# Application Note: AZD068
# A short guide on trackpad layout

## Contents



## 1. Introduction

This document provides the reader with a brief overview of important aspects that one should be aware of when designing a trackpad. A more comprehensive document on the subject is available on request from Azoteq (info@azoteq.com).

The design of a trackpad generally consists of two activities:

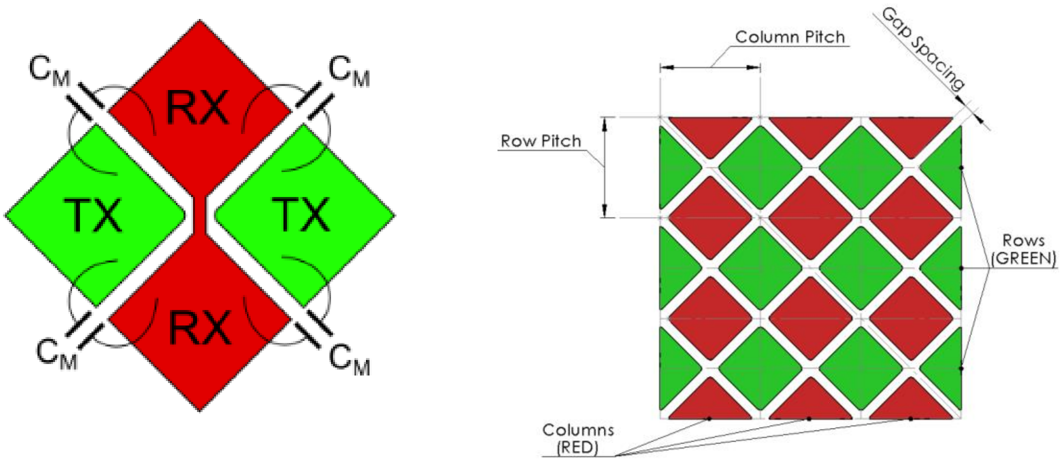
- Develop a sensor pattern using CAD software.
- Import the sensor pattern into a PCB editor, finalise the wire routing and export the manufacturing files.

## 2. Develop sensor pattern using CAD software

The following subsections describe the various aspects that should be considered when creating a sensor pattern using CAD software.

### 2.1. Sensors/Channels

A trackpad is a two-dimensional array of sensors. Each sensor consists of a TX conductor and a RX conductor that are in close proximity. Refer to Figure 1 for an illustration of a sensor and of a trackpad.




(a) Sensor/Channel (b) Trackpad

**Figure 1: Arrangement of sensors in a trackpad.**

### 2.2. Gap between diamonds

The gap between the TX and RX electrodes determines how far a signal is projected as well as the level of noise in the measured signal. A sensor with a larger gap will be able to detect a user further away but will have more noise than a sensor with a smaller gap. Typical gap dimensions are provided in Table 1.

**Table 1: Gap between TX and RX electrodes**

| | Minimum | Typical | Maximum |
|---|---|---|---|
| Gap | 0.1mm | 0.3mm | 0.5mm |

### 2.3. Spacing/pitch inside pattern

The distance between the sensors in a trackpad is referred to as the pitch. The pitch determines the range of finger sizes that can reliably be detected by the trackpad. The minimum finger diameter is approximately equal to $\sqrt{xPitch^2 + yPitch^2}$. Typical dimensions for the pitch of a trackpad are provided in Table 2.

Table 2: Sensor pitch: Distance between sensors in trackpad.

| | Minimum | Typical | Maximum |
|---|---|---|---|
| Pitch | 4mm | 5-7 mm | 8mm |

## 2.4. Ground ring

It is good practise to place an exposed (not covered by solder mask) ground ring around the trackpad. The ring can be placed on multiple layers and connected using vias to avoid building a loop antenna. The purpose of the ring is to provide ESD protection. Care should be taken to ensure that the minimum copper clearance at the board edge, as determined by the relevant manufacturing process, is adhered to.

