國 立 交 通 大 學

顯示科技研究所碩士班

碩士論文

利用脈衝重疊偵測之
主動觸控面板的研究

Study on Active Touch Panel
Using Pulse Overlapping Detection

研 究 生：林寬達　　Student : Kuan-Ta Lin

指導教授：戴亞翔 博士　　Advisor : Dr. Ya-Hsiang Tai

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碩 士 論 文

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摘　要

在本篇論文中，我們提出了一個新的主動式觸控電路，我們只須用到二或三個 TFT 和兩個連續的閘極脈衝。利用觸摸面板時 RC 時間常數的改變，造成脈衝重疊，而讓 TFT 在面板被觸摸時瞬間開啟，並利用偵測 TFT 開啟時的電流去判斷觸摸與否。並且此電路比較不會因為 TFT 之臨限電壓變異而有影響，改善了先前主動式觸控面板的缺點。我們也提出觸控面板設計的流程，並成功的設計出 42 吋的觸控面板。

Study on Active Touch Panel Using Pulse Overlapping Detection

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Display Institute,

National Chiao Tung University

Abstract

In this thesis, we propose a novel active touch panel circuit, and we only use two or three TFTs and two consecutive gate pulses. We use the RC time constant changes when panel is touched to induce pulse overlapping, and TFTs turn on temporarily. We detect the on current of TFTs to judge whether panel is touched or not. The proposed circuit improves the disadvantage of other active touch panels. Especially, it is hardly influenced by threshold voltage variation of TFTs. We also propose a design procedure of proposed circuit, and we design a 42-inch touch panel successfully.

Acknowledgements

首先我要感謝我的指導教授戴亞翔博士，老師積極認真的研究態度、講求效率的處事原則及謹慎周全的思慮，是我這兩年中感受最深刻的。老師也時常告訴我們許多人生經驗和做事的態度，老師教導的這些經驗累積，讓我在碩士生涯獲益許多。在此，對老師致上最深的敬意。

感謝這一條研究的路上，朋友們的相伴。感謝小瓜呆、少宏、趴趴學長在課業上的指導及耐心與我討論相關問題，助我解決研究過程中的諸多疑惑。感謝這兩年來和我一起奮鬥的夥伴們，政哲、冠銘，還有隔壁實驗室的同學，立勳、ping、金剛，謝謝你們豐富了我的生活、也擴展了我的視野。也要感謝學弟們：政達、承旻、柏成的幫忙。

在此，我要感謝我的家人及女友玉涵，在我遇到困難時，總是給我支持和鼓勵。有我的家人幫助以及你們給我的愛，讓我能無後顧之憂的完成碩士學位，在此向你們送上我所有的感謝。

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Chapter 3

Chapter 1

Introduction

1.1 Background

Touch Panel (TP) has attracted much attention in various applications because of it makes user interface more convenient and various. It can provide extra functionalities such as drawing, writing, and multi-touch. For this reason, TP has been widely used as an input device for mobile system such as PDA, digital camera, smart phone, and tablet-PC.

TP can be divided into two main categories. One is passive matrix TP, and the other is active matrix TP. For passive matrix TP, the earliest type is resistive type, which uses two ITO films biased and dot spacers holding the structure between them. Fig. 1-1 shows the structure of resistive touch panel. When touching, the pressure of the external force makes the upper ITO layer contact with the lower ITO and the voltage drop at that touching point becomes zero. Consequently, the touching input function can be realized by recognize the site of the short circuit. Although the resistive touch panel operation is simple, the physical abrasion can lower its reliability.

Recently, Projective Capacitive Touch Panel (PCT) is adapted. Almost all of the smart phone and tablet-PC use PCT because of its high sensitivity. The sketch map of its operation principle is shown in Fig. 1-2 and Fig. 1-3. Not like the resistive type, it does not need any external force. The PCT function is carried out by using IC to detect the change of capacitive value when human's hands touch on the panel. There are two disadvantages in PCT. One is that, because the change of capacitive value is small, the IC must be very sensitive, that makes the PCT expensive. Another weak point in PCT is that, when panel size becomes large, touch signal is hardly to be read by IC. Active matrix is an effective solution to achieve a large size

TP.

There are two major technologies to achieve active matrix TP; one of them is optical sensor, which is shown in Fig. 1-4 [1].The optical sensor is widely studied since hydrogenated amorphous silicon has a sufficiently large photosensitivity for use as an optical sensor. It detects light reflected from screens or shadows made by external illumination when the screen is touched. However these properties make it difficult to use such device as a touch sensor since the sensor is apt to respond to unintended light noise.

Another way to achieve active TP is Liquid-Crystal Capacitance Detector. It uses a capacitive touch sensor which is composed of a liquid crystal capacitor and sensing transistors. Fig. 1-5 and Fig. 1-6 show the cross-sectional view of a capacitive sensor and the sensing circuit [2]. The sensor is fabricated on a TFT and a color filter substrate. When one pushes the upper CF substrate, there is a slight reduction in cell gap and the capacitance of Css increases, therefore voltage of point A decreases. For this reason, the drain current Ids becomes smaller when sensor is touched. The output signal is different when sensor is touched or untouched.

Liquid-Crystal Capacitance Detector has two disadvantages. One is that, because of the transistor Tss is always on, it always consumes power whether pixel is touched or not. The other disadvantage is even more serious. In a sensing array, different sensing pixels on the vertical line share the same readout circuit. Because of the threshold voltage variation of the TFTs in different sensing pixels, touch signal and untouched signal in different pixels are difficultly distinguished by the same readout circuit. The simulation circuit and result are shown in fig. 1-8 and 1-9, respectively. In fig 1-9, we can see that, touch signal and untouched signal are almost the same when threshold voltage shifts 2V in one pixel but -2V in another pixel. When this case happens, the readout circuit cannot distinguish whether the pixel is touched or not.

1.2 Motivation

In this thesis, we attempt to develop a new active touch panel circuit which can achieve following properties:

(1)Low power consumption when a pixel is untouched.

(2)Signal can be read easily when a pixel is touched.

(3)Circuit has high tolerance of threshold voltage variation.

1.3 Thesis Organization

After the introduction in Chapter 1, the proposed touch sensing pixel circuit is described in chapter 2. In chapter 3, we propose the design flow chart, and we successfully design a 42 inch touch panel. Finally, conclusions will be given in Chapter 4.

The section organization of this thesis is listed below:

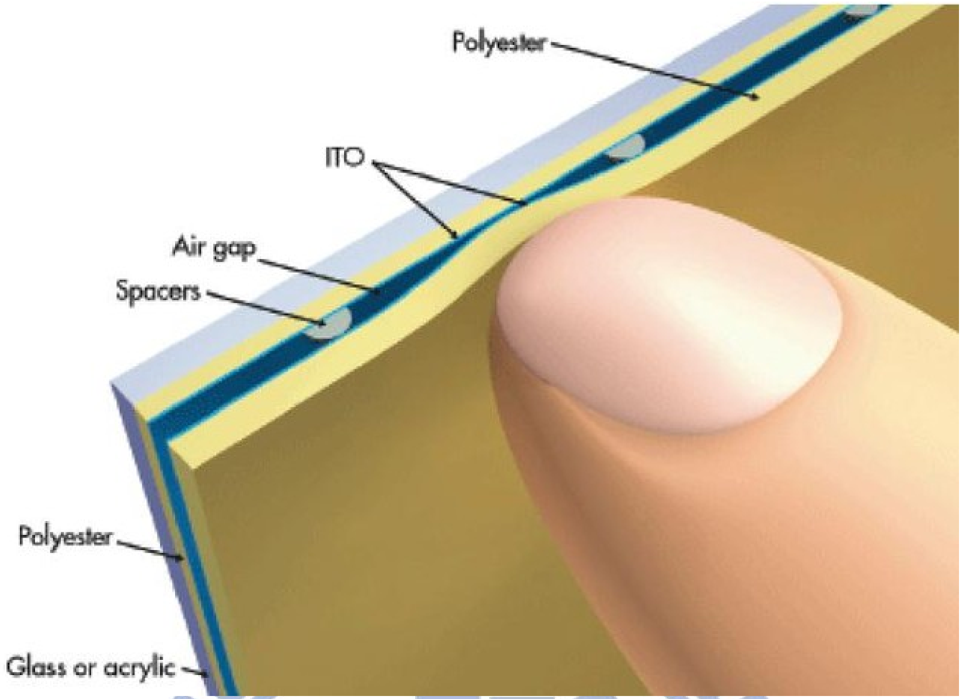


Fig. 1-1 The cross-section view of the resistive touch panel

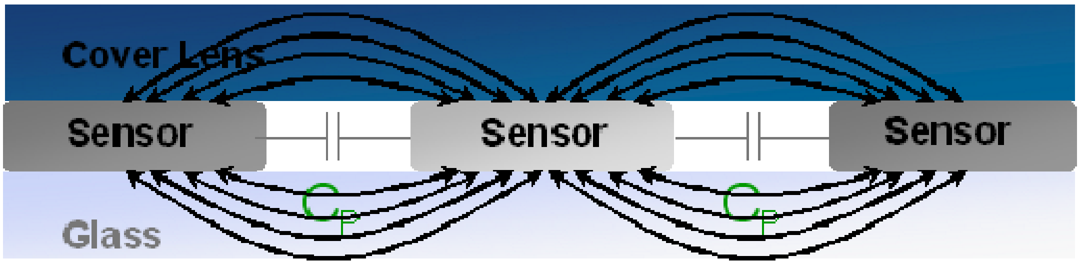


Fig. 1-2 The sketch map of PCT operation principle with panel is untouched

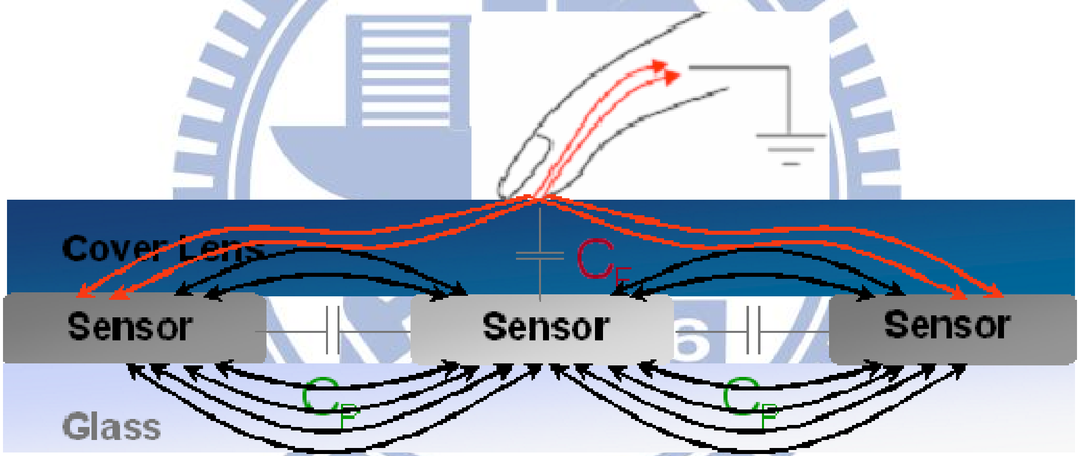


Fig. 1-3 The sketch map of PCT operation principle with panel is touched

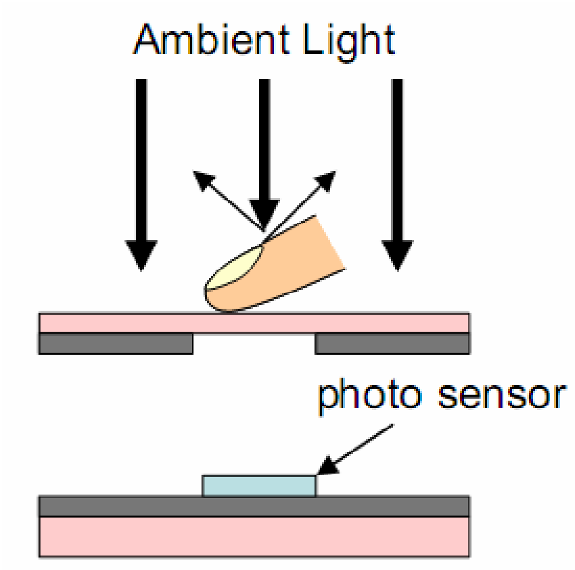


Fig. 1-4 Optical photo sensor

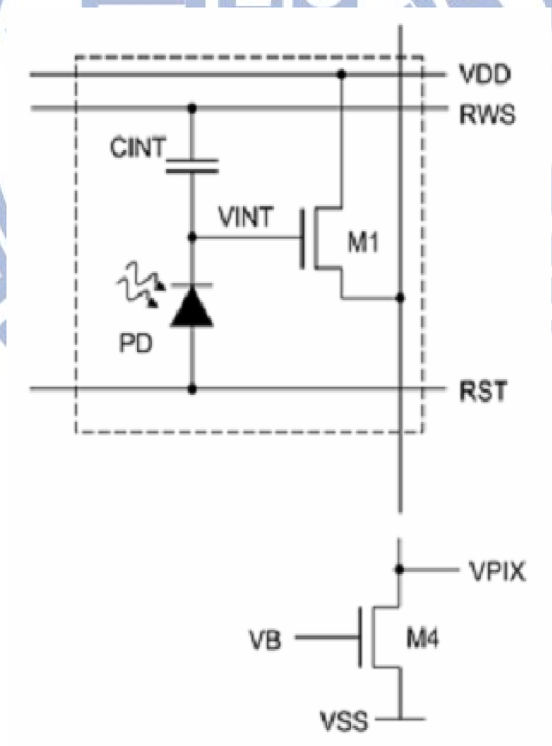


Fig. 1-5 Sensing circuit of optical photo sensor

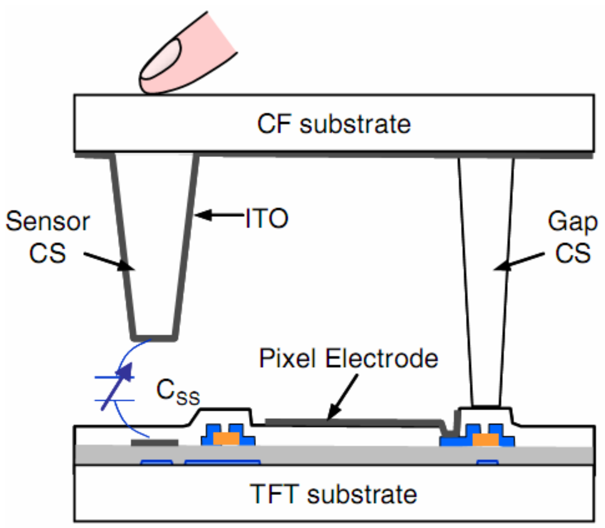


Fig. 1-6 Cross-sectional view of a capacitive sensor

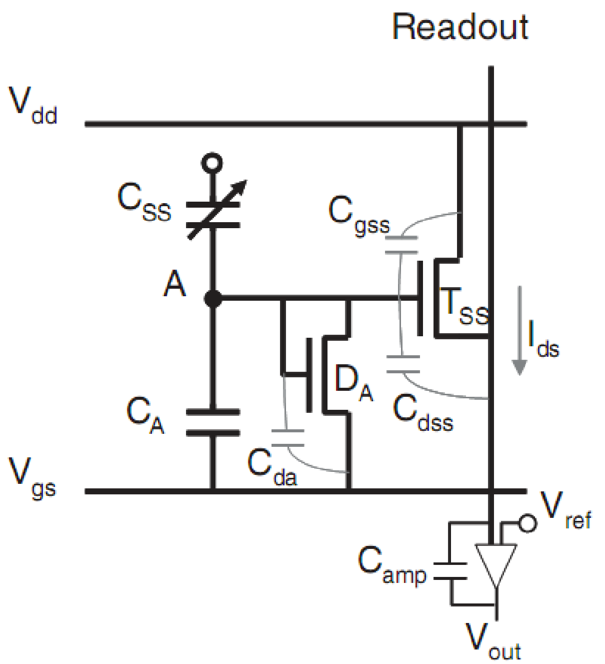


Fig. 1-7 Sensing circuit of Liquid-Crystal Capacitance Detector

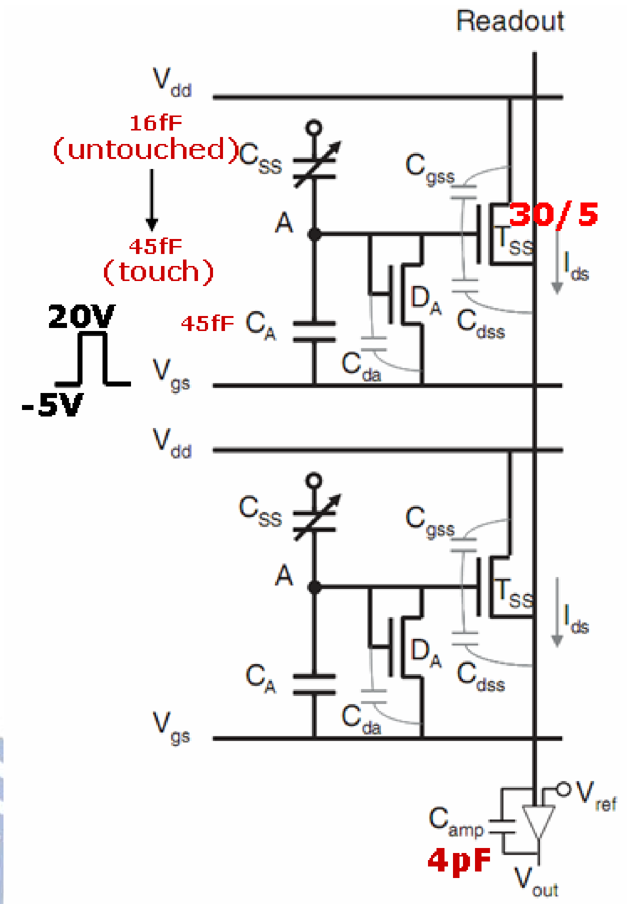


Fig. 1-8 Simulation circuit of Liquid-Crystal Capacitance Detector

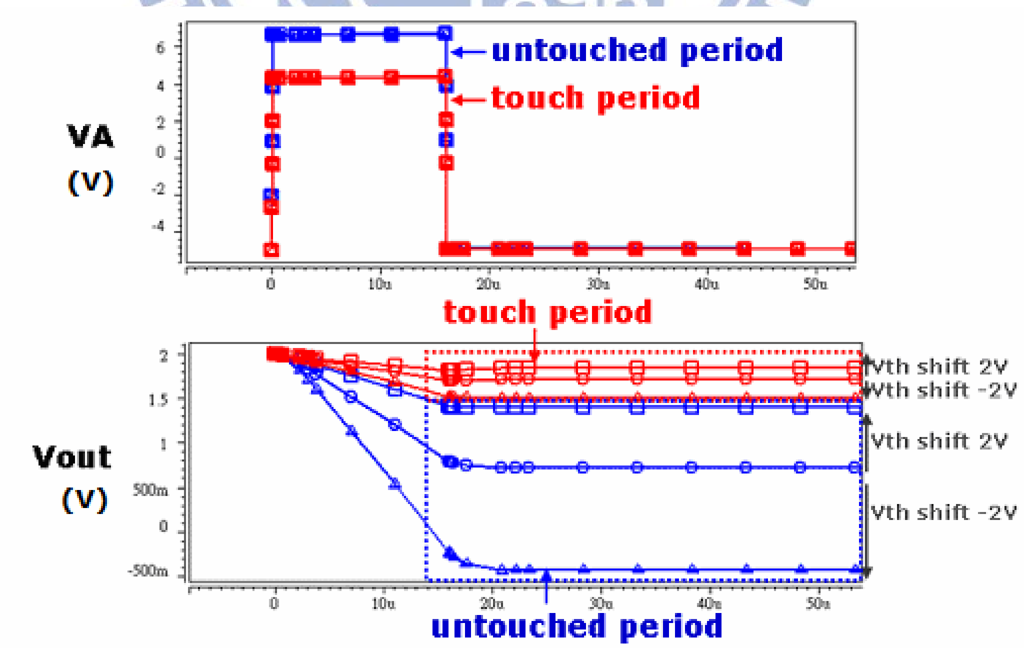


Fig. 1-9 Simulation result of Liquid-Crystal Capacitance Detector

Chapter 2

Touch Panel Pixel Circuit

2.1 2T1R1C Pixel Circuit

2.1.1 Scan pulse distortion and overlapping

In display, the original scan signal is given as a pulse, which is shown in Fig. 2-1. When the N_{th} scan pulse turns off, the $(N+1)_{th}$ scan pulse becomes turn-on immediately. As we know, there are some parasitic resistances and capacitances on the scan line. When a scan pulse propagates on the scan line, it gets distorted by the parasitic resistances and capacitances, so that the pulse at scan far end has delay with a RC time constant, and its shape is shown in Fig. 2-2. In Fig. 2-2, we can see that as the N_{th} scan pulse not completely turning off, the $(N+1)_{th}$ scan pulse starts to turn on. It causes there is a temporary pulse overlapping which lets TFT turn on out of control. It is not what we want to see in display.

On the contrary, in the proposed touch sensing circuit, we intentionally use TFT On current which is induced by pulse overlapping to detect whether pixel is touched or not.

2.1.2 Proposed circuit

The proposed sensing circuit is composed of two TFTs connected in series, one resistance R, and one sensing capacitance Csen, which is shown in Fig. 2-3(a). We feed two consecutive scan pulses N and N+1 at node A and B, as shown in Fig. 2-3(b). When sensing pad is untouched, the pulse at node C is almost the same as that at node B, which is shown in Fig. 2-4(a), and the two TFTs are not in ON state at the same time. In such am case, there is no current occurs when pixel is untouched. On the other hand, when sensing pad is touched by human's hand, the pulse at node C is distorted by the resistance R and sensing capacitance Csen, which is shown in Fig. 2-4(b). The distorted pulse at node C overlaps with the pulse at node A temporarily. The pulse overlapping when sensing pad is touched causes both TFTs turn ON concurrently. Therefore, when pixel is touched, there is a significant ON current, which can be a judgment for whether pixel is touched or not.

2.1.3 Experiment for scan near end

We use two types of TFTs to verify the proposed idea experimentally. One is IGZO TFT, and the other is a-Si TFT. The structure and I-V curve of IGZO TFT are shown in Fig. 2-5(a) and Fig. 2-5(b). The structure and I-V curve of a-Si TFT are shown in Fig. 2-6(a) and Fig. 2-6(b), respectively.

In experiment, the resistance R is 10MΩ, the sensing capacitance Csen is 50pF, and both TFTs are 100μm/10μm in size. The pulses are based at -10V and boosted to 10V. We use a 1MΩ resistor to transform the sensing current to voltage for the measurement of oscilloscope for IGZO TFT. For a-Si TFT, a 10MΩ resistor is used instead because of its current is smaller than that of IGZO TFT. The circuit and operation voltage are shown in Fig. 2-7. The results of IGZO and a-Si TFTs are shown in Fig. 2-8 and 2-9, respectively. In the results, we can observe that the waveform at node g1 in untouched period still has some distortion because of the resistance R and the gate capacitance of TFT. In order to prevent the pulse overlapping in untouched period, we design an output enable interval between two pulses. In touched period, the waveform at node g1 is more distorted by the sensing capacitance Csen to make pulse overlapping temporarily happen, and a transient ON current flow through the readout resistance. It is observed by the output voltage spike. It is an apparent signal of touch.

2.1.4 Experiment of 2T1R1C pixel circuit for scan far end

In 2.1.3, the pulses are fed to the circuit directly. However, the pixel circuit is in an array. We have to consider the pixel in the scan far end where the scan pulse is distorted by some parasitic resistances and capacitances on the bus. Since the principle of proposed sensing method is relation to RC time constant, we have to verify that if the sensing method still can work when the scan pulse is distorted. We use a 100kΩ resistance and 2nF capacitance to make the scan pulse distorted to have a RC time constant of 0.2ms, which is a severe condition to be 20% of the 1ms pulse width. All the other experiment conditions are kept the same as the experiment for the scan near end, including the output enable interval. The circuit is shown in Fig. 2-10 and the experiment result for IGZO and a-Si TFT are shown in Fig. 2-11 and 2-12, respectively. In the results, we can see that there is still a significant different between touched signal and untouched signal. It is verified that the proposed sensing method still can work even when pulse is distorted by scan bus.

2.2 1T1R1C pixel circuit

We can further simplify the proposed touch sensing pixel circuit from 2T1R1C to 1T1R1C. The 1T1R1C pixel circuit is shown in Fig. 2-13(a). We also apply two consecutive scan pulses N and N+1 at node A and B as shown in Fig. 2-13(b). The operation principle is almost the same as 2T1T1C pixel circuit. When pixel is untouched, the pulses at node A and C is shown in Fig. 2-14(a). The TFT conducts no current because when the pulse at node C turns on the TFT, the voltage at node A is the same as the voltage at source, and when voltage at node A is high, the pulse at node C turns off the TFT. When pixel is touched, the pulses at node A and C are shown in Fig. 2-14(b). The pulse at node C is distorted to overlap with the pulse at node A to induce a current in the TFT.

2.2.1 Experiment of 1T1R1C pixel circuit

We use the same parameters as in 2T1R1C pixel circuit to do the experiment for the 1T1R1C circuit Experiment circuits for the scan near and far end are shown in Fig. 2-15(a) and (b), correspondingly. The experiment result of scan near end for IGZO and a-Si TFT are shown in Fig. 2-16 and 2-17, respectively. For scan far end, experiment results for IGZO and a-Si TFT are shown in Fig. 2-18 and 2-19, respectively. No matter in the scan near end or far end, the results show a significant different between touch signal and untouched signal. It verifies the proposed 1T1R1C pixel circuit is functional.

2.3 Analysis of Threshold Voltage Variation

The effect of threshold voltage variation on the proposed circuit is analyzed. The analysis method is the same as that in chapter1. We use the same TFTs size, Camp to perform simulation. The simulation circuit and result are shown in Fig. 2-20 and 2-21, respectively. In the result, we can see that, there still is a 0.4V difference between touched signal and untouched signal when threshold voltage shifts 5V in one pixel but -5V in another pixel. The result shows that proposed circuit possesses high tolerance of threshold voltage variation. This is because the untouched signal is not affected by threshold voltage variation in such a design.

2.4 Simple Demonstration

The proposed touch sensing pixel circuit is simply demonstrated. We use two inverters to connect with the output node of the pixel circuit as a digital buffer to drive an LED connected in series with the inverters, which circuit is shown in Fig. 2-22. When pixel is touched, there is a current to arise the output voltage, and the LED becomes illuminant. On the contrary, when pixel is untouched, the LED stays dark. The pictures of demonstration when pixel is untouched and touched are shown in Fig. 2-23 and 2-24, respectively.

