QT11x VARIATIONS

QT111	**Longer recalibration timeouts**
QT112	**Faster response time**
QT113	**Variable gain to 0.03pF**
QT114	**See separate QT114 datasheet**
QT115	**Variable gain, daisy-chaining**

3 April 2000

QT111 QProx™ 8-pin Sensor

See QT110 datasheet for primary information. This sheet only lists differences with the QT110.

Description

The QT111 is a touch sensor IC having recalibration timeouts ("max on-duration") of 5 minutes and infinity. This allows the device to be used in situations where recalibration timeouts are not desired, for example in certain consumer, machine tool and process control applications where continuous touch over long periods is desired, like hand-on-joystick sensors, dead-man switches, etc. Although the primary application of the device is still as a 'touch sensor', longer timeouts also aknowledge alternate uses for the QT110 family, for example in process controls.

Differences with QT110

The QT111 sensor is exactly the same in all respects to the QT110 with the following exceptions shown in bold (refer to Table 2-1 in the QT110 datasheet):

Table 2-1 Output Mode Strap Options

	Tie Pin 3 to:	Tie Pin 4 to:	Max On-Duration
DC Out	Vdd	Vdd	**300s**
DC Out	Vdd	Gnd	**infinite**
Toggle	Gnd	Gnd	**300s**
Pulse	Gnd	Vdd	**300s**

All other operating modes, specifications, and wiring should be read from the QT110 data sheet.

Cautionary Notes

Care should be taken in infinite timeout mode that the Cs and Cx capacitances and the Vcc supply do not drift substantially over the course of a detection; if any of these parameters change sufficiently during the course of an active detection (remember: drift compensation is never performed during a detection event) the sensor can either 'stick on' after the detected object is removed, or, the QT110's apparent sensitivity will be substantially reduced for a period of time until drift compensation can recover the proper reference level. If possible, uses the lowest gain setting when using with long timeouts.

If the sensor 'sticks on' after the detected object or substance is removed from the sense element, the only way to clear the sensor may be to remove power momentarily in order to induce a full recalibration.

Package Marking

DIP Package: DIP devices are marked 'QT111'
SO8 Package: Marked 'QT1' and also laserscribed '1'

QT112 QProx™ 8-pin Sensor

See QT110 datasheet for primary information. This sheet only lists differences with the QT110.

Description

The QT112 is a variant of the QT110 having a faster response time of 49ms worst case, and 25ms typical. It is designed for those touch sensing applications where faster speed is paramount, for example in games and toys where rapid reaction time is critical, or in machine tool controls where speed is important. It trades off power consumption for speed. Also, note that the device has a consensus filter count 2 instead of 4, and does not have an acoustic driver for a piezo 'beeper'.

Differences with the QT110

The QT112 sensor is exactly the same in all respects to the QT110 with the following exceptions (refer to Tables 4.3, 4.4, and 4.5 in the QT110 datasheet):

4.3 AC SPECIFICATIONS **Vdd = 3.0, Ta = recommended operating range**

Parameter	Description	Min	Typ	Max	Units	Notes
T_{BS}	Burst spacing interval		24		ms	
T_R	Response time		49		ms	

4.4 SIGNAL PROCESSING

Description	Min	Typ	Max	Units	Notes
Consensus filter length		2		samples	
Positive drift compensation rate		1,250		ms/level	
Negative drift compensation rate		24		ms/level	

4.5 DC SPECIFICATIONS

Vdd = 3.0V, Cs = 10nF, Cx = 5pF, Ta = recommended range, unless otherwise noted

Parameter	Description	Min	Typ	Max	Units	Notes
I_{DD}	Supply current		60		µA	

Piezo Driver Note: The piezo acoustic driver has been removed, as the duration required to operate the beeper would interfere with the sensing interval and slow down the device.

All other operating modes, specifications, and wiring should be taken from the QT110 data sheet.

Package Marking

DIP Package: DIP devices are marked 'QT112'

SO8 Package: Marked 'QT1' and also laserscribed '2'

QT113 QProx™ 8-pin Sensor

See QT110 datasheet for primary information. This sheet only lists differences with the QT110.

Description

The QT113 is a variant of the QT110 having variable sensitivity and faster response time in most cases. Unlike the QT110, it has a variable threshold which can be modified by simply altering the value of the sample capacitor Cs, which acts to modify gain. In addition, it also includes an 'infinite' max on-duration timeout, so that it is possible to prevent a recalibration during prolonged detections.

