E V A L U A C I O N   D E L   P E R S O N A L

D O C E N T E

CURSO: CAD CIRCUITOS IMPRESOS 1992.

FECHA: del 20 al 30 de abril
lunes a viernes
de 17 a 21 hrs.

C O N F E R E N C I S T A		DOMINIO DEL TEMA	EFICIENCIA EN EL USO DE AYUDAS AUDIOVISUALES	MANTENIMIENTO DEL INTERES (COMUNICACION CON LOS ASISTENTES AMENIDAD, FACILIDAD DE EXPRESION)	PUNTUALIDAD	PROMEDIO
1.-	ING. MARTIN PEREZ MONDRAGON					
2.-	ING. SERGIO AMBRIZ MAGUEY					
3.-	ING. EDGAR O. BECERRIL LERIN					
4.						
5.-						
EVALUACION TOTAL						

ESCALA DE EVALUACION: 1 A 10

CURSO: CAD CIRCUITOS IMPRESOS 1992.

FECHA: del 20 al 30 de abril
lunes a viernes
de 17 a 21 hrs.

	T E M A	ORGANIZACION Y DESARROLLO DEL TEMA	GRADO DE PROFUNDIDAD LOGRADO EN EL TEMA	GRADO DE ACTUALIZACION LOGRADO EN EL TEMA	UTILIDAD PRACTICA DEL TEMA	PROMEDIO
1.-	INTRODUCCION AL DISEÑO ASISTIDO					
2.-	DISEÑO ESQUEMATICO					
3.	ELABORACION DE UN CIRCUITO					
	IMPRESO A PARTIR DEL DISEÑO ESQ.					
	EVALUACION TOTAL					

ESCALA DE EVALUACION: 1 A 10

EVALUACION DEL CURSO

CONCEPTO		
1.-	APLICACION INMEDIATA DE LOS CONCEPTOS EXPUESTOS	
2.-	CLARIDAD CON QUE SE EXPUSIERON LOS TEMAS	
3.-	GRADO DE ACTUALIZACION LOGRADO EN EL CURSO	
4.-	CUMPLIMIENTO DE LOS OBJETIVOS DEL CURSO	
5.-	CONTINUIDAD EN LOS TEMAS DEL CURSO	
6.-	CALIDAD DE LAS NOTAS DEL CURSO	
7.-	GRADO DE MOTIVACION LOGRADO EN EL CURSO	
	EVALUACION TOTAL	

ESCALA DE EVALUACION: 1 A 10

1.- ¿Qué le pareció el ambiente en la División de Educación Continua?

MUY AGRADABLE ☐ AGRADABLE ☐ DESAGRADABLE ☐

2.- Medio de comunicación por el que se enteró del curso:

PERIODICO EXCELSIOR ANUNCIO TITULADO DIVISION DE EDUCACION CONTINUA ☐

PERIODICO NOVEDADES ANUNCIO TITULADO DIVISION DE EDUCACION CONTINUA ☐

FOLLETO DEL CURSO ☐

CARTEL MENSUAL ☐

RADIO UNIVERSIDAD ☐

COMUNICACION CARTA, TELEFONO, VERBAL, ETC. ☐

REVISTAS TECNICAS ☐

FOLLETO ANUAL ☐

CARTELERA UNAM "LOS UNIVERSITARIOS HOY" ☐

GACETA UNAM ☐

3.- Medio de transporte utilizado para venir al Palacio de Minería:

AUTOMOVIL PARTICULAR ☐ METRO ☐ OTRO MEDIO ☐

4.- ¿Qué cambios haría en el programa para tratar de perfeccionar el curso?

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5.- ¿Recomendaría el curso a otras personas? ☐ SI ☐ NO

5.a. ¿Qué periódico lee con mayor frecuencia?

____

____

6.- ¿Qué cursos le gustaría que ofreciera la División de Educación Continua?

____

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____

7.- La coordinación académica fué:

EXCELENTE ☐ BUENA ☐ REGULAR ☐ MALA ☐

8.- Si está interesado en tomar algún curso INTENSIVO ¿Cuál es el horario más conveniente para usted?

LUNES A VIERNES DE 9 a 13 H. Y DE 14 A 18 H. (CON COMIDAD) ☐

LUNES A VIERNES DE 17 a 21 H. ☐

LUNES A MIERCOLES Y VIERNES DE 18 A 21 H. ☐

MARTES Y JUEVES DE 18 A 21 H. ☐

VIERNES DE 17 A 21 H. SABADOS DE 9 A 14 H. ☐

VIERNES DE 17 A 21 H. SABADOS DE 9 A 13 H. DE 14 A 18 H. ☐

OTRO ☐

9.- ¿Qué servicios adicionales desearía que tuviese la División de Educación Continua, para los asistentes?

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____

____

10.- Otras sugerencias:

____

____

____

FACULTAD DE INGENIERIA U.N.A.M.
DIVISION DE EDUCACION CONTINUA

CAD -CIRCUITOS IMPRESOS-

ING. MARTIN PEREZ MONDRAGON

INTRODUCCION AL DISEÑO ASISTIDO POR COMPUTADORA

El Diseño Electrónico Asistido por Computadora (**DEAC** o su equivalente anglosajon de **C.A.E**) podemos considerarlo como una rama específica del **CAD/CAM** de tipo general.

Las principales aplicaciones del CAD/CAM se dan en dos campos de acción principalmente: **EL MECANICO Y EL ELECTRONICO**, dominando el primero con un 50% el mercado, mientras que el diseño electrónico alcanza tan solo el 19%, (según datos referidos al 1988).

El mercado de CAD electrónico, conocido como E.D.A. (Electronic Design Automation) ha experimentado, a lo largo de 1989, una serie de uniones, fusiones y alianzas entre empresas del sector que posibilitan la oferta de una serie de productos capaces de funcionar en entornos más amplios.

EVOLUCION DE LAS COMPUTADORAS PERSONALES Y WORKSTATION

A principios de los 70's, surgen a partir de las necesidades de fabricantes de electrónica ó mécanicos, las **herramientas CAD**, las cuales han experimentado, evidentemente, grandes cambios de acuerdo con la tecnología.

Durante esta década se empleaban las minicomputadoras a las cuales se conectaban terminales que servian a programas funcionando el "Batch". En 1971, INTEL introduce el primer microprocesador, el 4004 y en 1974 presentaba el 8080, por otra parte, MOTOROLA presentaba el x6800.

A principios de los 80's, APOLLO crea la estación de trabajo (WorkStations) con el un concepto novedoso de potentes gráficos y red local produciendose el cambio de **CAD** a **CAE** (Ingeniería Asistida por Computadora), donde el software desarrollado permitía al ingeniero Concebir, Diseñar, Simular, Modificar, Verificar y Documentar un circuito a un placa de circuito impreso, desde una potente máquina colocada en su mesa de trabajo.

Por otra parte, a finales de los 80's, surgén las tecnologías de integración **RISC Y CISC** poniendo a disposición del fabricante de software máquinas sin limitaciones tecnologicas, capaces de desarrollar aplicaciones más complejas, de tal manera que las actuales PC's equipadas con 80386 o 80486, se comparan tanto en prestaciones de la CPU como en precio con las actuales WoskStation, dicho termino se encuentra ligado indisolublemente cada vez que se habla de **CAD/CAM/CIM/CAE.**

INTRODUCCION

Algunos de los sistemas de computación más avanzados que se emplean hoy en día, se diseñan contemplando la generación de despliegues gráficos, reconociendose así el valor de una imagen como un medio eficaz de comunicación.

Prácticamente, no existe en la actualidad ningún área en la cual no se pueda utilizar la graficación con alguna ventaja; sí, se encuentran gráficas en la mayoría de las aplicaciones en ciencia e ingeniería se basaron en equipos costosos y complicados, lo cual se ha superado debido a los adelantos registrados en computación permitiendo así acceder a la graficación como una herramienta útil y práctica a bajo costo.

Durante las fases de evolución del CAD/CAM podemos identificar a finales de la década de los 70's, la integración de la graficación por computadora al proceso de diseño, originando el crecimiento de la tecnología CAD - Computer-Aided Design- o Diseño Asistido por Computadora. Esta tecnología ofrece poderosas herramientas para el diseño en ingeniería, pemitiendo, entre otras cosas, agilizar el proceso de conceptualización, modelado, análisis y documentación de un producto con las etapas respectivas de retroalimentación, formando así, un ambiente de control de ciclo cerrado que contrasta con los mecanismos tradicionales de diseño.

La influencia de la tecnología CAD ha alcanzado las áreas de eléctrica y electrónica, con ejemplos como el diseño de circuitos electrónicos empleando sistemas interactivos basados en íconos gráficos para la representación de los diferentes componentes, con lo cual un diseñador puede construir un circuito, agregando compoentes en forma sucesiva extraídos de una Base de Dato. Además, el despliegue gráfico puede emplearse para comparar circuitos equivalentes con la finalidad de minimizar el número de componentes o bien, para llevar a cabo una mayor integración.

TIPOS DE MAQUINAS	
NIVEL TECNOLOGICO **Características**	**NIVEL DE APLICACION** **Características**
* Los estandares que imperan en la PC son la compatibilidad, tanto en Hardware como en software, mientras que en las estaciones de trabajo se impone el UNIX en cuanto a Sistema Operativo, el MOTIF en cuanto a interfase de usuario, el OSI en comunicaciones y el PHIGS en gráficos. * En arquitectura, la PC comienza con 8 bits y crece hasta 32 bits, prevaleciendo en la actualidad los equipos con CPU de 16 bits, mientras que en las WorkStation, la mayoria son de 32 bits y algunas de 64 bits. * Las ventajas de un WorkStation suelen estar siempre por encima de las PC, aunque el auge experimentado por las máquinas con 386 y 486 ha igualadoel nivel de prestaciones. Entre las ventajas que han mejorado las estaciones de trabajo respecto a las PC's son algunas de las siguientes: mayor definición a nivel de gráficos, lentitud de visualización, limitado margen de direccionamiento de la memoria, baja potencia de cálculo de la CPU y bajo nivel de conectividad.	* La PC se encuentra orientada fundamentalmente a manjejar textos y números, mientras que una WorkStation está orientada a manejar gráficos. * La PC funciona "normalmente" en un entorno monousuario tratando de incrementar la productividad del individuo mientras que el entorno de trabajo de una WorkStation es por lo general, multiusuario

EVOLUCION A MEDIANO PLAZO EN CUANTO A NIVEL TECNOLOGICO Y NIVEL DE APLICACION.

	ARQUITECTURA	GRAFICOS	SISTEMAS OPERATIVOS
PC	Tienden hacia el nuevo bus estandard EISA (MicroChanel de IBM) y CPU 80486.	Aparecen los primeros sistemas en 3D así como sistemas capaces de manejar más de 100000 vectores por seg. en 2D.	Se estandariza tanto en UNIX como en 0S/2 en los dos equipo mientras que en interfases de usuario, vemos como el MOTIF empieza a incorporarse al mundode las PC a través de UNIX.
WORKSTATION	Tienden a una mejora en los chips, así como la ejecución de multiples instrucciones por cada ciclo de reloj.	Incrementa sus ventajas en 3D en tiempo real con capacidades como fotorealismo.	

JUSTIFICACION Y NECESIDAD DEL CAE.

En la actualidad los objetivos básicos de toda empresa en el entorno económico consisten en incrementar la **PRODUCTIVIDAD** y mejorar la **COMPETITIVIDAD**. Para ello, es necesario reducir los costos involucrados en la fase de desarrollo del producto, el tiempo empleado desde la especificación hasta la puesta en el mercado del producto; así como incrementar la **CALIDAD** del producto..

En este tipo de técnicas es donde el **CAD/CAM/CAE** ha puesto de relieve la importancia de automatizar informaticamente cualquier proceso industrial desde el diseño hasta la manufactura.

dicha información incide de forma directa sobre dicho proceso de varias formas:

* Reducción de tiempos y sencillez en la etapa de diseño.

* Seguridad de un correcto funcionamiento ya que se ha simulado el prototipo sin necesidad de elaborarlo.

* Fácil integración sin problemas adicionales, dentro de un proceso en serie para su manufactura.

* Obtención de un producto económico, de óptima calidad y en el menor tiempo posible.

El proceso típico de fabricación de un determinado producto electrónico podemos sintetizarlo en las siguientes fases:

* Construcción del Prototipo
* Pruebas y Puestas a Punto del Prototipo
* Elaboración en Serie del Producto Final

EVOLUCION DEL CAE.

Los primeros sistemas de diseño surgieron como replica de los procesos tradicionales, con la ventaja de la facilidad de uso, edición y rápidez.

Conforme el hardware evoluciona y disminuyen los costos del equipo, los sistemas son más rápidos ylas bases de datos de mayores dimensiones, fue apareciendo un fénomeno de insatisfacción en los usuarios: Un buen programa de dibujo, no bastaba; era necesario un sistema que diseñara el producto desde el principio (Diagrama Esquemático) hasta el final (Placa de Circuito Impreso Terminado) siguiendo **Reglas de Diseño.**

Como sonsecuencia de estas necesidades surguieron los paquetes de **CAE**, cuyas reglas de diseño referidas al CAE electrónico, se mencionan a continuación:

* **Captura de Diseños Esquemáticos**
* **Diseño de Circuitos Analógicos y Digitales**
* **Simulación Lógicas y Analógicas de Dichos Circuitos**
* **Análisis Térmico**
* **Diseño de la Placa de Circuito Impreso (PCB)**
* **Proceso de Electrómecanica.**

VENTAJAS EN EL USO DE PAQUETES CAE

* **Facilidad y Comodidad en el Diseño**
* **Rápidez, Exactitud y Uniformidad en la Fabricación**
* **Alto Porcentaje de Exito**
* **Eliminación de la Necesidad de Prototipos**
* **Aumento de la Productividad**
* **Productos más Competitivos**

PRESENTE Y FUTURO DEL MERCADO CAE

Se considerá hoy en día que más del 30% de los diseños industriales se realizan con herramientas CAE. Empero, debido a la mayor complejidad y competitividad del mercado, se prevee que antes del año 2000 el grado de utilización se aproximará al 80%.

Los costos asociados a la detección de errores en el desarrollo pueden representar hasta 1000 veces más si se detectan en una fase final del producto que si se realiza en las específicaciones.

El factor tiempo también repercute de forma prioritaria en el desarrollo de prototipos. Los circuitos son cada vez más complejos, desarrollando mayor número de funciones, por lo tanto, deben diseñarse en un menor plazo de tiempo. La competencia es cada día mayor y el tiempo de lanzamiento de un producto es primordial al momento de conseguir mayores beneficios.

CARACTERISTICAS

Las características de cualquier software de CAE partiendo de la base del CAD, podemos enfocarla bajo dos aspectos:

* **Común**
* **Específico**

y en cada uno de estos aspectos, dos niveles:

* **Hardware**
* **Software**

Características comunes a cualquier paquete de CAD

HARWARE:

* Necesidades de tarjetas gráficas y monitores que presenten una resolución y color adecuados respectivamente EGA, VGA, SuperVGA.

* Velocidad de ejecución y presentación de gráficos, lo que nos obliga a trabajar con equipos AT como mínimo (80286 12MHz), y para gráficos muy densos, utilizar coprocesador matématico.

* Periféricos de E/S ádecuados. Ratones y Tabletas digitalizadoras a la entrada, por otro lado graficadores e impresoras láser a la salida.

* Memoria RAM suficiente (640K mínimo) y disco duro (20 Mb. mínima).

SOFTWARE:

* Herramientas gráficas adecuadas (Menús tipo persiana con selección de opciones mediante ratón, menús de íconos, procurando dejar el máximo espacio libre de pantalla).

* Niveles adecuados, tanto en lo referente a escalas como en lo referente a zoom

* Edición adecuada, tanto de texto (tamaño, tipo de letra, posición, etc.) como de gráficos (buena resolución, acorde con el hardware)

* Facilidad en la colocación, copia, borrado, y desplazamiento de objetos.

* Menús de Ayuda (On-Line) y de configuración lo más flexible posible (driver's de todo tipo) de forma que no exista restrinciones en el uso del equipos

* Libreria de objetos, lo más extensa posible.

* Creación de archivos que pueden ser exportados o importados por otros paquetes.

CARACTERISTICAS ESPECIFICAS DE UN SISTEMA CAE

* Amplia biblioteca de componentes, lo más actualizada posible y con posibilidad de edición de componentes

* Recomposición automática de líneas de conexión

*Numeración automática de componentes

* Incorporación de uno o más verificadores de normas y reglas eléctricas

*Conversión de esquemas de versiones anteriores

* Simulación de los circuitos diseñados

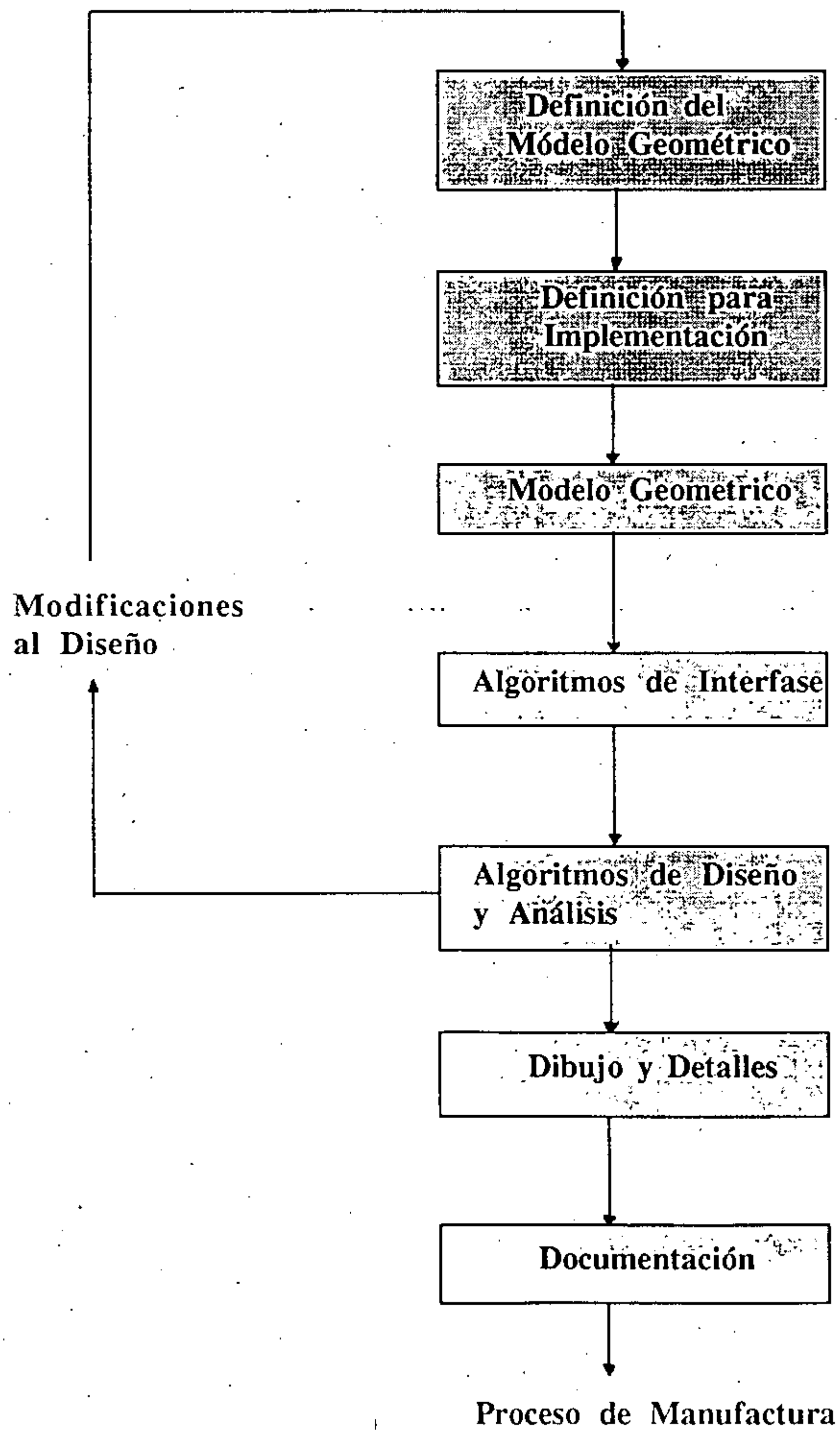
* Obtención del circuito impreso a partir del diagrama esquemático, mediante trazado manual o automático.

* Análisis térmico

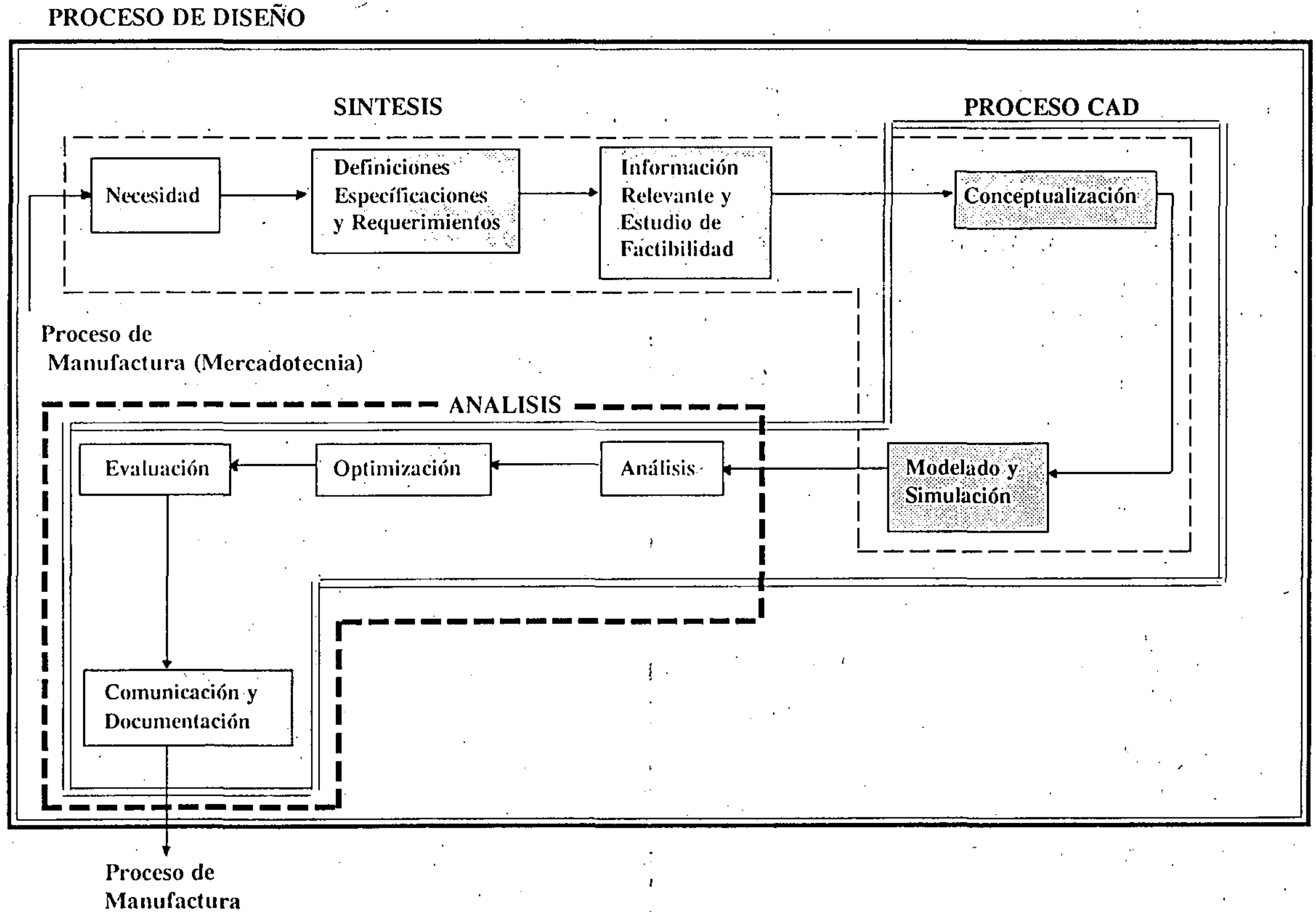
* Interfase para control numérico.

HERRAMIENTAS CAD REQUERIDAS POR EL PROCESO DE DISEÑO	
Fase de Diseño	**Herramientas CAD**
Conceptualización	Técnicas de Modelado Geómetrico: Asistencia gráfica, Manipulaciones, Visualización.
Modelado y Simulación	Algunos como: Animación, Ensamblado, Paquetes Especiales para Modelado FEM.
Análisis	Software para análisis; Paquetes de Acuerdo a la Necesidad, Paquetes Comerciales
Optimización	Optimización Estructural
Evaluación	Dimensionamiento: Tolerancias, Especificaciones del Material, Control Numérico.
Comunicación y Documentación	Dibujo y Detalles; Ensamble de Piezas

IMPLEMENTACION DE UN TIPICO PROCESO CAD DENTRO DE UN SISTEMA CAD/CAM



CICLO DE PRODUCCION TIPICO



DISEÑO ESQUEMATICO

(OrCAD)

OBJETIVOS

I) Proporcionar los elementos necesarios para elaborar un circuito impreso empleando como herramientas los sistemas **OrCAD** y **smARTWORK.**

II) Proporcionar las bases para modificar y crear componentes en el sistema de diseño esquemático.

OrCAD

Es una herramienta para diseño esquemático. Su Fácil uso de menús permite la creación, edición, manipulación, almacenamiento e impresión de esquemas electrónicos.

DRAFT: Es un editor esquemas de OrCAD, que permite crear, editar y salvar hojas esquemáticas. Además carga los manejadores de los dispositivos periféricos necesarios como: impresora, video, graficador; así como las librerias necesarias.

NOTA: DRAFT/C se emplea para configurar el sistema.

Dentro de las características de DRAFT se incluye:

- Acceso a más de 6000 elementos en las librerias
- Partes equivalentes a D'Morgan
- Crear líneas, buses, conectores, etiquetas, etc.
- Rotación y espejo de elementos
- Movimiento, copias y borrado de objetos o bloques de objetos
- Disponibilidad de una malla visible de puntos
- Paneo automático de la hoja de trabajo
- 5 niveles de acercamiento
- Niveles ilimitado de jerarquía
- Directorio de librerias
- Busqueda de cadenas
- Opción de orientación textos (verticales y horizontales)
- Soporta cinco tamaños de hojas de trabajo
- Etc.

LIBRERIAS

Incluye librerias muy extensas de las más comunes en la industria, tales como:

- TTL
- CMOS
- MEMORY
- ECL
- DISCRETAS
- ANALOGICAS
- MICROPROCESADORES
- DISPOSITIVOS PERIFERICOS
- ETC.

UTILERIAS

TREELIST: Rastrea la organización jerárquica de las hojas y despliega su estructura, nombre de la hoja raíz así como las asociadas a ésta.

ANNOTATE: Actualiza automáticamente cualquier componente dentro de un diseño esquemático , numerándolo de forma correlativa, si éste se ha incluido al diseño esquemático. Actualizando en número de pines asociados a dicho componente.

PRINTALL: Imprime una hoja esquemática o grupo de hojas esquemáticas utilizando una impresora.

PLOTALL: Imprime una hoja esquemática o grupo de hojas esquemáticas utilizando un graficador.

PARTLIST: Reporta todas los elementos utilizados en el diseño esquemático o grupo de hojas esquemáticas (diseño jerárquico).

ERC: Lleva a cabo una verificación de reglas eléctricas comunes, para advertir si existe algún error como, p. ej. entradas sin señal, pines desconectados, etc.

NETLIST: Genera un archivo (NETLIST) adecuado para ser capturado por un programa de colocación de componentes (PCB), en diferentes formatos, empleados por programas de PCB de los más usuales.

BACKANNO: Actualiza las referencias correspondientes a componentes que han sido agregados o modificados dentro de un diseño esquemático después de la ejecución de **Annotate**

CROSSREF: Muestrea cualquier diseño esquemático, recopilando información sobre los componentes empleados, y crea un archivo de referencia que contiene la localización de cada componente.

CLEANUP: Checa las conexiones, buses, uniones, etiquetas y cualquier objeto, mostrando mensajes oportunos cuando detecta algún elemento gráfico duplicado, borrandolo.

EXTRACT: Crea archivos fuente, para ser utilizados por el módulo de PLD´S a partir de archivos creados con SDT.

FLDATTRB: Modifica los atríbutos, (referencia, valor y campos) de los componentes que integran un diagrama esquemático, ya sea de bloques, jerárquico o simple, haciendo que estos sean visibles o invisibles.

FLDSTUFF: Modifica los atríbutos (referencia y campos) de aquellos componentes que han sido definidos a través de un archivo tipo texto y que previamente han sido combinados mediante **KEY FIELD**.

LIBARCH: Permite crear una librería fuente a partir de sólo los componentes empleados en un diseño esquemático.

SIMPLE: Convierte diseños jerárquicos complejos en jerarquías simples.

XFEROVL: Transfiere información de configuración desde una versión a otra del archivo ORCADSDT.OVL. Esto sólo es posible con versiones de OrCAD/SDT III superiores a la 3.12.

DECOMP: Esta utileria, es un decompilador de librerias de OrCAD, (archivos con extensión .LIB) a librerias en archivos fuentes. Los archivos fuente se pueden editar usando un editor de textos. De esta manera se pueden agregar o modificar elementos de las librerias.

COMPOSER: Es un compilador de libreria; se emplea para convertir la libreria de archivo fuente (formato ASCII) en libreria de archivo objeto para ser utilizada por DRAFT.

REQUERIMIENTOS DE HARDWARE

A continuación se detalla un configuración mínima para que el sistema funcione con un rendimiento adecuado:

* Una computadora PC/XT o AT ó compatibles.
* Coprocesador matemático opcional.
* 640 Kbytes de RAM.
* Sistema Operativo MS-DOS mayor a ver. 2.0.
* Disco duro de 20 Mbytes mínimo de capacidad.
* Tarjeta gráfica recomendable: EGA color.
* Uno o dos puertos serie (para ratón y plotter).
* Un puerto paralelo.
* Ratón.
* Graficador HP o compatibles.

OrCAD

DRAFT.EXE
DRAFT.OVL
ERC.EXE
ANNOTATE.EXE
NETLIST.EXE
TREELIST.EXE
COMPOSER.EXE
ETC.

DRIVER

PRINTER.DRV
(Manejadores de: tarjetas gráficas, impresoras, graficadores)

LIBRARY

CMOS.LIB
DEVICE.LIB
INTEL.LIB
MOTO.LIB
TTL.LIB
ECL.LIB
ANALOG.LIB
MEMORY.LIB
ETC.

SHEET

Directorio para los diseños esquemáticos

CONFIGURACION RECOMENDADA PARA DISCO DURO.

6.9 PLOTALL

Purpose:

Plots a group of schematic sheets which may be a hierarchy, flat file, one sheet file structure, or an annotation file. As an option, grid references may be specified.

Format: PLOTALL *source* [*destination*] [/A][/C][/E][/F][/G][/O][/Q]

Remarks:

The *source* may be either the root sheet name of a hierarchical file structure, the name of a text file in a flat file structure, or the file name of a one sheet file structure.

If the *source* is the name of a text file in a flat file structure, the /F switch must be included. If the *source* is the file name of a one sheet file structure, the /O switch must be included. If the source is the annotation file created by the ANNOTATE program, then the /A switch must be included on the invocation line.

The *destination* is any valid DOS path name and is where the output of the program is to be placed. If a *destination* is not specified, the output of the PLOTALLprogram is directed to the serial channel specified in the plotter configuration (refer to Section 2 for configuration information).

The /A switch causes the PLOTALL program to read the source path as an annotation file.

The /C switch causes the configuration menu to be invoked. This allows the OrCAD/SDT environment to be modified.

The /E switch causes the utility program to display the message "Type Any Key To Continue", enabling the system to pause for you to remove the DRIVER/LIBRARY disk in drive B and insert the

SHEET.disk: This switch is used only on systems with two floppy disk drives.

The /F switch causes the PLOTALL program to read the source as a text file, for flat file structure applications.

The /G switch causes GRID REFERENCES to be included in the sheet when plotting.

The /O switch causes the file name of the source to be read as a one sheet file structure.

The /Q switch causes the PLOTALL program to run "quietly". This means that only the invocation messages and error messages if any, are displayed. If this switch is not specified, the program will display intermediate tracking activity.

6.9.1 Invocation Examples Using Hierarchical Structured Files

1. To plot sheets in a hierarchical schematic:

   PLOTALL *root.sch*

   Where *root.sch* is the path and name of the root sheet in the hierarchy.

2. To plot a sub-sheet in a hierarchical schematic:

   PLOTALL *subsheet.sch* /O

Where *subsheet.sch* is the path and name of the sub-sheet in the hierarchy, /O signifies that the *subsheet.sch* file name is a single sheet.

6.9.2 Invocation Examples Using Flat File Structures

1. To plot a flat file structure containing multiple sheets:

PLOTALL *flatfile.txt* /F

Where *flatfile.txt* is a text file containing a list of schematic file names to be plotted, /F is used to signify that *flatfile.txt* is a text file.

2. To plot one sheet in a flat file structure:

   PLOTALL *sheetname.sch* /O

   Where *sheetname.sch* is the name of the single sheet in the flat file structure, /O is used to signify that *sheetname.sch* is a single sheet schematic.

6.9.3 Invocation Examples Using A One Sheet File Structure

1. To plot a single sheet schematic:

   PLOTALL *sheetname.sch* /O

   Where *sheetname.sch* is the name of the single sheet schematic, /O is used to signify that *sheetname.sch* is a single sheet schematic.

6.9.4 Invocation Example - Directing The Output To A File

1. To direct the output of the PLOTALL program to a file:

   PLOTALL *sheetname.sch whatfile* /O

   Where *sheetname.sch* is the name of the single sheet schematic, *whatfile* is the path and file name to place the PLOTALL information, and /O is used to signify that *sheetname.sch* is a single sheet schematic.

NOTE

The file *whatfile* may be sent to a plotter using the DOS MODE and COPY commands. For example, if your plotter is connected to serial channel 1, enter the following at the DOS prompt:

COPY *whatfile* COM1:

For additional information on the MODE and COPY commands, refer to your DOS Users Manual.

6.9.5 Plotting Schematics Based on Annotation Files

1. To plot schematics based on the annotation file information:

   PLOTALL *annotation.out* /A

   Where *annotation.out* is the output from the ANNOTATE program, /A causes the PLOTALL program to read *annotation.out* as an annotation file.

6.9.6 Setting Up The Plotter Configuration

To setup the plotter configuration, go to the DRAFT configuration menu by entering the following from the DOS command line:

PLOTALL /C

Press the <P> and <L> keys to configure the plotter drivers, serial channel, baud rates, parity and word length.

