MLX91220 Application Note

Thermal Management

Contents

1. Scope

The MLX91220 is an Integrated Current Sensor that senses the current flowing through the leadframe of the SOIC package. By virtue of fixing the current conductor position with respect to the monolithic CMOS sensor, a fully integrated, factory-calibrated, Hall-effect current sensor is obtained.

The current flowing through the Printed Circuit Board (PCB) trace and the Integrated Circuit's leadframe causes heating that needs to be well understood and managed through PCB layout or cooling methods.

This application note aims to provide guidelines regarding the thermal management for MLX91220 and MLX91221. For more detailed discussions on the specifics of your application, please reach your local sales representative or our Application Engineering team.

2. Current capability

2.1. Theory

Each semiconductor has a transistor junction temperature (or junction temperature): the maximum limit for the safe operation of the integrated circuit. Going above this junction temperature can create irreversible damage. Please refer to the datasheet for absolute maximum ratings. For the MLX91220 the junction temperature is $T_j = 165\,°C$.

The junction temperature depends on several variables whose effect can be difficult to dissociate. In our application, the factors are:

- The applied current I
- Air ("ambient") temperature T_A
- Package thermal characteristics related to material properties
- Printed Circuit Board Layout on which the sensor is mounted (thermal mass)
- Presence of a cooling system (extracting the heat from the thermal mass, incl the package itself)

2.2. Hardware

It is not straightforward to dissociate the sensor package's thermal characteristic from the PCB thermal characteristics. All thermal performance presented in this application note were assessed on the standard Melexis Evaluation Board for 91220. The layout is available online.[1]

The MLX91220_SOICX_EVB is built with two 105 µm copper layers and has ENIG surface finishing. This design allows to have an efficient heatsink in order to extract the heat generated inside the sensor.

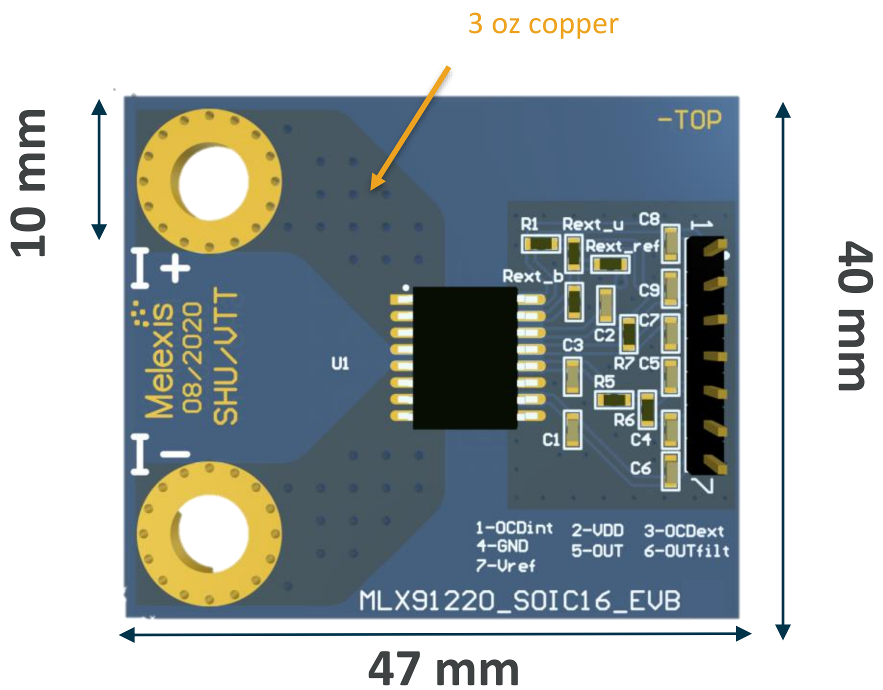


Figure 1: Evaluation board for MLX91220 SOIC-16

[1] *The thermal performances presented in the application note does not apply for the version 2 of the Evaluation Board (MLX91220_SOICX_EVB2).*

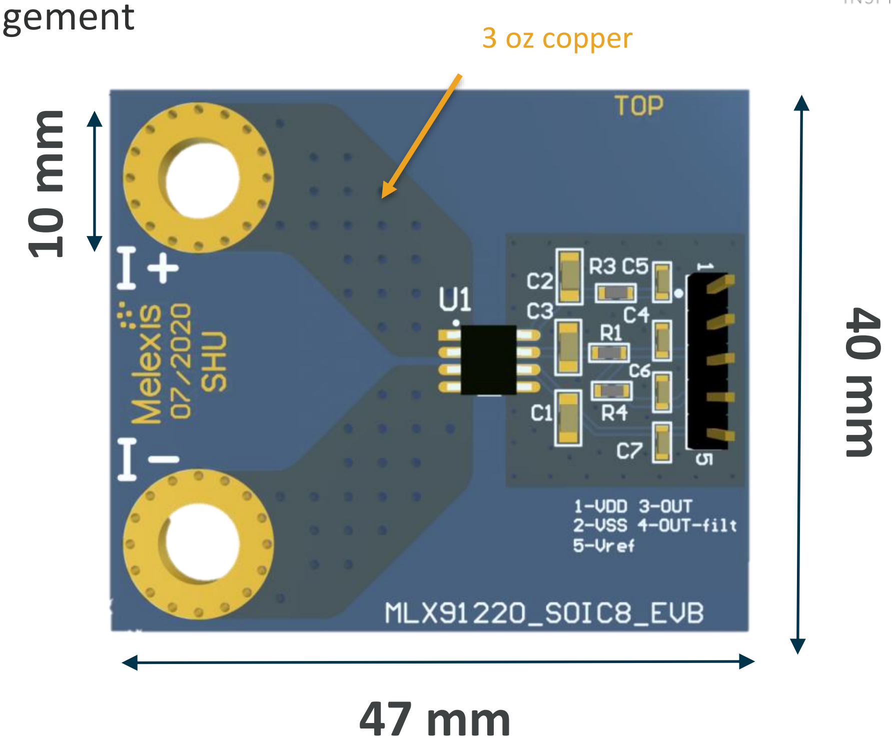


Figure 2: Evaluation for MLX91220 SOIC-8

3. Current specification

DC Operating Parameters for T_A as specified by the Temperature suffix (K).

