



## 650 V GaNFast™ Power IC

### 1. Features

#### GaNFast™ Power IC

- Large cooling pad
- Thermally-enhanced version of NV6117
- Enhanced thermals when using CS resistor
- Monolithically-integrated gate drive
- Wide  $V_{CC}$  range (10 to 30 V)
- Programmable turn-on  $dV/dt$
- 200 V/ns  $dV/dt$  immunity
- 800 V Transient Voltage Rating
- 650 V Continuous Voltage Rating
- Low 125 m $\Omega$  resistance
- Zero reverse recovery charge
- ESD protection – 1 kV (HBM), 1 kV (CDM)
- 2 MHz operation

#### Small, low-profile SMT QFN

- 6 x 8 mm footprint, 0.85 mm profile
- Minimized package inductance

#### Sustainability

- RoHS, Pb-free, REACH-compliant
- Up to 40% energy savings vs Si solutions
- System level 4kg CO<sub>2</sub> Carbon Footprint reduction

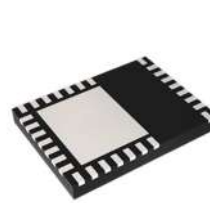
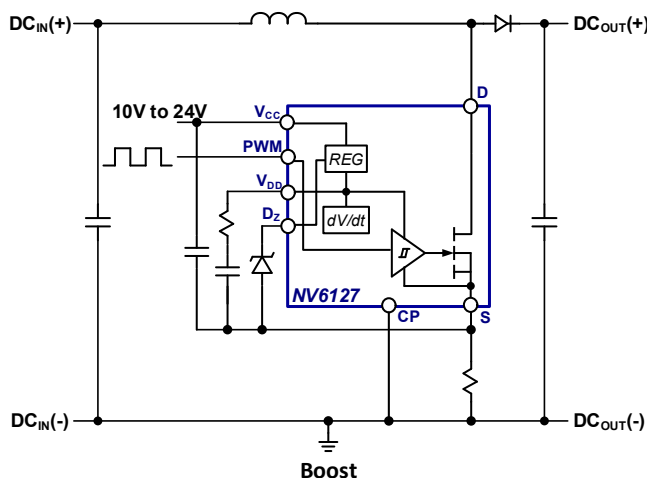
#### Product Reliability

- 20-year limited product warranty  
(see Section 14 for details)

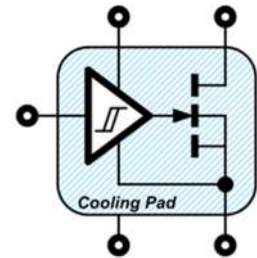
### 2. Topologies / Applications

- AC-DC, DC-DC, DC-AC
- QR Flyback, PFC, AHB, Buck, Boost, Half bridge, Full bridge, LLC resonant, Class D
- Wireless power, Solar Micro-inverters, LED lighting, TV SMPS, Server, Telecom

### 4. Typical Application Circuits



QFN 6 x 8 mm



Simplified schematic

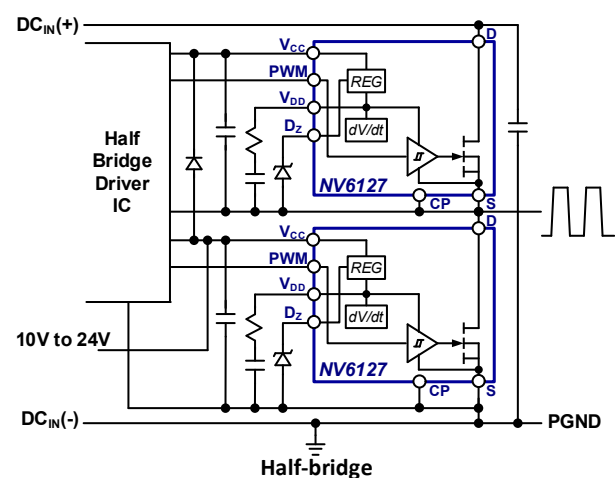
### 3. Description

The NV6127 is a thermally-enhanced version of the popular NV6117 650 V GaNFast™ power IC, optimized for high-frequency and soft-switching topologies.

Monolithic integration of FET, drive and logic creates an easy-to-use 'digital in, power out' high performance powertrain building block, enabling designers to create the fastest, smallest, most efficient integrated powertrain in the world.

The highest  $dV/dt$  immunity, high-speed integrated drive and industry standard low-profile, low-inductance, 6 x 8 mm SMT QFN package allow designers to exploit Navitas GaN technology with simple, quick, dependable solutions for breakthrough power density and efficiency.

Navitas' GaNFast™ power ICs extend the capabilities of traditional topologies such as flyback, half-bridge, resonant, etc. to MHz+ and enable the commercial introduction of breakthrough designs.



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## 6. Specifications

### 6.1. Absolute Maximum Ratings<sup>(1)</sup>

(with respect to Source (pad) unless noted)

SYMBOL	PARAMETER	MAX	UNITS
$V_{DS(TRAN)}$	Transient Drain-to-Source Voltage <sup>(2)</sup>	800	V
$V_{DS(CONT)}$	Continuous Drain-to-Source Voltage	-7 to +650	V
$V_{CC}$	Supply Voltage	30	V
$V_{PWM}$	PWM Input Pin Voltage	-3 to +30	V
$V_{DZ}$	$V_{DD}$ Setting Pin Voltage	6.6	V
$V_{DD}$	Drive Supply Voltage	7.2	V
$V_{CP}$	Cooling Pad Voltage	-10 to +10	V
$I_D$	Continuous Drain Current (@ $T_C = 100^\circ\text{C}$ )	12	A
$I_D$ PULSE	Pulsed Drain Current (10 $\mu\text{s}$ @ $T_J = 25^\circ\text{C}$ )	24	A
$I_D$ PULSE	Pulsed Drain Current (10 $\mu\text{s}$ @ $T_J = 125^\circ\text{C}$ )	16	A
dV/dt	Slew Rate on Drain-to-Source	200	V/ns
$T_J$	Operating Junction Temperature	-55 to 150	$^\circ\text{C}$
$T_{STOR}$	Storage Temperature	-55 to 150	$^\circ\text{C}$

(1) Absolute maximum ratings are stress ratings; devices subjected to stresses beyond these ratings may cause permanent damage.

(2)  $V_{DS(TRAN)}$  allows for surge ratings during non-repetitive events that are <100us (for example start-up, line interruption) and repetitive events that are <400ns (for example repetitive leakage inductance spikes). Refer to Section 8.10 for detailed recommended design guidelines.

### 6.2. Recommended Operating Conditions<sup>(3)</sup>

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS
$V_{DZ}$	Drive Supply Set Zener Voltage <sup>(4)</sup>	5.8	6.2	6.6	V
$V_{DD}$	Drive Supply Voltage	5.5		7.0	V
$I_{DD\_EXT}$	Regulator External Load Current			3.0	mA
$R_{DD}$	Gate Drive Turn-On Current Set Resistance <sup>(5)</sup>	10	25		$\Omega$
$V_{PWM}$	PWM Input Pin Voltage	0	5	Min. of ( $V_{CC}$ or 20)	V
$V_{CC}$	Supply Voltage	10		24	V
$T_C$	Operating Case Temperature	-40		125	$^\circ\text{C}$

(3) Exposure to conditions beyond maximum recommended operating conditions for extended periods of time may affect device reliability.

(4) Use of Zener diode other than 6.2 V is not recommended. See for recommended part numbers of 6.2 V Zener diodes.

(5)  $R_{DD}$  resistor must be used. Minimum 10 Ohm to ensure application and device robustness.