To configure OrCAD/SDT for the plotter driver, select the letter that corresponds to the plotter driver that you are using at the "Enter Letter to Select the Plotter to be used->" prompt. If your plotter name does not appear, press <S> for Special.

When selected, the plotter driver name only appears on the "CONFIGURATION OF OrCAD/SDT" menu.

To modify the serial channel, baud rate, parity, or word length configuration, press the colon <:> key at the "Enter Letter to Select the Plotter to be used->" prompt.

Enter a "1" for serial channel 1, or a "2" for serial channel 2 at the "Channel 1 or 2 ->" prompt.

After you select the serial channel, you may select the baud rate, parity, and word length that is required.

To modify the baud rate, enter the letter that corresponds to the baud rate you require at the "Baud Rate ->" prompt.

To modify the parity, enter the number that corresponds to the parity you require at the "Parity ->" prompt.

To modify the word length, enter the number that corresponds to the word length you require at the "Word Length ->" prompt.

When you return to the "CONFIGURATION OF OrCAD/SDT" menu, be sure to update the information by pressing the letter <U>.

Typical configuration for HP and HI plotters is as follows:

Baud Rate : 2400 or 9600
Parity : No Parity
Word Length: 8 bits

6.9.7 Plotter Cable Wiring Diagrams

The PLOTALL utility program uses BIOS to communicate to the serial port. It does not talk to the hardware directly. This is to insure compatibility to all PC's and compatibles.

For this reason, additional wires other than TXD and RXD must be connected to implement hardware handshake.

Figure 6-20 shows a wiring diagram that is required for connecting a PC/XT (25 pin connector) to a plotter. Figure 6-21 shows a wiring diagram that is required for connecting a PC AT (9 pin connector) to a plotter.

Since this cable connects the TXD and RXD lines, it also works with software that communicates to the hardware directly.

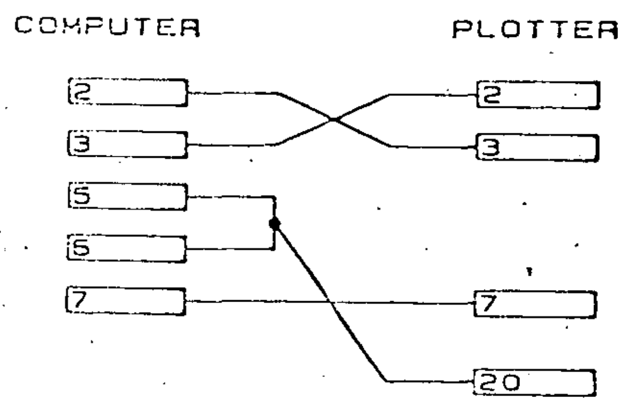


Figure 6-20. PC/XT 25-Pin Cable Wiring Diagram

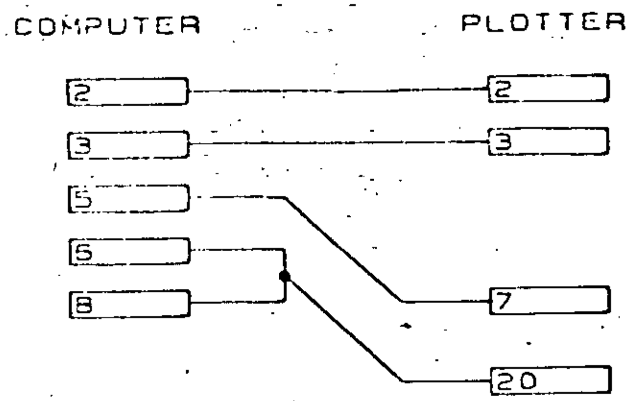


Figure 6-21. PC AT 9-Pin Cable Wiring Diagram

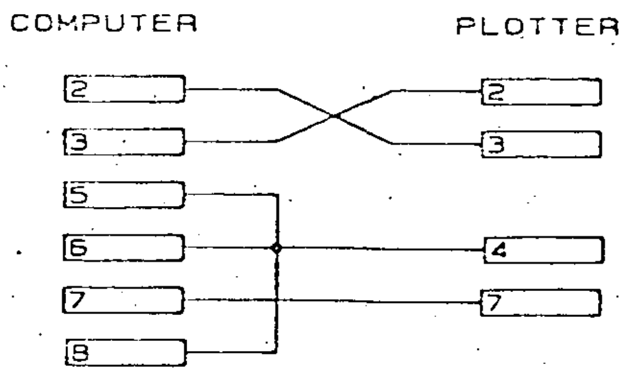


Figure 6-22. PC/XT 25-Pin Cable to IOline Plotter

6.9.8 Plotter Problems

Most plotter problems are typically a result of incorrectly wired plotter cables. If you have difficulty with your plotter, check the following items before proceeding or calling OrCAD:

1. Wire the cable as shown in Figures 6-20, 6-21, and 6-22 above. If your plotter works with another software package, and does not work with OrCAD, the first item to check is the wiring of your cable. Chances are, the other CAD packages only require the TXD and RXD signal lines. OrCAD requires additional connections.

   The cable must be wired correctly as recommended!

2. Check for an open in the cable by performing a continuity check.

3. Read your plotter manual to be sure you understand how the plotter operates. Know how it is programmed for baud rate,parity, word length, and find out what these settings are.

4. Check to make sure that the plotter baud rate, parity, and word length settings correspond to the plotter configuration information.

   For HI plotters, if data and parity do not match, the message: "<<<error>>> Unable to read back from plotter"appears on the screen.

5. Use DOS to send a plot file to the plotter. This will be useful for isolating whether the problem is in the serial port hardware or the plotter hardware. To do this, first send the worksheet to a plot file as outlined below:

   PLOTALL *sheetname.sch whatfile* /O

   > Where *sheetname.sch* is the name of the single sheet schematic, *whatfile* is the path and file name to place the PLOTALL information, and /O is used to signify that *sheetname.sch* is a single sheet schematic.

   Then, use the DOS MODE command to configure the serial channel as follows:

   MODE COM1:2400,N,8,1,P <ENTER>

This assumes that you are using serial channel 1 (COM1) and have your plotter set for 2400 baud. For more information on the MODE command, refer to your DOS users guide for Asynchronous Communications.

After the serial channel has been configured, send the plot file to the plotter using the DOS COPY command as follows:

COPY *whatfile* COM1: <ENTER>

Where *whatfile* is the name of the plot file.

If the plotter works, this indicates the problem may be in the plotter cable (incorrectly wired), or the hardware handshaking is incorrectly set (check PLOTALL configuration).

If the plotter does not work, this indicates that there is a hardware problem. Check the the following: serial card, incorrect serial channel configuration, plotter hardware, or a cable problem.

6. If yours is an IOline plotter, be sure you have PROM version 114 or greater.

6.9.9 Output Scaling

OrCAD does not control the scale of the plotter output. Output scaling is controlled entirely by your plotter. Plotter scaling is typically controlled by the size of the paper used, P1 and P2 point settings (HP plotters), rotation settings, and the default settings on the plotter.

If you change the size of the worksheets you are plotting, (plotting a C size, then a B size worksheet for example) always RESET the plotter when changing worksheet size. If you have further scaling questions, refer to your specific plotter manual.

6.9.10 Plotter Hints

When making a plot, use the proper pens and paper designed for the plotter. Plotter paper has a "memory" to it. If it hangs on the plotter bed for a period of time, it will stretch. This effects the registration of the plot. Plotter paper is also temperature sensitive. Be sure that the paper is at room temperature before plotting. The longer the drawing takes to plot, the more care must be exercised with the paper.

The configuration of the plotter includes the ability to change the velocity of the pens. When the pen can not draw at the speed the plotter is capable of moving, reduce the velocity. You will need to consult your plotter manual for the range to set the velocity. The velocity can be set only in whole number values.

When you make a plot with different pens, the plotter has a registration inaccuracy that must be considered. If you wish to have the highest quality plot, always use only one pen.

When you make a plot on a paper size that does not match the worksheet size, the plotter drivers will scale the drawing to fit the paper selected. We do not recommend making a plot more than one size off of the worksheet size since the width of the pen is fixed. For example, you can plot a C size worksheet on B, C, or D and it will work fine. If you plot an E worksheet on A paper, you will not be able to read the writing. If you plot an A worksheet on E size paper, the bit mapped devices will be "grainy".

When you are directed by the program to change paper or pens, always wait until the plotter has finished the present plotting activity. Before sending a plot directly to the plotter, be sure that the plotter is on line, the pen(s) are properly set up, and the paper size is correct. When you have a pen that must be manually changed, the PLOTALL program will pause and inform you of the objects to be plotted with the new pen.

6.9.11 HP Plotters

The HP plotter family has a facility to set the corner points of the plot and automatically scale the plot to be within these points. These points are called P1 and P2.

When you change the paper size, or at power up, these points are set to default values which depend on the size of the paper and the plotter's margin requirements. You may reset P1 and P2 to the outer most boundary of the paper and the plot will be slightly larger.

If you plot on paper that is not the same size as the worksheet, you will have to manually adjust the locations of P1 and P2 to correct for the aspect ratio.

6.9.12 HI Plotters

The HI plotter family does not automatically scale the drawing. If you direct the output of the PLOTALL program to a file you will be prompted, for each plot, for the paper size to use for the plot. The aspect ratio is corrected for both direct-to-plotter and re-directed-to-file plots.

The HI 40 Series defaults to 2400 baud, and the 50 Series defaults to 9600.

Always check to make sure that the plotter baud rate, and data bit settings correspond to the plotter configuration (refer to "Setting Up The Plotter Configuration" above).

If data and parity do not match, the message: "<<<error>>> Unable to read back from plotter" appears on the screen.

Be sure that the plotter is on-line before beginning a plot. The HI plotters do not have a means to set the velocity to the power-up default. If you change any of the velocity settings of the pens in the configuration, you will need to set them all. The velocity ranges can be found in the plotter operation manual for your specific plotter.

6.9.13 Suppressing the Title Block and Border

To suppress the title block and border of the worksheet, invoke the Configuration Menu by entering "DRAFT /C" from the DOS command line.

Press <C> <T> to obtain the "Color Table / Plotter Pen Table". At the "Command ->" prompt, press the <P> <M> keys. Then, press <9> <9> followed by the <ENTER> key. The plotter pen is now IGNORED for drawing the worksheet title block and border.

6.10 PRINTALL

Purpose:

Prints a group of schematic sheets which may be a hierarchy, flat file, one sheet file structure, or an annotation file. As options, grid references, scaled output, and wide paper can be specified.

Format:

PRINTALL *source* [*destination*] [/A][/C][/E][/F][/G][/O][/Q][/S][/W]

Remarks:

The *source* may be either the root sheet name of a hierarchical file structure, the name of a text file in a flat file structure, or the file name of a one sheet file structure.

If the *source* is the name of a text file in a flat file structure, the /F switch must be included. If the *source* is the file name of a one sheet file structure, the /O switch must be included. If the *source* is the annotation file created by the ANNOTATE program, then the /A switch must be included on the invocation line.

The *destination* is any valid DOS path name and is where the output of the program is to be placed. If a *destination* is not specified, the output of the PRINTALL program is directed to the printer PRN.

The /A switch causes the PRINTALL program to read the *source* path as an annotation file.

The /C switch causes the configuration menu to be invoked. This allows the OrCAD/SDT environment to be modified.

The /E switch causes the utility program to display the message "Type Any Key To Continue", enabling the system to pause for you to remove the DRIVER/LIBRARY disk in drive B and insert the

SHEET disk. This switch is used only on systems with two floppy disk drives.

The /F switch causes the PRINTALL program to read the *source* as a text file, for flat file structure applications.

The /G switch causes GRID REFERENCES to be included in the sheet printout.

The /O switch causes the file name of the *source* to be read as a one sheet file structure.

The /Q switch causes the PRINTALL program to run "quietly". This means that only the invocation messages and error messages if any, are displayed. If this switch is not specified, the program will display intermediate tracking activity.

The /S switch causes the PRINTALL program to generate scaled output. If this switch is not specified, then the printer will print the worksheet in compressed mode.

The /W switch causes the printing to formatted for wide paper. With this switch, the printing will be setup for 13" wide paper based on the parameters of the printer driver. If the /W switch is not present, then the printing will be formatted for 8" paper.

NOTE

> Epson MX printers cannot print in compressed mode. Therefore, printer output will always be in scale mode even if you attempt to print compressed.

6.10.1 Invocation Examples Using Hierarchical Structured Files

1. To print sheets in a hierarchical schematic:

   PRINTALL *root.sch /S*

Where *root.sch* is the path and name of the root sheet in the hierarchy.

2. To print a sub-sheet in a hierarchical schematic:

   PRINTALL *subsheet.sch* /O /S

   Where *subsheet.sch* is the path and name of the sub-sheet in the hierarchy, /O signifies that the *subsheet.sch* file name is a single sheet.

6.10.2 Invocation Examples Using Flat File Structures

1. To print a flat file structure containing multiple sheets:

   PRINTALL *flatfile.txt* /F

   Where *flatfile.txt* is a text file containing a list of schematic file names to be printed, /F is used to signify that *flatfile.txt* is a text file.

2. To print one sheet in a flat file structure:

   PRINTALL *sheetname.sch* /O

   Where *sheetname.sch* is the name of the single sheet in the flat file structure, /O is used to signify that *sheetname.sch* is a single sheet schematic.

6.10.3 Invocation Examples Using A One Sheet File Structure

1. To print a single sheet schematic:

   PRINTALL *sheetname.sch* /O /S

Where *sheetname.sch* is the name of the single sheet schematic, /O is used to signify that *sheetname.sch* is a single sheet schematic.

2. To direct the output of the PRINTALL program to a file:

   PRINTALL *sheetname.sch whatfile* /O

   Where *sheetname.sch* is the name of the single sheet schematic, *whatfile* is the path and file name to place the PRINTALL information, and /O is used to signify that *sheetname.sch* is a single sheet schematic.

NOTE

> Since *whatfile* is a binary print file, it will consume an extensive amount of disk space.

The file *whatfile* may be sent to a printer using the DOS COPY Command. For example, enter the following at the DOS prompt:

COPY *whatfile prn:* /b

For additional information on the COPY Command, refer to your DOS Users Manual.

6.10.4 Printing Schematics Based on Annotation Files

1. To print schematics based on the annotation file information:

   PRINTALL *annotation.out* /A /S

   Where *annotation.out* is the output from the ANNOTATE program, /A causes the PRINTALL program to read *annotation.out* as an annotation file.

7. LIBRARIES

This section explains how to create your own "custom" part libraries for use with OrCAD/SDT. Section 7 describes the COMPOSER and DECOMP utilities. Then, it describes the steps you would go through to create a custom library and provides numerous examples. The section then presents a formal description of OrCAD's Symbol Description Language and concludes with examples of complete library source files.

7.1 An Overview of the Library Development Process

To create a custom library, you need a text editor and the COMPOSER utility. COMPOSER takes a library source file, which you created with the text editor, and produces a library data file, readable by DRAFT. You may also find the DECOMP utility useful. DECOMP takes a library data file and produces a library source file. You can think of DECOMP as the inverse of COMPOSER. Creating a custom library consists of the following three steps, as illustrated in Figure 7-1.

1. Create a library, text, or source file. The convention is to give the file a .SRC extension. The source file is an ASCII text file that contains instructions in OrCAD's Symbol Description Language.

   You can use any text editor. The only requirement is that it produce an ASCII file without any hidden formatting characters. For example, Wordstar in the non-document mode produces such an ASCII file.

2. Compose the source file using the COMPOSER utility. This is similar to a compilation; it produces another file, a data file readable by DRAFT. The convention is to give this data file a .LIB extension.

3. Reconfigure DRAFT to add the new library to the list of library files.

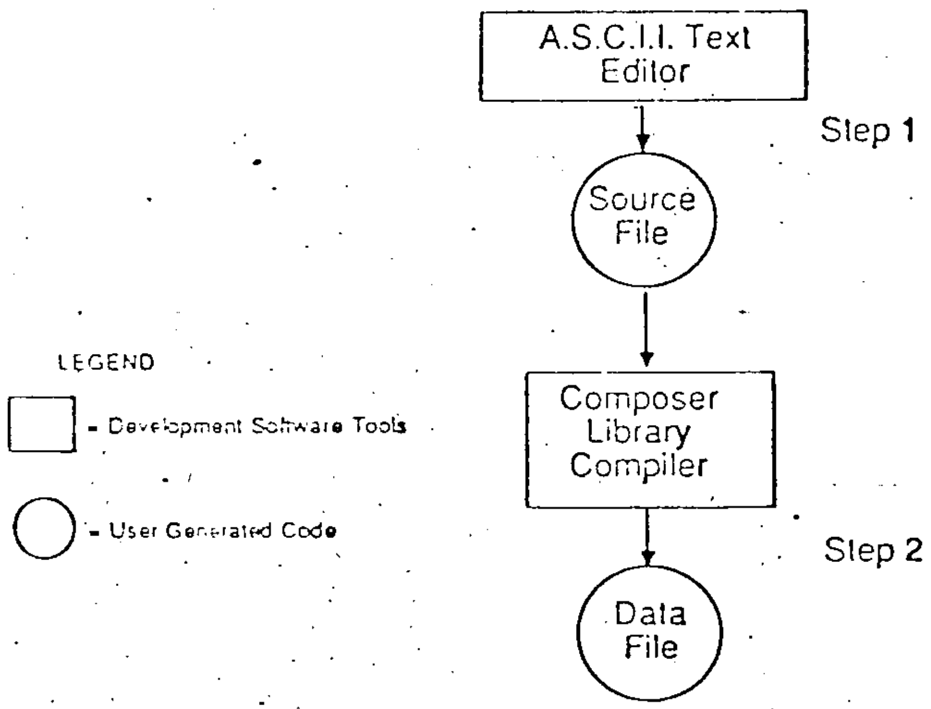


Figure 7-1: The Library Development Process

OrCAD Systems supplies a number of part libraries for use with DRAFT. Part of configuring DRAFT means choosing what libraries it will have access to. The libraries you choose at configuration time are loaded into RAM when you invoke DRAFT. This eliminates disk searching and provides for quick part retrieval.

You can choose from OrCAD-supplied libraries as well as your own custom libraries to load into DRAFT. The custom libraries that you create will behave just like the OrCAD-supplied libraries.

OrCAD-supplied libraries are shipped as library data files. This is for your convenience (data files are ready to use) and also to save disk space. A library source file takes up much more disk space than its corresponding library data file. A source file can be four or five times as large as its data file.

By applying DECOMP to an OrCAD-supplied library, you can construct a source version of that library. This feature is useful if the library you want to create has parts similar, but not identical, to those in the OrCAD-supplied library. With a text editor, you can extract the similar parts and edit them. The supplied libraries also serve as an extensive list of examples. If, while creating your own library, you get stuck, you can always look inside a source version of a supplied library "to see how OrCAD did it."

Creating custom libraries is preferable to modifying OrCAD-supplied libraries. If you modify an existing library, you run the risk of future OrCAD updates negating your changes. It is not good practice to run DECOMP on an OrCAD-supplied library, edit the resulting source file, and then run COMPOSER and replace the original library.

You may have parts with the same name in different libraries. If you do and those libraries are selected, DRAFT searches through the libraries in the order you specify at configuration time.

7.2 The COMPOSER and DECOMP Utilities

The COMPOSER utility is called COMPOSER.EXE and the DECOMP utility is called DECOMP.EXE. Both files are found on the LIBRARY disk. To execute either utility, you must be at the DOS command level in the directory that contains the utility you want to execute.

7.2.1 Invoking COMPOSER

COMPOSER *source library* <ENTER>

where: *source* is the name of the ASCII text file that describes your custom parts using OrCAD's Symbol Description Language. The .SRC extension is a convention, not a requirement. *library* is the name of the resulting library file. If you give the name of an existing file, COMPOSER asks if you want to overwrite the existing file. You cannot append to an existing file. <ENTER> represents the ENTER key on your computer. DOS commands are executed when you type the ENTER.

Both *source* and *library* may be complete pathnames -- that is, if either is in a directory other than your current directory, you must specify the complete path. Here are two examples.

COMPOSER *custom.src custom.lib* <ENTER>

The files COMPOSER.EXE and *custom.src* are in the same directory, and this directory is your working directory. This example creates the file *custom.lib* in your working directory.

COMPOSER \orcad\library*custom.src* \orcad\library*custom.lib* <ENTER>

The file COMPOSER.EXE is in your working directory, which is not necessarily \orcad\library. This example creates the file *custom.lib* in the directory \orcad\library.

7.2.2 Invoking DECOMP

DECOMP *library source* <ENTER>

where: *library* is the name of an existing library file. The .LIB extension is a convention, not a requirement. *source* is the name of the resulting ASCII text file that describes the parts in the specified library. Comments are included in the file for clarity. If you give the name of an existing file, DECOMP asks if you want to overwrite the existing file. You cannot append to an existing file. <ENTER> represents the ENTER key on your computer. DOS commands are executed when you type the ENTER.

As with COMPOSER, both *source* and *library* may be complete pathnames -- that is, if either is in a directory other than your current directory, you must specify the complete path.

Here are two examples.

DECOMP *custom.lib custom.src* <ENTER>

The files DECOMP.EXE and *custom.src* are in the same directory, and this directory is your working directory. This example creates the file *custom.src* in your working directory.

DECOMP \orcad\library*custom.lib* \orcad\library*custom.src* <ENTER>

The file DECOMP.EXE is in your working directory, which is not necessarily \orcad\library. This example creates the file *custom.src* in the directory \orcad\library.

Note that DECOMP does not return your source; it makes its own. For example, the comments in your original source are not reproduced. DECOMP adds its own comments. Also, DECOMP may rearrange the order of the part definitions. DECOMP lists parts in numeric order followed by parts in alphabetical order. For example, assume that you define two parts, one called resistor and one called 7400. You place resistor in your source file before 7400, run COMPOSER, then DECOMP to produce a new source file. Unlike your original source file, the new source file has 7400 listed before resistor.

7.3 Creating a Source File

A source file consists of a prefix definition followed by a series of part definitions. You can have only one prefix definition per library, and it occurs at the beginning of the library. There are two types of part definitions: block symbol definitions and bitmap symbol definitions. Comments are delimited with braces ({ }).

Block symbol definitions represent parts that are either square or rectangular. These parts are typically memory chips, microprocessors, peripheral controllers, and many TTL and CMOS devices. Bitmap symbol definitions represent parts that are complicated to define graphically. Instead, you draw them on a bitmap. They include such parts as resistors, diodes, transistors, MOSFETs, relays, and many others.

Note that lines in a source file end with a <RETURN>. The source examples in this section do not show the <RETURN>.

7.3.1 The Prefix Definition

The prefix definition is delimited by the keywords, PREFIX and END. The initial delimiter is the keyword PREFIX all alone on a line. Subsequent lines contain the definition itself. The terminating delimiter is the keyword END all alone on a line.

All source files must begin with a prefix definition. If you decide your custom library doesn't need a prefix definition, you must still supply a null prefix. A null prefix consists only of the delimiting keywords. Here is how a null prefix definition looks.

```
PREFIX
END
```

On the other hand, you may find a prefix definition very useful. OrCAD specifically designed the prefix definition to handle the various TTL logic families. For example, the 74LS00, the 74S00, and the 74ALS00 have different prefixes (74LS, 74S, and 74ALS), but the same suffix (00). When you use a prefix definition, you reduce the memory required to store multiple families of parts that have different prefixes, but the same suffix.

Here is an example of a prefix definition. The example comes from OrCAD System's TTL source library, TTL.LIB.

```
PREFIX
'74LS'    =  'LS'
'74S'     =  'S'
'74ALS'   =  'ALS'
'74AS'    =  'AS'
'74HCT'   =  'HCT'
'74HC'    =  'HC'
'74ACT'   =  'ACT'
'74AC'    =  'AC'
'74F'     =  'F'
'74'
END
```

DRAFT uses the prefix definition when you obtain a part with the Get command. Instead of entering the entire name of the part, you can enter just the suffix. DRAFT displays a pop-up menu that lists all the valid part names constructed by appending the suffix you provided with the prefixes in the prefix definition. For example, if TTL.LIB is one of your libraries and you enter the suffix 04, the pop-up menu lists the following parts.

```
74LS04
74S04
74ASL04
74AS04
74HCT04
74HC04
74F04
7404
```

A prefix definition is constructed as follows. First, enter the PREFIX keyword followed by a <RETURN>. Then, begin the first prefix string by entering a single quote ('). Type the prefix string. It consists of a string of printable ASCII characters no more than seven characters long. DRAFT does not distinguish between upper- and lower-case. Close a prefix string with another single quote.

Then, enter a <SPACE> followed by an equal sign (=) followed by another <SPACE>. To improve readability, you can delimit the equal sign with any number of <SPACE>s or <TAB>s. Now enter the shorthand string. This is the part of the prefix string that varies. The shorthand string also consists of no more than seven printable ASCII characters. Then, enter a <RETURN> and type the next line. You can define a maximum of sixteen prefix strings.

The shorthand string enables you to bypass the pop-up prefix menu and still enter an abbreviated part name. For example, you can obtain the part 74HC04, by supplying the GET command with the abbreviated name HC04. This is possible because HC is a shorthand string for 74HC.

7.3.2 The Part Definition

The part definition defines the part's name, its size (in unit lengths on the screen and in tenths of an inch on the printed worksheet), the number of parts per package and the pin functions (input, output, open collector, etc.). There are two types of part definitions: block symbol definitions and bitmap definitions.

You do not have to group your block definitions and bitmap definitions together. For example, your source file may contain a block definition, followed by a bitmap definition, followed by another block definition.

Block and bitmap definitions follow much the same syntax. A bitmap definition looks like a block definition followed by a bitmap. When COMPOSER sees a bitmap, it uses that bitmap to represent the part, rather than defaulting to a square or rectangle.

A symbol definition has the following fields.

- One or more part name strings. A name is a printable ASCII string enclosed in single quotes. If you have more than one part name string, delimit them with a <SPACE> or put them on separate lines. When obtaining a part, you can use any of your supplied names.

- An optional reference designator. The ANNOTATE utility automatically updates reference designators.

- The symbol size. Each unit represents a unit length on the screen and 0.1 inch on the printed worksheet. You give the X size first and then the Y size. On the same line you list the number of parts per package. If the part is a pin grid array, specify the keyword GRIDARRAY instead of the number of parts per package.

- The pin definition. Each pin is defined on a separate line. A pin definition consists of the following fields:

  - The pin position

  - The pin number or GRIDARRAY pin name

  - The optional DOT keyword (which places the inversion bubble at the pin position)

  - The optional CLK keyword (which places the clock symbol at the pin position)

  - The optional keyword SHORT (which places 0.1-inch leads at the pin position instead of the standard 0.3-inch leads). SHORT cannot be used with DOT or CLK

  - The pin function (IN, OUT, I/O, OC, PWR, PAS, HIZ)

  - The pin name string

- An optional bitmap. Use this if the symbol you want is not a square or rectangle.

- An optional conversion. This only has meaning if you've defined a bitmap. The most common use for converted bitmaps is to specify the DeMorgan equivalent of the defined part.

7.3.3 Block Symbol Definition

Illustrated below is an example of a block symbol definition. The example does not represent a real part, although it is similar to a JK flipflop. Figure 7-2 shows the symbol produced by this block definition.

```
'74EXAMP'
REFERENCE         'LATCH'
6     10    2
L1    3     11    SHORT  IN      'J'
L5    1     13    DOT CLK  IN    'CLK'
L9    2     12    SHORT  IN      'K'
B3    15    14    DOT  IN        'CL'
T3    4     10    DOT  IN        'P'
R1    6     7     OUT            'Q'
R9    5     9     OUT            'Q\'
T0    16    16    PWR            'VCC'
B0    8     8     PWR            'GND'
```

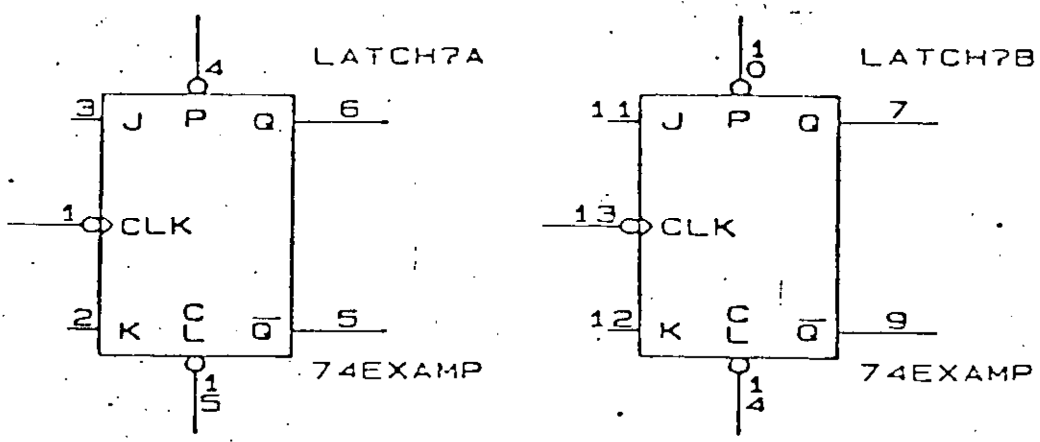


Figure 7-2: The Block Symbol for 74EXAMP

Part name string. The example has only one part name string, '74EXAMP'.

Reference designator. After the part name string comes the optional reference designator.

For this example, the reference designator would appear on the screen as LATCH?A. Note the question mark. When you run the ANNOTATE utility the question mark will be replaced with a number. For example, if the reference designator for a resistor were R? and there are 16 resistors in your design, ANNOTATE would change the designators to R1, R2, ... R16.

This example has more than one part per package, so the reference designator appears with an A after the question mark. ANNOTATE then sequences the letters. ANNOTATE would convert the A of the second part into a B. For example, after running ANNOTATE, the first two occurrences of the 74EXAMP would appear as LATCH1A and LATCH1B, the next two as LATCH2A and LATCH2B, etc. If you omit the REFERENCE line, the default designator U?A appears.

Figure 7-3 illustrates the relationship between the number of parts per package and the reference designator that appears on the part. You must specify a part name, that is what lets you extract the device from the library. However, the REFERENCE keyword is an option. If the REFERENCE keyword has not been specified, it defaults to a designator of "U".

	NUMBER OF PARTS PER PACKAGE	
SOURCE FILE ...	0	1 OR MORE
DOES NOT USE "REFERENCE" KEYWORD	NOTHING IS DISPLAYED	"U" IS DEFAULT REFERENCE DESIGNATOR
USES "REFERENCE" KEYWORD	USES REFERENCE KEYWORD YOU ENTER IN SOURCE LIBRARY	USES REFERENCE KEYWORD YOU ENTER IN SOURCE LIBRARY

Figure 7-3. Controlling Display of Reference Designators

What appears when you call up a part is determined as follows.

1. If the device has 0 parts per package and you do not specify a REFERENCE key word, none appears. Nor does the part name appear.

2. If the device has 0 parts per package and you specify a REFERENCE key word, it appears. It consists of the string you specified followed by a question mark. ANNOTATE replaces the ? with a sequential number. The part name also appears.

3. If the device has one or more parts per package, and you do not specify a REFERENCE key word, a default reference designator (U?A) appears. ANNOTATE replaces the ? with a sequential number that identifies the occurrence of the device and replaces the A with a letter that cycles through the parts of a device. The part name also appears.

4. If the device has one or more parts per package, and you specify a REFERENCE key word, it appears. It consists of the string you specified followed by ?A. The part name also appears.

XY size and parts/package. The next line has the three numbers 6 10 2. The first two represent the size. The size of the part is 6X by 10Y, where each unit represents one screen unit or 0.1 inch on the printed worksheet. The 2 indicates that there are two parts per package. If the part were a pin-grid array, you would supply the keyword GRIDARRAY in place of the number of parts per package.

Pin definitions. The rest of the example consists of the pin definitions. Consider the second pin position. The first field L5 locates the pin on the left side of the part in the fifth position counting from the top down. The Y dimension specified 11 possible positions, 0 through 10. The first possible position is L0 and the last is L10. The specified pin position (L5) is 0.5 inches from the top of the part, when seen on the printed worksheet.

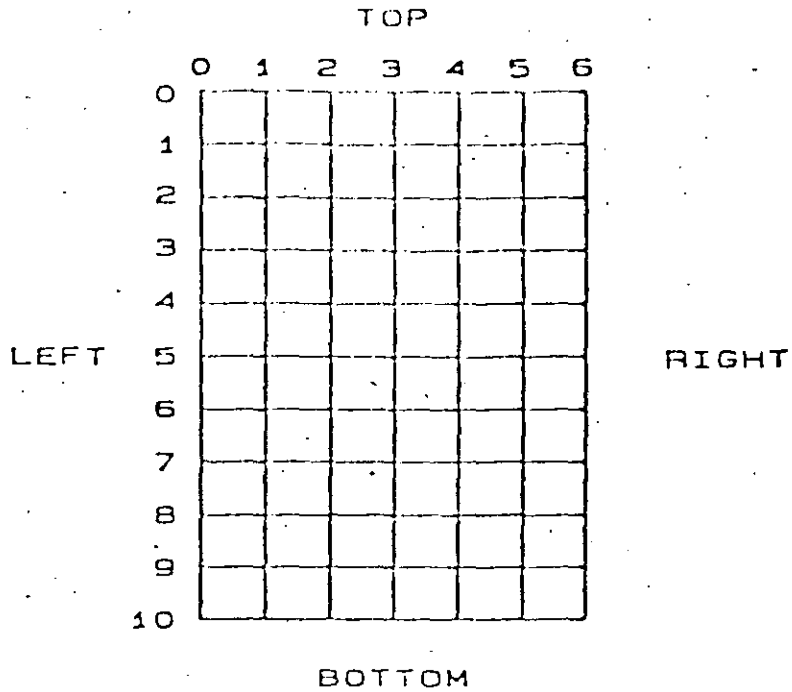


Figure 7-4. The Grid of a 6X by 10Y Block Symbol

The next two pin position fields identify the pin numbers, 1 for the first part of the package and 13 for the second part of the package. The pin at L5 specifies DOT to obtain the inversion bubble and CLK to get the clock symbol. In this case, DOT and CLK are modifiers of the pin function, IN.

R9 puts a pin on the right side in the ninth position, and B3 puts a pin on the bottom in the third position counting right. The two power supply connections are at the top and bottom in the zero position.

Figure 7-4 shows a grid that represents the possible pin positions for the 74EXAMP library part.

