

ETQ65H4333M - High Input Very-Low I_Q 500mA LDO

General Description

The ETQ65H4333M is a low dropout with 500mA load ability with enable function LDO. It operates from 3V ~ 40V. The quiescent current is 10uA with no load. The devices feature integrated short-circuit and over-current protection. It is quite suitable for standby microprocessor control-unit systems, especially in automotive applications.

ETQ65H4333M is available in the ESOP8 package.

Features

- Input Voltage Range from 3V to 40V
- 500mA Load Current
- I_Q is 12 μ A Typical
- Fixed Output Voltage 3.3V
- Low Dropout is 620mV at 500mA
- Power-Good Feature is Available
- Over-Temperature Protection
- Current-Limit Protection
- Automotive AEC-Q100 Grade 1 Qualified
 - Ambient Temperature Range of -40 °C to +125 °C
 - ESD HBM 2 KV PASS
 - ESD CDM 1.5 KV PASS
- Part No. and Package Information

Part No.	Package	Packing Option	MSL
ETQ65H4333M	ESOP8	Tape and Reel, 4K/Reel	Level 3

Applications

- Automotive constant-voltage power supply
- Automotive infotainment and cluster
- Automotive power supply for body electronics and lighting

ETQ65H4333M

Pin Configuration

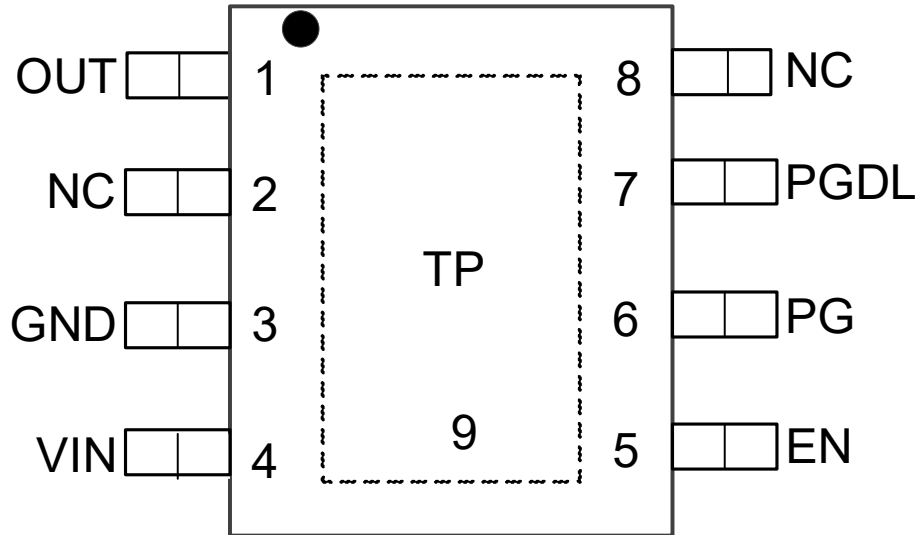


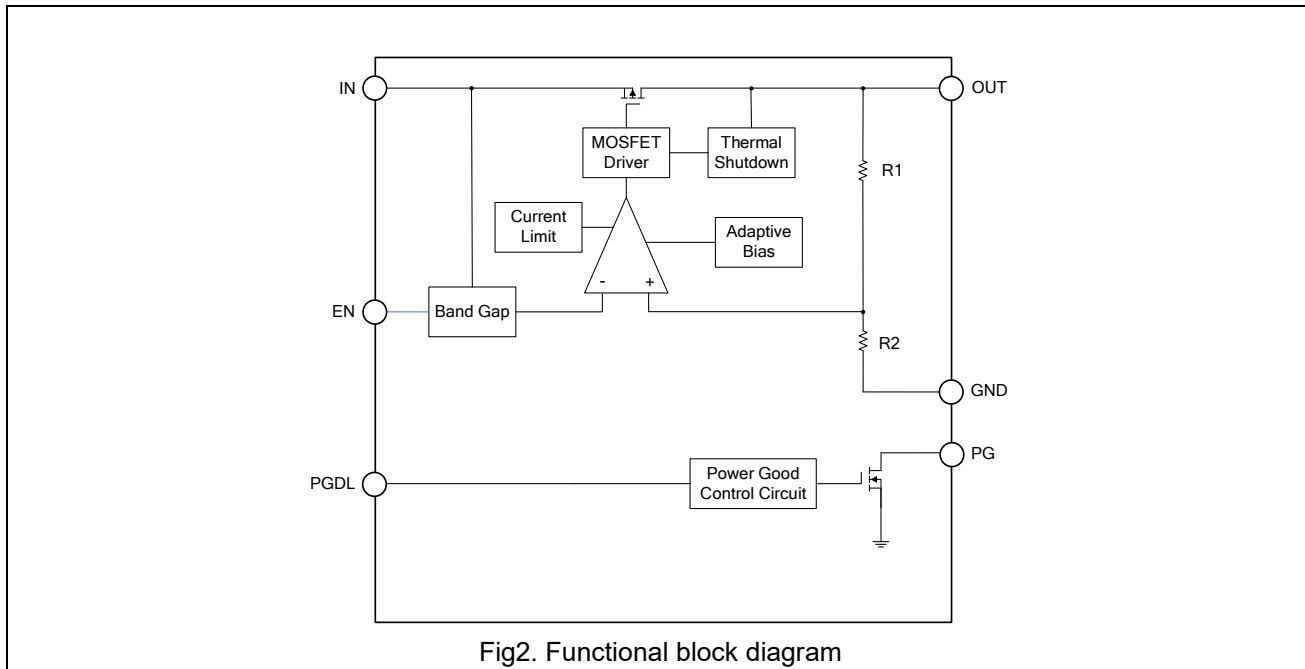
Fig1. TOP VIEW

Pin Function

Pin No.	Pin Name	Pin Function
1	OUT	Output Pin
2,8	NC	No Connect
3	GND	Ground Pin
4	VIN	Input Pin
5	EN	Enable Input Pin
6	PG	Power Good Pin
7	PGDL	PG Delay Pin
9	TP	Thermal Pad, Floating or Connect to GND

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Block Diagram



Functional Description

Input Capacitor

A 1 μ F~10uF ceramic capacitor is recommended to connect between VIN and GND pins to decouple input power supply glitch and noise. The amount of the capacitance may be increased without limit. This input capacitor must be located as close as possible to the device to assure input stability and less noise. For PCB layout, a wide copper trace is required for both VIN and GND.

Output Capacitor

