

which form a part hereof, and in which it is shown by way of illustration specific embodiments in which the invention may be practiced. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the preferred embodiments of the present invention.

[0024] Although embodiments of the present invention are described herein in relation to an electronic device having multi touch panel, it should be understood that the present invention is not limited to such devices, but is generally applicable to any electronic device which requires the processing and demodulation of incoming oscillating signals.

[0025] An embodiment of the present invention is directed to processing an incoming signal using a demodulation signal, while controlling the phase of the demodulation signal in relation to the incoming signal. The embodiments of the present invention can be used in variety of settings. One example of such a setting is an electronic device featuring a touch screen which is configured to detect multiple simultaneous touches thereon. A device including such a touch screen is described by FIGS. 1, 2a-c and 3a-c and the accompanying discussion below. As mention above, the present invention is not limited to the device discussed in FIGS. 1-3 but may be utilized in a variety of different devices.

[0026] Multi-touch touch-sensitive panels according to one embodiment of this invention can detect multiple touches (touch events or contact points) that occur at about the same time (and at different times), and identify and track their locations. FIG. 1 illustrates exemplary computing system 100 that uses multi-touch panel 124. Computing system 100 can include one or more multi-touch panel processors 102 and peripherals 104, and multi-touch subsystem 106. One or more processors 102 can include, for example, ARM968 processors or other processors with similar functionality and capabilities. However, in other embodiments, the multi-touch panel processor functionality can be implemented instead by dedicated logic, such as a state machine. Peripherals 104 may include, but are not limited to, random access memory (RAM) or other types of memory or storage, watchdog timers and the like. Multi-touch subsystem 106 can include, but is not limited to, one or more analog channels 108, channel scan logic 110 and driver logic 114. Channel scan logic 110 can access RAM 112, autonomously read data from the analog channels and provide control for the analog channels. This control can include multiplexing columns of multi-touch panel 124 to analog channels 108. In addition, channel scan logic 110 can control the driver logic and stimulation signals being selectively applied to rows of multi-touch panel 124. In some embodiments, multi-touch subsystem 106, multi-touch panel processor 102 and peripherals 104 can be integrated into a single application specific integrated circuit (ASIC).

[0027] Driver logic 114 can provide multiple multi-touch subsystem outputs 116 and can present a proprietary interface that drives high voltage driver, which is comprised of decoder 120 and subsequent level shifter and driver stage 118, although level-shifting functions could be performed before decoder functions. Level shifter and driver 118 can provide level shifting from a low voltage level (e.g. CMOS levels) to a higher voltage level, providing a better signal-to-noise (S/N) ratio for noise reduction purposes. Decoder 120 can decode the drive interface signals to one out of N outputs, whereas N is the maximum number of rows in the panel. Decoder 120 can be used to reduce the number of drive lines needed between the high voltage driver and multi-touch panel

124. Each multi-touch panel row input 122 can drive one or more rows in multi-touch panel 124. In some embodiments, driver 118 and decoder 120 can be integrated into a single ASIC. However, in other embodiments driver 118 and decoder 120 can be integrated into driver logic 114, and in still other embodiments driver 118 and decoder 120 can be eliminated entirely.

[0028] Multi-touch panel 124 can in some embodiments include a capacitive sensing medium having a plurality of row traces or driving lines and a plurality of column traces or sensing lines, although other sensing media may also be used. The row and column traces may be formed from a transparent conductive medium, such as Indium Tin Oxide (ITO) or Antimony Tin Oxide (ATO), although other transparent and non-transparent materials, such as copper, can also be used. In some embodiments, the row and column traces can be formed on opposite sides of a dielectric material, and can be perpendicular to each other, although in other embodiments other non-orthogonal orientations are possible. For example, in a polar coordinate system, the sensing lines can be concentric circles and the driving lines can be radially extending lines (or vice versa). It should be understood, therefore, that the terms "row" and "column," "first dimension" and "second dimension," or "first axis" and "second axis" as used herein are intended to encompass not only orthogonal grids, but the intersecting traces of other geometric configurations having first and second dimensions (e.g. the concentric and radial lines of a polar-coordinate arrangement). It should also be noted that in other embodiments, the rows and columns can be formed on a single side of a substrate, or can be formed on two separate substrates separated by a dielectric material. In some embodiments, the dielectric material can be transparent, such as glass, or can be formed from other materials, such as mylar. An additional dielectric cover layer may be placed over the row or column traces to strengthen the structure and protect the entire assembly from damage.

[0029] At the "intersections" of the traces, where the traces pass above and below each other (but do not make direct electrical contact with each other), the traces essentially form two electrodes (although more than two traces could intersect as well). Each intersection of row and column traces can represent a capacitive sensing node and can be viewed as picture element (pixel) 126, which can be particularly useful when multi-touch panel 124 is viewed as capturing an "image" of touch. (In other words, after multi-touch subsystem 106 has determined whether a touch event has been detected at each touch sensor in the multi-touch panel, the pattern of touch sensors in the multi-touch panel at which a touch event occurred can be viewed as an "image" of touch (e.g. a pattern of fingers touching the panel).) The capacitance between row and column electrodes appears as a stray capacitance on all columns when the given row is held at DC and as a mutual capacitance C_{sig} when the given row is stimulated with an AC signal. The presence of a finger or other object near or on the multi-touch panel can be detected by measuring changes to C_{sig} . The columns of multi-touch panel 124 can drive one or more analog channels 108 (also referred to herein as event detection and demodulation circuits) in multi-touch subsystem 106. In some embodiments, each column is coupled to one dedicated analog channel 108. However, in other embodiments, the columns may be couplable via an analog switch to a fewer number of analog channels 108.

[0030] Computing system 100 can also include host processor 128 for receiving outputs from multi-touch panel pro-