

## MCT8315A 高速センサレス台形制御、FET BLDC ドライバ内蔵

## 1 特長

- センサレス・モーター制御アルゴリズムを統合した 3 相 BLDC モーター・ドライバ
  - コード・フリーの高速台形波制御
  - 最大 3 kHz (電氣的周波数) をサポート
  - 非常に高速な起動時間 (50ms 未満)
  - 迅速な減速 (150ms 未満)
  - 120°または 150°変調のサポートによる音響性能の向上
  - 順方向再同期と反転駆動による風車制御のサポート
  - アナログ、PWM、周波数、または I<sup>2</sup>C ベースの速度入力
  - アクティブ消磁により電力損失を低減
  - モーターの起動と停止に関する設定可能なオプション
  - 速度 / 電力閉ループ・オプション
  - アンチ電圧サージ (AVS) 保護機能により、モーター減速時の DC バス電圧スパイクを防止
- 動作電圧: 4.5V~35V (絶対最大定格 40V)
- 高い出力電流能力: ピーク 4A
- 低い MOSFET ON 抵抗
  - T<sub>A</sub> = 25°Cでの R<sub>DS(ON)</sub> (HS + LS): 240mΩ (標準値)
- 低消費電力スリープ・モード
  - V<sub>VM</sub> = 24V、T<sub>A</sub> = 25°Cで 5μA (最大値)
- 速度ループの精度: 内部クロック使用時に 3%、外部クロックを基準とする場合は 1%
- 構成可能な不揮発性メモリ (EEPROM) にデバイス構成を保存
- 低インダクタンスのモーターをサポートするため、最大 100kHz の PWM 周波数に対応
- 電流センス機能を内蔵し外付け電流センス抵抗が不要
- 3.3V、20mA の LDO レギュレータを内蔵
- 3.3V / 5V、170mA の降圧レギュレータを内蔵
- 専用 DRVOFF ピンによる出力の無効化 (ハイ・インピーダンス)
- 拡散スペクトラムとスルーレート設定は EMI 低減に貢献
- 各種保護機能を内蔵
  - 電源低電圧誤動作防止 (UVLO)
  - 過電圧保護 (OVP)
  - モーター・ロック検出 (5 つの異なる種類)
  - 過電流保護 (OCP)
  - 熱警告およびシャットダウン (OTW/TSD)
  - フォルト状況表示ピン (nFAULT)
  - I<sup>2</sup>C インターフェイスによるフォルト診断 (任意)

## 2 アプリケーション

- ブラシレス DC (BLDC) モーター・モジュール
- ロボット掃除機吸引モーター
- モーター・サイクル・フューエル・ポンプ
- 電気器具のファンとポンプ
- 車載用のファンとブロワー
- CPAP 機器

## 3 概要

MCT8315A は、高速動作 (最大 3 kHz の電気周波数) または超高速起動時間 (50ms 未満) を必要とするお客様向けに、コード・フリーのセンサレス台形制御ソリューションをシングルチップで実現します。12V~24V のブラシレス DC モーターに対し、最大 4A のピーク電流供給が可能です。この MCT8315A は、絶対最大定格が 40V で、R<sub>DS(ON)</sub> が 240mΩ (ハイサイドとローサイド FET の合計) という低い値のハーフ・ブリッジを 3 つ内蔵しています。MCT8315A には、電圧調整可能な降圧レギュレータ (3.3V/5V、170mA) や LDO (3.3V/20mA) を含む電源管理回路が内蔵されており、外部回路に対し電源を供給できます。

センサレス台形制御は、不揮発性 EEPROM のレジスタに対する設定により (モーターの起動 / 停止動作、障害時の処理、閉ループ動作) を高度に設定可能であり、設定後のデバイスは、スタンドアロンで動作させることができます。MCT8315A は、PWM 信号、アナログ電圧、可変周波数の方形波、I<sup>2</sup>C 命令を介して速度コマンドを受信します。内蔵された多数の保護機能により、MCT8315A は、デバイス自体、モーター、およびシステムを故障イベントから保護します。

## 製品情報 (1)

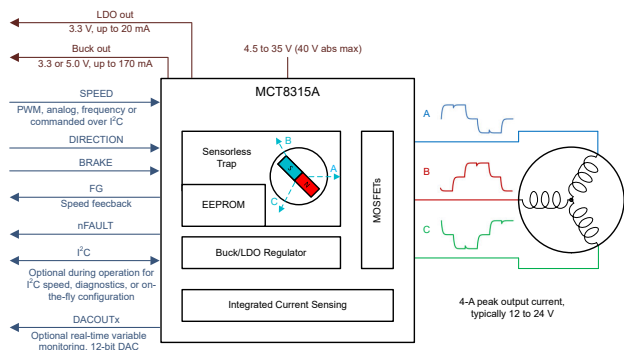
部品番号	パッケージ	本体サイズ (公称)
MCT8315A1V	VQFN (40)	7.00mm × 5.00mm

(1) 利用可能なパッケージについては、このデータシートの末尾にある注文情報を参照してください。

参考用のドキュメント:

- 『MCT8315A チューニング・ガイド』を参照してください
- 『MCT8315A EVM GUI』を参照してください





簡略回路図

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## 4 Revision History

Changes from Revision * (December 2022) to Revision A (April 2023)	Page
• Updated I <sup>2</sup> C Data Word section to clarify default I <sup>2</sup> C Target ID.....	<b>75</b>
• Updated CRC Byte Calculation section with CRC initial value.....	<b>79</b>

## 5 Pin Configuration and Functions

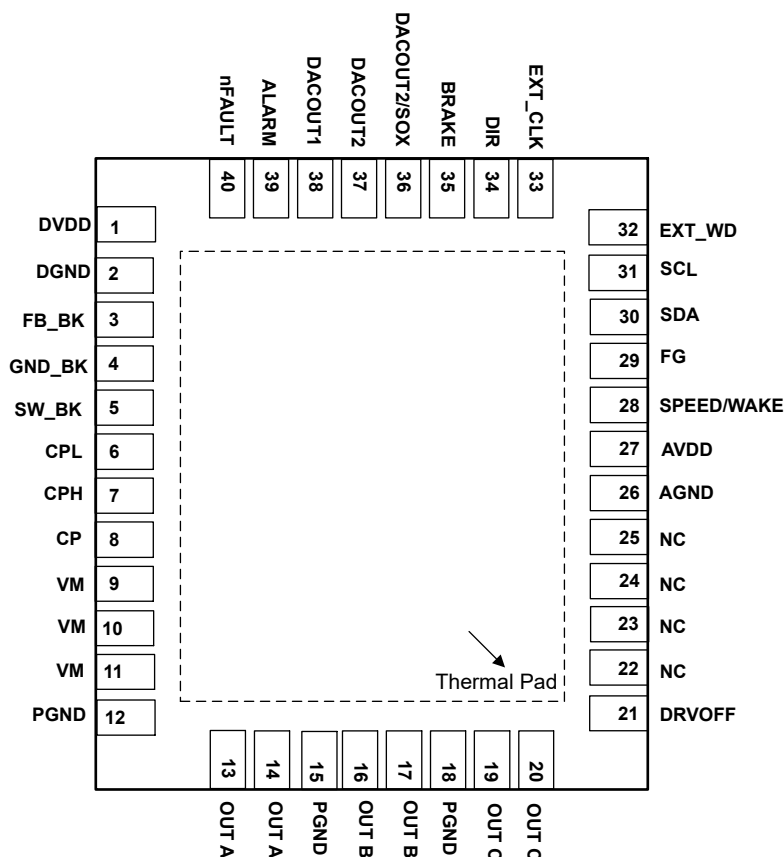


图 5-1. MCT8315A, 40-Pin VQFN With Exposed Thermal Pad, Top View

表 5-1. Pin Functions

PIN	40-pin Package	TYPE <sup>(1)</sup>	DESCRIPTION
NAME	MCT8315A		
AGND	26	GND	Device analog ground. Refer Layout Guidelines for connection recommendation.
ALARM	39	O	Alarm signal : push-pull output. Pulled logic high during fault condition, if enabled. If ALARM pin is not used, leave it floating.
AVDD	27	PWR O	3.3-V internal regulator output. Connect a X5R or X7R, 1-μF, 6.3-V ceramic capacitor between the AVDD and AGND pins. This regulator can source up to 20 mA for external circuits.
BRAKE	35	I	High → brake the motor Low → normal operation If BRAKE pin is not used, connect to AGND directly. If BRAKE pin is used to brake the motor, use an external 100-kΩ pull-down resistor (to AGND).
CP	8	PWR	Charge pump output. Connect a X5R or X7R, 1-μF, 16-V ceramic capacitor between the CP and VM pins.
CPH	7	PWR	Charge pump switching node. Connect a X5R or X7R, 47-nF, ceramic capacitor between the CPH and CPL pins. TI recommends a capacitor voltage rating at least twice the normal operating voltage of the device.
CPL	6	PWR	
DACOUT1	38	O	DAC output DACOUT1
DACOUT2	37	O	DAC output DACOUT2

**表 5-1. Pin Functions (continued)**

PIN	40-pin Package	TYPE <sup>(1)</sup>	DESCRIPTION
NAME	MCT8315A		
DACOUT2/S OX	36	O	Multi-purpose pin: DAC output when configured as DACOUT2 CSA output when configured as SOX
DGND	2	GND	Device digital ground. Refer Layout Guidelines for connection recommendation.
DIR	34	I	Direction of motor spinning; When low, phase driving sequence is OUT A → OUT B → OUT C When high, phase driving sequence is OUT A → OUT C → OUT B If DIR pin is not used, connect to AGND or AVDD directly (depending on phase driving sequence needed). If DIR pin is used for changing motor spin direction, use an external 100-kΩ pull-down resistor (to AGND).
DRVOFF	21	I	Coast (Hi-Z) all six MOSFETs.
DVDD	1	PWR	1.5-V internal regulator output. Connect a X5R or X7R, 2.2-μF, 6.3-V ceramic capacitor between the DVDD and DGND pins.
EXT_CLK	33	I	External clock reference input in external clock reference mode.
EXT_WD	32	I	External watchdog input.
FB_BK	3	PWR I/O	Feedback for buck regulator. Connect to buck regulator output after the inductor/resistor.
FG	29	O	Motor speed indicator : open-drain output; requires an external pull-up resistor to 1.8-V to 5.0-V.
GND_BK	4	GND	Buck regulator ground. Refer Layout Guidelines for connection recommendation.
NC	22, 23, 24, 25	-	No connection. Leave these pins floating.
nFAULT	40	O	Fault indicator: open drain output. Pulled logic low during fault condition; requires an external pull-up resistor to 1.8-V to 5.0-V.
OUTA	13, 14	PWR O	Half-bridge output A
OUTB	16, 17	PWR O	Half-bridge output B
OUTC	19, 20	PWR O	Half-bridge output C
PGND	12, 15, 18	GND	Device power ground. Refer Layout Guidelines for connection recommendation.
SCL	31	I	I <sup>2</sup> C clock input
SDA	30	I/O	I <sup>2</sup> C data line
SPEED/ WAKE	28	I	Device speed input; supports analog, frequency or PWM signals. The speed pin input can be configured through SPD_CTRL_MODE.
SW_BK	5	PWR	Buck switch node. Connect this pin to an inductor or resistor.
VM	9, 10, 11	PWR I	Device and motor power supply. Connect to motor supply voltage; bypass to PGND with a 0.1-μF capacitor plus one bulk capacitor. TI recommends a capacitor voltage rating at least twice the normal operating voltage of the device.
Thermal pad		GND	Connect to AGND

(1) I = input, O = output, GND = ground, PWR = power, NC = no connect

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating ambient temperature range (unless otherwise noted)<sup>(1)</sup>

	MIN	MAX	UNIT
Power supply pin voltage (V <sub>M</sub> )	−0.3	40	V
Voltage difference between ground pins (GND_BK, DGND, PGND, AGND)	−0.3	0.3	V
Charge pump voltage (CPH, CP)	−0.3	V <sub>M</sub> + 6	V
Charge pump negative switching pin voltage (CPL)	−0.3	V <sub>M</sub> + 0.3	V
Switching node pin voltage (SW_BK)	−0.3	V <sub>M</sub> + 0.3	V
Analog regulators pin voltage (AVDD)	−0.3	4	V
Analog regulators pin voltage (DVDD)	−0.3	1.7	V
Logic pin input voltage (BRAKE, DRVOFF, DIR, EXT_CLK, EXT_WD, SCL, SDA, SPEED)	−0.3	6	V
Open drain pin output voltage (nFAULT, FG)	−0.3	6	V
Output pin voltage (OUTA, OUTB, OUTC)	−1	V <sub>M</sub> + 1	V
Ambient temperature, T <sub>A</sub>	−40	125	°C
Junction temperature, T <sub>J</sub>	−40	150	°C
Storage temperature, T <sub>stg</sub>	−65	150	°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

### 6.2 ESD Ratings

			VALUE	UNIT
V <sub>(ESD)</sub>	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±2000	V
		Charged device model (CDM), per JEDEC specification JS-002 <sup>(2)</sup>	±750	

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.  
 (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

over operating ambient temperature range (unless otherwise noted)

			MIN	NOM	MAX	UNIT
V <sub>M</sub>	Power supply voltage	V <sub>M</sub>	4.5	24	35	V
I <sub>OUT</sub> <sup>(1)</sup>	Peak output winding current	OUTA, OUTB, OUTC			4	A
V <sub>IN_LOGIC</sub>	Logic input voltage	BRAKE, DRVOFF, DIR, EXT_CLK, EXT_WD, SPEED, SDA, SCL	−0.1		5.5	V
V <sub>OD</sub>	Open drain pullup voltage	nFAULT, FG	−0.1		5.5	V
I <sub>OD</sub>	Open drain output current capability	nFAULT, FG			5	mA
T <sub>A</sub>	Operating ambient temperature		−40		125	°C
T <sub>J</sub>	Operating junction temperature		−40		150	°C

- (1) Power dissipation and thermal limits must be observed

## 6.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		MCT8315A	UNIT
		RGF (VQFN)	
		40 Pins	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	28	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	16.7	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	8.9	°C/W
Ψ <sub>JT</sub>	Junction-to-top characterization parameter	1.8	°C/W
Ψ <sub>JB</sub>	Junction-to-board characterization parameter	8.9	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	3.5	°C/W

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

## 6.5 Electrical Characteristics

T<sub>J</sub> = –40°C to +150°C, V<sub>VM</sub> = 4.5 to 35 V (unless otherwise noted). Typical limits apply for T<sub>A</sub> = 25°C, V<sub>VM</sub> = 24 V

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>POWER SUPPLIES</b>						
I <sub>VMQ</sub>	VM sleep mode current	V <sub>VM</sub> > 6 V, V <sub>SPEED</sub> = 0, T <sub>A</sub> = 25 °C		3	5	μA
		V <sub>SPEED</sub> = 0, T <sub>A</sub> = 125 °C		3.5	7	μA
I <sub>VMS</sub>	VM standby mode current	V <sub>VM</sub> ≥ 12 V, Standby Mode, DRVOFF = High, T <sub>A</sub> = 25 °C, L <sub>BK</sub> = 47 uH, C <sub>BK</sub> = 22 μF		8	16	mA
		V <sub>VM</sub> > 6 V, Standby Mode, DRVOFF = High, T <sub>A</sub> = 25 °C, R <sub>BK</sub> = 22 Ω, C <sub>BK</sub> = 22 μF		25	29	mA
		V <sub>VM</sub> ≥ 12 V, Standby Mode, DRVOFF = High, L <sub>BK</sub> = 47 uH, C <sub>BK</sub> = 22 μF		8	16.5	mA
		V <sub>VM</sub> > 6 V, Standby Mode, DRVOFF = High, R <sub>BK</sub> = 22 Ω, C <sub>BK</sub> = 22 μF		25	29	mA
I <sub>VM</sub>	VM operating mode current	V <sub>VM</sub> > 6 V, V <sub>SPEED</sub> > V <sub>EX_SL</sub> , PWM_FREQ_OUT = 10000b (25 kHz), T <sub>A</sub> = 25 °C, L <sub>BK</sub> = 47 uH, C <sub>BK</sub> = 22 μF, No Motor Connected		11	18	mA
		V <sub>VM</sub> > 6 V, V <sub>SPEED</sub> > V <sub>EX_SL</sub> , PWM_FREQ_OUT = 10000b (25 kHz), T <sub>A</sub> = 25 °C, R <sub>BK</sub> = 22 Ω, C <sub>BK</sub> = 22 μF, No Motor Connected		27	30.5	mA
		V <sub>VM</sub> > 6 V, V <sub>SPEED</sub> > V <sub>EX_SL</sub> , PWM_FREQ_OUT = 10000b (25 kHz), L <sub>BK</sub> = 47 uH, C <sub>BK</sub> = 22 μF, No Motor Connected		11	17	mA
		V <sub>VM</sub> > 6 V, V <sub>SPEED</sub> > V <sub>EX_SL</sub> , PWM_FREQ_OUT = 10000b (25 kHz), R <sub>BK</sub> = 22 Ω, C <sub>BK</sub> = 22 μF, No Motor Connected		28	30.5	mA
V <sub>AVDD</sub>	Analog regulator voltage	0 mA ≤ I <sub>AVDD</sub> ≤ 20 mA	3.125	3.3	3.465	V
I <sub>AVDD</sub>	External analog regulator load				20	mA
V <sub>DVDD</sub>	Digital regulator voltage		1.4	1.55	1.65	V
V <sub>VCP</sub>	Charge pump regulator voltage	VCP with respect to VM	4.0	4.7	5.5	V

$T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{VM} = 4.5$  to  $35\text{ V}$  (unless otherwise noted). Typical limits apply for  $T_A = 25^{\circ}\text{C}$ ,  $V_{VM} = 24\text{ V}$

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>BUCK REGULATOR</b>						
$V_{BK}$	Buck regulator average voltage ( $L_{BK} = 47\text{ }\mu\text{H}$ , $C_{BK} = 22\text{ }\mu\text{F}$ )	$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 170\text{ mA}$ , BUCK_SEL = 00b	3.1	3.3	3.5	V
		$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 170\text{ mA}$ , BUCK_SEL = 01b	4.6	5.0	5.4	V
		$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 170\text{ mA}$ , BUCK_SEL = 10b	3.7	4.0	4.3	V
		$V_{VM} > 6.7\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 170\text{ mA}$ , BUCK_SEL = 11b	5.2	5.7	6.2	V
		$V_{VM} < 6.0\text{ V}$ (BUCK_SEL = 00b, 01b, 10b, 11b), $0\text{ mA} \leq I_{BK} \leq 170\text{ mA}$	$V_{VM} - I_{BK} \cdot (R_{LBK} + 2)^1$			V
$V_{BK}$	Buck regulator average voltage ( $L_{BK} = 22\text{ }\mu\text{H}$ , $C_{BK} = 22\text{ }\mu\text{F}$ )	$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 20\text{ mA}$ , BUCK_SEL = 00b	3.1	3.3	3.5	V
		$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 20\text{ mA}$ , BUCK_SEL = 01b	4.6	5.0	5.4	V
		$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 20\text{ mA}$ , BUCK_SEL = 10b	3.7	4.0	4.3	V
		$V_{VM} > 6.7\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 20\text{ mA}$ , BUCK_SEL = 11b	5.2	5.7	6.2	V
		$V_{VM} < 6.0\text{ V}$ (BUCK_SEL = 00b, 01b, 10b, 11b), $0\text{ mA} \leq I_{BK} \leq 20\text{ mA}$	$V_{VM} - I_{BK} \cdot (R_{LBK} + 2)^1$			V
$V_{BK}$	Buck regulator average voltage ( $R_{BK} = 22\text{ }\Omega$ , $C_{BK} = 22\text{ }\mu\text{F}$ )	$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 10\text{ mA}$ , BUCK_SEL = 00b	3.1	3.3	3.5	V
		$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 10\text{ mA}$ , BUCK_SEL = 01b	4.6	5.0	5.4	V
		$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 10\text{ mA}$ , BUCK_SEL = 10b	3.7	4.0	4.3	V
		$V_{VM} > 6.7\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 10\text{ mA}$ , BUCK_SEL = 11b	5.2	5.7	6.2	V
		$V_{VM} < 6.0\text{ V}$ (BUCK_SEL = 00b, 01b, 10b, 11b), $0\text{ mA} \leq I_{BK} \leq 10\text{ mA}$	$V_{VM} - I_{BK} \cdot (R_{BK} + 2)$			V
$V_{BK\_RIP}$	Buck regulator ripple voltage	$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 170\text{ mA}$ , Buck regulator with inductor, $L_{BK} = 47\text{ }\mu\text{H}$ , $C_{BK}$ $= 22\text{ }\mu\text{F}$	-100		100	mV
		$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 20\text{ mA}$ , Buck regulator with inductor, $L_{BK} = 22\text{ }\mu\text{H}$ , $C_{BK}$ $= 22\text{ }\mu\text{F}$	-100		100	mV
		$V_{VM} > 6\text{ V}$ , $0\text{ mA} \leq I_{BK} \leq 10\text{ mA}$ , Buck regulator with resistor, $R_{BK} = 22\text{ }\Omega$ , $C_{BK}$ $= 22\text{ }\mu\text{F}$	-100		100	mV



$T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{VM} = 4.5$  to  $35\text{ V}$  (unless otherwise noted). Typical limits apply for  $T_A = 25^{\circ}\text{C}$ ,  $V_{VM} = 24\text{ V}$

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{BK}$	External buck regulator load	$L_{BK} = 47\text{ }\mu\text{H}$ , $C_{BK} = 22\text{ }\mu\text{F}$ , BUCK_PS_DIS = 1b			170	mA
		$L_{BK} = 47\text{ }\mu\text{H}$ , $C_{BK} = 22\text{ }\mu\text{F}$ , BUCK_PS_DIS = 0b			170 – $I_{AVDD}$	mA
		$L_{BK} = 22\text{ }\mu\text{H}$ , $C_{BK} = 22\text{ }\mu\text{F}$ , BUCK_PS_DIS = 1b			20	mA
		$L_{BK} = 22\text{ }\mu\text{H}$ , $C_{BK} = 22\text{ }\mu\text{F}$ , BUCK_PS_DIS = 0b			20 – $I_{AVDD}$	mA
		$R_{BK} = 22\text{ }\Omega$ , $C_{BK} = 22\text{ }\mu\text{F}$ , BUCK_PS_DIS = 1b			10	mA
		$R_{BK} = 22\text{ }\Omega$ , $C_{BK} = 22\text{ }\mu\text{F}$ , BUCK_PS_DIS = 0b			10 – $I_{AVDD}$	mA
$f_{SW\_BK}$	Buck regulator switching frequency	Regulation Mode	20		535	kHz
		Linear Mode	20		535	kHz
$V_{BK\_UV}$	Buck regulator undervoltage lockout	$V_{BK}$ rising, BUCK_SEL = 00b	2.7	2.8	2.95	V
		$V_{BK}$ falling, BUCK_SEL = 00b	2.5	2.6	2.7	V
		$V_{BK}$ rising, BUCK_SEL = 01b	4.3	4.4	4.55	V
		$V_{BK}$ falling, BUCK_SEL = 01b	4.1	4.2	4.36	V
		$V_{BK}$ rising, BUCK_SEL = 10b	2.7	2.8	2.95	V
		$V_{BK}$ falling, BUCK_SEL = 10b	2.5	2.6	2.7	V
		$V_{BK}$ rising, BUCK_SEL = 11b	4.3	4.4	4.55	V
		$V_{BK}$ falling, BUCK_SEL = 11b	4.1	4.2	4.36	V
$V_{BK\_UV\_HYS}$	Buck regulator undervoltage lockout hysteresis	Rising to falling threshold, BUCK_SEL = 00b	90	200	400	mV
		Rising to falling threshold, BUCK_SEL = 01b	90	200	400	mV
		Rising to falling threshold, BUCK_SEL = 10b	90	200	400	mV
		Rising to falling threshold, BUCK_SEL = 11b	90	200	400	mV
$I_{BK\_CL}$	Buck regulator current limit threshold	BUCK_CL = 0b	360	600	910	mA
		BUCK_CL = 1b	80	150	250	mA
$I_{BK\_OCP}$	Buck regulator over current protection trip point		2	3	4	A
$t_{BK\_RETRY}$	Over current protection retry time		0.7	1	1.3	ms
<b>DRIVER OUTPUTS</b>						
$R_{DS(ON)}$	Total MOSFET on resistance (High-side + Low-side)	$V_{VM} > 6\text{ V}$ , $I_{OUT} = 1\text{ A}$ , $T_A = 25^{\circ}\text{C}$		240	260	m $\Omega$
		$V_{VM} < 6\text{ V}$ , $I_{OUT} = 1\text{ A}$ , $T_A = 25^{\circ}\text{C}$		250	270	m $\Omega$
		$V_{VM} > 6\text{ V}$ , $I_{OUT} = 1\text{ A}$ , $T_J = 150^{\circ}\text{C}$		360	400	m $\Omega$
		$V_{VM} < 6\text{ V}$ , $I_{OUT} = 1\text{ A}$ , $T_J = 150^{\circ}\text{C}$		370	415	m $\Omega$
SR	Phase pin slew rate switching low to high (Rising from 20 % to 80 %)	$V_{VM} = 24\text{ V}$ , SLEW_RATE = 00b	13	25	45	V/ $\mu\text{s}$
		$V_{VM} = 24\text{ V}$ , SLEW_RATE = 01b	30	50	80	V/ $\mu\text{s}$
		$V_{VM} = 24\text{ V}$ , SLEW_RATE = 10b	80	125	185	V/ $\mu\text{s}$
		$V_{VM} = 24\text{ V}$ , SLEW_RATE = 11b	130	200	280	V/ $\mu\text{s}$
SR	Phase pin slew rate switching high to low (Falling from 80 % to 20 %)	$V_{VM} = 24\text{ V}$ , SLEW_RATE = 00b	14	25	45	V/ $\mu\text{s}$
		$V_{VM} = 24\text{ V}$ , SLEW_RATE = 01b	30	50	80	V/ $\mu\text{s}$
		$V_{VM} = 24\text{ V}$ , SLEW_RATE = 10b	80	125	185	V/ $\mu\text{s}$
		$V_{VM} = 24\text{ V}$ , SLEW_RATE = 11b	110	200	280	V/ $\mu\text{s}$

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 $T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{VM} = 4.5$  to  $35\text{ V}$  (unless otherwise noted). Typical limits apply for  $T_A = 25^{\circ}\text{C}$ ,  $V_{VM} = 24\text{ V}$ 

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t <sub>DEAD</sub>	Output dead time (high to low / low to high)	V <sub>VM</sub> = 24 V, SR = 25 V/μs		1800	3000	ns
		V <sub>VM</sub> = 24 V, SR = 50 V/μs		1100	1400	ns
		V <sub>VM</sub> = 24 V, SR = 125 V/μs		650	850	ns
		V <sub>VM</sub> = 24 V, SR = 200 V/μs		500	550	ns
SPEED INPUT - PWM MODE						
f <sub>PWM</sub>	PWM input frequency		0.01		100	kHz
Res <sub>PWM</sub>	PWM input resolution	f <sub>PWM</sub> = 0.01 to 0.35 kHz	11	12	13	bits
		f <sub>PWM</sub> = 0.35 to 2 kHz	11	13	14	bits
		f <sub>PWM</sub> = 2 to 3.5 kHz	11	11.5	12	bits
		f <sub>PWM</sub> = 3.5 to 7 kHz	12	13	13.5	bits
		f <sub>PWM</sub> = 7 to 14 kHz	11	12	12.5	bits
		f <sub>PWM</sub> = 14 to 29.2 kHz	10	11.5	12	bits
		f <sub>PWM</sub> = 29.3 to 60 kHz	9	10.5	11	bits
		f <sub>PWM</sub> = 60 to 100 kHz	8	9	10	bits
SPEED INPUT - ANALOG MODE						
V <sub>ANA_FS</sub>	Analog full-speed voltage		2.95	3	3.05	V
V <sub>ANA_RES</sub>	Analog voltage resolution			732		μV
SPEED INPUT - FREQUENCY MODE						
f <sub>PWM_FREQ</sub>	PWM input frequency range	Duty cycle = 50%	3		32767	Hz
SLEEP MODE						
V <sub>EN_SL</sub>	Analog voltage to enter sleep mode	SPD_CTRL_MODE = 00b (analog mode)			40	mV
V <sub>EX_SL</sub>	Analog voltage to exit sleep mode	SPD_CTRL_MODE = 00b (analog mode)	2.2			V
t <sub>DET_ANA</sub>	Time needed to detect wake up signal on SPEED pin	SPD_CTRL_MODE = 00b (analog mode) V <sub>SPEED</sub> > V <sub>EX_SL</sub>	0.5	1	1.5	μs
t <sub>WAKE</sub>	Wakeup time from sleep mode	V <sub>SPEED</sub> > V <sub>EX_SL</sub> to DVDD voltage available, SPD_CTRL_MODE = 00b (analog mode)		3	5	ms
t <sub>EX_SL_DR_A</sub> NA	Time taken to drive motor after exiting from sleep state	SPD_CTRL_MODE = 00b (analog mode) V <sub>SPEED</sub> > V <sub>EX_SL</sub> , ISD detection disabled			30	ms
t <sub>DET_PWM</sub>	Time needed to detect wake up signal on SPEED pin	SPD_CTRL_MODE = 01b (PWM mode), V <sub>SPEED</sub> > V <sub>IH</sub>	0.5	1	1.5	μs
t <sub>WAKE_PWM</sub>	Wakeup time from sleep mode	V <sub>SPEED</sub> > V <sub>IH</sub> to DVDD voltage available, SPD_CTRL_MODE = 01b (PWM mode) or 11b (Frequency mode)		3	5	ms
t <sub>EX_SL_DR_P</sub> WM	Time taken to drive motor after wakeup from sleep state	SPD_CTRL_MODE = 01b (PWM mode) V <sub>SPEED</sub> > V <sub>IH</sub> , ISD detection disabled			30	ms
t <sub>DET_SL_ANA</sub>	Time needed to detect sleep command, analog mode	SPD_CTRL_MODE = 00b (analog mode) V <sub>SPEED</sub> < V <sub>EN_SL</sub> , SLEEP_TIME = 00b or 01b	0.5	1	2	ms
		SPD_CTRL_MODE = 00b (analog mode) V <sub>SPEED</sub> < V <sub>EN_SL</sub> , SLEEP_TIME = 10b	14	20	26	ms
		SPD_CTRL_MODE = 00b (analog mode) V <sub>SPEED</sub> < V <sub>EN_SL</sub> , SLEEP_TIME = 11b	140	200	260	ms

$T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{VM} = 4.5$  to  $35\text{ V}$  (unless otherwise noted). Typical limits apply for  $T_A = 25^{\circ}\text{C}$ ,  $V_{VM} = 24\text{ V}$

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{\text{DET\_SL\_PWM}}$	Time needed to detect sleep command, PWM or frequency mode	SPD_CTRL_MODE = 01b (PWM mode) or 11b (Frequency mode), $V_{\text{SPEED}} < V_{\text{IL}}$ , SLEEP_TIME = 00b	0.035	0.05	0.065	ms
		SPD_CTRL_MODE = 01b (PWM mode) or 11b (Frequency mode), $V_{\text{SPEED}} < V_{\text{IL}}$ , SLEEP_TIME = 01b	0.14	0.2	0.26	ms
		SPD_CTRL_MODE = 01b (PWM mode) or 11b (Frequency mode), $V_{\text{SPEED}} < V_{\text{IL}}$ , SLEEP_TIME = 10b	14	20	26	ms
		SPD_CTRL_MODE = 01b (PWM mode) or 11b (Frequency mode), $V_{\text{SPEED}} < V_{\text{IL}}$ , SLEEP_TIME = 11b	140	200	260	ms
$t_{\text{EN\_SL}}$	Time needed to stop driving motor after detecting sleep command	$V_{\text{SPEED}} < V_{\text{EN\_SL}}$ (analog mode) or $V_{\text{SPEED}} < V_{\text{IL}}$ (PWM mode) (and SPEED_CTRL = 0 (I <sup>2</sup> C mode))		1	2	ms
<b>STANDBY MODE</b>						
$t_{\text{EX\_SB\_DR\_ANA}}$	Time taken to drive motor after exiting standby mode, analog mode	SPD_CTRL_MODE = 00b (analog mode), $V_{\text{SPEED}} > V_{\text{EX\_SB}}$ , ISD detection disabled			6	ms
$t_{\text{EX\_SB\_DR\_PWM}}$	Time taken to drive motor after exiting standby mode, PWM mode	SPD_CTRL_MODE = 01b (PWM mode) $V_{\text{SPEED}} > V_{\text{IH}}$ , ISD detection disabled			6	ms
$t_{\text{DET\_SB\_ANA}}$	Time needed to detect standby mode, analog mode	SPD_CTRL_MODE = 00b (analog mode), $V_{\text{SPEED}} < V_{\text{EN\_SB}}$	0.5	1	2	ms
$t_{\text{DET\_SB\_PWM}}$	Time needed to detect standby command, PWM/ mode	SPD_CTRL_MODE = 01b (PWM mode), $V_{\text{SPEED}} < V_{\text{IL}}$ , SLEEP_TIME = 00b	0.035	0.05	0.065	ms
		SPD_CTRL_MODE = 01b (PWM mode), $V_{\text{SPEED}} < V_{\text{IL}}$ , SLEEP_TIME = 01b	0.14	0.2	0.26	ms
		SPD_CTRL_MODE = 01b (PWM mode), $V_{\text{SPEED}} < V_{\text{IL}}$ , SLEEP_TIME = 10b	14	20	26	ms
		SPD_CTRL_MODE = 01b (PWM mode), $V_{\text{SPEED}} < V_{\text{IL}}$ , SLEEP_TIME = 11b	140	200	260	ms
$t_{\text{DET\_SB\_FRE\_Q}}$	Time needed to detect standby mode, Frequency mode	SPD_CTRL_MODE = 11b (Frequency mode), $V_{\text{SPEED}} < V_{\text{IL}}$		4000		ms
$t_{\text{DET\_SB\_DIG}}$	Time needed to detect standby mode, I <sup>2</sup> C mode	SPD_CTRL_MODE = 10b (I <sup>2</sup> C mode), SPEED_CTRL = 0b		1	2	ms
$t_{\text{EN\_SB}}$	Time needed to stop driving motor after detecting standby command	All speed input modes		1	2	ms
<b>LOGIC-LEVEL INPUTS (BRAKE, DIR, EXT_CLK, EXT_WD, SPEED)</b>						
$V_{\text{IL}}$	Input logic low voltage	AVDD = 3 to 3.6 V			$0.25 \cdot V_{\text{DD}}$	V
$V_{\text{IH}}$	Input logic high voltage	AVDD = 3 to 3.6 V			$0.65 \cdot V_{\text{DD}}$	V
$V_{\text{HYS}}$	Input hysteresis		50	500	800	mV
$I_{\text{IL}}$	Input logic low current	AVDD = 3 to 3.6 V	-0.15		0.15	μA
$I_{\text{IH}}$	Input logic high current	AVDD = 3 to 3.6 V	-0.3		0	μA
$R_{\text{PD\_SPEED}}$	Input pulldown resistance	SPEED pin To GND	0.6	1	1.4	MΩ
<b>OPEN-DRAIN OUTPUTS (nFAULT, FG)</b>						
$V_{\text{OL}}$	Output logic low voltage	$I_{\text{OD}} = -5\text{ mA}$			0.4	V
$I_{\text{OZ}}$	Output logic high current	$V_{\text{OD}} = 3.3\text{ V}$	0		0.5	μA
<b>I<sup>2</sup>C Serial Interface</b>						
$V_{\text{I2C\_L}}$	Input logic low voltage		-0.5		$0.3 \cdot V_{\text{DD}}$	V

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 $T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{VM} = 4.5$  to  $35\text{ V}$  (unless otherwise noted). Typical limits apply for  $T_A = 25^{\circ}\text{C}$ ,  $V_{VM} = 24\text{ V}$ 

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V <sub>I2C_H</sub>	Input logic high voltage		0.7*AVD D		5.5	V
V <sub>I2C_HYS</sub>	Hysteresis		0.05*AV DD			V
V <sub>I2C_OL</sub>	Output logic low voltage	Open-drain at 2mA sink current	0		0.4	V
I <sub>I2C_OL</sub>	Output logic low current	V <sub>I2C_OL</sub> = 0.6V			6	mA
I <sub>I2C_IL</sub>	Input current on SDA and SCL		-10 <sup>2</sup>		10 <sup>2</sup>	μA
C <sub>i</sub>	Capacitance for SDA and SCL				10	pF
t <sub>of</sub>	Output fall time from V <sub>I2C_H</sub> (min) to V <sub>I2C_L</sub> (max)	Standard Mode			250 <sup>3</sup>	ns
		Fast Mode			250 <sup>3</sup>	ns
t <sub>SP</sub>	Pulse width of spikes that must be suppressed by the input filter	Fast Mode	0		50 <sup>4</sup>	ns
OSCILLATOR						
f <sub>OSCREF</sub>	External clock reference	EXT_CLK_CONFIG = 000b		8		kHz
		EXT_CLK_CONFIG = 001b		16		kHz
		EXT_CLK_CONFIG = 010b		32		kHz
		EXT_CLK_CONFIG = 011b		64		kHz
		EXT_CLK_CONFIG = 100b		128		kHz
		EXT_CLK_CONFIG = 101b		256		kHz
		EXT_CLK_CONFIG = 110b		512		kHz
		EXT_CLK_CONFIG = 111b		1024		kHz
EEPROM						
EE <sub>Prog</sub>	Programming voltage		1.35	1.5	1.65	V
EE <sub>RET</sub>	Retention	T <sub>A</sub> = 25 °C		100		Years
		T <sub>J</sub> = -40 to 150 °C	10			Years
EE <sub>END</sub>	Endurance	T <sub>J</sub> = -40 to 150 °C	1000			Cycles
		T <sub>J</sub> = -40 to 85 °C	20000			Cycles
PROTECTION CIRCUITS						
V <sub>UVLO</sub>	Supply under voltage lockout (UVLO)	VM rising	4.3	4.4	4.51	V
		VM falling	4.1	4.2	4.3	V
V <sub>UVLO_HYS</sub>	Supply under voltage lockout hysteresis	Rising to falling threshold	110	200	350	mV
t <sub>UVLO</sub>	Supply under voltage deglitch time		3	5	7	μs
V <sub>OVP</sub>	Supply over voltage protection (OVP) threshold	Supply rising, OVP_EN = 1, OVP_SEL = 0	32.5	34	35	V
		Supply falling, OVP_EN = 1, OVP_SEL = 0	31.8	33	34.3	V
		Supply rising, OVP_EN = 1, OVP_SEL = 1	20	22	23	V
		Supply falling, OVP_EN = 1, OVP_SEL = 1	19	21	22	V
V <sub>OVP_HYS</sub>	Supply over voltage protection hysteresis	Rising to falling threshold, OVP_SEL = 1	0.9	1	1.1	V
		Rising to falling threshold, OVP_SEL = 0	0.7	0.8	0.9	V
t <sub>OVP</sub>	Supply over voltage deglitch time		2.5	5	7	μs
V <sub>CPUV</sub>	Charge pump under voltage lockout (above VM)	Supply rising	2.25	2.5	2.75	V
		Supply falling	2.2	2.4	2.6	V
V <sub>CPUV_HYS</sub>	Charge pump UVLO hysteresis	Rising to falling threshold	65	100	150	mV

$T_J = -40^{\circ}\text{C}$  to  $+150^{\circ}\text{C}$ ,  $V_{VM} = 4.5$  to  $35\text{ V}$  (unless otherwise noted). Typical limits apply for  $T_A = 25^{\circ}\text{C}$ ,  $V_{VM} = 24\text{ V}$

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$V_{AVDD\_UV}$	Analog regulator (AVDD) under voltage lockout	Supply rising	2.7	2.85	3	V
		Supply falling	2.5	2.65	2.8	V
$V_{AVDD\_UV\_HYS}$	Analog regulator under voltage lockout hysteresis	Rising to falling threshold	180	200	240	mV
$I_{OCP}$	Over current protection trip point	OCP_LVL = 0b	5.5	9	12	A
		OCP_LVL = 1b	9	13	18	A
$t_{OCP}$	Over current protection deglitch time	OCP_DEG = 00b	0.02	0.2	0.4	$\mu\text{s}$
		OCP_DEG = 01b	0.2	0.6	1.2	$\mu\text{s}$
		OCP_DEG = 10b	0.5	1.2	1.8	$\mu\text{s}$
		OCP_DEG = 11b	0.9	1.6	2.5	$\mu\text{s}$
$t_{RETRY}$	Over current protection retry time	OCP_RETRY = 0	4	5	6	ms
		OCP_RETRY = 1	425	500	575	ms
$T_{OTW}$	Thermal warning temperature	Die temperature ( $T_J$ )	135	145	155	$^{\circ}\text{C}$
$T_{OTW\_HYS}$	Thermal warning hysteresis	Die temperature ( $T_J$ )	20	25	30	$^{\circ}\text{C}$
$T_{TSD\_BUCK}$	Thermal shutdown temperature (Buck)	Die temperature ( $T_J$ )	170	180	190	$^{\circ}\text{C}$
$T_{TSD\_BUCK\_HYS}$	Thermal shutdown hysteresis (Buck)	Die temperature ( $T_J$ )	20	25	30	$^{\circ}\text{C}$
$T_{TSD}$	Thermal shutdown temperature (FET)	Die temperature ( $T_J$ )	165	175	185	$^{\circ}\text{C}$
$T_{TSD\_HYS}$	Thermal shutdown hysteresis (FET)	Die temperature ( $T_J$ )	20	25	30	$^{\circ}\text{C}$

- (1)  $R_{LBK}$  is resistance of inductor  $L_{BK}$ .
- (2) If AVDD is switched off, I/O pins must not obstruct the SDA and SCL lines.
- (3) The maximum  $t_f$  for the SDA and SCL bus lines (300 ns) is longer than the specified maximum  $t_{of}$  for the output stages (250 ns). This allows series protection resistors ( $R_s$ ) to be connected between the SDA/SCL pins and the SDA/SCL bus lines without exceeding the maximum specified  $t_f$ .
- (4) Input filters on the SDA and SCL inputs suppress noise spikes of less than 50 ns.

## 6.6 Characteristics of the SDA and SCL bus for Standard and Fast mode

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	NOM	MAX	UNIT
<b>Standard-mode</b>						
$f_{SCL}$	SCL clock frequency		0		100	kHz
$t_{HD\_STA}$	Hold time (repeated) START condition	After this period, the first clock pulse is generated	4			$\mu\text{s}$
$t_{LOW}$	LOW period of the SCL clock		4.7			$\mu\text{s}$
$t_{HIGH}$	HIGH period of the SCL clock		4			$\mu\text{s}$
$t_{SU\_STA}$	Set-up time for a repeated START condition		4.7			$\mu\text{s}$
$t_{HD\_DAT}$	Data hold time <sup>(2)</sup>	I2C bus devices	0 <sup>(3)</sup>		<sup>(4)</sup>	$\mu\text{s}$
$t_{SU\_DAT}$	Data set-up time		250			ns
$t_r$	Rise time for both SDA and SCL signals				1000	ns
$t_f$	Fall time of both SDA and SCL signals <sup>(3)</sup> <sup>(6)</sup> <sup>(7)</sup> <sup>(8)</sup>				300	ns
$t_{SU\_STO}$	Set-up time for STOP condition		4			$\mu\text{s}$
$t_{BUF}$	Bus free time between STOP and START condition		4.7			$\mu\text{s}$
$C_b$	Capacitive load for each bus line <sup>(9)</sup>				400	pF
$t_{VD\_DAT}$	Data valid time <sup>(10)</sup>				3.45 <sup>(4)</sup>	$\mu\text{s}$
$t_{VD\_ACK}$	Data valid acknowledge time <sup>(11)</sup>				3.45 <sup>(4)</sup>	$\mu\text{s}$

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	NOM	MAX	UNIT
V <sub>nL</sub>	Noise margin at the LOW level	For each connected device (including hysteresis)	0.1*AVD D			V
V <sub>nh</sub>	Noise margin at the HIGHlevel	For each connected device (including hysteresis)	0.2*AVD D			V
Fast-mode						
f <sub>SCL</sub>	SCL clock frequency		0		400	KHz
t <sub>HD_STA</sub>	Hold time (repeated) START condition	After this period, the first clock pulse is generated	0.6			μs
t <sub>LOW</sub>	LOW period of the SCL clock		1.3			μs
t <sub>HIGH</sub>	HIGH period of the SCL clock		0.6			μs
t <sub>SU_STA</sub>	Set-up time for a repeated START condition		0.6			μs
t <sub>HD_DAT</sub>	Data hold time <sup>(2)</sup>		0 <sup>(3)</sup>		<sup>(4)</sup>	μs
t <sub>SU_DAT</sub>	Data set-up time		100 <sup>(5)</sup>			ns
t <sub>r</sub>	Rise time for both SDA and SCL signals		20		300	ns
t <sub>f</sub>	Fall time of both SDA and SCL signals <sup>(3)</sup> <sup>(6)</sup> <sup>(7)</sup> <sup>(8)</sup>		20 x (AVDD/ 5.5V)		300	ns
t <sub>SU_STO</sub>	Set-up time for STOP condition		0.6			μs
t <sub>BUF</sub>	Bus free time between STOP and START condition		1.3			μs
C <sub>b</sub>	Capacitive load for each bus line <sup>(9)</sup>				400	pF
t <sub>VD_DAT</sub>	Data valid time <sup>(10)</sup>				0.9 <sup>(4)</sup>	μs
t <sub>VD_ACK</sub>	Data valid acknowledge time <sup>(11)</sup>				0.9 <sup>(4)</sup>	μs
V <sub>nL</sub>	Noise margin at the LOW level	For each connected device (including hysteresis)	0.1*AVD D			V
V <sub>nh</sub>	Noise margin at the HIGHlevel	For each connected device (including hysteresis)	0.2*AVD D			V

(1) All values referred to  $V_{IH(min)}$  (0.3V<sub>DD</sub>) and  $V_{IL(max)}$  levels

(2)  $t_{HD\_DAT}$  is the data hold time that is measured from the falling edge of SCL, applies to data in transmission and the acknowledge.

(3) A device must internally provide a hold time of at least 300 ns for the SDA signal (with respect to the  $V_{IH(min)}$  of the SCL signal) to bridge the undefined region of the falling edge of SCL.

(4) The maximum  $t_{HD\_DAT}$  could be 3.45  $\mu$ s and .9  $\mu$ s for Standard-mode and Fast-mode, but must be less than the maximum of  $t_{VD\_DAT}$  or  $t_{VD\_ACK}$  by a transition time. This maximum must only be met if the device does not stretch the LOW period ( $t_{LOW}$ ) of the SCL signal. If the clock stretched the SCL, the data must be valid by the set-up time before it releases the clock.

(5) A Fast-mode I2C-bus device can be used in a Standard-mode I2C-bus system, but the requirement  $t_{SU\_DAT}$  250 ns must then be met. This will automatically be the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line  $t_{r(max)} + t_{SU\_DAT} = 1000 + 250 = 1250$  ns (according to the Standard-mode I2C-bus specification) before the SCL line is released. Also the acknowledge timing must meet this set-up time.

(6) If mixed with HS-mode devices, faster fall times according to Table 10 are allowed.

(7) The maximum  $t_f$  for the SDA and SCL bus lines is specified at 300 ns. The maximum fall time for the SDA output stage  $t_f$  is specified at 250 ns. This allows series protection resistors to be connected in between the SDA and the SCL pins and the SDA/SCL bus lines without exceeding the maximum specified  $t_f$ .

(8) In Fast-mode Plus, fall time is specified the same for both output stage and bus timing. If series resistors are used, designers should allow for this when considering bus timing.

(9) The maximum bus capacitance allowable may vary from the value depending on the actual operating voltage and frequency of the application.

(10)  $t_{VD\_DAT}$  = time for data signal from SCL LOW to SDA output (HIGH or LOW, depending on which one is worse).

(11)  $t_{VD\_ACK}$  = time for Acknowledgement signal from SCL LOW to SDA output (HIGH or LOW, depending on which one is worse).

## 6.7 Typical Characteristics

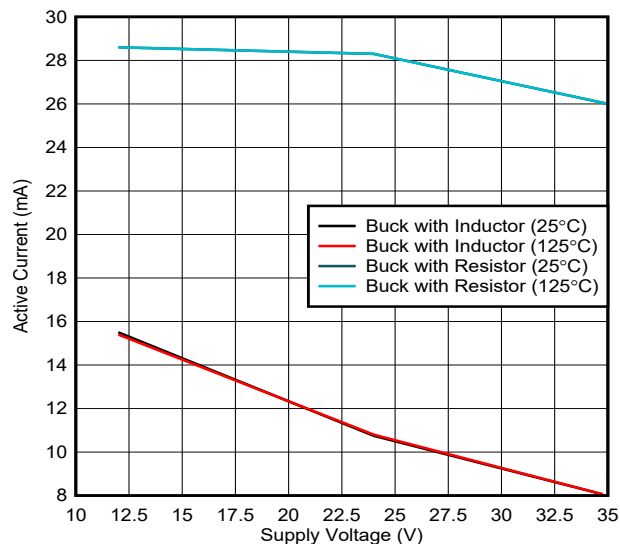


Figure 6-1. Supply current over supply voltage

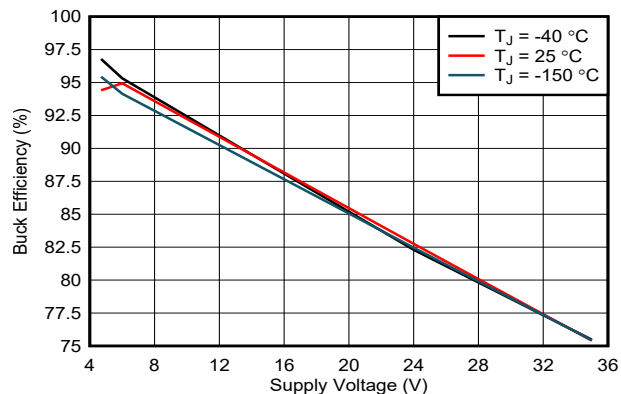


Figure 6-2. Buck regulator efficiency over supply voltage

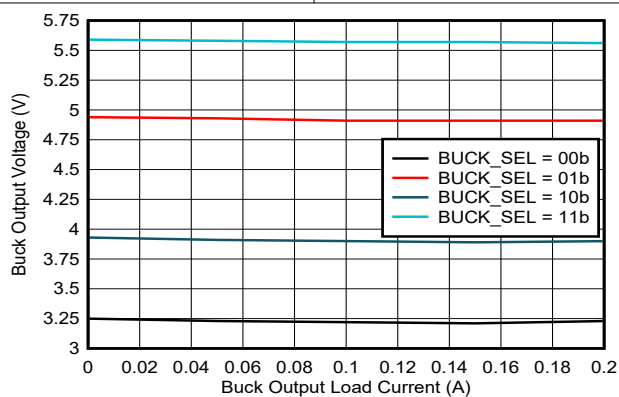


Figure 6-3. Buck regulator output voltage over load current

## 7 Detailed Description

### 7.1 Overview

The MCT8315A provides a single-chip, code-free sensorless trapezoidal solution for customers requiring high speed operation (up to 3 kHz electrical speed) or very fast start-up time (< 50ms) for 12- to 24-V brushless-DC motors requiring up to 4-A peak phase currents.

The MCT8315A integrates three  $\frac{1}{2}$ -bridges with 40-V absolute maximum capability and a low  $R_{DS(ON)}$  of 240-m $\Omega$  (high-side + low-side FETs) to enable high power drive capability. Current is sensed using integrated current sensing circuits which eliminate the need for external current sense resistors. Power management features including an output voltage-adjustable buck regulator and 3.3-V LDO generate the necessary voltage rails for the device and can also be used to power external circuits.

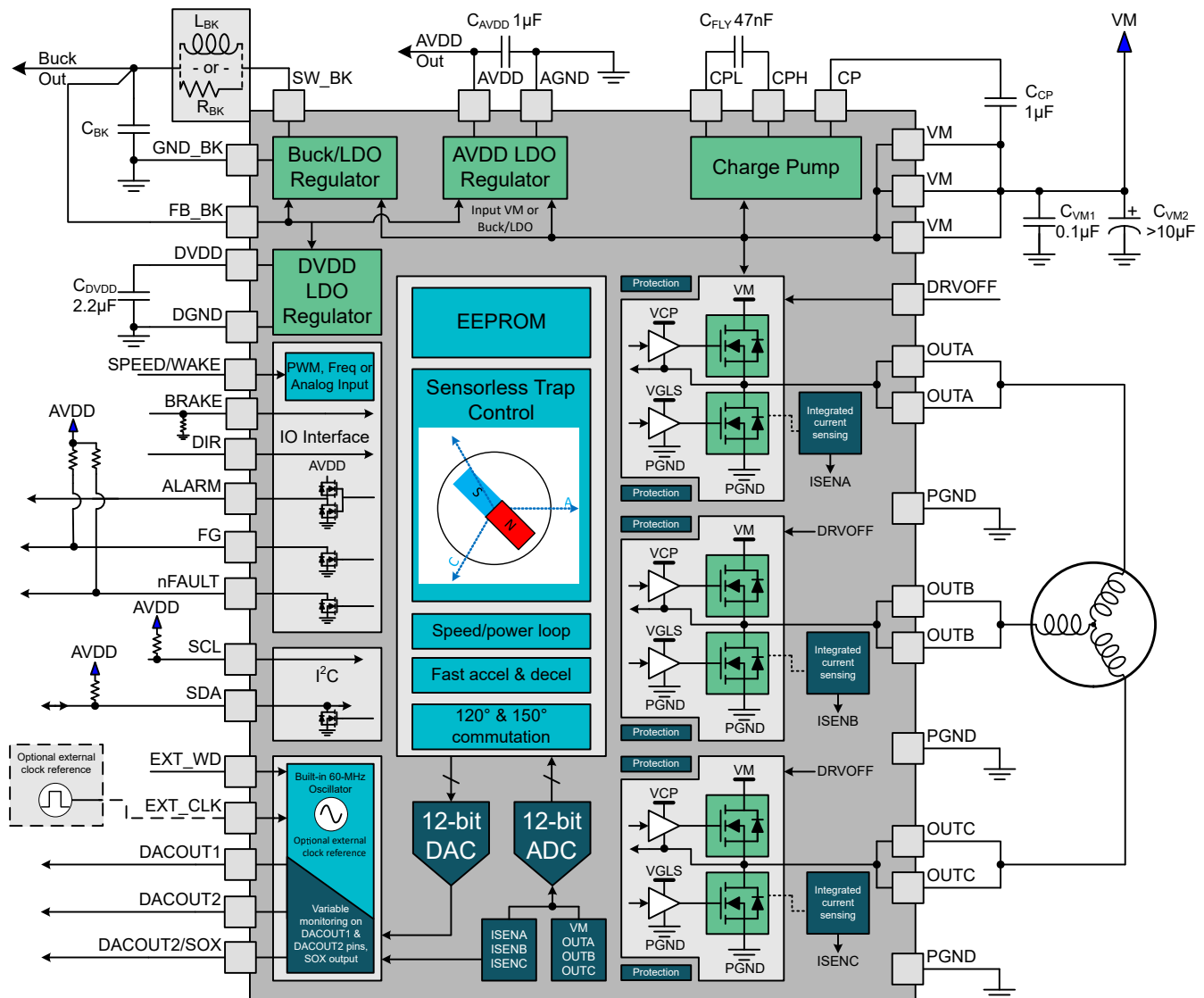
Sensorless trapezoidal control is highly configurable through register settings ranging from motor start-up behavior to closed loop operation. Register settings can be stored in non-volatile EEPROM, which allows the device to operate stand-alone once it has been configured. MCT8315A allows for a high level of monitoring; variables like duty cycle, motor speed, DC bus power can be displayed and observed as an analog output via two 12-bit DACs. This feature provides an effective method to tune speed loops as well as motor acceleration. The device can receive a speed command through a PWM signal, analog voltage, frequency input or I<sup>2</sup>C instruction.

In-built protection features include power-supply under voltage lockout (UVLO), charge-pump under voltage lockout (CPUV), over current protection (OCP), AVDD under voltage lockout (AVDD\_UV), buck regulator UVLO, motor lock detection and over temperature warning and shutdown (OTW and TSD). Fault events are indicated by the nFAULT pin with detailed fault information available in the registers.

The MCT8315A device is available in a 0.5-mm pin pitch, VQFN surface-mount package. The VQFN package size is 7 mm  $\times$  5 mm with a height of 1 mm.



## 7.2 Functional Block Diagram



7-1. MCT8315A Functional Block Diagram

## 7.3 Feature Description

### 7.3.1 Output Stage

The MCT8315A consists of integrated 240-mΩ (combined high-side and low-side FETs' on-state resistance) NMOS FETs connected in a three-phase bridge configuration. A doubler charge pump provides the proper gate-bias voltage to the high-side NMOS FETs across a wide operating voltage range in addition to providing 100% duty-cycle support. An internal linear regulator provides the gate-bias voltage for the low-side MOSFETs.

