SH1412
Capacitive Touchpad Controller for Notebook Applications

HID & SYSTEM MANAGEMENT PRODUCTS

DESCRIPTION

The SH1412 capacitive touchpad controller uses advanced capacitive position and motion sensing algorithms. Just a few low-tolerance external components are needed.

The touchpad follows the industry standard of using multiple lines to detect the presence of a user's finger. Once a finger is in close proximity to the touchpad, its position is calculated along with its pressure on the touchpad surface. Sophisticated algorithms filter out any noise from the finger, or from other sources, such as cell phones.

The SH1412 appears to the host system as a standard three-button mouse; no special driver is required. If the Semtech driver is used, more advanced functions such as edge motion, gestures, and wheel functionality are available.

Typically consuming less than 4 mA, the SH1412 is ideal for battery-operated systems. PS/2® communication is bidirectional at 10 kbps. The SH1412 returns up to 100 mouse reports per second, and is compatible with the standard two-button mouse protocol and the standard three-button mouse protocol. It implements all commands from and to the system (as defined in the IBM® PS/2 mouse communication protocol).

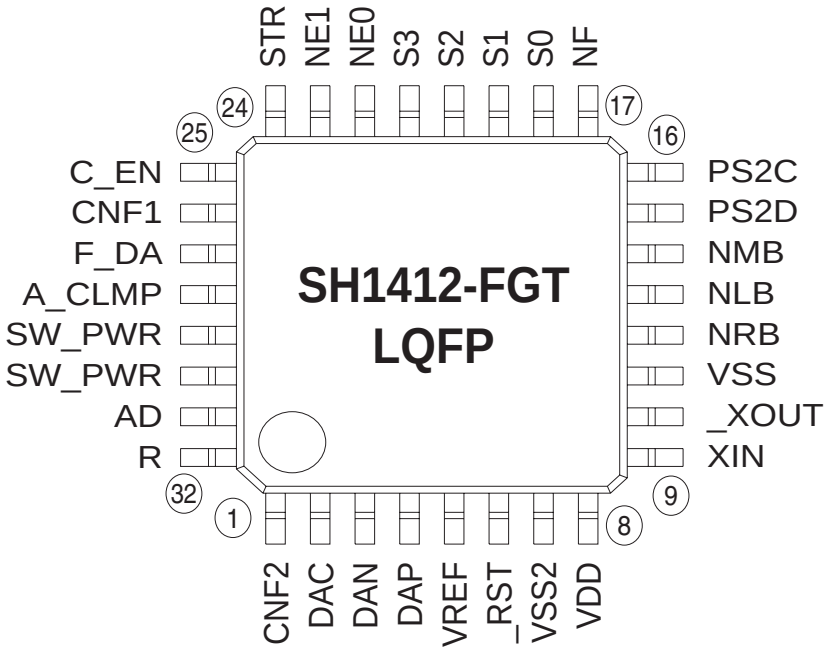
FEATURES

- Light touch and precise control
- Industry-standard PS/2 interface
- Up to 3 buttons for touchpad features
- Full wheel mouse support
- Highly resistant to EMI and RFI noise
- > 500 DPI resolution
- 80 reports per second
- 5 V operating voltage at 4 mA
- Ideal for Chinese character input
- Protected by issued and pending US and international patents
- Low-tolerance components; Y5V capacitors and 5% resistors
- 32-pin LQFP package

APPLICATIONS

- Notebooks/laptops
- Consumer products
- Portable/handheld computers
- Keyboards
- Instrumentation

