WiPDA 2021
IEEE
The 8th IEEE Workshop on Wide Bandgap Power Devices & Applications
Nov 7-11, 2021 | Virtual Conference

Advances in GaN Power ICs: Efficiency, Reliability & Autonomy

Dan Kinzer, Co-Founder, COO / CTO
dan.kinzer@navitassemi.com

Navitas

Energy • Efficiency • Sustainability

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GaNFast™ with GaNSense™
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GaNFast™
Power IC
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The Enabling Force

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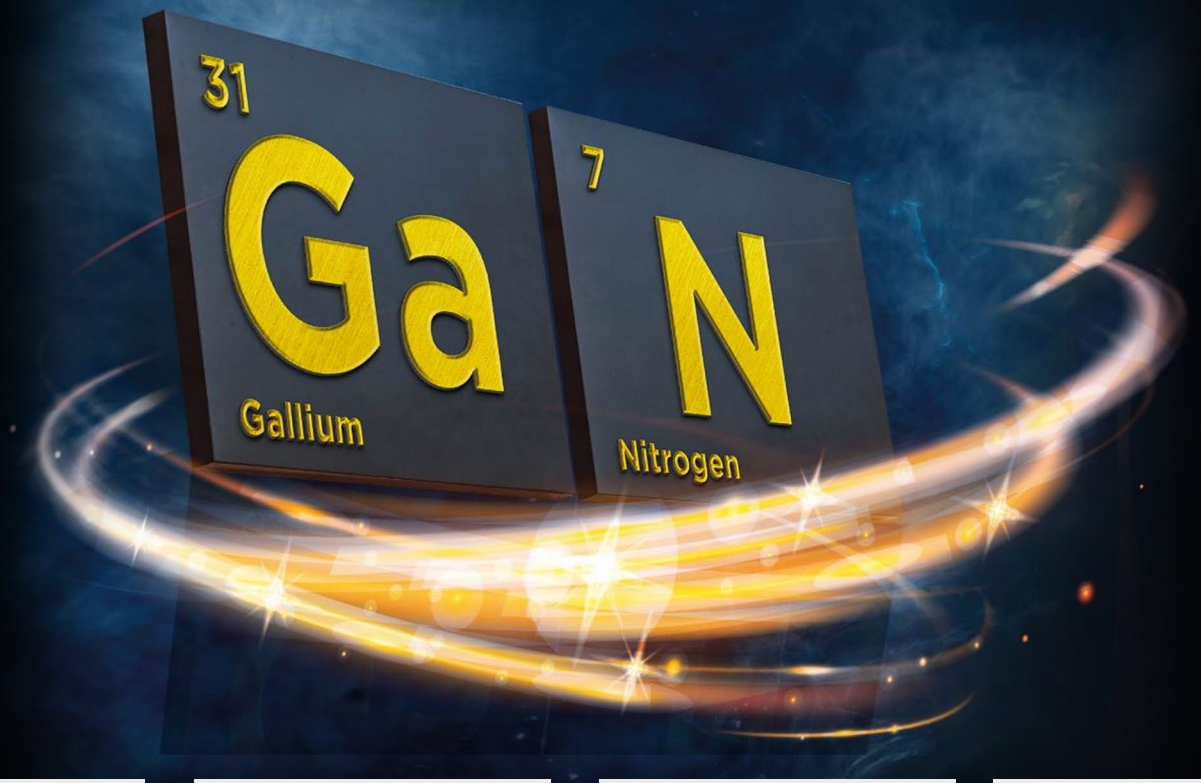

20x Faster Switching	**3x** Smaller & Lighter	**Up To 40%** Energy Savings	**Up To 3x** Higher Power Density	**3x** Faster Charging	**20%** Lower System Cost

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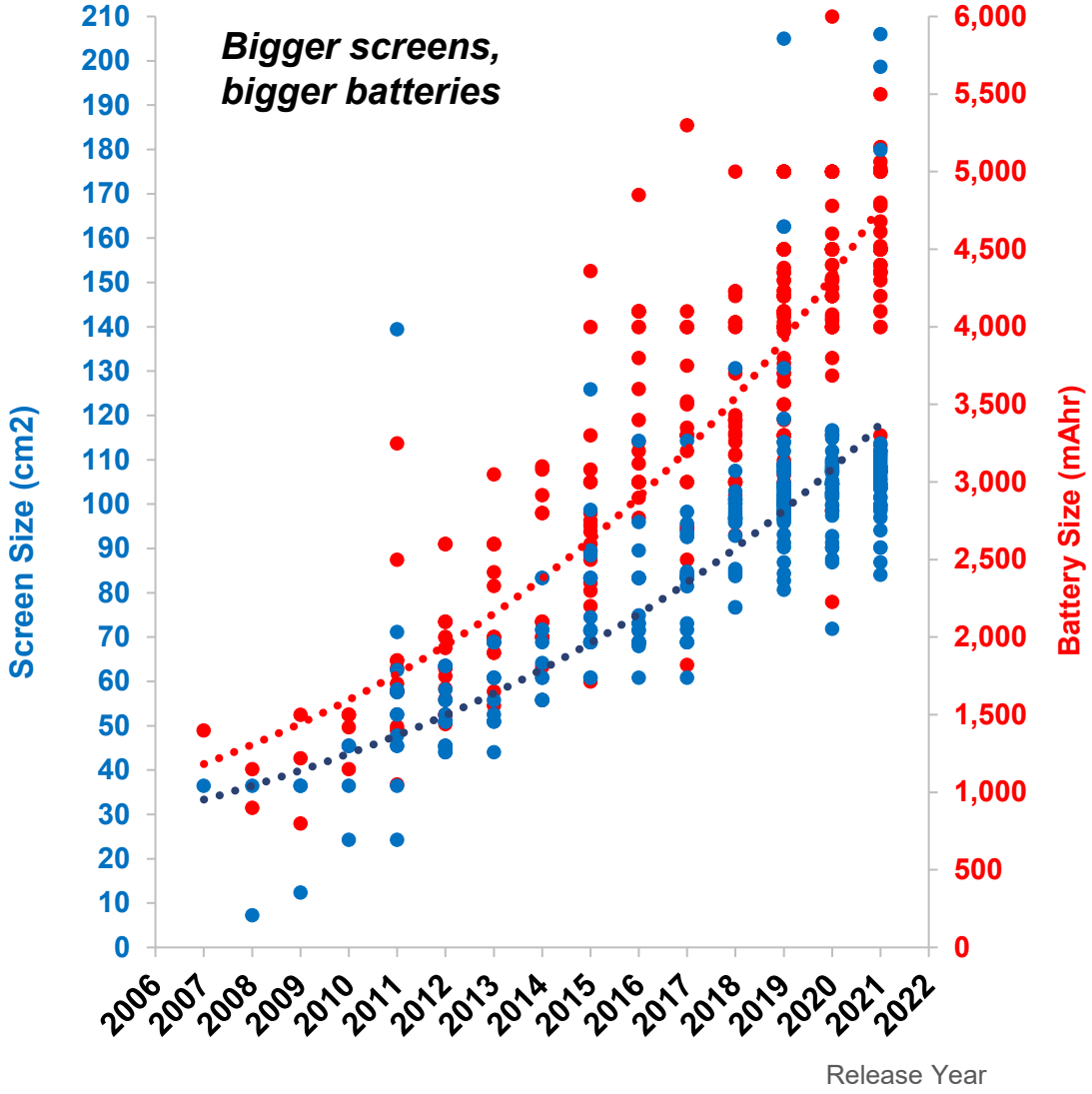
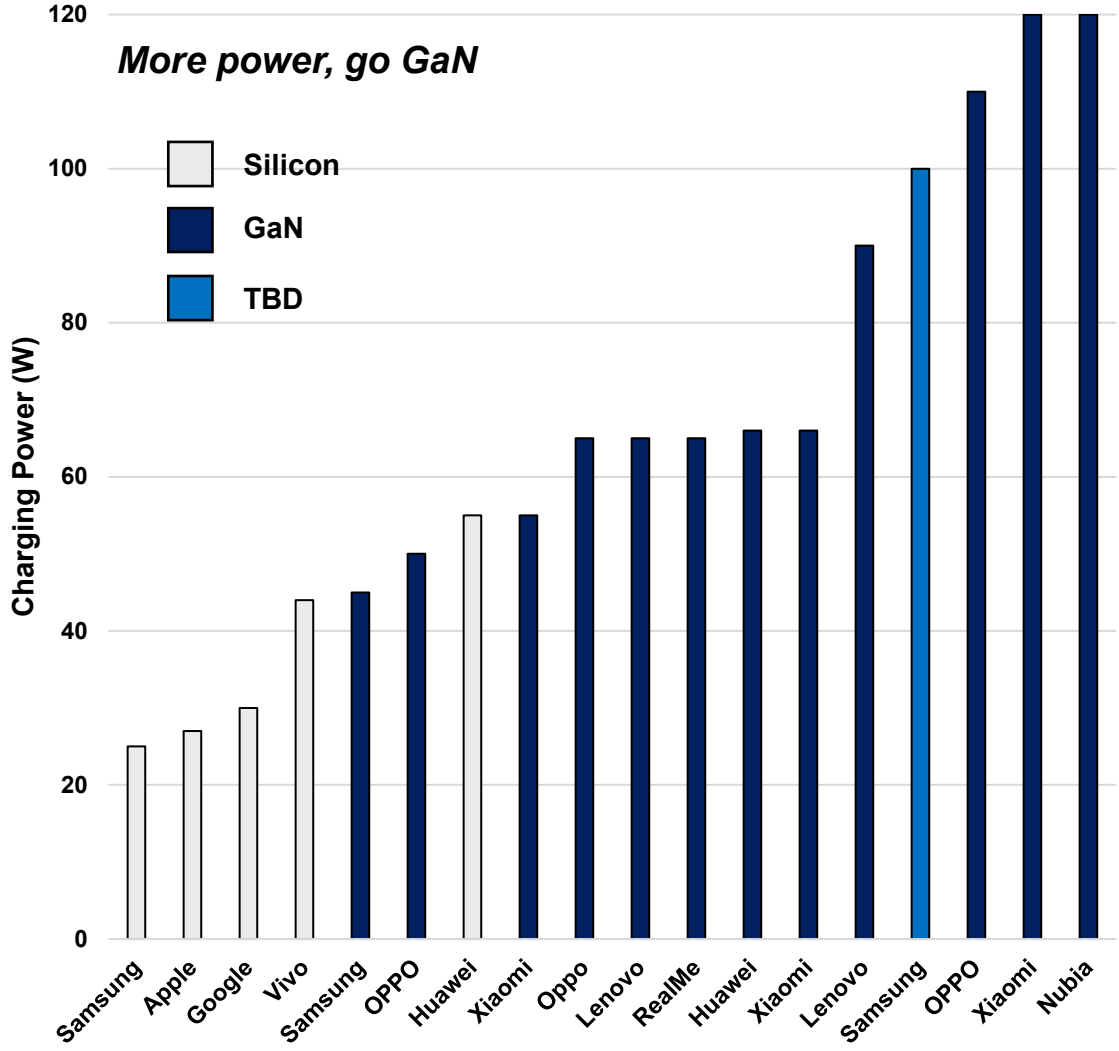
Power-Hungry Smartphones Use GaN





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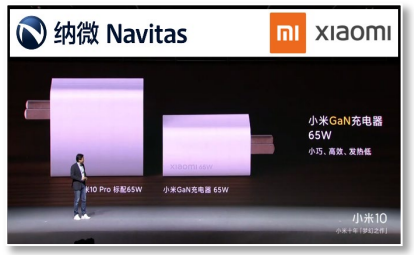
(1) Navitas survey of public information, including gsmareana.com, Nov 2nd 2021

Chargers go GaNFast

Tier 1 OEMs



Aftermarket Examples

160+
GaN Chargers In Mass Production

150+
GaN Chargers In Development (MP 2021-2022)

90%+
Mobile OEMs Designing With Navitas GaN ICs

30M+
GaN ICs Shipped(1)

Zero
GaN Field-Failures(1)

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Note: #Charger metrics as of November 2nd, 2021. Shipments as of October 31st 2021
(1) Based on no customer-reported consumer failures for production shipments through October 31st 2021.

The GaNFast Evolution

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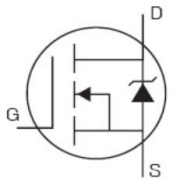
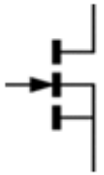
Silicon FET



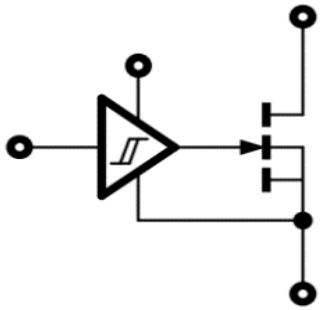
- Old, slow technology
- High Qg
- High Coss
- Fsw < 100kHz

Discrete GaN



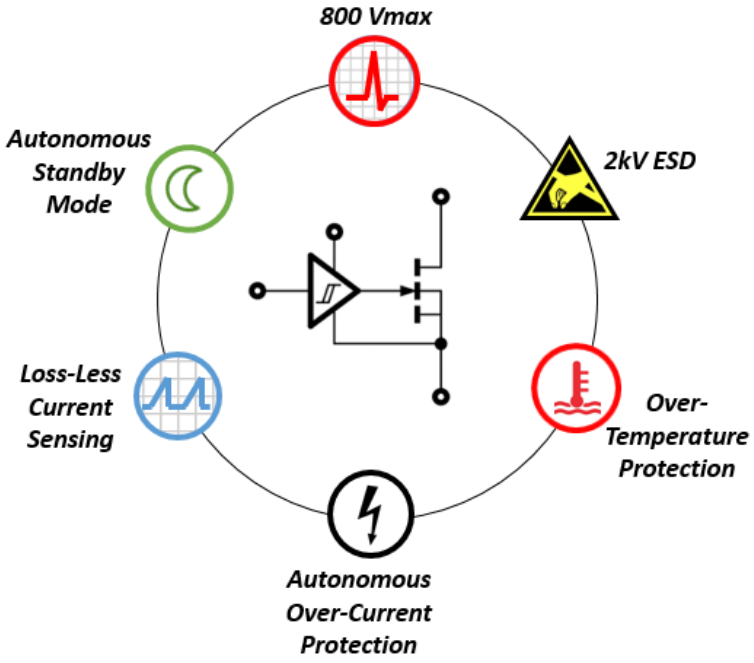
- Exposed gate
- External gate drive
- dV/dt sensitivity
- Layout sensitivity
- ESD sensitivity
- Unknown reliability
- Unknown robustness

GaNFast™



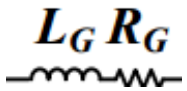
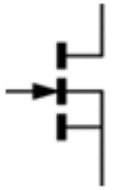
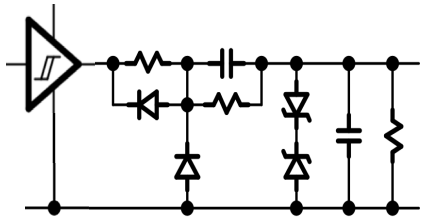
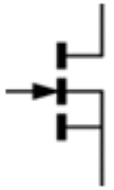
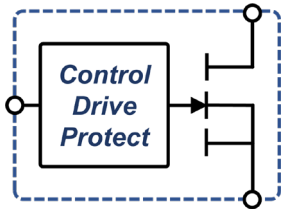
- Internal Gate
- Integrated Gate Drive
- dV/dt Immunity
- Layout Insensitive
- 2KV ESD rating
- Proven Reliability
- Proven Robustness

GaNFast™ with GaNSense™



- Autonomous Standby
- Autonomous Protection
- Loss-less Current Sensing
- High Precision
- High Efficiency

Critical Integration: GaNFast

	Driver Drive, control & protection	Parasitics Limit speed & efficiency	Power Device Si or GaN	Speed Switching Frequency	Power Density Faster Charging, Smaller Size	
Silicon Discrete	 *(in system controller)*			**< 100 kHz**		**<0.5 W/cc**
GaN Discrete	 *(complex circuit)*			**< 200 kHz**		**<1 W/cc**
Navitas GaN IC				**Up to 2 MHz** ***(3-10x faster)***		**>>1 W/cc**

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Loss-Less Current Sensing: Why?

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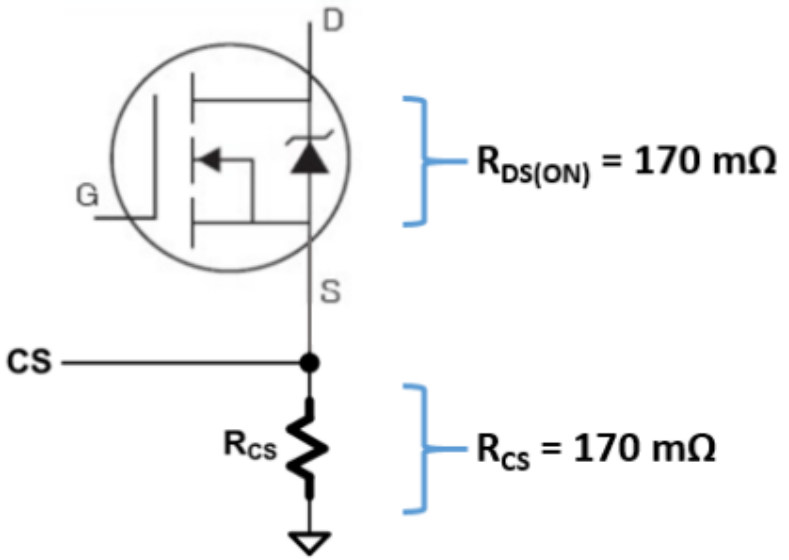
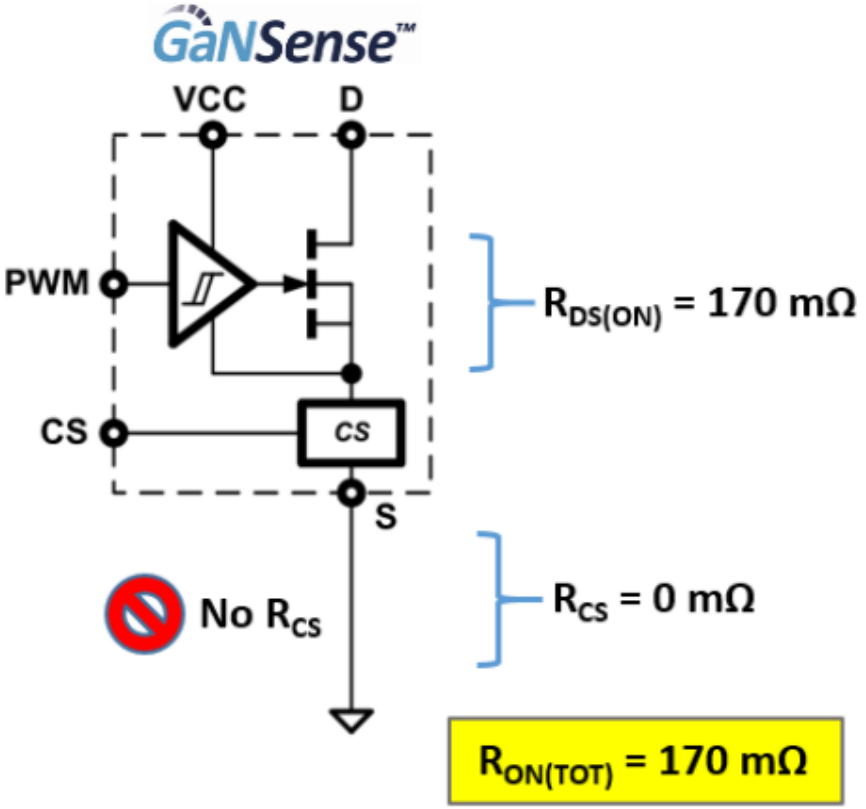
External Resistor Sensing Method



