# Application note

## Thermal/Mechanical design recommendations - IR products

## Contents

## 1. Scope

The scope of this document is to summarize all thermal and mechanical design parameters that may affect the performance of the IR sensor. The goal is to give guidelines for a good performance design, thus helps the design team to successfully incorporate a Melexis IR product into the final product.

## 2. Glossary of terms

- IR – **I**nfra **R**ed
- BB – **B**lack **B**ody (Reference source of IR radiation)
- FOV - **F**ield **O**f **V**iew
- D:S – **D**istance To **S**pot
- PCB – **P**rinted **C**ircuit **B**oard

## 3. Applications considerations

In order to get the best performance from Melexis IR products the following error sources must be taken into account

### 3.1. Thermal noise

The bigger thermal mass the sensor has the less sensitive it is to the so called thermal noise caused by the air movement around the sensor. If the device does not have factory installed metal cap, it has small thermal mass thus it is more sensitive to thermal noise. In order to reduce the noise, one should consider additional metal cap installed on top of the package (make sure the FOV is not obstructed in any way) which increase the thermal mass of the device thus considerably reducing the sensitivity of the device to thermal noise. In general when the device is installed in a concealed space the thermal noise is reduced as well.

Possible ways to minimize the impact of the thermal noise are:

- Adding additional metal cap to increase the thermal mass
- Shield the sensor from surroundings and elements.

### 3.2. Thermal gradient

For accurate measurements it is imperative that the IR device is not in a so called thermal gradient i.e. when a measurement takes place the sensor must be in isothermal equilibrium. Possible sources for thermal gradients are:

- Heating from surrounding electronics
- Heat transfer from the front of the device (touching the sensor or the surrounding plastic)
- Fast change of the ambient temperature
- Sensor is placed in a place with air draft and currents with temperature of the air fluctuating

Possible ways to minimize the impact of the thermal gradients are:

- Adding additional cap with good thermal conductivity (helps to equalize the temperature along the sensor package and “smooth” out the thermal fluctuations)
- Placed as far as possible from heat dissipating electronics or other heat sources
- Brake the thermal path on the PCB on which the sensor is installed (add slots where possible)

Make sure that the heat inside the enclosure has alternative heat escape paths than the sensor

### 3.3. Impact of the FOV obstruction

In order not to impact the accuracy of the device it is a must that the FOV is not obstructed in any way. The sensor is used behind a cover which must not be “seen” by the sensor by any mean.

## 4. Design considerations

Following design parameters and their impact over the performance are considered:

- Additional metal cap
- Air is the best thermal isolator, so air gap between metal cap and the plastic cover will reduce thermal transfer between different parts
- Front side of the sensor is most sensitive to thermal noise, so it is best to provide air gap between front side and cap, in addition to the air gab between cap and plastic cover
- Influence of the plastic cover position relative to TO metal can (FOV impact and touching the sensor obstruction)
- PCB slits around the sensor, to break thermal path from other electronics on the PCB.

Melexis does recommend using the additional metal cap (make sure the design of such comply with the design consideration stated ion this document and the datasheet).

Pros of using additional metal cap:

- Improved thermal noise performance
- Possibility to customize the shape of the metal cap i.e. it is possible to have the flange on the metal cap instead of changing the TO46 package design
- Better performance when installed in the final product as the sensor is calibrated as one whole unit
- Can be customized to match the final product design

Cons of using additional metal cap:

- Price
- Size
- Possible violation some of the recommendations

## 5. General IR sensor design proposals (considerations)

In the proposed designs hereafter we incorporate all features that help to minimize the parasitic effects thus to be able to get the best performance from the sensor:

- Metal cap (for increased thermal mass and even distribution of the temperature along the sensor package)
    - For positioning in the axial direction of the cap, top surface of the sensor is used as base. It is the contact surface between the cap and the sensor in perpendicular plane against the axis.
    - Thermal conducting glue is used between the sensor and the metal cap.

- Plastic cover
    - Protection bumps around sensor opening, to prevent touching the sensor. Minimal contact surface resulting in small thermal transfer between plastic shell and the sensor.
    - Three spacer bumps are proposed in order to align and center the sensor in the opening of the plastic cover and create an air gap for insulation.
    - In order to achieve smaller size of whole device it is possible to remove direction tap of TO package.
    - O-ring isolation is proposed in order to achieve hermeticity (in cases where need to).
- PCB
    - Sensor is soldered on separate PCB, where no thermal sources are presented, connected to the main PCB with wires, flex PCB or connector.
    - PCB slits are cut around the sensor in order to break thermal path.