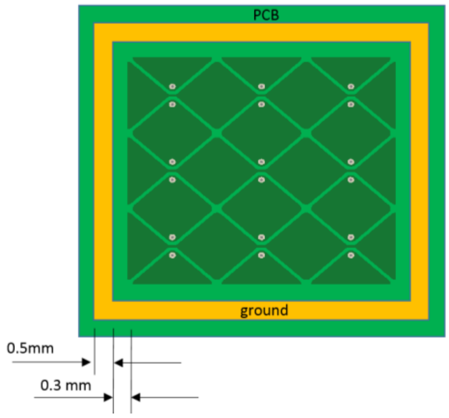


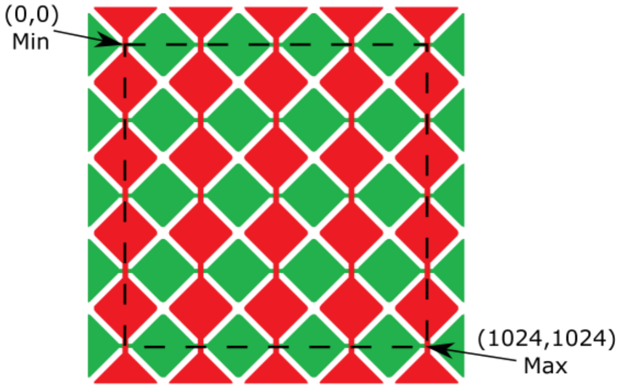

Figure 2: Illustration of a ground ring around a trackpad pattern.

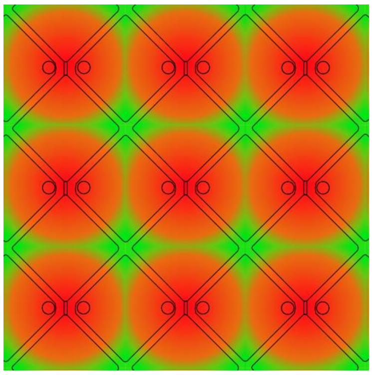
## 2.5. Sensitivity

The sensitivity of a trackpad is not uniform over the entire surface of the sensor pattern. An illustration of the sensitivity of a trackpad is provided in Figure 3 (b).

## 2.6. Active area

The active area of a trackpad is the area for which X and Y coordinates are reported. It starts at the centre of the first channel in the first row and ends at the centre of the last channel in the last row. An illustration of the active area is provided in Figure 3 (a). Note that there is always a dead band around a trackpad that cannot be used. The dead band becomes smaller as the pitch is decreased.



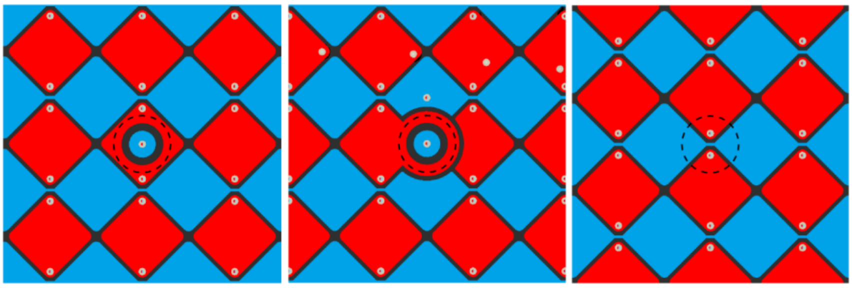



(a) (b)

**Figure 3: An illustration of the active area of a trackpad is shown in (a) and an illustration of the change in sensor sensitivity over the trackpad is shown in (b). Red is areas of high sensitivity and green is areas of lower sensitivity.**

### 2.7. Metal domes

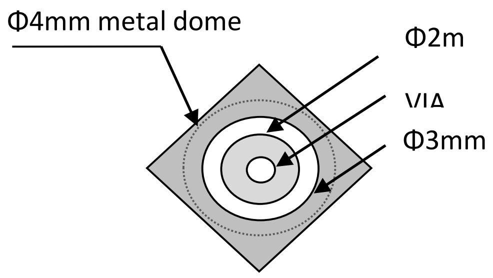
Metal domes can be placed on the sensor pattern and the action of depressing them can be detected (as the channel snap output). The metal dome should be positioned in such a way that it partially covers both a RX and a TX. The conductors must be covered by solder mask so that it is impossible for the metal dome to form a short-circuit between the TX and the RX electrodes. It is also good practice to add a thin (~0.1mm) single-sided adhesive tape over the sensor area. The placement of a metal dome on a trackpad will always degrade the performance of the trackpad. It is however possible to minimise the interference caused by the metal dome by positioning the domes at suitable locations. Suitable metal dome locations are shown in Figure 4.

