CLAIMS

What is claimed is:

1. A method performed by a data processing apparatus associated with a sensor, the sensor comprising a plurality of trace lines oriented in a matrix configuration, a front end interface, a plurality of transmitters coupled with the front end interface, and a plurality of receivers, wherein respective transmitters correspond to and are coupled with a first location of respective trace lines, and respective receivers are coupled with a second location of the respective trace lines, the method comprising:

determining orthogonal excitation waveforms having an orthogonal waveform sequence, wherein the orthogonal excitation waveforms are orthogonal to each other and define an integration period that is longer than a time constant of a feedback resistor and a feedback capacitor connected in parallel between an input of a transimpedance amplifier;

simultaneously transmitting, on each of at least two of the transmitters, one of the orthogonal excitation waveforms such that at least two of the transmitters are configured to transmit respective orthogonal waveform sequences for a duration equal to an integration time, wherein the transmitting occurs on less than all transmitters in the sensor, and wherein a length of the integration time is determined based on a number of transmitters simultaneously transmitting the one of the orthogonal excitation waveforms, the length of the integration time increasing as the number of transmitters simultaneously transmitting increases;

receiving at least two of the orthogonal excitation waveforms at least at two of the receivers, wherein each of the at least two orthogonal excitation waveforms are received at one of the respective receivers;

receiving information for at least an expected received waveform; and

for each of the at least two receivers, correlating the received excitation waveform against the expected received waveform.

2. The method of claim 1, wherein the sensor comprises a capacitive touch sensor-, wherein the orthogonal excitation waveforms are orthogonal to noise in the sensor.

3. The method of claim 1, wherein the matrix configuration comprises n columns of trace lines, and wherein each simultaneous transmission of the transmitters occurs in the ~~an~~ integration time, the method further comprising determining a number of integration times as a function of a number of simultaneous transmissions from at least two of the transmitters.

4. The method of claim 1, wherein the sensor is configured to be located within a physical proximity to a liquid crystal display to at least have an ability to interact with the liquid crystal display, wherein the liquid crystal display comprises a scan line frequency that is about 30 kHz to 135 kHz.

5. The method of claim 1, further comprising performing code division multiplexing, wherein each trace line in a group of four trace lines comprises a distinct code for the orthogonal waveform sequences.

6. The method of claim 5, wherein the code division multiplexing comprises a Manchester-coded Hadamard sequence.

7. The method of claim 1, wherein determining the orthogonal excitation waveforms comprises:

selecting a first frequency for modulation;

generating a pseudo-noise sequence around the first frequency;

generating a carrier signal for the pseudo-noise sequence; and

modulating a number of cycles of the carrier signal around the first frequency with the pseudo-noise sequence.

8. The method of claim 7, wherein the first frequency is around 100 kHz, and wherein the number of carrier signals is less than ten.

9. The method of claim 7, further comprising:

identifying a frequency associated with noise in the sensor; and

selecting at least one of the orthogonal excitation waveforms to be orthogonal to the frequency associated with the noise.

10. The method of claim 1, wherein the determined orthogonal excitation waveforms are a function of a frequency for modulation and a pseudo-noise sequence at the frequency for modulation.

11. The method of claim 1, further comprising:

taking a noise spectrum of noise associated with the sensor;

taking a measurement of noise in the sensor by evaluating the noise spectrum associated with the sensor;

identifying the noise based on the evaluation of the noise spectrum; and

determining the orthogonal excitation waveforms by making the orthogonal excitation waveforms orthogonal to the identified noise in the sensor.

12. The method of claim 11, further comprising:

continuing to take the measurement to identify the noise that is orthogonal to the orthogonal excitation waveforms by identifying the noise from the highest noise source in the noise spectrum over a time frame; and

adaptively determining the orthogonal excitation waveforms by using the noise associated with the highest noise source that is continuously identified in the noise spectrum.

13 The method of claim 11, further comprising:

periodically taking the measurement to identify the noise that is orthogonal to the orthogonal excitation waveforms by identifying the noise from the highest noise source in the noise spectrum; and

adaptively determining the orthogonal excitation waveforms by using the noise associated with the highest noise source that is periodically identified in the noise spectrum.

14 The method of claim 11, wherein the identified noise is associated with a frequency of operation of a cold-cathode fluorescent backlight or a frequency associated with a liquid crystal display.

