600kHz 18V 3A Synchronous AOT Step-Down Converter

FEATURES

- 70mΩ/35mΩ Low $R_{DS(ON)}$ Internal FETs
- High Efficiency Synchronous-Mode Operation
- Wide Input Range:4.5V to 18V
- Output Voltage from 0.765V
- 600kHz Switch Frequency
- Up to 3A, 3.5A@1.2V Output Current
- AOT control to achieve fast transient responses
- Power Save Mode at Light Load
- Integrated Internal Compensation
- Stable with Low ESR Ceramic Output Capacitors
- Over Current Protection with Hiccup Mode
- Thermal Shutdown
- Inrush Current Limit and Soft Start
- Build in Input Over Voltage Protection
- Available in TSOT23-6 Package

DESCRIPTION

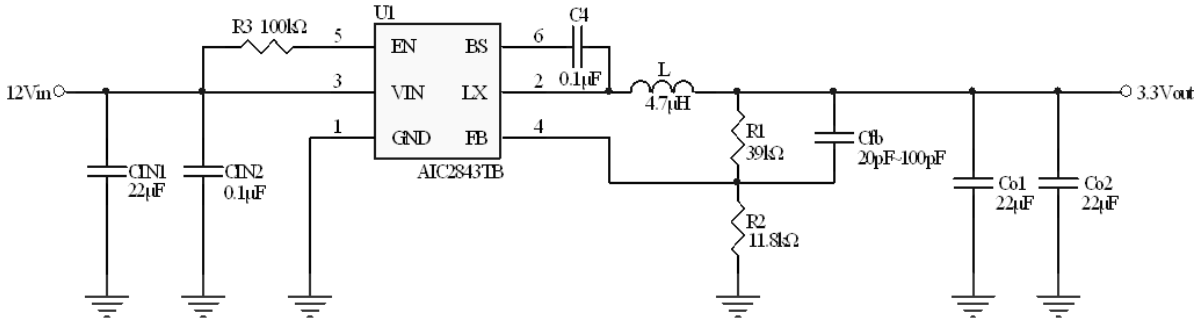
The AIC2843TB is a high efficiency 600kHz, Adaptive On-Time (AOT) control mode synchronous step-down DC-DC converter capable of delivering up to 3A current. AIC2843TB integrates main switch and synchronous switch with very low $R_{DS(ON)}$ to minimize the conduction loss. Low output voltage ripple and small external inductor and capacitor size are achieved with 600kHz switching frequency. It adopts the AOT architecture to achieve fast transient responses for high voltage step down applications.

The AIC2843TB requires a minimum number of readily available standard external components and is available in a 6-pin TSOT23-6 ROHS compliant package.

APPLICATIONS

- Digital Set Top Boxes
- Flat Panel Television and Monitors
- Notebook Computer
- Wireless and DSL Modems

APPLICATIONS CIRCUIT



AIC2843TB Typical Application Circuit

ORDERING INFORMATION

AIC2843TBXXXXX

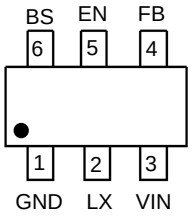
- PACKING TYPE
  TR: TAPE & REEL
  BG: BAG
- PACKAGE TYPE
  K6F: TSOT23-6
- G: Green Package

Example: AIC2843TBGK6FTR

→ TSOT23-6 Green Package and Tape & Reel Packing Type

PIN CONFIGURATION

SOT23-6
TOP VIEW



Note: Pin1 is determined by orienting the package marking as shown.

Top Mark: TT3XXX (TT3: Device Code, XXX: Inside Code)

Part No.	Marking
AIC2843TBGK6F	TT3XXX

ABSOLUTE MAXIMUM RATINGS

VIN Pin and EN Pin Voltage ..... - 0.3V to 20V

LX Pin Voltage ..... - 0.3V to 20V

LX Pin Voltage (10ns transient)..... - 4V to 25V

FB Pin Voltage ..... - 0.3V to 6V

BS Pin Voltage ..... (V_{LX}-0.3V) to (V_{LX}+6V)

Junction Temperature (Note2)..... 160°C

Lead Temperature (Soldering, 10 sec)..... 260°C

Storage Temperature Range ..... - 65°C ~ 150°C

Operating Junction Temperature Range ..... - 40°C ~ 125°C

Thermal Resistance Junction to Ambient, θ_{JA} (Note3) TSOT23-6..... 100°C/W

Power Dissipation TSOT23-6..... 1000mW

(Assume no Ambient Airflow, no Heatsink)

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

ELECTRICAL CHARACTERISTICS

(V_{IN}=12V, V_{OUT} =3.3V, T_A=25°C, unless otherwise specified.) (Note1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}		4.5		18	V
OVP Threshold	V_{OVP}			19.3		V
UVLO Rising Threshold	V_{UVLO}		4.0			V
UVLO Hysteresis				0.45		V
Quiescent Current		V_{EN}=2.0V, V_{FB}= V_{REF} x 105%		300		μA
Shutdown Current		V_{IN}=12V, V_{EN}=0V		5	10	μA
Regulated Feedback Voltage	V_{FB}	T_A=25°C,4.5V≤V_{IN} ≤18V	0.750	0.765	0.780	V
High-Side Switch On-Resistance	$R_{DS(ON)1}$			70		mΩ
Low-Side Switch On-Resistance	$R_{DS(ON)2}$			35		mΩ
High-Side Switch Leakage Current		V_{EN}=0V, V_{LX}=0V	1		10	μA
Switch Vally Current Limit		Minimum Duty Cycle		4		A
On Time		V_{IN}=12V, V_{OUT}=1.2V, I_{OUT}=1A	132	166	200	ns
Oscillation Frequency	f_{OSC}			600		kHz
Maximum Duty Cycle	D_{MAX}			65		%
Minimum On-Time	T_{ON}			80		ns
Soft Start Time				1		ms
Hiccup on Time				1.2		ms
Hiccup Time Before Restart				3.6		ms
EN High-Level Input Voltage			1.5			V
EN Low-Level Input Voltage					0.3	V
Thermal Shutdown Threshold (Note4)	T_{SD}			165		°C
Thermal Shutdown Hysteresis (Note4)				30		°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).

