Single 7.6A Peak Current Low-Side Gate Driver

General Description

The LM5114 is designed to drive low-side MOSFETs in boost type configurations or to drive secondary synchronous MOSFETs in isolated topologies. With strong sink current capability, the LM5114 can drive multiple FETs in parallel. The LM5114 also has the features necessary to drive low-side enhancement mode Gallium Nitride (GaN) FETs. The LM5114 provides inverting and non-inverting inputs to satisfy requirements for inverting and non-inverting gate drive in a single device type. The inputs of the LM5114 are TTL/CMOS Logic compatible and withstand the input voltages up to 14V regardless of the VDD voltage. The LM5114 has split gate outputs, providing flexibility to adjust the turn-on and turn-off strength independently. The LM5114 has fast switching speed and minimized propagation delays, facilitating high-frequency operation. The LM5114 is available in SOT-23 6-pin package and LLP-6 package with an exposed pad to aid thermal dissipation.

Typical Applications

- Boost converters
- Flyback and forward converters
- Secondary synchronous FETs drive in isolated topologies
- Motor control

Features

- Independent source and sink outputs for controllable rise and fall times
- +4V to +12.6V single power supply
- 7.6A/1.3A peak sink/source drive current
- 0.23Ω open-drain pull-down sink output
- 2Ω open-drain pull-up source output
- 12ns (typical) propagation delay
- Matching delay time between inverting and non-inverting inputs
- TTL/CMOS logic Inputs
- 0.68V input hysteresis
- Up to +14V logic inputs (Regardless of VDD voltage)
- Low input capacitance: 2.5pF (typical)
- -40°C to +125°C operating temperature range
- Pin-to-Pin compatible with MAX5048

Package

- SOT-23-6
- LLP-6 (3mm x 3mm)

Block Diagram

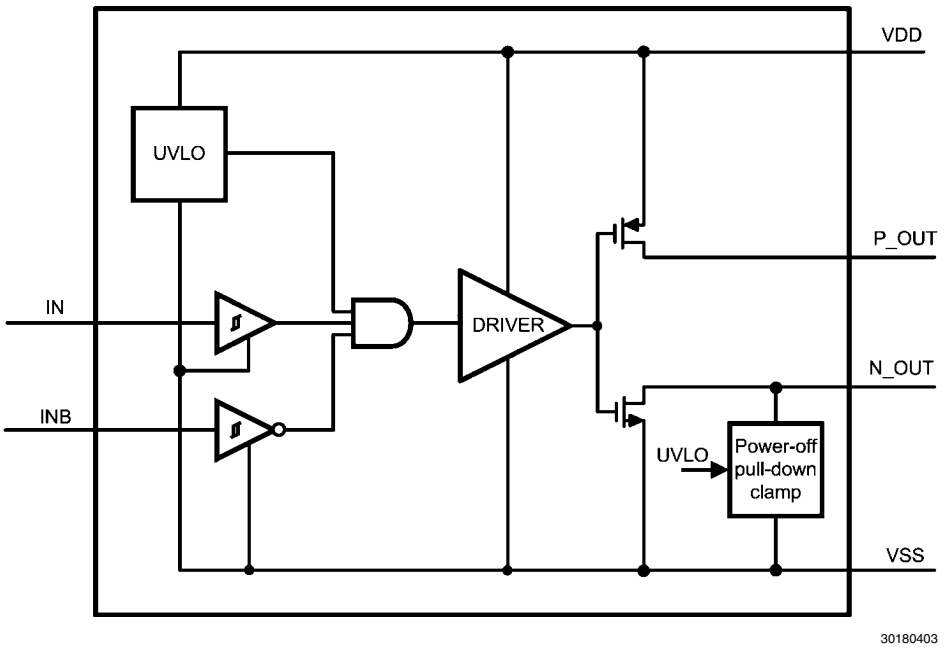


FIGURE 1.

