Interlink Electronics
FSR™ Force Sensing Resistors™

Ring Sensor
Integration Guide

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1 Introduction

The Interlink Electronics Standard Ring Sensor is a radial position sensor for menu navigation. It functions as a rotary potentiometer with the ability to detect a user's position for scrolling and allows for a more intuitive user experience. The Ring Sensor is an easy to integrate, high resolution sensor ideal for media players, mobile phones, control panels, medical instruments and home entertainment devices. Measurement is simple enough that it can be accomplished directly with the device's host processor without the need for a dedicated microprocessor.

The purpose of this document is to guide users through the successful integration of the Interlink Electronics Ring Sensor.

2 Scope

This Integration Guide provides the OEM integrator with all of the necessary technical information to successfully integrate the Ring Sensor into products such as:

- Personal media players
- Mobile phones
- Control panels
- Medical instruments
- Home entertainment devices

Sensor part number is detailed in section 7.

3 Theory of Operation

The Interlink Ring Sensor is designed to overcome the shortcomings of a simple angular potentiometer. A normal ring-shaped potentiometer would have a ring of resistor material broken by a small gap. Electrodes on either side of the gap would be used to place a potential across the ring. Touching a wiper against the ring would bring the wiper to a potential that is proportional to angle. The problem with this arrangement is that when the wiper touches the gap, the potential is undetermined. If the wiper is broad (as it is with a finger) the wiper could touch both electrodes at once. In this case the potential on the wiper would be some kind of average of the two electrodes.

To solve this problem, the Interlink Ring Sensor has a continuous ring of resistor. Three electrodes that are separated by 120° of arc drive this ring. The method is detailed on the next page.

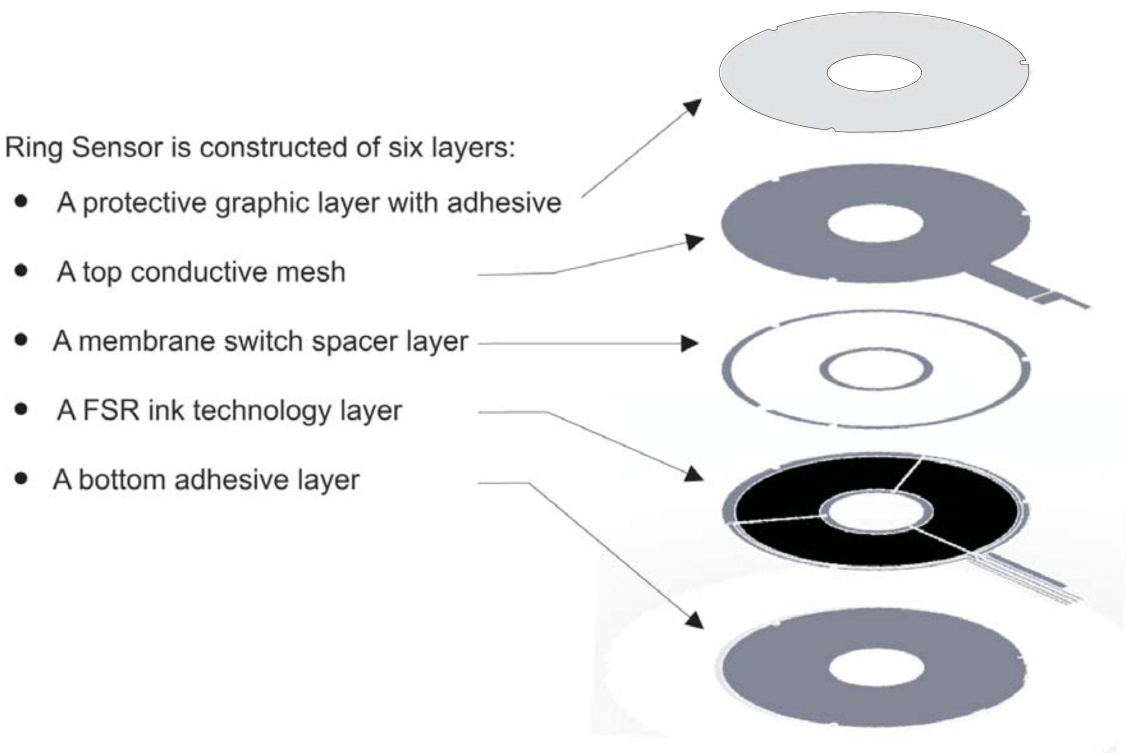


Figure 1: Exploded view of the Ring Sensor.

At any one time, the two drivelines furthest from the point of touch are being driven.

