[0035] This can be extended to multiple dimensions. Signals can be applied so as to drop linearly in the X dimension and then in the Y dimension. However, this cannot be accomplished by merely putting strip conductors on the edge of a resistive sheet—the unused conductors will short along the desired dimension. One partial solution is to break the strip conductors into a series of small connection points that can be disconnected when driving the other axis. A more practical approach places the conductors in the four corners, and calibrate for the non-linear field patterns that result.

[0036] System Operation

[0037] During operation, images can be projected onto the table. The projection can be overhead projection, or rear projection when the touch surface is transparent or translucent. For many applications, such as, games or industrial control, the image can be fixed on the touch sensitive surface by other means, or a mix of fixed and projected images can be used. If the touch surface is mounted on a wall, as described below, the projection can be conventional, or any other projection means can be used.

[0038] In the case the surface is mounted on a table top, users sitting in the conductive chairs **121-122** cause a capacitive coupling between the transmitter and the receivers **200** when the touch surface is touched by a body part, e.g., fingers or toes, or a conductive pointers held by the users. In effect, the user couples the transmitter to the receivers via the touch screen.

[0039] The coupled signal is analyzed to determine the locations that are capacitively coupled to each chair and hence the unique locations pointed at by each seated user can be identified.

[0040] The system can be understood with the aid of a simplified equivalent circuit as shown in **FIG. 4**. C_{table} **401** represents the capacitance between the user's finger and a transmitting antenna of the surface. C_{chair} **402** represents the capacitance between the user and a conducting chair. The coupling capacitance is the series combination of these two capacitances:

$$C_{coupling}=(C_{table}*C_{chair})/(C_{table}+C_{chair})$$

[0041] Because the coupling area of a finger is very small compared to the entire upper torso in a conducting chair, C_{table} tends to be very small compared to C_{chair}. Thus, the $C_{coupling}$ is approximately equal to C_{table}. This means that the precise capacitive coupling via the chair is inconsequential. In the case the coupling is via a conducting floor plate, the coupling area of feet is far smaller, but still very large compared to a finger. One might think that thick-soled shoes might be problematic because they dramatically increase the spacing between the conductors. However, we have found that we get more than sufficient coupling, partially because the thick rubber soles have a high dielectric constant increasing the capacitance.

[0042] For the system to work well, we prefer fairly independent coupling paths among the users. This constraint is violated if two or more users, or their chairs are touching, or are in very close physical proximity. In this regard, social norms of "personal space" are sufficient to keep the inter-user coupling acceptably small.

[0043] However, this behavior can be explicitly exploited. By touching another user, or the user's chair, the touches of either user are interpreted as touches for both users. Typically, the coupling "through" a second user is considerably weaker, and thus it is possible to determine a "primary" user versus "shared" users. This provides a simple and intuitive mechanism for users to jointly indicate a selection.

[0044] As noted above, the system can work in one of two ways—the touch surface can be a large array of antennas transmitting uniquely identifiable signals to a small number of receivers associated with particular users, or a large array of antennas receiving a small number of uniquely identifiable signals from transmitters associated with particular users. We have found the former to be a superior configuration for a number of reasons. Primary, the transmitter can be driven with logic level signals that are easy to generate in large number. Receivers are somewhat more complex to implement. Thus, we chose the configuration that minimizes the number of receivers.

[0045] There are many ways of generating uniquely identifiable signals, as described in detail below. In signal processing terms, we can use an orthogonal set of signals. For example, every antenna is driven at a different frequency. A receiver that is coupled to a number of antennas then identifies a particular user by examining the spectrum of the received signal. However, generating the numerous frequencies required for a large array can be relatively expensive.

[0046] Time division multiplexing is another option. In this case, each antenna is separately driven in turn by a fixed frequency, and the timing of the received signals is used to determine which antennas are presently coupled. This system is very simple to implement because the receivers are particularly simple because they are looking for a single frequency. However, this technique may not be appropriate for very large arrays. The problem is a fairly subtle one caused by the interplay of the various constraints.

[0047] For high responsivity, the entire array must be scanned ten to a hundred times per second. However, as noted above, practical modulating frequencies are limited to the sub-MHz. range. This leaves very few modulation cycles per antenna, making receiver design difficult, especially considering of other interfering sources of noise.

[0048] There are ways of reducing the scan time that help to extend the practicality of time division multiplexing schemes. Large numbers of antennas can be driven simultaneously to see if there is coupling from any of them. Thus, binary search patterns may be used to locate particular touch points in roughly logarithmic time. However, this is not as straight forward as at first implied. In general, there will be degrees of coupling to multiple antennas, so in practice, these searches narrow down the candidate areas, which are then searched exhaustively.

[0049] As anyone familiar with telephone systems will note, in addition to time and frequency division multiplexing, code division multiplexing can be considered. In fact, this turns out to be a particularly elegant approach for large arrays. A simple generating polynomial is used to generate a pseudo random bit sequence with the property that the autocorrelation of this sequence is extremely small everywhere except at zero. This sequence is then fed into a long shift register to generate a binary tapped delay line with one tap per an antenna. The taps directly modulate the antennas.