ACOUSTIC CONDITION SENSOR EMPLOYING A PLURALITY OF MUTUALLY NON-ORTHOGONAL WAVES

CONTINUING DATA

[0001] The present application for U.S. patent is a Continuation-in-Part of U.S. patent application Ser. No. 08/424,216, allowed, expressly incorporated herein by reference in its entirety.

TECHNICAL FIELD OF THE INVENTION

[0002] The present invention relates to an acoustic touch position sensor, and more particularly to such a sensor wherein a coordinate position, and optionally an absorption characteristic, of an acoustic disturbance is determined by analyzing a plurality of received signals. The present invention allows the sensing system to employ waves to differ in path geometry, and/or wave characteristic type, e.g., mode, frequency, waveform, velocity, and/or wavelength. This system advantageously allows redundant position measurement and/or differential wave perturbation sensing.

BACKGROUND OF THE INVENTION

[0003] Acoustic touch position sensors are well known. A common system includes two sets of transducers, each set having a different axis aligned respectively with the axes of a physical Cartesian coordinate system defined by a substrate. An acoustic pulse is generated by one transducer, propagating as a Rayleigh wave along an axis which intersects an array of reflective elements, each element angled at 45° and spaced corresponding to an integral number of wavelengths of the acoustic wave pulse. Each reflective element reflects a portion of the wave along a path perpendicular to the axis, across an active region of the substrate, to an opposing array and transducer which is a mirror image of the first array and transducer. The transducer in the mirror image array receives an acoustic wave consisting of superposed portions of the wave reflected by the reflective elements of both arrays, directed antiparallel to the emitted pulse. Wavepaths in the active region of the sensor have characteristic time delays, and therefore a wavepath or wavepaths attenuated by an object touching the active region may be identified by determining a timing of an attenuation in the composite returning waveform. A second set of arrays and transducers are provided at right angles to the first, and operate similarly. Since the axis of a transducer corresponds to a physical coordinate axis of the substrate, the timing of an attenuation in the returning wave is indicative of a Cartesian coordinate of a position on the substrate, and the coordinates are determined sequentially to determine the two dimensional Cartesian coordinate position of the attenuating object.

[0004] The applicability of such systems as commonly employed is restricted by the following major limitations. First, acoustically absorptive contamination in localized regions, e.g. a water drop on a known Rayleigh-wave sensor, result in large areas of shadowing in which two-dimensional touch positions cannot be reconstructed. Second, the configurational requirements of these sensors limits their versatility with regard to shape and size. Third, reconstruction of touch coordinates may lead to ambiguities when more than one touch is applied simultaneously. Finally, such sensors provide limited touch characteristic information from which to differentiate valid touches from false touches, e.g. fingers from water drops. The present invention addresses these problems.

[0005] Present commercial touch screen products generally serve applications in which the touchscreen is an input device that is intended to be used by one user at a time. An automatic-teller-machine (ATM) banking application is typical. While many customers may sequentially use a touchscreen based automatic teller machine, each user in turn has a private dialog with the system. In contrast, few if any touchscreen products are presently available for applications in which the touchscreen is an input device that is intended to be used by more than one user simultaneously.

[0006] a. Parallel Transducer Arrays

[0007] Acoustic touch position sensors are known to include a touch panel or plate having an array of transmitters positioned along a first edge of a substrate for simultaneously generating parallel surface acoustic waves that directionally propagate through the panel to a corresponding array of detectors positioned opposite the first array on a second edge of the substrate. Another pair of transducer arrays is provided at right angles to the first set. Touching the panel at a point causes an attenuation of the waves passing through the point of touch, thus allowing interpretation of an output from the two sets of transducer arrays to indicate the coordinates of the touch. This type of acoustic touch position sensor is shown in U.S. Pat. No. 3,673,327 and WO 94/02911, Toda, incorporated herein by reference. By employing a direct acoustic path from a transmitting transducer to a corresponding receiving transducer, an acoustic path length which is approximately equal to the height or width of the substrate is provided, as shown in **FIG. 1**. Because the acoustic wave diverges, a portion of a wave emitted from one transmitting transducer will be incident on a set of receiving transducers, as shown in **FIG. 2**.

[0008] b. Reflective Arrays

[0009] In order to reduce the number of transducers required for an acoustic touchscreen, Adler, Re. 33,151, and U.S. Pat. No. 4,700,176, provide a reflective array for reflecting portions of an acoustic wave along incrementally varying paths. Therefore, if two such arrays are disposed opposite one another, as shown in **FIG. 4, a** single transmit and receive transducer will allow touch sensing along one axis of the substrate, with a maximum acoustic path length of twice the height plus width or twice the width plus height of the touch sensitive area. The maximum acoustic path length is a useful metric for acoustic touch sensors because most materials, e.g., glass, have a relatively constant acoustic power loss expressed in dB per unit length; the greater the path length, the greater the attenuation. In many cases, it is this attenuation of the acoustic signal which limits the design of the touchscreen, and therefore it is generally desired to have high acoustic efficiency in each of the touchscreen components to allow design leeway. Thus, for example, greater numbers of transducers may be selectively deployed to allow larger substrates, and likewise, with limited size substrates, acoustic paths may be folded to reduce a required number of transducers.