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MM® LC 1201 AND MM® LC 961 Graphics Tablets

Technical Reference

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The MMLC, hereafter refered to as 'the Equipment', generates and uses radio frequencies. If not installed and used in strict accordance with Summagraphics's instructions, the Equipment could interfere with your radio or television reception.

The Equipment has been tested and found to perform within the Class B limits for a computing device according to the specifications in Subpart J, Part 15 of the Federal Communications Commission (FCC) Rules. The Equipment design provides reasonable protection against RFI in a residential installation. However, keep the following in mind:

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  1. Re-orient the radio or TV antenna.
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Contents

Chapter 1 Overview

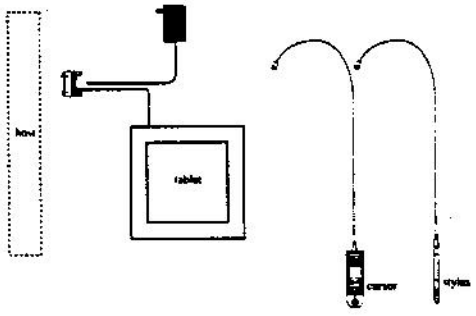
SECTION A WHAT IS THE MMLC?

The MMLC is a graphics tablet. A graphics tablet is an input device that lets you translate two-dimensional information, such as a drawing, into a computer readable format. Its many uses include:

- steering a computer screen pointer
- picking locations on menus
- drawing and tracing

The components required for a functional MMLC are:

- the tablet
- a stylus or cursor
- an interface cable
- a power supply



The **tablet** is like a drawing board. The **stylus** and **cursor** are hand-held devices that you use for pointing or drawing on the tablet. The **interface cable** links the tablet to the host (computer). The **power source** can be either the host or a power supply.

SECTION B HOW THE MMLC WORKS

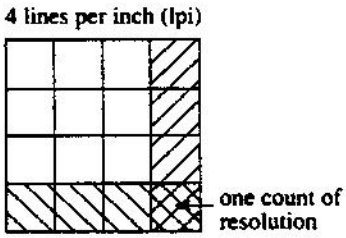
The MMLC translates the stylus/cursor position on the tablet into digital information and communicates that information to the host. The stylus/cursor position is expressed as an X,Y coordinate pair. One coordinate pair is a **report.**

Valid reports can be collected only when the stylus/cursor is in the tablet's active area and in proximity:

- **The active area** is the 12 by 12-inch rectangle within the groove on the tablet surface.
- **Proximity** is the maximum distance above the active area that the stylus/cursor can be held and report a valid position. The proximity is approximately 1/2-inch. This means that the stylus/cursor and tablet need not be in direct contact with each other to issue reports. You can have up to a 1/2-inch of material (drawings, photos, etc.) between the tablet and stylus/cursor, and it will still issue reports.

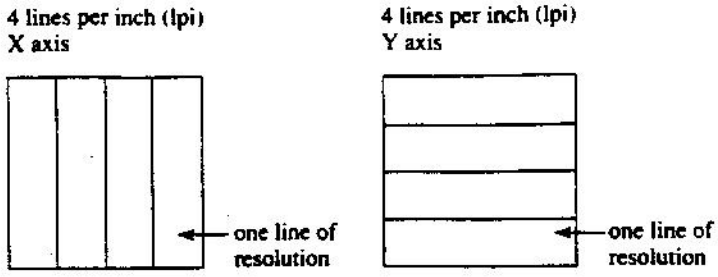
The active area and proximity, in effect, establish a three-dimensional volume within which the stylus/cursor can issue valid reports. Reports issued from outside this volume are **out-of-prox** and, therefore, do not represent the current position of the stylus/cursor.

Reports are measured in counts of resolution. **Resolution** is the "fineness" of detail that the tablet can distinguish. Resolution is expressed in lines per inch (lpi) or lines per millimeter (lpmm). This terminology is slightly misleading, however. Resolution should be expressed in "bands per ..." or "lanes per ..." because these "lines" have perceivable width at lower resolution settings.

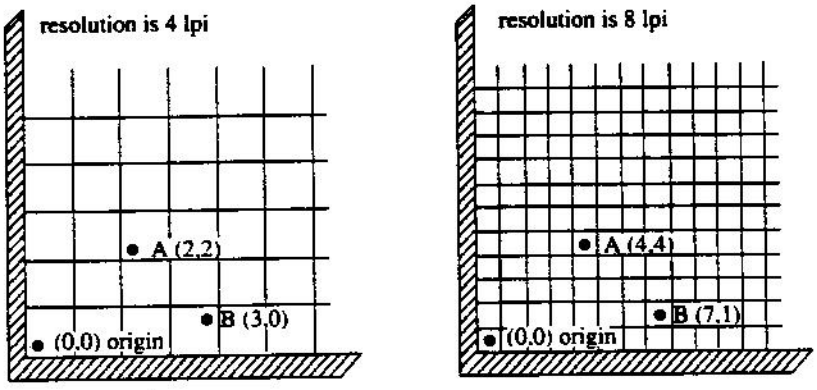


The higher the resolution, e.g. 100 lpi or 200 lpi, the narrower the bands of resolution become. Eventually, the bands become so narrow that they are easier to conceptualize as "lines" of no measurable width.

As previously stated, reports are measured in counts of resolution. As shown below, each square is one **count of resolution**. The tablet reports the same coordinates for any point within the square.



With different resolution settings, you can get different reports for the same tablet location. In the illustration below, points A and B are the same physical locations on the tablet, but their coordinates are different because of the resolution setting.



points	absolute coordinates	relative coordinates
A	(2,2)	
B	(3,0)	(1,-2)

points	absolute coordinates	relative coordinates
A	(4,4)	
B	(7,1)	(3,-3)

Reports are in absolute or relative coordinates. **Absolute coordinates** are coordinates measured from the the tablet's **origin** (0,0). **Relative coordinates** are measured "relative to" the last report location. In the illustration above, point B is issued after point A. Therefore, in relative coordinates, point B is measured relative to point A. The tablet defaults to absolute coordinates.

Chapter 2 Assembly and Installation

The standard MMLC configuration includes the items listed below.

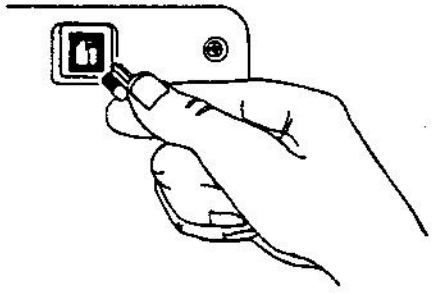
- a tablet with interface cable attached
- one set (four) rubber feet
- one MMLC 1201 and MMLC 961 Technical Reference

Purchasable options include:

- a cursor or stylus
- power supply
- attachable tilt stand

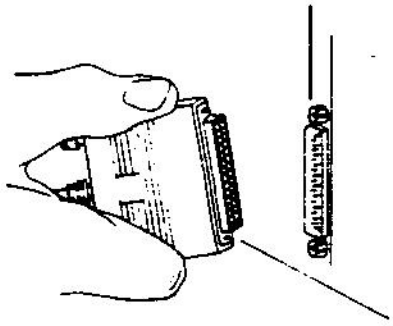
Note: Always have the computer power off when you attach or detach any part of the MMLC. If the power is on, nothing serious happens to the MMLC, but it might corrupt the file you are working with or cause the computer to act strangely. (This is true for any computer peripheral.)

1. Plug the stylus/cursor into the phone-type socket on the back of the tablet.

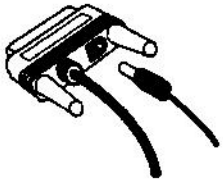


The cursor and stylus are interchangeable. But, before changing from one to the other, unplug the MMLC power supply. (This allows the MMLC's internal software to fine tune for each device.)

2. Plug the 25-pin D connector of the interface cable into the computer's asynchronous communications (RS-232-C) port. Tighten the connector screws. If your computer has a 9-pin connector, use a 9-pin-to-25-pin adapter cable between the tablet and your computer.



3. Plug the power supply barrel connector into the interface cable's D connector.



Plug the power supply into a grounded electrical outlet. Use only a MMLC power supply. Substituting with a different power supply could permanently damage the tablet and the stylus/cursor.

Chapter 3 Communicating with the Host

SECTION A INTRODUCTION

For successful communication between the MMLC and its host, the hardware interface, baud rate, report format, and command format must be compatible.

This chapter also provides notes on the initial communications with the host and guidelines for writing a software driver.

SECTION B HARDWARE INTERFACE

The hardware interface consists of one cable terminated with a 25-pin female D connector. (If the computer requires a different connector, contact your Summagraphics representative for information about adapters.)

The interface accommodates RS-232-C and is full duplex, asynchronous, and serial.

SIGNAL LEVELS

The table below specifies the signal levels for data transmissions:

RS-232-C Signal Levels

	Interchange Voltage	
RS-232-C Interface	-3V to -12 V	+3V to +12 V
Binary States	1	0
Signal Condition	Mark	Space

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 the above table. Refer to that publication for definitions of the terms used in this table.

