2μA, 600mA Low Dropout Voltage Linear Regulator

FEATURES

- 2μA Ground Current at no Load
- ±2% Output Accuracy
- 600mA Output Current
- 10nA Disable Current (by option)
- Wide Operating Input Voltage Range: 1.2V to 5.5V
- Dropout Voltage: 0.36V at 600mA (V_{OUT}=3.3V)
- Support Fixed Output Voltage 1.2V, 1.5V, 1.6V, 1.8V, 2.5V, 2.8V, 3.0V, 3.3V
- Stable with Ceramic or Tantalum Capacitor
- Current Limit Protection
- Over-Temperature Protection
- SOT23-3, SOT23-5, DFN-4(1x1) and DFN-6(2x2) Packages Available

APPLICATIONS

- Portable, Battery Powered Equipment
- Low Power Microcontrollers
- Laptop, Palmtops and PDAs
- Wireless Communication Equipment
- Audio/Video Equipment
- Car Navigation Systems

DESCRIPTION

The AIC1706B series are a group of low-dropout (LDO) voltage regulators offering the benefits of wide input voltage range from 1.2V to 5.5V, low dropout voltage, low power consumption, and miniaturized packaging.

Quiescent current of only 2μA makes these devices ideal for powering the battery-powered, always-on systems that require very little idle-state power dissipation to a longer service life. There is an option of shutdown mode by selecting the parts with the EN pin and pulling it low. The shutdown current in this mode goes down to only 100nA (typical).

The AIC1706B series of linear regulators are stable with the ceramic output capacitor over its wide input range from 1.2V to 5.5V and the entire range of output load current (0mA to 600mA).

■ TYPICAL APPLICATION CIRCUIT

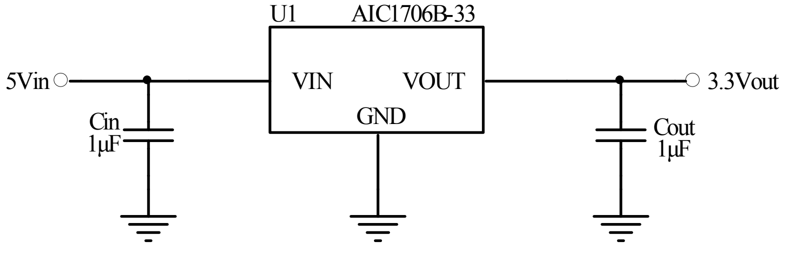


Fig. 1 Typical Application Circuit of Fixed V_{OUT} LDO

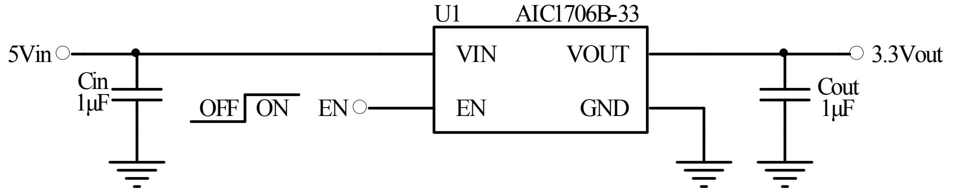


Fig. 2 Typical Application Circuit of Fixed V_{OUT} LDO with Enable Function

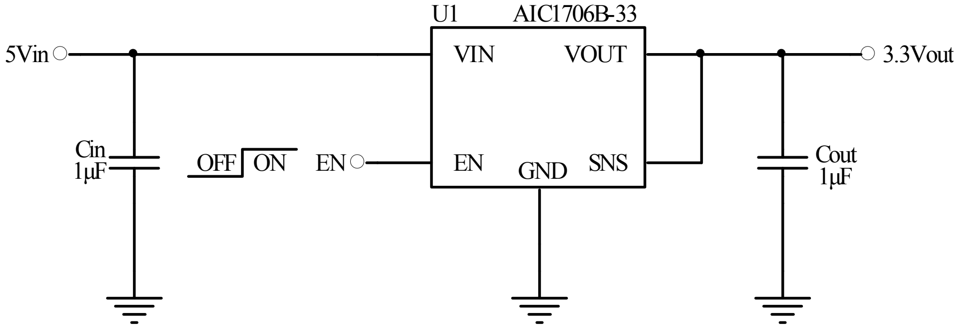


Fig. 3 Typical Application Circuit of Fixed V_{OUT} LDO with Enable and Sense Functions

