TrackPoint System Version 4.0
Engineering Specification

B. Olyha   CSS Electronic Engineering
J. Rutledge   Mathematical Sciences

Originator Contacts   Bob Olyha
                             IBM T. J. Watson Research Center
                             Route 134
                             P.O. Box 218 M.S. 31-123
                             Yorktown Heights, NY 10598-0218
                             U.S.A.

                             Phone (914) 945-3210 [IBM tieline 862-3210]
                             FAX   (914) 945-4148 [IBM tieline 862-4148]
                             Lotus Notes: Bob Olyha/Watson/IBM@IBMUS
                             internet: rolyha@us.ibm.com

                             Joe Rutledge
                             IBM T. J. Watson Research Center
                             Route 134
                             P.O. Box 218 M.S. 31-250
                             Yorktown Heights, NY 10598-0218
                             U.S.A.

                             Phone (914) 945-1175 [IBM tieline 862-1175]
                             FAX   (914) 945-3434 [IBM tieline 862-3434]
                             Lotus Notes: Joe Rutledge/Watson/IBM@IBMUS
                             internet: rutledg@watson.ibm.com

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
1 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

Table of Contents

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
3 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
4 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

1   GENERAL DESCRIPTION

1.1 INTRODUCTION

This specification defines the TrackPoint integrated pointing device on a PS/2 style keyboard assembly, a force sensing pointing device assembly to be used with a PS/2 type computer system. The TrackPoint sensor is an isometric joystick embedded on the keyboard between the *G*, *H* and *B* keys, with *mouse buttons* embedded on the keyboard below the space bar. The sensor and buttons can also be used independently of a keyboard. This document will specify the mechanical characteristics, logical and electrical functions and interfaces, and performance criteria.

1.2 DESCRIPTION

The TrackPoint system consists of an isometric joystick located in the keyboard between the G, B and H keys, its associated selection buttons and a processing element which interfaces with the PS/2 Auxiliary Device Port. The joystick (Pointing Stick) is operated with the fingertip, placed on its cap which extends at most 1 mm above the adjacent keys. Functionally it provides cursor positioning and graphic input, duplicating the function of a mouse or trackball, but without requiring the user to leave typing position, and without any additional device to be carried, or requiring desk space. Special processing gives the user a sense of ease of use and positive control not previously available in a joystick.

The TrackPoint system is a PS/2 Mouse Type 2a, as defined in the IBM architecture document PS/2 Mouse Architecture Types 1 and 2. The TrackPoint system has an internal processing element which interfaces with the host through the PS/2 Auxiliary Device port. The logical function and electrical interface are completely compatible with the PS/2 Mouse, and mouse drivers and other software may be used unaltered. The TrackPoint controller also serves as host to an additional PS/2 Mouse or compatible device (via switch S2 below), which may be used in conjunction with the TrackPoint system. If the Auxiliary Device port is required for a non-compatible device, the TrackPoint controller may be commanded to disable itself and to enter transparent mode in which it relays all signals between the host and the non-compatible device (refer to schematic switch S1 below). The TrackPoint controller also has extended functions, such as MultiPoint, for which special drivers are required
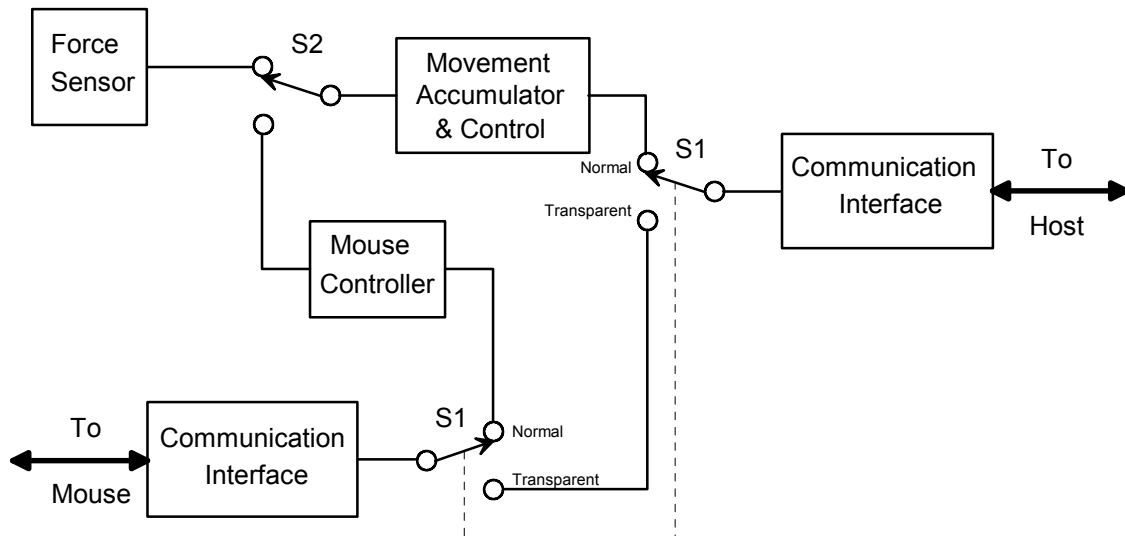
YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
5 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2   FUNCTIONAL SPECIFICATION

2.1 POWER ON RESET

The TrackPoint logic shall execute a Power On Reset (POR) when power is applied to the device. The POR shall be timed to occur 600 ms ± 20 % from the time power is applied to the TrackPoint controller. Activity on the clock and data lines is ignored prior to the completion of the diagnostic sequence. (See RESET mode of operation.)

2.2 BACKGROUND PROCESSING

The following tasks are to be performed at all times, unless individually disabled.

2.2.1 FORCE AND BUTTON SAMPLING

The forces being applied to the X, Y, and Z axis and the buttons must be sampled at the rate of at least 80 per second. For mechanical buttons, samples should be taken at approximately 200 Hz or faster, to capture short duration button events.

2.2.2 INPUT FORCE PROCESSING

Horizontal input force (X and Y axes) is transformed into cursor movement according to a Transfer Function (with memory) which is detailed in "TrackPoint Transfer Function", page 40. Movement increments are accumulated in the Movement Accumulators at each sample, and the integer parts (Mickeys) are available for transmission to the host as required. When a transmission occurs the integer part of both accumulators is cleared, but the fractional part is unchanged.

Input force values are also placed in RAM locations, where they may be accessed by the host by read-out commands or in Burst Mode. X and Y force are measured at 10 bit precision, and Z force at 8 bit precision. The high order 8 bits of the X and Y values are used by the Transfer Function algorithms; the low order 8 bits are used by the Drift Correction algorithms. One unit (h count) in the high-order X or Y register corresponds to 3.2 grams force in the corresponding direction, so one unit (l count) in the low-order register corresponds to 0.8 grams force.

Vertical force (Z axis) forms the basis for the Press to Select (PtS) function of TrackPoint System Version 4.0. PtS is a function that maps temporal patterns of force on the pointing stick cap to button and movement signals transmitted to the host. The intention is to allow the user to perform selection and dragging in a natural fashion as part of the pointing gesture, using only the stick and not the buttons. The PtS function can be adjusted by a number of parameters as described under the "TrackPoint Controller Commands" section beginning on page 20. These parameters are typically adjusted through the use of a user interface presented by the host operating system, the specifics of which will not be covered in this specification.

From the user's perspective, the required function satisfies:

1. Normal use of the stick for moving the cursor should never produce a button signal, regardless of the amount of force used.

    A sharper than normal application of Z axis force downward on the stick should be reported as a button press, occurring at the point on the screen at which the cursor was located when the application of force began.

2. When a press has been recognized, the button continues to be reported 'down' until the Z axis force returns to a 'normal' level, or until there is a sharp reversal from falling to rising Z axis force, as when the Z axis force is partially released and then sharply applied again.

   If a press is held for a long time, the force required to continue to hold it should be minimized.

3. Two presses occurring within the 'double press' time should be reported as occurring at the same point on the screen without intermediate movement - that is no movement signals should be transmitted during the transmission of the 'down - up - down' sequence.

4. If a press is held longer than the 'double press' time, and movement occurs, the subsequent release should be reported at the point at which a sharp reduction of Z axis force began, as with a press. Optionally, the user may elect to have the release reported where the Z axis force crossed the release threshold.

5. Optional feature: Select on Release. A press may also be recognized as a sharp release of Z axis force; a press so recognized should be immediately followed by a release. This allows the user to make a selection by holding the Z axis force normally used for fast cursor movement as the target is approached and then lifting the finger quickly when the target is reached.

6. Optional feature: Tap Filter. A sharp force immediately preceded by a 'hands off' period of 100 msec is recognized as a press in a sixth 'direction', and may be assigned to any button combination (including no button). This can be used to eliminate selections caused by accidental hits on the stick while typing, and in the center-button scrolling mode to perform scrolling without using the mechanical button. Movement data is suppressed for the duration of the tap.

2.2.3 DRIFT CORRECTION

Due to the significant temperature sensitivity of the force sensors and circuit components, it is necessary to recalibrate the zero force origin of each axis on a periodic basis. In order to properly recalibrate, it is necessary to determine when a 'hands off' condition exists (i.e. when no force is being applied). This is done by monitoring the X and Y axis low order (l count) force samples, and when there is minimal change in the readings (no more than ±1 l count) for a specified length of time (0.56 seconds by default) it is assumed that the hands off condition exists. At this time the X, Y, and Z axis origins are reset to the smoothed current value of the X, Y, and Z axis force samples respectively. It should be noted that noise introduced by any source other than applied sensor forces will severely impact the effectiveness of this technique. Parameter controlled smoothing can partially compensate for moderate noise.

The Z axis, due to its higher drift sensitivity, also uses two additional drift correction mechanisms. Since Z axis forces can only be applied in one direction, if the Z axis value ever exceeds the Z axis origin in the incorrect direction, the Z axis origin will track the present value of the Z axis. The remaining drift correction mechanism is: when the Z axis running average approaches the Z axis origin (within 3 counts by default) the Z axis origin will be reset to the present Z axis value. This last drift correction is limited in frequency, by default to once per second.

2.2.4 PS/2 HOST INTERFACE

The host system may initiate a request-to-send condition at any time. The TrackPoint controller is required to accept the host transmission within 10 milliseconds. Refer to "TrackPoint Controller Data Input" on page 50 for further details and timing.

2.2.5 EXTERNAL POINTING DEVICE INTERFACE

The external pointing device may be attached or detached at any time. When no mouse is recognized as attached, the TrackPoint controller polls at nominally 500 millisecond intervals by transmitting a x"F2" command. When the mouse responds with x"FA 00", a sequence of commands is transmitted to set the current status (sample rate, resolution, scaling) and put the mouse into Enabled Stream mode. If the mouse is a TrackPoint controller its sample rate is set to be the same as that of the parent TrackPoint controller, otherwise it is set to 200 per second, in order to improve the response time of many current mice. Set Resolution and Set Scaling commands received from the host are relayed to the mouse.

Reset commands x"FF" are also relayed to the mouse, and the TrackPoint controller waits for its response before responding to the host. If the mouse's response is Failure (x"FC 00") the TrackPoint controller reports Failure to the host. If the mouse fails to respond, it is considered to be absent, and is ignored. A Reset command is sent to the mouse (if present as determined by the x"F2" command) at power-on, as part of the TrackPoint controller's power-on reset sequence, and if Failure is reported by the mouse, the TrackPoint controller also reports Failure.

Continued presence of the mouse (which may be inactive) is verified by x"F4" commands at nominal 0.5 second intervals. Thus the detachment of the mouse will be recognized within approximately 0.5 seconds.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
8 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.3 MODES OF OPERATION

The following are descriptions of the seven modes of operation.

2.3.1 RESET

Following power on, assertion of the TrackPoint controller's hardware reset pin, or acceptance of the RESET command, the TrackPoint controller will execute a set of diagnostics to insure maximum integrity of the device. The functions performed will be a processor test, a checksum verification of the internal program ROM, a RAM integrity test, and check that the analog input from the sensor is within limits. The buttons are not checked, but may be tested by the keyboard controller during the keyboard POST routines. The external pointing device, if connected, will also be sent a RESET command by the controller and its response will be verified. Commands from the host shall be ignored during POST execution. Execution of the diagnostic sequence shall take a maximum of 500 msec. Note that this is in addition to the time required for power on stabilization (VCC > 4.5V). (This is typically under 300 msec.) The test of the analog sensor will only be done during the initial power on test (or after the issuance of the x"E2 7F" command as described on page 36). The result of this initial analog sensor test will be used for all subsequent responses to the RESET command. This prevents reporting of errors when the sensor is being moved during RESET command processing.

Immediately following satisfactory completion of the diagnostics, a completion code of x"AA" shall be transmitted to the host followed by an I.D. code of x"00". The TrackPoint controller will then be set to the following defaults: sampling rate of 100 reports per second, stream mode, disabled, resolution 02, and scaling reset. No further action will occur until a command is received from the host. Any commands sent to the TrackPoint controller prior to the completion of POST will be ignored.

Immediately following a failure to successfully complete the diagnostics, the TrackPoint controller will send an error code of x"FC" followed by an I.D. code of x"00". The source of the error can be determined by the command x"E2 25" as described on page 38. At this time, the TrackPoint controller will remain in its default state and await further command input from the host.

2.3.2 STREAM

Stream mode is the TrackPoint controller's normal operating mode. Stream mode may be either Enabled or Disabled. In Enabled Stream mode, the TrackPoint controller attempts to transmit three byte data packets to the host at the rate set by the "Set Sampling Rate" command. At each transmission time, a packet is sent if there has been activity since the preceding transmission. Activity consists of either motion (a non-zero value in either Motion Accumulator integer part) or a change in button state. In Stream mode (but not in Remote mode) any changed button state occurring during the interval will be reported, even if the button has already returned to its previous state (*sticky button*).

In Disabled stream mode no transmissions are initiated by the TrackPoint controller; otherwise it is the same as Enabled Stream mode. The TrackPoint controller should always be disabled before a command is transmitted to it that requires a response.

The motion and button accumulators receive data from either the TrackPoint controller or the mouse, according to the following algorithm. At any given time either the TrackPoint controller or the mouse or neither is in control. If neither is in control, then the first to become active takes control. If one is in control, it remains in control until it has been inactive for at least 0.38 seconds, when it loses control. For this purpose, 'activity' includes holding a button in its 'down' state in addition to making a change in button state.

These modes are set with a "Set Stream Mode" command, and the "Enable" or "Disable" commands respectively.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
9 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.3.3 REMOTE

In this mode the TrackPoint controller will transmit data only in response to a "Read Data" command. Buttons are reported in their state at the time of transmission (no sticky button). Refer to "Set Remote Mode" on Page 14 for further details.

The treatment of the mouse is the same as in Stream mode.

This mode set by a "Set Remote Mode" command.

2.3.4 WRAP

This mode is set by a "Set Wrap Mode" command, and reset by a "Reset Wrap Mode" or "Reset" command. In this mode any byte of data sent from the host, except "Reset Wrap Mode" or "Reset", will be returned by the TrackPoint controller. If a parity or framing error is detected, a resend x"FE" will be returned to the system. A second consecutive parity or framing error will return an error x"FC". While in wrap mode system commands x"FE" and x"FC" are treated as data and will return x"FE" and x"FC" respectively. Refer to Set Wrap Mode on page 15 for further details.

The mouse is ignored in this mode, and no communication takes place.

This mode is set by a "Set Wrap Mode" command, and reset by a "Reset Wrap Mode" or "Reset" command.

2.3.5 TWO HANDED (MULTIPOINT)

In this mode, data packets from the TrackPoint controller and the mouse are interlaced and transmitted to the host. Data from the mouse (external device) will have the third button bit set to 1, so that the host can determine the original source of the data (assuming that no real third button is in use). The host will then typically employ a software driver to control two cursors on the display, or to control two distinct input functions. Operation in this mode without a specialized software driver in the host will likely cause problems with standard drivers when both devices are active, and for this reason, whenever the "Set Sample Rate" command is received, the *two_handed* flag bit will be cleared. Optionally this clearing can be disabled by setting the *sticky2* bit as described under the x"E2 47 2D 04" command on page 22.

This mode is entered by setting a TrackPoint controller flag bit (x"E2 47 2D 01") as described on page 22.

While operating in Two Handed mode, the sampling rate will be as set by the "Set Sampling Rate" command. However, when both the TrackPoint controller and the mouse are active, reports will be alternated between the two devices, so that the effective reporting rate from each device will be cut in half. For this reason, sampling rates of 60 reports per second and above are recommended while in two handed mode to maintain smooth cursor movement.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
10 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.3.6 TRANSPARENT

In this mode all communication from the host is passed through to the external device, and all communication from the external device is sent directly to the host. Data packets must conform to the timing and electrical specifications as stated in the ELECTRICAL SPECIFICATION section beginning on page 47. This mode is set by one of two "Set Transparent Mode" commands. Refer to S1 in the diagram on page 5 for a schematic representation of Transparent mode.

