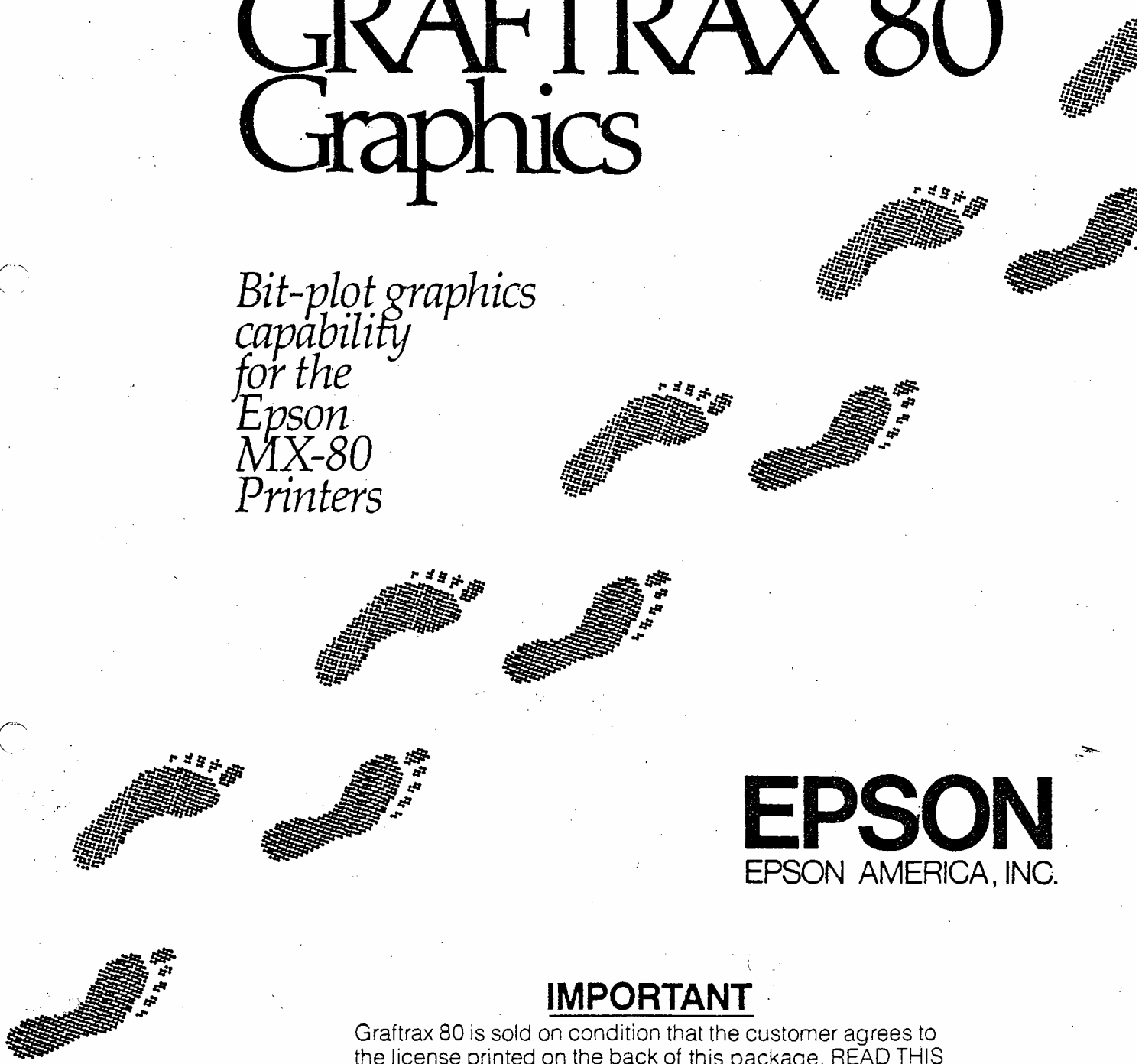# GRAFTRAX 80 Graphics

*Bit-plot graphics capability for the Epson MX-80 Printers*

# EPSON

EPSON AMERICA, INC.

## IMPORTANT

Graftrax 80 is sold on condition that the customer agrees to the license printed on the back of this package. READ THIS LICENSE CAREFULLY. By opening this package, you signify that you agree to the terms of this license.

NOTE: GRAFTRAX 80 will not function with the Epson 8141 serial interface.

# GRAFTRAX-80

## JUNE 1981

GRAFTRAX-80 is an in printer option for the EPSON MX-80 SERIES printers. The upgrade kit consists of the following:

        3 2716 EPROMS
        1 MANUAL
        1 LICENSING AGREEMENT


    The following tools are needed for installation:

        1 phillips head screwdriver
        1 I.C removal tool or flat screwdriver
        1 pair diagonal cutters


## NOTICE:

USE OF THIS MANUAL ASSUMES YOU HAVE READ AND UNDERSTOOD THE
EPSON MX-80 PRINTER USERS MANUAL BY DR. D.A. LIEN, OF COMPUSOFT
PUBLISHING CO. THIS MANUAL ALSO ASSUMES YOU HAVE A REASONABLE
UNDERSTANDING OF YOUR COMPUTER AND THE BASIC LANGUAGE.

### DISCLAIMER OF ALL WARRANTIES AND LIABILITY

# INSTALLATION INSTRUCTIONS

1. Remove the upper case from the printer, by removing the four
   phillips head screws from the bottom of the case.

2. Turn printer upright holding the top and the bottom of the
   case together. Use care not to lose the screws that you
   have just removed.

3. Carefully pull the black knob off the shaft, on the right
   side of the printer.

4. Slowly lift the left side of the printer case and slide it
   off the shaft, sticking out of the right hand side. Beware
   of the wires attached to the switches and indicator lamps
   on the top half. Carefully stand the top half of the case
   on its right hand side next to the protruding shaft.