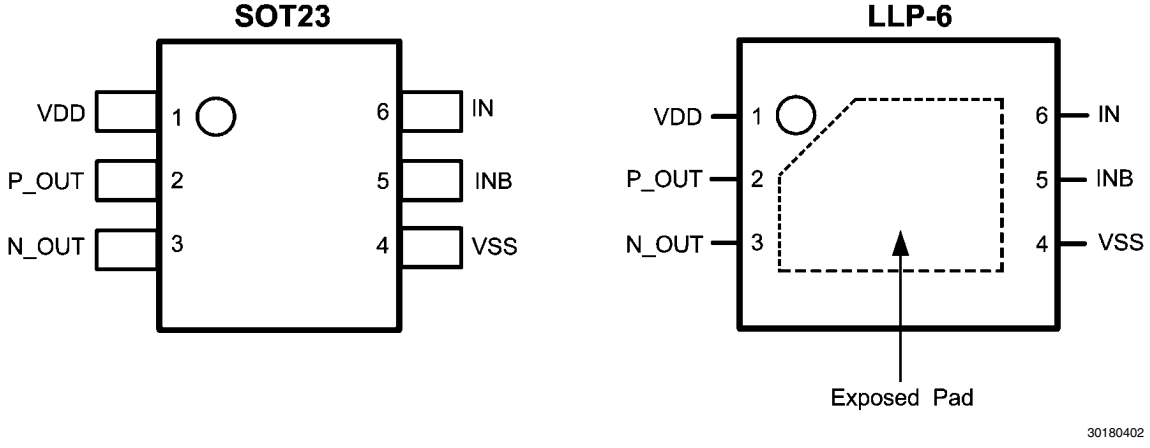
Input Options

Base Part Number	Input Thresholds
LM5114A	CMOS
LM5114B	TTL

Truth Table

IN	INB	P_OUT	N_OUT
L	L	OPEN	L
L	H	OPEN	L
H	L	H	OPEN
H	H	OPEN	L

Connection Diagram



Ordering Information

Order Number	Package Type	Package Drawing	Supplied As
LM5114AMF	SOT-6	MF06A	1000 Units / Tape & Reel
LM5114AMFX	SOT-6	MF06A	3000 Units / Tape & Reel
LM5114ASD	LLP-6	SDE06A	1000 Units / Tape & Reel
LM5114ASDX	LLP-6	SDE06A	4500 Units / Tape & Reel
LM5114BMF	SOT-6	MF06A	1000 Units / Tape & Reel
LM5114BMFX	SOT-6	MF06A	3000 Units / Tape & Reel
LM5114BSD	LLP-6	SDE06A	1000 Units / Tape & Reel
LM5114BSDX	LLP-6	SDE06A	4500 Units / Tape & Reel

Pin Descriptions

Pin No.		Name	Description	Applications Information
SOT-23-6	LLP-6			
1	1	VDD	Gate drive supply	Locally decouple to VSS using low ESR/ESL capacitor located as close as possible to the IC.
2	2	P_OUT	Source-current output	Connect to the gate of the MOSFET with a short, low inductance path. A gate resistor can be used to adjust the turn-on speed.
3	3	N_OUT	Sink-current output	Connect to the gate of the MOSFET with a short, low inductance path. A gate resistor can be used to adjust the turn-off speed.
4	4	VSS	Ground	All signals are referenced to this ground.
5	5	INB	Inverting logic input	Connect to VSS when not used.
6	6	IN	Non-inverting logic input	Connect to VDD when not used.
	EP	It is recommended that the exposed pad on the bottom of the package is soldered to ground plane on the PC board to aid thermal dissipation.		

Absolute Maximum Ratings (*Note 1*)

VDD to VSS	−0.3 to 14V
IN, INB to VSS	−0.3 to 14V
N_OUT to VSS	−0.3 to VDD +0.3V
P_OUT to VSS	−0.3 to VDD +0.3V
Junction Temperature	+150°C
Storage Temperature Range	−55 to +150°C
ESD Rating HBM	2kV

Recommended Operating Conditions

VDD	+4.0 to 12.6V
Junction Temperature	−40 to +125°C

Electrical Characteristics

Limits in standard type are for T_J = 25°C only; limits in boldface type apply over the junction temperature (T_J) range of -40°C to +125°C. Minimum and Maximum limits are guaranteed through test, design, or statistical correlation. Typical values represent the most likely parametric norm at T_J = 25°C, and are provided for reference purposes only. Unless otherwise specified, V_{DD} = +12V (*Note 2*).

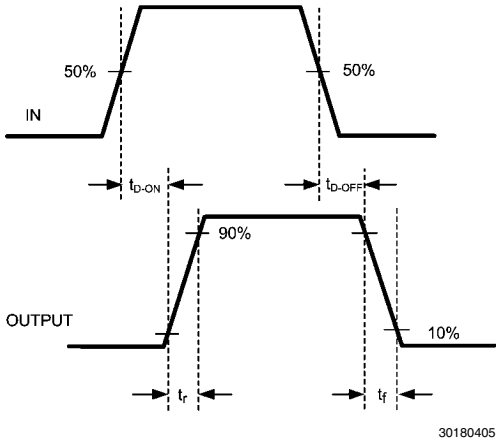
Symbol	Parameter	Conditions		Min	Typ	Max	Units
POWER SUPPLY							
V_{DD}	VDD Operating Voltage			**4.0**		**12.6**	V
UVLO	VDD Undervoltage Lockout	VDD Rising		**3.25**	3.6	**4.00**	V
	VDD Undervoltage Lockout Hysteresis				0.4		V
	VDD Undervoltage lockout to Output delay time	VDD Rising			300		ns
I_{DD}	VDD Quiescent Current	IN = INB = VDD			0.95	**1.9**	mA
N-CHANNEL OUTPUT							
R_{ON-N} (SOT-23-6)	Driver Output Resistance – Pulling Down	VDD = 10V, I_{N-OUT} = -100mA	T_J = +25°C		0.23	0.26	Ω
			T_J = +125°C		0.38	0.43	Ω
		VDD = 4.5V, I_{N-OUT} = -100mA	T_J = +25°C		0.24	0.28	Ω
			TJ = +125°C		0.40	0.47	Ω
R_{ON-N} (LLP-6)	Driver Output Resistance – Pulling Down	VDD = 10V, I_{N-OUT} = -100mA	T_J = +25°C		0.31	0.34	Ω
			T_J = +125°C		0.46	0.51	Ω
		VDD = 4.5V, I_{N-OUT} = -100mA	T_J = +25°C		0.32	0.36	Ω
			T_J = +125°C		0.48	0.55	Ω
	Power-off Pull Down Resistance	VDD = 0V, I_{N-OUT} = -10mA			3.3	10	Ω
	Power-off Pull Down Clamp Voltage	VDD = 0V, I_{N-OUT} = -10mA			0.85	1.0	V
I_{LK-N}	Output Leakage Current	N_OUT = VDD			6.85	**20**	µA
I_{PK-N}	Peak Sink Current	C_L = 10,000pF			7.6		A
P-CHANNEL OUTPUT							
R_{ON-P} (SOT-23-6)	Driver Output Resistance – Pulling Up	VDD = 10V, I_{P-OUT} = 50mA	T_J = +25°C		2.00	3.00	Ω
			T_J = +125°C		2.85	4.30	Ω
		VDD = 4.5V, I_{P-OUT} = 50mA	T_J = +25°C		2.20	3.30	Ω
			T_J = +125°C		3.10	4.70	Ω
R_{ON-P} (LLP-6)	Driver Output Resistance – Pulling Up	VDD = 10V, I_{P-OUT} = 50mA	T_J = +25°C		2.08	3.08	Ω
			T_J = +125°C		2.93	4.38	Ω
		VDD = 4.5V, I_{P-OUT} = 50mA	T_J = +25°C		2.28	3.38	Ω
			T_J = +125°C		3.18	4.78	Ω
I_{LK-P}	Output Leakage Current	P_OUT = 0			0.001	**10**	uA
I_{PK-P}	Peak Source Current	CL = 10,000pF			1.3		A
LOGIC INPUT							

