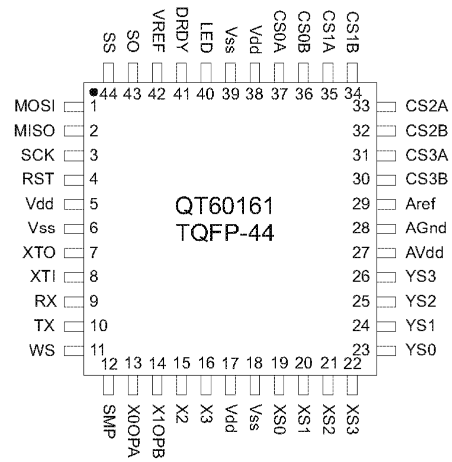
PRELIMINARY

QT60161

16 KEY QMatrix™ KEYPANEL SENSOR IC

- Advanced second generation QMatrix controller
- 16 touch keys through any dielectric
- 100% autocal for life - no adjustments required
- SPI Slave or Master/Slave interface to a host controller
- Parallel scan interface for electromechanical compatibility
- Keys individually adjustable for sensitivity, response time, and many other critical parameters
- Sleep mode with wake pin
- Synchronous noise suppression
- Mix and match key sizes & shapes in one panel
- Adjacent key suppression feature
- Panel thicknesses to 5 cm or more
- Low overhead communications protocol
- 44-pin TQFP package



APPLICATIONS -

- Security keypanels
- Industrial keyboards
- Appliance controls
- Outdoor keypads
- ATM machines
- Touch-screens
- Automotive panels
- Machine tools

The QT60161 digital charge-transfer (“QT”) QMatrix™ IC is designed to detect human touch on up 16 keys when used in conjunction with a scanned, passive X-Y matrix. It will project the keys through almost any dielectric, e.g. glass, plastic, stone, ceramic, and even wood, up to thicknesses of 5 cm or more. The touch areas are defined as simple 2-part interdigitated electrodes of conductive material, like copper or screened silver or carbon deposited on the rear of a control panel. Key sizes, shapes and placement are almost entirely arbitrary; sizes and shapes of keys can be mixed within a single panel of keys and can vary by a factor of 20:1 in surface area. The sensitivity of each key can be set individually via simple functions over the SPI or UART port, for example via Quantum’s QmBtn program, or from a host microcontroller. Key setups are stored in an onboard eeprom and do not need to be reloaded with each powerup.

The device is designed specifically for appliances, electronic kiosks, security panels, portable instruments, machine tools, or similar products that are subject to environmental influences or even vandalism. It can permit the construction of 100% sealed, watertight control panels that are immune to humidity, temperature, dirt accumulation, or the physical deterioration of the panel surface from abrasion, chemicals, or abuse. To this end the device contains Quantum-pioneered adaptive auto self-calibration, drift compensation, and digital filtering algorithms that make the sensing function robust and survivable.

The part can scan matrix touch keys over LCD panels or other displays when used with clear ITO electrodes arranged in a matrix. It does not require 'chip on glass' or other exotic fabrication techniques, thus allowing the OEM to source the matrix from multiple vendors. Materials such as such common PCB materials or flex circuits can be used.

External circuitry consists of a resonator and a few capacitors and resistors, all of which can fit into a footprint of less than 6 sq. cm (1 sq. in). Control and data transfer is via either a SPI or UART port; a parallel scan port provides backwards compatibility with scanned electromechanical keys.

The QT60161 makes use of an important new variant of charge-transfer sensing, transverse charge-transfer, in a matrix format that minimizes the number of required scan lines. Unlike some older technologies it does not require one sensing IC per key.

