Chapter

1

Drawing Electrical Diagrams

In this chapter, we will learn the following to World Class standards:

- **Training Designers to Draw Electrical Diagrams**
- **Creating Electrical Symbols for an Electrical Diagram**
- **Creating a Terminal Block Symbol**
- **Creating a Ground Block Symbol**
- **Drawing the Electrical Schematic using Blocks**
- **Creating an Electronic Symbol Library**

Training Designers to Draw Electrical Diagrams

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When training an individual to design products that utilize electricity to function, we need to start with the simplest of products and add complexity as we continue in our experience. There are several reasons to progress in this manner. One, the use of electricity in a product introduces a degree of danger that the designer did not see in developing mechanical assemblies. While drilling holes and shearing metal can result in bodily injury, the danger was visible. When working with electricity, the flow of electrons is invisible to the eye and an inexperienced Designer or Engineer can inadvertently touch a live circuit, which results in an electrical shock. Therefore, we need to include an additional level of safety in our training and designs.

One of the simplest electrical products to construct is designing an on-off switch assembly. The project on these units will include drawing an electrical diagram, creating multiple purchase part drawings, making fabrication drawings, creating graphics and building an assembly drawing. All of these tasks are simple to achieve and yet deserve attention to construct a workable product.

The first step is to draw the electrical diagram. We will learn how to make a handful of electrical symbols, then draw a simple wiring diagram and lastly build a Computer Aided Design (CAD) electrical symbols library.

Creating Electrical Symbols for an Electrical Diagram

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The key device in our electrical assembly is the toggle switch to turn on our device. You can use a toggle switch like the one shown in figure 1.1 or you can substitute the device with an equivalent part that can switch the same amount of electricity. Some designers will pick a switch actuator or human interface with a lower profile like a pushbutton. Others will concentrate on choosing a more decorate toggle or one that is colorful. Whatever the feel the person gets from using the device, the actuator will not affect the overall action resulting from turning the switch on or off.

In our assembly, we are switching the following electrical parameters.

Action: On – Off
Actuator: Maintain Toggle
Nominal voltage: 125 volts AC
Current: 10 amps inductive load
Poles: Single

Figure 1.1 – Shape of the Socket

We went out on the Internet to find a switch that will meet our parameters and found a device made by Eaton Corporation. With this switch, we can choose three different ways to attach wire to the device. One is by screw terminal, the other is by soldering and the last is by spade terminal. The switches come in different circuit configurations, such as On – Off – On, On – Off and On – On. We can pick a maintain action where the toggle stays in the position set or a momentary action where the toggle stays in a certain position and we close the circuit for a brief time.

Momentary switches are like the buttons on a keyboard where a computer user sends a short signal representing a letter or number to the computer. The maintain switch is like the light switch on the wall where the on position keeps the ceiling light on. Figure 1.2 shows the switch selected.

ECONOSWITCH E10E SERIES TOGGLE SWITCH PRODUCT SELECTION

Type of Operation	Current Ratings — Amperes						Circuit with Lever Position			Screw Terminals
	28 Vdc			115 Vac, 60 or 400 Hz					Down (Keyway)	Catalog Number
	Lamp Load	Resistive Load	Inductive Load	Lamp Load	Resistive Load	Inductive Load	Up	Center		
One-Pole										
Maintained	5	20	15	3	15	10	ON	OFF	ON	E10E118DS
Maintained	5	20	15	3	15	10	ON	NONE	OFF	E10E118AS
Maintained	5	20	15	3	15	10	ON	NONE	ON	E10E118ES
Momentary	4	15	10	2	15	7	ON❶	OFF	ON❶	E10E118GS
Momentary	4	15	10	2	15	7	OFF	NONE	ON❶	E10E118BS
Two-Pole										
Maintained	7	20	15	4	15	15	ON	OFF	ON	E10E218DS
Maintained	7	20	15	4	15	15	ON	NONE	OFF	E10E218AS
Maintained	7	20	15	4	15	15	ON	NONE	ON	E10E218ES
Momentary	5	18	10	2	11	8	ON❶	OFF	ON❶	E10E218GS
Momentary	5	18	10	2	11	8	OFF	NONE	ON❶	E10E218BS

❶ Momentary contact.

Figure 1.2 – Selecting the Toggle Switch from the Eaton Online Switch Catalog[1]

