Dual Channel LDO Regulators with Enable

❖ GENERAL DESCRIPTION

The AX6644/5 is a high accurately, low noise, high ripple rejection ratio, low dropout, dual CMOS LDO voltage regulators with enable function. The EN function allows the output of each regulator to be turned off independently, resulting in greatly reduced power consumption.

The AX6644/5 has the soft start function to suppress the inrush current. The current limit is over 250mA per channel and also operates as a short protection for the output current limiter. The output voltage for each regulator is set independently by internal setting.

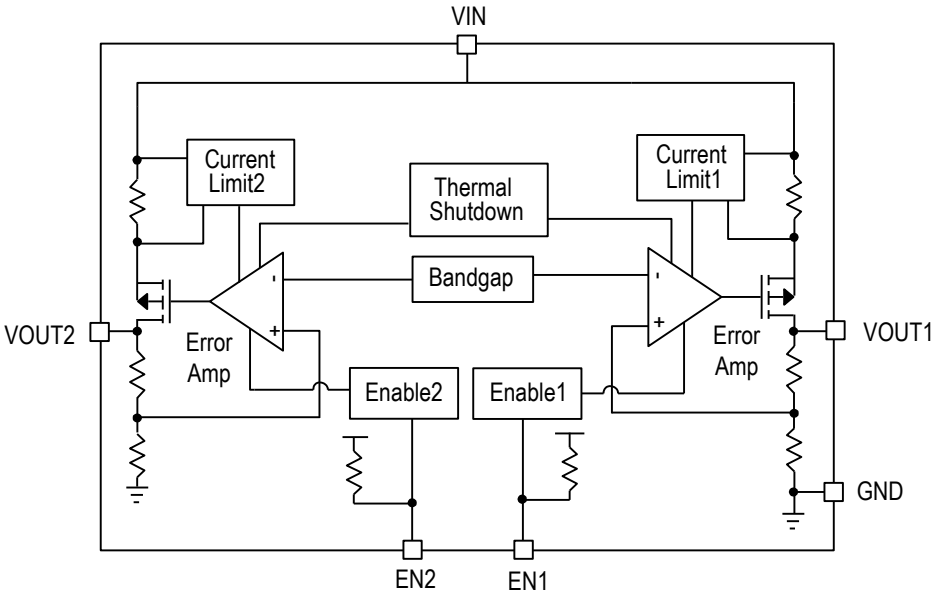
The AX6644/5 is fully compatible with low ESR ceramic capacitors, reducing cost and improving output stability. This high level output stability is maintained even during frequent load fluctuations, due to the excellent transient response performance and high PSRR achieved across a broad range of frequency. It is available in the TSOT-23-6L and TDFN-6L packages.

❖ FEATURES

- Input voltage range :2.5V to 6V
- Varied fixed output voltage combinations
- 200mV Dropout at 200mA output current ($V_{OUT} \geqq 2.5V$)
- Output current: 200mA/channel (typ.)
- Low quiescent current: 60μA (typ.)
- Current Limit and Short current protections
- Thermal shutdown protection
- Fast transient response
- Low ESR Capacitor Compatible (X7R, X5R)
- Available in the 6-Pin Pb-Free TSOT-23 and TDFN-6L packages

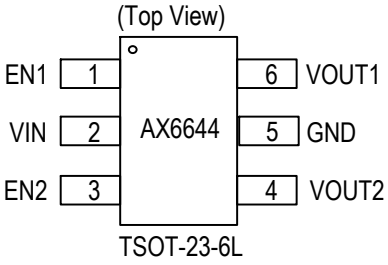
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❖ BLOCK DIAGRAM

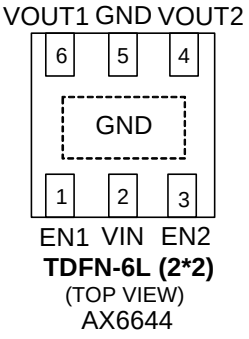


❖ PIN ASSIGNMENT

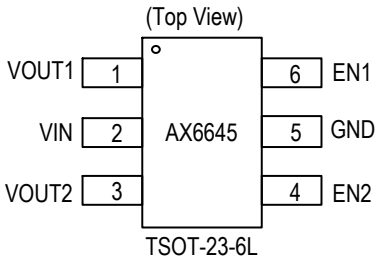
The packages of AX6644/5 are TSOT-23-6L and TDFN-6L; the pin assignment is given by:



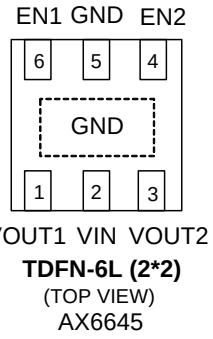
TSOT-23-6L



TDFN-6L (2*2)
(TOP VIEW)
AX6644



TSOT-23-6L



TDFN-6L (2*2)
(TOP VIEW)
AX6645

Name	Description
VIN	Power input
GND	Ground
EN1	VOUT1 Enable Control Pin
EN2	VOUT2 Enable Control Pin
VOUT1	Output1 Voltage
VOUT2	Output2 Voltage

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❖ ORDER/MARKING INFORMATION

Order Information

AX6644 X XX X

Output Type	Package	Packing
(Refer Table)	CT : TSOT-23-6L Z6 : TDFN-6L (2*2)	Blank : Bag A : Taping

