Technical Bulletin
STMicroelectronics' L7983 and L6983 Synchronous Step-Down Converters

Overview

The industrial sensors market size is expected to grow very quickly in the next few years. This growth is attributed to the increased adoption of industrial automation in the manufacturing sector to expand production capacity and gather real-time data across various operations. The integration of cloud computing technologies that use industrial sensors to optimize manufacturing output and improve environmental sustainability will also positively impact global market demand.

The demand for these smart sensors is also increasing in a number of other industries (e.g., petrochemical, semiconductor, food processing, and transportation) because of their ability to collect, transmit and process data.

Many industries still operate on decades-old machinery that is not outfitted with sensors. This is due to industry-specific requirements and the lack of readily-available solutions. The development of customized sensors will support the modernization of equipment, which will also require dedicated and optimized power supplies for these sensors.

ST's L7983 Synchronous Switching Regulator

ST's L7983 is a 60 V, 300 mA synchronous step-down switching regulator with 10 µA quiescent current. It is designed for industrial market applications, such as 12 V, 24 V and 48 V buses, sensors and low-noise applications (LNM).

Features:
- V_{IN}_typ: 24 V
- V_{OUT}: 5 V
- I_{OUT}: 0.3 A max
- Inductor ripple: 82 mA (@V_{IN}_typ)
- FSW: 2.2 MHz

In this article we present a typical application scenario operating with 24 Vin -> 5 Vout, fsw = 2.2 MHz, 80 mA current ripple, 50 mA - 300 mA load at a fixed switching frequency of 2.2 MHz (Figure 1).

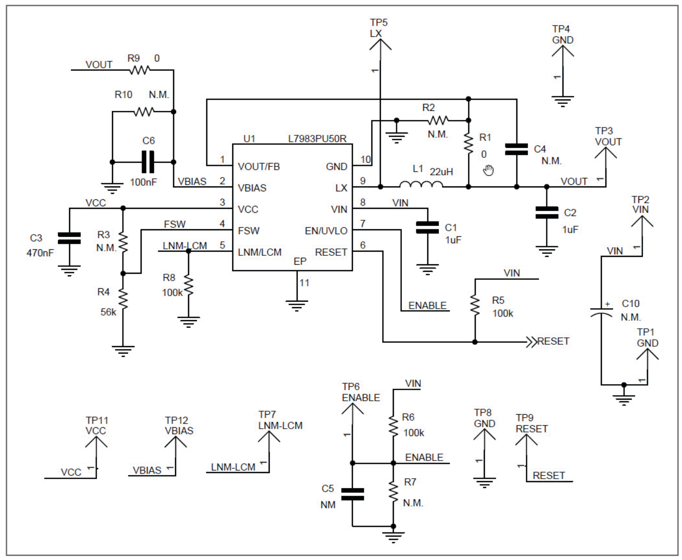

Figure 1 - L7983 5V/2.2MHz evaluation board schematic

Three Coilcraft LPS4012-223 (22 uH) power inductors were selected as the recommended solutions for the L7983 evaluation boards. They offer a good balance between compact size and efficiency.

The LPS4012 is a high-performance, compact, low-profile (4.0 x 4.0 x 1.2 mm) ferrite-shielded component offering excellent current handling and low DC resistance.

For applications requiring a smaller footprint, consider Coilcraft's 3.0 x 3.0 x 1.5 mm LPS3015-223 (22 uH). Coilcraft's XFL3012-223 (22 uH) is another option. It has a 3.0 x 3.0 mm footprint (with a maximum height of 1.2 mm) and features a composite material for high current handling, low DCR and low AC losses.

Power conversion efficiency measurements taken in the ST Lab in "Low Consumption Mode" (LCM – Figure 2) and "Low Noise Mode" (LNM – Figure 3) show that all three selected

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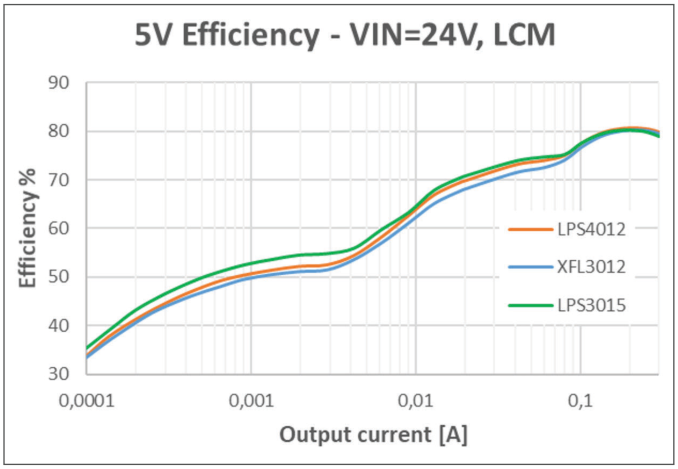

Figure 2 - "Low Consumption Mode" (LCM) power conversion efficiency measurements

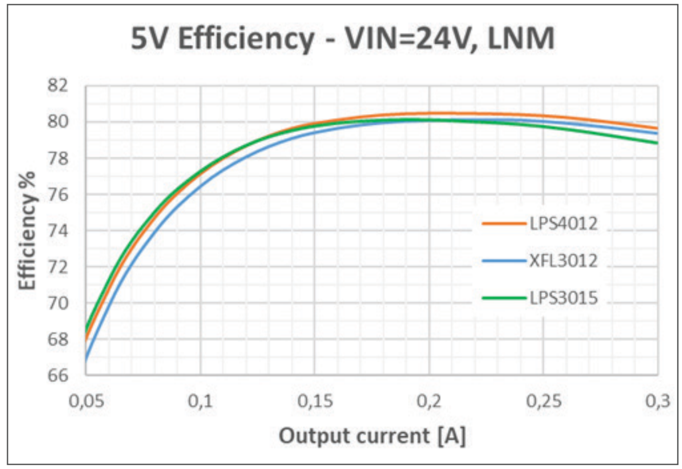

Figure 3 - "Low Noise Mode" (LNM) power conversion efficiency measurements

components operate with substantially the same efficiency over the entire range of output currents.

For a more detailed performance analysis of the power inductors, we use Coilcraft's DC-DC Optimizer Tool available at www.coilcraft.com. Based on the parameters of the power converter, the tool calculates the required inductor specifications, identifies off-the-shelf part numbers and provides a side-by-side performance analysis.

In just a few clicks, users can go from V_{in}/V_{out} converter requirements to selecting an inductor based upon the results of the losses and saturation analysis – all with verified inductor data as per Figure 4.

Part Number	L nominal (µH)	L actual at Ipeak (µH)	L actual at IDC (µH)	I peak (A)	ΔIL%	CCM / DCM	Isat (A)	Irms (A)	DCR Typ @ 25°C (mΩ)	Total losses (mW)	Part temp. (°C)	Max Temp Rating (°C)	Length (mm)	Width (mm)	Height (mm)	Mount
LPS4012-223 Sample Buy	22.0	21.7	21.7	0.34	29%	CCM	0.79	0.70	540	53	33°C	125°C	4.1	4.1	1.2	SM
XFL3012-223 Sample Buy	22.0	18.8	19.5	0.35	33%	CCM	0.52	0.80	608	84	35°C	125°C	3.2	3.2	1.3	SM
LPS3015-223 Sample Buy	22.0	21.2	21.4	0.35	30%	CCM	0.50	0.57	742	72	37°C	165°C	3.15	3.15	1.5	SM

Figure 4 - Results from Coilcraft DC-DC Optimizer analysis

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The tool indicates that the LPS4012 is the most efficient part with only 53 mW of total losses and a very limited contribution from Core + AC winding losses (Figure 5).

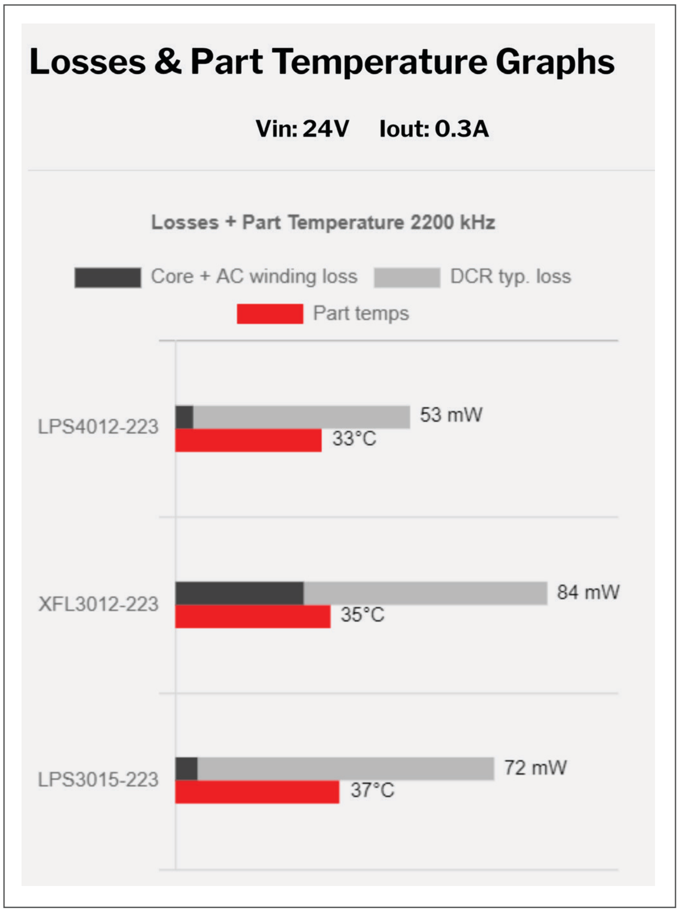

Figure 5 - Power inductor loss analysis

For all the selected inductors, the major contribution comes from wire DC resistance (DCR) – conduction loss.

The smallest inductor, the XFL3012, shows higher total losses, but its impact on the solution is very similar to the larger inductors. Compliant with the AEC-Q200 Grade 3 standard (-40 to +85°C ambient), the XFL3012 is also a very robust component.

The temperature increase of all three parts above 25°C (ambient) is reasonably low, and they all stay within a 4°C difference.

ST's analyses of the total losses (Figures 6 and 7) show that the selected components have almost the same impact on losses across the entire range of output currents, with lower losses contributed by the LPS4012 solution in high current range in LNM mode.

A deeper analysis of inductor performance, pushing operating conditions to the limits, can provide a better evaluation of the inductors.

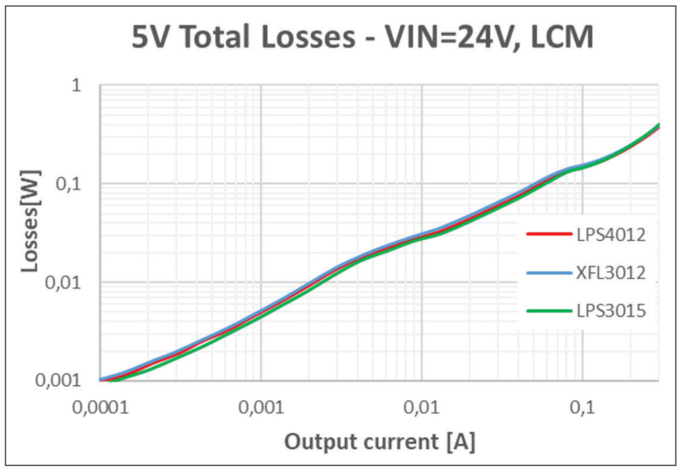

Figure 6 - Total losses, LCM circuit

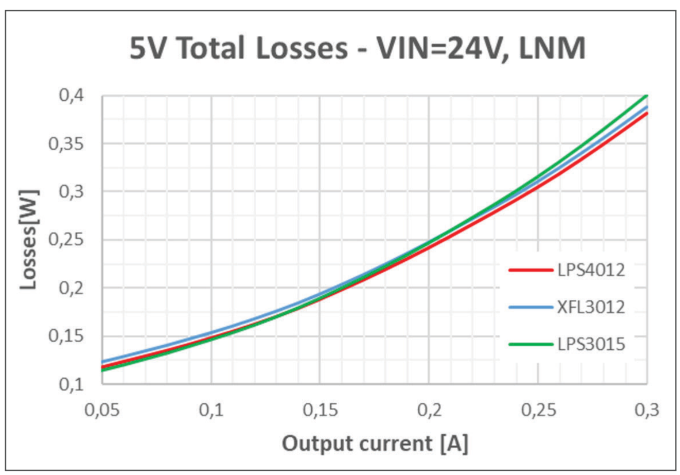

Figure 7 - Total losses, LNM circuit

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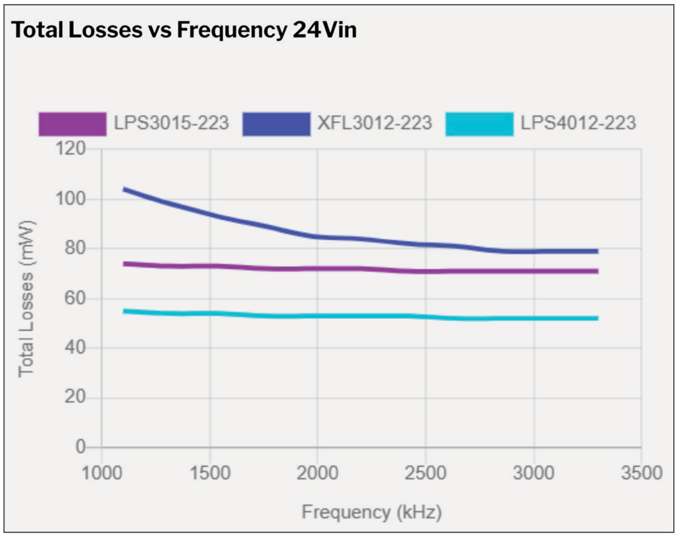

Figure 8 - Total Losses vs. Frequency

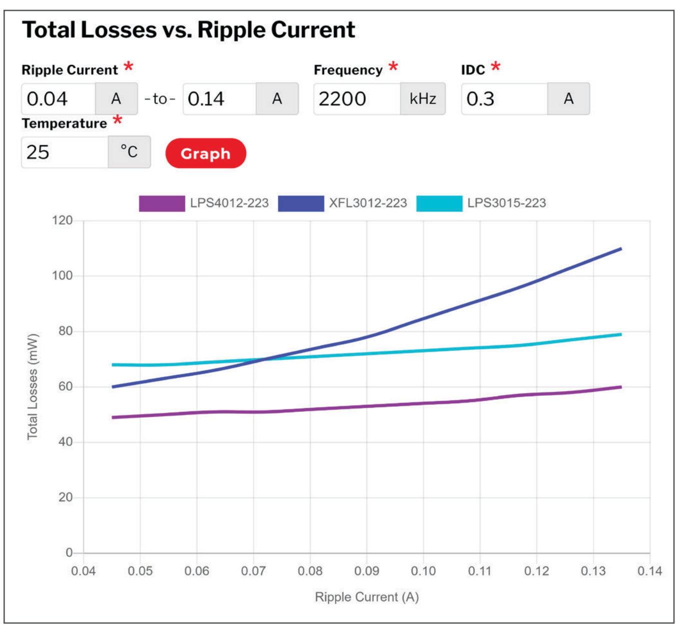

Figure 9 - Total Losses vs. Ripple Current

The DC-DC Optimizer tool allows users to evaluate inductor losses vs. frequency at maximum input voltage and losses vs. ripple current (Figures 8 and 9).

The 2.2 MHz operating switching frequency and 80 mA ripple current are a good compromise, especially for the XFL3012. This complete view of power inductor performance allows users to speed up their design cycle and brings useful data that helps them feel more confident in their inductor selection and decision making process.

ST's L6983 Synchronous Step-Down Converter

Another suitable option for industrial applications is the ST L6983 synchronous step-down converter, a monolithic step-down regulator capable of delivering up to 3 A DC to the load. The wide input voltage range makes the device suitable for a broad range of applications, particularly for 24 V buses in industrial power systems/sensors and always-on applications (Figure 10).

Features:

- V_{IN}: 24 V
- V_{OUT}: 5 V
- I_{OUT}: 0.3 A max
- Inductor ripple: 82 mA (@V_{IN}_typ)
- FSW: 2.2 MHz

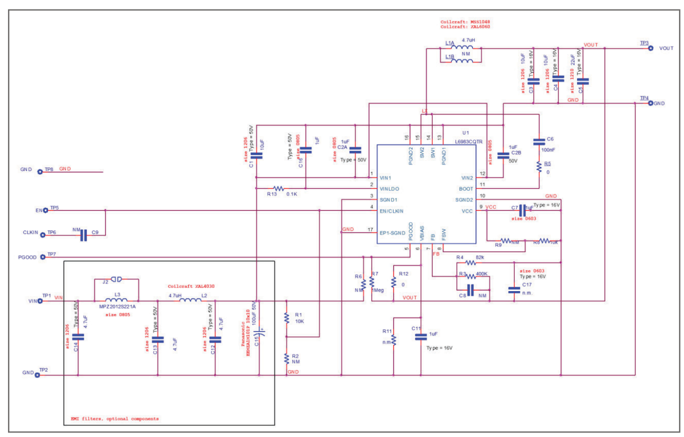

Figure 10 - L6983 5 V/1.0 MHz evaluation board schematic

Three power inductors were selected for the L6983, each striking a balance between compact size and efficiency. Coilcraft's 10 x 10 x 4.8 mm MSS1048-472 (4.7 uH) was chosen as the recommended solution for the evaluation board.

Coilcraft's XGL Family of Power Inductors

Coilcraft recently released its XGL Family of composite-material power inductors that offers the lowest DC losses in the industry and extremely low AC losses for a wide range of DC-DC converters, from hundreds of kHz up to 5+ MHz.

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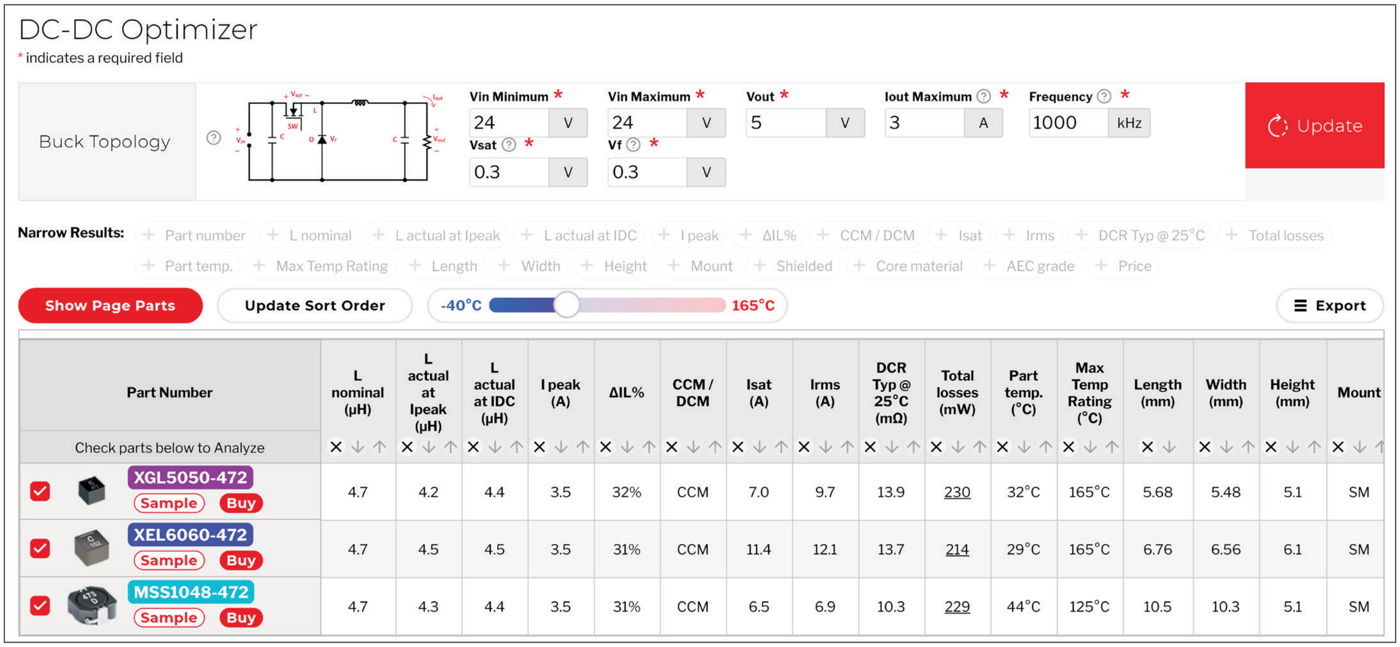