### 6.3. ESD Ratings

SYMBOL	PARAMETER	MAX	UNITS
HBM	Human Body Model (per JS-001-2014)	1,000	V
CDM	Charged Device Model (per JS-002-2014)	1,000	V

### 6.4. Thermal Resistance

SYMBOL	PARAMETER	TYP	UNITS
$R_{\theta JC}^{(6)}$	Junction-to-Case	1.5	°C/W
$R_{\theta JA}^{(6)}$	Junction-to-Ambient	40	°C/W

(6)  $R_{\theta}$  measured on DUT mounted on 1 square inch 2 oz Cu (FR4 PCB)

## 6.5. Electrical Characteristics

Typical conditions:  $V_{DS} = 400\text{ V}$ ,  $V_{CC} = 15\text{ V}$ ,  $V_{DZ} = 6.2\text{ V}$ ,  $F_{SW} = 1\text{ MHz}$ ,  $T_{AMB} = 25\text{ °C}$ ,  $I_D = 6\text{ A}$ ,  $R_{DD} = 10\text{ }\Omega$  (or specified)

SYMBOL	PARAMETER	MIN	TYP	MAX	UNITS	CONDITIONS
<b><math>V_{CC}</math> Supply Characteristics</b>						
$I_{QCC}$	$V_{CC}$ Quiescent Current		0.85	1.5	mA	$V_{PWM} = 0\text{ V}$
$I_{QCC-SW}$	$V_{CC}$ Operating Current		2.85		mA	$F_{SW} = 1\text{ MHz}$ , $V_{DS} = \text{Open}$
<b>Low-Side Logic Input Characteristics</b>						
$V_{PVMH}$	Input Logic High Threshold (rising edge)			4	V	
$V_{PVML}$	Input Logic Low Threshold (falling edge)	1			V	
$V_{I-HYS}$	Input Logic Hysteresis		0.5		V	
$T_{ON}$	Turn-on Propagation Delay		11		ns	Fig.1, Fig.2
$T_{OFF}$	Turn-off Propagation Delay		9		ns	Fig.1, Fig.2
$T_R$	Drain rise time		6		ns	Fig.1, Fig.2
$T_F$	Drain fall time		3		ns	Fig.1, Fig.2
<b>Switching Characteristics</b>						
$F_{SW}$	Switching Frequency			2	MHz	
$t_{PW}$	Pulse width	0.02		1000	$\mu\text{s}$	
<b>GaN FET Characteristics</b>						
$I_{DSS}$	Drain-Source Leakage Current		0.3	25	$\mu\text{A}$	$V_{DS} = 650\text{ V}$ , $V_{PWM} = 0\text{ V}$
$I_{DSS}$	Drain-Source Leakage Current		10	50	$\mu\text{A}$	$V_{DS} = 650\text{ V}$ , $V_{PWM} = 0\text{ V}$ , $T_C = 125\text{ °C}$
$R_{DS(ON)}$	Drain-Source Resistance		125	180	m $\Omega$	$V_{PWM} = 6\text{ V}$ , $I_D = 6\text{ A}$
$R_{DS(ON)}$	Drain-Source Resistance		259		m $\Omega$	$V_{PWM} = 6\text{ V}$ , $I_D = 6\text{ A}$ , $T_C = 125\text{ °C}$
$V_{SD}$	Source-Drain Reverse Voltage		3.2	5	V	$V_{PWM} = 0\text{ V}$ , $I_{SD} = 6\text{ A}$
$Q_{OSS}$	Output Charge		27		nC	$V_{DS} = 400\text{ V}$ , $V_{PWM} = 0\text{ V}$
$Q_{RR}$	Reverse Recovery Charge		0		nC	
$C_{OSS}$	Output Capacitance		27		pF	$V_{DS} = 400\text{ V}$ , $V_{PWM} = 0\text{ V}$
$C_{O(er)}^{(7)}$	Effective Output Capacitance, Energy Related		41		pF	$V_{DS} = 400\text{ V}$ , $V_{PWM} = 0\text{ V}$
$C_{O(tr)}^{(8)}$	Effective Output Capacitance, Time Related		67		pF	$V_{DS} = 400\text{ V}$ , $V_{PWM} = 0\text{ V}$

(7)  $C_{O(er)}$  is a fixed capacitance that gives the same stored energy as  $C_{OSS}$  while  $V_{DS}$  is rising from 0 to 400 V

(8)  $C_{O(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{OSS}$  while  $V_{DS}$  is rising from 0 to 400 V

## 6.6. Switching Waveforms

( $T_C = 25\text{ }^{\circ}\text{C}$  unless otherwise specified)

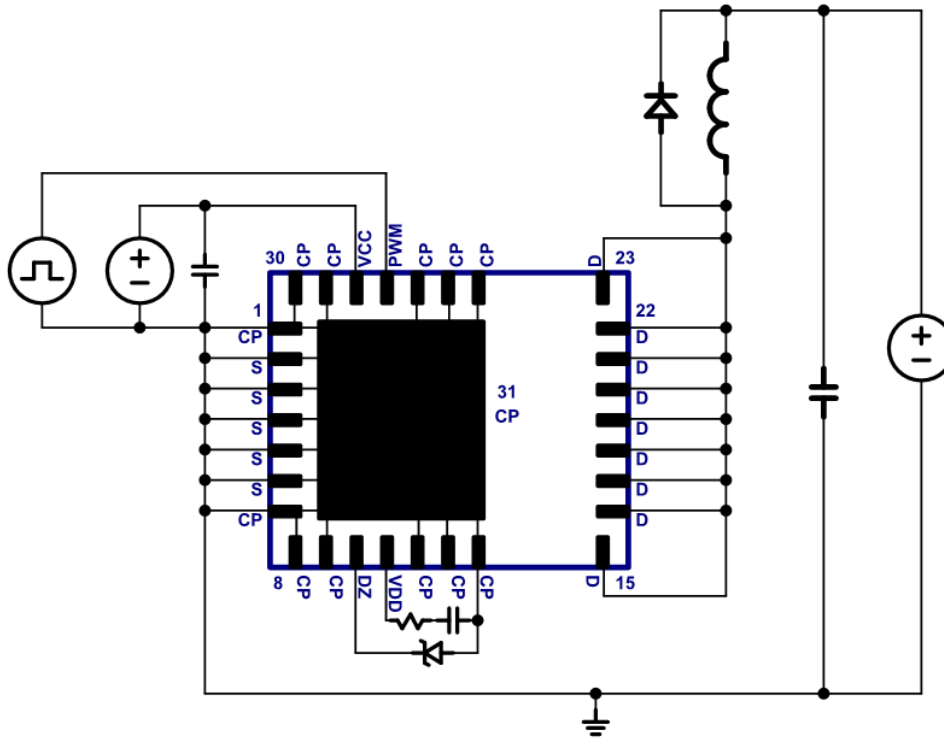


Fig. 1. Inductive switching circuit

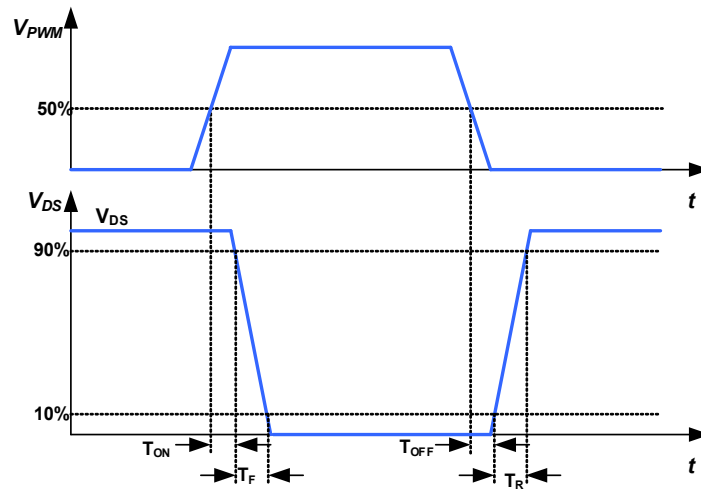


Fig. 2. Propagation delay and rise/fall time definitions

## 6.7. Characteristic Graphs

(GaN FET,  $T_C = 25^\circ\text{C}$  unless otherwise specified)

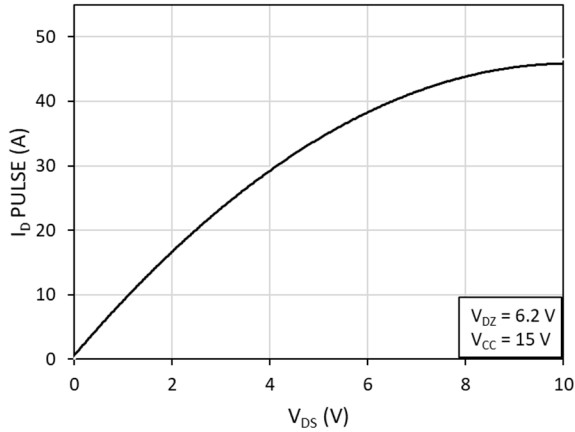


Fig. 3. Pulsed Drain current ( $I_D$  PULSE) vs. drain-to-source voltage ( $V_{DS}$ ) at  $T = 25^\circ\text{C}$