Table 1: Current specifications based on MLX91220/1_Datasheet_rev1.0

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Electrical Resistance of the Primary Current Path	R_{IP_SOIC8} R_{IP_SOIC16}	T_A=25°C		0.9 0.75		mΩ mΩ
Measurement Range	IP_{MAX}	Option Code ABx-x10 Option Code ABx-x20 Option Code ABx-x25 Option Code ABx-x30 Option Code ABx-x38 Option Code ABx-x50 Option Code ABx-x75		10 20 25 30 38 50 75		A A A A A A A
Nominal Current	IP_{NOM}	Option Code ABx-x10 Option Code ABx-x20 Option Code ABx-x25 Option Code ABx-x30 Option Code ABx-x38 Option Code ABx-x50 Option Code ABx-x75		4 8 10 12 15 20 30		A A A A A A A
Linearity Error	NL	Current in range IP_{NOM}, T_A=25°C			±0.3	%FS
Linearity Error	NL	Current in range IP_{MAX}, T_A=25°C			±0.6	%FS
Current Capability Error! Reference source not found.	IP_{C85_SOIC8} IP_{C25_SOIC8}	Continuous, T_A=-40 to 85°C Continuous, T_A=25°C			±25 ±35	A A
	IP_{C85_SOIC16} IP_{C25_SOIC16}	Continuous, T_A=-40 to 85°C Continuous, T_A=25°C			±30 ±40	A A

Modeling & simulation

Figure 4 and Figure 3 display the combined effect of current and ambient temperature on the value of Junction Temperature. These values have been assessed on the Melexis evaluation board with 3 oz of Copper on 2 layers (cf. 2.2 Hardware), and form the steady state thermal situation after several minutes of settling time without forced airflow or other active cooling mechanisms in place. Although the linear measurement range is wider, the steady-state current should be chosen such that it does not bring the junction temperature above the operating temperature range. Having the heatsink designed such that it can extract the heat generated inside the sensor extends the maximum current capability.

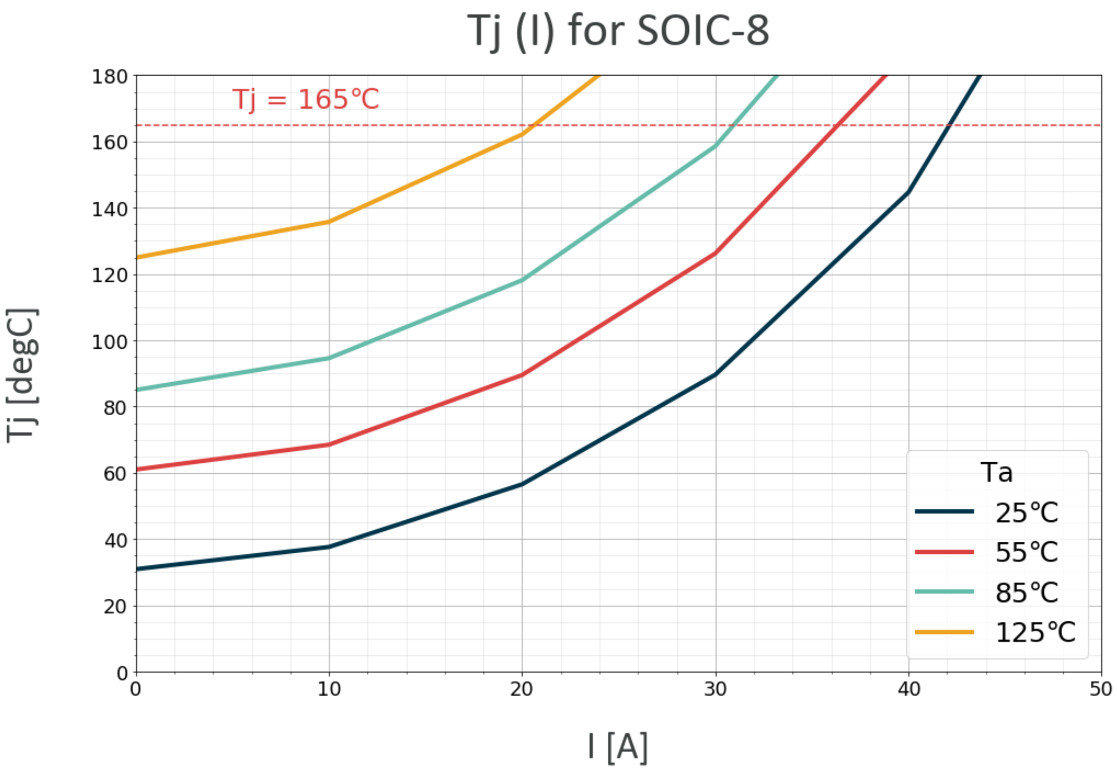


Figure 3: Typical junction temperature [°C] on SOIC8 vs applied current [A] and ambient temperature [°C].

