MAX25307/MAX25308

Two/Three-Output, Low-Noise LDO Linear Regulators

General Description

The MAX25307/MAX25308 are a two/three-output linear regulator family that deliver up to 600mA on channel 1 and up to 300mA on channels 2 and 3 with only 37μV_{RMS} of output noise from 10Hz to 100kHz. These regulators maintain ±1.25% output accuracy over a wide input voltage range, requiring only 155mV (max) of input-to-output headroom at full load. The 1.95mA maximum no-load supply current is independent of dropout voltage. Each output is factory programmable between 0.6V to 3.7875V in 12.5mV steps. No external components are needed except for the input, output, and bypass capacitors. Each output has an independent enable input and $\overline{RESET}$ output.

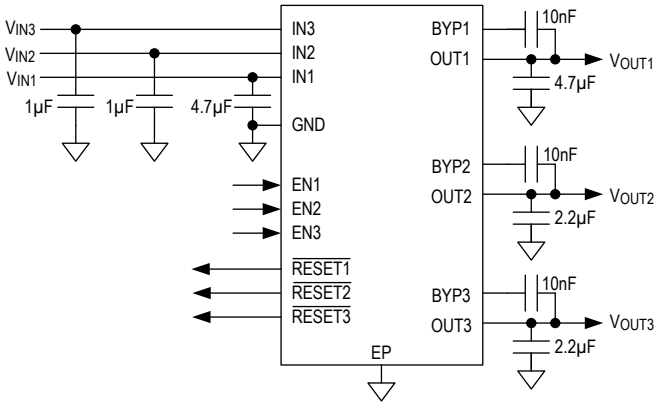
Applications

- Infotainment Systems
- Point of Load
- Advanced Driver-Assistance Sytems (ADAS)

Benefits and Features

- 1.7V to 5.5V Input Voltage Range
- Factory-Selectable Output Voltage of 0.6V to 3.7875V in 12.5mV Steps
- 37μV_{RMS} Output Noise, 10Hz to 100kHz
- 1.95mA (max) Operating Supply Current
- 70dB PSRR at 10kHz
- 600mA Maximum Output Current (OUT1)
- 300mA Maximum Output Current (OUT2/3)
- ±1.25% DC Accuracy over Load, Line, and Temperature
- 155mV (max) Dropout at $I_{MAX1/2/3}$ Load ($3.3V_{IN}$)
- < 1µA Shutdown Supply Current
- Overcurrent and Overtemperature Protection
- Output-to-Input Reverse Current Protection
- Individual $\overline{RESET}$ Outputs
- 3mm x 3mm, 16-Pin TQFN Package
- -40°C to +125°C Grade 1 Automotive Temperature Range

Simplified Block Diagram



Ordering Information appears at end of data sheet.

19-101040; Rev 6; 11/25

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Absolute Maximum Ratings

IN1, IN2, IN3, EN1, EN2, EN3 to GND ..... -0.3V to +6V
OUT1 to GND ..... -0.3V to IN1 + 0.3V
OUT2 to GND ..... -0.3V to IN2 + 0.3V
OUT3 to GND ..... -0.3V to IN3 + 0.3V
BYP1, BYP2, BYP3 to GND ..... -0.3V to +6V
RESET1, RESET2, RESET3 to GND ..... -0.3V to +6V
Output Short-Circuit Duration ..... Continuous

Package Thermal Characteristics
T1633+7C
Continuous Power Dissipation
TQFN (derate 21.52mW/°C above 70°C) 1721.69mW
Operating Junction Temperature .....-40°C to +150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (Soldering, 10 seconds) .....+300°C
Soldering Temperature (reflow) .....+260°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Recommended Operating Conditions

PARAMETER	SYMBOL	CONDITION	TYPICAL RANGE	UNIT
Ambient Temperature Range			-40 to +125	°C

Note: These limits are not guaranteed.

Package Information

TQFN

Package Code	T1633+7C
Outline Number	21-0136
Land Pattern Number	90-0032
Thermal Resistance, Four-Layer Board:	
Junction to Ambient (θ_{JA})	46.47°C/W
Junction to Case (θ_{JC})	5.58°C/W

For the latest package outline information and land patterns (footprints), go to ***www.maximintegrated.com/packages***. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to ***www.maximintegrated.com/thermal-tutorial***.

Electrical Characteristics

($V_{IN1,2}$ = 3.3V, V_{IN3} = 3.6V, C_{OUT1} = 4.7µF, $C_{OUT2,3}$ = 2.2µF, $C_{BYP\_}$ = 10nF, T_J = -40°C to +150°C, unless otherwise noted. Typical values are at T_A= +25°C under normal conditions, unless otherwise specified. (*Note 1*) (*Note 3*))

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	$V_{IN\_}$	Guaranteed by output accuracy	1.7		5.5	V
Input Undervoltage Lockout	V_{IN_UVLO}	$V_{IN\_}$ rising	1.5		1.69	V
Input Undervoltage Lockout Hysteresis	$V_{IN\_UVLO\_HYS}$	$V_{IN\_}$ UVLO hysteresis		100		mV
Supply Current	$I_{Q\_}$	All outputs off		1		µA
		I_{OUT} = 0mA, $V_{IN1,2}$ = 3.3V, V_{IN3} = 3.6V, $V_{EN\_}$ = $V_{IN\_}$		1.2	1.95	mA

Electrical Characteristics (continued)