PIN ASSIGNMENTS

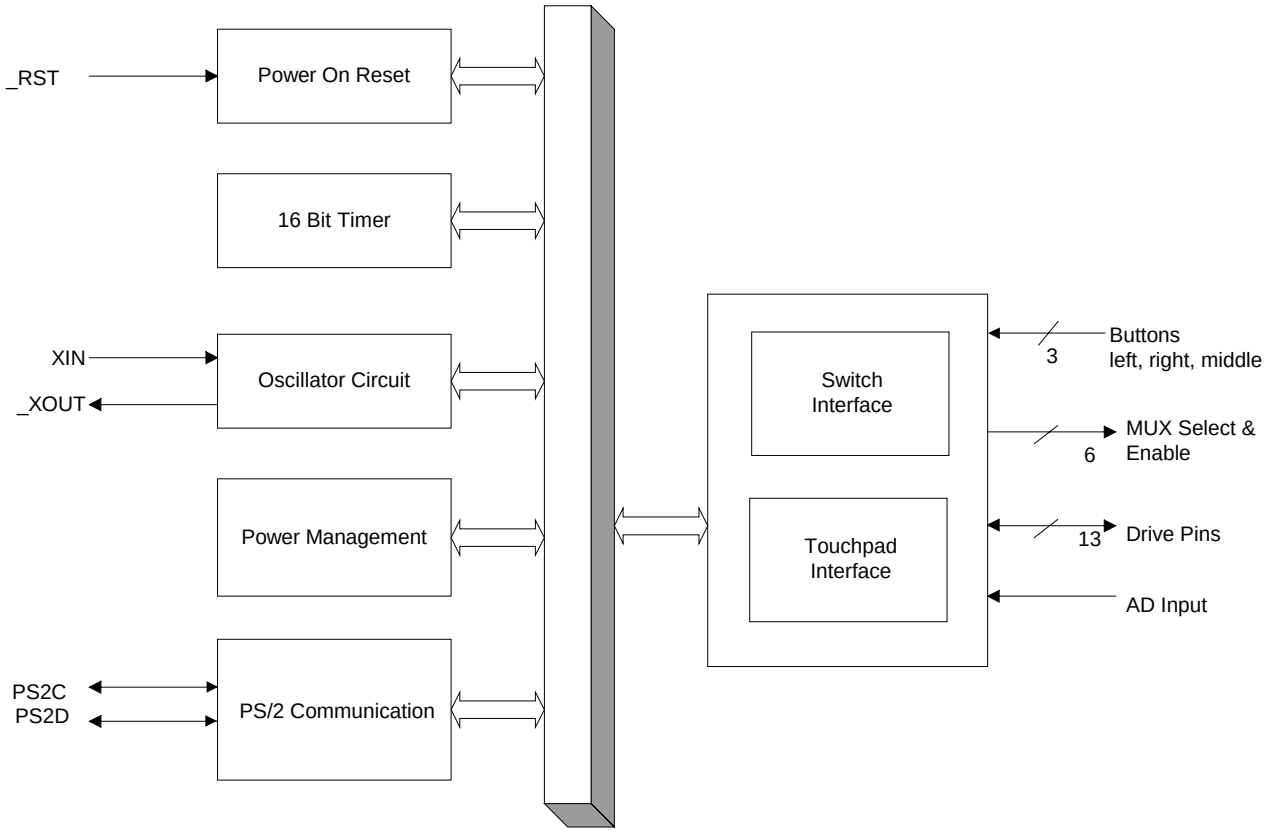


ORDERING CODE

Package Options	Pitch	TA= -20° C to +85° C
32-pin plastic LQFP	0.8 mm	SH1412-FGT Lead (Pb) free; fully RoHS and WEEE compliant

Other Materials	Type	Order number
SH1412 evaluation kit	Evaluation kit	EVK-SH1412

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

The SH1412 consists functionally of the major sections shown in the block diagram on the previous page. These include the touchpad interface, the 16-bit timer, the oscillator circuit, and the host PS/2 communication port. All sections communicate with each other and operate concurrently.

PIN DEFINITIONS

Mnemonic	Pin	Type	Name and Function
VDD	8	P	Power supply: 4.5 V – 5.5 V
VSS	11	P	Ground
VSS2	7	P	Ground
_RST	6	I	Reset: apply 0 V for orderly start-up
_XOUT	10	O	Oscillator output: open for external clock input or one side of the ceramic resonator with built-in load capacitors
XIN	9	I	Oscillator input: external clock input or one side of the ceramic resonator with built-in load capacitors
PS2C	16	I/O (nd)	Host PS/2 clock
PS2D	15	I/O (nd)	Host PS/2 data
SW_PWR	29	O	Switched power: switched power drive
SW_PWR	30	O	Switched power: switched power drive
VREF	5	AI	Reference voltage for built-in A/D
STR	24	O	Start signal for sampling circuit
C_EN	25	O	Clamp enable signal for sampling circuit
F_DA	27	I/O	Fine DA output for sampling circuit
A_CLMP	28	I/O	Analog clamp signal for sampling circuit
AD	31	AI	Analog input from sampling circuit
R	32	I/O	Integration control signal
DAC	2	I/O	DA coarse control to sampling circuit
DAN	3	I/O	DA negative fine control to sampling circuit
DAP	4	I/O	DA positive fine control to sampling circuit
NF	17	O	Force sample reset signal
NMB	14	I/O	Middle button
NLB	13	I/O	Left button
NRB	12	I/O	Right button
NE0	22	O	MUX0 enable signal
NE1	23	O	MUX1 enable signal
S0	18	O	MUX channel select signal 0
S1	19	O	MUX channel select signal 1
S2	20	O	MUX channel select signal 2
S3	21	O	MUX channel select signal 3
CNF1	26	I	Configuration input 1
CNF2	1	I	Configuration input 2

Note: An underscore before a pin/lead mnemonic denotes an active low signal.
Pin Types Legend: AI=Analog Input; I=Input; O=Output; I/O=Input or Output; I/O (nd)=Input or Output with N-channel Open Drain driver

HOST INTERFACE

The SH1412 communicates with the host system using the high-speed PS/2 synchronous interface.

BUILT-IN FEATURES

The SH1412 provides the following built-in functions:

Tap: Select

Double-tap: Execute

Double-tap, holding and dragging on the second tap: Drag

FEATURES WITH DRIVER

EdgeMotion – When pointing motion on the touchpad reaches the edge, the cursor continues to move in the direction it was going

TapZones – Areas on the touchpad can be configured to run programs or execute functions

Wheel Mouse – Areas on the touchpad can be defined to allow wheel mouse operation

POWER CONSUMPTION

The SH1412 typically consumes less than 4 mA. Low power consumption makes it ideal for use in battery-operated systems.

SIGNAL CONDITIONING CIRCUIT

The touchpad interfaces with a PCB-based capacitive sensor matrix. The capacitive sensor consists of 12 horizonal PCB traces (called rows) and 20 vertical PCB traces (called columns). To sample the X position, the SH1412 scans all columns and measures the the capacitance between the column traces and the ground plane. The finger's touching above the column traces adds more capacitance, and the capacitance change is propotional to the distance and touch area between the finger and the column. The SH1412 derives the X position value and pressure value from these capacitance changes. The SH1412 samples the Y position in the same way. The SH1412 samples all columns and rows one by one, and shares the same amplifier circuit by using two 16-to-1 analog mux (multiplexer) chips.

MOUSE EMULATION

The SH1412 emulates a standard 3-button mouse or a standard wheel mouse. When the Semtech driver is installed, an extended set of features are available (see *Capacitive Touchpad User Interface* documentation for more information). The SH1412 module and driver combination is designed to compensate for a variety of tricks and fixes that are typically seen in embedded 8042 keyboard controller chips. These include but are not limited to the following:

(1) Keyboard controllers automatically reconfiguring the PS/2 channels on the fly to 3-byte or 4-byte mode.

(2) Keyboard controllers filtering “non-standard” PS/2 commands, meaning that the “vendor-specific” commands are responded to at the controller level with either 0xFE or 0xFA values.

Every attempt has been made to send custom commands to the SH1412 device by using standard PS/2 commands so that the minimum of keyboard controller interference is seen.

PS2 COMMUNICATION

At start-up or reset, the SH1412 waits between 300 and 500 milliseconds, then sends 0xAA to the host, followed by a device ID of 0x00. Then the SH1412 sets itself to its default values, i.e., incremental stream mode with 1:1 scaling, and a report rate of 100 Hz. The SH1412 then disables itself until it receives a command from the host.

PS/2 LEGACY REPORTS

The adjacent table shows the PS/2 legacy report format. 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 and the corresponding overflow bit is set.

PS/2 ERROR HANDLING

For every correct command or parameter received from the host, the SH1412 sends an acknowledge (0xFA). If an invalid command or parameter is received, the SH1412 issues a resend request (0xFE). If an invalid input is again received, the device transmits an error code (0xFC) 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 SH1412 has responded or 25 milliseconds have elapsed.

PS2 LEGACY DATA REPORT

Byte 1			
	b0	Left button status	1 = depressed
	b1	Right button status	1 = depressed
	b2	Middle button status	1 = depressed
	b3	1	Always = 1
	b4	X8 MSb of X data, sign bit	1 = negative
	b5	Y8 MSb of Y data, sign bit	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	
Byte 3			
	b0	Y0 LSb of Y data	
	b1	Y1	
	b2	Y2	
	b3	Y3	
	b4	Y4	
	b5	Y5	
	b6	Y6	
	b7	Y7	

STANDARD PS/2 STATUS REPORT

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

PS2 EXTENDED

Where the SH1412 really starts to perform is when it is configured in extended function mode. In this mode, all the advanced features of the SH1412 are available, including support for macro regions, sensitivity, and Chinese character recognition. In this mode, the SH1412 reports position data in a 6-byte absolute data report.

The adjacent list shows the PS/2 extended report format for absolute. In the data report, each of the two position values (X and Y) is expressed as a 12-bit integer and the Z bit or pressure value stored as a 7-bit integer value.

To enter this mode, a special sequence of standard commands is sent to the SH1412, which then identifies itself and enters into the extended mode reporting.

The sequence of commands is as follows.

1. Set sampling rate to 80rps (0xF3, 0x50)

2. Set sampling rate to 60rps (0xF3, 0x3C)

3. Set sampling rate to 100rps (0xF3, 0x64)

5. Read device type (0xF2)

If successful, the SH1412 responds with a value of 0x13.

