LC717A30UR

Capacitance-Digital-Converter LSI for Electrostatic Capacitive Touch Sensors

The LC717A30UR is a high performance, low cost, and highly usable capacitance converter for electrostatic capacitive touch and proximity sensors.

8 capacitance-sensing input channels ideal for use in any end products that needs an array of switches. The LC717A30UR facilitates a short system development time through its automatic calibration function and minimal external components. The detection result (ON/OFF) for each sensor is read out by the serial interface (I^2C or SPI).

Features

- Differential Capacitive Detection Using Mutual Capacitance
- Operates with Small to Large Capacitance Sensor Input Pads
- Capacitance Detection Down to Femto-Farad Level
- Measurement Time 16 ms for 8 Sensors
- Minimal External Components
- Selectable Interface: I^2C or SPI
- Current Consumption: 0.8 mA (V_{DD} = 5.5 V)
- Supply Voltage: 2.6 V to 5.5 V
- AEC−Q100 Qualified and PPAP Capable

Typical Applications

- Automotive: Smart Key, Control Switches, Car Audio, Proximity
- Consumer: Home Appliance, White Goods, Induction Cooking
- Industrial: Security Lock
- Computing: PC Peripherals, Audio Visual Equipment
- Lighting: Remote Control Switches

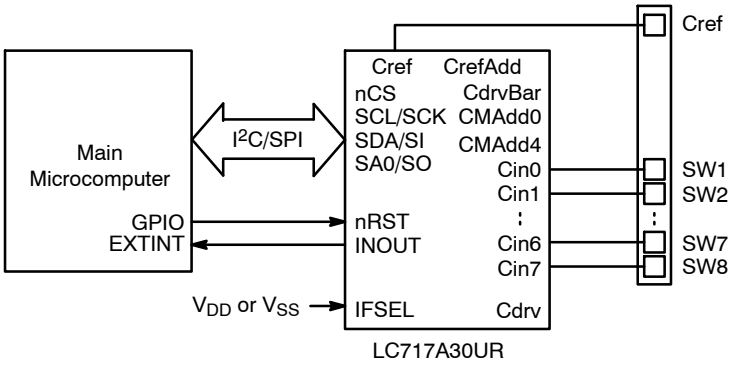
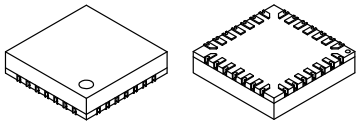


Figure 1. Application Schematic 1

ON Semiconductor®

www.onsemi.com



Top View Bottom View

VCT28 3.5 × 3.5
CASE 601AE

MARKING DIAGRAM



XXXXX = Specific Device Code
Y = Year
M = Month
DDD = Additional Traceability Data

ORDERING INFORMATION

See detailed ordering and shipping information on page 9 of this data sheet.

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8 small capacitance sensors channels and 4-wire SPI interface.

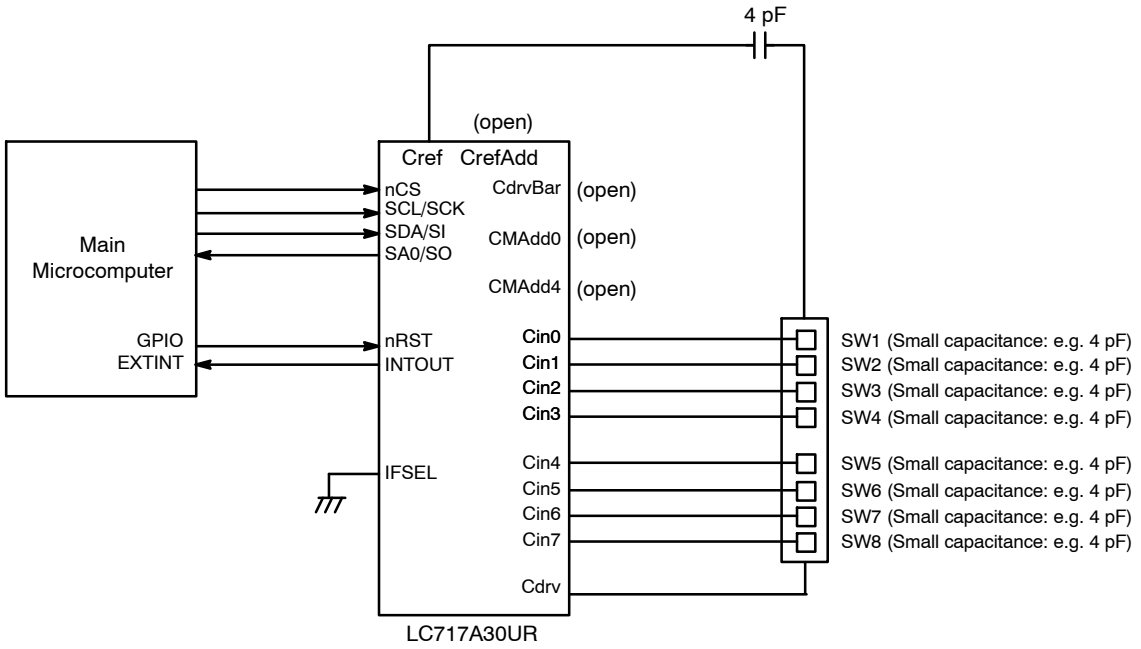


Figure 2. Application Schematic 2

8 large capacitance sensors and I^2C interface.

