Low Noise CMOS Triple LDOs Regulator

❖ GENERAL DESCRIPTION

The AX6640 is a three channel, high accurately, low quiescent current, low noise, low dropout CMOS LDO regulator. The regulator performance is optimized for battery-powered systems to deliver ultra low noise and low quiescent current. Regulator ground current increases only slightly in dropout, further prolonging the battery life.

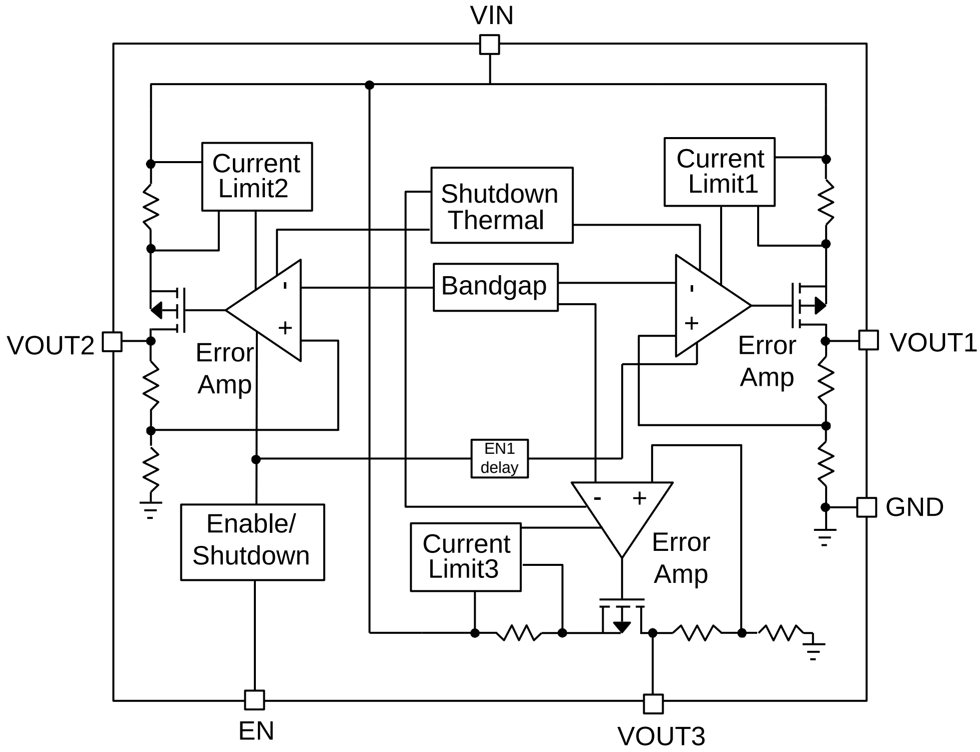
The AX6640 has the soft start function to suppress the inrush current. Built-in current-limit and thermal shutdown functions prevent any fault condition from IC damage.

The AX6640 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 package.

❖ FEATURES

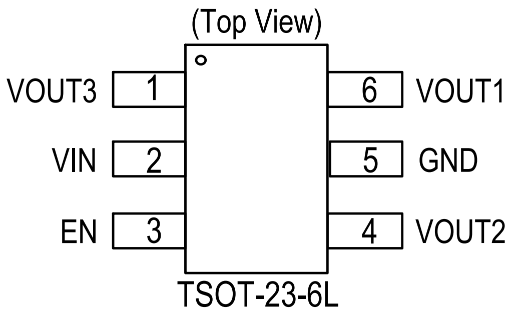
- Input voltage range: 3.0V to 5.5V
- Operating Output voltage type :
  Channel 1 output voltage: 1.8V, 2.8V and 3.3V
  Channel 2 output voltage: 2.8V and 3.3V
  Channel 3 output voltage: 2.8V and 3.3V
- 100mV Dropout at 100mA output current (V_{OUT}=3.3V)
- Output current is up to 150mA/each channel
- Low quiescent current 90μA(typ.)
- Fast transient response
- Current Limit protection
- Thermal shutdown protection
- Low ESR Capacitor Compatible
- Available in the 6-Pin Pb-Free TSOT-23 package

❖ BLOCK DIAGRAM



❖ PIN ASSIGNMENT

The package of AX6640 is TSOT-23-6L; the pin assignment is given by:



Name	Description
VIN	Power input
GND	Ground
EN	Enable Control Pin, pull low shutdown VOUT1 and VOUT2
VOUT1	Output1 Voltage
VOUT2	Output2 Voltage
VOUT3	Output3 Voltage

