Full-Screen Capacitive Fingerprint Sensor and Touch Sensor

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Keywords : Fingerprint sensor; Touch sensor; Capacitive; Full screen; LTPS

ABSTRACT

We have developed a novel full-screen capacitive fingerprint and touch sensor, which can scan and detect a user's fingerprint anywhere on a display, using Low Temperature Poly-silicon (LTPS) technology and Analog Front End Integrated Circuit (AFE IC) technology. Due to its excellent detection performance, the sensor can detect high quality fingerprint image even through the cover glass.

1. INTRODUCTION

The fingerprint sensor has become one of the key components in the ubiquitous mobile space, because of its excellent usability. Thus, much research and development has been performed in this field in the past years. Our focus is on developing a fingerprint sensor based on the LTPS technology [1][5]. Some of the LTPS technology-based sensors are already in mass-production.

Recently, screen area for mobile devices like smartphones has grown larger while the border or the bezel area has shrunk. Consequently, there is not enough area on the surface of the device for the implementation of a fingerprint sensor. Therefore, it is highly desirable to implement the fingerprint sensor in the screen area.

Such mobile devices, which do exist in the market, adopt a fingerprint sensing method that is usually optical [2] or ultrasonic-based [3]. Typically, those mobile devices also use a capacitive touch sensor, thus, both sensor spaces are necessary in the mobile device. This makes constraint for compactness of the mobile device. Furthermore, because the data is transferred via a host controller on the mobile device, having two separate sensors results in a large time-delay when either sensor transmits or receives data to and from the other. As a result, the mobile device has a lag in system response time.

2. TECHNOLOGIES

2.1 Concept of the Full-Screen Capacitive Fingerprint and Touch Sensor

The functional concepts of the full-screen capacitive fingerprint and touch sensor are described in Fig.1.

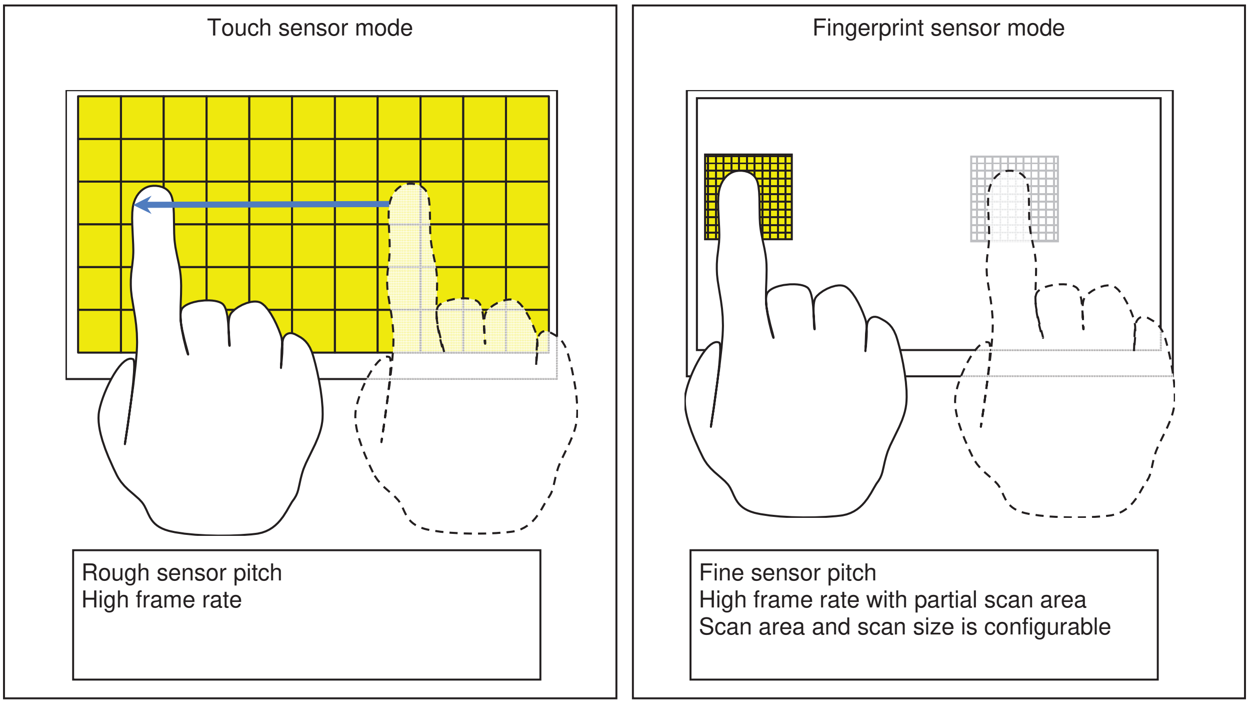

Figure 1. Function concept of full-screen capacitive fingerprint sensor

This sensor can scan the fingerprint anywhere within the screen area. Moreover, the sensor is employed as both a fingerprint sensor and a touch sensor. For touch sensing mode, the sensing report rate is fast, and the scanning pitch is coarse. On the other hand, during fingerprint sensing mode, in order to acquire sufficient image quality for authentication, the scanning pitch is fine. In addition, during the fingerprint sensing mode, the scanning area is limited to the finger size to decrease the image size and scanning time. Our new sensor can achieve a frame scan time within 130 msec for fingerprint mode, when the scanning area is approximately 10×10 mm.

