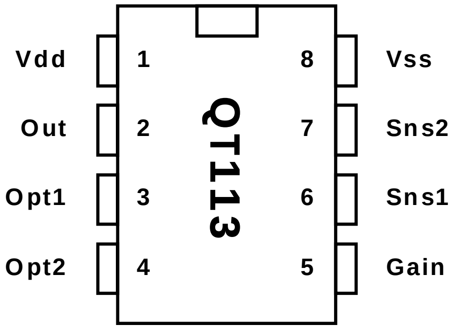
QProx™ QT113 / QT113H

CHARGE-TRANSFER TOUCH SENSOR

- **Projects a proximity field through air**
- **Less expensive than many mechanical switches**
- **Sensitivity easily adjusted via capacitor value**
- **Turns small objects into intrinsic touch sensors**
- **100% autocal for life - no adjustments required**
- **2.5 to 5V, 600µA single supply operation**
- **Toggle mode for on/off control (strap option)**
- **10s, 60s, infinite auto-recal timeout (strap options)**
- **Gain settings in 2 discrete levels**
- **HeartBeat™ health indicator on output**
- **Active-low (QT113) or active-high outputs (QT113H)**
- **Only one external part required - a 1¢ capacitor**



APPLICATIONS -

- **Light switches**
- **Prox sensors**
- **Appliance control**
- **Security systems**
- **Access systems**
- **Pointing devices**
- **Elevator buttons**
- **Toys & games**

The QT113 charge-transfer ("QT'") touch sensor is a self-contained digital IC capable of detecting near-proximity or touch. It will project a proximity sense field through air, via almost any dielectric, like glass, plastic, stone, ceramic, and most kinds of wood. It can also turn small metal-bearing objects into intrinsic sensors, making them responsive to proximity or touch. This capability coupled with its ability to self calibrate continuously can lead to entirely new product concepts.

It is designed specifically for human interfaces, like control panels, appliances, toys, lighting controls, or anywhere a mechanical switch or button may be found; it may also be used for some material sensing and control applications provided that the presence duration of objects does not exceed the recalibration timeout interval.

The QT113 requires only a common inexpensive capacitor in order to function.

Power consumption is only 600µA in most applications. In most cases the power supply need only be minimally regulated, for example by Zener diodes or an inexpensive 3-terminal regulator.

The QT113's RISC core employs signal processing techniques pioneered by Quantum; these are specifically designed to make the device survive real-world challenges, such as 'stuck sensor' conditions and signal drift. Even sensitivity is digitally determined and remains constant in the face of large variations in sample capacitor C_S and electrode C_X. No external switches, opamps, or other analog components aside from C_S are usually required.

The option-selectable toggle mode permits on/off touch control, for example for light switch replacement. The Quantum-pioneered HeartBeat™ signal is also included, allowing a host microcontroller to monitor the health of the QT113 continuously if desired. By using the charge transfer principle, the IC delivers a level of performance clearly superior to older technologies in a highly cost-effective package.

AVAILABLE OPTIONS

T_A	SOIC	8-PIN DIP
0^0C to $+70^0$C	QT113-S	QT113-D
0^0C to $+70^0$C	QT113H-S	QT113H-D
-40^0C to $+85^0$C	QT113-IS	-
-40^0C to $+85^0$C	QT113H-IS	-

Quantum Research Group Ltd

R1.10/0104

1 - OVERVIEW

The QT113 is a digital burst mode charge-transfer (QT) sensor designed specifically for touch controls; it includes all hardware and signal processing functions necessary to provide stable sensing under a wide variety of changing conditions. Only a single low cost, non-critical capacitor is required for operation.

Figure 1-1 shows the basic QT113 circuit using the device, with a conventional output drive and power supply connections.

1.1 BASIC OPERATION

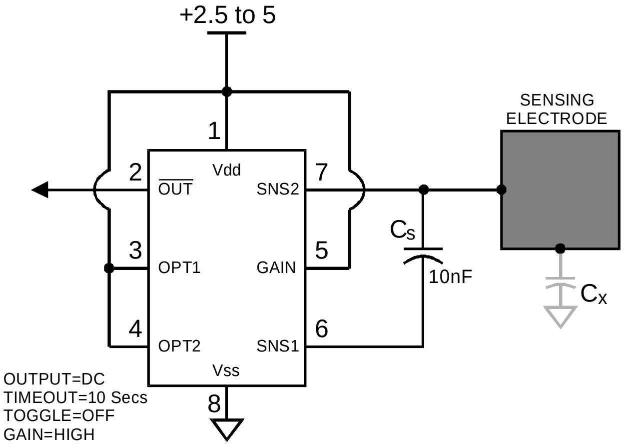
The QT113 employs bursts of charge-transfer cycles to acquire its signal. Burst mode permits power consumption in the microamp range, dramatically reduces RF emissions, lowers susceptibility to EMI, and yet permits excellent response time. Internally the signals are digitally processed to reject impulse noise, using a 'consensus' filter which requires three consecutive confirmations of a detection before the output is activated.

The QT switches and charge measurement hardware functions are all internal to the QT113 (Figure 1-2). A 14-bit single-slope switched capacitor ADC includes both the required QT charge and transfer switches in a configuration that provides direct ADC conversion. The ADC is designed to dynamically optimize the QT burst length according to the rate of charge buildup on Cs, which in turn depends on the values of Cs, Cx, and Vdd. Vdd is used as the charge reference voltage. Larger values of Cx cause the charge transferred into Cs to rise more rapidly, reducing available resolution; as a minimum resolution is required for proper operation, this can result in dramatically reduced apparent gain. Conversely, larger values of Cs reduce the rise of differential voltage across it, increasing available resolution by permitting longer QT bursts. The value of Cs can thus be increased to allow larger values of Cx to be tolerated (Figures 4-1, 4-2, 4-3 in Specifications, rear).