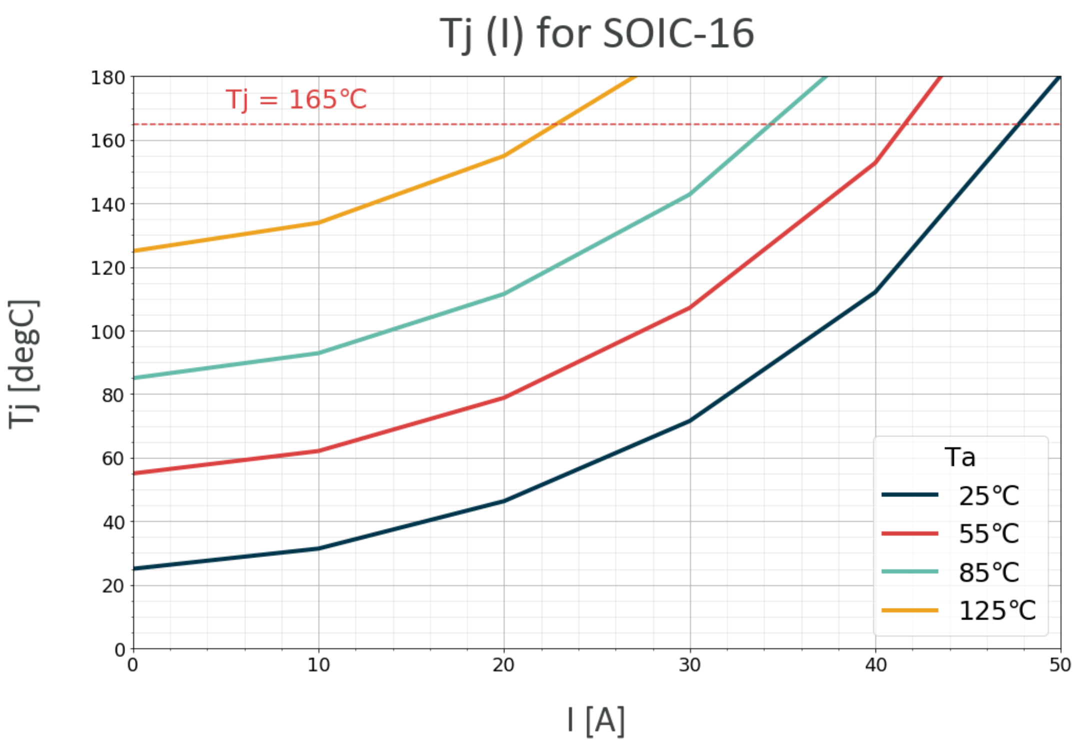


Figure 4: Typical junction temperature [°C] on SOIC16 vs applied current [A] and ambient temperature [°C].

4. General recommendations for PCB design

PCB design is a key aspect of thermal management. It is essential to have a layout with low thermal resistance, hence a better heat dissipation and a lower self-heating of the MLX91220. It is also recommended to use thermal vias.

The self-heating of the sensor affects its overall performances (sensitivity & offset drifts) and can be destructive if the junction temperature exceeds 165 °C.

Copper trace thickness recommendations:

1. Using at least one single 105 µm (3 oz) trace.
2. Using at least two 70 µm traces (2x 2oz), linked by many vias, uniformly distributed. Tracks must be aligned on top of each other.
3. 35 µm plating thickness are recommended.

5. Current capability with fixed temperature at primary pins

At application level, it can be difficult to assess the thermal junction value of the sensor for a new PCB design. It is easier to control the temperature of a specific location on the PCB. In this section,current capability of the sensor will be presented for a fixed primary pin temperature.

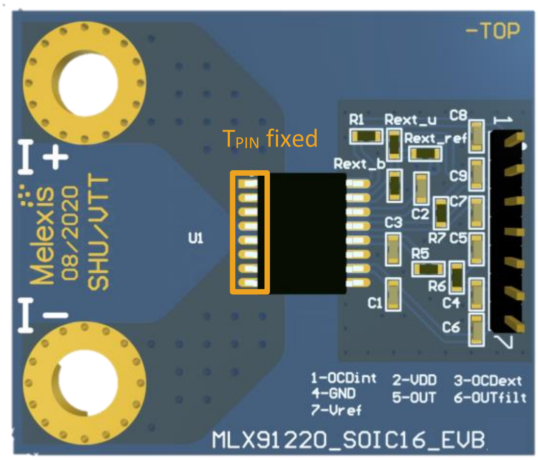


Figure 5: T_{PIN} fixed on MLX91220_SOIC16_EVB

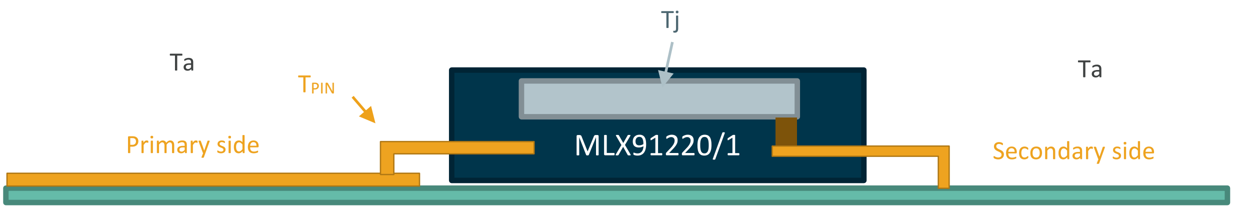


Figure 6: Temperature point on application PCB

Please note that the results are based on an ideal heat sink. It is unlikely for most application to be able to keep 25 °C on the primary side while 100 A is flowing through the PCB (cf. Figure 9) so the results must be interpreted with the correct understanding of the thermal environment. We advise you to:

1. Determine the max (continuous or RMS) current of your application
2. Determine the maximum temperature you would reach on T_{PIN} on the primary side
3. Confirm with the graphs below that you are in a safe zone.