5. Remove the black 2332 ROM from the socket, near the back of
   the printer. This IC is plugged into socket 1B (see
   figure A). Removal is performed using an IC removal tool
   or flat blade screwdriver. Gently pry straight up on the
   IC being careful not to damage the IC socket.

6. Using a pair of cutters cut the small wire loop (jumper J1)
   located near the center of the printer, next to a very
   large IC labeled 8049.(see figure A)

7. Carefully insert the three EPROM's marked 1B,2B,3B into the
   three respective sockets marked 1B,2B,3B.

   A. Make sure that Pin 1 (the edge of the EPROM with the
      moon shaped notch in it) is facing the front of the
      printer.
   B. Carefully push the 2716's into the sockets taking care
      not to bend over any of the pins.
   C. Visually inspect the chips to insure that none of the
      pins have been bent during installation.

8. The switch setting will need to be modified to be used with
   GRAFTRAX-80. See figure B for the function of each of the
   dip switches.

9. After you are sure that you have set the dip switches
   correctly, reassemble the MX-80 in the reverse order of
   disassembly.

10. Run a self test by depressing the line feed button and
    turning the printer's power on. If the self test does not
    work, inspect the 2716's for bent pins, and make sure that
    the jumper J1 is not connected.
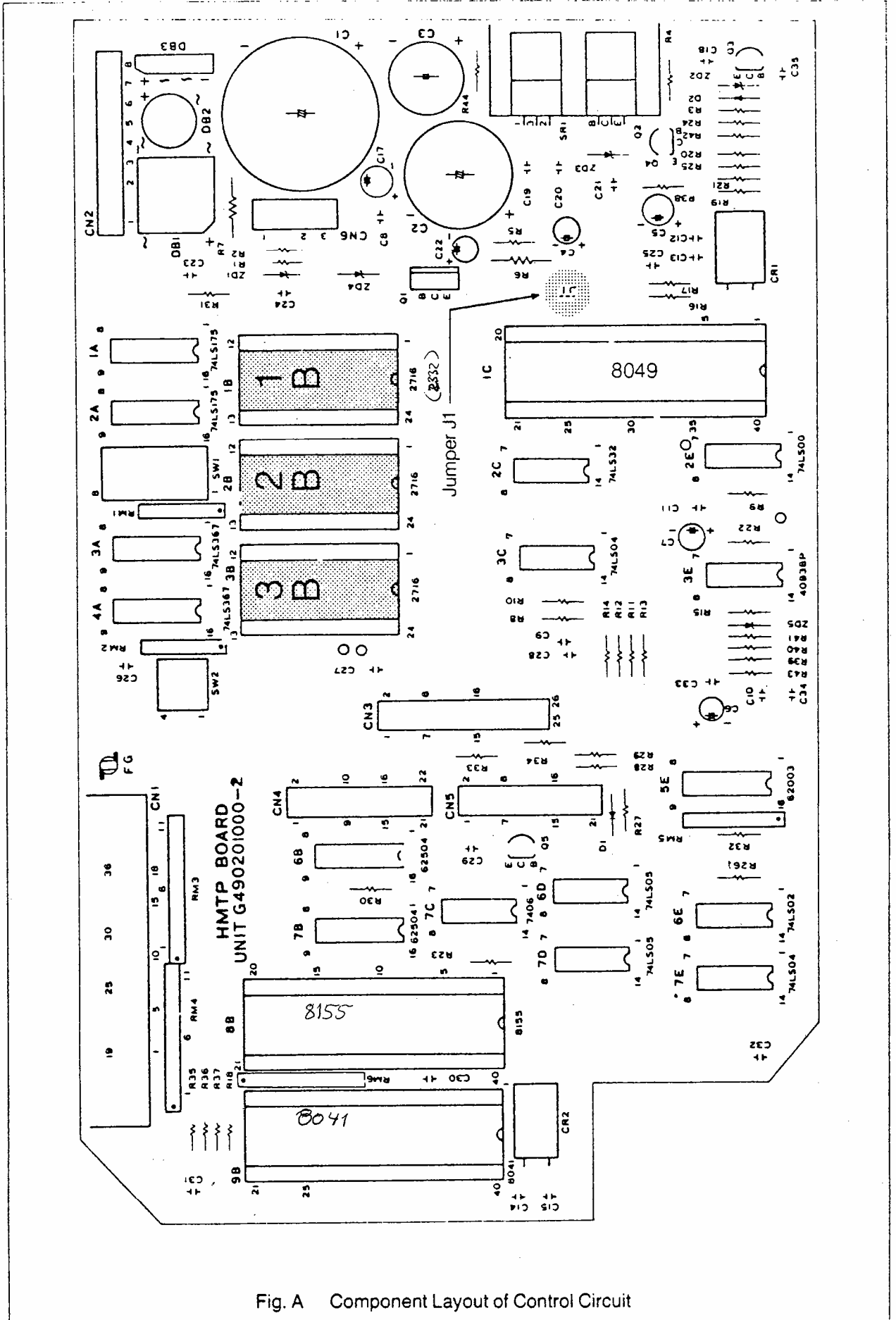
Fig. A    Component Layout of Control Circuit

# PRINTER SWITCH SETTINGS

|   | ON SW-2 OFF |
|---|---|
| 4 |   | X |
| 3 |   | X |
| 2 |   | X |
| 1 |   | X |

|   | ON SW-1 OFF |
|---|---|
| 8 | X |   |
| 7 |   | X |
| 6 | X |   |
| 5 |   | X |
| 4 |   | X |
| 3 | X |   |
| 2 | X |   |
| 1 |   | X |