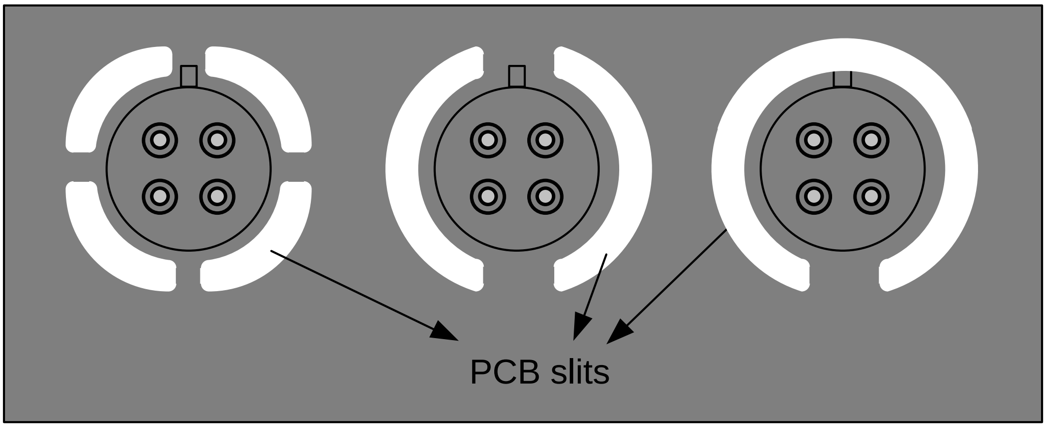


*Figure 1 Adding slits on the PCB around the sensor to cut the thermal path*

## 6. Specific Design proposals

### 6.1. Thermal gradient flux direction on PCB

#### 6.1.1. MLX90614/616

MLX90614xCx versions are gradient compensated (MLX90614xAx and MLX90614xBx are not) and this compensation works best when the sensor is oriented in a certain way in respect to the heat source. The gradient direction must be in the same direction as the tab of the sensor (see below) i.e. the sensor tap should point either to the heat source or away from the heat source and try to avoid tap to point direction perpendicular to the heat transfer (gradient).

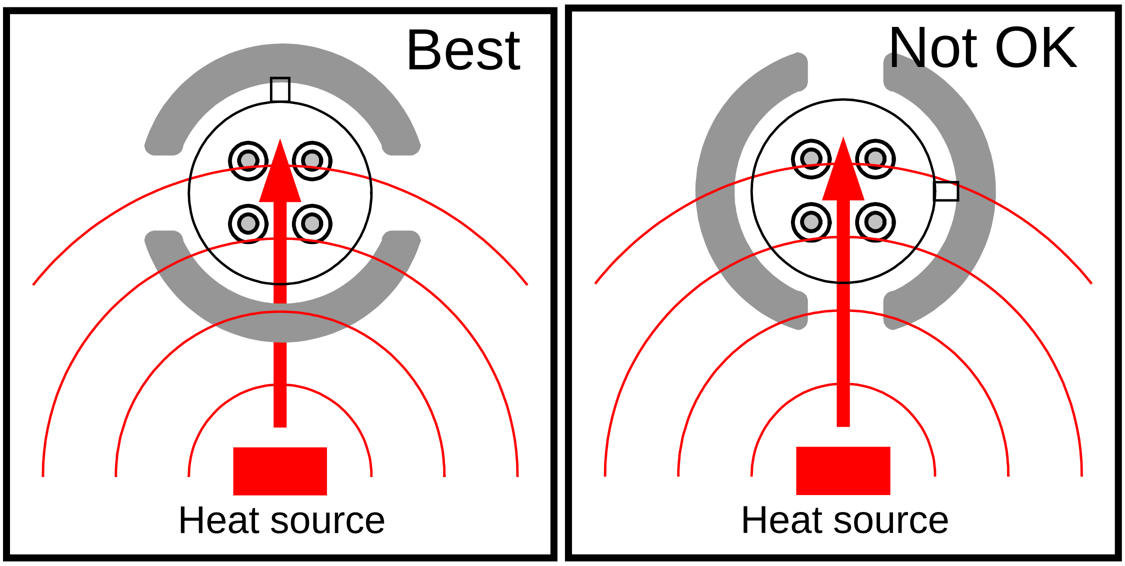


*Figure 2 Tap orientation and PCB slits in respect to the thermal gradient flux*

#### 6.1.2. MLX90615

The MLX90615Dxx does not incorporate thermal gradient compensation thus it is thermal flux direction independent i.e. there is no preferred direction of the heat source. H

However this doesn't mean that it is not prone to the thermal gradient and all measures must be taken in order to minimize the thermal gradients.

