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## ABSTRACT

TI has a large portfolio of power modules offered in different types of packages. This application report offers an overview of several module package types and provides some guidance on soldering topics and considerations.

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## 1 Introduction

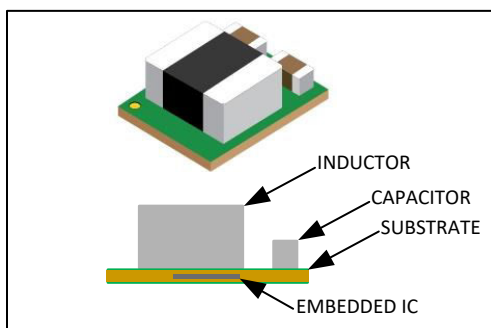
Power modules aim to simplify power supply design by integrating the power converter IC along with an inductor or inductors, a capacitor or capacitors, and other passive components into a single power module package. The modules come in different types of packages depending on their voltage ratings, current ratings, and target applications. This document addresses some common questions about power modules including the following:

- Package construction details
- MSL ratings and soldering reflow profile
- Back side mounting capability
- Rework guidance for prototyping

## 2 Package Types

### 2.1 MicroSiP

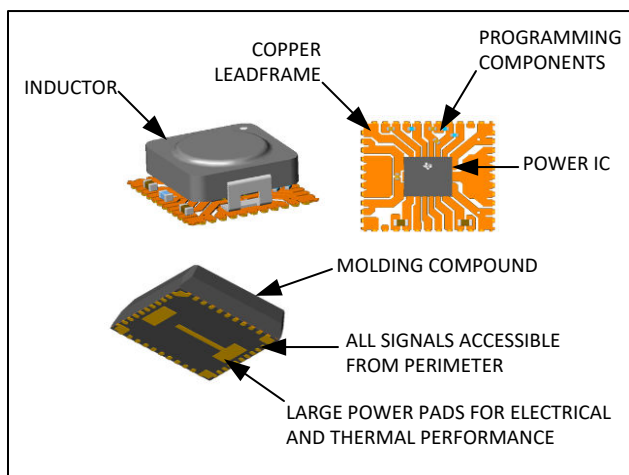
The MicroSiP package features a substrate with an IC embedded inside and passive components mounted on top. Usually, the components on top consist of an inductor and capacitors. [Figure 2-1](#) shows an illustration of this package construction.



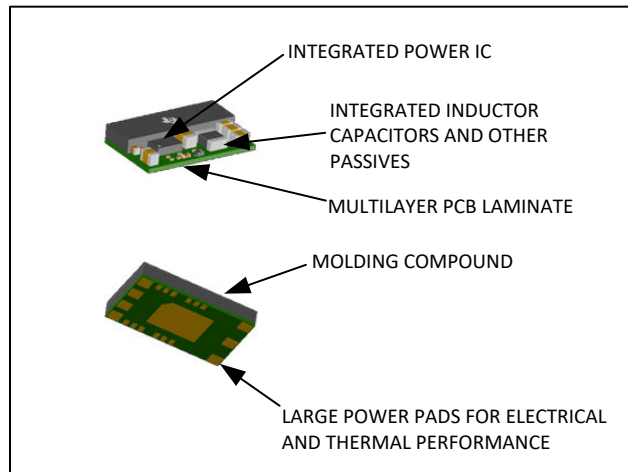
**Figure 2-1. LMZM23601 (36 V, 1 A) Module in MicroSiP Package**

### 2.2 QFN Overmolded

The QFN overmolded package can be based on a leadframe or a PCB laminate. The package integrates the inductor, power IC, along with programming components. The leadframe-based package uses a thick copper leadframe for routing. The PCB laminate based package uses a thin multilayer PCB for mounting and routing all of the integrated components and signals. See the illustrations in [Figure 2-2](#) and [Figure 2-3](#) for examples of these QFN module packages.



