The eGaN® FET Journey Continues

EFFICIENT POWER CONVERSION

Kilowatt Laser Driver with 120 A, sub-10 nanosecond pulses in < 3 cm^2 using a GaN FET

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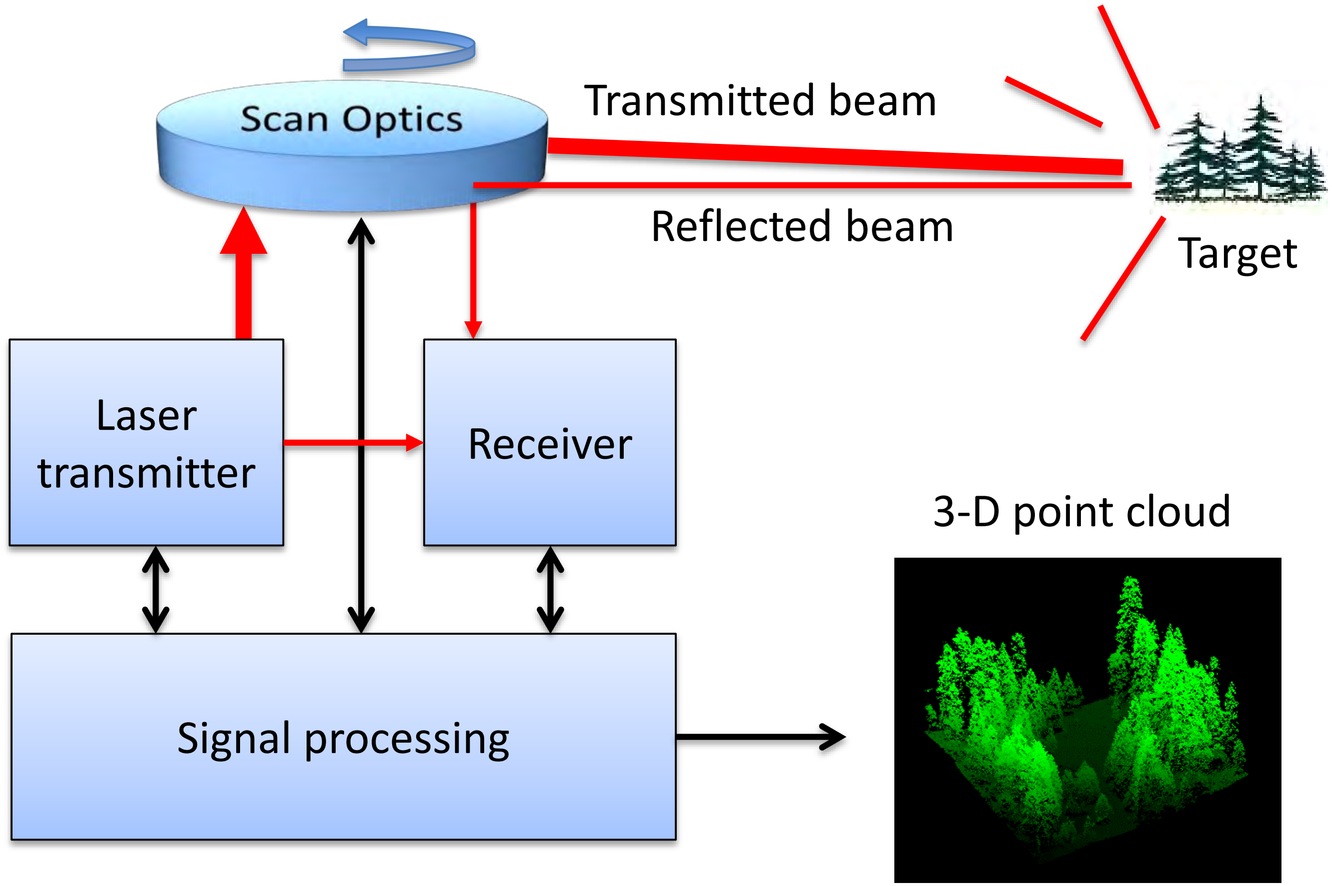
What is Lidar?

