receive transducer at a characteristic time period. Thus, the controller need only detect the temporal characteristics of an attenuation to determine the axial coordinate position. Measurements are taken along two axes sequentially in order to determine a Cartesian coordinate position.

[0019] Other known systems, described in more detail below, employ a single reflective array for separating as a plurality of wave paths, and superposing as a composite waveform, the signal from the transducer, through the active region, along a plurality of paths and then back to the transducer, by providing an acoustically reflective edge spaced parallel to the reflective array, causing the dispersed wave to traverse the active region twice, as shown in **FIG. 5**. See, U.S. Pat. No. 5,177,327, FIG. 10 and accompanying text, incorporated herein by reference.

[0020] FIG. 11 of U.S. Pat. No. 4,700,176 teaches the use of a single transducer for both transmitting the wave and receiving the sensing wave, with a single reflective array employed to disperse and recombine the wave. Such systems therefore employ a reflective structure opposite the reflective array. As a result, an acoustic wave passes through the active region twice, with consequent increased wave absorption by the touch but also increased overall signal attenuation due to the reflection and additional pass through the active region of the substrate. Thus, the acoustic wave may be reflected off an edge of the substrate or an array of 180° reflectors parallel to the axis of the transmission reflective grating and reflected back through the substrate to the reflective array and retrace its path back to the transducer. The transducer, in this case, is time division multiplexed to act as transmitter and receiver, respectively, at appropriate time periods. A second transducer, reflective array and reflective edge are provided for an axis at right angles to allow determination of a coordinate of touch along perpendicular axes.

[0021] A known system by Electro-Plasma (Milbury Ohio) employs a bisected reflecting array in order to reduce an acoustic wavepath, as shown in **FIG. 6A**. Therefore, a maximum path length of an acoustic wave along the composite reflecting array from a transducer is about one half of the total width, with transducers each sending acoustic waves toward the bisection point. Thus, the orthogonal set of paths will be longer, with a maximum total path length of two times the height plus the width. In this system, transmitting transducers are excited individually and produce identical types of waves, portions of which travel along parallel paths, with a small overlap of acoustic wave coverage of the touchscreen in order to avoid a dead zone in the touch region. The acoustic waves follow the traditional paths corresponding to axes parallel to the Cartesian coordinate axes. A similar type system would bisect both sets of reflective arrays, as shown in **FIG. 6B**.

[0022] The "triple transit" system, shown in **FIG. 8**, provides for a single transducer which produces a sensing wave for detecting touch on two orthogonal axes, which both produces and receives the wave from both axes. In this case, the area in which touch is to be sensed is generally oblong, such that the longest characteristic delay along one path is shorter than the shortest characteristic delay along the second path, thereby allowing differentiation between the two axes based on time of reception. See, U.S. Pat. Nos. 5,072,427, 5,162,618, and 5,177,327, incorporated herein by reference. The maximum path length of the triple transit design is four times the width plus two times the height. Due to the significant difference in path lengths, the X and Y signals are non-overlapping, as shown in **FIG. 9C**.

[0023] d. Controller Algorithms

[0024] The wave pattern of one type of known acoustic touch sensors is dispersed along the axis of the transmitting reflective array, traverses the substrate and is recombined, e.g., by another reflective grating, into an axially propagating wave, dispersed in time according to the path taken across the substrate, and is directed to a receiving transducer in a direction antiparallel to the transmitted wave, which receives the wave and converts it into an electrical signal for processing based on signal amplitude received as a function of time. Thus, according to this system, only two transducers per axis are required. Because of the antiparallel path, the time delay of a perturbation of the electrical signal corresponds to a distance traveled by the wave, which in turn is related to the axial distance from the transducer along the reflecting arrays traveled by the wave before entering the active area of the substrate, i.e., approximately two times the distance along the axis of the array plus the spacing between the arrays. A typical set of return waveforms is shown in **FIG. 9**.

[0025] The location of a touch is determined by detecting an attenuation of the received signal amplitude either in absolute terms or as compared to a standard or reference received waveform. Thus, for each axis, a distance may be determined, and with two orthogonal axes, a unique coordinate for the attenuation determined. Acoustic touch position sensors of this type are shown in U.S. Pat. Nos. 4,642,423, 4,644,100, 4,645,870, 4,700,176, 4,746,914 and 4,791,416, incorporated herein by reference. U.S. Pat. Nos. Re. 33,151, and 4,700,176 also disclose a touch sensor system having a set of diverging acoustic paths which are incident on a reflective array having elements located along an arc and spaced to meet coherency criteria. See, Re. 33,151. and 4,700,176, **FIG. 16** and accompanying text, incorporated herein by reference. This touch sensor produces a unidimensional output which corresponds to an angular position of a touch.

[0026] According to known systems, a number of algorithms are employed to determine the coordinate position of a touch. The simplest algorithm is a threshold detection, in which an amplitude of a received signal is compared to a set value. Any dip below that value is considered indicative of a touch. More sophisticated is an adaptive threshold, in which the threshold varies based on actual sets of received data, thus allowing increased sensitivity and rejection of artifacts of limited amplitude.

[0027] A control circuit may operate in a number of modes, e.g., number of transducers and configuration. In known systems having a rectangular substrate without redundancy, the number of transducers varies: 1 (triple transit); 2 (ExZec/Carroll Touch); 4 (Adler); and 6 (ElectroPlasma). There is a natural 8 transducer arrangement, not present in prior art designs, which is an extension of 6 transducer scheme in which 4 transducers are used for both X and Y axis measurements; see **FIG. 6B**.