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Method and apparatus for interfacing with a touch sensor

Abstract

An apparatus (**40**) and method (**700**) provide power-efficient reading of a touch sensor (**10**) by performing transform-based reading of the touch sensor (**10**) according to a read configuration (**80**) that accounts for touch-surface areas that are indicated as touch targets (**68**) for receiving touch input. Advantages such as power savings and more robust touch detection flow from the intelligent selection of which sensing lines (**14**) of the touch sensor (**10**) to excite and which excitation frequencies (**52**) to use for exciting them.

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Background/Summary

TECHNICAL FIELD

(1) The invention relates to touch sensors and particularly relates to interfacing with touch sensors.

BACKGROUND

(2) Touch sensors, such as capacitive touchscreens find widespread use, in everything from laptops and other personal computing devices, such as smartphones and tablets, to banking terminals, point-of-sale terminals, etc. Interfacing with touch sensors imposes several challenges, such as balancing the amount and complexity of the interface circuitry against performance and cost. Among other things, “performance” refers to the time required for reading the touch sensor to determine whether or where the touch surface of the touch sensor is being touched, as well as the power consumption associated with detecting touch inputs.

(3) While PCT/EP2020/086794 discloses an advantageous approach to reading touch sensors using frequency-domain techniques, the growing sophistication of touch-based electronics and the software applications they run only increases the challenges of interfacing with touch sensors. Particular challenges exist with respect to multi-application software environments and the need to balance a user's quality of experience with respect to touch-based control against the desire to reduce the power cost and circuit complexity associated with touch-sensor interfacing.

SUMMARY

(4) An apparatus and method provide power-efficient reading of a touch sensor by performing transform-based reading of the touch sensor according to a read configuration that accounts for touch-surface areas that are indicated as touch targets for receiving touch input. Advantages such as power savings and more robust touch detection flow from the intelligent selection of which sensing lines of the touch sensor to excite and which excitation frequencies to use for exciting them.

(5) In one embodiment, a method performed by an apparatus comprises receiving host signaling from host processing circuitry, indicating touch targets for respective software applications running on a host system, each touch target being a respective area of a touch surface of a touch sensor. The method further includes determining a read configuration for transform-based reading of the touch sensor, in dependence on the indicated touch targets. Determining the read configuration includes selecting sensing lines of the touch surface to be excited for detecting touch inputs to the touch targets and selecting excitation frequencies to be used for exciting the selected sensing lines. Still further, the method includes reading the touch sensor according to the read configuration.

(6) In another embodiment, an apparatus is configured for interfacing with a touch sensor, with the apparatus comprising interface circuitry and processing circuitry. The processing is configured to receive, via the interface circuitry, host signaling from host processing circuitry of a host system, the host signaling indicating touch targets for respective software applications running on the host system, each touch target being a respective area of a touch surface of the touch sensor. The processing circuitry is further configured to determine a read configuration for transform-based reading of the touch sensor, in dependence on the indicated touch targets, including selecting sensing lines of the touch surface to be excited for detecting touch inputs to the touch targets, and selecting excitation frequencies to be used for exciting the selected sensing lines. Still further, the

processing circuitry is configured to read the touch sensor based on controlling reading circuitry according to the read configuration, the reading circuitry integrated or associated with the processing circuitry.
(7) Another embodiment comprises an apparatus that is configured for interfacing with a touch sensor, with the apparatus comprising a set of processing units or modules. The modules include a host interface module that is configured to receive host signaling from host processing circuitry of a host system, the host signaling indicating touch targets for respective software applications running on the host system, each touch target being a respective area of a touch surface of the touch sensor. Further modules include a configuration module that is configured to determine a read configuration for transform-based reading of the touch sensor, in dependence on the indicated touch targets, including selecting sensing lines of the touch surface to be excited for detecting touch inputs to the touch targets, and selecting excitation frequencies to be used for exciting the selected sensing lines. Still further, a sensor read module is configured to read the touch sensor based on controlling reading circuitry according to the read configuration.
(8) Another embodiment comprises a computer-readable medium storing computer program instructions that when executed by one or more processors of an apparatus configure the apparatus for interfacing with a touch sensor. Particularly, the computer program instructions include instructions for configuring the apparatus to receive host signaling from host processing circuitry of a host system, the host signaling indicating touch targets for respective software applications running on the host system, each touch target being a respective area of a touch surface of the touch sensor. Further included are instructions for configuring the apparatus to determine a read configuration for transform-based reading of the touch sensor, in dependence on the indicated touch targets, including selecting sensing lines of the touch surface to be excited for detecting touch inputs to the touch targets, and selecting excitation frequencies to be used for exciting the selected sensing lines. Still further, instructions are included for configuring the apparatus to read the touch sensor based on controlling reading circuitry according to the read configuration.
(9) Of course, the present invention is not limited to the above features and advantages. Indeed, those skilled in the art will recognize additional features and advantages upon reading the following detailed description, and upon viewing the accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIGS. **1** and **2** are block diagrams of an example touch sensor having a touch surface spanned by sensing lines.
(2) FIG. **3** is a block diagram of circuitry configured for performing a transform-based reading a touch sensor, according to one embodiment.
(3) FIG. **4** is a plot of example frequency-domain values produced by the circuitry of FIG. **3**, for detecting touch inputs.
(4) FIG. **5** is a block diagram of a host system that includes an apparatus configured for interfacing with a touch sensor, according to an embodiment.
(5) FIG. **6** is a block diagram of further example details for a touch sensor.
(6) FIG. **7** is a logic flow diagram of a method of reading a touch sensor, according to an embodiment.
(7) FIG. **8** is a block diagram of an apparatus configured for interfacing with a touch sensor, according to an embodiment.
(8) FIGS. **9** and **10** are block diagrams of an apparatus configured for interfacing with a touch sensor, according to another embodiment.
(9) FIG. **11** is a block diagram of a host device according to another example embodiment.

(10) FIG. **12** is a block diagram of a unit comprising a touch sensor and an apparatus for reading the touch sensor, according to one embodiment.
(11) FIG. **13** is a block diagram of a mobile communication device according to one embodiment, wherein the device includes the unit of FIG. **12**.

DETAILED DESCRIPTION

(12) FIG. **1** illustrates a typical touch sensor **10** having a touch surface **12** configured for sensing touch inputs from a user (not shown). Various technologies are available for implementation of the touch sensor **10**, with one example being implementation of the touch sensor **10** as a capacitive touchscreen. An example arrangement involving capacitive touch sensor technology includes a capacitive touchscreen comprising a substrate with an X-Y grid of capacitors formed thereon or therein and arranged as intersecting screen columns and screen rows.