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + (P_D \times \theta_{JA})$. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_{D(MAX)} = (T_{J(MAX)}-T_A)/\theta_{JA}$.

Note 3: Measured on JESD51-7, 4-layer PCB.

Note 4: Thermal shutdown threshold and hysteresis are guaranteed by design.

TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN}=12V, V_{OUT}=1.05V, I_{OUT}=0.1A ~ 1.5A

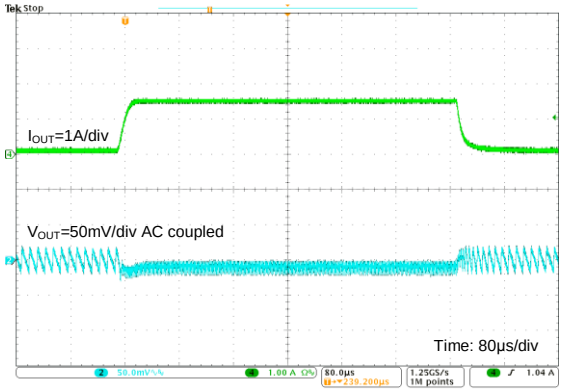


Fig. 1 Load Transient

V_{IN}=12V, V_{OUT}=1.05V, I_{OUT}=0.75A ~ 2.25A

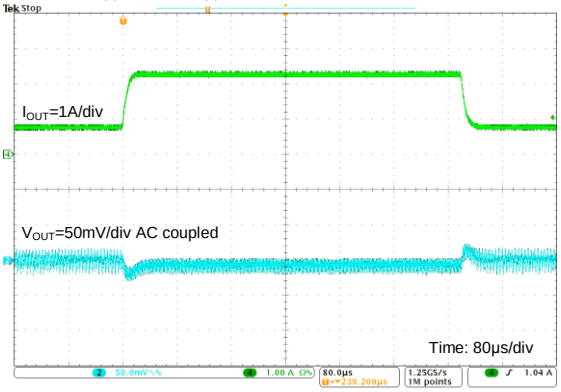


Fig. 2 Load Transient

V_{IN}=12V, V_{OUT}=1.05V, I_{OUT}=0.3A ~ 2.7A

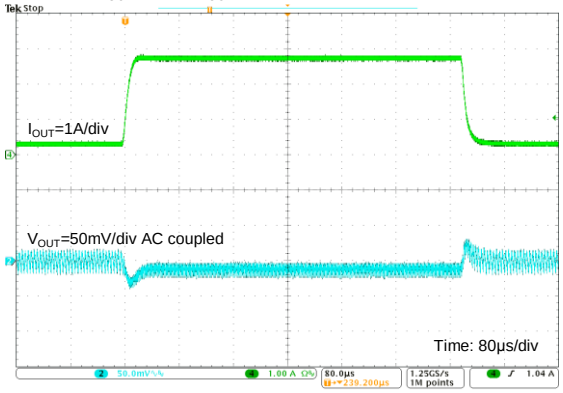


Fig. 3 Load Transient

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=0.1A ~ 1.5A