*set like this 17/12-81*

|        | ON                | OFF                |
|--------|-------------------|--------------------|
| SW1-1  | 132 C/LINE        | 80 C/LINE          |
| SW1-2  | CR=PRINT          | CR=PRINT + LF      |
| SW1-3  | BUFFER FULL=PRINT | BUFFER FULL=PRINT +LF |
| SW1-4  | ITALIC            | NORMAL             |
| SW1-5  | EMPHASIZED        | NORMAL             |
| SW1-6  | BUZZER ON         | BUZZER OFF         |
| SW1-7  | SLASHED ZERO      | REGULAR ZERO       |
| SW1-8  | SELECT FIXED      | SELECT NOT FIXED   |
|        |                   |                    |
| SW2-1  | NOT USED          | NOT USED           |
| SW2-2  | NOT USED          | NOT USED           |
| SW2-3  | AUTO LF WITH CR   | LF MUST BE FROM HOST |
| SW2-4  | TRS-80 MODE       | NORMAL MODE        |

## FIGURE B

THE FOLLOWING IS A LIST OF ALL THE FUNCTION CODES WHICH ARE AVAILABLE, ONCE YOU HAVE INSTALLED THE GRAFTRAX-80 FIRMWARE.

# FUNCTIONS CODES

| HEX | ASCII | DESCRIPTION |
|-----|-------|-------------|
| 1B 30 | ESC 0 | Sets line spacing to 8 lines per inch. |
| 1B 31 | ESC 1 | Sets line spacing to 7/72 per line. |
| 1B 32 | ESC 2 | Sets line spacing to 6 lines per inch. |
| 1B 33 | ESC 3 n | Sets line spacing to n/216 of an inch. (1/3 of a dot vertical) $1 \leq n \leq 254$ |
| 1B 34 | ESC 4 | Switches to the alternate italics character set. |
| 1B 35 | ESC 5 | Switches to the standard character set. |
| 1B 38 | ESC 8 | Enables paper transfer even if the printer is out of paper |
| 1B 39 | ESC 9 | Cancels the paper out function. |
| 1B 3A | ESC : | Sets the RADIO SHACK mode. (causes the printer to respond to all standard TRS-80 graphics numbers.) |
| 1B 3B | ESC ; | Cancels the RADIO SHACK mode. |
| 1B 3C | ESC < | Home head causes the print head to move to the left end of the carriage. |
| 1B 3D | ESC = | Clears the M.S.B. function. |
| 1B 3E | ESC > | Sets the M.S.B. in the printer. This is for use with 7 bit computers to access the TRS-80 block graphics. |
| 1B 3F | ESC ? n1-n37 | Redefines the escape codes to the user's specifications. |
| 1B 40 | ESC @ | Reset printer, causes the printer to reinitialize to cold start settings. |
| 1B 41 | ESC A n | Sets line spacing to n/72 of an inch (1/72 is equal to one vertical dot) No longer needs to be followed by an Escape "2" to be initiated. $1 \leq 85$ |
| 1B 42 | ESC B n1 n2....null ¦ 255 | Set vertical tabs. Clears all previous vertical tabs and sets new tab stops at |

(n1,n2..) A maximum of 16 tabs allowed.
$1 \leq n \leq 254$

| | | |
|---|---|---|
| 1B 43 | ESC C n | Sets form length to n lines. |

$1 \leq n \leq 255$

1B 44  ESC D n1 n2...NUL ! 255

Sets horizontal tabs. Clears all of the
previous horizontal tabs and sets new
tab stops at (n1,n2..) A maximum of 16
tabs allowed.
NOTE: Tab column 0 is print column 1,
tab column 1 is print column 2......and
tab column 79 is print column 80.
$1 \leq n \leq 131$

1B 45  ESC E        Sets the emphasized printing mode.  May
now be turned on/off in the same line.

1B 46  ESC F        Cancels the emphasized printing mode.

1B 47  ESC G        Sets the double-strike mode.  May now be
turned on/off in the same line.

1B 48  ESC H        Cancels the double strike printing mode.

1B 49  ESC I        NOT USED AT THIS TIME

1B 4A  ESC J n1 n2   Sets bit image graphics in the 960 mode
and prints at 480 mode speed.

1B 4B  ESC K n1 n2   Sets bit image graphics in the 480 mode.
The next n1+n2 bytes will be printed as
dot graphics.
$1 \leq n1 \leq 255$
$0 ! 1 ! 255 \leq n2$  (255 is equal to 0)
                    (1 is equal to 256)

1B 4C  ESC L n1 n2   Sets bit image graphics in the 960 mode.
The next n1+n2 bytes will be printed as
dot graphics.
$1 \leq n1 \leq 255$
$0 ! 255 \leq n2 \leq 3$  (255 is equal to 0)
                    (1 is equal to 256)
                    (2 is equal to 512)
                    (3 is equal to 768)

1B 4D  ESC M        NOT USED AT THIS TIME

1B 4E  ESC N        NOT USED AT THIS TIME

1B 4F  ESC O        NOT USED AT THIS TIME

1B 50  ESC P        Sets the compressed character print
mode. (16.5 cpi)

1B 51  ESC Q        Cancels the compressed character mode.

| 1B 52 | ESC R | NOT USED AT THIS TIME |
|-------|-------|-----------------------|
| 1B 53 | ESC S | Sets the expanded character print mode. (5 cpi) |
| 1B 54 | ESC T | Cancels the expanded character mode. |
| 7 | 7 | Bell character. Rings the bell for a period of approx. 1/3 of a second. |
| 8 | 8 | Backspace character. Forces the printer to print its buffer, home the print head and decrement the character count by 1. |
| 9 | 9 | Horizontal tab character. Causes the print head to mode to the next tab stop. |
| A | 10 | Line feed character. Causes the printer to feed paper at the rate of the current line feed setting and print its buffer. |
| B | 11 | Vertical tab character. Causes the printer to advance the paper to the next vertical tab stop. |
| C | 12 | Form feed character. Causes the printer to advance the paper to the next logical top of form. |
| D | 13 | Carriage return character. Prints the contents of the buffer and resets the buffer character count to zero. |
| E | 14 | Shift out character. Prints the remainder of the line in expanded characters unless cancelled by DC4. |
| F | 15 | Shift in character. Prints all the following characters in condensed mode until cancelled by DC2. NOTE: This mode may now be mixed on the same line with normal and expanded characters. |
| F E | 15 14 | Shift in/shift out together cause the remainder of the line to be printed in the condensed/expanded mode unless cancelled by a DC2 and DC4. |
| 11 | 17 | DC2-Device Select 1 character. Selects the printer and allows it to receive data. |
| 12 | 18 | DC2-Device Select 2 character. Cancels the condensed character mode. |
| 13 | 19 | DC3-Device Select 3 character. Deselects the printer and prevents it from receiv- |

ing data.