AVAILABLE OPTIONS

T_A	TQFP Part Number
0^0C to +70^0C	QT60161-S
-40^0C to +105^0C	QT60161-AS

QUANTUM RESEARCH GROUP

Pat Pend. R1.01/02.02

Contents

Table 1.1 Device Pin List

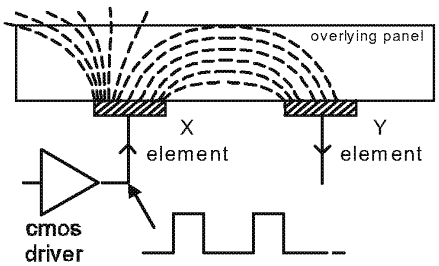
Pin	Name	Type	Description
1	MOSI	I/O PP	Master-Out / Slave In SPI line. In Master/Slave SPI mode is used for both communication directions. In Slave SPI mode is the data input (in only).
2	MISO	I/O PP	Master-In / Slave Out SPI line. Not used in Master/Slave SPI mode. In Slave mode outputs data to host (out only).
3	SCK	I/O PP	SPI Clock. In Master mode is an output; in Slave mode is an input
4	RST	I	Reset input, active low reset
5	Vdd	Pwr	+5V supply
6	Vss	Pwr	Ground
7	XTO	O PP	Oscillator drive output. Connect to resonator or crystal.ply
8	XTI	I	Oscillator drive input. Connect to resonator or crystal, or external clock source.
9	RX	I	UART receive input
10	TX	O PP	UART transmit output
11	WS	I	Wake from Sleep / Sync to noise source
12	SMP	O PP	Sample output control
13	X0OPA	I/O PP	X0 Drive matrix scan / Communications option A input
14	X1OPB	I/O PP	X1 Drive matrix scan / Communications option B input
15	X2	O PP	X2 Drive matrix scan
16	X3	O PP	X3 Drive matrix scan
17	Vdd	Pwr	+5V supply
18	Vss	Pwr	Ground
19	XS0	I	XS0 Scan input line
20	XS1	I	XS1 Scan input line
21	XS2	I	XS2 Scan input line
22	XS3	I	XS3 Scan input line
23	YS0	O PP	YS0 Scan output line
24	YS1	O PP	YS1 Scan output line
25	YS2	O PP	YS2 Scan output line
26	YS3	O PP	YS3 Scan output line
27	AVdd	Pwr	+5 supply for analog sections
28	AGnd	Pwr	Analog ground
29	Aref	Pwr	+5 supply for analog sections
30	CS3B	I/O PP	Cs3 control B
31	CS3A	I/O PP	Cs3 control A
32	CS2B	I/O PP	Cs2 control B
33	CS2A	I/O PP	Cs2 control A
34	CS1B	I/O PP	Cs1 control B
35	CS1A	I/O PP	Cs1 control A
36	CS0B	I/O PP	Cs0 control B
37	CS0A	I/O PP	Cs0 control A
38	Vdd	Pwr	+5 supply
39	Vss	Pwr	Ground
40	LED	O PP	Active low LED status drive / Activity indicator
41	DRDY	O OD	Data ready output for Slave SPI mode; active low
42	Vref	I	Vref input for conversion reference
43	SO	O PP	Oscilloscope sync output
44	SS	I/O OD	Slave select for SPI direction control; active low

I/O: I = Input
O = Output
Pwr = Power pin
I/O = Bidirectional line
PP = Push Pull output drive
OD = Open drain output drive

1 Overview

QMatrix devices are digital burst mode charge-transfer (QT) sensors designed specifically for matrix geometry touch controls; they include all signal processing functions necessary to provide stable sensing under a wide variety of changing conditions. Only a few low cost external parts are required for operation. The entire circuit can be built in under 6 square centimeters of PCB area.

Figure 1-1 Field flow between X and Y elements



The device has a wide dynamic range that allows for a wide variety of key sizes and shapes to be mixed together in a single touch panel. These features permit new types of keypad features such as touch-sliders, back-illuminated keys, and complex warped panels.

The devices use an SPI interface running at up to 3MHz rates to allow key data to be extracted and to permit individual key parameter setup, or, a UART port which can run at rates to 57.6 Kbaud. The serial interface protocol uses simple commands; the command structure is designed to minimize the amount of data traffic while maximizing the amount of information conveyed.

In addition to normal operating and setup functions the device can also report back actual signal strengths and error codes over the serial interfaces.

QmBtn software for the PC can be used to program the IC as well as read back key status and signal levels in real time.

A parallel scan port is also provided that can be used to directly replace membrane type keypads.