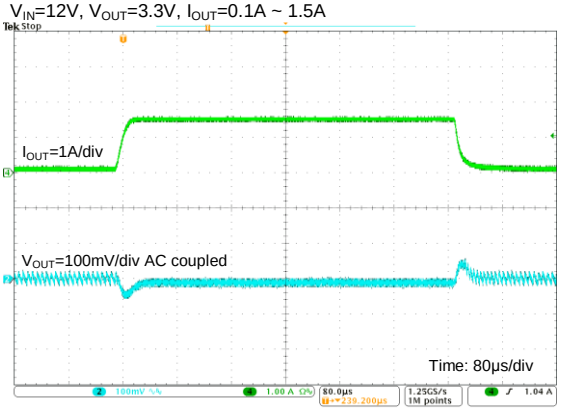


Fig. 4 Load Transient

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=0.75A ~ 2.25A

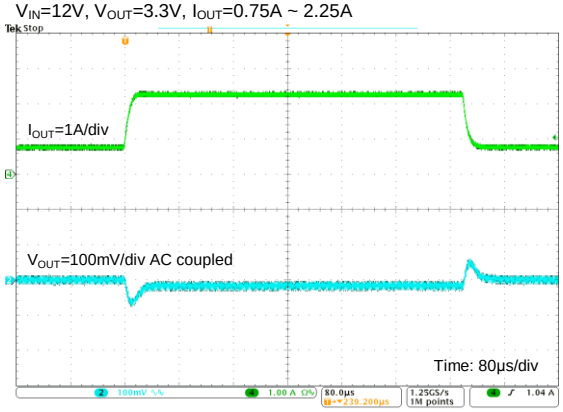


Fig. 5 Load Transient

V_{IN}=12V, V_{OUT}=3.3V, I_{OUT}=0.3A ~ 2.7A

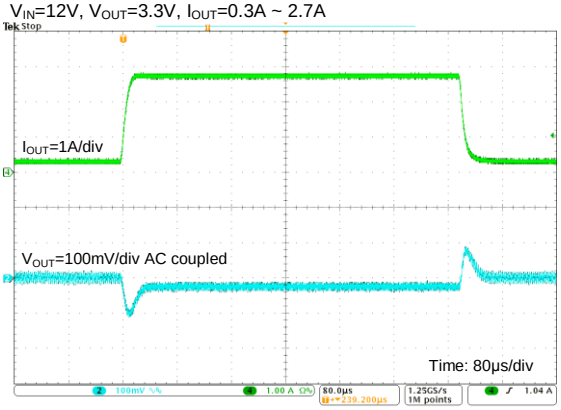


Fig. 6 Load Transient

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

V_{IN}=12V, V_{OUT}=5V, I_{OUT}=0.1A ~ 1.5A

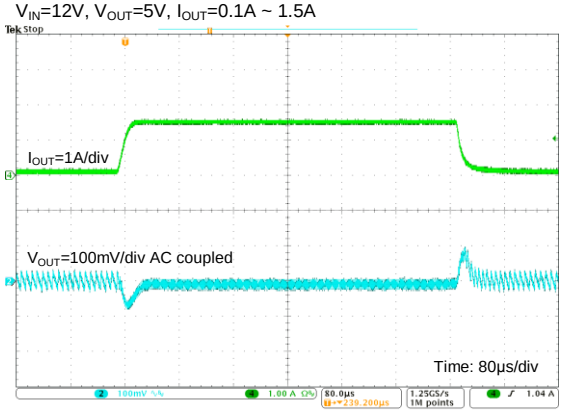


Fig. 7 Load Transient

V_{IN}=12V, V_{OUT}=5V, I_{OUT}=0.75A ~ 2.25A

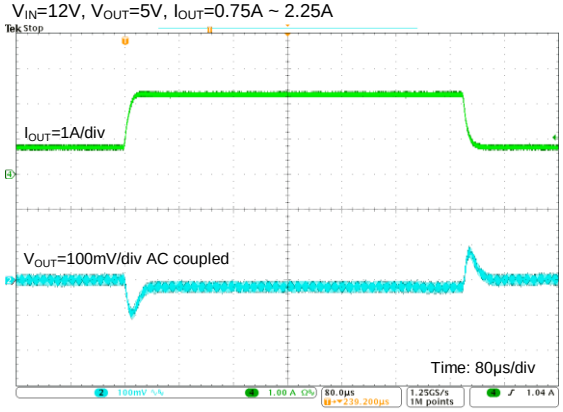


Fig. 8 Load Transient

V_{IN}=12V, V_{OUT}=5V, I_{OUT}=0.3A ~ 2.7A

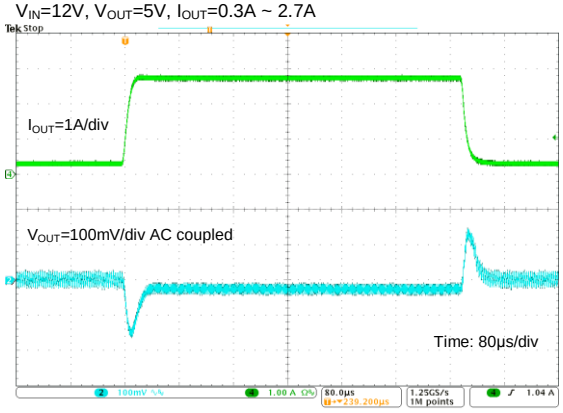


Fig. 9 Load Transient

V_{IN} =12V, V_{OUT} =3.3V, No Load