Before making a schematic of the simple circuit, we need to draw the electrical symbol for a switch and store the symbol in our library for future use. Set the grid by right clicking on the Grid on the Status bar at the bottom of the graphical display and the Drafting Settings window will appear as shown in Figure 1.3. Set the Grid X and Y spacing to 0.25 and the Snap X and Y spacing to 0.03125. When we draw electrical diagrams and schematics, we can work much quicker when our symbols and lines are on a grid. The principle applies not only to electrical diagramming, but also to hydraulic and pneumatic circuits we will construct in the World Class CAD Civil Design textbooks.
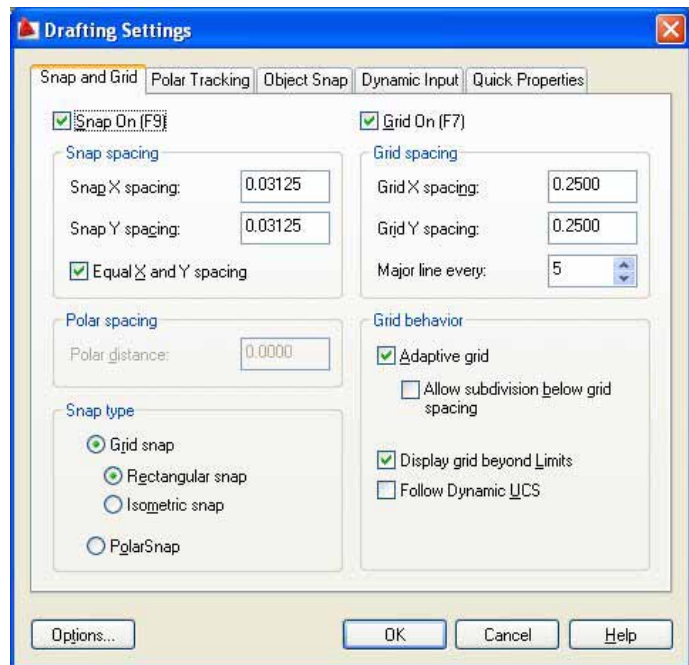
Figure 1.3 – Setting the Grid and Snap

[1] E10 Toggle Switch Catalog, 2008, Eaton Corporation
http://www.eaton.com/EatonCom/Markets/Electrical/Products/LogicControl/PushbuttonsSelectors/E10ToggleSwitches/index.htm

To make the switch symbol, we draw a single circle using a grid point as the center point and snap the aperture one snap poistion to the right to draw a 0.0625 diameter circle. Draw another circle 0.25 to the right on another grid point. Draw a line from the right quadrant of the first circle to the tangent point shown in figure 1.4. Rotate the line that represents the wiper of the switch symbol up 30 degrees using the left side of the line as the base point. The switch should appear as shown in figure 1.5.
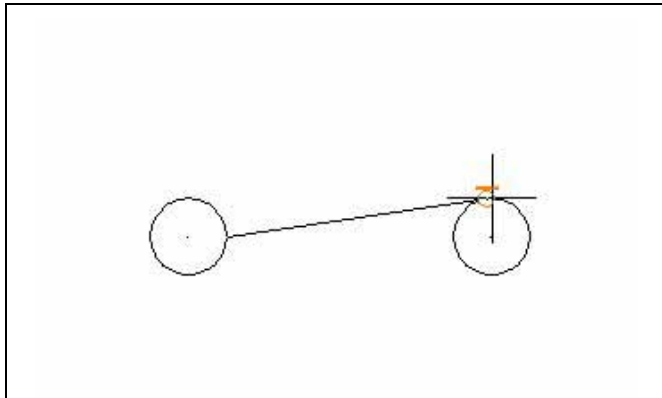