| | | |
|---|---|---|
| 14 | 20 | DC4-Device Select 4 character. Cancels the expanded character mode. |
| 18 | 24 | Cancel character. This code no longer has any effect upon the printer. |
| 16 | 27 | Escape character. This code preceeds many of the above function codes, and informs the printer that a special function code follows it. |
| 7F | 127 | Delete character. Removes the last character input into the printer buffer. |

# NEW FEATURES OF GRAFTRAX-80

## BELL CHARACTER

BELL                    HEX 7                    DEC 7

The bell period on the MX-80 has been shortened from 3 seconds per bell character to 1/3 of a second.

## BACKSPACE CHARACTER

BS                      HEX 8                    DEC 8

This command, when sent to the printer, will cause the contents of the printer's buffer to be printed, the print head sent to home at the left margin, and the character count decremented by one. The next character received will be printed when the buffer becomes full or when a carriage return or line feed character is received.

**NOTE:** THE DOUBLE STRIKE MODE SHOULD NOT BE USED WITH THE BACKSPACE COMMAND. IF IT IS USED, THE PAPER WILL "CREEP" DUE TO THE PAPER BEING ADVANCED 1/216 OF AN INCH EACH TIME A CHARACTER IS DOUBLE STRUCK.

## HORIZONTAL TAB CHARACTER

HT                      HEX 9                    DEC 9

The printer's horizontal tabs have been given a default of every 8 print positions with a maximum of 16 tab stops.

## VERTICAL TAB CHARACTER

VT                      HEX B                    DEC 11

The printer's vertical tabs have been given a default of every line with a maximum of 16 tab stop when set by the user.

## CANCEL CHARACTER

CAN                     HEX 18                   DEC 24

This command is no longer recognized by the printer as a valid function code.

## SET 6 LINES PER INCH LINE SPACING

ESC 2                   HEX 1B 32                DEC 27 50

This command no longer puts into effect the line spacing

changed by the ESC A command.  Its new use is to set line spacing to the default of 6 lines per inch.


## SET n/216 OF A DOT LINE SPACING
ESC 3 n                    HEX 1B 33 n              DEC 27 51 n

This command will set the vertical line spacing to n/216 of an inch, n may be in the range of 1-255.  A 0 will produce a line feed of 256/216 of an inch.

NOTE:  1/216 of an inch is equal to one step of the stepper motor, or 1/3 of a dot.  Due to the inconsistency of paper and the method of feeding the paper 1/3 line feed prints as approx. 1/2 of a dot.  It is recommended that you use a multiple of 1/216 or 3/216 line spacing, when in this line feed mode. Computers which can only pass 7 data bits to the printer are limited to a maximum of 127/216.


## SWITCH TO ITALICS CHARACTER SET
ESC 4                      HEX 1B 34                DEC 27 52

The italics character set may be printed in any of the twelve print modes.  They may also be turned on and off anywhere in your text.


## SET TRS-80 MODE
ESC :                      HEX 1B 3A                DEC 27 58

All the features of the printer may now be used while in the TRS-80 mode.  The only difference  between this and the standard mode is that the block graphics characters are shifted from Decimal 160 Hex A0 to Decimal 128 Hex 80.  The TRS-80 control codes listed on page 82 of the MX-80 users manual will no longer function.

NOTE:  DO NOT SET THE M.S.B WITH THE SET M.S.B COMMAND AND USE THIS MODE.  THE TRS-80 MODE WILL NOT WORK CORRECTLY IN THIS STATE.


## CANCEL TRS-80 MODE
ESC ;                      HEX 1B 3B                DEC 27 59

This command cancels the TRS-80 mode.


## HOME PRINT HEAD
ESC <                      HEX 1B 3C                DEC 27 60

This command causes the print head to return to home at

the left margin.  This mode is useful for computers which can't separate the carriage return from the line feed, and for printing unidirectional or any other need to position the print head to the left.  This is a one line command, and **WILL NOT** remain in effect for each line after it is issued.

## SET MOST SIGNIFICANT BIT
          ESC >                    HEX 1B 3E          DEC 27 62

        This command is useful to all users of 7 bit computers such as the APPLE ][.  The eighth bit or M.S.B.  is set in the printer to allow printing of the TRS-80 block graphic character set.  All ASCII codes sent to the printer will have the high order bit set to a one.
**NOTE:** THE M.S.B DOES NOT REMAIN SET WHEN ENTERING THE PRINTER ESCAPE SEQUENCES.

EXAMPLE: Set form length.
        [L]PRINT CHR$(27);"C";CHR$(88)
If the M.S.B. remains set while trying to process this command the printer will interpret the above as CHR$(155) CHR$(195) and CHR$(216).  A 155 is an Escape which would be correct. The 195 and the 216 are both TRS-80 block graphic characters.  The printer will not understand this as a set form length command, therefore ignores the M.S.B. when processing escape codes.

**NOTE:** DO NOT use the set M.S.B. command in the TRS-80 mode. It will not work properly and the results won't be desirable. TRS-80 users do not need to set the M.S.B., and other computer owners do not need to use the TRS-80 mode.