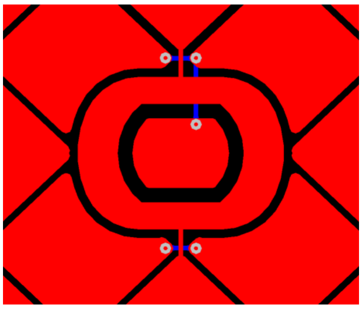


(a) (b) ( c)

**Figure 4: Possible metal dome positions on a diamond pattern arranged from best to worse. The best location is shown in (a). Note that the arrangement shown in (c) should still result in a trackpad with acceptable performance.**

The typical sensor dimensions for a metal dome with a diameter of 4mm are provided in Figure 5 (a). A metal dome can have any shape or size. It is advisable to use the smallest possible metal dome that still provides adequate haptic feedback to the user. This is because the metal dome blocks some of the fields around the sensor and a smaller dome has a smaller effect. If the metal dome is positioned on top of a single diamond, as shown in Figure 4 (a) and (b), the best course of action is to change the shape of the diamonds in the area so that the diamond beneath the metal dome still has some area that is not entirely covered by the dome. This concept is illustrated in Figure 4 (b) and Figure 5 (b).



(a) (b)

Figure 5: Dimensions for a typical metal dome button is provided in (a) and an illustration of a non-standard metal dome button is provided in (b).

### 2.8. PCBs with arbitrary outlines

A trackpad can have any arbitrary outline. It is however advisable to use a rectangular shape as this ensures that all of the channels on the edges have the same copper area and therefore similar sensitivity. Figure 6 shows the channels on a round trackpad. Channels 5 and 2 are almost non-existent and will not be very sensitive.

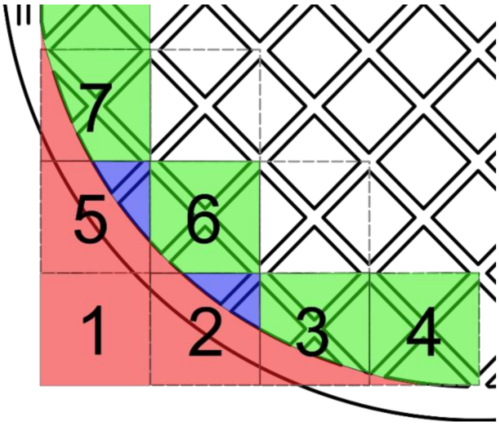


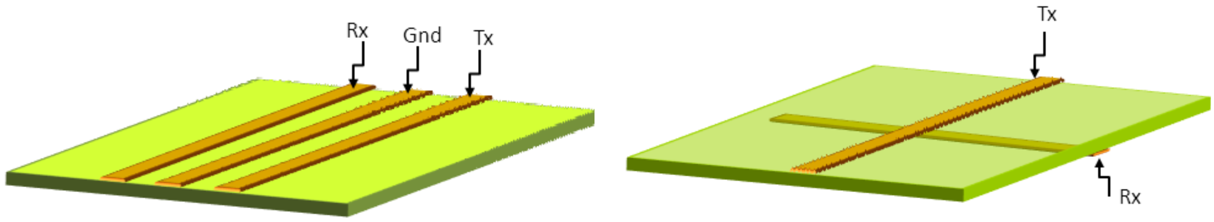

Figure 6: Diamond pattern for a round trackpad. Channels 5 and 2 will not be very sensitive and will probably have to be disabled.

## 3. Finalise trackpad in PCB editor

A sensor pattern that was created using CAD software can be exported as a DXF-file and imported into a PCB editor. The following subsections discuss the routing of the electrical connections and the placement of the IC.

### 3.1. Shielding

As mentioned earlier, a sensor is formed when a TX track is positioned in close proximity to a RX track. It follows that TX and RX tracks should be routed separately and should only come in close proximity at the actual sensor. TX and RX tracks should always be shielded from each other using ground, and should only cross each other at 90˚ angles to minimise the cross-coupling. These concepts are illustrated in Figure 7.

