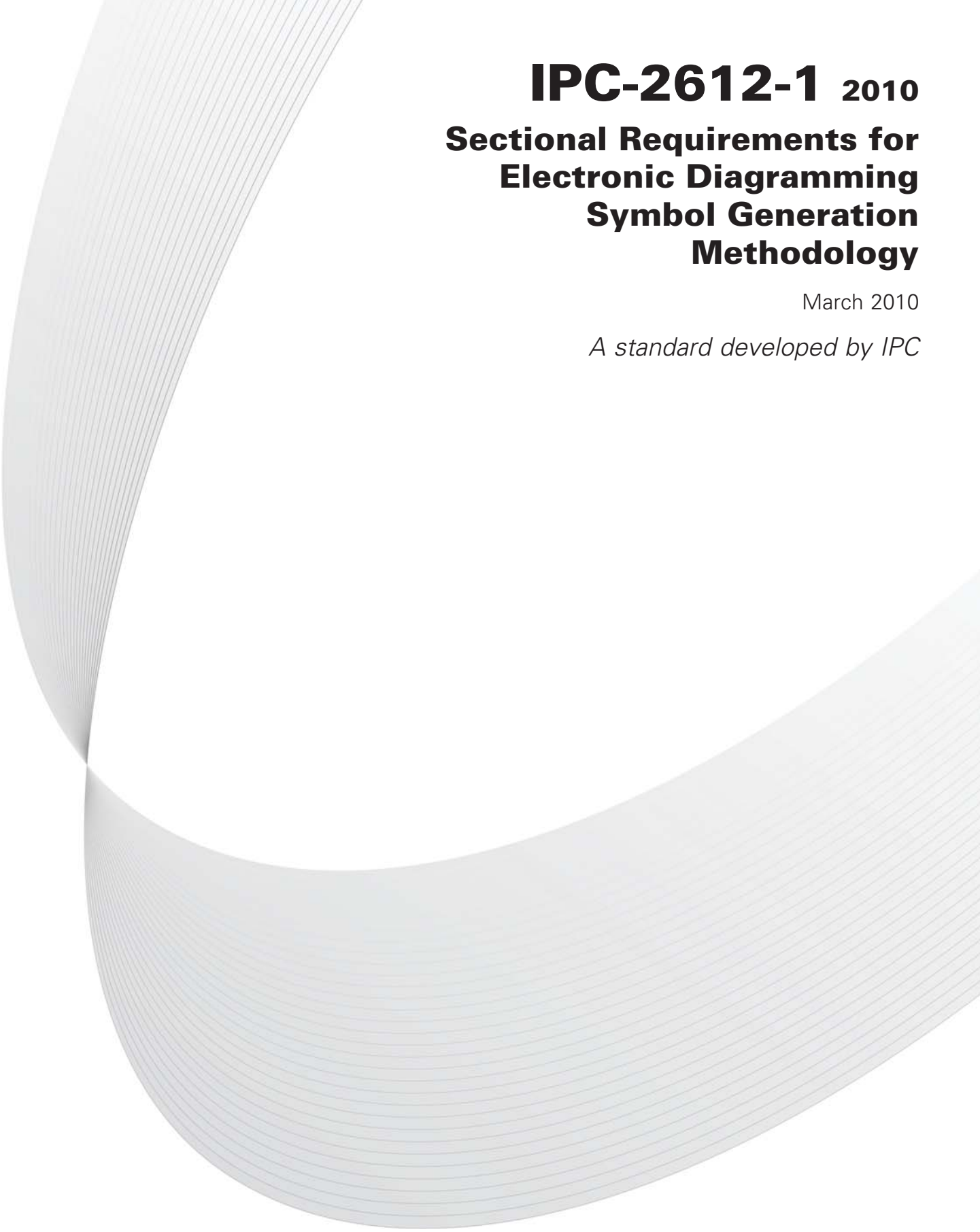




IPC-2612-1 2010

Sectional Requirements for Electronic Diagramming Symbol Generation Methodology

March 2010

A standard developed by IPC

Association Connecting Electronics Industries



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IPC-2612-1-2010

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Developed by the Electronic Documentation Technology Committee
(2-40) of IPC

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development of future revisions.

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Acknowledgment

Any document involving a complex technology draws material from a vast number of sources. While the principal members of the Electronic Documentation Technology Committee (2-40) are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of the IPC extend their gratitude.