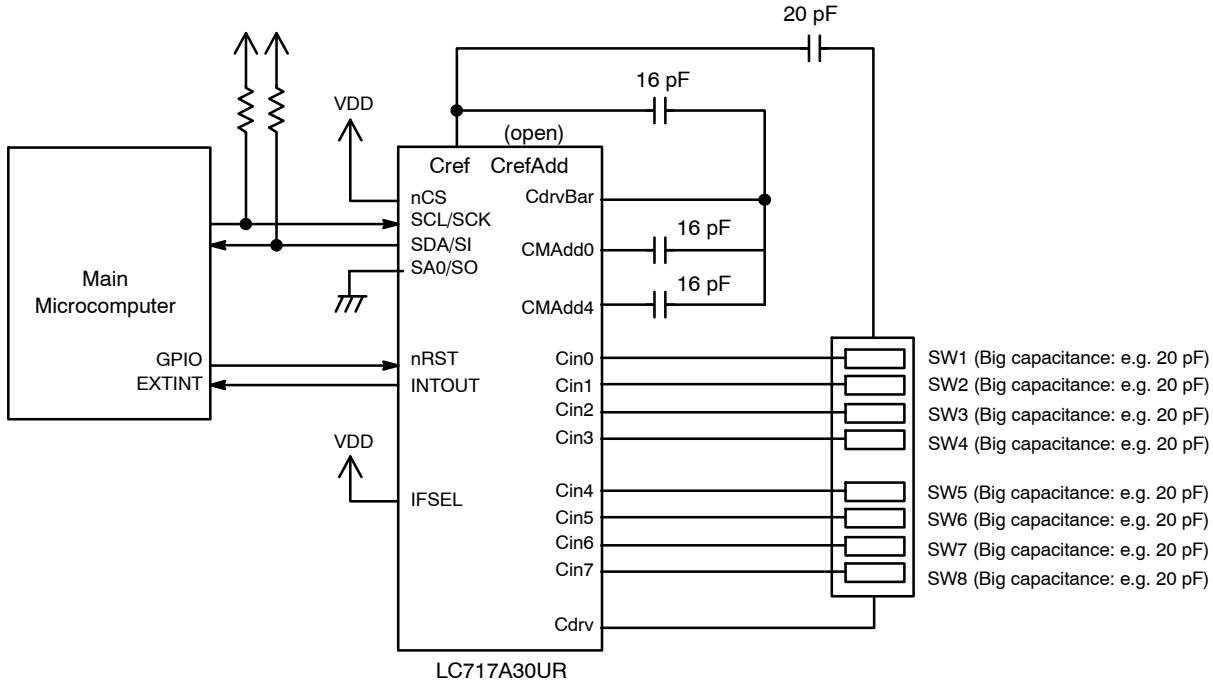


Figure 3. Application Schematic 3

BLOCK DIAGRAM

The LC717A30UR is a capacitance-digital converter LSI that can detect capacitance at the femto farad level. It consists a multiplexer that selects the input channels, a two-stage amplifier that detects the changes in the capacitance and outputs analog-amplitude values, an A/D converter, a system clock, a power-on reset circuit, control logic and interface, I^2C bus or SPI.