The Interlink sensor is shown schematically in Fig. 2. The sensor has four connections. Three of the connections are drivelines for the resistor ring. The fourth line is the sense line.

The algorithm for measuring this sensor is straightforward and can be implemented in any small microcontroller. Described in Section 5 is an algorithm using one eight-bit ADC and three general-purpose I/O lines. Instead of an ADC, one could also use an op-amp voltage follower and a slope converter.

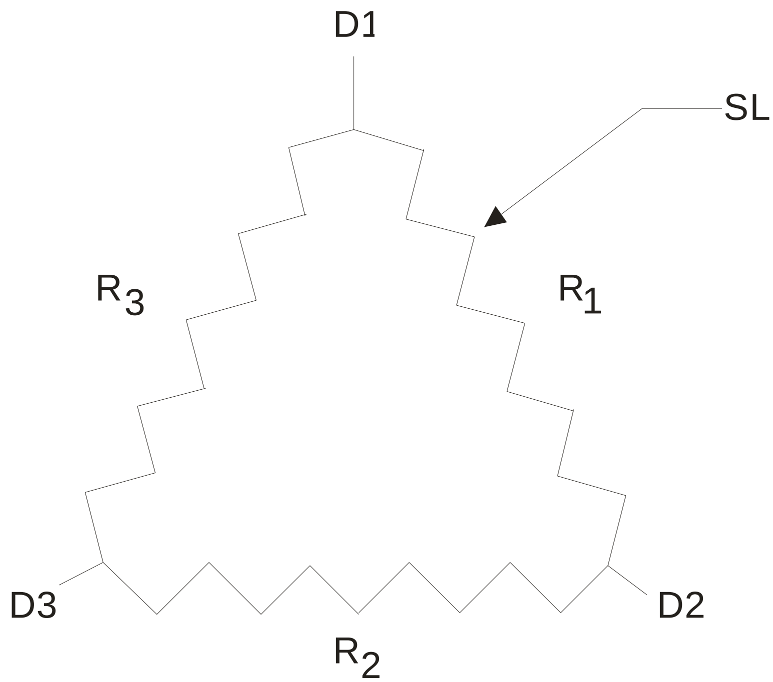


Figure 2: Schematic representation of the Ring Sensor.

4 Mounting and Connection

4.1 Mounting

There are a few critical elements to consider when mounting the Ring Sensor:

- The mounting surface should be free of any raised features (e.g. copper traces on a PCB or dust contamination) as they will interfere with the sensor's proper operation.
- If the sensor is being mounted to a PCB, it should be installed after PCB assembly is complete. Heat generated during the soldering of components can damage the Ring Sensor.
- When laminating the sensor, be sure to use a hard roller or other depression tool to ensure proper bonding of the sensor's pressure-sensitive adhesive and the removal of any air bubbles.