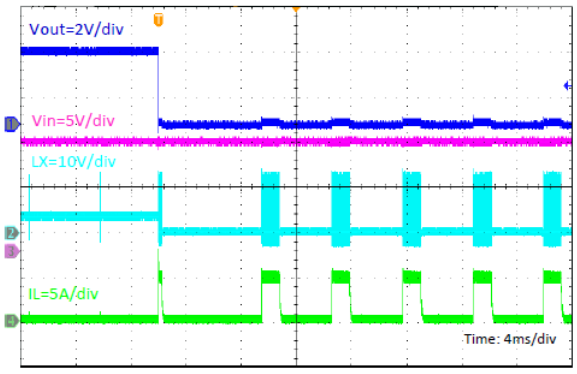


Fig. 10 Output Short Entry

V_{IN}=12V, V_{OUT} =3.3V, No Load

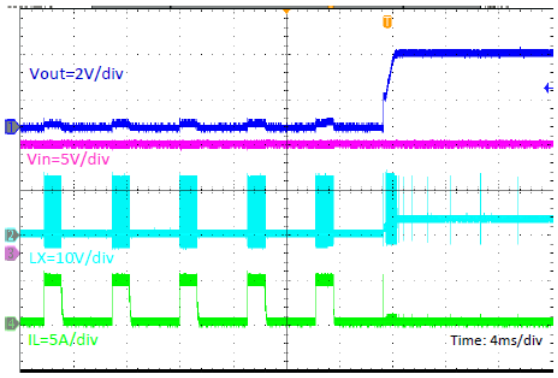


Fig. 11 Output Short Recovery

V_{IN} =12V, V_{OUT} =3.3V, I_o =3A

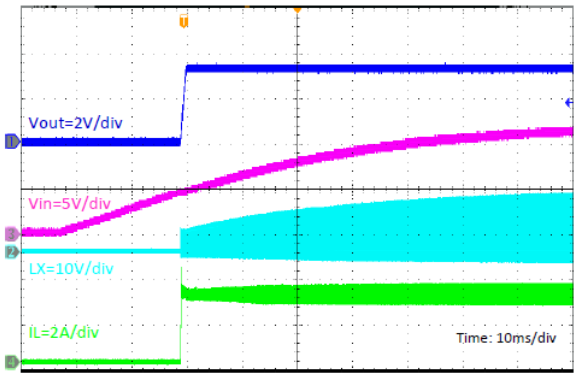


Fig. 12 Input Power On

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

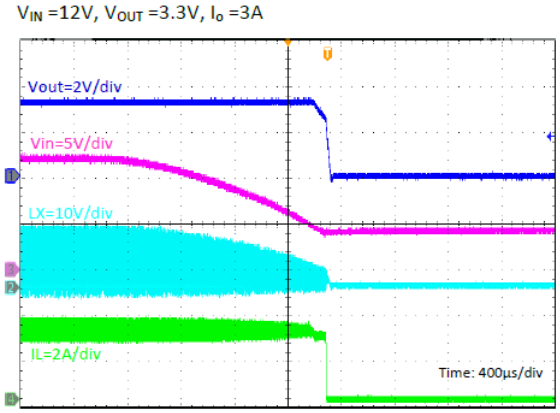


Fig. 13 Input Power Down

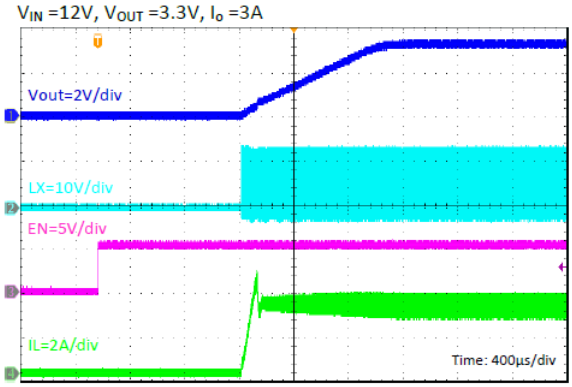


Fig. 14 EN Enable Power On

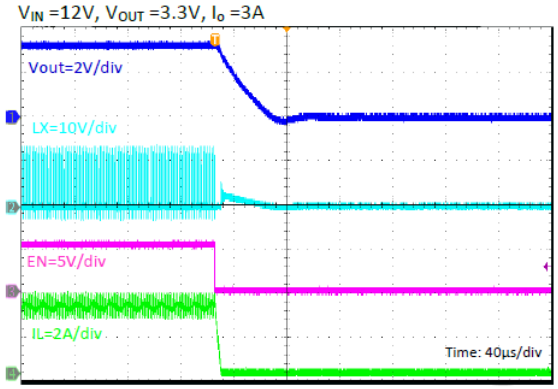


Fig. 15 EN Disable Power Down

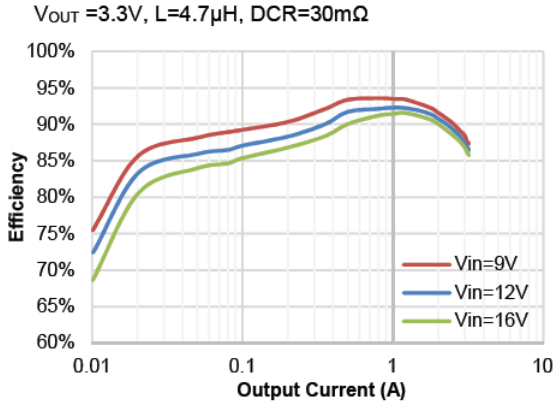


Fig. 16 Efficiency vs. Output Current (V_{OUT}=3.3V)

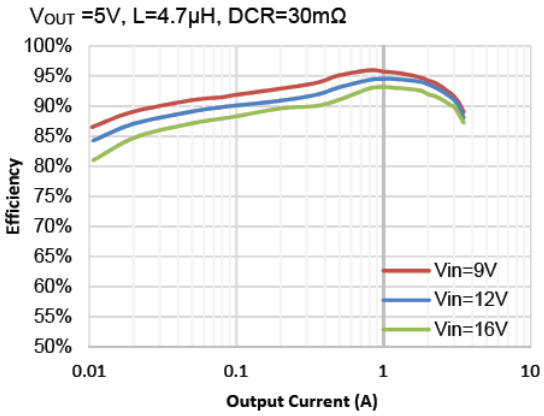


Fig. 17 Efficiency vs. Output Current (V_{OUT}=5V)

