2A 550k/1.1MHz Synchronous PWM Step-Down Converter

■ FEATURES

- 2.5V to 6V Input Voltage Range
- Adjustable Output Voltage from 0.8V to Vin
- 2.0A Guaranteed Output Current
- 94% Efficiency at Heavy Load
  (Vin=5V, Vout=3.3V, Iout=2.0A)
- Low $R_{DS(ON)}$ Internal Switches: 110mΩ
- No Schottky Diode Required
- 100% Duty Cycle in Low Dropout Operation
- Fixed 550k/1.1MHz Operating Frequency
- Optional Soft-Start Internal Fixed 1ms Soft-Start

■ APPLICATIONS

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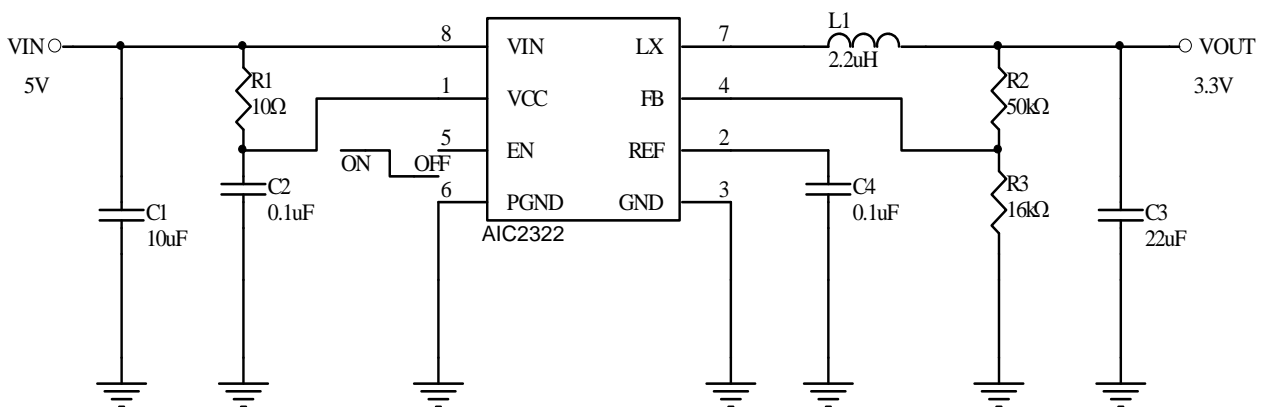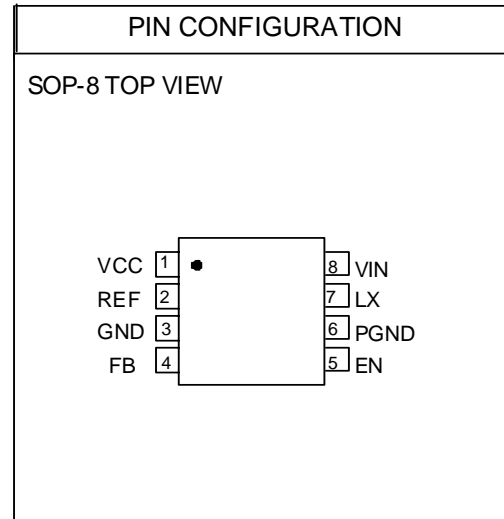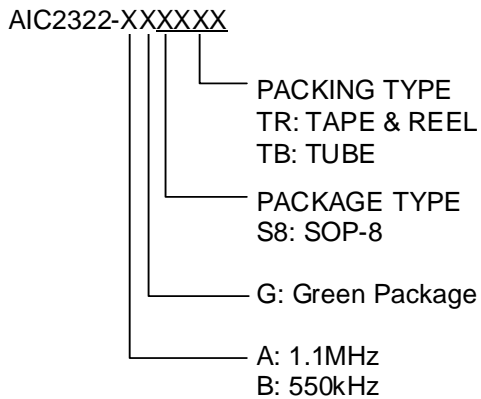- Battery-Operated Devices (1 Li-Ion or 3 NiMH/ NiCd).

■ DESCRIPTION

The AIC2322 is a low-noise, pulse-width-modulated (PWM), DC-DC step-down converter. The device features an internal synchronous rectifier for high efficiency; it requires no external Schottky diode. Shutdown mode places the device in standby, reducing supply current to under 2μA. Other features of the AIC2322 include high efficiency for all load range, low dropout voltage, short circuit protection, and over temperature protection.