❖ ORDER/MARKING INFORMATION

Order Information

AX6640 X XX X

- Output Type (Refer Table)
- Package — CT: TSOT23-6L
- Packing — A : Taping

Output type code: (V_{OUT1}+V_{OUT2}+V_{OUT3})
A: 1.8V+2.8V+2.8V
B: 2.8V+2.8V+2.8V
C: 1.8V+3.3V+2.8V
D: 3.3V+2.8V+2.8V
E: 1.8V+2.8V+3.3V

Top Marking

L L Y W X

- X → ID Code: Internal
- W → Week: 01~26(A~Z), 27~52(a~z)
- Y → Year : 7 = 2007, A = 2010
- L L → Identification code

Appendix

Part Number	Identification code
AX6640ACTA	Ma
AX6640BCTA	Mf
AX6640CCTA	Mg
AX6640DCTA	Mh
AX6640ECTA	Mk

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

Characteristics	Symbol	Rating	Unit
V_{IN} Pin Voltage	V_{IN}	GND - 0.3 to GND + 6.5	V
Output Voltage	V_{OUT1}/V_{OUT2}/V_{OUT3}	GND - 0.3 to V_{IN} + 0.3	V
Enable Voltage	EN	GND - 0.3 to V_{IN} + 0.3	V
Power Dissipation	PD	(T_J-T_A) / θ_{JA}	mW
Storage Temperature Range	I_{SD}	-65 to +150	°C
Operating Junction Temperature Range	T_{OPJ}	-40 to +125	°C
Junction Temperature	T_J	-40 to +150	°C
Thermal Resistance from Junction to case	θ_{JC}	180	°C/W
Thermal Resistance from Junction to ambient	θ_{JA}	250	°C/W

