Application Brief

Solving Power Design Challenges in Medical Imaging Applications

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Medical imaging equipment, including X-ray systems, ultrasound scanners, and MRI systems, is widely used to create images of internal organs and other structures in the body in a non-invasive manner. In general, all of these applications use either x-rays, sound waves or radio waves to produce the images. For example, transducers used in ultrasound sensors generate sound waves above 20 kHz. The sound produced is transformed into an electric signal that is sensitive to interference. Because of this, the system's power designs must be able to reduce noise and ripple to improve performance and image resolution. This article will discuss imaging equipment design challenges and how point of load buck regulators addresses them.

Table 1 lists devices that are highlighted for Ultrasound scanner power management. Included are both digital and analog designs in discrete and module form factor. Digital designs include PMBus for voltage scaling and telemetry while modules are devices with an integrated inductor.

Table 1. Imaging Power Management Devices

	GPN	Vin	Iout	Features	Module Option
High Efficiency	TPS543320	4 V - 18 V	3 A	Highest efficiency 12 V/6 A converter in market pin compatible 3 A, 6 A, 8 A family, selectable Fsw: 500 kHz, 750 kHz, 1 MHz, 1.5 MHz, 2.2 MHz	TPSM843320
	TPS543620	4 V - 18 V	6 A		TPSM843620
	TPS543820	4 V - 18 V	8 A		TPSM843820
	TPS543 A22	4 V - 18 V	12 A	90% efficient at 12 V->1 V, 1 MHz, 15 A load, fixed freq with no external compensation = less passives, pin compatible 12 A, 16 A, 20 A, 25 A family, selectable Fsw: 500 kHz, 750 kHz, 1 MHz, 1.5 MHz, 2.2 MHz	
	TPS543 A26	4 V - 18 V	16 A		TPSM843B22
	TPS543B22	4 V - 18 V	20 A		TPSM843 A26
	TPS543B25	4 V - 18 V	25 A		TPSM843 A22
Digital	TPS546B24S	2.95 V - 16 V	10 A	Stack x4, fixed frequency operation with synchronization, extensive PMBus command, over 90% efficiency 12 VIN, 1 Vout, 500 kHz from 6-12 A	
	TPS546 A24S	2.95 V - 16 V	20 A		
	TPS546D24S	2.95 V - 16 V	40 A		
Low noise	TPS62912	3 V - 17 V	2 A	Eliminates LDO and passive post filtering, spread spectrum reduces spurious noise and EMI, low 1/f noise for optimum phase noise	TPSM82912
	TPS62913	3 V - 17 V	3 A		TPSM82913
Low I_Q	TPS62901	3 V - 17 V	1 A	4 µA quiescent current, optimizes battery lifetime and energy budget, 1% accurate and low ripple output in forced-PWM configuration	TPSM82901
	TPS62902	3 V - 17 V	2 A		TPSM82902
	TPS62903	3 V - 17 V	3 A		TPSM82903
	TPS62932	3.8 V - 30 V	2 A	Adjustable switching frequency by RT pin: 300kHz-2.2MHz, 12 uA typical quiescent current, EMI friendly featured	
	TPS62933	3.8 V - 30 V	3 A		

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Challenges

High efficiency in a compact form factor design

High efficiency power dense designs benefit all kinds of imaging systems. With the continued demand for smaller designs to make imaging systems like ultrasound scanners more portable comes the challenge of creating high efficiency compact designs. The limited board space in some equipment requires a greater emphasis on a small footprint power design. A key device family suitable for this challenge can be the TPSM843620 and TPSM843B22 family of modules. When comparing modules to converters it is important to note that modules offer an optimized package size because of the integrated inductor. TPSM843620 and TPSM843B22 modules are fixed frequency with selectable switching frequencies ranging from 500kHz to 2.2MHz which also help minimize noise and ripple. The key feature for these devices is the ability to provide high efficiency while running at the mentioned range of switching frequencies demonstrated in Figure 1. TPSM843620 comes in a MicroSiP package that is best for space constrained applications because of the 3D construction and converter embedded directly within the PCB. TPSM843B22 comes in an over molded QFN which improves adhesion to lead frame and reduces exposure of internals. In this package the die and the passives are placed on lead frame and over molded.

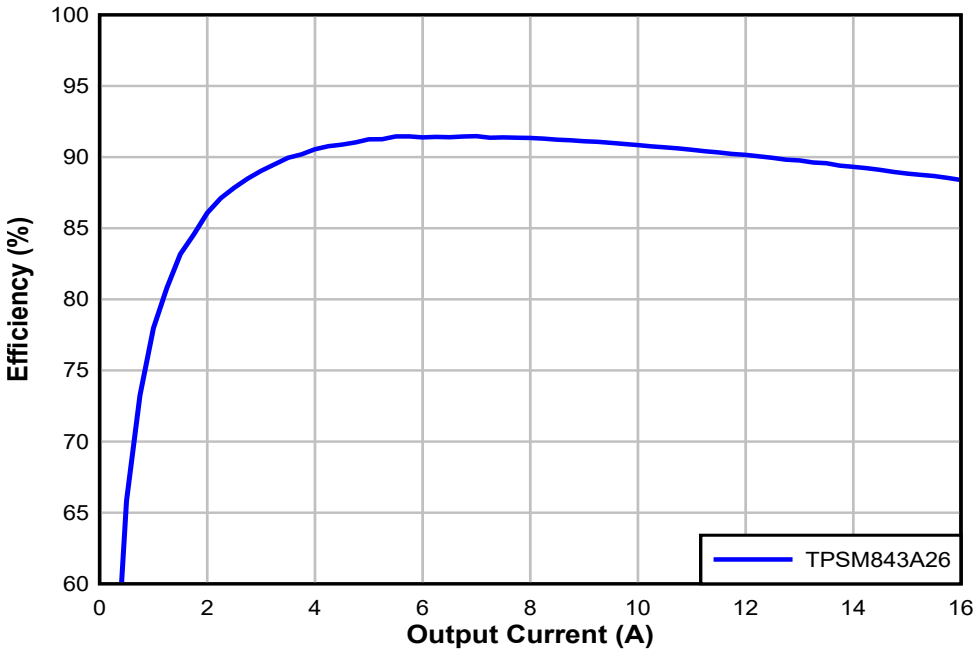

Figure 1. Efficiency Graph TPSM843 A26 in 1.8 Vout, 12 Vin, Fsw = 1 MHz

Noise Emissions

Another critical challenge for medical devices is reducing noise and ripple from power supplies which can affect the performance of sensitive ADCs, DACs, AFEs, and clocking devices. In noise sensitive applications, switching DC/DC converters and modules are typically followed by an LDO and ferrite bead filter. LDO's require a voltage drop of 300mV to 500mV to achieve low noise performance. When loads are small, the power loss and thermals are manageable. For larger loads of 2A and above, devices like the TPS62913 and TPSM82913 allow removal of the LDO without sacrificing performance. Less than 20uVrms noise spectral density of the converter and controller is achieved by implementing a NRSS pin to filter the internal band gap. Less than 10uVrms output voltage ripple is achieved by implementing internal compensation for a ferrite bead filter as shown in Figure 2 and Figure 3. TPSM82913 modules also feature a small design size with integrated passives and high efficiency allowing it to support other Imaging requirements also.

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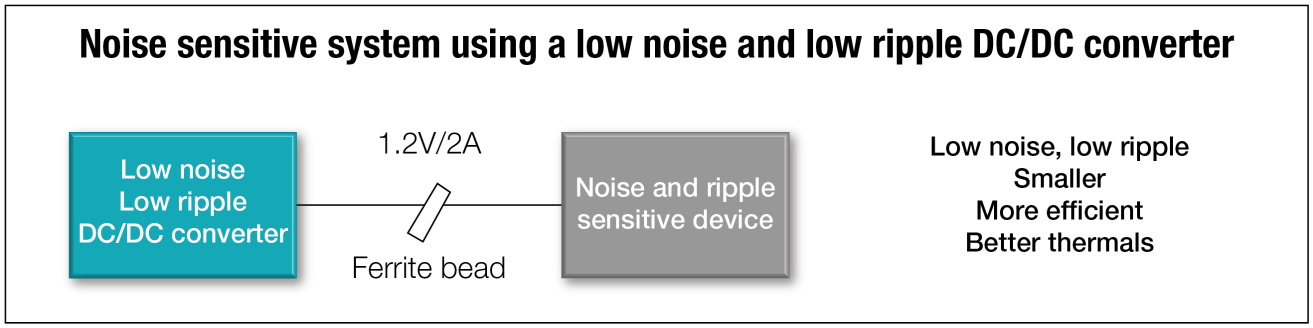

Figure 2. Example of a Noise sensitive system using a low noise and low ripple DC/DC converter