The QT113 is designed for contact sensing applications where faster speed and high sensitivity are paramount, for example when sensing through thick panels or windows in machine tool applications or certain types of security monitoring. The QT113 trades off power consumption for speed and sensing range. Also, note that the device has a consensus filter count of 3 instead of 4, and does not have the drive capability for a piezo 'beeper'.

Differences with the QT110

The QT113 IC is exactly the same in all respects to the QT110 with the following exceptions (refer to Tables 4.2, 4.3, 4.4, and 4.5 in the QT110 datasheet).

4.2 RECOMMENDED OPERATING CONDITIONS

Cx Load Capacitance . . . . 0 to 100pF
Cs . . . . 10nF to 500nF

4.3 AC SPECIFICATIONS VDD = 3.0, TA = RECOMMENDED OPERATING RANGE

Parameter	Description	Min	Typ	Max	Units	Notes
T_{BS}	Burst spacing interval	2.1		80	ms	Cs = 10nf to 500nf, Cx = 0
T_{BL}	Burst length	0.5		75	ms	Cs = 10nf to 500nf, Cx = 0
T_R	Response time	8		300	ms	Note 1

Note 1: Lengthens with increasing Cs but decreases with increasing Cx; see Chart 3.

4.4 SIGNAL PROCESSING

Description	Min	Typ	Max	Units	Notes
Threshold differential, high gain		-		%	Note 1
Threshold differential, medium gain		-		%	Note 1
Threshold differential, low gain		-		%	Note 1
Threshold differential, fixed	6		12	counts	Note 1
Hysteresis		17		%	w.r.t. threshold cts.
Consensus filter length		3		samples	
Positive drift compensation rate		1,000		ms/level	
Negative drift compensation rate		100		ms/level	

Note 1: All percentage thresholds have been eliminated and replaced with fixed thresholds (high, low gains) w.r.t. the reference level

4.5 DC SPECIFICATIONS VDD = 3.0V, CS = 10NF, CX = 10PF, TA = RECOMMENDED RANGE

Parameter	Description	Min	Typ	Max	Units	Notes
I_{DD}	Supply current		700		µA	Cs = 10nF to 100nF
S[1]	Sensitivity - high gain		-		pF	Note 1
S[2]	Sensitivity - medium gain		-		pF	Note 1
S[3]	Sensitivity - low gain		-		pF	Note 1
S	Sensitivity range	1,000	-	28	fF	Typical, see figs 1, 2; Note 1, 2

Note 1: All percentage thresholds have been eliminated and replaced with a fixed threshold w.r.t. reference level
Note 2: Sensitivity depends on value of Cx and Cs. Refer to Charts 1, 2.

QT115 QProx™ 8-pin Sensor

Piezo Driver Note
The piezo acoustic driver has been removed, as the duration required to operate the beeper would interfere with the sensing interval and slow down the device.

Sensitivity Adjustment
The gain pin adjustment is via fixed thresholds slaved to the reference level. Likewise, gain strapping is different from the QT110: instead of connecting the Gain pin to SNS1 or SNS2, Gain must be connected to either Vdd (+) or Gnd as shown in Table 1-1 below. The E110 board does not directly support this and a wire should be run from the centerpost of the Gain jumper strip to either switched-Vdd or Gnd, as desired.

Table 1-1 Gain Setting Strap Options

Gain	Tie Pin 5 to:
Low (12 counts)	Gnd
High (6 counts)	Vdd

The sensitivity of the circuit is governed also by the relative sizes of Cs and Cx. A detection is made if the signal rises by 6 or 12 counts from the reference level depending on gain pin strapping; this amount, unlike the QT110, is not ratiometric to the signal level and therefore the sensitivity can be altered by simply changing Cs (and by changing gain strapping). To provide a consistent level of sensitivity, only stable types of capacitors are recommended for Cs, such as NPO, C0G, PPS film, and certain types of polycarbonate when used over normal room temperature ranges.

Larger values of Cs will make the sensor more sensitive, while larger amounts of Cx will desensitize it (see Charts 1, 2). Minimizing stray Cx is crucial if high levels of sensitivity are desired. By using values of Cs around 0.47uF (470nF), proximity distances of several centimeters can easily be obtained from small electrodes.

NOTE: It is extremely important to maintain stable levels of Vdd, as the supply is used as a reference. Minor fluctuations in Vdd WILL cause false triggers or rapid swings in gain. DO NOT use bench power supplies or supply circuits shared with other digital functions. Ordinary 78L05 class regulators are fine in almost all cases. The QT113 is an extremely sensitive device. Do not take power supply issues lightly.