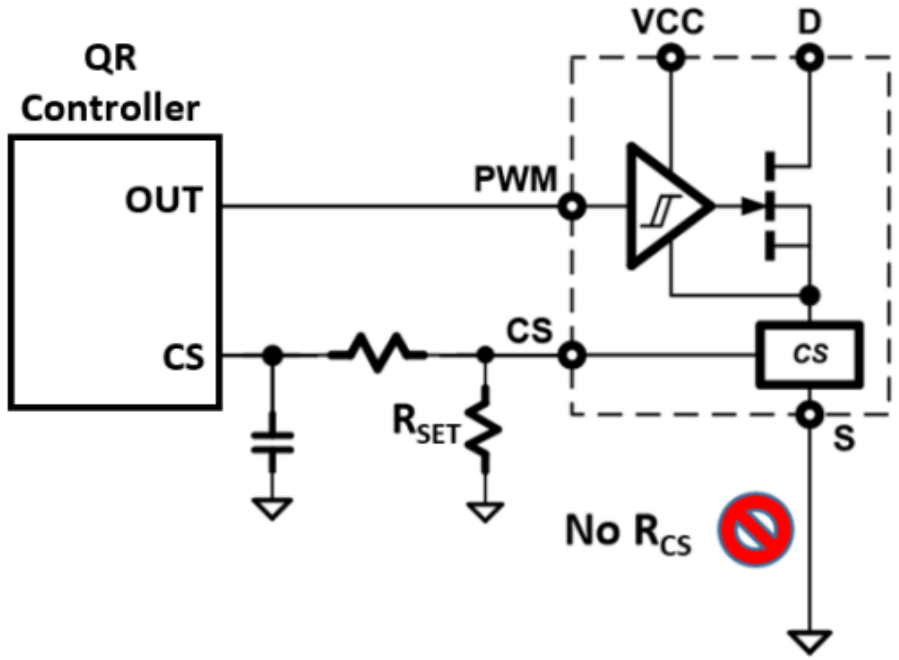
- Reduce $R_{DS(ON)\_TOTAL}$ by 50%
- Efficiency increased +0.5%

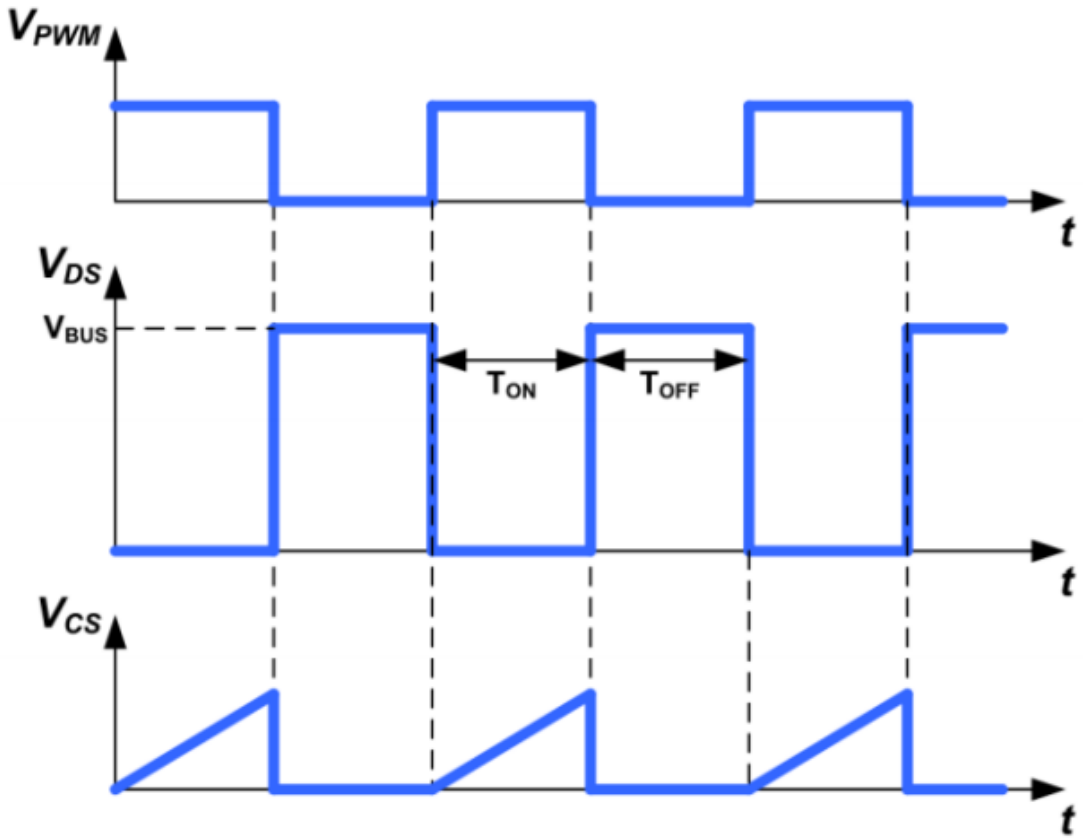


- No R_{CS} PCB hotspot (-85°C)
- No R_{CS} PCB footprint (-30 mm^2)

GaNSense™

Loss-Less Current Sensing: How?

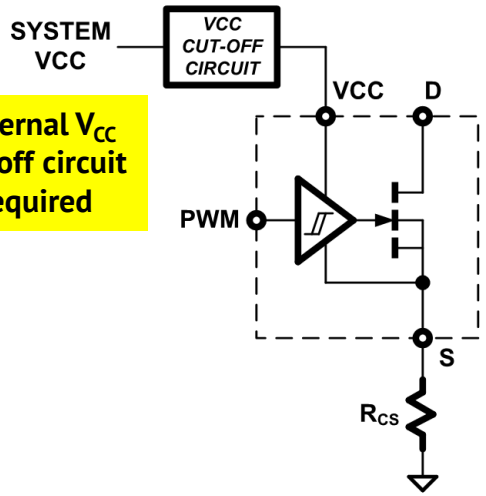




GaNSense™

Autonomous Standby Mode

GaNFast™

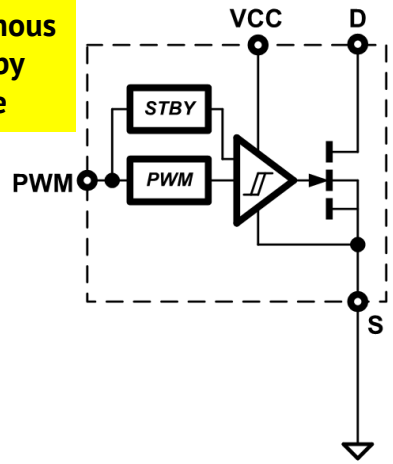


External V_{CC} cut-off circuit required

- External V_{CC} cut-off circuit required
- Requires system enable signal

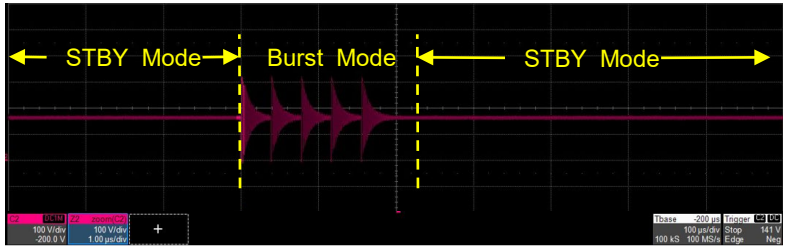
GaNFast™ with GaNSense™

Autonomous Standby Mode



- Autonomous standby mode
- Enters STBY during no PWM
- Fast wake-up at next PWM
- Standby power reduction (-17%)
- Removes 5 components

17% Lower Standby Loss



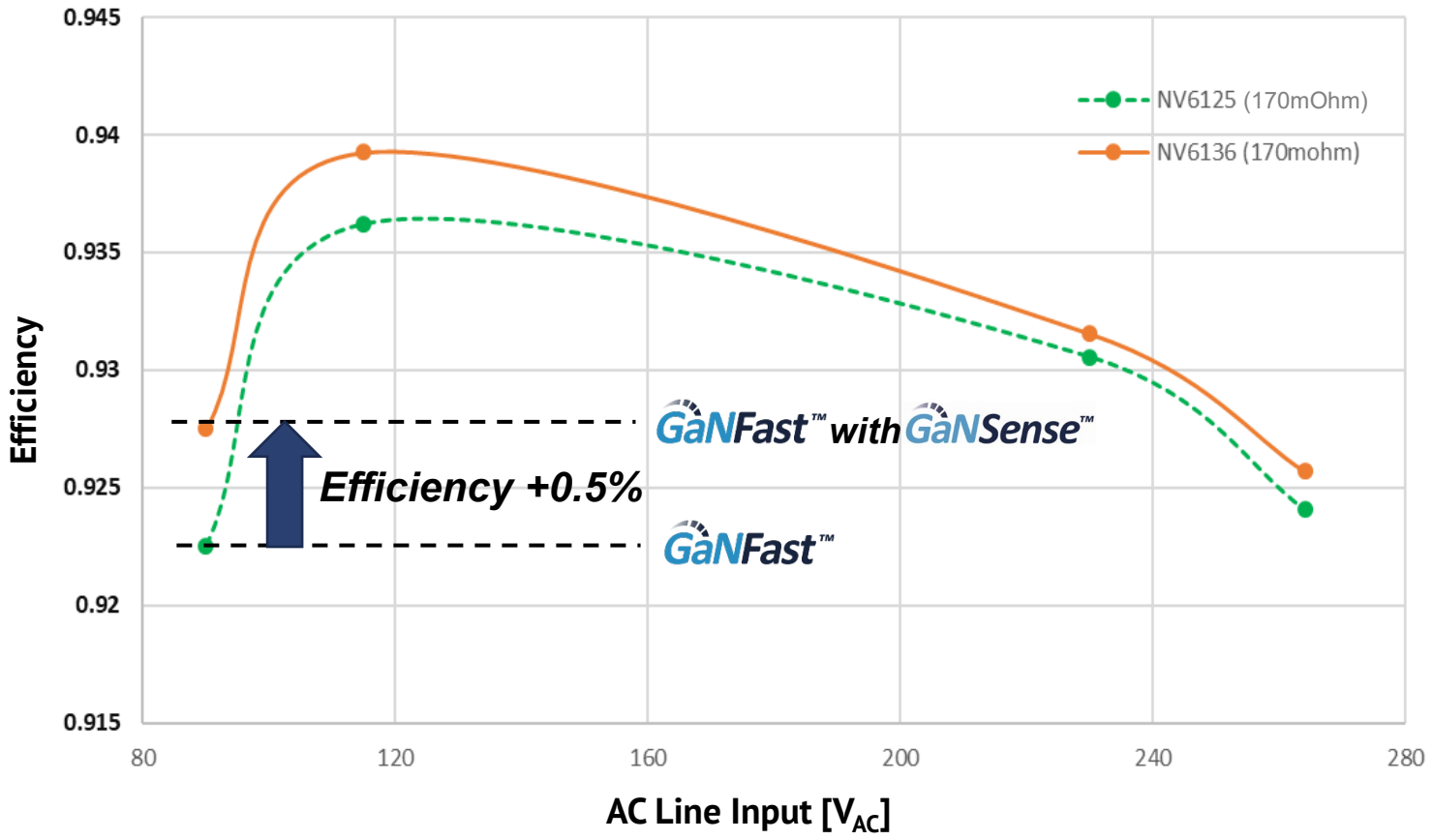
HFQR, no load

P_{IN} (no load)	115 V_{AC}	230 V_{AC}
NV6125	39 mW	40 mW
NV6136	33 mW	33 mW

- Enters STBY during no PWM signal
- Wakes up again at each burst

The Efficiency Benefit

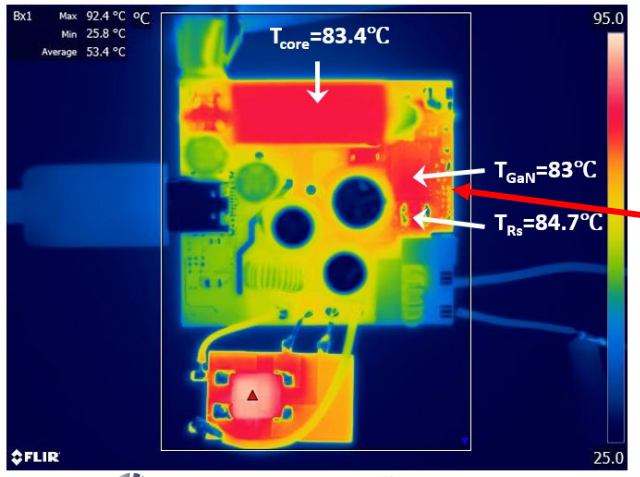
Efficiency (60W HFQR, 20V/3A)



0.5% higher efficiency, same $R_{DS(ON)}$, lower $R_{ON(TOTAL)}$

60W HFQR, 90V_{AC}, 20V/3A, 1 Hour

GaNFast™

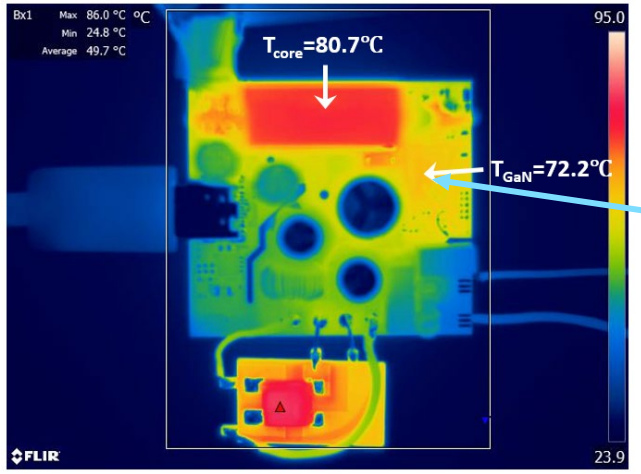


NV6125

$R_{DS(ON)}$ = 170 mΩ
R_{CS} = 170 mΩ
$R_{ON(TOT)}$ = 340 mΩ

R_{CS} HOT-SPOT = 85°C!

GaNFast™ with GaNSense™



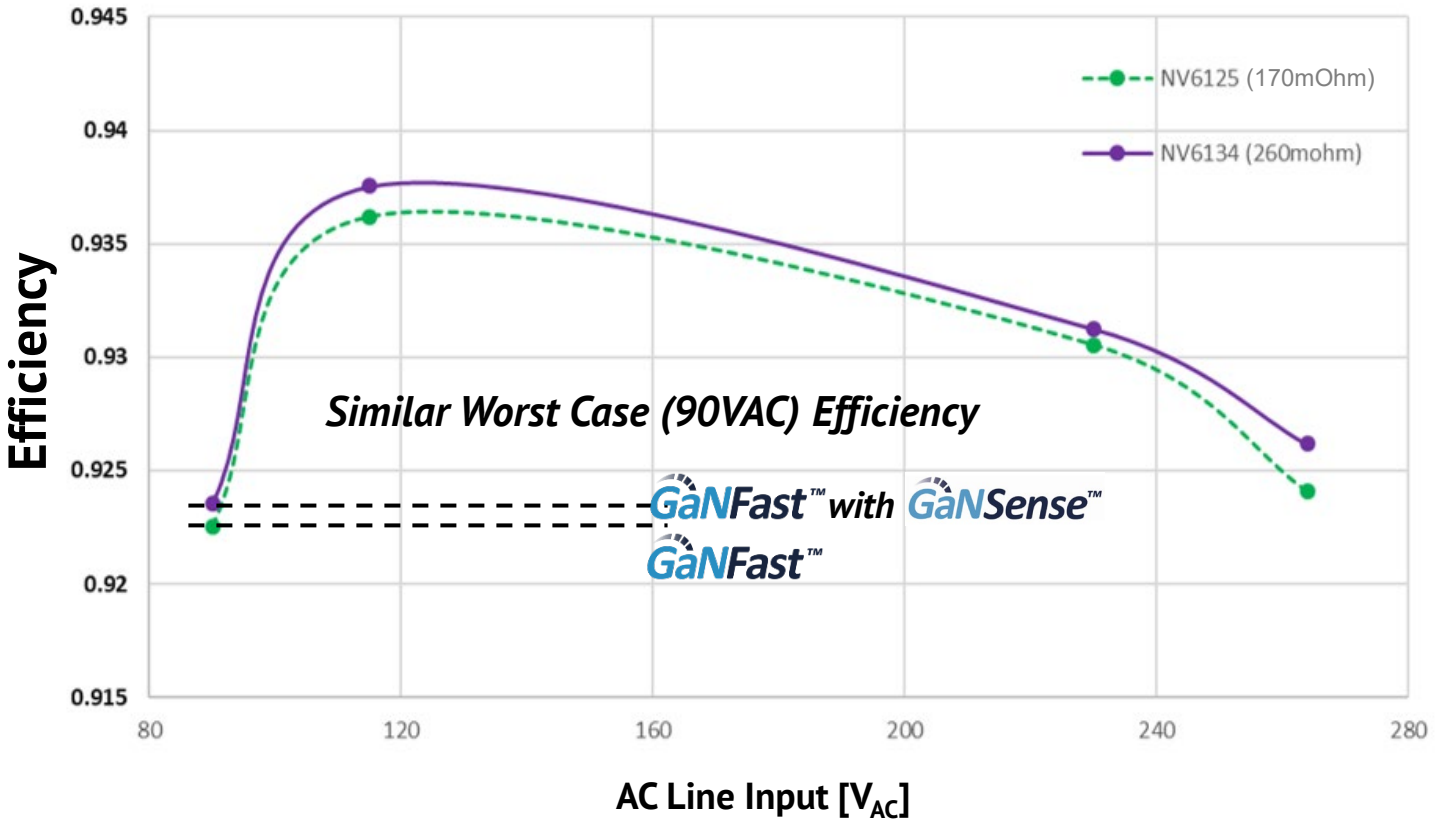
NV6136

$R_{DS(ON)}$ = 170 mΩ
R_{CS} = 0 mΩ
$R_{ON(TOT)}$ = 170 mΩ

NO R_{CS} HOT-SPOT T_{GaN} 10°C Cooler

The System Cost Benefit

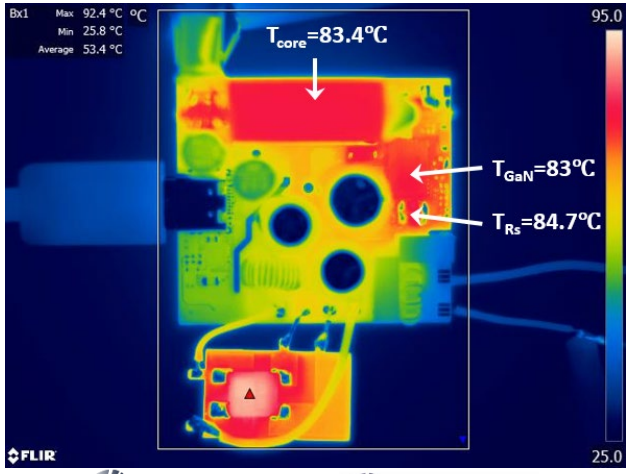
Efficiency (60W HFQR, 20V/3A)



Same efficiency, smaller chip, same $R_{ON(TOTAL)}$

60W HFQR, 90V_{AC}, 20V/3A, 1 Hour

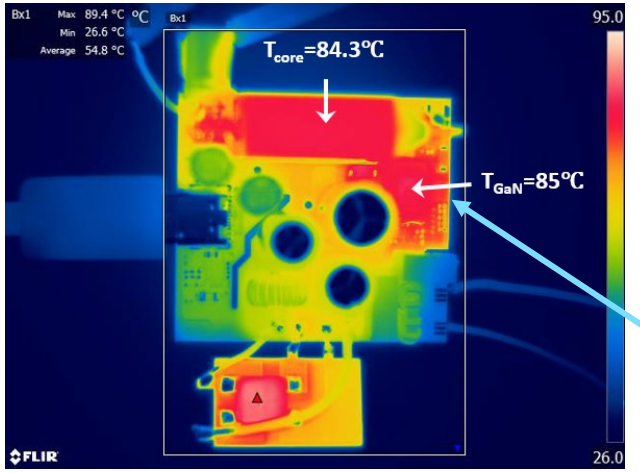
GaNFast™



NV6125

$R_{DS(ON)}$ = 170 mΩ
R_{CS} = 170 mΩ
$R_{ON(TOT)}$ = 340 mΩ

GaNFast™ with GaNSense™



NV6134

$R_{DS(ON)}$ = 260 mΩ
R_{CS} = 0 mΩ
$R_{ON(TOT)}$ = 260 mΩ

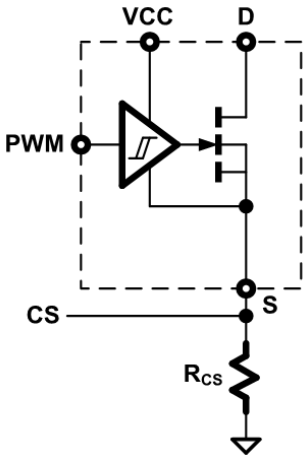
No R_{CS} Similar Temperatures

Autonomous Over-Current Protection (OCP)

GaNFast™

Uses QR controller OCP function

T_{OCP} = 180 ns

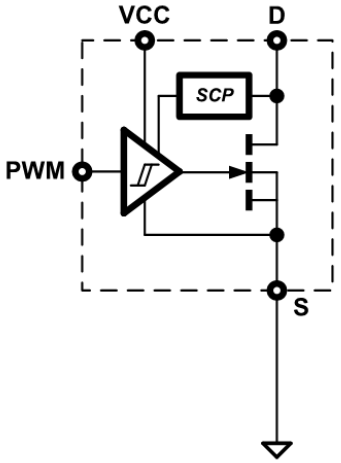


- Existing solutions use ext. R_{CS}
- Filter + controller delay slow

GaNFast™ with GaNSense™

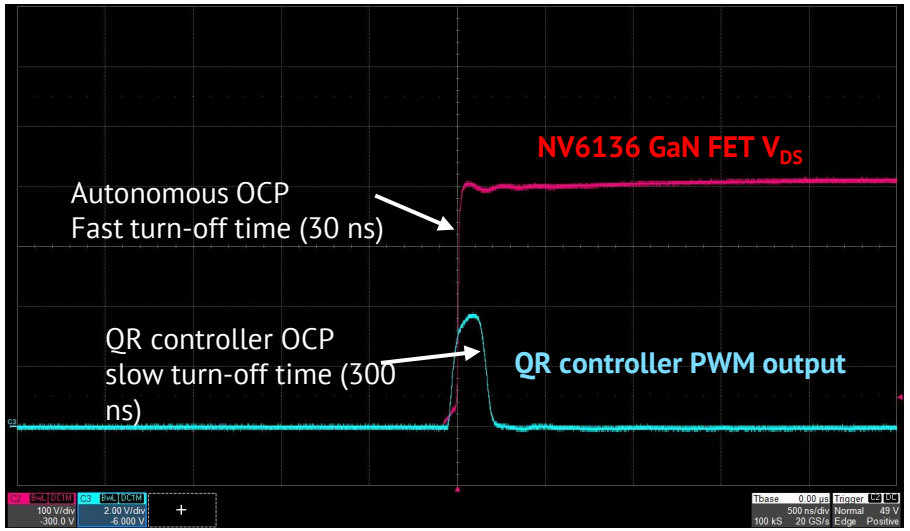
Integrated SCP function

T_{OCP} = 30 ns



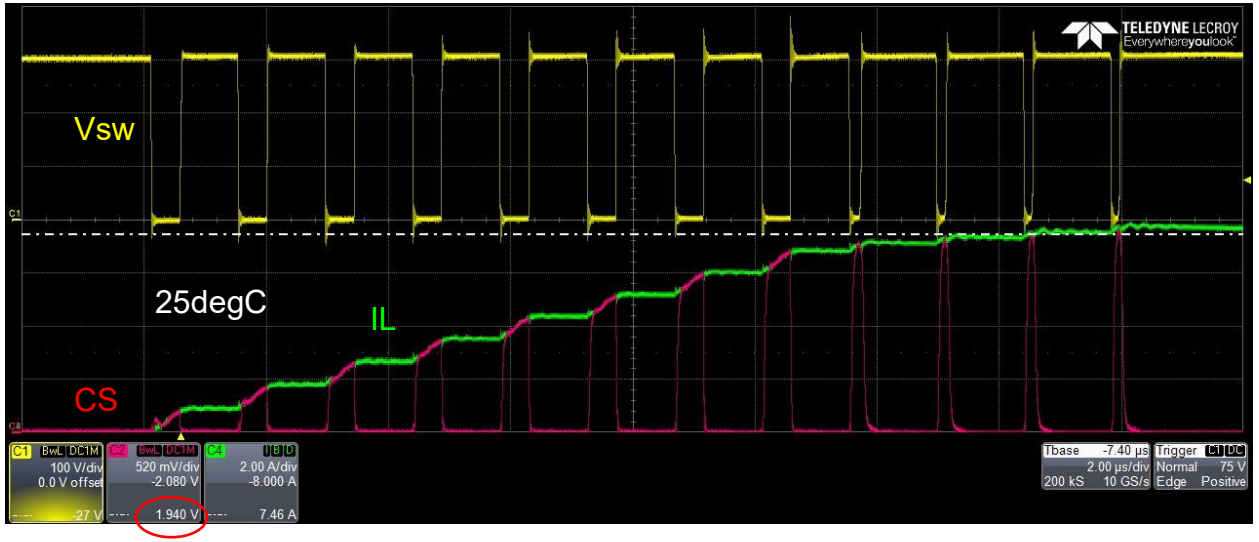
- Autonomous OCP
- Real-time self-protection
- Cycle-by-cycle protection
- Excellent robustness

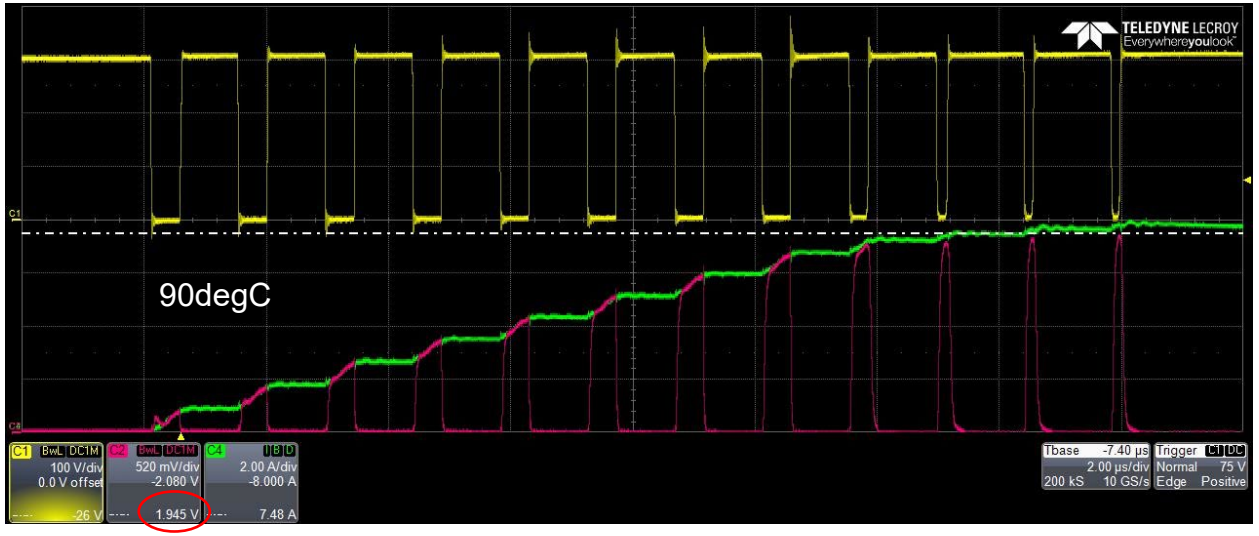
6x faster protection



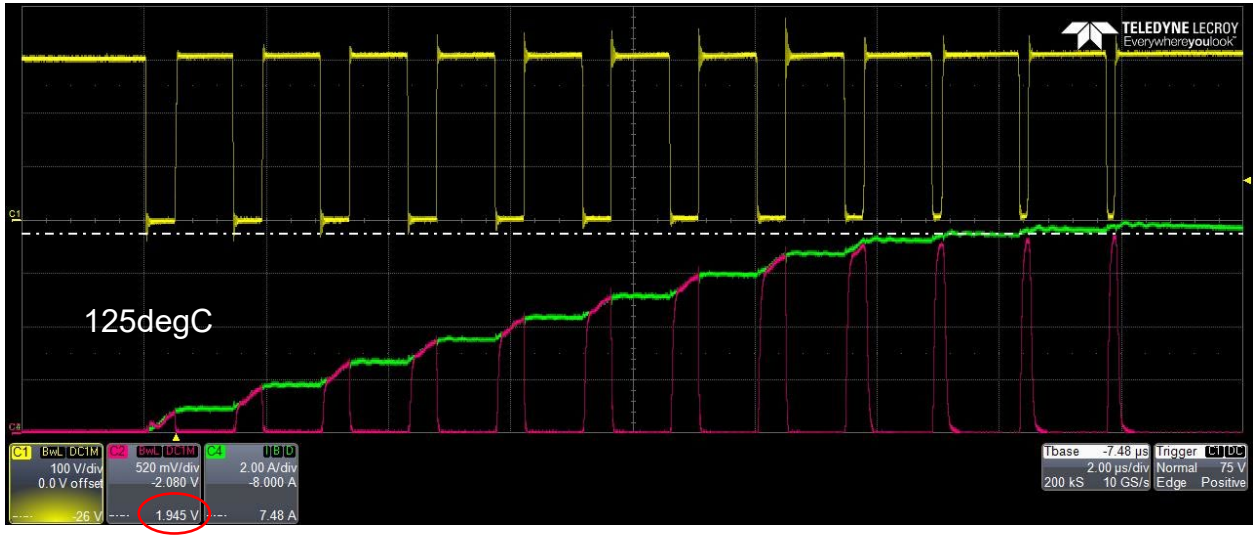
- QR controller OCP = slow turn-off (180 ns)
- NV6136 OCP = fast turn-off (30 ns)

Over-Current Protection (OCP) cont.



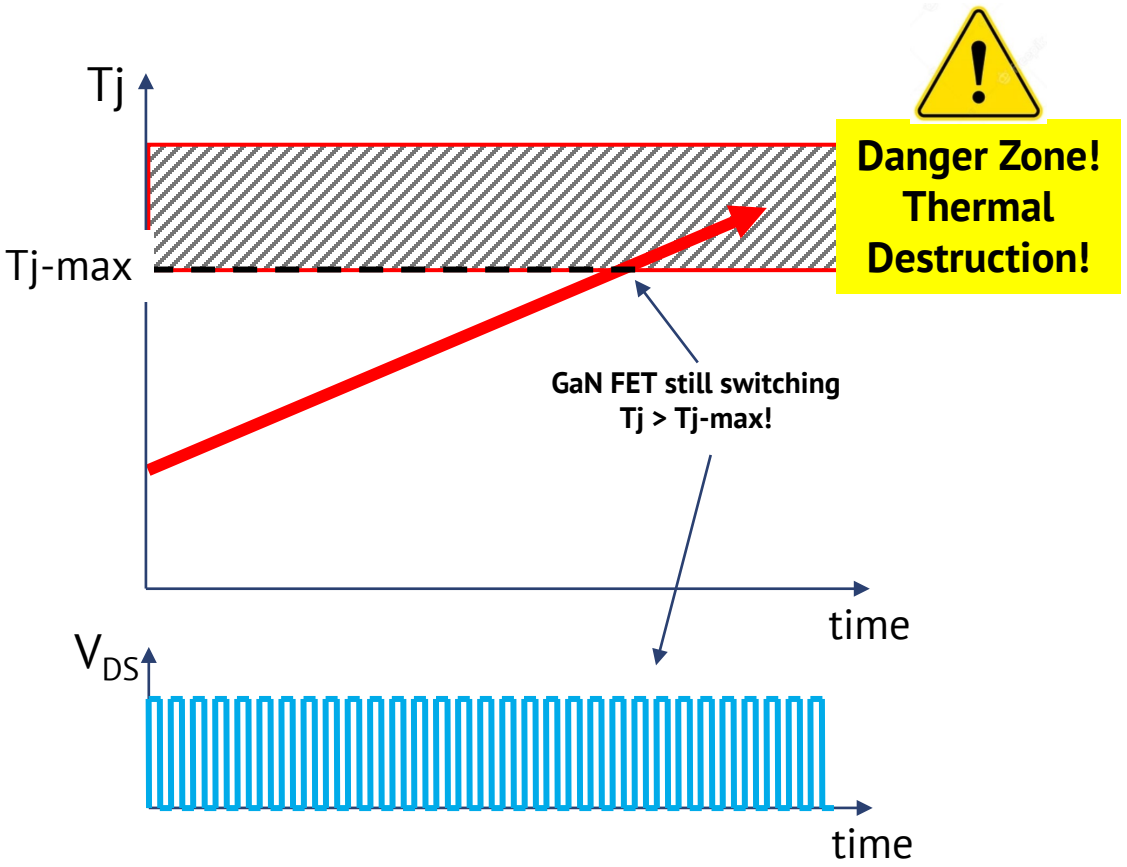


- NV6134A in double pulse tester
- CS signal matches I_{DS} current, independent of temperature
- OCP uses CS signal, and the trip point is consistent over temperature
- OCP is cycle by cycle, and limits inductor current