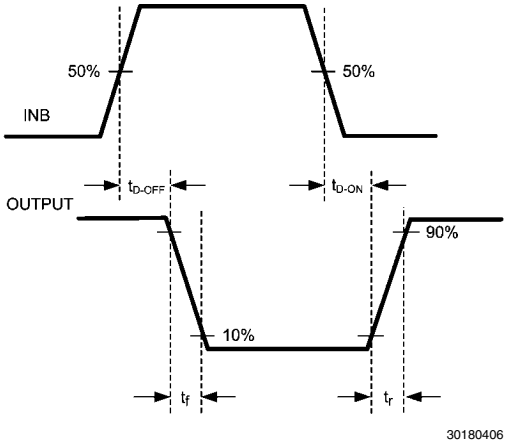
Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{IH}	Logic 1 Input Voltage	LM5114A		**0.67X VDD**			V
		LM5114B		**2.4**			V
V_{IL}	Logic 0 Input Voltage	LM5114A				**0.33X VDD**	V
		LM5114B				**0.8**	V
V_{HYS}	Logic-Input Hysteresis	LM5114A			1.6		V
		LM5114B			0.68		V
	Logic-Input Current	INB = VDD or 0			0.001	**10**	uA
C_{IN}	Input Capacitance				2.5		pF
THERMAL RESISTANCE							
θ_{JA}	Junction to Ambient	SOT-23-6			90		°C/W
		LLP-6			60		°C/W
SWITCHING CHARACTERISTICS FOR VDD = +10V							
t_R	Rise Time	C_L = 1000pF			8		ns
		C_L = 5000pF			45		ns
		C_L = 10,000pF			82		ns
t_F	Fall Time	C_L = 1000pF			3.2		ns
		C_L = 5000pF			7.5		ns
		C_L = 10,000pF			12.5		ns
t_{D-ON}	Turn-On Propagation Delay	C_L = 1000pF	LM5114A	**5**	12	**30**	ns
			LM5114B	**6**	12	**25**	ns
t_{D-OFF}	Turn-Off Propagation Delay	C_L = 1000pF	LM5114A	**5**	12	**30**	ns
			LM5114B	**6**	12	**25**	ns
	Break-before-make Time				2.5		ns
SWITCHING CHARACTERISTICS FOR VDD = +4.5V							
t_R	Rise Time	C_L = 1000pF			12		ns
		C_L = 5000pF			41		ns
		C_L = 10,000pF			74		ns
t_F	Fall Time	C_L = 1000pF			3.0		ns
		C_L = 5000pF			7.0		ns
		C_L = 10,000pF			11.3		ns
t_{D-ON}	Turn-On Propagation Delay	C_L = 1000pF	LM5114A	**5**	17	**36**	ns
			LM5114B	**8**	14	**27**	ns
t_{D-OFF}	Turn-Off Propagation Delay	C_L = 1000pF	LM5114A	**5**	17	**36**	ns
			LM5114B	**8**	14	**27**	ns
	Break-Before-Make Time				4.2		ns

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but does not guarantee specific performance limits. For guaranteed specifications and conditions, see the Electrical Characteristics.

Note 2: Min and Max limits are 100% production tested at 25°C. Limits over the operating temperature range are guaranteed through correlation using Statistical Quality Control (SQC) methods. Limits are used to calculate National's Average Outgoing Quality Level (AOQL).

Timing Diagram (*Note 3*)

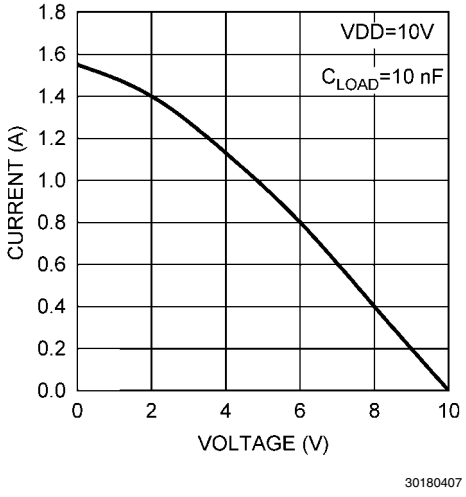




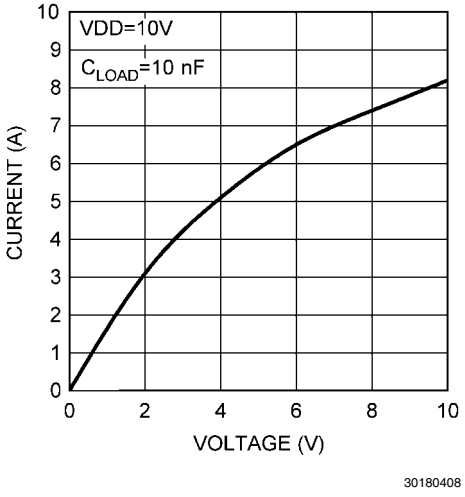
Note 3: P_OUT and N_OUT are tied together.

