

DRV8363 48V Battery Three-Phase Smart Gate Driver with Accurate Current Sensing and Advanced Monitoring

1 Features

- Three phase half-bridge gate driver
 - Drives six N-channel MOSFETs (NMOS)
 - 8 to 85V wide operating voltage range
 - Bootstrap architecture for high-side gate driver
 - Supports 50mA average gate switching current enables driving 400nC MOSFETs at 20kHz
 - Trickle charge pump to support 100% PWM duty cycle and to generate overdrive supply to drive external cut-off or reverse polarity protection circuit
- Smart Gate Drive architecture
 - 15-level configurable peak gate drive current up to 1000 / 2000mA (source / sink)
 - Closed-loop automatic deadtime insertion based on gate-source voltage monitoring
 - Configurable soft shutdown to minimize inductive voltage spikes during overcurrent shutdown
- Low-side Current Sense Amplifier
 - 1mV low input offset across temperature
 - 4-level adjustable gain
 - Adjustable output bias to support unidirectional or bidirectional sensing
- SPI-based detailed configuration and diagnostics
- DRVOFF pin to disable driver independently
- High voltage wake up pin (nSLEEP)
- Dedicated ASCIN pin to control motor braking (active short circuit)
- 6x, 3x, 1x, and Independent PWM Modes
- Supports 3.3V and 5V Logic Inputs
- Integrated protection features
 - Battery and power supply voltage monitors
 - MOSFET V_{DS} and R_{sense} over current monitors
 - MOSFET V_{GS} gate fault monitors
 - Device thermal warning and shutdown
 - Fault condition indicator pin

2 Applications

- Appliances, Cordless Garden and Power Tools, Lawnmowers
- Brushless-DC (BLDC) Motor Modules and PMSM
- Fans, Pumps, and Servo Drives
- E-Bikes, E-Scooters, and E-Mobility
- Cordless Vacuum Cleaners
- Drones, Industrial & Logistics Robots, and RC Toys

3 Description

The DRV8363 is an integrated smart gate driver for 48V three-phase BLDC applications. The device provides three half-bridge gate drivers, each capable of driving high-side and low-side N-channel power MOSFETs. The DRV8363 generates the correct gate drive voltages using an external 12V supply and an integrated bootstrap diode for the high-side MOSFETs. The Smart Gate Drive architecture supports configurable peak gate drive current from 16mA up to 1A source and 2A sink. The DRV8363 can operate with a wide input range from 8V to 85V at the motor connection. A trickle charge pump allows for the gate drivers to support 100% PWM duty cycle control and provides overdrive gate drive voltage of external switches.

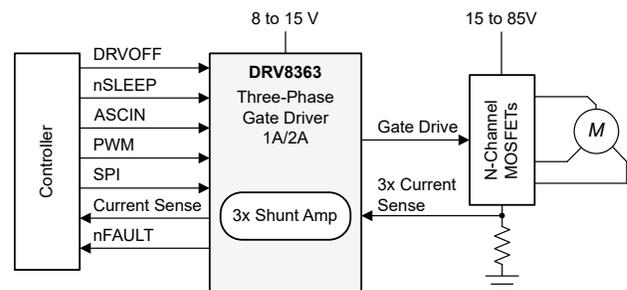
The DRV8363 provides low-side current sense amplifiers to support resistor based low-side current sensing. The low offset of the amplifiers enables the system to obtain precise motor current measurements.

A wide range of diagnostics and protection features are integrated with the DRV8363 enables a robust motor drive system design and helps eliminate the need of external components. The highly configurable device response allows the device to be integrated seamlessly into a variety of system designs.

Package Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE (NOM) ⁽²⁾
DRV8363	QFN (48)	7mm × 7mm

- (1) For all available packages, see the orderable addendum at the end of the data sheet.
- (2) The package size (length × width) is a nominal value and includes pins, where applicable.



Simplified Schematic

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4 Pin Functions 48-Pin DRV8363

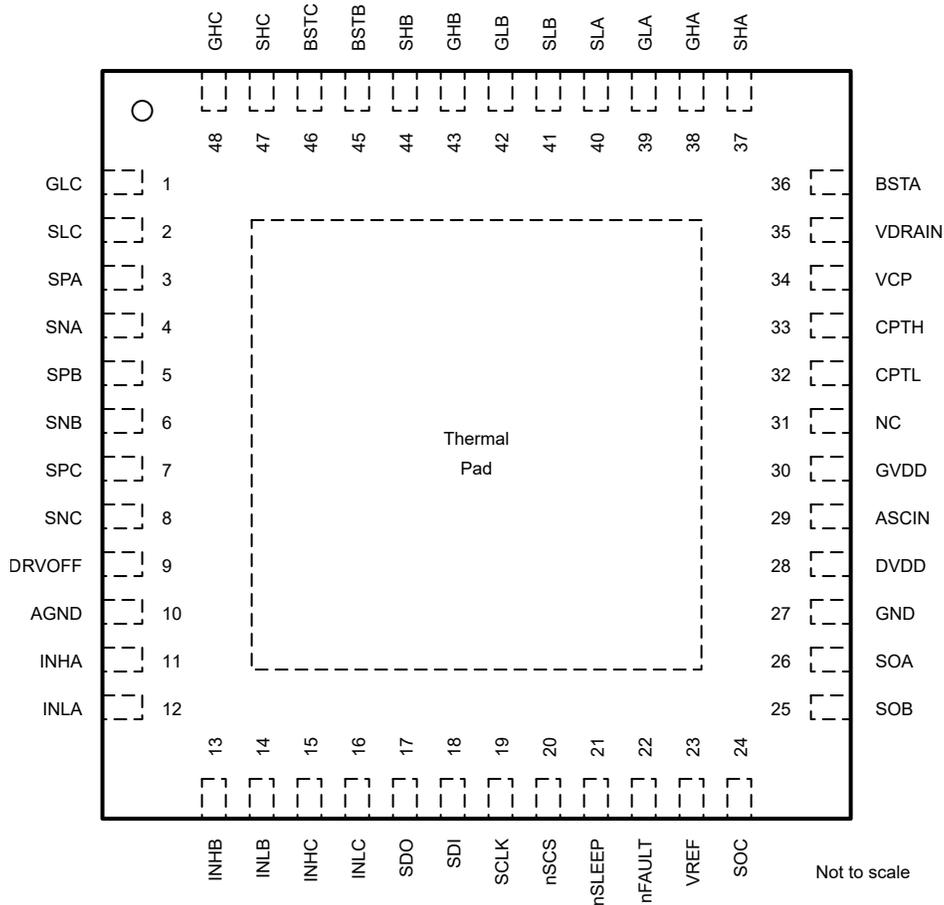


Figure 4-1. DRV8363 Package 48-Pin QFN With Exposed Thermal Pad Top View

Table 4-1. Pin Functions (48-QFN)

PIN		I/O ⁽¹⁾	DESCRIPTION
NAME	NO.		
GLC	1	O	Low-side gate driver output. Connect to the gate of the low-side power MOSFET.
SLC	2	I	Low-side source sense input. Connect to the low-side power MOSFET source.
SPA	3	I	Low-side current shunt amplifier input. Connect to the low-side power MOSFET source and high-side of the current shunt resistor.
SNA	4	I	Current sense amplifier input. Connect to the low-side of the current shunt resistor.
SPB	5	I	Low-side current shunt amplifier input. Connect to the low-side power MOSFET source and high-side of the current shunt resistor.
SNB	6	I	Current sense amplifier input. Connect to the low-side of the current shunt resistor.
SPC	7	I	Low-side current shunt amplifier input. Connect to the low-side power MOSFET source and high-side of the current shunt resistor.
SNC	8	I	Current sense amplifier input. Connect to the low-side of the current shunt resistor.
DRVOFF	9	I	Active high shutdown input to pull-down gate driver outputs GHx and GLx.
AGND	10	PWR	Device ground.
INHA	11	I	High-side gate driver control input. This pin controls the output of the high-side gate driver.
INLA	12	I	Low-side gate driver control input. This pin controls the output of the low-side gate driver.

Table 4-1. Pin Functions (48-QFN) (continued)

PIN		I/O ⁽¹⁾	DESCRIPTION
NAME	NO.		
INHB	13	I	High-side gate driver control input. This pin controls the output of the high-side gate driver.
INLB	14	I	Low-side gate driver control input. This pin controls the output of the low-side gate driver.
INHC	15	I	High-side gate driver control input. This pin controls the output of the high-side gate driver.
INLC	16	I	Low-side gate driver control input. This pin controls the output of the low-side gate driver.
SDO	17	O	Serial data output.
SDI	18	I	Serial data input.
SCLK	19	I	Serial clock input.
nSCS	20	I	Serial chip select.
nSLEEP	21	I	Gate driver nSLEEP. When this pin is logic low the device goes to a low-power sleep mode.
nFAULT	22	OD	Fault indicator output. This pin is pulled logic low during a fault condition and requires an external pullup resistor.
VREF	23	PWR	External voltage reference for current sense amplifiers.
SOC	24	O	Current sense amplifier output.
SOB	25	O	Current sense amplifier output.
SOA	26	O	Current sense amplifier output.
GND	27	PWR	Device ground
DVDD	28	PWR	3.3V / 5V LDO output. Connect to adjacent GND with a >10V-rated ceramic capacitor.
ASCIN	29	I	ASC external trigger pin. When this pin is logic high, the device turns on all three low-side or high-side gates.
GVDD	30	PWR	Gate driver power supply input. Connect an externally regulated 8V-15V supply with a GVDD-rated ceramic between the GVDD and GND pins.
NC	31	NC	Not connected. Leave pin floating.
CPTL	32	PWR	Trickle charge pump switching node. Connect a charge pump flying capacitor between CPTL and CPTH pins.
CPTH	33	PWR	Trickle charge pump switching node. Connect a charge pump flying capacitor between CPTL and CPTH pins.
VCP	34	PWR	Trickle charge pump storage capacitor. Connect a ceramic capacitor between VCP and VDRAIN pins.
VDRAIN	35	PWR	High-side drain sense and charge pump power supply input.
BSTA	36	O	Bootstrap output pin. Connect a bootstrap capacitor between BSTA and SHA
SHA	37	I	High-side source sense input. Connect to the high-side power MOSFET source.
GHA	38	O	High-side gate driver output. Connect to the gate of the high-side power MOSFET.
GLA	39	O	Low-side gate driver output. Connect to the gate of the low-side power MOSFET.
SLA	40	I	Low-side source sense input. Connect to the low-side power MOSFET source.
SLB	41	I	Low-side source sense input. Connect to the low-side power MOSFET source.
GLB	42	O	Low-side gate driver output. Connect to the gate of the low-side power MOSFET.
GHB	43	O	High-side gate driver output. Connect to the gate of the high-side power MOSFET.
SHB	44	I	High-side source sense input. Connect to the high-side power MOSFET source.
BSTB	45	O	Bootstrap output pin. Connect a bootstrap capacitor between BSTB and SHB
BSTC	46	O	Bootstrap output pin. Connect a bootstrap capacitor between BSTC and SHC
SHC	47	I	High-side source sense input. Connect to the high-side power MOSFET source.
GHC	48	O	High-side gate driver output. Connect to the gate of the high-side power MOSFET.

(1) Signal Types: I = Input, O = Output, I/O = Input or Output., PWR = Power

5 Specification

5.1 Absolute Maximum Ratings

Over recommended operating conditions (unless otherwise noted)⁽¹⁾

		MIN	MAX	UNIT
Gate driver regulator pin voltage	GVDD	-0.3	20	V
High-side drain pin voltage	VDRAIN	-0.3	85	V
Bootstrap pin voltage	BSTx	-0.3	105	V
Bootstrap pin voltage	BST with respect to SH	-0.3	20	V
Logic pin voltage	nSLEEP, DRVOFF, ASCIN	-0.3	35	V
Logic pin voltage	nFAULT	-0.3	6	V
	INHx, INLx	-0.3	35	
	SCLK, nSCS, SDI, SDO	-0.3	6	
Trickle charge pump output pin voltage	VCP	-0.3	100	V
Trickle charge pump high-side pin voltage	CPTH	-0.3	VCP + 0.3	V
Trickle charge pump low-side pin voltage	CPTL	-0.3	VDRAIN + 0.3	V
High-side gate drive pin voltage	GH	-5	105	V
Transient high-side gate drive pin negative voltage	GH, 1 μ s	-20		V
High-side gate drive pin voltage	GH with respect to SH	-0.3	20	V
Transient high-side gate drive pin current	GH with respect to SH, $V_{GH} < V_{SH}$ (device internal diode voltage), 100-ns		3	A
High-side source pin voltage	SH, DC	-5	105	V
Transient high-side source pin negative voltage	SH, 1 μ s	-20		V
High-side source pin slew rate	SH, $V_{BST-SH} > 4.3V$		20	V/ns
Low-side gate drive pin voltage	GL, DC	-5	$V_{GVDD} + 0.3$	V
Transient low-side gate drive pin negative voltage	GL, 1 μ s	-16		V
Low-side gate drive pin voltage	GL with respect to SL	-0.3	20	V
Transient 100-ns low-side gate drive pin current	GL with respect to SL, $V_{GL} < V_{SL}$ (device internal diode voltage), 100-ns		3	A
Transient 100-ns low-side gate drive pin current	GL with respect to GVDD, GVDD_LS, $V_{GL} < V_{GVDDx}$ (device internal diode voltage) 100ns		3	A
Low-side source sense pin voltage	SL	-5	$V_{GVDD} + 0.3$	V
Transient low-side source sense pin negative voltage	SL, 1 μ s	-16		V
Gate driver supply to low-side source pin voltage	$V_{GVDD} - V_{SL}$		30	V
Gate drive current	GH, GL	Internally Limited	Internally Limited	A
Current sense amplifier reference input pin voltage	VREF	-0.3	5.5	V
Shunt amplifier input pin voltage	SN, SP	-1	1	V
Transient 500-ns shunt amplifier input pin voltage	SN, SP, 500ns	-16	20	V
Shunt amplifier output pin voltage	SO	-0.3	$V_{VREF} + 0.3$	V
GVDD supply voltage ramp			1	V/us
CSAREF supply voltage ramp			3	V/us
VDRAIN supply voltage ramp	GVDD = 12V		3	V/us
Junction temperature, T_J		-40	150	$^{\circ}C$
Storage temperature, T_{stg}		-65	150	$^{\circ}C$

(1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions.

If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime

5.2 ESD Ratings Auto

			VALUE	UNIT	
V _(ESD)	Electrostatic discharge	Human body model (HBM), per AEC Q100-002 ⁽¹⁾ HBM ESD Classification Level 2	±2000	V	
		Charged device model (CDM), per AEC Q100-011 CDM ESD Classification Level C4B	Corner pins		±750
			Other pins		±500

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

5.3 Recommended Operating Conditions

Over operating temperature range (unless otherwise noted)

			MIN	NOM	MAX	UNIT
V _{GVDD}	Power supply voltage	GVDD	8		15	V
V _{VDRAIN}	High-side drain pin voltage	VDRAIN, low-side gate drive, and high-side gate drive switching with bootstrap	0		85	V
	High-side drain pin voltage	VDRAIN, to support trickle charge pump capability $V_{TCP\ min} > V_{BST_UV\ max}$ (falling), for high-side gate drive 100% and no BST_UV detection. $VDRAIN > GVDD + 4V$, $GVDD > 9V$	13		85	V
V _{BST-SH}	Bootstrap pin voltage with respect to SH	BST ($V_{BST} - V_{SH}$), high-side gate drive switching and no BST_UV detection, $V_{BST-SH\ min} > V_{BST_UV\ max}$ (rising),	6.1		20	V
V _{BST}	Bootstrap pin voltage	BST	0		105	V
V _{SH}	High-side source pin voltage	SH	-2		85	V
I _{TRICKLE}	Trickle charge pump external load current	Combined total of phase loads and VCP external loads			4	mA
V _I	Input voltage	INH, INL, SDI, SCLK, nSCS	0		5.5	V
f _{PWM} ⁽¹⁾	PWM frequency		0		200	kHz
V _{OD}	Open drain pullup voltage	nFAULT			5.5	V
I _{OD}	Open drain output current	nFAULT			-5	mA
V _{VREF}	Current sense amplifier reference voltage	VREF	3.0		5.5	V
T _A	Operating ambient temperature		-40		125	°C
T _J	Operating junction temperature		-40		150	°C

(1) Power dissipation and thermal limits must be observed

5.4 Thermal Information 1pkg

THERMAL METRIC ⁽¹⁾		DRV8363	UNIT
		RGZ (QFN)	
		48	
R _{θJA}	Junction-to-ambient thermal resistance	24.1	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	12.9	°C/W
R _{θJB}	Junction-to-board thermal resistance	7.6	°C/W
Ψ _{JT}	Junction-to-top characterization parameter	0.2	°C/W
Ψ _{JB}	Junction-to-board characterization parameter	7.3	°C/W
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance	2.0	°C/W

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

5.5 Electrical Characteristics

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLIES (GVDD, VDRAIN, DVDD)						
$I_{VDRAIN_UNP_WR}$	VDRAIN sleep current under GVDD unpowered	GVDD = 0V, VDRAIN = 48V, $V_{BST-SH} = 0V$, nSLEEP=0V, Tj 25°C; SH=VDRAIN & 0V Leakage current of VDRAIN when SH=0V; Leakage current of VDRAIN+SH when SH=VDRAIN [all 3 predriver phases put together]	2	4.5	13.5	μA
I_{GVDD}	GVDD standby mode current	GVDD = 12V, VDRAIN = 48V, INH = INL = 0; DRVOFF = Low, SHx=0V. TCP = ON No external Load on VCP. [TCP switches will be toggling]	9.5	13.4	17.5	mA
I_{GVDD}	GVDD standby mode current	GVDD = 12V, VDRAIN = 48V, INH = INL = 0; DRVOFF = High, SHx=VDRAIN TCP = ON No external Load on VCP. [TCP switches will be ON]	9.7	11.7	17.1	mA
I_{VDRAIN}	VDRAIN active mode current	GVDD = 12V, VDRAIN = 48V, INH = INL = Switching @ 20kHz; SH=0 when INL=1, SH=VDRAIN when INH=1; SH retains voltage when INH=INL=0; NO FETs connected. TCP is ON, TCP switches will toggle	4.3	5.2	6.9	mA
I_{GVDD}	GVDD active mode current	GVDD = 12V, VDRAIN = 48V, INH = INL = Switching @ 20kHz; SH=0 when INL=1, SH=VDRAIN when INH=1; SH retains voltage when INH=INL=0; NO FETs connected. TCP is ON, TCP switches will toggle	9.8	13.1	20	mA
t_{WAKE}	Turnon time	GVDD = 12V nSLEEP = High to active mode (outputs ready) (nFAULT = High)			10	ms
I_{LBS_HSPU}	Bootstrap pin leakage current during high-side pull-up	INH = High, SH=VDRAIN=85V; TCP switch off; TDRIVE=0; $V_{BST-SH}=12V$	200	340	450	μA
V_{DVDD_RT}	DVDD Digital regulator voltage (Room Temperature)	$V_{GVDD} \geq GVDD_UVH$, $0\text{ mA} \leq I_{DVDD} \leq 30\text{ mA}$ external load + 0mA-5mA internal digital load, Tj= 25°C, DVDD_LVL=0	3.23	3.3	3.37	V
V_{DVDD_RT}	DVDD Digital regulator voltage (Room Temperature)	$V_{GVDD} \geq GVDD_UVH$, $30\text{ mA} \leq I_{DVDD} \leq 100\text{ mA}$ external load + 0mA-5mA internal digital load, Tj= 25°C, DVDD_LVL=0	3.23	3.3	3.37	V
V_{DVDD}	DVDD Digital regulator voltage	$V_{GVDD} \geq GVDD_UVH$, $0\text{ mA} \leq I_{DVDD} \leq 30\text{ mA}$ external load + 0mA-5mA internal digital load, DVDD_LVL=0	3.21	3.3	3.39	V
V_{DVDD}	DVDD Digital regulator voltage	$V_{GVDD} \geq GVDD_UVH$, $30\text{ mA} \leq I_{DVDD} \leq 100\text{ mA}$ external load + 0mA-5mA internal digital load, DVDD_LVL=0	3.21	3.3	3.39	V
V_{DVDD_RT}	DVDD Digital regulator voltage (Room Temperature)	$V_{GVDD} \geq 6.5V$, $0\text{ mA} \leq I_{DVDD} \leq 30\text{ mA}$ external load + 0mA-5mA internal digital load, Tj= 25°C, DVDD_LVL=1	4.9	5	5.1	V
V_{DVDD_RT}	DVDD Digital regulator voltage (Room Temperature)	$V_{GVDD} \geq 6.5V$, $30\text{ mA} \leq I_{DVDD} \leq 100\text{ mA}$ external load + 0mA-5mA internal digital load, Tj= 25°C, DVDD_LVL=1	4.9	5	5.1	V

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V _{DVDD}	DVDD Digital regulator voltage	V _{GVDD} ≥ 6.5V, 0 mA ≤ I _{DVDD} ≤ 30 mA external load + 0mA-5mA internal digital load, DVDD_LVL=1	4.85	5	5.15	V
V _{DVDD}	DVDD Digital regulator voltage	V _{GVDD} ≥ 6.5V, 30 mA ≤ I _{DVDD} ≤ 100 mA external load + 0mA-5mA internal digital load, DVDD_LVL=1	4.85	5	5.15	V
LOGIC-LEVEL INPUTS (INHx, INLx, nSLEEP, etc.)						
V _{IL}	Input logic low voltage	NSLEEP pin. GVDD>6V			0.8	V
V _{IL}	Input logic low voltage	DRVOFF pin. GVDD>6V			0.8	V
V _{IL}	Input logic low voltage	INLx, INHx, ASCIN, SDI, SCLK, nSCS. GVDD>6V			0.8	V
V _{IH}	Input logic high voltage	NSLEEP pin. GVDD>6V	2.2			V
V _{IH}	Input logic high voltage	DRVOFF pin. GVDD>6V	2.2			V
V _{IH}	Input logic high voltage	INLx, INHx, DRVOFF, ASCIN, SDI, SCLK, nSCS GVDD>6V DVDD<4V	2.2			V
V _{IH}	Input logic high voltage	INLx, INHx, DRVOFF, ASCIN, SDI, SCLK, nSCS GVDD>6V DVDD<5.25V	2.6			V
V _{IH}	Input logic high voltage	INLx, INHx, DRVOFF, ASCIN, SDI, SCLK, nSCS GVDD>6V DVDD<6V	2.9			V
V _{OH}	SDO Voh	DVDD > 2.5V; ILOAD=5mA; SDO=H			500	mV
V _{OL}	SDO Vol	DVDD > 2.5V; ILOAD=5mA; SDO=L			500	mV
V _{HYS}	Input hysteresis	NSLEEP	100	250	500	mV
V _{HYS}	Input hysteresis	DRVOFF	50	200	400	mV
V _{HYS}	Input hysteresis	INLx, INHx, DRVOFF, ASCIN, SDI, SCLK, nSCS	50	200	400	mV
I _{IL}	Input logic low current	INLx, INHx, DRVOFF, ASCIN, SDI, SCLK = 0V	-1	0	1	μA
R _{PU}	Input pullup resistance	nSCS to DVDD pin	50	100	200	kΩ
R _{PD}	Input pulldown resistance	SDI, SCLK to GND	50	100	200	kΩ
R _{PD}	Input pulldown resistance	INLx, INHx, DRVOFF, ASCIN, NSLEEP to GND.	150	250	350	kΩ
t _{NSLEEP_DG}	NSLEEP input deglitch time		1	2	4	μs
t _{DRVOFF_DG}	DRVOFF input deglitch time		1	2	4	μs
OPEN-DRAIN OUTPUT (nFAULT)						
V _{OL}	Output logic low voltage	I _{OD} = 5 mA, GVDD > 4V			0.4	V
I _{OZ}	Output logic high current	V _{OD} = 5 V	-1		1	μA
BOOTSTRAP DIODE (BST)						
V _{BOOTD}	Bootstrap diode forward voltage	I _{BOOT} = 100 μA			0.82	V
V _{BOOTD}	Bootstrap diode forward voltage	I _{BOOT} = 10 mA			1	V
V _{BOOTD}	Bootstrap diode forward voltage	I _{BOOT} = 100 mA			1.6	V
R _{BOOTD}	Bootstrap dynamic resistance (ΔV _{BOOTD} /ΔI _{BOOT})	I _{BOOT} = 100 mA and 50 mA	3.9	4.8	9	Ω
TRICKLE CHARGE PUMP (VCP)						
V _{TCP}	Trickle charge pump output voltage	V _{VCP-VDRAIN} , V _{DRAIN} > 15V, GVDD>11V, V _{DRAIN} >GVDD+4V; External load I _{VCP} < 4mA	10.3	10.7	10.9	V
V _{TCP}	Trickle charge pump output voltage	V _{VCP-VDRAIN} , V _{DRAIN} > 15V, 8V<GVDD<11V, V _{DRAIN} >GVDD+4V; External load I _{VCP} < 2mA	7.5	7.8	8.0	V

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
	Trickle charge pump output voltage	$V_{VCP-VDRAIN}$, $V_{DRAIN}=GVDD$, $8V < GVDD < 11V$, External load $I_{VCP} < 2mA$	4.0	5.4	6.7	V
V_{BST_TCPOFF}	BST monitor voltage for VCP to stop charging the BST cap (rising voltage)	$INLx = 0$; $SHx = 0$, V_{DRAIN} ; $V_{DRAIN} = 48V, 85V$	12.0	13.2	14.6	V
$T_{PRECHARGE}$	Startup time for bootstrap precharge	$INH=INL=0$; $BST_UVLO=$ highest level; $TCP_SWITCH=PRECHARGE$ mode (5mA); $GVDD > 11V$, $V_{DRAIN} > GVDD + 4V$; $SHx=V_{DRAIN}$;		1.5	3	ms
I_{TCP_NRM}	VCP to BST switch current; normal mode	$BST=SH=0$; $V_{VCP}>15V$; $TCP_HD_DIS=1$; $TCP_SW_CURLIM=0$;		1.25		mA
I_{TCP_NRM}	VCP to BST switch current; normal mode	$BST=SH=0$; $V_{VCP}>15V$; $TCP_HD_DIS=1$; $TCP_SW_CURLIM=1$;		2.3		mA
I_{TCP_PCHG}	VCP to BST switch current; Precharge mode	$BST=SH=0$; $V_{VCP}>15V$;		5.2		mA
I_{TCP_HD}	VCP to BST switch current; high duty cycle mode with $TCP_SW_HD_CURLIM=0b00$	$BST=SH=0$; $V_{VCP}>15V$; $TCP_HD_DIS=0b$; $TCP_SW_HD_CURLIM=0b00$;		7.7		mA
I_{TCP_HD}	VCP to BST switch current; high duty cycle mode with $TCP_SW_HD_CURLIM=0b01$	$BST=SH=0$; $V_{VCP}>15V$; $TCP_HD_DIS=0b$; $TCP_SW_HD_CURLIM=0b01$;		6.4		mA
I_{TCP_HD}	VCP to BST switch current; high duty cycle mode with $TCP_SW_HD_CURLIM=0b10$	$BST=SH=0$; $V_{VCP}>15V$; $TCP_HD_DIS=0b$; $TCP_SW_HD_CURLIM=0b10$;		10.5		mA
I_{TCP_HD}	VCP to BST switch current; high duty cycle mode with $TCP_SW_HD_CURLIM=0b11$	$BST=SH=0$; $V_{VCP}>15V$; $TCP_HD_DIS=0b$; $TCP_SW_HD_CURLIM=0b11$;		9.2		mA
GATE DRIVERS (GH, GL, SH, SL)						
V_{GSHx_LO}	High-side gate drive low level voltage ($V_{GH} - V_{SH}$)	$I_{GHx} = -10 mA$; $V_{GVDD} = 12V$; $IDRIVE = 1000mA$, No FETs connected	0	0.022	0.2	V
V_{GSHx_HI}	High-side gate drive high level voltage ($V_{BST} - V_{GH}$)	$I_{GHx} = 10 mA$; $V_{GVDD} = 12V$; $IDRIVE = 500mA$, No FETs connected	0	0.09	0.2	V
V_{GSLx_LO}	Low-side gate drive low level voltage ($V_{GL} - V_{SL}$)	$I_{GLx} = -10 mA$; $V_{GVDD} = 12V$; $IDRIVE = 1000mA$, No FETs connected	0	0.022	0.2	V
V_{GSLx_HI}	Low-side gate drive high level voltage ($V_{GVDD} - V_{GL}$)	$I_{GLx} = 10 mA$; $V_{GVDD} = 12V$; $IDRIVE = 500mA$, No FETs connected	0	0.09	0.2	V

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I _{DRIVEP0}	Peak source gate current	V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0x0	9	16	26	mA
I _{DRIVEP1}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0x1	19	32	52	mA
I _{DRIVEP2}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0x2	38	64	103	mA
I _{DRIVEP3}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0x3	57	96	154	mA
I _{DRIVEP4}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0x4	76	128	205	mA
I _{DRIVEP5}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0x5	96	160	256	mA
I _{DRIVEP6}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0x6	115	192	308	mA
I _{DRIVEP7}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0x7	134	224	359	mA
I _{DRIVEP8}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0x8	153	256	410	mA
I _{DRIVEP9}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0x9	172	288	461	mA
I _{DRIVEP10}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0xA	192	320	512	mA
I _{DRIVEP11}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0xB	230	384	615	mA
I _{DRIVEP12}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0xC	307	512	820	mA
I _{DRIVEP13}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0xD	460	768	1229	mA
I _{DRIVEP14}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0xE	614	1024	1639	mA
I _{DRIVEP15}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDRVP_xx = 0xF	614	1024	1639	mA

