



*The Institute for
Interconnecting
and Packaging
Electronic Circuits*

IPC-D-351

Printed Board Drawings in Digital Form

ANSI/IPC-D-351

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- Minimize time to market
- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feed back system on use and problems for future improvement

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- Increase time-to-market
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- Tell you how to make something
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Users of this standard are encouraged to participate in the
development of future revisions.

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Acknowledgment

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Printed Board Drawings in Digital Form

1.0 SCOPE

The data contained in this specification is intended to supplement ANSI/IPC-D-350, specifically in the area of describing printed wiring board related drawings in digital form. It is intended that the basic record formats described in D-350 also apply to the record format described in this supplement. These formats may be used for transfer of drawings between printed wiring board designers, manufacturers and customers.

The intent of this specification is to convey additional requirements, guidelines and examples necessary to provide the data structures and concepts for drawing description in digital form.

This supplement pertains to four basic types of drawings:

- Printed board schematic diagram (see Figure 1-1)
- Printed board master drawing (see Figure 1-2)
- Printed board assembly drawing (see Figure 1-3)
- Miscellaneous part drawings (see Figure 1-4)

1.1 Format Compatibility The concepts detailed in this standard are supplemented by the descriptions defined in other companion IPC standards. It is the intent that the family of IPC-D-35X standards detail the various record formats.

Data redundancy is kept to a minimum by using various standards for appropriate data descriptions dependent upon the use of the data.

The following shows the correlation between the IPC standard and the record formats that are defined in each particular standard.

IPC-D-35X

Standards Record Description

- IPC-D-350** Artwork Records
- IPC-D-350** Board Description Records
- IPC-D-351** Schematic Drawing Records
- IPC-D-351** Master Drawing Records
- IPC-D-351** Assembly Drawing Records
- IPC-D-351** Miscellaneous Part Drawing Records
- IPC-D-352** Electrical Description Records
- IPC-D-352** Bill of Material Records
- IPC-D-353** Testing Format Records
- IPC-D-354** Library Description Records

Users are encouraged to maintain data in a form that is self-sufficient, and is not impacted by changes in supple-

mentary data used in the design process. Thus, library description records may be repeated on archived data. All records shall be in the appropriate format defined in the IPC standard related to the particular record type.

2.0 APPLICABLE DOCUMENTS

The following documents, of the issue currently in effect, form a part of this standard to the extent specified herein.

2.1 IPC¹

- IPC-T-50** Terms and Definitions
- IPC-D-300** Printed Board Dimensions and Tolerances
- IPC-D-310** Suggested Guidelines for Artwork Generation and Measurement Techniques for Printed Circuits
- IPC-D-325** Printed Board Documentation
- IPC-D-350** Printed Board Description in Digital Form
- IPC-D-354** Library Format Description for Printed Board Digital Data Bases

2.2 American National Standards Institute²

- ANSI X3/TR-1-77** American National Dictionary for Information Processing
- ANSI X3.12** Subroutine Record Format Standardization
- ANSI X3.22** Recorded Magnetic Tape for Information Interchange
- ANSI X3.26** Hollerith Punched Card Code
- ANSI X3.39** Recorded Magnetic Tape
- ANSI X3.54** Recorded Magnetic Tape
- ANSI Y14.5** Dimensioning and Tolerancing for Engineering Drawing
- ANSI Y32.1** Logic Diagram Standards
- ANSI Y32.16** Electrical and Electronic Reference Designations
- ANSI Z210.1** Metric Practice Guide (ASTM E380-72)

2.3 Department of Defense³

- W-T-0051** Tape, Electronic Data Processing, 1971
- DOD-STD-I00** Engineering Drawings

3.0 TERMS AND DEFINITIONS

Unless otherwise specified herein, terms and definitions shall be in accordance with IPC-T-50, ANSI X3.12 and the following:

