SEMTECH

ScreenCoder™ UR7HCTS2-S840
High-Performance, Low Power Touch Screen Controller/Digitizer

HID & SYSTEM MANAGEMENT PRODUCTS, MOUSECODER™ FAMILY

DESCRIPTION

The ScreenCoder™ SPI/Serial is a touch screen controller and integrated digitizer IC designed specifically for RISC-based systems, such as wireless Internet appliances. The small, single footprint IC interfaces the system via either the Serial Peripheral Interface (SPI) or Asynchronous Serial Interface.

Unlike simple A/D implementations, the ScreenCoder™ SPI/Serial does not require complicated software drivers and no processing burden is placed on the CPU. Due to the IC's superior data processing and sampling rate, the ScreenCoder™ SPI/Serial is ideal for use in systems requiring handwriting recognition.

Patented-power management techniques are also implemented so that the IC only consumes 1uA of current most of the time, even with the external mouse connected. The IC operates at 3 to 5 Volts.

Features of Semtech's motion algorithm include resistance to RF and other noise which provides smooth and precise motion control. The UR7HCTS2-S840 also works flawlessly with any 4 or 8-wire touch screen, regardless of size or manufacturer.

The cost-effective solution requires few external components, allowing for a simple and real estate saving implementation.

FEATURES

- Touch screen controller / digitizer in a single, small footprint IC
- Interfaces the system via either Serial Peripheral Interface (SPI) and Asynchronous Serial Interface
- Works with any 4- or 8-wire resistive touch screen, regardless of size, material or vendor
- Provides high resolution of 1000 points per axis and a sampling rate of 200Hz
- Accurate, quick touch response due to advanced sampling technology and patented algorithms
- Zero-Power™ operation — IC typically consumes less than 1μA
- Highly resistant to RF and other noise sources
- Uses sophisticated power management for maximum power savings
- Offers external PS/2 port for the hot-plug connection of an external PS/2 pointing device
- Capable of providing other features, such as battery monitoring and GPIO
- PS/2 and USB interfaces available
- Available in small 7mm X 7mm 32-pin LQFP package

APPLICATIONS

- Wireless Internet Appliances
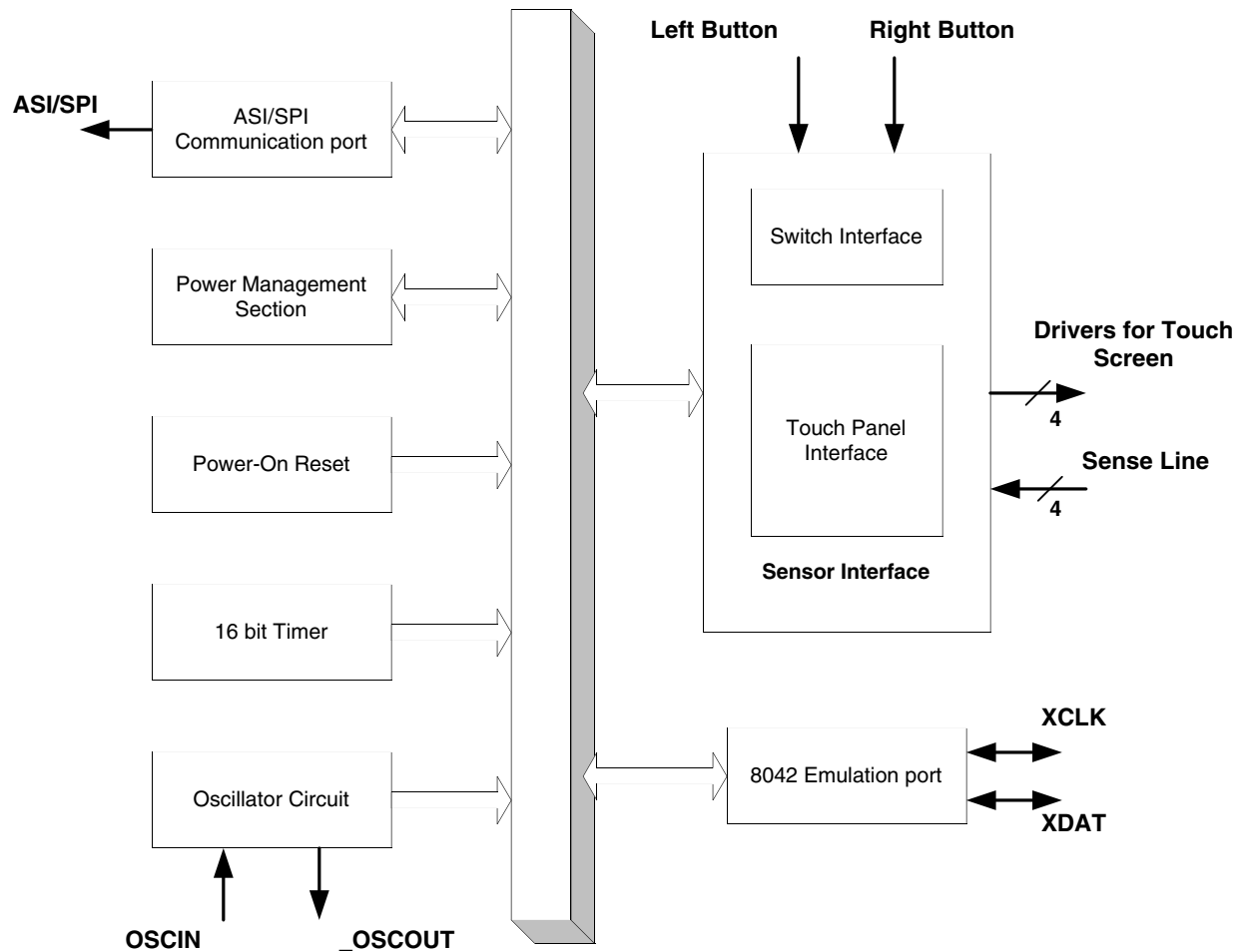- Handheld PCs (H/PCs)
- Web Phones
- Portable Systems