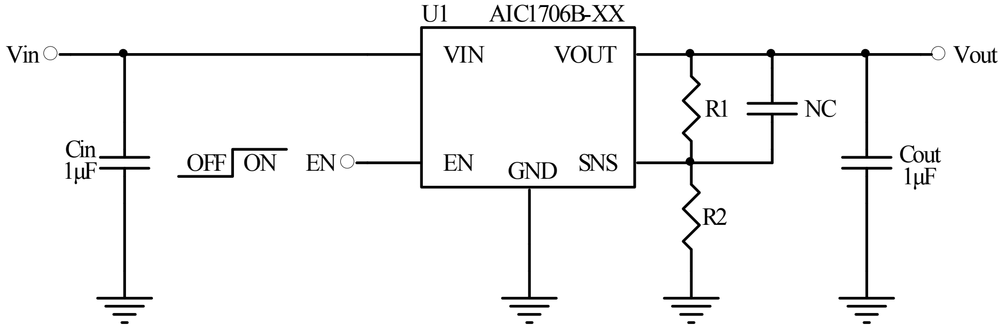


Fig. 4 Adjustable Output Voltage LDO Application Circuit by AIC1706B-XXGU5S

ORDERING INFORMATION

AIC1706B-XXXXXXXX

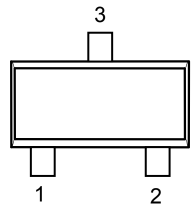
- PACKING TYPE
  - TR: TAPE & REEL
  - BG: BAG
- PACKAGE TYPE
  - U3: SOT23-3
  - U5: SOT23-5
  - U5S: SOT23-5
  - D4A: DFN-4(1x1)
  - D6A: DFN-6(2x2)
- G: GREEN PACKAGE
- OUTPUT VOLTAGE
  - 12: 1.2V
  - 15: 1.5V
  - 16: 1.6V
  - 18: 1.8V
  - 25: 2.5V
  - 28: 2.8V
  - 30: 3.0V
  - 33: 3.3V

Example: AIC1706B-33GU3TR
→ 3.3V Version, in Green SOT23-3 Package and Tape & Reel Packing Type

PIN CONFIGURATION

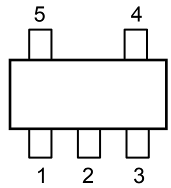
SOT23-3(U3)
TOP VIEW

1: GND
2. VOUT
3. VIN



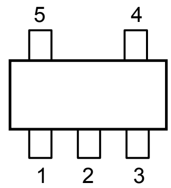
SOT23-5(U5)
TOP VIEW

1: VIN
2. GND
3. EN
4. NC
5. VOUT



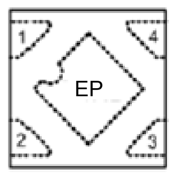
SOT23-5(U5S)
TOP VIEW

1: VIN
2. GND
3. EN
4. SNS
5. VOUT



DFN-4(1X1)
TOP VIEW

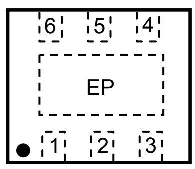
1: VOUT
2. GND
3. EN
4. VIN



Note: The exposed pad should leave floating or tie to GND.

DFN-6(2X2)
TOP VIEW

1: VOUT
2. NC
3. GND
4. EN
5. NC
6. VIN



Note: The exposed pad should leave floating or tie to GND.

ABSOLUTE MAXIMUM RATINGS

VIN Pin to GND Pin Voltage .... -0.3V to 6.5V

VOUT Pin and EN Pin to GND Pin Voltage .... -0.3V to 6V

VOUT Pin to VIN Pin Voltage .... -6V to 0.3V

Storage Temperature Range .... -60ºC~150ºC

Lead Temperature (Soldering, 10 sec) 260ºC

Junction Temperature 150ºC

Operating Ambient Temperature Range T_A .... -40ºC~85ºC

Thermal Resistance Junction to Case, $R\theta_{JC}$	SOT23-3	115°C/W
	SOT23-5	115°C/W
	DFN-4(1x1)	65°C/W
	DFN-6(2x2)	30°C/W
Thermal Resistance Junction to Ambient, $R\theta_{JA}$	SOT23-3	250°C/W
	SOT23-5	250°C/W
	DFN-4(1x1)	195°C/W
	DFN-6(2x2)	165°C/W

(Assume no Ambient Airflow)

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

ELECTRICAL CHARACTERISTICS

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

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
Supply Voltage		V_{IN}	1.2		5.5	V
DC Output Voltage Accuracy	I_{LOAD}=0.1mA		-2		2	%
SNS Input Current	SNS=V_{OUT}	I_{SNS}		0.5		μA
Dropout Voltage (Note 2)	I_{LOAD}=600mA, V_{OUT}≥3V	V_{DROP_3V}		0.36		V
	I_{LOAD}=600mA, V_{OUT}=2.8V	$V_{DROP\_2.8V}$		0.45		
	I_{LOAD}=600mA, V_{OUT}=2.5V	$V_{DROP\_2.5V}$		0.45		
	I_{LOAD}=600mA, V_{OUT}=1.8V	$V_{DROP\_1.8V}$		0.57		
	I_{LOAD}=600mA, V_{OUT}=1.5V	$V_{DROP\_1.5V}$		0.71		
	I_{LOAD}=600mA, V_{OUT}=1.2V	$V_{DROP\_1.2V}$		0.9		
GND Current	I_{LOAD}=0mA	I_Q		2		μA
Shutdown GND Current	V_{EN}=0V, V_{OUT}=0V	I_{SD}		0.1	0.5	μA
V_{OUT} Shutdown Leakage Current	V_{EN}=0V, V_{OUT}=0V	I_{LEAK}		0.1	0.5	μA
Enable Threshold Voltage	EN Rising	V_{IH}	1.0			V
	EN Falling	V_{IL}			0.4	
EN Input Current	V_{EN}=5V	I_{EN}		10	100	nA
Line Regulation	I_{LOAD}=30mA, 1.5V≤V_{IN}≤5.5V or (V_{OUT}+0.2V)≤V_{IN}≤5.5V	ΔLINE		0.2		%
Load Regulation	10mA≤I_{LOAD}≤300mA	ΔLOAD		0.2		%
Output Current Limit	V_{OUT}=0V	I_{LIM}	601	1100		mA
Power Supply Rejection Ratio	V_{OUT}=1.2V, I_{LOAD}=5mA, V_{IN}=2V, f=100Hz	PSRR		80		dB
	V_{OUT}=1.2V, I_{LOAD}=5mA, V_{IN}=2V, f=1kHz			75		
Output Voltage Noise	V_{IN}=3.5V, I_{LOAD}=0.1A, BW=10Hz to 100kHz, C_{OUT}=1μF, V_{OUT}=1.2V			80		μV_{RMS}
	V_{IN}=3.5V, I_{LOAD}=0.1A, BW=10Hz to 100kHz, C_{OUT}=1μF, V_{OUT}=2.8V			120		
Thermal Shutdown Temperature	I_{LOAD}=10mA	T_{SD}		155		℃
Thermal Shutdown Hysteresis	I_{LOAD}=10mA	ΔT_{SD}		15		℃
Discharge Resistance	V_{EN}=0V, V_{OUT}=0.1V			100		Ω