#### 6.1.3. MLX90640 / MLX90641

Although MLX90640Bxx and MLX90641Bxx do incorporate thermal gradient compensation it is thermal flux direction independent i.e. there is no preferred direction of the heat source.

However this doesn't mean that it is not prone to the thermal gradient and all measures must be taken in order to minimize the thermal gradients.

# 7. FOV and D:S

## 7.1. FOV

The definition for FOV according to the datasheet is the angle at which the IR signal drop to 50% see below.

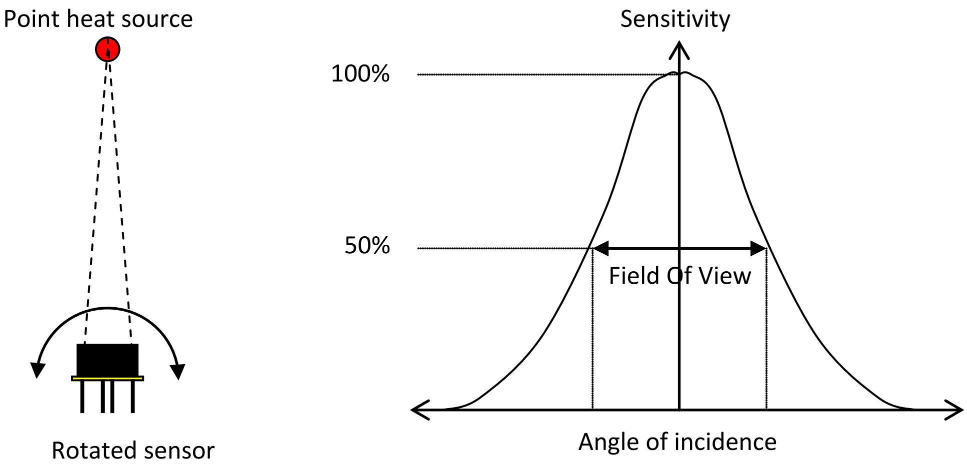


*Figure 3 FOV definition*

The most important feature on the next drawings is the angle of plastic cover is wider than the sensor FOV. It is mandatory that the plastic cover don't block the FOV. Design recommendations presented on the next drawings:

- Plastic cover to protect form surroundings. (Metal caps (where applicable) are designed and assembled by Melexis)
- Spacer bumps
- Air gaps

Hereafter the one can see Melexis recommendation and limitations for different device package designs.

NOTE: The shown designs are just for example and the one may change it according their needs observing the recommendations.