Note the SHORT keyword in the first pin position. Pins with the SHORT keyword have 0.1-inch leads rather than the default 0.3 inches. The SHORT keyword, however, cannot be used with with DOT or CLK keywords. Finally, the 'CLK' gives the pin a name Power pins. One possible pin function is PWR for power. Note that power pins do not appear on the screen. The NETLIST utility, however, does categorize all power pins that are connected to library parts.

If you want to make power pins visible, change the pin function from PWR to IN or PAS. If you do this, you may notice that the power pin overlaps other pin names on the symbol. To avoid this overlap, you must reposition the power pin in the corresponding library source file.

Parts per Package. If the device has more than one part per package, you can selectively display the pins. For example, assume you wanted to display the power pins VCC and GND, but only on the second part of the device, not on the first. You could do that by coding the last two lines of the block symbol as follows.

```
T0  0   16   PAS  'VCC'
B0  0   8    PAS  'GND'
```

When you place this symbol on the screen, the power pins do not display because the first column of pin locations contains a 0. When you place another symbol on the screen, it looks identical to the first. Both are called LATCH?A, and neither shows the power pins. However, if you exit DRAFT and run the ANNOTATE utility with the /M option (this causes the annotation information to be merged into the sheet directly) and then look at the sheet again with DRAFT, you'll see the two parts labeled LATCH1A and LATCH1B. The power pins appear only on the second part of the device, LATCH1B.

This technique also works for non-power pins. By specifying a pin number of 0, you can cause a pin not to appear for the part of a package.

However, if your device has one part per package, specifying a pin number of 0 does not prevent the pin from appearing. The pin appears with a pin number of 0. If your device has 0 parts per package, you cannot specify pin numbers, and consequently, none appear. Figures 7-5A and 7-5B illustrate how the number of parts per package, the pin number, and the ANNOTATE utility affect the screen symbol.

The device 74ONE is identical to 74EXAMP, except that it has one part per package. Note that the ANNOTATE utility affects both the pinout and reference designator for 74EXAMP, but only the reference designator for 74ONE. Also note that in Figure 7-5A and 7-5B, the locations of the power pins were moved from T0 and B0 to R3 and R7, so that they would not overlap existing pins.

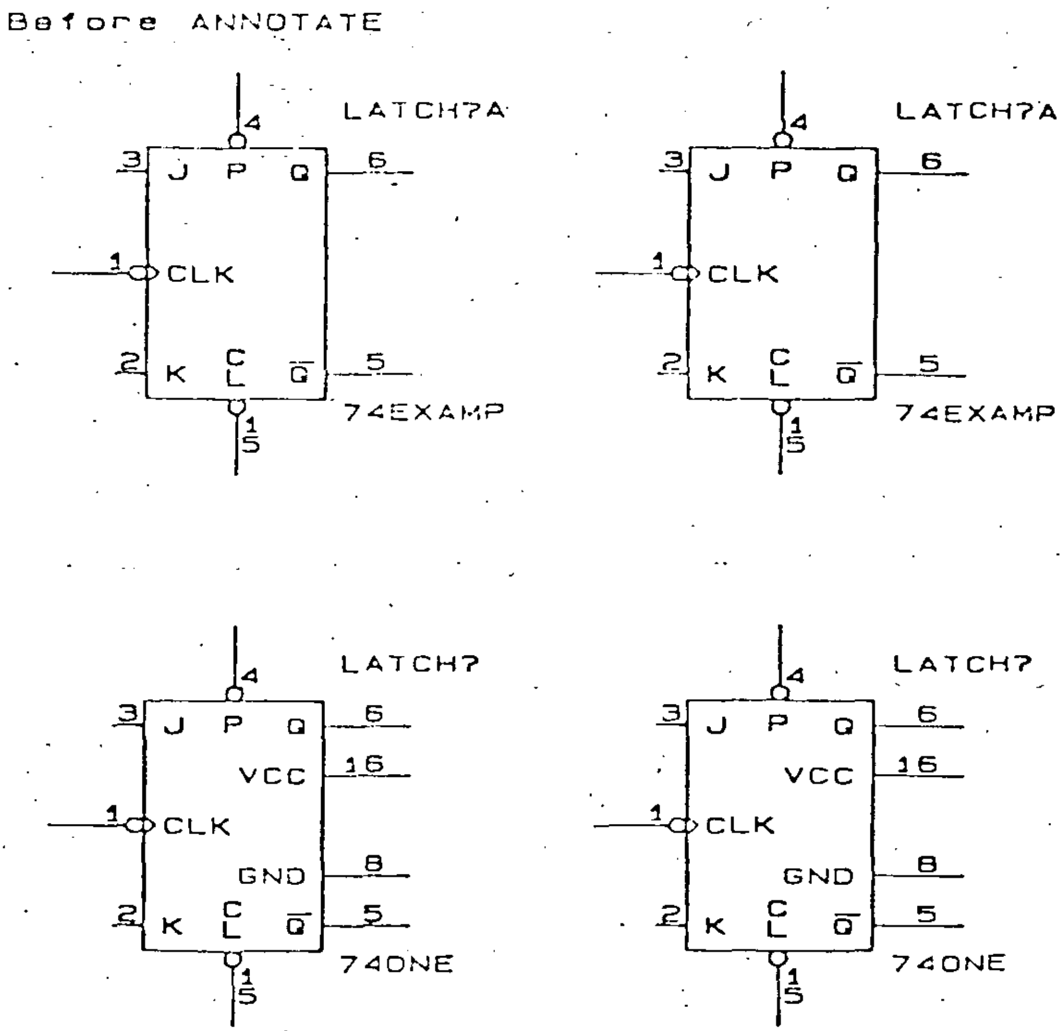


Figure 7-5A. Before Annotation

After ANNOTATE

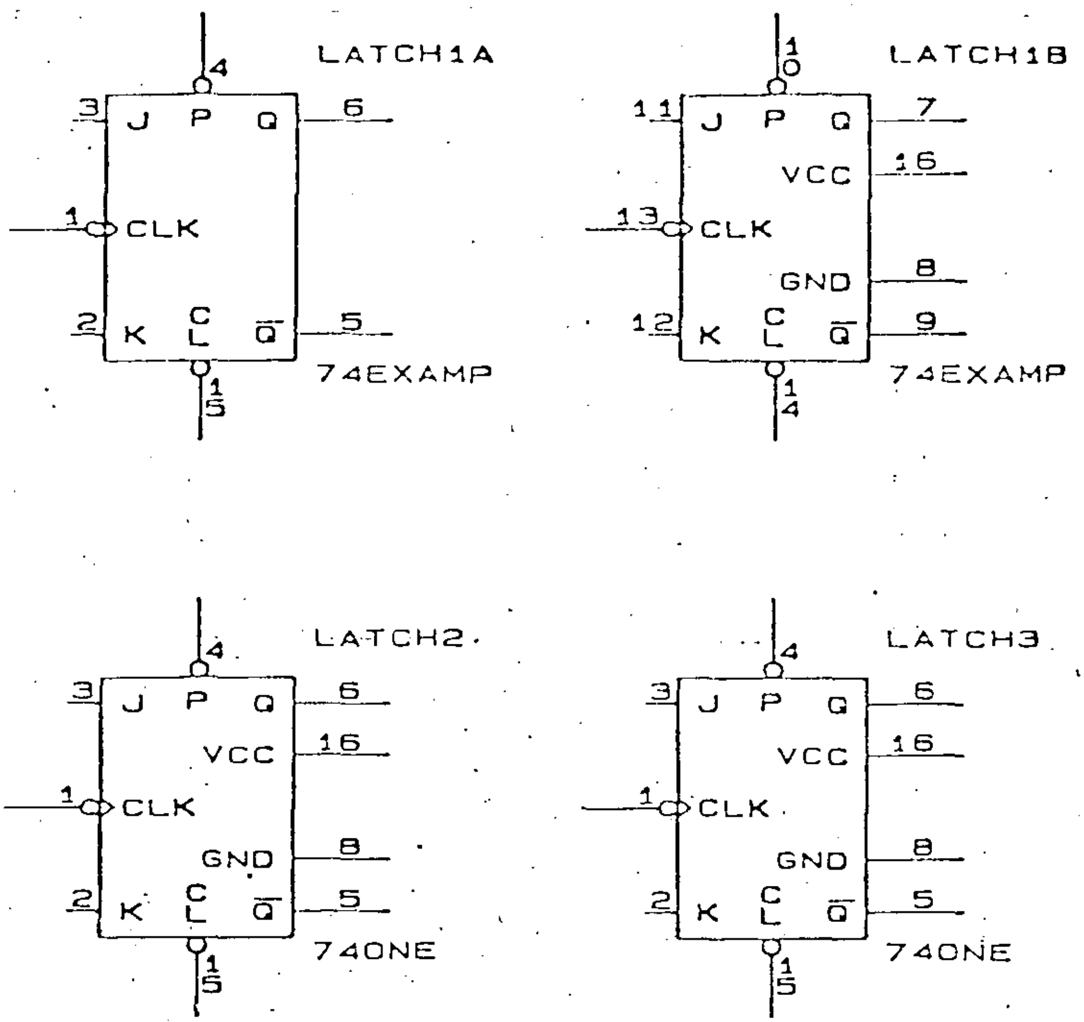


Figure 7-5B. After Annotation

If a device has more than one part per package, you may want power pins on some parts present and the power pins on other parts not to be present.

Pin-grid array. If the part were a pin-grid array, you would supply the gridarray pin name instead of the pin number. A gridarray name consists of a capital letter followed by a number. The letter is in the range A through S, and the number is in the range 1 through 16. There can be no space between the letter and the number.

Here is an example of a pin-grid array part definition. The example is the 68020 from the Motorola library, MOTO.LIB. The definition is quite long so only the first few lines are shown.

Figure 7-6 shows the resulting screen figure.

```
'68020'
15    66    GRIDARRAY
L1    C2    CLK IN 'CLK IN'
L3    J12   IN     'I\P\L\0\'  (the \ bars the pin name)
L4    J13   IN     'I\P\L\1\'
L5    H12   IN     'I\P\L\2\'
            .
            .
            .
```

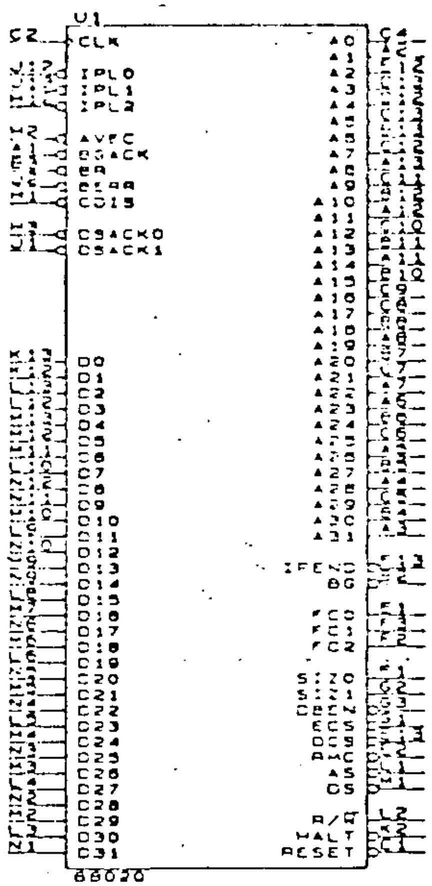


Fig. 7-6. The Block Symbol for 68020

Pin string. The pin string is delimited by single quotes. If you want a single quote as part of the pin string, you must use two single quotes. For example, 'CLK''s' defines the string CLK's. Also, a backslash after the pin string name puts a bar over the name. 'Q\' results in Q with a bar over it. If you have a multi-letter pin name, you must put a \ after each letter. For example, the 68020 shows IPL0, and the corresponding pin string entry in the part definition is 'I\P\L\0\'.

Note that the power pins do not appear on the screen. The NETLIST utility, however, does categorize all power supply pins that are connected to library parts.

7.3.4 Bitmap Symbol Definition

Creating a bitmap is an easy way to represent non-square or non-rectangular parts such as resistors, diodes, transistors, MOSFETs, relays, and many others. DRAFT draws complex parts on the screen by selectively turning on pixel bits that represent the library part. Activating the correct pixel bit is controlled by a bitmap in the library source file you created. You create the bitmap in the library source file.

To define a part with a bitmap, you define the part just as you would if it were a block symbol, but you include a bitmap after the last pin definition. You can either draw out the bitmap with periods (.) and pound signs (#), or you can reference a previously drawn-out bitmap. Previously drawn-out means the bitmap was defined previously in the library source file.

You would reference a previously drawn-out bitmap if two parts had different pinouts, but the same symbol. For example, the 7439 and the 7400 have the same symbol, but different pinouts. Assume that you've defined the 7400 and you're now defining the 7439. Instead of drawing another bitmap for the 7439, you can use the 7400's bitmap by including the line

```
BITMAP '7400'
```

There are four points you should keep in mind when creating bitmaps, as opposed to block symbols.

1. You have to pay more attention to pin placement. The pin definition line and the bitmap have different scales, and you need to take the conversion into account when you draw the symbol.

2. Although you can put a pin name in the pin definition, the pin name will not appear on the screen. The pin name will, however, be recognized by the NETLIST utility.

3. A bitmap symbol gives you the opportunity to define a converted symbol. Bitmap devices always have a normal form. You have the

option of also defining a converted form. Block symbols cannot have a converted form. When you use the GET command and extract a part from a library, it appears in normal form. The resulting menu enables you to choose its converted form instead. You define what the converted form is when you create the library source file. Typically, users define the converted form as the DeMorgan equivalent of the normal form.

4. The maximum number of bits allowed in a bitmap is 16,384. The bitmap begins after the last pin definition. A pound sign (#) indicates that the pixel bit is turned on, and a period (.) indicates that the pixel bit is turned off.

Each . or # represents a screen pixel spacing of 0.01 inch in the X direction. Each line of the bitmap represents 0.01 inch in the Y direction. Remember, the X and Y sizes in the part definition are given in units of 0.1 inch. For example, if you specify X an Y to be 3 and 2, your bitmap actually is 31 characters in the X direction and 21 lines in the Y direction. The extra 1 results because the bitmap starts counting at zero.

An example should make this clearer. Here is a part definition for a resistor.

```
{Part definition for a resistor}
'resistor'
REFERENCE          'R'
3  2  0
L1    PAS          ''
R1    PAS          ''

           {Top side}
{00}...............................
{01}...............................
{02}...............................
{03}...............................
{04}...............................
{05}...............................
{06}...............................
{07}...#...........#...........#...
{08}..#.#.........#.#.........#.#..
{09}.#...#.......#...#.......#...#.  {Right side}
{10}#.....#.....#.....#.....#.....#
{11}.......#...#.......#...#.......
{12}........#.#.........#.#........
{13}.........#...........#.........
{14}...............................
{15}...............................
{16}...............................
{17}...............................
{18}...............................
{19}...............................
{20}...............................

           {Bottom side}
```

Note that the number of parts per package is given as 0. Hence, there are no columns for pin numbers. The pin types are PAS for passive, and there are no pin names (however, they may be specified).

The X size is specified as 3, so the bitmap has lines that are 31 characters long. The Y size is specified as 2, so the bitmap has 21 lines. The part definition specifies two pins, one on the left in the first position (L1) and another on the right in the first position (R1). The pin positions are always spaced 0.1 inch apart. As far as the bitmap is concerned, pin positions are at lines 0, 10, 20, 30, etc.

The line numbers are enclosed in comment delimiters. It isn't necessary to number the bitmap lines this way, but doing so makes the bitmap more readable.

You can reduce the size of bitmaps used in your library by observing the following rules.

1. An empty row (one that has only dots) can be represented by a dot in the zeroth column. If that is the only character on the row, then the row is held as cleared.

2. Empty rows below the actual symbol need not appear in the bitmap.

3. Periods are not required after the last # in a row.

Here is an example of the same resistor definition that follows the reduction rules just described. Figure 7-7 shows the symbol that results from this part definition.

{Part Definition for a resistor.}

```
'RESISTOR'
REFERENCE 'R'
3 2 0
L1    PAS  ''
R1    PAS  ''

                    {Top side}
{00}.
{01}.
{02}.
{03}.
{04}.
{05}.
{06}.
{07}...#...........#...........#
{08}..#.#.........#.#.........#.#
{09}.#...#.......#...#.......#...#          {Right side}
{10}#.....#.....#.....#.....#.....#
{11}.......#...#.......#...#
{12}........#.#.........#.#
{13}.........#...........#

                    {Bottom side}
```

Figure 7-7. The Symbol for a Resistor

After defining a bitmap, you have the option of defining a conversion bitmap. As stated previously, the typical use of a conversion bitmap is to supply a DeMorgan equivalent symbol, but more generally a conversion specifies another bitmap that is displayed on the screen whenever you choose the Convert option of the GET command. You can return to the original bitmap by selecting the Normal subcommand option.

You begin the specification of a conversion bitmap with the keyword CONVERT. The conversion bitmap consists of pin definitions followed by a bitmap. If the conversion has been previously defined, you can reference it by including the name of the part that has the conversion in single quotes.

The next example should clarify the use of conversion bitmaps. First, is the definition of the 7400. Then, comes the conversion bitmap -- it's the DeMorgan equivalent of the 7400. Figure 7-8 shows the normal and converted symbols that result from this part definition.

The 7400 has five pins, two of which are power pins that do not appear in the symbol. The screen size is 6 X-units and 4 Y-units. It has four parts per package.

The conversion bitmap uses the same XY size and parts per package as the normal bitmap. You must, however, redefine the pins. Note the DOT keyword missing from the redefinition of the pin at R2.

Note that the conversion bitmap has the same number of parts per package as the normal bitmap. The number of parts per package determines how many columns of pin numbers appear in the definition. The converted definition must have the same number of columns as the normal definition.

```
'7400'
6    4    4
L1   1    4    9    12   IN        'I0'
L3   2    5    10   13   IN        'I1'
R2   3    6    8    11   DOT  OUT  'O'
T0   14   14   14   14        PWR  'VCC'
B0   7    7    7    7         PWR  'GND'
```

```
{00}##############################################
{01}#.............................................###
{02}#................................................##
{03}#..................................................##
{04}#....................................................#
{05}#.....................................................#
{06}#......................................................#
{07}#.......................................................#
{08}#........................................................#
{09}#.........................................................#
{10}#.........................................................#
{11}#..........................................................#
{12}#..........................................................#
{13}#...........................................................#
{14}#...........................................................#
{15}#...........................................................#
{16}#............................................................#
{17}#............................................................#
{18}#............................................................#
{19}#............................................................#
{20}#............................................................#
{21}#............................................................#
{22}#............................................................#
{23}#............................................................#
{24}#............................................................#
{25}#...........................................................#
{26}#...........................................................#
{27}#...........................................................#
{28}#..........................................................#
{29}#..........................................................#
{30}#.........................................................#
{31}#.........................................................#
{32}#........................................................#
{33}#.......................................................#
{34}#......................................................#
{35}#.....................................................#
{36}#....................................................#
{37}#..................................................##
{38}#................................................##
{39}#.............................................###
{40}##############################################
```

```
CONVERT
L1    1    4    9    12        IN     'I0'
L3    2    5    10   13        IN     'I1'
R2    3    6    8    11        OUT    'O'
T0    14   14   14   14        PWR    'VCC'
B0    7    7    7    7         PWR    'GND'

(00)#################################
(01).#...............................####
(02)..#..................................###
(03)...#....................................##
(04)....#.....................................##
(05).....#......................................##
(06)......#.......................................#
(07)..###.#........................................#
(08).#...##.........................................#
(09)#.....##.........................................#
(10)#.....##..........................................#
(11)#.....#.#..........................................#
(12).#...#...#..........................................#
(13)..###....#...........................................#
(14).........#............................................#
(15).........#.............................................#
(16)..........#.............................................#
(17)..........#..............................................#
(18)..........#...............................................#
(19)..........#................................................#
(20)..........#.................................................#
(21)..........#................................................#
(22)..........#...............................................#
(23)..........#..............................................#
(24)..........#.............................................#
(25).........#.............................................#
(26).........#............................................#
(27)..###....#...........................................#
(28).#...#...#..........................................#
(29)#.....#.#..........................................#
(30)#.....##..........................................#
(31)#.....##.........................................#
(32).#...##.........................................#
(33)..###.#........................................#
(34)......#.......................................#
(35).....#......................................##
(36)....#.....................................##
(37)...#....................................##
(38)..#..................................###
(39).#...............................####
(40)#################################
```

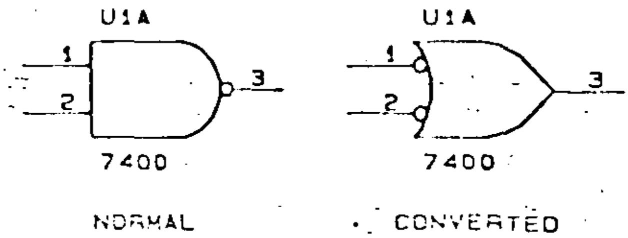


Figure 7-8. The 7400 Symbol and its Conversion

7.4 SDL Reference

This section is a complete description of how to define a part in a custom library. It presents OrCAD's Symbol Description Language (SDL) in the form of syntax diagrams. A syntax diagram consists of identifiers (enclosed in ovals) and tokens (enclosed in rectangles). The syntax diagram is also followed by a textual representation.

7.4.1 Syntax Diagram

Figure 7-9 is an example of a syntax diagram. It represents the complete syntax for a library source file.

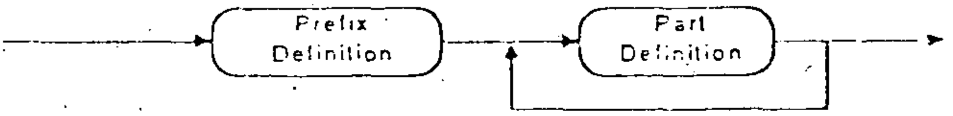


Figure 7-9. Syntax Diagram for a Library Source File

To read a syntax diagram, observe the following rules.

1. Read a syntax diagram from left to right.

2. Every path that you follow in the direction of the arrows represents a correct syntax form.

3. Junctions represent a connection point where you have the choice of selecting another path. For example, the syntax diagram for the library source file shown in Figure 7-9 has a junction after a part definition. You can choose to complete the diagram or to make another part definition.

4. You cannot continue along a path that goes against the arrows. For example, in Figure.7-9 after making a part definition you cannot choose to return to the prefix definition.

5. Text enclosed in ovals represents an identifier. Text enclosed in squares represents a token.

What are identifiers? Identifiers serve as placeholders for a more detailed level of syntax structure. They do not represent command syntax or tokens. Rather, they provide the ability to give a overview of the syntax. When you create the part, you must work down through all the nested identifiers. For example the syntax diagram for a library source file shown in Figure 7-9 has two identifiers and no tokens. This section will now expand each of those identifiers and present all the possible tokens.

What are tokens? They are the building blocks of a library source file. Just as a sentence is made up of words, a library source file is made up of tokens. A token belongs to one of the following categories.

- Numeric constants. A numeric constant consists of one or more whole-number digits.

  Examples: 15
  2
  127

- Character strings. A character string consists of one or more alphanumeric ASCII characters.

  Examples: 74ALS04
  ZENER
  L5
  CLOCK

- Keywords. A keyword is one of the following

BITMAP	Takes an argument (an ASCII string representing a part name) and represents the bitmap of the identified part.

CLK	Represents the clock symbol in a pin definition.
CONVERT	Introduces a converted bitmap. With an argument, it refers to the converted bitmap of a bitmap symbol.
DOT	Represents the inversion bubble in a pin definition
END	Delimits the close of a prefix definition.
GRIDARRAY	Specifies that the device is a pin-grid array. Used in place of the number of parts per package.
HIZ	Identifies the pin as a high impedance (3-state) output.
IN	Identifies the pin as an input.
I/O	Identifies the pin as input/output.
OC	Identifies the pin as open collector.
OUT	Identifies the pin as an output.
PAS	Identifies the pin as passive.
PREFIX	Delimits the beginning of a prefix definition.
PWR	Identifies the pin as a power pin. The PWR keyword prevents a pin from being displayed.
REFERENCE	Takes an argument (an ASCII string representing a reference value). Overrides the default reference value.
SHORT	Specifies that the pin lead lengths be 0.1 inch instead of the normal 0.3 inch.

7.4.2 Textual Representation of Syntax

In addition to the syntax diagram, syntax is represented in text. The symbols are defined as follows.

italics Text enclosed in *italics* represents either a character string or a numeric constant.

[] Text enclosed in square brackets is optional. You choose whether to type it in or not. Do not type the square brackets.

{} Text enclosed in braces is required. You must enter what's represented within the braces.

, If items within square brackets or braces are separated by commas, you must choose one of them only. Do not type the comma.

... Three periods mean you can repeat the last item. How many times you can repeat the item depends on the context. Do not type the periods.

Here is an example of syntax represented in text.

pos [*pin#*...,*grid*...]

First, you must enter a representation of *pos*. An accompanying description explains what you can put in for *pos*. The square brackets around the next item indicate that you don't have to enter it at all. If you do, you must choose between *pin#* or *grid*; and you can choose a repeated number of each.

7.4.3 PREFIX Definition

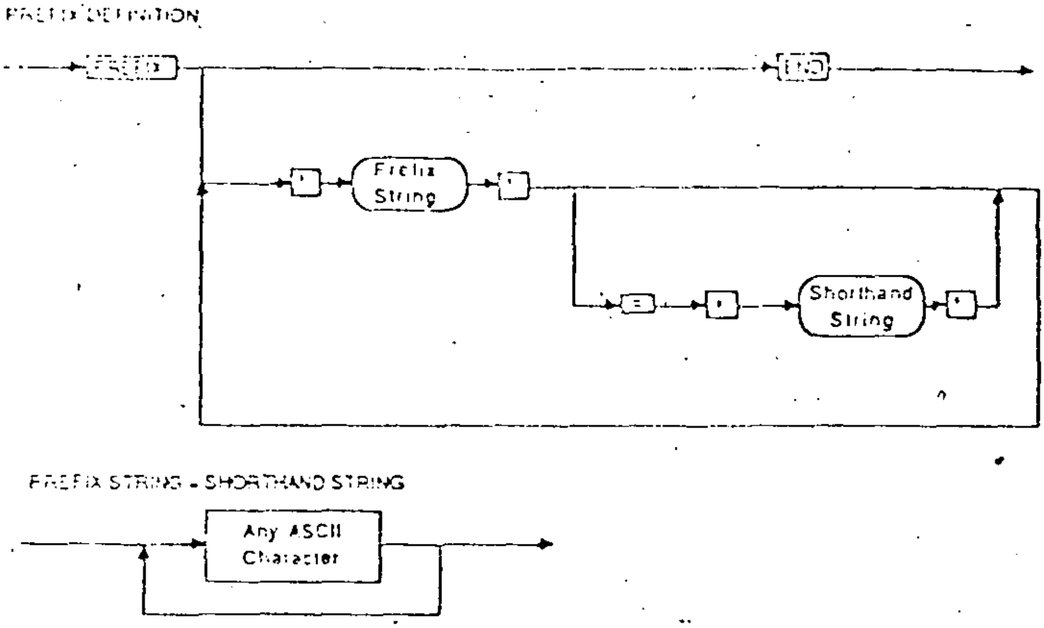


Figure 7-10. Syntax Diagram For a Prefix Definition

```
PREFIX
[ 'prefix string' [= 'shorthand string' ]]
        .
        .
        .
END
```

where:

prefix string	A character string of up to seven printable ASCII characters. You can have a maximum of 16 prefix strings.
shorthand string	A character string of up to seven printable ASCII characters.

NOTES

The equal sign must be separated by one or more <SPACE>s or <TAB>s.

EXAMPLES

Example:

```
PREFIX
'74LS'     =  'LS'
'74S'      =  'S'
'74ALS'    =  'ALS'
'74AS'     =  'AS'
'74HCT'    =  'HCT'
'74HC'     =  'HC'
'74ACT'    =  'ACT'
'74AC'     =  'AC'
'74F'      =  'F'
'74'
END
```

Example:

```
PREFIX
END
```

7.5.4. Part Definition

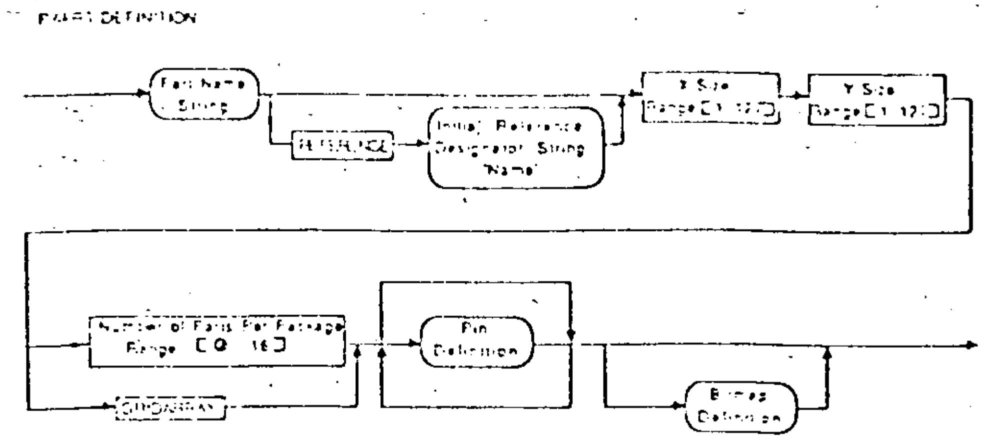


Figure 7-11. Syntax Diagram for a Part Definition

'*part name string*'...
[REFERENCE '*ref string*']
X size Y size { *parts/pckg* ,' GRIDARRAY}
pin definition
•
•
•
[*bitmap definition*]
[*conversion bitmap*]

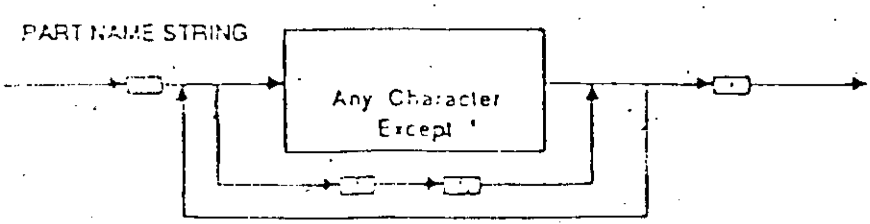


Figure 7-12. The Part Name String

where:

part name string	A character string of up to seven printable ASCII characters that identifies the part. This is the string that can be used as an argument for the Get command.
ref string	A character string of printable ASCII characters. If present, the reference designator replaces the default reference designator.
X size	A numeric constant in the range 1 to 127. The horizontal size of the part as it appears on a printed worksheet. Each entry corresponds to one unit length on the screen or 0.1 inch on a printed worksheet.
Y size	A numeric constant in the range 1 to 127. The vertical size of the part as it appears on a printed worksheet. Each entry corresponds to one unit length on the screen or 0.1 inch on a printed worksheet.
parts/pckg	A numeric constant in the range 0 to 16. If you specify a 0, the pins are not numbered on the symbol.
pin definition	These are identifiers for a more detailed *bitmap definition* level of syntax. See the corresponding *conversion bitmap* entry.

NOTES

To improve readability, you can include comments within a part definition. You can also place blank lines within a source file. Typically blank lines are placed between different part definitions.

EXAMPLES

Example 1:

```
'2114'   '2148'
  6    14    1

pin definition
     .
     .
     .
```

(Two part name strings. These may be on the same or separate lines.)

Example 2:

```
'7474'     '74ALS74'  '74LS74'   '74S74'
'74HC74'   '74AC74'
6     6       2
pin definition
          .
          .
          .
```

7.4.5 Pin Definition

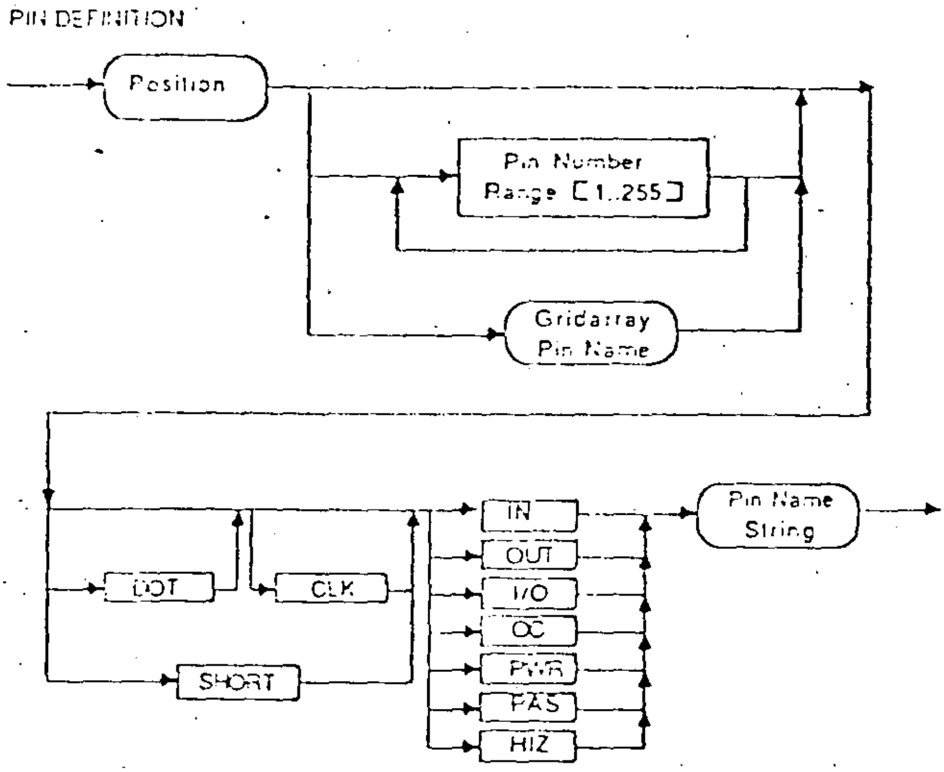


Figure 7-13. Syntax Diagram for a Pin Definition>

```
pos      [ pin#, grid .] [DOT] [CLK] [IN]     pinname
                        [SHORT]    [OUT]
                                   [I/O]
                                   [OC]
                                   [PWR]
                                   [PAS]
                                   [HIZ]
```

where:

pos A letter followed by a number. The letter is one of the following: T, L, R, B where

T indicates the top of the symbol.
L indicates the left side of the symbol.
R indicates the right side of the symbol.
B indicates the bottom of the symbol.

The number represents the distance along the indicated side. The distance is measured in unit lengths on the screen and in 0.1 inches on the printed worksheet. For example, if the block symbol were 6X by 10Y the grid used for placing pins is as follows. The figure below shows the location of L3.