When this mode is entered via the "Set Hard Transparent Mode" command, only a power on reset will terminate this mode. While in "Hard" transparent mode, no interpretation of the data stream is made by the TrackPoint controller.

When this mode is entered via the "Set Soft Transparent Mode" command, a power on reset or a "Cancel Soft Transparent Mode" command will terminate this mode. While in "Soft" transparent mode, the only interpretation of the data stream made by the TrackPoint controller is to detect the "Cancel Soft Transparent Mode" command. When the last byte of this command is received from the host and transmitted to the external device, the microcontroller will return to the same state it was in prior to entering transparent mode.

While operating in this mode the TrackPoint controller will receive a single byte at a time and output this byte as received, in either direction (host to attached device or visa versa). If a parity error is detected by the TrackPoint controller when receiving a byte from either the host or attached device, the erroneous byte shall be passed on as received. If a framing error is detected by the TrackPoint controller when receiving a command from the host, a "Resend" command (x"FE") is returned to the host and no transmission is made to the attached device. A second consecutive framing error causes the TrackPoint controller to return the error code "FC" to the host. If a framing error is received by the TrackPoint controller from the attached device, the received byte is discarded, and no transmission is initiated to the host.

This mode is intended to allow the host to interact directly with devices connected to the external auxiliary channel (pointing device) connector, for identification and configuration. It can also be used to provide an interface to non-mouse-like devices which utilize the PS/2 auxiliary device port, such as the Prescott TouchScreen and various bar-code readers and specialized keyboards.

Refer to the x"E2 45" command on page 21 for further information on the "Set Hard Transparent Mode" command, and to the x"E2 4E" command on page 23 for further information on the "Set Soft Transparent Mode" command.

2.3.7 BURST

This mode is intended for hardware debugging purposes or for specialized driver applications. Once the burst flag bit is set, the TrackPoint controller will initiate 6 byte data packets at the rate of 80 packets per second. It is imperative that the host service these interrupts in a timely fashion so that the 80 reports per second rate is not delayed, otherwise the force sampling intervals will become erratic. The first three bytes are the normal data packet as transmitted in Stream Mode, except that they are transmitted regardless of activity, perhaps with zero movement. Bytes 4, 5, and 6 will contain the contents of internal RAM values at addresses *burst1*, *burst2*, and *burst3* respectively. Refer to the E2,81,51-53 commands on how to set *burst1-3*. To exit this mode, the burst bit should be cleared, and a pot set request (x"E2 47 23 10") and reset (x"FF") should be performed.

The external device is ignored in this mode, and no communication takes place.

This mode is entered by setting a TrackPoint controller flag bit (x"E2 47 28 80") as described on page 35.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
11 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.4 COMMANDS

The TrackPoint controller shall transmit an ACK (x"FA") response to the host immediately following any valid input from the host other than a resend (x"FE"), a cancel soft transparent (x"E2 B9") command, or if operating in Transparent or Wrap mode (see "Wrap" on page 10). If the TrackPoint controller is interrupted during output of an ACK, it shall discard the ACK and accept and respond to the new command.

Whenever the TrackPoint controller receives a command other than those listed in this section, it will return a resend (x"FE") command to the host. The TrackPoint controller will continue operating in the state it was in prior to receipt of an invalid command. If two invalid commands are received in succession, an error code of x"FC" will be transmitted to the host.   The system should then reset its state and restart any command sequence it was in the process of transmitting.

The count accumulators in the TrackPoint controller will be cleared after receiving any valid command except "Resend" and TrackPoint controller prefix (x"E2") commands. Following a "Read Data" command, the integer parts of the accumulators are cleared after a data transmission from the TrackPoint controller (refer to section 2.5 on page39 for details on the count accumulators).

2.4.1 RESET (x"FF")

The system will issue a "Reset" command to initiate a software reset and internal self-test by the TrackPoint controller. See "Reset" on page 9 for additional details. TrackPoint controller response will be x"FA" followed by the two byte packet x"AA 00" or x"FC 00". A resend command after this command has completed will return a two byte packet.

Also refer to x"E2 7F" on page 36 for a related command.

2.4.2 RESEND (x"FE")

The system can send this command when it detects an error in any transmission from the TrackPoint controller. The "Resend" command should be sent following a TrackPoint controller packet transmission and before the system enables the interface allowing the next TrackPoint controller output. On receipt of "Resend", the TrackPoint controller retransmits the previous packet, of one, two, or three bytes as the case may be. The ACK byte x"FA" is not counted in determining the size of a packet unless it was the only response, in which case the x"FA" will be resent.

If a "Resend" command is received by the TrackPoint controller from the host immediately following a three byte data packet transmission from the TrackPoint controller to the host, the TrackPoint controller should resend the three byte data packet.

This command may also be sent by the TrackPoint controller and is described in "Commands" on page 12 and "Error Handling" on page 46 of this document.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
12 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.4.3 SET DEFAULT (x"F6")

The "Set Default" command will reinitialize the five conditions set by the "Reset" command. Following receipt of this command, the TrackPoint controller will set a sampling rate of 100 reports per second, resolution 02, stream mode, disabled, scaling off. The Accumulators and button status bits will be cleared. No further action will occur until another command is sent from the host. This command differs from a RESET (x"FF") command in that no diagnostic checks performed, there is no minimum completion time, and the completion code is not transmitted. TrackPoint controller response will be x"FA". A resend command after this command has completed will return a one byte packet (x"FA").

2.4.4 DISABLE (x"F5")

When in stream mode, this command disables the initiation of transmissions by the TrackPoint controller. While disabled, the TrackPoint controller will respond to all other commands. If the TrackPoint controller is in stream mode, the host should disable it prior to sending any command that requires a response from the TrackPoint controller. When in remote mode, this command has no effect, but will be reflected in the status byte as described in "Status Request" (x"E9") on page 16, and will be effective on return to Stream mode. TrackPoint controller response will be x"FA". A resend command after this command has completed will return a one byte packet (x"FA").

2.4.5 ENABLE (x"F4")

After POR (Power On Reset), a Reset command, or a Disable command, the TrackPoint controller is disabled from initiating any data transmissions. This command allows the TrackPoint controller to begin transmissions to the host if it is in stream mode at the current sampling rate. When in remote mode, this command has no effect, but will be stored for later use when in stream mode and will be reflected in the status byte as described in "Status Request" (x"E9") on page 16. TrackPoint controller response will be x"FA". A resend command after this command has completed will return a one byte packet (x"FA").

2.4.6 SET SAMPLING RATE (x"F3,XX")

This command is effective only stream mode. When in remote mode, this command has no effect, but will be stored for later use when in stream mode and in the status byte as described in "Status Request" (x"E9") on page 16. A rate of 100 reports per second is the reset default. This is a two byte command where the second byte indicates the sampling rate. The actual sampling rate must be within a range of -20% to +10% of the rate specified in the second byte (see below). The rate at which the TrackPoint controller's sensors are measured will always be an integer multiple of the stream mode sample (reporting) rate. The minimum sensor measurement rate is 80 per second, to maintain proper performance. TrackPoint controller response will be x"FA". A resend command after this command has completed will return a one byte packet (x"FA"). The sampling rates specified by the second byte of this command are:

Second Byte (Hex XX)	Sample Rate	Force Sampling Rate
0A	10 reports per second	80 conversions per second
14	20 reports per second	80 conversions per second
28	40 reports per second	80 conversions per second
3C	60 reports per second	120 conversions per second
50	80 reports per second	80 conversions per second
64	100 reports per second	100 conversions per second
C8	200 reports per second	100 conversions per second

For second bytes not listed in the table above, a x"FE" resend command should be sent by the TrackPoint controller. At this time the host should resend the correct second byte. If an incorrect second byte is sent for a second time in a row, the TrackPoint controller shall return a x"FC". See "Error Handling" on page 46 for further details on error reporting.

This command also has the side affect of conditionally clearing "Two Handed Mode". Refer to page 10 for further details on Two Handed mode.

2.4.7 READ DEVICE TYPE (x"F2")

The TrackPoint controller will always respond with an x"00" to this command, corresponding to a "mouse-like" device. To detect the presence of a TrackPoint system specifically, refer to the "Read Secondary ID" (x"E1") command on page 19. A resend command after this command has completed will return a one byte packet (x"00").

2.4.8 SET REMOTE MODE (x"F0")

This command resets stream mode. In remote mode, data values are reported only in response to a "Read Data" command. While in this mode "Set Scaling" state will have no effect on reported data. TrackPoint controller response will be x"FA". A resend command after this command has completed will return a one byte packet (x"FA").

The external device will, by default, be disabled while the TrackPoint controller is in remote mode. Optionally a TrackPoint controller flag bit [*remmouenb*] may be set to enable the external device. Refer to the "E2 47 2D 10" command on page 28 for details on this option.

2.4.9 SET WRAP MODE (x"EE")

This command places the TrackPoint controller in wrap mode. After transmission of the ACK byte, all data bytes except x"FF" or x"EC" that are sent to the TrackPoint controller will be immediately returned by the TrackPoint controller (without ACK). The TrackPoint controller will remain in the wrap mode until it receives a "Reset Wrap Mode" (x"EC") or "Reset" (x"FF") command.

2.4.10 RESET WRAP MODE (x"EC")

This command resets wrap mode. The TrackPoint controller will return to the previous mode of operation after receiving this command. However, if "Set Wrap Mode" is entered after the TrackPoint controller has been operating in "Stream Mode", the TrackPoint controller will reenter "Stream Mode" disabled after receipt of a "Reset Wrap Mode" command. If the TrackPoint controller is not in the wrap mode when this command is received, the command will be acknowledged, but its state will not be affected. TrackPoint controller response will be x"FA". A resend command after this command has completed will return a one byte packet (x"FA").

2.4.11 READ DATA (x"EB")

This command requests that the TrackPoint controller transmit all the data defined in the data packet format as described in "Data Report" on page 39. This command may be executed in either remote or stream mode. The data will be transmitted even if there has been no activity since the last report. The integer portion of the count accumulators will be cleared. TrackPoint controller response will be x"FA" followed by a three byte packet with the data format as specified in "Data Report" on page 39. A resend command after this command has completed will return a three byte packet. If a resend command is received at any time within the three byte packet, the entire three byte packet will be resent by the TrackPoint controller.

2.4.12 SET STREAM MODE (x"EA")

This command sets the TrackPoint controller in stream mode. This command resets remote mode. If enabled, data will be transmitted to the system in the format described in "Data Report" on page 39 when there is any activity detected, at the rate specified by the current sampling rate. TrackPoint controller response will be x"FA". A resend command after this command has completed will return a one byte packet (x"FA").

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
15 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.4.13 STATUS REQUEST (x"E9")

When this command is issued by the host, the TrackPoint controller will respond with a 3-byte status report as follows:

Byte 1	Description
Bit 0 (LSB)	1 = Right button depressed (TrackPoint system or external device)
Bit 1	1 = Middle button depressed (TrackPoint system or external device)
Bit 2	1 = Left button depressed (TrackPoint system or external device)
Bit 3	0 = Always (Reserved for future use)
Bit 4	0 = Scaling 1:1 / 1 = Scaling 2:1
Bit 5	0 = Disable / 1 = Enable
Bit 6	0 = Stream mode / 1 = Remote mode
Bit 7 (MSB)	0 = Always (Reserved for future use)
Byte 2	Current resolution setting *(Same format as second byte of "E8" command)*
Byte 3	Current sampling rate *(Same format as second byte of "F3" command)*

Note: Byte 1 has a different format than that which is used in "Data Report" on page 39. TrackPoint controller response will be x"FA" followed by a three byte packet as specified above. A resend command after this command has completed will return a three byte packet.

Note on middle button: This bit may be masked out for compatibility with applications which require this bit to be 0. Refer to Pointing Stick Command x"E2 4B" for more details. It is also used in MultiPoint mode to indicate source of data.

2.4.14 SET RESOLUTION (x"E8,XX")

This command has no effect for the TrackPoint controller but will be transmitted to the external device if AND when it is attached. The second byte will be stored for use in responding to the "Status Request" (x"E9") command as described on page 16. This command is used with mice to relate travel distance to Mickeys reported and this relationship differs between mice.

The default value is x"02". TrackPoint controller response will be x"FA". A resend command after this command has completed will return a one byte packet (x"FA").

For second bytes other than x"00", x"01", x"02", x"03", a resend command (x"FE") should be sent by the TrackPoint controller. At this time the host should resend the correct second byte. If an incorrect second byte is sent for a second time in a row, the TrackPoint controller shall return a x"FC". See "Error Handling" on page 46 for further details on error reporting.

2.4.15 SET SCALING 2:1 (x"E7")

This command has no effect in the TrackPoint controller, but will be transmitted to the external mouse if AND when it is attached. Scaling will be stored for use in responding to a "Status Request" command (x"E9") as described on page 16.

Note: There are two commands which modify the TrackPoint controller's transfer function in a more appropriate and flexible manner than the Resolution and Scaling commands. Refer to the *snstvty* (x"E2 81 4A XX") and *value6* (x"E2 81 60 XX") parameters on pages 24 and 24 for further information. Acceleration functions generally available in the drivers may also be used, but this is not recommended.

TrackPoint controller response will be x"FA". A resend command after this command has completed will return a one byte packet (x"FA").

2.4.16 RESET SCALING 1:1 (x"E6")

This command has no effect in the TrackPoint controller but will be transmitted to the external mouse if AND when it is attached. Scaling will be stored for use in responding to a "Status Request" command (x"E9") as described on page 16. TrackPoint controller response will be x"FA". A resend command after this command has completed will return a one byte packet (x"FA").

2.4.17 READ EXTENDED ID (PnP STRING) (x"D0")

This command shall return the extended ID of the pointing device. The maximum length of the extended ID is 256 bytes. The pointing device will first respond with an acknowledge (x"FA"), followed by the extended ID string. If any transmission error is detected by the host, the x"D0" command should be resent, and the process restarted. If a Resend command (x"FE") is sent, only the last single byte will be resent, and the remainder of the string will be discarded. The following table describes the fields for the extended ID string. Refer to Appendix B beginning on page 71 for more details on the contents of these fields.

Field Name	Size (bytes)	YKT3E string (ASCII)	Description
Other ID	< 17	M 19990623	Additional Plug and Play ID
Begin Extended ID	1	(	Start of Extended ID
PnP Revision Level	2	☺$	Plug and Play Specification Revision Level
Manufacturer ID	3	IBM	Manufacturer ID assigned by EISA
Product Number	3	378	Manufacturer assigned unique Product Number
Product Revision	1	0 (or) 1	Manufacturer assigned product revision number (see Appendix: 0=2 Buttons, 1=3 Buttons)
End Extended ID	1	)	End of Extended ID

Note that the Product Revision character of this string may be dynamically altered by changing the *button2* TrackPoint control bit as described in section 2.4.19.7.

2.4.18 READ SECONDARY ID (x"E1")

This command will read the secondary device ID of the pointing device (2 bytes). The least significant byte is sent first. The TrackPoint controller will always return x"01" for the first byte, and a second byte which denotes a specific set of functional specifications. Differing ROM versions are used to denote changes within a given functional set. Current assignments are as follows:

SECONDARY ID (HEX XXXX)	MACHINE TYPE
0101	(8xC752 PLCC implementation), Versions 8E, 98
0201	(8xC752 PDIP implementation), Version A4
0301	(8xC752 PDIP, PLCC implementations), Version AB
0401	(H8-3332 QFP implementation), Version 03
0501	(8xC749 implementation), Versions B2, B4
0601	(8xC752, 8xC749 implementations), Versions B1, B3, B5, B8 (8xC754, SSOP implementation), Version 2B
0701	(H8-3332 QFP implementation), Version ?
0801	(H8-3332 QFP implementation), Version ?
0901	(H8-3332 QFP implementation), Version ?
0A01	(8xC754 SSOP implementation), Version 35
0B01	(8xC754 SSOP implementation), Versions 3A, 3B
0C01	(8xC754 SSOP implementation), Version 3C
0D01	(8xC754 SSOP implementation), Version 3D
0E01	(8xC754 SSOP implementation), Version 3E

2.4.19 TRACKPOINT CONTROLLER COMMAND (x"E2,…")

This command indicates a TrackPoint controller unique command. Valid commands will be responded to with an ACK to each command byte. Invalid commands will be responded to with a resend (x"FE"). Certain commands are not implemented in certain ROM versions. These commands will also be responded to with a resend (x"FE"). Count accumulators and status bits are not affected by these commands (unless these variables themselves are addressed).

For E2 arguments not listed in the tables below, a x"FE" resend command will be returned by the TrackPoint controller. At this time the host should resend the correct byte. If an incorrect argument is sent for a second time in a row, the TrackPoint controller will return a x"FC". See "Error Handling" on page 46 for further details on error reporting.

For commands listed below that begin with the sequence "E2 47" it is assumed that the TrackPoint controller flag bit being manipulated is cleared before this command is issued. This is the power on default case in all instances. The "E2 47" command toggles the state of a flag bit, and is described further on page 21.

Commands are listed here in functional order. For a numerically ordered listing, refer to Appendix A beginning on page 64.

2.4.19.1 TrackPoint Controller RAM Manipulation

COMMAND BYTES (Hex)	DESCRIPTION
E2 00 - E2 3F	Read from TrackPoint controller RAM location These commands will read the internal RAM location pointed to by the second byte and return its contents to the host as a single byte data packet.
E2 80 XX	Read from TrackPoint controller RAM location XX This command is a general purpose read command which is identical to the x"E2 00" - x"E2 3F" commands for arguments ≤ x"3F". Refer to the Appendix for current RAM address assignments.
E2 81 XX YY	Write byte YY to TrackPoint controller RAM location XX This command is a general purpose write command. Refer to the Appendix for descriptions of defined address locations. Do not use this command to set bit flags. Use the x"E2 47 XX XX" command instead. Extreme care should be exercised in using the "E2 81 XX YY" commands, since these will overwrite any RAM location named in the third byte, with the value in the fourth byte. If incorrect locations are addressed, the result is unpredictable and the TrackPoint controller may cease to function until the next hardware reset.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
20 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

E2 47 XX YY   TrackPoint controller RAM bit toggle command

This command will overwrite internal data values, and if used incorrectly will result in unpredictable software instabilities. This command toggles specific TrackPoint controller flag bits as mapped in Appendix A. This is a four byte command. Byte one and two are x"E2 47" which select this command. Byte three is the address of the internal RAM register, in the range of x"00"-x"FF". Flag bits are mapped into addresses x"20" - x"2F". Byte four is logically exclusive ORed with the current RAM value.

Example: To enable Press to Select, the bit flag to be set is bit 0 of RAM location 2C, as determined by Appendix A. The host would then follow this sequence: (all commands and responses are in HEX).

Time sequence	Host Command	Pointing Device Response	Description
1	E2		TrackPoint Controller Command
2		FA	Acknowledgment
3	2C		RAM address
4		FA	Acknowledgment
5		00	Bit 0 = 0
			If Bit 0 was = 1, it is already enabled; therefore stop here
6	E2		TrackPoint Controller Command
7		FA	Acknowledgment
8	47		Bit toggle command
9		FA	Acknowledgment
10	2C		RAM address
11		FA	Acknowledgment
12	01		Bit 0 mask (Bit 0 will toggle)
13		FA	Acknowledgment

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
21 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

Copyright IBM Corp. 1999

2.4.19.2 TrackPoint Controller Operational Modes

COMMAND BYTES (Hex XX)	DESCRIPTION

E2 47 2C 01   Toggle Press to Select (PtS) functions [*ptson*]

When the *ptson* bit is set, the Press to Select functions will be enabled. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit. Refer to page 6 for further details on Press to Select functions.

E2 47 2D 01   Toggle two handed mode [*two_handed*]

When the *two_handed* bit is set, the TrackPoint controller will enter "Two Handed mode" as described on page 10. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.   A set sample rate (x"F3 XX") command may clear this bit (refer to the "E2 47 2D 04" command below). The *moustat* byte should be cleared with the "E2 81 26 00" command immediately after clearing the *two_handed* bit to properly initialize the mouse button state. If the *nmbbit* flag is set, it must be cleared during operation in two handed mode and should have its value restored when leaving two handed mode. Refer to the "E2 47 2D 02" command on page 29 for details on the use of the *nmbbit* flag.

E2 47 2D 04   Toggle sticky two handed mode [*sticky2*]

When the *sticky2* bit is set, a set sample rate command (x"F3 XX") will be prevented from clearing the *two_handed* flag bit. Refer to "Two Handed mode" on page 10. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

E2 45
E2 47 2C 80   Set Hard Transparent Mode

This command will be acknowledged first, then enter "Hard" transparent mode. The only exit from this state is a hard reset (power cycle or reset pin asserted high). See "Soft Transparent" mode x"E2 4E" for similar function. This state can also be entered via the *config* register as described in the x"E2 27 2C 80" command on page 22. See "Transparent" on page 11 for further details about transparent mode.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
22 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

E2 4E   Set Soft Transparent Mode

This command will be acknowledged first, then enter "Soft" transparent mode. The external pointing device port will be disabled until the first transmission is initiated by the TrackPoint controller. This will ensure that unsolicited bytes will not be presented to the host which were pending on the communication channel from the external device. The only exit from this state is a hard reset (power cycle or reset pin asserted high) or a Cancel Soft Transparent Mode command x"E2 B9". See "Hard" Transparent mode x"E2 45" for similar function. See "Transparent" on page 11 for further details about transparent mode.

E2 B9   Cancel Soft Transparent Mode

This command will be transmitted to the externally connected device first and then cause an exit from transparent mode. The microcontroller will return to the state it was in prior to entering soft transparent mode. Care should also be taken in processing the response to the first byte of this command (x"E2"), as the lack of a response or a resend should be ignored, and the second byte (x"B9") sent. In general, the x"B9" byte will not be acknowledged, but with certain external devices this may be possible. See "Soft" Transparent mode command (x"E2 4E") on page 23 for additional information. See "Transparent" on page 11 for further details about transparent mode.

E2 47 28 80   Toggle Burst mode enable [*kburst*]

When the *kburst* bit is set, the TrackPoint controller will enter "Burst" mode as described on page 11. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will reset this bit to 0.

E2 44   Power down the TrackPoint controller permanently. The only recovery from this command is a hardware reset.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
23 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.4.19.3 Response - Transfer Function Parameters

| COMMAND BYTES (Hex XX) | DESCRIPTION |

E2 80 4A
E2 81 4A XX

Sensitivity Factor [*snstvty*]

This data value will be used to scale the input force prior to the application of the transfer function. The data will be divided by 128 and then multiplied with the calculated magnitude of the X and Y axis forces, and the result is truncated. The range of sensitivity will be 0 (x"00") to 1.99 (x"FF") times nominal. The power on default for this value is x"80" corresponding to a scale factor of 1.00. The sensitivity value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 4D
E2 81 4D XX

Negative Inertia Factor [*inertia*]

This parameter is used to scale the effect of the negative inertia algorithms. The range of this factor will be 0 (x"00") to 255 (x"FF"). The default value for *inertia* is x"06". This value is not affected by a reset (x"FF") or set default (x"F6") command. Refer to page 44 for additional information on Negative Inertia.

E2 80 60
E2 81 60 XX

Transfer Function Upper Plateau Speed [*value6*]

This parameter specifies the slope of the transfer function segment preceding the upper plateau, which in turn specifies the upper plateau speed. This parameter is provided to enhance performance with large format displays. The relationship between value6 and the upper plateau speed is approximately $Speed = 22 + 4.3(value6)$, with speed in units of mickeys per second. Refer to the "TrackPoint Transfer Function" section on page 41 for more information. The default value for *value6* is x"61" (97 decimal), which is appropriate for a 1024 x 768 pixel display with a 2 x acceleration in the mouse driver. This value is not affected by a reset (x"FF") or set default (x"F6") command.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
24 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.4.19.4 Press to Select Parameters

COMMAND BYTES (Hex XX)	DESCRIPTION

E2 47 2C 01   Toggle Press to Select (PtS) functions [*ptson*]

When the *ptson* bit is set, the Press to Select functions will be enabled. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit. Refer to pages 6 and 44 for further details on Press to Select functions.

E2 80 57
E2 81 57 XX   Backup Range [*reach*]

This PtS parameter specifies the range searched for maximum curvature, to find the point to back up to. The units are the number of force sample points, which is related to the sampling rate as shown in the x"F3 XX" command on page 14. The default value for *reach* is x"0A" (10 decimal). This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 58
E2 81 58 XX   Drag Hysteresis [*draghys*]

This PtS parameter is a fraction < 1. When a drag is recognized (mindrag samples after a press is recognized) the working threshold (*wthr*) is adjusted to make it easier (least significant bit of *draghys* = 1) or impossible (lsb = 0) to hold the drag. When lsb(*draghys*) = 1, $wthr = \frac{thr*draghys}{256}$. If lsb(draghys) = 0 then working threshold is set such that the drag is dropped immediately: $wthr = \frac{8*thr*draghys}{256}$. The default value for *draghys* is x"FF" (255 decimal) which sets *wthr* to *thr*. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 59
E2 81 59 XX   Minimum Drag [*mindrag*]

This PtS parameter specifies the number of force samples that Z must remain above working threshold to be recognized as a drag. The running average is frozen when a press occurs, so the working threshold does not follow Z during a press. This is also the time following a press during which all cursor movement is suppressed, to allow the press gesture to finish and to wait for a possible second press. The default value for *mindrag* is x"14" (20 decimal). This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 5C
E2 81 5C XX

Threshold [*thr*]

This PtS parameter is the Z axis force required to trigger a press or release, relative to the running average. Working threshold [*wthr*] is calculated from the sum of the threshold and running average. A 'press' occurs when Z force exceeds working threshold. The default value for *thr* is x"08". This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 5A
E2 81 5A XX

Up Threshold for release [*uthr*]

This PtS parameter contains the offset from running average to generate a select (click) on release. A 'press' occurs when Z force is less than *running average - uthr*. The default value for *uthr* is x"FF", so that select on release is disabled. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 5E
E2 81 5E XX

Z Time Constant [*zTc*]

This PtS parameter is the time constant of the running average of Z force. Its units are in force sampling time units as specified in the Set Sampling Rate command on page 14. This determines how sharp a press has to be to be recognized. The value of this parameter is 256/n, where n is the desired time constant. The running average is then calculated with the formula: $A = A + (N - A)\frac{X}{256}$ where A = running average, N = present sample, and X is *zTc*. The default value for *zTc* is x"26" (decimal 38) corresponding to a time constant of 6.7 samples. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 5D
E2 81 5D XX

Jenks Curvature [*jkcur*]

This PtS parameter, expressed in degrees, specifies the minimum curvature necessary to generate a double press without a release to working threshold between the presses. This condition only applies when the Z force is increasing. The default value for *jkcur* is x"87" corresponding to 135°. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 47 2D 08

Toggle Skip backups on release from drags when PTS is enabled [*skipback*]

When the *skipback* bit is set, backup cursor movement during releases from drags will be suppressed. The default value for this bit is 0. Refer to page 6 for further details on Press to Select functions. A reset (x"FF") or set default (x"F6") command will not affect this bit.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
26 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.4.19.5

This page is intentionally blank

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
27 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.4.19.6 External Device Parameters

COMMAND BYTES (Hex XX)	DESCRIPTION

E2 80 61
E2 81 61 XX

Device arbitration lockout delay time (*movdel*)

This parameter controls the amount of time after the last detected activity that either the TrackPoint controller or external pointing device retains control. "Activity" as used here also includes a held button. If it is desired not to include the external pointing device's buttons as "activity", the *nmbbit* bit flag can be set. Refer to the x"E2 2D 47 02" command on page 28 for the location of this flag. Its units are in force sampling time units as specified in the Set Sampling Rate command on page 14. The default value for *movdel* is x"26" (38 decimal) corresponding to nominally 380 ms. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 47 20 80

Toggle Enable source tag bit [*tagbit*]

When this bit is set, bit 3 of the data report will reflect the source of the reported data (TrackPoint controller or external pointing device). See "Data Report" on page 39 for additional details. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

E2 47 22 04

Toggle Force mouse status bit 3 to 1 [*forceb3*]

When the *forceb3* flag bit is set, bit 3 of the external device's status byte will be forced to 1 for use with the source tag bit (*tagbit*) as described in the x"E2 47 20 80" command. This enforces the rule that bit 3 of the status byte will be set to 1 when the data originated from the external device. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

E2 21   External device connected [*xdevin*] (READ ONLY)

Bit 3 is set when an external device has successfully responded to the x"F2" command with x"FA 00". This bit may be cleared when a sequence of commands is sent from the host with minimal delays between them. In this case, a maximum of 550ms may be necessary before the bit will be set again. For a more reliable indication of external device connection, soft transparent mode should be used to interrogate the external device port directly.

E2 47 23 01   Toggle Block Middle Button (TrackPoint controller and External Pointing Device) [*block3*]

Refer to "Data Report" on page 39 for more information on the effects of setting Bit 0. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

E2 47 23 02   Toggle External pointing device disabled [*mcomdis*]
E2 40   Disable External pointing device
E2 41   Enable External pointing device

When the *mcomdis* bit is set, the external pointing device clock and data lines are no longer driven by the TrackPoint controller. The default value for this bit is 0. The x"E2 40" and x"E2 41" commands will also respectively set and clear the *mcomdis* bit. A reset (x"FF") or set default (x"F6") command will not affect this bit.

E2 47 2D 02   Toggle Enable NMB switch mode [*nmbbit*]

This bit is intended for use in applications where a single set of physical buttons is shared between the TrackPoint controller and external pointing device(s). To utilize this function, the single set of physical buttons should be connected to the TrackPoint controller only. This will prevent delayed reporting of button events by the external device interfering with the TrackPoint controller's button reports. In this configuration, the *nmbbit* must be set to prevent a held button from locking out movement from one of the devices. When operating in two handed mode, this bit must be cleared. If the external device is intended to be used with the TrackPoint controller disabled (as in transparent mode), external logic must be incorporated to connect the buttons to the external device. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

Also refer to the x"E2 47 2D 80" command on page 36 for a related command when sharing physical buttons.

E2 80 4C   Hot plug delay time [*hpdelay*]
E2 81 4C XX

This parameter controls the rate of polling for detecting a hot plugged external device. Each increment is one force sampling interval (nominally 10 ms). The default value for *hpdelay* is x"32" (50 decimal) corresponding to nominally 500 ms. This value is not affected by a reset (x"FF") or set default (x"F6") command.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
29 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

E2 47 2D 10   Enable external pointing device in remote mode [*remmouenb*]

When the *remmouenb* bit is set, the external mouse will be enabled while the TrackPoint controller is in remote mode, otherwise the external device will be disabled while the TrackPoint controller is in remote mode. By default this bit is cleared. A reset (x"FF") or set default (x"F6") command will not affect this bit.

E2 47 2D 40   Toggle msfix bit [*msfix*]

If the external mouse is exhibiting poor click performance and/or the external mouse movement is choppy or intermittent setting this bit may improve its performance. When this bit is set to 1, the external mouse sample reporting rate will be set to the TrackPoint controller's reporting rate. If the bit is cleared, the external mouse will be set to 200Hz. This only applies to external devices which are not TrackPoints, as external TrackPoints will always be set to match the primary TrackPoint controller's reporting rate. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

E2 47 2E 80   Toggle suppression of F4 polling of external device [*stopF4*]

When the *stopF4* bit is set, the TrackPoint will not send F4 polling commands to the external device when it is idle. These polling commands are normally sent to detect hot unplugging of the external mouse. The *stopF4* bit should only be set when the external device is permanently attached to the TrackPoint controller. If the *stopF4* bit is set and the external device is disconnected, the potential exists for a 'stuck button' to be reported until the next reset is processed. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

2.4.19.7 Middle Button Controls

COMMAND   DESCRIPTION
BYTES
(Hex XX)

E2 4C   Toggle Block Middle Button (TrackPoint controller and External Pointing Device) [*block3*]
E2 47 23 01

In either form, this command will toggle the state of the Block Middle Button flag. The present state should always be read first (x"E2 4B" bit 0 or x"E2 23" bit 0) to ensure proper function. The power on default will have the middle button enabled (*block3* = 0). The flag value is not affected by a reset (x"FF") or set default (x"F6") command. Refer to "Data Report" on page 39 for more information on the effects of setting this bit.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
30 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

E2 4B   Read Extended Button Status

This command will return a single byte containing information about the number of hardware buttons available, and the number of buttons that are presented to the host. The format will consist of two 4 bit nibbles, the most significant 4 bits (bits 7-4) will contain the number of hardware buttons present in the TrackPoint controller , and the lower 4 bits (bits 3-0) will contain the number of buttons that may be presented to the host. The hardware nibble is formed by reading the *button2* bit of the *config* register (see x"E2 2C"). A 2 or 3 will then be placed into the hardware nibble to indicate the number of physical buttons present. The software nibble is formed by reading the state of the Block Middle Button flag ([*block3*] see x"E2 23") and reporting the result. A software nibble value of 2 indicates that the middle button will never be reported to the host as active, whether it has come from the TrackPoint controller or an external 3 button pointing device. The four valid responses will be x"22", x"23", x"32", x"33 ".

2.4.19.8 Drift Control Parameters

COMMAND
BYTES
(Hex XX)

DESCRIPTION

E2 80 5F
E2 81 5F XX

Drift Counter 1 Reset Value [*rstdft1*]

This parameter sets the period of time to test for a 'hands off' condition before a drift calibration occurs. This value is in units of 107 milliseconds per count. The default value for *rstdft1* is x"05" corresponding to a 533 millisecond period. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 64
E2 81 64 XX

XY running average drift time constant [*xydriftavg*]

This parameter sets the time constant used for the X and Y axis running average routines used in conjunction with a high sensitivity TrackPoint circuit for drift control only. This directly affects the performance of the drift cancellation algorithms. The least possible averaging which allows calibration to take place should be used, otherwise improper calibrations will occur during slow cursor movement. The formula used for running average is : $A = A + (N - A)\frac{X}{256}$ where A = running average, N = present sample (*lowx* or *lowy*, low order *l* counts), and X is *xydriftavg*. The default value for *xydriftavg* will depend upon the presence of a jumper between pins 26 and 21 of the TPM754. If the jumper is present (noisier sensor), the default value will be x"40" (decimal 64) corresponding to approximately a 4 sample average, otherwise the default value is x"80" (decimal 128) corresponding to a 2 sample average. This value is not affected by a reset (x"FF") or set default (x"F6") command.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
31 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

E2 80 4E   Z Axis drift limit [*pdriftlim*]
E2 81 4E XX

This PtS parameter controls the Z axis origin recalibration routine. When the running average of Z is within *pdriftlim* and a Z axis recalibration has not occurred within the time specified by the *pdrift_rel* parameter, the Z axis origin is recalibrated to the present Z axis value. The default value for *pdriftlim* is x"03". This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 4F   Z Axis drift reload value [*pdrift_rel*]
E2 81 4F XX

This PtS parameter controls the maximum rate at which a Z axis recalibration may occur due to proximity (*pdriftlim*) to the current Z axis origin. Each increment is one force sampling interval (nominally 10 ms). The default value for *pdrift_rel* is x"64" (100 decimal) corresponding to nominally 1 second. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 65   XY running average threshold [*xyavgthr*]
E2 81 65 XX

This parameter sets the limit for how far the running average can change in one cycle. If the difference between the running average and the trial value exceeds this running average threshold, the running average gets set to the current value instead of being updated using the running average routines. The default value for *xyavgthr* is x"FF" corresponding to a step size of 2. To calculate the value of *xyavgthr* use the formula 255 - step threshold - *drift*, where *drift* is the actual contents of the drift register located at address x"63". The minimum value for the step threshold is drift threshold + 1. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 47 23 80   Toggle Disable Drift Correction [*skipdrift*]

Setting this bit will disable the drift cancellation algorithms. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

E2 80 63   Drift Threshold [*drift*]
E2 81 63 XX

This parameter is used to set the threshold at which drift calibration will occur. Low drift thresholds should be used to maximize the effectiveness of the drift calibration algorithms. If the difference between the smoothed conversion value and the trial value remains within the internal drift threshold, drift calibration will occur. The format of this parameter is x"FF"- drift threshold. The default value for *drift* is x"FE", corresponding to a drift threshold of 1. A reset (x"FF") or set default (x"F6") command will not affect this byte.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
32 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.4.19.9 Calibration Parameters

COMMAND BYTES (Hex XX)	DESCRIPTION

E2 80 46
E2 81 46 XX

XY running average origin time constant [*xyavg_factor*]

This parameter sets the time constant used for the X and Y axis running average routines. When a drift calibration cycle occurs, the origin values are set to the current running average that was calculated using this parameter. The formula used for running average is: $A = A + (N - A)\frac{X}{256}$ where A = running average, N = present sample (*xlast* or *ylast*, high order *h* counts), and X is *xyavg_factor*. The default value for *xyavg_factor* is x"80" (decimal 128) corresponding to a 2 sample average. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 47 23 08

Toggle Skip Pot sets [*skippots*]

When this bit is set to 1, automatic pot recalibration cycles will not occur. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

E2 47 23 10

Toggle Pot set request [*setpots*]

This bit may be set at any time to force a pot recalibration cycle. This command will be acknowledged first and then the recalibration cycle will take approximately 310 milliseconds to complete. No other commands should be sent during this interval, otherwise the cycle will terminate and the pots will not be correctly set. After the cycle has been completed, this bit will clear itself. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect Bit 7.

E2 51

Force Recalibration cycle

This command will reset the X, Y, and Z origins to the current value of the X, Y, and Z axis respectively, and if these values are out of bounds, a DAC calibration cycle will be performed. This cycle will take approximately 310 milliseconds to complete. No other commands should be sent during this interval, otherwise the cycle will terminate and the pots will not be correctly set. The acknowledge byte will be sent <u>after</u> this process completes. Note that this is an exception to the rule that the acknowledge byte should follow the command within 25 ms.

E2 47 2D 20

Toggle Skip Automatic Z axis step [*skipzstep*]

Setting this bit will prevent the Z axis DAC from taking an up or down step as a result of the Z axis hitting the limits of the A/D range. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

2.4.19.10 Sensor Configuration Parameters

COMMAND BYTES (Hex XX)	DESCRIPTION

E2 81 2C XX   Set Default Configuration register [*config*]

Bit 0   1 = Press to Select (PtS) functions active [*ptson*]
Bit 1   Reserved
Bit 2   1 = Physical implementation uses 2 click buttons [*button2*]
Bit 3   1 = Invert X axis [*flipx*]
Bit 4   1 = Invert Y axis [*flipy*]
Bit 5   1 = Invert Z axis [*flipz*]
Bit 6   1 = Exchange X and Y axis [*swapxy*]
Bit 7   1 = Force Hard Transparent Mode [*ftrans*]

This register is meant to provide a single configuration byte that the host's BIOS can utilize to set defaults that are specific to a given application. For example the inversion bits can correct common wiring errors via BIOS control, and provide system level information, such as number of physical buttons, to the firmware. The default value for these bits is 0. A reset (x"FF") or set default (x"F6") command will not affect any bits in this register.

The Y and Z axis direction can also be controlled via physical pins on the TrackPoint controller. When one of these pins is connected to ground, the appropriate axis direction will invert. This inversion is applied in addition to any inversions set above (i.e. if both the physical pin were grounded and the corresponding *flip* bit were set to 1, the net result would be no inversion).

Changing the *button2* bit modifies the response to the Read Extended ID (PnP String) command (x"D0"). Refer to the x"D0" command description or Appendix B for additional details. The *button2* bit may also be modified with an external jumper. Refer to Appendix D for additional details.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
34 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.4.19.11 Debug Parameters

COMMAND BYTES (Hex XX)	DESCRIPTION

E2 80 51
E2 81 51 XX

Burst mode Byte # 1 Address [*burst1*]

This parameter contains the address of the first RAM location transmitted when in Burst mode and in response to the E2 4F command (see page 36). Refer to the Burst mode description on page 11 for more information. The default value for *burst1* is x"3F" (*plast*). This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 52
E2 81 52 XX

Burst mode Byte # 2 Address [*burst2*]

This parameter contains the address of the second RAM location transmitted when in Burst mode and in response to the E2 4F command (see page 36). Refer to the Burst mode description on page 11 for more information. The default value for *burst2* is x"3D" (*xlast*). This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 53
E2 81 53 XX

Burst mode Byte # 3 Address [*burst3*]

This parameter contains the address of the third RAM location transmitted when in Burst mode and in response to the E2 4F command (see page 36). Refer to the Burst mode description on page 11 for more information. The default value for *burst3* is x"3E" (*ylast*). This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 47 28 80

Toggle Burst mode enable [*kburst*]

Refer to "Burst" on page 11 for more details on Burst mode. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will reset this bit.

E2 46

Read ROM version. (READ ONLY)

The TrackPoint controller will return a single byte indicating its ROM version. For YKT3E this is x"3E".

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
35 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

E2 47 2D 80   Toggle suppress sync pulse on left button input pin [*nosync*]

Setting this bit will suppress the sync pulse which appears every conversion cycle on the left button input. This must be done when sharing physical buttons between the TrackPoint controller and another device. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will reset this bit.

Also refer to the x"E2 47 2D 02" command on page 29 for a related command when sharing physical buttons.

E2 4F XX   Write DAC value and return results

This function takes 1 argument, and returns 3 bytes. This function sets the X Y, and Z DACs to the input argument and returns the contents of the registers whose addresses are in the *burst1*, *burst2*, and *burst3* registers. By default, these are the Z, X, and Y axis conversion results. The user should be aware that after this function is executed, it is highly likely that a DAC calibration cycle will follow immediately, therefore before returning to normal operation, no commands should be sent to the TrackPoint controller for approximately 350 milliseconds, to allow the calibration cycle to complete.

E2 25   Power On Self Test results [*post*] (READ ONLY)

Bit 0   1 = Internal RAM failure [*ramfail*]
Bit 1   1 = Internal ROM failure [*romfail*]
Bit 2   Reserved
Bit 3   1 = X axis out of range at power up [*xfail*]
Bit 4   1 = Y axis out of range at power up [*yfail*]
Bit 5   1 = External pointing device POST error [*moufail*]
Bit 6   Reserved
Bit 7   Reserved

Bits 0, 1, and 5 of this register are refreshed during every RESET command. Bits 3 and 4 are only updated with a power on reset or with the x"E2 7F" command. The data in this register will remain valid until the next RESET command. This may be read after the receipt of a failing POST to determine the cause of failure. In all cases where a POST failure is reported, one or more of these bits will be set.

E2 7F   Power on Reset

Following the acknowledgment to this command, the microcontroller will proceed to execute instructions from its power on or hard reset vector. All parameters will be reset to their power on default values, and a POST completion response of x"AA 00" or x"FC 00" will be transmitted upon completion. Be aware that if BIOS has changed any of the configuration bits (See x"E2 2C" on page 34) these will be reset to their power on default state. If it is desirable to retain these state bits, the user should read them with the x"E2 2C" command prior to the issuance of the x"E2 7F" command, and restore these values after completion with the x"E2 81 2C XX" command.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
36 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.4.19.12 Analog to Digital Conversion

COMMAND BYTES (Hex XX)	DESCRIPTION

E2 47 20 10   Toggle Disable TrackPoint controller Sampling [*samdis*]

This bit controls the TrackPoint controller's force conversion process. When it is set to 1, the force sensing conversion routines will be bypassed, thus saving power and improving response time for both the host and the external pointing device interfaces. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

E2 80 44-45
E2 81 44-45 XX   X, Y Axis Conversion power on Delay time [*delayh, delayl*] (16 bit)

Address 44 = low byte, address 45 = high byte

This RAM pair contains the delay value for the time between the start of the timing ramp and the beginning of the actual conversion timing window. Each increment is $\frac{1}{3}$μs. The formula for this time is *delayh,delayl* = x"FC00" - (delay increments). The default value for *delayh,delayl* is x"FA,80" corresponding to 128 μs. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 62
E2 81 62 XX   Z Axis Conversion power on Delay time [*delayhz*]

This RAM location contains the upper 8 bits of the delay value for the time between the start of the timing ramp and the beginning of the actual conversion timing window. The lower 8 bits are in the *delayl* register. Each increment is $\frac{1}{3}$μs. The formula for this time is *delayh,delayl* = x"FF00" - (delay increments). The default value for *delayhz,delayl* is x"FD,80" corresponding to 128 μs. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 47
E2 81 47 XX   Operational Amplifier power up delay [*opadelay*]

This parameter contains the delay value for the time between power application and X axis conversion start. Each increment is 10 μs. The default value for *opadelay* is x"74" (116 decimal) corresponding to 1160 μs. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 48
E2 81 48 XX

DAC settling time delay [*dacdelay*]

This parameter contains the delay value for the time between the changing of the DAC and X axis conversion start. Each increment is 2 μs. The default value for *dacdelay* is x"C8" (200 decimal) corresponding to 400 μs. This value is not affected by a reset (x"FF") or set default (x"F6") command.

E2 80 49
E2 81 49 XX

Gap delay time [*gapdelay*]

This parameter contains the delay value for the time between the zeroing of the DAC and subsequent DAC value change. Each increment is 4 μs. The default value for *gapdelay* is x"C8" (200 decimal) corresponding to 800 μs. This value is not affected by a reset (x"FF") or set default (x"F6") command.

2.4.19.13 Miscellaneous Functions

COMMAND
BYTES
(Hex XX)

DESCRIPTION

E2 52

Generate Tactile output pulse

This command will cause the tactile output pin to pulse low for approximately 10 ms, independent of the state of the *skiptac* control bit, described below.

E2 47 2E 20

Toggle Disable Tactile output [*skiptac*]

This bit controls the tactile output pin. When this bit is set, the tactile output is disabled. The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

E2 47 2C 02

Toggle 'Half-Tactile' control [*halftac*]

This bit controls the function of the tactile output. When this bit is set, a tactile pulse will be generated (if allowed by *skiptac*) by presses only (not releases). The default value for this bit is 0. A reset (x"FF") or set default (x"F6") command will not affect this bit.

2.5 DATA REPORT

When the TrackPoint controller is operating in Stream Enabled mode, a data report will be transmitted at the end of a sample interval if there is activity to report.

There is activity to report if the integer part of either the X or Y accumulator is non-zero, or if a button report state has changed since the last report. A button's report state is 'depressed' (1) if it has been depressed at any time since the last report, otherwise 'not depressed' (0).

Both motion and button state change may be reported in the same packet. However, applications and drivers differ in the order in which they used motion and button data, so if the sequence of movement and button state is important, it is necessary to report them in separate packets. This occurs in Press-to-Select, where the button action must be applied after the 'backup' movement is completed.

Negative values are expressed in two's complement where 1 output unit in the negative direction would be expressed with all bits on and the sign bit active. The count accumulator must not wrap around, if a count greater than the format allows occurs during a sample period the maximum count will be reported and the overflow bit for that coordinate will be set.

In remote mode, a data report is only transmitted in response to a "Read Data" command. The buttons are reported in their current state at the time of transmission.

The following is the data report format. It is identical for stream or remote mode. The data packet format is three bytes long.

Byte 1	Bit 0	Left button status	1 = Depressed	
	Bit 1	Right button status	1 = Depressed	
	Bit 2	Middle button status	1 = Depressed	See note below
	Bit 3	Source Tag	1 = Default	See note below
	Bit 4	X data sign	1 = Negative	
	Bit 5	Y data sign	1 = Negative	
	Bit 6	X data overflow	1 = Overflow	
	Bit 7	Y data overflow	1 = Overflow	
Byte 2		X data		
Byte 3		Y data		

Bit 3 can be used to re-synchronize data packets, since bit 3 of byte 1 will always be a 1 (see Source Tag bit exception below), and bit 3 of bytes 2 and 3 may be 0 or 1.

Note on middle button: This bit may be masked out for compatibility with applications which require this bit to be 0. Refer to the "Read Extended Button status" command (x"E2 4B") on page 31 for more details.
In Two Handed (MultiPoint) mode, this bit is used to identify the source of the report - 1 for the external device, 0 for the TrackPoint controller. This allows the user to simulate a second pointing device. A physical third button may also be present, in which case this bit will be 1 if the button is down, 0 if up.

Note on Source Tag bit: This bit can be used optionally to indicate the source of data being reported. When this option is enabled (toggled by the x"E2 47 20 80" command) , the bit will be = 0 in reports originating in the TrackPoint controller, and it will be 0 or 1 as received in reports originating in the external pointing device. Caution should be used when setting this bit, as many mouse drivers use this bit to synchronize data bytes within packets.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
39 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

This may cause erroneous button events and movement data to be presented to the graphical user interface. A reset (x"FF") or set default (x"F6") command will have no effect on the state of the source tag enable option.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
40 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.6 TRACKPOINT TRANSFER FUNCTION

A primary function of the TrackPoint system is to measure the force applied to the cap by the user's finger, and to transmit corresponding mouse movement signals (Mickeys) and 'button' signals to the host, where they are further processed by the driver and/or application to (normally) produce cursor movement and selection or other actions. This correspondence is the TrackPoint Transfer Function. It is convenient to describe it in two stages: the first stage in principal maps a physical force vector (x, y, z) into a digital vector (triple of integers **(x, y, z)**), and the second maps a time sequence of these digital vectors into a time sequence of movement and button signals.

2.6.1 ANALOG-DIGITAL TRANSFER FUNCTION

The first stage includes the electro-mechanical transducers and all of the analog processing and A/D conversion, and can be specified only to within stated tolerances.

X output **x** in counts at any time is defined as the difference between the value of last raw X sample (*xlast*), RAM location x"3D" and the value of x axis origin (*xorigin*), RAM location x"36" , **x** = (x"3D") - (x"36").

Similarly, **y** = (x"3E") - (x"37") and **z** = (x"3F") - (x"38"). This defines the output vector (**x**, **y**, **z**).

The stick has a Cartesian coordinate system with mutually perpendicular X, Y and Z axes, with origin at the point on the stick axis 1 mm below the high point of the cap. The positive X axis is defined as the direction in which **y** and **z** are zero and **x** is positive,. The Y axis points away from the user, defined by the further constraint that **z** is zero for force in the Y direction. The Z axis points up from the keyboard, perpendicular to X and Y. [1]

The positive X axis should lie within 10° of the direction to the right along the line of the keys. The positive Z axis should lie within 5° of the normal to the plane of the keyboard.

For convenience we will measure forces in *counts force*, 1 count force = 3.2 grams force (313.6 Newtons) for X and Y, and 1 count force = 10 grams force for Z. We assume that forces are applied at the origin (as above, top center of the stick) as pure force vectors (no torques). Thus for a nominal stick and analog section, (x, y, z) = **(x, y, z)** [2].

An applied force vector (x, y, z) will result in an output vector **(x, y, z),** which should have a direction within 0.1 radians (5.73 degrees) of that of the applied force vector, and a magnitude within ±10% of the magnitude of the applied force vector, ignoring noise and digitization error.[3]

In particular, for horizontal force (x, y, 0) this requires that $|z| \leq 0.1 \times |(x, y, 0)|$.

---

[1] Electrical polarities of the axes may differ from these default polarities, depending on the sensor. Configuration bits may be set by the host to compensate.   See 2.4.19.9, Sensor Configuration Parameters.   The default correspondence is:

To the right of the keyboard	X positive
To the top of keyboard (away from user)	Y positive
Down into the keyboard	Z negative

[2] Note that because of the unequal scales on the axes the vector magnitudes and directions are different from the geometrical directions - to get geometrical directions, multiply the z (or **z**) component by 10/3.2 .

[3] These tolerances are such that variation within them has no measurable effect on performance. In production they may be difficult to attain, and some relaxation may be negotiated on a case-by-case basis. Note that they include circuit as well as sensor tolerances.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
41 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

The error vector (x, y, z) - **(x, y, z)** should vary smoothly with (X,Y,Z). This specification may be quantified in the future.

The working range, to which these specifications apply, is from 0 to 100 counts (320 grams force) in both directions in X and Y, and from 0 to -50 counts (500 grams downward) in Z.

2.6.1.1 Dynamic Response

In response to a step-function in applied force in the X and Y axis, the magnitude of the output vector should reach within ±0.5 counts (2 counts in the low-order output) of its final value within 0.2 seconds, and within ±0.25 counts (1 count in the low-order output) within 0.5 seconds, for any step within the working range.

In response to a step-function in applied force in the Z axis, the magnitude of the output vector should reach within 2 counts of its final value within 0.2 seconds, and within one count within 0.5 seconds, for any step within the working range. It should not overshoot by more than one count at any time.

2.6.1.2 Temperature Sensitivity

Output should vary with temperature by no more that 1 count on each axis per 4° C.

2.6.1.3 Noise

Noise is the short-term variation in output which occurs when no force is applied to the stick. Long-term variation is called 'drift'. The distinction is not sharp, and is related to the 'drift counter' value, RAM location x"5F", default value corresponding to 533 msec. - variations within shorter intervals are 'noise', longer period variations are 'drift'. Rate of drift may appear as noise, and is constrained by the following requirements:

X and Y outputs **(x, y)** should be constant within ±0.25 counts (1 count in the low-order output) over any period of 0.53 seconds. [4]

Z output **(z)** should be constant within ±2 counts over any period of 3 seconds more than 30 seconds after power-up.

2.6.1.4 Flexure Resistance

Outputs must have minimal sensitivity to flexing of the stick base. This is a constraint on the pointing stick - keyboard system. Outputs must be less than 2 counts for heavy typing (300 grams force) anywhere on the keyboard.

[4] As with sensitivity, this is an ideal specification that may be difficult to meet. Relaxation may be negotiated on a case-by-case basis. Higher noise level may be tolerated by increasing the degree of smoothing (see 2.4.19.9 Calibration Parameters), with some loss in performance.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
42 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.6.2 DIGITAL TRANSFER FUNCTION

Horizontal **(x, y)** and vertical **(z)** components are treated largely independently, except that when Press-to-Select is active the horizontal component may be modified or suppressed around the time of detection of a press. The horizontal transfer function, which normally generates the mouse movement signals (in Mickeys) may depend on two consecutive force samples - see Negative Inertia below - but will be initially described as a time-independent mapping from horizontal force **(x, y)** to movement signals *(x, y)* . The mapping is direction-preserving, that is $x/y = $ **x/y**, $|(x, y)| = $ **T**(|**(x, y)**|), where **T** is indicated by the following figure.
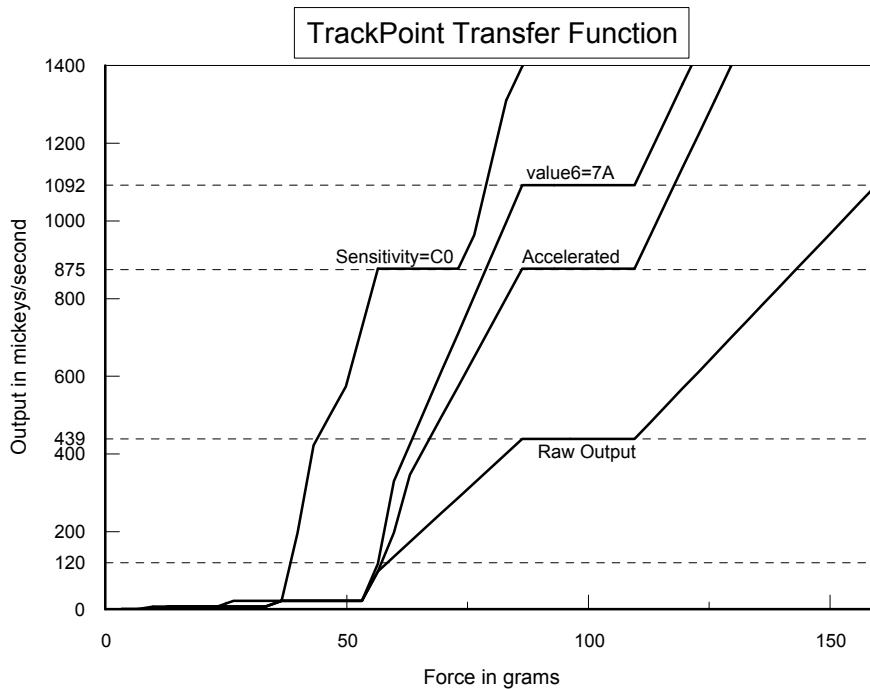
As shown in the figure above, the movement data is a nonlinear function of the force applied to the TrackPoint sensor. The magnitude of the X and Y forces is first calculated using the formula $|(x, y)| = \sqrt{X^2 + Y^2}$. The Negative Inertia algorithm as described on page 44 is then optionally applied to this magnitude, after which the transfer function is applied. The scalar output of the transfer function is then converted back to its X and Y components and accumulated to a precision of 2^{-8} output units (17 bits). The curve labeled "Raw Output" is the output of the transfer function when the power on defaults are used, and the mouse driver has no acceleration profile. However, most mouse drivers do have an acceleration profile which typically doubles its output for input speeds above 150 mickeys per second. The curve labeled "Accelerated" shows the net effect after this acceleration profile is applied. Note that the usual mouse driver acceleration profiles are applied independently to the X and Y components, so that the result is not direction-preserving.

There are two available parameters which modify the transfer function. The first is the sensitivity parameter (*snstvty*) as described in the x"E2 81 4A XX" command on page 24. This parameter modifies the input to the transfer function, by increasing or decreasing the force necessary to arrive at a particular output speed. An example of this is shown above in the curve labeled "Sensitivity". The second parameter (*value6*) controls the upper plateau speed as indicated in the curve labeled "value6". This controls the high speed performance, and is typically modified when changing between differing display formats. Refer to the description of the "E2 81 60 XX" on page 24 for further details on the use of this parameter.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
43 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.6.3 NEGATIVE INERTIA

The Negative Inertia algorithm modifies the input magnitude to the transfer function during transient force applications. The algorithm adds to the existing force an amount equal to $I * (Z_1 - Z_0)$, where I is the inertia factor as described in the x"E2 81 4D XX" command on page 24, Z_1 is the present magnitude, and Z_0 is the magnitude of the previous sample. The transfer function is applied to this result, and the output is scaled by the factor $\frac{1}{[1+I(1-\frac{Z_0}{Z_1})]}$.

If $Z_0 = Z_1$, this has no effect. If $Z_0 = 0$, it reduces the motion by $\frac{1}{I+1}$, which reduces excessive effects at low speed. When the *inertia* factor is set to zero, the algorithm is disabled.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
44 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

2.6.4

This section is intentionally blank

2.6.5 MAXIMUM OUTPUT SPEED

The maximum output speed (with the default value for *value6*) from the TrackPoint controller is greater than or equal to 3600 output units/sec corresponding to a 360 gram lateral force. Standard accelerated mouse drivers apply at least a 2x increase in speed at this level resulting in an apparent speed in excess of 7200 output units/sec as reported to the application using the pointing device. If the negative inertia algorithm is enabled, transient forces may generate even higher output rates.

2.7 ERROR HANDLING

The TrackPoint controller shall issue a resend command following receipt of an invalid command or argument (data) or any input with incorrect parity or framing. The resend command is x"FE". If an invalid argument is received, x"FE" will be returned, at which time the system should resend the argument (not the command and argument). If two invalid inputs are received in succession, an error code of x"FC" shall be transmitted to the host. Upon receipt of a x"FC" the system should reset the pointing device to return it to a known state.

The response from the TrackPoint controller will be transmitted within 25 ms following a host transmission. This timing restriction is limited to the acknowledgment byte x"FA" and the two error responses, x"FE" and x"FC". (Refer to the x"E2 51" command on page 33 for a special exception to this rule). The response time for any additional bytes that may be generated as a result of host command are variable, and depend on the specific command. Refer to the notations within the "Commands" section beginning on page 12 for host commands that may generate longer than normal response times. Unless otherwise stated, TrackPoint controller responses will typically be under 1 millisecond.

If the TrackPoint controller is in stream mode, the host must disable the TrackPoint controller before issuing any command requiring a response from the TrackPoint controller (refer to section 3.3.3 on page 50 for specifics). When a command requiring a response is issued, the host should not issue another command until the response is received or 25 ms has elapsed.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
46 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

3   ELECTRICAL SPECIFICATION

3.1 SUPPLY VOLTAGE

One voltage level will be available to the TrackPoint controller at the system connector.

Vcc = 5 V ± 10 %, Vss = 0V

No more than 100 mV peak to peak differential noise and ripple will be present on the + 5 Volt line.

On power on/off the TrackPoint controller shall tolerate a voltage overshoot of Vcc +30% or a voltage undershoot of Vss - 0.5 V with no damage.

3.1.1 DEFINITION

The term "-" level is defined to be equivalent to a voltage, V, measured between a signal source and network ground such that $0.0\ V \leq V \leq + 0.7\ V$.   A signal at a "-" level is a logical "0".

The term "+" level is defined to be equivalent to a voltage, V, measured between a signal source and network ground such that $2.4\ V \leq V \leq + 5.5\ V$. A signal at a "+" level is logical "1".

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
47 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

3.2 POINTING STICK

Refer to section 2.6.1 on page 41 for stick electromechanical specifications.

3.2.1 ELECTRICAL OUTPUT

The stick may have either 4 or 5 electrical terminals, denoted Common or -, X, Y, Bias, and optionally ZBias. Optionally the X and Y terminals may be divided into X+ and X- and Y+ and Y- respectively at the stick and in the cable; in this case the respective + and - terminals are to be jumpered together, e.g. at the connector, and will be treated as a single terminal hereinafter. A voltage V applied from Bias to Common results in a voltage ½V ±1% at X and Y. If terminal Zbias is present, a voltage V from Z Bias to Common results in a voltage ½V ±1% at terminal Bias; if terminal ZBias is not present, the resistance from Bias to Common must be controlled within ±1% of its nominal value. Note: these tolerances depend on stick sensitivity; higher sensitivity allows looser tolerances.[5]

Stick electromechanical properties are measured by voltage change at the X and Y terminals per volt across Bias and Common, and for Z, either

1. if ZBias is present, by voltage change at Bias per volt across ZBias and Common, or
2. if ZBias is not present, by voltage change at Bias per volt across a resistive voltage divider in which a fixed resistor of value equal to the resistance from Bias to Common is the top element, Bias is the center terminal, and Common is the bottom terminal.

Force is applied with reference to the top surface of the cap. Horizontal (X,Y) force is applied horizontally in the plane 1 mm below the high point of the cap. Z force is applied uniformly over the top of the cap, in the downward direction (see section 4.1.3). A general force, with X, Y, and Z components, is considered to be applied to the point on the axis of the stick, 1mm below the high point of the cap. It is assumed that the force is a pure vector (no torque or moment components).

3.2.2 IMPEDANCE

The effective electrical resistance from Bias to Common shall be at least 350Ω; that is, with 5 volts applied, no more than 14.3 milliamps should flow. The nominal resistance (and tolerance, where Z Bias is present) will be negotiated on a case by case basis, trading off power demands against noise sensitivity.

3.2.3 POWER REQUIREMENT

The TrackPoint controller shall consume less than 25 milliamperes peak current drain (excluding external pointing device) when powered on. Average current drain should be less than 6 milliamperes.

---

[5] The tolerance on X and Y in percent is ±0.7*XYSens., where XYSens. is Horizontal sensitivity in µV/g/V. (This assumes a DAC step of 18 counts for X and Y.)
The tolerance on Z if ZBias is present in percent is ±6*ZSens., where Zsens. is Vertical sensitivity in µV/g/V. (This assumes a DAC step of 50 counts for Z.)
The tolerance on R(Bias,Common) if ZBias is not present is such as to give ±5*ZSens for center voltage of a divider consisting of the stick and a fixed resistor of the same nominal resistance.

3.3 DATA TRANSMISSION

The TrackPoint controller communicates bidirectionally using the clock and data signal lines. Each of these lines is driven by open collector devices allowing either the TrackPoint controller or the host to force a line to the "-" level. During idle state, CLK and DATA are both at a "+" level.

The TrackPoint's DATA and CLK open collector drivers should have pull-up resistors of 4.7 KΩ ± 10 %.   The external pointing device DATA and CLK bidirectional pins should have pull-up resistors of 10 KΩ ± 10 %.

3.3.1 CLOCK LINE

During data transmission, "CLK" will be used to clock serial data to and from the TrackPoint controller. The TrackPoint controller generates the clocking signal when sending data to and receiving data from the host.

The host can inhibit TrackPoint controller transmission by forcing the "CLK" line to a "-" level. Data may go high or low during the inhibit state.

3.3.2 DATA LINE

The system requests that the TrackPoint controller receive system data output by forcing the DATA line to a "-" level and allowing CLK line to go to a "+" level.

Each transmission will consist of 11 bits transmitted serially on the data line. A logical "1" is transmitted as a "+" level.   The 11 bit data stream is defined as follows:

1st Bit	Start Bit	Always "0"
2nd Bit	Data Bit 0	Least Significant Bit
3rd Bit	Data Bit 1	
4th Bit	Data Bit 2	
5th Bit	Data Bit 3	
6th Bit	Data Bit 4	
7th Bit	Data Bit 5	
8th Bit	Data Bit 6	
9th Bit	Data Bit 7	Most Significant Bit
10th Bit	Parity Bit	Odd Parity
11th Bit	Stop Bit	Always "1"

The parity bit will be "1" or "0" such that the eight data bits plus parity bit will always contain an odd number of 1's.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
49 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

3.3.3 TRACKPOINT CONTROLLER DATA OUTPUT

When the TrackPoint controller is READY to transmit data, it must first check for "Inhibit" or system "request to send" status on clock and data lines. If CLK is low (inhibit status), data shall be continuously updated in the TrackPoint controller and no transmissions shall be started. If CLK is high and DATA is low (request to send), data shall be also updated in the TrackPoint controller , the TrackPoint controller shall input system data, and no transmissions shall be started by the TrackPoint controller until CLK and DATA are both high.

When CLK and DATA lines are both high, the TrackPoint controller shall proceed to output "0" start bit, eight data bits, parity bit and stop bit if a transmission is required. Data shall be valid prior to the falling edge of CLK and beyond the rising edge of CLK.   During transmission the TrackPoint controller shall check for line contention by checking for a "-" level on CLK at intervals not to exceed 100 microseconds.   Contention occurs when the system lowers CLK to inhibit TrackPoint controller output after the TrackPoint controller has started a transmission. If this occurs prior to the rising edge of the tenth clock (parity bit), the TrackPoint controller shall internally store its data packet in the TrackPoint controller buffer and return DATA and CLK to "+" level. If the contention does not occur by the tenth clock, the TrackPoint controller shall complete the transmission.

Following a transmission, the system may inhibit the TrackPoint controller until it processes the data.

3.3.4 TRACKPOINT CONTROLLER DATA INPUT

When the host is ready to send data to the TrackPoint controller , it will first check to see if the TrackPoint controller is transmitting data. If the TrackPoint controller is transmitting, the host can override TrackPoint controller output by forcing "CLK" to a "-" level prior to the tenth clock. If the TrackPoint controller transmission is beyond this point, the system will receive the transmission.

If the TrackPoint controller is not transmitting or if the host chooses to override TrackPoint controller output, the host will force CLK to a "-" level for a period not less than 100 microseconds while preparing for output. When the host is ready to output "0" start bit (data line will be low), it will allow CLK to go to a "+" level. The TrackPoint controller shall check for this state periodically at intervals not to exceed 10 milliseconds.

If "Request to send" is detected, the TrackPoint controller shall clock in 11 bits. Following the tenth clock the TrackPoint controller shall check for a "+" level on DATA line, and if found, the TrackPoint controller shall force DATA low (line control bit), and clock once more. This signals the host to return to "Ready State" in which it can accept TrackPoint controller output or go to "inhibit" mode until ready. If DATA is found at a "-" level following clock ten, this is a framing error and the TrackPoint controller shall continue to clock until DATA is high, then clock the line control bit and request a resend.

For each system command or data transmission to the TrackPoint controller that requires a TrackPoint controller response, the system must wait for up to 25 ms for the TrackPoint controller to respond before sending its next output.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
50 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

3.4 TRACKPOINT CONTROLLER SENDING DATA TIMING

The following describes the typical sequence of events when the system is receiving data from the TrackPoint controller.

1. The TrackPoint controller checks the CLK line. If the line is inactive (low), output from the TrackPoint controller is not allowed.
2. The TrackPoint controller checks the DATA line. If the line is inactive (low), the TrackPoint controller receives data from the system.
3. The TrackPoint controller checks the CLK line periodically during the transmission at intervals not exceeding 100 microseconds. If the TrackPoint controller finds that the system is holding the CLK line inactive (low), the transmission is terminated. The system can terminate transmission anytime during the first 10 clock cycles. When a transmission is terminated, the TrackPoint controller should return to the state it was in prior to the transmission. If the transmission was terminated during a multi-byte packet transmission, retransmission starting with the byte that was terminated should commence once the system releases the CLK line. If the system has data to send, the terminated packet should not be resent.
4. A final check for terminated transmission is performed at least 5 microseconds after clock ten.
5. The system can hold the CLK line inactive (low) to inhibit the next transmission.
6. The system can set the DATA line inactive (low) if it has a byte to transmit to the TrackPoint controller. The DATA line is set inactive (low) when the start bit (always 0) is placed on the DATA line.
7. The system releases the CLK line to allow the next transmission.
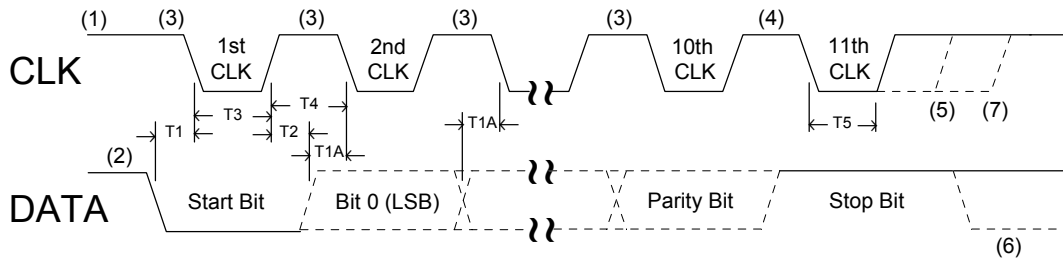
System samples data while CLK is low.

	Timing Parameter	Spec Min/Max	Version 3E Typical
T1	Time from DATA transition to falling edge of CLK 1	5/25µs	17µs
T1A	Time from DATA transition to falling edge of CLK 2-11	5/25µs	12µs
T2	Time from rising edge of CLK to DATA transition	5/T4-5µs	21µs
T3	Duration of CLK inactive (low)	30/50µs	36µs
T4	Duration of CLK active (high)	30/50µs	34µs
T5	Time to TrackPoint controller inhibit after clock 11 to ensure the TrackPoint controller does not start another transmission	>0/50µs	>0/180µs
TCR	Line contention checking interval	0/100µs	71µs

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
51 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

3.5 TRACKPOINT CONTROLLER RECEIVING DATA TIMING

The following describes the typical sequence of events when the system is sending data to the TrackPoint controller.

1. The system checks for a TrackPoint controller transmission in process. If a transmission is in process and beyond the 10th clock, the system must receive the data.
2. The TrackPoint controller checks the CLK line. If the line is inactive (low), an I/O operation is not allowed.
3. The TrackPoint controller checks the DATA line. If the line is inactive (low), the system has data to transmit. The DATA line is set inactive (low) when the start bit (always 0) is placed on the DATA line.
4. The TrackPoint controller sets the CLK line inactive (low). The system then places the first bit on the DATA line. Each time the TrackPoint controller sets the CLK line inactive (after falling edge), the system places the next bit on the DATA line until all bits are transmitted.
5. The TrackPoint controller samples the DATA line for each bit while the CLK line is active (high). Data must be stable within 1 microsecond after the rising edge of the CLK line.
6. The TrackPoint controller checks for a positive-level stop bit after the 10th clock. If the DATA line is inactive (low), the TrackPoint controller continues to clock until the DATA line becomes active (high). Then the TrackPoint controller clocks the line-control bit and, at the next opportunity, sends a Resend command to the system.
7. The TrackPoint controller pulls the DATA line inactive (low), producing the line-control bit.
8. The system can pull the CLK line inactive (low), inhibiting the TrackPoint controller.
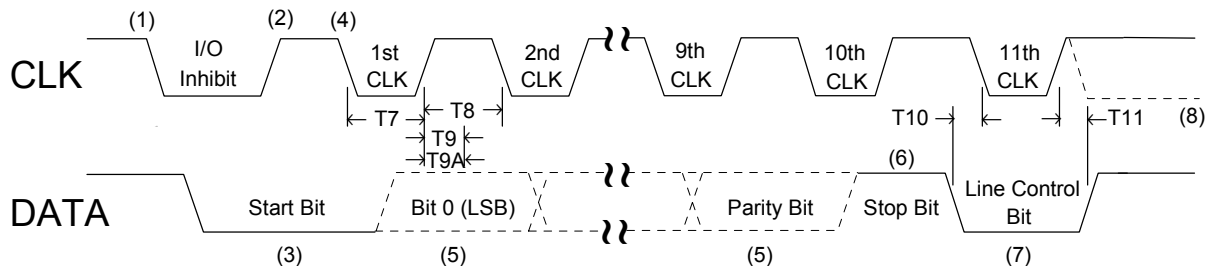
TrackPoint controller samples data while CLK is high.

	Timing Parameter	Spec Min/Max	Version 3E Typical
T7	Duration of CLK inactive (low)	30/50μs	36μs
T8	Duration of CLK active (high)	30/50μs	34μs
T9	Time from inactive to active CLK transition, used to time when the TrackPoint controller samples DATA	5/25μs	
T9A	Time from rising edge of CLK to TrackPoint controller DATA sample		17μs
T10	Time from falling edge of line control bit to falling edge of clock 11 CLK		13μs
T11	Time from rising edge of clock 11 CLK to rising edge of line control bit		17μs
TCX	Line contention checking interval	0/100μs	70μs

3.6 EXTERNAL DEVICE SENDING DATA TIMING

The following describes the typical sequence of events when the TrackPoint controller is receiving data from the external device.

1. The external device checks the CLK line. If the line is inactive (low), output from the external device is not allowed.
2. The external device checks the DATA line. If the line is inactive (low), the external device controller receives data from the TrackPoint controller.
3. The external device checks the CLK line periodically during the transmission at intervals not exceeding 100 microseconds.   If the external device finds that the TrackPoint controller is holding the CLK line inactive (low), the transmission is terminated. The TrackPoint controller can terminate transmission anytime during the first 10 clock cycles. When a transmission is terminated, the external device should return to the state it was in prior to the termination.   If the transmission was terminated during a multi-byte packet transmission, retransmission starting with the byte that was terminated should commence once the system releases the CLK line. If the TrackPoint controller has data to send, the terminated packet should not be resent.
4. A final check for terminated transmission is performed at least 5 microseconds after clock ten.
5. The TrackPoint controller can hold the CLK line inactive (low) to inhibit the next transmission.
6. The TrackPoint controller can set the DATA line inactive (low) if it has a byte to transmit to the external device. The DATA line is set inactive (low) when the start bit (always 0) is placed on the DATA line.
7. The TrackPoint controller releases the CLK line to allow the next transmission.
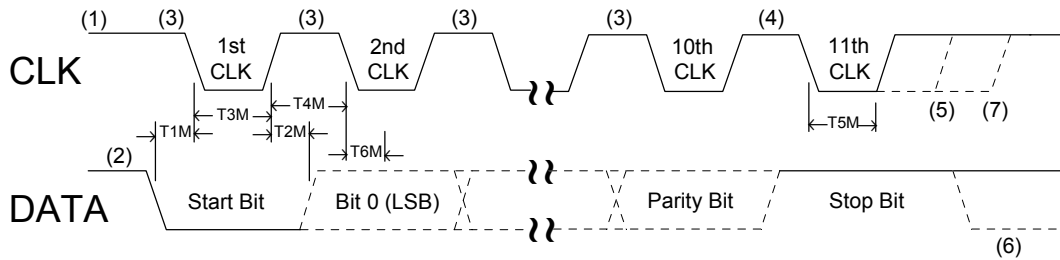
TrackPoint controller samples data while CLK is low.

Timing Parameter		Spec Min/Max	Version 3E Typical
T1M	Time from DATA transition to falling edge of CLK	5/25μs	
T2M	Time from rising edge of CLK to DATA transition	5/T4M-5μs	
T3M	Duration of CLK inactive (low)	30/50μs	
T4M	Duration of CLK active (high)	30/50μs	
T5M	Time to auxiliary device inhibit after clock 11 to ensure the auxiliary device does not start another transmission	>0/50μs	42μs
T6M	Time from falling edge of CLK to TrackPoint controller DATA sample		5μs

3.7 EXTERNAL DEVICE RECEIVING DATA TIMING

The following describes the typical sequence of events when the TrackPoint controller is sending data to the external device.

1. The TrackPoint controller checks for an external device transmission in process.
2. If a transmission is in process and beyond the 10th clock, the TrackPoint controller must receive the data.
3. The external device checks the CLK line. If the line is inactive (low), an I/O operation is not allowed
4. The external device checks the DATA line. If the line is inactive (low), the TrackPoint controller has data to transmit. The DATA line is set inactive (low) when the start bit (always 0) is placed on the DATA line.
5. The external device sets the CLK line inactive (low). The TrackPoint controller then places the first bit on the DATA line. Each time the external device sets the CLK line inactive (after falling edge), the TrackPoint controller places the next bit on the DATA line until all bits are transmitted.
6. The external device samples the DATA line for each bit while the CLK line is active (high). Data must be stable within 1 microsecond after the rising edge of the CLK line.
7. The external device checks for a positive-level stop bit after the 10th clock. If the DATA line is inactive (low), the external device continues to clock until the DATA line becomes active (high). Then the external device clocks the line-control bit and, at the next opportunity, sends a Resend command to the TrackPoint controller.
8. The external device pulls the DATA line inactive (low), producing the line-control bit.
9. The TrackPoint controller can pull the CLK line inactive (low), inhibiting the external device.
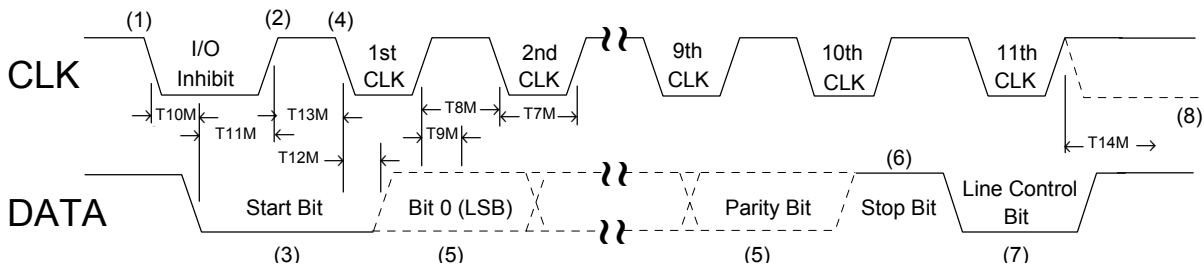
External device samples data while CLK is high

	Timing Parameter	Spec Min/Max	Version 3E Typical
T7M	Duration of CLK inactive (low)	30/50μs	
T8M	Duration of CLK active (high)	30/50μs	
T9M	Time from inactive to active CLK transition, used to time when the auxiliary device samples DATA	5/25μs	
T10M	Time from CLK inhibit to start bit inactive		52μs
T11M	Time from start bit inactive to CLK active		52μs
T12M	Time from CLK falling edge to DATA transition		22μs
T13M	Transmit response time	0/10ms	15ms
T14M	Receive Timeout (Time to auxiliary device response)	0/25ms	25ms

.

4   MECHANICAL SPECIFICATIONS

4.1 POINTING STICK

4.1.1 POINTING STICK MECHANICAL

In a keyboard application, the Pointing Stick proper is located at the intersection of the B, G and H keys on the keyboard. Its base is rigidly located with respect to the keyboard frame; it may either be a separate part firmly attached to the frame, or it may be molded as an integral part of the frame, or it may be attached to some other part of the system rigidly located with respect to the keyboard. The shaft carries a cylindrical cap, the top surface of which is 0.5 mm to 1 mm above the high points of the adjacent keys. The height and base footprint (if any) depend on the application.

4.1.2 OVERLOAD

As a minimum requirement for normal operating conditions, the stick should sustain a horizontal loading of 2.5 Kg, repeated 16 times at successive directional intervals of 45°, without damage. The stick should sustain a vertical load of 6 Kg repeated 16 times without damage. Higher overload limits may be required for protection against accidental overload, or for system reasons. Limits of 4 Kg horizontal and 20 Kg vertical have been used in the ThinkPad application.

4.1.3 LIFE

The stick assembly must sustain 8,000,000 full cycles of horizontal deflection under a peak force of 250 grams without significant deterioration. A full cycle of deflection is either a rotating application of force through 360°, or an alternating application of force, in one direction followed by the opposite direction, the directions of successive cycles shifting to cover substantially all directions.

The stick assembly must sustain 8,000,000 full cycles of vertical deflection under a peak force of 400 grams without significant deterioration. A full cycle of deflection begins with zero force, increases to 400 grams, and returns to zero.

The intention is that nearly all sticks will reach this life - it should be the 3 sigma point in the distribution, perhaps.

4.2 CAP

The cap presents a top surface of approximately 6mm diameter, which is designed to provide maximum traction for the user's fingertip, resting on it and pressing laterally. Traction and wear properties must be at least as good as the TrackPoint III 'cats tongue' cap. The surface properties should be resistant to contamination with skin oils, hand lotions, and similar likely contaminants. The cap must slip on firmly, and not move relative to the shaft under normal use (lateral force up to 380 grams). To maintain performance, there must be provision for easy replacement of the TrackPoint cap by the user without tools.

The material of the cap (or of anything else) should not contain excess volatiles (e.g. sulfur) capable of producing a significantly corrosive environment for any other of the stick's components.

4.2.1 CRUSHABLE CAP SPECIFICATIONS

The rubber cap should compress (reduce in height) by a distance of 1 mm under a downward force of 3 pounds applied by a hard flat surface. The rubber cap should return to its specified height after release of the downward force. The compression for a force of less than ½ pound should be less than 0.2 mm.

4.3 BUTTONS

The switch travel is to be 0.3 mm to 1.0 mm with a force of 70 to 140 grams measured at the center of the button. There must be a definite tactile peak at its operating point.

Buttons must be located in front of the space bar, centered on the location of the Pointing Stick (center of B key). It must be possible to operate them with the side of the unbent, relaxed thumb, with the heel of the hand resting on available support at a comfortable distance (approximately 8 cm) in front of the space bar. "Available support" is either the surface of the keyboard, if it extends far enough, or the surface on which the keyboard/computer rests, in all of its normal working configurations (e.g. legs extended or not).

If an external pointing device shares physical buttons with the TrackPoint controller, refer to the x"E2 2D 47 02" command on page 28 for important design requirements.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
56 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

5   PERFORMANCE SPECIFICATIONS

The TrackPoint system shall meet the following requirements. The word "operate" means that the TrackPoint system meets all the specifications in this document.

5.1 ENVIRONMENT

The TrackPoint system shall operate in the non-air conditioned building environment with normal winter heating and normal ventilation.

5.1.1 TEMPERATURE

Operating:	15.6° C	to	60.0° C
Power-off:	10.0° C	to	60.0° C
Storage:	0.6° C	to	60.0° C
Shipment:	-40.0° C	to	60.0° C

The TrackPoint system must be capable of operating satisfactorily at altitudes from 0 to 2135 meters above sea level and a 10% delta temperature guardband beyond the limits.0

The maximum temperature gradient that the TrackPoint system must withstand under conditions of shipment, storage, power-off, or operation is 20° C/minute (linear) up to 60° C maximum.