5.1. T_{PIN} = 25 °C

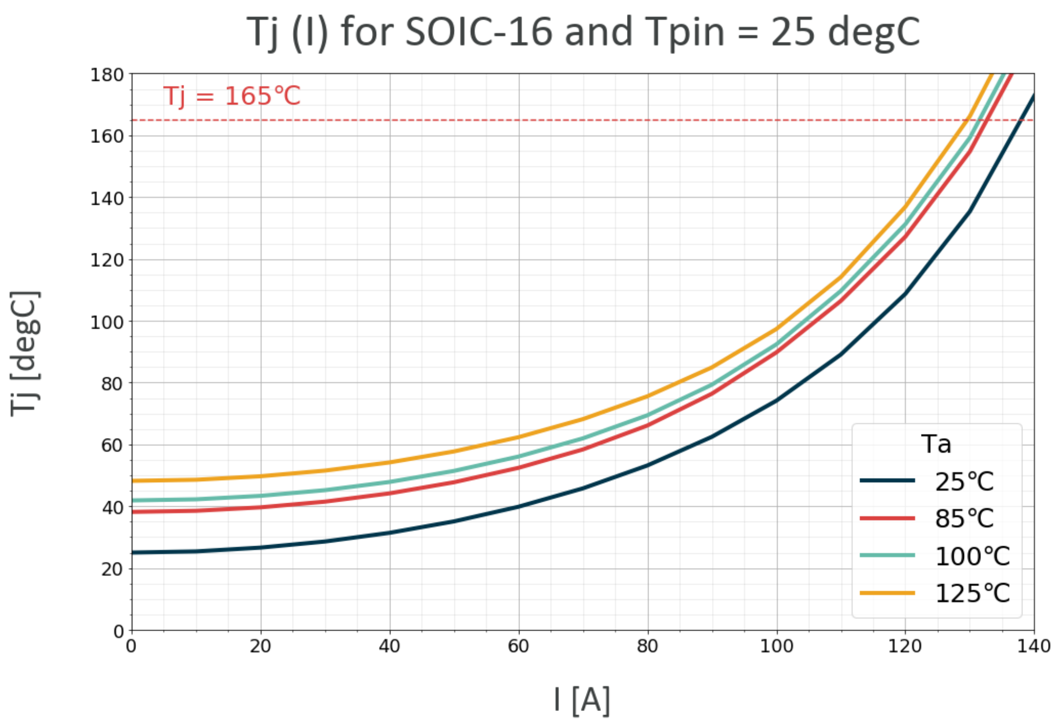


Figure 7: Typical junction temperature [°C] on SOIC16 vs applied current [A] and ambient temperature [°C] with T_{PIN} = 25 °C

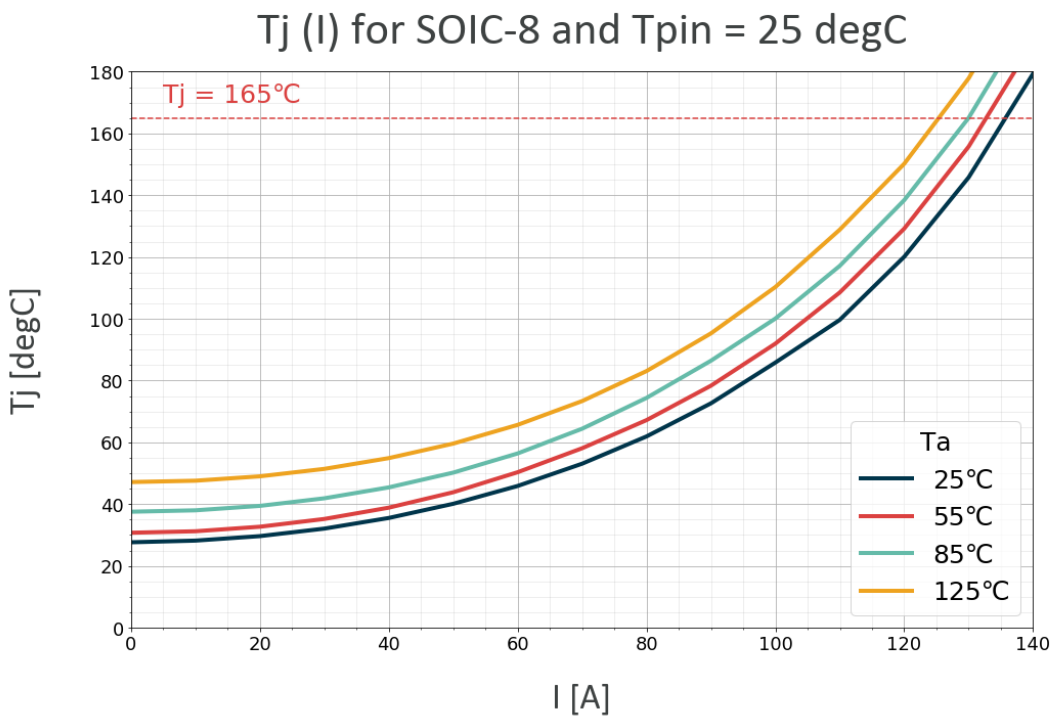


Figure 8: Typical junction temperature [°C] on SOIC8 vs applied current [A] and ambient temperature [°C] with T_{PIN} = 25 °C

5.2. T_{PIN} = 55 °C

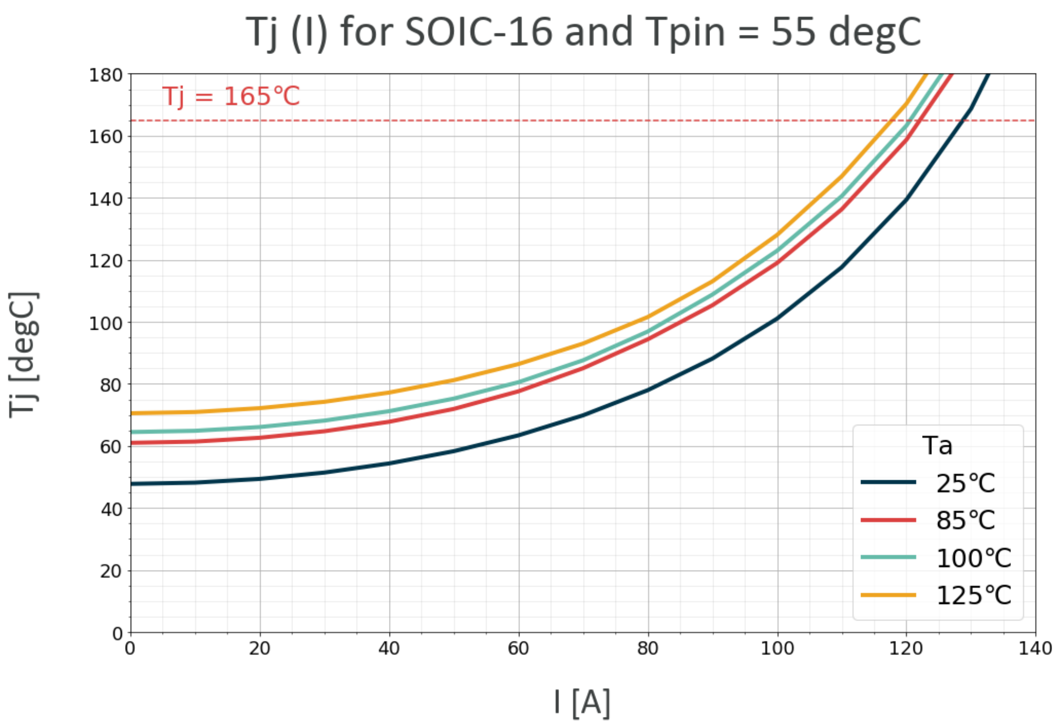


Figure 9: Typical junction temperature [°C] on SOIC16 vs applied current [A] and ambient temperature [°C] with T_{PIN} = 55 °C

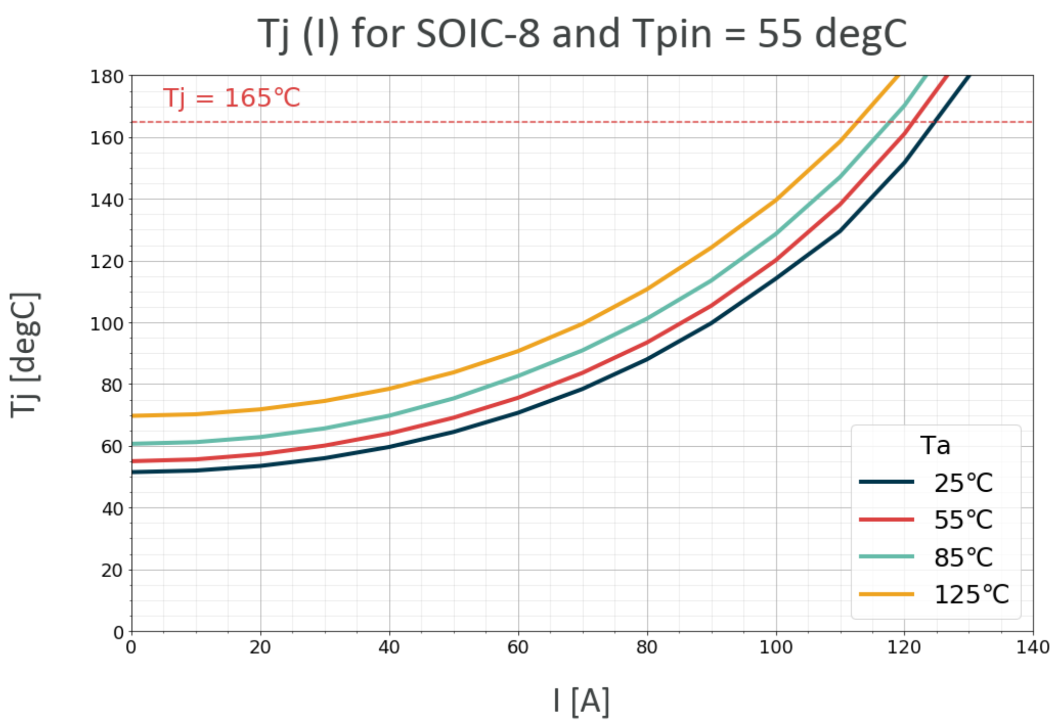


Figure 10: Typical junction temperature [°C] on SOIC8 vs applied current [A] and ambient temperature [°C] with T_{PIN} = 55 °C

5.3. T_{PIN} = 85 °C

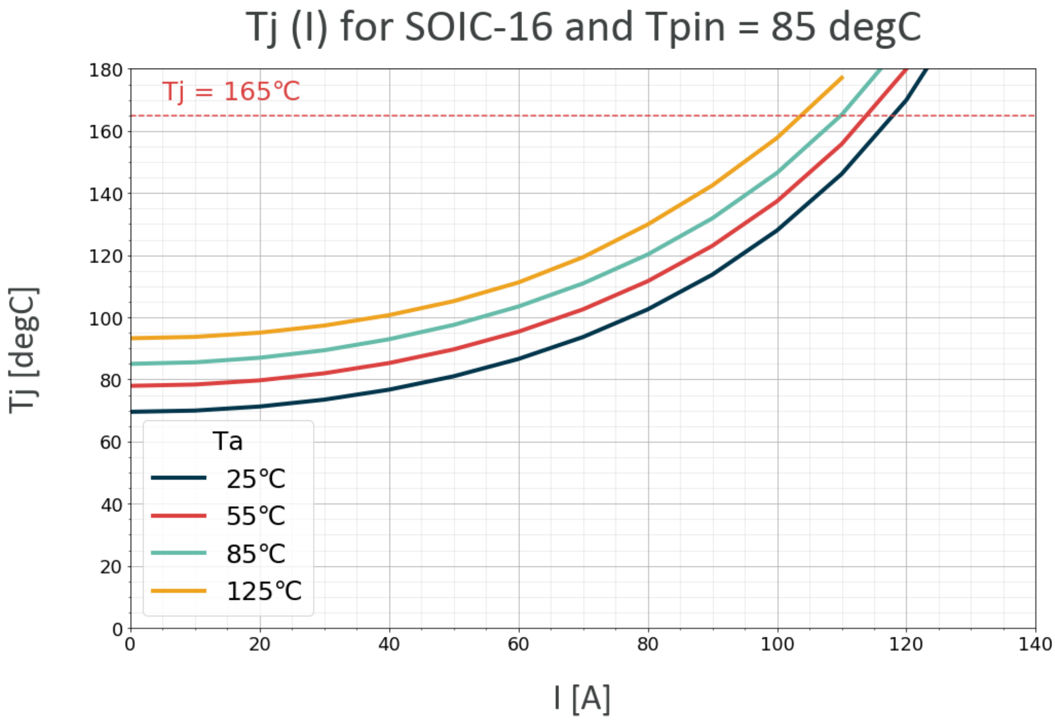


Figure 11: Typical junction temperature [°C] on SOIC16 vs applied current [A] and ambient temperature [°C] with T_{PIN} = 85 °C

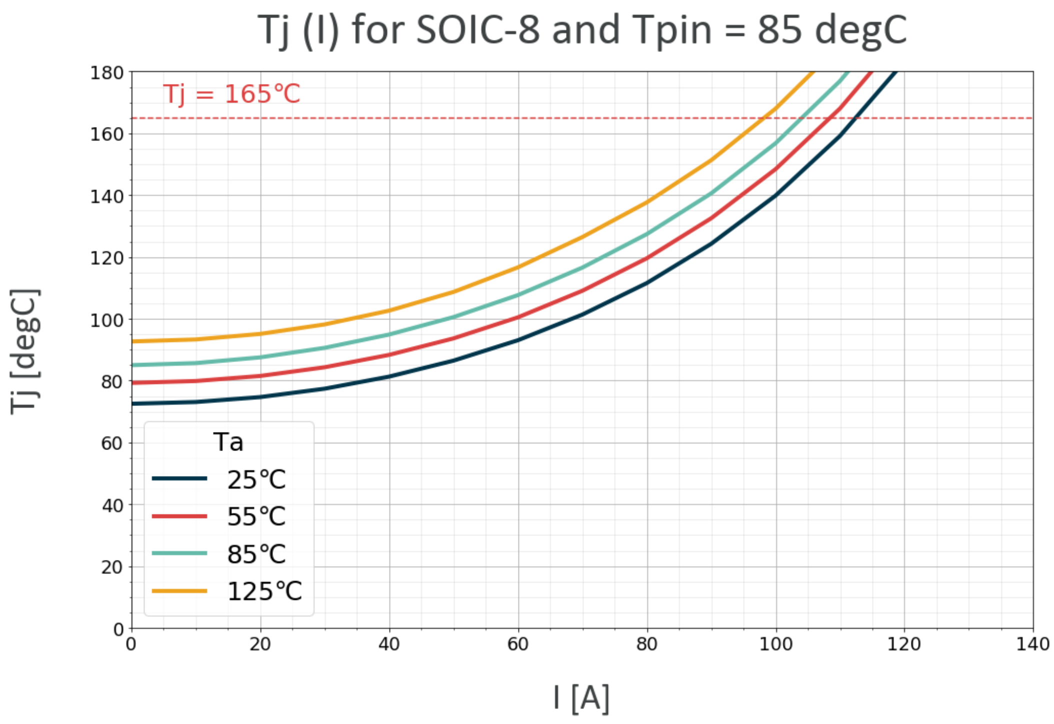


Figure 12: Typical junction temperature [°C] on SOIC8 vs applied current [A] and ambient temperature [°C] with T_{PIN} = 85 °C

5.4. T_{PIN} = 125 °C

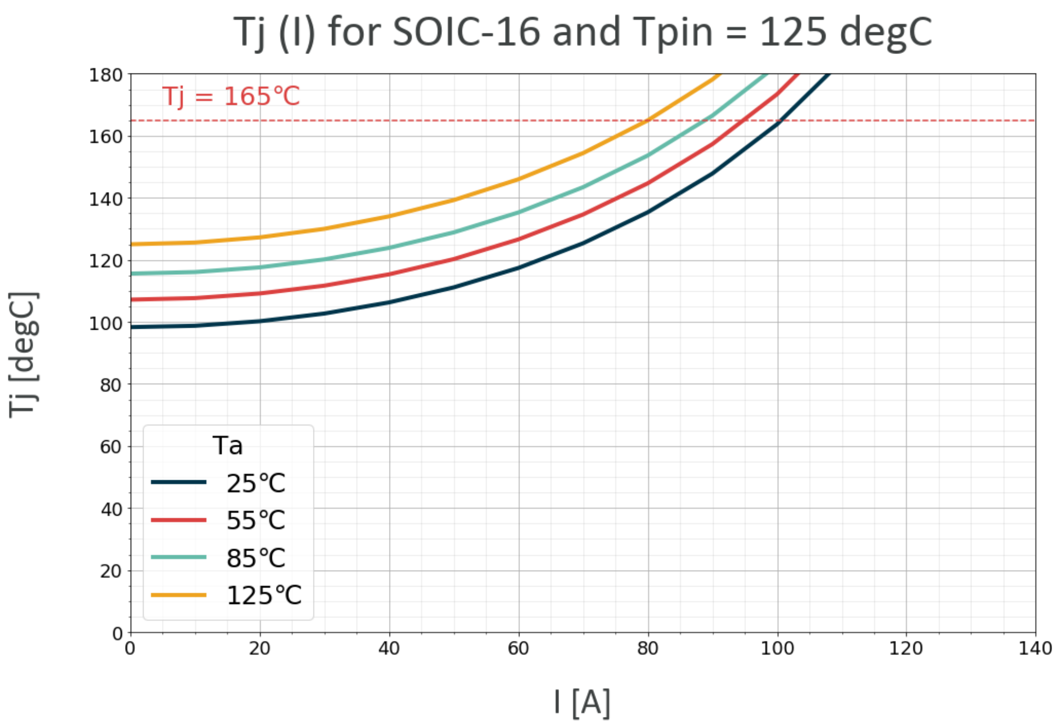


Figure 13: Typical junction temperature [°C] on SOIC16 vs applied current [A] and ambient temperature [°C] with T_{PIN} = 125 °C

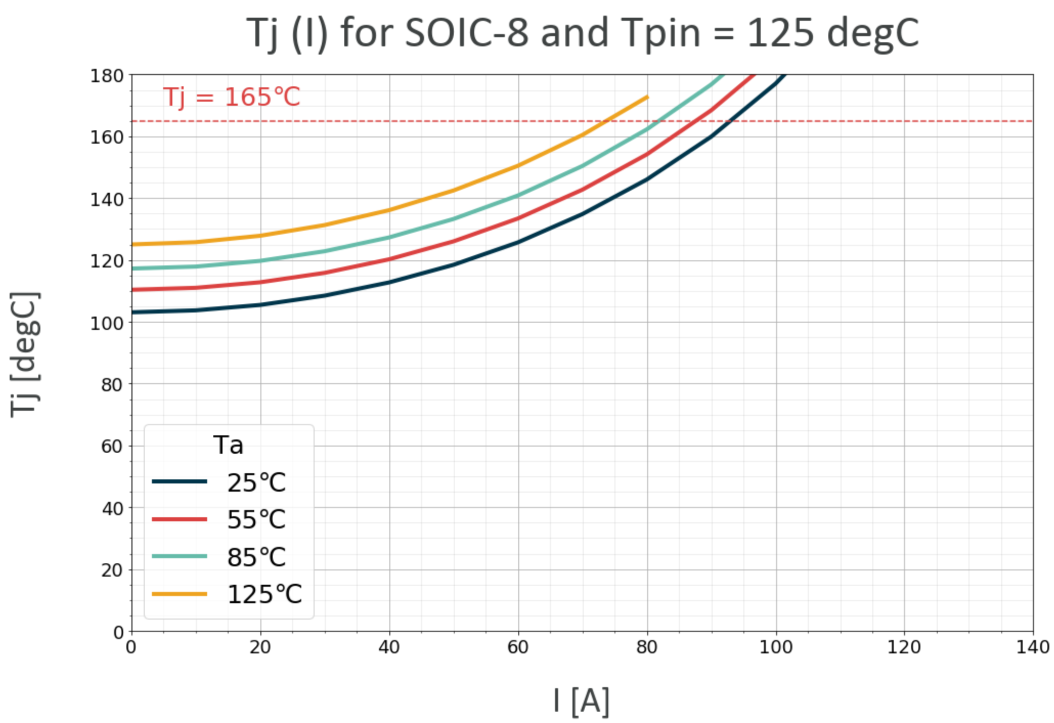
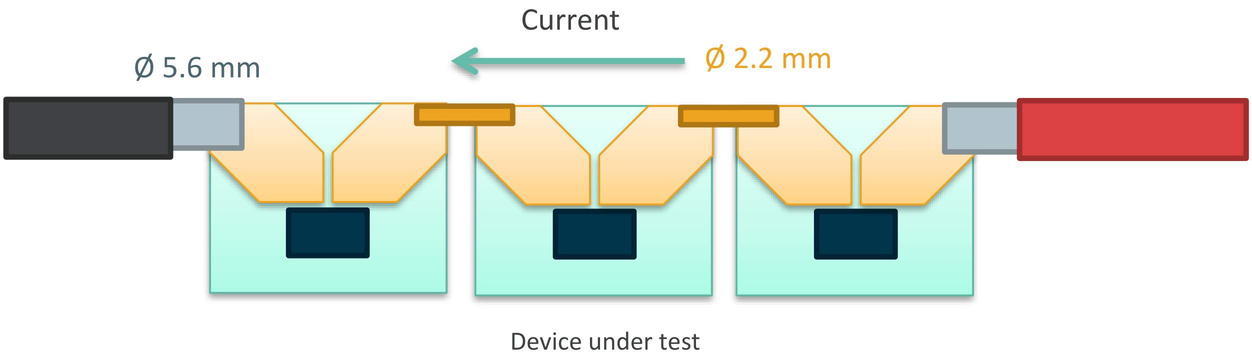