CONNECTOR PIN ASSIGNMENTS

The interface cable is a single, shielded cable. The pin assignments are shown below; pins not shown are not assigned.

RS-232-C Data/Power Cable Pin Assignments

Pin	Wire Name	Description
1	protective ground	protective, frame ground
2	transmit data	transmits data to host
3	receive data	receives data from host
7	signal ground	return for serial data and power

SECTION C BAUD RATE

Baud rate is the number of bits transmitted each second between host and peripheral (MMLC) or peripheral and host. Two baud rate configurations are available: a fixed rate of 9600 or a variable rate (between 75 and 19, 200) that conforms to the host's baud rate. The latter option is called **autobaud.**

The MMLC is configured at the factory to one of the baud rate configurations, usually the fixed baud rate setting (9600). You can change the baud rate configuration by removing or attaching jumpers inside the MMLC tablet. This is described in Appendix A.

Note: For a host whose baud rate is generated from something other than a crystal-controlled clock, we do not recommend using the autobaud feature. This is because the MMLC could miscalculate the baud rate, especially for very low rates.

If the MMLC is set up with autobaud, then each time the MMLC is powered up, send an ASCII space character <sp>. The MMLC uses that character to time the host's baud rate, then set its own to match.

SECTION D REPORT FORMAT

Two report formats are available, packed binary (SummaSketch format) or ASCII BCD.

(Note to users of other Summagraphics digitizers: The formats described here are specific to the MMLC series. Other Summagraphics products have similarly named formats, but their content may be different.)

Regardless of format, reports are in counts of resolution, not in inches or millimeters. (Counts of resolution are described in Chapter 1.)

You can choose to have parity enabled or not. If enabled, the parity is odd.

The MMLC is normally configured at the factory with the five-byte, packed binary format and parity is enabled. However, this can be changed by attaching or removing jumpers inside the MMLC. Instructions appear in Appendix A.

MMLC PACKED BINARY

The packed binary format varies, depending on whether the tablet is in Delta Mode or not. (See Chapter 4 "Operating Characteristics and Functions" for further information on Delta Mode.) In Delta Mode, each report consists of three bytes. When the tablet is not in Delta Mode, each report consists of five bytes.

MMLC Packed Binary Report Format (SummaSketch Format)

Stop Bit	P	MSB 7	6	5	4	3	2	1	LSB 0	Start Bit	Transmission Sequence
1	P	PH	PR	T	Sx	Sy	Fc	Fb	Fa	0	1st byte
1	P	0	X6	X5	X4	X3	X2	X1	X0	0	2nd byte
1	P	0	X13	X12	X11	X10	X9	X8	X7	0	3rd byte
1	P	0	Y6	Y5	Y4	Y3	Y2	Y1	Y0	0	4th byte
1	P	0	Y13	Y12	Y11	Y10	Y9	Y8	Y7	0	5th byte

MMLC Packed Binary Report Format with Delta Mode

Stop Bit	P	MSB 7	6	5	4	3	2	1	LSB 0	Start Bit	Transmission Sequence
1	P	PH	PR	T	Sx	Sy	Fc	Fb	Fa	0	1st byte
1	P	0	X6	X5	X4	X3	X2	X1	X0	0	2nd byte
1	P	0	Y6	Y5	Y4	Y3	Y2	Y1	Y0	0	3rd byte

Key:

- LSB is the least significant bit. MSB is the most significant bit.
- Fa, Fb, and Fc are the flag bits. They identify the status of the stylus and cursor buttons:

Stylus Buttons	Four-button cursor	Fc	Fb	Fa
none	none	0	0	0
tip button	1	0	0	1
barrel button	2	0	1	0
tip and barrel	3	0	1	1
	4	1	0	0
	1+2	0	1	1
	1+3	0	1	1
	1+4	1	0	1
	2+3	0	1	1
	2+4	1	1	0
	1+2+3	0	1	1
	1+2+4	1	1	1
	2+3+4	1	1	1
	1+2+3+4	1	1	1

- Sx and Sy are the X and Y coordinate signs. 1 is positive. 0 is negative. (In Delta Mode, the sign can be positive or negative. When not in Delta Mode, the sign is positive.)
- T is the Tablet Identifier. Your choice of 1 or 0. Command controlled.
- PR is the proximity bit. 0 is in-prox. 1 is out-of-prox.
- PH is the phasing bit, which is always 1.
- P is the parity bit (optional).
- X0, X1, etc. and Y0, Y1, etc. are the X and Y coordinate bits.

ASCII BCD REPORT FORMAT

The ASCII BCD format varies, depending on the resolution setting and on whether the tablet is in Delta Mode or not. The format also differs with the model, MMLC 1201 or MMLC 961. The formats appear below:

MMLC ASCII BCD Report Formats for MMLC 1201 and MMLC 961

MMLC 1201

Resolution	Report Format when not using Delta Mode	Report Format when using Delta Mode
1 to 508 lpi	XXXX,YYYY,F<CR><LF>	S0XXX,S0YYY,F<CR><LF>
1000 to 1016 lpi (40 lpmm)	XXXXX,YYYYY,F<CR><LF>	S00XXX,S00YYY,F<CR><LF>

MMLC 961

Resolution	Report Format when not using Delta Mode	Report Format when using Delta Mode
1 to 1016 lpi (40 lpmm)	XXXX,YYYY,F<CR><LF>	S0XXX,S0YYY,F<CR><LF>

Key:
- X is an X coordinate digit, where each digit is an ASCII character from 0 to 9
- , is an ASCII comma
- Y is a Y coordinate digit, where each digit is an ASCII character from 0 to 9

- S is a coordinate sign, ASCII + or -
- 0 is an ASCII zero
- F is the stylus and cursor flag character, identifying the button status:

Stylus Buttons	Four-button cursor	ASCII output
none	none	0
tip button	1	1
barrel button	2	2
tip and barrel	3	3
	4	4
	1+2	3
	1+3	3
	1+4	5
	2+3	3
	2+4	6
	1+2+3	3
	1+2+4	7
	2+3+4	7
	1+2+3+4	7

- <CR> is an ASCII carriage return character.
- <LF> is an ASCII line feed character.

SECTION E NOTES ON INITIAL COMMUNICATIONS WITH HOST

- From the time the MMLC is powered up or from the time the Reset command is issued, there is a 10 millisecond delay before the MMLC is ready to receive commands from the host.
- If the tablet is configured with autobaud, your first action must be to send an ASCII space character <SP> from the host to the tablet. This sets the baud rate.

SECTION F GUIDELINES FOR WRITING A SOFTWARE DRIVER

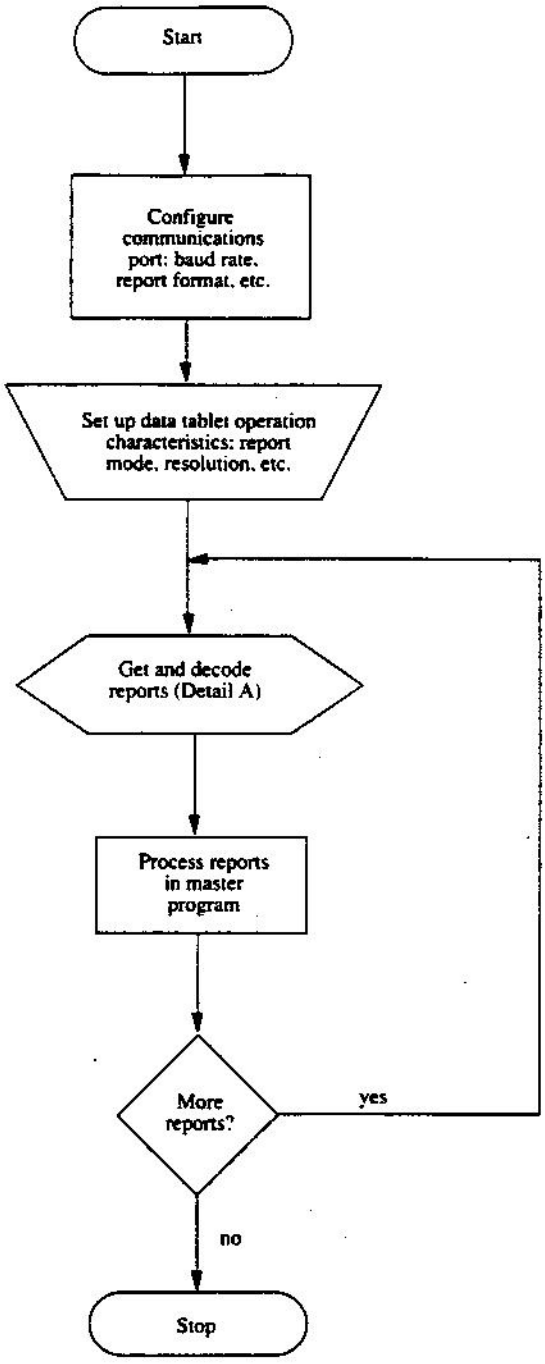
For your computer to make use of the data being sent to it from the tablet, your software (system or application) must contain a tablet device driver. The driver must be written for your specific MMLC configuration. The device driver is a program that collects and decodes the tablet data. This chapter provides guidelines for writing such a driver.