Figure 1.4 – Drawing a Switch Symbol   **Figure 1.5 – Rotating Wiper 30° Upward**
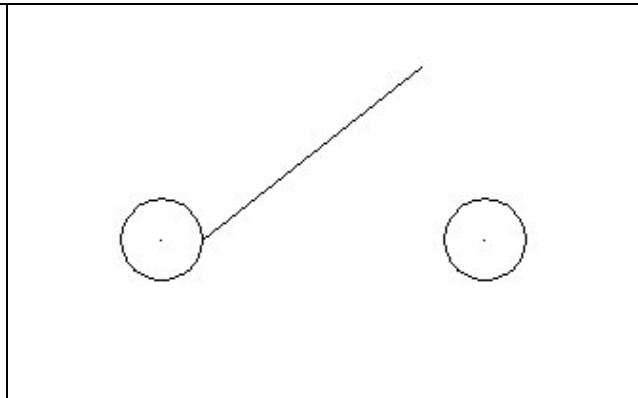
Before making our first electrical symbol block, we need to add the attribute definition by typing **Attdef** at the Command line. The Attribute Definition window will appear on the graphical display. Check the Constant checkbox in the Mode section of the window and the Prompt Attribute will grey out. For the Tag Attribute, type S, which is the letter assigned to designate a switch. The Default Attribute is "S". For the Text Settings, the justification is Right and the text height is 0.09375. When we press the OK command button as shown in figure 1.6, we will be able to place the S below and in the center of the switch as shown in figure 1.8.
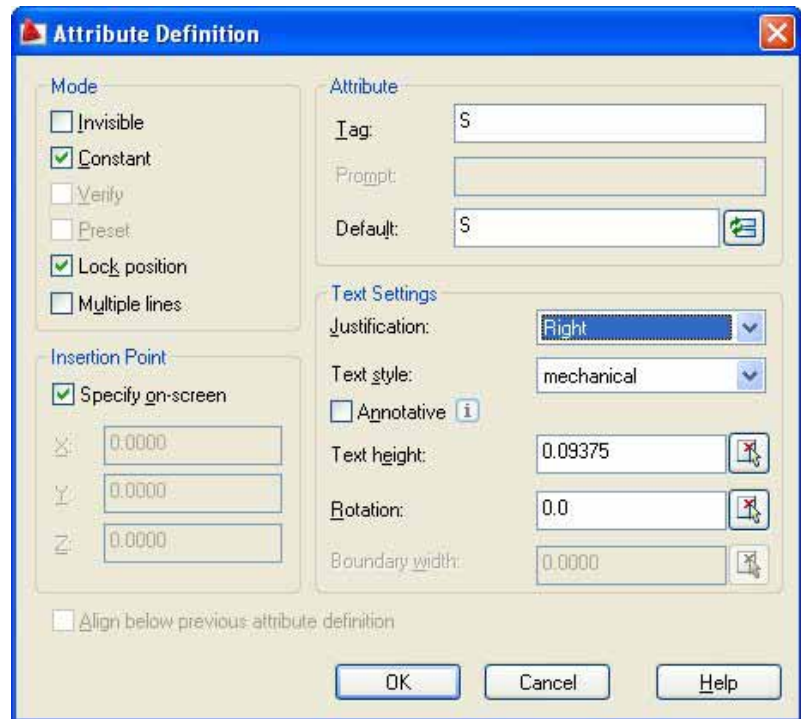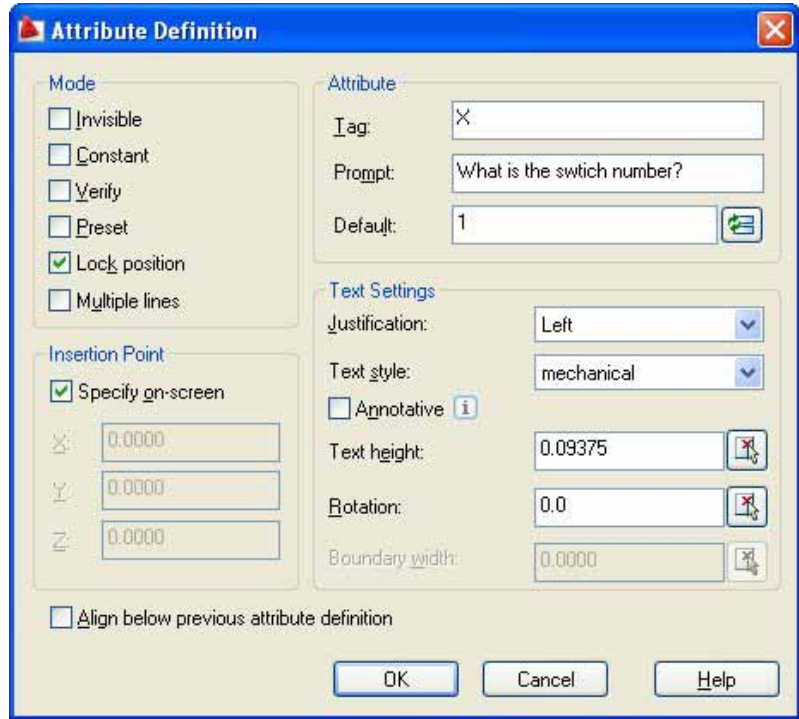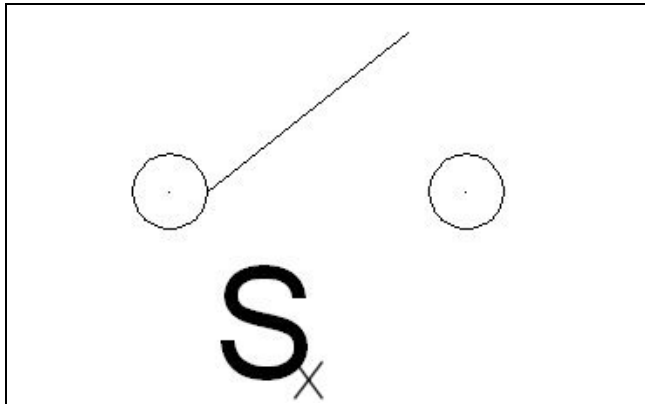

Figure 1.6 – Adding a Constant Attribute

When inserting the switch symbol in a drawing, we will only have to type the switch number when prompted since the S will always be constant in the symbol. Next, we need to add the variable attribute that will hold the switch number.

Again, type **Attdef** at the Command line. The Attribute Definition window will appear on the graphical display. Uncheck the Constant checkbox in the Mode section of the window and the Prompt Attribute will appear. For the Tag Attribute, type X, this will show us the position of the switch number. The Attribute Prompt is "What is the switch number?" The Default Attribute is "1". For the Text Settings, the justification is Left and the text height is 0.09375. When we press the OK command button as shown in figure 1.7, we will be able to place the X below and in the center of the switch as shown in figure 1.9.