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Sectional Requirements for Electronic Diagramming Symbol Generation Methodology

1 SCOPE

This standard establishes the requirements for generation of electronic symbols used in the documentation of electronic diagrams that define the electrical interconnectivity of electronic parts. The descriptions pertain to schematic symbols, logic symbols or Boolean truth tables required to define the circuit configuration. Where appropriate the standard also includes methodology for defining circuit flow, electrical or functional restrictions, or maintenance test procedures used to design or maintain the electronic product. The requirements pertain to both hard copy and electronic data descriptions.

1.1 Purpose

The purpose of the standard is to develop a protocol that fits well into both manual and automated documentation of electronic diagrams. In addition, the methodology permits the symbols to be placed and adjusted in a manner that facilitates showing how an electronic function can interact with other functions. In this regard, the symbol Input, Output, ground and voltage arrangement must fall on some form of the Cartesian coordinate system in order to facilitate the use of the symbols in automated diagramming tools.

1.2 Classification

Symbols have been organized into several categories and defined in the requirements according to the classification into which they belong. The classifications include:

- General symbols
- Electro mechanical symbols
- Discrete electronic functional symbols
- Logic representation and truth table symbols
- Semiconductor integration symbols
- Mechanical symbols

2 APPLICABLE DOCUMENTS

The following documents form a part of this standard to the extent specified herein. The revision of the document in effect at the time of solicitation **shall** take precedence.

2.1 IPC¹

IPC-T-50	<i>Terms and Definitions for Interconnecting and Packaging Electronic Circuits</i>
IPC-2611	<i>Generic Requirements for Electronic Product Documentation</i>
IPC-2611-1	<i>Generic Requirements for Electronic Product Data Base Storage Recommendation⁺</i>
IPC-2612	<i>Sectional Requirements for Electronic Diagramming Documentation (Schematic and Logic Descriptions)</i>
IPC-2613	<i>Electrical, Mechanical and Discrete Wiring Part Descriptions Documentation (Specification Control, Source Control, Wire Harness and Cabling)⁺</i>
IPC-2614	<i>Sectional Requirements for Board Fabrication Documentation</i>
IPC-2615	<i>Printed Board Dimensions and Tolerance⁺</i>
IPC-2616	<i>Sectional Requirements for Assembly Documentation (Electronic Printed Board and Module Assembly Descriptions)⁺</i>
IPC-2617	<i>Sectional Requirements for Board and Assembly Testing (Electrical, Environmental HAST, HALT, etc. Test)⁺</i>

¹ www.ipc.org

⁺ under consideration

IPC-2618 *Sectional Requirements for Bill of Material Documentation (Complete Listing of Parts, Materials, and Procurement Documents)*⁺

2.2 IEEE²

IEEE Std 315 *Standard Graphic Symbols for Electrical and Electronics Diagrams*

IEEE Std 91 *Standard Graphic Symbols for Logic Functions*

3 REQUIREMENTS

The following requirements **shall** be incorporated, where appropriate, into the detail descriptions of the IPC-2612.

3.1 Terms and Definitions

The definition of all terms **shall** be in accordance with IPC-T-50 and the following. An asterisk (*) by the term indicates that it is a reproduction from IPC-T-50 to assist the reader in interpretation of this standard.

3.1.1 bus *

One or more conductors used for transmitting data signals or power.

3.1.2 ground *

A common reference point for electrical circuit returns, shielding, or heat sinking.

3.2 Symbol Layout Rules

All schematic or logic symbols should be shown with inputs entering from the left side of the symbols with outputs exiting from the right side. Voltage and ground connections should be shown on a minimum of one symbol of the symbol type on the final diagram. In order to accomplish this requirement symbols that need this description have been provided with the connect points for the final diagram. The ground or the more negative voltage symbol should be shown as a function from the bottom of the symbol; the voltage or the most positive part of the voltage should be shown from the top connection.

3.2.1 Rules Pin Assignment

Symbol pins numbers and names **shall** match the component manufacturer data sheet. If the data sheet represents several functions within one container (Part) the pin identification number **shall** match the individual pin number on the physical package.

If the data sheet does not have pin numbers they **shall** be assigned at the time the symbol is developed in the symbol library and data base.

The descriptions in this standard will identify all pins using the rules established in clause 3.2. This includes any pins that are not connected to any internal functions. i.e. NC is label in the package with the pin number along side the lead.

