rows **102** and columns **103** of touch sensitive pads **105**. The pads, as will be described in greater detail act as antennas. The conductive touch pads **105** form a touch sensitive surface **300** that coincides with the displayed image. In the arrangement shown, the rows and columns are arranged in a diamond pattern, although it should be understood that other geometric patterns are also possible, as described below.

[**0019**] The conductive rows and columns of pads can be deposited on, for example, a laminated substrate using techniques similar to those used to fabricate printed circuit boards. The size and separation of the touch pads determine the effective resolution of the touch locations.

[**0020**] A transmitter **120** individually supplies uniquely identifiable electronic signals, described below, to the rows and columns of touch pads. As shown, the transmitter **120** includes a microprocessor **110**, shift registers **111**, latches **112**, and drivers **113**. There is a set of registers, latches, and drivers for the for the rows and columns of touch pads **105**.

[**0021**] In addition, there are chairs **121**-**122** arranged around the table, one for each user. The chairs include conductive parts, for example, the arms, legs, or seat. The conductive parts of each chairs are electrically connected to individual receivers **200**. It should be understood that other conductive items can also be used to identify users, e.g. conductive floor mats, wristbands, belts, etc. However, we prefer conductive chairs because they form a non-obtrusive, natural setting where users can easily operate the system in comfort. The receivers **200** are coupled to a processor **150** that controls the overall operation of the system **100**. See **FIG. 4** for a simplified schematic of the system of **FIG. 1**.

[**0022**] **FIG. 2** shows the receiver **200** in greater detail. The receiver **200** includes an amplifier **210** connected to a synchronous demodulator **220**. The output of the demodulator is coupled to an analog-to-digital convertor **200**, which in turn is coupled to a microprocessor **240**. The microprocessor receives synchronization signals **119** from the microcontroller **110** of the transmitter, and produces location coordinates for the processor via a serial, e.g., RS-232, interface **250**.

[**0023**] **FIG. 3** shows the details of the touch sensitive surface **300**. In one embodiment of the invention, the touch surface is constructed as a two-layer printer circuit board with edge connectors **311**-**312** connected to the respective drivers **113**. The layers include a first insulator layer **301**, a row layer **302**, a second insulator layer **303**, a column layer **304**, and a mechanical support layer **305**.

[**0024**] Antenna Patterns

[**0025**] There are a number of antenna patterns possible for the touch sensitive surface or antennas. Here we describe the more interesting ones. In a "full matrix" pattern, there are a very large number of antennas arranged in a regular grid. Such a matrix of individually driven antenna "pixels" allows an unambiguous determination of multiple touch locations, even for a single user.

[**0026**] Minor variations on the full matrix include the use of hexagons, triangles or some other tessellating geometry. There is no reason why the antennas must be on a flat surface. For some applications, the surface can conform to any appropriately shaped object. It such cases irregular patterns of antennas may be desired. Highly irregular patterns might also be useful for some applications where the pattern corresponds to some arbitrary image.

[**0027**] In practice, the full matrix pattern may not be needed for many applications. Although the simultaneous, multi-user feature is desired, perhaps it is sufficient for each user to indicate at most a single touch point, or a bounding box. This functionality can be obtained with a simple row and column pattern, as shown in **FIG. 1**, that drastically reduces the number of antennas.

[**0028**] Designing a row/column pattern is not trivial. The problem is that antennas also shield. So arranging a sheet of row conductors (antennas) and then covering the conductors with a sheet of column conductors will shield the row conductors anywhere they overlap. We have found the connected diamond pattern shown in **FIG. 1** to be a good choice. This pattern has the interesting property that the row conductors are identical to the column conductors, rotated by ninety degrees. This allowed us to design a single conductor pattern and use it for both rows and columns, saving manufacturing costs.

[**0029**] In practice, a user's touch will most likely span multiple rows and multiple columns with different degrees of coupling. These can be used to estimate a centroid for the point of touch, to obtain location with a higher resolution than the row and column spacing. However, an alternative way of using this information is to present a bounding box for the touch event, defined by the min and max rows and columns of antennas significantly coupled.

[**0030**] This leads to an interesting use of the device. A single user can touch two points to define a bounding box. This is a very natural way of selecting a rectangular area in graphics design systems. In practice, we suggest using two modes of operation: when the coupled area is small, presume the user is indicating a point, when the coupled area it large, presume that the user is trying to specify a bounding box. The end result is that even this simplified row/column design allows simultaneous multi-touch use for all users.

[**0031**] Of course, it would be an advantage when the row/column pattern can distinguish multiple touches from a single user. The problem is that given two X and two Y coordinates, the system cannot tell if the intended touches are (X1, Y1) and (X2, Y2) or (X1, Y2) and (X2, Y1). In most cases, timing information can be used to disambiguate the two cases. If (X1, Y1) and (X2, Y2) are coupled successively, we can estimate the pairings.

[**0032**] Analog Antennas

[**0033**] The purpose of the antenna arrays (conductive touch pads) is to generate coupling patterns that are location dependent in a simple manner. Alternatively, this can be accomplished using resistive sheets driven from multiple points.

[**0034**] The easiest way to think about this is to consider a one-dimensional case. A resistive strip is driven by an oscillator, first on one end, and then on the opposite end, each time grounding the undriven side. This produces a signal that linearly decreases in amplitude moving towards ground. Switching the driven side flips the direction of this linear drop. By looking at the ratio of the coupled signal during the two cases, touch locations can be determined.