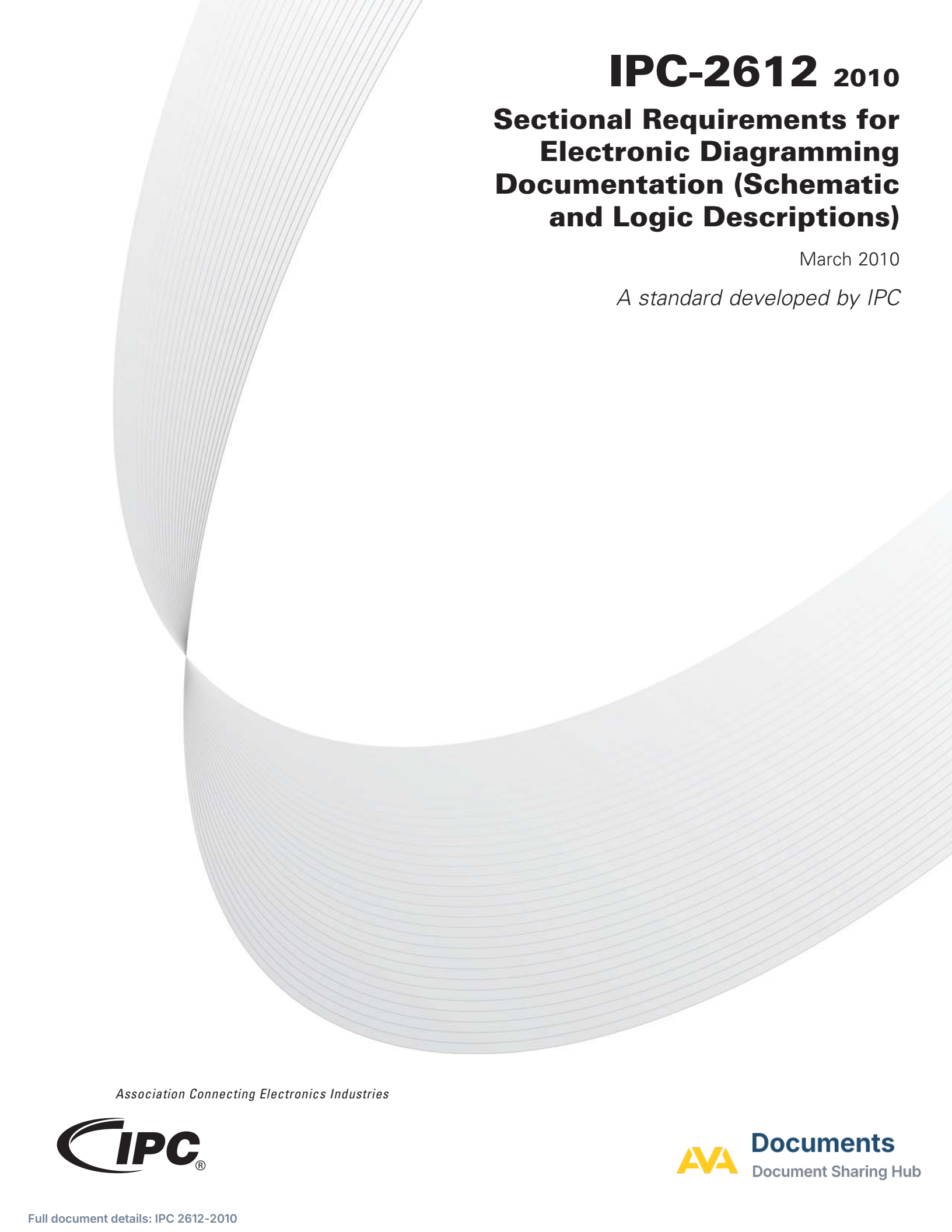




IPC-2612 2010

Sectional Requirements for Electronic Diagramming Documentation (Schematic and Logic Descriptions)

March 2010

A standard developed by IPC

Association Connecting Electronics Industries



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

Users of this publication are encouraged to participate in the
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 Documentation (Schematic and Logic Descriptions)

1 SCOPE

This standard establishes the requirements for the documentation of electronic diagrams used as the foundation for defining the electrical interconnectivity of electronic parts. The description pertains to either schematic diagrams, logic diagrams or Boolean truth tables and 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 hard copy, electronic copy or electronic data descriptions.