($V_{IN1,2}$ = 3.3V, V_{IN3} = 3.6V, C_{OUT1} = 4.7µF, $C_{OUT2,3}$ = 2.2µF, $C_{BYP\_}$ = 10nF, T_J = -40°C to +150°C, unless otherwise noted. Typical values are at T_A= +25°C under normal conditions, unless otherwise specified. (Note 1) (Note 3))

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Voltage Range (Note 4)	$V_{OUT\_}$	$V_{IN\_} \geq V_{OUT\_}$ + 0.3V, $V_{IN\_} \geq$ 1.7V		0.6		3.7875	V
Output Accuracy	ACC	$I_{OUT\_}$ from 0.1mA to $I_{MAX\_}$, $V_{IN\_}$ from $V_{OUT\_}$ + 0.3V to 5.5V, $V_{IN\_} \geq$ 1.7V, -40°C < T_J < +125°C		-1.25		+1.25	%
		$I_{OUT\_}$ from 0.1mA to $I_{MAX\_}$, $V_{IN\_}$ from $V_{OUT\_}$ + 0.3V to 5.5V, $V_{IN\_} \geq$ 1.7V, -40°C < T_J < +150°C		-1.5		+1.5	
Load Regulation		$I_{OUT\_}$ from 0.1mA to $I_{MAX\_}$, $V_{IN\_}$ = $V_{OUT\_}$ + 0.3V, $V_{OUT1,2,3}$ = factory setting			0.07		%
Line Regulation		$V_{IN\_}$ from $V_{OUT\_}$ + 0.3V to 5.5V, $V_{IN\_} \geq$ 1.7V, $I_{OUT1,2,3}$ = 0.1mA			0.06		%
LDO_ Dropout Voltage (Note 2)		$V_{IN\_}$ = 3.3V, $I_{OUT\_}$ = $I_{MAX\_}$			65	155	mV
Current Limit	I_{LIM1_HI}	I_{MAX1} = 600mA, $V_{IN1} \geq$ 1.7V, V_{OUT1} = 95% of regulation, $V_{IN1} \geq V_{OUT1}$ + 0.3V		650	790	930	mA
	$I_{LIM2,3\_HI}$	$I_{MAX2,3}$ = 300mA, $V_{IN2,3} \geq$ 1.7V, $V_{OUT2,3}$ = 95% of regulation, $V_{IN2,3} \geq V_{OUT2,3}$ + 0.3V		390	490	590	
Output Noise		$V_{OUT\_}$ = 1.2V, $I_{OUT\_}$ = 100mA, 10Hz to 100kHz, $C_{BYP\_}$ = 47nF			37		μV_{RMS}
Power Supply Rejection Ratio	PSRR	I_{OUT1} = 100mA, $I_{OUT2,3}$ = 50mA, 10kHz			70		dB
EN_ Input Threshold		$V_{IN\_}$ from 1.7V to 5.5V	EN_ rising			1.2	V
			EN_ falling	0.4			
EN_ Hysteresis					75		mV
EN_ Input Resistance		$V_{IN\_}$ from 1.7V to 5.5V	T_J = +25°C		2		MΩ
Input Reverse Current Threshold		Peak reverse current before $I_{IN\_}$ falls to less than 50µA			200		mA
Thermal Shutdown Threshold		T_J rising			170		°C
Thermal Shutdown Hysteresis					15		°C
Discharge Resistance		$V_{EN\_}$ = 0V			800		Ω
Startup Time		Delay from $V_{EN\_}$ high to $V_{OUT\_}$ starts rising			220		µs
$\overline{\text{RESET}}$							
$\overline{\text{RESET}}$_ OV Threshold		$V_{OUT\_}$ rising		104.6	108.3	111.7	%
$\overline{\text{RESET}}$_ UV Threshold		$V_{OUT\_}$ falling		88.3	91.7	94.7	%
$\overline{\text{RESET}}$_ Voltage, Low		$I_{RESET\_}$ = 1mA			10	100	mV
$\overline{\text{RESET}}$_ Filter Time					5		µs

Electrical Characteristics (continued)

($V_{IN1,2}$ = 3.3V, V_{IN3} = 3.6V, C_{OUT1} = 4.7µF, $C_{OUT2,3}$ = 2.2µF, $C_{BYP\_}$ = 10nF, $T_{J;}$ = -40°C to +150°C, unless otherwise noted. Typical values are at T_A= +25°C under normal conditions, unless otherwise specified. (*Note 1*) (*Note 3*))

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
$\overline{\text{RESET\_}}$ Leakage Current			-0.1	+0.001	+0.1	µA
$\overline{\text{RESET\_}}$ Hold Time		Option 1	0.425	0.5	0.575	ms
		Option 2	2.805	3.7	4.255	
		Option 3	6.29	7.4	8.51	
		Option 4	12.665	14.9	17.135	

Note 1: All units are 100% production tested at +25°C. All temperature limits are guaranteed by design and characterization.

Note 2: Dropout voltage is defined as (V_{IN} - V_{OUT}) when FET is fully turned ON.

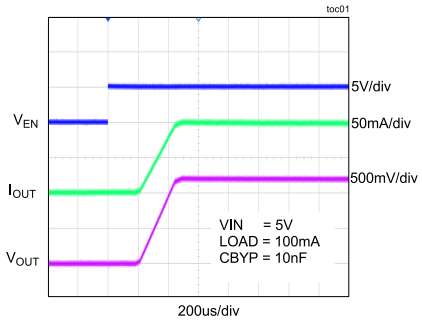
Note 3: The device is designed for continuous operation up to T_J = +125°C for 95,000 hours and T_J = +150°C for 5,000 hours.

