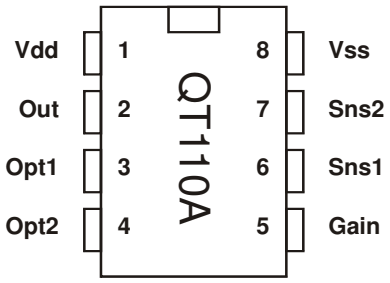
QT110A-ISG

NOT RECOMMENDED FOR NEW DESIGNS

- Less expensive than many mechanical switches
- Projects a 'touch button' through any dielectric
- 100% autocal for life - no adjustments required
- No active external components
- Piezo sounder direct drive for 'tactile' click feedback
- LED drive for visual feedback
- 2 ~ 5V single supply operation
- 10µA at 2.5V - very low power drain
- Toggle mode for on/off control (via option pins)
- 10s or 60s auto-recalibration timeout (via option pins)
- Pulse output mode (via option pins)
- Gain settings in 3 discrete levels
- Simple 2-wire operation possible
- HeartBeat™ health indicator on output
- Pb-Free packages



The QT110A is a Flash version of the QT110. The QT110A is form, fit and function compatible with the older device, except that the QT110A is more sensitive than the older device, necessitating a significant reduction in Cs capacitance.
See Section 1 on page 2 for differences.

This device is intended as a replacement for the QT110, and is not recommended for new designs.

For further device migration plans please consult your local Atmel or Quantum representative.

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1 - OVERVIEW

The QT110A is intended to replace the QT110 as a lower cost alternative. This device functions identically to the QT110, except that it is more sensitive. To compensate for the sensitivity increase, it is required to do either of these two things:

1. Increase the Cx loading to ground on SNS2 by 10pF
2. Decrease the Cs value

Option 1 is very simple and guarantees that the sensitivity of the QT110A is identical to the older device. Option 2 requires some trial and error to test the sensitivity of the touch pad or prox field, so that it is about the same as before. Cs changes ranging from 10 to 60% may be required depending on the circuit layout and electrode design.

All other aspects of this datasheet are identical to the QT110 datasheet except for this section, the specification changes on pages 8 and 9, and the part marking.

1.1 BASIC OPERATION

The QT110A employs low duty cycle bursts of charge-transfer cycles to acquire its signal. Burst mode permits power consumption in the low microamp range, dramatically reduces EMC problems, and yet permits excellent response time. Internally the signals are digitally processed to reject impulse noise, using a 'consensus' filter which requires four consecutive confirmations of a detection before the output is activated.

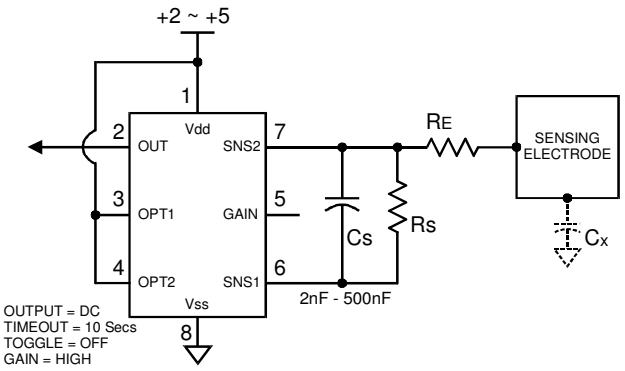
The QT switches and charge measurement hardware functions are all internal to the QT110A (Figure 1-3). A single-slope switched capacitor ADC includes both the required QT charge and transfer switches in a configuration that provides direct ADC conversion. Vdd is used as the charge reference voltage.

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.

The IC is highly tolerant of changes in Cs since it computes the signal threshold level ratiometrically. Cs is thus non-critical and can be an X7R type. As Cs changes with temperature, the internal drift compensation mechanism also adjusts for the drift automatically.

Piezo sounder drive: The QT110A can drive a piezo sounder after a detection for feedback. The piezo sounder replaces or augments the Cs capacitor; this works since piezo sounders are also capacitors, albeit with a large thermal drift coefficient. If C_{piezo} is in the proper range, no additional capacitor is required. If C_{piezo} is too small, it can simply be 'topped up' with a ceramic capacitor in parallel. The QT110A drives a ~4kHz signal across SNS1 and SNS2 to make the piezo (if installed) sound a short tone for 75ms immediately after detection, to act as an audible confirmation.

