uses a spinning platter and a mechanical arm to read and write information. The speed that the platter rotate allows you to read and write data faster. This is commonly referred to as RPM or revolution per minute. A hard drive with a higher RPM is faster. So if you go out and buy a hard drive today, you might see something like a 500 gigabyte, with 5,400 rpm. HDDs are prone to a lot more damage because there are a lot of moving parts. This susceptibility to damage went away with a new type of storage called solid state drive or SSD. SSDs have no moving parts. Are you familiar with a USB stick? SSDs operate in a similar way. The information is stored on microchips and data travels a lot faster than HDDs. The form factor for SSDs is also slimmer compared to their HDD cousins. Sounds great, doesn't it? So why doesn't everyone use SSDs? Well, both have their pros and cons. HDDs are more affordable, but they're more prone to damage. SSDs are less risky when it comes to losing data, but they're also more expensive. So you may not buy as much memory storage in SSDs than what you can get in HDDs. Believe it or not, there are even hybrid SSD and HDD drives out there. They offer SSD performance where you need it for things like system performance, such as putting your computer along with hard disk drives, but less important stuff like basic file storage. There are a few interfaces that hard drives use to connect our system. ATA interfaces are the most common ones. The most popular ATA drive is a Serial ATA or SATA, which uses one cable for data transfers. SATA drives are hot swappable, great term, don't you think? It means you don't have to turn off your machine to plug in a SATA drive. SATA drives move data faster and use a more efficient cable like this one than its predecessors. SATA has been the de facto interface for HDDs today. But people quickly found that using the SATA cable wasn't good enough for some of the blazing fast SSDs that were coming on the market. The interface couldn't

keep up with the speeds of the newest SSDs. So another interface standard was created called NVMe, or NVMe. Instead of using a cable to connect your drive to your machine, the drive was added as an expansion slot, which allows for greater throughput of data and increased efficiency.

in the modern day sdds are better than hdds

# Supplemental Reading for Data Storage

## Data Storage Measurements

In this reading, you will learn about the different names for measurements of data storage capacities and file sizes. Data storage capacity increases in step with the evolution of computer hardware technology. Larger storage capacities allow for dynamic growth in file sizes. These advances make it possible for companies like Netflix and Hulu to store thousands of feature-length films in high video quality formats.

There are standardized sets of terms used to name the ever expanding sizes of data storage and files. For example, the common terms used to describe file sizes and hard drive storage capacity include: bytes, kilobytes, megabytes, gigabytes, and terabytes. However, if you are a computer engineer, you might use a different set of terms.

### Data storage measurement nomenclature

Table illustrating decimal values for data storage measurements

- **Decimal nomenclature:** kilobyte, megabyte, gigabyte, terabyte, petabyte, exabyte, zettabyte, yottabyte

The decimal naming system for computer storage uses the metric system of prefixes from the International System of Units: kilo, mega, giga, tera, peta, exa, zetta, and yotta. These prefixes may also be referred to as the decimal system of prefixes. The metric/decimal nomenclature represent a base-10 approximation of the actual amount of data storage bytes. The metric system prefixes were selected to simplify the marketing of computer products.

Table illustrating binary values for data storage measurements

- **Binary nomenclature:** kibibyte, mebibyte, gibibyte, tebibyte, pebibyte, exbibyte, zebibyte, yobibyte

The binary naming system is a standard set by the International Organization for Standardization (ISO) in partnership with the International Electrotechnical Commission (IEC). The ISO 80000 and IEC 80000 guides to units of measurement define the International System of Quantities (ISQ). The prefixes kibi-, mebi-, gibi-, -tebi-, pebi-, exbi-, zebi-, and yobi- were created by the IEC organization. They are a blend of the first two letters of the metric prefix fused with the first two letters of the word “binary” (example: **mega**byte + **binary** + **byte**= mebibyte).

Binary measurements of computer data are more accurate than decimal system measurements. While decimal nomenclature is commonly used to market computers and computer parts to the general public, binary nomenclature is often used in computer engineering for numerical accuracy.

## Quantities of storage measurements

As data storage grows, the need for new terminology to describe the exponentially larger byte quantities grows too. The current byte nomenclature, mathematical representations, and storage capacities are as follows:

- **One bit:** Also called a binary digit, bits store an electric signal as 1. The absence of an electric signal is stored as 0, which is also the default value of a bit. One bit can store only one value, either 1 or 0. These two possible values are the basis of the binary number system (base-2) that computers use. All numbers in a base-2 system increase exponentially as powers of 2.

- **One byte:** One byte stores eight bits of ones and zeros that translate to a symbol or basic computer instruction. Examples: 01101101 is the byte that translates to the letter “m.” The byte 01111111 tells the computer to delete the character to the right of the cursor.

- **One kilobyte (1 KB):**

- **Kilobyte (KB) decimal format:**  $10^3 = 1,000$  bytes

- **Kibibyte (KiB) binary format:**  $2^{10} = 1,024$  bytes

- **Decimal inaccuracy:** Off by -2.4% or -24 bytes

- **Name origin:** “Kilo-” is a French derivation from the Ancient Greek word for “thousand” A kilobyte is one thousand bytes.

- **1 KB can hold:** A short text file or a small icon as a 16x16 pixel .gif file.

- - One megabyte (1 MB):
    - **Megabyte (MB) decimal format:**  $10^6 = 1,000,000$  bytes
    - **Mebibyte (MiB) binary format:**  $2^{20} = 1,048,576$  bytes
    - **Decimal inaccuracy:** Off by -4.9% or -48,576 bytes
    - **Name origin:** “Mega-” is derived from the Ancient Greek word for “large.” A megabyte is a large number of bytes.
    - **1 MB can hold:** Approximately one minute of music in a lossless .mp3 format or a short novel.

- - One gigabyte (1 GB):

- 

**Gigabyte (GB) decimal format:**  $10^9 = 1,000,000,000$  bytes

- 

**Gibibyte (GiB) binary format:**  $2^{30} = 1,073,741,824$  bytes

- 

**Decimal inaccuracy:** Off by -7.4% or -73,741,824 bytes

- 

**Name origin:** “Giga-” is derived from the Ancient Greek word for “giant.” A gigabyte is a giant number of bytes.

- 

**1 GB can hold:** Between 2.5-3 hours of music in .mp3 format or 300 high-resolution images.

- 

**One terabyte (1 TB):**

- 

**Terabyte (TB) decimal format:**  $10^{12} = 1,000,000,000,000$  bytes

- 

**Tebibyte (TiB) binary format:**  $2^{40} = 1,099,511,627,776$  bytes

-

**Decimal inaccuracy:** Off by -10.0%

○

**Name origin:** “Tera-” is a shortened form of “tetra-”, which was derived from the Ancient Greek word for the number four. The  $10^{12}$  decimal format can also be written as  $1000^4$  (one-thousand to the 4th power). “Tera-” in Ancient Greek means “monster.” You might think of the word “terabyte” as a monstrously large number of bytes.

○

**1 TB can hold:** Approximately 200,000 songs in .mp3 format or 300 hours of video.

•

**One petabyte (PB):**

○

**Petabyte (PB) decimal format:**  $10^{15} = 1,000,000,000,000,000$  bytes

○

**Pebibyte (PiB) binary format:**  $2^{50} = 1,125,899,906,842,624$  bytes

○

**Decimal inaccuracy:** Off by -12.6%

○

**Name origin:** “Peta-” is derived from the Ancient Greek word “penta” meaning five. The  $10^{18}$  decimal format can also be written as  $1000^5$  (one-thousand to the

5th power).

- 

**1 PB can hold:** The content from 1.5 million CD-ROM discs or 500 billion pages of text.

- 

**One exabyte (EB):**

- 

**Exabyte (EB) decimal format:**  $10^{18} = 1,000,000,000,000,000,000$  bytes

- 

**Exbibyte (EiB) binary format:**  $2^{60} = 1,152,921,504,606,846,976$  bytes

- 

**Decimal inaccuracy:** Off by -15.3%

- 

**Name origin:** “Exa-” was derived from the Ancient Greek word for six. The  $10^{18}$  decimal format can also be written as  $1000^6$  (one-thousand to the 6th power).

- 

**1 EB can hold:** Approximately 11 million movies in 4k video resolution or 3,000 copies of the entire United States Library of Congress.

- **One zettabyte (ZB):**

- **Zettabyte (ZB) decimal format:**  $10^{21} = 1,000,000,000,000,000,000,000$  bytes
- **Zebibyte (ZiB) binary format:**  $2^{70} = 1,180,591,620,717,411,303,424$  bytes
- **Decimal inaccuracy:** Off by -18.1%
- **Name origin:** “Zetta” was derived from the Latin word “septem” which means seven. The  $10^{21}$  decimal format can also be written as  $1000^7$  (one-thousand to the 7th power).
- **1 ZB can hold:** Seagate reports one zettabyte can hold 30 billion movies in 4k video resolution.

- **One yottabyte (YB):**

- **Yottabyte (YB) decimal format:**  $10^{24} = 1,000,000,000,000,000,000,000,000$  bytes

- 
- Yobibyte (YiB) binary format:**  $2^{80} = 1,208,925,819,614,629,174,706,176$  bytes
- 
- Decimal inaccuracy:** Off by -20.9%
- 
- Name origin:** “Yotta” is Ancient Greek for eight. The  $10^{24}$  decimal format can also be written as  $1000^8$  (one-thousand to the 8th power).
- 
- 1 YB can hold:** In 2011, a cloud storage company estimated that one yottabyte could hold the data of one million data centers.
- In 2023 its estimated that the total size of the internet is larger than 1 yottabyte
- 
- 

## Ask ChatGPT4

how large is the internet estimated to be in exabytes?

-

“

The size of the Internet or the total amount of data created globally is not specified directly in exabytes in the sources I found. However, we can infer some information based on the data provided. It was expected that 2020 would see the creation of 44 zettabytes (1 zettabyte = 1 million petabytes = 1 billion terabytes = 1 trillion gigabytes = 1,000 exabytes) of data, and the world was expected to generate 103 zettabytes of data by 2023. The impending age of the yottabyte (1,000 zettabytes) is in sight, implying that we are moving towards generating and managing data volumes in the order of thousands of zettabytes?<sup>1</sup>?