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I _{DRIVEN0}	Peak sink gate current	V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0x0	19	32	52	mA
I _{DRIVEN1}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0x1	38	64	103	mA
I _{DRIVEN2}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0x2	76	128	205	mA
I _{DRIVEN3}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0x3	115	192	308	mA
I _{DRIVEN4}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0x4	153	256	410	mA
I _{DRIVEN5}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0x5	192	320	512	mA
I _{DRIVEN6}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0x6	230	384	615	mA
I _{DRIVEN7}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0x7	268	448	717	mA
I _{DRIVEN8}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0x8	307	512	820	mA
I _{DRIVEN9}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0x9	345	576	922	mA
I _{DRIVEN10}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0xA	384	640	1024	mA
I _{DRIVEN11}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0xB	460	768	1229	mA
I _{DRIVEN12}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0xC	614	1024	1639	mA
I _{DRIVEN13}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0xD	921	1536	2458	mA
I _{DRIVEN14}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0xE	1228	2048	3277	mA
I _{DRIVEN15}		V _{BST} -V _{SH} = V _{GVDD} = 12V, IDR _{VN} _xx = 0xF	1228	2048	3277	mA
R _{PD_LS}	Low-side passive pull down	GL to SL, V _{GL} - V _{SL} = 2V	60	85	120	kΩ
R _{PDSA_HS}	High-side semiactive pull down	GVDD_UV = 1 GH to SH, V _{GH} - V _{SH} = 2V	2	4	8	kΩ
I _{PUHOLD_L}	High-side pull-up hold low current	I _{HOLD_SEL} = 0	614	1024	1639	mA
I _{PUHOLD_H}	High-side pull-up hold high current	I _{HOLD_SEL} = 1	153	256	410	mA
I _{PDSTRONG_LS}	Low-side pull-down strong current		1228	2048	3277	mA
I _{PDSTRONG_HS}	High-side pull-down strong current		1228	2048	3277	mA
GATE DRIVERS TIMINGS						
t _{PDR_LS}	Low-side rising propagation delay	INL to GL rising, V _{GVDD} > 8V	45	63	90	ns
t _{PDF_LS}	Low-side falling propagation delay	INL to GL falling, V _{GVDD} > 8V	45	64	90	ns
t _{PDR_HS}	High-side rising propagation delay	INH to GH rising, V _{GVDD} = V _{BST} - V _{SH} > 8V	45	62	90	ns
t _{PDF_HS}	High-side falling propagation delay	INH to GH falling, V _{GVDD} = V _{BST} - V _{SH} > 8V	45	65	90	ns

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t _{PD_MATCH}	Matching propagation delay of low-side gate driver	GL turning ON to GL turning OFF, From V _{GL-SL} = 1V to V _{GL-SL} = V _{GVDD} - 1V; V _{GVDD} = V _{BST} - V _{SH} > 8V; V _{SH} = 0V to 90V, no load on GH and GL	-8	±4	8	ns
	Matching propagation delay of high-side gate driver	GH turning ON to GH turning OFF, From V _{GH-SH} = 1V to V _{GH-SH} = V _{BST-SH} - 1V; V _{GVDD} = V _{BST} - V _{SH} > 8V; V _{SH} = 0V to 90V, no load on GH and GL	-10	±4	10	ns
t _{PD_MATCH_P H}	Matching propagation delay per phase	Deadtime disabled. GL turning OFF to GH turning ON, From V _{GL-SL} = V _{GVDD} - 1V to V _{GH-SH} = 1V; V _{GVDD} = V _{BST} - V _{SH} > 8V; V _{SH} = 0V to 90V, no load on GH and GL, dead time disabled	-12	±4	12	ns
		Deadtime disabled. GH turning OFF to GL turning ON, From V _{GH-SH} = V _{BST-SH} - 1V to V _{GL-SL} = 1V; V _{GVDD} = V _{BST} - V _{SH} > 8V; V _{SH} = 0V to 90V, no load on GH and GL	-11	±4	11	ns
t _{PW_MIN}	Reaction time of pre-driver for rising and falling of INH/INL	No deglitch time implemented. Test with INH=INL; Independant mode; look for pulse width when GH-SH/GL-SL > 2V; GVDD=BST-SH > 8V	5	25	50	ns
t _{DEAD}	Digital gate drive dead time	DEADT = 0000b = 0h		70		ns
t _{DEAD}	Digital gate drive dead time	DEADT = 0001b = 1h		120		ns
t _{DEAD}	Digital gate drive dead time	DEADT = 0010b = 2h		180		ns
t _{DEAD}	Digital gate drive dead time	DEADT = 0011b = 3h		300		ns
t _{DEAD}	Digital gate drive dead time	DEADT = 0100b = 4h		400		ns
t _{DEAD}	Digital gate drive dead time	DEADT = 0101b = 5h		500		ns
t _{DEAD}	Digital gate drive dead time	DEADT = 0110b = 6h		600		ns
t _{DEAD}	Digital gate drive dead time	DEADT = 0111b = 7h		750		ns
t _{DEAD}	Digital gate drive dead time	DEADT = 1000b = 8h		1000		ns
t _{DEAD}	Digital gate drive dead time	DEADT = 1001b = 9h		1.5		us
t _{DEAD}	Digital gate drive dead time	DEADT = 1010b = Ah		2		us
t _{DEAD}	Digital gate drive dead time	DEADT = 1011b = Bh		2.5		us
t _{DEAD}	Digital gate drive dead time	DEADT = 1100b = Ch		3		us
t _{DEAD}	Digital gate drive dead time	DEADT = 1101b = Dh		3.5		us
t _{DEAD}	Digital gate drive dead time	DEADT = 1110b = Eh		5		us
t _{DEAD}	Digital gate drive dead time	DEADT = 1111b = Fh		10		us
t _{DEAD}	Analog propagation delay dead time variation	Inserted on top of digital deadtime	-12	4	12	ns
t _{MINDEAD_VG S_HS}	Minimum gate drive dead time (shortest available) of VGS monitor mode; HS falling to LS rising	VGS monitor dead time insertion mode. t _{DEAD_CFG} < 130ns, V _{GVDD} > 8V, V _{BST-SH} > 8V; 0V < V _{SH} = <90V	220	480	550	ns
t _{MINDEAD_VG S_LS}	Minimum gate drive dead time (shortest available) of VGS monitor mode; LS falling to HS rising	VGS monitor dead time insertion; t _{DEAD_CFG} < 130ns, V _{GVDD} > 8V, V _{BST-SH} > 8V; 0V < V _{SH} = <90V	240	480	550	ns
CURRENT SHUNT AMPLIFIERS (SNx, SOx, SPx, VREF)						
A _{CSA}	Sense amplifier gain	CSAGAIN = 00b	4.9	5	5.08	V/V
		CSAGAIN = 01b	9.85	10	10.15	V/V
		CSAGAIN = 10b	19.7	20	20.3	V/V
		CSAGAIN = 11b	39.4	40	40.8	V/V

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
A _{CSA_ERR_D} RIFT	Sense amplifier gain error temperature drift		-30		30	ppm/°C
NL	Non linearity Error			0.01	0.05	%
t _{SET}	Settling time to ±1%	V _{STEP} = 1.6 V, A _{CSA} = 5 V/V, C _{SO} = 500pF; VREF=4.5V-5.5V; k=1/2; Cboardroute=0pF-60pF		0.6	1.6	µs
		V _{STEP} = 1.6 V, A _{CSA} = 10 V/V, C _{SO} = 500pF; VREF=4.5V-5.5V; k=1/2; Cboardroute=0pF-60pF		0.65	1.6	µs
		V _{STEP} = 1.6 V, A _{CSA} = 20 V/V, C _{SO} = 500pF; VREF=4.5V-5.5V; k=1/2; Cboardroute=0pF-60pF		0.7	1.6	µs
		V _{STEP} = 1.6 V, A _{CSA} = 40 V/V, C _{SO} = 500pF; VREF=4.5V-5.5V; k=1/2; Cboardroute=0pF-60pF		1.25	2.1	µs
t _{SET}	Settling time to ±1%	V _{STEP} = 1.6 V, A _{CSA} = 5 V/V, C _{SO} = 60pF; VREF=4.5V-5.5V; k=1/2; Cboardroute=0pF-60pF		0.3	0.6	µs
		V _{STEP} = 1.6 V, A _{CSA} = 10 V/V, C _{SO} = 60pF; VREF=4.5V-5.5V; k=1/2; Cboardroute=0pF-60pF		0.35	0.6	µs
		V _{STEP} = 1.6 V, A _{CSA} = 20 V/V, C _{SO} = 60pF; VREF=4.5V-5.5V; k=1/2; Cboardroute=0pF-60pF		0.35	0.7	µs
		V _{STEP} = 1.6 V, A _{CSA} = 40 V/V, C _{SO} = 60pF; VREF=4.5V-5.5V; k=1/2; Cboardroute=0pF-60pF		0.6	0.9	µs
BW	Bandwidth	A _{CSA} = 5 V/V, C _{LOAD} = 60-pF, small signal -3 dB	3	5	7	MHz
		A _{CSA} = 10 V/V, C _{LOAD} = 60-pF, small signal -3 dB	2.5	4.8	6.6	MHz
		A _{CSA} = 20 V/V, C _{LOAD} = 60-pF, small signal -3 dB	2	4	5.4	MHz
		A _{CSA} = 40 V/V, C _{LOAD} = 60-pF, small signal -3 dB	1.75	3	4.2	MHz
t _{SR}	Output slew rate	V _{STEP} = 1.6 V, A _{CSA} = 5 V/V, C _{LOAD} = 60-pF, low to high transition		14		V/µs
		V _{STEP} = 1.6 V, A _{CSA} = 10 V/V, C _{LOAD} = 60-pF, low to high transition		13		V/µs
		V _{STEP} = 1.6 V, A _{CSA} = 20 V/V, C _{LOAD} = 60-pF, low to high transition		13		V/µs
		V _{STEP} = 1.6 V, A _{CSA} = 40 V/V, C _{LOAD} = 60-pF, low to high transition		6		V/µs
V _{SWING}	Output voltage range	V _{VREF} = 3	0.25		2.75	V
V _{SWING}	Output voltage range	V _{VREF} = 5.5	0.25		5.25	V
V _{SWING}	Output voltage range	V _{VREF} = 3 to 5.5 V	0.25		V _{VREF} - 0.25	V
V _{COM}	Common-mode input range		-0.15		0.15	V
V _{DIFF}	Differential-mode input range	Gain A _{CSA} = 5 V/V	-0.3		0.3	V
V _{OFF}	Input offset voltage	V _{SP} = V _{SN} = GND; T _J = -40°C, G=5V/V	-2.65		2.65	mV
V _{OFF}	Input offset voltage	V _{SP} = V _{SN} = GND; T _J = -40°C, G=10, 20, 40V/V	-1.5		1.5	mV
V _{OFF}	Input offset voltage	V _{SP} = V _{SN} = GND; T _J = 25°C, G=5V/V	-2.65		2.65	mV

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V _{OFF}	Input offset voltage	V _{SP} = V _{SN} = GND; T _J = 25°C, G=10, 20, 40V/V	-1.5		1.5	mV
V _{OFF}	Input offset voltage	V _{SP} = V _{SN} = GND; T _J = 150°C, G=5V/V	-2.65		2.65	mV
V _{OFF}	Input offset voltage	V _{SP} = V _{SN} = GND; T _J = 150°C, G=10, 20, 405V/V	-1.5		1.5	mV
V _{OFF}	Input offset voltage	V _{SP} = V _{SN} = GND; G=5V/V	-2.6		2.6	mV
V _{OFF_DRIFT}	Input drift offset voltage	V _{SP} = V _{SN} = GND	-10	0	10	μV/°C
V _{BIAS}	Output voltage bias ratio	V _{SP} = V _{SN} = GND		0.5		
V _{BIAS_ACC}	Output voltage bias ratio accuracy		-1.2		1.8	%
I _{BIAS}	Input bias current	V _{SP} = V _{SN} = GND, V _{VREF} = 3V to 5.5V			100	μA
I _{BIAS_OFF}	Input bias current offset	I _{SP} - I _{SN}	-2.5		2.5	μA
CMRR	Common-mode rejection ratio	DC		80		dB
		20 kHz		60		dB
PSRR	Power-supply rejection ratio	GVDD to SOx, DC		100		dB
PSRR	Power-supply rejection ratio	GVDD to SOx, 20 kHz		63		dB
PSRR	Power-supply rejection ratio (VREF)	VREF to SOx, DC, Differential		85		dB
		VREF to SOx, 20 kHz, Differential		90		dB
PSRR	Power-supply rejection ratio (VREF)	VREF to SOx, 20 kHz, Single Ended		40		dB
I _{CSA_SUP}	Supply leakage current for CSA during GVDD unpowered	VREF, V _{VREF} = 3.V to 5.5V, GVDD = 0V, VDRAIN = 48V / 0V			1000	nA
I _{CSA_SUP}	Supply current for CSA	VREF, V _{VREF} = 3.V to 5.5V		4.5	6.5	mA
T _{CMREC}	Common mode recovery time			2	2.5	us
RIPPLE	SOx output ripple voltage	Peak to peak, VREF = 3 to 5.5V, SOx cap = 500pf, Input referred, SOx/ GAIN		850	1100	μV
C _{LOAD}	Maximum load capacitance			10		nF
PROTECTION CIRCUITS						
V _{GVDD_UV_BST}	GVDD undervoltage warning threshold rising	GVDD_UV_BST_LV = 1b	9.25	9.6	9.95	V
V _{GVDD_UV_BST}	GVDD undervoltage warning threshold falling	GVDD_UV_BST_LVL = 1b	9.1	9.45	9.8	V
V _{GVDD_UV_BST}	GVDD undervoltage warning threshold rising	GVDD_UV_BST_LVL = 0b	10.25	10.65	10.95	V
V _{GVDD_UV_BST}	GVDD undervoltage warning threshold falling	GVDD_UV_BST_LVL = 0b	10.1	10.45	10.8	V
V _{GVDD_UVH}	GVDD undervoltage fault threshold rising		7.2	7.55	7.9	V
V _{GVDD_UVH}	GVDD undervoltage fault threshold falling		7	7.35	7.7	V
V _{GVDD_UVLO}	GVDD undervoltage lockout threshold		5.35	5.65	5.95	V
V _{GVDD_UVLO}	GVDD undervoltage lockout threshold		5.25	5.55	5.85	V
V _{GVDD_OV}	GVDD overvoltage threshold rising		16.9	17.65	18.4	V
V _{GVDD_OV}	GVDD overvoltage threshold falling		16.5	17.25	18	V
t _{GVDD_UVOV_DEG}	GVDD under/overvoltage deglitch			12		μs
V _{VDRAIN_UVH}	VDRAIN undervoltage fault threshold rising	VDRAIN_UVH_LVL = 0b	18	19	20	V
V _{VDRAIN_UVH}	VDRAIN undervoltage fault threshold falling	VDRAIN_UVH_LVL = 0b	17	18	19	V
V _{VDRAIN_UVH}	VDRAIN undervoltage fault threshold rising	VDRAIN_UVH_LVL = 01b	20	21	22	V

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V _{VDRAIN_UVH}	VDRAIN undervoltage fault threshold falling	VDRAIN_UVH_LVL = 01b	19	20	21	V
V _{VDRAIN_UVH}	VDRAIN undervoltage fault threshold rising	VDRAIN_UVH_LVL = 10b	22	23	24	V
V _{VDRAIN_UVH}	VDRAIN undervoltage fault threshold falling	VDRAIN_UVH_LVL = 10b	21	22	23	V
V _{VDRAIN_UVH}	VDRAIN undervoltage fault threshold rising	VDRAIN_UVH_LVL = 11b	24	25	26	V
V _{VDRAIN_UVH}	VDRAIN undervoltage fault threshold falling	VDRAIN_UVH_LVL = 11b	23	24	25	V
V _{VDRAIN_UVL}	VDRAIN undervoltage threshold to disable TCP rising	VDRAIN_UVL_LVL = 0b	10.2	10.7	11.2	
V _{VDRAIN_UVL}	VDRAIN undervoltage threshold to disable TCP falling	VDRAIN_UVL_LVL = 0b	10	10.5	11	V
V _{VDRAIN_UVL}	VDRAIN undervoltage threshold to disable TCP rising	VDRAIN_UVL_LVL = 1b	5.15	5.65	5.95	V
V _{VDRAIN_UVL}	VDRAIN undervoltage threshold to disable TCP falling	VDRAIN_UVL_LVL = 1b	5.05	5.55	5.85	V
t _{VDRAIN_UV_DEG}	VDRAIN undervoltage deglitch			12		µs
V _{VDRAIN_OV}	VDRAIN overvoltage fault threshold rising	VDRAIN_OV_LVL = 0b.	55.5	58	60.5	V
V _{VDRAIN_OV}	VDRAIN overvoltage fault threshold falling	VDRAIN_OV_LVL = 0b.	53.5	56	58.5	V
V _{VDRAIN_OV}	VDRAIN overvoltage fault threshold rising	VDRAIN_OV_LVL = 1b.	57.5	60	62.5	V
V _{VDRAIN_OV}	VDRAIN overvoltage fault threshold falling	VDRAIN_OV_LVL = 1b.	55.5	58	60.5	V
V _{VDRAIN_OV}	VDRAIN overvoltage fault threshold rising	VDRAIN_OV_LVL = 10b.	59.5	62	64.5	V
V _{VDRAIN_OV}	VDRAIN overvoltage fault threshold falling	VDRAIN_OV_LVL = 10b.	57.5	60	62.5	V
V _{VDRAIN_OV}	VDRAIN overvoltage fault threshold rising	VDRAIN_OV_LVL = 11b.	78	81.5	84	V
V _{VDRAIN_OV}	VDRAIN overvoltage fault threshold falling	VDRAIN_OV_LVL = 11b.	76	79.5	82	V
t _{VDRAIN_OV_DEG}	VDRAIN overvoltage deglitch			6.5		µs
V _{VCP_UV}	VCP undervoltage fault threshold rising		6.7	7.6	8.4	V
V _{VCP_UV}	VCP undervoltage fault threshold falling		6.5	7.4	8.2	V
t _{VCP_UV_DEG}	VCP undervoltage deglitch			12		µs
V _{BST_UV_HI}	Bootstrap undervoltage level (high) rising	8V < GVDD < 9V; PREDRV_BST_UVLO=1	4.5	5.15	5.8	V
V _{BST_UV_HI}	Bootstrap undervoltage level (high) falling	8V < GVDD < 9V; PREDRV_BST_UVLO=1	4.4	5.05	5.7	V
V _{BST_UV_LO}	Bootstrap undervoltage level (low) rising	GVDD > 9V; PREDRV_BST_UVLO=0	5.45	6.1	6.8	V
V _{BST_UV_LO}	Bootstrap undervoltage level (low) falling	GVDD > 9V; PREDRV_BST_UVLO=0	5.35	6	6.65	V
t _{BST_UV_DEG}	Bootstrap undervoltage deglitch			6		µs
V _{DVDD_UV}	DVDD undervoltage fault threshold rising		2.6	2.75	2.9	V
V _{DVDD_UV}	DVDD undervoltage fault threshold falling		2.5	2.65	2.8	V
V _{DVDD_OV}	DVDD overvoltage fault threshold rising	DVDD_LDO_SEL = 0b (3.3V)	3.7	3.85	4.0	V

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V _{DVDD_OV}	DVDD overvoltage fault threshold falling	DVDD_LDO_SEL = 0b (3.3V)	3.65	3.8	3.95	V
V _{DVDD_OV}	DVDD overvoltage fault threshold rising	DVDD_LDO_SEL = 1b (5V)	5.55	5.75	5.95	V
V _{DVDD_OV}	DVDD overvoltage fault threshold falling	DVDD_LDO_SEL = 1b (5V)	5.5	5.7	5.9	V
t _{DVDD_OV_DEG}	DVDD overvoltage deglitch			18		µs
V _{VREF_UV}	VREF undervoltage fault threshold rising	VREF Rising	2.05	2.2	2.35	V
V _{VREF_UV}	VREF undervoltage fault threshold falling	VREF falling	1.85	2	2.15	V
t _{VREF_UV_DEG}	VREF undervoltage deglitch			12		µs
TOTW	Overtemperature warning threshold rising		127	142	157	°C
TOTW	Overtemperature warning threshold falling		121	136	151	°C
TOTSD	Overtemperature shutdown threshold rising		161	176	191	°C
TOTSD	Overtemperature shutdown threshold falling		155	170	185	°C
VVDS_LVL0	VDS overcurrent fault level	VDS_LVL_x = 0000b	0.075	0.1	0.120	V
VVDS_LVL1	VDS overcurrent fault level	VDS_LVL_x = 0001b	0.125	0.15	0.170	V
VVDS_LVL2	VDS overcurrent fault level	VDS_LVL_x = 0010b	0.175	0.2	0.220	V
VVDS_LVL3	VDS overcurrent fault level	VDS_LVL_x = 0011b	0.27	0.3	0.33	V
VVDS_LVL4	VDS overcurrent fault level	VDS_LVL_x = 0100b	0.38	0.4	0.42	V
VVDS_LVL5	VDS overcurrent fault level	VDS_LVL_x = 0101b	0.475	0.5	0.525	V
VVDS_LVL6	VDS overcurrent fault level	VDS_LVL_x = 0110b	0.57	0.6	0.63	V
VVDS_LVL7	VDS overcurrent fault level	VDS_LVL_x = 0111b	0.67	0.7	0.73	V
VVDS_LVL8	VDS overcurrent fault level	VDS_LVL_x = 1000b	0.76	0.8	0.84	V
VVDS_LVL9	VDS overcurrent fault level	VDS_LVL_x = 1001b	0.86	0.9	0.94	V
VVDS_LVL10	VDS overcurrent fault level	VDS_LVL_x = 1010b	0.95	1.0	1.05	V
VVDS_LVL11	VDS overcurrent fault level	VDS_LVL_x = 1011b	1.43	1.5	1.57	V
VVDS_LVL12	VDS overcurrent fault level	VDS_LVL_x = 1100b	1.9	2.0	2.1	V
VVGS_FLT	VGS fault threshold rising	Fault VGS monitor mode. VGS rising	0.6	1.2	1.7	V
VVGS_FLT	VGS fault threshold falling	Fault VGS monitor mode. VGS falling	0.5	1.1	1.6	V
tVGS_DG0	VGS fault programmable deglitch	VGS_DEG = 00b		0.5		µs
tVGS_DG1	VGS fault programmable deglitch	VGS_DEG = 01b		1.0		µs
tVGS_DG2	VGS fault programmable deglitch	VGS_DEG = 10b		1.5		µs
tVGS_DG3	VGS fault programmable deglitch	VGS_DEG = 11b		2.0		µs
tBLNK0	VDS/VGS monitoring programmable blanking period	VDS_VGS_BLK = 000b		0		µs
tBLNK1	VDS/VGS monitoring programmable blanking period	VDS_VGS_BLK = 001b		0.5		µs
tBLNK2	VDS/VGS monitoring programmable blanking period	VDS_VGS_BLK = 010b		1.0		µs
tBLNK3	VDS/VGS monitoring programmable blanking period	VDS_VGS_BLK = 011b		2.0		µs
tBLNK4	VDS/VGS monitoring programmable blanking period	VDS_VGS_BLK = 100b		6.0		µs

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
tBLNK5	VDS/VGS monitoring programmable blanking period	VDS_VGS_BLK = 101b		8.0		µs
tBLNK6	VDS/VGS monitoring programmable blanking period	VDS_VGS_BLK = 110b		10.0		µs
tBLNK7	VDS/VGS monitoring programmable blanking period	VDS_VGS_BLK = 111b		12.0		µs
tVDS_DG0	V _{DS} protection deglitch time	VDS_DEG = 000b		0.5		µs
tVDS_DG1	V _{DS} protection deglitch time	VDS_DEG = 001b		1.0		µs
tVDS_DG2	V _{DS} protection deglitch time	VDS_DEG = 010b		1.5		µs
tVDS_DG3	V _{DS} protection deglitch time	VDS_DEG = 011b		2.0		µs
tVDS_DG4	V _{DS} protection deglitch time	VDS_DEG = 100b		4.0		µs
tVDS_DG5	V _{DS} protection deglitch time	VDS_DEG = 101b		6.0		µs
tVDS_DG6	V _{DS} protection deglitch time	VDS_DEG = 110b, 111b		8.0		µs
Trip_Drift	Aging drift of LS and HS VDS thresholds		-2	0	2	mV
t _{DS_CMP}	VDS Comparator delay	Delay time of device internal comparator. Set overcurrent condition. VDS (comparator input voltage) from 0V to max of V _{DS_LVL} (DC) +50mV (comparator output rising)			1	µs
		Delay time of device internal comparator. Clear overcurrent condition. VDS (comparator input voltage) from VDRAIN to min of V _{DS_LVL} (DC) -50mV (comparator output falling)			1	
I _{OPENLOAD_PU}	Open load pullup current on SH pin		2.4	3.5	6	mA
I _{OPENLOAD_PD}	Open load pulldown current on SH pin		2.4	4.2	6	mA
RSHUNT_OCP						
V _{RSHUNT_OC P}	SNS_OCP threshold	RSHUNT_OCP_LVL=0	VREF*0.20	VREF*0.80		
V _{RSHUNT_OC P}	SNS_OCP threshold	RSHUNT_OCP_LVL=1	VREF*0.10	VREF*0.90		
RSHUNT_OCP_VAR	SNS_OCP threshold variation	RSHUNT_OCP_LVL=0,1, k=1/2, SN/SP Common mode =0V	-3.2		3.2	%
RSHUNT_OCP_VAR	SNS_OCP threshold variation	RSHUNT_OCP_LVL=0,1, k=1/2, SN/SP Common mode =-0.175V	-3.5		3.5	%
RSHUNT_OCP_VAR	SNS_OCP threshold variation	RSHUNT_OCP_LVL=0,1, k=1/2, SN/SP Common mode =0.7V	-3.8		3.8	%
RSHUNT_OCP_VAR	SNS_OCP threshold variation	RSHUNT_OCP_LVL=0,1, k=1/8, SN/SP Common mode =0V	-2		2	%
RSHUNT_OCP_VAR	SNS_OCP threshold variation	RSHUNT_OCP_LVL=0,1, k=1/8, SN/SP Common mode =-0.175V	-2		2	%
RSHUNT_OCP_VAR	SNS_OCP threshold variation	RSHUNT_OCP_LVL=0,1, k=1/8, SN/SP Common mode =0.7V	-2		2	%
t _{SNS_OCP_DEG}	SNS_OCP Deglitch	SNS_OCP_DEG = 00b		3		µs
t _{SNS_OCP_DEG}	SNS_OCP Deglitch	SNS_OCP_DEG = 01b		6		µs
t _{SNS_OCP_DEG}	SNS_OCP Deglitch	SNS_OCP_DEG = 10b		9		µs

Over operating junction temperature range and recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{\text{SNS_OCP_DEG}}$	SNS_OCP Deglitch	SNS_OCP_DEG = 11b		12		μs

5.6 SPI Timing Requirements

$V_{GVDD} = 8$ to 15 V, over operating temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
t_{CLK}	SCLK minimum period	100			ns
t_{CLKH}	SCLK minimum high time	50			ns
t_{CLKL}	SCLK minimum low time	50			ns
t_{SU_SDI}	SDI input data setup time	15			ns
t_{H_SDI}	SDI input data hold time	25			ns
t_{D_SDO}	SDO output data delay time, $C_L = 20$ pF	SCLK high to SDO valid, $C_L = 20$ pF		50	ns
t_{SU_nSCS}	nSCS input setup time	25			ns
t_{H_nSCS}	nSCS input hold time	25			ns
t_{HI_nSCS}	nSCS minimum high time before active low	450			ns
t_{ACC_nSCS}	nSCS access time	nSCS low to SDO ready		50	ns
t_{DIS_nSCS}	nSCS disable time	nSCS high to SDO high impedance		50	ns

5.7 SPI Timing Diagrams

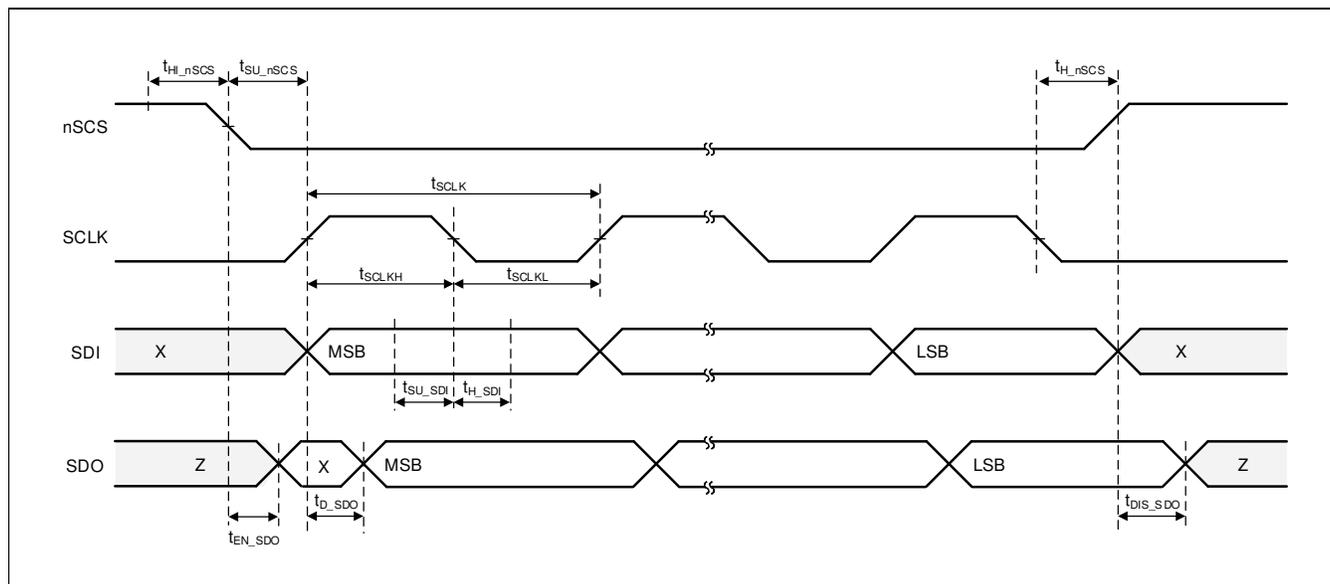


Figure 5-1. SPI Peripheral Mode Timing Diagram

6 Detailed Description

6.1 Overview

The DRV8363 is an integrated 8V to 85V gate driver for three-phase motor drive applications. These devices decrease system component count, cost, and complexity by integrating three independent half-bridge gate drivers, a trickle charge pump, and a linear regulator for the supply of a low power microcontroller. The device also integrates up to three current shunt (or current sense) amplifiers. A standard serial peripheral interface (SPI) provides a simple method for configuring the various device settings and reading fault diagnostic information through an external controller.

The gate drivers support external N-channel high-side and low-side power MOSFETs and can drive up to 1-A source, and 2A sink peak currents. A bootstrap capacitor generates the supply voltage of the high-side gate drive. The supply voltage of the low-side gate driver is supplied externally at a nominal 12V.