1.1 Purpose

The purpose of this document is to establish a consistent set of naming conventions, schematic and logic attributes, and documentation standards. The standard should ensure that all schematics and logic descriptions contain the information required for inspection, hardware realization, software development, and design reuse.

The initial schematic/ logic diagram designates the electrical functions and interconnectivity to be provided by the printed board and its assembly. The schematic should define, when applicable, critical circuit layout areas, shielding requirements, grounding and power distribution requirements, the allocation of test points, and any pre-assigned input/output connector locations. Schematic information may be generated as hard copy or computer data (manually or automated).

1.2 Classification

Classification of Schematic and logic diagrams **shall** meet the requirements of IPC-2611. The classification concepts **shall** include the Grade and completeness characteristics of the electrical diagrams.

There are three grades of documentation defined in the IPC-2610 series. A specific grade **shall** consist of a letter to define the differences between hard copy and electronic data, and a number (mode) that defines the completeness of the documentation procurement package.

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-2581	<i>Generic Requirements for Printed Board Assembly Products</i> Manufacturing Description Data and Transfer Methodology
IPC-2611	<i>Generic Requirements for Electronic Product Documentation</i>
IPC-2611-1	<i>Generic Requirements for Electronic Product Data Base Storage Recommendations</i> ⁺
IPC-2613	<i>Sectional Requirements for Electrical, Mechanical and Discrete Wiring Part Descriptions Documentation</i> (specification control, source control, wire harness and cabling) ⁺
IPC-2614	<i>Sectional Requirements for Board Fabrication Documentation</i> (printed circuit board description, including embedded passives)
IPC-2615	<i>Printed Board Dimensions and Tolerances</i> (principles of general and geometric dimensioning practices) ⁺

¹ www.ipc.org

+ under consideration

- IPC-2616 *Sectional Requirements for Assembly Documentation* (electronic printed board and module assembly descriptions)⁺
- IPC-2617 *Sectional Requirements for Board and Assembly Testing* (electrical, environmental, HAST, HALT, etc. test)⁺
- 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*
- IEEE STD 267 *Recommended Practice for the Preparation and Use of Symbols*

3 REQUIREMENTS

The requirements of IPC-2611 and IPC-2581 (XML data descriptions) are a mandatory part of this standard. Those documents describe the generic requirements for the general documentation and data descriptions formats. The generic details in each standard specifically provide data related to design, printed board manufacturing, assembly and test.

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 schematic diagram*

A diagram which provides the electrical continuity of a particular circuit.

3.1.2 analog circuit*

An electrical circuit that provides a continuous relationship between its input and output.

3.1.3 logic*

The functional digital circuits used to perform computational functions.

3.1.4 logic diagram*

A drawing that depicts the multistate device implementation of logic functions with logic symbols and supplementary notations that show the details of signal flow and control, but not necessarily the point-to-point wiring.

3.1.5 logic family*

A collection of logic functions using the same form of electronic circuit, e.g., emitter-coupled logic (ECL), transistor-transistor logic (TTL), complementary metaloxide semiconductor logic (CMOS).

3.1.6 drawings

Hard copy or electronic documentation (example pdf etc.) to which all formatting criteria applies.

3.1.7 hard copy

Information in the form of text and illustration on media that permits handling and transportation

² www.ieee.org

3.1.8 electronic documentation

Information in the form of text and illustration in computer format media that permits computer viewing, electronic data transfer and hard copy reproduction.

3.2 Documentation Requirements

The documentation package **shall** meet the requirements of the IPC-2610 series of documentation standards. The grade of documentation for Schematic and Logic diagrams **shall** be described in the contract. Grades may be A1, B1, C1, A2, B2, C2, A3, B3, or C3 and **shall** be in accordance with the requirements listed in Table 3-1. If no grade is specified, Grade B2 will be assumed.