In terms of storage, advancements in technology are being made to manage this enormous amount of data. For instance, IBM's 'Elastic Storage' technology, which was part of the Watson system, is designed to handle architectural limits stretching into the thousands of yottabytes (1 yottabyte = 1 million petabytes)?<sup>2</sup>?. Moreover, an increasing amount of data is unstructured, showing a compound annual growth rate (CAGR) of 38%, and solutions are being developed to handle this surge in data, including innovations in software, hardware, and algorithms for scale-out storage and the implementation of an intelligent data fabric to manage data across systems, regions, and clouds?<sup>3</sup>?

In 2022, the combined shipment volume of the world's top five External Controller-Based (ECB) storage vendors was triple the volume in 2012, but it is still insufficient to meet the demands of the upcoming yottabyte era. Huawei projects that this figure will multiply ten times by 2032, surpassing 100 exabytes. However, this figure pertains to the storage industry and not the total size of the Internet or global data volume?<sup>3</sup>?

In summary, while a specific figure in exabytes for the total size of the Internet in 2023 isn't readily available, we are currently in an era where we are generating and dealing with data in the scale of zettabytes (each of which is equivalent to 1,000

exabytes), and moving towards the yottabyte era. I would need more time to search further to find a more precise estimate in exabytes for the total size of the Internet in 2023.

# Power Supplies

In order to get our computer to work, let's give it some power. Computers have a power supply that converts electricity from your wall to something usable. There are two types of electricity DC or direct current which flows in one direction and AC or alternating current which changes directions constantly. Our computers use DC voltage so we have to have a way to convert the AC voltage from our power company to something we can use. That's what our power supply does. It converts the A C we get from the wall into low voltage DC power that we can use and transmit throughout our computer. So let's talk about power supplies, I actually have one right here. Lemme show you how one looks like, take it out right here. So, most power supply units have a fan which is right in here, they also have voltage information which is normally listed underneath or on the side. And cables like this one to power your motherboard and a power cable. Have you ever plugged one of your devices into the wall outlet and fried your device? If you haven't, you're really lucky, after completing this lesson, hopefully you'll know how to avoid that situation. To understand electricity, let's use the example of water pipes. Our tanks have a faucet that's connected to a pressurized water tank. When we turn on the faucet, water comes out. This is sort of how electricity works, when we plug in appliance into a wall outlet and turn it on, a flow electricity comes out. If we added more pressure to our water tank, would more water come out of it? The higher the pressure, the more water there will be. When it comes to electricity, we refer to the pressure as voltage. So, when I was on vacation to my surprise, when I plugged in the 120 volt appliance into a 220 volt outlet, the power came bursting through and fried my charger. If it was the other way around and a 220 volt appliance was plugged into 120 volt outlet, I wouldn't have seen the same outcome. I'll still be able to get electricity, but slowly. This would be similar to if a water tank was only half pressurized it will draw water but slowly, in some cases though, this can deteriorate the performance of the device and cause damage in the long-term. As a general rule, be sure to use the proper voltage for your electronics. We refer to the amount of electricity coming out as current or amperage and it's measured in amps. We can think of amps as pulling electricity as opposed to voltage, which pushes electricity. Amps will pull as much electricity needed, but voltage will just give you everything. Look on the back of one of your device charges. You might see something like 1 or 2.1 A, charging a device with 2.1 amps will actually charge a device faster because it's able to put more current from a 2.1 amp than a 1 amp charger. Finally, the other important part of the electricity that you'll need to know is the wattage. Wattage is the amount of volts and amps that the device needs. If your power supply has too low the wattage, you won't be able to power your computer, so make sure you have enough. This doesn't mean that if you have a large power supply you will overpower your computer. Power supplies just give you the amount that your system needs. It's best to err on the side of large power supplies, you can power most basic desktops with a 500 watt power supply. But if you're doing something more demanding on your computer like playing a high resolution video game or doing a lot of video production and rendering, you will likely need a bigger power supply for your computer. On the other hand, if all you're doing is just browsing the web, the power supply that comes with your computer should be fine. All kinds of issues are caused by a bad power supply. Sometimes the computer doesn't even turn on at all,

since power supplies can fail for lots of reasons like burnouts, power surges or even lightning strikes. Knowing how to diagnose power issues and replace a failed power supply is a skill every IT support specialist should have in their toolbox.

# Supplemental reading: Power Supplies

## Power Supplies

In this reading, you will learn how to select the correct power supply for a personal computer (PC) to support the main components of the PC.

As you learned in a previous video, computer systems require a direct current (DC) of electricity to operate. However, power companies deliver electricity in alternating currents (AC). AC power can damage the internal components of a computer. To solve this problem, computer power supplies are used to convert the AC from the wall socket to DC. Power supplies also reduce the voltage delivered to the computer's internal components.

## Computer architecture

Computer architecture refers to the engineering design of computers and the interconnecting hardware components that together create computing devices that meet functional, performance and cost goals. Power supplies are part of the hardware layer of a computer's architecture. You learned earlier about the other major hardware components of a computer's architecture, including the motherboard, chipsets, CPUs, RAM, storage, peripherals, expansion slots and cards, etc. These components influence the size and type of power supply a computer needs.

## Selecting a power supply

### Local input voltage

A main consideration when selecting a computer power supply is the voltage delivered to common wall sockets in your country. Power standards for input voltages can vary from country to country. The most common voltage inputs are 110-120 VAC and 220-240 VAC. VAC stands for volts of alternating current.

- 

### Voltages in the Americas

North, Central, and parts of South America use the 110-127 VAC standard for common wall sockets. Computers and power supplies sold in these regions are designed to use this level of power.

- 

### **Voltages for most of the world**

Most countries use the 220-240 VAC standard for common wall sockets. Computers and power supplies sold in these areas are designed to use this higher voltage.

- Japan is one unique outlier on using more than one voltage standard within the country. they use both the 110-127VAC standard and 220-240 VAC standard.

Please visit [WorldStandards “Plug, socket & voltage by country”](#) to find your country’s voltage standards.

It is important to use the correct voltage power supply or power converter for the computer’s voltage specifications. Imagine that you have a customer who imported a PC from a country that uses a different standard for input voltage. You will need to adapt the input power to protect the computer. Some options for doing this might include:

- 

Replace the power supply with a unit that uses the appropriate voltage for the target country.

- 

Install a power supply model that includes a dual-voltage switch that can be toggled from 110-120VAC to 220-240VAC.

- 

Plug the computer into an external power converter that then plugs into a normal wall socket. Power converters can be purchased from any store that sells international travel merchandise.

Without a power converter, the following problems may be experienced:

If a computer needs	But the wall socket delivers	The result will be
220-240VAC	110-120VAC	not enough power for the computer to run properly
110-120VAC	220-240VAC	too much power, which will damage the computer's internal parts

## Motherboard engineering specifications

The motherboard and form factor specifications document will provide a list of compatible power supply types to help you select the correct part. The ATX form factor is the most common motherboard design for full-sized, personal desktop computers. You may also find a version of the ITX form factor in smaller computers. The form factor size and components embedded in the motherboards will create a starting point for the minimum power supply wattages required.

## Power consumption of components

The number of internal components and peripherals the computer will need to support will also determine the minimum wattage a power supply must provide. For example, a basic computer that is designed for word processing and surfing the Internet should work with a standard power supply. However, some computers may need higher wattage power supplies to support items like a powerful CPU, multiple CPUs, multiple hard drives, video rendering applications, a top-tier graphics processing unit (GPU) for gaming, and more.

## Voltages and pin connectors

The internal hardware components of a computer require varied input voltages to operate. Voltage regulators embedded in the motherboard of the computer control the amount of power that is delivered to the computer's various internal components.

Voltage	Examples of components that use each voltage level
3.3V	DIMMs, chipsets, and some PCI/AGP cards
5V	SIMMS, disk drive logic, ISA, and some voltage regulators
12V	Motors and voltage regulators with high outputs

The computer's power supply plugs into an adapter on the computer's motherboard. The wiring for this connection uses color coded wires. Each wire color carries a different voltage of electricity to the motherboard or serves as a grounding wire. A standard ATX motherboard power adaptor has either 20-pins or 24-pins to connect these wires. The 20-pin design is an older technology. The 24-pin connector was developed to provide more power to support additional expansion cards, powerful CPUs, and more. The 24-pin connector has become the standard for today's personal computer power supplies and motherboards.

The power supply will have multiple connectors that plug into the motherboard, hard drives, and graphic cards. Each cable has a specific purpose and delivers the appropriate amount of electricity to the following parts:

Connections from a PC power supply (ATX 2)

1.  
Floppy disk drive (obsolete)
2.  
"Molex" universal (e.g. IDE hard drives, optical drives)

3.  
SATA drives
4.  
Graphics cards 8-pin, separable for 6-pin
5.  
Graphics cards 6-pin
6.  
Motherboard 8-pin
7.  
Motherboard P4 connector, can be combined to 8-pin mainboard connector 12V
8.  
ATX2 24-pin, divisible 20+4, and can therefore also be used for old 20-pin connections

The new ATX 3.0 adds a PCIe 5.0 12VHPWR connector featuring 12 + 4 pins to supply up to 600W. also nvidia uses a (maybe) proprietary 16 pin 2VHPWR cable on newer gpus (as of the 4090's release and is extremely fragile)

## Key takeaways

When selecting a power supply for a computer, the following items should be taken into consideration:

1.  
Wall socket input voltage standard for the country where the computer will be used;

2.  
The number and power consumption needs of the computer's internal components;
3.  
The motherboard model and form factor engineering specifications and requirements.

## Resources for more information

For more information on these topics, please visit:

- [Plug, socket & voltage by country](#) - List of countries around the world and their voltage standards for common wall sockets and plug types.
- [How to Diagnose and Replace a Failed PC Power Supply](#) - Step-by-step illustrated instructions on how to diagnose a power supply failure and replace it on a desktop PC.

# Mobile Devices

Hi there, it's me again. You might remember me from the previous module, and no worries if not, what's important is to make sure you've got the latest info on mobile devices. You'll see me again throughout the rest of this module. Mobile devices are computers too, they have CPUs, RAM, storage, power systems and peripherals. What's special about them is because they're mobile. They're portable and usually powered by batteries. Some are tablets or smartphones. Other mobile devices are optimized to perform a specific set of tasks, like fitness trackers, which are very integrated. Remember the systems that we showed you earlier, the components can be taken out and held in components together in a way that you can't take apart. The smaller the device, the more integrated the components are directly to the device's motherboard. Very small mobile devices use a system on a chip or SOC. A system on a chip is all onto a single chip. Not only is our SOC small, they use less battery power than if those components were separate peripherals. Smartphones connect to Bluetooth headphones, for example. Mobile devices can also be a peripheral to your smartphone. That same fitness tracker might use a heart rate monitor as a peripheral. It's proprietary ports and connectors. You might need to have a specific adapter or connector for charging a device or the physical shape or the intended use of the mobile device makes a standard connection like USB, a bad choice. If you had a micro-USB for, that port will be damaged if exposed to water. So instead, it's designed with a custom charging port. Some of the standard power data and display connector types you'll find used in mobile devices. This is a USB-C, micro-USB, a micro HDMI, and the mini HDMI, and this is a mini display port. Because mobile devices are general purpose operating systems and application software that specifically designed to maximize their performance. We'll dive into this later. As an IT support specialist, you might be responsible for helping end-users with their mobile devices. This might include troubleshooting mobile devices. Don't worry, we're going to break all this down for you. One super important thing, mobile devices can come from your own devices. We call this bring your own device or BYOD. You should be careful to use your own devices for work. To know how to handle these devices is always best to refer to your organization's policy.

# Batteries and Charging Systems

Sometimes instead of being plugged into a power outlet all the time, we want to take our technology with us. Mobile technology uses rechargeable batteries to carry power with the device wherever we take it. Rechargeable devices might have an external charger for removable batteries, or might have a cradle stand or wireless charger. Look at this phone, we can top up the battery just by laying it on this wireless inductive charging pad. Isn't that cool? It's also pretty clever technology. Rechargeable batteries have a limited lifespan, which is measured in charge cycles. A charge cycle is one full charge and discharge of a battery. When a battery is reaching the end of its lifespan, it may take longer to charge and might not hold as much charge as when it was new. For some devices, you compare the current cycle count of your battery with the rate at cycle count of that battery type, to see how much more life to expect out of it. You need an external power source to add power to a battery. This could come from a wall outlet, another battery, or even a solar panel. You also need a charging circuit that manages the power transfer from the external power source to the rechargeable battery. This circuit works a lot like a power supply unit or PSU that we looked at earlier. It makes sure the input power is converted to the correct output power. Instead of using a large PSU, rechargeable devices use more portable power adapters, power supplies or chargers. A portable power supply powers the device while also charging the battery. This might sound obvious, but you need to make sure that you use the right charger for the right device. Mismatching chargers to devices can damage the battery, the device and the charger. A lot of chargers and power supplies use USB connectors, but you'll see a wide variety of charging connectors. Rechargeable batteries can be damaged by very cold or very hot environments. Don't charge or discharge rechargeable batteries unless they're within their safe operating temperature range. It's not just that a damaged rechargeable battery might not perform well, it can also be very dangerous. Batteries can swell, rupture, and sometimes even catch fire. Before working with a damaged battery, you should know how to safely handle it. When a battery reaches the end of its life, you'll need to replace it. Some devices will slow themselves down when a battery is getting old to make the battery last longer. If your device is running much slower than usual or shutting down unexpectedly, one thing to check is the battery life. Some devices have batteries that are designed to be replaced by the end-user. Other devices have batteries that are very difficult to replace, like small laptops and mobile devices. As an IT support specialist, you might receive special training on how to replace batteries and devices that you support. Or you might be the person sending the device out for battery replacement and then returning the device to the end-user. IT support specialist often have to troubleshoot battery life and device charging. The first step is to make sure the charger, the battery and the device are all designed to work with each other. We'll talk about sending out devices for repair and troubleshooting skills in future videos, so stay tuned. For iOS and Android, there are also some things that you could do to make the battery last as long as possible. It's a good idea for you to be familiar with these things so that

you can help educate end-users on the best ways to get the most out of their mobile devices.

# Supplemental Readings for Batteries and Charging Systems

Check out these links for more information:

You can learn about [Inductive Charging](#).

Read more about batteries and charge cycles for [Windows](#) or [Macs](#). You can also check out: [Safe handling of lithium-ion batteries](#).

Finally, learn how to maximize your batteries for [iOS](#) or [Android](#).

# Peripherals and Ports

Let's take a look at the back of our computer again. Here you see lots of connectors or ports we can plug in different known as peripherals. A peripheral is basically anything that you connect your computer externally that adds function also known as universal serial bus devices, are the most popular connections for our gadgets. USB has gone through encounter USB 2.0, USB 3.0, and 3.1 in today's system. In the chart let's pay attention to the details using Mb/s in actually different units. MB is megabyte or unit of data storage while capital Mb/s is a megabit per second, which is 40 megabit a second to mean that you can transfer 40 megabytes of data per second. Remember that one byte is you need an eight megabits per second connection speed. You will also need compatible USB ports to go with your port, you won't get 3.0 transfer speed but you can still use the port since it's backward compatible, meaning older I to differentiate, let me show you. In general, USB 2.0 are black and USB 3.0 are blue and 3.1 ports are teal. This is types of USB connectors and you can read about all of them in the supplemental reading right after this video, the Type C connector, which is meant to replace many peripheral connections. It's quickly becoming a universal standard peripherals, you should also be aware of display peripherals. There are some common impulse standards to know connections, but you might encounter some older standards too, DVI. DVI cables are generally just output video, if presentation, and you want audio too, you may be out of luck, instead, you want to look at one of the following categories and computers nowadays, and outputs both video and audio. Another standard that's become popular among many video. In addition to audio and video, USB Type C can also do data transfer and power. As an IT support specialist devices a lot. Now, you'll be able to distinguish between the major types.

(Required)

en

?

# Supplemental Reading on Connector Types

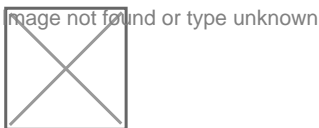
## Connector Types

A computer has many physical ports or connectors. You can use these connectors to connect devices that add functionality to your computing, such as a keyboard, mouse, or monitor. These external devices are called peripherals. IT often works with and troubleshoots these peripherals, so it is helpful to understand the types of connectors. This reading will cover different types of connectors and their uses.

## USB Connectors

### USB 2.0, 3.0 & 3.1

USB connectors transfer data and power to devices connected to a computer. USB connectors are the most popular connectors for all types of peripherals.



There are three generations of USB type A connectors in use today: USB 2.0, 3.0, and 3.1. Here are the differences between the three generations:

- USB 2.0: Black port on the computer, 480 Mbps transfer speed
- USB 3.0: Blue port on computer, 5 Gbps transfer speed

- USB 3.1: Teal port on the computer, 10 Gbps transfer speed

USB ports are backwards compatible, meaning a USB port can connect any of the three generations of USB type A connectors. The connected cable will determine the speed of data transfer. Connecting a USB 3 to a USB 2 port will result in 480 megabits (Mbps) per second of speed.

## Micro USB, USB-C & Lightning Port

Micro USB, USB-C, USB4 (Thunderbolt), and Lightning Ports are smaller connectors that carry more power than older USB connectors and have faster data transfer speeds. These connectors are used for devices like smartphones, laptops, and tablets.

Micro USB, USB-C, USB4 and Lightning Port Connectors

- **Micro USB** is a small USB port found on many non-Apple cellphones, tablets, and other portable devices.
- **USB-C** is the newest reversible connector with either end having the same build. USB-C cables replace traditional USB connectors since they can carry significantly more power and transfer data at 20 Gbps.
- **USB4** uses Thunderbolt 3 protocol and USB-C cables to transfer data at speeds of 40 Gbps and provide power as well.

- **Lightning Port** is a connector exclusive to Apple that is similar to USB-C. It is used for charging and connecting devices to computers, external monitors, cameras and other peripherals.

## Communication Connectors

Different cable connectors are used to share information between devices and connect to the internet. IT professionals maintain network systems that use different types of communication connectors.

POTS, DSL, Cable Internet and Fiber-optic cable connectors

- **Plain Old Telephone Service (POTS)** refers to cables transmitting voice through twisted copper pair wires. Landline telephones, dial-up internet, and alarm systems use POTS. The RJ-11 (Register Jack 11) connector is used for POTS.
- **Digital Subscriber Line (DSL)** provides access to high-speed networks or the internet through telephone lines and a modem. The RJ-45 connects a computer to network elements and is mostly used with ethernet cables.
- **Cable Internet** uses a cable TV infrastructure and a modem to provide high-speed internet access to users. An F type connector is commonly used with cable modems..

- **Fiber-optic cables** contain strands of glass fibers inside an insulated casing that send data long-distance and allow for higher-bandwidth communication. The major internet providers use fiber-optic cables for high-speed internet service.

## Device Connectors

IT professionals will encounter legacy devices that still use older connectors such as DB89 and Molex.

### DB89 and Molex device connectors

**DB89** connectors are used for older peripherals like keyboards, mice, and joysticks. An IT professional may still encounter a DB89 connector for external tools a computer uses and should recognize the cable to connect to the appropriate port.

**Molex** connectors provide power to drives or devices inside the computer. Molex connectors are used for connecting a hard drive, disc drive (CD-ROM, DVD, Blu-ray), or a video card.

## Punch Down Blocks

A punch down block is a terminal strip used to connect telephone or data lines. Punch down blocks are a quick and easy way to connect wiring. IT professionals use punch down blocks to change a wire or make a new connection for a telephone system or Local Area Network (LAN).

### Punch Down Blocks used to connect telephone or data lines

These are the most common cables and connectors. As technology advances, these cables and connectors will also change.

## Key Takeaways

IT professionals need to be familiar with cables and connectors used to attach peripheral devices to computers.

- USB connectors are the most common connector type and they transfer data and power to devices connected to a computer.
- Communication connectors, such as RJ-45 and fiber optic cables, connect devices to the internet and one another.
- IT professionals may encounter legacy devices that use older connectors such as DB89 and Molex.
- Punch down blocks are terminal strips used to connect telephone or data lines.

# Supplemental reading Cables ( remind admin to download and rehost the pdfs linked )

[\(Link to original post from nvidia\)](#)

## Terminology and Basic Definitions

### Cable Form Factors and Connector Types

**SFP (Small Form Factor Pluggable)** – A transceiver or cable with a one or two lanes (channel) in each direction. All cables and transceivers commonly used in datacenters are bidirectional.

**SFP+** denotes the 10 – 14 Gb/s type of AOC/transceivers, while **SFP28** is the notation for the 25-28 Gb/s products with an SFP form factor. The noted data rate is the data rate in each direction.

SFP-DD, a double-density version of SFP, with 2 lanes in a form factor with same width as the SFP is defined, but are not part of Nvidia's product portfolio at the time of release of this paper.

SFP transceivers are part of the Ethernet architecture, but not used in InfiniBand systems.

**QSFP (Quad Small Form Factor Pluggable)** – A bidirectional transceiver or cable with 4 lanes in each direction.

**Standards:** Electrical pinout, memory registers, and mechanical dimensions for both **SFP** and **QSFP** devices are defined in the public MSA (Multi-source Agreement) standards available at:

[www.snia.org/sff/specifications](http://www.snia.org/sff/specifications).

**QSFP+** denotes cables/transceivers for 4 x (10 – 14) Gb/s applications, while **QSFP28** denotes the 4 x (24...28) = 100 Gb/s product range with QSFP form factor, used for InfiniBand EDR 100Gb/s ports and 100Gb/s Ethernet (100GbE) ports. The **QSFP28** interface is specified in SFF-8679.

**QSFP56** denotes 4 x (50...56) Gb/s in a QSFP form factor. This form factor is used for InfiniBand HDR 200Gb/s and 200/400GbE Ethernet cables/transceivers in Nvidia's portfolio.

**QSFP-DD** refers to a double-density version of the QSFP transceiver supporting 200 GbE and 400 GbE Ethernet. It employs 8 lanes operating at up to 25Gb/s NRZ modulation or 50Gb/s PAM4 modulation. QSFP-DD cables will in general not work in standard QSFP cages, but switches/NICs with QSFP-DD cages may support the older QSFP transceivers/cables.

**OSFP (Octal Small Form Factor Pluggable)** is wider and longer than QSFP and accommodates 8 lanes side-by-side. This form factor is used for 200/400/800G transceivers in Nvidia's InfiniBand NDR portfolio. More info on <https://osfpmsa.org>

**AOC (Active Optical Cable)** – An optical fiber cable with an optical transceiver with the fibers bonded inside and not removable. The optical transceiver converts the host electrical signals into light pulses and back. Bonding the fiber inside means the AOC only needs to be tested electrically and eliminates the costly optical testing.

**Transceiver** (transmitter and receiver) is a converter with an electrical connector in one end and optical connector in the other end. It can have one or more parallel lanes in each direction (transmit and receive).








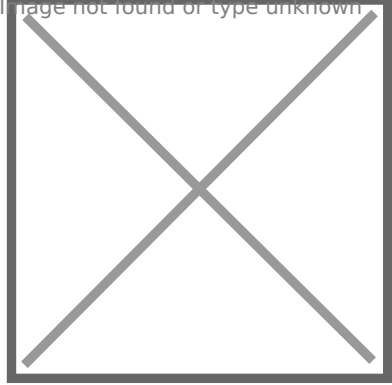
**Transceiver or AOC?** – You can argue that two transceivers connected with a patch cable replace an AOC. However, if you don't have cleaning tools and experience with optical connectors, it is safer to use an AOC where the optical cable is fixed inside the 'connector'. The AOC's 'connectors' are actually similar to detachable transceivers, but they work as a kit with a well-known transceiver at the other end. AOCs don't have any issue with multi-vendor interoperability. Nevertheless, it is easier to replace a pair of transceivers than an AOC since you don't have to install a new cable as the cable is already in place.

Traditionally, AOCs are more common in InfiniBand installations, while transceivers with patch cables are more common in Ethernet systems with structured cabling.

**DAC (Direct Attached Copper)** cable or **PCC (Passive Copper Cable)** – A high-speed electrical cable with an SFP or QSFP connector in each end, but no active components in the RF connections. The term 'passive' means that there is no active processing of the electrical signal. The DACs still have an EEPROM, a memory chip in each end, so the host system can read which type of cable is plugged in, and how much attenuation it should expect.

### ***Cable/Transceiver Form Factors and Connector Definitions***

Definition	Photo
DAC (Direct Attach Copper) cable with <b>QSFP</b> connector	 image not found or type unknown

Definition	Photo
DAC with SFP connector	image not found or type unknown 
AOC (Active Optical Cable) with <b>QSFP</b> connector	image not found or type unknown 
QSA (QSFP to SFP Adapter)	image not found or type unknown 
<b>QSFP</b> transceiver QSFP28 Transceiver for 100G transmission QSFP56 Transceiver for 200G transmission QSFP112 Transceiver for 400G transmission	image not found or type unknown  image not found or type unknown 
<b>QSFP-DD</b> transceiver 8 lane 200/400G transceiver	image not found or type unknown 
<b>OSFP</b> transceiver Single/Dual 8 lane 1/2 x 400G transceiver	image not found or type unknown 
<b>SFP</b> transceivers 25G SFP28 Transceiver (~1 W)	image not found or type unknown 

- QSFP56/SFP56 has 4/1-channels like the QSFP28/SFP28 generation but twice the data rate.
- Same Duplex LC and MPO-12 optical connector as QSFP28/SFP28 generation
- QSFP56 offers more space and thermal dissipation capacity
- 50G PAM4 doubles the data rate
- SFP56 ports accept SFP28 devices; QSFP56 ports accept QSFP28 devices
- QSFP28/SFP28 ports will NOT accept newer QSFP56/SFP56 devices
- SFP-DD ports will accept SFP+, SFP28, and SFP56 devices

SFP-DD is a 2-channel device, and hence requires a new optical connector scheme. Two types are currently (2019) supported by the SFP-DD MSA: Corning/US Conec MDC, and Senko SN.

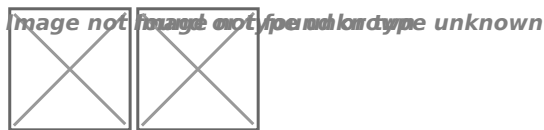
# Optical Transmission and Fiber Types

**MMF (Multi-Mode Fiber)** – The type of fiber used for VCSEL (Vertical Cavity Surface Emitting Laser) based transmission, normally operating at 850 nm wavelength. Its maximum reach is 100 m for 25 Gb/s line rates. Multi-mode fiber has a large light carrying core (50  $\mu\text{m}$ ) and matches the diameter of VCSEL lasers and PIN detectors making assembly very low cost.

**OM2, OM3, OM4 (Optical Multi-mode)** are classifications of MMF for different reach and speeds. Higher number indicates lower degradation of the optical signal, and longer reach. MMF cables commonly have the colors shown below, but standards are not fully consistent.

- **OM2 - orange** – used for data rates at 1-14 Gb/s, 62.5  $\mu\text{m}$  fiber core diameter
- **OM3 - aqua** – 70 m reach for 25/100 Gb/s transceivers, 50  $\mu\text{m}$  core diameter
- **OM4 - aqua** – 100 m reach for 25/100 Gb/s transceivers, 50  $\mu\text{m}$  core diameter
- **OM5 - aqua green** – not commonly used (2023)

## Multi-mode fiber patch cords



**SMF (Single-Mode Fiber)** – The type of fiber used for Indium Phosphide or Silicon Photonics based transceivers, operating at 1310 or 1550 nm wavelength. Single-mode fiber usually has a yellow jacket and can reach 100s of km. The tiny 7-9  $\mu\text{m}$  light carrying core makes building single-mode optics much more expensive than multi-mode optics.

**CWDM, WDM, DWDM, (Coarse Wavelength Division Multiplexing, Normal, Dense)** – a technology for transmitting multiple optical signals through the same fiber. All signals have different wavelengths (colors). WDM transceivers make it possible to reduce the number of fibers in the link to two, one for transmit, and one for receive.

Dense WDM employs a very narrow 0.78 nm laser wavelength spacing used in single-mode links. The laser needs to be temperature controlled so these devices usually employ an electrical cooler – which adds cost.

Coarse WDM employs a wide 20 nm laser wavelength spacing used in single-mode links and because of the wide wavelength spacing does not require a cooler, so less expensive.

Short WDM (SWDM) employs 4 different wavelengths multi-mode VCSEL lasers.

**PSM4 (Parallel Single-Mode 4 fiber)** is the opposite of WDM in the sense that each signal is transferred in its own fiber. This requires 4 fibers in each direction but enables simpler transceiver design since all signals can have same wavelength and no optical MUX/DeMUX (AWG) is required and no TEC (Thermo Electric Cooler) to stabilize the laser wavelengths. PSM4 is a MSA (Multi Source Agreement), i.e. a standard supported by a number of transceiver vendors.

# Reach of Transceivers

Transceivers are classified with data- rate and reach, governed by the IEEE Ethernet standards. For 100 - 400 Gb/s transceivers the most common definitions are:

- 100GBASE-**CR4** - 100 Gb/s, standard for DAC cables (twisted pair) for short reaches, up to about 7 m.
- 100GBASE-**SR4** -100 Gb/s, SR4=Short Reach (100 meters on OM4 multimode fiber), 4 fibers
- 100GBASE-**LR4** - 100 Gb/s, LR=Long Reach (10 km using WDM on SMF), 2 fibers
- 100GBASE-**ER4** - 100 Gb/s, ER=Extended Reach (30-40 km using WDM on SMF), 2 fibers
- 100GBASE-**ZR** - 100 Gb/s, ZR is not an IEEE standard, 80+ km reach.
- 200GBASE-CR4 - 200 Gb/s on DAC (passive copper) twisted pair cable, up to 3 m
- 200GBASE-SR4 - 200 Gb/s, SR4=Short Reach (100 meters on OM4 multimode fiber), 4 fibers
- 200GBASE-DR4 - 200 Gb/s, DR4 = 500 meters on single mode fibers, 4 fibers per direction
- 200GBASE-FR4 - 200 Gb/s, FR4 = 2 km, single mode fibers using WDM, 1 fiber per direction
- 200GBASE-LR4 - 200 Gb/s, LR4 = long reach, 10 km, single mode fibers using WDM, 1 fiber per direction
- 400GBASE-DR4 - 400 Gb/s, 500 meters on single mode fiber, 4 fibers each direction
- 400GBASE- FR4 - 400 Gb/s, WDM, 2 km on 1 single mode fiber/direction, 4 electrical lanes
- 400GBASE-FR8 - 400 Gb/s, WDM, 2 km on 1 single mode fiber/direction, 8 electrical lanes

All 200/400 Gb links use PAM4 signaling\_which implies that Forward Error Correction (FEC) is required.

The interface types listed above are examples for 100, 200, and 400 GbE links. The IEEE 802 standards define a wide range of standards for different Physical Media Devices (PMDs), see [https://en.wikipedia.org/wiki/Terabit\\_Ethernet#200G\\_port\\_types](https://en.wikipedia.org/wiki/Terabit_Ethernet#200G_port_types). and PMD Naming Conventions figure below. Some of the transceiver types are not IEEE standards but separate industry MSAs (Multi-Source Agreements) usually formed by a leading transceiver company. PSM4, SWDM4, CWDM4 and 400G FR4, are examples.

## **PMD Naming Conventions**

Image not found or type unknown



Ref. [https://iee802.org/3/cn/public/18\\_11/anslow\\_3cn\\_01\\_1118.pdf](https://iee802.org/3/cn/public/18_11/anslow_3cn_01_1118.pdf)

In the Data rate block, 200G (200 Gb/s) was added after 2018 when the above figure was published.

# Optical Connector Types

High-speed cables make use of edge ‘gold-finger’ connectors on the electrical side which attaches to the host system (switch, network card on server/storage). On the optical side, the following connector types are the most common:

**MPO (Multi-fiber Push On)**, is a connector standard supporting multiple rows with up to 12 fibers in each. A QSFP transceiver with MPO receptacle uses the outermost 4 positions on each side. The center 4 positions are not used.

## ***Single-row MPO Connectors used in QSFP Transceivers***

Image not found or type unknown



**MTP connectors** are a vendor specific proprietary high-precision version of MPO connectors.

The optical port in the parallel 2 x 4-lane QSFP optical transceiver is a male MPO connector with alignment pins, mating with fiber-optic cables with female MPO connector. The connector contains a 12-channel MT ferrule (allows to bundle multiple channels into a single connector).

## ***QSFP28 Optical Receptacle and Channel Orientation for Male MPO Connector***

Image not found or type unknown



## ***Female MPO Cable Connector Optical Lane Assignment***

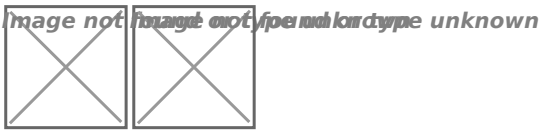
Image not found or type unknown



**Reference: IEC specification IEC 61754-7.**

**LC connectors** are used for both single-mode and multi-mode fibers and are used in both SFP and QSFP MSA transceivers.

**Duplex LC Connector and SFP Transceiver with LC Receptacles**



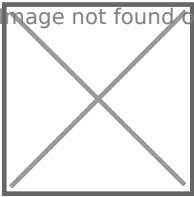






There are many other optical connector standards. MPO and LC are commonly used for data center patch cables and transceivers.

# Optical Patch Cables

The choice of Optical patch cable depends on the type of transceivers you need to connect.

**Transceivers and Cable Connectors**

Transceiver	Reach and Type	Connector on Transceiver	Connector on Patch Cable
MMA2P00-MFM1T02A	25G SR SFP 10G SR SFP 2 fiber multimode	Multimode Duplex LC/UPC image not found or type unknown	Duplex LC/UPC image not found or type unknown
MC2210411-SR4 MMA1B00-xxxx MMA1T00-VS	40G SR4 QSFP 100G SR4 QSFP 200G SR4 QSFP  2x4 fiber multimode	Multimode Male MPO/UPC (with pins) image not found or type unknown	Female MPO/UPC (with holes) image not found or type unknown
MMA1L20-AR	25G LR SFP 2 fiber Single mode	Single mode Duplex LC/UPC	Duplex LC w single-mode fiber image not found or type unknown
MC2210511-LR4 MMA1L30-CM  MMA1L10-CR	40G CWDM, QSFP, 100G CWDM, QSFP, 2km 100G LR4 QSFP 2 fiber Single mode	Single mode Duplex LC/UPC image not found or type unknown	

Transceiver	Reach and Type	Connector on Transceiver	Connector on Patch Cable
MMS1C10-CM	PSM4, QSFP, 500m	Single mode MPO/APC (8 fiber, Angle polished connector)	Female MPO/APC with single-mode fiber. The key is centered
MMS4X00	2x4 fiber single mode		
	Two 8-fiber Single mode in one unit		
T-DQ8FNS-N00	QSFP-DD SR8	Male MPO16/APC (16 fiber Angle Polished Connector)	Female MPO16/APC with multi-mode fiber. The key is offset.
MMA4U00-WS-F	2x8 fiber Multi-mode		
MMA4Z00	OSFP SR8	Male MPO12/APC (12 fiber Angle Polished Connector)	Female MPO12/APC with multi-mode fiber
	Two 8-fiber Multi-mode in one unit		

Recently, NVIDIA devices with OSFP form factor have been expanded to work in both Ethernet and InfiniBand systems.

## NV Link

A third type of application is NV Link (used in NVIDIA DGX systems). The DGX systems are equipped with either ConnectX-6 or ConnectX-7 HCAs (network adapters). Systems with ConnectX-6 adapters can use the MMA4U00-WS-F transceiver. Systems with ConnectX-7 adapters have OSFP connector and can use MMA4Z00 and MMS4X00 transceivers listed above.

## UPC vs APC connectors

In the past, longer-reach single-mode applications like 100GBASE-LR4 allowed for greater insertion loss. With less-expensive transceivers entering the market comes a reduced insertion loss allowance. Compared to the 6.3 dB allowed for 100GBASE-LR4 which supports 100G up to 10 kilometers, the short-reach 100GBASE-DR applications up to 500 meters comes at just 3 dB. Just

like 100G multimode applications, designers need to be aware of their loss budgets that could limit the number of connections in the channel.

With single-mode fiber and higher data rates, return loss is more of a concern. Too much light reflected back into the transmitter can cause bit errors and poor performance. The reflections can be significantly reduced using angled physical contact (APC) connectors, where an 8-degree angled end face causes reflected light to hit and be absorbed by the cladding.

Generally, there are some basic considerations related to the use of single-mode fiber. A single mode is more difficult to keep clean than multimode. A speck of dust on a 62.5 or 50  $\mu\text{m}$  multimode fiber core blocks a lot less light than on a 9 $\mu\text{m}$  single-mode fiber core.

When inspecting APC single-mode connectors, you want to make sure to use an APC inspection probe tip designed to match the angle of the APC connector. This is required as part of the inspection equipment.

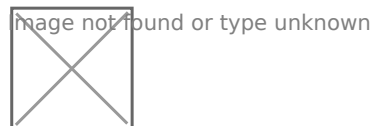
For APC connectors, note that not the entire end face of the connector is in contact with the cleaning device. It cleans the middle portion of the connector where the fibers are located and does not catch contamination at the outer parts.

While no damage will occur if you connect an APC connector to the input, you will get a warning about the received power being too low. To test products with APC connectors, you will need two hybrid UPC-to-APC cords and two APC-to-APC cords to make the connection. For Tier 2 OTDR testing, since reflections are absorbed by the cladding and return loss is very small when using APC connectors, the OTDRs will show APC connections as a non-reflective loss like a good fiber splice.

For 200GBASE-DR4 and 400GBASE-DR4 short-reach single mode applications, MPO connectors are in use as they require 8 fibers, with 4 sending and 4 receiving at 50 or 100 Gb/s. That's where a tester like Fluke Networks' MultiFiber Pro or Viavi's Sidewinder with dedicated on-board MPO connector which scan all fibers simultaneously is highly recommended to avoid time-consuming use of MPO to LC fan-out cords to separate the multiple fibers into single fiber channels.

For testing single mode fiber systems, you also want to make sure you're testing at both the 1310 and 1550nm wavelengths. Not only if these two wavelengths pass so will everything in between, but slight bends might not show up at the 1310 nm wavelength.

#### **UPC vs APC connector**



## Connecting a server with QSFP network card/transceiver to a QSFP port in a switch

The fiber that connects with the transmitter’s lane 1 must end at receiver lane 1 at the far end of the cable. Position 1 of the MPO connector at the near end of the cable connects to position 12 of the opposite MPO connector.

Use a patch cable with MPO connectors at both ends, and with crossed connections as shown below.

**MPO to MPO Patch Cable Fiber Position**

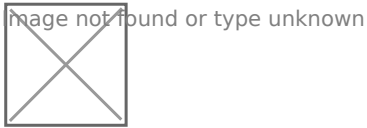
Left Cord	Connection	Right Cord
1	 image not found or type unknown	12
2	 image not found or type unknown	11
3	 image not found or type unknown	10
4	 image not found or type unknown	9
5	Not Connected	8
6	Not Connected	7
7	Not Connected	6
8	Not Connected	5
9	 image not found or type unknown	4
10	 image not found or type unknown	3
11	 image not found or type unknown	2
12	 image not found or type unknown	1

This is sometimes referred to as a 'Type B cable',

ref. <https://www.flukenetworks.com/blog/cabling-chronicles/101-series-12-fiber-mpo-polarity>

Multiple MPO patch cables can be connected in series, but each added connector pair increases modal dispersion in the link which again impairs performance. An odd number of 'crosses' must be used between transceivers at the two ends to get transmitters connected with receivers.