The IC is responsive to both Cx and Cs, and changes in Cs can result in substantial changes in sensor gain.

Option pins allow the selection or alteration of several special features and sensitivity.

Figure 1-1 Standard mode options



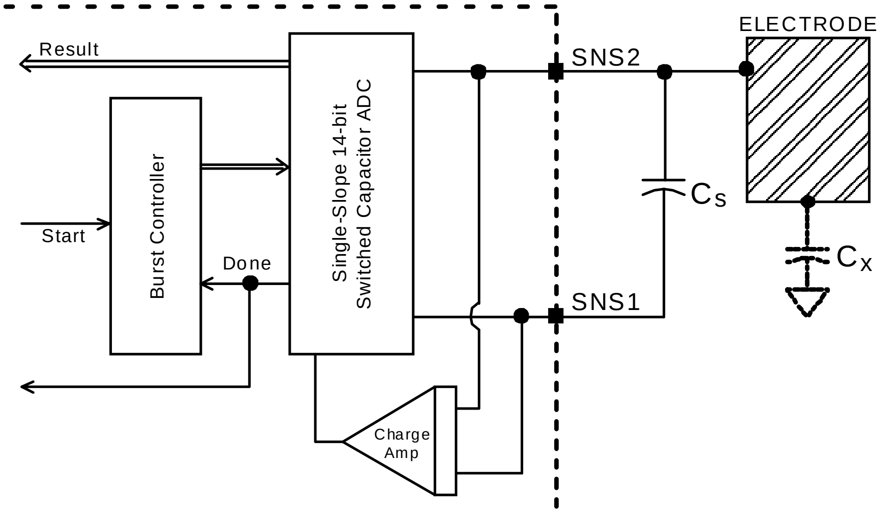
1.2 ELECTRODE DRIVE

The internal ADC treats Cs as a floating transfer capacitor; as a direct result, the sense electrode can be connected to either SNS1 or SNS2 with no performance difference. In both cases the rule Cs >> Cx must be observed for proper operation. The polarity of the charge buildup across Cs during a burst is the same in either case.

It is possible to connect separate Cx and Cx' loads to SNS1 and SNS2 simultaneously, although the result is no different than if the loads were connected together at SNS1 (or SNS2). It is important to limit the amount of stray capacitance on both terminals, especially if the load Cx is already large, for example by minimizing trace lengths and widths so as not to exceed the Cx load specification and to allow for a larger sensing electrode size if so desired.

The PCB traces, wiring, and any components associated with or in contact with SNS1 and SNS2 will become touch sensitive and should be treated with caution to limit the touch area to the desired location. Multiple touch electrodes can be used, for example to create a control button on both sides of an object, however it is impossible for the sensor to distinguish between the two touch areas.

Figure 1-2 Internal Switching & Timing



1.3 ELECTRODE DESIGN

1.3.1 Electrode Geometry and Size

There is no restriction on the shape of the electrode; in most cases common sense and a little experimentation can result in a good electrode design. The QT113 will operate equally well with long, thin electrodes as with round or square ones; even random shapes are acceptable. The electrode can also be a 3-dimensional surface or object. Sensitivity is related to electrode surface area, orientation with respect to the object being sensed, object composition, and the ground coupling quality of both the sensor circuit and the sensed object.

If a relatively large electrode surface is desired, and if tests show that the electrode has more capacitance than the QT113 can tolerate, the electrode can be made into a sparse mesh (Figure 1-3) having lower Cx than a solid plane. Sensitivity may even remain the same, as the sensor will be operating in a lower region of the gain curves.

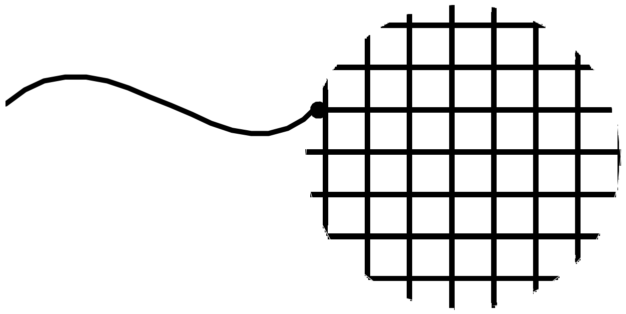
1.3.2 KIRCHOFF'S CURRENT LAW

Like all capacitance sensors, the QT113 relies on Kirchoff's Current Law (Figure 1-4) to detect the change in capacitance of the electrode. This law as applied to capacitive sensing requires that the sensor's field current must complete a loop, returning back to its source in order for capacitance to be sensed. Although most designers relate to Kirchoff's law with regard to hardwired circuits, it applies equally to capacitive field flows. By implication it requires that the signal ground and the target object must both be coupled together in some manner for a capacitive sensor to operate properly. Note that there is no need to provide actual hardwired ground connections; capacitive coupling to ground (Cx1) is always sufficient, even if the coupling might seem very tenuous. For example, powering the sensor via an isolated transformer will provide ample ground coupling, since there is capacitance between the windings and/or the transformer core, and from the power wiring itself directly to 'local earth'. Even when battery powered, just the physical size of the PCB and the object into which the electronics is embedded will generally be enough to couple a few picofarads back to local earth.