Figure 1.7 – Adding a Variable Attribute

Figure 1.8 – Placing a Constant Attribute
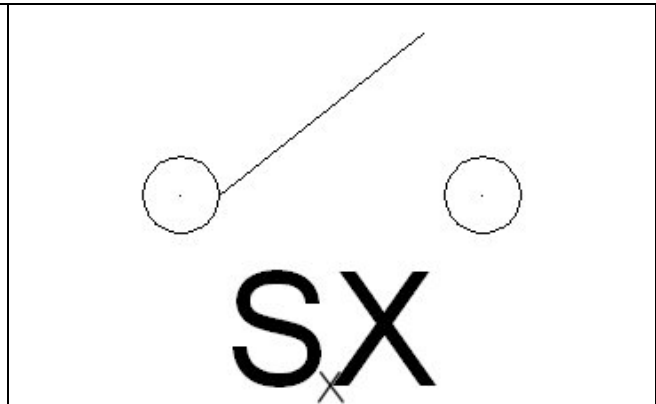
Figure 1.9 – Placing a Variable Attribute

To finish making our first electrical symbol, we select the Create Block tool on the Ribbon above the graphics display. The Block Definition window will appear as shown in figure 1.11. The Block name will be "switch_spst". We should put the electrical category in the name first, followed by the more specific definition such as SPST, meaning Single Pole, Single Throw.
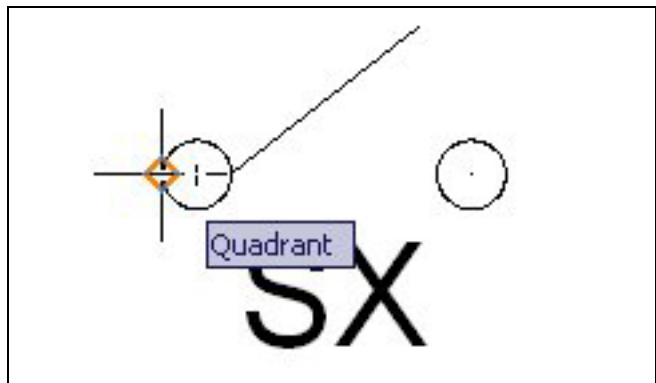

Figure 1.10 – Picking the Insertion Point

Use the Pick Point button to select the insertion point of the electrical symbol as shown in figure 1.10. Then pick the Select Objects button and select the two circles, the line the "S" and then the "X". When we insert a Block with Attributes into a future drawing, the prompts will be asked in the order that we select them when creating the block. Pick the Delete radial button to remove the block from the graphical display. We can make the block so the symbol cannot be exploded, so we uncheck the Allow Exploding checkbox. If you are building an entire block library, we suggest that a description would be appropriate. After all of these items are complete, select the OK command button and the block is now located in the local drawing file. Eventually we will use the Wblock command to move the information to a separate file.
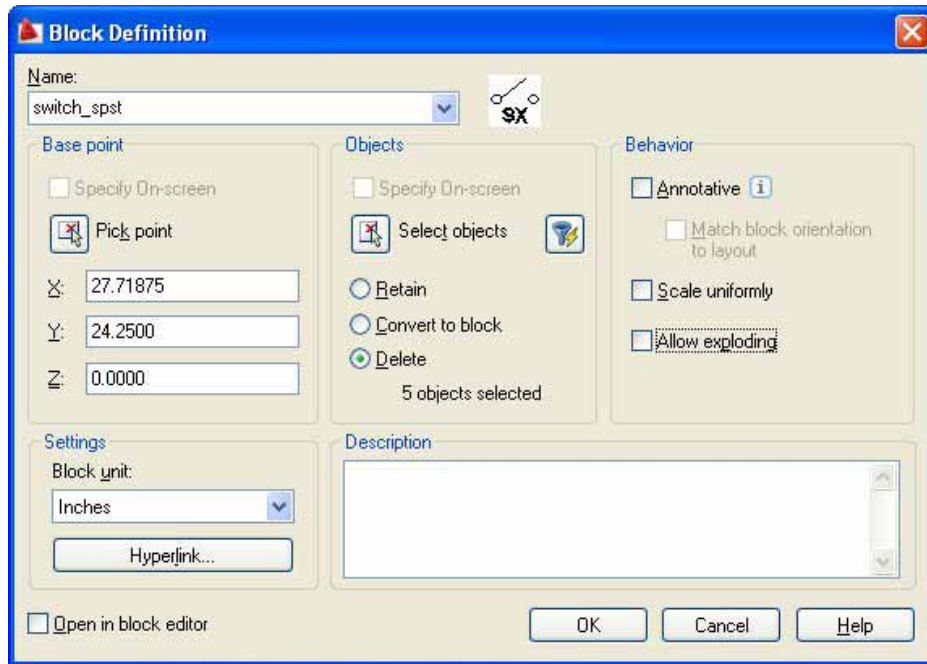

Figure 1.11 – Creating the Block Definition

Creating a Terminal Block Symbol

The second electrical symbol we will make is one for a terminal block. A terminal block typically is long electrical device that has screw down terminal to land a wire from an external device. On the opposite side of the terminal block, just across from the external wire is the internal screw terminal. The external and internal terminals are connected by a bus bar. Figure 1.12 shows a terminal block used in the communications industry that has hundreds of connections from the outside world.

Figure 1.12 – Terminal Block

The terminal block needs to be rated for the following specifications:

Terminals: 3
Nominal Voltage: 125 VAC
Current: 10 Amps
Wire Gauge: 18 AWG

Figure 1.13 – Terminal Block made by Buchanan[2]

We will acquire a Europa Terminal Block made by Tyco Electronics as shown in figure 1.13. This terminal block can be cut down to three terminals, has a voltage rating of 250 volts AC and a current capacity of 30 amperes.

