

SK7100 PS/2 Pointing Stick Mouse Encoder

Sprintek Corporation

FEATURES

- Low cost and space saving solution
- Built-in oscillator, analog and digital circuit
- Low count of total components. Only several resistors and capacitor are needed
- Advanced motion control algorithm
- Z-Tap algorithm to simulate left button click, double click and drag
- CellMute technology filters the wireless EMI noise from cellular phones and wireless networks
- Works with standard Windows® mouse drivers
- Works with Lenovo TrackPoint® drivers
- Low profile QFN 32 pin package: 5x5mm 0.95 Max (LxWxH)
- Low power consumption. 650uA (idle), 4.6 mA (operation)
- 3.0V to 5.25V operating voltage
- Industry temperature range: -40°C to +85°C

APPLICATION

- Notebooks/Laptops
- Handhelds
- Keyboards
- Instrumentation

ORDERING INFORMATION

SK7100-LF QFN 32-pin, 0.5mm pitch, (5x5mm 0.95 MAX), Pb-Free

DESCRIPTION

The SK7100 pointing stick mouse encoder is a cost-effective, space-saving and highly integrated IC that interfaces a force-stick sensor to PS/2 port.

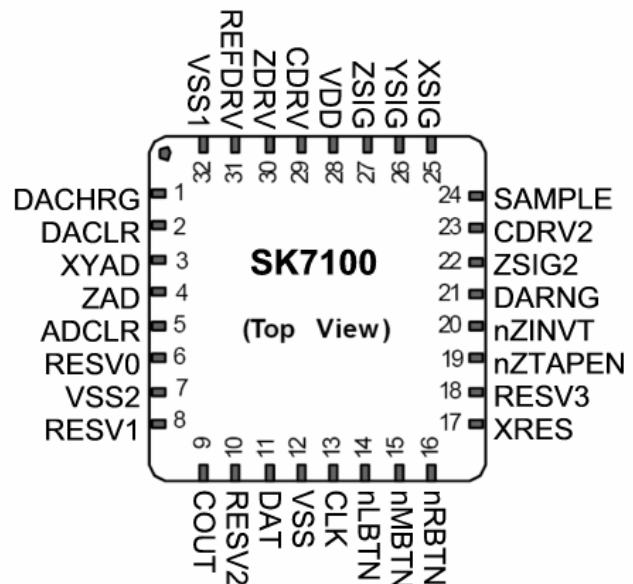
The SK7100 works with most of popular force stick sensors with tolerance up to +/- 20%. The SK7100 highly integrates oscillator, analog and digital circuit. Only several low tolerance external components are needed.

Typically, consuming 650uA in idle state, the SK7100 is ideal for battery-operated systems.

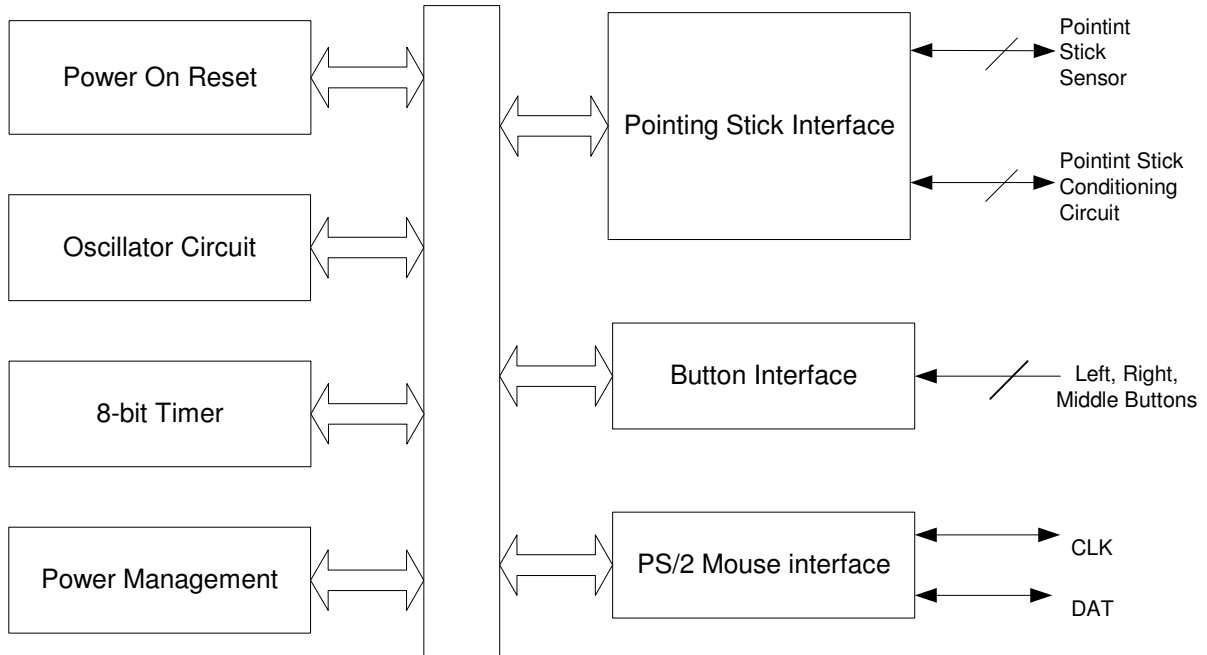
Deploying CellMute technology to filter the wireless EMI noise from cellular phones and wireless networks, the SK7100 can work quietly in wireless environment.