PS2 EXTENDED DATA REPORT (TOUCHPAD)

Byte 1			
	b0	Left button status	1 = depressed
	b1	Right button status	1 = depressed
	b2	Middle button status	1 = depressed
	b3	0	Always = 0
	b4	Y11 MSb of Y data	
	b5	0	Always = 0
	b6	0	Always = 0
	b7	1	Always = 1
Byte 2			
	b0	X7 X data report particle	
	b1	X8 "	
	b2	X9 "	
	b3	X10 "	
	b4	X11 "	
	b5	Y9 Y data report particle	
	b6	Y10 "	
	b7	0	Always = 0
Byte 3			
	b0	X0 LSb of X data	
	b1	X1 X data report particle	
	b2	X2 "	
	b3	X3 "	
	b4	X4 "	
	b5	X5 "	
	b6	X6 "	
	b7	0	Always = 0
Byte 4			
	b0	4th button status	1 = depressed
	b1	5th button status	1 = depressed
	b2	0	Always = 0
	b3	0	Always = 0
	b4	Y7 Y data report particle	
	b5	Y8 "	
	b6	1	Always = 1
	b7	1	Always = 1
Byte 5			
	b0	Y0 LSb of Y data	
	b1	Y1 Y data report particle	
	b2	Y2 "	
	b3	Y3 "	
	b4	Y4 "	
	b5	Y5 "	
	b6	Y6 "	
	b7	0	Always = 0
Byte 4			
	b0	Z0 LSb of Z data	
	b1	Z1 Z data report particle	
	b2	Z2 "	
	b3	Z3 "	
	b4	Z4 "	
	b5	Z5 "	
	b6	Z6 "	
	b7	0	Always = 0

PS/2 MODE COMMANDS

When the reset (0xFF) command is received, the SH1412 sets the following default parameters: Incremental Stream Mode, 1:1 scaling, report rate of 100 Hz, and disabled. It then sends 0xAA to the host followed by a device ID of 0x00.

The host sends the resend last data stream (0xFE) command when the host detects an error in any SH1412 transmission. The device then resends the last output data packet to the host. This transmission occurs after a SH1412 transmission and before the host enables the interface allowing the next SH1412 output.

The set default status (0xF6) command re-initializes the device to its condition at power-up.

The disable (0xF5) command stops the device from transmitting all reports. However, the mode does not change; the SH1412 can still respond to commands. If the disable command is issued while the device is transmitting a report, the SH1412 immediately stops the transmission and disables itself.

The reset echo mode (0xEC) command turns off echo mode.

The set prompt (remote) mode (0xF0) command sets the device to prompt mode. Data values are then reported only in response to a read report (0xEB) command.

If the set echo mode (0xEE) command is received, the SH1412 immediately returns any data bytes it receives except 0xFF or 0xEC.

If the SH1412 is in Incremental Stream Mode, the enable command (0xF4) command allows it to begin data transmission. If the device is in prompt mode, the enable command only updates the internal status of the SH1412.

The SH1412 responds to the set sampling rate (0xF3) command in both stream and prompt modes, but it updates its internal status only if this command is enacted while the device is in the stream mode.

The SH1412 responds to the read device type (0xF2) command with the device ID of 0x00.