Converting component data information to logic symbols requires techniques of interpretation to determine the relationship of the inputs, outputs, power and ground connection in sufficient detail to facilitate the diagramming function required by the IPC-2612. In some instances the data sheets are somewhat vague as to the various functions of the semiconductor package or electronic module. All pins **shall** be identified including those that are not connected to the IC internal logic.

The methodology of pin identification may be varied depending on the application and the methodology used to define the electronic data set. In one instance the no-connects can be part of the symbol; in other instances, they may be described at the time the schematic or logic diagram is developed. Techniques include describing the no-connects with an X or an NC or, if not defined on the symbol in the diagram,

² www.ieee.org

they may be listed in a table or a separate report. The conditions are selected based on application and complexity of the unconnected pins regarding their number or whether they are active or inactive connections in the circuit or the package. The following example shows the pin assignment and logic symbol development for a particular data sheet of a quad flat pack (QFP) that contains various logic functions. Figure 3-1 shows the physical package and pin arrangement, while Figure 3-2 shows the functional block diagram of the component supplier data sheet.

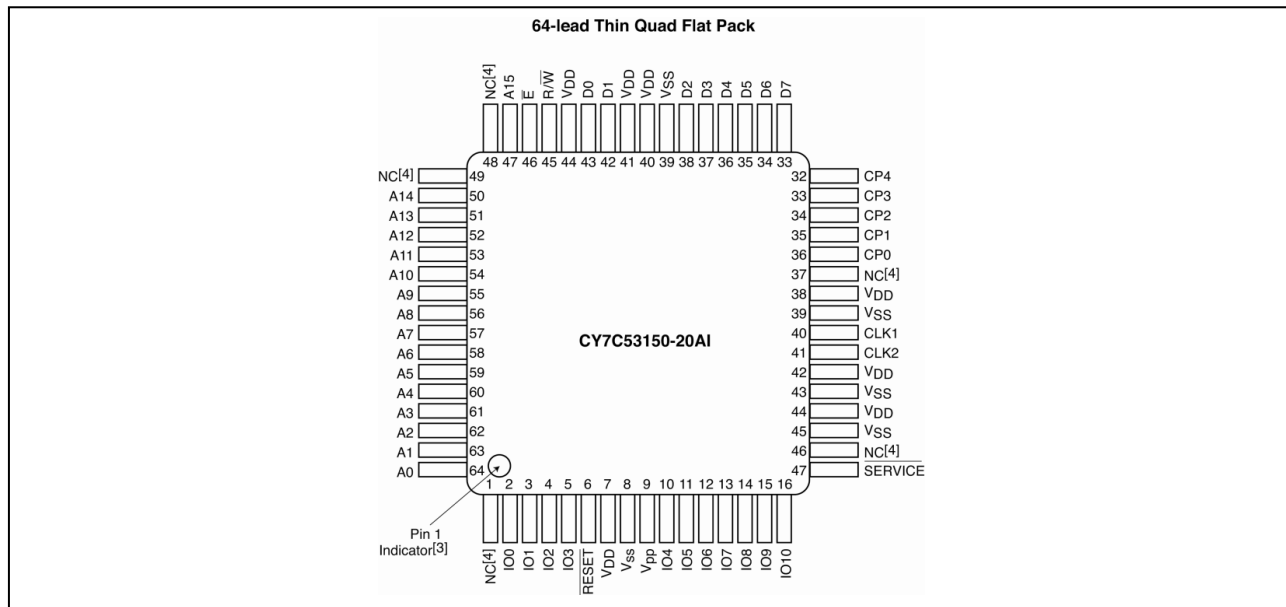