Output Mode and Timing Changes
The QT113 has different output mode strap options from the QT110 as shown:

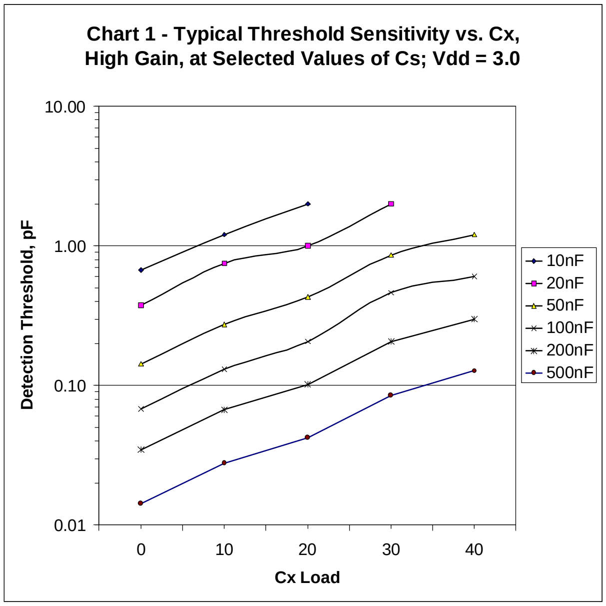
Table 2-1 Output Mode Strap Options

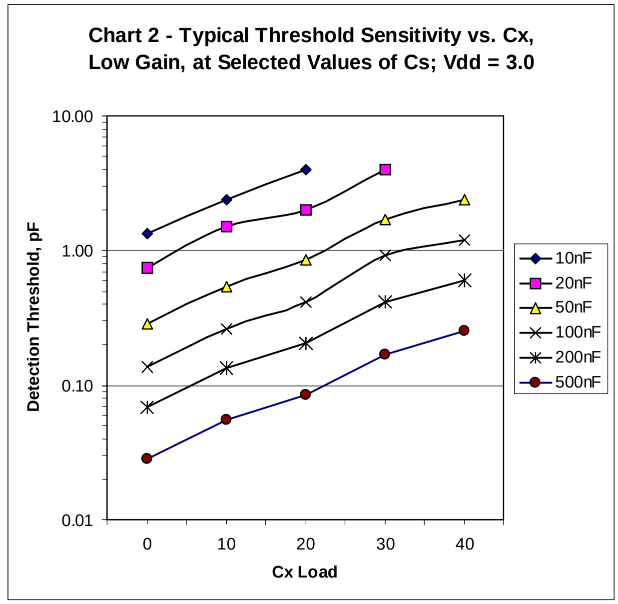
	Tie Pin 3 to:	Tie Pin 4 to:	Max On-Duration
DC Out	Vdd	Vdd	10s
DC Out	Vdd	Gnd	60s
Toggle	Gnd	Gnd	10s
DC Out	Gnd	Vdd	**infinite**

The only change is that 'Pulse Mode' has been replaced by a DC Out mode having no recalibration timeout (max on-duration set to infinite).

All other operating modes, specifications, and wiring should be taken from the QT110 data sheet.

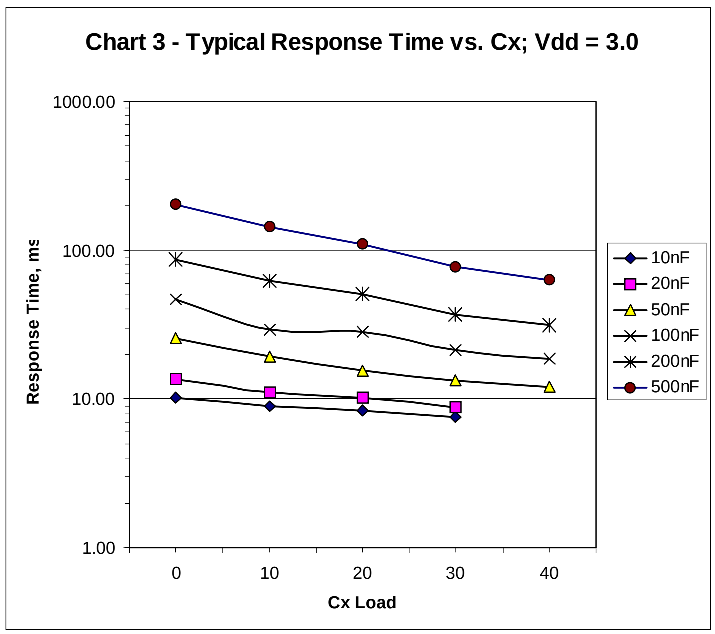
Calibration and Drift Compensation
Calibration and drift compensation operate in the same manner as in the QT110. With large values of Cs and small values of Cx, drift compensation will appear to operate more slowly than with the converse. Note that the positive and negative drift compensation rates are different.