PIN ASSIGNMENTS
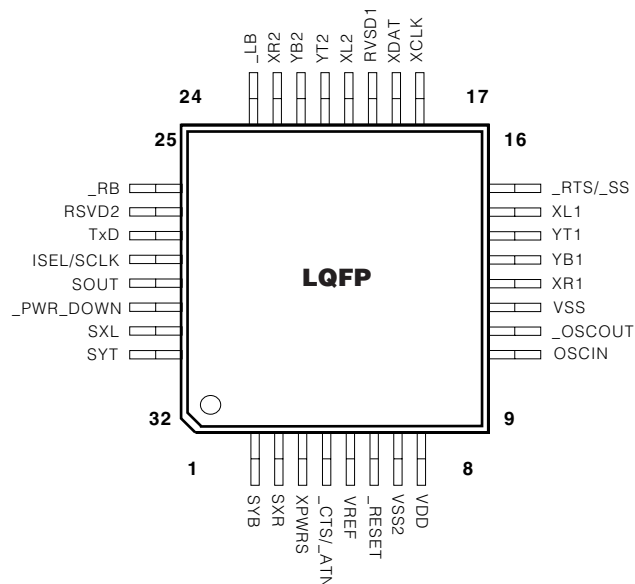
ORDERING CODE

Package Options	Pitch in mm's	TA=-20° C to +85° C
32-pin, Plastic LQFP	0.8	UR7HCTS2-S840-FG

Other Materials	Type	Order number
ScreenCoder™ SPI/Serial	Evaluation Kit	EVK7-TS2-S840-XXX

Note 1: XXX= Denotes Revision number

BLOCK DIAGRAM

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PIN DEFINITIONS

Mnemonic	Pin #	Type	Name and Function
VDD	8	P	**Power Supply**
VSS	11	P	**Ground**
VSS2	7	P	**Ground**
OSCIN	9	I	**Oscillator Input:** external clock input or one side of the Ceramic Resonator with built-in Load Capacitors
_OSCOUT	10	O	**Oscillator Output:** open for external clock input or other side of the Ceramic Resonator with built-in Load Capacitors
_RESET	6	I	**Reset:** apply 0V to provide orderly start-up
XCLK	17	I/O (nd)	**External Mouse Clock:** PS/2 clock signal from external mouse; keep open if unused
XDAT	18	I/O (nd)	**External Mouse Data:** PS/2 data signal from external mouse; keep open if unused
_LB	24	I/O (nd)	**Left Button:** active low
_RB	25	I/O (nd)	**Right Button:** active low
XR1, XR2	12, 23	I/O	**Sensor's Excitation Driver:** connect to X Right
YB1, YB2	13, 22	I/O	**Sensor's Excitation Driver:** connect to Y Bottom
YT1, YT1	14, 21	I/O	**Sensor's Excitation Driver:** connect to Y Top
XL1, XL2	15, 20	I/O	**Sensor's Excitation Driver:** connect to X Left
VREF	5	AI	**Reference Voltage** for built-in A/D
SXL	31	AI	**Sense line:** for X Left
SYT	32	AI	**Sense line:** for Y Top
SYB	1	AI	**Sense line:** for Y Bottom
SXR	2	AI	**Sense line:** for X Right
_PWR_DOWN	30	I	**Hardware Power Down:** tie high if unused
XPWRS	3	AI	**External Mouse Power Sense:** connect to switched power plane for the external pointing device or tie high if external mouse port is used; tie low if external mouse port is unused
_SS/_RTS	16	I	**Slave Select / Ready To Send:** active low, host ready to get data
_ATN/_CTS	4	O	**Attention / Clear To Send:** active low, request data transfer
TXD	27	O	**Data Output:** Serial mode
SCLK/ISEL	28	I	**Interface Select / SPI Clock**: tie low for Serial
SOUT	29	I/O	**Data Output:** SPI mode
RSVD1-2	19,26	I/O	**Reserved:** Keep open

Note: An underscore before a pin 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

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FUNCTIONAL DESCRIPTION

The UR7HCTS2-S840 consists functionally of five major sections (see the Functional Diagram). These are the Sensor Interface, Power Management section, the 16-Bit Timer, the Oscillator Circuit and the Serial Peripheral Interface (SPI) and the Asynchronous Serial Interface (Serial). All sections communication with each other and operate concurrently.

OSCILLATOR

This IC has a built-in Oscillator circuit capable of operations with an external 4.00 MHz Clock source, or a Ceramic Resonator (preferably with built-in Load Capacitors). Note, that the Crystals can NOT be used. The ScreenCoder™ SPI/Serial frequently switches its Oscillator OFF and ON in order to operate with the least amount of power consumption. Due to very high Q, the Crystal-based oscillators have exceedingly long Start-up time and can not be used with the ScreenCoder™ SPI/Serial .