### 7.3.2 Device Interface

MCT8315A supports I<sup>2</sup>C interface to provide end application design with adequate flexibility. MCT8315A allows controlling the motor operation and system through BRAKE, DIR, DRVOFF, EXT\_CLK, EXT\_WD and SPEED/WAKE pins. MCT8315A also provides different signals for monitoring internal variables, speed, fault and phase current feedback through DACOUT1, DACOUT2, FG, nFAULT, ALARM and SOX pins.

#### 7.3.2.1 Interface - Control and Monitoring

##### Motor Control Signals

- When BRAKE pin is driven 'High', MCT8315A enters brake state. Low-side braking (see [Low-Side Braking](#)) is implemented during this brake state. MCT8315A decreases output speed to value defined by BRAKE\_DUTY\_THRESHOLD before entering brake state. As long as BRAKE is driven 'High', MCT8315A stays in brake state. Brake pin input can be overwritten by configuring BRAKE\_INPUT over the I<sup>2</sup>C interface.
- The DIR pin decides the direction of motor spin; when driven 'High', the sequence is OUT A → OUT C → OUT B, and when driven 'Low', the sequence is OUT A → OUT B → OUT C. DIR pin input can be overwritten by configuring DIR\_INPUT over the I<sup>2</sup>C interface.
- When DRVOFF pin is driven 'High', MCT8315A stops driving the motor by turning OFF all MOSFETs (coast state). When DRVOFF is driven 'Low', MCT8315A returns to normal state of operation, as if it was restarting the motor (see [DRVOFF Functionality](#)). DRVOFF does not cause the device to go to sleep or standby mode; the digital core is still active. Entry and exit from sleep or standby condition is controlled by SPEED pin.
- SPEED/WAKE pin is used to control motor speed and to wake up MCT8315A from sleep mode. SPEED pin can be configured to accept PWM, frequency or analog input signals. It is used to enter and exit from sleep and standby mode (see [表 7-3](#)).

##### External Oscillator and Watchdog Signals

- EXT\_CLK pin can be used to provide an external clock reference (see [External Clock Source](#)).
- EXT\_WD pin can be used to provide an external watchdog signal (see [External Watchdog](#)).

##### Output Signals

- DACOUT1 outputs internal variable defined by address in register DACOUT1\_VAR\_ADDR. DACOUT1 is refreshed every PWM cycle (see [DAC outputs](#)).
- DACOUT2 outputs internal variable defined by address in register DACOUT2\_VAR\_ADDR. DACOUT2 is refreshed every PWM cycle (see [DAC outputs](#)).
- FG pin provides pulses which are proportional to motor speed (see [FG Configuration](#)).
- nFAULT (active low) pin provides fault status in device or motor operation.
- ALARM pin, if enabled using ALARM\_PIN\_EN, provides fault status in device or motor operation. When ALARM pin is enabled, report only faults are reported only on ALARM pin (as logic high) and not reported on nFAULT pin (as logic low). When ALARM pin is enabled, actionable faults are reported on ALARM pin (as logic high) as well as on nFAULT pin (as logic low). When ALARM pin is disabled, it is in Hi-Z state and all faults (actionable and report only) are reported on nFAULT as logic low. ALARM pin should be left floating when unused/disabled.
- SOX pin provides the output of one of the current sense amplifiers.

#### 7.3.2.2 I<sup>2</sup>C Interface

The MCT8315A supports an I<sup>2</sup>C serial communication interface that allows an external controller to send and receive data. This I<sup>2</sup>C interface lets the external controller to configure the EEPROM and read detailed fault and

motor state information. The I<sup>2</sup>C bus is a two-wire interface using the SCL and SDA pins which are described as follows :

- The SCL pin is the clock signal input.
- The SDA pin is the data input and output.

### 7.3.3 Step-Down Mixed-Mode Buck Regulator

The MCT8315A has an integrated mixed-mode buck regulator to supply regulated 3.3-V or 5-V power for an external controller or system voltage rail. Additionally, the buck output can also be configured to 4-V or 5.7-V for supporting the extra headroom for an external LDO for generating a 3.3-V or 5-V supplies. The output voltage of the buck is set by BUCK\_SEL.

The buck regulator has a low quiescent current of ~1-2 mA during light loads to prolong battery life. The device improves performance during line and load transients by implementing a pulse-frequency current-mode control scheme which requires less output capacitance and simplifies frequency compensation design.

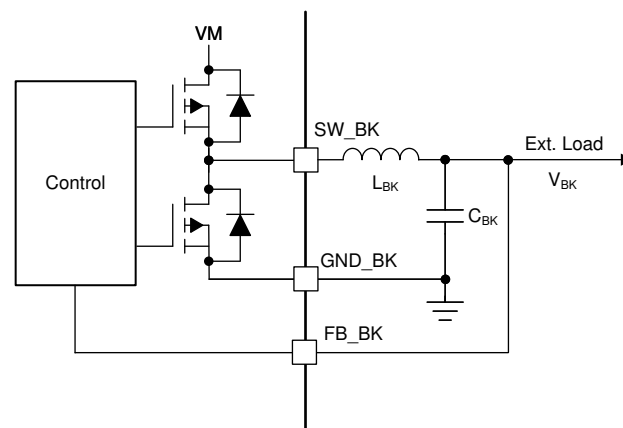
**表 7-1. Recommended settings for Buck Regulator**

Buck Mode	Buck output voltage	Max output current from AVDD (I <sub>AVDD_MAX</sub> )	Max output current from Buck (I <sub>BK_MAX</sub> )	Buck current limit	AVDD power sequencing
Inductor - 47 $\mu$ H	3.3-V or 4-V	20 mA	170 mA - I <sub>AVDD</sub>	600 mA (BUCK_CL = 0b)	Not supported (BUCK_PS_DIS = 1b)
Inductor - 47 $\mu$ H	5-V or 5.7-V	20 mA	170 mA - I <sub>AVDD</sub>	600 mA (BUCK_CL = 0b)	Supported (BUCK_PS_DIS = 0b)
Inductor - 22 $\mu$ H	5-V or 5.7-V	20 mA	20 mA - I <sub>AVDD</sub>	150 mA (BUCK_CL = 1b)	Not supported (BUCK_PS_DIS = 1b)
Inductor - 22 $\mu$ H	3.3-V or 4-V	20 mA	20 mA - I <sub>AVDD</sub>	150 mA (BUCK_CL = 1b)	Supported (BUCK_PS_DIS = 0b)
Resistor - 22 $\Omega$	5-V or 5.7-V	20 mA	10 mA - I <sub>AVDD</sub>	150 mA (BUCK_CL = 1b)	Not supported (BUCK_PS_DIS = 1b)
Resistor - 22 $\Omega$	3.3-V or 4-V	20 mA	10 mA - I <sub>AVDD</sub>	150 mA (BUCK_CL = 1b)	Supported (BUCK_PS_DIS = 0b)

#### 7.3.3.1 Buck in Inductor Mode

The buck regulator in MCT8315A is primarily designed to support low inductance of 47- $\mu$ H and 22- $\mu$ H. A 47- $\mu$ H inductor allows the buck regulator to operate up to 170-mA load current support, whereas applications requiring current up to 20-mA can use a 22- $\mu$ H inductor which saves component size.

☒ 7-2 shows the connection of buck regulator in inductor mode.



**☒ 7-2. Buck (Inductor Mode)**

### 7.3.3.2 Buck in Resistor mode

If the external load requirement is less than 10-mA, the inductor can be replaced with a resistor. In resistor mode the power is dissipated across the external resistor and the efficiency is lower than buck in inductor mode.

Figure 7-3 shows the connection of buck in resistor mode.

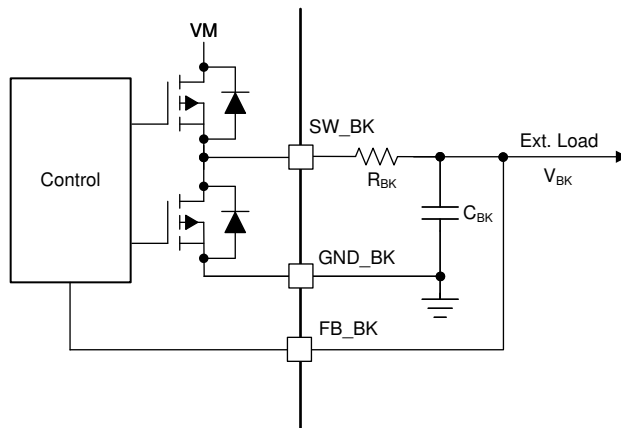


Figure 7-3. Buck (Resistor Mode)

### 7.3.3.3 Buck Regulator with External LDO

The buck regulator also supports the voltage requirement to supply an external LDO to generate standard 3.3-V or 5-V output rail with higher accuracies. The buck output voltage should be configured to 4-V or 5.7-V to provide extra headroom to support the external LDO for generating 3.3-V or 5-V rail as shown in Figure 7-4. This allows for a lower-voltage LDO design to save cost and better thermal management due to low drop-out voltage.

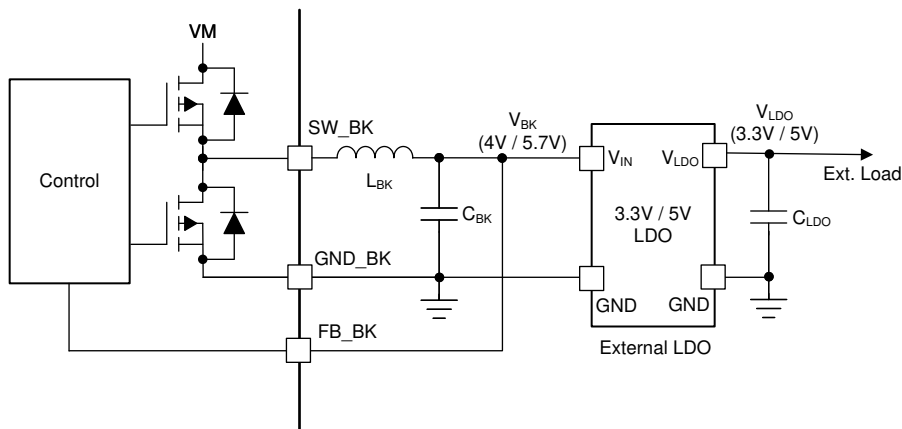
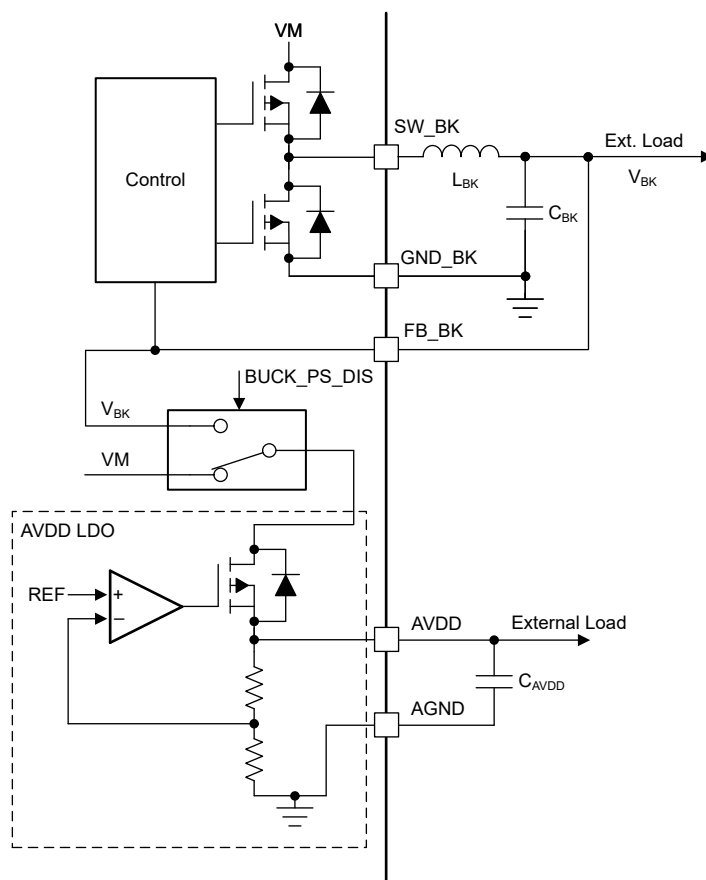


Figure 7-4. Buck Regulator with External LDO

### 7.3.3.4 AVDD Power Sequencing from Buck Regulator

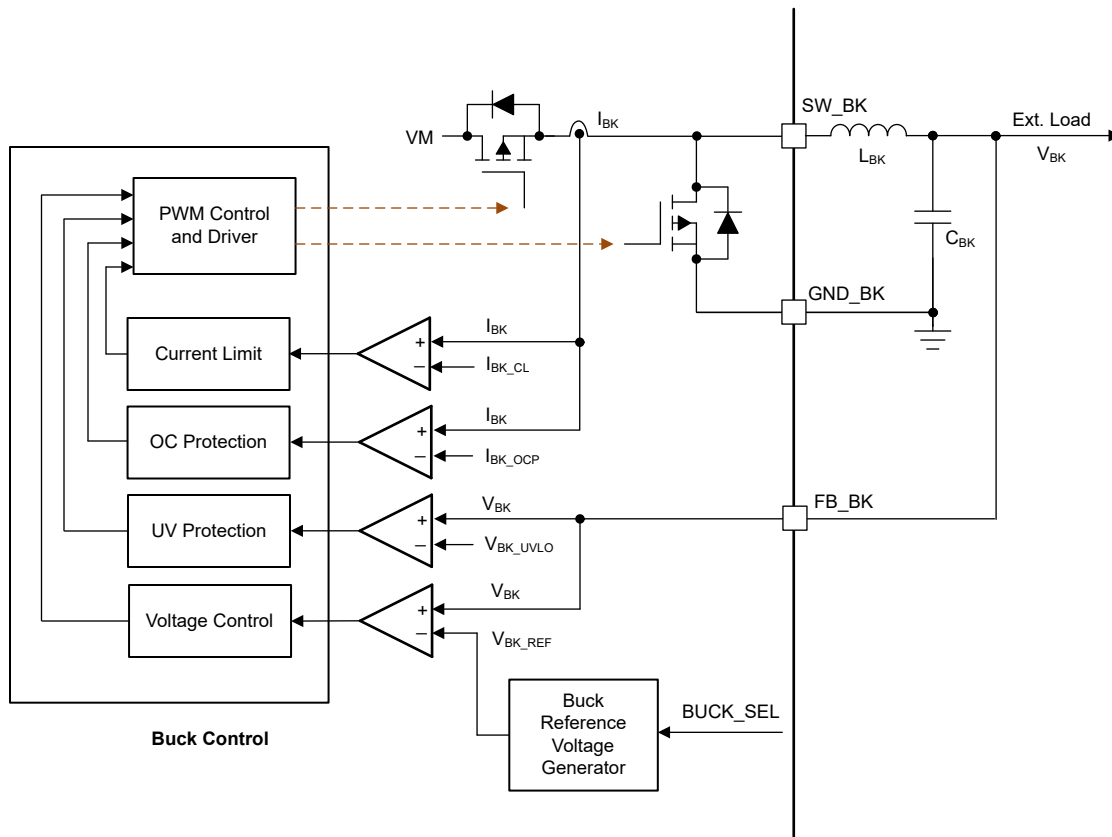
The AVDD LDO has an option of using the power supply from mixed mode buck regulator to reduce the device power dissipation. The power sequencing mode allows on-the-fly changeover of AVDD LDO input from DC mains (VM) to buck output ( $V_{BK}$ ) as shown in Figure 7-5. This sequencing can be configured through the BUCK\_PS\_DIS bit. Power sequencing is supported only when buck output voltage is set to 5-V or 5.7-V.



✎ 7-5. AVDD Power Sequencing from Mixed Mode Buck Regulator

### 7.3.3.5 Mixed Mode Buck Operation and Control

The buck regulator implements a pulse frequency modulation (PFM) architecture with peak current mode control. The output voltage of the buck regulator is compared with the internal reference voltage ( $V_{BK\_REF}$ ) which is internally generated depending on the buck output voltage setting (BUCK\_SEL) which constitutes an outer voltage control loop. Depending on the comparator output going high ( $V_{BK} < V_{BK\_REF}$ ) or low ( $V_{BK} > V_{BK\_REF}$ ), the high-side power FET of the buck turns on and off respectively. An independent current control loop monitors the current in high-side power FET ( $I_{BK}$ ) and turns off the high-side FET when the current becomes higher than the buck current limit ( $I_{BK\_CL}$  set by BUCK\_CL) - this implements a current limit control for the buck regulator. ✎ 7-6 shows the architecture of the buck and various control/protection loops.



**7-6. Buck Operation and Control Loops**

### 7.3.3.6 Buck Under Voltage Protection

If at any time the voltage on the FB\_BK pin (buck regulator output) falls lower than the  $V_{BK\_UV}$  threshold, both the high-side and low-side MOSFETs of the buck regulator are disabled. MCT8315A goes into reset state whenever buck UV event occurs, since the internal circuitry in MCT8315A is powered from the buck regulator output.

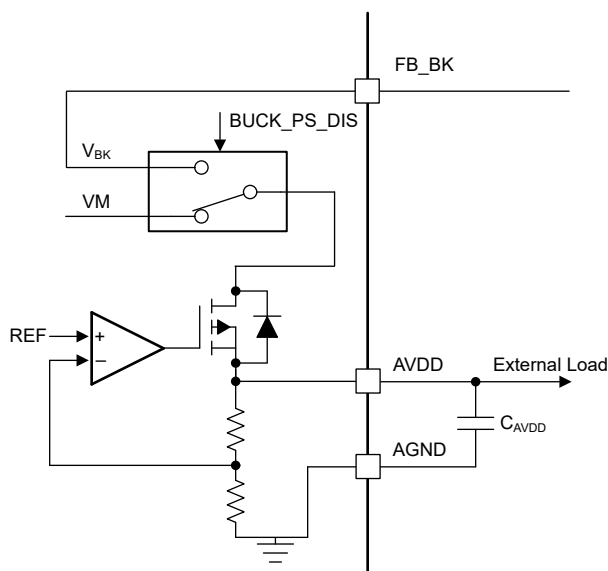
### 7.3.3.7 Buck Over Current Protection

The buck over current event is sensed by monitoring the current flowing through high-side MOSFET of the buck regulator. If the current through the high-side MOSFET exceeds the  $I_{BK\_OCP}$  threshold for a time longer than the deglitch time ( $t_{OCP\_DEG}$ ), a buck OCP event is recognized and both the high-side and low-side MOSFETs of the buck regulator are disabled. MCT8315A goes into reset state whenever buck OCP event occurs, since the internal circuitry in MCT8315A is powered from the buck regulator output.

### 7.3.4 AVDD Linear Voltage Regulator

A 3.3-V linear regulator is integrated into MCT8315A and is available for use by external circuitry. This AVDD LDO regulator is used for powering up the internal circuitry of the device and additionally, this regulator can also provide the supply voltage for a low-power MCU or other external circuitry supporting up to 20-mA. The output of the AVDD regulator should be bypassed near the AVDD pin with a X5R or X7R, 1- $\mu$ F, 6.3-V ceramic capacitor routed directly back to the adjacent AGND ground pin.

The AVDD nominal, no-load output voltage is 3.3-V.



**图 7-7. AVDD Linear Regulator Block Diagram**

Use 式 1 to calculate the power dissipated in the device by the AVDD linear regulator with VM as supply (BUCK\_PS\_DIS = 1b)

$$P = (V_{VM} - V_{AVDD}) \times I_{AVDD} \quad (1)$$

For example, at a  $V_{VM}$  of 24-V, drawing 20-mA out of AVDD results in a power dissipation as shown in 式 2.

$$P = (24 \text{ V} - 3.3 \text{ V}) \times 20 \text{ mA} = 414 \text{ mW} \quad (2)$$

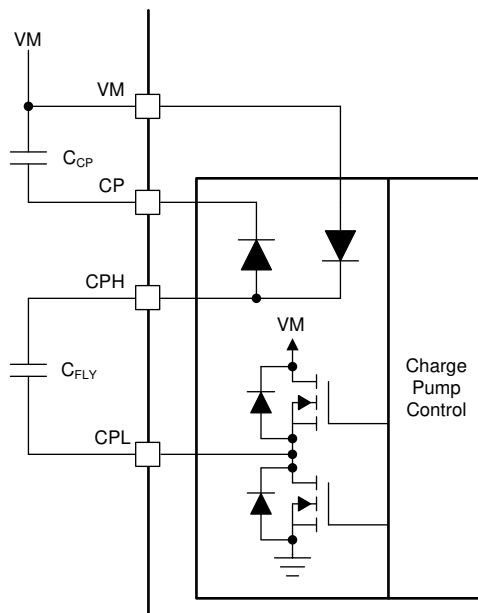
Use 式 3 to calculate the power dissipated in the device by the AVDD linear regulator with buck output as supply (BUCK\_PS\_DIS = 0b)

$$P = (V_{FB\_BK} - V_{AVDD}) \times I_{AVDD} \quad (3)$$

### 7.3.5 Charge Pump

Since the output stages use N-channel FETs, the device requires a gate-drive voltage higher than the VM power supply to turn-on the high-side FETs. The MCT8315A integrates a charge-pump circuit that generates a voltage above the VM supply for this purpose.

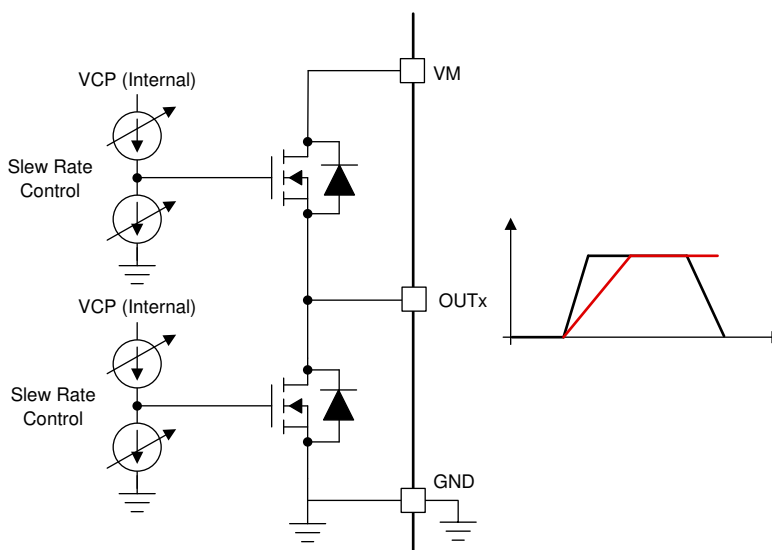
The charge pump requires two external capacitors ( $C_{CP}$ ,  $C_{FLY}$ ) for operation. See 图 7-1 and 表 5-1 for details on these capacitors (value, connection, and so forth).



7-8. Charge Pump

### 7.3.6 Slew Rate Control

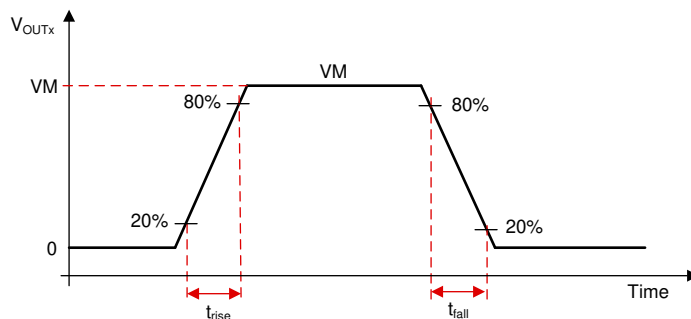
An adjustable gate-drive current control is provided for the output stage MOSFETs to achieve configurable slew rate for EMI mitigation. The MOSFET VDS slew rate is a critical factor for optimizing radiated emissions, total energy and duration of diode recovery spikes and switching voltage transients related to parasitic elements of the PCB. This slew rate is predominantly determined by the control of the internal MOSFET gate current as shown in 7-9.



7-9. Slew Rate Circuit Implementation

The slew rate of each half-bridge can be adjusted through SLEW\_RATE settings. Slew rate can be configured as 25-V/ $\mu$ s, 50-V/ $\mu$ s, 125-V/ $\mu$ s or 200-V/ $\mu$ s. The slew rate is calculated by the rise-time and fall-time of the voltage on OUTx pin as shown in 7-10.

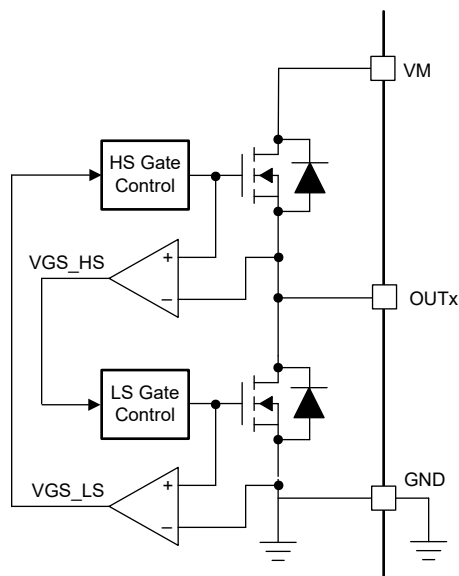




**Figure 7-10. Slew Rate Timings**

### 7.3.7 Cross Conduction (Dead Time)

The device is fully protected against any cross conduction of MOSFETs - during the switching of high-side and low-side MOSFETs, MCT8315A avoids shoot-through events by inserting a dead time ( $t_{dead}$ ). This is implemented by sensing the gate-source voltage ( $V_{GS}$ ) of the high-side and low-side MOSFETs and ensuring that  $V_{GS}$  of high-side MOSFET has dropped below turn-off level before switching on the low-side MOSFET of same half-bridge (or vice-versa) as shown in Figure 7-11 and Figure 7-12. The  $V_{GS}$  of the high-side and low-side MOSFETs ( $V_{GS\_HS}$  and  $V_{GS\_LS}$ ) shown in Figure 7-12 are internal signals.



**Figure 7-11. Cross Conduction Protection**

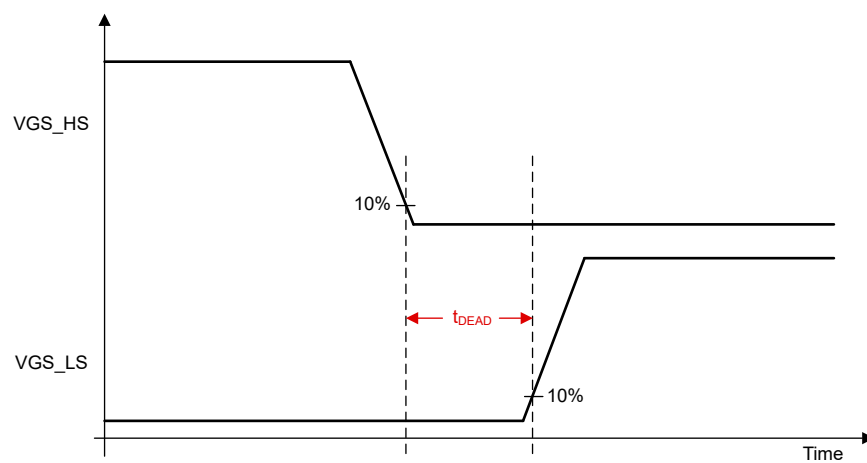


图 7-12. Dead Time

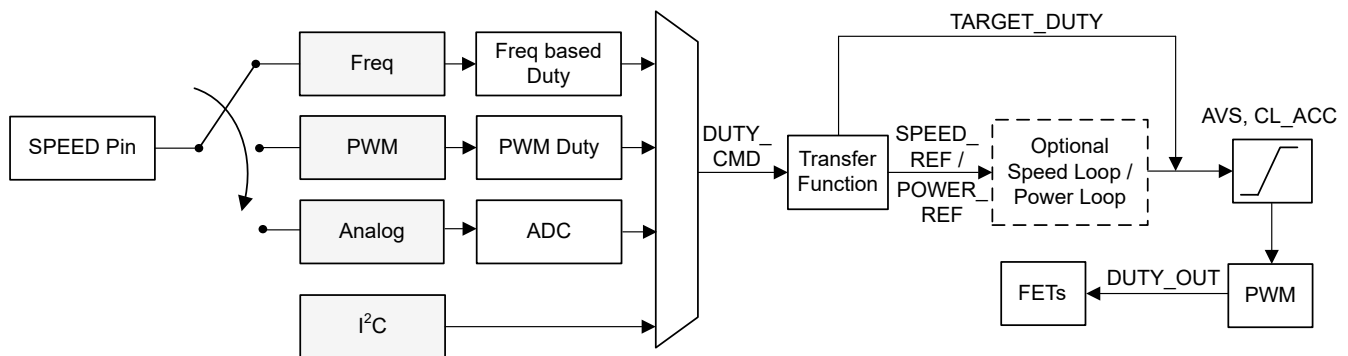
### 7.3.8 Speed Control

The MCT8315A offers four methods of directly controlling the speed of the motor. The speed control method is configured by SPD\_CTRL\_MODE. The speed command can be controlled in one of the following four ways.

- PWM input on SPEED pin by varying duty cycle of input signal
- Frequency input on SPEED pin by varying frequency of input signal
- Analog input on SPEED pin by varying amplitude of input signal
- Over I<sup>2</sup>C by configuring SPEED\_CTRL

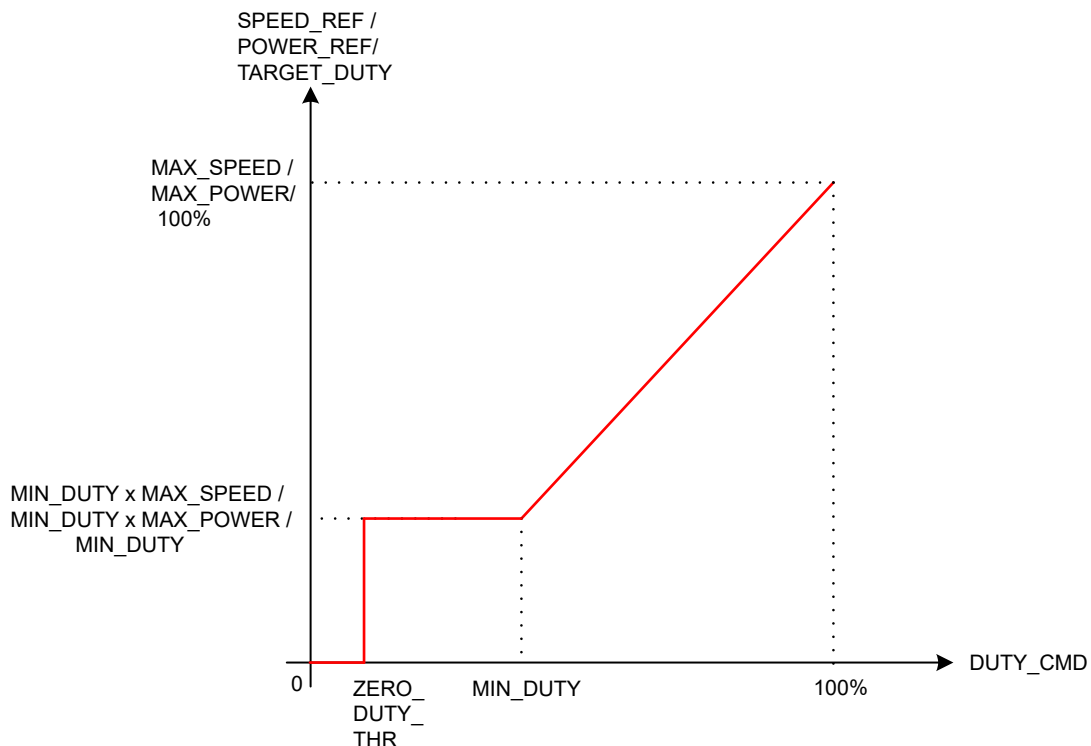
The speed can also be indirectly controlled by varying the supply voltage ( $V_M$ ).

The signal path from SPEED pin input (or I<sup>2</sup>C based speed input) to output duty cycle (DUTY\_OUT) applied to FETs is shown in [Figure 7-13](#).



**Figure 7-13. Multiplexing the Speed Command**

[Figure 7-14](#) shows the transfer function between DUTY\_CMD and SPEED\_REF / POWER\_REF / TARGET\_DUTY.



**Figure 7-14. Speed Input Transfer Function**

When speed/power loop is disabled ( $\text{CLOSED\_LOOP\_MODE} = 00b$ ),  $\text{DUTY\_CMD}$  sets the  $\text{TARGET\_DUTY}$  in % -  $\text{TARGET\_DUTY}$  is 100% when  $\text{DUTY\_CMD}$  is 100% and  $\text{TARGET\_DUTY}$  is equal to  $\text{MIN\_DUTY}$  when  $\text{DUTY\_CMD}$  is set to  $\text{MIN\_DUTY}$ .  $\text{TARGET\_DUTY}$  stays clamped at  $\text{MIN\_DUTY}$  for  $\text{ZERO\_DUTY\_THR} \leq \text{DUTY\_CMD} \leq \text{MIN\_DUTY}$ .

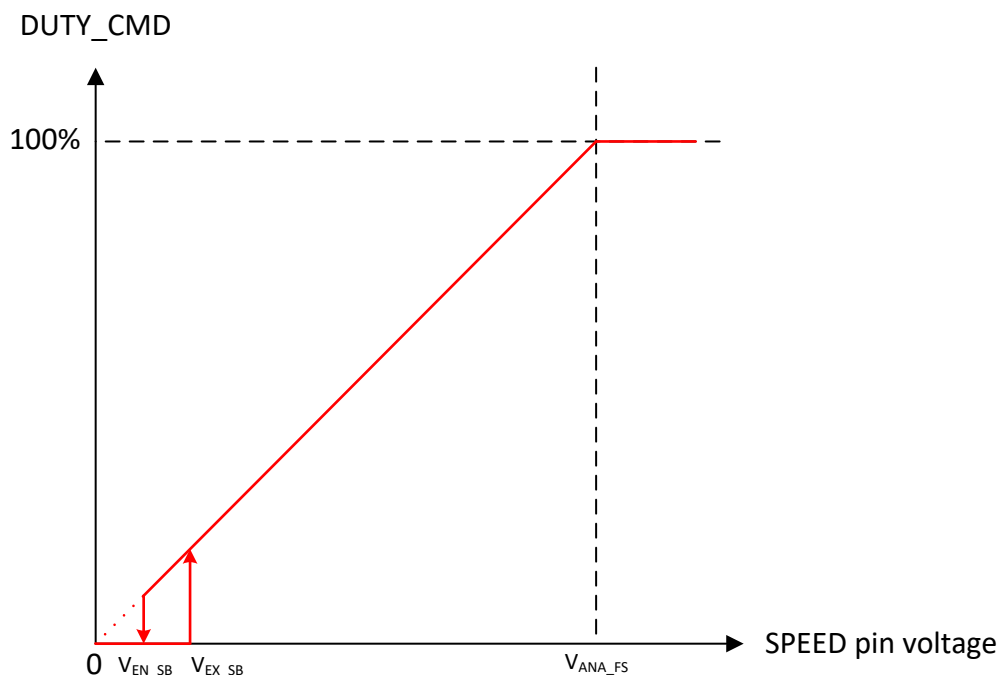
When speed loop is enabled ( $\text{CLOSED\_LOOP\_MODE} = 01b$ ),  $\text{DUTY\_CMD}$  sets the  $\text{SPEED\_REF}$  in Hz.  $\text{MAX\_SPEED}$  sets the  $\text{SPEED\_REF}$  at  $\text{DUTY\_CMD}$  of 100%.  $\text{MIN\_DUTY}$  sets the minimum  $\text{SPEED\_REF}$  ( $\text{MIN\_DUTY} \times \text{MAX\_SPEED}$ ).  $\text{SPEED\_REF}$  stays clamped at ( $\text{MIN\_DUTY} \times \text{MAX\_SPEED}$ ) for  $\text{ZERO\_DUTY\_THR} \leq \text{DUTY\_CMD} \leq \text{MIN\_DUTY}$ .

When power loop is enabled ( $\text{CLOSED\_LOOP\_MODE} = 10b$ ),  $\text{DUTY\_CMD}$  sets the  $\text{POWER\_REF}$  in W.  $\text{MAX\_POWER}$  sets the  $\text{POWER\_REF}$  at  $\text{DUTY\_CMD}$  of 100%.  $\text{MIN\_DUTY}$  sets the minimum  $\text{POWER\_REF}$  ( $\text{MIN\_DUTY} \times \text{MAX\_POWER}$ ).  $\text{POWER\_REF}$  stays clamped at ( $\text{MIN\_DUTY} \times \text{POWER\_REF}$ ) for  $\text{ZERO\_DUTY\_THR} \leq \text{DUTY\_CMD} \leq \text{MIN\_DUTY}$ .

$\text{ZERO\_DUTY\_THR}$  sets the  $\text{DUTY\_CMD}$  below which  $\text{SPEED\_REF}$  /  $\text{POWER\_REF}$  /  $\text{TARGET\_DUTY}$  is set to zero and motor is in stopped state.  $\text{AVS}$ ,  $\text{CL\_ACC}$  configure the transient characteristics of  $\text{DUTY\_OUT}$ ; the steady state value of  $\text{DUTY\_OUT}$  is directly configured in % through  $\text{TARGET\_DUTY}$  (when speed/power loop is disabled) or through  $\text{SPEED\_REF}$ / $\text{POWER\_REF}$  (when speed/power loop is enabled).

### 7.3.8.1 Analog Mode Speed Control

Analog input based speed control can be configured by setting  $\text{SPD\_CTRL\_MODE}$  to 00b. In this mode, the duty command ( $\text{DUTY\_CMD}$ ) varies with the analog voltage input on the  $\text{SPEED}$  pin ( $V_{\text{SPEED}}$ ). When  $0 \leq V_{\text{SPEED}} \leq V_{\text{EN\_SB}}$ ,  $\text{DUTY\_CMD}$  is set to zero and the motor is stopped. When  $V_{\text{EX\_SB}} \leq V_{\text{SPEED}} \leq V_{\text{ANA\_FS}}$ ,  $\text{DUTY\_CMD}$  varies linearly with  $V_{\text{SPEED}}$  as shown in [Figure 7-15](#).  $V_{\text{EX\_SB}}$  and  $V_{\text{EN\_SB}}$  are the standby entry and exit thresholds - refer [Section 7.4.1.2](#) for more information on  $V_{\text{EX\_SB}}$  and  $V_{\text{EN\_SB}}$ . When  $V_{\text{SPEED}} > V_{\text{ANA\_FS}}$ ,  $\text{DUTY\_CMD}$  is clamped to 100%.



**Figure 7-15. Analog Mode Speed Control**

### 7.3.8.2 PWM Mode Speed Control

PWM based speed control can be configured by setting  $\text{SPD\_CTRL\_MODE}$  to 01b. In this mode, the PWM duty cycle applied to the  $\text{SPEED}$  pin can be varied from 0 to 100% and duty command ( $\text{DUTY\_CMD}$ ) varies linearly with the applied PWM duty cycle. When  $0 \leq \text{Duty}_{\text{SPEED}} \leq \text{Duty}_{\text{EN\_SB}}$ ,  $\text{DUTY\_CMD}$  is set to zero and the motor is

stopped. When  $\text{Duty}_{\text{EX\_SB}} \leq \text{Duty}_{\text{SPEED}} \leq 100\%$ ,  $\text{DUTY\_CMD}$  varies linearly with  $\text{Duty}_{\text{SPEED}}$  as shown in 図 7-16.  $\text{Duty}_{\text{EX\_SB}}$  and  $\text{Duty}_{\text{EN\_SB}}$  are the standby entry and exit thresholds - refer セクション 7.4.1.2 for more information on  $\text{Duty}_{\text{EX\_SB}}$  and  $\text{Duty}_{\text{EN\_SB}}$ . The frequency of the PWM input signal applied to the SPEED pin is defined as  $f_{\text{PWM}}$  and the range for this frequency can be configured through  $\text{SPD\_PWM\_RANGE\_SELECT}$ .

注

1.  $f_{\text{PWM}}$  is the frequency of the PWM signal the device can accept at SPEED pin to control motor speed. It does not correspond to the PWM output frequency that is applied to the motor phases. The PWM output frequency can be configured through  $\text{PWM\_FREQ\_OUT}$  (see セクション 7.3.15).
2.  $\text{SLEEP\_TIME}$  should be set longer than the off time in PWM signal ( $V_{\text{SPEED}} < V_{\text{IL}}$ ) at lowest duty input. For example, if  $f_{\text{PWM}}$  is 10 kHz and lowest duty input is 2%,  $\text{SLEEP\_TIME}$  should be more than 98  $\mu\text{s}$  to ensure there is no unintended sleep entry.

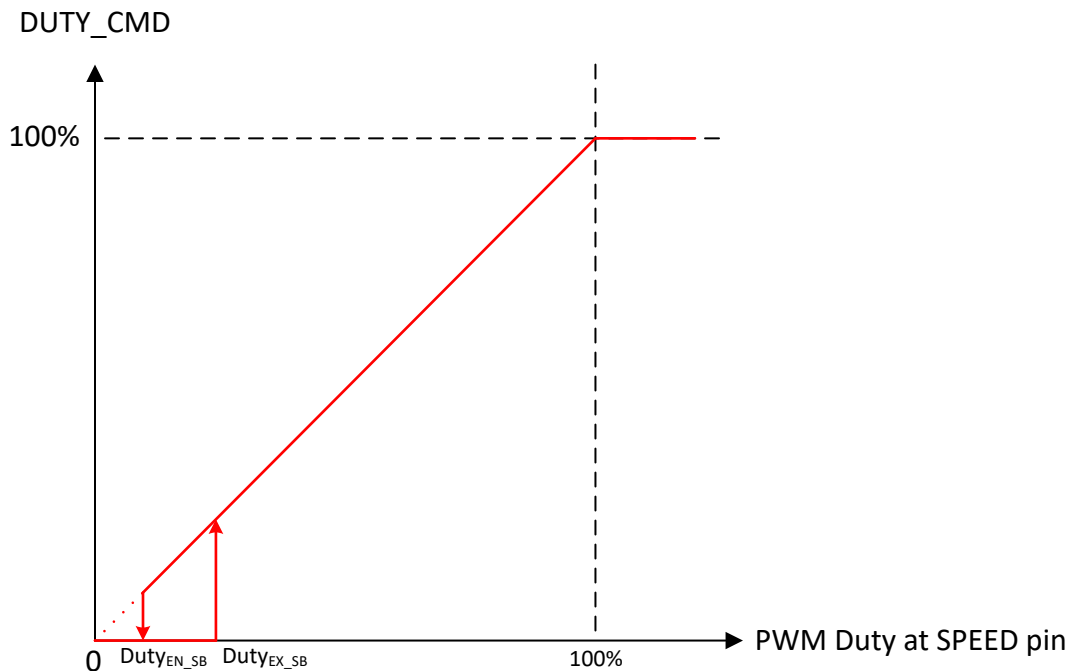


図 7-16. PWM Mode Speed Control

### 7.3.8.3 I<sup>2</sup>C based Speed Control

I<sup>2</sup>C based serial interface can be used for speed control by setting  $\text{SPD\_CTRL\_MODE}$  to 10b. In this mode, the speed command can be written directly into  $\text{SPEED\_CTRL}$ . The SPEED pin can be used to control the sleep entry and exit - if SPEED pin input is set to a value lower than  $V_{\text{EN\_SL}}$  after  $\text{SPEED\_CTRL}$  has been set to 0b for a time longer than  $\text{SLEEP\_TIME}$ , MCT8315A enters sleep state. When SPEED pin  $> V_{\text{EX\_SL}}$ , MCT8315A exits sleep state and speed is controlled through  $\text{SPEED\_CTRL}$ . If  $0 \leq \text{SPEED\_CTRL} \leq \text{SPEED\_CTRL}_{\text{EN\_SB}}$  and SPEED pin  $> V_{\text{EX\_SL}}$ , MCT8315A is in standby state. The relationship between  $\text{DUTY\_CMD}$  and  $\text{SPEED\_CTRL}$  is shown in 図 7-17. Refer セクション 7.4.1.2 for more information on  $\text{SPEED\_CTRL}_{\text{EN\_SB}}$ ,  $\text{EX\_SB}$  and  $\text{SPEED\_CTRL}_{\text{EN\_SB}}$ .

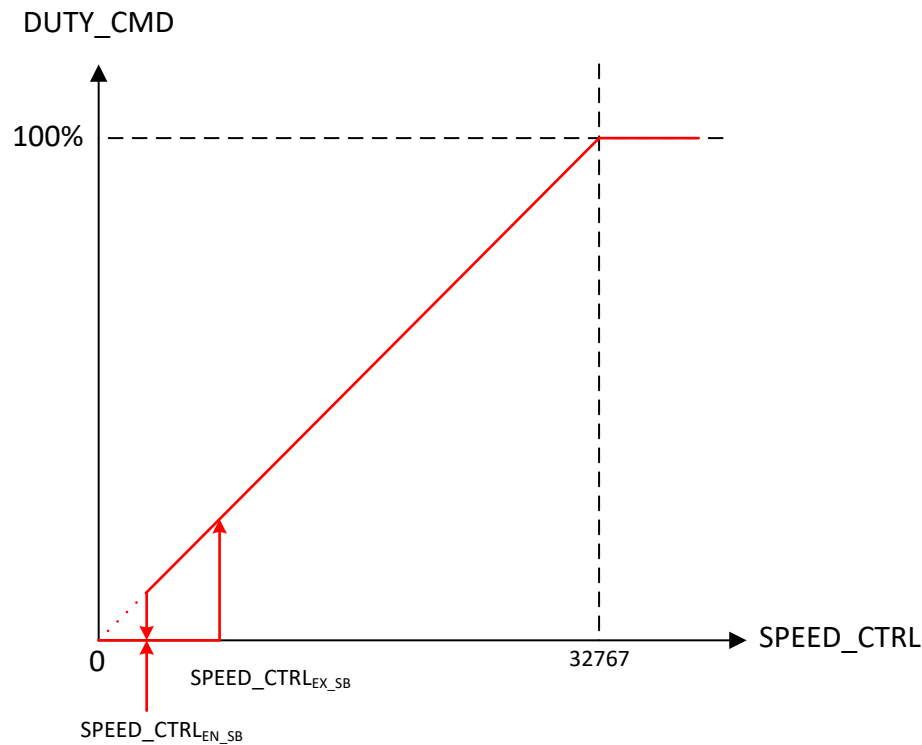
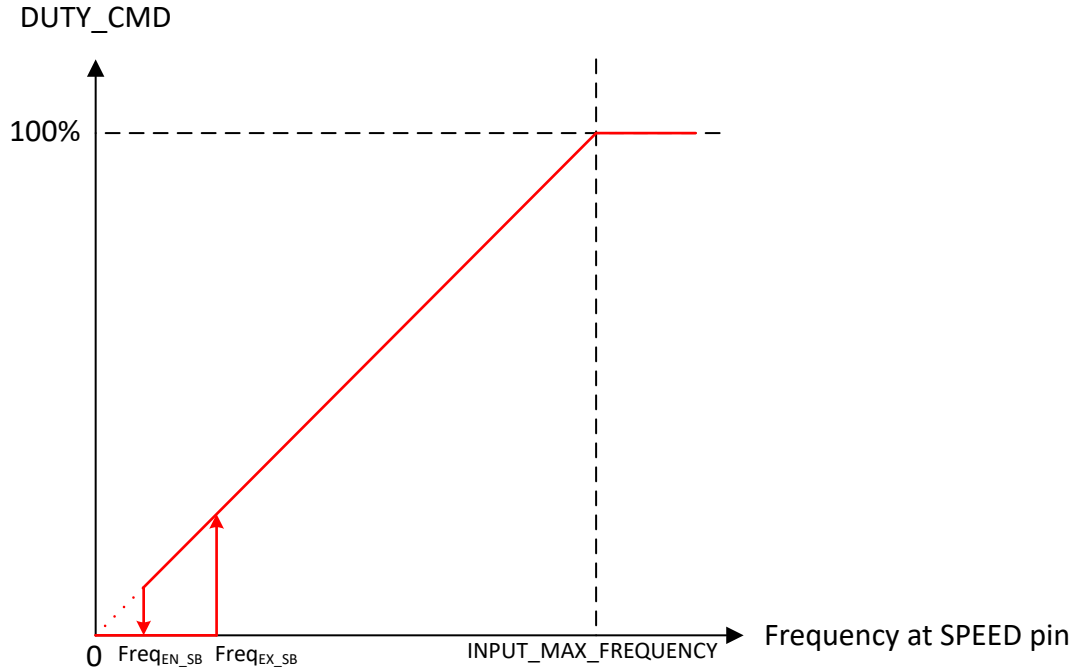


图 7-17. I2C Mode Speed Control

#### 7.3.8.4 Frequency Mode Speed Control

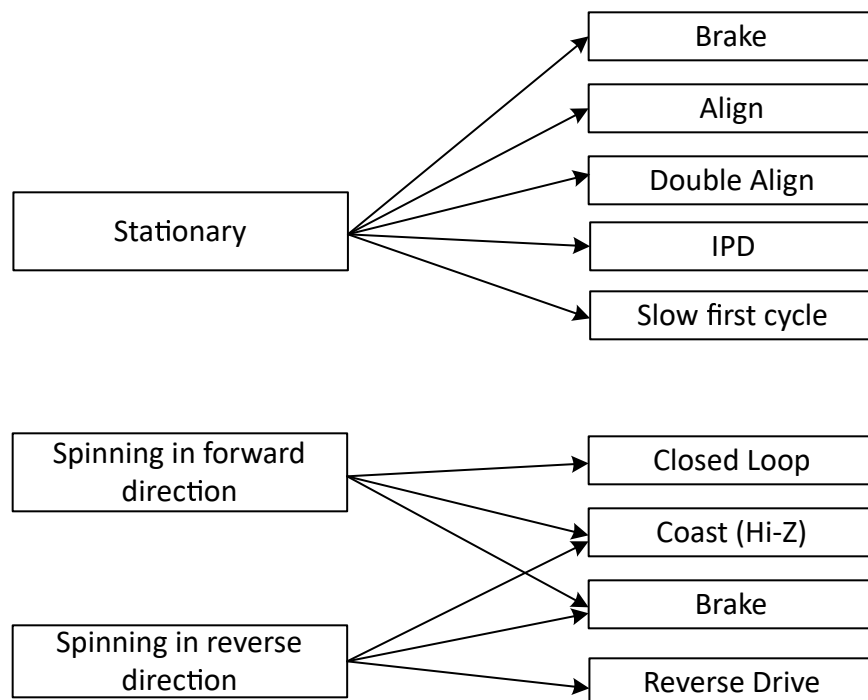
Frequency based speed control is configured by setting SPD\_CTRL\_MODE to 11b. In this mode, duty command varies linearly as a function of the frequency of the square wave input at SPEED pin. When  $0 \leq \text{Freq}_{\text{SPEED}} \leq \text{Freq}_{\text{EN\_SB}}$ , DUTY\_CMD is set to zero and the motor is stopped. When  $\text{Freq}_{\text{EX\_SB}} \leq \text{Freq}_{\text{SPEED}} \leq \text{INPUT\_MAX\_FREQUENCY}$ , DUTY\_CMD varies linearly with  $\text{Freq}_{\text{SPEED}}$  as shown in 图 7-18.  $\text{Freq}_{\text{EX\_SB}}$  and  $\text{Freq}_{\text{EN\_SB}}$  are the standby entry and exit thresholds - refer セクション 7.4.1.2 for more information on  $\text{Freq}_{\text{EX\_SB}}$  and  $\text{Freq}_{\text{EN\_SB}}$ . Input frequency greater than INPUT\_MAX\_FREQUENCY clamps the DUTY\_CMD to 100%.



7-18. Frequency Mode Speed Control

### 7.3.9 Starting the Motor Under Different Initial Conditions

The motor can be in one of three states when MCT8315A begins the start-up process. The motor may be stationary, spinning in the forward direction, or spinning in the reverse direction. The MCT8315A includes a number of features to allow for reliable motor start-up under all of these conditions. 7-19 shows the motor start-up flow for each of the three initial motor states.



7-19. Starting the motor under different initial conditions

## 注

"Forward" means "spinning in the same direction as the commanded direction", and "Reverse" means "spinning in the opposite direction as the commanded direction".

**7.3.9.1 Case 1 – Motor is Stationary**

If the motor is stationary, the commutation must be initialized to be in phase with the position of the motor. The MCT8315A provides various options to initialize the commutation logic to the motor position and reliably start the motor.

- The align and double align techniques force the motor into alignment by applying a voltage across particular motor phases to force the motor to rotate in alignment with this phase.
- Initial position detect (IPD) determines the position of the motor based on the deterministic inductance variation, which is often present in BLDC motors.
- The slow first cycle method starts the motor by applying a low frequency cycle to align the rotor position to the applied commutation by the end of one electrical rotation.

MCT8315A also provides a configurable brake option to ensure the motor is stationary before initiating one of the above start-up methods. Device enters open loop acceleration after going through the configured start-up method.

**7.3.9.2 Case 2 – Motor is Spinning in the Forward Direction**

If the motor is spinning forward (same direction as the commanded direction) with sufficient speed (BEMF), the MCT8315A resynchronizes with the spinning motor and continues commutation by going directly to closed loop operation. By resynchronizing to the spinning motor, the user achieves the fastest possible start-up time for this initial condition. This resynchronization feature can be enabled or disabled through RESYNC\_EN. If resynchronization is disabled, the MCT8315A can be configured to wait for the motor to coast to a stop and/or apply a brake. After the motor has stopped spinning, the motor start-up sequence proceeds as in Case 1, considering the motor is stationary.

**7.3.9.3 Case 3 – Motor is Spinning in the Reverse Direction**

If the motor is spinning in the reverse direction (the opposite direction as the commanded direction), the MCT8315A provides several methods to change the direction and drive the motor to the target speed reference in the commanded direction.

The reverse drive method allows the motor to be driven so that it decelerates through zero speed. The motor achieves the shortest possible spin-up time when spinning in the reverse direction.

If reverse drive is not enabled, then the MCT8315A can be configured to wait for the motor to coast to a stop and/or apply a brake. After the motor has stopped spinning, the motor start-up sequence proceeds as in Case 1, considering the motor is stationary.

## 注

Take care when using the reverse drive or brake feature to ensure that the current is limited to an acceptable level and that the supply voltage does not surge as a result of energy being returned to the power supply.



### 7.3.10 Motor Start Sequence (MSS)

Figure 7-20 shows the motor-start sequence implemented in the MCT8315A device.

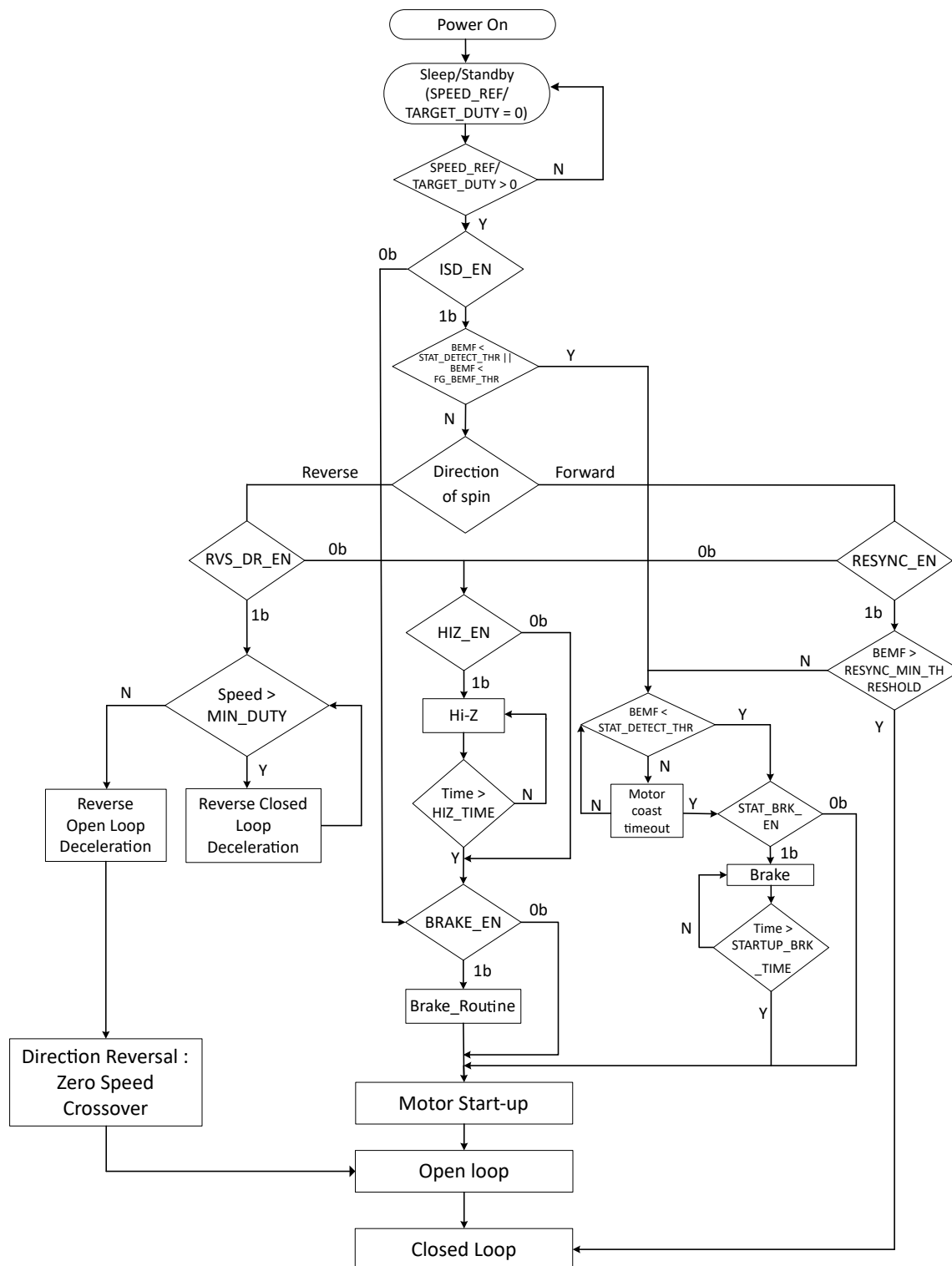
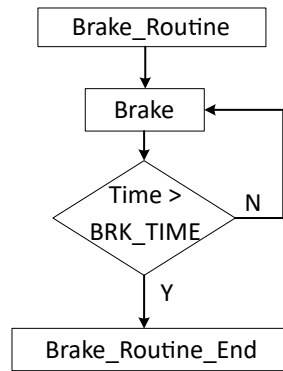


Figure 7-20. Motor Start Sequence



**Figure 7-21. Brake Routine**

**Power-On State**

This is the initial state of the Motor Start Sequence (MSS) when MCT8315A is powered on. In this state, MCT8315A configures the peripherals, initializes the algorithm parameters from EEPROM and prepares for driving the motor.

