PE5004 Keyboard
Capacitive Sensor Matrix
Control IC Keyboard Application

Introduction

The PE5004 is a high precision capacitive sensing circuit which uses amplitude modulation for very fast stimulating and reading of capacitive sensor arrays and single sensors.
A number of up to 100 sensors per chip can be selected by the user. Multiple sensor arrays can be easily cascaded. All Sensors can be addressed individually making it possible to integrate several different types of buttons, sliders, wheels and touch matrix arrays with one single PE5004.

Capacitive sensor elements are easy and cost effective to build especially when regularly arranged like on a PC keyboard. A typical PC keyboard has more than 100 buttons making it necessary to use two PE5004. Using two ICs even allows to employ some channels for a touch pad.
The sensors themselves can be built with little effort on a two layer printed circuit board. Using more than two layers will help shielding of sensor lines from digital or environmental interference effects and will increase sensitivity. When more keys will be required e.g. for function key pads or even for a touch pad a second PE5004 will also be required. Larger buttons like the 'Space' key would also be supported by more than just one sensor node. Only one USB controller IC is additionally required to make up for the whole HID-compatible USB keyboard.

This application note provides information on how to set up this application. A PCB layout, schematic and the source code is available for new applications.

For hints and information on sensor layout, calibration and firmware please refer to AppNote13.
For information on the working principle and complete description of the PE5004 and a guide how to design capacitive sensors please refer to the PE5004 data sheet.

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Initial Version V1.0	01/2011		

2   Keyboard layout

The detection of a touched key is based on modifications of the capacitance between two sensor electrodes due to changes of the dielectric constant or additional capacitor plates. In both cases the overall capacitance of the sensor is increased if a material different to air gets in the range of the fringe field between both electrodes.

The covering material over the sensor field must be non-conducting as e.g. metal would shield the electrodes from the touching finger. A high dielectric constant of the covering material and a low thickness would increase the influence of the finger on the capacitance change. Material like glass or plastic is suitable.

The material of the sensor carrying printed circuit board (PCB) itself should be of low permittivity to lower parasitic capacitance. Connections to the buttons shall be as short as possible. If that is not possible they should at least be shielded and/or not be crossing active digital lines to avoid crosstalk. The more of these recommendations will be followed the better will be the capacitance sensitivity of the keyboard layout.

Certain keys can be used for proximity sensing modes for the reduction of power consumption. The rest of the touch buttons can be in a non-scan mode. Even a kind of gesture recognition can be implemented in the keyboard to recognize e.g. a wipe or circle with the hand in proximity over the keypads. This function is not software supported for a HID and requires additional software interface programming.
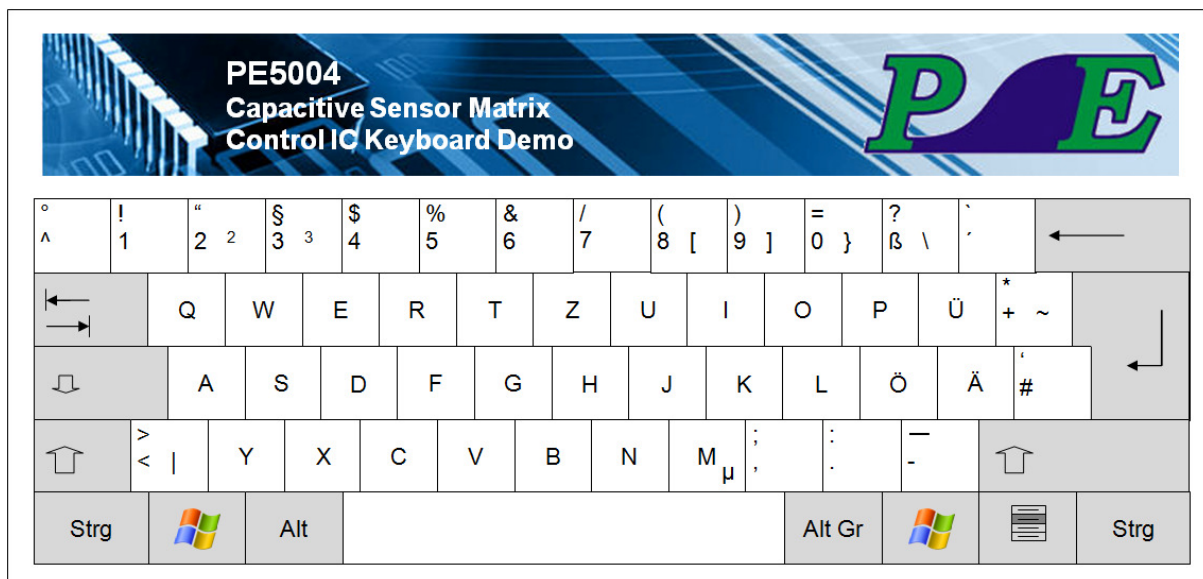