■ APPLICATIONS CIRCUIT

Typical Application Circuit

■ PIN CONFIGURATION

AIC2322-XXXXXX

— PACKING TYPE
  TR: TAPE & REEL
  TB: TUBE

— PACKAGE TYPE
  S8: SOP-8

— G: Green Package

— A: 1.1MHz
  B: 550kHz

Example: AIC2322-AGS8TR
→ Fixed 1.1MHz Operating Frequency
   With GREEN SOP-8 Package and
   TAPE & REEL Packing Type

PIN CONFIGURATION

SOP-8 TOP VIEW

VCC 1	8 VIN
REF 2	7 LX
GND 3	6 PGND
FB 4	5 EN

■ ABSOLUTE MAXIMUM RATINGS

Supply Input Volatge, VCC, VIN .... -0.3V to 6.5V

LX Pin Switch Voltage .... -0.3V to (VIN + 0.3V)

Other I/O Pin Voltage .... -0.3V to (VCC + 0.3V)

PGND to GND .... +/-0.3 V

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   SOP-8 .... 40°C/W

Thermal Resistance Junction to Ambient   SOP-8 .... 160°C/W

Latch-Up 200mA

HBM (Human Body Mode) 4kV

(Assume no Ambient Airflow, no Heatsink)

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

ELECTRICAL CHARACTERISTICS

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

PARAMETER	CONDITIONS	SYMBOL	MIN	TYP	MAX	UNITS
Input Voltage Range		V_{IN}	2.5		6	V
Under Voltage Lockout Threshold	V_{CC} Rising	$V_{UVLO(R)}$		2.3		V
	V_{CC} Falling	$V_{UVLO(F)}$		2.1		V
Output Adjustment Range		V_{OUT}	0.8		V_{IN}	V
Shutdown Current	V_{EN} = 0V	I_{SD}		1	2	μA
Quiescent Current	I_{OUT} = 0A, V_{FB} = 1V No Switching	I_Q		550		μA
Standby Current	I_{OUT} = 0A, Switching	I_{SB}		600	900	μA
Feedback Reference Voltage		V_{REF}	0.784	0.8	0.816	V
V_{OUT} Line Regulation	V_{IN} = 2.5V to 5.5V, I_{OUT}=0A		-2		2	%
FB Leakage Current		I_{FB}		0.1	0.2	μA
EN Supply Current		I_{EN}		3.5		μA
En Logic High			1.5		V_{CC}	V
EN Logic Low			0		0.5	V
P-Channel On-Resistance	V_{IN} = 3.3V	$R_{DSH(ON)}$		110		mΩ
N-Channel On-Resistance	V_{IN} = 3.3V	$R_{DSL(ON)}$		80		mΩ
Switch Leakage Current	V_{EN} = 0V, V_{IN} = 5.5V			0.1	1	μA
Peak Inductor Current		I_{PK}	2.6	3.4		A
Oscillator Frequency (A Version)		f_{OSCA}	920	1100	1280	kHz
Oscillator Frequency (B Version)		f_{OSCB}	468	550	632	kHz
Maximum Duty Cycle		D_{MAX}	100			%
Thermal Shutdown Trip Point		T_{OTP}		150		°C
Thermal Shutdown Hysteresis		T_{OTP_HYS}		25		°C
Soft-Start Charge Current		I_{SS}		4		μA

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).
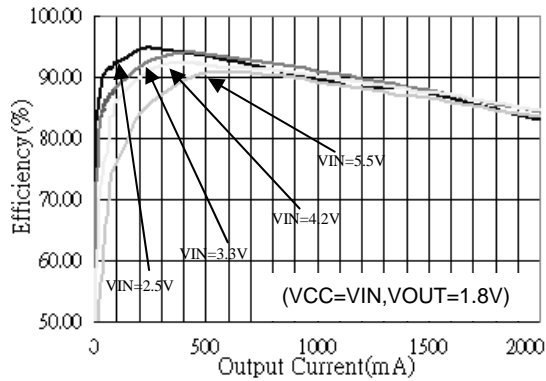
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TYPICAL PERFORMANCE CHARACTERISTICS

(C1=10µF,C3=22µF,L1=2.2µH,TA=25℃,unless otherwise noted)

