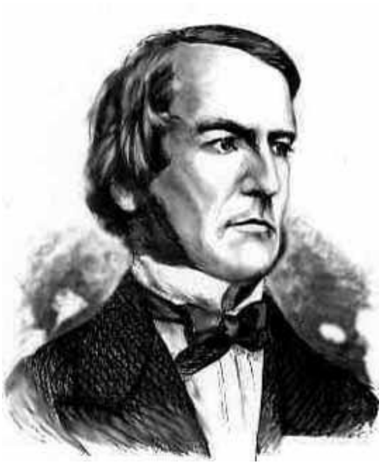
The pre-history of computers

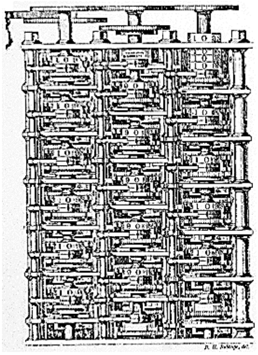
Our PC's have "spiritual roots" going back 350 years. Mathematicians and philosophers like Pascal, Leibnitz, Babbage and Boole laid the foundations with their theoretical work. The Frenchman, Blaise Pascal, lived from 1623-1662, and was a mathematical genius from a very young age.

As an 18-year-old, he constructed a calculating machine, and his mathematical theories have had enormous significance to all later scientific research.

The Englishman, George Boole (1815-1864), was also a natural talent. He grew up in very humble surroundings, and was largely self-taught. When he was 20 years old, Boole founded a mathematics school and then began to develop the symbolic logic which is currently the cornerstone of every program.



Another Englishman, Charles Babbage, began developing various mechanical calculating machines in 1823, which are today considered to be the theoretical forerunners of the computer. Babbage's "analytical machine" could perform data calculations using punched cards. The machine was never fully realised; the plan was to power it using steam. and his staff constructed various programs (software) for his calculating machine. Babbage is therefore called the "father of the computer" today.



However, it was only in the 20th century that electronics advanced sufficiently to make practical exploitation of these theories interesting. The Bulgarian John Vincent Atanasoff (1903- 1995) is the inventor of the *electronic digital computer*. Atanasoff was a genius.

At the age of nine, he studied algebra with the help of his mother Iva Lucena Purdy, a mathematics schoolteacher.

Motherboard:-

Alternatively referred to as the mb, mainboard, mobo, mobd, backplane board, base board, main circuit board, planar board, system board, or a logic board on Apple computers. The motherboard is a printed circuit board that is the foundation of a computer, located on the back side or at the bottom of the computer case. It allocates power to the CPU, RAM, and all other computer hardware components. Most importantly, the motherboard allows hardware components to communicate with one another.

History:-

The IBM personal computer contained the first motherboard, which was referred to as the "breadboard" and was released in 1981. The breadboard provided a platform for the computers RAM and CPU and also had ports for a keyboard, mouse and cassette tape. The first motherboard is considered to be one used in the IBM Personal Computer, released in 1981. At the time, IBM referred to it as a "planar" instead of a motherboard. The IBM Personal Computer and the motherboard inside it would set the standard for IBM-compatible computer hardware going forward.

When compared to modern motherboards, the planar provided the function of supplying a circuit board with expansion slots for other hardware devices. The original breadboard also provided a built in audio capability as well, while also having a system named a bus to manage the flow of information. The original breadboard provided a built-in audio capability as well, while also possessing an information transportation system, appropriately named a "bus," to manage the flow of information.

Before generation of Microprocessors i.e. in 1st, 2nd and 3rd generation computers, the computer was usually built in a card-cage case or mainframe with components connected by a backplane consisting of a set of slots themselves connected with wires; in very old designs the wires were discrete connections between card connector pins.

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But printed circuit boards soon became the standard practice in the late 1970s. The Central Processing Unit, memory and peripherals were housed on individual printed circuit boards which plugged into the **backplane**. (A backplane is a circuit board that connects several connectors in parallel to each other, so that each pin of each connector is linked to the same relative pin of all the other connectors, forming a computer bus.)

During the late 1980s and 1990s, it was found that increasing the number of peripheral functions on the PCB was very economical. Hence, single Integrated Circuits (ICs), capable of supporting low-speed peripherals like serial ports, mouse, keyboards, etc., were included on the motherboards. By the late 1990s, motherboards began to have full range of audio, video, storage and networking functions on them. Higher end systems for 3D gaming and graphic cards were also included later.

Micronics, Mylex, AMI, DTK, Orchid Technology, Elitegroup, etc. were few companies that were early pioneers in the field of motherboard manufacturing but, companies like Apple and IBM soon took over.

An Old Motherboard

Companies like IBM and Apple offered high end, sophisticated motherboards that included upgraded features and superior performance over prevailing motherboards.

- ❖ **1975**: Introduction of Apple I, a device that consisted a motherboard, a keyboard and a display.
- ❖ **1987**: Elitegroup Computer Systems Co. Ltd was established in Taiwan and became the largest supplier of motherboards in the world.
- ❖ **1989**: AsusTek, one of Taiwan's top 5 company, started manufacturing graphic cards.
- ❖ **1993**: First International Computer Inc. becomes the largest motherboard manufacturer in the world.
- ❖ **1997**: Intel Corp. plans to add to its monopoly in microprocessor by manufacturing motherboards.
- ❖ **2000**: ATI Technologies Inc. announces graphic cards technology, an advancement, in computer graphics.
- ❖ **2007**: AsusTek becomes the world's largest maker of computer motherboards.

- **2009** – The Mobile ITX – As of 2012, VIAS Mobile – ITX is the world’s smallest complaint motherboard form factor. Just 60 MM by 60 MM.

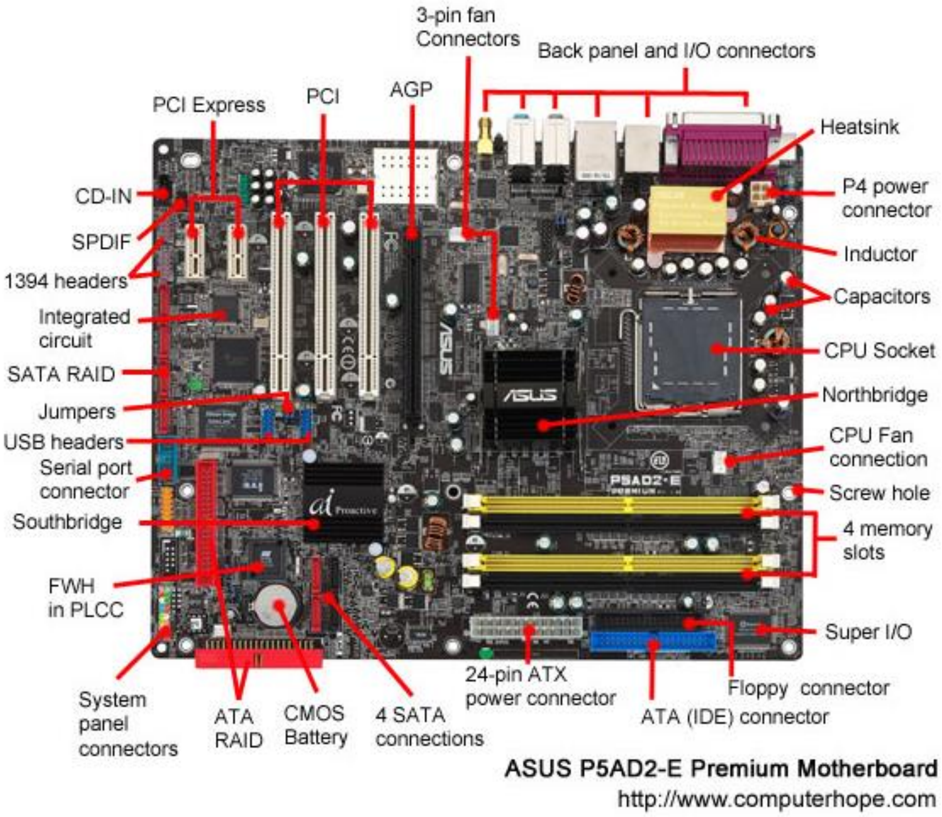
Motherboard Components:-

A typical desktop computer has its microprocessor, main memory, and other essential components connected to the motherboard. Other components such as external storage, controllers for video display and sound, and peripheral devices may be attached to the motherboard as plug-in cards or via cables, although in modern computers it is increasingly common to integrate some of these peripherals into the motherboard itself.