An output capacitor is required for the stability of the LDO. The recommended output capacitance is from 1 μ F to 10 μ F, Equivalent Series Resistance (ESR) is from 5m Ω to 100m Ω , and temperature characteristics are X7R or X5R. Higher capacitance values help to improve load/line transient response. The output capacitance may be increased to keep low undershoot/overshoot. Place output capacitor as close as possible to OUT and GND pins.

Enable

The ETQ65H4333M delivers the output power when it is set to enable state. When it works in disable state, there is no output power and the operation quiescent current is almost zero. The enable pin (EN) is active high.

Dropout Voltage

The ETQ65H4333M uses a PMOS pass transistor to achieve low dropout. When $(V_{IN} - V_{OUT})$ is less than the dropout voltage (V_{DROP}), the PMOS pass device is in the linear region of operation and the input-to-output resistance is the $R_{DS(ON)}$ of the PMOS pass element. V_{DO} scales approximately with output current because the PMOS device behaves like a resistor in dropout mode. As with any linear regulator, PSRR and transient response degrade as $(V_{IN} - V_{OUT})$ approaches dropout operation.

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Power Good

The ETQ65H4333M provides an open-drain PG Pin. The PG pin is an open-drain output and should be connected to VOUT. When VOUT rises 93% of VOUT, the PG Pin is pulled to high by VOUT. When VOUT falls to 89% of VOUT, the PG Pin is pulled to 0V. The delay time (t_{PGDL}) can be defined by adding a capacitor (C_{PGDL}) on PGDL through below equation:

$$t_{PGDL} = C_{PGDL} \times 5.2V / 5\mu A$$

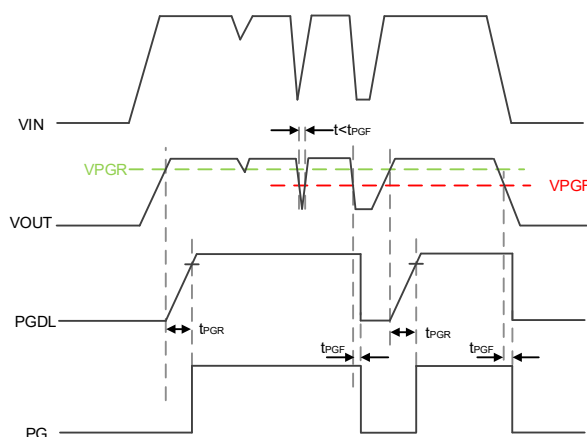


Fig3. Power Good Timing

Thermal Shutdown

Thermal shutdown protection disables the output when the junction temperature rises to approximately 155°C. Disabling the device eliminates the power dissipated by the device, allowing the device to cool. When the junction temperature cools to approximately 130°C, the output circuitry is again enabled.