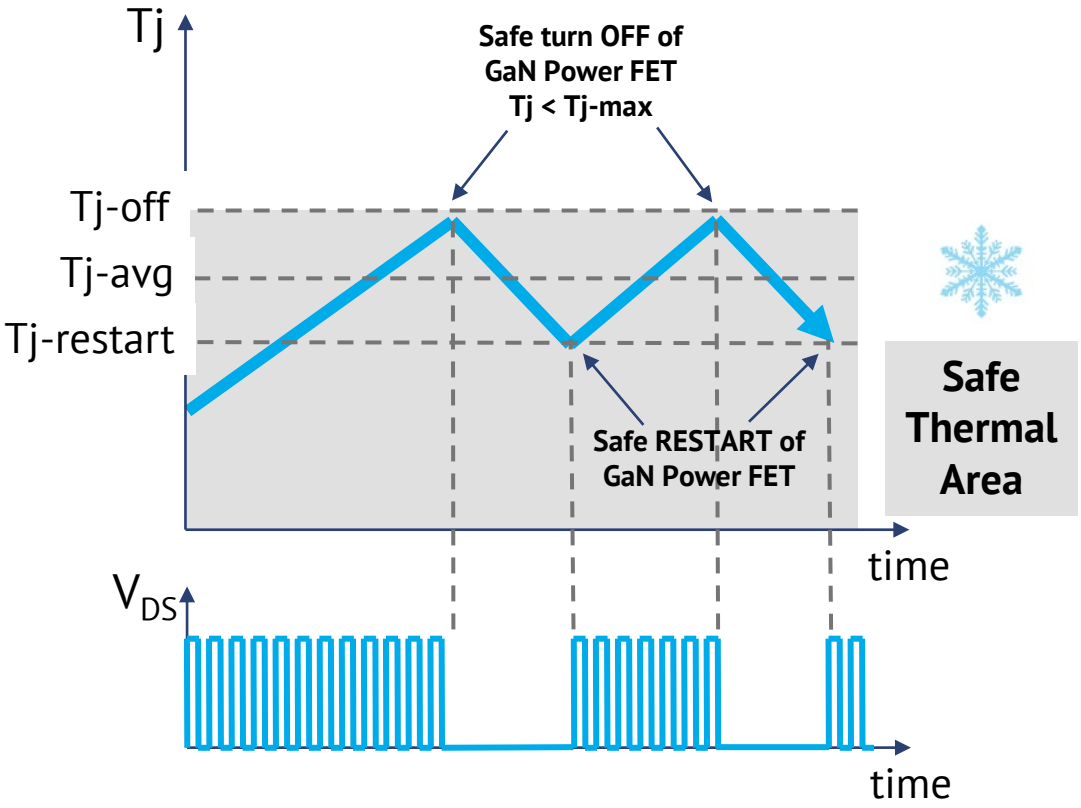


Over-Temperature Protection

Discrete GaN

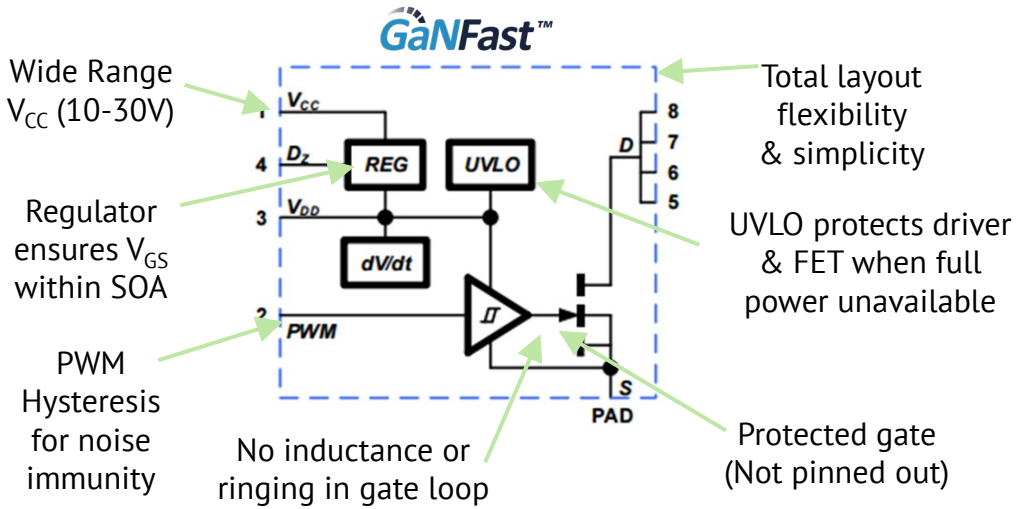


GaNSense IC w/OTP

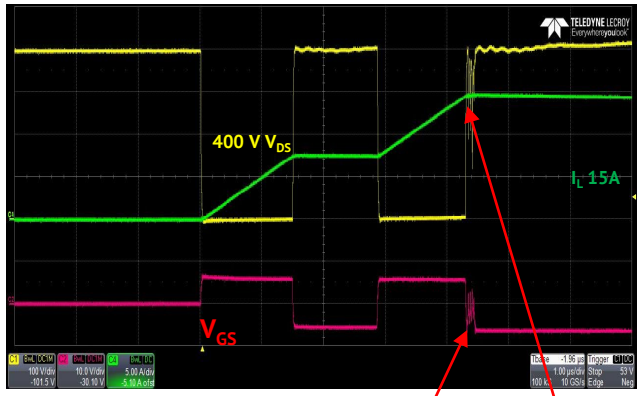


Leaders in Reliability

Reliability by Design

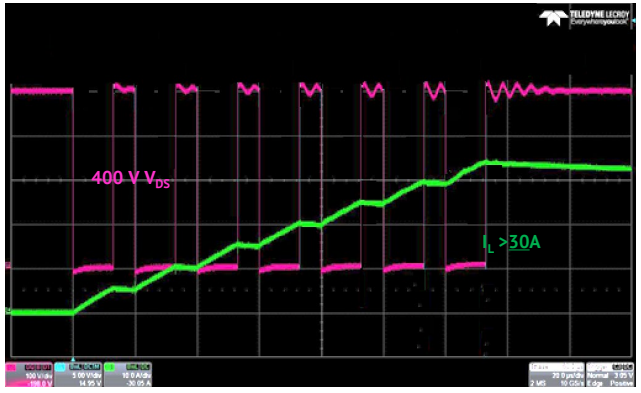


Unprotected GaN



- **Exposed gate**
- **Faulty switching**
- **Dangerous ringing & glitching!**
- **Significant reliability risks**

Navitas GaN Power IC



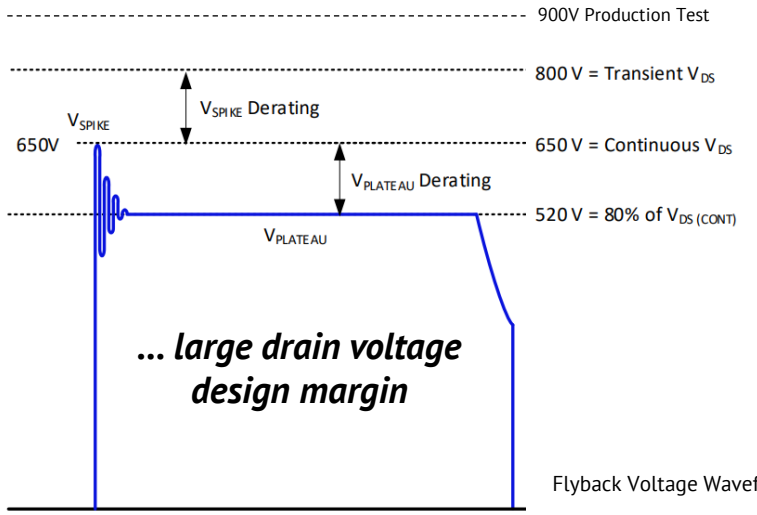
- **Integrated gate drive**
- **Clean switching**
- **Safe, robust and reliable performance**