The driver usually sits between the application and the serial interface. The driver should be able to: 1) receive reports and status information from the tablet via the serial interface; 2) transmit this data to the application; 3) receive high level commands from the application that control the tablet.

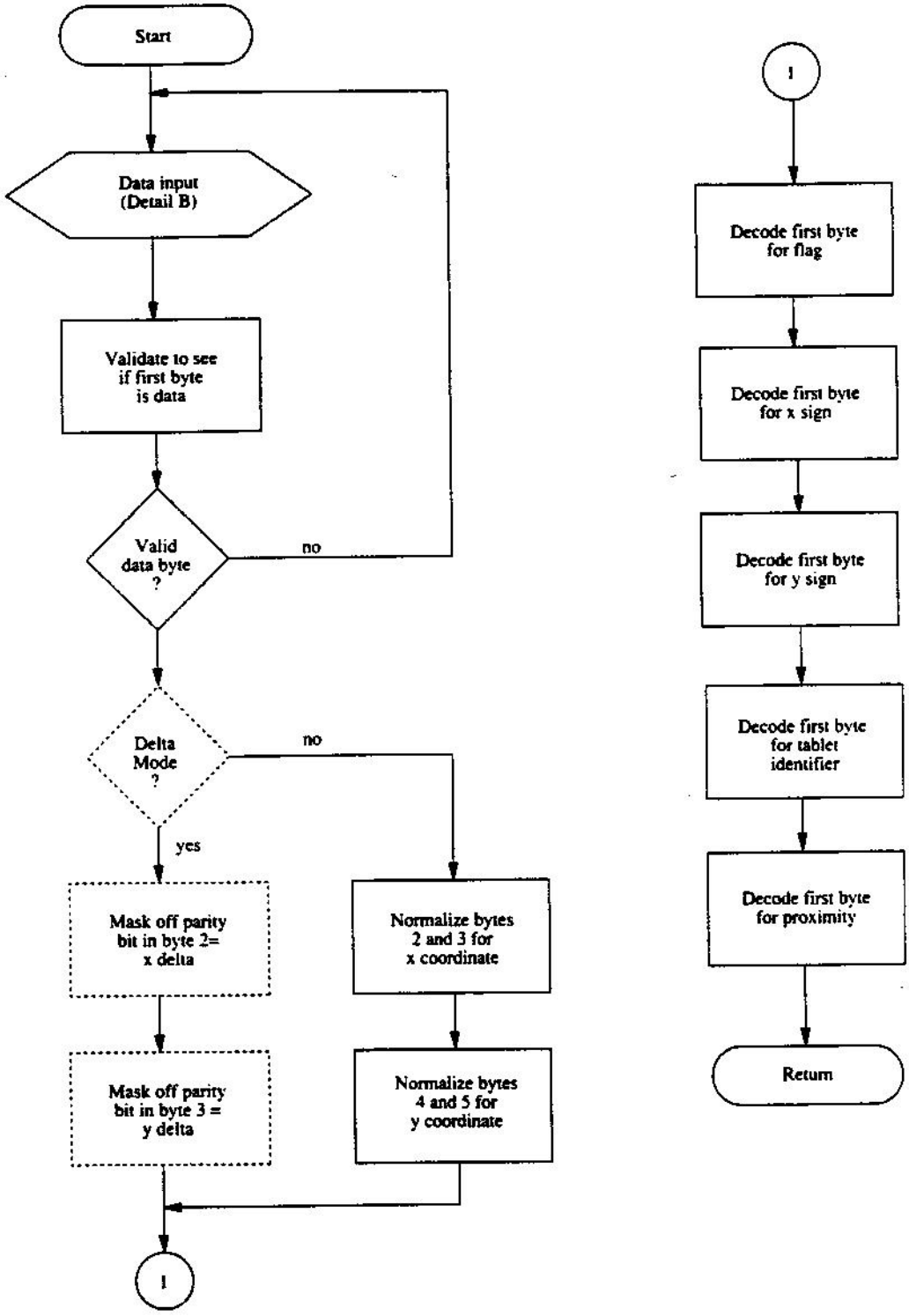
The flowcharts are for an MMLC using the packed binary report format. The steps are general for any set of operating characteristics. Remote Request Mode and Delta Mode require additional steps. These are highlighted by dotted or dashed lines.

Note: In the context of these charts, "normalize" means to combine the two coordinate bytes into the format required by your master program.

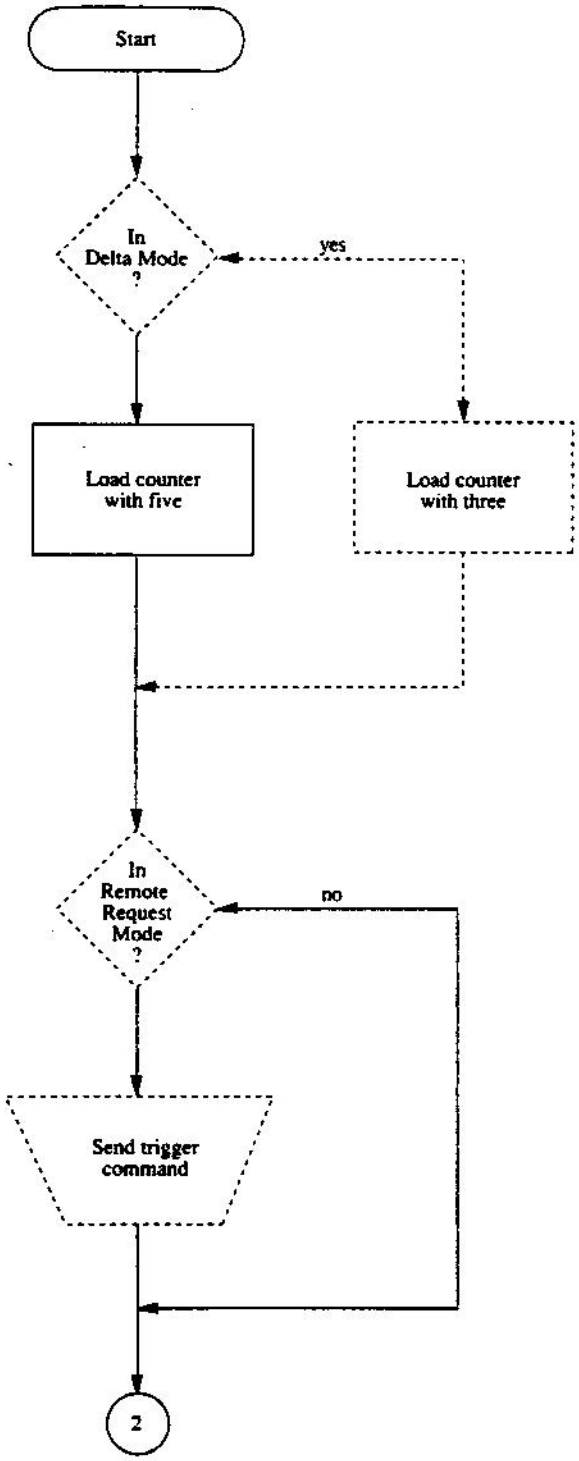
General Flowchart for Master Program to Read and Process Data Tablet Reports

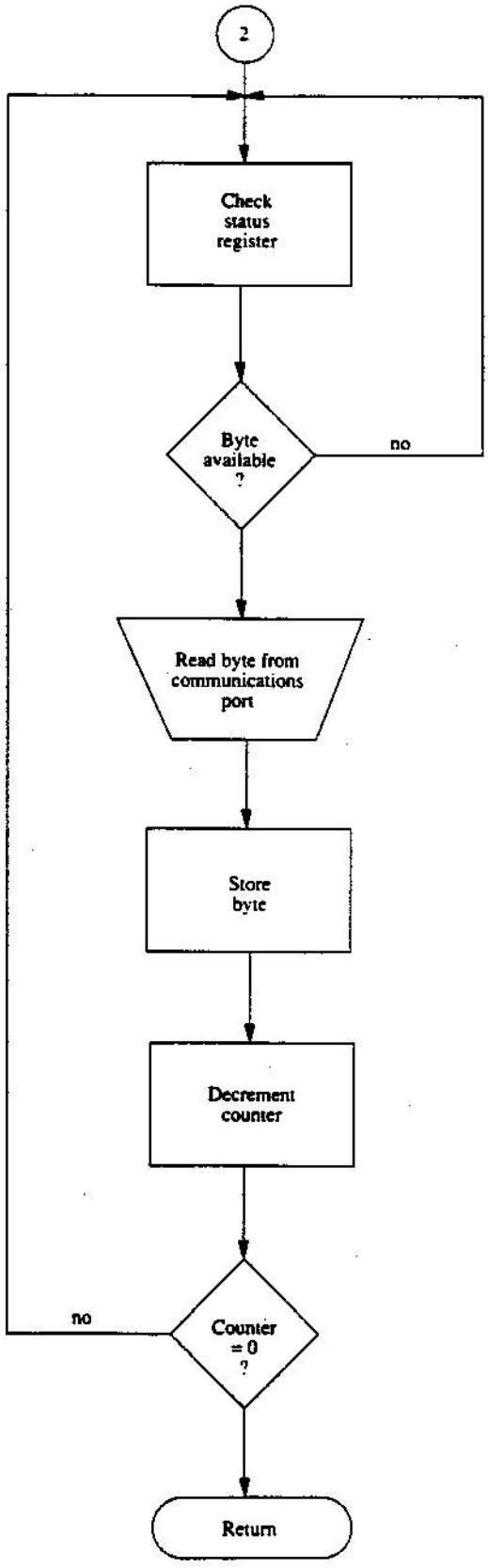


Detail A: Get and Decode Reports Subroutine



Detail B: Data Input Subroutine





Chapter 4 Operating Characteristics and Functions

The MMLC has a variety of operating characteristics and functions that you can control with commands from the host. For example, you can define:

- report flow
- tablet resolution

The tablet accepts commands from the host at any rate, except after reset. The MMLC requires 10 milliseconds to reinitialize after receiving a reset command.