Figure 3-1 Semiconductor Quad Flat Pack Device

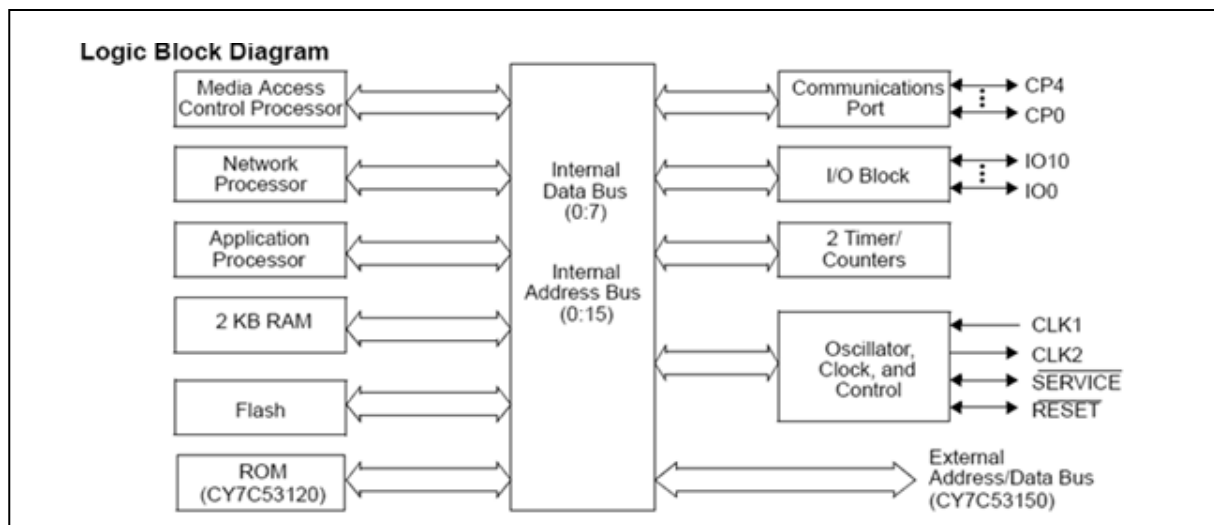


Figure 3-2 Semiconductor Data Sheet Block Diagram

The objective of the logic diagram is to convert the part block diagram into a significant graphical symbol that follows the rules established by the IPC-2612. The symbol relationship for the conversion to be included in a symbol library will vary according to the overall function of the entire assembly. As the semiconductor devices become more complex and perform more functions the circuit designer may segment the logic symbols into several different images (two, three, four etc.). The rationale for segmentation is usually based on the interconnectivity of the total system or assembly function. Figure 3-3 shows the logic diagrams that represent the block diagram shown in Figure 3-2.

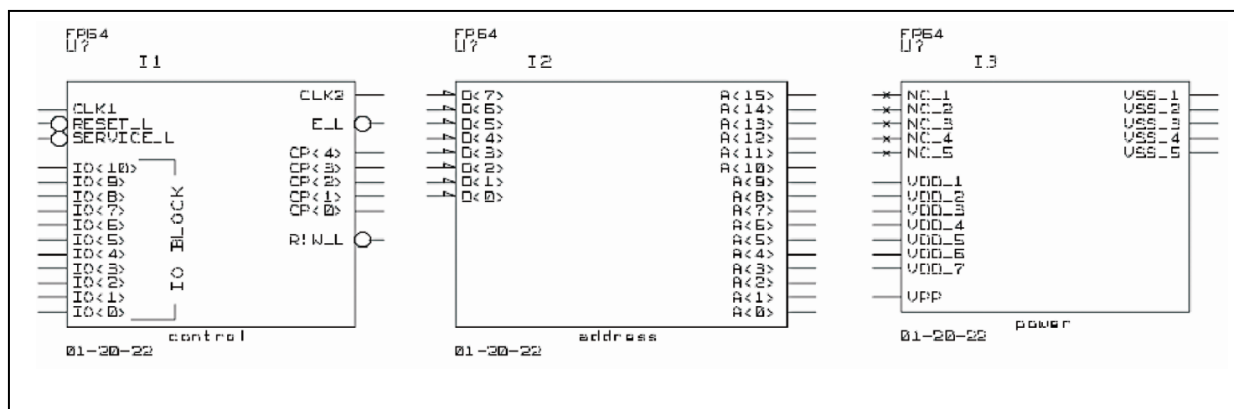


Figure 3-3 Logic Diagrams Depicting Control, Address, and Power Functions for the 64 pin Device

3.2.2 Pin Descriptions

Pins descriptions in logic symbols consists of a straight line that should be proportional to the text used to name pin functions and pin numbers. The relationship is based on the image proportions of the text size indicated in clause 3.2.3, and should be of sufficient clarity to enhance the readability of the function. Since many of the complex (non-distinctive) logic symbols are rectangular, certain conventions have been adopted in order to facilitate the readability and understanding of the logic functional characteristics.

In general, if the straight line comes to the rectangular symbol from the left, the line represents an input to the device; straight lines coming from the right hand side of the rectangle represent single outputs. Power is usually provided as a straight line from the top of the symbol while ground is shown with a straight line from the bottom of the symbol. These general rules may vary at times in order to clearly define the total logic functional characteristics of the part.

Sometimes a line modifier is added to the line in order to aid in the interpretation of the individual signal. A small bubble shown next to either side of the rectangle, to which the line end (input or output) is attached signifies a negated signal (negative or LOW). Other line modifiers have been used to distinguish an Active LOW input where a triangle is shown with the base touching the rectangle or a triangle facing the opposite direction on the right hand side signifying an active LOW output. The X symbol has also been used to signify that the pin is inactive and is not connected within the semiconductor device. In addition the initials NC are added during the development of the final diagram to signify that although the function is active within the device it is not connected to the circuitry of the assembly.

It may be unusual to see both an X and the NC net name assigned on the final diagram, however at times a pin is not connected to the circuitry in order to avoid radiating antennas or electromagnetic interference.

3.2.3 Grid Layout and Symbol Proportion Concepts

A single layout grid **shall** be established for all the symbols. The symbol pins **shall** be located on the established grid and be compatible with the layout grid for the schematic and logic diagram arrangement and interconnection properties. Symbol proportions are based on the concepts identified in Appendix A of IEEE 91 which identifies all symbols in accordance with the height of the text used for signal names, pin numbers etc. The text is described as consisting of 4 units. Other symbols including line separation are defined in increments of the text units. As an example line to line separation equals 4 Units (approximately 1.25 mm at 1:1), polarity symbol shown as an input equals 3 units, and line to line with text in between equals 8 units. IPC-2612 sets the requirements for letter height as the “H” dimension.

3.2.4 Pin Grouping

Symbols with multiple pin arrangements should have the pins shown on the grid and in a manner that promotes clarity and interconnection functionality. Usually pins are organized into group functions. To facilitate the clarity recommendation it is suggested to have two grid elements used between pin function groupings.

3.2.5 Reference Designator Place Holders

All symbols **shall** include a location for the assigned reference designator of the symbol. The established designator list is shown in Appendix A. If an appropriate designator is not shown a unique designator should be established and the definition documented on the schematic diagram.

3.2.6 Type Designations

Semiconductors and other devices with standard type designations **shall** be identified by reference designation and type designation. The symbol library **shall** contain the master list of appropriate type designations and be assigned to the selected symbol at the time the symbol is instantiated on the diagram. See examples in Figure 3-4.

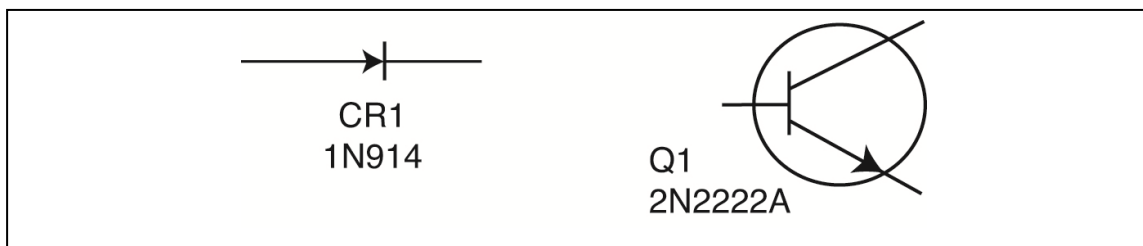
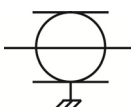
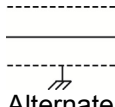
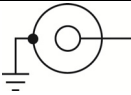
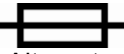


Figure 3-4 Example of Semiconductor Type Designations

4 GENERAL SYMBOLS

Ammeter		An ammeter is a measuring instrument used to measure the flow of electric current in a circuit. Electric currents are measured in amperes, hence the name.
Antenna, Balanced		A balanced (dipole) antenna is an antenna with a center-fed driven element for transmitting or receiving radio frequency energy.
Antenna, General		The general antenna is a component designed to send and receive radio waves.
Antenna, Loop	Shielded Unshielded	The loop antenna represents an arrangement of conductors that generate a radiating electromagnetic field in response to an applied alternating voltage and the associated alternating electric current, or can be placed in an electromagnetic field so that the field will induce an alternating current in the antenna and a voltage between its terminals.
Antenna, Unbalanced		The unbalanced (whip) antenna is the most common example of a monopole antenna, an antenna with a single driven element and a ground plane.
Battery		A battery is a device consisting of one or more electrochemical cells, which store chemical energy and make it available in an electrical form. There are two types of batteries, primary (disposable) and secondary (rechargeable), both of which convert chemical energy to electrical energy.
Test Point		A test point is used to represent a special point of access to an electrical circuit that is used for electrical testing purposes. (* from T-50)
Voltmeter		A voltmeter is used for measuring the electrical potential difference between two points in an electric circuit.