Depending on power dissipation, thermal resistance, and ambient temperature, the thermal protection circuit may cycle on and off. This cycling limits regulator dissipation, protecting the LDO from damage as a result of overheating. Activating the thermal shutdown feature usually indicates excessive power dissipation as a result of the product of the ($V_{IN} - V_{OUT}$) voltage and the load current. For reliable operation, limit junction temperature to 150°C maximum.

Thermal Considerations

For continuous operation, do not exceed absolute maximum junction temperature. The maximum power dissipation depends on the thermal resistance of the IC package, PCB layout, rate of surrounding airflow, and difference between junction and ambient temperature. The maximum power dissipation can be calculated by the following formula:

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

where $T_{J(MAX)}$ is the maximum junction temperature, T_A is the ambient temperature, and θ_{JA} is the junction to ambient thermal resistance. For recommended operating condition specifications the maximum junction temperature is 150°C and T_A is the ambient temperature. The junction to ambient thermal resistance, θ_{JA} is layout dependent. The maximum power dissipation depends on the operating ambient temperature for fixed $T_{J(MAX)}$ and thermal resistance (θ_{JA}).

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Current-Limit Protection

The ETQ65H4333M provides current limit function to prevent the device from damages during over-load or shorted-circuit condition. This current is detected by an internal sensing transistor.

Layout Guidelines

- Place input and output capacitors as close to the device as possible.
- Use copper planes for device connections in order to optimize thermal performance.
- Place thermal vias around the device to distribute heat.
- Do not place a thermal via directly beneath the thermal pad of the DRV package. A via can wick solder or solder paste away from the thermal pad joint during the soldering process, leading to a compromised solder joint on the thermal pad.

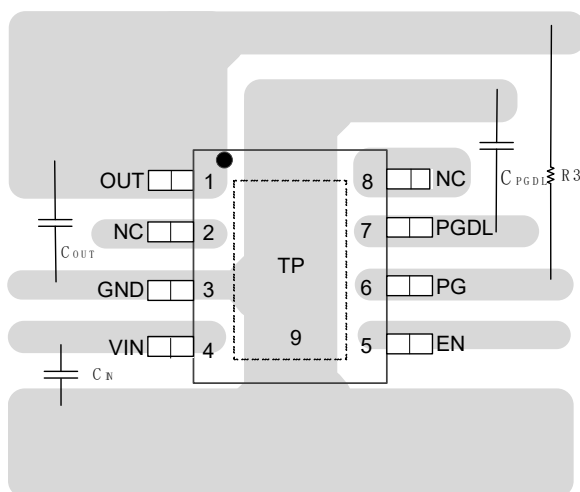


Fig4. Layout Guidelines

ON/OFF Input Operation

The ETQ65H4333M is turned on by setting the EN pin higher than V_{IH} threshold, and is turned off by pulling it lower than V_{IL} threshold. IN port needs to be powered on before the EN port. The recommended sequence diagram:

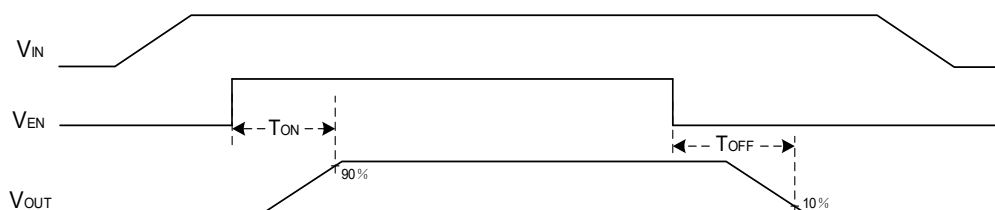


Fig5. Recommended sequence diagram

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Absolute Maximum Ratings

Symbol	Rating	Value	Unit
V _{IN}	Input Voltage ⁽¹⁾	0~45 & V _{IN} >V _{EN}	V
V _{OUT}	Output Voltage	-0.3~25	V
V _{EN}	Chip Enable Input Voltage	-0.3~45	V
V _{PG}	Power Good Voltage	-0.3~25	V
V _{PGDL}	Power Good Delay Voltage	-0.3~6	V
T _{J(MAX)}	Maximum Junction Temperature	150	°C
T _{STG}	Storage Temperature	-65~150	°C
ESD ⁽²⁾	HBM Capability	±2000	V
	CDM Capability	±1500	V
L _U	Latch up Current Maximum Rating ⁽²⁾	±200	mA

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

Note1: Refer to Electrical Characteristics and Application Information for Safe Operating Area and IN port needs to be powered on before the EN port.

Note2: This device series incorporates ESD protection and is tested by the following methods:

HBM tested per AEC-Q100-002(JEDEC JS-001);

CDM tested per AEC-Q100-011(JEDEC JS-002);

Latch up Current Maximum Rating tested per AEC-Q100-004(JEDEC JESD78F).

Thermal Characteristics

Symbol	Ratings	Value	Unit
R _{θJA}	Thermal Characteristics, Thermal Resistance, Junction-to-Air	69.5	°C/W
P _D	Max Power Dissipation @25°C	1.8	W

Recommended Operating Conditions

Symbol	Item	Rating	Unit
V _{IN}	Input Voltage	3 to 40	V
I _{OUT}	Output Current	0 to 500	mA
T _A	Operating Ambient Temperature	-40 to 105	°C
C _{IN}	Input Capacitor Value	1 to 10	μF
C _{OUT}	Output Capacitor Value	1 to 10	μF
R _{PG}	Pull-up Resistor of Power-Good	1 to 100	kΩ
ESR	Input and Output Capacitor Equivalent Series Resistance (ESR)	5 to 100	mΩ

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Electrical Characteristics

($V_{IN} = V_{OUT} + 2V$; $I_{OUT} = 10mA$, $C_{IN} = C_{OUT} = 1.0\mu F$, $T_A = -40^{\circ}C \sim 125^{\circ}C$ unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$.)⁽³⁾

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Operating Input Voltage ⁽⁴⁾		3.0		40	V
I_Q	Quiescent Current	$I_{OUT} = 0mA$		12	20	μA
I_{Q_OFF}	Standby Current	$V_{EN} = 0V$, $T_A = 25^{\circ}C$		0.1	1	μA
V_{OUT}	Feedback Voltage	$T_A = +25^{\circ}C$	3.234	3.3	3.366	V
		$-40^{\circ}C \leq T_A \leq 125^{\circ}C$	3.16	3.3	3.44	
V_{DROP}	Dropout Voltage ⁽⁵⁾	$I_{OUT} = 500mA$, $T_A = +25^{\circ}C$		620	900	mV
$Line_{REG}$	Line Regulation	$V_{OUT} + 2V \leq V_{IN} \leq 40V$ $I_{OUT} = 10mA$		0.01	0.1	%/V
$Load_{REG}$	Load Regulation	$1mA \leq I_{OUT} \leq 500mA$, $V_{IN} = V_{OUT} + 2V$		15	45	mV
I_{LMT}	Current Limit	$V_{IN} = V_{OUT} + 2V$		1000	1500	mA
V_{ENH}	EN Pin Threshold Voltage	EN Input Voltage "H"	1.4			V
V_{ENL}	EN Pin Threshold Voltage	EN Input Voltage "L"			0.3	V
PSRR	Power Supply Rejection Ratio ⁽⁶⁾	$f = 1 kHz$, $V_{IN} = V_{OUT} + 2V$, $I_{OUT} = 20mA$		70		dB
e_n	Output Noise Voltage ⁽⁶⁾	$V_{IN} = V_{OUT} + 2V$, $I_{OUT} = 1mA$, $f = 10Hz$ to $100KHz$, $C_{OUT} = 1\mu F$		125		μV_{rms}
V_{PG_R}	PG Rising Threshold	V_{OUT}/V_{OUT_SET} , when V_{OUT} rising	89	93	97	%
V_{PG_F}	PG Falling Threshold	V_{OUT}/V_{OUT_SET} , when V_{OUT} falling	85	89	93	%
t_{D_PGR}	PG Rising Delay	$C_{PGDL} = 0nF$		400	600	μs
t_{D_PGF}	PG Falling Delay	$C_{PGDL} = 0nF$	2	10		μs
T_{SD}	Thermal Shutdown Temperature ⁽⁶⁾	Temperature Increasing from $T_A = +25^{\circ}C$		155		$^{\circ}C$
T_{SDH}	Thermal Shutdown Hysteresis ⁽⁶⁾	Temperature Falling from T_{SD}		25		$^{\circ}C$

Note3: Here V_{IN} means internal circuit can work normal. If $V_{IN} < V_{OUT}$, Output voltage follows V_{IN} ($I_{OUT} = 1mA$), circuit is safety.