Note 4: Not production tested, characterized by ATE.

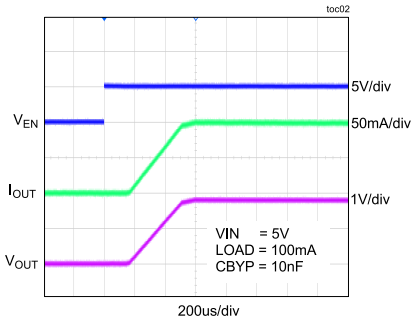
Typical Operating Characteristics

($V_{IN\_}$ = 3.3V, $V_{OUT1/2/3}$ = 1.2V/1.8V/3.3V, T_A = +25°C, C_{IN1} = 4.7µF, $C_{IN2,3}$ = 1µF, C_{OUT1} = 4.7µF, $C_{OUT2,3}$ = 2.2µF, $C_{BYP\_}$ = 10nF, unless otherwise noted.)

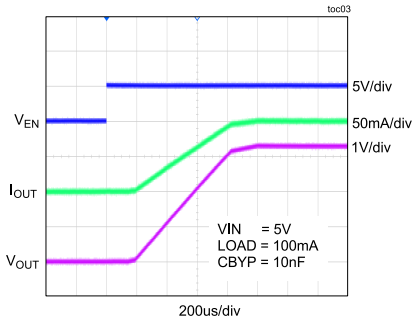
CH1 STARTUP WAVEFORM



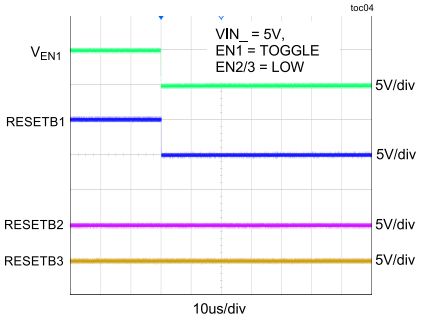
CH2 STARTUP WAVEFORM



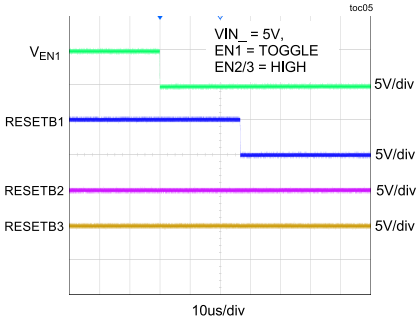
CH3 STARTUP WAVEFORM



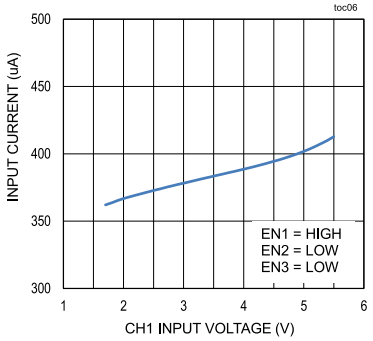
CH1 RESETB TOGGLE WAVEFORM



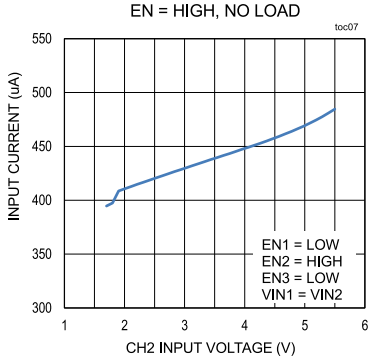
CH1 RESETB TOGGLE WAVEFORM



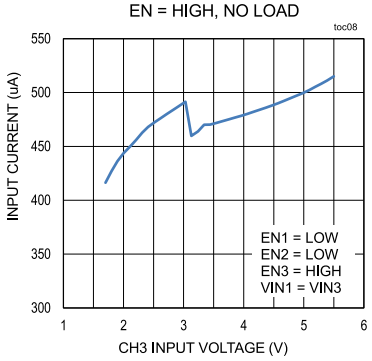
CH1 QUIESCENT CURRENT
EN = HIGH, NO LOAD



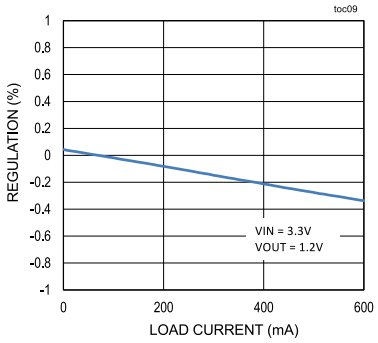
CH2 QUIESCENT CURRENT
EN = HIGH, NO LOAD



CH3 QUIESCENT CURRENT
EN = HIGH, NO LOAD



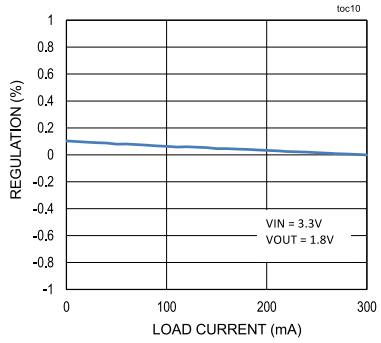
CH1 LOAD REGULATION



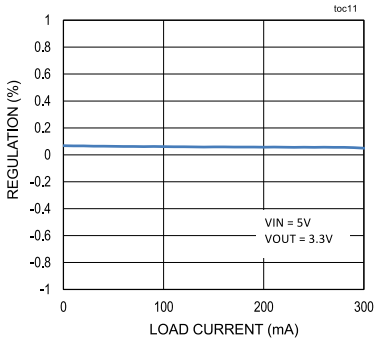
Typical Operating Characteristics (continued)

($V_{IN\_}$ = 3.3V, $V_{OUT1/2/3}$ = 1.2V/1.8V/3.3V, T_A = +25°C, C_{IN1} = 4.7µF, $C_{IN2,3}$ = 1µF, C_{OUT1} = 4.7µF, $C_{OUT2,3}$ = 2.2µF, $C_{BYP\_}$ = 10nF, unless otherwise noted.)

