APPARATUS AND METHOD FOR DETECTING MULTIPLE BUTTONS WITH ONE PIN

TECHNICAL FIELD

[0001] This invention relates to the field of user interface devices and, in particular, to touch-sensor devices.

BACKGROUND

[0002] Computing devices, such as notebook computers, personal data assistants (PDAs), and mobile handsets, have user interface devices, which are also known as human interface device (HID). One user interface device that is common is a touch-sensor button. A basis touch-sensor button emulates the function of a mechanical button. Touch-sensor buttons may be embedded into different types of operational panels of electronic devices. For example, touch-sensor buttons may be used on operational or control panels of household appliances, consumer electronics, mechanical devices, and the like. Touch-sensor buttons may also be used in conjunction with, or in place of, other user input devices, such as keyboards, mice, trackballs, or the like.

[0003] FIG. **1**A illustrates a conventional sensing device having three touch-sensor buttons. Conventional sensing device **100** includes button **101**, button **102**, and button **103**. These buttons are conventional touch-sensor buttons. These three buttons may be used for user input using a conductive object, such as a finger.

[0004] FIG. **1**B illustrates a conventional sensing device of three touch-sensor buttons **101**-**103** coupled to a processing device **110**. Processing device **110** is used to detect whether a conductive object is present on either, or none, of the touch-sensor buttons **101**-**103**. To detect the presence of the conductive object, the processing device **110** may include capacitance sensors **104**-**106**, which are coupled to buttons **101**-**103**, respectively. The capacitance sensors of the processing device are coupled to the touch-sensor buttons in a one-to-one configuration. Accordingly, the processing device **110** scans the touch-sensor buttons **101**-**103** using the capacitance sensors **104**-**106**, and measures the capacitance on the touch-sensor buttons **101**-**103**.

[0005] Each of the conventional touch-sensor buttons **101**-**103** may be made of a sensor element of conductive material, such as copper-clad. The conductive material may be form shaped in a circular shape (illustrated in FIG. **1**A), or even in a rectangular shape (illustrated in FIG. **1**B). The touch-sensor buttons may be capacitance sensor buttons, which may be used as non-contact switches. These switches, when protected by an insulating layer, offer resistance to severe environments.

[0006] It should be noted that the conventional configuration of FIG. **1**B includes a one-to-one configuration of touch-sensor buttons to capacitance sensors. There are other conventional configurations that may use less capacitance sensors to measure the capacitance on the three touch-sensor buttons. These conventional configurations, however, still require a one-to-one configuration of pins to touch-sensor buttons. Accordingly, by adding more buttons, the processing device needs to have more pins to correspond to the one-to-one configuration of pins to touch-sensor buttons. Similarly, by increasing the pin count, the scan time to scan the sensor elements increases. In addition, the memory of the processing device, which may be used to store program data and/or temporary data (e.g., raw measurement data, differential counts, baseline measurement data, and the like), increases by increasing the pin count.

[0007] Another conventional button is a one-pin resistor configuration. The one-pin resistors configuration includes a resistor for each button. As the button is pressed, the resistor is introduced into the circuit, as a voltage divider, dropping a reference voltage to a lower voltage level. When the button is pressed, the voltage on the pin is changed (e.g., lowered) due to the change in voltage introduced by the resistor. The one-pin resistor configuration may be used in a keyboard of multiple keyboard keys. The keyboard keys each include a resistor coupled to each button. The voltage changes based on which key has been pressed, allowing the controller to determine which key has been pressed.

[0008] Another conventional one-pin-per button configuration is a resistance matrix of a conventional keyboard. The resistance matrix includes multiple rows and columns. All the rows are each connected to a pull-up resistor, and all the columns are each connected to a pull-down transistor. Above the resistance matrix there are multiple buttons (e.g., keyboard keys). Upon pressing a button, the corresponding row and column (X, Y) will be shorted together. These conventional resistance scan matrix designs have large pin counts because every row and every column is connected to a pin. The pin count for these conventional resistance matrix keyboards is the sum of the number of rows and the number of columns. Having a large pin count, may increase the die area of the circuit, or alternatively, or may decrease the robustness of the circuit by decreasing the possibility of additional functionality in the same circuit with limited pins. Also, the resistance scan matrix keyboards cannot be built in very small areas because it is limited by the pull-up resistor and mechanical button for each keyboard key. For example, the mechanical button of each keyboard key may have an area of about 0.5 centimeters (cm)×0.5 cm, the total keyboard area will be at least 25.25 cm^2 for a keyboard having **101** keyboard keys (e.g., 101×0.5 cm×0.5 cm=25.25 cm^2).

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings.

[0010] FIG. **1**A illustrates a conventional touch-sensor pad.

[0011] FIG. **1**B illustrates a conventional linear touch-sensor slider.

[0012] FIG. **2** illustrates a block diagram of one embodiment of an electronic system having a processing device for detecting a presence of a conductive object.

[0013] FIG. **3**A illustrates a varying switch capacitance.

[0014] FIG. **3**B illustrates one embodiment of a sensing device coupled to a processing device.

[0015] FIG. **3**C illustrates one embodiment of a relaxation oscillator.

[0016] FIG. **4** illustrates a block diagram of one embodiment of a capacitance sensor including a relaxation oscillator and digital counter.

[0017] FIG. **5**A illustrates a top-side view of one embodiment of a sensor array of sensor elements for detecting a presence of a conductive object on the sensor array of a touch-sensor pad.