Typical Performance Characteristics

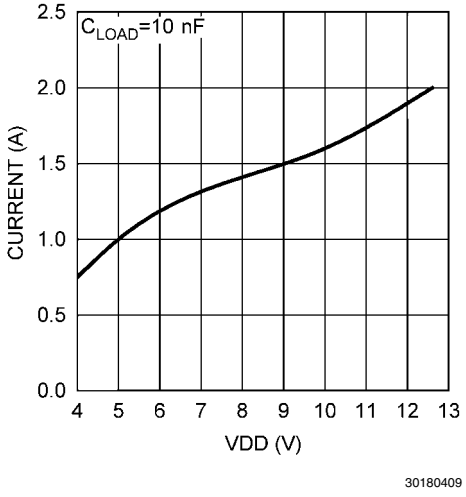
Source Current vs. Output Voltage



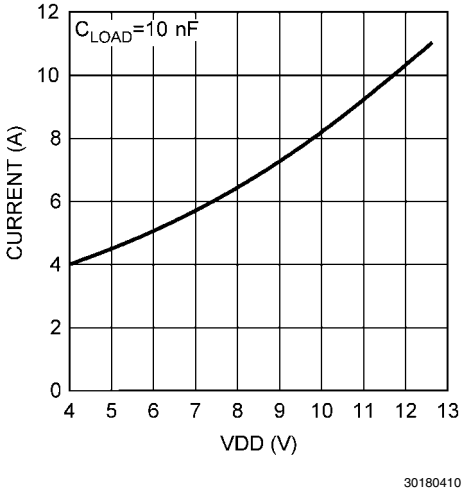
Sink Current vs. Output Voltage



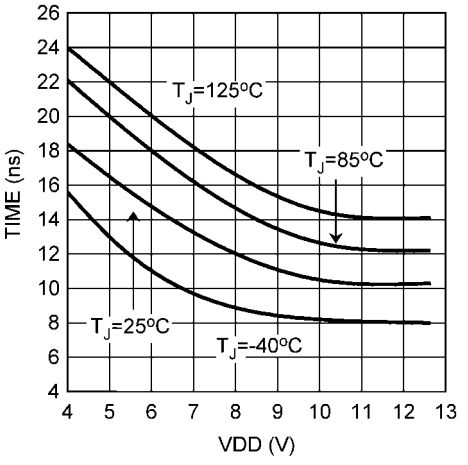
Peak Source Current vs. V_{DD} Voltage



Peak Sink Current vs. V_{DD} Voltage



LM5114A Turn-On Propagation Delay vs. V_{DD}



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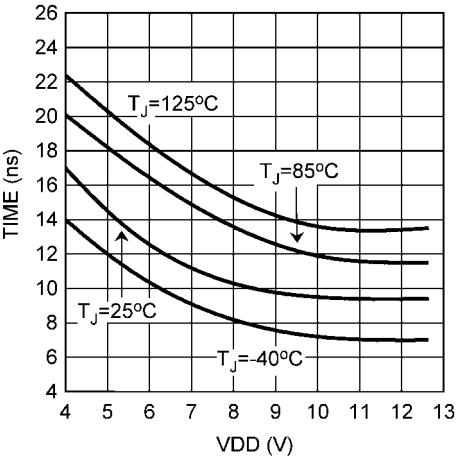
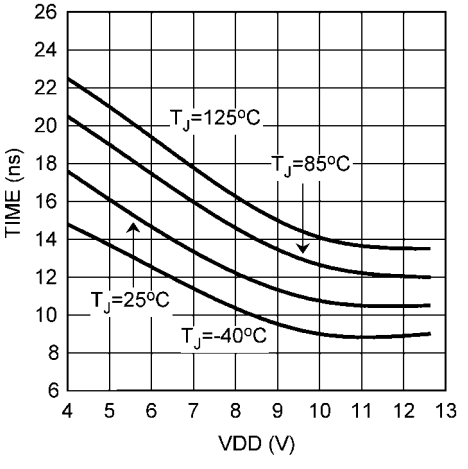
LM5114A Turn-Off Propagation Delay vs. V_{DD}