1.3.3 VIRTUAL CAPACITIVE GROUNDS

When detecting human contact (e.g. a fingertip), grounding of the person is never required. The human body naturally has several hundred picofarads of 'free space' capacitance to the local environment (Cx3 in Figure 1-4), which is more than two orders of magnitude greater than that required to create a return path to the QT113 via earth. The QT113's PCB however can be physically quite small, so there may be little 'free space' coupling (Cx1 in Figure 1-4) between it and the environment to complete the return path. If the QT113 circuit ground cannot be earth grounded by wire, for example via the supply connections, then a 'virtual capacitive ground' may be required to increase return coupling.

Figure 1-3 Mesh Electrode Geometry



A 'virtual capacitive ground' can be created by connecting the QT113's own circuit ground to:

(1) A nearby piece of metal or metallized housing;
(2) A floating conductive ground plane;
(3) A nail driven into a wall;
(4) A larger electronic device (to which its output might be connected anyway).

Free-floating ground planes such as metal foils should maximize exposed surface area in a flat plane if possible. A square of metal foil will have little effect if it is rolled up or crumpled into a ball. Virtual ground planes are more effective and can be made smaller if they are physically bonded to other surfaces, for example a wall or floor.

1.3.4 FIELD SHAPING

The electrode can be prevented from sensing in undesired directions with the assistance of metal shielding connected to circuit ground (Figure 1-5). For example, on flat surfaces, the field can spread laterally and create a larger touch area than desired. To stop field spreading, it is only necessary to surround the touch electrode on all sides with a ring of metal connected to circuit ground; the ring can be on the same or opposite side from the electrode. The ring will kill field spreading from that point outwards.

If one side of the panel to which the electrode is fixed has moving traffic near it, these objects can cause inadvertent detections. This is called 'walk-by' and is caused by the fact that the fields radiate from either surface of the electrode equally well. Again, shielding in the form of a metal sheet or foil connected to circuit ground will prevent walk-by; putting a small air gap between the grounded shield and the electrode will keep the value of Cx lower and is encouraged. In the case of the QT113, sensitivity can be high enough (depending on Cx and Cs) that 'walk-by' signals are a concern; if this is a problem, then some form of rear shielding may be required.

1.3.5 SENSITIVITY

The QT113 can be set for one of 2 gain levels using option pin 5 (Table 1-1). This sensitivity change is made by altering the internal numerical threshold level required for a detection. Note that sensitivity is also a function of other things: like the value of Cs, electrode size, shape, and orientation, the composition and aspect of the object to be sensed, the thickness and composition of any overlaying panel material, and the degree of ground coupling of both sensor and object.

1.3.5.1 Increasing Sensitivity

In some cases it may be desirable to increase sensitivity further, for example when using the sensor with very thick panels having a low dielectric constant.

Sensitivity can often be increased by using a bigger electrode, reducing panel thickness, or altering panel composition. Increasing electrode size can have diminishing returns, as high values of Cx will reduce sensor gain (Figures

Figure 1-4 Kirchoff's Current Law

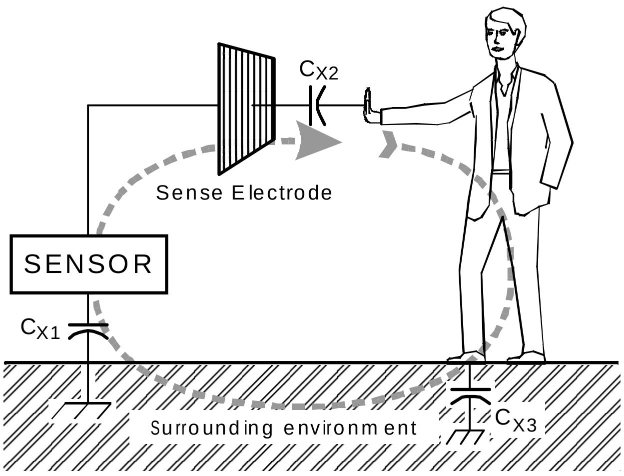
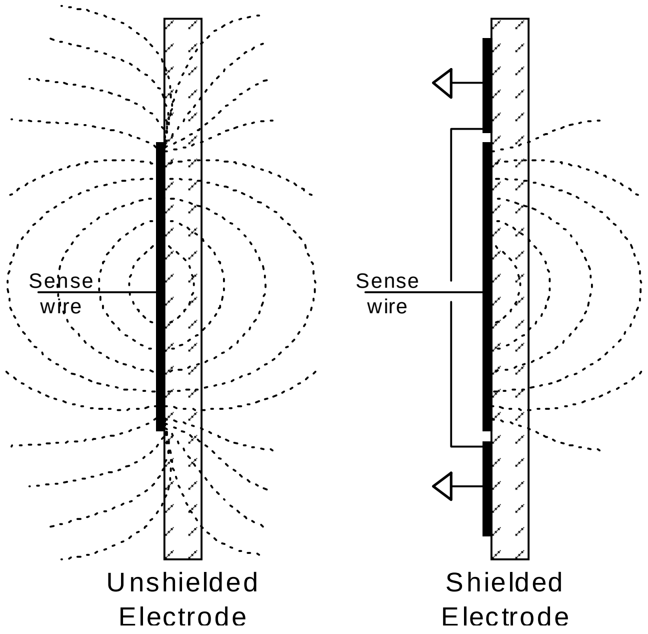


Figure 1-5 Shielding Against Fringe Fields



4-1 to 4-3). The value of Cs also has a dramatic effect on sensitivity, and this can be increased in value (up to a limit). Also, increasing the electrode's surface area will not substantially increase touch sensitivity if its diameter is already much larger in surface area than the object being detected. The panel or other intervening material can be made thinner, but again there are diminishing rewards for doing so. Panel material can also be changed to one having a higher dielectric constant, which will help propagate the field through to the front. Locally adding some conductive material to the panel (conductive materials essentially have an infinite dielectric constant) will also help; for example, adding carbon or metal fibers to a plastic panel will greatly increase frontal field strength, even if the fiber density is too low to make the plastic bulk-conductive.