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

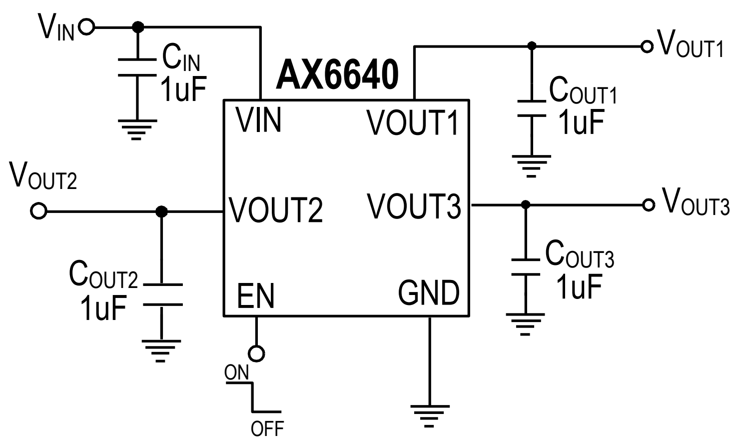
❖ ELECTRICAL CHARACTERISTICS

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

<table>
<tr><th>Characteristics</th><th>Symbol</th><th colspan="2">Conditions</th><th>Min</th><th>Typ</th><th>Max</th><th>Units</th></tr>
<tr><td>Input Voltage</td><td>V_{IN}</td><td colspan="2">(Note 1) I_{OUT}=30mA</td><td>3</td><td>-</td><td>5.5</td><td>V</td></tr>
<tr><td>Output Voltage Accuracy</td><td>ΔV_{OUT}</td><td colspan="2">$I_{OUT1,2,3}$ =1mA</td><td>-2</td><td>-</td><td>+2</td><td>%</td></tr>
<tr><td>Output Voltage Temperature Coefficient</td><td></td><td colspan="2">I_{OUT}=30mA (Note 4)</td><td>-</td><td>±100</td><td>-</td><td>PPM/ºC</td></tr>
<tr><td>Supply Current</td><td>I_{CC}</td><td colspan="2">$I_{OUT1,2,3}$ =0mA, V_{IN}=5V</td><td>-</td><td>90</td><td>120</td><td>μA</td></tr>
<tr><td>Shutdown Current</td><td>I_{sd}</td><td colspan="2">EN=0V, I_{OUT3}=0mA, V_{IN}=5V</td><td>-</td><td>40</td><td>70</td><td>μA</td></tr>
<tr><td rowspan="3">Dropout Voltage</td><td rowspan="3">V_{DROP}</td><td rowspan="3">I_{OUT}=100mA, Vo=Vo-2%</td><td>V_{OUT}=1.8V</td><td>-</td><td>700</td><td>1000</td><td rowspan="3">mV</td></tr>
<tr><td>V_{OUT}=2.8V</td><td>-</td><td>150</td><td>250</td></tr>
<tr><td>V_{OUT}=3.3V</td><td>-</td><td>100</td><td>200</td></tr>
<tr><td>Current Limit (Note 2)</td><td>I_{LIMIT}</td><td colspan="2">Each Channel</td><td>170</td><td>300</td><td>-</td><td>mA</td></tr>
<tr><td>Line Regulation</td><td>ΔV_{LINE}</td><td colspan="2">I_{OUT}=10mA
V_{IN}=V_{OUT}+1V to 5.5V</td><td>-</td><td>0.1</td><td>0.2</td><td>%/V</td></tr>
<tr><td>Load Regulation (Note 3)</td><td>ΔV_{LOAD}</td><td colspan="2">I_{OUT}=1~100mA V_{IN}=3.5V</td><td>-</td><td>10</td><td>30</td><td>mV</td></tr>
<tr><td>Ripple Rejection</td><td>PSRR</td><td colspan="2">F=1KHz, ,I_{OUT} =30mA</td><td>-</td><td>-60</td><td>-</td><td>dB</td></tr>
<tr><td rowspan="2">Enable Input Threshold</td><td>V_{ENH}</td><td colspan="2"></td><td>1.5</td><td>-</td><td>-</td><td rowspan="2">V</td></tr>
<tr><td>V_{ENL}</td><td colspan="2"></td><td>-</td><td>-</td><td>0.4</td></tr>
<tr><td>Enable Current</td><td>I_{EN}</td><td colspan="2">V_{IN}=5V, V_{EN}=0V or 5V</td><td>-</td><td>-</td><td>0.1</td><td>μA</td></tr>
<tr><td>V_{OUT1} delay (Note5)</td><td>T_{DELAY}</td><td colspan="2">V_{IN}=5V</td><td>-</td><td>60</td><td>-</td><td>μS</td></tr>
<tr><td>Thermal Shutdown Temperature</td><td>T_{ST}</td><td colspan="2"></td><td>-</td><td>150</td><td>-</td><td>ºC</td></tr>
<tr><td>Thermal Shutdown Hysteresis</td><td>T_{SH}</td><td colspan="2"></td><td>-</td><td>30</td><td>-</td><td>ºC</td></tr>
</table>

Note1: $V_{IN\ (min)}$ = V_{OUT}+V_{DROP}
Note2: Current limit is measured at constant junction temperature by using pulsed testing with a low ON time.
Note3: Regulation is measured at constant junction temperature by using pulsed testing with a low ON time.
Note4: Guaranteed by design.
Note5: In enable on condition, T_{DELAY}=T_{VOUT1}-T_{VOUT2}

❖ APPLICATION CIRCUIT



Rev.1.1 Jul.27, 2010

❖ FUNCTION DESCRIPTIONS

The AX6640 is a highly accurate, Triple, 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.

Enable Function

EN pin control channel1 and channel2 enable and disable functions. When the EN pin is switched to the power off level, the operation of partial 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. When channel1 is from disable to enable, there is 60uS delay in power-ON or enable-ON.

Dropout Voltage

A regulator's minimum input-output voltage differential, or dropout voltage, determines the lowest usable supply voltage. The AX6640 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 AX6640 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 minimum 170mA.

Thermal Shutdown Protection

Thermal Shutdown protection limits total power dissipation of AX6640. 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 30°C, resulting in a pulsed output during continuous thermal shutdown conditions.

Thermal shutdown protection is designed to protect the AX6640 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 AX6640 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. 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.

Input Capacitor

An input capacitance of 1μF 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 AX6640 is designed specifically to work with very small ceramic output capacitors. A ceramic capacitor (temperature characteristics X7R, X5R) in 1μF is suitable for the AX6640 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 AX6640 series can deliver a current of up to 150mA/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.

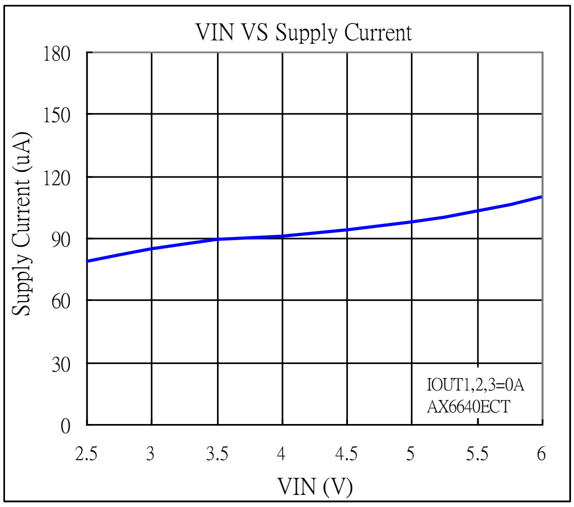
$$P_D = (V_{IN} - V_{OUT})\, I_{OUT} + V_{IN}\, I_{GND}$$