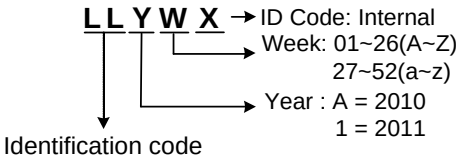
AX6645 X XX X

Output Type	Package	Packing
(Refer Table)	CT : TSOT-23-6L Z6 : TDFN-6L (2*2)	Blank : Bag A : Taping

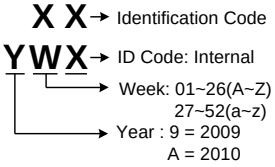
Output type code: (V_{OUT1}+V_{OUT2})

A: 1.5V+2.8V	F: 2.8V+1.2V	L: 3.0V+3.3V	Y: 2.8V+1.5V	N: 1.2V+3.3V
B: 1.8V+2.8V	G: 2.8V+1.8V	M: 3.3V+3.3V	T: 1.5V+3.3V	
C: 1.8V+2.6V	H: 2.8V+3.0V	P: 1.8V+3.0V	V: 1.5V+3.0V	
D: 1.8V+3.3V	J: 2.8V+3.3V	Q: 1.5V+2.5V	W: 1.2V+2.8V	
E: 2.5V+2.8V	K: 3.0V+3.0V	R: 3.3V+1.8V	X: 1.2V+1.2V	

Top Marking (TSOT-23-6L)



Top Marking (TDFN-6L)



Appendix

Part Number	Identification code
AX6644A	PA
AX6644B	PB
AX6644C	PC
AX6644D	PD
AX6644E	PE
AX6644F	PF
AX6644G	PG
AX6644H	PH
AX6644J	PJ
AX6644K	PK
AX6644L	PL
AX6644M	PM
AX6644N	P7
AX6644P	PP
AX6644Q	PQ
AX6644R	PR
AX6644Y	PS
AX6644T	PT
AX6644V	PV
AX6644W	PX
AX6644X	P1

Part Number	Identification code
AX6645A	Pa
AX6645B	Pb
AX6645C	Pd
AX6645D	Pe
AX6645E	Pf
AX6645F	Pg
AX6645G	Ph
AX6645H	Pj
AX6645J	Pm
AX6645K	Pn
AX6645L	Pq
AX6645M	Pr
AX6645N	P8
AX6645P	Ps
AX6645Q	Pt
AX6645R	Pu
AX6645Y	Pw
AX6645T	Py
AX6645V	Pz
AX6645W	Po
AX6645X	P2

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❖ ABSOLUTE MAXIMUM RATINGS (at T_A=25°C)

Characteristics		Symbol	Rating	Unit
V_{IN} Pin Voltage		V_{IN}	GND - 0.3 to + 6.5	V
Output Voltage		V_{OUT1} /V_{OUT2}	GND - 0.3 to V_{IN} + 0.3	V
Enable Voltage		EN1/EN2	GND - 0.3 to V_{IN} + 0.3	V
Power Dissipation	TSOT-23-6L	PD	400	mW
	TDFN-6L		830	
Storage Temperature Range		T_{ST}	-40 to +150	°C
Operating Temperature Range		T_{OP}	-40 to +85	°C
Junction Temperature		T_J	-40 to +125	°C
Thermal Resistance from Junction to case	TSOT-23-6L	θ_{JC}	180	°C/W
	TDFN-6L		25	
Thermal Resistance from Junction to ambient	TSOT-23-6L	θ_{JA}	250	°C/W
	TDFN-6L		120	

Note: θ_{JA} is measured with the PCB copper area of approximately 1 in^2(Multi-layer). That need connect to GND pin or exposed pad (TDFN-6L)

❖ ELECTRICAL CHARACTERISTICS

(V_{IN}=5V, T_A = 25°C, unless otherwise noted)

Characteristics	Symbol	Conditions		Min	Typ	Max	Units
Input Voltage	V_{IN}	I_{OUT}=10mA		2.5	-	6	V
Output Voltage Accuracy	ΔV_{OUT}	I_{OUT} = 1mA, V_{IN} = 5V, V_{OUT} >1.8V		-2	-	+2	%
		I_{OUT} = 1mA, V_{IN} = 5V, V_{OUT} ≦1.8V		-0.04	-	0.04	V
Quiescent Current (Channel1+ Channel2)	I_{CC}	$I_{OUT1,2}$ = 0mA, V_{IN} = 5V		-	60	100	μA
Dropout Voltage	V_{DROP}	I_{OUT}=200mA, V_{OUT}=V_{OUT}-2%	V_{OUT}=1.2V	-	1100	1500	mV
			V_{OUT}=1.5V	-	800	1200	
			V_{OUT}=1.8V	-	500	900	
			V_{OUT} ≧2.5V	-	200	400	
Current Limit **(Note 1)**	I_{LIMIT}	V_{IN} = V_{OUT}+1.0V, V_{EN} = V_{IN}		250	-	-	mA
Short Circuit Current	I_{short}	Output Voltage<0.25*V_{OUT}, each channel		-	150	-	mA
Line Regulation	ΔV_{LINE}	I_{OUT} = 1mA, V_{IN} = V_{OUT}+1V to 6.0V		-	0.2	0.3	%/V