The SK7100 partially implements the Lenovo TrackPoint® extended command protocol and can work with Lenovo TrackPoint® device drivers directly.

PIN ASSIGNMENTS



FUNCTION BLOCK DIAGRAM



PIN DEFINITION

Pin No	Type	Name	Description
1	IO, A	DACHRG	DA capacitor charge
2	IO	DACLR	Clear DA capacitor
3	IO	XYAD	X and Y AD conversion drive
4	IO	ZAD	Z AD conversion drive
5	IO	ADCLR	Clear AD capacitor
6	IO	RESV0	Reserved pin
7	P	VSS2	Ground connection
8	IO	RESV1	Reserved pin
9	O	COUT	Comparator output
10	IO	RESV2	Reserved pin
11	IO	DAT	PS/2 mouse data
12	P	VSS	Ground connection
13	IO	CLK	PS/2 mouse clock
14	IO	nLBTN	Left button: active low with internal pull-up resistor.
15	IO	nMBTN	Middle button: active low with internal pull-up resistor.
16	IO	nRBTN	Right button: active low with internal pull-up resistor.
17	I	XRES	Active high external reset with internal pull down.
18	IO	RESV3	Reserved pin
19	IO	nZTAPEN	Z-Tap function enable pin: leave floating for disable; tied to ground for enable.
20	IO	nZINVT	Invert Z signal: leave floating for not inverting; tied to ground for inverting.
21	IO	DARNG	DA adjustment range setting: leave floating for high range; tied to ground for low range.
22	IO	ZSIG2	Second sensor Z signal input
23	IO	CDRV2	Second sensor common drive
24	IO, A	SAMPLE	Sample capacitor input
25	IO, A	XSIG	Sensor X signal input
26	IO, A	YSIG	Sensor Y signal input
27	IO, A	ZSIG	Sensor Z signal input
28	P	VDD	Power supply
29	IO	CDRV	Sensor common drive
30	IO	ZDRV	Sensor Z drive
31	IO	REFDRV	Reference voltage drive
32	P	VSS1	Ground connection.

LENGENG A = Analog, I = Input, O = Output, IO = Input/Output

The center pad on the QFN package should be connected to ground (VSS) for best mechanical, thermal, and electrical performance. If not connected to ground, it should be electrically floated and not connected to any other signal.

FUNCTION BLOCK DESCRIPTION

The SK7100 consists functionally of several major sections (see the block diagram on the previous page). These include the pointing stick interface, the button interface, the oscillator circuit, the 8-bit timer, and the PS/2 mouse interface. All sections communicate with each other and operate concurrently.

Pointing Stick Interface

The SK7100 interfaces with a sensor that has four strain gauges – one on each of the sides. If force is applied precisely in the X direction, it produces a change of resistance of only the two X gauges. Force in the Y direction causes changes only in the Y gauges. One of the pair of gauges increases, while the other decreases in resistance. If the user presses on the sensor from the top (Z axis), all of the strain gauges increases in resistance. When the test current is passed through the gauges, these resistance changes are converted into voltage changes.

The signal conditioning circuit balances and amplifies the incoming signals for digitizing by a built-in A/D converter. Sprintek's circuit can correct a significant imbalance between the gauges in each X and Y pair ($\pm 20\%$), allowing relaxed manufacturing tolerances for the sensors and cabling.

The SK7100 implements Z-Tap feature. The feature allows users to tap on pointing stick to simulate left button click, double click and drag functions. The feature can be enabled by connecting JMP3; otherwise the feature will be disabled at default.

Quick tap – left button click (select)

Quick tap twice – left button double click (execute)

Press and hold – left button down (Start drag); Release – left button up (Release drag)

Quick release – left button click (select). The feature is enabled by driver only.