1. Publications are available from the IPC, 2215 Sanders Rd., Northbrook, IL 60076-6135.

2. To obtain documents, write: American National Standards Institute, 1430 Broadway, New York, NY 10018.

3. To obtain documents, write: Naval Publications & Forms Center, 5801 Tabor Road, Philadelphia, PA 19120.



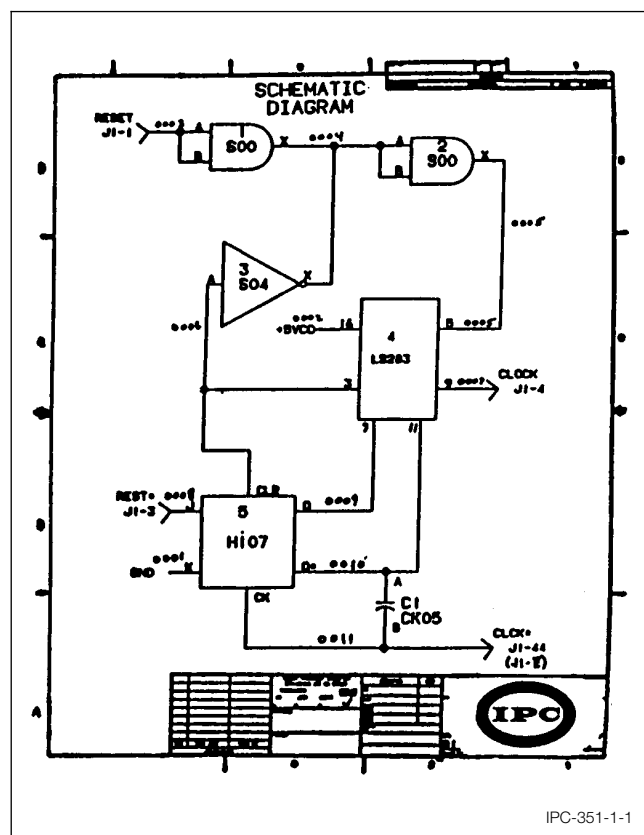


Figure 1-1 Printed Board Schematic Diagram

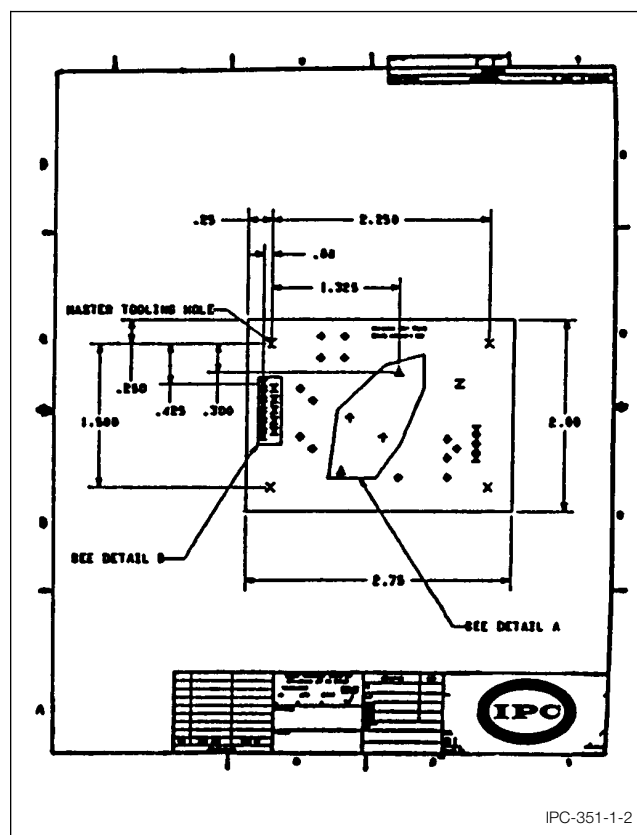


Figure 1-2 Printed Board Master Drawing

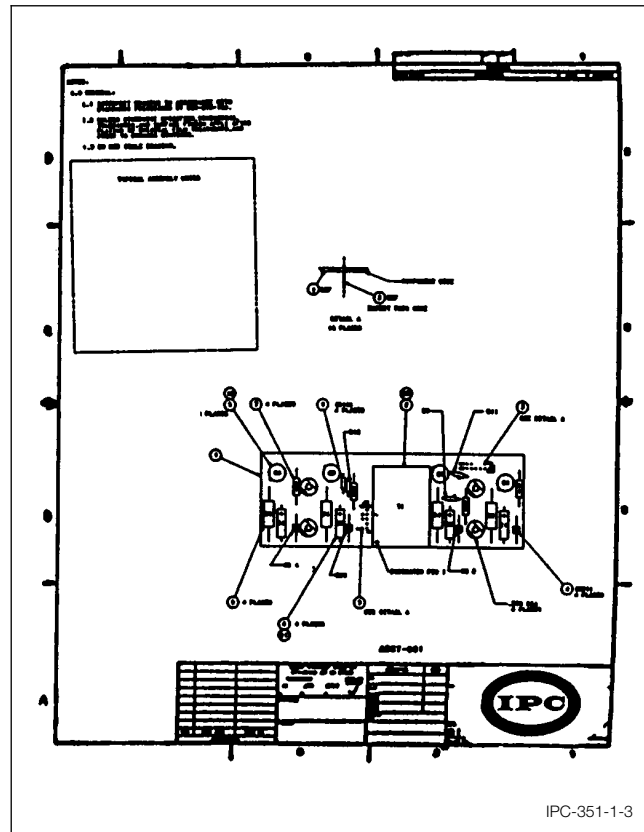


Figure 1-3 Printed Board Schematic Diagram

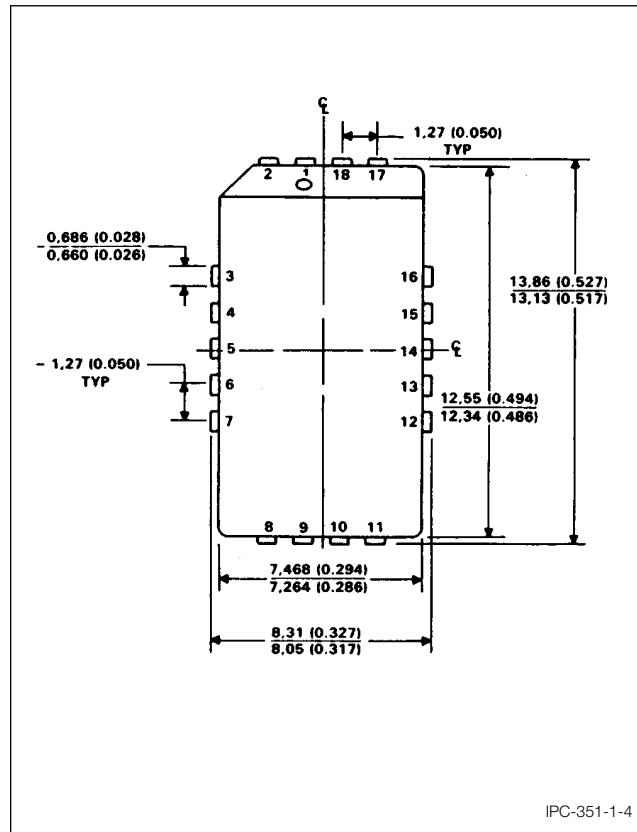


Figure 1-4 256K PLCC Mechanical Data

3.1 Annotation Text or legend pertinent to a design; text may appear as data related to legend on a printed wiring board, lettering on a drawing, or other types of symbols.

3.2 Comment Records A record that provides, or refers to, additional descriptive material needed to further clarify the control of the data set.

3.3 Complex or Composite Records A term used to define a collection of records that make up an electrical pattern or function used repeatedly in a design. Both the definition and relationship of such records are covered and referred to as subroutine definition and subroutine definition call.

3.4 Data Information Module (DIM) A group of records which contain related data intended to describe a specific function or task.

3.5 Data Layer A specific group of related records within any individual Data Information Module.

3.6 Feature Location Record A type of record that defines lines, points, or annotations.

3.7 Job Set A group of one or more Data Information Modules.

3.8 Modal Form The technique where the description of a unique feature in a data base (interconnection, single identification, conductor width restrictions, etc.) or other pertinent information is given only once at the beginning of a related set of data.

3.9 Parameter Record A record that defines the characteristics of a subsequent set of records, such as job identification, electrical description, tolerances, etc. Parameter records direct the computer program on how to interpret the records that follow in the job stream.

3.10 Physical Layer A conductive board layer or artwork image representing a complete conductive layer.

3.11 Subroutine As noted in ANSI X3.12 but defined using IPC record format descriptions. This record type provides a framework for constructing complex or composite records.

3.12 Subroutine Call. As noted in ANSI X3.12 but defined using IPC record format. This record type provides a framework for the manner in which complex or composite records are used in the data stream.

4..0 GENERAL REQUIREMENTS

4.1 Data Hierarchy Drawings shall be described in data records within a hierarchical structure as shown in Figure 4-1. The formats of the records applying to the drawings are specified herein.

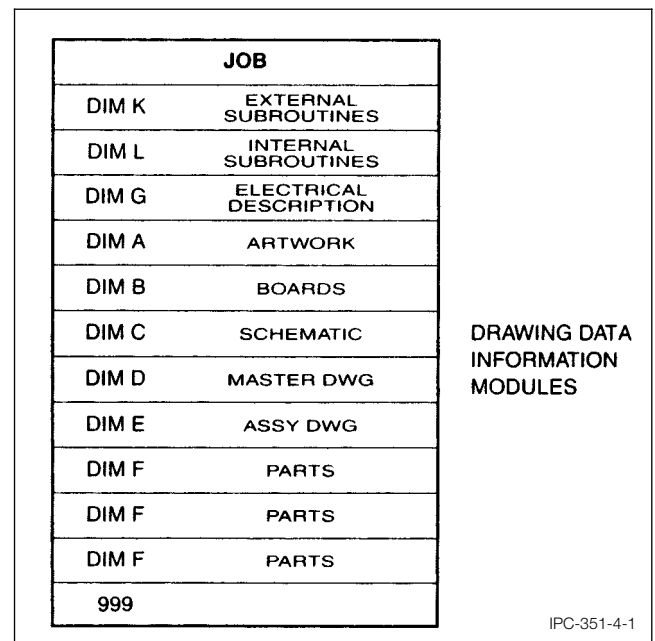


Figure 4-1 Hierarchy of Data in a Job Set

4.1.1 Job Set Definition The job set is headed by a job record (para. 5.1) and ended by an end of job record (para. 5.1.1). A job set shall consist of one or more Data Information Modules (DIM) that pertain to a single electronic interconnection product. Each different Data Information Module may occur only once in a job set, except DIM F. Each DIM shall contain a number (NUM parameter record; see para. 5.5). The DIM shall also contain title (para. 5.4) and revision (para. 5.6) parameter records. A Data Information Module is terminated by the occurrence of another DIM or end-of-job record.

4.1.2 Data Information Module Definition Drawing Data Information Modules (codes K, L, C, D, E and F) are composed of data records, parameter cards, and comment records, all of which are used to describe a particular drawing. See Figure 4-2. The data for the drawing is divided into sheets (sheet parameter card, paragraph 5.7) and further grouped into data layers (paragraph 7.3.2). Each sheet may be composed of one or more data layers.