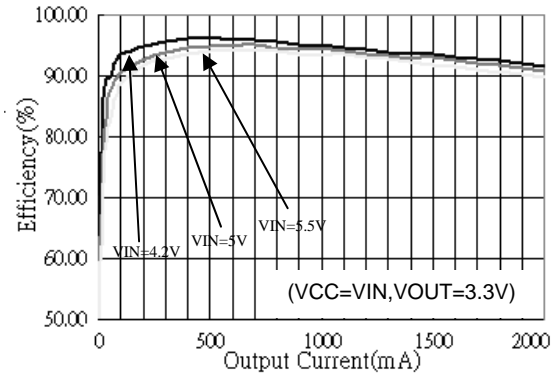Fig. 1 Efficiency vs Load Current

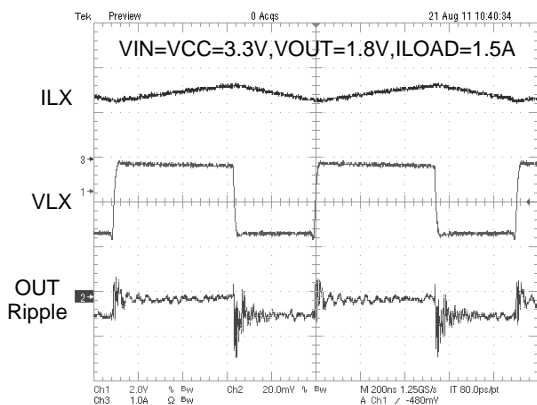

Fig. 2 Efficiency vs Load Current
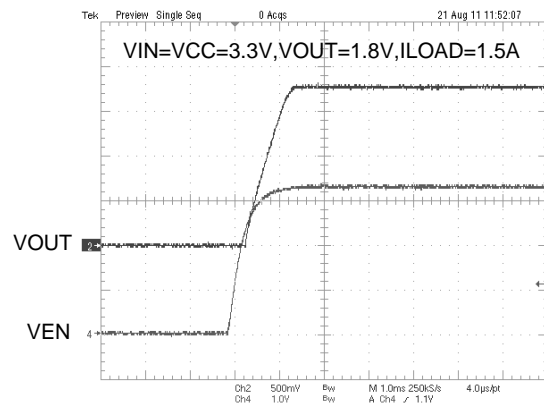

Fig. 3 Switching Waveform
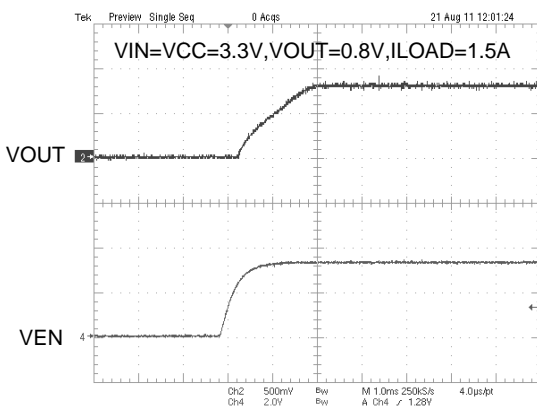

Fig. 4 Soft Start Waveform
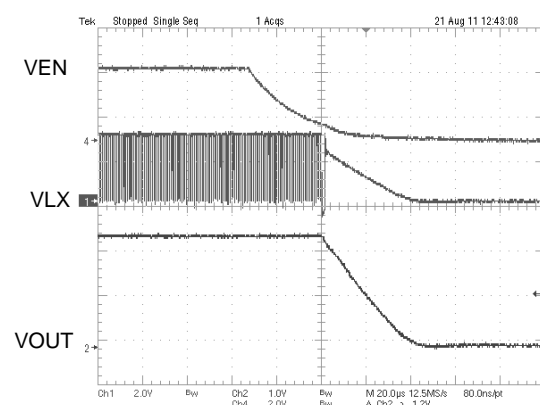

Fig. 5 Soft Start Waveform

Fig. 6 Shoutdown Waveform

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TYPICAL PERFORMANCE CHARACTERISTICS (Continued)
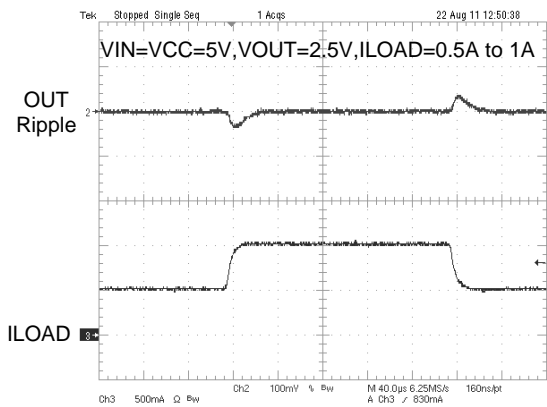