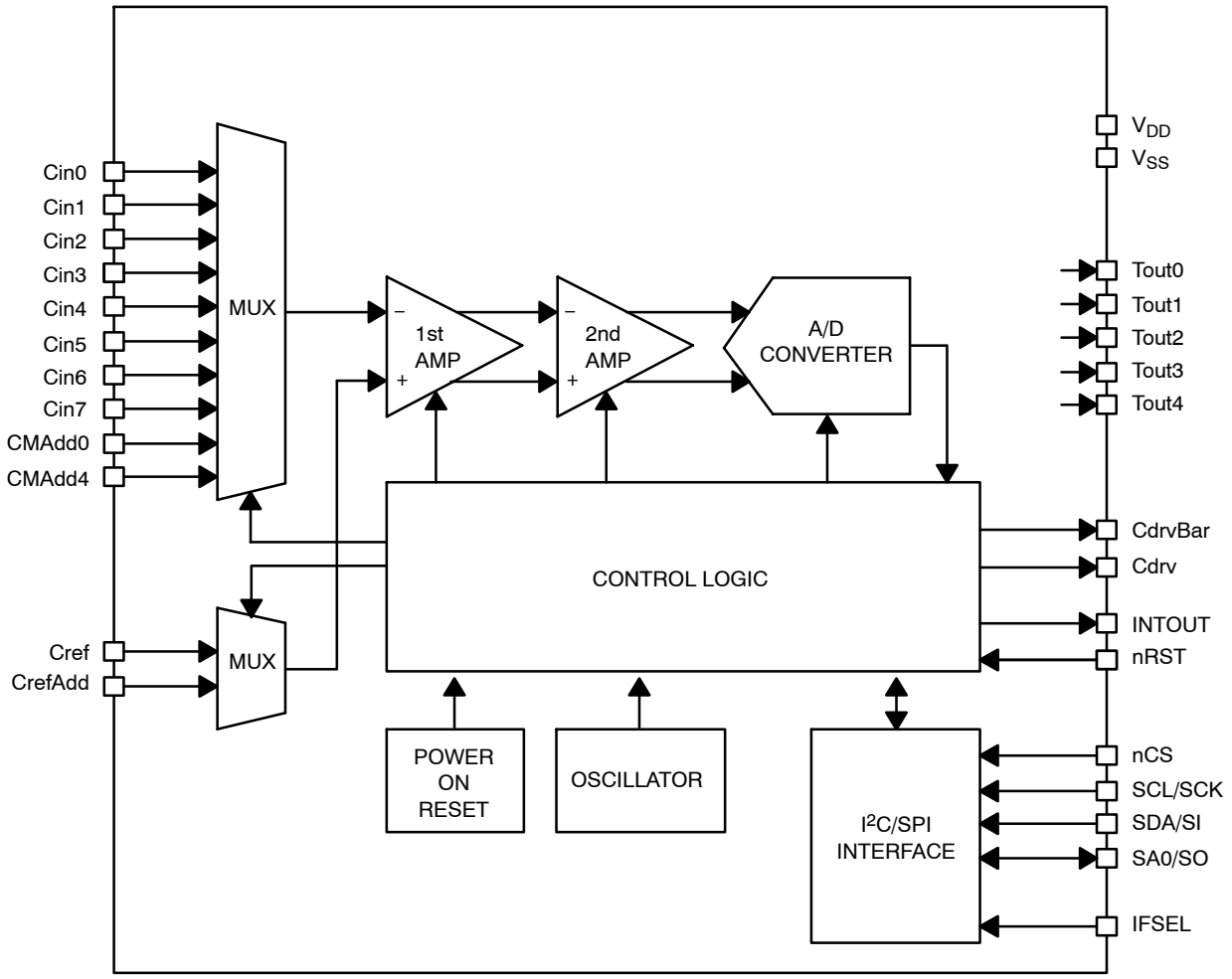


Figure 4. Simplified Block Diagram

PIN ASSIGNMENT

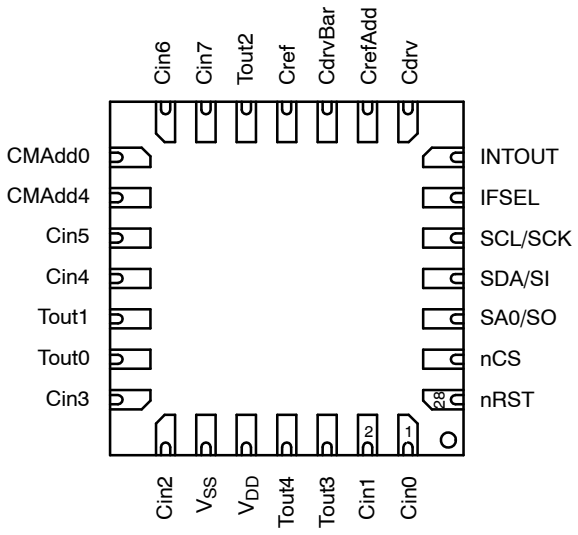


Figure 5. Pin Assignment (Bottom View)

Table 1. PIN ASSIGNMENT

Pin No.	Pin Name	I/O	Description
5	V_{DD}	Power	Power supply (+2.6 V to +5.5 V) (Note 1)
6	V_{SS}	Power	Ground (Notes 1, 2)
1	Cin0	I/O	Sensor inputs. Cin0 to Cin7 are connected to the inverting input of the 1st amplifier through the multiplexer. All unused input pins must remain open. Cdrv and Cin printed circuit board patterns should be close to each other as they are capacitively coupled.
2	Cin1	I/O	
7	Cin2	I/O	
8	Cin3	I/O	
11	Cin4	I/O	
12	Cin5	I/O	
15	Cin6	I/O	
16	Cin7	I/O	
9	Tout0	O	Test pin, must remain open
10	Tout1	O	
17	Tout2	O	
3	Tout3	O	
4	Tout4	O	
14	CMAdd0	I/O	Offset capacitance input pin for the sensor inputs 0 to 3. When using large sensor pads with high capacitance, additional capacitance is added between CMAdd0 and CdrvBar. See Figure 3. Remain open if not in use.
13	CMAdd4	I/O	Offset capacitance input pin for the sensor inputs 4 to 7. When using large sensor pads with high capacitance, additional capacitance is added between CMAdd4 and CdrvBar. See Figure 3. Remain open if not in use.

Table 1. PIN ASSIGNMENT (continued)

Pin No.	Pin Name	I/O	Description
18	Cref	I/O	Reference capacitance input pins. See Figures 2 and 3. When using large sensor pads with high capacitance, additional capacitance maybe added for Cref. See Figure 3. Remain open if not in use.
20	CrefAdd	I/O	
19	CdrvBar	O	Capacitance sensors drive signal inversion output. When using large sensor pads with high capacitance, additional capacitance is added between CMAdd0 and CMAdd4 and CdrvBar. See Figure 3. Remain open if not in use.
21	Cdrv	O	Capacitance sensors drive output. Cdrv and Cin printed circuit board patterns should be close to each other as they are capacitively coupled.
22	INTOUT	O	Interrupt output pin. (Active high) Remain open if not in use
23	IFSEL	I	Interface Select. IFSEL = "Low" (V_{SS}): SPI mode IFSEL = "High" (V_{DD}): I^2C mode
24	SCL/SCK	I	I^2C = SCL clock input SPI = SCK clock input
25	SDA/SI	I/O	I^2C = SDA data input/output SPI = SI data input
26	SA0/SO	I/O	I^2C = SA0 slave address selection input SPI = SO data output
27	nCS	I	I^2C = "High" (V_{DD}) SPI = nCS chip select inversion input
28	nRST	I	Reset signal inversion input pin. nRST = "Low" (V_{SS}), in reset state Cin0 to Cin7, CMAdd0, CMAdd4, Cref, CrefAdd, CdrvBar and Tout0 to Tout4 are "Hi−Z"

1. For noise de-coupling place a high-valued capacitor and a low-valued capacitor in parallel between V_{DD} and V_{SS}. The small-valued capacitor, at least 0.1 μF, should be mounted near the LSI.
2. When V_{SS} terminal is not grounded, in battery-powered mobile equipment, detection sensitivity may be degraded.