The command byte format uses the same conventions as those used in the report formats: one start bit, eight data bits, an optional parity bit, and a stop bit.

Most commands are one byte long. Others, like Increment Mode and Set X, Y Scale, require more bytes. The MMLC command buffer can hold ten bytes, therefore, up to ten bytes can be sent to the MMLC in quick succession.

So that the MMLC is operable upon arrival at your facility, it is set to predefined default settings. The unit defaults to these each time you turn on the tablet or issue the Reset command.
A summary of the defaults appears in the Reset command section and in Appendix D.

SECTION A CONTROLLING THE REPORT FLOW

Use the operating characteristics described in this section to control:

- When reports are issued
- How fast reports are issued
- The coordinate system

Furthermore, reports can be gated (allowed to flow or not) with the Start and Stop Transmission commands.

Some characteristics are called **modifiers** because they are used in combination with a **primary mode**. Primary modes are Stream, Switch Stream, Point, and Remote Request modes. Modifiers are Delta, Increment, and Axis Update modes, as well as Report Rate. Certain combinations are valid; others are not. For further information, refer to "Combining Characteristics", near the end of this section.

PRIMARY MODES

Point Mode

Command Syntax: <command>

	ASCII command
Point Mode	B

In Point Mode, the tablet issues one report when you press a stylus/cursor button. If the cursor is out of proximity and a button is pressed, the last valid report is reissued once. (If the report format is packed binary, the proximity bit is set to one, indicating that the cursor or stylus is out of proximity.)

Remote Request Mode

Command Syntax: <mode command><trigger command>

	ASCII Command
Remote Request Mode	
Mode	D
Trigger	P

In Remote Request Mode, the tablet issues one report each time the host sends a trigger command. Issue the mode command once. Thereafter, send only a trigger command for each report. After you send the trigger command, the tablet issues the report within two to ten milliseconds. Subsequent reports can be issued up to the maximum report throughput.

If the cursor or stylus is out of proximity, the last valid report is reissued each time a trigger command is sent. (If the report format is packed binary, the proximity bit is set to one, indicating the cursor or stylus is out of proximity.

Stream Mode

Command Syntax: <command>

	ASCII command
Stream Mode	@

In Stream Mode, the tablet issues reports continuously, whether a stylus/cursor button is pressed or not.

If the cursor or stylus is out of proximity and no buttons are pressed, the last valid report is transmitted three times. If a button is pressed, the last valid report is issued continuously. (In both cases, if the report is packed binary, the proximity bit is set to one, indicating that the cursor or stylus is out of proximity.

Hint: To eliminate redundant reports from being issued when the cursor or stylus is stationary, use Stream Mode together with Increment Mode, setting the increment value to one.

Switch Stream Mode

Command Syntax <command>

	ASCII command
Switch Stream Mode	A

In Switch Stream Mode, the tablet issues reports continuously while you press a stylus/cursor button. The Report Rate, described below, controls the number of reports issued per second.

If the stylus/cursor is out-of-prox and a button is pressed, the last valid report is issued continuously. (If the report is packed binary, the proximity bit is set to one, indicating that the cursor or stylus is out of proximity.)

MODIFIERS

Delta Mode

Command Syntax: <command>

	ASCII command
Delta Mode	E

In Delta Mode, the MMLC issues reports as relative coordinates, rather than as absolute coordinates. Relative coordinates are measured "relative to" the last issued report, unlike absolute coordinates, which are measured from the tablet origin.

In Delta Mode, reports can have positive or negative values.

Reports issued while the cursor or stylus is out of proximity are zero. (If the report format is packed binary, the proximity bit is set to one, indicating that the cursor or stylus is out of proximity.)

Increment Mode

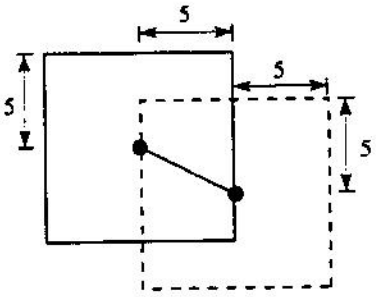
Command Sequence: <mode command><increment value>

	ASCII command
mode command	I
increment value	<SP> to z

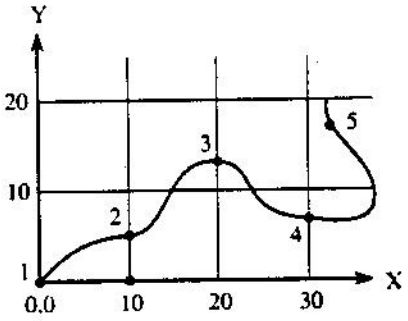
In Increment Mode, the tablet sends a report only when the stylus/cursor has traveled a minimum distance in the X or Y direction. This minimum distance is the increment. The increment applies to both axes and is measured in counts (of resolution).

How Increment Mode Works

The last report issued becomes the center of an imaginary square. The square's sides measure twice the increment value. The stylus/cursor can move anywhere inside the imaginary square without the tablet issuing a report. When the stylus/cursor touches the square, the increment is met, and the tablet transmits a report. The intersection point becomes the center of a new imaginary square. The process repeats. The following illustration shows the imaginary square created around a report point. The increment is five.



The following example shows the reports issued as the stylus/cursor travels across the tablet. The increment is ten. We have assumed that the first point collected is the origin (0,0).



The points issued are:

Point	Report	Description
1	(0,0)	First point collected in Increment Mode.
2	(10,5)	The increment is met along the X axis. The tablet reports the actual Y location.

No point is transmitted between points 2 and 3 because the stylus/cursor did not move ten counts in either the X or Y direction.

3	(20,13)	The increment is met along the X axis. The tablet reports the actual Y location.
4	(30,7)	The increment is met along the X axis. The tablet reports the actual Y location.
5	(32,17)	The increment is met along the Y axis. The tablet reports the actual X location.

How to Use Increment Mode

Send the mode command, then the increment value. The increment value is in counts (of resolution) and can be a decimal whole number from 0 to 95. (The default is zero.) Add 32 (decimal), a required offset, to the desired increment, then convert the sum into your preferred number base. For example, if the desired increment value is 10 (decimal),

desired increment	+ 32 =	*increment value in decimal*	=	*increment value in hexadecimal*	=	*increment value in ASCII*
10	+ 32 =	$42_{decimal}$	=	$2A_{hexadecimal}$	=	*ASCII

To disable Increment Mode, set the increment to zero with the ASCII space character, <SP>.

Axis Update Mode

Command Sequence: <mode command><update value>

	ASCII command
mode command	G
update value	<SP> to z

Axis Update Mode is particularly useful if you are using a grid on the tablet, and you want reports sent only at grid intersection points.

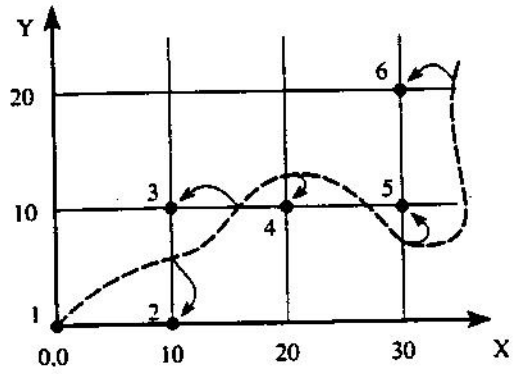
In Axis Update Mode, the unit sends a report only when the stylus/cursor has traveled a certain distance in the X or Y direction. This distance is the **update**. The update applies to both axes and is measured in counts (of resolution).

How Axis Update Mode Works

Every time the stylus/cursor returns to proximity, the tablet uses the first report as a reference point. From that reference point, an imaginary grid emanates with grid intervals equal to the update. Each time the stylus/cursor crosses a grid line, the tablet sends a report. Unlike Increment Mode, when the update has been met for one axis, the tablet repeats the last value for the other axis. The following example shows the reports issued as the stylus/cursor travels across the tablet. The update is ten. We have assumed that the initial reference point is the origin (0,0).