Fig. 7 Load Transient Response
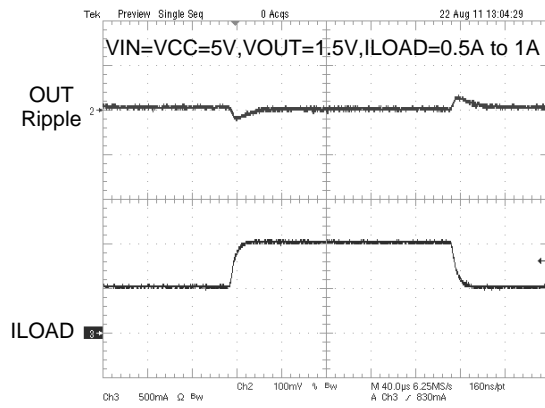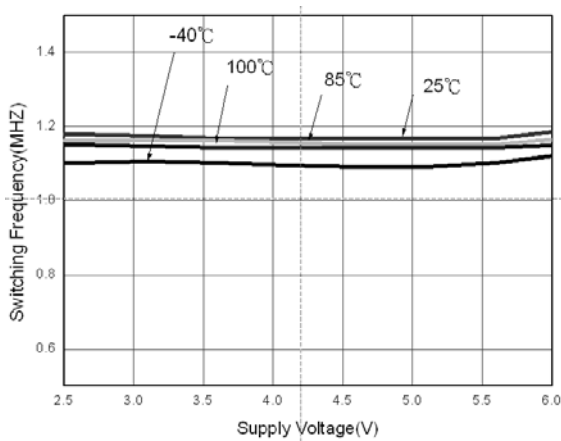

Fig. 8 Load Transient Response

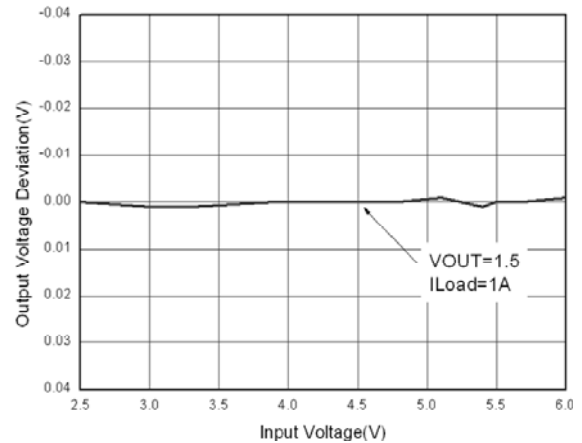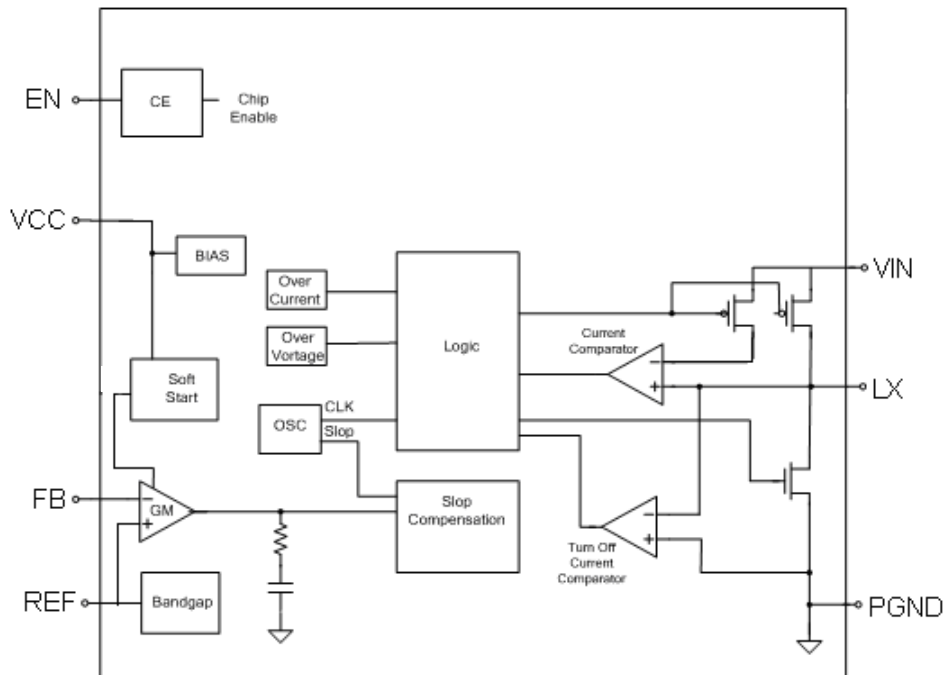
Fig. 9 Switching Frequence vs Input Voltage