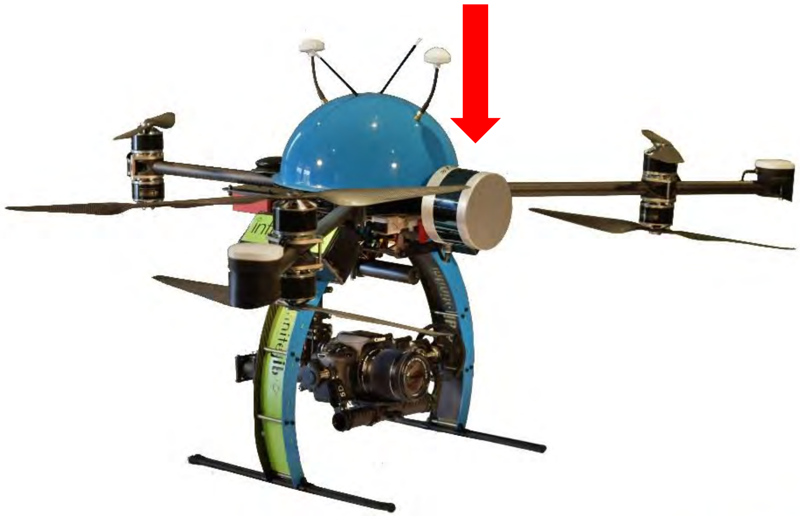


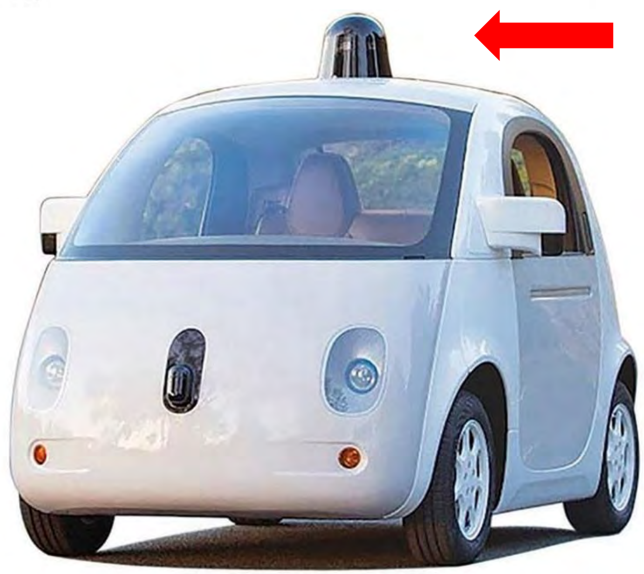
http://ucanr.edu/blogs/green//blogfiles/11605_original.png

Types of lidar

- Time of flight (TOF) for distance measurement
- Doppler
- Spectroscopic
- Multispectral
- Polarized
- …

