

What is claimed is:

1. A method for reducing ~~the an~~ effect of noise in a touch sensitive device having rows and columns, which touch sensitive device senses touch through processing touch signals present on the columns, comprising:

determining a first signal space in which to generate a first plurality of signals for use in a touch sensor;

simultaneously generating the first plurality of signals for use in the touch sensor in the first signal space, each of the first plurality of signals being generated on separate ones of the rows;

sensing at least one column signal on at least one column;

replacing the first signal space with a second signal space in which to generate a second plurality of signals for use in the touch sensor;

simultaneously generating the second plurality of signals for use in the touch sensor in ~~the a~~ second frequency space; and,

sensing at least some of the second plurality of signals to identify a touch event in the touch sensitive device.

2. The method of claim 1, wherein the first and second signal spaces comprise first and second frequency spaces, respectively.

~~3. The method of claim 1, wherein the first and second signal spaces comprise first and second time spaces, respectively.~~

~~4.3.~~ The method of claim 1, wherein the first and second signal spaces comprise first and second code spaces, respectively.

~~5. The method of claim 1, wherein the step of determining a first signal space comprises selecting the first signal space.~~

~~6. The method of claim 1, wherein the step of determining a first signal space comprises computing the first signal space.~~

~~7. — The method of claim 1, wherein the step of determining a first signal space comprises determining a first signal space at design time.~~

~~8. — The method of claim 1, wherein the step of determining a first signal space comprises determining a first signal space at manufacturing time.~~

~~9. — The method of claim 1, wherein the step of determining a first signal space comprises determining a first signal space at run time.~~

~~10. — The method of claim 1, wherein the step of replacing the first signal space with the second signal space is performed in response to a change in status.~~

~~11. — The method of claim 10, wherein the change in status comprises input from a sensor.~~

~~12. — The method of claim 10, wherein the change in status comprises input from a plurality of sensors.~~

~~13. — The method of claim 10, wherein the change in status comprises an input from an operating system running on the touch sensitive device.~~

~~14. — The method of claim 10, wherein the change in status comprises an input from an application running on the touch sensitive device.~~

~~15. — The method of claim 10, wherein the change in status comprises an input from circuitry running on the touch sensitive device.~~

~~16. — The method of claim 10, wherein the change in status comprises a determination of interference in the first signal space.~~

~~17. — The method of claim 16, wherein the interference in the first signal space comprises interference from a source external to the touch sensitive device.~~

~~18. — The method of claim 1, wherein the column signal is a touch signal.~~

19.4. The method of claim 1, wherein the step of generating the first plurality of signals for use in the touch sensor in the first signal space comprises generating a plurality of unique orthogonal signals.

~~20. The method of claim 1, further comprising a step of identifying interference in at least one touch signal.~~

~~21. The method of claim 20, wherein the step of identifying interference comprises identifying at least one frequency space in which interference occurs.~~

~~22. The method of claim 20, wherein the step of identifying interference comprises identifying at least one time space in which interference occurs.~~

~~23. The method of claim 20, wherein the step of identifying interference comprises identifying at least one code space in which interference occurs.~~

24.5. A method for reducing ~~the~~an effect of noise in a touch sensitive device having rows and columns, which touch sensitive device senses touch through processing touch signals present on the columns, comprising:

determining a first signal-to-row map with which to generate a first plurality of signals for use in a touch sensor;

simultaneously generating a first plurality of signals for use in the touch sensor using the first signal-to-row map, each of the first plurality of signals being generated on separate ones of the rows;

sensing at least one column signal on at least one column;

replacing the first signal-to-row map with a second signal-to-row map with which to generate a second plurality of signals for use in the touch sensor;

simultaneously generating the second plurality of signals for use in the touch sensor using the second signal-to-row map; and,

sensing at least some of the second plurality of signals to identify a touch event in the touch sensitive device.

25.6. The method of claim 24.5, wherein the step of replacing the first signal-to-row map with a second signal-to-row map comprises:

determining consistency in a signal ~~received~~sensed on the at least one column; and,

replacing the first signal-to-row map with a second signal-to-row map that provides a higher level of consistency in the signal ~~received~~sensed on the at least one column.