2.2 Module Structure of the Full-Screen Capacitive Fingerprint and Touch Sensor

The module structure of the sensor is described by Fig.2.

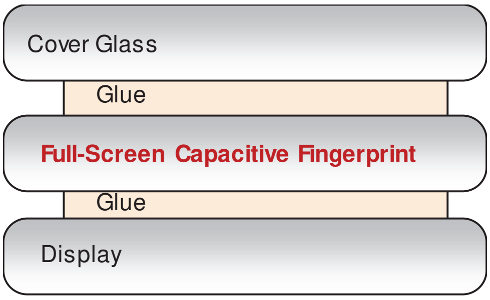

Figure 2. Module structure of full-screen capacitive fingerprint sensor

This sensor is stacked on the display as shown in Fig.2. The optical characteristics of the sensor, such as transmittance, are critical to avoid degrading display performance. To improve the transmittance derived from the sensor aperture ratio, a single sensor electrode functions both as a fingerprint sensor and as a touch sensor. This ensures that the transmittance of the sensor exceeds 80%, including the cover glass. The sensor substrate is highly transparent as shown in Fig.3.

Figure 3. Sensor substrate

For protection of the mobile device, the sensor module is assumed to have a cover glass on top. In order to ensure that the sensor can detect the fingerprint through the cover glass, an enhancement circuit for the fingerprint signal and a noise reduction circuit for external noise were integrated into the sensor substrate. As a result, the new sensor can acquire the fingerprint image with a good Signal to Noise Ratio (SNR) through 0.3 mm cover glass.

As mentioned before, the sensor has two driving modes: fingerprint sensing mode and touch sensing mode. Each mode requires different driving methodologies: the touch sensing mode requires driving bundled sensor lines [4], whereas the fingerprint sensing mode requires driving individual fine pitch lines. Thus, the driving circuitry in the sensor substrate is expected to be complex. Using LTPS technology, the necessary circuitry was implemented in the border of the sensor glass within a compact area. As a result, the left and right border widths are narrow and less than 1 mm.

2.3 Analog Front End Technology for Full-Screen Capacitive Fingerprint and Touch Sensor

Analog front end integrated circuit (AFE-IC) technology was developed to control the driving modes for both fingerprint sensing and touch sensing. The IC has multi-detection channels for parallel analog sensing. These channels are shared by the fingerprint sensing mode and the touch sensing mode in order to optimize the use of the IC area. There are analog detection settings for each sensing mode, which allows for the independent optimization of the analog settings. The dual sensing mode allows for the finger position obtained during the touch sensing mode to be quickly used as the scan position during the subsequent fingerprint scanning mode. As a result, sensing mode transition involving data feedback was achieved in less than 10 msec.

The IC has two communication interfaces (I/F) with the host as show in Fig.4. This architecture is assumed for usage on a high security system such as the Android system. The fingerprint data is transferred to the secure world through the fingerprint I/F, thus, the fingerprint authentication is performed securely. In contrast, the touch sensing data is transferred to the normal world through the touch sensor I/F, thus, the sensor can be used in the same way as a conventional touch sensor device.

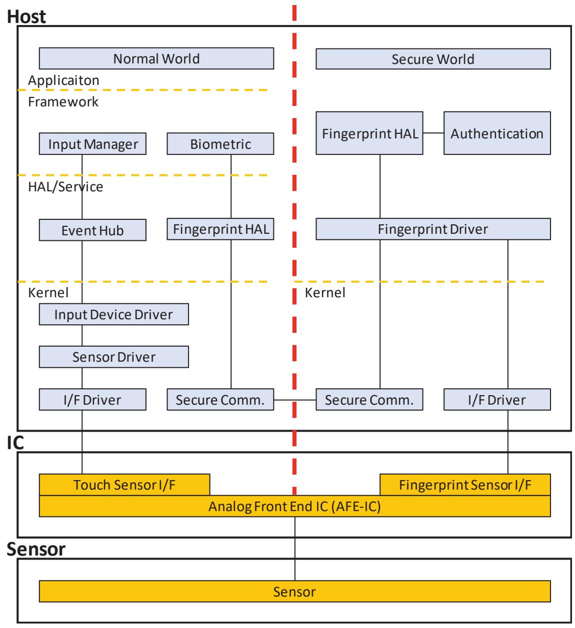

Figure 4. Sensor system architecture

3. RESULTS

In conclusion, we developed a 6.5-inch demo sample sensor that integrates the technologies described above. This sample includes both touch sensing and fingerprint sensing modes, and both sensing images are displayed on the LCD behind the sensor.

