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MM 1201 and MM 961

Technical Reference

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"This equipment generates and uses radio frequency and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been tested and found to comply with the limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio and television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

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If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications commission helpful:

"How to Identify and Resolve Radio-TV Interference Problems."

This booklet is available from the U.S. Government Printing Office, Washington, D.C. 20402, Stock No. 004-00-00345-4."

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Preface

This book provides technical information on the MM series of digitizers. It is for readers who have a general knowledge of computers and computer terminology.

The "Quick Reference Sheet of Specifications" is included in the rear of this book as a guide to default settings and other specifications. Table 11, Command Formats, provides a complete list of all MM commands, with their ASCII, hexadecimal, and binary equivalents.

For your convenience, site preparation and service information are included in Section E, "Site Preparation, Assembly, and Care".

Revision Information

This manual replaces an earlier manual of the same title (document number 84-DM11-630) published in June, 1983.

Nearly every page of this book has undergone at least small changes; the data formats descriptions in Section B, and all of Section C have been substantially rewritten for clarity and to include the following new material:

- Eight-bit and ASCII BCD data formats
- Automatic Baud Rate feature
- Set Tablet Origin command for MM 1201
- Higher and lower resolutions than previously available
- Grid Round Off command
- Check Code diagnostic command
- Jumper selection of certain features

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INTRODUCTION

A digitizer is an input device. It allows you to translate graphic information, such as maps, drawings, or video images, into digital information suitable for a digital device, such as a computer or a computer terminal.

The MM series of digitizers are tablets whose surface is flat, except for a narrow groove. Within the groove is the "active area" for digitizing. The active area represents a Cartesian plane in that X,Y coordinates (coordinate pairs) identify points on it. This document sometimes refers to these coordinate pairs as, simply, "data".

"Digitizing" is locating points by moving a device (either a cursor or a stylus) over the tablet's active area. The cursor operates when it is within a "proximity" of one half inch to the digitizer. The stylus operates when it is within a proximity of one quarter inch to the digitizer.

When you attach the digitizer to your computer, you must program your computer to communicate with it.

SECTION A - HARDWARE COMPONENTS

The standard hardware components of an MM digitizer are a tablet, its tilt mounting, a power and data cable, and a stylus or cursor. See the "MM Digitizer Components and Assembly" drawing on page 21. The MM's components are described below:

COMPONENTS	DESCRIPTIONS
tablet	a device that provides an area for digitizing.
tilt mounting	a support attached to the back of the tablet. The Model 961 tilts either four and one half degrees or five and one half degrees, depending on its orientation. The Model 1201 tilts zero degrees, between four and six degrees, or between ten and fourteen degrees, depending on whether or not you use the tilt mechanism, and how you position it.
power and data cable	a six foot (approximately two meter) cord and plug that connect the digitizer to its host device for communications and power. Refer to Section B for interfacing information.
cursor	a device with a clear plastic base with cross hairs for accurately sighting points. The cursor has three buttons. It is attached to a forty-inch cable. A four-button cursor is available as an option.
stylus	a device that is held like a pen. The stylus has one switch on its barrel and one that is activated by its tip. It comes with a non-marking refill; an optional marking tip is available in blue. The stylus is attached to a forty-inch cable.

SECTION B - INTERFACING TO A COMPUTER

The MM 961 and 1201 digitizers come with either a TTL interface or an EIA RS-232-C interface. Both are full duplex, asynchronous, serial interfaces. Each uses an RS-232-C protocol. They differ in their voltage levels and the number of pins in their connectors. (The appropriate connector is attached to your power and data cable at the factory.)

On special order, either interface can be adapted to operate from a power supply of +15 volts (for the TTL interface) or +/-15 volts (for the EIA RS-232-C interface).

Baud Rate

The baud rate is the number of bits transmitted each second. It is set at 9600. An Automatic Baud Rate is available as an option; it offers computer-selectable rates of 75 to 19,200 (see Table 11, "Command Formats", for the Automatic Baud Rate command format).

Data Output Format

Three data formats are available: packed binary, the three-byte Delta format, and ASCII BCD format. Each of these three formats can use either 9-bit bytes, which contain a parity bit, or eight-bit bytes with no parity. The data and byte formats are jumper selectable; if you wish to change the format, refer to Section E for jumpering information.

- Packed Binary Format: The digitizer and host communicate in packed binary format. If you choose it, each 9-bit byte includes a parity bit (parity is odd). If you choose no parity, each byte contains eight bits. Each byte is framed by one start bit (a logical high or space) and by one stop bit (a logical low or mark). Data is output from the digitizer to the host in five bytes. Output data is transmitted beginning with the least significant bit; the most significant bit is reserved for the phasing bit. This allows fourteen bits for coordinate data. Table 1 charts the packed binary format.

- Delta Mode and Packed Binary: Packed binary format with Delta Mode on contains only three bytes, and the coordinates it reports are relative to the last cursor or stylus position, rather than absolute coordinate positions. Table 2 charts the Delta Mode packed binary format. (Delta Mode is a program-selectable data collection mode explained in Section C.)

- ASCII BCD Format: In this format, the decimal coordinate data are transmitted as ASCII digits. The ASCII digits are of course transmitted as binary codes; thus the format is known as Binary Coded Decimal, or ASCII BCD. The format uses from 13 to 17 bytes, depending on the resolution you have selected. The ASCII BCD format is shown on page 7 (MM 1201) and page 8 (MM 961).

ASCII BCD is made up of nine-bit bytes (if parity is odd) or eight-bit bytes (if no parity). The seven least significant bits represent the character, the eighth bit is zero, and the ninth bit (if used) is the parity bit.

- Delta Mode and ASCII BCD: ASCII BCD format with Delta Mode on differs from other modes only in that the coordinates it reports are relative to the last cursor or stylus position, rather than absolute coordinate positions. The ASCII BCD formats on pages 7 and 8 include the Delta Mode versions.

The packed binary format for data output is charted below:

Table 1
Packed Binary Data Output Format

Stop Bit	P	7	6	5	4	3	2	1	0	Start Bit
1	P	1	Px	T	Sx	Sy	Sw3	Sw2	Sw1	0
1	P	0	X6	X5	X4	X3	X2	X1	X0	0
1	P	0	X13	X12	X11	X10	X9	X8	X7	0
1	P	0	Y6	Y5	Y4	Y3	Y2	Y1	Y0	0
1	P	0	Y13	Y12	Y11	Y10	Y9	Y8	Y7	0

Key:

P = parity (odd; no parity in 8-bit format)
Px = proximity:
0 = in proximity
1 = out of proximity
T = Tablet Identifier, either 0 or 1 (for dual tablet configurations)
See Table 6, "Command Formats", for its remote settings.
Sy,Sx = sign bit, always 1
Sw3 = 1 : (stylus N/A) cursor button #3 pressed
Sw2 = 1 : stylus barrel switch pressed, cursor button #2 pressed
Sw1 = 1 : stylus pen tip pressed, cursor button #1 pressed
X0-13 = X coordinate bits, where X0 is the least significant bit
Y0-13 = Y coordinate bits, where Y0 is the least significant bit

Table 2 charts the packed binary data format as modified by Delta Mode:

Table 2
Delta Mode - Packed Binary Data Output Format

Stop Bit	P	7	6	5	4	3	2	1	0	Start Bit
1	P	1	Px	T	Sx	Sy	Sw3	Sw2	Sw1	0
1	P	0	X6	X5	X4	X3	X2	X1	X0	0
1	P	0	Y6	Y5	Y4	Y3	Y2	Y1	Y0	0

Key:

P = parity (odd; no parity in 8-bit format)
Px = proximity,
0 = in proximity, 1 = out of proximity
T = Tablet Identifier, either 0 or 1 (for dual tablet configurations)
See Table 6, "Command Formats", for its remote settings.
Sy,Sx = sign bit
1 = positive
0 = negative
Sw3 = 1 : (stylus N/A) cursor button #3 pressed
Sw2 = 1 : stylus barrel switch pressed, cursor button #2 pressed
Sw1 = 1 : stylus pen tip pressed, cursor button #1 pressed
X0-13 = X coordinate bits, where X0 is the least significant bit
Y0-13 = Y coordinate bits, where Y0 is the least significant bit

ASCII BCD Data Format for the MM 1201

The ASCII BCD data format appears as follows for the MM 1201 with the resolution you have chosen (MM 961 ASCII BCD format appears on the following page):

All modes except Delta Mode:

1 to 508 lpi:	1000 lpi and 40 lpmm (1016 lpi):
XXXX,YYYY,F CR LF	XXXXX,YYYYY,F CR LF

Delta Mode:

1 to 508 lpi:	1000 lpi and 40 lpmm (1016 lpi):
S0XXX,S0YYY,F CR LF (First digit zero.)	S00XXX,S00YYY,F CR LF (First two digits zero.)

Key:

- S - Coordinate sign: "+" for all modes except Delta Mode. Under Delta Mode it may be "+" or "-".
- X - A digit of the X coordinate, where each digit is an ASCII character, 0 through 9.
- Y - A digit of the Y coordinate, where each digit is an ASCII character, 0 through 9.
- , - ASCII comma, the delineator character.
- F - Flag character. Identifies the status of the stylus switches or cursor buttons:
  - 0 = No buttons pressed.
  - 1 = Cursor: right-most button pressed.
    Stylus: switch at tip pressed.
  - 2 = Cursor: middle button pressed.
    Stylus: switch on barrel pressed.
  - 4 = Cursor: left-most button pressed.
  - 3 = Cursor: right and middle buttons pressed.
    Stylus: both switches pressed.
  - 5 = Cursor: left and right buttons pressed.
  - 6 = Cursor: middle and left buttons pressed.
  - 7 = Cursor: all three buttons pressed.
- CR - Carriage return.
- LF - Line Feed.

ASCII BCD Data Format for the MM 961

The ASCII BCD data format appears as follows for the MM 961 with the resolution you have chosen (MM 1201 ASCII BCD format appears on the previous page):

All modes except Delta Mode:

1 to 1016 lpi: XXXX,YYYY,F CR LF

Delta Mode:

SOXXX,SOYYY,F CR LF (First digit of each coordinate zero.)

Key:

S - Coordinate sign: "+" for all modes except Delta Mode. Under Delta Mode it may be "+" or "-".

X - A digit of the X coordinate, where each digit is an ASCII character, 0 through 9.

Y - A digit of the Y coordinate, where each digit is an ASCII character, 0 through 9.

, - ASCII comma, the delineator character.

F - Flag character. Identifies the status of the stylus switches or cursor buttons:

- 0 = No buttons pressed.
- 1 = Cursor: right-most button pressed.
  Stylus: switch at tip pressed.
- 2 = Cursor: middle button pressed.
  Stylus: switch on barrel pressed.
- 4 = Cursor: left-most button pressed.
- 3 = Cursor: right and middle buttons pressed.
  Stylus: both switches pressed.
- 5 = Cursor: left and right buttons pressed.
- 6 = Cursor: middle and left buttons pressed.
- 7 = Cursor: all three buttons pressed.

CR - Carriage return.

LF - Line Feed.

Signal Levels

Tables 3 and 4 below illustrate the signal level definitions for data transmissions.

Table 3
RS-232-C Signal Level Definitions*

	Interchange Voltage	
EIA RS-232-C Interface	-3V to -12V	+3V to +12V
Binary states	1	0
Signal condition	Mark	Space
Function	Off	On

Table 4
TTL Signal Level Definitions*

	Interchange Voltage	
TTL Interface	0V to 0.8V	2.4V to 5V
Binary states	1	0
Signal condition	Mark	Space
Function	Off	On

* EIA Standard RS-232-C: Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange, by the Engineering Department of the Electronic Industries Association (Washington, D.C.: EIA, 1969) is the source for Table 3 (Table 4 has the same format because the TTL interface operates similarly). Refer to that publication for definitions of the terms used in these tables.

Connector Pin Assignments

The interface cable is a single, shielded cable. The TTL interface cable has a single 9-pin "D" male connector. The EIA RS-232-C interface cable has a single 25-pin "D" male connector. Refer to Tables 5 and 6 below for the pin assignments.

Table 5
TTL Interface Pin Assignments

Pin *	Wire Name	Description
1	Protective ground	Frame ground
2	Transmitted data	Serial data from tablet to computer
3	Received data	Serial data and commands from computer to tablet
7	Signal ground	Return for serial data and power
9	+12V supply	Power for tablet from computer: 0.25A at 10% regulation

* Pins not shown are not connected.

Table 6
EIA RS-232-C Interface Pin Assignments

Pin *	Wire Name	Description
1	Protective ground	Frame ground
2	Transmitted data	Serial data from tablet to computer
3	Received data	Serial data and commands from computer to tablet
7	Signal ground	Return for serial data and power
9	+12V supply	Power for tablet from computer: 0.25A at 10% regulation
15	-12V supply	Power from computer: 0.1A, 10% regulation for RS-232-C driver

* Pins not shown are not connected.

SECTION C - OPERATING CHARACTERISTICS

How an MM Operates

The MM translates the movement of its stylus or cursor into digital information and communicates the information to your computer (the MM's host). The units of movement on the digitizer pad are called lines or counts of resolution; by default there are 500 lines of resolution per inch (lpi) in each direction (X and Y) on the MM pad. This resolution can be adjusted by command from the host.

As it is collected, data is formatted and is sent to your computer as binary numbers relating to the distance and direction moved in the X (horizontal) or Y (vertical) direction. This manual refers to these numbers as X,Y coordinates (coordinate pairs), and their transmission is referred to as an output report.

As the cursor/stylus leaves proximity, only three coordinate pairs (the same as the last in-proximity pair) are transmitted (with the out-of-proximity flag on). Then the MM will stop transmitting until the corsor or stylus comes back into proximity. However, if a cursor or stylus switch is depressed while the cursor is out of proximity, then the last data collected within proximity are transmitted (still with the out-of-proximity flag on).

The MM digitizers have twenty-one operating characteristics, which can be set by remote commands from the host. This section describes seventeen operating characteristics and provides all their command formats.

Four diagnostic operating characteristics and their commands are described in Section D.

Baud Rate

The baud rate is the number of bits transmitted each second. The standard MM baud rate is 9600, set at the factory. However, with the optional Automatic Baud Rate feature, the MM matches its host computer's baud rate within the range of 75 to 19,200 bits each second.