4.1.3 Circuit Topology When circuit topology information from DIM L artwork records is used on drawings, the data shall be interpreted according to IPC-D-350 requirements. When agreed to between sender and receiver, topology information may be modified to substitute outlines for solid/outlined and filled features.

4.2 Basic Record Types

P DIM D		
GENERAL COMMENTS P TITLE P NUM P REV SUBROUTINES		GENERAL COMMENTS, PARAMETER CARDS AND SUBROUTINES
DATA LAYER 01	DRAWING RECORDS	
DATA LAYER 02	DRAWING RECORDS	DRAWING DESCRIPTION DATA LAYERS
DATA LAYER 03	DRAWING RECORDS	
P SCALE 421 04 421 05 421 06 421 07	SUBROUTINES FROM DIM L TO DEFINE	SUBROUTINE DATA LAYERS FROM DIM L
P SHEET 01 COMP 01 04		
P SHEET 02 COMP 02 05		4 DRAWING SHEETS THAT ARE DESCRIBED BY VARIOUS DATA LAYERS
P SHEET 03 COMP 03 06		
P SHEET 04 COMP 01 07		

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Figure 4-2 Example of a 4-Sheet Master Drawing

4.2.1 Parameter Records (Section 5.0)**4.2.2 Comment Records** (Section 6.0)**4.2.3 Feature/Location Records** (Section 7.0)**4.2.4 Complex or Composite Records** (Section 8.0)**4.2.5 End of Job Record** (Paragraph 5.1.1)

4.3 Data Set Descriptions The data shall explicitly describe absolute (not incremental) value, the contour and location of each individual feature, or a composite feature of the electronic interconnection product.

The location of each of the individual elements of a composite element shall be defined with reference to the composite datum, using data records.

Individual features shall be defined as being either lands, holes, line segments, annotation, or individual elements of a complex/composite feature. A feature shall not be defined more than once at a specific location in any Data Information Module.

4.4 Data Orientation (see Figure 4-3)

4.4.1 All data relating to the physical description of an electronic interconnection product shall be viewed from the side of the assembly that contains the components, looking through to the opposite side. For those electronic assemblies that have components on more than one side, any external side may be designated as the primary side; the opposite external side shall be designated as the secondary side. The primary side shall be defined as physical layer 1. Physical layers may be conductive or nonconductive as required to describe the physical or electrical properties of the interconnection product.

4.4.2 When coordinates are used to describe physical information, the origin shall be the same for all layers of

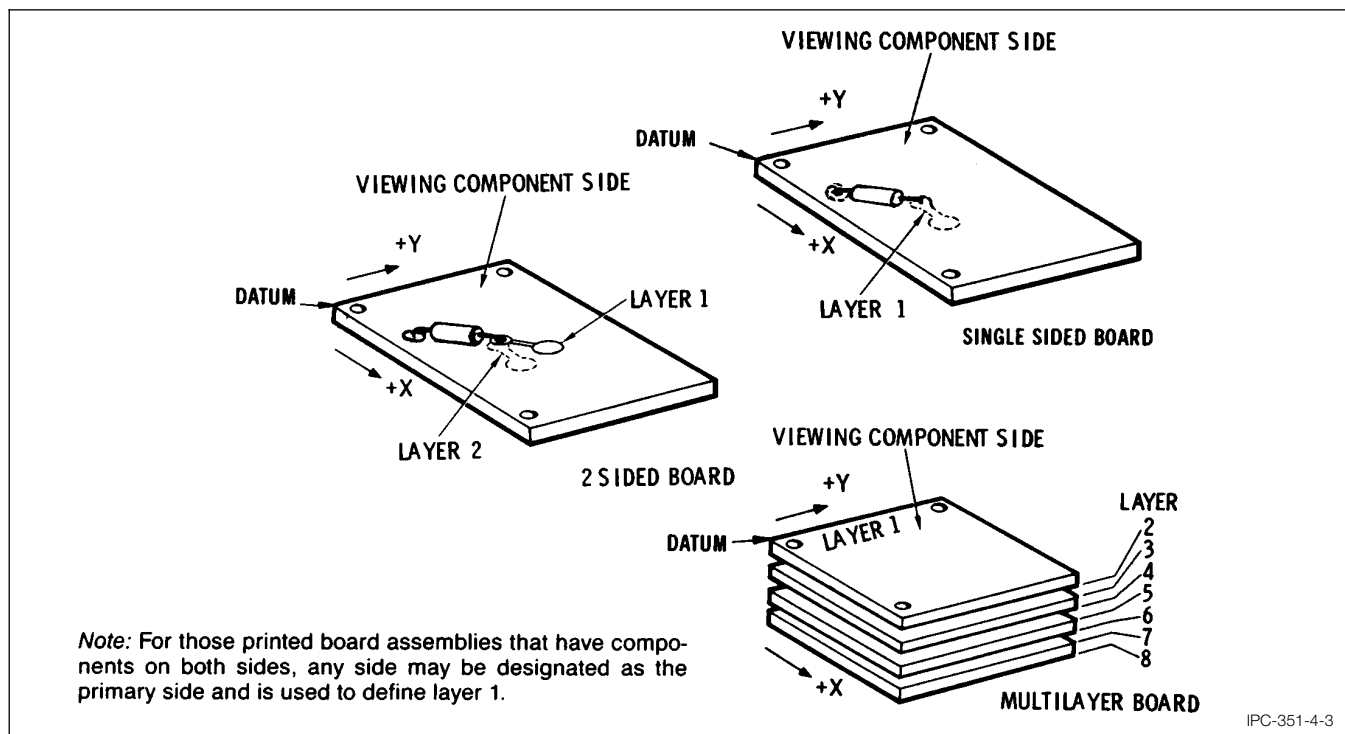


Figure 4-3 Printed Wiring Viewing

interconnection description within a Data Information Module (DIM) and shall follow the standard Cartesian coordinate reference system. Positive and negative X-Y values are permitted.

4.4.3 All features and location records shall be defined at 1:1 scale with respect to the drawing, not necessarily with respect to the part. When used, the data may be modified through the presence of a “scale” parameter record. See paragraph 5.8.

4.4.4 Physical layers shall be numbered consecutively starting from the component side as layer 1. (See IPC-D-325.)

4.5 Transfer Media and Data Formats The data shall be restricted to the printable ASCII character set, and be transmitted on standard 80 column punched cards, on magnetic tape (7 or 9 track), or on other communications interfaces, such as disk (removable, hard or floppy) which shall be mutually agreed to by the sender and receiver.

4.5.1 Punched Cards Punched cards shall conform to the requirements of ANSI X3.26.

4.5.2 Magnetic Tape

4.5.2.1 Unrecorded tape shall conform to W-T-0051.

4.5.2.2 Nine-track recording tape shall conform to ANSI X3.22 for 800 CPI, X3.39 for 1600 CPI and X3.54 for 6250 CPI.

4.5.2.3 Seven-track recording tape shall be NRZI compatible, 800 BPI and odd parity. The ASCII characters shall be recorded as shown below.

TRACK	C	B	A	8	4	2	1
X = 1st ASCII char	P	D	X7	X6	X5	X4	X3
Y = 2nd ASCII char	P	X2	X1	D	Y7	Y6	Y5
Z = 3rd ASCII char	P	Y4	Y3	Y2	Y1	D	Z7
D = Don't care (1 or 0)	P	Z6	Z5	Z4	Z3	Z2	Z1
P = Parity	etc.						

4.5.2.4 Magnetic tape recording format shall be 80-column card-image, packed 20 cards (1600 bytes) to the block. No magnetic labels shall be written on the tape.