To begin to create the electronic symbol for the terminal block, Draw a rectangle that is 0.50 wide by 0.25 as shown in figure 1.14.
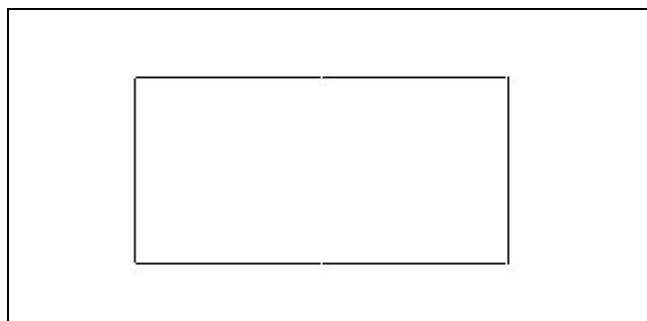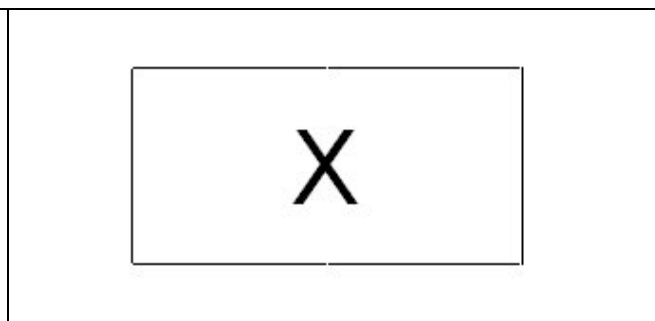

Figure 1.14 – A Terminal Block Symbol   **Figure 1.15 – Adding the Attribute**

[2] Europa Terminal Block, 2008, Tyco Electronics Corporation,
http://catalog.tycoelectronics.com/catalog/bin/TE.Connect?C=16696&M=PPROP&P=&BML=&LG=1&PG=1&ID
S=370022,370023,370024,370009,370010,370012,370014,370015,370016,370018,370019,370021,370025,370026,
370028,370029,370030,370031,370032,370034&N=1#features

Type **Attdef** at the Command line. The Attribute Definition window will appear on the graphical display. For the Tag Attribute, type X, this will show us the position of the switch number. The Attribute Prompt is "What is the terminal number?" The Default Attribute is "1". For the Text Settings, the justification is Middle and the text height is 0.09375. When we press the OK command button as shown in figure 1.16, we will be able to place the X in the exact center of the terminal block as shown in figure 1.15.
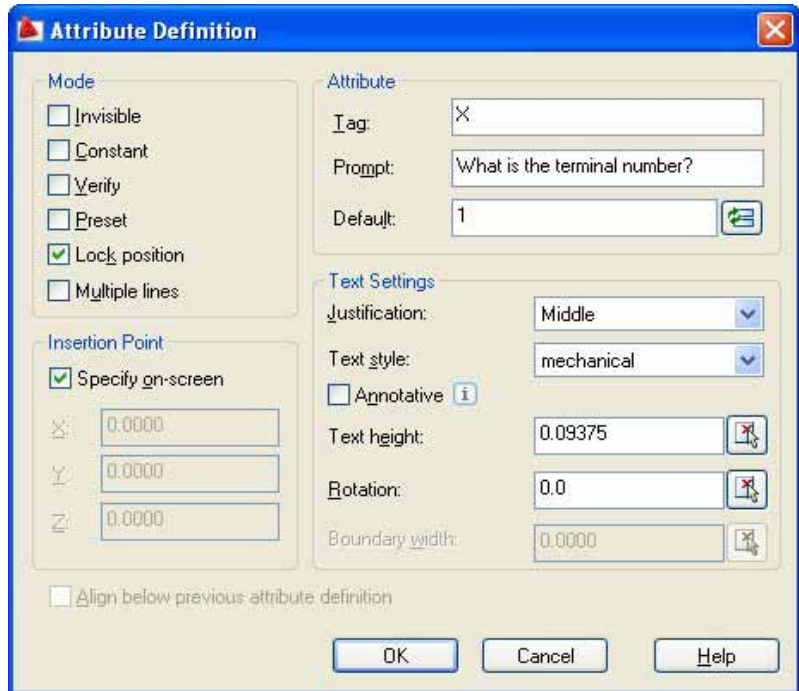

Figure 1.16 – Adding a Constant Attribute

To finish making our electrical symbol, we select the Create Block tool on the Ribbon above the graphics display. The Block Definition window will appear as shown in figure 1.17. For this electrical symbol's name we will type in the textbox "terminal_block".
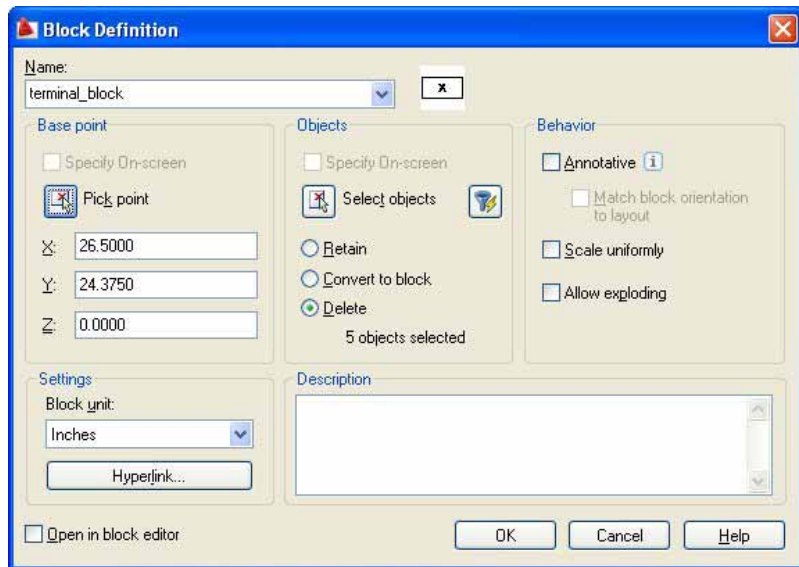

Figure 1.17 – Creating the Terminal Block Definition

Use the Pick Point button to select the insertion point of the electrical symbol as shown in figure 1.18. Then pick the Select Objects button and select the 4 lines and then the "X". Always remember when we insert a Block with Attributes into a drawing, the prompts will be asked in the order that we select them when creating the block. Pick the Delete radial button to remove the block from the graphical display. We still want to make the symbol so it cannot be exploded, so we uncheck the Allow Exploding checkbox.
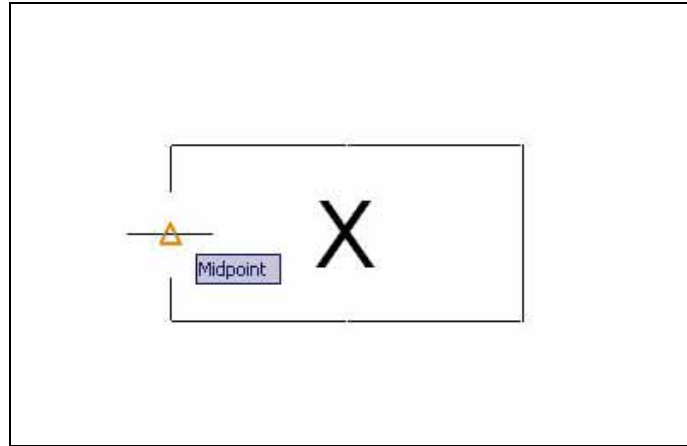

Figure 1.18 – Picking the Insertion Point

Creating a Ground Symbol

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The third electrical symbol we will make is one for the electrical ground. This symbol does not have any attributes associated with the graphic. Ground wires perform a safety function in electrical design. We attach the ground wire to a screw terminal on the metal electrical enclosure. If the wire, switch or terminal block eventually breaks from either material failure or improper assembly and maintenance, then any current running in the enclosure from the broken electrical device can flow to Earth ground.
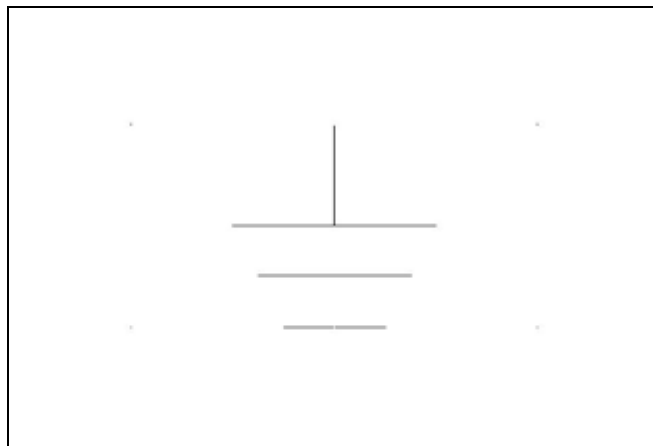

Figure 1.19 – Terminal Block

To finish making our electrical symbol, we select the Create Block tool on the Ribbon above the graphics display. The Block Definition window will appear as shown in figure 1.22. This electrical symbol's name will be "ground_chasis".
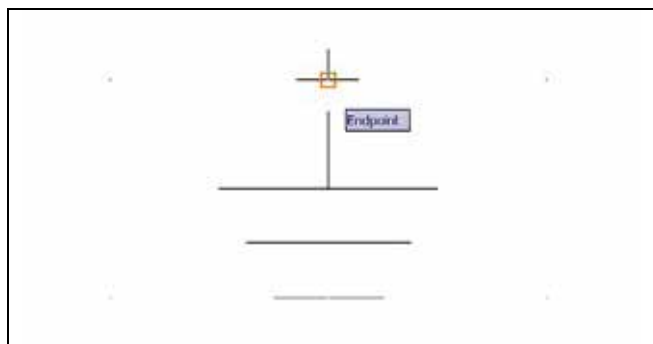

Figure 1.20 – Picking the Insertion Point

Use the Pick Point button to select the insertion point of the electrical symbol as shown in figure 1.20. Then pick the Select Objects button and select the 4 lines. Pick the Delete radial button to remove the block from the graphical display. We still want to make the symbol so it cannot be exploded, so we uncheck the Allow Exploding checkbox.
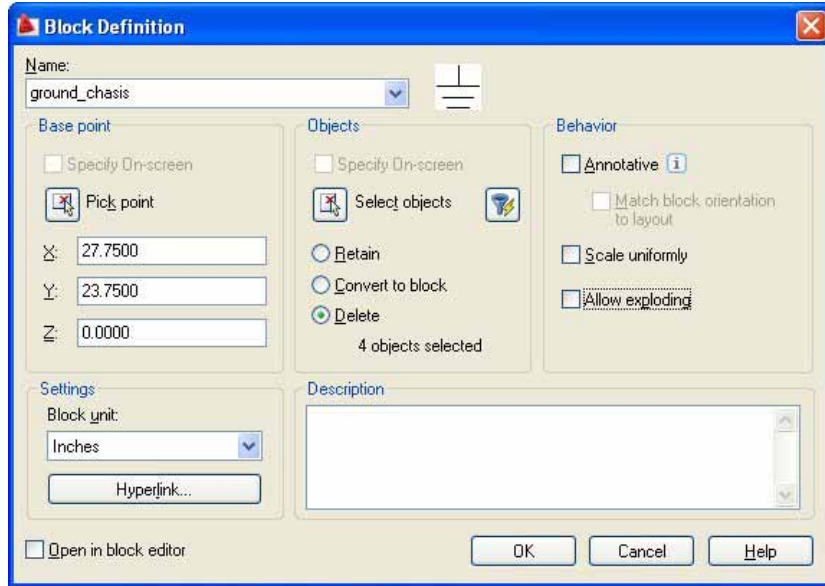

Figure 1.21 – Creating the Chassis Ground Block Definition

Drawing the Electrical Schematic

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To draw the schematic of the switch assembly, we work in the same drawing that contains the electrical symbols. The drawing should be similar to the diagram shown in figure 1.22.
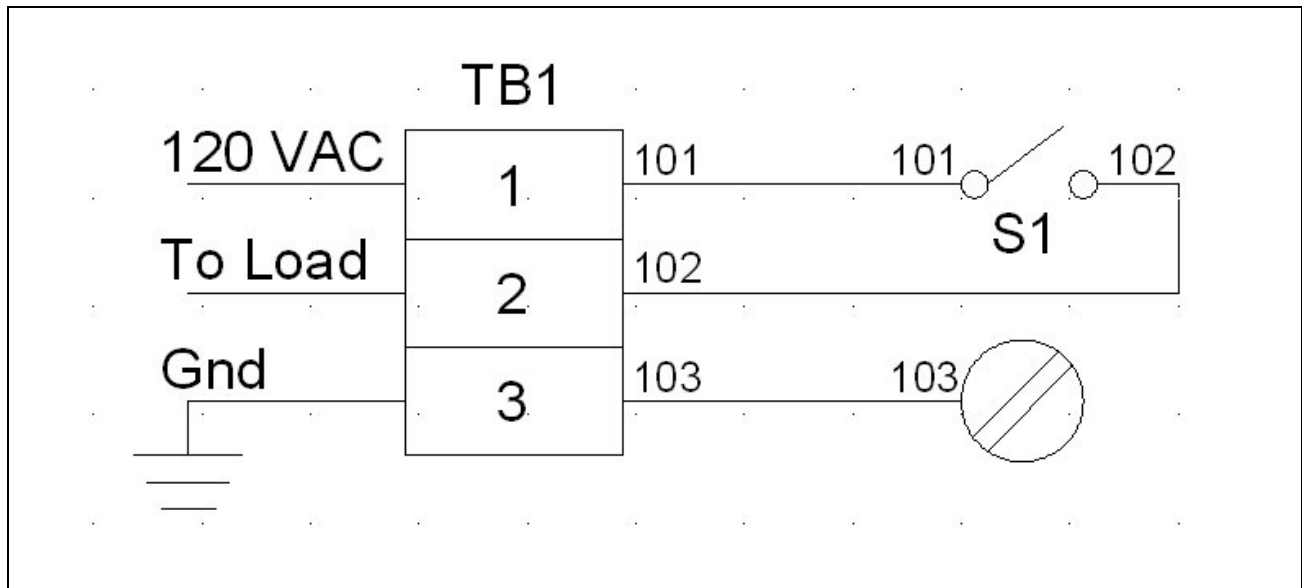