A Smart Gate Drive architecture provides the ability to dynamically adjust the strength of the gate drive output current which lets the gate driver control the VDS switching speed of the power MOSFET. This feature lets the user remove the external gate drive resistors and diodes, reducing the component count in the bill of materials (BOM), cost, and area of the printed circuit board (PCB). The architecture also uses an internal state machine to protect against short-circuit events in the gate driver, control the half-bridge dead time, and protect against dV/dt parasitic turn on of the external power MOSFET.

The DRV8363 integrates current sense amplifiers for monitoring current level through all the external half-bridges using a low-side shunt resistor. The gain setting of the current sense amplifier can be adjusted through SPI commands.

In addition to the high level of device integration, the DRV8363 provides a wide range of integrated protection features. These features include power supply undervoltage/overvoltage monitoring (GVDD UV/OV), drain supply undervoltage/overvoltage monitoring (VDRAIN UV/OV), VDS overcurrent monitoring, R_{SENSE} over current monitoring (SNS_OCP), and overtemperature monitoring/shutdown (OTW and OTSD). Fault events are indicated by the nFAULT pin.

6.2 Functional Block Diagram

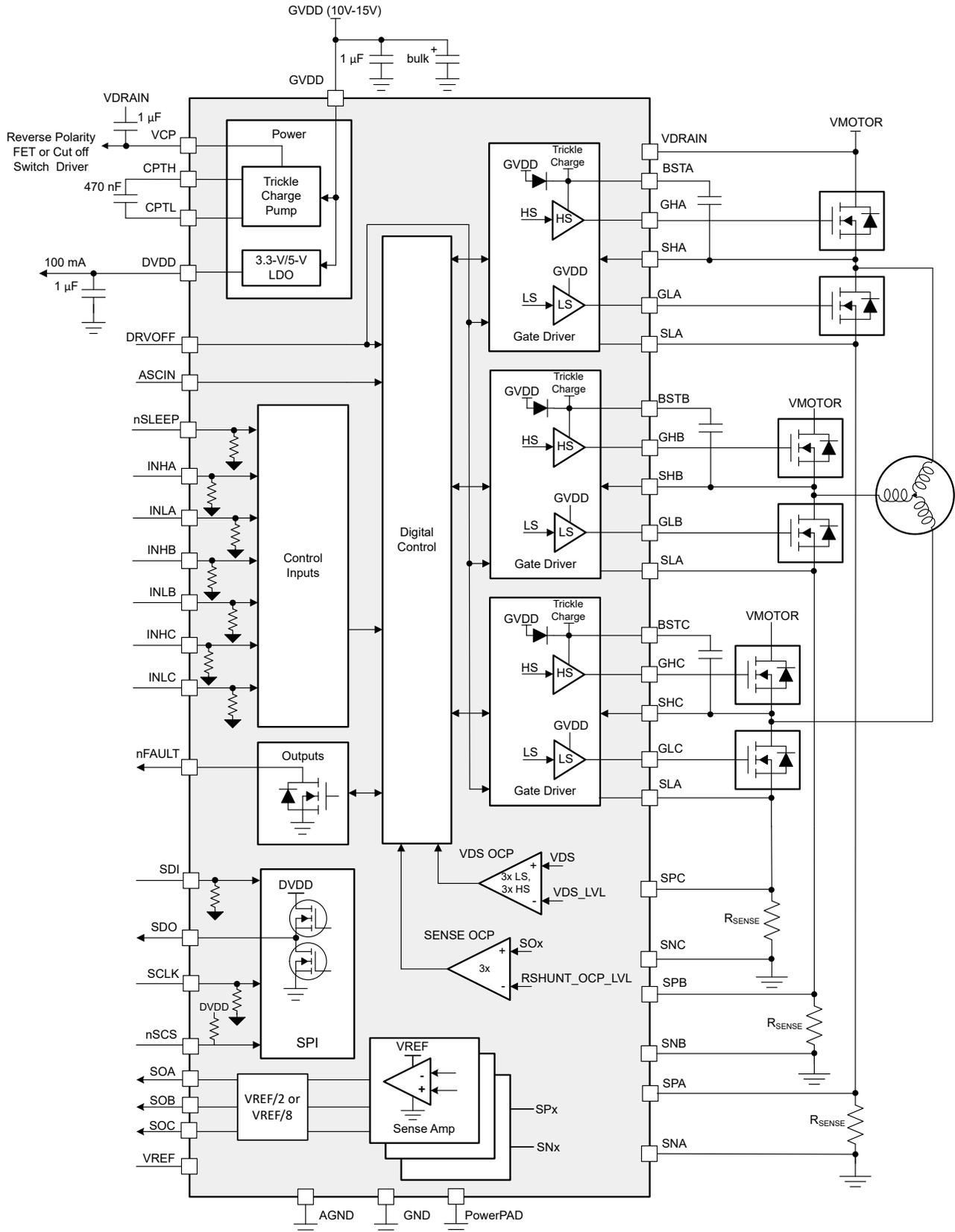


Figure 6-1. Block Diagram of DRV8363

6.3 Feature Description

6.3.1 Three BLDC Gate Drivers

The DRV8363 integrates three, half-bridge gate drivers, each capable of driving high-side and low-side N-channel power MOSFETs. The bootstrap circuit provides the correct gate bias voltage to the high-side MOSFET across a wide operating condition, and an integrated trickle charge pump supports 100% duty cycle operation. The half-bridge gate drivers can be used in combination to drive a three-phase motor or separately to drive other types of loads.

6.3.1.1 PWM Control Modes

The DRV8363 provides four different PWM control modes to support various commutation and control methods. PWM control mode is adjustable through PWM_MODE register bits.

6.3.1.1.1 6x PWM Mode

In 6x PWM mode, the corresponding INHx and INLx signals control the output state as listed in [Table 6-1](#).

Table 6-1. 6x PWM Mode Truth Table

INLx	INHx	GLx	GHx	Note
0	0	L	L	
0	1	L	H	
1	0	H	L	
1	1	L	L	Shoot through protection

6.3.1.1.2 3x PWM Mode with INLx enable control

In 3x PWM mode, the INHx pin controls each half-bridge and supports two output states: low or high. The INLx pin is used to put both high-side and low-side gate drive outputs low. If the state is not required, tie all INLx pins to logic high. The corresponding INHx and INLx signals control the output state as listed in [Table 6-2](#).

Table 6-2. 3x PWM Mode Truth Table

INLx	INHx	GLx	GHx
0	X	L	L
1	0	H	L
1	1	L	H

6.3.1.1.3 1x PWM Mode

In 1x PWM mode, the device uses 6-step block commutation tables that are stored internally. This feature allows for a three-phase BLDC motor to be controlled using one PWM sourced from a simple controller. The PWM is applied on the INHA pin and determines the output frequency and duty cycle of the half-bridges.

The half-bridge output states are managed by the INLA, INHB, and INLB pins which are used as state logic inputs. The state inputs can be controlled by an external controller or connected directly to the digital outputs of the Hall effect sensor from the motor (INLA = HALL_A, INHB = HALL_B, INLB = HALL_C). The 1x PWM mode usually operates with synchronous rectification (low-side MOSFET recirculation).

The INHC input controls the direction through the 6-step commutation table which is used to change the direction of the motor when Hall effect sensors are directly controlling the state of the INLA, INHB, and INLB inputs. Tie the INHC pin low if this feature is not required.

The INLC input brakes the motor by turning off all high-side MOSFETs and turning on all low-side MOSFETs when the INLC pin is pulled low. This brake is independent of the state of the other input pins. Tie the INLC pin high if this feature is not required.

Table 6-3. Synchronous 1x PWM Mode (PWM1X_COM = 0b)

LOGIC AND HALL INPUTS							GATE DRIVE OUTPUTS ⁽¹⁾						DESCRIPTION
STATE	INHC = 0			INHC = 1			PHASE A		PHASE B		PHASE C		
	INLA	INHB	INLB	INLA	INHB	INLB	GHA	GLA	GHB	GLB	GHC	GLC	
Stop	0	0	0	0	0	0	L	L	L	L	L	L	Stop
Align	1	1	1	1	1	1	PWM	!PWM	L	H	L	H	Align
1	1	1	0	0	0	1	L	L	PWM	!PWM	L	H	B → C
2	1	0	0	0	1	1	PWM	!PWM	L	L	L	H	A → C
3	1	0	1	0	1	0	PWM	!PWM	L	H	L	L	A → B
4	0	0	1	1	1	0	L	L	L	H	PWM	!PWM	C → B
5	0	1	1	1	0	0	L	H	L	L	PWM	!PWM	C → A
6	0	1	0	1	0	1	L	H	PWM	!PWM	L	L	B → A

(1) !PWM is the inverse of the PWM signal.

Table 6-4. Asynchronous 1x PWM Mode (PWM1X_COM = 1b)

LOGIC AND HALL INPUTS							GATE DRIVE OUTPUTS						DESCRIPTION
STATE	INHC = 0			INHC = 1			PHASE A		PHASE B		PHASE C		
	INLA	INHB	INLB	INLA	INHB	INLB	GHA	GLA	GHB	GLB	GHC	GLC	
Stop	0	0	0	0	0	0	L	L	L	L	L	L	Stop
Align	1	1	1	1	1	1	PWM	L	L	H	L	H	Align
1	1	1	0	0	0	1	L	L	PWM	L	L	H	B → C
2	1	0	0	0	1	1	PWM	L	L	L	L	H	A → C
3	1	0	1	0	1	0	PWM	L	L	H	L	L	A → B
4	0	0	1	1	1	0	L	L	L	H	PWM	L	C → B
5	0	1	1	1	0	0	L	H	L	L	PWM	L	C → A
6	0	1	0	1	0	1	L	H	PWM	L	L	L	B → A

Figure 6-2 and Figure 6-3 show the different possible configurations in 1x PWM mode.

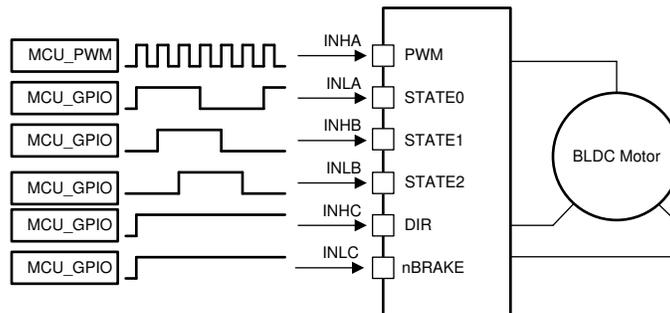


Figure 6-2. 1x PWM—Simple Controller

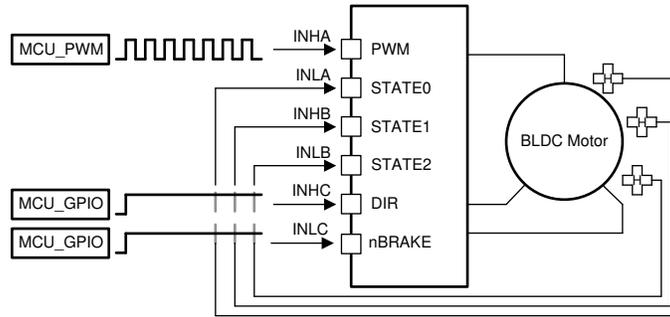


Figure 6-3. 1x PWM—Hall Effect Sensor

6.3.1.2 Gate Drive Architecture

The gate driver uses a complimentary, push-pull topology for both the high-side and low-side drivers. This topology allows for both a strong pullup and pulldown of the external MOSFET gates. The low side gate drivers are supplied directly from the GVDD supply. For the high-side gate drivers, a bootstrap diode and capacitor are used to generate the floating high-side gate voltage supply. The bootstrap diode is integrated and an external bootstrap capacitor is used on the BSTx pin. To support 100% duty cycle control, a trickle charge pump is integrated into the device. The trickle charge pump is connected to the BSTx node to prevent voltage drop due to the leakage currents of the driver and external MOSFET.

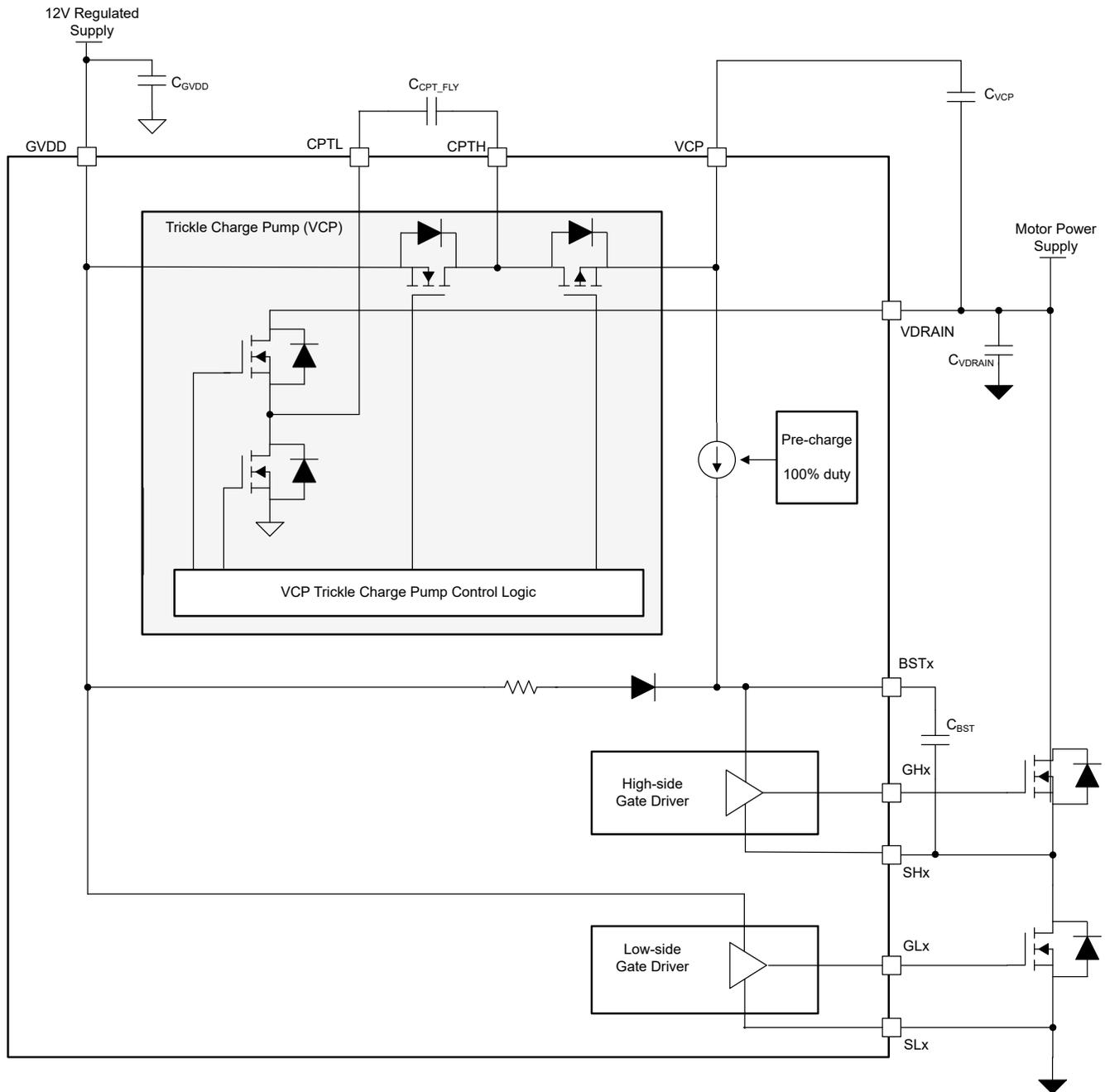


Figure 6-4. DRV8363 Gate Driver Power Supply Architecture

6.3.1.2.1 Bootstrap diode

The bootstrap diode is necessary to generate the high-side bias and is included in the driver device. The diode anode is connected to GVDD through an internal resistor and cathode connected to BSTx. With the C_{BST} capacitor connected to BSTx and the SHx pins, the C_{BST} capacitor charge is refreshed every switching cycle when SHx transitions to ground. The capacitor value C_{BST} is dependent on the gate charge of the high-side MOSFET and must be selected considering PWM control and voltage drop of the MOSFET gate. The boot diode provides fast recovery times, low diode resistance, and voltage rating margin to allow for efficient and reliable operation.

6.3.1.2.2 VCP Trickle Charge pump

The device has charge pump that provides current to C_{BST} bootstrap capacitor so that the bootstrap capacitor stays charged. This allows the gate driver to operate at 100% duty cycle. The charge pump also supports pre-charge of C_{BST} capacitor at power up.

By default, the trickle charge pump to bootstrap connection is configured in "high duty cycle" mode. When $TCP_HD_DIS = 0$, the VCP-BSTx pull-up is activated as soon as INHx goes high, at the strength defined by $TCP_HD_SW_CURLIM$. This can help maintain the BSTx voltage during high duty cycle transients where the BSTx capacitor cannot fully recharge through the bootstrap diode due to limited low-side on time.

If $TCP_HD_DIS = 1$, then the VCP-BSTx pull-up will be in "normal mode," where the pull-up will wait for TCP_SW_DLY to expire after the rising edge of INHx before enabling the pullup at strength defined by TCP_SW_CURLIM . This mode will reduce load on the trickle charge pump for reduced power dissipation, and can help avoid accidentally overloading the trickle charge pump leading to a VCP undervoltage.

In addition to the support of 100% PWM duty cycle operation, the VCP charge pump is designed to support an overdrive supply for external components. The supply voltage V_{VCP} is available on VCP pin and the voltage is regulated with respect to VDRAIN, where a capacitor is connected between VCP and VDRAIN pins. The VCP voltage can be used for an overdrive supply of external switch control circuits such as battery reverse protection switch, high-side switch, or motor phase isolation switches. While the VCP charge pump is designed to support these external loads, care must be taken to avoid exceeding the total current limit of the overdrive supply.

6.3.1.2.3 Gate Driver Output

The gate drivers use a Smart Gate Drive architecture to provide switching control of the external power MOSFETs, additional steps to protect the MOSFETs, and tradeoffs between efficiency and robustness. This architecture is implemented through two components called IDRIVE and TDRIVE. The IDRIVE gate drive current and TDRIVE gate drive time is initially selected based on the parameters of the external power MOSFET used in the system and the desired rise and fall times.

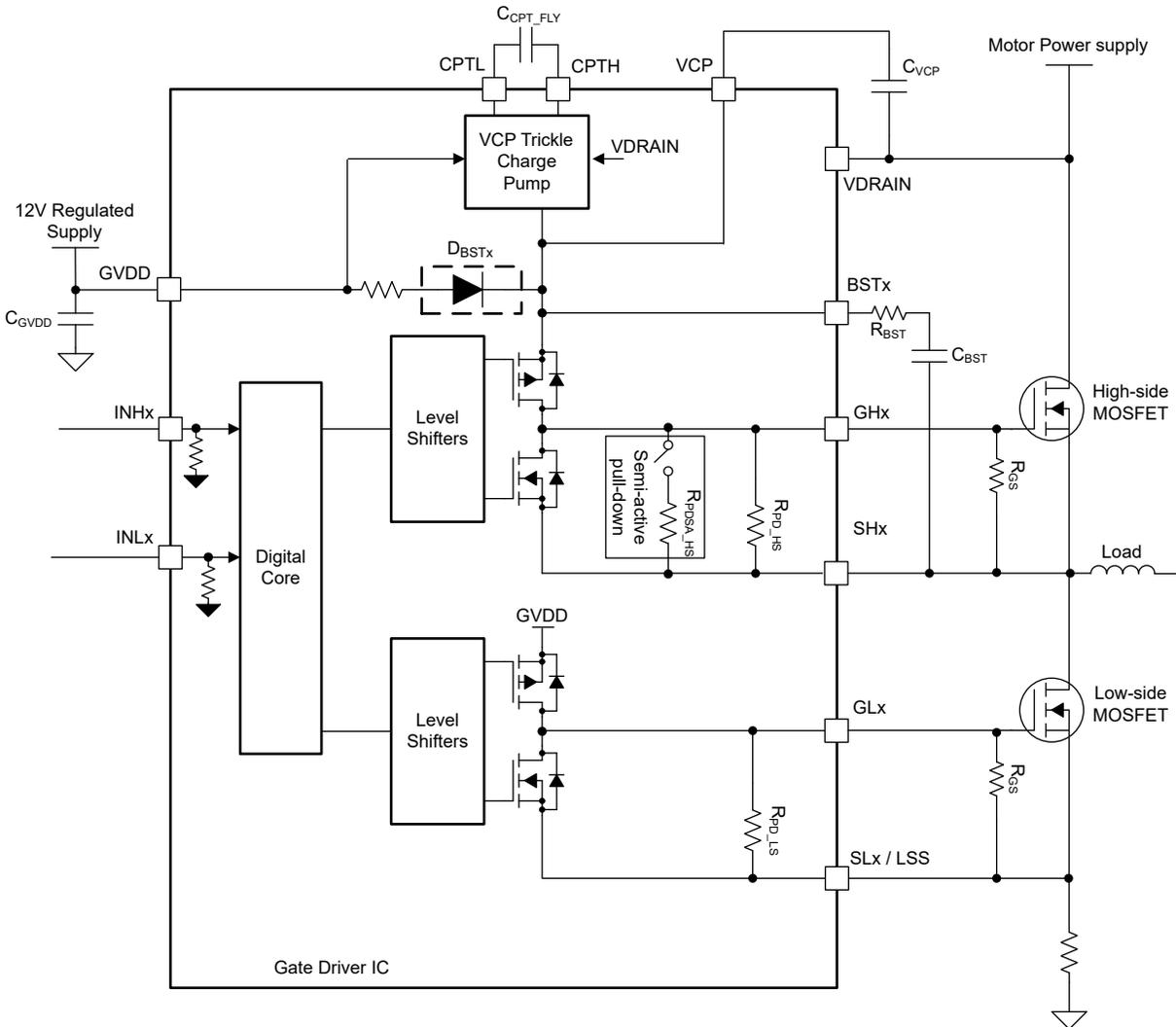


Figure 6-5. Gate Driver Architecture

6.3.1.2.4 Passive and Semi-active pull-down resistor

Each gate driver has a passive pull-down between the gate and source to keep the external MOSFETs turned off in unpowered conditions. In addition, the high side output integrates a semi-active pull-down circuit to further reduce the gate impedance during SLEEP/shutdown mode.

6.3.1.2.5 TDRIVE/IDRIVE Gate Drive Timing Control

The device integrates TDRIVE/IDRIVE gate drive timing control to control switching speed and prevent parasitic dV/dt gate turn on of external MOSFETs. Configurable pull-up current I_{DRVP} and pull-down current I_{DRVN} enable the independent adjustment of rising and falling slew rate without the need for external series gate resistors. Strong pull-down I_{STRONG} current is enabled after the expiration of t_{DRIVE_N} to pull the MOSFET strongly off and keep it off during the switching of the opposite side of the half-bridge. This feature helps to remove parasitic charge that couples into the MOSFET gate when the half-bridge switch-node voltage slews rapidly.

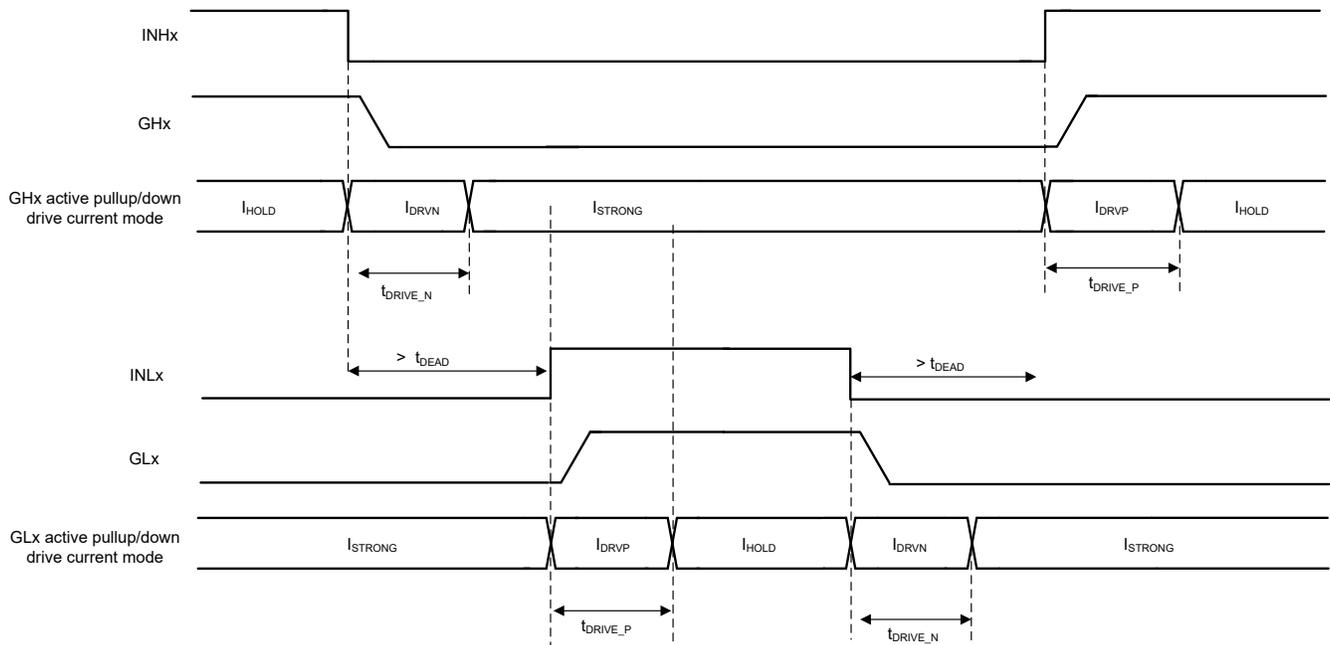


Figure 6-6. TDRIVE Gate Drive Timing Control

6.3.1.2.6 Propagation Delay

The propagation delay time (t_{pd}) is measured as the time between an input logic edge to a detected output change. This time has two parts consisting of the digital propagation delay, and the delay through the analog gate drivers.

To support multiple control modes and dead time insertion, a small digital delay is added as the input command propagates through the device. Lastly, the analog gate drivers have a small delay that contributes to the overall propagation delay of the device.

6.3.1.2.7 Deadtime and Cross-Conduction Prevention

In 6xPWM mode of DRV8363, high-side INHx and low-side INLx inputs operate independently, with an exception to prevent cross conduction when the high and low side of the same half-bridge are turned ON at same time. The device pulls high- and low- side gate outputs low to prevent shoot through condition of power stage and a fault STP_FLT is reported when high- and low-side inputs are logic high at the same time.

In 6xPWM mode, if SPI register bit DEADT_MODE is 0b and DEADT_MODE_6X is 00b, the device monitors INHx and INLx and inserts dead time if the period of INHx=INLx=low is shorter than t_{DEAD} . Other than 6xPWM mode, dead time is always inserted regardless of the configuration.

Note

If PWM_MODE is set to 001b - 101b, the STP_MODE bit shall be set to 1b to avoid a false flag of STP_FLT. The SPI register bit STP_MODE = 0b can be used only for PWM_MODE = 000b (6xPWM mode).

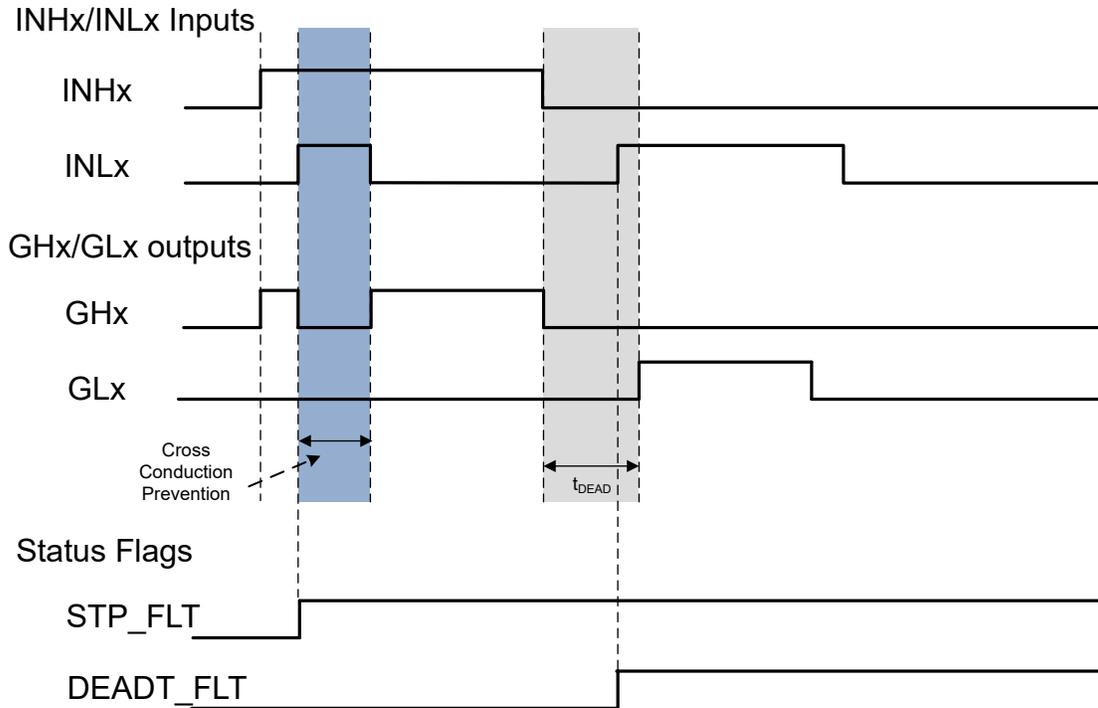


Figure 6-7. Cross Conduction Prevention and Dead time Insertion

6.3.2 DVDD Linear Voltage Regulator

A 100mA output linear regulator is integrated into the device and is available for use by external circuitry. The LDO can be configured for 3.3V or 5V output. This regulator can provide the supply voltage for a low-power MCU or other circuitry supporting low current. The output of the DVDD regulator is bypassed near the DVDD pin with a 1µF ceramic capacitor. TI recommends to use an X5R or X7R capacitor rated for 16V or greater to maintain sufficient effective capacitance. The ground return from the capacitor is routed back to the adjacent GND ground pin.