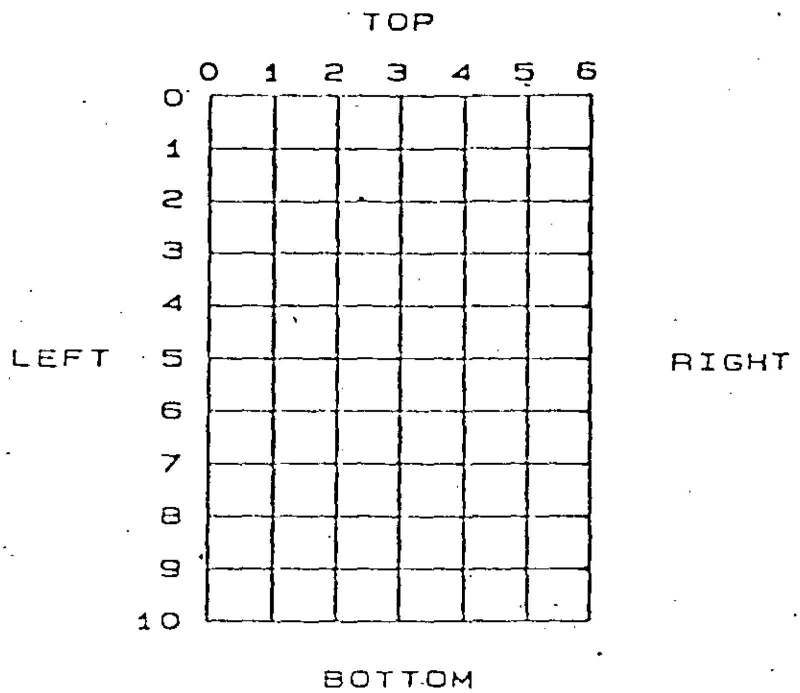


Figure 7-14. The Grid of a 6X by 10Y Block Symbol

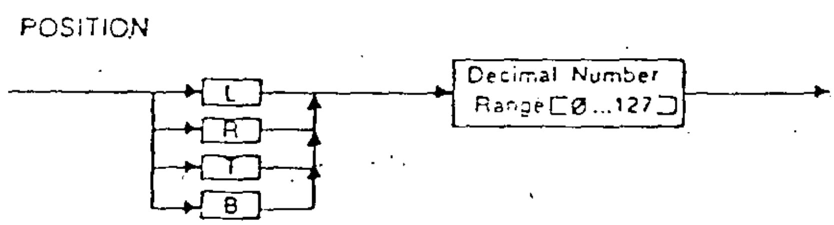


Figure 7-15. The Position Syntax Diagram

pin#
A numeric constant representing the pin number. This is the pin number that appears in the screen symbol.

grid
A letter followed by a number. *grid* represents the pin-grid array pin number. You can only choose a pin-grid array pin number if, in place of *parts/pckg*, you chose the keyword GRIDARRAY. The letter must be in the range A through S; the number must be in the range 1 through 15.

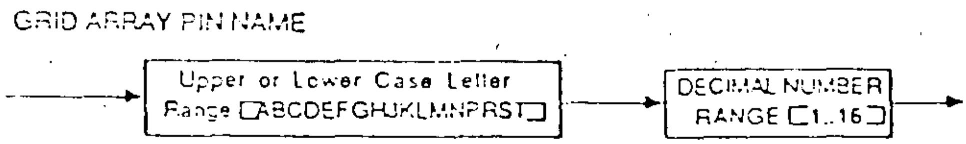


Figure 7-16. Gridarray Pin Name Syntax Diagram

SHORT
A keyword that places a short lead length at the specified pin. The normal lead length is 3 screen units or 0.3 inches on the printed worksheet. When the SHORT keyword is present, the lead length is 1 screen unit or 0.1 inch on the printed worksheet. The SHORT keyword cannot describe a pin that also has either the CLK or DOT keywords.

DOT
A keyword that places the inversion symbol (the bubble) at the specified pin location. The DOT keyword cannot describe a pin that also has the SHORT keyword. The primary use of the bubble is to identify pins that have logic negation, either at an input or an at an output. The figure below shows the inversion symbol.

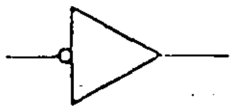


Figure 7-17. The Inversion DOT Symbol

CLK A keyword that places the clock symbol at the specified pin location. The CLK keyword cannot describe a pin that also has the SHORT keyword. The figure below shows the CLK symbol.

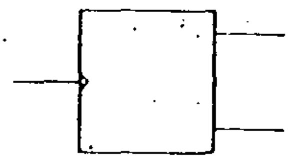


Figure 7-18A. The CLK Symbol

You can use the CLK keyword in conjunction with the DOT keyword to produce a DOT CLK symbol. The figure below shows the DOT CLK symbol.

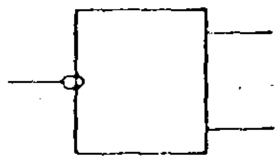


Figure 7-18B. The DOT CLK Symbol

IN	A keyword that identifies the pin as an input.
OUT	A keyword that identifies the pin as a standard totem-pole output.
I/O	A keyword that identifies the pin as a dual function input/output pin.
OC	A keyword that identifies the pin as an open collector or open drain.
PWR	A keyword that identifies a power pin, such as Vcc, Gnd, Vss, Vdd, and others. Power pins are not displayed on library parts when they appear on the screen or printed worksheet. However, the NETLIST utility connects all power supply pins that are defined in library source files.
PAS	A keyword that identifies a pin as passive. Passive pins are typically pins on passive devices such as resistors, transistors, inductors, and others.
HIZ	A keyword that identifies a pin as a high-impedance (3-state) output.
pin name	A character string that represents a name for the specified pin. For block symbols, this name

appears on the screen or the printed worksheet. Pin names do not appear on the screen or the printed worksheet when they are are part of pin definitions for a a bitmap symbol. However, you may still choose to use pin names in bitmap symbols. The NETLIST utility still recognizes them, and you may find them useful as personal references.

You can enter pin names either in upper- or in lower-case, but they always appear in upper-case.

The backslash (\) and single quote (') are special characters. A backslash (\) after a character indicates that the character should have a bar over it. If you want to bar multiple characters, you must place a backslash after each character. The single quote delimits the part name string. If you want a single quote as part of the pin string, you must escape it with another single quote.

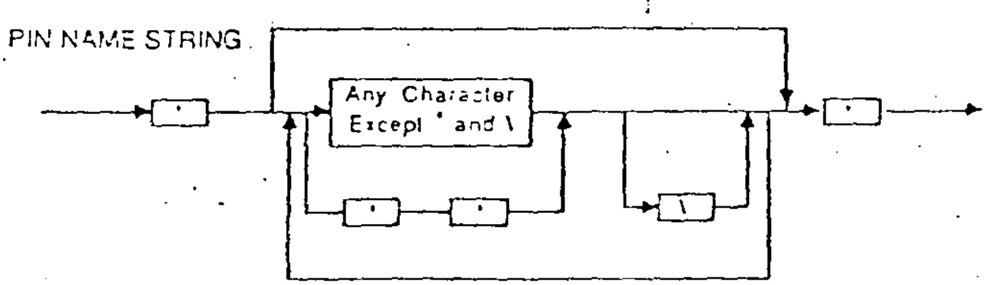


Figure 7-19. Pin Name String Syntax Diagram

EXAMPLES

Example:

```
'2114'  '2148'
6       14      1
L1      5       IN      'A0'
L2      6       IN      'A1'
L3      7       IN      'A2'
L4      4       IN      'A3'
L5      3       IN      'A4'
L6      2       IN      'A5'
L7      1       IN      'A6'
L8      17      IN      'A7'
L9      16      IN      'A8'
L10     15      IN      'A9'
L12     8       IN      'C\S\'
L13     10      IN      'W\E\'
R1      14      HIZ     'D0'
R2      13      HIZ     'D1'
R3      12      HIZ     'D2'
R4      11      HIZ     'D3'
T0      18      PWR     'VCC'
B0      9       PWR     'GND'
```

Example:

```
'68020'  (This device is in a pin-grid array package.)
15      66      GRIDARRAY
L1      C2      CLK IN          'CLK'
                  .
                  .
                  .
```

Example:

```
'7474'      '74ALS74'     '74AS74'     '74LS74'     '74S74'
'74HC74'    '74AC74'
6       6       2
L2      2       12      IN              'D'
L4      3       11      CLK IN          'CK'
B3      1       13      DOT IN          'CL'
                                         .
                                         .
                                         .
```

7.4.6 Bitmap Definition

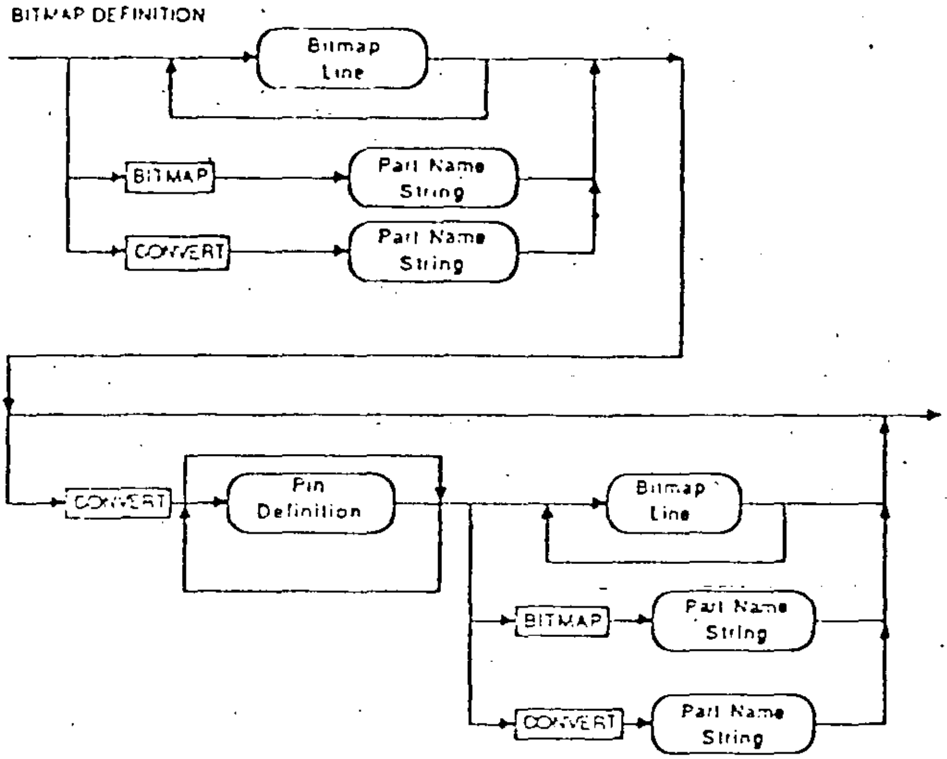


Figure 7-20. The Bitmap Syntax Diagram

[[.,#]...,BITMAP *'part name'* ,CONVERT*'part name'*]

where:

. A . represents cleared pixel bit that is not displayed on the screen.

\# A # represents a set pixel bit.

- If you use the BITMAP option, be sure that the part name you refer to is previously defined. Be aware that DECOMP may reorder part definitions. DECOMP order parts numerically and then alphabetically.

EXAMPLES

```
Example 1:

'CAPACITOR'
2       3       0
T1      FAS     ''
B1      FAS     ''
(    0123456789012345678901234567890)
(    0         1         2         3)
(00)..........#
(01)..........#
(02)..........#
(03)..........#
(04)..........#
(05)..........#
(06)..........#
(07)..........#
(08)..........#
(09)..........#
(10)..........#
(11)..........#
(12)..........#
(13)#######################
(14).
(15).
(16).
(17).
(18).....###########
(19)...###.....#....###
(20).##.......#......##
(21)#.........#.........#
(22)..........#
(23)..........#
(24)..........#
(25)..........#
(26)..........#
(27)..........#
(28)..........#
(29)..........#
(30)..........#
```

Example 2: BITMAP '7400'

{This takes the bitmap defined for the device 7400.}

Example 3: CONVERT '7400'

{This takes the conversion bitmap defined for the device 7400. This part must have a conversion bitmap if the library source file is to COMPOSE without errors.}

7.4.7 Conversion Bitmap

```
CONVERT
pin definitions
   .
   .
   .
bitmap definition
```

where:

pin definition	A previously described identifier. Note that the pin definition for a converted bitmap must have the same value for parts/pckg and the normal bitmap.
bitmap definition	A previously described identifier.
part name	A previously defined part name that has a converted bitmap.

NOTES

If you use the CONVERT '*part name*' option, be sure that the part name you refer to is previously defined. Be aware that DECOMP may reorder part definitions. DECOMP orders parts numerically and then alphabetically.

EXAMPLES

```
Example 1:  CONVERT
            L1    1     4     9     12    IN    'I0'
            L3    2     5     10    13    IN    'I1'
            R2    3     6     8     11    OUT   'O'
            T0    14    14    14    14    PWR   'VCC'
            B0    7     7     7     7     PWR   'GND'

00)#################################
01).#...............................####
02)..#..................................###
03)...#....................................##
04)....#......................................##
05).....#.......................................##
06)......#........................................#
07)..###.#.........................................#
08).#...##..........................................#
09)#.....##..........................................#
10)#.....##...........................................#
11)#.....#.#...........................................#
12).#...#...#...........................................#
13)..###....#............................................#
14).........#.............................................#
15).........#..............................................#
16)..........#..............................................#
17)..........#...............................................#
18)..........#................................................#
19)..........#.................................................#
20)..........#..................................................#
21)..........#.................................................#
22)..........#................................................#
23)..........#...............................................#
24)..........#..............................................#
25).........#..............................................#
26).........#.............................................#
27)..###....#............................................#
28).#...#...#...........................................#
29)#.....#.#...........................................#
30)#.....##...........................................#
31)#.....##..........................................#
32).#...##..........................................#
33)..###.#.........................................#
34)......#........................................#
35).....#.......................................##
36)....#......................................##
37)...#....................................##
38)..#..................................###
39).#...............................####
40)#################################
```

```
Example 2:  CONVERT '7400'
```

7.5 A Final Example: Making a Connector

A typical custom part is a connector. You could use module ports to make a connector, but OrCAD doesn't recommend it. If you use module ports to represent a connector, the NETLIST utility has no way of knowing what the pin numbers are.

Instead, use module ports to represent hierarchical and flat file signals that go from one sheet to another. Connectors, however, such as the DB25 or the IBM 62-pin edge connector, are best represented as library parts. In that way, you treat connectors as physical devices with pin names, which is what they are.

Here is a partial example of a part definition for an IBM 62-pin edge connector.

```
'CONNECTOR IBM'
10      32      0
L1      IN      'B1'
L2      IN      'B2'
L3      IN      'B3'
L4      IN      'B4'
L5      IN      'B5'
L6      IN      'B6'
        .
        .
        .
L30     IN      'B30'
L31     IN      'B31'
R1      IN      'A1'
R2      IN      'A2'
R3      IN      'A3'
R4      IN      'A4'
R5      IN      'A5'
R6      IN      'A6'
        .
        .
        .
R30     IN      'A30'
R31     IN      'A31'
```

7.6 Examples of Source Libraries

Using the techniques discussed just described, we can now examine some examples of library source files. Remember, comments are enclosed within braces {...}. We present three sample source libraries.

SAMPLE_1.SRC	This file contains some typical block symbol definitions. It has some memory devices and two microprocessors, the 8086MAX (the 8086 in maximum mode) and the 68020 (a pin-grid array).
SAMPLE_2.SRC	This file contains some standard TTL devices. Note the use of a prefix definition.
SAMPLE_3.SRC	This file contains some typical bitmap definitions. It has an AND gate with its DeMorgan equivalent, and antenna, a capacitor, a triode, and other non-square or non-rectangular symbols.

Although these examples separate the kinds of definitions (block from bitmap) into different libraries, that is not a requirement. You can intersperse block and bitmap definitions in the same file.

To use these sample files, construct a pure ASCII file (no formatting characters) and execute the COMPOSER utility. Then reconfigure DRAFT to recognize the new library. For example, to COMPOSE the sample files, enter the following commands on the DOS command line. The file COMPOSER.EXE and the sample files must be in the same directory.

```
COMPOSER  SAMPLE_1.SRC SAMPLE_1.LIB   <RETURN>
COMPOSER  SAMPLE_2.SRC SAMPLE_2.LIB   <RETURN>
COMPOSER  SAMPLE_3.SRC SAMPLE_3.LIB   <RETURN>
```

Then, reconfigure DRAFT, as outlined in Section 2. You can add one or more of the resulting library files. DRAFT expects the library files to have a pathname constructed by placing the library prefix (set with the LP command) before the library file (set with the LF command).

7.6.1 SAMPLE_1.SRC: A Block Symbol Library Source File

```
{Beginning of source file, SAMPLE_1.SRC}

PREFIX
END
{The following are memory devices}

{1K x 4 static RAM}
'2114'    '2148'    '2149'    '5513'    '5514'    '9114'    '9124'
6         14        1
L1        5         IN        'A0'
L2        6         IN        'A1'
L3        7         IN        'A3'
L4        4         IN        'A4'
L5        3         IN        'A5'
L6        2         IN        'A6'
L7        1         IN        'A7'
L8        17        IN        'A7'
L9        16        IN        'A8'
L10       15        IN        'A9'
L12       8         IN        'C\S\'
L13       10        IN        'W\E\'
R1        14        HIZ       'D0'
R2        13        HIZ       'D1'
R3        12        HIZ       'D2'
R4        11        HIZ       'D3'
T0        18        PWR       'VCC'
B0        9         PWR       'GND'
```

{All of the above memory devices have the same block symbol. The part's size is 6X by 14Y, and it has one part per package.}

```
{256K x 1 dynamic RAM}
'21256'   '51C256'  '50256'   '50257'   '81256'   '81257'   '6256'
'6257'    '4256'    '4257'    '41256'   '37256'
6         14        1
L1        5         IN        'A0'
L2        7         IN        'A1'
L3        6         IN        'A2'
L4        12        IN        'A3'
L5        11        IN        'A4'
L6        10        IN        'A5'
L7        13        IN        'A6'
L8        9         IN        'A7'
L9        1         IN        'A8'
L11       4         IN        'R\A\S'
L12       15        IN        'C\A\S\'
L13       3         IN        'W\E\'
R1        14        HIZ       'D0'
```

```
R3        2        IN      'D1'
T0        8        PWR     'VCC'
B0        16       PWR     'VSS'

(4K x 8 EPROM)
'2732'
7         16       1
L1        8        IN      'A0'
L2        7        IN      'A1'
L3        6        IN      'A2'
L4        5        IN      'A3'
L5        4        IN      'A4'
L6        3        IN      'A5'
L7        2        IN      'A6'
L8        1        IN      'A7'
L9        23       IN      'A8'
L10       22       IN      'A9'
L11       19       IN      'A10'
L12       21       IN      'A11'
L14       18       IN      'C\E\'
L15       20       IN      'O\E\/VPP'
R1        9        HIZ     'O0'
R2        10       HIZ     'O1'
R3        11       HIZ     'O2'
R4        13       HIZ     'O3'
R5        14       HIZ     'O4'
R6        15       HIZ     'O5'
R7        16       HIZ     'O6'
R8        17       HIZ     'O7'
T0        24       PWR     'VCC'
B0        12       PWR     'GND'
```

(The following are microprocessor devices)

```
'8086MAX'
13        32       1
R1        16       I/O     'AD0'
R2        15       I/O     'AD1'
R3        14       I/O     'AD2'
R4        13       I/O     'AD3'
R5        12       I/O     'AD4'
R6        11       I/O     'AD5'
R7        10       I/O     'AD6'
R8        9        I/O     'AD7'
R9        8        I/O     'AD8'
R10       7        I/O     'AD9'
R11       6        I/O     'AD10'
R12       5        I/O     'AD11'
R13       4        I/O     'AD12'
R14       3        I/O     'AD13'
R15       2        I/O     'AD14'
R16       39       I/O     'AD15'
R17       38       OUT     'A16/S3'
```

```
R18     37          OUT     'A17/S4'
R19     36          OUT     'A18/S5'
R20     35          OUT     'A19/S6'
R22     34          OUT     'B\H\E\/S7'
R24     26  DOT     OUT     'S0'
R25     27  DOT     OUT     'S1'
R26     28  DOT     OUT     'S2'
R28     32          OUT     'R\D\'
R29     29  DOT     OUT     'LOCK'
R30     25          OUT     'QS0'
R31     24          OUT     'QS1'
L3      22          IN      'READY'
L4      19          CLK IN  'CLK'
L5      21          IN      'RESET'
L7      18          IN      'INTR'
L27     31  DOT     I/O     'RQ/GT0'
L28     30  DOT     I/O     'RQ/GT1'
L29     17          IN      'NMI'
L30     23  DOT     IN      'TEST'
L31     33          IN      'M\X\'
T0      40          PWR     'VCC'
B0      20          PWR     'GND'
B5      1           PWR     'GND'
```

(This device is in a pin-grid array package. Notice the keyword GRIDARRAY in place of parts per package)

```
'68020'
16      53          GRIDARRAY
L1      C2                  CLK IN    'CLK'
L3      J12  DOT            IN        'IPL0'
L4      J13  DOT            IN        'IPL1'
L5      H12  DOT            IN        'IPL2'
L7      H2   DOT            IN        'AVEC'
L8      A1   DOT            IN        'BGACK'
L9      B3   DOT            IN        'BR'
L10     J2   DOT            IN        'BERR'
L11     H1   DOT            IN        'CDIS'
L13     H3   DOT            IN        'DSACK0'
L14     J1   DOT            IN        'DSACK1'
L21     K13                 I/O       'D0'
L22     K12                 I/O       'D1'
L23     L13                 I/O       'D2'
L24     L12                 I/O       'D3'
L25     M13                 I/O       'D4'
L26     M12                 I/O       'D5'
L27     M11                 I/O       'D6'
L28     L10                 I/O       'D7'
L29     N12                 I/O       'D8'
L30     N11                 I/O       'D9'
L31     M10                 I/O       'D10'
L32     L9                  I/O       'D11'
L33     N10                 I/O       'D12'
```

L34	M8	I/O	'D13'
L35	N8	I/O	'D14'
L36	L7	I/O	'D15'
L37	M7	I/O	'D16'
L38	N6	I/O	'D17'
L39	M6	I/O	'D18'
L40	L6	I/O	'D19'
L41	N5	I/O	'D20'
L42	M5	I/O	'D21'
L43	N4	I/O	'D22'
L44	L5	I/O	'D23'
L45	M4	I/O	'D24'
L46	N3	I/O	'D25'
L47	M3	I/O	'D26'
L48	L4	I/O	'D27'
L49	N2	I/O	'D28'
L50	M2	I/O	'D29'
L51	L3	I/O	'D30'
L52	N1	I/O	'D31'
R1	C3	OUT	'A0'
R2	A1	OUT	'A1'
R3	E12	OUT	'A2'
R4	D13	OUT	'A3'
R5	D12	OUT	'A4'
R6	C13	OUT	'A5'
R7	B13	OUT	'A6'
R8	C12	OUT	'A7'
R9	A13	OUT	'A8'
R10	C11	OUT	'A9'
R11	B12	OUT	'A10'
R12	A12	OUT	'A11'
R13	C10	OUT	'A12'
R14	B11	OUT	'A13'
R15	A11	OUT	'A14'
R16	B10	OUT	'A15'
R17	C9	OUT	'A16'
R18	C8	OUT	'A17'
R19	B8	OUT	'A18'
R20	A8	OUT	'A19'
R21	B7	OUT	'A20'
R22	C7	OUT	'A21'
R23	A7	OUT	'A22'
R24	A6	OUT	'A23'
R25	B6	OUT	'A24'
R26	C6	OUT	'A25'
R27	A5	OUT	'A26'
R28	B5	OUT	'A27'
R29	A4	OUT	'A28'
R30	C5	OUT	'A29'
R31	B4	OUT	'A30'
R32	A3	OUT	'A31'
R34	F13 DOT	OUT	'IPEND'
R35	B2 DOT	OUT	'BG'
R37	E1	OUT	'FCO'

```
R38     F3              OUT     'FC1'
R39     F2              OUT     'FC2'
R41     F1              OUT     'SIZ0'
R42     G2              OUT     'SIZ1'
R43     G3   DOT        OUT     'DBEN'
R44     G1   DOT        OUT     'ECS'
R45     E13  DOT        OUT     'OCS'
R46     E2   DOT        OUT     'RMC'
R47     L1   DOT        OUT     'AS'
R48     M1   DOT        OUT     'DS'
R50     L2              OUT     'R/W\'
R51     K2   DOT        I/O     'HALT'
R52     C1   DOT        I/O     'RESET'
T0      A9              PWR     'VCC'
T1      D1              PWR     'VCC'
T3      D2              PWR     'VCC'
T6      E3              PWR     'VCC'
T9      G11             PWR     'VCC'
T12     G13             PWR     'VCC'
T15     M5              PWR     'VCC'
T16     N8              PWR     'VCC'
B0      A10             PWR     'GND'
B1      G12             PWR     'GND'
B3      H13             PWR     'GND'
B6      J3              PWR     'GND'
B9      K1              PWR     'GND'
B12     L7              PWR     'GND'
B15     N7              PWR     'GND'
B16     B9              PWR     'GND'

(End of source file, SAMPLE_1.SRC)
```

7.6.2 SAMPLE_2.SRC: A TTL Block Symbol Library Source File

```
{Beginning of the source file, SAMPLE_2.SRC}

PREFIX
'74LS'        -      'LS'
'74S'         -      'S'
'74ALS'       -      'ALS'
'74AS'        -      'AS'
'74HCT'       -      'HCT'
'74HC'        -      'HC'
'74ACT'       -      'ACT'
'74AC'        -      'AC'
'74F'         -      'F'
'74'
END


'7442' '74LS42' '74HC42' '7443' '7444'
5          11             1
L4         1              IN           'A'
L5         15             IN           'B'
L6         13             IN           'C'
L7         12             IN           'D'
R10        11             DOT  OUT     '9'
R9         10             DOT  OUT     '8'
R8         9              DOT  OUT     '7'
R7         7              DOT  OUT     '6'
R6         6              DOT  OUT     '5'
R5         5              DOT  OUT     '4'
R4         4              DOT  OUT     '3'
R3         3              DOT  OUT     '2'
R2         2              DOT  OUT     '1'
R1         1              DOT  OUT     '0'
T0         16             PWR          'VCC'
B0         8              PWR          'GND'


'7446' '7447' '74LS47'
6          8              1
L1         4              IN           'R\B\O\'
L2         5              IN           'R\B\I\'
L3         3              IN           'L\T\'
L4         7              IN           '1'
L5         1              IN           '2'
L6         2              IN           '4'
L7         6              IN           '8'
R7         14             DOT  OC      'G'
R6         15             DOT  OC      'F'
R5         9              DOT  OC      'E'
R4         10             DOT  OC      'D'
R3         11             DOT  OC      'C'
```

```
R2        12        DOT OC      'B'
R1        13        DOT OC      'A'
T0        16        PWR         'VCC'
B0        8         PWR         'GND'
```

```
'7474'    '74ALS74' '74AS74' '74LS74' '74S74'
'74HC74'  '74AC74'
6         6         2
L2        2         12          IN        'D'
L4        3         11          CLK IN    'CK'
B3        1         13          DOT IN    'CL'
T3        4         10          DOT IN    'P'
R4        6         8           OUT       'Q\'
R2        5         9           OUT       'Q'
T0        14        14          PWR       'VCC'
B0        7         7           PWR       'GND'
```

{This part has two parts per package. The far left column represents the pin position. The second column contains the pin numbers of the first D flip-flop in the package. The third column contains the pin number of the second D flip-flop in the package. Note the power pins on 14 and 7. They are required for both devices.}

```
'74ALS160' '74AS160' '74LS160' '74HC160'
'74ALS161' '74AS161' '74LS161' '74HC161'
'74ALS162' '74AS162' '74LS162' '74S162'  '74HC162'
'74ALS163' '74AS163' '74LS163' '74S163'  '74HC163'
B         10        1
B4        1         DOT IN      'CL'
L1        9         DOT IN      'LD'
L2        10        IN          'ENT'
L3        7         IN          'ENP'
L4        2         CLK IN      'CLK'
L6        3         IN          'A'
L7        4         IN          'B'
L8        5         IN          'C'
L9        6         IN          'D'
R9        11        OUT         'QD'
R8        12        OUT         'QC'
R7        13        OUT         'QB'
R6        14        OUT         'QA'
R4        15        OUT         'CO'
T0        16        PWR         'VCC'
B0        8         PWR         'GND'
```

{End of the source file, SAMPLE_2.SRC}

7.6.3 SAMPLE_3.SRC: A Bitmap Symbol Library Source File

```
{Beginning of the source file, SAMPLE_3.SRC}

PREFIX
END

'7400'
6         4         4
L1        1         4         9         12        IN        'I0'
L3        2         5         10        13        IN        'I1'
R2        3         6         8         11 DOT    OUT       'O'
T0        14        14        14        14        PWR       'VCC'
B0        7         7         7         7         PWR       'GND'
{00}#####################################################
{01}#....................................................###
{02}#.......................................................##
{03}#..........................................................##
{04}#............................................................#
{05}#.............................................................#
{06}#..............................................................#
{07}#...............................................................#
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{35}#.............................................................#
{36}#............................................................#
{37}#..........................................................##
{38}#.......................................................##
{39}#....................................................###
{40}#####################################################
```
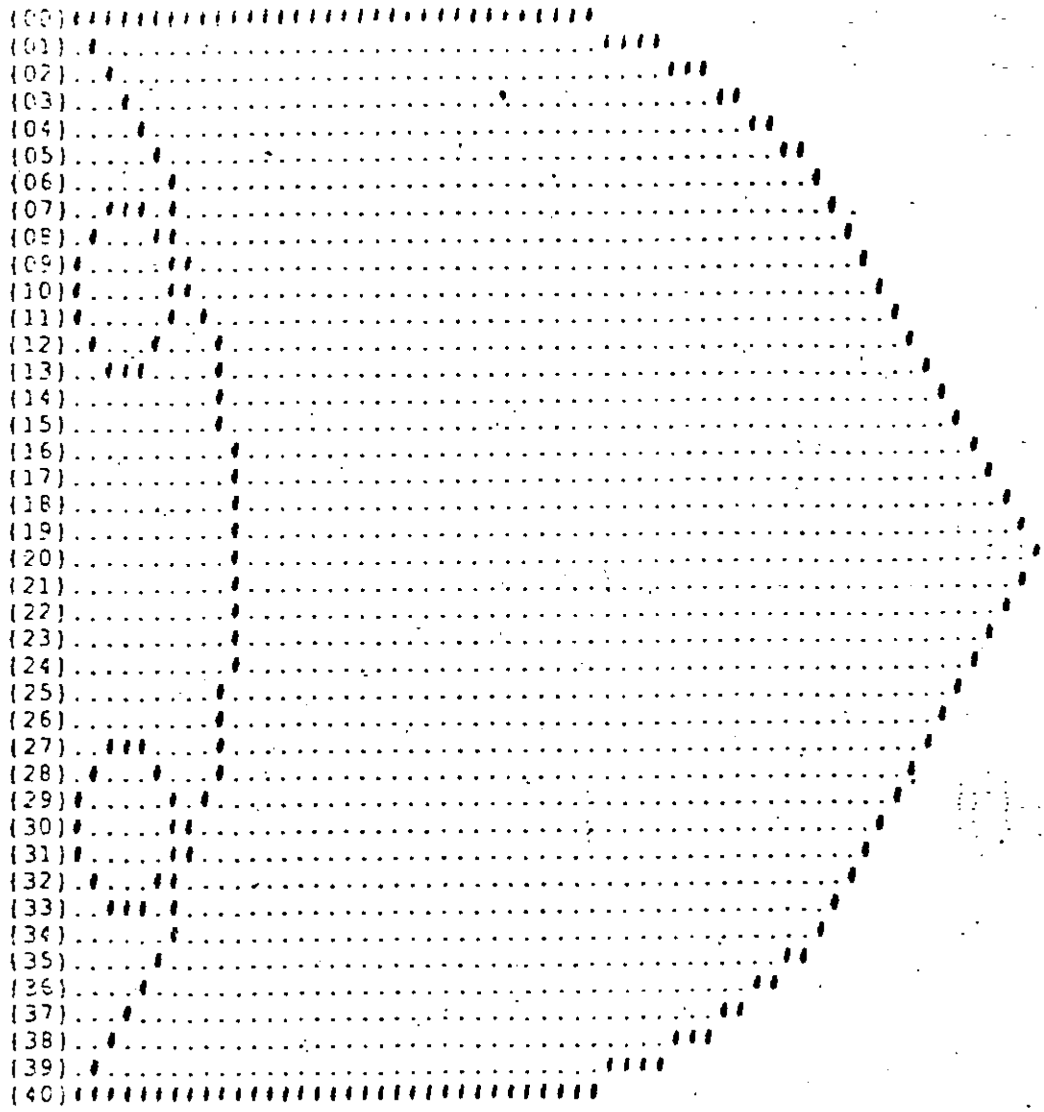

```
CONVERT
L1      1      4      9      12     IN     'I0'
L3      2      5      10     13     IN     'I1'
R2      3      6      8      11     OUT    'O'
T0      14     14     14     14     PWR    'VCC'
B0      7      7      7      7      PWR    'GND'
```



```
'74ALS10'
6         4         3
L1        1         3         9          IN        'I0'
L2        2         4         10         IN        'I1'
L3        13        5         11         IN        'I2'
R2        12        6         8    DOT   OUT       'O'
T0        14        14        14         PWR       'VCC'
B0        7         7         7          PWR       'GND'
BITMAP '7400'
CONVERT
L1        1         3         9          IN        'I0'
L2        2         4         10         IN        'I1'
L3        13        5         11         IN        'I2'
R2        12        6         8          OUT       'O'
T0        14        14        14         PWR       'VCC'
B0        7         7         7          PWR       'GND'
(00)#################################
(01).#...............................####
(02)..#..................................###
(03)...#....................................##
(04)....#.....................................##
(05).....#......................................##
(06)......#.......................................#
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(35).....#......................................##
(36)....#.....................................##
(37)...#....................................##
(38)..#..................................###
(39).#...............................####
(40)#################################
```

```
'7402'
6        4        4
L1       2        5        8        11            IN     '10'
L3       3        6        9        12            IN     '11'
R2       1        4        10       13   DOT      OUT    'O'
T0       14       14       14       14            PWR    'VCC'
B0       7        7        7        7             PWR    'GND'
(00)!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
(01).!...............................!!!!
(02)..!..................................!!!
(03)...!....................................!!
(04)....!.....................................!!
(05).....!......................................!!
(06)......!.......................................!
(07)......!........................................!
(08).......!........................................!
(09).......!.........................................!
(10)!!!!!!!!!.........................................!
(11)........!..........................................!
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(30)!!!!!!!!!.........................................!
(31).......!.........................................!
(32).......!........................................!
(33)......!........................................!
(34)......!.......................................!
(35).....!......................................!!
(36)....!.....................................!!
(37)...!....................................!!
(38)..!..................................!!!
(39).!...............................!!!!
(40)!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
=CONVERT
L1        2         5         8         11        DOT       IN'I0'
L3        3         6         9         12        DOT       IN'I1'
R2        1         4         10        13                  OUT'O'
T0        14        14        14        14        PWR'VCC'
B0        7         7         7         7         PWR'GND'
BITMAP '7400'

'7433' '74LS33' '74ALS33'
6         4         4
L1        2         5         8         11                  IN'I0'
L3        3         6         9         12                  IN'I1'
R2        1         4         10        13        DOT       OUT'O'
T0        14        14        14        14        PWRVCC'
B0        7         7         7         7         PWR'GND'
BITMAP '7402'
CONVERT
L1        2         5         8         11        DOT       IN'I0'
L3        3         6         9         12        DOT       IN'I1'
R2        1         4         10        13                  OUT'O'
T0        14        14        14        14        PWR'VCC'
B0        7         7         7         7         PWR'GND'
BITMAP '7400'
```