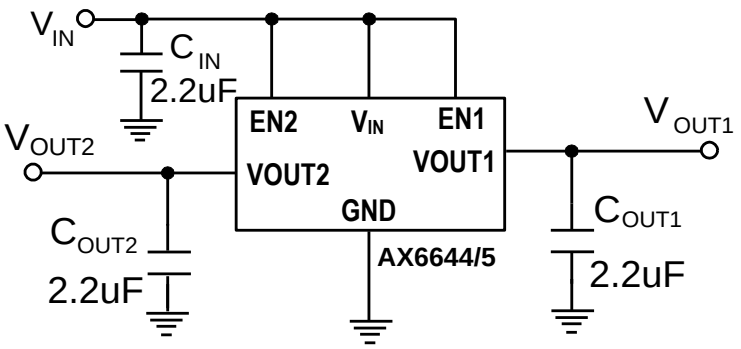
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❖ ELECTRICAL CHARACTERISTICS (CONTINUOUS)

Load Regulation **(Note 2)**	ΔV_{LOAD}	I_{OUT} = 1~100mA, V_{IN} = V_{OUT}+1V	-	0.01	0.03	%/mA
Ripple Rejection	PSRR	F = 120Hz, ,I_{OUT} = 30mA	-	60	-	dB
Output Voltage Temperature Coefficient		I_{OUT} = 1mA **(Note 3)**	-	±100	-	PPM/°C
Enable Input Threshold	V_{ENH}		2.0	-	-	V
	V_{ENL}		-	-	0.6	
Enable pull-high current (each channel)	$I_{EN1,2}$	$V_{EN1,2}$ = 0V	-	1	2	µA
Shutdown Current	I_{SD}	$I_{OUT1,2}$ = 0mA, V_{IN} = 5V, $V_{EN1,2}$ = 0V	-	2	4	µA
Thermal Shutdown Temperature	T_{ST}		-	150	-	°C
Thermal Shutdown Hysterisis	T_{SH}		-	40	-	°C

Note 1: Current limit is measured at constant junction temperature by using pulsed testing with a low ON time.
Note 2: Regulation is measured at constant junction temperature by using pulsed testing with a low ON time.
Note 3: Guaranteed by design.

❖ APPLICATION CIRCUIT



❖ FUNCTION DESCRIPTIONS

The AX6644/5 is a highly accurate, dual, low noise, CMOS LDO voltage regulators with enable function. The output voltage for each regulator is set independently by fuse trimming. As illustrated in function block diagram, it consists of a reference, error amplifier, a P-channel pass transistor, an ON/OFF control logic and an internal feedback voltage divider. The band gap reference is connected to the error amplifier, which compares the reference with the feedback voltage and amplifies the voltage difference. If the feedback voltage is lower than the reference voltage, the pass- transistor gate is pulled lower, which allows more current to pass to the V_{OUT} pin and increases the output voltage. If the feedback voltage is too high, the pass transistor gate is pulled up to decrease the output voltage. The output voltage is feed back through an internal resistive divider connected to V_{OUT} pin. Additional blocks include an output current limiter, thermal sensor, and shutdown logic.

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Enable Function

EN1 and EN2 pin start and stop the corresponding outputs independently. When the EN pin is switched to the power off level, the operation of all internal circuit stops, the build-in P-channel MOSFET output transistor between pins V_{IN} and V_{OUT} is switched off, allowing current consumption to be drastically reduced.

Dropout Voltage

A regulator's minimum input-output voltage differential, or dropout voltage, determines the lowest usable supply voltage. The AX6644/5 use a P- channel MOSFET pass transistor, its dropout voltage is function of drain-to-source on-resistance $R_{DS\,(ON)}$ multiplied by the load current.

$$V_{DROPOUT} = V_{IN} - V_{OUT} = R_{DS(ON)} * I_{OUT}$$

Current Limit

Each channel of AX6644/5 includes a fold back current limiter. It monitors and controls the pass transistor's gate voltage, estimates the output current, and limits the output current within 250mA.

Thermal Shutdown Protection

Thermal Shutdown protection limits total power dissipation of AX6644/5. When the junction temperature exceeds T_J = +150°C, a thermal sensor turns off the pass transistor, allowing the IC to cool down. The thermal sensor turns the pass transistor on again after the junction temperature cools down by 40°C, resulting in a pulsed output during continuous thermal shutdown conditions.

Thermal shutdown protection is designed to protect the AX6644/5 in the event of fault conditions. For continuous operation, the absolute maximum operating junction temperature rating of T_J = +125°C should not be exceeded.

❖ APPLICATION INFORMATION

Like any low-dropout regulator, the AX6644/5 requires input and output decoupling capacitors. The device is specifically designed for portable applications requiring minimum board space and smallest components. These capacitors must be correctly selected for good performance (see Capacitor Characteristics Section). Please note that linear regulators with a low dropout voltage have high internal loop gains which require care in guarding against oscillation caused by insufficient decoupling capacitance.

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Input Capacitor

An input capacitance of 2.2μF is required between input pin and ground directly (the amount of the capacitance may be increased without limit). The input capacitor must be located less than 1cm from the device to assure input stability. A lower ESR capacitor allows the use of less capacitance, while higher ESR type (like aluminum electrolytic) requires more capacitance. Capacitor types (aluminum, ceramic and tantalum) can be mixed in parallel, but the total equivalent input capacitance/ ESR must be defined as above to stable operation. There are no requirements for the ESR on the input capacitor, but tolerance and temperature coefficient must be considered when selecting the capacitor to ensure the capacitance will be 1μF over the entire operating temperature range.