Fig. 10 Output Voltage Deviation vs Input Voltage

BLOCK DIAGRAM

Functional Block Diagram of AIC2322

PIN DESCRIPTIONS

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

■ APPLICATION INFORMATION

Operation

The AIC2322 is a low-noise step-down DC/DC converter with current-mode PWM control architecture. It features an internal synchronous rectifier, which eliminates the external Schottky diode and increases efficiency. During normal operation, the AIC2322 can regulate its output voltage through a feedback control circuit, which is composed of an error amplifier; a current comparator and several control signal generators. By comparing the feedback voltage to the reference voltage of 0.8V, the error amplifier varies its output voltage. The output voltage of the error amplifier is compared with the summing signal of current sensing signal and slope compensation signal to determine the duty cycle of internal main power switch (P-channel MOSFET). While the main power switch is turned on, the synchronous power switch (N-channel MOSFET) will be turned off through anti-short-through block. Similarly, when the main power switch is turned off, the synchronous power switch will be turned on until the inductor current starts to reverse or the beginning of the next switching cycle.

Current Limitation

The AIC2322 provides current limit function by using an internal sensing resistor. When the main power switch turns on, current follows through the internal sensing resistor. And current amplifier senses the voltage, which crosses the resistor, and amplifies it. While the sensed voltage gets higher than reference voltage, the current limitation function is activated. While the current limitation function is activated, the duty cycle will be reduced to limit the output power to protect the internal power switches.

Short Circuit Protection

While the output is shorted to ground, the switching frequency of AIC2322 will be reduced to one fourth of the normal switching frequency. This lower switching frequency ensures the inductor current has more time to discharge, thereby preventing inductor current runaway. The switching frequency will automatically return to its designed value while short circuit condition is released.

Shutdown

By connecting the EN pin to GND, the AIC2322 can be shut down to reduce the supply current to 2µA (typical). At this operation mode, the output voltage of step-down converter is equal to 0V.

100% Duty Cycle Operation

When the input voltage approaches the output voltage, the AIC2322 smoothly transits to 100% duty cycle operation. This allows AIC2322 to regulate the output voltage until AIC2322 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 AIC2322 achieves 100% duty cycle operation by extending the turn-on time of the main power switch. If the summing signal of current sensing signal and slope compensation signal does not reach the output voltage level of the error amplifier at the end of 90% switching period, the main power switch is continuously turned on and the oscillator remains off until the summing signal of current sensing signal and slope compensation signal reaches the output voltage level of the error amplifier. After the summing signal of current sensing signal and slope compensation signal reaches the output voltage level of the error amplifier, the main power switch is turned off and the synchronous power switch is turned on for a constant off time. At the end of the constant off time, the next switching cycle is begun. While the input voltage approaches the output voltage, the switching frequency decreases gradually to smoothly transit to 100% duty cycle operation.

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

Components Selection

Inductor
The inductor selection depends on the current ripple of inductor, the input voltage and the output voltage.

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

Accepting a large current ripple of inductor allows the use of a smaller inductance. However, higher current ripple of inductor can cause higher output ripple voltage and large core loss. By setting an acceptable current ripple of inductor, a suitable inductance can be obtained from above equation.

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 value of inductor current can be calculated according to the following equation.

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

Input Capacitor and Output Capacitor
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.

$$I_{CINRMS} \approx \sqrt{I_{OUT(MAX)}^2 \times \frac{V_{OUT}\left(V_{IN} - V_{OUT}\right)}{V_{IN}^2} + \frac{\Delta I_L^2}{12}}$$

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

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

For lower output voltage ripple, the use of low ESR ceramic capacitor is recommended. The tantalum capacitor can also be used well, but its ERS is larger than that of ceramic capacitor.