EXTERNAL PS/2 INTERFACE

There is one external PS/2 port for the connection of standard PS/2 devices, including a Microsoft WheelMouse or 5-Button Mouse. The mouse motion data is sent out in relative format. The external PS/2 port also supports hot-plug; users can connect the mouse to the system at any time without rebooting.
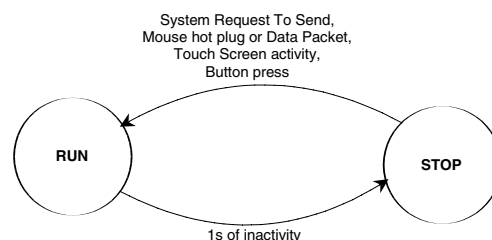
POWER MANAGEMENT

The ScreenCoder™ SPI/Serial implements two power management methods: Self-Power Management™ and System-coordinated Power Management.

Self-Power Management™

Self-Power Management™ is a method implemented by the IC that, independently of any system intervention, results in the lowest power consumption possible within the present parameters of its operation. Through Self-Power Management™, the IC is capable of typically operating at only 1uA, independently of the state of the Host system. Self-Power Management™ primarily determines the actual power consumption of the IC. When the host is in the active state, the IC can still operate most of the time at only 1uA, even when an active external PS/2 device is attached to it.

Self-Power Management™ offers three modes of operation: Stop, Run and Wait. "Stop" mode is the lowest power consumption mode. In this mode, the oscillator is stopped and the IC consumes only the leakage current. This is the default mode to which the IC will revert when it is idle.   "Wait" mode is entered when the IC is waiting for a response or continuation of data stream from the PS/2 device. The duration of wait mode is limited to 40ms, within which time the IC will either receive new data from the PS/2 device or enter "Stop" mode. Typical power consumption in this mode is several hundred uAs. "Run" mode is entered briefly, only to process an event. The IC will only remain in this mode when there are pending tasks, such as PS/2 report reception or initialization of the PS/2 device.

Figure 1: Self-Power Management™ State

System Request To Send,
Mouse hot plug or Data Packet,
Touch Screen activity,
Button press

RUN

STOP

1s of inactivity

System-coordinated Power Management

Normal Operation State:

In normal operation state, both the _PWR_DOWN and XPWRS pins are in high state. The ScreenCoder™ SPI/Serial operations are controlled by Self-Power Management™.

Critical Suspend:

At any time, the Host may negate the _PWR_DOWN pin in order to force the ScreenCoder™ SPI/Serial into a "critical suspend" mode. This signal can be activated (driven low) due to specific conditions of the Host's operations (for example, a discharged battery), or due to actions of the Operating System or BIOS.

During the "critical suspend", the ScreenCoder™ SPI/Serial will shut down all of the pointing activities.

External PS/2 power down:

The ScreenCoder™ SPI/Serial monitors the state of the power supply rail for the external PS/2 pointing device through the XPWRS pin. If the IC senses that the external PS/2 device has been powered-down by the host, it will actively eliminate shot-through current in the input buffers for the clock and data lines by driving both low.

The ScreenCoder™ SPI/Serial will re-initialize the external PS/2 pointing device when the power to the external PS/2 port is restored.

Figure 2: System-coordinated Power Management
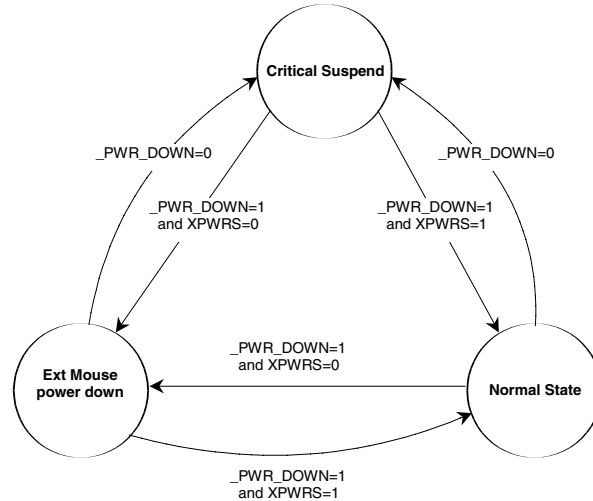
TOUCH SCREEN SENSOR INTERFACE

The ScreenCoder™ SPI/Serial can acquire data from any four- or eight-wire resistive touch screen sensors. The sensor interface has the following features:

Touch detection

The IC periodically checks touch pressure applied to the panel. If there is no touch, the IC will not perform measurements and will not send data to system. When touch pressure is detected, the IC further qualifies and determines the amount of pressure. Semtech's proprietary, patent-pending touch detection algorithm performs this test very quickly, accommodating sensors with various plate-to-plate capacitances.

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Touch Measurement

Position information is only collected if it has been determined that the touch pressure is sufficient for an accurate reading. To obtain position information from the Resistive Touch Screen Sensor, the ScreenCoder™ SPI/Serial uses four internal drivers (two pins for each driver) and four sense lines. During sampling, the drivers of the X-axis are activated by setting one X-drive high and the other X-drive low. The drivers for Y-axis are set floating. This action produces a voltage gradient across the touch screen's surface in the X direction. The internal A/D measures both the voltage across the activated X-plane and the voltage potential between the planes. Next, the drivers for the Y-axis are activated while the drivers for X-axis are set floating. Again, the internal A/D measures both voltage across the activated plane and potential between the planes. The X and Y absolute position is obtained from these four A/D measurements. The IC keeps measuring the touch pressure even while the positioning data is acquired. If insufficient touch pressure is detected during sampling of the position, the current data set will be rejected.

Touch algorithm

Due to vibration and electrical noise, the raw data can not be used directly. Internal data processing delivers consistent position accuracy and quick touch response.

Resolution

The ScreenCoder™ SPI/Serial uses a built-in A/D converter to get the touch position. The maximum absolute position resolution is 1000 points per direction. Resolution varies somewhat for different touch screen sensors, due to voltage droop on connecting wires and sensor's mechanical construction.

Touch screen from different makers

Operating parameters for the touch screens from different manufacturers vary depending on the size of the sensor, material it is made from, and mechanical construction. The ScreenCoder™ SPI/Serial takes these properties into account, and adjusts automatically for plate-to-plate capacitance, intrinsic plate resistances, etc.

Touch-screen's coordinates

The zero point for the touchscreen is at the left upper corner. See the diagram to the right.

(0,0)

X

Y

Buttons

The ScreenCoder™ SPI/Serial implements left and right buttons. The buttons information is combined with external mouse's buttons information when it is sent to the system. Typically, the buttons are not used, they are provided as a development aid.

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SERIAL PERIPHERAL INTERFACE (SPI) AND ASYNCHRONOUS SERIAL INTERFACE (SERIAL)

The ScreenCoder™ SPI/Serial supports either Serial Peripheral Interface (SPI) or Asynchronous Serial Interface (Serial) communication based on the power-up setting of the ISEL/SCLK pin. To select the Asynchronous Serial Interface, connect ISCL/SCLK to VSS. For SPI interface, SCLK must idle high.

Data Packet Format for ScreenCoder™ SPI/Serial

The ScreenCoder™ SPI/Serial has two different types of mouse packages. One type is for absolute position data from the touch screen sensor and one is for relative data from the external PS/2 device.

For both the Relative and Absolute mode package format, each packet contains 4 bytes. The 7th bit of each byte is used for synchronization. The 7th bit for the first byte is 1 and for the other bytes is 0. The resolution for absolute position is 10 bits (approximately 1000 points in X and Y directions.) The relative mouse data format supports operations with WheelMouse and 5-button mice.

Identification and Revision for ScreenCoder™ SPI/Serial

The UR7HCTS2-S840 offers a special identification and revision package. This package uses the absolute mode format, but will not appear in the normal absolute mode. For normal absolute mode, the first byte will be 80 Hex or 9F Hex. This special 4-byte package is identified by the first byte, 81 Hex. This data package is sent upon power-up.

ABSOLUTE MODE PACKAGE FORMAT

	Bit Number							
Byte #	7	6	5	4	3	2	1	0
1	1	0	0	0	0	0	0	0
		Mouse	Absolute	1 penup	1 penup	1 penup	1 penup	1 penup
2	0	Y9	Y8	Y7	X*	X9	X8	X7
3	0	X6	X5	X4	X3	X2	X1	X0
4	0	Y6	Y5	Y4	Y3	Y2	Y1	Y0

RELATIVE MODE PACKAGE FORMAT

	Bit Number							
Byte #	7	6	5	4	3	2	1	0
1	1	0	1	Ysign	Xsign	M	R	L
		Mouse	Relative					
2	0	X6	X5	X4	X3	X2	X1	X0
3	0	Y6	Y5	Y4	Y3	Y2	Y1	Y0
4	0	X*	B5	B4	Z3	Z2	Z1	Z0

Note 2: The bits that are marked with X* are reserved for future use. Now the value given is zero.

Note 3: The X / Y data from external mouse is 9 bits. In our report, we truncate it to 8 bits. The reduction is based on the fact that X / Y increments are seldom beyond the range of +127/-128. For mouse data that exceeds this range, the ScreenCoder™ SPI/Serial will give +127/-128.V8-V0: Revision   Hex 40   (Current Revision here)

IDENTIFICATION AND REVISION REPORT PACKAGE FORMAT

	Bit Number							
Byte #	7	6	5	4	3	2	1	0
1	1	0	0	0	0	0	0	1
2	0	F4	V8	V7	C3	C2	C1	C0
3	0	P2	P1	P0	F3	F2	F1	F0
4	0	V6	V5	V4	V3	V2	V1	V0

(See Note 4 below)

Note 4:

C3-C0: Class ID	Hex 7	UR7HC
F4-F0: Family ID	Hex A	TS2
P2-P0: Sub Product Family	Hex 1	S840
V8-V0: Revision	Hex 40	(Current Revision here)

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Baud rate:

The ScreenCoder™ SPI/Serial transmits data at 19200 Baud, using the recommended 4MHz oscillator.

Protocol:

In Serial mode, the ScreenCoder™ SPI/Serial supports transmission in one direction only (IC to Host). The IC starts the transmission to the system when it has mouse/keyboard package pending. The data format is one start bit, 8 data bits, no parity and one stop bit.

1. The ScreenCoder™ SPI/Serial asserts _CTS low to indicate that a packet transfer will start.
2. The Host asserts _RTS low to indicate that it is ready to receive data.
_RTS low means that system can receive data (e.g. UART is operational).
3. The UR7HCTS2-S840 places data on TXD line when it detects the _RTS low.
4. When one package is successfully transmitted, the IC raises _CTS.

Notes on the Protocol:

To assure fast transmission, the system must assert _RTS low as soon as possible. If the system is ready to receive the data, it doesn't have to raise _RTS between packages.

The UR7HCTS2-S840 checks _RTS after every byte transmission. If _RTS returns to high, it means that the transmission was unsuccessful. The IC will raise _CTS to abort the transmission and the entire package will be re-transmitted.