### 7.1.1. MLX90615DAA

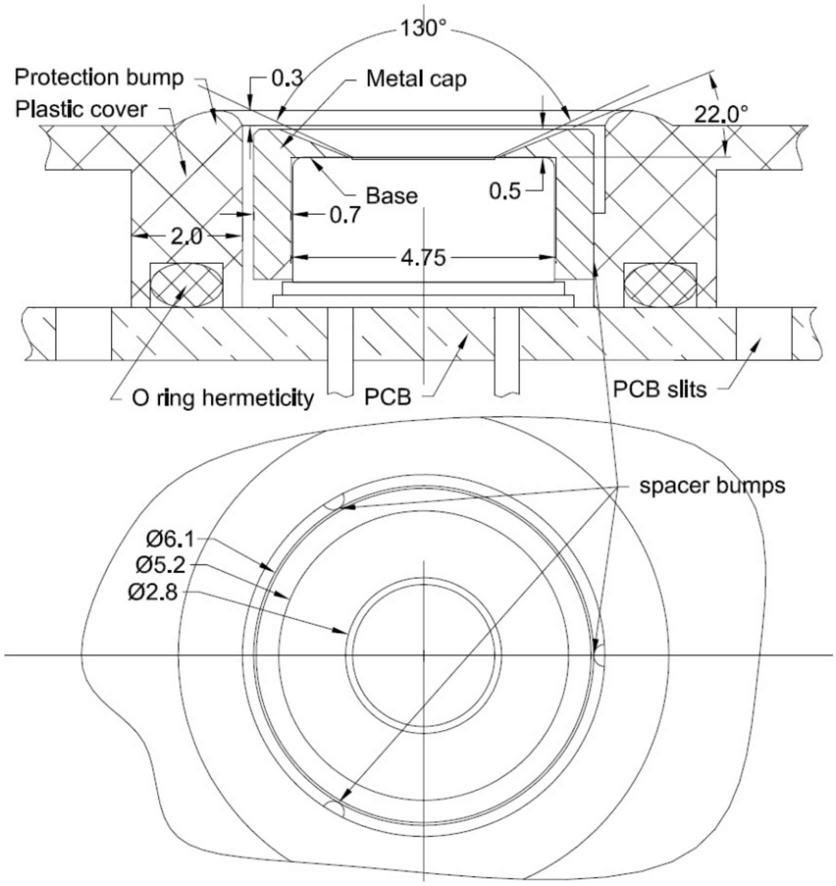


*Figure 4 Plastic shell design proposal drawing, MLX90615DAA*

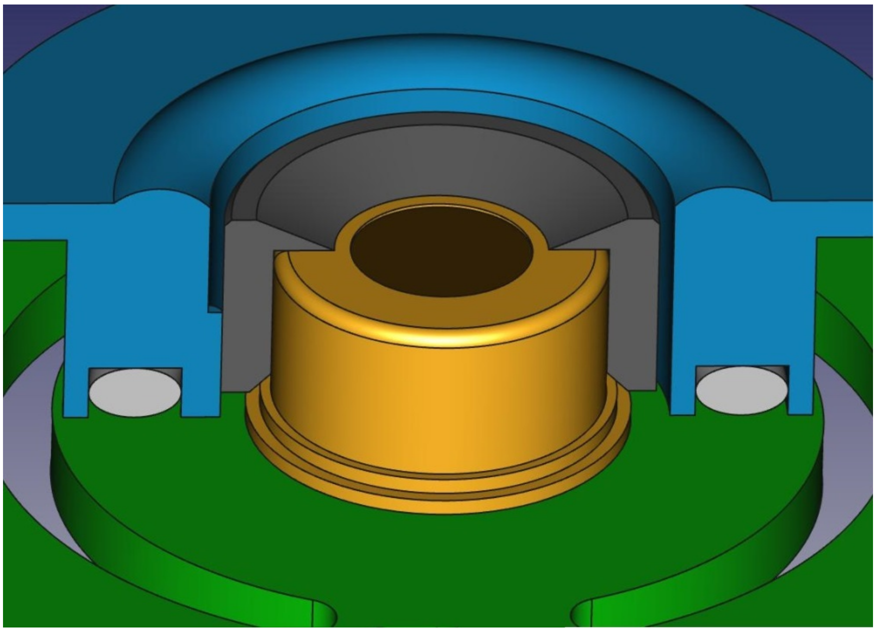

*Figure 5 Plastic shell design proposal drawing (3D view), MLX90615DAA*

### 7.1.2. MLX90615DAG

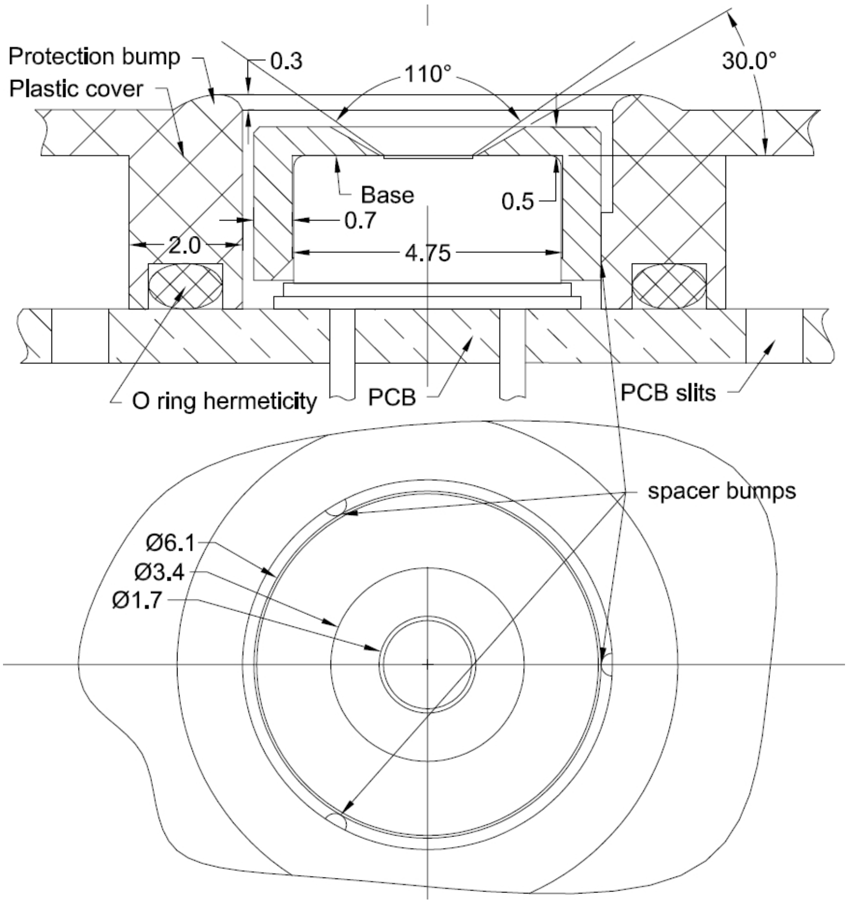


*Figure 6 Plastic shell design proposal drawing, MLX90615DAG*

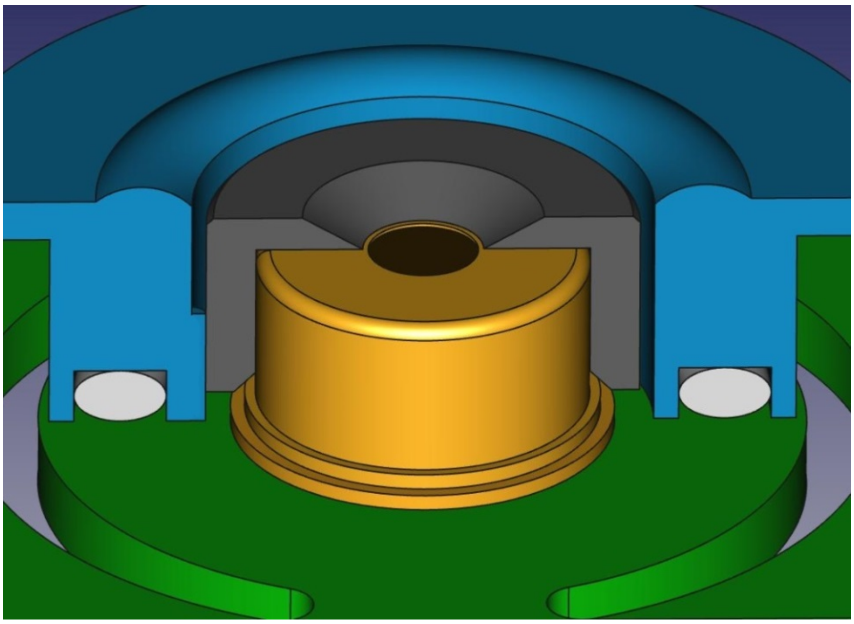

*Figure 7 Plastic shell design proposal drawing (3D view), MLX90615DAG*

