TPS7H3302-SP、TPS7H3302-SEP 耐放射線性特性、3A、DDR 終端レギュレータ

1 特長

- QMLP TPS7H3302-SP の SMD (Standard Microcircuit Drawing) 5962R14228 が利用可能
- 宇宙向け強化プラスチックの VID (Vendor Item Drawing) V62/22615 が利用可能
- 吸収線量 (TID) 特性
  - 吸収線量 (TID) 100krad(Si) または 50krad(Si) までの放射線耐性保証 (RHA)
- シングル イベント効果 (SEE) の特性
  - シングル イベント ラッチアップ (SEL)、シングル イベント ゲート ラプチャー (SEGR)、シングル イベント バーンアウト (SEB) の耐性:LET = 70MeV-cm^2/mg まで
  - シングル イベント過渡 (SET)、シングル イベント機能割り込み (SEFI)、シングル イベント アップセット (SEU) の耐性:70MeV-cm^2/mg まで
- DDR、DDR2、DDR3、DDR3L、DDR4 終端アプリケーションをサポート
- 入力電圧:2.5V レールと 3.3V レールをサポート
- 0.9V まで引き下げられた独立した低電圧入力 (VLDOIN) により電力効率が向上
- 3A のシンクおよびソース ターミネーション レギュレータ
- イネーブル入力とパワー グッド出力による電源シーケンス
- VTT ターミネーション レギュレータ
  - 出力電圧範囲:0.5～1.75V
  - 3A のシンクおよびソース電流
- センス入力を備えた高精度分圧回路を内蔵
- リモート センシング (VTTSNS)
- VTTREF バッファ付きリファレンス
  - VDDQSNS に対する 49%～51% の精度 (±3mA)
  - ±10mA のシンクおよびソース電流
- 低電圧誤動作防止 (UVLO)、過電流制限 (OCL) 機能を内蔵
- プラスチック パッケージ

2 アプリケーション

- 衛星用電源システム (EPS)
- コマンドとデータの処理 (C&DH)
- 光学画像処理ペイロード
- レーダー画像処理ペイロード

3 概要

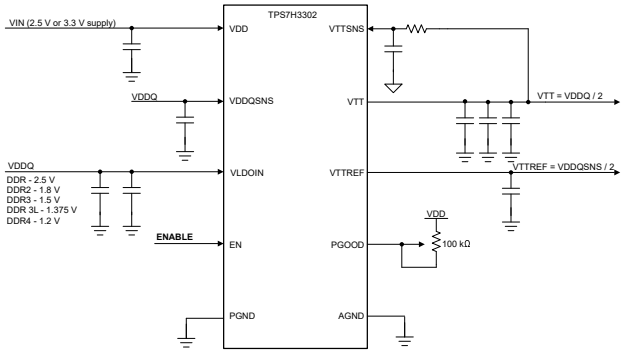
TPS7H3302 は、耐放射線性のダブル データ レート (DDR) 3A ターミネーション レギュレータで、VTTREF バッファが内蔵されています。このレギュレータは、シングル ボード コンピュータ、ソリッド ステート レコーダ、ペイロード処理などの宇宙向け DDR 終端アプリケーション用に、包括的でコンパクトな低ノイズ ソリューションを提供するように特化して設計されています。

TPS7H3302 は DDR、DDR2、DDR3、DDR3L、DDR4 を使用する DDR VTT 終端アプリケーションをサポートしています。TPS7H3302 VTT レギュレータの高速過度応答により、読み取り / 書き込み状況で非常に安定した電源を実現できます。また、TPS7H3302 には、VTT をトラッキングしてソリューション サイズをさらに縮小する VTTREF 電源も内蔵されています。シンプルな電源シーケンスを実現するために、TPS7H3302 にはイネーブル入力とパワーグッド出力 (PGOOD) の両方が内蔵されています。イネーブル信号を使用して、Suspend to RAM (S3) パワーダウン モードで VTT を放電することもできます。

製品情報

部品番号 (1)	グレード	パッケージ (2)
5962R1422802PYE	QMLP-RHA	HTSSOP (32) 6.10mm × 11.00mm 質量 = 0.184g
TPS7H3302MDAPTSEP	SEP	
TPS7H3302EVM	評価ボード	EVM

(1) 追加情報は、Device Options の表をご覧ください。
(2) 寸法と質量の値は公称値です。



DDR アプリケーションの簡略回路図

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4 Device Options

GENERIC PART NUMBER	RADIATION RATING(1)	GRADE(2)	PACKAGE	ORDERABLE PART NUMBER
TPS7H3302-SP	TID of 100 krad(Si) RLAT, DSEE free to 70 MeV-cm^2/mg	QMLP-RHA	32-Pin HTSSOP DAP	5962R1422802PYE
TPS7H3302-SEP	TID of 50 krad(Si) RLAT, DSEE free to 48 MeV-cm^2/mg	Space Enhanced Plastic	32-Pin HTSSOP DAP	TPS7H3302MDAPTSEP
TPS7H3302EVM	None	Evaluation Board	EVM	TPS7H3302EVM

(1) TID is total ionizing dose and DSEE is destructive single event effects. Additional information is available in the associated TID reports and SEE reports for each product.
(2) For additional information about part grade, view SLYB235.

5 Pin Configuration and Functions

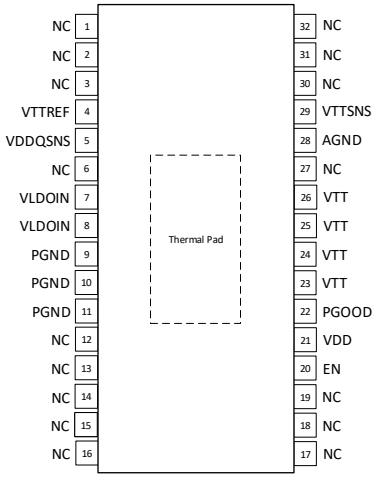


図 5-1. DAP Package, 32-Pin HTSSOP (Top View)

Pin Functions

PIN		I/O[1]	DESCRIPTION
NAME	NO.		
VTTREF	4	O	Reference output. Connect to GND through 0.1-µF ceramic capacitor.
VDDQSNS	5	I	VDDQ sense input. Reference input for VTTREF.[2]
VLDOIN	7	I	Supply voltage for the LDO. Connect to VDDQ voltage or an alternate voltage source.
	8		
PGND	9	—	Power ground. Connect to system ground.
	10		
	11		
EN	20	I	Enable pin. Driving this pin to logic high enables the device; driving this pin to logic low disables the device.
VDD	21	I	2.5- or 3.3-V power supply. A ceramic decoupling capacitor with a value between 1 and 10 µF is required.
PGOOD	22	O	PGOOD output pin. PGOOD pin is an open drain output to indicate the output voltage is within specification.
VTT	23	O	Power output for VTT LDO.
	24		
	25		
	26		
AGND	28	—	Signal ground. Connect to system ground.
VTTSNS	29	I	Voltage sense for VTT. Place capacitor close to pin. Route sense line to VTT near load.
NC	1-3, 6, 12-19, 27, 30-32	—	No connect. These pins are not internally connected. It is recommended to connect these pins to ground to prevent charge buildup; however, these pins can also be left open or tied to any voltage between ground and VDD.
Thermal Pad		—	Connect to PGND. This is internally floating.

(1) I = Input, O = Output, — = Other
(2) VDDQSNS shall be connected to the regulated voltage supplying VDDQ. If the VDDQ supply is also used for VLDOIN, an RC filter is recommended to isolate transients from VLDOIN to VDDQ.

6 Specifications

6.1 Absolute Maximum Ratings

over operating temperature range and all voltages with respect to AGND (unless otherwise noted)(1)

		MIN	MAX	UNIT
Input voltage	VDD, VLDOIN, VTTSNS, VDDQSNS	–0.36	3.6	V
	EN	–0.3	3.6	
	PGND to AGND	–0.3	0.3	
Output voltage	VTT, VTTREF	–0.3	3.6	V
	PGOOD	–0.3	3.6	
Junction temperature	T_J	–55	150	°C
Storage temperature	T_{stg}	–55	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
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins(1)	±4000	V
		Charged device model (CDM), per ANSI/ESDA/JEDEC JS-002, all pins(2)	±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

all voltages with respect to AGND (unless otherwise noted)

		MIN	NOM	MAX	UNIT
Input voltage	VDD	2.375		3.5	V
	VDDQSNS	1		3.5	
	VLDOIN	0.9		3.5	
	EN, VTTSNS, PGOOD	–0.1		3.5	
	PGND	–0.1		0.1	
Output voltage	VTT	–0.1		3.5	V
	VTTREF	–0.1		1.8	
Input current	PGOOD	0		4	mA
Output current	VTT	–3		3	A
	VTTREF	–0.01		0.01	
Junction temperature	T_J	–55		125	°C

6.4 Thermal Information

THERMAL METRIC[1]		TPS7H3302-SEP HTSSOP DAP 32-PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	25.9	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	15.9	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	7.9	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	0.2	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	7.9	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	1.1	°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

Over 2.375 ≤ VDD ≤ 3.5 V, VLDOIN = 1.8 V, VDDQSNS = 1.8 V, EN = VDD, T_A = – 55°C to 125°C; Standard DDR Application; all voltages with respect to AGND, unless otherwise noted

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
SUPPLY CURRENTS							
I_{VDD}	Quiescent current	EN = 3.3 V, no load			18	30	mA
$I_{VDD(SHDN)}$	Shutdown current	EN = 0 V, no load	VDDQSNS = 0 V		1.75	3	mA
			VDDQSNS > 0.78 V		5	6	
I_{VLDOIN}	Quiescent current of VLDOIN	EN = 3.3 V, no load			450	1200	µA
$I_{VLDOIN(SHDN)}$	Shutdown current of VLDOIN	EN = 0 V, no load			0.5	1	µA
$I_{VDDQSNS}$	VDDQSNS input current	EN = 3.3 V			4	6	µA
VTT OUTPUT							
VTTSNS	Output DC voltage, VTT	I_{VTT} = 5 mA	VDDQSNS = VLDOIN = 2.5 V (DDR1)	1.24	1.25	1.26	V
			VDDQSNS = VLDOIN = 1.8V (DDR2)	0.89	0.9	0.91	
			VDDQSNS = VLDOIN = 1.5 V (DDR3)	0.745	0.752	0.759	
			VDDQSNS = VLDOIN = 1.35 V (DDR3L)	0.67	0.677	0.684	
			VDDQSNS = VLDOIN = 1.2 V (DDR4)	0.596	0.602	0.608	
		I_{VTT} = –5 mA	VDDQSNS = VLDOIN = 2.5 V (DDR1)	1.25	1.26	1.27	V
			VDDQSNS = VLDOIN = 1.8V (DDR2)	0.9	0.91	0.92	
			VDDQSNS = VLDOIN = 1.5 V (DDR3)	0.752	0.76	0.768	
			VDDQSNS = VLDOIN = 1.35 V (DDR3L)	0.675	0.685	0.692	
			VDDQSNS = VLDOIN = 1.2 V (DDR4)	0.602	0.61	0.618	
		–1 A ≤ I_{VTT} ≤ 1 A	VDDQSNS = VLDOIN = 2.5 V (DDR1)	1.24	1.26	1.28	V
			VDDQSNS = VLDOIN = 1.8V (DDR2)	0.885	0.910	0.93	
			VDDQSNS = VLDOIN = 1.5 V (DDR3)	0.735	0.76	0.78	
			VDDQSNS = VLDOIN = 1.35 V (DDR3L)	0.66	0.69	0.72	
			VDDQSNS = VLDOIN = 1.2 V (DDR4)	0.585	0.6	0.63	