An MM with the factory-set baud rate requires no procedure at power-up to set the baud rate.

Every time it is powered up, an MM with the Automatic Baud Rate feature must first be set to the correct baud rate to communicate

with its host. To set the baud rate, send the MM an ASCII SPACE character. The MM calculates the baud rate by timing that character. Once it has done so, the MM is then operational, with other operating characteristics initially set to the default parameters.

If the Automatic Baud Rate feature is on, ASCII SPACE must be the first character sent to the MM after power-up. Note, however, that the Reset command does not affect the baud rate.

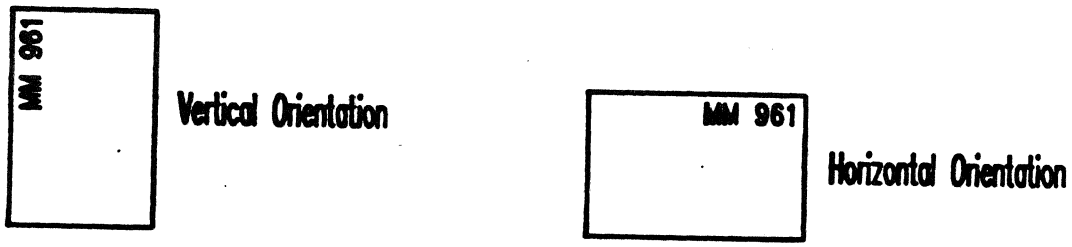
Origin

The origin is the point on the tablet where the X,Y coordinates are 0,0.

On the MM 961, Set Tablet Origin sets the tablet for use either horizontally (9" x 6") or vertically (6" x 9"), with the 0,0 point in the lower left corner in either case. The default orientation is vertical. (See Figure 1.)

On the MM 1201, the origin can be set to the lower left corner or the upper left corner. The lower left corner is the origin's default location.

Figure 1
Vertical and Horizontal Orientation (Model 961)



On the 961, the tablet's orientation is vertical on power-up or Reset. Send an ASCII b to set the orientation to horizontal; send an ASCII c to re-orient the tablet vertically.

The 1201 has its origin in the lower left corner on power-up or Reset. Send an ASCII b to set the origin to the upper left corner; an ASCII c will return the origin to the lower left corner.

Coordinate Output Rate

The Coordinate Output Rate is the number of coordinate pairs which the digitizer collects and transmits each second. Available rates are 2, 20, 50, and 100.

The default coordinate output rate is 100. To change it, issue the appropriate ASCII character, as follows:

Table 7
Coordinate Output Rate Commands

Coordinate Output Rate (pairs per second)	ASCII Command
2	T
20	S
50	R
100	Q

Data Collection Modes

The seven Data Collection Modes described below govern the ways that the digitizer collects data. The default is Switch Stream Mode. In brief, the data collection modes are:

Stream
Switch Stream
Point
Remote Request
Delta
Incremental
Axis Update

Stream Mode

In Stream Mode, the digitizer collects data continuously as long as the cursor or stylus is within proximity, even if a cursor button or a stylus switch is not pressed. (Proximity is the maximum distance a cursor or stylus can be held from the tablet while collecting correct data.)

To select Stream Mode, issue an ASCII @.

Switch Stream Mode

In Switch Stream Mode, the digitizer collects data continuously only if a cursor button or a stylus switch is pressed.

Switch Stream is the default mode; to change back to it, issue an ASCII A. Hold down a cursor button or the stylus switch to collect coordinate pairs. Releasing the button or switch ends the data stream.

Point Mode

Point Mode causes the digitizer to collect each coordinate pair individually when a point is identified by pressing a cursor button or a stylus switch.

To select Point Mode, issue an ASCII B. Press a cursor button or the stylus switch to transmit a coordinate pair.

Remote Request Mode

Remote Request Mode means that the tablet sends data only upon the host's request. (Note that if requested, a coordinate pair will be sent even when the cursor or stylus is out of proximity; in this case an out-of-proximity flag is sent along with the data.)

Select this mode with an ASCII D; then use the ASCII P (Remote Request command) as needed to request the digitizer to send a coordinate pair.

Delta Mode

Delta Mode means that the MM digitizer performs like a "mouse". It sends the host the distance and direction from the last point digitized instead of the absolute coordinate position.

An ASCII E selects Delta Mode. Refer to Section B for the Delta data format.

Increment Mode

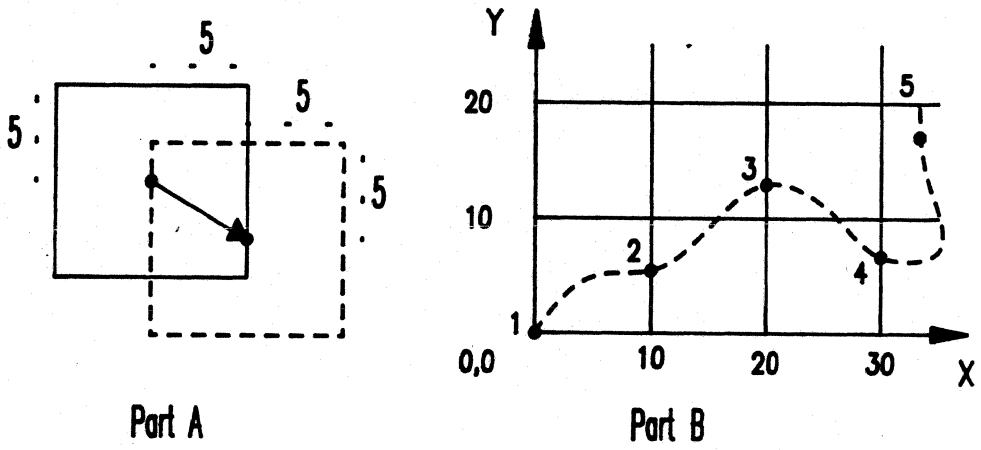
Increment Mode allows the digitizer to send a new coordinate pair only when the cursor or stylus has traveled a minimum (selectable) distance through either the X or the Y axis (positive or negative direction). Once transmitted, this point is at the center of an imaginary square whose sides are twice the increment value. Thus, without transmitting a coordinate pair, the cursor can move

anywhere inside the imaginary square. As soon as the distance requirement is satisfied along one axis, the MM transmits the actual X and Y coordinates of the point. This point then defines the center of a new imaginary square.

If a point is requested before the cursor or stylus has traveled the minimum incremental distance along at least one axis, the last value transmitted is sent again.

Figure 2 illustrates operation in this mode. Part A shows the imaginary square created around each point transmitted; the set increment distance equals 5. Part B shows the actual points collected as the cursor or stylus travels across the tablet; here, the set increment distance equals 10.

Figure 2
Increment Mode Example



The five points collected in part B are numbered in order. The set increment distance equals 10.

1 = (0,0)
2 = (10,5) - Only X is satisfied. The actual value of Y is transmitted.

No point is transmitted between points 2 and 3 because the cursor or stylus did not move 10 lines (or counts) in either the X or the Y direction. (If a point were requested, the coordinates for point 2 would be re-transmitted.)

3 = (20,13) - The increment is satisfied from the last point along the X axis only; the MM transmits the new coordinates.
4 = (30,7) - The increment is satisfied from the last point along the X axis only; the MM transmits the new coordinates.
5 = (32,17) - The increment is satisfied from the last point along the Y axis only; the MM transmits the new coordinates.