(The following are electrical and electronic parts)

```
'ANTENNA'
2                   1         0
B1                  OUT       'ANT'
(  0)#####################
(  1).#........#........#.
(  2)..#.......#.......#..
(  3)...#......#......#...
(  4)....#.....#.....#....
(  5).....#....#....#.....
(  6)......#...#...#......
(  7).......#..#..#.......
(  8)........#.#.#........
(  9).........###.........
( 10)..........#..........
```

```
'CAP'
'CAPACITOR'
REFERENCE  'C'
(X Size =) 2        (Y Size =) 1        (Parts per Package =)) 0
T1        SHORT   PAS      '1'
B1        SHORT   PAS      '2'
(  0)..........#..........
(  1)..........#..........
(  2).####################.
(  3).....................
(  4).....................
(  5).....................
(  6).....................
(  7)......#########......
(  8)...###....#....###...
(  9).##.......#.......##.
( 10)..........#..........

'GND POWER'
(X Size =)  2       (Y Size =)  1       (Parts per Package =)  0
T1                 PWR      'GND'
(  0)#####################
(  1).....................
(  2).....................
(  3)...###############...
(  4).....................
(  5).....................
(  6)......#########......
(  7).....................
(  8).....................
(  9).........###.........
( 10).....................
```

```
'MOSFET N'
REFERENCE   'Q'
3           2        0
L2          SHORT    IN        'GATE'
T2          SHORT    IN        'DRAIN',
B2          SHORT    IN        'SOURCE'
(   0).........#..........#.........
(   1).........#..........#.........
(   2)....#....############.........
(   3)....#....#....................
(   4)....#....#....................
(   5)....#....#.....#..............
(   6)....#....#....##..............
(   7)....#....#...###..............
(   8)....#....#..####..............
(   9)....#....#.#####..............
(  10)....#....############.........
(  11)....#....#.#####....#.........
(  12)....#....#..####....#.........
(  13)....#....#...###....#.........
(  14)....#....#....##....#.........
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(  16)....#....#..........#.........
(  17)....#....#..........#.........
(  18)....#....############.........
(  19)....#....#..........#.........
(  20)#####....#..........#.........
```

```
'TRIODE'
4          4          0
L2         IN         'GRID'
B0         IN         'CATHODE'
B1         IN         'FILAMENT_1'
B3         IN         'FILAMENT_2'
T2         IN         'PLATE'
(00)..............#############
(01)............##......#......##
(02)..........##........#........##
(03)........##..........#..........##
(04).......#............#............#
(05)......#.............#.............#
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(35).....##..........#.....#..........#
(36)....#..#........#.......#........#
(37)...#....##.....#.........#.....##
(38)..#.......##..#...........#..##
(39).#..........##.............##
(40)#.........###.#############.###
```

APPENDIX A

SUMMARY OF LIBRARY COMPONENTS

Directory of ANALOG.LIB

1458	1558	7621	ADC0801
ADC0802	ADC0803	ADC0804	ADC0805
ADC0808	ADC0809	DAC0800	DAC0801
DAC0802	DAC0806	DAC0807	DAC0808
DAC8408	LF13741H	LF13741N	LF147D
LF147N	LF155H	LF156H	LF157H
LF255H	LF256H	LF257H	LF347D
LF347N	LF351H	LF351N	LF353H
LF353N	LF355H	LF355N	LF356H
LF356N	LF357H	LF357N	LF411H
LF411N	LF412H	LF412N	LF441H
LF441N	LF442H	LF442N	LF444D
LF444N	LH0002N	LH0003H	LH0004H
LM101H	LM101J	LM101J14	LM102H
LM107H	LM107J	LM107J14	LM108H
LM108J	LM108J8	LM10H	LM10N
LM11D	LM11H	LM11N	LM124
LM13080N	LM13080P	LM1458H	LM1458J
LM1458N	LM146J	LM148J	LM149
LM1558H	LM1558J	LM158H	LM159J
LM192H	LM192J	LM201H	LM201J
LM201J14	LM202H	LM207H	LM207J
LM207J14	LM208H	LM208J	LM208J8
LM218H	LM224	LM246J	LM246N
LM248	LM248J	LM258H	LM2900J
LM2900N	LM2904N	LM2924J	LM2924N
LM292H	LM292J	LM301H	LM301J
LM301J14	LM301N	LM302H	LM307H
LM307J	LM307J14	LM307N	LM308H
LM308J	LM308J8	LM318H	LM324
LM3301N	LM339	LM3401N	LM346J
LM346N	LM348	LM348J	LM348N
LM349N	LM358H	LM358N	LM359J
LM359N	LM3900N	LM392H	LM392J
LM392N	LM4250H	LM4250J	LM555
LM709H	LM709N	LM709N8	LM725H

LM725N	LM741L	LM741H	LM741J14
LM741N	LM741N14	LM747	LM747H
LM747J	LM748H	LM748J	LM748N
LM7805	LM7806	LM7808	LM7810
LM7812	LM7815	LM7818	LM7824
LM7885	MC1455	MC1555	MC1741
NE555	OPAMP	TL072	TL082
TL092	UA741	VOLTAGE REGULATOR	

Directory of ASSEMBLY.LIB

08 PIN	14 PIN	16 PIN	24 PIN
28 PIN	40 PIN [illegible]	40 PIN TOP	CAP 2XT
EDGE CONNECTOR	RESISTOR 1X2	RESISTOR 1X3	RESISTOR 1X5
RESISTOR PACK	TO-220	TO-39	TO 92
XTAL			

Directory of CMOS.LIB

4000	4001	4002	4006	4007	4008	4009	4010	4011
4012	4013	4014	4015	4016	4017	4018	4019	4020
4021	4022	4023	4024	4025	4026	4027	4028	4029
4030	4031	4032	4033	4034	4035	4037	4038	4040
4041	4042	4043	4044	4045	4046	4047	4048	4049
4050	4051	4052	4053	4054	4055	4056	4057	4059
4060	4063	4066	4068	4069	4070	4071	4072	4073
4075	4076	4077	4078	4081	4082	4085	4086	4089
4093	4094	4095	4096	4098	4099	4501	4502	4503
4504	4505	4506	4508	4510	4511	4512	4513	4514
4515	4516	4517	4518	4519	4520	4521	4522	4524
4526	4527	4528	4529	4530	4531	4532	4534	4536
4537	4538	4539	4541	4543	4544	4547	4549	4551
4552	4553	4554	4555	4556	4557	4558	4559	4560
4561	4562	4566	4568	4569	4572	4573	4574	4575
4580	4581	4582	4583	4584	4585	4597	4598	4599
5101	14000	14001	14002	14006	14007	14008	14011	14012
14013	14014	14015	14016	14017	14018	14020	14021	14022
14023	14024	14025	14027	14028	14029	14032	14034	14035
14038	14040	14042	14043	14044	14046	14051	14052	14053
14066	14068	14069	14070	14071	14072	14073	14075	14076
14077	14078	14081	14082	14093	14094	14099	14160	14161
14162	14163	14174	14175	14194	14501	14502	14503	14504
14505	14506	14508	14510	14511	14512	14513	14514	14515
14516	14517	14518	14519	14520	14521	14522	14524	14526
14527	14528	14529	14530	14531	14532	14534	14536	14537
14538	14539	14541	14543	14544	14547	14549	14551	14552
14553	14554	14555	14556	14557	14558	14559	14560	14561
14562	14566	14568	14569	14572	14573	14574	14575	14580
14581	14582	14583	14584	14585	14597	14598	14599	40102

40101	40102	40103	40104	40105	40106	40115	40116	40160
40161	40162	40163	40174	40175	40182	40192	40193	40194
42100	45100	45101	45104	45106	45107	45109	45112	145104
145106	145107	145109	145112					

Directory of DEVICE.LIB

12 HEADER	1RSW10	1RSW12
1RSW3	1RSW6	2RSW12
2RSW3	2RSW5	4 HEADER
ANTENNA	BATTERY	BNC
BRIDGE	BUZZER	CAP
CAPACITOR	CAPACITOR FEED	CAPACITOR POL
CAPACITOR VAR	CIRCUIT BREAKER	COAX
CONNECTOR COAX	CONNECTOR COAX-F	CONNECTOR COAX-M
CONNECTOR DB15	CONNECTOR DB25	CONNECTOR DB9
CRYSTAL	DIODE	DIODE BREAKDOWN
DIODE SCHOTTKY	DIODE TUNNEL	DIODE VARACTOR
DIODE ZENER	DIODE ZENER1	FUSE
GND EARTH	GND FIELD SIGNAL	GND POWER
GND SIGNAL	GTO	INDUCTOR
INDUCTOR IRON	INDUCTOR IRON1	INDUCTOR ISOLATED
INDUCTOR VAR	INDUCTOR VARIABLE IRON	JFET N
JFET P	JUMPER	LAMP
LAMP NEON	LED	METER AMP
METER MA	METER MV	METER UA
METER UV	METER VOLT	METER VU
MICROPHONE	MOSFET DUAL G/N	MOSFET DUAL G/P
MOSFET N	MOSFET P	MOTOR SERVO
MOTOR STEPPER	NPN	NPN DAR
NPN DIAC	OPTO ISOLATOR	OPTO ISOLATOR-A
PHONEJACK	PHONEJACK STEREO	PHONEJACK STEREO.SW
PHONEPLUG	PHOTO NPN	PHOTODIODE
PLUG AC FEMALE	PLUG AC MALE	PNP
PNP DAR	PNP DIAC	POT
R	R-PACK	RCA JACK
RELAY DPST	RELAY SPDT	RELAY SPST
RESISTOR	RESISTOR 8PACK	RESISTOR BRIDGE
RESISTOR TAPPED	RESISTOR VAR	RESISTOR VAR 2
SCR	SIGNAL AC	SOURCE CURRENT
SOURCE VOLTAGE	SPARK GAP	SPARK GAP CAP
SPEAKER	SW DIP-4	SW DIP-8
SW PUSHBUTTON	SW SPDT	SW SPST
THERMAL FUSE	THERMISTOR	TRANSFORMER
TRANSFORMER AIR CORE	TRANSFORMER CT	TRANSFORMER ISOLATED
TRANSFORMER STEPUP	TRANSFORMER VAR	TRANZORB
TRIAC	TRIAC DRIVER	TRIGGERED SPARK GAP
TRIODE	TUBE PHOTO MULTIPLIER	UJT N
UJT P	VARISTOR	

Directory of ECLLIB

MC10100	MC10101	MC10102	MC10103	MC10104	MC10105	MC10106
MC10107	MC10109	MC10110	MC10111	MC10113	MC10114	MC10115
MC10116	MC10117	MC10118	MC10119	MC10121	MC10123	MC10124
MC10125	MC10128	MC10129	MC10130	MC10131	MC10132	MC10133
MC10134	MC10135	MC10136	MC10137	MC10138	MC10139	MC10141
F10145A	MC10153	MC10154	MC10158	MC10159	MC10160	MC10161
MC10162	MC10163	MC10164	MC10165	MC10166	MC10168	MC10170
MC10171	MC10172	MC10173	MC10174	MC10175	MC10176	MC10177
MC10178	MC10179	MC10180	MC10181	MC10182	MC10186	MC10188
MC10189	MC10190	MC10191	MC10193	MC10195	MC10197	MC10210
MC10211	MC10212	MC10216	MC10231	F10402	F10414	F10415
F10416	F10422	F10470	F10474	MC10500	MC10501	MC10502
MC10503	MC10504	MC10505	MC10506	MC10509	MC10514	MC10515
MC10516	MC10517	MC10518	MC10519	MC10521	MC10530	MC10531
MC10532	MC10534	MC10535	MC10536	MC10537	MC10538	MC10539
MC10541	MC10558	MC10559	MC10560	MC10561	MC10562	MC10563
MC10564	MC10565	MC10566	MC10568	MC10570	MC10571	MC10572
MC10574	MC10575	MC10576	MC10578	MC10579	MC10580	MC10581
MC10582	MC10586	MC10588	MC10590	MC10591	MC10593	MC10595
MC10597	MC10610	MC10611	MC10612	MC10616	MC10631	F100101
F100102	F100107	F100112	F100113	F100114	F100117	F100118
F10012	F100123	F100124	F100125	F100126	F100130	F100131
F100136	F100141	F100142	F100145	F100150	F100151	F100155
F100156	F100158	F100160	F100163	F100164	F100165	F100166
F100171	F100179	F100180	F100181	F100182	F100183	F100194
[illegible]	[illegible]	[illegible]	F100416	F100422	F100470	F100474
F100170/4						
F100170/8						

Directory of INTEL.LIB

Z80	Z80PIO	8031	80C31	8032	8035	80C35
8039	80C39	8040	8041	8042	8044	8048
80C48	8049	80C49	8050	8051	80C51	8052
8085	8086MAX	8086MIN	8087	8088MAX	8088MIN	8089
8096	8097	8155	8156	8185	8203	8205
8206	8207	8208	8212	8216	8226	8231
8237	8237A	8243	8251	8251A	8253	8254
82C54	8255	82C55	8256	8257	8259A	8272
8272A	8273	8274	8275	8276	8279	8282
8283	8284	8286	8287	8288	8289	8291
8292	8294	8294A	8295	8344	8396	8397
8641	8741	8742	8744	8748	8749	8751
8755	80186	80188	80286	80287	80386	8206-2
82062	82064	82188	82284	82288	82289	82384
82501	82530	82586MA	82586MI	82588EI	82588HM	82720
82731						

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10H8	10L8	12H6	12L6	14H4	14L4	14L8	16C1
16H2	16L2	16A4	16R4	16RP4	16X4	16L6	16RP6
16R6	16H8	16HD8	16L8	16LD8	16P8	16R8	16RP8
16V8	16Z8	18L4	18P8	20C1	20L2	20R4	20X4
20R6	20L8	20R8	20V8	20X8	315	406	426
12L10	1400	1420	1421	1430	1600	1601	18S42
18S46	18SA46	20L10	20X10	2015	2016	2018	2019
2063	2064	2068	2069	2114	2115	2125	2130
2141	2147	2148	2149	2164	2167	2168	2186
2187	22V10	24S10	24SA10	24S41	24SA41	24S81	2600
2620	2630	27S12	2716	27S18	27S19	27S20	27S21
27S29	27S30	27S31	2732	27S32	27S33	27S40	27S41
27S43	2764	27C64	2816	2817	2864	28S56	3628
3636	3764	39V18	4016	4044	4104	4161	4164
4256	4257	4264	4416	4564	4864	48C64	5063
5133	5143	51C64	51C65	51C66	51C67	51C68	51C69
52B13	52B23	52B33	5301	5305	5306	5330	5331
5340	5341	5349	5352	5353	5381	5513	5514
5516	5517	5564	5565	5600	5604	5605	5610
5623	5624	5625	6116	6147	6164	6167	6256
6257	6264	6267	6287	6301	6305	6306	6330
6331	6340	6341	6349	6352	6353	6380	6381
6665	7051	7052	7053	7056	7057	7058	7121E
7122E	7128E	7131	7132	7134	7137	7138	7142E
7602	7603	7610	7611	7620	7621	7640	7641
7642	7643	7649	7680	7681	7685	8128	8167
8168	82S23	8264	8266	8281	8416	8417	8418
8464	87C64	9044	9064	9114	9124	9128	9244
9864	99C68	18S030	18SA030	21256	25044	25045	25085

25058	25C59	25168	25169	27010	27011	27128	27S180
27S181	27S185	27S190	27S191	27S200	27210	27256	27C256
27S280	27S281	27S290	27S291	27S12	27S13	27S16	28S116
28S166	29611	29621	29625	29630	29631	29651	29661
29650	29681	37256	41256	48416	50256	50257	51C256
51C259	57256	74S198	74S287	74S288	74S387	74S472	74S474
74S475	74S570	74S571	74S572	74S573	76160	76161	76164
76165	76321	76641	81255	81257	81416	82S123	82S126
82S129	82S130	82S131	82S136	82S137	82S147	82S180	82S181
82S185	82S190	82S191	82S321	87S180	87S181	87S185	87S190
87S191	87S280	87S281	87S290	87S291	93415	93417	93425
93427	93436	93438	93446	93448	93Z450	93Z451	93452
93453	93Z510	93Z511	93S12	93Z541	63S16E1		

Directory of MOTO.LIB :

6800	68A00	68B00	6801	6801EM	6801NM	6802
6802NS	6803	6803EM	6805	6809	6809E	68HC09E
6810	6821	6822	6829	68HC34	6835	6839
6840	6844	6845	6846	6847	6847Y	6850
6852	6854	6875	6875A	68000CC	68000D	68000GA
68008D	68008Q	68010CC	68010D	68010GA	6801U4	6801U4EM
6801U4NM	68020	6803U4	6803U4EM	6804J2	6804P2	68HC04P2
68HC04P3	6805K2	6805P2	6805R2	6805T2	6805U2	6805K3
6805R3	6805U3	6805P4	6805P6	68120EM	68120NM	68120SC
68121EM	68121NM	68121SC	68440	68451	68681	68901
6836E16	6836R16	68705R3	68705U3	68705R5	68705U5	146805E2
146805E3						

Directory of RF.LIB :

AIR INDUCTOR	AIR INDUCTOR VARIABLE	AIR INDUCTOR WIPER
AIR T INDUCTOR	ANTENNA DIPOLE	ANTENNA NETWORK
ANTENNA-1	ANTENNA-2	ARROW
BOX	CAPACITOR FEED	CIRCLE
COAX PLUG	COAX RECEPTACLE	CONNECTOR COAX
CONNECTOR COAX-F	CONNECTOR COAX-M	CRT
ENVELOPE	FLYBACK	GROUNDED CAP
HOTLINE JACK	PENTODE	PHASE SHIFTER
PHASE SHIFTER BELT	PHASE SHIFTER THICK	PSB
PST	RF SPDT	RF SPDT
STDA115	STDA116	STEPUP
SWITCH NETWORK	TETRODE	TRANSMISSION LINE
TRANSMISSION SCREEN	TRIODE	TRIODE VCAP

Directory of TTL.LIB

	74LS	74S	74ALS	74AS	74HCT	74HC	74ACT	74AC	74F	74
00	**	**	**	**	**	**	**	**	**	**
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Directory of TTL.LIB Continued..

	74LS	74S	74ALS	74AS	74HCT	74HC	74ACT	74AC	[illegible]	74
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Directory of TTL.LIB Continued

	74LS	74S	74ALS	74AS	74HCT	74HC	74ACT	74AC	74F	74
97	..	..	..	..	..	..	..	..	..	**
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Directory of TTL_LIB Continued

	74LS	74S	74ALS	74AS	74BCT	74HC	74ACT	74AC	74F	74
153	**	**	**	**	**	**	**	**	**	**
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	74LS	74S	74ALS	74AS	74HCT	74HC	74ACT	74AC	74F	74
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Directory of TTL.LIB Continued:

	74LS	74S	74ALS	74AS	74HCT	74HC	74ACT	74AC	74F	74
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CIRCUITOS IMPRESOS

(smARTWORK)

smARTWORK™

Wintek Personal Computer Software

Wintek Corporation
1801 South Street
Lafayette, Indiana 47904-2993
Telephone: (317) 742-8428
Telex: 70-9079 (WINTEK CORP UD)

Version Number ______________

License Number ______________

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These programs were written by:

Mark Corzine
Jim Wilson
Neal Young
Steve Belter

smARTWORK Reference Manual

Table of Contents

(4)

Preface

"smARTWORK" is a computer software package designed to aid in the design and production of artwork for printed-circuit boards. This manual is a guide to the use of smARTWORK on the IBM Personal Computer. The following topics are included:

* What the programs can do
* Machine and peripheral requirements for operation
* How to start the programs
* Using smARTWORK to create and edit your artwork
* Saving and loading your data
* Producing paper, vellum, or polyester film copies of the finished artwork
* Advanced techniques for more complex layouts

* Error messages from the program and what to do when they appear

0 Manual Organization

The information in this manual is organized into several major sections:

* Chapter 1 contains an introduction to smARTWORK, what it is designed to do, and a list of required computer hardware for its use.
* Chapter 2 covers how to start the programs and backup procedures for the programs and for your data.
* Chapters 3 through 6 include a brief tutorial on how to use the program.
* The remaining chapters are for reference: they describe in detail all aspects of the program and its use.
* The appendices contain information for quick reference, including the error messages and an order form for replacement diskettes.

0.2 Reference Material

While this manual contains a complete description of smARTWORK and how it is used, you may need to refer to the following manuals which describe the use of the IBM Personal Computer and its Operating System:

* IBM Personal Computer Guide to Operations manual

* IBM Personal Computer Disk Operating System manual

* IBM Personal Computer Technical Reference manual

You may also need the manuals which were supplied by the manufacturer of your printer, plotter, and mouse.

In addition to the above manuals, the following books are filled with useful information concerning the design, layout, and manufacturing of printed-circuit boards:

* Preben Lund, Generation of Precision Artwork for Printed Circuit Boards, 1978, John Wiley & Sons, New York, NY.

* Darryl Lindsey, The Design & Drafting of Printed Circuits, 1982, Bishop Graphics, Inc., Westlake Village, CA.

0.3 Hardware Summary

A complete description of the hardware required to use smARTWORK is included in the next chapter. What follows here is a short summary of machine requirements for quick reference:

* IBM Personal Computer or XT with 192K RAM, two disk drives, and DOS Version 2.0

* IBM Color/Graphics Adapter with RGB color or black-and-white monitor

* Epson MX-100 or FX-100 dot-matrix printer

* Houston Instrument Hiplot DMP-41 pen-and-ink plotter (optional)

* Microsoft Mouse (optional)

0.4 Program History

Wintek Corporation's primary products are microcomputer circuit boards designed for dedicated industrial applications. When a search of the available printed-circuit-board CAD programs did not produce a product which could handle complex layouts for a reasonable price, Wintek's engineers and computer scientists decided to write their own.

The original program was written in C to run under Bell Laboratories' UNIX operating system on a Digital Equipment PDP-11/44 minicomputer. Visitors and friends who saw the program being used for in-house projects often asked about buying the program. The result was smARTWORK, an improved version of the original in-house program, tailored to run on the inexpensive and widely available IBM Personal Computer.

Wintek offers the most complete line of 6800-family microprocessor, memory, and real-world interface modules. Resident and cross-software products include assemblers, linkers, high-level language compilers, interpreters, debuggers, math packages, and operating systems. For a catalog covering your complete source of microcomputer products write or call:

Wintek Corporation
1801 South Street
Lafayette, Indiana 47904-2993
Telephone: (317) 742-8428
Telex: 70-9079 (WINTEK CORP UD)

Chapter 1

Introduction

One common step in the design and manufacturing of modern electrical equipment is the layout of printed-circuit boards. This process is normally accomplished at a drafting board, using special tape on sheets of drafting film to indicate the location and shape of conductors at two or four times actual size. Once completed, this artwork is then reduced photographically, producing a negative which is used as the pattern for the final printed-circuit boards.

Generation of the tape artwork is a slow process requiring considerable skill and experience. Certain line widths and spacing must be observed to produce a layout which can be manufactured with a good yield.

The completed tape and drafting film artwork is relatively fragile. Only a limited number of changes or modifications may be made before the tape begins to lose its adhesion. Producing several versions of a circui oard may require that the artwork be generated from scratch several times.

With an inexpensive personal computer nd smARTWORK, both the expert and the ovice can produce professional-looking printed-circuit artwork in a fraction of the time it would take using older techniques. This computer-aided design system allows quick and accurate revision and regeneration of previous work.

1.1 Capabilities

"smARTWORK" is a software package for the IBM Personal Computer which is designed to aid in the design and production of artwork for printed-circuit boards. The creen of the computer becomes a window nat shows a portion of a large layout vorkspace. This window can be moved around he workspace to show any portion of the ayout. You can choose to view one side or oth sides of the board at one time.

Using the keyboard, you can place and emove conductor pads and traces. All conuctors are perfectly vertical, horizontal, r run at 45 degrees. The program ensures hat conductor spacing is adequate and that ine widths do not become too narrow for eproduction. All pad-to-pad spacing is ixed at multiples of 0.05 inches.

"smARTWORK" is designed specifically for rinted-circuit-board artwork. The program nderstands electrical connections. If you ant to connect two conductors with a conuctive trace, you simply identify the two

conductors using the cursor. The program will automatically find the shortest route between those conductors and connect them. It will not cross other conductors on the same side of the board, and will make numerous bends and turns if required.

If a shorter path exists starting at points other than the ones you specified, the program will find and use that path. Of course, sometimes you may want to specify the exact route to be used. "smARTWORK" allows you to do that too. Removing all or a portion of a trace is just as easy.

Two trace widths are allowed. You can change from thin to wide traces at any time. Trace widths are easily changed after the traces have been added to the layout.

If you decide you need more space between two components, the program allows you to "spread" the layout along any vertical or horizontal axis. Any connection which existed before spreading the layout is maintained by appropriate conductors.

Your layout can be saved as a standard DOS disk file. These files may be duplicated as needed, allowing you to keep old revisions, or to make different versions of a board starting from a single master.

Paper copies of your artwork are produced using a dot-matrix printer. Paper, vellum, or polyester film copies may be created using a pen-and-ink plotter. Camera-ready artwork is available from either output device at twice normal size

(2X artwork). A quick, normal-size check-plot can also be printed.

In addition to the arrow keys, the pro- ' am allows (but does not require) the use ᒪ a mouse to move the cursor. The two switches on the mouse can be used to specify the starting and ending points for a conductor, or may be used to erase an existing trace.

1.2 Artwork Specifications

"smARTWORK" can handle either single-sided or double-sided printed-circuit boards. The maximum size of a board is determined in part by the output device used to produce the camera-ready artwork, r t the program will handle boards up to . n by sixteen inches. There is no limitation on the complexity of the board within this 10" by 16" space.

To minimize defects, smARTWORK enforces certain minimum trace spacings and fixed trace widths. These conductor sizes and spacings have been chosen to guarantee that the circuit board can be manufactured with a high yield.

Thin Line Width	12 mils (0.012")
Wide Line Width	50 mils (0.050")
Pad Diameter	62 mils (0.062")
Minimum Spacing	19 mils (0.019")

L..rger conductors which are any multiple of 50 mils across can be constructed.

All pads begin as circles 62 mils in diameter. The edge of pad will be "shaved" when it approaches a neighboring conductor, thus maintaining 19-mil spacing. Larger pads can be constructed when needed (see the chapter on "Advanced Techniques"). All pad-to-pad spacing is fixed at multiples of 50 mils. There is room to place a single thin trace between two pads which are 0.1 inches apart.

Right-angle turns in traces are made using two 45-degree angles. Intersections are softened using curves or 45-degree wedges.

All of the distances above are nominal values, since the actual distances are determined in part by the medium being used (type of paper, vellum, or polyester film), the condition of the ribbon and hammer intensity (for the printer), and the type and condition of the pen tip and ink (for the plotter).

1.3 Required Hardware

The programs are supplied on a 5.25 inch minifloppy diskette formatted for use on an IBM Personal Computer running PC-DOS Version 2.0 (or later DOS versions). The computer should have two disk drives: one floppy drive for the program disk and either a floppy or hard disk drive to hold the workspace data files. "smARTWORK" requires a minimum of 192K bytes of central memory (RAM) for its operation.

Your computer must also have the IBM Color/Graphics Adapter board, with either an RGB color monitor or a (non-IBM) black-and-white monitor. The color monitor is required to simultaneously view both sides of a double-sided circuit board. If you have a black-and-white monitor, you may view one side of a double-sided board at a time. Depressing a single key allows you to switch from one side to the other. "smARTWORK" cannot use the IBM Monochrome Adapter board.

An Epson FX-100 or MX-100 (with Graftrax) or equivalent dot-matrix printer will be required to produce quick checkplots (actual size, low-quality) of your artwork. The dot-matrix printer can also be used to produce twice-normal-size plots which can be reduced photographically to produce prototype-quality printed-circuit boards. This camera-ready "plotting" uses the high-resolution graphics mode of the printer. Note that the size of a board plotted on the printer is limited in size by the width of the platen. The printer normally uses a parallel interface with the computer.

High-quality camera-ready artwork is produced by smARTWORK using a Houston Instrument DMP-41 pen-and-ink plotter. This plot is also twice normal size, ready for photoreduction for circuit-board manufacturing. The plot is produced on paper, vellum, or polyester film using a liquid-ink pen with a 0.6 mm tip. A serial interface is used to connect the computer to the DMP-41.

Most people will use the arrow keys on the keyboard to position the cursor on the display screen. "smARTWORK" is designed to allow the use of a Microsoft Mouse, which facilitates positioning of the cursor and directing the routing. While it is convenient, the mouse is optional and is not required.

While many manufacturers claim that their computer is "compatible" with the IBM Personal Computer, only those machines which closely emulate the operation of the IBM Color/Graphics Adapter will run smARTWORK. In order to gain acceptable speed when displaying the circuit-board artwork, the program accesses the display memory directly, bypassing the operating system. Numerous calls to the BIOS are also present and must be emulated by the operating-system software.

Human convenience was considered during the selection of the keys that direct the program's operation. The right hand moves the cursor with the arrow keys or mouse, while the left hand is positioned over the function keys to direct the placement of pads and runs. "Clones" which have not copied the keyboard layout and the available keys may make the program much more difficult to operate.

"smARTWORK" will not run on IBM's PCjr.

Chapter 2

Getting Started

This manual assumes that you are familiar with the connection and operation of your computer and its operating system. If not, now is a good time to read and understand the first three chapters of the IBM Guide to Operations manual. It explains the hardware components of your computer system, how and where cables are connected, and the location of switches and controls. A description of the required hardware and peripherals is located in the previous chapter under the heading "Required Hardware".

The keyboard has eighty-three keys. Make sure you are familiar with its layout and the use of the "Enter", "Backspace", "Shift", Alt, Ctrl, Caps Lock, Num Lock and function keys (F1...F10). Note that the "Enter", "Backspace", and "Shift" keys are designated by arrows on their keytops. There are also arrow keys which can be used to move the cursor up, down, left, and right.

Chapter 3 of the Guide to Operations manual also includes a good introduction to the disk operating system, DOS. Make sure you understand how to start DOS, set the date and time, and back up the DOS diskette. You should also know how to list, rename, copy, and erase files.

Now is also a good time to make sure your printer works. If you will be using a plotter or the mouse, make sure they have been connected properly. The manuals which came with these devices should explain how to connect them to your computer and how to check them for proper operation. Additional useful information may be found in the IBM Technical Reference manual.

? 1 Starting smARTWORK

In a plastic pocket in the back of this manual is the diskette containing the smARTWORK software files. It also contains a form which you should complete and return to Wintek to obtain a (free) backup diskette.

The diskette contains four files:

1. EDIT.EXE is the main program for WORK. It allows you to create, d and edit your printed-circuit ar the screen of your computer.

PLOT.EXE is the program whi use to produce hard copy th i-matrix printer plotter. It reads the your artwork from a f using the EDIT.EXE program.

3. SMART.STA is a data file used by both the EDIT.EXE and PLOT.EXE programs. SMART.STA must reside on a Wintek diskette in drive A when either EDIT.EXE or PLOT.EXE is started.

4. DEMO.PCB is a printed-circuit-board workspace file that is used in the tutorial in Chapter 4.

The smARTWORK diskette is write-protected to minimize the chances for accidental damage to its contents.

The EDIT and PLOT programs may be copied to another diskette or drive using the DOS COPY command. While these programs may be run from another drive (from the XT hard disk, for example), EDIT and PLOT will only work when either the diskette shipped with the manual or the backup diskette sent to you by Wintek is present in drive A. If one of your diskettes fails, you may use a copy of the form in the Appendices to order a replacement.

The procedure for starting the EDIT program of smARTWORK is listed in step-by-step detail below. In brief: turn on the computer, start DOS running, set the date and time, insert the smARTWORK diskette in drive A, and type the name of the smARTWORK program you wish to execute (i.e., EDIT).

These instructions are for the IBM Personal Computer. If you are using an IBM PC-XT or another machine, the steps for starting the operating system may be different. Check the Guide to Operations

manual for your machine for specifics.

1. Insert your DOS diskette into drive A and close the drive door.

2. Turn on the power to the system unit (the computer) and the monitor.

3. After the delay associated with the Power-On Self-Test, DOS will be loaded from the DOS diskette.

4. Set the system's date and time. If you have a clock-calendar board installed in your machine, this step may be accomplished using an AUTOEXEC.BAT file. You should now see the DOS prompt on the screen: A>. This prompt will appear in all of the examples given concerning DOS commands. In every case, DOS will provide the A>; you should type the letters following the >.

5. If you have the Microsoft Mouse, install the mouse driver by typing MOUSE (followed by the "Enter" key) following the DOS prompt:

   A>MOUSE

   Note that the mouse driver software (MOUSE.COM) must be present on your DOS diskette. This step can also be accomplished using an AUTOEXEC.BAT or CONFIG.SYS file. If you do not have the Microsoft Mouse, skip this step.

6. If your computer has both the IBM Mono-chrome Adapter and the IBM Color/Graphics Adapter, switch to the Color/Graphics board using the MODE command following the DOS prompt:

A>MODE BW80

This step can also be accomplished using an AUTOEXEC.BAT file. If you do not have both display adapters, or if the DOS prompts are displayed using the Color/Graphics board, skip this step.