Figure 1 - A 62 Keys Layout for the reference design

3   USB Interface

3.1   Description

The USB interface board is only 39 x 19 mm² small and needs very few devices. It serves two functions. One purpose is the register setup and readout of the measurement results of the PE5004 capacitive multitouch sensor chip by the microcontroller. The controller also contains the ASCII table for each sign to be transmitted to the PC. The other purpose is to serve the HID communication. The complete source code is available at www.pe-gmbh.com.

3.2   Layout and schematic

Dev.	Value/Name
C18	100µF
C19	100µF
C1	470pF
R26/27	27ohm
U$11	FAN2502
X2	MINI-USB-Connector
U$3	CY7C64356-48LTXC
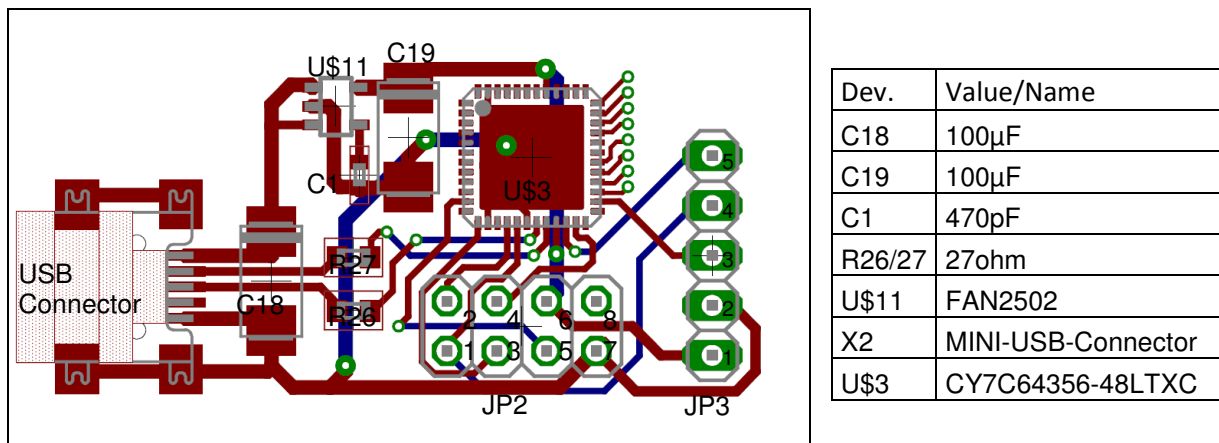
Figure 2 - USB interface board with Microcontroller Layout
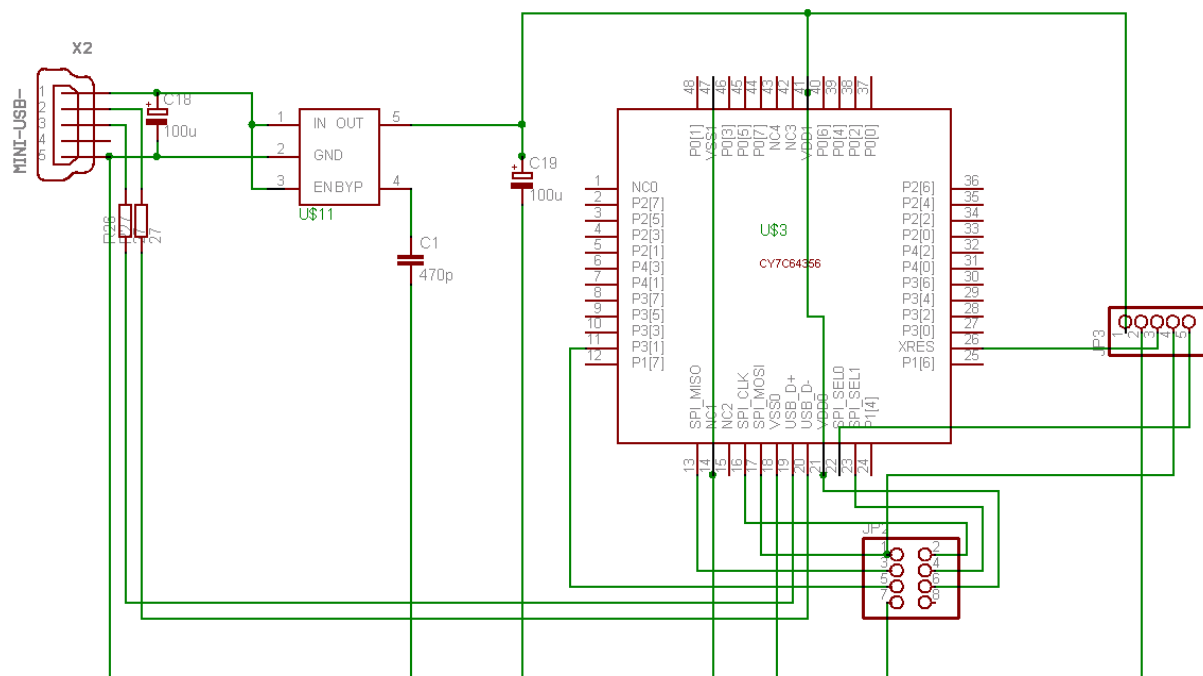
Figure 3 - Schematic of USB interface board