~~26.— The method of claim 24, wherein the step of determining a first signal-to-row map comprises selecting the first signal-to-row map.~~

~~27.— The method of claim 24, wherein the step of determining a first signal-to-row map comprises computing the first signal-to-row map.~~

~~28.— The method of claim 24, wherein the step of determining a first signal-to-row map comprises determining the first signal-to-row map at design time.~~

~~29.— The method of claim 24, wherein the step of determining a first signal-to-row map comprises determining the first signal-to-row map at manufacturing time.~~

~~30.— The method of claim 24, wherein the step of determining a first signal-to-row map comprises determining the first signal-to-row map at run time.~~

~~31.— The method of claim 24, wherein the step of replacing the first signal-to-row map with the second signal-to-row map is performed in response to a change in status.~~

~~32.— The method of claim 31, wherein the change in status comprises input from a sensor.~~

~~33.— The method of claim 31, wherein the change in status comprises input from a plurality of sensors.~~

~~34.— The method of claim 31, wherein the change in status comprises an input from an operating system running on the touch sensitive device.~~

~~35.— The method of claim 31, wherein the change in status comprises an input from an application running on the touch sensitive device.~~

~~36.— The method of claim 31, wherein the change in status comprises an input from circuitry running on the touch sensitive device.~~

~~37.— The method of claim 31, wherein the change in status comprises a determination of interference in the first signal space.~~

~~38.— The method of claim 37, wherein the interference in the first signal space comprises interference from a source external to the touch sensitive device.~~

~~39.— The method of claim 24, wherein the column signal is a touch signal.~~

~~40. The method of claim 24, wherein the step of generating the first plurality of signals comprises generating a plurality of unique orthogonal signals.~~

~~41. The method of claim 24, further comprising a step of identifying interference in at least one touch signal.~~

~~42. The method of claim 41, wherein the step of identifying interference comprises identifying at least one frequency space in which interference occurs.~~

~~43. The method of claim 41, wherein the step of identifying interference comprises identifying at least one time space in which interference occurs.~~

~~44. The method of claim 41, wherein the step of identifying interference comprises identifying at least one code space in which interference occurs.~~

~~45. The method of claim 24, wherein the step of replacing the first signal-to-row map with a second signal-to-row map is performed iteratively.~~

~~46.7.~~ A method for reducing ~~the an~~ effect of noise in a touch sensitive device having rows and columns, which touch sensitive device senses touch through processing touch signals present on the columns, comprising:

selecting a first frequency space in which to generate a first plurality of signals for use in a touch sensor;

simultaneously generating the first plurality of signals for use in the touch sensor in the first frequency space, each of the first plurality of signals being generated on separate ones of the rows;

sensing at least one column signal on at least one column;

identifying a first electromagnetic interference frequency in at least one touch signal;

selecting a second frequency space in which to generate signals for use in the touch sensor, the second frequency space being selected to mitigate collision with the first electromagnetic interference frequency;

simultaneously generating a second plurality of touch signals for use in the touch sensor in the second frequency space; and

sensing at least some of the second plurality of touch signals to identify a touch event in the touch sensitive device.

~~47.8.~~ The method of claim ~~46~~7, wherein the step of identifying the first electromagnetic interference frequency in at least one touch signal is performed dynamically.

~~48.9.~~ The method of claim ~~46~~7, further comprising applying the generated second plurality of touch signals to a region of a touch sensor of the touch sensitive device.

~~49.10.~~ The method of claim ~~46~~7, further comprising applying the generated second plurality of touch signals to all of the rows of the touch sensitive device.

~~50.~~ ~~The method of claim 46, wherein the step of identifying first electromagnetic interference frequency comprises using known touch signals.~~

~~51.11.~~ The method of claim ~~46~~7, wherein the step of identifying the first electromagnetic interference frequency comprises using known touch signals that are determined through a sensor fusion technique in which received touch signals are cross-referenced against received signals from device sensors other than a touch sensor.