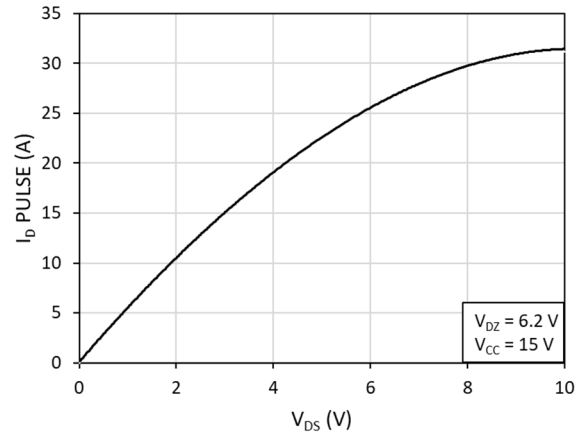


Fig. 4. Pulsed Drain current ( $I_D$  PULSE) vs. drain-to-source voltage ( $V_{DS}$ ) at  $T = 125^\circ\text{C}$

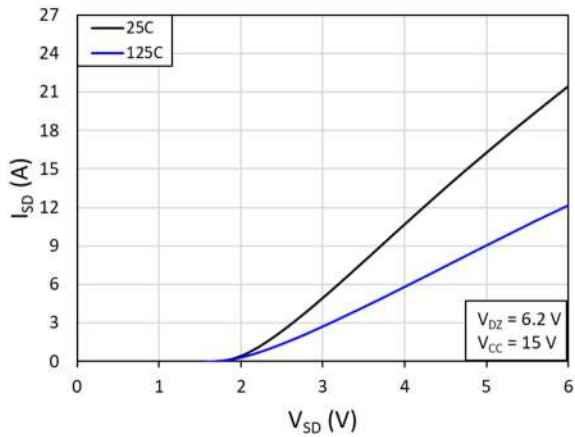


Fig. 5. Source-to-drain reverse conduction voltage

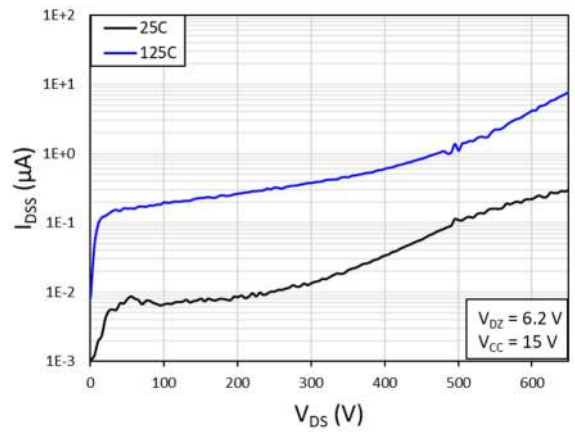


Fig. 6. Drain-to-source leakage current ( $I_{DSS}$ ) vs. drain-to-source voltage ( $V_{DS}$ )

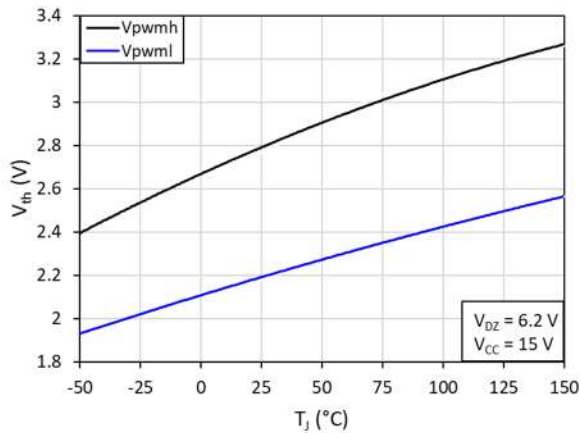


Fig. 7.  $V_{PWMH}$  and  $V_{PWML}$  vs. junction temperature ( $T_J$ )

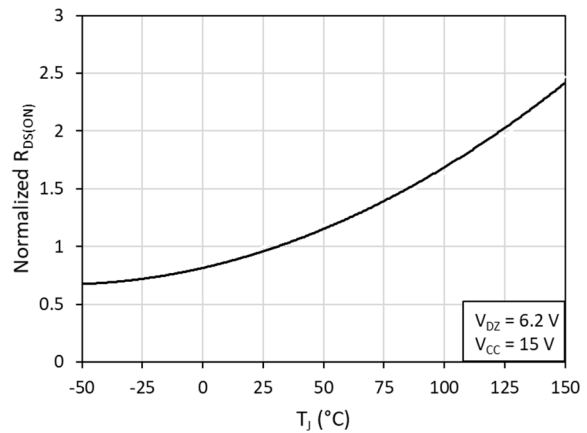


Fig. 8. Normalized on-resistance ( $R_{DS(ON)}$ ) vs. junction temperature ( $T_J$ )



## Characteristic Graphs (Cont.)

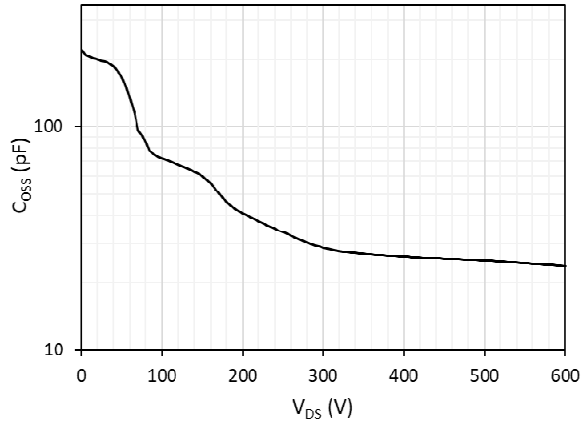


Fig. 9. Output capacitance ( $C_{OSS}$ ) vs. drain-to-source voltage ( $V_{DS}$ )

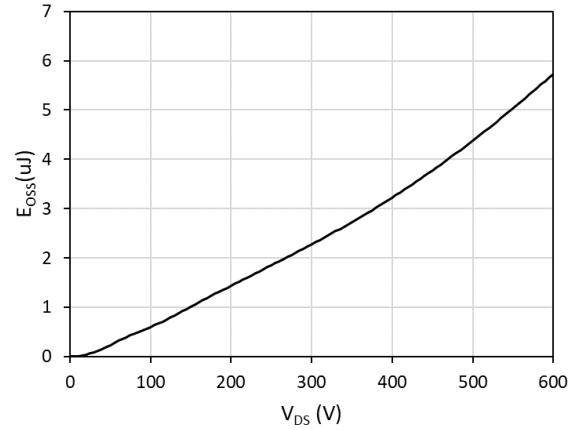


Fig. 10. Energy stored in output capacitance ( $E_{OSS}$ ) vs. drain-to-source voltage ( $V_{DS}$ )

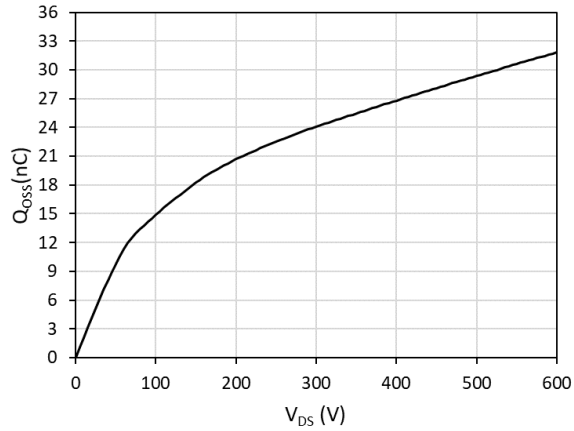


Fig. 11. Charge stored in output capacitance ( $Q_{OSS}$ ) vs. drain-to-source voltage ( $V_{DS}$ )

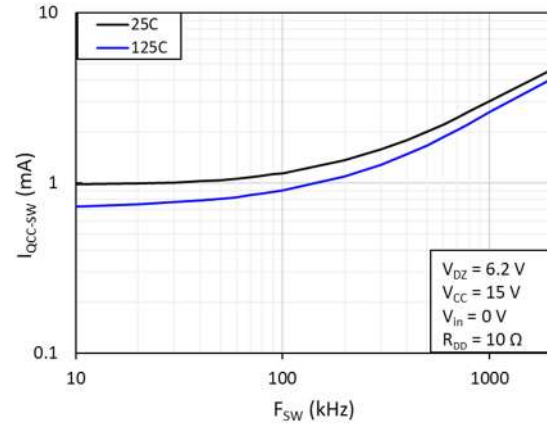


Fig. 12.  $V_{CC}$  operating current ( $I_{QCC-SW}$ ) vs. operating frequency ( $F_{SW}$ )