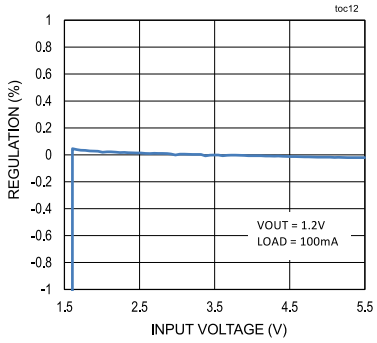
CH2 LOAD REGULATION



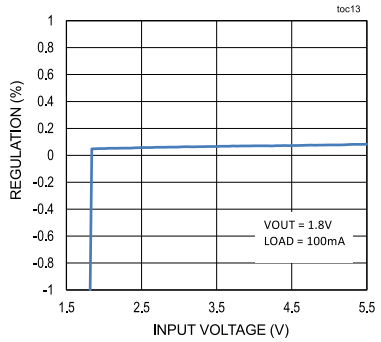
CH3 LOAD REGULATION



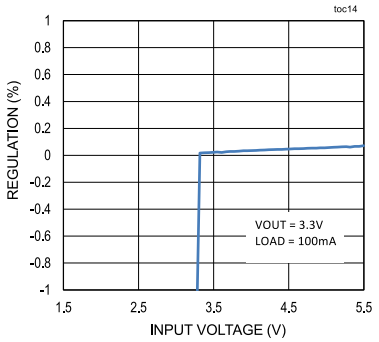
CH1 LINE REGULATION



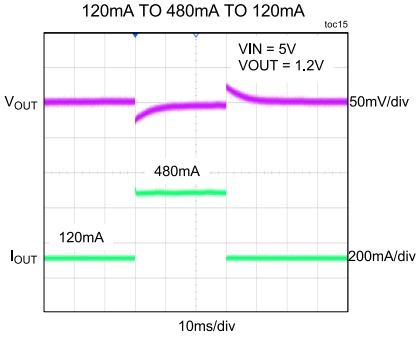
CH2 LINE REGULATION



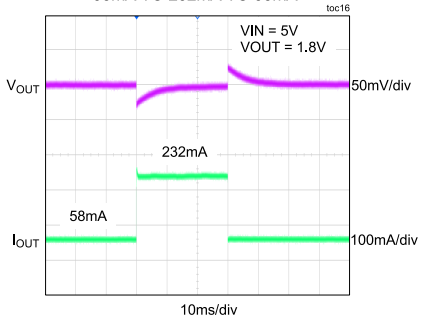
CH3 LINE REGULATION



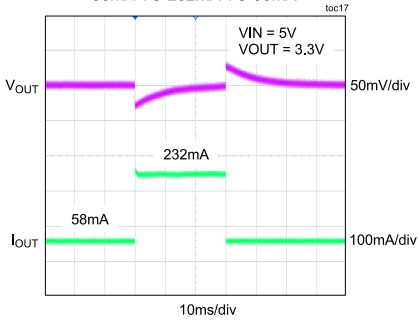
CH1 LOAD TRANSIENT RESPONSE
120mA TO 480mA TO 120mA



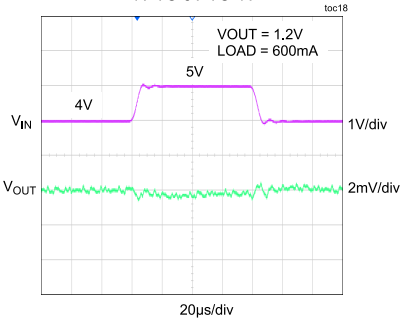
CH2 LOAD TRANSIENT RESPONSE
58mA TO 232mA TO 58mA



CH3 LOAD TRANSIENT RESPONSE
58mA TO 232mA TO 58mA



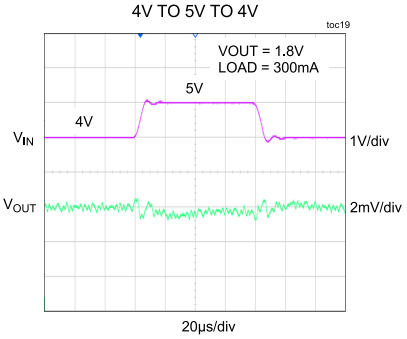
CH1 LINE TRANSIENT RESPONSE
4V TO 5V TO 4V



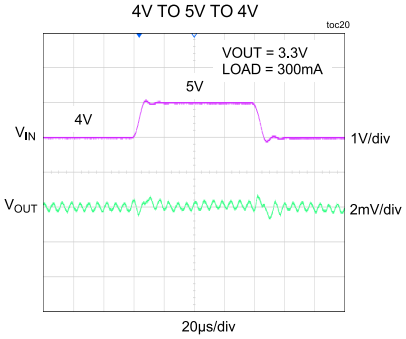
Typical Operating Characteristics (continued)

($V_{IN\_}$ = 3.3V, $V_{OUT1/2/3}$ = 1.2V/1.8V/3.3V, T_A = +25°C, C_{IN1} = 4.7µF, $C_{IN2,3}$ = 1µF, C_{OUT1} = 4.7µF, $C_{OUT2,3}$ = 2.2µF, $C_{BYP\_}$ = 10nF, unless otherwise noted.)