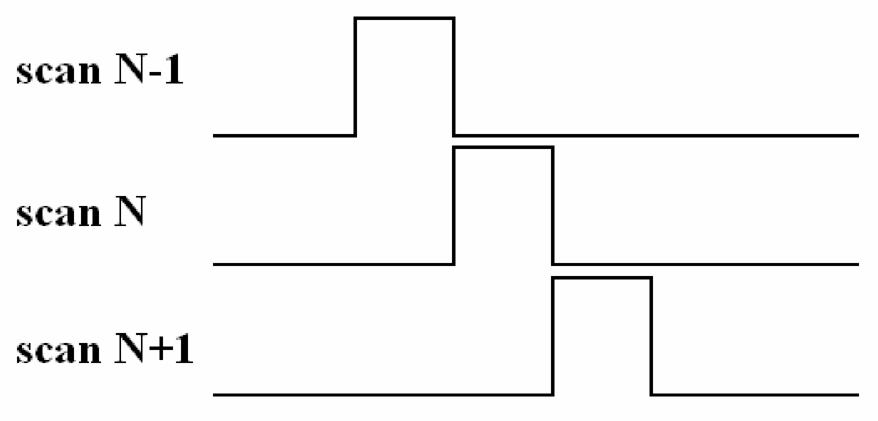


Fig. 2-1 The original scan signal of display at scan near end

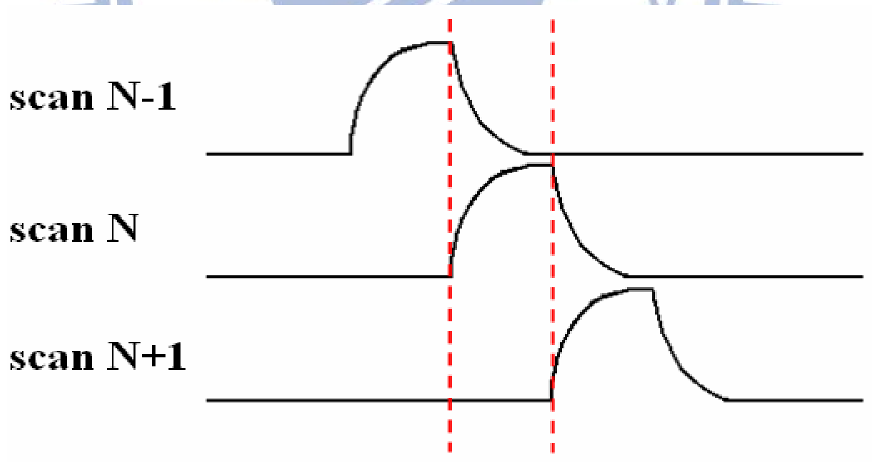
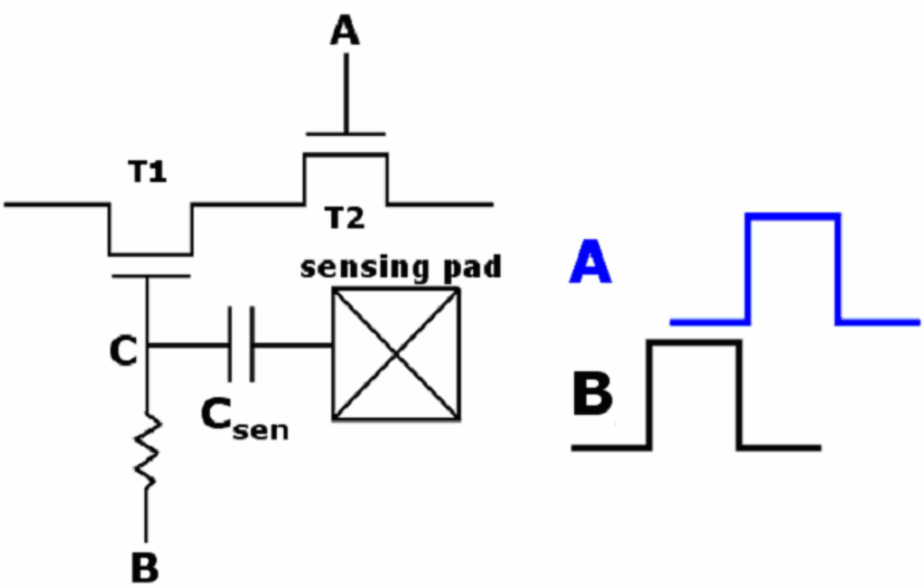


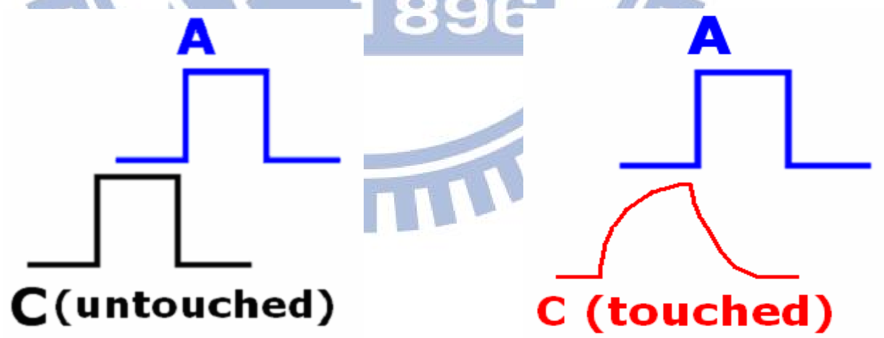
Fig. 2-2 The original scan signal of display at scan far end



(a) (b)

Fig. 2-3 (a) 2T1R1C touch sensing pixel circuit

(b) Pulses at node A and B of 2T1R1C pixel circuit



(a) (b)