Response Time

The QT113's response time is highly dependent on burst length, which in turn is dependent on Cs and Cx (see Charts 1, 2). With increasing Cs, response time slows, while increasing levels of Cs reduce response time. Chart 3 shows the typical effects of Cs and Cx on response time.



HeartBeat™ Signal

The QT113's HeartBeat pulse works exactly the same as in the QT110 except that the HeartBeat rate is the same as the burst rate, which can vary from 2ms to 100ms depending on Cs and Cx. Detection methods for this health indicator should take this into account. As with the QT110, the HB signal can be suppressed if not wanted by a variety of simple methods.

Package Marking

DIP Package: DIP devices are marked 'QT113'

SO8 Package: Marked 'QT1' and also laserscribed '3'

QT115 QProx™ 8-pin Sensor

See QT110 datasheet for primary information.

Description

The QT115 is a variant of the QT110 having variable sensitivity and the ability to daisy-chain, allowing multiple QT115's to be used in immediate proximity to each other to create a small touch panel of up to 10 keys. Like the QT113, it has a variable threshold which can be modified by simply altering the value of the sample capacitor Cs, which acts to modify gain. It does not include any of the option jumpers found on the QT110 or QT113; instead it has a single option jumper for 'Master' or 'Slave' mode operation.

The QT115 includes 'Sync Out' and 'Sync In' pins for daisy-chaining. The first IC in the chain is the Master while the remaining devices in the chain are slaves. Daisy-chaining lets each device take its turn in generating a burst, free from interference by the other QT devices. In Master mode the IC operates autonomously, and generates a 20us negative Sync Out pulse on pin 3 after each burst. In Slave mode the IC issues a detection burst only after it receives a negative Sync pulse on pin 4 from a prior device in the chain, which could be another Slave or a Master. Slave devices in turn issue a 20us Sync pulse after each burst on pin 3.

The QT115 is designed for contact and prox sensing applications where high sensitivity is paramount, for example when sensing through thick panels or windows or for security monitoring. The QT115 trades off power consumption for speed and sensing range. Also, note that the device has a consensus filter count of 3 instead of 4, and does not have the drive capability for a piezo 'beeper'.

If desired, the Master device can be eliminated and the chain of Slave devices can be mastered from an external pulse source of 20us negative pulses at the desired repetition rate. This potentially allows for faster operation.

Differences with the QT110

The QT115 IC is exactly the same in all respects to the QT110 with the following exceptions (refer to Tables 5.2, 5.3, 5.4, and 5.5 in the QT110 datasheet).

5.2 RECOMMENDED OPERATING CONDITIONS

Cx Load Capacitance . . . . 0 to 100pF
Cs . . . . 10nF to 500nF

5.3 AC SPECIFICATIONS **VDD = 3.0, TA = RECOMMENDED OPERATING RANGE**

Parameter	Description	Min	Typ	Max	Units	Notes
$T_{BS}1$	Burst spacing interval, master	30	40		ms	Cs = 10nf to 500nf, Cx = 0
$T_{BS}2$	Burst spacing interval, slave	2			ms	Cs = 10nf, Cx = 0
T_{BL}	Burst length	0.5		75	ms	Cs = 10nf to 500nf, Cx = 0
T_R	Response time	8		300	ms	Note 1

Note 1: Lengthens with increasing Cs but decreases with increasing Cx; see Chart 3.

5.4 SIGNAL PROCESSING

Description	Min	Typ	Max	Units	Notes
Threshold differential, fixed		6		counts	Note 1
Hysteresis		17		%	w.r.t. threshold cts.
Consensus filter length		3		samples	
Positive drift compensation rate		1,800		ms/level	
Negative drift compensation rate		40		ms/level	
Post-detection recalibration timer duration		10		secs	

Note 1: All percentage thresholds have been eliminated and replaced with a fixed threshold w.r.t. the reference level

5.5 DC SPECIFICATIONS VDD = 3.0V, CS = 10NF, CX = 10PF, TA = RECOMMENDED RANGE

Parameter	Description	Min	Typ	Max	Units	Notes
I_{DD}	Supply current, master mode		60		µA	Cs = 10nF to 100nF
I_{DD}	Supply current, slave mode		700		µA	Cs = 10nF to 100nF
S	Sensitivity range	1,000	-	28	fF	Typical, see figs 1, 2; Note 1, 2

Note 1: All percentage thresholds have been eliminated and replaced with a fixed threshold w.r.t. reference level
Note 2: Sensitivity depends on value of Cx and Cs. Refer to Charts 1, 2.