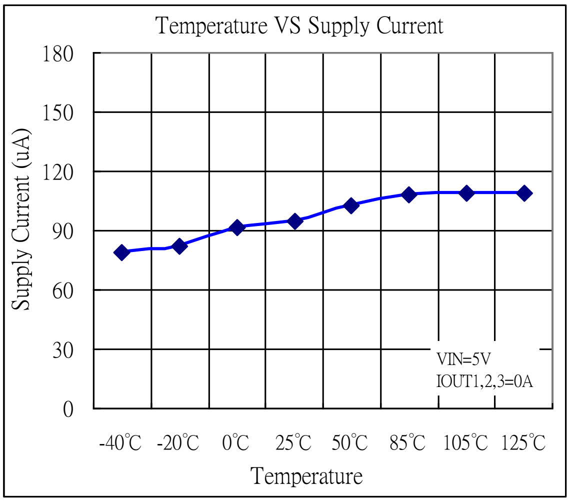
The final operating junction temperature for any set of conditions can be estimated by the following thermal equation:

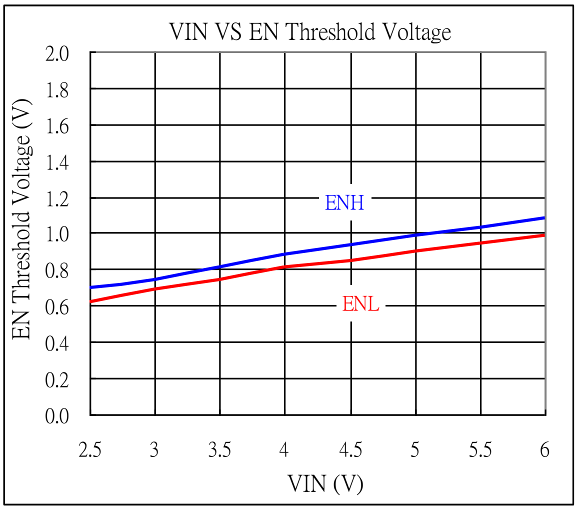
$$P_{D\,(MAX)} = (T_{J\,(MAX)} - T_A) / \theta_{JA}$$

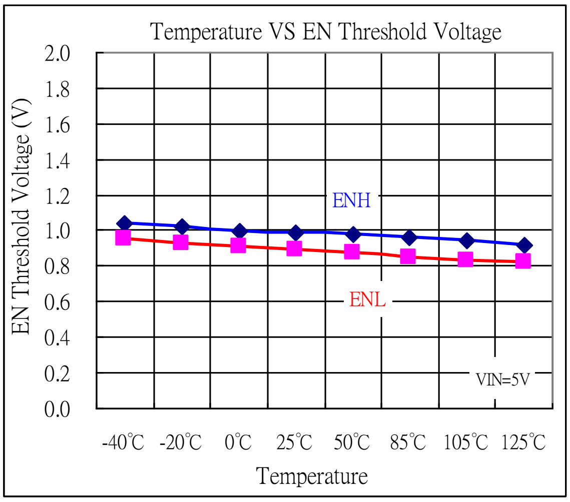
Where $T_{J\,(MAX)}$ is the maximum junction temperature of the die (125°C) and T_A is the maximum ambient temperature. The junction to ambient thermal resistance (θ_{JA}) for TSOT-23-6L package is recommended 250°C/W.