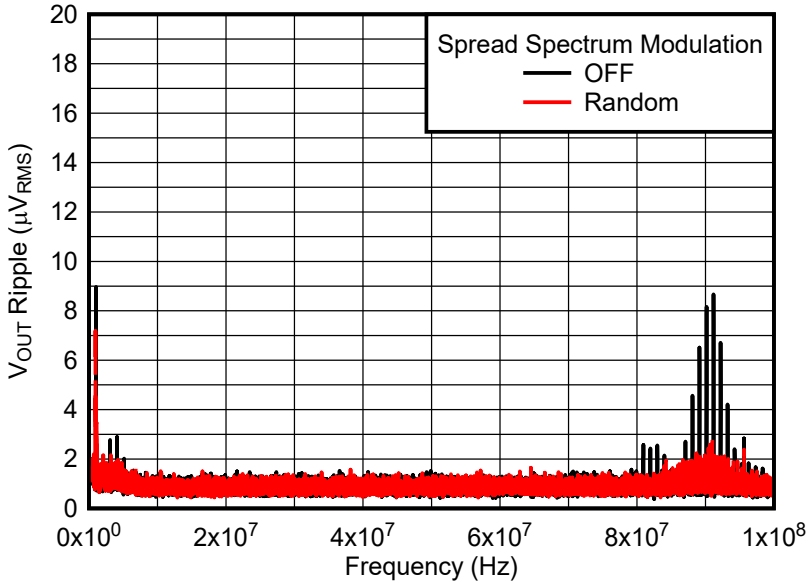

Figure 3. V_{OUT} Ripple FFT After the Second L-C Filter for TPSM82913

Quiescent Current

I_Q, or no-load quiescent current, is an obstacle that duty-cycled low-power systems have to overcome. Low I_Q power designs allow for longer battery life and reduce power consumption. When it comes to portable and handheld imaging equipment, low I_Q is an important feature to have due to them spending the majority of the time in standby/sleep mode, which tends to be a limiting factor in the battery life of the device. When I_Q is reduced, there are trade-offs in transient noise performance, die package area, and output power range. We are making deliberate trade-offs to optimize battery life and it is important to note that some rails may not need this feature since they are not always powered on. The TPSM82903 family of modules is a low current option that covers 1A/2A/3 A in a small compact uSIP package made for Low $I_Q$demanding equipment. With a quiescent current of 4 µA, this family can support the demands of portable or handheld scanners. A graph of the I_Q for TPSM82903 is shown in Figure 4.

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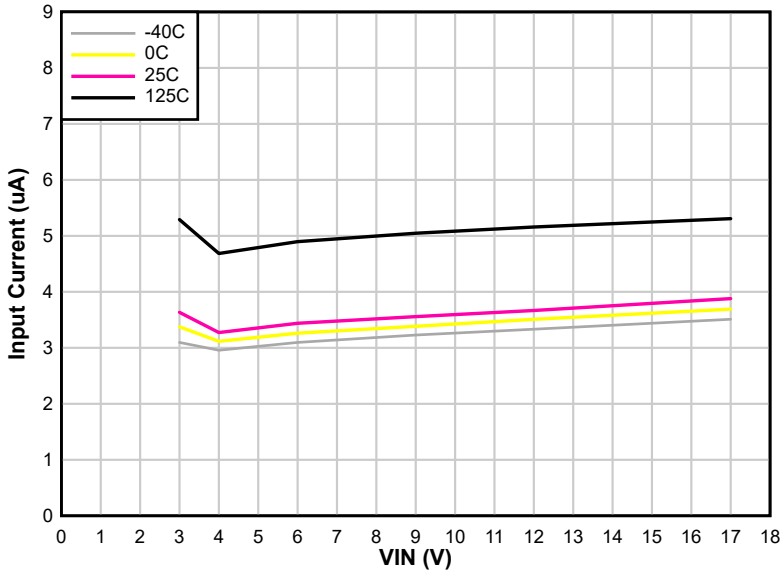

Figure 4. Typical Quiescent Current vs VIN for TPSM82903

Conclusion

When looking into power management designs for medical imaging systems, several key requirements involved need to be considered to choose the most optimized device. Power dense buck converters and modules help the equipment as well as optimize your devices. The low noise devices highlighted reduce and control harmonics produced in the equipment and also allows for the removal of the LDO in some applications. Lastly, having devices with Low I_Q allows for better battery life and the ability to maximize efficiency in portable or handheld equipment.

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