### 7.1.3. MLX90614xxA

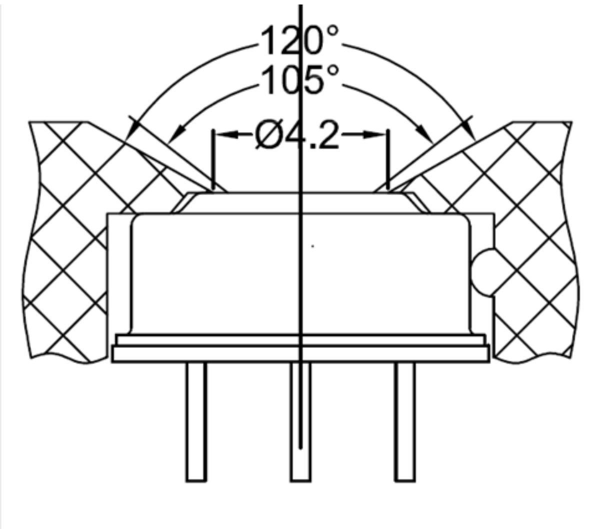


*Figure 8 Plastic shell design proposal drawing, MLX90614xxA*

### 7.1.4. MLX90614xCC

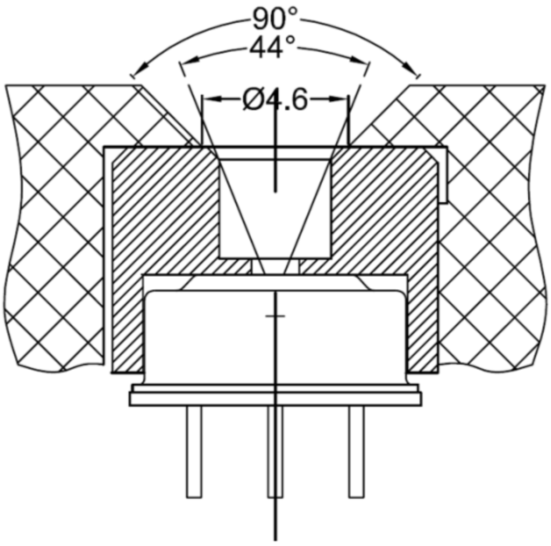


*Figure 9 Plastic shell design proposal drawing, MLX90614xCC*

### 7.1.5. MLX90614xCF/xCI

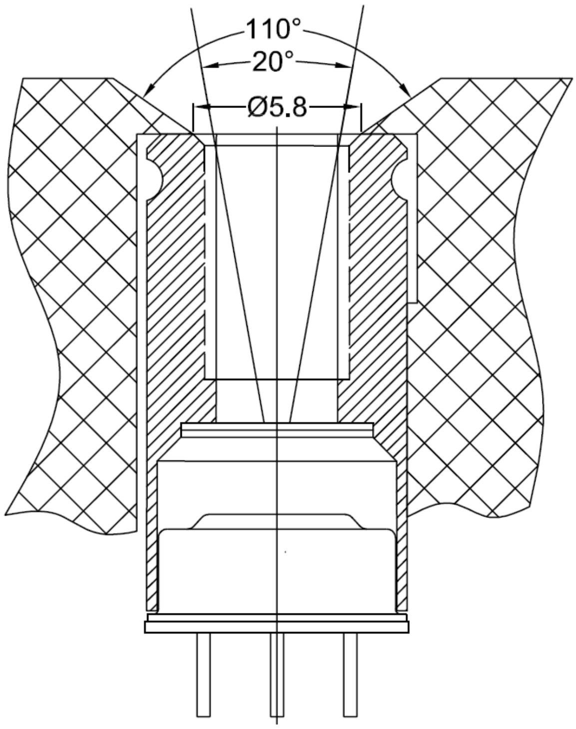


*Figure 10 Plastic shell design proposal drawing, MLX90614xCF, MLX90621BAB, MLX90640BAB and MLX90641BAB (actual drawing shows MLX90614xCF)*