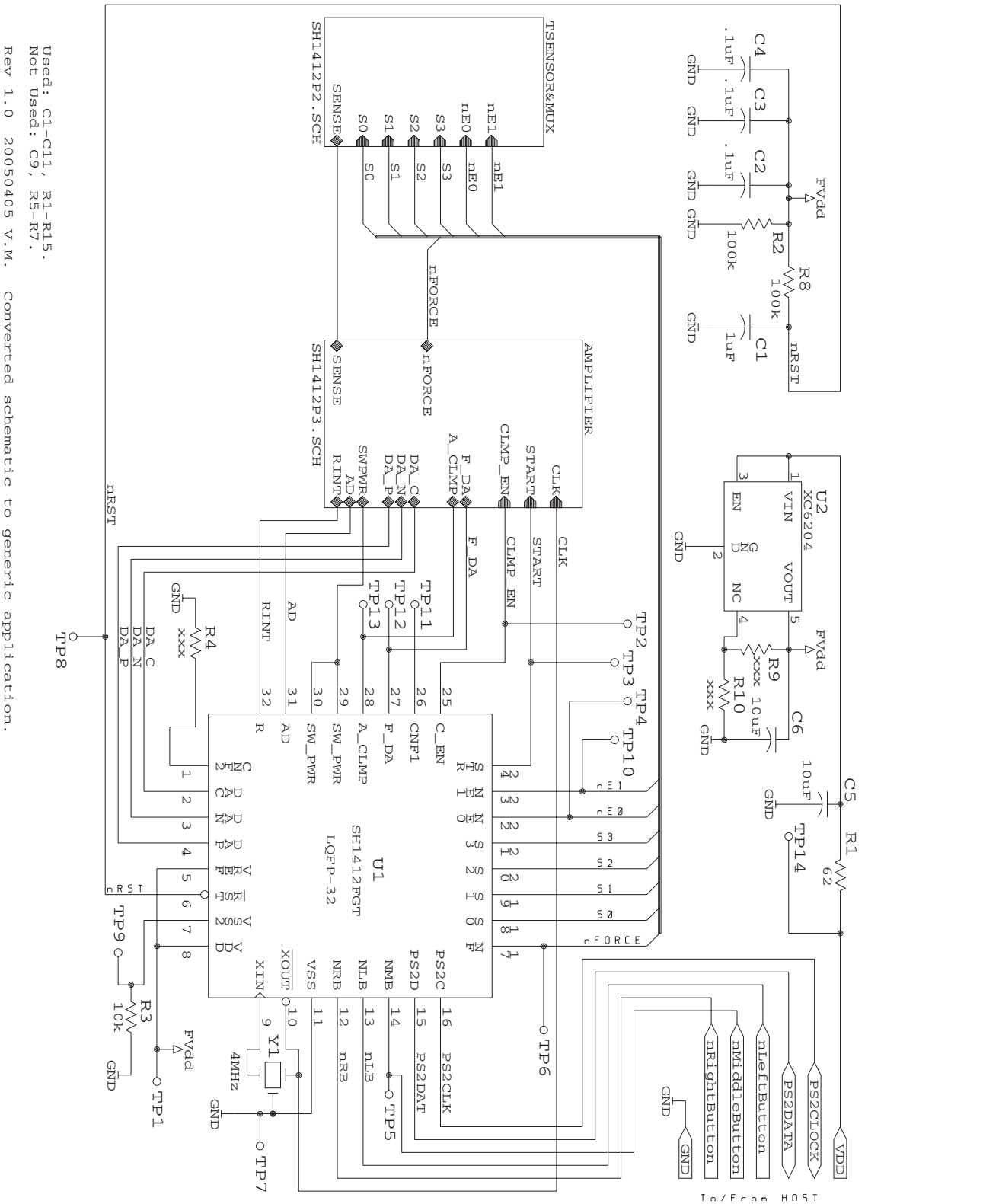
The read report (0xEB) command prompts the SH1412 for a position report. The report occurs even if the device has not moved and the status of the switches did not change.