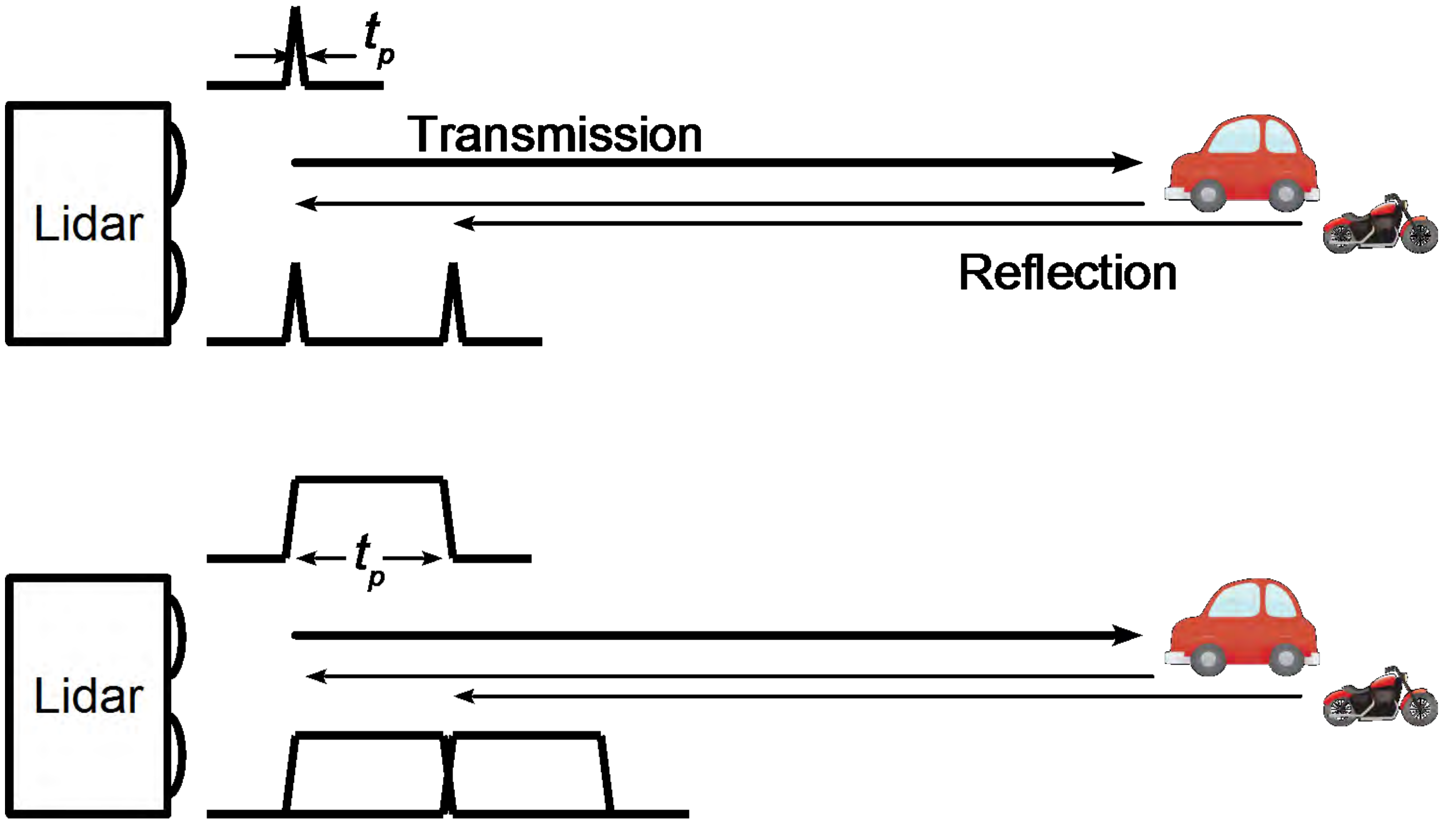
LiDAR for Autonomous Vehicles





Importance of pulse shape

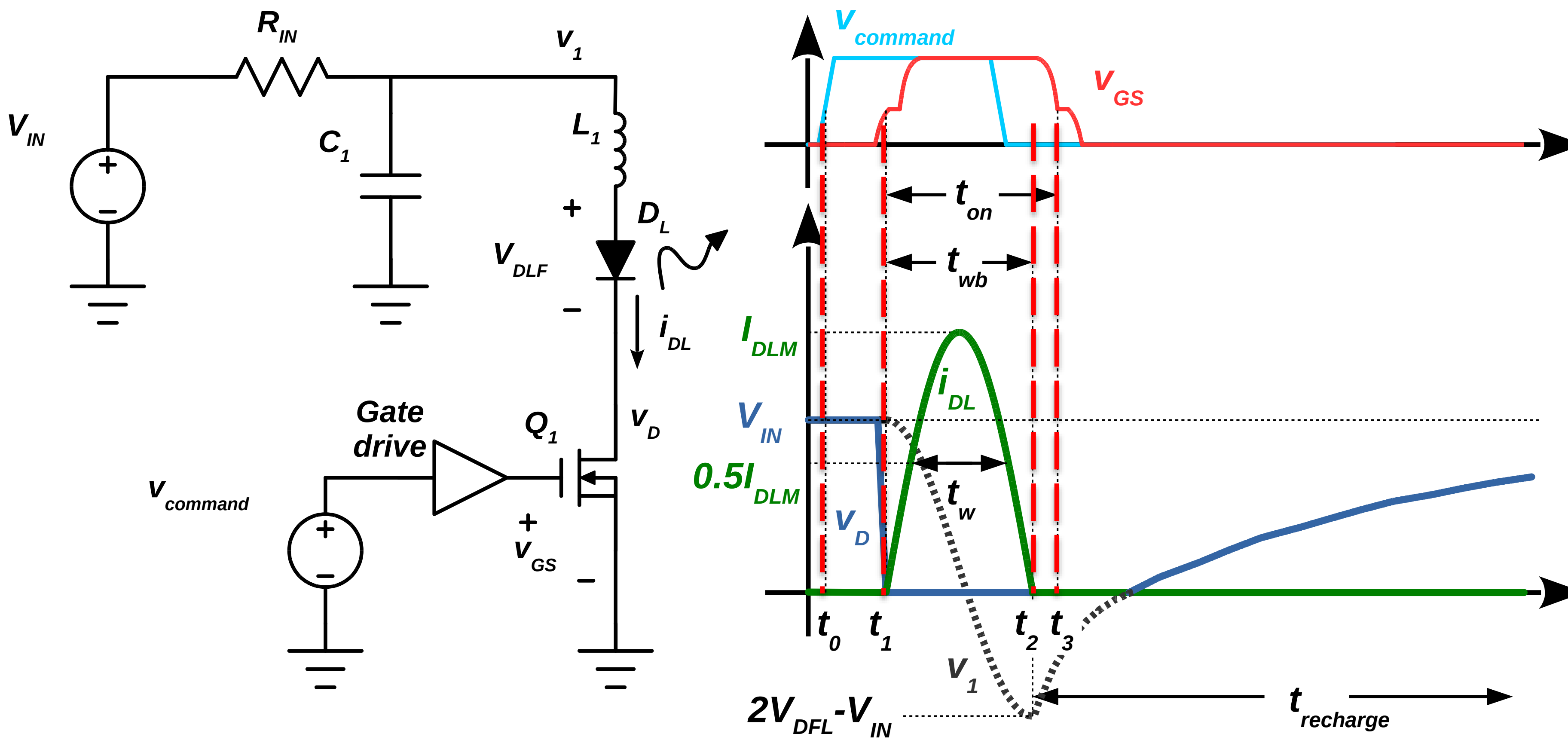
$t_d = 2d/c$



Importance of pulse power

- 300 m range for 10 s response
  - Detection
  - Recogition
  - Decision
  - Controlled deceleration
- High peak laser current ~150 A
- Wider pulse acceptable for distant targets

Leading edge (resonant) control



Lidar is a pulsed power application

Leading edge control

Peak Current:

$$I_{DLpk} = \frac{V_{IN} - V_{DLF}}{R_0}$$

Characteristic impedance:

$$R_0 = \sqrt{\frac{L_1}{C_1}}$$

Half-amplitude pulse width (HAPW):

$$t_w = t_{res}\frac{\pi - 2\sin^{-1}\frac{1}{2}}{2\pi} = \frac{t_{res}}{3}$$

Resonant frequency:

$$t_{res} = 2\pi\sqrt{L_1 C_1} = 2t_{wb}$$

Recharge time constant:

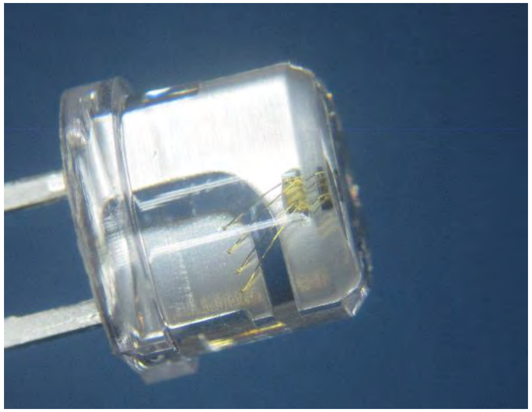
$$\tau_{chrg} = R_1 C_1$$

Required capacitor charging voltage:

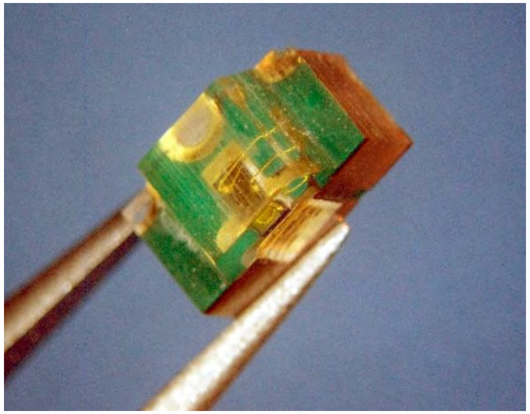
$$V_{IN} = \frac{2\pi L_1}{3t_w} I_{DLpk} + V_{DLF}$$

