In this Why GaN webinar, we discuss why GaN makes a great solution for multiple applications used in robotics and drones.

您好，我是亚太区高级FAE经理邱亮明。

非常感谢您参加我们今天举行的线上研讨会。

在这个“为什么使用氮化镓器件”研讨会，我们将讨论“面向机器人和无人机的应用， 为什么氮化镓器件是很好的解决方案？”

议题

EFFICIENT POWER CONVERSION

- 基于氮化镓器件的机器人和无人机应用
  - 电机驱动器
  - 机器视觉：飞行时间(ToF) / 激光雷达
  - DC/DC 电源供电
- 为何使用氮化镓器件？
- 面向机器人和无人机的氮化镓(eGaN)产品系列

Today we will discuss the multiple applications where GaN has a significant benefit within robotic and drone systems. These include (build 1) motor drives, (build 2) machine vision, and (build 3) the DC-DC power supplies. (build 4) We will then examine why GaN is such an ideal solution for these systems. (Build 5) and finally we will review the discrete and integrated product portfolio that is available to support these systems.

今天我们将讨论氮化镓器件在机器人和无人机系统应用中的显著优势，包括电机驱动、机器视觉和DC/DC电源。

然后，我们将探讨为什么氮化镓器件可以支持工程师在这些系统构建出理想的解决方案。

最后，我们将展示支持这些系统的分立式氮化镓器件和集成电路系列。

机器人和无人机

There are three major applications within robotics and drones that we will discuss today. (Build 1) motor drives (Build 2) time-of-flight/lidar systems for machine vision and (Build 3) the DC-DC power supply.

今天我们将讨论机器人和无人机的三个主要应用， 包括电机驱动、用于机器视觉的飞行时间/激光雷达系统和DC/DC电源。

First, let’ s look at motor drives

首先，让我们来看看电机驱动器。

为什么使用BLDC电机?

受欢迎的BLDC电机:

- 高扭矩和高功率密度
- 广阔的速度范围
- 高效
- 无刷式可确保低EMI

主要应用:

- 机器人 – 精准控制
- 无人机 – 重量轻
- eBikes – 小型化、重量轻

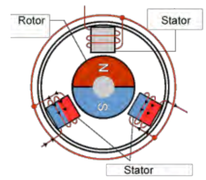


Image courtesy of: Renesas

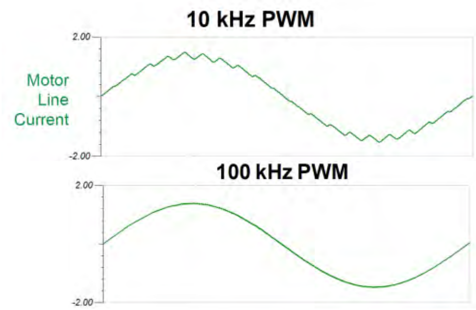
Image courtesy of: https://electricbikereport.com/

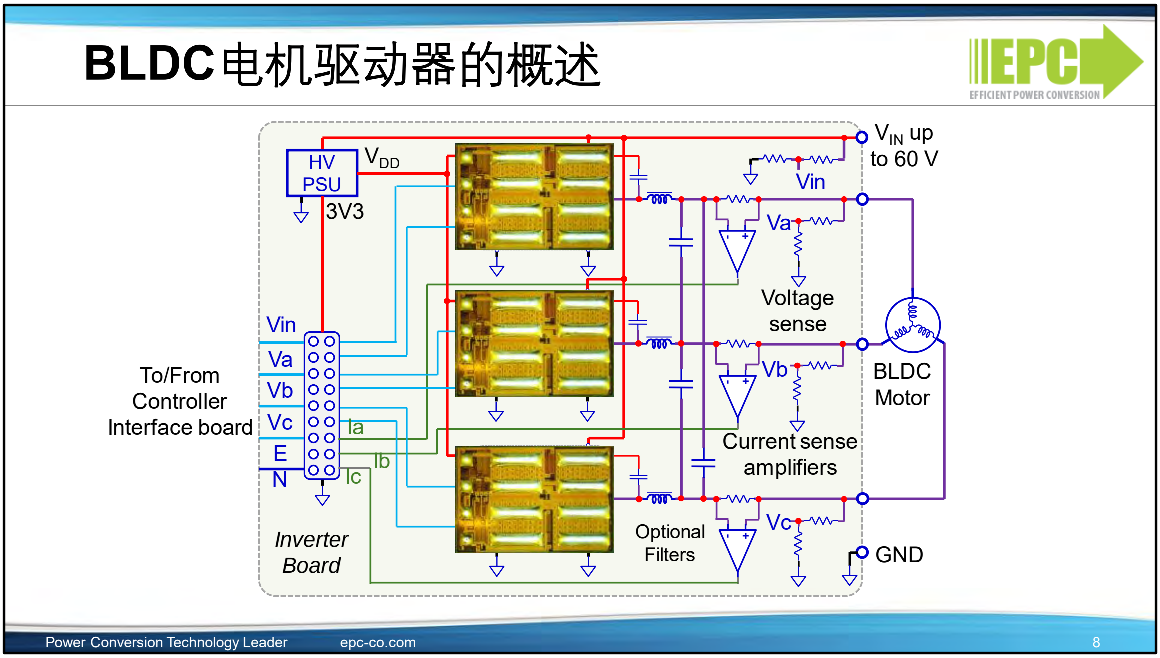
基于氮化镓器件的电机驱动器的优势

GaN FET/IC快速开关 、Q_{RR} = 0

更高的开关频率　　　　更短促的死区时间

- 更少干扰 → 更少可听噪声
- 更低电流纹波 → 减少磁性功耗
- 更低扭矩纹波 → 改善精准度
- 更低滤波 → 更低成本, 更轻和更小型化
- 支持具有低电感的电机

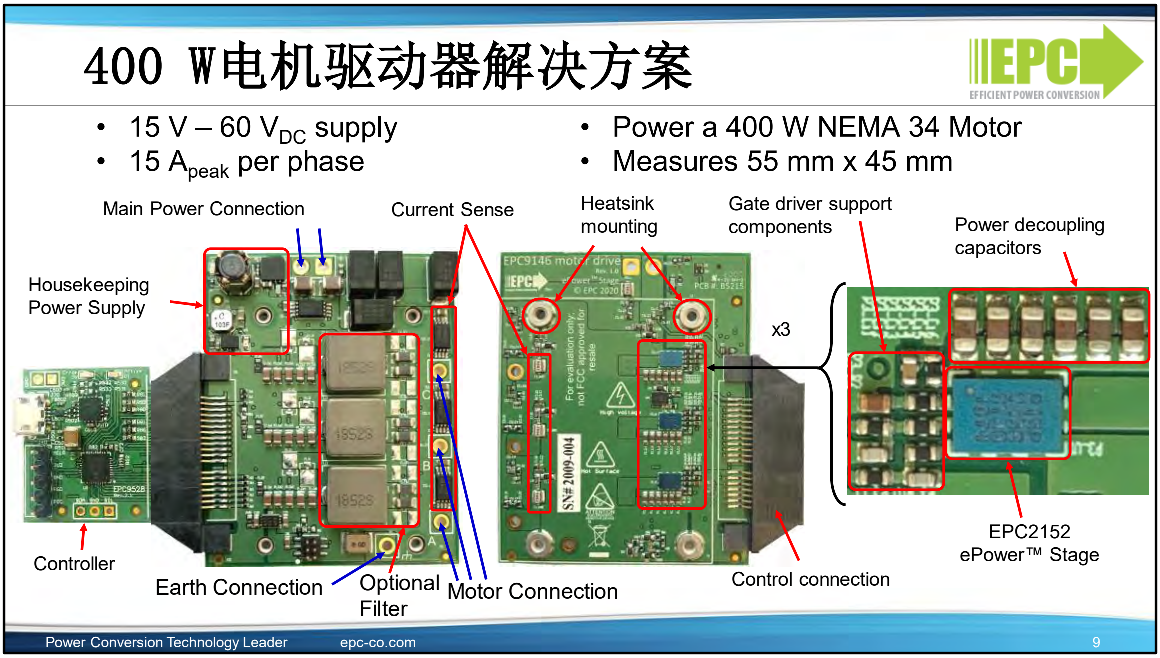




Here is the EPC2146 high-performance BLDC motor drive available as a demonstration system from EPC.
(build 1) Each of the half-bridge power stages use one EPC2152 ePower Stage and requires only a few support capacitors.