- **Few things that a motherboard nowadays include are:**
  - **sockets** (or slots) in which one or more microprocessors may be installed.
  - **slots** into which the system's main memory is to be installed (typically in the form of DIMM modules containing DRAM chips).
  - a **chipset** which forms an interface between the CPU's front-side bus, main memory, and peripheral buses.
  - **non-volatile memory chips** (usually Flash ROM in modern motherboards) containing the system's firmware or BIOS.
  - a **clock generator** which produces the system clock signal to synchronize the various components.
  - **slots for expansion cards** (these interface to the system via the buses supported by the chipset).
  - **power connectors**, which receive electrical power from the computer power supply and distribute it to the CPU, chipset, main memory, and expansion cards.

Additionally, nearly all motherboards include logic and connectors to support commonly used input devices, such as PS/2 connectors for a mouse and keyboard. Occasionally video interface hardware is also integrated into the motherboard. Additional peripherals such as disk controllers and serial ports are provided as expansion cards.

Given the high thermal design power of high-speed computer CPUs and components, modern motherboards nearly always include heat sinks and mounting points for fans to dissipate excess heat.



- **CPU Sockets**
  - A CPU socket or slot is an electrical component that attaches to a printed circuit board (PCB) and is designed to house a CPU (also called a microprocessor).
  - It is a special type of integrated circuit socket designed for very high pin counts. A CPU socket provides many functions, including a physical structure to support the CPU, support for a heat sink, facilitating replacement (as well as reducing cost), and most importantly, forming an electrical interface both with the CPU and the PCB.
  - CPU sockets can most often be found in most desktop and server computers (laptops typically use surface mount CPUs), particularly those based on the Intel x86 architecture on the motherboard. A CPU socket type and motherboard chipset must support the CPU series and speed.

- **Integrated Peripherals**
  - It is possible to include support for many peripherals on the motherboard. By combining many functions on one PCB, the physical size and total cost of the system may be reduced; highly integrated motherboards are thus especially popular in small form factor and budget computers.

- **Peripheral Card Slots**

- A standard ATX motherboard will typically have one PCI-E 16x connection for a graphics card, two conventional PCI slots for various expansion cards, and one PCI-E 1x. A standard EATX motherboard will have one PCI-E 16x connection for a graphics card, and a varying number of PCI and PCI-E 1x slots. It can sometimes also have a PCI-E 4x slot.

- Some motherboards have two PCI-E 16x slots, to allow more than 2 monitors without special hardware, or use a special graphics technology called SLI (for Nvidia) and Crossfire (for ATI). These allow 2 graphics cards to be linked together, to allow better performance in intensive graphical computing tasks, such as gaming and video editing.
- Virtually all motherboards come with at least four USB ports on the rear, with at least 2 connections on the board internally for wiring additional front ports that may be built into the computer's case.
- Ethernet is also included. Ethernet is a standard networking cable for connecting the computer to a network or a modem.
- A sound chip is always included on the motherboard, to allow sound output without the need for any extra components. This allows computers to be far more multimedia-based than before. Some motherboards contain video outputs on the back panel for integrated graphics solutions (either embedded in the motherboard, or combined with the microprocessor, such as the Intel HD Graphics).

Computer Cooling

- Motherboards are generally air cooled with heat sinks often mounted on larger chips, such as the Northbridge, in modern motherboards. If the motherboard is not cooled properly, it can cause the computer to crash.
- Passive cooling, or a single fan mounted on the power supply, was sufficient for many desktop computer CPUs until the late 1990s; since then, most have required CPU fans mounted on their heat sinks, due to rising clock speeds and power consumption. Most motherboards have connectors for additional case fans as well.
- Newer motherboards have integrated temperature sensors to detect motherboard and CPU temperatures, and controllable fan connectors which the BIOS or operating system can use to regulate fan speed. Some computers (which typically have high-performance microprocessors, large amounts of RAM, and high-performance video cards) use a water-cooling system instead of many fans.

Bus & Bus Speed

- A bus is simply a circuit that connects one part of the motherboard to another. The more data a bus can handle at one time, the faster it allows information to travel. The speed of the bus, measured in megahertz (MHz), refers to how much data can move across the bus simultaneously.
- Bus speed usually refers to the speed of the front side bus (FSB), which connects the CPU to the northbridge. FSB speeds can range from 66 MHz to over 800 MHz. Since the CPU reaches the memory controller though the northbridge, FSB speed can dramatically affect a computer's performance.

Memory

- The speed of the chipset and busses controls how quickly it can communicate with other parts of the computer. The speed of the RAM connection directly controls how fast the computer can access instructions and data, and therefore has a big effect on system performance. A fast processor with slow RAM is going nowhere.
- The amount of memory available also controls how much data the computer can have readily available. RAM makes up the bulk of a computer's memory. The general rule of thumb is the more RAM the computer has, the better.
- Much of the memory available today is dual data rate (DDR) memory. This means that the memory can transmit data twice per cycle instead of once, which makes the memory faster. Also, most motherboards have space for multiple memory chips, and on newer motherboards, they often connect to the northbridge via a dual bus instead of a single bus. This further reduces the amount of time it takes for the processor to get information from the memory.
- A motherboard's memory slots directly affect what kind and how much memory is supported. Just like other components, the memory plugs into the slot via a series of pins. The memory module must have the right number of pins to fit into the slot on the motherboard.

Form factor

- Motherboards are produced in a variety of sizes and shapes called computer form factor, some of which are specific to individual computer manufacturers.
- The current desktop PC form factor of choice is ATX. A case's motherboard and PSU form factor must all match, though some smaller form factor motherboards of the same family will fit larger cases. For example, an ATX case will usually accommodate a microATX motherboard.
- Laptop computers generally use highly integrated, miniaturized and customized motherboards. This is one of the reasons that laptop computers are difficult to upgrade and expensive to repair. Often the failure of one laptop component requires the replacement of the entire motherboard, which is usually more expensive than a desktop motherboard due to the large number of integrated components.

Bootstrapping using the BIOS

- Motherboards contain some non-volatile memory to initialize the system and load an **operating system** from some external peripheral device.
- Most modern motherboard designs use a BIOS, stored in an EEPROM chip soldered or socketed to the motherboard, to bootstrap an operating system. When power is first applied to the motherboard, the BIOS firmware tests and configures memory, circuitry, and peripherals. This Power-On Self Test (POST) may include testing some of the following devices:

1. video adapter
2. cards inserted into slots, such as conventional PCI
3. thermistors, voltages, and fan speeds for hardware monitoring
4. CMOS used to store BIOS setup configuration
5. keyboard and mouse
6. network controller
7. optical drives: CD-ROM or DVD-ROM
8. SCSI hard drive
9. IDE, EIDE, or SATA hard disk
10. security devices, such as a fingerprint reader or the state of a latch switch to detect intrusion
11. USB devices, such as a memory storage device

Mother board buses:-

The “bus” part at the end of the word is one of the standard endings used in Latin but it grew beyond its importance in this case and the vehicle was eventually called a “bus”. This in turn became a word which was used to mean to transport something from place to place. Later the term “bus bar” was used by electricians to mean a bar of metal that transported electricity from one location to another. From here it was a small step to the modern use of “bus” to mean a set of connections that transports signals, or more abstractly data, from one place to another.

In computer architecture, a **bus** is a subsystem that transfers data or power between computer components inside a computer or between computers and typically is controlled by device driver software. Unlike a point-to-point connection, a bus can logically connect several peripherals over the same set of wires. Each bus defines its set of connectors to physically plug devices, cards or cables together.

A bus is simply a circuit that connects one part of the motherboard to another. The more data a bus can handle at one time, the faster it allows information to travel. The speed of the bus, measured in megahertz (MHz), refers to how much data can move across the bus simultaneously.

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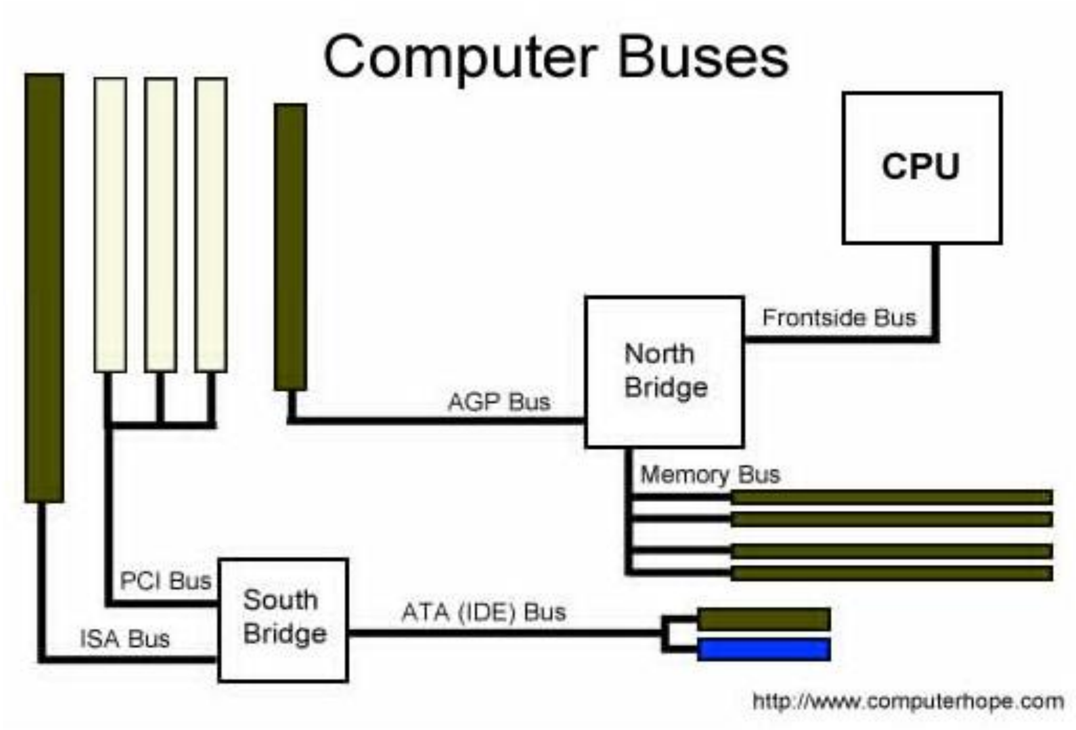
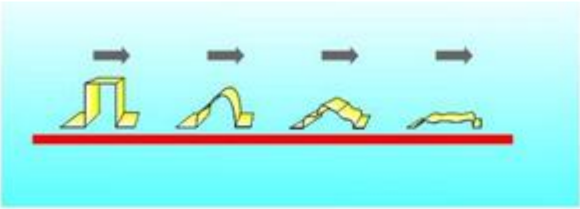
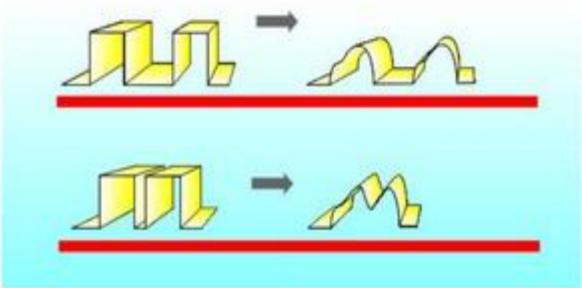


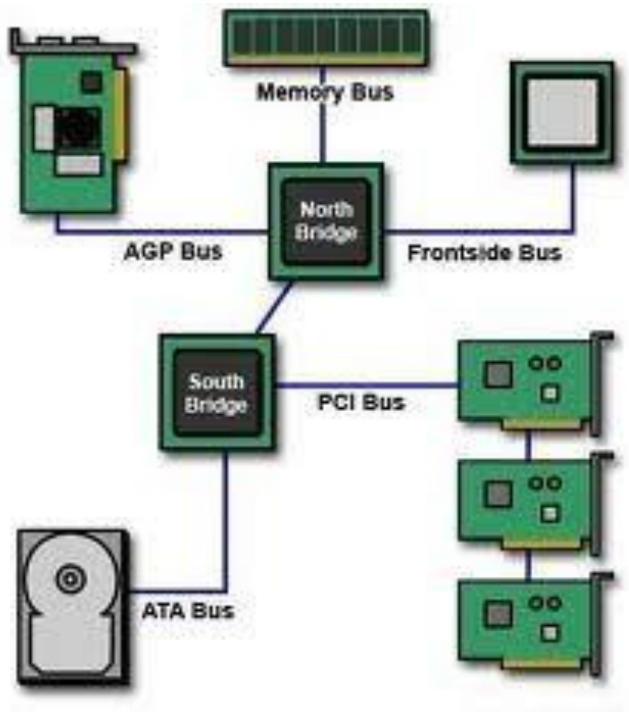
The electronics of connecting to a bus is fairly straightforward and is accomplished by using buffer chips. Usually a bus will have an upper limit on the number of devices that can be connected to it and this is just a function of how much power the buffer chips can put into driving the bus. In addition there is almost certain to be a length restriction. The reason for this is to do with the way high-speed signals deteriorate as they travel down wires. The faster the data needs to move the more this effect becomes important and it explains why a bus cannot work at an arbitrarily high speed.



As a pulse travels down a wire it slowly degenerates until it is lost in the electrical noise



f two pulses are too close together then after travelling a short way you can't tell that they are two pulses



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Here are some of the other busses found on a motherboard:

- The **back side bus** connects the CPU with the level 2 (L2) cache, also known as secondary or external cache. The processor determines the speed of the back side bus.
- The **memory bus** connects the northbridge to the memory.
- The **IDE** or **ATA** bus connects the southbridge to the disk drives.
- The **AGP** bus connects the video card to the memory and the CPU. The speed of the AGP bus is usually 66 MHz.
- The **PCI** bus connects PCI slots to the southbridge. On most systems, the speed of the PCI bus is 33 MHz.

In modern PCs you only find the PCI and ISA buses (besides USB, which we do not know much about yet). But, over the years, there have been other buses. Here is a diagram of the various I/O buses. Then comes a more detailed description of each of the buses:

Bus	Year	Bus width	Bus speed	Max. throughput (theoretical)
PC and XT	1980-82	8 bit	Synchronous with CPU: 4.77 - 6 MHz	4-6 MBps
ISA (AT) Simple bus.	1984	16 bit	Synchronous: 8-10 MHz	8 MBps
MCA. Advanced, intelligent bus by IBM.	1987	32 bit	Asynchronous: 10.33 MHz	40 MBps
EISA. Bus for servers.	1988	32 bit	Synchronous: max. 8 MHz	32 MBps
VL. High speed bus, used in 486s.	1993	32 bit	Synchronous: 33-50 MHz	100-160 MBps
PCI. Intelligent, advanced high speed bus.	1993	32 bit	Asynchronous: 33 MHz	132 MBps
USB. Modern, simple, and intelligent bus.	1996	Serial		1.2 MBps
FireWire (IEEE1394). High-speed I/O bus for storage, video etc.	1999	Serial		80 MBps
USB 2.0	2001	Serial		12-40 MBps

The physical aspects of the I/O buses:-

Physically, the I/O bus consists of tracks on the printed circuit board. These tracks are used as:

- Data tracks, which each can move one bit at a time
- Address tracks, which identify where data should be sent to
- Other tracks for clock ticks, voltage, verification signals, etc.

When data are sent on the bus, they must be supplied with a receiver. Therefore, each device on the bus has an address. Similarly, the RAM is divided in sections, each having its address. Prior to sending data, a number is sent on the address track, to identify where the data should be sent to.

The bus width

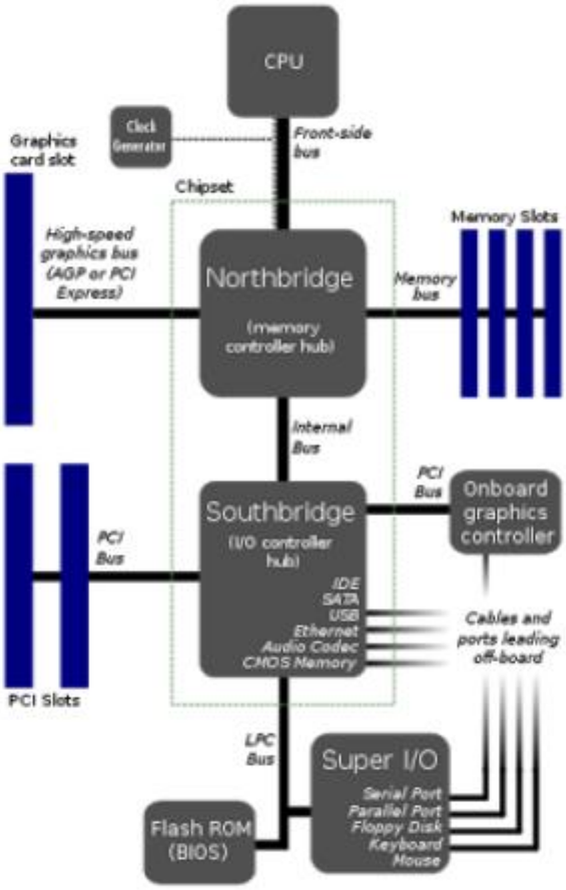
The number of data tracks determine the data transfer capacity. The ISA bus is slow, partly because it only has 16 data tracks. The modern PCs send 32 bits per clock tick. On the ISA bus, 32 bits must be divided in two packages of 16 bits. This delays the data transfer. Another I/O bus concept is wait states.

Wait states

Wait states are small pauses. If an ISA adapter cannot keep up with the incoming data flow, its controller sends wait states to the CPU. Those are signals to the CPU to "hold on for a sec." A wait state is a wasted clock tick. The CPU skips a clock tick, when not occupied. Thus the old and slow ISA adapter can significantly reduce the operating speed of a modern computer.

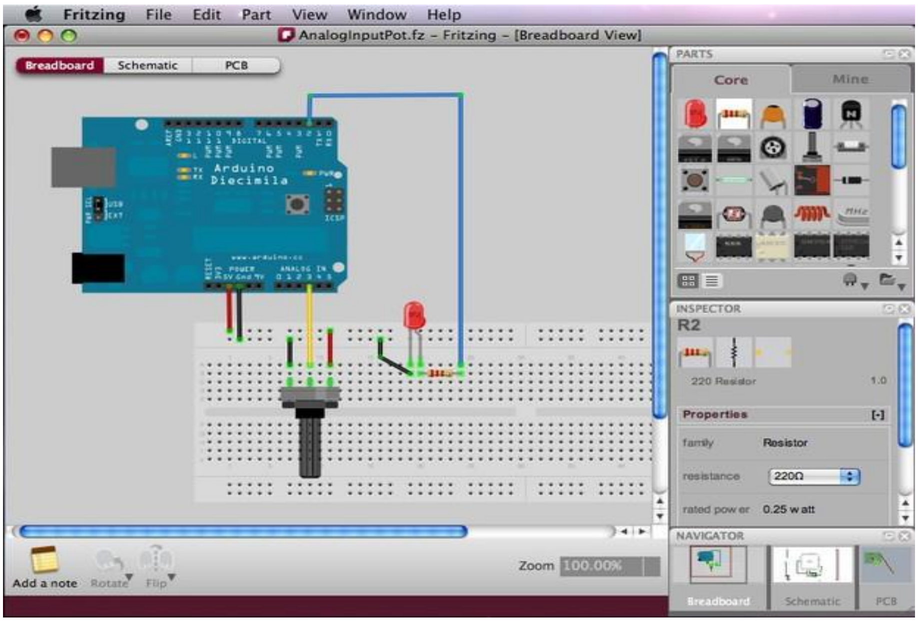
Another aspect is the IRQ signals, which the components use to attract attention from the CPU. That and the concepts DMA and bus mastering, are described in module 5, which deals with adapters.

Motherboards Layout:-

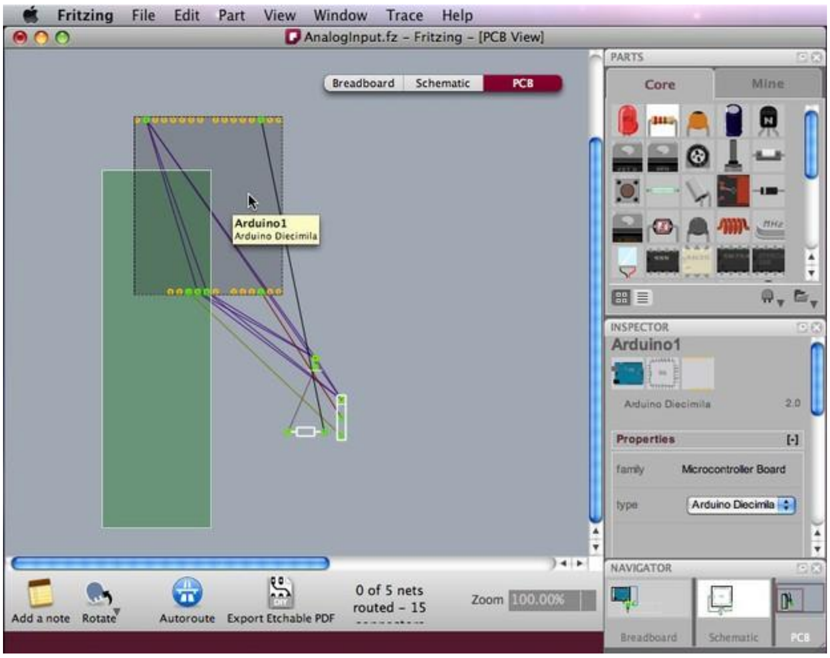


Block Diagram of Modern Motherboard

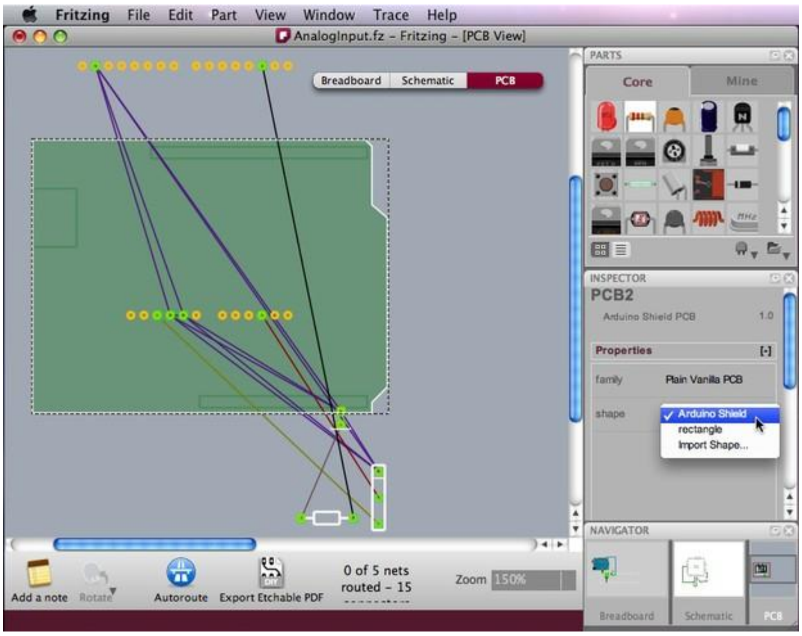
The block diagram of the motherboard suggests that a motherboard is the most important part of a computer that allows all the parts of our computer to receive power and communicate with one another.



Selecting PCB View in the Navigator will show a completely different illustration of the same circuit. The green rectangle is the board itself, on which parts will be arranged. It is automatically placed as you open a new sketch. Parts are shown as footprints, including the Arduino footprint, and you can identify them by selecting or placing the cursor on them to see their labels. The thin connecting lines are the Rat's Nest (more about the Rat's Nest below).



You might want to resize the board, or use an Arduino shield or a board with a custom shape. Select the board and choose/edit your prefered shape in the Inspector.



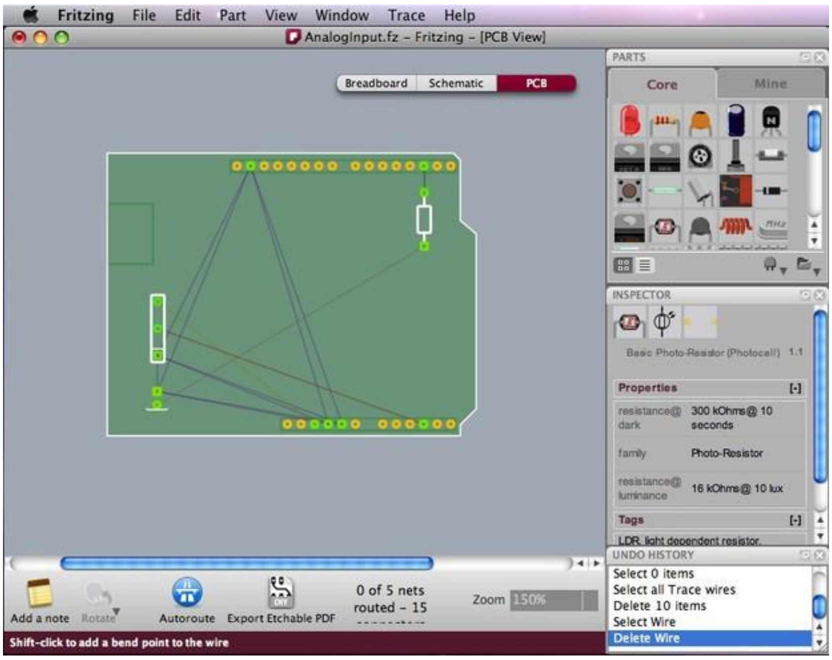
Arranging parts on the board

The first step in designing a PCB layout is arranging the parts on the board. There are some very important issues to consider here, because the location of parts on the board will have a great effect on how successful the routing process will be.

Follow these guidelines:

1. Place the parts with the most connections in the middle of the board.
2. Notice that Arduino's footprint should also be positioned on the board, just like other parts (new in version 3.0).
3. Rotate and position parts, leaving enough space between them (don't forget their actual size!).
4. If the board is too small, redefine its width and height in the Inspector or alternatively resize the board by dragging its corners. Learn how to design a PCB with a custom shape.
5. Don't place parts too close to the edges of the board.
6. To avoid short circuits, don't place parts too close to the USB connector outline on the Arduino Shield.
7. When designing stack shields, parts' heights should also be considered.

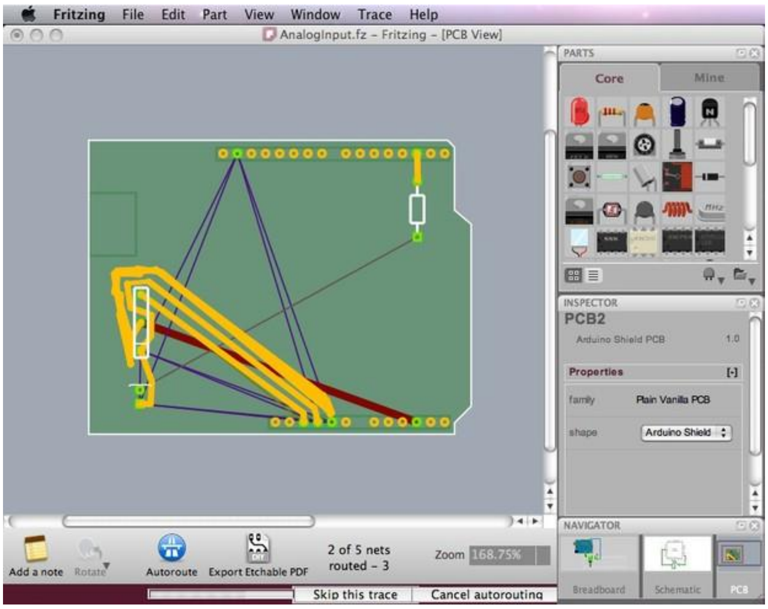
The following screenshot shows one out of many possible part arrangements for the given circuit:



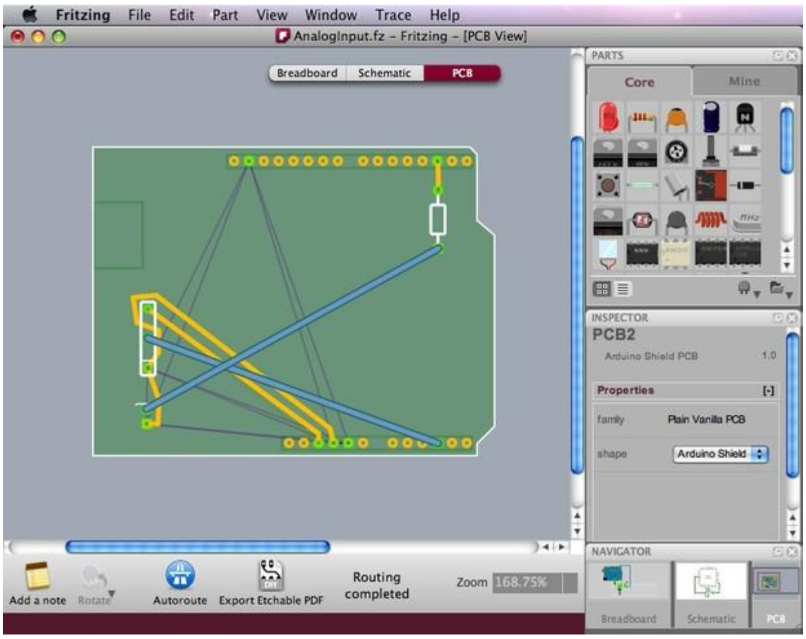
Auto-routing

After positioning all parts on the board, be aware that parts are not really connected to each other yet. The thin connecting lines that you see (Rat's Nest Layer) only act as a guideline. We would now want Fritzing to automatically generate the connection traces between parts. Click the Auto-route function from the bottom menu bar.

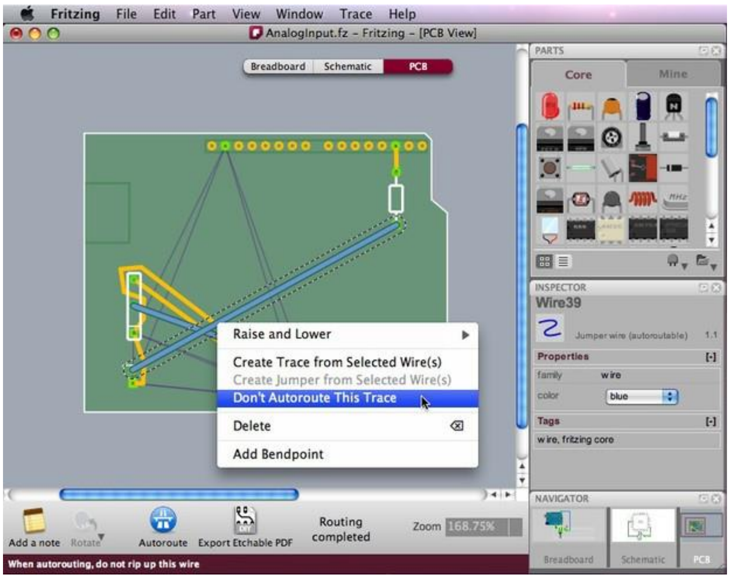
If you notice that Fritzing is struggling trying to generate a connection, you can press the "Skip this Trace" button or "Cancel Auto-routing" in the bottom menu while in process.