Figure 14: Typical junction temperature [°C] on SOIC8 vs applied current [A] and ambient temperature [°C] with T_{PIN} = 125 °C

6. Measurements

6.1. Setup

Beyond the Printed Circuit Board design, the way the current source is connected to the Printed Circuit Board is also important. A thick cable (thermally equivalent to a bigger heatsink) will dissipate heat better than a thin cable resulting in a lower junction temperature at the sensor level. To have measurements independent of the effect of the setup, we have connected our Device Under Test to thin cables as shown in the image below.



6.2. Results

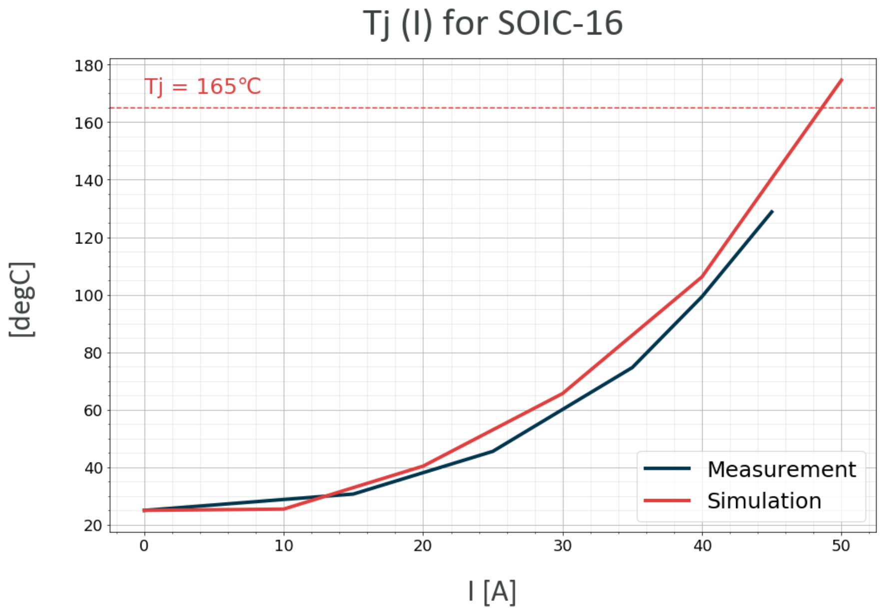


Figure 15: Comparison of simulation and measurement results for SOIC16 package at Room Temperature

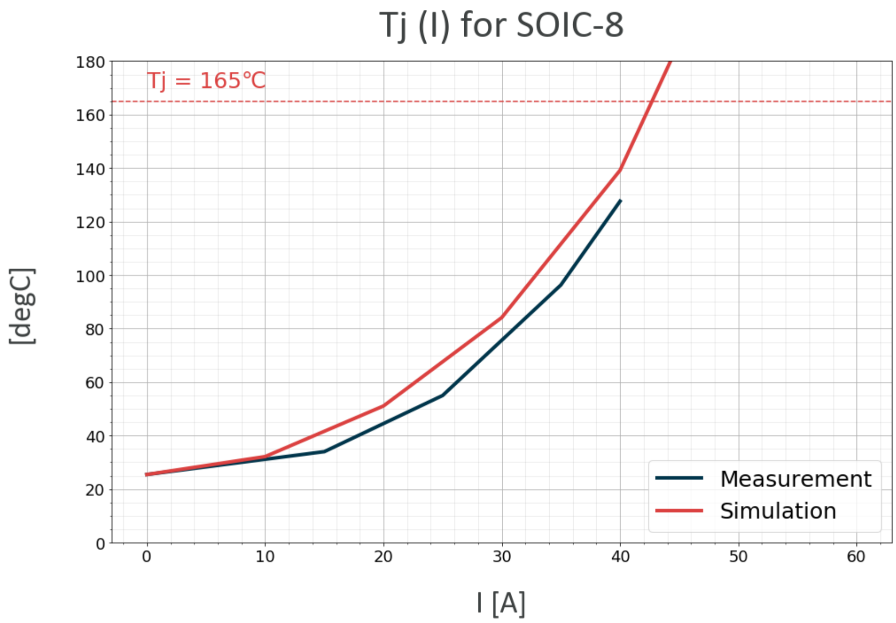


Figure 16: Comparison of simulation and measurement results for SOIC8 package at Room Temperature

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8. Revision history table

Revision	Date	Description/comments
1.0	December 2020	Initial release