7. Remove the DOS diskette from drive A. Insert the smARTWORK diskette into drive A and close the drive door.

8. Type the name of the smARTWORK program you wish to use following the DOS prompt:

A>EDIT

Note that you must use the smARTWORK diskette supplied with this manual or a backup diskette sent to you by Wintek. This diskette must contain the SMART.STA file and must be physically located in drive A.

9. Once the program has loaded from the diskette, a title page containing the name of the program, its version number, and your license number will be displayed on the screen. If you wish, you may remove the smARTWORK diskette at this time. When you QUIT the program, you should either insert the smARTWORK diskette again (to run the PLOT program) or another DOS diskette. If your

machine contains the minimum amou of RAM needed t... ute the smARTWORK Editor, you may be required to insert a DOS diskette containing the file COMMAND.COM when quitting.

The title page displayed when the program first st...s contains several pieces of useful in...mation. The name of the program, "Printed-Circuit-Board Artwork Editor" (for EDIT) or "Printed-Circuit-Board Artwork Plotter" (for PLOT), will appear in the center of the screen. In the lower-left corner of the screen will be the program version number. Your license number will be shown in the lower-right hand corner.

You will need the program version and license numbers whenever you contact Wintek ... replacement diskettes, program updates, or assistance. Write them down on the title page of the manual for easy reference.

This title page will be displayed on the screen until you type a single key. Any key will work, but most people use the space bar or the "Enter" key. If you are running the EDIT program, the screen will clear, showing you a blank page with the cursor (a small white box) in the lower-left corner. If you are running the PLOT program, a menu that gives you a choice of the kind of plot to be made will appear.

2.2 Backups

As any experienced computer user knows, you should maintain a backup copy of all program and data files just in case of accidents (power failure, fire, flood, spilled coffee, and so forth).

The printed-circuit workspace files you create using smARTWORK are standard DOS binary data files that can be copied using the DOS COPY and DISKCOPY commands. You cannot put your data files on the smARTWORK diskette, since it is write-protected. You should keep your data files on a separate diskette which can be easily copied to make backups.

Both the <u>Guide to Operations</u> and the <u>Disk Operating System</u> manuals describe how to use the COPY and DISKCOPY commands to make backup copies of your data files. If you are using a hard disk for your data files, you may wish to use the BACKUP command.

Because the smARTWORK software requires that a Wintek-supplied smARTWORK diskette reside in drive A, Wintek will provide you with one free backup copy. A form you may use to request your backup copy is contained in the plastic pocket which held the original diskette in the back of this manual. Don't procrastinate until you need the backup -- order it now! If you need a replacement because one of the original Wintek diskettes is no longer usable, an order blank is contained in the Appendices.

Chapter 3

Tutorial: Lesson 1

"smARTWORK" was designed to be easy to use. You should be able to learn the elementary instructions in a short time, since there are a limited number of commands that you must remember to edit your artwork.

The four lessons in the tutorial section of the manual are designed to give you a brief introduction to the smARTWORK programs. Once you are familiar with the topics covered here, you may proceed to the reference section of the manual for a detailed description of each command and function. Some hints and procedures for producing more complex layouts are included in the "Advanced Routing" and "Advanced Techniques" chapters.

Lesson 1 is a simple walk-through of the procedures used to start the Editor, enter commands, and quit when you are done.

3.1 Starting the Program

The chapter titled "Getting Started" contains a step-by-step description of the procedure required to bootstrap the computer and start the smARTWORK Editor. If you skipped over those instructions, go back and read the section "Starting smARTWORK".

Once you understand the startup instructions, you should proceed to load DOS into the computer and set the date and time. Now remove the DOS diskette and insert the smARTWORK diskette into drive A. Type the name of the smARTWORK Editor (EDIT) following the prompt from DOS (A>):

A>EDIT

The red light on the front of drive A will light as the computer loads the program from the disk. Once loaded, the Editor will display its title page. Note that the title page includes both the program version number and your license number.

When you have finished reading the title page, press the space bar to erase the title information.

The almost-blank screen you now see represents a 2" high by 4" wide portion (window) of the total 10"-high-by-16"-wide work area (workspace). These dimensions (2" by 4" window, 10" by 16" workspace) are the linear distances that will exist on the printed-circuit board that will be produced from your artwork.

Your window can be moved to show a different portion of the workspace, and you can look at either side of the board. Since there is nothing on either side of the board now, these commands will be saved for later.

Notice the small white box located in the lower-left corner of the screen. This box is the cursor, which you will move using the arrow keys on the right side of the keyboard. The cursor is used as a pointer when you are placing pads on the workspace and routing conductors from one place to another.

3.2 Handling Error Messages

Press the space bar. You will hear the computer's speaker emit a low-pitched tone, the screen will scroll up one line, and the following message will appear:

unknown command

"smARTWORK" is complaining because "space bar" is not a command it recognizes.

The program detects a number of potential errors, and will respond in a similar fashion whenever it has a problem. A list of the possible error messages, their meanings, and suggested responses are listed in an appendix.

Once you have read the message, you can clear the text message and restore the screen by pressing the "Enter" key. No other commands will be recognized until you press "Enter".

3.3 Entering Commands

Most instructions that you will give the program are made by a single keystroke, usually a function key (F1 through F10) or an arrow key. Other commands require more information, or are potentially catastrophic, such as: loading a file into the workspace, saving the workspace in a file, and quitting the program. These latter commands are entered using the command line.

Press the "Enter" key. Once again the workspace will scroll upwards on the screen and a prompt will appear:

COMMAND>

You may now type a command on the keyboard. If you make a mistake, you may erase the last letter by hitting the "Backspace" key. The entire entry may be discarded by pressing the "Esc" key. When you have finished typing the command, striking the "Enter" key will cause the program to interpret and execute your command. If you do not want to enter a command, clear the line (using "Esc"), then press "Enter".

When the program finishes executing the command, the bottom line will disappear and the workspace display will scroll back to its normal position.

Bring up the command prompt, if it is not showing now, by hitting the "Enter" key again. Type in the characters hi mom (don't hit the "Enter" key yet). The command line should look like this:

COMMAND> hi mom

Now press the "Backspace" key three times. The letters in mom will disappear one at a time. Now type dad. The command line should now look like this:

COMMAND> hi dad

Pressing the "Esc" key will clear the command line:

COMMAND>

If you type hi dad and then hit the "Enter" key, you will get the unknown command error message. Clear it from the screen by pressing "Enter" again. The next section contains an example of using a real command: quit.

3.4 Quitting

Almost as important as knowing how to start smARTWORK is knowing how to stop it. The "quit" command is used whenever you want to return to DOS or turn off the computer.

Bring up the command line, and type quit.

COMMAND> quit

Pressing the "Enter" key will cause the display line to change to the following message:

DISCARD CURRENT WORKSPACE (y/n) ?

Since quitting the program will cause whatever is in the workspace (in memory) to be lost, the program reminds you of the consequences of stopping. (The workspace can be saved in a disk file by using the "save" command.) If you have already saved your work, or if you don't want to save the current workspace, type y and then the "Enter" key. Typing anything else followed by "Enter" will cause the quit command to be ignored and will restore the workspace display.

Chapter 4

Tutorial: Lesson 2

The CRT screen of the computer shows a 2" high by 4" wide portion (window) of the total 10"-high-by-16"-wide work area (workspace). You can display either side of the board or both sides of the board at the same time. By moving the cursor, you can move the window left and right (panning) or up and down (scrolling) to see other parts of the workspace.

Lesson 2 is a brief introduction to the display functions and the cursor operation.

4.1 Loading a File

In order to experiment with the display, you will need to load the demonstration file that is included on the smARTWORK diskette into the workspace. First, start the smARTWORK Editor (if it is not already running), and advance past the title page by pressing the space bar. You should be looking at a blank screen with the cursor (small white box) in the lower-left-hand corner.

Press the "Enter" key to bring up the command-line prompt:

COMMAND>

The "load" command is used to read the layout contained in a disk file. Make sure the smARTWORK diskette is still in drive A, then type the following command: load a:demo.pcb. The command line should now look like this:

COMMAND> load a:demo.pcb

If you make a mistake, correct it using the "Backspace" and "Esc" keys.

Pressing the "Enter" key will cause the display line to change to the following message:

DISCARD CURRENT WORKSPACE (y/n) ?

Since loading a new layout description file will destroy anything you currently have in the workspace, the program checks with you before reading the layout from the disk. Type y and then the "Enter" key. (Typing anything else followed by "Enter" will cause the "load" command to be ignored.)

Four things will happen in quick succession:

1. The red light on the front of drive A will light as the computer loads the demonstration layout file from the disk.

2. The message:

   DISCARD CURRENT WORKSPACE (y/n) ? y

   will disappear from the screen.

3. A portion of a circuit-board layout will appear on the screen.

4. The computer will beep to tell you that it has finished loading the layout into the workspace.

One quick note before continuing: you can make additions, deletions, and any other changes to the layout in the workspace without affecting the file on the disk. <u>To save the workspace</u> (and change the file), <u>you must use the "save" command</u>.

4.2 Changing Layers

"smARTWORK" allows you to have two sides, or layers, on your circuit-board artwork. It doesn't matter which layer you use as the component side or the solder side; for simplicity, the two sides will be called the upper layer and the lower layer.

When smARTWORK loads a file from the disk, it always displays the lower layer on the screen. To look at the upper layer, press the "PgUp" key. The upper layer will quickly appear. To switch back to the lower layer, press the "PgDn" key. If you are already viewing the lower layer, pressing "PgDn" will have no effect. Similarly, "PgUp" will be ignored while viewing the upper layer.

If pressing "PgUp" or "PgDn" causes an "Unknown command" error, the "Num Lock" key has been pressed, causing the numeric keypad to be shifted. Acknowledge the error message by pressing "Enter", then press the "Num Lock" key to unshift the numeric keypad.

4.3 Displaying in Color

If you have an RGB color monitor attached to your computer, you can see both sides of the board at the same time. (If you are using a black-and-white monitor, you can try the following functions without hurting either the computer or the monitor, but the display will probably not make a lot of sense.)

Press "Alt-F1" by holding down the "Alt" key while you hit the "F1" function key. The screen will go blank, then the layout will appear again, but in green, red, and yellow.

The layer of the board that was displayed on the screen before you pressed Alt-F1 is shown in green. The other layer of the board is shown in red. Where the two layers coincide, the screen will be yellow.

The Alt-F1 key toggles the display between the black-and-white single-layer display and the color dual-layer display. If you have a color monitor, you will probably find yourself using both modes, depending on whether you are concentrating on one side of the board, or worrying about connections on both sides.

Switch the screen into the dual-layer color mode. The "PgUp" and "PgDn" keys still work when the display is in color: they simply change which layer is shown in red and which layer is shown in green.

Look for the cursor in the lower-left-hand corner of the screen (unless you have moved it already with the arrow keys). As you will find out in the next chapter, the cursor color is always the same as the color of the "active" layer. This means that the cursor color will remain the same when you use the "PgUp" and "PgDn" keys.

Several other function keys affect the color display. Depending on your vision, personal preferences, and RGB monitor, you may find you prefer a different format than the green-red-yellow combination.

Alt-F2 toggles the intensity of the background color of the screen. Up to now, the background has been black. The Alt-F4 function key is used to switch between a black background and a blue one.

Alt-F3 allows you to switch the foreground color set from green-red-yellow to cyan-magenta-white. Note again that you can always identify the active layer by looking at the color of the cursor. Incidentally, the selection of foreground-color groups (green-red-yellow and cyan-magenta-white) is fixed by the IBM Color/Graphics Adapter.

Alt changes the way the program displays areas of the board which have copper on both layers. The program allows you to display the board so that the active layer overlays the other, or "idle," layer of the board. Wherever a trace on the idle layer passes under a conductor on the active layer, it disappears.

Alt-F6 allows you to select the color to be used to display the active layer. You may pick red instead of green, or magenta instead of cyan.

Once you have had a chance to experiment with all six of the function keys Alt-F1 through Alt-F6, continue with the next section in this lesson.

4.4 Moving the Cursor

Whenever you are placing a pad on the layout, or specifying the endpoint of a trace you wish to route, you will use the cursor to point to the exact spot of interest. Up until now, the cursor (the small square box) has remained in the lower-left-hand corner of the screen.

On the right side of the keyboard are four arrow keys that can be used to move the cursor. These arrows share keytops which are also marked with the numbers 2, 4, 6, and 8. Don't confuse the "Shift", "Enter", or "Backspace" keys with these arrow keys.

Press the up-arrow key. The cursor will move up a very short distance to the next "cell" on the screen. This distance corresponds to 50 mils (0.050 inches) on your final artwork.

Press the right-arrow key twice. The cursor will move two cells to the right, or a distance of a tenth of an inch (0.050" + 0.050" = 0.100"). The cursor is always located exactly over a cell: it never straddles two or more cells.

This movement of 50 mils makes measuring distances between pads very easy. If you need a tenth of an inch between two leads of a component, just press the appropriate arrow key twice.

If you want to move farther than 50 mils, you can use the "Shift" key with the arrow keys to move 5 cells (0.25 inches) at a time up or down, or 10 cells (0.5 inches) at a time left or right. The auto-repeat function of the keyboard can also be used to move the cursor rapidly around the screen by keeping an arrow key depressed.

If the preceding explanation seems a little confusing because you observe that the distance the cursor moves is large when unshifted and small when the "Shift" key is used, your "Num Lock" key has been pressed. Press "Num Lock" to unshift the numeric keypad.

"PgUp" will be ignored while viewing the upper layer.

If pressing "PgUp" or "PgDn" causes an "Unknown command" error, the "Num Lock" key has been pressed, causing the numeric keypad to be shifted. Acknowledge the error message by pressing "Enter", then press the "Num Lock" key to unshift the numeric keypad.

4.3 Displaying in Color

If you have an RGB color monitor attached to your computer, you can see both sides of the board at the same time. (If you are using a black-and-white monitor, you can try the following functions without affecting either the computer or the monitor, but the display will probably not make a lot of sense.)

Press "Alt-F1" by holding down the "Alt" key while you hit the "F1" function key. The screen will go blank, then the layout will appear again, but in green, red, and yellow.

The layer of the board that was displayed on the screen before you pressed Alt-F1 is shown in green. The other layer of the board is shown in red. Where the two layers coincide, the screen will be yellow.

The Alt-F1 key toggles the display between the black-and-white single-layer display and the color dual-layer display. If you have a color monitor, you will probably find yourself using both modes, depending on whether you are concentrating on one side of the board, or worrying about connections on both sides.

Switch the screen into the dual-layer color mode. The "PgUp" and "PgDn" keys still work when the display is in color: they simply change which layer is shown in red and which layer is shown in green.

Look for the cursor in the lower-left-hand corner of the screen (unless you have moved it already with the arrow keys). As you will find out in the next chapter, the cursor color is always the same as the color of the "active" layer. This means that the cursor color will remain the same when you use the "PgUp" and "PgDn" keys.

Several other function keys affect the color display. Depending on your vision, personal preferences, and RGB monitor, you may find you prefer a different format than the green-red-yellow combination.

Alt-F2 toggles the intensity of the background color of the screen. Up to now, the background has been black. The Alt-F4 function key is used to switch between a black background and a blue one.

Alt-F3 allows you to switch the foreground color set from green-red-yellow to cyan-magenta-white. Note again that you can always identify the active layer by looking at the color of the cursor. Incidentally, the selection of foreground-color groups (green-red-yellow and cyan-magenta-white) is fixed by the IBM Color/Graphics Adapter.

5.1 Placing Pads

Move the cursor to the center of the ...een using the arrow keys. Now press the "F3" function key (not "Alt-F3", just "F3"). The cursor disappears and in its place appears an annulus that represents a circuit-board pad. This conductor pattern is used to represent a hole in the circuit board with copper surrounding it on both sides. Pressing one of the arrow keys will make the cursor reappear beside the pad. F3 is the PLACE PAD function key. +F3

The pad is placed on both layers of the board. You can only place a pad when there is space for it on both sides of the layout. If you try to place a pad where it ...ould connect with one or more conductors ... either side, the program will give you a... error message like occupied cell in cylinder or too close to adjacent conductor.

Move the cursor so that it is located over the pad, then press the F4 function key. The cursor will disappear again, showing the empty cell where the pad used to be. Removing a pad with the $\boxed{F4}$ function key deletes the pad from both layers of the board. F4 is the REMOVE PAD function key. -F4

When you place a pad on the layout using the F3 key or remove a pad using the F4 key, the cursor disappears. In general, ...e cursor will disappear temporarily when...er you place or remove a conductor, so that you can see your result. The cursor will reappear when you move it.

To place two pads one-tenth of an inch apart, press F3, strike an arrow key twice, then hit F3 again. With a little practice, you can create a simple rhythm to place a series of pads in a row on tenth-inch centers: F3, arrow, arrow, F3, arrow, arrow, F3, etc.

Practice placing and removing pads now. Lay out a couple of 14-pin IC patterns: two rows of seven pads on tenth-inch centers with the rows 0.3 inches apart. While there is a command to place dual-in-line (DIP) packages on the screen, with a little practice you will find you can do it quickly one pad at a time. (The "dip" command is described in the reference section of the manual.)

5.2 Adding Traces

In order to experiment with adding traces to a layout, place a number of pads on the screen. During the following discussion, the terms "trace," "run," and "route" all refer to a thin conductor connecting two pads or other areas of copper.

Move the cursor so that it covers one of the pads, then press the F1 function key. The cursor will change from a box to three horizontal lines. Now move the cursor to another pad. Press F1 again. After a short pause (depending on the distance between the pads), a trace will appear which joins the pads. F1 is the MARK ROUTE function key.

4.5 Scrolling

What you have been viewing on the screen the CRT is a small portion of the entire workspace maintained by the program. At any one time, the screen will contain a 2" by 4" area of your layout. The workspace, though, is 10" by 16" in size.

Use the up-arrow key to move the cursor to the upper edge of the screen. If you try to move the cursor beyond the upper edge, the whole screen will shift down, showing a new portion of the workspace. Similarly, if you try to move the cursor past the right edge of the screen, the display will shift left, showing a another portion of the larger work area.

If you move the cursor to the edge of the screen and the screen does not scroll, you have reached the edge of the world (or at least the edge of the workspace).

The "Home" key can be used to return the cursor and the display to the lower-left-hand corner of the workspace. Again, if you get an "unknown command" error message when you press "Home", the "Num Lock" key has shifted the numeric keypad.

Before leaving this chapter, become familiar with the operation of the cursor and scrolling the screen.

If you have a Microsoft Mouse connected to your computer, it can also be used to move the cursor (see the chapter "Using the Mouse").

Chapter 5

Tutorial: Lesson 3

Up to now, the tutorial has covered very basic material: starting the program, entering commands, changing the display, and moving the cursor. Here is where the fun begins: creating and changing circuit-board artwork.

Before proceeding, create a blank diskette using the DOS FORMAT command. You will use this disk to save a copy of your work at the end of this lesson. DO NOT USE "FORMAT" ON THE WINTEK smARTWORK DISKETTE: "FORMAT" DELETES ALL EXTANT INFORMATION FROM A DISKETTE.

Now start the smARTWORK Editor again. Scroll the screen, if necessary, to a blank portion of the workspace in order to experiment with the following topics.

The cursor shape is an indicator of whether or not "routing" is in progress. After you press F1 the first time, the cursor changes from its normal box shape to three horizontal lines. Once you have pressed F1 to specify the endpoint of the route and the trace has been drawn, the cursor once again becomes a box.

You can start or end a trace on any conductor, not just a pad. If you press F1 to start a route, but the cursor is not on a conductor, the program will complain: route has no anchor. Note that the program looks for the shortest route between the two electrical networks, not just a route between the particular points you identified with the cursor.

If there is not a straight-line path from the start to the end of the route, the program will try to find the shortest route which does not touch another conductor. If a route is not found, the program will report: can't find a route.

A route can be removed by positioning the cursor above any portion of the trace, then pressing F2. F2 is the REMOVE ROUTE function key. If you delete a pad (using F4) that has traces connected to it on either layer, both the pad and the traces will be removed.

The amount of time it takes to find a route depends on the length of the run and on the size of the two electrical networks connected to the starting and ending points. If you decide you don't want to wait, you can interrupt the route by pressing "Ctrl-Break" (hold down the "Ctrl" key

while you press the "Scroll Lock/Break" key). The message: routing interrupted will be displayed.

If you have a mouse connected to your computer (the input device, not the furry creature), the left button is the same as the MARK ROUTE (F1) key. The right button has the same effect as the REMOVE ROUTE (F2) key. For more information, see the "Using the Mouse" chapter in the reference section of the manual.

If you don't like the route a program has found, a method is discussed in the next section for specifying the exact path to be used.

5.3 Interactive Routing

There will be times when you want to make a route follow a particular path: you may be worried about crosstalk, or you may want to avoid an area because of other components to be added later. "smARTWORK" allows you to guide the routing instead of letting the program find the path.

Using the cursor, move the screen to a clear area of the workspace. Place a pad in the center of the screen and a second pad about ten cells to the right.

Move the cursor to the pad on the left, then press F1. Now move the cursor up five cells and press F1 again (even though the cursor is over a blank cell). After a slight pause, the program will draw a trace beginning at the pad and extending to the

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cursor.

Note that the cursor is still three horizontal lines. This indicates that routing is in progress. Move the cursor right by twenty cells and press F1. A trace will appear bridging the gap from where the cursor was to the new cursor location.

Press the "Backspace" key. The cursor will backtrack one cell, removing the trace in that cell. You may use the "Backspace" key whenever a route is in progress to slowly consume the trace you have been creating. Keep pressing "Backspace" until the cursor is directly above the pad on the right.

Now move the cursor to the pad on the right and press F1. "SMARTWORK" will complete the route to the pad, and the cursor will return to the normal box shape. (A route must always start on a conductor and end on a conductor.) If necessary, you may place a pad (using F3) while a route is in progress, and then route to it.

Now is a good time for you to practice adding traces, using both the pad-to-pad routing and the interactive routing.

5.4 Fat Traces and Fatcells

It is often necessary to create a conductor which is wider than 12 mils (for power supply and ground runs, for example). "SMARTWORK" allows you to change any thin trace to a wide trace. You may also place a 50-mil square of copper in any cell.

Move to a clean area of the workspace and place two pads on the screen about fifteen cells apart, with one cell slightly above the other. Route a trace between the two pads by placing the cursor over one pad, pressing F1, moving to the other pad, and pressing F1 again.

Now move the cursor so that it straddles the thin trace anywhere along its length. Press the F5 function key. The thin (12-mil) trace will be replaced by a wider run. This fat trace will be 50 mils wide on the final board. Any sharp corners shown on the screen will be softened when the artwork is plotted. F5 is the WIDEN function key.

If you place the cursor over a fat run and press F6, a thin trace will replace the fat one. F6 is the SHRINK function key.

If you try to widen a trace which passes close to other conductors, the trace will only be widened where there is room to do so without causing any new connections.

Move the cursor to a blank cell and press F7. A square conductor which is 50 mils on a side will appear in place of the cursor. You may place a "fatcell" in an isolated location, next to other fatcells

Chapter 6

Tutorial: Lesson 4

Once you have created your layout using the smARTWORK Editor, you will need to make a physical copy of it so that it can be photographed and manufactured. The Plotter program (the file PLOT.EXE on the smARTWORK diskette) takes a file created by the Editor as its input, then produces a copy on paper using either a dot-matrix printer or pen-and-ink plotter.

This lesson covers the creation of 1X (normal-size) checkplots and 2X (twice-normal-size) artwork using the Epson printer. Using the Houston Instrument plotter to make 2X artwork is similar to this process; the details have been left to the chapter "Pen-and-Ink Artwork" in the reference section of this manual.

6.1 Making a Checkplot

Whenever you are designing a large or complex circuit board, you will probably discover the need for a paper copy of the layout. You may wish to see the entire board at one time, or may wish to check the connections and spacing of the layout as it currently exists.

The Plotter program can produce a quick, normal-size plot of the layout on an Epson dot-matrix printer (either the FX-100 or the MX-100 model). It is designed to be produced quickly (relative to the 2X camera-ready artwork).

The checkplot option is a low-quality 1X copy of the artwork. Pads appear as squares; diagonals will be somewhat ragged. Fatcells and wide runs still have squared edges. The title lines include the current date and time, the name of the file being plotted, a hole count (number of pads on the board) and approximate board dimensions.

Starting the smARTWORK Plotter is very similar to starting the Editor. Place the smARTWORK diskette into drive A, then type the name of the Plotter program following the prompt from DOS:

```
A>PLOT
```

The red light on the front of drive A will light as the computer loads the program from the disk. Once loaded, the Plotter will display its title page. Note that the Plotter title page also includes both the program version number and your license to for a fat run, or around pads to increase their size. An isolated fatcell may be removed by positioning the cursor over it and pressing F6. F7 is the PLACE FATCELL function key.

5.5 Saving a File

Once you have created your layout on the screen of the computer, you will want to save it on the disk. This will allow you to use the "load" command to edit it again, and it will allow you to print or plot it using the smARTWORK Plotter program.

Press the "Enter" key to bring up the command line prompt:

COMMAND>

The "save" command is used to write the layout contained in memory to a disk file. Place the blank, formatted diskette you created at the beginning of this lesson in drive B, then type the following command: save b:lesson3.pcb. The command line should now look like this:

COMMAND> save b:lesson3.pcb

The filename extension (.pcb) is optional, but makes it easy to identify the type of file. If you make a mistake, correct it using the "Backspace" and Esc keys. You cannot save workspace files on the smARTWORK program diskette; it is write-protected.

Pressing the "Enter" key will cause the red light on the front of drive B to light momentarily. Then the light will go out while the program prepares the data in memory for saving. The light on drive B will light again while the workspace is written to the disk. Finally, the program will beep to tell you it is done, and the command line will disappear from the screen. The whole process may take thirty seconds or more, so don't worry if it seems like a long time.

"smARTWORK" has written a copy of the workspace to the disk for later use by either the smARTWORK Editor or Plotter programs. The file name is b:lesson3.pcb. Any drive and legal DOS file name may be used. Files created using the "save" command may be copied using the DOS COPY and DISKCOPY commands. Always back up your workspace files on a regular schedule.

You may continue to edit your layout at this point without using the "load" command to restore your work, since the artwork is still in memory.

It is a good idea to save your work periodically as you are creating or editing it. If you write it to the disk every half hour, a power failure or memory parity error can't destroy eight hours of work.

Always keep a spare, empty, formatted diskette handy, just in case the disk you are using fills up or goes bad while you are in the smARTWORK Editor. That way you'll get a second chance to save your work if you get a disk error while using the "save" command.

numb

When you have finished reading the title page, press the space bar to erase the title information and display a menu of available output formats.

In the upper-right-hand corner of the screen, the program will print the current system date. This date and the current time will be printed on any output produced by the Epson. If the date is not correct, you can exit the plotter program and use the DOS DATE and TIME commands to correct the system date and time.

Several numbered choices will be displayed on the screen. Find the choice labeled 1X dot-matrix checkplot, type its number, and press "Enter".

The screen will clear again, and the following prompt will appear:

Input file containing the board layout:

Type the name of the demonstration layout file which is included on the smARTWORK diskette: a:demo.pcb. Use the "Backspace" or Esc keys to correct any typing mistakes.

The end of the prompt line should now look like this:

... the board layout: a:demo.pcb

Press the "Enter" key. The red light on the A drive will light as the program reads the layout description file.

The program may reject the input filename by sending a low tone over the speaker and erasing the input filename. This means either that it couldn't find the file or that it couldn't understand the file's contents. Make sure that the smARTWORK diskette is in drive A, the name of the file is spelled correctly, and that the named file actually contains a smARTWORK layout.

Next, the prompt for the output port will be displayed:

Output device or file name: lpt1:

The output of the Plotter program is normally written directly to the printer. Since the printer is usually connected to the first parallel port, the program provides a default device name: lpt1:. If this name is correct, simply press the "Enter" key.

If the printer is connected to another port, or if you wish to write the output to a file instead of directly to the printer, use the Esc or "Backspace" key to remove the default device name. Then enter the correct device name (for example, com1:, com2:, aux:, prn:, or lpt2:) or DOS filename and press "Enter".

If the program emits the low tone, erases your response, and prints the default device name again, the device name or filename was in the wrong format, or DOS returned an error when the program tried to use it. Either correct your response or fix the printer, then try it again.

Onc ou have entered the input filename and the output device, smARTWORK will ask you whether you want to print both sides of the board, the lower layer only, or the upper layer only. (The lower layer of the board is the layer the Editor displays when you press the "PgDn" key.) Press the "B" key (B for Both), then strike "Enter".

The program will print the message Working..., then pause for nearly a minute while it prepares the layout for printing. A portion of a checkplot is shown on the next page.

Each layer of the board will be printed on a separate sheet of paper. Several lines of text above each plot give the date, time, and filename. (The usefulness of this information will become apparent when you have collected eight or ten checkplots of a board undergoing revision.) The program also prints the approximate size of the board in inches, and a count of the number of pads on the layout.

Despite the coarse nature of the output, the checkplot is printed at normal size. This means you can check the spacing between components and around connectors, either by using a ruler or by actually placing the components of interest directly on the plot.

Once you have developed your layout and checked it with a checkplot, you're ready to produce the final 2X artwork.

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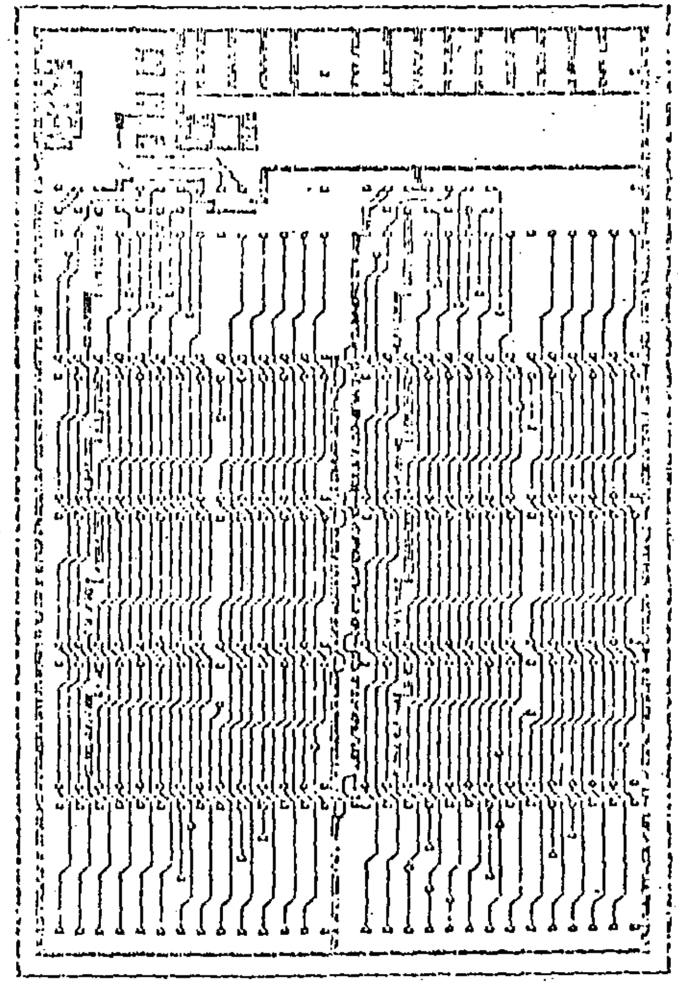
```
checkplot  v1.0 r0                27 Jun 1984
file:   a:demo.pcb
approx. size:  3.00 by  4.50 in.
```



6.2 Camera-Ready Artwork

The camera-ready artwork produced by the rogram will be created at twice normal size. Hence, a circuit-board layout 10" by 16" in size will produce a 20" by 32" plot. This 2X artwork is then photographed and reduced 50% to create a negative used in the production of the final printed-circuit board.

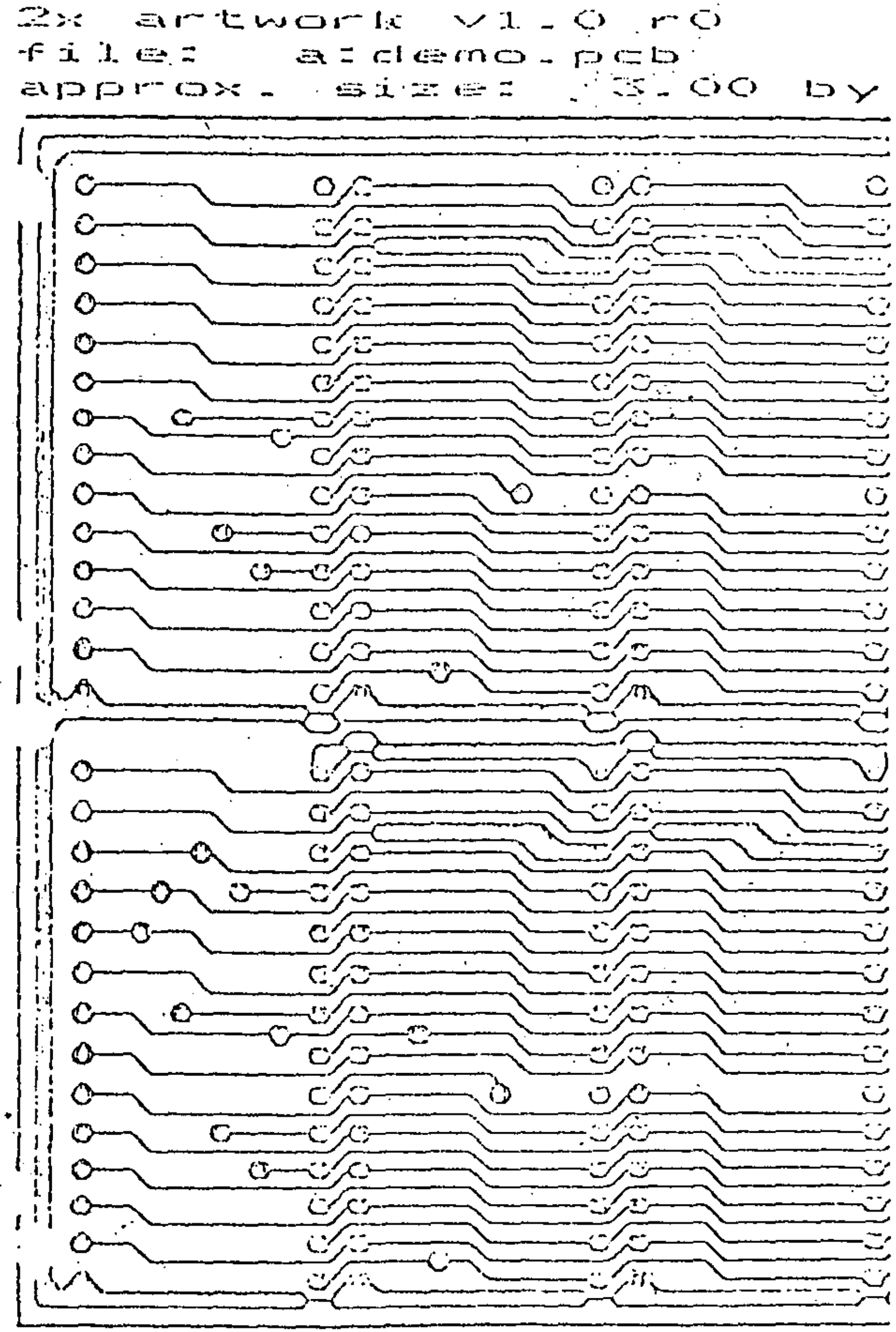
Twice-normal-size artwork is available from either the Epson printer or Houston Instrument plotter. The remainder of this lesson will take you through the steps required to produce 2X artwork on the dot-matrix printer. Pen-and-ink artwork generation using the Houston Instrument plotter is covered in the chapter "Pen-and-Ink Artwork".