The output voltage of LDO can be selected through LDO_SEL register bit.

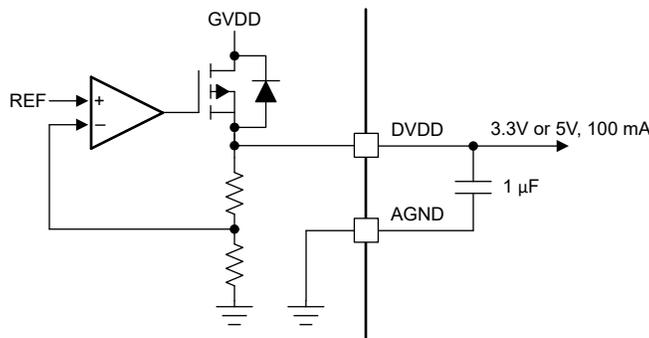


Figure 6-8. DVDD Linear Regulator Block Diagram

The power dissipated in the device by the DVDD linear regulator can be calculated as $P = (V_{GVDD} - V_{DVDD}) \times I_{DVDD}$

6.3.3 Low-Side Current Sense Amplifiers

The DRV8363 devices integrate high-performance low-side current sense amplifier for current measurements using low-side shunt resistors. Low-side current measurements are commonly used to implement overcurrent protection, external torque control, or brushless DC commutation with the external controller. The current sense amplifiers feature nine configurable gain settings between 5 and 40 V/V, which can be configured through SPI commands. The CSA output is referenced to the external voltage reference pin (VREF). The CSA output offset can be configured between 1/2 xVREF or 1/8 xVREF to support bidirectional or unidirectional current sensing as needed.

Note

By default, CSA output is disabled. CSA output can be enabled in SPI register IC_CTRL2.

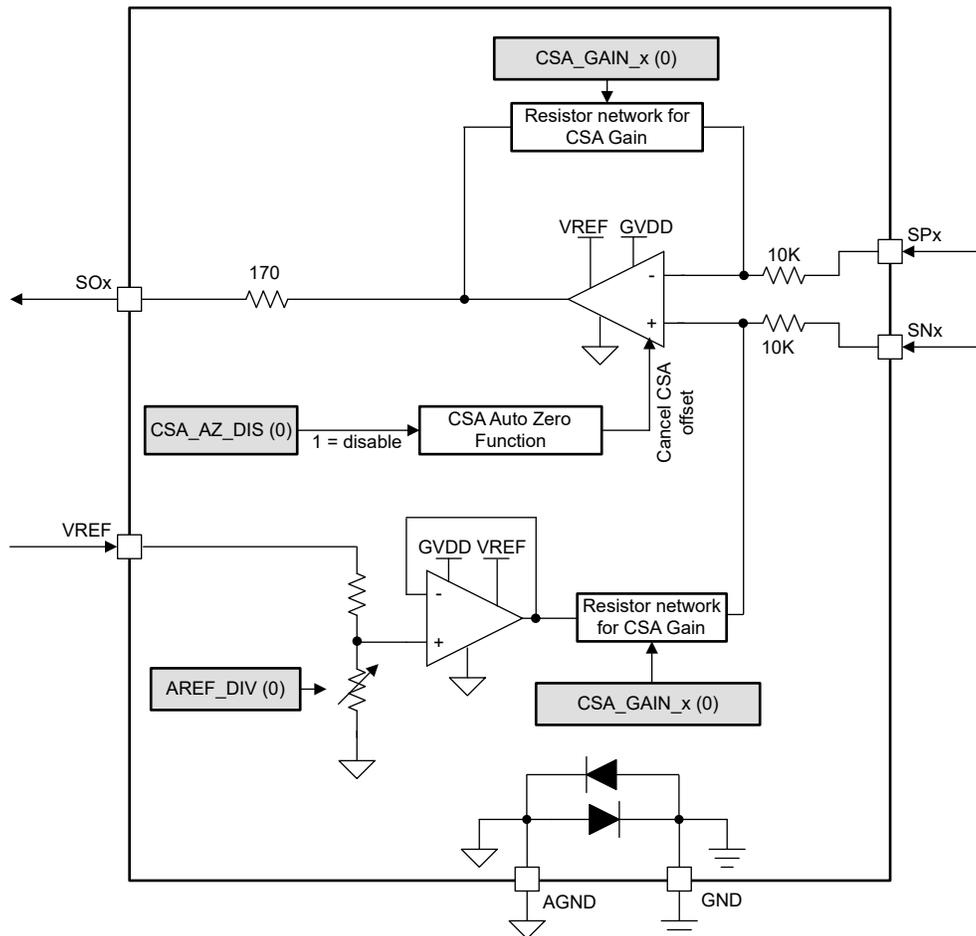


Figure 6-9. Current-Sense Amplifier Diagram

6.3.3.1 Unidirectional Current Sense Operation

The DRV8363 internally generates a common mode voltage of 1/8 x VREF to obtain maximum resolution for current measurement. The current sense amplifier operates in a unidirectional mode and the SO pin outputs an analog voltage equal to the voltage across the SP and SN pins multiplied by the gain setting (G_{CSA}).

Use Equation 1 to calculate the current through the shunt resistor.

$$I = \frac{V_{SOx} - V_{VREF}/8}{G_{CSA} \times R_{SENSE}} \quad (1)$$

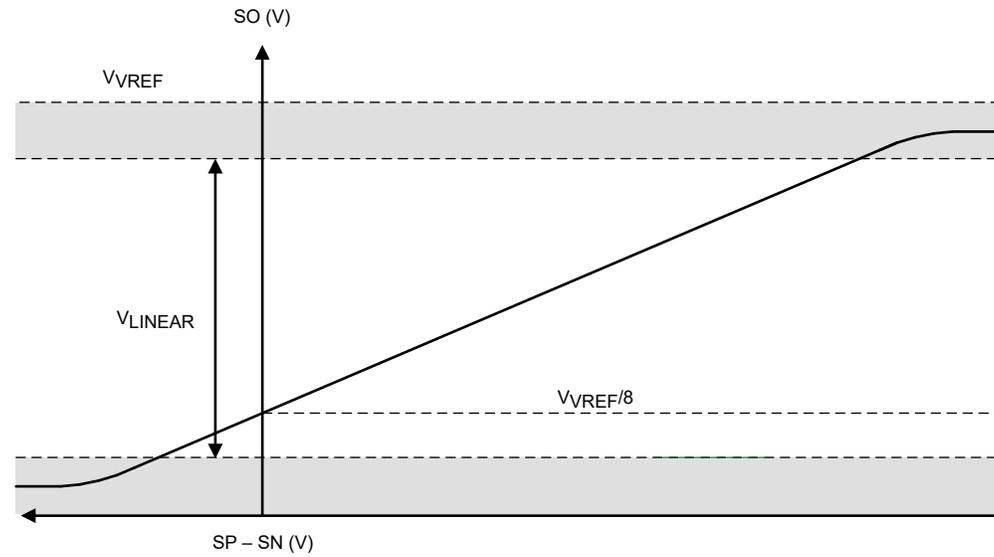


Figure 6-10. Unidirectional Current-Sense Output

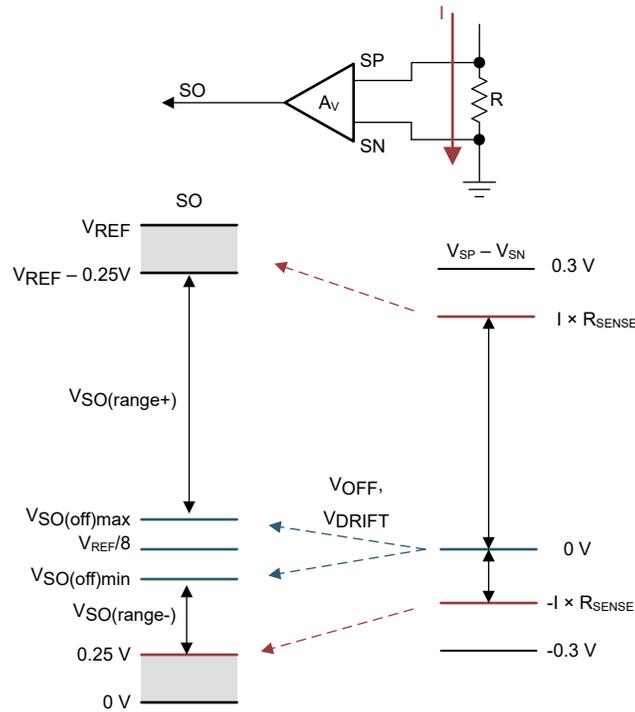


Figure 6-11. Unidirectional Current-Sense Regions

6.3.3.2 Bidirectional Current Sense Operation

In this mode, DRV8363 internally generates a common mode voltage of $\frac{1}{2} \times V_{REF}$ to enable bidirectional current measurement. The current sense amplifier operates in a bidirectional mode and the SO pin outputs an analog voltage equal to the voltage across the SP and SN pins multiplied by the gain setting (G_{CSA}).

Use Equation 2 to calculate the current through the shunt resistor ($A_{REF_DIV} = V_{REF} / 2$ case).

$$I = \frac{V_{SOx} - \frac{V_{VREF}}{2}}{G_{CSA} \times R_{SENSE}} \quad (2)$$

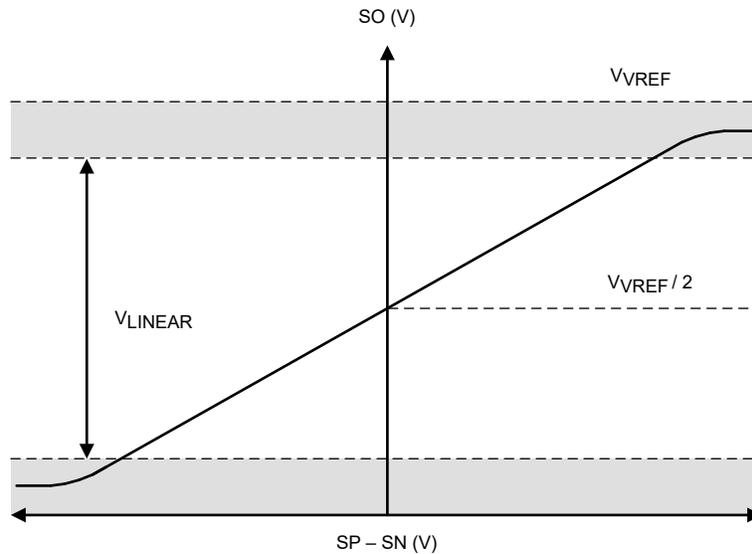


Figure 6-12. Bidirectional Current Sense Output

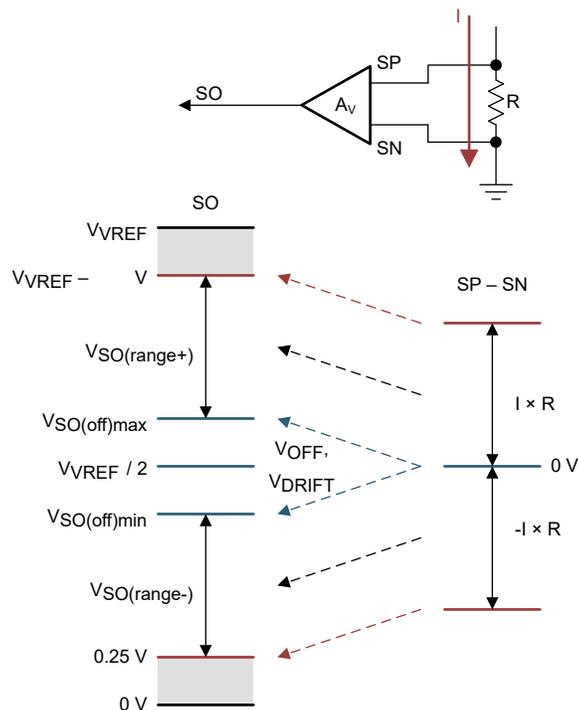


Figure 6-13. Bidirectional Current Sense Regions

6.3.4 Gate Driver Shutdown

If a fault condition is detected or DRVOFF pin is driven by system, the device takes an action of gate driver shutdown. The high-side and low-side gate driver outputs are pulled down to turn off external MOSFETs.

6.3.4.1 DRVOFF Gate Driver Shutdown

When DRVOFF is driven high, the gate driver goes into shutdown mode, overriding signals on inputs pins INHx and INLx. DRVOFF bypasses the internal digital logic and is connected directly to the predriver. This pin provides a mechanism for externally monitored faults to disable the gate driver directly bypassing the external controller. When the DRVOFF pin is driven high, the device disables the gate driver and triggers the shutdown sequence.

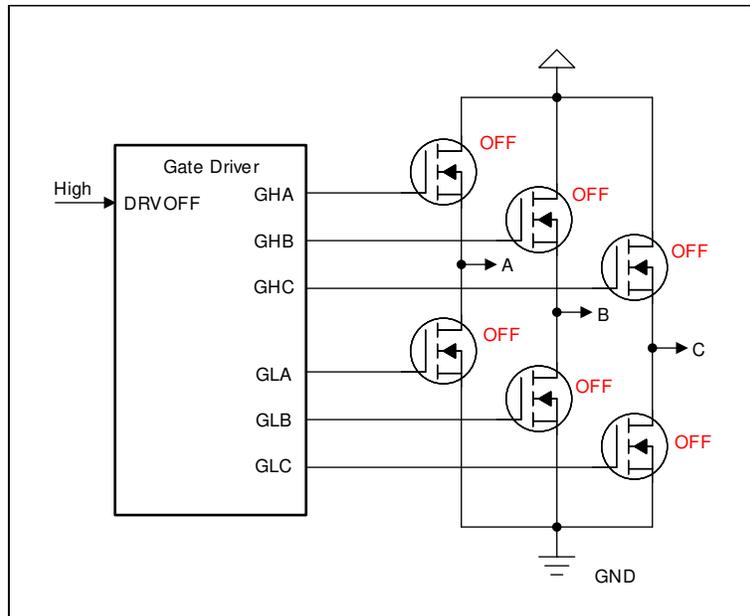


Figure 6-14. DRVOFF Gate Driver Output State

6.3.4.2 Soft Shutdown Timing Sequence

In the event of an overcurrent fault shutdown, the DRV8363 utilizes a soft shutdown sequence to minimize inductive spikes in the power stage. The shutdown drive current can be programmed with SPI register IDRVN_SD. The gate driver uses I_{DRVN_SD} for t_{DRVN_SD} time to discharge the gate of the MOSFET. After completion of shutdown sequence, gate driver outputs are in passive/semi-active pull-down mode.

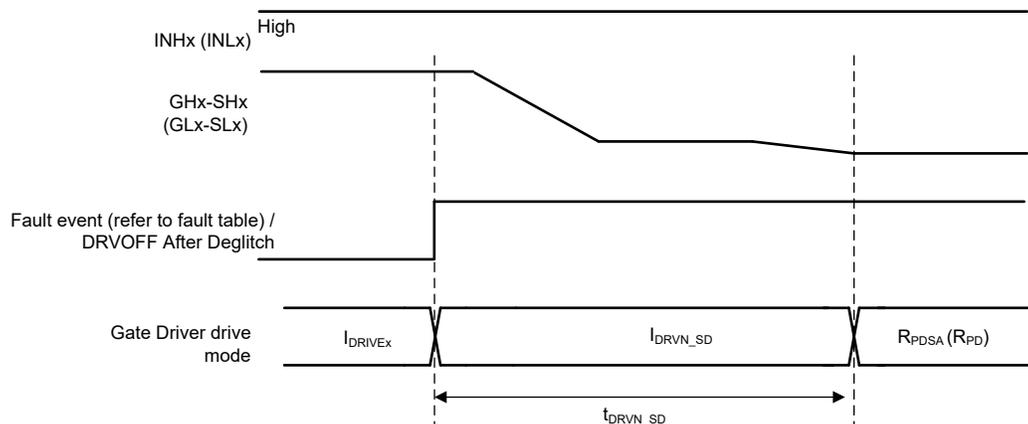


Figure 6-15. Gate Drive Shutdown Sequence

6.3.5 Active Short Circuit

To help systems driving high-inertia loads, or systems that may be exposed to generator-mode conditions (where the motor is being externally turned), the DRV8363 incorporates an advanced Active Short Circuit feature. This feature, which can be triggered through the ASCIN pin, through SPI, or automatically in response to VDRAIN Overvoltage, turns on all three high-side or all three low-side MOSFETs to recirculate the motor current and avoid further increasing the supply voltage through diode rectification.

The default selection for high-side or low-side ASC is configurable through the ASC_POLARITY bit. However, in order to provide robustness through a variety of operating conditions and system fault scenarios, the DRV8363 will automatically switch between high-side and low-side ASC. This behavior is summarized in the chart below:

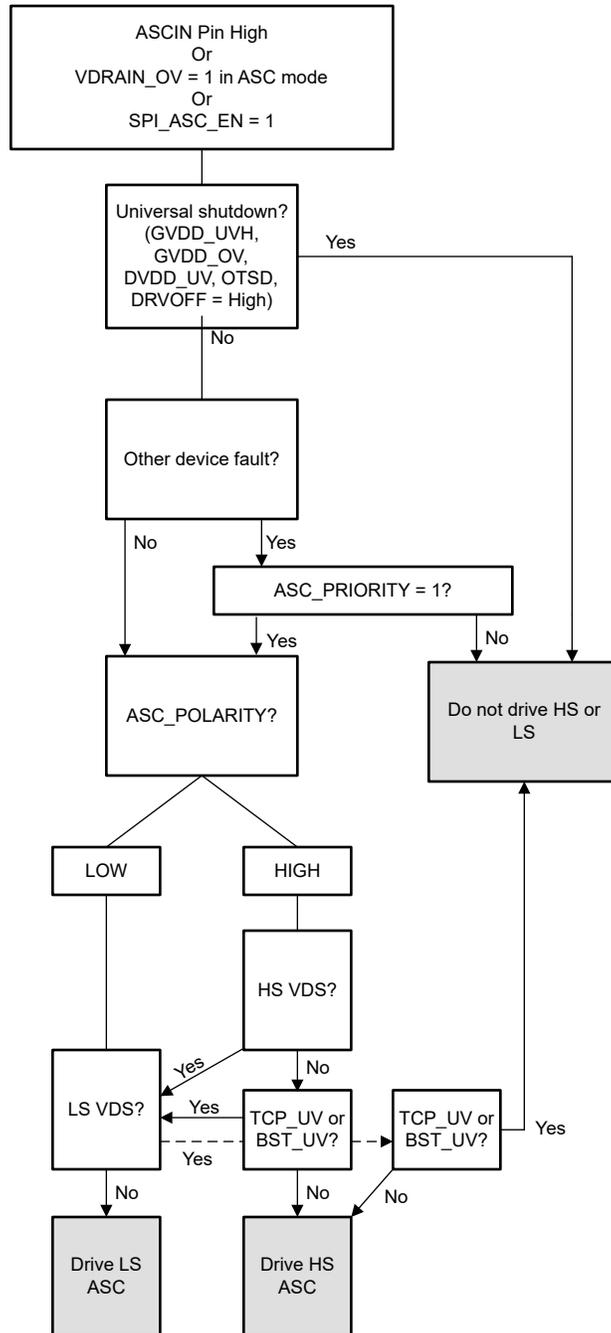


Figure 6-16. Active Short Circuit Logic

6.3.6 Gate Driver Protective Circuits

6.3.6.1 GVDD Undervoltage Lockout (GVDD_UV)

If at any time the voltage on the GVDD pin falls lower than the V_{GVDD_UV} threshold voltage for longer than the $t_{GVDD_UV_DG}$ time, the device detects a GVDD undervoltage event. After detecting the GVDD_UV undervoltage event, the gate driver disabled, charge pump disabled and nFAULT pin is driven low. After GVDD_UV condition is cleared, the fault state remains latched and can be cleared through an SPI command.

6.3.6.2 GVDD Overvoltage Fault (GVDD_OV)

If at any time the power supply voltage on the GVDD pin exceeds the V_{GVDD_OV} threshold for longer than the $t_{GVDD_OV_DG}$ time, the DRV8363 detects a GVDD overvoltage event. After detecting the overvoltage condition, the gate driver is disabled, charge pump is disabled, and nFAULT pin is driven low. After GVDD_OV condition is cleared, the fault state remains latched and can be cleared through an SPI command.

6.3.6.3 VDRAIN Undervoltage Fault (VDRAIN_UV)

If at any time the supply voltage on the VDRAIN pins falls below the V_{VDRAIN_UV} threshold for longer than the $t_{vdrain_uv_dg}$ time, the DRV8363 detects a VDRAIN undervoltage event. After detecting the undervoltage condition, the gate driver is disabled, charge pump is disabled, and nFAULT pin is driven low. After the VDRAIN_UV condition is cleared, the fault state remains latched and can be cleared through an SPI command.

6.3.6.4 VDRAIN Overvoltage Fault (VDRAIN_OV)

If at any time the power supply voltage on the VDRAIN pin exceeds the V_{VDRAIN_OV} threshold for longer than the $t_{VDRAIN_OV_DG}$ time, the DRV8363 detects a VDRAIN overvoltage event. After detecting the overvoltage condition, the gate driver is disabled, charge pump is disabled, and nFAULT pin is driven low. After the VDRAIN_OV condition is cleared, the fault state remains latched and can be cleared through an SPI command. The VDRAIN_OV threshold can be adjusted based on expected supply range using the VDRAIN_OV_LVL register field.

6.3.6.5 VCP Undervoltage Fault (CP_OV)

If at any time the voltage between the VCP and VDRAIN pins falls below the V_{CP_UV} threshold for longer than the $t_{CP_UV_DG}$ time, the DRV8363 detects a VCP undervoltage event. After detecting the undervoltage condition, the gate driver is disabled, charge pump is disabled, and nFAULT pin is driven low. After the VCP_UV condition is cleared, the fault state remains latched and can be cleared through an SPI command.

6.3.6.6 BST Undervoltage Lockout (BST_UV)

If at any time the voltage across BTSx and SHx pins falls lower than the V_{BST_UV} threshold voltage for longer than the $t_{BST_UV_DG}$ time, the device detects a BST undervoltage event. After detecting the BST_UV undervoltage event, the gate driver disabled and nFAULT pin is driven low. After BST_UV condition is cleared, the fault state remains latched and can be cleared through an SPI command.

6.3.6.7 MOSFET V_{DS} Overcurrent Protection (VDS_OCP)

The device has adjustable V_{DS} voltage monitors to detect overcurrent or short-circuit conditions on the external power MOSFETs. A MOSFET overcurrent event is sensed by monitoring the V_{DS} voltage drop across the external MOSFET $R_{DS(on)}$. The high-side VDS monitors measure between the VDRAIN and SHx pins and the low-side VDS monitors measure between the SHx and SLx pins. If the voltage across external MOSFET exceeds the V_{DS_LVL} threshold for longer than the t_{DS_DG} deglitch time, a VDS_OCP event is recognized. After detecting the VDS overcurrent event, all of the gate driver outputs are driven low to disable the external MOSFETs and nFAULT pin is driven low. VDS level and deglitch time are programmable.

can be adjusted through the VGS_DEG register field. The deglitch timer does not start until after the blanking time has elapsed following a rising/falling PWM signal. TI recommends to set this value based on the system noise level and acceptable fault tolerance timing.

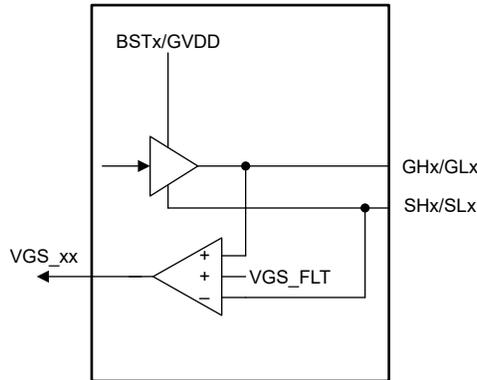


Figure 6-19. DRV8363 V_{GS} Monitors

6.3.6.9 Shunt Overcurrent Protection (SNS_OCP)

Overcurrent is also monitored by sensing the output of the current sense amplifier (SO_x). If at any time the voltage of SO_x exceeds the V_{RSHUNT_OCP} threshold for longer than the t_{SNS_OCP_DEG} deglitch time, a SNS_OCP event is recognized.

The V_{RSHUNT_OCP} thresholds are defined relative to V_{VREF}, and are bidirectional, allowing overcurrent to be detected in either the forward or the reverse direction. There are two threshold settings available to configure through the SNS_OCP_LVL bit: 80%/20% mode, or 90%/10% mode. The effective current level of this monitor can be calculated as:

$$I_{\text{SENSE_OCP}} = \frac{V_{\text{RSHUNT_OCP}} - \frac{V_{\text{VREF}}}{k}}{\text{Gain} \times R_{\text{SHUNT}}} \quad (3)$$

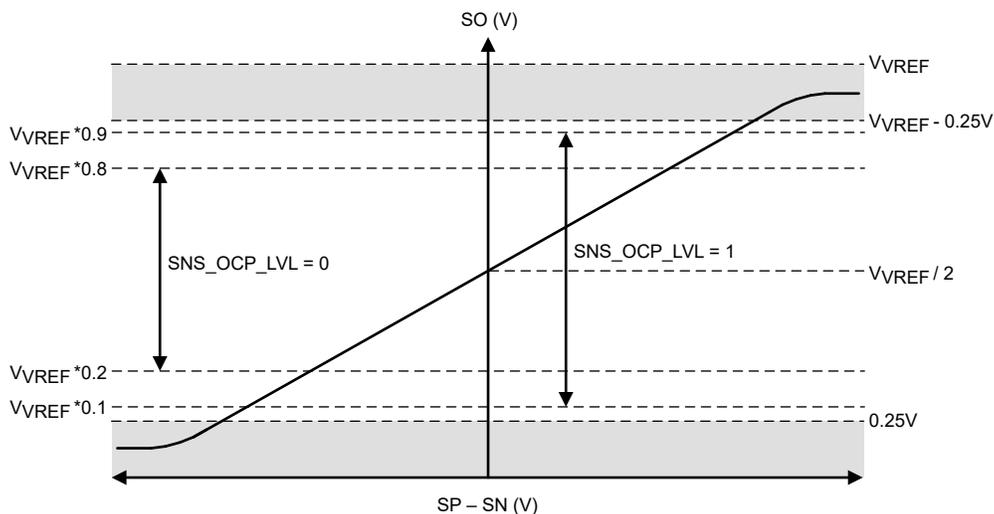


Figure 6-20. SNS_OCP Thresholds

Device response to detection of an SNS_OCP event is configurable through the SNS_OCP_MODE bits. The shutdown mode is also configurable through the SNS_OCP_STD_SHD bit. TI recommends using "standard" shutdown mode if reaching the OCP threshold is a normal part of operation (such as when using Autorecovery or CBC mode) to avoid excess MOSFET heating from soft shutdown mode.

6.3.6.10 Thermal Shutdown (OTSD)

If the die temperature exceeds the trip point of the thermal shutdown limit (T_{OTSD}), OTSD event is recognized. After detecting the OTSD overtemperature event, if OTSD_MODE is Fault mode, all of the gate driver outputs are driven low to disable the external MOSFETs, charge pump and current sense are disabled, and nFAULT pin is driven low. After OTSD condition is cleared, the fault state remains latched and can be cleared through an SPI command (CLR_FLT). The OTSD_MODE is Fault mode by default. If OTSD condition is detected during device power up, nFAULT stays low and charge pump and current sense remain disabled until OTSD condition is removed and SPI command (CLR_FLT) is sent by MCU.

6.3.6.11 Thermal Warning (OTW)

If the die temperature exceeds the trip point of the thermal warning (T_{OTW}), the OTW bit is set in the registers of SPI devices. The device performs no additional action and continues to function. After the die temperature falls lower than the hysteresis point of the thermal warning, the OTW bit remains latched and can be cleared through an SPI command CLR_FLT. If OTW bit is 1b, nFAULT stays high when WARN_MODE bit 1b.

6.3.6.12 OTP CRC

After each power up, the device performs an OTP CRC check. If the calculated CRC8 checksum does not match the CRC8 checksum stored in the internal OTP memory, the OTP_CRC failed flag is set.

6.3.6.13 SPI Watchdog Timer

The device integrates a programmable window-type SPI watchdog timer to verify that the external controller is operating. The SPI watchdog timer can be enabled by writing a 1 to WDT_EN SPI register bit. The watchdog timer is disabled by default. When the watchdog timer is enabled, an internal timer starts to count up. A valid SPI access resets the timer. This valid SPI access must be issued between the lower window time and the upper window time. If a watchdog timer fault is detected, nFAULT pin is asserted low.

6.3.6.14 Phase Diagnostic

The device integrates a current source and a switch between VDRAIN and SHx device pins and between SHx device pin and the device ground for each channel. The switches can be individually enabled and disabled via SPI register bits PH_DIAG_Hx and PH_DIAG_Lx. If PH_DIAG_Hx is 1b, the source current I_{PHD_SRC} of SHx pin is enabled. If PH_DIAG_Lx is 1b, the sink current I_{PHD_SNK} of SHx pin is enabled. When any of PHDEN_Hx and PHDEN_Lx register bits are set to 1, the VDS overcurrent detection flags, VDS_Hx and VDS_Lx, change from the fault detection flag to the status flag of VDS comparators. The combination of the integrated current sources and VDS status flags can be used for the phase diagnostics such as an open fault detection of motor load, without activating external MOSFETs.

The DRV8363 also features automatic open load and MOSFET short detection sequences. To run the automatic open load detection, set the OPEN_DET_EN bit to 1b. To run the automatic MOSFET short detection sequence, set the SHORT_DET_EN bit to 1b. Please note that only one automatic sequence can be run at a time. The results of the sequence is reported in the IC_STAT3 register.