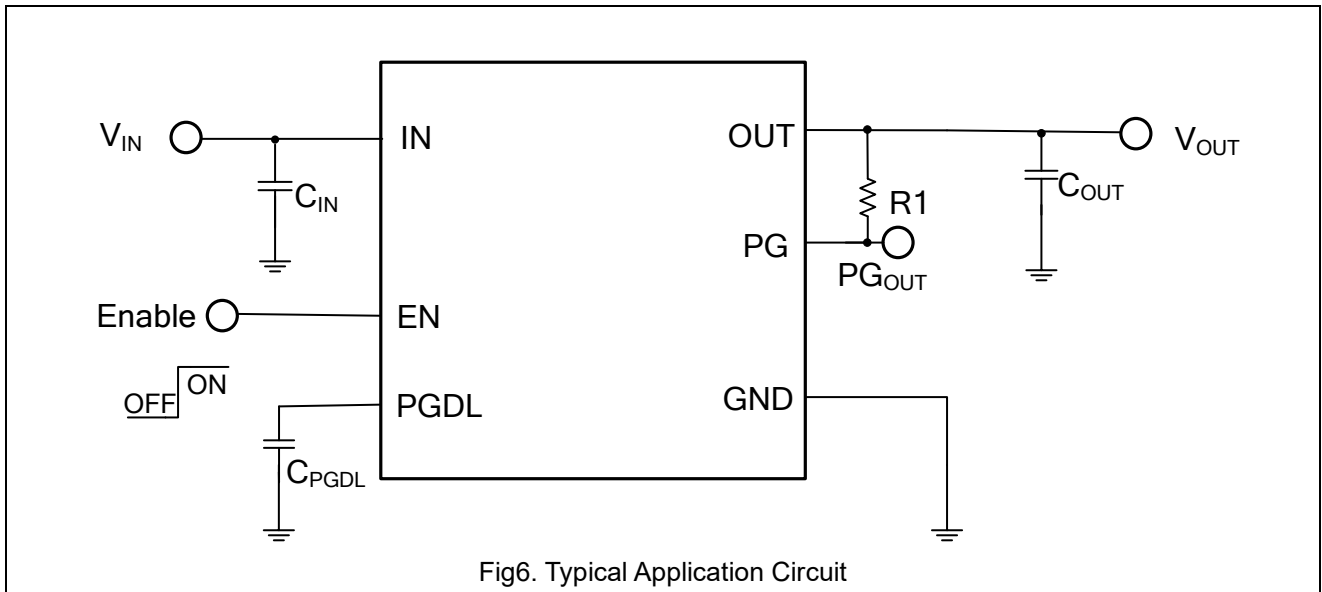
Note4: The minimum operating voltage is 3.0V. $V_{DROP} = V_{IN(min)} - V_{OUT}$.

Note5: V_{DROP} FT test method: test the V_{OUT} voltage at $V_{SET} + V_{DROP_{MAX}}$ with 500mA output current.

Note6: Guaranteed by design and characterization. not a FT item.

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Application Circuits

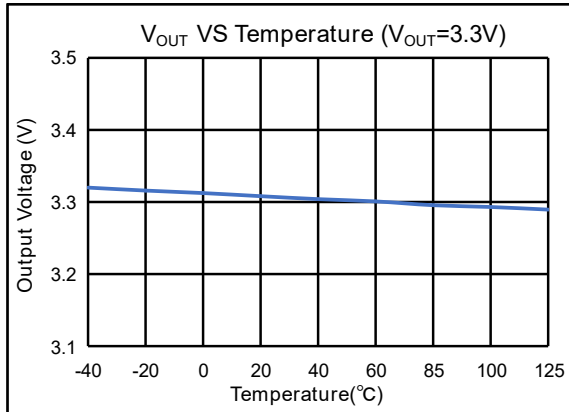


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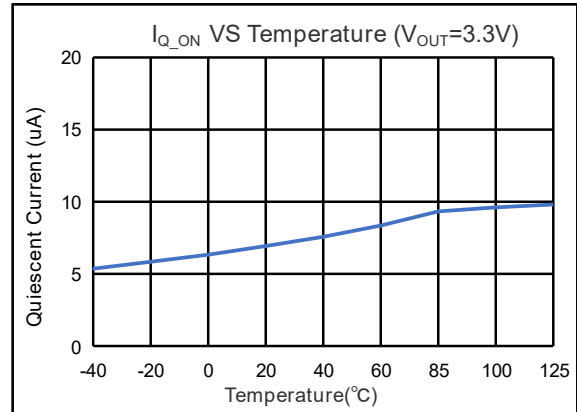
Typical Characteristics

