Freescale Semiconductor
Application Note

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E-field Keyboard Designs

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1 Introduction

This application note provides the fundamentals for designing keyboards with electric field (E-field) devices MC33794, MC34940, and MC33941. It describes the E-field basic operation and single and multiplexed electrodes. It also provides example keyboards you can use in your designs.

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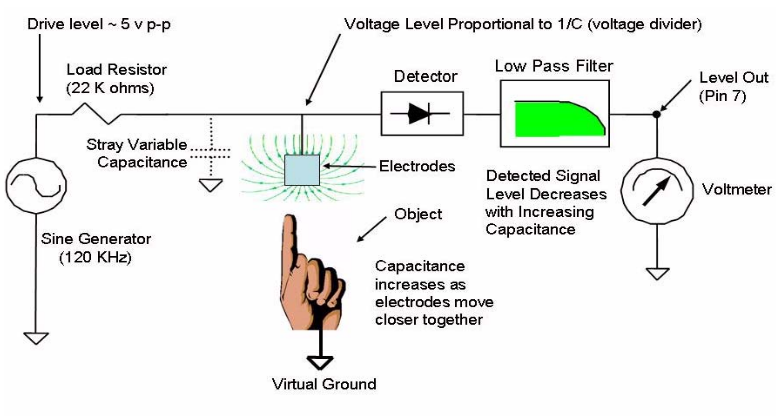
2 E-field Keyboards



2.1 E-field Device Basic Operation

The E-field device uses sine wave generation to derive the electric field used to sense a person's finger or any other conductive object. Inside the device, the electric field is derived by the oscillator circuitry. The oscillator circuitry generates a high purity, low frequency, 5 V peak-to-peak sine wave. This AC signal is fed through an internal 22 kΩ resistor to a multiplexer that directs the signal to the selected electrode or reference pin or to an internal measurement node. Unselected electrodes are automatically connected to the circuit ground by the IC.

The point where each electrode is connected back to the IC forms an AC voltage divider. The top leg of the divider is the 22 kΩ resistor; the bottom leg of the divider is a capacitor. Because the divider is fed with an AC sine wave, the bottom leg is controlled by capacitive reactance. All of the variables drop out of the equation:

$$Xc = 1 / (2 \times Pi \times F \times C) \qquad \textit{Eqn. 1}$$

except Pi and F, which are constant. So, all that remains is 1/C, where C is the capacitance formed by the finger or other stimulus approaching the electrode. After the divider, the signal is rectified and filtered and becomes an analog voltage output on pin 12 of the device. As the finger or stimulus moves closer to the electrode, the capacitance becomes larger. This results in a voltage drop across the internal 22 kΩ resistor. The voltage drop causes a voltage change at the electrode input pin. An on-board rectifier in the IC converts the AC signal to DC level. The DC level is then low-pass filtered using an internal series resistor and an external parallel capacitor. This DC voltage is multiplied, offset, and sent to the LEVEL pin of the IC.

2.2 Human Interface Detection to Keyboards

The E-field device can detect anything that is either conductive or has different dielectric properties than the electrodes' surroundings. Human beings are well suited for E-field imaging because the human body is composed mainly of water that has a high dielectric constant and contains ionic matter. This makes humans very conductive. The body also provides a good electrical coupling path to earth ground used for return ground of the IC. Thus, when a finger is brought near to a metal electrode, an electrical path is formed. This path produces a change in electric field current that is detected by the E-field device and is translated to a different output voltage.

2.3 Basic Keyboard Designs

2.3.1 Single Electrode Design

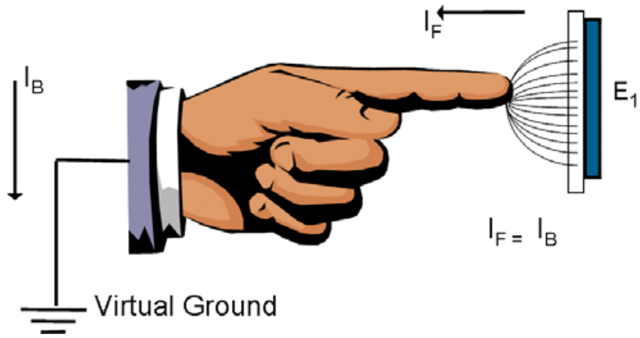


Figure 1. Single Electrode Design

In a single electrode keypad design, all keys are composed of a single plate or pad of copper. The keyboard design is referred to as a single electrode keypad design. Each electrode or keypad is coupled back to the E-field device through a series capacitor. The assumption is that the finger is capacitive coupled or connected to virtual ground. As the finger approaches the single electrode, it provides a conductive path from charged electrode to ground. Each time the key is selected by the E-field device, the keypad or electrode will change the output voltage of the LEVEL pin. Single electrodes or keys are not limited to keyboard design; single pads can also be used to detect proximity of a human hand or object. Figure 2 shows a few examples of single electrode designs.

