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(54) **SYSTEM FOR AND METHOD OF TRANSFERRING CHARGE TO CONVERT CAPACITANCE TO VOLTAGE FOR TOUCHSCREEN CONTROLLERS**

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USPC **345/174**; 345/173; 178/18.01; 178/18.06

(58) **Field of Classification Search**
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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,527,096	A	7/1985	Kindlmann
5,313,141	A	5/1994	Kimball

5,463,283	A	10/1995	Sanderson
5,789,870	A	8/1998	Remson
6,466,036	B1	10/2002	Philipp
6,937,124	B1	8/2005	Nakamura et al.
7,061,327	B2	6/2006	Doy
7,176,753	B2	2/2007	Noda et al.
7,283,120	B2	10/2007	Grant
7,667,371	B2	2/2010	Sadler et al.

(Continued)

FOREIGN PATENT DOCUMENTS

WO	9743825	11/1997

OTHER PUBLICATIONS

Publication No. US-2011-0261005-A1, Publication Date: Oct. 27, 2011, U.S. Appl. No. 12/986,776, filed Jan. 7, 2011, Ashutosh Ravindra Joharapurkar.

(Continued)

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(57) **ABSTRACT**

A touchscreen controller system determines the actual locations of multiple simultaneous touches by eliminating mutual capacitance between adjacent rows and columns during self-capacitance measurements and selectively enabling mutual capacitance during mutual capacitance measurements. During the self-capacitance measurements, the controller system generates a set of candidate touch locations, which includes the locations of real and ghost touches. During the mutual capacitance measurements, only the locations in the candidate set are measured and, from these measurements, the actual touch locations are determined. By limiting the mutual capacitive measurements to only a small subset of the locations over the entire touch panel, real touch locations are determined on a linear order. Also, by using on-chip integration capacitors, embodiments of the invention are able to perform each measurement in a single cycle.
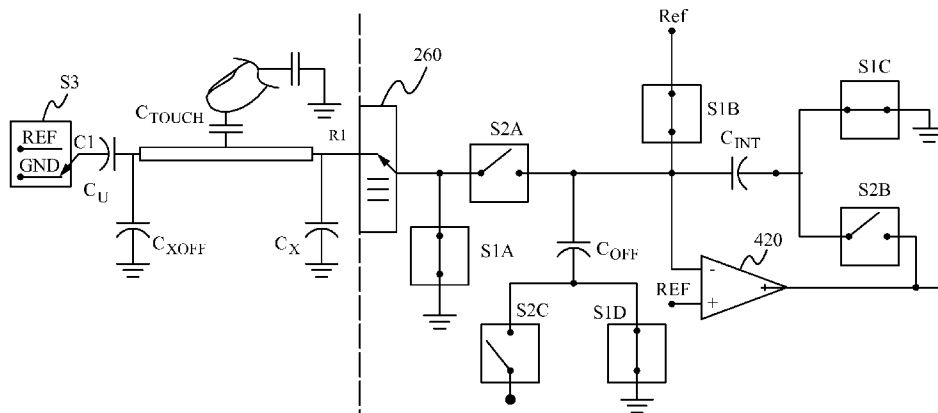
12 Claims, 13 Drawing Sheets

400

(56)   **References Cited**

U.S. PATENT DOCUMENTS

2003/0067449	A1		4/2003	Yoshikawa et al.	
2003/0174121	A1		9/2003	Poupyrev et al.	
2006/0119586	A1		6/2006	Grant et al.	
2008/0055277	A1		3/2008	Takenaka et al.	
2008/0062145	A1		3/2008	Shahoian et al.	
2010/0156823	A1		6/2010	Paleczny et al.	
2010/0245286	A1	*	9/2010	Parker	345/174
2011/0025629	A1	*	2/2011	Grivna et al.	345/173
2011/0061949	A1	*	3/2011	Krah et al.	178/18.06
2011/0084936	A1	*	4/2011	Chang et al.	345/174
2011/0156839	A1	*	6/2011	Martin et al.	333/172

OTHER PUBLICATIONS

Publication No. US-2011-0261006-A1, Publication Date: Oct. 27, 2011, U.S. Appl. No. 12/986,841, filed Jan. 7, 2011, Ashutosh Ravindra Joharapurkar.