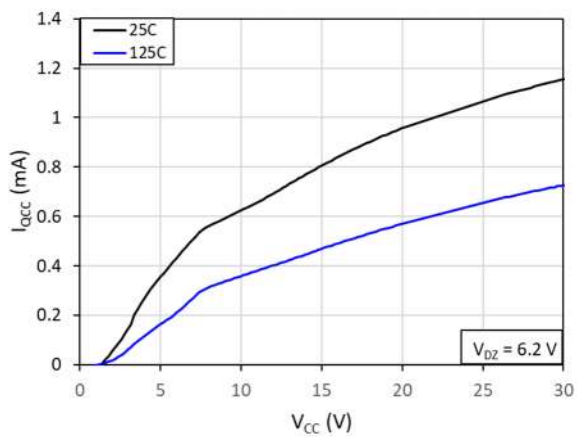


Fig. 13.  $V_{CC}$  quiescent current ( $I_{QCC}$ ) vs. supply voltage ( $V_{CC}$ )

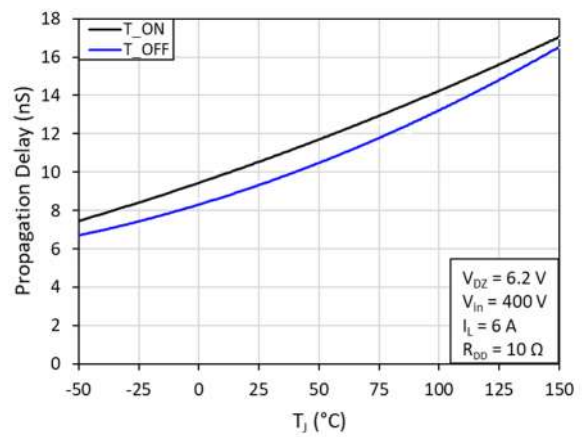


Fig. 14. Propagation delay ( $T_{ON}$  and  $T_{OFF}$ ) vs. junction temperature ( $T_J$ )



## Characteristic Graphs (Cont.)

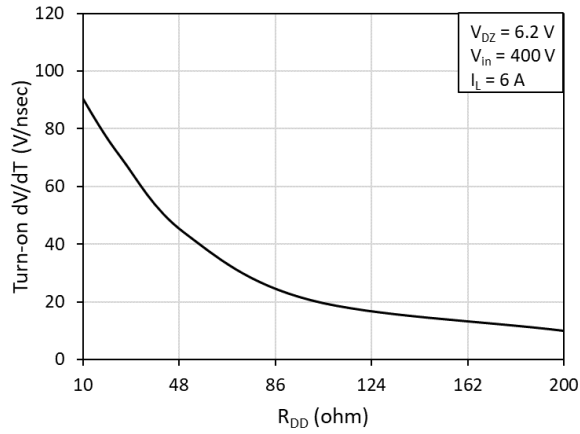


Fig. 15. Slew rate ( $dV/dt$ ) vs. gate drive turn-on current set resistance ( $R_{DD}$ ) at  $T = 25$  °C

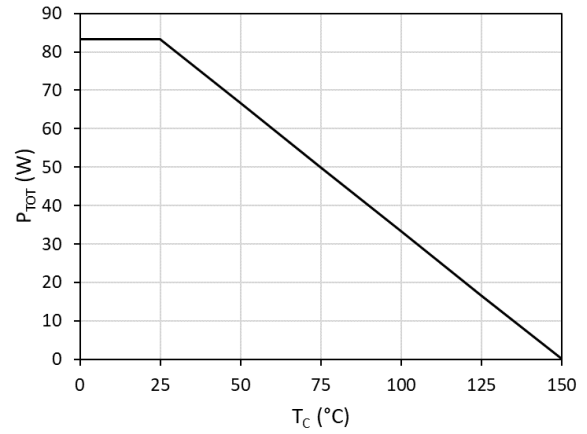


Fig. 16. Power dissipation ( $P_{TOT}$ ) vs. case temperature ( $T_C$ )

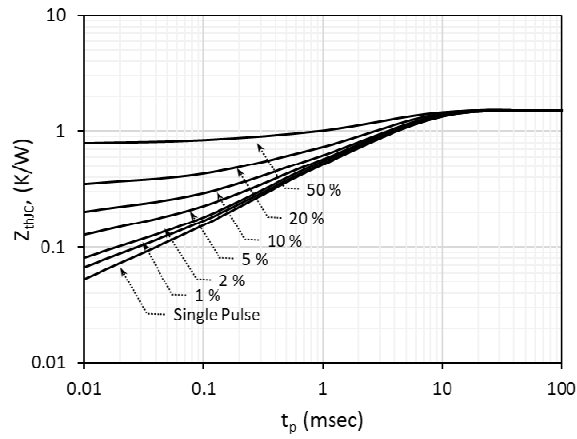
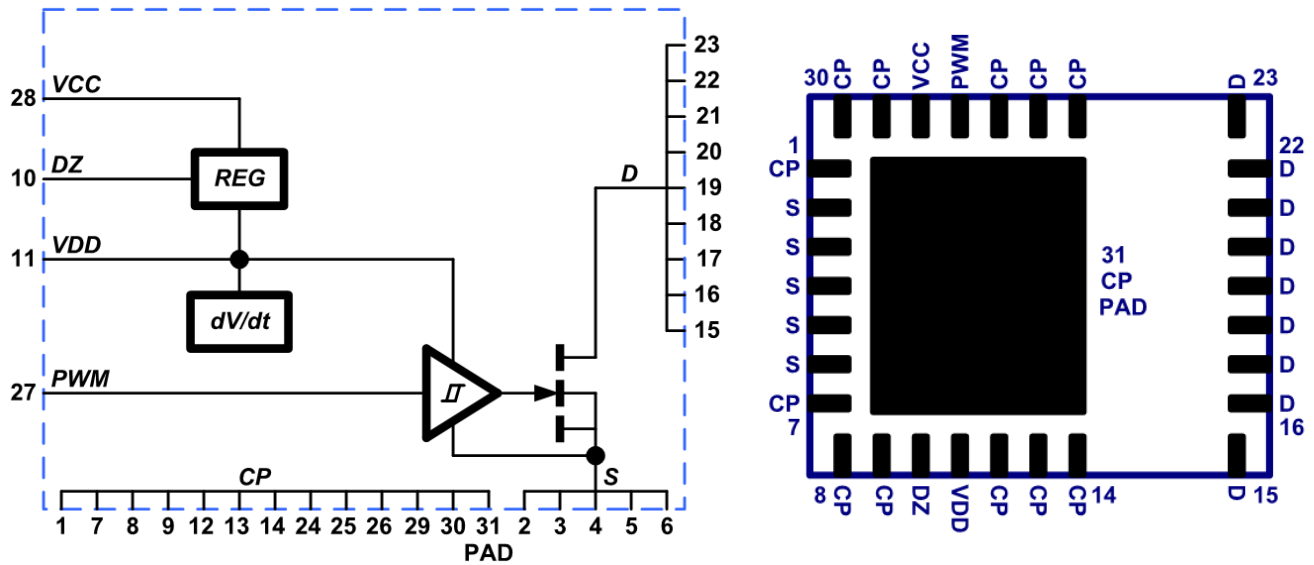


Fig. 17. Max. thermal transient impedance ( $Z_{thJC}$ ) vs. pulse width ( $t_p$ )

## 7. Internal Schematic, Pin Configurations and Functions



Package Top View

Pin		I/O <sup>(1)</sup>	Description
Number	Symbol		
1,7,8,9,12,13,14,24,25,26,29,30,31	CP	T	Metal cooling pad on bottom of package for thermal management. <b>CP must be connected to Source or circuit PGND. Do not leave CP unconnected or floating!</b>
2,3,4,5,6	S	O, G	Source of power FET & GaN IC supply ground.
10	D <sub>Z</sub>	I	Gate drive supply voltage set pin (connect 6.2 V Zener to GND).
11	V <sub>DD</sub>	I	Gate drive supply voltage. Gate drive turn-on current set pin (using R <sub>DD</sub> ).
27	PWM	I	PWM input
28	V <sub>CC</sub>	P	Supply voltage (10V to 24V)
15,16,17,18,19,20,21,22,23	D	P	Drain of power FET

(1) I = Input, O = Output, P = Power, G = GaN IC Ground, T = Thermal

## 8. Functional Description

The following functional description contains additional information regarding the IC operating modes and pin functionality.