QMatrix technology employs transverse charge-transfer ('QT') sensing, a new technology that senses the changes in an electrical charge forced across an electrode set.

Figure 1-2 Field Flows When Touched

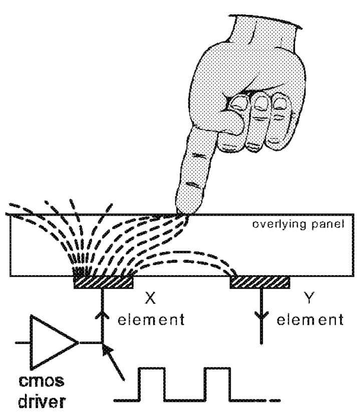
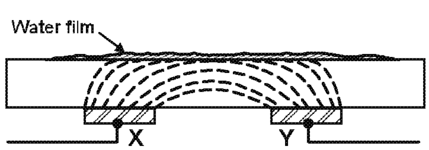


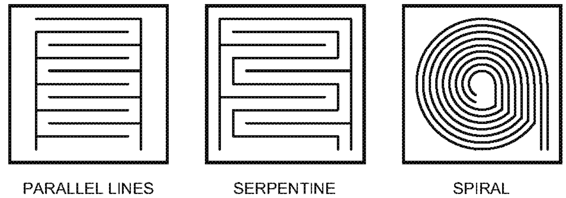
Figure 1-3 Fields With a Conductive Film



1.1 Field Flows

Figure 1-1 shows how charge is transferred across an electrode set to permeate the overlying panel material; this charge flow exhibits a high dQ/dt during the edge transitions of the X drive pulse. The charge driven by the X electrode is partly received onto the corresponding Y electrode which is then processed. The part uses 4 'X' edge-driven rows and 4 'Y' sense columns to sense up to 16 keys.

Figure 1-4 Sample Electrode Geometries



The charge flows are absorbed by the touch of a human finger (Figure 1-1) resulting in a decrease in coupling from X to Y. Thus, received signals decrease or go negative with respect to the reference level during a touch.

As shown in Figure 1-3, water films cause the coupled fields to increase slightly, making them easy to distinguish from touch.

1.2 Circuit Overview

A basic circuit diagram is shown in Figure 1-5. The 'X' drives are sequentially pulsed in groupings of bursts. At the intersection of each 'X' and 'Y' line in the matrix itself, where a key is desired, should be an interdigitated electrode set similar to those shown in Figure 1-4. Consult Quantum for application assistance on key design.

The device uses fixed external capacitors to acquire charge from the matrix during a burst of charge-transfer cycles; the burst length can be varied to permit digitally variable key signal gains. The charge is converted to digital using a single-slope conversion process.

Burst mode operation permits the use of a passive matrix, reduces RF emissions, and provides excellent response times.

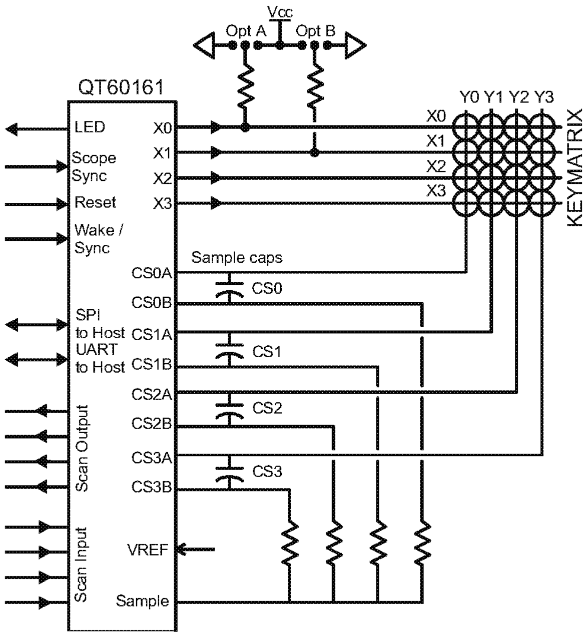
Refer to Section 3 for more details on circuit operation.