**Sleep/Standby**

In this state, SPEED\_REF/POWER\_REF/TARGET\_DUTY is set to zero and MCT8315A is either in sleep or standby mode depending on DEV\_MODE and SPEED/WAKE pin voltage.

**SPEED\_REF/POWER\_REF/  
TARGET\_DUTY > 0 Judgement**

When SPEED\_REF/POWER\_REF/TARGET\_DUTY is set to greater than zero, MCT8315A exits the sleep/standby state and proceeds to ISD\_EN judgement. As long as SPEED\_REF is set to zero, MCT8315A stays in sleep/standby state.

**ISD\_EN Judgement**

MCT8315A checks to see if the initial speed detect (ISD) function is enabled (ISD\_EN = 1b). If ISD is enabled, MSS proceeds to the BEMF < STAT\_DETECT\_THR judgement. Instead, if ISD is disabled, the MSS proceeds directly to the BRAKE\_EN judgement.

**BEMF < STAT\_DETECT\_THR or  
BEMF < FG\_BEMF\_THR  
Judgement**

ISD determines the initial condition (speed, angle, direction of spin) of the motor (see [セクション 7.3.10.1](#)). If motor is deemed to be stationary (BEMF < STAT\_DETECT\_THR or BEMF < FG\_BEMF\_THR), the MSS proceeds to second BEMF < STAT\_DETECT\_THR judgement. If the motor is not stationary, MSS proceeds to verify the direction of spin.

**Direction of spin Judgement**

The MSS determines whether the motor is spinning in the forward or the reverse direction. If the motor is spinning in the forward direction, the MCT8315A proceeds to the RESYNC\_EN judgement. If the motor is spinning in the reverse direction, the MSS proceeds to the RVS\_DR\_EN judgement.

**RESYNC\_EN Judgement**

If RESYNC\_EN is set to 1b, MCT8315A proceeds to BEMF > RESYNC\_MIN\_THRESHOLD judgement. If RESYNC\_EN is set to 0b, MSS proceeds to HIZ\_EN judgement.

**BEMF >  
RESYNC\_MIN\_THRESHOLD  
Judgement**

If motor speed is such that BEMF > RESYNC\_MIN\_THRESHOLD, MCT8315A uses the speed and position information from ISD to transition to the closed loop state (see [Motor Resynchronization](#)) directly. If BEMF < RESYNC\_MIN\_THRESHOLD, MCT8315A proceeds to BEMF < STAT\_DETECT\_THR judgement.

**BEMF < STAT\_DETECT\_THR  
Judgement**

If motor speed is such that BEMF > STAT\_DETECT\_THR, MCT8315A proceeds to motor coast timeout. If BEMF < STAT\_DETECT\_THR, MCT8315A proceeds to STAT\_BRK\_EN judgement.

<b>Motor Coast Timeout</b>	MCT8315A waits for 200000 PWM cycles for the motor to coast down to a speed where $BEMF < STAT\_DETECT\_THR$ ; after 200000 PWM cycles lapse in the motor coast state, MCT8315A proceeds to $STAT\_BRK\_EN$ judgement irrespective of BEMF. If $BEMF < STAT\_DETECT\_THR$ during motor coast before the 200000 cycle timeout, MCT8315A proceeds to $STAT\_BRK\_EN$ judgement immediately.
<b>STAT_BRK_EN Judgement</b>	The MSS checks if the stationary brake function is enabled ( $STAT\_BRK\_EN = 1b$ ). If the stationary brake function is enabled, the MSS advances to the stationary brake routine. If the stationary brake function is disabled, the MSS advances to motor start-up state (see <a href="#">セクション 7.3.10.4</a> ).
<b>Stationary Brake Routine</b>	The stationary brake routine can be used to ensure the motor is completely stationary before attempting to start the motor. The stationary brake is applied by turning on all three low-side driver MOSFETs for a time configured by $STARTUP\_BRK\_TIME$ .
<b>RVS_DR_EN Judgement</b>	The MSS checks to see if the reverse drive function is enabled ( $RVS\_DR\_EN = 1b$ ). If it is enabled, the MSS transitions to check speed of the motor in reverse direction. If the reverse drive function is not enabled ( $RVS\_DR\_EN = 0b$ ), the MSS advances to the $HIZ\_EN$ judgement.
<b>Speed &gt; MIN_DUTY Judgement</b>	The MSS checks if the speed (in reverse direction) is higher than the speed at $MIN\_DUTY$ - till the speed (in reverse direction) is higher than the speed at $MIN\_DUTY$ , MSS stays in reverse closed loop deceleration. When speed (in reverse direction) drops below the speed at $MIN\_DUTY$ , the MSS transitions to reverse open loop deceleration.
<b>Reverse Open Loop Deceleration and Zero Speed Crossover</b>	In reverse open loop deceleration, the MCT8315A decelerates the motor in open-loop till speed reaches zero. At zero speed, direction changes and MCT8315A begins open loop acceleration.
<b>HIZ_EN Judgement</b>	The MSS checks to determine whether the coast (Hi-Z) function is enabled ( $HIZ\_EN = 1b$ ). If the coast function is enabled ( $HIZ\_EN = 1b$ ), the MSS advances to the coast routine. If the coast function is disabled ( $HIZ\_EN = 0b$ ), the MSS advances to the $BRAKE\_EN$ judgement.
<b>Coast (Hi-Z) Routine</b>	The device coasts the motor by turning OFF all six MOSFETs for a certain time configured by $HIZ\_TIME$ .
<b>BRAKE_EN Judgement</b>	The MSS checks to determine whether the brake function is enabled ( $BRAKE\_EN = 1b$ ). If the brake function is enabled ( $BRAKE\_EN = 1b$ ), the MSS advances to the brake routine. If the brake function is disabled ( $BRAKE\_EN = 0b$ ), the MSS advances to the motor start-up state (see <a href="#">セクション 7.3.10.4</a> ).
<b>Brake Routine</b>	MCT8315A implements a brake by turning on all three (high-side or low-side) MOSFETs for $BRK\_TIME$ . Brake is applied either using high-side or low-side MOSFETs based on $BRK\_MODE$ configuration.
<b>Closed Loop</b>	In this state, the MCT8315A drives the motor with sensorless trapezoidal commutation based on either zero cross detection or BEMF integration.

#### 7.3.10.1 Initial Speed Detect (ISD)

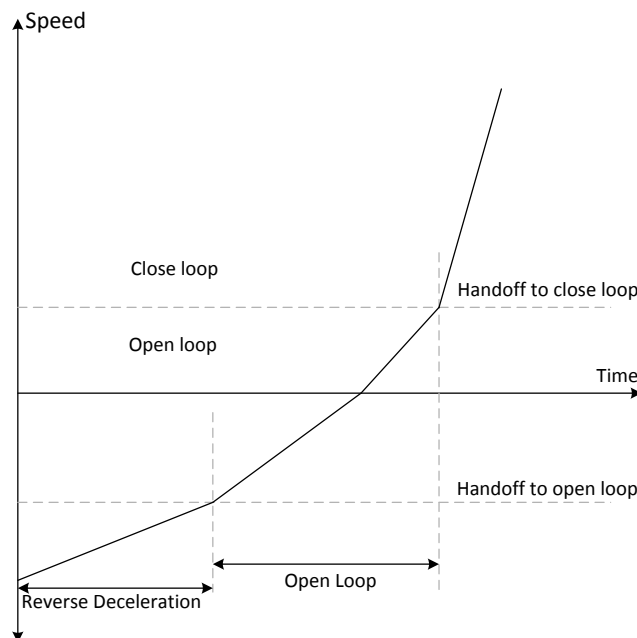
The ISD function is used to identify the initial condition of the motor and is enabled by setting  $ISD\_EN$  to 1b. The initial speed, position and direction is determined by sensing the three phase voltages. ISD can be disabled by setting  $ISD\_EN$  to 0b. If the function is disabled ( $ISD\_EN$  set to 0b), the MCT8315A does not perform the initial speed detect function and proceeds to check if the brake routine ( $BRAKE\_EN$ ) is enabled.

### 7.3.10.2 Motor Resynchronization

The motor resynchronization function works when the ISD and resynchronization functions are both enabled and the device determines that the initial state of the motor is spinning in the forward direction (same direction as the commanded direction). The speed and position information measured during ISD are used to initialize the drive state of the MCT8315A, which can transition directly into closed loop state without needing to stop the motor. In the MCT8315A, motor resynchronization can be enabled/disabled through RESYNC\_EN bit. If motor resynchronization is disabled, the device proceeds to check if the motor coast (Hi-Z) routine is enabled.

### 7.3.10.3 Reverse Drive

The MCT8315A uses the reverse drive function to change the direction of the motor rotation when ISD\_EN and RVS\_DR\_EN are both set to 1b and the ISD determines the motor spin direction to be opposite to that of the commanded direction. Reverse drive includes synchronizing with the motor speed in the reverse direction, reverse decelerating the motor through zero speed, changing direction, and accelerating in open loop in forward (or commanded) direction until the device transitions into closed loop in forward direction (see [Figure 7-22](#)). MCT8315A uses the same parameter values for open to closed loop handoff threshold (OPN\_CL\_HANDOFF\_THR), open loop acceleration rates (OL\_ACC\_A1, OL\_ACC\_A2) and open loop current limit (OL\_ILIMIT) in the reverse direction as in the forward direction..



**Figure 7-22. Reverse Drive Function**

### 7.3.10.4 Motor Start-up

There are different options available for motor start-up from a stationary position and these options can be configured by MTR\_STARTUP. In align and double align mode, the motor is aligned to a known position by injecting a DC current. In IPD mode, the rotor position is estimated by applying 6 different high-frequency pulses. In slow first cycle mode, the motor is started by applying a low frequency cycle.

#### 7.3.10.4.1 Align

Align is enabled by configuring MTR\_STARTUP to 00b. The MCT8315A aligns the motor by injecting a DC current using a particular phase pattern (phase-C high-side FET and phase-B low-side FET are ON) - current flowing into phase-B and flowing out from phase-C for a certain time configured by ALIGN\_TIME.

The duty cycle during align is defined by ALIGN\_DUTY. In MCT8315A, current limit during align is configured by ALIGN\_CURR\_THR.

A fast change in the phase current during align may result in a sudden change in the driving torque and this could result in acoustic noise. To avoid this, the MCT8315A ramps up duty cycle from 0 to until it reaches ALIGN\_DUTY at a configurable rate set by ALIGN\_RAMP\_RATE. At the end of align routine, the motor will be aligned at the known position.

#### 7.3.10.4.2 Double Align

Double align is enabled by configuring MTR\_STARTUP to 01b. Single align is not reliable when the initial position of the rotor is 180° out of phase with the applied phase pattern. In this case, it is possible to have start-up failures using single align. In order to improve the reliability of align based start-up, the MCT8315A provides the option of double align start-up. In double align start-up, MCT8315A uses a phase pattern for the second align that is 60° out of phase with the first align phase pattern in the commanded direction. In double align, relevant parameters like align time, current limit, ramp rate are the same as in the case of single align - two different phase patterns are applied in succession with the same parameters to ensure that the motor will be aligned to a known position irrespective of initial rotor position.

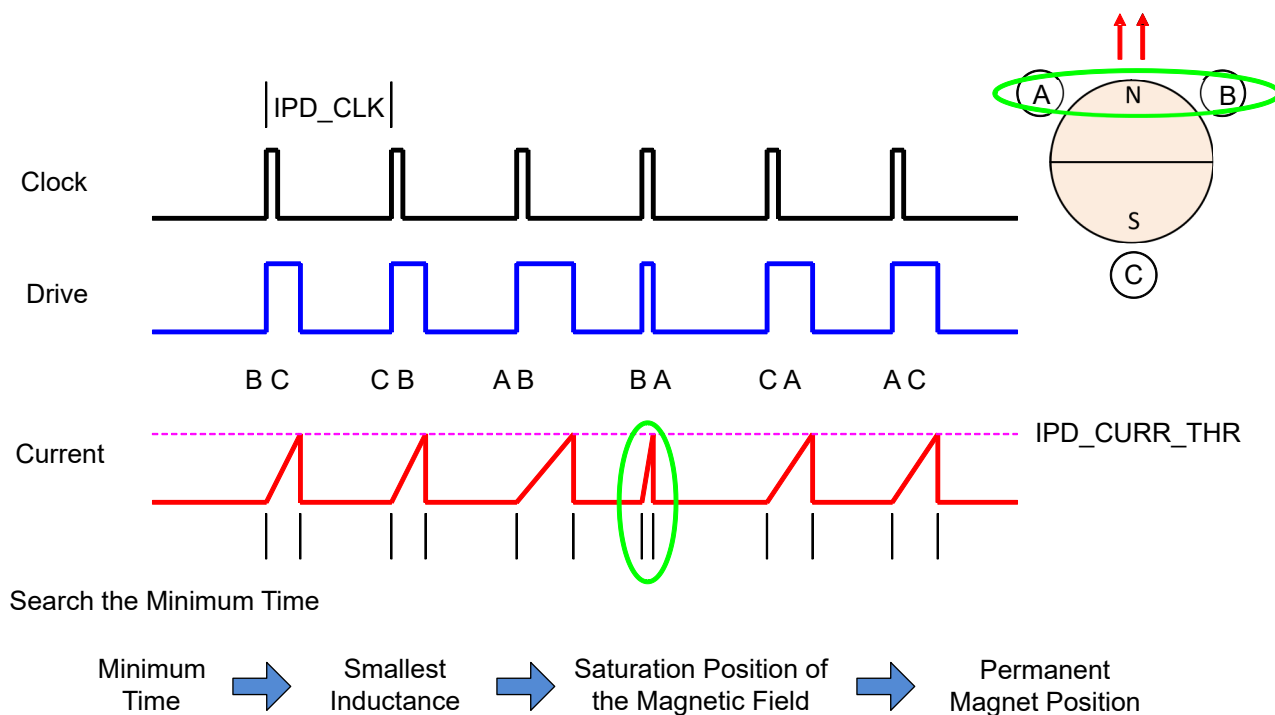
#### 7.3.10.4.3 Initial Position Detection (IPD)

Initial Position Detection (IPD) can be enabled by configuring MTR\_STARTUP to 10b. In IPD, inductive sense method is used to determine the initial position of the motor using the spatial variation in the motor inductance.

Align or double align may result in the motor spinning in the reverse direction before starting open loop acceleration. IPD can be used in such applications where reverse rotation of the motor is unacceptable. IPD does not wait for the motor to align with the commutation and therefore can allow for a faster motor start-up sequence. IPD works well when the inductance of the motor varies as a function of position. IPD works by pulsing current in to the motor and hence can generate acoustics which must be taken into account when determining the best start-up method for a particular application.

##### 7.3.10.4.3.1 IPD Operation

IPD operates by sequentially applying six different phase patterns according to the following sequence: BC-> CB-> AB-> BA-> CA-> AC (see [Figure 7-23](#)). When the current reaches the threshold configured by IPD\_CURR\_THR, the MCT8315A stops driving the particular phase pattern and measures the time taken to reach the current threshold from when the particular phase pattern was applied. Thus, the time taken to reach IPD\_CURR\_THR is measured for all six phase patterns - this time varies as a function of the inductance in the motor windings. The state with the shortest time represents the state with the minimum inductance. The minimum inductance is because of the alignment of the north pole of the motor with this particular driving state.

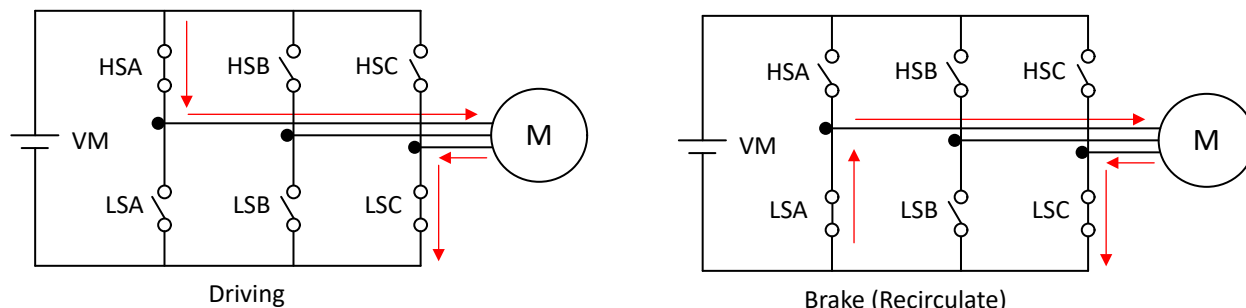


✎ 7-23. IPD Function

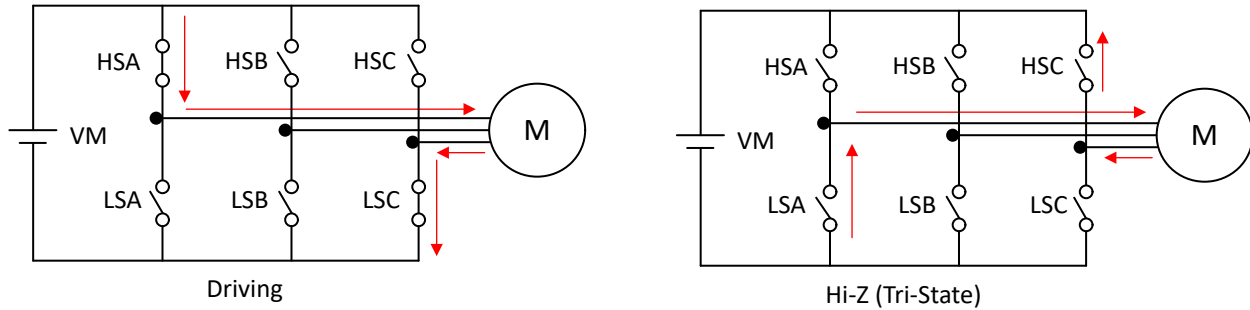
#### 7.3.10.4.3.2 IPD Release Mode

Two modes are available for configuring the way the MCT8315A stops driving the motor when the current threshold is reached. The recirculate (or brake) mode is selected if `IPD_RLS_MODE = 0b`. In this configuration, the low-side (LSC) MOSFET remains ON to allow the current to recirculate between the MOSFET (LSC) and body diode (LSA) (see ✎ 7-24). Hi-Z mode is selected if `IPD_RLS_MODE = 1b`. In Hi-Z mode, both the high-side (HSA) and low-side (LSC) MOSFETs are turned OFF and the current recirculates through the body diodes back to the power supply (see ✎ 7-25).

In the Hi-Z mode, the phase current has a faster settle-down time, but that can result in a voltage increase on  $V_M$ . The user must manage this with an appropriate selection of either a clamp circuit or by providing sufficient capacitance between  $V_M$  and PGND to absorb the energy. If the voltage surge cannot be contained or if it is unacceptable for the application, recirculate mode must be used. When using the recirculate mode, select the `IPD_CLK_FREQ` appropriately to give the current in the motor windings enough time to decay to 0-A before the next IPD phase pattern is applied.



✎ 7-24. IPD Release Mode - Brake (0b)

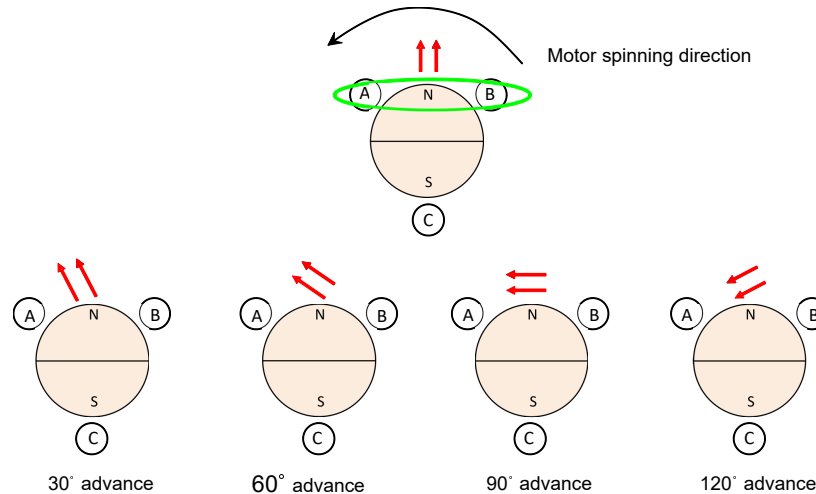


**Figure 7-25. IPD Release Mode - Tristate (1b)**

#### 7.3.10.4.3 IPD Advance Angle

After the initial position is detected, the MCT8315A begins driving the motor in open loop at an angle specified by IPD\_ADV\_ANGLE.

Advancing the drive angle anywhere from 0° to 180° results in positive torque. Advancing the drive angle by 90° results in maximum initial torque. Applying maximum initial torque could result in uneven acceleration to the rotor. Select the IPD\_ADV\_ANGLE to allow for smooth acceleration in the application (see [Figure 7-26](#)).



**Figure 7-26. IPD Advance Angle**

#### 7.3.10.4.4 Slow First Cycle Startup

Slow First Cycle start-up is enabled by configuring MTR\_STARTUP to 11b. In slow first cycle start-up, the MCT8315A starts motor commutation at a frequency defined by SLOW\_FIRST\_CYCLE\_FREQ. The frequency configured is used only for first cycle, and then the motor commutation follows acceleration profile configured by open loop acceleration coefficients A1 and A2. The slow first cycle frequency has to be configured to be slow enough to allow motor to synchronize with the commutation sequence. This mode is useful when fast startup is desired as it significantly reduces the align time.

#### 7.3.10.4.5 Open loop

Upon completing the motor position initialization with either align, double align, IPD or slow first cycle, the MCT8315A begins to accelerate the motor in open loop. During open loop, fixed duty cycle is applied and the cycle by cycle current limit functionality is used to regulate the current.

In MCT8315A, open loop current limit threshold is selected through OL\_ILIMIT\_CONFIG and is set either by CBC\_ILIMIT or OL\_ILIMIT based on the configuration of OL\_ILIMIT\_CONFIG. Open loop duty cycle is configured through OL\_DUTY. While the motor is in open loop, speed (and commutation instants) is determined by [Figure 4](#). In MCT8315A, open loop acceleration coefficients, A1 and A2 are configured through OL\_ACC\_A1 and

OL\_ACC\_A2 respectively. The function of the open-loop operation is to drive the motor to a speed at which the motor generates sufficient BEMF to allow the BEMF zero-crossing based commutation control to accurately drive the motor.

$$\text{Speed (t)} = A1 * t + 0.5 * A2 * t^2 \quad (4)$$

#### 7.3.10.4.6 Transition from Open to Closed Loop

MCT8315A has an internal mechanism to determine the motor speed for transition from open loop commutation to BEMF zero crossing based closed loop commutation. This feature of automatically deciding the open to closed handoff speed can be enabled by configuring AUTO\_HANDOFF to 1b. If AUTO\_HANDOFF is set to 0b, the open to closed loop handoff speed needs to be configured by OPN\_CL\_HANDOFF\_THR. The closed loop in this section does not refer to closed speed loop - it refers to the commutation control changing from open loop (equation based) to closed loop (BEMF zero crossing based).

#### 7.3.11 Closed Loop Operation

In closed loop operation, the MCT8315A drives the motor using trapezoidal commutation. The commutation instant is determined by the BEMF zero crossing on the phase which is not driven (Hi-Z). The duty cycle of the applied motor voltage is determined by DUTY OUT (see [Speed Control](#)).

##### 7.3.11.1 120° Commutation

In 120° commutation, each phase is driven for 120° and is Hi-Z for 60° within each half electrical cycle as shown in [Figure 7-27](#). In 120° commutation there are six different commutation states. 120° commutation can be configured by setting COMM\_CONTROL to 00b. MCT8315A supports different modulation modes with 120° commutation which can be configured through PWM\_MODUL.

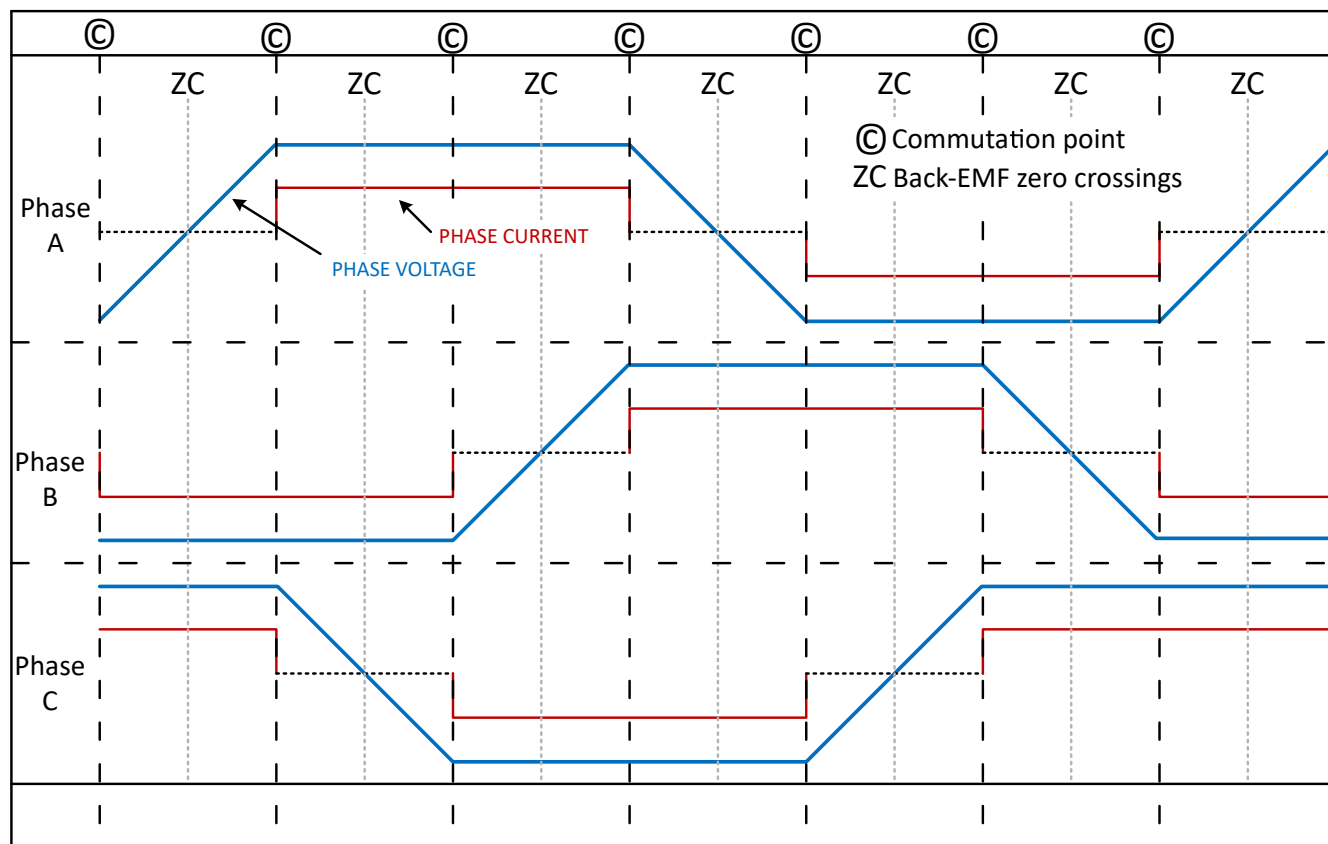
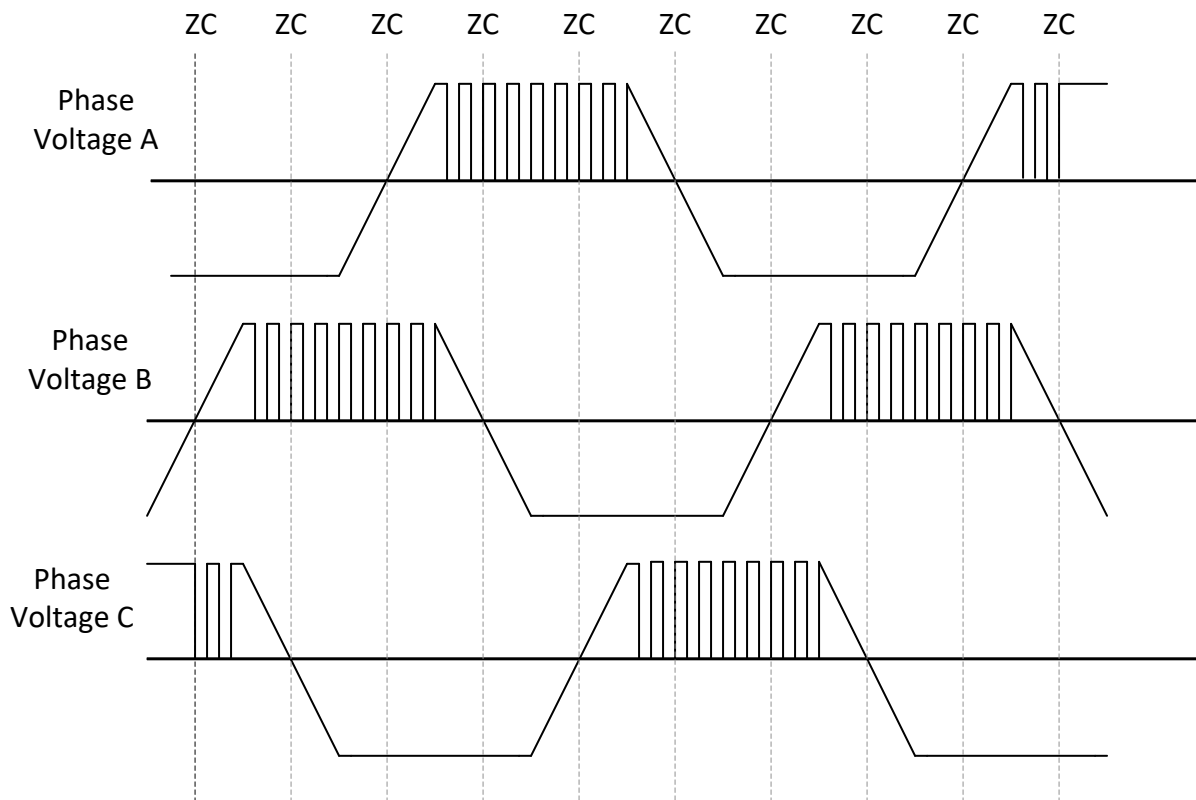


Figure 7-27. 120° commutation



#### 7.3.11.1.1 High-Side Modulation

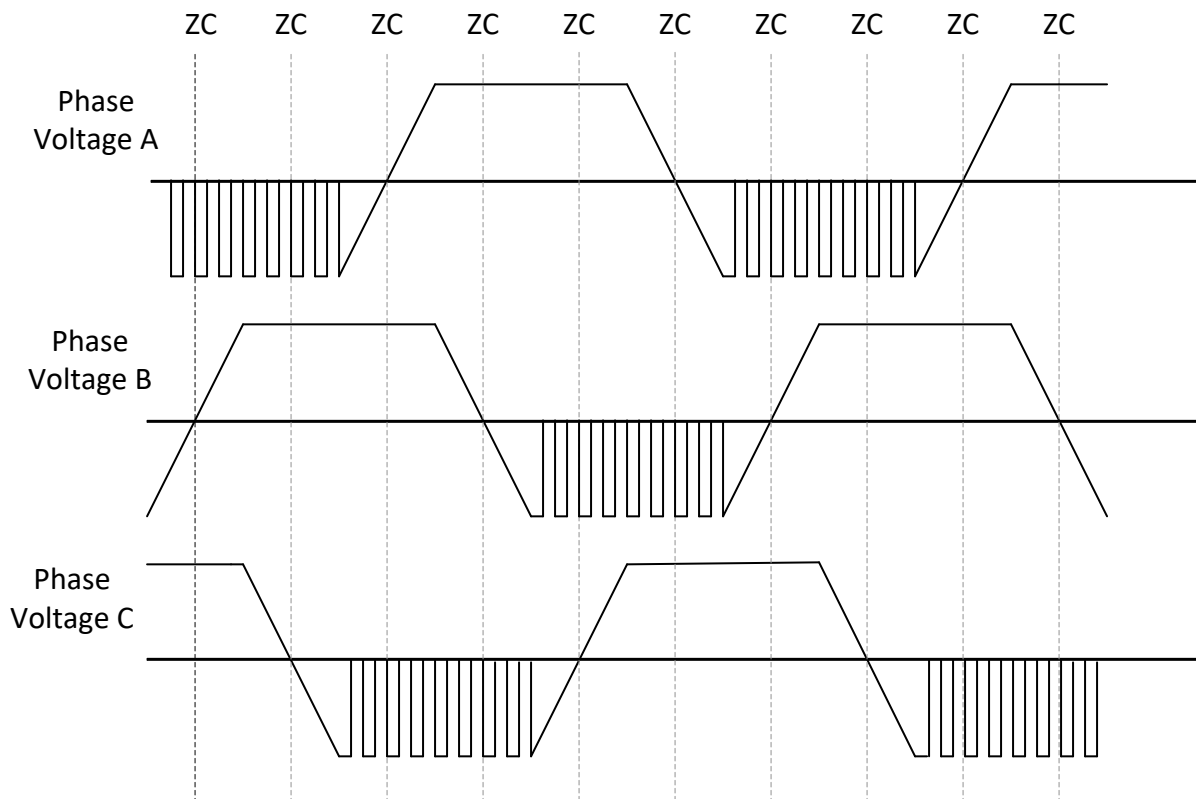
High-side modulation can be configured by setting PWM\_MODUL to 00b. In high-side modulation, for a given commutation state, one of the high-side FETs is switching with the commanded duty cycle DUTY\_OUT, while the low-side FET is ON with 100% duty cycle (see [Figure 7-28](#)).



**Figure 7-28. 120° commutation in High Side Modulation Mode**

#### 7.3.11.1.2 Low-Side Modulation

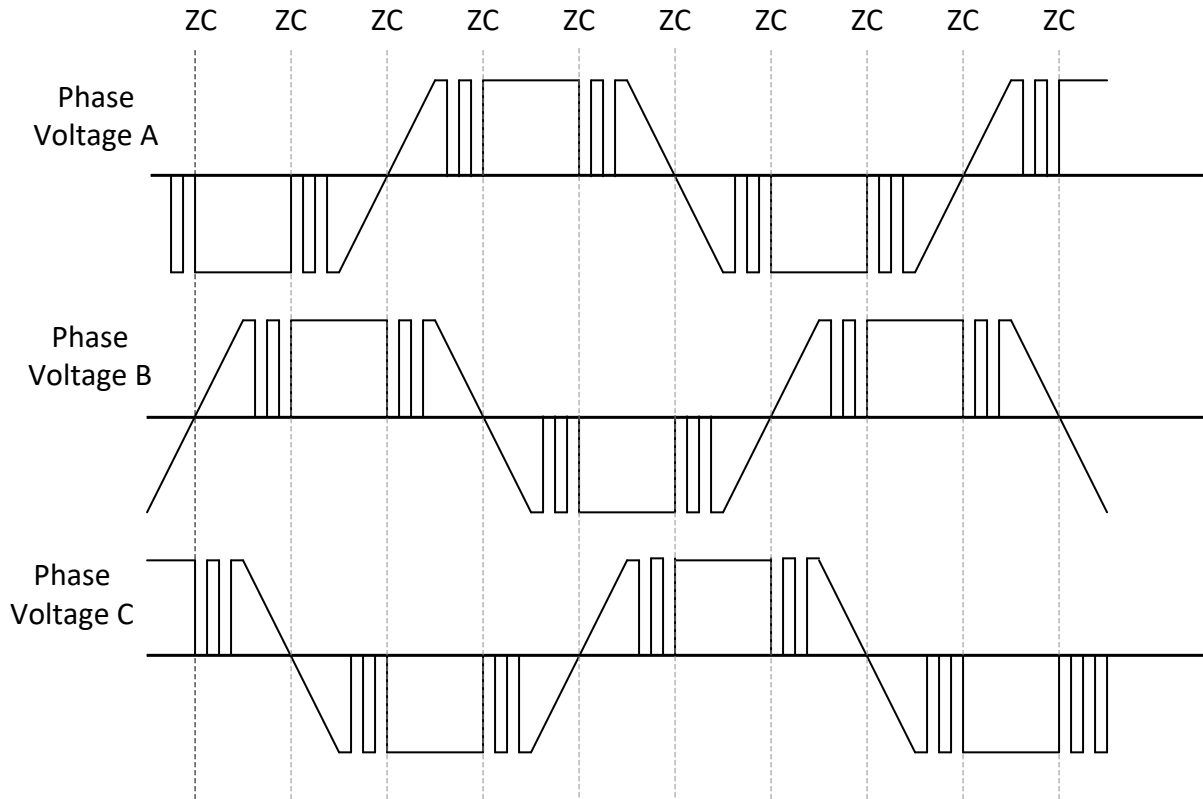
Low-side modulation can be configured by setting PWM\_MODUL to 01b. In low-side modulation, for a given commutation state, one of the low-side FETs is switching with the commanded duty cycle DUTY\_OUT, while the high-side FET is ON with 100% duty cycle (see [Figure 7-29](#)).



**FIG 7-29. 120 ° commutation in Low Side Modulation Mode**

#### 7.3.11.1.3 Mixed Modulation

Mixed modulation can be configured by setting PWM\_MODUL to 10b. In mixed modulation, MCT8315A dynamically switches between high and low-side modulation (see [FIG 7-30](#)). The switching losses are distributed evenly amongst the high and low-side MOSFETs in mixed modulation mode.



**FIG 7-30. 120° commutation in Mixed Modulation Mode**

### 7.3.11.2 Variable Commutation

Variable commutation can be configured by setting `COMM_CONTROL` to 01b. 120° commutation may result in acoustic noise due to the long Hi-Z period causing some torque ripple in the motor. In order to reduce this torque ripple and acoustic noise, the MCT8315A uses variable commutation to reduce the phase current ripple at commutation by extending 120° driving time and gradually decreasing duty cycle prior to entering Hi-Z state. In this mode, the phase is Hi-Z between 30° and 60° and this window size is dynamically adjusted based on speed. A smaller window size will typically give better acoustic performance. [FIG 7-31](#) shows 150° commutation with 30° window size.

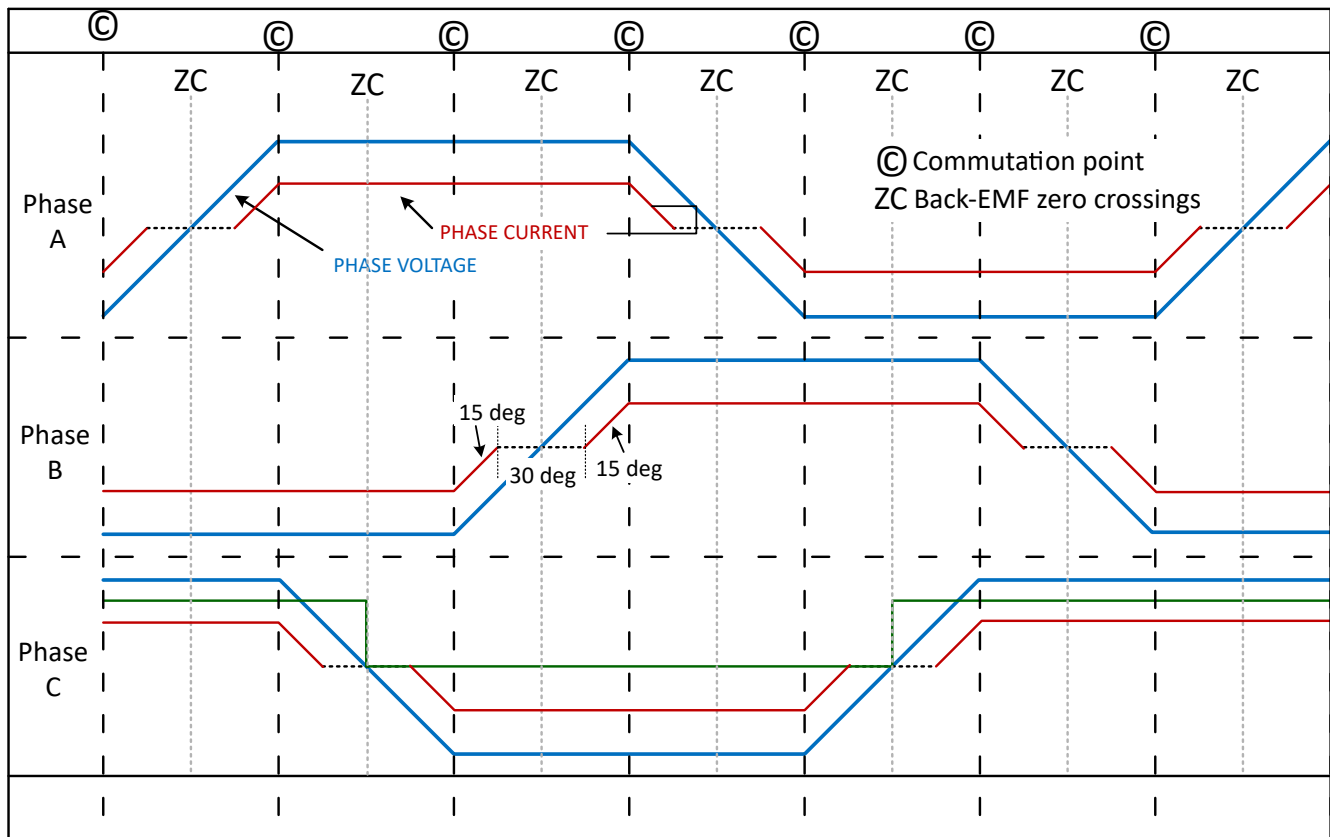


图 7-31. 150° commutation

注

Different modulation modes are supported only with 120° commutation; variable commutation uses mixed modulation mode only.

### 7.3.11.3 Lead Angle Control

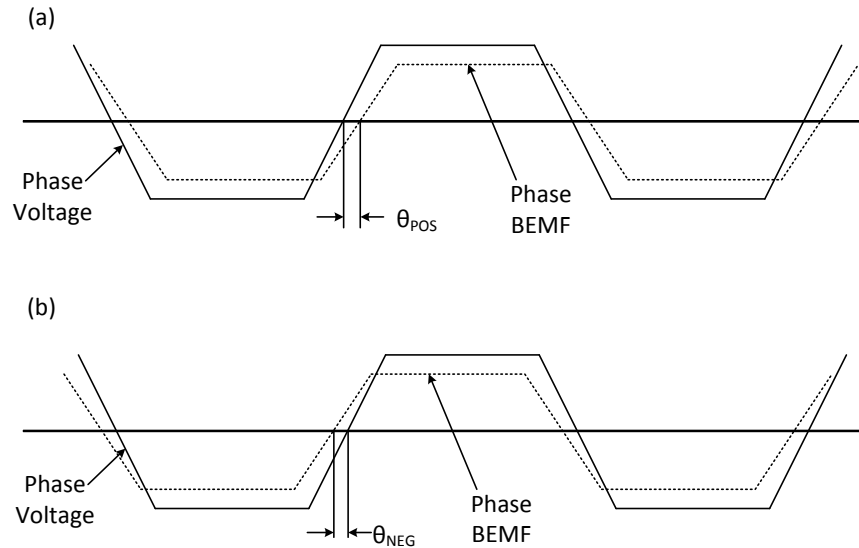
To achieve the best efficiency, it is often desirable to control the drive state of the motor so that the motor phase current is aligned with the motor BEMF voltage. MCT8315A provides the option to advance or delay the phase voltage from the commutation point by adjusting the lead angle. The lead angle can be adjusted to obtain optimal efficiency. This can be accomplished by operating the motor at constant speed and load conditions and adjusting the lead angle (LD\_ANGLE) until the minimum current is achieved. The MCT8315A has the capability to apply both positive and negative lead angle (by configuring LD\_ANGLE\_POLARITY) as shown in 图 7-32

Lead angle can be calculated by  $\{\text{LD\_ANGLE} \times 0.12\}^\circ$ ; for example, if the LD\_ANGLE is 0x1E and LD\_ANGLE\_POLARITY is 1b, then a lead angle of +3.6°(advance) is applied. If LD\_ANGLE\_POLARITY is 0b, then a lead angle of -3.6°(delay) is applied.

注

For 120° commutation, the negative lead angle is limited to -20°; any lead angle lower than that will be clamped to -20°.

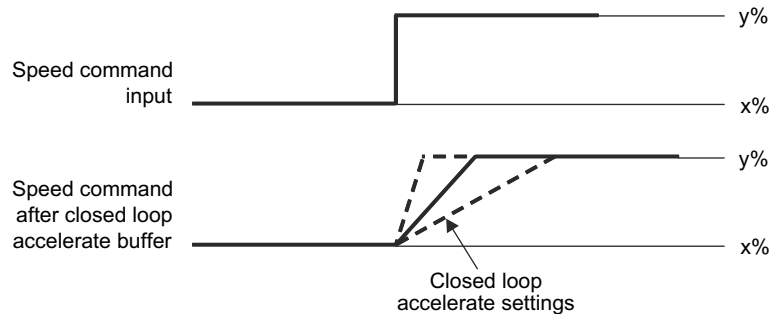
For variable commutation, negative lead angle is not supported and positive lead angle is limited to +15°. Anything configured higher than +15° or lower than 0° will be clamped to 15° and 0° respectively.



**Figure 7-32. Positive and Negative Lead Angle Definition**

#### 7.3.11.4 Closed loop accelerate

To prevent sudden changes in the torque applied to the motor which could result in acoustic noise, the MCT8315A device provides the option of limiting the maximum rate at which the speed command can change. The closed loop acceleration rate parameter sets the maximum rate at which the speed command changes (shown in Figure 7-33). In the MCT8315A, closed loop acceleration rate is configured through CL\_ACC.



**Figure 7-33. Closed loop accelerate**

#### 7.3.12 Speed Loop

MCT8315A has a speed loop option which can be used to maintain constant speed under varying operating conditions. Speed loop is enabled by setting CLOSED\_LOOP\_MODE to 01b.  $K_p$  and  $K_i$  coefficients are configured through SPD\_POWER\_KP and SPD\_POWER\_KI. The output of speed loop (SPEED\_PI\_OUT) is used to generate the DUTY\_OUT (see Figure 7-13). The PI controller output upper ( $V_{MAX}$ ) and lower bound ( $V_{MIN}$ ) saturation limits are configured through SPD\_POWER\_V\_MAX and SPD\_POWER\_V\_MIN respectively. When output of the speed loop saturates, the integrator is disabled to prevent integral wind-up. The speed loop PI controller is as in Figure 7-34.

SPEED\_REF is derived from duty command input and maximum motor speed (MAX\_SPEED) configured by user (see Equation 5). In speed loop mode, minimum SPEED\_REF is set by MIN\_DUTY \* MAX\_SPEED.

$$\text{SPEED\_REF} = \text{DUTY\_CMD} * \text{MAX\_SPEED} \quad (5)$$

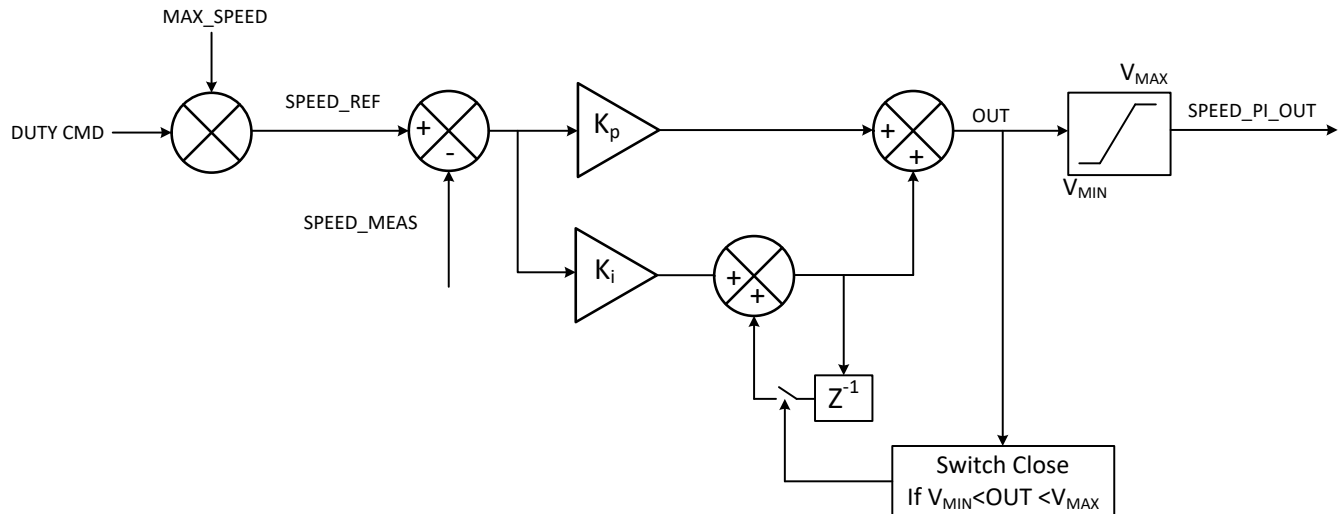


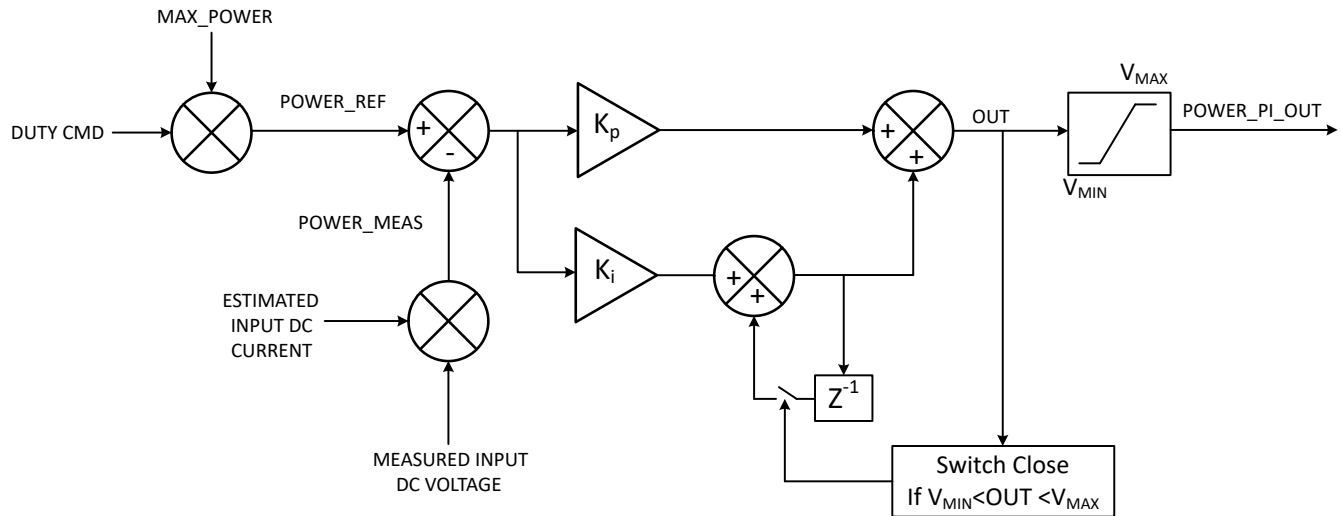
图 7-34. Speed Loop

### 7.3.13 Input Power Regulation

MCT8315A provides an option of regulating the (input) power instead of motor speed - this input power regulation can be done in two modes, namely, closed loop power control and power limit control. Input power regulation (instead of motor speed) mode is selected by setting CLOSED\_LOOP\_MODE to 10b. This should be accompanied by setting CONST\_POWER\_MODE to 01b for closed loop power control or to 10b for power limit control. In either of the power regulation modes, the maximum power that MCT8315A can draw from the DC input supply is set by MAX\_POWER - the power reference (POWER\_REF in 图 7-35) varies as function of the duty command input (DUTY\_CMD) and MAX\_POWER as given by 式 6. The hysteresis band for the power reference is set by CONST\_POWER\_LIMIT\_HYST. In both the power regulation modes, the minimum power reference is set by MIN\_DUTY x MAX\_POWER.

$$\text{POWER\_REF} = \text{DUTY\_CMD} \times \text{MAX\_POWER} \quad (6)$$

In both the power regulation modes, MCT8315A uses the same PI controller parameters as in the speed loop mode.  $K_p$  and  $K_i$  coefficients are configured through SPD\_POWER\_KP and SPD\_POWER\_KI. The PI controller output upper ( $V_{MAX}$ ) and lower bound ( $V_{MIN}$ ) saturation limits are configured through SPD\_POWER\_V\_MAX and SPD\_POWER\_V\_MIN respectively. The key difference between closed loop power control and power limit control is in when the PI controller decides the DUTY\_OUT (see 图 7-13) applied to FETs. In closed loop power control, DUTY\_OUT is always equal to POWER\_PI\_OUT from the PI controller output in 图 7-35. However, in power limit control, the PI controller decides the DUTY\_OUT only if  $\text{POWER\_MEAS} > \text{POWER\_REF} + \text{CONST\_POWER\_LIMIT\_HYST}$ . If  $\text{POWER\_MEAS} < \text{POWER\_REF} + \text{CONST\_POWER\_LIMIT\_HYST}$ , the PI controller is not used and DUTY\_OUT is equal to DUTY\_CMD. Essentially, in closed loop power control, input power is always actively regulated to POWER\_REF whereas, in power limit control, input power is only limited to POWER\_REF and not actively regulated to POWER\_REF. When output of the power PI loop saturates, the integrator is disabled to prevent integral wind-up.



**FIG 7-35. Power Regulation**

### 7.3.14 Anti-Voltage Surge (AVS)

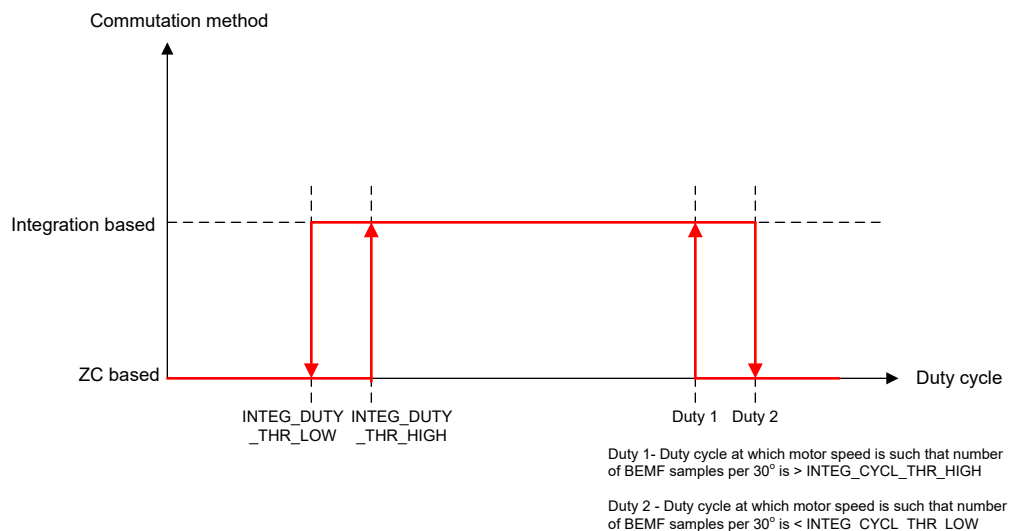
When a motor is driven, energy is transferred from the power supply into the motor. Some of this energy is stored in the form of inductive and mechanical energy. If the speed command suddenly drops such that the BEMF voltage generated by the motor is greater than the voltage that is applied to the motor, then the mechanical energy of the motor is returned to the power supply and the  $V_M$  voltage surges. The AVS feature works to prevent this voltage surge on  $V_M$  and can be enabled by setting AVS\_EN to 1b. AVS can be disabled by setting AVS\_EN to 0b. When AVS is disabled, the deceleration rate is configured through CL\_DEC\_CONFIG

### 7.3.15 Output PWM Switching Frequency

MCT8315A provides the option to configure the output PWM switching frequency of the MOSFETs through PWM\_FREQ\_OUT. PWM\_FREQ\_OUT has range of 5-100 kHz. In order to select optimal output PWM switching frequency, user has to make tradeoff between the current ripple and the switching losses. Generally, motors having lower L/R ratio require higher PWM switching frequency to reduce current ripple.