Publication No. US-2011-0261007-A1, Publication Date: Oct. 27, 2011, U.S. Appl. No. 12/986,881, filed Jan. 7, 2011, Ashutosh Ravindra Joharapurkar.

Publication No. US-2011-0260990-A1, Publication Date: Oct. 27, 2011, U.S. Appl. No. 12/986,991, filed Jan. 7, 2011, Yassir Ali.

Publication No. US-2011-0261008-A1, Publication Date: Oct. 27, 2011, U.S. Appl. No. 12/987,008, filed Jan. 7, 2011, Ashutosh Ravindra Joharapurkar.

Non-Final Office Action dated Sep. 29, 2011, U.S. Appl. No. 12/315,690, filed Dec. 5, 2008, Anthony Stephen Doy.

International Search Report dated Dec. 3, 2009, PCT Patent Application Serial No. PCT/US 09/61359, Filed Oct. 20, 2009, Maxim Integrated Products, Inc.

Daniel Carrica et al., "Random Sampling Applied to the Measurement of a DC Signal Immersed in Noise", pp. 1319-1323, IEEE Transactions on Instrumentation and Measurement, vol. 50, No. 5, Oct. 2001.
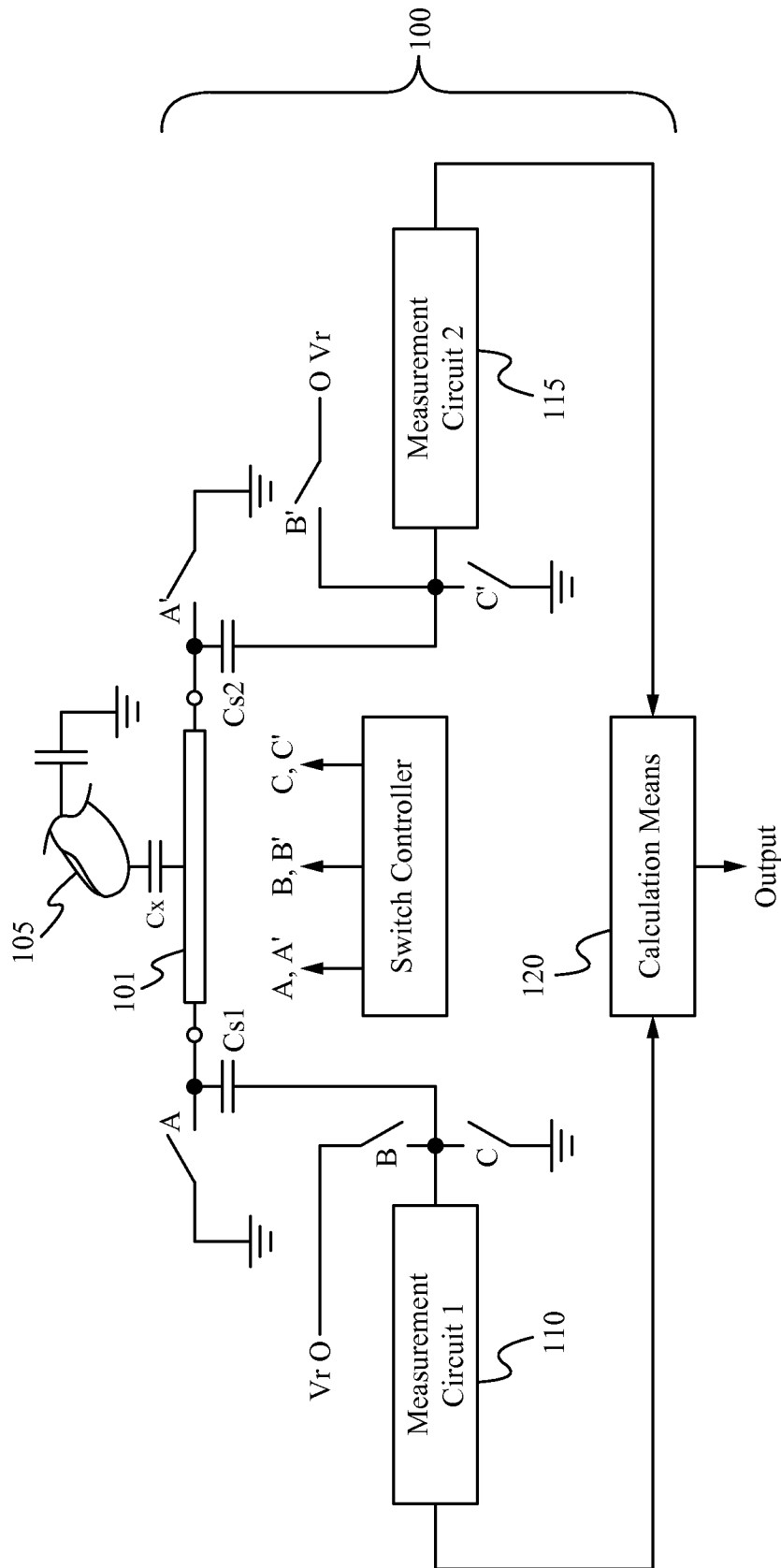
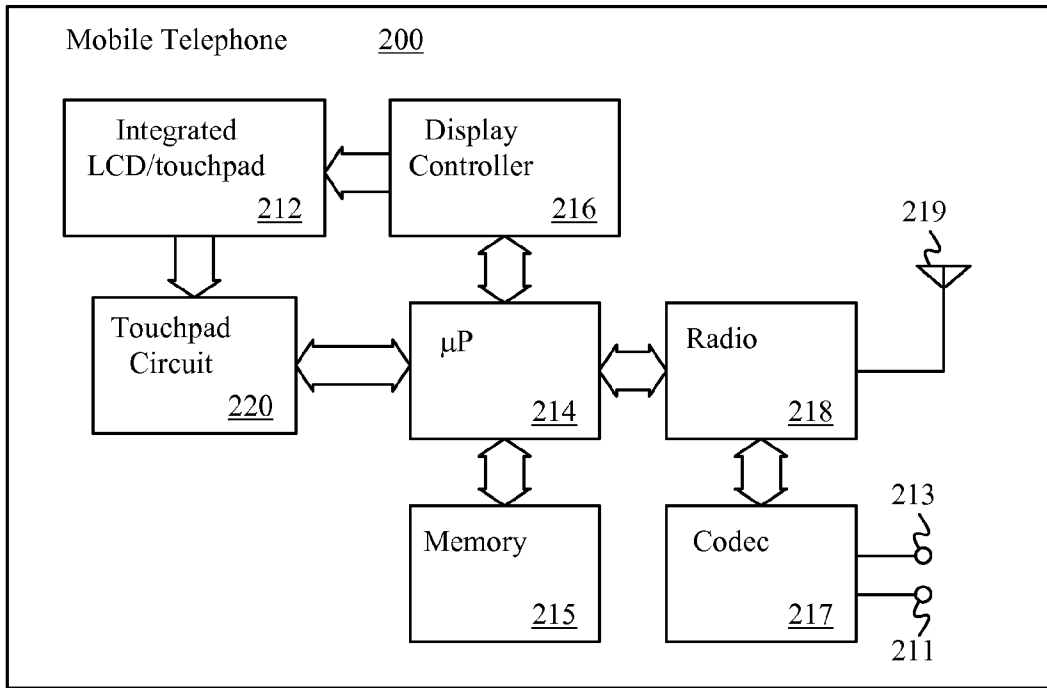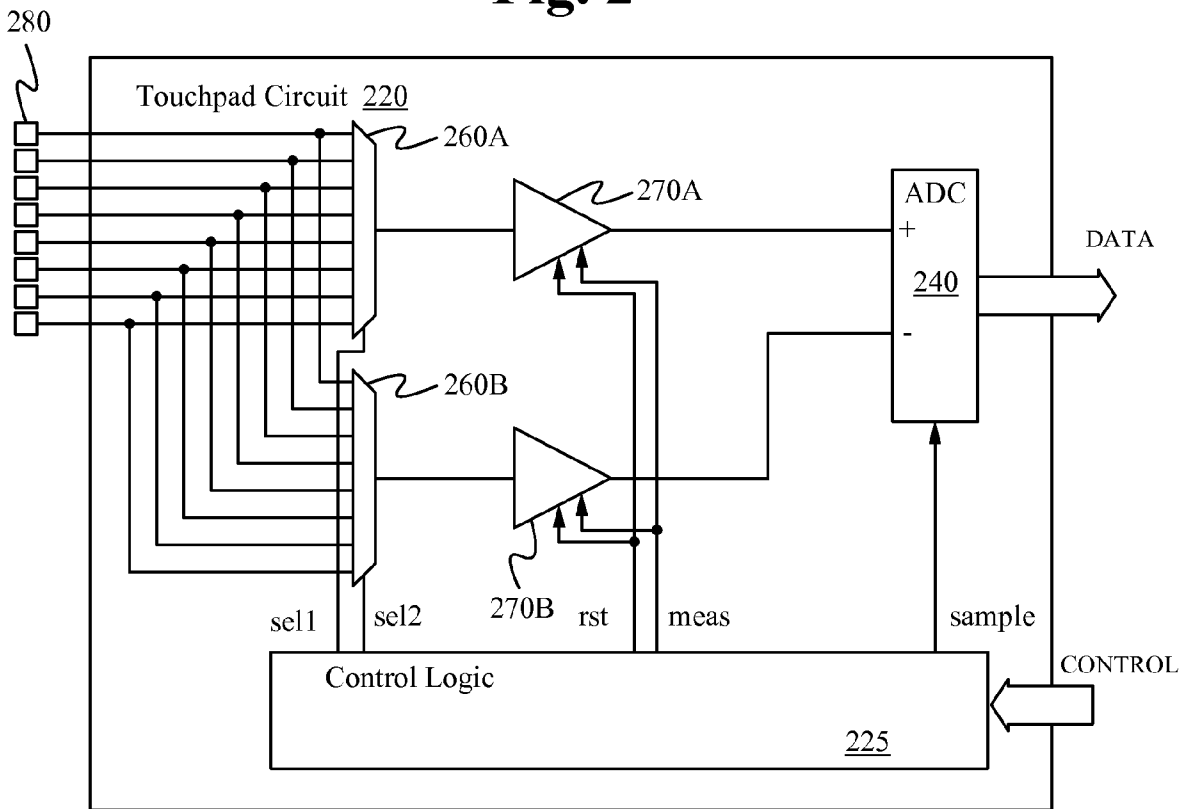* cited by examiner