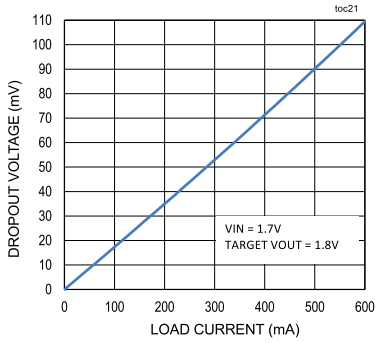
CH2 LINE TRANSIENT RESPONSE
4V TO 5V TO 4V



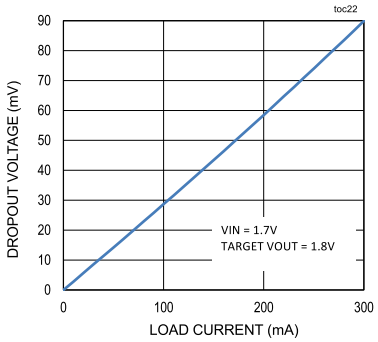
CH3 LINE TRANSIENT RESPONSE
4V TO 5V TO 4V



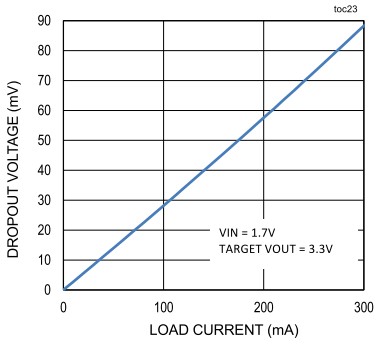
CH1
DROPOUT VOLTAGE vs. LOAD CURRENT



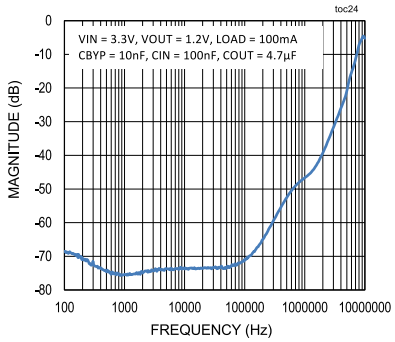
CH2
DROPOUT VOLTAGE vs. LOAD CURRENT



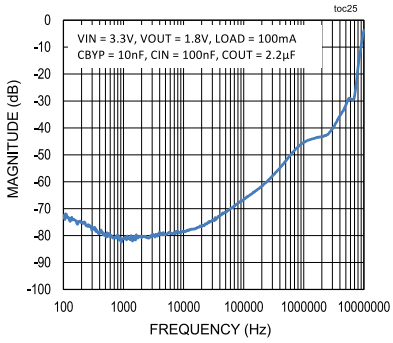
CH3
DROPOUT VOLTAGE vs. LOAD CURRENT



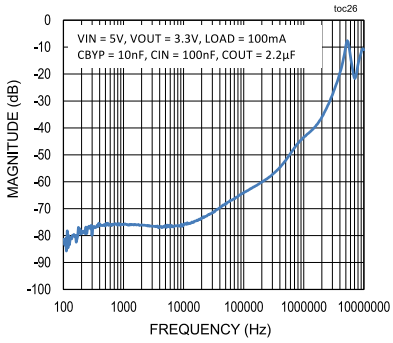
CH1
PSRR vs. FREQUENCY



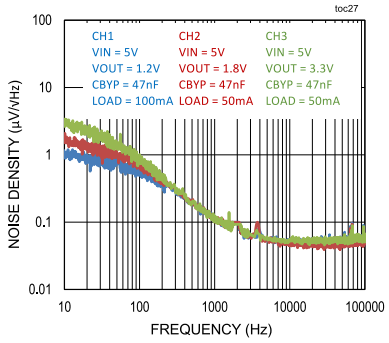
CH2
PSRR vs. FREQUENCY



CH3
PSRR vs. FREQUENCY

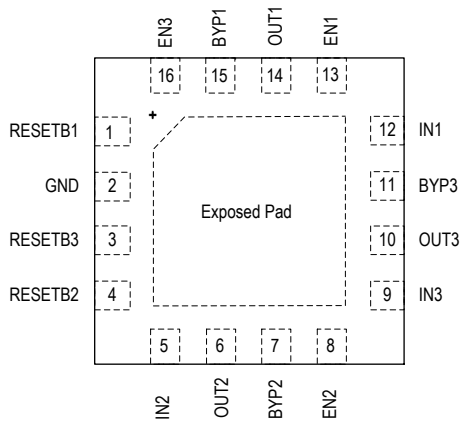