6.5 Electrical Characteristics (続き)

Over 2.375 ≤ VDD ≤ 3.5 V, VLDOIN = 1.8 V, VDDQSNS = 1.8 V, EN = VDD, T_A = – 55°C to 125°C; Standard DDR Application; all voltages with respect to AGND, unless otherwise noted

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
V_{DO}	Dropout voltage, V_{DO} = VLDOIN – VTTREF VDO recorded when VTT – VTTREF = 50 mV	VDDQSNS = 2.5 V (DDR1)	I_{VTT} = 0.5 A		5	60	mV
			I_{VTT} = 1 A		60	180	
			I_{VTT} = 2 A		190	465	
		VDDQSNS = 1.8 V (DDR2)	I_{VTT} = 0.5 A		8	70	
			I_{VTT} = 1 A		65	200	
			I_{VTT} = 2 A		190	475	
		VDDQSNS = 1.5 V (DDR3)	I_{VTT} = 0.5 A		5	65	
			I_{VTT} = 1 A		60	180	
			I_{VTT} = 2 A		180	420	
		VDDQSNS = 1.35 V (DDR3L)	I_{VTT} = 0.5 A		4	60	
			I_{VTT} = 1 A		60	180	
			I_{VTT} = 2 A		175	420	
		VDDQSNS = 1.2 V (DDR4)	I_{VTT} = 0.5 A		4	60	
			I_{VTT} = 1 A		60	180	
			I_{VTT} = 2 A		175	420	
$VTT_{(TOL)}$	VTT Tolerance to VTTREF (VTT – VTTREF)	I_{VTT} = -3 A		1	18	30	mV
		I_{VTT} = 3 A		-30	-15	-1	
$I_{LIM\_SRC\_VTT}$	VTT sourcing current limit	Ramp output 0 A to 10 A, record current when VTT reaches lowest value		5		9	A
$I_{LIM\_SNK\_VTT}$	VTT sinking current limit	Ramp output 0 A to -10 A, record current when VTT reaches highest value		5		10	A
R_{DSCHRG}	VTT discharge resistance	VDDQSNS = 0 V, VTT = 0.3 V, EN = 0 V			7	25	Ω
POWER GOOD							
$V_{PG(LOW, Falling)}$	VTT PGOOD threshold with respect to VTTREF	PGOOD window lower falling threshold		-21%	-20%	-18%	
$V_{PG(LOW, Rising)}$		PGOOD window lower rising threshold		-17%	-15%	-13%	
$V_{PG(HI, Falling)}$	VTT PGOOD threshold with respect to VTTREF	PGOOD window High falling threshold		13%	15%	17%	
$V_{PG(HI, Rising)}$		PGOOD window High rising threshold		18%	20%	21%	
$V_{PG(HYST)}$	VTT PGOOD hysteresis				5%		
$t_{PG(delay)}$	PGOOD startup delay	Startup rising edge, VTTSNS within 20% of VTTREF			4		ms
$t_{PG\_BAD(delay)}$	PGOOD bad delay	VTTSNS outside of the ±20% PGOOD window			1.95		µs
$V_{PG(OL)}$	Power good output low	$I_{PGOOD(SINK)}$ = 4 mA				0.4	V
$I_{PG(LKG)}$	Power good leakage	VTTSNS = VTTREF (PGOOD high impedance), PGOOD = VDD + 0.2 V			0.07	1	µA
VDDQSNS AND VTTREF							
$VDDQSNS_{UVLO}$	VDDQSNS UVLO turn-on threshold	VDDQSNS rising			750	900	mV
$VDDQSNS_{UVLO(HYST)}$	VDDQSNS UVLO hysteresis				75	150	
VTTREF	VTTREF voltage			VDDQSNS / 2			V

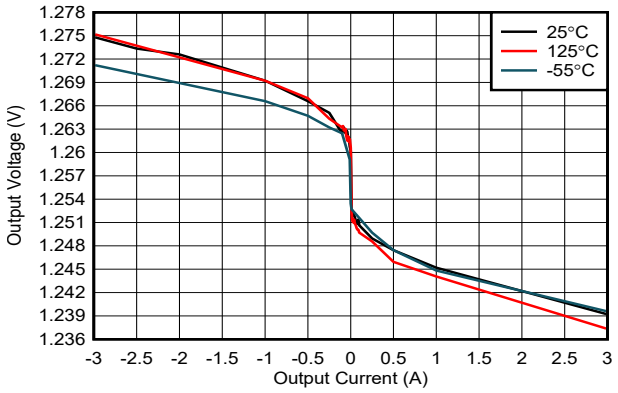
6.5 Electrical Characteristics (続き)

Over 2.375 ≤ VDD ≤ 3.5 V, VLDOIN = 1.8 V, VDDQSNS = 1.8 V, EN = VDD, T_A = – 55°C to 125°C; Standard DDR Application; all voltages with respect to AGND, unless otherwise noted

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
VTTREF	VTTREF voltage tolerance to VDDQSNS	-10 mA ≤ I_{VTTREF} ≤ 10 mA	VDDQSNS = 2.5 V	49%		51%	
			VDDQSNS = 1.8 V	49%		51%	
			VDDQSNS = 1.5 V	49%		51.25%	
			VDDQSNS = 1.35 V	49%		51.5%	
			VDDQSNS = 1.2 V	49%		51.5%	
		-3 mA ≤ I_{VTTREF} ≤ 3 mA	VDDQSNS = 1.5 V	49%		51%	
			VDDQSNS = 1.35 V	49%		51%	
			VDDQSNS = 1.2 V	49%		51%	
$I_{LIM\_SRC\_VTTREF}$	VTTREF sourcing current limit	Sourcing current ramped from 0 to 55mA. Find when VTTREF drops to half its original value		35	45		mA
$I_{LIM\_SNK\_VTTREF}$	VTTREF sinking current limit	Sinking current ramped from 0 to 16.5mA. Find when VTTREF hits peak value		12	15		mA
$I_{VTTREF(dis)}$	VTTREF discharge current	EN = 0 V, VDDQSNS = 0 V, VTTREF = 0.5 V			1.3		mA
UVLO AND ENABLE							
VDD_{UVLO}	VDD UVLO turn-on threshold				2.18	2.3	V
$VDD_{UVLO(HYST)}$	VDD UVLO hysteresis				40		mV
V_{IH_EN}	Enable high-level input voltage (turn-on)					1.7	V
V_{IL_EN}	Enable low-level input voltage (turn-off)			0.3			V
$V_{EN(HYS)}$	Enable hysteresis voltage				700		mV
$I_{EN(LKG)}$	Enable input leakage current			-1		1	µA

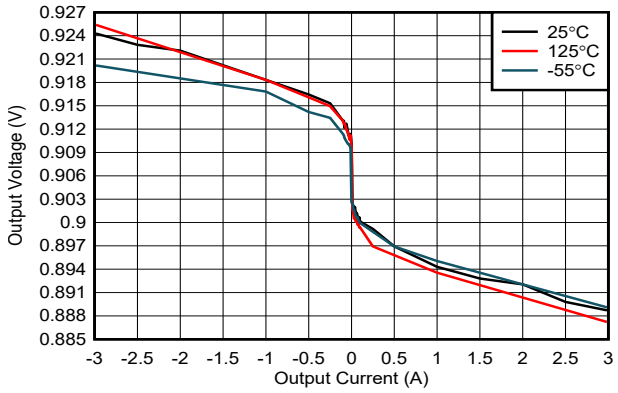
6.6 Typical Characteristics

For 図 6-1through 図 6-11, (3 × 150-µF tantalum + 4 × 4.7-µF MLCC) or equivalent capacitance/ESR are used on VTT output