Button Interface

The SK7100 scans the button status along with the pointing stick sensor sampling.

PS/2 Mouse Interface

The SK7100 has internal 5.6K pull-up resistors on data and clock lines. The SK7100 follows IBM standard PS/2 mouse protocol to communicate with the host. The SK7100 transforms the digitized X, Y data into mouse report format and send it to the host. The SK7100 command protocol is described in the PS/2 communication section in this document.

Power Management

The SK7100 has four power modes: operation mode, idle with Z-Tap mode, idle mode and power down mode. The SK7100 automatically switches the power modes to minimize the power consumption.

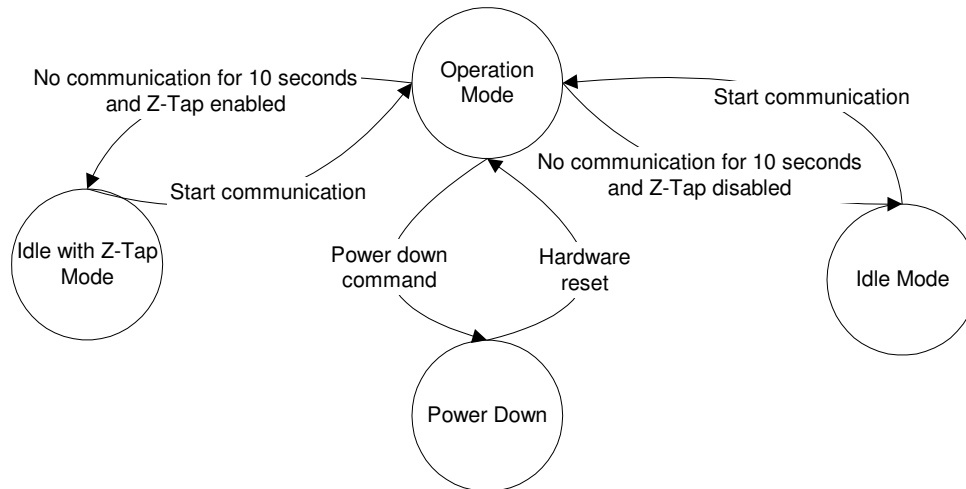
When there is any communication between the SK7100 and host, the SK7100 stays in operation mode. The SK7100 fully runs to get the best performance. The power consumption is about 4.6mA in this mode.

When there is not communication between the SK7100 and host for 10 seconds, and Z-Tap is enabled, the SK7100 switches to idle with Z-Tap mode. In this mode, the SK7100 works like operation mode and

then put itself into sleep for the idle time between samplings. The power consumption is about 1.8mA in this mode.

When there is not communication between the SK7100 and host for 10 seconds, and Z-Tap is disabled, the SK7100 switches to idle mode. In this mode, the SK7100 samples at rate of 1/3 of operation mode and then put itself into sleep for the idle time between samplings. The power consumption is about 650uA in this mode.

When the SK7100 receives power down command "E2, 44", the SK7100 enters power down mode. The only way to put the SK7100 out of from power down mode is a hardware reset. The power consumption is about 3uA in this mode.



Power Mode State Transition Diagram

Power On Reset Circuit

The SK7100 has build-in low voltage detector. The reset threshold is set to 2.92V.

Oscillator Circuit

The SK7100 has build-in oscillator circuit and no external crystal or resonator is needed. The SK7100 includes operation oscillator circuit and sleep oscillator circuit. The operation circuit provides the clock to all internal circuit. The sleep oscillator circuit provides clock to 8-bit timer to wakeup the SK7100 from sleep mode.

8-bit Timer

The 8-bit timer provides the timing control for PS/2 communication, pointing stick sampling, sleep timer wakeup.

PS/2 COMMUNICATION

Power on Reset

At start-up or reset, the SK7100 waits for about 650 milliseconds, and then sends x"AA" to the host, followed by a device ID of x"00". Then the IC sets itself to its default values, i.e. incremental stream mode with 1:1 scaling, and a sampling rate of 100 Hz. The IC then disables itself until a command x"F4" is received from the host.

PS/2 Data Report Format

The list shows the PS/2 report formats. In the data report, each of the two position values (X and Y) is expressed as a 9-bit two's complement integer with the most significant bit (the sign bit) stored separately in byte 1. If there is an overflow of the accumulator, the maximum positive or negative count is reported. The overflow bits are always set to 0.