Figure 1-1 Standard mode options



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

1.2 ELECTRODE DRIVE

The internal ADC treats Cs as a floating transfer capacitor; as a direct result, the sense electrode can in theory be connected to either SNS1 or SNS2 with no performance difference. However, the noise immunity of the device is improved by connecting the electrode to SNS2, preferably via a series resistor Re (Figure 1-1) to roll off higher harmonic frequencies, both outbound and inbound.

In order to reduce power consumption and to assist in discharging Cs between acquisition bursts, a 470K series resistor Rs should be connected across Cs (Figure 1-1).

The rule Cs >> Cx must be observed for proper operation. Normally Cx is on the order of 10pF or so, while Cs might be 10nF (10,000pF), or a ratio of about 1:1000.

It is important to minimize the amount of unnecessary stray capacitance Cx, for example by minimizing trace lengths and widths and backing off adjacent ground traces and planes so as keep gain high for a given value of Cs, 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.

1.3 ELECTRODE DESIGN

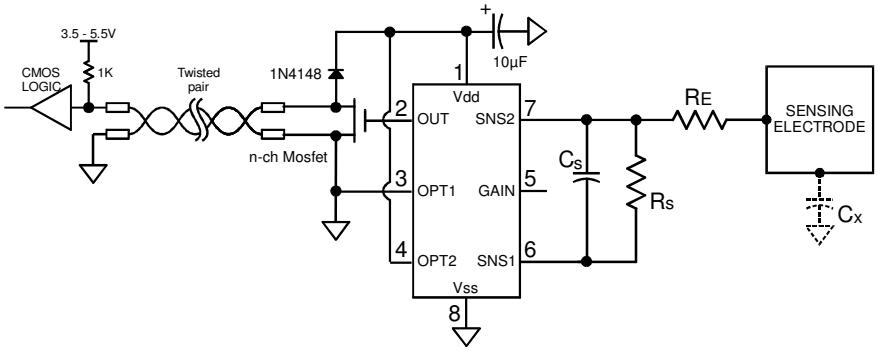
1.3.1 Electrode Geometry and Size

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 QT110A 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.

1.3.2 Kirchoff's Current Law

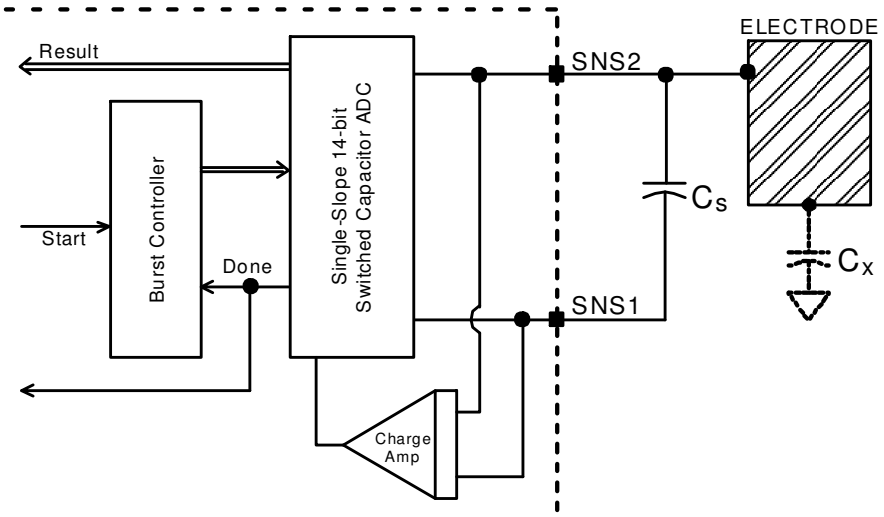
Like all capacitance sensors, the QT110A relies on Kirchoff's Current Law (Figure 1-5) to detect the change in capacitance of the electrode. This law as applied to capacitive sensing

Figure 1-2 2-wire operation, self-powered



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.

Figure 1-3 Internal Switching & Timing



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 1-3), which is more than two orders of magnitude greater than that required to create a return path to the QT110A via earth. The QT110A's PCB however can be physically quite small, so there may be little 'free space' coupling (Cx1 in Figure 1-3) between it and the environment to complete the return path. If the QT110A 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.

A 'virtual capacitive ground' can be created by connecting the QT110A's own circuit ground to:

- A nearby piece of metal or metallized housing;
- A floating conductive ground plane;
- Another electronic device (to which its might be connected already).

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 Sensitivity

The QT110A can be set for one of 3 gain levels using option pin 5 (Table 1-1). If left open, the gain setting is high. The sensitivity change is made by altering the numerical threshold level required for a detection. It is also a function of other things: 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 are all influences.

Gain plots of the device are shown on page 9.