5.1.2 RELATIVE HUMIDITY

Non-condensing

Operating:	5%	to	95%	
Power-off:	5%	to	95%	
Storage:	5%	to	95%	
Shipment:	5%	to	100%	(Excluding Rain)

5.1.3 WET BULB TEMPERATURE

Operating:			26.7° C	maximum
Power-off:			26.7° C	maximum
Storage:	0.6° C	to	29.4° C	
Shipment:	0.6° C	to	29.4° C	

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
57 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

5.1.4 CORROSIVE GASES

The following are the concentration limits of gases that may be present in the environment. These concentrations are the maximum that will exist for 95% of the time.

Upper limits expressed as arithmetic mean values (averaged over one year) in $\mu g/m^3$ (micrograms per cubic meter).

Hydrogen Sulfide	4.6 $\mu g/m^3$
Sulfur Dioxide	1300 $\mu g/m^3$
Nitrogen Dioxide	320 $\mu g/m^3$
Ozone	260 $\mu g/m^3$
Ammonia	56 $\mu g/m^3$

5.1.5 PARTICULATE LIMITS

The following are the limits of particulates that may be present in the environment. Upper limits expressed as arithmetic mean values in $\mu g/m^3$ or $\mu g/cm^2/30$ days are:

Suspended Particles

Annual average = 150 $\mu g/m^3$
50% of values less than = 138 $\mu g/m^3$
80% of values less than = 207 $\mu g/m^3$

NOTE: Base sampling period - 24 hours

Settable Particulates

Annual average = 500 $\mu g/cm^2/month$
50% of values less than = 460 $\mu g/cm^2/month$
80% of values less than = 690 $\mu g/cm^2/month$

NOTE: Sample collection time - 30 days

5.1.6 VIBRATION AND SHOCK

The TrackPoint system may be subjected to vibration and shock during both its shipment and its operation. The following sections define the levels of vibration and shock that the TrackPoint system shall tolerate.

5.1.6.1 Vibration

When the TrackPoint system is packaged for shipment, it must meet IBM Corporate Standard C-H 1-9711-005 on Packaged IBM Products. The TrackPoint system shall operate error free when it is subjected to either the continuous or the transient vibration levels as stated in IBM Corporate Standard C-S 1-9711-002 as follows:

1. The TrackPoint system will be subjected to a continuous vibration of 0.07 G's peak acceleration from 10 to 500 Hz, and of constant double amplitude displacement below 10 Hz. The sweep rate is eight decades per hour.   A decade is a frequency range from one frequency to ten times that frequency.

2. The TrackPoint system will be subjected to a transient vibration of 0.11 G's peak acceleration from 10 to 500 Hz, and of constant double amplitude displacement below 10 Hz.

3. Any motion caused by the vibration and detected by the TrackPoint system can be reported to the system as legitimate travel.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
58 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

5.1.6.2 Shock

The TrackPoint system shall operate error-free and not be damaged when it is subjected to either vertical or horizontal shock. The maximum vertical shock is equivalent to dropping the TrackPoint system (upright position) three feet onto a rigid surface. The maximum horizontal shock is equivalent to sliding the TrackPoint system into a vertical obstruction with an impact velocity of 1.0 meter /second.

In addition to the after mentioned, the TrackPoint system must meet IBM Corporate Standard C-S 1-9711-007 Operational Shock Levels for IBM Hardware Products for Non-Stationary Products (Class S3).

5.2 RELIABILITY

This section specifies the usage, failure criteria and maximum failure rate for the TrackPoint system. An electrical failure is defined as the occurrence of any of the following:

- Invalid transmission protocol
- Improper response to a command
- Invalid data frame format
- Unsuccessful completion of the RESET diagnostics
- Switch actuation unreported or falsely reported
- Cursor movement unreported or falsely reported

A mechanical failure exists when the the reported movement deviates by more than ±10% from the expected transfer function as shown in section 2.6.

5.2.1 USAGE

The usage assumed for the above criteria is:

- 12,000 power-on hours life
- 180 power-on hours/month
- 80 power on-off cycles/month
- 40,000 switch actuations/month
- Input supply voltage to be held within ±10% of nominal

5.2.2 DEFECT CRITERIA

The TrackPoint system shall be considered a defective unit when it no longer meets any of the requirements stated in this specification, or when a button switch fails to work properly.

5.2.3 FAILURE RATE

The mean time between failures of the TrackPoint system shall be no less than 45,000 operating hours of continuous use.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
59 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

5.2.4 TEST PROCEDURES

The following sequence of commands and responses must be verified as a minimum requirement.

Time Sequence	Host Command	Pointing Device Response	Description
1	DD		OS/2 Touch screen Interrogation
2		FE	Invalid Command
3	F2		Read Device Type
4		FA	Acknowledgment
5		00	Mouse Type
6	FF		Reset
7		FA	Acknowledgment
8		AA	POST Completion Code
9		00	POST Completion ID
10	F4		Enable
11		FA	Acknowledgment
12	FF		Reset
13		FA	Acknowledgment
14		AA	POST Completion Code
15		00	POST Completion ID
16	E7		Set Scaling
17		FA	Acknowledgment
18	E9		Status Request
19		FA	Acknowledgment
20		30	Scaling set, enable
21		02	4 counts/mm
22		64	60 reports/second
23	E8		Set Resolution
24		FA	Acknowledgment
25	03		8 counts/mm
26		FA	Acknowledgment
27	E6		Reset Scaling
28		FA	Acknowledgment
29	F3		Set Sampling Rate
30		FA	Acknowledgment
31	3C		60 reports/second
32		FA	Acknowledgment

A more rigorous test should include sequences of all valid and invalid commands, error recovery tests, force sensitivity (i.e. gain) and long term analog circuit monitoring. Operation in wrap mode at high speeds for a long duration should also be verified to ensure compatibility with specific auxiliary device controllers. This should also include timing sequences with randomly distributed timing gaps, to ensure the responsiveness of the TrackPoint controller. Operation in Burst mode, if implemented, should also be performed to verify desired noise performance of the analog circuitry. A large sequence of commands can also be sent to the TrackPoint controller and its responses compared with a known 'good' pointing device's responses.

5.3 ELECTROMAGNETIC COMPATIBILITY (EMC)

Tests for conformance to these requirements will be performed with the TrackPoint system attached to a representative host computer. The host computer and each of its peripherals must meet the overall system EMC requirements with the TrackPoint system attached.

5.3.1 ELECTROMAGNETIC INTERFERENCE (EMI)

To allow for manufacturing and component variability, the following requirements shall be met with a minimum of 6bB of margin.

5.3.1.1 FCC Requirements

The TrackPoint system shall comply with the United States Federal Communication Commission (FCC) Rules and Regulations, part 15, sub-part J, computing devices class B Peripheral Devices and Class B Internal Peripheral Devices radiation limits, as detailed in IBM National Bulletin N-B 2-001-026.

5.3.1.2 Industry Canada Requirements

The TrackPoint system shall comply with the Canadian Industry Canada regulations for Class B Digital Apparatus radiation limits, as detailed in IBM National Bulletin N-B 2-001-026.

5.3.1.3 European Union (EU) Requirements

The TrackPoint system shall comply with the European Union's EN55022 Emission requirements for Class B ITE devices as detailed in IBM National Bulletin N-B 2-0001-031.

5.3.1.4 VCCI Requirements

The TrackPoint system shall comply with Japan's VCCI Class B ITE requirements as detailed in IBM National Bulletin N-B 2-0001-403.

5.3.2 ELECTROSTATIC DISCHARGE REQUIREMENTS

The TrackPoint system shall operate without error when subjected to the Class 2 Limits. as defined in IBM Corporate Standard C-S 2-0001-005, Electrostatic Discharge Immunity Limits. The products, which have been independently tested, when attached to a host product, shall not degrade the host ESD performance of the class established for that host product.

Class	Direct ESD		Indirect ESD
	Furniture	Personnel	Furniture
2	1400 V	8000 V	2100 V
2 (Critical Error)	2800 V	12000 V	4200 V

In addition, the TrackPoint system must also conform to the ESD immunity requirements of EN 50082-1, as detailed in IBM Corporate Bulletin C-B 2-0001-034.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
61 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

5.3.3 ELECTROMAGNETIC SUSCEPTIBILITY (FIELDS)

The TrackPoint system must operate without errors when subjected to the following electromagnetic fields, as described in IBM Corporate Standard C-S 2-0001-012 Radiated Electromagnetic Susceptibility.

Frequency Range	Field Strength
500 Khz - 30 Mhz	7 Vrms/m
30 Mhz - 108 Mhz	2 Vrms/m
136 Mhz - 174 Mhz	30 V/m (peak)
174 Mhz - 230 Mhz	2 Vrms/m
440 Mhz - 512 Mhz	30 V/m (peak)
806 Mhz - 845 Mhz	42 V/m (peak)

In addition, the TrackPoint system must also conform to the radiated electromagnetic filed immunity requirements of EN 50082-1, as detailed in IBM Corporate Bulletin C-B 2-0001-037.

5.3.4 RADAR SUSCEPTIBILITY

The TrackPoint system must operate without errors when exposed to the following RADAR fields:

Frequency	Pulse Width	Pulse Rate	Field Strength
600 Mhz	4 μs	250 Hz	13 V/m (peak)
1.3 Ghz	3 μs	333 Hz	10 V/m (peak)
2.8 Ghz	1 μs	1 Khz	13 V/m (peak)

5.4 SAFETY REQUIREMENTS

1. The TrackPoint system shall conform to the following standards:

- UL-478 5th edition, "Information-Processing and Business Equipment"
- IEC-435, "Safety of Data Processing Equipment"

2. No exposed parts which are accessible by the operator shall have a voltage potential.

3. The components used in the TrackPoint system shall conform to the following standards:

- UL-796, "Electrical Printed-Wiring Boards"
- UL-94, "Standard for Plastic Material"
- Printed circuit board must be UL recognized board 94V-1 or better.
- Components must not contain Polychlorinated Biphenyl (PCB) in any form
- The unit must not contain any known or suspected carcinogens (cancer causing agents)

4. The TrackPoint system shall conform to the national requirements of the countries intended for installation in accordance with the corresponding subset.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
62 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

5.5 FLAMMABILITY REQUIREMENTS

1. Material flammability class of plastic covers/enclosures shall be meet the 130 mm (5") enclosure flammability test criteria of IEC 950, Appendix A-1, UL 746C, Section 26, and CSA 22.2 No.220, Clause 6.10.6.

2. Other plastic material not used for cover/enclosure shall be material flammability class rating of UL94-V1 or better.

3. Parts which may be exposed to any ignition source must meet the specific ignition resistance, high current arc ignition, heat and hot wire ignition test requirements and so on.

4. All conductive surface treatment should also meet UL746C 'Polymeric Materials - Use In Electrical Equipment Evaluations' requirement.   (Both material and process.)

Appendix A - TRACKPOINT CONTROLLER ADDRESS MAP

RAM address	Bit Position	Name	Description
00		reg00	working register, indirection pointer
01		reg01	working register, indirection pointer
02		strcnt	stream mode counter
03		samcnt	A/D sampling counter
04		ansprth reg04	table out msb, two's complement msb working register
05		reg05	working register
06		reg06	working register
07		reg07	working register
08		rate	sample rate byte
09		zpt	z pointer
0A		ramsave saver1	working register r1 temporary save register
0B		bpt	backup data pointer
0C		res	resolution, used only for external devices
0D		ansprtl	table out lsb, two's complement lsb
0E		nbu	number of pointer to back up
0F		flip	number of button changes pending
10		pqtr	
11		lxmit1	last byte transmitted
12		lxmit2	2nd to last byte transmitted
13		lxmit3	3rd to last byte transmitted
14		qtr	quiet - transitions in progress
15		dftcnt1	drift counter 1 (MSB)
16		mrate	external mouse sampling rate
17		xdevtyp	external device type, (response to x"F2") only valid when xdevin=1
18		xmsb	x msb register
19		xlsb	x lsb register
1A		xpot	x pot value
1B		ppot	p pot value
1C		ymsb	y msb register
1D		ylsb	y lsb register
1E		ypot	x msb register
1F		lastmag	magnitude of previous sample

RAM address	Bit Position	Name	Description
20		reg20	bit fields
	0	mskip	skip mouse
	1	mmove	mouse is active (moving or button pressed)
	2	invld	invalid command received
	3	joyskip	skip joystick conversion
	4	samdis	A/D converter disabled
	5	caughtup	stick samples on time
	6	reg20.6	unassigned
	7	tagbit	1 = force curstat.3 to 0 if TrackPoint controller data
21		reg21	bit fields
	0	xsbit	x axis sign bit 1=negative
	1	ysbit	y axis sign bit 1=negative
	2	mwait	mouse timeout or protocol error
	3	xdevin	external device attached (responds to F2)
	4	flops	table out = 0
	5	reg21.5	unassigned
	6	lxmit	3 byte transmission
	7	sxmit	2 byte transmission
22		reg22	bit fields
	0	wrap	wrap mode
	1	stransp	software exit transparent enabled
	2	forceb3	1 = force moustat.3 to 1
	3	reg22.3	reserved for future use (for E9)
	4	scale	0=1:1, 1=2:1
	5	menb	pointing stick stream mode enable
	6	remote	1=remote, 0=stream
	7	reg23.7	reserved for future use (for E9)
23		reg23	bit fields
	0	block3	mid button blocked
	1	mcomdis	mouse poll disable
	2	powerup	initial pot set done
	3	skippots	bypass pot setting
	4	setpots	set pots due to out of bounds
	5	rerror	parity/framing receive error
	6	byte1x	packet byte # 1 pending
	7	skipdrift	skip drift correction

RAM address	Bit Position	Name	Description
24		drftcnt2	drift counter 2 (LSB)
25		post	power on self test register
	0	ramfail	post RAM failed
	1	romfail	post ROM failed
	2	post.2	unassigned
	3	xfail	post x axis failed (out of bounds after initial pot set)
	4	yfail	post y axis failed (out of bounds after initial pot set)
	5	moufail	post mouse port failed (mouse responded to FF and did not return AA 00)
	6	post.6	unassigned
	7	post.7	unassigned
26		moustat	external mouse status byte
	0	mleft	external mouse left button
	1	mrght	external mouse right button
	2	mmidb	external mouse middle button
	3	moustat.3	mouse unused status bit
	4	moustat.4	mouse x sign bit
	5	moustat.5	mouse y sign bit
	6	moustat.6	mouse overflow x bit
	7	moustat.7	mouse overflow y bit
27		curstat	current status
	0	left	composite left button
	1	right	composite right button
	2	middle	composite middle button
	3	curstat.3	unused status bit (must be 1)
	4	xacbit	x accumulator sign bit
	5	yacbit	y accumulator sign bit
	6	overx	x accumulator overflow bit
	7	overy	y accumulator overflow bit
28		reg28	bit fields
	0	lssign1	left slope temporary sign bit
	1	lssign2	left slope temporary sign bit
	2	hysflg	drag hysteresis in effect
	3	uphit	select on release transition in progress
	4	jkflg	jenks release active
	5	rel	oldest pending button action is a release
	6	reg28.6	unassigned
	7	kburst	burst mode enable

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
66 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

RAM address	Bit Position	Name	Description
29		reg29	bit fields
	0	reg29.0	unassigned
	1	dacdbb	dac debug bit, when set dacset will continually run
	2	m_dir	external mouse port direction
	3	dat_bit	temporary mouse serial data
	4	arb	two handed xmit arbitration bit
	5	quiet	sensor has not been drifting
	6	tpturn	TP's turn to xmit
	7	backing	backup in progress
2A		reg2a	bit fields
	0	e2match	E2 received during transparent
	1	mreset	mouse being reset
	2	dos4fix	correct for DOS4 DOSSHELL and slow (Mighty) mice
	3	psbit	temporary sign bit
	4	xcip	x axis conversion in progress
	5	ycip	y axis conversion in progress
	6	pcip	z axis conversion in progress
	7	skipz	skip z axis conversions when set
2B		reg2b	bit fields
	0	mbit1	mouse input buffer 1 full
	1	mbit2	mouse input buffer 2 full
	2	mbit3	mouse input buffer 3 full
	3	new_mbyte	new mouse byte has arrived
	4	long_mouse	long mouse timeout is running
	5	mpending	mouse packet xmit pending
	6	mbusy	mouse transaction in progress
	7	mtimeout	mouse timeout
2C		config	Configuration byte
	0	ptson	press to select enable
	1	halftac	tactile pulse on press only (not release)
	2	button2	2 physical buttons exist
	3	flipx	invert x axis
	4	flipy	invert y axis
	5	flipz	invert z axis
	6	reg2C.6	unassigned
	7	ftrans	force hard transparent mode