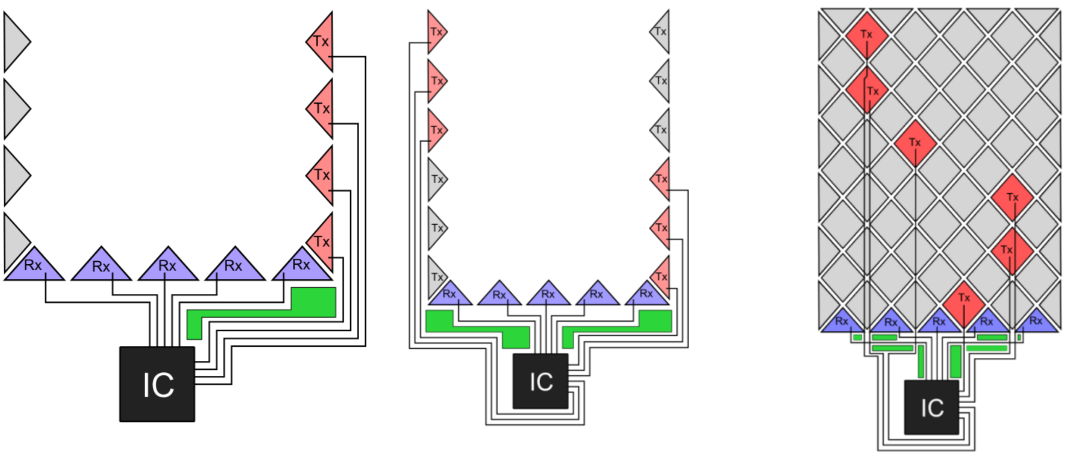



(a) (b)

Figure 7: RX and TX tracks should be shielded from each other using ground (a). When a TX and a RX track have to cross, it is preferable to cross the tracks at 90˚ to minimise the coupling.

### 3.2. Typical IC placement and routing

The IC can be positioned beneath the trackpad or outside of the trackpad. If the IC is positioned outside of the trackpad, the performance of the sensor will be better, but the sensing area will be smaller. The patterns shown in Figure 8 (a) and (b) provide the best results as they minimise unwanted cross-coupling. The pattern in Figure 8 (c) results in the largest sensor area (for a fixed PCB size), followed by the pattern in (b) and then that in (a). The pattern in Figure 8 (b) provides a good trade-off between sensor size and trackpad performance. In Figure 8 (c) it is important to note that TX tracks can only be routed beneath TX diamonds and RX tracks can only be routed beneath RX diamonds. Whenever a TX track is beneath a RX diamond, or a RX track is beneath a TX diamond, the diamond has to be cut to remove the parallel TX-RX section.




(a) (b) ( c)

Figure 8: Typical routing patterns for cases where the IC is positioned outside of the trackpad area. RXs are blue, TXs are red and ground is green. The pattern in ( c) has the largest sensor area, followed by (b) and then (a).

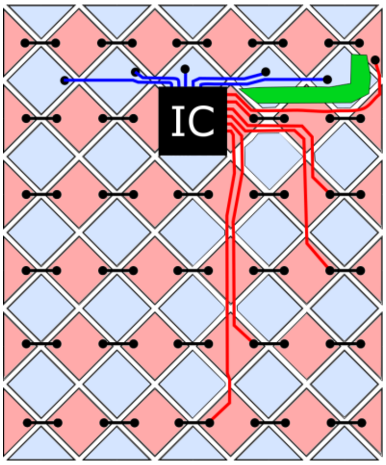



Figure 9: Advised routing pattern for situations where the IC has to be positioned beneath the trackpad area. Note that for a two-layer board the pitch cannot be smaller than the width/length of the IC.

In situations where the IC has to be located beneath the trackpad area, it is advisable to follow the pattern illustrated in Figure 9. Here the IC is positioned in such a manner that the maximum number of RX pins are located beneath a RX diamond and the maximum number of TX pins are located beneath a TX diamond. Again, TX tracks are only allowed to be routed beneath TX diamonds and RX tracks are only allowed to be routed beneath RX diamonds.

### 3.3. Connections at metal dome footprints

As mentioned earlier, a metal dome footprint contains both a RX electrode and a TX electrode. The connection for the internal pad should be as short as possible, as illustrated in Figure 10 (a). Said connection will create a section where a TX is routed beneath a RX or a RX is routed beneath a TX. Again it is advisable to cut the sensor to remove the parallel section.

### 3.4. Ground

In addition to the exposed ground ring on the sensor layer, ground should also be placed on the routing layer. The copper density of the ground depends on the distance between the sensor layer and the routing layer. The different cases are discussed below.