The maximum time of T1 is 10ms. If the system cannot assert _RTS low after 10ms of _CTS low, the IC will raise _CTS to abort the transmission request. After that, the ScreenCoder™ SPI/Serial will try to start the transmission again.
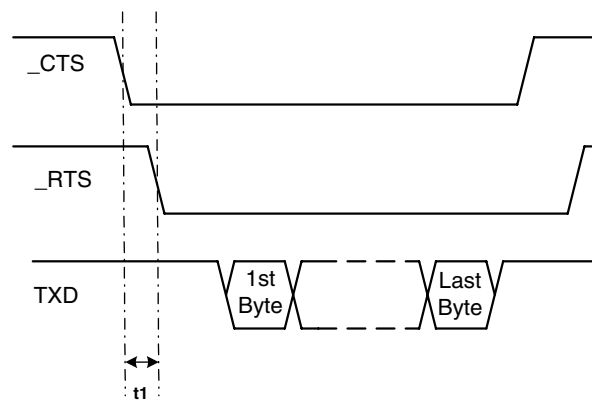

Figure 1: Serial Transmission Timing

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The Serial Peripheral Interface (SPI) is a synchronous bi-directional multi-slave protocol. In SPI mode, the ScreenCoder™ SPI/Serial acts as a slave device. The IC only supports transmission and doesn't support receiving. SPI data transfer can be performed at a maximum clock rate of 500 KHz. The SDATA pin outputs data every time the transfer clock changes from high to low level.

Protocol:

1. The UR7HCTS2-S840 asserts _ATN low to indicate that a mouse packet is waiting for transfer.
2. The Host asserts _SS low to indicate that it is ready to receive data. _SS low means the system selected SPI ScreenCoder™ SPI/Serial as its communication device.
3. On detecting _SS low, the IC enables the SPI interface and places data in the SPI data TX buffer. After a short delay, the system supplies eight clocks to get the data from the IC. The minimum time t2 from _SS low to first SPI clock is 50us.
4. When a byte is transferred successfully, the system has to wait a minimum of 50us to begin the clocks for next byte transmission.
5. When the mouse package is transmitted, the system stops the SPI clock. If it needs to communicate with other SPI devices, it has to wait for _ATN return to high. _ATN high means the SPI port of UR7HCTS2-S840 is now in high Impedance State.
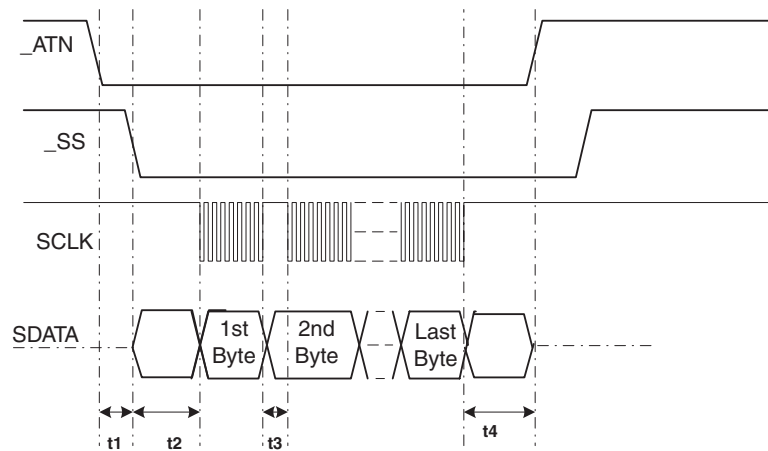
Figure 2: SPI Transmission Timing: (_SS toggles for every package).

Notes on the Protocol:

To assure the fast transmission, system must assert _SS low as soon as possible, see Figure 2. If the system is ready to get data, it doesn't have to raise _SS between packages, see Figure 3.

SPI Communication Timing Parameters

Symbol	Description	Min	Max	Units
t1	_ATN low to _SS low		10	ms
t2	_SS low to first clock (_SS toggles for every package)	50	5000	us
t2'	_ATN low to first clock (_SS low)	50	5000	us
t3	Last clock of transmitted byte to next byte's first clock	50	5000	us
t4	Last byte TX finish to _ATN to high		30	us
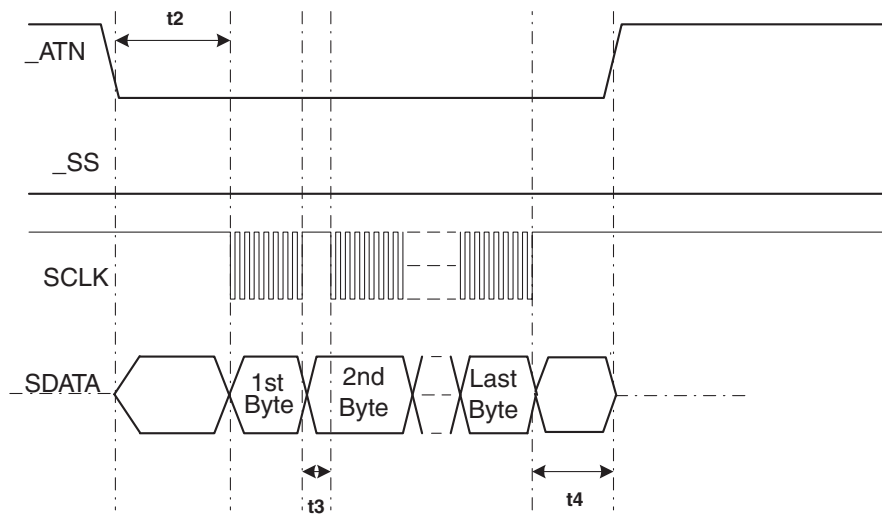
Figure 3: SPI Packet Transmission Timing: (_SS low always).