Table 2. PIN FUNCTIONS

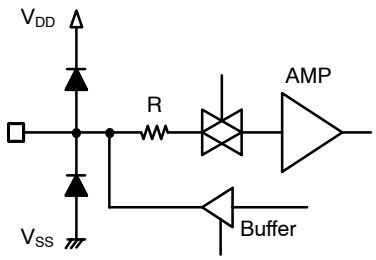
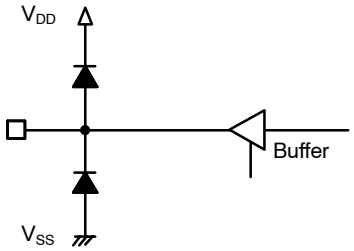
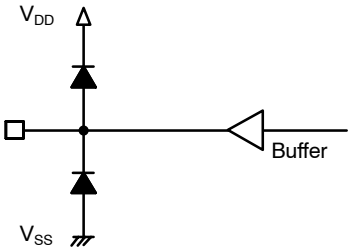
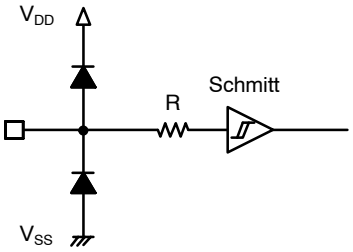
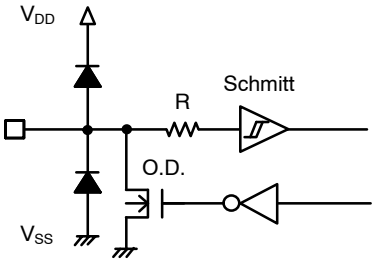
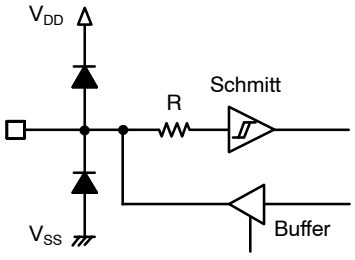
Pin No.	Pin Name	I/O	Pin Functions	Pin Type
5	V_{DD}	Power	Power supply (+2.6 V to +5.5 V)	
6	V_{SS}	Power	Ground	
1	Cin0	I/O	Capacitance sensor input 0	
2	Cin1	I/O	Capacitance sensor input 1	
7	Cin2	I/O	Capacitance sensor input 2	
8	Cin3	I/O	Capacitance sensor input 3	
11	Cin4	I/O	Capacitance sensor input 4	
12	Cin5	I/O	Capacitance sensor input 5	
15	Cin6	I/O	Capacitance sensor input 6	
16	Cin7	I/O	Capacitance sensor input 7	
13	CMAdd4	I/O	Additional offset capacitance input pin for the sensor inputs 4 to 7	
14	CMAdd0	I/O	Additional offset capacitance input pin for the sensor inputs 0 to 3	
18	Cref	I/O	Reference capacitance input	
20	CrefAdd	I/O	Additional reference capacitance input	

Table 2. PIN FUNCTIONS (continued)

Pin No.	Pin Name	I/O	Pin Functions	Pin Type
9	Tout0	O	Output for tests	
10	Tout1	O	Output for tests	
17	Tout2	O	Output for tests	
3	Tout3	O	Output for tests	
4	Tout4	O	Output for tests	
19	CdrvBar	O	Capacitance sensors drive signal inversion output	
21	Cdrv	O	Capacitance sensors drive output	
22	INTOUT	O	Interrupt output	
23	IFSEL	I	Switching control input of the serial data communication interface	
24	SCL/SCK	I	SCL clock input (I^2C)	
		I	SCK clock input (SPI)	
27	nCS	I	nCS chip select inversion input (SPI)	
28	nRST	I	External reset signal inversion input	
25	SDA/SI	I/O	SDA data input/output (I^2C)	
		I	SI data input (SPI)	
26	SA0/SO	I	SA0 slave address selection input (I^2C)	
		O	SO data output (SPI)	

ABSOLUTE MAXIMUM RATINGS (V_{SS} = 0 V)

Symbol	Parameter	Value	Unit
V_{DD}	Supply Voltage Range	−0.3 to +6.5	V
V_{IN}	Input Voltage Range (Note 3)	−0.3 to V_{DD}+0.3	V
V_{OUT}	Output Voltage Range (Note 4)	−0.3 to V_{DD}+0.3	V
I_{OP}	Peak Output Current Range (Notes 4, 5)	−8.0 to +8.0	mA
I_{OA}	Total Outputs Current Range (Note 6)	−40 to +40	mA
P_{dmax}	Maximum Power Dissipation (Note 7)	160	mW

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

3. Apply to Cin0 to Cin7, CMAdd0, CMAdd4, Cref, CrefAdd ,SCL/SCK ,SDA/SI ,SA0, nCS, nRST, IFSEL.
4. Apply to Cdrv, CdrvBar, SDA, SO, INTOUT, Tout0 to Tout4.
5. Limited to one pin, with duty cycle under 50%.
6. Total value with duty cycle under 25%.
7. T_A = 105°C, Single-layer glass epoxy board (76.1 × 114.3 × 1.6 mm).

RECOMMENDED OPERATING CONDITIONS (V_{SS} = 0 V)

Symbol	Parameter	Min	Max	Unit
V_{DD}	Operating Supply Voltage Range (Note 8)	2.6	5.5	V
V_{IH}	Input High-level Voltage Range (Note 9)	0.8 V_{DD}	V_{DD}	V
V_{IL}	Input Low-level Voltage Range (Note 9)	0	0.2 V_{DD}	V
T_A	Ambient Temperature Range	−40	105	°C

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

8. For noise de-coupling place a high-valued capacitor and a low-valued capacitor in parallel between V_{DD} and V_{SS}. The small-valued capacitor, at least 0.1 μF, should be mounted near the LSI. In addition, it is recommended that the power supply ripple + noise is less than ±40 mV.
9. Apply to SCL/SCK ,SDA/SI ,SA0, nCS, nRST, IFSEL.