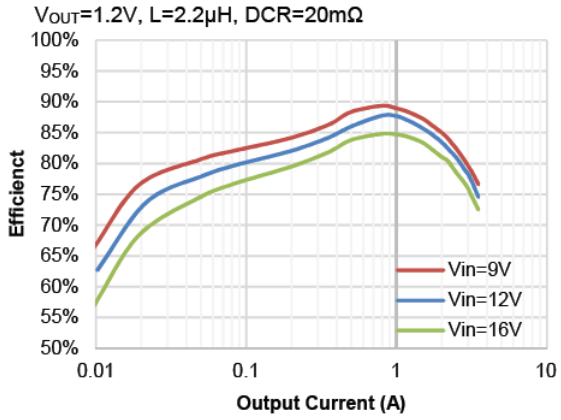
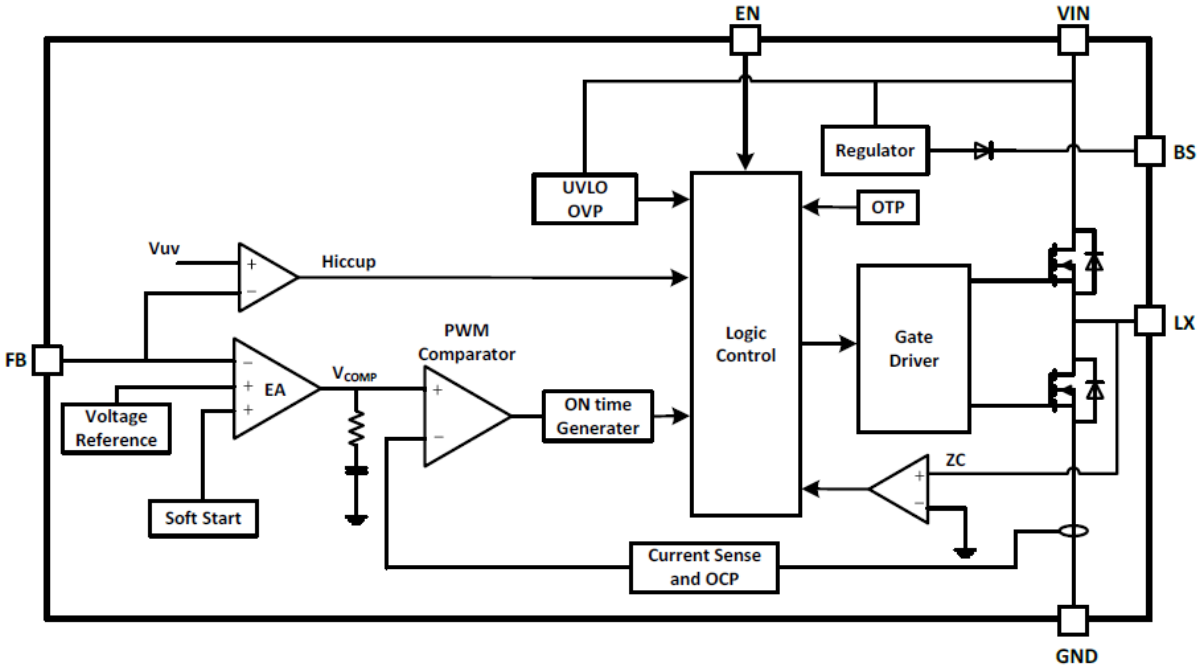


Fig. 18 Efficiency vs. Output Current (V_{OUT}=1.2V)

BLOCK DIAGRAM



Functional Block Diagram of AIC2843TB

PIN DESCRIPTIONS

Pin No.	Pin Name	Pin Function
1	GND	Ground.
2	LX	Switching Pin.
3	IN	Power supply Pin.
4	FB	Output voltage feedback input. Connect FB to the center point of the external resistor divider.
5	EN	Drive this pin to a logic-high to enable the IC. Drive to a logic-low to disable the IC and enter micro-power shutdown mode. Don't floating EN.
6	BS	Bootstrap. A capacitor connected between LX and BS pins is required to form a floating supply across the high-side switch driver.

APPLICATION INFORMATION

Internal Regulator

The AIC2843TB is an adaptive on-time (AOT) step down DC/DC converter that provides excellent transient response with no extra external compensation components. This device contains low resistance, high voltage high side and low side power MOSFETs, and operates at 600kHz operating frequency to ensure a compact, high efficiency design with excellent AC and DC performance.

Error Amplifier

AIC2843TB adopts operational transconductance amplifier (OTA) as error amplifier. The error amplifier compares the FB pin voltage with the internal FB reference (V_{REF}) and outputs a current proportional to the difference between the two. This output current is then used to charge or discharge the internal compensation network to form the V_{COMP} voltage, which is used to compare with the low side power MOSFET current sensing signal and trigger on time pulse. The optimized internal compensation network minimizes the external component counts and simplifies the control loop design.

Internal Soft-Start

The soft-start is implemented to prevent the converter output voltage from overshooting during startup. When the chip starts, the internal circuitry generates a soft-start voltage (SS) ramping up from 0V to V_{REF}. When it is lower than the internal FB reference (V_{REF}), SS overrides REF so the error amplifier uses SS as the reference. When SS is higher than V_{REF}, V_{REF} regains control. The SS time is internally fixed to 1ms typically.

Over-Current-Protection and Short Circuits Protection

The AIC2843TB has cycle-by-cycle valley current limit function. When the inductor current valley value is larger than the valley current limit during low side MOSFET on state, the device enters into valley over current protection mode and low side MOSFET keeps on state until inductor current drops down to the value equal or lower than the valley current limit, and then on time pulse could be generated and high side MOSFET could turn on again.

If the output is short to GND and the output voltage drop until feedback voltage V_{FB} is below the output under-voltage V_{UV} threshold which is typically 60% of V_{REF}, AIC2843TB enters into hiccup mode to periodically disable and restart switching operation. The hiccup mode helps to reduce power dissipation and thermal rise during output short condition. The period of AIC2843TB hiccup mode is typically 4.8ms.

Startup and Shutdown

If both VIN and EN are higher than their appropriate thresholds, the chip starts switching operation. The reference block starts first, generating stable reference voltage and currents, and then the internal regulator is enabled. The regulator provides stable supply for the remaining circuitries. Three events can shut down the chip: EN low, VIN low and thermal shutdown. In the shutdown procedure, the signaling path is first blocked to avoid any fault triggering. The V_{COMP} voltage and the internal supply rail are then pulled down. The floating driver is not subject to this shutdown command.

