# QT102

## QTouch™ Toggle-Mode Charge-Transfer IC

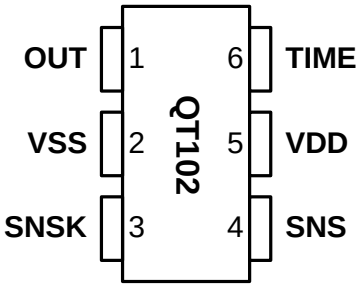
### With Power Management Functions

*This datasheet is applicable to all revision 2.3 chips*

The QT102 is a single key QTouch™ chip combining a touch-on / touch-off toggle mode with timeout and timing override functions, oriented especially towards power control of small appliances and battery-operated products. With its tiny low-cost SOT-23 package, this device can suit almost any product needing a power switch or other toggle-mode controlled function.

A unique 'Green' feature of the QT102 is the timeout function, which can turn off power after a specified time delay ranging from minutes to hours. Furthermore, external 'sustain' and 'cancel' functions permit designs where the timeout needs to be extended further or terminated early. A user's interaction with a product might trigger a 'sustain' input, prolonging the time to shutoff. A safety sensor, such as a tip-over switch on a space heater, can feed the 'cancel' function to terminate early.

Like all QTouch™ devices, the QT102 features automatic self-calibration, drift compensation, and spread-spectrum burst modulation in order to provide for the most reliable touch sensing possible. This device brings inexpensive, easy-to-implement capacitive touch sensing to all kinds of appliances and equipment, from toys to coffee makers. The small, low cost SOT-23 package lets this unique combination of features reside in almost any product.




## AT A GLANCE

| | |
|---|---|
| **Number of keys:** | One toggle mode (touch-on / touch-off), plus programmable auto-off delay and external cancel |
| **Technology:** | Patented spread-spectrum charge-transfer (direct mode) |
| **Key outline sizes:** | 6mm x 6mm or larger (panel thickness dependent); widely different sizes and shapes possible |
| **Electrode design:** | Solid or ring electrode shapes |
| **PCB Layers required:** | One |
| **Electrode materials:** | Etched copper, silver, carbon, Indium Tin Oxide (ITO) |
| **Electrode substrates:** | PCB, FPCB, plastic films, glass |
| **Panel materials:** | Plastic, glass, composites, painted surfaces (low particle density metallic paints possible) |
| **Panel thickness:** | Up to 50mm glass, 20mm plastic (electrode size dependent) |
| **Key sensitivity:** | Settable via external capacitor |
| **Interface:** | Digital output, active high or active low (hardware configurable) |
| **Moisture tolerance:** | Good |
| **Power:** | 2V ~ 5.5V; 23µA at 2V |
| **Package:** | SOT23-6 (3x3mm) RoHS compliant |
| **Signal processing:** | Self-calibration, auto drift compensation, noise filtering |
| **Applications:** | Power switch replacement in countertop appliances, irons, battery powered toys, heaters, lighting controls, automotive interior lighting, commercial and industrial equipment such as soldering stations and cooking equipment |
| **Patents:** | **QTouch™** (patented Charge-transfer method) |

**AVAILABLE OPTIONS**

| $T_A$ | SOT23-6 |
|---|---|
| -40ºC to +85ºC | QT102-ISG |

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# 1 Overview

## 1.1 Introduction

The QT102 is a single key device featuring a touch on / touch off (toggle) output with a programmable auto switch-off capability.

The QT102 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 low cost, noncritical components are required for operation.

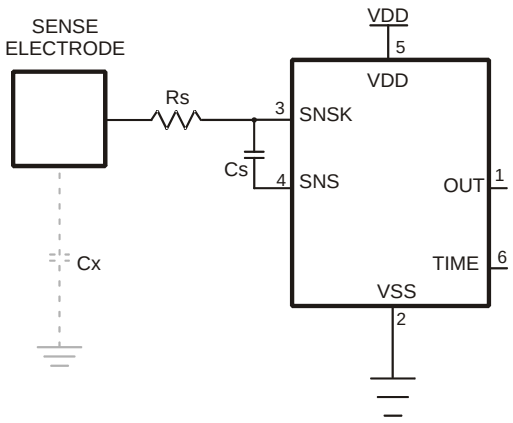
The QT102 employs bursts of charge-transfer cycles to acquire its signal. Burst mode permits power consumption in the microamp range, dramatically reduces RF emissions, lowers susceptibility to EMI, and yet permits excellent response time. Internally the signals are digitally processed to reject impulse noise, using a 'consensus' filter which requires four consecutive confirmations of a detection before the output is activated.

The QT switches and charge measurement hardware functions are all internal to the QT102.

## 1.2 Electrode Drive

Figure 1.1 shows the sense electrode connections (SNS, SNSK) for the QT102.

**Figure 1.1 Sense Connections**




For optimum noise immunity, the electrode should only be connected to the SNSK pin.

In all cases the sample capacitor Cs should be much larger than the load capacitance (Cx). Typical values for Cx are 5 - 20pF while Cs is usually 1 - 50nF.

**Note:** Cx is not a physical discrete component on the PCB, it is the capacitance of the touch electrode and wiring. It is show in Figure 1.1 to aid understanding of the equivalent circuit.

Increasing amounts of Cx destroy gain, therefore it is important to limit the amount of load capacitance on both SNS terminals. This can be done, for example, by minimizing trace lengths and widths and keeping these traces away from power or ground traces or copper pours.

The traces and any components associated with SNS and SNSK will become touch sensitive and should be treated with caution to limit the touch area to the desired location.

A series resistor, Rs, should be placed in line with SNSK to the electrode to suppress electrostatic discharge (ESD) and Electromagnetic Compatibility (EMC) effects.

## 1.3 Sensitivity

### 1.3.1 Introduction

The sensitivity of the QT102 is a function of such things as:

- the value of Cs
- electrode size and capacitance
- electrode shape and orientation
- the composition and aspect of the object to be sensed
- the thickness and composition of any overlaying panel material
- the degree of ground coupling of both sensor and object

### 1.3.2 Increasing Sensitivity

In some cases it may be desirable to increase sensitivity; for example, when using the sensor with very thick panels having a low dielectric constant. Sensitivity can often be increased by using a larger electrode or reducing panel thickness. Increasing electrode size can have diminishing returns, as high values of Cx will reduce sensor gain.

The value of Cs also has a dramatic effect on sensitivity, and this can be increased in value with the trade-off of slower response time and more power. 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. Panel material can also be changed to one having a higher dielectric constant, which will better help to propagate the field.