4 The keypad board

4.1 Description

The keypad is realized by a simple 2 layer board with 74 sensor keys. The location of the PE5004 has been choosen to yield the best average distance to all capacitors without too many additional wire crossings. The chosen position is always a compromise. The potentially ideal location would be in the middle of the keypad layout but then more crossings would be required. If the board is manufactured with 4 layers two layers could be used for shielding. Despite the fact that the reference design has been realized with hand wired copper line connections the key detection is still very good. This clearly classifies the extremely good performance of the PE5004. Due to the larger keys for "Space" and "Enter" more sensors for those keys had to be implemented. Furthermore the multitouch capability of the PE5004 allows to use the "Shift" or "Alt" keys in conjunction with any other key so that double or triple key combinations can easily be implemented.

The USB Interface board is attached to the board only by the 8 pinhead connector. Not even a capacitor is required on this board.
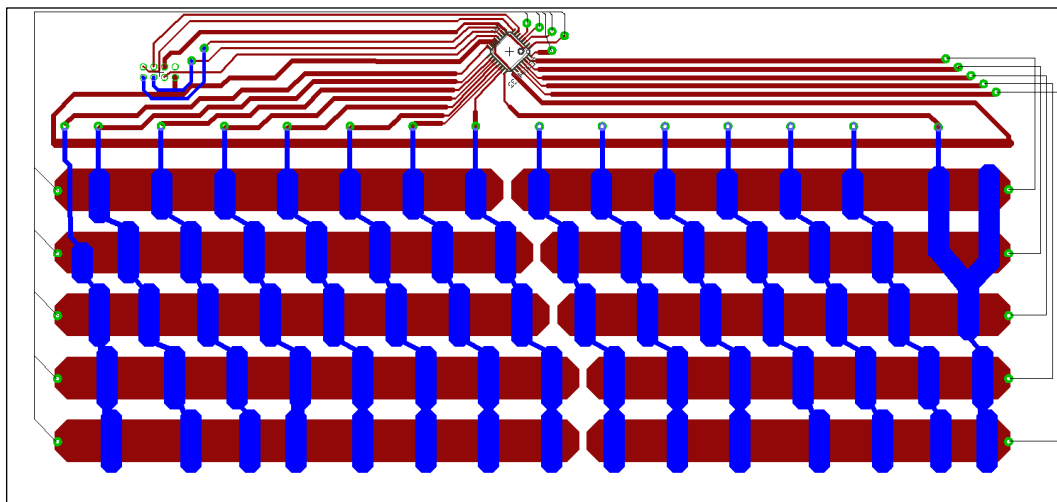
Figure 4 - Layout of the keypad board with 74 sensor keys (234 x 112 mm²)