~~52.~~ ~~The method of claim 51, wherein the device sensors other than the touch sensor comprises at least one sensor selected from the set of sensors consisting of: accelerometers, gyrometers, magnetometers, piezoelectric sensors, force sensors, or optical sensors.~~

~~53.12.~~ The method of claim ~~46~~7, wherein the step of identifying the first electromagnetic interference frequency comprises using known touch signals that are determined through application logic in which received touch signals are cross-referenced against the known position of current user interface elements.

~~54.~~ ~~The method of claim 46, wherein the step of identifying first electromagnetic interference frequency comprises using known touch signals that are determined through operating system logic in which received touch signals are cross-referenced against the known position of current user interface elements.~~

~~55.~~ ~~The method of claim 46, wherein the step of identifying first electromagnetic interference frequency comprises performing a statistical analysis to distinguish noise from touch signals within a signal of a touch sensitive device.~~

~~56. — The method of claim 55, wherein the analysis comprises reasonably identifying touch signals within a signal of a touch sensitive device and reasonably identifying noise within the signal of the touch sensitive device.~~

~~57.13. The method of claim 467, wherein the step of selecting a second frequency space comprises selecting at least one frequency space that results in interference being more evenly spread across the touch sensor's surface area.~~

~~58. — The method of claim 46, wherein the step of selecting a second frequency space comprises selecting at least one frequency space that results in interference being avoided in a specified portion of a user interface.~~

~~59. — The method of claim 46, further comprising a step of selecting at least one time space in which to generate signals for use in the touch sensor.~~

~~60. — The method of claim 46, further comprising a step of selecting at least one code space in which to generate the signals for use in the touch sensor.~~

~~61. — The method of claim 46, further comprising a step of dynamically selecting a specific modulation scheme.~~

~~62. — The method of claim 61, wherein the step of dynamically selecting a specific modulation scheme is performed between sensor input frames.~~

~~63. — The method of claim 61, wherein the step of dynamically selecting a specific modulation scheme optimizes latency performance of at least a portion of a surface area of the touch sensor.~~

~~64. — The method of claim 46, further comprising steps of selecting at least one time space in which to generate the signals for use in the touch sensor and selecting at least one code space in which to generate the signals for use in the touch sensor.~~

~~65. — The method of claim 6, further comprising entering a time division multiplexing mode for a given time period.~~

~~66. — The method of claim 46, further comprising a step of entering a hybrid frequency-division multiplexing and time division multiplexing mode for a given time period.~~

~~67. The method of claim 46, further comprising a step of entering a hybrid frequency-division multiplexing, time division multiplexing, and code division multiplexing mode for a given time period.~~

~~68.14.~~ A method for reducing ~~the-an~~ effect of noise in a touch sensitive device having rows and columns, which touch sensitive device senses touch through processing touch signals present on the columns, comprising:

a. simultaneously generating signals for use in ~~the-a~~ touch sensor, each of the signals being generated on separate ones of the rows;

b. sensing at least one touch signal on at least one column;

c. repeating steps a. and b. to identify at least one recurring period during which an electromagnetic interference is present in at least one touch signal;

d. selecting a time space in which to generate signals, the time space being selected to mitigate collision with the periodic electromagnetic interference by avoiding the recurring period;

e. simultaneously generating signals in the time space, each of the signals being generated on separate ones of the rows; and

f. sensing a plurality of touch signals to identify a touch event in the touch sensitive device.

~~69.15.~~ A low-latency touch sensitive device comprising:

first and second plurality of conductors arranged such that:

each of ~~the~~ paths of the conductors of the first plurality of conductors cross each of the paths of the conductors of the second plurality of conductors, and wherein

when the touch sensitive device is not being touched, a first amount of signal is coupled between them, and

when the touch sensitive device is being touched, a different amount of signal is coupled between them;

a signal generator adapted to simultaneously generate a plurality of unique orthogonal signals within a signal space, each unique orthogonal signal being orthogonal to each of the other unique orthogonal signals;

a receiver associated with the second plurality of conductors, the receiver being adapted to receive signals present on each of the second plurality of conductors;

a signal processor adapted to decode the signals present on each of the second plurality of conductors, and for each of the signals present on each of the second plurality of conductors to determine which of the unique orthogonal signals are contained in the signal;

the signal processor being further adapted to identify a first electromagnetic interference frequency in the signals present on each of the second plurality of conductors, and adapted to revise ~~the a~~ frequency space to mitigate collision with the first electromagnetic interference frequency.

~~70.16.~~ A method for reducing ~~the an~~ effect of noise in a touch sensitive device having rows and columns, which touch sensitive device senses touch through processing touch signals present on the columns, comprising:

determining a first code space in which to generate a first plurality of signals for use in a touch sensor;

simultaneously generating the first plurality of signals for use in the touch sensor in the first code space, each of the first plurality of signals being generated on separate ones of the rows;

sensing at least one column signal on at least one column;

replacing the first code space with a second code space in which to generate a second plurality of signals for use in the touch sensor;

simultaneously generating the second plurality of signals for use in the touch sensor in ~~the a~~ second frequency space; and

sensing at least some of the second plurality of signals to identify a touch event in the touch sensitive device.

~~71. — The method of claim 70, wherein the step of determining a first code space comprises selecting the first code space.~~

~~72. — The method of claim 70, wherein the step of determining a first code space comprises computing the first code space.~~

73. — The method of claim 70, wherein the step of determining a first code space comprises determining a first code space at design time.

74. — The method of claim 0, wherein the step of determining a first code space comprises determining a first code space at manufacturing time.

75. — The method of claim 70, wherein the step of determining a first code space comprises determining a first code space at run time.

76. — The method of claim 70, wherein the step of replacing the first code space with the second code space is performed in response to a change in status.

77. — The method of claim 76, wherein the change in status comprises input from a sensor.

78. — The method of claim 76, wherein the change in status comprises input from a plurality of sensors.

79. — The method of claim 76, wherein the change in status comprises an input from an operating system running on the touch sensitive device.

80. — The method of claim 76, wherein the change in status comprises an input from an application running on the touch sensitive device.

81. — The method of claim 76, wherein the change in status comprises an input from circuitry running on the touch sensitive device.

82. — The method of claim 76, wherein the change in status comprises a determination of interference in the first code space.

83. — The method of claim 82, wherein the interference in the first code space comprises interference from a source external to the touch sensitive device.

84. — The method of claim 70, wherein the column signal is a touch signal.

85. — The method of claim 70, wherein the step of generating the first plurality of signals for use in the touch sensor in the first code space comprises generating a plurality of unique orthogonal signals.

~~86. The method of claim 70, further comprising a step of identifying interference in at least one touch signal.~~

~~87. The method of claim 86, wherein the step of identifying interference comprises identifying at least one frequency space in which interference occurs.~~

~~88. The method of claim 86, wherein the step of identifying interference comprises identifying at least one time space in which interference occurs.~~

~~89. The method of claim 86, wherein the step of identifying interference comprises identifying at least one code space in which interference occurs.~~

~~90.~~17. A method for reducing ~~the~~an effect of noise in a touch sensitive device having rows and columns, which touch sensitive device senses touch through processing touch signals present on the columns, comprising:

determining a first signal space in which to generate a first plurality of signals for use in a touch sensor;

simultaneously generating the first plurality of signals for use in the touch sensor in the first signal space, each of the first plurality of signals being generated on separate ones of the rows;

sensing at least one touch signal on at least one column;

identifying a first electromagnetic interference signal in at least one touch signal;

selecting a second signal space in which to generate signals for use in the touch sensor, the second signal space being selected to mitigate collision with the first electromagnetic interference signal;

simultaneously generating a second plurality of touch signals for use in the touch sensor in the second signal space; and

sensing at least some of the second plurality of touch signals to identify a touch event in the touch sensitive device.

~~91. The method of claim 90, wherein the first and second signal spaces comprise first and second frequency spaces, respectively.~~

92. — ~~The method of claim 90, wherein the first and second signal spaces comprise first and second time spaces, respectively.~~

93. — ~~The method of claim 90, wherein the first and second signal spaces comprise first and second code spaces, respectively.~~

94. — ~~The method of claim 90, wherein the step of determining a first signal space comprises selecting the first signal space.~~

95. — ~~The method of claim 90, wherein the step of determining a first signal space comprises computing the first signal space.~~

96. — ~~The method of claim 90, wherein the step of determining a first signal space comprises determining a first signal space at design time.~~

97. — ~~The method of claim 90, wherein the step of determining a first signal space comprises determining a first signal space at manufacturing time.~~

98. — ~~The method of claim 90, wherein the step of determining a first signal space comprises determining a first signal space at run time.~~

99. — ~~The method of claim 90, wherein the step of selecting a second signal space is performed in response to a change in status.~~

100. — ~~The method of claim 99, wherein the change in status comprises input from a sensor.~~

101. — ~~The method of claim 99, wherein the change in status comprises input from a plurality of sensors.~~

102. — ~~The method of claim 99, wherein the change in status comprises an input from an operating system running on the touch sensitive device.~~

103. — ~~The method of claim 99, wherein the change in status comprises an input from an application running on the touch sensitive device.~~

104. — ~~The method of claim 99, wherein the change in status comprises an input from circuitry running on the touch sensitive device.~~

~~105.— The method of claim 90, wherein the first electromagnetic interference signal comprises interference from a source external to the touch sensitive device.~~

~~106.— The method of claim 90, wherein the column signal is a touch signal.~~

~~107.— The method of claim 90, wherein the step of generating the first plurality of signals for use in the touch sensor in the first signal space comprises generating a plurality of unique orthogonal signals.~~

~~108.~~18.A method for reducing ~~the~~an effect of noise in a touch sensitive device having rows and columns, which touch sensitive device senses touch through processing touch signals present on the columns, comprising:

selecting a frequency space in which to generate a plurality of signals for use in a touch sensor;

simultaneously generating a plurality of signals for use in the touch sensor in the frequency space, each of the plurality of signals being generated such that there are at least two different signals present on each of a plurality of rows;

sensing presence and level of the plurality of a plurality of signals on at least one column;

identifying a touch signal based on a determination that the signals present on the at least one column correspond to the plurality of the signals generated on at least one row.

~~109.— The method of claim 108, wherein the determination comprises a determination that a majority of signals present on the at least one column correspond to the plurality of the signals generated on at least one row.~~

~~110.— The method of claim 108, wherein the determination comprises a determination that all of the signals present on the at least one column correspond to the plurality of the signals generated on at least one row.~~

~~111.~~19.A method for reducing ~~the~~an effect of noise in a touch sensitive device having rows and columns, which touch sensitive device senses touch through processing touch signals present on the columns and rows, comprising:

selecting a frequency space in which to generate a plurality of signals for use in a touch sensor;

simultaneously generating the plurality of signals for use in the touch sensor in the frequency space, each of the plurality of signals being generated on separate ones of the rows and columns;

sensing presence and level of the plurality of signals on at least one column and at least one row;

identifying a touch signal when a signal present on the at least one column corresponds to the signal generated on the at least one row and a signal present on the at least one row corresponds to the signal generated on the at least one column.

~~112.— A method for reducing the effect of noise in a touch sensitive device having rows and columns, which touch sensitive device senses touch through processing touch signals present on the columns, comprising:~~

~~—— generating a first plurality of signals for use in the touch sensor in the first frequency space, each of the first plurality of signals being generated on separate ones of the rows;~~

~~—— sensing at least one column signal on at least one column;~~

~~—— identifying electromagnetic interference in the signal present on the at least one column;~~

~~—— using the identification of electromagnetic interference to report a level of interference to device software.~~

~~113.— The method of claim 112, wherein the device software comprises software that positions graphical user interface elements on a display according to the reported level of interference.~~

~~114.— The method of claim 113, wherein the device software positions noise-tolerant graphical user interface elements into regions of the display having more than a determined level of noise.~~