(13) Regardless of the sensing technology used, FIG. **2** depicts a known, example arrangement where “sensing lines” **14** span the touch surface **12** for detecting single-point touches or multi-point touches, e.g., “pinches”, “swipes”, or other “gesture” inputs. Fourteen sensing lines **14-1** through **14-14** appear in the example depiction, with lines **14-1** through **14-7** arranged in a “row” orientation and lines **14-8** through **14-14** arranged in a column orientation. Other crisscrossing arrangements may be used, equivalently, and this disclosure uses the reference number “**14**” without suffixing to refer to any given one or more sensing lines, unless suffixing is needed for clarity. Implementations of the touch sensor **10** may include many sensing lines **14** crisscrossing the touch surface **12**, with the density or spacing of adjacent sensing lines **14** defining the maximum resolution at which touch points can be determined within the coordinates of the touch surface **12**.

(14) Detecting whether a touch input is present or absent within the region of the touch surface **12** through which a particular sensing line **14** runs involves applying an excitation signal **16** to one end of the sensing line **14** and measuring or otherwise evaluating the resulting sensing signal **18** output from the other end of the sensing line **14**. For example, the voltage and/or another characteristic of a sensing signal **18** varies in dependence on whether there is a touch input within the region of the touch surface **12** that corresponds to the sensing line **14** outputting the sensing signal **18**. For example, detecting touch inputs in any one or more of the regions of the touch surface **12** labeled as “A”, “B”, “C”, and “D” in the diagram involves applying excitation signals **16** at least to the sensing lines **14** that run through or bound those regions, and evaluating the resulting sensing signals **18**.

(15) Using the suffixing illustrated in FIG. **2**, sensing lines **14-1**, **14-2**, **14-8**, and **14-9** run through or bound the regions A, B, C, and D. Applying excitation signal **16-1** to the sensing line **14-1** yields the sensing signal **18-1**, applying excitation signal **16-2** to the sensing line **14-2** yields the sensing signal **18-2**, applying excitation signal **16-8** to the sensing line **14-8** yields the sensing signal **18-8**, and applying excitation signal **16-9** to the sensing line **14-9** yields the sensing signal **18-9**. Detecting whether touch inputs are present in any one or more of the regions A, B, C, and D involves jointly evaluating the sensing signals **18-1**, **18-2**, **18-8**, and **18-9**. For example, a touch input within region A affects, or most strongly affects, sensing signals **18-1** and **18-8**. Of course, the figure depicts a coarse arrangement of sensing lines **14** and in a practical application, there may be a much higher density of sensing lines **14** crisscrossing the regions A, B, C, and D.

(16) “Transform-based reading” of touch sensors **10** is of particular interest herein. Transform-based reading refers to the use of frequency-domain transformations for detecting touch inputs to a touch sensor **10**. Specifically, transform-based reading involves using analog frequency tones as the excitation signals **16**, which results in the sensing signals **18** being corresponding frequency tones having an amplitude or other signal characteristic that depends on the presence or absence of touch inputs. Applying a frequency-domain transform to such sensing signals yields frequency-domain sensing values corresponding to the frequency tone(s) of the excitation signal(s) in use. A distinguishing feature of transform-based reading is that touch detection is based on obtaining and

evaluating these frequency-domain sensing values.
(17) One advantage of transform-based reading is that multiple simultaneously generated sensing signals **18** can be combined and transformed together, to produce resulting frequency-domain sensing values in frequency bins or spectral positions corresponding to the frequency tones of the excitation signals **16**. Consequently, the involved device or system need not generate and perform measurements on the sensing signals one at a time, such as would be required in more conventional "scanning" arrangements that use a multiplexed analog-to-digital converter to measure the voltage of each excitation signal.
(18) FIG. **3** illustrates a simplified example of transform-based reading that is based on two sensing lines **14-1** and **14-2**. A first excitation signal **16-1** at frequency f**1** is applied to one end of the sensing line **14-1** and results in a first sensing signal **18-1** at frequency f**1** being output from the other end of the sensing line **14-1**. Likewise, applying a second excitation signal **16-2** at frequency f**2** to one end of the sensing line **14-2** results in a second sensing signal **18-2** at frequency f**2** being output from the other end of the sensing line **14-2**. Assuming simultaneous application of the first and second excitation signals **16-1** and **16-2**, the resulting two sensing signals **18-1** and **18-2** are combined in the analog domain via a combiner **20**, to produce a combined sensing signal **22** that includes frequency-separable signal components corresponding to the first and second sensing signals **18-1** and **18-2**.
(19) Digitizing the combined sensing signal **22** in analog-to-digital conversion (ADC) circuitry **24**, along with any filtering and amplification, yields a digitized combined sensing signal **26**. Frequency domain transform (FDT) circuitry **28** performs a frequency-domain transform, such as a Discrete Fourier Transform (DFT), on the digitized combined sensing signal **26** to obtain frequency-domain sensing values **30** corresponding to excitation-signal frequencies contained in the digitized combined sensing signal **26**. The FDT processing may also detect spurious or unwanted values but values not corresponding to the excitation frequencies included in the digitized combined sensing signal **26** can be ignored. Thus, in the example of FIG. **3**, the frequency-domain sensing values **30** that are of interest for touch detection include a value v.sub.f1 corresponding to the first sensing signal **18-1** at f**1**, and a value v.sub.f2 corresponding to the second sensing signal **18-2** at f**2**.
(20) FIG. **4** illustrates an example touch-detection scenario that assumes the presence of a touch input along the region of the touch surface **12** corresponding to the second sensing line **14-2** and the absence of a touch input along the region of the touch surface **12** corresponding to the first sensing line **14-1**. With no touch inputs changing the capacitance or other electrical attribute of the first sensing line **14-1**, the corresponding sensing value **30** for v.sub.f1 is at a nominal or reference magnitude (within some tolerance range). Contrastingly, with a touch input changing the capacitance or other electrical attribute of the second sensing line **14-2**, the corresponding sensing value **30** for v.sub.f2 exhibits a reduced magnitude, thus indicating the presence of a touch input somewhere along the region of the touch surface **12** corresponding to the second sensing line **14-2**.
(21) When one set of sensing lines **14** runs in a first direction of the touch surface **12** (e.g., row-wise) and another set runs in a second direction of the touch surface **12** (e.g., column-wise), a touch event generally affects one or more sensing lines **14** that run in the first direction and one or more sensing lines **14** that run in the second direction. Thus, "locating" a touch event, i.e., determining where the touch point is on the touch surface **12**, may be performed by correlating the sensing value(s) **30** that are associated with the first direction and have magnitudes that exhibit the presence of a touch input with the sensing value(s) **30** that are associated with the second direction and have magnitudes that exhibit the presence of a touch input.
(22) FIG. **5** illustrates an apparatus **40** that is configured to perform transform-based reading of a touch sensor **10**. The apparatus **40** comprises an integrated circuit (IC) in one or more embodiments. In at least one example implementation, the apparatus **40** comprises processing circuitry **42** configured for transform-based reading of the touch sensor **10** and includes or is

associated with memory **44**, such as for holding "touch target" information—i.e., information about which regions of the touch surface **12** of the touch sensor **10** are targets for touch detection. Other information that may be held in the memory **44** on a "live" or running basis is which excitation frequencies are available to use for excitation signals **16**. There may be a predefined or dynamically-determined set of available excitation frequencies.