Reliability

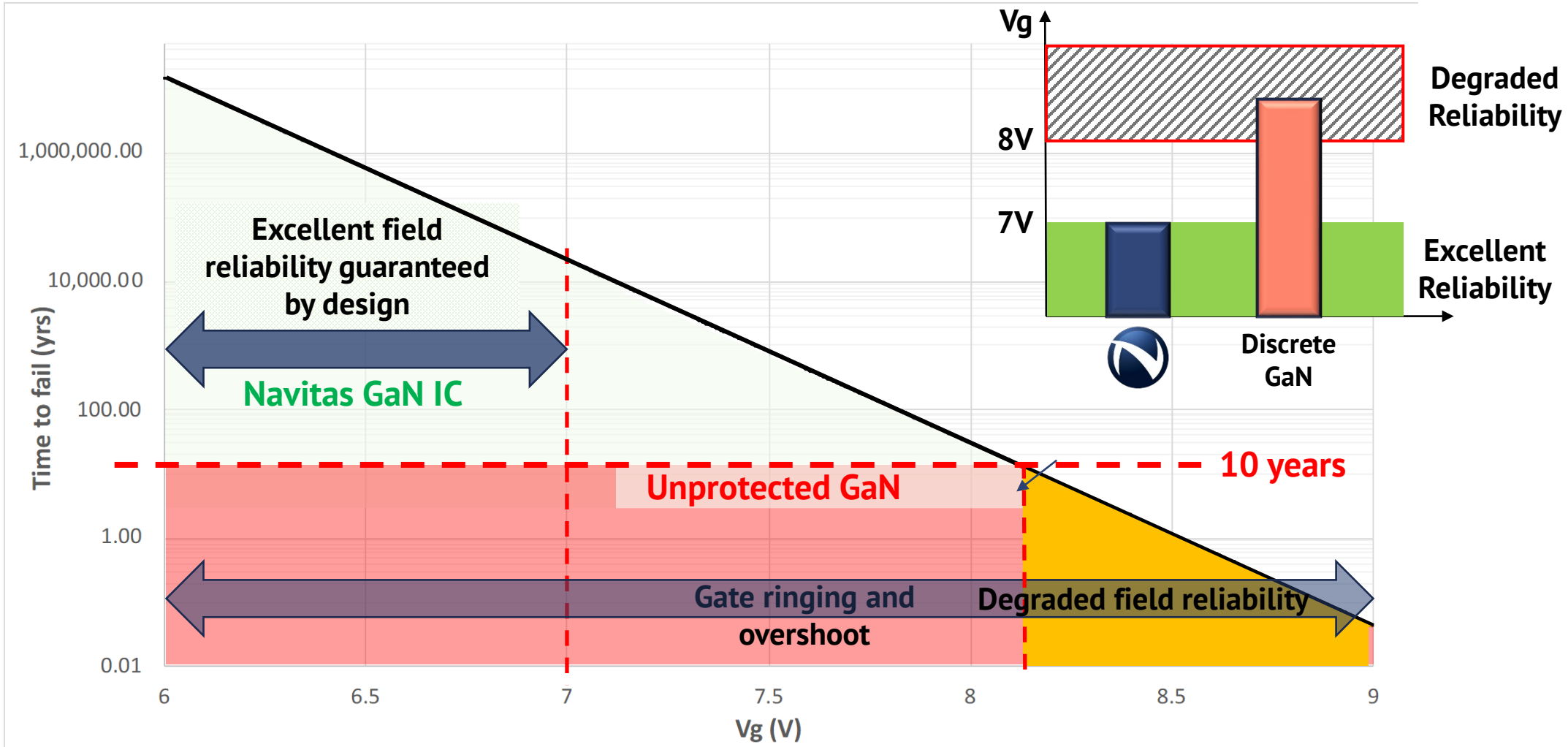
As of October 31st, 2021

30,000,000+ GaNFast power ICs shipped	116B+ Device Hours In the Field
0 Failures	0 ppm
0.16 FIT Rate	5.8B Equivalent Device Hours Tested

Integrated Drain Reliability



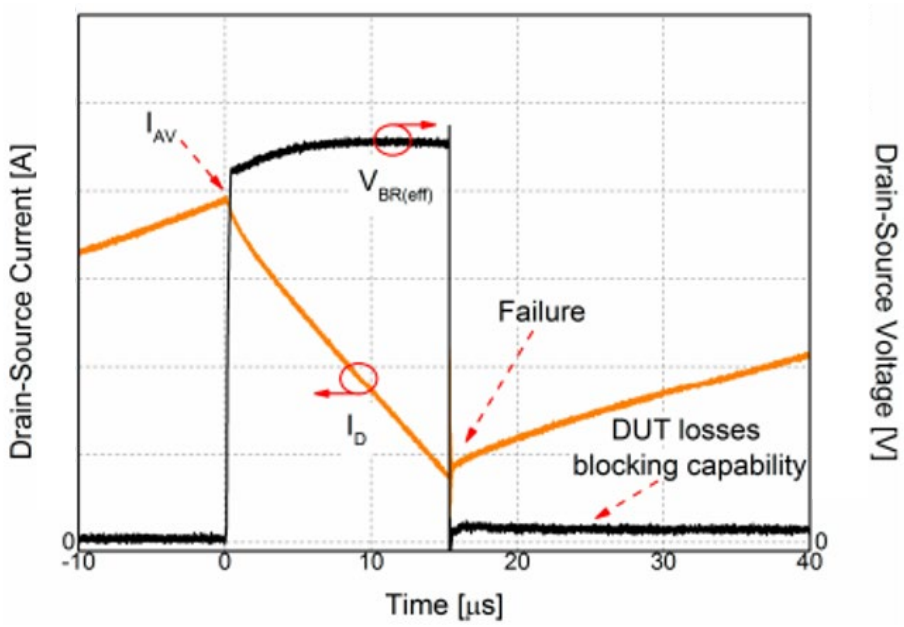
Precise Gate Voltage = Excellent Reliability



- Patented integrated regulator circuit guarantees operation with >>10+ years of estimated life
- Integrated driver eliminates parasitic inductance, delivers precise gate drive and maintains device within SOA

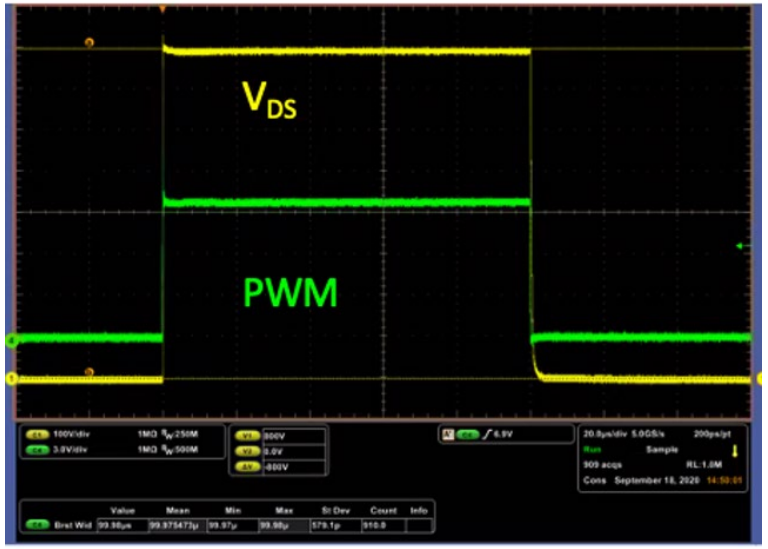
Voltage Surge Testing

Si Avalanche Testing



- Voltage limited by avalanche breakdown
- Large energy loss during overvoltage
- Usually tested only once at final test
- Repetitive avalanche can lead to failure

Navitas GaN IC Surge Testing

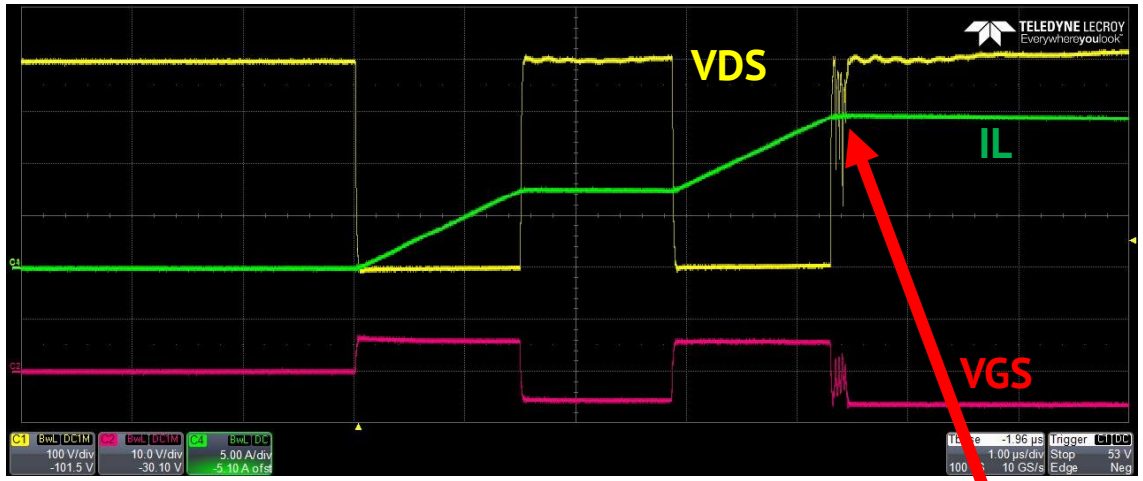


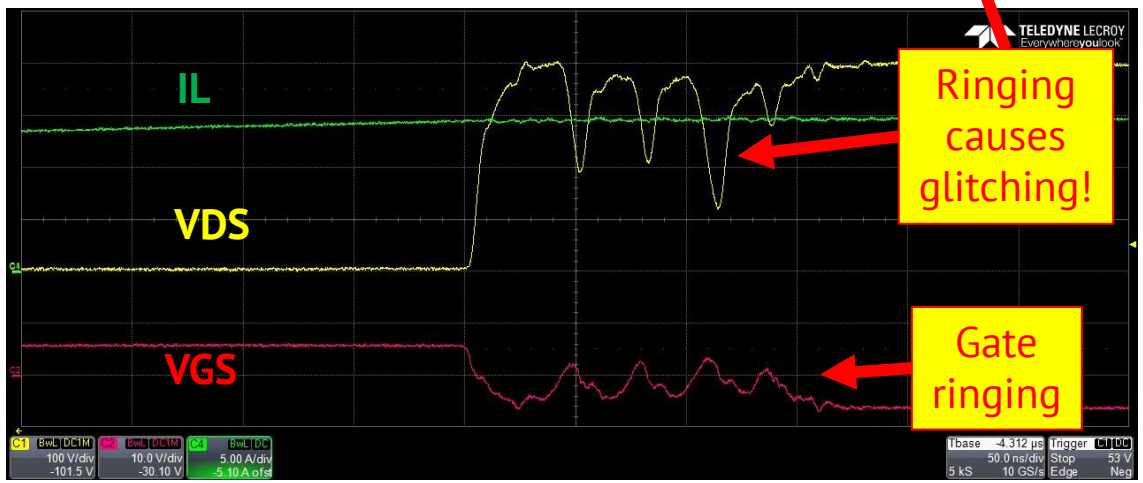
100µs pulse width, V_{DS} = 800 V

- 3,600,000,000 spikes, no failures!
- Negligible energy loss during overvoltage
- No $R_{DS(ON)}$ shift
- No I_{DSS} shift