Setting the Output Voltage

The external resistor divider is used to set the output voltage (see Typical Application on page 1). Choose R1 to be around 39kΩ for optimal transient response. R2 is then given by:

$$R_2 = \frac{R_1}{\frac{V_{out}}{V_{FB}} - 1}$$

Table 1 Selection for Common Output Voltages

V_{OUT}(V)	R1(kΩ)	R2(kΩ)	C_{FB}(pF)	L(μH)
5	39	7.04	33	4.7
3.3	39	11.8	33	4.7
2.5	39	17.2	33	3.3
1.8	39	28.8	33	2.2
1.5	39	40.6	33	2.2
1.2	39	68.6	33	1.5
1	18	58.6	33	1.0

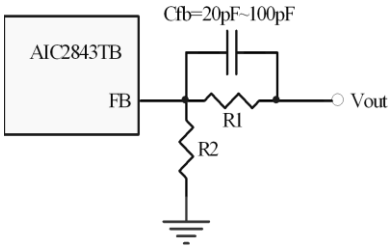


Fig. 19 Feedback Network

Selecting the Inductor

A 1.0μH to 4.7μH inductor with a DC current rating of at least 25% percent higher than the maximum load current is recommended for most applications. For highest efficiency, the inductor DC resistance should be as small as possible. For most designs, the inductance value can be derived from the following equation.

$$L = \frac{V_{out} \times (V_{in} - V_{out})}{V_{in} \times \Delta I_L \times f_{OSC}}$$

Where ΔI_L is the inductor ripple current. Choose inductor ripple current to be approximately 30% if the maximum load current 3A. The maximum inductor peak current is:

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2}$$

Under light load conditions below 100mA, larger inductance is recommended for improved efficiency.

Selecting the Output Capacitor

The output capacitor (Co1 and Co2) is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left[1 - \frac{V_{OUT}}{V_{IN}}\right] \times \left[R_{ESR} + \frac{1}{8 \times f_S \times (C_{O1} + C_{O2})}\right]$$

Where L is the inductor value and R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor. In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly caused by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_S^{\,2} \times L \times (C_{O1} + C_{O2})} \times \left[1 - \frac{V_{OUT}}{V_{IN}}\right]$$

In the case of tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left[1 - \frac{V_{OUT}}{V_{IN}}\right] \times R_{ESR}$$

The characteristics of the output capacitor also affect the stability of the regulation system. The AIC2843TB can be optimized for a wide range of capacitance and ESR values.

PCB Layout GuideConsideration

PCB layout is very important to achieve stable operation. It is highly recommended to duplicate EVB layout for optimum performance. If change is necessary, please follow these guidelines and take figures 20~21 for reference.

(1) Keep the path of switching current short and minimize the loop area formed by Input capacitor, VIN pin and GND.

(2) Bypass ceramic capacitors are suggested to be

put close to the VIN Pin.

(3) Ensure all feedback connections are short and direct. Place the feedback resistors as close to the chip as possible.

(4) VOUT, LX away from sensitive analog areas such as FB.

(5) Connect VIN, LX, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.