When choosing the input and output ceramic capacitors, X5R and X7R types are recommended because they retain their capacitance over wider ranges of voltage and temperature than other types.

Output Voltage Programming
By connecting a resistive divider R_2 and R_3, the output voltage of AIC2322 step-down converter can be set. V_{OUT} can be calculated as:
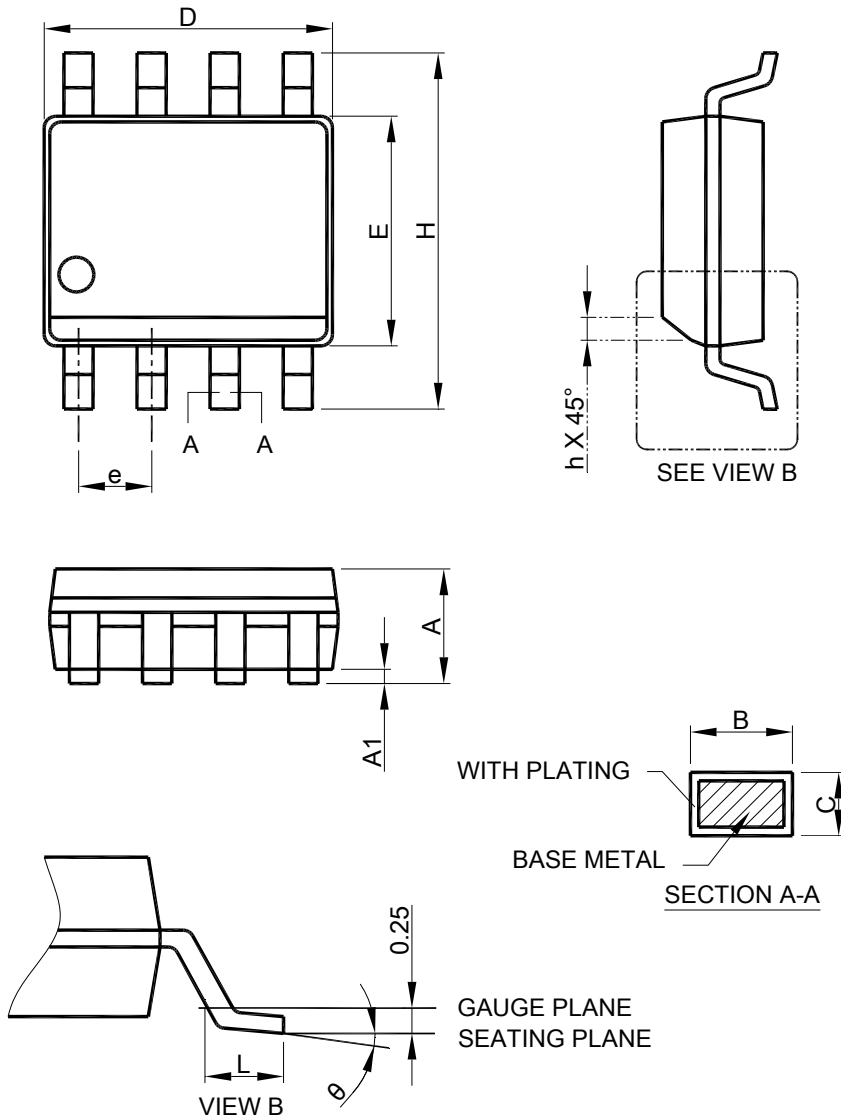
$$V_{OUT} = 0.8 \times \left(1 + \frac{R_2}{R_3}\right)$$

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

Layout Consideration
In order to ensure a proper operation of AIC2322, 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 main power switch, the internal synchronous 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. The VFB pin should be connected to the feedback resistors directly and the route should be away from the noise sources.

PHYSICAL DIMENSIONS (unit: mm)

● **SOP-8 Package**

Note: 1. Refer to JEDEC MS-012AA.
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 "E" does not include inter-lead flash or protrusions.
4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.

SYMBOL	SOP-8	
	MILLIMETERS	
	MIN.	MAX.
A	1.35	1.75
A1	0.10	0.25
B	0.33	0.51
C	0.19	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27 BSC	
H	5.80	6.20
h	0.25	0.50
L	0.40	1.27
θ	0°	8°

Note: