
DVD-46C

Introduction to Mechanical Assembly

Below is a copy of the narration for DVD-46C. The contents for this script were developed by a review group of industry experts and were based on the best available knowledge at the time of development. The narration may be helpful for translation and technical reference.

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Introduction

Electronic Products begin as an idea. Bringing that idea to life requires a team of creative and dedicated professionals, each performing their specific part in the manufacturing process.

Fabrication of the printed circuit board is the foundation of each electronic assembly. Next, electronic components are placed on the board and soldered. The final step is to attach any mechanical hardware and install the finished assembly into a cabinet.

This video will take a look at the tools and hardware that are used during this mechanical assembly process. We'll also discuss the proper installation of hardware. Then we'll show the interconnection of electronic assemblies, and finally, the construction of the cabinet. Many of the mechanical assembly processes also involve soldering. In this video we will focus on the hardware or mechanical portion of the assembly.

Let's begin by looking at some of the handling considerations that you'll need to be aware of during the performance of your job. Electronic Assemblies are very fragile, and mishandling can easily result in bent component leads or electrical damage to the components. To minimize contact with the circuit board or components on the board, the board should always be handled by the edges. Some companies require employees to wear gloves during the assembly process. Touching the board with your bare hands will leave a film of oil, moisture, and salt. This residue contaminates the board and will eventually corrode connections on the board causing increased soldering defects and potential electrical failures.

Also be aware that one of the main reasons for electrical failure of an assembled circuit board is damage to components due to electro-static discharge, or "ESD". You naturally build up static electricity in your body as you move due to friction. This static electricity can be discharged into the components when you touch the board or come within arms' length of the board. Wrist straps and heel straps are designed to dissipate static electricity safely. They should always be worn in

areas electronic parts or assemblies are located. Remember, heel straps don't do any good unless you keep your feet on a grounded surface.

There is another reason that it is not a good idea to handle boards by the surface. Sharp lead ends may protrude from the board and they can cut your fingers. If you have any questions you should check with your supervisor. Each company has their own specific handling practices and your supervisor or team leader can inform you about the proper procedure for your department.

Now let's talk about your work environment. Designing work stations and tools to be compatible with the way the human body works has become more of a concern in recent years. This practice, called "ergonomics," has been shown to reduce injury and stress, while at the same time increasing productivity.

People come in different sizes and shapes. Some of your work stations are adjustable to allow you to place the work-surface at a height that is comfortable to you. If you need to use components and tools frequently, it's most efficient to arrange them around your position in a semi-circle. One of the primary benefits of ergonomic planning is the reduction of bending, reaching and stretching that can make your job more tiring than it needs to be.

Another result of ergonomic thinking is that more tools are now being designed to better fit your hand and tools are being redesigned to perform specific jobs more easily and efficiently. Since you may repeat the same assembly task often throughout the day, it's helpful to keep in mind some hints on how to reduce cumulative trauma disorder, sometimes called repetitive motion fatigue. The proper size tool can reduce the amount of excess motion and exertion. Always grasp the tool firmly. Keep your wrist straight: It should be in line with your forearm. Remember, the goal of ergonomics is to increase your personal safety and reduce fatigue and stress.

Now let's take a look at the steps involved in the entire assembly process. This overview will help you understand the context of the specific Mechanical Assembly operations you may be performing.

Any assembly process begins with reading the Process Instructions. The Process Instructions should break down the board assembly steps by station. Each job, or group of boards going through the same assembly process, should be accompanied by these instructions.

The Process Instructions will include a parts list, called a bill of materials or BOM which tells you which components are needed.

The documentation may also include Assembly Drawings. The drawings may show parts placement and the overall layout of the board and the final assembly.

The Assembly Drawings may also include partial, exploded, or color-coded views to explain specific details of the drawings. The engineers who have designed the assembly will indicate the correct placement of components and mechanically assembled hardware on these drawings.

Items such as washers, spacers, insulators and shields must be installed correctly according to the documentation or they may not function properly.

For more information on workmanship standards relating to mechanical assembly, see the IPC document A-610: Acceptability of Electronic Assemblies and the ANSI / J Standard-001.

In addition to the Bill of Materials and the Assembly Drawings, Process Instructions may also include Method Sheets. The Method Sheets will tell you which parts or components need to be mechanically assembled, how to assemble them, and in what order.

The first step in the assembly process is preparing the electronic components for placement. Using the Process Instructions, people in the stock area pull the parts needed for each specific board run and place them into bins or ESD protective bags. This is called picking parts, or kitting.

To prepare components for placement, it may be necessary to bend or form the leads. The placement of components onto the board can be done by machine, by hand placement or insertion, or by Operator-Assisted Hand Insertion machine.