(23) For example, there may be a maximum of N excitation frequencies that can be generated/used simultaneously, going from a minimum frequency to a maximum frequency in uniform frequency steps, where Nis an integer. Further, in one or more embodiments that evaluate the viability or desirability of individual excitation frequencies for use, e.g., in embodiments that assess the noise or interference experienced on individual excitation frequencies, there may be a dynamically-defined set of available excitation frequencies, e.g., those excitation frequencies having measured noise or interference below some defined threshold, which may be predetermined or dynamically-computed as a function of the particular sensing-reading requirements in play.

(24) The apparatus **40** further includes or is associated with reading circuitry **46** that is configured to apply excitation signals **16** to the touch sensor **10** and detect or otherwise sense corresponding sensing signals **18** from the touch sensor **10**. Characteristics defining the reading circuitry **46** include its ability to apply multiple excitation signals **16** simultaneously to the touch sensor **10** and, correspondingly, and form and digitize a combined sensing signal from the multiple sensing signals **18** that are correspondingly output from the touch sensor **10**. The digitized combined sensing signal may then be transformed into frequency-domain values by the reading circuitry **46** or by the processing circuitry **42**, which in at least one embodiment integrates all or part of the reading circuitry **46**. However implemented, the reading circuitry **46** is configured to be controlled by the processing circuitry **42**, to select which sensing lines **14** of the touch surface **12** of the touch sensor **10** are excited during a read of the touch sensor **10**, and further select which excitation frequencies are used to excite those sensing lines **14**.

(25) An excitation signal generator **48** generates analog frequency tones for use as the excitation signals **16**. In an example embodiment, the excitation signal generator **48** is controllable by the processing circuitry **42** to generate or otherwise output at any time specific selected frequencies from a set **50** of N excitation frequencies **52**. The value N may equal the total number of sensing lines **14** of the touch sensor **10** or may be some fraction of that total and the set **50** of excitation frequencies **52** may be predefined, e.g., covering a defined spectrum going from a lowest excitation frequency **52** to a highest excitation frequency **52** and with a defined spacing. In at least one embodiment, Nis an integer that at least equals the maximum number of sensing lines **14** to be excited simultaneously in any given read of the touch sensor **10**, e.g., the maximum number of "columns" or "rows" of the touch sensor **10**.

(26) The apparatus **40** provides an intelligent touch-sensor interface for host processing circuitry **62** of a host system **60** that incorporates the apparatus **40**. Example host systems **60** include personal computing devices such as smartphones, tablets, and laptops, but the host system **60** may be essentially any electronic system that incorporates a touch sensor **10** for user interaction. In an example of such interaction, the host processing circuitry **62** provides a runtime environment **64** in which one or more software applications **66** may be running at any given time. Of course, the applications **66** running may change over time and the term "application" in this context has broad meaning. For example, one or more of the applications **66** may be low-level operating-system applications or functions that run in parallel or in a background sense relative to any higher-level applications that may be executing in the runtime environment **64**.

(27) An advantageous illustration of the intelligent interfacing provided to the host processing circuitry **62** by the apparatus **40** arises in the context of touch targets **68**, where FIG. **5** depicts four touch targets **68-1**, **68-2**, **68-3**, and **68-4**, as a non-limiting example. At any given time, an individual application **66** in the runtime environment **64** may use or be interested only in a particular region or regions of the touch surface **12**. For example, a given application **66** may

display only one or a few touch controls at any time and is therefore "interested" only in touch inputs directed to such regions, which are touch targets **68** for that respective application **66**.

(28) Of course, the number of applications **66** running and the number and location of the corresponding touch targets **68** may vary dynamically, as applications **66** are launched or terminated on the host system **60**, or as the "focus" changes between running applications **66**. Thus, host signaling **70** incoming from the host processing circuitry **62** changes dynamically, to indicate the touch targets **68** currently of interest and the apparatus **40** in one or more embodiments maintains a data structure in the memory **44** that represents the "current set" of touch targets **68** to be read on the touch sensor **10** by the apparatus **40**. For example, the apparatus **40** tracks or otherwise remembers which touch targets **68** are in use at any given time.

(29) Particularly, the apparatus **40** is configured to determine a "read configuration" to use for reading the touch sensor **10**, in dependence on the number and arrangement of the touch targets **68** to be read. In at least one embodiment, the apparatus **40** further bases the read configuration on touch-detection requirements associated with the touch targets **68**. The term "touch-detection requirements" at least refers to one or both of a "responsiveness" requirement and a "resolution" requirement. Further, in at least one embodiment, the read configuration depends on determining "available" excitation frequencies **52**. For example, out of a set **50** of excitation frequencies **52**, noise measurements may indicate that one or more of them are too noisy for use or that one or more of them are preferred for use.

(30) If the number of available excitation frequencies **52** is less than the number of separate excitation frequencies **52** needed in the particular reading scenario at issue, the apparatus **40** may perform the read as successive, related read operations that reuse one or more of the available excitation frequencies **52**. For example, if there are fourteen row-oriented sensing lines **14** to read and all require distinction for touch-resolution purposes, and there are only ten available excitation frequencies, the apparatus **40** may read a first subset of the sensing lines **14** in one operation and then read a remaining subset of the sensing lines **14** in a successive operation, with the two operations together being considered part of the same overall "reading" of the touch sensor **10**.

(31) Although the evaluation of available excitation frequencies **52** may be dynamic, i.e., the prevailing noise conditions may change, a possible source of narrowband noise that affects one or more excitation frequencies **52** but not others is clock or switching noise present in the host system **60**. Embodiments of the apparatus **40** that assess the presence or level of narrowband noise with respect to individual excitation frequencies offer, among other advantages, the ability to tailor or adapt the excitation frequencies **52** used for touch-sensor reading to the noise environment experienced in the host system **60**.

(32) The responsiveness requirement indicates an allowable or maximum touch-detection latency for a respective touch target **68** and may be understood as dictating read-cycle timing, permissible excitation-signal voltages, etc. The resolution requirement indicates an allowable or minimum touch-detection resolution for a respective touch target **68**. Further, touch-detection requirements may include touch-type requirements, e.g., information about the nature of the touch inputs to be recognized, such as single touches, multiple touches, swipes, pinches, or other gesture-detection.

(33) As an example of using touch-type requirements, the apparatus **40** may decide on the need for higher or lower touch-detection resolution or more or less responsive touch detection, in dependence on whether a given touch target **68** requires high detection speed, e.g., in case swipe detection is needed. In at least one embodiment, the host signaling **70** indicates respective touch targets **68**, e.g., where each touch target **68** is expressed in relative or absolute coordinates that the apparatus **40**, if necessary, translates into X-Y coordinates of the touch surface **12**. Corresponding information provided via the host signaling **70** includes, in one or more embodiments, touch-detection requirement information for the respective touch targets **68**. If such information is not provided, the apparatus **40** in one or more embodiments assumes default touch-detection requirements.