1.3.5.2 Decreasing Sensitivity

In some cases the QT113 may be too sensitive, even on low gain. In this case gain can be lowered further by a number of strategies: making the electrode smaller, making the electrode into a sparse mesh using a high space-to-conductor ratio (Figure 1-3), or by decreasing Cs.

2 - QT113 SPECIFICS

2.1 SIGNAL PROCESSING

The QT113 processes all signals using 16 bit math, using a number of algorithms pioneered by Quantum. The algorithms are specifically designed to provide for high 'survivability' in the face of numerous adverse environmental changes.

2.1.1 DRIFT COMPENSATION ALGORITHM

Signal drift can occur because of changes in Cx and Cs over time. It is crucial that drift be compensated for, otherwise false detections, non-detections, and sensitivity shifts will follow.

Drift compensation (Figure 2-1) is performed by making the reference level track the raw signal at a slow rate, but only while there is no detection in effect. The rate of adjustment must be performed slowly, otherwise legitimate detections could be ignored. The QT113 drift compensates using a slew-rate limited change to the reference level; the threshold and hysteresis values are slaved to this reference.

Once an object is sensed, the drift compensation mechanism ceases since the signal is legitimately high, and therefore should not cause the reference level to change.

The QT113's drift compensation is 'asymmetric': the reference level drift-compensates in one direction faster than it does in the other. Specifically, it compensates faster for decreasing signals than for increasing signals. Increasing signals should not be compensated for quickly, since an approaching finger could be compensated for partially or entirely before even approaching the sense electrode. However, an obstruction over the sense pad, for which the sensor has already made full allowance for, could suddenly be removed leaving the sensor with an artificially elevated reference level and thus become insensitive to touch. In this latter case, the sensor will compensate for the object's removal very quickly, usually in only a few seconds.

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.

Table 1-1 Gain Setting Strap Options

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

2.1.2 THRESHOLD CALCULATION

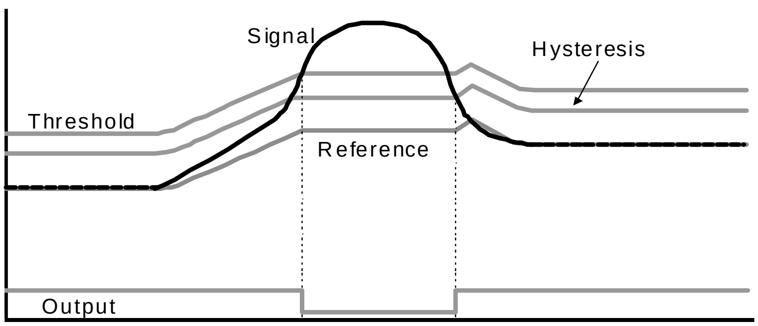
Unlike the QT110 device, the internal threshold level is fixed at one of two setting as determined by Table 1-1. These setting are fixed with respect to the internal reference level, which in turn can move in accordance with the drift compensation mechanism..

The QT113 employs a hysteresis dropout below the threshold level of 17% of the delta between the reference and threshold levels.

2.1.3 MAX ON-DURATION

If an object or material obstructs the sense pad the signal may rise enough to create a detection, preventing further

Figure 2-1 Drift Compensation



operation. To prevent this, the sensor includes a timer which monitors detections. If a detection exceeds the timer setting, the timer causes the sensor to perform a full recalibration (when not set to infinite). This is known as the Max On-Duration feature.

After the Max On-Duration interval, the sensor will once again function normally, even if partially or fully obstructed, to the best of its ability given electrode conditions. There are two finite timeout durations available via strap option: 10 and 60 seconds (Table 2-1).

2.1.4 DETECTION INTEGRATOR

It is desirable to suppress detections generated by electrical noise or from quick brushes with an object. To accomplish this, the QT113 incorporates a detect integration counter that increments with each detection until a limit is reached, after which the output is activated. If no detection is sensed prior to the final count, the counter is reset immediately to zero. In the QT113, the required count is 3.

The Detection Integrator can also be viewed as a 'consensus' filter, that requires three detections in three successive bursts to create an output.

