Hybrid Concurrent Driving Technique for Large Touch Screen Panels.

Malik Summair A.[1,2], Saad Arslan[1,2], Hyung Won Kim[1]
[1]School of Electronics Engineering,
Chungbuk National University,
Cheongju, South Korea.
[2]Elect. Dept., COMSATS University, Islamabad, Pakistan.
summair@, saad@, hwkim@cbnu.ac.kr

Jaehun Jun[3], Hyunkyu Park[3]
[3]LG Display,
Seoul, South Korea
jhjun@lgdisplay.com, logicpark@lgdisplay.com

Abstract—**Large interactive touch screen displays are witnessing widespread acceptance among users, while approaching hundreds of Tx/Rx channels and reducing useable bandwidth. This presents several challenges and renders conventional touch detection methods ineffective. For smaller displays, employing concurrent Tx driving methods like Frequency Division Concurrent Driving (FDCD) or Coded Division Concurrent Driving (CDCD) improves SNR and substantially enhances report rate. In larger Touch Screen Panels (TSPs), however, it becomes difficult to drive the entire panel concurrently with either orthogonal frequencies or codes. In this work, a hybrid concurrent driving technique, which combines both FDCD and CDCD, is proposed and evaluated. The proposed driving technique aims to achieve better efficiency in terms of utilizing limited frequency bandwidth and improving the SNR. This work realizes the proposed driving technique by a MATLAB implementation. This paper includes SNR analysis for various scenarios, to evaluate the effectiveness of the proposed technique. The analysis reveals that the proposed method performs reliably under significant amount of noise for all corner cases.**

Keywords;Touch Screen Panles(TSP);Frequency Division Concurrent Driving (FDCD); Coded Division Concurrent driving (CDCD); Coded Frequency Division Driving(CFDD).

I. Introduction

Large Touch Screen Panels (TSP) are getting common these days as the main interaction medium in tablet PC's, smart-home appliances, interactive kiosks and automobiles. Capacitive TSP's, which are widely being used for smaller devices are now being used for large-sized devises as well [1]. Self-capacitance and mutual capacitance TSP's are competing and the later has the advantage of detecting all corner cases for a touch anywhere at the screen [2]. With the increase in the applications the demand for the large size of the touch screen is rapidly increasing (larger than 10 inch). The realization of a mutual-capacitance touch-sensing system, for TSPs spanning over 30 inches, is becoming challenging. This is because the SNR of conventional sequential drive controllers degrade as the number of sensor channels increases. Employing a concurrent Tx driving method, which applies driving signals simultaneously to all Tx channels, improves the SNR [3].

Among various types of concurrent driving techniques being used for TSP's, Frequency Division Concurrent Driving (FDCD) and Code Division Concurrent Driving (CDCD) are popular for achieving high performance. FDCD is based on conventional Orthogonal Frequency Division Multiplexing (OFDM). Tx lines are concurrently applied with sine waves of different orthogonal frequencies. FDCD provides better scan rates and SNR, However, the bandwidth for the large size TSP's is too narrow to simultaneously allow vast range of orthogonal frequencies. CDCD method is based on conventional Code Division Multiplexing (CDM). The CDM modulation method is based on a modulation matric which encodes the Tx driving signals. For this purpose, Walsh-Hadamard Matrix (HM) are widely used to encode the driving Tx signals. HM has rows and columns mutually orthogonal to each other. HM is used in many different applications, such as multiplexing and coding in communications. Higher signal power is achieved using simultaneous driving of TSP channels that are specified by orthogonal codes, notably Walsh-Hadamard sequences [4]. However, the encoding sequences of HM has a large offset value for the first column. To avoid the large offset value, modified HM is used in this work. In this work, we propose a hybrid concurrent driving technique called Code Frequency Division Driving (CFDD), which combines both FDCD and CDCD.