V_{OUT} = 3.3V

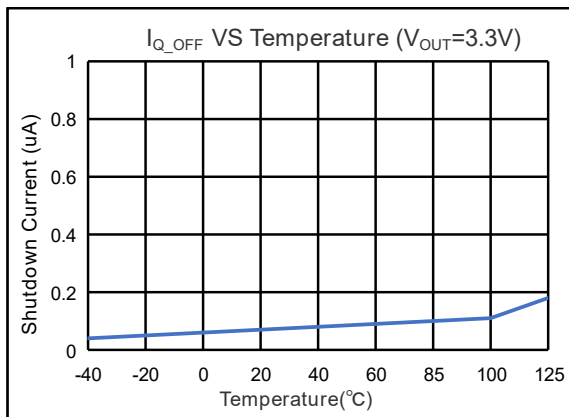
(V_{IN} = V_{OUT} + 2V; I_{OUT} = 10mA, C_{IN} = C_{OUT} = 1.0μF, T_A = -40°C ~125°C unless otherwise noted. Typical values are at T_A = +25°C.)



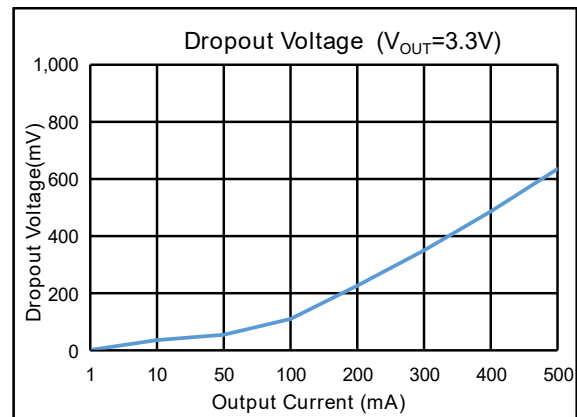
Output Voltage VS Temperature



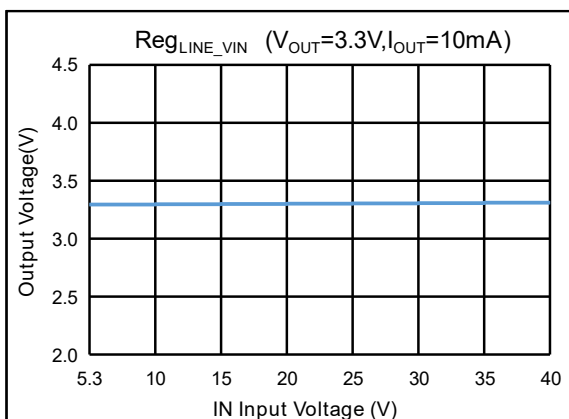
Supply Current VS Temperature



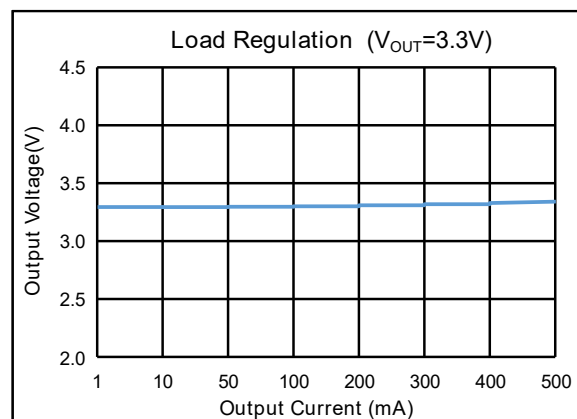
Shutdown Current VS Temperature



Dropout Voltage VS Output Current



Output Voltage VS Input Voltage



