[0118] where Vc is the voltage across the integrating capacitor **37** before the output switch **31** was closed, C is the capacitance of the integrating capacitor **37**, and A and D are equal to their values when input switch **30** was closed as shown in Equation 1. Multiple switchings of the input **30** and output **31** switches as described above produce a voltage on the integrating capacitor **37** that reflects the proximity of a touch device **38** to the sensing electrode **33**.

[0119] **FIG. 3A** is a schematic diagram of the proximity sensor in which the shorting transistor **36** and the voltage-to-voltage translation device **35** are replaced by a resistor **40** and a current-to-voltage translation device **41**, respectively. The integrating function of capacitor **37** shown in **FIG. 2** is, in this variation of the proximity sensor, carried out by the capacitor **39** shown in **FIG. 3A**. Those skilled in the art will see that this variation of the proximity sensor produces a more linear output **58** from multiple switchings of the input and output switches, depending on the relative value of the resistor **40**. Alternatively, the resistor **40** can be replaced by a shorting switch **69** (cf. **FIG. 3B**) to improve linearity. Although, the circuits shown in **FIG. 3** provide a more linear output than the circuit shown in **FIG. 2** the circuits of **FIG. 3** generally require dual power supplies while the circuit of **FIG. 2** requires only one.

[0120] The electrical switches shown in **FIG. 2** can be implemented with various transistor technologies: discrete, integrated, thin film, thick film, polymer optical, etc. One such implementation is shown in **FIG. 4A** where field effect transistors (FETs) are used as the input **30**, output **31**, and shorting **36** switches. The FETs are switched on and off by voltages applied to their gate terminals (**43**, **44**, and **55**). For the purpose of this description we will assume the FET is switched on when its gate voltage is logic 1 and switched off when its gate voltage is logic 0. A controller **42** is used to apply gate voltages as a function of time as shown in **FIG. 4B**. In this example, a sequence of three pairs of pulses (**43** and **44**) are applied to the input and output transistor gates. Each pair of pulses **43** and **44** produces a voltage change across the integrating capacitor **37** as shown in Equation 2. The number of pulse pairs applied to input **43** and output **44** gates depends on the desired voltage across integrating capacitor **37**. In typical applications the number is between one and several hundred pulse-pairs.

[0121] **FIG. 5** shows the proximity sensor circuitry appropriate for use in a system comprising an array of proximity sensors **47** as in a multi-touch surface system. The proximity sensor **47** consists of the input transistor **30**, the output transistor **31**, the sensing electrode **33**, the dielectric cover **32** for the sensing electrode **33**, and conductive traces **43**, **44**, **45**, and **46**. The conductive traces are arranged so as to allow the proximity sensors **47** comprising a 2D array to be closely packed and to share the same conductive traces, thus reducing the number of wires needed in a system. **FIG. 6** shows an example of such a system where the input nodes **46** of all proximity sensors are connected together and connected to a power supply **34**. The output nodes **45** of all proximity sensors are connected together and connected to a single integrating capacitor **37**, a single shorting transistor **36**, and a single voltage-to-voltage amplifier **35**. In this implementation, a single proximity sensor **47** is enabled at a time by applying a logic 1 signal first to its input gate **43** and then to its output gate **44**. This gating of a single proximity sensor **47** one at a time is done by input gate controller **50** and output gate controller **51**. For example, to enable the proximity sensor **47** in the lower right corner the input gate controller **50** would output a logic one pulse on conductive trace **43***a*. This is followed by a logic one pulse on conductive trace **44***h* produced by output gate controller **51**. Repetition of this pulse as shown in **FIG. 4B** would cause charge to build up on integrating capacitor **37** and a corresponding voltage to appear at the output of the amplifier **58**. The entire array of proximity sensors **47** is thus scanned by enabling a single sensor at a time and recording its output.

[0122] **FIG. 7A** is a schematic of typical circuitry useful for converting the proximity sensor output **58** to a digital code appropriate for processing by computer. The proximity sensor output **58** is typically non-zero even when there is no touch device (e.g., ref. no. **38** in **FIG. 2**) nearby. This non-zero signal is due to parasitic or stray capacitance present at the common node **48** of the proximity sensor and is of relatively constant value. It is desirable to remove this non-zero background signal before converting the sensor output **58** to a digital code. This is done by using a differential amplifier **64** to subtract a stored record of the background signal **68** from the sensor output **58**. The resulting difference signal **65** is then converted to a digital code by an ADC (analog to digital converter) **60** producing a K-bit code **66**. The stored background signal is first recorded by sampling the array of proximity sensors **47** (**FIG. 6**) with no touch devices nearby and storing a digital code specific for each proximity sensor **47** in a memory device **63**. The particular code corresponding to the background signal of each proximity sensor is selected by an M-bit address input **70** to the memory device **63** and applied **69** to a DAC (digital to analog converter) **61**.

[0123] The 2D array of proximity sensors **47** shown in **FIG. 6** can be connected in groups so as to improve the rate at which the entire array is scanned. This is illustrated in **FIG. 8** where the groups are arranged as columns of proximity sensors. In this approach, the input nodes of the proximity sensors are connected together and connected to a power supply **34**, as in **FIG. 6**. The output gates **44** are also connected in the same way. However, the input gates **43** are now all connected together and the output nodes **45** are connected to only those proximity sensors **47** within a row and to a dedicated voltage amplifier **35**. With this connection method, all of the proximity sensors in a column are enabled at a time, thus reducing the time to scan the array by a factor N, where N is the number of proximity sensors in a group. The outputs **58***a*-*h* could connect to dedicated converter circuitry as shown in **FIG. 7A** or alternatively each output **58***a*-*h* could be converted one at a time using the circuitry shown in **FIG. 7B**. In this figure, the output signals from each group **58***a*-*h* are selected one at a time by multiplexer **62** and applied to the positive input of the differential amplifier **64**. With this later approach, it is assumed that the ADC **60** conversion time is much faster than the sensor enable time, thus providing the suggested speed up in sensor array scanning.

[0124] **FIG. 9** shows a typical circuit useful for the control of the proximity sensor's output gate **44**. It consists of three input signals **75**, **76**, **78** and two output signals **44**, **77**. The output gate signal **44** is logic 1 when both inputs to AND gate **79** are logic 1. The AND input signal **77** becomes logic 1 if input signal **76** is logic 1 when input signal **78** transitions from logic 0 to logic 1, otherwise it remains logic 0. A linear