2.1.5 FORCED SENSOR RECALIBRATION

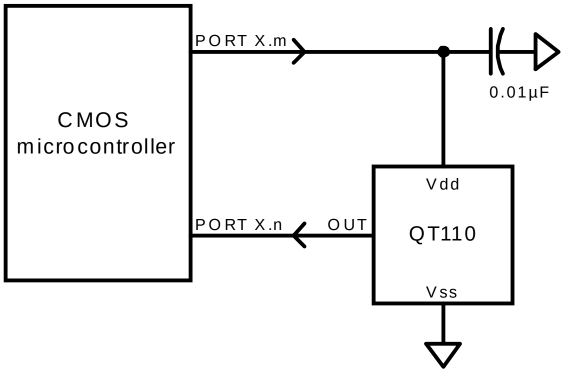
The QT113 has no recalibration pin; a forced recalibration is accomplished only when the device is powered up. However, supply drain is low so it is a simple matter to treat the entire IC as a controllable load; simply driving the QT113's Vdd pin directly from another logic gate or a microcontroller port (Figure 2-2) will serve as both power and 'forced recal'. The source resistance of most CMOS gates and microcontrollers are low enough to provide direct power without problem. Note that most 8051-based micros have only a weak pullup drive capability and will require CMOS buffering. 74HC or 74AC series gates can directly power the QT113, as can most other microcontrollers.

Option strap configurations are read by the QT113 only on powerup. Configurations can only be changed by powering the QT113 down and back up again; again, a microcontroller can directly alter most of the configurations and cycle power to put them in effect.

2.1.6 RESPONSE TIME

The QT113's response time is highly dependent on burst length, which in turn is dependent on Cs and Cx (see Figures 4-1, 4-2). With increasing Cs, response time slows, while increasing levels of Cs reduce response time. Figure 4-3 shows the typical effects of Cs and Cx on response time.

Figure 2-2 Powering From a CMOS Port Pin



2.2 OUTPUT FEATURES

The QT113 is designed for maximum flexibility and can accommodate most popular sensing requirements. These are selectable using strap options on pins OPT1 and OPT2. All options are shown in Table 2-1.

2.2.1 DC MODE OUTPUT

The output of the QT113 can respond in a DC mode, where the output is active-low upon detection. The output will remain active-low for the duration of the detection, or until the Max On-Duration expires (if not infinite), whichever occurs first. If a max on-duration timeout occurs first, the sensor performs a full recalibration and the output becomes inactive until the next detection.

In this mode, three Max On-Duration timeouts are available: 10 seconds, 60 seconds, and infinite.

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

Infinite timeout is useful in applications where a prolonged detection can occur and where the output must reflect the detection no matter how long. In infinite timeout mode, the designer should take care to be sure that drift in Cs, Cx, and Vdd do not cause the device to ‘stick on’ inadvertently even when the target object is removed from the sense field.

2.2.2 TOGGLE MODE OUTPUT

This makes the sensor respond in an on/off mode like a flip flop. It is most useful for controlling power loads, for example in kitchen appliances, power tools, light switches, etc.

Max On-Duration in Toggle mode is fixed at 10 seconds. When a timeout occurs, the sensor recalibrates but leaves the output state unchanged.

2.2.3 HEARTBEAT™ OUTPUT

The QT113 output has a full-time HeartBeat™ ‘health’ indicator superimposed on it. This operates by taking 'Out' into a 3-state mode for 300µs once after every QT burst. This output state can be used to determine that the sensor is operating properly, or, it can be ignored using one of several simple methods.

The HeartBeat indicator can be sampled by using a pulldown resistor on Out, and feeding the resulting negative-going pulse into a counter, flip flop, one-shot, or other circuit. Since Out is normally high, a pulldown resistor will create negative HeartBeat pulses (Figure 2-3) when the sensor is not detecting an object; when detecting an object, the output will remain low for the duration of the detection, and no HeartBeat pulse will be evident.

If the sensor is wired to a microcontroller as shown in Figure 2-4, the microcontroller can reconfigure the load resistor to either ground or Vcc depending on the output state of the QT113, so that the pulses are evident in either state.

Figure 2-3

Getting HearBeat pulses with a pull-down resistor

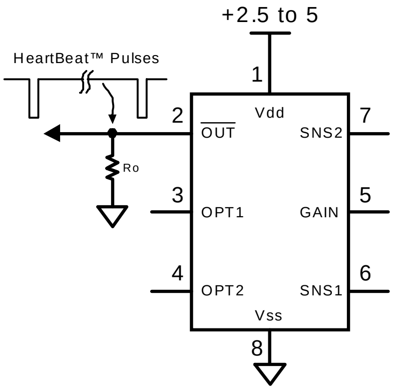
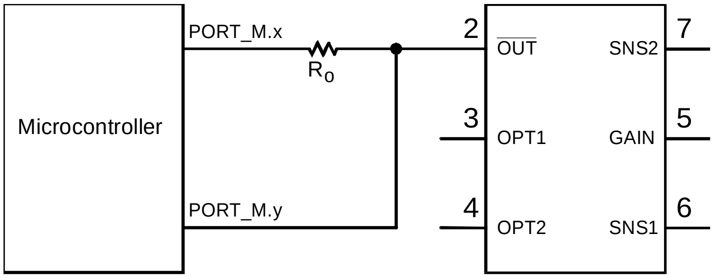


Figure 2-4

Using a micro to obtain HB pulses in either output state



Electromechanical devices like relays will usually ignore this short pulse. The pulse also has too low a duty cycle to visibly affect LED's. It can be filtered completely if desired, by adding an RC timeconstant to filter the output, or if interfacing directly and only to a high-impedance CMOS input, by doing nothing or at most adding a small non-critical capacitor from Out to ground (Figure 2-5).