Laser diodes

SPL PL90_3

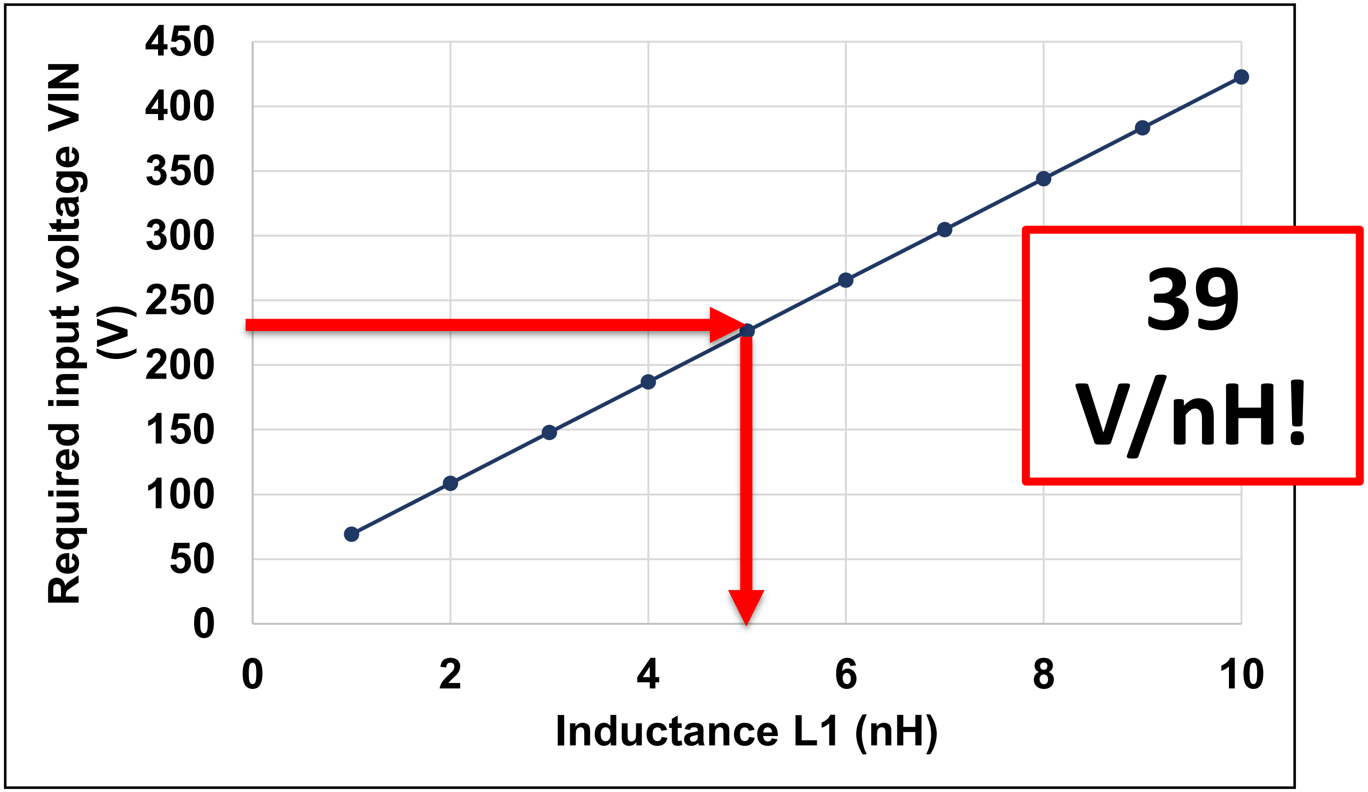


TPGAD1S09H



Part No.	λ [nm]	I_{Fmax} [A]	V_{Fmax} [V]	$P_{opt,max}$ [W]	Package	L [nH]
TPGAD1S09H	905	30	12.5	75	Surface mount	2
SPL PL90_3	905	30	9	75	Through hole	5