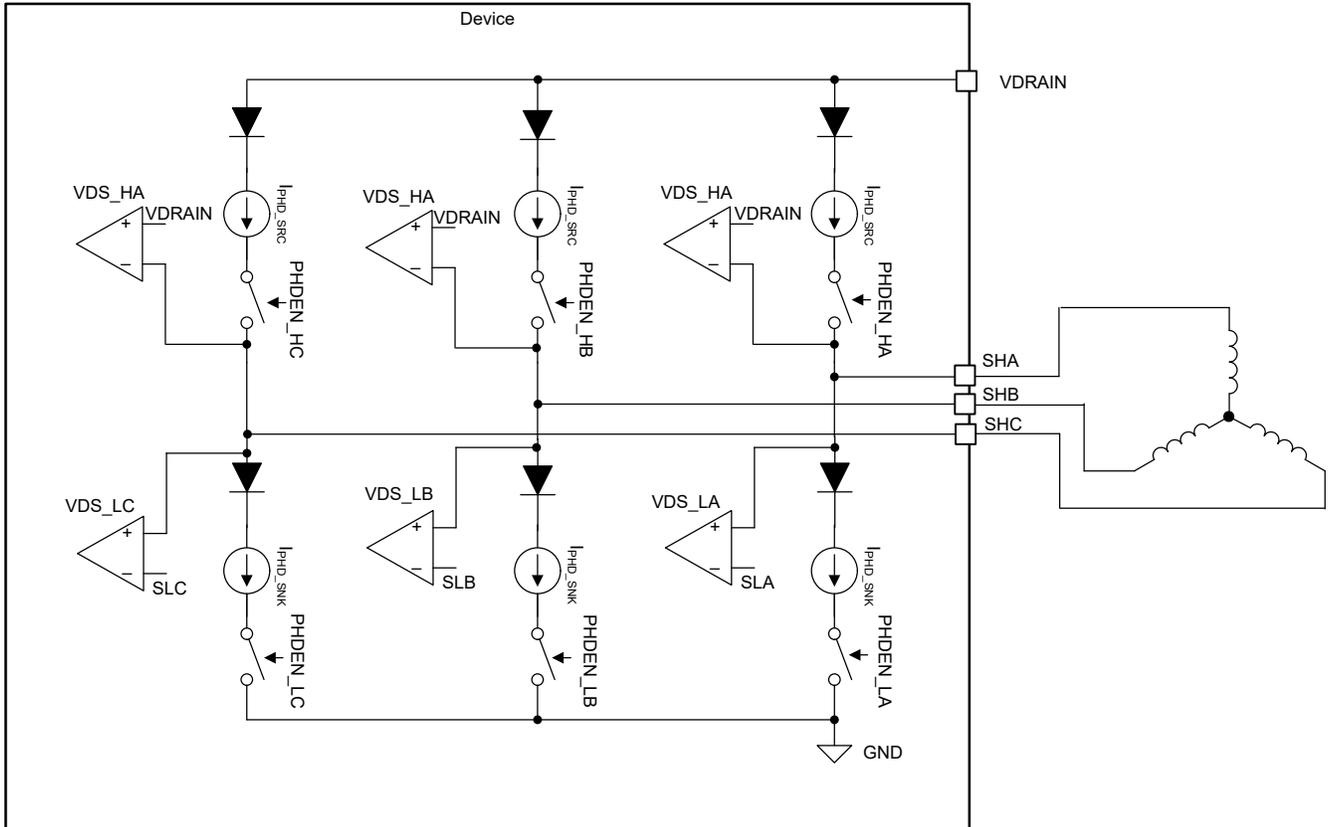


Figure 6-21. Phase Diagnostic

6.4 Fault Detection and Response Summary Table (Fault Table)

Table 6-5. Fault Detection and Response Summary

NAME	SPI FLAG BIT	CONDITION	MODE	DIGITAL CORE	GATE DRIVERS	CHARGE PUMP	CURRENT SENSE	RESPONSE
GVDD Undervoltage Lockout	N/A	GVDD < GVDD_UVLO	N/A	Reset	Disabled	Disabled	Disabled	Gate drive shutdown, device shutdown, nFAULT
GVDD Undervoltage Warning	GVDD_UVH	GVDD < GVDD_UVH	GVDD_UVH_MOD E = 0 (Warning)	Active	Active	Active	Active	SPI Report, nFAULT
			GVDD_UVH_MOD E = 1 (Fault)	Active	Disabled (Weak Pulldown)	Active	Active	Gate drive shutdown, SPI Report, nFAULT
GVDD Undervoltage BST Warning	GVDD_UV_BST	GVDD < GVDD_UV_BST	GVDD_UV_BST_M ODE = 00b (RT Warning)	Active	Active	Active	Active	SPI Report (Unlatched), nFAULT
			GVDD_UV_BST_M ODE = 01b (Fault)	Active	Active	Active	Active	SPI Report, VCP_UV disabled, BST_UV_LVL forced to 1b, nFAULT
			GVDD_UV_BST_M ODE = 10b (RT Fault)	Active	Active	Active	Active	SPI Report (Unlatched), VCPI_UV disabled, BST_UV_LVL forced to 1b, nFAULT
			GVDD_UV_BST_M ODE = 11b (Disabled)	Active	Active	Active	Active	N/A
GVDD overvoltage	GVDD_OV	GVDD > GVDD_OV	GVDD_OV_MODE = 0b (Warning)	Active	Active	Active	Active	SPI Report, nFAULT
			GVDD_OV_MODE = 1b (Fault)	Active	Disabled (Standard shutdown)	Disabled	Active	SPI Report, Gate drive shutdown, nFAULT

Table 6-5. Fault Detection and Response Summary (continued)

NAME	SPI FLAG BIT	CONDITION	MODE	DIGITAL CORE	GATE DRIVERS	CHARGE PUMP	CURRENT SENSE	RESPONSE
VDRAIN Undervoltage Low Threshold	VDRAIN_UVL	VDRAIN < VDRAIN_UVL	VDRAIN_UVL_MO DE = 00b (Warning)	Active	Active	Active	Active	SPI Report, nFAULT
			VDRAIN_UVL_MO DE = 01b (Warning RT)	Active	Active	Active	Active	SPI Report (Unlatched), nFAULT
			VDRAIN_UVL_MO DE = 10b (Fault)	Active	Disabled (Standard shutdown)	Disabled	Active	SPI Report, Gate drive shutdown, nFAULT
			VDRAIN_UVL_MO DE = 11b (Disabled)	Active	Active	Active	Active	N/A
VDRAIN Undervoltage High Threshold	VDRAIN_UVH	VDRAIN < VDRAIN_UVH	VDRAIN_UVH_MO DE = 00b (Warning)	Active	Active	Active	Active	SPI Report, nFAULT
			VDRAIN_UVH_MO DE = 01b (Warning RT)	Active	Active	Active	Active	SPI Report (Unlatched), nFAULT
			VDRAIN_UVH_MO DE = 10b (Fault)	Active	Disabled (Standard shutdown)	Active	Active	SPI Report, Gate drive shutdown, nFAULT
			VDRAIN_UVH_MO DE = 11b (Disabled)	Active	Active	Active	Active	N/A
VDRAIN Overvoltage	VDRAIN_OV	VDRAIN > VDRAIN_OV	VDRAIN_OV_MOD E = 00b (Warning)	Active	Active	Active	Active	SPI Report, nFAULT
			VDRAIN_OV_MOD E = 01b (Fault)	Active	Disabled (Standard shutdown)	Active	Active	SPI Report, Gate drive shutdown, nFAULT
			VDRAIN_OV_MOD E = 10b (ASC Latched)	Active	Active (ASC enabled)	Active	Active	SPI Report, nFAULT
			VDRAIN_OV_MOD E = 11b (ASC RT)	Active	Active (ASC enabled)	Active	Active	SPI Report, nFAULT

Table 6-5. Fault Detection and Response Summary (continued)

NAME	SPI FLAG BIT	CONDITION	MODE	DIGITAL CORE	GATE DRIVERS	CHARGE PUMP	CURRENT SENSE	RESPONSE
DVDD Overvoltage	DVDD_OV	DVDD > DVDD_OV	DVDD_MODE = 0b (Warning)	Active	Active	Active	Active	SPI Report, nFAULT
			DVDD_MODE = 1b (Fault)	Active	Disabled (Standard shutdown)	Disabled	Active	SPI Report, Gate drive shutdown, nFAULT
Overtemperature Warning	OTW	Internal temperature > OTW	N/A	Active	Active	Active	Active	SPI Report, nFAULT
Overtemperature Shutdown	OTSD	Internal temperature > OTSD	OTSD_MODE = 0b (Warning)	Active	Active	Active	Active	SPI Report, nFAULT
			OTSD_MODE = 1b (Fault)	Disabled	Disabled (Standard shutdown)	Disabled	Disabled	SPI Report, Gate drive shutdown, nFAULT
Overtemperature Shutdown, Trickle Charge Pump	OTSD_TCP	Internal charge pump temperature > OTSD	N/A	Active	Active	Disabled	Active	SPI Report, nFAULT
VCP Undervoltage	VCP_UV	VCP < VCP_UV	VCP_UV_MODE = 00b (Warning)	Active	Active	Active	Active	SPI Report, nFAULT
			VCP_UV_MODE = 01b (Fault)	Active	Disabled (Standard shutdown)	Active	Active	SPI Report, Gate drive shutdown, nFAULT
			VCP_UV_MODE = 10b (Fault, TCP Shutdown)	Active	Disabled (Standard shutdown)	Disabled	Active	SPI Report, Gate drive shutdown, nFAULT
			VCP_UV_MODE = 11b (Disabled)	Active	Active	Active	Active	N/A

Table 6-5. Fault Detection and Response Summary (continued)

NAME	SPI FLAG BIT	CONDITION	MODE	DIGITAL CORE	GATE DRIVERS	CHARGE PUMP	CURRENT SENSE	RESPONSE
Bootstrap Undervoltage	BST_x_UV	BSTx < BST_UV	BST_UV_MODE = 000b, 110b (Warning)	Active	Active	Active	Active	SPI Report, nFAULT
			BST_UV_MODE = 001b (Fault RT, Active Pulldown)	Active	HS Off (Active Pulldown), LS Active	Active	Active	SPI Report, Gate drive shutdown, nFAULT
			BST_UV_MODE = 010b (Fault RT, Weak Pulldown)	Active	HS Off (Weak Pulldown), LS Active	Active	Active	SPI Report, Gate drive shutdown, nFAULT
			BST_UV_MODE = 011b (Fault, Active Pulldown)	Active	HS Off (Active Pulldown), LS Active	Active	Active	SPI Report, Gate drive shutdown, nFAULT
			BST_UV_MODE = 100b (Fault, Weak Pulldown)	Active	HS Off (Weak Pulldown), LS Active	Active	Active	SPI Report, Gate drive shutdown, nFAULT
			BST_UV_MODE = 101b (Fault, Weak Pulldown, TCP switch off)	Active	HS Off (Weak Pulldown), LS Active	Disabled	Active	SPI Report, Gate drive shutdown, nFAULT
			BST_UV_MODE = 111b (Disabled)	Active	Active	Active	Active	N/A
VREF Undervoltage	VREF_UV	VREF < VREF_UV	N/A	Active	Active	Active	Disabled	SPI Report, nFAULT
VDS OCP	VDS_xx	VDS > VDS_LVL	VDS_OCP_MODE = 0b (Warning)	Active	Active	Active	Active	SPI Report, nFAULT
			VDS_OCP_MODE = 1b (Fault)	Active	Disabled (Soft shutdown)	Active	Active	SPI Report, Gate drive shutdown, nFAULT

Table 6-5. Fault Detection and Response Summary (continued)

NAME	SPI FLAG BIT	CONDITION	MODE	DIGITAL CORE	GATE DRIVERS	CHARGE PUMP	CURRENT SENSE	RESPONSE
Sense OCP	OCP_SNS_x	SOx > SNS_OCP_LVL	SNS_OCP_MODE = 000b (Warning)	Active	Active	Active	Active	SPI Report, nFAULT
			SNS_OCP_MODE = 001b (Fault)	Active	Disabled (Soft shutdown)	Active	Active	SPI Report, nFAULT
			SNS_OCP_MODE = 010b (Warning RT)	Active	Active	Active	Active	SPI Report (Unlatched), nFAULT
			SNS_OCP_MODE = 011b (Fault RT)	Active	Disabled (Soft shutdown)	Active	Active	SPI Report (Unlatched), Gate drive shutdown, nFAULT
			SNS_OCP_MODE = 100b (Limit Mode)	Active	Disabled (Standard shutdown)	Active	Active	Gate drive shutdown until next PWM edge
			SNS_OCP_MODE = 111b (Disabled)	Active	Active	Active	Active	N/A
VGS Monitor	VGS_xx	VGS voltage above/below threshold for off/on state	VGS_MODE = 0b (Warn)	Active	Active	Active	Active	SPI Report, nFAULT
			VGS_MODE = 1b (Fault)	Active	Disabled (Standard shutdown)	Active	Active	SPI Report, nFAULT
Watchdog Monitor	WDT_FLT	Watchdog not serviced in window	N/A	Active	Disabled (Standard shutdown)	Active	Active	SPI Report, nFAULT
Deadtime Protection	DEADT_FLT	Deadtime less than DEADT setting	DEADT_MODE_6X = 00b (Fault)	Active	Minimum deadtime enforced	Active	Active	SPI Report, Gate driver outputs enforced, nFAULT
			DEADT_MODE_6X = 01b (Enforce only)	Active	Minimum deadtime enforced	Active	Active	SPI Report, Gate driver outputs enforced, nFAULT
			DEADT_MODE_6X = 10b (Disabled)	Active	Active	Active	Active	N/A
			DEADT_MODE_6X = 11b (Warning)	Active	Minimum deadtime enforced	Active	Active	Active

Table 6-5. Fault Detection and Response Summary (continued)

NAME	SPI FLAG BIT	CONDITION	MODE	DIGITAL CORE	GATE DRIVERS	CHARGE PUMP	CURRENT SENSE	RESPONSE
Shoot-through Protection	STP_FLT	INHx + INLx simultaneously high	STP_MODE = 0b (Warning + Enforce)	Active	Enforced (Low while both inputs high)	Active	Active	SPI Report, Outputs enforced
			STEP_MODE = 1b (Enforce only)	Active	Enforced (Low while both inputs high)	Active	Active	Outputs enforced
SPI Clock Fault	SPI_CLK_FLT	SPI frame has incorrect number of clocks (not 24 or 32 bits)	N/A	Active	Active	Active	Active	SPI Report, nFAULT, SPI transaction rejected
SPI Address Fault	SPI_ADDR_FLT	SPI Invalid Address Access	N/A	Active	Active	Active	Active	SPI Report, nFAULT, SPI transaction rejected
SPI CRC Fault	SPI_CRC_FLT	SPI CRC value mismatch	N/A	Active	Active	Active	Active	SPI Report, nFAULT, SPI transaction rejected
SPI Parity Fault	SPI_PAR_FLT	SPI parity bit value mismatch	N/A	Active	Active	Active	Active	SPI Report, nFAULT, SPI transaction rejected
OTP CRC Fault	OTP_CRC_FLT	Corruption of internal OTP values	N/A	Active	Disabled (Weak Pulldown)	Active	Active	SPI Report, nFAULT
Device Mode Fault	DEV_MODE_FLT	Device in TI test mode	N/A	Active	Active	Active	Active	SPI Report, nFAULT
Bootstrap Precharge Timeout	BST_TIMEOUT_FLT	Bootstrap precharge not completed by end of timeout period	N/A	Active	Active	Active	Active	SPI Report, nFAULT
Open Load Detection	OPEN_WARN_x	Open load detected by open test sequence	N/A	Active	Active	Active	Active	SPI Report, nFAULT

Table 6-5. Fault Detection and Response Summary (continued)

NAME	SPI FLAG BIT	CONDITION	MODE	DIGITAL CORE	GATE DRIVERS	CHARGE PUMP	CURRENT SENSE	RESPONSE
Short to Battery Detection	SHT_VDD_WARN_ x	Short to battery detected by short test sequence	N/A	Active	Active	Active	Active	SPI Report, nFAULT
Short to GND Detection	SHT_GND_WARN _x	Short to ground detected by short test sequence	N/A	Active	Active	Active	Active	SPI Report, nFAULT

6.5 Device Functional Modes

6.5.1 Gate Driver Functional Modes

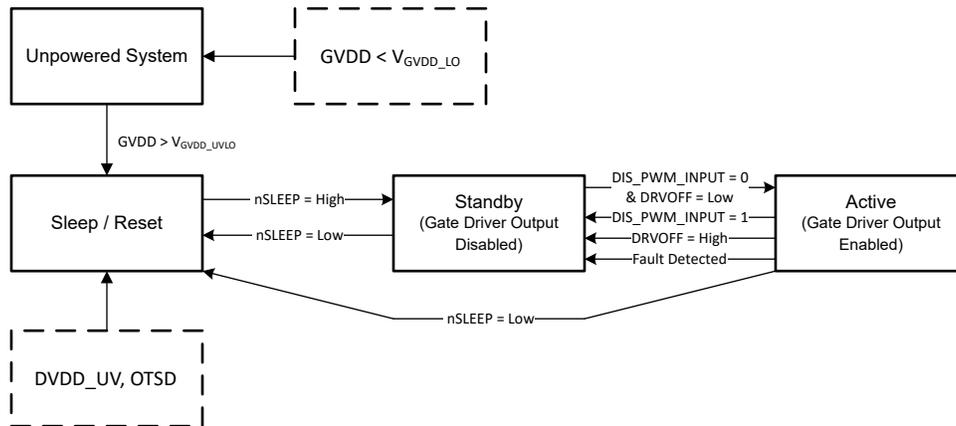


Figure 6-22. Functional State Diagram

6.5.1.1 Sleep Mode

The nSLEEP pin manages the state of the DRV8363. When the nSLEEP pin is low, the device goes to a low-power sleep mode. In sleep mode, all gate drivers are disabled, sense amplifiers are disabled, all external MOSFETs are disabled, the VCP trickle charge pump is disabled, and the DVDD regulator is disabled. The t_{SLEEP} time must elapse after a falling edge on the nSLEEP pin before the device goes to sleep mode. The device comes out of sleep mode automatically if the nSLEEP pin is pulled high. The t_{WAKE} time must elapse before the device is ready for inputs. While in Sleep mode, the nFAULT pin is pulled low.

6.5.1.2 Standby Mode

When the nSLEEP pin is high and the V_{GVDD} voltage is greater than the $V_{\text{GVDD_UVLO}}$ voltage, the device goes to standby mode. In this mode the DVDD regulator and VCP trickle charge pump are active, but the MOSFET output drive stage is inactive. If the device is powering up for the first time, then it will proceed to Active mode once the VCP and BSTx voltages have cleared their respective UV thresholds.

A fault condition, holding DRVOFF high, or setting DIS_PWM_INPUT = 1 will cause the device to enter and stay in standby mode. If the device is in Standby mode due to a fault condition, then it will re-enter Active mode once the fault flag has been cleared.

6.5.1.3 Active Mode

If there are no fault conditions, DRVOFF is low, and DIS_PWM_INPUT = 0, the device will enter the Active mode. In this mode the MOSFET outputs are active, and will respond to INHx/INLx inputs.

6.6 Programming

6.6.1 SPI

The device uses a serial peripheral interface (SPI) bus to set device configurations, operating parameters, and read out diagnostic information. The device SPI operates in secondary mode and connects to an external controller. If SPI CRC (SPI_CRC_EN = 0b) is enabled, the SPI input data (SDI) word consists of a 24 bit word, with one read/write bit, one parity bit, 6-bit address, and 16 bits of data. The SPI output data (SDO) word consists of a 24 bit word, with an 8-bit status data, and 16 bits of register data. If SPI CRC is enabled (SPI_CRC_EN = 1b), an additional 8 bit CRC (initial value 0xFF, polynomial 0x2F) is added to the end of the frame, increasing the total SPI data word length to 32 bits.

A valid frame must meet the following conditions:

- The SCLK pin is low when the nSCS pin transitions from high to low and from low to high.
- The nSCS pin is pulled high for at least 400ns between words.
- When the nSCS pin is pulled high, any signals at the SCLK and SDI pins are ignored and the SDO pin is set Hi-Z.
- Data is captured on the falling edge of SCLK and data is propagated on the rising edge of SCLK.
- The most significant bit (MSB) is shifted in and out first.
- A full 24 (or 32) SCLK cycles must occur for transaction to be valid.
- If the data word sent to the SDI pin is not 24 (or 32) bits, a frame error occurs and the data word is ignored.
- For a write command, the existing data in the register being written to is shifted out on the SDO pin following the 8 bit command data.
- The SDO pin is a push-pull type output.
- The SPI fault is confirmed at the rising edge of nSCS.

6.6.2 SPI Format

The SDI data word is 24 (or 32) bits long and consists of the following format:

- 1 parity bit, P. The parity bit uses an even parity scheme, so the number of ones in the SPI frame should be even. If SPI_CRC_EN = 1b, this bit is "Don't Care".
- 6 address bits, A5-A0
- 1 read or write bit, W0. W0 = 0b for write command and W0 = 1b for read command.
- 16 data bits, D15-D0
- 8-bit CRC if SPI_CRC_EN = 1b.

The SDO data word is 24 (or 32) bits long and consists of the following format.

- 1 fault status bit, F. This bit is identical to IC_STAT1 FAULT register bit.
- 7 "Don't Care" bits.
- 16 data bits, D15-D0. This is read data of the addressed register. For write command, it is the data previously stored in the addressed register.
- 8-bit CRC if SPI_CRC_EN = 1b

6.6.3 SPI Format Diagrams

Table 6-6. SDI Input Data Word Format for SPI (24-bit, CRC disabled)

PARITY	ADDRESS							RW	DATA														
B23	B22	B21	B20	B19	B18	B17	B16	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
P	A5	A4	A3	A2	A1	A0	W0	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0

Table 6-7. SDO Output Data Word Format (24-bit, CRC disabled)

STATUS								DATA															
B23	B22	B21	B20	B19	B18	B17	B16	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
FAULT	DC	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0						

Table 6-8. SDI Input Data Word Format for SPI (32-bit, CRC enabled)

PARITY	ADDRESS							RW	DATA														CRC								
B31	B30	B29	B28	B27	B26	B25	B24	B23	B22	B21	B20	B19	B18	B17	B16	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
DC	A5	A4	A3	A2	A1	A0	W0	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	C7	C6	C5	C4	C3	C2	C1	C0

Table 6-9. SDO Output Data Word Format (32-bit, CRC enabled)

STATUS								DATA														CRC									
B31	B30	B29	B28	B27	B26	B25	B24	B23	B22	B21	B20	B19	B18	B17	B16	B15	B14	B13	B12	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1	B0
FAULT	DC	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	C7	C6	C5	C4	C3	C2	C1	C0						

6.7 Register Maps

This section is a preliminary register map of DRV8363, and is subject to change.

6.7.1 STATUS Registers

Table 6-10 lists the memory-mapped registers for the STATUS registers. All register offset addresses not listed in Table 6-10 should be considered as reserved locations and the register contents should not be modified.

Table 6-10. STATUS Registers

Offset	Acronym	Description	Section
0h	IC_STAT1	IC Status Register 1	Section 6.7.1.1
1h	IC_STAT2	IC Status Register 2	Section 6.7.1.2
2h	IC_STAT3	IC Status Register 3	Section 6.7.1.3
3h	IC_STAT4	IC Status Register 4	Section 6.7.1.4
4h	IC_STAT5	IC Status Register 5	Section 6.7.1.5
5h	IC_STAT6	IC Status Register 6	Section 6.7.1.6

Complex bit access types are encoded to fit into small table cells. Table 6-11 shows the codes that are used for access types in this section.

Table 6-11. STATUS Access Type Codes

Access Type	Code	Description
Read Type		
R	R	Read
Reset or Default Value		
-n		Value after reset or the default value

6.7.1.1 IC_STAT1 Register (Offset = 0h) [Reset = 8080h]

IC_STAT1 is shown in [Table 6-12](#).

Return to the [Summary Table](#).

Table 6-12. IC_STAT1 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	SPI_OK	R	1h	No SPI Fault is detected 0h = SPI Fault is detected 1h = No fault
14	FAULT	R	0h	Logic OR of FAULT status registers. Inverse mirror of nFAULT pin. 0h = nFAULT pin is high. No fault events detected. 1h = nFAULT pin is low. One or multiple fault events detected.
13	WARN	R	0h	Logic OR of WARN status, except OTW 0h = No warning event detected 1h = One or multiple warning event detected
12	VDS	R	0h	Logic OR of VDS overcurrent detection 0h = No VDS events detected. 1h = One or multiple VDS events detected.
11	VGS	R	0h	Logic OR of VGS detection 0h = No VGS events detected. 1h = One or multiple VGS events detected.
10	SNS_OCP	R	0h	Logic OR of Sense overcurrent detection 0h = No sense overcurrent events detected. 1h = One or multiple sense overcurrent events detected.
9	OV	R	0h	Logic OR of supply voltage overvoltage detection 0h = No overvoltage events detected. 1h = One ore more overvoltage events detected.
8	UV	R	0h	Logic OR of supply voltage undervoltage detection 0h = No undervoltage events detected. 1h = One ore more undervoltage events detected.
7	RESET_STAT	R	1h	Digital reset status: follows digital reset signal. Cleared by setting CLR_FLT=1. 0h = Signal has been cleared by setting CLR_FLT to 1 1h = Digital has come out from reset
6	RESERVED	R	0h	Reserved
5	RESERVED	R	0h	Reserved
4	RESERVED	R	0h	Reserved
3	RESERVED	R	0h	Reserved
2	RESERVED	R	0h	Reserved
1	OTW	R	0h	Overtemperature Warning Status Bit 0h = No event is detected 1h = Overtemperature warning event detected
0	DRV_STAT	R	0h	Indicates Driver Enable Status: driver is following INxx inputs. Status will start as 0b, but will self-set to 1b at completion of power-up sequence. 0h = Driver output is disabled 1h = Driver output is enabled

6.7.1.2 IC_STAT2 Register (Offset = 1h) [Reset = 0000h]

IC_STAT2 is shown in [Table 6-13](#).

Return to the [Summary Table](#).

Table 6-13. IC_STAT2 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	RESERVED	R	0h	Reserved
14	RESERVED	R	0h	Reserved
13	RESERVED	R	0h	Reserved
12	RESERVED	R	0h	Reserved
11	RESERVED	R	0h	Reserved
10	SNS_OCP_A	R	0h	Overcurrent on External Sense Resistor Status Bit on phase A 0h = No fault detected 1h = Fault detected
9	SNS_OCP_B	R	0h	Overcurrent on External Sense Resistor Status Bit on phase B 0h = No fault detected 1h = Fault detected
8	SNS_OCP_C	R	0h	Overcurrent on External Sense Resistor Status Bit on phase C 0h = No fault detected 1h = Fault detected
7	RESERVED	R	0h	Reserved
6	PH_DIAG_ACTIVE	R	0h	PH_DIAG is active (one or more of PH_DIAG_xx is high) 0h = PH_DIAG not currently active 1h = PH_DIAG is currently active
5	VDS_HA	R	0h	VDS Overcurrent Status on the A High-side MOSFET 0h = No fault detected 1h = Fault detected
4	VDS_LA	R	0h	VDS Overcurrent Status on the A Low-side MOSFET 0h = No fault detected 1h = Fault detected
3	VDS_HB	R	0h	VDS Overcurrent Status on the B High-side MOSFET 0h = No fault detected 1h = Fault detected
2	VDS_LB	R	0h	VDS Overcurrent Status on the B Low-side MOSFET 0h = No fault detected 1h = Fault detected
1	VDS_HC	R	0h	VDS Overcurrent Status on the C High-side MOSFET 0h = No fault detected 1h = Fault detected
0	VDS_LC	R	0h	VDS Overcurrent Status on the C Low-side MOSFET 0h = No fault detected 1h = Fault detected

6.7.1.3 IC_STAT3 Register (Offset = 2h) [Reset = 0000h]

IC_STAT3 is shown in [Table 6-14](#).

Return to the [Summary Table](#).

Table 6-14. IC_STAT3 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	SHT_VDD_FLT_A	R	0h	Short-to-battery status on phase A 0h = No fault detected 1h = Fault detected
14	SHT_VDD_FLT_B	R	0h	Short-to-battery status on phase B 0h = No fault detected 1h = Fault detected
13	SHT_VDD_FLT_C	R	0h	Short-to-battery status on phase C 0h = No fault detected 1h = Fault detected
12	SHT_GND_FLT_A	R	0h	Short-to-GND status on phase A 0h = No fault detected 1h = Fault detected
11	SHT_GND_FLT_B	R	0h	Short-to-GND status on phase B 0h = No fault detected 1h = Fault detected
10	SHT_GND_FLT_C	R	0h	Short-to-GND status on phase C 0h = No fault detected 1h = Fault detected
9	OPEN_FLT_A	R	0h	Open load status on phase A 0h = No fault detected 1h = Fault detected
8	OPEN_FLT_B	R	0h	Open load status on phase B 0h = No fault detected 1h = Fault detected
7	OPEN_FLT_C	R	0h	Open load status on phase C 0h = No fault detected 1h = Fault detected
6	RESERVED	R	0h	Reserved
5	VGS_HA	R	0h	Gate driver fault status on the A High-side MOSFET. 0h = No fault detected 1h = Fault detected
4	VGS_LA	R	0h	Gate driver fault status on the A Low-side MOSFET. 0h = No fault detected 1h = Fault detected
3	VGS_HB	R	0h	Gate driver fault status on the B High-side MOSFET. 0h = No fault detected 1h = Fault detected
2	VGS_LB	R	0h	Gate driver fault status on the B Low-side MOSFET. 0h = No fault detected 1h = Fault detected
1	VGS_HC	R	0h	Gate driver fault status on the C High-side MOSFET. 0h = No fault detected 1h = Fault detected
0	VGS_LC	R	0h	Gate driver fault status on the C Low-side MOSFET. 0h = No fault detected 1h = Fault detected

6.7.1.4 IC_STAT4 Register (Offset = 3h) [Reset = 0000h]

IC_STAT4 is shown in [Table 6-15](#).

Return to the [Summary Table](#).

