[0223] The Irrelevant "Steady Noises" Problem, and its Solution

[0224] The Display Panel Irrelevant "Steady Noises" Problem

[0225] Reference is now made to **FIG. 15**, which is a simplified diagram which demonstrates what may be referred to as the display panel signal problem. Two sensor conductors **210** and **212** oscillate in reference to ground **214** by virtue of any of the above embodiments. As mentioned above, the sensor is located over an electronic display. Capacitances **216** and **218** are created between conductors **210** and **212** and the display panel **220**. As the display panel, represented electrically by resistances **220**, does not oscillate in reference to the common ground **214** two signals, (Sa) and (Sb), which may be regarded as oscillating leakage currents, are provided on conductors **210** and **212** respectively.

[0226] As long as the oscillation phase and magnitude do not change (Sa) and (Sb) remain identical over time. Sa and Sb are thus referred to herein as steady noises. It is noted that the parasitic capacitance between the sensor and the display can also change due to environmental conditions etc. This may affect the signal as well.

[0227] In an ideal environment, (Sa)=(Sb), and therefore no signal differentiation is amplified, by differential amplifier **222** which is connected between the two sensors **210** and **212**, unless a user's finger touches a conductor. However, in practice, there are slight differences in distance, overlapping area, screen structure, intermediate material, temperature, etc. (Sa)≠(Sb), and therefore, a "steady noise": (Sa)−(Sb) is produced. The steady noise is amplified by the differential amplifier **222**. Such "steady noises" based on (Sa) and (Sb) exist on any two sensor conductors connected by a differential amplifier, and thus it may be said that similar differentials to (Sa)−(Sb) are being amplified by any of the differential amplifiers connecting sensor conductors in the system. The result is various amplified steady noises that, although steady over time, are detected by the detector. The presence of these steady noises reduces the level of accuracy possible in detecting the user's finger's location.

[0228] The Mapping Solution

[0229] Reference is now made to **FIG. 16**, which has an upper part **16A** which shows the display panel as a grid **230** of sensor lines **232**, each pair of sensor lines being connected to a differential amplifier **234**. In one preferred embodiment of the present invention, the solution to the problem described above comprises mapping the various panel display amplified signal differentiations. As demonstrated in **FIG. 16B, a** value of steady noise is determined and mapped for each pair of sensor conductors. Such mapping is preferably achieved as follows:

[0230] (Sa) is the "steady noise" created on the sensor conductor connected to the positive side of the amplifier by the flat panel display. (Sb) is the "steady noise" created on a second conductor connected to the negative side of the amplifier by the flat panel display. A diff amplifier connects these two conductors. The differentiation between (Sa) and (Sb) is amplified by the diff amplifier.

[0231] 1. The amplified signal is converted by A/D to a digital representation

[0232] 2. The DSP performs FFT/DFT on the digital signal

[0233] 3. Actions 1-3 are repeated for a predetermined number of times (for example 20 times). Averaging is then performed. Averaging minimizes variable noises that may provide temporary distortions of the measurement. The average value is then stored in the differential map.

[0234] 4. Actions 1-4 are performed for each pair of conductors connected by a diff amplifier.

[0235] The result is a map, referred to herein as a differential map, and represented by **FIG. 16B** which includes both the magnitude and the phase of the differential signals recorded for each sensor pair. Each recorded magnitude phase pair represents the display panel "steady noise" of each pair of sensor conductors connected by a differential amplifier. The magnitude and phase are for a specific oscillation frequency.

[0236] In a preferred embodiment, the system uses a single frequency for detection of fingers. However, in additional embodiments, more than one frequency could be used and the system may switch between the frequencies or even oscillate at more than one frequency simultaneously. If more than one frequency is being used, than more than one map is created. Preferably one map is created for each frequency.

[0237] Once the differential map is stored in memory, it can be used to compensate for the display panel signal steady noise phenomenon. Reference is now made to **FIG. 17** which is a simplified schematic diagram illustrating a two-conductor sensor arrangement exhibiting the steady noise phenomenon. The display panel creates "steady noises" (Sa) and (Sb) on sensor conductors **240** and **242** respectively. The user's finger creates an (Sf) signal, which is the signal it is desired to measure. The overall differential, as determined by differential amplifier **244**, between the sums of signals on both sensor conductors is: {(Sa)+(Sf)}−(Sb)} The overall differential is amplified by the diff amplifier **244** and sampled by the detector **246**. The DSP component **248** reads the differentiation {(Sa)−(Sb)} stored within the differential map **250**. The DSP **250** subtracts the differential from the sampled signal. As {(Sa)+(Sf)}−(Sb)}−{(Sa-Sb)}=(Sf) the DSP is able to isolate and identify the finger signal, and identify the finger's location.

[0238] Such a mapping process is used in the preferred embodiment of the present invention in order to solve the problem of steady noises injected by the panel display. The same method can be used in the same and other embodiments of the present invention in order to solve any type of steady noise problem. Examples of potential sources for steady noise include: differences in input impedance, differences in input capacitance, insufficient common mode rejection, etc.

[0239] Detection of Signaling Objects Through the Mapping Process Problem and its Solutions

[0240] The mapping process creates the following problem:

[0241] An object, usually a finger, a hand or combination of fingers and hands, placed on the display panel during the mapping process creates a signal. When the hand is removed a difference over the values initially stored within the