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. $V_{DROP} = V_{IN} - V_{OUT}$ when the V_{OUT} is 98% of its target value.

TYPICAL PERFORMANCE CHARACTERISTICS

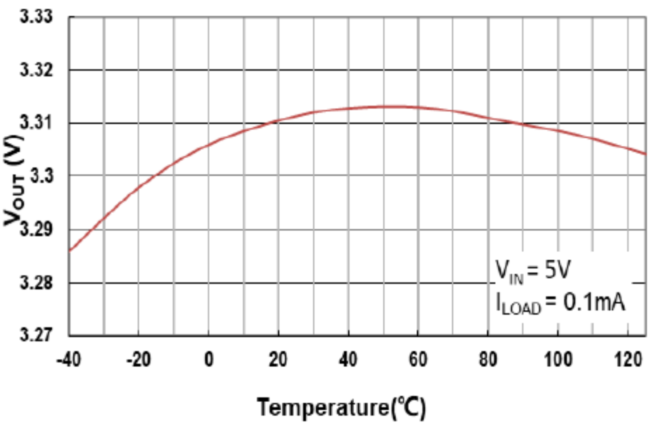


Fig. 5 Output Voltage vs. Temperature

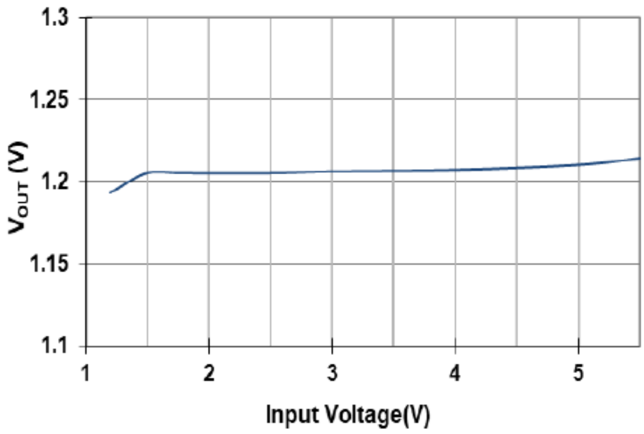


Fig. 6 Output Voltage vs. Input Voltage

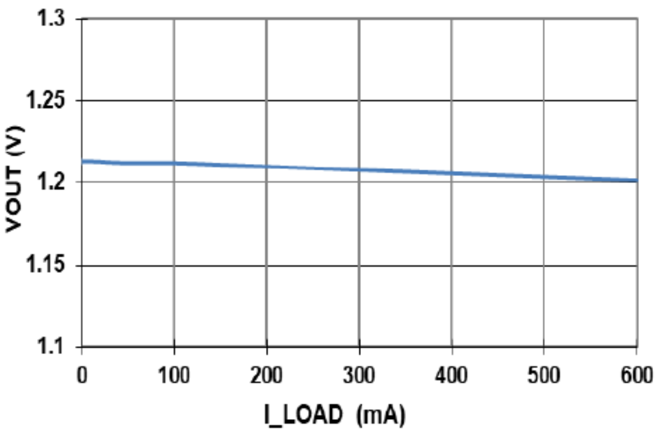


Fig. 7 Output Voltage vs. Load Current

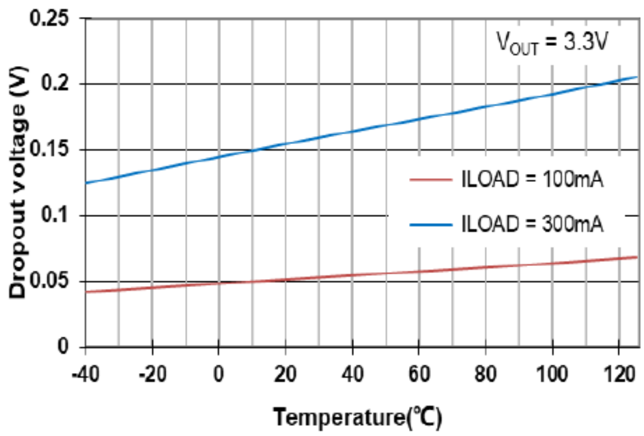