这里是EPC2146高性能无刷直流电动机驱动器，可作为EPC的演示系统。

每个半桥功率级使用一个EPC2152 ePower 功率级，而且只需要几个电容。



The EPC2146 3-phase BLDC motor drive was designed and built to operate from a 15 V through 60 V main DC supply and deliver a peak current of 15 A into each phase of the motor.
我们设计和制造EPC2146三相无刷直流电机驱动器，主要在15 V至60 V的主直流电源下运行，并向每相电机提供15 A的峰值电流。

The drive can power a 400 W NEMA 34 size BLDC motor and measures just 55 by 45 mm. The drive includes the following features
这个驱动器可为400 W NEMA 34规格的无刷直流电机供电，而且尺寸仅为55 x 45 mm，它的特点包括:

A main DC supply connection and a housekeeping power supply that operates off the main supply to provide 12 V for the ePower stage and 3.3 V for the controller
1） 一个主直流电源连接和一个辅助管理电源，在主电源之外运行，为ePower功率级提供12 V电压，并为控制器提供3.3 V电压。

(Build 2)
A motor connection including an earth

2） 一个包括接地的电机连接

(Build 3)
A current sense for each of the phases
3） 每个相位的电流传感器

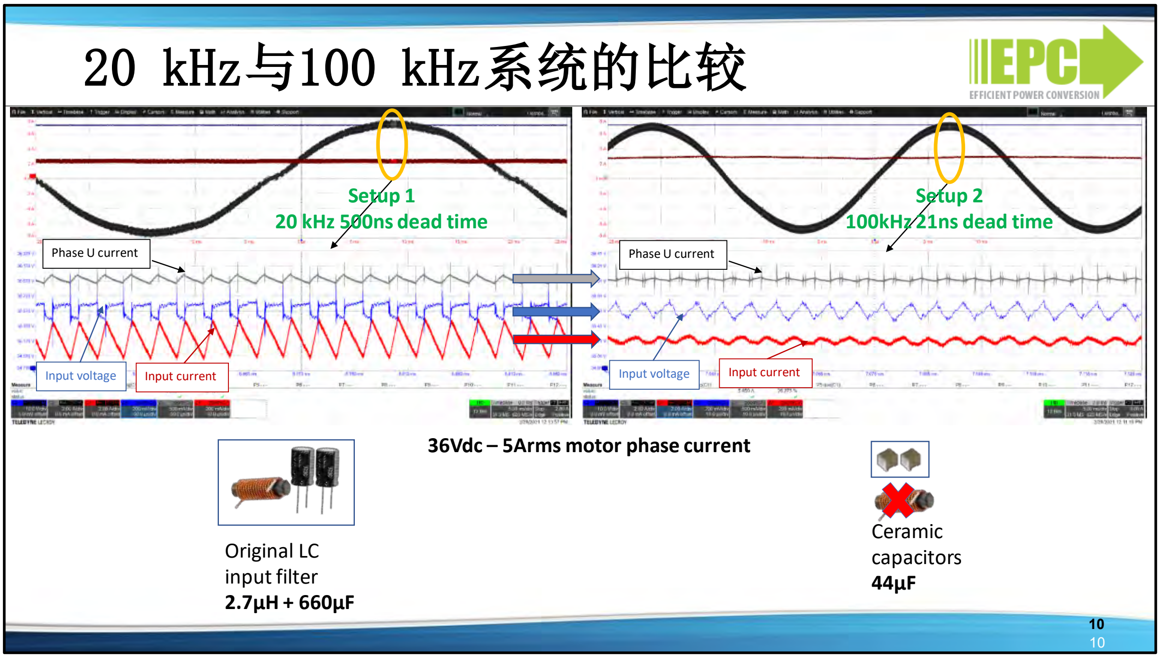
(Build 4)
An optional Filter to reduce dv/dt on the motor windings
4) 可选的滤波器，以减少电机绕组上的dv/dt

(Build 5）
A heatsink mounting option
5） 可选安装散热器

(Build 6)
The ePower stages showing the zoomed in portion for one of the phases and The EPC2152 ePower stage that can operate from 20 kHz through 1 MHz switching frequency
这里的ePower功率级显示了其中一个相位的放大部分。EPC2152 ePower功率级可在20 kHz至1 MHz的开关频率下工作。

(Build 7)
The power stage decoupling capacitors and the gate driver support components
这里是功率级去耦电容和栅极驱动器的支持元件。

(Build 8)
And finally the controller and controller connection
最后是控制器和控制器连接。



Here are the experimental results of the comparison between two setups in the same conditions other than PWM frequency and input filters.
这里是两个设置，它们在相同条件下的实验结果的比较，除了它们的PWM频率和输入滤波器不同。

(Build 1) The system on the left is designed for 20 kHz and has the input filter designed accordingly.
左边的系统是为20 kHz设计的，并且设计了相应的输入滤波器。

In this case with a 2.7 uH inductor and 660 uF electrolytic capacitors. It is running at 36Vdc 5Arms motor phase current
我们使用2.7 uH的电感和660 uF的电解电容。 它在36 Vdc、 5 Arms的电机相电流下工作。

On the oscillogram is superimposed a zoom image at the positive peak of the motor phase current.
在振荡图上叠加了电机相电流的正峰值的放大图像。

The blue curve that shows a ripple at double of the PWM frequency is the input voltage ripple of 200mV peak to peak.
蓝色曲线显示，在两倍PWM频率下，峰值-峰值输入纹波电压为200 mV。

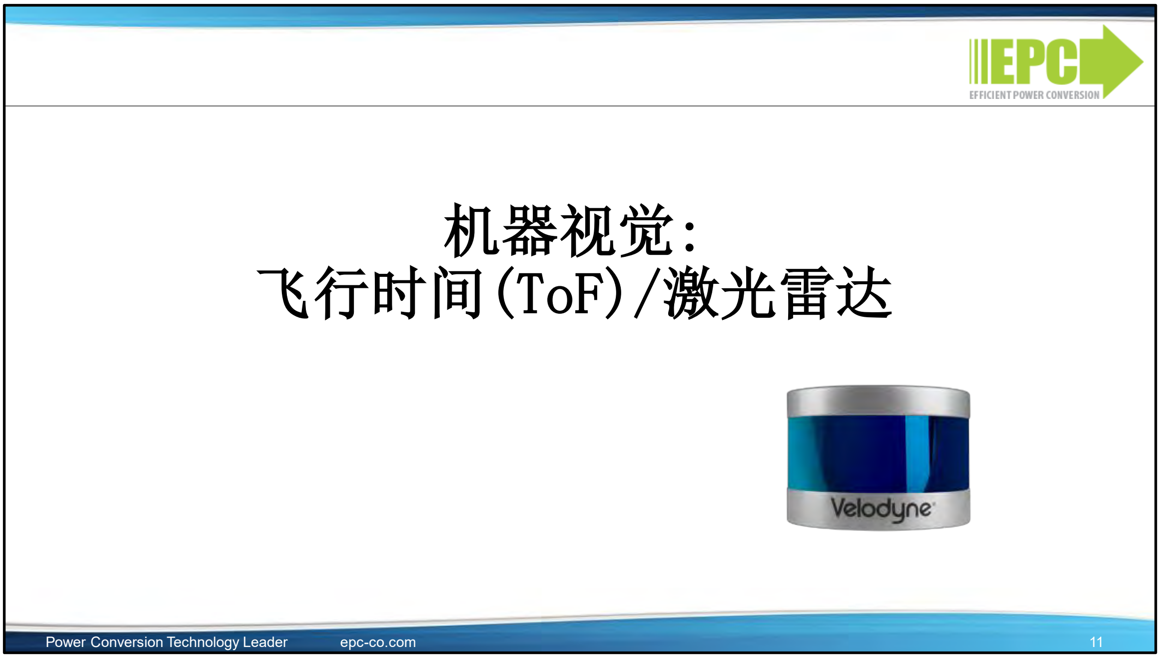
The red curve is the input current ripple of 500mA peak to peak.
红色曲线显示，峰值-峰值输入纹波电流为500 mA。

The grey curve is the motor phase current ripple at 100mA peak to peak.
灰色曲线显示，峰值-峰值电机相位纹波电流为100 mA。

(Build 2) The system on the right is designed for 100 kHz operation and the input filter has been sized accordingly with on 44 uF ceramic capacitors and no input inductor.
右边的系统是为100 kHz的操作而设计的，输入滤波器的尺寸也相应地采用了44 uF的陶瓷电容，和没有输入电感。

When comparing the 20 kHz system to the 100 kHz system, it is clear that the ripple from input voltage, input current and output current are each smaller than the ripple in the 100 kHz system.
当比较20 kHz系统和100 kHz系统时，很明显，20 kHz系统无论是在输入电压、输入电流和输出电流的纹波都比100 kHz系统的纹波小。

(Build 3) Aside from being much smaller and lighter due to the input filter improvements, and if the setup 1 passes EMI tests with LC input filter, then setup 2 is likely to pass the same tests with just 44uF ceramic capacitors.
除了由于输入滤波器的改进而变得更小、更轻之外，如果第一种设置通过了带有LC输入滤波器的EMI测试，那么第二种设置很可能只是用44 uF陶瓷电容，就可以通过同样的测试。



The next application for eGaN technology in robotics is machine vision.