The points issued are:

Point	Report	Description
1	(0,0)	Reference point, the first point collected in Axis Update Mode.
2	(10,0)	X update was met. Y was not. Last Y value repeated.
3	(10,10)	Y update was met. X was not. Last X value repeated.
4	(20,10)	X update was met. Y was not. Last Y value repeated.
No point is issued between points 4 and 5 because the same report is not issued consecutively.		
5	(30,10)	X update was met. Y was not. Last Y value repeated.
6	(30,20)	Y update was met. X was not. Last X value repeated.



How to Use Axis Update Mode

Before sending the mode command, place the stylus/cursor on the tablet at one of your desired grid intersection points. Send the mode command, then the update value. The update value is in counts (of resolution) and can be a decimal whole number from 0 to 90. (The default is zero.) Add 32 (decimal), a required offset, to the desired update value, then convert the sum into your preferred number base. For example, if the desired update value is 10 (decimal),

desired update	+	32	=	*update value in decimal*	=	*update value in hexadecimal*	=	*update value in ASCII*
10	+	32	=	$42_{decimal}$	=	$2A_{hexadecimal}$	=	$^{*}_{ASCII}$

To disable Axis Update Mode, set the update to zero with the ASCII space character, <SP>.

Report Rate

Command Syntax: <command>

	ASCII command
Report Rate equal to:	
max. throughput	Q
max. throughput/2	R
max. throughput/8	S
max. throughput/32	T

The Report Rate is the number of reports the tablet issues each second. Use it with Stream or Switch Stream Mode. The rate can be set to the maximum report throughput or to some factor (1/2, 1/8, or 1/32) of the maximum.

The maximum report throughput appears in the table below. These numbers represent the maximum number of reports that can be issued when the tablet is in Stream, Switch Stream, or Remote Request Mode. When these modes are combined with other modes, e.g. Increment or Axis Update Mode, the throughput is affected. (Refer to the following section, "Combining Characteristics", for further information.)

Note that the maximum report throughput depends on the baud rate at which the tablet is set; the report format; and whether the tablet is in Delta Mode or not:

Maximum Report Throughput in Reports per Second (rps)

Baud Rate	Packed Binary Format 5-byte (not Delta Mode)	Packed Binary Format 3-byte (Delta Mode)	ASCII BCD* Format (approximately)
19,200	166	200	94
9,600	116	157	55
4,800	70	102	30
2,400	39	60	16
1,200	20	33	8
600	10.6	17	4
300	5.4	8.4	2
150	3.7	4.1	1

* The maximum report throughput can vary from these numbers when the tablet is in Delta Mode or with the resolution setting.

COMBINING CHARACTERISTICS

The table below identifies the possible combinations of operating characteristics. Notes appear under the table that highlight some of the nuances of these combinations.

Combining Operating Characteristics

Modifiers	Primary Modes			
	Stream	Switch Stream	Point	Remote Request
Increment	valid	valid	invalid	valid
Axis Update	valid	valid	invalid	valid
Delta	valid	valid	invalid	valid
Report Rate	valid	valid	invalid	invalid

- Increment Mode and Axis Update Mode cannot be combined with each other.
- When you combine Axis Update Mode with Stream or Switch Stream Mode and a stylus or cursor button is pressed, the last report is reissued.
- When you combine Increment Mode with Stream or Switch Stream Mode and a stylus or cursor button is pressed, no report is issued until the increment is met.
- When you combine Remote Request Mode with Increment or Axis Update Mode, reports are issued as follows:
    - If the increment or update value has been met before you issue a trigger, the triggered report equals or exceeds the last report.
    - If the increment or update value has not been met before you issue a trigger, no report is transmitted. If the increment or update value is then met, a report is not transmitted until the trigger is issued.
    - If the increment or update value has not been met before you issue a trigger and you issue a trigger at the same time you press a cursor or stylus button, the last valid report is reissued.
- Remote Request Mode or Point Mode override the Report Rate.
- The Report Rate affects Stream or Switch Stream Mode when combined with Increment or Axis Update Mode. Because the MMLC controls the Report Rate with an internal trigger, reports are issued as follows:

- If the increment or update value has been met before the MMLC issues a trigger, the triggered report equals or exceeds the report that satisfies the increment or update.

- If the increment or update value has not been met before the MMLC issues a trigger, no report is transmitted.

Transmission Control

Command Syntax: <command>

	ASCII command
Stop Transmission	DC3
Start Transmission	DC1

The Stop Transmission and Start Transmission commands act as software gates, controlling data transmission from the MMLC to the host. They control data flow, regardless of the report collection mode (Stream, Point, etc.). Stop Transmission and Start Transmission are equivalents of the protocols XOFF and XON.

Stop Transmission places the tablet on standby. It is useful for systems that do not constantly use the tablet. End the standby state by sending the Start Transmission command.

If a report is interrupted by Stop Transmission, no data is lost. The report is severed at the end of the byte. When the Start Transmission command is issued, the next byte in that report is sent, intact. To avoid corrupted data, the host software should not look for a phasing bit at the beginning of a resumed transmission.

SECTION B SETTING THE RESOLUTION

Resolution is the "fineness" of detail that the tablet can distinguish. Resolution is expressed in lines per inch (lpi) or lines per millimeter (lpmm).

The tablet resolution can be set with the functions Resolution, Grid Roundoff, or Set X,Y Scale. Grid Roundoff and Set X, Y Scale lend themselves to certain applications. For example:

- Grid Roundoff, in effect, divides the tablet into a grid. This simplifies setting up the tablet for applications using menus, scaled maps, etc.
- Set X, Y Scale matches the tablet resolution to the resolution of another two-dimensional object. This simplifies mapping the tablet to a terminal screen, a photo, an X-ray, etc.

RESOLUTION

Command Syntax : <command>

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

Use the Resolution command to set the MMLC to one of the resolutions listed in the table above.

GRID ROUNDOFF

Command Syntax: <command>

	ASCII command
Roundoff setting of:	
1 lpi	l
2 lpi	n
4 lpi	p

Use Grid Roundoff to set the tablet resolution to one, two, or four lines per inch. This, in effect, divides the tablet into a 1 inch, 1/2 inch, or 1/4 inch grid.

SET X,Y SCALE

Command Syntax: <mode command><X low byte><X high byte><Y low byte><Y high byte>

	ASCII command
mode command	r
X axis resolution, low byte	N/A
X axis resolution, high byte	N/A
Y axis resolution, low byte	N/A
Y axis resolution, high byte	N/A

Use Set X,Y Scale to match the tablet resolution to the resolution of another two-dimensional object. Set X,Y Scale lets you define the resolution of each axis, independently. Resolutions can be from 1 to 508 lines per inch. The following instructions describe how to use Set X, Y Scale:

1. Determine the resolution for the entire length of the axis. If the number is fractional, round it to the next higher whole number.

   - If the object's resolution is expressed as one number, encompassing the axis, ensure that the corresponding MMLC axis length divides evenly into that number. If it doesn't, the MMLC truncates the resolution value to a whole number.

     For example: When matching a vertically-oriented MMLC 961 to a vertically-oriented terminal with resolutions of 800 pixels (horizontal) by 1024 pixels (vertical), the X axis resolution is 800; the Y axis resolution is 1024. However,

     object's resolution / axis length
     800 / 6 inches = 133.33 per inch
     1024 / 9 inches = 113.77 per inch

The MMLC would truncate these numbers to 133 and 113. Therefore, round them to 134 and 114, respectively. Re-multiply the rounded number by the axis length to derive the resolution for the entire axis.

134 x 6 inches = 804 is the X axis resolution
114 x 9 inches = 1026 is the Y axis resolution

- If the object's resolution is expressed in units per inch, e.g. 37 lines per inch, multiply that number by the corresponding MMLC axis' length. For example, for an MMLC 1201:

object's resolution	x	length of the corresponding MMLC axis	=	axis resolution
37 lpi	x	11.7 inches	=	432.9

Round the number to the next higher whole number (433).

2. Convert the axis resolution value to a hexadecimal number. For example:

$804_{decimal} = 324_{hexadecimal}$

3. If the number is less than four digits, pack the number with zeros to the left. For example, express the number 324 as 0324.

4. Separate the hexadecimal number into two two-digit parts, the least significant byte (low byte) and the most significant byte (high byte). For example, separate the number 0324 into:

0324	=	03	24
		high byte	low byte

5. Repeat the steps given above for the other axis.

6. Send the Set X,Y Scale commands in the prescribed sequence:

<mode command><X low byte><X high byte><Y low byte><Y high byte>

An example: The command sequence for a vertically-oriented MMLC 961 matched to a vertically-oriented terminal with resolutions of 804 pixels (horizontal) by 1026 pixels (vertical) is:

r24030204 where the mode command is in ASCII
7224030204 where the mode command is in hexadecimal

Note: To change the resolution of only one axis, send zeros for the value of the axis you want to remain unchanged.