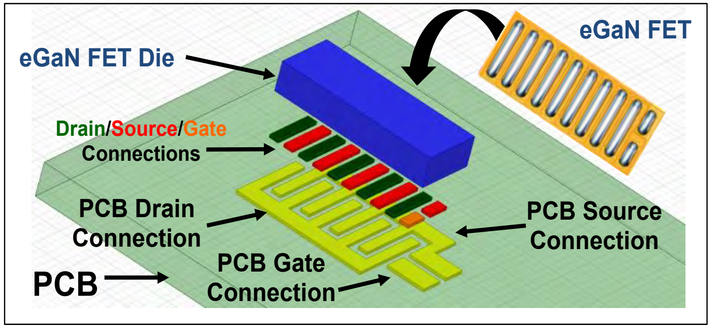
Impact of stray inductance

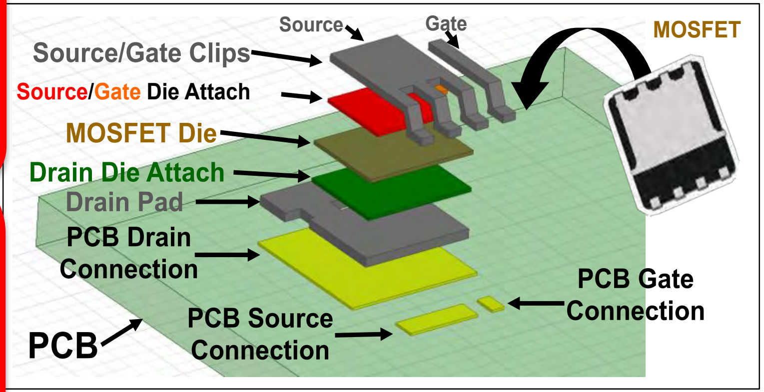


Design conditions: Peak current $I_{DL,pk}$ = 150 A, t_w = 8 ns

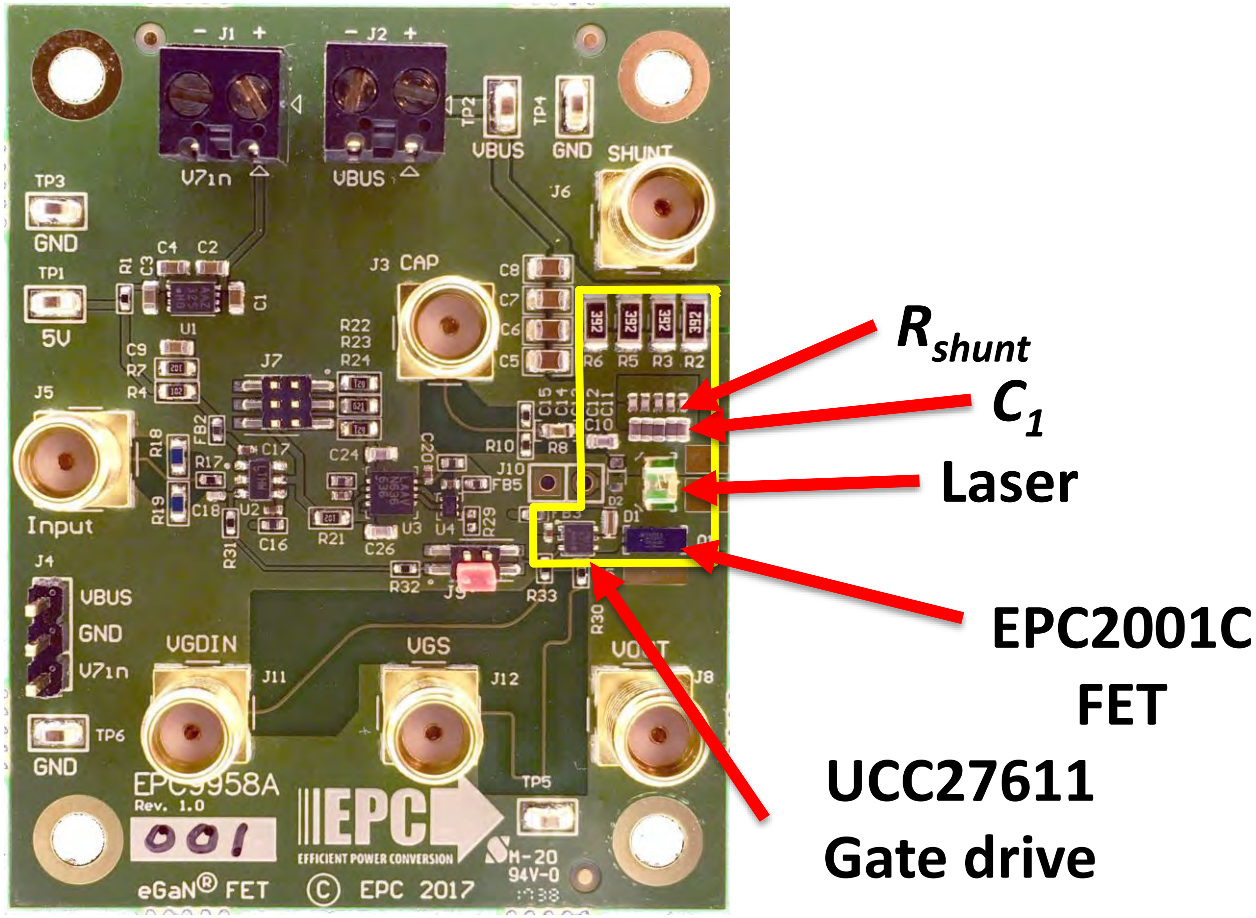
Why GaN?