eGaN技术在机器人领域的另一个应用是机器视觉。

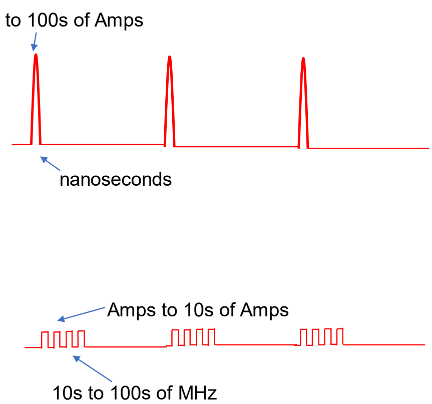
Lidar and Time of Flight (or ToF), give vision to robotics
激光雷达和飞行时间（ToF）为机器人技术提供了视觉效果。

eGaN devices are leading this application and support both Lidar for navigation and Time of Flight for collision avoidance.
eGaN器件引领这种应用的发展，支持用于导航的激光雷达，和用于避免碰撞的飞行时间。

With eGaN devices drones can (build 1) see farther, faster and better.
eGaN器件使得无人机可以看得更远、更快、更清晰。

对于机器视觉，eGaN器件的价值

- **远距激光雷达**
  - 小尺寸、超高峰值电流
    - 高功率、远距、广阔范围
  - 超快速
    - 窄脉冲 = 高分辨率
- **ToF 摄像机（短距激光雷达）**
  - 微型
  - 超高频功能
- **氮化镓集成电路**
  - 缩小尺寸
  - 增加 fsw
  - 降低成本



GaN devices have benefits for both long range and short-range solutions.
氮化镓器件对远距和短距的解决方案都有好处。

(build 1) Long range lidar is used for navigation and can see targets up to hundreds of meters. These systems require very short pulses, in the nanosecond range, with very high peak currents, up to hundreds of amps. This allows long and wide range and high resolution. Finally, size is very small.
远距离激光雷达用于导航，可以看到数百米外的目标。这些系统需要非常短的脉冲，在纳秒范围内，具有非常高的峰值电流，可达数百安培。这允许长而宽的范围和高分辨率。最后，尺寸非常小。

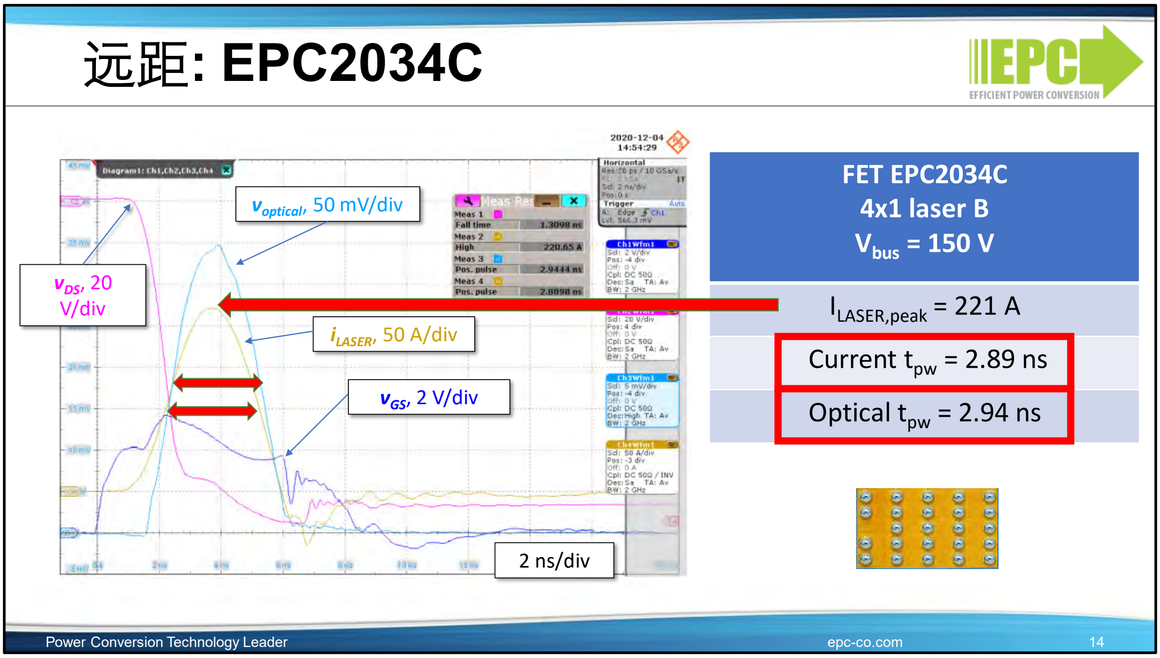
(build 2) eGaN devices enable Lidar shorter pulses, because the rise time plus the fall time is almost 100 times smaller than Si MOSFETs. Additionally, tiny eGaN FETs deliver very high pulsed current. This makes eGaN FETs THE Lidar solution, as proven by their dominance in Lidar applications at all the major players.
eGaN器件能够实现激光雷达的更短脉冲，因为上升沿时间加上下降沿时间，几

乎比硅MOSFET小100倍。此外，微型eGaN FET可以提供非常高的脉冲电流。这使得eGaN FET成为激光雷达的解决方案，它在所有主要厂商的激光雷达应用中占有主导地位，就证明了这一点。

(build 3) Time of flight (TOF) cameras, or short range lidar, need to be very small, and tiny TOF modules have excellent range and accuracy. Pulse currents are smaller than long range lidar, typically less than 10 A,
飞行时间(TOF)摄像机，或是短距离激光雷达，都需要小型化的TOF模块，它具有出色的距离感测和精度。脉冲电流比长距离激光雷达小，通常小于10 A。

(build 4) but the pulse frequency needs to be very high, tens or hundreds of MHz, to guarantee high resolution at short distances.
但脉冲频率需要非常高，几十或几百兆赫，才可以实现短距离的高分辨率。

(build 5) eGaN devices are very small and monolithic integration
(build 5) can further reduce size, increase frequency, and reduce cost.
eGaN器件的尺寸非常小，而且单片集成电路可以进一步缩小尺寸、提高频率和降低成本。

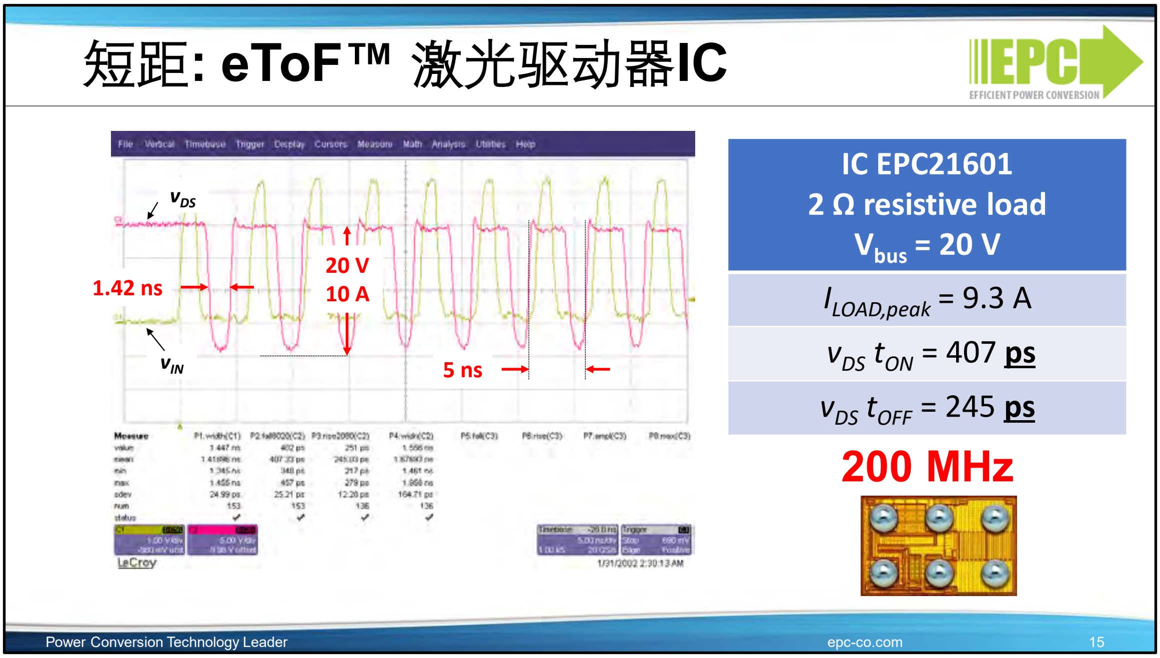


So here's a real-world example using the EPC2034C. It's 200 volt rated, eGaN FET and it can conduct about 250 amperes in a pulse. But it's only 12 square mm in size, so it's pretty tiny. You have a 221 ampere laser pulse peak. And it's only 2.9 nanoseconds wide. So, it's under that three nanoseconds that we're talking about. And of course, you can look at the optical power, we're measuring the return signal. And it's also under three nanoseconds. This is state-of-the-art today. And as you can see, it is hard to achieve because you need very low power loop inductance and very, very low common source.