4.5.2.5 A magnetic tape may contain several job sets. Each job set must be terminated with a hardware generated “end-of-file” mark. The last job set shall be terminated with two “end-of-file” marks.

4.5.3 Logical record length requirements as specified in paragraph 4.5.2.4 above shall also apply to disk.

5.0 PARAMETER RECORDS

Parameter record characteristics shall be delineated by a “P” in column 1 followed by one of the words: JOB, DIM, UNITS, TITLE, NUM, REV, SHEET, and SCALE beginning in column 4.

5.1 Parameter-JOB (See Figure 5-1.) The word “JOB” in columns 4-6 preceded by a “P” in column 1 shall indicate the beginning of a job set. Columns 10 through 72 may be used for comments such as job or other identification. This record shall be the first record in the data.

5.1.1 End-of-Job The characters 999 in columns 1-3 shall indicate the end of job. This record shall be the last record in the data.

5.1.2 Layer Identification All data layers described in a Data Information Module shall be identified with a unique two-digit number (see paragraph 7.3.2).

5.2 Parameter-DIM (Data Information Module) (See Figure 5-2). The word “DIM” in columns 4-6, preceded by a “P” in column 1 shall indicate the start of a Data Information Module. The DIM parameter record may appear anywhere in a job set (see data hierarchy paragraph 4.1). Each different DIM parameter may be used more than once. (A Data Information Module is terminated by the occurrence of another DIM parameter or end of job record. (See paragraph 4.1.1.)

Column 10 shall contain a unique letter code describing the type of records that follow the DIM parameter record. The

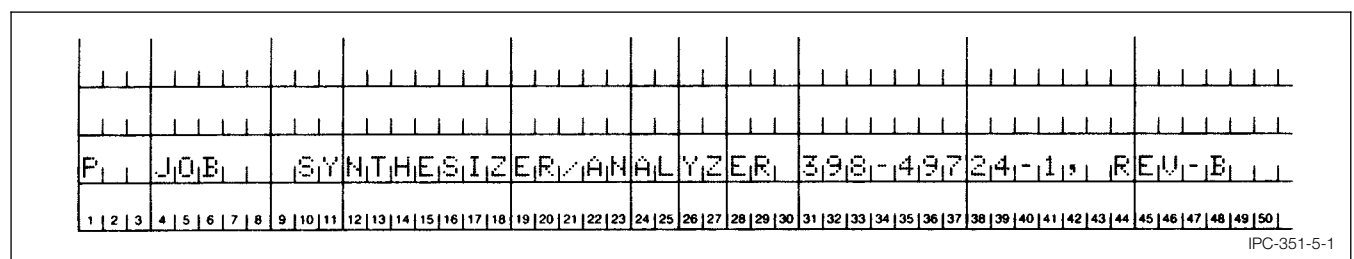


Figure 5-1 Parameter—"JOB"

[illegible]

Figure 5-2 Parameter—"DIM"

DIM parameter record is also described in other IPC-D-35X standards (see Table 5-1).

The order of DIM subsets is optional except as follows:

1. When DIM K, External Library Description, is used, this data shall be the first Data Information Module in the job set.
2. When DIM L, Internal Job Library, definitions are used, the data shall follow the DIM K data. If no DIM K data are present, then the DIM L data shall be the first Data Information Module in the job set.
3. When DIM G, Electrical Description, is used, the data shall immediately follow the DIM L data. If no DIM L and/or DIM K data are present, then the DIM G data shall be the first Data Information Module in the job set.

The relationship of DIM records, DIM codes, and IPC standards is shown in Table 5-1.

Table 5-1 Record Interrelationship

<i>Record Type</i>	<i>Code Ltr</i>	<i>DIM Identifier</i>	<i>IPC Standard</i>
P DIM	A	Artwork Records	IPC-D-350
P DIM	B	Board Description Records	IPC-D-350
P DIM	C	Schematic Drawing Records	IPC-D-351
P DIM	D	Master Drawing Records	IPC-D-351
P DIM	E	Assembly Drawing Records	IPC-D-351
P DIM	F	Miscellaneous Part Drawing Records	IPC-D-351
P DIM	G	Electrical Description Records	IPC-D-352
P DIM	H	Bill of Material Records	IPC-D-352
P DIM	J	Testing Format Records	IPC-D-353
P DIM	K	External Library Description Records	IPC-D-354
P DIM	L	Internal Job Library Description	IPC-D-354

Columns 12 through 72 may contain the DIM identifier shown in Table 5-1.

5.3 Parameter-UNITS (See Figure 5-3.) The word “UNITS” in columns 4-8, preceded by a “P” in column 1, shall indicate units-of-measurement-specification. Columns 10-11 shall contain the word “SI” or columns 10-13 shall

contain the word “CUST” to indicate metric or customary units of measurement. ANSI Z210.1-1971 should be reviewed by those using metric units. The UNITS record shall immediately follow the job record, thus having one unit record in a single job set.

[illegible]

Figure 5-3 Parameter—"UNITS"

5.4 Parameter-TITLE (See Figure 5-4.) The word “TITLE” in columns 4-8, preceded by a “P” in column 1, shall indicate the title of a Data Information Module defined by a “DIM” parameter record (artwork title, schematic title, etc.) Columns 10 through 72 shall be used to contain the exact title, which shall also be used in the title block of the appropriate drawing(s). Titles requiring more than one line of text shall use separate continuation records for each line of text (see Table 7-2.) Any printable ASCII characters are allowed.

P	T	I	T	L	E	I	P	C	3	5	X	S	A	M	P	L	E							
0	0	0				D	E	M	O	N	S	T	R	A	T	I	O	N	J	O	B			
C																								
P	N	U	M			I	P	C	-	B	-	2	5	-	3	5	X							
C																								
P	R	E	V			A																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

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Figure 5-4

The title record shall follow directly after (except for comment records) the DIM record, and relate to that particular data information module. There may be several title records in a complete job set.

5.5 Parameter-NUM (See Figure 5-4.) The word “NUM” in columns 4-6, preceded by a “P” in column 1, shall indicate the part number for a data information module defined by a DIM parameter record (artwork number, schematic number, etc.). Columns 10 through 72 are used to contain the number which shall be left justified and shall also be used in the number block(s) of the appropriate drawing(s). Any printable ASCII characters are allowed.

The NUM record shall follow directly after (except for comment records) the title record to which it applies. There may be several NUM records in the job set, however they must be unique and pertain only to the data information module in which they occur.

5.6 Parameter-REV (See Figure 5-4.) The word “REV” in columns 4-6, preceded by a “P” in column 1, shall indicate the revision identifier of data defined by a DIM parameter record. Columns 10 through 72 shall be used to contain the revision identifier, left justified. The revision identifier shall also be used in the revision block(s) of the appropriate drawing(s). Any printable ASCII characters are allowed.

The revision record (when used) shall follow the TITLE and NUM parameter records and pertain only to the DIM in which it is referenced. The REV parameter record may appear several times in the job set.

5.7 Parameter-SHEET (See Figure 5-5.) The word SHEET in columns 4-8, preceded by a “P” in column 1, shall indicate a composite data specification. The sheet parameter record is used to relate data layer(s) to sheets of drawings. A two-digit number contained in columns 10-11 shall identify the sheet on which the described features are located. Columns 13-16 shall contain the code “COMP” to indicate that the subsequent data layer(s) are used to compose the sheet noted in columns 10-11. Columns 18-19, 21-22, . . . , 69-70 shall contain the numbers of the one or more data layers which make up the particular sheet(s) of the drawing(s).