Part Number	L nominal (µH)	L actual at Ipeak (µH)	L actual at IDC (µH)	I peak (A)	ΔIL%	CCM / DCM	Isat (A)	Irms (A)	DCR Typ @ 25°C (mΩ)	Total losses (mW)	Part temp. (°C)	Max Temp Rating (°C)	Length (mm)	Width (mm)	Height (mm)	Mount
XGL5050-472 Sample Buy	4.7	4.2	4.4	3.5	32%	CCM	7.0	9.7	13.9	230	32°C	165°C	5.68	5.48	5.1	SM
XEL6060-472 Sample Buy	4.7	4.5	4.5	3.5	31%	CCM	11.4	12.1	13.7	214	29°C	165°C	6.76	6.56	6.1	SM
MSS1048-472 Sample Buy	4.7	4.3	4.4	3.5	31%	CCM	6.5	6.9	10.3	229	44°C	125°C	10.5	10.3	5.1	SM

Figure 11 - Results from Coilcraft DC-DC Optimizer analysis

Once again using the Coilcraft DC-DC Optimizer tool (Figures 11 and 12), we examine the performance of the new XGL Family to compare the performance of smaller coils like the XGL5050-472 (5 x 5 x 5 mm) and XGL6060-472 (6 x 6 x 6 mm) to that of larger parts like the MSS1048 (10 x 10 x 5 mm).

As shown in Figure 12, it is instantly evident that the 5 x 5 x 5 mm XGL5050 new composite material part shows the same losses as the much larger, traditionally assembled ferrite coil (MSS1048), while also exhibiting substantially lower temperature increases.

The overall loss analysis conducted by ST also shows that composite coils perform slightly better (Figures 13 and 14, next page).

Coilcraft's new-generation, composite-material XGL Family coils are also extremely robust parts with AEC-Q200 Grade 1 qualification for operating conditions up to 125°C (ambient).

Finally, the circuit efficiency measurements (Figures 15 and 16) show that the new XGL technology outperforms the traditional ferrite part, especially at low output load in both LCM and LNM operating modes.

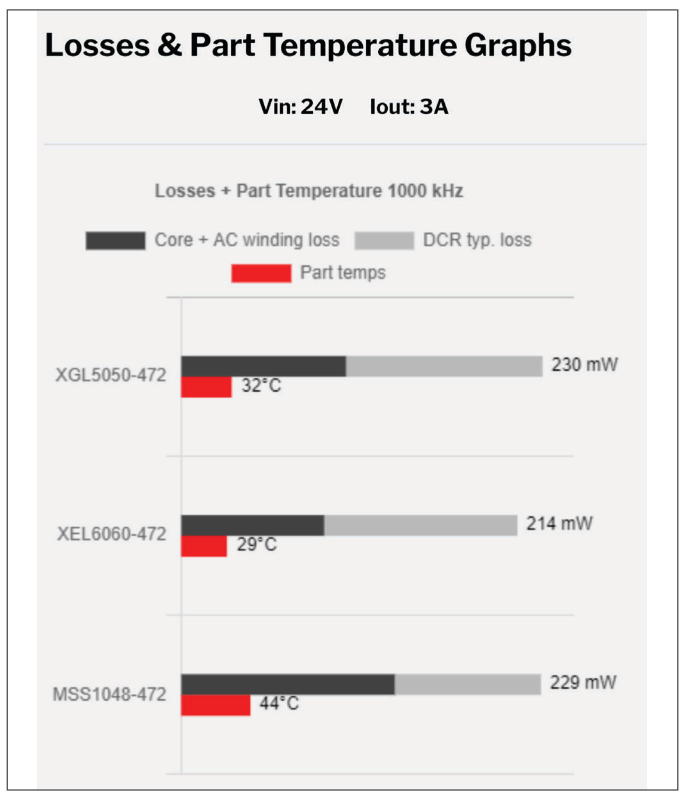

Figure 12 - Power inductor loss analysis

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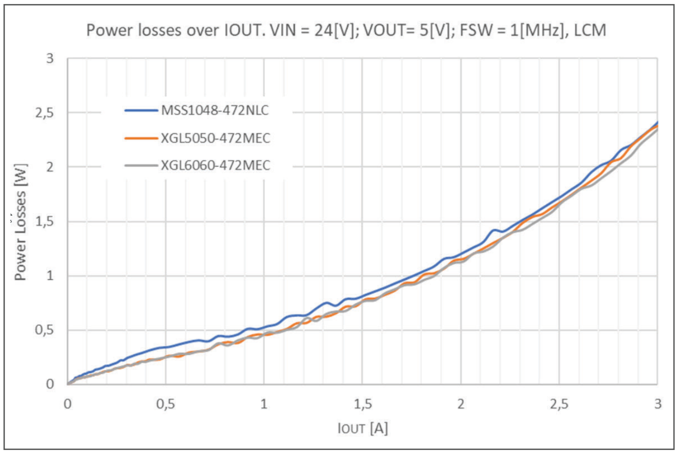