Output Capacitor

The AX6644/5 is designed specifically to work with very small ceramic output capacitors. A ceramic capacitor (temperature characteristics X7R, X5R) in 1μF is suitable for the AX6644/5 application. The recommended capacitance for the device is 2.2μF, X5R or X7R dielectric ceramic, between V_{OUT} and GND for stability, but it may be increased without limit. Higher capacitance values help to improve transient. The output capacitor's ESR is critical because it forms a zero to provide phase lead which is required for loop stability.

Thermal Considerations

The AX6644/5 series can deliver a current of up to 200mA/channel over the full operating junction temperature range. However, the maximum output current must be debated at higher ambient temperature to ensure the junction temperature does not exceed 125°C. With all possible conditions, the junction temperature must be within the range specified under operating conditions. Power dissipation can be calculated based on the output current and the voltage drop across regulator.

$$P_D = (V_{IN} - V_{OUT})\, I_{OUT} + V_{IN}\, I_{GND}$$

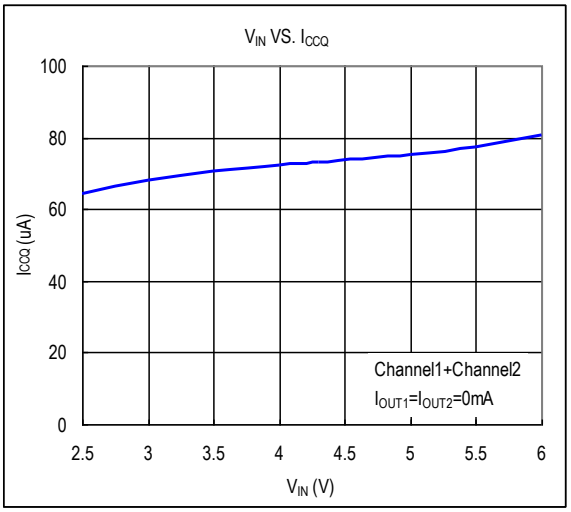
The final operating junction temperature for any set of conditions can be estimated by the following thermal equation:

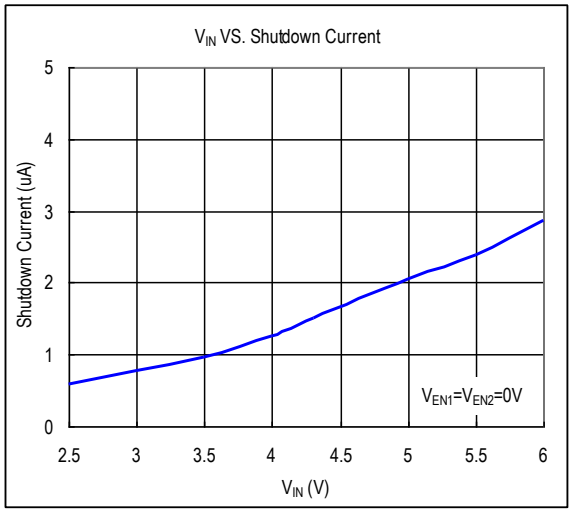
$$P_{D\,(MAX)} = (T_{J\,(MAX)} - T_A) / \theta_{JA}$$

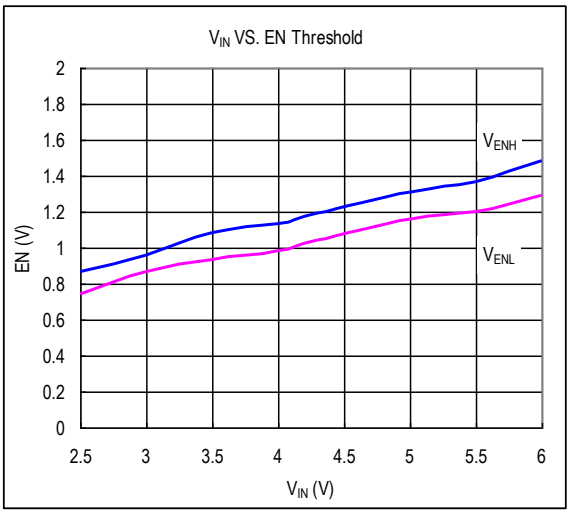
Where $T_{J\,(MAX)}$ is the maximum junction temperature of the die (125°C) and T_A is the maximum ambient temperature. The junction to ambient thermal resistance (θ_{JA}) for TSOT-23-6L package is recommended 250°C/W.