7. To verify the resolution settings, use the Send Configuration command.

SECTION C OTHER REMOTE COMMANDS

ORIGIN

Command Syntax: <command>

	ASCII command
Origin location:	
Horizontal (961) or Upper Left (1201)	b
Vertical (961) or Lower Left (1201)	c

Use the Origin command to define the location of the tablet's origin (0,0).

On the MMLC 1201, the origin can be assigned to the lower left corner or the upper left corner. The default location is the lower left corner. (When the origin is in the upper left corner, the Y coordinates are positive, not negative. This departure from the standard Cartesian coordinate system is to aid in the compatibility between the MMLC and terminals with a screen origin in the upper left corner.)

On the MMLC 961, the origin can be assigned to the lower left corner of the tablet in a vertical or horizontal orientation. The default orientation is vertical.

TABLET IDENTIFIER

Command Syntax: <command>

	ASCII command
Tablet Identifier equal to:	
zero	0
one	1

Use Tablet Identifier to set a bit in the packed binary report format to a one or a zero. This can be helpful in dual-tablet systems to distinguish between the reports coming from one tablet versus the other.

RESET (TO FACTORY DEFAULTS)

Command Syntax: <command>

	ASCII command
Reset	nul

Use Reset to run the Self Test diagnostic function and return the MMLC operating characteristics to the factory-set defaults. The defaults are:

Resolution:	500 lpi
Report Rate:	maximum
Report Mode:	Switch Stream
Increment:	0
Axis Update:	0
Origin:	
MMLC 961:	for vertical orientation
MMLC 1202:	lower left corner
Tablet Identifier:	0

Reset does not affect the autobaud setting.

Note: After Reset is issued, there is a 10 millisecond delay before the MMLC is ready to receive information from the host.

SEND CONFIGURATION

Command Syntax: <command>

	ASCII command
Send Configuration	a

Use Send Configuration to send a report to the host that identifies the Tablet Identifier setting and the resolution setting of each axis.

The last item is especially helpful to verify a Set X,Y Scale setting. The report format is as follows:

Output Format of Send Configuration

Stop Bit	P	MSB 7	6	5	4	3	2	1	LSB 0	Start Bit	Transmission Sequence
1	P	PH	PR	T	Sx	Sy	0	0	0	0	Flag byte
1	P	0	b6	b5	b4	b3	b2	b1	b0	0	X low byte
1	P	0	b13	b12	b11	b10	b9	b8	b7	0	X high byte
1	P	0	b6	b5	b4	b3	b2	b1	b0	0	Y low byte
1	P	0	b13	b12	b11	b10	b9	b8	b7	0	Y high byte

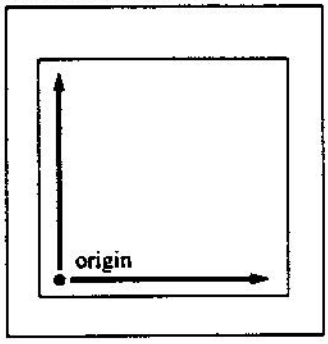
Key:

LSB	least significant bit
MSB	most significant bit
P	parity (optional)
PH	phasing bit, set to 1
PR	proximity bit, set to 0
T	Tablet Identifier bit, 1 or 0
Sx and Sy	sign bits, set to 1 (positive)
b0 to b13	maximum X or Y value at set resolution

Chapter 5 Checking the Data Tablet

A quick, functional check of the data tablet can be performed by connecting the MMLC to a terminal and moving the cursor or stylus across the tablet's active area. The X and Y values should increase as the cursor or stylus slides from the tablet origin toward the end of the axis. This is depicted in the following illustration, where the origin is located at the lower left corner:

When stylus/cursor moves vertically, X is constant, Y increases.



When stylus/cursor moves horizontally, Y is constant, X increases.

Other mechanisms for checking an MMLC are the diagnostic functions: Self Test, Send Test Results, Echo, and Code Check.

Like the MMLC's operating characteristics, the diagnostic functions are initiated by remote commands from the host. Each function and its command are described in this chapter.

This chapter also provides guidelines for troubleshooting.

SECTION A DIAGNOSTIC FUNCTIONS

SELF TEST

Command Syntax: <command>

	ASCII command
Self Test	t

Use Self Test to perform tests on the tablet and cursor or stylus. Self Test checks:

- the analog circuitry
- the cursor or stylus connection, operation, and location
- the digital circuitry

Self Test is automatically performed each time the power to the data tablet is turned on or the Reset command is issued. You can also initiate it with the command appearing above. The test results are stored in the data tablet and can be accessed with the Send Test results command.

SEND TEST RESULTS

Command Syntax: <command>

	ASCII command
Send Test Results	w

Use Send Test Results to transmit the results of the most recently performed Self Test to the host. The results are transmitted in one byte with the following format:

Output Format of Send Test Results

Stop Bit	MSB 8	7	6	5	4	3	2	1	LSB 0	Start Bit
1	P	T	0	0	0	PR	D	C	A	0

A	analog circuitry test; pass = 1, fail = 0
C	cursor/stylus connection and cursor/stylus coil operation test; pass = 1, fail = 0
D	digital circuitry test; pass = 1, fail = 0
PR	cursor/stylus on/off tablet; on = 1, off = 0
T	total test result. (This result is based only on the results of tests A, C, D.) Pass = 1, fail = 0.

ECHO

Command Syntax: <command>

	ASCII command
Echo	k

Use Echo to ensure that the interface between the MMLC and the host is operating correctly. Issue the Echo command, then issue any character sequence. In turn, each character is transmitted to the MMLC and echoed back to the host. If the interface is working properly, the sent character matches the echoed character.

Note that the character sequence is passed through, not acted upon by, the MMLC. Therefore, remote commands issued while ECHO is in effect are ignored by the MMLC.

Issuing the Reset command or powering down the unit aborts the Echo function.

CODE CHECK

Command Syntax: <command>

	ASCII command
Code Check	x

Use Code Check to identify the version of firmware in the MMLC or to detect a change in the firmware.

The Code Check function issues a number, called the **checksum**, to the host. The checksum uniquely identifies the version of firmware in the MMLC.

When your MMLC first arrives, record the checksum. Each time a Code Check is performed, the checksum should be the same. A change in the checksum means a change has occurred in the firmware.

The checksum is in the following six-byte format:

.#HHHH

where HHHH is a hexadecimal number in ASCII. The checksum is in this format, regardless of the format being used for data reports.

FACTORY TEST

Command Syntax: *Do not use this command. It is for factory use only.*

	ASCII command
Factory Test	z

Do not issue the Factory test command. It is documented here only for completeness.

If you issue the command by mistake, powering down the unit clears the function. The Reset command does not clear it.

SECTION B TROUBLESHOOTING

If the MMLC fails to operate or fails the diagnostics, follow these steps:

1. Power down the MMLC.
2. Check that the cables are firmly attached.
3. Ensure that the host is working properly.
4. If possible, issue each diagnostic command and review the results.

If the MMLC is still malfunctioning, contact the Summagraphics Customer Service department (see chapter 6 for address and phone number).

Chapter 6 Operating Environment, Installation, Care, and Service

SECTION A OPERATING ENVIRONMENT

TEMPERATURE AND HUMIDITY

Operate the MMLC 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

Acceptable 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 of operation.

SECTION B POWER

An MMLC with an RS-232-C interface requires 0.20A at +12VDC with +/-10% regulation.

SECTION C FCC CONSIDERATIONS

As stated in the FCC statement at the front of this book, the MMLC must be installed and operated in accordance with the procedures appearing in this manual.

In addition, to ensure that EMI shielding requirements are met, the host's interface cabling connector must have a metal shroud, grounded to the host chassis.

SECTION D CARE AND CLEANING

Avoid banging or dropping the tablet, cursor, or stylus.

Never immerse any part in fluid.

Disconnect the tablet from its power source before cleaning it.

The tablet surface is made of plastic. To clean, use only a cotton flannel cloth with a mild detergent and water. Never use a hydrocarbon cleaner such as acetone, or an abrasive cloth. These mar the tablet finish.

SECTION E SERVICE

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

Customer Service Department
Summagraphics Corporation
60 Silvermine Road
Seymour, Connecticut 06483

Telephone number (203) 881-5400

If you return an MMLC for repair, a Return Authorization Number must be on the outside of the package and on all accompanying paperwork. Obtain a Return Authorization Number from the Customer Service Department. When contacting Customer Service, please have ready the tablet serial number and the purchase order number.

Do not ship any equipment to Summagraphics without a Return Authorization Number.

Appendix A Jumper Assignments

The parity, baud rate option, or report format can be changed on the MMLC by removing or attaching jumpers. A jumper is a tiny plastic cap containing a U-shaped metal wire. The jumpers are located on the printed circuit board (PCB) inside the tablet case.