Fig. 1 (Prior Art)

Mobile Telephone   200

Integrated LCD/touchpad   212

Display Controller   216

219

Touchpad Circuit   220

μP   214

Radio   218

Memory   215

Codec   217

213

211

Fig. 2

280

Touchpad Circuit   220

260A

270A

ADC
+
240
-

DATA

260B

270B

sel1   sel2   rst   meas   sample

CONTROL

Control Logic   225

Fig. 3

300

Fig. 4

DOCKET ALARM
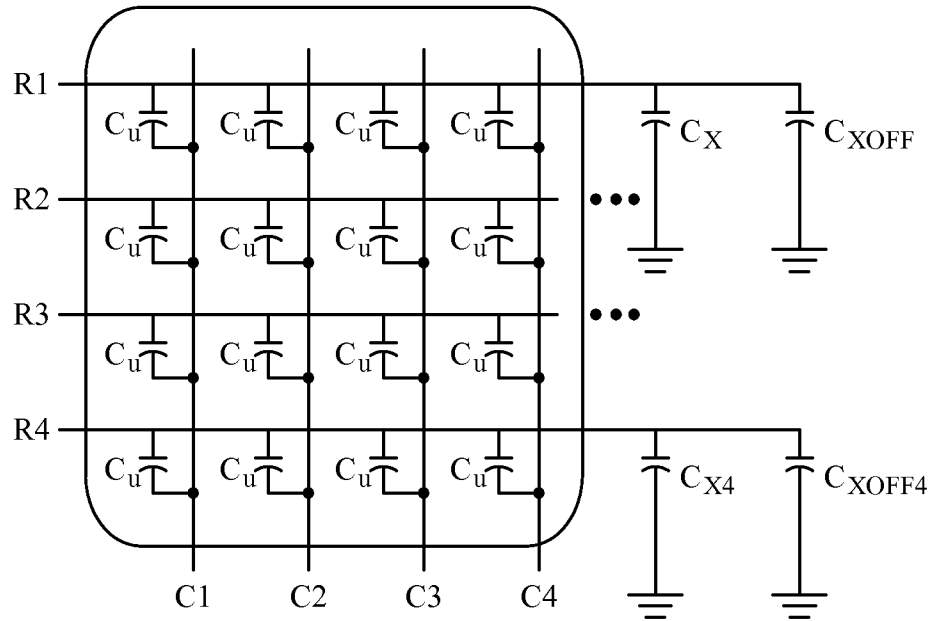
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