Ground planes around and under the electrode and its SNSK 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. Metal areas near the electrode will reduce the field strength and increase Cx loading and should be avoided, if possible. Keep ground away from the electrodes and traces.

### 1.3.3 Decreasing Sensitivity

In some cases the QT102 may be too sensitive. In this case gain can be easily lowered further by decreasing Cs.

## 1.4 Recalibration Timeout

If an object or material obstructs the sense electrode the signal may rise enough to create a detection, preventing further operation. To stop this, the sensor includes a timer which monitors detections. If a detection exceeds the timer setting (known as the Max On-duration) the sensor performs a full recalibration. This does not toggle the output state but ensures that the QT102 will detect a new touch correctly. The timer is set to activate this feature after ~ 30s. This will vary slightly with Cs.

## 1.5 Forced Sensor Recalibration

The QT102 has no recalibration pin; a forced recalibration is accomplished when the device is powered up, after the recalibration timeout or when the auto-off override is released.

However, supply drain is low so it is a simple matter to treat the entire IC as a controllable load; driving the QT102's $V_{DD}$ pin directly from another logic gate or a microcontroller port 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 problems.

## 1.6 Drift Compensation

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

Drift compensation (Figure 1.2) 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 QT102 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 QT102'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, 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.

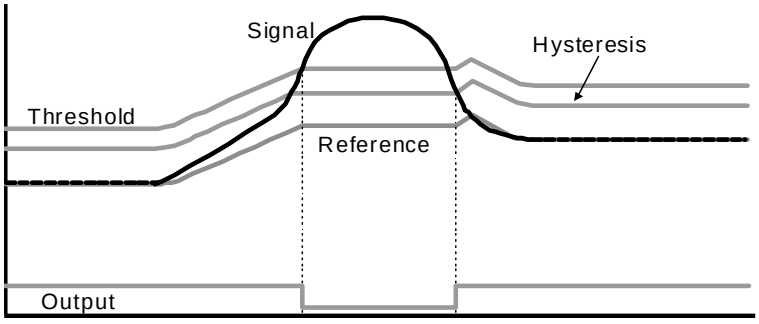
## 1.7 Response Time

The QT102's response time is highly dependent on burst length, which in turn is dependent on Cs and Cx. With increasing Cs, response time slows, while increasing levels of Cx reduce response time.

## 1.8 Spread Spectrum

The QT102 modulates its internal oscillator by ±7.5 percent during the measurement burst. This spreads the generated noise over a wider band reducing emission levels. This also reduces susceptibility since there is no longer a single fundamental burst frequency.

**Figure 1.2 Drift Compensation**



# 2 Wiring and Parts

## 2.1 Application Note

Refer to Application Note AN-KD02, downloadable from the Quantum website for more information on construction and design methods. Go to http://www.qprox.com, click the Support tab and then Application Notes.

## 2.2 Cs Sample Capacitor

Cs is the charge sensing sample capacitor. The required Cs value depends on the thickness of the panel and its dielectric constant. Thicker panels require larger values of Cs. Typical values are 1nF to 50nF depending on the sensitivity required; larger values of Cs demand higher stability and better dielectric to ensure reliable sensing.

The Cs capacitor should be a stable type, such as X7R ceramic or PPS film. For more consistent sensing from unit to unit, 5 percent tolerance capacitors are recommended. X7R ceramic types can be obtained in 5 percent tolerance at little or no extra cost. In applications where high sensitivity (long burst length) is required the use of PPS capacitors is recommended.

## 2.3 Rs Resistor

Series resistor Rs is in line with the electrode connection and should be used to limit ESD currents and to suppress radio frequency interference (RFI). It should be approximately 4.7kΩ to 33kΩ.

Although this resistor may be omitted, the device may become susceptible to external noise or RFI. For details of how to select these resistors see the Application Note AN-KD02 (Section 2.1).

## 2.4 Power Supply, PCB Layout

The power supply can range between 2.0V and 5.5V. If the power supply is shared with another electronic system, care should be taken to ensure that the supply is free of digital spikes, sags, and surges which can adversely affect the device. The QT102 will track slow changes in $V_{DD}$, but it can be badly affected by rapid voltage fluctuations. It is highly recommended that a separate voltage regulator be used just for the QT102 to isolate it from power supply shifts caused by other components.

If desired, the supply can be regulated using a Low Dropout (LDO) regulator. See Application Note AN-KD02 (see Section 2.1) for further information on power supply considerations.

Suggested regulator manufacturers:

- Toko (XC6215 series)
- Seiko (S817 series)
- BCDSemi (AP2121 series)

**Parts placement:** The chip should be placed to minimize the SNSK trace length to reduce low frequency pickup, and to reduce Cx which degrades gain. The Cs and Rs resistors (see Figure 2.1) should be placed as close to the body of the chip as possible so that the trace between Rs and the SNSK pin is very short, thereby reducing the antenna-like ability of this trace to pick up high frequency signals and feed them directly into the chip. A ground plane can be used under the chip and the associated discretes, but the trace from the Rs resistor and the electrode should not run near ground, to reduce loading.

For best EMC performance the circuit should be made entirely with SMT components.

**Electrode trace routing:** Keep the electrode trace (and the electrode itself) away from other signal, power, and ground traces including over or next to ground planes. Adjacent switching signals can induce noise onto the sensing signal; any adjacent trace or ground plane next to, or under, the electrode trace will cause an increase in Cx load and desensitize the device.

***Important Note: for proper operation a 100nF (0.1µF) ceramic bypass capacitor must be used directly between $V_{DD}$ and $V_{SS}$, to prevent latch-up if there are substantial $V_{DD}$ transients; for example, during an ESD event. The bypass capacitor should be placed very close to the device's power pins.***