### ***Connecting MPO Cables with an MPO adapter***



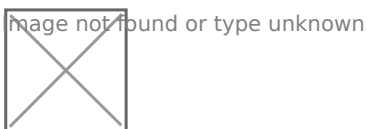
If two transceivers are to be directly connects, a "cross-over" fiber cable must be used to align the transmitters on one end to the receivers on the other end.

## Connecting servers with SFP network card/transceivers to a QSFP port in a switch

A QSFP port and transceiver contains four independent transmit/receive pairs. I.e. you can connect 4 servers with SFP cards/transceivers to a single QSFP port in a switch. This enables connection of four 10GbE NICs to one 40GbE port, or four 25GbE NICs to one 100GbE port.

In either case you need an MPO to four Duplex LC splitter (breakout) cable. Either multi-mode or single-mode optics can be used depending on the reach needed.

### ***Servers sharing QSFP Switch ports***



The QSFP ports of the switch must be configured to work in split mode, with the 4 lanes working in 'split' mode; that is, the lanes operate as independent channels instead of operating as a single logic port. This can be achieved with passive copper splitter cables (DACs) or with optical splitter cables. Switch ports (not NIC ports) can be configured to operate in split mode.

Optical transceivers for the optical solution are not shown in the figure above.

Splitter cable examples: 25/100 GbE

- MCP7F00 – 100 Gb 1:4 splitter DAC, max 3 m

- MCP7H00 – 100 Gb 1:2 splitter DAC, max 3 m
- MFA7A20 – 100 Gb 1:2 optical splitter, up to 20 m long tails
- MFA7A50 – 100 Gb 1:4 optical splitter, up to 30 m long tails

Splitter cable examples: 50/200 GbE

- MCP7H50 – 200 Gb 1:2 optical splitter DAC, max 3 m
- MFS1S50 – 200 Gb 1:2 optical splitter, up to 30 m long tails
- MFS1S90 – 200 Gb 2:2 optical H-cable, up to 30 m long tails

Note 1: network adapter card ports cannot be split – only switch ports.

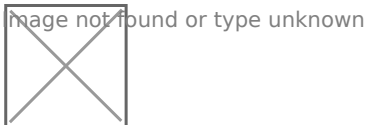
Note 2: The total number of ports that can be split with cables is based on the specific number of MACs inside the switch chip. See the switch documentation for specific configuration limits.

Optical splitter cables are available in the market for use between SR4 and SR transceivers.

## InfiniBand

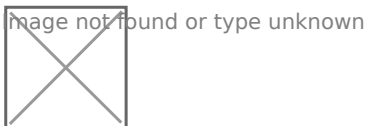
Port splitting/sharing a switch port across multiple servers was originally implemented for Ethernet, but is also available with the latest NDR generation of InfiniBand networking products. A wide variety of copper and optical cables have been developed for splitting 400/800G port capacity across 2 or 4 servers/hosts. Contact the NVICIA Networking team for more information on this topic.

### ***Multi-mode splitter (breakout) cable***



For longer reaches, a single-mode QSFP PSM4 transceiver can be connected to up to four NICs with LR transceivers using a single-mode splitter cable. Today, a common split is a 100G PSM4 split to 2x50G PSM4 transceivers used in large servers or storage systems.

### ***Single-mode splitter (breakout) cable (not an NVIDIA product)***



You cannot split the channels of a WDM transceiver using simple splitter cables. WDM transmitters use a single pair of fibers with the four channels carried on light of different wavelengths.

# Networking Standards

**LinkX®** is the product line brand for NVIDIA's DAC, AOC and transceivers products that supports InfiniBand and Ethernet.

**InfiniBand** (IB) is a computer-communications standard used in high-performance computing that features very high throughput and very **low latency**. InfiniBand is commonly used in HPC (High-Performance Computing) and hyperscale datacenters. InfiniBand is promoted by the InfiniBand Trade Association (IBTA), <http://www.infinibandta.org/>. See [InfiniBand: Introduction to InfiniBand for End Users](#) for an introduction.

**Ethernet** (ETH) is a family of general computer networking technologies commonly used inside and outside datacenters. It comprises a wide number of standards, commonly referred to as IEEE 802.3, which is promoted by IEEE ([www.ieee.org](http://www.ieee.org)).

Form Factors, power classes, connector definitions and management interface specifications are found in <https://www.snia.org/sff/specifications2>.

## InfiniBand (IB) and Ethernet (ETH) Cables Differences

The main differences between the two protocols are as follows:

- InfiniBand links up to Nx25 Gb/s; generally, don't use Forward Error Correction to minimize link latency. For higher data rates, FEC is a necessity.
- CDR (Clock and Data Retiming) default state:
  - IB EDR: Clock/data recovery (CDR, or retiming) is bypassed/disabled except for AOCs 30 m or longer running Nx25 Gb/s or lower rates.
  - IB HDR: Clock/data recovery (retiming) is as well as FEC are necessary for error free transmission due to the physical nature of PAM4 signaling.
  - Ethernet 100G: The CDR is default on.  
The CDR must be disabled to pass data at lower rates, for example 40 Gb/s.
  - 200/400 GbE (Ethernet) – CDR and FEC are both required for error free transmission. 25/100 GbE is supported but lower data rates are not generally supported.
- Copper cables:
  - IB EDR: The cable length and related attenuation determines if the operation can be achieved without FEC.

- Ethernet 25/100GbE: Reed Solomon Forward Error Correction or RS-FEC is enabled by default for cables denoted CA-25G-L which are longer than 3 m. FEC is not required for cables denoted CA-25G-N which are up to 3 m long.

The EEPROM memory map of QSFP28 (100 Gb/s cables/transceivers) is defined in specification SFF-8636 for 4-lane transceivers, and for SFP28 (25 Gb/s cables/transceivers) in SFF-8472 for 1-lane transceivers.

Management of transceivers with more than 4 lanes is defined in the Common Management Interface Standard (CMIS),

<http://www.qsfp-dd.com/wp-content/uploads/2021/11/CMIS5p1.pdf>

Transceivers with QSFP formfactor and 4 lanes can also be CMIS compatible. You need to read the memory map to tell if a given transceiver is the SFF or the CMIS type.

Memory map differences summary (informative):

- A summary is given in IB Vol 2 Annex A3.2: InfiniBand vs. Ethernet Memory Map Differences – QSFP/QSFP+ <https://cw.infinibandta.org/document/dl/8125> (membership required).
- IB EDR loss budget (asymmetric): IB Vol 2 Annex A2.5 EDR Overall Link Budget for Linear Channels (informative)
- Ethernet: IEEE 802.3 clause 92 – copper cables, clause 83 – Physical Medium Attachment (PMA) including CDRs

# LinkX Product Qualification

All LinkX® cables and transceivers for data rates up to InfiniBand EDR and 25/100 GbE (Ethernet) are tested in Nvidia end-to-end systems for pre-FEC BER of 1E-15 as part of our product qualification; more specifically, as part of the System Level Performance (SLP) test.

IB HDR, 200 GbE and higher data rates, cables and transceivers are different from previous generations. Due to the nature of physics of the PAM4 modulation used in these cables and transceivers, error-free transmission is only achievable with the use of FEC. This type of cables/transceivers are qualified at 1E-15 effective BER in Nvidia InfiniBand/Ethernet end-to-end systems.

# Supplemental Reading for Projectors

## Projectors

Projectors are display devices for when you need to share information with people in the same location! Most projectors can be used just like any other display on a computer, and with a few differences, can be troubleshoot just like any other display device. For example, projectors can have **dead** or **stuck pixels**, and can acquire **image burn-in**, just like other types of displays.

## Connectors and Cables

You will connect a computer to a projector using a display cable like [VGA](#), [DVI](#), [HDMI](#), or [DisplayPort](#). When you do this, the computer's operating system will detect that a new display has been added. Depending on what your computer's video adapter supports, this new display can be **extended** or **mirrored** just like if you had added a second monitor!

- [Windows - How to connect to a projector or PC](#)
- [MacOS - How to connect a display, TV or projector to Mac](#)
- [Ubuntu - How to connect another monitor to your computer](#)

A lot of times, display issues with projectors come down to the connectors and the cables that you are using. Because people frequently connect and disconnect from projectors, the cables and connectors can become worn out or damaged. Always consider this early in your troubleshooting if

the projection display flickers or disappears.

## Device Drivers

Just like other display devices, if your computer does not correctly recognize the display resolution of the projector it may default to a very low-resolution **VGA mode** like 640x480 or 1024x768. If this happens, your computer may need a device driver for your projector. Take a look at the support website for your projector's manufacturer!

## Lighting

Older projectors often rely on expensive, hot, very bright **incandescent** bulbs, or **lamps**. If a projector gets too hot for the lamp to safely operate, the projector will shut down. If the lamp burns out, the projector will either not work or will shut itself down. It is increasingly common for projectors to rely on LED lights, rather than incandescent lamps. These LED lights have far fewer issues with overheating, and have much longer lifespans than incandescent lamps.

## Calibration

Sometimes, like when a projector is first installed, reset, or moved, you will need to **calibrate** the projector image to account for the distance and angle that the projector is installed at. If the image is skewed or [keystoned](#), you might need to recalibrate the projector geometry. Calibrating the image involves focusing the image, and making adjustments to the image to make it square and aligned with the projection surface. Every projector is a little different, so refer to the vendor documentation to complete this task!