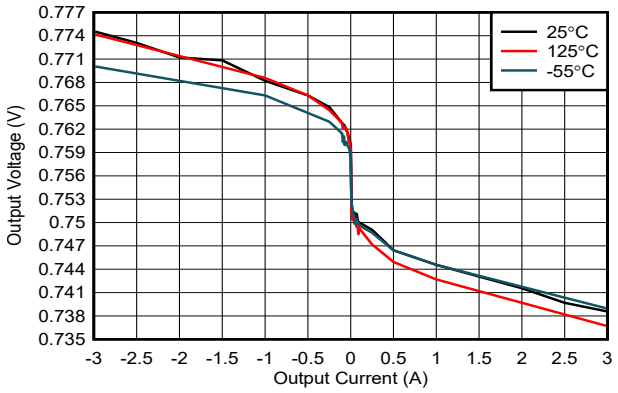
VDD = 3.6 V VDDQSNS = 2.5

図 6-1. Output Voltage vs Output Current



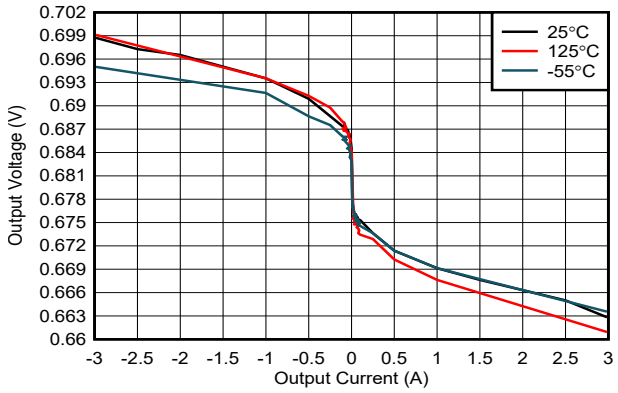
VDD = 3.6 V VDDQSNS = 1.8 V

図 6-2. Output Voltage vs Output Current



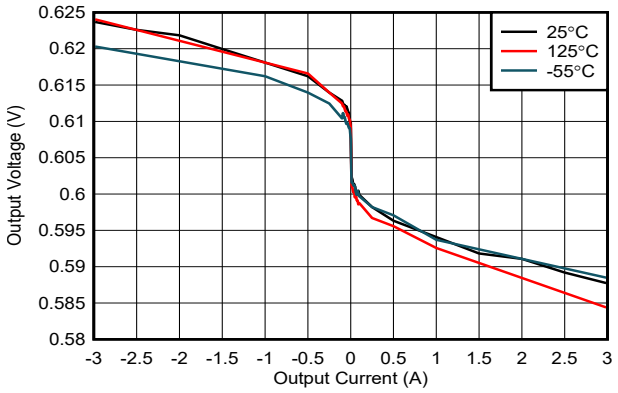
VDD = 3.6 V VDDQSNS = 1.5 V

図 6-3. Output Voltage vs Output Current



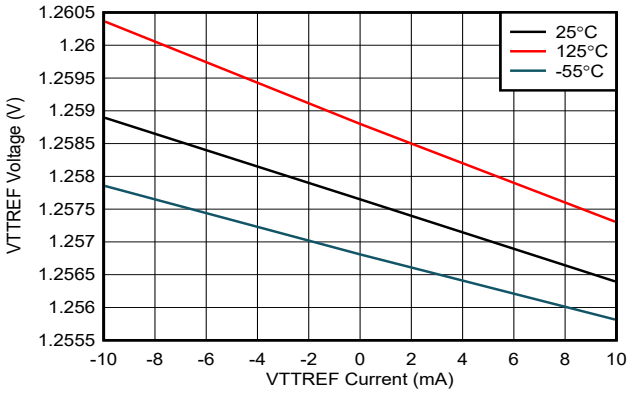
VDD = 3.6 V VDDQSNS = 1.35 V

図 6-4. Output Voltage vs Output Current



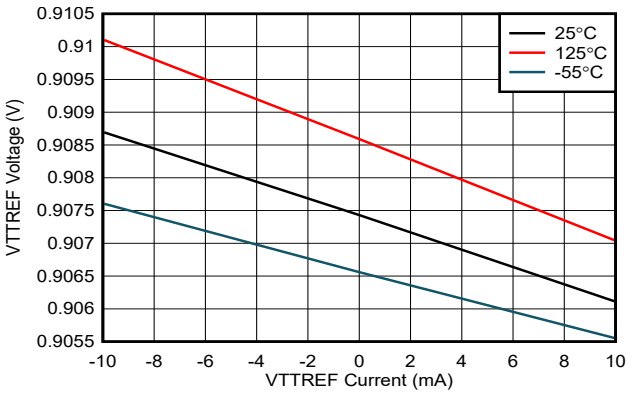
VDD = 3.6 V VDDQSNS = 1.2 V

図 6-5. Output Voltage vs Output Current



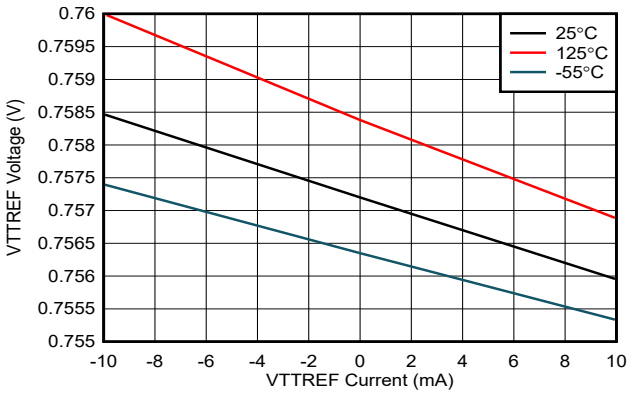
VDDQSNS = 2.5 V

図 6-6. VTTREF Voltage vs VTTREF Current



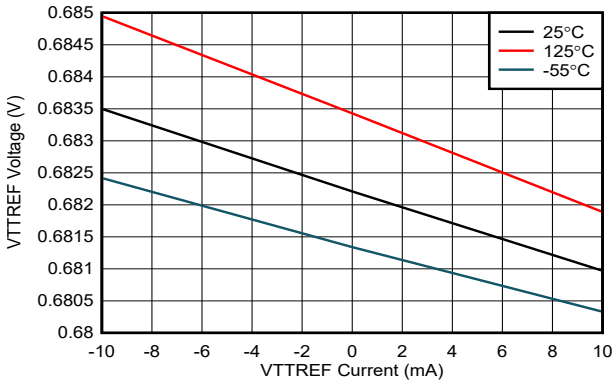
VDDQSNS = 1.8V

図 6-7. VTTREF Voltage vs VTTREF Current



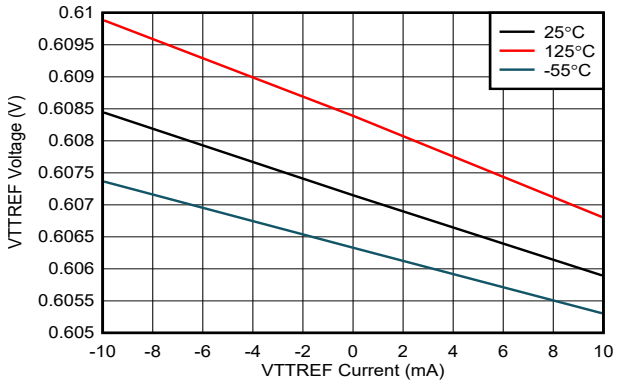
VDDQSNS = 1.5 V

図 6-8. VTTREF Voltage vs VTTREF Current



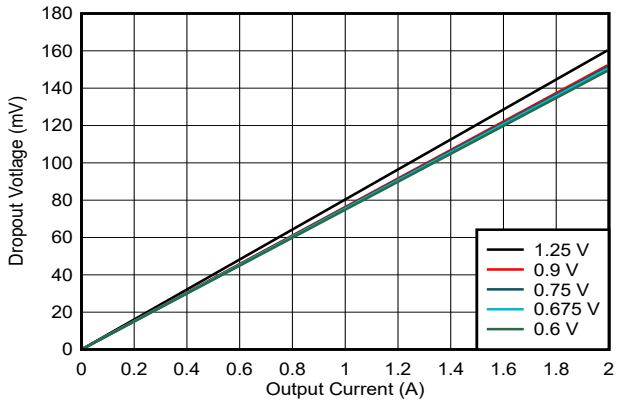
VDDQSNS = 1.35 V

図 6-9. VTTREF Voltage vs VTTREF Current



VDDQSNS = 1.2V

図 6-10. VTTREF Voltage vs VTTREF Current



VDD = 3.6 V

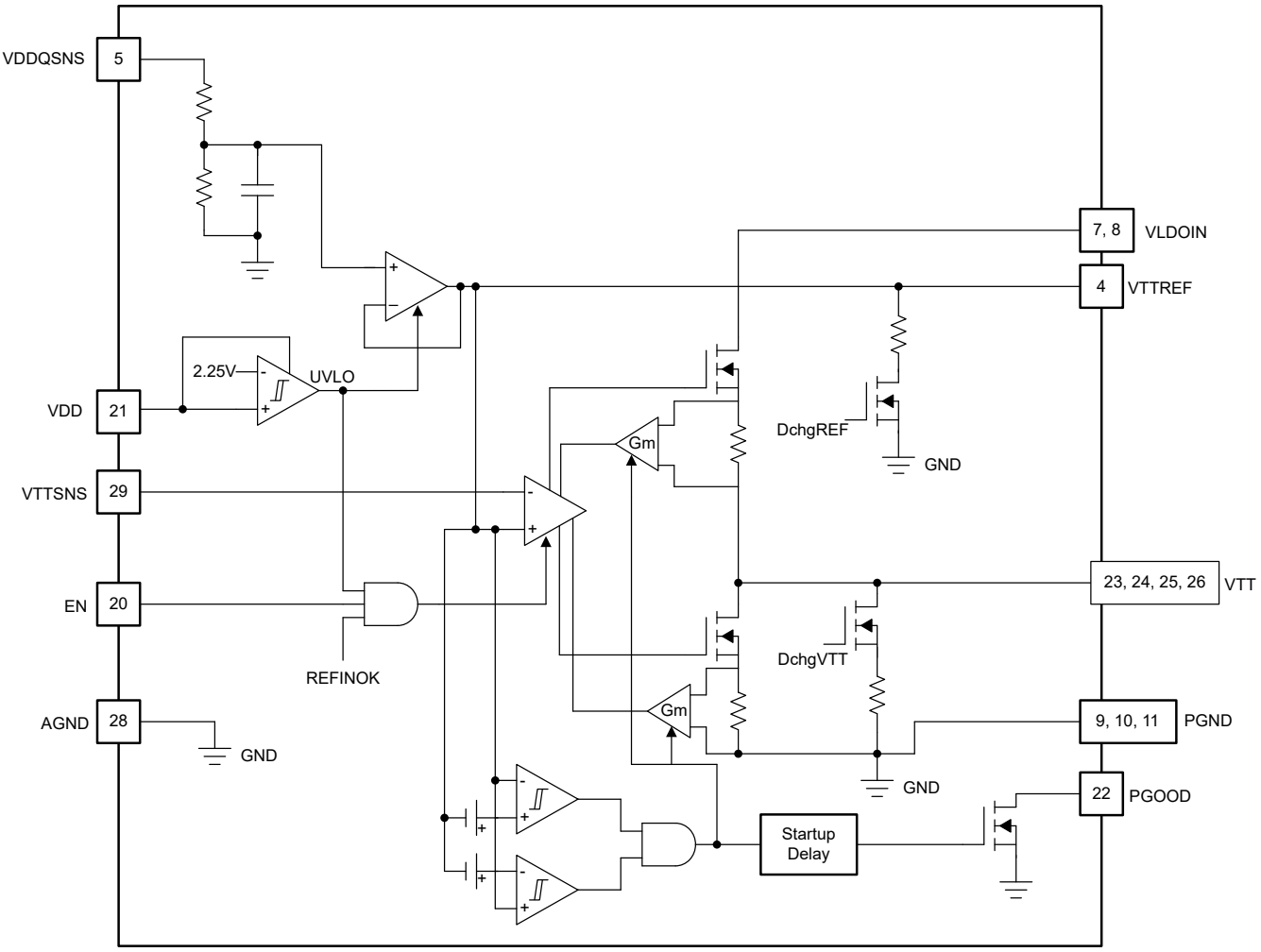
図 6-11. Dropout Voltage vs Output Current

7 Detailed Description

7.1 Overview

The TPS7H3302 device is a sink and source double data rate (DDR) termination regulator specifically designed for low input voltage, low-noise systems where space and mass are a key consideration.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 VTT Sink and Source Regulator

The TPS7H3302 is a 3-A sink and source tracking termination regulator incorporating a high performance, low-dropout (LDO) linear regulator specifically designed for low input voltage, and low external component count systems where board area is a key application parameter. The LDO regulator employs a fast feedback loop so that ceramic capacitors can be used to support the fast load transient response. To achieve tight regulation with minimum effect of trace resistance, a remote sensing pin (VTTSNS) should be connected to the positive pin of the output capacitor(s) as a separate trace from the high-current path of VTT.

The TPS7H3302 has a dedicated pin (VLDOIN) for connection to the VTT power supply, in order to minimize the LDO power dissipation. The minimum VLDOIN voltage is highlighted in Electrical Characteristics : TPS7H3302 (VLDOIN to VTT headroom) for various load conditions.