Such a problem might happen because parts were not arranged properly on the board or when there is just no possible route. You will then need to Hand-route the trace (more bout hand-route below) or create a jumper. Jumpers are connections that need to be soldered with external wires. These are shown as blue connections while traces are shown as orange ones. In the screenshot below, two jumper wires were created after the routing between connectors failed.



If you are happy with some of the traces and want to keep them untouched, or you know in advance that some connections need jumpers, you might want to tell Fritzing to exclude some connections in the auto-routing process. To do so, select the connections you want to exclude, choose "Don't Autoroute this trace" in the right-click menu or in the Trace menu. Only then press Auto-route. The selected traces will be left untouched while all other connections will be auto-routed. Any traces that were handrouted are automatically marked as "Don't Autoroute."



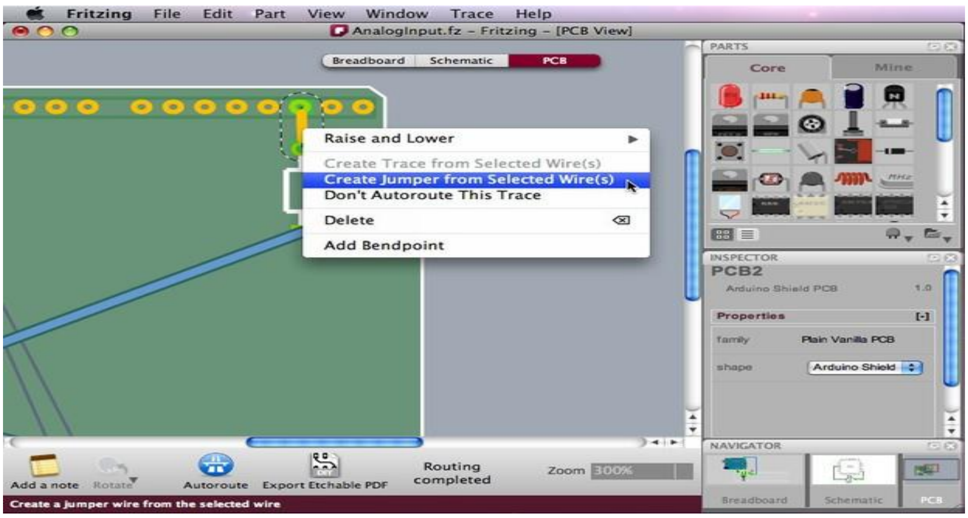
Be aware that if you moved a part after auto-routing or hand-routing, the routing traces are not corrected automatically. You will need to be cautious when moving parts and make sure you don't create any short circuits.

Hand-routing

Use any of the following methods to hand-route traces and jumpers:

1. The safest way is to right-click a Rat's nest wire and choose "Create Trace from Selected Wire(s)" or "Create Jumper from Selected Wire(s)". This will avoid making any changes in the circuit that you built in Breadboard View.
2. Another way is to simply click a part's connector, and drag to make a connection. A trace will be created. To create a jumper, just right-click on the trace and choose "Create Jumper from Selected Wire(s)". To avoid incorrect wiring, we strongly recommend you follow the Rat's nest wire connections while using this method.

Note that while clicking and holding on a connector, all equipotential connectors are highlighted (in yellow). This shows the whole set of connections attached to this particular connection, and can really help to make hand-routing decisions. Once again, take good care not to cross wires!



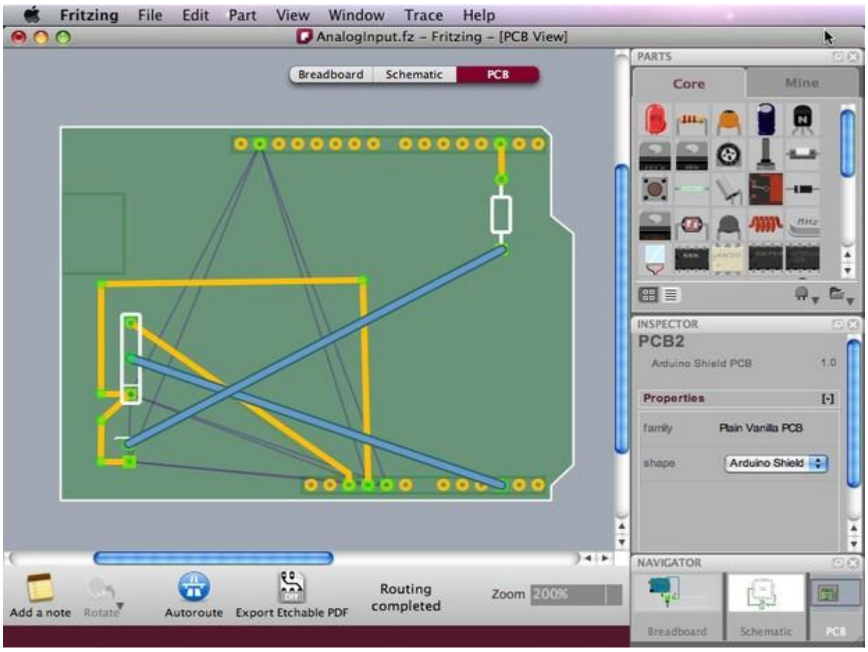
Guidelines for better routing

For both auto- and hand-routing, follow these guidelines:

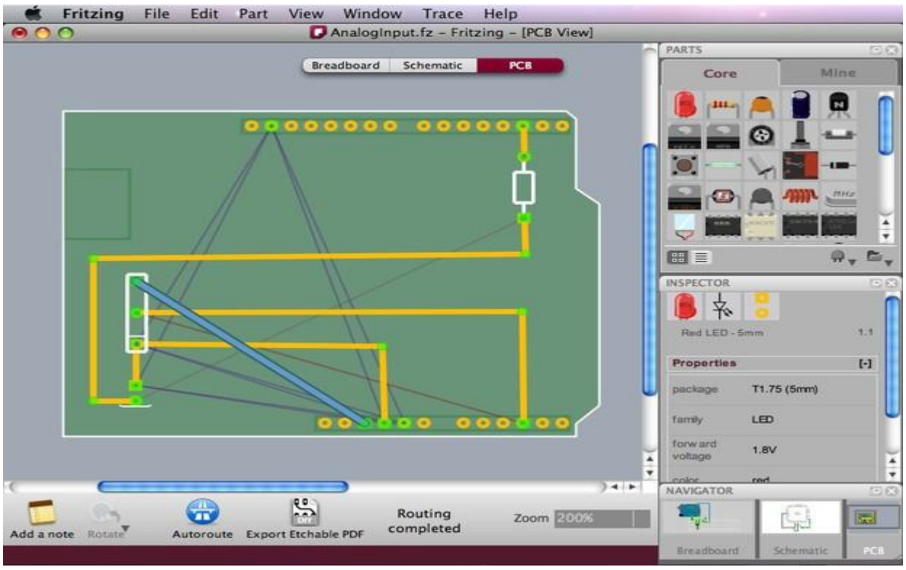
1. Place the parts with the most connections in the middle of the board.
2. Try to get short connections by moving and rotating parts.
3. Use the highlighting of equipotential connectors feature.
4. Add bend points for tidy routing and so that lines do not cross.
5. Don't forget the traces can go under parts like resistors.
6. Use jumper wires instead of watching the auto-route go crazy.

Editing Traces

To achieve a better and nicer design, you would need to edit traces by moving, adjusting width and adding bend points. Width adjustment can be done in the Inspector. Please note that thin traces might ruin in a DIY PCB production, so keeping traces in medium thickness is safer. To create a bend points drag it simply out of a trace.



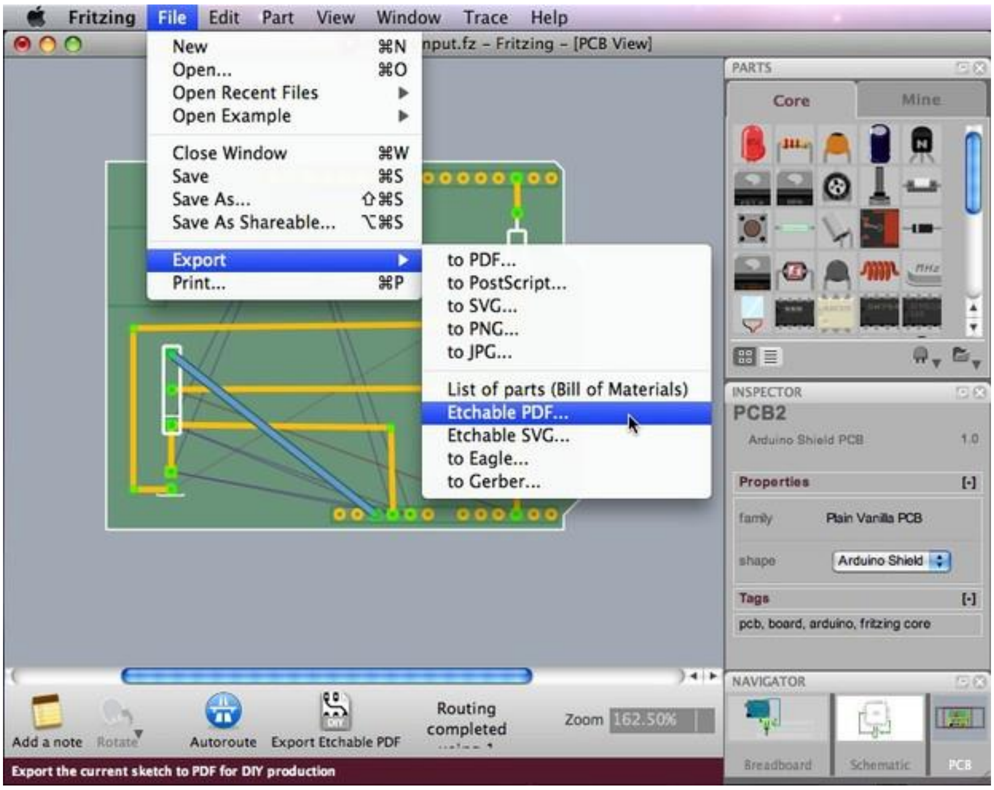
Sometimes, it would be possible to edit traces in a way that will reduce the number of jumpers. The routing in the screenshot above was edited and a better design was achieved:



Export Options

Fritzing features a variety of export options. When you are happy with your PCB design, you can choose to export JPG, PNG, etchable PDF and even Gerber files (for sending a professional PCB manufacturing service). The Bill of Materials option generates a list of all parts in the circuit. From the menu bar choose File > Export > and the desired format.

- For DIY PCB production, use the Etchable PDF option which exports only the necessary design for etching.
- When exporting Gerber files, create a folder for the gerbers, and zip. it before sending to a manufacturer.



So hopefully, this tutorial helped you understand the PCB design process. Good luck and show us what you've done!

Design PCB:-

Step 1: Tools & Materials

Here are the tools and material that you are going to need.

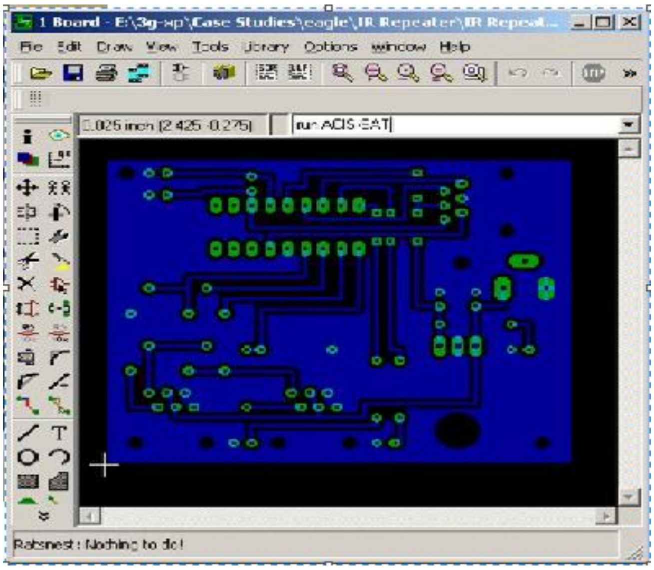
Tools:

- Mini Drill (Dremel)
- Flat Iron
- Laser Printer / Photocopying Machine
- Latex Gloves
- Eye Protection

Materials:

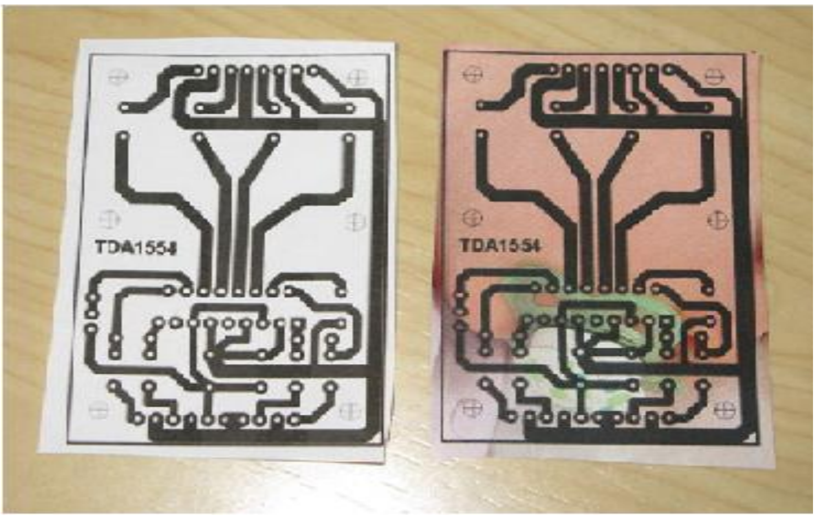
- Etching Solution (Ferric Chloride)
- PCB Board
- Fine Tipped Marker
- Ruler (optional)
- Magazine Paper / Glossy Paper
- Plastic Tweezers / Plastic Straws
- Small Piece of Cloth
- Sanding Paper

Step 2: Making Your Circuit Board Design



If you already have a PCB layout then there's no problem you can just skip this step and go to the other one, you might as well write your design directly on the board, if you don't have plans doing the printing method. Before you make your own customizes PCB board you should first design your own PCB layout. You can can make your own PCB layout by using a decent PCB designing software. For me the best PCB board design software is Eagle Layout Editor, but for people who are looking for a less complicated software can use Microsoft Powerpoint.

Step 3: Printing Your PCB Layout



When you print your layout be sure to use a *Laser Printer* or a *Photocopying Machine*, Inkjet Printers wouldn't work since its ink is soluble with water so it won't transfer its ink on the PCB board. Use any kind of glossy paper, magazine papers would do.

Summary:

What Paper Should I Use:

- Photo Paper
- Magazine Paper
- Glossy Paper

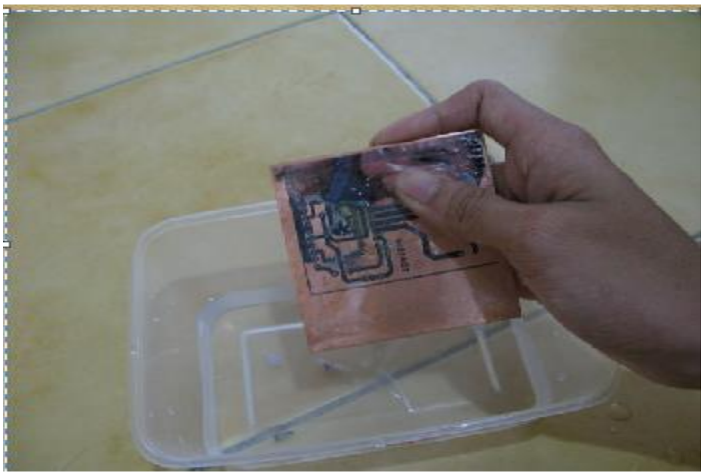
What Printer Should I Use?

