Trackball and Mouse PS2/RS232 Encoder With Ballistic Gain

Description

The UR7HCMTB TrackCoder™ is a low-power, single-chip mouse and trackball encoder that interfaces a trackball/mouse photodiode sensing circuit and three switches.
The UR7HCMTB provides protocol auto-sensing, allowing the device to be linked through either the serial or PS/2 mouse port of the host system.
The UR7HCMTB will auto-switch between the Serial and PS/2 mouse communication protocols depending on the port to which the device is actually connected.

The IC provides three-button mouse functionality. It is compatible with the IBM/Microsoft two-button and Logitech three-button mouse protocols.

The UR7HCMTB offers a factory programmable Ballistic Gain table that may be switched on and off dynamically. A fourth button is available to act as an on/off switch.

Communication through the serial port is half-duplex at a fixed speed of 1200 Baud. PS/2 communication, at 10 kbps, is bidirectional. The UR7CMTB supports all commands from and to the system, as defined in the IBM PS/2 Mouse Communication Protocol.

The URH7CMTB is a CMOS device operating at 4 MHz. The low-power consumption of the IC makes it suitable for battery-operated systems. Power in the serial mode, as in any standard mouse, can be drawn from the RS232 lines of the host system.

The URH7CMTB is available in Plastic DIP and SOIC packages. Custom versions are also available.

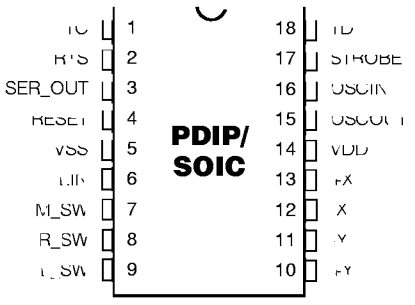
Features

- *Autoselectable RS232 and PS/2 hardware interface*
- *Implements two- and three-button mouse – IBM/Microsoft/Logitech-compatible*
- *Provides built-in direct interface for phototransistors*
- *Factory programmable hysteresis and Fine Gain control*
- *Strobed Illumination of of phototransistors*
- *CMOS/TTL digital inputs and non-strobed version available*
- *Factory-programmable Ballistic Gain table*
- *Ballistic Gain can be switched on & off dynamically, optionally using 4th button*
- *Test mode for quadrature encoder's adjustment and calibration*
- *Low power consumption in a 3 to 6 Volt operating range*
- *Small 18 pin PDIP or SOIC packages available*
- *Sun Microsystems and Custom versions available*

Applications

- *Embedded pointing devices*
- *Industrial panels*
- *Instrumentation*
- *Standard mouse and trackball devices*
- *Custom system interfaces*

