1A, 1.5MHz AOT Synchronous Step-Down DC/DC Converter

FEATURES

- 2.5V to 6V Input Voltage Range
- 1.0A Guaranteed Output Current
- Up to 95% Efficiency
- Low $R_{DS(ON)}$ Internal Switch : 110mΩ
- Stable with Low ESR Output Ceramic Capacitors
- No Schottky Diode Required
- 100% Duty Cycle in Low Dropout Operation
- 1.5MHz Operating Frequency
- Accurate Reference 0.6V Provides Low Output Voltages
- 17µA Quiescent Current
- Under Voltage Lockout
- Cycle by Cycle Over Current Protection
- Short Circuit Protection
- Over Temperature Protection
- Available in a TSOT23-8 Package

DESCRIPTION

The AIC2259 is an adaptive on time control synchronous step down converter. The device features an internal synchronous rectifier for high efficiency; it requires no external Schottky diode.

The AIC2259 main control loop uses adaptive on time control that provides a fast transient response without external compensation component. The low impedance internal MOSFET supports high efficiency operation. The AIC2259 has a proprietary circuit that the device to adapt to all ceramic capacitors.

Other features of the AIC2259 include high efficiency, low dropout voltage, over current protection, short circuit protection, and over temperature protection. It is available in a small 8 pins TSOT23-8 package.

APPLICATIONS

- LCD TV
- Multi-function Peripheral
- CPU I/O Supplies
- Cordless Phones
- PDAs and Handy-Terminals
- Battery-Operated Devices (1 Li-Ion or 3 NiMH/ NiCd)

APPLICATIONS CIRCUIT

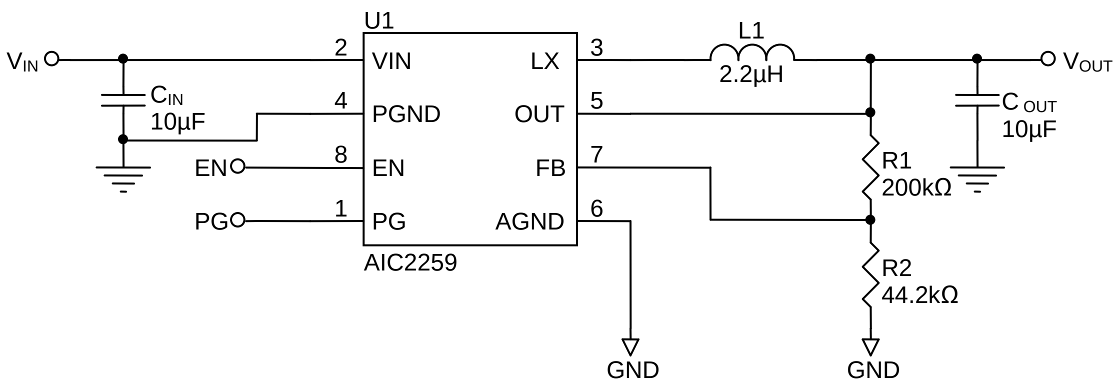


Fig. 1 AIC2259 Application Circuit

■ ORDERING INFORMATION

AIC2259 XXXXX

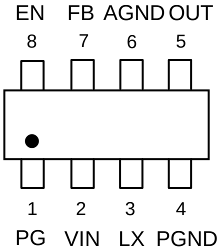
- PACKING TYPE
  TR: TAPE & REEL
  BG: BAG
- PACKAGE TYPE
  K8: TSOT23-8
- G: Green Package

Example: AIC2259GK8TR
→ TSOT23-8 Green Package and Tape & Reel Package Type

Part No.	Marking
AIC2259GK8	2259G

PIN CONFIGURATION

TO VIEW TSOT23-8



■ ABSOLUTE MAXIMUM RATINGS

VIN, LX Voltage		6.5V
EN, FB, OUT & PG Pin Voltage		-0.3 V to V_{IN}
Operating Ambient Temperature Range T_A		-40°C to 85°C
Operating Maximum Junction Temperature T_J		150°C
Storage Temperature Range T_{STG}		-65°C to 150°C
Lead Temperature (Soldering 10 Sec.)		260°C
Thermal Resistance Junction to Case	TSOT23-8	115°C/W
Thermal Resistance Junction to Ambient	TSOT23-8	250°C/W
(Assume no Ambient Airflow)		

Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

ELECTRICAL CHARACTERISTICS

(T_A=25°C, V_{IN}=5V unless otherwise specified.) (Note 1)