Table 1-1 Gain Strap Options

Gain	Tie Pin 5 to:
High	Leave open
Medium	Pin 6
Low	Pin 7

The Gain input should never be tied to anything other than SNS1 or SNS2, or left unconnected (for high gain setting).

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.

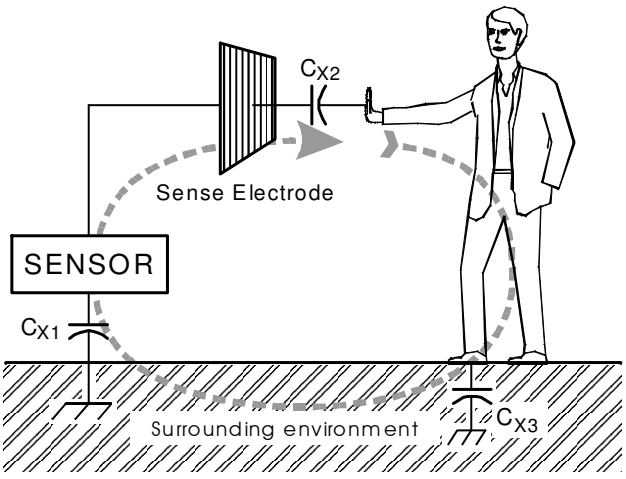
Sensitivity can often be increased by using a bigger electrode, reducing panel thickness, or altering panel composition to one having a higher dielectric constant. Increasing electrode size can have diminishing returns, as high values of Cx will reduce sensor gain.

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. Metal areas near the electrode will reduce the field strength and increase Cx loading and are to be avoided for maximal gain.

Ground planes around and under the electrode and its SNS trace will cause high Cx loading and destroy gain. The possible signal-to-noise ratio benefits of ground area are more than negated by the decreased gain from the circuit, and so ground areas around electrodes are discouraged. Keep ground, power, and other signals traces away from the electrodes and SNS wiring.

The value of Cs has a minimal effect on sensitivity with these devices, but if the Cs value is too low there can be a sharp drop-off in sensitivity.

Figure 1-5 Kirchoff's Current Law



2 - QT110A SPECIFICS

2.1 SIGNAL PROCESSING

The QT110A processes all signals using a number of algorithms pioneered by Quantum. The algorithms are specifically designed to provide for high 'survivability' in the face of all kinds of 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. Cs drift has almost no effect on gain since the threshold method used is ratiometric. However Cs drift can still cause false detections if the drift occurs rapidly.

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 QT110A 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 QT110A'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 touching the sense pad. 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.

2.1.2 Threshold Calculation

Sensitivity is dependent on the threshold level as well as ADC gain; threshold in turn is based on the internal signal reference level plus a small differential value. The threshold value is established as a percentage of the absolute signal level. Thus, sensitivity remains constant even if Cs is altered dramatically, so long as electrode coupling to the user remains constant. Furthermore, as Cx and Cs drift, the threshold level is automatically recomputed in real time so that it is never in error.

The QT110A employs a hysteresis dropout below the threshold level of 50% of the delta between the reference and threshold levels.

The threshold setting is determined by option jumper; see Section 1.3.4.

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 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. 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 nominal timeout durations available via strap option: 10 and 60 seconds. The accuracy of these timeouts is approximate.

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 QT110A 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 QT110A, the required count is 4.

The Detection Integrator can also be viewed as a 'consensus' filter, that requires four detections in four successive bursts to create an output. As the basic burst spacing is 75ms, if this spacing was maintained throughout all 4 counts the sensor would react very slowly. In the QT110A, after an initial detection is sensed, the remaining three bursts are spaced about 20ms apart, so that the slowest reaction time possible is 75+20+20+20 or 135ms and the fastest possible is 60ms, depending on where in the initial burst interval the contact first occurred. The response time will thus average about 95ms.

2.1.5 Forced Sensor Recalibration

The QT110A has no recalibration pin; a forced recalibration is accomplished only when the device is powered up. However, the supply drain is so low it is a simple matter to treat the entire IC as a controllable load; simply driving the QT110A's Vdd pin directly from another logic gate or a microprocessor port (Figure 2-2) will serve as both power and 'forced recal'. The source resistance of most CMOS gates and microprocessors is low enough to provide direct power without any problems. Almost any CMOS logic gate can directly power the QT110A.

A 0.01uF minimum bypass capacitor close to the device is essential; without it the device can break into high frequency oscillation.

Option strap configurations are read by the QT110A only on powerup. Configurations can only be changed by powering the QT110A down and back up again; again, a microcontroller can directly alter most of the configurations and cycle power to put them in effect.

2.2 OUTPUT FEATURES

The devices are 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.

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 the pin(s) are tied low.

2.2.1 DC Mode Output

The output of the device can respond in a DC mode, where the output is active-low upon detection. The output will remain active for the duration of the detection, or until the Max

Figure 2-1 Drift Compensation

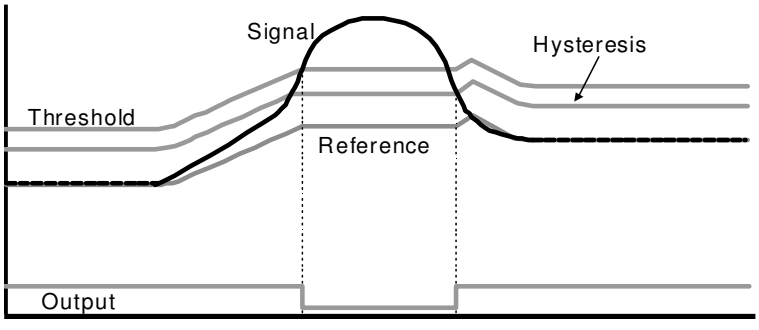


Figure 2-2 Powering From a CMOS Port Pin

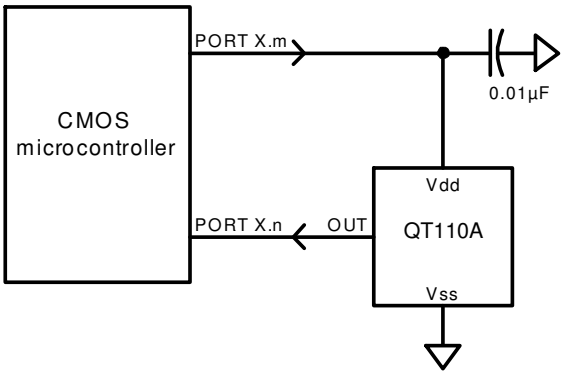
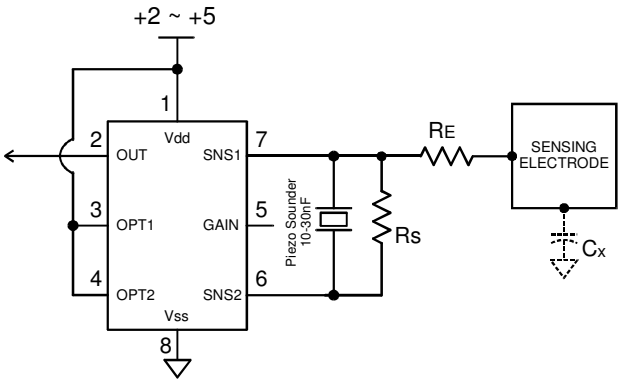


Figure 2-3 Damping Piezo Clicks with Rs



On-Duration expires, whichever occurs first. If the latter occurs first, the sensor performs a full recalibration and the output becomes inactive until the next detection.

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

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.

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
Pulse	Gnd	Vdd	10s

2.2.3 Pulse Mode Output

This mode generates a negative pulse of 75ms duration with every new detection. It is most useful for 2-wire operation, but can also be used when bussing together several devices onto a common output line with the help of steering diodes or logic gates, in order to control a common load from several places.

Max On-Duration is fixed at 10 seconds if in Pulse output mode.

Note that the beeper drive does not operate in Pulse mode.

2.2.4 Piezo Acoustic Drive

A piezo drive signal is generated for use with a piezo sounder immediately after a detection is made; the tone lasts for a nominal 95ms to create a ‘tactile feedback’ sound.

The sensor drives the piezo using an H-bridge configuration for the highest possible sound level. The piezo is connected across pins SNS1 and SNS2 in place of Cs or in addition to a parallel Cs capacitor. The piezo sounder should be selected to have a peak acoustic output in the 3.5kHz to 4.5kHz region.

Since piezo sounders are merely high-K ceramic capacitors, the sounder will double as the Cs capacitor, and the piezo's metal disc can even act as the sensing electrode. Piezo transducer capacitances typically range from 6nF to 30nF in value; at the lower end of this range an additional capacitor should be added to bring the total Cs across SNS1 and SNS2 to at least 10nF, or possibly more if Cx is above 5pF

Piezo sounders have very high, uncharacterized thermal coefficients and should not be used if fast temperature swings are anticipated, especially at high gains. They are also generally unstable at high gains; even if the total value of Cs is largely from an added capacitor the piezo can cause periodic false detections.