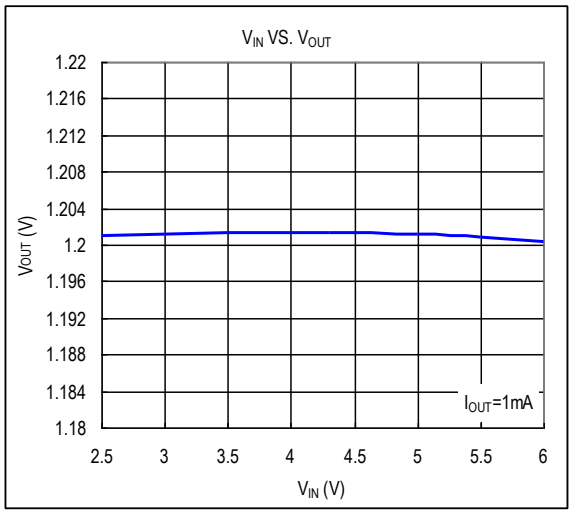
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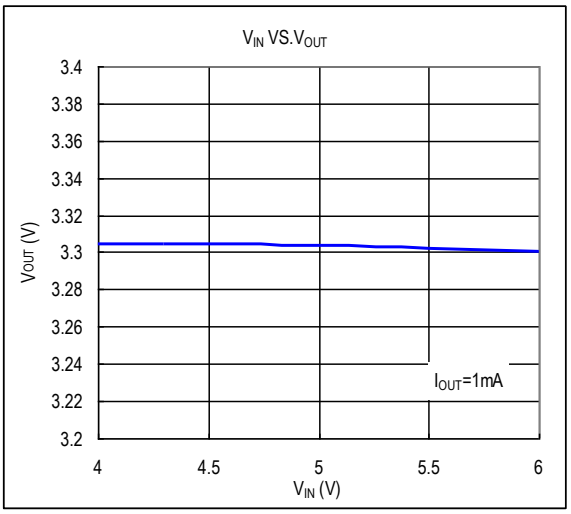
❖ TYPICAL CHARACTERISTICS