PARAMETER	CONDITIONS	SYMBOL	MIN	TYP	MAX	UNITS
Input Voltage Range		V_{IN}	2.5		6.0	V
Adjustable Output Range		V_{OUT}	V_{REF}		V_{IN}-0.2V	V
Feedback Voltage	V_{IN} = 5V	V_{FB}	0.588	0.6	0.612	V
FB Input Current	V_{FB} = V_{IN}	I_{FB}	-50		50	nA
P-Channel On-Resistance	I_{OUT} = 0.2A	$P_{RDS(ON)}$		140		mΩ
N-Channel On-Resistance	I_{OUT} = 0.2A	$N_{RDS(ON)}$		110		mΩ
LX Leakage Current	V_{LX}=0V or V_{LX}=6V		-1		1	μA
Peak Inductor Current	V_{IN} = 5V	I_{PK}	1.3	1.6		A
Quiescent Current	I_{OUT} = 0mA, V_{FB}=V_{REF} + 5%	I_Q		17	25	μA
Shutdown Supply Current	EN = GND	I_{SHDN}		0.1	1	μA
EN High-Level Input Voltage	V_{IN}=2.5V to 5.5V	V_{EN_H}	1.5			V
EN Low-Level Input Voltage	V_{IN}=2.5V to 5.5V	V_{EN_L}			0.4	V
Under Voltage Lockout Threshold	Vin rising	V_{UVLO}	2.0	2.2	2.4	V
Under Voltage Lockout Hystersis		ΔV_{UVLO}		0.3		V
On-Time	V_{IN}=5V, V_{OUT}=1.2V	T_{ON}		160		ns
	V_{IN}=3.6V, V_{OUT}=1.2V			222		
Operating Frequency	V_{OUT}=1.2V	f_O		1.5		MHz
Minimum Off-Time		$T_{OFF(MIN)}$		60		ns
Maximum Duty Cycle		D_{MAX}	100			%
Soft-Start Period		T_{SS}		1.5		ms

ELECTRICAL CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	SYMBOL	MIN	TYP	MAX	UNITS
Power Good Threshold Voltage	Rising referred to V_{FB}			90		%
Power Good Hysteresis				5		%
Power Good Delay				50		μS
Power Good Voltage Low	Sink 1mA	V_{PGL}			0.4	V
Power Good Voltage High	V_{IN}=5V, V_{FB}=0.6V	V_{PGL}	4.9			V
Power Good Internal Pull Up Resistor		R_{PG}		500		kΩ
Thermal Shutdown Temperature				150		°C
Thermal Shutdown Hysteresis				25		°C

Note 1: Specifications are production tested at T_A=25°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with Statistical Quality Controls (SQC).

■ TYPICAL PERFORMANCE CHARACTERISTICS

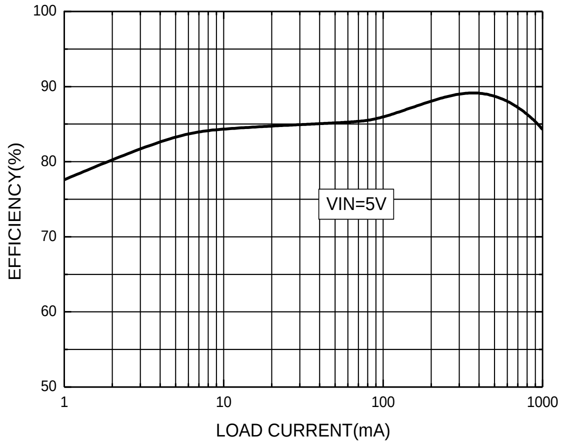


Fig. 1 Efficiency vs. Output Current (V_{OUT}=1V)

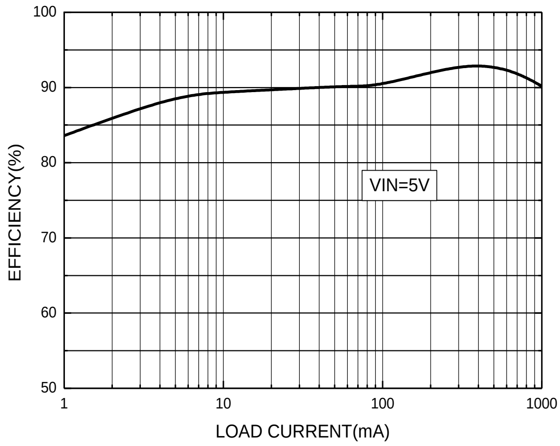


Fig. 2 Efficiency vs. Output Current (V_{OUT}=1.8V)

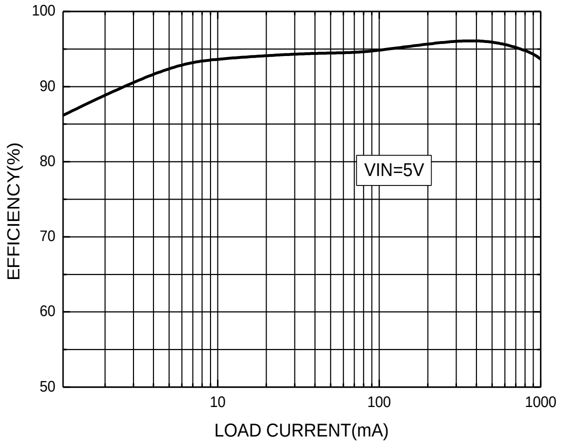


Fig. 3 Efficiency vs. Output Current (V_{OUT}=3.3V)

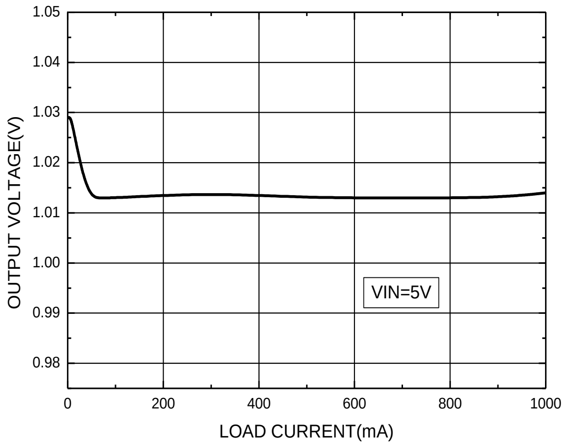


Fig. 4 Output Voltage vs. Load Current (V_{OUT}=1V)

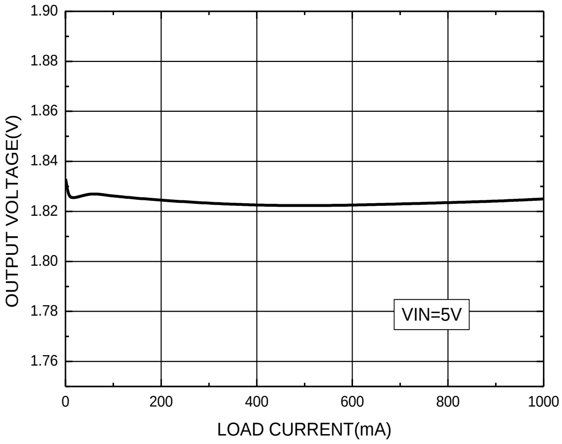


Fig. 5 Output Voltage vs. Load Current (V_{OUT}=1.8V)

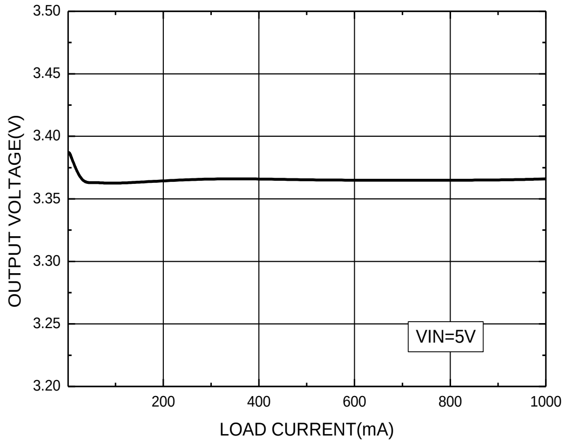


Fig. 6 Output Voltage vs. Load Current (V_{OUT}=3.3V)