ELECTRICAL CHARACTERISTICS

(V_{DD} = 2.6 to 5.5 V, V_{SS} = 0 V, T_A = −40 to + 105°C, Unless otherwise specified, the Cdrv drive frequency is f_{CDRV} = 121 kHz.)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
COMMON						
V_{OH1}	Output High-level Voltage (Note 10)	I_O = −1.5 mA, V_{DD} = 2.6 to 3.6 V	0.8 V_{DD}	–	–	V
V_{OH2}		I_O = −3.0 mA, V_{DD} = 3.6 to 5.5 V	0.8 V_{DD}	–	–	V
V_{OL1}	Output Low-level Voltage (Note 10)	I_O = +1.5 mA, V_{DD} = 2.6 to 3.6 V	–	–	0.2 V_{DD}	V
V_{OL2}		I_O = +3.0 mA, V_{DD} = 3.6 to 5.5 V	–	–	0.2 V_{DD}	V
V_{OL3}	Tout0 to Tout4 pins Output Low-level Voltage	I_O = +1.5 mA	–	–	0.2 V_{DD}	V
V_{OL4}	SDA pin Output Low-level Voltage	I_O = +3.0 mA	–	–	0.4	V
I_{IH}	Input High-level Current (Note 11)	V_I = V_{DD}	–	–	1.0	μA
I_{IL}	Input Low-level Current (Note 11)	V_I = V_{SS}	−1.0	–	–	μA
I_{OFF}	Output Off Leakage Current (Note 12)	V_I = V_{DD} or V_I = V_{SS}	−1.0	–	1.0	μA
I_{DD1}	Current Consumption	Initial setting, Long interval operation, Sensor pins are open (Note 13), V_{DD} = 5.5 V	–	0.8	2.2	mA
I_{DD2}		Initial setting, Short interval operation, Sensor pins are open (Note 13), V_{DD} = 5.5 V	–	3.25	6.5	mA
I_{STBY}		Sleep mode (Sleep period) Sensor pins are open (Note 13)	–	0.1	70	μA

ELECTRICAL CHARACTERISTICS (continued)
(V_{DD} = 2.6 to 5.5 V, V_{SS} = 0 V, T_A = −40 to + 105°C, Unless otherwise specified, the Cdrv drive frequency is f_{CDRV} = 121 kHz.)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
CAPACITANCE SENSOR FUNCTION						
Cin_{SENSE}	Cin Detection Sensitivity	Measurements conducted using the test mode in the LSI, Minimum gain setting	0.0476	0.068	0.0884	LSB/fF
I_{Cin}	Sensor Pin Leakage Current (Note 14)	$V_I = V_{DD}$ or $V_I = V_{SS}$	–	±25	±500	nA
f_{CDRV}	Cdrv Drive Frequency	With 121 kHz setting	84.85	121.21	157.57	kHz
POWER-ON RESET FUNCTION						
t_{NRST}	nRST Minimum Pulse Width		1.0	–	–	μs
t_{POR}	Power-on Reset Time		–	–	20	ms
t_{POROP}	Power-on Reset Operation Condition: Hold Time		10	–	–	ms
V_{POROP}	Power-on Reset Operation Condition: Input Voltage		–	–	0.1	V
t_{VDD}	Power-on Reset Operation Condition: Power Supply Rise Rate	0 V to V_{DD}	1.0	–	–	V/ms
INTERVAL OPERATION TIMING						
T_{LIVAL1}	Long Interval Time	V_{DD} = 2.6 to 4.5 V, Long interval mode (Long interval time is set to 101 ms)	35	101	145	ms
T_{LIVAL2}		V_{DD} = 4.5 to 5.5 V, Long interval mode (Long interval time is set to 101 ms)	40	101	125	ms
T_{SIVAL1}	Short Interval Time	V_{DD} = 2.6 to 4.5 V, Short interval mode (Short interval time is set to 5 ms)	1.7	5	7.3	ms
T_{SIVAL2}		V_{DD} = 4.5 to 5.5 V, Short interval mode (Short interval time is set to 5 ms)	1.9	5	6.3	ms
I²C COMPATIBLE BUS INTERFACE TIMING						
f_{SCL}	SCL Clock Frequency	SCL	–	–	400	kHz
$t_{HD;\ STA}$	START Condition Hold Time	SCL, SDA	0.6	–	–	μs
t_{LOW}	SCL Clock Low Period	SCL	1.3	–	–	μs
t_{HIGH}	SCL Clock High Period	SCL	0.6	–	–	μs
$t_{SU;\ STA}$	Repeated START Condition Setup Time	SCL, SDA	0.6	–	–	μs
$t_{HD;\ DAT}$	Data Hold Time	SCL, SDA	0	–	0.9	μs
$t_{SU;\ DAT}$	Data Setup Time	SCL, SDA	0.5	–	–	μs
t_r/t_f	SDA, SCL Rise/Fall Time	SCL, SDA	–	–	0.3	μs
$t_{SU;\ STO}$	STOP Condition Setup Time	SCL, SDA	0.6	–	–	μs
t_{BUF}	STOP-to-START Bus Release Time	SCL, SDA	2.5	–	–	μs
SPI INTERFACE TIMING						
f_{SCK}	SCK Clock Frequency	SCK	–	–	5.0	MHz
t_{LOW}	SCK Clock Low Time	SCK	100	–	–	ns
t_{HIGH}	SCK Clock High Time	SCK	100	–	–	ns
t_r/t_f	Input Signal Rise/Fall Time	nCS, SCK, SI	–	–	300	ns
$t_{SU;\ NCS}$	nCS Setup Time	nCS, SCK	200	–	–	ns
$t_{SU;\ SCK}$	SCK Clock Setup Time	nCS, SCK	100	–	–	ns
$t_{SU;\ SI}$	Data Setup Time	SCK, SI	100	–	–	ns
$t_{HD;\ SI}$	Data Hold Time	SCK, SI	100	–	–	ns

ELECTRICAL CHARACTERISTICS (continued)
(V_{DD} = 2.6 to 5.5 V, V_{SS} = 0 V, T_A = −40 to + 105°C, Unless otherwise specified, the Cdrv drive frequency is f_{CDRV} = 121 kHz.)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
SPI INTERFACE TIMING						
$t_{HD;\ NCS}$	nCS Hold Time	nCS, SCK	200	–	–	ns
$t_{HD;SCK}$	SCK Clock Hold Time	nCS, SCK	700	–	–	ns
t_{CPH}	nCS Standby Pulse Width	nCS	300	–	–	ns
t_{CHZ}	Output High Impedance Time from nCS	nCS, SO	–	–	100	ns
t_V	Output Data Determination Time	SCK, SO	–	–	100	ns
$t_{HD;\ SO}$	Output Data Hold Time	SCK, SO	0	–	–	ns
t_{CLZ}	Output Low Impedance Time from SCK Clock	SCK, SO	100	–	–	ns

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.
10. Apply to Cdrv, CdrvBar, SO, INTOUT.
11. Apply to SCL/SCK, SDA/SI, SA0, nCS, nRST, IFSEL.
12. Apply to Cdrv, CdrvBar, SDA, SO.
13. Sensor pins (Cin0 to Cin7, CMAdd0, CMAdd4, Cref, CrefAdd) are open condition.
14. Apply to Cin0 to Cin7, CMAdd0, CMAdd4, Cref, CrefAdd.