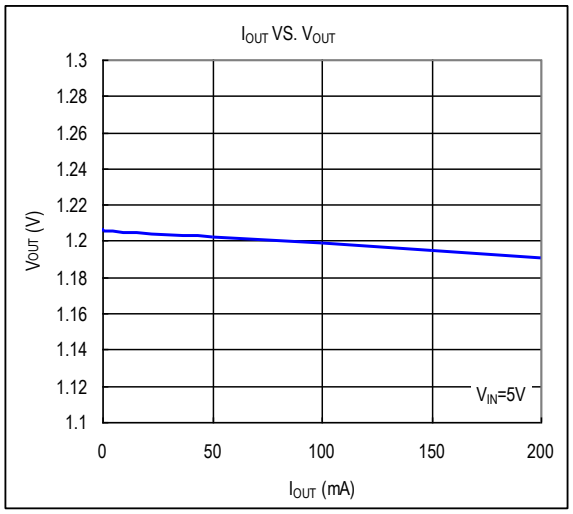






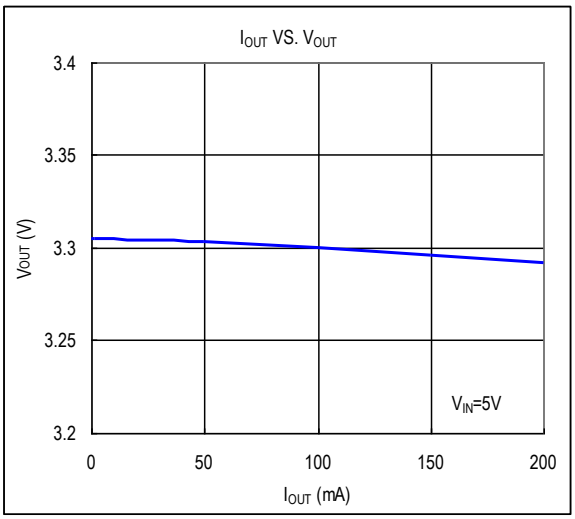


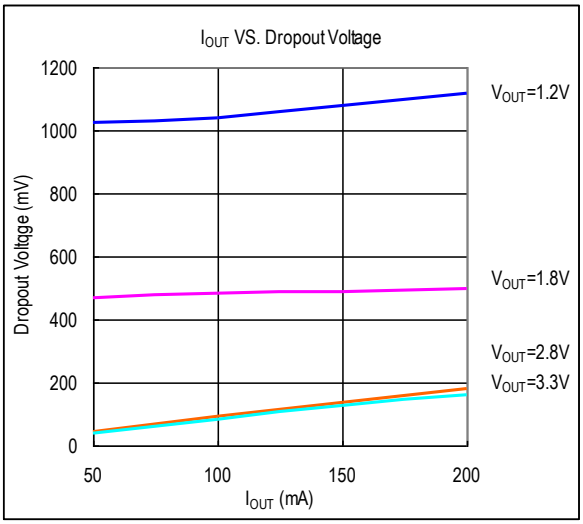


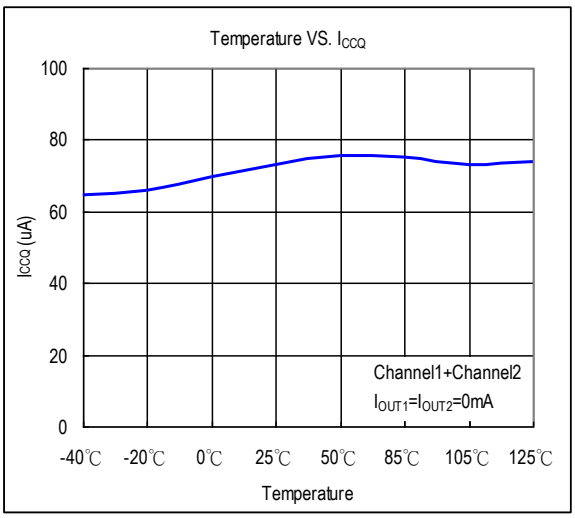


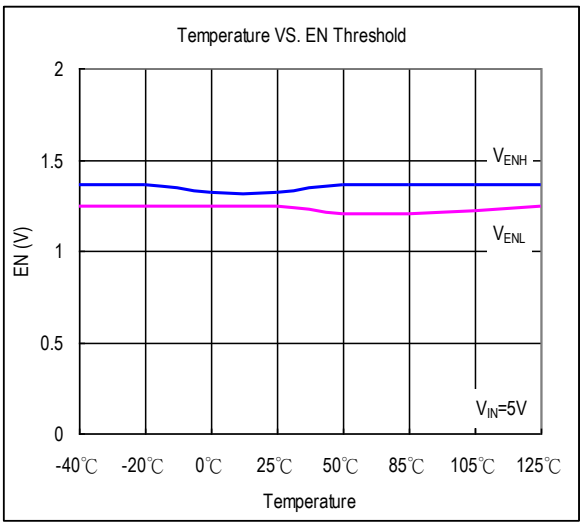
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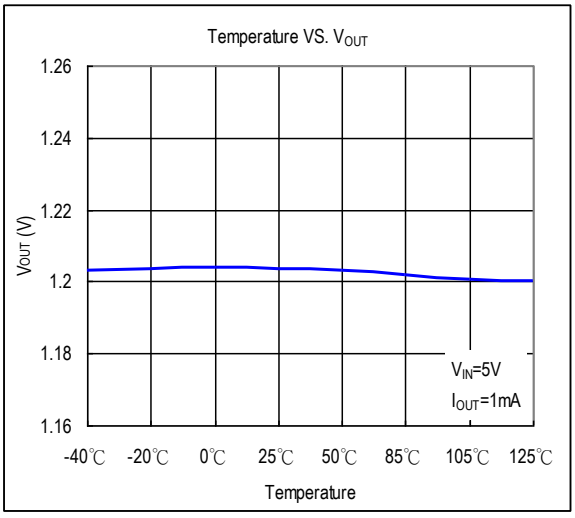
❖ TYPICAL CHARACTERISTICS (CONTINUOUS)

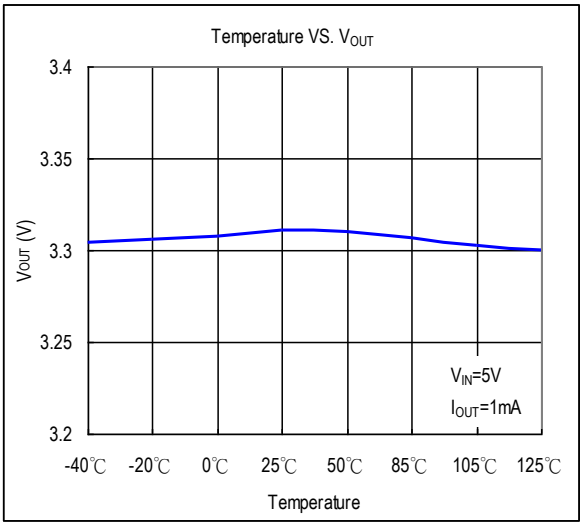








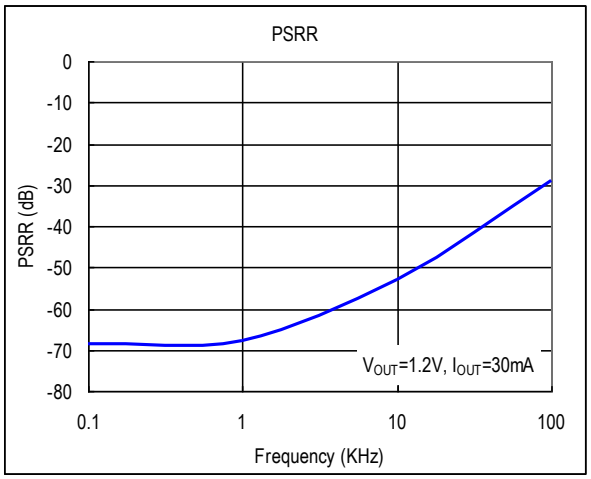




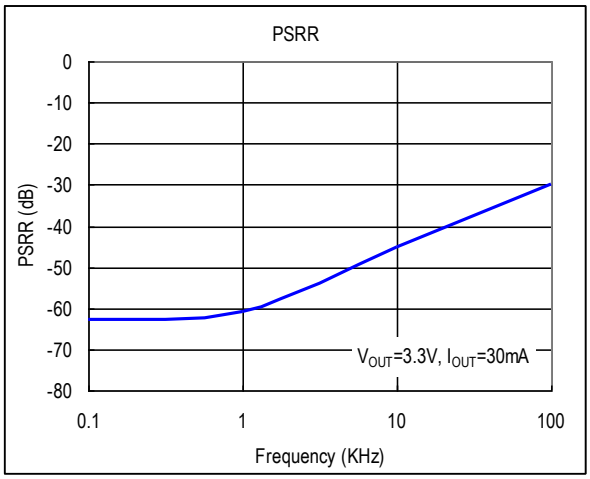
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❖ TYPICAL CHARACTERISTICS (CONTINUOUS)