Byte 1	b0	Left Button status	1 = depressed
	b1	Right Button Status	1 = depressed
	b2	Middle Button Status	1 = depressed
	b3	Reserved Always = 1	
	b4	X8: MSB of X data, sign bit	1 = negative
	b5	Y8: MSB of Y data, sign bit	1 = negative
	b6	Always 0	
	b7	Always 0	
Byte 2	b0	X0: LSB of X data	
	b1	X1	
	b2	X2	
	b3	X3	
	b4	X4	
	b5	X5	
	b6	X6	
	b7	X7	
Byte 3	b0	Y0: LSB of Y data	
	b1	Y1	
	b2	Y2	
	b3	Y3	
	b4	Y4	
	b5	Y5	
	b6	Y6	
	b7	Y7	

PS/2 Error Handling

The SK7100 sends an acknowledge x"FA" for every correct command or parameter received from the host.

The SK7100 issues a Resend request x"FE" after the receipt of an invalid input. If a second invalid input is received after the Resend request, an error code x"FC" is transmitted to the host. Resend and error codes are sent for both commands and parameters. A response from the SK7100 is transmitted within 25 milliseconds. If the SK7100 is in stream mode, the host must disable the SK7100 before issuing a command that requires a response from the SK7100.

Standard PS/2 Commands

The SK7100 implements all standard PS/2 mouse commands.

Reset (x"FF")

The system will issue a "Reset" command to initiate a software reset. The SK7100 controller will set a sampling rate of 100 reports per second, resolution 02, stream mode, disabled, scaling off. The SK7100 controller response will be x"FA" followed by the two byte packet x"AA 00".

Resend (x"FE")

The system can send this command when it detects an error in any transmission from the SK7100 controller. The "Resend" command should be sent following a SK7100 controller packet transmission and before the system enables the interface allowing the next SK7100 controller output. On receipt of "Resend", the SK7100 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 SK7100 controller from the host immediately following a three byte data packet transmission from the SK7100 controller to the host, the SK7100 controller should resend the three byte data packet.

Set Default (x"F6")

Following receipt of this command, the SK7100 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. The SK7100 controller response will be x"FA".

Disbale (x"F5")

When in stream mode, this command disables the initiation of transmissions by the SK7100 controller. While disabled, the SK7100 controller will respond to all other commands. If the SK7100 controller is in stream mode, the host should disable it prior to sending any command that requires a response from the SK7100 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"), and will be effective on return to Stream mode. The SK7100 controller response will be x"FA".

Enable (x"F4")

This command allows the SK7100 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"). The SK7100 controller response will be x"FA".

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"). 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 valid values are x"0A", x"14", x"28", x"3C", x"50", x"64", x"C8". The SK7100 controller response will be x"FA".

The actual sampling rate of SK7100 is always 100 per second. The sensor measurement rate is 100 per second, to maintain proper performance.

Read Device Type (x"F2")

The SK7100 controller will always respond with an x"00" to this command, corresponding to a "mouse-like" device.

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. The SK7100 controller response will be x"FA".

Set Wrap Mode (x"EE")

This command places the SK7100 controller in wrap mode. After transmission of the ACK byte, all data bytes except x"FF" or x"EC" that are sent to the SK7100 controller will be immediately returned by the SK7100 controller (without ACK). The SK7100 controller will remain in the wrap mode until it receives a "Reset Wrap Mode" (x"EC") or "Reset" (x"FF") command.

Reset Wrap Mode (x"EC")

This command resets wrap mode. The SK7100 controller will return to the previous mode of operation after receiving this command. However, if "Set Wrap Mode" is entered after the SK7100 controller has been operating in "Stream Mode", the SK7100 controller will reenter "Stream Mode" disabled after receipt of a "Reset Wrap Mode" command. If the SK7100 controller is not in the wrap mode when this command is received, the command will be acknowledged, but its state will not be affected. The SK7100 controller response will be x"FA".

Read Data (x"EB")

This command requests that the SK7100 controller transmit all the data defined in the data packet format as described in "Data Report". 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. The SK7100 controller response will be x"FA" followed by a three byte packet with the data format as specified in "Data Report".

Set Stream Mode (x"EA")

This command sets the SK7100 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" when there is any activity detected. The SK7100 controller response will be x"FA".

Status Request (x"E9")

When this command is issued by the host, the SK7100 controller will respond with a 3-byte status report as follows:

Byte 1	b0	Right Button Status	1 = depressed
	b1	Middle Button Status	1 = depressed
	b2	Left Button status	1 = depressed
	b3	Reserved Always = 0	
	b4	Scaling	0 = 1:1; 1 = 2:1
	b5	Enable/Disable	0 = Disable; 1 = Enable
	b6	Stream/Remote mode	0 = Stream; 1 = Remote
	b7	Always 0	
Byte 2	Current resolution		
Byte 3	Current sampling rate		

Set Resolution (x"E8,XX")

This command has no effect for the SK7100 controller. The default value is x"02". The SK7100 controller response will be x"FA". Valid values are x"00", x"01", x"02", x"03".