1.3 Communications

The device uses two variants of SPI communications, Slave-only and Master-Slave, a UART interface, plus a parallel scan interface. Over the serial interfaces are used a command and data transfer structure designed for high levels of flexibility using minimal numbers of bytes. For more information see Sections 4 and 5.

The parallel scan port permits the replacement of electromechanical keypads that would be scanned by a microcontroller; the scan interface mimics an electromechanical keyboard's response.

Figure 1-5 Circuit Block Diagram



2 Signal Processing

The device calibrates and processes signals using a number of algorithms specifically designed to provide for high survivability in the face of adverse environmental challenges. The QT60161 provides a large number of processing options which can be user-selected to implement very flexible, robust keypanel solutions.

2.1 Negative Threshold

See also command ^A, page 21

The negative threshold value is established relative to a key's signal reference value. The threshold is used to determine key touch when crossed by a negative-going signal swing after having been filtered by the detection integrator (Section 2.6). Larger absolute values of threshold desensitize keys since the signal must travel farther in order to cross the threshold level. Conversely, lower thresholds make keys more sensitive.

As Cx and Cs drift, the reference point drift-compensates for these changes at a user-settable rate (Section 2.4); the threshold level is recomputed whenever the reference point moves, and thus it also is drift compensated.

The threshold is user-programmed on a per-key basis using the setup process (Section 5).

2.2 Positive Threshold

See also command ^B, page 21

The positive threshold is used to provide a mechanism for recalibration of the reference point when a key's signal moves abruptly to the positive. These transitions are described more fully in Section 2.7.

The threshold is user-programmed using the setup process described in Section 5 on a per-key basis.

2.3 Hysteresis

See also command ^C and ^D, page 21

Refer to Figure 1-6. The QT60161 employs programmable hysteresis levels of 12.5%, 25%, or 50% of the delta between the reference and threshold levels. There are different hysteresis settings for positive and negative thresholds which can be set by the user. The percentage refers to the distance between the reference level and the threshold at which the detection will drop out. A percentage of 12.5% is less hysteresis than 25%, and the 12.5% hysteresis point is closer to the threshold level than to the reference level.

The hysteresis levels are set for all keys only; it is not possible to set the hysteresis differently from key to key on either the positive or negative hysteresis levels.

2.4 Drift Compensation

See also commands ^H, ^I, page 22

Signal levels can drift because of changes in Cx and Cs over time. It is crucial that such drift be compensated, else false detections, non- detections, and sensitivity shifts will follow. The QT60161 can compensate for drift using two setups, ^H and ^I.

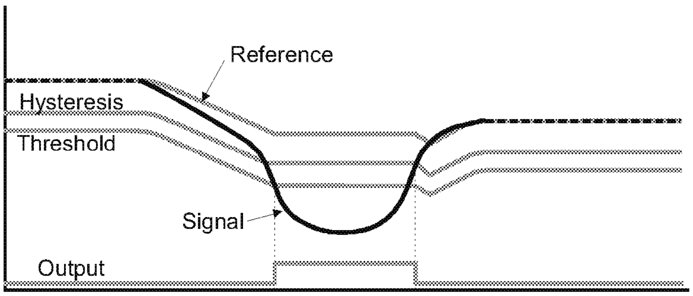
Drift compensation is performed by making the reference level track the raw signal at a slow rate, but only while there is no detection in effect. The rate of adjustment must be performed slowly, otherwise legitimate detections could be ignored. The devices drift compensate using a slew-rate limited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

When a finger is sensed, the signal falls since the human body acts to absorb charge from the cross-coupling between X and Y lines. An isolated, untouched foreign object (a coin, or a water film) will cause the signal to rise very slightly due to the enhanced coupling thus created. These effects are contrary to the way most capacitive sensors operate.

Once a finger is sensed, the drift compensation mechanism ceases since the signal is legitimately detecting an object. Drift compensation only works when the key signal in question has not crossed the negative threshold level (Section 2.1).

The drift compensation mechanism can be made asymmetric if desired; the drift-compensation can be made to occur in one direction faster than it does in the other simply by setting ^H and ^I to different settings.

Figure 1-6 Detection and Drift Compensation



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