[illegible]

Figure 5-5 Parameter—"SHEET"

5.7.1 Data layer numbers correspond to entries in the Feature Dimension L-field; see paragraph 7.3.2.

5.8 Parameter-SCALE (See Figure 5-6.) The word SCALE in columns 4-8, preceded by a “P” in column 1, shall indicate a change in the scale factor of the data. Columns 10 through 17 shall be used to contain the scale factor. The scale factor may be any number greater than 0. The rightmost digit shall be established as 0.0001. If a value is assigned, no blanks shall appear in columns 10-17. The scale factor is modal and multiplicative. The scale factor applies to all dimensional data in the LDA and FDA fields and subroutine calls. The scale factor does not apply to angular values or numeric values in the LDA field that describes a characteristic.

[illegible]

Figure 5-6 Parameter—"SCALE"—for 8.5 Scale Factor

6.0 COMMENT RECORDS

The letter “C” in column 1 of a record shall indicate “comment.” Columns 4 through 72 may be used for comment of descriptive material in any form desired except as otherwise specified herein. Comment Records support the numeric data by referencing pertinent descriptive information, specifications and documents. Use of the printable ASCII character set is permitted in Comment Records. (See Figure 6-1.)

7.0 FEATURE/LOCATION AREA FORMAT

7.1 General Information

7.1.1 Major Data Areas Within Each Record The Feature/ Location records shall consist of 80 columns divided into four major areas as shown in Table 7-1.

C,	PART,	OF,	CONTRACT,	27534,	DATA,	DEVELOPED,	TO	IPC-D-	3508
C,	ORTHOGONAL,	AND,	45-DEGREE	DIRECTION	ONLY				
C,	BOARD	MATERIAL	PER MIL-P-	13949,	(FLGEP062	CL/1A1A)			

IPC-351-6-1

Figure 6-1 Examples of Comment Records

Table 7-1 Major Data Areas of Feature/Location Record

AREA	COLUMNS	FUNCTION
1	1-3	Operations Codes (paragraph 7.2)
2	4-30	Features Description Area (FDA) (paragraph 7.3)
3	31-72	Locations Description Area (LDA) (paragraph 7.4)
4	73-80	This area is recommended for alphanumeric identification and/or sequence number (paragraph 7.5). This area shall not contain data necessary to the printed board definition.

7.1.2 Subgroups Within Major Areas Specific data fields or subgroups exist within the FDA (Area 2) and LDA (Area 3). Each of these subgroups shall be prefixed by a specific letter. When a prefix letter is present, the corresponding value field shall be filled (a prefix letter and a blank field or a blank prefix and filled value field is not permitted). Leading zeros within the FDA value fields shall be included; leading zeros within the LDA value fields may be dropped.

7.2 Operations Code Description Area (See Table 7-2.) Columns 1, 2, and 3 shall be reserved for the Operations Code used in conjunction with the FDA and LDA area. This code shall delineate the type of feature being defined. Feature types are LINE, POINT, ANNOTATION, SUBROUTINE DEFINITION and SUBROUTINE CALL. The Operations Code shall be explicitly stated on each record. Since each column of the Operations Code contains a particular type of information, the Operations Code field can be interpreted as being three separate codes in adjacent positions. A zero in any position shall represent a continuation of the operation defined by the previous entry in that column. When the basic record type (column 1 code) changes, column 2 shall be explicitly redefined.

7.2.1 Operations Code Column 1 Column 1 values of the three-column Operations Code shall be in accordance with Table 7-3.

7.2.2 Operations Code Column 2 Column 2 values of the three-column Operations Code shall be used for specifying the functional interpretation of the following data record when column 1 contains a "1", "3", or "5". See Table 7-2 for examples.

7.2.3 Operations Code Column 3 The third column of the Operations Code field shall describe the format of XY fields in the LDA. Interpretation of data in the LDA differs for each column 2 code. The content of each XY field in the LDA shall be based upon the type of LINE being defined, such as straight or circular. Relationships of each column 2 code to the LDA XY values are shown in Table 7-4. Complex geometries can be defined by combining these basic constructions.

7.3 Features Description Area (FDA) Columns 4-30 shall be reserved for a physical description of a given

unique feature or for other pertinent data. The specific information used in this area shall be placed into preassigned columns forming fields of record. Each field shall be prefaced by a letter code to identify function. See Table 7-5. The number of fields and type of information contained in these fields shall vary according to the record used. Table 7-6 defines the considerations for the FDA field for line, point, annotation and subroutine records.

7.3.1 Feature Dimension Field

7.3.1.1 Column 4 There shall be a "D" in column 4 for a Feature Dimension.

7.3.1.2 Columns 5-8 Columns 5-8 shall be reserved for a description of feature size. This information shall denote line width, or feature land size at the location described in subsequent LDA fields (paragraph 7.4). The values in this field shall represent the feature size in ten-thousandths (0.0001) of an inch or one-thousandths (0.001) of a millimeter. This same feature size shall continue to apply to all locations described in this record and all following records until a new value is placed in columns 5-8.

When subsequent records supply positional information for the same feature, columns 4-8 may be left blank; this is referred to as modal form. See Figure 7-4.

7.3.2 Data Layer Code Field - Columns 9-11

7.3.2.1 Column 9 There shall be an "L" in column 9 for a "Data Layer" code.

7.3.2.2 Columns 10-11 Information contained in columns 10-11 shall identify the "data layer" of the feature described in the record. Data layers may be established by the user as required, and are related to one or more drawing sheets by means of SHEET parameter records. (See paragraph 5.7.)

7.3.3 Node Identification Field-Columns 12-18

7.3.3.1 Column 12 There shall be an "S" in column 12 of Line and Point records for "Node Identification."

7.3.3.2 Columns 13-18 Where a record describes an electrical feature and no continuity test is required, the only information required shall be "NULL" in columns 13-18.

Table 7-2 Operations Codes Descriptions

All Operations Codes have three digits. The use of the decimal-point symbol (.) in the listing below indicates the position of a digit and illustrates that the Operations Code for these records also may be interpreted as three single-digit Operations Codes in adjacent positions.

GENERAL RECORDS

Columns
123

000 or 0 . . or . 0 . or . . 0 Continuation in present mode; valid for all types of records.

999 End of job.

LINE RECORDS

Columns
123

1 . . Begin new line containing one or more line segments.

. 1 . Linear interpolation.

. 2 . Circular interpolation.

. 4 . Linear "paint in" area outline.

. 5 . Circular "paint in" area outline.

*. 7 . Linear part outline.

*. 8 . Circular part outline.

. . 1 Format #1

. . 2 Format #2

SUBROUTINE DEFINITION RECORDS

Columns
123

2 . . Begin subroutine definition

. 1 . Subroutine definition of a complex feature (executed by a subroutine CALL)

. 2 . Definition of a Point Record special shape (executed as a point record with generic code of G4)

. 3 . Subroutine for dimension description or call out with arrow head

. . 1 Format #1

. . 2 Format #2

299 End of subroutine

POINT RECORDS

Columns
123

3 . . Begin new point record.

*. 1 . Feature (land) and hole concentric at the point.

. 2 . Feature (land) only at the point.

*. 3 . Hole only at the point.

*. 4 . Tooling feature and hole at the point.

. 5 . Tooling feature only at the point.

*. 6 . Tooling hole only at the point.

. . 1 Format #1

. . 2 Format #2

SUBROUTINE CALL RECORDS

Columns
123

4 . . Subroutine call

. 1 . Linear repeat or step-and-repeat

. 2 . Rotary repeat or step-and-repeat

. . 1 Format #1¹

. . 2 Format #2¹

ANNOTATION RECORDS

Columns
123

5 . . Begin annotation/dimension record

. 1 . Begin new annotation record

. 2 . Subroutine call for dimension guidelines, call out guidelines, and the appropriate annotation records to go along with that subroutine.