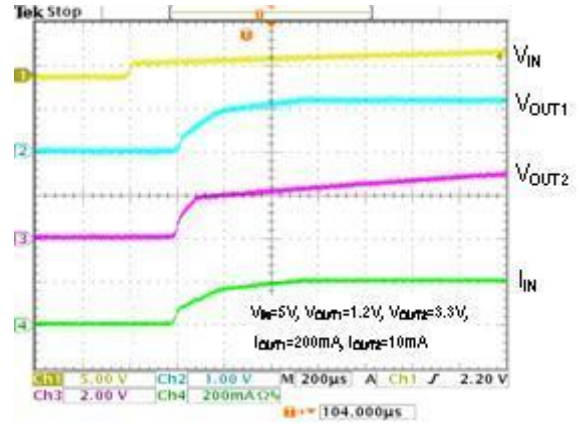
PSRR



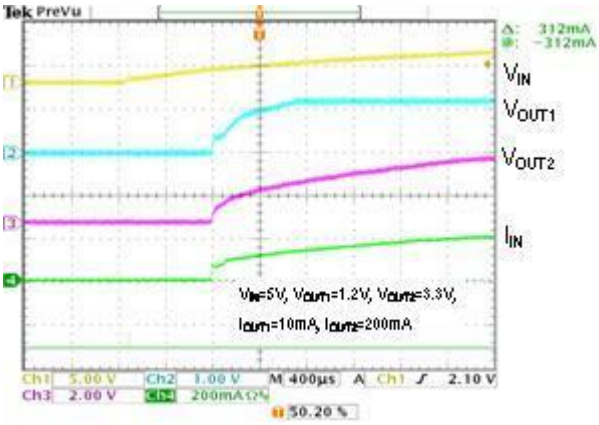
PSRR



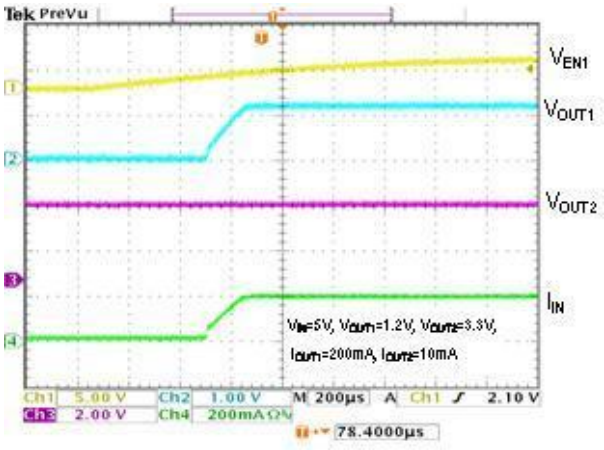
Power ON



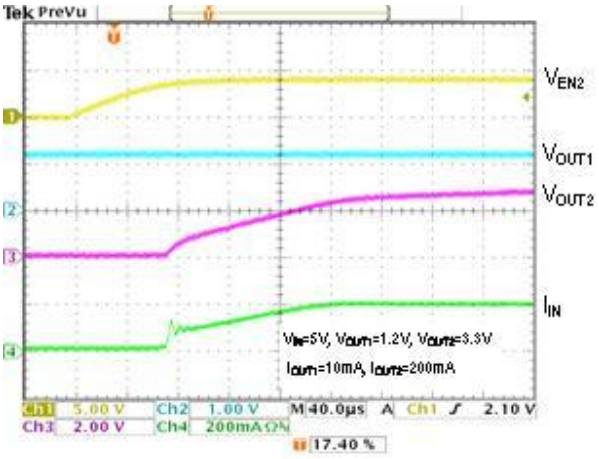
Power ON



EN ON (EN1)



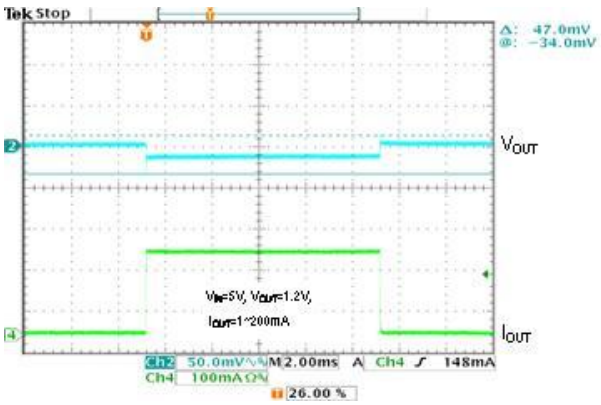
EN ON (EN2)



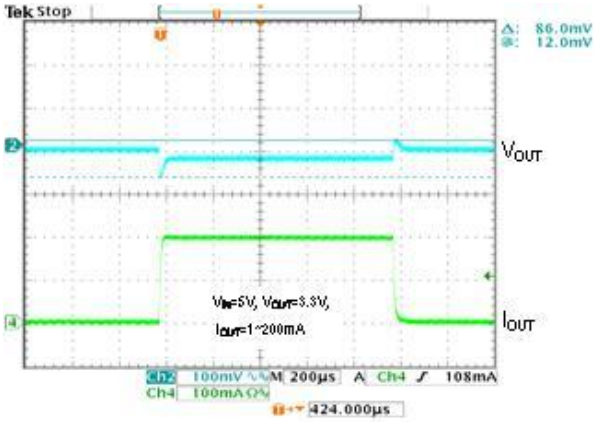
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❖ TYPICAL CHARACTERISTICS (CONTINUOUS)