Parameter	EPC2001C	BSZ146N10 LS5
Technology	GaN HEMT	Si MOSFET
$V_{DS,max}$ [V]	100	100
$R_{DS(on)}$ [mΩ]	6	21
$I_{pulse,max}$ [A]	150	160
Q_{Gtot} [nC]	7.5	15
R_{gate} [Ω]	0.3	1.0
$R_{gate} \cdot Q_{Gtot}$ [Ω•nC]	2.3	15
L_{gate} [nH]	0.3	3.0
L_{source} [nH]	0.1	0.3
L_{drain} [nH]	0.1	1.0
Package [mm x mm]	LGA 4.1 x 1.6	DFN 3.3x3.3

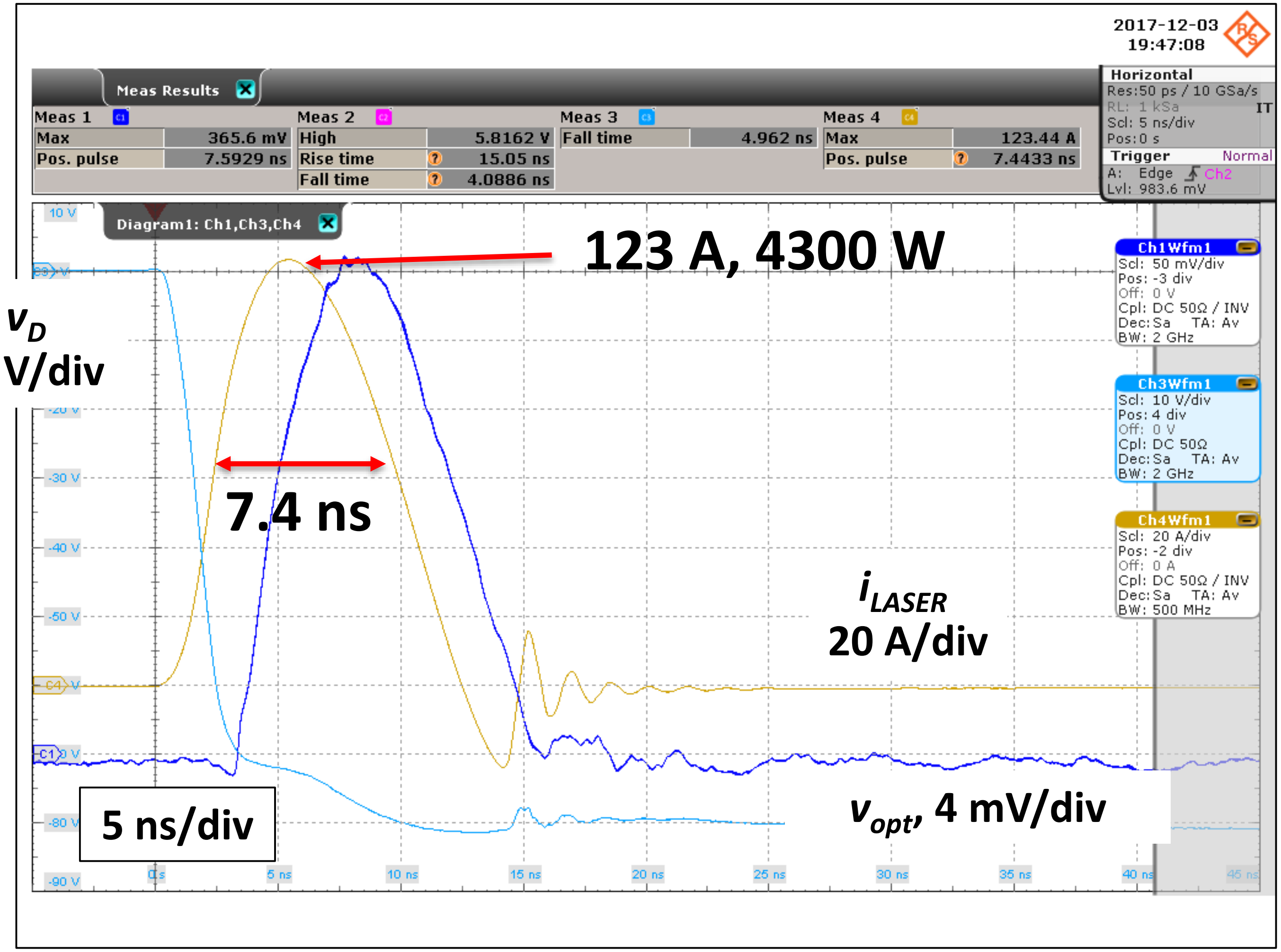




EPC9958A test board



EPC2001C Waveforms



V_{IN} = 83 V, C_{BUS} =7.5 nF, 7.4 ns, with a peak current of 123 A.

LMG1020 Driver

- Texas Instruments announced LMG1020 ultrafast GaN FET driver in March 2018.

0.8 mm x 1.2 mm

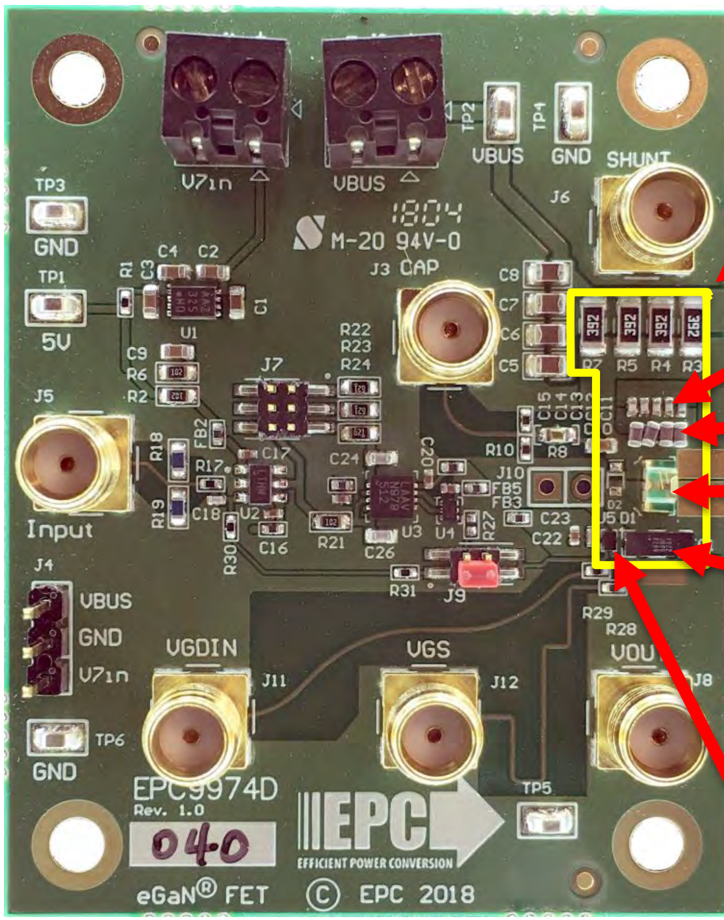
Parameter	Value (typical)
Propagation delay	2.6 ns
Min. pulse width	1 ns
Turn-on peak current	7 A
Turn-off peak current	5 A

EPC2047

Parameter	EPC2001C	EPC2047
Technology	Gen 4	Gen 5
$V_{DS,max}$ [V]	100	200
$R_{DS(on)}$ [mΩ]	6	7
$I_{pulse,max}$ [A]	150	160
Q_{Gtot} [nC]	7.5	8.2
R_{gate} [Ω]	0.3	0.5
$R_{gate} \cdot Q_{Gtot}$ [Ω•nC]	2.3	4.1
L_{gate} [nH]	0.3	0.3
L_{source} [nH]	0.1	0.1
L_{drain} [nH]	0.1	0.1
Package [mm x mm]	LGA 4.1 x 1.6	BGA 4.6 x 1.6

Gen 5 GaN offers similar performance to Gen 4...
at 2X voltage rating
Need higher voltage to reach 150 A goal