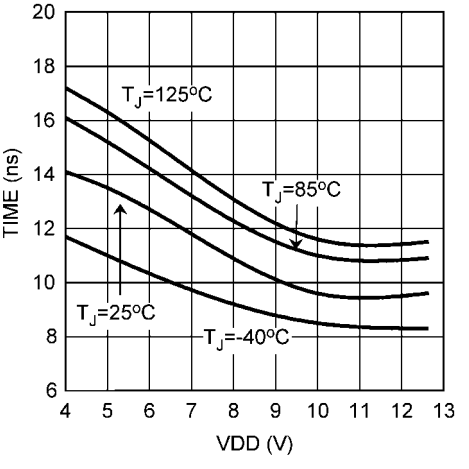
30180435

LM5114B Turn-On Propagation Delay vs. V_{DD}



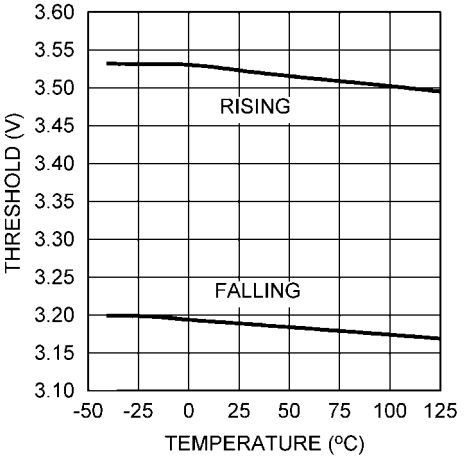
30180411

LM5114B Turn-Off Propagation Delay vs. V_{DD}



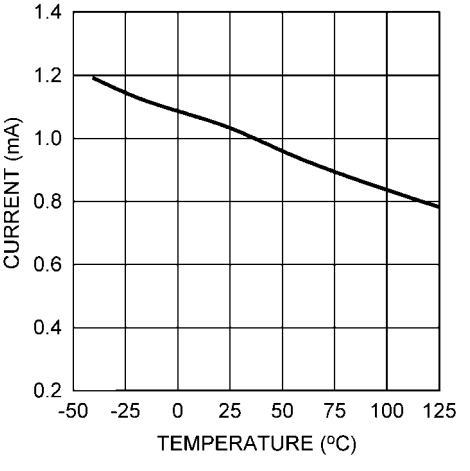
30180412

UVLO Threshold vs. Temperature



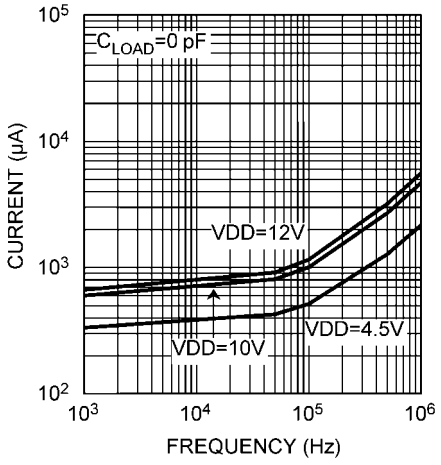
30180413

Quiescent Current vs. Temperature



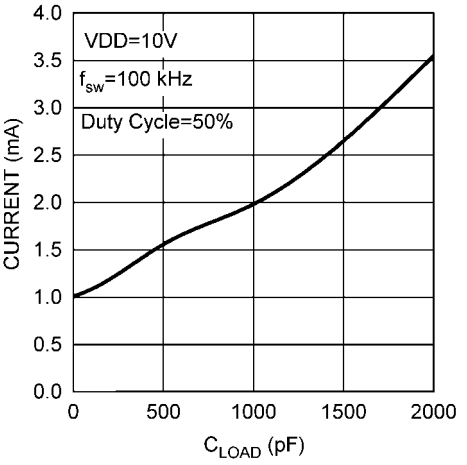
30180415

Supply Current vs. Frequency



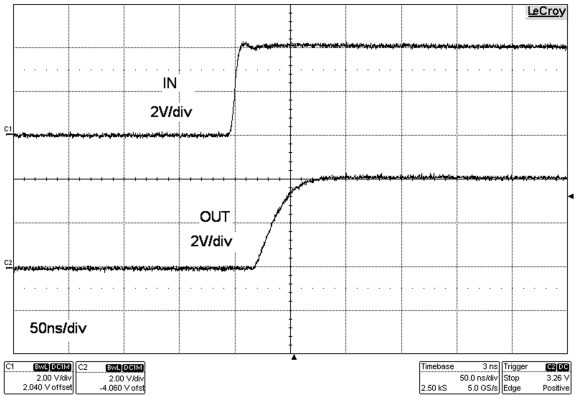
30180416

Supply Current vs. Capacitive Load



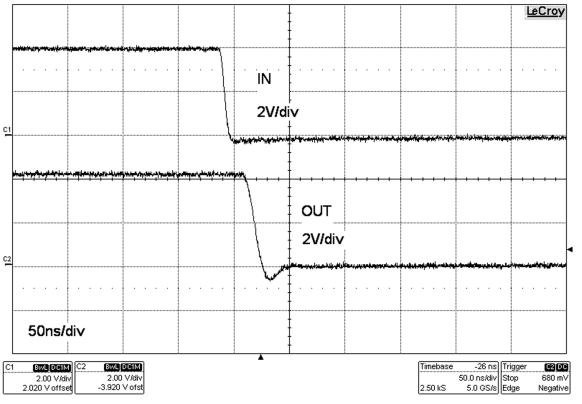
30180417

Input Voltage vs. Output Voltage (V_{DD} = 4V, C_L = 5000pF)



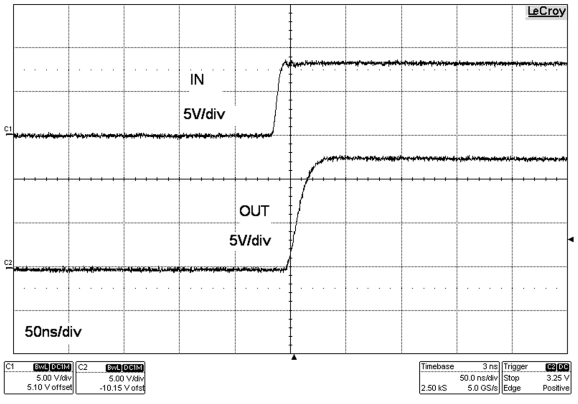
30180418

Input Voltage vs. Output Voltage (V_{DD} = 4V, C_L = 5000pF)



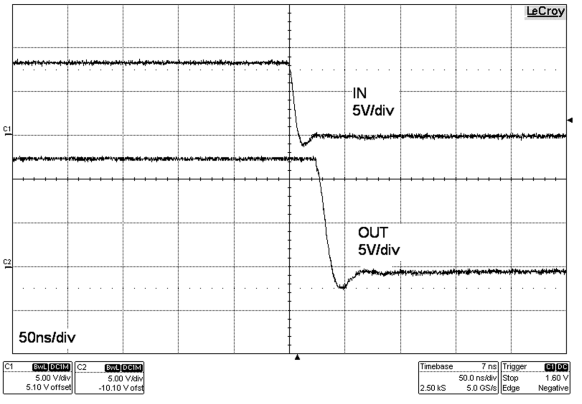
30180426

Input Voltage vs. Output Voltage (V_{DD} = 12V, C_L = 5000pF)