All components that will be attached by an automated soldering method must be placed on the board at this time. Automated soldering includes wave soldering for through-hole components and a variety of reflow soldering methods used for surface mount components. The Process Instructions or Method Sheets will tell you which components can safely be attached before automated soldering. Certain components can be damaged by the preheating and soldering process, the board cleaning process, or possible chemical reactions with flux. These components need to be attached later. Like components, some mechanical parts must also go through automated soldering to provide an electrical connection and secure their mechanical connection.

Portions of the board may need to be masked to protect against solder adhering to areas which must be kept free of solder. These may include surface mount lands and open through-holes which need to be soldered during final assembly.

Each board may be inspected several times during the assembly sequence. The best time to visually inspect for component orientation, polarity, and correct values is before the components are soldered to the board. Also check that components and connectors are not tilted or angled farther than is allowed by workmanship standards. For more information on these specifications, again you can refer to section three of IPC document A-610. Again it is much easier to correct these problems before automated soldering than to rework them later.

After the automated soldering and cleaning process, any remaining components and hardware are attached to the board. Plated hardware should be attached to the board after wave soldering. Otherwise it may build up deposits of solder as it passes through the molten solder during wave soldering.

Other components and hardware that should be assembled after automated soldering include water or flux sensitive parts such as LEDs, lights, and switches; and heat sensitive parts such as fuses, plastic capacitors, and nylon washers.

Next, all components and hardware on the board may be visually inspected to insure that they provide sound mechanical connections. When necessary, electrical connections may also be checked at this time. Automated electrical testing is called "In-Circuit Testing" or ICT.

Parts used to mount the board into the final assembly are attached to the board after automated soldering. Later in this video we will show examples of the installation of "mounting parts" such as card ejectors, handles, and face panels.

The next step is cabinet assembly, where the shell of the product is built, boards are mounted into the cabinet, and the electronic assemblies are inter-connected.

Finally, the completed product may be tested to make sure that it functions as designed.

Tools

In this next section we will discuss general categories of tools used in the mechanical assembly process.

Drivers are often used to fasten threaded hardware. The most common driver is the hand screwdriver, but drivers can also be electric or pneumatic.

There are many types of fastener heads that we'll discuss in the section on hardware. It is important to select the driver that will fit the fastener head squarely and firmly. The wrong size or shape of driver can strip the fastener head or the driver tip.

Wrenches are another way of tightening threaded fasteners. The wrench end will be either a socket, box end or open end. Once again, it is important that the tool fits squarely and snugly.

Adjustable wrenches can be useful in non-critical situations such as a cabinet assembly where torque, or amount of tightness, is not specified. They should never be used to work on the board.

Both drivers and wrenches can be fitted with torque devices so that the tool will stop tightening when a pre-specified torque setting or tightness has been reached. Different materials, components, and fastener sizes can withstand different amounts of torque. Over-torqueing can easily crack a board, component, or fastener, possibly resulting in the scrapping of an entire assembly and a big waste of time and money. Under-torqueing can allow hardware to work loose over time. Never use a hand torque wrench to remove fasteners. This can damage the tool or change the torque setting of the tool.

Needle-nose pliers or tweezers are tools often used in the mechanical assembly process to reach into tight areas. The small tips can hold parts too small to hold with your fingers or place parts more accurately.

Cutters are used to trim protruding leads and to cut wires to length. Cutters may have either straight or angled blades. Also they come in various sizes. The correct size cutters should be used for each job

One method of attaching wires to the board is with a crimper. First strip the wire, then insert it into the crimping hardware and squeeze the tool to compress the connector end of the hardware. The connector is usually called a lug. Crimping provides both a mechanical and an electrical connection.

A drill is typically used in the mechanical assembly process to rework, repair, or modify a board. If the electrical design of the board has changed since the board was manufactured, a drill tip called a ball mill may be used to interrupt an electrical path which is no longer needed.

Adhesive is another tool commonly used in the mechanical assembly process. Some components may be elevated above the board surface to avoid overheating. If a component is large, adhesive may be used for additional support. Be careful that the adhesive does not get on your hands or areas of the board where it is not needed. You may have to cut away un-needed adhesive. A non-elevated adhesive bond may also be used to hold components in place for wave soldering. These components may also be bonded with adhesive tape or double-sided foam tape.

The process by which hardware is attached to the board with a press is called a "swaging operation." Swaging presses may be powered pneumatically, or mechanically, by hand. A hand press is called an "arbor press."

Swaged hardware is pressed through a plated barrel hole or non-plated hole drilled in the board. Pressing flattens and widens the hardware, creating a flange on the back side of the board which provides a mechanical hold. Two types of flanges are funnel and rolled.

If the swaged part has been pressed into a plated through-hole, wave soldering can be used to further improve the mechanical and electrical connection. Parts are less often swaged into plated through-holes because of the possibility of damaging the barrel wall during the swaging operation.

Hardware

The next section covers the hardware used in the mechanical assembly process and how to attach the hardware with the tools we just discussed.

The part numbers for each piece of hardware will be found on the bill of materials. Parts may be supplied to you in bins or bags marked with the part number.

First we will discuss two types of threaded fasteners: bolts and screws.

Bolts are used to fasten two or more parts. They require a nut or threaded device to remain secure.

Screws may also be used with securing hardware. Some screws are capable of being used without pre-threaded mating surfaces. Thread forming screws are used when there are no threads on either part to be attached, such as plastic cases or enclosures. Machine screws are used when the part or parts needing to be fastened already have threaded holes. Machine screws require a nut or other threaded device to fasten. Some components may have non-threaded holes through which a bolt or screw may be inserted and fastened with a nut.

Bolts and screws come in a variety of head types. These include pan-head, round-head, and flat countersunk. There are also hex, and recessed hex heads. Flat countersunk screws are flush with the surface of the board or component when fully tightened. They are used in situations where clearance is an issue.

Threaded fasteners also come in a variety of drive types. Each type of drive requires the matching type of driver tool. A slotted or straight drive fastener requires a bladed driver. A fastener with a recessed cross point drive requires a Phillips driver. Recessed cross point fasteners are often small and can easily strip or burr if the correct size Phillips driver is not used. A double drive fastener may be tightened with either a bladed or Phillips driver. This is one of the few situations where it would be acceptable to use a bladed driver with a cross point fastener. Other drive types include the hex pattern which uses a specific wrench to tighten, and the recessed hex pattern which uses an Allen wrench.

Make sure that the driver is the proper size to fit snugly into the head of the fastener. A loose fit can allow the driver to slip from the slot and strip the head of the fastener or damage the board or component. A stripped head can make the fastener very difficult to tighten or remove.

When a fastener is driven through the board, a wrench is used to hold a nut on the other side. Make sure that the threads of the fastener are matched to the nut. There are two thread types: Universal Fine called UNF, and Universal Coarse called UNC. UNF is more likely to be used to attach components or hardware to the board, while UNC bolts are typically used to assemble the final cabinet. In addition to the thread size, the diameter of the bolt, nut, and board hole must also match. Unmatched hardware just won't fit together and cannot be properly fastened.

A final note on threaded fasteners: The process instructions may call for a thread sealant to be used with screws, bolts, and nuts. Otherwise, vibration could cause the mechanical connection to work loose over time. The sealant is dispensed into the threaded fastener holes and onto the bottom third of the threads of the fastener. When all fasteners which require sealant have been tightened, the sealant is allowed to cure before the board is stressed or any further assembly takes place.

Washers are often used with threaded fasteners. Flat washers distribute the stress of fastening to the surrounding material and protect the surface of the board or component from being damaged by the twisting action of fastening.

Locking washers dig into the surfaces they come in contact with, providing an additional bond. Lock washers come in several shapes: the two most common are split and star. Remember to orient the lock washer so that the non-locking side is against the soft surface to avoid damage to

the board surface. There is an exception to this general rule: In some cases a star washer may be used to make contact with a grounding surface on a board.

Insulating washers are used to slow the transfer of heat between heat-generating components and the board. Or they may be used to isolate differing voltage potentials on the board. Placement is critical. If the insulating material is not against the board, heat can easily transfer to the board.

In addition, a sleeve may be used to insulate and shield the component lead or fastener as it passes through the through-hole in the board.

In some cases it is desirable to transfer heat from a component to the board or a heat sink so that the component does not overheat. Thermal material is placed between the component and the board, the component and a heat sink, or a heat sink and the board to facilitate the transfer and dispersal of heat.

Without heat sinks, components such as voltage regulators, power transistors, and some microprocessors will not function reliably. Heat sinks moderate the temperature of the component in two primary ways. One is by exchanging heat with the surrounding air. This type of heat sink may stand up from the board. Another type of heat sink lies flush with the board and dissipates heat into the board, as well as into the air. Care should always be taken during installation. For a heat sink to dissipate heat efficiently it must not be cracked or have any of the fins broken off.

A mounting spacer is another method of protecting the board from heat build-up. The spacer is used as a stand-off or heat-sink between the board and a heat generating component.

Another way to cool components is to mount a small fan directly on a microprocessor with clips or adhesive. Then electrical leads are attached to the fan according to the process instructions.