### 7.3.16 Fast Start-up (< 50 ms)

MCT8315A has the capability to accelerate a motor from 0 to 100% speed within 50ms. This will only work on low inertia motors which are capable of this level of acceleration. In order to achieve fast start-up, the commutation instant detection needs to be configured to hybrid mode by setting INTEG\_ZC\_METHOD to 1b. In the hybrid mode, the commutation instant is determined by using back-EMF integration at low-medium speeds and by using built-in comparators (BEMF zero crossing) at higher speeds. MCT8315A automatically transitions between back-EMF integration and comparator based commutation depending on the motor speed as shown in [FIG 7-36](#). The duty cycles for commutation method transition at lower speeds are directly configured by INTEG\_DUTY\_THR\_LOW and INTEG\_DUTY\_THR\_HIGH and at higher speeds are indirectly configured by INTEG\_CYC\_THR\_LOW and INTEG\_CYC\_THR\_HIGH. These duty cycles should be configured to provide a sufficient hysteresis band to avoid repeated commutation method transitions near threshold duty cycles. The BEMF threshold values used to determine the commutation instant in the back-EMF integration method are configured by BEMF\_THRESHOLD1 and BEMF\_THRESHOLD2.

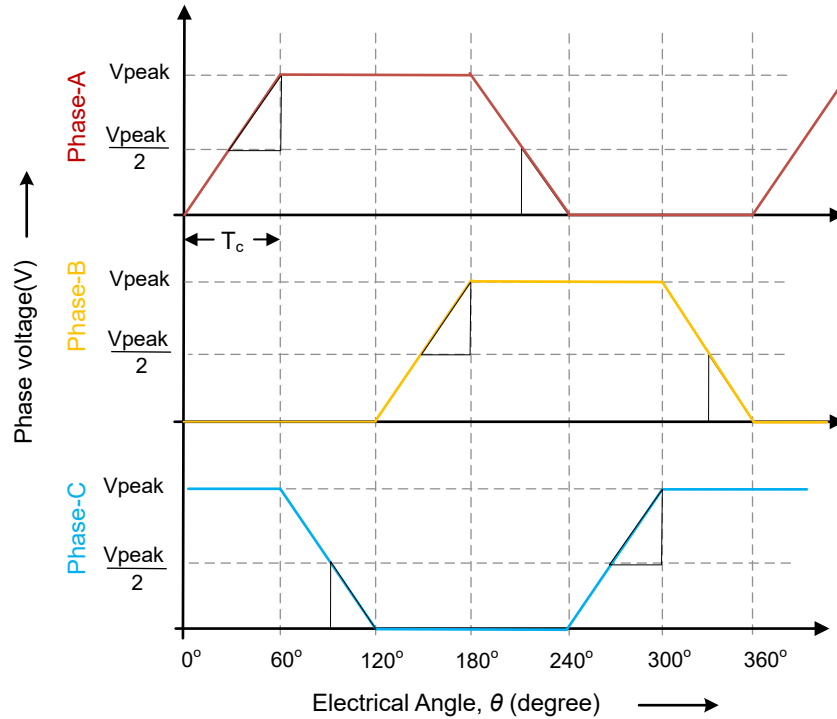


**7-36. Commutation Method Transition**

### 7.3.16.1 BEMF Threshold

7-37 shows the three-phase voltages during 120° trapezoidal operation. It is seen that one of the phases will always be floating within a 60° commutation interval and MCT8315A integrates this floating phase voltage (which denotes the motor back-EMF) in the back-EMF integration method to detect the next commutation instant. The floating phase voltage can either be increasing or decreasing and the algorithm starts the integration after the zero cross detection in order to eliminate integration errors due to variable degauss time. The floating phase voltage is periodically sampled (after zero cross) and added (discrete form of integration). BEMF threshold (BEMF\_THRESHOLD1 and BEMF\_THRESHOLD2) value is set such that the integral value of the floating phase voltage crosses the BEMF\_THRESHOLD1 or BEMF\_THRESHOLD2 value at (or very near) to the commutation instant. BEMF\_THRESHOLD1 is the threshold for rising floating phase voltage and BEMF\_THRESHOLD2 is the threshold for falling floating phase voltage. If BEMF\_THRESHOLD2 is set to 0, then BEMF\_THRESHOLD1 is used as the threshold for both rising and falling floating phase voltage.





**FIG 7-37. Back-EMF integration using floating phase voltage**

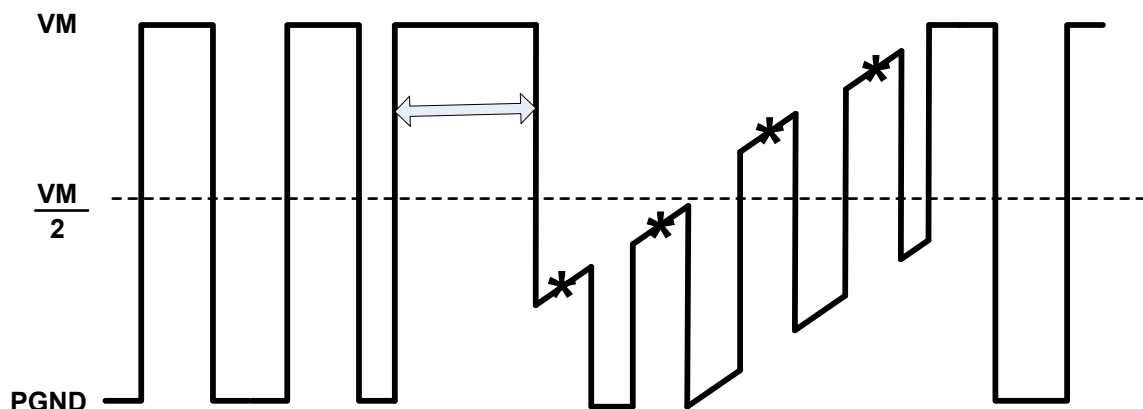
In FIG 7-37,  $V_{peak}$  is the peak-peak value of the back-EMF,  $V_{peak}/2$  denotes the zero cross of the back-EMF and  $T_c$  is the commutation interval or time period of the 60° window. The highlighted triangle in each 60° window is the integral value of back-EMF used by the algorithm to determine the commutation instant. This integral value, which can be approximated as the area of the highlighted triangle, is given by 式 7.

$$\left(\frac{1}{2}\right) * (V_{peak}/2) * T_c/2 \quad (7)$$

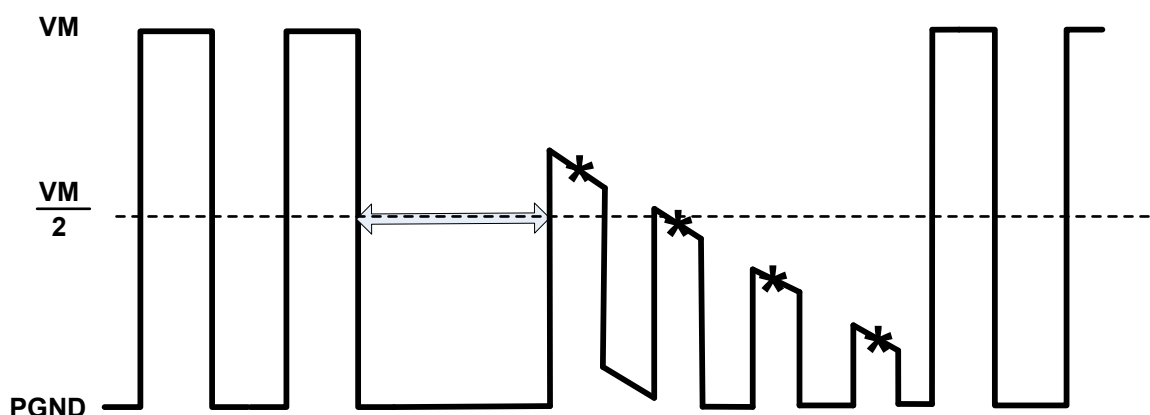
See for an example application on setting the BEMF threshold.

### 7.3.16.2 Dynamic Degauss

In MCT8315A, the degauss time can be dynamically computed after the commutation for a precise detection of the zero crossing instant. This is done by enabling the dynamic degauss feature (DYN\_DEGAUSS\_EN is set to 1b). This feature allows the motor control algorithm to capture the zero crossing instant after the outgoing (floating) phase voltage is completely settled; that is, when the outgoing phase current has decayed to zero and the outgoing (floating) phase voltage is not clamped (to either VM or PGND) and represents the true back-EMF. This accurate measurement of zero cross instant allows fast acceleration of the motors (< 50ms) using MCT8315A.



Degauss time (shown by double-sided arrow) after commutation during which the outgoing (floating) phase voltage is clamped to VM (by negative outgoing phase current) during increasing back-EMF; sampling of back-EMF (denoted by \*) should start after degauss time is over for accurate zero cross instant detection



Degauss time (shown by double-sided arrow) after commutation during which the outgoing (floating) phase voltage is clamped to PGND (by positive outgoing phase current) during decreasing back-EMF; sampling of back-EMF (denoted by \*) should start after degauss time is over for accurate zero cross instant detection

**图 7-38. Degauss Time**

### 7.3.17 Fast Deceleration

MCT8315A has the capability to decelerate a motor quickly (100% to 10% speed reduction within tens of ms) without pumping energy back into the input DC supply using the fast deceleration feature in conjunction with the AVS feature. The fast deceleration feature can be enabled by setting FAST\_DECEL\_EN to 1b; AVS\_EN should be set to 1b to prevent energy pump-back into the input DC supply. This combination enables a linear braking effect resulting in a fast and smooth speed reduction without energy pump-back into the DC input supply. This feature combination can also be used during reverse drive (see [Reverse Drive](#)) or motor stop (see [Active Spin-Down](#)) to reduce the motor speed quickly without energy pump-back into the DC input supply.

The deceleration time can be controlled by appropriately configuring the current limit during deceleration, FAST\_DECEL\_CURR\_LIM. A higher current limit results in a lower deceleration time and vice-versa. A higher than necessary current limit setting may result in motor stall faults, at low target speeds, due to excessive braking torque. This can also lead to higher losses in MCT8315A, especially in repeated acceleration-deceleration cycles. Therefore, the FAST\_DECEL\_CURR\_LIM should be chosen appropriately, so as to decelerate within the required time without resulting in stall faults or overheating.

FAST\_BRK\_DELTA is used to configure the target speed hysteresis band to exit the fast deceleration mode and re-enter motoring mode when motor reaches the target speed. For example, if FAST\_BRK\_DELTA is set to 1%,

the fast deceleration is deemed complete when motor speed reaches within 1% of target speed. Setting a higher value for FAST\_BRK\_DELTA may eliminate motor stall faults, especially when high FAST\_DECEL\_CURR\_LIM values are used. Setting a higher value for FAST\_BRK\_DELTA will also result in higher speed error between target speed and motor speed at the end of deceleration mode - motor will eventually reach the target speed once motoring mode is resumed. FAST\_DECEL\_CURR\_LIM and FAST\_BRK\_DELTA should be configured in tandem to optimize between lower deceleration time and reliable (no stall faults) deceleration profile.

FAST\_DEC\_DUTY\_THR configures the speed below which fast deceleration will be implemented. For example, if FAST\_DEC\_DUTY\_THR is set to 70%, any deceleration from speeds above 70% will not use fast deceleration until the speed goes below 70%. FAST\_DEC\_DUTY\_WIN is used to set the minimum deceleration window (initial speed - target speed) below which fast deceleration will not be implemented. For example, if FAST\_DEC\_DUTY\_WIN is set to 15% and 50%→40% deceleration command is received, fast deceleration is not used to reduce the speed from 50% to 40% since the deceleration window (10%) is smaller than FAST\_DEC\_DUTY\_WIN.

MCT8315A provides a dynamic current limit option during fast deceleration to improve the stability of fast deceleration when braking to very low speeds; using this feature the current limit during fast deceleration can be reduced as the motor speed decreases. This feature can be enabled by setting DYNAMIC\_BRK\_CURR to 1b. The current limit at the start of fast deceleration (at FAST\_DEC\_DUTY\_THR) is configured by FAST\_DECEL\_CURR\_LIM and the current limit at zero speed is configured by DYN\_BRK\_CURR\_LOW\_LIM; the current limit during fast deceleration varies linearly with speed between these two operating points when dynamic current limit is enabled. If dynamic current limit is disabled, current limit during fast deceleration stays constant and is configured by FAST\_DECEL\_CURR\_LIM.

### 7.3.18 Active Demagnetization

MCT8315A has smart rectification features (active demagnetization) which decreases power losses in the device by reducing diode conduction losses. When this feature is enabled, the device automatically turns ON the corresponding MOSFET whenever it detects diode conduction. This feature can be enabled by configuring EN\_ASR.

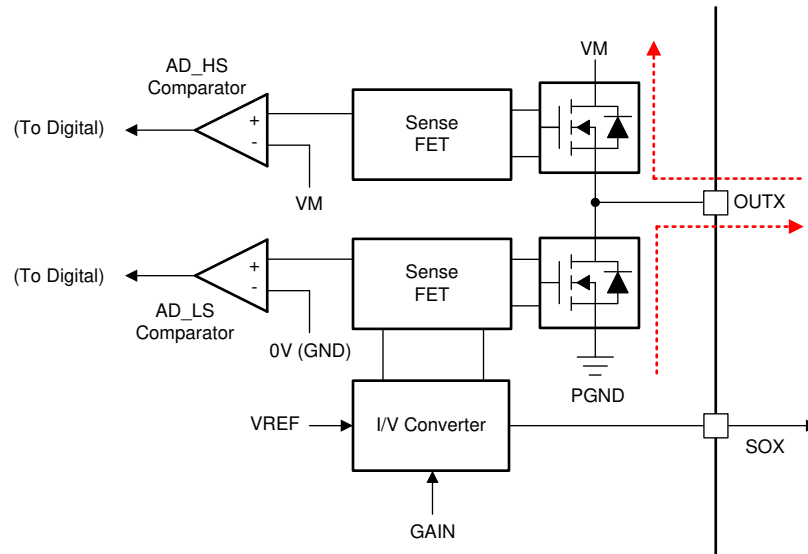
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注

EN\_ASR needs to be set to 1b to enable active demagnetization.

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The MCT8315A device includes a high-side (AD\_HS) and low-side (AD\_LS) comparator which detects the negative flow of current in the device on each half-bridge. The AD\_HS comparator compares the sense-FET output with the supply voltage (VM) threshold, whereas the AD\_LS comparator compares with the ground (0-V) threshold. Depending upon the flow of current from OUTx to VM or PGND to OUTx, the AD\_HS or the AD\_LS comparator trips. These comparator outputs provide a reference point for the operation of active demagnetization feature.

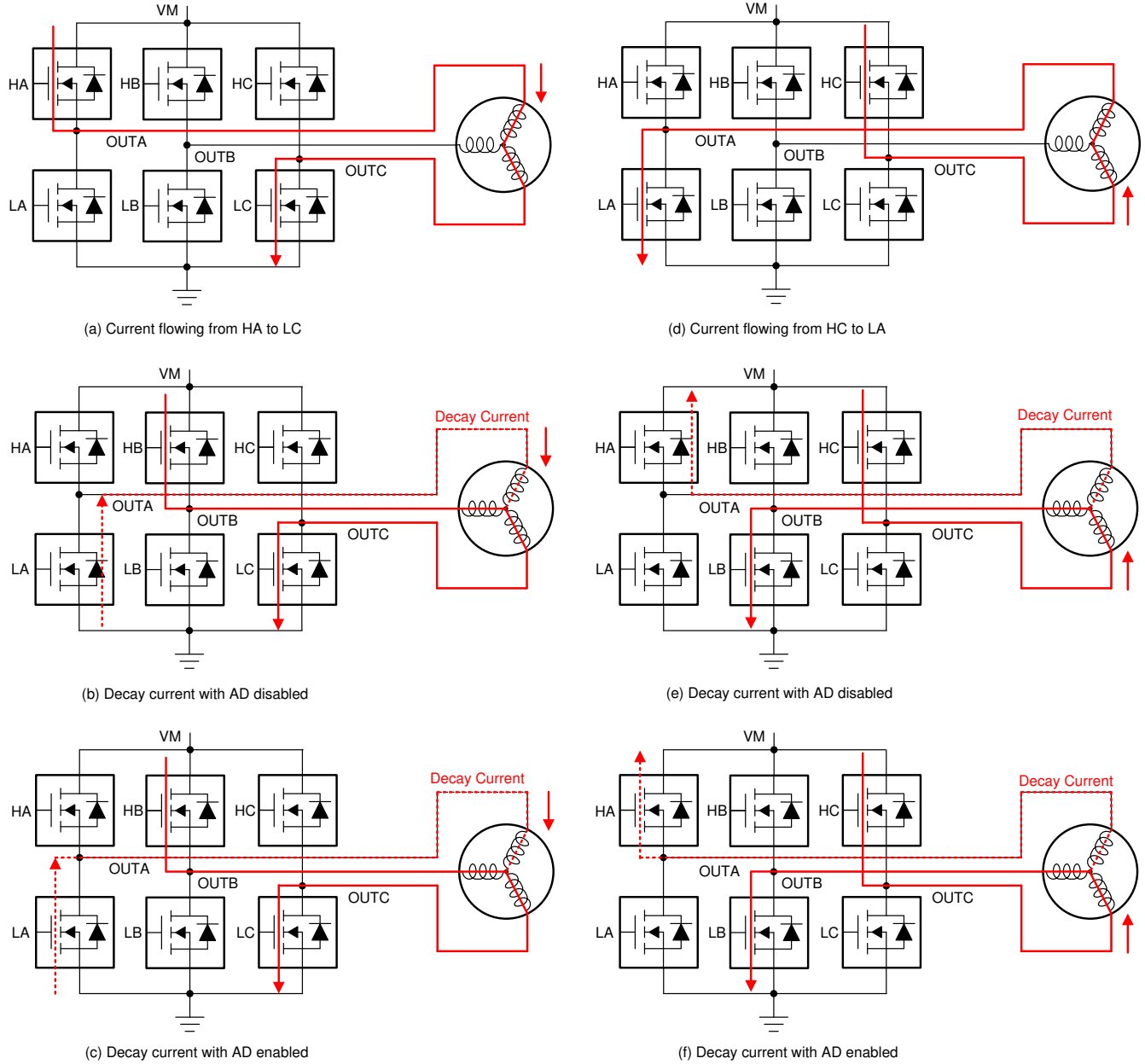


**7-39. Active Demagnetization Operation**

#### 7.3.18.1 Active Demagnetization in action

7-40 shows the operation of active demagnetization during the BLDC motor commutation. As shown in 7-40 (a), the current is flowing from HA to LC in one commutation state. During the commutation change over as shown in 7-40 (b), the HB FET is turned ON (and HA FET is turned OFF), and the commutation current (due to motor inductance) in OUTA flows through the body diode of LA. This results in a higher diode loss depending on the commutation current. This commutation loss is reduced by turning on the LA FET for the commutation time as shown in 7-40 (c).

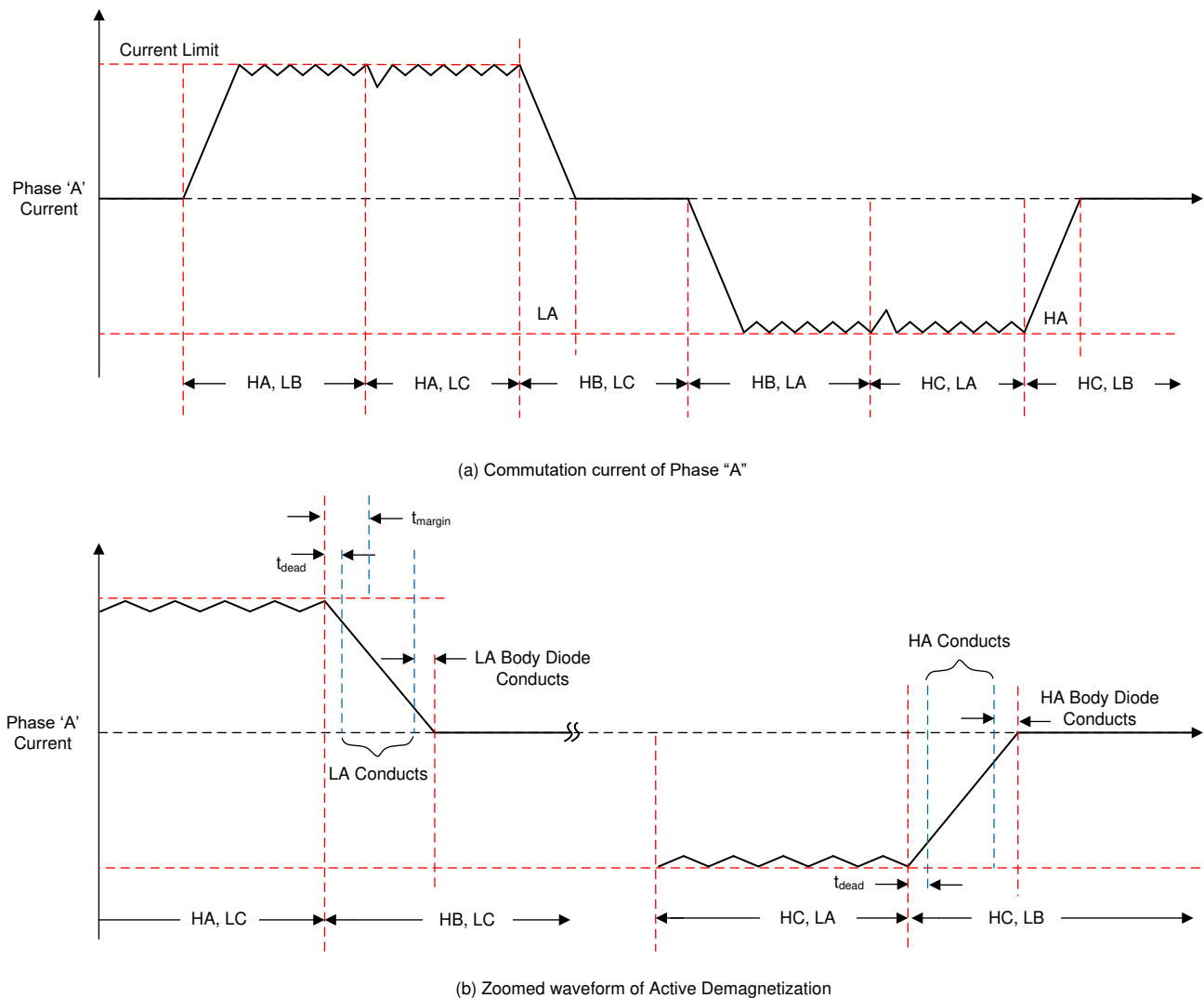
Similarly, the active demagnetization operation of a high-side FET is realized in 7-40 (d), (e) and (f).



**FIG 7-40. Active Demagnetization in BLDC Motor Commutation**

✎ 7-41 (a) shows the BLDC motor phase current waveforms with Active Demagnetization with trapezoidal commutation. This figure shows the operation of various switches in a single commutation cycle.

✎ 7-41 (b) shows the zoomed waveform of commutation cycle.



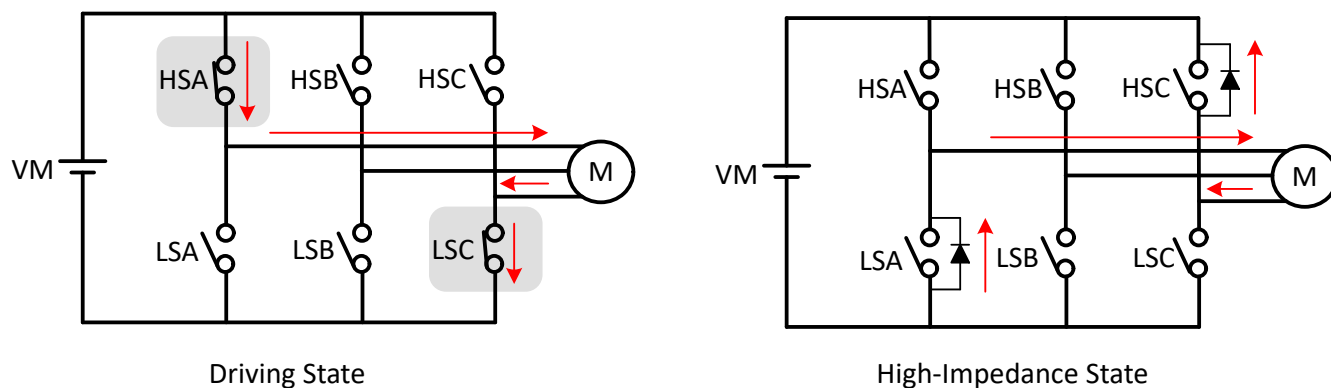
✎ 7-41. Current Waveforms with Active Demagnetization

### 7.3.19 Motor Stop Options

The MCT8315A provides different options for stopping the motor which can be configured by MTR\_STOP.

#### 7.3.19.1 Coast (Hi-Z) Mode

Coast (Hi-Z) mode is configured by setting MTR\_STOP to 000b. When motor stop command is received, the MCT8315A will transition into a high impedance (Hi-Z) state by turning off all MOSFETs. When the MCT8315A transitions from driving the motor into a Hi-Z state, the inductive current in the motor windings continues to flow and the energy returns to the power supply through the body diodes in the MOSFET output stage (see example ✎ 7-42).



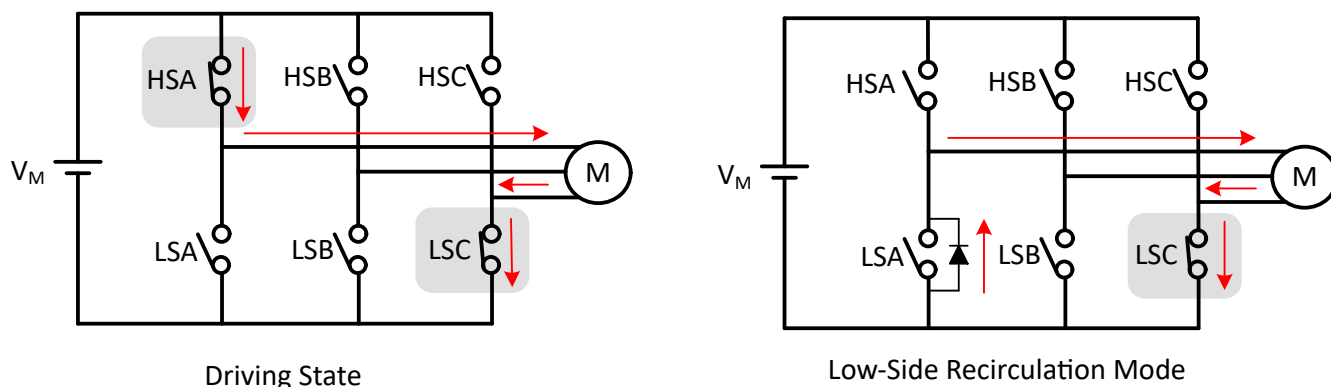
**FIG 7-42. Coast (Hi-Z) Mode**

In this example, current is applied to the motor through the high-side phase-A MOSFET (HSA) and returned through the low-side phase-C MOSFET (LSC). When motor stop command is received all 6 MOSFETs transition to Hi-Z state and the inductive energy returns to supply through body diodes of MOSFETs LSA and HSC.

### 7.3.19.2 Recirculation Mode

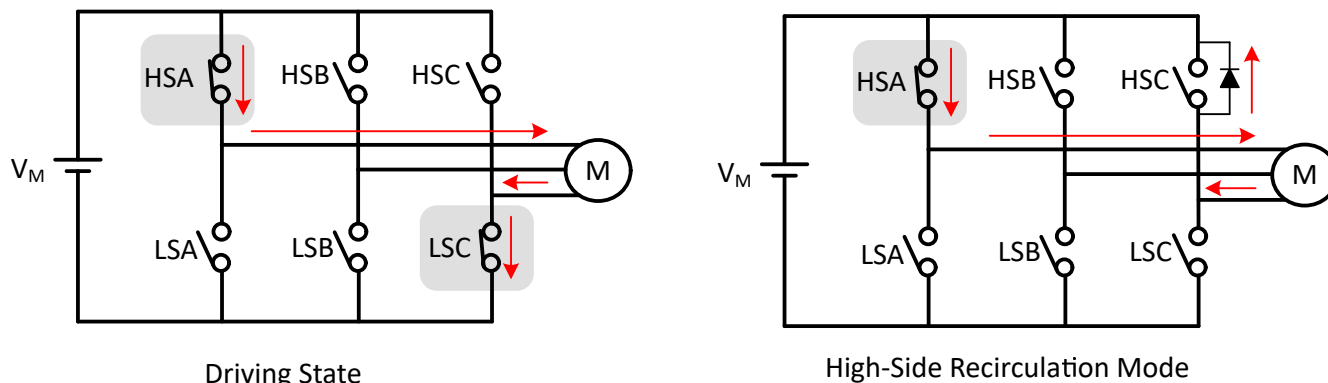
Recirculation mode is configured by setting MTR\_STOP to 001b. In order to prevent the inductive energy from returning to DC input supply during motor stop, the MCT8315A allows current to circulate within the MOSFETs by selectively turning OFF some of the active (ON) MOSFETs for a certain time (auto calculated recirculation time to allow the inductive current to decay to zero) before transitioning into Hi-Z by turning OFF the remaining MOSFETs.

If high-side modulation was active, prior to motor stop command, then the high-side MOSFET is turned OFF on receiving motor stop command and the current recirculation takes place through low-side MOSFET (see example FIG 7-43). Once the recirculation time lapses, the low-side MOSFET also turns OFF and all MOSFETs are in Hi-Z state.



**FIG 7-43. Low-Side Recirculation**

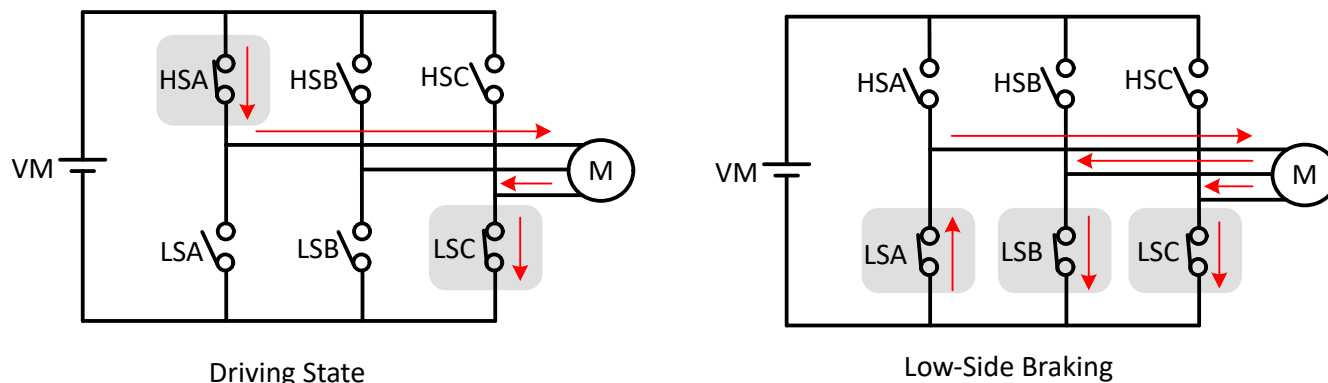
If low-side modulation was active, prior to motor stop command, then the low-side MOSFET is turned OFF on receiving motor stop command and the current recirculation takes place through high-side MOSFET (see example FIG 7-44). Once the recirculation time lapses, the high-side MOSFET also turns OFF and all MOSFETs are in Hi-Z state.



**Figure 7-44. High-Side Recirculation**

### 7.3.19.3 Low-Side Braking

Low-side braking mode is configured by setting MTR\_STOP to 010b. When a motor stop command is received, the output speed is reduced to a value defined by ACT\_SPIN\_BRK\_THR prior to turning all low-side MOSFETs ON (see example [Figure 7-45](#)) for a time configured by MTR\_STOP\_BRK\_TIME. If the motor speed is below ACT\_SPIN\_BRK\_THR prior to receiving stop command, then the MCT8315A transitions directly into the brake state. After applying the brake for MTR\_STOP\_BRK\_TIME, the MCT8315A transitions into the Hi-Z state by turning OFF all MOSFETs.



**Figure 7-45. Low-Side Braking**

The MCT8315A can also enter low-side braking through BRAKE pin input. When BRAKE pin is pulled to HIGH state, the output speed is reduced to a value defined by BRAKE\_DUTY\_THRESHOLD prior to turning all low-side MOSFETs ON. In this case, MCT8315A stays in low-side brake state till BRAKE pin changes to LOW state.

### 7.3.19.4 High-Side Braking

High-side braking mode is configured by setting MTR\_STOP to 011b. When a motor stop command is received, the output speed is reduced to a value defined by ACT\_SPIN\_BRK\_THR prior to turning all high-side MOSFETs ON (see example [Figure 7-46](#)) for a time configured by MTR\_STOP\_BRK\_TIME. If the motor speed is below ACT\_SPIN\_BRK\_THR prior to receiving stop command, then the MCT8315A transitions directly into the brake state. After applying the brake for MTR\_STOP\_BRK\_TIME, the MCT8315A transitions into Hi-Z state by turning OFF all MOSFETs.



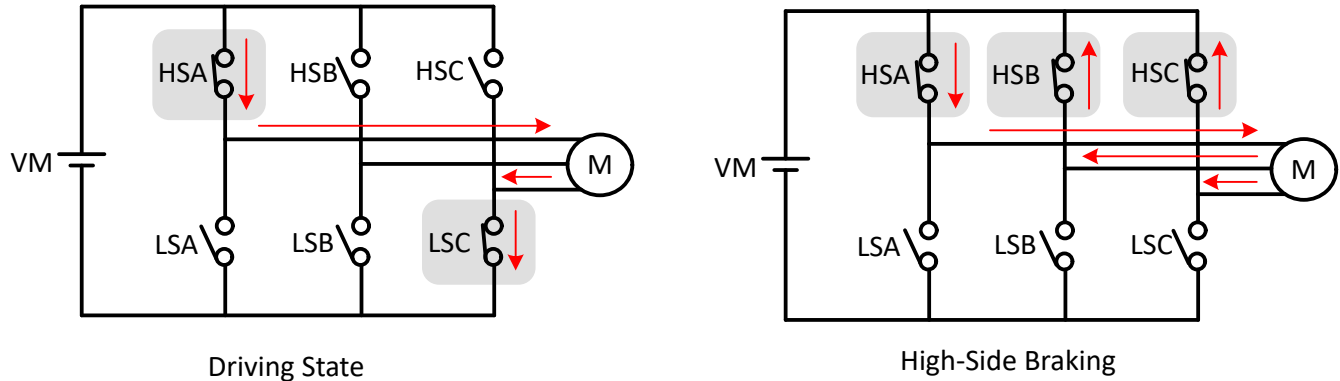


Figure 7-46. High-Side Braking

### 7.3.19.5 Active Spin-Down

Active spin down mode is configured by setting MTR\_STOP to 100b. When motor stop command is received, MCT8315A reduces duty cycle to ACT\_SPIN\_BRK\_THR and then transitions to Hi-Z state by turning all MOSFETs OFF. The advantage of this mode is that by reducing duty cycle, the motor is decelerated to a lower speed thereby reducing the phase currents before entering Hi-Z. Now, when motor transitions into Hi-Z state, the energy transfer to power supply is reduced. The threshold ACT\_SPIN\_BRK\_THR needs to be configured high enough for MCT8315A to not lose synchronization with the motor.

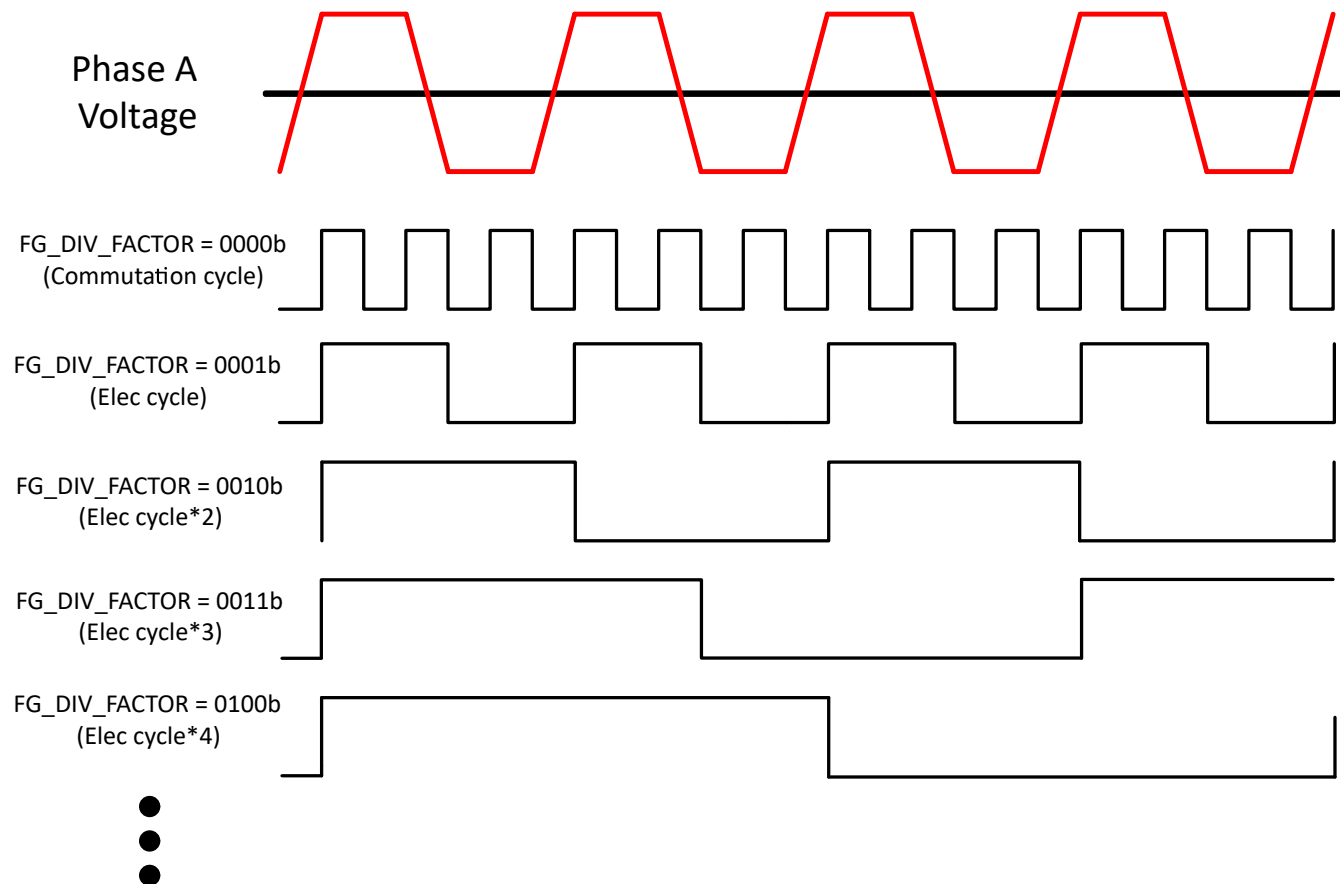
### 7.3.20 FG Configuration

The MCT8315A provides information about the motor speed through the Frequency Generate (FG) pin and provides an FG output until the motor back-EMF falls below FG\_BEMF\_THR.

#### 7.3.20.1 FG Output Frequency

The FG output frequency can be configured by FG\_DIV\_FACTOR. In MCT8315, FG toggles once every commutation cycle if FG\_DIV\_FACTOR is set to 0000b. Many applications require the FG output to provide a pulse for every mechanical rotation of the motor. Different FG\_DIV\_FACTOR configurations can accomplish this for 2-pole up to 30-pole motors.

Figure 7-47 shows the FG output when MCT8315A has been configured to provide FG pulses once every commutation cycle (electrical cycle/3), once every electrical cycle (2 poles), once every two electrical cycle (4 poles), once every three electrical cycles (6 poles), once every four electrical cycles (8 poles), and so on.



7-47. FG Frequency Divider

### 7.3.20.2 FG Open-Loop and Lock Behavior

During closed loop operation, the driving speed (FG output frequency) and the actual motor speed are synchronized. During open-loop operation, however, FG may not reflect the actual motor speed. During motor-lock condition, the FG output is driven high.

The MCT8315A provides three options for controlling the FG output during open loop, as shown in 7-48. The selection of these options is configured through FG\_SEL.

If FG\_SEL is set to,

- 00b: When in open loop, the FG output is based on the driving frequency.
- 01b: When in open loop, the FG output will be driven high.
- 10b: The FG output will reflect the driving frequency during open loop operation in the first motor start-up cycle after power-on, sleep/standby; FG will be held high during open loop operation in subsequent start-up cycles.

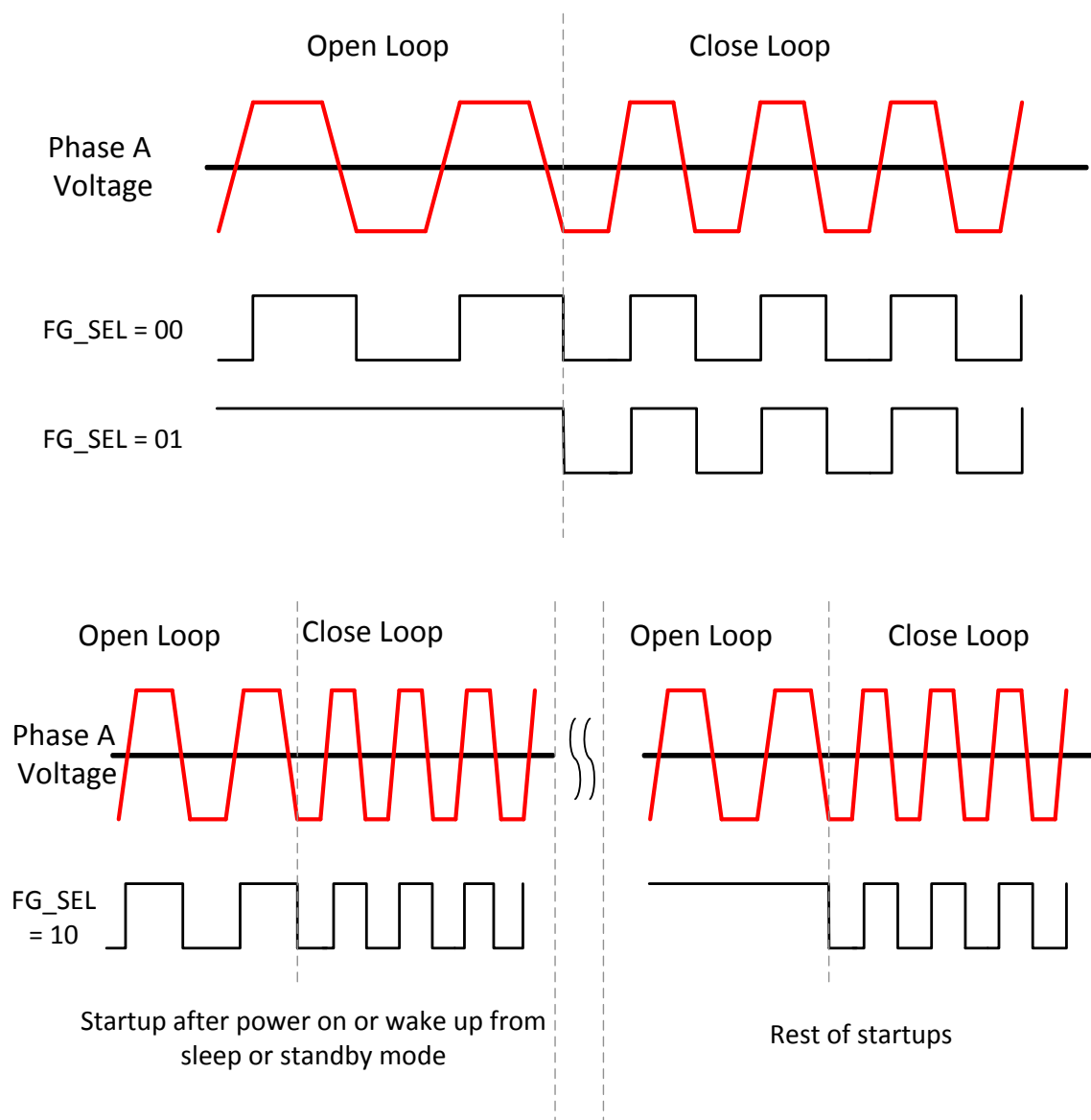


图 7-48. FG Behavior During Open Loop

### 7.3.21 Protections

The MCT8315A is protected from a host of fault events including motor lock, VM undervoltage, AVDD undervoltage, buck undervoltage, charge pump undervoltage, overtemperature and overcurrent events. 表 7-2 summarizes the response, recovery modes, power stage status, reporting mechanism for different faults.

## 注

1. Actionable faults (latched or retry) are always reported on nFAULT pin (as logic low).
2. Actionable faults (latched or retry) are reported on ALARM pin (as logic high) when ALARM\_PIN\_EN is set to 1b.
3. Report only faults are reported on nFAULT (as logic low) only when ALARM\_PIN\_EN is set to 0b. When ALARM\_PIN\_EN is set to 1b, report only faults are reported only on ALARM pin (as logic high) while nFAULT stays high (external pull-up).
4. Priority order for multi-fault scenarios is latched > slower retry time fault > faster retry time fault > report only fault. For example, if a latched and retry fault happen simultaneously, the device stays latched in fault mode until user issues clear fault command by writing 1b to CLR\_FLT. If two retry faults with different retry times happen simultaneously, the device retries only after the longer (slower) retry time lapses.
5. Recovery refers only to state of FETs (Hi-Z or active) after the fault condition is removed. Automatic indicates that the device automatically recovers (and FETs are active) when retry time lapses after the fault condition is removed. Latched indicates that the device waits for clearing of fault condition (by writing 1b to CLR\_FLT bit) to make the FETs active again.
6. Actionable (latched or retry) faults can take up to 200-ms after fault response (FETs in Hi-Z) to be reported on nFAULT pin (as logic low), ALARM pin (as logic high) and fault status registers.
7. Latched faults can take up to 200-ms after CLR\_FLT command is issued (over I<sup>2</sup>C) to be cleared.

表 7-2. Fault Action and Response

FAULT	CONDITION	CONFIGURATION	REPORT	FETs	DIGITAL	RECOVERY
VM undervoltage	$V_{VM} < V_{UVLO}$	—	—	Hi-Z	Disabled	Automatic: $V_{VM} > V_{UVLO}$
AVDD undervoltage	$V_{AVDD} < V_{AVDD\_UV}$	—	—	Hi-Z	Disabled	Automatic: $V_{AVDD} > V_{AVDD\_UV}$
Buck undervoltage (BUCK_UV)	$V_{FB\_BK} < V_{BK\_UV}$	—	—	Active/Hi-Z	Active/Disabled	Automatic: $V_{FB\_BK} > V_{BK\_UV}$
Charge pump undervoltage (VCP_UV)	$V_{CP} < V_{CPUV}$	—	nFAULT and GATE_DRIVER_FAULT_STATUS register	Hi-Z	Active	Automatic: $V_{VCP} > V_{CPUV}$
Over Voltage Protection (OVP)	$V_{VM} > V_{OVP}$	OVP_EN = 0b	None	Active	Active	No action
		OVP_EN = 1b	nFAULT and GATE_DRIVER_FAULT_STATUS register	Hi-Z	Active	Automatic: $V_{VM} < V_{OVP}$
Over Current Protection (OCP)	$I_{PHASE} > I_{OCP}$	OCP_MODE = 00b	nFAULT and GATE_DRIVER_FAULT_STATUS register	Hi-Z	Active	Latched: CLR_FLT
		OCP_MODE = 01b	nFAULT and GATE_DRIVER_FAULT_STATUS register	Hi-Z	Active	Retry: $t_{RETRY}$
		OCP_MODE = 10b	nFAULT and GATE_DRIVER_FAULT_STATUS register	Active	Active	No action
		OCP_MODE = 11b	None	Active	Active	No action
Buck Overcurrent Protection (BUCK_OCP)	$I_{BK} > I_{BK\_OCP}$	—	—	Hi-Z	Disabled	Automatic

**表 7-2. Fault Action and Response (continued)**

FAULT	CONDITION	CONFIGURATION	REPORT	FETs	DIGITAL	RECOVERY
Motor Lock (MTR_LCK )	Motor lock: Abnormal Speed; No Motor Lock; Loss of Sync	MTR_LCK_MODE = 0000b or 0001b	nFAULT and CONTROLLER_FA ULT_STATUS register	Hi-Z	Active	Latched: CLR_FLT
		MTR_LCK_MODE = 0010b	nFAULT and CONTROLLER_FA ULT_STATUS register	High side brake	Active	Latched: CLR_FLT
		MTR_LCK_MODE = 0011b	nFAULT and CONTROLLER_FA ULT_STATUS register	Low side brake	Active	Latched: CLR_FLT
		MTR_LCK_MODE = 0100b or 0101b	nFAULT and CONTROLLER_FA ULT_STATUS register	Hi-Z	Active	Retry: t <sub>LCK_RETRY</sub>
		MTR_LCK_MODE = 0110b	nFAULT and CONTROLLER_FA ULT_STATUS register	High side brake	Active	Retry: t <sub>LCK_RETRY</sub>
		MTR_LCK_MODE = 0111b	nFAULT and CONTROLLER_FA ULT_STATUS register	Low side brake	Active	Retry: t <sub>LCK_RETRY</sub>
		MTR_LCK_MODE = 1000b	nFAULT and CONTROLLER_FA ULT_STATUS register	Active	Active	No action
		MTR_LCK_MODE = 1xx1b	None	Active	Active	No action
Cycle by Cycle Current Limit (CBC_ILIMIT)	V <sub>SOX</sub> > CBC_ILIMIT	CBC_ILIMIT_MODE = 0000b	nFAULT and CONTROLLER_FA ULT_STATUS register	Recirculation	Active	Automatic: Next PWM cycle
		CBC_ILIMIT_MODE = 0001b	None	Recirculation	Active	Automatic: Next PWM cycle
		CBC_ILIMIT_MODE = 0010b	nFAULT and CONTROLLER_FA ULT_STATUS register	Recirculation	Active	Automatic: V <sub>SOX</sub> < CBC_ILIMIT
		CBC_ILIMIT_MODE = 0011b	None	Recirculation	Active	Automatic: V <sub>SOX</sub> < CBC_ILIMIT
		CBC_ILIMIT_MODE = 0100b	nFAULT and CONTROLLER_FA ULT_STATUS register	Recirculation	Active	Automatic: PWM cycle > CBC_RETRY_PWM_CYC
		CBC_ILIMIT_MODE = 0101b	None	Recirculation	Active	Automatic: PWM cycle > CBC_RETRY_PWM_CYC
		CBC_ILIMIT_MODE = 0110b	nFAULT and CONTROLLER_FA ULT_STATUS register	Active	Active	No action
		CBC_ILIMIT_MODE = 0111b, 1xxxb	None	Active	Active	No action

表 7-2. Fault Action and Response (continued)

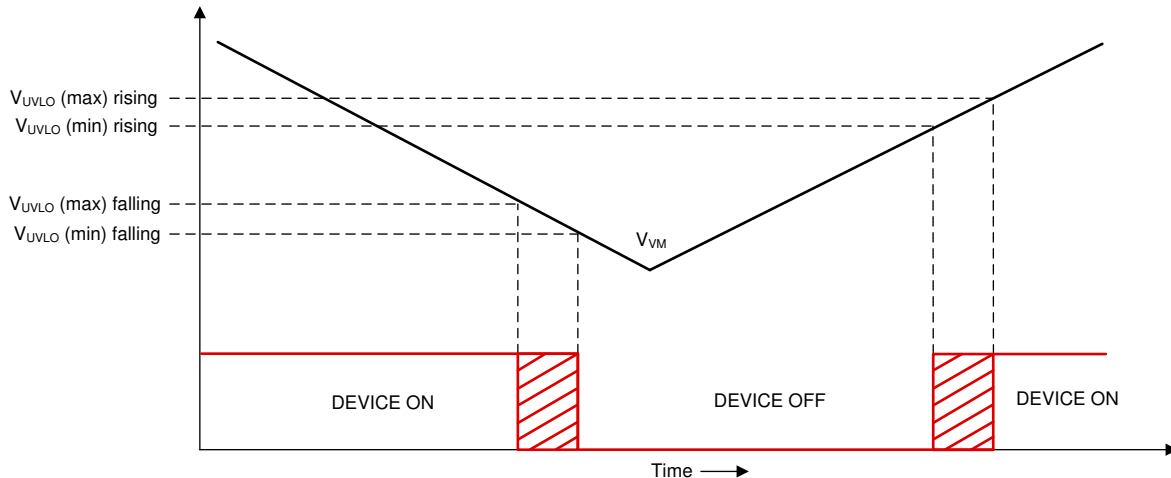
FAULT	CONDITION	CONFIGURATION	REPORT	FETs	DIGITAL	RECOVERY
Lock-Detection Current Limit (LOCK_ILIMIT)	$V_{SOX} > LOCK\_ILIMIT$	LOCK_ILIMIT_MODE = 0000b	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Latched: CLR_FLT
		LOCK_ILIMIT_MODE = 0001b	nFAULT and CONTROLLER_FAULT_STATUS register	Recirculation	Active	Latched: CLR_FLT
		LOCK_ILIMIT_MODE = 0010b	nFAULT and CONTROLLER_FAULT_STATUS register	High-side brake	Active	Latched: CLR_FLT
		LOCK_ILIMIT_MODE = 0011b	nFAULT and CONTROLLER_FAULT_STATUS register	Low-side brake	Active	Latched: CLR_FLT
		LOCK_ILIMIT_MODE = 0100b	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Retry: $t_{LCK\_RETRY}$
		LOCK_ILIMIT_MODE = 0101b	nFAULT and CONTROLLER_FAULT_STATUS register	Recirculation	Active	Retry: $t_{LCK\_RETRY}$
		LOCK_ILIMIT_MODE = 0110b	nFAULT and CONTROLLER_FAULT_STATUS register	High-side brake	Active	Retry: $t_{LCK\_RETRY}$
		LOCK_ILIMIT_MODE = 0111b	nFAULT and CONTROLLER_FAULT_STATUS register	Low-side brake	Active	Retry: $t_{LCK\_RETRY}$
		LOCK_ILIMIT_MODE = 1000b	nFAULT and CONTROLLER_FAULT_STATUS register	Active	Active	No action
		LOCK_ILIMIT_MODE = 1xx1b	None	Active	Active	No action
IPD Timeout Fault (IPD_T1_FAULT and IPD_T2_FAULT)	IPD TIME > 500ms (approx.), during IPD current ramp up or ramp down	IPD_TIMEOUT_FAULT_EN N = 0b	—	Active	Active	No action
		IPD_TIMEOUT_FAULT_EN N = 1b	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Retry: $t_{LCK\_RETRY}$
IPD Timeout Fault (IPD_T1_FAULT and IPD_T2_FAULT)	IPD TIME > 500ms (approx.), during IPD current ramp up or ramp down	—	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Latched: CLR_FLT
		—	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Latched: CLR_FLT
IPD Frequency Fault (IPD_FREQ_FAULT )	IPD pulse before the current decay in previous IPD pulse	IPD_FREQ_FAULT_EN = 0b	—	Active	Active	No action
		IPD_FREQ_FAULT_EN = 1b	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Retry: $t_{LCK\_RETRY}$
IPD Frequency Fault (IPD_FREQ_FAULT )	IPD pulse before the current decay in previous IPD pulse	—	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Latched: CLR_FLT
Maximum VM (overvoltage) fault	$V_{VM} > MAX\_VM\_MOTOR$ , if $MAX\_VM\_MOTOR \neq$ 000b	MAX_VM_MODE = 0b	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Latched: CLR_FLT
		MAX_VM_MODE = 1b	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Automatic: ( $V_{VM} < MAX\_VM\_MOTOR - 1$ )-V
Minimum VM (undervoltage) fault	$V_{VM} < MIN\_VM\_MOTOR$ , if $MIN\_VM\_MOTOR \neq$ 000b	MIN_VM_MODE = 0b	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Latched: CLR_FLT
		MIN_VM_MODE = 1b	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Automatic: ( $V_{VM} > MIN\_VM\_MOTOR + 0.5$ )-V

**表 7-2. Fault Action and Response (continued)**

FAULT	CONDITION	CONFIGURATION	REPORT	FETs	DIGITAL	RECOVERY
External Watchdog	Watchdog tickle does not arrive before configured time interval when EXT_WDT_EN = 1b. Refer <a href="#">セクション 7.5.5</a>	EXT_WDT_FAULT_MODE = 0b	nFAULT and CONTROLLER_FAULT_STATUS register	Active	Active	No action
		EXT_WDT_FAULT_MODE = 1b	nFAULT and CONTROLLER_FAULT_STATUS register	Hi-Z	Active	Latched: CLR_FLT
Bus Current Limit	$I_{VM} > \text{BUS\_CURRENT\_LIMIT}$ . Refer	BUS_CURRENT_LIMIT_ENABLE = 1b	nFAULT and CONTROLLER_FAULT_STATUS register	Active; motor speed will be restricted to limit DC bus current	Active	Automatic: Speed restriction is removed when $I_{VM} < \text{BUS\_CURRENT\_LIMIT}$
Current Loop Saturation	Indication of current loop saturation due to lower $V_{VM}$	SATURATION_FLAGS_EN = 1b	nFAULT and CONTROLLER_FAULT_STATUS register	Active; motor speed may not reach speed reference	Active	Automatic: motor will reach reference operating point upon exiting saturation
Speed Loop Saturation	Indication of speed loop saturation due to lower $V_{VM}$ , lower ILIMIT setting etc.,	SATURATION_FLAGS_EN = 1b	nFAULT and CONTROLLER_FAULT_STATUS register	Active; motor speed may not reach speed reference	Active	Automatic: motor will reach reference operating point upon exiting saturation
Thermal warning (OTW)	$T_J > T_{OTW}$	OTW_REP = 0b	—	Active	Active	No action
		OTW_REP = 1b	nFAULT and GATE_DRIVER_FAULT_STATUS register	Active	Active	Automatic: $T_J < T_{OTW} - T_{OTW\_HYS}$
Thermal shutdown (TSD)	$T_J > T_{TSD}$	—	nFAULT and GATE_DRIVER_FAULT_STATUS register	Hi-Z	Active	Automatic: $T_J < T_{TSD} - T_{TSD\_HYS}$

### 7.3.21.1 VM Supply Undervoltage Lockout

If at any time the input supply voltage on the VM pin falls lower than the  $V_{UVLO}$  threshold (VM UVLO falling threshold), all the integrated FETs, driver charge-pump and digital logic are disabled as shown in [Figure 7-49](#). MCT8315A goes into reset state whenever VM UVLO event occurs.



**Figure 7-49. VM Supply Undervoltage Lockout**

### 7.3.21.2 AVDD Undervoltage Lockout (AVDD\_UV)

If at any time the voltage on the AVDD pin falls lower than the  $V_{AVDD\_UV}$  threshold, all the integrated FETs, driver charge-pump and digital logic controller are disabled. Since internal circuitry in MCT8315A is powered through the AVDD regulator, MCT8315A goes into reset state whenever AVDD UV event occurs.

### 7.3.21.3 BUCK Undervoltage Lockout (BUCK\_UV)

If at any time the input supply voltage on the FB\_BK pin falls lower than the  $V_{BK\_UVLO}$  threshold, both the high-side and low-side MOSFETs of the buck regulator are disabled. Since internal circuitry in MCT8315A is powered through the buck regulator, MCT8315A goes into reset state whenever buck UV event occurs.

### 7.3.21.4 VCP Charge Pump Undervoltage Lockout (CPUV)

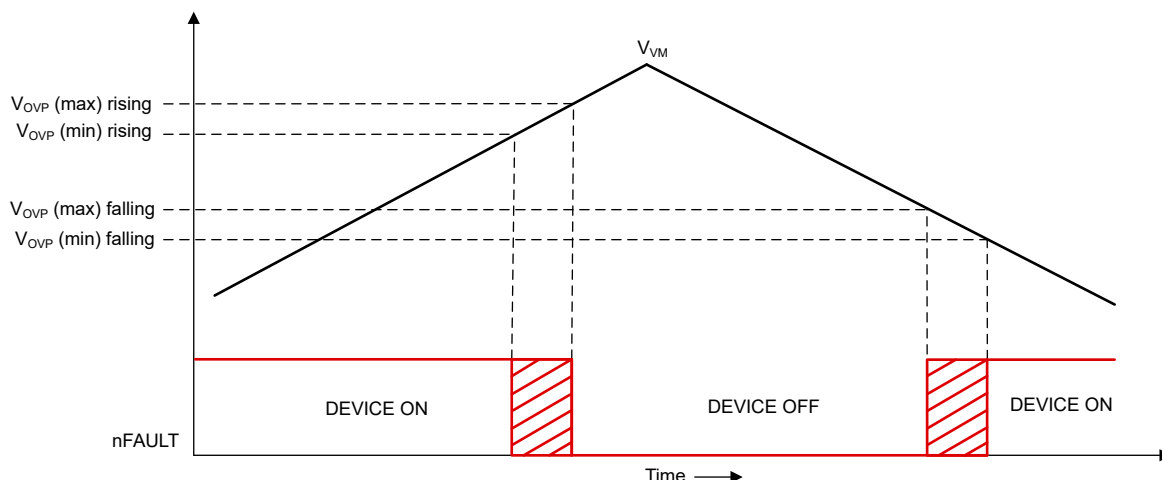
If at any time the voltage on the VCP pin (charge pump) falls lower than the  $V_{CPUV}$  threshold, all the integrated FETs are disabled and the nFAULT pin is driven low. The DRIVER\_FAULT and VCP\_UV bits are set to 1b in the status registers. Normal operation resumes (driver operation and the nFAULT pin is released) when the VCP undervoltage condition clears. The VCP\_UV bit stays set until cleared through the CLR\_FLT bit.

### 7.3.21.5 Overvoltage Protection (OVP)

If at any time input supply voltage on the VM pins rises higher than  $V_{OVP}$ , all the integrated FETs are disabled and the nFAULT pin is driven low. The DRIVER\_FAULT and OVP bits are set to 1b in the status registers. Normal operation resumes (driver operation and the nFAULT pin is released) when the OVP condition clears. The OVP bit stays set until cleared through the CLR\_FLT bit. Setting the OVP\_EN to 0b disables this protection feature.

The OVP threshold can be set to 22-V or 34-V based on the OVP\_SEL bit.





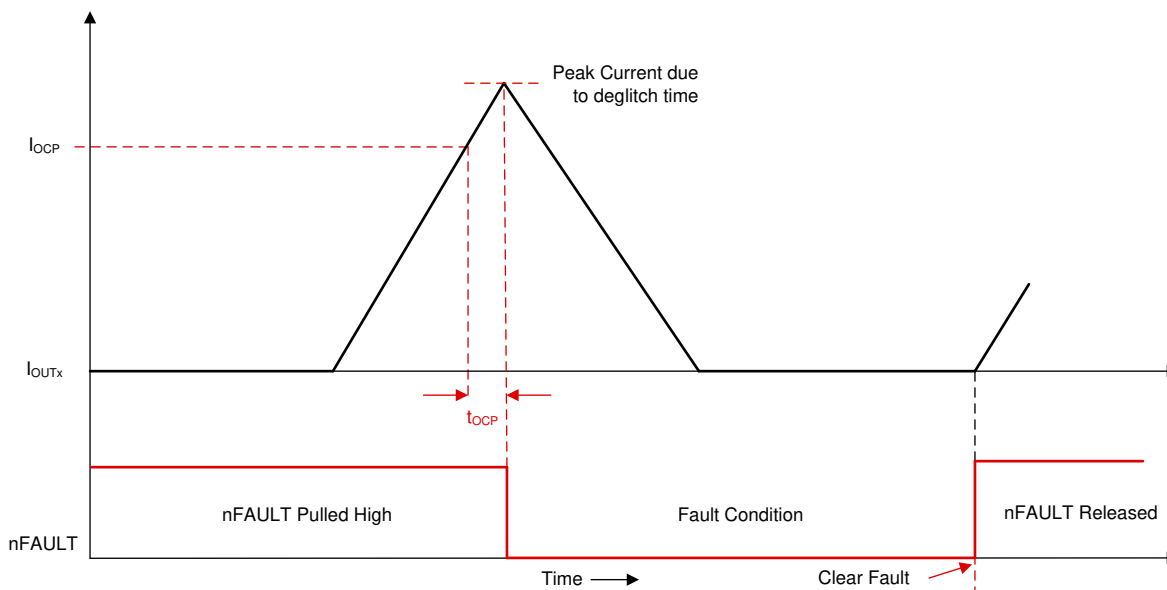
7-50. Over Voltage Protection

### 7.3.21.6 Overcurrent Protection (OCP)

MOSFET overcurrent event is sensed by monitoring the current flowing through the FETs. If the current across a FET exceeds the  $I_{OCP}$  threshold for longer than the deglitch time  $t_{OCP}$ , an OCP event is recognized and action is taken according to OCP\_MODE. The  $I_{OCP}$  threshold is set through the OCP\_LVL,  $t_{OCP}$  is set through OCP\_DEG and the OCP\_MODE can be configured in four different modes: latched shutdown, automatic retry, report only and disabled.

#### 7.3.21.6.1 OCP Latched Shutdown (OCP\_MODE = 00b)

When an OCP event happens in this mode, all MOSFETs are disabled and the nFAULT pin is driven low. The DRIVER\_FAULT, OCP and corresponding FET's OCP bits are set to 1b in the status registers. Normal operation resumes (driver operation and the nFAULT pin is released) when the OCP condition clears and a clear fault command is issued through the CLR\_FLT bit.



7-51. Overcurrent Protection - Latched Shutdown Mode

#### 7.3.21.6.2 OCP Automatic Retry (OCP\_MODE = 01b)

When an OCP event happens in this mode, all the FETs are disabled and the nFAULT pin is driven low. The DRIVER\_FAULT, OCP and corresponding FET's OCP bits are set to 1b in the fault status registers. Normal operation resumes automatically (gate driver operation and the nFAULT pin is released) after the  $t_{RETRY}$  (OCP\_RETRY) time elapses. The DRIVER\_FAULT bit is reset to 0b after the  $t_{RETRY}$  period expires. The OCP and corresponding FET's OCP bits are set to 1b until cleared through the CLR\_FLT bit.

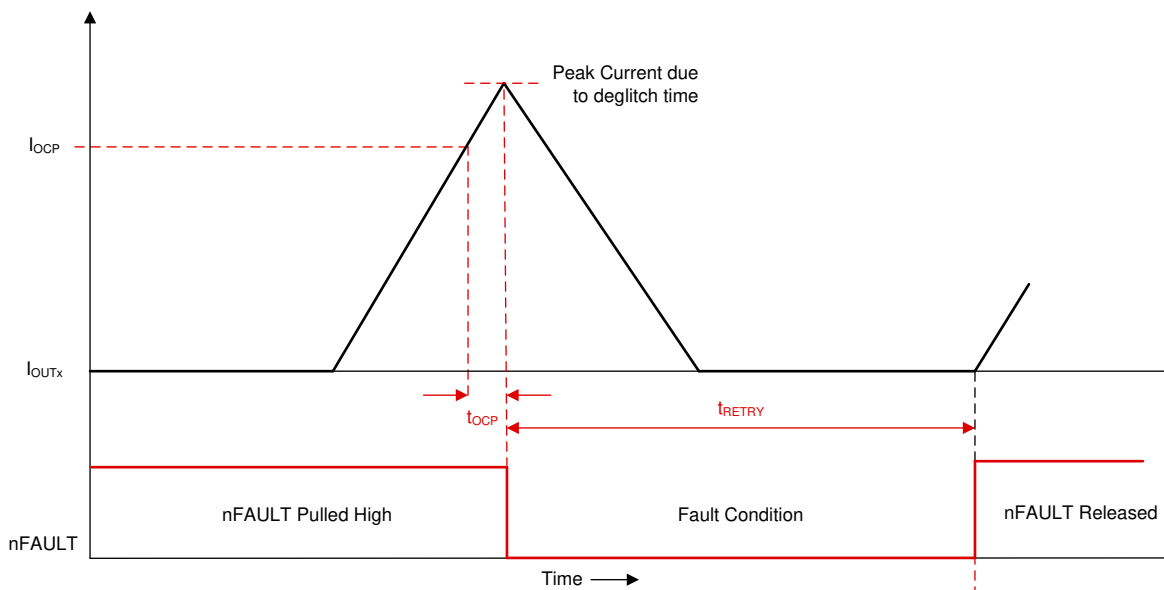


图 7-52. Overcurrent Protection - Automatic Retry Mode

#### 7.3.21.6.3 OCP Report Only (OCP\_MODE = 10b)

No protective action is taken when an OCP event happens in this mode. The overcurrent event is reported by setting the DRIVER\_FAULT, OCP, and corresponding FET's OCP bits to 1b in the fault status registers. The device continues to operate as usual. The external controller manages the overcurrent condition by acting appropriately. The reporting clears when the OCP condition clears and a clear fault command is issued through the CLR\_FLT bit.

#### 7.3.21.6.4 OCP Disabled (OCP\_MODE = 11b)

No action is taken when an OCP event happens in this mode.

### 7.3.21.7 Buck Overcurrent Protection

The buck overcurrent event is sensed by monitoring the current flowing through high-side MOSFET of the buck regulator. If the current through the high-side MOSFET exceeds the  $I_{BK\_OCP}$  threshold for a time longer than the deglitch time ( $t_{OCP}$ ), a buck OCP event is recognized and the buck regulator MOSFETs are disabled (Hi-Z). MCT8315A goes into reset state whenever buck OCP event occurs, since the internal circuitry in MCT8315A is powered from the buck regulator output.

#### 7.3.21.8 Cycle-by-Cycle (CBC) Current Limit (CBC\_ILIMIT)

Cycle-by-cycle (CBC) current limit provides a means of controlling the amount of current delivered to the motor. This is useful when the system must limit the amount of current pulled from the power supply during motor operation. The CBC current limit limits the current applied to the motor from exceeding the configured threshold. CBC current limit functionality is achieved by connecting the output of current sense amplifier  $V_{SOX}$  to a hardware comparator. If the voltage at output of current sense amplifier exceeds the CBC\_ILIMIT threshold, a CBC\_ILIMIT event is recognized and action is taken according to CBC\_ILIMIT\_MODE. Total delay in reaction to this event is dependent on the current sense amplifier gain and the comparator delay. CBC current limit in closed loop is set through CBC\_ILIMIT while configuration of OL\_ILIMIT\_CONFIG sets the CBC current limit in open

loop operation. Different modes can be configured through CBC\_ILIMIT\_MODE: CBC\_ILIMIT automatic recovery next PWM cycle, CBC\_ILIMIT automatic recovery threshold based, CBC\_ILIMIT automatic recovery number of PWM cycles based, CBC\_ILIMIT report only, CBC\_ILIMIT disabled.

#### 7.3.21.8.1 CBC\_ILIMIT Automatic Recovery next PWM Cycle (CBC\_ILIMIT\_MODE = 000xb)

When a CBC\_ILIMIT event happens in this mode, MCT8315A stops driving the FETs using recirculation mode to prevent the inductive energy from entering the DC input supply. The CBC\_ILIMIT bit is set to 1b in the fault status registers. Normal operation resumes at the start of next PWM cycle and CBC\_ILIMIT bit is reset to 0b. The status of CONTROLLER\_FAULT bit and nFAULT pin will be determined by CBC\_ILIMIT\_MODE. When CBC\_ILIMIT\_MODE is 0000b, CONTROLLER\_FAULT bit is set to 1b and nFAULT pin driven low until next PWM cycle. When CBC\_ILIMIT\_MODE is 0001b, CONTROLLER\_FAULT bit is not set to 1b and nFAULT is not driven low.

#### 7.3.21.8.2 CBC\_ILIMIT Automatic Recovery Threshold Based (CBC\_ILIMIT\_MODE = 001xb)

When a CBC\_ILIMIT event happens in this mode, MCT8315A stops driving the FETs using recirculation mode to prevent the inductive energy from entering the DC input supply. The CBC\_ILIMIT bit is set to 1b in the status registers. Normal operation resumes after  $V_{SOX}$  falls below CBC\_ILIMIT threshold and CBC\_ILIMIT bit is set to 0b. The status of CONTROLLER\_FAULT bit and nFAULT pin will be determined by CBC\_ILIMIT\_MODE. When CBC\_ILIMIT\_MODE is 0010b, CONTROLLER\_FAULT bit is set to 1b and nFAULT pin driven low until  $V_{SOX}$  falls below CBC\_ILIMIT threshold. When CBC\_ILIMIT\_MODE is 0011b, CONTROLLER\_FAULT bit is not set to 1b and nFAULT is not driven low.

#### 7.3.21.8.3 CBC\_ILIMIT Automatic Recovery after 'n' PWM Cycles (CBC\_ILIMIT\_MODE = 010xb)

When a CBC\_ILIMIT event happens in this mode, MCT8315A stops driving the FETs using recirculation mode to prevent the inductive energy from entering the DC input supply. The CBC\_ILIMIT bit is set to 1b in the fault status registers. Normal operation resumes after (CBC\_RETRY\_PWM\_CYC + 1) PWM cycles and CBC\_ILIMIT bit is set to 0b. The status of CONTROLLER\_FAULT bit and nFAULT pin will be determined by CBC\_ILIMIT\_MODE. When CBC\_ILIMIT\_MODE is 0100b, CONTROLLER\_FAULT bit is set to 1b and nFAULT pin driven low until (CBC\_RETRY\_PWM\_CYC + 1) PWM cycles lapse. When CBC\_ILIMIT\_MODE is 0101b, CONTROLLER\_FAULT bit is not set to 1b and nFAULT is not driven low.

#### 7.3.21.8.4 CBC\_ILIMIT Report Only (CBC\_ILIMIT\_MODE = 0110b)

No protective action is taken when a CBC\_ILIMIT event happens in this mode. The CBC current limit event is reported by setting the CONTROLLER\_FAULT and CBC\_ILIMIT bits to 1b in the fault status registers. The gate drivers continue to operate. The external controller manages the overcurrent condition by acting appropriately. The reporting clears when the CBC\_ILIMIT condition clears and a clear fault command is issued through the CLR\_FLT bit.

#### 7.3.21.8.5 CBC\_ILIMIT Disabled (CBC\_ILIMIT\_MODE = 0111b or 1xxxb)

No action is taken when a CBC\_ILIMIT event happens in this mode.

### 7.3.21.9 Lock Detection Current Limit (LOCK\_ILIMIT)

The lock detection current limit function provides a configurable threshold for limiting the current to prevent damage to the system. The MCT8315A continuously monitors the output of the current sense amplifier (CSA) through the ADC. If at any time, the voltage on the output of CSA exceeds LOCK\_ILIMIT for a time longer than  $t_{LOCK\_ILIMIT}$ , a LOCK\_ILIMIT event is recognized and action is taken according to LOCK\_ILIMIT\_MODE. The threshold is set through LOCK\_ILIMIT, the  $t_{LOCK\_ILIMIT}$  is set through LOCK\_ILIMIT\_DEG. LOCK\_ILIMIT\_MODE can be set to four different modes: LOCK\_ILIMIT latched shutdown, LOCK\_ILIMIT automatic retry, LOCK\_ILIMIT report only and LOCK\_ILIMIT disabled.

#### 7.3.21.9.1 LOCK\_ILIMIT Latched Shutdown (LOCK\_ILIMIT\_MODE = 00xxb)

When a LOCK\_ILIMIT event happens in this mode, the status of MOSFETs will be configured by LOCK\_ILIMIT\_MODE and nFAULT is driven low. Status of MOSFETs during LOCK\_ILIMIT:

- LOCK\_ILIMIT\_MODE = 0000b: All MOSFETs are turned OFF.

- LOCK\_ILIMIT\_MODE = 0001b: MOSFET which was switching is turned OFF while the one which was conducting stays ON till inductive energy is completely recirculated.
- LOCK\_ILIMIT\_MODE = 0010b: All high-side MOSFETs are turned ON.
- LOCK\_ILIMIT\_MODE = 0011b: All low-side MOSFETs are turned ON.

The CONTROLLER\_FAULT and LOCK\_ILIMIT bits are set to 1b in the fault status registers. Normal operation resumes (gate driver operation and the nFAULT pin is released) when the LOCK\_ILIMIT condition clears and a clear fault command is issued through the CLR\_FLT bit.

#### 7.3.21.9.2 LOCK\_ILIMIT Automatic Recovery (LOCK\_ILIMIT\_MODE = 01xxb)

When a LOCK\_ILIMIT event happens in this mode, the status of MOSFETs will be configured by LOCK\_ILIMIT\_MODE and nFAULT is driven low. Status of MOSFETs during LOCK\_ILIMIT:

- LOCK\_ILIMIT\_MODE = 0100b: All MOSFETs are turned OFF.
- LOCK\_ILIMIT\_MODE = 0101b: MOSFET which was switching is turned OFF while the one which was conducting stays ON till inductive energy is completely recirculated.
- LOCK\_ILIMIT\_MODE = 0110b: All high-side MOSFETs are turned ON
- LOCK\_ILIMIT\_MODE = 0111b: All low-side MOSFETs are turned ON

The CONTROLLER\_FAULT and LOCK\_ILIMIT bits are set to 1b in the fault status registers. Normal operation resumes automatically (gate driver operation and the nFAULT pin is released) after the  $t_{LCK\_RETRY}$  (configured by LCK\_RETRY) time lapses. The CONTROLLER\_FAULT and LOCK\_ILIMIT bits are reset to 0b after the  $t_{LCK\_RETRY}$  period expires.

#### 7.3.21.9.3 LOCK\_ILIMIT Report Only (LOCK\_ILIMIT\_MODE = 1000b)

No protective action is taken when a LOCK\_ILIMIT event happens in this mode. The lock detection current limit event is reported by setting the CONTROLLER\_FAULT and LOCK\_ILIMIT bits to 1b in the fault status registers. The gate drivers continue to operate. The external controller manages this condition by acting appropriately. The reporting clears when the LOCK\_ILIMIT condition clears and a clear fault command is issued through the CLR\_FLT bit.

#### 7.3.21.9.4 LOCK\_ILIMIT Disabled (LOCK\_ILIMIT\_MODE = 1xx1b)

No action is taken when a LOCK\_ILIMIT event happens in this mode.

#### 7.3.21.10 Thermal Warning (OTW)

If the die temperature exceeds the thermal warning limit ( $T_{OTW}$ ), nFAULT is pulled low and the OT and OTW bits in the gate driver status register are set to 1b. The reporting of OTW (on nFAULT and status bits) can be enabled by setting OTW\_REP to 1b. The device performs no additional action and continues to function. In this case, the nFAULT pin is released when the die temperature decreases below the hysteresis point of the thermal warning limit ( $T_{OTW} - T_{OTW\_HYS}$ ). The OTW bit remains set until cleared through the CLR\_FLT bit and the die temperature is lower than thermal warning limit. ( $T_{OTW} - T_{OTW\_HYS}$ ).

#### 7.3.21.11 Thermal Shutdown (TSD)

If the die temperature exceeds the thermal shutdown limit ( $T_{TSD}$ ), all the FETs are disabled, the charge pump is shut down, and the nFAULT pin is driven low. In addition, the DRIVER\_FAULT, OT and TSD bit in the status register are set to 1b. Normal operation resumes (driver operation and the nFAULT pin is released) when the die temperature decreases below the hysteresis point of the thermal shutdown limit ( $T_{TSD} - T_{TSD\_HYS}$ ). The TSD bit stays latched high indicating that a thermal event occurred until a clear fault command is issued through the CLR\_FLT bit. This protection feature cannot be disabled.

#### 7.3.21.12 Motor Lock (MTR\_LCK)

The MCT8315A continuously checks for different motor lock conditions (see [Motor Lock Detection](#)) during motor operation. When one of the enabled lock condition happens, a MTR\_LCK event is recognized and action is taken according to the MTR\_LCK\_MODE.

In MCT8315A, all locks can be enabled or disabled individually and retry times can be configured through LCK\_RETRY. MTR\_LCK\_MODE bit can operate in four different modes: MTR\_LCK latched shutdown, MTR\_LCK automatic retry, MTR\_LCK report only and MTR\_LCK disabled.

#### 7.3.21.12.1 MTR\_LCK Latched Shutdown (MTR\_LCK\_MODE = 00xxb)

When a MTR\_LCK event happens in this mode, the status of MOSFETs will be configured by MTR\_LCK\_MODE and nFAULT is driven low. Status of MOSFETs during MTR\_LCK:

- MTR\_LCK\_MODE = 0000b: All MOSFETs are turned OFF.
- MTR\_LCK\_MODE = 0001b: MOSFET which was switching is turned OFF while the one which was conducting stays ON till inductive energy is completely recirculated.
- MTR\_LCK\_MODE = 0010b: All high-side MOSFETs are turned ON.
- MTR\_LCK\_MODE = 0011b: All low-side MOSFETs are turned ON.

The CONTROLLER\_FAULT, MTR\_LCK and respective motor lock condition bits are set to 1b in the fault status registers. Normal operation resumes (gate driver operation and the nFAULT pin is released) when the MTR\_LCK condition clears and a clear fault command is issued through the CLR\_FLT bit.

#### 7.3.21.12.2 MTR\_LCK Automatic Recovery (MTR\_LCK\_MODE = 01xxb)

When a MTR\_LCK event happens in this mode, the status of MOSFETs will be configured by MTR\_LCK\_MODE and nFAULT is driven low. Status of MOSFETs during MTR\_LCK:

- MTR\_LCK\_MODE = 0100b: All MOSFETs are turned OFF.
- MTR\_LCK\_MODE = 0101b: MOSFET which was switching is turned OFF while the one which was conducting stays ON till inductive energy is completely recirculated.
- MTR\_LCK\_MODE = 0110b: All high-side MOSFETs are turned ON.
- MTR\_LCK\_MODE = 0111b: All low-side MOSFETs are turned ON.

The CONTROLLER\_FAULT, MTR\_LCK and respective motor lock condition bits are set to 1b in the fault status registers. Normal operation resumes automatically (gate driver operation and the nFAULT pin is released) after the t<sub>LCK\_RETRY</sub> (configured by LCK\_RETRY) time lapses. The CONTROLLER\_FAULT, MTR\_LCK and respective motor lock condition bits are reset to 0b after the t<sub>LCK\_RETRY</sub> period expires.

#### 7.3.21.12.3 MTR\_LCK Report Only (MTR\_LCK\_MODE = 1000b)

No protective action is taken when a MTR\_LCK event happens in this mode. The motor lock event is reported by setting the CONTROLLER\_FAULT, MTR\_LCK and respective motor lock condition bits to 1b in the fault status registers. The gate drivers continue to operate. The external controller manages this condition by acting appropriately. The reporting clears when the MTR\_LCK condition clears and a clear fault command is issued through the CLR\_FLT bit.

#### 7.3.21.12.4 MTR\_LCK Disabled (MTR\_LCK\_MODE = 1xx1b)

No action is taken when a MTR\_LCK event happens in this mode.

### 7.3.21.13 Motor Lock Detection

The MCT8315A provides different lock detect mechanisms to determine if the motor is in a locked state. Multiple detection mechanisms work together to ensure the lock condition is detected quickly and reliably. In addition to detecting if there is a locked motor condition, the MCT8315A can also identify and take action if there is no motor connected to the system. Each of the lock detect mechanisms and the no-motor detection can be disabled by their respective register bits (LOCK1/2/3\_EN).

#### 7.3.21.13.1 Lock 1: Abnormal Speed (ABN\_SPEED)

MCT8315A monitors the speed continuously and at any time the speed exceeds LOCK\_ABN\_SPEED, an ABN\_SPEED lock event is recognized and action is taken according to the MTR\_LCK\_MODE. In MCT8315A, the threshold is set through the LOCK\_ABN\_SPEED register. ABN\_SPEED lock can be enabled/disabled by LOCK1\_EN.

### 7.3.21.13.2 Lock 2: Loss of Sync (LOSS\_OF\_SYNC)

The motor is commutated by detecting the zero crossing on the phase which is in Hi-Z state. If the motor is locked, the back-EMF will disappear and MCT8315A will be not able to detect the zero crossing. If MCT8315A is not able to detect zero crossing for LOSS\_SYNC\_TIMES number of times, LOSS\_OF\_SYNC event is recognized and action is taken according to the MTR\_LCK\_MODE. LOSS\_OF\_SYNC lock can be enabled/disabled by LOCK2\_EN.

### 7.3.21.13.3 Lock3: No-Motor Fault (NO\_MTR)

The MCT8315A continuously monitors the relevant phase current (low-side phase in the present phase pattern); if the relevant phase current stays below NO\_MTR\_THR for a time longer than NO\_MTR\_DEG\_TIME, a NO\_MTR event is recognized. The response to the NO\_MTR event is configured through MTR\_LCK\_MODE. NO\_MTR lock can be enabled/disabled by LOCK3\_EN.

### 7.3.21.14 SW VM Undervoltage Protection

MCT8315A provides the option of a software based VM undervoltage protection. The VM level at which the software triggers the undervoltage fault is set by MIN\_VM\_MOTOR and the fault response to VM undervoltage is set by MIN\_VM\_MODE. If MIN\_VM\_MODE is set to 0b, VM undervoltage fault (at MIN\_VM\_MOTOR) is latched and the FETs are in Hi-Z until the fault condition is cleared by writing 1b to CLR\_FIT bit. If MIN\_VM\_MODE is set to 1b, VM undervoltage fault (at MIN\_VM\_MOTOR) automatically clears and the device starts motor operation once VM > MIN\_VM\_MODE.

### 7.3.21.15 SW VM Overvoltage Protection

MCT8315A provides the option of a software based VM overvoltage protection. The VM level at which the software triggers the overvoltage fault is set by MAX\_VM\_MOTOR and the fault response to VM overvoltage is set by MAX\_VM\_MODE. If MAX\_VM\_MODE is set to 0b, VM overvoltage fault (at MAX\_VM\_MOTOR) is latched and the FETs are in Hi-Z until the fault condition is cleared by writing 1b to CLR\_FIT bit. If MAX\_VM\_MODE is set to 1b, VM overvoltage fault (at MAX\_VM\_MOTOR) automatically clears and the device starts motor operation once VM < MAX\_VM\_MODE.

### 7.3.21.16 IPD Faults

The MCT8315A uses 12-bit timers to estimate the time during the current ramp up and ramp down during IPD, when the motor start-up is configured as IPD (MTR\_STARTUP is set to 10b). During IPD, the algorithm checks for a successful current ramp-up to IPD\_CURR\_THR, starting with an IPD clock of 10MHz; if unsuccessful (timer overflow before current reaches IPD\_CURR\_THR), IPD is repeated with lower frequency clocks of 1MHz, 100kHz, and 10kHz sequentially. If the IPD timer overflows (current does not reach IPD\_CURR\_THR) with all the four clock frequencies, then the IPD\_T1\_FAULT gets triggered. Similarly the algorithm checks for a successful current decay to zero during IPD current ramp down using all the mentioned IPD clock frequencies. If the IPD timer overflows (current does not ramp down to zero) in all the four attempts, then the IPD\_T2\_FAULT gets triggered.

IPD gives incorrect results if the next IPD pulse is commanded before the complete decay of current due to present IPD pulse. The MCT8315A can generate a fault called IPD\_FREQ\_FAULT during such a scenario. The IPD\_FREQ\_FAULT maybe triggered if the IPD frequency is too high for the IPD current limit and the IPD release mode or if the motor inductance is too high for the IPD frequency, IPD current limit and IPD release mode.



## 7.4 Device Functional Modes

### 7.4.1 Functional Modes

#### 7.4.1.1 Sleep Mode

In sleep mode, the MOSFETs, sense amplifiers, buck regulator, charge pump, AVDD LDO regulator and the I<sup>2</sup>C bus are disabled. The device can be configured to enter sleep (instead of standby) mode by configuring DEV\_MODE to 1b. SPEED pin and I<sup>2</sup>C speed command determine entry and exit from sleep state as described in 表 7-3.

#### 7.4.1.2 Standby Mode

The device can be configured to operate as a standby device by setting DEV\_MODE to 0b. In standby mode, the charge pump, AVDD LDO, buck regulator and I<sup>2</sup>C bus are active while the motor is in stopped state waiting for a suitable non-zero speed command. SPEED pin (analog, PWM or frequency based speed input) or I<sup>2</sup>C speed command (I<sup>2</sup>C based speed input) determines entry and exit from standby state as described in 表 7-3.

The thresholds for entering and exiting standby mode in different speed input modes are as follows,

1. Analog :  $V_{EN\_SB} = (ZERO\_DUTY\_THR \times V_{ANA\_FS})$ ,  $V_{EX\_SB} = ((ZERO\_DUTY\_THR + ZERO\_DUTY\_HYST) \times V_{ANA\_FS})$
2. PWM :  $Duty_{EN\_SB} = ZERO\_DUTY\_THR$ ,  $Duty_{EX\_SB} = (ZERO\_DUTY\_THR + ZERO\_DUTY\_HYST)$
3. I<sup>2</sup>C :  $SPEED\_CTRL_{EN\_SB} = ZERO\_DUTY\_THR \times 32767$ ,  $SPEED\_CTRL_{EX\_SB} = (ZERO\_DUTY\_THR + ZERO\_DUTY\_HYST) \times 32767$
4. Frequency :  $Freq_{EN\_SB} = ZERO\_DUTY\_THR \times INPUT\_MAX\_FREQUENCY$ ,  $Freq_{EX\_SB} = (ZERO\_DUTY\_THR + ZERO\_DUTY\_HYST) \times INPUT\_MAX\_FREQUENCY$

**表 7-3. Conditions to Enter or Exit Sleep or Standby Modes**

SPEED COMMAND MODE	ENTER STANDBY CONDITION	EXIT FROM STANDBY CONDITION	ENTER SLEEP CONDITION	EXIT FROM SLEEP CONDITION
Analog	$V_{SPEED} < V_{EN\_SB}$	$V_{SPEED} > V_{EX\_SB}$	$V_{SPEED} < V_{EN\_SL}$ for $t_{DET\_SL\_ANA}$	$V_{SPEED} > V_{EX\_SL}$ for $t_{DET\_ANA}$
PWM	$Duty_{SPEED} < Duty_{EN\_SB}$	$Duty_{SPEED} > Duty_{EX\_SB}$	$V_{SPEED} < V_{IL}$ for $t_{DET\_SL\_PWM}$	$V_{SPEED} > V_{IH}$ for $t_{DET\_PWM}$
I <sup>2</sup> C	$SPEED\_CTRL < SPEED\_CTRL_{EN\_SB}$	$SPEED\_CTRL > SPEED\_CTRL_{EX\_SB}$	SPEED_CTRL is set to 0b for SLEEP_TIME and $V_{SPEED} < V_{IL}$	$V_{SPEED} > V_{IH}$ for $t_{DET\_PWM}$
Frequency	$Freq_{SPEED} < Freq_{EN\_SB}$	$Freq_{SPEED} > Freq_{EX\_SB}$	$V_{SPEED} < V_{IL}$ for $t_{DET\_SL\_PWM}$	$V_{SPEED} > V_{IH}$ for $t_{DET\_PWM}$

注

$V_{SPEED}$  : SPEED pin input voltage,  $Duty_{SPEED}$  : SPEED pin input PWM duty,  $Freq_{SPEED}$  : SPEED pin input frequency

#### 7.4.1.3 Fault Reset (CLR\_FLT)

In the case of latched faults, the device goes into a partial shutdown state to help protect the power MOSFETs and system. When the fault condition clears, the device can go to the operating state again by setting the CLR\_FLT to 1b.

## 7.5 External Interface

### 7.5.1 DRVOFF Functionality

When DRVOFF pin is driven high, all six MOSFETs are put in Hi-Z state, irrespective of speed command. If motor speed command is non-zero when DRVOFF is driven high, device may encounter a fault like no motor or abnormal BEMF.

### 7.5.2 DAC outputs

MCT8315A has two 12-bit DACs which output analog voltage equivalent of digital variables on the DACOUT1 and DACOUT2 pins. The maximum DAC output voltage is 3-V. Signals available on DACOUT pins are useful in

tracking internal variables in real-time and can be used for tuning speed controller or motor acceleration time. The address for variables to be tracked on DACOUT1 and DACOUT2 are configured using DACOUT1\_VAR\_ADDR and DACOUT2\_VAR\_ADDR respectively. DACOUT1 is available on pin 38 and DACOUT2 can be configured on pin 36 by setting DAC\_SOX\_CONFIG to 00b. DACOUT2 is also available on pin 37. DAC\_CONFIG should be configured to 1b for pins 37, 38 to function as DAC outputs.

### 7.5.3 Current Sense Output

MCT8315A can provide the built-in current sense amplifiers' output on the SOX pin. SOX output is available on pin 36 and can be configured by DAC\_SOX\_CONFIG.

### 7.5.4 Oscillator Source

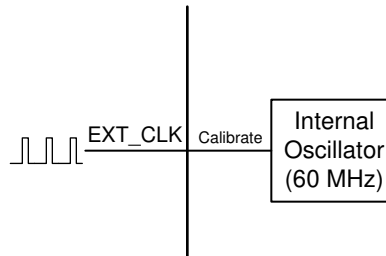
MCT8315A has a built-in oscillator that is used as the clock source for all digital peripherals and timing measurements. Default configuration for MCT8315A is to use the internal oscillator and it is sufficient to drive the motor without need for any external crystal or clock sources.

In case MCT8315A does not meet accuracy requirements of timing measurement or speed loop, then MCT8315A has an option to support an external clock reference.

In order to improve EMI performance, MCT8315A provides the option of modulating the clock frequency by enabling Spread Spectrum Modulation (SSM) through SSM\_CONFIG.

#### 7.5.4.1 External Clock Source

Speed loop accuracy of MCT8315A over the operating temperature range can be improved by providing a more accurate clock reference on EXT\_CLK pin as shown in [Figure 7-53](#). EXT\_CLK will be used to calibrate the internal clock oscillator - this will help match the accuracy of the internal clock oscillator to that of the external clock. External clock source can be selected by configuring CLK\_SEL to 11b and setting EXT\_CLK\_EN to 1b. The external clock source frequency can be configured through EXT\_CLK\_CONFIG.



**Figure 7-53. External Clock Reference**

注

External clock is optional and can be used when higher clock accuracy is needed. MCT8315A will always power up using the internal oscillator in all modes.

### 7.5.5 External Watchdog

MCT8315A provides an external watchdog feature - EXT\_WD\_EN bit should be set to 1b to enable the external watchdog. When this feature is enabled, the device waits for a tickle (low to high transition in EXT\_WD pin, EXT\_WD\_STATUS\_SET set to 1b in I<sup>2</sup>C mode) from the external watchdog input for a configured time interval; if the time interval between two consecutive tickles is higher than the configured time, a watchdog fault is triggered. This fault can be configured using EXT\_WD\_FAULT either as a report only fault or as a latched fault with outputs in Hi-Z state. The latched fault can be cleared by writing 1b to CLR\_FLT. When a watchdog timeout occurs, EXT\_WD\_TIMEOUT bit is set to 1b. In case, the next tickle arrives before the configured time interval elapses, the watchdog timer is reset and it begins to wait for the next tickle. This can be used to continuously monitor the health of an external MCU (which is the external watchdog input) and put the MCT8315A outputs in Hi-Z in case the external MCU is in an erroneous state.



The external watchdog input is selected using EXT\_WD\_INPUT and can either be the EXT\_WD pin or the I<sup>2</sup>C interface. The time interval between two tickles to trigger a watchdog fault is configured by EXT\_WD\_FREQ; there are 4 time (frequency) settings - 100ms (10Hz), 200ms (5Hz), 500ms (2Hz) and 1000ms (1Hz).

---

注

Watchdog should be disabled by setting EXT\_WD\_EN to 0b before changing EXT\_WD\_FREQ configuration.

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## 7.6 EEPROM access and I<sup>2</sup>C interface

### 7.6.1 EEPROM Access

MCT8315A has 1024 bits (16 rows of 64 bits each) of EEPROM, which are used to store the motor configuration parameters. Erase operations are row-wise (all 64 bits are erased in a single erase operation), but 32-bit write and read operations are supported. EEPROM can be written and read using the I<sup>2</sup>C serial interface but erase cannot be performed using I<sup>2</sup>C serial interface. The shadow registers corresponding to the EEPROM are located at addresses 0x000080-0x0000AE.

注

MCT8315A allows EEPROM write and read operations only when the motor is not spinning.

#### 7.6.1.1 EEPROM Write

In MCT8315A, EEPROM write procedure is as follows,

1. Write register 0x000080 (ISD\_CONFIG) with ISD configuration like resync enable, reverse drive enable, stationary detect threshold etc.,
2. Write register 0x000082 (MOTOR\_STARTUP1) with motor start-up configuration like start-up method, first cycle frequency, IPD parameters, align parameters etc.,
3. Write register 0x000084 (MOTOR\_STARTUP2) with motor start-up configuration like open loop acceleration, minimum duty cycle etc.,
4. Write register 0x000086 (CLOSED\_LOOP1) with motor control configuration like closed loop acceleration, PWM frequency, PWM modulation etc.,
5. Write register 0x000088 (CLOSED\_LOOP2) with motor control configuration like FG signal parameters, motor stop options etc.,
6. Write register 0x00008A (CLOSED\_LOOP3) with motor control configuration like fast start-up and dynamic degauss parameters including BEMF thresholds, duty cycle thresholds etc.,
7. Write register 0x00008C (CLOSED\_LOOP4) with motor control configuration like fast deceleration parameters including fast deceleration duty threshold, window, current limits etc.,
8. Write register 0x00008E (CONST\_SPEED) with motor control configuration like speed loop parameters including closed loop mode, saturation limits,  $K_p$ ,  $K_i$  etc.,
9. Write register 0x000090 (CONST\_PWR) with motor control configuration like input power regulation parameters including maximum power, constant power mode, power level hysteresis, maximum speed etc.,
10. Write register 0x000092 (FAULT\_CONFIG1) with fault control configuration like CBC, lock current limits and actions, retry times etc.,
11. Write register 0x000094 (FAULT\_CONFIG2) with fault control configuration like OV, UV limits and actions, abnormal speed level, motor lock setting etc.,
12. Write registers 0x000096 and 0x000098 (150\_DEG\_TWO\_PH\_PROFILE, 150\_DEG\_THREE\_PH\_PROFILE) with PWM duty cycle configurations for 150° modulation.
13. Write registers 0x00009A and 0x00009C (TRAP\_CONFIG1 and TRAP\_CONFIG2) with algorithm parameters like ISD BEMF threshold, blanking time, AVS current limits etc.,
14. Write registers 0x0000A4 and 0x0000A6 (PIN\_CONFIG1 and PIN\_CONFIG2) with pin configuration for DIR, BRAKE, DACOUT1 and DACOUT2, SOX, external watchdog etc.,
15. Write register 0x0000A8 (DEVICE\_CONFIG) with device configuration like device mode, external clock enable, clock source, speed input PWM frequency range etc.,
16. Write registers 0x0000AC and 0x0000AE (GD\_CONFIG1 and GD\_CONFIG2) with gate driver configuration like slew rate, CSA gain, OCP level, mode, OVP enable etc.,
17. Write 0x8A500000 into register 0x0000E6 to write the shadow register (0x000080-0x0000AE) values into the EEPROM.
18. Wait for 300ms for the EEPROM write operation to complete.

Steps 1-16 can be selectively executed based on registers/parameters that need to be modified. After all shadow registers have been updated with the required values, step 17 should be executed to copy the contents of the shadow registers into the EEPROM.

### 7.6.1.2 EEPROM Read

In MCT8315A, EEPROM read procedure is as follows,

1. Write 0x40000000 into register 0x0000E6 to read the EEPROM data into the shadow registers (0x000080-0x0000AE).
2. Wait for 100ms for the EEPROM read operation to complete.
3. Read the shadow register values, 1 or 2 registers at a time, using the I<sup>2</sup>C read command as explained in [セクション 7.6.2](#). Shadow register addresses are in the range of 0x000080-0x0000AE. Register address increases in steps of 2 for 32-bit read operation (since each address is a 16-bit location).

### 7.6.2 I<sup>2</sup>C Serial Interface

MCT8315A interfaces with an external MCU over an I<sup>2</sup>C serial interface. MCT8315A is an I<sup>2</sup>C target to be interfaced with a controller. External MCU can use this interface to read/write from/to any non-reserved register in MCT8315A

注

For reliable communication, a 100-μs delay should be used between every byte transferred over the I<sup>2</sup>C bus.

#### 7.6.2.1 I<sup>2</sup>C Data Word

The I<sup>2</sup>C data word format is shown in [表 7-4](#).

**表 7-4. I<sup>2</sup>C Data Word Format**

TARGET_ID	R/W	CONTROL WORD	DATA	CRC-8
A6 - A0	W0	CW23 - CW0	D15 / D31/ D63 - D0	C7 - C0

**Target ID and R/W Bit:** The first byte includes the 7-bit I<sup>2</sup>C target ID (default 0x00, but can be modified by setting I2C\_TARGET\_ADDR), followed by the read/write command bit. Every packet in MCT8315A the communication protocol starts with writing a 24-bit control word and hence the R/W bit is always 0.

**24-bit Control Word:** The Target Address is followed by a 24-bit control bit. The control word format is shown in [表 7-5](#).

**表 7-5. 24-bit Control Word Format**

OP_R/W	CRC_EN	DLEN	MEM_SEC	MEM_PAGE	MEM_ADDR
CW23	CW22	CW21- CW20	CW19 - CW16	CW15 - CW12	CW11 - CW0

Each field in the control word is explained in detail below.

**OP\_R/W – Read/Write:** R/W bit gives information on whether this is a read (1b) operation or write (0b) operation. For write operation, MCT8315A will expect data bytes to be sent after the 24-bit control word. For read operation, MCT8315A will expect an I<sup>2</sup>C read request with repeated start or normal start after the 24-bit control word.

**CRC\_EN – Cyclic Redundancy Check(CRC) Enable:** MCT8315A supports CRC to verify the data integrity. This bit controls whether the CRC feature is enabled or not.

**DLEN – Data Length:** DLEN field determines the length of the data that will be sent by external MCU to MCT8315A. MCT8315A protocol supports three data lengths: 16-bit, 32-bit and 64-bit.

**表 7-6. Data Length Configuration**

DLEN Value	Data Length
00b	16-bit
01b	32-bit
10b	64-bit

**表 7-6. Data Length Configuration (continued)**

DLEN Value	Data Length
11b	Reserved

**MEM\_SEC – Memory Section:** Each memory location in MCT8315A is addressed using three separate entities in the control word – Memory Section, Memory Page, Memory Address. Memory Section is a 4-bit field which denotes the memory section to which the memory location belongs like RAM, ROM etc.

**MEM\_PAGE – Memory Page:** Memory page is a 4-bit field which denotes the memory page to which the memory location belongs.

**MEM\_ADDR – Memory Address:** Memory address is the last 12-bits of the address. The complete 22-bit address is constructed internally by MCT8315A using all three fields – Memory Section, Memory Page, Memory Address. For memory locations 0x000000-0x000800, memory section is 0x0, memory page is 0x0 and memory address is the lowest 12 bits (0x000 for 0x000000, 0x080 for 0x000080 and 0x800 for 0x000800). All relevant memory locations (EEPROM and RAM variables) have MEM\_SEC and MEM\_PAGE values both corresponding to 0x0. All other MEM\_SEC, MEM\_PAGE values are reserved and not for external use.

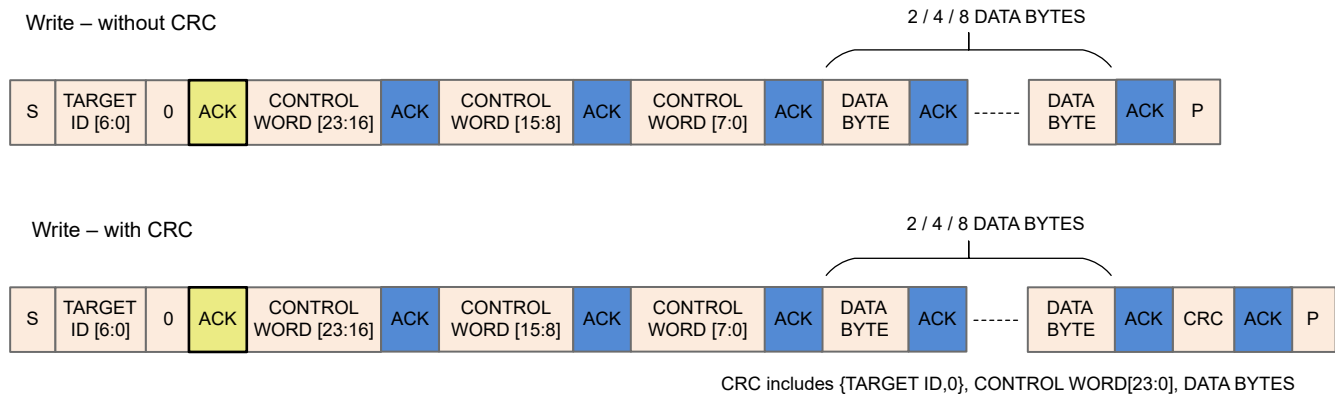
**Data Bytes:** For a write operation to MCT8315A, the 24-bit control word is followed by data bytes. The DLEN field in the control word should correspond with the number of bytes sent in this section. In case of mismatch between number of data bytes and DLEN, the write operation is discarded.

**CRC Byte:** If the CRC feature is enabled in the control word, CRC byte has to be sent at the end of a write transaction. Refer to [セクション 7.6.2.6](#) for detailed information on CRC byte calculation.

#### 7.6.2.2 I<sup>2</sup>C Write Transaction

MCT8315A write transaction over I<sup>2</sup>C involves the following sequence (see [図 7-54](#)).

1. I<sup>2</sup>C start condition.
2. Start is followed by the I<sup>2</sup>C target ID byte, made up of 7-bit target ID along with the R/W bit set to 0b. ACK in yellow box indicates that MCT8315A has processed the received target ID which has matched with its I<sup>2</sup>C target ID and therefore will proceed with this transaction. If target ID received does not match with the I<sup>2</sup>C ID of MCT8315A, then the transaction is ignored. and no ACK is sent by MCT8315A.
3. The target ID byte is followed by the 24-bit control word sent one byte at a time. Bit 23 in the control word is 0b as it is a write transaction. ACK in blue boxes correspond to acknowledgements sent by MCT8315A to the controller that the previous byte (of control word) has been received and next byte can be sent.
4. The 24-bit control word is then followed by the data bytes. The number of data bytes sent by the controller depends on the DLEN field in the control word.
  - a. While sending data bytes, the LSB byte is sent first. Refer to [セクション 7.6.2.4](#) for more details.
  - b. 16-bit/32-bit write – The data sent is written to the address mentioned in control word.
  - c. 64-bit Write – 64-bit is treated as two successive 32-bit writes. The address mentioned in control word is taken as Addr\_1. Addr\_2 is internally calculated by MCT8315A by incrementing Addr\_1 by 0x2. A total of 8 data bytes are sent. The first 4 bytes (sent in LSB first) are written to Addr\_1 and the next 4 bytes are written to Addr\_2.
  - d. ACK in blue boxes (after every data byte) correspond to the acknowledgement sent by MCT8315A to the controller that the previous data byte has been received and next data byte can be sent.
5. If CRC is enabled, the packet ends with a CRC byte. CRC is calculated for the entire packet (Target ID + W bit, Control Word, Data Bytes). MCT8315A will send an ACK on receiving the CRC byte.
6. I<sup>2</sup>C Stop condition from the controller to terminate the transaction.

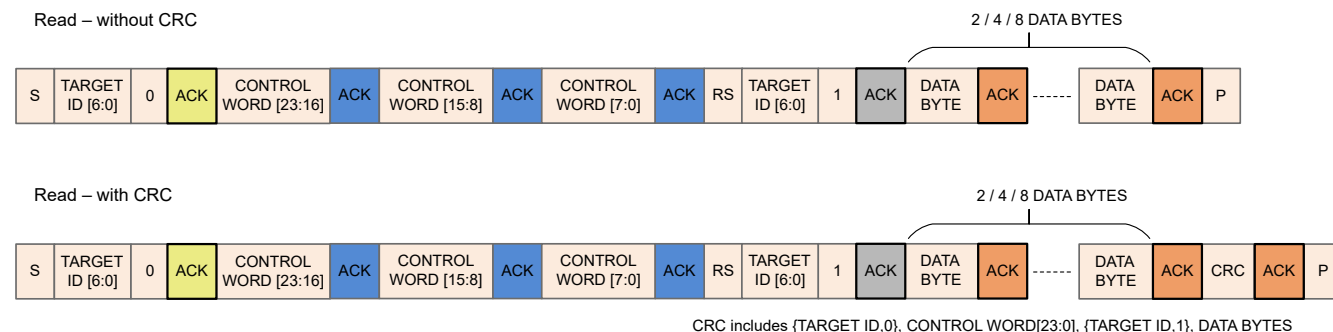


**7-54. I<sup>2</sup>C Write Transaction Sequence**

### 7.6.2.3 I<sup>2</sup>C Read Transaction

MCT8315A read transaction over I<sup>2</sup>C involves the following sequence (see 7-55).

1. I<sup>2</sup>C Start condition from the controller to initiate the transaction.
2. Start is followed by the I<sup>2</sup>C target ID byte, made up of 7-bit target ID along with the R/W bit set to 0b. ACK (in yellow box) indicates that MCT8315A has processed the received target ID which has matched with its I<sup>2</sup>C target ID and therefore will proceed with this transaction. If target ID received does not match with the I<sup>2</sup>C ID of MCT8315A, then the transaction is ignored and no ACK is sent by MCT8315A.
3. The target ID byte is followed by the 24-bit control word sent one byte at a time. Bit 23 in the control word is set to 1b as it is a read transaction. ACK (in blue boxes) correspond to acknowledgements sent by MCT8315A to the controller that the previous byte (of control word) has been received and next byte can be sent.
4. The control word is followed by a Repeated Start (RS, start without a preceding stop) or normal Start (P followed by S) to initiate the data (to be read back) transfer from MCT8315A to I<sup>2</sup>C controller. RS or S is followed by the 7-bit target ID along with R/W bit set to 1b to initiate the read transaction. MCT8315A sends an ACK (in grey box after RS) to the controller to acknowledge the receipt of read transaction request.
5. Post acknowledgement of read transaction request, MCT8315A sends the data bytes on SDA one byte at a time. The number of data bytes sent by MCT8315A depends on the DLEN field in the control word.
  - a. While sending data bytes, the LSB byte is sent first. Refer the examples in セクション 7.6.2.4 for more details.
  - b. 16-bit/32-bit Read – The data from the address mentioned in control word is sent back to the controller.
  - c. 64-bit Read – 64-bit is treated as two successive 32-bit reads. The address mentioned in control word is taken as Addr\_1. Addr\_2 is internally calculated by MCT8315A by incrementing Addr\_1 by 0x2. A total of 8 data bytes are sent by MCT8315A. The first 4 bytes (sent in LSB first) are read from Addr\_1 and the next 4 bytes are read from Addr\_2.
  - d. ACK in orange boxes correspond to acknowledgements sent by the controller to MCT8315A that the previous byte has been received and next byte can be sent.
6. If CRC is enabled in the control word, then MCT8315A sends an additional CRC byte at the end. Controller has to read the CRC byte and then send the last ACK (in orange). CRC is calculated for the entire packet (Target ID + W bit, Control Word, Target ID + R bit, Data Bytes).
7. I<sup>2</sup>C Stop condition from the controller to terminate the transaction.



**图 7-55. I<sup>2</sup>C Read Transaction Sequence**

### 7.6.2.4 I<sup>2</sup>C Communication Protocol Packet Examples

All values used in this example section are in hex format. I<sup>2</sup>C target ID used in the examples is 0x60.