## TURN OFF MOST SIGNIFICANT BIT
          ESC =                    HEX 1B 3D          DEC 27 61

        Turns off the most significant bit in the printer.

## REDEFINE ESCAPE CODES
          ESC ? n1...n37      HEX 1B 3F n1..n37    DEC 27 63 n1..n37

        This command allows the user to redefine the escape sequences used to access the many features of the printer.  All of the commands are stored in the printer and the codes, once entered, will be in effect until the printer is reset or turned off.

                The order of the fields is as follows:
                        1       1/8" line feed
                        2       7/72" line feed
                        3       1/6" line feed
                        4       n/216" line feed
                        5       Italics on
                        6       Italics off

|     |                        |
|-----|------------------------|
| 7   | Not used               |
| 8   | Not used               |
| 9   | Ignore paper out       |
| 10  | Cancel ignore paper out|
| 11  | TRS-80 mode            |
| 12  | Cancel TRS-80 mode     |
| 13  | Home print head        |
| 14  | Clear M.S.B.           |
| 15  | Set M.S.B.             |
| 16  | Redefine escape codes  |
| 17  | Reset printer          |
| 18  | Line feed by dots      |
| 19  | Vertical tab set       |
| 20  | Set form length        |
| 21  | Horizontal tab set     |
| 22  | Emphasized print on    |
| 23  | Emphasized print off   |
| 24  | Double strike on       |
| 25  | Double strike off      |
| 26  | Not used               |
| 27  | Fast 960 graphics      |
| 28  | 480 graphics           |
| 29  | 960 graphics           |
| 30  | Not used               |
| 31  | Not used               |
| 32  | Not used               |
| 33  | Set condensed mode     |
| 34  | Cancel condensed mode  |
| 35  | Not used               |
| 36  | Set expanded mode      |
| 37  | Cancel expanded mode   |

An example of how to change the escape code used to access the MX-80's print modes, using basic is as follows:

```
10 [L]PRINT CHR$(27);"?";"A";"B";"N";"O";"Z";"*"......
```

The above example will do the following:

A. Send the Escape character to the printer to tell it that the following character is a printer command.

B. Send the "?" command character to the printer, which means the following 37 bytes (character) will reassign 37 default Escape codes to the users specifications.

1. The 1/8" line feed will now be invoked with an Escape "A" instead of an Escape "0"

2. The 7/72" line feed will now be invoked with an Escape "B" instead of an Escape "1"

3. The 1/6" line feed will now be invoked with an Escape "N" instead of an Escape "2"

4. The n/216" line feed will now be invoked with an Escape "O" instead of an Escape "3"

5. The Italic character set will now be invoked with an Escape "Z" instead of an Escape "4"

6. The cancel Italics command will now be invoked with an Escape "*" instead of an Escape "5"

To keep this example as short as possible all 37 bytes

were not used.  If you are going to use this redefine command,
you MUST provide all 37 bytes after the Escape "?".  Your
string of characters CAN NOT contain a Decimal 0 Hex 0 or a
Decimal 255 Hex FF.  IF YOU SUPPLY ONE OF THE TWO ABOVE CODES,
THE RESULTS WILL BE UNPREDICTABLE.


## RESET PRINTER
ESC @                    HEX 1B 40                DEC 27 64


        This command will cause the printer to reset all the modes
to their default settings.

**NOTE:**  THE TOP OF FORM WILL ALSO BE RESET.  YOU SHOULD ISSUE
A FORM FEED COMMAND BEFORE SENDING THE RESET COMMAND, TO
MAINTAIN THE CORRECT T.O.F.
        THIS COMMAND WILL NOT FUNCTION PROPERLY WHEN USED WITH A
SERIAL INTERFACE.


## SET LINE SPACING
ESC A n1                 HEX 1B 41 n1             DEC 27 65 n1


        The syntax of this command has not been changed.  The new
procedure for its use is as follows:
        1. It is no longer necessary to send an Escape "2" follow-
           ing the Escape "A"
        2. The command now takes immediate effect, upon receipt.
        3. The Escape "2" function now sets the line spacing to
           6 lines per inch.


## SET VERTICAL TABS
ESC B n1 n2..0!255  HEX 1B 42 n1 n2..    DEC 27 66 n1 n2..


        The maximum vertical tabs have been decreased to 16 tab
stops.  If a vertical tab command is performed before the tabs
are set, one line feed will be performed.
        You can no longer add 128 to the values used to set
vertical tabs.  In addition you must exit the tab set routine
with the value 0 or 255.  **DO NOT** USE THE VALUE 128 TO
TERMINATE THE VERTICAL TAB SET ROUTINE. IT WILL NO LONGER WORK.

ex. old   10 [L]PRINT CHR$(27);"B";CHR$(148);CHR$(158);
             CHR$(168);CHR$(128)

ex. new   10 [L]PRINT CHR$(27);"B";CHR$(20);CHR$(30);CHR$(40);
             CHR$(255)


        TRS-80 owners, using Basic, must POKE the values 0,10,11,
and 12 into their system.  The reason for this is, the Basic
Interpreter processes these codes, instead of passing them to
the printer port.

ex.        10 POKE 14312,0
           20 IF PEEK(14312)<>63 GOTO 20

**NOTE:**   YOU MAY NO LONGER TERMINATE THE VERTICAL TAB SET
ROUTINE WITH A DEC 128 HEX 80.   IT MUST NOW BE TERMINATED WITH
A DEC 0 HEX 00 OR DEC 255 HEX FF.

## SET FORM LENGTH
        ESC C n1            HEX 1B 43 n1            DEC 27 67 n1

        The maximum form length has been increased from 66 lines
per page to 255 lines per page.