> *CAUTION: Disconnect the tablet from its power source before opening the case. Special care must be taken when the tablet case is open. Components on the PCB, especially the microprocessor, can be damaged or destroyed by electrostatic discharges. This can be avoided by preventing static electricity from building up. Here are some guidelines.*
>
> - *Have an antistatic floor covering under you and the tablet.*
> - *Use a conductive, grounded work surface.*
> - *Keep yourself at ground potential with conductive wrist bands and a 1 meg ohm resistor to ground.*
> - *Do not wear clothes or shoes made of materials that promote static electricity, e.g. nylon, polyester, or wool.*

To access the board, lay the tablet upside down on a table. Remove the phillips-head screws along the outer edge. Gently remove the tablet back. The jumpers are located along the edge containing the cursor/stylus connector. Use that connector as a landmark in locating the jumpers.

Jumper Assignments of PCB, Release B

Board Labels	Board Labels	Jumper attached/removed	Configuration
Set X,Y	Set X,Y	attached	packed binary format
Set X,Y	Set X,Y	removed	ASCII BCD format
BDR	BDR	attached	fixed baud rate of 9600
BDR	BDR	removed	autobaud
Z9-17*	Z10-17*	*	parity (odd) enabled
Z9-17*	Z10-17*	*	parity disabled

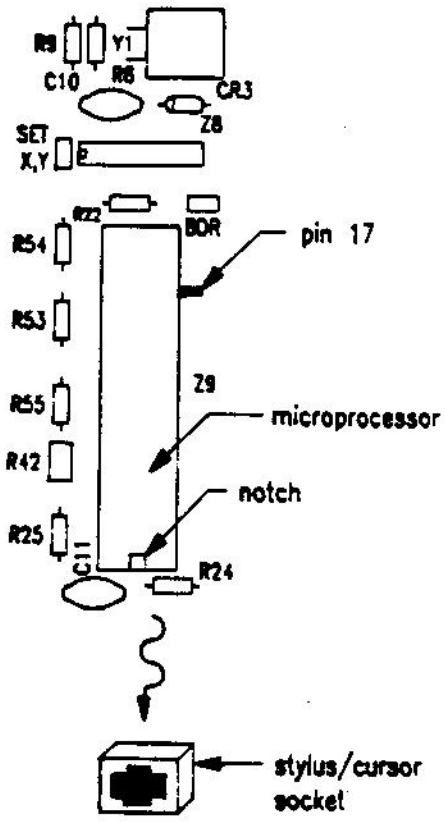
*Note: On Release of the PC board, parity is assigned to pin 17 of the microprocessor. Leaving the electrical connection intact configures the report format with a parity bit. Breaking that connection configures the report format with no parity bit. You can break the connection by bending the pin or cutting the run to ground. Both procedures are delicate and should only be performed if you are experienced in working with this type of hardware. The instructions are as follows:

- Bending the pin: First remove the microprocessor from its socket.

  CAUTION: The microprocessor is a costly and delicate item. Remove it from its socket very carefully.

  Bend pin 17 outward, away from the microprocessor. Bend it just enough to clear the microprocessor socket. Take care; the pin can break easily. Bending the pin back to its original shape is also likely to break it off; therefore, make this change with great discretion. When inserting the microprocessor into its socket, align the notch as shown in the figure.

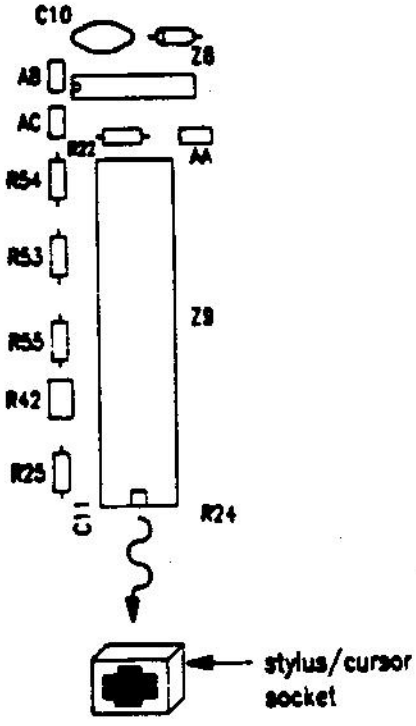
- Cutting the run to ground: This is a permanent alteration! Cut the run to ground for pin 17. Be careful to not cut adjoining runs.



Jumpers on MM 961, Revision B

Jumper Assignments of PCB, Release C or Higher

Board Labels in Figures A-3 and A-4	Jumper attached/removed	Configuration
AB	attached	packed binary format
AB	removed	ASCII BCD format
AA	attached	fixed baud rate of 9600
AA	removed	autobaud
AC	attached	parity (odd) enabled
AC	removed	parity disabled



Jumpers on MM 961.
Revision C or Higher

Appendix B Specifications

PHYSICAL DESCRIPTION

Model	Overall Dimensions	Active Area (nominal)	Weight
MMLC 961	9.69" x 12.94" x 0.74" 246 mm x 329 mm x 19 mm	6" x 9" 153 mm x 229 mm	max. 4 lbs. 1.8g
MMLC 1201	16.0" x 16.2" x 0.80" 406 mm x 412 mm x 20 mm	11.7" x 11.7" 297 mm x 297 mm	max. 7 lbs. 3.2 kg

POWER REQUIREMENTS

- RS-232-C Interface: 0.20 A at +12VDC +/- 10%

OPTIONAL POWER SUPPLIES

- USA: 102V to 132V, 58 Hz to 62 Hz, NEMA 5-15P plug
- International: 197V to 264V, 48 Hz to 52 Hz
- Japan: 90V to 110V, 42Hz to 62 Hz, NEMA 1-15P plug

MATERIAL AND COSMETICS

- Color: pearl white
- Finish: matte (silk-like)
- Material: Lucky 380 ABS plastic or equivalent.

OPERATING SPECIFICATIONS

An MMLC performs to the specifications listed below. The word "typical" is used to describe accuracy and proximity. Typical means the unit performs to that specification over more than 90 percent of the active area at 25 degrees Celsius. A slight degradation occurs at the extreme edges and corners of the active area.

Proximity ... 0.5" (12.7 mm) typical

Proximity is the maximum distance the cursor or stylus can be held above the active area and report the position of the stylus or cursor.

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

Accuracy is how closely a point's actual location is determined.

Jitter ... cursor: +/-1 least significant bit; stylus: +/-2 least significant bits

Jitter is the difference in values collected by the data tablet for the same point (for example, 10.999, 11.000, 11.001). Jitter is caused by electrical noise in the tablet's analog circuitry. Noise affects the signal that identifies a point. Jitter is measured as one unit of the set resolution.

Repeatability ... +/-0.010" (.250mm) or better

Repeatability is how closely you receive the same coordinates from the tablet when repeatedly locating the point. Repeatability takes temperature range and jitter into consideration.

Cursor Eccentricity ... +/-0.005" (.125) or better

Cursor eccentricity is how much the electrical center varies from the cross hair center as the cursor is rotated through 360 degrees.

Appendix C ASCII Conversion Chart

Decimal	Binary 7 6 5 4 3 2 1 0	Octal	Hex	ASCII Character	Control Function or Character Description
0	0 0 0 0 0 0 0 0	000	00	NUL	Null
1	0 0 0 0 0 0 0 1	001	01	SOH	Start of Heading
2	0 0 0 0 0 0 1 0	002	02	STX	Start of Text
3	0 0 0 0 0 0 1 1	003	03	ETX	End of Text
4	0 0 0 0 0 1 0 0	004	04	EOT	End of Transmission
5	0 0 0 0 0 1 0 1	005	05	ENQ	Enquiry
6	0 0 0 0 0 1 1 0	006	06	ACK	Acknowledge
7	0 0 0 0 0 1 1 1	007	07	BEL	Bell
8	0 0 0 0 1 0 0 0	010	08	BS	Backspace
9	0 0 0 0 1 0 0 1	011	09	HT	Horizontal Tab
10	0 0 0 0 1 0 1 0	012	0A	LF or NL	Line Feed or New Line
11	0 0 0 0 1 0 1 1	013	0B	VT	Vertical Tab
12	0 0 0 0 1 1 0 0	014	0C	FF	Form Feed
13	0 0 0 0 1 1 0 1	015	0D	CR or RT	Carriage Return
14	0 0 0 0 1 1 1 0	016	0E	SO	Shift Out
15	0 0 0 0 1 1 1 1	017	0F	SI	Shift In
16	0 0 0 1 0 0 0 0	020	10	DLE	Data Link Escape
17	0 0 0 1 0 0 0 1	021	11	DC1	Device Control 1
18	0 0 0 1 0 0 1 0	022	12	DC2	Device Control 2
19	0 0 0 1 0 0 1 1	023	13	DC3	Device Control 3
20	0 0 0 1 0 1 0 0	024	14	DC4	Device Control 4
21	0 0 0 1 0 1 0 1	025	15	NAK	Negative Acknowledge
22	0 0 0 1 0 1 1 0	026	16	SYN	Synchronous Idle
23	0 0 0 1 0 1 1 1	027	17	ETB	End Transmission Block
24	0 0 0 1 1 0 0 0	030	18	CAN	Cancel
25	0 0 0 1 1 0 0 1	031	19	EM	End of Medium
26	0 0 0 1 1 0 1 0	032	1A	SUB	Substitute
27	0 0 0 1 1 0 1 1	033	1B	ESC	Escape
28	0 0 0 1 1 1 0 0	034	1C	FS	File Separator
29	0 0 0 1 1 1 0 1	035	1D	GS	Group Separator
30	0 0 0 1 1 1 1 0	036	1E	RS	Record Separator
31	0 0 0 1 1 1 1 1	037	1F	US	Unit Separator
32	0 0 1 0 0 0 0 0	040	20	SP	Space
33	0 0 1 0 0 0 0 1	041	21	!	Exclamation Point
34	0 0 1 0 0 0 1 0	042	22	"	Double Quote
35	0 0 1 0 0 0 1 1	043	23	#	Number or Pound
36	0 0 1 0 0 1 0 0	044	24	$	Dollar
37	0 0 1 0 0 1 0 1	045	25	%	Percent
38	0 0 1 0 0 1 1 0	046	26	&	Ampersand
39	0 0 1 0 0 1 1 1	047	27	'	Apostrophe
40	0 0 1 0 1 0 0 0	050	28	(	Left Parenthesis
41	0 0 1 0 1 0 0 1	051	29	)	Right Parenthesis
42	0 0 1 0 1 0 1 0	052	2A	*	Asterisk
43	0 0 1 0 1 0 1 1	053	2B	+	Plus or Addition

cont.