Table 3. ORDERING INFORMATION

Device	Package	Shipping (Qty / Packing)†
LC717A30UR−NH	VCT28 3.5 × 3.5 (Pb-Free / Halogen Free)	2000 / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.

FUNCTIONAL DESCRIPTION

Power-on Reset (POR)

When power is turned on, power-on reset is enabled, it is released after power-on reset time, t_{POR}. Power-on reset operation condition; Power supply rise rate t_{VDD} must be at least 1.0 V/ms.

Since INTOUT pin changes from “High” to “Low” at the same time as reset release, it is possible to verify the timing of release of reset externally. During power-on reset, Cin0 to Cin7, CMAdd0, CMAdd4, Cref, CrefAdd, and CdrvBar are unknown.

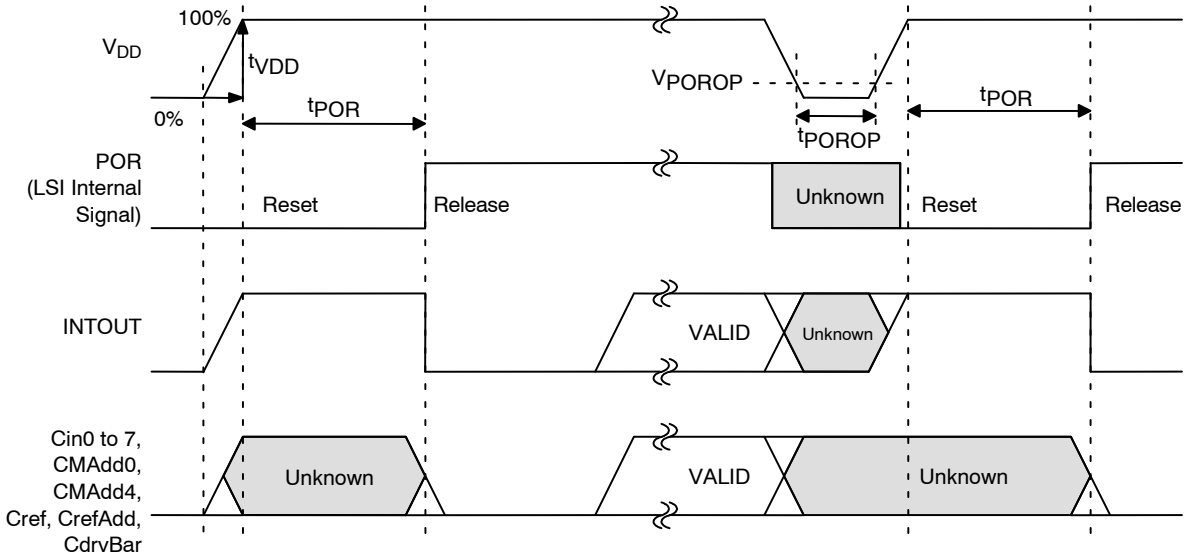


Figure 6. Power-on Sequence by the Power-on Reset

External Reset (nRST)

Reset State nRST = “Low”. Pins Cin0 to Cin7, CMAdd0, CMAdd4, Cref, CrefAdd and CdrvBar, are “Hi-Z” during reset state. The reset state is released after t_{POR}.

Since INTOUT pin changes from “High” to “Low” at the same time as the released of reset, it is possible to verify the timing of release of reset externally.