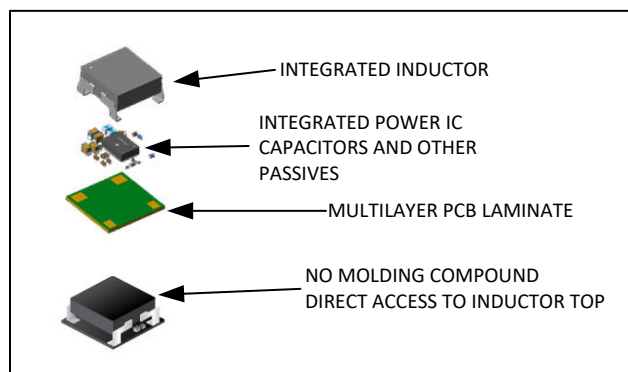
**Figure 2-2. LMZ36002 (60 V, 2 A) Module in Leadframe-based Overmolded QFN Package**



**Figure 2-3. TPSM84A21 (14V, 10A) module in PCB laminate based overmolded QFN package**

### 2.3 QFN Open Frame

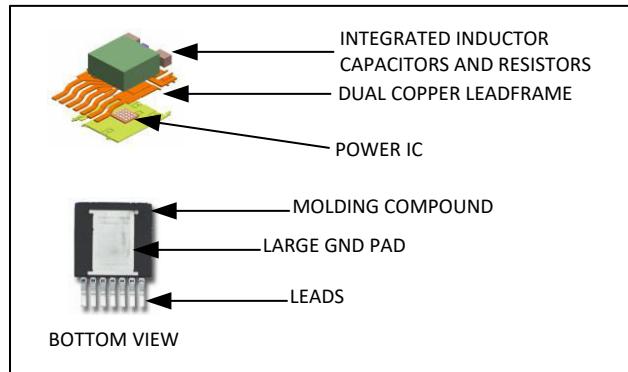
This QFN package consists of a multilayer laminate PCB with power IC, capacitors, resistors and inductor mounted on top. There is no molding compound encapsulating the circuitry. There is a direct access to the top of the inductor for potential heat transfer. See [Figure 2-4](#) for an illustration.



**Figure 2-4. TPSM846C23 (15 V, 35 A) Module in PCB Laminate Open Frame QFN Package**

## 2.4 Leaded

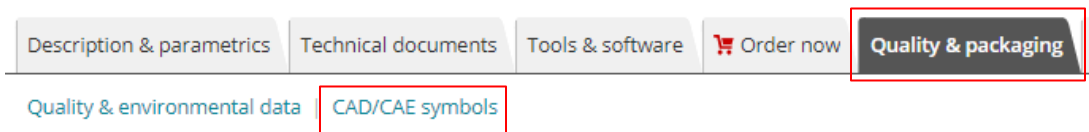
The leaded module packages include a dual copper leadframe with a power IC in between the leadframes. The integrated inductor, capacitor, and any other passives are situated on the top leadframe. There is molding compound encapsulating the package. There are leads and a large GND pad for good heat transfer and easy layout. [Figure 2-5](#) provides an illustration of this package construction.



**Figure 2-5. LMZ14203 (42 V, 3 A) Module in Leaded Overmolded PMOD Package**

## 3 Package CAD/CAE Symbols and Footprints

To streamline the design process, many of TI's modules have CAD symbols available for download under the Quality and Packaging section of the device product folder on TI.com. The PCB footprints and schematic symbols are available for download in a vendor neutral .bxl format, which can then be exported to the leading EDA CAD/CAE design tools formats using the Ultra Librarian Reader.



### Quality & environmental data

Part#	Eco Plan*	Lead / Ball Finish	MSL Rating / Peak Reflow	Material Content	DPPM Rate
TPSM84824MOLR	RoHS Exempt & Green	Call TI	Level-3-260C-168 HR	<a href="#">View</a>	

\* Eco-friendly classification: RoHS, RoHS Exempt or non-RoHS & Green or non-Green-please click on the Product Content Details "View" link in the table above for the latest information and additional product content details.

If the information you are requesting is not available online at this time, contact the [Customer Support Center](#) regarding the availability of this information.

### CAD/CAE symbols

Part#	Package   Pins	CAD File (.bxl)	STEP Model (.stp)
TPSM84824	QFM (MOL)   24	<a href="#">Download</a>	<a href="#">Download</a>

**Figure 3-1. Downloadable CAD Files**

## 4 Soldering

### 4.1 MSL Ratings

Electronic components can absorb moisture. When going through the reflow process, the absorbed moisture is rapidly heated. This can result in excessive pressure inside the component package. Excessive pressure can cause delamination and internal mechanical damage. The electronics industry has come up with Moisture Sensitivity Level (MSL) rating which defines the floor life between the time the drypack packing is opened and the time when the component goes through a reflow cycle. The absorption of moisture on the factory floor prior to PCB mounting is proportional to the ambient temperature and relative humidity. The MSL specification is provided with respect to 30°C and 60% relative humidity.

The MSL rating for each product can be found in the product data sheet in the package option addendum section. Alternatively, the MSL rating can be found under the Quality section in module product folder on TI.com. The MSL rating is also located on the product packaging label. See [Figure 4-1](#).

PACKAGE OPTION ADDENDUM SECTION OF THE DATASHEET:

PACKAGING INFORMATION									
Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)
LMZM23601SILR	ACTIVE	uSIP	SIL	10	3000	RoHS & Green	NIAU	Level-3-260C-168 HR	-40 to 125

QUALITY SECTION OF THE PRODUCT FOLDER ON TI.COM:

Quality & environmental data						
Part#	Eco Plan*	Lead / Ball Finish	MSL Rating / Peak Reflow	Material Content	DPPM / MTBF / FIT Rate	Qualification Summary
LMZM23601SILR	RoHS & Green	NIAU	Level-3-260C-168 HR	<a href="#">View</a>		<a href="#">View</a>

PACKAGING LABEL:



Figure 4-1. MSL Information Available at Various Locations

### 4.2 Reflow Profile

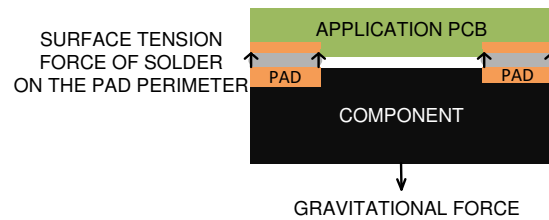
The maximum reflow temperature and number of allowed reflows can vary from device to device. The maximum temperature depends on the package volume and thickness. Refer to each data sheet of the device for the maximum reflow temperature and number of reflows. Refer to the [MSL Ratings and Reflow Profiles Application Note](#) for an example reflow profile based on J-STD-020 and additional soldering information.

### 4.3 Back Side PCB Mounting Considerations

Will the part fall off or stay on the board after a second reflow upside-down?

Some high density applications can require mounting the power module on the back side of the PCB. Normally, the PCB side with heavy components would be reflowed last. However, in some cases, there can be heavy components on both sides of the board. In such applications, the power module package can go through a second reflow while the component is upside-down. The feasibility of the component staying attached to the board during the second reflow depends on the component mass, component pad sizes, and the solder alloy surface tension. There are at least two empirical models in the industry to evaluate the back side mounting feasibility.

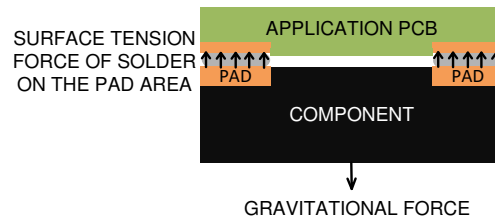
#### 4.3.1 Method 1 - Solder Surface Perimeter



**Figure 4-2. Component Held by the Solder Surface Tension Around the Pad Perimeter**

This method of evaluating the back side mounting feasibility was developed by [Smith, Connell, and Christian](#). The empirical model defines the force of the solder surface tension as a function of the overall *perimeter* of the component pads. The empirical model dictates 22 mg/mm of maximum recommended ratio of component mass to total pad *perimeter*.

#### 4.3.2 Method 2 - Solder Surface Area



**Figure 4-3. Component Held by the Solder Surface Tension Across the Pad Area**

This method of evaluating the back side mounting feasibility was developed by [Liu, Geiger, and Shangguan](#). The model considers the overall *area* of the component pads and dictates 47 mg/mm<sup>2</sup> of maximum recommended ratio of component mass to total pad *area*.

### 4.3.3 Back Side PCB Mounting Evaluation of TI Modules

Table 4-1 contains the back side PCB mounting feasibility evaluation of several TI module families, considering the following:

- Maximum mass / pad area  $\leq 47$  mg/mm<sup>2</sup>
- Maximum mass / pad perimeter  $\leq 22$  mg/mm

**Table 4-1. Back Side Feasibility With Second Reflow**

DEVICE	FEASIBILITY WITHOUT FIXTURE	PACKAGE TYPE	MASS (mg)	MASS / A (mg/mm <sup>2</sup> )	MASS / P (mg/mm)
LMZ10500	Y	MicroSiP	37.4	12.4	1.8
LMZ10501	Y	MicroSiP	37.4	12.4	1.8
LMZ21700	Y	MicroSiP	48	10.7	2.0
LMZ21701	Y	MicroSiP	48	10.7	2.0
LMZ30602	Y	QFN Overmolded	850	31.4	8.5
LMZ30604	Y	QFN Overmolded	850	31.4	8.5
LMZ30606	Y	QFN Overmolded	850	31.4	8.5
LMZ31503	Y	QFN Overmolded	1260	38.8	10.2
LMZ31506	Y	QFN Overmolded	1260	38.8	10.2
LMZ31520	N	QFN Overmolded	4960	67.2	25.5
LMZ31530	N	QFN Overmolded	4960	67.2	25.5
LMZ31704	N	QFN Overmolded	1430	68.2	13.8
LMZ31707	N	QFN Overmolded	1430	68.2	13.8
LMZ31710	N	QFN Overmolded	1430	68.2	13.8
LMZ34002	Y	QFN Overmolded	891	26.3	9.8
LMZ34202	N	QFN Overmolded	1475	52.7	13.7
LMZ35003	Y	QFN Overmolded	891	26.3	9.8
LMZ36002	N	QFN Overmolded	1475	52.7	13.7
LMZM23600	Y	MicroSiP	48.5	12.2	1.9
LMZM23601	Y	MicroSiP	48.5	12.2	1.9
LMZM33602	Y	QFN Overmolded	468	25.6	4.7
LMZM33603	Y	QFN Overmolded	468	25.6	4.7
LMZM33604	N	QFN Overmolded	1990	57.7	11.9
LMZM33606	N	QFN Overmolded	1990	57.7	11.9
TPS82084	Y	MicroSiP	53.5	14.5	2.6
TPS82085	Y	MicroSiP	53.5	14.5	2.6
TPS82130	Y	MicroSiP	62.5	16.9	3.1
TPS82140	Y	MicroSiP	62.5	16.9	3.1
TPS82150	Y	MicroSiP	62.5	16.9	3.1
TPSM265R1	Y	MicroSiP	37.7	13.9	1.6
TPSM41615	Y	QFN Open Frame	1319	28.5	6.4
TPSM41625	Y	QFN Open Frame	1319	28.5	6.4
TPSM53602	Y	QFN Overmolded	429	37.3	10.5
TPSM53603	Y	QFN Overmolded	429	37.3	10.5
TPSM53604	Y	QFN Overmolded	429	37.3	10.5
TPSM560R6	Y	QFN Overmolded	429	37.3	10.5
TPSM5601R5	Y	QFN Overmolded	429	37.3	10.5
TPSM5D1806	Y	QFN Overmolded	235	14.6	1.7
TLVM13630	Y	QFN Overmolded	123	13.1	1.9
TPSM63603	Y	QFN Overmolded	123	13.1	1.9