OUTPUT NOISE SPECTRAL DENSITY vs. FREQUENCY

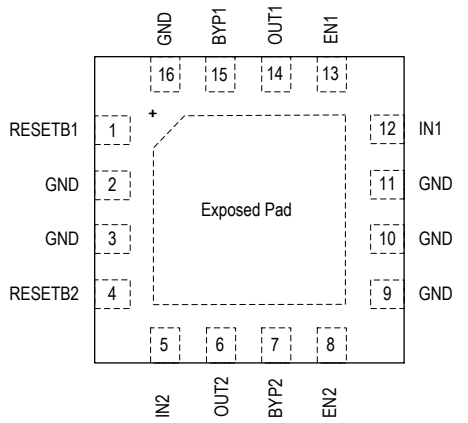


Pin Configurations

MAX25308



MAX25307



Pin Description

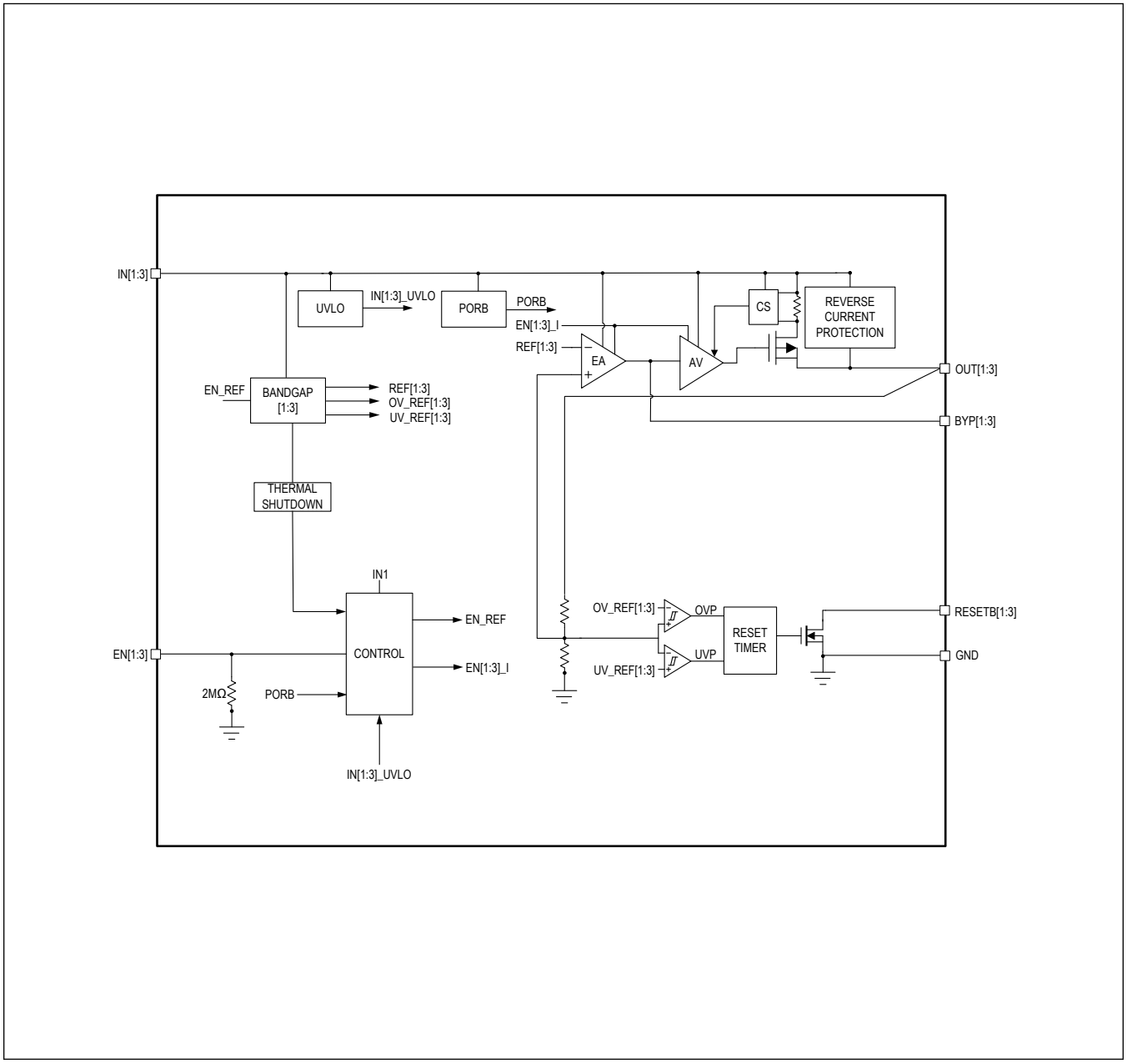
PIN		NAME	FUNCTION
MAX25308	MAX25307		
1	1	$\overline{\text{RESET1}}$	Active-Low RESET for Output 1. $\overline{\text{RESET1}}$ becomes high impedance when OUT1 is in regulation. Actively pulled down if OUT1 is outside the regulation window. To obtain a logic signal, connect a pullup resistor from this pin to a supply.
2	2	GND	Regulator Ground. Bring IN_ and OUT_ bypass capacitor GND connections to this pin.