15. The method of claim 1, wherein the sensor comprises a capacitive touch sensor, the capacitive touch sensor comprising a front-end circuit, the method further comprising:

preparing an input voltage for transmitting at an output of the front-end circuit for the capacitive touch sensor, the front-end circuit comprising at least a two-stage circuit with the first stage being configured to produce a transimpedance gain, and the second stage being configured to produce a voltage gain, wherein the preparation of the input voltage comprises:

producing the transimpedance gain in the first stage of the front-end circuit by configuring the first stage as an integrator circuit;

generating an output signal at the first stage by performing voltage division of the input voltage; and

amplifying the output signal of the first stage of the front-end circuit with the voltage gain of the second stage of the front-end circuit to produce an output signal for the second stage of the front-end circuit,

wherein the first stage comprises noise at a noise level such that the output signal for the second stage of the front-end circuit includes the noise of the first stage amplified by a function of the voltage gain of the second stage, and the noise at the output signal of the second stage is less than noise of the sensor that is derived from a liquid crystal display frequency or a frequency of operation of a cold-cathode fluorescent backlight, and

wherein a closed-loop transfer function of the front-end circuit is stable.

16. A system comprising:

a sensor, wherein the sensor comprises:

a plurality of trace lines oriented in a matrix configuration,

a front end interface,

a front-end circuit comprising at least a two-stage circuit with a first stage comprising a first transimpedance amplifier configured to produce a transimpedance gain based on a first feedback resistor and a feedback capacitor and a second stage

comprising a second transimpedance amplifier configured to produce a voltage gain based on a serially-connected resistor and a second feedback resistor, the first feedback resistor connected in parallel to the feedback capacitor and configured to provide a time constant that is less than an integration period, the serially-connected resistor connected in series to a serially-connected capacitor between the first transimpedance amplifier and the second transimpedance amplifier, the second feedback resistor connected between an input terminal and an output terminal of the second transimpedance amplifier,

a plurality of transmitters coupled with the front end interface, and

a plurality of receivers,

wherein respective transmitters correspond to and are coupled with a first location of respective trace lines, and respective receivers are coupled with a second location of the respective trace lines,

the system being configured to:

determine orthogonal excitation waveforms having an orthogonal waveform sequence and wherein the orthogonal excitation waveforms are orthogonal to each other and the frequency of the orthogonal excitation waveforms define the integration period;

simultaneously transmit, on each of at least two of the transmitters, one of the orthogonal excitation waveforms such that at least two of the transmitters are configured to transmit respective orthogonal waveform sequences, wherein the transmitting occurs on less than all transmitters in the sensor, the length of the integration period increasing as the number of transmitters simultaneously transmitting increases;

receive at least two of the orthogonal excitation waveforms at at least ~~at~~ two of the receivers, wherein each of the at least two orthogonal excitation waveforms are received at one of the respective receivers;

receive information for at least an expected received waveform; and

for each of the at least two receivers, correlate the received excitation waveform against the expected received waveform.

17. The system of claim 16, wherein the sensor comprises a capacitive touch sensor, wherein the orthogonal excitation waveforms are orthogonal to noise in the sensor.

18. The system of claim 16, wherein the matrix configuration comprises n columns of trace lines, and wherein the system is configured such that each simultaneous transmission of the transmitters occurs in an integration time, and the system is further configured for determining a number of integration times as a function of a number of simultaneous transmissions from at least two of the transmitters.

19. The system of claim 16, wherein the sensor is configured to be located within a physical proximity to a liquid crystal display to at least have an ability to interact with the liquid crystal display, wherein the liquid crystal display comprises a scan line frequency that is about 30 kHz to 135 kHz.

20. The system of claim 16, wherein the system is configured for performing code division multiplexing, wherein each trace line in a group of four trace lines comprises a distinct code for the orthogonal waveform sequences.

21. The system of claim 20, wherein the code division multiplexing comprises a Manchester-coded Hadamard sequence.

22. The system of claim 16, wherein the system is configured for determining the orthogonal excitation waveforms by:

selecting a first frequency for modulation;

generating a pseudo-noise sequence around the first frequency;

generating a carrier signal for the pseudo-noise sequence; and

modulating a number of cycles of the carrier signal around the first frequency with the pseudo-noise sequence.

23. The system of claim 22, wherein the first frequency is around 100 kHz, ~~and wherein~~ the number of carrier signals is less than ten, and wherein the serially-connected capacitor is selected to produce a 500:1 attenuation at 60 Hz and a second feedback capacitor is selected to produce a 10:1 attenuation at ten times the frequency of the orthogonal excitation waveforms.

24. The system of claim 22, wherein the system is configured for:

identifying a frequency associated with noise in the sensor; and

selecting at least one of the orthogonal excitation waveforms to be orthogonal to the frequency associated with the noise.