Wattmeter		A wattmeter is an instrument for measuring the electric power or the supply rate of electrical energy (Watts) of any given circuit.	 Alternate
Circuit Breaker		A circuit breaker is an automatically-operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit.	
Coaxial Cable		A coaxial cable is an electrical cable consisting of an inner conductor or several un-insulated conductors tightly twisted together, often surrounded by an insulating spacer, surrounded by an outer cylindrical conducting shield (sheath), and usually surrounded by a final insulating layer (jacket).	 Alternate
Jack, Coaxial		A coaxial jack is the receptacle for the coaxial power connector.	
Fuse		A fuse is a device used in electrical systems to protect against excessive current.	 Alternate
Galvanometer		A galvanometer is an analog electromechanical transducer that produces a rotary deflection, through a limited arc, in response to electric current flowing through its coil.	 Alternate
Ground, Analog		An analog ground provides a low inductance return path for analog devices	 Alternate
Ground, Chassis		A chassis ground is a common reference point for electrical circuit returns, shielding, or heat sinking by connect the circuit off board to the chassis by some device or wire.	 Alternate
Ground, Earth		An (earth) ground is a common reference point for electrical circuit returns, shielding, or heat sinking.	
Shielding		A specific layer or enclosure intended to protect a circuit, component or function from the influence of stray disruptive circuits, elements or environmental conditions.	
Microphone		A microphone is an acoustic-to-electric transducer or sensor that converts sound into an electrical signal.	
Speaker		A speaker is an electromechanical transducer that converts an electrical signal to sound.	 Alternate
Probe, Radio Frequency		A radio-frequency probe is an interface between an electrical circuit and radio waves with a frequency or rate of oscillation within the range of about 3 kHz to 300 GHz.	
Resonator		A resonator is a device or system that exhibits resonance or resonant behavior, that is, it naturally oscillates at some frequencies, called its resonance frequencies, with greater amplitude than at others.	
Lamp, Incandescent		An incandescent lamp is a source of artificial light that works by incandescence (a general term for heat-driven light emissions which includes the simple case of black body radiation).	
Lamp, Neon		A neon lamp is a gas discharge lamp containing primarily neon gas at low pressure.	

Unspecified Component		An unspecified component symbol may be used as a temporary placeholder in the schematic. These symbols should not be in a final or released schematic.
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5 ELECTROMECHANICAL SYMBOLS

Switches or components with switching functions (relays, circuit breakers, etc.) **shall** be shown as they would appear with no applied operating force.

Terminals should be omitted unless they are required (switches, relays, etc.). Terminals **shall** be marked to indicate actual markings on the component. Where there are no markings, arbitrary numbers or letters should be assigned to the terminals. A note should be added to the diagram explaining that this arbitrary identification is assigned for reference only and **shall** not be marked on the parts. The note should contain a pictorial example with the terminals identified. See Figure 5-1.

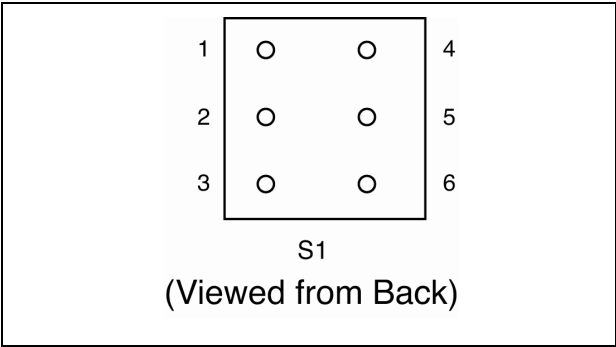


Figure 5-1 Switch/Relay Terminals

5.1 Mechanical Linkages

Mechanical linkage lines may be omitted when the interactive functions of multi-element devices are clear (switches, relays, etc.) as shown in Figure 5-2.