Fig. 8 Dropout Voltage vs. Temperature

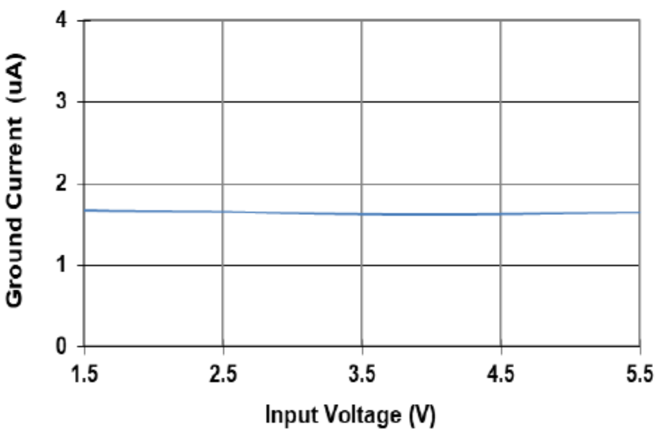


Fig. 9 Ground Current vs. Input Voltage

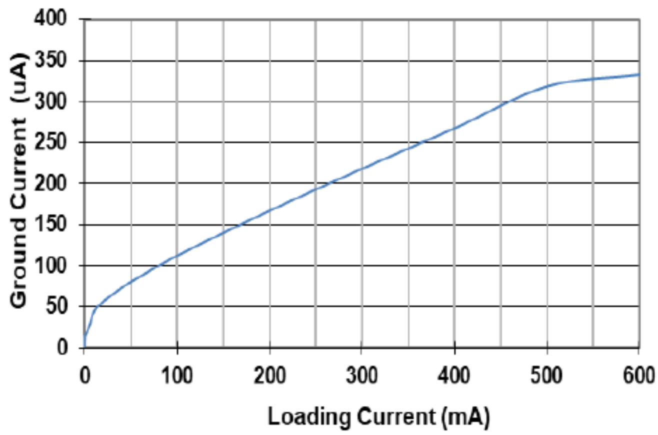


Fig. 10 Ground Current vs. Loading Current

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

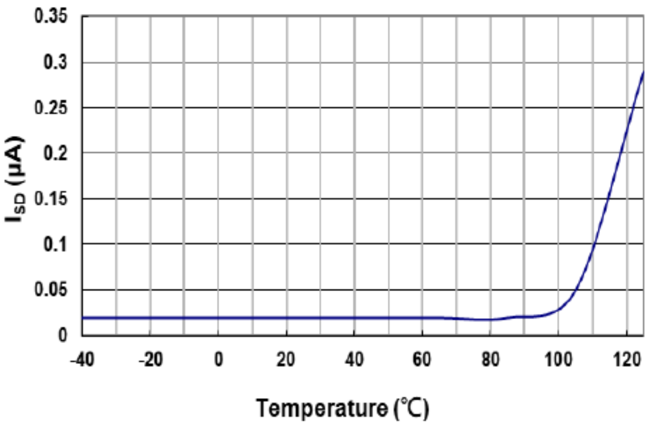


Fig. 11 Shutdown Ground Current vs. Temperature

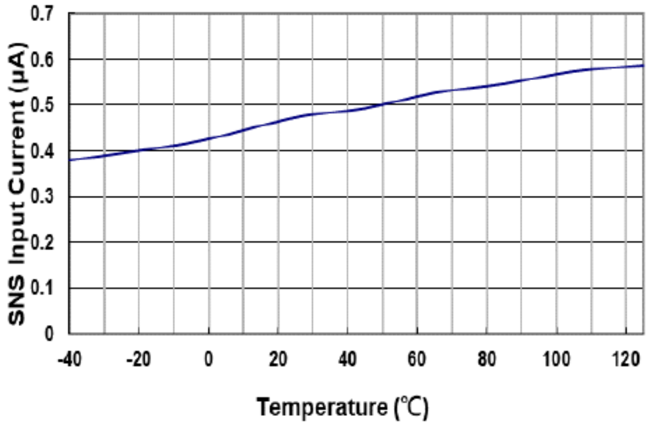


Fig. 12 SNS Input Current vs. Temperature

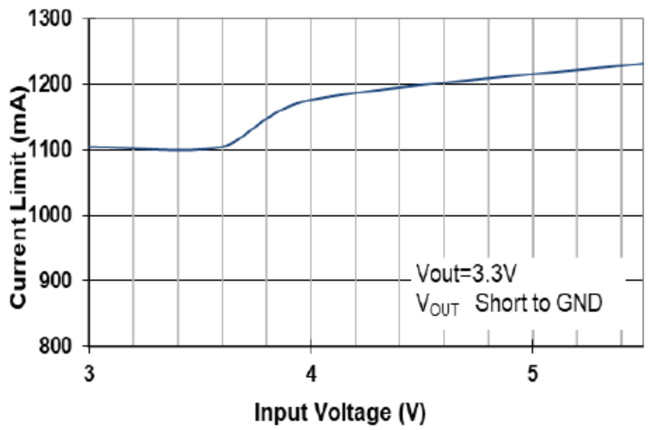


