The receiver then cross-correlates the received signal with the original sequence. Each lag in the cross-correlation signal corresponds to the coupling from a particular antenna. This allows all of the couplings to be determined by a single calculation.

[0050] The advantage of this code division multiplexing scheme is that it scales extremely well to large numbers of antennas. Adding antennas merely requires adding extra taps on the shift register. On the receiver side, FFT and other techniques can dramatically decrease the difficulty of the cross-correlation calculation. Unlike time division multiplexing, the effective antenna integration time remains long and constant with increasing number of antennas, avoiding noise issues.

[0051] Transmitting and Receiving

[0052] The capacitive coupling of our system relies on near field coupling. Therefore, far field radiation by the touch sensitive screen should be minimized to maximize the signal to noise ratio (SNR) at the receivers **200**. For this reason, the frequencies of the transmitted signals are kept low, e.g., under 1 MHz for practical table sizes. This has an important impact on the design of the system. At lower frequencies, integration time required at the receiver increases to achieve a usable SNR. As an advantage the frequencies are well below frequencies of the radio spectrum, making our system useable in environments where RF signals could interfere with the operation of other equipment.

[0053] Time Division Multiplexing

[0054] In a time division multiplexed transmitting scheme, each row and then each column of pads is individually driven, in turn, so that the number of individual transmitters can be relatively small. By measuring the times when the transmitted signals are present at the receivers **200**, the rows and columns coupled are readily differentiated. This can be accomplished with the synchronization signals **119**.

[0055] Code Division Multiplexing

[0056] Time synchronized signals are not the only easily separable signals. With code division multiplexing, orthogonal spreading codes at the transmitter allow multiple signals to occupy the same frequency bandwidth. In the receivers **200**, the multiple signals are then separated by correlating them with the original spreading code. With a properly chosen pseudo random noise (PRN) bit sequence, the autocorrelation function is very small everywhere except at zero.

[0057] Thus, by driving each row and column of pads by the same PRN bit sequence, but each sequence with a unique time delay, received signals can easily be separated by cross-correlating with the original sequence.

[0058] Therefore, a single PRN bit sequence is generated for the transmitter using a polynomial function. The PRN sequence is passed through a shift register to provide time delays. Then, the transmitted signals are spread by the PRN sequence from taps off the shift register and transmitted by the different receivers.

[0059] The code division multiplexed scheme has many advantages. First, locations on the entire table can be determined by one cross-correlation per receiver. Second, the effective integration time can be very long compared to the time division scheme. Third, the system is robust to many types of interference due to the spread spectrum operation.

[0060] Resistive Touch Screen

[0061] Rather than using detailed patterns of rows and columns pads, a single resistive substrate can also be used as the touch sensitive surface, as described above. In this case, a very small number of transmitters are used, for example one at each corner, or one at each side. The resistive drop across the substrate is different for each transmitter, so the relative amounts of signal capacitively coupled up to a user can be used to determine the touch location.

[0062] Alternative Embodiments

[0063] In an alternative embodiment, the electrical signals are driven in reverse so that the chairs **121-122** are coupled to unique transmitters, and the rows and columns are coupled to a single receiver.

[0064] In yet another embodiment, each unique location on the table can be individually coupled to a transmitter or a receiver. This arrangement enables the identification of multiple touch points by a single user.

[0065] In this design with individually addressable locations, there may not be sufficient time to integrate the signal over each location while still maintaining a reasonable overall update rate. In this case, we use a code division multiplexed scheme. By analyzing the received codes, the touch locations can be determined. Code division multiplexing allows sufficient integration time because time sliced integration for each location is not required.

[0066] Timing signals can also be used to disambiguate multiple simultaneous touches. Other geometric patters, such as a triangular mesh, also allow for multiple unambiguous touch locations. Note that the mesh spacing should be sufficiently small so that a fingertip spans at least one row and one column, yet large enough to maximize capacitive coupling.

[0067] Applications

[0068] The system according to our invention can be used in any of the interactive applications described above, but now we enable multiple users to operate the system simultaneously. In addition, the system can be used for a whole new genre of interactive games where multiple users either compete with each other, or collaborate to solve an unknown problem.

[0069] One of the key features of the system is its ability to detect multiple touches allowing a number of people to simultaneously interact with the system. For some cases, the identity of the user may be unimportant. Thus a single receiver can be used. A whimsical example can be a digital finger paint mural—a wall that allows users to finger paint messages and art that slowly change color and decay with time.

[0070] This system works by projecting digital video onto a full matrix of touch pads, with the adjacent floor being a single receiving electrode. Interestingly, the system can also be implemented with a row/column touch wall. In this case, the floor is partitioned into many separate receivers so as to provide each user with an independent coupling path. The system can scan all of these receivers for coupling, so that users can walk freely about.