The burst acquisition process induces a small but audible voltage step across the piezo resonator, which occurs when SNS1 and SNS2 rapidly discharge residual voltage stored on the resonator. The resulting slight clicking sound can be greatly reduced by placing a 470K resistor Rs in parallel with the resonator; this acts to slowly discharge the resonator, attenuating of the harmonic-rich audible step (Figure 2-3).

Note that the piezo drive does not operate in Pulse mode.

2.2.5 HeartBeat™ Output

The output has a full-time HeartBeat™ ‘health’ indicator superimposed on it. This operates by taking 'Out' into a 3-state mode for 350µs once before 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 2-4) when the sensor is not detecting an object; when detecting an object, the output will remain active 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 2-5, the controller can reconfigure the load resistor to either ground or Vcc depending on the output state of the device, so that the pulses are evident in either state.

Electromechanical devices will usually ignore this short pulse. The pulse also has too low a duty cycle to visibly activate 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 2-6).

2.2.6 Output Drive

The QT110A’s output is active low ; it can source 1mA or sink 5mA of non-inductive current.

Care should be taken when the IC and the load are both powered from the same supply, and the supply is minimally regulated. The device 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,

Figure 2-4
Getting HB pulses with a pull-down resistor

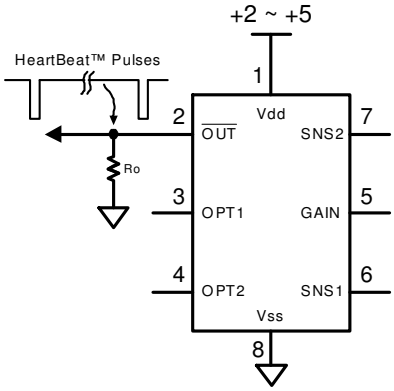
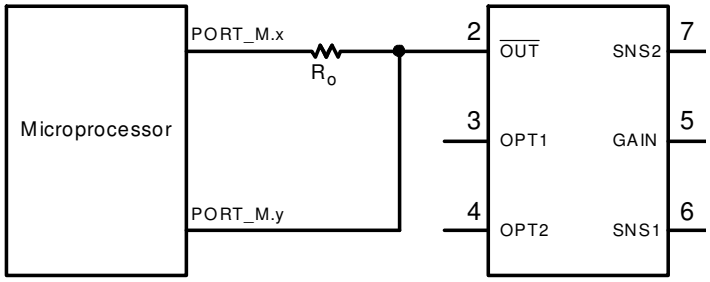


Figure 2-5
Using a micro to obtain HB pulses in either output state



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.

The output of the QT110A 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-low. If desired the LED can be connected from Out to ground, and driven on when the sensor is inactive, but only with less drive current (1mA).

3 - CIRCUIT GUIDELINES

3.1 SAMPLE CAPACITOR

When used for most applications, the charge sampler Cs can be virtually any plastic film or good quality ceramic capacitor. The type should be relatively stable in the anticipated temperature range. If fast temperature swings are expected, especially at higher sensitivity, a more stable capacitor might be required for example PPS film.

In most moderate applications a low-cost X7R type will work fine.

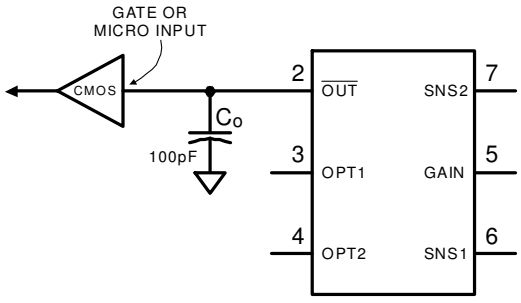
3.2 ELECTRODE WIRING

See also Section 3.4.

The wiring of the electrode and its connecting trace is important to achieving high signal levels and low noise. Certain design rules should be adhered to for best results:

1. Use a ground plane under the IC itself and Cs and Rs but NOT under Re, or under or closely around the electrode or its connecting trace. Keep ground away from these things to reduce stray loading (which will dramatically reduce sensitivity).
2. Keep Cs, Rs, and Re very close to the IC.
3. Make Re as large as possible. As a test, check to be sure that an increase of Re by 50% does not appreciably decrease sensitivity; if it does, reduce Re until the 50% test increase has a negligible effect on sensitivity.
4. Do not route the sense wire near other 'live' traces containing repetitive switching signals; the sense trace will pick up noise from them.

Figure 2-6 Eliminating HB Pulses



3.3 POWER SUPPLY, PCB LAYOUT

See also Section 3.4.