(34) FIG. **6** provides a working basis for understanding touch-detection resolution in the context of transform-based reading of the touch sensor **10**. Reading any region of the touch surface **12** at the "maximum" resolution requires the apparatus **40** to obtain a unique frequency-domain sensing value **30** for every sensing line **14** that is "involved" with that region. A particular sensing line **14** of the touch surface **12** is considered as being "involved" with a particular region of the touch surface **12** if it passes through the region or bounds the region, i.e., runs adjacent to the boundary of the region.

(35) If all involved sensing lines **14** are simultaneously excited and sensed, the apparatus **40** must use a different excitation frequency **52** for each one of the involved sensing lines **14**, to obtain a separate frequency-domain sensing value **30** for each involved sensing line **14**. As an alternative, in one or more embodiments where the sensing lines **14** are arranged in crisscrossing arrangements, e.g., one set running in a first direction and another set running in another direction, such as row/column directions, the apparatus **40** may read each set of sensing lines **14** separately and, therefore, may reuse excitation frequencies **52** as between the respective sets of sensing lines **14**. Indeed, with buffering of digitized sample values obtained from sensing signals **18** or combined sensing signals **26**, the apparatus **40** may excite successive subsets of sensing lines **14** from an overall set to be excited and save the frequency-domain sensing values **30** obtained from each subset excitation, with excitation frequencies **52** reused across the subsets.

(36) Consider a scenario where the touch target **68-2** shown in FIG. **6** logically functions as a single large control button, and where the application **66** that "owns" the touch target **68-2** is concerned only with whether the control button is or is not pressed. In such cases, the apparatus **40** in at least one embodiment intelligently adjusts the read configuration to allow for reading the touch target **68-2** at a lower resolution, which may save significant power. Reducing touch-detection resolution means exciting fewer than all involved sensing lines **14** or using fewer excitation frequencies **52** than there are excited sensing lines **14**, or both. For example, if the touch target **68-2** logically constitutes a single control button, the apparatus **40** may use the same excitation frequency **52** to excite all the row-wise sensing lines **14** that are involved with the touch target **68-2** and it may use a single excitation frequency **52** to excite all of the column-wise sensing lines **14** that are involved with the touch target **68-2**.

(37) In addition to, or as an alternative to, exciting multiple involved sensing lines **14** with the same excitation frequency **52**, the apparatus **40** in one or more embodiments reads a region of the touch surface **12** at a reduced resolution by exciting fewer than all involved sensing lines **14**. For example, the apparatus **40** excites every other one of the involved sensing lines **14**, every third one of the involved sensing lines **14**, etc. Reducing the number of excitation frequencies **52** used to read a region of the touch surface **12** or reducing the number of sensing lines **14** that are excited for the read offers multiple advantages, including reduced power consumption, not only with respect to power expended in the touch sensor **10**, but also with respect to power expended by the apparatus **40** for frequency-domain processing.

(38) Of course, there may be gradations of resolution reduction used by the apparatus **40**. For example, the touch target **68-2** may not need high touch-detection resolution per se, but the host signaling may indicate its use for swipe detection or other type of gesture-based input. Correspondingly, the apparatus **40** may subdivide the touch target **68-2** into several macro bands, such as macro rows or macro columns or bands, where each macro band encompasses two or more sensing lines, and where the apparatus **40** uses a different excitation frequency for each macro row or column, to support swipe detection.

(39) With respect to reading-performing touch detection-any touch target **68**, there will be some number of involved sensing lines **14**, according to the above definition of "involved". Then, depending upon the resolution requirements, the apparatus **40** may choose to excite fewer than all the involved sensing lines **14** and may choose to excite more than one of the involved sensing lines **14** simultaneously, using the same frequency. Therefore, with respect to reading any particular

touch target **68**, there will be one or more "excited" sensing lines **14**, meaning sensing lines **14** to which the apparatus **40** applies an excitation signal, and there will be one or more excitation frequencies **52** used for that excitation.

(40) Consider a generalized example of reading a given touch target **68** where there are ten involved sensing lines **14**. Reading the given touch target **68** at full resolution requires obtaining a separate sensing value **30** for each involved sensing line **14**. Energizing only a subset of the involved sensing lines **14** reduces the read resolution; similarly, simultaneously exciting two or more of the involved sensing lines **14** means that those two or more sensing lines **14** will be represented by the same sensing value **30** in the frequency domain, therefore reducing touch resolution.

(41) In this regard, one may view the same excitation frequency **52** being applied to multiple sensing lines **14** as the "same" excitation signal **16** being applied to them, or one may view each one of the multiple sensing lines **14** as having its own respective excitation signal **16**, with all such excitation signals **16** being at the same frequency. The more correct one of these two views depends on lower-level implementation details of excitation-signal generation and multiplexing or distribution. Such details are not germane to the underlying principles.

(42) A further complication handled by the apparatus **40** involves reading "interdependencies" between respective touch targets **68**. For example, consider a scenario where the touch target **68-1** requires full-resolution reading, meaning that the apparatus **40** must obtain a separate frequency-domain sensing value for each sensing line **14** involved with the touch-target **68-1**. Because the touch target **68-1** spans most of the column-oriented sensing lines **14** in the example of FIG. **6**, the apparatus **40** is obligated to use full-resolution excitation for the column-oriented sensing lines **14** involved with the touch target **68-1**, even though other touch targets **68** "below" the touch target **68-1** may not need full resolution. Any touch targets **68** that share involved sensing lines **14** are interdependent in the sense that the apparatus **40** must determine a read configuration that satisfies the most demanding touch-detection attribute(s) associated with the shared sensing lines **14**.

(43) The apparatus **40** in one or more embodiments maintains a read configuration with respect to the touch sensor **10** and performs corresponding transform-based reading of the touch sensor **10** dynamically, according to changing host signaling **70** incoming to the apparatus **40**. For example, the apparatus **40** maintains one or more data structures in the memory **44** that reflect the current set of touch targets **68** and the touch-detection requirements corresponding to each touch target **68**. Touch-detection requirements may be default requirements, e.g., full-resolution with a defined read-cycle timing or may be specified in the host signaling **70**. The read configuration used by the apparatus **40** dynamically reflects changes in the touch targets **68** and the corresponding touch-detection requirements.

(44) FIG. **7** illustrates a method **700** performed by an apparatus **40**, where the method **700** includes receiving (Block **702**) host signaling **70** from host processing circuitry **62**, indicating touch targets **68** for respective software applications **66** running on a host system **60**, each touch target **68** being a respective area of a touch surface **12** of a touch sensor **10**. The method **700** further includes the apparatus **40** determining (Block **704**) a read configuration **80** for transform-based reading of the touch sensor **10**, in dependence on the indicated touch targets **68**, including selecting sensing lines **14** of the touch surface **12** to be excited for detecting touch inputs to the touch targets **68**, and selecting excitation frequencies **52** to be used for exciting the selected sensing lines **14**. Method operations further include the apparatus **40** reading (Block **706**) the touch sensor **10** according to the read configuration **80**.

