factor has a square root dependence on frequency and, therefore, gives rise to a change in the impulse shape as picked up at the sensor position (in contrast, a pure delay, with no associated change in impulse shape, has a linear dependence on frequency). This is the well-known effect of dispersion of the propagation of bending waves.

[0104] Various approaches to performing dispersion correction, where a dispersive signal is transformed to a signal propagating in a non-dispersive medium, have been discussed above. A property of these transformation methods, which is beneficial for the efficient calculation of contact location, is the compensation for the dispersive effects for all time.

[0105] However, a simpler transformation may be employed for impulse reconstruction in accordance with the present invention. According to one such simpler transformation, a fixed amount of dispersion is removed from the dispersive sensor signals. Given the location of the contact to the touch sensitive plate, the dispersion of the impulse can be readily understood from the above equations. With the application of an inverse phase factor, corresponding to the contact/sensor separation, the initial signal picked up by each sensor may be compensated and the original impulse reconstructed. It is noted that later energy, associated with reflections/reverberation, will retain a dispersive property.

[0106] This simpler transformation approach is not directly suitable for determining the location of a contact event, since the dispersion removal process requires prior knowledge of the contact location. It is noted that an iterative procedure based on first arrivals and fixed amount of dispersion removal may be implemented, although this is likely to be less computationally efficient than a true dispersion correction transform. However, given the location of the contact from another method, such as a dispersion corrected correlation function, the reconstruction of the original impulse provides a number of benefits for an improved touch sensitive device.

[0107] **FIG. 14** illustrates a method involving use of an inverse phase factor as part of impulse reconstruction in accordance with an embodiment of the present invention. According to the approach shown in **FIG. 14**, bending waves propagating in a dispersive touch sensitive plate are sensed **360**, from which sensor signals exhibiting dispersion are generated **362**. The dispersive sensor signals are transformed to dispersion corrected signals **364**. Using the dispersion corrected signals, the location of contact to the touch sensitive plate is determined **366**. The separation distance between each pickup sensor and the contact location is determined **368**.

[0108] For each pickup sensor, an inverse phase factor is developed **370** using the respective contact/sensor separation distances. The inverse phase factor is applied **372** to the dispersive sensor signal to reconstruct the impulse **372** sensed by each of the pickup sensors. One or more features of the reconstructed impulses, such as arrival time, shape, amplitude, or other morphological feature, are compared to verify that the contact location computed in block **366** is correct.

[0109] For purposes of illustrating additional features of the present invention, reference is made to the bending wave touch sensitive device **400** shown in **FIG. 15**. According to this embodiment, a touch sensitive panel **402** is mounted into a frame **404** of an LCD monitor, with a front bezel and a rear housing made from a plastic molding. Mounted at each corner of the touch sensitive panel **402** is a pickup sensor **16**. The following discussion of **FIGS. 16-32** assumes that the methodologies associated with these Figures may be implemented in a touch sensitive device **400** of the type generally depicted in **FIG. 15**.

[0110] **FIG. 16** shows a plot of the touch sensitive panel area, with axis units of centimeters. The designations of the sensor numbers in each corner are indicated. In addition, a cross (plus sign) indicates the location of a contact that was generated by a finger touch on the panel. This contact generated a transient pulse of bending waves, which was converted to a voltage by each of the pickup sensors. The sensor signals were then pre-amplified, digitized, and high pass filtered at 10 kHz, resulting in the traces shown in **FIG. 17**. It is noted that all such graphs have y-axis units that are arbitrary, and x-axis units of sample number, taken at a 100 kHz sample rate.

[0111] The dispersion of the traces shown in **FIG. 17** is clear. In particular, the sensors furthest from the contact location (i.e., sensors **1** and **2**) show later arrival of energy and a more spread out impulse shape. When the inverse phase factor associated with the contact/sensor separation is applied to the raw sensor signal data of **FIG. 17**, the traces in **FIG. 18** result.

[0112] Whereas the dispersed traces shown in **FIG. 17** exhibit different shapes and arrival times, the traces shown in **FIG. 18** have a similar shapes (i.e., all have a positive going initial transient) and are time aligned. These traces demonstrate the correct reconstruction of the initial impulse. Techniques for determining impulse similarity between reconstructed impulses will be discussed in greater detail below.

[0113] The dispersion of the contact impulse may be viewed as a spatial filter, in that the signal at each sensor is filtered differently for every point on the touch sensitive plate. As previously discussed, the process of impulse reconstruction may be thought of as the application of an inverse filter for the first arrival energy, and may be implemented to verify that the contact location, as determined by the location determination algorithm, is consistent with the original pickup signals.

[0114] By way of example, **FIG. 19** shows the original contact location, as shown in **FIG. 16**, together with a position shifted 25 mm in both x- and y-directions. This illustrative example simulates an error, where the point location is reported away from the true location.

[0115] Impulse reconstruction is performed on the pickup signals, as shown in **FIG. 17**, but with the shifted location position. The results are shown in **FIG. 20**. It is clear that the reconstruction of the original impulse is no longer accurate, with significant variation between the different signals being evident. This spurious point may readily be detected and reported as being erroneous.

[0116] The verification of point location provided by a method of impulse reconstruction according to the present invention provides for enhanced functionality. For example, where an error in the calculation results, impulse reconstruction may be used to highlight the error and return no point.