**Table 4-1. Back Side Feasibility With Second Reflow (continued)**

DEVICE	FEASIBILITY WITHOUT FIXTURE	PACKAGE TYPE	MASS (mg)	MASS / A (mg/mm <sup>2</sup> )	MASS / P (mg/mm)
TPSM84209	Y	QFN Overmolded	110	13.2	2.9
TPSM84424	N	QFN Open Frame	678 <sup>(1)</sup>	170 <sup>(1)</sup>	42.4 <sup>(1)</sup>
TPSM84624	N	QFN Open Frame	678 <sup>(1)</sup>	170 <sup>(1)</sup>	42.4 <sup>(1)</sup>
TPSM846C23	N	QFN Open Frame	2900 <sup>(1)</sup>	125 <sup>(1)</sup>	75.5 <sup>(1)</sup>
TPSM846C24	N	QFN Open Frame	2900 <sup>(1)</sup>	125 <sup>(1)</sup>	75.5 <sup>(1)</sup>
TPSM84824	N	QFN Open Frame	678 <sup>(1)</sup>	170 <sup>(1)</sup>	42.4 <sup>(1)</sup>
TPSM84A21	Y	QFN Overmolded	725	13.6	7.1
TPSM84A22	Y	QFN Overmolded	725	13.6	7.1

(1) Calculation is based on the mass of the exposed inductor, which is the heavy component likely to fall off first.



#### 4.3.4 Reflow Fixture

As suggested by [Table 4-1](#), placing some devices on the back side of the PCB with a second reflow may not be feasible. In such cases, a reflow fixture can be designed to hold the heavy components during the second reflow. Contact TI for possible fixture suggestions based on the particular application board design.

### 5 Rework During Prototyping

Solder rework can sometimes be needed during product prototyping. When reworking components on a PCB, be sure to observe the maximum reflow temperature for the particular module. Also, it is important to keep in mind the board reflow history and the maximum number of reflow cycles for the particular module. For example, if the component is mounted on the back of the board, it may have gone through two reflow cycles already prior to the rework. Another important point is to follow the MSL requirements for the component. Baking of the board assembly can be required prior to rework to remove potential moisture and mitigate risk of damage to the module or other components on the board. Proper solder paste stencil must be used to ensure adequate solder paste coverage. Refer to the suggested solder paste pattern and solder stencil information in the product data sheet. Open frame and MicroSiP packages have exposed SMT components on top of the module. These components can also reflow during the rework procedure. Take care to avoid shifting or moving the exposed these SMT components during the rework, as this can affect the module operation.

### 6 References

- Smith, Sasha & Connell, David & Christian, Bev. (2010). Weight Limits for Double Sided Reflow of QFNs.
- Liu, Yueli & Geiger, David & Shangguan, Dongkai. (2005). Determination of Components Candidacy for Second Side Reflow with Lead-Free Solder. Proceedings - Electronic Components and Technology Conference. 970-976. 10.1109/ECTC.2005.1441389.

### 7 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from Revision A (September 2020) to Revision B (May 2021)</b>	<b>Page</b>
• Added <i>TPSM5601R5</i> and <i>TPSM63603</i> devices to the <i>Back Side Feasibility with Second Reflow</i> table.....	<a href="#">7</a>

<b>Changes from Revision * (December 2019) to Revision A (September 2020)</b>	<b>Page</b>
• Updated the numbering format for tables, figures, and cross-references throughout the document. ....	<a href="#">2</a>
• Added <i>TPSM41625</i> and <i>TPSM5D1806</i> devices to the <i>Back Side Feasibility with Second Reflow</i> table.....	<a href="#">7</a>

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