Fig. 13 Current Limit vs. Input Voltage

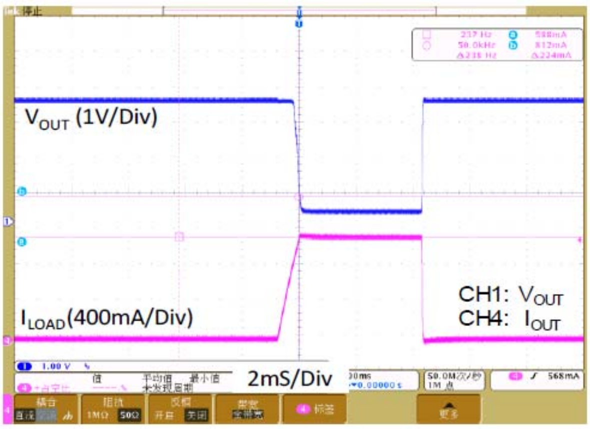


Fig. 14 Current Limit Response

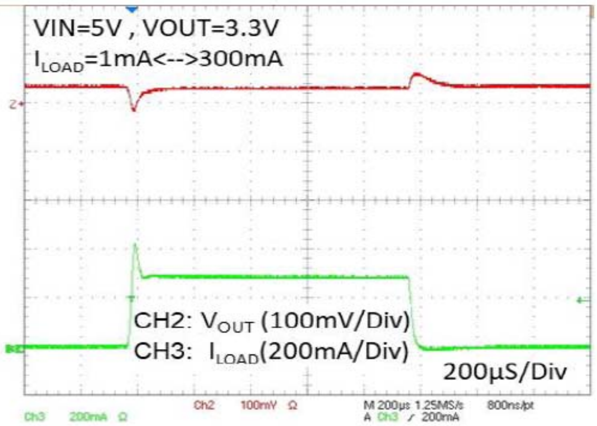


Fig. 15 Load Transient Response

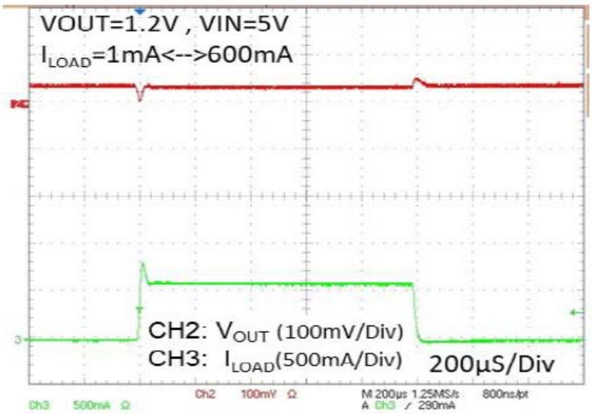


Fig. 16 Load Transient Response

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

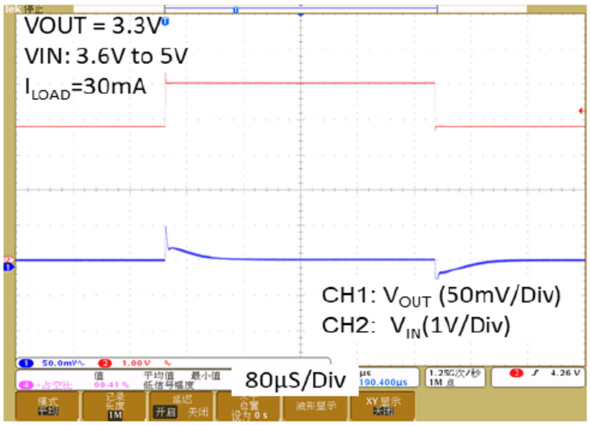


Fig. 17 Line Transient Response

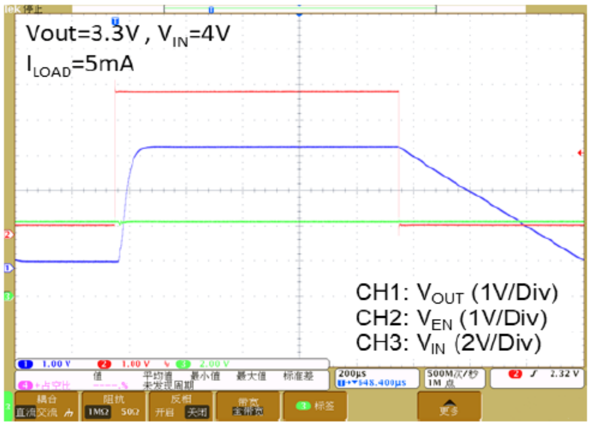
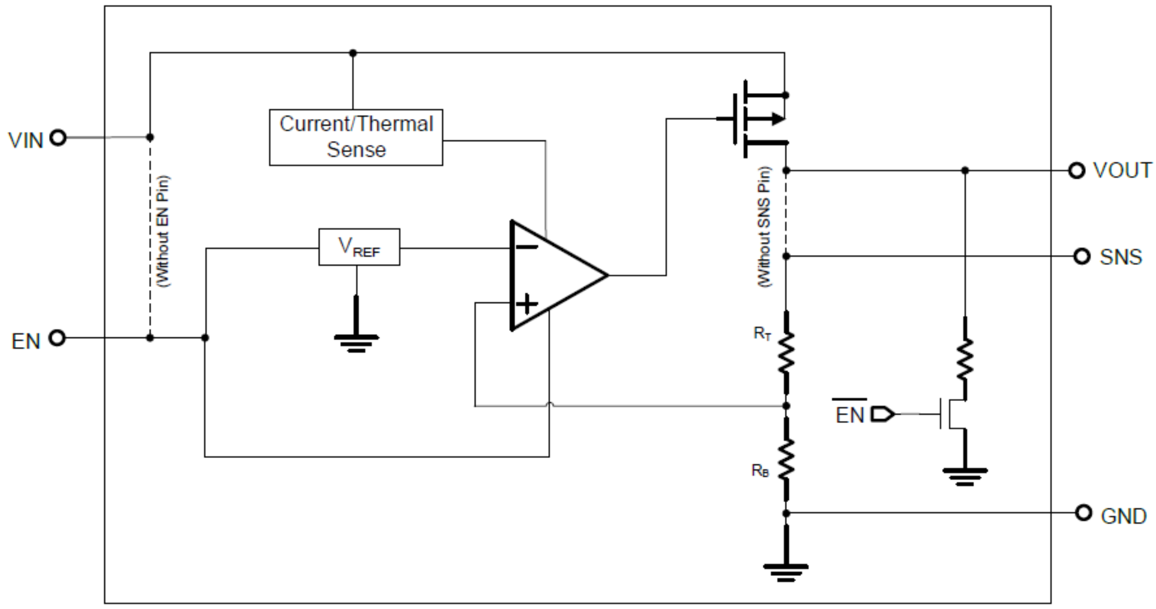


Fig. 18 V_{OUT} Turn On/Off by EN

BLOCK DIAGRAM



Functional Block Diagram of AIC1706B

PIN DESCRIPTION

VIN - Input of Supply Voltage.
GND - Ground.
VOUT - Output of the Regulator.
EN - Enable Control Input.
SNS - Sense of Output Voltage.
NC - No Internal Connection.

APPLICATION INFORMATION

INPUT-OUTPUT CAPACITOR REQUIREMENTS

The external input and output capacitors of AIC1706B series must be properly selected for stability and performance. Use a 1μF or larger input capacitor and place it close to the IC's VIN and GND pins. Any output capacitor meeting the minimum 1mΩ ESR (Equivalent Series Resistance) and effective capacitance between 1μF and 22μF requirement may be used. Place the output capacitor close to the IC's VOUT and GND pins. Increasing capacitance and decreasing ESR can improve the circuit's PSRR and line transient response.

CURRENT LIMIT

The AIC1706B series contain the current limiter of output power transistor, which monitors and controls the transistor, limiting the output current to 1100mA (typical). The output can be shorted to ground indefinitely without damaging the part.

DROPOUT VOLTAGE

The AIC1706B series use 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_{DROP} scales approximately with the output current because the PMOS device behaves as a resistor in dropout condition.

As any linear regulator, PSRR and transient response are degraded as (V_{IN} – V_{OUT}) approaches dropout condition.

ADJUSTABLE OUTPUT VOLTAGE APPLICATION

The AIC1706B with SNS pin also can work as an adjustable output voltage LDO. Figure 4 gives the connections for the adjustable output voltage application. The resistor divider from VOUT to SNS sets the output voltage when in regulation.

The voltage on the SNS pin sets the output voltage and is determined by the values of R1 and R2. To keep a good temperature coefficient of output voltage, the values of R1 and R2 should be selected carefully to ignore the temperature effect of input current at the SNS pin. A current greater than 50μA in the resistor divider is recommended to meet the above requirement. The adjustable output voltage can be calculated according to the following equation:

$$V_{OUT} = \frac{R_1 + R_2}{R_2} \times V_{SNS}$$

where V_{SNS} is determined by the output voltage selections in the ordering information of AIC1706B.

The minimum recommended 50μA in the resistor divider makes the application no longer a 2μA low quiescent LDO.

OTP (OVER TEMPERATURE PROTECTION)

The over temperature protection function of AIC1706B series will turn off the P-MOSFET when the junction temperature exceeds 155°C (typ.). Once the junction temperature cools down by approximately 15°C, the regulator will automatically resume operation.

THERMAL APPLICATION

For continuous operation, do not exceed the 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 as below:

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

where $T_{J(MAX)}$ is the maximum allowable junction temperature, and T_A is the ambient temperature suitable in application.

Power dissipation (P_D) is equal to the product of the output current and the voltage drop across the output pass element, as shown in the equation below:

$P_D = (V_{IN} – V_{OUT}) \times I_{OUT}$.