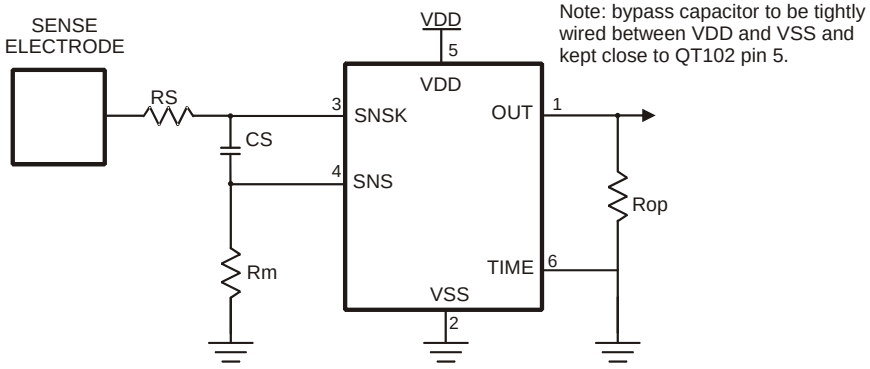
## 2.5 Wiring

**Table 2.1 Pin Descriptions**

| PIN | NAME | TYPE | DESCRIPTION |
|---|---|---|---|
| 1 | OUT | O | To switched circuit and output polarity selection resistor (Rop) |
| 2 | VSS | P | Ground power pin |
| 3 | SNSK | IO | To Cs capacitor and to sense electrode |
| 4 | SNS | IO | To Cs capacitor and multiplier configuration resistor (Rm)<br>Rm must be fitted and connected to either VSS or VDD. Refer to Section 3.5 for details. |
| 5 | VDD | P | Positive power pin |
| 6 | TIME | I | Timeout configuration pin, which must be connected to either VSS, VDD, OUT or an RC network. Refer to Section 3.5 for details. |

I Input only
O Output only, push-pull
OD Open drain output
IO Input and output
P Ground or power

**Figure 2.1 Basic Circuit Configuration**
(active high output, toggle on/off, no auto switch off)




Re Figure 2.1, check the following sections for component values:

- Section 2.2, page 5: Cs capacitor (Cs)
- Section 2.3, page 5: Sample resistor (Rs)
- Section 2.4, page 5: Voltage levels
- Section 3.5.2, page 8: Rm
- Section 3.3, page 7: Rop

# 3 Operation

## 3.1 Acquisition Modes

### 3.1.1 Introduction

The OUT pin of the QT102 can be configured to be active high or active low (see Section 3.3).

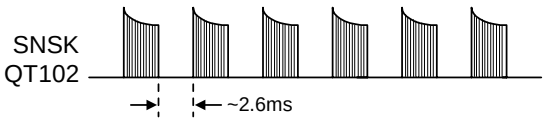
- If active high then
  - 'on' is high
  - 'off' is low
- If active low then
  - 'on' is low
  - 'off' is high

The acquisition mode depends on the state of the OUT pin (on or off) and whether a touch is detected. In the following text 'on' is when the output is in its active state.

### 3.1.2 OUT Pin 'On' (Fast Mode)

The QT102 runs in Fast mode when the OUT pin is on. In this mode the device runs at maximum speed at the expense of increased current consumption. The delay between bursts in Fast mode is approximately 2.6ms, as shown in Figure 3.1.

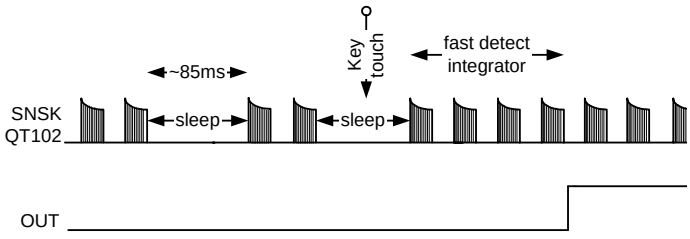
**Figure 3.1 Fast Mode Bursts**
(Output in On condition)




### 3.1.3 OUT Pin 'Off' (Low Power Mode)

The QT102 runs in Low Power (LP) mode if the OUT pin is off. In this mode it sleeps for approximately 85ms at the end of each burst, saving power but slowing response. On detecting a possible key touch, it temporarily switches to Fast mode until either the key touch is confirmed or found to be spurious (via the detect integration process). If the touch is confirmed the QT102 will switch to Fast mode as shown in Figure 3.2. If a touch is denied the device will revert to normal LP mode operation automatically.

**Figure 3.2 Low Power Mode/Touch Detection**




## 3.2 Signal Processing

### 3.2.1 Detect Integrator

It is desirable to suppress detections generated by electrical noise or from quick brushes with an object. To accomplish this, the QT102 incorporates a 'detect integration' (DI) 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 QT102, the required count is four.

The DI can also be viewed as a 'consensus' filter, that requires four successive detections to create an output.

### 3.2.2 Detect Threshold

The device detects a touch when the signal has crossed a threshold level. The threshold level is fixed at 10 counts.

## 3.3 Output Polarity Selection

The output (OUT pin) of the QT102 can be configured to have an active high or active low output by means of the output configuration resistor Rop. The resistor is connected between the output and either Vss or $V_{DD}$ (see Figure 3.3 and Table 3.1). A typical value for Rop is 100kΩ.

**Figure 3.3 Output Polarity**

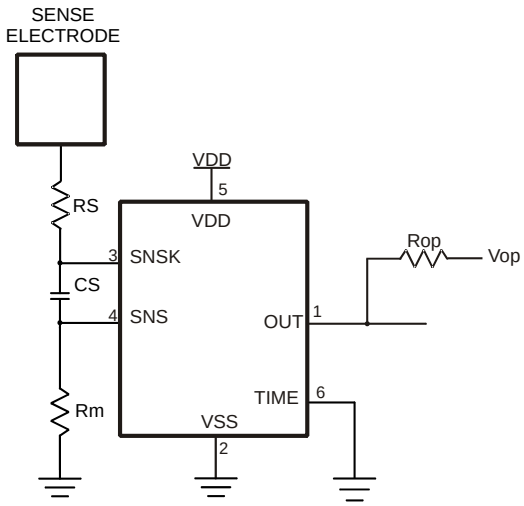
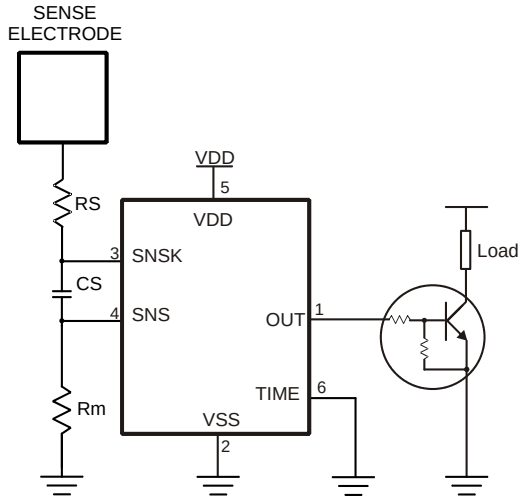



**Table 3.1 Output Configuration**

| Name (Vop) | Function (Output polarity) |
|---|---|
| Vss | Active high |
| $V_{DD}$ | Active low |

Note that some devices such as Digital Transistors have an internal biasing network that will naturally pull the OUT pin to its inactive state. If these are being used then the resistor Rop is not required (see Figure 3.4).