Figure 13 - LCM circuit total losses comparison

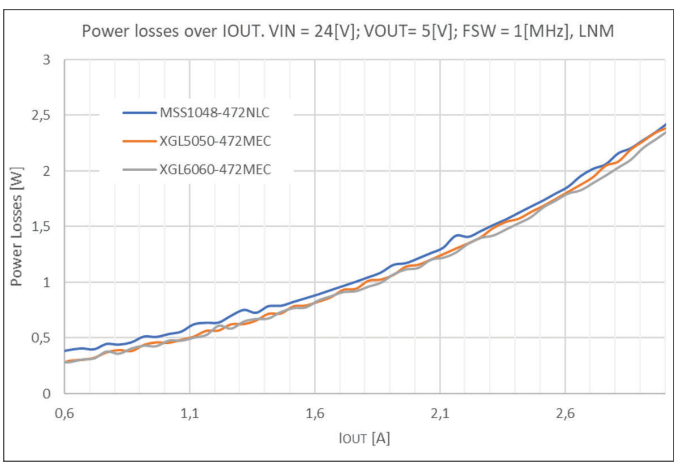

Figure 14 - LNM circuit total losses comparison

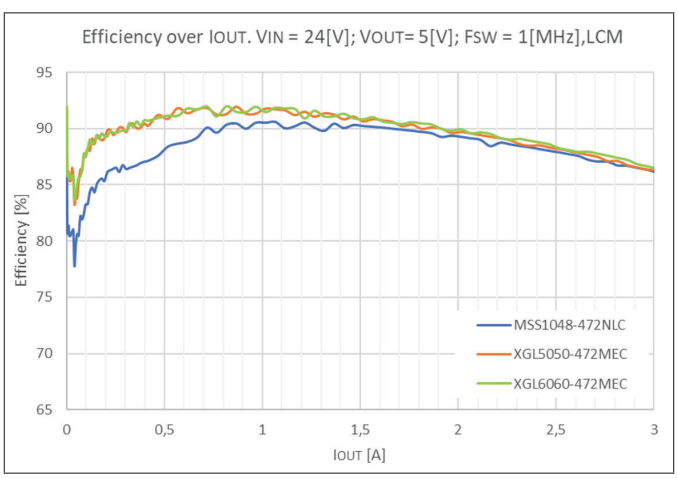

Figure 15 - LCM power conversion efficiency measurements

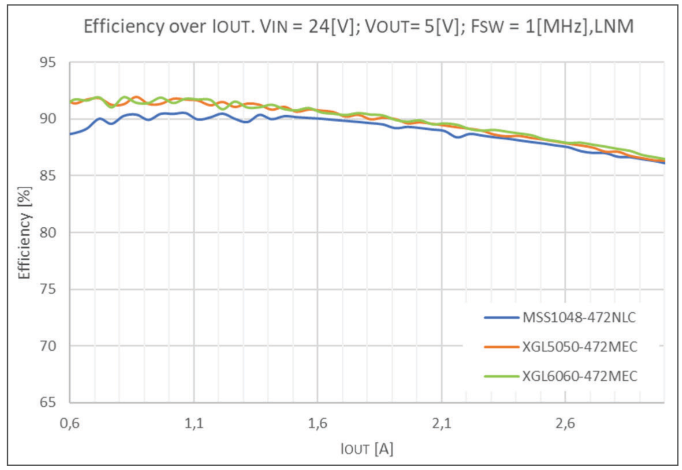

Figure 16 - LNM power conversion efficiency measurements

Conclusion

This article has shown how the new XGL composite-material technology from Coilcraft helps users design the most compact solution for their application with significant improvements in power efficiency, robustness and performance under high temperatures.

Coilcraft has also introducted its DC-DC Optimizer tool, specifically designed to help users search for, evaluate and order key power magnetics components, speeding up the design process. In just a few clicks, users are guided from entering their application's V_{IN}/V_{OUT} converter requirements to selecting the proper inductor thanks to a detailed loss and saturation analysis – all based on verified, empirical inductor data.

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