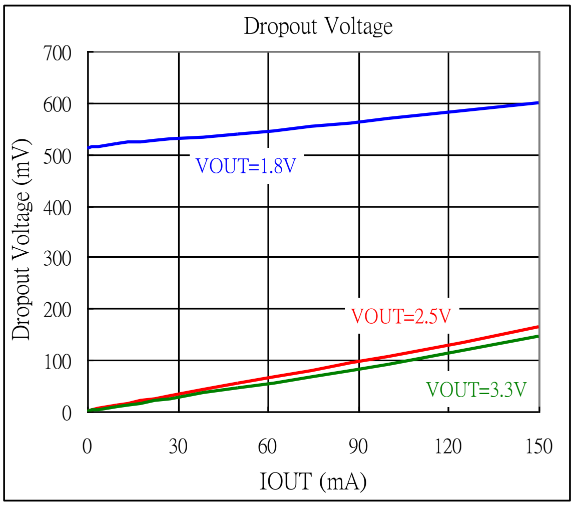
❖ TYPICAL CHARACTERISTICS

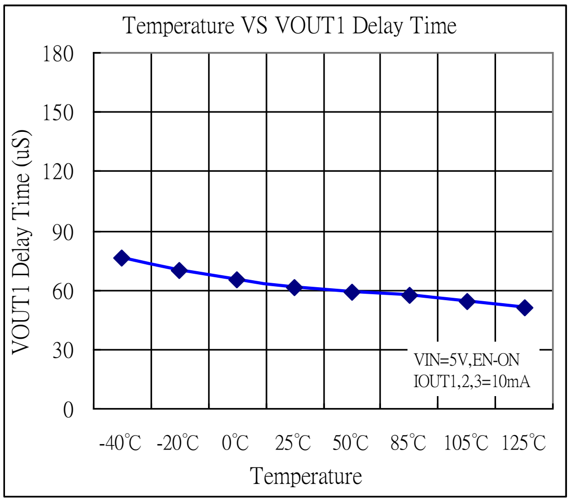




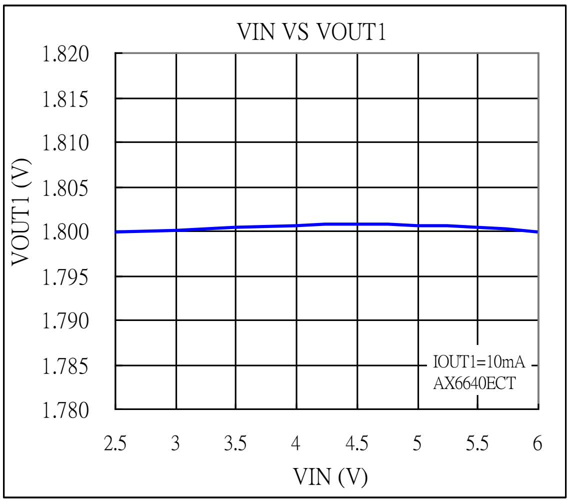


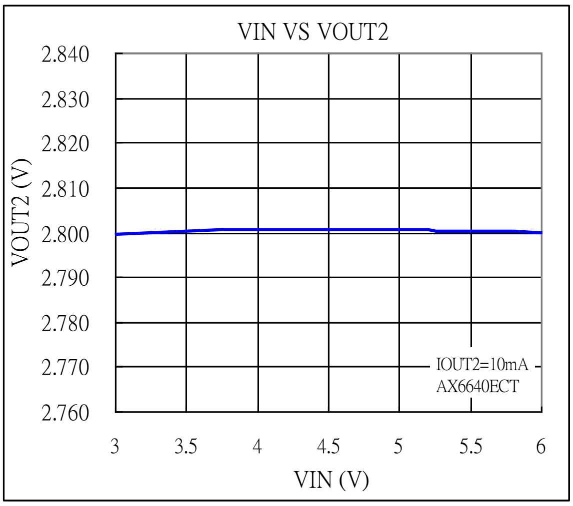


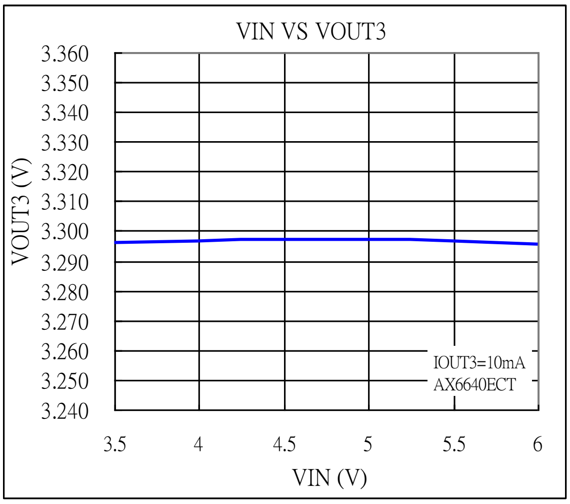


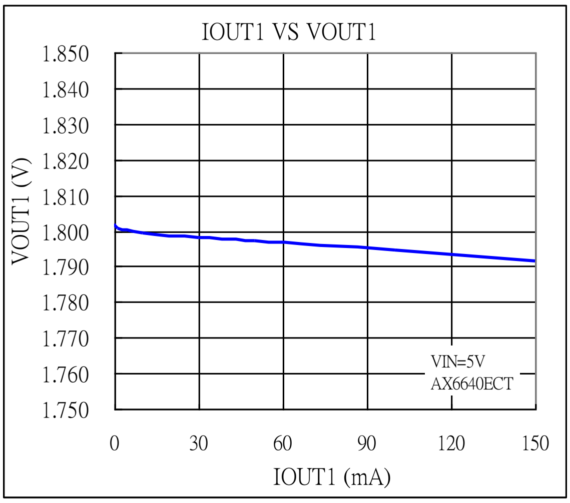


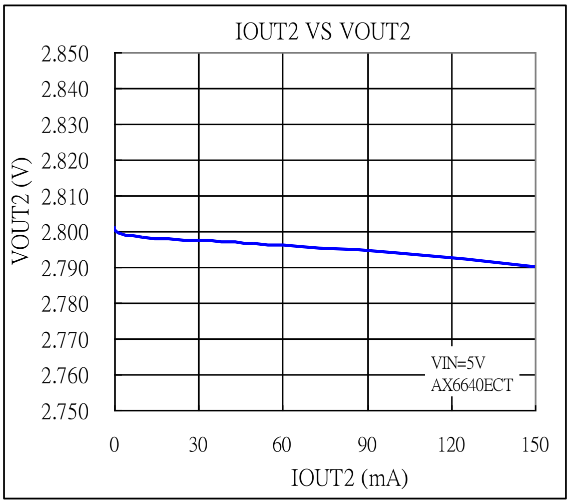