7.3.2 Reference Input (VDDQSNS)

The output voltage, VTT, is regulated to VTTREF. VDDQSNS incorporates an integrated resistor divider network. VDDQSNS should be connected to the memory supply bus (VDDQ). The TPS7H3302 supports VDDQSNS voltage from 1 V to 3.5 V, making it versatile and ideal for many types of low-power LDO applications.

7.3.3 Reference Output (VTTREF)

When it is configured for DDR termination applications, VTTREF buffers the DDR VTT reference voltage for the memory application. The VTTREF block consists of an on-chip 1/2 resistor divider and a low-pass filter (LPF). VTTREF tracks 1/2 of VDDQSNS typically within ±1%. It is typically capable of supporting a ±10 mA sink/source load current. VTTREF becomes active when VDDQSNS reaches 0.75V and VDD is above the UVLO threshold. When VTTREF is less than 0.675 V, VTTREF is disabled and subsequently discharges to GND through an internal MOSFET. VTT is also discharged following the discharge of VTTREF. VTTREF is independent of the EN pin state. To meet stability criteria, a ceramic capacitor of 0.1-µF minimum must be installed close to VTTREF (pin 4). Capacitor value at VTTREF (pin 4) must not exceed 2.2 µF.

7.3.4 EN Control (EN)

When EN is driven high, the TPS7H3302 VTT regulator begins normal operation. When EN is driven low, VTT discharges to GND through an internal 18-Ω (typical) MOSFET. VTTREF remains on when EN is driven low. EN is not tied high internally to prevent power sequencing issues with an external signal that may be controlling the enable. EN is a floating input and not internally tied, thus the user can have complete control over where and when the EN signal is generated. EN feeds directly into power-good (PGOOD). When enable is low, PGOOD is low.

7.3.5 Power-Good Function (PGOOD)

The TPS7H3302 provides an open-drain PGOOD output that goes high when the VTT output is within 20% of VTTREF (typ). PGOOD deasserts within 1.95 µs after the output exceeds the size of the power-good window. During initial VTT startup, PGOOD asserts high 4 ms (typ) after the VTT enters power-good window. Because PGOOD is an open-drain output, a 100-kΩ pullup resistor between PGOOD and a stable active supply voltage rail is recommended for proper operation.

7.3.6 V_{TT} Current Protection

The LDO has a constant overcurrent limit (OCL).

7.3.7 V_{IN} UVLO Protection

For VDD undervoltage lockout (UVLO) protection, the TPS7H3302 monitors VDD voltage. When the VDD voltage is lower than the UVLO threshold voltage, both the VTT and VTTREF regulators are powered off. This shutdown is a non-latch protection.

7.3.8 Thermal Shutdown

The TPS7H3302 includes thermal shutdown circuitry that typically activates at 210ºC with a 12ºC hysterysis; when engaged the VTT and VTTREF regulators are both shutoff and discharged by the internal discharge MOSFET. This description is only provided in order to provide a complete description of the TPS7H3302; the thermal shutdown feature is not included in the product specification as the plastic package is not designed for use at 210ºC.

7.4 Device Functional Modes

The TPS7H3302 is a 3-A sink and source LDO provides low output noise to meet system needs. In order to improve efficiency in the LDO, the TPS7H3302 LDO can operate from low VLDOIN voltage rail, thus using dual voltage source one for the VLDOIN that supports high-current and an alternate voltage sources that enables the VDDQSNS pin to track VDDQ.

In some cases VLDOIN and VDDQSNS pins are tied together. In the memory system, VDDQ is a high-current supply that powers the core, the I/O, and the logic of the memory. VTTREF is a low-current, precision reference voltage that provides a threshold between a logic high (one) and a logic low (zero) that adapts to changes in the I/O supply voltage. By providing a precision threshold that adapts to the supply voltage, VTTREF realizes wider noise margins than those possible with a fixed threshold and normal variations in termination and drive impedance. Specifications vary for different DDR technologies. For example DDR3 JEDEC JESD79-3F specifies 0.49 to 0.51 times VDDQ and draws only tens to hundreds of microamps. The TPS7H3302 VTTREF is designed to sink and source up to 10 mA.

8 Application and Implementation

注

以下のアプリケーション情報は、TI の製品仕様に含まれるものではなく、TI ではその正確性または完全性を保証いたしません。個々の目的に対する製品の適合性については、お客様の責任で判断していただくことになります。お客様は自身の設計実装を検証しテストすることで、システムの機能を確認する必要があります。

8.1 Application Information

The TPS7H3302 device is a highly-integrated sink and source LDO. The device is targeted to support VTT voltage for DDR memory applications and is capable of sourcing and sinking 3-A load current. The TPS7H3302EVM user's guide is available on ti.com, SLVUCK2. The guide highlights standard EVM test results, schematic, and bill of materials (BOM) for reference.

8.2 Typical Application

The design example describes a 2.5-V V_{IN}, DDR3 configuration.

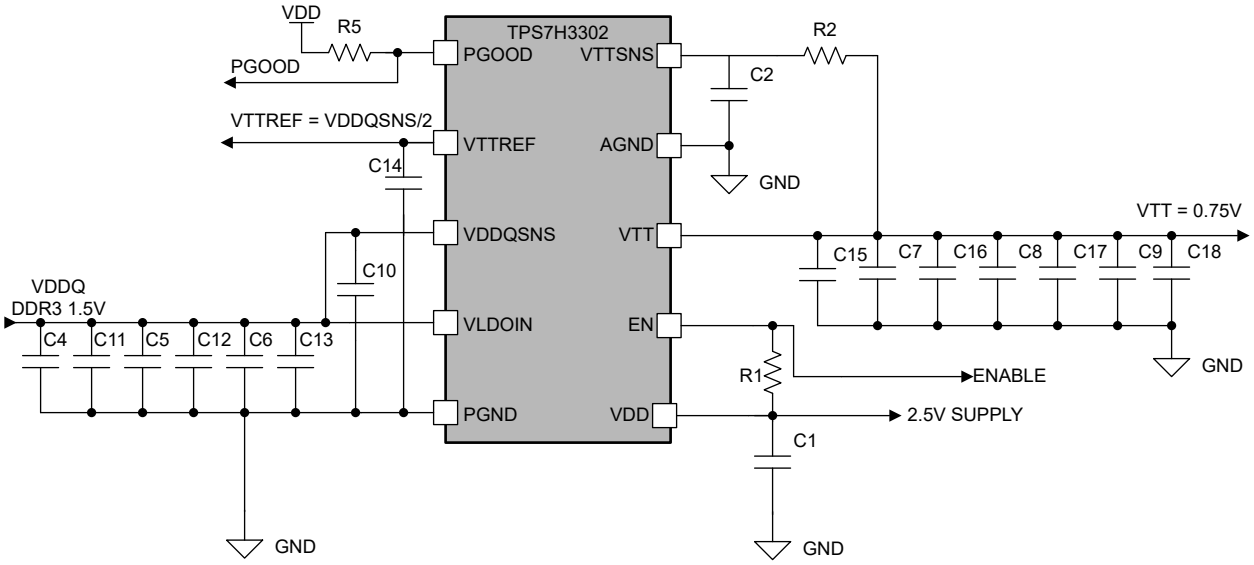


図 8-1. Typical Application Schematic

8.2.1 Design Requirements

See the セクション 6.3 for recommended limits.

8.2.2 Detailed Design Procedure

表 8-1. Design Example 1 List of Materials

REFERENCE DESIGNATOR	DESCRIPTION	SPECIFICATION	PART NUMBER	MANUFACTURER
R1, R5	Resistor	20 kΩ	RC0603JR-0720KL	Yageo
R2		392 Ω	RC0603FR-07392RL	Yageo
C1, C4, C5, C6, C11, C12,	Capacitor	10 µF, 16 V	GCM31CR71C106KA64K	Murata
C2		1000 pF, 10 V	CC0603KRX7R7BB102	Yageo
C7, C8, C9, C18		4.7 µF, 10 V	1210ZC475KAT2A	AVX
C10		1000 pF, 100 V	06031C102KAT2A	AVX
C13, C15, C16, C17		150 µF, 10 V	T530D157M010ATE005	Kemet
C14		2.2 µF, 25 V	08053C225KAT2A	AVX

8.2.2.1 VDD Capacitor

Add a ceramic capacitor, with a value between 1- and 10-µF, placed close to the VDD pin to minimize high frequency noise from the supply.

8.2.2.2 VLDO Input Capacitor

Depending on the trace impedance between the VLDOIN/VDDQ bulk power supply to the device, a transient increase of source current is supplied mostly by the charge from the VLDOIN/VDDQ input capacitor. Use a 150-µF (or greater) tantalum capacitor in parallel with a 4.7-µf ceramic capacitor to supply this transient charge. Provide more input capacitance as more output capacitance is used at VTT.

8.2.2.3 VTT Output Capacitor

For stable operation, the total capacitance of the VTT output pin must be greater than 470 µF. Attach three, 3 × 150-µF low-ESR tantalum capacitors in parallel with four 4.7 µF ceramic capacitors to minimize the effect of equivalent series resistance (ESR) and equivalent series inductance (ESL). If the total parallel ESR is greater than 2 mΩ, insert an R-C filter between the output and the VTTSNS input to achieve loop stability. The R-C filter time constant should be almost the same as or slightly lower than the time constant of the output capacitor and its ESR.

8.2.2.4 VTTSNS Connection

To achieve tight regulation with minimum effect of trace resistance, a remote sensing pin (VTTSNS) should be connected to the positive pin of the VTT pin output capacitor or capacitors as a separate trace from the high-current path from VTT. Consider adding a low-pass R-C filter at the VTTSNS pin in case the ESR of the VTT output capacitor or capacitors is larger than 2 mΩ. The R-C filter time constant should be approximately the same or slightly lower than the time constant of the VTT output capacitance and ESR.

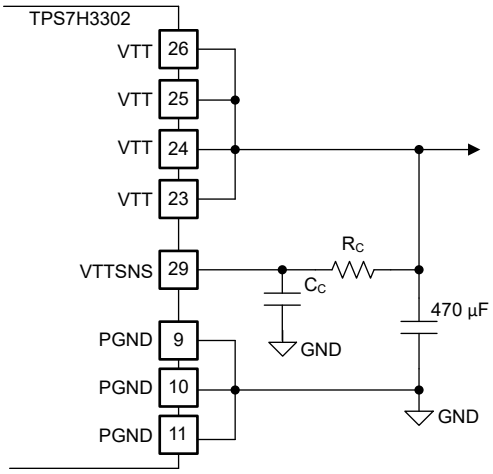


図 8-2. RC Filter for VTTSNS

8.2.2.5 Low VDD Applications

TPS7H3302 can be used in an application system where either a 2.5-V rail or a 3.3-V rail is available. The TPS7H3302 minimum input voltage requirement is 2.375 V. If a 2.5-V rail is used, ensure that the absolute minimum voltage (both DC and transient) at the device pin is 2.375 V or greater. The voltage tolerance for a 2.5-V rail input is between ±5% accuracy, or better.