**NOTE:**   WHENEVER THIS COMMAND IS ISSUED THE PRINTER WILL AUTO-
MATICALLY RESET THE TOP OF FORM.

## SET HORIZONTAL TABS
        ESC D n1 n2..0!255   HEX 1B 44 n1 n2..    DEC 27 68 n1 n2..

        The number of horizontal tabs has been decreased to 16 tab
stop maximum.   The default stops are every 8 print positions
after power on or reset.
        You can no longer add 128 to the values used to set
horizontal tabs.   In addition you must exit the tab set routine
with the value 0 or 255.   **DO NOT** USE THE VALUE 128 TO
TERMINATE THE HORIZONTAL TAB SET ROUTINE.   IT WILL NO LONGER
WORK.

ex. old   10 [L]PRINT CHR$(27);"D";CHR$(148);CHR$(158);
             CHR$(168);CHR$(128)

ex. new   10 [L]PRINT CHR$(27);"D";CHR$(20);CHR$(30);CHR$(40);
             CHR$(255)

        TRS-80 owners, using Basic must poke the values 0,10,11,
and 12 into their system.   The reason for this is, the Basic
interpreter processes these codes, instead of passing them to
the printer port.

ex.        10 POKE 14312,0
           20 IF PEEK(14312)<>63 GOTO 20

**NOTE:**   YOU MAY NO LONGER TERMINATE THE HORIZONTAL TAB SET
ROUTINE WITH A DEC 128  HEX 80.   IT MUST NOW BE TERMINATED WITH
A DEC 0 HEX 00 OR DEC 255 HEX FF.

## SET EMPHASIZED MODE
        ESC E              HEX 1B 45              DEC 27 69

        The emphasized print mode may be turned on or off anywhere

in your text and may be mixed with the double strike mode  on
the same line.


## CANCEL EMPHASIZED MODE
ESC F                HEX 1B 46              DEC 27 70

This command cancels the emphasized print mode.


## SET DOUBLE STRIKE MODE
ESC G                HEX 1B 47              DEC 27 71

The double strike print mode may be turned on or off any-
where in your text and may be mixed with the emphasized mode on
the same line.


## CANCEL DOUBLE STRIKE MODE
ESC H                HEX 1B 48              DEC 27 72

This command cancels the double strike print mode.


## BIT IMAGE GRAPHICS - 480 DOTS PER LINE
ESC K n1 n2          HEX 1B 4B n1 n2        DEC 27 75 n1 n2


**NOTE:** BIT IMAGE GRAPHICS WILL NOT FUNCTION WITH THE EPSON
8141 SERIAL INTERFACE, BUT WILL FUNCTION PROPERLY WITH THE
EPSON 8150 SERIAL INTERFACE.

This command puts the printer into the bit image graphics
mode.  A maximum of 480 columns of dots may be placed on one
line.  The text and graphics may be mixed on the same line.

ex. text....graphics....text....graphics....text...graphics
-----------------------------480 dots -----------------------

The variable n1 may be in the range of 0-255.  This value
specifies the number of horizontal dots to be printed on a
line.  If the variable n2 is equal to 1 this means to add the
value 256 to n1, if n2 is equal to 0 or 255 this means DO NOT
add 256 to n1.

ex. [L]PRINT CHR$(27);"K";CHR$(50);CHR$(0);

This will tell the printer that the next 50 characters it
will receive should be printed as bit image graphics.

n1=50 n2=0
50
+00
50

-16-

ex. [L]PRINT CHR$(27);"K";CHR$(50);CHR$(1);


    This will tell the printer that the next 306 characters it will receive should be printed as bit image graphics.

                    n1=50 n2=1
                        50
                     +256
                      306


    Computers that are only capable of outputting 7 data bits such as the APPLE ][ may only produce line lengths from 0-127 and 256-383 in the 480 graphics mode. Any computer capable of producing all 8 data bits may produce line lengths from 0-480. (The maximum number of dots is 480 per line in this mode)


    ASCII characters may be broken into binary as follows.

                    |128| 64| 32| 16|  8|  4|  2|  1|
        DEC 1     =|  0 |  0 |  0 |  0 |  0 |  0 |  0 |  1 |

                    |128| 64| 32| 16|  8|  4|  2|  1|
        DEC 2      |  0 |  0 |  0 |  0 |  0 |  0 |  1 |  0 |

                    |128| 64| 32| 16|  8|  4|  2|  1|
        DEC 201    |  1 |  1 |  0 |  0 |  0 |  1 |  1 |  1 |


    The binary "bits" correspond to the needles in the print head, as shown below.

        TOP       |128| 64| 32| 16|  8|  4|  2|  1|

         O
         O
         O
         O
         O
         O
         O
         O
         O
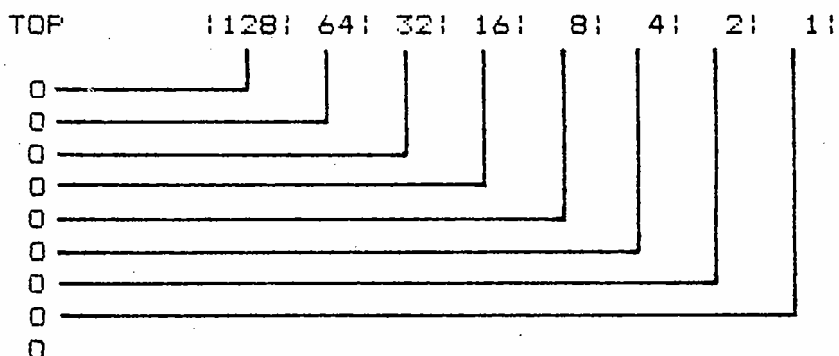
**NOTE:** DUE TO THE FACT THAT A CHARACTER IS MADE UP OF 8 DATA BITS, THE BOTTOM NEEDLE OF THE PRINT HEAD CAN NOT BE ADDRESSED.