Set Scaling 2:1 (x"E7")

This command has no effect in the SK7100 controller. The SK7100 controller response will be x"FA".

Reset Scaling 1:1 (x"E6")

This command has no effect in the SK7100 controller. The SK7100 controller response will be x"FA".

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 SK7100 controller response will be x"01, 0E".

Extended PS/2 Commands (x"E2")

The SK7100 extends PS/2 mouse commands to support pointing stick specific feature control using command x"E2".

Power Down (x"E2, 44")

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

Power On Reset (x"E2, 7F")

Following the acknowledgment to this command, the controller 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" will be transmitted upon completion.

Read ROM Version (x"E2, 46")

The command is to read ROM version. The SK7100 controller response will be x"3E".

Read Extended Button Status (x"E2, 4B")

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 controller, and the lower 4 bits (bits 3-0) will contain the number of buttons that may be presented to the host. The four valid responses will be x"22", x"23", x"32", x"33". The SK7100 controller response will be x"33".

Force Calibration (x"E2, 51")

This command will perform the whole pointing stick calibration cycle after the acknowledge byte is sent. The cycle will take approximately 600 milliseconds to complete. The SK7100 controller response will be x"FA".

The following commands are used to manipulate the SK7100 internal registers. Refer to the SK7100 internal register table following this section.

Quick Read Register (x"E2, XX")

This command is to read the contents of register "XX". The second byte is from x"00" to x"3F".

Read Register (x"E2, 80, XX")

This command is to read the contents of register "XX". The command is identical to the Quick Read Register command x"E2 XX" for arguments < x"3F".

Write Register (x"E2, 81, XX, YY")

This command is to write byte "YY" to register "XX".

Read Register Block (x"E2, 82, XX")

This command is to read the contents of register "XX" to "XX + 5". The response has 6 bytes and the content in low location is returned first.

Get Register Page Number (x"E2, 83")

This command is to return current register page number. The default page number is 0. The page number will be reset to 0 when the SK7100 receives commands Reset (x"FF") and Set Default (x"F6").

Set Register Page Number (x"E2, 84, XX")

This command is to set current register page to page "XX".

Toggle Register Bits (x"E2, 47, XX, YY")

This command is to toggle specific register bits. Byte three "XX" is the address of the register, in the range of x"00"-x"FF". Byte four is logically exclusive ORed with the current register value.

Internal Register Table in Page 0

Register Index	Bit Position	Description	Default
2C			b00x0000x
	0	Z-Tap enable. The bit is set by hardware configuration at default.	
	1	Unused	
	2	Unused	
	3	Invert X axis	
	4	Invert Y axis	
	5	Invert Z axis. The bit is set by hardware configuration at default.	
	6	Exchange X axis and Y axis	
	7	Unused	
42		0 = map Z-Tap state to left button; others = map Z-Tap state to right button.	00
4A		X and Y output sensitivity factor.	80
58		Drag control	00
	0	1 = drag enable; 0 = drag disable	
	1-7	unused	
5A		Release to select enable. 0xFF = disable; 0x00 = enable.	00
5E		Z time constant	38
90 - FF		SK7100 control and operation registers	

Internal Register Table in Page 1

The page 1 is configuration page. All register read operations will get data from non-volatile memory. All register write operation write data to RAM. Reading register x"C0" in this page leads to load non-volatile memory to RAM; Write register x"C0" in this page leads to write RAM copy to non-volatile memory. After writing register x"C0", a Power on Reset (x"E2, 7F") is required to make new configuration registers (x"06" to x"3F") take effect.

Register Index	Bit Position	Description	Default
00 – 01		Part number	71 00
02		Version	
03		Revision	
04		Manufacture product ID	00
05		Reserved	00
06 – 3F		Configuration registers	
C0		Register read operation = Read x"00" – x"3F" to RAM; Always return x"C0" when read. Register write operation = Write RAM copy to non-volatile memory. The write operation for this register takes about 250ms.	
Others		Reserved	

APPLICATION NOTES

Power Circuit

The reference design uses Torex Semiconductor's LDO XC6204B452 to keep power noise low. You may choose low noise LDOs from any other manufacturers.

Power Supply Voltage

The following table has put 2% tolerance of power supply voltage into consideration.

Power Supply	3.3V – 4.5V	3V – 3.3V	>4.5V
DARNG Setting	Floating	Tied to Ground	Call for support.