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

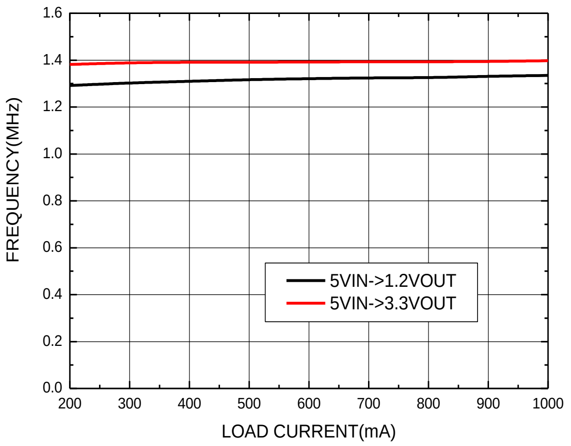


Fig. 7 Frequency vs. Load Current

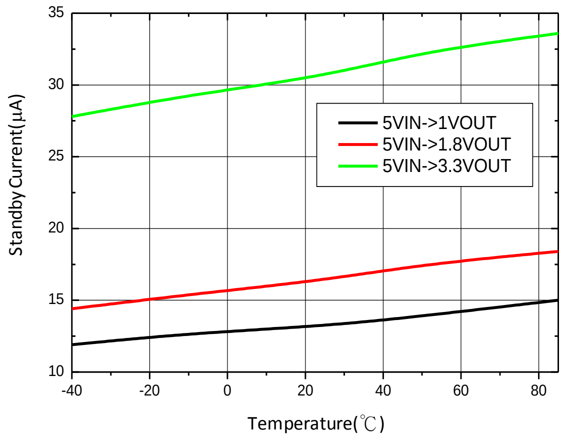


Fig. 8 Standby Current vs. Temperature

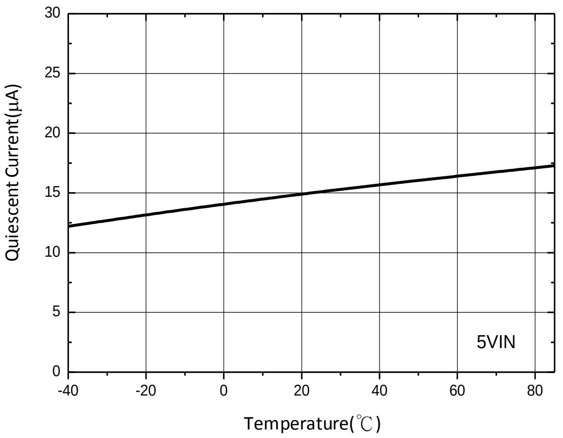


Fig. 9 Quiescent Current vs. Temperature

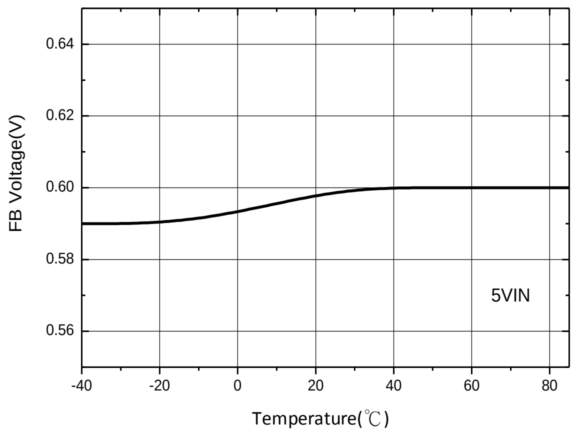


Fig. 10 FB Voltage vs. Temperature

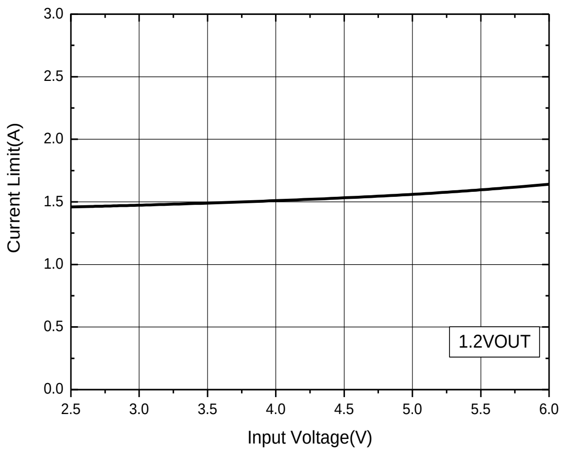


Fig. 11 Current Limit vs. Input Voltage

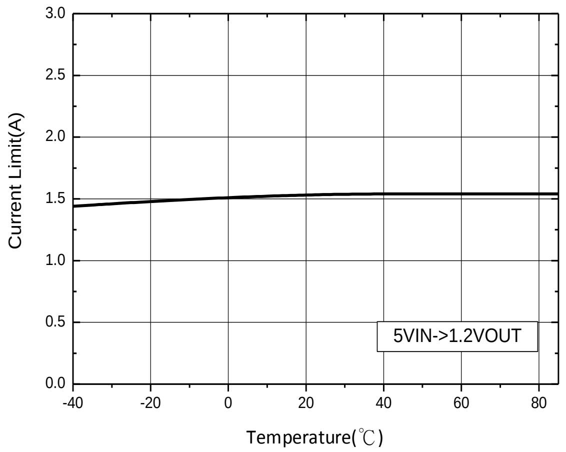


Fig. 12 Current Limit vs. Temperature

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

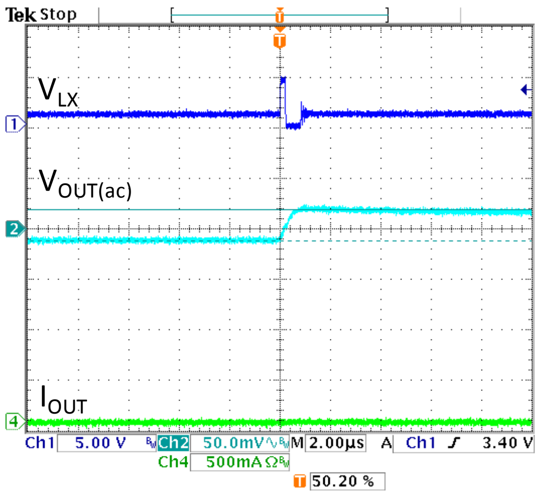


Fig. 13 Output Ripple (V_{IN}=5V, V_{OUT}=1.2V, I_{OUT}=0A)

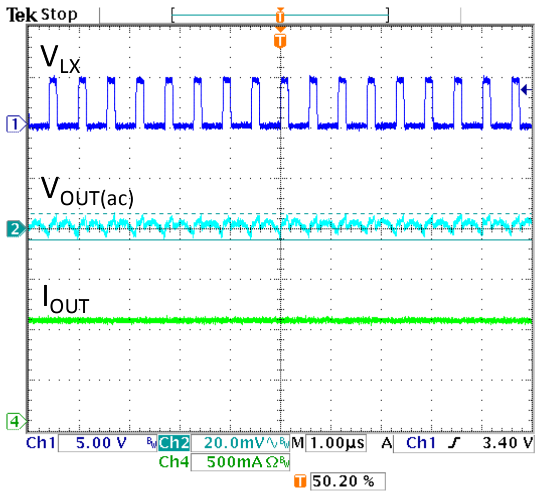


Fig. 14 Output Ripple (V_{IN}=5V, V_{OUT}=1.2V, I_{OUT}=1A)

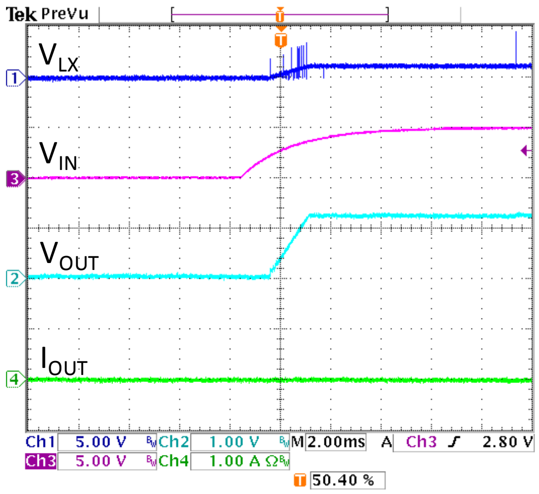


Fig. 15 V_{IN} Power On (V_{IN}=5V, V_{OUT}=1.2V, I_{OUT}=0A)