### 8.1. Start Up

When the  $V_{CC}$  supply is first applied to the NV6127, care should be taken such that the  $V_{DD}$  and  $D_Z$  pins are up at their correct voltage levels before the PWM input signal starts. The  $V_{DD}$  pin ramp up time is determined by the internal regulator current at this pin and the external  $C_{VDD}$  capacitor.  $C_{VDD}$  time constant should be calculated such that there is sufficient time to charge up the  $C_{VDD}$  capacitor to  $\sim 6V$ . In some scenarios, where fast startup is required, an optional diode in parallel with the  $R_{DD}$  can be used to ensure the  $C_{VDD}$  capacitor is fully charged before the first PWM pulse is applied. Also, since the  $D_Z$  pin voltage sets the  $V_{DD}$  voltage level, the  $V_{DD}$  pin will ramp up together with the  $D_Z$  pin (Fig. 18).

For half-bridge configurations, it is important that the  $V_{CC}$  supply, the  $D_Z$  pin, and the  $V_{DD}$  supply of the high-side GaNFast power IC are all charged up to their proper levels before the first high-side PWM pulses start. For LLC applications, a long on-time PWM pulse to the low-side ( $> 10 \mu s$ ) is typically provided by the LLC controller to allow the supply pins of the high-side GaNFast power IC to charge up (through the external bootstrap diode) to their correct levels before the first high-side PWM pulses start (Fig. 19).

For active clamp flyback (ACF) applications, the half-bridge must be ready very quickly due to the soft-start mode of the ACF controller. When the first few PWM pulses are generated by the ACF controller, the high-side supply pins of the GaNFast power IC will require a few low-side pulses to charge up (through the external bootstrap diode) before the high-side starts to switch (Fig. 20).

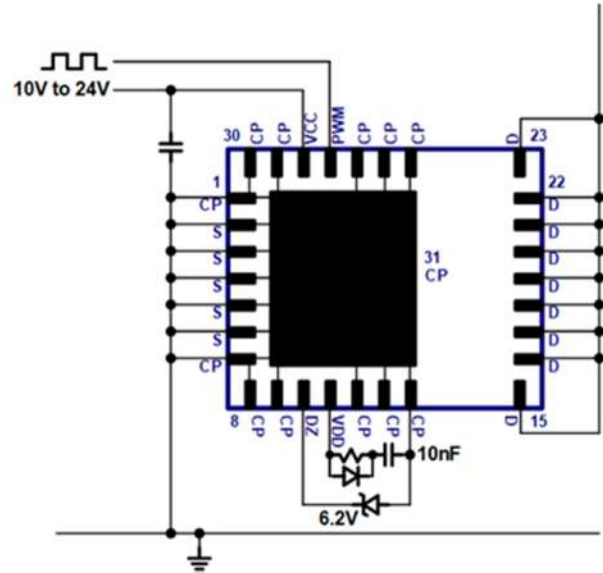


Fig. 18. Start-up circuit

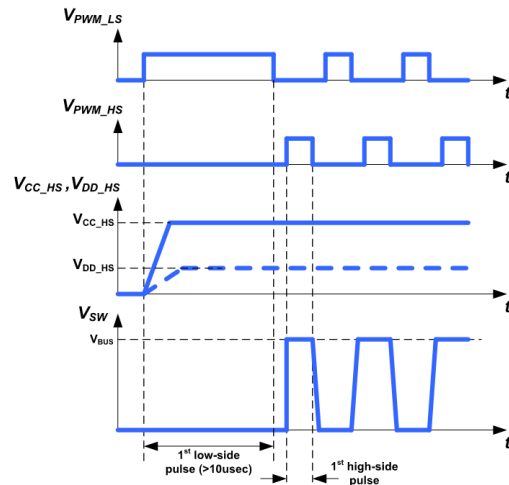


Fig. 19. LLC half-bridge start-up timing diagram

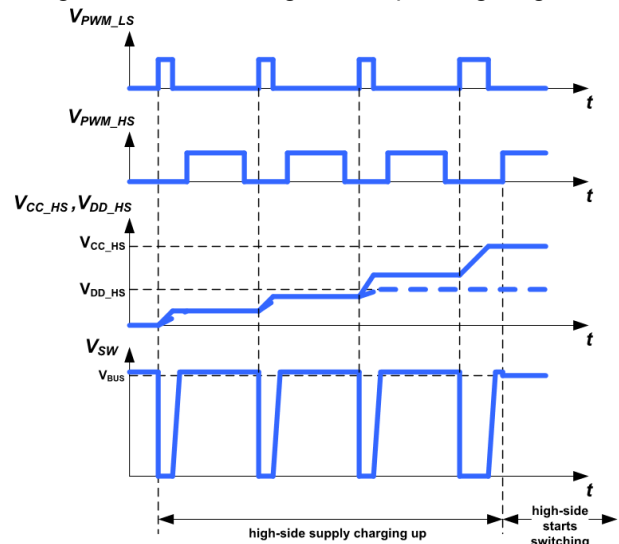


Fig. 20. ACF half-bridge start-up timing diagram





### 8.7. 3.3V PWM Input Circuit

For some applications where a 3.3 V PWM signal is required (DSP, MCU, etc.) an additional buffer can be placed before the PWM input pin (Fig. 26) with the buffer supply voltage connected to the  $V_{DD}$  capacitor.

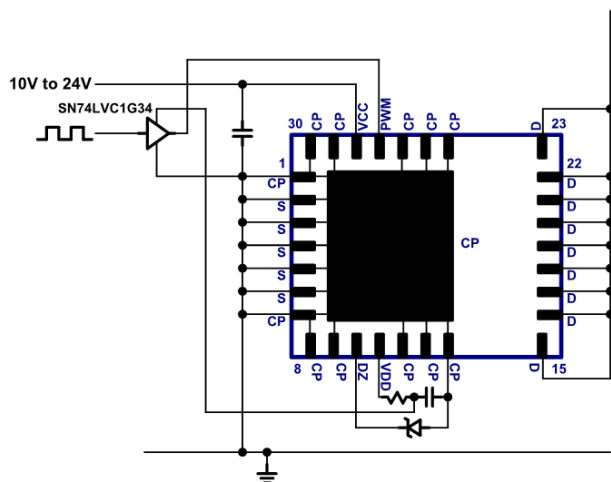


Fig. 26. 3.3 V PWM input buffer circuit

### 8.8. PCB Layout Guidelines

The design of the PCB layout is critical for good noise immunity, sufficient thermal management, and proper operation of the IC. Typical PCB layout examples for without current sensing resistor and with current sensing resistor, are all shown in Section 10.

The following rules should be followed carefully during the design of the PCB layout:

- 1) Place all IC filter and programming components directly next to the IC. These components include ( $C_{VCC}$ ,  $C_{VDD}$ ,  $R_{PWM}$ ,  $C_{PWM}$ ,  $R_{DD}$  and  $D_Z$ ).
- 2) Keep ground trace of IC filter and programming components separate from power GND trace. Do not run power GND currents through ground trace of filter components!
- 3) For best thermal management, place thermal vias in the source pad area to conduct the heat out through the bottom of the package and through the PCB board to other layers (see Section 0 for correct layout examples).
- 4) Use large PCB thermal planes (connected with thermal vias to the source pad) and additional PCB layers to reduce IC temperatures as much as possible (see Section 0 for correct layout examples).
- 5) For half-bridge layouts, do not extend copper planes from one IC across the components or pads of the other IC!
- 6) For high density designs, use a 4-layer PCB and 2 oz. copper to route signal connections. This allows layout to maintain large thermal copper planes and reduce power device temperature.



## 8.9. Recommended Component Values

The following table (Table I) shows the recommended component values for the external filter capacitors, Zener diode, and  $R_{DD}$  connected to the pins of the GaNFast power IC. These components should be placed as close as possible to the IC. Please see PCB Layout guidelines for more information. The Zener diode at the  $D_z$  pin should be a low-current type with a flat knee, and the min/max limits must be followed.  $R_{DD}$  must be a minimum of 10  $\Omega$  to ensure application and device robustness.

SYM	DESCRIPTION	PART NO.	SUPPLIER	MIN	TYP	MAX	UNITS
$C_{VCC}$	Maximum $V_{CC}$ supply capacitor				0.1		$\mu F$
$C_{VDD}$	$V_{DD}$ supply capacitor				0.01		$\mu F$
$R_{DD}$	Gate drive turn-on current set resistor			10	25		$\Omega$
$D_z$	$V_{DD}$ set Zener diode ( $D_z$ pin)	BZT52B6V2 RHG	Taiwan Semiconductor Corporation	5.8	6.2	6.6	V
		MM3Z6V2ST1G	ON-Semiconductor				
		PDZ6.2B.115	Nexperia (NXP)				
		PLVA662A.215	Nexperia (NXP)				
		LM3Z6V2T1	Leshan Radio Company				
$R_{PWM}$	PWM filter resistor				100		$\Omega$
$C_{PWM}$	PWM filter capacitor				100		pF

Table I. Recommended component values.