Adjust X, Y, Z Sampling Sensitivity

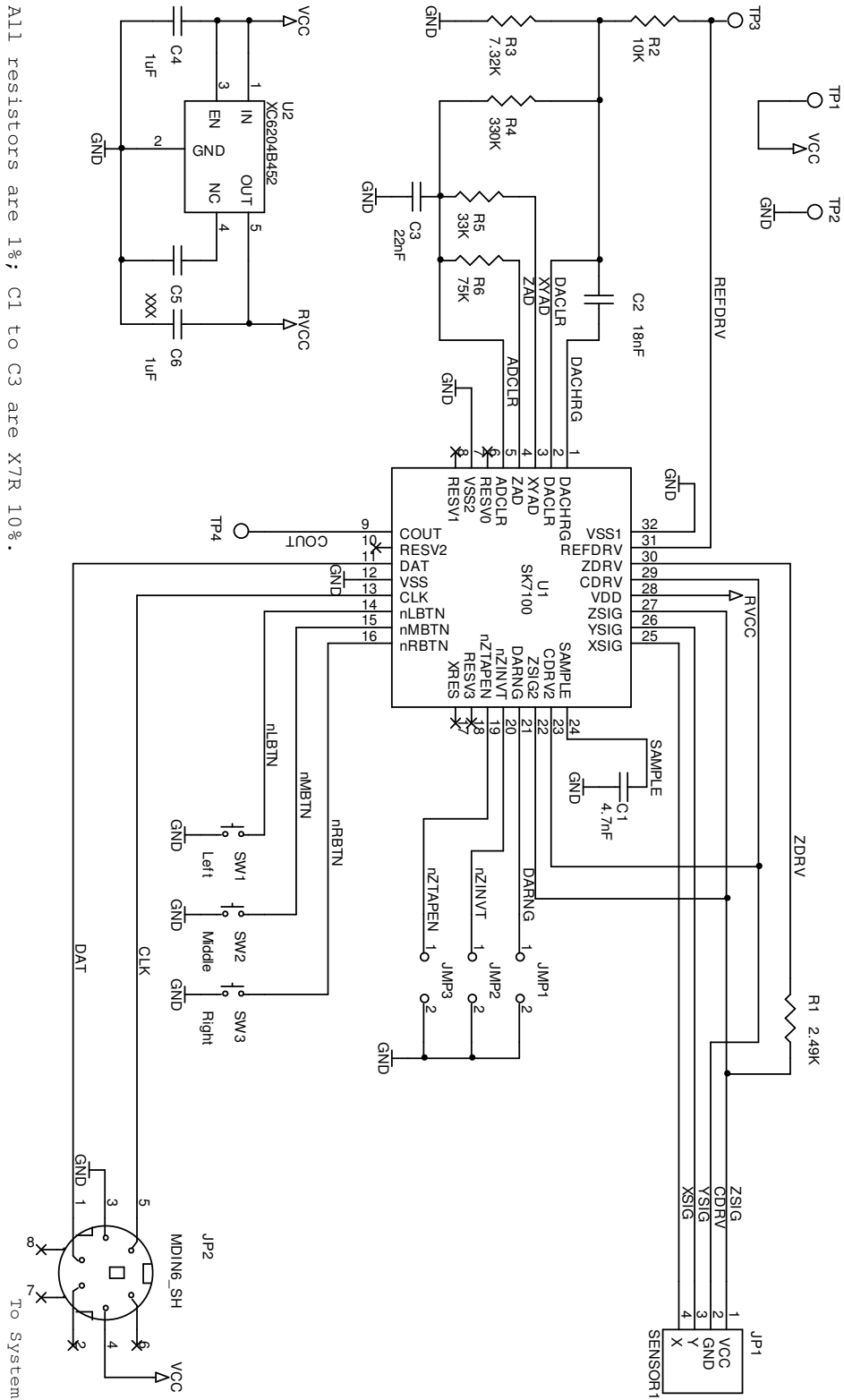
The sampling signal inputs in X, Y and Z can be adjusted through change hardware components R4, R5, R6. Increasing R4 causes bigger signal output in X, Y and Z axis; increasing R5 causes bigger signal output in X and Y axis; increasing R6 causes bigger signal output in Z axis.

C3 shall be X7R 10% or better to reduce the module signal output variance.

Use Different Sensors

The reference design uses a 2.5K ohm sensor. You may use different sensors from any pointing stick manufacturers. Change R1 to the closest value of sensor resistor value; and then follow “adjust X, Y, Z sampling sensitivity” to adjust X, Y and Z outputs. Adjust R4 first and then R5 and R6. For certain sensors, JMP2 need be tied to ground to invert Z input signal.