Next on our list of hardware used in the mechanical assembly process is the clip. Clips are mounted to the board with a bolt or screw or may be soldered into place. A component or heat sink may be pushed into the clip and held in place on the board by mechanical tension.

A pem nut, is a threaded nut which is "swaged" or pressed into metal on the surface of the board, the face panel, or the chassis. They are designed to provide a location to attach a bolt.

The opposite idea of the pem nut is called a stud. A stud is a bolt or screw which receives a nut or threaded hardware. The stud protrudes from the chassis into which it has been swaged. The stud provides a location for an electrical connection or a mounting location for a component or hardware.

To hold the board away from other boards or devices, a stand-off may be used. A metal plated, stainless steel, or aluminum stand-off will be attached to the board with a screw. Nylon or plastic stand-offs may be attached with screws or may have barbs which provide a mechanical hold through the board.

Terminals may be swaged and soldered to the board to provide a termination site for discrete wires. There are several types of terminals; some of which may provide more than one termination site. For more information on Hand Soldering Terminals, you may want to refer to IPC video VT-14.

A spade is soldered or swaged into the surface of the board. The mating spade connector is crimped onto a discrete wire and the connector is pushed onto the spade. This friction fit holds the connector in place.

All these discrete wires connecting to the board can interfere with other boards or assemblies if you don't bundle them together. Tie wraps, spot ties, or waxed lacing are used to organize and route wires away from locations where they may interfere with access to other components on the board.

Test pins provide a convenient site to test circuits on the board. They may be soldered or pressed into the board using the swaging process.

To mount hardware that must move, such as a card ejector, a roll pin is pressed through the hardware and the board. A roll pin allows rotation on its axis.

Hardware can also be attached to the board with a rivet. Rivets are pressed through the board and flared on the back side.

Card stiffeners may be used to help an assembly withstand vibration during final usage. Stiffeners also insure that a board won't warp or bow during wave soldering or get twisted during all the handling required in the assembly process. Card stiffeners are often made of stamped metal and are mounted to the board with bolts, screws, or made of non-conductive materials and mounted with adhesive.

Stamped sheet metal may be used to shield the components on the board from RFI (radio frequency interference) or EMI (electro-magnetic interference). These shields can also be made of foil which is tack soldered to the board. A type of shield called a tin can is also used to shield components.

A face plate may also be part of a chassis or it may be mounted directly to the edge of the board. The face plate may hold a connector in place and provides support against the mechanical stress of interconnection. The hardware used to mount face plates includes bolts, screws, nuts, and washers.

Handles may be attached to the board so that the installer doesn't have to touch the board surfaces.

Connectors or couplings may be mounted with screws, bolts, or nuts onto the board or the face panel. They provide an electrical connection to integrate the board into the final cabinet assembly.

That wraps up our look at some of the more common types of hardware and parts that are mechanically assembled.

Cabinet Assembly

In this final section, we will discuss the assembly of the cabinet. The board or boards, and all other mechanical devices are mounted into a box which the customer will see as the final product.

Some cabinets, such as a computer cabinet, may be built around a board cage, or card cage. This is the frame to which the boards and sides are attached. Card guides are mounted on the cage to receive the boards. The board will then slide onto the guides.

Sometimes boards are mounted directly to the cabinet.

After the boards are inserted into the cabinet, the electrical leads must be interconnected with the other devices and controls. Some connections have already been made at the time the boards were inserted into the slots in the board cage. Other connections are made with bundled wire cables or ribbon cables. These are plugged directly into connectors on the board.

Interconnection can also be made by discrete wires which are soldered or crimped to terminals on the board. These discrete wires may be part of a wiring harness used to distribute power from the power supply to each individually functioning circuit in the assembly. Once again, refer to your Process Instructions for the specific design. It should clearly lay out the routing of each wire connection.

In some assemblies, flexible circuit boards function in a similar way to ribbon cables or wiring harnesses. Flex circuits should be installed in the very last stages of the assembly operation because the material they are made of is more fragile. Be extra cautious in the areas where connectors are attached to the flex material.

Face panels are used to enclose the cage, protecting the components from dust and from being touched or bumped. User interface components such as switches, LED's, and meters are attached to the face panels. Also I/O ports, fans, connectors, and A/C inputs are secured to the panels that make up the cabinet.

After a final functional test and inspection, the product is labeled for consumer use, packaged, and shipped.

This program has presented an overview of the mechanical assembly process. By way of introduction, we've talked about issues related to assembly such as Electro-Static Discharge, board handling, ergonomics, and summarized the entire assembly process. Then we looked at the tools and hardware used in mechanical assembly. Finally we talked about the construction of the cabinet which houses the electrical assemblies. If you and the other members of your mechanical assembly team perform your jobs well, the final electronic product should function safely and properly for years to come.