这里有一个使用EPC2034C的实战案例。这个氮化镓场效应晶体管的额定电压为200 V，可以在一个脉冲传导约250安培的电流。但它的尺寸只有12平方毫米，所以它非常小型化。

激光脉冲峰值为221安培，而它只有2.9纳秒宽，低于我们所讨论的3纳秒。当然，你可以看一下光功率，我们测量返回信号，它也在三纳秒以下。

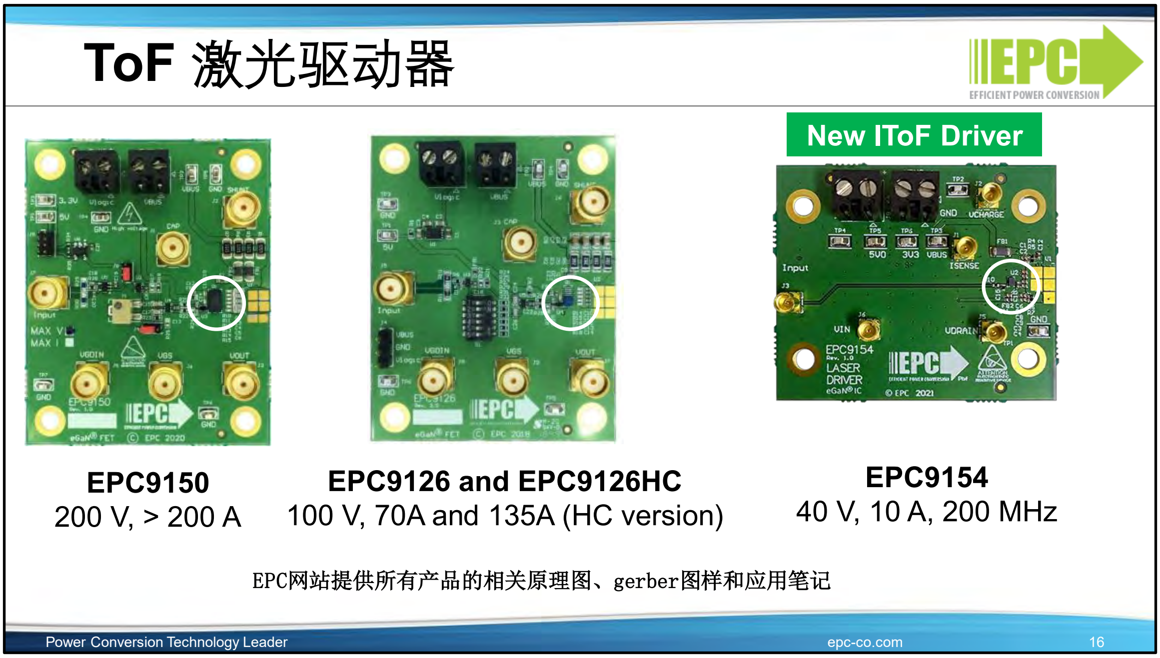
这是当今最先进的技术。正如你所看到的，这很难实现，因为你需要非常低的功率环路电感和非常、非常低的共源。



Now let' s go to very high frequency. So here we're delivering ten ampere pulses for a short range system. But in this case, the pulse width is down to 1.4 nanoseconds. Still delivering 10 amperes but it' s a five-nanosecond repetition which is 200 megahertz, so this will give you a high resolution in short distances, better than anything out there today.

现在我们来看看非常高的频率。

这里我们为一个短距离系统提供10安培的脉冲。但在这种情况下，脉冲宽度下降到1.4纳秒，仍然可以提供10安培，但它是5纳秒的重复，也就是200兆赫，所给你在短距离的高分辨率，要比目前的任何器件都更优越。



We also have demonstration boards to support ToF/lidar designs. The EPC9150 is the one that I showed you earlier with the 220-ampere pulse. It uses the EPC2034C, 200 V device.

我们也提供支持ToF/激光雷达设计的演示板。 EPC9150就是之前提到的那个具有220安培脉冲的电路板。它使用200 V的EPC2034C。

We also have the EPC9126 and 9126HC for high current, which can go up to 135 amperes. And our new board, the EPC9154, which uses the new eToF laser driver integrated circuit and it can run up to 200 Megahertz, delivering 10 amps and 40 volts.
我们还提供用于大电流的EPC9126和9126HC演示板，它可以达到135安培。还有新的板子，EPC9154，它使用新的eToF激光驱动器集成电路，可以在高达200 MHz下工作、实现10安培电流、40 V。

Of course, like all EPC products, schematics, gerbers, and app notes are available on our website.
当然，像所有的EPC产品一样，我们的网站提供所有产品的相关原理图、gerber图样和应用笔记。

The final application for robotics and drones are the DC-DC power supplies…

最后，让我们看看用于DC-DC电源的机器人和无人机。

基于eGaN器件的机器人在DC/DC转换的优势

EPC EFFICIENT POWER CONVERSION

- 更高功率密度
- 更小型化和更轻
  - 与硅MOSFET相比，基于氮化镓器件的解决方案的尺寸和重量减半而同时实现相同功率
- 可在更高频下工作，以进一步缩小尺寸
- 高效

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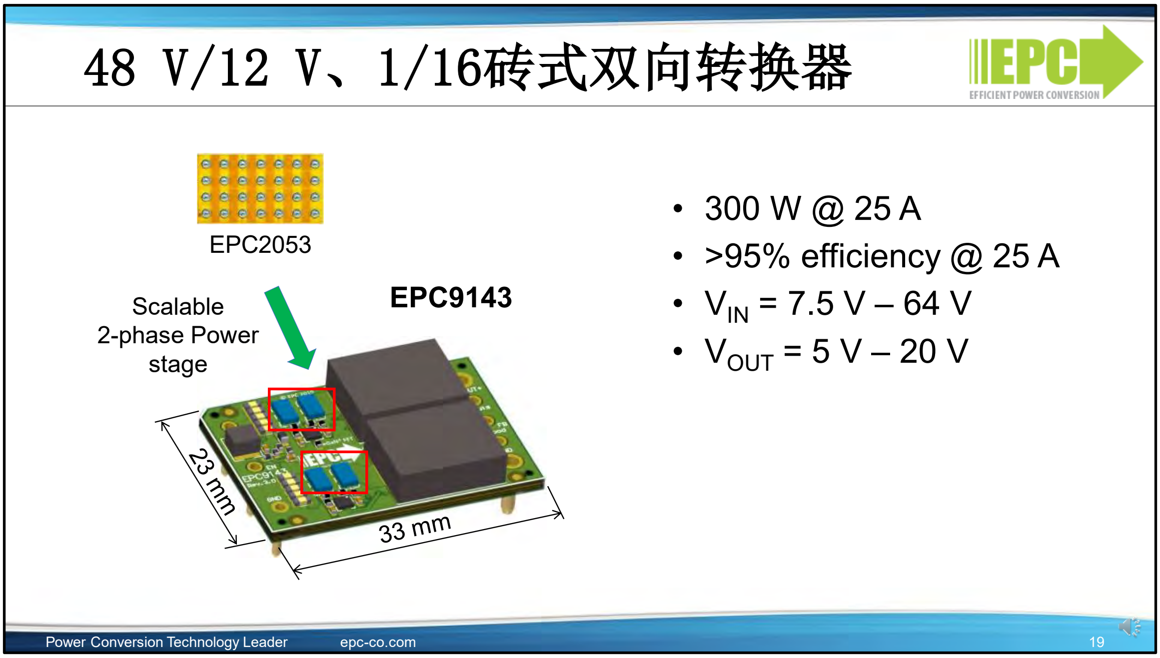
(Build 1) For the 48V DCDC, the fact that eGaN 100V FETs have the Best Figure of Merit for hard switching applications results in higher power density & efficiency vs Si MOSFET.
对于48V DC/DC应用，100 V 的eGaN FET在硬开关应用中具有最佳性能，因此与Si MOSFET相比，它的功率密度和效率更高。

The DCDC is (build 2) smaller & lighter, (build 3)half of the solution size and weight to deliver the same power vs Si MOSFETs. This is due to 5 times smaller RDSon form factor & better FOM at 100 V.
与Si MOSFET相比，基于氮化镓器件的DC/DC转换器更小、更轻，它的尺寸和重量只有一半但可以提供相同功率。这是由于氮化镓器件在100 V时的FOM优越5倍，而外形尺寸更小。

(build 4) The lower switching losses of eGaN devices enable higher frequency to further reduce size.
eGaN器件的开关损耗较低，从而实现更高的频率、进一步减小尺寸。

And finally, (build 5) eGaN devices allow higher battery efficiency

that results in longer battery life.
最后，eGaN器件可以提高电池效率，从而延长电池寿命。



DC-DC in smaller robotics and drones generally operate from 48V, that is 4x 12V battery packs in series. Vout is generally 12V. Size is very critical and generally limited to < 1000mm2. Bi- directional buck – boost design is often required to recharge the battery for more autonomy.
小型机器人和无人机的DC-DC通常从48 V运行，也就是4个串联的12V电池组。输出电压一般为12 V。尺寸是非常重要的，一般限制在<1000mm^2。双向降压-升压设计通常需要给电池充电，以获得更多的自主权。

A reference design for a bi-directional 48V to 12V 300W converter is available, the PN is EPC9143 and the application note is available.
我们提供双向48 V/12V的300 W转换器的参考设计，PN是EPC9143，备有应用笔记。

The design delivers 25A and 300 W power with 96% efficiency. This represents 33% higher efficiency compared to silicon solutions
这个设计提供25 A和300 W的功率，效率为96%。 这意味着与硅解决方案相比，效率提高了33%。

The design features an enhanced microcontroller that will enable users to configure the design for a 300W buck, or modify for a 300W boost or a bidirectional buck boost.
该设计具有一个增强型微控制器，使用户能够将设计配置为300 W降压，或修改为300 W升压或双向降压。

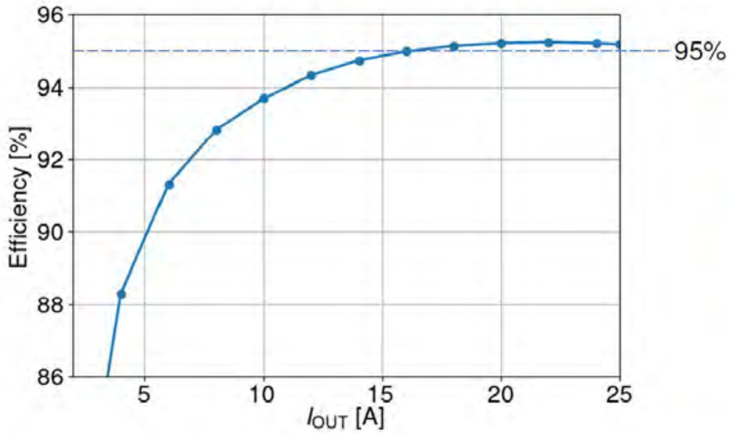
The default setting is a buck 300W to 12V regulated output. However, Vout could be set from 5V to 20V and Vin could vary from 7.5V to 64V.
预定设置是降压300W到12V的调节输出。然而，Vout可以设置为5 V到20 V，而Vin可以从7.5 V到64 V。

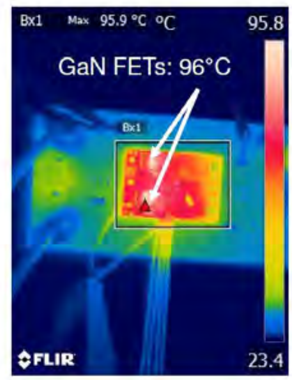
The switching frequency is 500 KHz that allows 300 W in the very small 1/16th brick format, which is just 33x23 mm2. This results in a power density greater than 610 W/in3.
开关频率为500 KHz，允许在非常小的1/16砖式转换器实现300W，仅是33 x 23 mm^2。 这导致功率密度大于610 W/in^3 。

The design is scalable and more phases can be added for higher power.
这个设计是可扩展的，可以增加更多的相位，从而实现更高的功率。

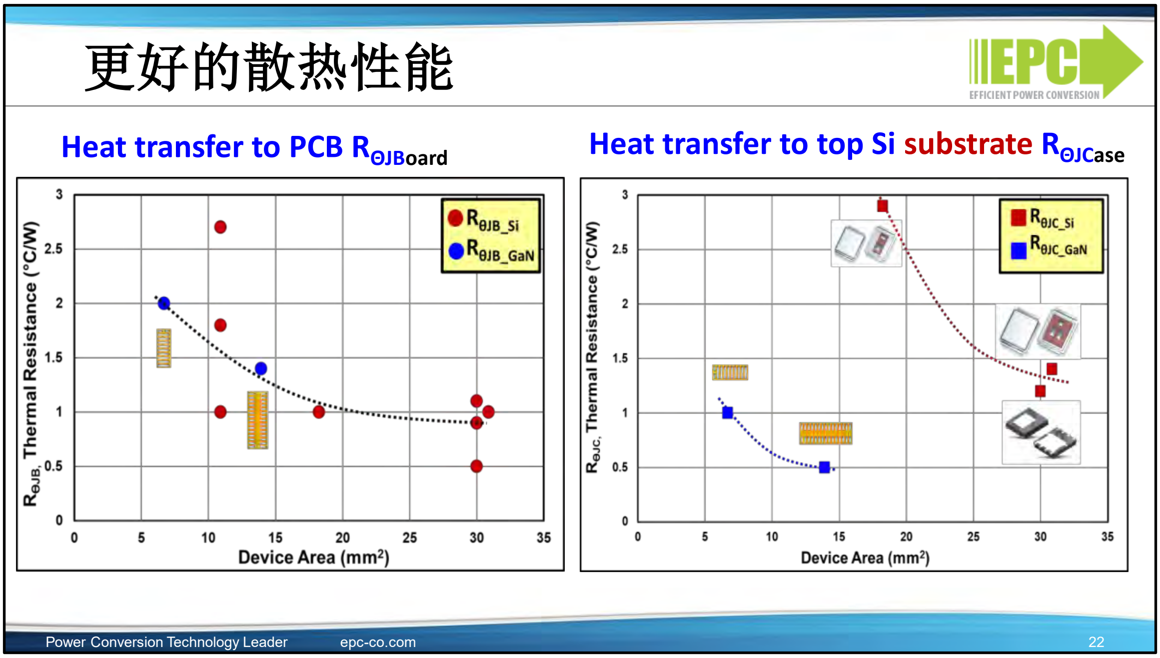
性能结果

48 V input, 12 V output, 1700 LFM airflow





为什么使用氮化镓器件?

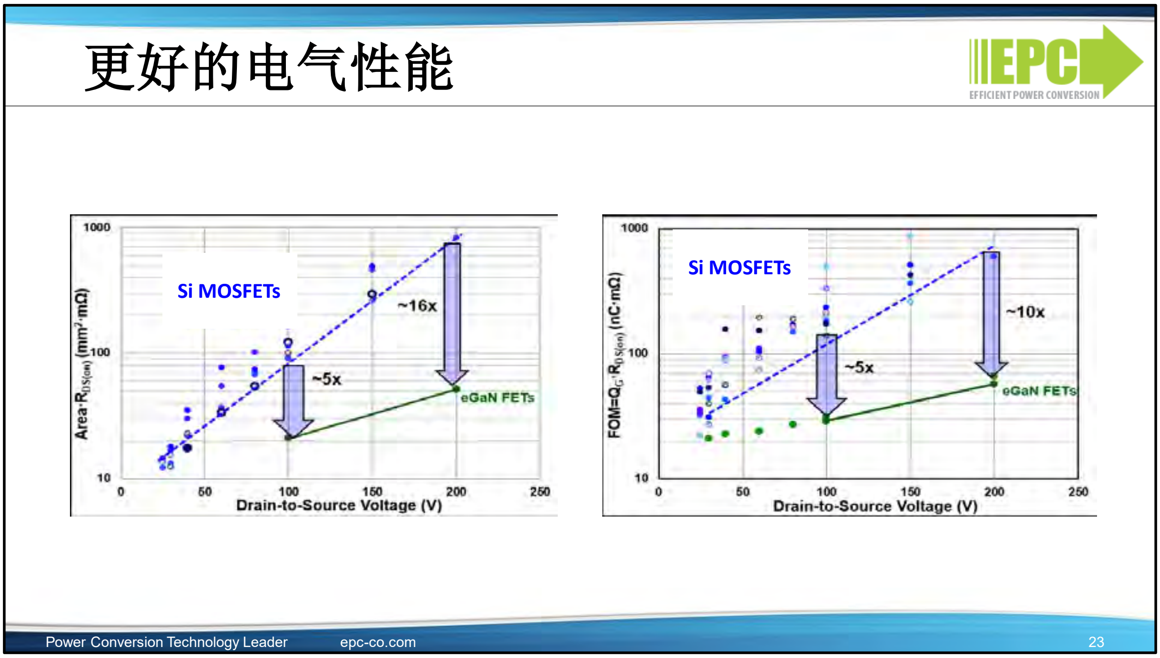


Even though our devices are very small, thermal is not a concern due to the excellent thermal properties of our eGaN dies. On the left you can see that the thermal resistance to pcb is similar to FETs.

尽管我们的器件非常小，但由于我们的eGaN芯片具有出色的散热性能，因此散热问题并不令人担忧。在左边，你可以看到到PCB的热阻与FET相似。

However, on the right we are comparing thermal resistance to case against the absolute best thermal package available for MOSFETs – the Direct FET. The eGaN devices are 6 times better than the best-in-class DirectFET because eGaN dies can dissipate heat through the pcb, top, AND the lateral sides.

然而，在右边，我们比较了到外壳的热阻与采用最佳散热封装的MOSFET—DirectFET的热阻。 eGaN器件比同类最佳的DirectFET好6倍，因为eGaN芯片可以从PCB的顶部和侧面散热。



In comparison to silicon MOSFETs, eGan transistors improve the key figure of merit, area x rdson, by 5 times at 100V. That improvement results in smaller size and lower cost or lower RDSon in the same size.
Additionally, the Figure of merit, RDSon x Qg, is also 5 times better than silicon, resulting in lower losses.
Finally, zero reverse recovery and less switching losses allow an increase in frequency for higher power density.

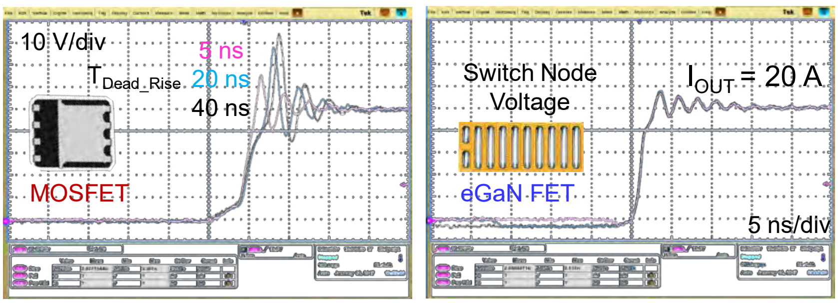
与硅MOSFET相比，eGan晶体管在100V 时的主要FOM（即面积 x $R_{DS(on)}$ ）提高了5倍。这个改进使得尺寸可以更小、成本更低，或在相同尺寸下实现更低的 $R_{DS(on)}$ 。

此外，FOM （$R_{DS(on)}$ x Qg）也比硅好5倍，从而实现更低的功耗。

最后，零反向恢复和更少的开关损耗可以提高频率、实现更高的功率密度。

EMI更低

- 更低的寄生电感
- 快速上升沿/下降沿时间，把噪声推向更高的频率，从而易于过滤
- 没有反向恢复



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Now this next topic is a question we get all the time due to the super fast switching speed of eGaN devices…what about EMI?
接下来的话题是我们经常收到的提问 – 由于eGaN器件的超快开关速度，EMI怎么办？

Gan Devices ***improve*** EMI and there are several reasons for that…
(1)Lower parasitic inductance reduces ringing energy. By adopting simple layout techniques, one can ensure significant reduction in EMI generation that adds zero cost to EMI mitigation.
(2) Fast Rise/ Fall Time moves noise spectrum to higher frequency for easier filtering. At higher frequencies, EMI reduction techniques are more effective ensuring lower cost to implement.
(3) Finally, eGaN FETs and ICs have zero reverse recovery and thus inherently generate less EMI energy in hard-switching converters.

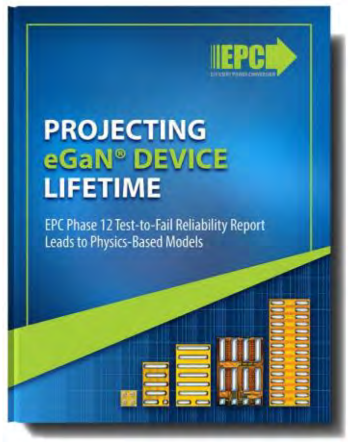
Gan器件**改善了EMI**，这有几个原因......
(1)较低的寄生电感减少了振铃能量。通过采用简单的布局技术，可以确保大幅减少EMI，这样，降低EMI的成本为零。
(2)快速上升沿/下降沿时间将噪声频谱移到更高的频率，以便更容易过滤。在

更高的频率下，减少EMI的技术更有效，成本就可以更低了。
(3) 最后，eGaN FET和IC具有零反向恢复，因此在硬开关转换器中所产生的EMI能量较少。

For more information on EMI view the How to GaN video on this topic.
关于EMI的更多信息，请观看关于该主题的《如何使用GaN》视频。

In summary, eGaN FETs and ICs are EMI compatible.
总之，eGaN FET和IC是兼容EMI的。

前所未有的稳固性



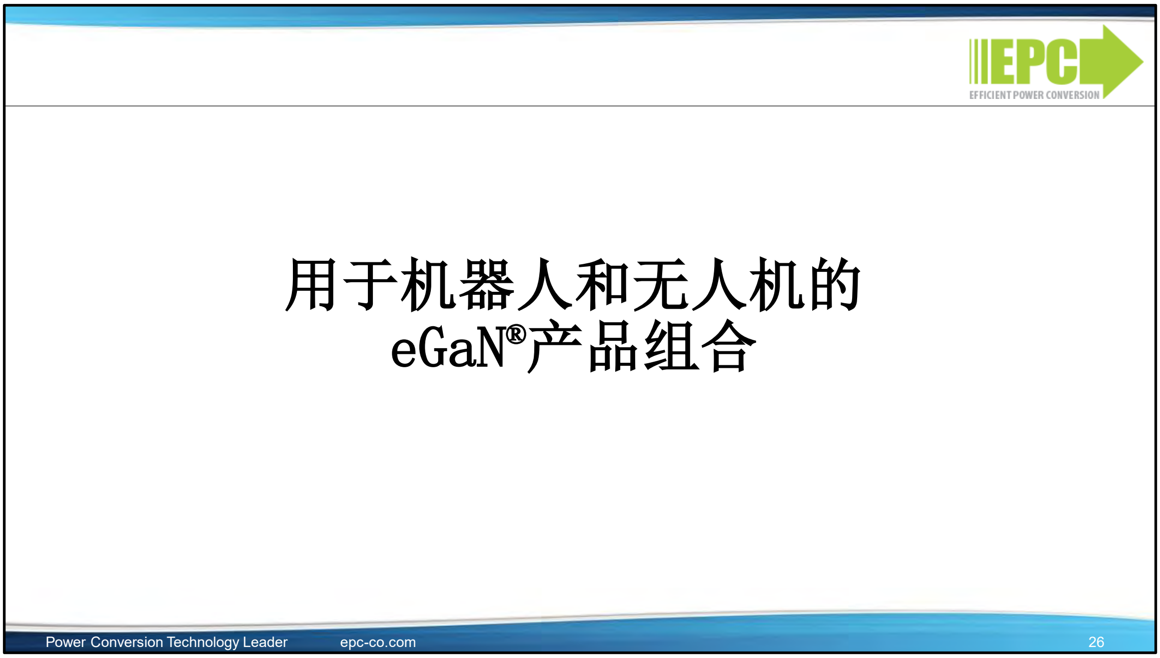
稳固性测试高于JEDEC标准（反复测试器件）

Another important feature is the unprecedent robustness of eGaN devices.
With a “test to Fail” approach to reliability testing, EPC tests devices well beyond JEDEC to improve robustness generation after generation. The test to fail report, Phase 12, is available on the EPC website.
This report details how by employing a test to fail methodology, intrinsic failure mechanisms can be identified and used to develop physics-based models to accurately project the safe operating life of a product over a more general set of operating conditions. This methodology is also employed to consistently produce more robust, higher performance, and lower cost products for power conversion applications.

氮化镓器件的另一个重要特性是它具有前所未有的稳固性。

宜普公司采用 “反复测试器件 ”的方法对氮化镓器件进行可靠性应力测试，该测试远远超过JEDEC标准的要求，从而提高一代又一代氮化镓器件的稳固性。第12阶段产品可靠性测试报告可以在宜普公司的网站找到。

该报告详细介绍了如何通过采用反复测试器件的方法，确定器件的内在故障机制，并用于开发基于物理学的模型，以准确预测到产品在更普遍的操作条件下的安全工作寿命。这种方法也被用于持续生产更坚固、更高性能、更低成本和各种电源转换应用所需的产品。


EFFICIENT POWER CONVERSION
用于机器人和无人机的
eGaN®产品组合
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100 V的产品

Parameter	EPC2051 (@ 5 V_{GS})	EPC2052 (@ 5 V_{GS})	EPC2045 (@ 5 V_{GS})	EPC2204 (@ 5 V_{GS})	EPC2053 (@ 5 V_{GS})	EPC2218 (@ 5 V_{GS})
$R_{DS(on)}$ typ	**20 mΩ**	**10 mΩ**	**5.6 mΩ**	**4.5 mΩ**	**3.2 mΩ**	**2.5 mΩ**
$R_{DS(on)}$ max	25 mΩ	12.5 mΩ	7 mΩ	5.6 mΩ	3.8 mΩ	3.2 mΩ
Q_G typ	1.7 nC	3.7 nC	5.9 nC	6.4 nC	12 nC	11.8 nC
Q_{GD} typ (1)	**0.3 nC**	**0.5 nC**	**0.8 nC**	**0.9 nC**	**1.5 nC**	**1.6 nC**
Q_{OSS} typ(1)	7.3 nC	13 nC	25 nC	25 nC	45 nC	46 nC
Q_{RR} typ	0 nC	0 nC	0 nC	0 nC	0 nC	0 nC
Area	**1.11 mm²**	**2.25 mm²**	**3.75 mm²**	**3.75 mm²**	**7 mm²**	**7 mm²**

(1) at V_{DS} = 50 V

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Here you see a full range of 100 V FETs from EPC with RDSon ranging from 20 mOhm to 2.5 mOhm (build 1). Gate charge is very small, (build 2) from 1.7 nC to 11.8 nC, Qgd is also very small, for very low switching losses, and Qrr is 0. The device area is ultra-small (build 3), from 1mm2 to 7mm2.