. . 1 Format #1²

. . 2 Format #2²

000 Columns 4-72 contain the text. This record must follow 51.

Format #1: Positional data (LDA Columns 31-72) formatted as three identical, adjacent X and Y fields.

Format #2: Positional data (LDA Columns 31-72) formatted as two identical, adjacent X and Y fields.

1. The first X, Y data points define the position of the subroutine pattern datum point, or origin. The second and third X, Y data points are used for linear or rotary replications arguments. The angle is specified in degrees for U.S. units and radians for metric units.
2. The first field contains the XY coordinate for the point of the arrow head, if only one arrow head is present. The second field contains the X and Y coordinate for either the line end or the center of a circle subscribing the call out designator. If two arrow heads are present, the first X and Y coordinate will be for the point of the arrow head closest to datum 00. The third field is left blank.

*NOTE: See Section 4.1.3. Asterisks only for DIM A or DIM B data subsets (see IPC-D-350).

Table 7-3 Column 1 Operations Code Values

<i>Code Value</i>	<i>Function</i>
0	Continuation record
1	Line record
2	Subroutine definition record (see paragraph 11.0)
3	Point record
4	Subroutine CALL record (see paragraph 11.0)
5	Annotation or lettering record

for electrical circuit paths. Where continuity test information is required, columns 13-18 shall contain a unique alphanumeric code for each circuit network (electrically continuous path). Identifiers may be duplicated on different layers and shall be part of the same composite (after lamination) electrical network. "NO" shall be entered in columns 17 and 18 for all nonelectrical features (e.g., non-plated holes, symbols, heatsinks).

7.3.4 Rotation, Hole Size, Character Height Field (Columns 19-23) There shall be an "H" in column 19 when the H field is used. The "H" field is not used with line records. Use of the "H" field is defined in paragraph 9.5. for point records (hole size), paragraph 10.1.3 for annotation records (character height), and paragraph 11.3.1.2 for subroutine calls (rotation).

7.3.5 Hole Type/Spacing Field (Columns 24-25) There shall be a "P" in column 24 when the "P" field is used. The P field is not used with line records. Use of the "P" field is defined in paragraph 9.6 for point records (hole type) and paragraph 10.1.5 for annotation records (spacing).

7.3.6 Generic Field (Columns 26-27) There shall be a "G" in column 26 when the G field is used. Use of the "G" field is defined in paragraph 8.6 for line records, paragraph 9.7 for point records, paragraph 10.1.4 for annotation records, and 11.2.2.1 for subroutine calls.

Table 7-5 Preassigned FDA Fields

<i>Columns</i>	<i>Letter Code</i>	<i>Function</i>
4-8	D	Feature dimension
9-11	L	Data layer code
12-18	S	Node identification
19-23	H	Hole size, annotation character height or standard symbol rotation
24-25	P	Hole type
26-27	G	Generic characteristics
28-30	U	Not presently assigned

7.3.7 Unassigned Field (Columns 28-30) Columns 28-30 are unassigned and have been reserved for future expansion.

7.4 Location Description Area (LDA) Columns 31-72 shall be reserved for locating features along the X and Y axis from a pre-established datum of zero point. This area shall be divided into either two or three identical fields.

7.4.1 Three Identical Fields When three identical fields are used, each field shall consist of 14 columns (31-44, 45-58, 59-72). The first column of each field shall contain the letter "X". The next column shall contain a "+" or "-" sign or blank; a blank shall be interpreted as a "+". The sign in turn is followed by five digits. The eighth position of each field (columns 38, 52, and 66) shall be reserved for

Table 7-4 OPCODE Column 2 Relationships with LDA X-Y Fields

Mode	Column 2 Code	Figure No.	Content of LDA X-Y Fields (Also see Paragraph 7.2.3)
Linear	1	7-1(a)(b)	Each X-Y pair defines a line-segment point.
Circular	2	7-1(c)(b)	First X-Y pair—arc or circle center point. Second X-Y pair—the X-field contains the start angle; the Y-field contains the finish angle; both expressed in degrees relative to positive horizontal axis following normal mathematical convention of counterclockwise being a positive angle. Third X-Y pair—the X-field contains the radius value while the Y-field contains direction of movement value. A positive direction value of 1 indicates counterclockwise motion; negative value of -1 defines clockwise.
Linear Circular	4 5	7-2	Same as 1 and 2 above except the points define an interior fill area.
Linear Circular	7 8	7-3	Same as 1 and 2 above except the points define a part outline.
Continuation	0		Whenever column 2 changes from zero, the first X-Y pair represents the start point of a new line.

Table 7-6 LINE Records

OP CODE	D FIELD	L FIELD	S FIELD	H FIELD	P FIELD	G FIELD	X-Y FIELD
11.							
12.							
14.							
15.							
*17.	(3)						
*18.	(3)						
*31.							
32.							
*33.							
*34.			(1)		(2)		
35.			(1)				
*36.					(2)		
51.							
52.							
21.							
22.							
23.							
41.		(4)					
42.		(4)					

*Used only in the DIM A or DIM B data subsets.

□ = No meaningful information, no entry needed in the field.

(1) Never a signal path, always enter "NO."

(2) Never a plated hole, always enter "0."

(3) Never a width, always enter "0."

(4) When a subroutine call is used within a subroutine definition, the L field may not be used.

the letter "Y", followed by a sign column, followed by five digits. Leading zeros may be eliminated; thus, they appear as blank characters.

The value of the smallest digit shall be either 0.001-inch (or 0.001-degrees) or 0.01-millimeter (or 0.01-radians). No decimal point shall appear within the digit string. All records using this format in LDA shall have a "1" (one) value in the third column of the Operations Code area, column 3. Millimeter units shall be interpreted only when the UNITS SI parameter has been employed.

7.4.2 Two Identical Fields When two identical fields are used, each field shall consist of 20 columns (31-50 and 51-70); columns 71-72 shall not be used. The first column of each field shall contain the letter "X". The next column shall contain a "+" or "-" sign or blank; a blank shall be interpreted as a "+". The sign in turn is followed by eight digits. The eleventh position of each field (column 41 and 61) shall be reserved for the letter "Y", followed by a sign column, followed by eight digits. Leading zeros may be eliminated; thus, they appear as blank characters.

The value of the right most digit shall be either 0.000-inch (or 0.0001-degrees) or 0.001-millimeter (or 0.001-radians). No decimal point shall appear within the digit string. All records using this format in the LDA shall have a "2"

value in the third column of the Operations Code area, column 3. Millimeter units shall be interpreted only when the UNITS SI parameter has been employed.

7.5 Unassigned Columns

7.5.1 Columns 73 through 80 are presently not assigned, and are reserved for future use.

8.0 LINE RECORD DEFINITION

Each LINE record shall be denoted by a "1" in column 1 and shall define one line containing one or more line segments. The continuation code "000" in columns 1-3 is used to define, not multiple-line groups, but only multiple-line segments within a single group of the same width, layer, and generic code; see paragraph 8.3. A line may be composed of any combination of straight or circular segments as shown in Table 7-4 and Figures 8-1, 8-2, and 8-3, defining either a simple feature, a complex "paint-in" area, or a complex "part outline."