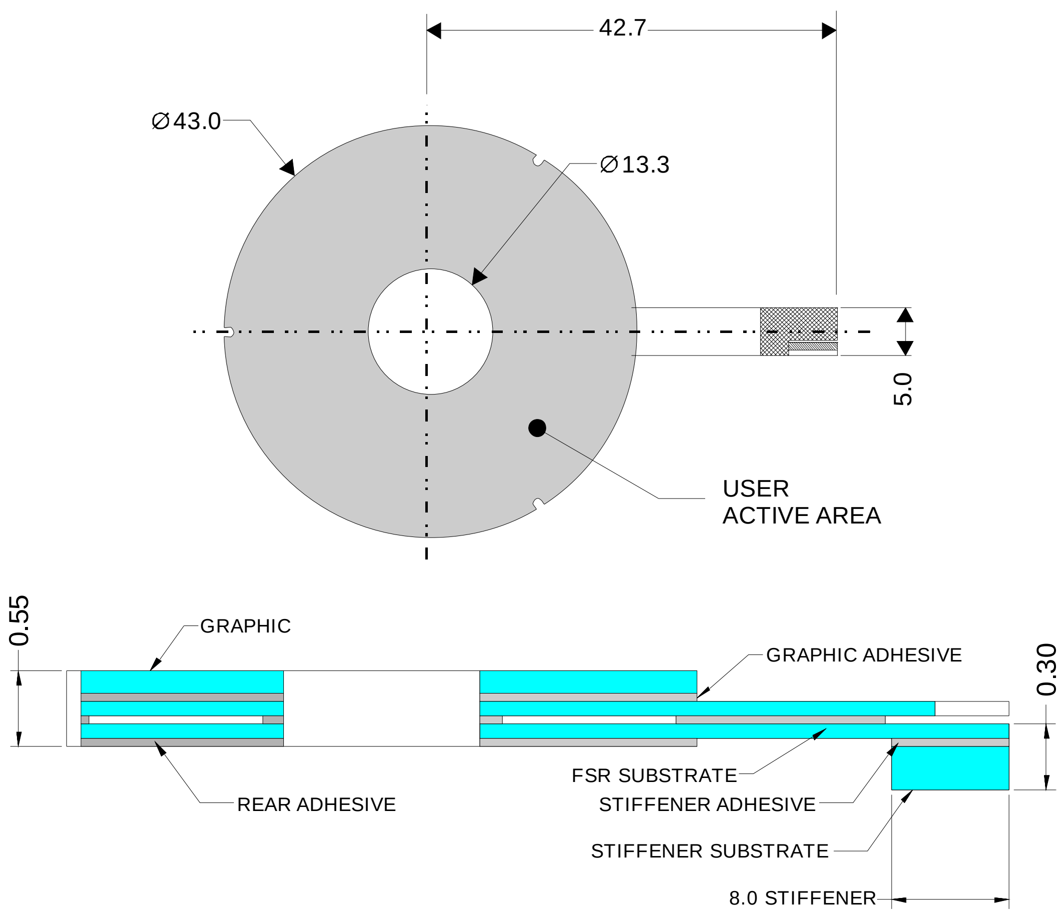


Figure 3: Overall dimensions of the Ring Sensor. All dimensions are in millimeters.

4.2 Connection

Recommended Tail Connector:
JST 4-pin SMT connector (JST Part Number: 04FM-1.0SP-1.0-TF)

Interlink recommends the above connector, but any compatible connector may be used. Note: Tail is two sided which requires a connector that has both upper and lower connections. Refer to Figures 4 for sensor tail dimensions.

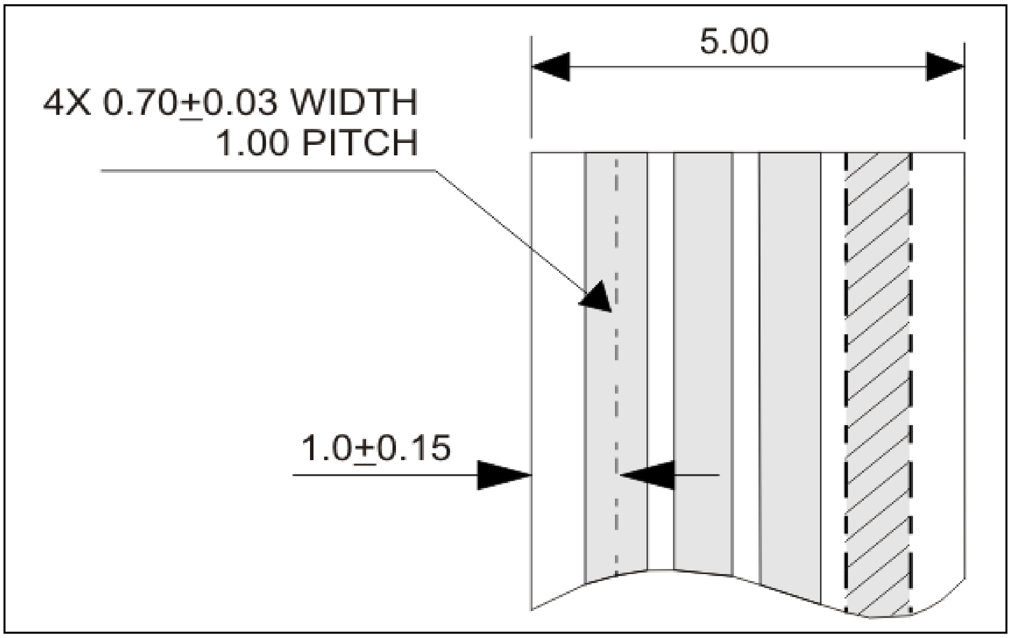


Figure 4: Top view of sensor tail. All dimensions are in millimeters.