II. Proposed Hybrid Concurrent Driving Technique

The proposed driving technique CFDD uses both FDCD and CDCD for driving and sensing TSP's signals, achieving high report rate and SNR, while occupying small bandwidth. For realizing the proposed technique, a MATLAB code is implemented targeting a TSP with up to 48 Tx channels. Instead of using actual TSP model, we are summing and attenuating all the Tx channels to obtain corresponding Rx signal as shown in Fig.1.

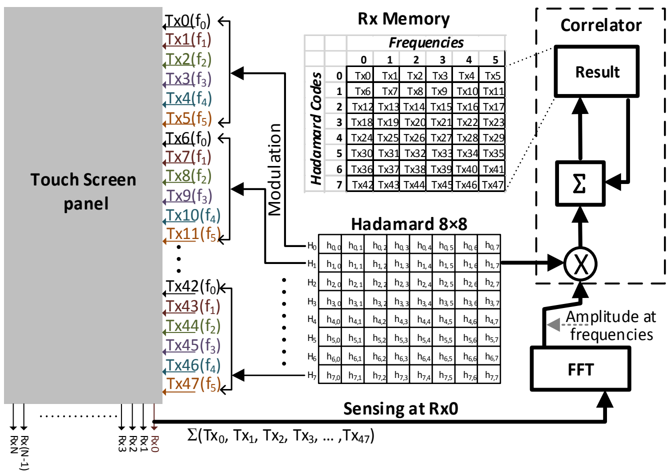

Fig. 1. Block diagram of the overall MATLAB implementation of the CFDD.

This research was sponsored by LG Display for an industry and university collaboration project. It was also funded and conducted under "the Competency Development Program for Industry Specialists "of the MOTIE, Operated by KIAT(No N0001883,HRD program for intelligent semiconductor industry),while it was also supported by the MSS(No. N0001132,HRD program for AI based IoT platform development).

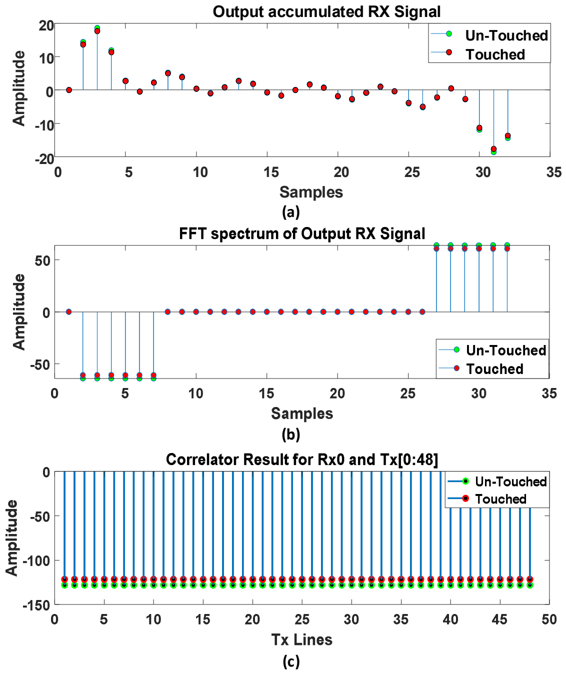

Fig. 2. (a) Rx signal (b) FFT output and (c) Correlator Result at 77dB SNR.

Table 1

Scenarios	Rx	FFT	Result
No touch	18.57	-64	-128
Single Touch	18.502	-64	-128
All Touch	17.64	-60.8	-121.6

We are using combination of an 8×8 HM code and 6 orthogonal frequencies for implementing CFDD. Here each code is used on six orthogonal frequencies, allowing simultaneous CFDD on 48 Tx lines. For simulating TSP response at Rx0, all Tx's are summed together with an attenuation factor. Afterwards, FFT is computed on the received signal at Rx0. In correlator, amplitude value at all 6 frequencies of FFT is multiplied with respective bit of HM, one by one in a column wise fashion. Then result is accumulated again with the new value and stored in the respective slot of register file for each Tx in the Rx memory.