Mode 3 represents the full mode and is applicable to all Grades. Grade A is all hard copy, Grade B is a mixture determined between supply chain partners, and Grade C is mostly electronic data and is usually used in combination with Mode 3 completeness.

Table 3-1 Schematic and Logic Diagram Completeness Mode Requirements

Description	Mode 1	Mode 2	Mode 3
Symbol and function	Y	Y	Y
Circuit Flow	N	Y	Y
Signal Names	N	Y	Y
Critical Circuit Identification	N	N	Y
Critical Signal Identification	N	Y	Y
Reference designator Assignment	N	Y	Y - Left to right preferred
Off sheet reference assigned	N	Y	Y
Component Indexing	N	N	Y
Fixed Pin and Gate Assignment	N	N	Y
Symbol Pin Number indication	N	N	Y

3.3 Diagramming Rules

Symbol pins **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. Symbols that are usually supplied in multiples per package are not identified with their respective package pin number in IPC-2612-1. These pin numbers **shall** be added to the symbol per the requirements of this standard.

The logic symbol description could become relatively complex in order to show the various functions of the semiconductor device. These characteristics are normally described in the component data sheets in either a graphical form or table format. IPC-2612-1 makes several recommendations as to how the logic symbol for complex semiconductor parts should be developed.

3.4 Format

The electrical data set may consist of several variations of format requirements. These are dependent on the method used to provide the electrical or interconnection information and are according to the class and mode of data transfer. Some popular format descriptions are:

- ANSI drawing (Paper format- A, B, C, D size)
- European/Asian drawing format (Paper format A-4, A-3, A-2, A-1)
- Electronic format (PDF, Word, Excel, Gerber, Visio)
- Content format (IPC-258X, ODBX++, XML schema)

When developing a paper copy the smallest drawing format that will accommodate the diagram should be used. Where more than one sheet is required, all sheets **shall** be the same size. These same principles should be used when developing computer graphical images.

3.5 Line Styles and Lettering

A medium width, solid line is recommended for most diagram applications. A medium width, short-dashed line should be used to indicate mechanical linkage. A heavy solid line should be used to indicate a bus line or major signal path.

Single stroke lettering is recommended for all applications on a drawing; i.e., notes, title, functions, etc. Helvetica or equivalent is the default font. Upper and lower case lettering is permitted, however upper case is preferred.

Schematic and logic diagram proportions are based on the concepts defined in Appendix A of IEEE 91 which specifies that all symbols be 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, polarity symbol shown as an input equals 3 units, and line to line with text in between equals 8 units.

The minimum letter height **shall** be 1.25 mm at a scale of 1:1. This minimum height characteristic is referred to as "H" and in font description has a font size of 4. The main requirement for any diagram is that it be legible when shown at 100% either on a computer screen or on paper format. It should be understood that if grid concepts and proportional conditions are not carefully considered, the transfer of data between tools could result in either symbol or text overlap. The distance between two adjacent lines on a schematic diagram should be maintained at **H** for line to line spacing without text, and **2H** for Line to line with text.

For these reasons, Helvetica was chosen as a neutral font. In order to establish what constitutes readability a font size of 8 is probably a good example of a readable text at 100% whereas a font of 6 becomes marginal and 10 is probably too large to be useful for very complex symbols or diagrams. See Table 3-2. Upper and lower case must fit into the **H** factor.

Table 3-2 Font Size Examples

Font Size Comparison		
Marginal	Readable	Oversize
Debug_Reset	Debug_Reset	Debug_Reset

3.6 Graphic Symbol Libraries

Graphic symbols **shall** conform to IPC-2612-1.

3.7 Abbreviations and Acronyms

Abbreviations **shall** be per IPC-T-50. Any abbreviations used that are not in the standard **shall** be explained by a note on the diagram. Also any acronyms used **shall** also be identified by a note. See Appendix A

Example:

Listed are abbreviations not called out in IPC-T-50:

- a) TwP = Twisted Pair (may be shown as TP on older documentation)
- b) CGF = Crystal Growth Furnace

4 GENERAL SCHEMATIC GUIDELINES

As a part of the data package, a final schematic and/or net list **shall** be prepared. The final schematic **shall** be back-annotated, so that the reference designator shown on the assembly drawing and the schematic/ logic diagram match.

