

A capacitive touch sensor providing an automatic switch-off function for an apparatus in which the sensor is incorporated is provided. The sensor comprises a sensing element coupled to a capacitance measurement circuit for measuring the capacitance of the sensing element. A control circuit is operable to determine from the capacitance measurement whether an object is in proximity with the sensor. The determined presence of an object may be used to toggle a function of the apparatus. Furthermore, when it is determined that an object has not been in proximity with the sensor for a predetermined time duration, an output signal for switching off the apparatus is provided. The predetermined time duration may be selected from a number of predefined time durations, or may be programmed using an resistor-capacitor network. Pulses may be applied to the control circuit to override features of the automatic switch-off functionality.

## BACKGROUND ART

**[0001]** This invention relates to proximity sensors. In particular, the invention relates to capacitive sensors for sensing the presence or touch of an object adjacent to a sensor.

**[0002]** Capacitive position sensors have recently become increasingly common and accepted in human interfaces and for machine control. For example, in the fields of portable media players it is now quite common to find capacitive touch controls operable through glass or plastic panels. Some mobile (cellular) telephones are also starting to implement these kinds of interfaces.

**[0003]** Many capacitive touch controls incorporated into consumer electronic devices for appliances provide audio and/or visual feedback to a user indicating whether a finger or other pointing object is present or approaches such touch controls. A capacitive sensing microprocessor may typically be comprised in touch-controlled devices which are arranged to provide an “on” output signal when a finger is adjacent to a sensor and an “off” output signal when a finger is not adjacent to a sensor. The signals are sent to a device controller to implement a required function dependent on whether a user’s finger is in proximity with or touching an associated touch control.

**[0004]** Some touch-controlled devices remain “on” or “active” despite the user having moved away from the device or a particular function no longer being required. This results in the device consuming a large amount of power which is not efficient.

**[0005]** There is therefore a need for an improved capacitive touch sensor which can regulate power usage.

## SUMMARY OF THE INVENTION

**[0006]** According to a first aspect of the invention there is provided a sensor for determining the presence of an object comprising: a sensing element; a capacitance measurement circuit operable to measure the capacitance of the sensing element; and a control circuit operable to determine whether an object is in proximity with the sensor based on a measurement of the capacitance of the sensing element, the control circuit further being operable to provide an output signal to control a function of an apparatus when it is determined that an object has not been in proximity with the sensor for a predetermined time duration.

**[0007]** The control circuit may be configured so that the predetermined time duration is selectable from a number of different predefined time durations.

**[0008]** The control circuit may include a time input terminal and the predetermined time duration may be selectable from the number of different predefined time durations according to a voltage applied to the time input terminal.

**[0009]** The control circuit may include a delay multiplier terminal and be configured so that a selected one of the number of different predefined time durations is multiplied by a multiplication factor according to a voltage applied to the delay multiplier terminal so as to provide the predetermined time duration.

**[0010]** The control circuit may be configured so that the predetermined time duration is programmable by a user to provide a user-selected time duration.

**[0011]** The sensor may comprise a resistor-capacitor (RC) network coupled to the control circuit and the predetermined time duration may depend on a time constant of the RC network.

**[0012]** The control circuit may include a delay multiplier terminal and be configured so that the user-selected time duration is multiplied by a multiplication factor according to a voltage applied to the delay multiplier terminal to provide the predetermined time duration.

**[0013]** The control circuit may be configured such that the provision of the output signal to control a function of an apparatus after the predetermined time duration may be overridden so the output signal is not provided when it is determined that an object has not been in proximity with the sensor for a predetermined time duration. For example, the control circuit may be operable to receive an override pulse and on receipt of the override pulse to retrigger the predetermined time duration to so as to extend the time before the output signal to control a function of an apparatus is provided.

**[0014]** The control circuit may be configured such that the provision of the output signal to control a function of an apparatus after the predetermined time duration may be overridden so the output signal is provided before it is determined that an object has not been in proximity with the sensor for a predetermined time duration. For example, the control circuit may be operable to receive an override pulse and on receipt of the override pulse to provide the output signal to control a function of an apparatus.

**[0015]** The sensor may be configured to perform a recalibration when the sensor is powered up, when an object is determined to be in proximity with the sensor for more than a timer setting, and / or when an override is released.

[0016] The control circuit may be configured such that the output signal is toggled between a high state and a low state when an object is determined to be in proximity with the sensor.

[0017] The function of an apparatus controlled by the output signal may be a switch-off function.

[0018] The capacitance measurement circuit may employ bursts of charge-transfer cycles to acquire measurements.

[0019] The capacitance measurement circuit may be configured to operate in one of more than one acquisition modes depending on the output signal, for example a low-power mode or a fast mode.

[0020] The capacitance measurement circuit and the control circuit may be comprised in a general purpose microcontroller under firmware control.

[0021] The capacitance measurement circuit and the control circuit may be comprised within a six-pin integrated circuit chip package, such as an SOT23-6.

[0022] According to a second aspect of the invention there is provided apparatus comprising a sensor according to the first aspect of the invention.

[0023] According to a third aspect of the invention there is provided a method for controlling a function of an apparatus comprising: determining whether an object is in proximity with a sensor based on a measurement of the capacitance of a sensing element and providing an output signal to control the function of the apparatus when it is determined that an object has not been in proximity with the sensor for a predetermined time duration.

[0024] The function of the apparatus controlled by the output signal may be a switch-off function.

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