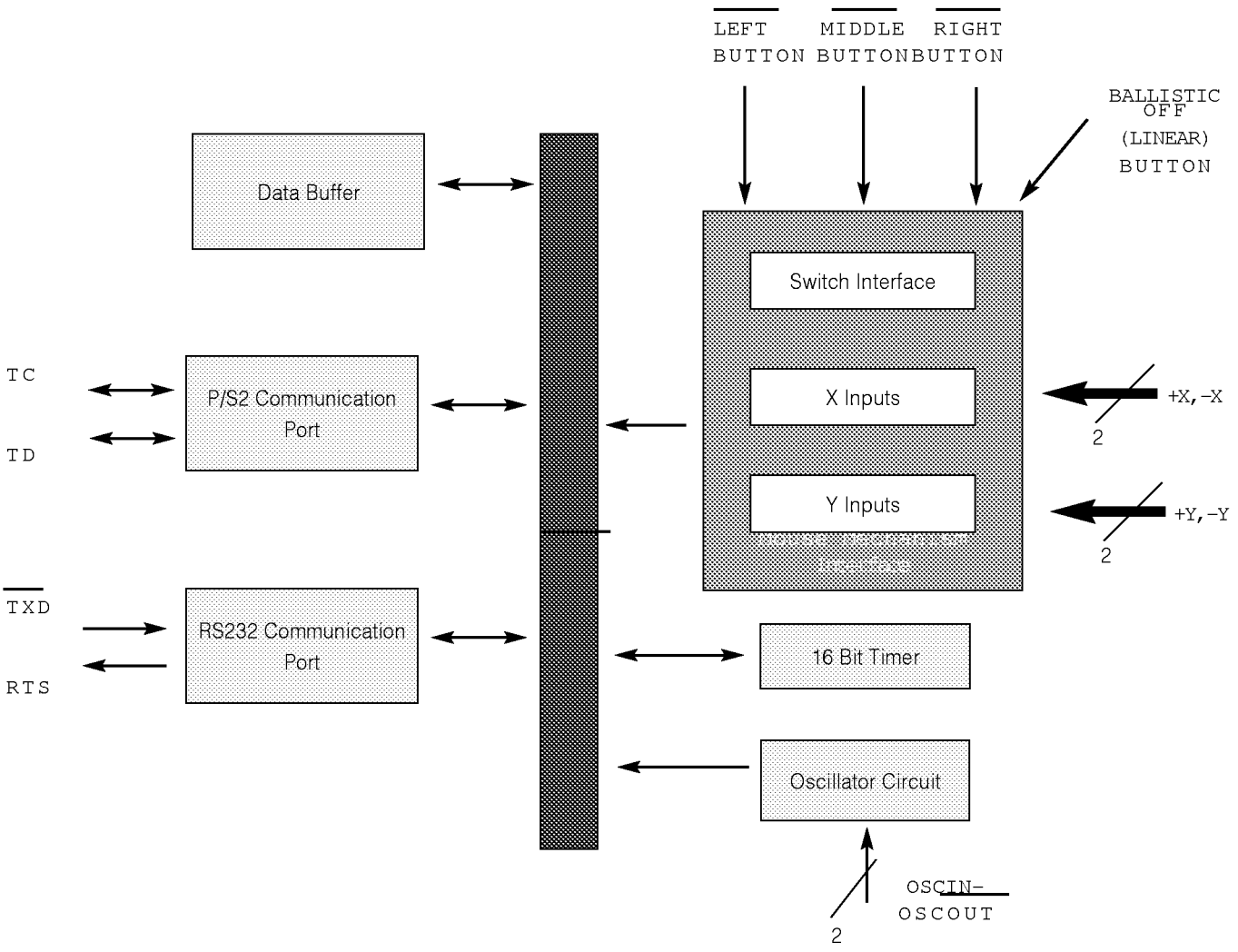
Pin Configuration



Ordering Code

PACKAGES	TA = 0 C TO +70 C	TA = −40 C TO +85 C
18 pin, Plastic DIP	UR7HCMTB-P	UR7HCMTB-CP
18 pin, SOIC	UR7HCMTB-DW	UR7HCMTB-CDW

Functional Diagram



Functional Description

The UR7HCMTB consists functionally of five major sections (see Functional Diagram, previous page). These are the Mouse Mechanism Interface, the 16 Bit Timer, the Oscillator Circuit, the PS/2 Communication Port and the RS232 Communication Port. All sections communicate with each other and operate concurrently.

Autoselect

At power-up, the UR7HCMTB will execute a power-on reset and determine the mode of operations.

Test Mode

Test Mode can be entered by shorting Pin 3 (an open drain I/O) to GND and then applying 6 to 10 Vdc power via the RS232 RTS Pin.

In Test Mode, the internal binary representation of the X or Y channel's quadrature encoders can be observed with an oscilloscope on Pin 8 and Pin 9 (both this function and the Left/Right Button function share Pins 8 and 9). The Middle Button selects X (when off) or y (when on) channel for observation on Pin 8 and Pin 9. Optimum LED current and the correct Electrical Angle for Quadrature Encoders can be obtained using a simple procedure.

Pin Description

	Pin Numbers			
Mnemonic	DIP	SOIC	TYPE	NAME AND FUNCTION
TC	1	1	I/O	**PS/2 Clock**
RTS	2	2	I	**Ready to Send**
SER_OUT	3	3	I/0, Open Drain	**Serial Tx Data Output, Test Mode Sense**
RESET	4	4	I	**Reset:** apply 0 V for orderly start up.
VSS	5	5	Power	**Ground**
LIN	6	6	I w/ Pullup	**Lin Switch:** low=non-ballistic (linear).
M_SW	7	7	I w/ Pullup	**Middle Switch:** low = on.
R_SW	8	8	I w/ Pullup	**Right Switch:** low = on.
L_SW	9	9	I w/ Pullup	**Left Switch:** low = on.
+Y	10	10	I w/ Pullup	**Vertical Input 1**
-Y	11	11	I w/ Pullup	**Vertical Input 2**
-X	12	12	I w/ Pullup	**Horizontal Input 1**
+X	13	13	I w/ Pullup	**Horizontal Input 2**
VDD	14	14	Power	**Power Supply**
OSCOUT	15	15	O	**Oscillator Output**
OSCIN	16	16	I	**Oscillator Input**
STROBE	17	17	O	**LED's Strobe**
TD	18	18	I/O	**PS/2 Data**

Pin Description Notes

The Internal Oscillator has a built-in feedback resistor. Only one (1) external component is needed for Clock generation. USAR recommends a 4.00 MHz Ceramic Resonator with built-in load capacitors.

LIN, M_SW. R_SW and L_SW inputs have built-in pull-up resistors. No additional components are required for a three-button design. However, if high levels of ESD and EMI are expected, than series protection resistors (47 Ohms to 1k Ohms) are recommended between the switches and the switches' inputs on the IC.

Ballistic Gain Operations

The Ballistic Gain Operations converts motion counts of +/-(0 to 31) to arbitrary table-defined counts, and counts of 32 or more into counts of 127. Customers can supply a 32-entry table or use USAR's proprietary profile. Ballistic operation is disabled when LIN is depressed. The LIN button can also be implemented as a short or selectable jumper on the PCB.

PS/2 Data Format

The following table shows the data report format. Values are expressed in a Two's Complement Format with a separate sign bit. If there is an overflow of the accumulator, the maximum positive or negative count is reported and the corresponding overflow bit is set.

Data Report Format Table

Byte 1			
	b0	Left Button status	1 = depressed
	b1	Right Button Status	1 = depressed
	b2	Middle Button Status	1 = depressed
	b3	Always = 1	
	b4	X data sign	1 = negative
	b5	Y data sign	1 = negative
	b6	X data overflow	1 = overflow
	b7	Y data overflow	1 = overflow
Byte 2			
	b0	X0: LSB of X data	
	b1	X1	
	b2	X2	
	b3	X3	
	b4	X4	
	b5	X5	
	b6	X6	
	b7	X7: MSB of X data	
Byte 3			
	b0	Y0: LSB of Y data	
	b1	Y1	
	b2	Y2	
	b3	Y3	
	b4	Y4	
	b5	Y5	
	b6	Y6	
	b7	Y7: MSB of Y data	

Status Report Format Table

Byte 1			
	b0	Right Button	1 = depressed
	b1	Middle Button	1 = depressed
	b2	Left Button	1 = depressed
	b3	Always = 0	
	b4	Scaling - 1:1 (0) / 2:1 (1)	
	b5	Disable - (0) / enable (1)	
	b6	Stream - (0) / prompt (1) mode	
	b7	Always = 0	
Byte 2			
	b0 - 1	Current resolution setting	
	b2 - 7	Always = 0	
Byte 3			
	b0-7	Current sampling rate	

PS/2 Mode Commands

At start-up or upon receiving a reset command, the Clock and Data lines of the TrackCoder™ can be pulled to a positive level. The UR7HCMTB will then wait between 300 and 500 milliseconds before sending an AAh to the host followed by a device ID of 00h. Then the IC will set itself to its default values, i.e. Incremental Stream Mode with 1:1 scaling, and a report rate of 100 Hz. The device will then disable itself until a command is sent from the host.

Error Handling

For every correct command or parameter received from the host, the UR7HCMTB sends an Acknowledge (FAh). If an invalid command or parameter is received, the UR7HCMTB issues a Resend Request (FEh). If an invalid input is again received, the device transmits an Error Code (FCh) to the host. Both error and Resend request responses are sent by the device within 25 milliseconds. The host may not issue any new commands until either the TrackCoder™ has responded or until 25 milliseconds have elapsed.

When the `Reset Command (FFh)` is enacted, the UR7HCMTB sets the following default parameters: Incremental Stream Mode, 1:1 scaling, disabled, and a report rate of 100 Hz and then sends AAh to the host followed by a device ID of 00h.

The host sends the `Resend Last Data Stream Command (FEh)` when it detects an error in any UR7HCMTB transmission. The device then resends the last output data stream to the host. This transmission occurs after a TrackCoder™ transmission and before the host enables the interface allowing the next TrackCoder™ output.

