top layer **512**. In another embodiment, the electrical signal is injected and current measured at contacts located at four positions of the bottom layer **514** and the top layer **512** serves as a return path reference layer. Although, in the above example, the electrical signal is injected and current is measured at contacts located at four positions on the touch sensor, any number of contacts may be used.

[**0060**] Another approach used to detect touch location on a touch sensor according to an embodiment of the invention is a 4-wire technique. **FIG. 6** illustrates a block diagram of a 4-wire system for detecting the location of a touch on a sensor. The system includes a two dimensional (x,y) touch sensor **610** and a controller **620**.

[**0061**] In this configuration, the touch sensor has two sets of contacts. Vertical contacts **615**, **617** are located on the top conductive layer **612**. Horizontal contacts **616**, **618** are located on the bottom conductive layer **614**. The 4-wire system operates by separately determining the x and y coordinates of the touch location.

[**0062**] For example, the x coordinate of the touch may be determined by energizing the top conductive layer **612** through the vertical contacts **615**, **617** of the touch sensor **610** coupled to the drive/sense circuitry **630**. The bottom conductive layer serves as the reference coupled through the horizontal contacts **616**, **618** to the controller **620**. The sense circuitry **630** measures the capacitive current flow at each of the vertical contacts **615**, **617**. The capacitive current measured at the vertical contacts **615**, **617** of the touch sensor **610** varies as a function of the x location of the touch location. The relative amounts of capacitive current flowing through the vertical contacts **615**, **617** indicate the x coordinate of a touch.

[**0063**] The y coordinate of the touch location may be determined by energizing the bottom conductive layer **614** through the horizontal contacts **616**, **618** coupled to the drive/sense circuitry **630**. The top conductive layer serves as the reference coupled to the controller through the vertical contacts **615**, **617**. The sense circuitry **630** measures the capacitive current flow at each of the horizontal contacts **616**, **618**. The capacitive currents measured at each of the horizontal contacts **616**, **618** varies as a function of the y location of the touch. The relative amounts of capacitive current flowing trough the horizontal contacts **616**, **618** indicate the y coordinate of a touch.

[**0064**] **FIG. 7** schematically illustrates the configuration of drive/sense circuitry and the touch sensor of the present invention used with simplified controller circuitry according to one embodiment. In this embodiment, the drive/sense circuitry **705**, **706** is connected to two contacts **707**, **708** located at opposite ends of a one dimensional touch sensor **710** for injecting an electrical signal and measuring the current. The touch sensing system **700** shown in **FIG. 7** is capable of detecting the x coordinate of the touch location. The sensing system is shown as a one dimensional system for simplicity, although it will be appreciated that the principles for one dimensional sensing may be extended to two dimensional sensing with the addition of at least one contact and associated circuitry. Furthermore, it should be appreciated that the circuit illustrated in **FIG. 7** is presented as only an example and that other configurations of closed-loop detection circuit may be used.

[**0065**] The drive/sense circuitry **705**, **706** of the sensing system **700** is connected to contacts **707**, **708** at each end of the touch sensor **710** for injecting an electrical signal and measuring the resultant current. A processor (not shown) uses the ratio of current values measured at the contacts **707**, **708** of the touch sensor **710** to determine a touch location. In the configuration of **FIG. 7**, the capacitive coupling of the touch sensor to earth ground is reduced and the system uses only a known low impedance connection **760** as a reference connection. Important features of this arrangement include the internally closed circuit of the detection system, which contrasts with other capacitive sensor circuits where the detection circuit is closed by the user. As a result of the internally closed circuit, the parameters of the detection circuit are known and are relatively stable with time. On the other hand, in other capacitive detection circuits, the coupling capacitance to earth ground may change between different times of use.

[**0066**] C_{sensor} **740** is a variable capacitance that changes upon application of a touch. Prior to a touch, C_{sensor} **740** has a fixed value primarily dependent on sensor parameters, including the distance between the conductive layers and dielectric constants of the gap filler material and protective layers, if any. Upon application of a touch, the sensor parameters change as the distance between the conductive layers decreases, causing a corresponding change in the value of C_{sensor} **740**. The change in the ratio of touch sensor current at the contacts **707**, **708** of the touch sensor due to a change in C_{sensor} **740** may be detected by a processor (not shown) and converted into touch location.

[**0067**] The low impedance reference connection **760** depicted in **FIG. 7** significantly decreases the effect of external capacitive coupling of the sensor to ground. The reduction of external capacitive coupling reduces the need to track and compensate for the effects of external capacitance, allowing a simplified controller circuitry to be used. External capacitance is additionally reduced by using a supporting layer with appropriate thickness and material properties to insulate the first conductive layer of the sensor from the environment. Therefore, stray capacitance, which is represented by $C_{internal}$ **730**, is fixed. The reduction in the dependence on the external capacitance and the fixed stray capacitance both result from the use of an internally closed circuit in the touch detection system.

[**0068**] The discussion presented in connection with **FIG. 7** describes touch sensing using a one dimensional touch sensor to facilitate illustration. The two dimensional coordinates of the touch location may be determined with the addition of one or more electrodes and associated circuitry. In a two dimensional configuration, the previously described 5-wire or 4-wire techniques may be used to detect the touch location.

[**0069**] The simplified controller illustrated in **FIG. 7** uses a low impedance reference connection, thereby reducing the effect of external capacitance on the system. The touch sensing system of present invention can be implemented with a simplified controller because external capacitive coupling of the sensor is reduced through the use of an internal low impedance reference connection and an insulating layer over the conducting layer. The use of a low impedance reference has advantages in addition to those previously discussed. First, because the touch sensor does not rely on a connection through earth ground, the sensor is touch instrument independent and may be used with a