8.1 Special Requirements for Line Records

8.1.1 LINE records used to define the outline enclosing a paint-in area shall contain zeros in columns 5-8 of the Feature Dimension field (paragraph 7.3.1).

```

C
C THE FOLLOWING IS AN EXAMPLE OF A CIRCULAR LINE SEGMENTS COMBINED WITH
C STRAIGHT LINE SEGMENTS ON LAYER 1, ROUND LINE ENDS. SEE FIGURE 8-1(B).
C BLANK FIELDS IN THE FDA OF EACH RECORD IMPLY MODAL DATA.
C RECORD 1 STRAIGHT LINE
C RECORD 2 90 DEG ARC CLOCKWISE (CW)
C RECORD 3 90 DEG ARC COUNTERCLOCKWISE (CCW)
C RECORD 4 CONTINUATION OF CCW ARC RECORD ABOVE
C RECORD 5 STRAIGHT LINE
C
111 L01 G1 X+01250Y+01000X+02125Y+01000 RECORD 1
021 X+02125Y+00000X+90000Y+00000X+01000Y+10000 RECORD 2
022 X+00041250Y+00000000X+01000000Y+02700000 RECORD 3
000 X+00010000Y-00010000 RECORD 4
011 X+04125Y-01000X+06133Y-01000 RECORD 5
C
C
C THE FOLLOWING IS AN EXAMPLE OF A PAINT-IN AREA USING BOTH LINEAR
C AND CIRCULAR MODES. MODAL FDA IS ASSUMED, EXCEPT FOR D-FIELD WHICH
C PROVIDES THE STARTING TOOL DIAMETER USED TO TRAVERSE THE FEATURE
C EXTREMITIES. TOOL DIAMETERS FOR SUBSEQUENT MOVEMENTS USED TO FILL
C IN THE REMAINING PAINT-IN AREA IS LEFT TO THE DISCRETION OF THE
C USER WITH THE ONLY REQUIREMENT BEING COMPLETE PAINT-IN.
C SEE FIGURE 8-2.
C
14100100 X 0Y 1200X 1000Y 1200X 2000Y 1400
051 X 2000Y 800X 9000Y 0X 600Y 1000
041 X 2600Y 800X 2600Y 0X 0Y 0
041 X 0Y 400
051 X 0Y 600X-9000Y 9000X 200Y-01000
041 X 0Y 800X 0Y 1200
C
C
C THE FOLLOWING IS AN EXAMPLE OF A PART-OUTLINE USING BOTH LINEAR
C AND CIRCULAR MODES. MODAL FDA IS ASSUMED.
C SEE FIGURE 8-3(A).
C
102 X 0Y 0X 1605290Y 1994710
070 X 18000Y 10000
072 X- 16970Y- 6000X- 12000Y- 6000
081 X- 1200Y- 400X-9000Y 0X 200Y- 1000
072 X- 10000Y- 4000X- 10000Y 4000
081 X- 1200Y 400X 0Y 9000X 200Y- 1000
072 X- 12000Y 6000X- 16970Y 6000
102 X 0Y 0X 0Y 3600000
000 X 2000Y- 10000
C
C
C THE FOLLOWING IS AN EXAMPLE OF A 40 MIL LINE FOR ANALOG GND
C CONSISTING OF 5 LINE SEGMENTS ON LAYER 1, ROUND LINE ENDS.
C
11100400L01 G1 X+00275Y+02300X+00278Y+02251X+00400Y+02125
000 X+00400Y+02025X+00575Y+01850X+00575Y+01500
C
C
C THE FOLLOWING IS AN EXAMPLE OF A 150 MIL SQUARE PAD USED AS A TOOLING
C FEATURE WITH A 125 MIL HOLE AT THREE LOCATIONS. NO PLATING.
C
331D1500L00 H1250P0G3 X+00000Y+00000X+00000Y+03650X+03200Y+03650
C
C
C THE FOLLOWING IS AN EXAMPLE OF A CHARACTER STRING, OFF THE BOARD AREA
C 100 MIL HIGH, DRAWN WITH A 20 MIL LINE, IN ORIENTATION 4.
C
511D0200L02 H1000 G4 X+01250Y-00050
000SYNTHESIZER/ANALYZER 398-49724-1 REV-B
C
C COMMENTING ON JOB IS A STRONGLY RECOMMENDED PRACTICE
C - BLANK COMMENTS CARDS PROVIDE PARAGRAPHING WHICH ENHANCES
C READABILITY

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Figure 7-4 Sample Computer Printout

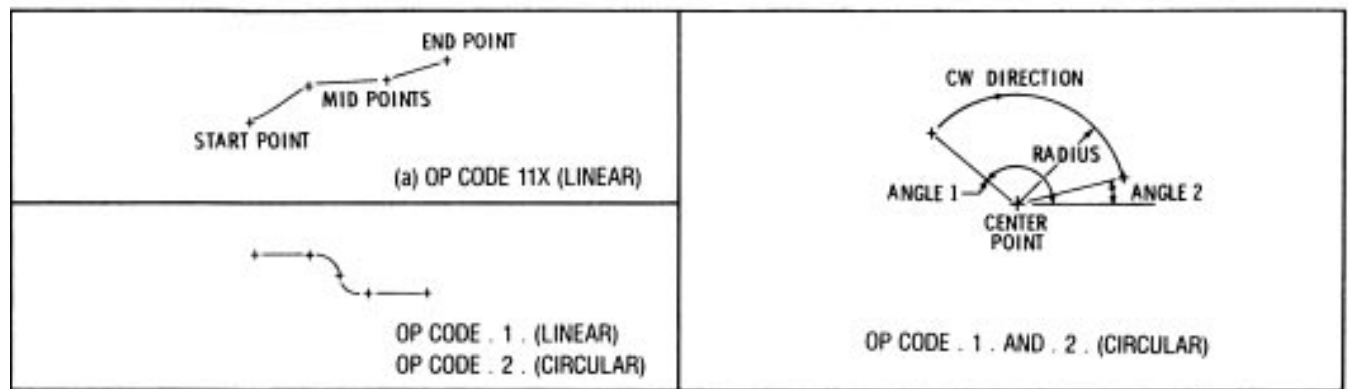


Figure 8-1 Linear and Circular Interpolation (See Table 7-4)

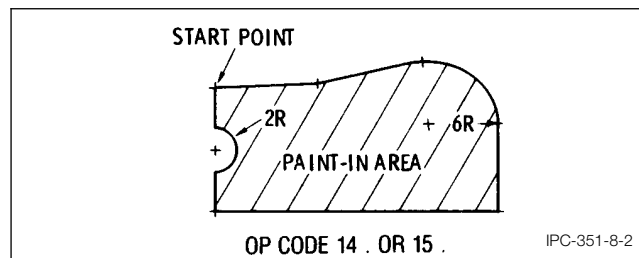


Figure 8-2 Area Outline Paint In (See Table 7-4)

area to be interior filled shall be composed of "14." or "15." type line segments which are contiguous, end-to-end, and terminate at the beginning point. A continuation record (or records) shall be used to complete the perimeter in accordance with the procedure outlined in paragraph 8.0. A paint-in area is defined to the right of the line moving in the direction of travel (clockwise). Complicated paint-in areas with internal voids (such as a doughnut shape) shall be broken into unambiguous adjacent definitions for manual or digital fill.

8.1.2 Line records used to define part outlines or cutouts shall be defined using "17." or "18." type line segments. A part cutout is defined to the right of the line moving in the direction of travel (counterclockwise).