The `Set Default Status Command (F6h)` re-initializes the device to its condition at power-up.

The `Disable Command (F5h)` stops the device from transmitting all reports. However, the mode does not change; the TrackCoder™ is still able to respond to commands. If the Disable Command is issued while the device is transmitting a report, the UR7HCMTB immediately stops the transmission and disables itself.

If the TrackCoder™ is in Incremental Stream Mode, the `Enable Command (F4h)` will allow it to begin data transmission. If the device is in Prompt Mode, the Enable Command will update the internal status of the TrackCoder™, but it will not allow the device to transmit data to the host either while it is moving or when a button is depressed.

The TrackCoder™ will respond to the `Set Sampling Rate Command (F3h)` in both Stream and Prompt Modes but will only update its internal status if this command is enacted while the device is in Stream Mode.

UR7HCMTB responds to the the `Read Device Type Command (F2h)` immediately after the Acknowledge with a 00h.

The `Set Prompt (Remote) Mode Command (F0h)` sets the device to Prompt Mode. Data values are then only reported in response to a `Read Report Command (EBh)`.

If the `Set Echo Mode Command (EEh)` is enacted, the TrackCoder™ will immediately return any data bytes except FF or EC.

The `Reset Echo Mode Command (ECh)` returns the device to its previous mode – disabled. If this command occurs while the UR7HCMTB is in either Stream or Prompt Modes, the command is ignored.

The `Read Report Command (EBh)` prompts the TrackCoder™ for a report. The report occurs even if the device did not move or if the status of the switches did not change. The report is sent by the UR7HCMTB following an Acknowledge.

The `Set Incremental Stream Mode Command (EAh)` sets the TrackCoder™ to Stream Mode and disables the device.

The `Status Request Command (E9h)` returns a 3 byte status report.

The `Set Resolution Command (E8h)` controls resolution, and the `Set 2:1 Scaling Command (E7h)` enables a coarse/fine tracking response. Resolution and Scaling Command are acknowledged and reported as activated, but their status is ignored.

The `Set 1:1 Scaling Command (E6h)` enables the values of movements to be transmitted to the host without any scaling.

Sequential Commands

Unlike normal commands, sequential commands must be enacted with a sequence of commands. If the sequence is not consecutive or is incorrect, the TrackCoder™ aborts the detection and responds the way it would normally respond to a command. The individual commands that comprise a sequential command have been designed so that the elements of a sequential command can be sent to the TrackCoder™ via the standard IBM PS/2 BIOS calls and the device only returns a valid response to the Standard Status Request. This ensures that, if the sequential command is sent via the BIOS, the status response will be accurately returned even if the BIOS does error detection. Thus, a programmer can have complete control of the mouse without having to access the device hardware port directly.

The UR7HCMTB TrackCoder™ implements a special sequential command that can be used to determine its ability to report three buttons. The sequential command is a series of commands to the TrackCoder™ that cause the device to respond to the last command (Read Status) with alternate information.

Sequence of commands:

1. Set Resolution = one count/ mm
   Direct: E8H,00H BIOS: INT15H, AX=C203H, BX=0
2. Set Scaling = 1:1
   Direct: E6H BIOS: INT15H, AX=C206H, BX=1
3. Set Scaling = 1:1
   Direct: E6H BIOS: INT15H, AX=C206H, BX=1
4. Set Scaling = 1:1
   Direct: E6H BIOS: INT15H, AX=C206H, BX=1
5. Read Status
   Direct: E9H BIOS: INT15H, AX=C206H, BX=0

The response to the Read Status Command is in the form:

Byte 1: Standard Status Information (buttons, scaling, etc.)
Byte 2: Number of mouse buttons (3)
Byte 3: Firmware Revision Number (encoded)

Serial Data Format

Serial Data Report Format Table

Byte 1			
	b0	X6	
	b1	X7: MSB of X Data	
	b2	Y6	
	b3	Y7: MSB of Y Data	
	b4	Right Button Status	1 = depressed
	b5	Left Button Status	1 = depressed
	b6	Always=1	
Byte 2			
	b0	X0: LSB of X data	
	b1	X1	
	b2	X2	
	b3	X3	
	b4	X4	
	b5	X5	
	b6	Always=0	
Byte 3			
	b0	Y0: LSB of Y data	
	b1	Y1	
	b2	Y2	
	b3	Y3	
	b4	Y4	
	b5	Y5	
	b6	Always=0	

Sun Version

A Sun Microsystems version of the TrackCoder™ is available. The sample schematic on the following page also includes information related to this Sun version.

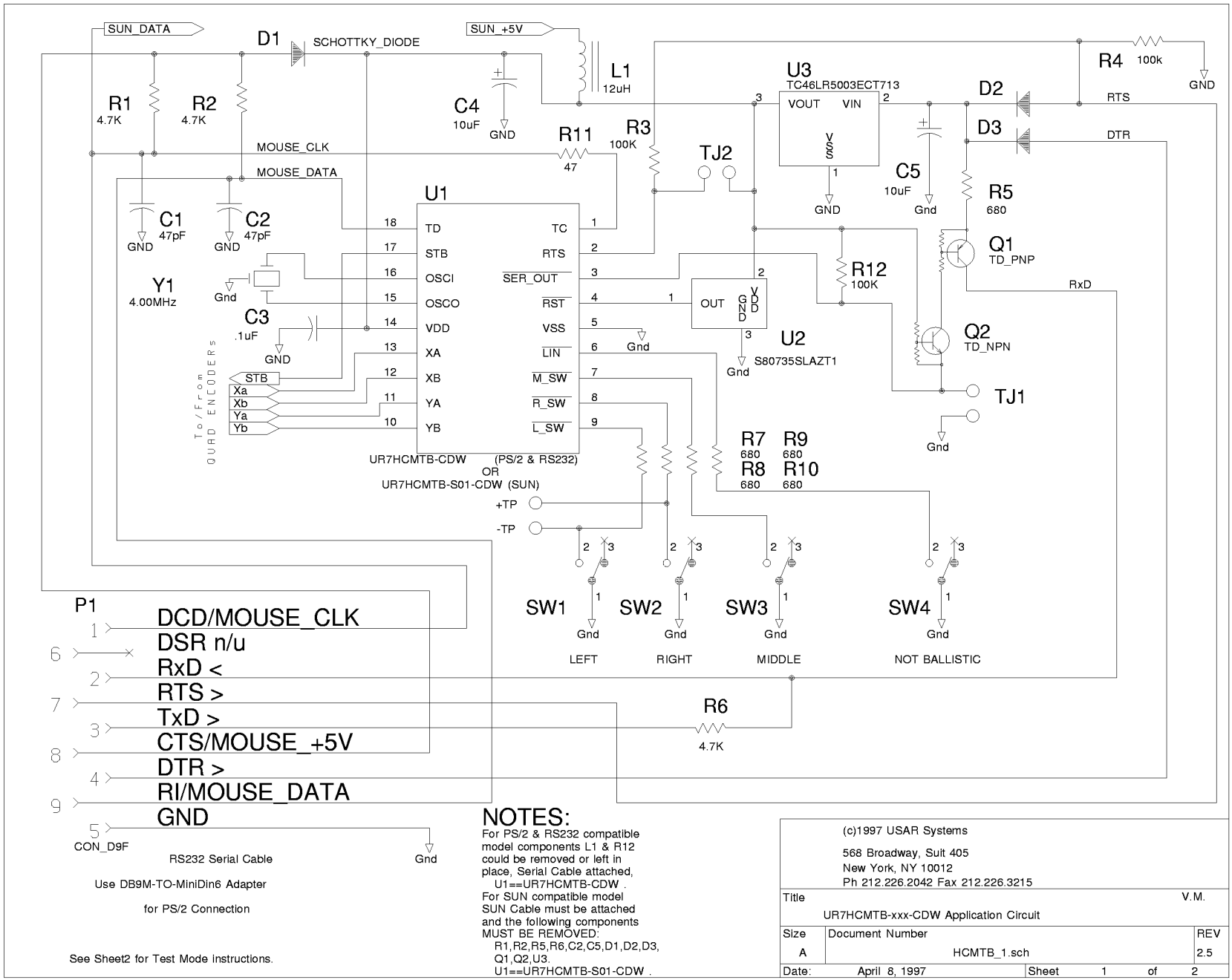
Serial Mode

Communication through the serial port is half-duplex at a fixed speed of 1200 Baud, 7N2 protocol.

At start-up and after each RTS toggle, the MouseCoder™ will send a two-character ASCII string "M3" indicating 3-button capability to the host.

A Data Report is sent if motion is detected, or if buttons either are pressed or released. Motion is reported relative to the last Report sent, in a Two's Complement Form and eight (8) bit resolution. In other words, the Maximum Motion values are -128 to +127, saturated at min/max for faster speeds.

Sample Schematic



NOTES:

For PS/2 & RS232 compatible model components L1 & R12 could be removed or left in place, Serial Cable attached,
U1==UR7HCMTB-CDW .
For SUN compatible model SUN Cable must be attached and the following components MUST BE REMOVED:
R1,R2,R5,R6,C2,C5,D1,D2,D3, Q1,Q2,U3.
U1==UR7HCMTB-S01-CDW .

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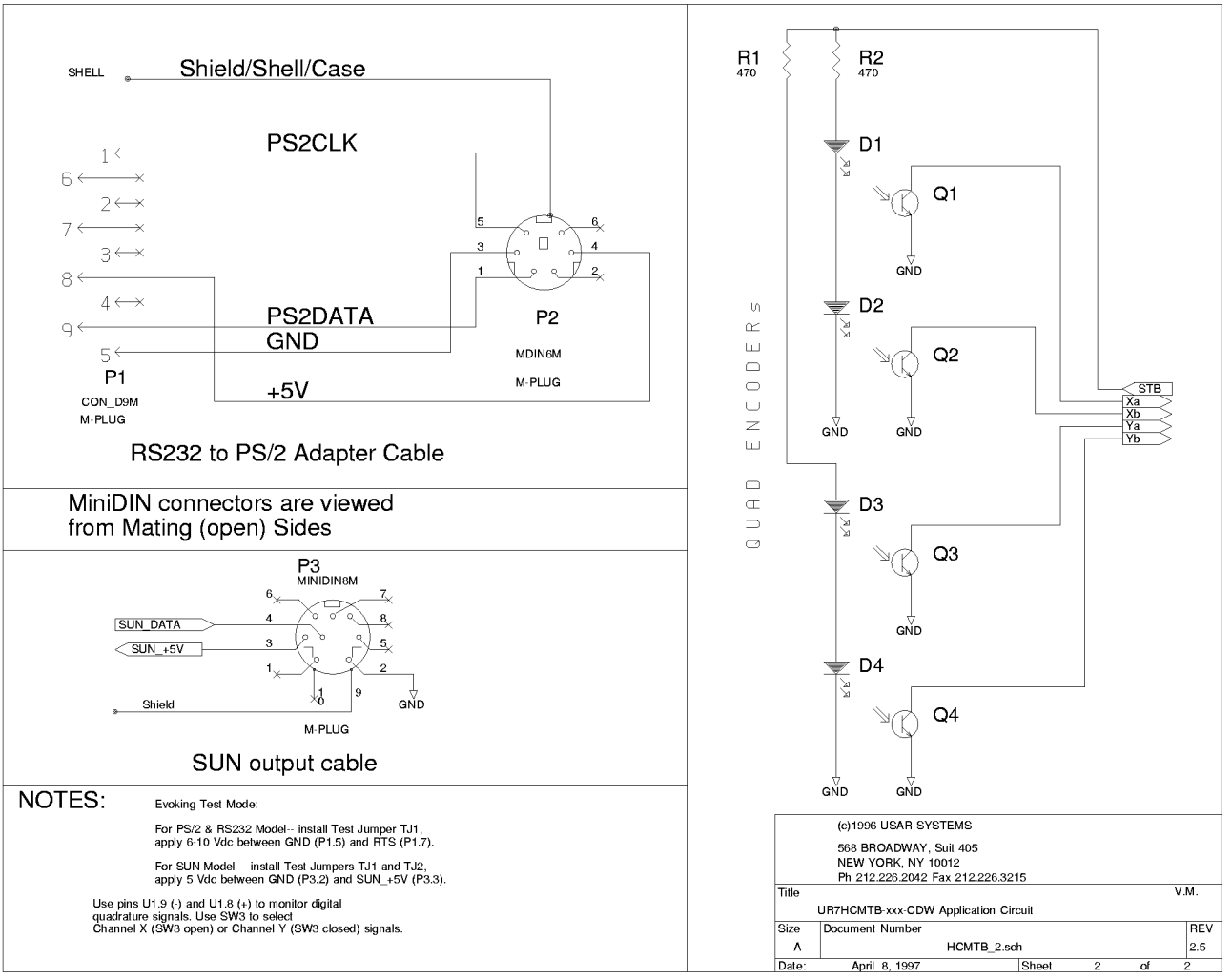
Title	UR7HCMTB-xxx-CDW Application Circuit		V.M.
Size A	Document Number HCMTB_1.sch		REV 2.5
Date: April 8, 1997		Sheet 1 of 2	

