

Detailed Comparison Between TPSM82903 and TPS82130



ABSTRACT

The TPSM8290x family (TPSM82903, TPSM82902, TPSM82901) is the next generation to the TPS821x0 (TPS82130, TPS82140, TPS82150) family. This application note explains the improvements that were made from the previous version to the new and how those changes benefit the designer. Key concepts discussed further include:

- Feature sets contribute to the smaller solution size and higher power density
- Less power loss and better thermals achieved by reduced quiescent current and improvements to the overall efficiency
- Increased flexibility enabling the applicability to a wide range of applications

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1 Introduction

The TPSM8290x (TPSM82903, TPSM82902, TPSM82901) family is the next generation of 17-V, low I_q, high efficiency, and flexible synchronous step-down DC-DC converter MicroSiP™ module that is improved upon the previous family TPS821x0 (TPS82130, TPS82140, TPS82150). [Table 1-1](#) shows the key features of each product and the improvements on the latest generation family. Each improved feature contributes to the leaps forward in the family. In turn, the improved device, a small part of a design, contributes to ground-breaking advancements in technology. This application report provides a comparison between these two device families, as well as an explanation of how the changes benefit the user more than the previous version.

Table 1-1. Feature Comparison of TPS821x0 and TPSM8290x

| Features | TPS82130 | TPSM8290x | Improvements |
|--|---|---|--|
| VOUT | 0.9 V to 6 V | 0.4 V to 5.5 V | TPSM82903 supports lower Vout down to 400 mV. |
| Typical quiescent current I _Q | 20uA | 4uA | Lower I _Q , longer battery life. See Section 5.1 . |
| FB accuracy (Full Temperature range) | 1.8% | 0.9% | Tighter V _{REF} accuracy. TPSM82903 also has VSET option that removes the requirements for external feedback resistors and improves that total system accuracy. See Section 5.2 . |
| Package size/Total solution size | 3.0 mmx2.8 mm MicroSiP™ / 29mm ² | 3.0 mmx2.8 mm MicroSiP™ / 25mm ² | Both device use the same package. The TPSM82903 has VSET option that can be used to save the external feedback resistors. Also the Softstart capacitor is optional. See Section 3.1 . |
| Smart configuration | No | Yes | Fewer external components needed to configure device. See Section 3.2 . |
| Recommended Junction Temperature | -40°C to 110°C | -40°C to 125°C | Supports higher T _j up to 125°C. See Section 4.1 . |
| Switching Frequency | 2.5 MHz | 2.5 MHz and 1 MHz | Provides Adjustable switching frequency. See Section 4.3 . |
| R _{DS(ON)} | 120 mΩ high side/50 mΩ low side | 62 mΩ high side/22 mΩ low side | Less power loss and better thermals. See Section 4.3 |
| Efficiency (12 Vin, 1.2 Vo, 3 A) | 71.5% | 76.5% | Improved efficiency. TPS82903 offers 1MHz F _{sw} , in addition to improved R _{DS(ON)} . See Section 4.3 . |
| Automatic Efficiency Enhancement (AEE) | No | Yes | High efficiency for varying duty cycles. See Section 4.2 . |
| Capacitive discharge | Using PG | Using Smart Config | Achieved internally when selected. See Section 5.3 . |
| Mode | Supports Auto PFM/PWM only | Supports both Auto PFM/PWM and FPWM | Forced PWM mode is offered in the TPSM8290x in addition to Auto PFM/PWM. See Section 4.4 . |
| VSET | No | Yes | This allows for internal divider that has lower BOM count and better overs systems accuracy. See Section 3.3 . |

2 Power Density

Power density is a term created to describe the power output of a device compared to its size. This is especially important in space constrained applications, or high functionality applications. These applications are mainly concerned with the space on the XY board area when talking about power density, but the Z (height) dimension can also be taken into consideration for total volume if desired. By shrinking the solution area, increasing the power output under similar conditions, or a combination of the two, the power density is positively impacted. As an example, comparing the 3-A rated parts in a case with 12 V on the input, 1.2 V on the output and in an ambient temperature of 65°C, the TPM8290x is able to give the full 3-A load for a power density of 110mA/mm². The TPS82130 provides 2.1 A for a power density of 72 mA/mm² due to more power losses in the device and the limited recommended junction temperature of 110°C vs 125°C. [Section 3](#) provides additional detail of how the total solution size went from 29mm² for TPS82130 to a solution size of 25mm² in TPSP82903. [Section 4](#) describes how efficiency and thermals impact how much power is able to get out of a part.