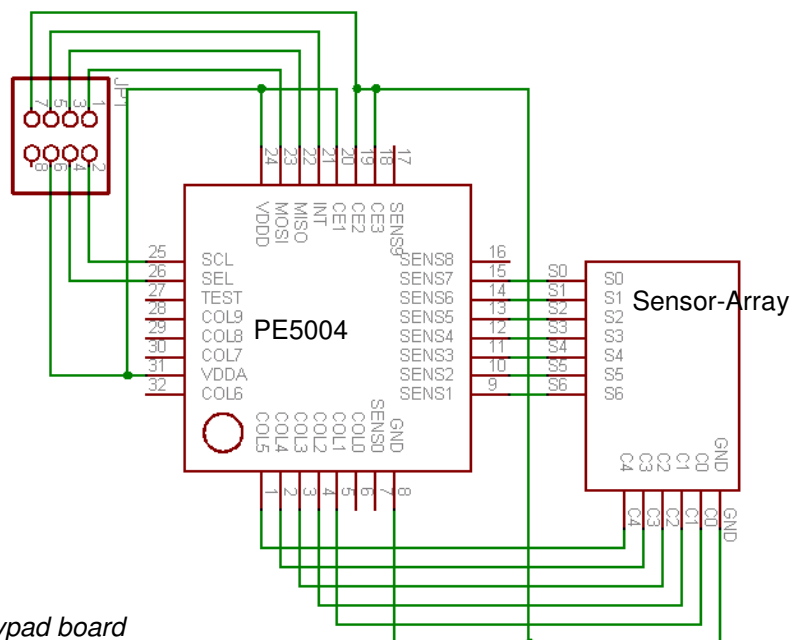
Figure 5 - Schematic of the keypad board

5   Conclusion

The PE5004 integrated circuit provides functionality in conjunction with any simple USB 8 bit microcontroller that allows for robust capacitive sensing keyboard applications. It is eminently suited for PC keyboards and touch pads.

The presented reference design can be considered to be the simplest keyboard design at all. Extensions like a touchpad or special keys can easily be implemented with additional PE5004 ICs. For a full-fledged PC keyboard with Function and Num keys and touchpad 3 PE5004 should be used. A single MCU can handle the interfacing.

Reference Touchpad sensor layouts can be found in Application Note No. 13 (AN13), available at www.pe-gmbh.com.

6.   Contact

Germany	**Stuttgart**	**Dresden**
	Productivity Engineering Process Integration GmbH Behringstrasse 7 D-71083 Herrenberg Germany Phone.: +49 (0) 70322798 0 Fax: +49 (0) 70322798 29 Email: info@pe-gmbh.com Web: www.pe-gmbh.com	Productivity Engineering GmbH Branch Sachsenallee 9 D-01723 Kesselsdorf Germany Phone.: +49 (0) 35204777 00 Fax: +49 (0) 35204777 000 Email: info@pe-gmbh.com