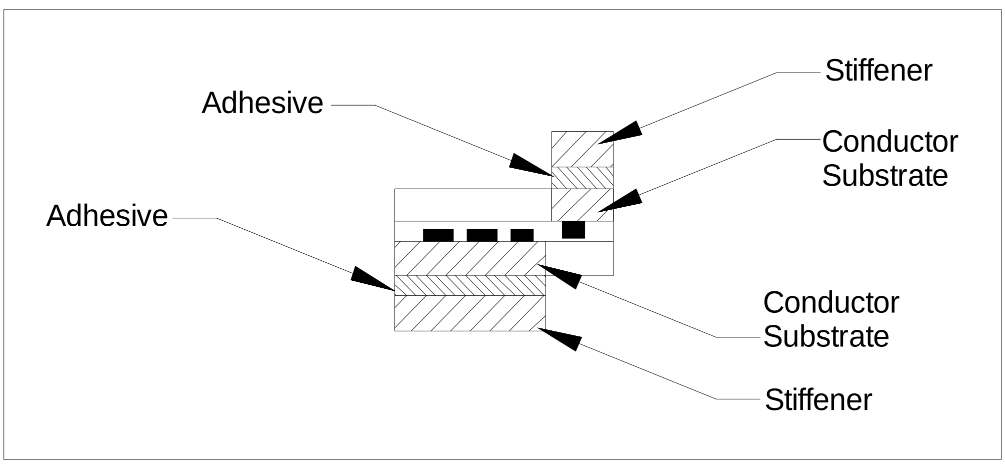
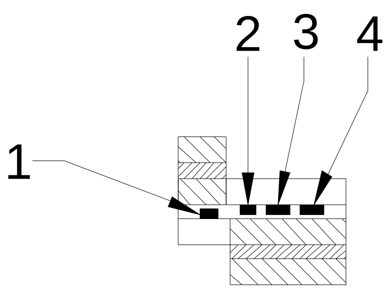


Figure 5: End view of sensor tail.

5 Measurement Techniques and Algorithms

The Interlink Electronics Ring Senor can measure radial position. The connection to the measuring microprocessor is relatively simple and requires only a few external components.



PINOUT	
PIN #	REF
1	SENSE LINE (SL)
2	DRIVE LINE 1 (D1)
3	DRIVE LINE 2 (D2)
4	DRIVE LINE 3 (D3)

Figure 6: Ring Sensor pin out.

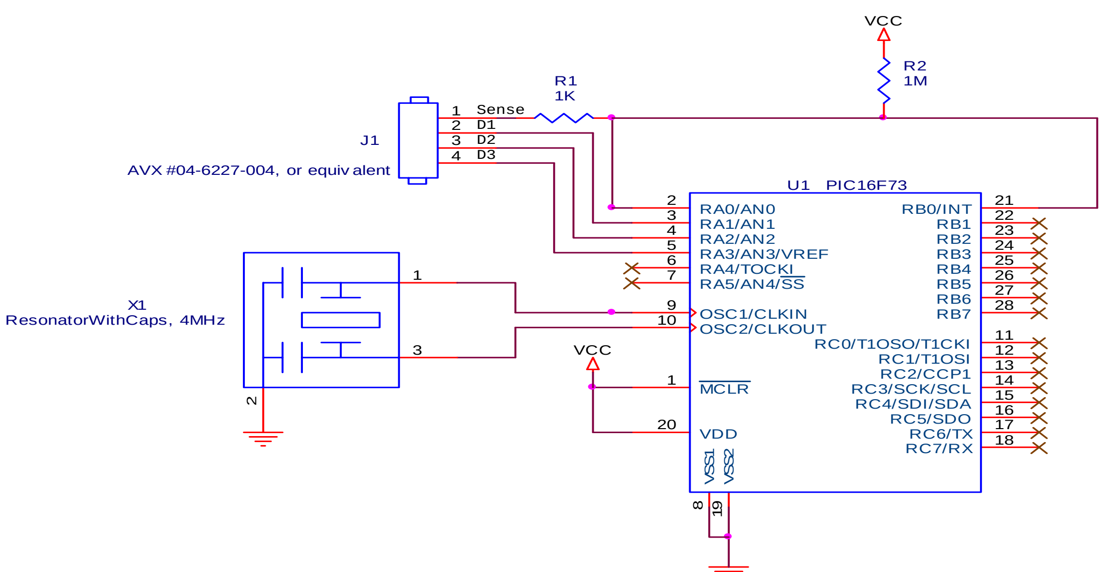


Figure 7: Circuit schematic.

5.1 Measuring Angle and Position

In the following discussion, the sensor is oriented with the tail at 12 o'clock. 0º is straight north (12 o'clock) and the angle increases clockwise. The drivelines are at 0°, 120° and 240°. It is useful to think of the ring as divided into three zones, with zone 1 defined as the 120° segment centered on D1, zone 2 as the 120° segment centered on D2, and zone 3 as the 120° segment centered on zone 3.

Determining the Touched Zone

The first part of the algorithm is to determine which zone is being touched. The goal is to determine which drive line is closest to the point of touch, so that the other two drive lines can be used in a later step to determine the precise touch location.

