THERMAL NOTE

EN5311/EN5312/EP5352/EP5362/EP5382QI
DC-DC Converters

Thermal Characteristics

The Enpirion EN5311QI, EN5312QI, EP5352QI, EP5362QI and EP5382QI DC-DC converters are packaged in 5x4x1.1mm 20-pin QFN packages that have the same thermal characteristics. The QFN packages are constructed with copper lead frames that have exposed thermal pads. The recommended maximum junction temperature for continuous operation is 125°C. Continuous operation above 125°C will reduce long-term reliability. The device has a thermal overload protection circuit designed to shut it off at an approximate junction temperature value of 150°C.

The silicon is mounted on a copper thermal pad that is exposed at the bottom of the package. The thermal resistance from the silicon to the exposed thermal pad is very low. In order to take advantage of this low resistance, the exposed thermal pad on the package should be soldered directly on to a copper ground pad on the printed circuit board (PCB). The PCB then acts as a heat sink. In order for the PCB to be an effective heat sink, the device thermal pad should be coupled to copper ground planes or special heat sink structures designed into the PCB (refer to the recommendations at the end of this note).

The junction temperature, T_J, is calculated from the ambient temperature, T_A, the device power dissipation, P_D, and the device junction-to-ambient thermal resistance, θ_{JA} in °C/W, as follows:

$$T_J = T_A + (P_D)(\theta_{JA})$$

The junction temperature, T_J, can also be expressed in terms of the device case temperature, T_C, and the device junction-to-case thermal resistance, θ_{JC} in °C/W, as follows:

$$T_J = T_C + (P_D)(\theta_{JC})$$

The device case temperature, T_C, is the temperature at the center of the exposed thermal pad at the bottom of the package.

The device junction-to-ambient and junction-to-case thermal resistances, θ_{JA} and θ_{JC}, are given in Table 1. The θ_{JC} is a function of the device design and is 15°C/W for the 20-pin QFN family of devices. The θ_{JA} is a function of user's system design parameters that include the thermal effectiveness of the customer PCB and airflow.

The θ_{JA} value of 65°C/W in Table 1 is for free convection with the device heat sunk to a copper plated four-layer PC board with a full ground and a full power plane following JEDEC EIJ/JESD 51 Standards. Because of the strong dependence on the thermal effectiveness of the PCB and the system design the actual θ_{JA} value will be a function of the specific application.

Figure 1 gives the power dissipation values for this family of devices as a function of the output current. The power dissipation at a given current value is primarily a function of the input voltage. Figure 2 gives the junction temperature rise as a function of the output current. Note that the maximum current rating of EP5352QI, EP5362QI and EP5382QI devices is 0.5A, 0.6A, and 0.8A respectively, while that of EN5311QI and EN5312QI is 1A.

Figure 3 provides the thermal de-rating curves for devices in the 5x4x1.1mm 20-pin package for typical Vin/Vout use conditions. The output current is given as a function of ambient temperature for a maximum operating junction temperature of 125°C and a typical θ_{JA} of 65°C/W.

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Table 1: Thermal Parameters

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS
Operating Ambient Temperature Range	T_{MAX}	-40		85	°C
Storage Temperature Range	T_{STG}	-65		150	°C
Operating Junction Temperature	T_J	- 40		125	°C
Thermal Shut off Temperature	T_S		150		°C
Thermal Resistance: Junction to Ambient (0 LFM)	θ_{JA}		65[1]		°C/W
Thermal Resistance: Junction to Case	θ_{JC}		15		°C/W
MSL per JEDEC J-STD-020A Level 3			260		°C

Note 1: Follows JEDEC EIJ/JESD 51 Standards, the device heat sunk to a heavy copper plated four-layer PC board.

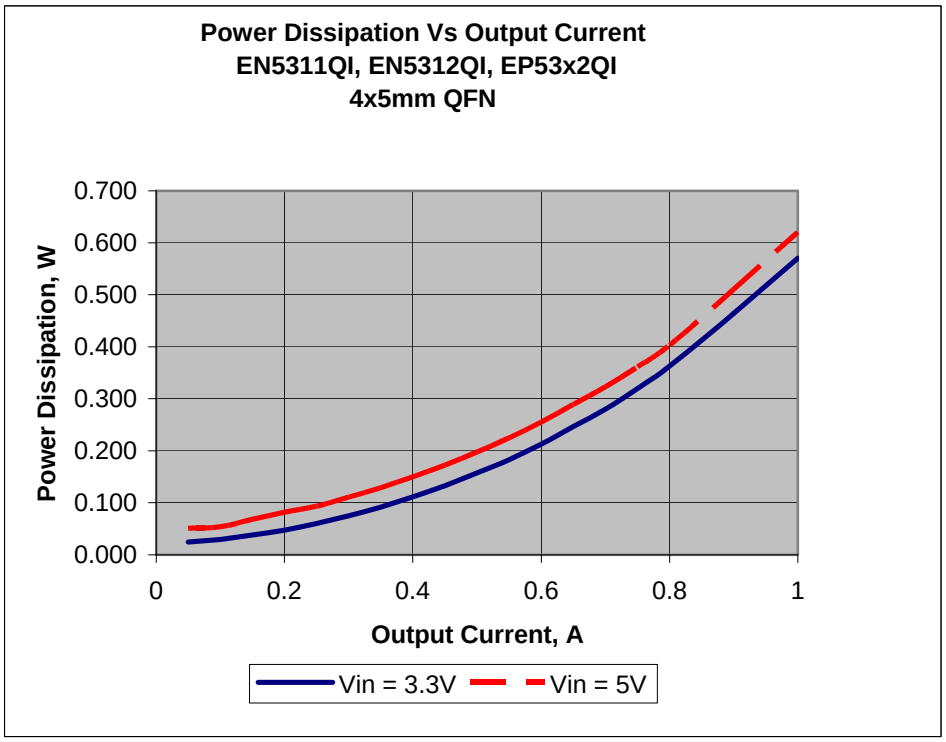
Recommendations

As noted earlier, the exposed thermal pad on the package should be soldered directly on to a copper ground land on a printed circuit board (PCB). The PCB then acts as a heat sink. In order for the PCB to be an effective heat sink, the device thermal pad should be coupled to copper ground planes or special heat sink structures designed into the PCB. Given below are recommended features for a thermally effective PCB:

1. The PCB should have a thermal land on the surface of the PCB for soldering to the thermal pad on the device. The PCB thermal land should be equal to or larger than the device thermal pad.
2. In the thermal land area, the PCB should have thermal vias that connect to one or more ground planes on the PCB.
3. The ground plane should be placed as close to the surface as possible (<0.25mm) to minimize the thermal path from the thermal land to the ground plane.
4. If a double sided PC board is used the thermal vias should terminate into a grounded area on the other side of the PCB. This grounded area should be made as large as possible. The board should be as thin as possible to make the thermal via length as short as possible.
5. The thermal vias should have a solid connection to the ground plane. Web or spoke connection methodology should not be used, as this will increase the thermal resistance.
6. If possible, the PCB should have a full copper plated power plane.
7. The drilled diameter of the thermal via in the PCB should be 0.3mm or less.
8. One should be able to put at least 4 thermal vias in the thermal land area of the PCB.
9. Use the thickest possible copper plating in the thermal vias (1 oz).
10. Use the thickest possible copper plating on every layer (1 to 2 oz).
11. Fill all unused areas on every layer of the PCB with copper, and use as many electrical and thermal vias as possible throughout the PCB.
12. Use wide traces and multiple vias as interconnect between layers for high current nodes. This will reduce i^2R heating and increase surface area for convective cooling.

Refer to Figure 4 for the description of the 5x4x1.1mm 20-pin package and the thermal pad.

Figure 1: Power Dissipation vs Output Current



Note that the maximum current rating of EP5352QI, EP5362QI and EP5382QI devices is 0.5A, 0.6A and 0.8A respectively. EN5311QI and EN5312QI are rated for 1A maximum.

Figure 2: Junction Temperature Rise vs Output Current, No Airflow

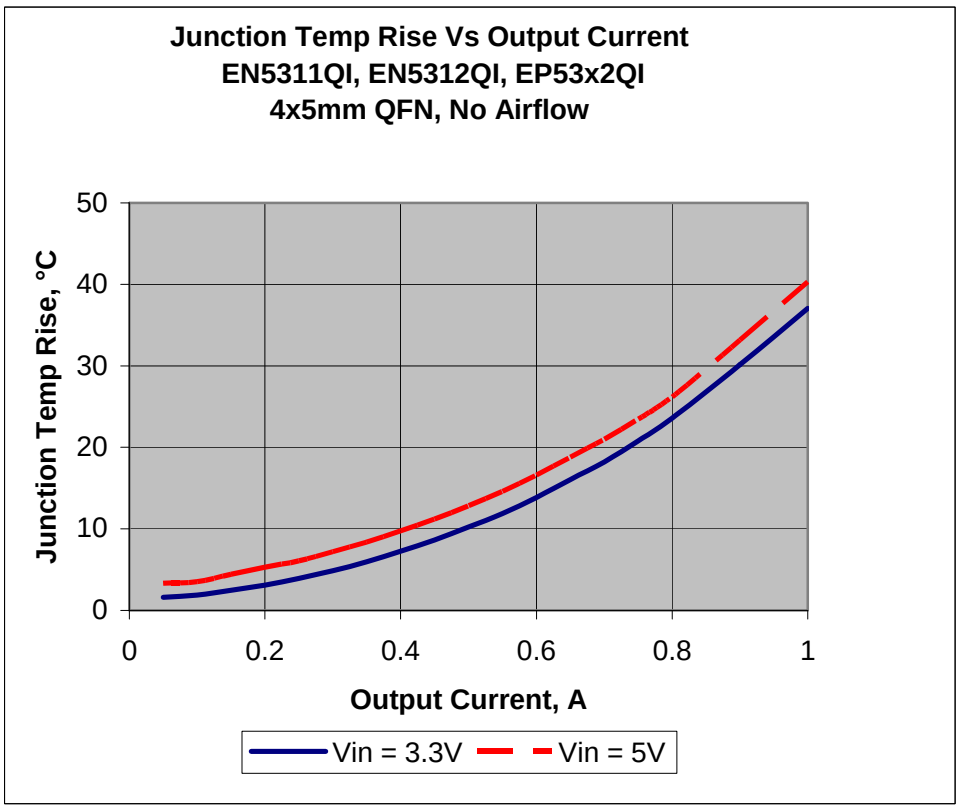
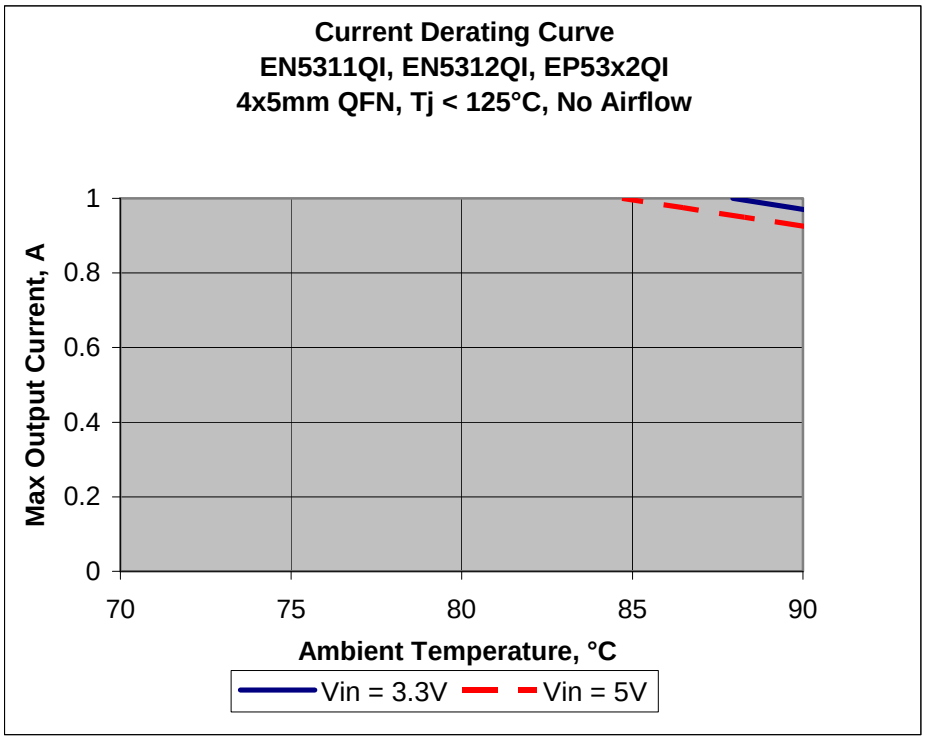
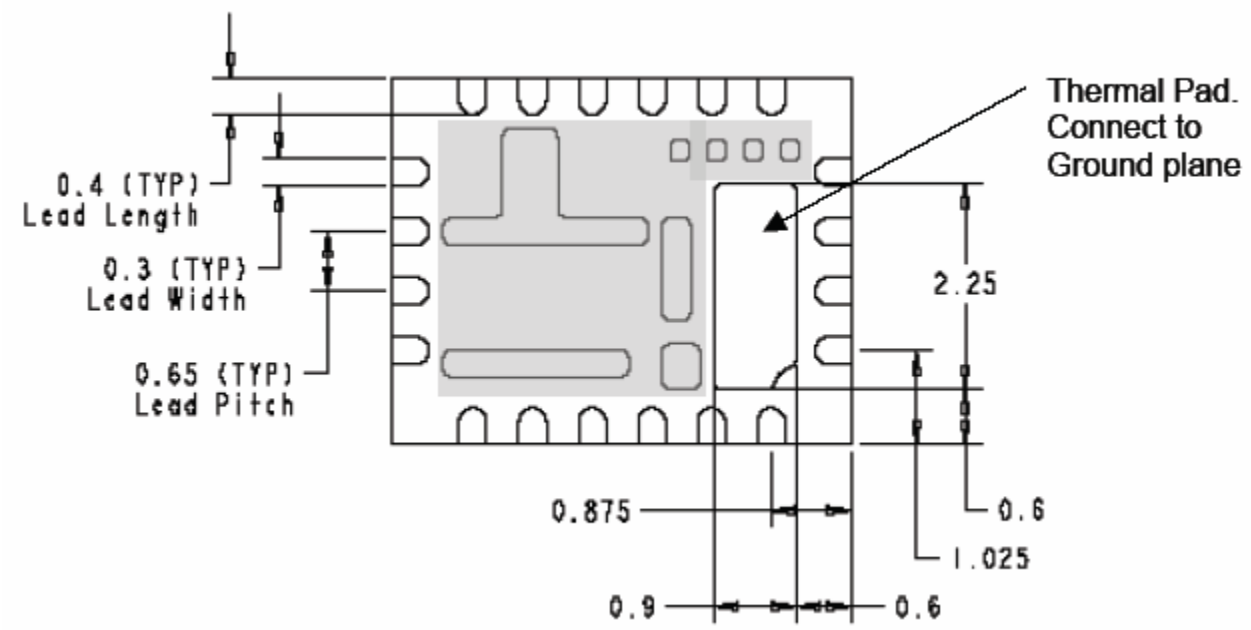


Figure 3: Maximum Output Current vs Ambient Temperature (T_{JMAX} = 125°C)



Note that the maximum current rating of EP5352QI, EP5362QI and EP5382QI devices is 0.5A, 0.6A and 0.8A respectively. EN5311QI and EN5312QI are rated for 1A maximum.

Figure 4: Enpirion 5x4x1.1mm 20-pin QFN Package and Thermal Pad Layout



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Contact Information

Enpirion, Inc.
685 Route 202/206
Suite 305
Bridgewater, NJ 08807
Phone: 908-575-7550
Fax: 908-575-0775