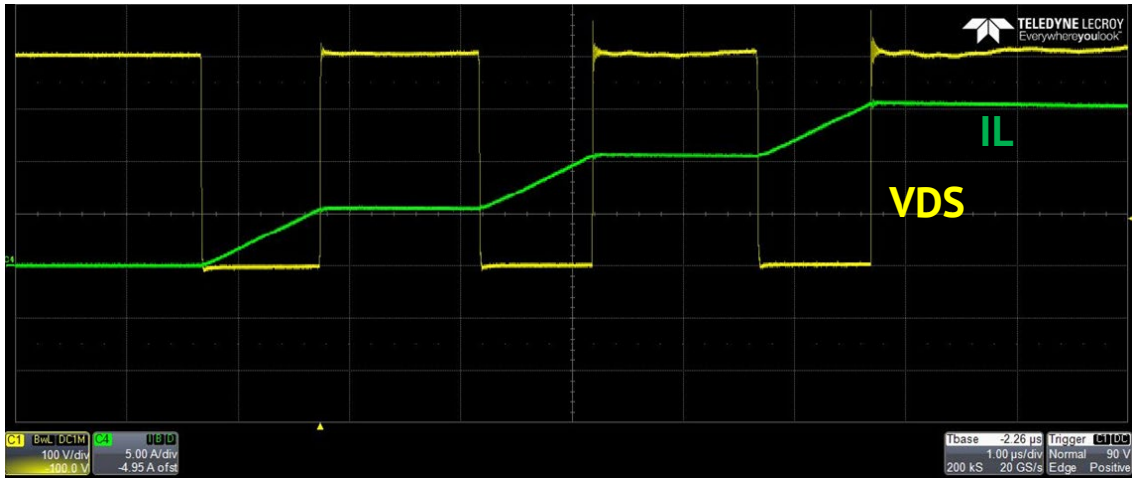
Reliable: Double-Pulse Test

Discrete





NV6136 GaNSense



- **Clean switching, no ringing and no glitching**

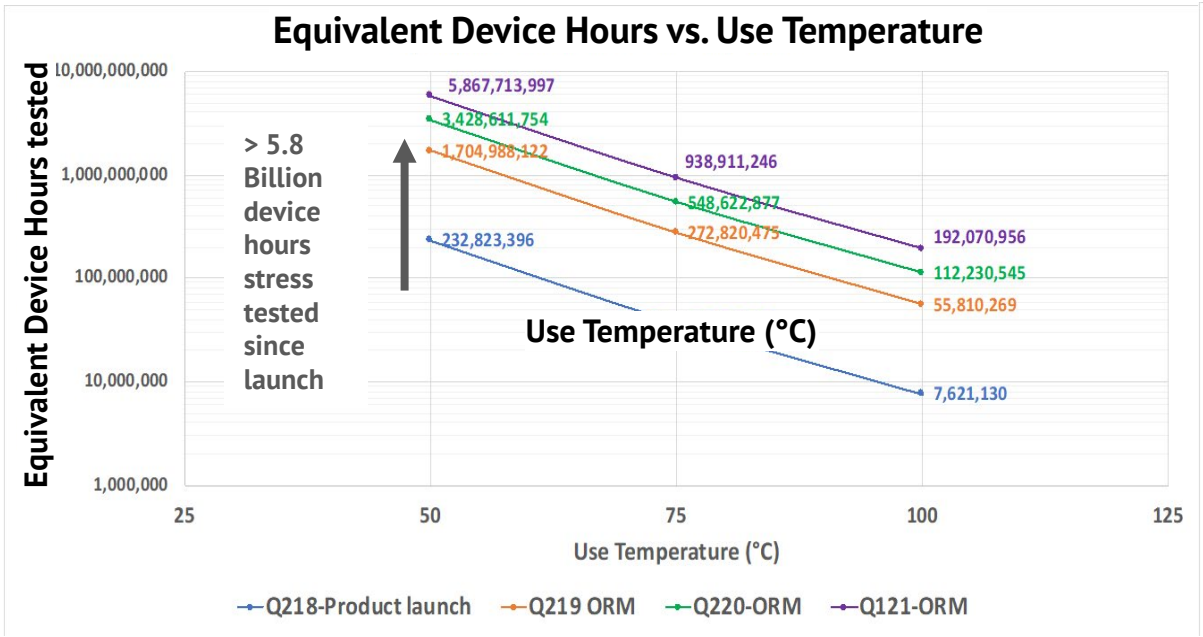
- **Ringing can lead to gate voltage over-stress, poor gate reliability, reduced lifetime**
- **Glitching can lead to poor EMI and device failure**

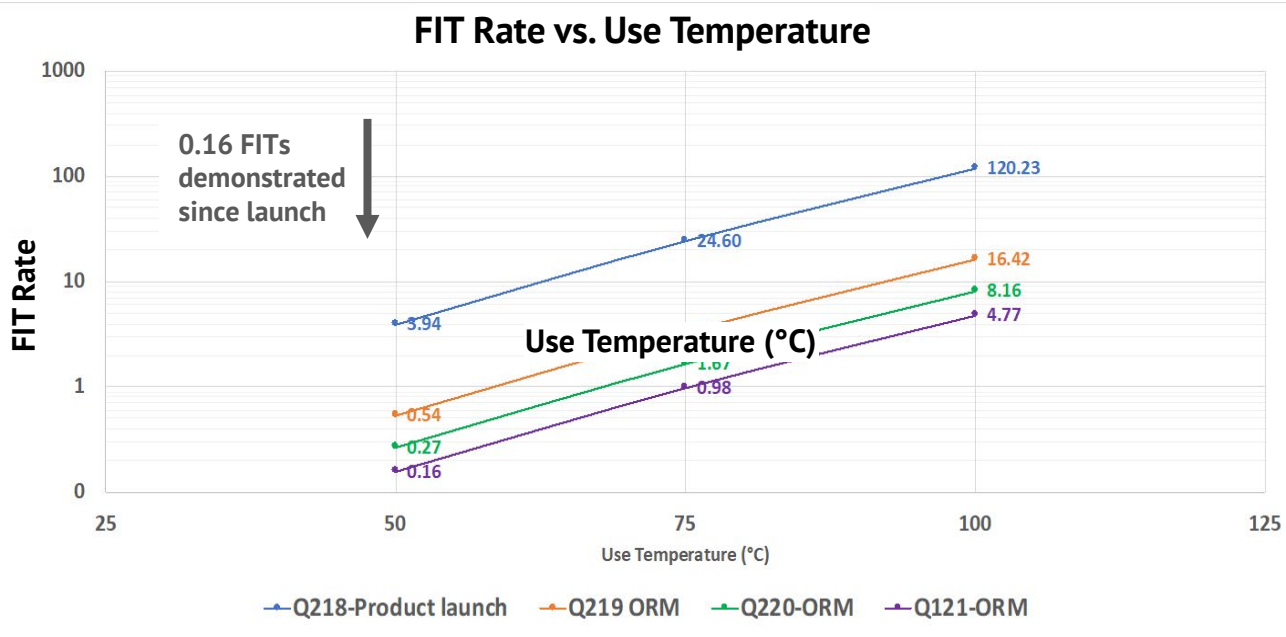
Production Reliability Monitoring

- Reliability monitoring of production material throughout 3 years of production
- 7,276 units tested on high-frequency, soft-switching application-focused stress testing from over 70 fab lots.

Reliability Statistics

Calculated for High Line condition using HTOL (ZVS) results





GaNSense Mass Production: 65W

Lenovo YOGA

Charger Power, Output(s)	65W 2CA	65W 2C		
				
Powertrain	Discrete GaN	NV6134 GaNFast with GaNSense		
Size (cc)	105	75	30%	Smaller
Power Density (W/cc)	0.6	0.9	50%	Higher
Efficiency (%) (1)	89.15%	92.50%	3.4%	Higher
Loss (W)	7.1	4.9	30%	Energy Savings
Drive, Protection Components	19	5	75%	Fewer
PCB Area (mm^2)	83	15	80%	Smaller
T_{CASE} max (°C) (1)	85°C	<77°C	8°C	Cooler

120W Xiaomi GaNFast

- **DCM boost PFC:**
  - **Silergy SY5072B**
  - **NV6134 GaNFast with GaNSense**
- **HFQR DC-DC**
  - **Onsemi NCP1342**
  - **NV6134 GaNFast with GaNSense**
  - **Planar transformer (shown)**

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120W
GaNFast with GaNSense

- 4,500 mAhr battery
- Graphene Li-Ion
- 0-100% in 17 minutes
- 20% smaller

Read More

xiaomi

Environment / Reduced CO_2 Emissions

4x-10x lower component CO_2 footprint than silicon

28% lower lifetime CO_2 footprint for chargers / adapters

Accelerate transition from ICE to EV by **3 years**, saving **20%/yr** of road sector emissions by 2050

GaN addresses **2.6 Gton / year** by 2050

Every GaNFast™ power IC shipped saves

4 kg CO_2

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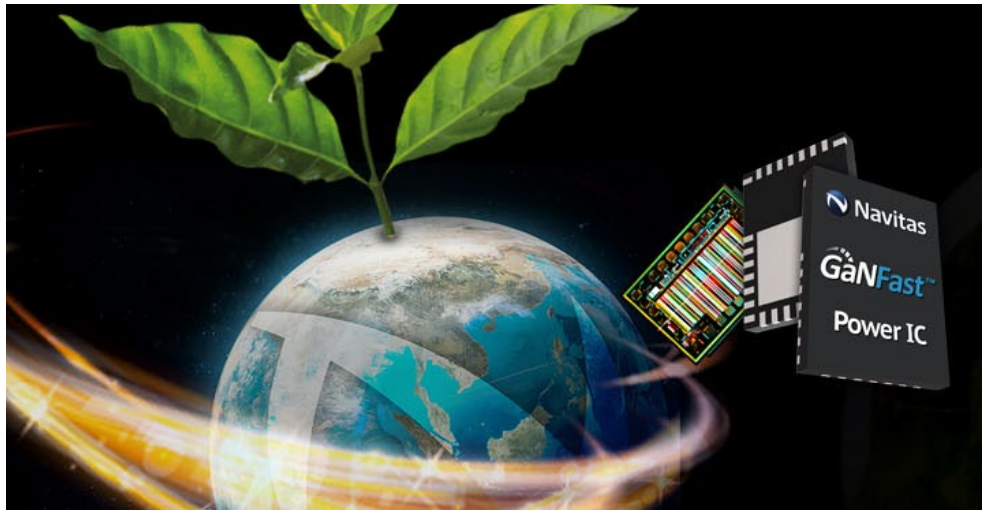
COP21·CMP11



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