### 7.1.6. MLX90621/40/41BxA

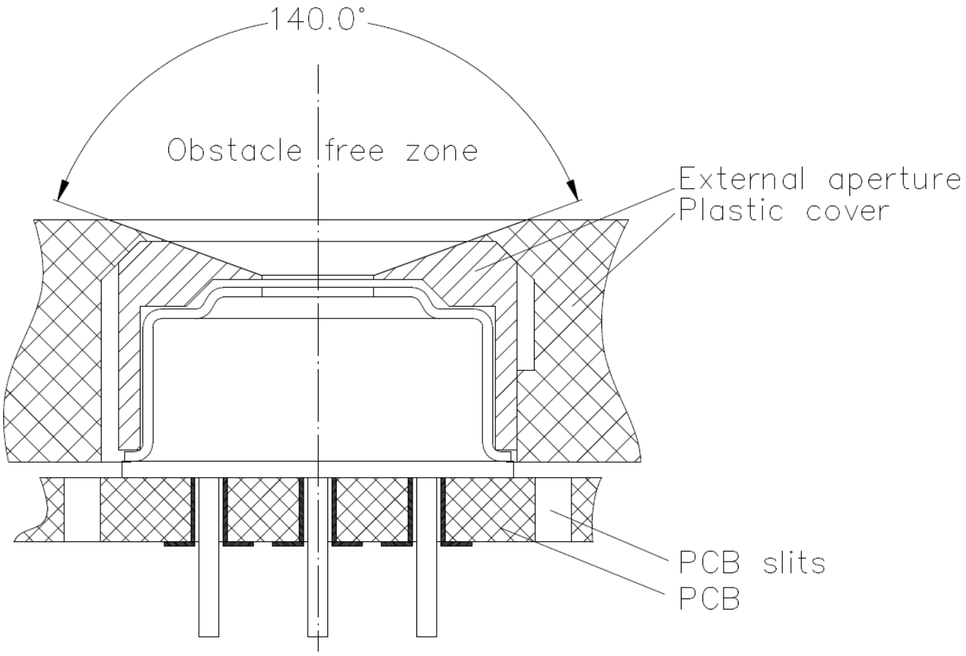


*Figure 11 Plastic shell design proposal drawing, MLX90621BAA, MLX90640BAA and MLX90641BCA*

## 7.2. Distance to spot (D:S)

Distance to spot ratio is the ratio between distance from sensor to object and the diameter of spot, which sensor “sees”. It is imperative that sensor sees only the object, i.e. there is nothing else in the spot zone, except the object.