Pin Description (continued)

PIN		NAME	FUNCTION
MAX25308	MAX25307		
3	—	$\overline{\text{RESET3}}$	Active-Low RESET for Output 3. $\overline{\text{RESET3}}$ becomes high impedance when OUT3 is in regulation. Actively pulled down if OUT3 is outside the regulation window. To obtain a logic signal, connect a pullup resistor from this pin to a supply.
4	4	$\overline{\text{RESET2}}$	Active-Low RESET for Output 2. $\overline{\text{RESET2}}$ becomes high impedance when OUT2 is in regulation. Actively pulled down if OUT2 is outside the regulation window. To obtain a logic signal, connect a pullup resistor from this pin to a supply.
5	5	IN2	Regulator Supply Input. Connect to a voltage between 1.7V and 5.5V, and bypass with a 1µF capacitor from IN2 to GND.
6	6	OUT2	Channel 2 Output. Sources maximum up to 300mA at output regulation voltage. Bypass with 2.2µF low ESR capacitor from OUT2 to GND.
7	7	BYP2	Bypass Capacitor Input 2. Connect 1nF to 100nF capacitor between OUT2 and BYP2 to reduce output noise and set the regulator soft-start rate.
8	8	EN2	Enable Input for Channel 2. Connect this pin to a logic signal to enable (V_{EN2} high) or disable (V_{EN2} low) the regulator output. Connect to IN_ with 10kΩ pullup resistor to keep the output enabled whenever a valid supply voltage is present.
9	—	IN3	Regulator Supply Input. Connect to a voltage between 1.7V and 5.5V and bypass with a 1µF capacitor from IN3 to GND.
10	—	OUT3	Channel 3 Output. Sources maximum up to 300mA at output regulation voltage. Bypass with 2.2µF low ESR capacitor from OUT3 to GND.
11	—	BYP3	Bypass Capacitor Input 3. Connect 1nF to 100nF capacitor between OUT3 and BYP3 to reduce output noise and set the regulator soft-start rate.
12	12	IN1	Regulator Supply Input. Connect to a voltage between 1.7V and 5.5V, and bypass with a 4.7µF capacitor from IN1 to GND.
13	13	EN1	Enable Input for Channel 1. Connect this pin to a logic signal to enable (V_{EN1} high) or disable (V_{EN1} low) the regulator output. Connect to IN_ with a 10kΩ pullup resistor to keep the output enabled whenever a valid supply voltage is present.
14	14	OUT1	Channel 1 Output. Sources up to 600mA at output regulation voltage. Bypass with 4.7µF low ESR capacitor from OUT1 to GND.
15	15	BYP1	Bypass Capacitor Input 1. Connect 1nF to 100nF capacitor between OUT1 and BYP1 to reduce output noise and set the regulator soft-start rate.
16	—	EN3	Enable Input for Channel 3. Connect this pin to a logic signal to enable (V_{EN3} high) or disable (V_{EN3} low) the regulator output. Connect to IN_ with a10kΩ pull up resistor to keep the output enabled whenever a valid supply voltage is present.
—	3,9,10,11,16	N.C.	Connect to Ground
EP	EP	EP	Exposed Pad. Connect the exposed pad to a ground plane with low thermal resistance to ambient to provide best heat sinking.

Functional Diagrams

Simplified Functional Diagram



Detailed Description

The MAX25307/MAX25308 are a two/three-output linear regulator family that deliver up to 600mA on channel 1 and 300mA on channels 2 and 3 with only 37μV_{RMS} of output noise from 10Hz to 100kHz. These regulators maintain ±1.25% output accuracy over a wide input voltage range, requiring only 155mV (max) of input-to-output headroom at full load. The 1.95mA maximum no-load supply current is independent of dropout voltage. Each output is factory programmable between 0.6V to 3.7875V in 12.5mV steps. No external components are needed except for the input, output, and bypass capacitors. Each output has an independent enable input and $\overline{RESET}$ outputs. A simplified functional diagram is shown in *Simplified Functional Diagram*.

Supply Inputs (IN1-3)

There is a separate supply input for each LDO. However, IN1 powers the common circuitry of the device. This requires power to the IN1 to be supplied before OUT2 and/or OUT3 can be turned on. If the supply for IN1 comes up last, this delays the soft-start for the other outputs until after IN1 is above the UVLO. It is acceptable that the enable inputs are high prior to the input supply being applied.

Enable (EN1-3)

The MAX25307/MAX25308 include individual enable inputs for each output (EN1/EN2/EN3). Pull EN_ low to shut down the output, or drive EN_ high to enable the output. If a separate enable signal is not available, connect EN_ to IN_ to keep the output enabled whenever a valid supply voltage is present.

Bypass (BYP)

The capacitor connected from BYP_ to OUT_ filters the noise of the reference, feedback resistors, and regulator input stage. The slew rate of the output voltage during startup is also determined by the BYP capacitor. A 0.01µF capacitor sets the slew rate to 5V/ms.

The BYP capacitor value can be adjusted from 0.001µF to 0.1µF to change the startup slew rate according to the following formula:

$$StartupSlewRate = (5V / ms) \times \left(\frac{0.01\mu F}{C_{BYP\_}}\right)$$

where $C_{BYP\_}$ is in µF.

Overcurrent Protection

The MAX25307/MAX25308 current limit provides protection during output overload or short-circuit conditions. If the output is shorted to GND, the output current is limited to the selected current limit. In such cases, the output falls out of regulation, and is $V_{OUT} = I_{LIM} \times R_{LOAD}$. In this condition, the pass element dissipates power equals to $(V_{IN} - V_{OUT}) \times I_{LIM}$, which increases junction temperature. When the junction temperature reaches approximately 170˚C (typ), a thermal overload circuit turns off the device. When the junction cools to 155˚C (typ), the device is turned on to reestablish regulation. While the fault persists, the device cycles between the current limit and thermal shutdown.

Overtemperature Protection

Overtemperature protection turns off the device when junction temperature rises to approximately 170˚C (typ). When junction temperature cools to approximately 155˚C (typ), the output turns back on to reestablish regulation. The thermal protection circuit can cycle on and off depending on power dissipation, thermal resistance, and ambient temperature. This cycling limits the power dissipation and protects the device from damage due to overheating.