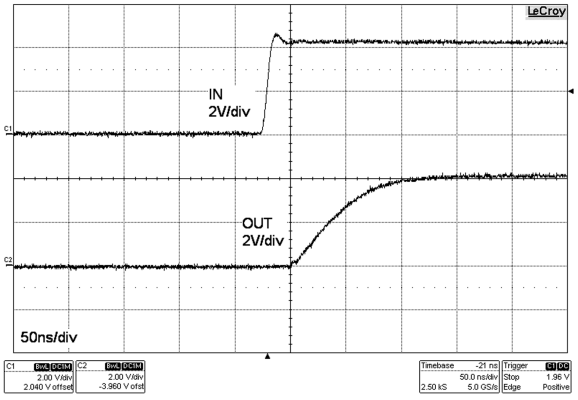
30180427

Input Voltage vs. Output Voltage (V_{DD} = 12V, C_L = 5000pF)



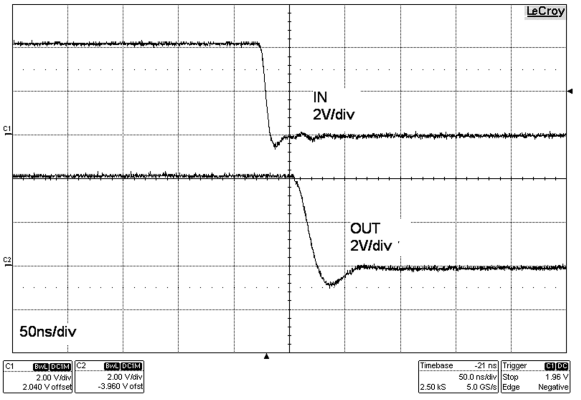
30180428

Input Voltage vs. Output Voltage
(V_{DD} = 4V, C_L = 10000pF)



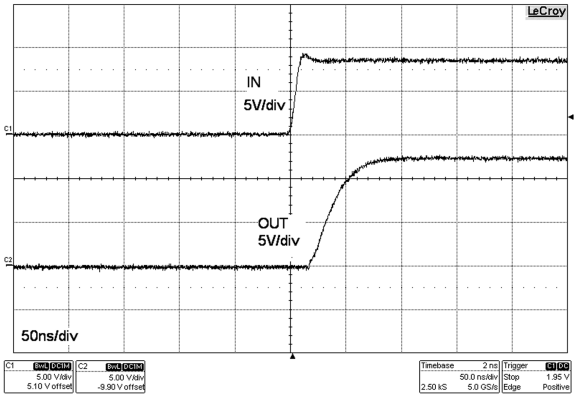
30180429

Input Voltage vs. Output Voltage
(V_{DD} = 4V, C_L = 10000pF)



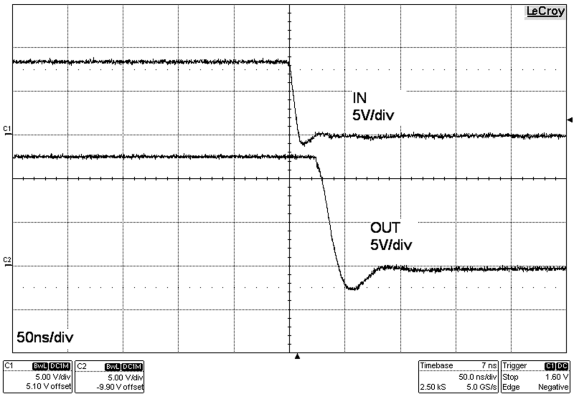
30180430

Input Voltage vs. Output Voltage
(V_{DD} = 12V, C_L = 10000pF)



30180431

Input Voltage vs. Output Voltage
(V_{DD} = 12V, C_L = 10000pF)