在这里，你可以看到宜普电源转换公司的全系列100 V FET，$R_{DS(on)}$范围从20 mOhm到2.5 mOhm。栅极电荷非常小，从1.7 nC到11.8 nC，而且Qgd也非常小，实现非常低的开关损耗，Qrr为0。器件的面积超小，从1mm²到7mm²。

EPC的100 V与硅80 V器件的比较

3.3 mm x 3.3 mm

(MOSFET Benchmark)

1.5 mm x 2.5 mm

(eGaN FET)

Parameter	BSZ070N08LS5 10 V_{GS}	EPC2204 5 V_{GS}	EPC GaN FET Improvement
$R_{DS(on)}$ typ	**7.2 mΩ**	**4.5 mΩ**	**38%**
$R_{DS(on)}$ max	9.2 mΩ	5.6 mΩ	**64%**
Q_G typ	15 nC	6.4 nC	**57%**
Q_{GD} typ	**5 nC @ 40 V_{DS}**	**0.9 nC @ 50 V_{DS}**	**82%**
Q_{OSS} typ	29 nC @ 40 V_{DS}	25 nC @ 50 V_{DS}	**14%**
Q_{RR} typ	**29 nC @ 40V Vr**	**0 nC**	**Infinitely**
Device Size	**10.9 mm^2**	**3.75 mm^2**	**66%**

Three times smaller, less losses, no reverse recovery, higher f_{SW}

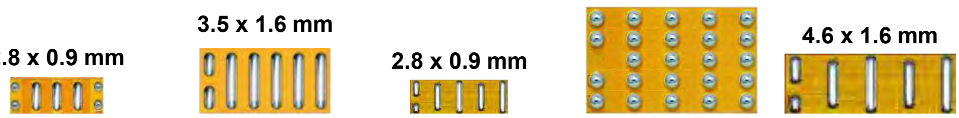
If we compare the performance of eGaN FET vs the benchmark silicon MOSFET, the (build 1) RDSon of the GaN device is 38% smaller despite the higher voltage rating of the eGaN device, (build 2) Qg is 57% smaller, Qgd 82% smaller, and (build 3) Qrr is 0. Additionally, the eGaN FET (build 4) is 1/3 of the size. Overall, eGaN devices are 3 times smaller, have less losses and no reverse recovery and enable higher switching frequency.

如果我们将eGaN FET的性能与基准硅MOSFET进行比较，尽管eGaN器件的额定电压较高，但GaN器件的$R_{DS(on)}$小了38%、Qg小了57%、Qgd小了82%，而且Qrr为0。

此外，eGaN FET的尺寸是MOSFET的1/3。

整体来说，eGaN器件的尺寸小了3倍、损耗更小、没有反向恢复，并且可以实现更高的开关频率。

200 V的产品



Parameter	EPC2019 (@ 5V Vgs)	EPC2010C (@ 5V Vgs)	EPC2207 (@ 5V Vgs)	EPC2034C (@ 5V Vgs)	EPC2215 (@ 5V Vgs)
$R_{DS(on)}$ typ	36 mΩ	18 mΩ	16 mΩ	6 mΩ	6 mΩ
$R_{DS(on)}$ max	50 mΩ	25 mΩ	22 mΩ	8 mΩ	8 mΩ
Q_G typ	1.8nC	3.7 nC	2.9 nC	11.1 nC	10 nC
Q_{GD} typ (1)	0.4nC	0.7 nC	0.6 nC	2 nC	1.6 nC
Q_{OSS} typ (1)	18nC	40 nC	22 nC	96 nC	68 nC
Q_{RR} typ	0nC	0 nC	0 nC	0nC	0 nC
Device Size	2.6mm^2	5.8mm^2	2.6 mm^2	12mm^2	7.36 mm^2

(1) at V_{DS} = 100 V

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Here you see a full range of 200 V FETs from EPC with RDSon ranging from 36 mOhm to 6 mOhm (build 1). Gate charge is very small, (build 2) from 1.8 nC to 10 nC, Qgd is also very small, for very low switching losses, and Qrr is 0. The device area is ultra-small (build 3), from 2.6mm2 to 7.4mm2.

在这里，你可以看到宜普公司的全系列200 V FET，$R_{DS(on)}$范围从36 mOhm 到 6 mOhm。栅极电荷非常小，从1.8 nC到10 nC，Qgd也非常小，实现非常低的开关损耗，和Qrr为0。器件的面积超小，从2.6 mm^2 到 7.4 mm^2。

EPC的200 V与硅器件的比较

Si MOSFET Benchmark

eGaN FET

9.9 mm x 11.7 mm   4.6 mm x 1.6 mm

Parameter	IPT111N20NFD (@ 10 V_{GS})	EPC2215 (@ 5 V_{GS})	EPC GaN FET Improvement
$R_{DS(on)}$ typ	**9 mΩ**	**6 mΩ**	**33% lower**
$R_{DS(on)}$ max	11.1 mΩ	8 mΩ	28% lower
Q_G typ	**65 nC**	**10 nC**	**6x lower**
Q_{GD} typ	8 nC @100V Vds	1.6 nC	80% lower
Q_{OSS} typ	162 nC @ 100V Vds	68 nC	58% lower
Q_{RR} typ	309 nC	0 nC	Infinitely lower
Device Size	**115.83 mm^2**	**7.36 mm^2**	**15x smaller**

15 times smaller, less losses, no reverse recovery, higher f_{SW}

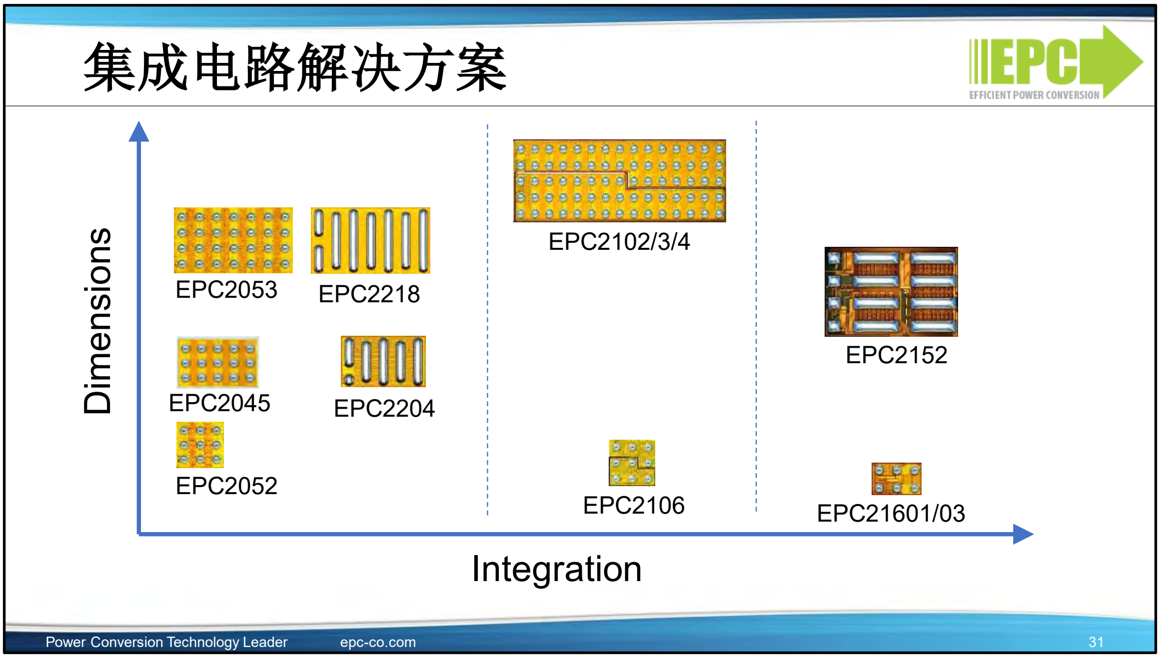
Power Conversion Technology Leader   epc-co.com   30

If we compare the performance of eGaN FET vs the benchmark silicon mosfet, the (build 1) RDSon of the GaN device is 33% smaller, (build 2) Qg is 6 times lower, Qd 80% lower, and (build 3) Qrr is 0. Additionally, the eGaN FET (build 4) is 15 times smaller. Overall, eGaN devices are 15 times smaller, have less losses and no reverse recovery, and enable higher switching frequency

如果我们将eGaN FET的性能与基准硅MOSFET进行比较，GaN器件的$R_{DS(on)}$小33%、Qg低6倍、Qd低80%，和Qrr为0。

此外，eGaN器件的体积要小15倍。

整体来说，eGaN器件的尺寸小了15倍、损耗更小、没有反向恢复，并且可以实现更高的开关频率。

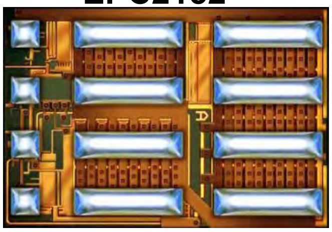


EPC also offers a flexible portfolio for motor drives application. Customers can select (build 1) discrete FETs, (build 2) integrated half bridges, or (build 3) our new integrated solutions