8.2.2.6 S3 and Pseudo-S5 Support

The TPS7H3302 provides S3 support by an EN function. The EN pin could be connected to an SLP_S3 signal in the end application. Both VTTREF and VTT are on when EN = high (S0 state). VTTREF is maintained while VTT is turned off and discharged via an internal discharge MOSFET when EN = low (S3 state). Please notice that the EN signal controls only the output buffer for VTT and therefore, while in S3 state, VDDQSNS is present in order to maintain data in volatile memory. As a result, when EN is set high to exit the S3 state, it is desired to bring VTT into regulation as fast as possible. This causes an output current controlled by the current limit of the device and the output capacitors.

When EN = low and the VDDQSNS voltage is less than 0.75 V(typically), TPS7H3302 enters pseudo-S5 state. Both VTT and VTTREF outputs are turned off and discharged to GND through internal MOSFETs when pseudo-S5 support is engaged (S4/S5 state). 図 8-3 shows a typical startup and shutdown timing diagram for an application that uses S3 and pseudo-S5 support.

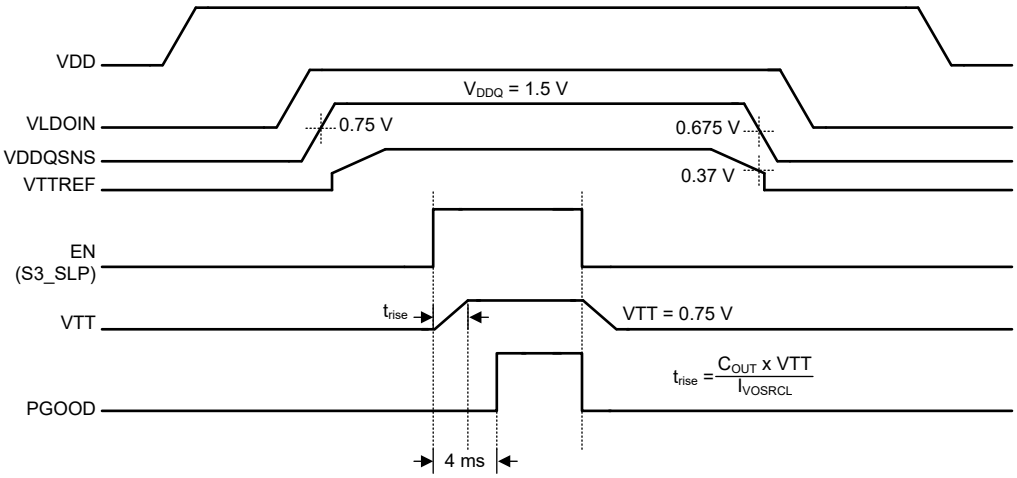


図 8-3. Typical Timing Diagram for S3 and Pseudo-S5 Support

8.2.2.7 Tracking Startup and Shutdown

The TPS7H3302 supports tracking startup of VDDQ and shutdown when EN is tied directly to the system bus and not used to turn on or turn off the device. During tracking startup, VTT follows VTTREF once VDDQSNS voltage is greater than 0.75 V. VDDQSNS incorporates a resistor divider network and a time constant of about 445 µs. The rise time of the VTT output is then a function of the rise time of VDDQSNS. If the VDDQSNS rise time is larger than 445 µs. Typically PGOOD is asserted 4 ms after VTT is within ±20% of VTTREF. During tracking shutdown, VTT falls following VTTREF until VTTREF reaches 0.37 V (typically). Once VTTREF falls below 0.37 V, the internal discharge MOSFETs are turned on and quickly discharge both VTTREF and VTT to GND. PGOOD is deasserted once VTT is beyond the ±20% range of VTTREF. 図 8-4 shows the typical timing diagram for an application that uses tracking startup and shutdown.

There are no sequencing requirements between VDD and VLDOIN. If VLDOIN is applied first followed by VDD there is no issue. VDD UVLO protection monitors VDD voltage. When VDD is lower than UVLO threshold both VTT and VTTREF regulators are powered off.

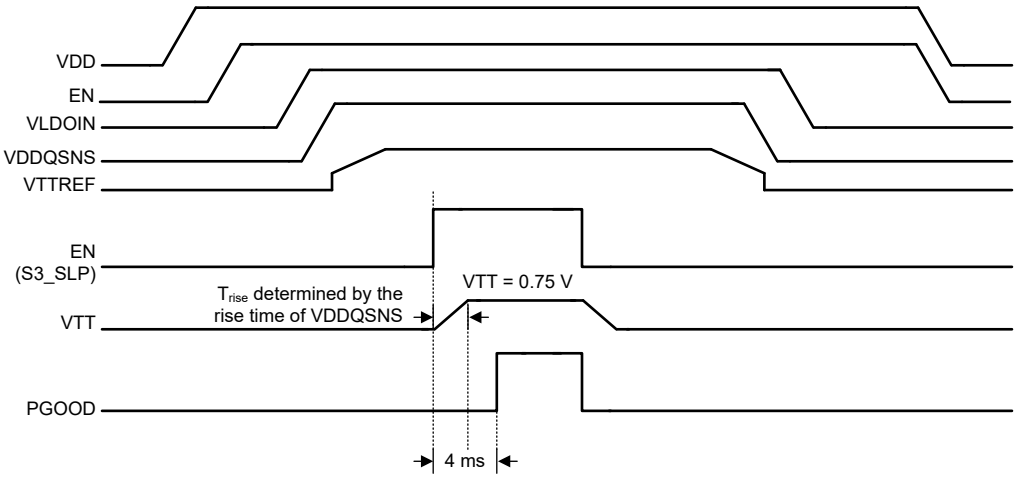


図 8-4. Typical Timing Diagram of Tracking Startup and Shutdown

8.2.2.8 Output Tolerance Consideration for VTT DIMM or Module Applications

The TPS7H3302 is specifically designed to power up the memory termination rail (as shown in 図 8-5). The DDR memory termination structure determines the main characteristics of the VTT rail, which is to be able to sink and source current while maintaining acceptable VTT tolerance. See 図 8-6 for typical characteristics for a single memory cell.

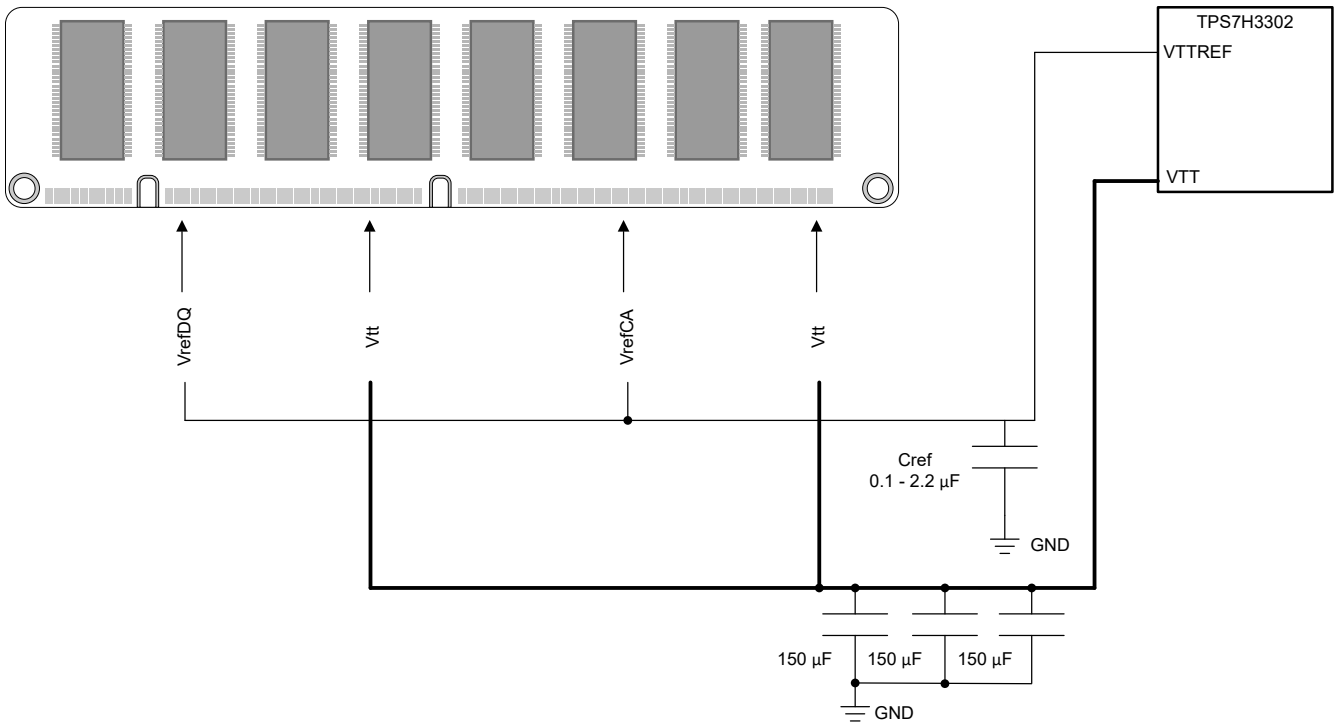


図 8-5. Typical Application Diagram for DDR3 VTT DIMM/Module Using TPS7H3302

In 図 8-6, when Q1 is on and Q2 is off:

- Current flows from VDDQ via the termination resistor to VTT.
- VTT sinks current.

In 図 8-6, when Q2 is on and Q1 is off:

- Current flows from VTT via the termination resistor to GND.
- VTT sources current.

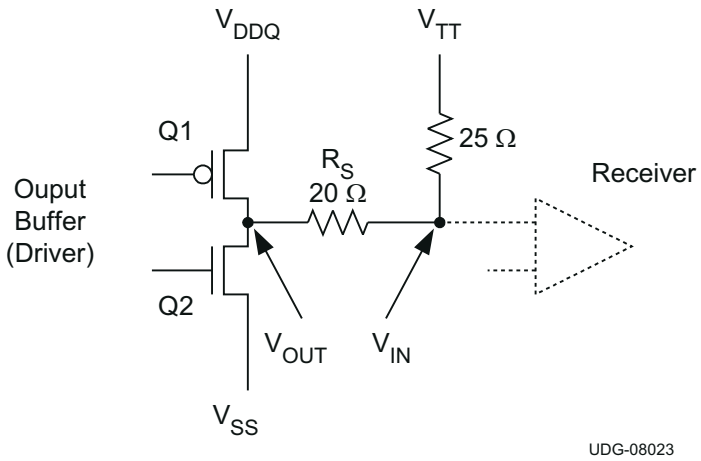


図 8-6. DDR Physical Signal System SSTL Signaling

Because VTT accuracy has a direct impact on the memory signal integrity, it is imperative to understand the tolerance requirement on VTT. Based on JEDEC VTT specifications for DDR and DDR2. See 表 8-2 for detailed information and JEDEC relevant specifications.

VTTREF – 40 mV < VTT < VTTREF + 40 mV, for both DC and AC conditions

The specification itself indicates that VTT must keep track of VTTREF for proper signal conditioning.

The TPS7H3302 specifies the regulator output voltage to be:

VTTREF – 30 mV < VTT < VTTREF + 30 mV, for both DC and AC conditions and –3 A < IVTT < 3 A.

The regulator output voltage is measured at the regulator side, not the load side. The tolerance is applicable to DDR, DDR2, DDR3 and low-power DDR3/DDR4 applications (see 表 8-2 for detailed information). To meet the stability requirement, a minimum output capacitance of 470 µF is needed, combination of both tantalum and ceramic capacitors. Considering the actual tolerance on the MLCC capacitors, four 4.7-µF ceramic capacitors in parallel with 3 × 150-µF low-ESR tantalum capacitor are sufficient to meet the above requirement. Higher ESR tantalum capacitors will require multiple tantalum capacitors in parallel with ceramic capacitors to meet system needs.

表 8-2. DDR, DDR2, DDR3, and LP DDR3 Termination Technology and Differences

	DDR	DDR2	DDR3	LOW POWER DDR3 (DDR3L)
FSB data rates	200, 266, 333 and 400 MHz	400, 533, 677 and 800 MHz	800, 1066, 1330 and 1600 MHz	Same as DDR3
Termination	Motherboard termination to VTT for all signals	On-die termination for data group. VTT used for termination of address, command and control signals.	On-die termination for data group. VTT used for termination of address, command and control signals.	Same as DDR3
Termination current demand	Max sink and source transient currents of up to 2.6 A to 2.9 A	Not as demanding • Only 34 signals (address, command, control) tied to VTT • ODT handles data signals Less than 1 A of burst current	Not as demanding • Only 34 signals (address, command, control) tied to VTT • ODT handles data signals Less than 1 A of burst current	Same as DDR3
Voltage level	2.5-V core and I/O 1.25-V VTT	1.8-V core and I/O 0.9-V VTT	1.5-V core and I/O 0.75-V VTT	1.35-V core and I/O 0.68-V VTT
Relevant JEDEC specification	JESD79F (SSTL_2 JESD8-9B)	DDR2 JESD79-2F (SSTL_18 JESD8-15)	DDR3 JESD79-3F	DDR3L JESD79-3-1A.01

The TPS7H3302 is designed as a Gm-driven LDO. The voltage droop between the reference input and the output regulator is determined by the transconductance and output current of the device. The typical Gm is 250 S at 3 A and changes with respect to the load in order to conserve the quiescent current (that is, the Gm is very low at no load condition). The Gm LDO regulator is a single pole system. Its unity gain bandwidth for the voltage loop is only determined by the output capacitance, as a result of the bandwidth nature of the Gm. (See 式 1)

$$F_{UGBW} = \frac{Gm}{2 \times \pi \times C_{OUT}} \quad (1)$$

where

- F_{UGBW} is the unity gain bandwidth
- Gm is transconductance
- C_{OUT} is the output capacitance

There are two limitations to this type of regulator when it comes to the output bulk capacitor requirement. To maintain stability, the zero location contributed by the ESR of the output capacitors should be greater than the –3-dB point of the current loop. This constraint means that higher ESR capacitors should not be used in the design. In addition, the impedance characteristics of the ceramic capacitor should be well understood in order to prevent the gain peaking effect around the Gm –3-dB point because of the large ESL, the output capacitor, and parasitic inductance of the VTT trace.

図 8-7 shows the bode plot simulation for a typical DDR3 configuration of the TPS7H3302, where:

- VDD = 2.4 V
- V_{VLDOIN} = 1.5 V
- VTT = 0.75 V
- I_{IO} = 3 A
- 3 × 150-µF low-ESR tantalum capacitors (T530D157M010ATE005) in parallel with 4 × 4.7-µF ceramic capacitor
- ESR = 1.66 mΩ
- ESL = 800 pH

The unity-gain bandwidth is approximately 85 kHz and the phase margin is 92°. The 0-dB level is crossed, the gain peaks because of the ESL effect. However, the peaking is kept well below 0 dB.

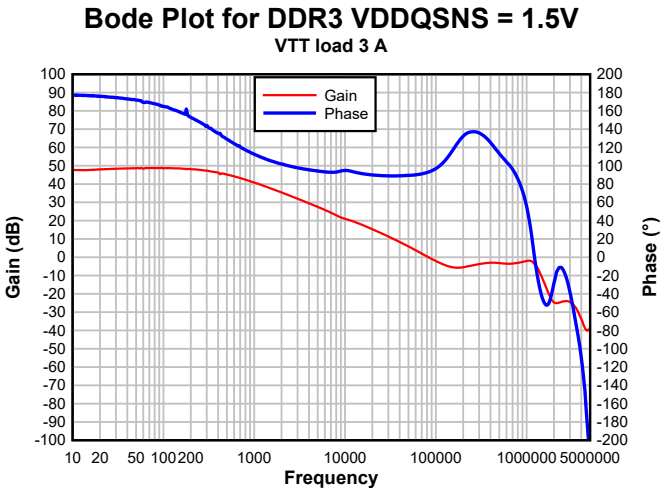


図 8-7. Bode Plot for a Typical DDR3 Configuration

The figure below shows the Load Regulation and Transient Plot shows the transient response for a typical DDR3 configuration. When the regulator is subjected to a ±1.875-A load step. The current shown only represents the device sourcing 1.875 A due to location of current probe.

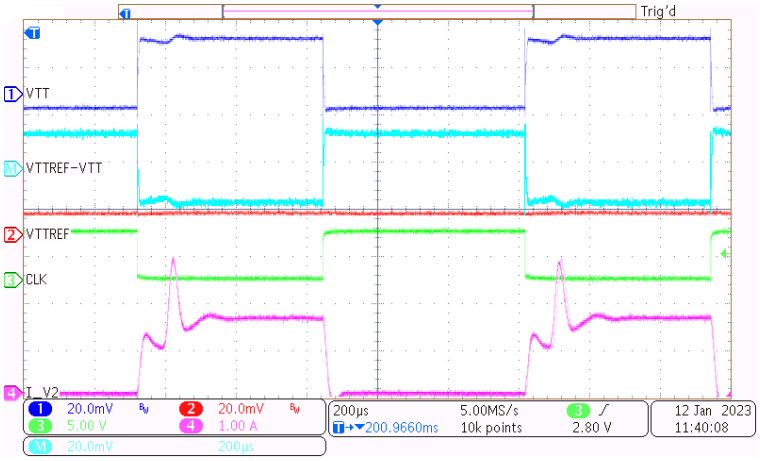


図 8-8. Transient Plot

8.2.2.9 LDO Design Guidelines

For TPS7H3302, a minimum of 420 mV (VLDOINMIN – VTTMAX) is needed in order to support a Gm driven sourcing current of 2 A based on the specified dropout voltage maximum at VDDQSNS = 1.5 V. Because the TPS7H3302 is essentially a Gm-driven LDO, its impedance characteristics are both a function of the 1/Gm and $R_{DS(on)}$ of the sourcing MOSFET (see TPS7H3302 Impedance Characteristics). The current inflection point of the design is between 3 A and 4 A. When I_{SRC} is less than the inflection point, the LDO is considered to be operating in the Gm region; when I_{SRC} is greater than the inflection point but less than the overcurrent limit point, the LDO is operating in the $R_{DS(on)}$ region. The typical sourcing $R_{DS(on)}$ is 154 mΩ with V_{IN} = 3 V and T_J = 125°C.

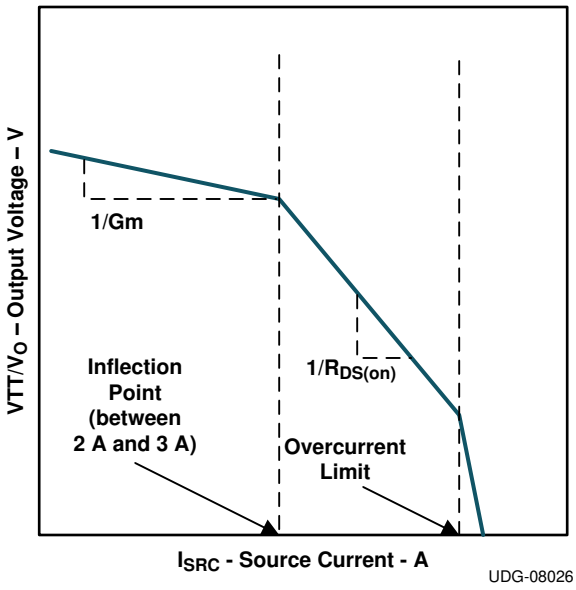


図 8-9. TPS7H3302 Impedance Characterisitcs

8.2.3 Application Curve

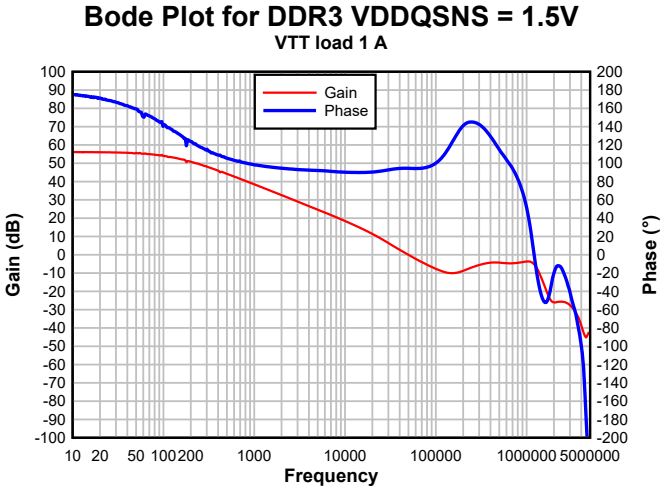


図 8-10. DDR2 2-A Load VDD = 2.4 V, VTT = 0.9 V

8.3 Power Supply Recommendations

TPS7H3302 is designed to support DDR, DDR2, DDR3, DDR3L, and DDR4 VTT applications. TPS7H3302 VLDOIN supports voltage range from 0.9 V to 3.5 V. The supply must be well regulated. Having a separate VLDOIN supply from DDR VDDQ allows designer to optimize system efficiency. VDD is used to bias the TPS7H3302 IC and its voltage range from 2.375 V to 3.5 V. This supply must be well regulated and bypassed with a ceramic capacitor with a value of 1 µF and 10 µF. TI recommends that VLDOIN and DDR supply VDDQ be isolated from each other. If this is not possible then an RC filter must be used to isolate VLDOIN and VDDQSNS. However, in so doing the dynamic tracking of VTT and VTTREF will be reduced. See the EVM user's guide SLVUCK2 for additional details.

8.4 Layout

8.4.1 Layout Guidelines

Consider the following points before starting the TPS7H3302 layout design.

- The input bypass capacitor for VLDOIN should be placed as close as possible to the pin with short and wide connections.
- The output capacitor for VTT should be placed close to the pin with short and wide connection in order to avoid additional ESR and/or ESL trace inductance.
- VTTSNS should be connected to the positive node of VTT output capacitors as a separate trace from the high-current power line. This configuration is strongly recommended to avoid additional ESR and/or ESL. If sensing the voltage at the point of the load is required, it is recommended to attach the output capacitor or capacitors at that point. Also, it is recommended to minimize any additional ESR and/or ESL of ground trace between the GND pin and the output capacitor or capacitors.
- Consider adding low-pass filter at VTTSNS if the ESR of the VTT output capacitor or capacitors is larger than 2 mΩ.
- VDDQSNS can be connected separately from VLDOIN. Remember that this sensing potential is the reference voltage of VTTREF. Avoid any noise-generating lines.
- The negative node of the VTT output capacitor or capacitors and the VTTREF capacitor should be tied together by avoiding common impedance to the high-current path of the VTT sink and source current.
- The GND and PGND pins should be connected to the thermal land underneath the die pad with multiple vias connecting to the internal system ground planes (for better result, use at least two internal ground planes). Use as many vias as possible to reduce the impedance between PGND/GND and the system ground plane. Also, place bulk caps close to the DIMM/module or memory load point and route the VTTSNS to the DIMM/module load sense point.
- In order to effectively remove heat from the package, properly prepare the thermal land. Apply solder directly to the package’s thermal pad. Numerous vias, 0.33 mm in diameter or smaller, connected from the thermal land to the internal/solder side ground plane or planes should also be used to help dissipation.

8.4.2 Layout Example

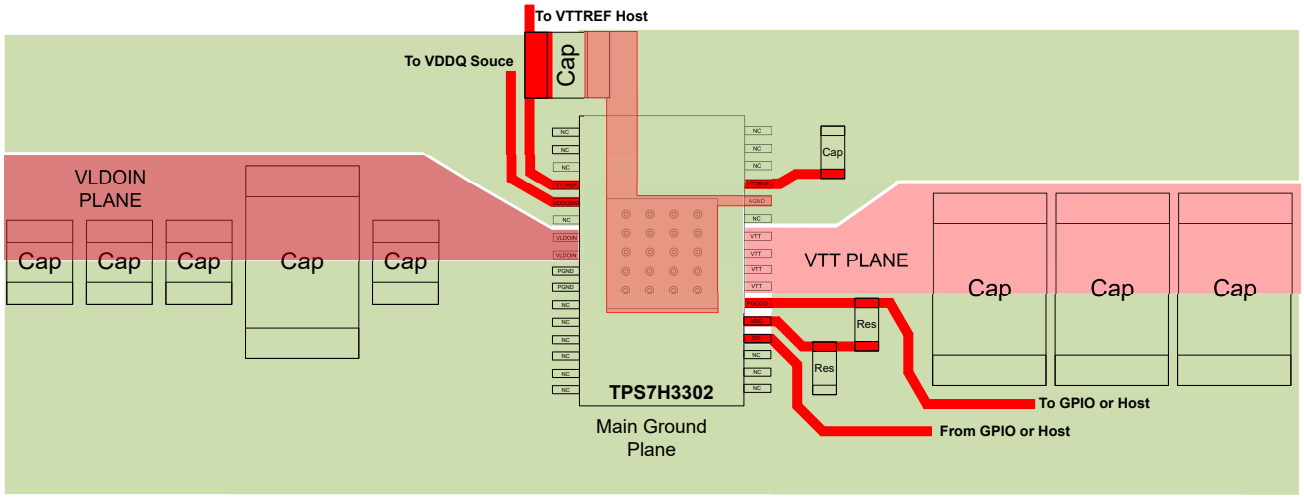


図 8-11. Layout Example

8.4.3 Thermal Considerations

VTT current can flow in both source and sink directions. As the TPS7H3302 is a linear regulator, power is dissipated internal to the device. When the device is sourcing current, the voltage difference between VLDOIN and VTT times IO (I_{IO}) current becomes the power dissipation as shown in 式 2.

$$P_{DISS\_SRC} = (V_{VLDOIN} - V_{VO}) \times I_{O\_SRC} \quad (2)$$

In this case, if VLDOIN is connected to an alternative power supply lower than the VDDQ voltage, overall power loss can be reduced. For the sink phase, VTT voltage is applied across the internal LDO regulator and the power dissipation (P_{DISS_SNK}) can be calculated by 式 3.

$$P_{DISS\_SNK} = V_{VO} \times I_{O\_SNK} \quad (3)$$

Because the device does not sink and source current at the same time and the IO current may vary rapidly with time, the actual power dissipation should be the time average of the above dissipations over the thermal relaxation duration of the system. Another source of power consumption is the current used for the internal current control circuitry from the VDD supply and the VLDOIN supply. This can be estimated as 5 mW or less during normal operating conditions. This power must be effectively dissipated from the package.

The thermal performance of an LDO depends on the printed circuit board (PCB) layout.

To further improve the thermal performance of this device, using a larger than recommended thermal land as well as increasing the number of vias helps lower the thermal resistance from junction to heat slug.

9 Device and Documentation Support

9.1 Documentation Support

9.1.1 Related Documentation

For related documentation see the following:

- Texas Instruments, *TPS7H3302-SEP Single-Event Effects Summary* radiation report (SLVK132)
- Texas Instruments, *TPS7H3302EVM-CVAL (HREL022)* user's guide (SLVUCK2)

9.2 Receiving Notification of Documentation Updates

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

9.3 サポート・リソース

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9.4 Trademarks

テキサス・インスツルメンツ E2E™ is a trademark of Texas Instruments.
すべての商標は、それぞれの所有者に帰属します。

9.5 静電気放電に関する注意事項

この IC は、ESD によって破損する可能性があります。テキサス・インスツルメンツは、IC を取り扱う際には常に適切な注意を払うことを推奨します。正しい取り扱いおよび設置手順に従わない場合、デバイスを破損するおそれがあります。

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。

9.6 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。

10 Revision History

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

Changes from Revision A (May 2023) to Revision B (December 2023)	Page
• TPS7H3302-SP のステータスを「製品プレビュー」から「量産データ」に変更	1
• Removal of "Product Preview" for TPS7H3302-SP	3
• Removed typical thermal shutdown	5
• Updated VTTREF accuracy to a percentage difference from VDDQSNS (DDR4, DDR3L, DDR3, DDR2 and DDR) at ±10 mA and ± 3 mA	5
• Modified description for Thermal Shutdown	14
• Updated part reference from TPS7H3302-SEP to TPS7H3302 in image	17
• Change of part reference in image from TPS7H3302-SEP to TPS7H3302	20
• Correction of graphical error in Layout Example	27

Changes from Revision * (February 2023) to Revision A (May 2023) **Page**

- TPS7H3302-SEP のステータスを「事前情報」から「量産データ」に変更 1
- QMLP バージョン TPS7H3302-SP の製品プレビューを追加 1
- TPS7H3302-SP (製品プレビュー) の放射線定格を「特長」セクションと「デバイス オプション」表に統合 1

11 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962R1422802PYE	ACTIVE	HTSSOP	DAP	32	250	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-55 to 125	R1422802PY	Samples
TPS7H3302MDAPTSEP	ACTIVE	HTSSOP	DAP	32	250	RoHS & Green	NIPDAU	Level-3-260C-168 HR	-55 to 125	TPS7H3302	Samples
V62/22615-01XE	ACTIVE	HTSSOP	DAP	32	250	RoHS & Green	NIPDAU	Level-3-260C-168 HR		TPS7H3302	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF TPS7H3302-SEP, TPS7H3302-SP :