❖ TYPICAL CHARACTERISTICS (CONTINUOUS)

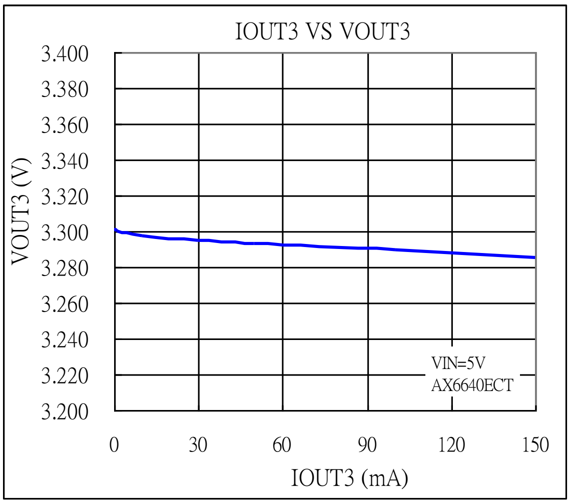




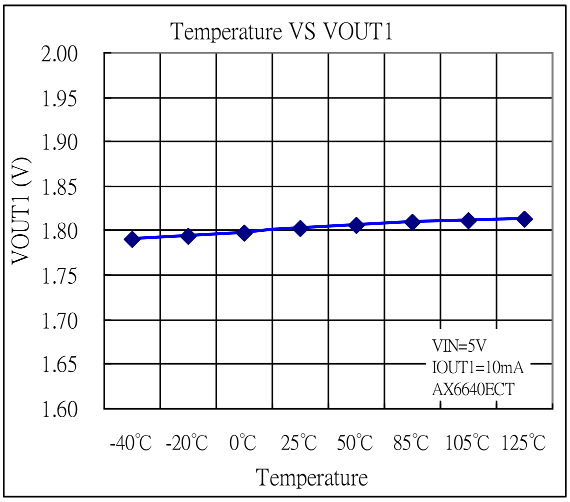


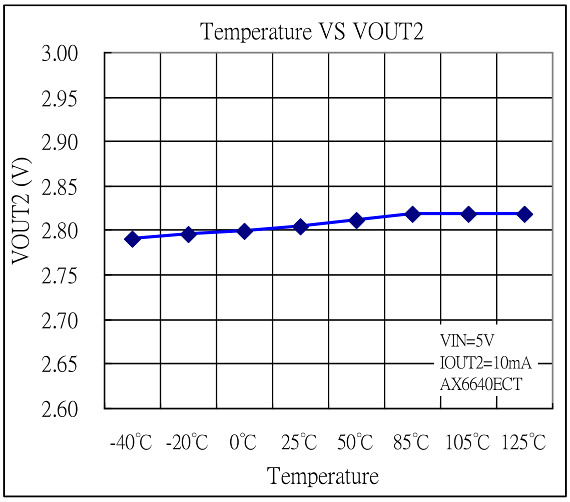


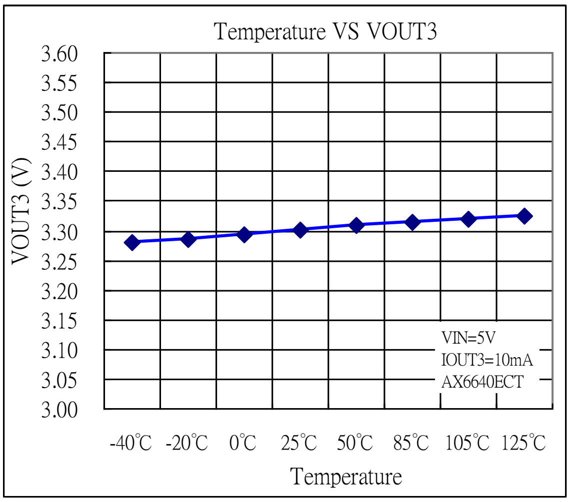




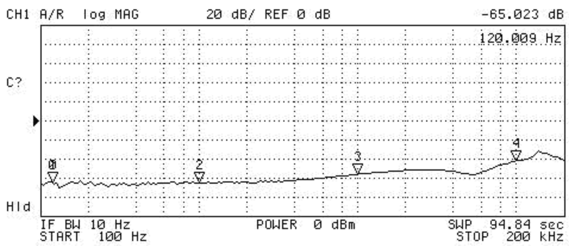
❖ TYPICAL CHARACTERISTICS (CONTINUOUS)