The set incremental stream mode (0xEA) command sets the SH1412 to stream mode and disables the device.

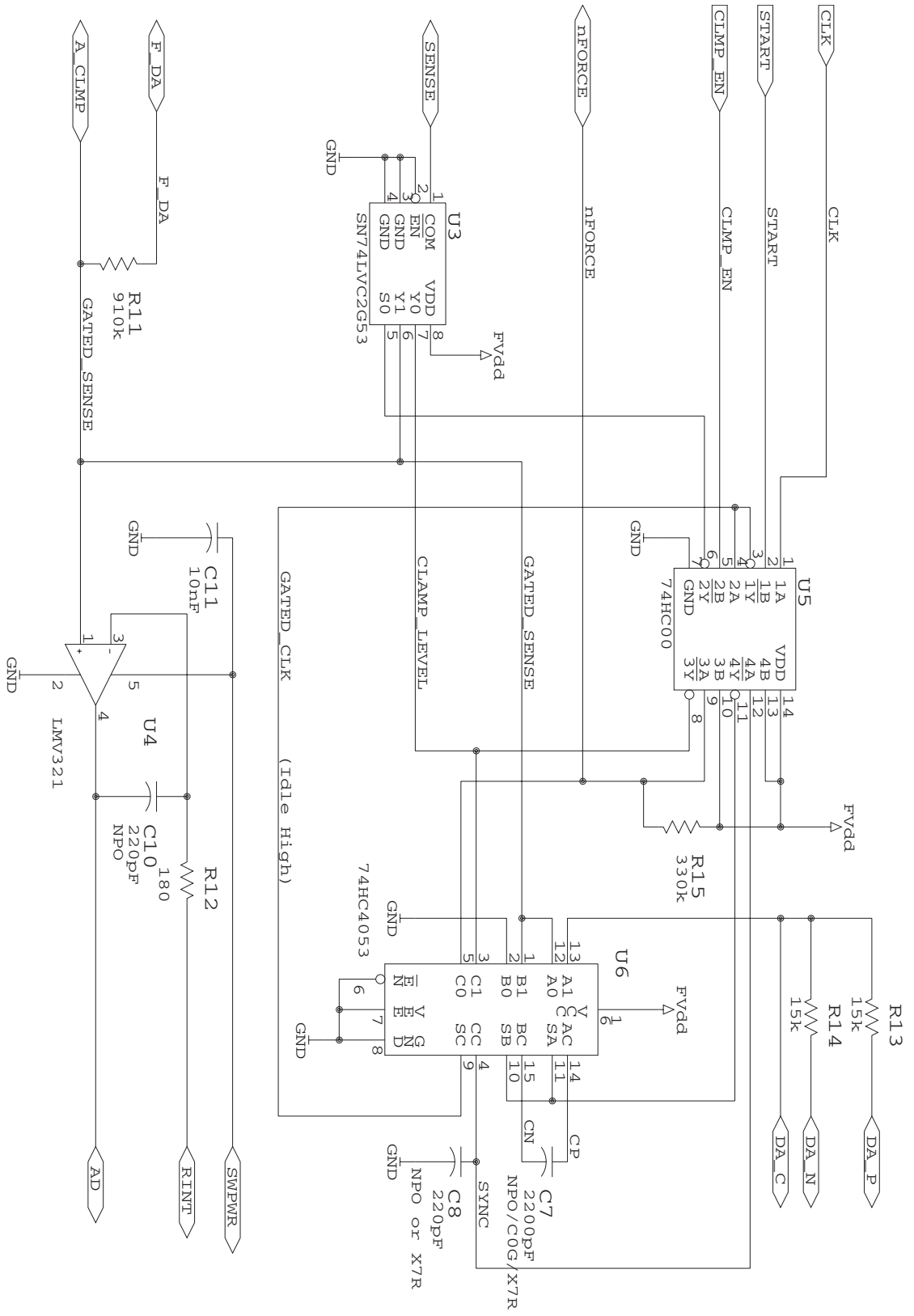
The status request (0xE9) command returns a 3-byte status report.