An increment value can be set to any integer in the range 0 to 90; the default value is zero. The increment distance is the product of the increment value multiplied by a single line of resolution. (For example, if the resolution is set to 500 lpi and the increment is 10, a single line of resolution is equivalent to one five-hundredth of an inch, and the increment distance is 1/50th of an inch.)

To program the Increment Mode, send an ASCII I followed by the increment value. To avoid possible confusion with ASCII control characters, add 32 (decimal, equivalent to 20 hexadecimal) to the value before transmitting it.

For example, to set the increment value to 10, add 10 + 32, and convert to hex (2A). The command you transmit is thus: I 2A .

To change back to the default increment value of zero, send the command I SP (where the second character is an ASCII SPACE).

Hint: Set the increment value to 1 in Stream Mode to eliminate redundant data while keeping the full resolution.

Axis Update Mode

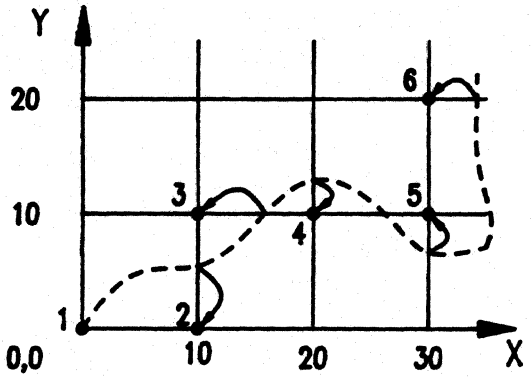
Like Increment Mode, Axis Update Mode causes the digitizer to output a coordinate pair only when a set distance is satisfied in either the X or Y direction (or in both at once). The last coordinate pair is retransmitted if a button or switch is pressed before the increment distance is satisfied.

Unlike Increment Mode, Axis Update sends the last transmitted value for the axis on which the update value was not satisfied.

Every time the cursor or stylus returns to proximity, the MM uses the first point it collects as its reference. Note that for small axis update values at high resolutions, as the cursor or stylus approaches the tablet surface, it is possible that the MM will transmit more than one point. Under these conditions it is best to set the cursor or stylus at a desired reference point and then begin Axis Update Mode.

Figure 3 illustrates the series of points transmitted in an example where (0,0) is the first point found in proximity.

Figure 3
Axis Update Example



The five points collected are numbered in order. The Axis Update distance equals 10.

1	=	(0,0)	
2	=	(10,0)	- Only X is satisfied Y retains its last value
3	=	(10,10)	- Only Y is satisfied X retains its last value
4	=	(20,10)	- Only X is satisfied Y retains its last value

No point is collected between 4 and 5 because the same value is never transmitted consecutively.

5	=	(30,10)	- Only X is satisfied Y retains its last value
6	=	(30,20)	- X retains its last value Only Y is satisfied

The update value can be any integer between 0 and 90; the update distance is the product of this value and a single line of resolution. For example, if the update value is 20 and the resolution was set to 500 lpi, a single line of resolution is equivalent to one five-hundredth of an inch, and the update distance is twenty five-hundredths of an inch, or 1/25th of an inch. The default update value is zero.

To program Axis Update Mode, send an ASCII G followed by the update value. To avoid possible confusion with ASCII control characters, add 32 (decimal, equivalent to 20 hexadecimal) to the value before transmitting it.

For example, to set the update value to 20, add 20 + 32, and convert to hex (34). The command you transmit is thus: G 34 .

Controlling Resolution

Resolution is the smallest distance that the digitizer distinguishes. It is measured in lines per inch (lpi) or lines per millimeter (lpmm). Three commands are available to control the MM's resolution: Resolution, Grid Roundoff, and Set X,Y Scale.

Resolution

Resolutions accessible via the Resolution commands are 100, 200, 400, 500, and 1000 lpi, and 10, 20, and 40 lpmm (the equivalents of 254, 508, and 1016 lpi).

The resolution default is 500 lpi. Issue the appropriate ASCII character to select the resolution you require, as shown in the table below.

Table 8
Resolution Commands

Resolution (lpi)	ASCII command	Resolution (lpmm)	ASCII command
100	d	10 (254 lpi)	f
200	e	20 (508 lpi)	i
400	g	40 (1016 lpi)	q
500	h		
1000	j		

Grid Round Off

Grid Round Off is useful to reduce necessary software in menu applications. Three resolutions are available with this operating characteristic: 1, 2, or 4 lpi. Such low resolutions effectively divide the digitizing area into a 1 inch, 1/2 inch, or 1/4 inch grid, respectively.

Issue the appropriate ASCII command character as shown in Table 9 to specify the low resolution you require:

Table 9
Grid Round Off Commands

Resolution (lpi)	ASCII command
1	l
2	n
4	p

Set X,Y Scale

Set X,Y Scale lets you achieve any resolution between 1 and 508 lpi. Set X,Y Scale also allows setting different values for the X and Y axes. Use Set X,Y Scale to relate the digitizer's resolution to your CRT screen's resolution.

The Set X,Y Scale command has the format:

r X_{LSByte} X_{MSByte} Y_{LSByte} Y_{MSByte}

where r is the ASCII command character, and the next four bytes are hexadecimal digits specifying the X and Y values.

Note that the least significant byte of each hexadecimal number is transmitted first, followed by the most significant byte.

If you transmit an invalid value (outside 1 to 508) in one axis, the tablet will keep the previous value in that axis, and accept the new, correct value for the other axis. This can be used to advantage by sending the new desired value for the one axis and two ASCII NULs for the other. The tablet will ignore the NULs and keep the previous value for that axis.

The following is a sample use of the Set X,Y Scale command.

Example: Using Set X,Y Scale

Typically, you may wish to set up the tablet to match a CRT's vertical and horizontal resolutions.

For instance, to match an MM 961 (oriented horizontally) to a CRT with horizontal and vertical resolutions of 1200 x 4800 pixels, transmit these values for each axis. (Each line, or count, will be equivalent to one pixel.)

X Axis = 1200 lpi Y Axis = 4800 lpi

Next, convert these decimal numbers to hexadecimal numbers.

$1200_{10} = 460_{16}$ $4800_{10} = 12C0_{16}$

Since the hexadecimal numbers are entered in bytes, divide them accordingly.

X_{MSByte}	X_{LSByte}	Y_{MSByte}	Y_{LSByte}
4	60	12	C0

Now enter the Set X,Y Scale command with its values in the correct format, the least significant byte of each axis preceding the most significant byte.

Format: r X_{LSByte} X_{MSByte} Y_{LSByte} Y_{MSByte}

Actual Command: r 60 4 C0 12

Transmission Control

Stop Transmission (XOFF) places the digitizer on standby. It is useful in system configurations that do not use the digitizer constantly. End the standby state by sending the Start Transmission command.

Start Transmission (XON) starts the digitizer from the Stop Transmission standby state.

Issue the Stop Transmission command with an ASCII DC3. To resume transmission, send an ASCII DC1.

Identify Tablet

The Set Tablet Identification commands are useful in a dual-tablet configuration; a tablet may be identified as 0 or 1. The default tablet identifier is 0.