4.1 Diagram Title

The schematic or logic title is always on the first page of paper formats or the header of an electronic file. In paper descriptions the title page **shall** contain the document title block. The second sheet of schematic may be left blank for the addition of future notes.

4.2 Format Usage

Schematics **shall** include the appropriate format as defined in 3.4. Schematics must contain a revision date updated with a list of any schematic changes.

4.3 Legibility

Schematics should be legible when printed on 11 x 17 inch or A3 paper or other hard copy media. An 8.5 x 11 inch paper (A4) is an option provided the image is legible.

4.4 Off Page or Off Screen References

Schematics should include clear off page or off screen references.

4.5 Terminating Resistors

Terminating resistors should be located on the schematic diagram near the components to which they physically perform the terminating function.

4.6 Bypass Capacitors

Bypass capacitors are commonly shown on the sheet or file with the components they bypass. They may be located on a separate sheet or file as a graphic or in a table, when space is limited.

5 COMPONENT SYMBOLS AND NUMERICAL VALUES

Every electrical component should have one or more symbols on the schematic to represent its connectivity. Bypass capacitors may be shown in a table per clause 4.6.

5.1 Common Voltage

When a schematic note is included in a prominent place identifying a common voltage rating, power rating, or tolerance, these values may be omitted from conforming components.

5.1.1 Fixed Voltage

Fixed voltage regulating devices (e.g. linear regulators, zener diodes) should have an indication of their voltage rating, tolerance, and power rating with the suffixes 'V', '%', and 'W' or 'mW' respectively

5.1.2 Adjustable Voltage

Adjustable voltage regulating devices should have an indication of their tolerance and power rating as described above, and **shall** be accompanied on the schematic with a note indicating the configured voltage.

5.2 Resistor Symbols

Resistor symbols should contain an indication of their value. Unless otherwise specified in the schematic notes (see section 9), when there is no suffix, the value shown is in ohms, K for kilohms, M for

megohms. The power rating **shall** also be defined with the value and suffix 'W' for watts, or 'mW' for milliwatts; the required tolerance will always have a '%' suffix.

Resistor symbols should contain an indication of their value.

5.3 Capacitor Symbols

Capacitor symbols should contain an indication of their value with the suffix "F" for farads, "μF" for microfarads or "pF" for picofarads. The voltage rating **shall** also be defined with the value and suffix 'V' for volts or kV for kilo-volts; the tolerance will default to 10% unless otherwise indicated.

5.4 Switching Devices

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

6 LAYOUT

Schematic diagrams **shall** be arranged so that they read functionally from left to right and/or top to bottom. Complex diagrams may be laid out in two or more image descriptions (hard copy sheets or electronic graphics). Each image should read from left to right.

Where possible, terminations for external connections or interrupted signal paths should be located at the outer edges of the diagram image.

Reference designations **shall** be assigned from left to right, top to bottom, prior to back-annotation. After a schematic has been completed and is ready for checking, added parts or changes may be incorporated without resequencing reference designations; a note to this effect should be added to the diagram.

Example Note:

The following reference designations are out of sequence. Their locations are as follows:

R16: Sheet 3, Zone 3B

R22: Sheet 4, Zone 2A

6.1 Connecting Lines

Connecting lines **shall** be drawn with as few crossovers and direction changes as possible. The lines should be drawn vertically or horizontally where possible. When a line must be drawn on an angle, it should be kept as short as practicable. The minimum spacing of lines at one-to-one scale is 5.0 mm.

6.2 Junctions

All connecting lines **shall** be shown as single junctions where possible. The junction **shall** be illustrated using the "filled dot" method. A "no dot" method or multiple junction with filled dot method **shall not** be used, but may be present in legacy design documentation. See Figure 6-1.