Flexible Electronics Devices for Smart Card Applications

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Abstract

Flexible electronics devices such as plastic display, thin film battery, membrane switch, organic memory for smart card applications will be presented. The performance and power consumption of various display technologies will be compared for OTP requirement in smart cards. Wireless power transmission by RF coupling through an antenna provides a potential power solution to smart cards. Finally, the general trend of smart card future developments will be discussed.

Introduction

Smart cards with magnetic strip or a combination of IC with magnetic strip have been widely used today for financial transaction purposes. However, because of the online shopping and online banking become more and more popular, the security issues of each online transaction become a serious concern. It is reported that the financial losses due to card frauds such as stolen cards, lost cards, forged cards and ID theft were over 1.2 billion US dollars last year. In the past few years, more and more electronics components have been added to a smart card to increase its security features.[1] Fig. 1 shows different technologies have been incorporated to a smart card to demonstrate an additional layer of protection against card frauds. For example, an acoustic device was incorporated to a smart card to provide a voice identification through a phone system during each financial transaction. A biometric device such as finger print recognition sensor was added to identify the card owner. Moreover, a plastic display was incorporated to a smart card to provide so called OTP (One Time Password) function for each online transaction. In this paper, different display technologies including electrophoretic display, electrochromic display, liquid crystal display and light emitting diode are analyzed and compared for display card applications. Furthermore, bringing an efficient power solution to a smart card becomes an important issue when more and more features are added. In this paper, wireless power transmission by RF coupling through an antenna and rectifier circuit in a smart card will be discussed.

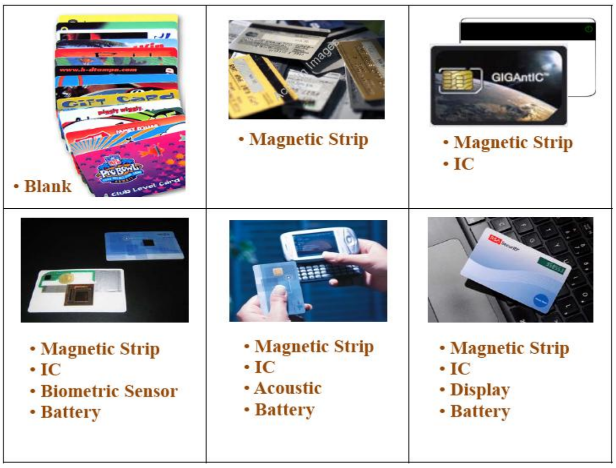


Fig. 1. Recent developments in smart card technologies for online shopping or online banking applications.

Discussions

A typical smart card comprises a three-layer structure including an inlay, which contains most of electronics parts, sandwiched between two plastic sheets. According to ISO specification, the total thickness of a smart card is 0.8mm and the thickness of the inlay is no more than 0.45mm. For a display card, the basic electronic components include display, driver IC, battery and supporting logic circuits. From the manufacturing point of view, it is a challenge for assembling all the needed components to an inlay within the ISO Spec especially when more electronic parts and power capacity are needed in order to increase smart cards' features. Fig. 2 shows a comparison of different display technologies which have been demonstrated for display card applications.

Display Technology	Display driving condition	Power consumption for all segment turned on	Number of switching (turned on for 30sec) based on a 20mAh battery
Liquid Crystal	Capacitance Driving ~ pF range (Bistability= NO) T_{on} = 20msec	0.01mW	888,000
Electrophoretic	Cap/current Driving 200uA (Bistability= YES) T_{on} = 1 sec	3mW	30,000
Electrochromic	Current Driving 10mA (Bistability= 5sec) T_{on} = 200msec	18mW	12,000
Light Emitting Diode	Current Driving 50uA/seg (Bistability= NO) T_{on} < 1msec	1/4 duty = 1.55mW 1/10 duty = 0.62mW 1/16 duty = 0.38mW	11,600 (1/4 duty) 28,600 (1/10 duty) 46,800 (1/16 duty)

Fig. 2, The comparison of different display technologies for display card applications.