Table 6-15. IC_STAT4 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	RESERVED	R	0h	RESERVED
14	DVDD_OV	R	0h	DVDD overvoltage detection 0h = No event is detected 1h = DVDD overvoltage event detected
13	VDRAIN_OV	R	0h	VDRAIN overvoltage status 0h = No fault detected 1h = Fault detected
12	VDRAIN_UVH	R	0h	VDRAIN undervoltage status, High threshold 0h = No fault detected 1h = Fault detected
11	VDRAIN_UVL	R	0h	VDRAIN undervoltage status, Low threshold 0h = No fault detected 1h = Fault detected
10	VCP_UV	R	0h	VCP undervoltage status 0h = No fault detected 1h = Fault detected
9	GVDD_OV	R	0h	GVDD overvoltage status 0h = No fault detected 1h = Fault detected
8	GVDD_UVH	R	0h	GVDD undervoltage status, high threshold 0h = No fault detected 1h = Fault detected
7	GVDD_UV_BST	R	0h	GVDD undervoltage status, BST 0h = No fault detected 1h = Fault detected
6	RESERVED	R	0h	
5	RESERVED	R	0h	
4	VREF_UV	R	0h	VREF undervoltage status 0h = No fault detected 1h = Fault detected
3	BST_TIMEOUT_FLT	R	0h	BST timeout fault during power-up (either BST_UV or VCP_UV remained high for longer than ~10ms during power-up sequence) 0h = No fault detected 1h = Fault detected
2	BSTA_UV	R	0h	BST undervoltage on the A High-side MOSFET 0h = No fault detected 1h = Fault detected
1	BSTB_UV	R	0h	BST undervoltage on the B High-side MOSFET 0h = No fault detected 1h = Fault detected
0	BSTC_UV	R	0h	BST undervoltage on the C High-side MOSFET 0h = No fault detected 1h = Fault detected

6.7.1.5 IC_STAT5 Register (Offset = 4h) [Reset = 0000h]

IC_STAT5 is shown in [Table 6-16](#).

Return to the [Summary Table](#).

Table 6-16. IC_STAT5 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	RESERVED	R	0h	RESERVED
14	RESERVED	R	0h	RESERVED
13	RESERVED	R	0h	
12	RESERVED	R	0h	
11	OTSD_TCP	R	0h	Overtemperature Shutdown TCP Status Bit 0h = No event is detected 1h = Overtemperature shutdown TCP event detected
10	OTSD	R	0h	Overtemperature Shutdown Status Bit 0h = No event is detected 1h = Overtemperature shutdown event detected
9	WDT_FLT	R	0h	Watchdog timer fault status 0h = No fault detected 1h = Fault detected
8	SPI_PAR_FLT	R	0h	SPI parity bit fault status 0h = No fault detected 1h = Fault detected
7	SPI_CRC_FLT	R	0h	SPI CRC fault status 0h = No fault detected 1h = Fault detected
6	SPI_ADDR_FLT	R	0h	SPI address fault status 0h = No fault detected 1h = Attempted access to invalid register address detected
5	SPI_CLK_FLT	R	0h	SPI clock fault status 0h = No fault detected 1h = Incorrect number of SCLK cycles detected
4	OTP_CRC_FLT	R	0h	OTP CRC fault status 0h = No fault detected 1h = Fault in device OTP settings detected. Issuing a CLR_FLT command will enable gate drive output, but this fault reporting bit will remain latched.
3	DEV_MODE_FLT	R	0h	Device mode fault status 0h = No fault detected 1h = Fault detected
2	RESERVED	R	0h	
1	STP_FLT	R	0h	Shoot-through protection fault status 0h = No fault detected 1h = Shoot-through input condition detected (INHx/INLx high simultaneously)
0	DEADT_FLT	R	0h	Deadtime protection fault status 0h = No fault detected 1h = Minimum dead time violation detected

6.7.1.6 IC_STAT6 Register (Offset = 5h) [Reset = 0000h]

IC_STAT6 is shown in [Table 6-17](#).

Return to the [Summary Table](#).

Table 6-17. IC_STAT6 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	RESERVED	R	0h	
14	RESERVED	R	0h	
13	RESERVED	R	0h	
12	RESERVED	R	0h	
11	RESERVED	R	0h	
10	RESERVED	R	0h	
9	RESERVED	R	0h	
8	RESERVED	R	0h	
7	VDRAIN_UVOV_RAW	R	0h	Un-latched status bit of VDRAIN OV/UV monitor output 0h = No fault detected 1h = Fault detected
6	GVDD_UVOV_RAW	R	0h	Un-latched status bit of GVDD OV/UV monitor output 0h = No fault detected 1h = Fault detected
5	BST_VCP_UV_RAW	R	0h	Un-latched status bit of BST UV and VCP UV monitor output 0h = No fault detected 1h = Fault detected
4	VREF_UV_RAW	R	0h	Un-latched status but of VREF UV monitor output 0h = No fault detected 1h = Fault detected
3	DVDD_OV_RAW	R	0h	Un-latched status bit of DVDD OV monitor output 0h = No fault detected 1h = Fault detected
2	OTSD_RAW	R	0h	Un-latched status bit of OTSD monitor output 0h = No fault detected 1h = Fault detected
1	RESERVED	R	0h	
0	RESERVED	R	0h	

6.7.2 CONTROL Registers

Table 6-18 lists the memory-mapped registers for the CONTROL registers. All register offset addresses not listed in Table 6-18 should be considered as reserved locations and the register contents should not be modified.

Table 6-18. CONTROL Registers

Offset	Acronym	Description	Section
9h	IC_CTRL1	IC Control Register 1	Section 6.7.2.1
Ah	IC_CTRL2	IC Control Register 2	Section 6.7.2.2
Bh	GD_CTRL1	Gate Drive Control Register 1	Section 6.7.2.3
Ch	GD_CTRL2	Gate Drive Control Register 2	Section 6.7.2.4
Dh	GD_CTRL3	Gate Drive Control Register 3	Section 6.7.2.5
Eh	GD_CTRL4	Gate Drive Control Register 4	Section 6.7.2.6
Fh	GD_CTRL5	Gate Drive Control Register 5	Section 6.7.2.7
13h	CSA_CTRL1	CSA Control Register 1	Section 6.7.2.8
14h	CSA_CTRL2	CSA Control Register 2	Section 6.7.2.9
15h	MON_CTRL1	Monitor Control Register 1	Section 6.7.2.10
16h	MON_CTRL2	Monitor Control Register 2	Section 6.7.2.11
17h	MON_CTRL3	Monitor Control Register 3	Section 6.7.2.12
18h	MON_CTRL4	Monitor Control Register 4	Section 6.7.2.13
19h	MON_CTRL5	Monitor Control Register 5	Section 6.7.2.14
1Ah	MON_CTRL6	Monitor Control Register 6	Section 6.7.2.15
1Bh	DIAG_CTRL1	Diagnostic Control Register 1	Section 6.7.2.16
1Ch	IC_CTRL_SP	IC Control Special Register	Section 6.7.2.17

Complex bit access types are encoded to fit into small table cells. Table 6-19 shows the codes that are used for access types in this section.

Table 6-19. CONTROL Access Type Codes

Access Type	Code	Description
Read Type		
R	R	Read
Write Type		
W	W	Write
Reset or Default Value		
-n		Value after reset or the default value

6.7.2.1 IC_CTRL1 Register (Offset = 9h) [Reset = 0106h]

IC_CTRL1 is shown in [Table 6-20](#).

Return to the [Summary Table](#).

Table 6-20. IC_CTRL1 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	DIS_PWM_INPUT	R/W	0h	Disable PWM inputs 0h = Gate driver outputs are controlled by INHx and INL digital inputs. 1h = INHx and INLx digital inputs are ignored and the gate driver outputs are pulled low (active pull down) by default.
14	WARN_MODE	R/W	0h	Warning nFAULT mode; Control nFAULT response for warning events 0h = No nFAULT reporting for warning response. Status flags are set. 1h = nFAULT is driven low for warning response. Status flags are set.
13	DIS_SSC	R/W	0h	TI Internal design parameter: No change is required unless notified by TI. The bit disables Spread Spectrum Clocking feature of the device internal oscillator 0h = Normal operation. Spread Spectrum Clocking feature is enabled. 1h = Spread Spectrum Clock feature is disabled for TI debug purpose.
12	RESERVED	R	0h	Reserved
11	ASC_LS_FORCE	R/W	0h	Force LS ASC under any non-global-shutdown condition (even under OCP_VDS_LS_x fault) if LS ASC is activated. This will not affect HS ASC. 0h = LS ASC is not forced 1h = LS ASC is forced as described
10	ASC_POLARITY	R/W	0h	ASC on LS or HS 0h = ASC by turning ON all LS FETs 1h = ASC by turning ON all HS FETs
9	SPI_ASC_EN	R/W	0h	Enable ASC (OR'ed with ASCIN pin) 0h = Normal operation mode 1h = Enable ASC
8	ASC_PRIORITY	R/W	1h	ASC priority over faults other than OTSD, GVDD_UVH, GVDDD_OV, and DRVOFF. These three listed faults have always priority over ASC. 0h = ASC has lower priority than all faults 1h = ASC has priority over faults other than OTSD, GVDD_UVH and DRVOFF (default)
7	RESERVED	R	0h	Reserved
6	RESERVED	R	0h	Reserved
5	RESERVED	R	0h	Reserved
4	RESERVED	R	0h	Reserved
3-1	LOCK	R/W	3h	Lock and unlock the register setting Bit settings not listed have no effect. 3h = Unlock all the registers 6h = Lock the settings by ignoring further register writes except to these bits.

Table 6-20. IC_CTRL1 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
0	CLR_FLT	R/W	0h	Clear fault. After fault event is detected and fault flag is set, it's recommended to issue CLR_FLT command first, then ENABLE_DRV command next in a separate SPI frame. If CLR_FLT and ENABLE_DRV commands are issued in the same SPI frame, CLR_FLT is higher priority and ENABLE_DRV will not be set if fault flag is already latched and the device is waiting CLR_FLT. 0h = No action 1h = Clear faults. Bit will not self-clear, but clear fault operation is only performed once when this register/bit is written.

6.7.2.2 IC_CTRL2 Register (Offset = Ah) [Reset = 0000h]

IC_CTRL2 is shown in [Table 6-21](#).

Return to the [Summary Table](#).

Table 6-21. IC_CTRL2 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	RESERVED	R	0h	Reserved
14	RESERVED	R	0h	Reserved
13	RESERVED	R	0h	Reserved
12	RESERVED	R	0h	Reserved
11	RESERVED	R	0h	Reserved
10	RESERVED	R	0h	Reserved
9	RESERVED	R	0h	Reserved
8	RESERVED	R	0h	Reserved
7	RESERVED	R	0h	Reserved
6	TCP_SW_CURLIM	R/W	0h	TCP Switch current limit after TCP_SW_DLY 0h = 1.25mA (typ) 1h = 2.3mA (typ)
5-4	TCP_SW_HD_CURLIM	R/W	0h	TCP Switch HD current limit for High Duty cycle (TCP_HD_DIS=0) 0h = 7.7mA (typ) 1h = 6.4mA (typ) 2h = 10.5mA (typ) 3h = 9.2mA (typ)
3	TCP_SW_DLY	R/W	0h	Delay time to activate trickle charge pump after the device detects PWM inactive (INHx=INLx=Low) 0h = 100us (typ) 1h = 250us (typ)
2	TCP_HD_DIS	R/W	0h	VCP/TCP high-duty disabled 0h = TCP High-Duty cycle is enabled 1h = TCP High-Duty cycle is disabled
1-0	TCP_SW_MODE	R/W	0h	VCP/TCP mode control 0h = Normal VCP/TCP operation. VCP/TCP is enabled at power up. TCP SW responds to PWM inputs. TCP SW is enabled even if SPI DIS_PWM_INPUT is 1. When DRVOFF is high and if system expects the device to keep BST cap stay charged, TCP_SW_MODE must be 00b. 1h = VCP/CPTH-SHx switch is disabled. VCP/TCP charge pump clock is active. 2h = VCP/TCP shutdown. Both VCP/CPTH-SHx switch and VCP/TCP charge pump clock are disabled. 3h = Normal VCP/TCP operation. VCP/TCP is enabled at power up.

6.7.2.3 GD_CTRL1 Register (Offset = Bh) [Reset = 0038h]

GD_CTRL1 is shown in [Table 6-22](#).

Return to the [Summary Table](#).

Table 6-22. GD_CTRL1 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	PWM1X_COM	R/W	0h	1x PWM Commutation Control 0h = 1x PWM mode uses synchronous rectification 1h = 1x PWM mode uses asynchronous rectification
14	PWM1X_DIR	R/W	0h	1x PWM Direction. In 1x PWM mode this bit is ORed with the INHC (DIR) input
13-12	PWM1X_BRAKE	R/W	0h	1x PWM output configuration 0h = Outputs follow commanded inputs 1h = Turn on all three low-side MOSFETs 2h = Turn on all three high-side MOSFETs 3h = Turn off all six MOSFETs (coast)
11	RESERVED	R	0h	Reserved
10	RESERVED	R	0h	Reserved
9-8	PWM_MODE	R/W	0h	PWM mode 0h = 6x PWM mode (INHx/INLx) 1h = 3x PWM mode with INLx enable control 2h = 1x PWM mode (INHx/INLx) 3h = Independent
7	STP_MODE_6X	R/W	0h	Control reporting for STP faults in 6xPWM mode 0h = Reporting enabled (outputs forced low) 1h = Reporting disabled (outputs forced low)
6-3	DEADT	R/W	7h	Gate driver dead time 0h = 70ns 1h = 120ns 2h = 180ns 3h = 300ns 4h = 400ns 5h = 500ns 6h = 600ns 7h = 750ns 8h = 1000ns 9h = 1.5us Ah = 2us Bh = 2.5us Ch = 3us Dh = 3.5us Eh = 5us Fh = 10us
2	DEADT_MODE	R/W	0h	Open Loop/Closed Loop 0h = Dead time is inserted when device input (INHx or INLx) goes low 1h = Dead time is inserted by monitoring gate driver outputs (GHx or GLx)

Table 6-22. GD_CTRL1 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
1-0	DEADT_MODE_6X	R/W	0h	<p>Dead Time Violation Response Mode for 6 PWM mode only. NOTE: Other than 6 PWM mode, dead time is always inserted regardless of the DEADT_MODE bit and no fault is reported to the MCU.</p> <p>0h = Dead-time protection is enabled. Reporting is performed. Gate driver control signals are enforced low during the dead time period. SPI fault flag is set and nFAULT pin is driven low when dead time condition is detected.</p> <p>1h = Dead-time protection is enabled. Reporting is not performed. Gate driver control signals are enforced low during the dead time period. SPI fault flag is never set and nFAULT pin stays high when dead time condition is detected.</p> <p>2h = Dead-time protection is disabled. No dead time is inserted. No SPI fault flag is set and the nFAULT1 pin stays high. This is applied to both cases when DEADT_MODE is 0b (monitoring INH or INL) and 1b (monitoring GHx or GLx).</p> <p>3h = Dead-time protection is enabled and SPI fault is set but no nFAULT reporting is performed. Gate driver outputs are forced low during dead time period. nFAULT pin stays high when dead time condition is detected.</p>

6.7.2.4 GD_CTRL2 Register (Offset = Ch) [Reset = 7700h]

GD_CTRL2 is shown in [Table 6-23](#).

Return to the [Summary Table](#).

Table 6-23. GD_CTRL2 Register Field Descriptions

Bit	Field	Type	Reset	Description
15-12	TDRVP	R/W	7h	Peak source pull up drive timing 0h = 200ns 1h = 300ns 2h = 400ns 3h = 500ns 4h = 650ns 5h = 750ns 6h = 900ns 7h = 1000ns 8h = 1.4us 9h = 1.6us Ah = 2us Bh = 2.2us Ch = 2.6us Dh = 3us Eh = 3.5us Fh = 4us
11-8	TDRVN	R/W	7h	Peak sink pull down drive timing 0h = 200ns 1h = 300ns 2h = 400ns 3h = 500ns 4h = 650ns 5h = 750ns 6h = 900ns 7h = 1000ns 8h = 1.4us 9h = 1.6us Ah = 2us Bh = 2.2us Ch = 2.6us Dh = 3us Eh = 3.5us Fh = 4us
7	RESERVED	R	0h	Reserved
6	RESERVED	R	0h	Reserved
5	RESERVED	R	0h	Reserved
4	IHOLD_SEL	R/W	0h	Select IHOLD pull-up and pull-down current. IHOLD_SEL bit must be configured while PWM is inactive (ENABLE_DRV is 0b). 0h = IHOLD pull-up 1024mA (typ) 1h = IHOLD pull-up 256mA (typ)

Table 6-23. GD_CTRL2 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
3-0	IDRVN_SD	R/W	0h	Soft shutdown drive current. 0h = 32mA 1h = 64mA 2h = 128mA 3h = 192mA 4h = 256mA 5h = 320mA 6h = 384mA 7h = 448mA 8h = 512mA 9h = 576mA Ah = 640mA Bh = 768mA Ch = 1024mA Dh = 1536mA Eh = 2048mA Fh = 2048mA

6.7.2.5 GD_CTRL3 Register (Offset = Dh) [Reset = 0000h]

GD_CTRL3 is shown in [Table 6-24](#).

Return to the [Summary Table](#).

Table 6-24. GD_CTRL3 Register Field Descriptions

Bit	Field	Type	Reset	Description
15-12	IDRVP_HA	R/W	0h	High-side A peak source pull up current. 0h = 16mA 1h = 32mA 2h = 64mA 3h = 96mA 4h = 128mA 5h = 160mA 6h = 192mA 7h = 224mA 8h = 256mA 9h = 288mA Ah = 320mA Bh = 384mA Ch = 512mA Dh = 768mA Eh = 1024mA Fh = 1024mA
11-8	IDRVN_HA	R/W	0h	High-side A peak sink pull down current. 0h = 32mA 1h = 64mA 2h = 128mA 3h = 192mA 4h = 256mA 5h = 320mA 6h = 384mA 7h = 448mA 8h = 512mA 9h = 576mA Ah = 640mA Bh = 768mA Ch = 1024mA Dh = 1536mA Eh = 2048mA Fh = 2048mA
7-4	IDRVP_LA	R/W	0h	Low-side A peak source pull up current. 0h = 16mA 1h = 32mA 2h = 64mA 3h = 96mA 4h = 128mA 5h = 160mA 6h = 192mA 7h = 224mA 8h = 256mA 9h = 288mA Ah = 320mA Bh = 384mA Ch = 512mA Dh = 768mA Eh = 1024mA Fh = 1024mA

Table 6-24. GD_CTRL3 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
3-0	IDRVN_LA	R/W	0h	Low-side A peak sink pull down current. 0h = 32mA 1h = 64mA 2h = 128mA 3h = 192mA 4h = 256mA 5h = 320mA 6h = 384mA 7h = 448mA 8h = 512mA 9h = 576mA Ah = 640mA Bh = 768mA Ch = 1024mA Dh = 1536mA Eh = 2048mA Fh = 2048mA

6.7.2.6 GD_CTRL4 Register (Offset = Eh) [Reset = 0000h]

GD_CTRL4 is shown in [Table 6-25](#).

Return to the [Summary Table](#).

Table 6-25. GD_CTRL4 Register Field Descriptions

Bit	Field	Type	Reset	Description
15-12	IDRVP_HB	R/W	0h	High-side B peak source pull up current. 0h = 16mA 1h = 32mA 2h = 64mA 3h = 96mA 4h = 128mA 5h = 160mA 6h = 192mA 7h = 224mA 8h = 256mA 9h = 288mA Ah = 320mA Bh = 384mA Ch = 512mA Dh = 768mA Eh = 1024mA Fh = 1024mA
11-8	IDRVN_HB	R/W	0h	High-side B peak sink pull down current. 0h = 32mA 1h = 64mA 2h = 128mA 3h = 192mA 4h = 256mA 5h = 320mA 6h = 384mA 7h = 448mA 8h = 512mA 9h = 576mA Ah = 640mA Bh = 768mA Ch = 1024mA Dh = 1536mA Eh = 2048mA Fh = 2048mA
7-4	IDRVP_LB	R/W	0h	Low-side B peak source pull up current. 0h = 16mA 1h = 32mA 2h = 64mA 3h = 96mA 4h = 128mA 5h = 160mA 6h = 192mA 7h = 224mA 8h = 256mA 9h = 288mA Ah = 320mA Bh = 384mA Ch = 512mA Dh = 768mA Eh = 1024mA Fh = 1024mA

Table 6-25. GD_CTRL4 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
3-0	IDRVN_LB	R/W	0h	Low-side B peak sink pull down current. 0h = 32mA 1h = 64mA 2h = 128mA 3h = 192mA 4h = 256mA 5h = 320mA 6h = 384mA 7h = 448mA 8h = 512mA 9h = 576mA Ah = 640mA Bh = 768mA Ch = 1024mA Dh = 1536mA Eh = 2048mA Fh = 2048mA

6.7.2.7 GD_CTRL5 Register (Offset = Fh) [Reset = 0000h]

GD_CTRL5 is shown in [Table 6-26](#).

Return to the [Summary Table](#).

Table 6-26. GD_CTRL5 Register Field Descriptions

Bit	Field	Type	Reset	Description
15-12	IDRVP_HC	R/W	0h	High-side C peak source pull up current. 0h = 16mA 1h = 32mA 2h = 64mA 3h = 96mA 4h = 128mA 5h = 160mA 6h = 192mA 7h = 224mA 8h = 256mA 9h = 288mA Ah = 320mA Bh = 384mA Ch = 512mA Dh = 768mA Eh = 1024mA Fh = 1024mA
11-8	IDRVN_HC	R/W	0h	High-side C peak sink pull down current. 0h = 32mA 1h = 64mA 2h = 128mA 3h = 192mA 4h = 256mA 5h = 320mA 6h = 384mA 7h = 448mA 8h = 512mA 9h = 576mA Ah = 640mA Bh = 768mA Ch = 1024mA Dh = 1536mA Eh = 2048mA Fh = 2048mA
7-4	IDRVP_LC	R/W	0h	Low-side C peak source pull up current. 0h = 16mA 1h = 32mA 2h = 64mA 3h = 96mA 4h = 128mA 5h = 160mA 6h = 192mA 7h = 224mA 8h = 256mA 9h = 288mA Ah = 320mA Bh = 384mA Ch = 512mA Dh = 768mA Eh = 1024mA Fh = 1024mA

Table 6-26. GD_CTRL5 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
3-0	IDRVN_LC	R/W	0h	Low-side C peak sink pull down current. 0h = 32mA 1h = 64mA 2h = 128mA 3h = 192mA 4h = 256mA 5h = 320mA 6h = 384mA 7h = 448mA 8h = 512mA 9h = 576mA Ah = 640mA Bh = 768mA Ch = 1024mA Dh = 1536mA Eh = 2048mA Fh = 2048mA

6.7.2.8 CSA_CTRL1 Register (Offset = 13h) [Reset = 0000h]

CSA_CTRL1 is shown in [Table 6-27](#).

Return to the [Summary Table](#).

Table 6-27. CSA_CTRL1 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	RESERVED	R	0h	Reserved
14	RESERVED	R	0h	Reserved
13	RESERVED	R	0h	Reserved
12	RESERVED	R	0h	Reserved
11	RESERVED	R	0h	Reserved
10	RESERVED	R	0h	Reserved
9	RESERVED	R	0h	Reserved
8	RESERVED	R	0h	Reserved
7	RESERVED	R	0h	Reserved
6	RESERVED	R	0h	Reserved
5-4	CSA_AZ_TMAX	R/W	0h	Max delay to toggle CSA_CLK if no PWM input switching 0h = 250us 1h = 1ms 2h = 5ms 3h = No delay
3	CSA_AZ_DIS	R/W	0h	Current Sense Amplifier Auto Zero function disable 0h = CSA Auto Zero function is enabled. This bit should be 0b during normal PWM/CSA operation. 1h = CSA Auto Zero function is disabled. The purpose of this bit is to disable switching activity of current sense amplifier for auto zero function. Refer to timing requirements if this bit is used.
2	CSA_A_DIS	R/W	0h	Disable CSA channel A 0h = CSA channel A enabled 1h = CSA channel A disabled
1	CSA_B_DIS	R/W	0h	Disable CSA channel B 0h = CSA channel B enabled 1h = CSA channel B disabled
0	CSA_C_DIS	R/W	0h	Disable CSA channel C 0h = CSA channel C enabled 1h = CSA channel C disabled

6.7.2.9 CSA_CTRL2 Register (Offset = 14h) [Reset = 0000h]

CSA_CTRL2 is shown in [Table 6-28](#).

Return to the [Summary Table](#).

Table 6-28. CSA_CTRL2 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	AREF_DIV	R/W	0h	VREF dividing ratio 0h = 1/2 1h = 1/8
14	RESERVED	R	0h	Reserved
13	RESERVED	R	0h	Reserved
12	RESERVED	R	0h	Reserved
11-8	WDT_TEST	R/W	0h	SPI Test field, write access here has no effect on device settings. Also used for WDT, any valid SPI write to this field will reset the watchdog timer if accessed within the correct window.
7	RESERVED	R	0h	Reserved
6	RESERVED	R	0h	Reserved
5-4	CSA_GAIN_A	R/W	0h	CSA Gain of SOA. Gain can be updated during PWM operation. Undefined settings (1001b - 1111b) are 40. 0h = 5 1h = 10 2h = 20 3h = 40
3-2	CSA_GAIN_B	R/W	0h	CSA Gain of SOB. Gain can be updated during PWM operation. Undefined settings (1001b - 1111b) are 40. 0h = 5 1h = 10 2h = 20 3h = 40
1-0	CSA_GAIN_C	R/W	0h	CSA Gain of SOC. Gain can be updated during PWM operation. Undefined settings (1001b - 1111b) are 40. 0h = 5 1h = 10 2h = 20 3h = 40

6.7.2.10 MON_CTRL1 Register (Offset = 15h) [Reset = 4000h]

MON_CTRL1 is shown in [Table 6-29](#).

Return to the [Summary Table](#).

Table 6-29. MON_CTRL1 Register Field Descriptions

Bit	Field	Type	Reset	Description
15-14	VDRAIN_OV_LVL	R/W	1h	VDRAIN Overvoltage threshold level 0h = 36V (typ) 1h = 54V (typ) 2h = 72V (typ) 3h = 84V (typ)
13-12	VDRAIN_UVH_LVL	R/W	0h	VDRAIN UV High threshold level 0h = 18V 1h = 20V 2h = 22V 3h = 24V
11	VDRAIN_UVL_LVL	R/W	0h	VDRAIN UV Low threshold level 0h = 10.5V 1h = 5.55V
10-8	VDRAIN_OV_MODE	R/W	0h	When set for ASC mode: HS or LS ASC from ASC_POLARITY bit If VDRAIN_OV=1 while WPD on VDS response then ASC and LS APD (no WPD) regardless of ASC_POLARITY 0h = Warning mode (latched) 1h = Fault mode (latched) 2h = ASC mode (latched, HS or LS based on ASC_POLARITY or VDS fault) 3h = ASC mode (autorecovery, HS or LS based on ASC_POLARITY or VDS fault) 4h = Default mode 5h = Default mode 6h = Default mode 7h = No report. No shutdown.
7-6	VDRAIN_UVH_MODE	R/W	0h	VDRAIN monitor mode for under voltage monitor 0h = Warning mode (latched) 1h = Fault mode (latched) 2h = Warning mode (autorecovery) 3h = No report. No shutdown.
5-4	VDRAIN_UVL_MODE	R/W	0h	VDRAIN monitor mode for under voltage monitor 0h = Warning mode (latched) 1h = Fault mode (latched) 2h = Warning mode (autorecovery) VDS faults are disabled 3h = No report. No shutdown.
3	GVDD_UVH_MODE	R/W	0h	GVDD_UVH monitor mode 0h = Warning mode (latched) 1h = Fault mode (latched)
2-1	GVDD_UV_BST_MODE	R/W	0h	GVDD_UV_BST monitor mode. nFAULT remains high regardless of WARN_MODE. 0h = Warning mode (autorecovery), VCP_UV input remains enabled, BST_UV_LVL not forced 1h = Warning special mode (latched), VCP_UV input disabled, BST_UV_LVL is 1 2h = Warning special mode (autorecovery), VCP_UV input disabled, BST_UV_LVL is 1 3h = No report. No action.
0	GVDD_UV_BST_LVL	R/W	0h	GVDD_UV_BST monitor threshold level. 0h = 10.6V (typ) 1h = 9.6V (typ)

6.7.2.11 MON_CTRL2 Register (Offset = 16h) [Reset = 8003h]

MON_CTRL2 is shown in [Table 6-30](#).

Return to the [Summary Table](#).

Table 6-30. MON_CTRL2 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	GVDD_OV_MODE	R/W	1h	GVDD monitor mode of over voltage monitor 0h = Warning mode (latched) 1h = Fault mode (latched)
14	VDRAIN_UVL_MASK	R/W	0h	If active it masks VDRAIN_UVL during first power-up sequence. 0h = Normal operation 1h = VDRAIN_UVL is masked during first power-up sequence
13	RESERVED	R	0h	Reserved
12	RESERVED	R	0h	Reserved
11	SNS_OCP_STD_SHD	R/W	0h	Shutdown type for SNS_OCP faults 0h = Soft shutdown sequence (uses IDRIVENS D) 1h = Standard shutdown sequence (uses IDRIVEN)
10	SNS_OCP_A_EN	R/W	0h	Shunt OCP enable for channel A 0h = Shunt OCP for channel A disabled 1h = Shunt OCP for channel A enabled
9	SNS_OCP_B_EN	R/W	0h	Shunt OCP enable for channel B 0h = Shunt OCP for channel B disabled 1h = Shunt OCP for channel B enabled
8	SNS_OCP_C_EN	R/W	0h	Shunt OCP enable for channel C 0h = Shunt OCP for channel C disabled 1h = Shunt OCP for channel C enabled
7	SNS_OCP_LVL	R/W	0h	Threshold voltage of V_{SENSE} overcurrent protection (shunt OCP). Threshold is represented as a % of VREF. 0h = 80%/20% of VREF-GND 1h = 90%/10% of VREF-GND
6	RESERVED	R	0h	Reserved
5	SNS_OCP_TRETRY	R/W	0h	Sense OCP retry time 0h = 1ms 1h = 9ms
4-2	SNS_OCP_MODE	R/W	0h	Monitor mode of V_{SENSE} overcurrent protection (Rshunt monitor) 0h = Warning mode (latched) 1h = Fault mode (latched) 2h = Warning mode (autorecovery) 3h = Fault mode (autorecovery) 4h = Limit mode (autorecovery CBC) 5h = Default mode 6h = Default mode 7h = No report. No shutdown.
1-0	SNS_OCP_DEG	R/W	3h	Deglint time of V_{SENSE} overcurrent protection (Rshunt monitor) 0h = 3.0us (typ) 1h = 6.0us (typ) 2h = 9.0us (typ) 3h = 12.0us (typ)

6.7.2.12 MON_CTRL3 Register (Offset = 17h) [Reset = 5101h]

MON_CTRL3 is shown in [Table 6-31](#).

Return to the [Summary Table](#).

Table 6-31. MON_CTRL3 Register Field Descriptions

Bit	Field	Type	Reset	Description
15-14	VDS_MODE	R/W	1h	VDS overcurrent mode 0h = Warning mode (latched) 1h = Fault mode (latched) 2h = Default mode 3h = No report. No shutdown.
13-11	VDS_VGS_BLK	R/W	2h	VDS overcurrent and VGS blanking time 0h = 150ns 1h = 500ns 2h = 1us 3h = 2us 4h = 6us 5h = 8us 6h = 10us 7h = 12us
10-8	VDS_DEG	R/W	1h	VDS overcurrent deglitch time 0h = 500ns 1h = 1us 2h = 1.5us 3h = 2us 4h = 4us 5h = 6us 6h = 8us 7h = 8us
7-6	VGS_MODE	R/W	0h	VGS monitor mode 0h = Warning mode (latched) 1h = Fault mode (latched) 2h = Default mode 3h = No report. No shutdown.
5	RESERVED	R	0h	Reserved
4	RESERVED	R	0h	Reserved
3	RESERVED	R	0h	Reserved
2-0	VGS_DEG	R/W	1h	VGS monitor deglitch time 0h = 500ns 1h = 1us 2h = 1.5us 3h = 2us 4h = 2us 5h = 2us 6h = 2us 7h = 2us

6.7.2.13 MON_CTRL4 Register (Offset = 18h) [Reset = 0000h]

MON_CTRL4 is shown in [Table 6-32](#).

Return to the [Summary Table](#).

Table 6-32. MON_CTRL4 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	RESERVED	R	0h	Reserved
14	RESERVED	R	0h	Reserved
13	RESERVED	R	0h	Reserved
12	RESERVED	R	0h	Reserved
11	RESERVED	R	0h	Reserved
10	RESERVED	R	0h	Reserved
9	RESERVED	R	0h	Reserved
8	RESERVED	R	0h	Reserved
7	RESERVED	R	0h	Reserved
6	RESERVED	R	0h	Reserved
5	WDT_FLT_MODE	R/W	0h	Watchdog Time Fault Mode 0h = Warning mode (latched) 1h = Fault mode (latched). Gate Driver shutdown.
4	WDT_CNT	R/W	0h	Watchdog Time Fault Count 0h = One time WDT fault reports status flag and asserts nFAULT1 pin low. 1h = Three consecutive faults report status flag and assert nFAULT pin low. Internal counter is cleared to 0 after the three consecutive faults are detected. Internal counter can also be cleared if WDT_EN is cleared to 0b.
3	WDT_MODE	R/W	0h	Watchdog Time MODE 0h = Any valid read access reset the watchdog timer 1h = A valid write access to CSA_CTRL2 resets the watchdog timer
2-1	WDT_W	R/W	0h	Watchdog Timer window tWDL (lower window) and tWDU (upper window) 0h = tWDL 0.5ms tWDU 10ms 1h = tWDL 1ms tWDU 20ms 2h = tWDL 2ms tWDU 40ms 3h = tWDL 2ms tWDU 40ms
0	WDT_EN	R/W	0h	Watchdog Time Enable 0h = Watchdog timer disabled 1h = Watchdog timer enabled

6.7.2.14 MON_CTRL5 Register (Offset = 19h) [Reset = 0000h]

MON_CTRL5 is shown in [Table 6-33](#).

Return to the [Summary Table](#).

Table 6-33. MON_CTRL5 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	RESERVED	R	0h	Reserved
14	RESERVED	R	0h	Reserved
13	RESERVED	R	0h	Reserved
12	RESERVED	R	0h	Reserved
11	RESERVED	R	0h	Reserved
10	RESERVED	R	0h	Reserved
9	RESERVED	R	0h	Reserved
8	RESERVED	R	0h	Reserved
7	RESERVED	R	0h	Reserved
6	DVDD_OV_MODE	R/W	0h	DVDD monitor for overvoltage 0h = Warning mode (latched) 1h = Fault mode (latched)
5-4	VCP_UV_MODE	R/W	0h	VCP monitor mode of under voltage monitor 0h = Warning mode (latched) 1h = Fault mode (latched, TCP ON) 2h = Fault mode (latched, TCP OFF) 3h = No report. No shutdown.
3	BST_UV_LVL	R/W	0h	BST pin undervoltage threshold level V_{BST_UV} 0h = 6.0V (typ) 1h = 5.0V (typ)
2-0	BST_UV_MODE	R/W	0h	BST pin UV monitor mode. 0h = Warning mode (latched) 1h = Fault mode (real time) HS Active PD 2h = Fault mode (real time) HS Weak PD 3h = Fault mode (latched) HS Active PD 4h = Fault mode (latched) HS Weak PD 5h = Fault mode (latched) HS Weak PD, TCP_SW OFF 6h = Default mode 7h = No report. No action.

6.7.2.15 MON_CTRL6 Register (Offset = 1Ah) [Reset = 2000h]

MON_CTRL6 is shown in [Table 6-34](#).

Return to the [Summary Table](#).

Table 6-34. MON_CTRL6 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	RESERVED	R	0h	Reserved
14	RESERVED	R	0h	Reserved
13	ALL_CH	R/W	1h	All channel shutdown enable 0h = Associated faulty half-bridge is shutdown (active pull down) in response to VDS, VGS and SNS_OCP. nFAULT goes low after all three channels have the faults. For a recovery sequence to re-start PWM, MCU uses CLR_FLT. 1h = All three half-bridges are shutdown (semi-active pull down) in response to VDS, VGS and SNS_OCP. nFAULT goes low if one or multiple channels have the faults.
12	RESERVED	R	0h	Reserved
11-8	VDS_LVL_A	R/W	0h	VDS overcurrent threshold for phase A 0h = 100mV 1h = 150mV 2h = 200mV 3h = 300mV 4h = 400mV 5h = 500mV 6h = 600mV 7h = 700mV 8h = 800mV 9h = 900mV Ah = 1.0V Bh = 1.5V Ch = 2.0V
7-4	VDS_LVL_B	R/W	0h	VDS overcurrent threshold for phase B 0h = 100mV 1h = 150mV 2h = 200mV 3h = 300mV 4h = 400mV 5h = 500mV 6h = 600mV 7h = 700mV 8h = 800mV 9h = 900mV Ah = 1.0V Bh = 1.5V Ch = 2.0V
3-0	VDS_LVL_C	R/W	0h	VDS overcurrent threshold for phase C 0h = 100mV 1h = 150mV 2h = 200mV 3h = 300mV 4h = 400mV 5h = 500mV 6h = 600mV 7h = 700mV 8h = 800mV 9h = 900mV Ah = 1.0V Bh = 1.5V Ch = 2.0V

6.7.2.16 DIAG_CTRL1 Register (Offset = 1Bh) [Reset = 0000h]

DIAG_CTRL1 is shown in [Table 6-35](#).

Return to the [Summary Table](#).

Table 6-35. DIAG_CTRL1 Register Field Descriptions

Bit	Field	Type	Reset	Description
15	RESERVED	R	0h	RESERVED
14	RESERVED	R	0h	RESERVED
13	RESERVED	R	0h	RESERVED
12	RESERVED	R	0h	RESERVED
11	OPEN_DET_EN	R/W	0h	Automated offline open load detection. Must be run separately from automated short detection. Bit auto-clears when sequence complete. 0h = Normal operation 1h = Automated open-load detection is enabled
10	SHORT_DET_EN	R/W	0h	Automated offline short detection. Must be run separately from open load detection. Open load detection will be skipped if both open load and short detection are run simultaneously. Bit auto-clears when sequence complete. 0h = Normal operation 1h = Automated short-load detection is enabled
9-8	OFFLINE_DLY	R/W	0h	Automated offline detection delay 0h = 50us (typ) 1h = 250us (typ) 2h = 1ms (typ) 3h = 2.2ms (typ)
7	TCP_LL_MODE	R/W	0h	To reduce TCP_SWITCH current limit for phase diagnostics 0h = Normal TCP_SWITCH current limit 1h = Reduced TCP_SWITCH current limit (230uA, typical)
6	PH_DIAG_LL	R/W	0h	Phase diagnostic low leakage with predriver enabled/disable 0h = PWM'ing allowed during phase diagnostic 1h = No PWM'ing allowed during phase diagnostic
5	PH_DIAG_HA	R/W	0h	Phase diagnostic pull-up enable for phase A 0h = Diagnostic current source disabled 1h = Diagnostic current source enabled
4	PH_DIAG_LA	R/W	0h	Phase diagnostic pull-down enable for phase A 0h = Diagnostic current source disabled 1h = Diagnostic current source enabled
3	PH_DIAG_HB	R/W	0h	Phase diagnostic pull-up enable for phase B 0h = Diagnostic current source disabled 1h = Diagnostic current source enabled
2	PH_DIAG_LB	R/W	0h	Phase diagnostic pull-down enable for phase B 0h = Diagnostic current source disabled 1h = Diagnostic current source enabled
1	PH_DIAG_HC	R/W	0h	Phase diagnostic pull-up enable for phase C 0h = Diagnostic current source disabled 1h = Diagnostic current source enabled
0	PH_DIAG_LC	R/W	0h	Phase diagnostic pull-down enable for phase C 0h = Diagnostic current source disabled 1h = Diagnostic current source enabled

6.7.2.17 IC_CTRL_SP Register (Offset = 1Ch) [Reset = 0805h]

IC_CTRL_SP is shown in [Table 6-36](#).

Return to the [Summary Table](#).

Table 6-36. IC_CTRL_SP Register Field Descriptions

Bit	Field	Type	Reset	Description
15	RESERVED	R	0h	Reserved
14	RESERVED	R	0h	Reserved
13	SPI_CRC_EN	R/W	0h	Enable SPI CRC 0h = No CRC, 24-bit frame 1h = CRC enabled, 32-bit frame
12	DVDD_LVL	R/W	0h	Bit to control LDO output voltage 0h = 3.3V 1h = 5V
11	OTSD_MODE	R/W	1h	Overtemperature shutdown mode 0h = Warning mode (latched) 1h = Fault mode (latched)
10	RESERVED	R	0h	RESERVED
9	RESERVED	R	0h	RESERVED
8	RESERVED	R	0h	RESERVED
7	RESERVED	R	0h	RESERVED
6	RESERVED	R	0h	RESERVED
5	RESERVED	R	0h	RESERVED
4	RESERVED	R	0h	RESERVED
3	RESERVED	R	0h	RESERVED
2-0	LOCK2	R/W	5h	Unlock and lock this register Bit settings not listed have no effect. 2h = Unlock this register 5h = Lock the settings of this register by ignoring further writes except to these bits.

7 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

7.1 Application Information

The DRV8363 is primarily used in applications for three-phase brushless DC motor control. The design procedures in the [Section 7.2](#) section highlight how to use and configure the device.

7.2 Typical Application

7.2.1 Typical Application with 48-pin package

Figure shows a typical application diagram of DRV8363 48-pin package.

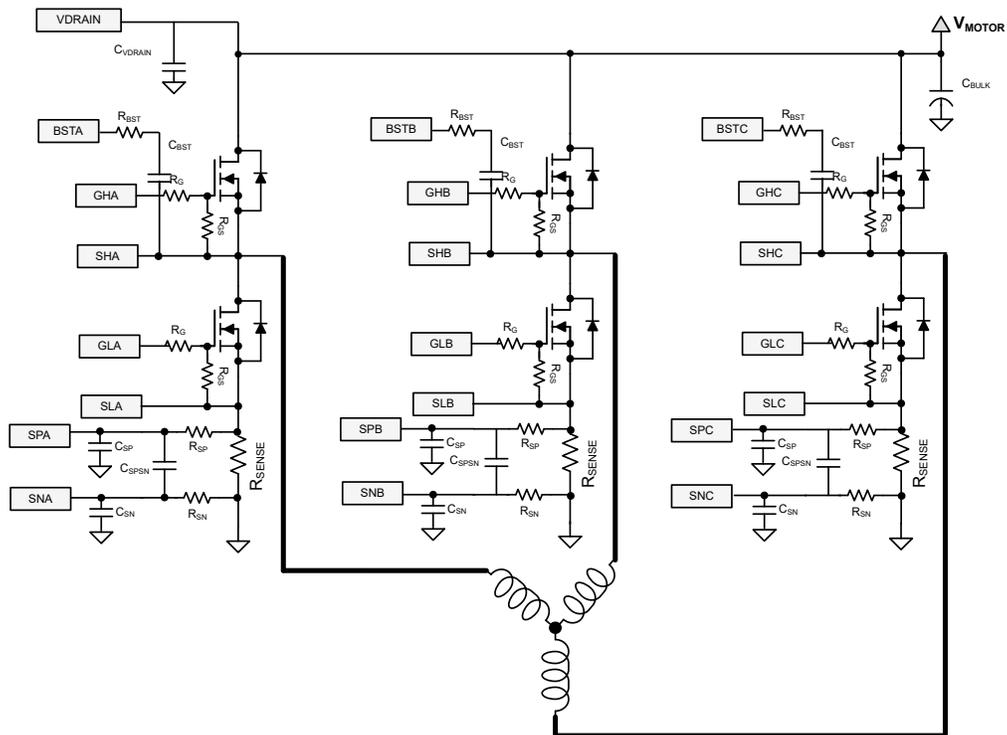
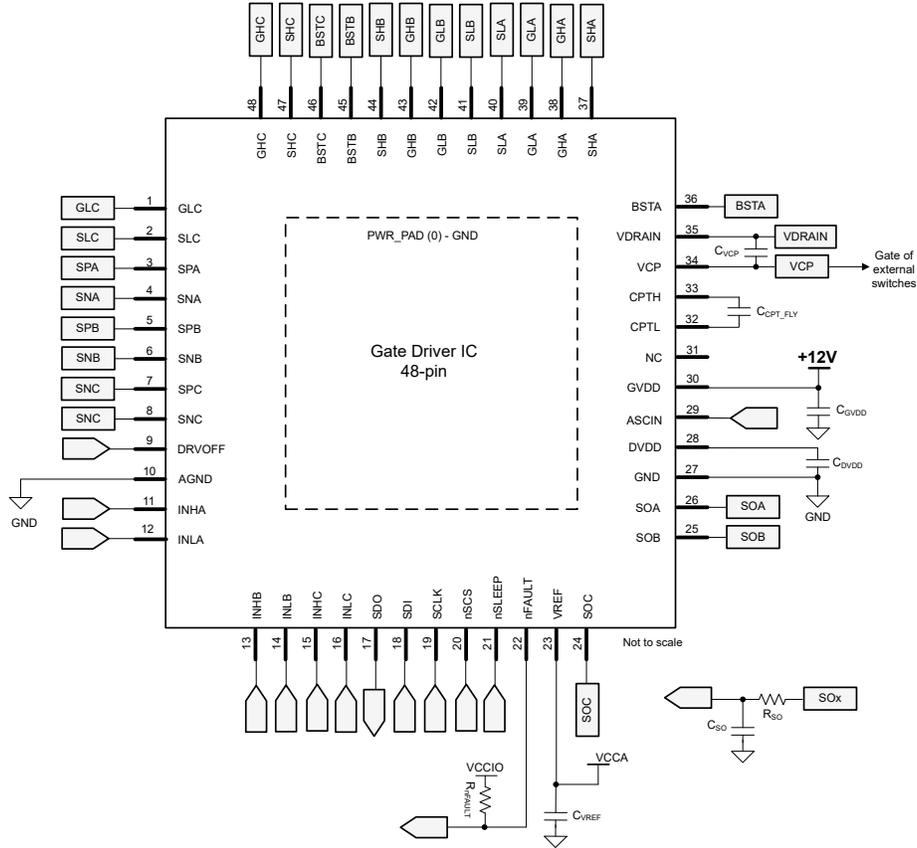


Figure 7-1. DRV8363 Typical Application Schematic

7.2.1.1 External Components

External components lists the recommended external components.

Table 7-1. External Components (48-pin Package)

COMPONENT	PIN1	PIN2	RECOMMENDED
C _{GVDD}	GVDD	GND	10-μF ceramic capacitor rated for GVDD.
C _{DVDD}	DVDD	GND	1.0-μF ceramic capacitor rated for DVDD voltage
C _{CPT_FLY}	CPTH	CPTL	1.0-μF ceramic capacitor rated for GVDD voltage
C _{VCP}	VCP	VDRAIN	1.0-μF ceramic capacitor rated for GVDD voltage
R _{nFAULT}	VCCIO	nFAULT	10 kΩ pulled up the MCU I/O power supply or DVDD
C _{VREF}	VREF	GND	0.1-μF ceramic capacitor rated for VREF voltage
C _{BULK}	V _{MOTOR}	GND	100-μF - 1000-μF rated for V _{MOTOR} ; Depending on system configuration
C _{VDRAIN}	VDRAIN	GND	1-μF rated for VDRAIN
C _{BST}	BSTx	SHx	1.0-μF, 20-V ceramic capacitor between BSTx and SHx depending on the total gate charge of external MOSFET Q _g . $C_{BST} > 40 \times Q_g / (V_{GHX} - V_{SHx})$
R _{BST}	BSTx	SHx	OPTIONAL: 3-Ω series resistor between BSTx and SHx to help prevent C _{BST} from being overcharged if big negative transient voltage is observed on SHx pin.
R _G	GHx, GLx	Gate of external MOSFET	OPTIONAL: 2-Ω series resistor between GHx/GLx and Gate of external MOSFET.
R _{GS}	GHx, GLx	Source of external MOSFET	OPTIONAL: 100-kΩ pull down resistor between GHx/GLx and Source of external MOSFET.
R _{SENSE}	SPx	SNx	0.5-mΩ Shunt resistor for current sense amplifier. System design parameter.
R _{SO}	MCU ADC	SOx	160-Ω for current sense amplifier output filter
C _{SO}	MCU ADC	GND	470-pF ceramic capacitor rated for VREF for current sense amplifier output filter
R _{SP} , R _{SN}	SPx/SNx	R _{SENSE}	OPTIONAL: 10-Ω for current sense amplifier input filter.
C _{SPSN}	SPx	SNx	OPTIONAL: 1-nF ceramic capacitor for current sense amplifier input filter.
C _{SP} , C _{SN}	SPx/SNx	GND	OPTIONAL: 1-nF ceramic capacitor for current sense amplifier input filter.

7.2.2 Application Curves

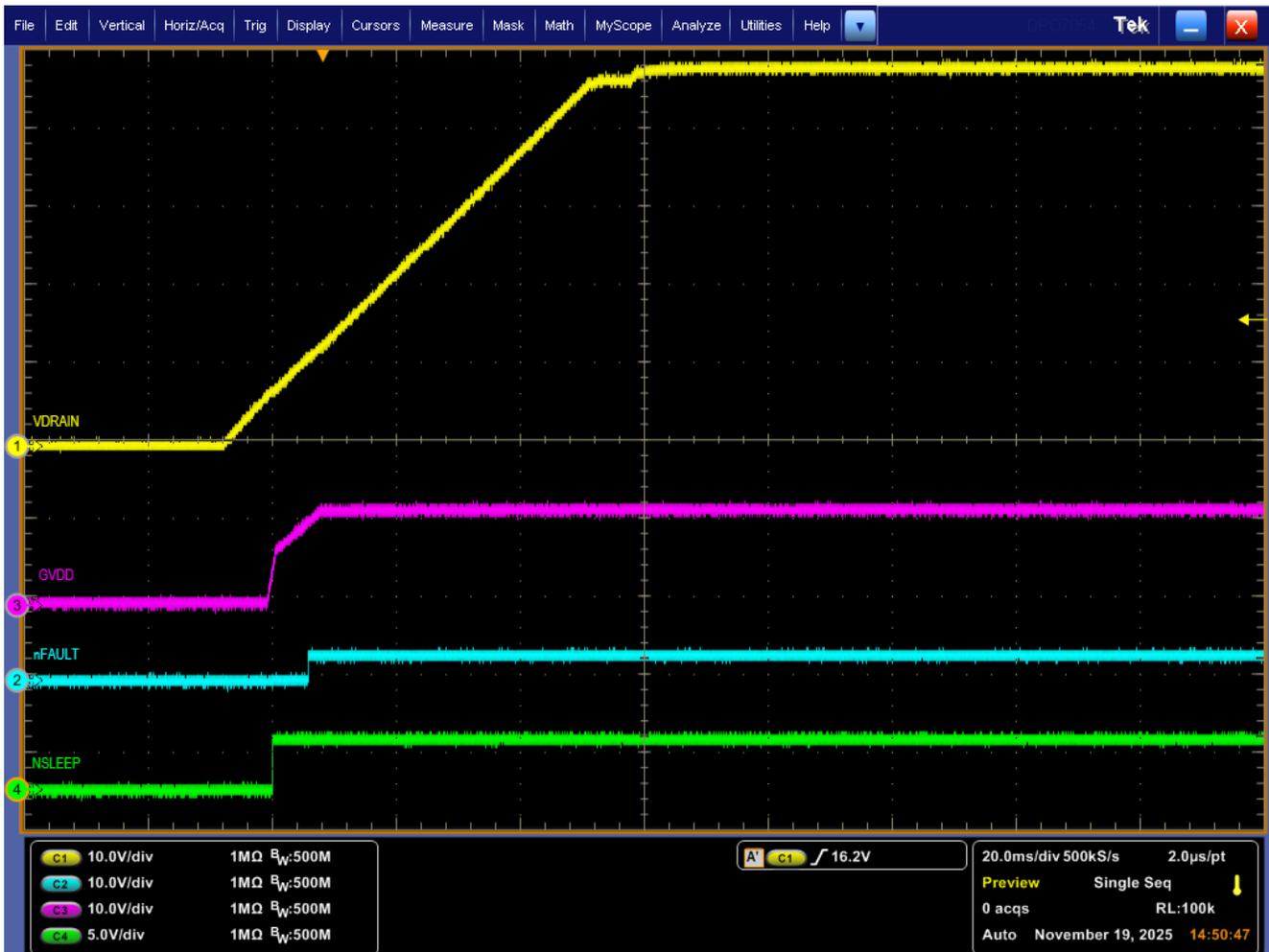


Figure 7-2. Device Powerup

7.3 Layout

7.3.1 Layout Guidelines

- Minimize length and impedance of GHx, SHx, GLx, and SLx traces. Use as few vias as possible to minimize parasitic inductance. TI also recommends to increase these trace widths to 15-20mil shortly after routing away from the device pin to minimize parasitic resistance.
- Keep BSTx capacitors close to the respective pins. TI highly recommends to place this capacitor on the same side of the PCB to avoid parasitic via inductance.
- Keep CPTH/CPTL flying capacitor as close to the device pins as possible. TI highly recommends to place this capacitor on the same side of the PCB to avoid parasitic via inductance.
- Keep GVDD capacitor close to GVDD pin. TI highly recommends to place this capacitor on the same side of the PCB to avoid parasitic via inductance.
- Keep DVDD capacitor close to DVDD pin. TI highly recommends to place this capacitor on the same side of the PCB to avoid parasitic via inductance. Additionally, the GND-return connection of the DVDD capacitor is routed directly back to the adjacent GND pin to avoid adding parasitic inductance and resistance to the DVDD regulator loop.
- VDRAIN connection is routed such that the connection observes an "average" of the three phases to help maintain VDS accuracy. TI also recommends to connect VDRAIN close to the high-side bulk capacitance

to help stabilize the input to VDRAIN and avoid exceeding the pin abs max rating. Keep VDRAIN capacitor close to VDRAIN pin to supply steady switching current for the charge pump.

- Additional bulk capacitance is required to bypass the high current path on the external MOSFETs. This bulk capacitance is placed such that the bulk capacitance minimizes the length of any high current paths through the external MOSFETs. The connecting metal traces are as wide as possible, with numerous vias connecting PCB layers. These practices minimize inductance and let the bulk capacitor deliver high current.
- Connect SLx pins to individual MOSFET sources, not directly to GND, for accurate VDS detection and better transient resistance.
- Route SNx/SPx pins in parallel from the sense resistor to the device. Place filtering components close to the device pins to minimize post-filter noise coupling. Verify that SNx/SPx stay separated from GND plane to achieve best CSA accuracy.
- Place SO filtering components close to the MCU/ADC input to minimize post-filter noise coupling.
- The exposed pad is used for thermal dissipation, not electrical grounding, and has a high-impedance connection to the GND/AGND pins. Therefore, TI recommends to connect the exposed pad to the best thermal GND, and to connect the GND/AGND pins to the MCU-reference GND.

8 Device and Documentation Support

8.1 Documentation Support

8.1.1 Related Documentation

- Texas Instruments, [Understanding Smart Gate Drive \(Rev. D\) application report](#)
- Texas Instruments, [Brushless-DC Motor Driver Considerations and Selection Guide \(Rev. A\) application report](#)
- Texas Instruments, [Designing High-Side and 3-Phase Isolator MOSFET Circuits in Motor Apps application note](#)
- Texas Instruments, [Best Practices for Board Layout of Motor Drivers \(Rev. B\) application note](#)
- Texas Instruments, [PowerPAD™ Thermally Enhanced Package application report](#)
- Texas Instruments, [PowerPAD™ Made Easy application report](#)
- Texas Instruments, [Sensored 3-Phase BLDC Motor Control Using MSP430 application report](#)
- Texas Instruments, [Hardware Design Considerations for an Electric Bicycle Using a BLDC Motor application report](#)

8.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

8.3 Support Resources

8.4 Trademarks

All trademarks are the property of their respective owners.

8.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.6 Glossary

[TI Glossary](#)

This glossary lists and explains terms, acronyms, and definitions.

9 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision * (June 2025) to Revision A (November 2025)

Page

10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGE OPTION ADDENDUM

PACKAGING INFORMATION

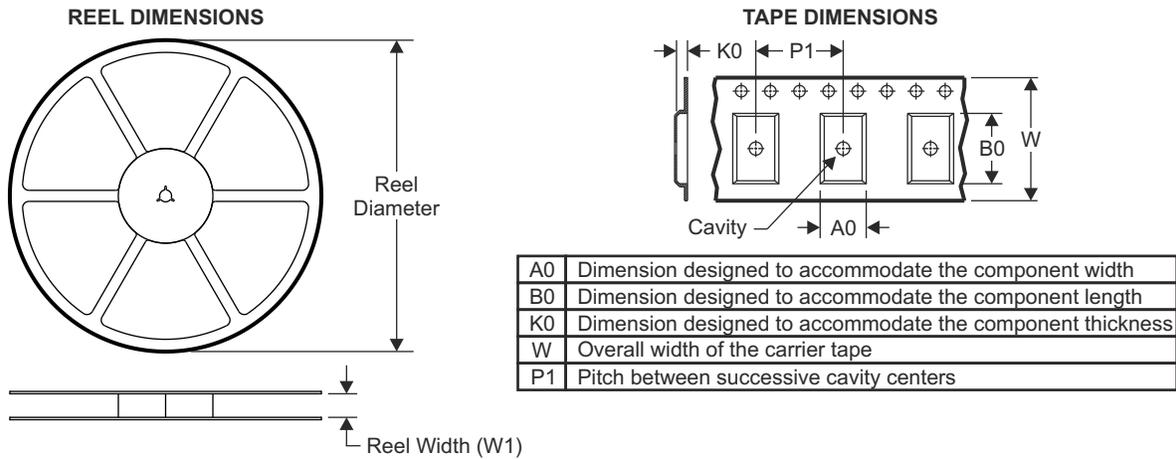
Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/Ball material (4)	MSL rating/Peak reflow (5)	Op temp (°C)	Part marking (6)
DRV8363RGZR	Active	Preproduction	VQFN (RGZ) 48	1000 TRAY	Yes	NiPdAu	Level-3-260C-168 HR	-40 to 125	DRV8363

- (1) **Status:** For more details on status, see our [product life cycle](#).
- (2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.
- (3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.
- (4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.
- (5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.
- (6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part. Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

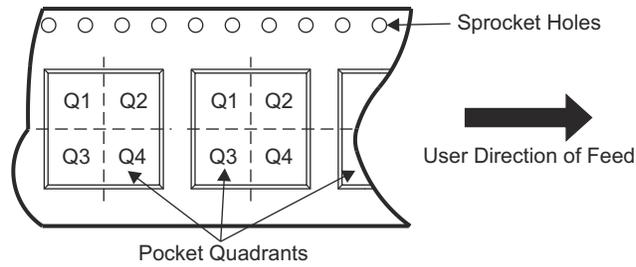
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10.1 Tape and Reel Information

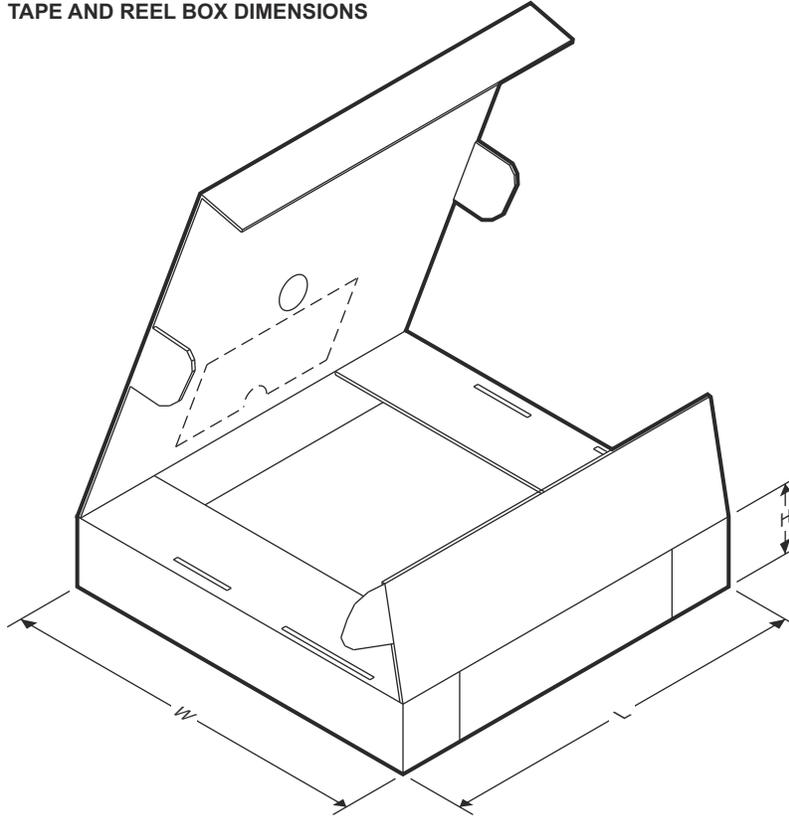


QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
DRV8363RGZR	VQFN	RGZ	48	1000	330.0	16.4	9.6	9.6	1.5	12.0	16.0	2

TAPE AND REEL BOX DIMENSIONS



Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PDRV8363QRGZRQ1	VQFN	RGZ	48	1000	336.6	336.6	31.8

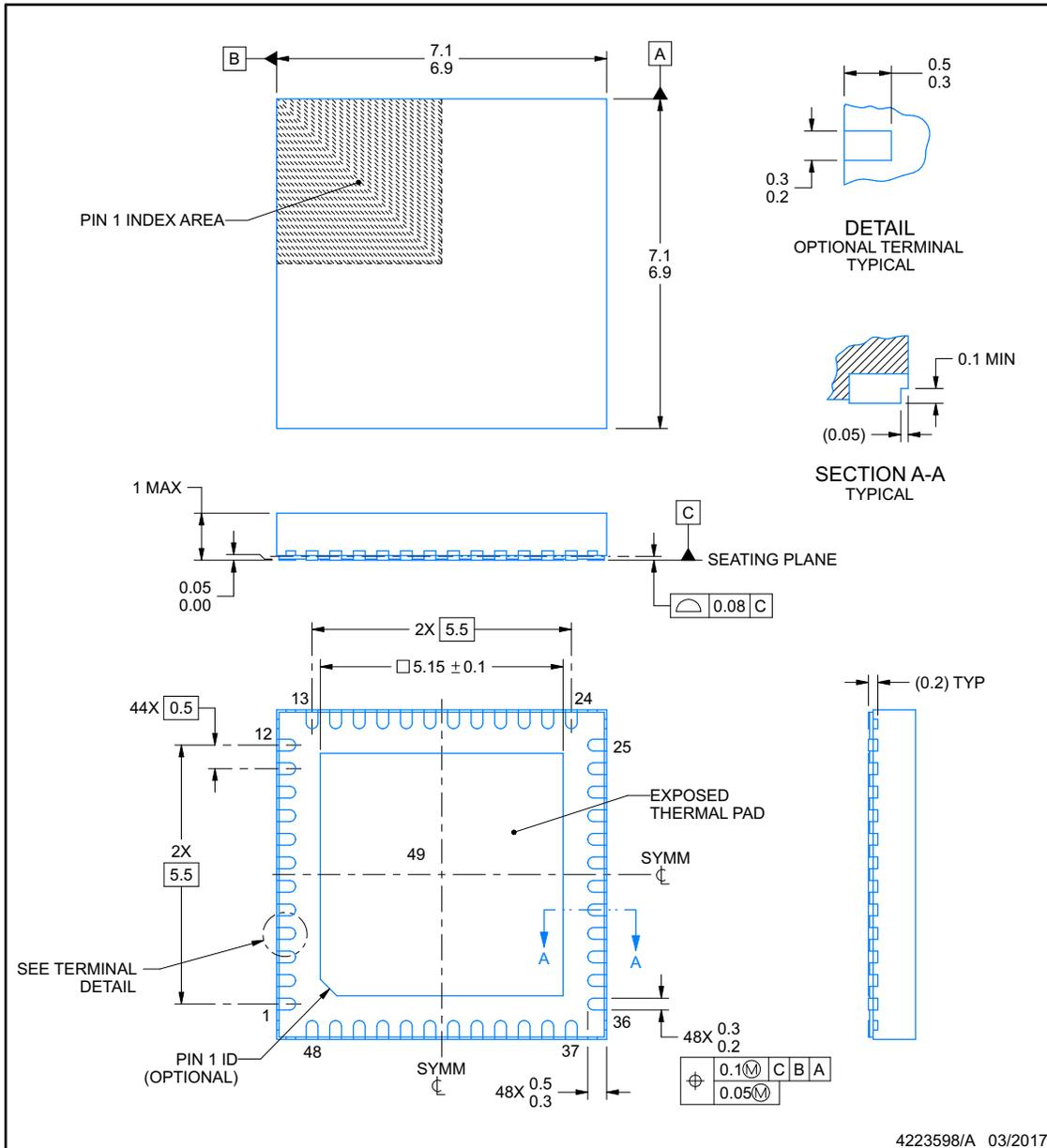


RGZ0048N

PACKAGE OUTLINE

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



4223598/A 03/2017

NOTES:

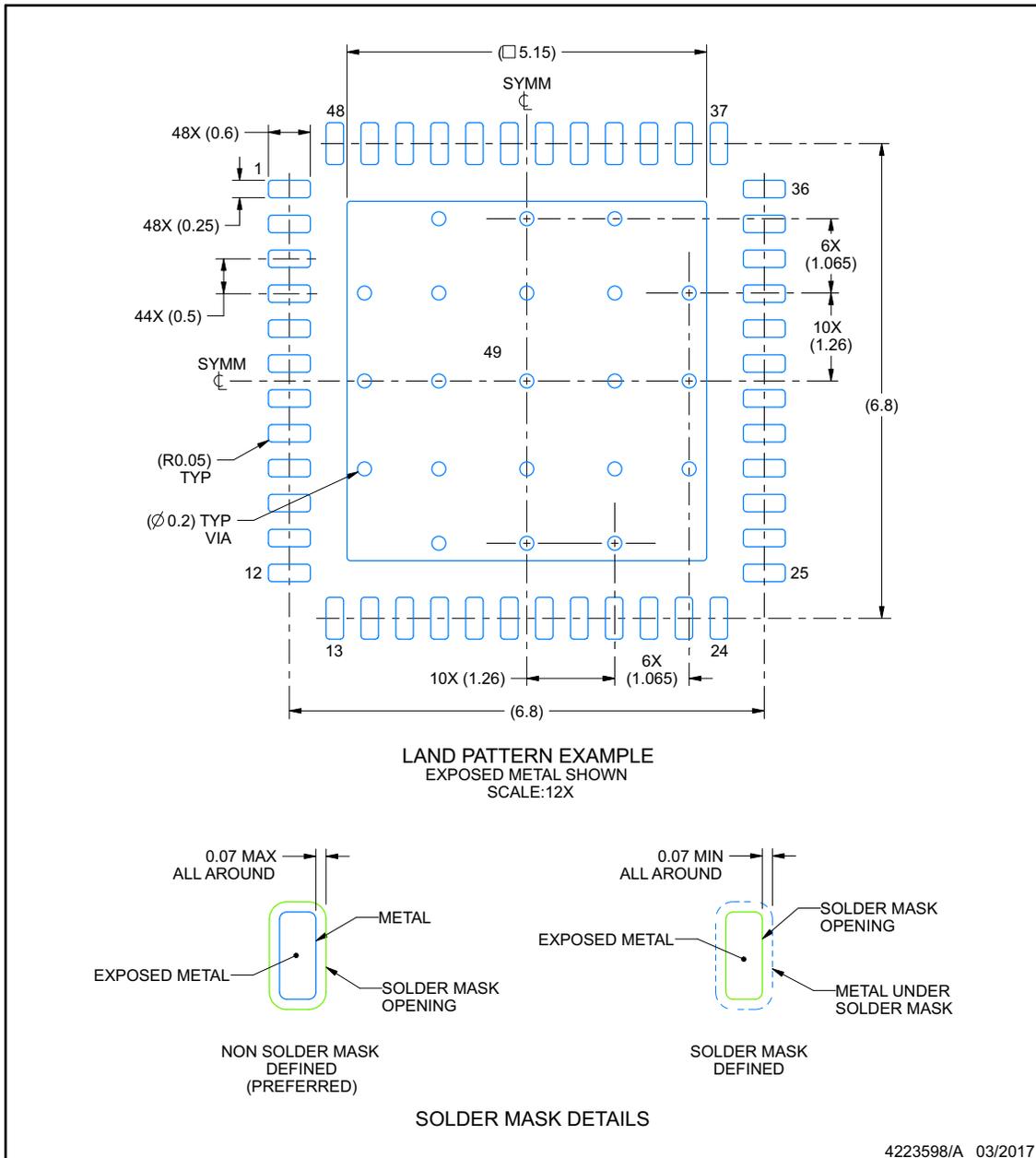
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

EXAMPLE BOARD LAYOUT

RGZ0048N

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



NOTES: (continued)

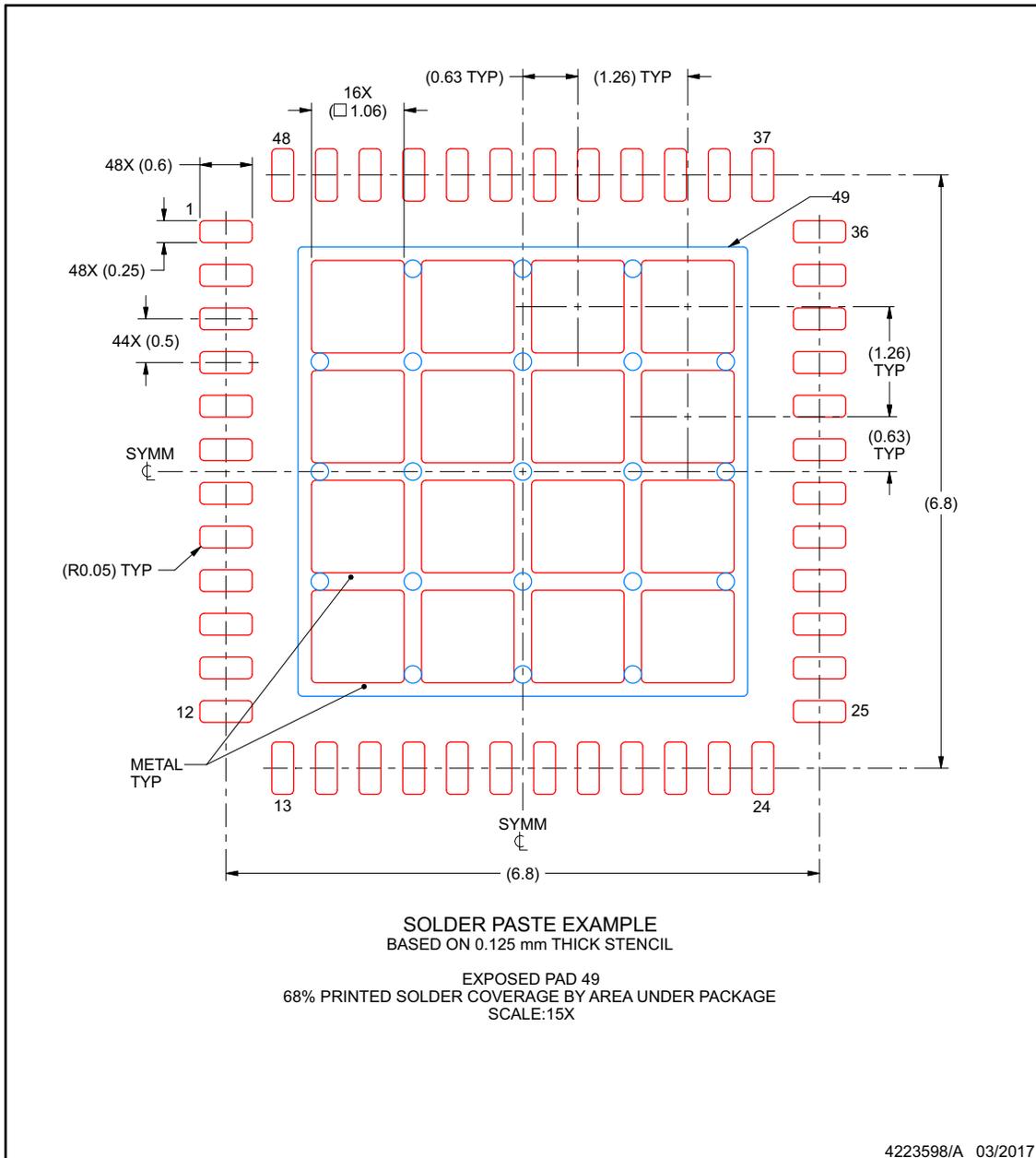
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slua271).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

EXAMPLE STENCIL DESIGN

RGZ0048N

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package Pins	Package qty Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
DRV8363RGZR	Active	Production	VQFN (RGZ) 48	4000 LARGE T&R	-	NIPDAU	Level-3-260C-168 HR	-40 to 150	DRV8363 RGZ

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

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(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

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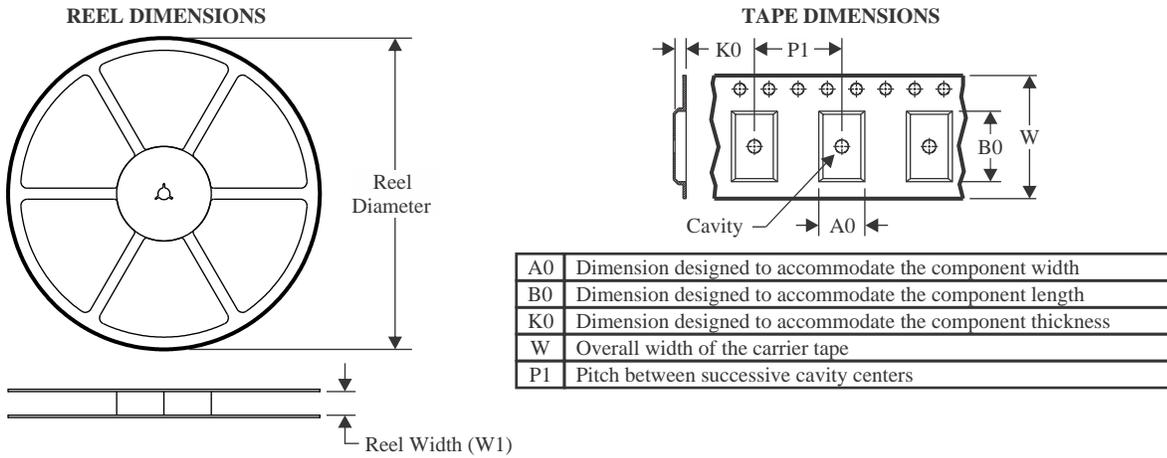
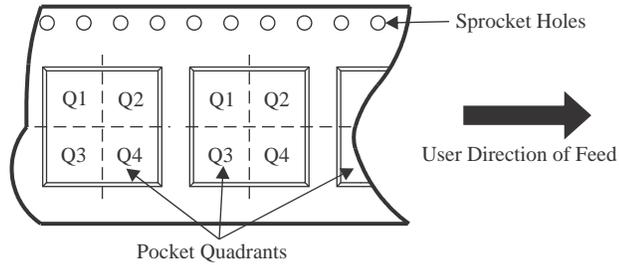
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OTHER QUALIFIED VERSIONS OF DRV8363 :

- Automotive : [DRV8363-Q1](#)

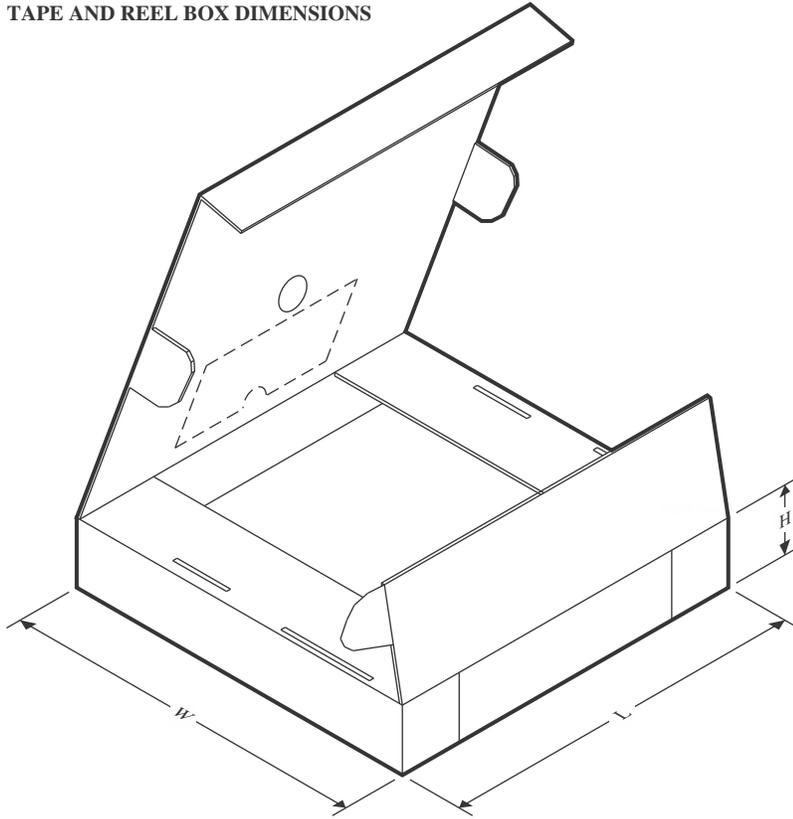
NOTE: Qualified Version Definitions:

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
DRV8363RGZR	VQFN	RGZ	48	4000	330.0	16.4	7.3	7.3	1.1	12.0	16.0	Q2

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DRV8363RGZR	VQFN	RGZ	48	4000	367.0	367.0	38.0

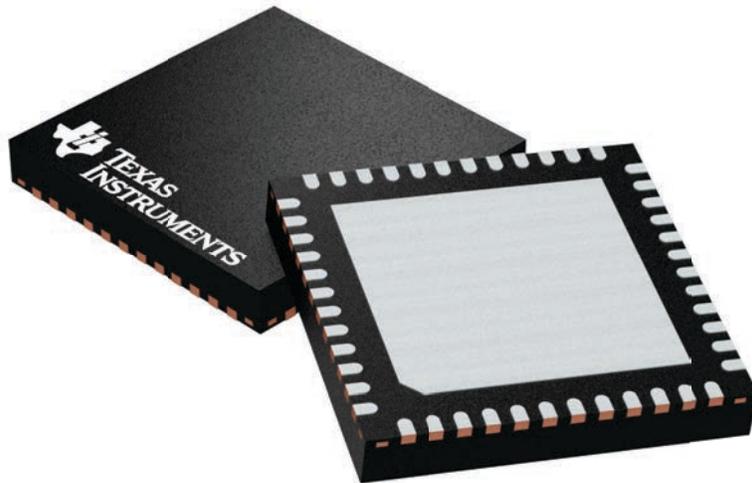
GENERIC PACKAGE VIEW

RGZ 48

VQFN - 1 mm max height

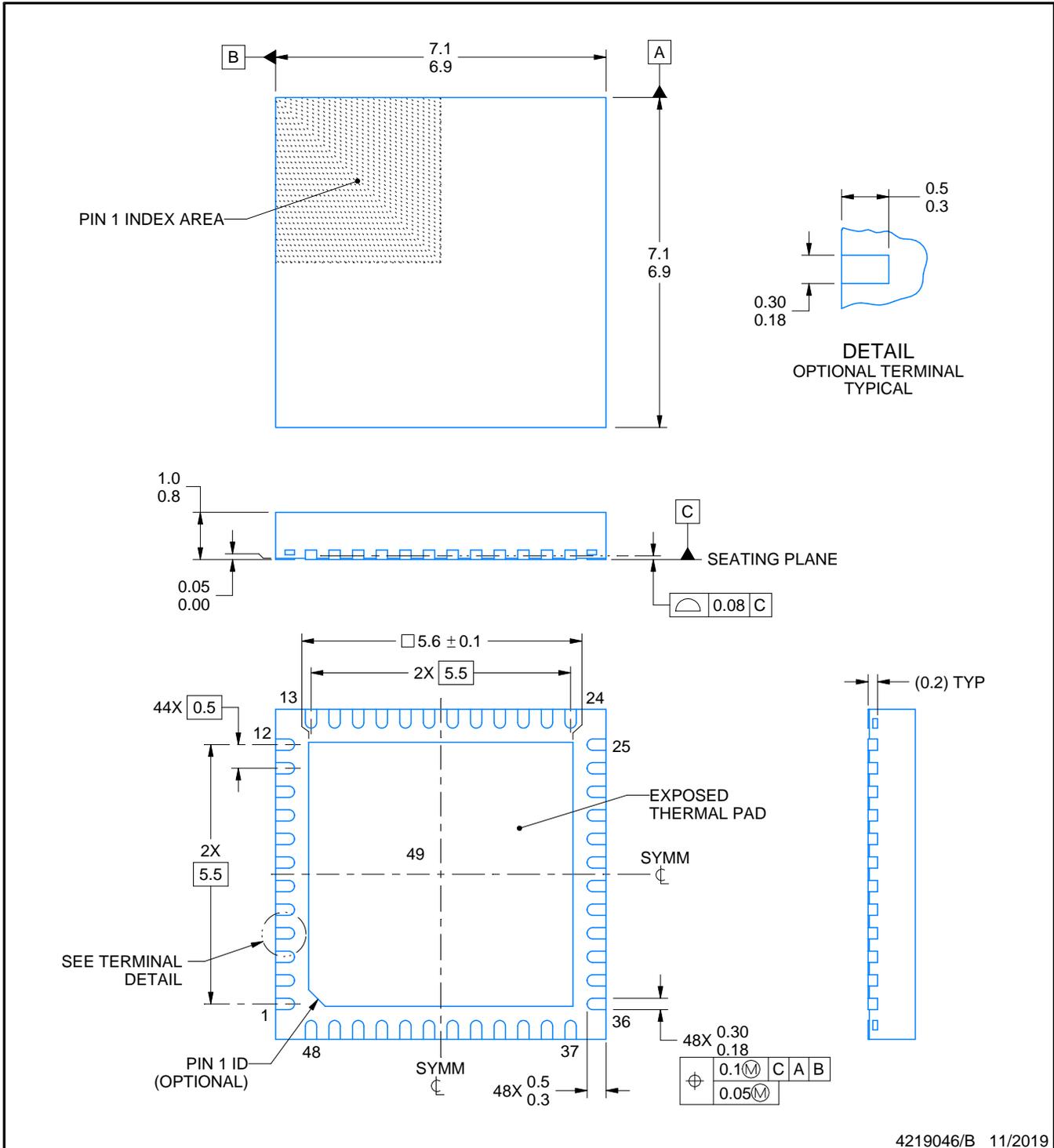
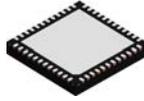
7 x 7, 0.5 mm pitch

PLASTIC QUADFLAT PACK- NO LEAD



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4224671/A



4219046/B 11/2019

NOTES:

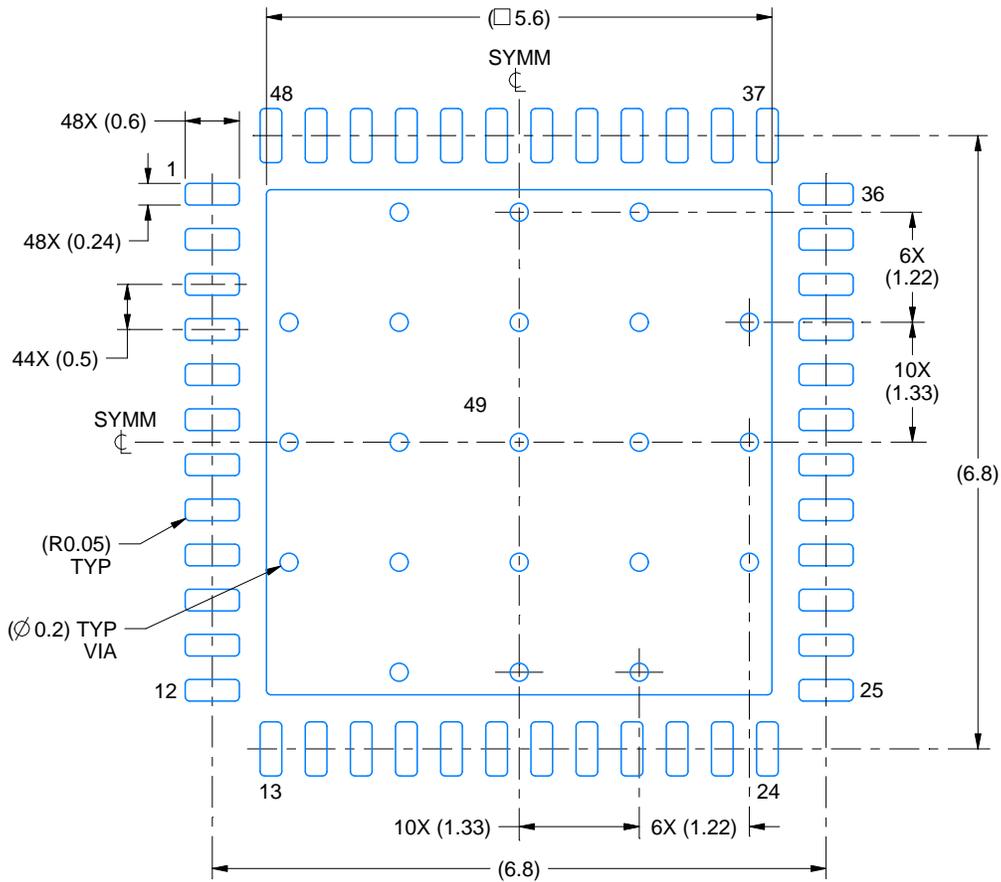
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

EXAMPLE BOARD LAYOUT

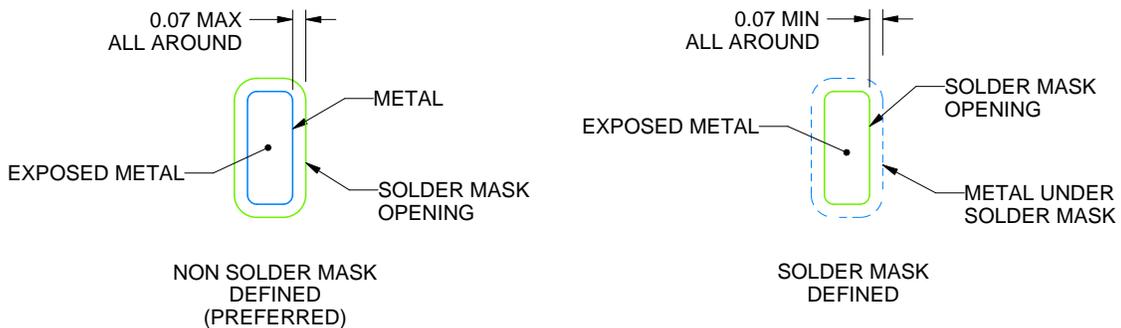
RGZ0048D

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:12X



SOLDER MASK DETAILS

4219046/B 11/2019

NOTES: (continued)

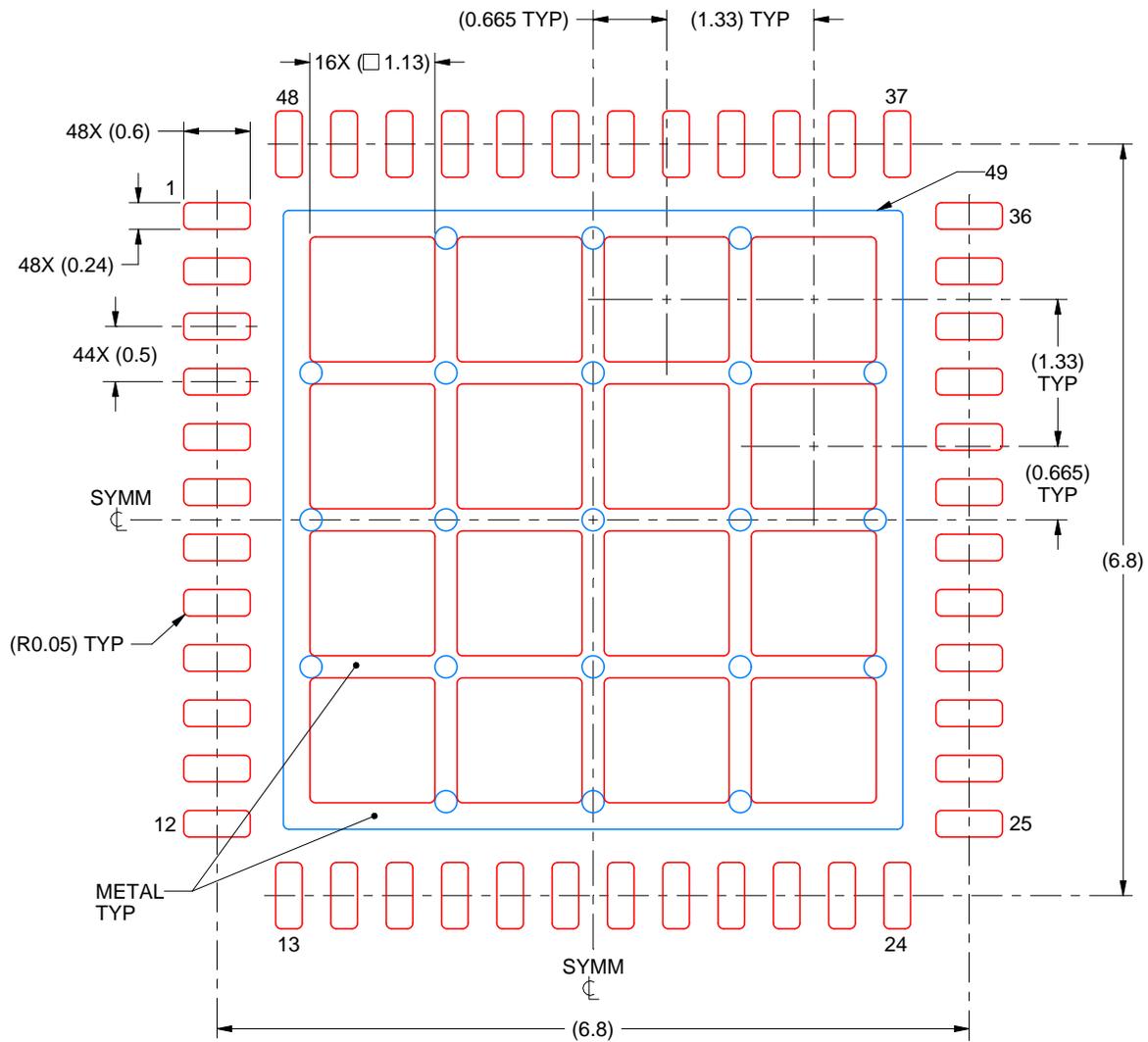
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sluea271).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

EXAMPLE STENCIL DESIGN

RGZ0048D

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



SOLDER PASTE EXAMPLE
 BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 49
 66% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE
 SCALE:15X

4219046/B 11/2019

NOTES: (continued)

- 6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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