**Example for 32-bit Write Operation:** Address – 0x00000080, Data – 0x1234ABCD, CRC Byte – 0x45 (Sample value; does not match with the actual CRC calculation)

**表 7-7. Example for 32-bit Write Operation Packet**

Start Byte		Control Word 0				Control Word 1		Control Word 2	Data Bytes				CRC
Target ID	I <sup>2</sup> C Write	OP_R/W	CRC_EN	DLEN	MEM_SEC	MEM_PAGE	MEM_ADDR	MEM_ADDR	DB0	DB1	DB2	DB3	CRC Byte
A6-A0	W0	CW23	CW22	CW21-CW20	CW19-CW16	CW15-CW12	CW11-CW8	CW7-CW0	D7-D0	D7-D0	D7-D0	D7-D0	C7-C0
0x60	0x0	0x0	0x1	0x1	0x0	0x0	0x0	0x80	0xCD	0xAB	0x34	0x12	0x45
0xC0		0x50				0x00		0x80	0xCD	0xAB	0x34	0x12	0x45

**Example for 64-bit Write Operation:** Address - 0x00000080, Data Address 0x00000080 - Data 0x01234567, Data Address 0x00000082 – Data 0x89ABCDEF, CRC Byte – 0x45 (Sample value; does not match with the actual CRC calculation)

**表 7-8. Example for 64-bit Write Operation Packet**

Start Byte		Control Word 0				Control Word 1		Control Word 2	Data Bytes				CRC
Target ID	I <sup>2</sup> C Write	OP_R/W	CRC_EN	DLEN	MEM_SEC	MEM_PAGE	MEM_ADDR	MEM_ADDR	DB0 - DB7				CRC Byte
A6-A0	W0	CW23	CW22	CW21-CW20	CW19-CW16	CW15-CW12	CW11-CW8	CW7-CW0	[D7-D0] x 8				C7-C0
0x60	0x0	0x0	0x1	0x2	0x0	0x0	0x0	0x80	0x67452301EFCDA89				0x45
0xC0		0x60				0x00		0x80	0x67452301EFCDA89				0x45

**Example for 32-bit Read Operation:** Address – 0x00000080, Data – 0x1234ABCD, CRC Byte – 0x56 (Sample value; does not match with the actual CRC calculation)

**表 7-9. Example for 32-bit Read Operation Packet**

Start Byte		Control Word 0				Control Word 1		Control Word 2	Start Byte		Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
Target ID	I <sup>2</sup> C Write	R/W	CRC_EN	DLEN	MEM_SEC	MEM_PAGE	MEM_ADDR	MEM_ADDR	Target ID	I <sup>2</sup> C Read	DB0	DB1	DB2	DB3	CRC Byte
A6-A0	W0	CW23	CW22	CW21-CW20	CW19-CW16	CW15-CW12	CW11-CW8	CW7-CW0	A6-A0	W0	D7-D0	D7-D0	D7-D0	D7-D0	C7-C0
0x60	0x0	0x1	0x1	0x1	0x0	0x0	0x0	0x80	0x60	0x1	0xCD	0xAB	0x34	0x12	0x56

**表 7-9. Example for 32-bit Read Operation Packet (continued)**

0xC0	0xD0	0x00	0x80	0xC1	0xCD	0xAB	0x34	0x12	0x56
------	------	------	------	------	------	------	------	------	------

#### 7.6.2.5 I<sup>2</sup>C Clock Stretching

The I<sup>2</sup>C peripheral in MCT8315A implements clock stretching under certain conditions when there are pending I<sup>2</sup>C interrupts waiting to be processed. During clock stretching, MCT8315A pulls SCL low and the I<sup>2</sup>C bus is unavailable for use by other devices. The following is a list of conditions under which clock stretching can occur:

- Start interrupt pending:** There are two scenarios when a start interrupt can result in clock stretching,
  - When target ID is a match, I<sup>2</sup>C peripheral in MCT8315A raises a start interrupt request. Until this start interrupt request is processed, clock is stretched. Upon processing this request, clock is released and an ACK (marked in yellow or grey in [図 7-54](#) and [図 7-55](#)) is sent to the controller for continuing with the transaction.
  - If Start (followed by target ID match) for a new transaction is received when a receive interrupt from previous transaction is yet to be processed, clock is stretched until both the receive interrupt and start interrupt are processed in chronological order. This process ensures that previous transaction is executed correctly before initiating the next transaction.
- Receive interrupt pending:** When a receive interrupt is waiting to be processed and the receive register is full which occurs when two successive bytes (data or control) have been received by MCT8315A (separated by one ACK shown as blue boxes in [図 7-54](#) and [図 7-55](#)) without the receive interrupt generated by the first byte being processed. Upon receive of second byte, clock is stretched until receive interrupt generated by the first byte is processed.
- Transmit buffer is empty:** In case of a transmit interrupt pending (to send data back to controller), if the transmit buffer is waiting to be populated with data to be read back to the controller, clock stretching is done until the transmit buffer is populated with requested data. After the buffer is populated, clock is released and data is sent to controller.

#### 注

I<sup>2</sup>C clock stretching is timed out after 5 ms by MCT8315A to allow I<sup>2</sup>C bus access for other devices on the same bus.

#### 7.6.2.6 CRC Byte Calculation

An 8-bit CCIT polynomial ( $x^8 + x^2 + x + 1$ ) and CRC initial value 0xFF is used for CRC computation.

**CRC Calculation in Write Operation:** When the external MCU writes to MCT8315A, if the CRC is enabled, the external MCU has to compute an 8-bit CRC byte and add the CRC byte at the end of the data. MCT8315A will compute CRC using the same polynomial internally and if there is a mismatch, the write request is discarded. Input data for CRC calculation by external MCU for write operation are listed below:

- Target ID + write bit.
- Control word – 3 bytes
- Data bytes – 2/4/8 bytes

**CRC Calculation in Read Operation:** When the external MCU reads from MCT8315A, if the CRC is enabled, MCT8315A sends the CRC byte at the end of the data. The CRC computation in read operation involves the start byte, control words sent by external MCU along with data bytes sent by MCT8315A. Input data for CRC calculation by external MCU to verify the data sent by MCT8315A are listed below :

- Target ID + write bit
- Control word – 3 bytes
- Target ID + read bit
- Data bytes – 2/4/8 bytes



## 7.7 EEPROM (Non-Volatile) Register Map

### 7.7.1 Algorithm\_Configuration Registers

表 7-10 lists the memory-mapped registers for the Algorithm\_Configuration registers. All register offset addresses not listed in 表 7-10 should be considered as reserved locations and the register contents should not be modified.

**表 7-10. ALGORITHM\_CONFIGURATION Registers**

Offset	Acronym	Register Name	Section
80h	ISD_CONFIG	ISD configuration	ISD_CONFIG Register (Offset = 80h) [Reset = 00000000h]
82h	MOTOR_STARTUP1	Motor start-up configuration 1	MOTOR_STARTUP1 Register (Offset = 82h) [Reset = 00000000h]
84h	MOTOR_STARTUP2	Motor start-up configuration 2	MOTOR_STARTUP2 Register (Offset = 84h) [Reset = X]
86h	CLOSED_LOOP1	Closed loop configuration 1	CLOSED_LOOP1 Register (Offset = 86h) [Reset = 00000000h]
88h	CLOSED_LOOP2	Closed loop configuration 2	CLOSED_LOOP2 Register (Offset = 88h) [Reset = 00000000h]
8Ah	CLOSED_LOOP3	Closed loop configuration 3	CLOSED_LOOP3 Register (Offset = 8Ah) [Reset = 14000000h]
8Ch	CLOSED_LOOP4	Closed loop configuration 4	CLOSED_LOOP4 Register (Offset = 8Ch) [Reset = 00000000h]
8Eh	CONST_SPEED	Constant speed configuration	CONST_SPEED Register (Offset = 8Eh) [Reset = 00000000h]
90h	CONST_PWR	Constant power configuration	CONST_PWR Register (Offset = 90h) [Reset = 00000000h]
96h	150_DEG_TWO_PH_PROFILE	150° Two-ph profile	150_DEG_TWO_PH_PROFILE Register (Offset = 96h) [Reset = 00000000h]
98h	150_DEG_THREE_PH_PROFILE	150° Three-ph profile	150_DEG_THREE_PH_PROFILE Register (Offset = 98h) [Reset = 00000000h]
9Ah	TRAP_CONFIG1	Trap configuration 1	TRAP_CONFIG1 Register (Offset = 9Ah) [Reset = 00000000h]
9Ch	TRAP_CONFIG2	Trap configuration 2	TRAP_CONFIG2 Register (Offset = 9Ch) [Reset = 00200000h]

Complex bit access types are encoded to fit into small table cells. 表 7-11 shows the codes that are used for access types in this section.

**表 7-11. Algorithm\_Configuration Access Type Codes**

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



### 7.7.1.1 ISD\_CONFIG Register (Offset = 80h) [Reset = 00000000h]

ISD\_CONFIG is shown in [図 7-56](#) and described in [表 7-12](#).

Return to the [Summary Table](#).

Register to configure initial speed detect settings

**図 7-56. ISD\_CONFIG Register**

31	30	29	28	27	26	25	24
PARITY	ISD_EN	BRAKE_EN	HIZ_EN	RVS_DR_EN	RESYNC_EN	STAT_BRK_EN	STAT_DETECT_THR
R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h
23	22	21	20	19	18	17	16
STAT_DETECT_THR	BRK_MODE	RESERVED	RESERVED	RESERVED	RESERVED	BRK_TIME	
R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h
15	14	13	12	11	10	9	8
BRK_TIME				HIZ_TIME			STARTUP_BRK_TIME
R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h
7	6	5	4	3	2	1	0
STARTUP_BRK_TIME	RESYNC_MIN_THRESHOLD	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED	RESERVED
R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h

**表 7-12. ISD\_CONFIG Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30	ISD_EN	R/W	0h	ISD enable 0h = Disable 1h = Enable
29	BRAKE_EN	R/W	0h	Brake enable 0h = Disable 1h = Enable
28	HIZ_EN	R/W	0h	Hi-Z enable 0h = Disable 1h = Enable
27	RVS_DR_EN	R/W	0h	Reverse drive enable 0h = Disable 1h = Enable
26	RESYNC_EN	R/W	0h	Resynchronization enable 0h = Disable 1h = Enable
25	STAT_BRK_EN	R/W	0h	Enable or disable brake during stationary 0h = Disable 1h = Enable
24-22	STAT_DETECT_THR	R/W	0h	Stationary BEMF detect threshold 0h = 5 mV 1h = 10 mV 2h = 15 mV 3h = 20 mV 4h = 25 mV 5h = 30 mV 6h = 50 mV 7h = 100 mV

表 7-12. ISD\_CONFIG Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
21	BRK_MODE	R/W	0h	Brake mode 0h = All three low-side FETs turned ON 1h = All three high-side FETs turned ON
20	RESERVED	R/W	0h	Reserved
19-17	RESERVED	R/W	0h	Reserved
16-13	BRK_TIME	R/W	0h	Brake time 0h = 10 ms 1h = 50 ms 2h = 100 ms 3h = 200 ms 4h = 300 ms 5h = 400 ms 6h = 500 ms 7h = 750 ms 8h = 1 s 9h = 2 s Ah = 3 s Bh = 4 s Ch = 5 s Dh = 7.5 s Eh = 10 s Fh = 15 s
12-9	HIZ_TIME	R/W	0h	Hi-Z time 0h = 10 ms 1h = 50 ms 2h = 100 ms 3h = 200 ms 4h = 300 ms 5h = 400 ms 6h = 500 ms 7h = 750 ms 8h = 1 s 9h = 2 s Ah = 3 s Bh = 4 s Ch = 5 s Dh = 7.5 s Eh = 10 s Fh = 15 s
8-6	STARTUP_BRK_TIME	R/W	0h	Brake time when motor is stationary 0h = 1 ms 1h = 10 ms 2h = 25 ms 3h = 50 ms 4h = 100 ms 5h = 250 ms 6h = 500 ms 7h = 1000 ms
5-3	RESYNC_MIN_THRESH OLD	R/W	0h	Minimum phase BEMF below which the motor is coasted instead of resync 0h = computed based on MIN_DUTY 1h = 300 mV 2h = 400 mV 3h = 500 mV 4h = 600 mV 5h = 800 mV 6h = 1000 mV 7h = 1250 mV
2-0	RESERVED	R/W	0h	Reserved

### 7.7.1.2 MOTOR\_STARTUP1 Register (Offset = 82h) [Reset = 00000000h]

MOTOR\_STARTUP1 is shown in [図 7-57](#) and described in [表 7-13](#).

Return to the [Summary Table](#).

Register to configure motor startup settings<sup>1</sup>

**図 7-57. MOTOR\_STARTUP1 Register**

31	30	29	28	27	26	25	24
PARITY	MTR_STARTUP		ALIGN_RAMP_RATE			ALIGN_TIME	
R/W-0h	R/W-0h		R/W-0h			R/W-0h	
23	22	21	20	19	18	17	16
ALIGN_TIME			ALIGN_CURR_THR			IPD_CLK_FREQ	
R/W-0h			R/W-0h			R/W-0h	
15	14	13	12	11	10	9	8
IPD_CLK_FREQ		IPD_CURR_THR			IPD_RLS_MODE		
R/W-0h		R/W-0h			R/W-0h		
7	6	5	4	3	2	1	0
IPD_ADV_ANGLE		IPD_REPEAT		SLOW_FIRST_CYC_FREQ			
R/W-0h		R/W-0h		R/W-0h			

**表 7-13. MOTOR\_STARTUP1 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-29	MTR_STARTUP	R/W	0h	Motor start-up method 0h = Align 1h = Double Align 2h = IPD 3h = Slow first cycle
28-25	ALIGN_RAMP_RATE	R/W	0h	Align voltage ramp rate 0h = 0.1 V/s 1h = 0.2 V/s 2h = 0.5 V/s 3h = 1 V/s 4h = 2.5 V/s 5h = 5 V/s 6h = 7.5 V/s 7h = 10 V/s 8h = 25 V/s 9h = 50 V/s Ah = 75 V/s Bh = 100 V/s Ch = 250 V/s Dh = 500 V/s Eh = 750 V/s Fh = 1000 V/s

表 7-13. MOTOR\_STARTUP1 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
24-21	ALIGN_TIME	R/W	0h	Align time 0h = 5 ms 1h = 10 ms 2h = 25 ms 3h = 50 ms 4h = 75 ms 5h = 100 ms 6h = 200 ms 7h = 400 ms 8h = 600 ms 9h = 800 ms Ah = 1 s Bh = 2 s Ch = 4 s Dh = 6 s Eh = 8 s Fh = 10 s
20-17	ALIGN_CURR_THR	R/W	0h	Align current threshold (Align current threshold (A) = ALIGN_CURR_THR / CSA_GAIN) 0h = Reserved 1h = 0.1V 2h = 0.2 V 3h = 0.3 V 4h = 0.4 V 5h = 0.5 V 6h = 0.6 V 7h = 0.7 V 8h = 0.8 V 9h = 0.9 V Ah = 1 V Bh = 1.1 V Ch = 1.2 V Dh = 1.3 V Eh = 1.4 V Fh = 1.5 V
16-14	IPD_CLK_FREQ	R/W	0h	IPD clock frequency 0h = 50 Hz 1h = 100 Hz 2h = 250 Hz 3h = 500 Hz 4h = 1000 Hz 5h = 2000 Hz 6h = 5000 Hz 7h = 10000 Hz
13-10	IPD_CURR_THR	R/W	0h	IPD current threshold (IPD current threshold (A) = IPD_CURR_THR / CSA_GAIN) 0h = Reserved 1h = Reserved 2h = 0.2 V 3h = 0.3 V 4h = 0.4 V 5h = 0.5 V 6h = 0.6 V 7h = 0.7 V 8h = 0.8 V 9h = 0.9 V Ah = 1 V Bh = 1.1 V Ch = 1.2 V Dh = 1.3 V Eh = 1.4 V Fh = 1.5 V

**表 7-13. MOTOR\_STARTUP1 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
9-8	IPD_RLS_MODE	R/W	0h	IPD release mode 0h = Brake 1h = Tristate 2h = Reserved 3h = Reserved
7-6	IPD_ADV_ANGLE	R/W	0h	IPD advance angle 0h = 0° 1h = 30° 2h = 60° 3h = 90°
5-4	IPD_REPEAT	R/W	0h	Number of times IPD is executed 0h = one 1h = average of 2 times 2h = average of 3 times 3h = average of 4 times
3-0	SLOW_FIRST_CYC_FRE Q	R/W	0h	Frequency of first cycle 0h = 0.05 Hz 1h = 0.1 Hz 2h = 0.25 Hz 3h = 0.5 Hz 4h = 1 Hz 5h = 2 Hz 6h = 3 Hz 7h = 5 Hz 8h = 10 Hz 9h = 15 Hz Bh = 25 Hz Ch = 50 Hz Dh = 100 Hz Eh = 150 Hz Fh = 200 Hz

### 7.7.1.3 MOTOR\_STARTUP2 Register (Offset = 84h) [Reset = X]

MOTOR\_STARTUP2 is shown in [Figure 7-58](#) and described in [Table 7-14](#).

Return to the [Summary Table](#).

Register to configure motor startup settings2

**Figure 7-58. MOTOR\_STARTUP2 Register**

31	30	29	28	27	26	25	24
PARITY	OL_ILIMIT_CONFIG	OL_DUTY				OL_ILIMIT	
R/W-0h	R/W-0h	R/W-0h				R/W-0h	
23	22	21	20	19	18	17	16
OL_ILIMIT	OL_ACC_A1					OL_ACC_A2	
R/W-0h	R/W-0h					R/W-0h	
15	14	13	12	11	10	9	8
OL_ACC_A2			OPN_CL_HANDOFF_THR				
R/W-0h			R/W-0h				
7	6	5	4	3	2	1	0
AUTO_HANDOFF	FIRST_CYCLE_FREQ_SEL	MIN_DUTY				RESERVED	
R/W-0h	R/W-0h	R/W-0h				R-X	

**Table 7-14. MOTOR\_STARTUP2 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30	OL_ILIMIT_CONFIG	R/W	0h	Open loop current limit configuration 0h = Open loop current limit defined by OL_ILIMIT 1h = Open loop current limit defined by ILIMIT
29-27	OL_DUTY	R/W	0h	Duty cycle limit during open loop 0h = 10% 1h = 15% 2h = 20% 3h = 25% 4h = 30% 5h = 40% 6h = 50% 7h = 100%
26-23	OL_ILIMIT	R/W	0h	Open loop current limit (OL current threshold (A) = OL_CURR_THR / CSA_GAIN) 0h = Reserved 1h = 0.1V 2h = 0.2 V 3h = 0.3 V 4h = 0.4 V 5h = 0.5 V 6h = 0.6 V 7h = 0.7 V 8h = 0.8 V 9h = 0.9 V Ah = 1 V Bh = 1.1 V Ch = 1.2 V Dh = 1.3 V Eh = 1.4 V Fh = 1.5 V

**表 7-14. MOTOR\_STARTUP2 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
22-18	OL_ACC_A1	R/W	0h	Open loop acceleration A1 0h = 0.005 Hz/s 1h = 0.01 Hz/s 2h = 0.025 Hz/s 3h = 0.05 Hz/s 4h = 0.1 Hz/s 5h = 0.25 Hz/s 6h = 0.5 Hz/s 7h = 1 Hz/s 8h = 2.5 Hz/s 9h = 5 Hz/s Ah = 7.5 Hz/s Bh = 10 Hz/s Ch = 12.5 Hz/s Dh = 15 Hz/s Eh = 20 Hz/s Fh = 30 Hz/s 10h = 40 Hz/s 11h = 50 Hz/s 12h = 60 Hz/s 13h = 75 Hz/s 14h = 100 Hz/s 15h = 125 Hz/s 16h = 150 Hz/s 17h = 175 Hz/s 18h = 200 Hz/s 19h = 250 Hz/s 1Ah = 300 Hz/s 1Bh = 400 Hz/s 1Ch = 500 Hz/s 1Dh = 750 Hz/s 1Eh = 1000 Hz/s 1Fh = No Limit (32767) Hz/s

表 7-14. MOTOR\_STARTUP2 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
17-13	OL_ACC_A2	R/W	0h	Open loop acceleration A2 0h = 0.005 Hz/s <sup>2</sup> 1h = 0.01 Hz/s <sup>2</sup> 2h = 0.025 Hz/s <sup>2</sup> 3h = 0.05 Hz/s <sup>2</sup> 4h = 0.1 Hz/s <sup>2</sup> 5h = 0.25 Hz/s <sup>2</sup> 6h = 0.5 Hz/s <sup>2</sup> 7h = 1 Hz/s <sup>2</sup> 8h = 2.5 Hz/s <sup>2</sup> 9h = 5 Hz/s <sup>2</sup> Ah = 7.5 Hz/s <sup>2</sup> Bh = 10 Hz/s <sup>2</sup> Ch = 12.5 Hz/s <sup>2</sup> Dh = 15 Hz/s <sup>2</sup> Eh = 20 Hz/s <sup>2</sup> Fh = 30 Hz/s <sup>2</sup> 10h = 40 Hz/s <sup>2</sup> 11h = 50 Hz/s <sup>2</sup> 12h = 60 Hz/s <sup>2</sup> 13h = 75 Hz/s <sup>2</sup> 14h = 100 Hz/s <sup>2</sup> 15h = 125 Hz/s <sup>2</sup> 16h = 150 Hz/s <sup>2</sup> 17h = 175 Hz/s <sup>2</sup> 18h = 200 Hz/s <sup>2</sup> 19h = 250 Hz/s <sup>2</sup> 1Ah = 300 Hz/s <sup>2</sup> 1Bh = 400 Hz/s <sup>2</sup> 1Ch = 500 Hz/s <sup>2</sup> 1Dh = 750 Hz/s <sup>2</sup> 1Eh = 1000 Hz/s <sup>2</sup> 1Fh = No Limit (32767) Hz/s <sup>2</sup>



**表 7-14. MOTOR\_STARTUP2 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
12-8	OPN_CL_HANDOFF_THR	R/W	0h	Open to closed loop handoff threshold 0h = 1 Hz 1h = 4 Hz 2h = 8 Hz 3h = 12 Hz 4h = 16 Hz 5h = 20 Hz 6h = 24 Hz 7h = 28 Hz 8h = 32 Hz 9h = 36 Hz Ah = 40 Hz Bh = 45 Hz Ch = 50 Hz Dh = 55 Hz Eh = 60 Hz Fh = 65 Hz 10h = 70 Hz 11h = 75 Hz 12h = 80 Hz 13h = 85 Hz 14h = 90 Hz 15h = 100 Hz 16h = 150 Hz 17h = 200 Hz 18h = 250 Hz 19h = 300 Hz 1Ah = 350 Hz 1Bh = 400 Hz 1Ch = 450 Hz 1Dh = 500 Hz 1Eh = 550 Hz 1Fh = 600 Hz
7	AUTO_HANDOFF	R/W	0h	Auto handoff enable 0h = Disable Auto Handoff (and use OPN_CL_HANDOFF_THR) 1h = Enable Auto Handoff
6	FIRST_CYCLE_FREQ_SEL	R/W	0h	First cycle frequency select 0h = Defined by SLOW_FIRST_CYC_FREQ 1h = 0 Hz
5-2	MIN_DUTY	R/W	0h	Min operational duty cycle 0h = 1.5 % 1h = 2 % 2h = 3 % 3h = 4 % 4h = 5 % 5h = 6 % 6h = 7 % 7h = 8 % 8h = 9 % 9h = 10 % Ah = 12 % Bh = 15 % Ch = 17.5 % Dh = 20 % Eh = 25 % Fh = 30 %
1-0	RESERVED	R	X	Reserved

#### 7.7.1.4 CLOSED\_LOOP1 Register (Offset = 86h) [Reset = 00000000h]

CLOSED\_LOOP1 is shown in [图 7-59](#) and described in [表 7-15](#).

Return to the [Summary Table](#).

Register to configure close loop settings1

**图 7-59. CLOSED\_LOOP1 Register**

31	30	29	28	27	26	25	24
PARITY	COMM_CONTROL		CL_ACC				
R/W-0h	R/W-0h		R/W-0h				
23	22	21	20	19	18	17	16
CL_DEC_CON FIG	CL_DEC					PWM_FREQ_OUT	
R/W-0h	R/W-0h					R/W-0h	
15	14	13	12	11	10	9	8
PWM_FREQ_OUT			PWM_MODUL		PWM_MODE	LD_ANGLE_PO LARITY	LD_ANGLE
R/W-0h			R/W-0h		R/W-0h	R/W-0h	R/W-0h
7	6	5	4	3	2	1	0
LD_ANGLE							RESERVED
R/W-0h							R/W-0h

**表 7-15. CLOSED\_LOOP1 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-29	COMM_CONTROL	R/W	0h	Trapezoidal commutation mode 0h = 120° Commutation 1h = Variable commutation between 120° and 150° 2h = Reserved 3h = Reserved

**表 7-15. CLOSED\_LOOP1 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
28-24	CL_ACC	R/W	0h	Closed loop acceleration rate 0h = 0.005 V/s 1h = 0.01 V/s 2h = 0.025 V/s 3h = 0.05 V/s 4h = 0.1 V/s 5h = 0.25 V/s 6h = 0.5 V/s 7h = 1 V/s 8h = 2.5 V/s 9h = 5 V/s Ah = 7.5 V/s Bh = 10 V/s Ch = 12.5 V/s Dh = 15 V/s Eh = 20 V/s Fh = 30 V/s 10h = 40 V/s 11h = 50 V/s 12h = 60 V/s 13h = 75 V/s 14h = 100 V/s 15h = 125 V/s 16h = 150 V/s 17h = 175 V/s 18h = 200 V/s 19h = 250 V/s 1Ah = 300 V/s 1Bh = 400 V/s 1Ch = 500 V/s 1Dh = 750 V/s 1Eh = 1000 V/s 1Fh = 32767 V/s
23	CL_DEC_CONFIG	R/W	0h	Closed loop decel configuration 0h = Close loop deceleration defined by CL_DEC 1h = Close loop deceleration defined by CL_ACC

表 7-15. CLOSED\_LOOP1 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
22-18	CL_DEC	R/W	0h	Closed loop deceleration rate 0h = 0.005 V/s 1h = 0.01 V/s 2h = 0.025 V/s 3h = 0.05 V/s 4h = 0.1 V/s 5h = 0.25 V/s 6h = 0.5 V/s 7h = 1 V/s 8h = 2.5 V/s 9h = 5 V/s Ah = 7.5 V/s Bh = 10 V/s Ch = 12.5 V/s Dh = 15 V/s Eh = 20 V/s Fh = 30 V/s 10h = 40 V/s 11h = 50 V/s 12h = 60 V/s 13h = 75 V/s 14h = 100 V/s 15h = 125 V/s 16h = 150 V/s 17h = 175 V/s 18h = 200 V/s 19h = 250 V/s 1Ah = 300 V/s 1Bh = 400 V/s 1Ch = 500 V/s 1Dh = 750 V/s 1Eh = 1000 V/s 1Fh = 32767 V/s

**表 7-15. CLOSED\_LOOP1 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
17-13	PWM_FREQ_OUT	R/W	0h	Output PWM switching frequency 0h = 5 kHz 1h = 6 kHz 2h = 7 kHz 3h = 8 kHz 4h = 9 kHz 5h = 10 kHz 6h = 11 kHz 7h = 12 kHz 8h = 13 kHz 9h = 14 kHz Ah = 15 kHz Bh = 16 kHz Ch = 17 kHz Dh = 18 kHz Eh = 19 kHz Fh = 20 kHz 10h = 25 kHz 11h = 30 kHz 12h = 35 kHz 13h = 40 kHz 14h = 45 kHz 15h = 50 kHz 16h = 55 kHz 17h = 60 kHz 18h = 65 kHz 19h = 70 kHz 1Ah = 75 kHz 1Bh = 80 kHz 1Ch = 85 kHz 1Dh = 90 kHz 1Eh = 95 kHz 1Fh = 100 kHz
12-11	PWM_MODUL	R/W	0h	PWM modulation. 0h = High-Side Modulation 1h = Low-Side Modulation 2h = Mixed Modulation 3h = Reserved
10	PWM_MODE	R/W	0h	PWM mode 0h = Single Ended Mode 1h = Complementary Mode
9	LD_ANGLE_POLARITY	R/W	0h	Polarity of applied lead angle 0h = Negative 1h = Positive
8-1	LD_ANGLE	R/W	0h	Lead Angle {Lead Angle (deg) = LD_ANGLE * 0.12}
0	RESERVED	R/W	0h	Reserved

### 7.7.1.5 CLOSED\_LOOP2 Register (Offset = 88h) [Reset = 00000000h]

CLOSED\_LOOP2 is shown in [图 7-60](#) and described in [表 7-16](#).

Return to the [Summary Table](#).

Register to configure close loop settings2

**图 7-60. CLOSED\_LOOP2 Register**

31	30	29	28	27	26	25	24
PARITY	FG_SEL		FG_DIV_FACTOR			RESERVED	
R/W-0h	R/W-0h		R/W-0h			R/W-0h	
23	22	21	20	19	18	17	16
FG_BEMF_THR			MTR_STOP			MTR_STOP_BRK_TIME	
R/W-0h			R/W-0h			R/W-0h	
15	14	13	12	11	10	9	8
MTR_STOP_BRK_TIME		ACT_SPIN_BRK_THR			BRAKE_DUTY_THRESHOLD		
R/W-0h		R/W-0h			R/W-0h		
7	6	5	4	3	2	1	0
AVS_EN	CBC_ILIMIT				RESERVED		
R/W-0h	R/W-0h				R/W-0h		

**表 7-16. CLOSED\_LOOP2 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-29	FG_SEL	R/W	0h	FG mode select 0h = Output FG in open loop and closed loop 1h = Output FG in only closed loop 2h = Output FG in open loop for the first try. 3h = Reserved
28-25	FG_DIV_FACTOR	R/W	0h	FG division factor 0h = Divide by 3 (2-pole motor mechanical speed/3) 1h = Divide by 1 (2-pole motor mechanical speed) 2h = Divide by 2 (4-pole motor mechanical speed) 3h = Divide by 3 (6-pole motor mechanical speed) 4h = Divide by 4 (8-pole motor mechanical speed) 5h = Divide by 5 (10-pole motor mechanical speed) 6h = Divide by 6 (12-pole motor mechanical speed) 7h = Divide by 7 (14-pole motor mechanical speed) 8h = Divide by 8 (16-pole motor mechanical speed) 9h = Divide by 9 (18-pole motor mechanical speed) Ah = Divide by 10 (20-pole motor mechanical speed) Bh = Divide by 11 (22-pole motor mechanical speed) Ch = Divide by 12 (24-pole motor mechanical speed) Dh = Divide by 13 (26-pole motor mechanical speed) Eh = Divide by 14 (28-pole motor mechanical speed) Fh = Divide by 15 (30-pole motor mechanical speed)
24	RESERVED	R/W	0h	Reserved
23-21	FG_BEMF_THR	R/W	0h	FG output BEMF threshold 0h = +/- 1mV 1h = +/- 2mV 2h = +/- 5mV 3h = +/- 10mV 4h = +/- 20mV 5h = +/- 30mV 6h = Reserved 7h = Reserved

**表 7-16. CLOSED\_LOOP2 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
20-18	MTR_STOP	R/W	0h	Motor stop method 0h = Hi-z 1h = Recirculation 2h = Low-side braking 3h = High-side braking 4h = Active spin down 5h = Reserved 6h = Reserved 7h = Reserved
17-14	MTR_STOP_BRK_TIME	R/W	0h	Brake time during motor stop 0h = 1 ms 1h = 2 ms 2h = 5 ms 3h = 10 ms 4h = 15 ms 5h = 25 ms 6h = 50 ms 7h = 75 ms 8h = 100 ms 9h = 250 ms Ah = 500 ms Bh = 1000 ms Ch = 2500 ms Dh = 5000 ms Eh = 10000 ms Fh = 15000 ms
13-11	ACT_SPIN_BRK_THR	R/W	0h	Duty cycle threshold for motor stop using active spin down, low- and high-side braking 0h = Immediate 1h = 50 % 2h = 25 % 3h = 15 % 4h = 10 % 5h = 7.5 % 6h = 5 % 7h = 2.5 %
10-8	BRAKE_DUTY_THRESH OLD	R/W	0h	Duty cycle threshold for BRAKE pin based low-side braking 0h = Immediate 1h = 50 % 2h = 25 % 3h = 15 % 4h = 10 % 5h = 7.5 % 6h = 5 % 7h = 2.5 %
7	AVS_EN	R/W	0h	AVS enable 0h = Disable 1h = Enable

**表 7-16. CLOSED\_LOOP2 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
6-3	CBC_ILIMIT	R/W	0h	Cycle by Cycle (CBC) current limit (CBC current limit (A) = $\text{CBC\_ILIMIT} / \text{CSA\_GAIN}$ ) 0h = Reserved 1h = 0.1 V 2h = 0.2 V 3h = 0.3 V 4h = 0.4 V 5h = 0.5 V 6h = 0.6 V 7h = 0.7 V 8h = 0.8 V 9h = 0.9 V Ah = 1 V Bh = 1.1 V Ch = 1.2 V Dh = 1.3 V Eh = 1.4 V Fh = 1.5 V
2-0	RESERVED	R/W	0h	Reserved



#### 7.7.1.6 CLOSED\_LOOP3 Register (Offset = 8Ah) [Reset = 14000000h]

CLOSED\_LOOP3 is shown in 图 7-61 and described in 表 7-17.

Return to the [Summary Table](#).

### Register to configure close loop settings3

### 7-61. CLOSED\_LOOP3 Register

31	30	29	28	27	26	25	24
PARITY	DYN_DGS_FILT_COUNT		DYN_DGS_UPPER_LIM		DYN_DGS_LOWER_LIM		INTEG_CYCL_THR_LOW
R/W-0h	R/W-0h		R/W-2h		R/W-2h		R/W-0h
23	22	21	20	19	18	17	16
INTEG_CYCL_THR_LOW	INTEG_CYCL_THR_HIGH		INTEG_DUTY_THR_LOW		INTEG_DUTY_THR_HIGH		BEMF_THRES_HOLD2
R/W-0h	R/W-0h		R/W-0h		R/W-0h		R/W-0h
15	14	13	12	11	10	9	8
BEMF_THRESHOLD2					BEMF_THRESHOLD1		
R/W-0h				R/W-0h			
7	6	5	4	3	2	1	0
BEMF_THRESHOLD1			INTEG_ZC_ME_THOD	DEGAUSS_MAX_WIN			DYN_DEGAUSS_EN
R/W-0h			R/W-0h		R/W-0h		R/W-0h

**表 7-17. CLOSED\_LOOP3 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-29	DYN_DGS_FILT_COUNT	R/W	0h	Number of samples needed for dynamic degauss check 0h = 15 1h = 20 2h = 30 3h = 12
28-27	DYN_DGS_UPPER_LIM	R/W	2h	Dynamic degauss voltage upper bound 0h = (VM - 0.09) V 1h = (VM - 0.12) V 2h = (VM - 0.15) V 3h = (VM - 0.18) V
26-25	DYN_DGS_LOWER_LIM	R/W	2h	Dynamic degauss voltage lower bound 0h = 0.03 V 1h = 0.06 V 2h = 0.09 V 3h = 0.12 V
24-23	INTEG_CYCL_THR_LOW	R/W	0h	Number of BEMF samples per 30° below which commutation method switches from integration to ZC 0h = 3 1h = 4 2h = 6 3h = 8
22-21	INTEG_CYCL_THR_HIGH	R/W	0h	Number of BEMF samples per 30° above which commutation method switches from ZC to integration 0h = 4 1h = 6 2h = 8 3h = 10

**表 7-17. CLOSED\_LOOP3 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
20-19	INTEG_DUTY_THR_LOW	R/W	0h	Duty cycle below which commutation method switches from integration to ZC 0h = 12 % 1h = 15 % 2h = 18 % 3h = 20 %
18-17	INTEG_DUTY_THR_HIGH	R/W	0h	Duty cycle above which commutation method switches from ZC to integration 0h = 12 % 1h = 15 % 2h = 18 % 3h = 20 %

**表 7-17. CLOSED\_LOOP3 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
16-11	BEMF_THRESHOLD2	R/W	0h	<p>BEMF threshold for integration based commutation during falling floating phase voltage</p> <p>0h = 0</p> <p>1h = 25</p> <p>2h = 50</p> <p>3h = 75</p> <p>4h = 100</p> <p>5h = 125</p> <p>6h = 150</p> <p>7h = 175</p> <p>8h = 200</p> <p>9h = 225</p> <p>Ah = 250</p> <p>Bh = 275</p> <p>Ch = 300</p> <p>Dh = 325</p> <p>Eh = 350</p> <p>Fh = 375</p> <p>10h = 400</p> <p>11h = 425</p> <p>12h = 450</p> <p>13h = 475</p> <p>14h = 500</p> <p>15h = 525</p> <p>16h = 550</p> <p>17h = 575</p> <p>18h = 600</p> <p>19h = 625</p> <p>1Ah = 650</p> <p>1Bh = 675</p> <p>1Ch = 700</p> <p>1Dh = 725</p> <p>1Eh = 750</p> <p>1Fh = 775</p> <p>20h = 800</p> <p>21h = 850</p> <p>22h = 900</p> <p>23h = 950</p> <p>24h = 1000</p> <p>25h = 1050</p> <p>26h = 1100</p> <p>27h = 1150</p> <p>28h = 1200</p> <p>29h = 1250</p> <p>2Ah = 1300</p> <p>2Bh = 1350</p> <p>2Ch = 1400</p> <p>2Dh = 1450</p> <p>2Eh = 1500</p> <p>2Fh = 1550</p> <p>30h = 1600</p> <p>31h = 1700</p> <p>32h = 1800</p> <p>33h = 1900</p> <p>34h = 2000</p> <p>35h = 2100</p> <p>36h = 2200</p> <p>37h = 2300</p> <p>38h = 2400</p> <p>39h = 2600</p> <p>3Ah = 2800</p> <p>3Bh = 3000</p> <p>3Ch = 3200</p> <p>3Dh = 3400</p> <p>3Eh = 3600</p>

表 7-17. CLOSED\_LOOP3 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
				3Fh = 3800

表 7-17. CLOSED\_LOOP3 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
10-5	BEMF_THRESHOLD1	R/W	0h	<p>BEMF threshold for integration based commutation during rising floating phase voltage</p> <p>0h = 0</p> <p>1h = 25</p> <p>2h = 50</p> <p>3h = 75</p> <p>4h = 100</p> <p>5h = 125</p> <p>6h = 150</p> <p>7h = 175</p> <p>8h = 200</p> <p>9h = 225</p> <p>Ah = 250</p> <p>Bh = 275</p> <p>Ch = 300</p> <p>Dh = 325</p> <p>Eh = 350</p> <p>Fh = 375</p> <p>10h = 400</p> <p>11h = 425</p> <p>12h = 450</p> <p>13h = 475</p> <p>14h = 500</p> <p>15h = 525</p> <p>16h = 550</p> <p>17h = 575</p> <p>18h = 600</p> <p>19h = 625</p> <p>1Ah = 650</p> <p>1Bh = 675</p> <p>1Ch = 700</p> <p>1Dh = 725</p> <p>1Eh = 750</p> <p>1Fh = 775</p> <p>20h = 800</p> <p>21h = 850</p> <p>22h = 900</p> <p>23h = 950</p> <p>24h = 1000</p> <p>25h = 1050</p> <p>26h = 1100</p> <p>27h = 1150</p> <p>28h = 1200</p> <p>29h = 1250</p> <p>2Ah = 1300</p> <p>2Bh = 1350</p> <p>2Ch = 1400</p> <p>2Dh = 1450</p> <p>2Eh = 1500</p> <p>2Fh = 1550</p> <p>30h = 1600</p> <p>31h = 1700</p> <p>32h = 1800</p> <p>33h = 1900</p> <p>34h = 2000</p> <p>35h = 2100</p> <p>36h = 2200</p> <p>37h = 2300</p> <p>38h = 2400</p> <p>39h = 2600</p> <p>3Ah = 2800</p> <p>3Bh = 3000</p> <p>3Ch = 3200</p> <p>3Dh = 3400</p> <p>3Eh = 3600</p>

**表 7-17. CLOSED\_LOOP3 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
				3Fh = 3800
4	INTEG_ZC_METHOD	R/W	0h	Commutation method select 0h = ZC based 1h = Integration based
3-1	DEGAUSS_MAX_WIN	R/W	0h	Maximum degauss window 0h = 22.5° 1h = 10° 2h = 15° 3h = 18° 4h = 30° 5h = 37.5° 6h = 45° 7h = 60°
0	DYN_DEGAUSS_EN	R/W	0h	Dynamic degauss detection 0h = Disable 1h = Enable

### 7.7.1.7 CLOSED\_LOOP4 Register (Offset = 8Ch) [Reset = 0000000h]

CLOSED\_LOOP4 is shown in [図 7-62](#) and described in [表 7-18](#).

Return to the [Summary Table](#).

Register to configure close loop settings4

**図 7-62. CLOSED\_LOOP4 Register**

31	30	29	28	27	26	25	24
PARITY	RESERVED						
R/W-0h	R/W-0h						
23	22	21	20	19	18	17	16
RESERVED				WCOMP_BLANK_EN	FAST_DEC_DUTY_WIN		
R/W-0h				R/W-0h	R/W-0h		
15	14	13	12	11	10	9	8
FAST_DEC_DUTY_THR			DYN_BRK_CURR_LOW_LIM				DYNAMIC_BRK_CURR
R/W-0h			R/W-0h				R/W-0h
7	6	5	4	3	2	1	0
FAST_DECEL_EN	FAST_DECEL_CURR_LIM				FAST_BRK_DELTA		
R/W-0h	R/W-0h				R/W-0h		

**表 7-18. CLOSED\_LOOP4 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-20	RESERVED	R/W	0h	Reserved
19	WCOMP_BLANK_EN	R/W	0h	Enable WCOMP blanking during fast deceleration 0h = Disable 1h = Enable
18-16	FAST_DEC_DUTY_WIN	R/W	0h	Fast deceleration duty window 0h = 0 % 1h = 2.5 % 2h = 5 % 3h = 7.5 % 4h = 10 % 5h = 15 % 6h = 20 % 7h = 25 %
15-13	FAST_DEC_DUTY_THR	R/W	0h	Fast deceleration duty threshold 0h = 100 % 1h = 95 % 2h = 90 % 3h = 85 % 4h = 80 % 5h = 75 % 6h = 70 % 7h = 65 %

表 7-18. CLOSED\_LOOP4 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
12-9	DYN_BRK_CURR_LOW_LIM	R/W	0h	Fast deceleration dynamic current limit lower threshold (Deceleration current lower threshold (A) = DYN_BRK_CURR_LOW_LIM / CSA_GAIN) 0h = Reserved 1h = 0.1 V 2h = 0.2 V 3h = 0.3 V 4h = 0.4 V 5h = 0.5 V 6h = 0.6 V 7h = 0.7 V 8h = 0.8 V 9h = 0.9 V Ah = 1 V Bh = 1.1 V Ch = 1.2 V Dh = 1.3 V Eh = 1.4 V Fh = 1.5 V
8	DYNAMIC_BRK_CURR	R/W	0h	Enable dynamic decrease in current limit during fast deceleration 0h = Disable 1h = Enable
7	FAST_DECEL_EN	R/W	0h	Fast deceleration enable 0h = Disable 1h = Enable
6-3	FAST_DECEL_CURR_LIM	R/W	0h	Deceleration current threshold (Fast Deceleration current limit upper threshold (A) = FAST_DECEL_CURR_LIM / CSA_GAIN) 0h = Reserved 1h = 0.1 V 2h = 0.2 V 3h = 0.3 V 4h = 0.4 V 5h = 0.5 V 6h = 0.6 V 7h = 0.7 V 8h = 0.8 V 9h = 0.9 V Ah = 1 V Bh = 1.1 V Ch = 1.2 V Dh = 1.3 V Eh = 1.4 V Fh = 1.5 V
2-0	FAST_BRK_DELTA	R/W	0h	Fast deceleration exit speed delta 0h = 0.5 % 1h = 1 % 2h = 1.5 % 3h = 2 % 4h = 2.5 % 5h = 3 % 6h = 4 % 7h = 5 %



### 7.7.1.8 CONST\_SPEED Register (Offset = 8Eh) [Reset = 00000000h]

CONST\_SPEED is shown in [図 7-63](#) and described in [表 7-19](#).

Return to the [Summary Table](#).

Register to configure Constant speed mode settings

**図 7-63. CONST\_SPEED Register**

31	30	29	28	27	26	25	24
PARITY	RESERVED	SPD_POWER_KP					
R/W-0h	R/W-0h	R/W-0h					
23	22	21	20	19	18	17	16
SPD_POWER_KP				SPD_POWER_KI			
R/W-0h				R/W-0h			
15	14	13	12	11	10	9	8
SPD_POWER_KI							
R/W-0h							
7	6	5	4	3	2	1	0
SPD_POWER_V_MAX				SPD_POWER_V_MIN		CLOSED_LOOP_MODE	
R/W-0h				R/W-0h		R/W-0h	

**表 7-19. CONST\_SPEED Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30	RESERVED	R/W	0h	Reserved
29-20	SPD_POWER_KP	R/W	0h	Speed/ Power loop Kp (Kp = SPD_LOOP_KP / 10000)
19-8	SPD_POWER_KI	R/W	0h	Speed/ Power loop Ki (Ki = SPD_LOOP_KI / 1000000)
7-5	SPD_POWER_V_MAX	R/W	0h	Upper saturation limit for speed/ power loop 0h = 100 % 1h = 95 % 2h = 90 % 3h = 85 % 4h = 80 % 5h = 75 % 6h = 70 % 7h = 65 %
4-2	SPD_POWER_V_MIN	R/W	0h	Lower saturation limit for speed/power loop 0h = 0 % 1h = 2.5 % 2h = 5 % 3h = 7.5 % 4h = 10 % 5h = 15 % 6h = 20 % 7h = 25 %
1-0	CLOSED_LOOP_MODE	R/W	0h	Closed loop mode 0h = Disabled 1h = Speed Loop 2h = Power Loop 3h = Reserved

### 7.7.1.9 CONST\_PWR Register (Offset = 90h) [Reset = 00000000h]

CONST\_PWR is shown in [Figure 7-64](#) and described in [Table 7-20](#).

Return to the [Summary Table](#).

Register to configure Constant power mode settings

**Figure 7-64. CONST\_PWR Register**

31	30	29	28	27	26	25	24
PARITY	MAX_SPEED						
R/W-0h	R/W-0h						
23	22	21	20	19	18	17	16
MAX_SPEED							
R/W-0h							
15	14	13	12	11	10	9	8
MAX_SPEED	DEADTIME_COMP_EN	MAX_POWER					
R/W-0h	R/W-0h	R/W-0h					
7	6	5	4	3	2	1	0
MAX_POWER				CONST_POWER_LIMIT_HYST		CONST_POWER_MODE	
R/W-0h				R/W-0h		R/W-0h	

**Table 7-20. CONST\_PWR Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-15	MAX_SPEED	R/W	0h	Maximum Speed (Maximum Speed (Hz) = MAX_SPEED / 16)
14	DEADTIME_COMP_EN	R/W	0h	Enable dead time compensation 0h = Disable 1h = Enable
13-4	MAX_POWER	R/W	0h	Maximum power (Maximum power (W) = MAX_POWER / 4)
3-2	CONST_POWER_LIMIT_HYST	R/W	0h	Hysteresis for input power regulation 0h = 5 % 1h = 7.5 % 2h = 10 % 3h = 12.5 %
1-0	CONST_POWER_MODE	R/W	0h	Input power regulation mode 0h = Disabled 1h = Closed Loop Power Control 2h = Power Limit Control 3h = Reserved

### 7.7.1.10 150\_DEG\_TWO\_PH\_PROFILE Register (Offset = 96h) [Reset = 00000000h]

150\_DEG\_TWO\_PH\_PROFILE is shown in [図 7-65](#) and described in [表 7-21](#).

Return to the [Summary Table](#).

Register to configure 150 degree modulation TWO phase duty

**図 7-65. 150\_DEG\_TWO\_PH\_PROFILE Register**

31	30	29	28	27	26	25	24
PARITY	TWOPH_STEP0			TWOPH_STEP1			TWOPH_STEP2
R/W-0h	R/W-0h			R/W-0h			R/W-0h
23	22	21	20	19	18	17	16
TWOPH_STEP2		TWOPH_STEP3			TWOPH_STEP4		
R/W-0h		R/W-0h			R/W-0h		
15	14	13	12	11	10	9	8
TWOPH_STEP5			TWOPH_STEP6			TWOPH_STEP7	
R/W-0h			R/W-0h			R/W-0h	
7	6	5	4	3	2	1	0
TWOPH_STEP7	RESERVED						
R/W-0h	R/W-0h						

**表 7-21. 150\_DEG\_TWO\_PH\_PROFILE Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-28	TWOPH_STEP0	R/W	0h	150° modulation , Two ph - step duty - 0 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
27-25	TWOPH_STEP1	R/W	0h	150° modulation , Two ph - step duty - 1 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
24-22	TWOPH_STEP2	R/W	0h	150° modulation, Two ph - step duty - 2 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %

表 7-21. 150\_DEG\_TWO\_PH\_PROFILE Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
21-19	TWOPH_STEP3	R/W	0h	150° modulation, Two ph - step duty - 3 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
18-16	TWOPH_STEP4	R/W	0h	150° modulation, Two ph - step duty - 4 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
15-13	TWOPH_STEP5	R/W	0h	150° modulation, Two ph - step duty - 5 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
12-10	TWOPH_STEP6	R/W	0h	150° modulation, Two ph - step duty - 6 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
9-7	TWOPH_STEP7	R/W	0h	150° modulation, Two ph - step duty - 7 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
6-0	RESERVED	R/W	0h	reserved bits for algo parameter update

### 7.7.1.11 150\_DEG\_THREE\_PH\_PROFILE Register (Offset = 98h) [Reset = 00000000h]

150\_DEG\_THREE\_PH\_PROFILE is shown in [図 7-66](#) and described in [表 7-22](#).

Return to the [Summary Table](#).

Register to configure 150 degree modulation Three phase duty

**図 7-66. 150\_DEG\_THREE\_PH\_PROFILE Register**

31	30	29	28	27	26	25	24
PARITY	THREEPH_STEP0			THREEPH_STEP1			THREEPH_ST EP2
R/W-0h	R/W-0h			R/W-0h			R/W-0h
23	22	21	20	19	18	17	16
THREEPH_STEP2		THREEPH_STEP3			THREEPH_STEP4		
R/W-0h		R/W-0h			R/W-0h		
15	14	13	12	11	10	9	8
THREEPH_STEP5			THREEPH_STEP6			THREEPH_STEP7	
R/W-0h			R/W-0h			R/W-0h	
7	6	5	4	3	2	1	0
THREEPH_ST EP7	LEAD_ANGLE_150DEG_ADV		RESERVED				
R/W-0h	R/W-0h		R/W-0h				

**表 7-22. 150\_DEG\_THREE\_PH\_PROFILE Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-28	THREEPH_STEP0	R/W	0h	150° modulation, Three ph - step duty - 0 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
27-25	THREEPH_STEP1	R/W	0h	150° modulation, Three ph - step duty - 1 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
24-22	THREEPH_STEP2	R/W	0h	150° modulation, Three ph - step duty - 2 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %

表 7-22. 150\_DEG\_THREE\_PH\_PROFILE Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
21-19	THREEPH_STEP3	R/W	0h	150° modulation, Three ph - step duty - 3 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
18-16	THREEPH_STEP4	R/W	0h	150° modulation, Three ph - step duty - 4 0h = 0.0 % 1h = 0.5 % 2h = 0.75 % 3h = 0.8375 % 4h = 0.875 % 5h = 0.9375 % 6h = 0.975 % 7h = 0.99 %
15-13	THREEPH_STEP5	R/W	0h	150° modulation, Three ph - step duty - 5 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
12-10	THREEPH_STEP6	R/W	0h	150° modulation, Three ph - step duty - 6 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
9-7	THREEPH_STEP7	R/W	0h	150° modulation, Three ph - step duty - 7 0h = 0% 1h = 50 % 2h = 75 % 3h = 83.75 % 4h = 87.5 % 5h = 93.75 % 6h = 97.5 % 7h = 99 %
6-5	LEAD_ANGLE_150DEG_ADV	R/W	0h	Angle advance for 150° modulation 0h = 0° 1h = 5° 2h = 10° 3h = 15°
4-0	RESERVED	R/W	0h	Reserved

### 7.7.1.12 TRAP\_CONFIG1 Register (Offset = 9Ah) [Reset = 00000000h]

TRAP\_CONFIG1 is shown in [図 7-67](#) and described in [表 7-23](#).

Return to the [Summary Table](#).

Register to configure internal Algorithm Variables

**図 7-67. TRAP\_CONFIG1 Register**

31		30		29		28		27		26		25		24	
PARITY		RESERVED				RESERVED						RESERVED			
R/W-0h		R/W-0h				R/W-0h						R/W-0h			
23		22		21		20		19		18		17		16	
OL_HANDOFF_CYCLES				RESERVED						AVS_NEG_CURR_LIMIT					
R/W-0h				R/W-0h						R/W-0h					
15		14		13		12		11		10		9		8	
AVS_LIMIT_HYST		ISD_BEMF_THR										ISD_CYCLE_THR			
R/W-0h		R/W-0h						R/W-0h							
7		6		5		4		3		2		1		0	
ISD_CYCLE_THR		RESERVED		RESERVED				ZC_ANGLE_OL_THR				FAST_STARTUP_DIV_FACTOR			
R/W-0h		R/W-0h		R/W-0h				R/W-0h				R/W-0h			

**表 7-23. TRAP\_CONFIG1 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-29	RESERVED	R/W	0h	Reserved
28-26	RESERVED	R/W	0h	Reserved
25-24	RESERVED	R/W	0h	Reserved
23-22	OL_HANDOFF_CYCLES	R/W	0h	Open loop handoff cycles 0h = 3 1h = 6 2h = 12 3h = 24
21-19	RESERVED	R/W	0h	Reserved
18-16	AVS_NEG_CURR_LIMIT	R/W	0h	AVS negative current limit (AVS negative current limit (A) = (AVS_NEG_CURRENT_LIMIT * 3 / 4095) / CSA_GAIN) 0h = 0 1h = -40 2h = -30 3h = -20 4h = -10 5h = 10 6h = 20 7h = 30
15	AVS_LIMIT_HYST	R/W	0h	AVS current hysteresis (AVS positive current limit (A) = ((AVS_LIMIT_HYST + AVS_NEG_CURR_LIMIT) * 3 / 4095) / CSA_GAIN) 0h = 20 1h = 10

表 7-23. TRAP\_CONFIG1 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
14-10	ISD_BEMF_THR	R/W	0h	ISD BEMF threshold (ISD BEMF threshold = 200 * ISD_BEMF_THR) 0h = 0 1h = 200 2h = 400 3h = 600 4h = 800 5h = 1000 6h = 1200 7h = 1400 8h = 1600 9h = 1800 Ah = 2000 Bh = 2200 Ch = 2400 Dh = 2600 Eh = 2800 Fh = 3000 10h = 3200 11h = 3400 12h = 3600 13h = 3800 14h = 4000 15h = 4200 16h = 4400 17h = 4600 18h = 4800 19h = 5000 1Ah = 5200 1Bh = 5400 1Ch = 5600 1Dh = 5800 1Eh = 6000 1Fh = 6200
9-7	ISD_CYCLE_THR	R/W	0h	ISD cycle threshold 0h = 2, 1h = 5, 2h = 8, 3h = 11, 4h = 14, 5h = 17, 6h = 20, 7h = 23
6	RESERVED	R/W	0h	Reserved
5-4	RESERVED	R/W	0h	Reserved
3-2	ZC_ANGLE_OL_THR	R/W	0h	Angle above which the ZC detection is done during OL 0h = 5° 1h = 8° 2h = 12° 3h = 15°
1-0	FAST_STARTUP_DIV_FACTOR	R/W	0h	Dynamic A1, A2 change rate 0h = 1 1h = 2 2h = 4 3h = 8



### 7.7.1.13 TRAP\_CONFIG2 Register (Offset = 9Ch) [Reset = 00200000h]

TRAP\_CONFIG2 is shown in [Figure 7-68](#) and described in [Table 7-24](#).

Return to the [Summary Table](#).