**Figure 3.4 Output Connected to Digital Transistor**



## 3.4 Output Drive

The OUT pin is active high and can sink or source up to 2mA. When a large value of Cs (>20nF) is used the OUT current should be limited to <1mA to prevent gain-shifting side effects, which happen 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.

## 3.5 Auto Off Delay

### 3.5.1 Introduction

In addition to toggling the output on/off with key touch, the QT102 can automatically switch the output off after a specific time. This feature can be used to save power in situations where the switched device could be left on inadvertently.

The QT102 has:

- three predefined delay times (Section 3.5.2)
- the ability to set a user-programmed delay (Section 3.5.3)
- the ability to override the auto off delay (Section 3.5.4)

The TIME and SNS pins are used to configure the Auto Off delay and must always be connected in one of the ways described in Sections 3.5.2, 3.5.3 and 3.5.4.

### 3.5.2 Auto Off - Predefined Delay

To configure the predefined delay the TIME pin is hard wired to Vss, Vdd or OUT as shown in Tables 3.2 and 3.3. This provides nominal values of 15 minutes, 60 minutes or infinity (remains on until toggled off).

A single 1MΩ resistor (Rm) is connected between the SNS pin and the logic level Vm to provide three auto off functions: delay multiplication, delay override and delay retriggering. On power-up the logic level at Vm is assessed and the delay multiplication factor is set to x1 or x24 accordingly (see Figure 3.5 and Table 3.4). At the end of each acquisition cycle the logic level of Vm is monitored to see if an Auto off delay override is required (see Section 3.5.4).

Setting the delay multiplier to x24 will decrease the key sensitivity. To compensate, it may be necessary to increase the value of Cs.

**Figure 3.5 Predefined Delay**

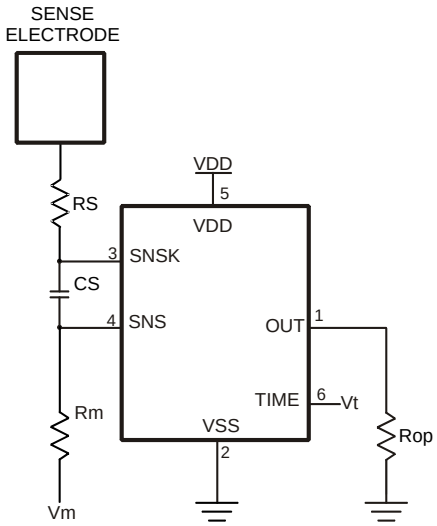



**Table 3.2 Predefined Auto-off Delay (Active High Output)**

| Vt | Auto-off delay ($t_o$) |
|---|---|
| Vss | Infinity (remain on until toggled to off) |
| Vdd | 15 minutes |
| OUT | 60 minutes |

**Table 3.3 Predefined Auto-off Delay (Active Low Output)**

| Vt | Auto-off delay ($t_o$) |
|---|---|
| Vss | 15 minutes |
| $V_{DD}$ | Infinity (remain on until toggled to off) |
| OUT | 60 minutes |

**Table 3.4 Auto-off Delay Multiplier**

| Vm | Auto-off delay multiplier |
|---|---|
| Vss | **$t_o$ x 1** |
| $V_{DD}$ | **$t_o$ x 24** |

### 3.5.3 Auto Off - User-programmed Delay

If a user-programmed delay is required a resistor and capacitor can be used to set the auto-off delay (see Table 3.5 and Figure 3.6 The delay time is dependent on the RC time constant (Rt x Ct) the output polarity and the supply voltage. Section 3.5.5 gives full details of how to configure the QT102 to have auto-off delay times ranging from 1 minute to up to 24 hours.

**Table 3.5 Programmable Auto Off Delay**

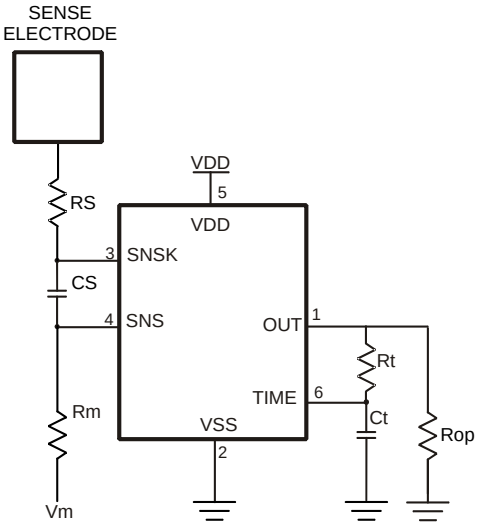
(Vm = Vss (delay multiplier = 1), $V_{DD}$ = 3.5V)

| Output Type | Auto Off Delay (seconds) |
|---|---|
| Active high | (Rt x Ct x 15) / 42 |
| Active low | (Rt x Ct x 15) / 14.3 |

K values (42 and 14.3) are obtained from Figures 3.10 and 3.11.

**Note:** Rt is in kΩ, Ct is in nF.

**Figure 3.6 Programmable Delay**




### 3.5.4 Auto Off - Overriding the Auto Off Delay

In normal operation the QT102 output is turned off automatically after the auto-off delay. In some applications it may be useful to extend the auto-off delay ('sustain' function) or to switch the output off immediately ('cancel' function). This can be achieved by pulsing the voltage on the delay multiplier resistor Rm as shown in Figures 3.7 and 3.8.

**Figure 3.7 Override Pulse (Delay Multiplier x1)**

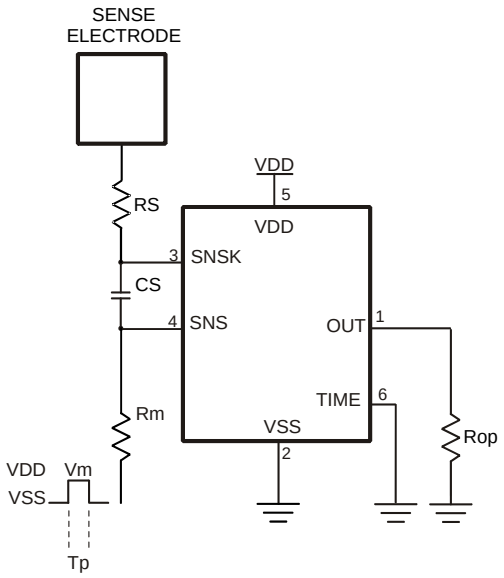
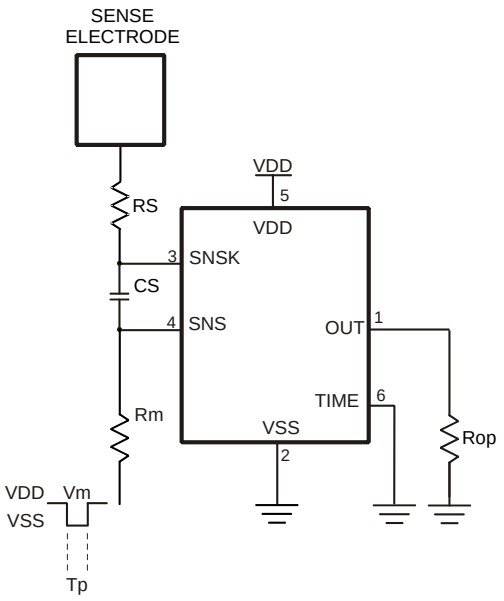



**Figure 3.8 Override Pulse (Delay Multiplier x24)**




To ensure the pulse is detected it must be present for a time greater than the burst length as shown in Table 3.6.

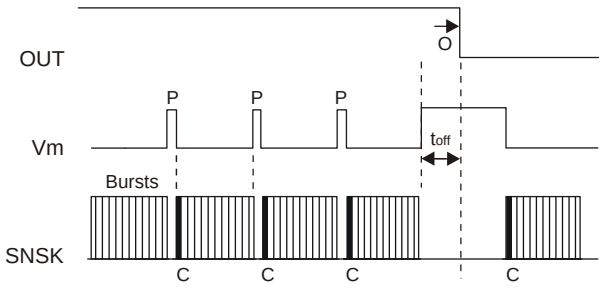
**Table 3.6 Time Delay Pulse**

| Pulse Duration | Action |
|---|---|
| tp > burst time + 10ms (typical value 25ms) | Retrigger (reload auto-off delay counter) |
| tp > burst time + 50ms (typical value 65ms) | Switch output to off state and inhibit further touch detection until Vm returns to original state |

While Vm is held in the override state the QT102 inhibits bursts and waits for Vm to return to its original state. When Vm returns to its original state the QT102 performs a sensor recalibration before continuing in its current output state.

Figure 3.9 shows override pulses being applied to a QT102 with delay multiplier set to x1.

**Figure 3.9 Overriding Auto Off**




P - override (reload auto off delay)
O - switch output off (toff burst time + 50ms)
C - sensor recalibration

### 3.5.5 Configuring the User-programmed Auto-off Delay

As described in Section 3.5.3, page 8, the QT102 can be configured to give auto-off delays ranging from minutes to hours by means of a simple CR network and the delay multiplier input.

With the delay multiplier set at x1 the auto-off delay is calculated as follows:

Delay value = integer value of $\frac{Rt \times Ct}{K}$ x 15 seconds.

And $Rt \times Ct = \frac{Delay\ (in\ seconds) \times K}{15}$

**Note:** Rt is in kΩ, Ct is in nF.

To ensure correct operation it is recommended that the value of $\frac{Rt \times Ct}{K}$ is between 4 and 240.

Values outside this range may be interpreted as the hard wired options TIME linked to OUT and TIME linked to 'off' respectively, causing the QT102 to use the relevant predefined auto-off delays.

The charts in Figures 3.10 and 3.11 show typical values of K versus supply voltage for a QT102 with active high or active low output.

**Example using the formula to calculate Rt and Ct**

Requirements:

- Active high output (Vop connected to VSS)
- Auto-off delay 45 minutes
- VDD = 3.5V

Proceed as follows:

1. Calculate Auto-off delay in seconds 45 x 60 = 2700
2. Obtain K from Figure 3.10, K= 42
3. Calculate $Rt \times Ct = \frac{2700 \times 42}{15} = 7560$
4. Decide on a value for Rt or Ct (e.g.Ct = 47nF)
5. Calculate $Rt = \frac{7560}{47} = 160k$

As an alternative to calculation, Figures 3.12 and 3.13 show charts of typical curves of auto-off delay against resistor and capacitor values for active high and active low outputs at various values of VDD (delay multiplier = x1).

**Figure 3.10 Active High Output**

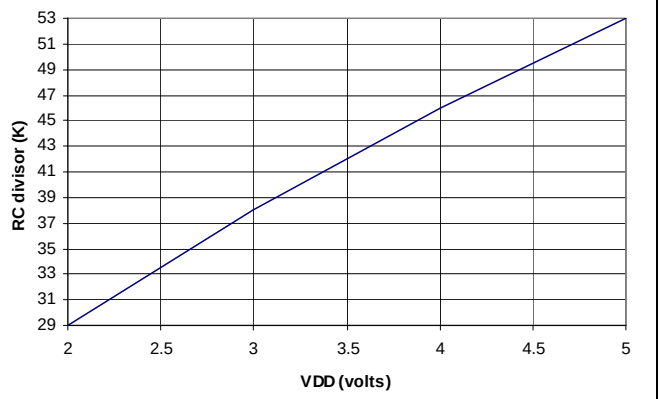



**Figure 3.11 Active Low Output**

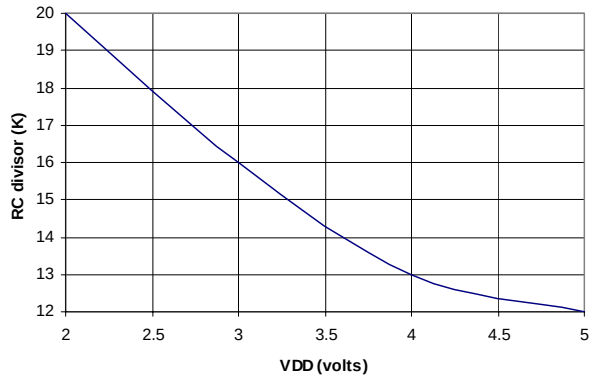
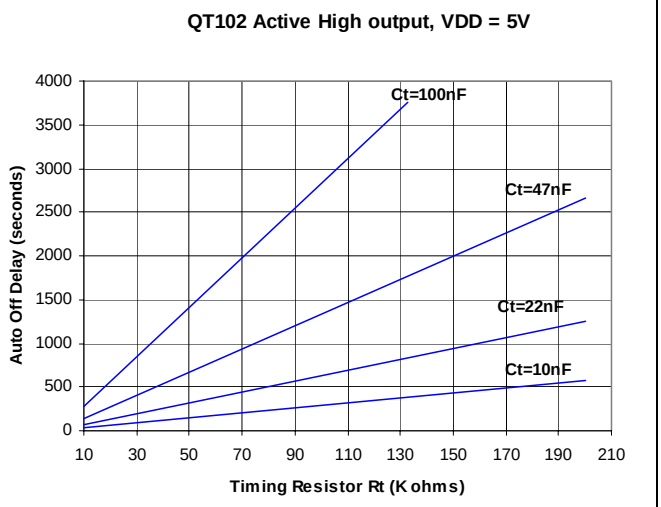
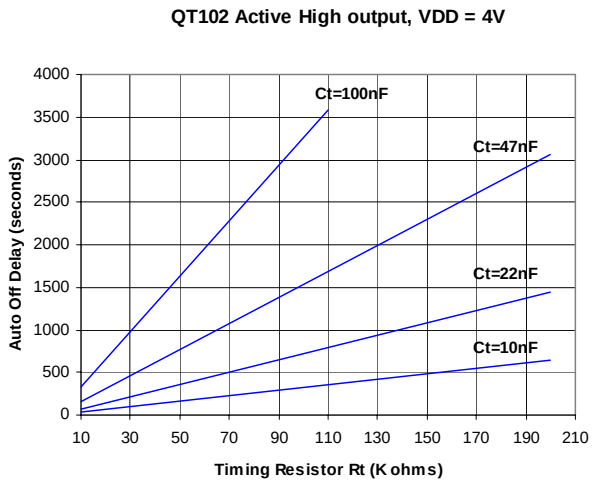
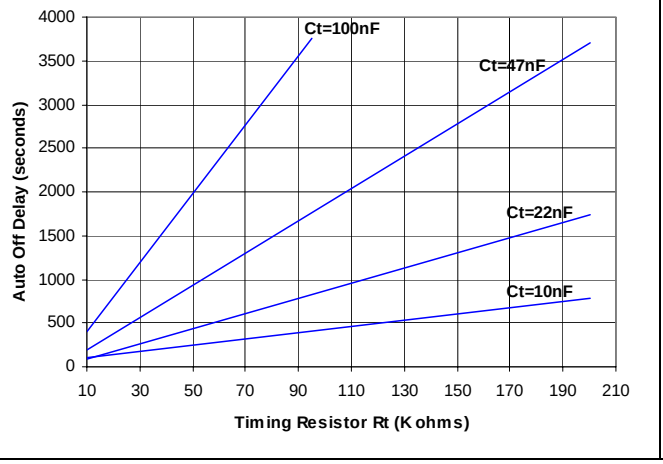



**Figure 3.12 Auto-off Delay, Active High Output,**
Vm = Vss (delay multiplier = x1)



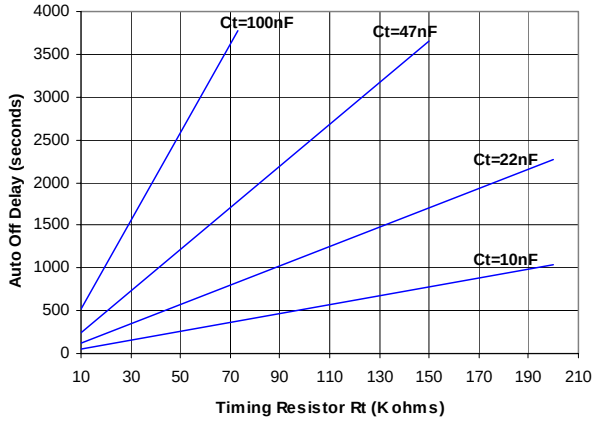
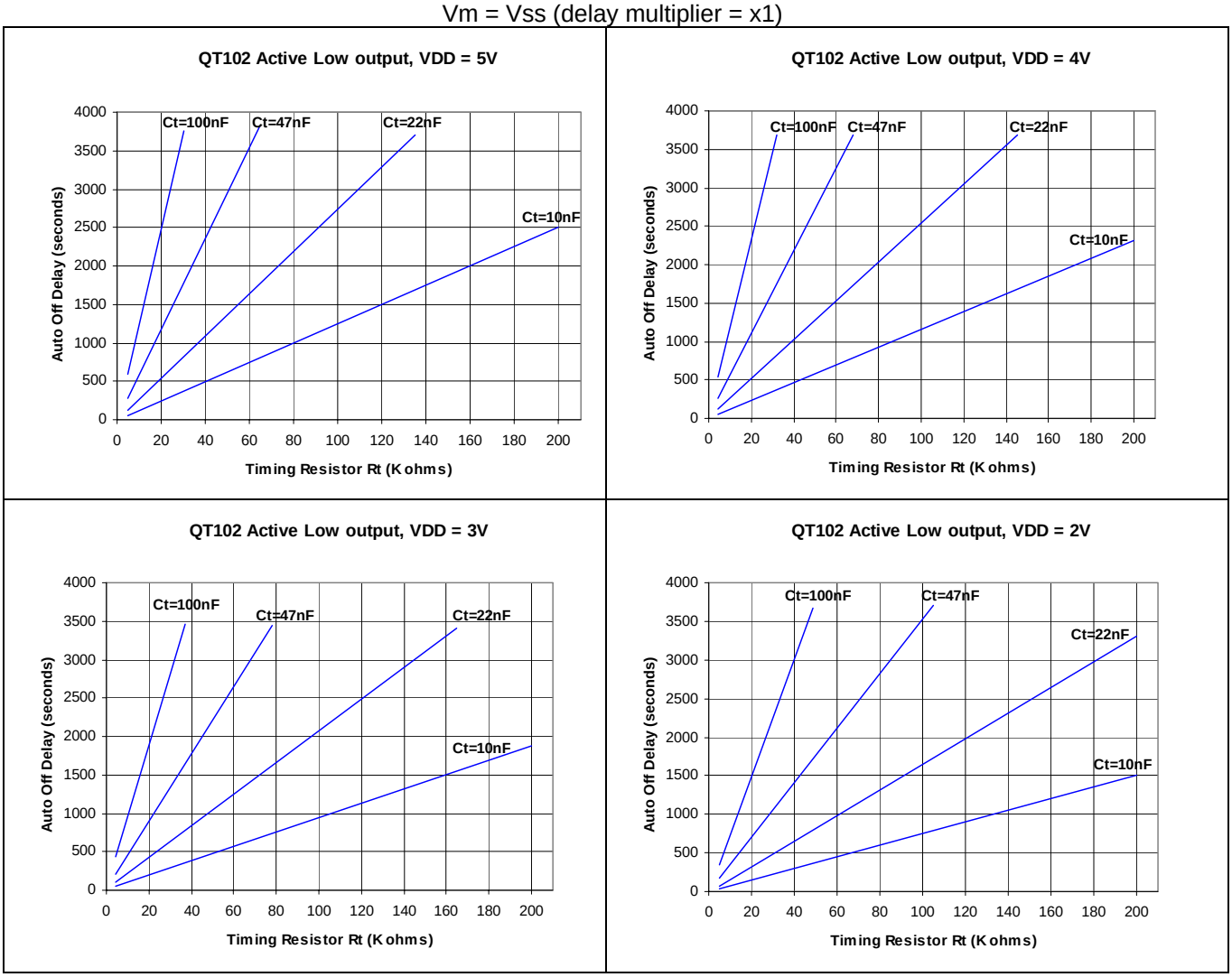



**Figure 3.13 Auto-off Delay, Active Low Output,**
Vm = Vss (delay multiplier = x1)




**Example using a chart to calculate Rt and Ct**

Requirements:

- Active low output (Vop connected to VSS)
- Auto-off delay 10 hours
- VDD = 4V

1. Calculate Auto-off delay in seconds 10 x 60 x 60 = 36000. This value is outside of the range of the charts so use the x24 multiplier (connect Rm to VDD).

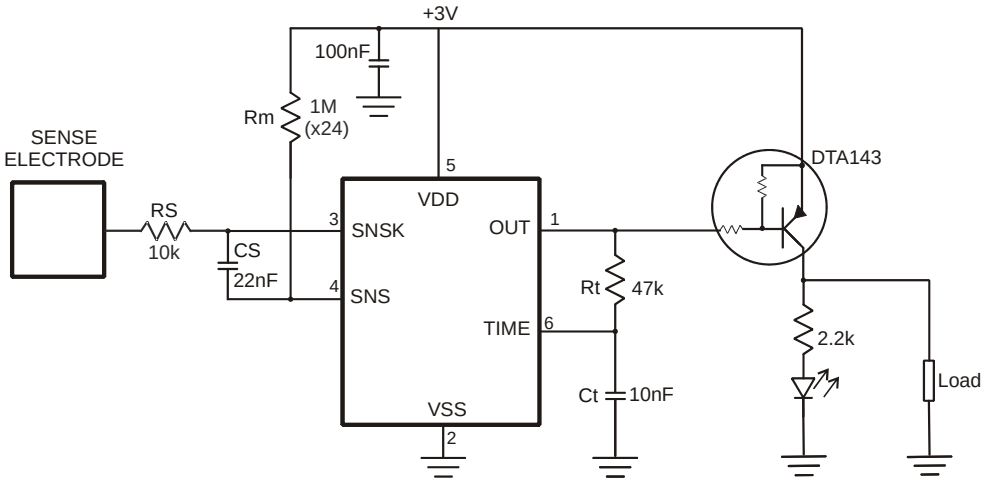
   **Note:** this will decrease the key sensitivity, so it may be necessary to increase the value of Cs.

2. Find $\frac{36000}{24}$ = 1500 on the 4V chart in Figure 3.13
3. This shows the following Rt / Ct combinations: 100nF / 10k, 47nF / 27k, 22nF / 60k or 10nF / 130k

**Note:** the Auto-off delay times shown are nominal and will vary slightly from chip to chip and with capacitor and resistor tolerance.

## 3.6 Examples of Typical Applications

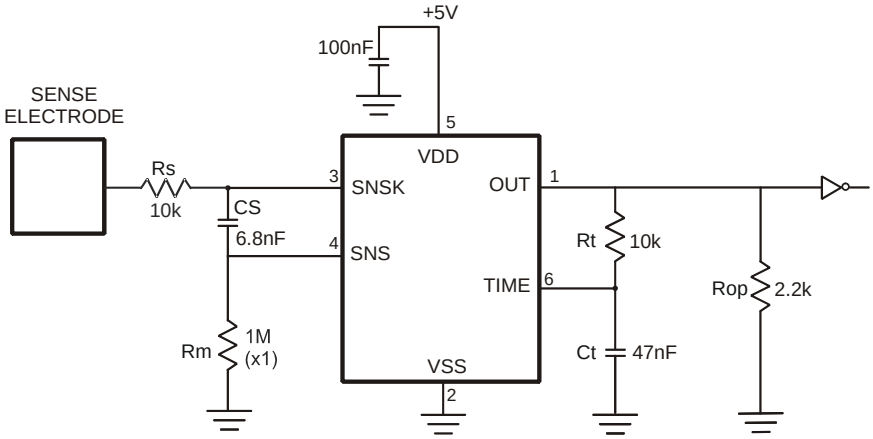
**Figure 3.14 Application 1**
Active low, driving PNP transistor, auto off time 500s x 24 (3.33 hours)




Auto off time obtained from 3V chart in Figure 3.13

Setting the delay multiplier to x24 will decrease the key sensitivity, so it may be necessary to increase the value of Cs.

**Figure 3.15 Application 2**
Active high, driving high impedance, auto off time 135s x 1 (2.25 minutes)




Auto off time obtained from 5V chart in Figure 3.12.

# 4 Specifications

## 4.1 Absolute Maximum Specifications

Operating temp. . . . . -40°C to +85°C
Storage temp. . . . . -55°C to +125°C
$V_{DD}$. . . . . 0 to +6.5V
Max continuous pin current, any control or drive pin. . . . . ±20mA
Short circuit duration to $V_{SS}$, any pin. . . . . infinite
Short circuit duration to $V_{DD}$, any pin. . . . . infinite
Voltage forced onto any pin. . . . . -0.6V to ($V_{DD}$ + 0.6) Volts



**CAUTION:** Stresses beyond those listed under 'Absolute Maximum Specifications' may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum specification conditions for extended periods may affect device reliability.