(45) Receiving (Block **702**) the host signaling **70** comprises, for example, receiving touch-target indications on a per-application basis, for the respective software applications **66** running on the host system **60**. Correspondingly, determining (Block **704**) the read configuration **80** with respect to such host signaling **70** comprises determining the read configuration **80** according to an aggregation of indicated per-application touch targets **68** received over time.

(46) Receiving (Block **702**) the host signaling **70** in other instances or in another embodiment comprises receiving changing indications of touch targets **68**. Determining (Block **704**) the read configuration **80** with respect to such host signaling **70** comprises determining the read configuration **80** dynamically, responsive to the changing indications of touch targets **68**.
(47) Receiving (Block **702**) the host signaling **70** in other instances or in another embodiment comprises receiving indications from the host processing circuitry **62** regarding touch targets **68** currently in use by software applications **66** running on the host system **60**. Determining (Block **704**) the read configuration **80** with respect to such host signaling **70** comprises determining the read configuration **80** according to the touch targets **68** currently in use.
(48) Selecting the sensing lines **14** of the touch surface **12** to be excited includes, in one or more embodiments, selecting all sensing lines **14** involved with the touch targets **68** or selecting fewer than all involved sensing lines **14**, in dependence on touch-resolution requirements associated with respective ones of the touch targets **68** and a relative positioning of the touch targets **68** on the touch surface **12**.
(49) Selecting the excitation frequencies **52** to be used for exciting the selected sensing lines **14** comprises, in one or more embodiments, selecting as many excitation frequencies **52** as there are selected sensing lines **14** to be simultaneously excited, or selecting fewer excitation frequencies **52** than there are selected sensing lines **14** to be simultaneously excited, in dependence on touch-resolution requirements associated with respective ones of the touch targets **68** and a relative positioning of the touch targets **68** on the touch surface **12**.
(50) At least one embodiment includes identifying "available" excitation frequencies **52**, e.g., based on measuring noise present in sensing signals **18** generated using respective excitation frequencies **52** from a set **50** of excitation frequencies. An "available" frequency **52** is one that has measured noise below a defined noise threshold, which may be an absolute threshold, or one determined on a relative basis. Choosing which excitation frequencies **52** to use or choosing how many different excitation frequencies **52** to use is conditioned on how many and which ones of the excitation frequencies **52** are available.
(51) Determining the read configuration **80** in one or more embodiments comprises determining it in further dependence on touch-detection requirements associated with the touch targets **68**. The touch-detection requirements in this regard include at least one of touch-resolution requirements, touch-responsive requirements, or touch-type requirements.
(52) Selecting the excitation frequencies **52** to be used for exciting the selected sensing lines **14** comprises, in one or more embodiments, choosing individual excitation frequencies **52** from among a set **50** of excitation frequencies **52**, in dependence on noise or interference measurements associated with respective ones of the excitation frequencies **52** in the set **50** of excitation frequencies **52**. Correspondingly, in at least one embodiment, the method **700** includes measuring noise or interference present in sensing signals **18** to obtain the noise or interference measurements, the sensing signals **18** being output from respective sensing lines **14** of the touch sensor **10** while the respective sensing lines **14** are excited with respective ones of the excitation frequencies **52** in the set **50** of excitation frequencies **52**.
(53) Selecting the excitation frequencies **52** to be used for exciting the selected sensing lines **14** comprises, in at least one embodiment, choosing individual excitation frequencies **52** from among a set **50** of excitation frequencies **52** to minimize a frequency range spanned by the selected excitation frequencies **52**, e.g., to reduce the needed sampling frequency for a corresponding reduction in power consumption.
(54) In at least one embodiment, choosing individual excitation frequencies **52** from among a set of excitation frequencies **52** comprises choosing excitation frequencies **52** to minimize or otherwise reduce the processing time required for frequency-domain transformations performed for the transform-based reading of the touch sensor **10**. Consider a first example scenario where the number of sensing lines **14** to be excited is four adjacent lines of the touch surface **12** and the

overall frequency range spanned by the chosen excitation frequencies **52** is 100 kHz, and the regular frequency-domain transformation produces 1 bin per 1 kHz, resulting in 100 bins. Given that only four sensing lines **14** are excited for the read, the selected excitation frequencies can be picked at 25 kHz frequency spacing and the frequency-domain transformation can be adjusted to produce only four bins at the specific frequencies instead of the usual 100 bins. Doing so reduces processing time and power consumption.

(55) In another scenario, the spectrum might be quite noisy, and a higher frequency-domain transformation resolution would be needed (e.g., 1 bin every 100 Hz) for better representation of the touch input, the number of bins will be increased, especially around the excitation frequencies **52** used in the reading, at the expense of processing time and power consumption.

(56) Selecting the excitation frequencies **52** to be used for exciting the selected sensing lines **14** comprises, in at least one embodiment, identifying candidate excitation frequencies **52** from among a set **50** of excitation frequencies **52**, based on noise measurements associated with respective excitation frequencies **52** in the set **50**, and limiting selection consideration to the candidate excitation frequencies **52**. That is, for any particular selection strategy or combination of selection strategies, the excitation frequencies **52** that are considered to be “available” for selection may be restricted, on the basis of noise measurements.

(57) In at least one embodiment of the method **700**, the host signaling **70** is dynamic. Correspondingly, determining the read configuration **80** comprises adapting the read configuration **80** responsive to any one or more of the following: the touch targets **68** changing, touch-detection requirements of the touch targets **68** changing, or a touch-target focus changing.

(58) FIG. **8** illustrates one embodiment of an apparatus **40** configured for interfacing with a touch sensor **10**. The apparatus **40** comprises a set **800** of modules, also referred to as processing units, which may be realized as logical or functional circuitry instantiated using underlying physical circuitry, e.g., one or more microprocessors and supporting clocking and memory circuitry.

(59) The modules **800** include a host interface module **802** that is configured to receive host signaling **70** from host processing circuitry **62** of a host system **60**, the host signaling **70** indicating touch targets **68** for respective software applications **66** running on the host system **60**, and each touch target **68** being a respective area of a touch surface **12** of a touch sensor **10**. A configuration module **804** is configured to determine a read configuration **80** for transform-based reading of the touch sensor **10**, in dependence on the indicated touch targets **68**. The configuration module **804** at least logically includes a sensing-line selection module **806** that is configured to select sensing lines **14** of the touch surface **12** to be excited for detecting touch inputs to the touch targets **68**, and an excitation-frequency selection module **808** that is configured to select excitation frequencies **52** to be used for exciting the selected sensing lines **14**. Further, the set **800** of modules includes a sensor read module **810** that is configured to read the touch sensor **10** based on controlling reading circuitry **46** according to the read configuration **80**, the reading circuitry **46** integrated or associated with the processing circuitry **42**.