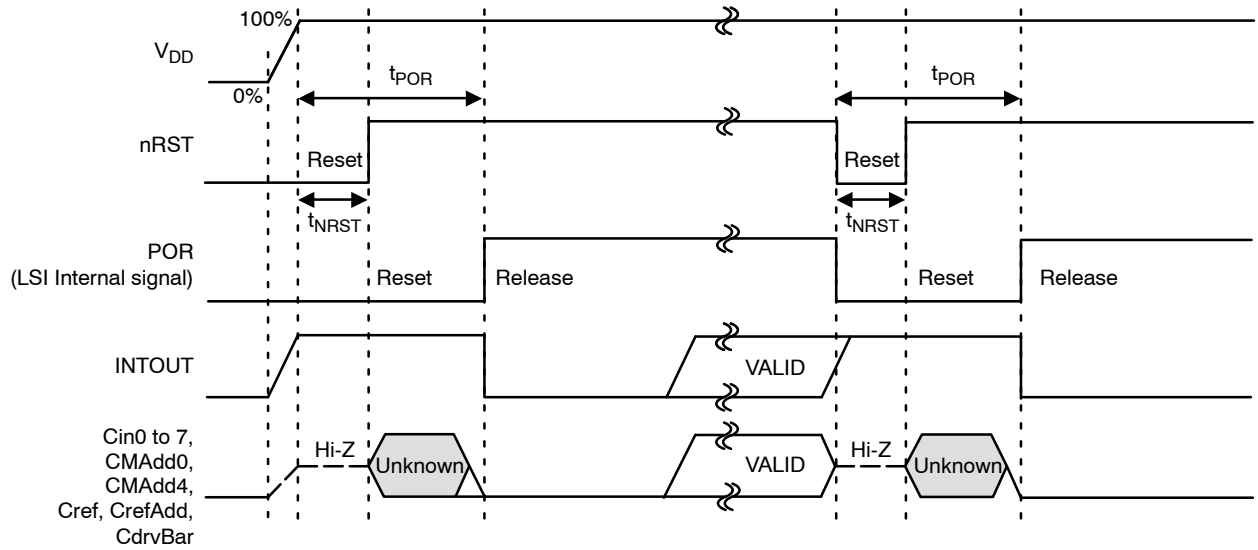


Figure 7. Power-on Sequence by the External Reset

I²C Data Timing

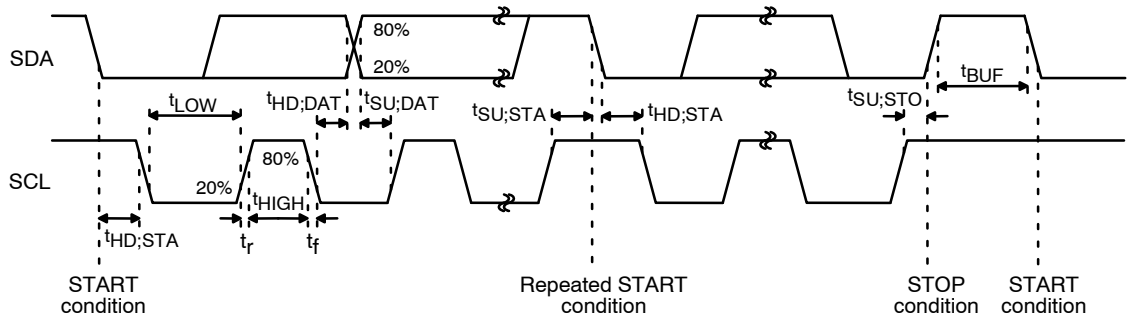


Figure 8. I²C Data Timing

I²C Communication Formats

Write Format

When using the Write format of I²C the data can be written into sequentially incremented addresses.



Figure 9. I²C Write Format

Read Format

When using the Read format of I²C the data can be read from sequentially incremented addresses.



Figure 10. I²C Read Format

I²C Slave Address

SA0 pin is used to select the slave address

Table 4. I²C SLAVE ADDRESS

SA0 Pin Input	7 bit Slave Address	Binary Notation	8 bit Slave Address
Low	0x16	00101100b (Write)	0x2C
		00101101b (Read)	0x2D
High	0x17	00101110b (Write)	0x2E
		00101111b (Read)	0x2F

SPI Data Timing (Mode 0/Mode 3)

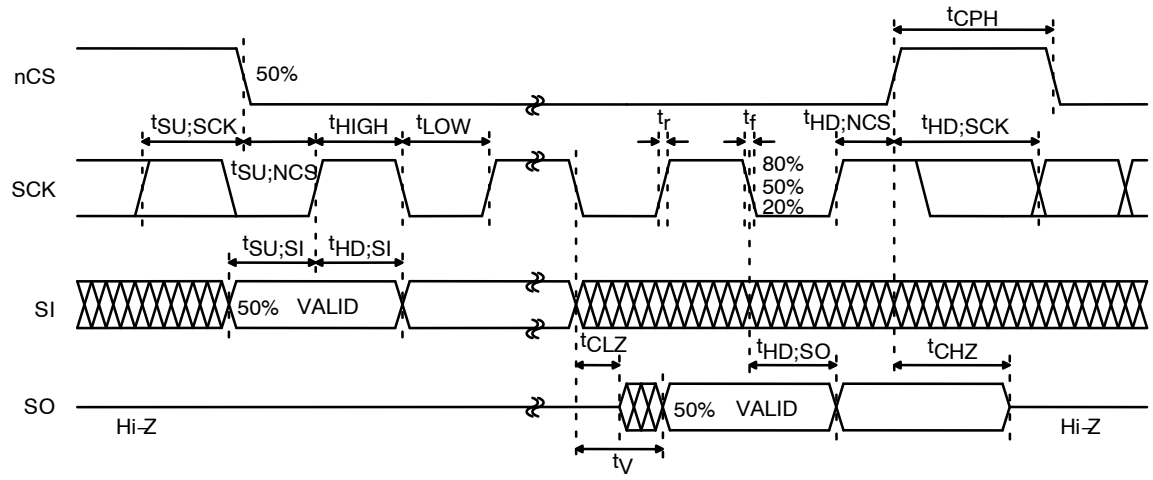


Figure 11. SPI Data Timing

SPI Write Format (Example of Mode 0)

When using the SPI Write format the data can be written into sequentially incremented addresses with preserving nCS = “L”.

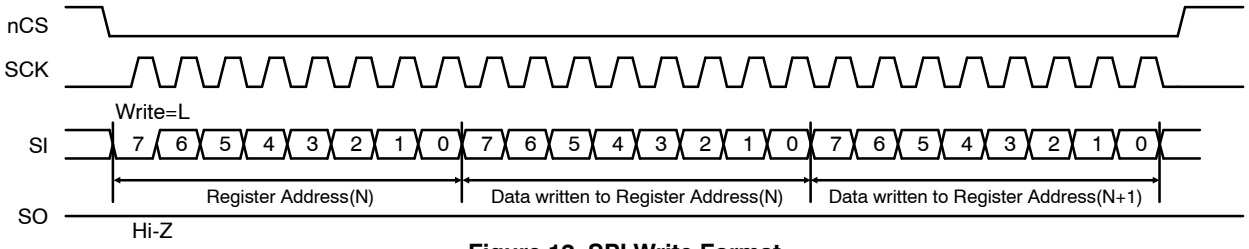


Figure 12. SPI Write Format

SPI Read Format

When using the SPI Read format the data can be read from sequentially incremented addresses with preserving nCS = “L”.