Decimal	Binary 7 6 5 4 3 2 1 0	Octal	Hex	ASCII Character	Control Function or Character Description
44	0 0 1 0 1 1 0 0	054	2C	,	Comma
45	0 0 1 0 1 1 0 1	055	2D	-	Hyphen
46	0 0 1 0 1 1 1 0	056	2E	.	Period
47	0 0 1 0 1 1 1 1	057	2F	/	Slash
48	0 0 1 1 0 0 0 0	060	30	0	
49	0 0 1 1 0 0 0 1	061	31	1	
50	0 0 1 1 0 0 1 0	062	32	2	
51	0 0 1 1 0 0 1 1	063	33	3	
52	0 0 1 1 0 1 0 0	064	34	4	
53	0 0 1 1 0 1 0 1	065	35	5	
54	0 0 1 1 0 1 1 0	066	36	6	
55	0 0 1 1 0 1 1 1	067	37	7	
56	0 0 1 1 1 0 0 0	070	38	8	
57	0 0 1 1 1 0 0 1	071	39	9	
58	0 0 1 1 1 0 1 0	072	3A	:	Colon
59	0 0 1 1 1 0 1 1	073	3B	;	Semicolon
60	0 0 1 1 1 1 0 0	074	3C	<	Less Than
61	0 0 1 1 1 1 0 1	075	3D	=	Equals
62	0 0 1 1 1 1 1 0	076	3E	>	Greater Than
63	0 0 1 1 1 1 1 1	077	3F	?	Question Mark
64	0 1 0 0 0 0 0 0	100	40	@	Commercial At
65	0 1 0 0 0 0 0 1	101	41	A	
66	0 1 0 0 0 0 1 0	102	42	B	
67	0 1 0 0 0 0 1 1	103	43	C	
68	0 1 0 0 0 1 0 0	104	44	D	
69	0 1 0 0 0 1 0 1	105	45	E	
70	0 1 0 0 0 1 1 0	106	46	F	
71	0 1 0 0 0 1 1 1	107	47	G	
72	0 1 0 0 1 0 0 0	110	48	H	
73	0 1 0 0 1 0 0 1	111	49	I	
74	0 1 0 0 1 0 1 0	112	4A	J	
75	0 1 0 0 1 0 1 1	113	4B	K	
76	0 1 0 0 1 1 0 0	114	4C	L	
77	0 1 0 0 1 1 0 1	115	4D	M	
78	0 1 0 0 1 1 1 0	116	4E	N	
79	0 1 0 0 1 1 1 1	117	4F	O	
80	0 1 0 1 0 0 0 0	120	50	P	
81	0 1 0 1 0 0 0 1	121	51	Q	
82	0 1 0 1 0 0 1 0	122	52	R	
83	0 1 0 1 0 0 1 1	123	53	S	
84	0 1 0 1 0 1 0 0	124	54	T	
85	0 1 0 1 0 1 0 1	125	55	U	
86	0 1 0 1 0 1 1 0	126	56	V	
87	0 1 0 1 0 1 1 1	127	57	W	
88	0 1 0 1 1 0 0 0	130	58	X	
89	0 1 0 1 1 0 0 1	131	59	Y	

cont.

Decimal	Binary 7 6 5 4 3 2 1 0	Octal	Hex	ASCII Character	Control Function or Character Description
90	0 1 0 1 1 0 1 0	132	5A	Z	
91	0 1 0 1 1 0 1 1	133	5B	[	Left Square Bracket
92	0 1 0 1 1 1 0 0	134	5C	\	Back Slash
93	0 1 0 1 1 1 0 1	135	5D	]	Right Square Bracket
94	0 1 0 1 1 1 1 0	136	5E	^	Circumflex
95	0 1 0 1 1 1 1 1	137	5F	_	Underscore
96	0 1 1 0 0 0 0 0	140	60	`	Left Single Quote
97	0 1 1 0 0 0 0 1	141	61	a	
98	0 1 1 0 0 0 1 0	142	62	b	
99	0 1 1 0 0 0 1 1	143	63	c	
100	0 1 1 0 0 1 0 0	144	64	d	
101	0 1 1 0 0 1 0 1	145	65	e	
102	0 1 1 0 0 1 1 0	146	66	f	
103	0 1 1 0 0 1 1 1	147	67	g	
104	0 1 1 0 1 0 0 0	150	68	h	
105	0 1 1 0 1 0 0 1	151	69	i	
106	0 1 1 0 1 0 1 0	152	6A	j	
107	0 1 1 0 1 0 1 1	153	6B	k	
108	0 1 1 0 1 1 0 0	154	6C	l	
109	0 1 1 0 1 1 0 1	155	6D	m	
110	0 1 1 0 1 1 1 0	156	6E	n	
111	0 1 1 0 1 1 1 1	157	6F	o	
112	0 1 1 1 0 0 0 0	160	70	p	
113	0 1 1 1 0 0 0 1	161	71	q	
114	0 1 1 1 0 0 1 0	162	72	r	
115	0 1 1 1 0 0 1 1	163	73	s	
116	0 1 1 1 0 1 0 0	164	74	t	
117	0 1 1 1 0 1 0 1	165	75	u	
118	0 1 1 1 0 1 1 0	166	76	v	
119	0 1 1 1 0 1 1 1	167	77	w	
120	0 1 1 1 1 0 0 0	170	78	x	
121	0 1 1 1 1 0 0 1	171	79	y	
122	0 1 1 1 1 0 1 0	172	7A	z	
123	0 1 1 1 1 0 1 1	173	7B	{	Left Curved Bracket
124	0 1 1 1 1 1 0 0	174	7C	|	Vertical Line
125	0 1 1 1 1 1 0 1	175	7D	}	Right Curved Bracket
126	0 1 1 1 1 1 1 0	176	7E	~	Tilde
127	0 1 1 1 1 1 1 1	177	7F	DEL	Delete (rubout)

Appendix D *Quick Reference Sheet*

REMOTE COMMANDS

Command	ASCII	HEX
Autobaud	SP	20
Origin:		
horizontal(961)	b	62
vertical (961)	c	63
Report Modes:		
Stream Mode	@	40
Switch Stream Mode	A	41
Point Mode	B	42
Remote Request Mode		
mode command	D	44
trigger command	P	50
Delta Mode	E	45
Increment Mode		
command	I	49
value	SP to z	20 to 7A
Axis Update Mode		
command	G	47
value	SP to z	20 to 7A
Report Rate:		
max/32	T	54
max/8	S	53
max/2	R	52
maximum	Q	51
Send Configuration	a	61
Self Test	t	74
Send Test Results	w	77
Reset	NUL	00

Command	ASCII	HEX
Resolution:		
10 lpmm (254 (lpi)	f	66
20 lpmm (508) lpi	i	69
40 lpmm (1016 lpi)	q	71
100 lpi	d	64
200 lpi	e	65
400 lpi	g	67
500 lpi	h	68
1000 lpi	j	6A
Grid Roundoff:		
1 lpi	l	6C
2 lpi	n	6E
4 lpi	p	70
Set X,Y Scale	r	
X axis low byte	N/A	OO to FF
X axis high byte	N/A	OO to FF
Y axis low byte	N/A	OO to FF
Y axis high byte	N/A	OO to FF
Stop Transmission	DC3	13
Start Transmission	DC1	11
Tablet identifier		
zero	0	30
one	1	31
Echo	k	6B
Code Check	x	
Factory Test (don't use)	z	7A

DEFAULT OPERATING CHARACTERISTICS

Resolution	500 lpi
Report Rate	maximum
Report Mode	Switch Stream
Increment	0
Axis Update	0
Origin:	
MMLC 961	for vertical orientation
MMLC 1201	lower left corner
Tablet Identifier	0

DEFAULT CONFIGURATION

Report Format	8-bit packed binary, including one stop bit and parity (odd) enabled
Baud Rate	9600, fixed