Start the Plotter program again, and advance to the output format and output device menu. This time enter the number of the choice which combines 2X dot-matrix artwork with the type of dot-matrix printer you are using.

The input file, output device name, and board layer prompting will be the same as that for the 1X checkplot. Use the demonstration file a:demo.pcb as the input file again, and plot both layers.

After the one-minute pause required to prepare the layout for printing, the program will print the artwork a side at a time. Each layer will have several lines of text printed above it that give the date, time, filename, approximate dimensions, and number of holes. These title lines are printed in large letters, so that they can be easily read from the 50% film copies. A portion of a 2X printer output is shown on the next page.

The printing of the board artwork is much slower than the printing of the checkplot. In addition to printing lines which



are twi as long, the print head makes at least three passes over each line to get the best plot resolution.

Other changes from the CRT display and checkplot will be obvious too. The wide traces and fatcells have been smoothed to create diagonal runs and to soften 90-degree inside and outside corners. The diagonal thin traces are much smoother also. Pads have been shaved when a conductor passes nearby.

<u>NOTE THAT THE 2X ARTWORK IS ROTATED 90 DEGREES from the way it is shown on the CRT or is printed on a checkplot.</u> This allows the long dimension of the workspace (16-inch dimension) to be printed down the page. If your layout will exceed 6.5 inches in one dimension, make sure you orient your layout so that the long dimension is horizontal on the screen so that it will be printed down the page on the printer.

This 2X dot-matrix artwork is not as smooth and uniform as the output produced on the pen-and-ink plotter. It will normally be more than sufficient for prototyping. Many of the defects you can see by looking closely at the output will disappear when it is reduced by 50% to normal size.

There are a number of things you can do to enhance the quality of the 2X camera-ready artwork produced by a dot-matrix printer. These techniques and suggestions are contained in the chapter "Dot-Matrix Artwork", which is contained in the reference section of the manual.

This chapter concludes the tutorial section of this manual. Now that you have been introduced to the basic operation of the smARTWORK Editor and Plotter programs, you should read the reference chapters which follow. Several of the more complex operations were omitted from the tutorial to keep it simple. A complete description of all aspects of the smARTWORK programs is contained in the reference chapters.

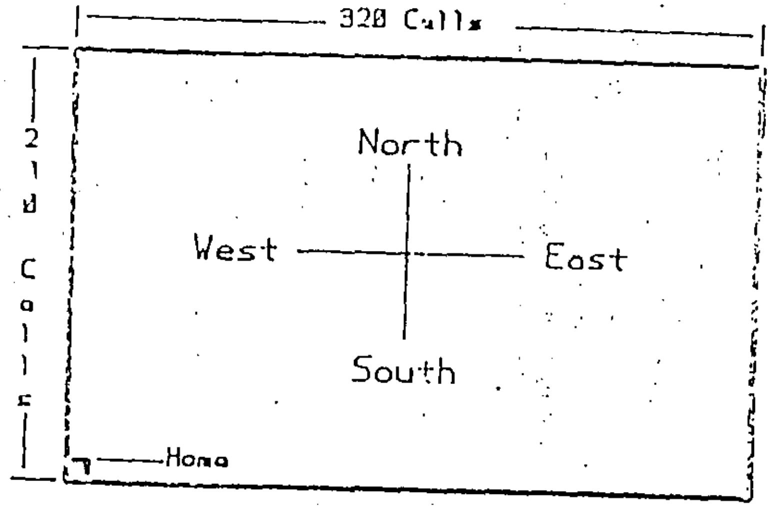
Chapter 7

Fundamentals of Operation

This chapter explains many of the details of the smARTWORK environment: the workspace, the graphic elements used to create the artwork, the display of the art-work on the screen, the forms of input to the program, and the audible and visible feedback from the program.

7.1 The Workspace

All artwork editing is done within a pair of rectangular grids called the <u>workspace</u>. Each grid is divided into 64000 squares, or <u>cells</u>. Each of the two grids corresponds to one layer of the printed-circuit board; each square of a grid represents a 50-mil (0.050 inch) square section of the final printed-circuit board at 1x magnification. The figure below shows the dimensions of a grid, as well as the way that the four points of the compass are used to refer to motion across a grid.

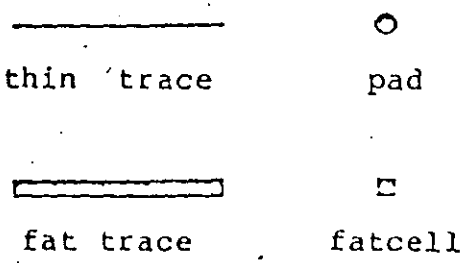


The lower-left (southwest) corner of each grid is called the <u>home</u> position. The grids can also be described as X-Y (Cartesian) coordinate grids. In this case, the home position is the origin of the current X-Y plane, and the +X and +Y axes extend eastward and northward, respectively, from the origin.

The dimensions of the workspace are sufficient for designing a printed-circuit board of two 10-by-16-inch layers. For convenience, the layers are referred to as the <u>upper</u> and <u>lower</u> layers. The words "upper" and "lower" imply nothing about the topology of the final artwork, since the layers are plotted independently.

7.2 Artwork Elements

The four elements from which the program builds the artwork for a printed-circuit board are shown in the figure below:



Each element represents a conductive area on the printed-circuit board.

The thin trace represents a circuit-board signal conductor, while the fat trace represents a power-supply or ground conductor. Either type of trace can appear in a rectilinear (north-south or east-west) or a diagonal (northeast-southwest or northwest-southeast) orientation. A complex trace can be built from any series of these simple traces.

The basic element of the fat trace is the fatcell, which represents a one-cell-square area of a conductor. Fatcells can be placed anywhere on the grid to represent arbitrary patterns of conductive material.

The pad represents a conductor-plated pad, via, or feedthrough hole in the printed-circuit board. It is the only element that is three-dimensional: that is, a pad represents a cylinder that passes through both board layers, while the other

elements represent conductor patterns that appear on just one board surface.

..3 1- and 2-Layer Displays

Each editing display shows the layout of a forty-by-eighty-cell section of one of the workspace layers. This display is known as the window into the workspace. Only one layer at a time is available for editing: it is called the active layer, while the other layer is called the idle layer.

No grid lines or markings appear on the editing displays.

The single-layer editing display is eated using the high-resolution black-and-white graphics mode of the IBM Color/Graphics Adapter. As the name implies, this display is a window into one layer of the workspace.

The dual-layer editing display uses the medium-resolution color graphics mode of the IBM Color/Graphics Adapter. Various color schemes are used to create a window into both layers of the workspace simultaneously. The display-option functions described in the "Display Functions" chapter are used to switch between single- and dual-layer displays, and to set up various color combinations for the dual-yer display.

The dual-layer display is designed for use with an RGB color monitor. If you wish to use a black-and-white monitor, you will fi the single-layer display to be more informative than the dual-layer display. No design functions are lost when using a black-and-white monitor with the single-layer display.

7.4 Display Distortion

The Houston Instrument DMP-41 plotter that generates camera-ready artwork is capable of x-y resolution approximating 0.005 inch. Although every attempt has been made to make the editing displays appear as realistic as possible, the IBM Color/Graphics Adapter and most RGB color monitors are not designed for resolution as fine as that of the plotter. There are some respects in which this difference in resolution is apparent:

(1) When plotted at a magnification of 2X, the dimensions of a cell are 0.100" by 0.100", for height-to-width ratio of 1 to 1. The ratio of vertical to horizontal dimensions of a cell on the editing displays, though, is approximately 1.625 to 1. This difference is usually only apparent in large areas of fatcells.

(2) The x and y increments in diagonal fat traces are visible on the editing displays as a "stairstep" pattern. When these traces are plotted on the DMP-41, however, they appear as perfect diagonals.

(3) Fatcells can only be connected to pads or other fatcells on the north, south,

east, and west faces. Although a fatcell may appear on the display to almost touch a pad or another fatcell that borders it on a northeast, northwest, southeast, or southwest corner, the final artwork plot will place a definite gap between such conductors.

(4) There are slight discontinuities in the edges of pads and diagonal thin traces on the editing displays. These do not appear in the plotted artwork.

7.5 Program Input

Three kinds of input are used in the editing program:

1. function-key input
2. command-line input
3. mouse input (optional)

Function-key and command-line inputs are entered from the keyboard.

If you have the Microsoft Mouse attached to your system, you can use its motion to control the cursor and its buttons to enter the two most frequently used function keys. The mouse is covered in detail in the chapter titled "Using the Mouse".

Function keys are used to manipulate the symbols of the editing display and the data they represent. A function keystroke causes an editing function, such as a cursor movement or the insertion or deletion of an artwork element, to be executed immediately. The changes in the editing display that reflect the execution of a function depend on the nature of the function. Function-key inputs cannot be typed ahead.

The combination of single keystrokes and immediate execution lets you edit a layout quickly and efficiently.

7.6 Audible and Visual Cues

The program uses two audio tones to signal various conditions. The low tone (110 Hz: second A below middle C) indicates that an error has occurred, while the high tone (440 Hz: A above middle C) signals the successful completion of certain functions and commands.

During a normal editing session, the screen is completely filled by an editing display, and the program responds to any function-key input. If an error occurs, though, the following events occur:

(1) normal program execution is suspended

(2) the editing display scrolls up to leave a blank space

(3) an error message appears in the blank space

(4) a low tone signals an error

At this point, you should acknowledge the error message by pressing the "Enter" key. Any other input will be ignored. After the

acknowledgement, the error message disappears, the editing display scrolls back into position, and normal execution contin-s.

Some commands (like the ones that read and write disk files) take some time to execute. When such a command has been completed without error, a high tone signals that the program is once again awaiting input.

A complete list of text messages appears in Appendix A.

Chapter 8

Command-Line Input

Command-line input is similar to DOS input: a command prompt is issued, characters are echoed on the display screen, backspacing and line cancellation are allowed, and the "Enter" key must be depressed before the command is processed. This kind of input is used to issue commands that are used infrequently or are too complex to be expressed in a single keystroke, such as loading the workspace from a disk file.

Whenever the program is awaiting a function-key input, you can switch to command-line input by pressing the "Enter" key. The program will respond by:

(1) suspending normal execution

(2) scrolling up the editing display to leave blank space at the bottom

(3) placing the COMMAND> prompt in the lower-left-hand corner of the display

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As you type a command, the characters will be echoed on the command line. ''nprintable characters are discarded to the und of a low tone. All upper-case char- ters are converted to lower case. If you reach the right margin, excess characters will be discarded with a low tone. You can backspace with the "Backspace" key, or cancel the entire line with the "Esc" key.

The command will not be processed until you press the "Enter" key again. If the command executes successfully, the command line disappears and the normal editing display is restored. Any error will invoke an error message.

If you change your mind about entering a ommand after the prompt appears, just ave the command line blank and press nter". The normal editing display will be restored immediately.

8.1 Confirming a Command

Some commands will completely destroy the current workspace. To keep you from inadvertently destroying important work, such commands, after you enter them on the command line, will ask the following question via the command line:

DISCARD CURRENT WORKSPACE (y/n) ?

proceed with the command, type y and press the "Enter" key. The command will execute, ending with either a high tone to signal success or an error message. To abort the command, type anything but y and pre the "Enter" key. The normal editing disp_ay will be restored immediately.

8.2 Command-Line Errors

Any group of characters in a command that is set off by spaces from other groups of characters is a parameter. Each command requires a different number of parameters. If you enter more parameters than are necessary for a command, the command is rejected with the message: too many parameters. Any entered command that the program does not recognize is rejected with the message: unknown command.

8.3 The CLEAR Command

To discard all artwork in the workspace and start again from scratch, use the following command:

```
COMMAND> clear
```

The following sequence will ensue:

(1) the program asks you to confirm the command

(2) all artwork in the workspace is discarded

(3) the cursor is moved to the southwest corner of the lower layer of the workspace

(4) a high tone signals completion

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.4 The QUIT Command

To clear the screen and return immedi-ely to DOS, use the following command:

```
COMMAND> quit
```

This command also asks for confirmation.

8.5 The SAVE Command

To write a disk file that contains the current workspace, use the following command:

```
COMMAND> save filename
```

ere "filename" is any file name that is ..gal under DOS. The entire workspace will be ritten to the specified file in a form that can be read back into the workspace with the LOAD command. This command may take a while to execute; a high tone signals completion.

Possible errors during the SAVE command are:

active route exists
can't write output file
missing filename
too many parameters

8.6 The LOAD Command

To read a previously saved workspace from a disk file, use the following command:

COMMAND> load filename

where "filename" is any file name that is legal under DOS. You will be asked to confirm the LOAD command. If the specified file was written by the smARTWORK SAVE command, the workspace will be loaded from the specified file. The lower layer of the workspace will become the active layer; the cursor will appear in the southwest corner of the layer. A high tone signals completion of the LOAD.

Possible errors during the LOAD command are:

active route exists
can't read input file
missing filename
too many parameters

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Chapter 9

Display Functions

"smARTWORK" can display a layout one layer at a time in black and white, or both layers at the same time in color.

9.1 Change Layer: PgUp/PgDn

When the Editor is displaying the layout in black and white, only one layer of the board can be seen at a time. The "PgUp" key positions the editing window over the upper grid or upper layer of the workspace, while the "PgDn" key makes the lower grid the active layer. The x-y position of the cursor does not change when changing layers. If the requested layer is already the active layer, the layer-changing function is ignored.

Both workspace layers can be displayed simultaneously in the editing window. With the help of an RGB color monitor, the conductors on each layer appear in a different color. The six <u>foreground</u> <u>colors</u> (red, green, yellow, magenta, cyan, white) represent conducting areas, while the two background colors (blue, black) represent insulating areas. Although both layers appear in the window, only the active layer is available for editing. As a visual reminder, the cursor color is always the same as the active layer color. The active layer can be changed at will using the "PgUp" and "PgDn" keys.

Since the design of a color display that is both informative and pleasing to the eye is very much a matter of individual taste, the program allows you to select several of the fundamental display elements.

The alternate function keys Alt-F1 through Alt-F6 are used to set up the dual-layer editing displays. The Alt-F1 through Alt-F4 keys control various attributes of the display hardware itself, while Alt-F5 and Alt-F6 are used to define the relationship between data in the workspace and the colors of the display. The Alt-F1 key is useful when either type of editing display is on the screen; the other keys are useful for dual-layer editing only.

If you have a color display, experiment with these six functions to find the display that you like best. If you remember that the cursor color is always the same as the active layer color, you shouldn't become confused. For more information about the displays created by the IBM Color/Graphics Adapter, see the IBM Technical Reference manual.

9.2 Color, B/W Modes: Alt-F1

The Alt-F1 key switches between:

(1) the single-layer, high-resolution, black-and-white display

(2) the dual-layer, medium-resolution, color display

9.3 Select Intensity: Alt-F2

The Alt-F2 key toggles the intensity of the background color.

9.4 Select Color Set: Alt-F3

The Alt-F3 key switches between the two sets of colors offered by the IBM Color/Graphics Adapter. The color sets are:

Set I	Set II
red	magenta
green	cyan
yellow	white

9.5 B ground Color: Alt-F4

The Alt-F4 key switches between the two ckground colors that seem most suitable r use with both foreground sets: blue and black.

9.6 2- or 3-Color Set: Alt-F5

The Alt-F5 key switches between the two-color and three-color scheme of displaying the active layer superimposed on the idle layer. In the two-color scheme, each layer is displayed in a different color. At any point where the two layers coincide, the active layer hides the idle layer. The three-color scheme uses the ird color to display the coincident nts.

9.7 Set Active Color: Alt-F6

The Alt-F6 key swaps the active-layer color with the idle-layer color.

By using the Alt-F3 and Alt-F6 keys, any one of four color groups can be used to construct a three-color display:

	Group 1	Group 2
active layer	red	green
le layer	green	red
coincident points ...	yellow	yellow

	Group 3	Group 4
active layer	magenta	cyan
idle layer	cyan	magenta
coincident points ...	white	white

Two-color displays are constructed using the same groups, except that the "coincident points" color is omitted from each group.

9.8 Set Window Size: Alt-F7

Normally, the screen shows a two-inch by four-inch window of the workspace. The Alt-F7 key switches between this normal display and the full display, which shows the entire ten-inch by sixteen-inch workspace on one screen. Because of the limitations of the display hardware, only the active layer is shown, and the display is in black and white. It may take the program up to twenty seconds to paint the full display on the screen, so be patient.

Chapter 10

The Cursor

The cursor is used to point to places and objects in the workspace on the current, or active, layer. It can be moved using the arrow keys or the mouse.

10.1 Shape and Color

The cursor appears on each editing display as a one-by-one-cell figure. Its position is called the focus, and the cell at that position is called the focal cell. The cursor always occupies one cell of the layout grid: it is never partly in one cell and partly in another. The cursor hides the contents of the focal cell, but the cell contents are changed only upon explicit request. The contents of the focal cell will be displayed again when the cursor is moved.

The shape and color of the cursor give important information about what the program is doing. The normal cursor shape is

a square, or box, that outlines the focal cell. When an "active route" exists, though, the cursor shape changes to three lateral bars. Active routes are explained in the chapter describing "Interactive Routing."

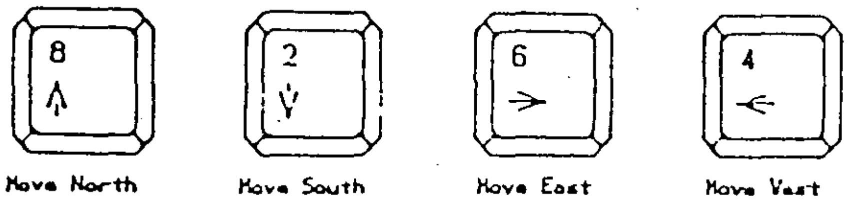
When using the dual-layer display, always remember that the color of the cursor is the same as the color of the active layer symbols.

The cursor can be moved using the cursor-movement functions described in the next section. Whenever the cursor reaches any of the four window edges, the display scrolls to show a slightly different window into the workspace. A cursor movement from the bottom to the top of the screen presents a south-to-north (+Y) movement in the workspace; a left-to-right screen move represents a west-to-east (+X) workspace move.

10.2 Moving the Cursor

All of the cursor-movement function keys are in the numeric keypad, which is at the right-hand side of the IBM-PC keyboard.

The four arrow keys move the cursor back and forth across the plane of the active layer, in the directions indicated below:



Depressing a movement key will move the cursor one cell in the indicated direction. Using a "Shift" key with a movement key will produce larger movements: five cells for north-south movements, ten cells for east-west movements.

If the distance the cursor moves is large when unshifted, and small with the "Shift" key, your "Num Lock" key has been pressed. Press "Num Lock" to unshift the numeric keypad.

If the requested movement carries the cursor across one of the window edges, the window is automatically scrolled to follow the cursor. If the cursor has reached a boundary of the workspace, attempts to move the cursor beyond the boundary will be ignored. If the north or east workspace boundaries appear in the editing window, they are represented as half-intensity solid bars that extend from the workspace boundary to the edge of the window.

The "Home" key moves the cursor to the home position of the active layer.

Chapter 11

Placing and Removing Pads

The pad represents a conductor-plated empty cylinder that passes through both layers of the board: it is the only three-dimensional element used in the program. It appears on the editing display an annular (or doughnut) shape. The pad is defined to be one cell in diameter.

When a pad symbol is placed at some x-y position on the active layer, it is automatically duplicated on the idle layer at the same x-y position. A pad may be placed at a given x-y position only if its placement will not change any connections between conductors on either layer. Once a pad has been placed, it can serve as a terminal point for traces on either layer.

When a pad is removed, it is removed from both layers simultaneously. In addition, any traces that are connected to such a pad are also removed.

The PLACE PAD function described in this chapter places a single pad into the layout. The SIP and DIP commands, which are described in the chapter entitled "Advanced Commands", are used to place all the pads for a single- or dual-inline package at once.

11.1 PLACE PAD (F3)

The PLACE PAD function key places a pad at the focus. An attempt to place a pad at an x-y position that already contains a conductor on either layer will be rejected with the message: occupied cell in cylinder. If you attempt to place a pad at a position that would cause the new pad to be connected to an existing adjacent conductor on either layer, the keystroke will be rejected with the message: too close to adjacent conductor.

11.2 REMOVE PAD (F4)

If there is a pad at the focus, the REMOVE PAD function key will remove it, along with any traces connected to it. Removal of connected traces follows the rules set forth in the chapter on "Interactive Routing". If there is no pad at the focus, REMOVE PAD is ignored.

Chapter 12

Interactive Routing

A route is simply a thin trace with two endpoints. It may be short or long, and may contain any number of turns, bends, and inflections. By definition, a junction of thin traces is an endpoint for all routes that arrive at the junction. In addition, a junction between a route and a fatcell or a route and a pad defines an endpoint of the route.

A route that terminates at another conductor (thin trace, fatcell, or pad) is said to be anchored at that endpoint, while a route that has an endpoint "in the middle of nowhere" is said to have a dangling end. A route can thus be anchored at both ends, anchored at one end (thus dangling at one end), or dangling at both ends.

Routes are built, or run, one at a time, although the construction of a route may, at your discretion, be done as a series of routes between intermediate points. The route currently being run, if any, is called the active route.

While the word "endpoint" is applied to a terminus of an active route, each completed trace (whether thin or wide) also has two termini, called stops. A stop is defined as any of the following:

* a point where two or more traces meet
* a point where a trace meets a pad
* a point where a thin trace meets a fat trace or a fatcell

Stops are used to limit the scope of functions that operate on traces.

12.1 MARK ROUTE (F1)

Most routing is done with the following four-step point-to-point method:

(1) place the cursor over one endpoint of the desired route

(2) press the MARK ROUTE key to mark this "source" endpoint

(3) move the cursor to the other endpoint of the desired route

(4) press MARK ROUTE again to mark this "target" endpoint

The program will attempt to find a short route between the two points that fits the design rules and avoids crossing existing traces. The source endpoint must be anchored, but the target endpoint may dangle.

Whenever the cursor has a square shape, there is no active route; the cursor may be moved to the source endpoint to prepare for marking. Whenever there is an active route, the cursor appears as three lateral bars; the program expects the next endpoint mark to be at the target endpoint. As soon as the target is marked, the program begins to seek the best route between the points. The amount of time that it takes to find a route depends on the distance between the points and the density of conductors already on the layout.

The MARK ROUTE function is used to mark both the source and target endpoints of a route. Pressing the F1 key marks the focus as an endpoint. If the cursor is positioned over two parallel traces at once, the message cursor is straddling traces indicates that the mark is ambiguous. If you attempt to mark a source endpoint that is not on a conductor, the keystroke is rejected with the message: route has no anchor. If the program finds that all paths from source to target are blocked by obstacles, the can't find a route message is issued.

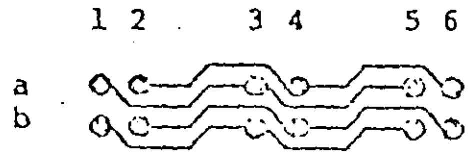
If the route is run successfully to an anchored endpoint, the active route is ended and the cursor resumes it square shape. If the route is run successfully to a dangling endpoint, the route remains active: the former target endpoint automatically becomes the new source endpoint, thus allowing a route to be run from point to point indefinitely. The program will respond to no keystroke besides "interrupt route" while it is searching for a route.

12.2 Interrupt Route

After target point is marked and the program begins searching for a route, it is possible to interrupt the search process by pressing "Ctrl-Break" (hold down the "Ctrl" key while you press the "Scroll Lock/Break" key). The program will respond immediately with the message: routing interrupted. In addition, the cursor remains at the target point, the route remains active, and the program will once again accept any function keystroke. If Ctrl-Break is pressed when the program is not searching for a route, the following message appears: not busy - interrupt ignored.

12.3 REPEAT ROUTE (F8)

It is often necessary to run a series of routes that have exactly the same shape, but that connect different sets of points. The layout section in the figure below is an example of this:



(The labels are for the convenience of this example, and do not actually appear on the editing display.)

The REPEAT ROUTE function can speed up such repetitive layouts. After running one route with the usual source-target marking method, the cursor is moved to the next target endpoint. Pressing the REPEAT ROUTE key at this point will cause a route with the same shape as the previous route to be run backwards from the new target to the new source endpoint. In the example, the REPEAT ROUTE function can be used to lay out the repetitive patterns quickly, as follows:

* manually run the route from a1 to a3
* move the cursor to b3 and press F8 to run the b1-b3 route
* move the cursor to b5 and press F8 to run the b3-b5 route
* move the cursor to a5 and press F8 to run the a3-a5 route
* manually run the route from a2 to a4
* move the cursor to b4 and press F8 to run the b2-b4 route
* move the cursor to b6 and press F8 to run the b4-b6 route
* move the cursor to a6 and press F8 to run the a4-a6 route

A route being run by REPEAT ROUTE stops when it collides with another conductor, or when it reaches the expected position of the source endpoint.

12.4 B'^KSPACE ROUTE

When an active route exists, you may :casionally overshoot the point at which ›u wanted to stop. The BACKSPACE ROUTE .unction key (the "Backspace" key) will remove a small section of the route at the dangling end; the route remains active. Repeated use of the "Backspace" key will gradually eat away the route until a junction, fatcell, pad, or dangling end is reached. There is no longer an active route when the backspacing process reaches a stop in this manner; the cursor returns to the box shape. If there is no active route, attempts to backspace are rejected with the message: nothing to backspace.

·.5 REMOVE ROUTE (F2)

The REMOVE ROUTE function removes conductors from the active layer. If there is an active route, REMOVE ROUTE deletes the entire active route, regardless of the position of the focus. This occurs even if no part of the active route is displayed on the screen. If there is no active route, the following rules apply:

(1) If there is a pad at the focus, all thin traces that are connected to the pad on the active layer will be deleted up to the first stop. Fatcells and fat traces connected to the pad are not affected. The pad itself can be removed only with the REMOVE PAD function.

(2) If there is a fatcell at the focus,

the fatcell itself will be deleted In addition, all thin traces connecte to the fatcell will be deleted up t the first stop. Fatcells and fa traces connected to the fatcell at th focus are not affected.

(3) If there is a thin trace or a junctio of thin traces at the focus, each thi trace will be deleted up to the firs stop.

(4) If the cursor is straddling two paral lel (that is, unconnected) traces, th REMOVE ROUTE keystroke is rejecte with the message: cursor is straddlin traces.

(5) If there is no conductor at the focu: REMOVE ROUTE is ignored.

Chapter 13

Widening and Shrinking Traces

All traces constructed using the routing process are thin traces. There are function keys for converting such thin traces to fat traces, to convert fat traces back to thin traces, and to place individual fatcells on the layout grid.

13.1 PLACE FATCELL (F7)

Each time the PLACE FATCELL function key is pressed, a fatcell is placed at the focus. Fatcells may be placed in isolated locations, laid end-to-end to form fat traces, or placed around pads to increase the size of the conducting area. In addition, fatcells may be placed in the middle of existing thin traces to form temporary or permanent junctions. An attempt to place a fatcell directly onto a pad, though, will be rejected with the message: can't fatten a pad.

13.2 WIDEN (F5)

The WIDEN function is used to widen all thin traces that are connected to the conductor at the focus. If there is no conductor at the focus, the WIDEN function places a fatcell there, just as the PLACE FATCELL function does. Otherwise, the program will select a thin trace connected to the focus and widen it until a stop is reached. This process is repeated for each thin trace connected to the focus.

The WIDEN function will not widen any section of a trace which, if widened, would cause a new electrical connection to be made. Nonetheless, the widening process will proceed past that point: it is not treated as a stop.

If no thin traces are connected to the conductor at the focus, the WIDEN keystroke is ignored.

13.3 SHRINK (F6)

The SHRINK function is used to shrink all fat traces that are connected to the conductor at the focus. If the conductor at the focus is a fatcell with no connections, the SHRINK function removes it completely. Otherwise, the program will select a fat trace connected to the focus and shrink it until a stop is reached. This process is repeated for each fat trace connected to the focus.

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Wh   ver the SHRINK function is used on a fat trace with a dangling end, the final fatcell at the dangling end is removed completely.

If no fat traces are connected to the focus; the SHRINK keystroke is ignored.

Chapter 14

Using the Mouse

If you have a Microsoft Mouse attached to your computer, you can use it to make the layout editing process even more convenient. If you do not have a Microsoft Mouse, you may skip this chapter.

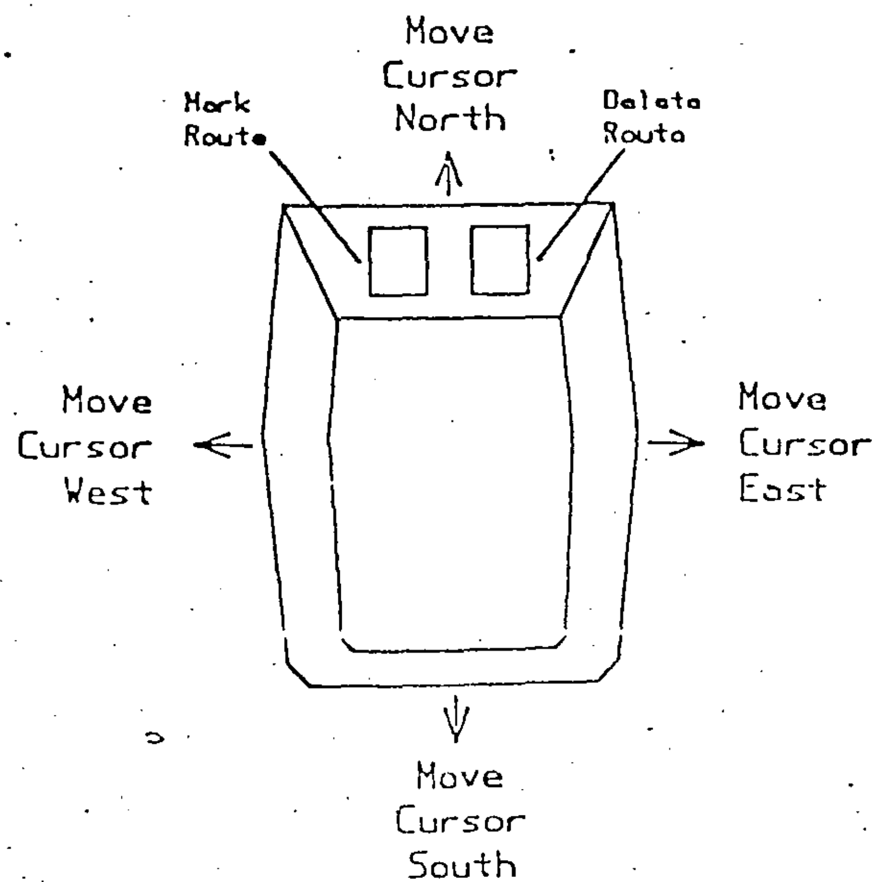
Before attempting to use the mouse with the smARTWORK software, you should read the parts of the Microsoft Mouse manual that describe both hardware and software installation. You must have installed the mouse driver software by issuing a MOUSE command (either manually or from a .BAT file) before running smARTWORK.

After you enter the smARTWORK program, no mouse input is accepted until you issue the mouse command, as shown:

```
COMMAND> mouse
```

The smARTWORK program will then activate the mouse. If there is missing hardware, a hardware malfunction, or missing mouse-driver software, the error message mouse installation failed is issued. Otherwise, high tone signals successful activation.

The most convenient way to use the mouse is to place it on a flat surface directly to the right of the computer keyboard, with the cord and buttons pointing away from you. You can then control the cursor with your right hand on the mouse, as shown in the following diagram:



In addition, you can use the mouse buttons to perform the two most common editing functions. Depressing the left button executes the MARK ROUTE function; depressing the right button executes the DELETE ROUTE function. To perform successive functions with a mouse button, you must depress the button, release it, and depress it again: there is no equivalent of "auto-repeat" operation with the mouse buttons.

Chapter 15

Advanced Commands

Each command described in this chapter consists of a command keyword followed by one or more parameters. For convenience of notation, keywords and literal character strings are shown in upper case, while single-letter parameter symbols are shown in lower case. Characters that actually appear on the smARTWORK display will all be typed and displayed in lower case.

15.1 The CLEAVE Command

The CLEAVE command spreads out closely spaced routes so that new routes can be run between them. It has the form:

```
COMMAND> cleave d
```

The "d" parameter that follows CLEAVE specifies one of the four compass directions: it must be one of the four letters n, s, e, or w. Each CLEAVE command operates on a well-defined rectangular area of the workspace.

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As an example, the definition of the cleave n rectangle follows:

1) north edge: the row of cells that contains the northernmost nonempty cell in the workspace

(2) south edge: the row of cells that contains the focus

(3) east and west edges: the easternmost and westernmost columns of cells in the workspace, respectively.

The cleave n command translates the contents of each cell within the rectangle one cell to the north, thus creating an east-west "cleft" in the workspace at the southern edge of the rectangle. All electrical connections are preserved by bridging the cleft with thin north-south traces at the points where connections must be maintained.

The other three forms of the command work like cleave n, pushing a rectangular section of the layout toward one of the workspace edges. If there is no empty space between the leading edge of the rectangle and the edge of the workspace, the command is rejected with the message: no expansion space at board edge.

For convenience of discussion, we have referred to the area of the workspace upon which CLEAVE operates as a rectangle. Each CLEAVE command, however, operates on congruent rectangles in each layer of the workspace. This ensures that pad alignments are preserved after a CLEAVE operation.