Fig. 2-4 (a) Pulses at node A and C when pixel is untouched

(b) Pulses at node A and C when pixel is touched

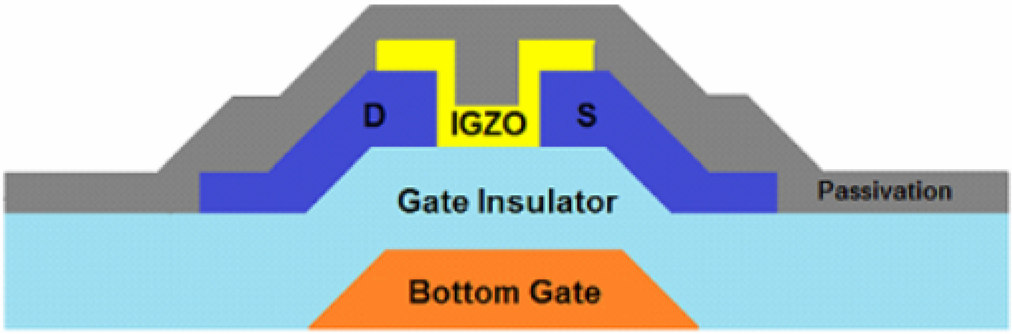


Fig. 2-5(a) Structure of IGZO TFT

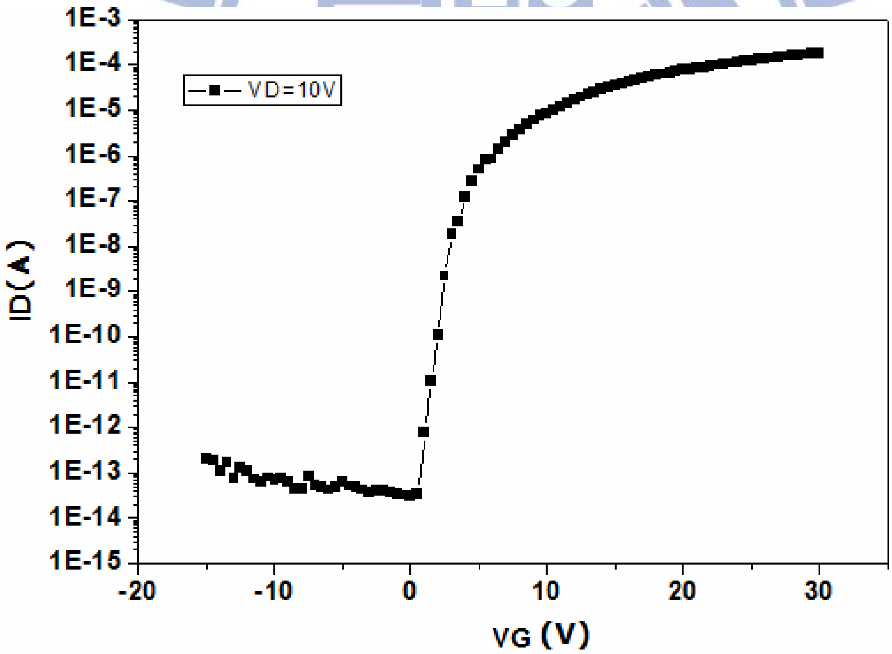


Fig. 2-5(b) ID-VG curves of IGZO TFT

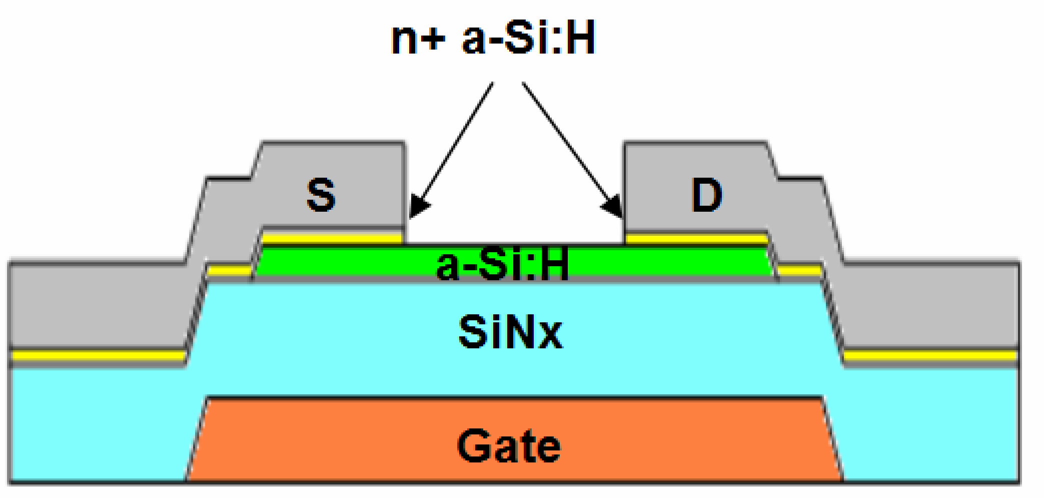


Fig. 2-6(a) Structure of a-Si TFT

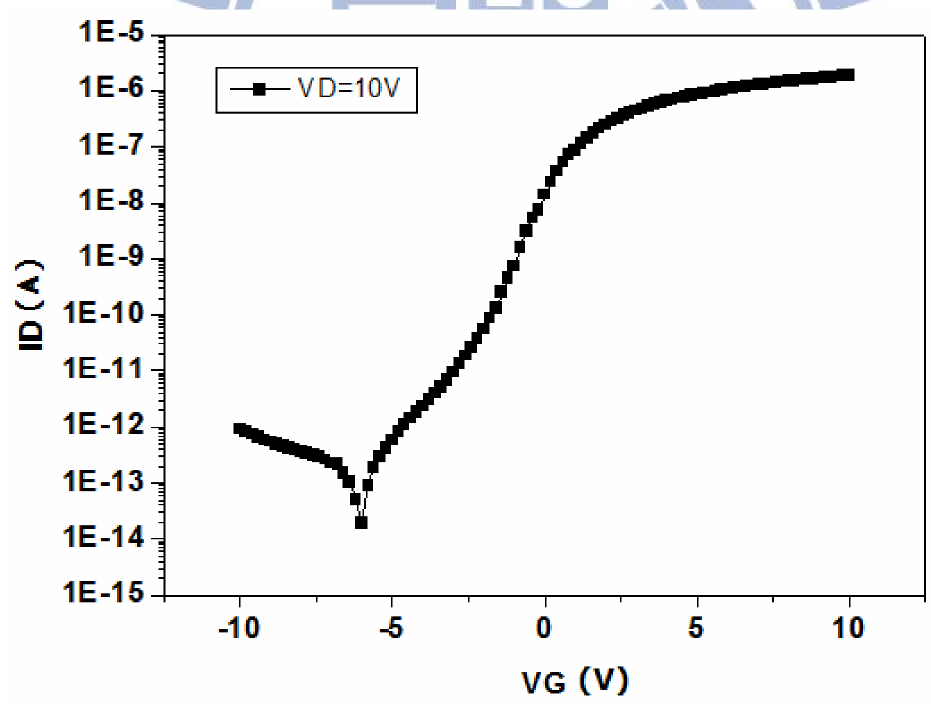


Fig. 2-6(b) ID-VG curves of a-Si TFT

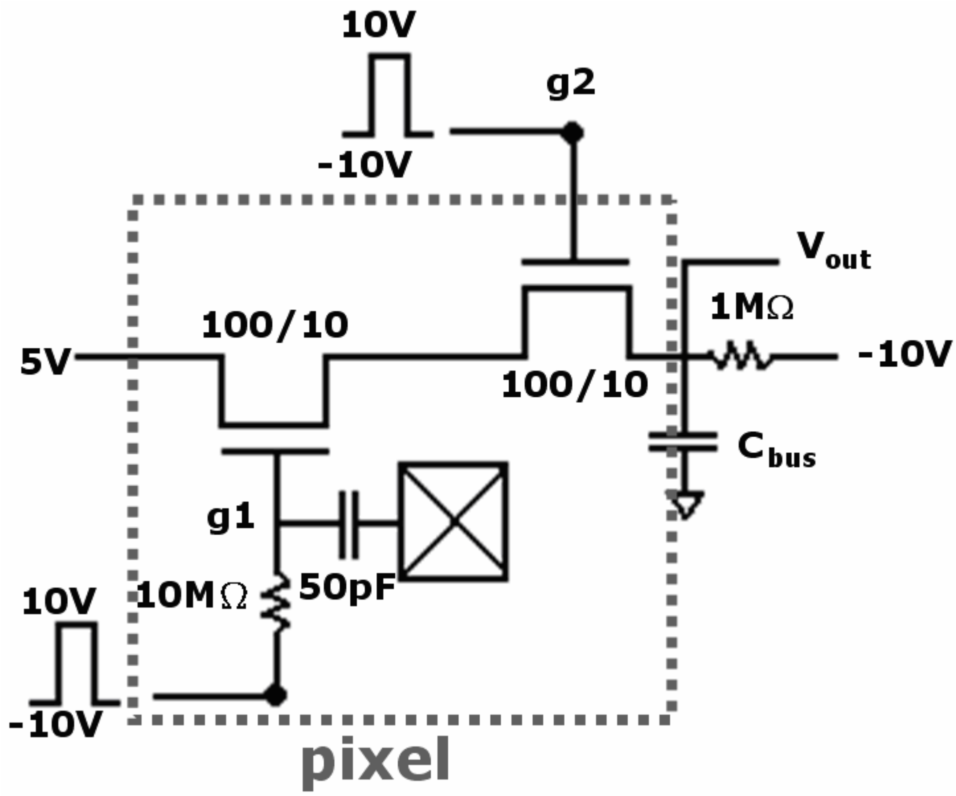


Fig. 2-7 2T1R1C pixel circuit of experiment for scan near end

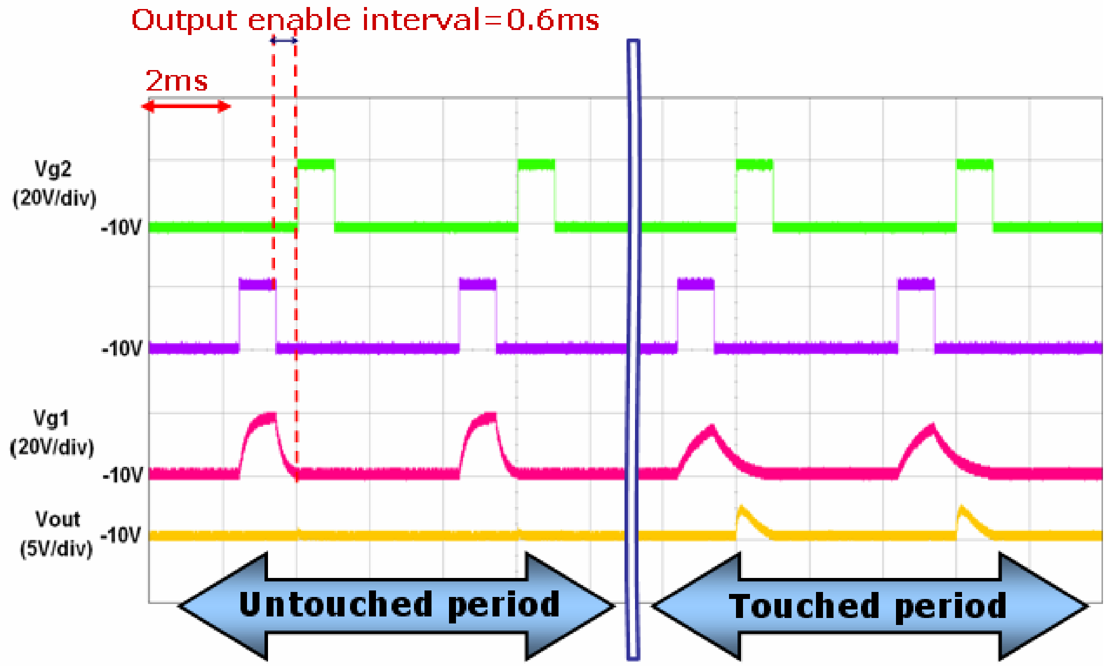


Fig. 2-8 2T1R1C pixel circuit experiment result for IGZO TFT for scan near end

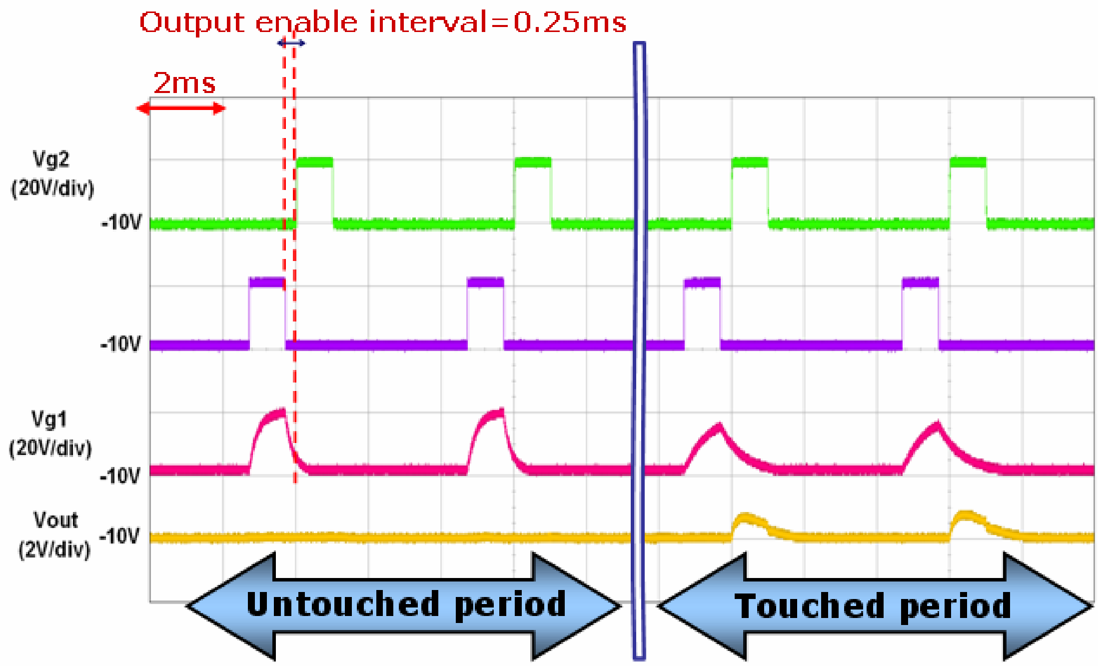


Fig. 2-9 2T1R1C pixel circuit experiment result for a-Si TFT for scan near end

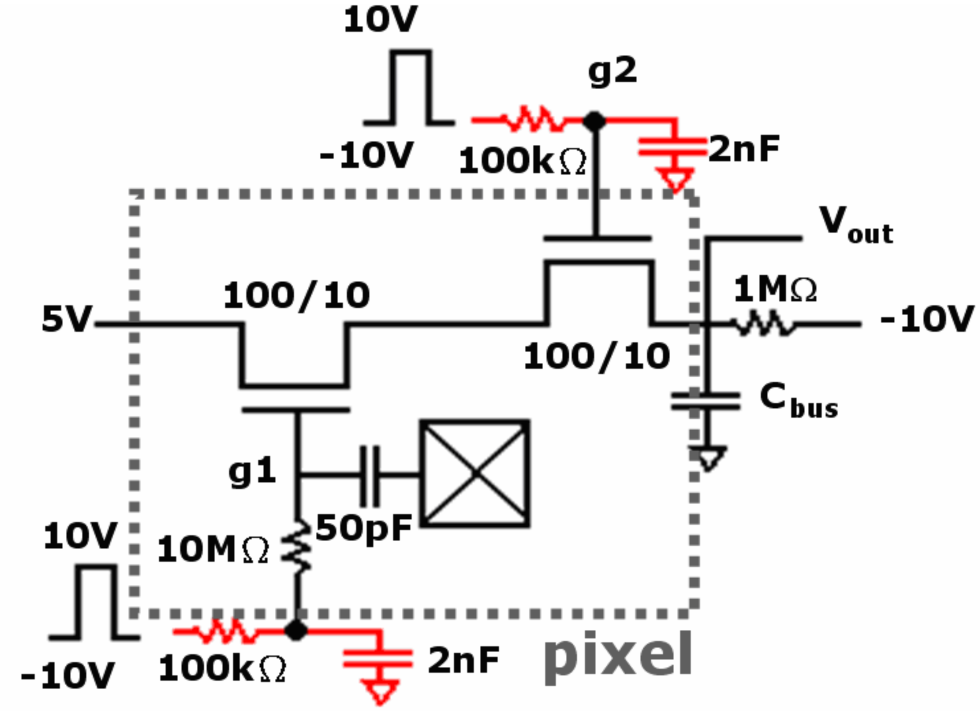


Fig. 2-10 2T1R1C pixel circuit of experiment for scan far end

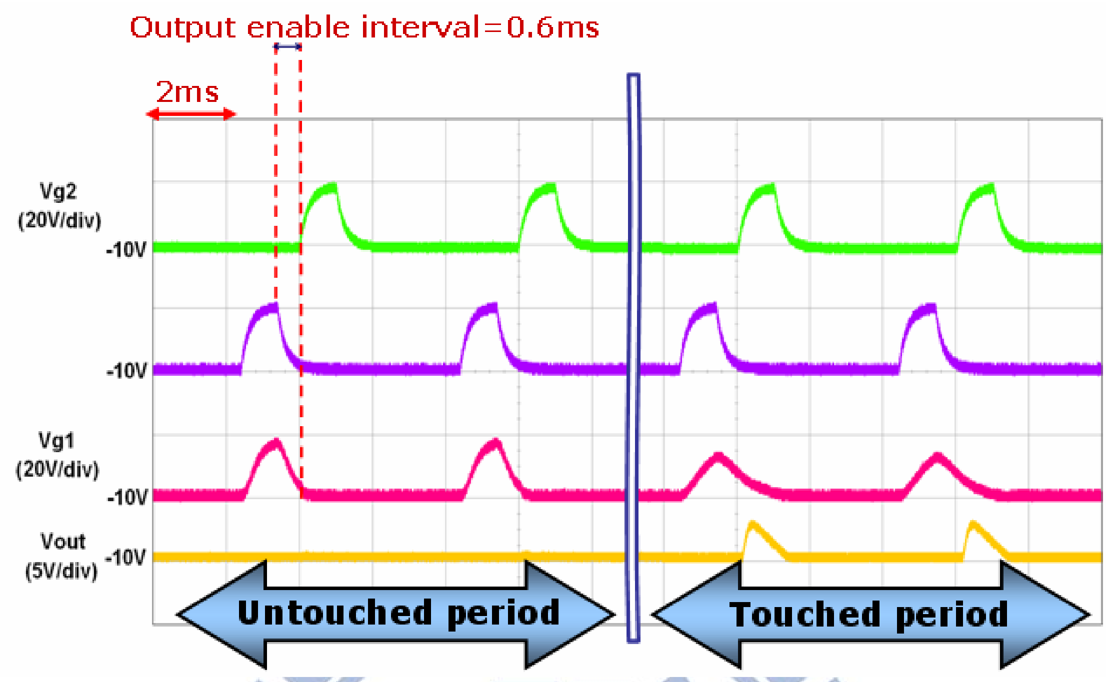


Fig. 2-11 2T1R1C pixel circuit experiment result for IGZO TFT for scan far end

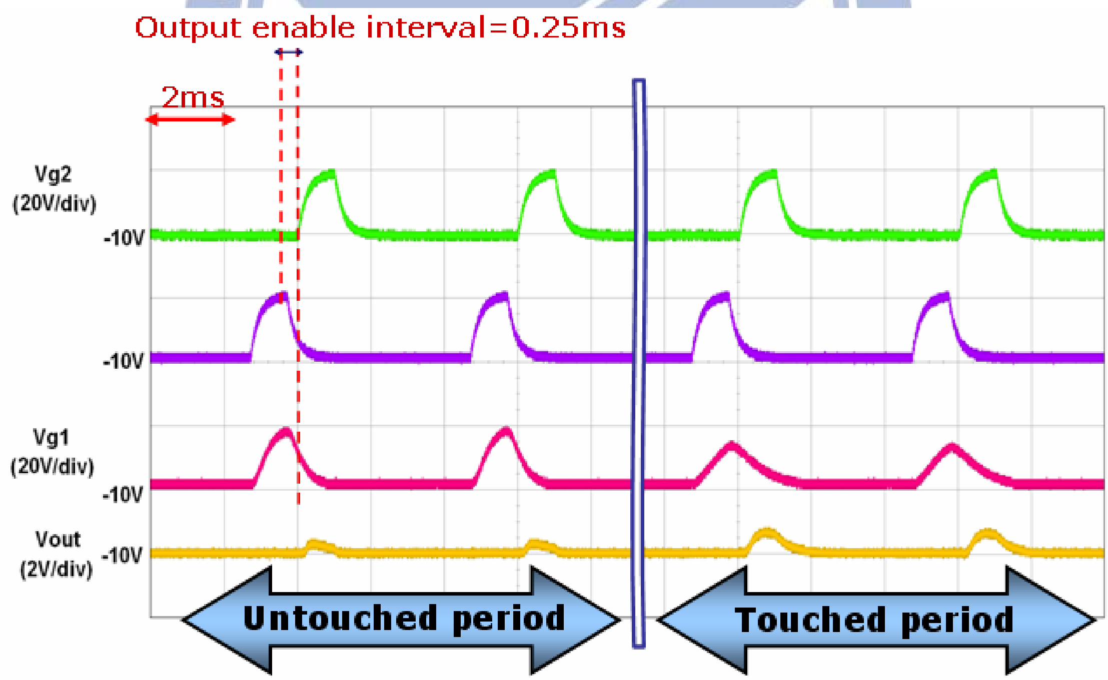
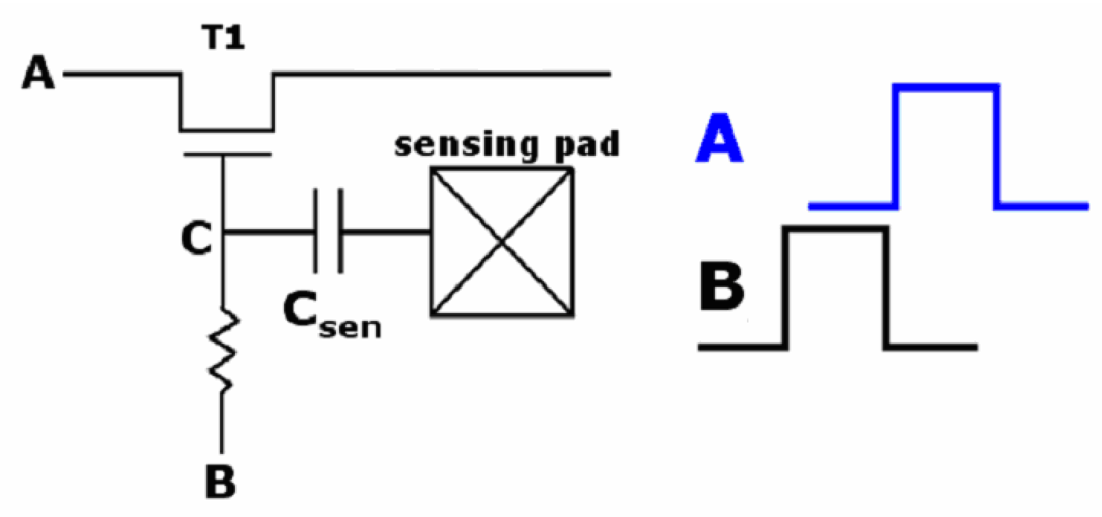


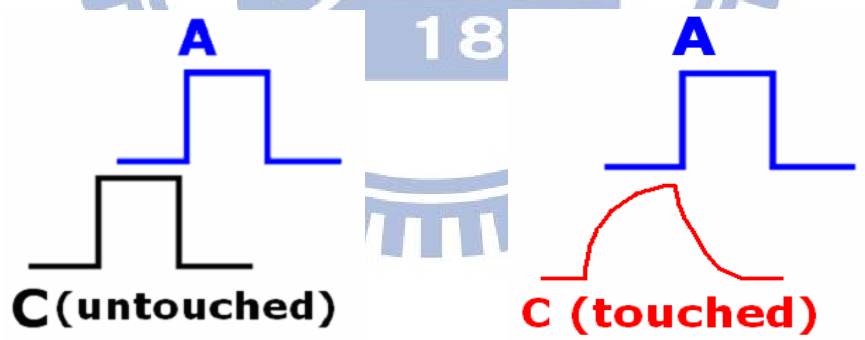
Fig. 2-12 2T1R1C pixel circuit experiment result for a-Si TFT for scan far end



(a) (b)

Fig. 2-13 (a) 1T1R1C touch sensing pixel circuit

(b) Pulses at node A and B of 1T1R1C pixel circuit



(a) (b)