25. The system of claim 16, wherein the determined orthogonal excitation waveforms are a function of a frequency for modulation and a pseudo-noise sequence at the frequency for modulation.

26. The system of claim 16, wherein the system is configured for:

taking a noise spectrum associated with the sensor;

taking a measurement of noise in the sensor by evaluating the noise spectrum associated with the sensor;

identifying the noise based on the evaluation of the noise spectrum; and

determining the orthogonal excitation waveforms by making the orthogonal excitation waveforms orthogonal to the identified noise in the sensor.

27. The system of claim 26, wherein the system is configured for:

continuing to take the measurement to identify the noise that is orthogonal to the orthogonal excitation waveforms by identifying the noise from the highest noise source in the noise spectrum over a time frame; and

adaptively determining the orthogonal excitation waveforms by using the noise associated with the highest noise source that is continuously identified in the noise spectrum.

28. The system of claim 26, wherein the system is configured for:

periodically taking the measurement to identify the noise that is orthogonal to the orthogonal excitation waveforms by identifying the noise from the highest noise source in the noise spectrum; and

adaptively determining the orthogonal excitation waveforms by using the noise associated with the highest noise source that is periodically identified in the noise spectrum.

29. The system of claim 26, wherein the system comprises a cold-cathode fluorescent backlight or a liquid crystal display, wherein the identified noise is associated with a frequency of operation of the cold-cathode fluorescent backlight or a frequency associated with the liquid crystal display.

30. The system of claim 16, wherein the sensor comprises a capacitive touch sensor, wherein the capacitive touch sensor comprises the ~~a~~ front-end circuit, and the system is further configured for:

preparing an input voltage for transmitting at an output of the front-end circuit for the capacitive touch sensor, ~~the front-end circuit comprising at least a two-stage circuit with the first stage being configured to produce a transimpedance gain, and~~ the second stage of the front end circuit being configured to produce the ~~a~~ voltage gain, wherein the preparation of the input voltage comprises:

producing the transimpedance gain in the first stage of the front-end circuit by configuring the first stage as an integrator circuit;

generating an output signal at the first stage by performing voltage division of the input voltage; and

amplifying the output signal of the first stage of the front-end circuit with the voltage gain of the second stage of the front-end circuit to produce an output signal for the second stage of the front-end circuit,

wherein the first stage comprises noise at a noise level such that the output signal for the second stage of the front-end circuit includes the noise of the first stage amplified by a function of the voltage gain of the second stage, and the noise at the output signal of the second stage is less than noise of the sensor that is derived from a liquid crystal display frequency or a frequency of operation of a cold-cathode fluorescent backlight, and

wherein a closed-loop transfer function of the front-end circuit is stable.

31. A system comprising:

a sensor, wherein the sensor comprises:

a plurality of trace lines oriented in a matrix configuration,

a front end interface,

a plurality of transmitters coupled with the front end interface, and

a plurality of receivers,

wherein respective transmitters correspond to and are coupled with a first location of respective trace lines, and respective receivers are coupled with a second location of the respective trace lines,

means for determining orthogonal excitation waveforms having an orthogonal waveform sequence including taking a noise spectrum associated with the sensor and taking a measurement of noise in the sensor by evaluating the noise spectrum associated with the sensor, and wherein the orthogonal excitation waveforms are orthogonal to each other and to the noise in the sensor;

identifying the noise based on the evaluation of the noise spectrum; and

determining the orthogonal excitation waveforms by making the orthogonal excitation waveforms orthogonal to the identified noise in the sensor;

means for simultaneously transmitting, on each of at least two of the transmitters, one of the orthogonal excitation waveforms such that at least two of the transmitters are configured to transmit respective orthogonal waveform sequences for a duration equal to an integration time, wherein the transmitting occurs on less than all transmitters in the sensor, and wherein a length of the integration time is determined based on a number of transmitters simultaneously transmitting the one of the orthogonal excitation waveforms the length of the integration time increasing as the number of transmitters simultaneously transmitting increases;

means for receiving at least two of the orthogonal excitation waveforms at at least ~~at~~ two of the receivers, wherein each of the at least two orthogonal excitation waveforms are received at one of the respective receivers;

means for receiving information for at least an expected received waveform; and

for each of the at least two receivers, means for correlating the received excitation waveform against the expected received waveform.

32. The method of claim 1, wherein the sensor comprises a capacitive touch sensor~~, wherein the orthogonal excitation waveforms are orthogonal to noise in the sensor~~.