Figure 1.22 – The Schematic of the Switch Assembly

In the AutoCAD drawing file, insert the terminal block symbol by selecting the Block and References Tab on the AutoCAD Ribbon. Pick the Insert Block tool on the left side of the menu and the Insert window will appear as shown in figure 1.23.
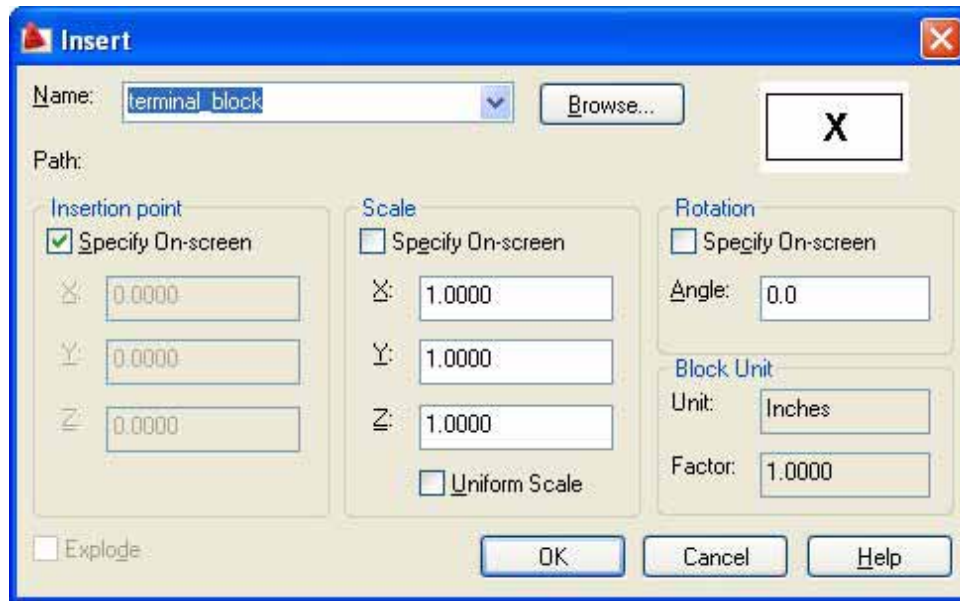

Figure 1.23 – Inserting a Electrical Symbol using an AutoCAD Block Library

The scale will remain as 1.0, so go ahead and choose the OK command button and place the terminal block on the graphical display. There will be a prompt at the command line as to what is terminal block number. Since the default is "1", just Enter and the terminal block will be numbered "1". Repeat the process two more times, except the numbers will be "2" and then "3".

Insert the single pole single throw switch and ground symbol using the Insert Block function, and finish the wiring schematic. Label the incoming wires as 120 VAC, to Load and Ground. There will be a phase wire connected to terminal 1, a wire to the load (such as a lamp) on terminal 2 and a wire to the electrical ground in the building connected to terminal 3.

On the inside of the enclosure, a wire will run from terminal 1 to the switch, a wire from the switch to terminal 2. The third internal wire will go from terminal 3 to a screw mounting the panel to the enclosure. Wires should be labeled or color-coded. We will place numbers on the hook up wires inside the enclosure.

Complete the drawing by placing the diagram inside a drawing border. Complete the title block information and have the drawing checked.

Creating an Electronic Symbol Library

Use the WBlock command to send the local blocks to a folder holding the entire electrical symbols library. Type WBlock at the command line and the Write Block window will appear on the graphical display as shown in figure 1.24. Electrical symbol libraries can cost hundreds to thousands of dollars for a company and the majority of the symbols in the library will not be used,

so we recommend that Designers take the time and learn to make their own library. The process is quick and we will know how to make, insert and read electrical diagrams all the better.
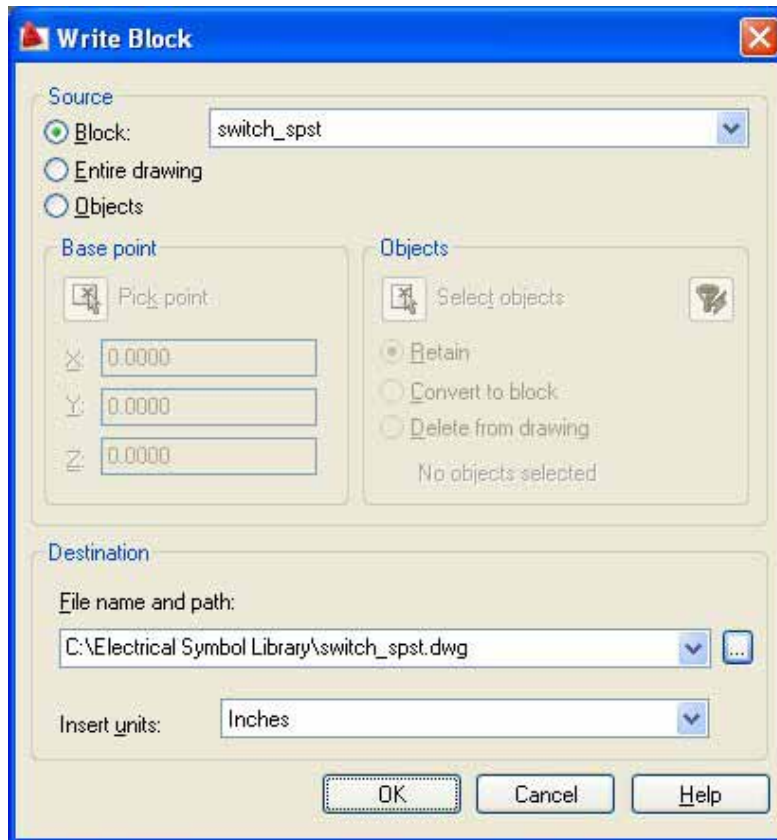

Figure 1.24 – Sending the Local Blocks to an External File in the Electrical Symbols Library

* World Class CAD Challenge 9-1 * - Draw an electrical symbol of a switch, terminal block and chassis ground. Create a wiring diagram of a on-off switch assembly using the CAD block symbols along with border and completed title block in 30 minutes.

Continue this drill four times using some other ideas, such as single pole, double throw switch or with multiple switches, each time completing the drawing under 30 minutes to maintain your World Class ranking.