Finding which drive line is closest to the point of touch can be done quickly with three measurements. In each measurement, two of the drivelines are set high and one is set low. The closest driveline will be the one with the lowest ADC reading. Here are the detailed steps required for this measurement:

1. Set lines D2 and D3 high, and D1 low.
2. Measure the sense line using the ADC. Call this V1.
3. Set lines D1 and D3 high, and D2 low.
4. Measure the sense line using the ADC. Call this V2.
5. Set lines D1 and D2 high, and D3 low.
6. Measure the sense line using the ADC. Call this V3.

Then following code can be used to determine which zone is being touched:

```
if(v1<=v2)
{
        if(v1<=v3)
                zone=1;
        else
                zone=3;
}
else
{
        if(v2<v3)
                zone=2;
        else
                zone=3;
}
```

Measuring the Angle of Touch

Once the zone of touch is known, the actual angular touch position can be measured. The angle can be measured with a single measurement.

If zone 1 is being touched, then drive lines two and three will be used for the angle measurement. Similarly for zones 2 and 3; the rule is to drive the two lines that are furthest from the touch point to perform the angle measurement. Here are steps for measuring the angle if zone 1 is being touched:

1. Configure driveline D1 as an input, effectively disconnecting it from the sensor.
2. Set D3 low and D2 high (so that the potential increases clockwise).
3. Measure the sense line using the ADC. Call this Vtheta.

One could improve angular resolution by measuring Vtheta several times and accumulating the results. The calculation of the touch angle from Vtheta will be described in a later section.

Because the ADC could have a few counts of noise on it, a second measurement could be performed to “sanity check” the results. This would be exactly the same as the measurement described above, but with the drive lines set so that the potential increases counterclockwise. In the zone 1 example, this means that D2 would be set low and D3 would be set high. Call the voltage from this measurement Vtheta_inverse. One can then check that Vtheta and Vtheta_inverse are complements, as in this code example:

```
if(abs(255-v_theta-v_theta_inv)<10)
      sensor_active_flag=1;
```

If Vtheta and the complement of Vtheta_inverse are not equal to within some tolerance, then no valid touch was found.

Calculating the Touch Angle from Vtheta

The voltage Vtheta was measured by applying 256 counts over an angle of 240°. Voltage can therefore be converted to angle by multiplying by 240/256. Conveniently, 240/256 reduces to the ratio 15/16. If the touch was in zone 1, 120° must be added to the angle. If the touch was in zone 2, 240° must be added to the angle. And if the touch was in zone 3, no offset is required. Finally, the result should be checked to see if it exceeds 359°. The following code example shows the complete conversion of Vtheta to angle theta:

```
theta=(v_theta*15)/16;  //convert from voltage to angle

if(1==zone)             //Add necessary offsets
      theta+=120;
else if (2==zone)
      theta+=240;
else if (3==zone)
      theta+=0;

if(theta>359)           //sanity check angle
      theta-=360;
```

5.2 Averaging Multiple Samples

Because consecutive samples may straddle the rollover from 359° to 0°, a special trick is required for averaging multiple samples. For example a simple average of 358° and 2° would give 180° but it should give 0°.

Although several methods are possible, the following is very simple and does not require much code. In this description, theta[0] is the most recent measurement, theta[1] is the next most recent, etc.

First, calculate the average. Then compare the average with theta[0]. If the average and theta[0] are too different (we have chosen 50°), then we assume that we have encountered the zero-crossing problem. In that case, we then offset all small angles by 360 and re-calculate the average. If the result ends up greater than 359°, then subtract 360°. Here is a code example:

```
tempint=(theta[0]+theta[1]+theta[2]+theta[3])/4;
if(abs(tempint-theta[0])>50)        //If avg is weird
{
     tempint=0;
     for(loop=0; loop<4; loop++)
     {
          tempint+=theta[loop];
          if(theta[loop] < 50)      //If angle is small
               tempint+=360;  //    add 360°
     }
     tempint/=4;
}
theta_out=tempint/4;

if(theta_out>359)
     theta_out-=360;
```

6 Actuator

The Interlink Electronics Ring Sensor has a protective graphic overlay; this allows for a finger or custom stylus to be used.

7 Orderable Part Numbers

- **Hardware Development Kit (54-00024)**
  - QTY 1 Ring Sensor Demo
  - QTY 10 Ring Sensors
  - QTY 1 Ring Sensor Integration Guide
  - QTY 5 Connectors, 4 Pin
  - QTY 1 Ring Sensor Data Sheet
- **Ring Sensor, (40-24131)**

8 Intellectual Property and Other Legal Matters

Interlink Electronics holds several domestic and international patents for its Force Sensing Resistor technology. FSR and Force Sensing Resistor are company trademarks. All other trademarks are the property of their respective owners.

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