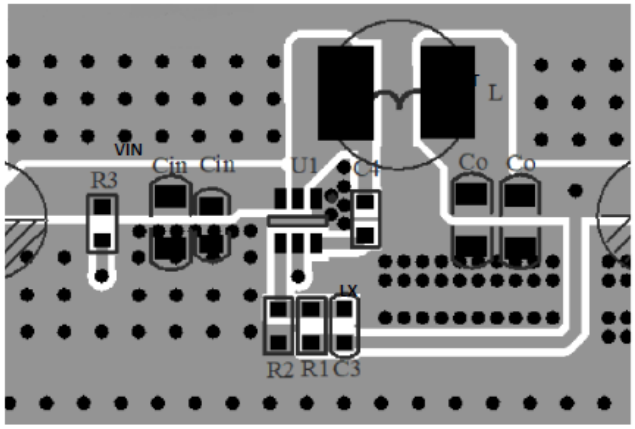


Fig. 20 Top Layer

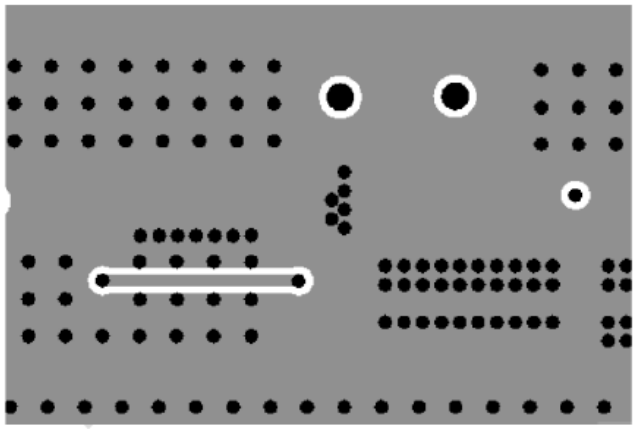


Fig. 21 Bottom Layer

APPLICATION EXAMPLES

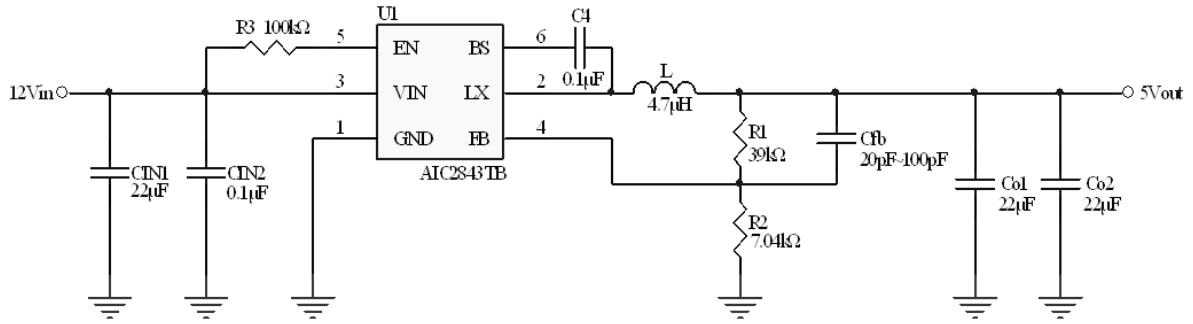


Fig. 22 AIC2843TB Application Circuit for $12V_{IN}$, 5V Output Application

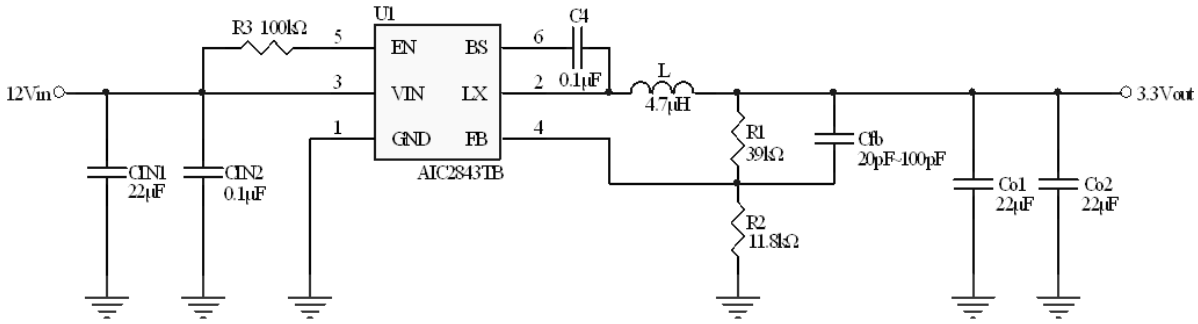


Fig. 23 AIC2843TB Application Circuit for $12V_{IN}$, 3.3V Output Application

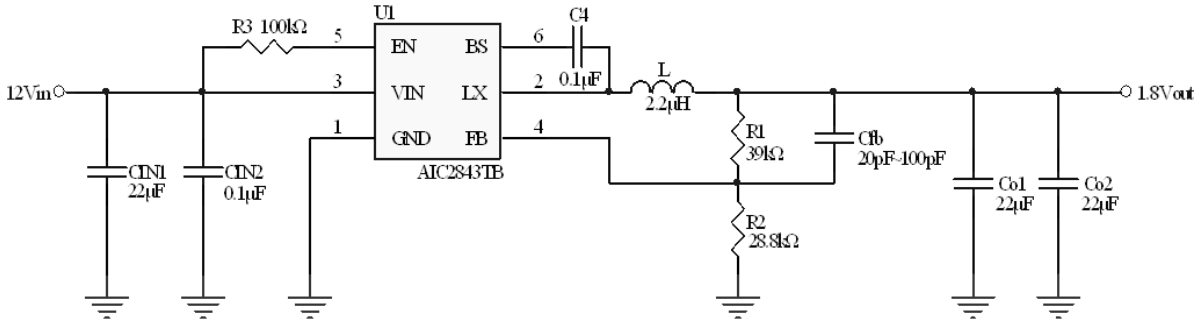


Fig. 24 AIC2843TB Application Circuit for $12V_{IN}$, 1.8V Output Application

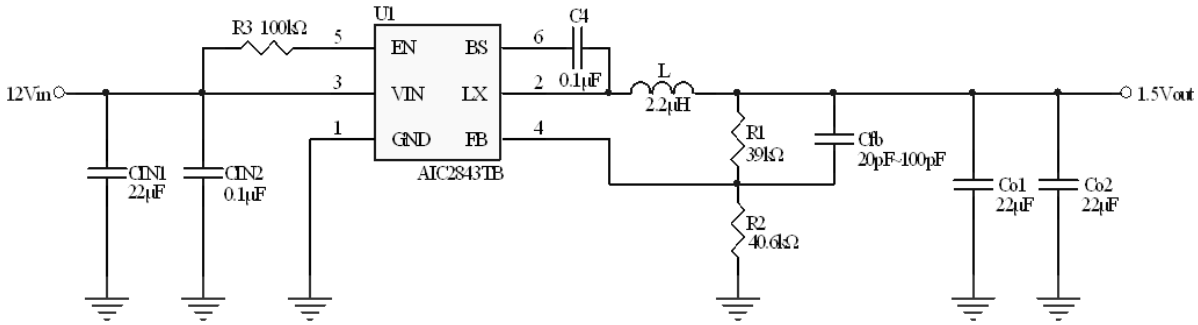


Fig. 25 AIC2843TB Application Circuit for $12V_{IN}$, 1.5V Output Application

APPLICATION EXAMPLES (Continued)