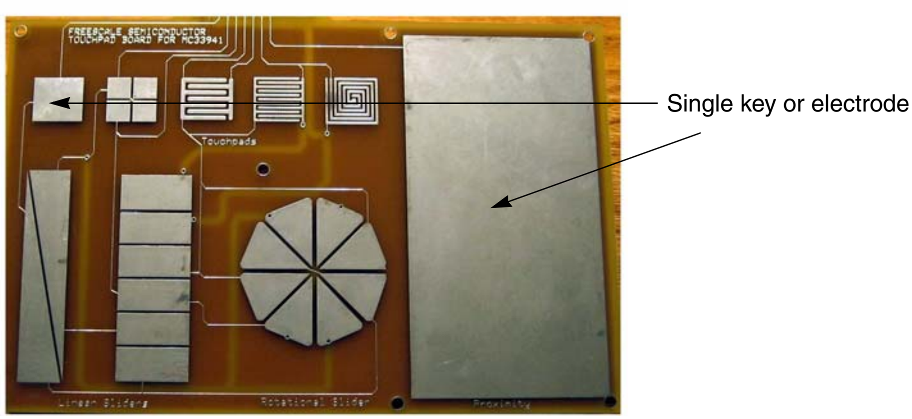


Figure 2. MC33941 Demo Kit E-field Board

2.4 Multiplexed Electrode Design

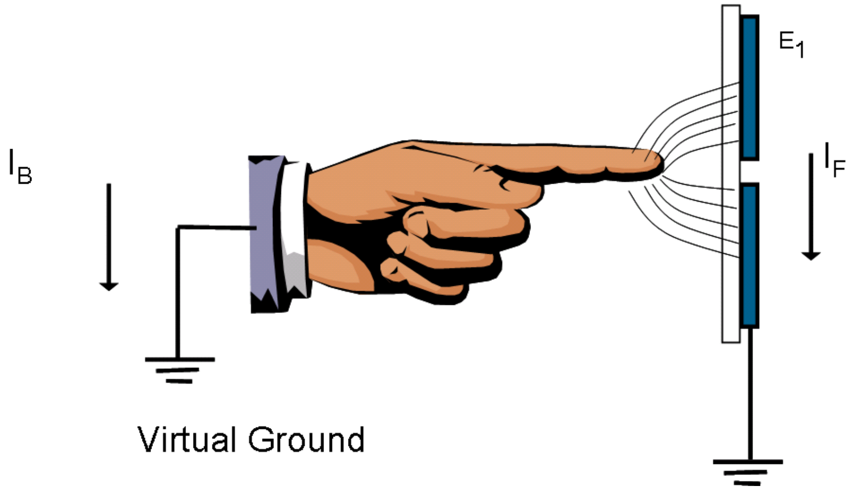


Figure 3. Multiplexed Electrode Design

In a multiplexed or dual electrode keypad design, all keys are composed of two plates or pads of copper. This keyboard design is referred to as a multiplexed electrode keypad design. For dual sensors, one electrode is charged and the other is at ground to increase sensitivity. This happens because inside the E-field device, unselected electrodes are grounded. As the finger approaches the dual electrodes, it provides a conductive path from charged electrode to ground through the finger and from charged electrode to ground through the grounded electrode. In other words, the closer the finger gets to the electrode, the greater the electrode loading. Each time a key is touched, two electrodes for each key will change the output voltage of the LEVEL pin. Figure 4 shows an example of multiplexed electrode keys.

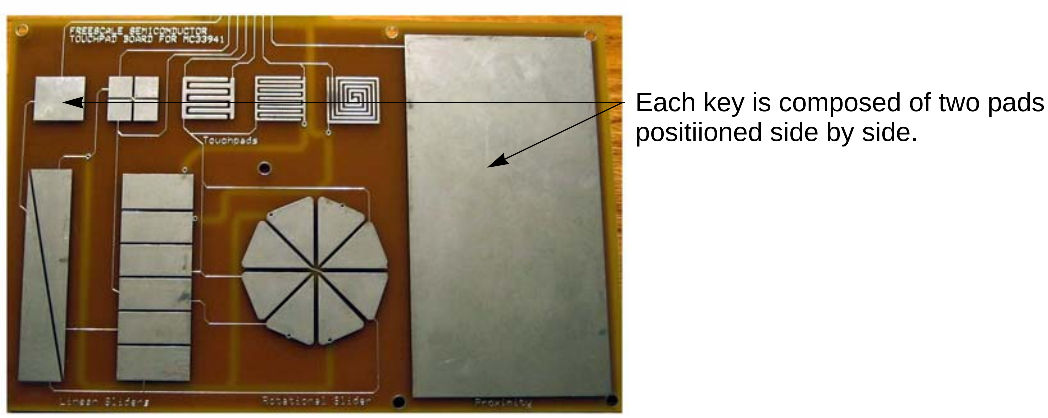


Figure 4. MC33941 Demo Kit E-field Board

3 References

Link to example keyboards in EXPRESSPCB format:
http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=DEMO1985MC34940E&fpsp=1&tab=Design_Tools_Tab

Touch Panel Application Note:

http://www.freescale.com/files/sensors/doc/app_note/AN1985.pdf

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