Piezo Driver Note

The piezo acoustic driver has been removed, as the duration required to operate the beeper would interfere with the sensing interval and slow down the device.

Sensitivity Adjustment Note

The device has a fixed threshold point of 6 counts of deviation. Gain pin adjustment (pin 5) has been eliminated and replaced with a strap option for Master / Slave mode:

Table 1-1 Master/Slave Strap Options

Mode	Tie Pin 5 to:
Master	**Vdd**
Slave	**Gnd**

The sensitivity of the circuit is governed by the relative sizes of Cs and Cx. A detection is made if the signal rises by 6 counts from the reference level; this amount, unlike the QT110, is not ratiometric to the signal level and therefore the sensitivity can be altered by simply changing Cs. To provide a consistent level of sensitivity, only stable types of capacitors are recommended for Cs, such as NPO, C0G, PPS film, and certain types of polycarbonate when used over normal room temperature ranges.

Larger values of Cs will make the sensor more sensitive, while larger amounts of Cx will desensitize it (see Charts 1, 2). Minimizing stray Cx is crucial if high levels of sensitivity are desired. By using values of Cs around 0.47uF (470nF), proximity distances of several centimeters can easily be obtained from small electrodes.

NOTE: It is extremely important to maintain stable levels of Vdd, as the supply is used as a reference. Minor fluctuations in Vdd WILL cause false triggers or rapid swings in gain. DO NOT use bench power supplies or supply circuits shared with other digital functions. Ordinary 78L05 class regulators are fine in almost all cases. The QT115 is an extremely sensitive device... do not take power supply issues lightly.

Pin Functions

The QT115 pins are defined as shown:

Table 2-1 QT115 Pin Functions

PIN	Function	Description
1	Vdd	Power, +3V to +5V
2	Out	Active-low output
3	Sync Pulse Out (master or slave mode)	20us nominal negative sync pulse
4	Sync Pulse In (slave mode only)	>10us, <50us negative pulse input to trigger in slave mode In Master Mode: Connect to either Gnd or Vcc.
5	Master/Slave select	Vdd = Master mode, Gnd = Slave mode (strap option)
6	SNS1	QT Sense pin 1
7	SNS2	QT Sense pin 2
8	Gnd	Ground, 0V

Calibration and Drift Compensation

Calibration and drift compensation operate similarly to the QT110. With large values of Cs and small values of Cx, drift compensation will appear to operate more slowly than with the reverse. Note that the positive and negative drift compensation rates are different; the sensor will compensate more quickly for the removal of an object than it will to the introduction of an object.

The QT1115 uses a fixed recalibration timeout of 10 seconds.

Response Time

The QT115's response time is entirely dependent on the burst rate. In Master mode the nominal burst rate is 40ms, and 3 successive bursts are required to confirm a detection, giving a nominal 120ms response time.

In slave mode, the burst rate and hence response time are dependent on the input sync pulse rate. Faster sync pulse rates will lead to faster response times.

HeartBeat™ Signal

The QT115's HeartBeat pulse works exactly the same as in the QT110 except that the HeartBeat rate is the same as the burst rate. In Master mode, the HeartBeat signal occurs just before the acquisition burst. In slave mode, it occurs just after receipt of the slave pulse on pin 4. As with the QT110, the HB signal can be suppressed if not wanted by a variety of simple methods.

Notes on Daisy Chaining QT115's

The QT115 is intended to be daisy-chained for the purpose of allowing each of the sensors to operate without interference from other devices in the chain. This allows electrodes from each device to be placed immediately adjacent the other electrodes with only the barest of gaps.

Individual devices in the chain can have unique sensitivities. QT113-style sensing allow for very high sensitivity levels if required. One device can be used with a large metal area to create a prox detector capable of many centimeters range, for example to activate the panel, equipment, or a light upon a mere hand-wave. The other devices in the chain can be used to implement low-gain touch switches that must be contacted by a fingertip for activation. The net effect of this configuration can be quite dramatic.

The only limitation is that the sum of the burst lengths, which depends on load Cx and the Cs capacitor, must not be so long that burst of the last device in the chain overlaps the burst of the first device. Should this occur, the first and last devices may interfere with each other if the electrodes and wiring are adjacent to each other. One simple solution to this problem is to physically separate the traces and electrodes from devices that have overlapping bursts.

Package Marking

DIP Package: DIP devices are marked 'QT115'

SO8 Package: Marked 'QT1' and also laserscribed '5'