The set resolution (0xE8) command controls resolution, the set 2:1 scaling (0xE7) command enables a coarse/fine tracking response, and the set 1:1 scaling (0xE6) command enables the values of movements to be transmitted to the host without any scaling. Due to Semtech's advanced motion algorithm, the set resolution and scaling commands are acknowledged and reported as activated, but their status is ignored.

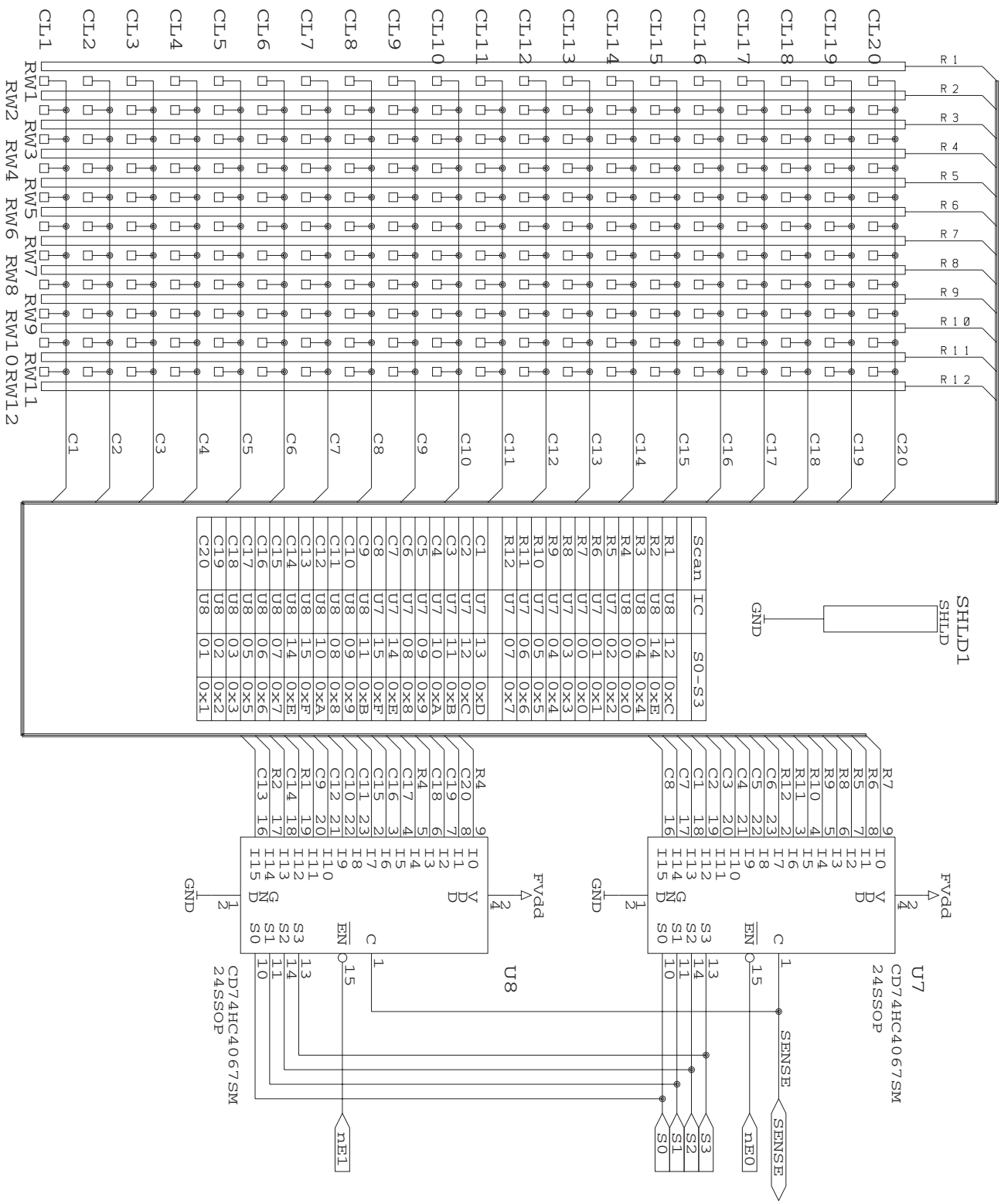
SH1412 APPLICATION CIRCUIT PAGE 1



SH1412 APPLICATION CIRCUIT PAGE 2



SH1412 APPLICATION CIRCUIT PAGE 3



SH1412-FGT BILL OF MATERIALS FOR APPLICATION CIRCUIT

SH1412-FGT BOM

Designator	Description	Value	Tolerance	Package	Mfg.	Mfg. P.N.
Y1	4.00 MHz resonator with caps	4.00 Mhz			Murata	CSTCR4M00G53
U1	SH1412 touchpad controller			LQFP-32	Semtech	SH1412-FGT
U2	MicroPower voltage regulator	4.2-4.5 V		SOT-23-5	Torex	XC6204
U3	Dual analog multiplexer			SSOP-8	TI	SN74LVC2G53DCTR
U4	Single operational amplifier			SOT-23-5	National	LMV321M5X
U5	Quad 2-input NAND gate			TSSOP-14	TI	CD74HC00M96
U6	Triple 2 ch analog multiplexer			TSSOP	TI	CD74HC4053PWR
U7,U8	16 ch analog multiplexer			SSOP-24	TI	CD74HC4067SM96
R1	Chip resistor	62 Ω	± 5%	0402	Generic	
R2,R8	Chip resistor	100 KΩ	± 5%	0402	Generic	
R3	Chip resistor	10 KΩ	± 5%	0402	Generic	
R4	Chip resistor N/U			0402		
R9	Chip resistor N/U			0402		
R10	Chip resistor N/U			0402		
R11	Chip resistor	910 KΩ	± 5%	0402	Generic	
R12	Chip resistor	180 Ω	± 5%	0402	Generic	
R13,R14	Chip resistor	15 KΩ	± 5%	0402	Generic	
R15	Chip resistor	330 KΩ	± 5%	0402	Generic	
C1	Chip capacitor	1 µF	±10%	0603	Generic	
C2,C3,C4	Chip capacitor	0.1 µF	± 10%	0603	Generic	
C5,C6	Chip capacitor	10 µF	+80%/-20%	1206	Generic	
C7	Chip capacitor	2200 pF	NPO or COG	0603	Generic	
C8,C10	Chip capacitor	220 pF	± 5%	0603	Generic	
C11	Chip capacitor	0.01 µF	± 10%	0603	Generic	

Note: Resistors R9 and R10, unused in the application circuit, allow for a variety of voltage regulator ICs to be installed at location U2, utilizing exactly the same PCB footprint.

ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings

Ratings	Symbol	Value	Unit
Supply voltage	V_{DD}	-0.3 to 5.5	V
Input voltage	V_{IN}	V_{SS} - 0.3 to V_{DD} + 0.3	V
Current drain per pin (not including Vss or Vdd)	I	20	mA
Operating temperature SH1412	T_A	T_{LOW} to T_{HIGH} -20 to +85	°C
Storage temperature range	T_{STG}	-40 to +125	°C
ESD rating (human body model)	V_{ESD}	2.0	kV