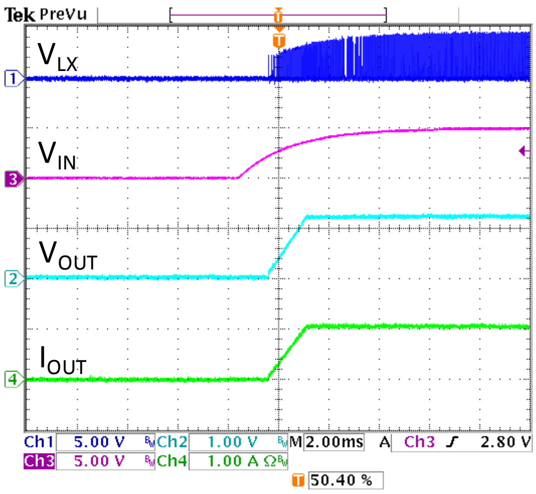


Fig. 16 V_{IN} Power On (V_{IN}=5V, V_{OUT}=1.2V, I_{OUT}=1A)

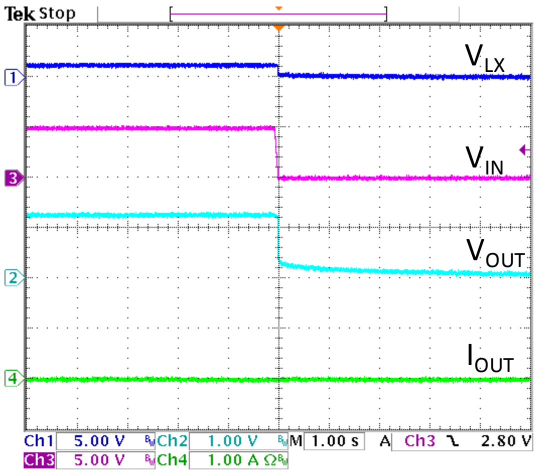


Fig. 17 V_{IN} Power Off (V_{IN}=5V, V_{OUT}=1.2V, I_{OUT}=0A)

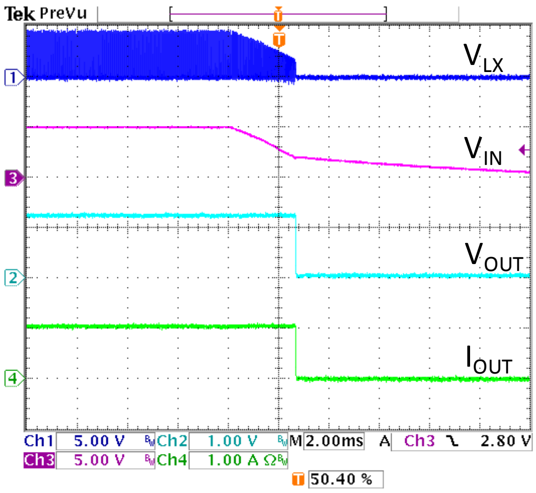


Fig. 18 V_{IN} Power Off (V_{IN}=5V, V_{OUT}=1.2V, I_{OUT}=1A)

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

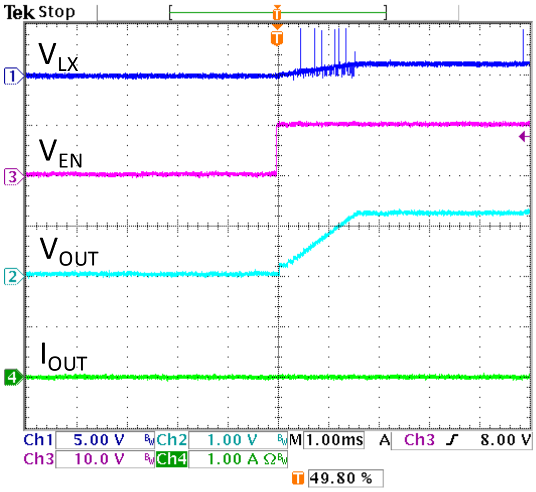


Fig. 19 EN Start Up (V_{IN}=5V, V_{OUT}=1.2V, I_{OUT}=0A)

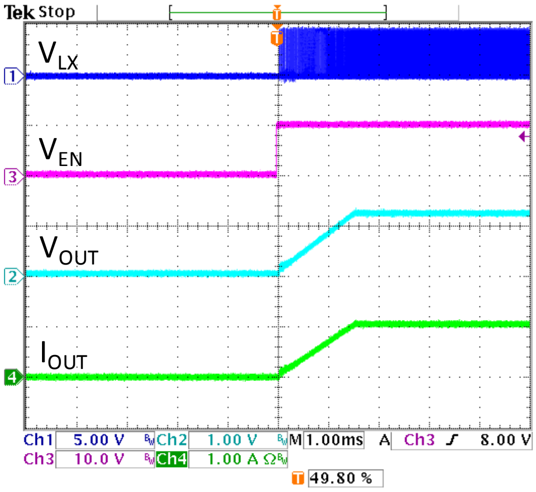


Fig. 20 EN Start Up (V_{IN}=5V, V_{OUT}=1.2V, I_{OUT}=1A)

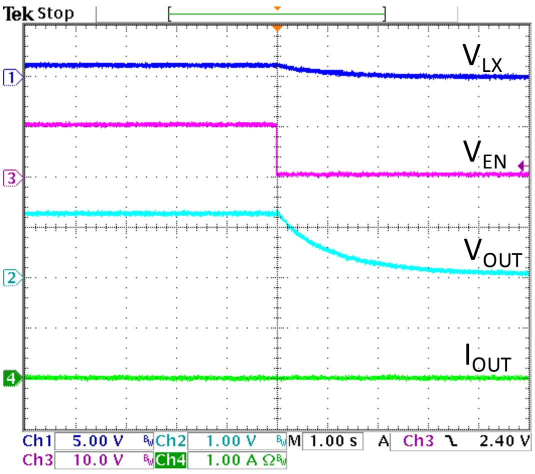


Fig. 21 EN Shutdown (V_{IN}=5V, V_{OUT}=1.2V, I_{OUT}=0A)