- Catalog : TPS7H3302-SEP
- Space : TPS7H3302-SP

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

GENERIC PACKAGE VIEW

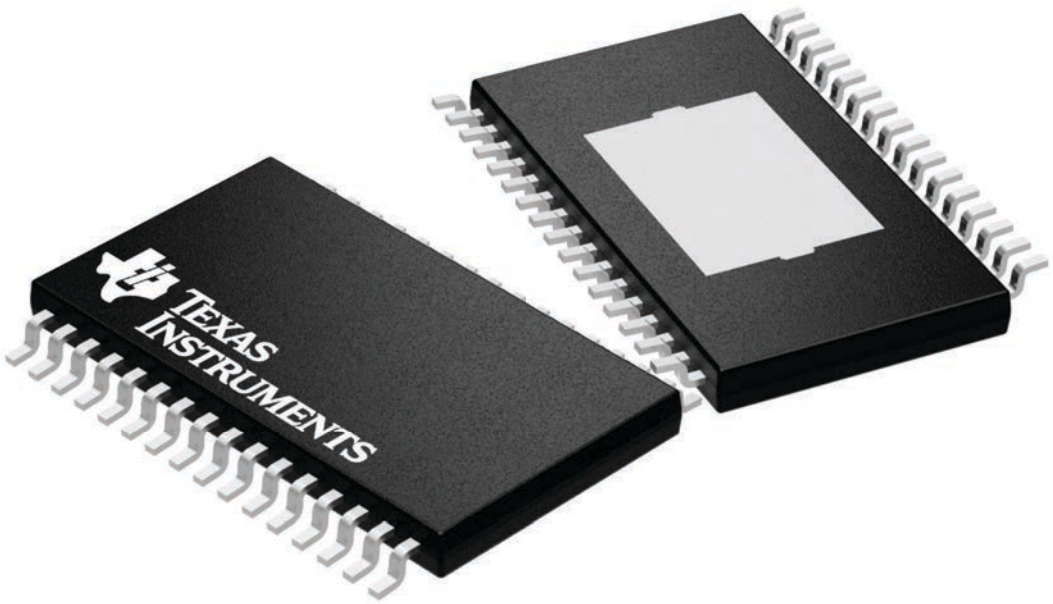
DAP 32

PowerPAD™ TSSOP - 1.2 mm max height

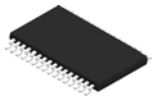
8.1 x 11, 0.65 mm pitch

PLASTIC SMALL OUTLINE

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



4225303/A

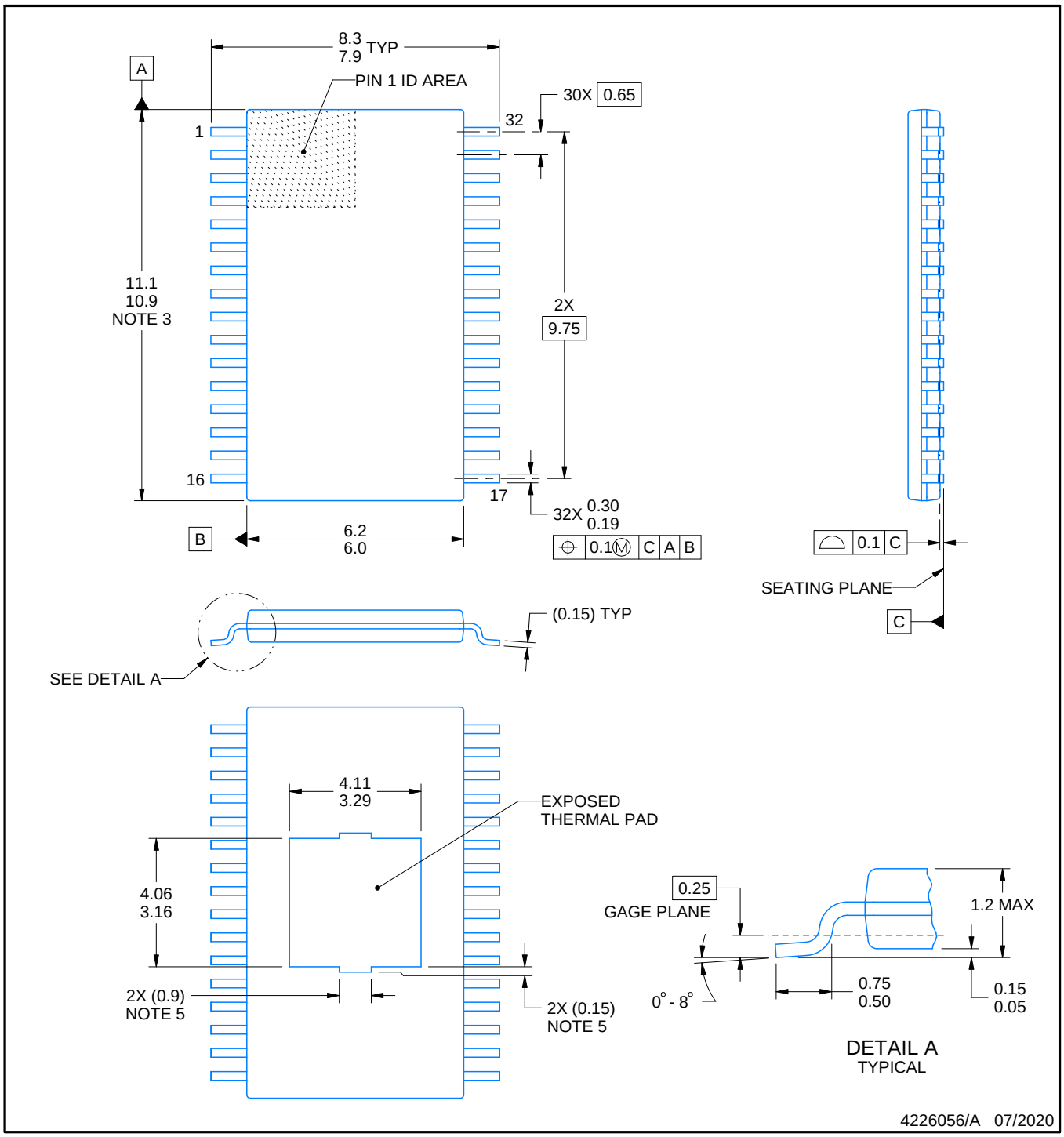


PACKAGE OUTLINE

DAP0032F

PowerPAD™ TSSOP - 1.2 mm max height

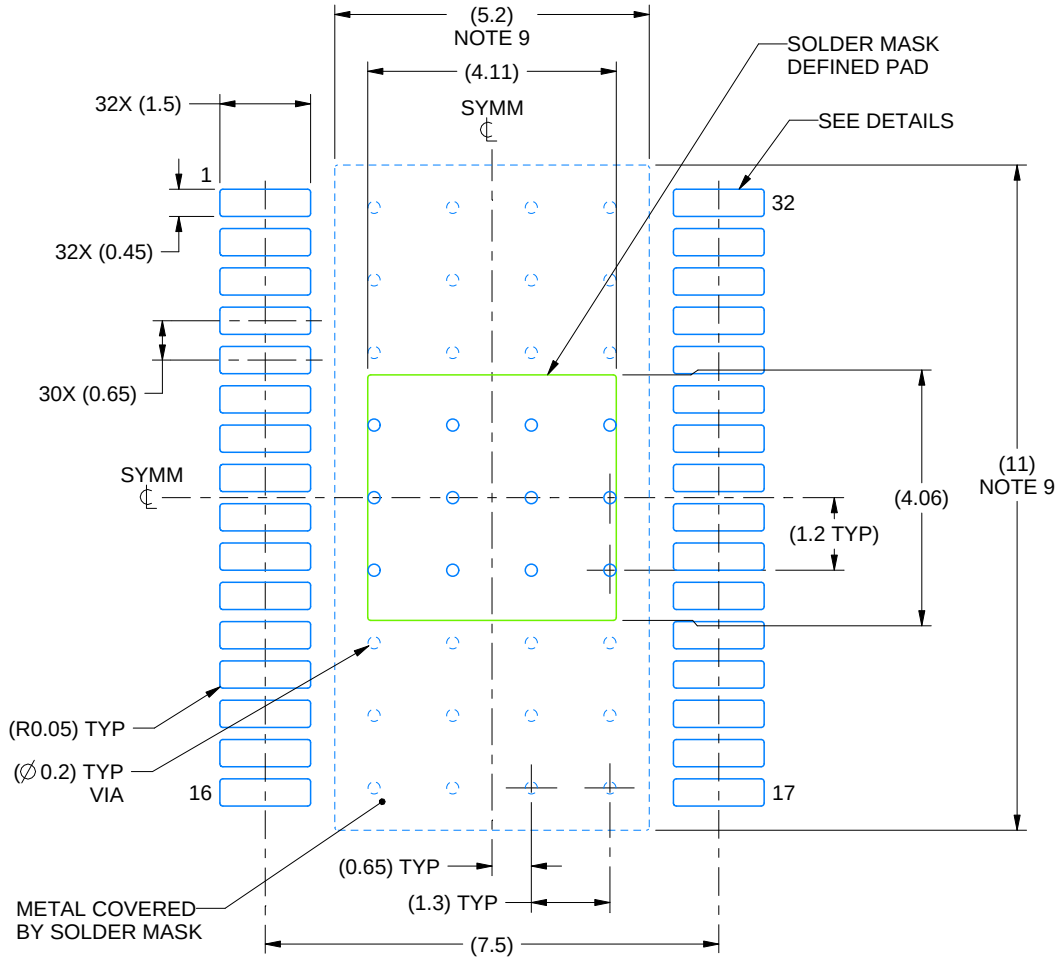
PLASTIC SMALL OUTLINE



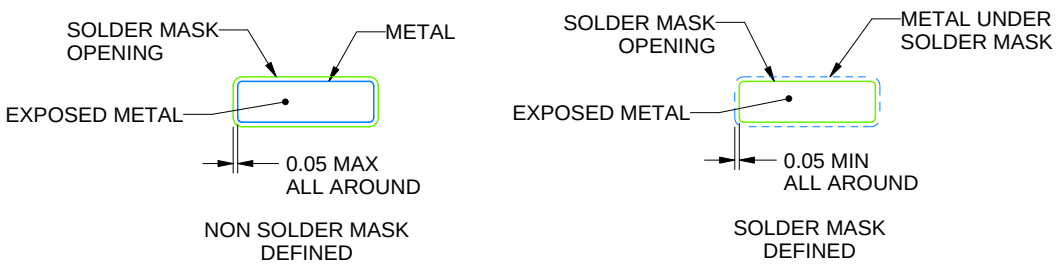
PowerPAD is a trademark of Texas Instruments.

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. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. Reference JEDEC registration MO-153.
5. Features may differ and may not be present.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS
NOT TO SCALE

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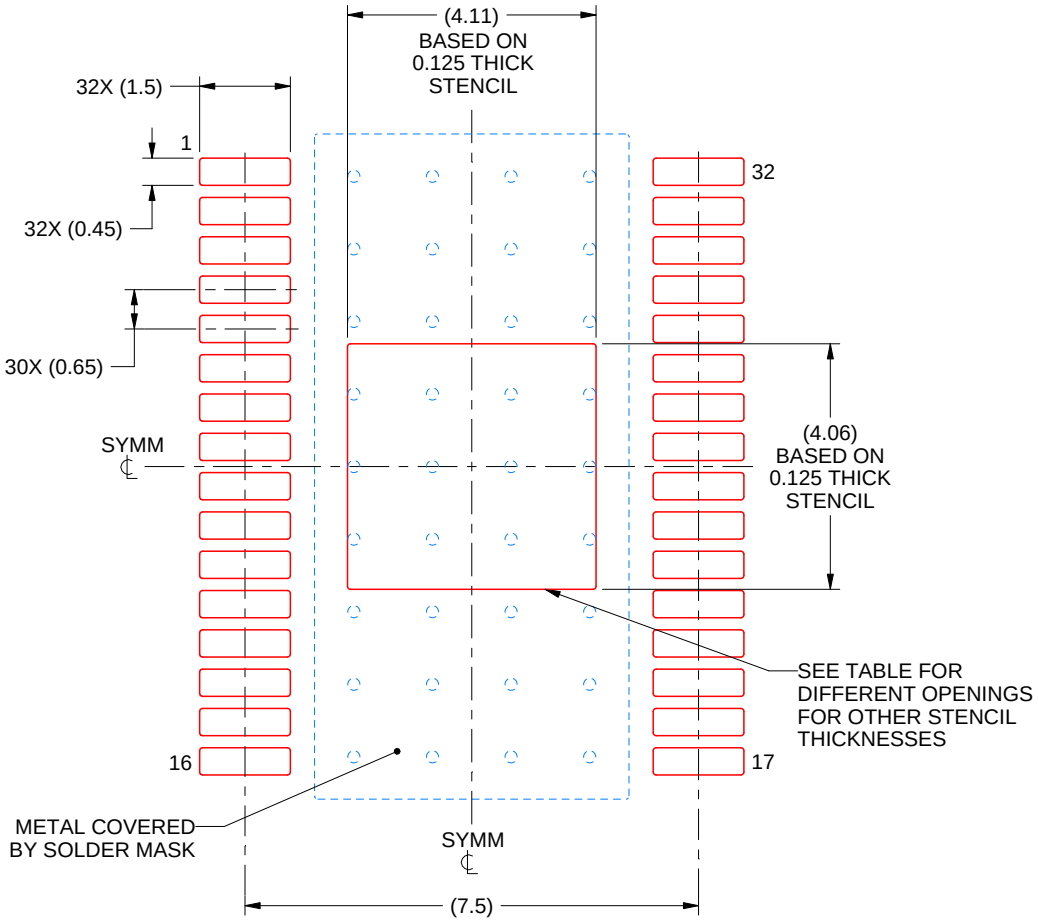
NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.
8. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature numbers SLMA002 (www.ti.com/lit/slma002) and SLMA004 (www.ti.com/lit/slma004).
9. Size of metal pad may vary due to creepage requirement.



SOLDER PASTE EXAMPLE
EXPOSED PAD
100% PRINTED SOLDER COVERAGE BY AREA
SCALE:8X

STENCIL THICKNESS	SOLDER STENCIL OPENING
0.1	4.60 X 4.54
0.125	4.11 X 4.06 (SHOWN)
0.15	3.75 X 3.71
0.175	3.47 X 3.43

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NOTES: (continued)

10. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
11. Board assembly site may have different recommendations for stencil design.

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