The time needed to execute a CLEAVE is directly proportional to the size of the rectangle, and can range from a few seconds to several minutes. In every case, though, the CLEAVE process is overwhelmingly faster than the corresponding manual process of taking apart a complex layout and rebuilding it in order to squeeze in a route that was not anticipated in the early stages of the layout process. In short, CLEAVE is to be used as a last resort to escape from a situation where you have, so to speak, painted yourself into a corner that allows no other route of escape.

15.2 The SIP and DIP Commands

The SIP command will place all the pads for a single-inline package at once. It has the following form:

COMMAND> sip d n

where "d" is one of the compass directions (n, s, e, or w, just as in the CLEAVE command), and "n" is the number of pins in the package. The pin-1 pad will be placed at the focus; the remaining pads will be placed at 0.1-inch intervals along a line that extends in the indicated direction away from pin 1.

The command

COMMAND> sip e 8

would, for example, place the pad for pin 1 of an eight-pin single-inline package at the focus, then place the remaining pads at

0.1-inch intervals along a line that extends eastward from the focus.

The DIP command will place all the pads for a dual-inline package at once. It has the following form:

COMMAND> dip d n c

where "d" and "n" have the same meaning as they do in the SIP command. The "c" parameter specifies the distance between the two rows of the package in tenths of an inch. The pin-1 pad is placed at the focus; the pads for pins 1 through (n/2) are placed along a line extending in the indicated direction away from the focus. The second row of pads, for pins (n/2 + 1) through n, are placed along a line parallel to and (c/10) inches away from the initial line. The direction of an imaginary vector drawn from the pin-1 pad to the pin-n pad will be the same as the corresponding vector that could be drawn between those pins in standard descriptions of dual-inline packages.

The command

COMMAND> dip e 16 3

would, for example, place the pin-1 pad of a sixteen-pin dual-inline package at the focus, then place the pads for pins 2 through 8 at 0.1-inch intervals along a line that extends eastward from the focus. It would then place the pin-16 pad 0.3 inches north of the pin-1 pad, and finally place the pads for pins 15 through 9 at 0.1-inch intervals along a line that extends eastward from the pin-16 pad.

The SIP and DIP commands may report any of errors that can occur when placing a single pad (e.g., occupied cell in cylinder). In addition, the error message stopped at workspace border may appear whenever either SIP or DIP encounters a workspace border while travelling along the line of pads that it is placing. Whenever an error occurs, either command will terminate immediately instead of attempting to place any remaining pads.

Chapter 16

Advanced Routing

The routing algorithm used by the smARTWORK Editor is designed to enforce a set of design rules which assure that the resulting printed circuit board is very manufacturable. This is important in subsequent production; it results in high yield, low cost per board, and maximum profit in the finished product.

Sometimes, however, the user may wish to override the automatic path chosen by the router. Aesthetics or operator "look-ahead" factors may enter into the routing considerations in a way that the routing algorithm may not anticipate.

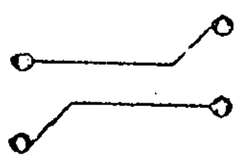
This chapter explains a variety of ways for the user to guide the router so that runs may be precisely placed. These methods are not unique: the adept designer would probably arrive at either these or alternate means to achieve the same ends even without this explanation.

These techniques in no way increase the manufacturability of the resulting board. They may be useful to either the meticulous designer who wants to produce eye-pleasing artwork or the person who wishes to understand the finer points of the router operation to increase its effectiveness.

16.1 Routing Direction

When interconnecting one network with another, the router attempts to run a line from the "source" (the network marked first) to the "target" (the network marked last). All other things being equal, the route is first laid parallel to the axis where the distance between source and target is largest. When the two distances are equal, the route then proceeds diagonally to the target.

The examples below show this effect. In the top route, the leftmost (source) pad was marked before the rightmost (target) pad. In the lower route, the opposite is true. The routes span equal distance, but they turn at different points.



In short, if you don't like the route from A to B, try routing from B to A.

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16.2 Connecting Pairs of Pins

It is often necessary to connect pairs of pins where the pins are in two collinear rows. If left to itself, the router might make the interconnections shown below:

All the connections were specified marking the left pads first. Note that the right sides are neat and angular while the left sides are "crumpled."

One method for counteracting this effect is to use fatcells to specify intermediate routing endpoints. Below, a set of fatcells are inserted to serve as temporary endpoints. In the left-hand figure that follows, these endpoints were marked first to specify the intermediate endpoints; the original pads were then marked as targets. In the right-hand figure, the operation is almost complete, with a single half-route remaining.

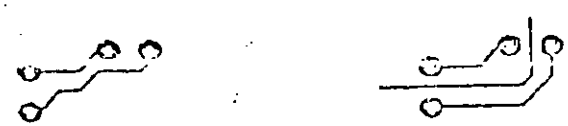
Once both traces have been routed to the intermediate fatcell, use the SHRINK function to replace the fatcell with a thin trace.

16.3 Incremental Routing

The :emental routing feature of the mARTWORK package can sometimes be used to dvantage by the user, as shown in the xamples that follow.

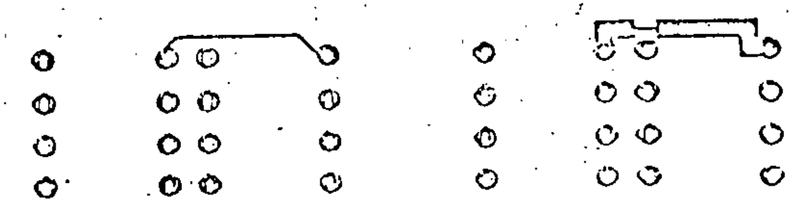
The automatic router tends to avoid pads. Thus, when routing close to a pad, it may be necessary to "hand-hold" the router. In the following example, the left-hand route was generated automatically. In the right-hand version, the incremental-route feature was used to specify the cells just to the left and just below the offending pad.

Sometimes the router will run traces that leave insufficient clearance for a trace that the user knows must be inserted later. In the example that follows, the routes on the left were generated automatically by the router. In the right-hand example, the user applied the incremental-routing feature to force a route that allowed the insertion of the third trace.

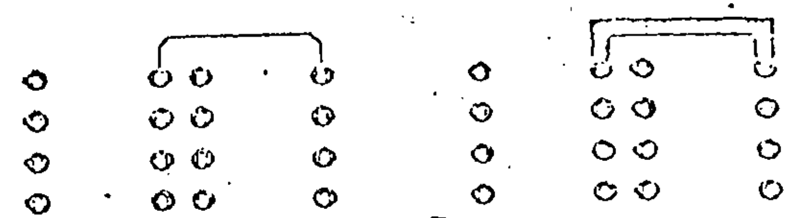


Sometimes it is necessary to force the router to use a suboptimum path. In the left-hand example below, a power-supply interconnection is attempted between the

corner pins of an IC. When th run is widened, as shown on the right, inadequacy of this path is apparent.



When the router is forced to take the suboptimum route by specifying two intermediate cells, the widened version shown below is more appropriate.

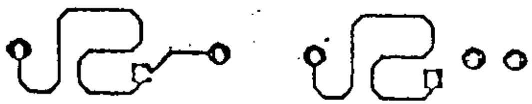


16.4 Fatcells as Ripstops

Sometimes, the user wishes to reroute small portion of a long route. Rather tha removing the entire route and startin over, the user can choose to remove only portion of the route by insertin "ripstops" to limit the action of REMOV ROUTE.

In the example below, the operator wants to reroute the right portion of the trace, thus leaving room to insert a pad.

In the figure on the left, a fatcell is inserted at a midpoint on the trace. The right-hand example shows the layout after the right half-trace has been removed and the pad inserted.



Finally, the new route is made (left) and subsequently shrunk (right).

When several runs must be ripstopped, fatcells are best applied in a zig-zag pattern. This avoids building connections between the runs. (Remember, fatcells are not connected when they appear to touch only at their corners.)

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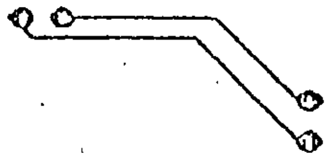
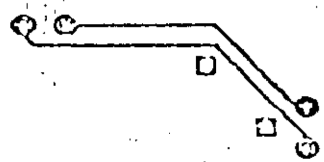
16.5 Deflecting Routes

The fatcell can also be used as an "obstacle" to deflect the router from its normal path. This technique can be used to squeeze runs into a tighter bundle than would otherwise occur. Incremental routing is insufficient to produce a tighter layout than that shown in the left-hand example below. The addition of the two fatcells in the right-hand example forces the lower run closer to the upper one.

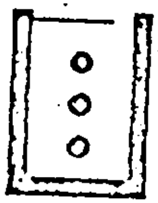


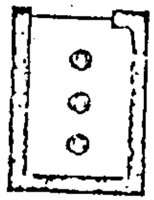


16.6 Routing a Loop

Sometimes a closed loop of conductor is required. Analog circuits, for example, sometimes require a guard band; a digital board is often framed with a ground loop. This operation requires the router to interconnect a "source" and "target" net which are already interconnected. Most of the loop can be made using incremental routing, but the final closure can only be made by inserting a fatcell to close the loop. After this manual operation, the route may be widened or shrunk as desired.

In the left-hand example below, a closure of a pen "U" was attempted, leaving he result shown. The final closure was ade with a single fatcell, as shown on the ight. In a subsequent operation, the thin race will be widened.





Chapter 17

Advanced Techniques

This chapter includes several tips for confining routes to bounded areas of the workspace, manipulating wide traces, creating larger pads, and handling connectors or components which cannot be placed on 50-mil centers.

17.1 Confining Routes

It is often necessary to confine all routing to a particular area of the workspace, prevent routes from passing through a particular area, or both. Three characteristics of closed conductor loops can be used to effect such constraints:

(1) A route whose endpoints lie within a closed loop will lie completely within the loop.

(2) A route whose endpoints lie outside of a closed loop will lie completely outside the loop.

3) It is not possible to create a route which has one endpoint inside of and the other outside of a closed loop.

When designing a five-by-seven-inch ircuit-board, for example, you will want o confine all routing to a five-by-seven-nch area of the workspace. To do this, un a loop around a five-by-seven-inch sec-ion of the lower layer, then close it ccording to the instructions in the Advanced Routing" chapter. When this is one, run a loop on the upper layer that oincides with the lower-layer loop. Any oute that you begin within either loop is uaranteed to remain within it. You may emove the confining loops before generat-ng artwork, if you like.

Conversely, if you design a board that .l eventually have a two-inch-diameter ole punched through it at a certain point, ou will want to prevent routes from pass-ng through the area to be punched. To do his, run and close a loop that cir-umscribes the restricted area on each ayer. Any route that you begin outside of ither loop is guaranteed to lie completely utside of it. Again, you may remove the onfining loops before generating artwork.

7.2 Removing a Wide Trace

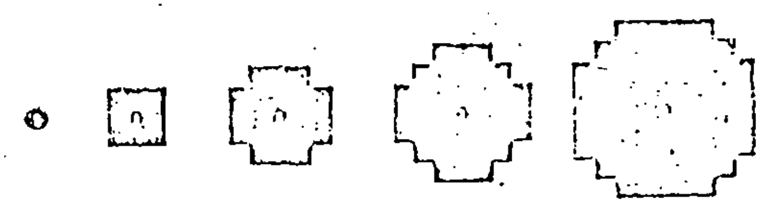
To delete a widened trace that comprises single width of fatcells, first SHRINK he run and then perform the REMOVE ROUTE unction. If this is not done, the REMOVE OUTE function simply deletes the single atcell at the focus.

17.3 Fatcells as WIDEN Stops

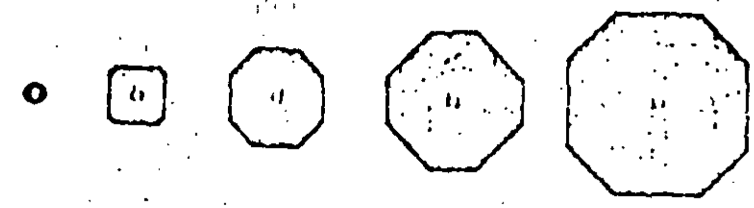
In a technique similar to ripstopping, fatcells can be used to limit run-widening. Since the WIDEN function ceases whenever a junction is encountered, the widening can be "pinched off" by inserting a fatcell into a run at the point where widening is to terminate. In the example below, only the left half of the run is widened. First, as shown on the left, a fatcell is inserted where the widening should stop. The cursor is then placed over the left subtrace, and the WIDEN function is invoked.

17.4 Building Large Pads

When a larger solder area is needed for a component than is afforded by a single pad, the area around the pad can be built up using fatcells. The examples show a single pad, and pads augmented by 8, 20, 36, and 68 fatcell neighbors.



In the final artwork, the exposed corner of the fatcells will be shaved, yielding the results shown below:



Pads may also be augmented by two or four neighboring fatcells.

17.5 Retouching Artwork

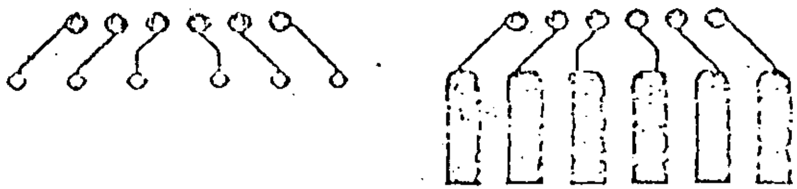
Occasionally, the need arises to do something the router simply cannot do. When this occurs, the only recourse is to retouch the final artwork. Some examples are shown here.

In an extremely tight layout, there may be no room to run a widened trace. Two solutions are shown below. In the first example, the trace is left thin. Retouching can be done later to widen the narrowed region of the run. The trace will not be fully 0.50" wide, but it will suffice in most applications.

An alternate solution is to run two thin traces, as shown on the left. The artwork is retouched to flesh out the space between the two thin runs (right).

HINT: Always retouch in a contrasting color (red, for example) so that the retouching can be easily located for duplication when the artwork is revised.

Another problem that arises is installation of a connector on centers other than multiples of 0.05". This problem has become less frequent as the 0.05" connector has emerged as the industry standard. When this occurs, features on the 0.05" grid can be used to "hold a place" for the connector in approximately correct locations. After the artwork is plotted, the connector is added with conventional stick-on patterns, pads and tape. In the example shown below, a 0.156" edge-connector is added to the artwork. The left-hand illustration shows fatcells marking the approximate locations of the connector fingers and serving as "anchors" during routing. The right-hand illustration shows the artwork after the connector fingers are added manually.



Chapter 18

Dot-Matrix Artwork

Once you have entered your printed-circuit-board artwork using smARTWORK's Editor and saved the result in a file on the disk, the smARTWORK Plotter may be used to create a copy of the artwork on paper. This chapter describes using the dot-matrix printer for hardcopy output.

18.1 Types of Output

The smARTWORK Plotter program can produce 1X checkplots or 2X artwork using either an Epson FX-100 or MX-100 printer.

The checkplot option is a low-quality 1X copy of the artwork. Pads appear as squares; diagonals will be somewhat ragged. Fatcells and wide runs still have squared edges. The title lines include the current date and time, the name of the file being plotted, a hole count (number of pads on the board) and approximate board dimensions.

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The 2X artwork option is used to create paper copies of the layout which are then reduced photographically to create prototype-quality printed-circuit boards. This camera-ready "plotting" uses the high-resolution graphics mode of the printer. While the edges of the conductors are not as smooth as those produced by the pen-and-ink plotter, most of this roughness will disappear when reduced to 1X.

In contrast with the checkplot, the 2X artwork has the wide traces and fatcells smoothed to create diagonal runs and to soften 90-degree inside and outside corners. Pads appear as circles, except where they have been shaved because of a nearby conductor. Note that two-sided boards may suffer from registration problems caused by the stretching of the paper where it is hammered by the print head.

18.2 Using the Program

To run the smARTWORK Plotter, you must place the smARTWORK diskette into drive A. Type the name of the smARTWORK Plotter following the prompt from DOS:

```
A>PLOT
```

Once loaded, the Plotter program will display its title page. Note that the screen includes both the program version number and your license number.

When you have finished reading the title page, press the space bar to erase the title information. The next screen is a me which allows you to choose between several types of output for either the dot-matrix printer or pen-and-ink plotter.

Find the menu entry that matches the output format you want (either 1X dot-matrix checkplot or 2X dot-matrix artwork). Type the number of your choice, then hit "Enter".

The screen will clear again, and the following prompt will appear:

Input file containing the board layout:

The program will pause, awaiting the name of a layout file you created using the smARTWORK Editor. Enter the filename in standard DOS format (e.g., a:demo.pcb). Use the "Backspace" or Esc keys to correct any typing mistakes. Press the "Enter" key after typing the filename. The program will pause as it reads the layout description file.

The program may reject the input filename by sending a low tone over the speaker and erasing the input filename. This means either that it couldn't find the file or that it couldn't understand the file's contents. Make sure that the name of the file is spelled correctly, and that the named file actually contains a smART-WORK layout.

Next, the prompt for the output port will appear:

Output device or file name: lpt1:

The output of the Plotter program is

normally written directly to the printer. Since the printer is usually connected to the first parallel port, the program provides a default device name: lpt1:. If this name is correct, simply press the "Enter" key.

If the printer is connected to another port, or if you wish to write the output to a file instead of directly to the printer, use the Esc or "Backspace" keys to remove the default device name. Then enter the correct device name (for example, com1:, com2:, aux:, prn:, or lpt2:) or DOS filename and press "Enter".

If the program emits the low tone, erases your response, and prints the default device name again, the device name or filename was in the wrong format, or DOS returned an error when the program tried to use it. Either change your response or fix the printer.

Once you have entered the input filename and the output device, smARTWORK will ask you whether you want to print both sides of the board, the lower layer only, or the upper layer only. (The lower layer of the board is the layer the Editor displays when you press the "PgDn" key.) Press the B key (for Both), L key (for Lower), or U key (for Upper), then strike "Enter".

The program will print the message: Working..., then pause for nearly a minute while it prepares the layout for printing. Examples of dot-matrix printer output can be found in the "Tutorial: Lesson 4" chapter.

Ea ayer of the board will be printed on a eparate sheet of paper. Several lines of text above each plot give the date, time, and filename. The program also prints the approximate size of the board in inches, and a count of the number of pads on the layout.

18.3 Suggestions

Several precautions should be taken to optimize "prototype quality" output from the dot-matrix 2X artwork:

* Make sure the platen-release lever is in the "release" position so that the paper is pulled through the printer using the pin-feed mechanism. Make sure that the paper bail is used to hold the paper against the platen.

* Move the print-intensity control back to its minimum-impact position to minimize streaks caused by the printer ribbon brushing against the paper.

* Make sure that the paper feeding from the paper box into the printer is free from any tension caused by the sides of the paper box, printer cables, or paper leaving the printer.

* Leave several sheets of paper attached to the paper leaving the printer so that their weight provides a uniform tension on the page being printed.

* If the plot of one side of a board will extend across a fold in the paper, align

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the paper so that the fold is away from the print head to minimize smearing caused by the ribbon.

* Use a good-quality printer paper to minimize the stretching of the image caused by the print hammers.

* After printing a two-sided board, check the registration of the pad holes by superimposing the two sides in front of a light source and viewing the holes through the paper. The stretching of the paper is aggravated by large unbroken areas of fatcells. Try to avoid these large areas of copper by substituting an interconnecting grid of fatcells and/or normal runs. This is good practice anyway, since large (unbroken) areas of copper can cause problems during etching of the circuit board.

* If you abort printing in the middle of a plot, you will probably need to turn the printer off and then back on to reset it. Otherwise, the printer may be trapped in the middle of a graphics command and ignore the initial commands sent at the start of the next plot.

* Because of the porous nature of paper, archive your artwork using both the diskette and the 1X film created during the photographic reduction process. Over a period of months, the ink will bleed into the paper and reduce the sharpness of the image.

Chapter 19

Pen-and-Ink Artwork

Besides producing paper copies of your layout on a dot-matrix printer, the smART-WORK Plotter program can drive a Houston Instrument DMP-41 pen-and-ink plotter. Using the DMP-41, you can produce camera-ready 2X artwork on paper, vellum, or polyester film.

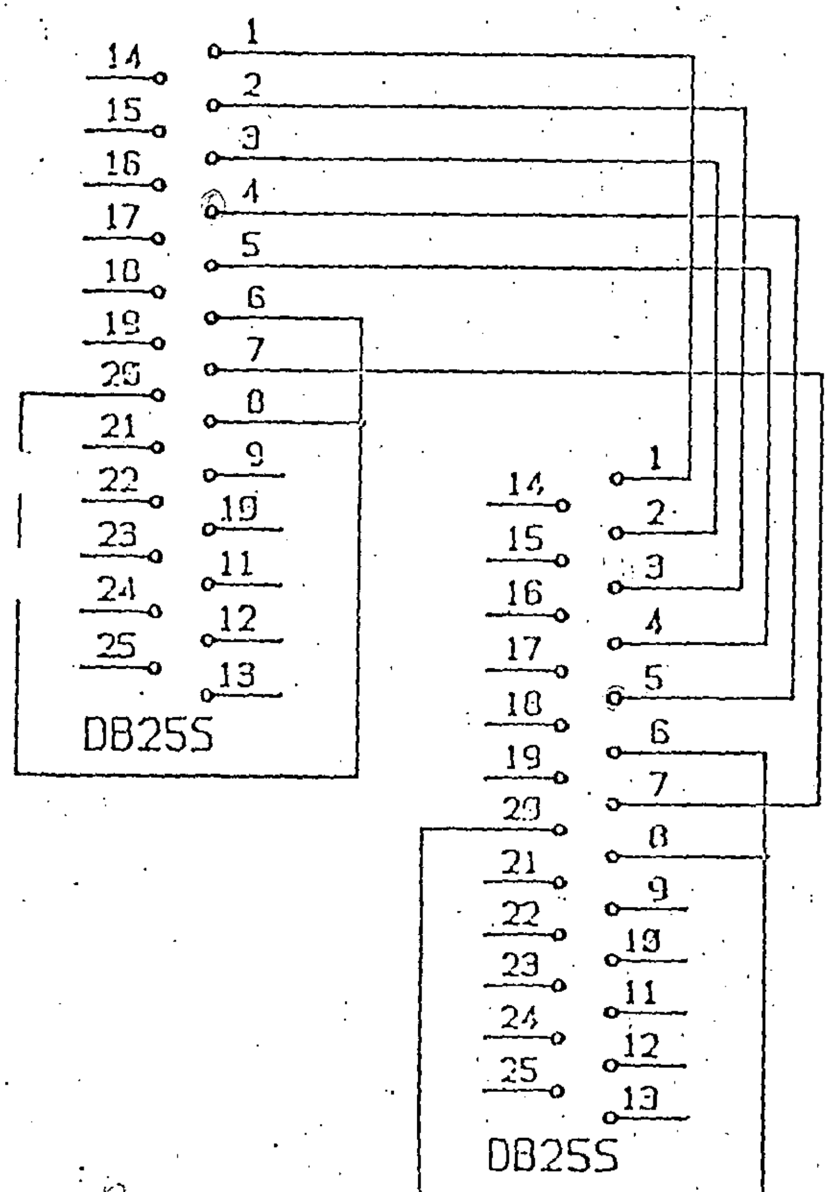
19.1 Connecting the Plotter

The DMP-41 plotter is normally connected to the IBM PC using a serial interface. While instructions for wiring the plotter to a computer are contained in the manual which comes with the DMP-41, the following suggestions may facilitate the process.

A wiring diagram for the RS-232 cable needed to connect the PC and the plotter is shown below. Make the cable six to ten feet long, depending on the physical locations of the two devices. The cable is

symmetric, so that each end may be used with either serial port.

IBM "com1" Port



Houston Serial Conn...

The gram assumes that the plotter will be connected to the IBM PC's com1: port (a default you may override). Communication occurs at 2400 baud -- the default condition after the DMP-41 is powered on.

The smARTWORK Plotter program depends on the CTS (clear-to-send) input to the PC's serial port to control the flow of data from the program to the DMP-41's input buffer. This lead must be asserted (it is active low) in order for the computer to send characters. The DMP-41 may temporarily suspend its input stream by taking CTS to the unasserted state.

The DSR (data set ready) input to the PC's serial port must remain asserted during the entire transmission from the computer to the plotter. Two output leads from the serial port, RTS (request-to-send) and DTR (data terminal ready), are asserted by the program.

19.2 Liquid-Ink Plotting

In order to produce high-quality plots for photographic reduction, you will need to use a liquid-ink pen with the Houston Instrument plotter. While you can use the felt-tip pens provided with the DMP-41 for rough drawings, they do not give the controlled line width or opacity required for camera-ready artwork.

The liquid-ink-pen adapter is sold by Houston Instrument, Koh-I-Noor, and Staedtler. You must use a pen tip designed for computer plotters. Standard tips do

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not work (they fit the holder, but they don't draw properly). Wintek strongly recommends a tungsten-carbide point, since steel points wear out rapidly when used in this application.

The smARTWORK Plotter software assumes the use of a 0.6-millimeter pen tip. Subject to variations caused by humidity, type of ink, and plotting medium, this should yield artwork with 12-mil thin lines and 19-mil spacing. If you prefer a slightly wider trace, you may wish to try a 0.7-millimeter pen tip. Nominal dimensions for plots made with the 0.7-mm tip are 14-mil thin traces and 17-mil spacing.

Initially, you will probably wish to buy both a 0.6- and a 0.7-mm pen tip. You will also need the pen adapter and a pen-cleaning kit. The Koh-I-Noor part numbers for these items are:

63TB-2/.60	0.6-mm tungsten carbide pen tip
63TB-2.5/.70	0.7-mm tungsten carbide pen tip
7006WOP	Plotter pen adapter
3068-SYKT	Syringe pen cleaner/starter kit

Almost as important as the choice of pen tip is the choice of ink and medium. Wintek has had good luck with Koh-I-Noor #3080 Rapidraw Ink on vellum. You may wish to use polyester film for artwork which will be archived or which contains large areas of un ken copper.

Cleanliness is everything. Make sure the pen has been completely cleaned before beginning a new plot. If you have trouble with ink blots, skipping, ragged edges, or the centers of pads being filled, CLEAN THE PEN!

19.3 Using the Program

The procedure for using the smARTWORK Plotter program to create pen-and-ink artwork is almost identical to the procedure for the dot-matrix printer. An outline of the steps required are repeated here with changes where appropriate.

To run the smARTWORK Plotter, you must place the smARTWORK diskette into drive A. Type the name of the smARTWORK Plotter following the prompt from DOS:

A>PLOT

Once loaded, the Plotter program will display its title page. Note that the screen includes both the program version number and your license number.

When you have finished reading the title page, press the space bar to erase the title information. The next screen is a menu which allows you to choose between several types of output for either the dot-matrix printer or pen-and-ink plotter.

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Find the menu entry that matche the output format you want (2X pen-and-in rt-work). Type the number of your choice, then hit "Enter".

The screen will clear again, and a list output devices will appear. Type the number that will select your plotter, then hit "Enter".

The screen will clear again, and the following prompt will appear:

Input file containing the board layout:

The program will pause, awaiting the name of a layout file you created using the smARTWORK Editor. Enter the filename in standard DOS format (e.g., a:demo.pcb). Use the "Backspace" or Esc keys to correct any typing mistakes. Press the "Enter" key fter typing the filename. The program ill pause as it reads the layout file.

The program may reject the input filename by emitting a low tone and erasing the input filename. This means either that it couldn't find the file or that it couldn't understand the file's contents. Make sure that the name of the file is spelled correctly, and that the named file actually contains a smARTWORK layout.

Next, the prompt for the output port will appear:

Output device or file name: com1:

he Plotter program normally writes its output directly to the pen-and-ink plotter. Since the plotter is usually connected to the fir   serial port, the program provides a defau   device name: com1:. If this name is correct, simply press the "Enter" key.

If the printer is connected to another port, or if you wish to write the output to a file instead of directly to the printer, use the Esc or "Backspace" keys to remove the default device name. Then enter the correct device name (for example, com2:, aux:, prn:, lpt1:, or lpt2:) or DOS filename and press "Enter".

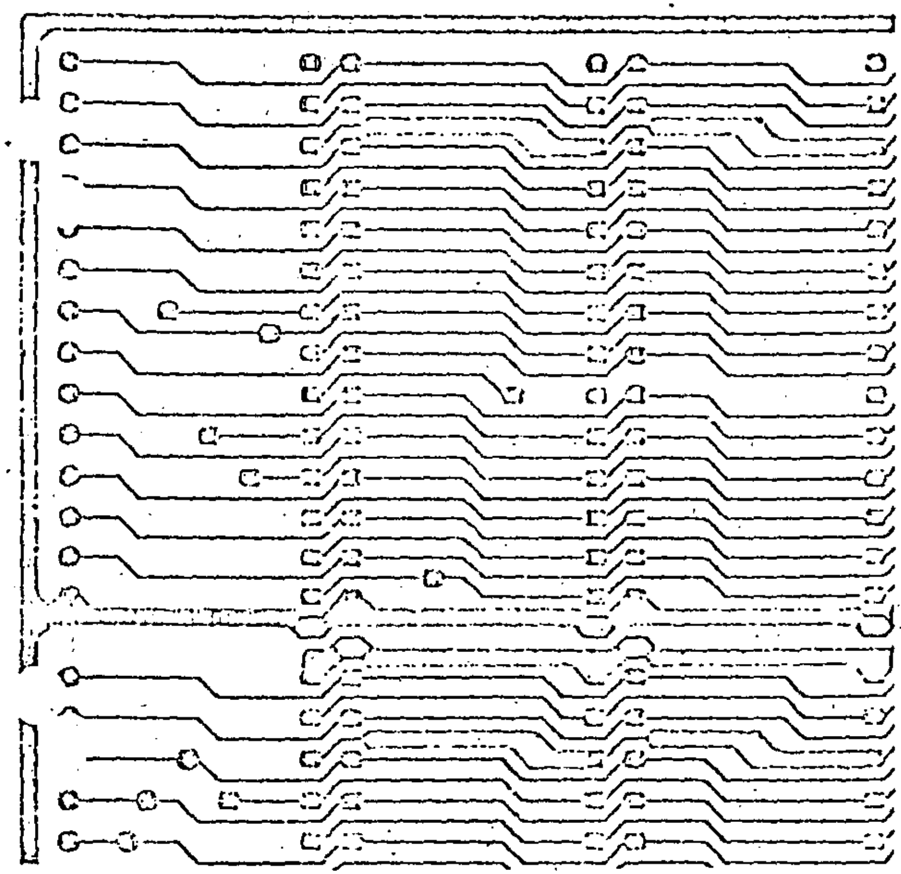
If the program emits the low tone, erases your response, and prints the default device name again, the device name or filename was in the wrong format, or DOS returned an error when the program tried to use it. Either change your response or fix the plotter.

You may write the plot-output text to a file instead of directly to the plotter. If you eventually copy that file to the plotter, you will need to initialize the serial port using the DOS MODE command. The normal settings for the port are 2400 baud, eight data bits, no parity bit, two stop bits, and retry time-out errors.

Once you have entered the input filename and the output device, smARTWORK will ask you whether you want to plot both sides of the board, the lower layer only, or the upper layer only. (The lower layer of the board is the layer the Editor displays when you press the "PgDn" key.) If you request to have both sides plotted, both plots must fit on the same sheet of paper. Press the B key (for Both), L key (for Lower), or U key (for Upper), then strike "Enter".

The final prompt requests the size of the paper that you have loaded into plotter. "C-size" drawings use paper that is 17 by 22 inches in size, and allow plotting to occur in an area 15 by 20 inches. " size" drawings use paper that is 22 by 34 inches, and allow plotting over a 20 by 32 inch region. Type either C or D, then press "Enter".

The program will print the message: Working..., then pause for nearly a minute while it prepares the layout for plotting. A portion of an example plot is shown below:



Each layer of the board will be surrounded by a border drawn with a dashed line. You may use the corners of this border as registration targets when plotting two-sided artwork. The program uses the dashed line to start the ink flowing properly through the pen tip.

19.4 Troubleshooting

Most of the problems that will occur with the generation of plotter artwork will be related to some combination of the pen tip, ink, and medium (paper, vellum, or polyester film). Here are some typical problems and checklists for diagnosis:

* No ink flow: Check ink supply. Check for clogged pen tip. Check for surface contact in pen-down position. Clean, inspect point, and restart pen.

* Pen skips -- inconsistent or irregular lines: Check point. Clean if clogged; replace if damaged or worn. Check and adjust pen-force setscrew. Check drawing surface for imperfections or contamination. Keep hands clean while working with drafting medium, and always handle it at edges. Wipe surface with clean, lint-free towel.

* Pen point clogs frequently: Check and adjust pen-force setscrew. Check pen point for wear or damage. Check for drawing-surface contamination.

* Ink blob at line start: Check and adjust pen-force setscrew. Check pen point for wear or damage.

  Ink smears: Check for excessive humidity in plotting area. Check for drawing-surface contamination. Experiment with faster-drying ink.

* Poor ink adhesion: Check for drawing-surface contamination. Check for deteriorated or contaminated ink. Verify proper combination of ink and medium.

* Poor registration or inaccurate dimensions: Try using polyester film instead of paper or vellum. Check roller and pinch wheels for dirt.

Koh-I-Noor produces an excellent catalog describing its products that includes suggestions for using liquid-ink pens and a troubleshooting guide. Request a copy of the Koh-I-Noor Plotter Supplies catalog from your local dealer or directly from Koh-I-Noor:

Koh-I-Noor Rapidograph Inc.
P. O. Box 68
Bloomsbury, NJ 08804
Telephone (201) 479-4124

Appendix A

Command Summary

The following page contains a succinct summary of each function key and command recognized by the smARTWORK Editor.

Single-Keystroke Functions:

MARK ROUTE -- F1	F2 -- REMOVE ROUTE
PLACE PAD -- F3	F4 -- REMOVE PAD
WIDEN -- F5	F6 -- SHRINK
PLACE FATCELL -- F7	F8 -- REPEAT ROUTE

Change layer -- PgUp or PgDn keys
Backspace route -- Backspace key
Interrupt route -- Ctrl-Break
Move Cursor 1 Cell -- Arrow keys
Move 5 or 10 Cells -- Shift-Arrow keys
Prompt for Command -- Enter key

Display-Control Functions:

Alt-F1 -- Toggle color-b/w mode
Alt-F2 -- Toggle color intensity
Alt-F3 -- Toggle color scheme
Alt-F4 -- Toggle background color
Alt-F5 -- Toggle opaque/transparent mode
Alt-F6 -- Toggle active layer's color
Alt-F7 -- Toggle window size

Command-Line Input:

clear
cleave <direction>
SIP- dip <direction> <# pins> <spacing>
load <filename>
mouse
quit
save <filename>
sip <direction> <# pins>
Backspace -- Delete character
Esc -- Erase response
Enter -- Process response

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