## 4.2 Recommended Operating Conditions

$V_{DD}$. . . . . +2.0 to 5.5V
Short-term supply ripple+noise. . . . . ±5mV
Long-term supply stability. . . . . ±100mV
Cs value. . . . . 1nF to 50nF
Cx value. . . . . 5 to 20pF

## 4.3 AC Specifications

$V_{DD}$ = 3.0V, Cs = 10nF, Cx = 5pF, Ta = recommended range, unless otherwise noted

| Parameter | Description | Min | Typ | Max | Units | Notes |
|---|---|---|---|---|---|---|
| $T_{RC}$ | Recalibration time | | 250 | | ms | Cs and Cx dependent |
| $T_{PC}$ | Charge duration | | 2 | | µs | ±7.5% spread spectrum variation |
| $T_{PT}$ | Transfer duration | | 2 | | µs | ±7.5% spread spectrum variation |
| $T_{G1}$ | Time between end of burst and start of the next (Fast mode) | | 2.6 | | ms | |
| $T_{G2}$ | Time between end of burst and start of the next (LP mode) | | 85 | | ms | Increases with reducing $V_{DD}$ |
| $T_{BL}$ | Burst length | | 20 | | ms | Vdd, Cs and Cx dependent. See Section 2.2 for capacitor selection. |
| $T_R$ | Response time | | | 100 | ms | |

## 4.4 Signal Processing

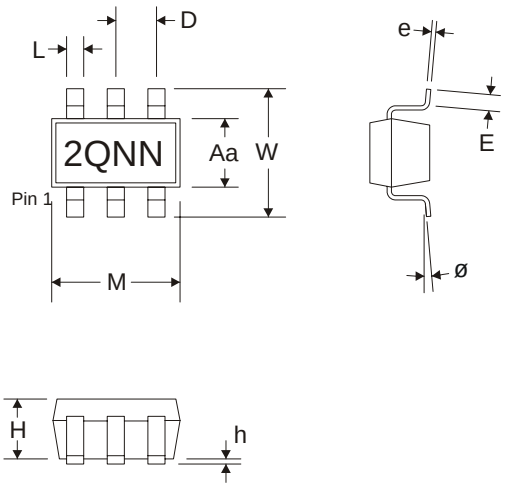
| Description | Min | Typ | Max | Units | Notes |
|---|---|---|---|---|---|
| Threshold differential | | 10 | | counts | |
| Hysteresis | | 2 | | counts | |
| Consensus filter length | | 4 | | samples | |
| Recalibration timer duration | | 40 | | secs | Will vary with $V_{DD}$ |

## 4.5 DC Specifications

$V_{DD}$ = 3.0V, Cs = 10nF, Cx = 5pF, Ta = recommended range, unless otherwise noted

| Parameter | Description | Min | Typ | Max | Units | Notes |
|---|---|---|---|---|---|---|
| $V_{DD}$ | Supply voltage | 2 | | 5.5 | V | |
| $I_{DD}$ | Supply current | 5 | | 600 | µA | Depending on supply and run mode |
| Iddl | Supply current, LP Mode | | 23<br>37<br>90 | | µA | 2V<br>3V<br>5V |
| $V_{DDS}$ | Supply turn-on slope | 100 | | | V/s | Required for proper start-up |
| $V_{IL}$ | Low input logic level | | | 0.8 | V | |
| $V_{HL}$ | High input logic level | 2.2 | | | V | |
| $V_{OL}$ | Low output voltage | | | 0.6 | V | OUT, 4mA sink |
| $V_{OH}$ | High output voltage | $V_{DD}$-0.7 | | | V | OUT, 1mA source |
| $I_{IL}$ | Input leakage current | | | ±1 | µA | |
| $C_X$ | Load capacitance range | 0 | | 100 | pF | |
| $A_R$ | Acquisition resolution | | 9 | 14 | bits | |

## 4.6 Mechanical Dimensions




**Note:** the part marking shown is for high volume parts. Samples may be shipped marked 02NN.

| Package type: SOT23-6 | | | | | | |
|---|---|---|---|---|---|---|
| | Millimeters | | | Inches | | |
| Symbol | Min | Max | Notes | Min | Max | Notes |
| M | 2.8 | 3.10 | | 0.110 | 0.122 | |
| W | 2.6 | 3.0 | | 0.102 | 0.118 | |
| Aa | 1.5 | 1.75 | | 0.059 | 0.069 | |
| H | 0.9 | 1.3 | | 0.035 | 0.051 | |
| h | 0.0 | 0.15 | | 0 | 0.006 | |
| D | - | - | 0.95 BSC | - | - | 0.038 BSC |
| L | 0.35 | 0.5 | | 0.014 | 0.02 | |
| E | 0.35 | 0.55 | | 0.014 | 0.022 | |
| e | 0.09 | 0.2 | | 0.004 | 0.008 | |
| | | | | | | |
| Ø | 0º | 10º | | 0º | 10º | |

## 4.7 Marking

| SOT23-6 Part Number | Marking |
|---|---|
| QT102-ISG | 2QNN (where NN is variable) |

**Note:** the part marking shown is for high volume parts. Samples may be shipped marked 02NN.

## 4.8 Moisture Sensitivity Level (MSL)

| MSL Rating | Peak Body Temperature | Specifications |
|---|---|---|
| MSL1 | 260$^{O}$C | IPC/JEDEC J-STD-020C |

# 5 Datasheet Control

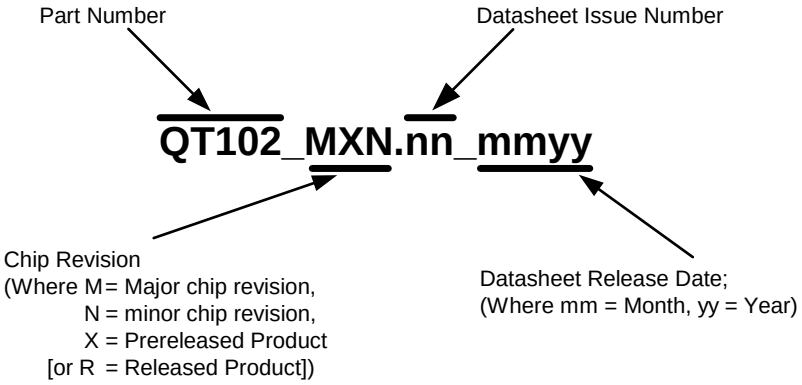
## 5.1 Changes

**Changes this issue (datasheet issue 5)**

Section 2.5

Section 5.1

## 5.2 Numbering Convention




*A minor chip revision (N) is defined as a revision change which does not affect product functionality or datasheet. The value of N is usually only stated for released parts (R).*

**NOTES:**

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## Corporate Headquarters

1 Mitchell Point
Ensign Way, Hamble SO31 4RF
Great Britain
Tel: +44 (0)23 8056 5600 Fax: +44 (0)23 8045 3939

## www.qprox.com

## North America

651 Holiday Drive Bldg. 5 / 300
Pittsburgh, PA 15220 USA
Tel: 412-391-7367 Fax: 412-291-1015

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***Developer: Kevin Snoad***