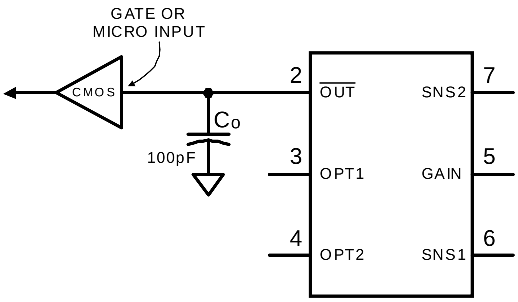
The QT113H variant has an active-high output; the heartbeat signal of the QT113H works in exactly the same manner.

2.2.4 Output Drive

The QT113's `output is active low and can sink up to 5mA of non-inductive current. If an inductive load is used, such as a small relay, the load should be diode clamped to prevent damage. When set to operate in a proximity mode (at high gain) the current should be limited to 1mA to prevent gain shifting side effects from occurring, which happens when the load current creates voltage drops on the die and bonding wires; these small shifts can materially influence the signal level to cause detection instability as described below.

Care should be taken when the QT113 and the load are both powered from the same supply, and the supply is minimally regulated. The QT113 derives its internal references from the power supply, and sensitivity shifts can occur with changes in Vdd, as happens when loads are switched on. This can induce detection 'cycling', whereby an object is detected, the load is turned on, the supply sags, the detection is no longer sensed, the load is turned off, the supply rises and the object is reacquired, *ad infinitum*. To prevent this occurrence, the output should only be lightly loaded if the device is operated from an unregulated supply, e.g. batteries. Detection 'stiction', the opposite effect, can occur if a load is *shed* when Out is active.

Figure 2-5 Eliminating HB Pulses



The output of the QT113 can directly drive a resistively limited LED. The LED should be connected with its cathode to the output and its anode towards Vcc, so that it lights when the sensor is active. If desired the LED can be connected from Out to ground, and driven on when the sensor is inactive.

The QT113H variant has an active-high output.

3 - CIRCUIT GUIDELINES

3.1 SAMPLE CAPACITOR

Charge sampler Cs can be virtually any plastic film or medium-K ceramic capacitor. The acceptable Cs range is from 10nF to 500nF depending on the sensitivity required; larger values of Cs demand higher stability to ensure reliable sensing. Acceptable capacitor types include polycarbonate, PPS film, or NPO/C0G ceramic.

3.2 OPTION STRAPPING

The option pins Opt1 and Opt2 should never be left floating. If they are floated, the device will draw excess power and the options will not be properly read on powerup. Intentionally, there are no pullup resistors on these lines, since pullup resistors add to power drain if tied low.

The Gain input should be connected to either Vdd or Gnd.

Tables 1-1 and 2-1 show the option strap configurations available.

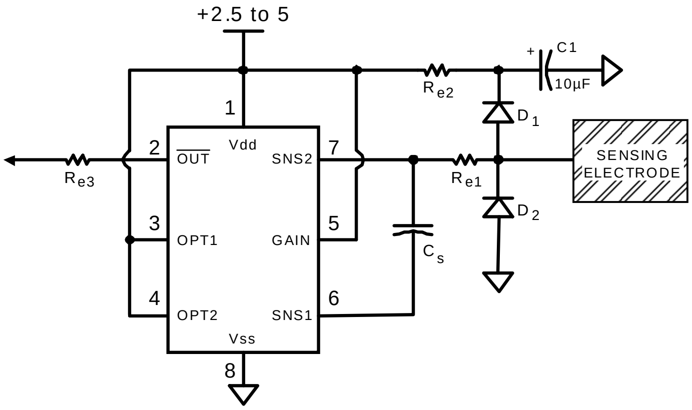
3.4 POWER SUPPLY, PCB LAYOUT

The power supply can range from 2.5 to 5.0 volts. At 3 volts current drain averages less than 600µA in most cases, but can be higher if Cs is large. Increasing Cx values will actually *decrease* power drain. Operation can be from batteries, but be cautious about loads causing supply droop (see *Output Drive*, previous section).

As battery voltage sags with use or fluctuates slowly with temperature, the QT113 will track and compensate for these changes automatically with only minor changes in sensitivity.

If the power supply is shared with another electronic system, care should be taken to assure that the supply is free of

Figure 3-1 ESD Suppression Circuit



digital spikes, sags, and surges which can adversely affect the QT113. The QT113 will track slow changes in Vdd, but it can be affected by rapid voltage steps.

if desired, the supply can be regulated using a conventional low current regulator, for example CMOS regulators that have low quiescent currents.

3.5 ESD PROTECTION

In cases where the electrode is placed behind a dielectric panel, the QT113 will usually be adequately protected from direct static discharge. However, even with a plastic or glass panel, transients can still flow into the electrode via induction, or in extreme cases, via dielectric breakdown. Porous materials may allow a spark to tunnel right through the material; partially conducting materials like 'pink poly' will conduct the ESD right to the electrode. Testing is required to reveal any problems. The QT113 does have diode protection on its terminals which can absorb and protect the device from most induced discharges, up to 20mA; the usefulness of the internal clamping will depending on the dielectric properties, panel thickness, and rise time of the ESD transients.

ESD dissipation can be aided further with an added diode protection network as shown in Figure 3-1, in extreme cases. Because the charge and transfer times of the QT113 are relatively long, the circuit can tolerate very large values of Re, even to 100k ohms in most cases where electrode Cx is small. The added diodes shown (1N4150 or equivalent low-C diodes, or a single BAV99 dual-diode) will shunt the ESD transients away from the part, and Re1 will current limit the rest into the QT113's own internal clamp diodes. C1 should be around 10µF if it is to absorb positive transients from a human body model standpoint without rising in value by more than 1 volt. If desired C1 can be replaced with an appropriate Zener diode. Directly placing semiconductor transient protection devices, Zeners, or MOV's on the sense lead is not advised; these devices have extremely large amounts of unstable parasitic C which will swamp the QT113 and render it useless.