Sample images shown in Fig.5. and Fig.6. represent the fingerprint images scanned by the sample sensor with a 0.3 mm cover glass. Table 1 shows the sample specification.

Evaluation confirmed that the SNR was 16.5 dB for fingerprint sensing through a 0.3 mm cover glass and adhesive layer. This SNR value is proven to be sufficient to authenticate fingerprints on the basis of on our internal testing.

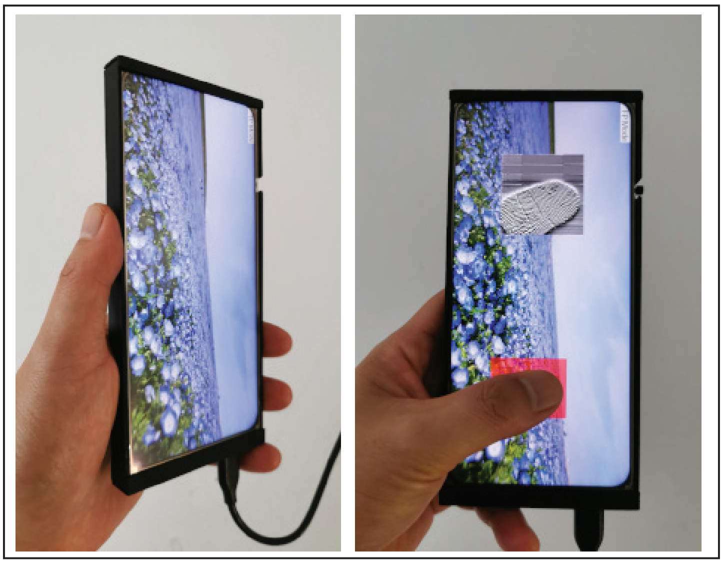

Figure 5. Demo sample

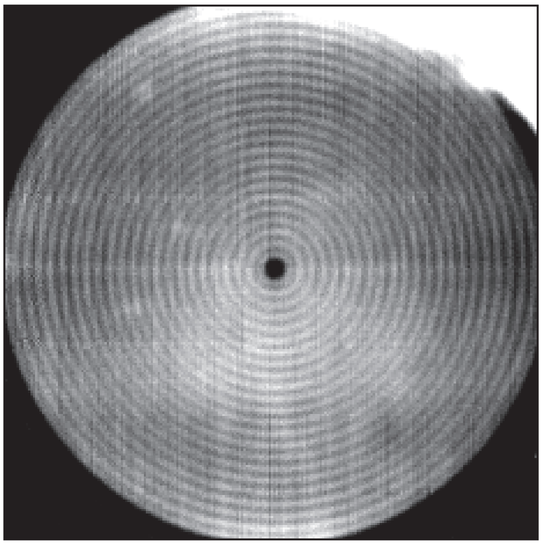

Figure 6. Artificial fingerprint scan image with 0.3 mm cover glass

Table 1. Sample sensor specification

		Spec	Note
Common	Sensor size	6.5 inch	
	Transmittance	> 80%	Reference = air
	Sensor active area	70.5 × 151.6 mm	
	Border size (Left&Right)	< 1 mm	
	Sensing mode transition	< 10 msec	Controlled by IC
Touch Sensor	Sensor pitch	3.9 × 4.0 mm	
	Frame rate	120 Hz	
	SNR	45 dB	
	Accuracy	0.39 mm	
	Precision	0.00 mm	
	Jitter	0.00 mm	
	Linearity	0.67 mm	
Fingerprint Sensor	Sensor resolution	313 ppi	
	Scan area size	Variable	5.2 × 5.2mm ~ full-screen
	Scan speed	134 msec	@Scan area = 10.4 × 10.4mm
	SNR	16.5 dB	With 0.3 mm cover glass

4. CONCLUSIONS

A capacitive fingerprint sensor that can scan and detect a fingerprint anywhere within the screen area was developed.

This sensor can be employed as both a fingerprint sensor and a touch sensor, thus mobile devices employing the sensor can decrease the number of sensor modules, increasing the compactness and decreasing the weight.

Moreover, data communication between the fingerprint sensing mode and touch sensing mode is fast because the sensor is managed by single IC. As a result, sensing mode transition involving data feedback was achieved in less than 10 msec.

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