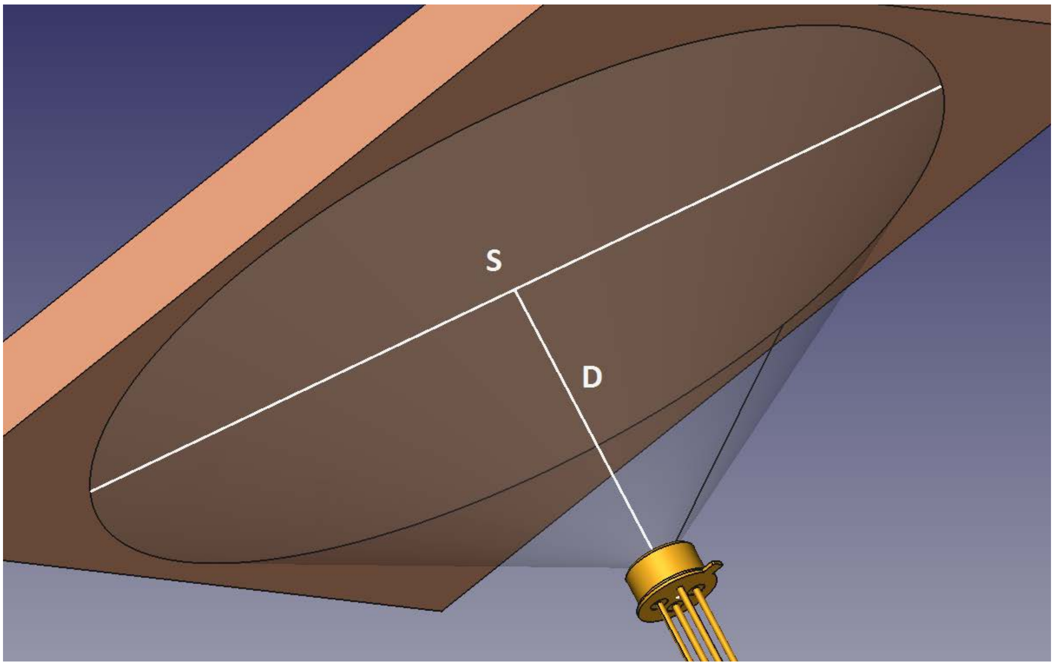


*Figure 12 Distance to Spot ratio*

Please note that used angles in this document cover 100% of the FOV (real FOV). While **FOV angles given in the Datasheet are defined as 50% signal level**. In order to get the best results, it is a must that the FOV is not obstructed in any way.