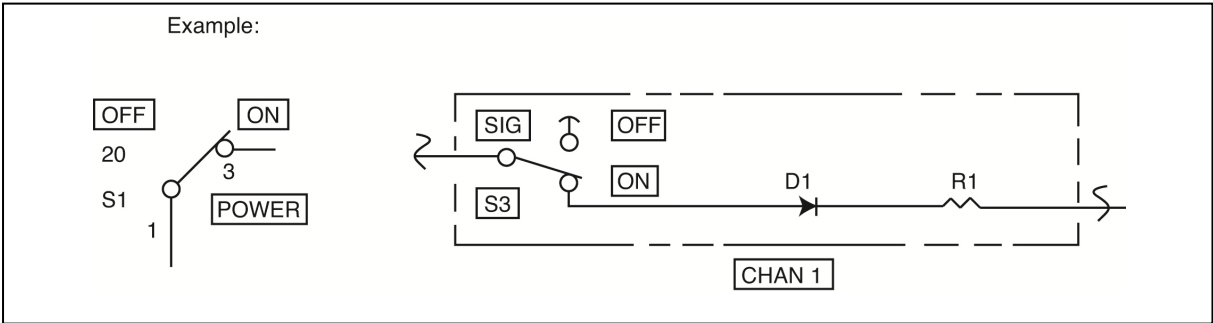


Figure 5-2 Switches/Relays

5.2 Connectors

Connectors **shall** be depicted by one of the methods shown in Figure 5-3.

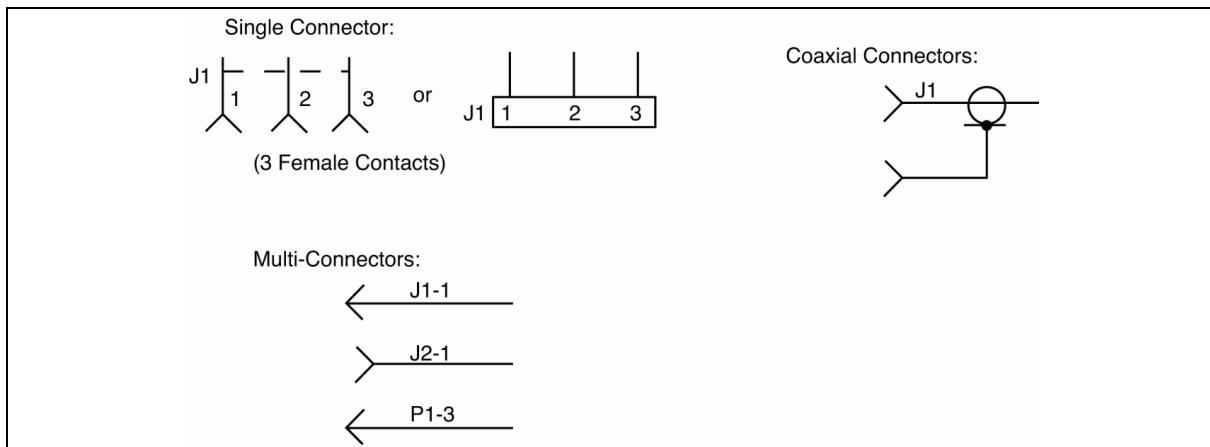


Figure 5-3 Connector Symbols

5.3 Multi-Element Symbols

Switching functions may be more clearly depicted and the diagram made easier to read by showing the contacts of switching devices separated from each other and from the actuating coil. Each set of contacts **shall** be clearly identified by the reference designation.

Female Contact, General		The general female contact symbol shows connections that represent the socket portion of a connector system.	
Male Contact, General		The general male contact symbol shows connections that represent the pin portion of a connector system.	
Ferrite Bead		A ferrite bead is a passive electric component used to protect high frequency noise in electronic circuits.	 Alternate
Jack, Phono		A phono jack is a socket commonly used in the audio/video market to connect to sound amplification and image systems.	
Jack, Phone, 2-Conductor		A 2-conductor phone jack is a socket that connects to voice and audio systems.	
Jack, Phone, 2-Conductor Interrupting		A 2-conductor interrupting phone jack symbol represents a socket that connects to voice and audio systems and permits interruption of the existing audio.	
Jack, Phone, 3-Conductor		A 3-conductor phone jack symbol represents a socket that connects to voice and audio systems	