An ASCII 0 (zero) specifies 0 as the tablet identification number; an ASCII 1 specifies 1 as the tablet identification number. Reset sets the tablet to the default, which is zero.

Reset

To return to the tablet's operating default values, enter the Reset command. Reset runs a self test (described in Section D),

returns the MM to the default operating characteristics, clears RAM, and checks to see if a stylus or cursor is plugged in. Note that the Reset command does not affect the Baud Rate, even when the Automatic Baud Rate feature is in effect.

Issue an ASCII NUL character to perform a Reset.

Status

Send Configuration causes the digitizer to state in the data output (shown in Table 10) the current Tablet Identifier and the maximum X and Y values possible (which identify the current Resolution or Set X,Y Scale values).

The Send Configuration command is an ASCII a.

Table 10
Send Configuration Output Format

Stop Bit	8	7	6	5	4	3	2	1	0	Start Bit	
1	P	1	0	T	1	1	0	0	0	0	Flag Byte
1	P	0	X6	X5	X4	X3	X2	X1	X0	0	X LSByte
1	P	0	X13	X12	X11	X10	X9	X8	X7	0	X MSByte
1	P	0	Y6	Y5	Y4	Y3	Y2	Y1	Y0	0	Y LSByte
1	P	0	Y13	Y12	Y11	Y10	Y9	Y8	Y7	0	Y MSByte

Key:

Flag Byte Bit Definition =
- 8 : P = parity, odd is standard
- 7 : phasing bit, always 1
- 6 : proximity bit:
  - 0 = in proximity
  - 1 = out of proximity
- 5 : T = Tablet Identifier bit, 1 or 0
- 4,3 : sign bits, always 1 for positive
  - (except in Delta Mode, where:
  - 0 = negative
  - 1 = positive)
- 2-0 : always 0

LSByte = least significant byte
MSByte = most significant byte
Resolution Bits =
- X0 - X13 : reflect maximum X value at set resolution
- Y0 - Y13 : reflect maximum Y value at set resolution

Table 11
Command Formats

COMMAND	BINARY											ASCII	HEX
	Stop Bit	P	7	6	5	4	3	2	1	0	Start Bit		
Automatic Baud Rate:													
option	1	P	0	0	1	0	0	0	0	0	0	SP	20
Set Tablet Origin:													
Horizontal (961);													
Upper Left (1201)	1	P	0	1	1	0	0	0	1	0	0	b	62
Vertical (961);													
Lower Left (1201)	1	P	0	1	1	0	0	0	1	1	0	c	63
Data Collection Modes:													
Stream Mode	1	P	0	1	0	0	0	0	0	0	0	@	40
Switch Stream Mode	1	P	0	1	0	0	0	0	0	1	0	A	41
Point Mode	1	P	0	1	0	0	0	0	1	0	0	B	42
Remote Request Mode:													
command	1	P	0	1	0	0	0	1	0	0	0	D	44
Remote Request	1	P	0	1	0	1	0	0	0	0	0	P	50
Delta Mode	1	P	0	1	0	0	0	1	0	1	0	E	45
Increment:													
command	1	P	0	1	0	0	1	0	0	1	0	I	49
value	1	P	0	I7	I6	I5	I4	I3	I2	I1	0	!-z	21-7A
Axis Update:													
command	1	P	0	1	0	0	0	1	1	1	0	G	47
value	1	P	0	G7	G6	G5	G4	G3	G2	G1	0	!-z	21-7A
Coordinate Output Rate:													
2 pairs per second	1	P	0	1	0	1	0	1	0	0	0	T	54
20 pps	1	P	0	1	0	1	0	0	1	1	0	S	53
50 pps	1	P	0	1	0	1	0	0	1	0	0	R	52
100 pps	1	P	0	1	0	1	0	0	0	1	0	Q	51
Resolution:													
10 lpmm (254 lpi)	1	P	0	1	1	0	0	1	1	0	0	f	66
20 lpmm (508 lpi)	1	P	0	1	1	0	1	0	0	1	0	i	69
40 lpmm (1016 lpi)	1	P	0	1	1	1	0	0	0	1	0	q	71
100 lpi	1	P	0	1	1	0	0	1	0	0	0	d	64
200 lpi	1	P	0	1	1	0	0	1	0	1	0	e	65
400 lpi	1	P	0	1	1	0	0	1	1	1	0	g	67
500 lpi	1	P	0	1	1	0	1	0	0	0	0	h	68
1000 lpi	1	P	0	1	1	0	1	0	1	0	0	j	6A
Grid Roundoff:													
1 lpi	1	P	0	1	1	0	1	1	0	0	0	l	6C
2 lpi	1	P	0	1	1	0	1	1	1	0	0	n	6E
4 lpi	1	P	0	1	1	1	0	0	0	0	0	p	70

NOTE: Series of 1-7 and 1-16 in the binary chart illustrate the number of bits available for transmitting a value. An I or G is merely a reminder that the command precedes the value.

Table 11
Command Formats
(continued)

COMMAND	BINARY											ASCII	HEX
	Stop Bit	P	7	6	5	4	3	2	1	0	Start Bit		
Set X,Y Scale	1	P	0	1	1	1	0	0	1	0	0	r	72
X-axis LSB	1	P	X8	X7	X6	X5	X4	X3	X2	X1	0	not applicable	
X-axis MSB	1	P	X16	X15	X14	X13	X12	X11	X10	X9	0	not applicable	
Y-axis LSB	1	P	Y8	Y7	Y6	Y5	Y4	Y3	Y2	Y1	0	not applicable	
Y-axis MSB	1	P	Y16	Y15	Y14	Y13	Y12	Y11	Y10	Y9	0	not applicable	
Stop Transmission	1	P	0	0	0	1	0	0	1	1	0	DC3	13
Start Transmission	1	P	0	0	0	1	0	0	0	1	0	DC1	11
Set Tablet Identifier:													
zero	1	P	0	0	1	1	0	0	0	0	0	0	30
one	1	P	0	0	1	1	0	0	0	1	0	1	31
Reset	1	P	0	0	0	0	0	0	0	0	0	nul	00
Send Configuration	1	P	0	1	1	0	0	0	0	1	0	a	61
Self-Test	1	P	0	1	1	1	0	1	0	0	0	t	74
Send Test Results	1	P	0	1	1	1	0	1	1	1	0	w	77
Echo	1	P	0	1	1	0	1	0	1	1	0	k	6B
Check Code	1	P	0	1	1	1	1	0	0	0	0	x	78
Factory Test (DO NOT USE)												z	7A

NOTE: Series of 1-7 and 1-16 in the binary chart illustrate the number of bits available for transmitting a value. An X or Y indicates an X or Y coordinate.

SECTION D - CHECKING THE DIGITIZER

The MM digitizers have both automatic diagnostics that are performed by the digitizer each time it is turned on or Reset is sent, and diagnostic operations that you enter as remote commands from the host.

The automatic diagnostics and the Self Test both check:

- the analog circuitry,
- the digital circuitry,
- the cursor or stylus
  (if it is unplugged, the test reports a failure), and
- the current site of the cursor or stylus
  (on or off the digitizer).

This last test does not report a failure; it is informative only. Results from the automatic diagnostics are stored in the digitizer.