(60) FIG. **9** depicts example details for a host system **60** that includes the apparatus **40** and reading circuitry **46**, for interfacing a touch sensor **10** with host processing circuitry **62**. Here, an overall set of sensing lines **14** of the touch surface **12** is arranged in a row/column arrangement, with “R” designating given rows and “C” designating given columns. That is, some sensing lines **14** are row sensing lines **14** and some are column sensing lines **14**.

(61) In an example implementation with respect to the depicted arrangement, the apparatus **40** reads the touch sensor **10** by performing a row read and a column read at different times and using the sensing value(s) **30** resulting from the row read and the sensing value(s) **30** resulting from the column read to detect and locate touch inputs to the touch surface **12**. To this end, the apparatus **40** controls the reading circuitry **46** to excite selected row sensing lines **14** using selected excitation frequencies **52**, and the combiner **20** combines the resulting sensing signals **18** to obtain a combined sensing signal **22** with respect to the rows, which is then digitized by the ADC circuitry

24 and frequency-domain transformed by the FDT circuitry **28** to produce row sensing values **30**. The same process repeats with respect to the columns to obtain column sensing values **30**.

(62) Here, it should be noted that the frequency-domain transform may be applied twice, once to obtain sensing values **30** for row-oriented sensing lines **14** and again to obtain sensing values **30** for column-oriented sensing lines **14**. Such an approach allows excitation frequencies to be reused as between row sensing and column sensing. Alternatively, even though the row sensing and column sensing are still performed at different times, the excitation frequencies **52** used for row excitation are different than those used for column excitation. Although this approach requires more excitation frequencies **52**, it allows the digitized samples of the combined sensing signal **22** obtained for the rows to be frequency-domain transformed along with the digitized samples of the combined sensing signal **22** obtained for the columns. Here, it will be appreciated that the ADC circuitry **24** or the FDT circuitry **28** in one or more embodiments contains one or more buffers, for such buffering activities.

(63) Another item illustrated in FIG. **9** is interface/communication circuitry **90**, which is included in the host system **60** in one or more embodiments. Such circuitry comprises, for example, a wireless communication interface operative to couple the host system **60** to a Wireless Local Area Network (WLAN) or Wide Area Network (WAN), such as a cellular communication network.

(64) FIG. **10** depicts example implementation details for the reading circuitry **46**. First multiplexing circuitry **100** operates under control by the processing circuitry **42** of the apparatus **40**, to perform row excitation or column excitation. Second multiplexing circuitry **102** operates in cooperation with the first multiplexing circuitry to provide either row sensing signals **18** or column sensing signals **18** to the combiner **20**. That is, when the first multiplexing circuitry **100** performs row excitation, the combiner **20** receives row sensing signals **18** for combining into a combined sensing signal **22** that has an excitation-frequency component corresponding to every excitation frequency **52** used in the row excitation. When the first multiplexing circuitry **100** performs column excitation, the combiner **20** receives column sensing signals **18** for combining into a combined sensing signal **22** that has an excitation-frequency component corresponding to every excitation frequency **52** used in the column excitation.

(65) Clocking/synchronization circuitry **104** of the reading circuitry **46** provides synchronized operation of the first and second multiplexing circuitry **100** and **102** and may operate responsive to the processing circuitry **42** of the apparatus **40**, e.g., on a triggered or cycling basis. The processing circuitry **42** is included in digital-domain circuitry **106** that includes the FDT **28** and the memory **44**, e.g., for holding sensing values **30** or digitized samples output from the ADC **24** for combined sensing signals **22**. The ADC **24** belongs to analog-domain circuitry **110**, that may include a chopper amplifier **112** in one or more embodiments, for conditioning the combined sensing signal(s) **22** incoming to the ADC circuitry **24** for digitization. Particularly, the chopper amplifier **112** may provide noise reduction in at least some scenarios.

(66) Broadly, an apparatus **40** according to one or more embodiments is configured for interfacing with a touch sensor **10**. The apparatus **40** comprises interface circuitry **41** and processing circuitry **42**. The processing circuitry **42** is configured to receive, via the interface circuitry **41**, host signaling **70** from host processing circuitry **62** of a host system **60**. The host signaling **70** indicates touch targets **68** for respective software applications **66** running on the host system **60**, each touch target **68** being a respective area of a touch surface **12** of the touch sensor **10**.

(67) The processing circuitry **42** is further configured to determine a read configuration **80** for transform-based reading of the touch sensor **10**, in dependence on the indicated touch targets **68**, including selecting sensing lines **14** of the touch surface **12** to be excited for detecting touch inputs to the touch targets **68**, and selecting excitation frequencies **52** to be used for exciting the selected sensing lines **14**. Still further, the processing circuitry **42** is configured to read the touch sensor **10** based on controlling reading circuitry **46** according to the read configuration **80**, the reading circuitry **46** being integrated or associated with the processing circuitry **42**.

(68) The processing circuitry **42** comprises fixed circuitry or programmatically configured circuitry or a mix of both. For example, the apparatus **40** includes one or more microprocessors, Digital Signal Processors (DSPs), Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), Complex Programmable Logic Devices (CPLDs), or other arrangement of digital processing circuitry. In at least one embodiment, the processing circuitry **42** is realized based on the execution of stored computer program instructions.
(69) For example, the processing circuitry **42** comprises one or more microprocessors that are specially adapted to carry out the operations attributed herein to the processing circuitry **42**, based on the execution of computer program instructions from one or more computer programs stored in the memory **44** of the apparatus **40**. To this end, the memory **44** may comprise more than one type of memory or more than one memory device. More broadly, the memory **44** may comprise one or more storage devices and may include more than one type of storage device, such as volatile and non-volatile memory devices.
(70) The processing circuitry **42** in at least one embodiment is configured to receive touch-target indications on a per-application basis, for the respective software applications **66** running on the host system **60** and determine the read configuration **80** according to an aggregation of indicated per-application touch targets **68** received over time.
(71) The processing circuitry **42** in at least one embodiment is configured to receive the host signaling **70** as changing indications of touch targets **68**, and determine the read configuration **80** dynamically, responsive to the changing indications of touch targets **68**.
(72) The processing circuitry **42** in at least one embodiment is configured to receive, as the host signaling **70**, indications from the host processing circuitry **62** regarding touch targets **68** currently in use by software applications **66** running on the host system **60** and determining the read configuration **80** according to the touch targets **68** currently in use.
(73) For selecting the sensing lines **14** of the touch surface **12** to be excited, the processing circuitry **42** in one or more embodiments is configured to select all sensing lines **14** involved with the touch targets **68** or select fewer than all involved sensing lines **14**, in dependence on touch-resolution requirements associated with respective ones of the touch targets **68** and a relative positioning of the touch targets **68** on the touch surface **12**.
(74) For selecting the excitation frequencies **52** to be used for exciting the selected sensing lines **14**, the processing circuitry **42** in one or more embodiments is configured to select as many excitation frequencies **52** as there are selected sensing lines **14** to be simultaneously excited, or select fewer excitation frequencies **52** than there are selected sensing lines **14** to be simultaneously excited, in dependence on touch-resolution requirements associated with respective ones of the touch targets **68** and a relative positioning of the touch targets **68** on the touch surface **12**.
(75) The processing circuitry **42** in at least one embodiment is configured to determine the read configuration **80** in further dependence on touch-detection requirements associated with the touch targets **68**, the touch-detection requirements including at least one of touch-resolution requirements, touch-responsive requirements, or touch-type requirements.
(76) For selecting the excitation frequencies **52** to be used for exciting the selected sensing lines **14**, the processing circuitry **42** in one or more embodiments is configured to choose individual excitation frequencies **52** from among a set **50** of excitation frequencies **52**, in dependence on noise or interference measurements associated with respective ones of the excitation frequencies **52** in the set **50** of excitation frequencies **52**. Here, the processing circuitry **42** is configured to measure noise or interference present in sensing signals **18** to obtain the noise or interference measurements, the sensing signals **18** being output from respective sensing lines **14** of the touch sensor **10** while the respective sensing lines **14** are excited with respective ones of the excitation frequencies **52** in the set **50** of excitation frequencies **52**.
(77) In one or more embodiments, for selecting the excitation frequencies **52** to be used for exciting the selected sensing lines **14**, the processing circuitry **42** is configured to choose individual