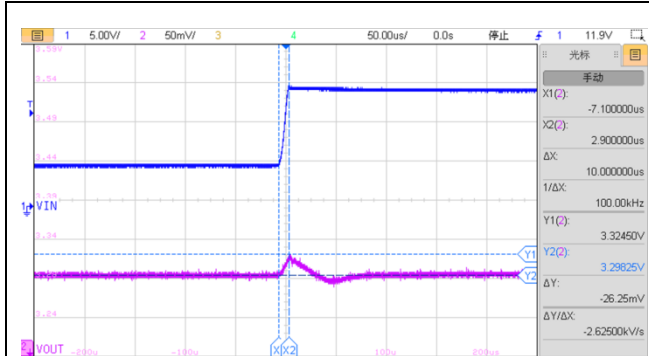
Output Voltage VS Output Current

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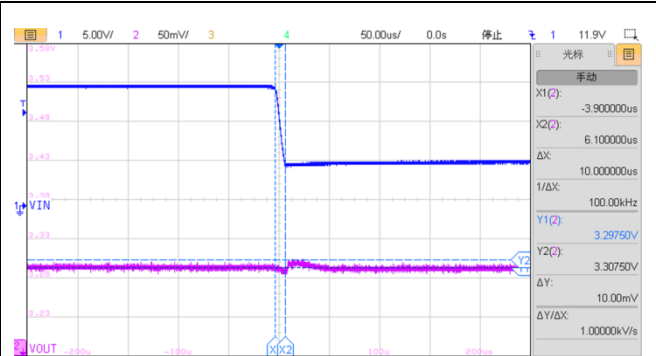
Typical Characteristics (Continued)

V_{OUT} = 3.3V

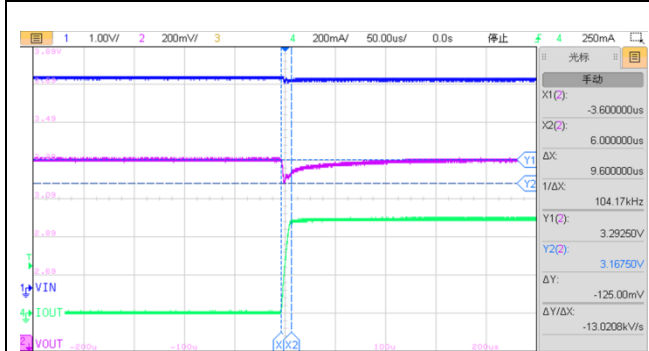
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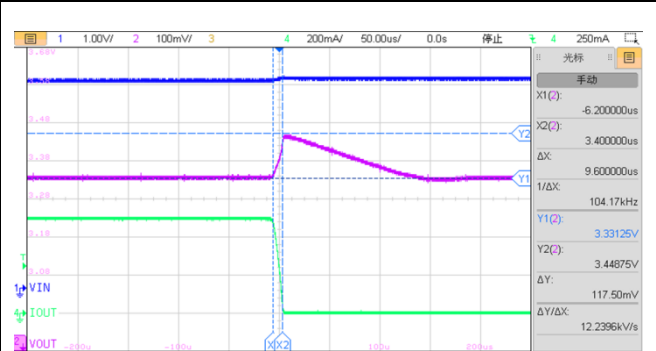
Line Transient Response
V_{IN}=5.3V~15V, V_{OUT}=3.3V, I_{OUT}=10mA



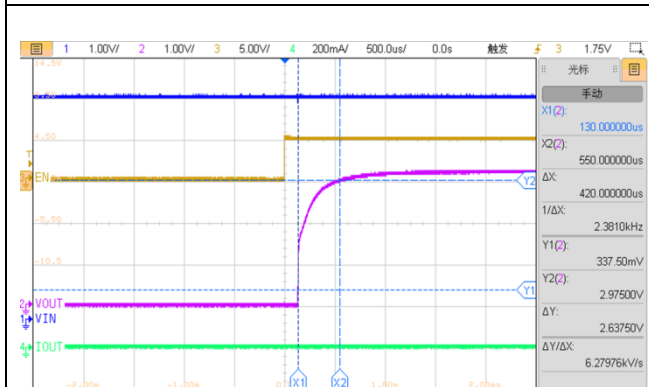
Line Transient Response
V_{IN}=15V~5.3V, V_{OUT}=3.3V, I_{OUT}=10mA