Output-to-Input Reverse Current Protection

The MAX25307/MAX25308 are also protected against reverse current when the output voltage is higher than the input. If extra output capacitance is used at the output, a power-down transient at the input would normally cause a large reverse current through a conventional regulator. The MAX25307/MAX25308 include a reverse voltage detector that trips when IN_ drops 10mV below OUT_, shutting off the regulator and opening the PMOS body diode connection, preventing any

reverse current.

$\overline{\text{RESET}}$ Outputs

The MAX25307/MAX25308 include an open-drain output, $\overline{\text{RESET}}$ for each output that goes low to indicate the output voltage is out of regulation. Connect a pullup resistor from this pin to an external supply. When the associated EN_ is low the $\overline{\text{RESET}}$_ is asserted. The hold time of all reset outputs is factory selectable between 0.5ms and 14.9ms.

Input Capacitor

A 4.7µF ceramic capacitor for channel 1 and 1µF ceramic capacitor for channels 2 and 3 are recommended for the input. Select a capacitor that maintains its capacitance over temperature and DC bias. Capacitors with X7R temperature characteristics generally perform well.

Output Capacitor

The minimum output capacitance for stability depends on the current configuration of the channel. See the following table for the capacitance requirements based on the output current capability.

OUTPUT CURRENT (I_{MAX}) (mA)	$C_{OUT(MIN)}$ (µF)	$C_{OUT(TYP)}$ (µF)
600	2.35	4.7
300	1.1	2.2

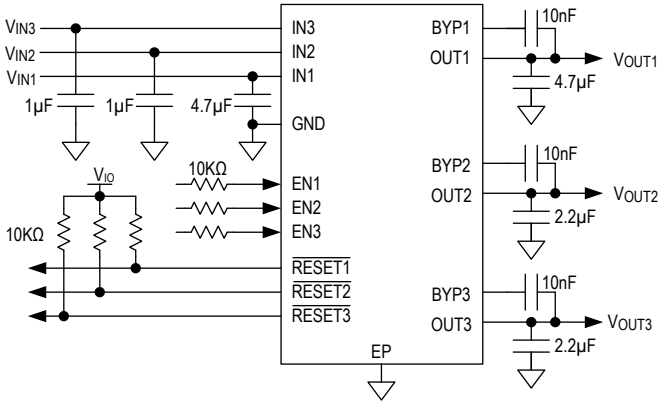
The typical output capacitance assumes an X7R capacitor with a working voltage high enough such that the fully derated output capacitance is greater than $C_{OUT(MIN)}$.

Thermal Considerations

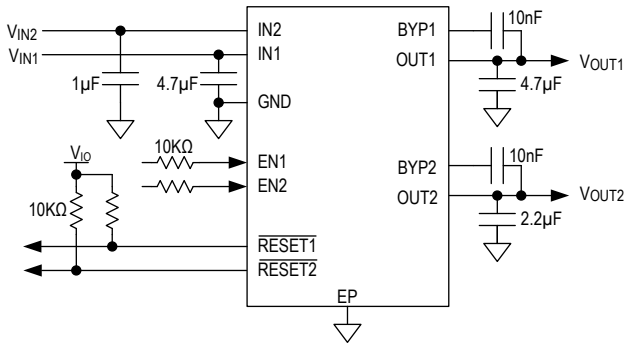
The MAX25307/MAX25308 are packaged in an 16-pin, 3mm x 3mm TQFN package with an exposed pad. The exposed pad is the main path for heat to leave the IC, and therefore must be connected to a ground plane with thermal vias to allow heat to dissipate from the device. Thermal properties of the IC package are given in the *Package Information* section.

Typical Application Circuits

Circuit 1 (MAX25308)



Circuit 2 (MAX25307)



Ordering Information

PART NUMBER	V_{OUT1} (V)	I_{MAX1} (A)	V_{OUT2} (V)	I_{MAX2} (A)	V_{OUT3} (V)	I_{MAX3} (A)	HOLD (ms)
TWO-OUTPUT LDOs							
MAX25307AATEA/V+*	3.3	0.6	1.8	0.3	—	—	3.7
MAX25307AATED/V+	2.8	0.6	1.8	0.3	—	—	0.5
MAX25307AATEJ/V+	3.3	0.6	1.8	0.3	—	—	0.5
THREE-OUTPUT LDOs							
MAX25308AATEA/V+	1.2	0.6	1.8	0.3	3.3	0.3	0.5
MAX25308AATEB/V+	1.8	0.6	0.8	0.3	1.2	0.3	0.5
MAX25308AATEC/V+	0.8	0.6	1.5	0.3	0.8	0.3	0.5
MAX25308AATEE/V+	2.5	0.6	1.8	0.3	1	0.3	3.7

** Potential future product.*

+ Denotes a lead(Pb)-free/RoHS-compliant package.

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	3/21	Initial release	—
1	11/23	Added MAX25307AATED/V+ to *Ordering Information*	14
2	10/24	Added MAX25308AATEB/V+ and MAX25308AATEC/V+ to *Ordering Information*	15
3	11/24	Denoted MAX25308AATEC/V+ as a Potential Future Product	15
4	3/25	Removed asterisk from MAX25308AATEC/V+ in *Ordering Information*	15
5	7/25	Added MAX25308AATEE/V+ to *Ordering Information*	15
6	11/25	Added MAX25307AATEJ/V+ to *Ordering Information*	15