# BIOS

Now we've seen all the key components to get our computer running. The last thing we'll go over is how our devices talk to each other. We know how programs execute from our hard drive to our CPU, but how do other things like a mouse click or a keyboard press gets sent to our CPU for processing? These are fairly basic devices. They don't contain any instructions that our CPU knows how to read. If you just clicked on a key from your keyboard, you'd only be sending a bite to the CPU. The CPU doesn't know what this is because it doesn't have instructions on how to deal with it. Turns out our devices also use programs to tell the CPU how to run them. These programs are called services or drivers. The drivers contain the instructions our CPU needs to understand external devices like keyboards, webcams, printers. Our CPU doesn't know that there is a device that it can talk to. It has to connect to something called the BIOS or basic input output services. The BIOS is software that helps initialize the hardware in our computer and gets our operating system up and running. Unlike the programs, you're probably used to running a web browser or operating system. The bios isn't stored on a hard drive. Our motherboard stores the bios in a special type of memory called the read only memory chip or ROM chip. Unlike RAM, ROM is non-volatile, meaning it won't erase the data if the computer is turned off. Once the operating system loads, we're able to load drivers from non-essential devices directly from the hard drive. In today's system there's another player for bios called UEFI, which stands for Unified Extensible Firmware Interface. UEFI performs the same function of starting your computer as a traditional BIOS, but it's more modern and has better compatibility and support for new hardware. Most hardware out there today comes with UEFI built in. Eventually, UEFI will become the predominant BIOS. When you turn on a computer, you might notice a beeping from time-to-time. Our computers run a test to make sure all the hardware is working correctly. This is called a power-on self-test or POST. The bios runs it when you boot up your computer. The POST figures out what hardware is on the computer. It happens before the BIOS initializes any hardware or loads up essential drivers. If there's an issue with anything at that point, there's no way to display it on the screen since things like the video driver haven't been loaded. Instead, the computer can usually produce a series of beeps, almost like Morse code, which will help identify the problem. Different manufacturers have different beep codes. If you computer successfully boots up, you may hear a single beep. If you hear two beeps, it could mean a POST error. It's best to refer to your motherboard manual to find out what each code means. Also, you should know that not all machines have built-in speakers. Don't worry if your computer boots without a beep. If it does have a built-in speaker, being able to distinguish what the beep codes mean is an extremely helpful tool when troubleshooting boot issues. One last thing, we will discuss our BIOS settings. There's a special chip on our motherboard called the CMOS chip. It stores basic data about boosting your computer, like the date, time, and how you want it to start up. You can change these settings by booting into CMOS or BIOS settings menu. It varies on different computers, but usually when you boot the computer, there will be a quick screen that tells you what button to push to get into the settings. From there, you can change the basic BIOS settings of your machine. In an IT support role, you might interact with the BIOS more often than you think. BIOS settings control which devices to boot to. In an IT role, you might need to change the settings more often than not. A frequently performed IT task is the reimaging of a computer.

The term refers to a disk image, which is a copy of an operating system. The process of reimaging involves wiping and installing an operating system. This procedure is typically performed using a program that stored on some external device, like a USB memory stick or a CD ROM, or even a server accessible through the network. To access these programs and perform the re-image, you will need to use the bios to tell the computer to boot up from that external device.

# Ben: Skills of IT professionals

The one great constant in the technology industry is its history of change and the speed of that change so no education is going to give anyone the skills they need for an entire career. You've got to have curiosity, you've got to have a lifetime of curiosity and a dedication to a lifetime of learning because the tools and technology that we use in this industry are always going to be changing. Great tech skills are really important but the important thing about technology is that it serves people and it serves the interests of people. You have to like people you have to like helping them, you have to have empathy and sympathy for their problems. That is the most important thing. There's no corner of our lines are of industry of government or society that IT and technology don't play a role in, and these are skills that don't just help you in your job, but they can help you with every facet of your life. They're going to be relevant to everything that we do in our lives for as far into the future as anyone can predict, try this program out. If you can learn this material, if you liked this material, then you can have a great career and technology and don't worry about the other stuff.

# Putting it All Together:

## Installing The Processor

Now that we've learned what the computer components are and how they work, we're going to assemble our very own computer, a full-sized desktop. Computers are incredibly fundamental to the work of an IT support specialist. They're used in pretty much every aspect of the job. Aside from work, knowing how to build a computer might inspire you to try all kinds of cool stuff. You could custom build a gaming rig to play the most advanced game at the highest settings, or like me, make a home media server for all your photos and videos. Knowing how to build a computer is a skill that can be useful in lots of interesting ways. Before we get started, let's lay down some ground rules for this ground-up build. Sorry, I couldn't help myself. We should think about electrostatic discharge and try to prevent unwanted static from harming our very expensive components. Have you ever rubbed your socks on a carpet then accidentally zap someone? That's pretty harmless. But if you do that to your new motherboard, you could completely destroy it. How do we prevent static discharge? We can go about this in two ways. You can touch an electrical device that's plugged in but not powered on. Fyi, you should do this every couple of minutes when assembling a new computer. Another option is to wear an anti-static wristband, like the one I have here. Let me get it.

:22

You connect the end of the clip to a non painted metal service like your computer and then you strap it on to your hands, and you're done. While we're on the subject of anti-static safety, I want to call out that when you buy computer parts, they'll come in anti-static bags to prevent accidental static electricity. Be sure to keep them inside the bags until you need to install them on your computer. Now, let's get making this computer. We'll start by laying down the foundation of our computer. The motherboard. Remember, there are lots of different form factors for motherboards and you want to make sure the one new purchase fits your computer case. We purchased a full-sized desktop case and have a full sized ATX motherboard. The motherboard, there are lots of screw holes which coincide with the holes in the desktop case too. You want to match up the holes on the motherboard to the holes on the desktop. Once you figure out which holes to use, screw in the standoffs. Standoffs are used to raise and attach your motherboard to the case. In this instance, our case has built-in standoffs. Let's start

1:27

by adding our components in. We'll start with the CPU. Let's take that out of our anti-static bag. You want to be very careful with these because they're very expensive and you don't want to drop

them.

1:43

Once we've taken out the bag, let's lineup the CPU with the motherboard socket. Something to note is this marker right here. This has to align with the CPU socket on the motherboard. Also, don't forget to make sure you get compatible CPUs that fit your motherboard. We have the LGA CPU in the LGA compatible motherboard socket. Let's go ahead and align the correct orientation of the CPU and secure it in place like this.

1:12

Like I mentioned before, you want to make sure that the pointers on the CPU and the socket are aligned. The easy part is putting a CPU in, the fun part is securing this. Just note that when you secure the CPU in the socket, you do need to use a bit of force so it's tightly secured in.

1:38

Perfect. Now the CPU is secured in the socket. Now that our CPU is in place, we need to add our heat sink on top of it. The heat sink is used to dissipate heat from our CPU. I'll show you some cool things. This part right here, this is what our CPU relies on to stay cool. It takes the heat from there and then uses this fan to blow it out. Before we attach the heat sink, we need to apply an even amount of thermal paste. Let me get that. This is the thermal paste. Thermal paste is used to better connect our CPU and heat sink, so the heat transfers from one to the other better. To get started, apply a dab of thermal paste and spread it evenly with a flat object. Let's do that on our CPU right here. The first thing that you want to do is slowly apply a slat dab on the CPU, like so.

1:46

Then with a flat object apply the thermal paste evenly throughout your CPU to go halfway right here, halfway right here, halfway right here, and then halfway right here.

1:04

Just make sure that it spread evenly throughout the CPU. You may have to do this multiple times to get this correct.

1:18

Once you have that in place, you're going to take your heat sink and then you're going to press it against the CPU. Something to note is these screws right here. They align with the CPU socket so they can guide you while you put the heat sink on.

1:51

Great. Once you have all four sockets aligned, go ahead and get your screwdriver and then tighten down the sockets.

':05

One thing to do is to make sure that you screw opposite sides first so you know that the heat sink is attached securely.

':25

One thing I like to do again is just to go over my screws to make sure everything is tightened securely.

':48

Great. Now that our screws are tightly on and our heat sink is secured to the CPU, you have to plug this power cable to the motherboard. This is important because this is what controls the fan speed via the motherboard. Perfect. Now you've fully installed and connected your CPU to the motherboard.

# Putting it All Together: Adding Graphics and Other Peripherals.

Let's go back to our massive connectors. There are few things I would like to highlight. This big one right here. This is the one that house our motherboard. Another one that we have, it's more of a legacy one is for pin Molex. These connections were used heavily before SATA came out. Now we use these connectors to power majority of the SATA devices today. Most modern machines today will probably use SATA connectors for your hard drives. It may come with Molex to SATA adapters. Now, it's time for the fun part. First, let's go ahead and connect our power supply to our motherboard. That's this big pin, as we discussed earlier. It's going to go in right here.

Plug that in like so.

Next, we're going to go ahead and power the CPU with this pin right here. Pretty tight, but you should be able to get it in.

There you go. What we just did was we have the power supply is powering the motherboard and the CPU. Now that we've hooked up to cable to our CPU and motherboard, next thing that we need to hook up are these cables that are sitting in our case. This is going to vary from case to case, but let's go through it. Some of these cables are used for your cases, buttons, and lights. For this one, I'm going to plug these in.

Our case cables are now secured to a motherboard. One good idea is sometimes your motherboard will come with some guides. This will help you fasten your cables to your motherboard so it's clean and tight on your case. I'm just going to go ahead and do that right here.

Now that we have our cables securely fastened to our case, let's not forget one more thing, how graphics card we'll need that so we can upload a video to our monitor. We're going to plug this graphics card into our PCI Express slot on our motherboard. Just like the RAM, you are going to put a little bit of pressure when you insert the same. Don't feel bad by putting a little bit of pressure and you hear a click like this,

which you've done it, you can tightly secure it to your case. This is going to vary from case to case.

There you go. Your graphics card has been installed. I think that's it. Let's cover up our computer. First make sure you take your anti-static bracelet away.

Get our case put that in like so. Just plug. That's it.

There you go. We finally built our machine. Last, but not least, let's connect our monitor keyboard, mouse to the desktop. First, let's get our keyboard. We're going to do is going to connect this USB to the USB port on our desktop.

Want to get our mouse, do the same thing, connect this to our USB port then finally, we're going to go ahead and connect our monitor. For this monitor we're going to go ahead and use a display port cable. Want to connect one end to our desktop like so. Next I'm going to plug this into my monitor.

This is the most interesting part. Let's see if all this works. I'm going to power it on, I got blue light, which is good, off course it's going to vary from system to system. Let's see if something shows up on the monitor. Computer is booting up. Let's see. It looks like the monitor is receiving signal. Just good it. There we have messages. Success, there we go. It's working perfect. If you're having issues with your computer not starting up, that's okay. Check that your power supply can supply the correct amount of wattage or make sure your connectors are in the right place. Oh, what's this non-system disk or disk area replace and strike any key when ready. Looks like our disk doesn't have an operating system to boot into. No worries. That's what we'll be discussing in the next set of lessons. We'll learn what an operating system is, and what the main operating systems are and how to install one. Well, good job. You've got your computer up and running and it monitors were seeing signal so that's it. Let's take a moment and think about what you just did. Not only did you learn about each component of a computer, but you figured out how they work individually and then we built one together. It's quite an accomplishment.