### 8.9.1. Zener Diode Selection

The Zener voltage is a critical parameter that sets the internal reference for gate drive voltage and other circuitry. The Zener diode needs to be selected such that the voltage on the  $D_z$  pin is within recommended operating conditions (5.8 V to 6.6 V) across operating temperature ( $-40^{\circ}C$  to  $125^{\circ}C$ ) and bias current (10  $\mu A$  to 1 mA). To ensure effective operation, the current vs. voltage characteristics of the Zener diode should be measured down to 10  $\mu A$  to ensure flat characteristics across the current operating range (10  $\mu A$  to 1 mA). The recommended part numbers (Table I) meet these requirements. If the Zener selected by user does not ensure that the voltage on the  $D_z$  pin is always within the recommended operating range, the functionality and reliability of the GaNFast power IC can be impacted. An external resistor ( $\sim 47$  k $\Omega$ ) between  $V_{CC}$  and  $D_z$  (Fig. 27) can improve Zener voltage stability by adding bias current to the  $D_z$  pin to ensure the voltage on the  $D_z$  pin is always within the recommended operating range. This will add  $\sim 200$   $\mu A$  of quiescent current.

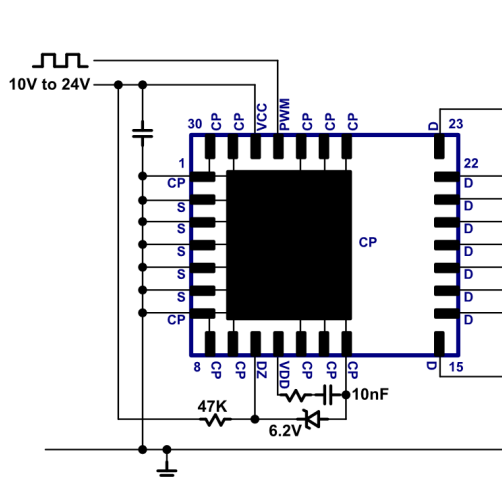


Fig. 27. Increasing Zener bias current for stable Zener voltage



## 8.10. Drain-to-Source Voltage Considerations

GaN Power ICs have been designed and tested to provide significant design margin to handle transient and continuous voltage conditions that are commonly seen in single-ended topologies, such as quasi-resonant (QR) flyback applications. The different voltage levels and recommended margins in a typical QR flyback can be analyzed using . When the device is switched off, the energy stored in the transformer leakage inductance will cause  $V_{DS}$  to overshoot to the level of  $V_{SPIKE}$ . The clamp circuit should be designed to control the magnitude of  $V_{SPIKE}$ . It is recommended to apply an 80% derating from  $V_{DS(TRAN)}$  rating (800V) to 650 V max for repetitive  $V_{DS}$  spikes under the worst case steady-state operating conditions. After dissipation of the leakage energy, the device  $V_{DS}$  will settle to the level of the bus voltage plus the reflected output voltage which is defined in Fig. 28 as  $V_{PLATEAU}$ . It is recommended to design the system such that  $V_{PLATEAU}$  follows a typical derating of 80% (520V) from  $V_{DS(CONT)}$  (650V). Finally,  $V_{DS(TRAN)}$  (800V) rating is also provided for events that occur on a non-repetitive basis, such as line surge, lightning strikes, start-up, over-current, short-circuit, load transient, and output voltage transition. 800V  $V_{DS(TRAN)}$  ensures excellent device robustness and no-derating is needed for these non-repetitive events, assuming the surge duration is  $< 100 \mu s$ . For half-bridge based topologies, such as LLC,  $V_{DS}$  voltage is clamped to the bus voltage.  $V_{DS}$  should be designed such that it meets the  $V_{PLATEAU}$  derating guideline (520V).

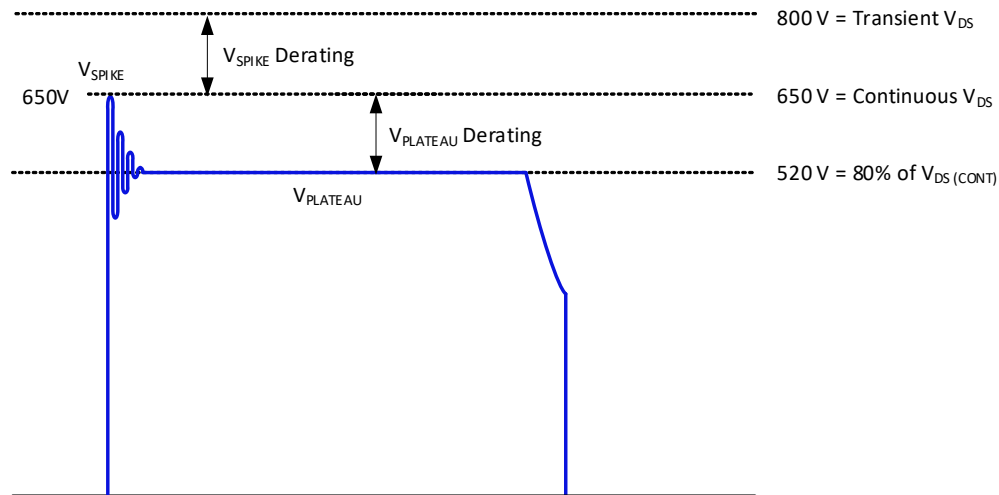
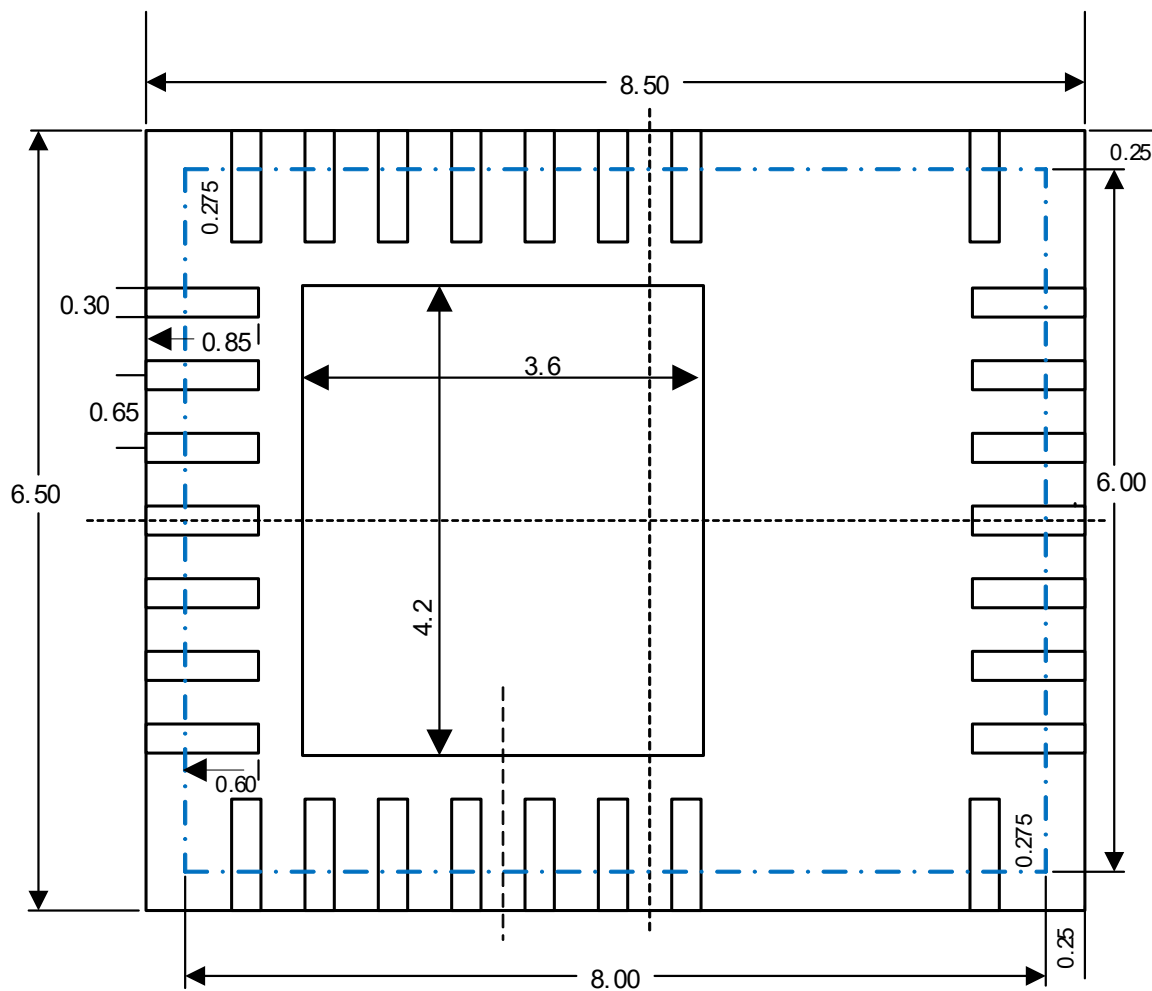