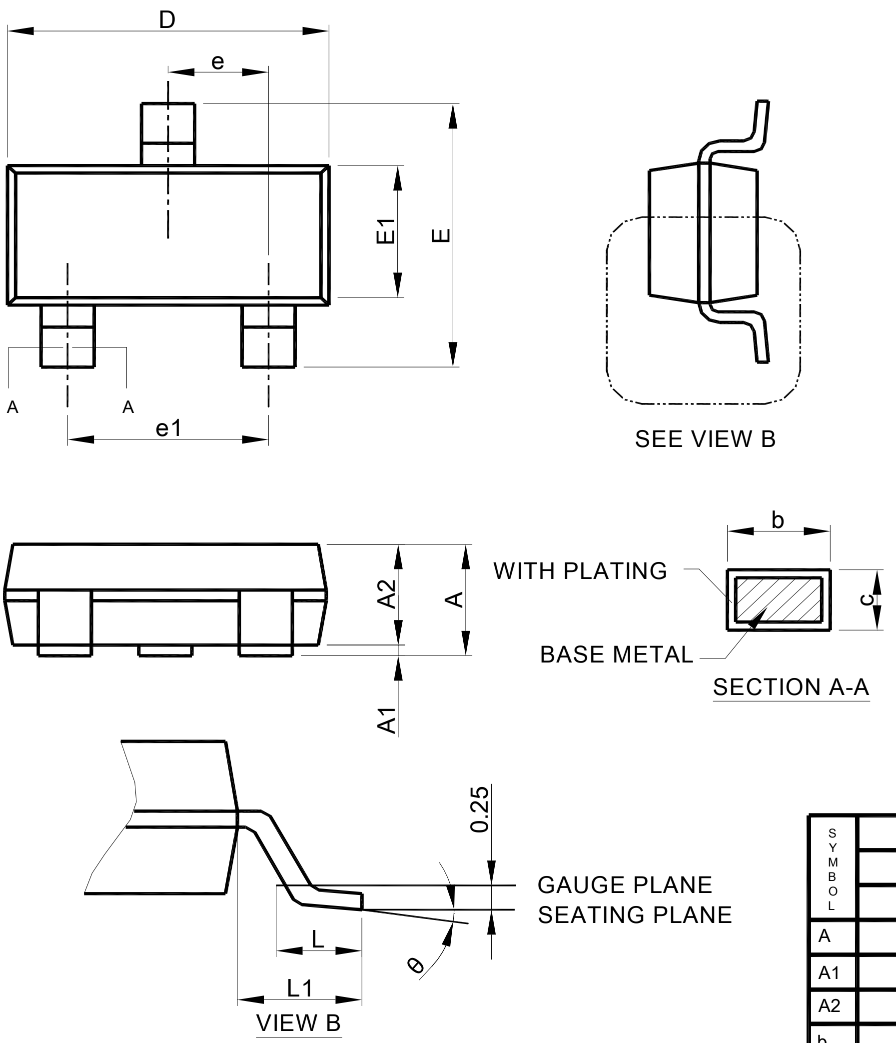
LAYOUT CONSIDERATION

By placing input and output capacitors on the same side of the PCB as the LDO, and placing them as close as is practical to the package can achieve the best performance. The ground connections for input and output capacitors must be back to the AIC1706B ground pin using as wide and as short of a copper trace as is practical.

Connections using long trace lengths, narrow trace widths, and/or connections through via must be avoided. These add parasitic inductances and resistance that results in worse performance especially during transient conditions.

PHYSICAL DIMENSIONS

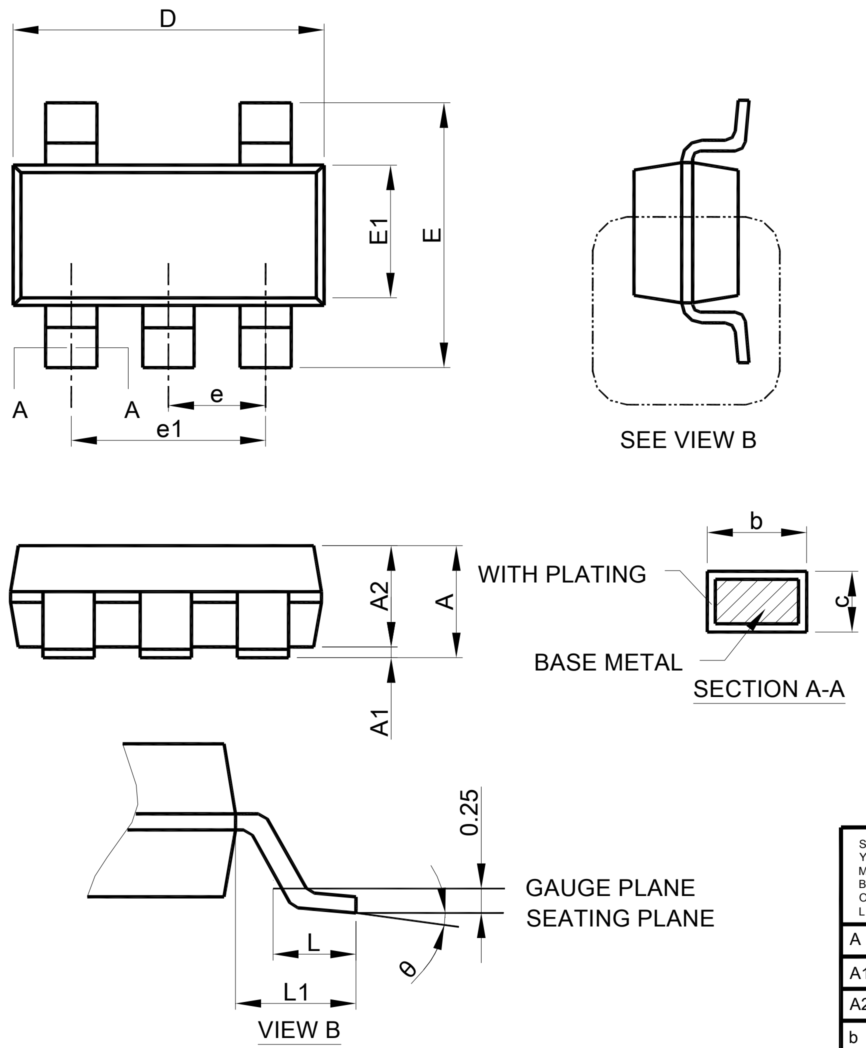
- **SOT23-3**



SYMBOL	SOT23-3	
	MILLIMETERS	
	MIN.	MAX.
A	0.95	1.45
A1	0.00	0.15
A2	0.90	1.30
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-178.
2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 10 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.