$$PD = \frac{\text{Current (mA)}}{\text{Area (mm}^2\text{)}} \quad (1)$$

3 Achieving a Smaller Solution

3.1 Fewer External Components

Both devices uses a small 3.0 mm × 2.8 mm MicroSiP™ package, however the size of the package is not the only thing that reduces the application size. External components also has important factor on both the cost and the area of the application. TPSP8290x has decreased the passives needed to configure the device. For 1.2 Vo application for example, there is no need to use external feedback resistors, VSET can be grounded. Also the soft start capacitor is not required (Optional), that can save an additional component. The result saves precious board space, BOM costs and design time.

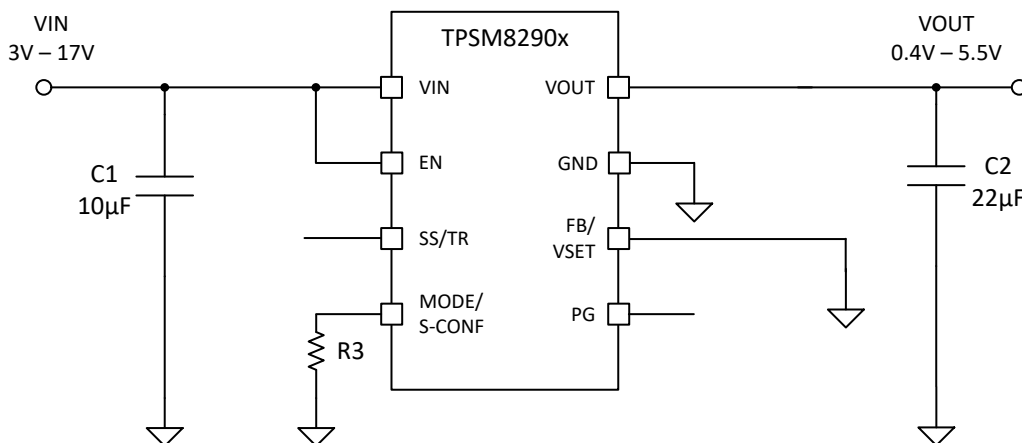
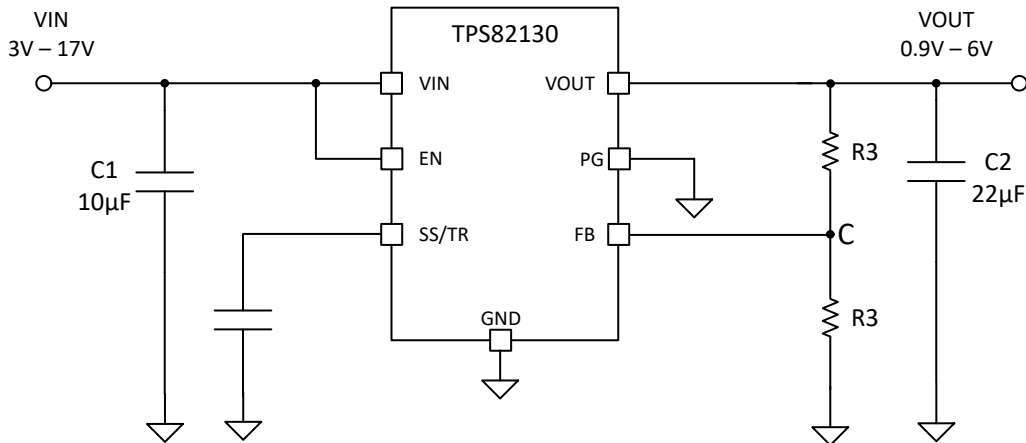


Figure 3-1. Typical Application Schematic of the TPSP82903

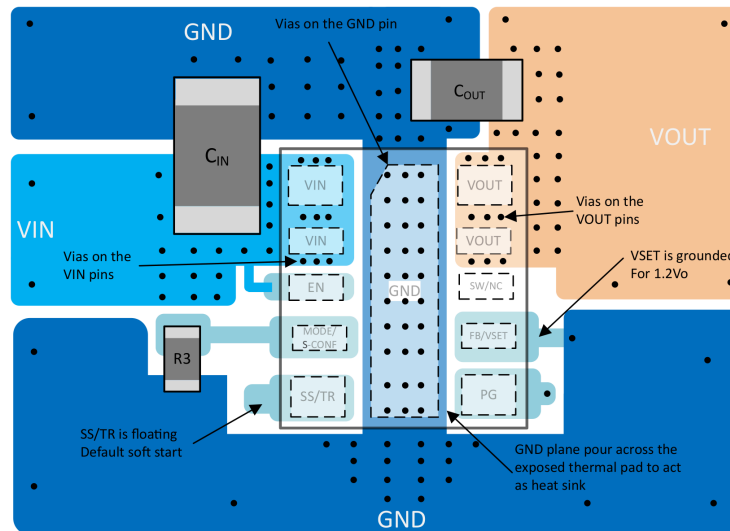

Figure 3-2. Typical Application Schematic of the TPS82130

3.2 Smart Configuration Pin

The smart configuration pin is one of the primary contributors to the space savings and a key differentiator between the next generation devices and their predecessors. The MODE/S-CONF pin allows the user the flexibility to select the settings of four features (Internal or external feedback, switching frequency, FPWM/PFM, and output discharge) with only one resistor. In the previous generation, this flexibility is not supported. There are several advantages associated with this pin, too many to discuss in this document. To learn more about smart config pins and all of their design benefits, reference the document [Multi-Function Pins for Easy Designing](#).

3.3 VSET

Using the MODE/S-CONF pin in conjunction with the FB/VSET pin, can be used to save an additional one or two resistors when setting the output voltage. Typically, to set an output voltage, a resistor divider is used on the feedback pin. The advantage to using the resistor divider is flexibility to choose any output value in the output voltage range. Both the TPS82130 and TPSM8290x have the ability to use a resistor divider to configure the Vout. Several applications use common voltages at point of load, so TPSM8290x has added the ability to select an output value from one of 16 common voltages preset options through the VSET function. These values vary from 0.4 V to 5.5 V. If one of those preset output voltages is desired for a design, the VSET function can be used to save one or even both resistors (if left floating or grounded) when configuring the output voltage, as shown in [Figure 3-3](#). The resulting total solution size is 25 mm².


Figure 3-3. Configuration for the Smallest Solution Size Using TPSM8290x

4 Reducing Power Loss

4.1 Junction Temperature

The TPSM8290x has extended the junction temperature to 125°C vs. the 110°C of the TPS82130 for a maximum life time of the device. This allows the device to be used at higher ambient temperatures with higher loads. With the 46.1°C/W $R_{\theta JA}$ of the TPS821x0, and with an ambient temperature of 65°C, the device is allowed to dissipate less than 1 W of power to reach the max junction temperature of 110°C. Whereas, the TPSM82903, has more than 1.25 W of allowable power to dissipate before the max junction temperature of 125°C is reached. This contributes to how much load the device can deliver under the same ambient temperature, V_{IN} , and V_{OUT} condition. Also, note that the TPSM82903 has better efficiency and has an option to run at 1 MHz (less switching losses).

For example, if we compare the two devices under the same conditions, 12-V input, 1.2-V output, and 60°C ambient. The TPS82130 can deliver only approximately 2.1 A whereas the TPSM82903 can deliver 3 A before the max junction temperature is reached. For the TPS82130 to deliver full load of 3 A, the ambient temperature has to be reduced to 45°C.

4.2 Automatic Efficiency Enhancement (AEE™)

The AEE™ feature in the TPSM8290x provides highest efficiency over the entire input voltage and output voltage range by automatically adjusting the converter's switching frequency when 2.5 MHz is selected. This is achieved by setting the predictive off-time of the converter. The efficiency of a switched mode converter is determined by the power losses during the conversion. The efficiency decreases when V_{OUT} decreases and or V_{IN} increases. To keep the efficiency high over the entire duty cycle range (V_{OUT}/V_{IN} ratio), the switching frequency is adjusted while maintaining the ripple current. Equation 2 shows the relationship between the inductor ripple current, switching frequency and duty cycle.

$$\Delta I_{L(max)} = V_{OUT} \times \left(\frac{1 - \frac{V_{OUT}}{V_{IN(max)}}}{L_{(min)} \times f_{sw}} \right) \quad (2)$$

Efficiency increases by decreasing switching losses and by preserving high efficiency for varying duty cycles while the ripple current amplitude remains low enough to deliver the full output current without reaching current limit. The AEE™ feature provides an efficiency enhancement for various duty cycles, especially for lower V_{out} values, where fixed frequency converters suffer from a significant efficiency drop. Furthermore, this feature compensates for the very small duty cycles of high V_{IN} to low V_{OUT} conversion, which limits the control range in other topologies.

When 2.5 MHz Auto PFM/PWM mode with AEE is selected, the efficiency can be better than the 1 MHz Auto PFM/PWM mode is some V_{IN}/V_{OUT} combinations at light loads conditions. For example at $V_{OUT}=1.2$ V and 15 V input, the efficiency is enhanced by almost 5% at 500 mA load and below.

4.3 Switching Frequencies and FET $R_{DS(ON)}$

The TPSM8290x switching frequency can be set to 1 MHz or 2.5 MHz using the smart configuration pin. This is useful to provide the user the flexibility to set the switching frequency that fits the applications. To improve the efficiency and reduce switching losses of the converter, 1 MHz can be selected, with condition V_{OUT} has to be less or equal to 2.0 V. This selection is ideal for most applications that have efficiency or thermals are the main concern. For applications $V_{OUT}>2.0$ V, 2.5 MHz is required.

The Figure 4-1 compares the efficiency of the two devices and that translates to thermal performance as shown in Figure 4-2 and Figure 4-3. The improved efficiency at heavy load is mainly coming from the improved $R_{DS(ON)}$ of the High side FET and Low side FET. The TPS82130 has double $R_{DS(ON)}$ of 120 mΩ/50 mΩ vs 62 mΩ/22 mΩ of the TPSM82903.

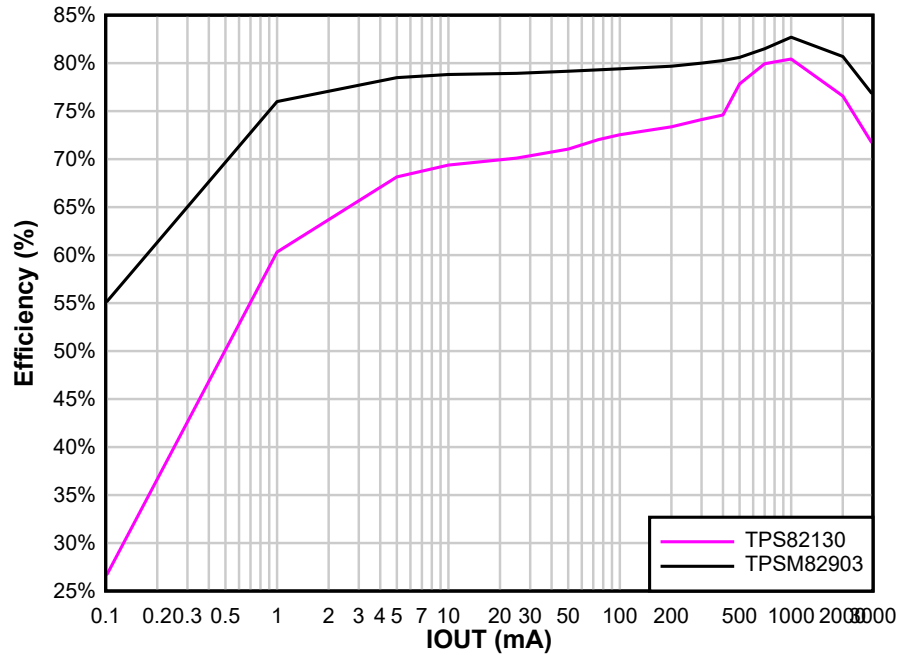


Figure 4-1. Efficiency Curves of TPMS82903 vs. TPS82130, VIN=12 V, VO=1.2 V in Auto PFM/PWM mode.

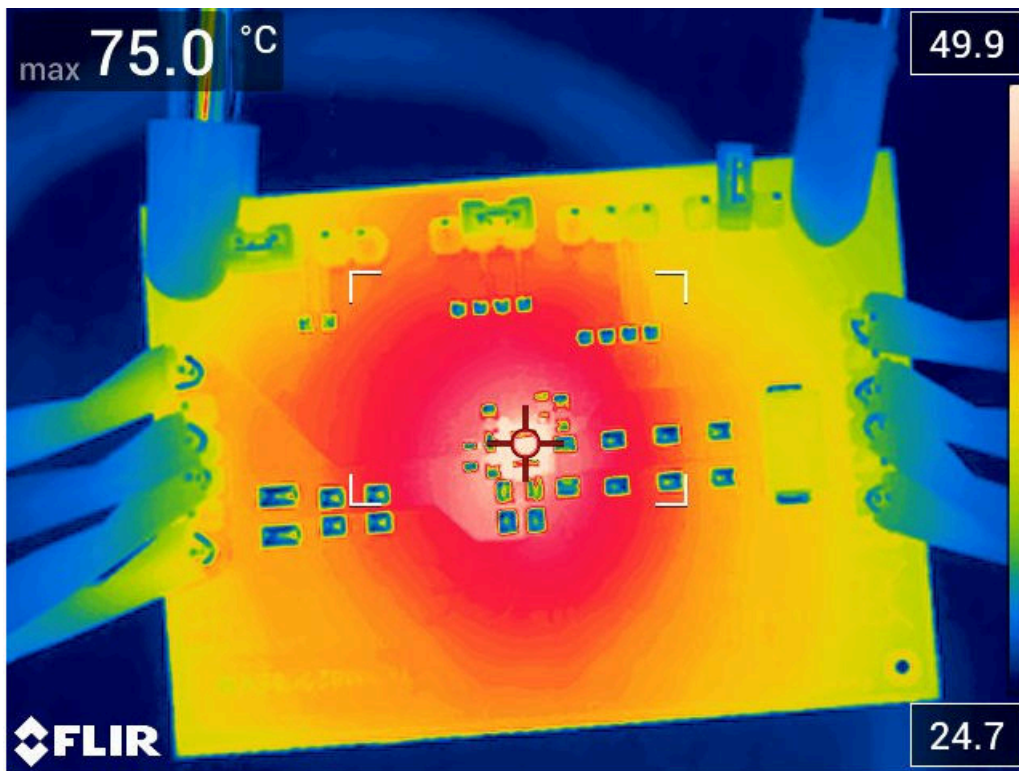


Figure 4-2. Thermal Performance of TPMS82903EVM, VIN=12 V, VO=1.2 V, 3 A.

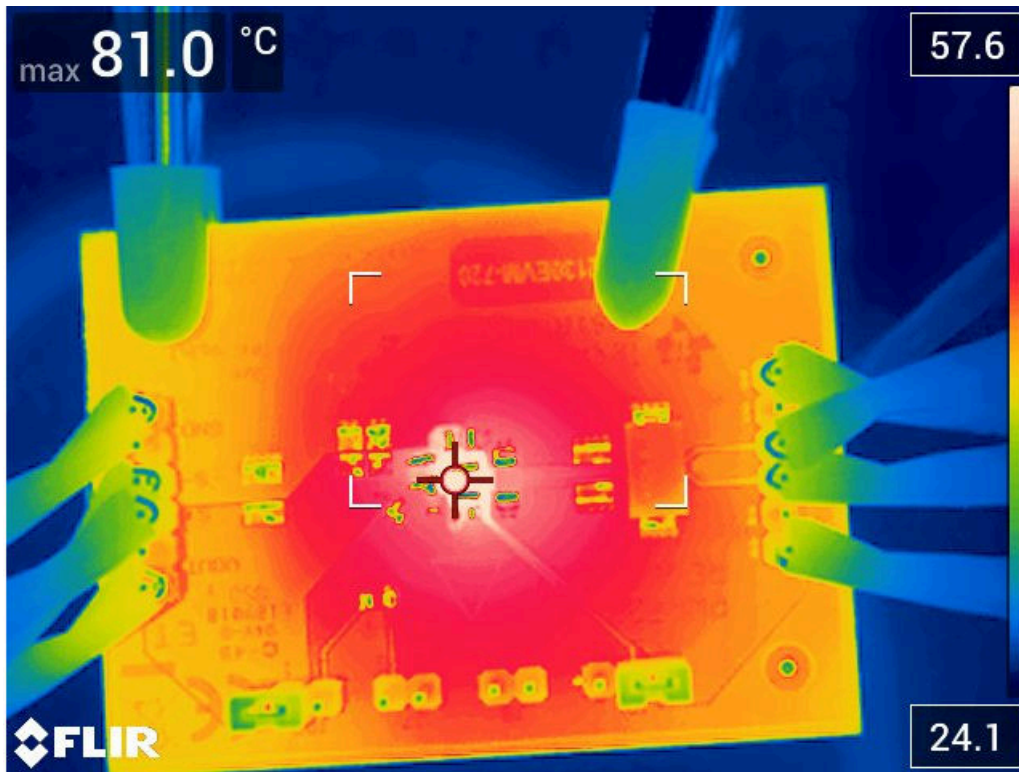


Figure 4-3. Thermal Performance of TPS82130EVM, VIN=12 V, VO=1.2 V, 3 A.

The thermal images shown in [Figure 4-2](#) and [Figure 4-3](#) were taken using FLIR thermal camera. The emissivity of the camera is set 0.94. The distance from the camera to the board is 5 inches. The measurements are taken without any airflow or controlled air. Room temperature is ~25°C.

4.4 Auto PFM/PWM vs. Forced PWM

To receive the best efficiency possible at light loads, the user can select the Power Save Mode Operation (Auto PFM/PWM) mode. This mode increases the efficiency by skipping switching pulses and reducing the device's current consumption and switching losses. Alternately, Forced Pulse Width Modulation (FPWM) forces the device to operate at nearly fixed frequency across load, this has some efficiency impact at light load but the user can easily predict the operating frequency and set filters as needed. The user can choose between these modes using the MODE/S-CONF pin discussed previously.

5 Application Flexibility

5.1 Quiescent Current

Low I_Q is a key spec for the applications where the device is operated in standby or shutdown mode for the majority of the time, so they are not drawing unnecessary power while not in use. For battery powered applications, the quiescent current is critical to extending the life of the battery and improves light load efficiency. The TPS82130 has low quiescent current of 20 μ A typical. The TPSM8290x quiescent current is reduced even further to 4 μ A typical. The battery in these applications are meant to last an extended amount of time without having to be replaced. The reduction of the I_Q will reduce the amount of current being drawn from the battery, therefore extending the battery life significantly.

5.2 Lower and More Accurate Output Voltages

TPS821x0 supports 0.9 V as minimum output with a 1.8% V_{out} accuracy combined with the accuracy of the two external feedback resistors used. This covers a lot of use cases, however not all. There are applications that require lower than 0.9 V_{out} , or a tighter spec for V_{out} accuracy and have previously been unable to use the TPS821x0 because of these requirements. TPSM8290x opens up the opportunity for these applications to take advantage of its high-performance feature set by supporting as low as 0.4 V output voltage when using VSET and as low as 0.6 V using the external feedback resistor option with a <1% V_{out} accuracy across full temperature range. If VSET option is selected, the external feedback resistors are not needed and thus the total system accuracy is improved for the fact that the external feedback resistor accuracy is no longer added to the feedback loop.

5.3 Capacitive Discharge

In some applications, the output voltage needs to get to zero as soon as the device is disabled. For that, an internal discharge circuit is implemented inside the device to discharge the remaining charge of the output capacitor as soon as the device is disabled. The purpose of the discharge function is to ensure a defined down-ramp of the output voltage when the device is being disabled but also to keep the output voltage close to 0 V when the device is off. The output discharge feature is only active once TPSM8290x has been enabled at least once since the supply voltage was applied. The internal discharge resistor is connected to the VOUT pin internally. The discharge function is enabled as soon as the device is deactivated, in thermal shutdown or in undervoltage lockout. The user can turn this feature on or off using the smart configuration pin.

In the TPS821x0, this feature is implemented using the PG pin. The TPS821x0 pulls the PG pin Low, when the device is shut down by EN, UVLO or thermal shutdown. Connecting PG to VOUT through a resistor can be used to discharge VOUT in those cases. The discharge rate can be adjusted by the pull up resistor, which is also used to pull up the PG pin in normal operation.

6 Summary

The comparison between the TPS821x0 family and the TPSM8290x family have exemplified the improvements in the new generation and how those improvements benefit the design the device is in. Decreased solution size, increased efficiency, implementation of the SCONFIG feature, and more all combine together to make significant advancements in the buck converter design for mid voltage applications.

7 References

- Texas Instruments, [Understanding the Trade-offs and Technologies to Increase Power Density](#) marketing white paper.
- Texas Instruments, [Multi-Function Pins for Easy Designing](#) application brief.
- Texas Instruments, [Which Pinout is Best?](#) article.

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