Fig. 2-14 (a) Pulses at node A and C when pixel is untouched

(b) Pulses at node A and C when pixel is touched

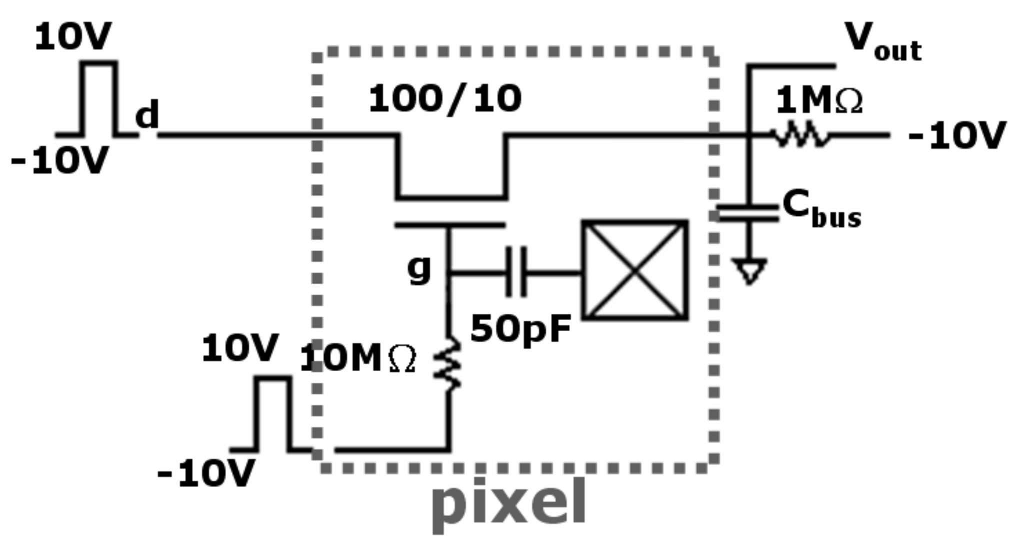


Fig. 2-15(a) 1T1R1C pixel circuit of experiment for scan near end

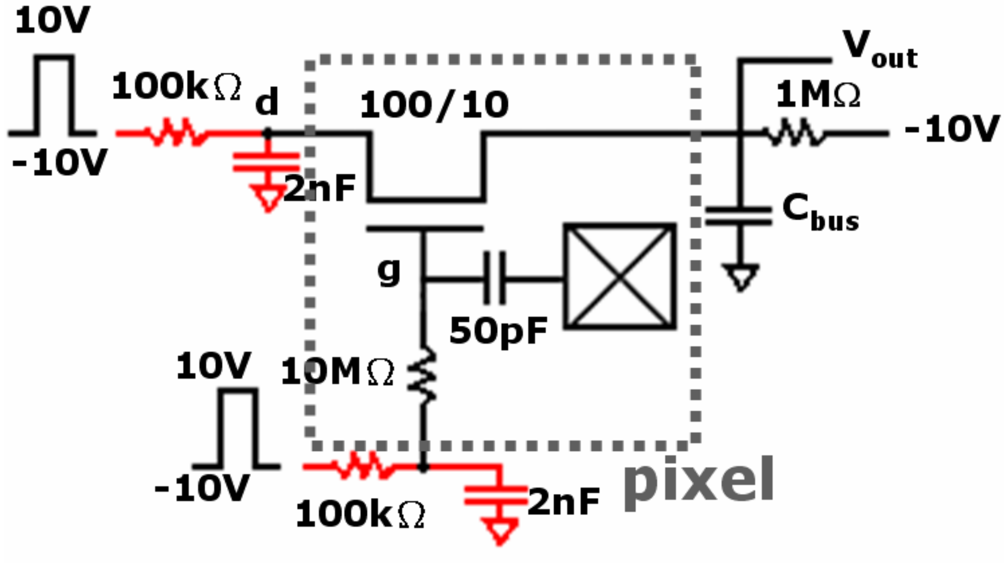


Fig. 2-15(b) 1T1R1C pixel circuit of experiment for scan far end

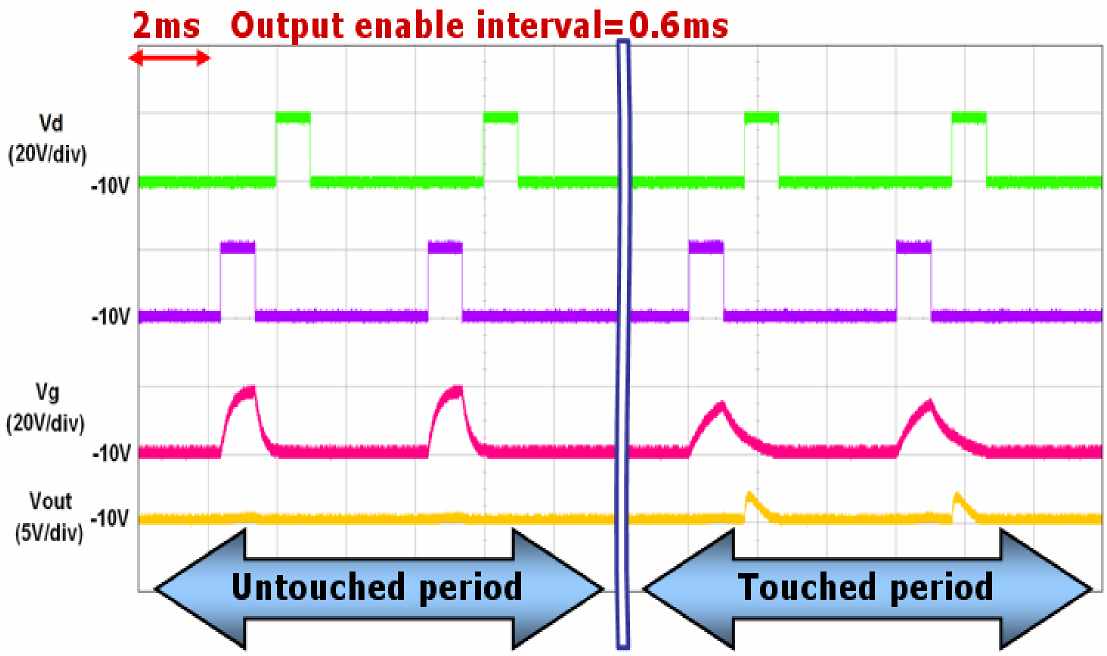


Fig. 2-16 1T1R1C pixel circuit experiment result for IGZO TFT for scan near end

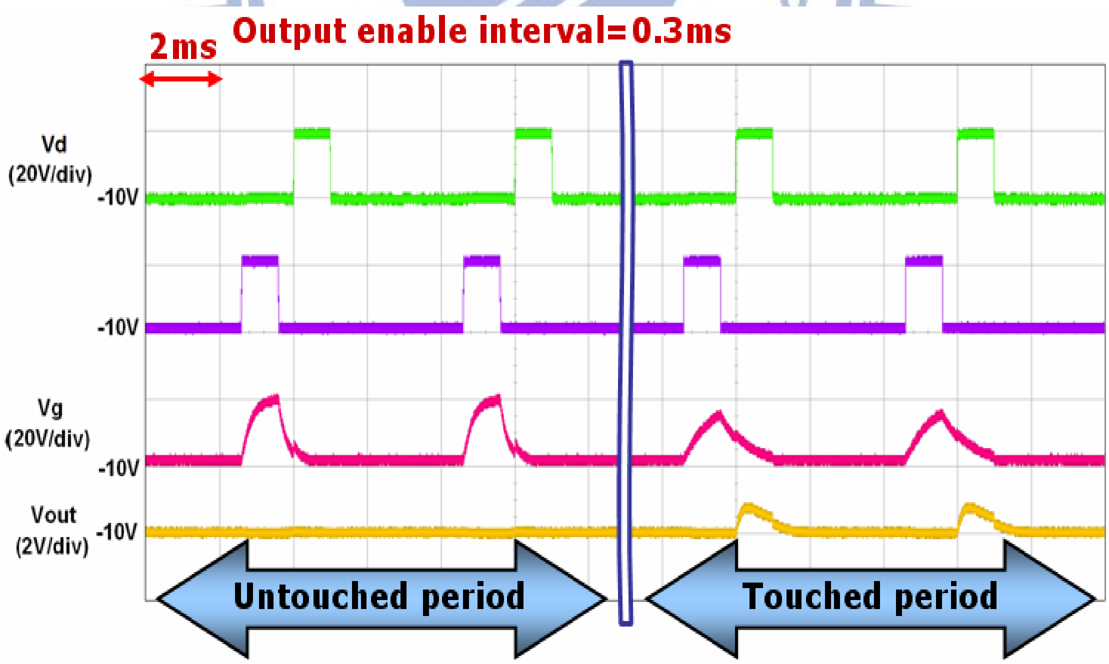


Fig. 2-17 1T1R1C pixel circuit experiment result for a-Si TFT for scan near end

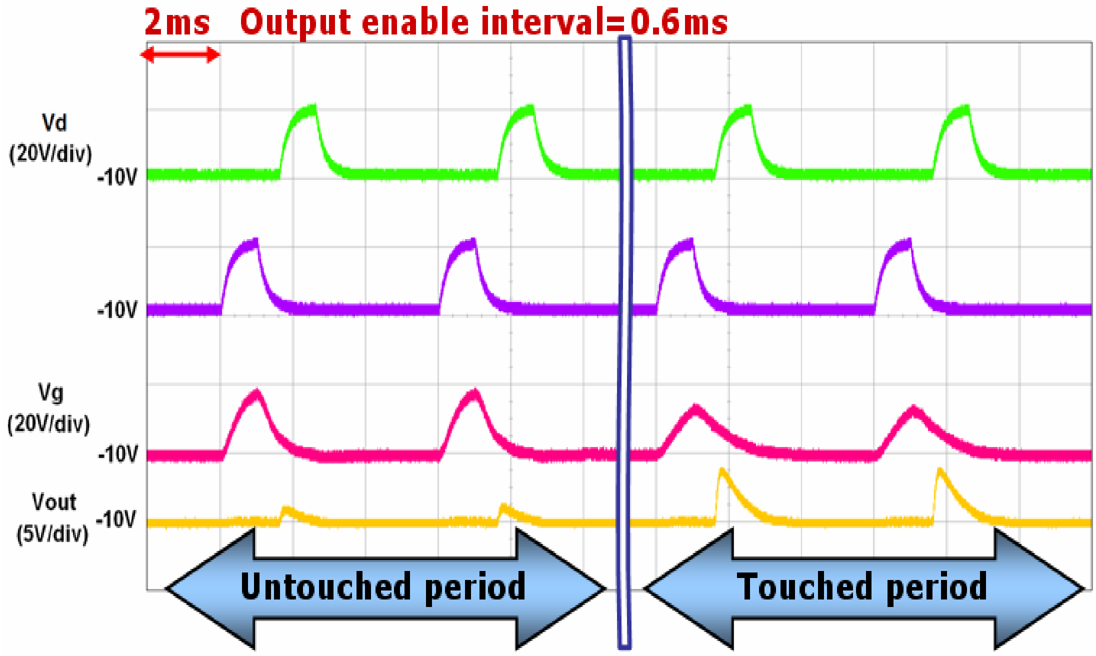


Fig. 2-18 1T1R1C pixel circuit experiment result for IGZO TFT for scan far end

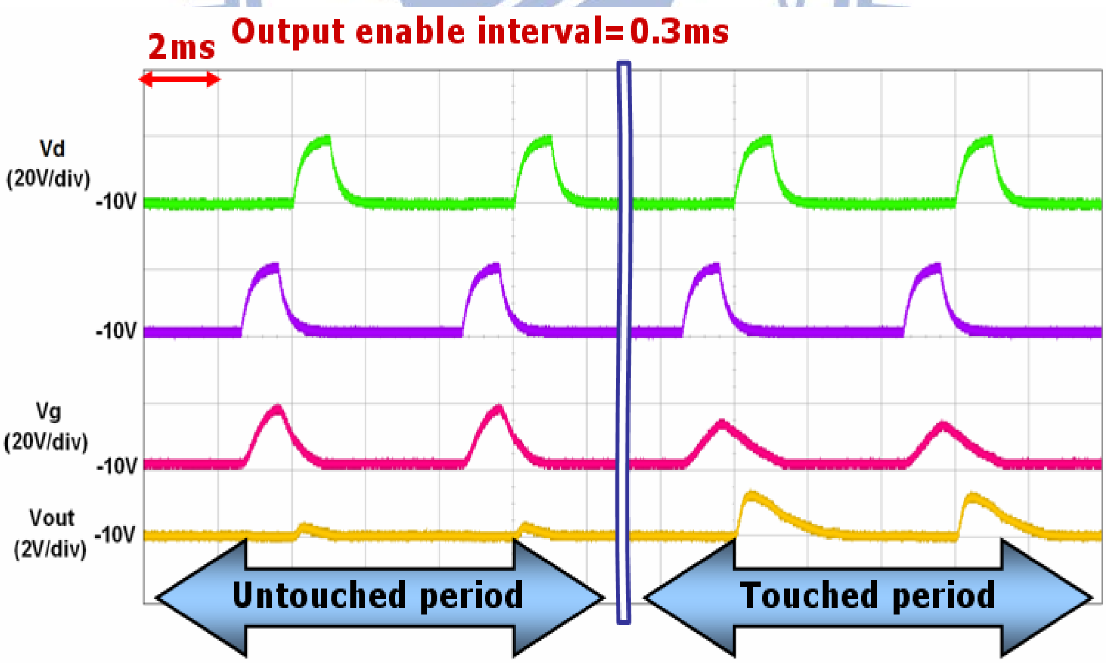


Fig. 2-19 1T1R1C pixel circuit experiment result for a-Si TFT for scan far end

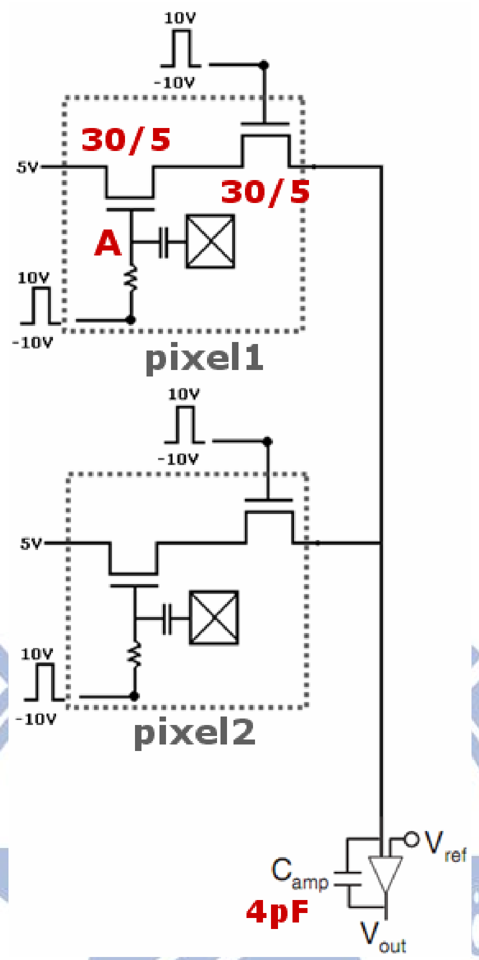


Fig. 2-20 Simulation of 2T1R1C sensing circuit for a-Si TFTs

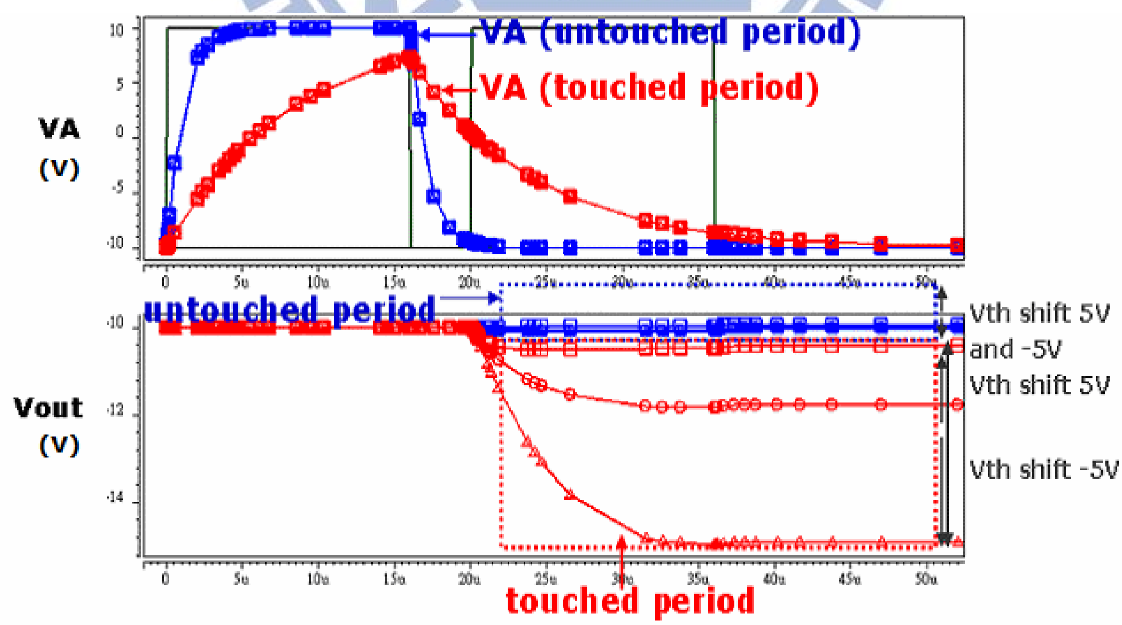


Fig. 2-21 Simulation result of 2T1R1C sensing circuit for a-Si TFTs

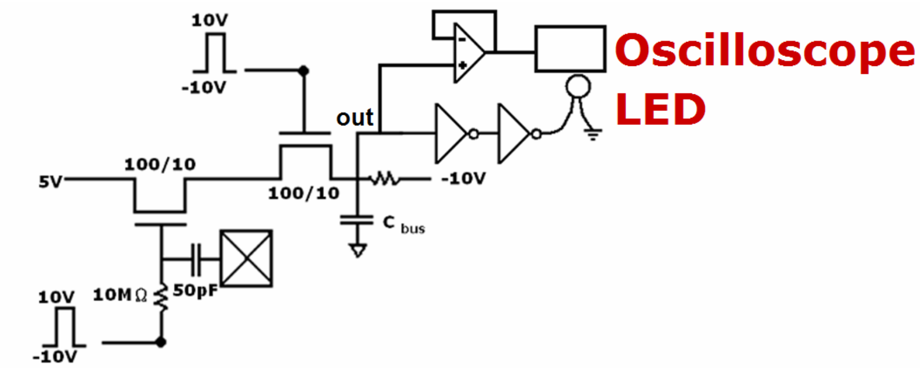


Fig. 2-22 Circuit of simple demonstration using a-Si TFTs

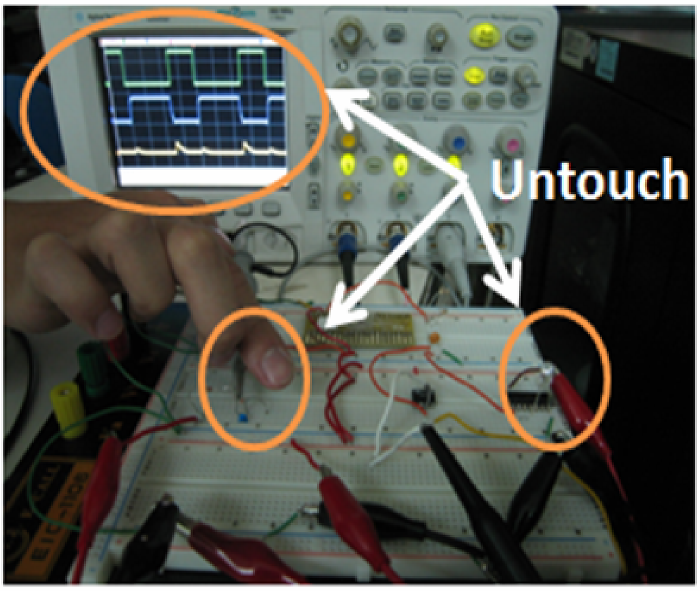


Fig. 2-23(a) Simple demonstration when pixel is untouched

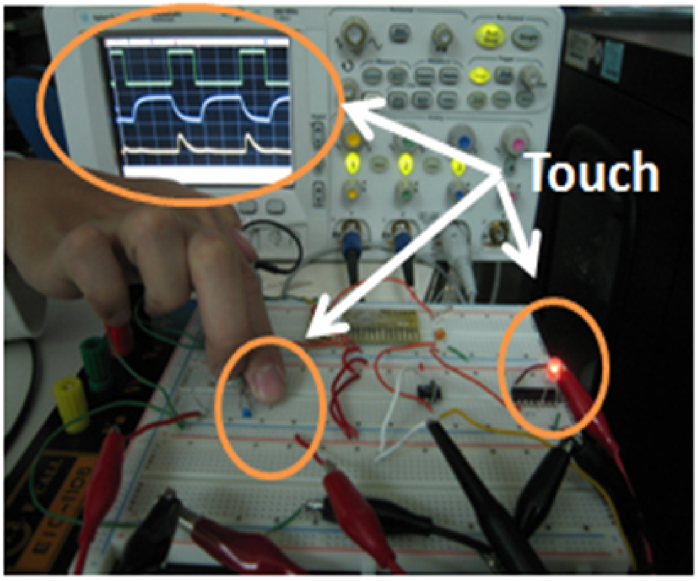


Fig. 2-23(b) Simple demonstration when pixel is touched

Chapter 3

Panel Design

In this chapter, we design a large size touch panel using proposed sensing circuit. Considering the value range and the adjustment of the resistance, the resistance R in the pixel circuit is replaced by TFT. Thus, the sensing circuits in Chapter 2 are changed to 3T1C and 2T1C, which are shown in Fig. 3-1 and 3-2, respectively.

3.1 Specifications, Bases, and Targets

Before design, we define specifications and design bases. The specifications are listed in Table 3.1

The design will be based on the following premises:

1. ITO is used as material of bus lines in order to increase the transparency of the panel.

2. A 0.1(mm) thick protection film with dielectric constant of 3.9 is used to cover on the touch sensing region, which creates the sensing capacitance Csen.

3. A comparator is used as the readout circuit on every data line, and there is about 50pF parasitic capacitances on each data bus.

4. Both IGZO TFT and a-Si TFT are used to do the design.

The design target is that when pixel is touched, the transient on current of TFTs can charge the data line to a significant voltage difference of 0.2V for the comparator to judge whether pixel is touched or not. The voltage difference is targeted at 0.2V so that the comparator can differentiate easily.

3.2 Design Considerations

There are many design factors in the proposed sensing method, such as bus line width, size of TFTs, and sensing capacitance. For example, to make the sensing area becomes larger, the scan line width is made thinner and it causes a large parasitic resistance on the scan line and thus a serious RC time constant delay. The delayed scan pulse at scan far end might result in a false touch signal. When this case happened, the same readout setting cannot be applied at both scan near and far ends. On the contrary, if the scan line width is designed to be wide, it squeezes the area of sensing region. The small sensing area corresponds to small sensing capacitance, which may not generate enough difference in the RC time constant when pixel is touched or not.

Another example is the size of RTFT the driving TFT. Increase in the TFT size can increase the ability to charge the data bus, while the gate capacitance of TFT increases, too. It has two consequences. One is that the difference of total capacitance at sensing node when pixel is touched or untouched is less significant. The other is the increased RC time constant delay of scan pulse. The tradeoff of the drivability of the driving TFT and the ratio of its gate capacitance to the sensing capacitance need to be considered.

3.3 Design Procedure

Due to these intertwined design factors, a design procedure is proposed to support our task. The proposed design procedure is shown in Fig. 3-3. It contains the following steps:

Step1: Specify panel size, aspect ratio, and resolution

Step2: Design line width of scan and data line

Step3: Calculate the area of sensing region, which value is the area of one pixel pitch subtracting the area of bus line and TFTs of one pixel. For a fast estimation, the area of TFTs is ignored because it is much smaller than the area of bus line. The value of sensing capacitance can be calculated accordingly.

Step4: Design sizes of both driving TFT and RTFT.

Step5: Calculate the parasitic capacitances and resistances on the buses.

Step 6: Verify the design by spice simulation.

The design procedure is repeated until the design passes the criteria of significant voltage difference between touch and untouched.

3.4 Simulation Result

Four pixels at the four corners of the panel are simulated. Ten stages resistances and capacitances are used to model the bus line. The simulation results of the 3T1C circuit at the four corners are shown in Fig. 3-4. The 2T1C circuit is simulated in the same way. Most of the voltage settings are described in chapter 2, except that the gate bias of RTFT is 15V for IGZO TFT and 20V for a-Si TFT. For the comparators in the peripheral out of the sensing array, a reset TFT is used to reset the output voltage for the sensing of the next row, which is also shown in Fig. 3-4.

The design results are listed in Table 3.2. The layout of 3T1C circuit is shown in Fig. 3-5. The simulation result of 3T1C and 2T1C circuits for IGZO TFT are shown in Fig. 3-6 and 3-7, respectively. The simulation result of 3T1C and 2T1C circuits for a-Si TFT are shown in Fig. 3-8 and 3-9, respectively. The results include the scan pulses and the output signals of the four pixels when they are touched or untouched. The output signal of the pixel at the scan far end is larger than that at the near end. It is because the pulse at scan far end possesses a larger RC time constant delay. The output signal of the pixel at data near end is larger than that at the data far end at the same time. It is because that when current occurs from data far end, it has to pass through many resistances and capacitances of data bus, and the output signal appears about 7μs RC time constant delay. However, when current occurs from data near end, it charges the output capacitance directly, and the output signal rise rapidly. Therefore the smallest touched signal appears at scan near end and data far end, and the largest untouched signal appears at scan far end and data near end, which are shown in the two dash line of the output signal. The smallest touched signal is larger than the largest untouched signal for 0.2V. It meets the design target successfully.

3.5 Comparison of Two Types Touch Panel

From the above simulation results, the output signal of 2T1C circuit and 3T1C circuit are almost the same. It seems that 2T1C circuit is good enough to make the touch panel. Since 2T1C occupies the minimum area of touch panel, it is better than 3T1C circuit.

However, there is still a concern of 2T1C circuit that when many pixels on the same scan line are touched simultaneously, every touched pixel drains current from the scan bus. This is not an issue for the 3T1C circuit, since the sensing current comes from the individual voltage bias buses in column. In 2T1C circuit, the sensing current are all drained from the same scan bus in row. It might cause a large current flow through resistances of scan bus, and thus the pulse high of scan voltage decrease. When many pixels are touched, the output signal may be influenced. Therefore, we have to confirm that if 2T1C circuit still can work when the heavy load of multi-touch happened.

We simulate the situation that when many pixels on the same scan line are touched simultaneously for both 3T1C and 2T1C circuits. The simulation circuits of both 3T1C and 2T1C are shown in Fig. 3-10 and 3-11, respectively, where all 10 pixels are touched in the time. The simulation results of scan pulse high voltage for both 3T1C and 2T1C circuits are shown in Fig. 3-12 and 3-13, respectively. We can observe that there is more decrease of scan pulse high voltage in 2T1C circuit than in 3T1C circuit. However, the decrease is as small as 0.22V. Even if there are one hundred pixels on the same scan line are touched simultaneously, the difference is only 2.2V.

We simulate a situation that when the scan pulse high voltage decreases from 10V to 7V to see if output signal still can meet the design target. The result is shown in Fig. 3-14. It can be seen that the minimum touched signal is still larger than the maximum untouched signal for 0.2V. The proposed 2T1C circuit still can work when more than 100 pixels are touched. The concern of voltage drop on the scan bus owing to multi-touch is relieved.

3.6 Summary

A 42 inch touch panel is successfully designed by both 3T1C and 2T1C sensing circuit using IGZO and a-Si TFTs, and proposed 2T1C sensing method can support at least 100 pixels of multi-touch.