Fig. 28. QR flyback drain-to-source voltage stress diagram

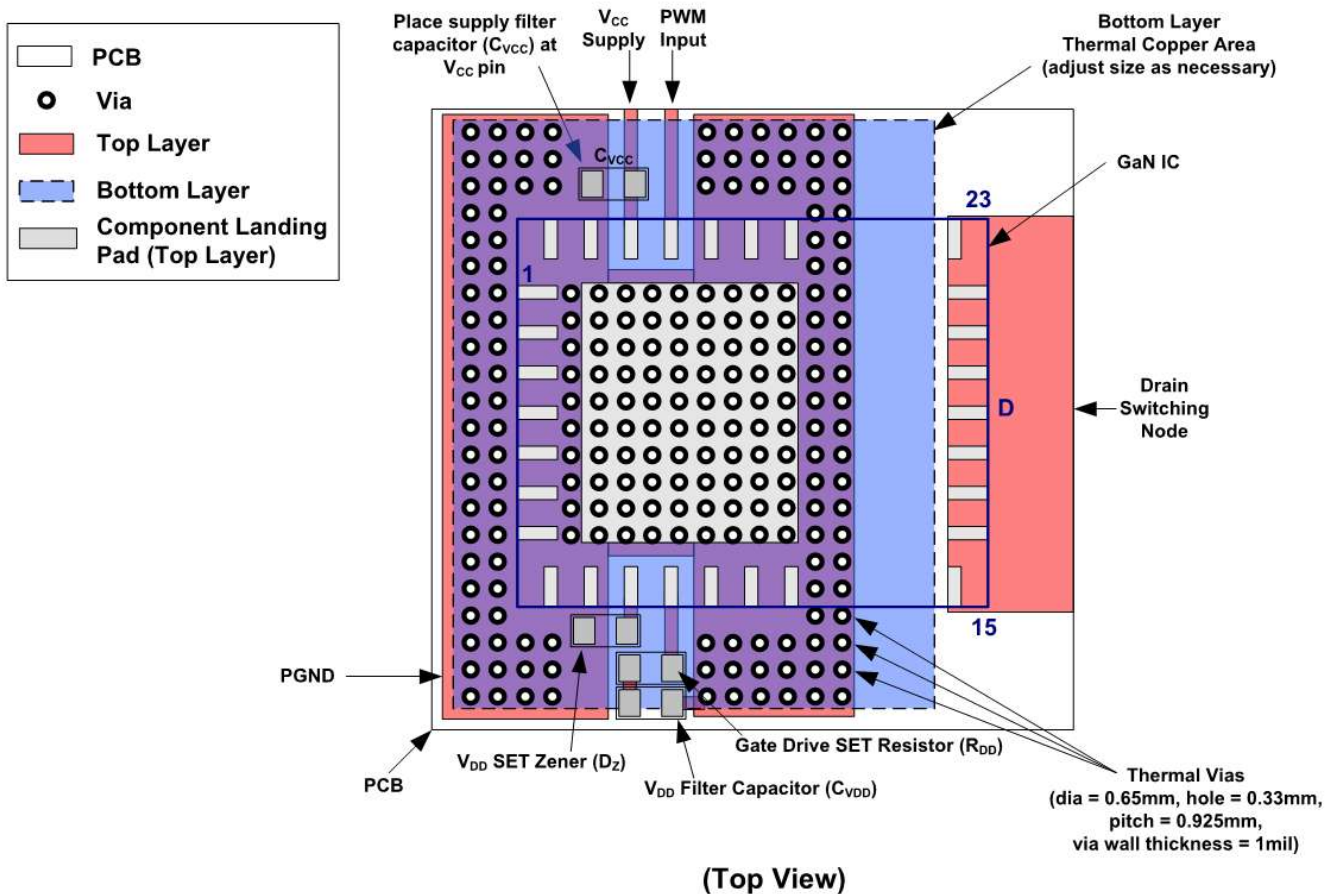
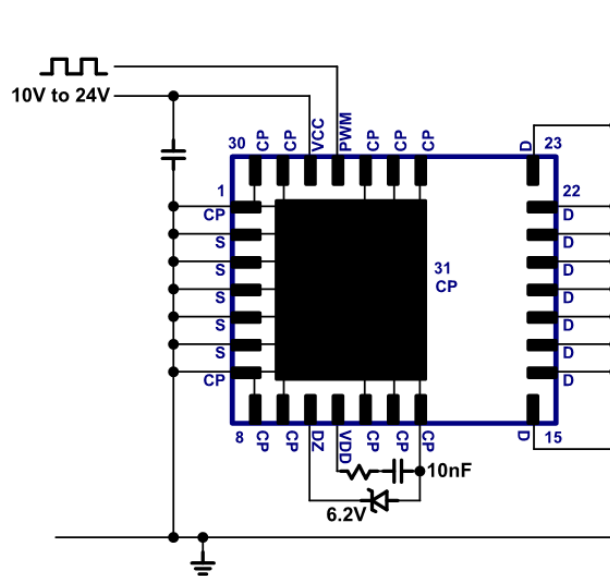
## 9. Recommended PCB Land Pattern



All dimensions are in mm

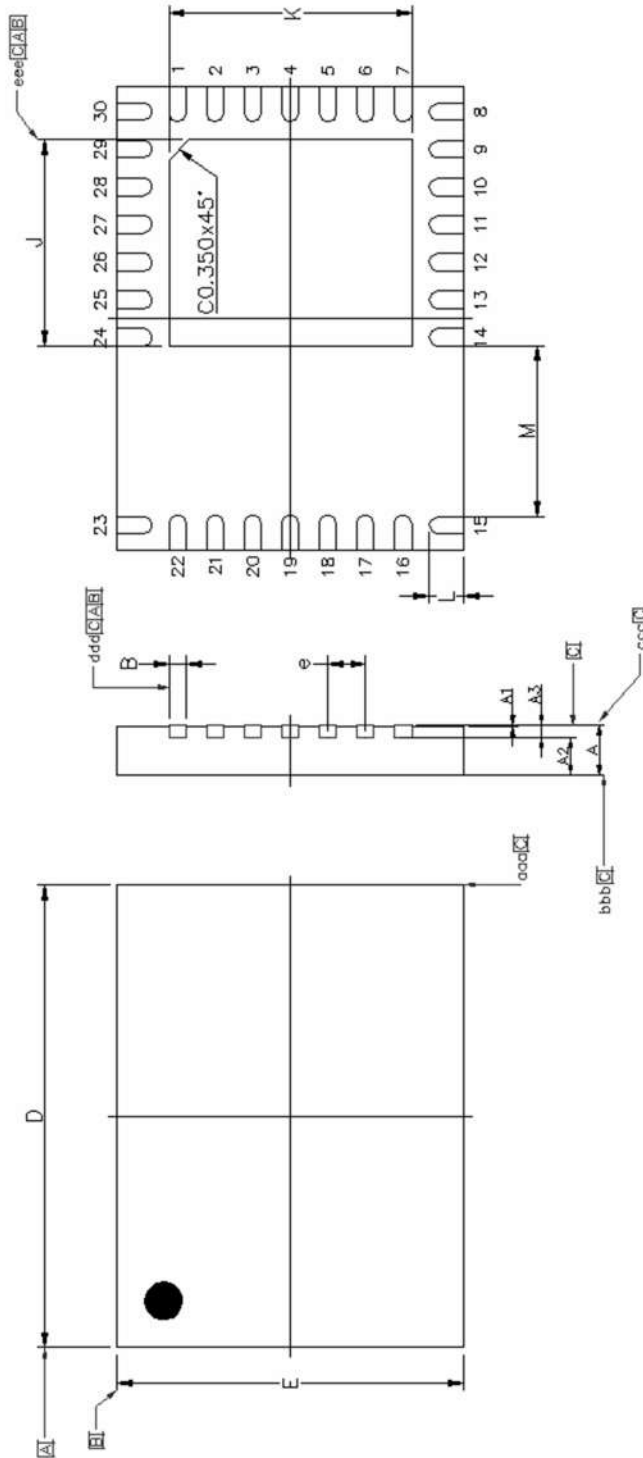
## 10. PCB Layout Guidelines

Without CS Resistor:



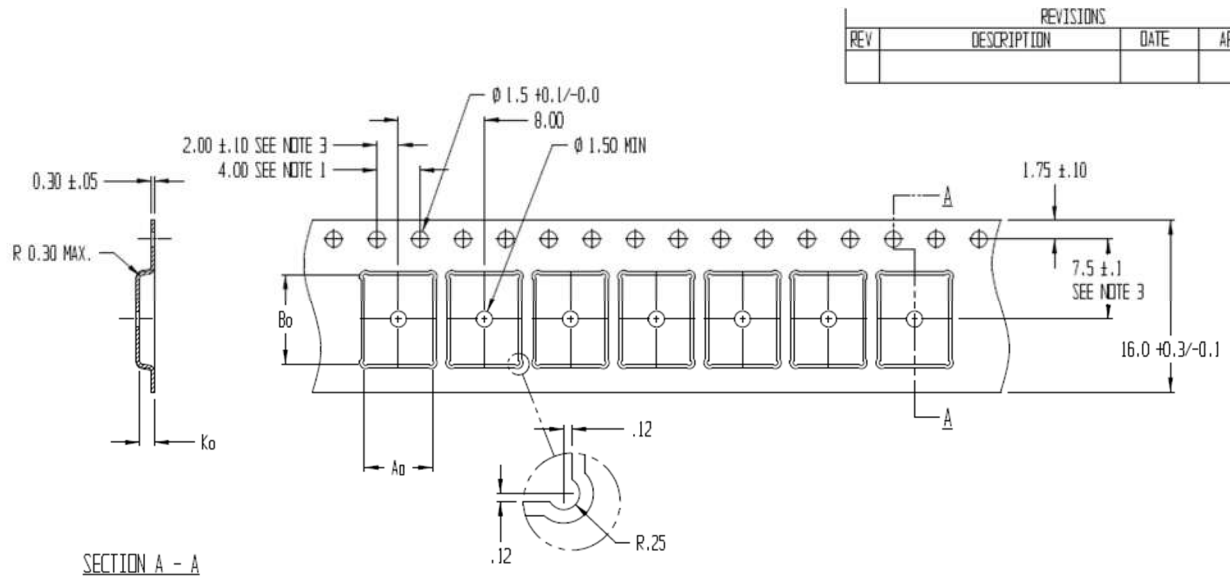


## 11. QFN Package Outline



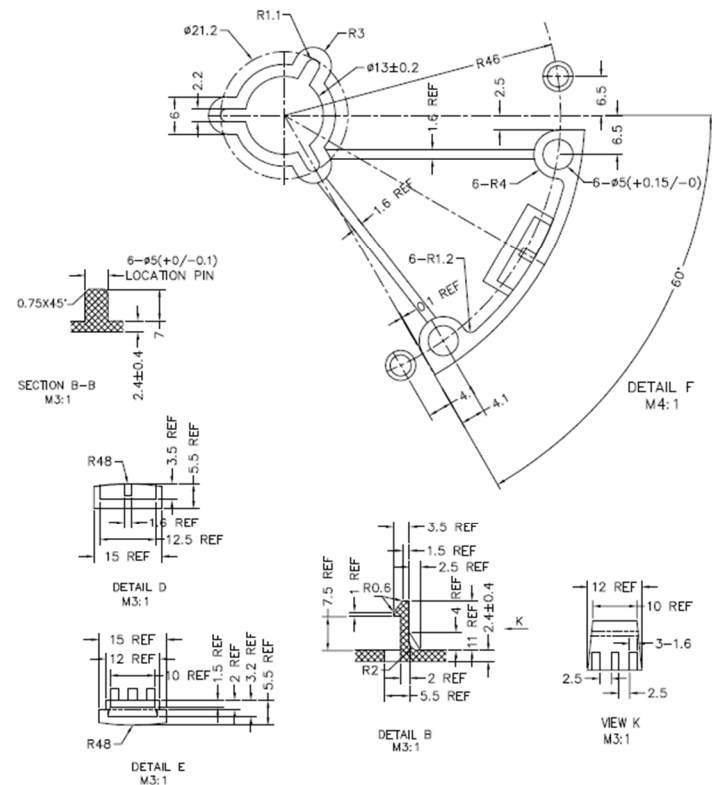
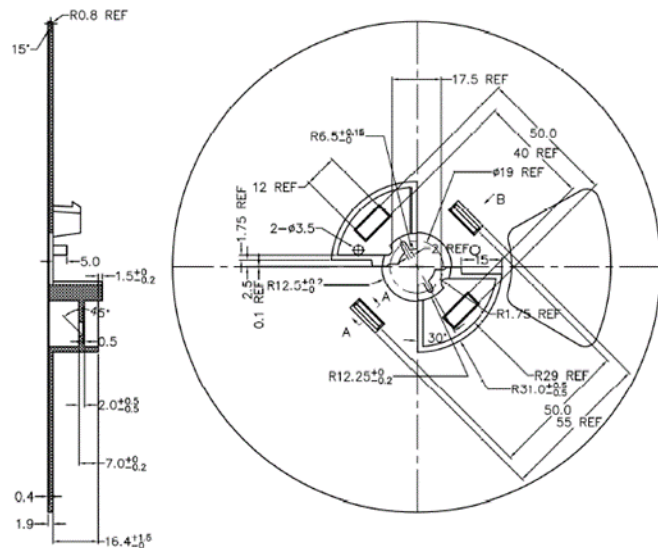
	SYMBOL	MIN	NOM	MAX		SYMBOL	MIN	NOM	MAX
TOTAL THICKNESS	A	0.8	0.85	0.9	EP SIZE	X	3.5	3.6	3.7
	A1	0.00	0.02	0.05		Y	4.1	4.2	4.3
MOLD THICKNESS	A2	---	0.65	---	LEAD LENGTH	L	0.55	0.6	0.65
L/F THICKNESS	A3	---	0.203 REF	---	HIGH VOLTAGE SPACING	M	2.85	2.95	3.05
LEAD WIDTH	B	0.25	0.3	0.35	PACKAGE EDGE TOLERANCE	aaa	---	0.1	---
	D	---	8.00 BSC	---	MOLD FLATNESS	bbb	---	0.1	---
BODY SIZE	E	---	6.00 BSC	---	COPLANARITY	ccc	---	0.08	---
	e	---	0.65 BSC	---	LEAD OFFSET	ddd	---	0.1	---
LEAD PITCH					EXPOSED PAD OFFSET	eee	---	0.1	---

## 12. Tape and Reel Dimensions



$A_0 = 6.35$   
 $B_0 = 8.35$   
 $K_0 = 1.40$







### 13. Ordering Information

Part Number	Operating Temperature Grade	Storage Temperature Range	Package	MSL Rating	Packing (Tape & Reel)
NV6127 RA	-40 °C to +125 °C T <sub>CASE</sub>	-55 °C to +150 °C T <sub>CASE</sub>	6 x 8 mm QFN	1	1,000 : 7" Reel
NV6127	-40 °C to +125 °C TCASE	-55 °C to +150 °C TCASE	6 x 8 mm QFN	1	5,000 : 13" Reel

### 14. 20-Year Limited Product Warranty

The 20-year limited warranty applies to all packaged Navitas GaNFast Power ICs in mass production, subject to the terms and conditions of, Navitas' express limited product warranty, available at <https://navitassemi.com/terms-conditions>. The warranted specifications include only the MIN and MAX values only listed in Absolute Maximum Ratings, ESD Ratings and Electrical Characteristics sections of this datasheet. Typical (TYP) values or other specifications are not warranted.



### 15. Revision History

Date	Status	Notes
Nov 22, 2019	Initial release	Added Section 8.10, updated Section 8.3 and figure 22
Jun 22, 2020	Revised	Updated guidelines in Section 8.1: Fast startup. Updated R <sub>DD</sub> specification. This datasheet revision applies to product prior to PCN2020-03-30
Sept 8, 2020	Revised	Datasheet updated in alignment with PCN2020-03-30. Product is marked with Lot Code ending in Z for traceability
Nov 24, 2021	Revised	Update repetitive spike duration time to <400ns
Apr 11, 2022	Revised	Added 20-Year Limited Product Warranty
Oct 11, 2022	Revision	Added Carbon Neutral logo

### Additional Information

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