# Mobile Device Repair

Repairing a mobile device is different from repairing larger, more generic computers. First, there are thousands of types of mobile devices. There's no way we can cover all the differences. Instead, let's check out some of the tools and techniques that you'll rely on to keep mobile devices in your organization running. As an IT support specialist, you might receive training in this area and be responsible for repairing devices that your organization owns. Before you attempt any repairs, make sure you're familiar with your organization's policy around mobile device repair. Depending on the device, you may or may not be able to repair it on your own. But not so fast, keep in mind that even when you can repair a device on your own, they will usually void the warranty. So check the impact on the warranty before working on a device. With specific training, you might be able to perform some repairs without violating the warranty of the device. For example, you might be allowed to replace a cracked smartphone screen without voiding the warranty, but you're probably not permitted to replace the damaged charging port. If you're not allowed to perform your own repairs, then it may be your job to send the device out for repair or replacement with an outside vendor or manufacturer. You should know and understand the return merchandise authorization or RMA process for each device that you deal with. The device's warranty or the service agreement that your organization has with the device's manufacturer will determine how and when it will be repaired or replaced. Depending on the device and your organization's policies, you might also need to make sure that there's no proprietary or personal data on the device before it is sent off for repair, by doing a factory reset on the device. A factory reset will remove all data, apps, and customizations from the device. When repairing a mobile device, follow the same best practices that we showed you for working on a PC. Protect against static discharge, use the right tools, keep parts organized and labeled. Taking pictures along the way can help a lot too. Follow vendor documentation and test the device to make sure it still works.

# Mobile Display Types

In this reading, you will learn about several types of displays used in modern mobile devices and monitors. As an IT Support professional, you may need to troubleshoot various types of displays. This might involve repairing damaged mobile device screens. You may even be responsible for selecting and ordering mobile devices for the employees of an organization. In your IT job role, you should have a basic understanding of the technology behind modern displays, as well as their common uses, positive features, and negative flaws. The top two technologies used in mobile system displays are Liquid Crystal Displays (LCD) and Light Emitting Diodes (LED).

## Liquid Crystal Display (LCD)

LCDs use liquid crystal technology. Liquid crystals have the properties of both a liquid and a solid. The crystals can be aligned in a variety of patterns and manipulated with electricity. How the liquid crystals are arranged and manipulated inside display panels affects refresh rates, image quality, and display performance. LCDs require backlighting, often provided by LEDs. Displays that need backlighting are also called non-emissive or passive displays. The backlighting unit (BLU) requires extra space, which makes LCD panels thicker and less flexible than other displays. Polarizers on either side of the liquid crystal layer control the path of the backlight to ensure the light is aimed toward the user.

The following are common LCD display types used for mobile devices:

### In-Plane Switching (IPS)

- **How it works:** In IPS displays, the liquid crystals are aligned horizontally to the screen. Electricity is passed between the ends of the crystals to control their behavior.
- **Uses:** IPS technology is used in touch screen displays and high-end monitors. They are often used for design, photography, video/film editing, animation, movies, and other media. They can also be used for games that rely on color accuracy and wide viewing

angles, as opposed to speed.

- 

**Positives:** IPS displays provide vibrant colors, high quality graphics, and wide viewing areas. Additionally, they offer excellent color reproduction, accuracy, and contrast.

- 

**Negatives:** IPS displays are expensive. They have low refresh rates and slow response times. However, response times have been improving as the IPS technology evolves. IPS displays can be affected by “IPS Glow”, where the backlight is visible from side viewing angles.

## Twisted Nematic (TN)

Twisted Nematic (TN) is the earliest LCD technology that is still in use today. The term nematic, which means “threadlike,” is used to describe the appearance of the molecules inside the liquid.

- 

**How it works:** In TN displays, the liquid crystals are twisted. When voltage is applied, the crystals will untwist to change the angle of the light they transmit.

- 

**Uses:** TN displays are appropriate for basic business use (e.g., email, document, and spreadsheet applications). They are also used for games that need rapid display response times.

- 

**Positives:** TN displays are low cost, easy to produce, have excellent refresh rates, response times, and resolutions. They are versatile and can be manufactured for any size and/or shape.

- **Negatives:** TN displays have narrow viewing angles, low image quality, color distortion, and poor color accuracy and contrast.

## VA-Vertical Alignment

- **How it works:** In VA displays, the liquid crystal molecules are vertically aligned. They tilt when electricity passes through them.
- **Uses:** VA displays are intended for general purpose. Provides mid-range performance for graphic work, movies, and TV.
- **Positives:** VA displays offer great contrast, deep black shades, and fast response times. They are mid-range quality for refresh rates, image quality, viewing angle, and color reproduction.
- **Negatives:** On VA displays, motion blur and ghosting occurs with fast-motion visuals.

## Organic Light Emitting Diodes (OLED)

OLEDs are diodes that emit light using organic (carbon-based) materials when electricity is passed through the diodes. Displays that are able to convert electricity into light are called emissive or active displays.

-

**How it works:** The basic structure of an OLED display consists of an emissive layer placed between a cathode (which injects electrons) and an anode (which removes electrons). Electricity enters through the cathode layer, passes into the emissive layer and conductive layer to create light, then out through the anode layer.

- 

**Uses:** OLED display technology can be used in foldable smartphones, rollable TVs, as backlighting in LCD TVs, for gaming, and inside VR headsets.

- 

**Positives:** OLED displays deliver excellent picture quality, wide viewing angles, infinite contrast, fast response rate, and brilliant colors with true blacks. They are energy efficient, simpler to make, and much thinner than LCDs. OLED panels can be built to be flexible and even rollable.

- 

**Negatives:** OLED displays are sensitive to light and moisture. Blue LEDs degrade faster than other LED colors causing color distortion over time. They are also prone to image retention and burn-in.

## Active Matrix Organic Light Emitting Diode (AMOLED)

Active Matrix Organic Light Emitting Diode (AMOLED) and Super AMOLED are recent technologies used in smartphone displays.

- 

**How it works:** AMOLED displays are a type of OLED panel that uses active matrix technology. Active-matrix displays have active capacitors arranged in a matrix with thin film transistors (TFTs). This technology enables the control of each individual pixel for rapid state changes, including changing brightness and color. AMOLEDs have touchscreen functions integrated into the screen.

- **Uses:** AMOLED and Super AMOLED panels are used in high-end mobile devices, flat screen monitors, curved screens, and touchscreens.
- **Positives:** AMOLED displays offer a high picture quality and fast response time. Color and brightness are consistent across the screen. Fast-moving images and motion are displayed clearly without blurring or ghosting. Super AMOLED panels can display a wider range of colors with enhanced contrast, which makes them easy to view in a wider variety of lighting conditions.
- **Negatives:** AMOLED displays have the same problems as OLED displays (listed above) plus AMOLED panels can be difficult and expensive to manufacture.

## Inorganic mini-LEDs (mLEDs)

Inorganic mini-LEDs (mLEDs) are a next-generation, emissive display technology.

- **How it works:** Mini-LED displays work the same way that OLED displays work, but the individual LED size is much smaller at approximately 50-60 micrometers.
- **Uses:** Mini-LED displays are used for LCD backlighting in smartphones, public information displays, signage, electronics, vehicle displays, and more. Mini-LEDs are also the tech behind “Liquid Retina XDR” screens.
- **Positives:** Mini-LED displays offer ultra high luminance, superior HDR fineness, long lifetimes, thin panels, and are readable in sunlight. They are also less expensive than

micro-LED displays.

- **Negatives:** Mini-LED displays, when used as LCD backlighting, are limited by the properties of LCD technology. Mini-LED displays for mobile devices are more expensive than OLED displays.

## Inorganic micro-LEDs ( $\mu$ LEDs)

Micro-LEDs ( $\mu$ LEDs) are also emissive, next-generation displays.

- **How it works:** Micro-LED displays work the same way that OLED displays work, but the individual LED size is extremely small at 15 micrometers.
- **Uses:** Micro-LED displays can be used in smartphones, AR/VR headsets, wearables, public information displays, wall-sized TVs, vehicle displays, and more.
- **Positives:** Micro-LED displays offer superior performances across virtually all common display features, such as brightness, reaction speeds, power consumption, durability, color gamut, stability, viewing angles, HDR, contrast, refresh rates, transparency, seamless connectivity, and more. Micro-LED displays are readable in sunlight and have sensor integration capability.
- **Negatives:** Micro-LED displays are expensive to manufacture and are not yet ready for mass production.

## Key takeaways

The two main technologies used in mobile displays are Liquid Crystal Display (LCD) and Organic Light Emitting Diodes (OLED). Each technology has its own benefits and drawbacks when used in mobile device displays, among other consumer goods.

- 

Common LCDs include:

- 

In-Plane Switching (IPS) displays

- 

Twisted Nematic (TN) displays

- 

VA-Vertical Alignment displays

- 

Common and upcoming OLED displays include:

- 

Active Matrix Organic Light Emitting Diode (AMOLED) displays

- 

Inorganic mini-LEDs (mLEDs) displays

-

Inorganic micro-LEDs (µLEDs) displays

# One program, many futures

One of my favorite parts of the program, was showing me how many different jobs have an IT department or use some aspect of IT. You can do pretty much anything, it's very motivating. The feeling of growth, is an amazing thing, having felt stagnant for so long, working at what I had considered to be dead end jobs, with no real vertical movement, and knowing that now you can advance, you can put yourself into so much more. Don't think about what you think IT is, think about all the possibilities or the expansion that IT actually goes into. The program was great for me, it gave me more understanding of what IT is and all the different opportunities you can get into, and I can go into hardware, I can go into cyber security, and that's the best part because it's not just keeping me grounded to one level. I am able to go further. This program, would definitely be the way to go to get your foot in the door, to learn and do more in this field that you're interested in. It has the basic fundamentals, it gives you the building blocks, and from there, the sky is the limit.