SCHEMATIC OF REFERENCE DESIGN



All resistors are 1%; C1 to C3 are X7R 10%.

BOM OF REFERENCE DESIGN

Item	Qty	Reference	Description	Manufacturer	Mfr Part Number *
1	1	C1	CAP 4700F 50V CERAMIC X7R 10% 1206	GENERIC	311-1173-1-ND
2	1	C2	CAP 18000PF 50V CERAMIC X7R 1206	GENERIC	311-1202-1-ND
3	1	C3	CAP 22000pF 50V CERAMIC X7R 10% 1206	GENERIC	311-1176-1-ND
4	2	C4, C6	CAP 1.0uF 25V CERAMIC X7R 10% 1206	GENERIC	495-1909-1-ND
5	1	C5	DO NOT POPULATE. May be used for other compatible regulators.	N/A	N/A
6	3	JMP1, JMP2, JMP3	HDR 2 POS 0.1"	N/A	N/A
7	1	JP1	2.5K POINTING STICK SENSOR	**	N/A
8	1	JP2	CONN MINI DIN RECEPT RT ANG 6POS	GENERIC	275-1043-ND
9	1	R1	RES 2.49K OHM 1/4W 1% 1206 SMD	GENERIC	RHM2.49KFCT-ND
10	1	R2	RES 10.0K OHM 1/4W 1% 1206 SMD	GENERIC	RHM10.0KFCT-ND
11	1	R3	RES 7.32K OHM 1/4W 1% 1206 SMD	GENERIC	RHM7.32KFCT-ND
12	1	R4	RES 330K OHM 1/4W 1% 1206 SMD	GENERIC	RHM330KFCT-ND
13	1	R5	RES 33.0K OHM 1/4W 1% 1206 SMD	GENERIC	RHM33.0KFCT-ND
14	1	R6	RES 75.0K OHM 1/4W 1% 1206 SMD	GENERIC	RHM75.0KFCT-ND
15	3	SW1, SW2, SW3	SWITCH TACT 6MM SQ 100GF MOM	GENERIC	SW263CT-ND
16	4	TP1, TP2, TP3, TP4	THRUHOLE TEST POINT	N/A	N/A
17	1	U1	POINTING STICK CONTROLLER, QFN	SPRINTEK	SK7100-LF
18	1	U2	LOW NOISE, LOW DROPOUT 4.5V LDO REGULATOR 2%	TOREX	XC6204B452MR

* If the manufacturer is "GENERIC", the "Mfr Part Number" is Digi-Key part number.

** Please contact us for the complete pointing stick sensor manufacturer list.

ELECTRONICS SPECIFICATION

Absolute Maximum Ratings

Symbol	Description	Min	Typ	Max	Units	Notes
TSTG	Storage Temperature	-55	-	+100	°C	
VDD	Supply Voltage on Relative to VSS	-0.5	-	+6.0	V	
VIO	DC Input Voltage	VSS-0.5	-	VDD+0.5	V	
VIOZ	DC Voltage Applied to Tri-State	VSS-0.5	-	VDD+0.5	V	
IMIO	Maximum Current into any Port Pin	-25	-	+50	mA	
ESD	Electro Static Discharge Voltage	2000	-	-	V	Human Body Model ESD
LU	Latch-up Current	-	-	200	mA	

Operating Temperature

Symbol	Description	Min	Typ	Max	Units	Notes
TOP	Operating Temperature	-40	-	+85	°C	