Register to configure internal Algorithm Variables

**Figure 7-68. TRAP\_CONFIG2 Register**

31	30	29	28	27	26	25	24
PARITY	TBLANK				TPWIDTH		
R/W-0h	R/W-0h				R/W-0h		
23	22	21	20	19	18	17	16
RESERVED	DGS_HIGH_IND_EN	RESERVED	ALIGN_DUTY			ZERO_DUTY_HYST	
R/W-0h	R/W-0h	R/W-1h	R/W-0h			R/W-0h	
15	14	13	12	11	10	9	8
RESERVED							
R/W-0h							
7	6	5	4	3	2	1	0
RESERVED							
R/W-0h							

**Table 7-24. TRAP\_CONFIG2 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-27	TBLANK	R/W	0h	Blanking time after PWM edge 0h = 0 $\mu$ s 1h = 1 $\mu$ s 2h = 2 $\mu$ s 3h = 3 $\mu$ s 4h = 4 $\mu$ s 5h = 5 $\mu$ s 6h = 6 $\mu$ s 7h = 7 $\mu$ s 8h = 8 $\mu$ s 9h = 9 $\mu$ s Ah = 10 $\mu$ s Bh = 11 $\mu$ s Ch = 12 $\mu$ s Dh = 13 $\mu$ s Eh = 14 $\mu$ s Fh = 15 $\mu$ s
26-24	TPWIDTH	R/W	0h	Comparator deglitch time 0h = 0 $\mu$ s 1h = 1 $\mu$ s 2h = 2 $\mu$ s 3h = 3 $\mu$ s 4h = 4 $\mu$ s 5h = 5 $\mu$ s 6h = 6 $\mu$ s 7h = 7 $\mu$ s
23	RESERVED	R/W	0h	Reserved
22	DGS_HIGH_IND_EN	R/W	0h	Degauss Filter for High Inductance Enable 0h = Disable 1h = Enable
21	RESERVED	R/W	1h	Reserved

**表 7-24. TRAP\_CONFIG2 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
20-18	ALIGN_DUTY	R/W	0h	Duty cycle limit during align 0h = 10 % 1h = 15 % 2h = 20 % 3h = 25 % 4h = 30 % 5h = 40 % 6h = 50 % 7h = 100 %
17-16	ZERO_DUTY_HYST	R/W	0h	Duty cycle hysteresis to exit standby 0h = 0 % 1h = 1 % 2h = 2 % 3h = 3 %
15-0	RESERVED	R/W	0h	Reserved

### 7.7.2 Fault\_Configuration Registers

表 7-25 lists the memory-mapped registers for the Fault\_Configuration registers. All register offset addresses not listed in 表 7-25 should be considered as reserved locations and the register contents should not be modified.

**表 7-25. FAULT\_CONFIGURATION Registers**

Offset	Acronym	Register Name	Section
92h	FAULT_CONFIG1	Fault configuration 1	<a href="#">FAULT_CONFIG1 Register (Offset = 92h)</a> <a href="#">[Reset = 00000000h]</a>
94h	FAULT_CONFIG2	Fault configuration 2	<a href="#">FAULT_CONFIG2 Register (Offset = 94h)</a> <a href="#">[Reset = 00000000h]</a>

Complex bit access types are encoded to fit into small table cells. 表 7-26 shows the codes that are used for access types in this section.

**表 7-26. Fault\_Configuration Access Type Codes**

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

### 7.7.2.1 FAULT\_CONFIG1 Register (Offset = 92h) [Reset = 00000000h]

FAULT\_CONFIG1 is shown in [図 7-69](#) and described in [表 7-27](#).

Return to the [Summary Table](#).

Register to configure fault settings1

**図 7-69. FAULT\_CONFIG1 Register**

31	30	29	28	27	26	25	24
PARITY	RESERVED	NO_MTR_DEG_TIME				CBC_ILIMIT_MODE	
R/W-0h	R/W-0h	R/W-0h				R/W-0h	
23	22	21	20	19	18	17	16
CBC_ILIMIT_M ODE	LOCK_ILIMIT				LOCK_ILIMIT_MODE		
R/W-0h	R/W-0h				R/W-0h		
15	14	13	12	11	10	9	8
LOCK_ILIMIT_ MODE	LOCK_ILIMIT_DEG				CBC_RETRY_PWM_CYC		
R/W-0h	R/W-0h				R/W-0h		
7	6	5	4	3	2	1	0
RESERVED	MTR_LCK_MODE				LCK_RETRY		
R/W-0h	R/W-0h				R/W-0h		

**表 7-27. FAULT\_CONFIG1 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30	RESERVED	R/W	0h	Reserved
29-27	NO_MTR_DEG_TIME	R/W	0h	No motor detect deglitch time 0h = 1 ms 1h = 10 ms 2h = 25 ms 3h = 50 ms 4h = 100 ms 5h = 250 ms 6h = 500 ms 7h = 1000 ms

**表 7-27. FAULT\_CONFIG1 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
26-23	CBC_ILIMIT_MODE	R/W	0h	Cycle by cycle current limit 0h = Automatic recovery next PWM cycle; nFAULT active; driver is in recirculation mode 1h = Automatic recovery next PWM cycle; nFAULT inactive; driver is in recirculation mode 2h = Automatic recovery if VSOX < CBC_ILIMIT; nFAULT active; driver is in recirculation mode (Only available with high-side modulation) 3h = Automatic recovery if VSOX < CBC_ILIMIT; nFAULT inactive; driver is in recirculation mode (Only available with high-side modulation) 4h = Automatic recovery after CBC_RETRY_PWM_CYC; nFAULT active; driver is in recirculation mode 5h = Automatic recovery after CBC_RETRY_PWM_CYC; nFAULT inactive; driver is in recirculation mode 6h = VSOX > CBC_ILIMIT is report only but no action is taken 7h = Cycle by Cycle limit is disabled 8h = Cycle by Cycle limit is disabled 9h = Cycle by Cycle limit is disabled Ah = Cycle by Cycle limit is disabled Bh = Cycle by Cycle limit is disabled Ch = Cycle by Cycle limit is disabled Dh = Cycle by Cycle limit is disabled Eh = Cycle by Cycle limit is disabled Fh = Cycle by Cycle limit is disabled
22-19	LOCK_ILIMIT	R/W	0h	Lock detection current limit (Lock detection current limit (A) = LOCK_ILIMIT / CSA_GAIN) 0h = Reserved 1h = 0.1 V 2h = 0.2 V 3h = 0.3 V 4h = 0.4 V 5h = 0.5 V 6h = 0.6 V 7h = 0.7 V 8h = 0.8 V 9h = 0.9 V Ah = 1 V Bh = 1.1 V Ch = 1.2 V Dh = 1.3 V Eh = 1.4 V Fh = 1.5 V

**表 7-27. FAULT\_CONFIG1 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
18-15	LOCK_ILIMIT_MODE	R/W	0h	Lock detection current limit mode 0h = Ilimit lock detection causes latched fault; nFAULT active; Gate driver is tristated 1h = Ilimit lock detection causes latched fault; nFAULT active; Gate driver is in recirculation mode 2h = Ilimit lock detection causes latched fault; nFAULT active; Gate driver is in high-side brake mode (All high-side FETs are turned ON) 3h = Ilimit lock detection causes latched fault; nFAULT active; Gate driver is in low-side brake mode (All low-side FETs are turned ON) 4h = Automatic recovery after tLCK_RETRY; Gate driver is tristated 5h = Automatic recovery after tLCK_RETRY; Gate driver is in recirculation mode 6h = Automatic recovery after tLCK_RETRY; Gate driver is in high-side brake mode (All high-side FETs are turned ON) 7h = Automatic recovery after tLCK_RETRY; Gate driver is in low-side brake mode (All low-side FETs are turned ON) 8h = Ilimit lock detection is in report only but no action is taken 9h = Ilimit lock detection is disabled Ah = Ilimit lock detection is disabled Bh = Ilimit lock detection is disabled Ch = Ilimit lock detection is disabled Dh = Ilimit lock detection is disabled Eh = Ilimit lock detection is disabled Fh = Ilimit lock detection is disabled
14-11	LOCK_ILIMIT_DEG	R/W	0h	Lock detection current limit deglitch time 0h = 1 ms 1h = 2 ms 2h = 5 ms 3h = 10 ms 4h = 25 ms 5h = 50 ms 6h = 75 ms 7h = 100 ms 8h = 250 ms 9h = 500 ms Ah = 1 s Bh = 2.5 s Ch = 5 s Dh = 10 s Eh = 25 s Fh = 50 s
10-8	CBC_RETRY_PWM_CYC	R/W	0h	Number of PWM cycles for CBC current limit to retry 0h = 0 1h = 1 2h = 2 3h = 3 4h = 4 5h = 5 6h = 6 7h = 7
7	RESERVED	R/W	0h	Reserved

表 7-27. FAULT\_CONFIG1 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
6-3	MTR_LCK_MODE	R/W	0h	Motor lock mode 0h = Motor lock detection causes latched fault; nFAULT active; Gate driver is tristated 1h = Motor lock detection causes latched fault; nFAULT active; Gate driver is in recirculation mode 2h = Motor lock detection causes latched fault; nFAULT active; Gate driver is in high-side brake mode (All high-side FETs are turned ON) 3h = Motor lock detection causes latched fault; nFAULT active; Gate driver is in low-side brake mode (All low-side FETs are turned ON) 4h = Automatic recovery after tLCK_RETRY; Gate driver is tristated 5h = Automatic recovery after tLCK_RETRY; Gate driver is in recirculation mode 6h = Automatic recovery after tLCK_RETRY; Gate driver is in high-side brake mode (All high-side FETs are turned ON) 7h = Automatic recovery after tLCK_RETRY; Gate driver is in low-side brake mode (All low-side FETs are turned ON) 8h = Motor lock detection is in report only but no action is taken 9h = Motor lock detection is disabled Bh = Motor lock detection is disabled Ch = Motor lock detection is disabled Dh = Motor lock detection is disabled Eh = Motor lock detection is disabled Fh = Motor lock detection is disabled
2-0	LCK_RETRY	R/W	0h	Lock retry time 0h = 100 ms 1h = 500 ms 2h = 1000 ms 3h = 2000 ms 4h = 3000 ms 5h = 5000 ms 6h = 7500 ms 7h = 10000 ms

### 7.7.2.2 FAULT\_CONFIG2 Register (Offset = 94h) [Reset = 00000000h]

FAULT\_CONFIG2 is shown in [図 7-70](#) and described in [表 7-28](#).

Return to the [Summary Table](#).

Register to configure fault settings2

**図 7-70. FAULT\_CONFIG2 Register**

31	30	29	28	27	26	25	24
PARITY	LOCK1_EN	LOCK2_EN	LOCK3_EN	LOCK_ABN_SPEED			
R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h			
23	22	21	20	19	18	17	16
LOSS_SYNC_TIMES			NO_MTR_THR			MAX_VM_MOD E	MAX_VM_MOT OR
R/W-0h			R/W-0h			R/W-0h	R/W-0h
15	14	13	12	11	10	9	8
MAX_VM_MOTOR		MIN_VM_MOD E	MIN_VM_MOTOR			AUTO_RETRY_TIMES	
R/W-0h		R/W-0h	R/W-0h			R/W-0h	
7	6	5	4	3	2	1	0
AUTO_RETRY_ TIMES	LOCK_MIN_SPEED			ABN_LOCK_SPD_RATIO		ZERO_DUTY_THR	
R/W-0h	R/W-0h			R/W-0h		R/W-0h	

**表 7-28. FAULT\_CONFIG2 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30	LOCK1_EN	R/W	0h	Lock 1 (Abnormal Speed) Enable 0h = Disable 1h = Enable
29	LOCK2_EN	R/W	0h	Lock 2 (Loss of Sync) Enable 0h = Disable 1h = Enable
28	LOCK3_EN	R/W	0h	Lock 3 (No Motor) Enable 0h = Disable 1h = Enable
27-24	LOCK_ABN_SPEED	R/W	0h	Abnormal speed lock threshold 0h = 250 Hz 1h = 500 Hz 2h = 750 Hz 3h = 1000 Hz 4h = 1250 Hz 5h = 1500 Hz 6h = 1750 Hz 7h = 2000 Hz 8h = 2250 Hz 9h = 2500 Hz Ah = 2750 Hz Bh = 3000 Hz Ch = 3250 Hz Dh = 3500 Hz Eh = 3750 Hz Fh = 4000 Hz

表 7-28. FAULT\_CONFIG2 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
23-21	LOSS_SYNC_TIMES	R/W	0h	Number of times sync lost for loss of sync lock fault 0h = Trigger after losing sync 2 times 1h = Trigger after losing sync 3 times 2h = Trigger after losing sync 4 times 3h = Trigger after losing sync 5 times 4h = Trigger after losing sync 6 times 5h = Trigger after losing sync 7 times 6h = Trigger after losing sync 8 times 7h = Trigger after losing sync 9 times
20-18	NO_MTR_THR	R/W	0h	No motor lock current threshold (No motor lock current threshold (A) = NO_MTR_THR / CSA_GAIN) 0h = 0.005 V 1h = 0.0075 V 2h = 0.010 V 3h = 0.0125 V 4h = 0.020 V 5h = 0.025 V 6h = 0.030 V 7h = 0.04 V
17	MAX_VM_MODE	R/W	0h	0h = Latch on Overvoltage 1h = Automatic clear if voltage in bounds
16-14	MAX_VM_MOTOR	R/W	0h	Maximum voltage for running motor 0h = No Limit 1h = 20.0 V 2h = 25.0 V 3h = 30.0 V 4h = 35.0 V 5h = 40.0 V 6h = Unused 7h = Unused
13	MIN_VM_MODE	R/W	0h	0h = Latch on Undervoltage 1h = Automatic clear if voltage in bounds
12-10	MIN_VM_MOTOR	R/W	0h	Minimum voltage for running motor 0h = No Limit 1h = 6.0 V 2h = 7.0 V 3h = 8.0 V 4h = 9.0 V 5h = 10.0 V 6h = 12.0 V 7h = 15.0 V
9-7	AUTO_RETRY_TIMES	R/W	0h	Number of automatic retry attempts 0h = No Limit 1h = 2 2h = 3 3h = 5 4h = 7 5h = 10 6h = 15 7h = 20
6-4	LOCK_MIN_SPEED	R/W	0h	Speed below which lock fault is triggered 0h = 0.5 Hz 1h = 1 Hz 2h = 2 Hz 3h = 3 Hz 4h = 5 Hz 5h = 10 Hz 6h = 15 Hz 7h = 25 Hz



**表 7-28. FAULT\_CONFIG2 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
3-2	ABN_LOCK_SPD_RATIO	R/W	0h	Ratio of electrical speed between two consecutive cycles above which abnormal speed lock fault is triggered 0h = 2 1h = 4 2h = 6 3h = 8
1-0	ZERO_DUTY_THR	R/W	0h	Duty cycle below which target speed is zero 0h = 1% 1h = 1.5% 2h = 2.0% 3h = 2.5%

### 7.7.3 Hardware\_Configuration Registers

表 7-29 lists the memory-mapped registers for the Hardware\_Configuration registers. All register offset addresses not listed in 表 7-29 should be considered as reserved locations and the register contents should not be modified.

**表 7-29. HARDWARE\_CONFIGURATION Registers**

Offset	Acronym	Register Name	Section
A4h	PIN_CONFIG1	Hardware pin configuration	<a href="#">PIN_CONFIG1 Register (Offset = A4h)</a> [Reset = 00000000h]
A6h	PIN_CONFIG2	Hardware pin configuration	<a href="#">PIN_CONFIG2 Register (Offset = A6h)</a> [Reset = 00000000h]
A8h	DEVICE_CONFIG	Device configuration	<a href="#">DEVICE_CONFIG Register (Offset = A8h)</a> [Reset = 00000000h]

Complex bit access types are encoded to fit into small table cells. 表 7-30 shows the codes that are used for access types in this section.

**表 7-30. Hardware\_Configuration Access Type Codes**

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

### 7.7.3.1 PIN\_CONFIG1 Register (Offset = A4h) [Reset = 00000000h]

PIN\_CONFIG1 is shown in [图 7-71](#) and described in [表 7-31](#).

Return to the [Summary Table](#).

Register to configure hardware pins

**图 7-71. PIN\_CONFIG1 Register**

31	30	29	28	27	26	25	24
PARITY	DACOUT1_VAR_ADDR						
R/W-0h	R/W-0h						
23	22	21	20	19	18	17	16
DACOUT1_VAR_ADDR					DACOUT2_VAR_ADDR		
R/W-0h					R/W-0h		
15	14	13	12	11	10	9	8
DACOUT2_VAR_ADDR							
R/W-0h							
7	6	5	4	3	2	1	0
DACOUT2_VA R_ADDR	BRAKE_INPUT		DIR_INPUT		SPD_CTRL_MODE		ALARM_PIN_E N
R/W-0h	R/W-0h		R/W-0h		R/W-0h		R/W-0h

**表 7-31. PIN\_CONFIG1 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-19	DACOUT1_VAR_ADDR	R/W	0h	12-bit address of variable to be monitored
18-7	DACOUT2_VAR_ADDR	R/W	0h	12-bit address of variable to be monitored
6-5	BRAKE_INPUT	R/W	0h	Brake input configuration 0h = Hardware Pin BRAKE 1h = Overwrite Hardware pin with Active Brake 2h = Overwrite Hardware pin with brake functionality disabled 3h = Reserved
4-3	DIR_INPUT	R/W	0h	Direction input configuration 0h = Hardware Pin DIR 1h = Overwrite Hardware pin with clockwise rotation OUTA-OUTB-OUTC 3h = Reserved
2-1	SPD_CTRL_MODE	R/W	0h	Speed input configuration 0h = Analog mode 1h = PWM mode 2h = 0x2 3h = Frequency mode
0	ALARM_PIN_EN	R/W	0h	Alarm Pin GPIO configuration 0h = Disabled (Hi-Z) 1h = Enabled

### 7.7.3.2 PIN\_CONFIG2 Register (Offset = A6h) [Reset = 00000000h]

PIN\_CONFIG2 is shown in 表 7-72 and described in 表 7-32.

Return to the [Summary Table](#).

Register to configure hardware pins

**表 7-72. PIN\_CONFIG2 Register**

31	30	29	28	27	26	25	24
PARITY	DAC_SOX_CONFIG	RESERVED	DAC_CONFIG	I2C_TARGET_ADDR			
R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h			
23	22	21	20	19	18	17	16
I2C_TARGET_ADDR				SLEEP_TIME		EXT_WD_EN	EXT_WD_INPUT
R/W-0h				R/W-0h		R/W-0h	R/W-0h
15	14	13	12	11	10	9	8
EXT_WD_FAULT	EXT_WD_FREQ	FG_PIN_FAULT_CONFIG			RESERVED		
R/W-0h	R/W-0h	R/W-0h			R/W-0h		
7	6	5	4	3	2	1	0
RESERVED							
R/W-0h							

**表 7-32. PIN\_CONFIG2 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-29	DAC_SOX_CONFIG	R/W	0h	Pin 36 configuration 0h = DACOUT2 1h = SOA 2h = SOB 3h = SOC
28	RESERVED	R/W	0h	Reserved
27	DAC_CONFIG	R/W	0h	Pin 37 and pin 38 configuration 0h = Reserved 1h = Pin 37 as DACOUT2 and pin 38 as DACOUT1
26-20	I2C_TARGET_ADDR	R/W	0h	I2C target address
19-18	SLEEP_TIME	R/W	0h	Sleep Time 0h = Check low for 50 $\mu$ s 1h = Check low for 200 $\mu$ s 2h = Check low for 20 ms 3h = Check low for 200 ms
17	EXT_WD_EN	R/W	0h	Enable external watchdog 0h = Disable 1h = Enable
16	EXT_WD_INPUT	R/W	0h	External watchdog source 0h = I2C 1h = GPIO
15	EXT_WD_FAULT	R/W	0h	External watchdog fault mode 0h = Report only 1h = Latched fault with Hi-Z outputs
14-13	EXT_WD_FREQ	R/W	0h	External watchdog frequency 0h = 10Hz 1h = 5Hz 2h = 2Hz 3h = 1Hz

表 7-32. PIN\_CONFIG2 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
12-11	FG_PIN_FAULT_CONFIG	R/W	0h	Fault on FG Pin Configuration 0h = FG continues to toggle till motor stops 1h = FG in Hi-Z state, pulled up externally 2h = FG pulled Low 3h = Reserved
10-0	RESERVED	R/W	0h	Reserved

### 7.7.3.3 DEVICE\_CONFIG Register (Offset = A8h) [Reset = 00000000h]

DEVICE\_CONFIG is shown in [図 7-73](#) and described in [表 7-33](#).

Return to the [Summary Table](#).

Register to configure device

**図 7-73. DEVICE\_CONFIG Register**

31	30	29	28	27	26	25	24
PARITY	INPUT_MAX_FREQUENCY						
R/W-0h	R/W-0h						
23	22	21	20	19	18	17	16
INPUT_MAX_FREQUENCY							
R/W-0h							
15	14	13	12	11	10	9	8
RESERVED	SSM_CONFIG	RESERVED		DEV_MODE	SPD_PWM_RANGE_SELECT	CLK_SEL	
R/W-0h	R/W-0h	R/W-0h		R/W-0h	R/W-0h	R/W-0h	
7	6	5	4	3	2	1	0
RESERVED	EXT_CLK_EN	EXT_CLK_CONFIG			RESERVED		
R/W-0h	R/W-0h	R/W-0h			R/W-0h		

**表 7-33. DEVICE\_CONFIG Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-16	INPUT_MAX_FREQUENCY	R/W	0h	Maximum frequency (in Hz) for frequency based speed input
15	RESERVED	R/W	0h	Reserved
14	SSM_CONFIG	R/W	0h	SSM enable 0h = Enable 1h = Disable
13-12	RESERVED	R/W	0h	Reserved
11	DEV_MODE	R/W	0h	Device mode select 0h = Standby mode 1h = Sleep mode
10	SPD_PWM_RANGE_SELECT	R/W	0h	PWM frequency range select 0h = 325 Hz to 100 kHz speed PWM input 1h = 10 Hz to 325 Hz speed PWM input
9-8	CLK_SEL	R/W	0h	Clock source 0h = Internal Oscillator 1h = Reserved 2h = Reserved 3h = External Clock input
7	RESERVED	R/W	0h	Reserved
6	EXT_CLK_EN	R/W	0h	External clock enable 0h = Disable 1h = Enable

**表 7-33. DEVICE\_CONFIG Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
5-3	EXT_CLK_CONFIG	R/W	0h	External clock frequency 0h = 8 kHz 1h = 16 kHz 2h = 32 kHz 3h = 64 kHz 4h = 128 kHz 5h = 256 kHz 6h = 512 kHz 7h = 1024 kHz
2-0	RESERVED	R/W	0h	Reserved

#### 7.7.4 Gate\_Driver\_Configuration Registers

表 7-34 lists the memory-mapped registers for the Gate\_Driver\_Configuration registers. All register offset addresses not listed in 表 7-34 should be considered as reserved locations and the register contents should not be modified.

**表 7-34. GATE\_DRIVER\_CONFIGURATION Registers**

Offset	Acronym	Register Name	Section
ACh	GD_CONFIG1	Gate driver configuration 1	<a href="#">GD_CONFIG1 Register (Offset = ACh)</a> [Reset = 00228000h]
AEh	GD_CONFIG2	Gate driver configuration 2	<a href="#">GD_CONFIG2 Register (Offset = AEh)</a> [Reset = 01200000h]

Complex bit access types are encoded to fit into small table cells. 表 7-35 shows the codes that are used for access types in this section.

**表 7-35. Gate\_Driver\_Configuration Access Type Codes**

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

### 7.7.4.1 GD\_CONFIG1 Register (Offset = ACh) [Reset = 00228000h]

GD\_CONFIG1 is shown in [Figure 7-74](#) and described in [Table 7-36](#).

Return to the [Summary Table](#).

Register to configure gated driver settings1

**Figure 7-74. GD\_CONFIG1 Register**

31	30	29	28	27	26	25	24
PARITY	RESERVED		RESERVED	SLEW_RATE		RESERVED	
R/W-0h	R/W-0h		R/W-0h	R/W-0h		R/W-0h	
23	22	21	20	19	18	17	16
CLR_FLT	RESERVED	RESERVED	RESERVED	OVP_SEL	OVP_EN	RESERVED	OTW_REP
R/W-0h	R/W-0h	R/W-1h	R/W-0h	R/W-0h	R/W-0h	R/W-1h	R/W-0h
15	14	13	12	11	10	9	8
RESERVED	RESERVED	OCP_DEG		OCP_RETRY	OCP_LVL	OCP_MODE	
R/W-1h	R/W-0h	R/W-0h		R/W-0h	R/W-0h	R/W-0h	
7	6	5	4	3	2	1	0
BEMF_THR	RESERVED	ADCOMP_TH_LS	ADCOMP_TH_HS	EN_ASR	EN_AAR	CSA_GAIN	
R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h	

**Table 7-36. GD\_CONFIG1 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30-29	RESERVED	R/W	0h	Reserved
28	RESERVED	R/W	0h	Reserved
27-26	SLEW_RATE	R/W	0h	Slew rate 0h = 25 V/μs 1h = 50 V/μs 2h = 125 V/μs 3h = 200 V/μs
25-24	RESERVED	R/W	0h	Reserved
23	CLR_FLT	R/W	0h	Clear fault 0h = No clear fault command is issued 1h = To clear the latched fault bits. This bit automatically resets after being written.
22	RESERVED	R/W	0h	Reserved
21	RESERVED	R/W	1h	Reserved
20	RESERVED	R/W	0h	Reserved
19	OVP_SEL	R/W	0h	Overvoltage protection level 0h = VM overvoltage level is 34-V 1h = VM overvoltage level is 22-V
18	OVP_EN	R/W	0h	Overvoltage protection enable 0h = Disable 1h = Enable
17	RESERVED	R/W	1h	Reserved
16	OTW_REP	R/W	0h	Overtemperature warning reporting on nFAULT 0h = Over temperature reporting on nFAULT is disabled 1h = Over temperature reporting on nFAULT is enabled
15	RESERVED	R/W	1h	Reserved
14	RESERVED	R/W	0h	Reserved

**表 7-36. GD\_CONFIG1 Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
13-12	OCP_DEG	R/W	0h	OCP deglitch time 0h = 0.2 $\mu$ s 1h = 0.6 $\mu$ s 2h = 1.2 $\mu$ s 3h = 1.6 $\mu$ s
11	OCP_RETRY	R/W	0h	OCP retry time 0h = 5 ms 1h = 500 ms
10	OCP_LVL	R/W	0h	OCP level 0h = 9 A (Typical) 1h = 13 A (Typical)
9-8	OCP_MODE	R/W	0h	OCP fault mode 0h = Overcurrent causes a latched fault 1h = Overcurrent causes an automatic retrying fault 2h = Overcurrent is report only but no action is taken 3h = Overcurrent is not reported and no action is taken
7	BEMF_THR	R/W	0h	BEMF comparator threshold 0h = BEMF comparator threshold is 20 mV 1h = BEMF comparator threshold is 100 mV
6	RESERVED	R/W	0h	Reserved
5	ADCOMP_TH_LS	R/W	0h	Active demag comparator threshold for low-side 0h = 100 mA 1h = 150 mA
4	ADCOMP_TH_HS	R/W	0h	Active demag comparator threshold for high-side 0h = 100 mA 1h = 150 mA
3	EN_ASR	R/W	0h	Active synchronous rectification enable 0h = Disable 1h = Enable
2	EN_AAR	R/W	0h	Active asynchronous rectification enable 0h = Disable 1h = Enable
1-0	CSA_GAIN	R/W	0h	Current Sense Amplifier (CSA) Gain 0h = 0.24 V/A 1h = 0.48 V/A 2h = 0.96 V/A 3h = 1.92 V/A



### 7.7.4.2 GD\_CONFIG2 Register (Offset = AEh) [Reset = 01200000h]

GD\_CONFIG2 is shown in [図 7-75](#) and described in [表 7-37](#).

Return to the [Summary Table](#).

Register to configure gated driver settings2

**図 7-75. GD\_CONFIG2 Register**

31	30	29	28	27	26	25	24
PARITY	DELAY_COMP_EN	TARGET_DELAY				RESERVED	BUCK_PS_DIS
R/W-0h	R/W-0h	R/W-0h				R/W-0h	R/W-1h
23	22	21	20	19	18	17	16
BUCK_CL	BUCK_SEL		RESERVED	RESERVED			
R/W-0h	R/W-1h		R/W-0h	R/W-0h			
15	14	13	12	11	10	9	8
RESERVED							
R/W-0h							
7	6	5	4	3	2	1	0
RESERVED							
R/W-0h							

**表 7-37. GD\_CONFIG2 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	PARITY	R/W	0h	Parity bit
30	DELAY_COMP_EN	R/W	0h	Driver delay compensation enable 0h = Disable 1h = Enable
29-26	TARGET_DELAY	R/W	0h	Target delay 0h = Automatic based on slew rate 1h = 0.4 $\mu$ s 2h = 0.6 $\mu$ s 3h = 0.8 $\mu$ s 4h = 1 $\mu$ s 5h = 1.2 $\mu$ s 6h = 1.4 $\mu$ s 7h = 1.6 $\mu$ s 8h = 1.8 $\mu$ s 9h = 2 $\mu$ s Ah = 2.2 $\mu$ s Bh = 2.4 $\mu$ s Ch = 2.6 $\mu$ s Dh = 2.8 $\mu$ s Eh = 3 $\mu$ s Fh = 3.2 $\mu$ s
25	RESERVED	R/W	0h	Reserved
24	BUCK_PS_DIS	R/W	1h	Buck power sequencing disable 0h = Buck power sequencing is enabled 1h = Buck power sequencing is disabled
23	BUCK_CL	R/W	0h	Buck current limit 0h = 600 mA 1h = 150 mA

表 7-37. GD\_CONFIG2 Register Field Descriptions (continued)

Bit	Field	Type	Reset	Description
22-21	BUCK_SEL	R/W	1h	Buck voltage selection 0h = Buck voltage is 3.3 V 1h = Buck voltage is 5.0 V 2h = Buck voltage is 4.0 V 3h = Buck voltage is 5.7 V
20	RESERVED	R/W	0h	Reserved
19-0	RESERVED	R/W	0h	Reserved

## 7.8 RAM (Volatile) Register Map

### 7.8.1 Fault\_Status Registers

表 7-38 lists the memory-mapped registers for the Fault\_Status registers. All register offset addresses not listed in 表 7-38 should be considered as reserved locations and the register contents should not be modified.

**表 7-38. FAULT\_STATUS Registers**

Offset	Acronym	Register Name	Section
E0h	GATE_DRIVER_FAULT_STATUS	Fault Status Register	<a href="#">GATE_DRIVER_FAULT_STATUS Register (Offset = E0h) [Reset = 00000000h]</a>
E2h	CONTROLLER_FAULT_STATUS	Fault Status Register	<a href="#">CONTROLLER_FAULT_STATUS Register (Offset = E2h) [Reset = 00000000h]</a>

Complex bit access types are encoded to fit into small table cells. 表 7-39 shows the codes that are used for access types in this section.

**表 7-39. Fault\_Status Access Type Codes**

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

### 7.8.1.1 GATE\_DRIVER\_FAULT\_STATUS Register (Offset = E0h) [Reset = 00000000h]

GATE\_DRIVER\_FAULT\_STATUS is shown in [Figure 7-76](#) and described in [Table 7-40](#).

Return to the [Summary Table](#).

Status of various faults

**Figure 7-76. GATE\_DRIVER\_FAULT\_STATUS Register**

31	30	29	28	27	26	25	24
DRIVER_FAULT	BK_FLT	RESERVED	OCP	NPOR	OVP	OT	RESERVED
R-0h	R-0h	R-0h	R-0h	R-0h	R-0h	R-0h	R-0h
23	22	21	20	19	18	17	16
OTW	TSD	OCP_HC	OCP_LC	OCP_HB	OCP_LB	OCP_HA	OCP_LA
R-0h	R-0h	R-0h	R-0h	R-0h	R-0h	R-0h	R-0h
15	14	13	12	11	10	9	8
RESERVED	OTP_ERR	BUCK_OCP	BUCK_UV	VCP_UV	RESERVED		
R-0h	R-0h	R-0h	R-0h	R-0h	R-0h		
7	6	5	4	3	2	1	0
RESERVED							
R-0h							

**Table 7-40. GATE\_DRIVER\_FAULT\_STATUS Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	DRIVER_FAULT	R	0h	Logic OR of driver fault registers 0h = No Gate Driver fault condition is detected 1h = Gate Driver fault condition is detected
30	BK_FLT	R	0h	Buck fault 0h = No buck regulator fault condition is detected 1h = Buck regulator fault condition is detected
29	RESERVED	R	0h	Reserved
28	OCP	R	0h	Overcurrent protection status 0h = No overcurrent condition is detected 1h = Overcurrent condition is detected
27	NPOR	R	0h	Supply power on reset 0h = Power on reset condition is detected on VM 1h = No power-on-reset condition is detected on VM
26	OVP	R	0h	Supply overvoltage protection status 0h = No overvoltage condition is detected on VM 1h = Overvoltage condition is detected on VM
25	OT	R	0h	Overtemperature fault status 0h = No overtemperature warning / shutdown is detected 1h = Overtemperature warning / shutdown is detected
24	RESERVED	R	0h	Reserved
23	OTW	R	0h	Overtemperature warning status 0h = No overtemperature warning is detected 1h = Overtemperature warning is detected
22	TSD	R	0h	Overtemperature shutdown status 0h = No overtemperature shutdown is detected 1h = Overtemperature shutdown is detected
21	OCP_HC	R	0h	Overcurrent status on high-side switch of OUTC 0h = No overcurrent detected on high-side switch of OUTC 1h = Overcurrent detected on high-side switch of OUTC

**表 7-40. GATE\_DRIVER\_FAULT\_STATUS Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
20	OCP_LC	R	0h	Overcurrent status on low-side switch of OUTC 0h = No overcurrent detected on low-side switch of OUTC 1h = Overcurrent detected on low-side switch of OUTC
19	OCP_HB	R	0h	Overcurrent status on high-side switch of OUTB 0h = No overcurrent detected on high-side switch of OUTB 1h = Overcurrent detected on high-side switch of OUTB
18	OCP_LB	R	0h	Overcurrent status on low-side switch of OUTB 0h = No overcurrent detected on low-side switch of OUTB 1h = Overcurrent detected on low-side switch of OUTB
17	OCP_HA	R	0h	Overcurrent status on high-side switch of OUTA 0h = No overcurrent detected on high-side switch of OUTA 1h = Overcurrent detected on high-side switch of OUTA
16	OCP_LA	R	0h	Overcurrent status on low-side switch of OUTA 0h = No overcurrent detected on low-side switch of OUTA 1h = Overcurrent detected on low-side switch of OUTA
15	RESERVED	R	0h	Reserved
14	OTP_ERR	R	0h	One-time programmable (OTP) error 0h = No OTP error is detected 1h = OTP Error is detected
13	BUCK_OCP	R	0h	Buck regulator overcurrent status 0h = No buck regulator overcurrent is detected 1h = Buck regulator overcurrent is detected
12	BUCK_UV	R	0h	Buck regulator undervoltage status 0h = No buck regulator undervoltage is detected 1h = Buck regulator undervoltage is detected
11	VCP_UV	R	0h	Charge pump undervoltage status 0h = No charge pump undervoltage is detected 1h = Charge pump undervoltage is detected
10-0	RESERVED	R	0h	Reserved

### 7.8.1.2 CONTROLLER\_FAULT\_STATUS Register (Offset = E2h) [Reset = 00000000h]

CONTROLLER\_FAULT\_STATUS is shown in [Figure 7-77](#) and described in [Table 7-41](#).

Return to the [Summary Table](#).

Status of various faults

**Figure 7-77. CONTROLLER\_FAULT\_STATUS Register**

31	30	29	28	27	26	25	24
CONTROLLER_FAULT	RESERVED	IPD_FREQ_FAULT	IPD_T1_FAULT	IPD_T2_FAULT	RESERVED		
R-0h	R-0h	R-0h	R-0h	R-0h	R-0h		
23	22	21	20	19	18	17	16
ABN_SPEED	LOSS_OF_SYNC	NO_MTR	MTR_LCK	CBC_ILIMIT	LOCK_ILIMIT	MTR_UNDER_VOLTAGE	MTR_OVER_VOLTAGE
R-0h	R-0h	R-0h	R-0h	R-0h	R-0h	R-0h	R-0h
15	14	13	12	11	10	9	8
EXT_WD_TIME_OUT	RESERVED						
R-0h	R-0h						
7	6	5	4	3	2	1	0
RESERVED					STL_EN	STL_STATUS	APP_RESET
R-0h					R-0h	R-0h	R-0h

**Table 7-41. CONTROLLER\_FAULT\_STATUS Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	CONTROLLER_FAULT	R	0h	Logic OR of controller fault registers 0h = No controller fault condition is detected 1h = Controller fault condition is detected
30	RESERVED	R	0h	Reserved
29	IPD_FREQ_FAULT	R	0h	Indicates IPD frequency fault 0h = No IPD frequency fault detected 1h = IPD frequency fault detected
28	IPD_T1_FAULT	R	0h	Indicates IPD T1 fault 0h = No IPD T1 fault detected 1h = IPD T1 fault detected
27	IPD_T2_FAULT	R	0h	Indicates IPD T2 fault 0h = No IPD T2 fault detected 1h = IPD T2 fault detected
26-24	RESERVED	R	0h	Reserved
23	ABN_SPEED	R	0h	Indicates abnormal speed motor lock condition 0h = No abnormal speed fault detected 1h = Abnormal Speed fault detected
22	LOSS_OF_SYNC	R	0h	Indicates sync lost motor lock condition 0h = No sync lost fault detected 1h = Sync lost fault detected
21	NO_MTR	R	0h	Indicates no motor fault 0h = No motor fault not detected 1h = No motor fault detected
20	MTR_LCK	R	0h	Indicates when one of the motor lock is triggered 0h = Motor lock fault not detected 1h = Motor lock fault detected

**表 7-41. CONTROLLER\_FAULT\_STATUS Register Field Descriptions (continued)**

Bit	Field	Type	Reset	Description
19	CBC_ILIMIT	R	0h	Indicates CBC current limit fault 0h = No CBC fault detected 1h = CBC fault detected
18	LOCK_ILIMIT	R	0h	Indicates lock detection current limit fault 0h = No lock current limit fault detected 1h = Lock current limit fault detected
17	MTR_UNDER_VOLTAGE	R	0h	Indicates motor undervoltage fault 0h = No motor undervoltage detected 1h = Motor undervoltage detected
16	MTR_OVER_VOLTAGE	R	0h	Indicates motor overvoltage fault 0h = No motor overvoltage detected 1h = Motor overvoltage detected
15	EXT_WD_TIMEOUT	R	0h	Indicates external watchdog timeout fault 0h = No external watchdog timeout fault detected 1h = External watchdog timeout fault detected
14-3	RESERVED	R	0h	Reserved
2	STL_EN	R	0h	Indicates STL is enabled in EEPROM 0h = STL Disable 1h = STL Enable
1	STL_STATUS	R	0h	Indicates STL success criteria Pass = 1b; Fail = 0b 0h = STL Fail 1h = STL Pass
0	APP_RESET	R	0h	App reset 0h = App Reset Fail 1h = App Reset Successful

## 7.8.2 System\_Status Registers

表 7-42 lists the memory-mapped registers for the System\_Status registers. All register offset addresses not listed in 表 7-42 should be considered as reserved locations and the register contents should not be modified.

**表 7-42. SYSTEM\_STATUS Registers**

Offset	Acronym	Register Name	Section
E4h	SYS_STATUS1	System Status Register1	<a href="#">SYS_STATUS1 Register (Offset = E4h)</a> [Reset = 00000000h]
EAh	SYS_STATUS2	System Status Register2	<a href="#">SYS_STATUS2 Register (Offset = EAh)</a> [Reset = 00000000h]
ECh	SYS_STATUS3	System Status Register3	<a href="#">SYS_STATUS3 Register (Offset = ECh)</a> [Reset = 00000000h]

Complex bit access types are encoded to fit into small table cells. 表 7-43 shows the codes that are used for access types in this section.

**表 7-43. System\_Status Access Type Codes**

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

### 7.8.2.1 SYS\_STATUS1 Register (Offset = E4h) [Reset = 00000000h]

SYS\_STATUS1 is shown in [Figure 7-78](#) and described in [Table 7-44](#).

Return to the [Summary Table](#).

Status of various system and motor parameters

**Figure 7-78. SYS\_STATUS1 Register**

31	30	29	28	27	26	25	24
VOLT_MAG							
R-0h							
23	22	21	20	19	18	17	16
VOLT_MAG							
R-0h							
15	14	13	12	11	10	9	8
SPEED_CMD							
R-0h							
7	6	5	4	3	2	1	0
SPEED_CMD							I2C_ENTRY_S TATUS
R-0h							R-0h

**Table 7-44. SYS\_STATUS1 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31-16	VOLT_MAG	R	0h	Applied DC input voltage (/10 to get DC input voltage in V)
15-1	SPEED_CMD	R	0h	Decoded speed command in PWM/Analog/Freq. mode (SPEED_CMD (%) = SPEED_CMD/32767 * 100%)
0	I2C_ENTRY_STATUS	R	0h	Indicates if I2C entry has happened 0h = I2C mode not entered through pin sequence 1h = I2C mode entered through pin sequence



### 7.8.2.2 SYS\_STATUS2 Register (Offset = EAh) [Reset = 0000000h]

SYS\_STATUS2 is shown in [図 7-79](#) and described in [表 7-45](#).

Return to the [Summary Table](#).

Status of various system and motor parameters

**図 7-79. SYS\_STATUS2 Register**

31	30	29	28	27	26	25	24
STATE				RESERVED			
R-0h				R-0h			
23	22	21	20	19	18	17	16
RESERVED						STL_FAULT	RESERVED
R-0h						R-0h	R-0h
15	14	13	12	11	10	9	8
MOTOR_SPEED							
R-0h							
7	6	5	4	3	2	1	0
MOTOR_SPEED							
R-0h							

**表 7-45. SYS\_STATUS2 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31-28	STATE	R	0h	Current status of state machine; 4-bit value indicating status of state machine 0h = SYSTEM_IDLE 1h = MOTOR_START 2h = MOTOR_RUN 3h = SYSTEM_INIT 4h = MOTOR_IPD 5h = MOTOR_ALIGN 6h = MOTOR_IDLE 7h = MOTOR_STOP 8h = FAULT 9h = MOTOR_DIRECTION Ah = HALL_ALIGN Ch = MOTOR_FREEWHEEL Dh = MOTOR_DESCEL Eh = MOTOR_BRAKE Fh = N/A
27-18	RESERVED	R	0h	Reserved
17	STL_FAULT	R	0h	STL fault status 0h = Pass 1h = Fail
16	RESERVED	R	0h	Reserved
15-0	MOTOR_SPEED	R	0h	Speed output (/10 to get motor electrical speed in Hz)

### 7.8.2.3 SYS\_STATUS3 Register (Offset = ECh) [Reset = 00000000h]

SYS\_STATUS3 is shown in 表 7-80 and described in 表 7-46.

Return to the [Summary Table](#).

Status of various system and motor parameters

**表 7-80. SYS\_STATUS3 Register**

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DC_BUS_CURR																DC_BATT_POW															
R-0h																R-0h															

**表 7-46. SYS\_STATUS3 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31-16	DC_BUS_CURR	R	0h	DC bus current (/256 to get DC bus current in A)
15-0	DC_BATT_POW	R	0h	Battery (input) power (/64 to get battery power in W)

### 7.8.3 Algo\_Control Registers

表 7-47 lists the memory-mapped registers for the Algo\_Control registers. All register offset addresses not listed in 表 7-47 should be considered as reserved locations and the register contents should not be modified.

**表 7-47. ALGO\_CONTROL Registers**

Offset	Acronym	Register Name	Section
E6h	ALGO_CTRL1	Algorithm Control Parameters	<a href="#">ALGO_CTRL1 Register (Offset = E6h) [Reset = 00000000h]</a>

Complex bit access types are encoded to fit into small table cells. 表 7-48 shows the codes that are used for access types in this section.

**表 7-48. Algo\_Control Access Type Codes**

Access Type	Code	Description
<b>Write Type</b>		
W	W	Write
<b>Reset or Default Value</b>		
-n		Value after reset or the default value

### 7.8.3.1 ALGO\_CTRL1 Register (Offset = E6h) [Reset = 00000000h]

ALGO\_CTRL1 is shown in [図 7-81](#) and described in [表 7-49](#).

Return to the [Summary Table](#).

Algorithm Control Parameters

**図 7-81. ALGO\_CTRL1 Register**

31	30	29	28	27	26	25	24
EEPROM_WRT	EEPROM_READ	CLR_FLT	CLR_FLT_RETRY_COUNT	EEPROM_WRITE_ACCESS_KEY			
W-0h	W-0h	W-0h	W-0h	W-0h			
23	22	21	20	19	18	17	16
EEPROM_WRITE_ACCESS_KEY				RESERVED			
W-0h				W-0h			
15	14	13	12	11	10	9	8
RESERVED							
W-0h							
7	6	5	4	3	2	1	0
RESERVED							EXT_WD_STATUS_SET
W-0h							W-0h

**表 7-49. ALGO\_CTRL1 Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	EEPROM_WRT	W	0h	Write the configuration to EEPROM 1h = Write to the EEPROM registers from shadow registers
30	EEPROM_READ	W	0h	Read the default configuration from EEPROM 1h = Read the EEPROM registers to shadow registers
29	CLR_FLT	W	0h	Clears all faults 1h = Clear all the driver and controller faults
28	CLR_FLT_RETRY_COUNT	W	0h	Clears fault retry count 1h = clear the lock fault retry counts
27-20	EEPROM_WRITE_ACCESS_KEY	W	0h	EEPROM write access key; 8-bit key to unlock the EEPROM write command
19-1	RESERVED	W	0h	Reserved
0	EXT_WD_STATUS_SET	W	0h	Watchdog status to be set by external MCU in I2C watchdog mode 0h = Reset automatically by the MCC 1h = To set the EXT_WD_STATUS_SET

### 7.8.4 Device\_Control Registers

[表 7-50](#) lists the memory-mapped registers for the Device\_Control registers. All register offset addresses not listed in [表 7-50](#) should be considered as reserved locations and the register contents should not be modified.

**表 7-50. DEVICE\_CONTROL Registers**

Offset	Acronym	Register Name	Section
E8h	DEVICE_CTRL	Device Control Parameters	<a href="#">DEVICE_CTRL Register (Offset = E8h)</a> [Reset = 00000000h]

Complex bit access types are encoded to fit into small table cells. [表 7-51](#) shows the codes that are used for access types in this section.

表 7-51. Device\_Control Access Type Codes

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

#### 7.8.4.1 DEVICE\_CTRL Register (Offset = E8h) [Reset = 00000000h]

DEVICE\_CTRL is shown in 表 7-82 and described in 表 7-52.

Return to the [Summary Table](#).

Device Control Parameters

**表 7-82. DEVICE\_CTRL Register**

31	30	29	28	27	26	25	24
RESERVED	SPEED_CTRL						
W-0h	W-0h						
23	22	21	20	19	18	17	16
SPEED_CTRL							
W-0h							
15	14	13	12	11	10	9	8
OVERVERRIDE	RESERVED						
W-0h	R-0h						
7	6	5	4	3	2	1	0
RESERVED							
R-0h							

**表 7-52. DEVICE\_CTRL Register Field Descriptions**

Bit	Field	Type	Reset	Description
31	RESERVED	W	0h	Reserved
30-16	SPEED_CTRL	W	0h	Digital speed command ( $\text{SPEED\_CTRL (\%)} = \text{SPEED\_CTRL} / 32767 * 100\%$ )
15	OVERVERRIDE	W	0h	Speed input select for I2C vs speed pin 0h = SPEED_CMD using Analog/Freq/PWM mode 1h = SPEED_CMD using SPD_CTRL[14:0]
14-0	RESERVED	R	0h	Reserved

#### 7.8.5 Algorithm\_Variables Registers

表 7-53 lists the memory-mapped registers for the Algorithm\_Variables registers. All register offset addresses not listed in 表 7-53 should be considered as reserved locations and the register contents should not be modified.

**表 7-53. ALGORITHM\_VARIABLES Registers**

Offset	Acronym	Register Name	Section
40Ch	INPUT_DUTY	Input Duty Cycle	<a href="#">INPUT_DUTY Register (Offset = 40Ch)</a> [Reset = 00000000h]
4F6h	CURRENT_DUTY	Current Duty Cycle	<a href="#">CURRENT_DUTY Register (Offset = 4F6h)</a> [Reset = 00000000h]
506h	SET_DUTY	Set Duty Cycle	<a href="#">SET_DUTY Register (Offset = 506h)</a> [Reset = 00000000h]
5B2h	MOTOR_SPEED_PU	Motor Speed in PU	<a href="#">MOTOR_SPEED_PU Register (Offset = 5B2h)</a> [Reset = 00000000h]
6F4h	DC_BUS_POWER_PU	DC Bus Power in PU	<a href="#">DC_BUS_POWER_PU Register (Offset = 6F4h)</a> [Reset = 00000000h]

Complex bit access types are encoded to fit into small table cells. 表 7-54 shows the codes that are used for access types in this section.

表 7-54. Algorithm\_Variables Access Type Codes

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

### 7.8.5.1 INPUT\_DUTY Register (Offset = 40Ch) [Reset = 00000000h]

INPUT\_DUTY is shown in [図 7-83](#) and described in [表 7-55](#).

Return to the [Summary Table](#).

Input duty cycle from SPEED pin or SPEED\_CMD (Input duty cycle( in %) = (Measured voltage on DAC pin) / 3V \*100 )

**図 7-83. INPUT\_DUTY Register**

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
INPUT_DUTY																															
R-0h																															

**表 7-55. INPUT\_DUTY Register Field Descriptions**

Bit	Field	Type	Reset	Description
31-0	INPUT_DUTY	R	0h	32-bit value indicating the duty cycle that the user commands Input duty cycle (in %) = (Input Duty Cycle / 2 <sup>30</sup> ) * 100

### 7.8.5.2 CURRENT\_DUTY Register (Offset = 4F6h) [Reset = 00000000h]

CURRENT\_DUTY is shown in [Figure 7-84](#) and described in [Table 7-56](#).

Return to the [Summary Table](#).

Current duty cycle (Current duty cycle( in %) = (Measured voltage on DAC pin) / 3V \*100 )

**Figure 7-84. CURRENT\_DUTY Register**

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CURRENT_DUTY																															
R-0h																															

**Table 7-56. CURRENT\_DUTY Register Field Descriptions**

Bit	Field	Type	Reset	Description
31-0	CURRENT_DUTY	R	0h	32-bit value indicating the duty cycle that is currently being applied. Current duty cycle (in %) = (Current Duty Cycle / 2 <sup>30</sup> ) * 100



### 7.8.5.3 SET\_DUTY Register (Offset = 506h) [Reset = 00000000h]

SET\_DUTY is shown in [Figure 7-85](#) and described in [Table 7-57](#).

Return to the [Summary Table](#).

Target duty cycle (Set duty cycle( in %) = (Measured voltage on DAC pin) / 3V \*100 )

**Figure 7-85. SET\_DUTY Register**

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SET_DUTY																															
R-0h																															

**Table 7-57. SET\_DUTY Register Field Descriptions**

Bit	Field	Type	Reset	Description
31-0	SET_DUTY	R	0h	32-bit value indicating the duty cycle that the FW wants. Set duty cycle (in %) = (Set Duty Cycle / 2 <sup>30</sup> ) * 100

#### 7.8.5.4 MOTOR\_SPEED\_PU Register (Offset = 5B2h) [Reset = 00000000h]

MOTOR\_SPEED\_PU is shown in [Figure 7-86](#) and described in [Table 7-58](#).

Return to the [Summary Table](#).

Motor speed in PU (Motor speed (in Hz) = (Measured voltage on DAC pin) / 3V \* Maximum speed (in Hz))

Maximum speed (in Hz) = MAX\_SPEED/16

**Figure 7-86. MOTOR\_SPEED\_PU Register**

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MOTOR_SPEED_PU																															
R-0h																															

**Table 7-58. MOTOR\_SPEED\_PU Register Field Descriptions**

Bit	Field	Type	Reset	Description
31-0	MOTOR_SPEED_PU	R	0h	32-bit value indicating the speed of the motor. Motor speed (in Hz) = (Motor Speed in PU / 2 <sup>30</sup> ) * (MAX_SPEED / 16)

### 7.8.5.5 DC\_BUS\_POWER\_PU Register (Offset = 6F4h) [Reset = 00000000h]

DC\_BUS\_POWER\_PU is shown in [図 7-87](#) and described in [表 7-59](#).

Return to the [Summary Table](#).

DC bus power in PU (DC bus power( in W) = (Measured voltage on DAC pin) / 3V \* Maximum power(in W))  
Maximum power (in W) = MAX\_POWER/4

**図 7-87. DC\_BUS\_POWER\_PU Register**

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
DC_BUS_POWER_PU																															
R-0h																															

**表 7-59. DC\_BUS\_POWER\_PU Register Field Descriptions**

Bit	Field	Type	Reset	Description
31-0	DC_BUS_POWER_PU	R	0h	32-bit value indicating the power drawn by the motor. DC Bus Power (in W) = (DC Bus Power in PU / 2 <sup>30</sup> ) * (MAX_POWER / 4)

## 8 Application and Implementation

### 注

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.

### 8.1 Application Information

The MCT8315A device is used in sensorless 3-phase BLDC motor control. The driver provides a high performance, high-reliability, flexible solution for robotic vacuum, fuel pumps, automotive fans and blowers, medical CPAP blowers etc., The following section shows a common application of the MCT8315A device.

### 8.2 Typical Applications

图 8-1 shows the typical schematic of MCT8315A.

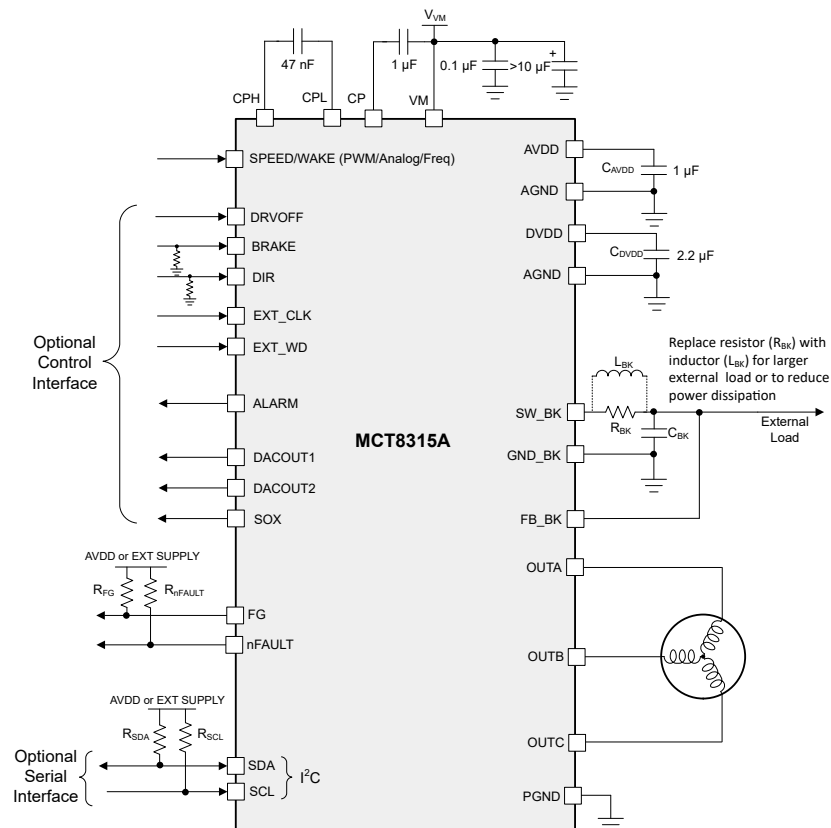


图 8-1. Primary Application Schematic

表 8-1 lists the recommended values of the external components for MCT8315A.

表 8-1. MCT8315A External Components

COMPONENTS	PIN 1	PIN 2	RECOMMENDED
C <sub>VM1</sub>	VM	PGND	X5R or X7R, 0.1-μF, TI recommends a capacitor voltage rating at least twice the normal operating voltage of the device
C <sub>VM2</sub>	VM	PGND	≥ 10-μF, TI recommends a capacitor voltage rating at least twice the normal operating voltage of the device

**表 8-1. MCT8315A External Components (continued)**

COMPONENTS	PIN 1	PIN 2	RECOMMENDED
C <sub>CP</sub>	CP	VM	X5R or X7R, 16-V, 1-μF capacitor
C <sub>FLY</sub>	CPH	CPL	X5R or X7R, 47-nF, TI recommends a capacitor voltage rating at least twice the normal operating voltage of the pin
C <sub>AVDD</sub>	AVDD	AGND	X5R or X7R, 1-μF, ≥ 6.3-V. In order for AVDD to accurately regulate output voltage, capacitor should have effective capacitance between 0.7-μF to 1.3-μF at 3.3-V across operating temperature.
C <sub>DVDD</sub>	DVDD	DGND	X5R or X7R, 2.2-μF, ≥ 6.3-V. In order for DVDD to accurately regulate output voltage, capacitor should have effective capacitance between 1.1-μF to 2.5-μF at 1.5-V across operating temperature.
C <sub>BK</sub>	FB_BK	GND_BK	X5R or X7R, buck-output rated capacitor
L <sub>BK</sub>	SW_BK	FB_BK	Buck-output inductor
R <sub>FG</sub>	1.8 to 5-V Supply	FG	5.1-kΩ, Pull-up resistor
R <sub>nFAULT</sub>	1.8 to 5-V Supply	nFAULT	5.1-kΩ, Pull-up resistor
R <sub>SDA</sub>	1.8 to 3.3-V Supply	SDA	5.1-kΩ, Pull-up resistor
R <sub>SCL</sub>	1.8 to 3.3-V Supply	SCL	5.1-kΩ, Pull-up resistor

Recommended application range for MCT8315A is shown in [表 8-2](#).