- Laser Printer
- Photocopying Machine

Step 4: Ironing The Printed PCB Layout

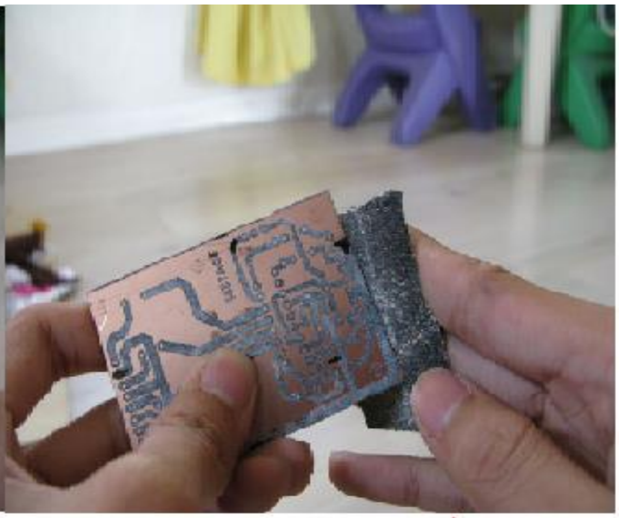
Use a laundry iron to iron your printed PCB layout to your board. Ironing the printed layout transfers the ink from the paper going to the PCB board. You need to set your iron's temperature to the highest setting if your paper is thick but if not, set it to the medium setting.

Step 5: Rubbing The Paper Off the Board



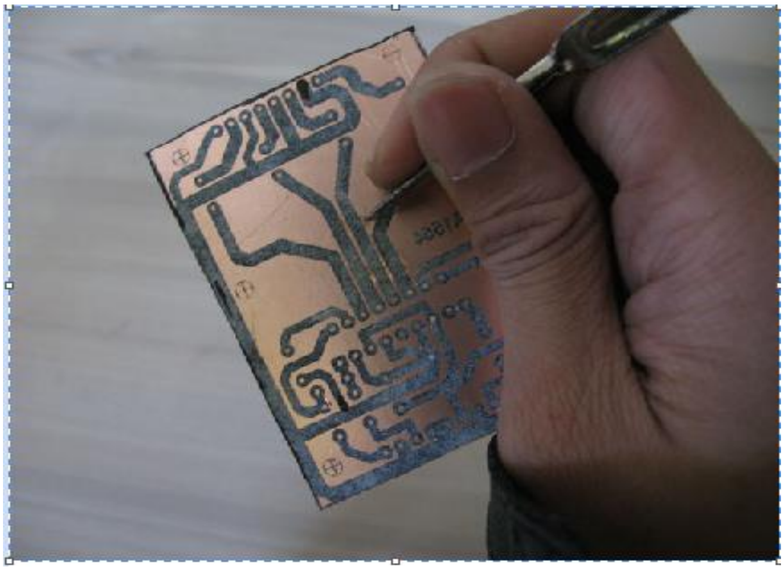
You need to soak the board to a container of tap water for about 2-5 mins, or you can rub it will you expose it on running water from the sink. Be sure to wait until the paper on the board becomes soggy, then rub it gently so the ink wont get removed when you rub the paper off the board.

Step 6: Sawing The Excess Board & Sanding It



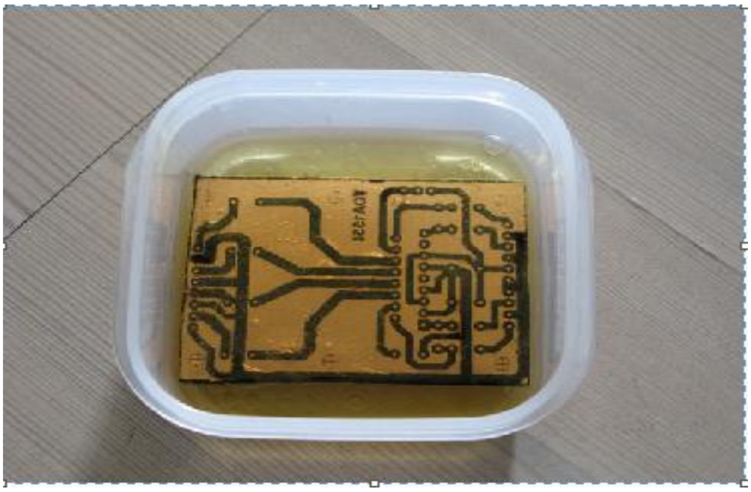
Saw the excess board with a metal saw. Next you need to sand the edges to smoothen the board with sanding paper, kindly use the finer so you will have a finner finish.

Step 7: Cleaning The Board & Restoring It



Even though you have rubbed the paper off the board there will still be excess paper left on the board, remove it using a very sharp object like the tip of the cutter, the point of a sharp compass or a tooth pick. When you had rub it off or you had sawed the excess board, some of the inked areas had been remove unintentionally, you should restore it with a marker and a ruler.

Step 8: Etching The PCB Board

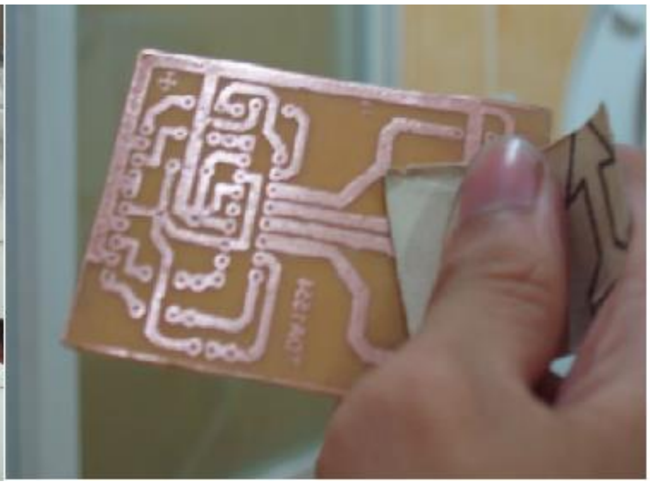


There are different variety of etching solution but the most common is Ferric Chloride. Get a plastic container, never use any kind of metal container. Pour th etching solution on your plastic container. Leave the PCB board for about 30-45 minutes in the container. After for about 30-45 minutes remove it from the container, leaving it for a long time will etch the ink protected area so please remove it when it's done.

Step 9: Rinsing The Board

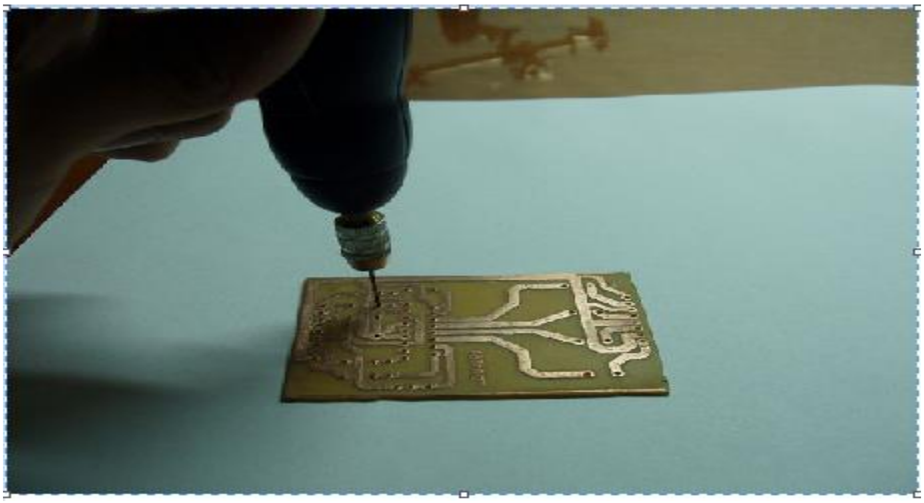
Rinse the PCB board with tap water, after etching it in the solution. Be sure to wear glover when cleaning it. It is advised to use plastic tweezers, please do not use metallic materials like pliers or your tool will end up like mine's, its rusty.

Step 10: Removing The Left Ink

First you should brush the remaining ink with laundry soap after etching the board to expose the copper part of the board, or you could clean it with a small piece of sanding paper (fine) while give it its shiny finish.

tep 11: Drilling The Holes



Drill the board with a mini drill a dermal tool will do. After drilling it rinse it again with water. Be sure to drill it on the copper side, since the copper layout will be your guide where to drill.