energy storage element is measured by the charge detector **24***a*. Measurements made in this manner for the various channels are then digitized by an analog to digital converter and used to determine the location and other characteristics of touches to the sensor.

[**0023**] The signal outputs of the multiple sub-circuits are sent to an analog multiplexer **30** which in turn sends the signals to an ADC **38**, preferably through an amplifier **36**. The ADC **38** is preferably 12-bit, wherein the first three bits are considered most significant bits (MSB). The ADC **38** digitizes voltages present at each of the charge detectors **24**.

[**0024**] A circuit and method are provided to automatically set a gain control to enable the connection of various screens to the circuit. The sub-circuits **52** of the present invention will charge until any one of the charge detectors **24** saturates. Once the controller circuit **5** detects that any one of the charge detectors **24** is saturated, it will stop charging automatically. The circuit can efficiently detect that a charge detector **24** is saturated by utilizing two programs in its firmware, the first program operating to sense the three most significant bits of the ADC, and the second program operating to measure and digitize voltage present at a charge detector **24**. The second program does not operate until all of the three most significant bits are equal to one for one of the charge detectors, i.e., that the value in the first 3 registers of the ADC **38** exceeds a threshold. If all 3 most significant bits are equal to one for a charge detector, then the voltage on the charge detector has reached a level indicating the charge detector is saturated and the circuit will then stop charging. By using these two programs in the firmware driving the circuit, the amount of measurement time required by the 12-bit ADC is minimized so that the circuit can operate faster. By automatically stopping the charging in the circuit, automatic gain control of the circuit is implemented. This reduces or eliminates the need for manually tuning a circuit for optimum operation when coupled to different sizes of screens, and the need for fine tuning a circuit that arises because of subtle differences between screens.

[**0025**] The circuits of the present invention can operate using a virtual ground set to some positive voltage between 0V and 5V, preferably to +2.5V. By using a virtual ground set at a positive voltage, a single polarity power supply (e.g., +5V for a +2.5V virtual ground) is the only required power source for the circuit.

[**0026**] In a preferred embodiment the potential at each of the electrodes (which are positioned around the periphery of the sensing area of the sensor, e.g., at the corners) will be the same. This will provide improved linearity for a more uniform and less distorted display. A circuit and method are provided to set the potential of all electrodes of a capacitive sensor to be the same. Each charge detector **24** of each sub-circuit **52** has a reference input (RefL, RefX, RefH, RefY). The voltage used as the reference for the circuit will generally have some variability as it is input into the charge detectors. For example, the variability is about 60 mV on a 2.5V reference, i.e., the reference voltage range is about 2.47-2.53V. A digital potentiometer **40** can be used to finely tune the reference voltage (e.g., 2.5V) as it is supplied to the reference inputs RefL, RefX, RefH, RefY of the respective charge detectors **24** so that the voltage on all the electrodes is the same. In addition the potentiometer **40** can be used to tune the reference voltage to adjust for any small DC offsets (e.g., 5-10 mV) that may be present at the output of the charge detectors or at the ADC **38**.

[**0027**] In a preferred scheme for measuring capacitance information from the sub-circuits in a sensor of the present invention, the electrodes are charged to a selected voltage (e.g., +2.5V) using a series of approximately 1 microsecond pulses, with the first switches **20** closed and the second switches **22** opened, and the capacitance of a subset of the electrodes (e.g., two of four) is measured by the detectors of the associated sub-circuits with the first switching elements opened and the second switching elements closed. The electrodes and therefore the screen are then discharged to ground using a gate **32**, and the capacitance of the remainder of the electrodes is then measured. Thus the discharging takes place between measurements of the multiple electrodes, thereby making the duty cycle approximately 50%. One advantage of this scheme is that the EMI produced by the circuit can be reduced.

[**0028**] **FIG. 3** is a circuit layout for an electronic circuit for use in a touchscreen system including a touchscreen sensor (e.g., a capacitive touch sensor) for transmitting data between a microcontroller and the sensor. **FIG. 3** includes the following elements: a resistor **60**, preferably a polymeric positive temperature coefficient device; a regulator **62**, preferably a voltage and current regulator; an EPROM chip **64**; an integrated circuit capable of converting serial RS232 data to universal serial bus data **66**; a voltage monitor **68**; an EPROM chip **70**; a buffer **72**, preferably a 3-state single bus buffer; a microcontroller **74**; and a serial (RS232) line driver/receiver **76**.

[**0029**] A controller circuit for a sensor as shown in **FIG. 3** transfers data between a microcontroller or computer and the sensor circuit. It is desired to use either an RS232 serial connection or a universal serial bus (USB) to transfer the data. Integrated circuits exist which can convert RS232 serial input to a USB compatible input. An example of such an integrated circuit is the FT232BM, available from FTDI. However, in many cases, it is desirable to have the controller circuit be able to use either an RS232 serial connection or a USB connection to transfer data A circuit can be configured to accommodate both data interface protocols by including an integrated circuit designed to convert RS232 input to USB input (**66**) and an RS232 line driver/receiver (**76**), and using a three-state bus buffer (**72**) to send a control signal to enable either the integrated circuit or the RS232 line driver to communicate with the microcontroller (**74**).

[**0030**] The foregoing detailed description of the invention includes passages which are chiefly or exclusively concerned with particular parts or aspects of the invention. It is to be understood that this is for clarity and convenience, that a particular feature may be relevant in more than just the passage in which it is disclosed, and that the disclosure herein includes all the appropriate combinations of information found in the different passages. Similarly, although the various figures and descriptions thereof relate to specific embodiments of the invention, it is to be understood that where a specific feature is disclosed in the context of a particular figure, such feature can also be used, to the extend appropriate, in the context of another figure, in combination with another feature, or in the invention in general.

[**0031**] It will be understood that the above-described arrangements of apparatus and the methods therefrom are