The power supply can range from 2 to 5.0 volts. At 2.5 volts current drain averages less than 10µA with Cs = 10nF, provided a 470K Rs resistor is used (Figure 2-6). Idd curves are shown in Figure 4-4.

Higher values of Cs will raise current drain. Higher Cx values can actually *decrease* power drain. Operation can be from batteries, but be cautious about loads causing supply droop (see *Output Drive*, Section 2.2.6) if the batteries are unregulated.

As battery voltage sags with use or fluctuates slowly with temperature, the IC 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 digital spikes, sags, and surges which can adversely affect the device. The IC 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 LDO regulators that have nanoamp quiescent currents. Care should be taken that the regulator does not have a minimum load specification, which almost certainly will be violated by the QT110A's low current requirement. Furthermore, some LDO regulators are unable to provide adequate transient regulation between the quiescent and acquire states, creating Vdd disturbances that will interfere with the acquisition process. This can usually be solved by adding a small extra load from Vdd to ground, such as 10K ohms, to provide a minimum load on the regulator.

Conventional non-LDO type regulators are usually more stable than slow, low power CMOS LDO types. Consult the regulator manufacturer for recommendations.

For proper operation a 100nF (0.1uF) ceramic bypass capacitor must be used between Vdd and Vss; the bypass cap

should be placed very close to the device's power pins. Without this capacitor the part can break into high frequency oscillation, get physically hot, stop working, or become damaged.

PCB Cleanliness: All capacitive sensors should be treated as highly sensitive circuits which can be influenced by stray conductive leakage paths. QT devices have a basic resolution in the femtofarad range; in this region, there is no such thing as 'no clean flux'. Flux absorbs moisture and becomes conductive between solder joints, causing signal drift and resultant false detections or temporary loss of sensitivity. Conformal coatings will trap in existing amounts of moisture which will then become highly temperature sensitive.

The designer should strongly consider ultrasonic cleaning as part of the manufacturing process, and in more extreme cases, the use of conformal coatings after cleaning and baking.

3.3.1 Supply Current

Measuring average power consumption is a challenging task due to the burst nature of the device's operation. Even a good quality RMS DMM will have difficulty tracking the relatively slow burst rate, and will show erratic readings.

The easiest way to measure Idd is to put a very large capacitor, such as 2,700µF across the power pins, and put a 220 ohm resistor from there back to the power source. Measure the voltage across the 220 resistor with a DMM and compute the current based on Ohm's law. This circuit will average out current to provide a much smoother reading.

To reduce the current consumption the most, use high or low gain pin settings only, the smallest value of Cs possible that works, and a 470K resistor (Rs) across Cs (Figure 1-1). Rs acts to help discharge capacitor Cs between bursts, and its presence substantially reduces power consumption.

3.3.2 ESD Protection

In cases where the electrode is placed behind a dielectric panel, the IC will be protected from direct static discharge. However even with a 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. Testing is required to reveal any problems. The device has diode protection on its terminals which will absorb and protect the device from most ESD events; the usefulness of the internal clamping will depending on the dielectric properties, panel thickness, and rise time of the ESD transients.

The best method available to suppress ESD and RFI is to insert a series resistor Re in series with the electrode as shown in Figure 1-1. The value should be the largest that does not affect sensing performance. If Re is too high, the gain of the sensor will decrease.

Because the charge and transfer times of the QT110A are relatively long (~2µs), the circuit can tolerate a large value of Re, often more than 10k ohms in most cases.

Diodes or semiconductor transient protection devices or MOV's on the electrode trace are not advised; these devices have extremely large amounts of nonlinear parasitic capacitance which will swamp the capacitance of the electrode and cause false detections and other forms of instability. Diodes also act as RF detectors and will cause serious RF immunity problems.

3.4 EMC AND RELATED NOISE ISSUES

External AC fields (EMI) due to RF transmitters or electrical noise sources can cause false detections or unexplained shifts in sensitivity.

The influence of external fields on the sensor is reduced by means of the Rseries described in Section 3.2. The Cs capacitor and Rseries (Figure 1-1) form a natural low-pass filter for incoming RF signals; the roll-off frequency of this network is defined by -

$$F_R = \frac{1}{2\pi R_{series} C_s}$$

If for example Cs = 22nF, and Rseries = 10K ohms, the rolloff frequency to EMI is 723Hz, vastly lower than any credible external noise source (except for mains frequencies i.e. 50 / 60 Hz). However, Rseries and Cs must both be placed very close to the body of the IC so that the lead lengths between them and the IC do not form an unfiltered antenna at very high frequencies.

PCB layout, grounding, and the structure of the input circuitry have a great bearing on the success of a design to withstand electromagnetic fields and be relatively noise-free.