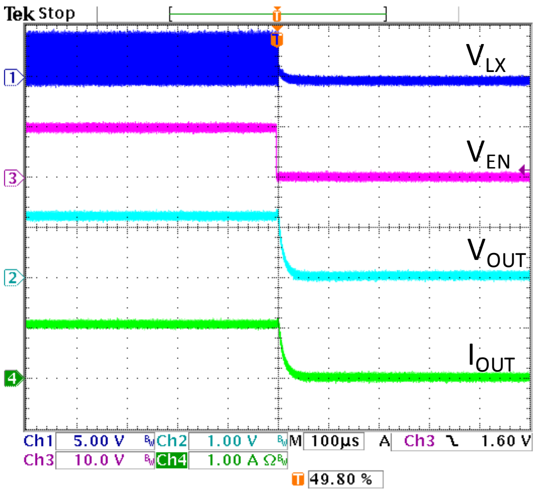


Fig. 22 EN Shutdown (V_{IN}=5V, V_{OUT}=1.2V, I_{OUT}=1A)

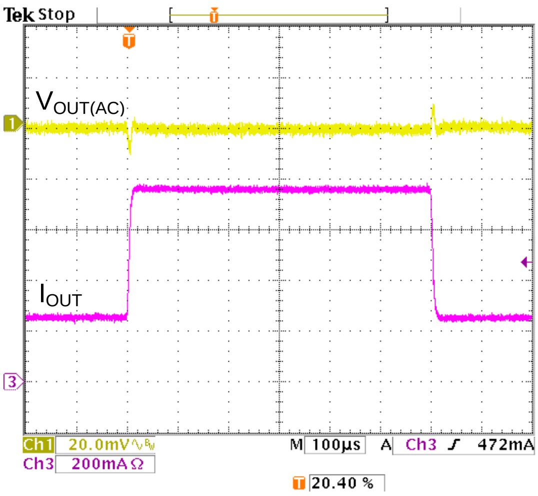
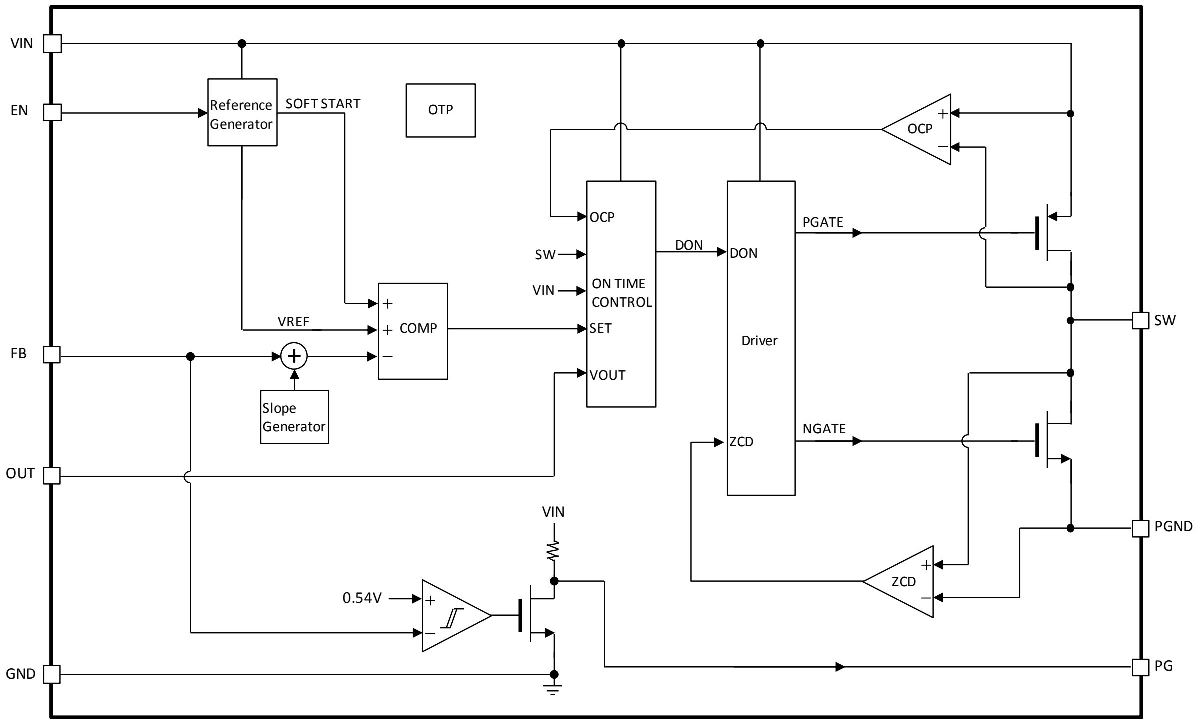


Fig. 23 Load Transient (V_{IN}=5V, V_{OUT}=1.0V, I_O=0.25-0.75A)

BLOCK DIAGRAM



Functional Block Diagram of AIC2259

PIN DESCRIPTIONS

Pin No.	Pin Name	Pin Function
1	PG	Power Good Indicator.
2	VIN	Power Input Supply. Decouple this pin to PGND with a capacitor.
3	LX	Internal Power MOSFET Switches Output. Connect this pin to the inductor.
4	PGND	Power Ground. Connect this pin to the negative terminal of C_{IN} and $C_{OUT.}$
5	OUT	Output Voltage Sense Pin.
6	AGND	Signal Ground. All small-signal components should connect to this ground, which in turn connects to PGND at one point.
7	FB	Feedback Pin. This pin receives the feedback voltage from a resistive divider connecting across the output.
8	EN	Enable Pin. Connect to logic high in normal operation. Forcing this ping to GND causes the device to be shutdown.