III. Simulation Results:

In this section, simulation results for the system shown in Fig. 1 are presented and are summarized in Table 1. The Rx values are the peak values of the superimposed signal received at the Rx side on Rx0 as shown in Fig. 2(a). This signal will be seen by ADC for further processing in hardware implementation and can saturate the ADC. For this purpose, a modified HM Code is used to reduce the offset value to half [4]. The FFT value is the peak amplitude value after FFT for orthogonal frequencies of interest/applied as shown in Fig. 2(b). And finally, the Result value is accumulated result after correlator for all Tx's, which will be stored in Rx memory as shown in Fig. 2(c).

IV. Signal to Noise Ratio Analysis

In this section an analysis for the SNR has been presented by introducing different noise signal levels and validating the effectiveness of the system at all the corner cases. Fig. 3(a) and (b) shows the simulation result for different values of the SNR

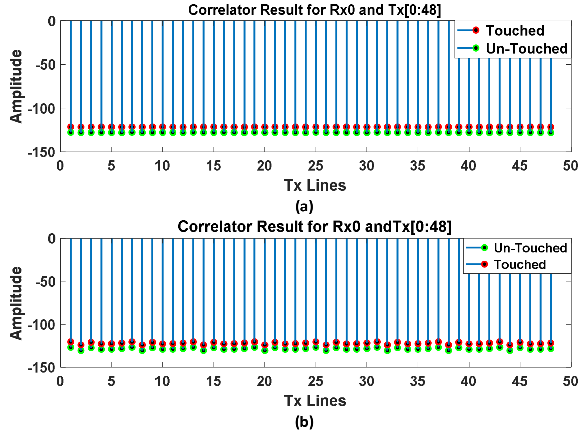

Fig. 3 Correlation results at (a) 55 dB SNR (b) 37 dB. SNR.

Table 2

Scenario/Values	SNR	Rx	FFT	Result
NO Noise (No-Touch)	NA	18.578	-64.000	-128.000
NO Noise (Touch)	NA	17.685	-60.800	-121.600
Noise No Touch	77.452	18.578	-64.008	-128.017
	55.931	18.581	-63.966	-127.933
	37.567	18.735	-65.466	-130.932
Noise (Touch)	77.020	17.645	-60.805	-121.610
	58.254	17.622	-60.777	-121.554
	37.819	17.517	-59.580	-119.161

for touched and un-touched cases respectively. Table 2 summarizes the results of the SNR analysis. As can been seen that at 77 dB and 55 dB the offset values are stable than compared with 37 dB SNR as reflected in Fig. 3. This analysis confirms that the proposed driving method can effectively detect all the corner cases for touched signals up till 37 dB SNR while keeping the correlation result constant.

V. Conclusion

The paper presented an improved technique for simultaneously driving all Tx channels of large TSP's, by combining the use of orthogonal frequencies and codes. This provides a system to accommodate more channels in the low bandwidth, while enhancing report rate and the SNR. After implementing different scenarios using modified HM, the large offset value at the Rx is reduced to half, compare to original HM. Thus, the value seen by ADC in the sensing circuit is reduced, alleviating ADC saturation problem. Therefore, proposed driving technique is suitable for Large TSP's requiring more channels to accommodate within low bandwidth, higher speed and SNR.

References

[1] M. G. A. Mohamed et al., "Efficient multi-touch detection algorithm for large touch screen panels," IEIE Trans. Smart Process. Comput., vol. 3, no. 4, pp. 246–250, Aug. 2014.

[2] U. Y. Jang et al., "Frequency division concurrent sensing method for high-speed detection of large touch screens," J. Korea Inst. Inf. Commun. *Eng.*, vol. 19, no. 4, pp. 895–902, Apr. 2015.

[3] G. Choi et al.," Symmetric Signal Reconstruction and Frequency-Division Differential Driving for High Rate Touch Screen Sensing" Journal of Display Technology, vol. 12, no. 11, Nov. 2016.

[4] H. Evangelaras et al.,"Application of Hadamard matrices",Journal Of telecommunication and Information Technology,2/2003.