Highly Sensitive Fingerprint Readout IC for Glass-Covered Mutual Capacitive Fingerprint Sensor

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Motivation & Technical Issues

1. Home button-less phone
   - Edge-to-edge display
   - Glass-covered fingerprint sensor

2. Driving electrodes
   - Valley
   - Ridge
   - Cost-effective
   - Simple manufacturing process

3. The cover glass protects the device from external forces
   - \( T_{\text{glass}} \): the thickness of glass
   - \( \text{Sensitivity} \propto \frac{1}{T_{\text{glass}}} \)

4. Noise Power (V^2/Hz)
   - Very small signal levels
   - Large display noise and lamp noise are coupled through the sensor
   - Electronic noise deteriorates SNR

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Overall Architecture of Fingerprint Authentication System

- For high sensitivity, HV driver applies 20V excitation signal through the fingerprint sensor
- DC offset and flicker noise is reduced by using modulation and demodulation process
- Differential sensing scheme is used for common mode rejection (CMR)
- $A_{\text{Total}} = A_{v1} + A_{v2} + A_{v3} = -37\text{dB}$,
  Where $A_{v1} = -86\text{dB}$ (@0.1T glass), $A_{v2} = 31\text{dB}$ and $A_{v3} = 18\text{dB}$
- Gain amplifier and mixer have band-pass operation at 1MHz, which filter out the out of band noise
Measurement Results

**w/ CM Noise**
- Ridge to Ridge $\Delta C_{RR} = 0$ (under 0.1T glass)
- Ridge to Valley $\Delta C_{RF} = 400\mu F$ (under 0.1T glass)

**w/o CM Noise (@0.1T glass)**
- Ridge to Ridge $\Delta C_{RR} = 0$ (under 0.2T glass)
- Ridge to Valley $\Delta C_{RF} = 200\mu F$ (under 0.2T glass)

SNR: 42dB

SNR: 38dB

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Performance summary & Conclusion

<table>
<thead>
<tr>
<th>Process</th>
<th>0.18μm CMOS process</th>
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</thead>
<tbody>
<tr>
<td>Channel</td>
<td></td>
</tr>
<tr>
<td>TX: 42</td>
<td>RX: 32</td>
</tr>
<tr>
<td>SNR (dB)</td>
<td></td>
</tr>
<tr>
<td>0.1T glass</td>
<td>42 dB</td>
</tr>
<tr>
<td>0.2T glass</td>
<td>38 dB</td>
</tr>
<tr>
<td>Noise Immunity</td>
<td></td>
</tr>
<tr>
<td>10 V&lt;sub&gt;PP&lt;/sub&gt;</td>
<td>0 ~ 300kHz</td>
</tr>
<tr>
<td>20 V&lt;sub&gt;PP&lt;/sub&gt;</td>
<td>0 ~ 270kHz</td>
</tr>
<tr>
<td>Die Area (mm&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>4.3</td>
</tr>
<tr>
<td>Supply</td>
<td>3.3V</td>
</tr>
<tr>
<td>Power</td>
<td>28mW (RX)</td>
</tr>
</tbody>
</table>

- A 42dB SNR is achieved, while variation of mutual capacitor is 400aF
- A 38dB SNR is achieved, while variation of mutual capacitor is 200aF
- Display noise and lamp noise can be rejected by noise rejection techniques