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ScreenCoder II UR7HCTS2-S840-FG SCI Interface
Document Number UR7HCTS2S820 Rev 0.60 VM
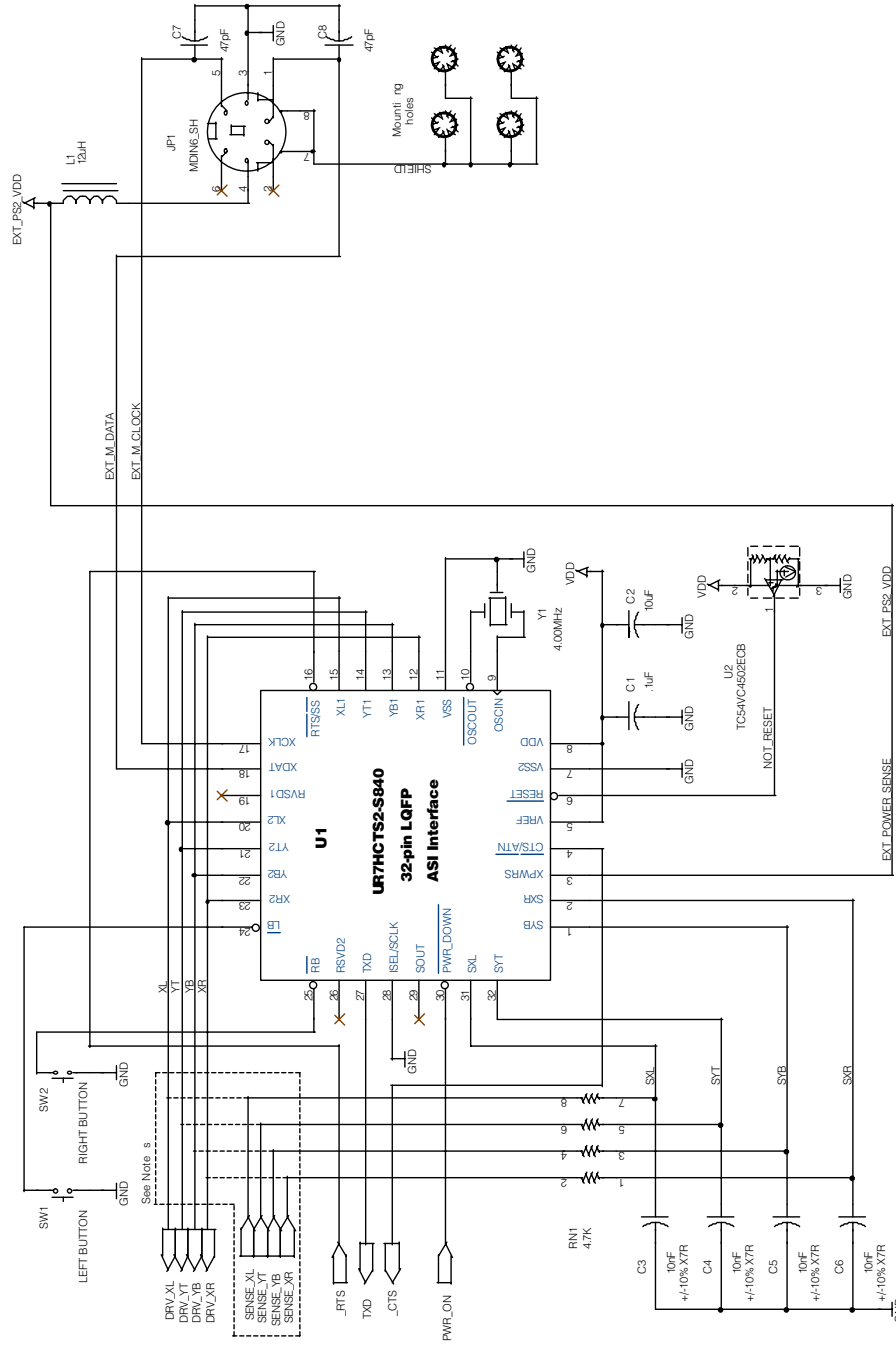
NOTES:

S840 == SCI/SPI Out. 4.00 MHz, 8/4 - wire Model 0.
Connect Drive and Sense lines together for the 4-wire Sensor.
Y1 == 4.00 MHz Ceramic Resonator with Built-in Load Capacitors.
Crystals can NOT be used.
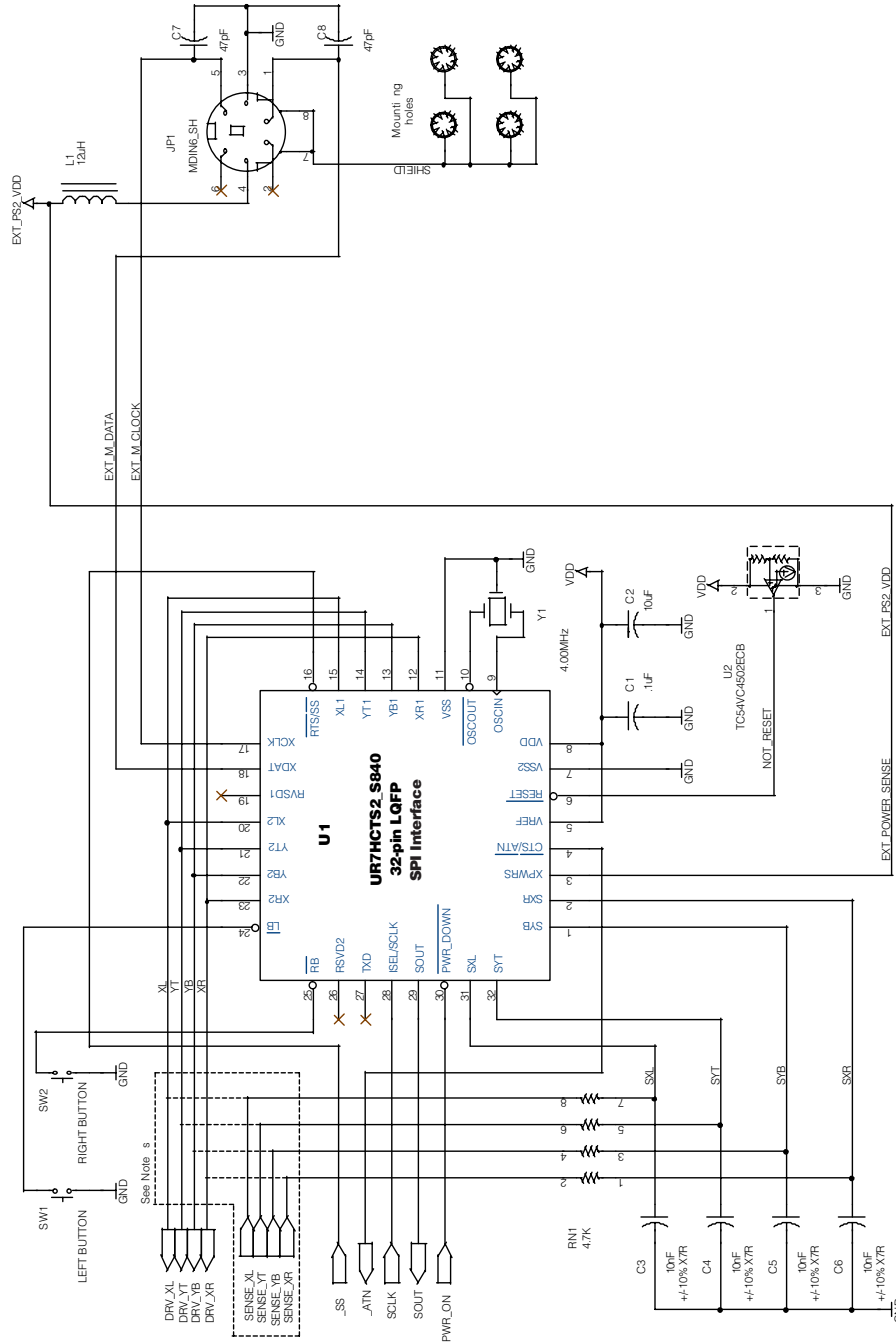
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ScreenCoder II UR7HCTS2-S840-FG SPI Interface
Document Number UR7HCTS2S840.sch Rev 0.60

U1
UR7HCTS2-S840
32-pin LQFP
SPI Interface

NOTES:
S840 == SCI/SPI Out, 4.00 MHz, 8/4- wire, Model0.
Connect Drive and Sense lines together for the 4-wire Sensor.
Y1 == 4.00 MHz Ceramic Resonator with Built-in Load Capacitors.
Crystals can NOT be used.

Detail F

Recommended PCB Footprint

Symbol	Dimension in Millimeters		
	Min	Nom	Max
A	–	–	1.7
A1	0	0.1	0.2
A2	–	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	–
HD	8.8	9.0	9.2
HE	8.8	9.0	9.2
L	0.3	0.5	0.7
L1	–	1.0	–
y	–	–	0.1
θ	0ϒ	–	10ϒ
b2	–	0.5	–
l2	1.0	–	–
MD	–	7.4	–
ME	–	7.4	–