These design rules should be adhered to for best ESD and EMC results:

1. Use only SMT components.
2. Keep Cs, Rs, Re and Vdd bypass cap close to the IC.
3. Maximize Re to the limit where sensitivity is not affected.
4. Do not place the electrode or its connecting trace near other traces, or near a ground plane.
5. Do use a ground plane under and around the QT110A itself, back to the regulator and power connector (but not beyond the Cs capacitor).
6. Do not place an electrode (or its wiring) of one QT11x device near the electrode or wiring of another device, to prevent cross interference.
7. Keep the electrode (and its wiring) away from other traces carrying AC or switched signals.
8. If there are LEDs or LED wiring near the electrode or its wiring (ie for backlighting of the key), bypass the LED wiring to ground on both its ends.
9. Use a voltage regulator just for the QT110A to eliminate noise coupling from other switching sources via Vdd. Make sure the regulator's transient load stability provides for a stable voltage just before each burst commences.

For further tips on construction, PCB design, and EMC issues browse the application notes and faq at **www.qprox.com**

4.1 ABSOLUTE MAXIMUM SPECIFICATIONS

Operating temp. . . . . -40 - 85C
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}. . . . . +2.0 to 5.5V
Supply ripple+noise. . . . . 10mV p-p max
Max Cx load capacitance. 100pF
Cs value. . . . . 4.7nF ~ 22nF X7R ceramic
Rs value. 470K 5%

4.3 AC SPECIFICATIONS

Vdd = 3.0, Cs = 10nF, Rs = 470K, Cx = 20pF, Ta = 20°C, unless otherwise noted.

Parameter	Description	Min	Typ	Max	Units	Notes
T_{RC}	Recalibration time		550		ms	
T_Q	Charge, transfer duration		2		µs	
T_{BS}	Burst spacing interval		75 95		ms ms	@ 5.0V Vdd @ 3.3V Vdd
T_{BL}	Burst length	0.5		7	ms	
T_R	Response time		129		ms	
F_P	Piezo drive frequency	3.6	4	4.4	kHz	
T_P	Piezo drive duration		75		ms	
T_{PO}	Pulse output width on Out		75		ms	
T_{HB}	Heartbeat pulse width		300		µs	
F_Q	Burst frequency		165		kHz	

4.4 SIGNAL PROCESSING

Vdd = 3.0, Cs = 10nF, Rs = 470K, Cx = 20pF, Ta = 20°C, unless otherwise noted.

Description	Min	Typ	Max	Units	Notes
Threshold differential, high gain		3.1		%	Note 1
Threshold differential, medium gain		4.7		%	Note 1
Threshold differential, low gain		6.25		%	Note 1
Hysteresis		50		%	Note 2
Consensus filter length		4		samples	
Positive drift compensation rate		750		ms/level	
Negative drift compensation rate		75		ms/level	
Post-detection recalibration timer duration	10		60	secs	Note 3

Note 1: Of absolute full scale signal
Note 2: Of signal threshold
Note 3: Strap option.

4.5 DC SPECIFICATIONS

Vdd = 3.0, Cs = 10nF, Rs = 470K, Cx = 20pF, Gain = High, Ta = 20°C, unless otherwise noted.

Parameter	Description	Min	Typ	Max	Units	Notes
V_{DDL}	Guaranteed min Vdd			2.45	V	
I_{DD}	Supply current		26 12 9.5		µA µA µA	@5.0V @3.3V @2.5V
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
A_R	Acquisition resolution		8		bits	
S[1]	Sensitivity - high gain		1.2		pF	Cx = 20pF, Cs = 15nF; Figure 4-1
S[2]	Sensitivity - medium gain		1.8		pF	Cx = 20pF, Cs = 15nF; Figure 4-2
S[3]	Sensitivity - low gain		3.8		pF	Cx = 20pF, Cs = 15nF; Figure 4-3