    If you were to send a decimal 1 (00000001) to the printer in the bit image graphics mode, only the second from the bottom needle would fire, and print one dot. A decimal 2 (00000010) would cause the third from the bottom needle to fire. A decimal 3 (00000011) would cause the second and third from the bottom needles to fire.... and so on.

    This will take some practice to "master" but once you have

worked with it for a while it will become much easier.

Some computers will not be able to send certain control codes to the printer due to the "features" of their system.

## APPLE ][

The APPLE will not pass the Decimal 9 Hex 09 or Decimal 13 Hex 0C to the printer correctly. These codes should be avoided unless you use a poke to Decimal location 49296 Hex C090. (if your printer is in slot number 1).

```
10 PR# 1
20 PRINT   CHR$ (27);"K";
30 POKE 49296,50
40 IF  PEEK (49601) < 0 GOTO 40
50 PRINT CHR$ (0);
60 FOR I=1 TO 50
70 POKE 49296,9
80 IF PEEK (49601) < 0 GOTO 80
90 NEXT I
100 PRINT
110 END
```

The above program does the following:

LINE 10 turns on slot number 1, the slot where the printer controller is plugged in.
LINE 20 tells the printer to enter graphics mode. Note the semi-colon at the end of this line tells the computer not to send a carriage return and a line feed.
LINE 30 tells the computer to send a decimal 50 to the printer controller, bypassing basic. Location 49296 is the address in the computer from where the printer receives data.
LINE 40 reads a special location in the printer controller card, which tells when the printer has picked up the data. When Decimal location 49601 Hex C1C1 is negative (bit 8 set), there is a character waiting to be picked up by the printer. When the data in location 49296 is picked up by the printer location 49601 becomes positive (bit 8 is turned off).
LINE 50 sends a decimal zero to the printer. Note the semi-colon at the end of the line.
LINE 60 sets up a variable loop which will range from 1 to 50.
LINE 70 places the ASCII character 9 into the computer's output location for slot 1.
LINE 80 tests to see if the printer has received the data.
LINE 90 checks to see if the variable I is at its maximum.
LINE 100 Empties the print buffer.
If yes, the program ends. If not, it adds 1 to the variable I and branches back to line 70.

## RADIO SHACK TRS-80 MODEL I

The MODEL I cannot send a decimal 0,10,11, or 12. These codes should be avoided while using basic. Unfortunately, the

zero cannot be avoided. You can substitute 255 for n2 and the
printer will treat it as the value zero. The example below
will show you how to poke a zero out to the printer driver.

```
10 LPRINT CHR$(27);"K";
20 POKE 14312,50
30 IF PEEK(14312)<>63 THEN GOTO 30
40 POKE 14312,0
50 IF PEEK(14312)<>63 THEN GOTO 50
60 FOR I=1 TO 50
70 LPRINT CHR$(1);
80 NEXT I
90 END
```

The above program does as follows:
LINE 10 sends an Escape K, which tells the printer to
enter the bit image graphics mode. Note the semi-colon which
tells the computer not to send a carriage return and line feed.
LINE 20 tells the computer to send a decimal 50 to the
printer, bypassing Basic.
LINE 30 tests to see if the printer has accepted the data.
If not, the program will keep testing until the printer accepts
the data.
LINE 40 sends a decimal zero to the printer. This tells
the printer not to add 256 to the previous byte (n1).
LINE 50 same as 30
LINE 60 set up a variable loop which ranges from 1 to 50.
LINE 70 prints the ASCII character 1 (the second from the
bottom needle of the print head). Note the semi-colon at the end
of the line.
LINE 80 checks to see if the variable I is equal to its
maximum. If yes, the program ends. If not, it adds 1 to I and
branches back to line 60.
This is a method to obtain a solid underscore using dot
graphics, and shows how to send a zero with a TRS-80 MODEL I.

As noted earlier in the text, the maximum number of dots
on one line is 480. If you plan to mix text and graphics on
the same line, you must figure out how many dots your text
takes up. This must be done to see how many dot columns are
left over for bit image graphics. The table below shows how
to calculate the number of dots per character.

```
NORMAL SIZE = 10    CPI = 6 DOTS PER CHARACTER OR SPACE
CONDENSED   = 16.5 CPI = 3 1/2 DOTS PER CHARACTER OR SPACE
EXPANDED    = 5    CPI = 12 DOTS PER CHARACTER OR SPACE
CONDEN/EXPA.= 8.25 CPI = 7 DOTS PER CHARACTER OR SPACE
```

ex.        25 characters of normal size text

```
25 X 6   =150
480 - 150 =330
```

This will leave you with 330 dot columns left over to be
used for dot graphics or more text on the same line.

**NOTE:** IF YOU SPECIFY MORE THAN 480 DOT COLUMNS PER LINE,

NOTHING WILL BE PRINTED AND THE PRINTER WILL ENTER AN ERROR
CONDITION, RING THE BELL 8 TIMES, AND HANG.  TO CLEAR THIS
CONDITION TURN THE PRINTER OFF AND BACK ON AGAIN AND CORRECT
YOUR PROGRAMMING ERROR.

## LINE SPACING WITH DOT GRAPHICS


        One dot is equal to 3/216 or 1/72 of an inch.  When you
are working with 8 dots vertically at a time, normal line
spacing should be 24/216 or 8/72, depending on if you are using
Escape "A" or Escape "3".  For 7 dots at a time (APPLE), use
21/216 or 7/72 line spacing.

ex.        10 [L]PRINT CHR$(27);"3";CHR$(24)
                                        BOTH ARE = TO 8 DOTS.
           10 [L]PRINT CHR$(27);"A";CHR$(8)

        This will place each row of 8 dots one right next to each
other vertically.



**NOTE:**  WHEN EVER THE LINE SPACING IS CHANGED FROM ANYTHING
BUT 6 LPI THE PRINTER WILL LOSE TRACK OF TOP OF FORM.



## BIT IMAGE GRAPHICS 960 DOTS PER LINE
        ESC L n1 n2          HEX 1B 4C n1 n2        DEC 27 76 n1 n2

        This command is identical to the 480 dot graphics mode
(ESC K), with the following exceptions.