The following four diagnostic commands check the digitizer's overall functioning and its tablet settings (see Table 11, "Command Formats", for their command formats):

Self Test
Send Test Results
Echo
Code Check

A fifth diagnostic command, Factory Test, must not be used except at the factory, and is documented here for completeness only.

Self Test

The Self Test command performs the tests (listed above) that also occur automatically each time the digitizer is turned on. The test results are stored in the digitizer.

Issue the ASCII t to perform the Self Test. To gain access to the results, use the Send Test Results command.

Send Test Results

Send Test Results transmits the results of the most recent diagnostics (either automatic diagnostics or Self Test) to the host. Send an ASCII w to issue the Send Test Results command. Its output format is shown in Table 12:

Table 12
Send Test Results Output Format

Test Bit Definition	Bit	Pass	Fail
Analog circuitry test	0	1	0
Cursor/stylus connection and cursor/stylus operation test	1	1	0
Digital circuitry test	2	1	0
Cursor/stylus off/on tablet	3	1(on)	0(off)
Internal use only - no data	4-6	0	
Total test results	7	1	0
Parity (odd is standard)	8	P	

Echo

The Echo command causes the digitizer to repeat information (except the Reset command) as it is received from the host, beginning with the next character sent after the Echo command itself. It is a diagnostic tool to test that the digitizer's interface and microprocessor are operating.

The Echo command is an ASCII k. End Echo by sending the Reset command.

Check Code

The Check Code command verifies that the program in ROM is valid. The output is called a "checksum". The checksum returns in six bytes, in the format:

.#HHHH

where each H is an ASCII hexadecimal digit.

The checksum changes with each version of the software. (The period and # sign always appear; only the hex digits change.) To learn the correct checksum for your system, send the Check Code command soon after you receive your MM from the factory. Write down the result of the command. Every subsequent time you run the Check Code command, the checksum should agree with this result.

Send an ASCII x as the Check Code command.

Factory Test

Do not use the Factory Test command, an ASCII z. It is intended for use at the factory only. If you issue the command by mistake, you must power the tablet off and on again to clear the function. The Reset command will not clear the Factory Test command.

In Case of Failure

If the MM digitizer fails to operate, fails the diagnostics, or doesn't perform the echo function correctly, follow these steps:

1. If you have accidentally issued the Factory Test command (an ASCII z), the MM must be powered down and powered up again to cancel that function. The Factory Test command is intended for use only at the factory.
2. Check that the interface cable is attached to the host's port and that the host is functioning properly.
3. Check the test results: the cursor or stylus may not be operating, or it may simply be unplugged.
4. Contact the Customer Service department at Summagraphics Corporation at: (800) 243-9388, extension 294 - toll-free Connecticut residents: (203) 384-1344, extension 294.

See Section E for service information.

SECTION E - SITE PREPARATION, ASSEMBLY, AND CARE

Environment

The MM digitizers operate within these temperature and humidity ranges:

+45 degrees to +110 degrees Fahrenheit
+7 degrees to +43 degrees Celsius

8% to 80% relative humidity, non-condensing

Non-operating conditions are:

-45 degrees to +145 degrees Fahrenheit
-43 degrees to +63 degrees Celsius

8% to 80% relative humidity, non-condensing

Extremes in environment can cause degradation in operation.

Power Requirements

MM tablets with the TTL interface are designed to run on a power supply from the host of 0.25A at +12VDC with +10% regulation.

MM tablets with the EIA RS-232-C interface are designed to run on a power supply from the host of 0.25A at +12VDC with +10% regulation and 0.1A at -12VDC with 10% regulation.

You can make a special order for a TTL interface that requires +15VDC or an EIA RS-232-C interface that requires +/-15VDC.

Unpacking

Unpack the MM digitizer carefully, examining the parts for damage. The package should include:

- one tablet
- one set of four feet
- one "MM 1201 and MM 961 Technical Reference", Publication 84-DM11-831
- one cursor, or
- one stylus (with a non-marking refill installed)

In Case of Damage

1. Inspect the shipment for exterior damage immediately upon receipt.
2. Open the shipment and inspect it for damage as soon as possible after receipt (within 72 hours).
3. Record that damaged items on the freight bill.
4. Write to the carrier: state that the shipment was damaged when it was received, and request an inspection.
5. Keep the shipment in its original container until an inspection is made.
6. Notify Summagraphics Corporation's Traffic Department immediately. (Use the same address and telephone number which is given for Service on the following page).

Assembly

Plug the interface cable's connector into the host's port. The TTL interface connector requires a 9-pin "D" female socket, AMP P/N 205203-1. The EIA RS-232-C interface connector requires a 25-pin "D" female socket, AMP P/N 205207-1. To lock the connector into its socket, equip the socket with a locking-post assembly, P/N 206514-1.

The cursor and stylus cables are interchangeable in the tablet's socket. To ensure the MM's maximum performance, you must turn the power off before exchanging them.

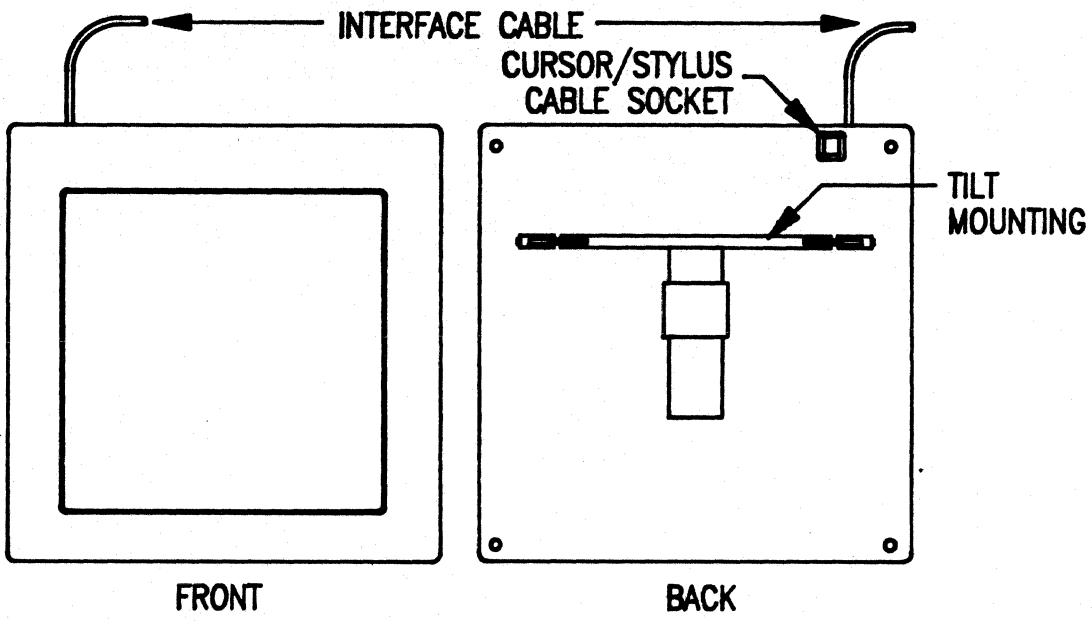
The tilt mounting is preassembled, but is detachable, allowing the tablet to lie flat if the four feet are attached. (Note that the feet are not detachable once mounted.) To remove the tilt mounting, slide it toward the top edge of the tablet, lift gently to clear the top edge of the groove, and continue pulling. The slide mechanism comes out as you pull. Stick on the feet approximately one inch from each corner. See Figure 4, "MM Digitizer Components and Assembly".

If the Automatic Baud Rate feature is in effect on your MM, the first character sent after power-up must be an ASCII SPACE, so that the MM can match the host's baud rate. (See Section C.)

Remember to send the Code Check command the first time you use the MM after you receive it from the factory, and write down the results. (See the Code Check command earlier in this Section.)

Jumper Selections

The MM series boards are equipped with several jumpers which allow access to features which greatly expand the tablet's capabilities. Table 13 lists the three jumpers and their functions; Figure 5 (MM 961) and Figure 6 (MM 1201) illustrate their locations.



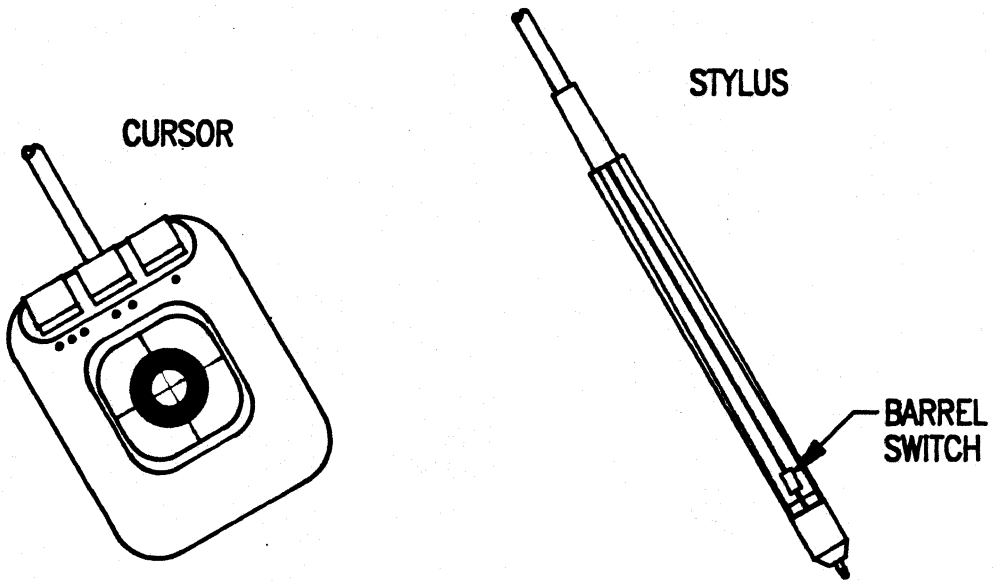


FIGURE 4
MM DIGITIZER COMPONENTS AND ASSEMBLY

Table 13
Jumper Options

Label in Figures 4/5	Jumper Name	Jumper IN/OUT	Feature
A	BIN/BCD	IN	Selects standard packed binary format
A	BIN/BCD	OUT	Selects ASCII BCD format
B	BDR	IN	Selects fixed 9600 baud rate
B	BDR	OUT	Selects Automatic Baud Rate feature
C	8/9 Bit	IN	Selects standard 9-bit bytes (odd parity)
C	8/9 Bit	OUT	Selects 8-bit bytes (no parity)

Removing the BIN/BCD jumper sets the MM to the Bit Pad One™ ASCII BCD data format, an option that can be used to communicate with a terminal such as the Lear Siegler ADM 5 (in which case power would have to be supplied through a separate power supply and interface cable).

Removing the BDR jumper allows the MM to match the host's baud rate in the range 75 to 19,200 baud. This Automatic Baud Rate feature is explained in Section C.

To remove the BIN/BCD or BDR jumpers, turn the tablet upside down and open it up. Refer to Figure 4 or 5 as appropriate, and locate the largest chip (the microprocessor) and the jumpers near it as indicated. Simply pull the jumper off the board.

On early versions of the tablet, the 8/9 Bit jumper is a fixed run to ground which must be cut in order to "remove" it. Turn the tablet upside down, open it up, and locate the line. Using a very shapr knife (such as an Exacto blade), cut it very carefully, avoiding adjacent printed circuit lines between the chip as well as the large printed circuit line along the edge of the tablet. If further information is needed, please telephone Summagraphics before attempting to cut the board (use the number listed under Service below).

On later versions of the tablet, simply pull off the 8/9 Bit jumper to select the 8-bit, no parity option.