EPC9974D test board



1.3 cm^2

R_{shunt}

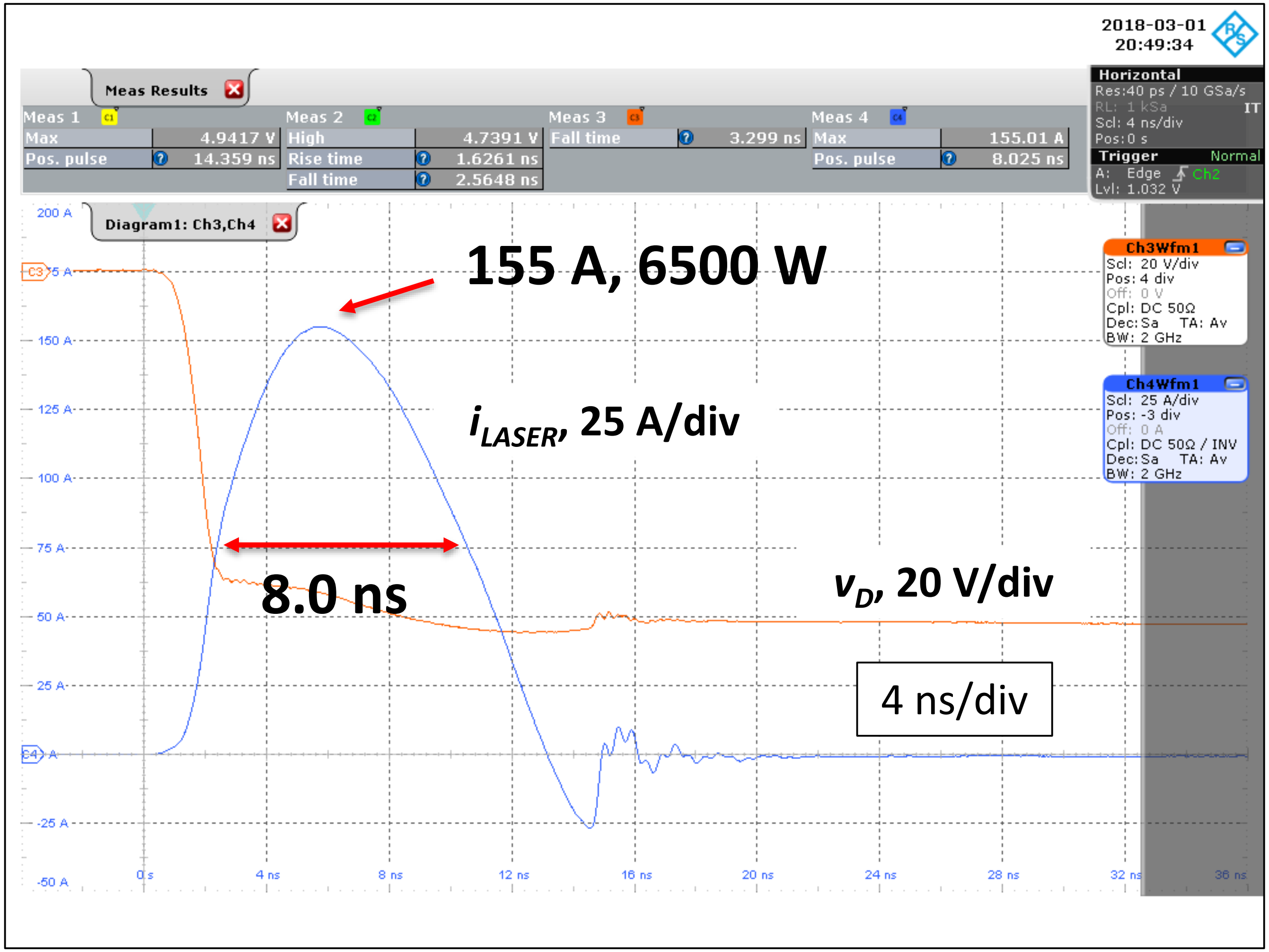
C_1

Laser

EPC2047 FET

LMG1020
Gate drive

EPC2047 with LMG1020



V_{BUS} = 105 V, I_{peak} = 155 A, 8.0 ns

Reality Check

- Many more parasitic components
  - Transistor, PCB, passives, etc.
  - Laser diode recovery
  - Very complex behavior possible
- The following practices make parasitics play bigger role:
  - Reducing L_{stray}
  - Forced laser turn-off (clamping and ringing)
  - Increasing switch speed
- Driver mechanical size is important (multi-channel lidar)
- Eye safety!

Improving laser drivers

- Reduction of laser inductance
- Reduction of other stray inductance
- Increase voltage
- Optimize FET parameters for laser pulses
- Integration of gate drive
- Dual edge control

Conclusion

- Time-of-flight lidar drivers are a pulsed power application
- Long range requires high peak power
- GaN FETs are the best known choice
- Inductance dominates the design
- GaN makes well controlled, high power pulses possible:
  - **123 A, 7.5 ns, 4300 W!**
  - **155 A, 8.0 ns, 6500 W!**
- Multiple paths to increase performance