DC Electrical Characteristics

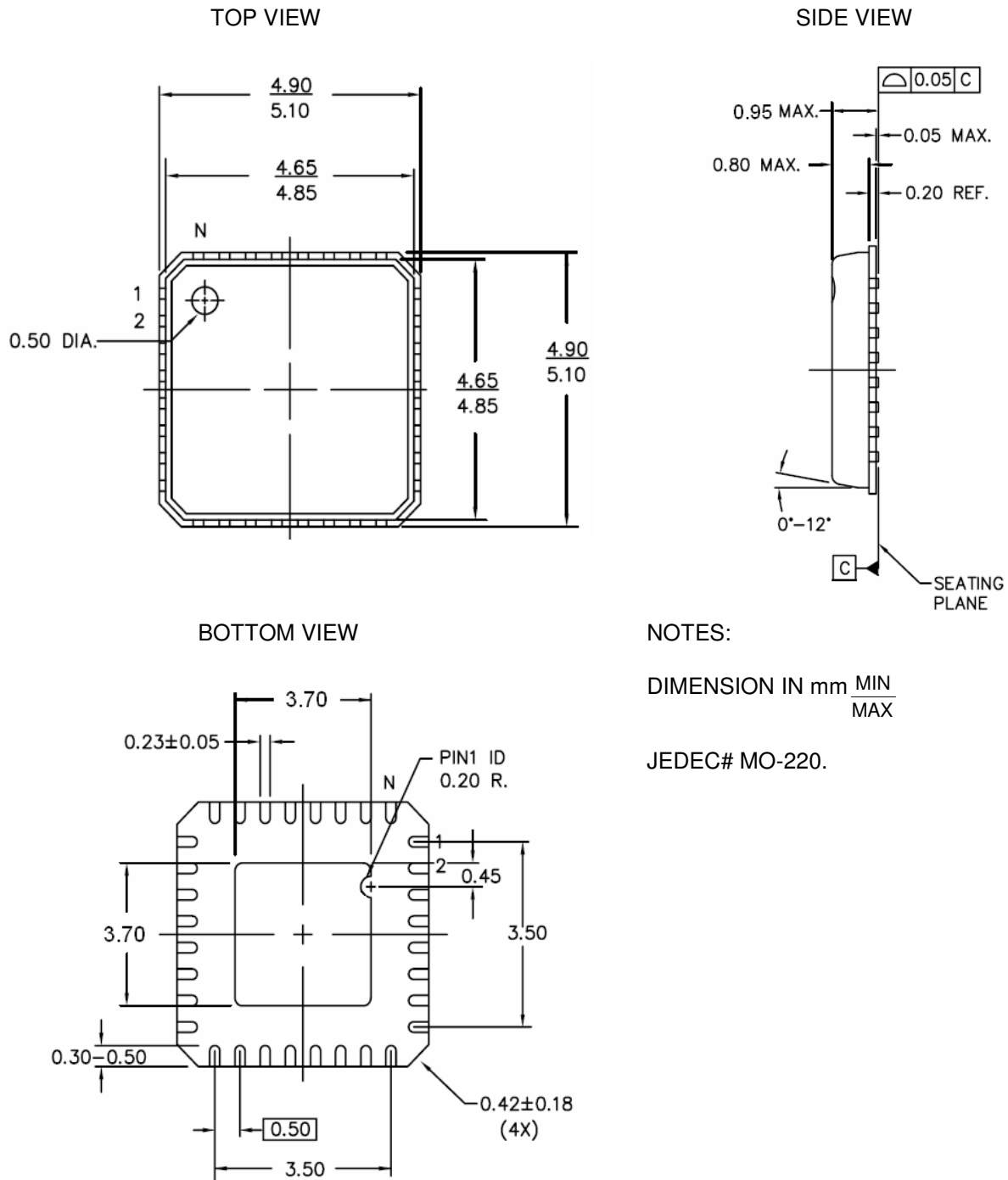
Symbol	Description	Min	Typ	Max	Units	Notes
VDD	Supply Voltage	3.0	-	+5.25	V	
IDD	Supply Current when IC is in operation mode		4.6		mA	
IIDLEZ	Supply Current when IC is in idle mode with Z-Tap enabled		1.8		mA	
IIDLE	Supply Current when IC is in idle mode with Z-Tap disabled		650		uA	
ISD	Supply Current when IC is in power down mode		3		uA	
RPU	Pull-up Resistor	4	5.6	8	kΩ	
VOH	High Output Level	VDD-1.0	-	-	V	
VOL	Low Output Level	-	-	0.75	V	
VIL	Input Low Level	-	-	0.8	V	
VIH	Input High Level	2.1	-	-	V	
VIL	Input Leakage Current (Absolute Value)	-	1	-	nA	
LVD	Low voltage Detection		2.92		V	

Sensor Characteristics

Symbol	Description	Min	Typ	Max	Units	Notes
RS	Each Sensor Resistor Value	0.3	-	10	kΩ	
R1/R2	Matching Ration in X and Y direction	80	-	120	%	
TRS	Tolerance of Each Sensor Resistor	-	-	20	%	

PACKAGING INFORMATION

SK7100-LF Drawing



NOTES:

DIMENSION IN mm $\frac{\text{MIN}}{\text{MAX}}$

JEDEC# MO-220.

SK7100-LF 32-Lead (5x5mm 0.95 MAX) QFN

SALE AND SERVICE INFORMATION

To obtain information about Sprintek Corporation or pointing stick controller family sales and technical support, reference the following information.

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REVISION HISTORY

Revision	Issue Date	Description
1.00	7/2/2007	Initial Release
1.01	8/10/2007	Minor schematic changes of C2 and R6.