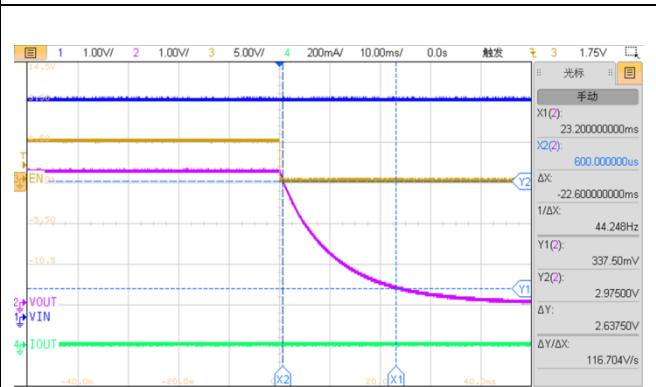
Load Transient Response
V_{IN}=5.3V, V_{OUT}=3.3V, I_{OUT}=1mA~500mA



Load Transient Response
V_{IN}=5.3V, V_{OUT}=3.3V, I_{OUT}=500mA~1mA



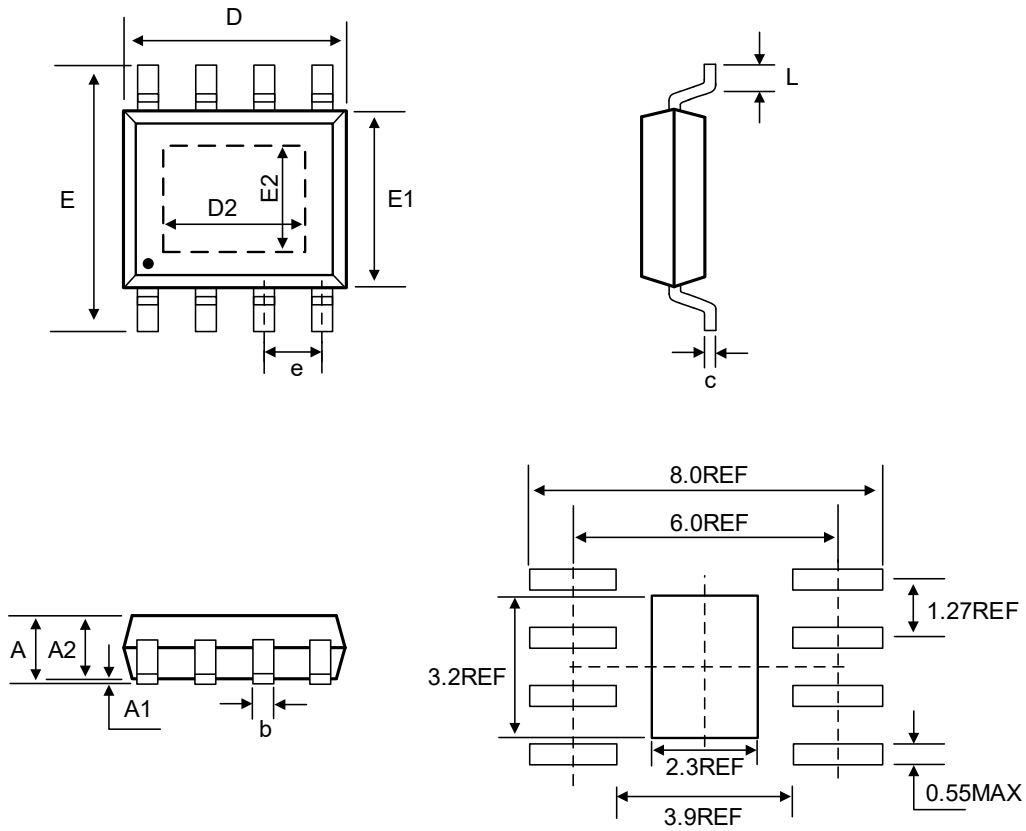
Ton
V_{IN}=5.3V, V_{OUT}=3.3V, I_{OUT}=0mA



Toff
V_{IN}=5.3V, V_{OUT}=3.3V, I_{OUT}=0mA

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Package Dimension



COMMON DIMENSIONS

(Unit: mm)

SYMBOL	MIN	NOM	MAX
A	-	-	1.90
A1	0.00	-	0.30
A2	1.20	1.40	1.60
b	0.35	-	0.47
c	0.15	-	0.27
D	4.70	4.90	5.10
E	5.80	6.00	6.20
D2	3.00	3.25	3.50
E1	3.70	3.90	4.10
E2	2.10	2.30	2.50
e	1.27BSC		
L	0.35	0.60	0.85

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Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
1.0	2025-11-29	Official Version	Pengjj	Guj,Liuxm	Liujiy