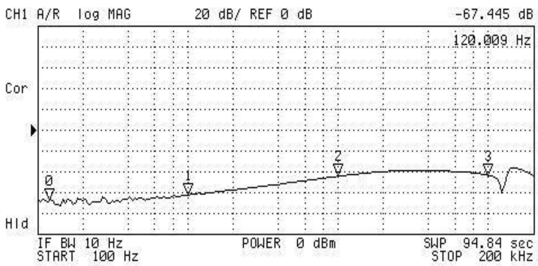


PSRR (VIN=5V, VOUT=1.8V, IOUT=150mA)



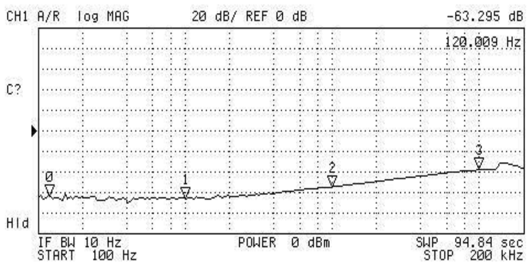
N	SWP PARAM	VAL
0	120.009 Hz	-65.023 dB
1	120.009 Hz	-65.023 dB
2	1.000677 kHz	-65.174 dB

PSRR (VIN=5V, VOUT=2.8V, IOUT=150mA)



N	SWP PARAM	VAL
0	120.009 Hz	-67.445 dB
1	1.000677 kHz	-62.479 dB

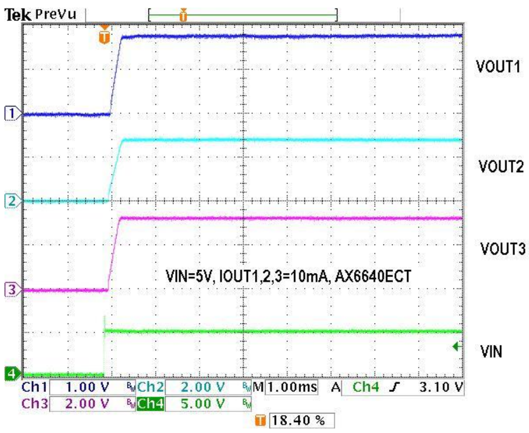
PSRR (VIN=5V, VOUT=3.3V, IOUT=150mA)



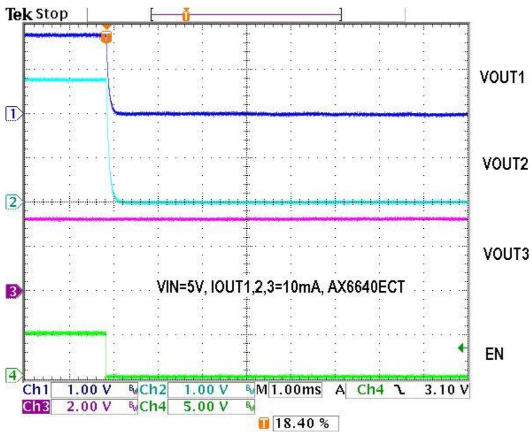
N	SWP PARAM	VAL
0	120.009 Hz	-63.295 dB
1	1.000677 kHz	-65.646 dB

❖ TYPICAL CHARACTERISTICS (CONTINUOUS)