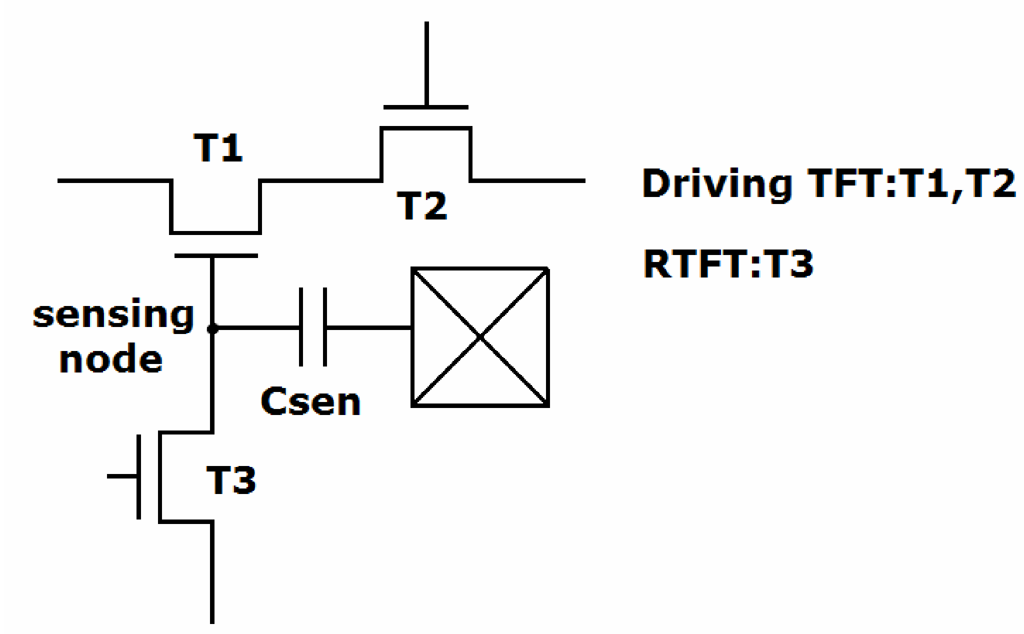


Fig. 3-1 3T1C touch sensing pixel circuit

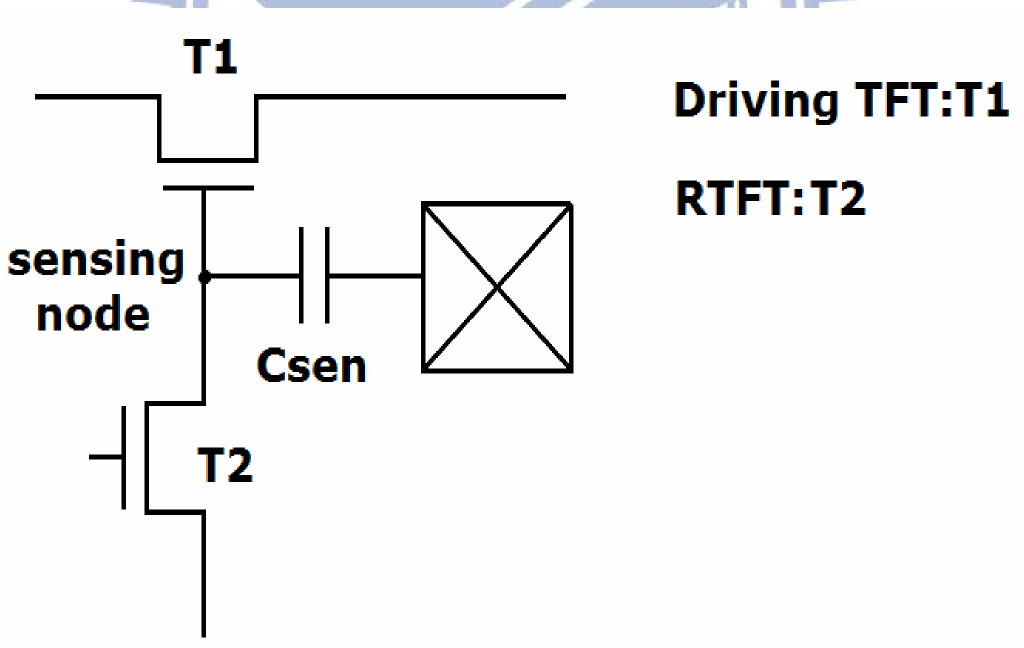


Fig. 3-2 2T1C touch sensing pixel circuit

Item	Specification	Unit
Panel size	42	inch
Aspect ratio	16:9	
Frame rate	60	Hz
Pixel pitch	1.9	mm
Pixel shape	Square	
Resolution	480 × 270	

Table 3.1 Design Specification of touch panel

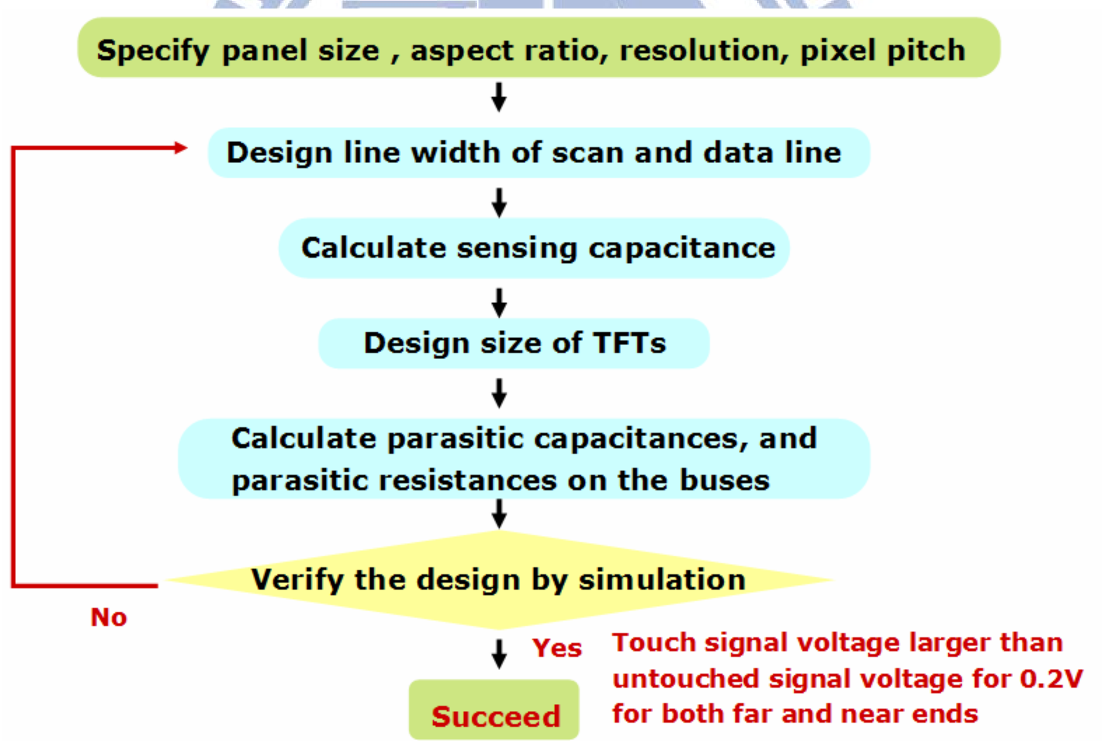


Fig. 3-3 Flow chart of design procedure

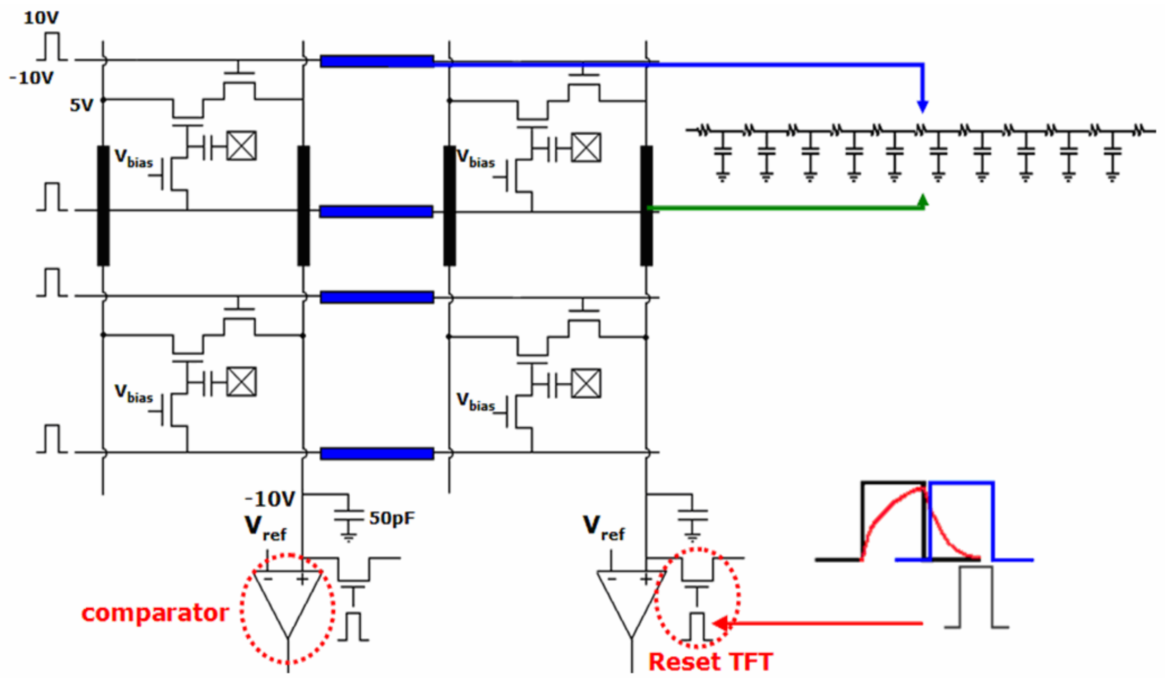


Fig. 3-4 Four corners simulation of 3T1C circuit

	IGZO TFT	**a-Si TFT**
Scan line width	446μm	446μm
Data line width	28μm	28μm
Sensing capacitance	0.92pF	0.92pF
Size of driving TFT	10μm/5μm	50μm/5μm
Size of RTFT	5μm/30μm	5μm/20μm
parasitic capacitance of scan line of each pixel	50fF	80fF
parasitic capacitance of data line of each pixel	0.6kΩ	0.6kΩ
parasitic resistance of scan line of each pixel	42fF	70fF
parasitic resistance of data line of each pixel	4.62kΩ	4.62kΩ