Re1 should be as large as possible given the load value of Cx and the diode capacitances of D1 and D2, but Re1 should be low enough to permit at least 6 timeconstants of RC to occur during the charge and transfer phases.

Re2 functions to isolate the transient from the QT113's Vdd pin; values of around 1K ohms are reasonable.

As with all ESD protection networks, it is crucial that the transients be led away from the circuit. PCB ground layout is crucial; the ground connections to D1, D2, and C1 should all go back to the power supply ground or preferably, if available, a chassis ground connected to earth. The currents should not be allowed to traverse the area directly under the QT113.

If the QT113 is connected to an external circuit via a cable or long twisted pair, it is possible for ground-bounce to cause damage to the Out pin; even though the transients are led away from the QT113 itself, the connected signal or power ground line will act as an inductor, causing a high differential voltage to build up on the Out wire with respect to ground. If this is a possibility, the Out pin should have a resistance Re3 in series with it to limit current; this resistor should be as large as can be tolerated by the load.

4.1 ABSOLUTE MAXIMUM SPECIFICATIONS

Operating temp	as designated by suffix
Storage temp	-55°C to +125°C
V_{DD}	-0.5 to +6.5V
Max continuous pin current, any control or drive pin	±20mA
Short circuit duration to ground, any pin	infinite
Short circuit duration to V_{DD}, any pin	infinite
Voltage forced onto any pin	-0.6V to (Vdd + 0.6) Volts

4.2 RECOMMENDED OPERATING CONDITIONS

V_{DD}	+2.5 to 5.5V
Short-term supply ripple+noise	±5mV
Long-term supply stability	±100mV
Cs value	10nF to 500nF
Cx value	0 to 100pF

4.3 AC SPECIFICATIONS

Vdd = 3.0, Ta = recommended operating range**, Cs=100nF unless noted**

Parameter	Description	Min	Typ	Max	Units	Notes
T_{RC}	Recalibration time		550		ms	
T_{PC}	Charge duration		2		µs	
T_{PT}	Transfer duration		2		µs	
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		30		ms	Cx = 10pF; See Figure 4-3
T_{HB}	Heartbeat pulse width		300		µs	

4.4 SIGNAL PROCESSING

Description	Min	Typ	Max	Units	Notes
Threshold differential		6 or 12		counts	Option pin selected
Hysteresis		17		%	Note 1
Consensus filter length		3		samples	
Positive drift compensation rate		1,000		ms/level	
Negative drift compensation rate		100		ms/level	
Post-detection recalibration timer duration		10, 60, infinite		secs	Option pin selected

Note 1: Percentage of signal threshold

4.5 DC SPECIFICATIONS

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

Parameter	Description	Min	Typ	Max	Units	Notes
V_{DD}	Supply voltage	2.45		5.25	V	
I_{DD}	Supply current		600	1,500	µA	
V_{DDS}	Supply turn-on slope	100			V/s	Required for proper startup
V_{IL}	Low input logic level			0.8	V	OPT1, OPT2
V_{HL}	High input logic level	2.2			V	OPT1, OPT2
V_{OL}	Low output voltage			0.6	V	OUT, 4mA sink
V_{OH}	High output voltage	Vdd-0.7			V	OUT, 1mA source
I_{IL}	Input leakage current			±1	µA	OPT1, OPT2
C_X	Load capacitance range	0		100	pF	
I_X	Min shunt resistance		1M		Ω	Resistance from SNS1 to SNS2
A_R	Acquisition resolution			14	bits	
S	Sensitivity range	1,000		28	fF	Note 2

Note 2: Sensitivity depends on value of Cx and Cs. Refer to Figures 4-1, 4-2.

Figure 4-1 - Typical Threshold Sensitivity vs. Cx, High Gain, at Selected Values of Cs; Vdd = 3.0

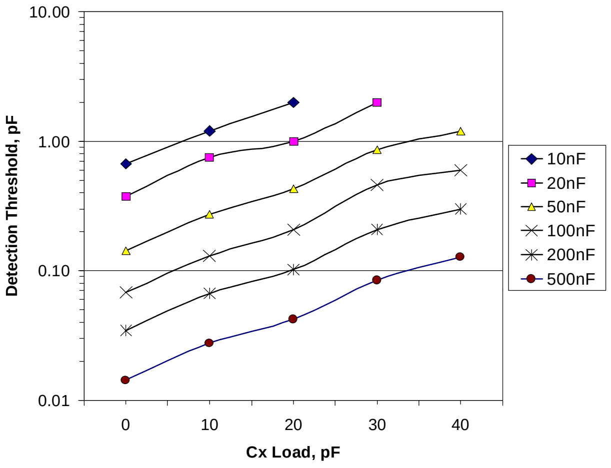


Figure 4-2 - Typical Threshold Sensitivity vs. Cx, Low Gain, at Selected Values of Cs; Vdd = 3.0