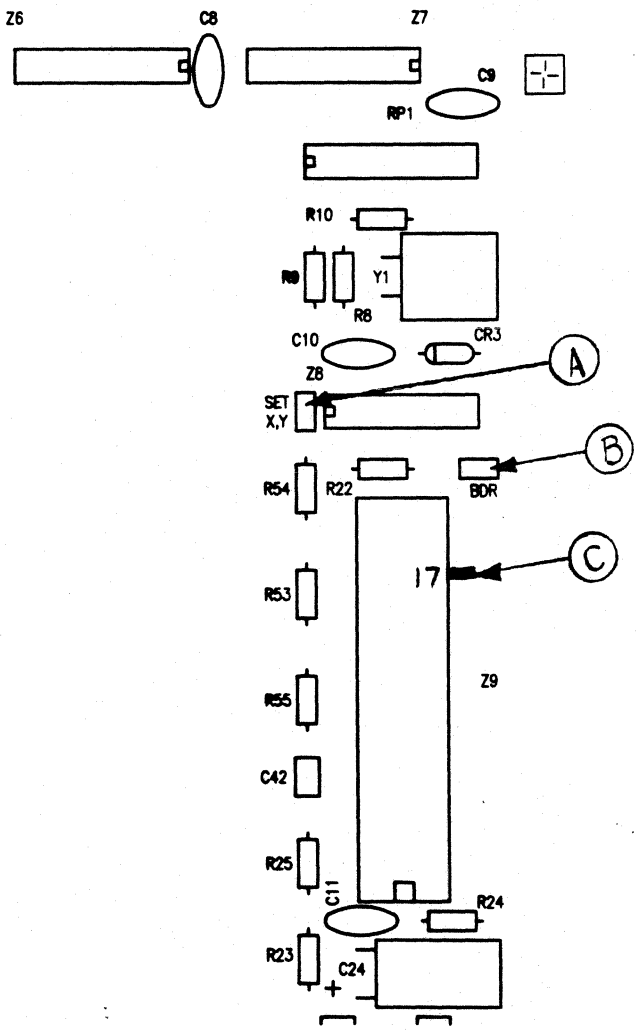


Figure 5
Jumper Locations - MM 961

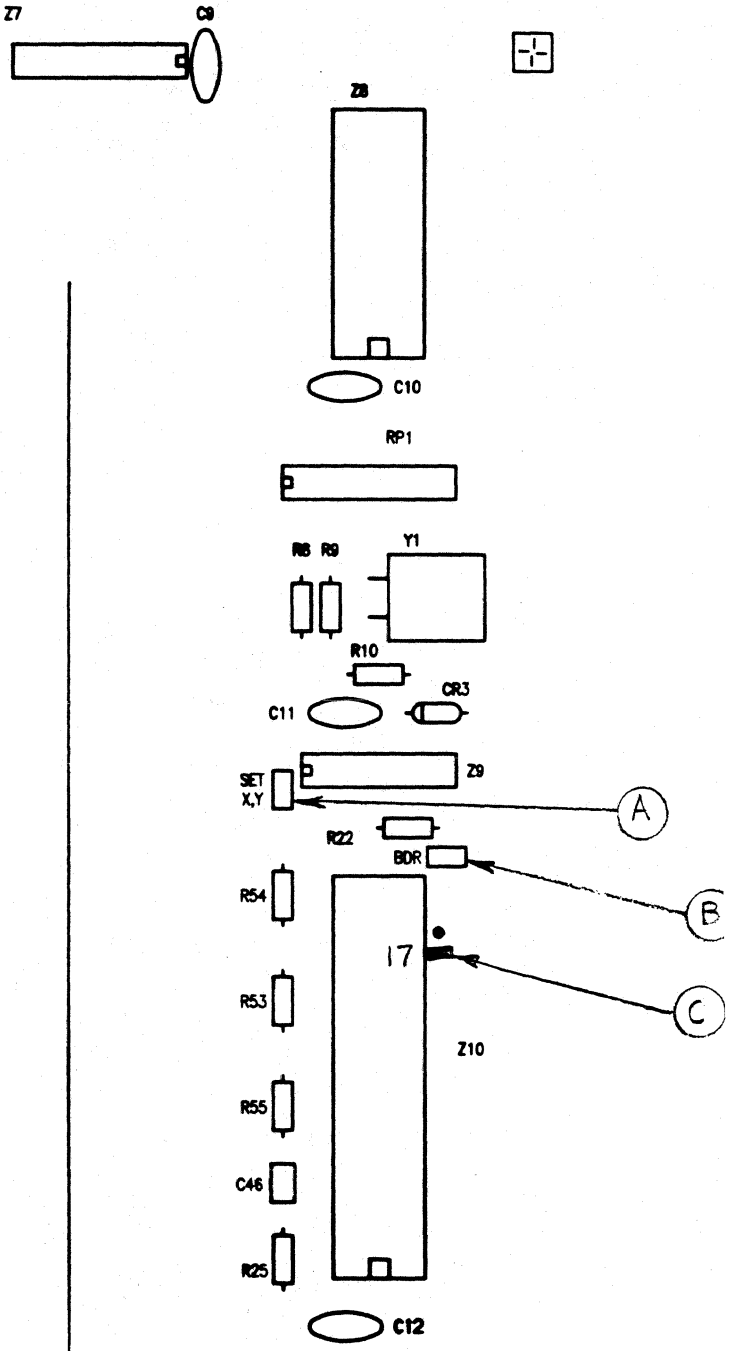


Figure 6
Jumper Locations - MM 1201

Care and Cleaning

Special handling is not required, but be careful. Avoid sharply banging or dropping the MM tablet and its cursor and stylus. Never immerse the tablet in fluid.

The MM tablet surface is made of a high-impact (Cycolac KJW flame-retardant ABS) plastic; use only a cotton flannel cloth with mild detergent and water to clean it. Never use an aromatic hydrocarbon cleaner such as acetone, or an abrasive cloth. These mar the tablet finish.

Service

For technical support and service, contact Summagraphics Corporation at this address:

Customer Service Department
Summagraphics Corporation
35 Brentwood Avenue
Fairfield, Connecticut 06430
(800) 243-9388 - toll-free
Connecticut residents: (203) 384-1344

If your MM is returned for repair, it must be identified by a Return Authorization Number (both on the outside of the package and on all corresponding paperwork). Telephone Customer Service to receive a Return Authorization Number; you will be asked for all pertinent serial numbers and purchase order numbers.

Do not ship any equipment to Summagraphics without getting authorization from Summagraphics first.

MM digitizers are repaired at:

Summagraphics Corporation
3785 Varsity Drive
Ann Arbor, Michigan 48104
(313) 973-1710

SECTION F - PERFORMANCE SPECIFICATIONS

The MM digitizers operate at the specifications listed below:

Proximity ..... 0.5" (12.7mm)

Proximity is the maximum distance the cursor or stylus can be held from the tablet to collect data accurately.

Accuracy ..... +/- 0.025" (.625mm)

Accuracy is how closely the digitizer transmits a point's actual location. The specified accuracy is guaranteed in the center of the active area.

Jitter ..... +/- 1 least significant bit

Jitter is the distance between different values the digitizer collects for the same point (for example, 10.999, 11.000, 11.001). Jitter is caused by "noise" in the tablet's analog circuitry. The "noise" affects the signal that identifies a point. Jitter is measured as one unit of the set resolution.

Repeatability ..... +/- 0.010"

Repeatability is how closely you receive the same coordinate point from the tablet when repeatedly locating the point. It considers factors such as temperature range and jitter.

QUICK REFERENCE SHEET OF SPECIFICATIONS

SPECIFICATIONS

Proximity	0.5 inch or 12.7mm
Accuracy	+/- 0.025" or .625mm
Jitter	+/- 1 LSB
Repeatability	+/- 0.010 inch
Resolution	100, 200, 400, 500, or 1000 lpi, 10, 20 or 40 lpmm
Set X,Y Scale	1 to 508 lpi
Coordinate Output Rate	2, 20, 50, or 100 pairs per second
Modes	Stream, Switch Stream, Point, Remote, and Delta

DEFAULTS

Resolution	=	500 lpi
Coordinate Output Rate	=	100 pairs per second
Data Collection Mode	=	Switch Stream
Increment	=	0
Axis Update	=	0
Set Tablet Origin:		
Model 961	=	Vertical
Model 1201	=	Lower left corner
Self-Test	=	Results stored in tablet
Tablet Identifier	=	0
Baud Rate	=	Fixed at 9600 bits per second (if BDR jumper in)

COMMUNICATION PARAMETERS

Automatic Baud Rate Option	=	75 - 19,200 bits per second (if BDR jumper out)

PHYSICAL DESCRIPTION

MODEL	OVERALL DIMENSIONS	ACTIVE AREA	WEIGHT
MM 961	9.69" x 12.94" x 0.74" 246mm x 329mm x 19mm	6" x 9" or 9" x 6" 152mm x 228mm or 228mm x 152mm	approx. 2 lbs. 0.9kg
MM 1201	16.0" x 16.2" x 0.80" 406mm x 412mm x 20mm	11.7" x 11.7" 228 mm x 228 mm	approx. 4 lbs. 1.8kg

POWER SUPPLY

TTL Interface	=	0.25A at +12VDC with 10% regulation
Special Order	=	0.25A at +15VDC with 10% regulation
EIA RS-232-C Interface	=	0.25A at +12VDC & 0.1A at -12VDC with 10% regulation
Special Order	=	0.25A at +15VDC with 10% regulation, and 0.1A at -15VDC with 10% regulation

COLOR = PEARL WHITE
FINISH = MATTE (SILK-LIKE)

SUMMAGRAPHICS' SALES OFFICES

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Fairfield, Connecticut 06430

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1201 Geneva, Switzerland

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Telex: 27622 Suma CH

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This form is for your comments and suggestions on this manual (not the equipment). Your comments are always welcome.

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Did you find this manual useful, understandable, and well organized? What improvements would you suggest?

_____

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Did you find errors in this manual? If so, please specify the error and its location (page and paragraph).

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