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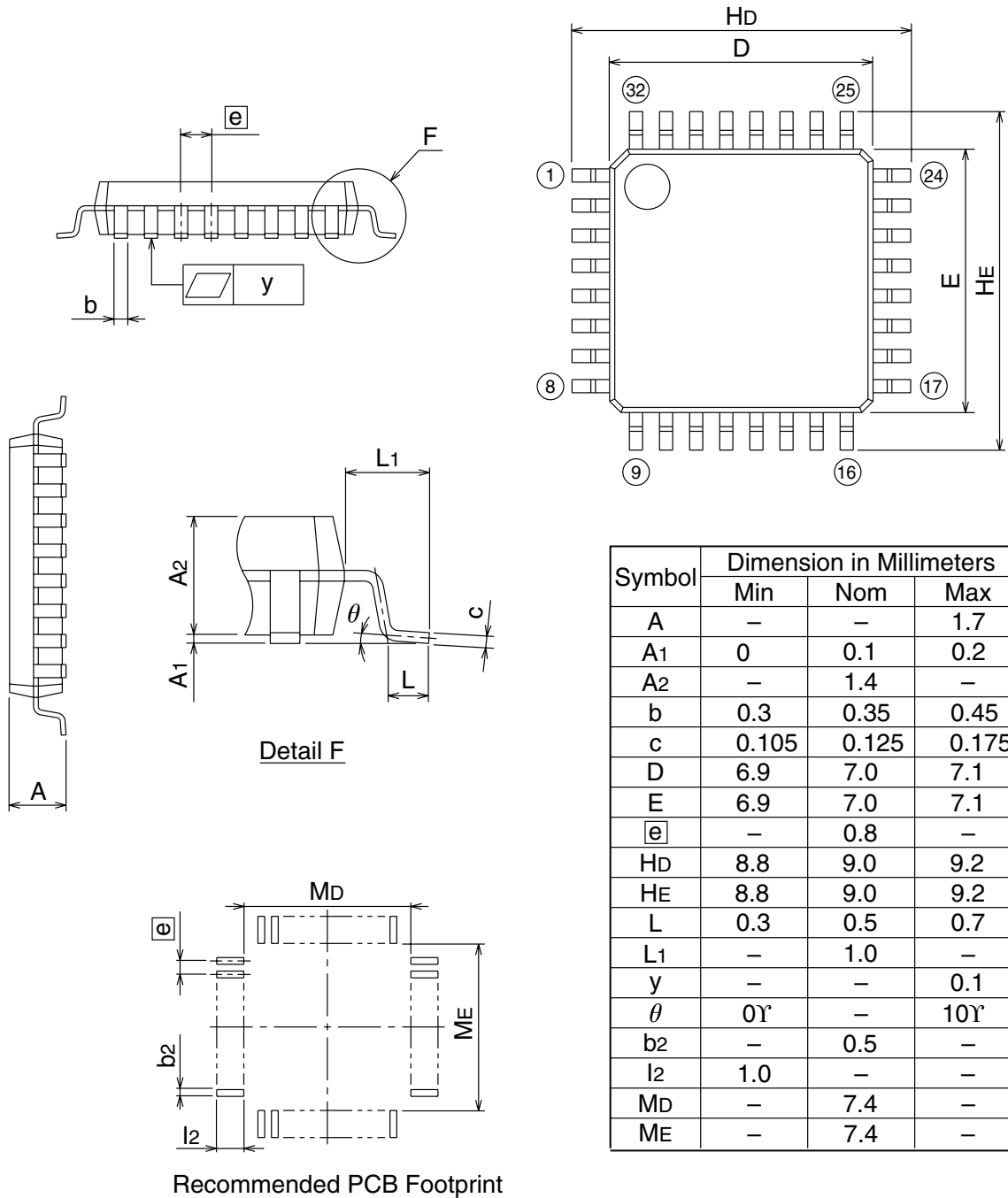
ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings

Ratings	Symbol	Value	Unit
Supply Voltage	Vdd	-0.3 to 7.0	V
Input Voltage	Vin	Vss -0.3 to Vdd +0.3	V
Current Drain per Pin (not including Vss or Vdd)	I	20	mA
Operating Temperature	Ta	T low to T high	° C
UR7HCTS2-S840		-20 to +85	° C
Storage Temperature Range	Tstg	-40 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	5.5	V
Output Voltage (10 µA load)	Voh	Vdd–0.1			V
	Vol			0.1	
Input High Voltage	Vih	0.8 x Vdd		Vdd	V
Input Low Voltage	Vil	Vss		0.2xVdd	V
Input Current	Iin			+/- 10	µA
Supply Current (Vdd=5.0 Vdc+/-10%, Vss=0)	Idd		3.0	TBD	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
■ Ceramic Resonator Option			4.0		
■ External Clock Option			4.0		

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UR7HCTS2-S840-FG BOM

Description	Quantity	Manufacturer	Part#	Description
Bare PCB:				
PCB1	1	USAR	PCB7-TS2-S840-060	SPI/Serial Touchscreen PCB
Capacitor:				
C1, C4	2	Generic	Any	47pF, 10%, Ceramic, X7R or NPO, SMT Size 1206
C2, C3, C7, C8	4	Generic	Any	1uF, 16V, Tantalum Cap, SMT, Size 1206
C5, C10	2	Generic	Any	10uF, 20V, Tantalum Cap, SMT, Size C
C6, C9	2	Generic	Any	.1uF Ceramic Chip Cap, Z5U, SMT, 1206
C11-C14	4	Generic	Any	.01uF, Ceramic Chip Cap, SMT, NPO, or X7R, 1206
Custom IC:				
U1	1	USAR	UR7HCTS2-S840-FG	SPI/Serial ScreenCoder™ Controller
U4	1	USAR	UR6HCASI-S40T-FB	SPI to Serial Test Chip
ICs:				
U2	1	Analog Devices	ADM232LJR	232 Driver_Receiver Chip in SMT
U3, U5	2	TelCom	TC54VC4302EMB	4.3V, Volt Detector, THD, TO-83
Inductor:				
L1	1	Generic	Any	12uH Inductor, SMT, 1210 (3225)
Push Button:				
Left, Right	2	Generic	Any	Switch, 8mm, light touch, THD
Resistor Network:				
RN1	1	CTS	744-083-472J	4.7K, 4 Resistor, 8 terminals, SMT
Resistor:				
R1	1	Generic	Any	4.7K Resistor, 5% Thick Film, SMT, 1206
R2	1	Generic	Any	10K Resistor, 5% Thick Film, SMT, 1206
R3	1	Generic	Any	1M Resistor, 5% Thick Film, SMT, 1206
Resonator:				
Y1, Y2	2	AVX	PBRC-4.00BR	4.00MHz Resonator, SMT

Note: Auxiliary components are not shown.

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