**表 8-2. Recommended Application Range**

Parameter	Min	Max	Unit
Motor voltage	4.5	35	V
Motor electrical speed	-	3000	Hz
Peak motor phase current	-	4	A

Default EEPROM configuration for MCT8315A is listed in [表 8-3](#). Default values are chosen for reliable motor start-up and closed loop operation. Refer to [MCT8315A tuning guide](#) which provides step by step procedure to tune a 3-phase BLDC motor in closed loop, conform to use-case and explore features in the device.

**表 8-3. Recommended Default Values**

Address Name	Address	Recommended Value
ISD_CONFIG	0x00000080	0x6EC4C100
MOTOR_STARTUP1	0x00000082	0x2EA610E4
MOTOR_STARTUP2	0x00000084	0x1221109C
CLOSED_LOOP1	0x00000086	0x0C321200
CLOSED_LOOP2	0x00000088	0x024224B0
CLOSED_LOOP3	0x0000008A	0x4CCC03E0
CLOSED_LOOP4	0x0000008C	0x000CE944
CONST_SPEED	0x0000008E	0x00A00510
CONST_PWR	0x00000090	0x5DC04C84
FAULT_CONFIG1	0x00000092	0x60F43025
FAULT_CONFIG2	0x00000094	0x7F87A009
TRAP_CONFIG1	0x0000009A	0x0548A186
TRAP_CONFIG2	0x0000009C	0x3A840000
150_DEG_TWO_PH_PROFILE	0x00000096	0x6ADB44A6
150_DEG_THREE_PH_PROFILE	0x00000098	0x392DFF80
PIN_CONFIG1	0x000000A4	0x2D720600
PIN_CONFIG2	0x000000A6	0x08000000

**表 8-3. Recommended Default Values (continued)**

DEVICE_CONFIG	0x000000A8	0x7FFF0000
PERIPH_CONFIG	0x000000AA	0x00000000
GD_CONFIG1	0x000000AC	0x1C440000
GD_CONFIG2	0x000000AE	0x00000000

Once the device EEPROM is programmed with the desired configuration, device can be operated stand-alone and I<sup>2</sup>C serial interface is not required anymore. Speed can be commanded using SPEED pin.

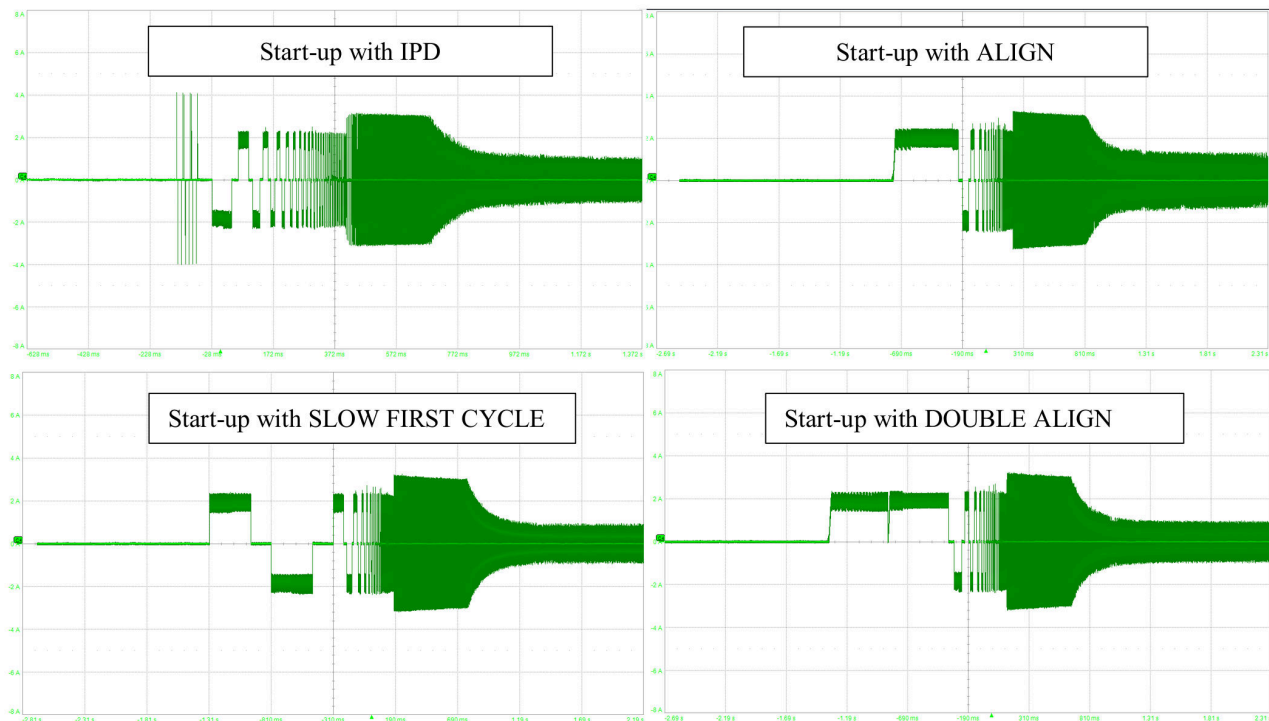
Below are the two essential parameters that are required to spin the motor in closed loop.

1. Maximum motor speed.
2. Cycle by cycle (CBC) current limit.

### 8.2.1 Application curves

#### 8.2.1.1 Motor startup

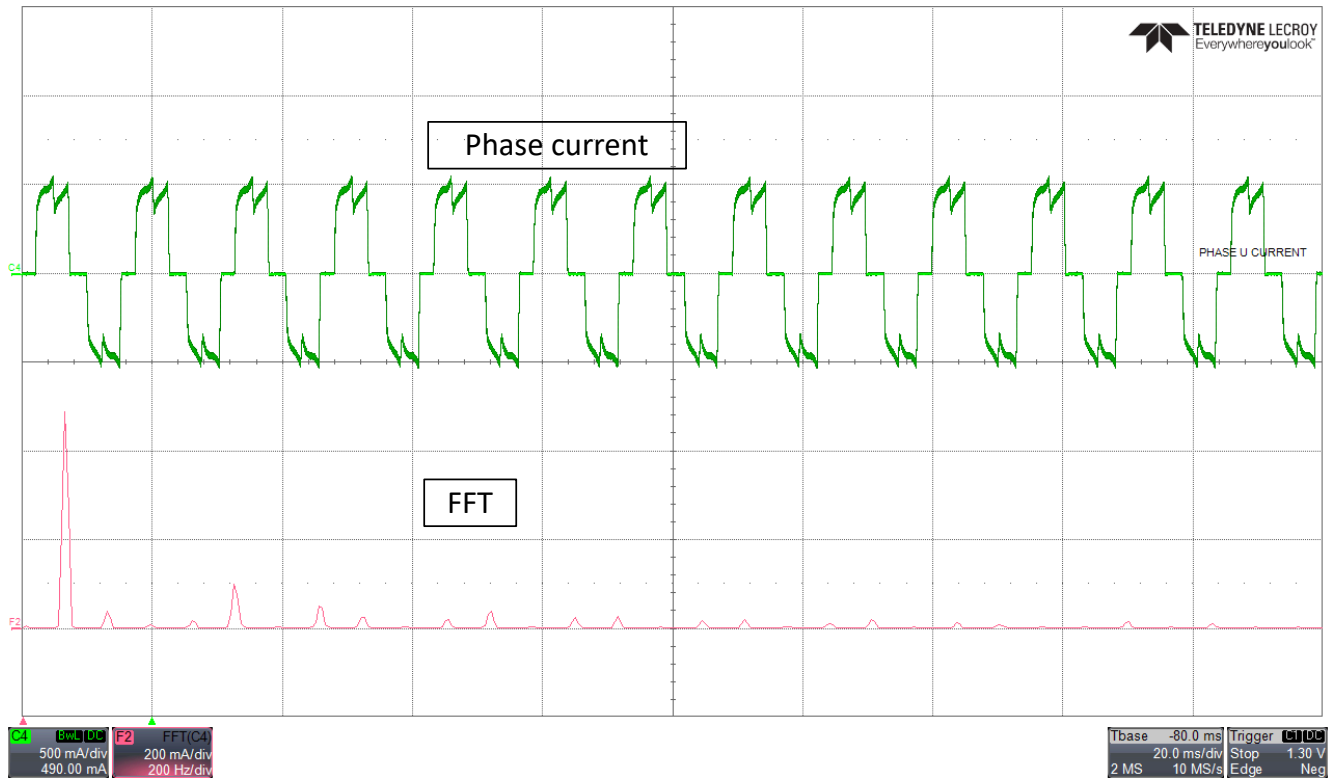
☒ 8-2 shows the phase current waveforms of various startup methods in MCT8315A such as align, double align, IPD and slow first cycle.

**☒ 8-2. Motor phase current waveforms of all startup methods**

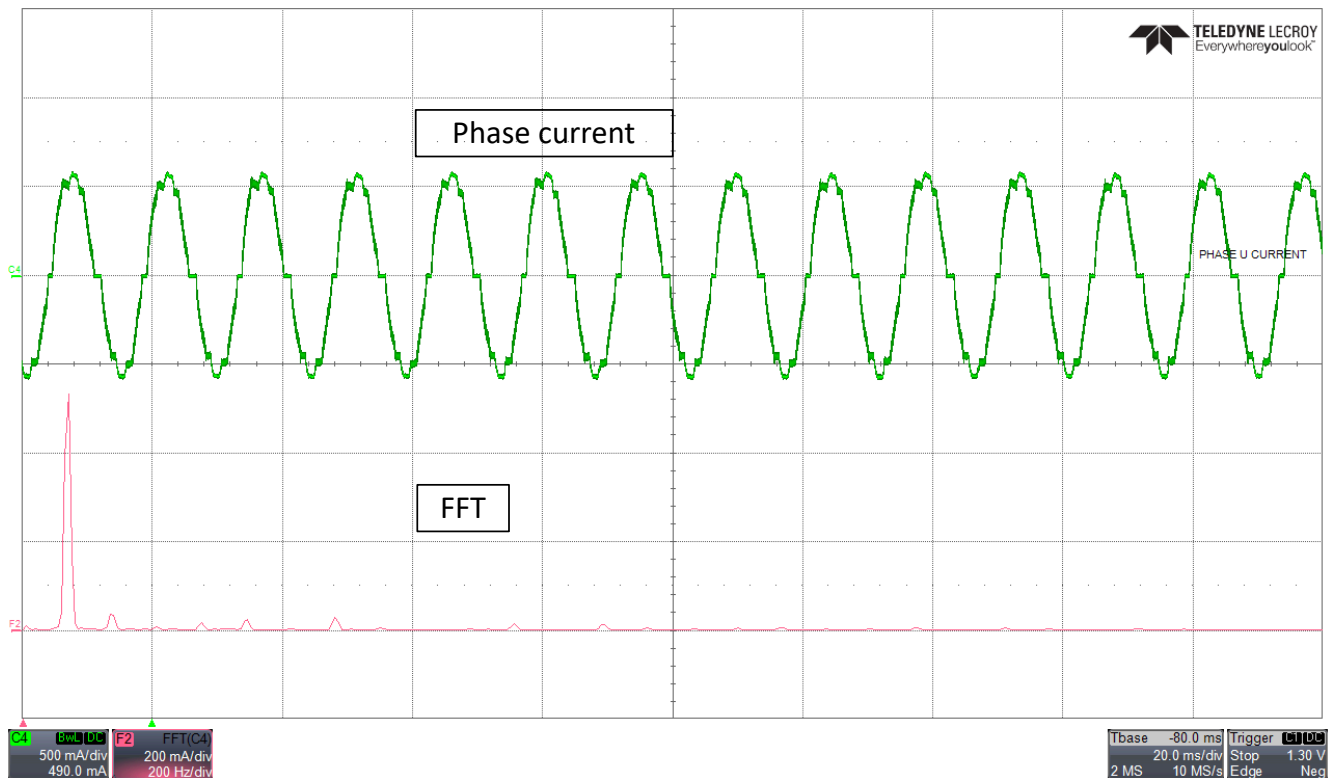
#### 8.2.1.2 120° and variable commutation

In 120° commutation scheme, each motor phase is driven for 120° and Hi-Z for 60° within each half electrical cycle, resulting in six different commutation states for a motor. ☒ 8-3 shows the phase current and current waveform FFT in 120° commutation mode. In variable commutation scheme, MCT8315A device switches dynamically between 120° and 150° trapezoidal commutation depending on motor speed. The device operates

in 150° mode at lower speeds and moves to 120° mode at higher speeds. [Figure 8-4](#) shows the phase current and current waveform FFT in 150° commutation.



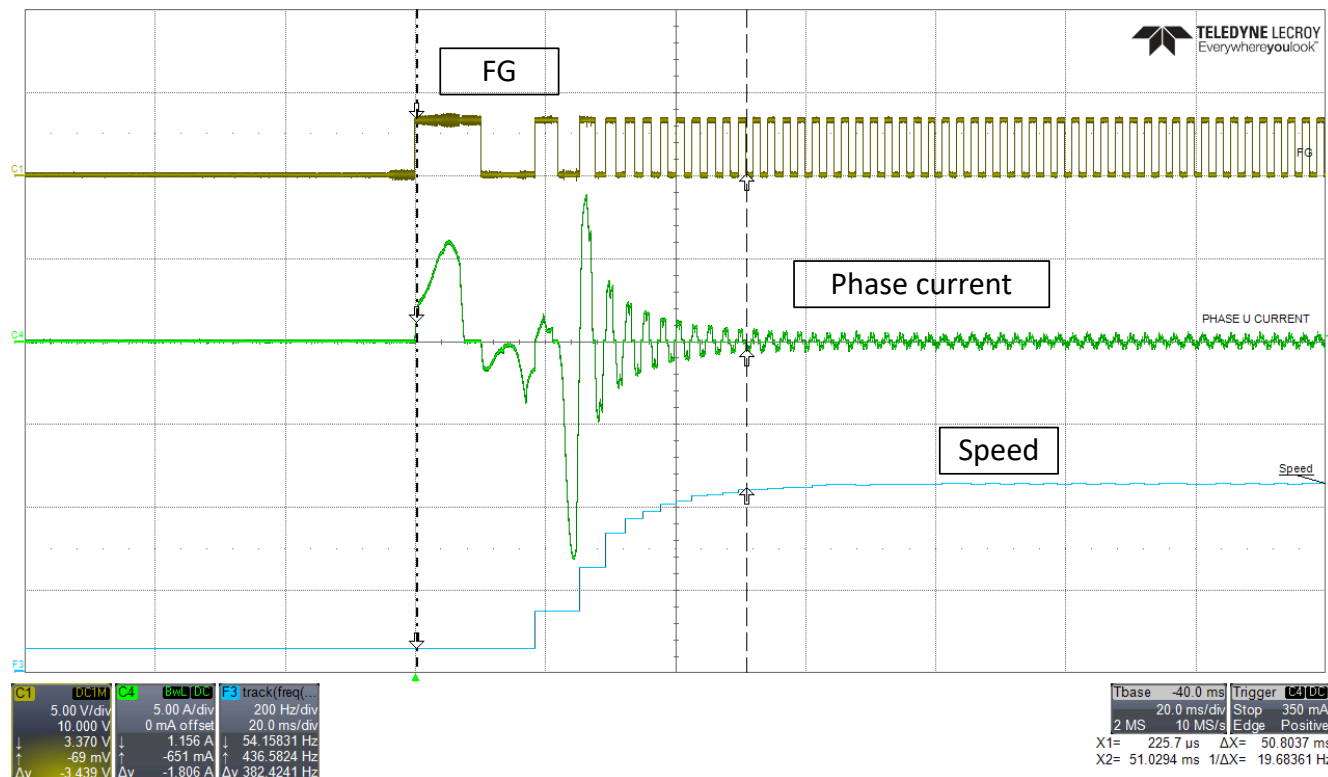
**Figure 8-3. Phase current and FFT - 120 °commutation**



**Figure 8-4. Phase current and FFT - 150°commutation**

### 8.2.1.3 Faster startup time

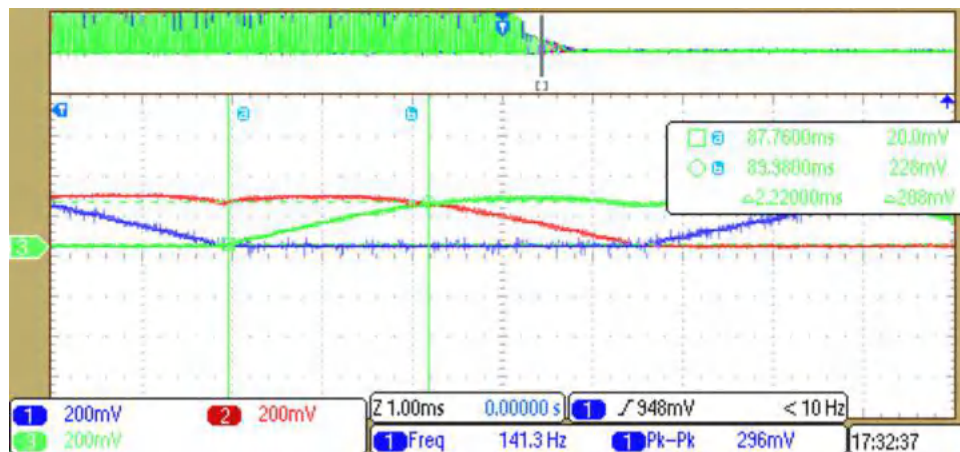
Startup time is the time taken for the motor to reach the target speed from zero speed. Faster startup time can be achieved in MCT8315A by tuning motor startup, open loop and closed loop settings. [Figure 8-5](#) shows FG, phase current and motor electrical speed waveform. Motor takes 50 ms to reach target speed from zero speed.



**Figure 8-5. Phase current, FG and motor speed - Faster startup time**

### 8.2.1.4 Setting the BEMF threshold

The BEMF\_THRESHOLD1 and BEMF\_THRESHOLD2 values used for commutation instant detection in MCT8315A can be computed from the motor phase voltage waveforms during coasting. For example, consider the three-phase voltage waveforms of a BLDC motor while coasting as in [Figure 8-6](#). The motor phase voltage during coasting is the motor back-EMF.



**Figure 8-6. Motor phase voltage during coasting**

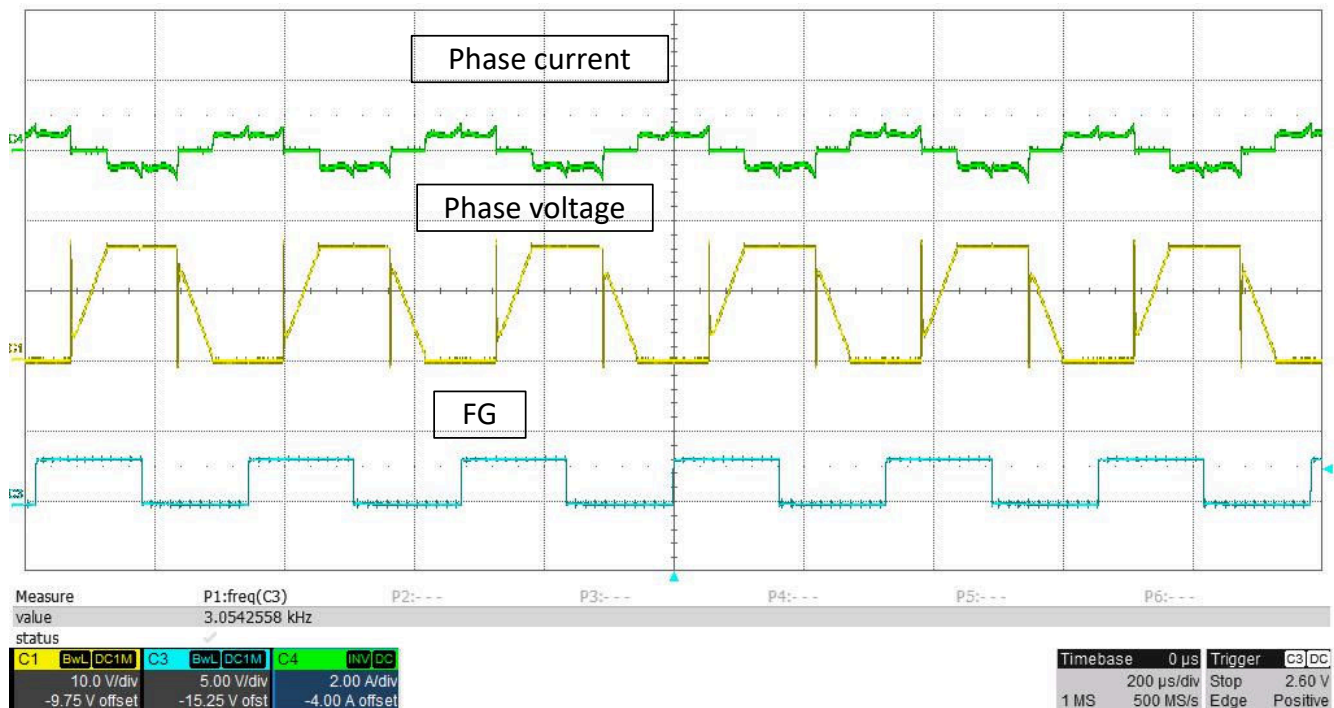


In [Figure 8-6](#), one floating phase voltage interval is denoted by the vertical markers on channel 3. The Vpeak (peak-peak back-EMF) on channel 3 is 208-mV and Tc (commutation interval) is 2.22-ms as denoted by the horizontal and vertical markers on channel 3. The digital equivalent counts for Vpeak and Tc are calculated as follows.

In MCT8315A, a 3-V analog input corresponds to 4095 counts(12-bit) and phase voltage is scaled down by 10x factor before ADC input; therefore, Vpeak of 208-mV corresponds to an ADC input of 20.8mV, which in turn equals 29 ADC counts. Assuming the PWM switching frequency is 25-kHz, one back-EMF sample is available every 40-μs. So, in a time interval of 2.22-ms, a total of 55 back-EMF samples are integrated. Therefore, the BEMF\_THRESHOLD1 or BEMF\_THRESHOLD2 value calculated as per [Equation 7](#) is  $(\frac{1}{2}) * (29/2) * (55/2) = 199$ . Hence, in this example, BEMF\_THRESHOLD1 and BEMF\_THRESHOLD2 are set to 8h (corresponding to 200 which is the closest value to 199) for commutation instant detection using back-EMF integration method during fast start-up. The exact speed at which the Vpeak and Tc values are measured to calculate the BEMF\_THRESHOLD1 and BEMF\_THRESHOLD2 values is not critical (as long as there is sufficient resolution in digital counts) since the product (Vpeak \* Tc) is, largely, a constant for a given BLDC motor.

### 8.2.1.5 Maximum speed

[Figure 8-7](#) shows phase current, phase voltage and FG of a motor that spins at maximum electrical speed of 3 kHz.



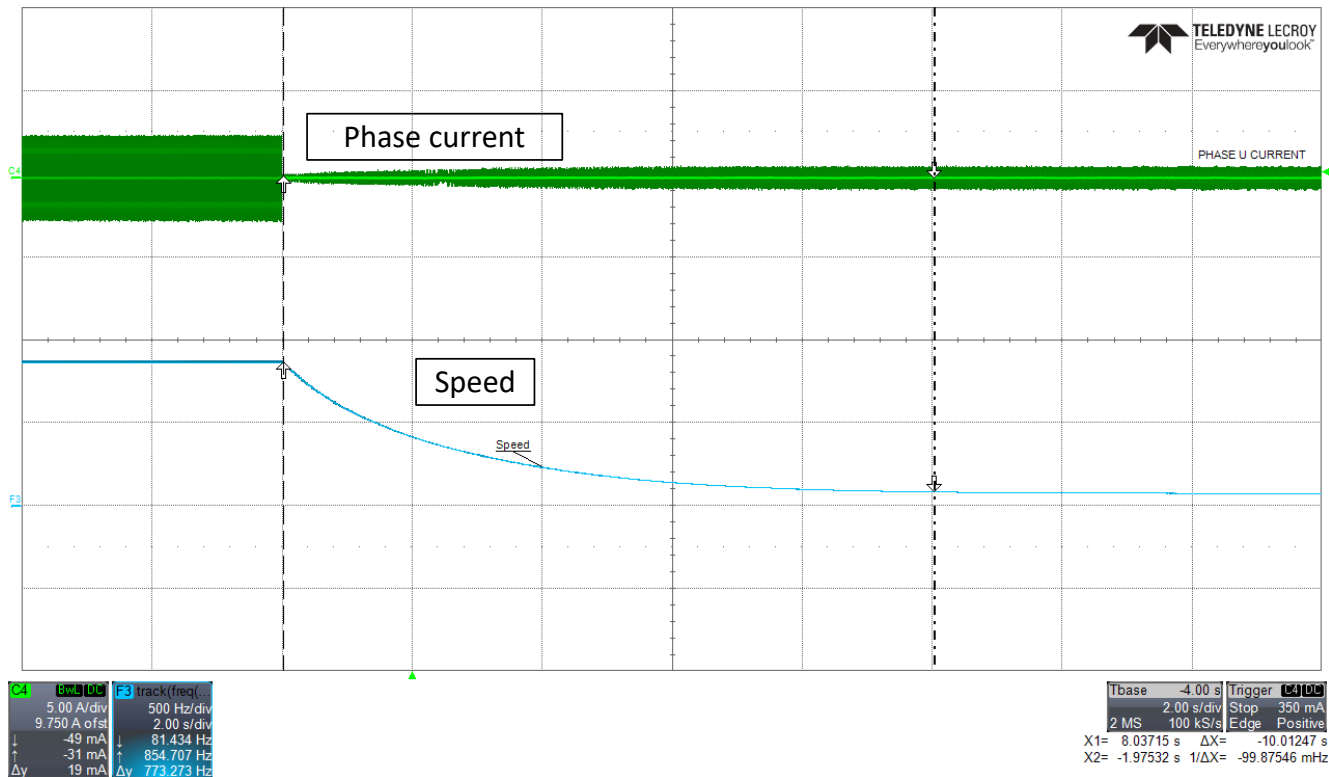
**Figure 8-7. Phase current, Phase voltage and FG at Maximum speed**

### 8.2.1.6 Faster deceleration

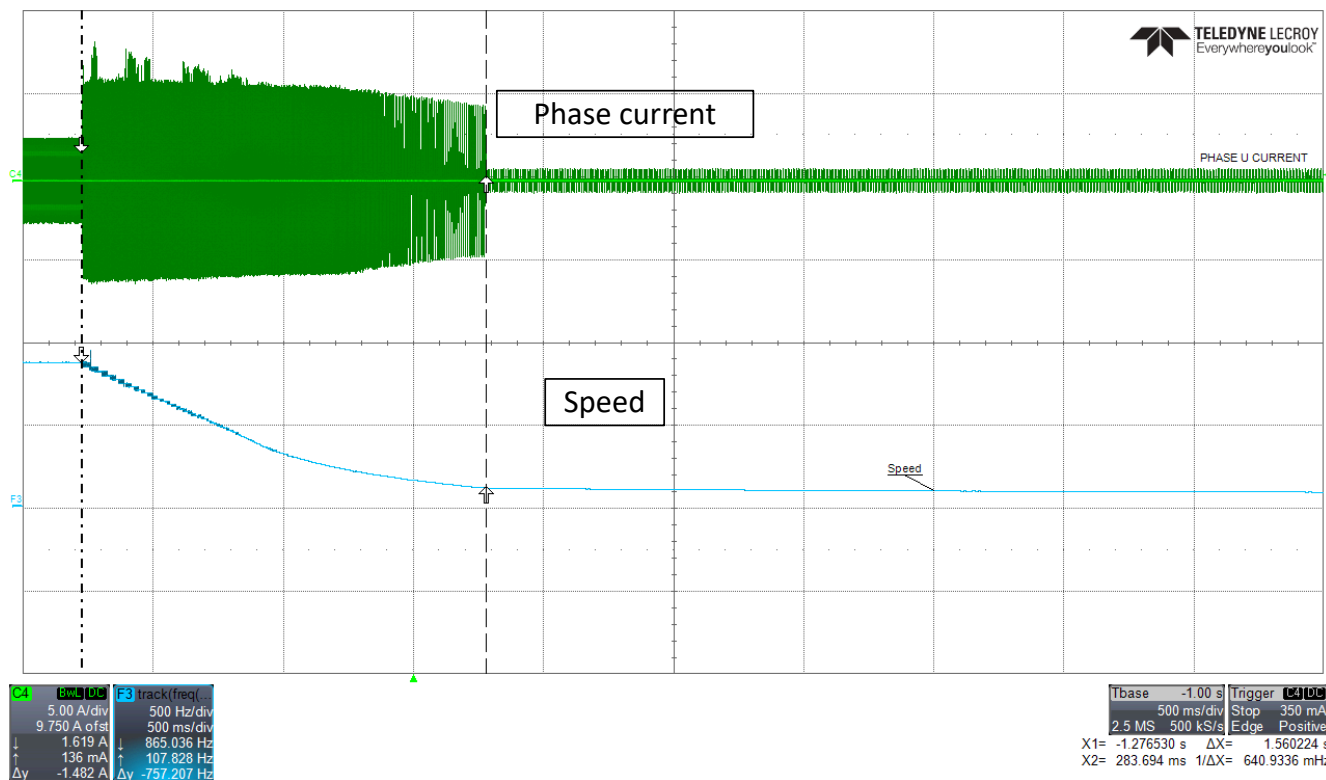
MCT8315A has features to decelerate the motor quickly. [Figure 8-8](#) shows phase current and motor electrical speed waveform when the motor decelerates from 100% duty cycle to 10% duty cycle. Time taken for the motor to decelerate from 100% duty cycle to 10% duty cycle when fast deceleration is disabled is around 10 seconds. [Figure 8-9](#) shows phase current and motor electrical speed waveform when the motor decelerates from 100% duty cycle to 10% duty cycle. Time taken for the motor to decelerate from 100% duty cycle to 10% duty cycle when fast deceleration is enabled is around 1.5 seconds.

注

Please note that when fast deceleration is enabled and anti-voltage surge (AVS) is disabled, there might be voltage spikes seen in supply voltage. Enable AVS to protect the power supply from voltage overshoots during motor deceleration.



8-8. Phase current and motor speed - Faster deceleration disabled




**8-9. Phase current and motor speed -Faster deceleration enabled**

## 9 Power Supply Recommendations

### 9.1 Bulk Capacitance

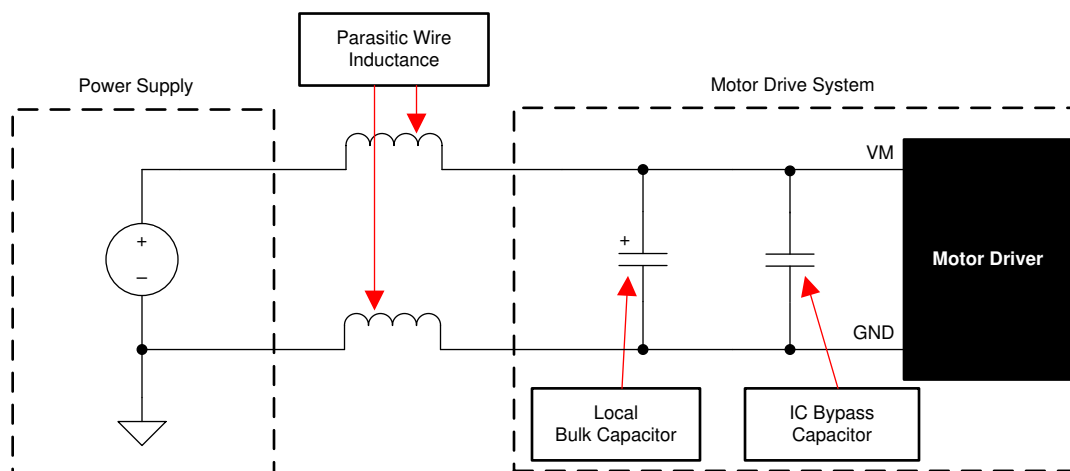
Having an appropriate local bulk capacitance is an important factor in motor drive system design. It is generally beneficial to have more bulk capacitance, while the disadvantages are increased cost and physical size.

The amount of local capacitance needed depends on a variety of factors, including:

- The highest current required by the motor system
- The capacitance and current capability of the power supply
- The amount of parasitic inductance between the power supply and motor system
- The acceptable voltage ripple
- The type of motor used (brushed DC, brushless DC, stepper)
- The motor braking method

The inductance between the power supply and the motor drive system limits the rate at which current can change from the power supply. If the local bulk capacitance is too small, the system responds to excessive current demands or dumps from the motor with a change in VM voltage. When adequate bulk capacitance is used, the VM voltage remains stable and high current can be quickly supplied.

The data sheet generally provides a recommended value, but system-level testing is required to determine the appropriate bulk capacitor.



**9-1. Example Setup of Motor Drive System With External Power Supply**

The voltage rating for bulk capacitors should be higher than the operating voltage, to provide margin for cases when the motor transfers energy to the supply.

## 10 Layout

### 10.1 Layout Guidelines

The bulk capacitor should be placed to minimize the distance of the high-current path through the motor driver device. The connecting metal trace widths should be as wide as possible, and numerous vias should be used when connecting PCB layers. These practices minimize parasitic inductance and allow the bulk capacitor to deliver high current.

Small-value capacitors should be ceramic, and placed closely to device pins.

The high-current device outputs should use wide metal traces.

To reduce noise coupling and EMI interference from large transient currents into small-current signal paths, grounding should be partitioned between PGND and AGND. TI recommends connecting all non-power stage circuitry (including the thermal pad) to AGND to reduce parasitic effects and improve power dissipation from the device. Optionally, GND\_BK can be split. Ensure grounds are connected through net-ties or wide resistors to reduce voltage offsets and maintain gate driver performance.

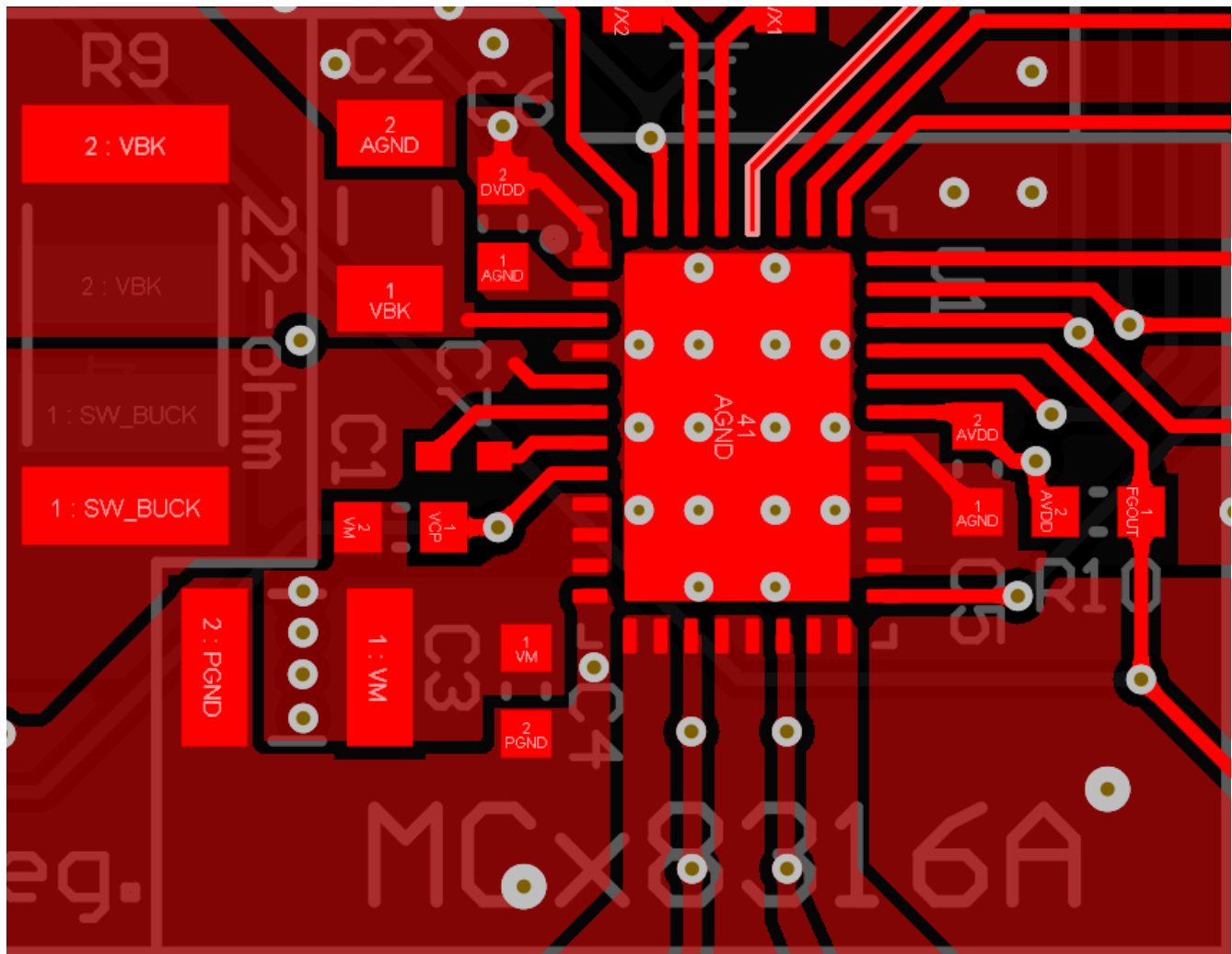
The device thermal pad should be soldered to the PCB top-layer ground plane. Multiple vias should be used to connect to a large bottom-layer ground plane. The use of large metal planes and multiple vias helps dissipate the  $I^2 \times R_{DS(on)}$  heat that is generated in the device.

To improve thermal performance, maximize the ground area that is connected to the thermal pad ground across all possible layers of the PCB. Using thick copper pours can lower the junction-to-air thermal resistance and improve thermal dissipation from the die surface.

Separate the SW\_BK and FB\_BK traces with ground separation to reduce buck switching from coupling as noise into the buck outer feedback loop. Widen the FB\_BK trace as much as possible to allow for faster load switching.

✉ 10-1 shows a layout example for the MCT8315A. Also, for layout example, refer to [MCT8315A EVM](#).

## 10.2 Layout Example



### ❏ 10-1. Recommended Layout Example

## 10.3 Thermal Considerations

The MCT8315A has thermal shutdown (TSD) as previously described. A die temperature in excess of 150°C (minimally) disables the device until the temperature drops to a safe level.

Any tendency of the device to enter thermal shutdown is an indication of excessive power dissipation, insufficient heatsinking, or too high an ambient temperature.

### 10.3.1 Power Dissipation

The power dissipated in the output FET resistance ( $R_{DS(on)}$ ) dominates power dissipation in MCT8315A.

At start-up and fault conditions, the FET current is much higher than normal operating FET current; remember to take these peak currents and their duration into consideration.

The total device power dissipation is the power dissipated in each of the three half-bridges added together along with standby power, LDO and buck regulator losses.

The maximum amount of power that the device can dissipate depends on ambient temperature and heatsinking.

Note that  $R_{DS(on)}$  increases with temperature, so as the device heats, the power dissipation increases. Take this into consideration when sizing the heatsink.

A summary of equations for calculating each loss is shown below in [表 10-1](#).

**表 10-1. Power Losses for MCT8315A**

Loss type	MCT8315A
Standby power	$P_{standby} = VM \times I_{VM\_TA}$
LDO	$P_{LDO} = (VM - V_{AVDD}) \times I_{AVDD}$ , if BUCK_PS_DIS = 1b $P_{LDO} = (V_{BK} - V_{AVDD}) \times I_{AVDD}$ , if BUCK_PS_DIS = 0b
FET conduction	$P_{CON} = 2 \times (I_{RMS(trap)})^2 \times R_{ds,on(TA)}$
FET switching	$P_{SW} = I_{PK(trap)} \times V_{PK(trap)} \times t_{rise/fall} \times f_{PWM}$
Diode	$P_{diode} = I_{PK(trap)} \times V_{diode} \times t_{dead} \times f_{PWM}$
Demagnetization	Without Active Demag: $3 \times I_{PK(trap)} \times V_{diode} \times t_{commutation} \times f_{motor\_elec}$ With Active Demag: $3 \times (I_{RMS(trap)})^2 \times R_{ds,on(TA)} \times t_{commutation} \times f_{motor\_elec}$
Buck	$P_{BK} = 0.11 \times V_{BK} \times I_{BK}$ ( $\eta_{BK} = 90\%$ )

## 11 Device and Documentation Support

### 11.1 サポート・リソース

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### 11.2 Trademarks

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### 11.3 静電気放電に関する注意事項



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ESD による破損は、わずかな性能低下からデバイスの完全な故障まで多岐にわたります。精密な IC の場合、パラメータがわずかに変化するだけで公表されている仕様から外れる可能性があるため、破損が発生しやすくなっています。

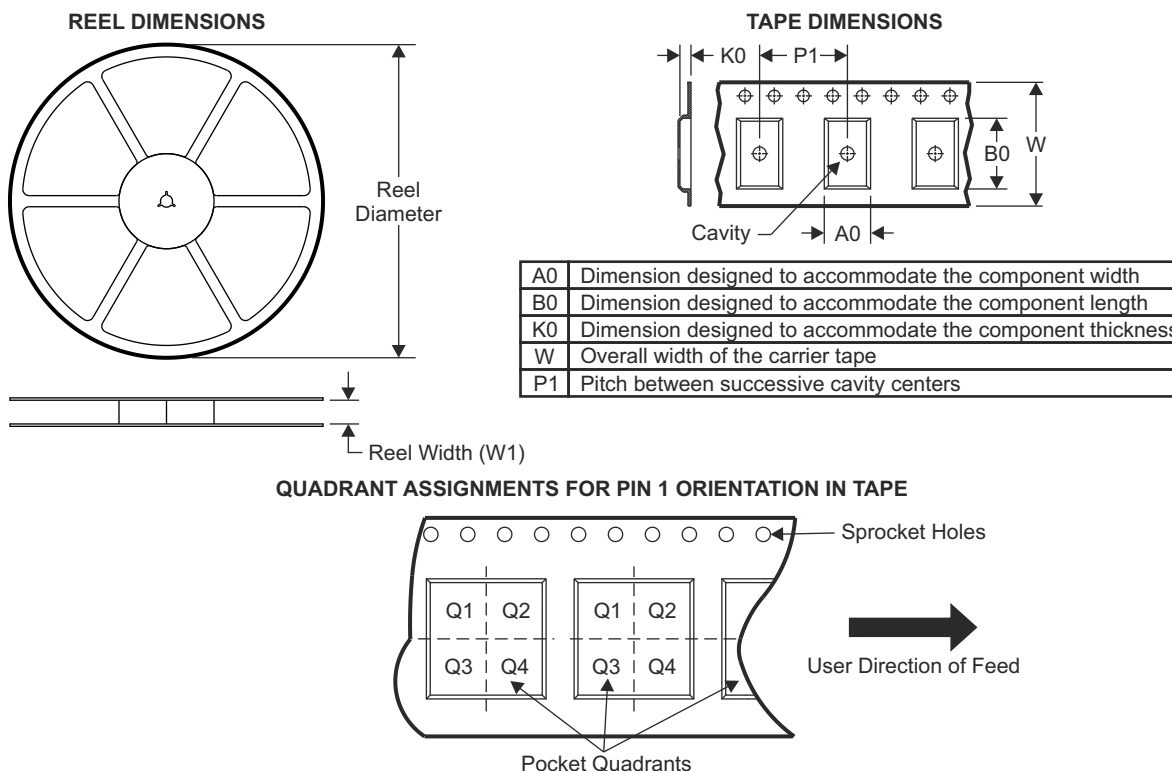
### 11.4 用語集

[テキサス・インスツルメンツ用語集](#) この用語集には、用語や略語の一覧および定義が記載されています。

## 12 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 device. This data is subject to change without notice and without revision of this document. For browser-based versions of this data sheet, see the left-hand navigation pane.

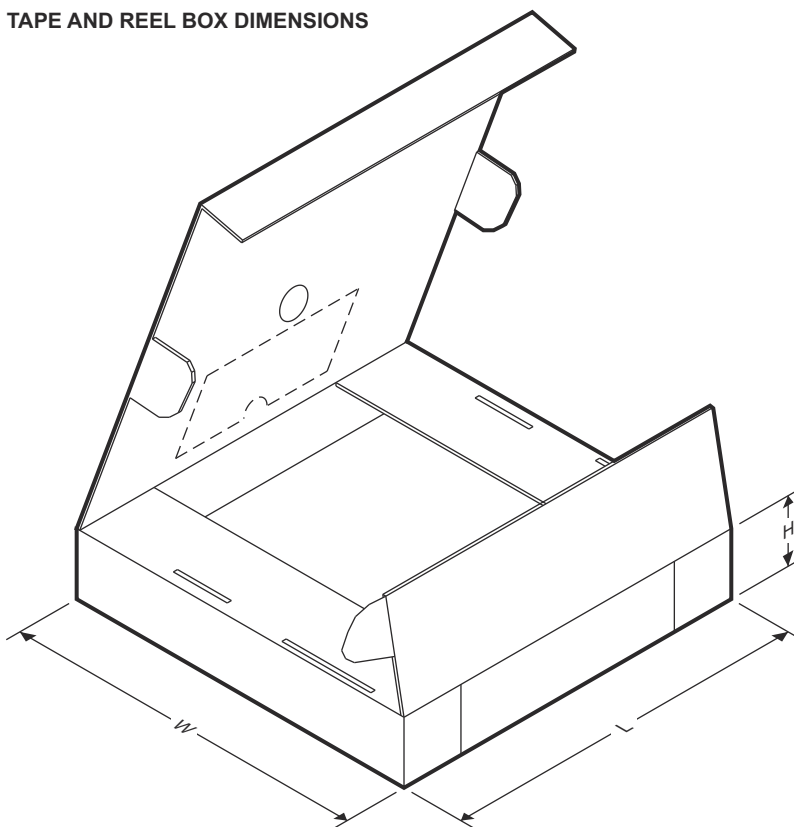
### 12.1 Tape and Reel Information





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
MCT8315A1VRGFR	VQFN	RGF	40	3000	330.0	16.4	5.25	7.25	1.45	8.0	16.0	Q1

**TAPE AND REEL BOX DIMENSIONS**



Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
MCT8315A1VRGFR	VQFN	RGF	40	3000	367.0	367.0	38.0

## 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)
<a href="#">MCT8315A1VRGFR</a>	Active	Production	VQFN (RGF)   40	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	MCT83 15A1V
MCT8315A1VRGFR.A	Active	Production	VQFN (RGF)   40	3000   LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	MCT83 15A1V
MCT8315A1VRGFR.B	Active	Production	VQFN (RGF)   40	3000   LARGE T&R	-	Call TI	Call TI	-40 to 125	

(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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## TAPE AND REEL INFORMATION



\*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
MCT8315A1VRGFR	VQFN	RGF	40	3000	330.0	16.4	5.25	7.25	1.45	8.0	16.0	Q1

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
MCT8315A1VRGFR	VQFN	RGF	40	3000	367.0	367.0	35.0

## GENERIC PACKAGE VIEW

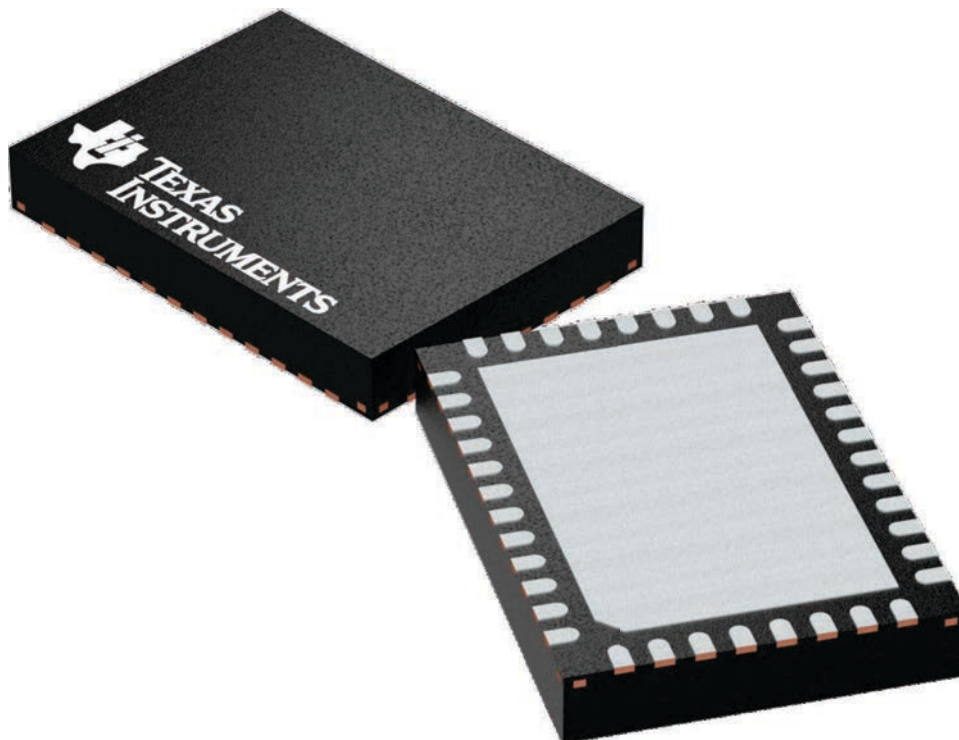
**RGF 40**

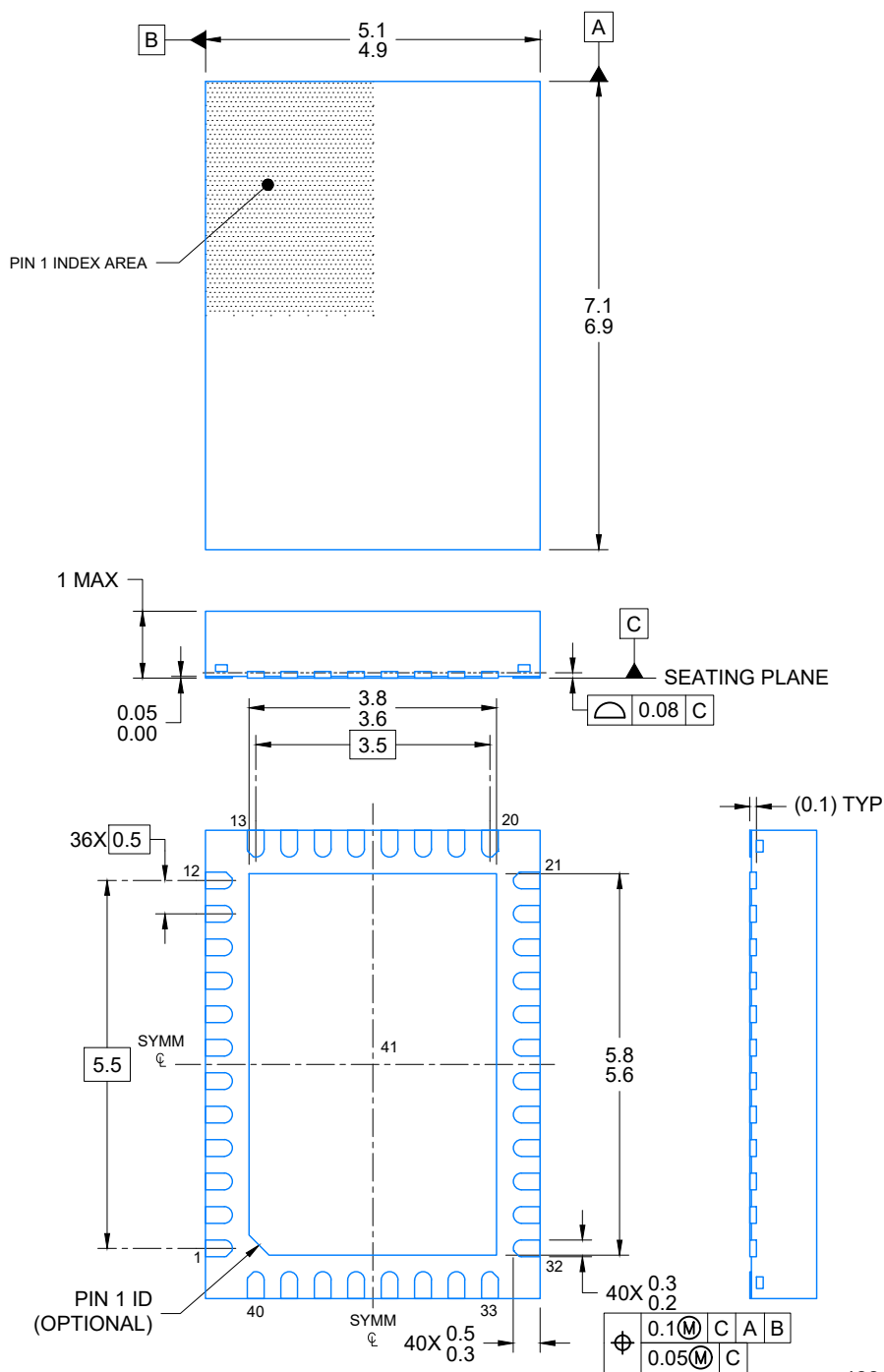
**VQFN - 1 mm max height**

5 x 7, 0.5 mm pitch

PLASTIC QUAD FLAT PACK- NO LEAD

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



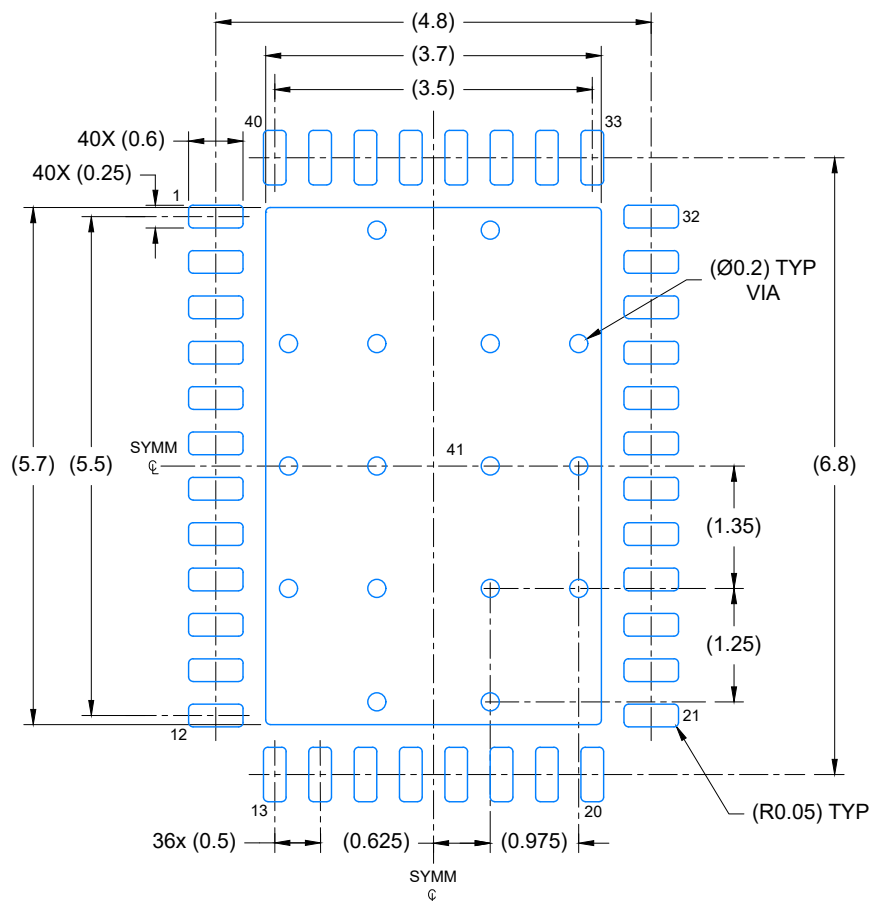


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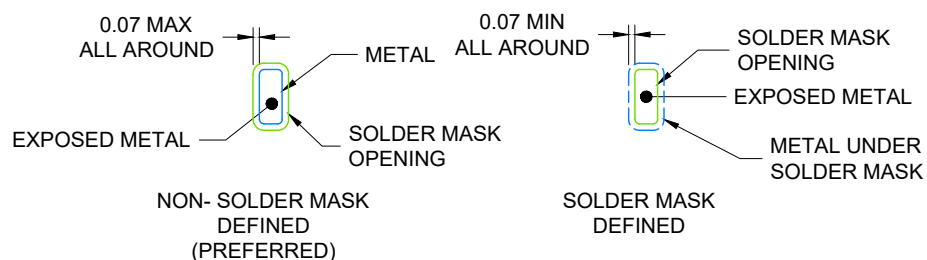
NOTES:

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 optimal thermal and mechanical performance.

PLASTIC QUAD FLAT PACK- NO LEAD



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE: 12X



## SOLDER MASK DETAILS

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NOTES: (continued)

4. 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](http://www.ti.com/lit/slua271)).
5. 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.

### VQFN - 1 mm max height

[illegible]

EXPOSED PAD  
69% PRINTED COVERAGE BY AREA  
SCALE: 12X



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