30180432

Typical Applications

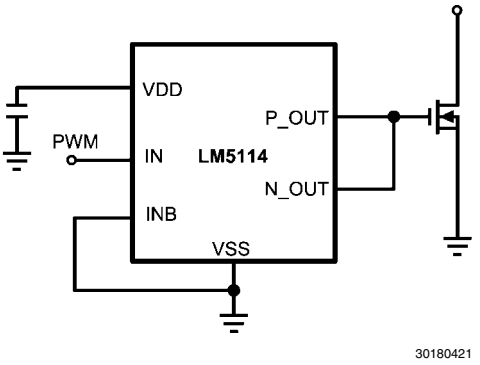


FIGURE 2. Non-inverting Application

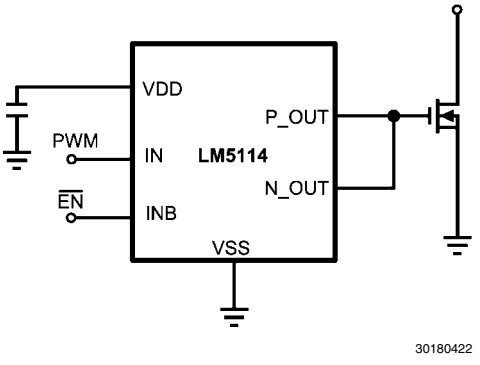


FIGURE 3. Non-Inverting Application with Enable Pin

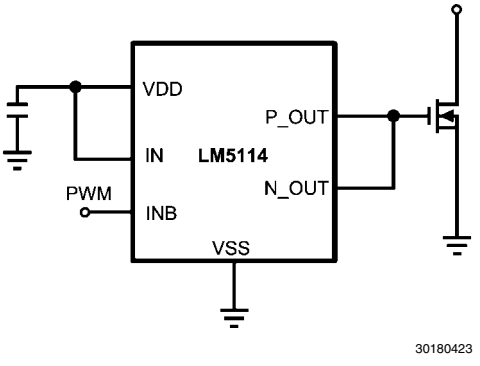


FIGURE 4. Inverting Application

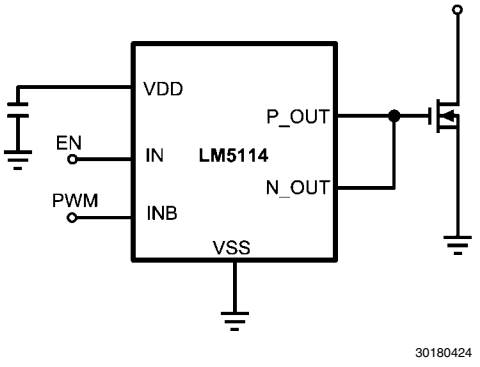


FIGURE 5. Inverting Application with Enable Pin

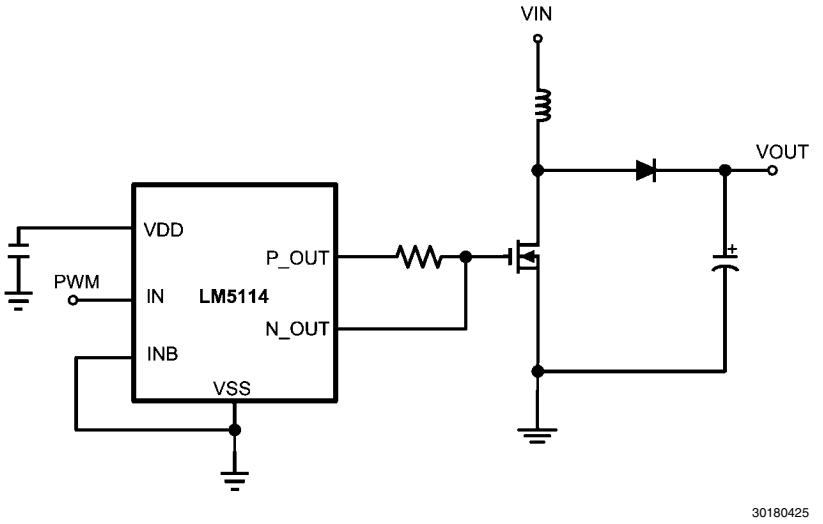


FIGURE 6. A Simplified Boost Converter

Detailed Operating Description

The LM5114 is designed to drive low-side MOSFETs in boost type configurations or to drive secondary synchronous MOSFETs in isolated topologies. The LM5114 offers both inverting and non-inverting inputs to satisfy requirements for inverting and non-inverting gate drive in a single device type. Inputs of the LM5114 are TTL Logic compatible and can withstand the input voltages up to 14V regardless of the VDD voltage. This allows inputs of the LM5114 to be connected directly to most PWM controllers. The split outputs of the LM5114 offer flexibility to adjust the turn-on and turn-off speed independently by adding additional impedance in either the turn-on path and/or the turn-off path.

The LM5114 includes an under-voltage lockout (UVLO) circuit. When the VDD voltage is below the UVLO threshold voltage, the IN and INB inputs are ignored, and if there is sufficient VDD voltage, the output NMOS is turned on to pull the N_OUT low. In addition, the LM5114 has an internal PNP transistor in parallel with the output NMOS. Under the UVLO condition, the PNP transistor will be on and clamp the N_OUT voltage below 1V. This feature ensures the N_OUT remaining low when VDD voltage is not sufficient to enhance the output NMOS.

The LM5114 has the features necessary to drive low-side enhancement mode GaN FETs. Due to the fast switching speed and relatively low gate voltage of enhancement mode GaN FETs, PCB layout is crucial to achieve reliable operation. Refer to the section of layout considerations for details.

Power Dissipation

It is important to keep the power consumption of the driver below the maximum power dissipation limit of the package at the operating temperature. The total power dissipation of the LM5114 is the sum of the gate charge losses and the losses in the driver due to the internal CMOS stages used to buffer the output as well as the power losses associated with the quiescent current.

The gate charge losses can be calculated with the total input gate charge as follows.

$$P_g = Q_g \times V_{DD} \times F_{sw}$$

Or

$$P_g = C_{LOAD} \times V_{DD}^2 \times F_{SW}$$

Where F_{sw} is switching frequency.

The power dissipation associated with the internal circuit operation of the driver can be estimated with the characterization curves of the LM5114. For a given ambient temperature, the maximum allowable power loss of the IC can be defined as