Figure 4-1 High Gain Sensitivity and Range @ Vdd = 3V

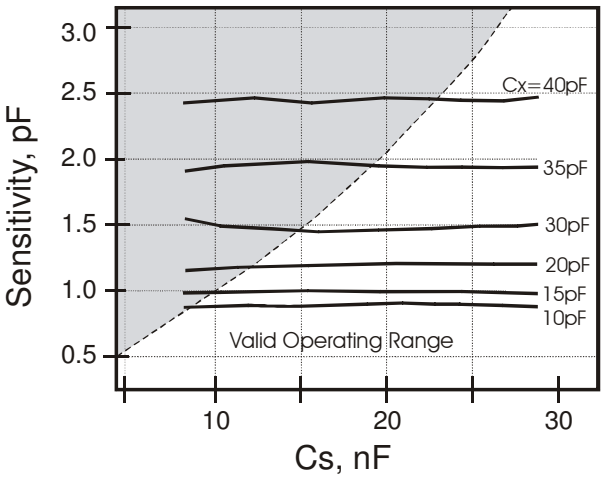


Figure 4-2 Medium Gain Sensitivity and Range @ Vdd = 3V

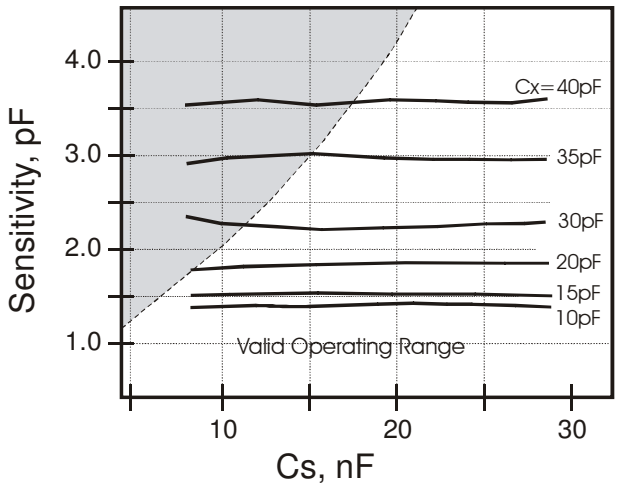


Figure 4-3 Low Gain Sensitivity and Range @ Vdd = 3V

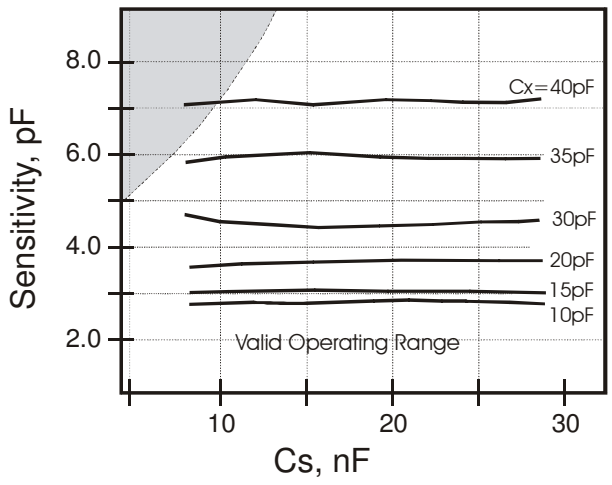
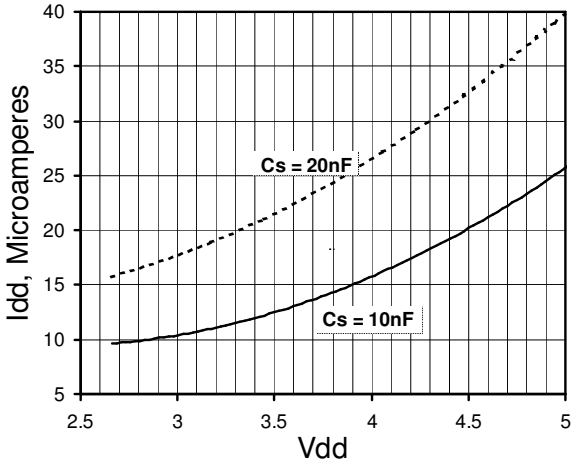
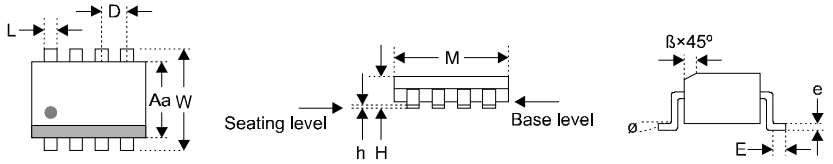


Figure 4-4 Typical Supply Current Vs Vdd Rs = 470K, Cx = 20pF, Gain = High



4.6 MECHANICAL



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	

5 - ORDERING INFORMATION

PART	TEMP RANGE	PACKAGE	MARKING
QT110A-ISG	-40 - 85C	SOIC-8 Lead-Free	Microchip markings

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This device covered under one or more of the following United States and international patents: 5,730,165, 6,288,707, 6,377,009, 6,452,514, 6,457,355, 6,466,036, 6,535,200. Numerous further patents are pending which may apply to this device or the applications thereof.

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