#### *Distance between the sensor layer and the routing layer is at least 0.6mm*

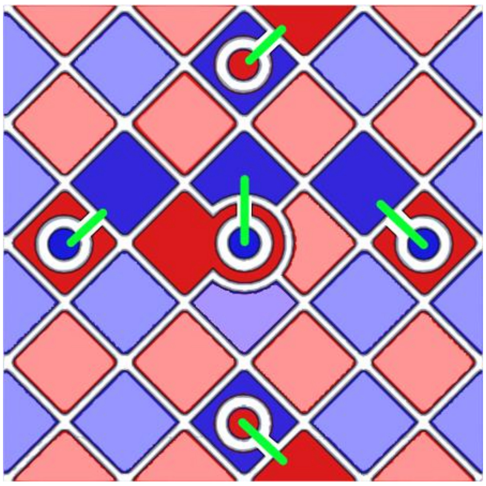
A solid ground pour can be placed on the routing layer.

#### *Distance between the sensor layer and the routing layer is smaller than 0.6mm*

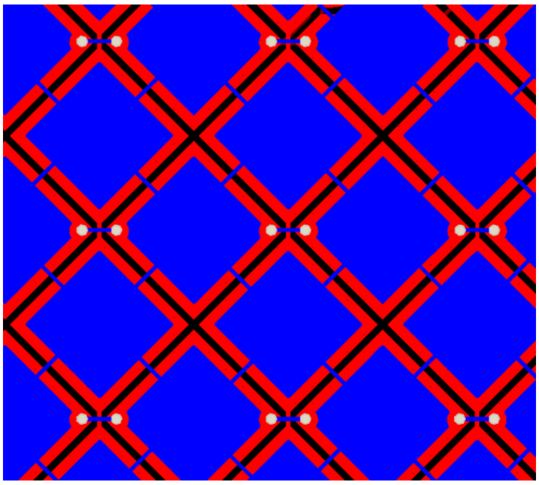
A hatched ground pour or a patterned ground should be used. A patterned ground is shown in Figure 10 (b). The idea behind a patterned ground is to remove the ground directly beneath the TX-RX gap. This ensures that the sensor will be able to detect a user further away. If the distance between the routing layer and the sensor layer is very small (<0.2mm) the ground on the routing layer can be a single track beneath the diamonds.

#### *Handheld devices with FR4 substrates*

For handheld devices it is beneficial to create a small ground island inside of the diamonds on the sensor layer to improve the coupling of a user to the ground plane of the PCB. This concept is illustrated in Figure 11.



(a)



(b)

Figure 10: Metal dome footprints with their internal pad connections are shown in (a). Note that the connections are made on a separate layer using vias and that the top layer footprint has been cut above the connecting tracks. A ground pattern is shown in (b).

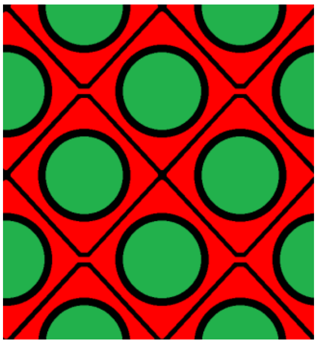


Figure 11: The technique to embed ground islands inside a sensor pattern is illustrated above. The ground islands are shown in green and the sensor electrodes are shown in red. The ground islands are connected using vias.

# 4. Mechanical stackup considerations

The overlay is an important part of any trackpad. This section briefly describes some of the different aspects that should be considered when choosing an overlay.

## 4.1 Airgaps

An overlay should not contain airgaps. If airgaps are however present they should not change in shape or size when a user operates the trackpad. The only exception to this rule is an airgap around a metal dome. The airgap around a metal dome should be minimised to the point that a user is just able to actuate the dome Care should be taken to choose a suitable adhesive so that air gaps do not form through continual use.

## 4.2 Isolation sheets

If a PCB design contains metal domes on a trackpad, it is good practice to place a PET isolation sheet between the PCB and the metal dome sticker. The use of an isolation sheet has the following distinct advantages:

- Increases the durability of the buttons (prevents a short-circuit due to continual use).
- Decreases the sensitivity to production variation of metal dome parameters (size, actuating force, etc.).

Table 3 contains recommendations for isolation sheet thicknesses.

**Table 3: Recommendation for isolation sheet thickness.**

| | Minimum | Typical | Maximum |
|---|---|---|---|
| Sheet thickness | 0.1mm | 0.14 mm | 0.2mm |

**Values are subject to the size and position of the metal domes on the diamond pattern, as well as the gap between diamonds. Larger domes and/or larger gaps between diamonds require thicker isolation sheets.**

## 5. Contact Information

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