$$P = \frac{\left(T_J - T_A \right)}{\theta_{JA}}$$

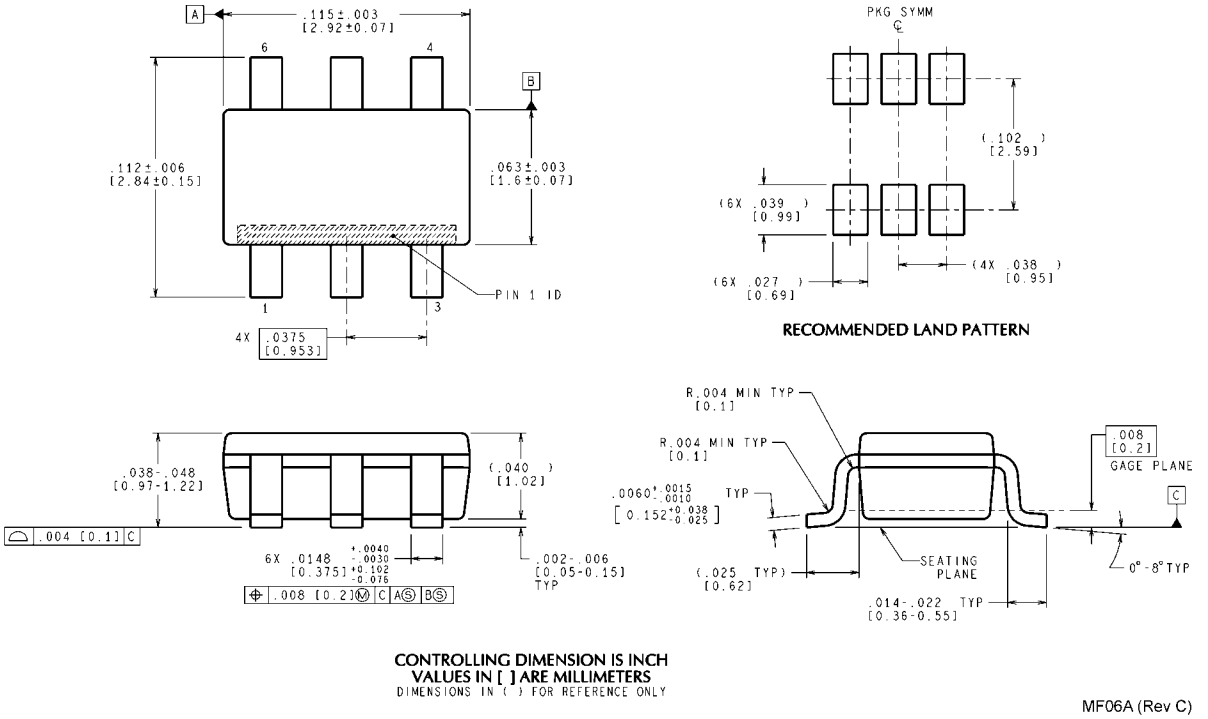
Where P is the total power dissipation of the driver.

Layout Considerations

Attention must be given to board layout when using LM5114. Some important considerations include:

1. The first priority in designing the layout of the driver is to confine the high peak currents that charge and discharge the FETs gate into a minimal physical area. This will decrease the loop inductance and minimize noise issues on the gate.
2. To reduce the loop inductance, the driver should be placed as close as possible to the FETs. The gate trace to and from the FETs are recommended to be placed closely side by side, or directly on top of one another.
3. A low ESR/ESL ceramic capacitor must be connected close to the IC, between VDD and VSS pins to support the high peak current being drawn from VDD during turn-on of the FETs. It is most desirable to place the VDD decoupling capacitor on the same side of the PC board as the driver. The inductance of via holes can impose excessive ringing on the IC pins.
4. The parasitic source inductance, along with the gate capacitor and the driver pull-down path, can form a LCR resonant tank, resulting in gate voltage oscillations. An optional resistor or ferrite bead can be used to damp the ringing.

Physical Dimensions inches (millimeters) unless otherwise noted



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MF06A (Rev C)

SOT-23-6 Outline Drawing
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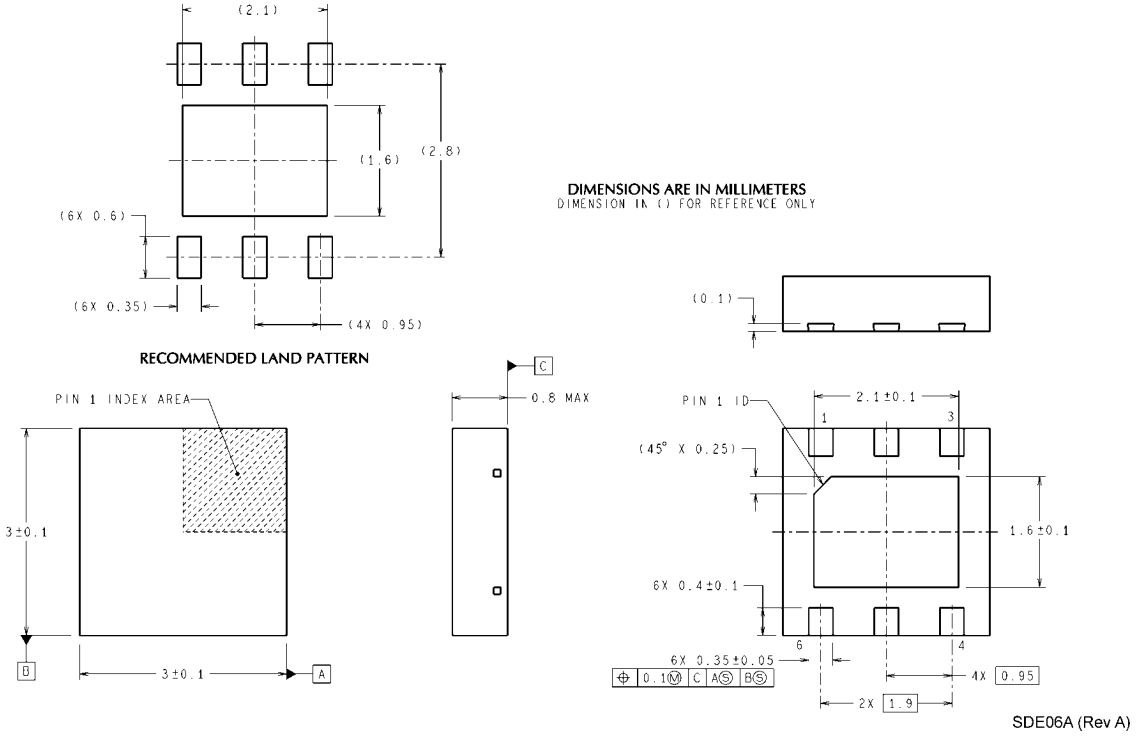

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Notes

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