excitation frequencies **52** from among a set **50** of excitation frequencies **52** to minimize a frequency range spanned by the selected excitation frequencies **52**. In at least one embodiment, for selecting the excitation frequencies **52** to be used for exciting the selected sensing lines **14**, the processing circuitry **42** is configured to identify candidate excitation frequencies **52** from among a set **50** of excitation frequencies **52**, based on noise measurements associated with respective excitation frequencies **52** in the set **50**, and select particular ones among the candidate excitation frequencies **52**, to minimize a frequency range spanned by the selected excitation frequencies **52**.
(78) In at least one embodiment, the host signaling **70** is dynamic and the processing circuitry **42** is configured to adapt the read configuration **80** responsive to any one or more of the following: the touch targets **68** changing, touch-detection requirements of the touch targets **68** changing, or a touch-target focus changing.
(79) The apparatus **40** in one or more embodiments comprises an Integrated Circuit (IC) or an IC assembly. In at least one embodiment, the apparatus **40** includes the reading circuitry **46**. For example, the apparatus **40** comprises a Multi-Chip Module (MCM) or a System-On-a-Chip (SoC) that includes ICs or modules embodying the interface circuitry **41**, the processing circuitry **42**, the reading circuitry **46**, and the excitation signal generator **48**. The apparatus **40** in such embodiments may be regarded as an integrated touch-sensor IC that provides convenient interfacing between host processing circuitry **62** and a touch sensor **10**, with the multiplicity of advantages that come from transform-based reading of the touch sensor **10** and the ability to tailor the particular sensing line(s) **14** that are excited and the particular excitation frequencies **52** that are used for excitement, in a manner that accounts for the touch-detection need of active or running software application(s) **66** while minimizing power consumption.
(80) FIG. **11** illustrates another example of a host system **60**, which includes host processing circuitry **62** and associated memory/storage **120**. The host processing circuitry **62** provides a runtime environment **64**, for execution of software applications **66** and a touch software driver **122** that provides for interfacing with the apparatus **40**, which may be included in a user interface **130** of the host system **60**, along with a touch sensor **10**. The touch software driver **122** provides, for example, signaling or message formatting that comports with the protocol(s) implemented in the apparatus **40**, for receiving touch-target information, touch-detection requirements, etc., and for transmitting touch-detection information to the host processing circuitry **62**, e.g., touch locations, durations, touch types, gesture information, etc.
(81) The example host system **60** further includes communication circuitry **124** that includes receiver circuitry **126** and transmitter circuitry **128**. Such circuitry may provide wired or wireless-communications operations for the host system **60**. Further elements of the host system **60** include a power supply **132**, which may include a battery. Example host systems **60** include personal computing devices, such as tablets, touch-enabled laptops, smart phones, in-vehicle infotainment screens, kiosk systems or other point of sale or retail displays used for interaction, etc.
(82) FIG. **12** depicts a “unit” or assembly **140** that includes a touch sensor **10** and an implementation of the apparatus **40** configured for reading the touch sensor **10**. For example, the touch sensor **10** is a capacitive touch screen and the apparatus **40** provides a power-efficient mechanism for reading the capacitive touch screen. Of course, other types or variations of touch sensor **10** may be included in the unit **140**, which may be provided for incorporation into various types of electronic systems or devices.
(83) FIG. **13** illustrates one example of such incorporation, where the unit **140** forms a part of an electronic device **150**. As an example, the electronic device **150** comprises a wireless communication terminal or other mobile communication device, such as a smart phone, tablet, or other computing device that includes the apparatus **40** for interfacing with a touch sensor **10**. According to terminology used by the Third Generation Partnership Project (3GPP), the electronic device **150** may be a “User Equipment” or “UE”.
(84) The electronic device **150** may be understood as an example host system **60**. In the illustrated

embodiment, the electronic device **150** includes communication circuitry **152**, processing and interface circuitry **154**, a user interface **156** that includes the unit **140**, and a power supply **158**, which may include a battery. The electronic device **150** is, for example, configured for operation in a cellular network or other Wide Area Network (WAN), such as in a wireless communication network that operates according to 3GPP specifications.

(85) Notably, modifications and other embodiments of the disclosed invention(s) will come to mind to one skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention(s) is/are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of this disclosure. Although specific terms may be employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.

Claims

1. A method performed by an apparatus, the method comprising: receiving host signaling from host processing circuitry, indicating touch targets for respective software applications running on a host system, each touch target being a respective area of a touch surface of a touch sensor and the host signaling indicating touch detection requirements corresponding to the touch targets indicated for the respective software applications; maintaining a data structure that represents a current set of touch targets, from among the indicated touch targets, the data structure indicating the touch detection requirements corresponding to the current set of touch targets; determining a read configuration for the touch sensor according to the current set of touch targets and the corresponding touch-detection requirements, as represented in the data structure, the read configuration defining which sensing lines of the touch sensor are selected for excitement and which excitation frequencies are used for exciting the selected sensing lines, for detecting touch inputs to respective ones among the current set of touch targets using frequency-domain transformations; and reading the touch sensor according to the read configuration.
2. The method of claim 1, wherein maintaining the data structure comprises updating the data structure responsive to receiving host signaling indicating a change in which software application among the respective software applications is active for touch inputs.
3. The method of claim 1, wherein receiving the host signaling comprises receiving changing indications of the current set of touch targets, and updating the data structure responsive to the changing indications.
4. The method of claim 1, wherein determining the read configuration includes setting the number of excitation frequencies used in relation to the number of sensing lines selected for excitation in dependence on the touch-detection requirements corresponding to the current set of touch targets.
5. The method of claim 1, wherein determining the read configuration includes selecting for excitation fewer than all sensing lines involved with the current set of touch targets or selecting fewer excitation frequencies than there are selected sensing lines, in dependence on touch-resolution requirements associated with respective ones among the current set of touch targets and a relative positioning of respective ones among the current set of touch targets on the touch surface.
6. The method of claim 1, wherein selecting which excitation frequencies are used for exciting the selected sensing lines comprises selecting as many excitation frequencies as there are selected sensing lines to be simultaneously excited, or selecting fewer excitation frequencies than there are selected sensing lines to be simultaneously excited, in dependence on touch-resolution requirements associated with respective ones among the current set of touch targets and a relative positioning of respective ones among the current set of touch targets on the touch surface.
7. The method of claim 1, wherein selecting which excitation frequencies are used for exciting the selected sensing lines comprises choosing individual excitation frequencies from among a set of

excitation frequencies, in dependence on noise or interference measurements associated with respective ones of the excitation frequencies in the set of excitation frequencies.

8. The method of claim 7, further comprising measuring noise or interference present in sensing signals to obtain the noise or interference measurements, the sensing signals being output from respective sensing lines of the touch sensor while the respective sensing lines are excited with respective ones of the excitation frequencies in the set of excitation frequencies.

9. The method of claim 1, wherein selecting which excitation frequencies are used for exciting the selected sensing lines comprises choosing individual excitation frequencies from among a set of excitation frequencies to minimize a frequency range spanned by the selected excitation frequencies.

10. The method of claim 1, wherein selecting which excitation frequencies are used for exciting the selected sensing lines comprises: identifying candidate excitation frequencies from among a set of excitation frequencies, based on noise measurements associated with respective excitation frequencies in the set; and limiting consideration of which excitation frequencies are used to the candidate excitation frequencies.

11. An apparatus configured for interfacing with a touch sensor, the apparatus comprising processing circuitry configured to: interface circuitry; and processing circuitry configured to: receive, via the interface circuitry, host signaling from host processing circuitry of a host system, the host signaling indicating touch targets for respective software applications running on the host system, each touch target being a respective area of a touch surface of the touch sensor and the host signaling indicating touch detection requirements corresponding to the touch targets indicated for the respective software applications; maintain a data structure that represents a current set of touch targets, from among the indicated touch targets, the data structure indicating the touch detection requirements corresponding to the current set of touch targets; determine a read configuration for the touch sensor according to the current set of touch targets and the corresponding touch-detection requirements, as represented in the data structure, the read configuration defining which sensing lines of the touch sensor are selected for excitement and which excitation frequencies used for exciting the selected sensing lines, for detecting touch inputs to respective ones among the current set of touch targets using frequency-domain transformations; and read the touch sensor based on controlling reading circuitry according to the read configuration, the reading circuitry integrated or associated with the processing circuitry.

12. The apparatus of claim 11, wherein the processing circuitry is configured to maintain the data structure by updating the data structure responsive to receiving host signaling indicating a change in which software application among the respective software applications is active for touch input.

13. The apparatus of claim 11, wherein the processing circuitry is configured to receive the host signaling as changing indications of the current set of touch targets, and determine the read configuration dynamically, responsive to the changing indications of the current set of touch targets.

14. The apparatus of claim 11, wherein, with respect to determining the read configuration, the processing circuitry is configured to set the number of excitation frequencies used in relation to the number of sensing lines selected for excitation in dependence on the touch-detection requirements corresponding to the current set of touch targets.

15. The apparatus of claim 11, wherein, with respect to determining the read configuration, the processing circuitry is configured to select fewer than all sensing lines involved with the current set of touch targets or select fewer excitation frequencies than there are selected sensing lines, in dependence on touch-resolution requirements associated with respective ones among the current set of touch targets and a relative positioning of respective ones among the current set of touch targets on the touch surface.

16. The apparatus of claim 11, wherein, for selecting which excitation frequencies are used for exciting the selected sensing lines, the processing circuitry is configured to select as many

excitation frequencies as there are selected sensing lines to be simultaneously excited, or select fewer excitation frequencies than there are selected sensing lines to be simultaneously excited, in dependence on touch-resolution requirements associated with respective ones of the touch targets and a relative positioning of respective ones among the current set of touch targets on the touch surface.

17. The apparatus of claim 11, wherein, for selecting which excitation frequencies are used for exciting the selected sensing lines, the processing circuitry is configured to choose individual excitation frequencies from among a set of excitation frequencies, in dependence on noise or interference measurements associated with respective ones of the excitation frequencies in the set of excitation frequencies.

18. The apparatus of claim 11, wherein, for selecting which excitation frequencies are used for exciting the selected sensing lines, the processing circuitry is configured to choose individual excitation frequencies from among a set of excitation frequencies to reduce the processing time required for frequency-domain transformations performed for the transform-based reading of the touch sensor.

19. The apparatus of claim 11, wherein, for selecting which excitation frequencies are used for exciting the selected sensing lines, the processing circuitry is configured to: identify candidate excitation frequencies from among a set of excitation frequencies, based on noise measurements associated with respective excitation frequencies in the set; and limit selection consideration to the candidate excitation frequencies.

20. The apparatus of claim 11, wherein the apparatus comprises an Integrated Circuit (IC) or an IC assembly.

21. The apparatus of claim 20, wherein the apparatus comprises an IC assembly that includes the reading circuitry.

22. An electronic device, the electronic device comprising: a touch sensor comprising a touch surface having sensing lines for sensing touch inputs to the touch surface; host processing circuitry of a host system that is configured for execution of one or more software applications that use the touch sensor as a control input; and an apparatus configured to interface the host processing circuitry with the touch sensor, the apparatus comprising: interface circuitry; and processing circuitry configured to: receive, via the interface circuitry, host signaling from the host processing circuitry of the host system, the host signaling indicating touch targets for respective software applications running on the host system, each touch target being a respective area of a touch surface of the touch sensor and the host signaling further indicating touch detection requirements corresponding to the touch targets indicated for the respective software applications; maintain a data structure that represents a current set of touch targets, from among the indicated touch targets, the data structure indicating the touch detection requirements corresponding to the current set of touch targets; determine a read configuration for the touch sensor according to the current set of touch targets and the corresponding touch-detection requirements, as represented in the data structure, the read configuration defining which sensing lines of the touch sensor are selected for excitement and which excitation frequencies used for exciting the selected sensing lines, for detecting touch inputs to respective ones among the current set of touch targets using frequency-domain transformations; and read the touch sensor based on controlling reading circuitry according to the read configuration, the reading circuitry integrated or associated with the processing circuitry.