Cable and Quadrature Specifications



Adjustment Procedure for Quadrature Encoders Mouse and TrackBall Assemblies, Photoelectric Sensing

1.) Install TEST_JUMPER (U1.3 to GND)

2.) Apply 6-10Vdc between the GND and RTS lines on the RS232 Interface (P1.5=GND, P1.7=RTS)
NOTE: Device should NOT be connected to either PS/2 or RS232 port.

3.) Connect oscilloscope to Pins 8 and 9.

4.) Use Middle Button (SW3) to select Channel X (SW3=OFF) or channel Y (SW3=ON).

5.) Institute continuous motion of the Ball.

6.) Adjust current for an appropriate pair of LEDs:
Decrease or Increase Limiting Resistor until digital outputs have a 50% duty cycle.
Increasing resistance (decreasing current) makes the High State of the waveform longer.
Small imbalances between pairs of the LEDs/Phototransistors can be removed by rotating the devices' bodies in the opposite directions as indicated on the sample schematic.

7.) Adjust Quadrature Encoder's Electrical Angle by moving devices' bodies as indicated in the diagram on the previous page.
Devices' pins may need to be unsoldered for this adjustment.

The figure below shows waveforms for collectors of phototransistors (Trace1/Trace3 == U1, Pins 10/11 or 12/13), and Test Mode outputs (Trace2/Trace4 = U1, Pin 8 and Pin 9).

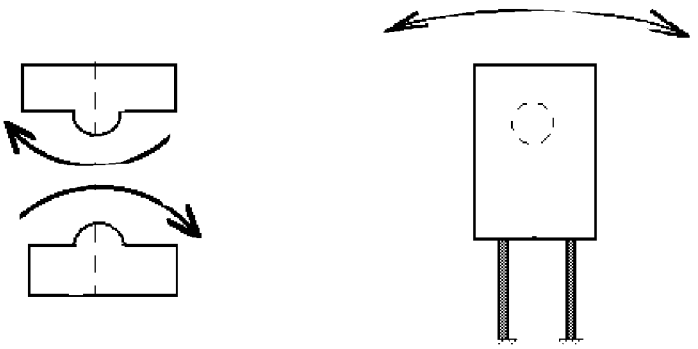


Figure 1: Waveforms for Collectors of Phototransistors

Electrical Specifications

Absolute Maximum Ratings

Ratings	Symbol	Value	Unit
Supply Voltage	V_{DD}	0 to 7.5	V
Input Voltage	V_{IN}	Vss -0.6 to V_{DD} +0.6	V
Current Drain per Pin (not including Vss or V_{DD})	I	20	mA
Operating Temperature UR7HCMTB-xx UR7HCMTB-Cxx	T_A	T low to T high 0 to +70 -40 to +85	° C
Storage Temperature Range	T_{STG}	-65 to +150	° C
Ambient Temperature Under Bias	Tbias	-55 to +125	° C

DC Electrical Characteristics, Temperature range=T low to T high unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Supply Voltage		3.0	5.0	6.0	V
Output Voltage	V_{OH} V_{OL}	V_{DD}–0.1		 0.1	V
Input High Voltage	V_{IH}	0.7xV_{DD}		V_{DD}	V
Input Low Voltage	V_{IL}	Vss		0.2xV_{DD}	V
Input Current	I_{IN}			+/- 1	µA
Internal Pull-up Current	I_{PUP}	50	250	500	µA
Supply Current Vdd=5.0 Vdc+/-10%, Vss=0	I_{DD}		2.0	3.5	mA

Control Timing (Vdd=5.0 Vdc +/–10%, Vss=0 Vdc, Temperature range=T low to T high unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency of Operation	fosc				MHz
■ Crystal Option			4.0		
■ External Clock Option			4.0		