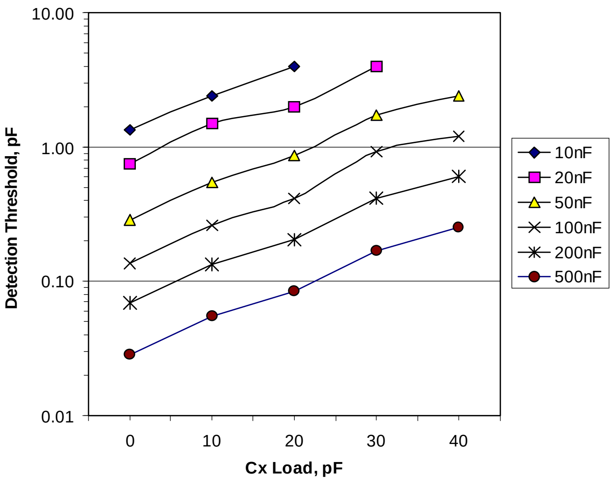
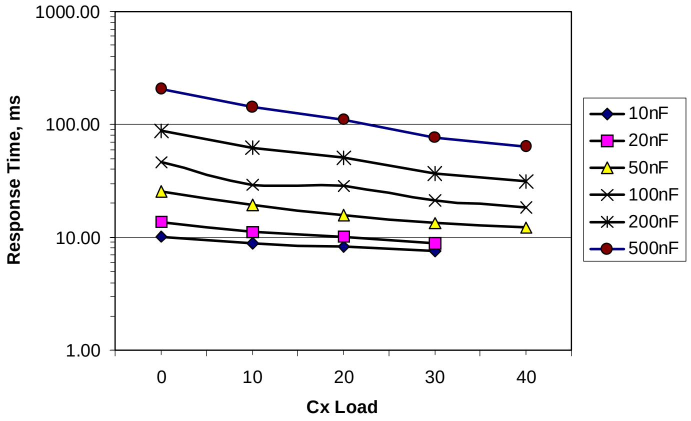
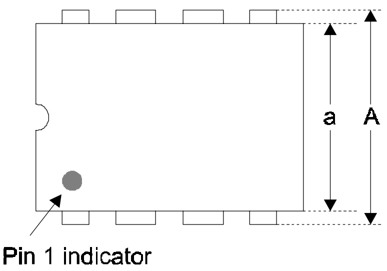


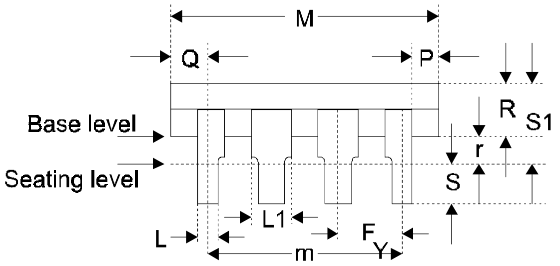
Chart 4-3 - Typical Response Time vs. Cx;
Vdd = 3.0

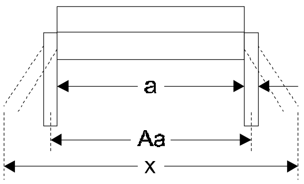


5 ORDERING INFORMATION

PART	TEMP RANGE	PACKAGE	MARKING
QT113-D	0 - 70C	PDIP	QT1 + 13
QT113-S	0 - 70C	SOIC-8	QT1 + 3
QT113-IS	-40 - 85C	SOIC-8	QT1 + F
QT113H-D	0 - 70C	PDIP	QT1 + 13H
QT113H-S	0 - 70C	SOIC-8	QT1 + E
QT113H-IS	-40 - 85C	SOIC-8	QT1 + K

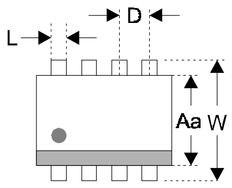


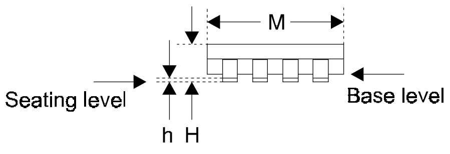


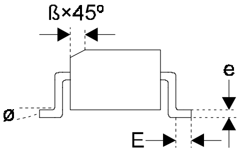


Package type: 8-pin Dual-In-Line

SYMBOL	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
a	6.096	7.112		0.24	0.28	
A	7.62	8.255		0.3	0.325	
M	9.017	10.922	Typical	0.355	0.43	Typical
m	7.62	7.62	BSC	0.3	0.3	BSC
Q	0.889	-		0.035	-	
P	0.254	-		0.01	-	
L	0.355	0.559		0.014	0.022	
L1	1.397	1.651		0.055	0.065	
F	2.489	2.591	Typical	0.098	0.102	Typical
R	3.048	3.81		0.12	0.15	
r	0.381	-		0.015	-	
S	3.048	3.556		0.12	0.14	
S1	-	4.064		-	0.16	
Aa	7.62	7.062	BSC	0.3	0.3	BSC
x	8.128	9.906		0.32	0.39	
Y	0.203	0.381		0.008	0.015	







Package type: 8-pin SOIC

SYMBOL	Millimeters			Inches		
	Min	Max	Notes	Min	Max	Notes
M	4.800	4.979		0.189	0.196	
W	5.816	6.198		0.229	0.244	
Aa	3.81	3.988		0.15	0.157	
H	1.371	1.728		0.054	0.068	
h	0.101	0.762		0.004	0.01	
D	1.27	1.27	BSC	0.050	0.05	BSC
L	0.355	0.483		0.014	0.019	
E	0.508	1.016		0.02	0.04	
e	0.19	0.249		0.007	0.01	
ß	0.381	0.762		0.229	0.03	
Ø	0º	8º		0º	8º	

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