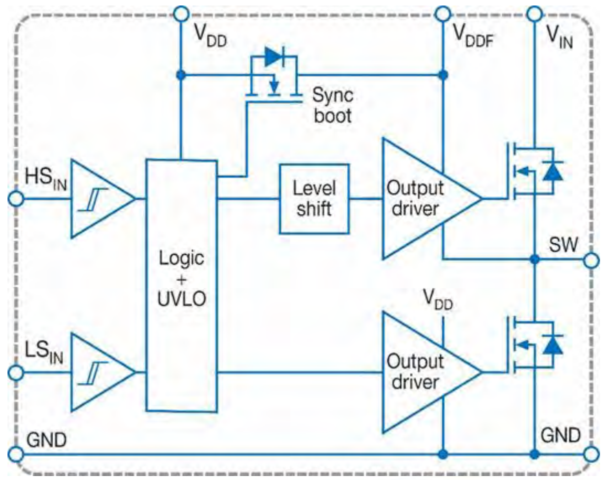
宜普电源转换公司还为电机驱动应用提供了灵活的产品组合。客户可以选择分立式FET、集成式半桥器件，或是我们新的集成电路解决方案。

集成功率级

EPC2152

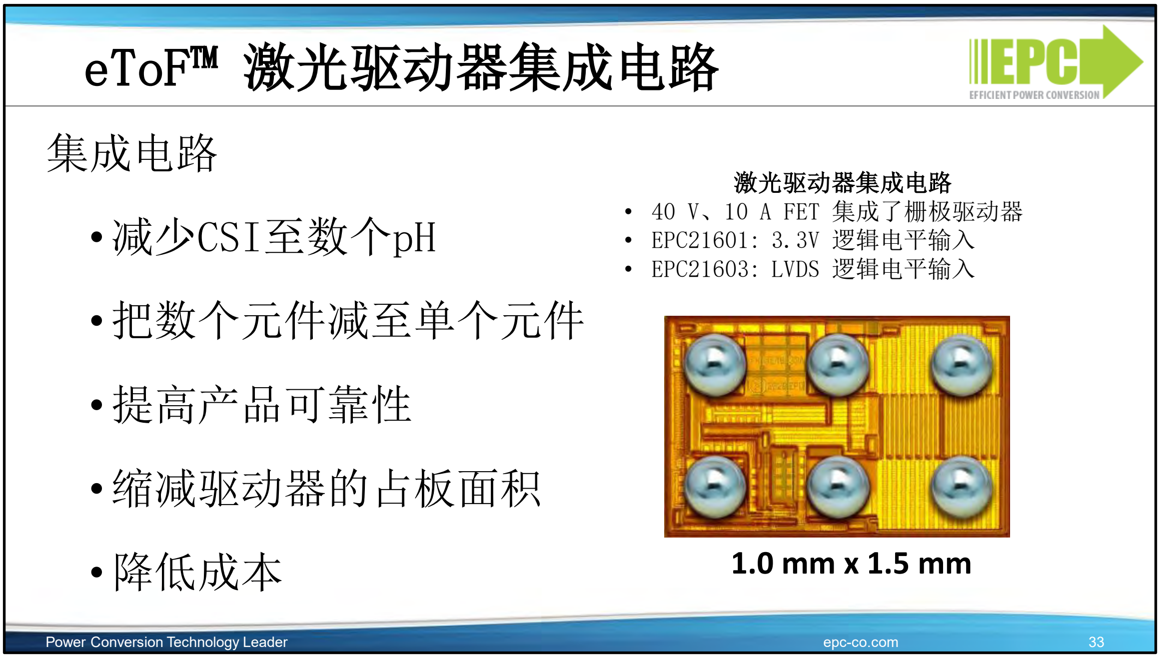


- 80 V_{IN} max
- 15 A @ 100 kHz
- 10 mΩ
- 10 mm²



The ePower Stage digital In and Power Out family simplifies design and will further reduce size. The devices is very small, only 10 mm2, and integrates drivers, level shifter, half bridge FETs and bootstrap. The maximum input voltage is 80V and the maximum current at 100 KHz is 15A.

ePower Stage数字输入和功率输出系列简化了设计，并将进一步减小尺寸。这个器件非常小，只有10mm²，并集成了驱动器、电平转换器、半桥FET和自举电路。最大输入电压为80V，100 KHz时的最大电流为15 A。



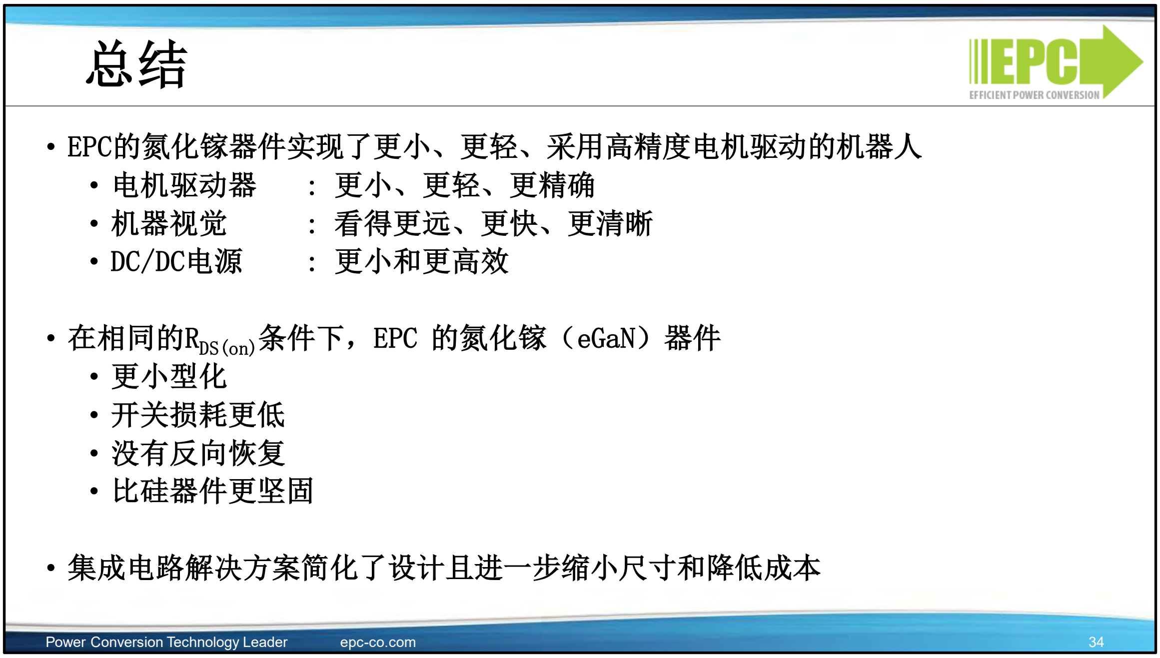
A new laser driver IC family includes both the driver and the integrated circuit in the same chip. It ‘s an integrated circuit that takes those two components and combines it into one eliminating virtually all of the inductance in the gate loop. The common source inductance is reduced to just a few picohenries. You could replace several parts with a single part. Of course, it’ s enhanced in reliability because it’ s just one chip instead of many. You have much smaller area and this chip it ‘s selling for less than $1 in quantities of half a million or more. It is a 3.3 volt logic level input and is capable of outputting 10 amperes in teeny tiny 1 mm by 1.5 mm format.

一个新的激光驱动器IC系列在同一芯片上包含驱动器和集成电路。这是一个集成电路，它将这两个元件合二为一，消除了栅极环路中几乎所有的电感。共源电感被减少到只有几皮赫。

你可以用这个元件取代几个元件。当然，它的可靠性也增强了，因为它只是一个芯片而不是多个芯片。

这个芯片的面积更小，而它在批量为50万个或以上时的销售单价不到1美元。

它的逻辑电平输入为3.3 V，能够输出10安培电流，尺寸仅为1 mm x 1.5 mm。



In summary, (build 1) EPC devices enable smaller, lighter, and higher precision robotics and drones. The motor drivers are smaller, lighter and more accurate.
总括来说，EPC的氮化镓器件能够实现更小、更轻且具有更高精度的机器人和无人机，电机驱动器可以更小、更轻、更精确。

The lidar systems see farther, faster, and better and the power supplies are smaller and more efficient for longer battery life and range.
基于氮化镓场效应晶体管的激光雷达系统可以看得更远、更快、更清晰，而且电源更小、更高效，可延长电池寿命和续航能力。

(Build 2) Given the same on-resistance, EPC eGaN devices are smaller, have lower switching dissipation, do not have no reverse recovery, and are more robust that silicon MOSFETs.
在相同的导通电阻下，eGaN器件更小、开关功耗更低、没有反向恢复，而且比硅MOSFET更坚固。

Lastly, (build 3) GaN integrated solutions simplify design and

further reduce size and cost for all of these applications.
最后，氮化镓集成电路解决方案简化了设计、进一步缩小所有这些应用的尺寸和降低成本。

For more detailed information about GaN FETs and ICs, please see the 3rd edition textbook, GaN Transistors for Efficient Power Conversion or view more videos in the How2GaN series.
And for more information on eGaN FETs and IC products and evaluation kits, go to epc-co.com

有关氮化镓场效应晶体管和集成电路的更多详细信息，请参看第三版教科书《氮化镓晶体管 - 高效功率转换》，或观看How2GaN系列的视频。

而更多关于eGaN FET和IC产品、评估套件的信息，请访问epc-co.com.cn。

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谢谢大家！