Table 3.2 The design results of touch panel for IGZO TFT and a-Si TFT

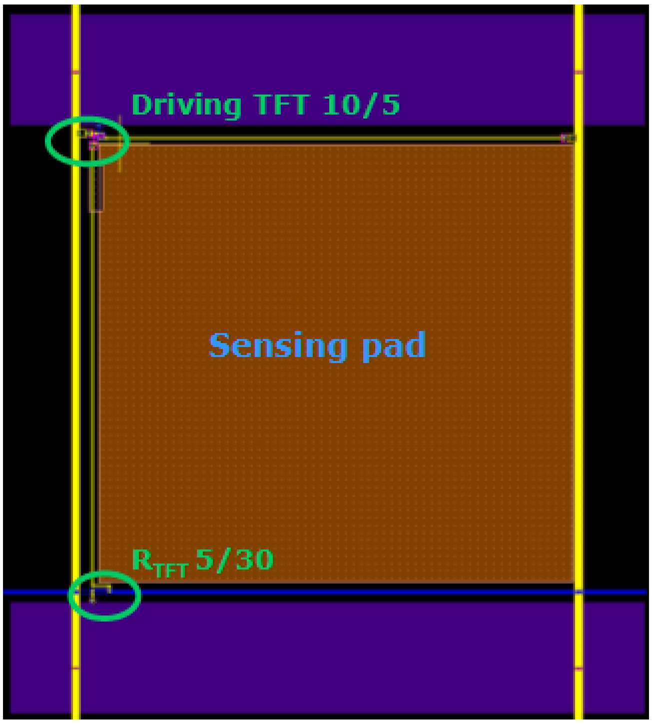


Fig. 3-5 Layout of 3T1C circuit

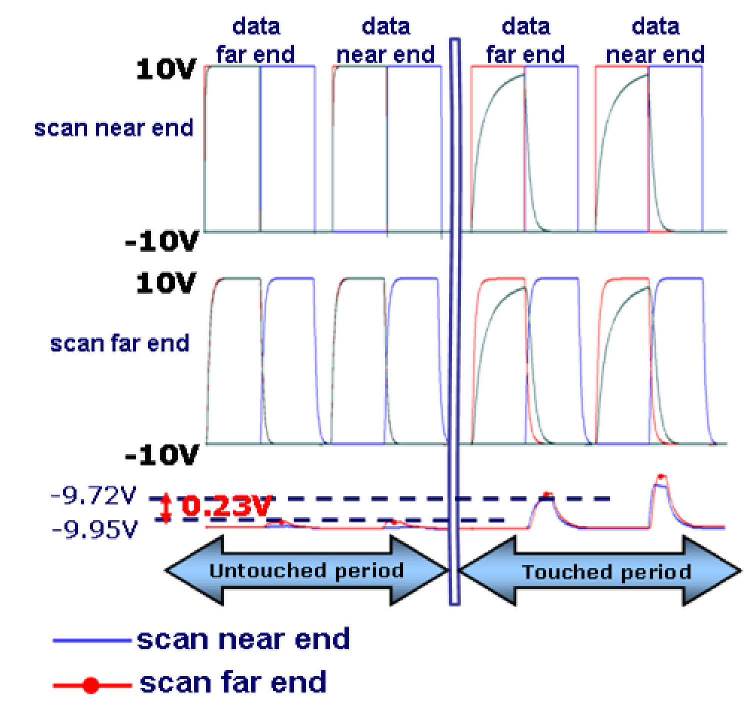


Fig. 3-6 Four corners simulation result of 3T1C circuit for IGZO TFT

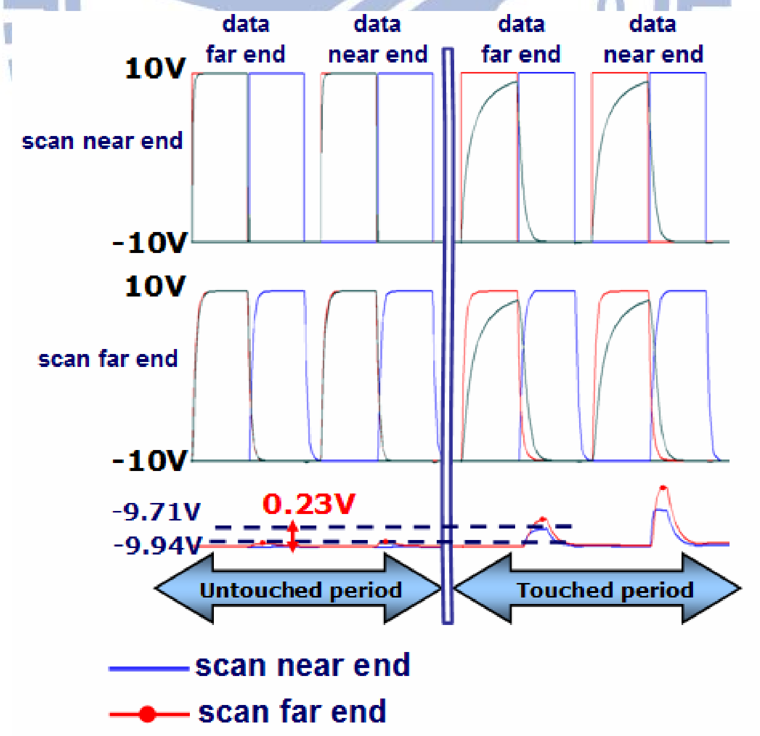


Fig. 3-7 Four corners simulation result of 2T1C circuit for IGZO TFT

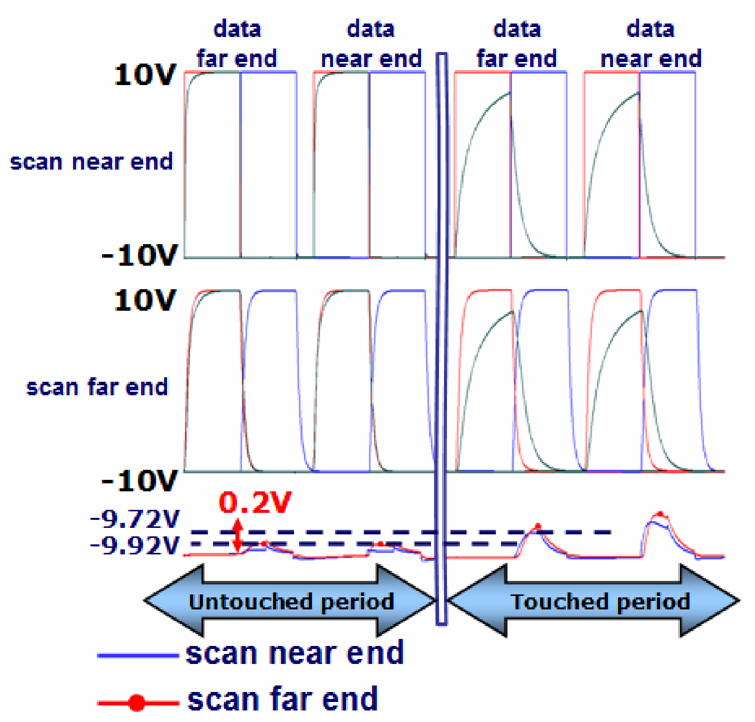


Fig. 3-8 Four corners simulation result of 3T1C circuit for a-Si TFT

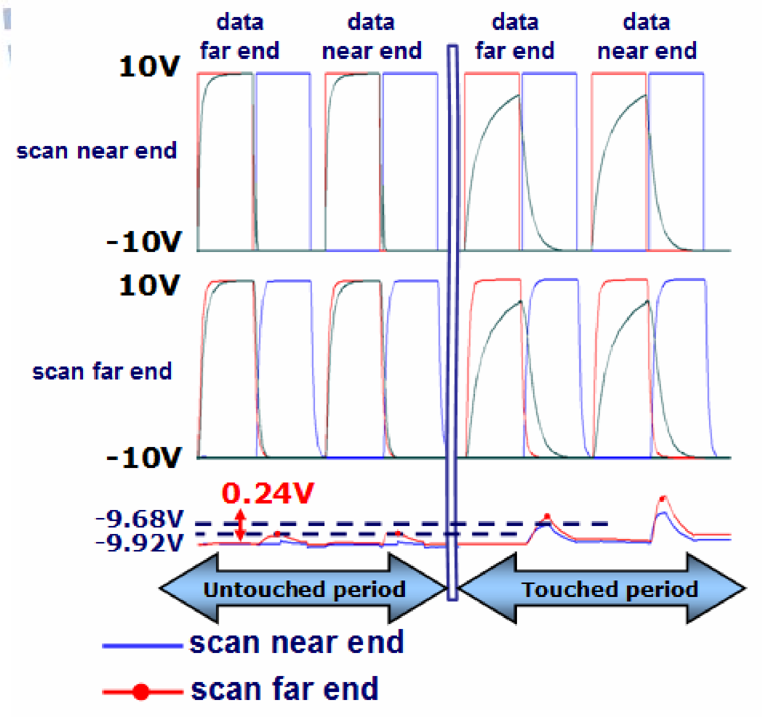


Fig. 3-9 Four corners simulation result of 2T1C circuit for a-Si TFT

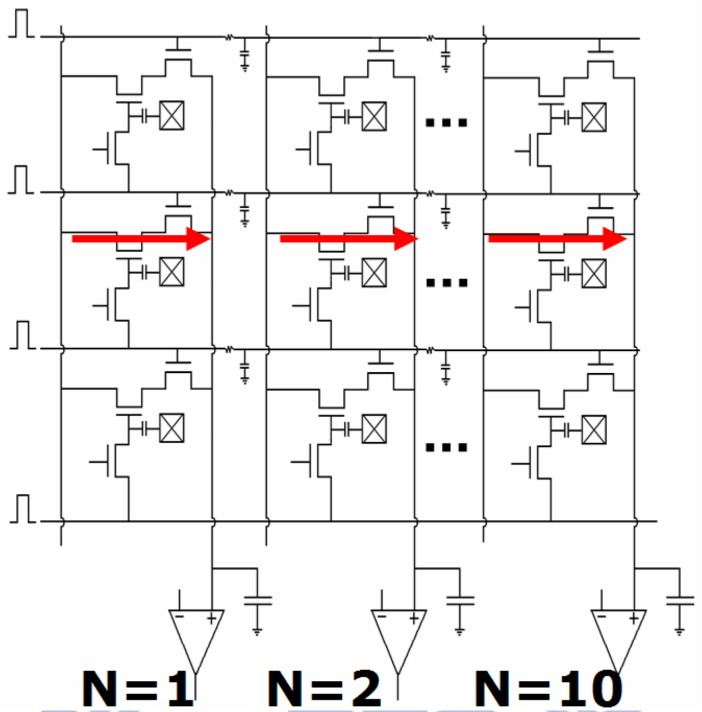


Fig. 3-10 Simulation circuit of multi-touch situation with 3T1C circuit

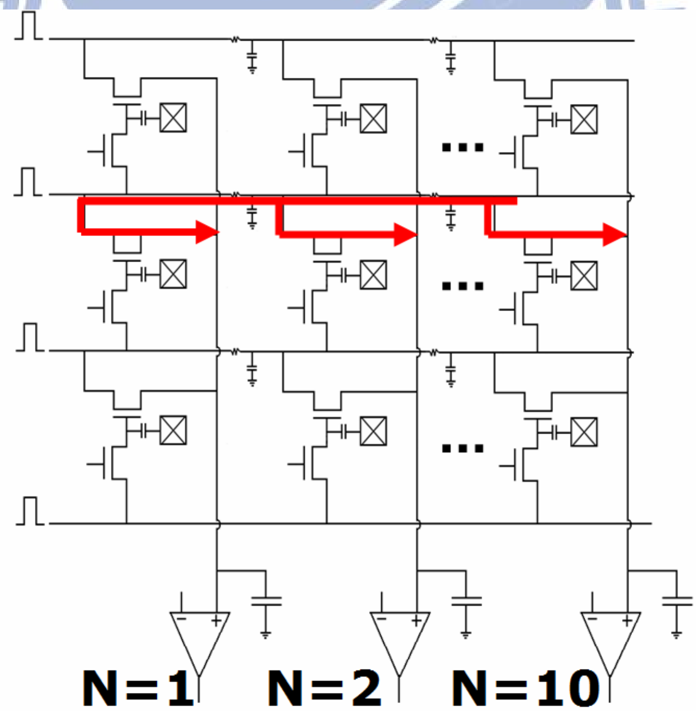


Fig. 3-11 Simulation circuit of multi-touch situation with 2T1C circuit

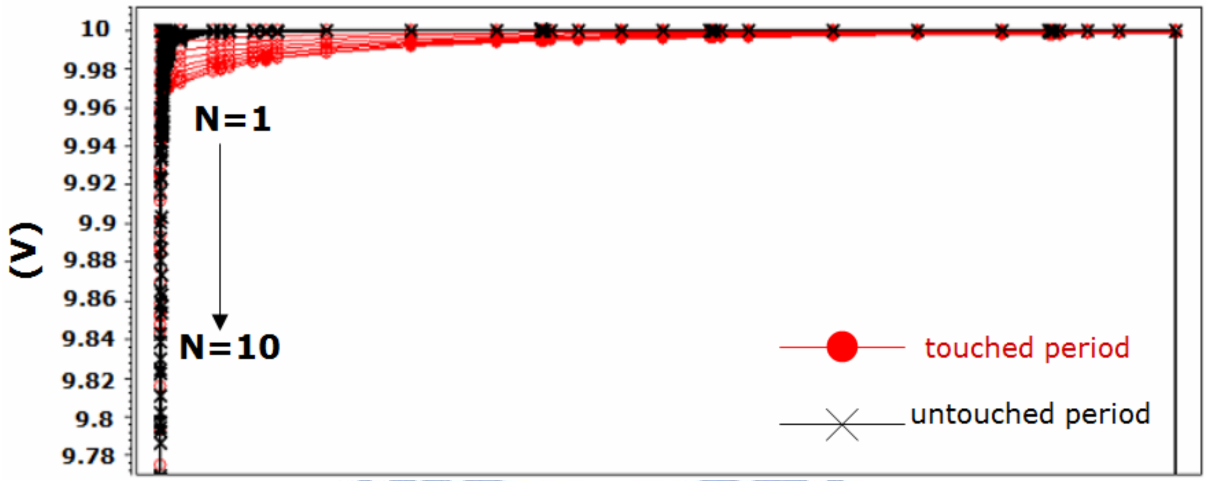


Fig. 3-12 Simulation result of pulse high of multi-touch situation with 3T1C circuit

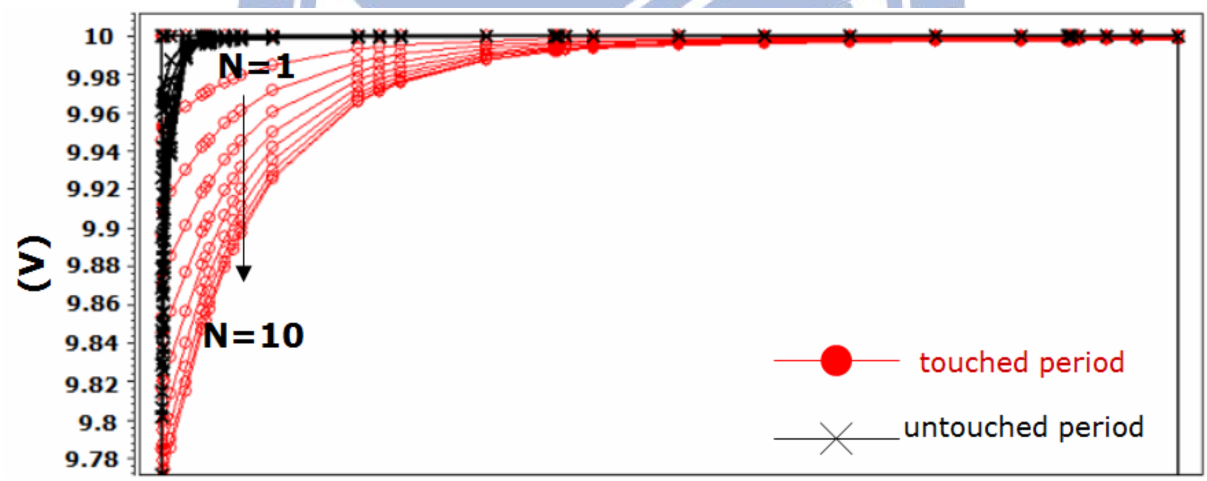


Fig. 3-13 Simulation result of pulse high of multi-touch situation with 2T1C circuit

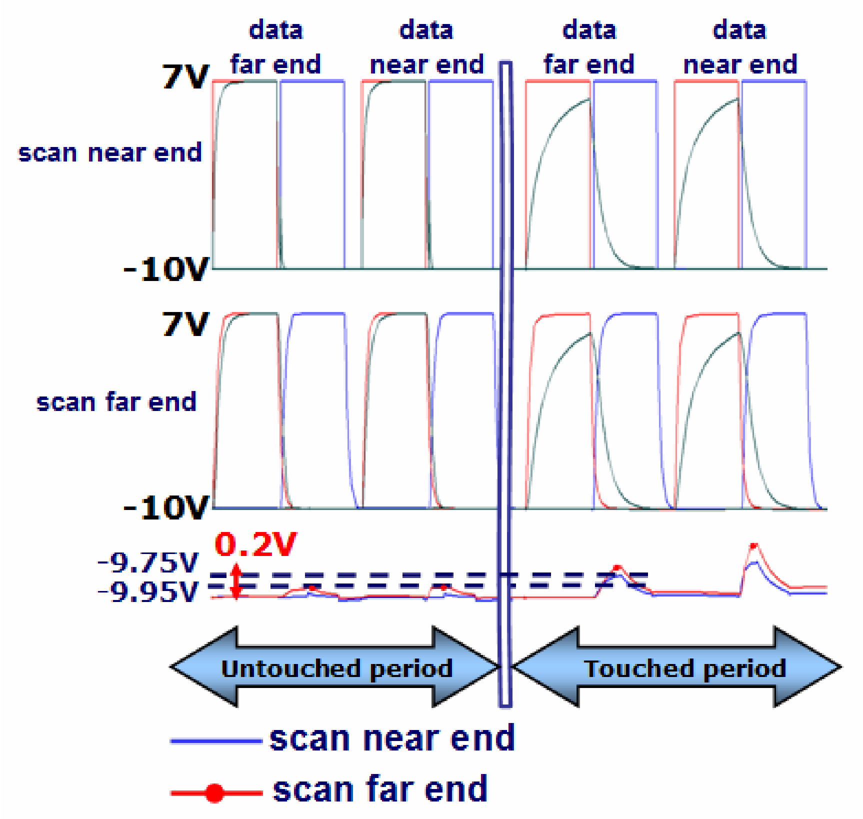


Fig. 3-14 Four corners simulation result of 2T1C circuit when pulse high decrease

Chapter 4

Conclusion & Future Works

<<Conclusion >>

A simple but novel concept of detecting RC time-constant change for the active matrix touch panel is proposed. The proposed circuit has many advantages. Firstly, the output signal of the transient on current of TFTs is significant and thus can be easily readout by low cost ICs. Secondly, current signal only occurs when a pixel is touched. The power consumption in operation is greatly reduced. Thirdly, Vth variation can be tolerated, which is the major advantage over the source follower type active touch panels. The proposed method provides an excellent way of implementing large area active matrix touch panels. A 42 inch touch panel is successfully designed by both 3T1C and 2T1C sensing circuit using both IGZO and a-Si TFTs.

<<Future works>>

1. Design in-cell active touch panel using proposed sensing method.
2. Design active touch panel which can sense touch force using proposed sensing method.

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