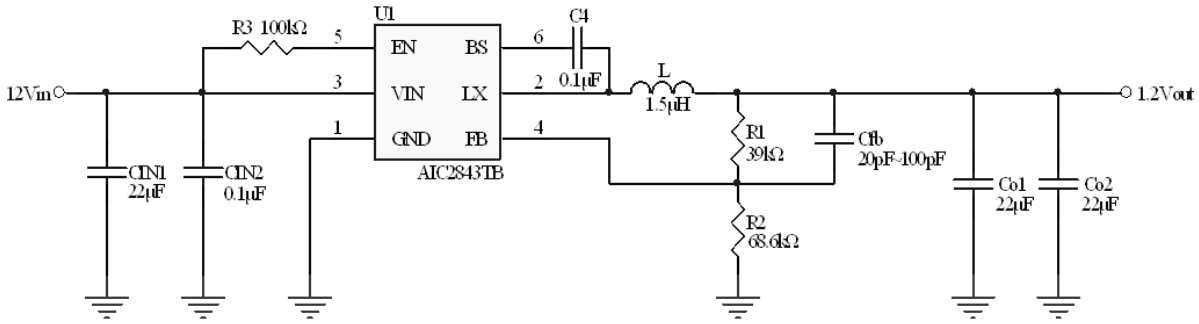


Fig. 26 AIC2843TB Application Circuit for $12V_{IN}$, 1.2V Output Application

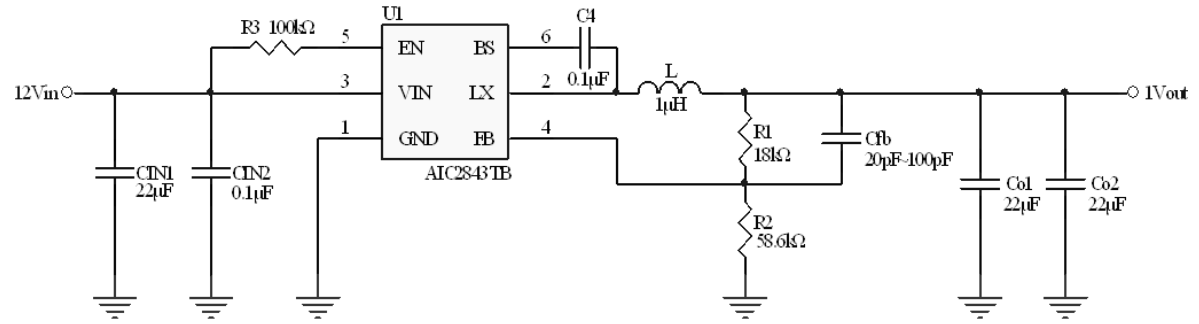
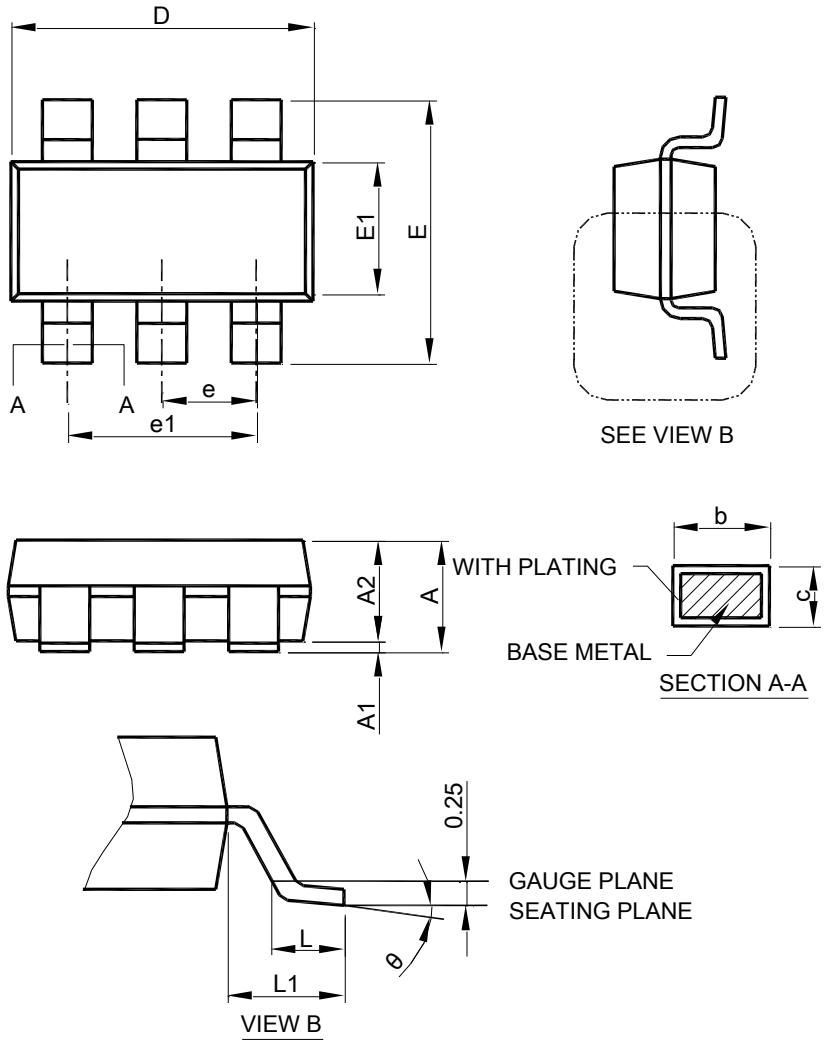


Fig. 27 AIC2843TB Application Circuit for $12V_{IN}$, 1V Output Application

PHYSICAL DIMENSIONS

- **TSOT23-6**



SYMBOL	TSOT23-6	
	MILLIMETERS	
	MIN.	MAX.
A	-	1.00
A1	0	0.10
A2	0.70	0.90
b	0.30	0.50
c	0.08	0.22
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.95 BSC	
e1	1.90 BSC	
L	0.30	0.60
L1	0.60 REF	
θ	0°	8°

Note : 1. Refer to JEDEC MO-193AA.
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.