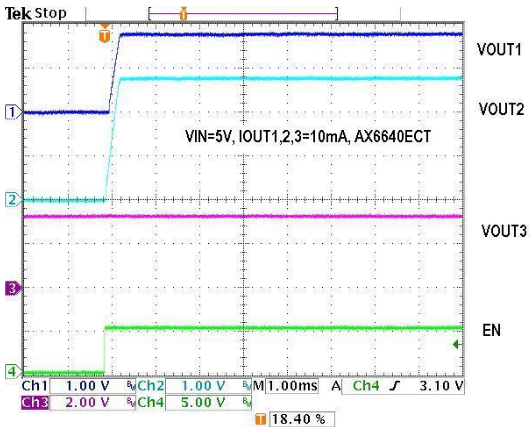
Power OFF → ON



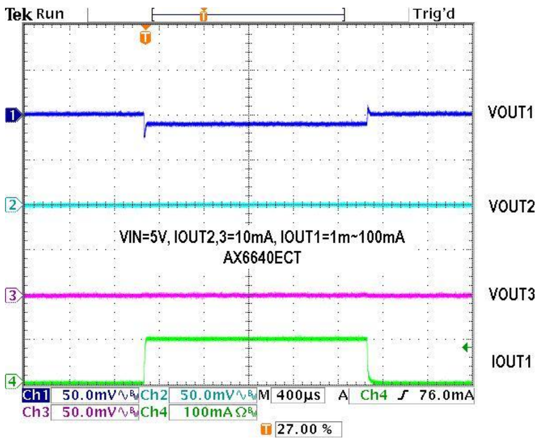
Power ON → OFF



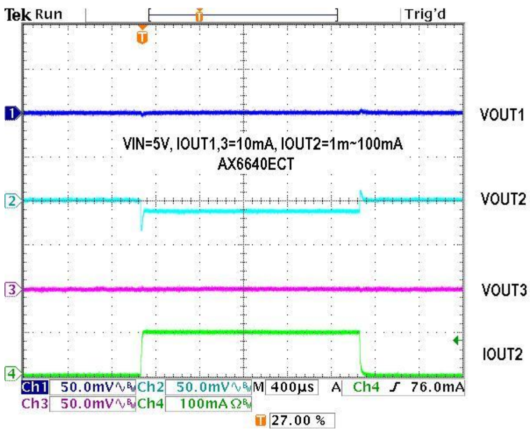
Enable ON



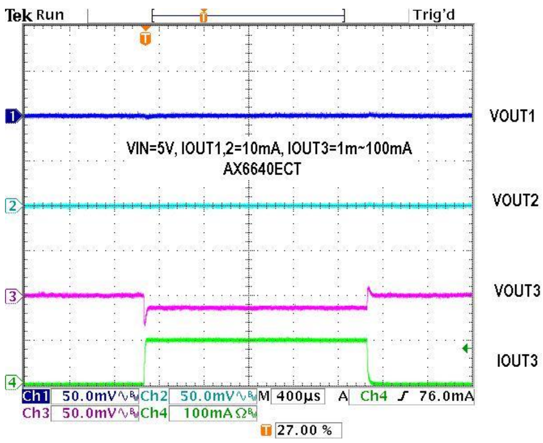
Load Transient (VOUT1)



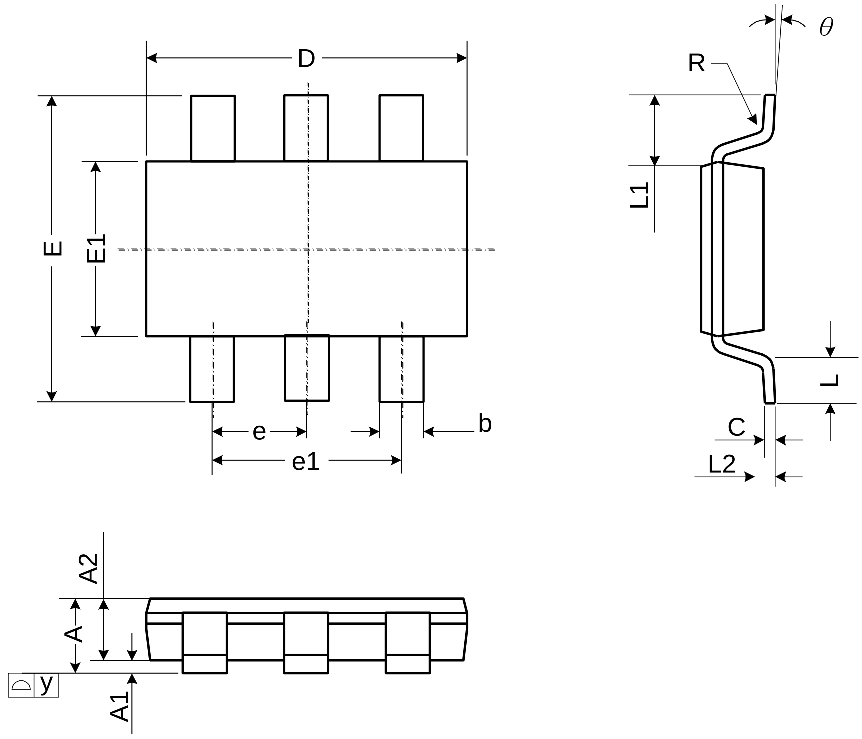
Load Transient (VOUT2)



Load Transient (VOUT3)



❖ PACKAGE OUTLINES



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