DC Electrical Characteristics, temperature range = T_{LOW} to T_{HIGH}

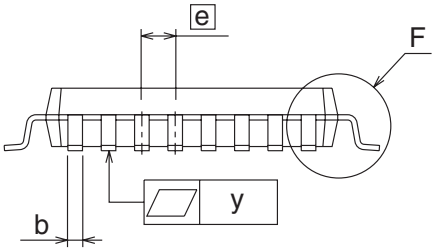
Characteristic	Symbol	Min	Typ	Max	Unit
Supply voltage	Vdd (FVdd)	3.0	4.3	5.5	V
Supply voltage for application circuit*	Vdd	4.5	5.0	5.5	V
Output voltage (10 µA load)	V_{OH}	V_{DD} – 0.1			V
	V_{OL}			0.1	
Input high voltage	V_{IH}	0.8 x V_{DD}		V_{DD}	V
Input low voltage	V_{IL}	V_{SS}		0.2 x V_{DD}	V
Input current	I_{IN}			+/- 10	µA
Supply current (V_{DD}=5.0 V_{DC}+/-10%, V_{SS}=0)	I_{DD}		3.0	6.0	mA

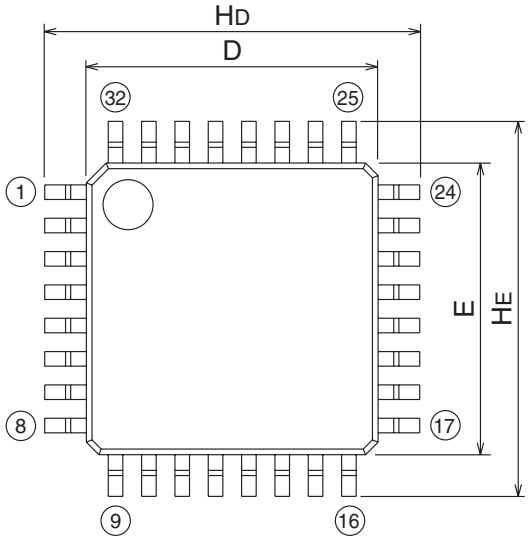
* When used with the recommended voltage regulator U2, having output of 4.2 – 4.3 Vdc and drop-out of less than 200 mV. Variations of this supply voltage due to noise should be completely contained within the indicated range of 4.5 – 5.5 V.

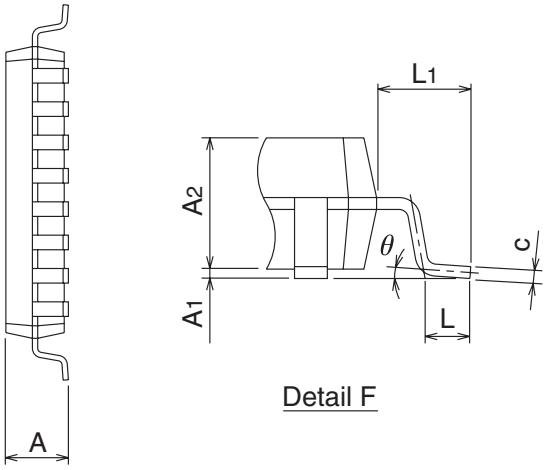
Control timing (V_{DD} = 5.0 V_{DC} +/-10%, V_{SS} = 0 V_{DC}, temperature range = T_{LOW} to T_{HIGH})

Characteristic	Symbol	Min	Typ	Max	Unit
Frequency of operation					
■ Ceramic resonator option	f_{OSC}		4.0		MHz
■ External clock option	f_{OSC}		4.0		MHz

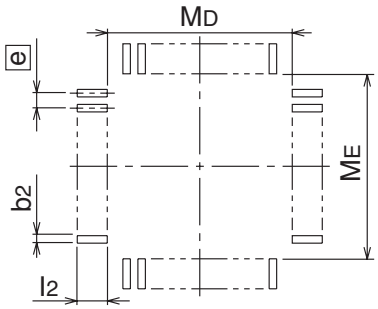
MECHANICAL INFORMATION FOR THE LQFP PACKAGE







Detail F



Recommended PCB Footprint

Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	–	–	1.55
A_1	0	0.1	0.2
A_2	–	1.4	–
b	0.3	0.35	0.45
c	0.105	0.125	0.175
D	6.9	7.0	7.1
E	6.9	7.0	7.1
e	–	0.8	–
H_D	8.8	9.0	9.2
H_E	8.8	9.0	9.2
L	0.3	0.5	0.7
L_1	–	1.0	–
y	–	–	0.1
θ	0°	–	10°
b_2	–	0.5	–
l_2	1.0	–	–
M_D	–	7.4	–
M_E	–	7.4	–

For sales information
and product literature,
contact:

Semtech Corporation
Human Interface Device (HID)
and System Management Division
200 Flynn Road
Camarillo, CA 93012-8790
http://www.semtech.com/
(805)498-2111 Telephone
(805)498-3804 Fax