8.2 Operations Code Definitions (Columns 1-3) Define the Operations Code (see paragraph 7.2). Column 1 shall contain a 1 to signify the start of a line record and a 0 for continuation of that line. Column 2 contains the number 1, 2, 4, 5, 7 or 8 to specify the type of line convention, i.e., linear, circular, linear paint-in, etc., as shown in Table 7-2. Column 3 contains a 1 or 2 to define the format of the LDA field (see Table 7-2).

8.3 "D" Field Definition (Columns 4-8) There shall be a "D" in column 4 for line width dimension. Columns 5 through 8 contain the value of the line width, represented in 0.0001 inch or 0.001 millimeter increments. The information is modal (see paragraph 7.3.1.2).

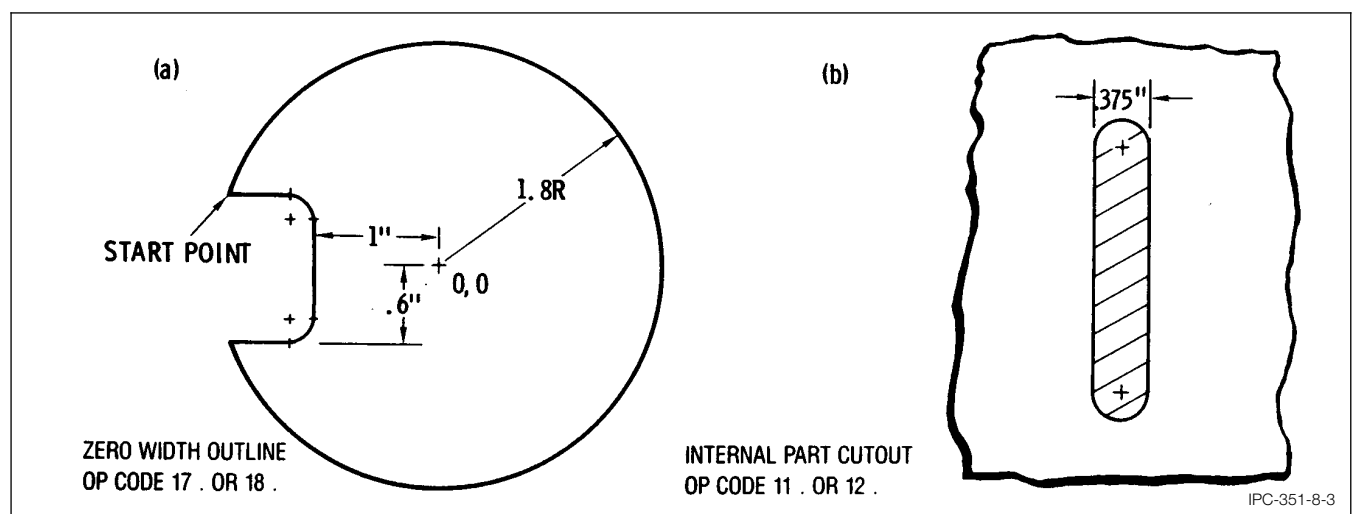


Figure 8-3 Part Outlines (See Table 7-4)

8.4 “L” Field Definition (Columns 9-11) There shall be an “L” in column 9 followed by a user assigned two-digit number to establish unique data layers of lines within a single Data Information Module. The user assigned numbers are unique to the Data Information Module in which they are specified.

8.5 “S” Field Definition (Columns 12-18) The “S” field (node identification) is not used in defining line records for drawings.

8.6 “H” Field Definition (Columns 19-23) The “H” field (hole size, character height and rotation) is not used in defining line records for drawings.

8.7 “P” Field Definition (Columns 24-25) The “P” field (hole type) is not used in defining line records for drawings.

8.8 “G” Field Definition (Columns 26-27) There shall be a “G” in column 26 to indicate that the subsequent column defines line end definition. Column 27 shall identify line-end shapes and line-end dimension relationships in accordance with Figure 8-4 and Table 8-1. This code shall apply to all locations described in this record and all following records until a new value is placed in columns 26-27. If no G code is present, G0 shall be assumed.

Table 8-1 Line Style

G Code	Function
0	Combination of A and D (See Fig. 8-4)
1	Combination of B and D (See Fig. 8-4)
2	Combination of A and C (See Fig. 8-4)
3	Combination of B and C (See Fig. 8-4)

8.9 LDA Field Definition (Columns 31-72) The LDA field shall contain the X and Y coordinates that locate the beginning and end of every line segment in accordance with the rules specified in Table 7-4. Two formats may be used to describe the X and Y data, either of which is permissible provided the proper Operations Code has been denoted in column 3 of the OP code field.

9.0 POINT RECORD DEFINITION

Each POINT record shall be denoted by a number “3” in column 1. Each POINT record can define several points using the available LDA fields, since no two points are related in the same sense as line segments.

9.1 Operations Code Definition (Columns 1-3) Define the Operations Code (see paragraph 7.2). Column 1 shall contain a 1 to signify the start of a point record and a 0 for continuation of that point. Column 2 contains the number 1, 2, 3, 4, 5, or 6 to specify the type of point convention,

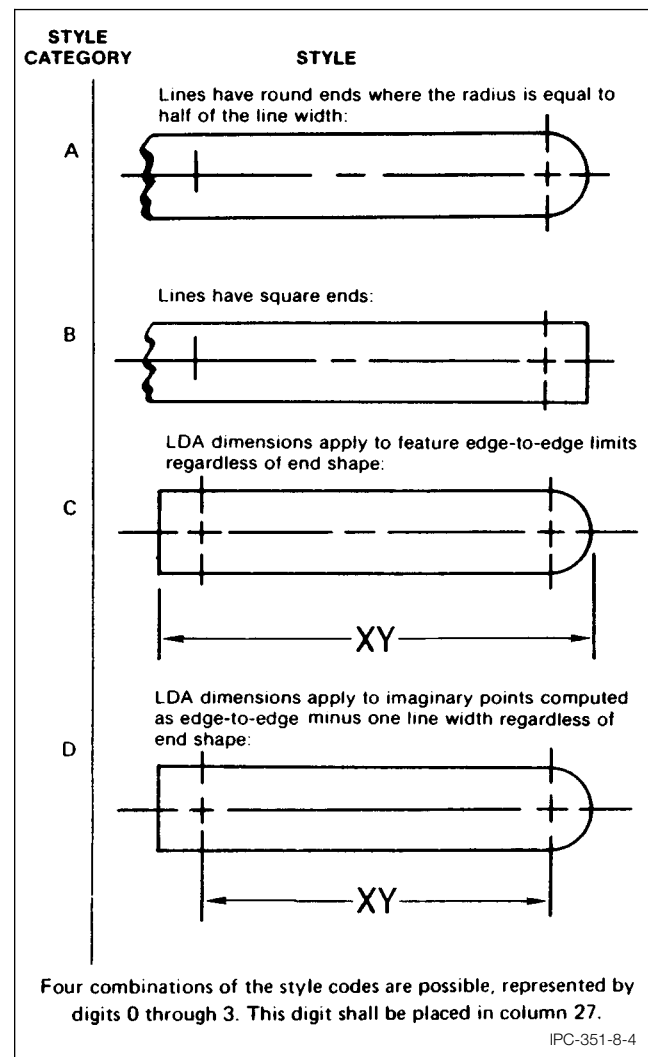


Figure 8-4 Line Style Code Definition

i.e., feature, hole, etc., as shown in Table 7-2. Column 3 contains a 1 or 2 to define the format of the LDA field (see Table 7-2).

9.2 “D” Field Definition (Columns 4-8) There shall be a “D” in column 4 to define that subsequent columns describe feature size dimensions in accordance with the requirements of type 3 OP codes shown in Table 7-2. Columns 5-8 contain the value of the feature dimension, represented in 0.0001 inch or 0.001 millimeter increments (see paragraph 7.3.1.2).

9.3 “L” Field Definition (Columns 9-11) There shall be an “L” in column 9 followed by a user assigned two-digit number to establish unique data layers of lines within a single Data Information Module. The user assigned numbers are unique to the Data Information Module in which they are specified.

9.4 “S” Field Definition (Columns 12-18) The “S” field (node identification) is not used in defining point records for drawings.