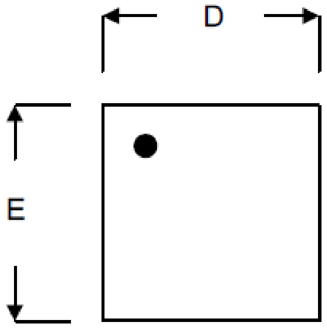
- **SOT23-5**

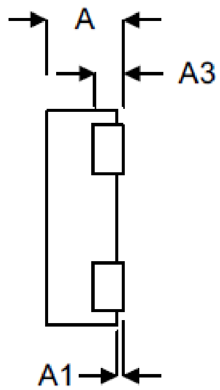


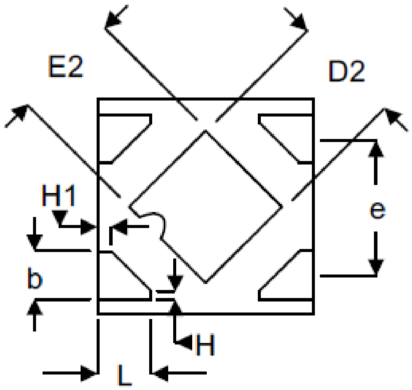
SYMBOL	SOT23-5	
	MILLIMETERS	
	MIN.	MAX.
A	0.95	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.30	0.50
c	0.08	0.22
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.95 BSC	
e1	1.90 BSC	
L	0.30	0.60
L1	0.60 REF	
θ	0°	8°

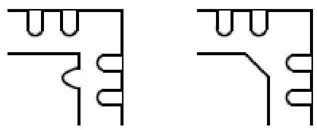
Note : 1. Refer to JEDEC MO-178AA.
2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 10 mil per side.
3. Dimension "E1" does not include inter-lead flash or protrusions.
4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.

- **DFN-4(1x1x0.37-0.65mm)**









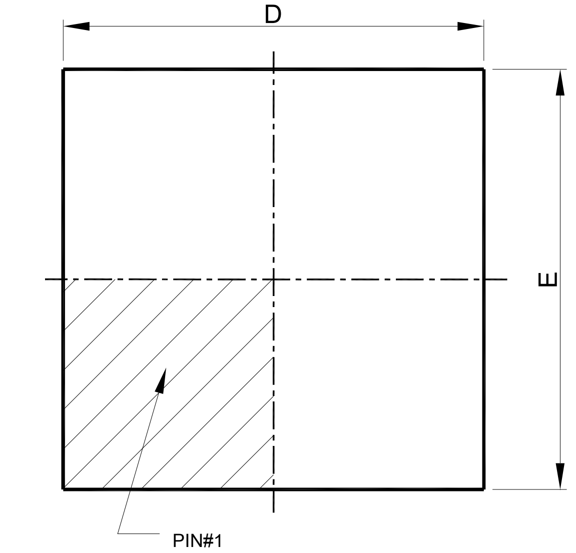
DETAILA

PIN #1 ID and Tie Bar Mark Options

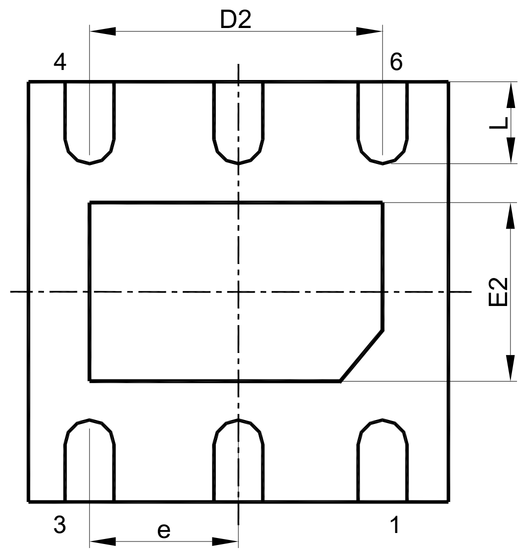
Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Millimeters	
	Min.	Max.
A	0.300	0.400
A1	0.000	0.050
A3	0.117	0.162
b	0.175	0.280
D	0.900	1.100
D2	0.430	0.550
E	0.900	1.100
E2	0.430	0.550
e	0.650	
L	0.200	0.300
H	0.039	
H1	0.064	

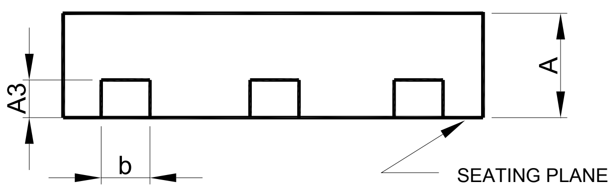
- **DFN-6 (2x2x0.75-0.65mm)**



TOP VIEW



BOTTOM VIEW



SIDE VIEW

SYMBOL	DFN-6 (2x2x0.75-0.65)	
	MILLIMETERS	
	MIN.	MAX.
A	0.70	0.80
A3	0.20 BSC	
b	0.20	0.35
D	2.00 BSC	
D2	1.10	1.60
E	2.00 BSC	
E2	0.55	0.85
e	0.65 BSC	
L	0.25	0.45

Note : 1. DIMENSION AND TOLERANCING CONFORM TO ASME Y14.5M-1994.
2.CONTROLLING DIMENSIONS：MILLIMETER，CONVERTED INCH DIMENSION ARE NOT NECESSARILY EXACT.
3.DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.10 AND 0.25 mm FROM TERMINAL TIP.