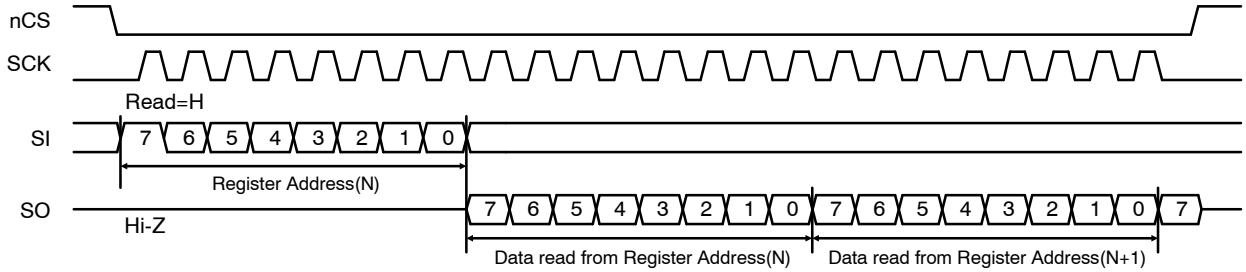
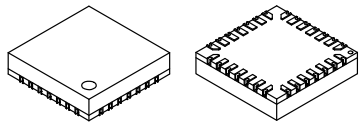


Figure 13. SPI Read Format

ON Semiconductor is licensed by the Philips Corporation to carry the I²C bus protocol.

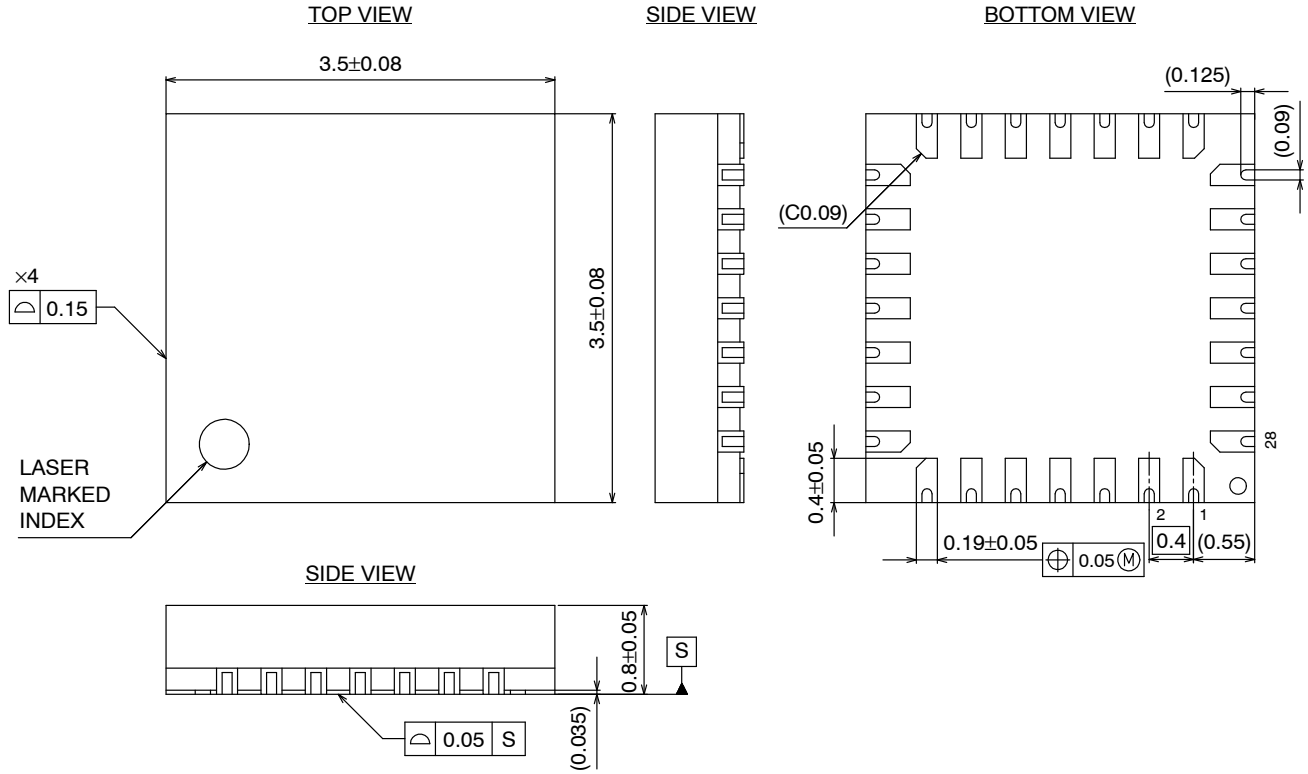
MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS

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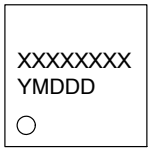


VCT28 3.5x3.5
CASE 601AE
ISSUE A

DATE 21 NOV 2013



GENERIC
MARKING DIAGRAM*



XXXXX = Specific Device Code
Y = Year
M = Month
DDD = Additional Traceability Data

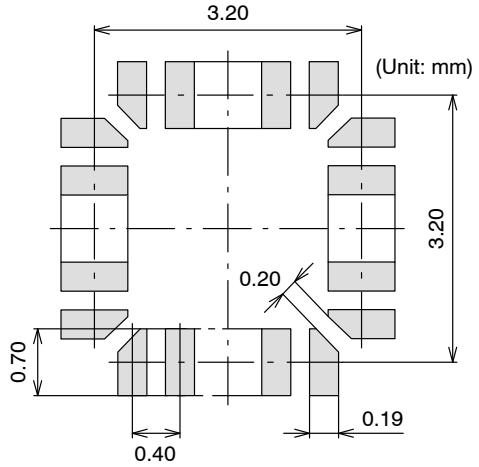
*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, “G” or microdot “ ▪”, may or may not be present.

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VCT28 3.5x3.5
CASE 601AE
ISSUE A

DATE 21 NOV 2013

SOLDERING FOOTPRINT*



NOTE: The measurements are not to guarantee but for reference only.

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

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