APPLICATION INFORMATION

The AIC2259 is an adaptive on-time control synchronous step down converter that can maintain almost fixed switching frequency over full input voltage range. It can deliver up to 1A output current from 2.5V to 6V input voltage. Unlike the traditional fixed frequency PWM control, the adaptive on-time control has the simpler control circuit and the faster transient response. During normal operation, the AIC2259 can regulate its output voltage through a feedback control circuit, which is composed of a comparator, a slope generator, a reference generator and several control signal generators. At the beginning of the switching cycle, the main power switch will be turned on and the synchronous power switch will be turned off. The main power switch will be turned off after the internal on-time timer expires. When the main power switch is turned off, the synchronous power switch will be turned on until the summing signal of feedback voltage signal and slope signal is lower than reference voltage signal or the inductor current starts to reverse. The AIC2259 will enter discontinuous conduction mode (DCM) operation while working at light load conditions.

Enable

When EN pin is set logic high, AIC2259 is put into active mode operation. By connecting the EN pin to GND, the device can be shutdown to reduce the supply to 0.1μA (typical). At this operation mode, the synchronous switch will turn off and the output voltage of step-down converter will reduce to 0V.

Soft Start

AIC2259 provides the soft-start function to prevent a large inrush current and output overshoot during start up period. During the soft-start period, the soft-start signal will limit the feedback threshold voltage at FB pin. When the soft-start signal voltage is higher than reference voltage, the feedback threshold voltage at FB pin reaches the desired value. The soft-start time is about 1.5ms (typical).

Power Good Indictor

AIC2259 contains an on-chip comparator for power good detection. If the output voltage is lower than power good low threshold, the output voltage of PG pin will be pulled low.

Over Current Protection

The AIC2259 has a cycle-by-cycle current limit to protect the internal power switches. The cycle-by-cycle current limit protection directly limits inductor peak current. When the current limit protection is activated for nine consecutive switching cycles, the AIC2259 will shut down the output power stage and then initiate the soft-start sequence. If the over current condition still exists after the soft-start ends, the AIC2259 will repeat this operation mode until the over current condition is released.

Over Temperature Protection

The AIC2259 includes a thermal-limiting circuit, which is designed to protect the device from excessive temperature. When the junction temperature exceeds T_J=150ºC, the thermal-limiting circuit turns the internal power switches off and allows the IC to cool. The hysteretic of the over temperature protection is 25°C (typical).

100% Duty Cycle Operation

When the input voltage approaches the output voltage, the AIC2259 smoothly transits to 100% duty cycle operation. This allows AIC2259 to regulate the output voltage until AIC2259 completely enters 100% duty cycle operation. In 100% duty cycle mode, the output voltage is equal to the input voltage minus the voltage, which is the drop across the main power switch.

The AIC2259 achieves 100% duty cycle operation by extending the turn-on time of the main power switch. While the input voltage approaches the output voltage, the switching frequency of power switches reduces gradually to smoothly transit to 100% duty cycle operation.

If input voltage is very close to output voltage, the switching mode goes from adaptive on-time control mode to 100% duty cycle operation. During this transient state mentioned above, large output ripple voltage may appear on output terminal.

Components Selection

Inductor

A 2.2μH inductor is recommended for most AIC2259 applications. Although small size and high efficiency are major concerns, the inductor should have low core losses at operation frequency and low ESR. For most designs, the inductance value can be derived from the following equations:

$$L \geq \frac{V_{OUT}}{f_{OSC} \cdot \Delta I_L}\left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where ΔI_L is the inductor ripple current.

In addition, it is important to ensure the inductor saturation current exceeds the peak value of inductor current in application to prevent core saturation. The peak inductor current can be calculated from:

$$I_{PEAK} = I_{OUT(max)} + \frac{V_{OUT}}{2 \times f_{OSC} \cdot L}\left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Input Capacitor Selection

To prevent the high input voltage ripple and noise resulted from high frequency switching, the use of low ESR ceramic capacitor for the maximum RMS current is recommended. The approximated RMS current of the input capacitor can be calculated according to the following equation.

$$I_{CINRMS} \approx \sqrt{I^2_{OUT(MAX)} \times \frac{V_{OUT}(V_{IN} - V_{OUT})}{V^2_{IN}} + \frac{\Delta I^2_L}{12}}$$

Low ESR, X5R or X7R, ceramic capacitors are ideal for this function. The capacitor should be placed as close to the IC as possible for the best. At least a 10μF ceramic capacitor is suggested for the input capacitor.