For a standard TN LCD, the power consumption is typically within the range of microamperes. So, for a 1.5cm x 3cm TN LCD, it can be continuously operated for over 2 years using a 20mAh flexible battery. However, most of the LCDs are still made on glass, which are not suitable for display card applications. On the other hand, electrophoretic displays such as E-Ink's microcapsule EPD and Sipix's Microcup EPD have been commonly used for display card today due to their image bistability. For a 1.5cm x 3cm segment EPD display, the image can be switched over 30,000 times using a 20mAh battery, yet the image quality may not be superior under poor lighting conditions. Another display technology is electrochromic display. Because it is based on current driving, the power consumption for a 1.5cm x 3cm display may take over 18mW, which is too high for a display card application. It is known that LEDs have excellent environmental durability and operating lifetime and they produce good image quality in various lighting conditions especially when optical designs are taken into considerations. Our analysis showed that, for a LED segment display, the power consumption can go below the mW range especially when 1/10 duty cycle is applied. Because of its excellent display performance and operating lifetime under a board range of environmental conditions, LED displays are good candidates for smart card applications.

Power management is another important topic for smart card applications especially when more features are added which requires more electronics components. In the past few years, few potential approaches have been addressed to bring power management to smart cards, including incorporating a thin film solar cell or using a direct contact method to recharge a secondary battery. In this paper, we'll focus on a wireless charging method to provide power solutions to a smart card. Fig. 3 shows a basic mechanism of wireless power transmission through a RF coupling of an antenna.

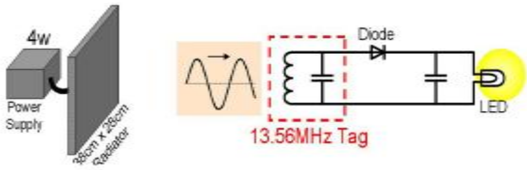
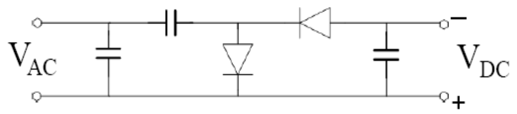
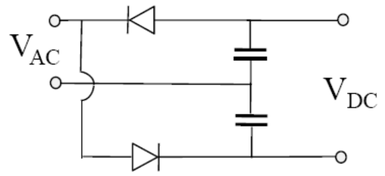


Fig. 3, A basic mechanism of wireless charging through a RF coupling of an antenna to turn on a LED.

Wireless energy transmission has been investigated for several years and has been implemented into actual products such as the remote charger for an electrical tooth brushers and contactless charger for cellular phones. More recently, flexible antenna and pressure sensor switch fabricated on plastic substrates using printing processes to form a RF coupling power transmission sheets was demonstrated for large area power transmitter applications.[2] Furthermore, polymer rectifier consisting printed antenna, organic diode and printed capacitor on a plastic substrate demonstrated the capability of converting 13.56MHz of RF power to a DC current to turn on a LED.[3] Fig. 4 shows two basic logic circuit designs of AC to DC rectifier through an antenna coil. Experiment results showed that the rectifier circuit of Fig. 4a is capable of converting a +/- 10V AC current from a 0.5W RFID reader to generate a 4V DC voltage at approximately 3mA current. Fig. 4b shows a 13V DC voltage was generated from a +/- 10V AC voltage through a Double Half Way Rectifier.[4] These rectifiers show a potential capability for recharge a secondary battery for smart card applications.



(4a)



(4b)

Fig. 4 The basic logic circuit designs of AC to DC rectifiers.

Summary

Recent smart card development trends show the demand of security enhancement to prevent financial losses due to card frauds. Biometric sensor and OTP technologies have been demonstrated for adding an additional layer of protection for a smart card during online transactions. Analytical results showed LED display is a good candidate for display card applications. Finally, a potential power solution to a smart card by the wireless power transmission approach was demonstrated.

References

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