### 7.2.1. Distance to Spot of MLX90615DAA

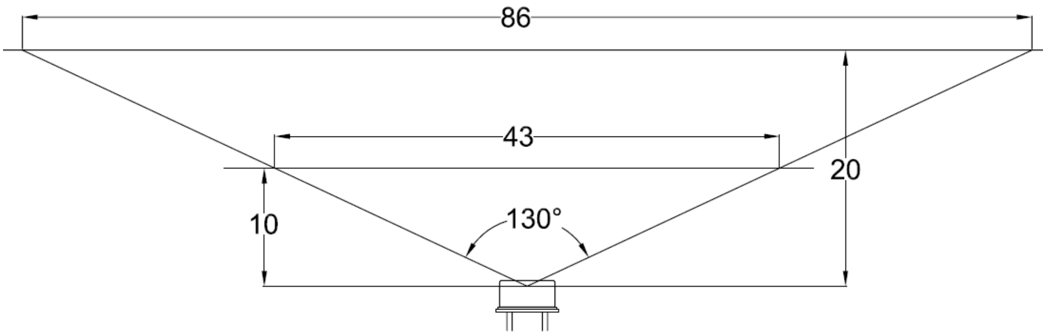


*Figure 13 Distance to Spot = 1:4.5 (MLX90615DAA)*

### 7.2.2. Distance to Spot of MLX90615DAG

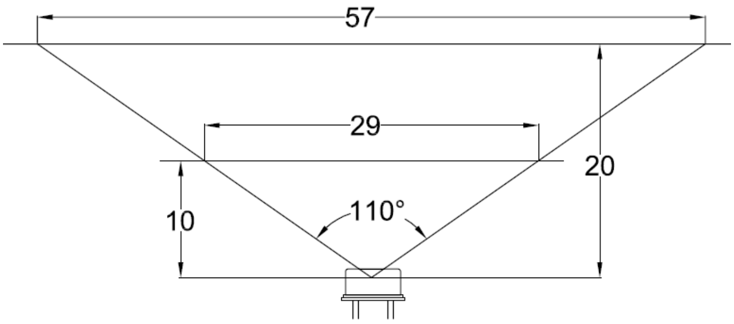


*Figure 14 Distance to Spot = 1:3.1 (MLX90615DAG)*

### 7.2.3. Distance to Spot of MLX90614xAA

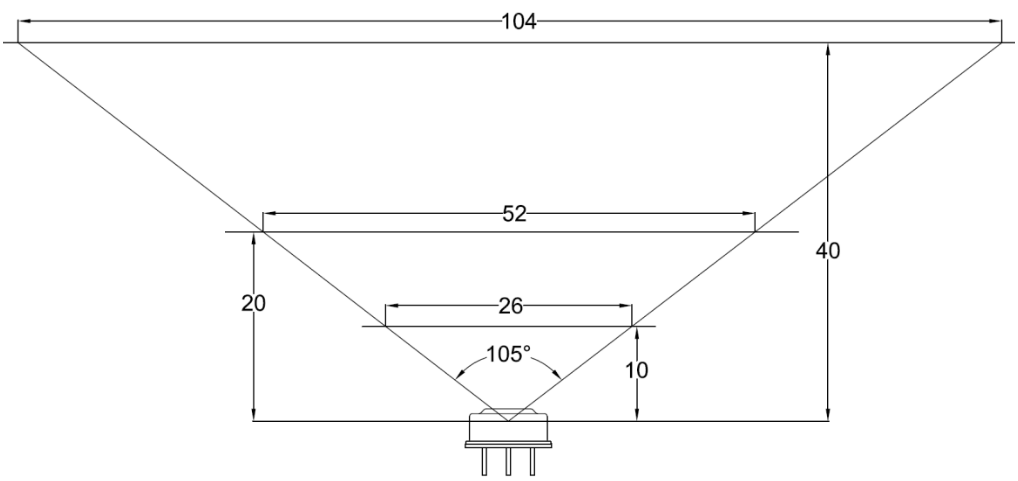


*Figure 15 Distance to Spot = 1:2.6 (MLX90614xAA)*

### 7.2.4. Distance to Spot of MLX90614xCC

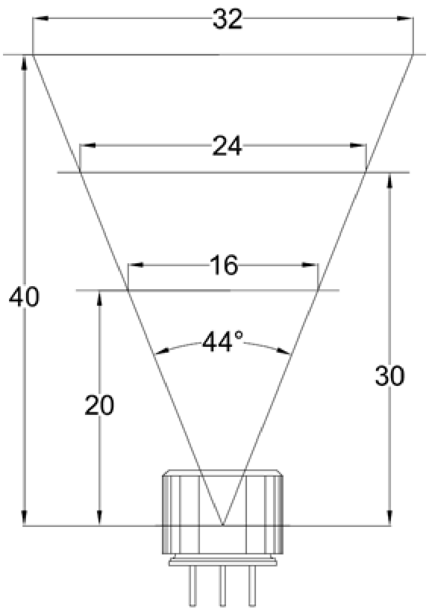


*Figure 16 Distance to Spot = 1:0.8 (MLX90614xCC)*

### 7.2.5. Distance to Spot of MLX90614xCF

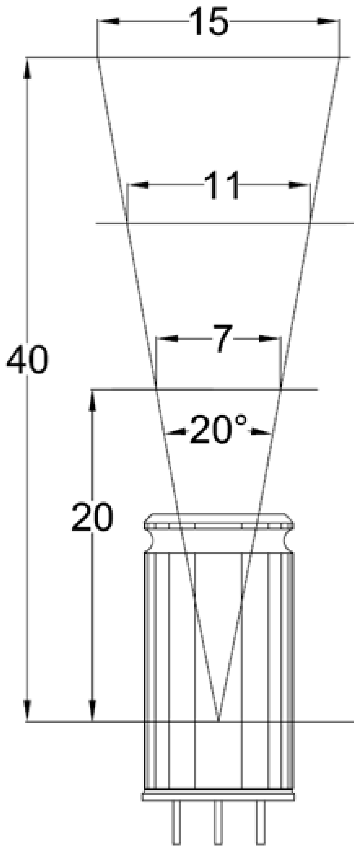


*Figure 17 Distance to Spot = 1:0.35 (MLX90614xCF)*

## 8. Related Melexis Products

This application note is applicable (as the described design considerations are mostly pure physics driven phenomenon) for following MLX products:

- MLX90614xxx
- MLX90615Dxx
- MLX90621Bxx
- MLX90640Bxx
- MLX90641Bxx

## 9. Disclaimer