Output Capacitor Selection

The selection of output capacitor depends on the required output voltage ripple. The output voltage ripple can be expressed as:

$$\Delta V_{OUT} = \frac{\Delta I_L}{8 \times f_{OSC} \cdot C_{OUT}} + ESR \cdot \Delta I_L$$

The output capacitor limits the output ripple during large load transient. For low output voltage ripple, the use of low ESR, X5R or X7R, ceramic capacitor is recommended. When choosing output capacitors, the voltage rating of output capacitor should be higher than the output voltage. 10μF ceramic capacitor may be needed for the output capacitor.

Setting the Output Voltage

An external resistor divider connected from the output voltage to FB pin is used to set the output voltage. The voltage divider divides the output voltage down to the feedback voltage by the ratio:

$$V_{FB} = V_{OUT}\frac{R_2}{R_1 + R_2}$$

The resistive divider should sit as close to FB pin as possible.

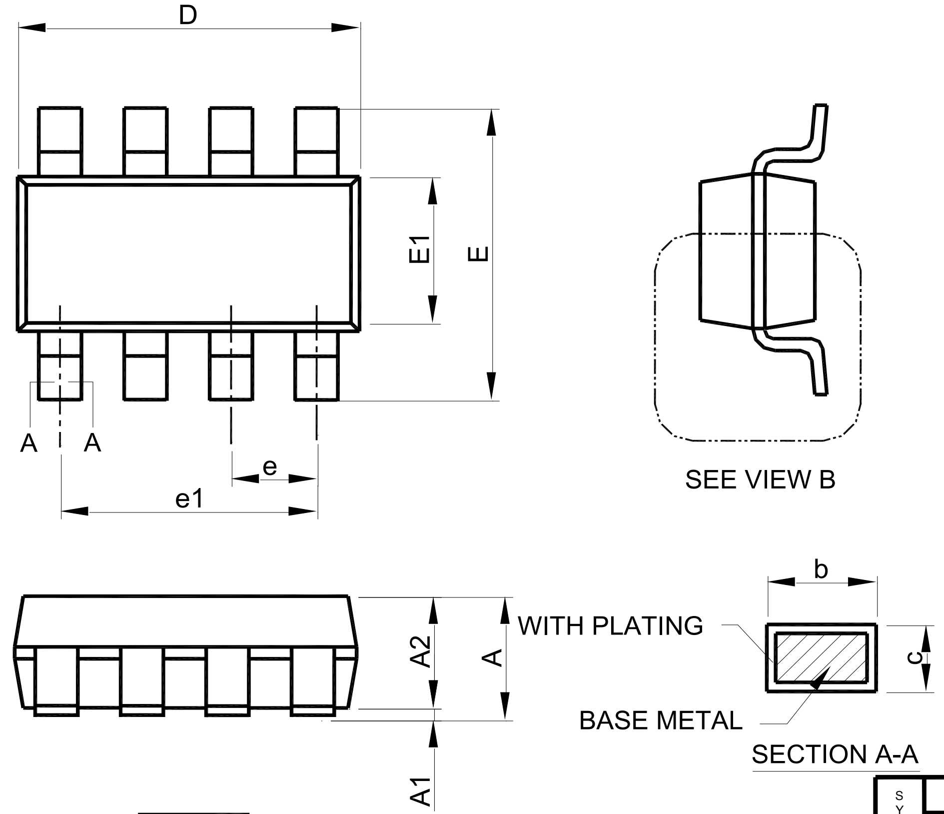
PCB Layout Guidance

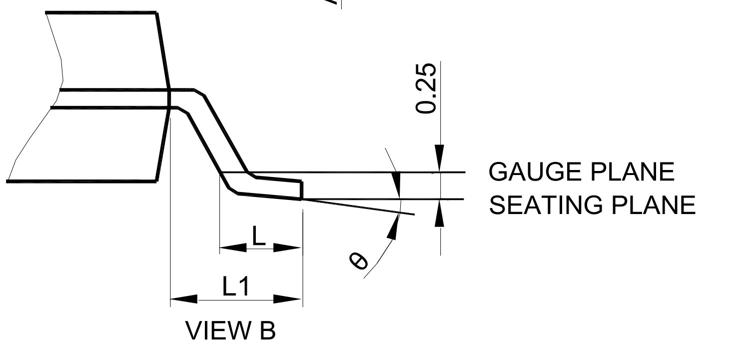
In order to ensure a proper operation of AIC2259, the following points should be managed comprehensively.

1. The input capacitor and V_{IN} should be placed as close as possible to each other to reduce the input voltage ripple and noise.
2. The output loop, which is consisted of the inductor, the internal power switch and the output capacitor, should be kept as small as possible.
3. The routes with large current should be kept short and wide.
4. Logically the large current on the converter should flow at the same direction.
5. In order to prevent the effect from noise, the IC's GND pin should be placed close to the ground of the input bypass capacitor.
6. The FB pin should be connected to the feedback resistors directly and the route should be away from the noise sources.

PHYSICAL DIMENSIONS

- **TSOT23-8**





SYMBOL	TSOT23-8	
	MILLIMETERS	
	MIN.	MAX.
A	-	1.00
A1	0	0.10
A2	0.70	0.90
b	0.20	0.40
c	0.08	0.22
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.65 BSC	
e1	1.95 BSC	
L	0.30	0.60
L1	0.60 REF	
θ	0°	8°

Note : 1. Refer to JEDEC MO-193E.
2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side.
3. Dimension "E1" does not include inter-lead flash or protrusions.
4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.