        If n2 = 2 then 512 is added to n1.

ex.        10   [L]PRINT CHR$(27)"L";CHR$(40);CHR$(2);

                            40
                          +512
                          ---
                          552
        This tells the printer to print the next 552 bytes as bit
image graphics.

        If n2 = 3 then 768 is added to n1.

ex.        10   [L]PRINT CHR$(27)"L";CHR$(123);CHR$(3);

                            124
                          +768
                          ---
                          892
        This tells the printer to print the next 892 bytes as bit
image graphics.


**NOTE:**  IF n2 IS GREATER THAN 3 OR IF n1 IS GREATER THAN 192,
AND n2 IS EQUAL TO 3, THEN THE PRINTER WILL ENTER AN ERROR
CONDITION.  THIS ERROR CONDITION MAY BE CLEARED BY TURNING THE
PRINTER OFF AND BACK ON AGAIN.

The difference between printing 480 dots per line and 960 dots per line is as follows

OOOOOOO   = 480 dots per line.

The dots are printed with one dot spacing between them in this mode

(((((((   = 960 dots per line.

The dots are printed with no space in between and there is a slight overlap of the dots.

Printing in the 960 bit image mode is performed at half the speed of the 480 bit image mode.


## BIT IMAGE GRAPHICS 960 DOTS PER LINE AT 480 SPEED

| ESC J n1 n2 | HEX 1B 4A n1 n2 | DEC 27 74 n1 n2 |
|---|---|---|

This mode may only be used by high speed assembly language driver routines.  Basic interpreters are too slow in execution to print in this mode.  If you try this mode using Basic you will loose many of the dots on each line.

When using this high speed mode there is still another restriction.  The same needle may not be struck twice in a row. The reason for this is the needles take 2 microseconds to hit and return to seat.  Printing at 480 speed the print head passes over a dot position every 1 microsecond.  For this reason it is impossible to strike the same needle twice in a row at this high speed.  If you attempt to strike the same needle twice in a row the printer will automatically toss away the second consecutive dot.  The printer will also print bi-directionally in this mode.  It should be noted that there is some misalignment between passes of the printhead from opposite directions.  This will vary from printer to printer and must be compensated for with computer software.


## SET CONDENSED PRINT MODE

| SI | HEX 0F | DEC 15 |
|---|---|---|
|  | OR |  |
| ESC P | HEX 1B 50 | DEC 27 80 |

This mode may now be turned on and off anywhere in your text, and mixed with normal and expanded characters.  A wider than normal gap may occur between normal and condensed width characters, or condensed and expanded characters.  This is due to the fact that condensed characters are not an even multiple of dots across, compared to normal or wide characters.

```
NORMAL   = 5    CPI
EXPANDED = 10   CPI
CONDENSED= 16.5 CPI
```

The above also holds true for the condensed expanded set of characters.

## CANCEL CONDENSED PRINT MODE

| | | |
|---|---|---|
| DC2 | HEX 12 | DEC 18 |
| | OR | |
| ESC Q | HEX 1B 51 | DEC 27 81 |

Cancels the condensed print mode.

## EXPANDED PRINT MODE

| | | |
|---|---|---|
| SO | HEX OE | DEC 14 |
| | OR | |
| ESC S | HEX 1B 53 | DEC 27 83 |

This mode has not been changed with graftrax. The only difference is that it may now be entered with the ESC S.

## CANCEL EXPANDED PRINT MODE

| | | |
|---|---|---|
| DC4 | HEX 14 | DEC 20 |
| | OR | |
| ESC T | HEX 1B 54 | DEC 27 84 |

This command cancels the expanded print mode. If the expanded print mode is not cancelled with this command it will automatically cancel at the end of the line.

# SPECIAL NOTES

When any change is made to the print mode (except the double width and Italics modes), the printer will perform a home print head to the left margin. The reason this feature was implemented, was to allow the changes in the print modes on the same line. If you change print modes on every line the printer will print unidirectionally.

The self test mode is entered by holding down the line feed switch and turning the printer's power on. The self test will work in two ways.
A. If the slashed zero switch (sw 1-7) is off, the self test mode will work as always.
B. If the slashed zero switch (sw 1-7) is on, the test will show all the printer's characters, including the italics and the slashed zero.

The printer has an error mode. This is activated in one of two ways:
A. If the print head should be stopped from moving for some unknown reason, the printer will stop printing, and sound the alarm 8 times.
B. If the number of bytes specified in the text and graphics mode (480 for 480 mode, and 960 for 960 mode) exceeds the maximum number allowed, the printer WILL NOT print the graphics line and will sound the alarm 8 times.

Both error conditions will only be cleared by powering the printer off and then back on again.

The horizontal and vertical tab set routines no longer can have 128 added to the parameters. The tab set ending marker must now be a Decimal 0, Hex 0, or Decimal 255, Hex FF to function correctly. If 128 is added to any of the fields the command will not function properly, and must be avoided.

The high order byte (n2), for entering the dot graphics mode, must be a 0 or 1 for 480 mode or 0,1,2,or 3 for 960 mode. For users who cannot enter a 0 you may substitute 255 for this field. The printer will treat 255 as 0, for the n2 portion of the field only.

When using the condensed print mode, do not change to the emphasized print mode, without first canceling the condensed mode. If you attempt to change to the emphasized print mode without first canceling the condensed mode some of your text will be over printed.

BIT IMAGE GRAPHICS WILL NOT FUNCTION WITH THE EPSON 8141 SERIAL INTERFACE. IF YOU WISH TO USE THE GRAPHICS PORTION OF GRAFTRAX-80 YOU MUST USE THE EPSON 8150 SERIAL INTERFACE BOARD.

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