~~115.— The method of claim 113, wherein the device software positions noise-intolerant graphical user interface elements into regions of the display having less than a determined level of noise.~~

~~116.20.~~ A method for reducing ~~the an~~ effect of noise in a touch sensitive device having rows and columns, which touch sensitive device senses touch through processing touch signals present on the columns, comprising:

simultaneously generating a first plurality of signals for use in ~~the a~~ touch sensor in ~~the a~~ first frequency space, each of the first plurality of signals being generated on separate ones of the rows;

sensing at least one column signal on at least one column;

identifying electromagnetic interference in the signal present on the at least one column;

receiving from device software an identification of size, location, and operating sensitivity of elements in a graphical user interface;

using the identification to configure operating sensitivity of a plurality of areas of a touch surface of the touch sensitive device.

~~117.21.~~ The method of claim ~~11620~~, wherein the step of using the identification to configure operating sensitivity comprises changing a modulation scheme used to modulate the first plurality of signals.

~~118.22.~~ The method of claim ~~11721~~, wherein regions of the touch surface that correspond to graphical user interface elements that are highly sensitive are modulated with a relatively high operating sensitivity modulation scheme.

~~119.23.~~ The method of claim ~~11721~~, wherein regions of the touch surface that correspond to graphical user interface elements that are lowly sensitive are modulated with a relatively low operating sensitivity modulation scheme.

~~120.—The method of claim 117, wherein the modulation scheme is selected to optimize processing power.~~

~~121.—The method of claim 117, wherein the modulation scheme is selected to optimize electrical power.~~

~~122.—The method of claim 117, wherein the modulation scheme is selected to optimize operating sensitivity.~~

~~123. The method of claim 122, wherein the step of selecting the modulation scheme to optimize operating sensitivity comprises optimizing parallelism of the touch sensitive device.~~

~~124. The method of claim 122, wherein the step of selecting the modulation scheme to optimize operating sensitivity comprises optimizing latency of the touch sensitive device.~~

~~125. The method of claim 122, wherein the step of selecting the modulation scheme to optimize operating sensitivity comprises optimizing dynamic range of the touch sensitive device.~~

~~126. The method of claim 122, wherein the step of selecting the modulation scheme to optimize operating sensitivity comprises optimizing sensing granularity of the touch sensitive device.~~

~~127.~~24.The method of claim ~~117~~21, wherein an optimal sensor modulation scheme is algorithmically implemented by application logic for each known region of a touch surface with different operating sensitivity requirements with every new frame of sensor input.

~~128. The method of claim 116, wherein user interface controls determined to have high operating sensitivity are explicitly defined by the application developer before run time.~~

~~129. The method of claim 116, wherein user interface controls determined to have high operating sensitivity are algorithmically defined by application logic at runtime of the user interface controls.~~

~~130. The method of claim 116, wherein operating sensitivity is defined by a user via a graphical user interface control.~~

~~131.~~25.A method for reducing ~~the~~an effect of noise in a touch sensitive device having rows and columns, which touch sensitive device senses touch through processing touch signals present on the columns, comprising:

selecting a first frequency space in which to generate a first plurality of signals for use in a touch sensor;

simultaneously generating the first plurality of signals for use in the touch sensor in the first frequency space, each of the first plurality of signals being generated on separate ones of the rows;

sensing at least one column signal on at least one column;

identifying a first electromagnetic interference frequency in at least one touch signal;

selecting a second frequency space in which to generate signals for use in the touch sensor, the second frequency space being selected to mitigate collision with the first electromagnetic interference frequency;

generating a second plurality of touch signals for use in the touch sensor in the second frequency space;

sensing at least some of the second plurality of touch signals to identify a touch event in the touch sensitive device; and

entering a mode in which time-division multiplexing is used exclusively and frequency-division multiplexing is not used.

~~132. The method of claim 131, wherein the touch signal comprises a signal generated as a result of a change in position of an object.~~

~~133. The method of claim 132, wherein the object comprises a finger.~~

~~134. The method of claim 132, wherein the object comprises a stylus.~~

~~135. The method of claim 132, wherein the object comprises a tangible object.~~