RAM address	Bit Position	Name	Description
2D		reg2d	bit fields
	0	two_handed	two handed mode enable
	1	nmbbit	remove external buttons from lockout arbitration
	2	sticky2	prevent clearing of two handed bit when rate is changed
	3	skipback	skip backups when pts is enabled
	4	remmouenb	remote mode mouse enable
	5	skipzstep	skip automatic Z DAC steps
	6	msfix	set external mouse reporting rate to TrackPoint controller's rate
	7	nosync	disable sync pulse on left button pin
2E		reg2E	bit fields
	0	saveET1	temporary ET1 flag save
	1	saveTR1	temporary TR1 flag save
	2	mparity	mouse receive parity bit
	3	drifting	sensor is drifting
	4	stepping	sensor is stepping (changing by a large amount)
	5	skiptac	disable tactile output
	6	bad_command	primary command byte is invalid
	7	stopF4	disable external device F4 polling
2F		bdown	button down
30		xravgl	x axis running average fraction
31		xravgh	x axis running average integer
32		yavgl	y axis running average fraction
33		yavgh	y axis running average integer
34		pavgl	p axis running average fraction
35		pavgh	p axis running average integer
36		xorigin	x axis origin
37		yorigin	y axis origin
38		porigin	p axis origin
39		bd	button down
3A		lslast	last left slope
3B		curlast	last curvature
3C		wthr	working threshold
3D		xlast	last raw x sample
3E		ylast	last raw y sample
3F		plast	last raw p sample
40		cpt	curvature pointer
41		b1mask	button 1 pts mask
42		b2mask	button 2 pts mask
43		b3mask	button 3 pts mask

RAM address	Bit Position	Name	Description
44		delayl	low byte ramp precount
45		delayh	hi byte ramp precount
46		xyavg_factor	xy axis running average factor
47		opadelay	op amp power on delay
48		dacdelay	dac settling delay
49		gapdelay	dac zero delay
4A		snstvty	sensitivity factor
4B		lasts	last status sent
4C		hpdelay	hot plug delay
4D		inertia	inertia factor
4E		pdriftlim	z axis drift limit
4F		pdrift_rel	z axis drift counter preset
50		pdriftcnt	z axis drift counter
51		burst1	burst byte 1 address
52		burst2	burst byte 2 address
53		burst3	burst byte 3 address
54		bdwptr	bd buffer write pointer 0..2
55		bdrptr	bd buffer read pointer 0..2
56		dirfac	direction factor
57		reach	curvature search limit
58		draghys	drag hysteresis factor
59		mindrag	minimum drag time
5A		uthr	up threshold
5B		butrad	center region button radius
5C		thr	threshold
5D		jkcur	jenks curvature
5E		ztc	z axis running average time constant
5F		rstdft1	drift counter 1 reset value
60		value6	pre-plateau segment transfer function slope
61		movdel	lockout delay after mouse or joystick move
62		delayhz	hi byte zramp precount
63		drift	drift parameter
64		xydriftavg	drift average factor
65		xyavgthr	threshold to reset running average origins
66		sxy_lo tpot ztemp	slope factor low byte temporary dac value temporary magnitude storage
67		sxy_hi pottarget	slope factor high byte target for pot set routine
68		xtemp torigin	temporary x conversion storage temporary origin

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
69 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

RAM address	Bit Position	Name	Description
69		ytemp	temporary y conversion storage
6A		samcntrel	sample counter reload
6B		xlowl	low byte of x axis raw (lowx) running average
6C		xlowh	high byte of x axis raw (lowx) running average
6D		psam	sample counter ticks
6E		polldel	hot plug poll retry delay
6F		mxstate mrec_cntr	mouse transmit/receive state counter
70		mbyte1	last 3 bits of address must be 000
71		mbyte2	last 3 bits of address must be 001
72		mbyte mxbyte	mouse receive byte mouse transmit byte
73		mbyte3	last 3 bits of address must be 011
74		savebd	last non-zero bd
75		ylowl	low byte of y axis raw (lowy) running average
76		ylowh	high byte of y axis raw (lowy) running average
77		mvdel	moving delay
78		uwthr	upper working threshold
79			unassigned
7A		bdlast	for tactile, last bd
7B		xlowoff	drift trial x
7C		ylowoff	drift trial y
7D		lowx	low byte of raw x conversion
7E		lowy	low byte of raw y conversion
7F			unassigned
80		debug	debug counter
81		pot0	temporary dac value
82			unassigned
83			unassigned
84			unassigned
85			unassigned
86-89		bds	bd buffer
8A-8E		zf	zf buffer
8F-93		ls	left slope buffer
94-A8		cur	curvature buffer
A9-C1		Xb	X backup buffer
C2-DA		Yb	Y backup buffer
DB-FF		SP	stack space

Appendix B - PLUG AND PLAY REFERENCE

This section details the specifications for the response to the "Read Extended ID" command (x"D0") as described on page 18. The maximum length of the extended ID is 256 bytes. The following table describes the fields for the extended ID string.

Field Name	Size (bytes)	Required	Description	Notes
Other ID	< 17	No	Additional Plug and Play ID	
Begin Extended ID	1	Yes	Start of Extended ID	
PnP Revision Level	2	Yes	Plug and Play Specification Revision Level	
Manufacturer ID	3	Yes	Manufacturer ID assigned by EISA	
Product Number	3	Yes	Manufacturer assigned unique Product Number	
Product Revision	1	Yes	Manufacturer assigned product revision number	
Extend	1	No	Field present indicator	3
Serial Number	8	No	Optional device serial number	
Extend	1	No	Field present indicator	3
Class ID	< 33	No	Windows 95 Class Identifier	
Extend	1	No	Field present indicator	3
Driver ID	< 41	No	Compatible Plug and Play IDs	
Extend	1	No	Field present indicator	3
User Name	< 41	No	Manufacturer supplied product name	
Checksum	2	(see note)	Extended ID checksum	4
End Extended ID	1	Yes	End of Extended ID	

Notes:

1. The entire length of the extended ID string, including all fields and delimiters, shall not exceed 256 characters. This is to minimize delays in system boot-up time.
2. Values for the extended ID fields, enclosed within the Begin PnP and EndPnP characters, must be static for a given device.
3. For all optional fields, the character string begins with the extend character "\". If an optional field is not present but subsequent fields are, that field shall be represented by a single "\" character. "\" is coded as x"5C". If the subsequent fields are not provided, then the "\" characters may be omitted.
4. The checksum is not required unless an Extend Field is present. The arithmetic checksum includes all characters in all fields from the Begin Extended ID to End Extended ID, exclusive of the checksum field.

Extended ID/PnP Field Definitions

Other ID   This fields contains an optional ID. The length of this field shall not exceed 16 bytes. This fields is optional and may be omitted. Use of BeginPnP or EndPnP characters (x"28",x"29") is not allowed. Use of <CR> and <LF> characters are allowed for readability.

YKT3E string (ASCII): `M 19990623`
YKT3E string (Hex): `4D203139393930363233`

Begin PnP   This character is used to mark the beginning of the extended ID record. The character used is the open parenthesis character, x"28". For the extended ID record to be valid, there must be a matching EndPnP character. See End PnP field definition.

YKT3E string (ASCII): `(`
YKT3E string (Hex): `28`

PnP Rev   The two byte revision code that represents the device's compliance level with the Plug and Play ISA specification. The 12 bit level in this fields is created by extracting bits 5 to 0 of byte 1 and concatenating it with bits 5 to 0 of byte 2. These 12 bits are treated as a hexadecimal number. Dividing this number by 100 decimal yields the version number, ranging from 0.00 (x"00 00") through 1.0 (x"01 24") to 40.95 (x"3F 3F"). PnP Revision codes that contain x"29" must not be used. This will preclude certain levels. For example, level 1.05 is coded as x"01 29" and its use is not permitted.

YKT3E string (ASCII):☺$
YKT3E string (Hex): `0124`

EISA Mfr ID   Each device manufacturer must have a unique three character EISA Identifier. The device manufacturer shall report its EISA ID in this field. This field, together with the Product Number and Product Revision fields are used to generate the Product ID used by the PnP BIOS routines to identify this device.

YKT3E string (ASCII): `IBM`
YKT3E string (Hex): `49424D`

Product Number   Devices complying with this specification shall contain a unique product number in this field. The characters in this field are restricted to valid hexadecimal characters, (i.e. 0-9, and A-F). This field, together with the EISA Mfr ID and Product Revision fields are used to generate the Product ID used by the PnP BIOS routines to identify this device.

YKT3E string (ASCII): `378`
YKT3E string (Hex): `333738`

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
72 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

Product Revision   This field contains the revision of the product, and is restricted to a single hexadecimal character, (i.e. 0-9, and A-F). This field, together with the EISA Mfr ID and Product Number fields are used to generate the Product ID used by the PnP BIOS routines to identify this device.

YKT3E (with *button2* set, (2 button implementation)) string (ASCII): `1`
YKT3E (with *button2* set, (2 button implementation)) string (Hex): `31`
YKT3E (with *button2* cleared , (3 button implementation)) string (ASCII): `0`
YKT3E (with *button2* cleared , (3 button implementation)) string (Hex): `30`

Product Serial Number   This field is optional. It contains a unique manufacturer serial number. The serial number is a 32 bit value in 8 ASCII encoded hexadecimal digits. The first character represents the most significant 4 bits.

`This field in not used in version YKT3E`

Class Name   This field is optional. The character string must not exceed 32 characters. If the device doesn't belong to a predefined class, this field must not be included in the record. The valid value for pointing devices is MOUSE. A list of valid classes can be found in the Microsoft™ Windows 95™ DDK.

`This field in not used in version YKT3E`

Compatible Device IDs   This field is optional. The character strings must not exceed 40 characters total. The field consists of one or more strings separated by the comma character "," (x"2C"). The Ids indicate a compatible device whose device driver will work with the current device. Each Device ID in the field has the same format as defined for EISA Mfr ID (three characters) and a Product ID (four characters). For example, a pointing device compatible with the IBM PS/2 Mouse would indicate the seven character ID of a known compatible IBM PS/2 Mouse.

`This field in not used in version YKT3E`

User Name   This field is optional. It must not exceed 40 characters. This field contains a user-readable and user-recognized product device description. It is expected that this field will be available for display by a Plug and Play User Interface. This field may not contain the EndPnP character, x"29". For readability, the User Name field may include <CR> <LF> characters.

`This field in not used in version YKT3E`

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
73 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

Checksum   This field is required but follows an Extend field because of its position in the record. This field is a modulo-256, 8 bit arithmetic checksum of all characters from Begin PnP field to End PnP field (inclusive), exclusive of the checksum characters themselves.   The value is represented as a two character hexadecimal number. The first character is the most significant digit, and the second character is the least significant digit

End PnP   This field is required. It is used to indicate the end of the Extended ID record. The value of this field must be x"29". The End PnP character, x"29", must not appear in the option information fields so that a device driver can properly detect the end of the Extended ID record.

YKT3E string (ASCII):)
YKT3E string (Hex): 29

These PnP specifications conform to "Plug and Play ISA Specification" Version 1.0a dated May 5, 1994 and are identical to the "Plug and Play External COM Device Specification" Version 1.00 dated February 28, 1995.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
74 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

IBM Engineering Specification

PnP ID / Product ID

This describes the format and formulation of the PnP ID or Product ID as it is generated by the PnP BIOS routines. The PnP ID is the seven character ASCII representation of the product identifier compressed into a 32 bit identifier. The seven character ID consists of a three character manufacturer code, a three character hexadecimal product identifier, and a one character hexadecimal revision number. For example, the third revision of the ABC company's device might have an uncompressed ID such as ABC1003.

The manufacturer code is a 3 uppercase character code that is compressed into 3 5-bit values a follows:

1. Find hex ASCII value for each letter
2. Subtract x"40" from each ASCII value
3. Retain 5 least significant bits for each letter by discarding upper 3 bits because they are always zero.
4. Compressed code = Concatenate 0 and the 3 5-bit values for the character.

The format of the compressed product identifier is as follows:

Byte	Description
0	Bit 7: Reserved Bits 6-2: 1st character of the compressed manufacturer code Bits 1-0: Upper 2 bits of the 2nd character of the compressed manufacturer code
1	Bits 7-5: Lower 3 bits of the 2nd character of the compressed manufacturer code Bits 4-0: 3rd character of the compressed manufacturer code. (bit 4 is most significant)
2	Bits 7-4: 1st hexadecimal digit of the product number. (bit 7 is most significant) Bits 3-0: 2nd hexadecimal digit of the product number. (bit 3 is most significant)
3	Bits 7-4: 3rd hexadecimal digit of the product number. (bit 7 is most significant) Bits 3-0: 4th hexadecimal digit of the product number. (bit 3 is most significant)

For the example above

Uncompressed ID (ASCII): ABC1003
Uncompressed ID (Hex): 41 42 43 31 30 30 33
Compressed ID Byte 0 (Hex): 04
Compressed ID Byte 1 (Hex): 43
Compressed ID Byte 2 (Hex): 10
Compressed ID Byte 3 (Hex): 03

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
75 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

Appendix C - REVISION HISTORY

July 2, 1999 (Version YKT3E)

This is a modification of version 3D to add functionality.

PnP string has been shortened to gain needed ROM space. The PnP ID will still change with the presence of the *button2* jumper (pins 27-23) or bit.

A Tap filter has been added to the Press to Select algorithms to prevent inadvertent presses during keyboard typing.

The Button Mask definitions have been changed to save ROM space and to accommodate the Tap filter.

The *xyavgthr* parameter has been added to improve the drift correction algorithm.

The drift calibration interval has been changed to 0.5 seconds from 3 seconds.

The *drift* parameter is now in RAM.

The analog sensitivity has been increased by a factor of 4 and 2 more bits are now available for use by the drift correction algorithms. The *trialx* and *trialy* parameters have been functionally replaced by the *xlowoff* and *ylowoff* variables.

The initial POST reset will save the results of the X and Y axis tests, and report these results for ALL subsequent resets, until either a hard reset or a x"E2 7F" command is processed. This will prevent error reports when a reset command is issued while the sensor is in use.

If a bad command is received during normal operation, a resend will be issued and TrackPoint controller operation will return to normal. The old behavior was to wait for the actual resend, which would cause the controller to wait indefinitely if it never came (preventing sampling and reports). For resend during multiple byte sequences, the behavior will remain as it was (wait for resend).

The contents of RAM location x"62" to x"81" have been reshuffled to gain space for new parameters.

Adding a jumper between pins 26 and 21 will change the default value of *xydriftavg* for noisier sticks.

IBM Engineering Specification

January 3, 1999 (Version YKT3D)

This is a modification of version 3B to add additional features that are found in version YKT3C. This also adds a bitswitch to suppress the F4 polling of the external device, which causes Logitech TouchPads to break.

PnP string has been modified to match the format of version 3C.

Bit switch *nosync* added at location 2D.7. When this bit is set, the sync pulse is suppressed.

Bit switch *skiptac* added at location 2E.5. When this bit is set, tactile output is suppressed.

Bit switch *halftac* added at location 2C.1. When this bit is set, the tactile pulses will only be generated by presses (not releases).

Bit switch *stopF4* added at location 2E.7. When this bit is set, the F4 polling of the external device is suppressed.

E2 52 will generate a tactile pulse, independent of the state of *skiptac*

The tactile pulse output is fixed at 10 milliseconds. The short pulse is no longer an option.

YKT3Eext.lwp	EC YKT3A	EC YKT3B	EC YKT3D	EC YKT3E
77 of 78	24 NOV 97	17 SEP 98	3 JAN 99	19 OCT 99

Engineering Specification

Appendix D - PIN AND JUMPER DESCRIPTIONS

Version	98, AB	B1	B3-B8	20	2B, 2C	3A	3B, 3D	3C	3E
Left Button Input Pin	25	25	25	25	25	25	25	25	25
Middle Button Input Pin	26	26	26	27	27	27	27	27	27
Right Button Input Pin	24	24	24	26	26	26	26	26	26
Tactile Pulse Output Pin	-	-	-	-	-	23	23	21	23
Sync Pulse Output Pin	-	-	-	27	27	27	25	25	25
Ground this pin to invert X	-	-	3	21	-	-	-	-	-
Ground this pin to invert Y	-	-	-	-	-	3	3	28 *(1)	3
Ground this pin to invert Z	-	-	-	-	-	28	28	28 *(1)	28
Add this jumper for 2 physical buttons	- *(3)	-	-	-	-	-	27-23	27-21	27-23
Add this jumper for 3 physical buttons	- *(3)	27-Gnd	27-Gnd	28-Gnd	28-Gnd	- *(2)	-	-	-
Add this jumper for Demo mode	-	-	-	-	-	27-23	26-21	26-21 *(4)	-
Add this jumper for noisier sticks	-	-	-	-	-	-	-	-	26-21 *(5)

Notes:

1. Grounding pin 28 inverts BOTH Y and Z axes.
2. Version 3A by default indicates 3 buttons.
3. Version 98 had no mechanism to determine number of buttons.
4. Demo mode jumper cannot co-exist with the 2 button jumper.
5. With this jumper installed a 1.5KΩ resistor is required for Mask ROM parts between pin 21 and +5V.