Load Transient



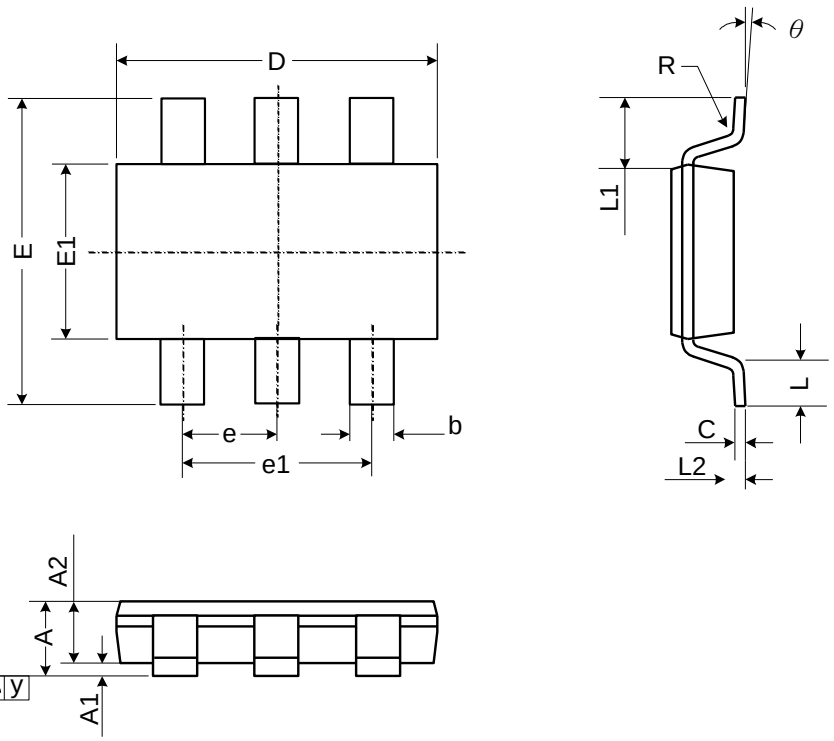
Load Transient



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❖ PACKAGE OUTLINES

(1) TSOT-23-6L

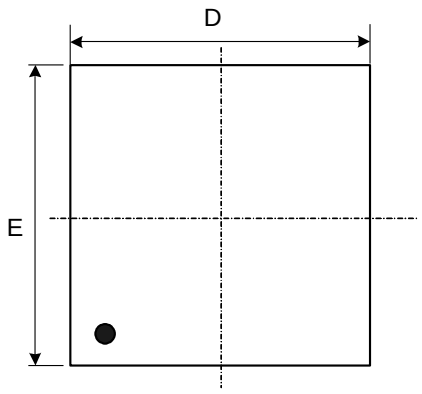


Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.10	-	-	0.043
A1	0.00	-	0.10	0	-	0.004
A2	0.70	0.90	1.00	0.028	0.035	0.039
b	0.30	0.40	0.50	0.012	0.016	0.020
C	0.08	0.14	0.20	0.003	0.006	0.008
D	2.80	2.90	3.00	0.110	0.114	0.118
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
e	0.95 BSC.			0.037 BSC.		
e1	1.90 BSC.			0.075 BSC.		
L	0.30	0.45	0.60	0.012	0.018	0.024
L1	0.60 REF.			0.024 REF.		
L2	0.25 BSC.			0.010 BSC.		
y	-	-	0.10	-	-	0.004
R	0.10	-	-	0.004	-	-
θ	0°	-	8°	0°	-	8°

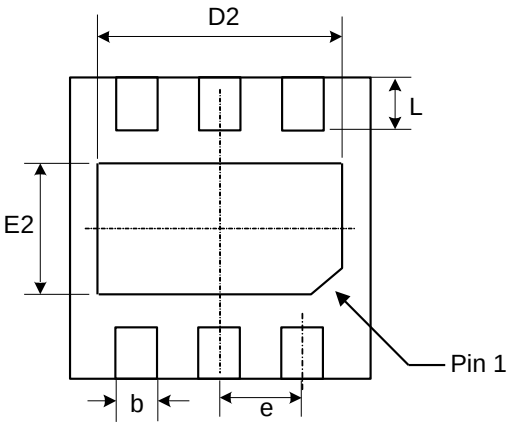
JEDEC outline: MO-193 AA

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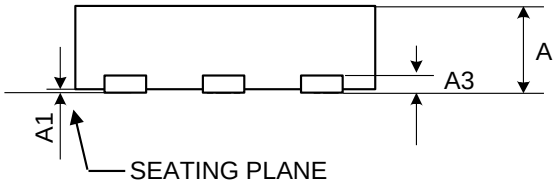
(2) TDFN-6L (2*2 0.75mm)



(Top View)



(Bottom View)



(SIDE View)

Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	0.70	0.75	0.80	0.028	0.030	0.031
A1	0.00	0.02	0.05	0.000	0.001	0.002
A3	0.203 REF.			0.008 REF.		
b	0.20	0.28	0.35	0.009	0.011	0.013
D	1.95	2.00	2.05	0.077	0.079	0.081
D2	1.35	1.50	1.65	0.055	0.059	0.063
E	1.95	2.00	2.05	0.077	0.079	0.081
E2	0.75	0.90	1.05	0.031	0.035	0.039
e	0.65 BSC.			0.026 BSC.		
L	0.20	0.30	0.40	0.008	0.012	0.016

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