High-Efficiency, 2A Step-Down DC-DC Converter

FEATURES

- Continuous 2A Output Current
- Low ESR Output Ceramic Capacitor Compatible
- Up to 95% Efficiency
- 0.25Ω On-Resistance of Internal Power MOSFET
- Fixed 440kHz Switching Frequency
- 10µA Shutdown Current
- 4.75V to 15V Wide Input Voltage Range
- Output Voltage Down to 0.9V
- Current Limit and Thermal Shutdown Protection
- Available in SOP-8 Exposed Pad Package

GENERAL DESCRIPTION

The AIC1565 is a high efficiency, step-down DC/DC converter that builds in a high power MOSFET. It offers continuous 2A output current over a very wide input voltage range with excellent load and line regulation.

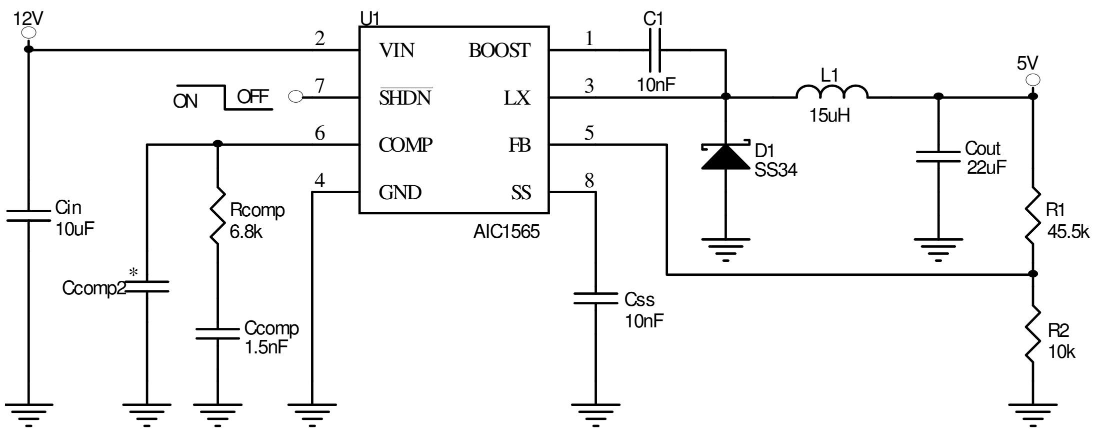
Well-performed current mode operation makes fast transient response and feedback loop stabilization easier.

The AIC1565 draws only 10µA supply current in shutdown mode. Current limit and thermal shutdown function are also provided to prevent damage. The AIC1565 is available in an 8-pin SOP exposed pad package.

APPLICATIONS

- LCD Monitors
- Communication Equipment
- Distributed Power Systems
- Digital Photo Frame

TYPICAL APPLICATION CIRCUIT



* Note: Ccomp2 is needed for high ESR output capacitor

Typical Application Circuit

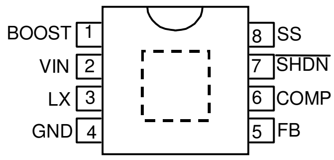
ORDERING INFORMATION

AIC1565XXXXX

- PACKING TYPE
  TR: TAPE & REEL
  TB: TUBE
- PACKAGING TYPE
  R8: SOP-8 Exposed Pad (Heat Sink)
- G: GREEN PACKAGE

PIN CONFIGURATION

SOP-8 Exposed Pad (Heat Sink)
TOP VIEW



Note:
The exposed pad must be connected with GND pin.

Example:

AIC1565GR8TR

→ GREEN SOP-8 Exposed Pad(Heat Sink) Package and TAPE & REEL Packing Type

ABSOLUTE MAXIMUM RATINGS

Input Voltage (V_{IN}) .... -0.3V to 16V

LX pin Voltage (V_{LX}) .... -1V to V_{IN} +1V

BOOST Pin Voltage .... V_{LX}-0.3V toV_{LX}+6V

$\overline{\text{SHDN}}$ Pin Voltage .... -0.3V to V_{IN}

All Other Pins Voltage .... -0.3V to 6V

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

Operating Maximum Junction Temperature T_J 150ºC

Storage Temperature Range T_{STG} .... -65ºC~150ºC

Lead Temperature (Soldering 10 Sec.) 260ºC

Thermal Resistance Junction to Case SOP-8 Exposed Pad* .... 15°C/W

Thermal Resistance Junction to Ambient SOP-8 Exposed Pad* .... 60°C/W

(Assume no Ambient Airflow)

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

*The package is place on a two layers PCB with 2 ounces copper and 2 square inch, connected by 8 vias.

■ ELECTRICAL CHARACTERISTICS

(V_{IN}=12V, $V_{\overline{SHDN}}$ =5V, T_A=25°C, unless otherwise specified.) (Note1)

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
Operation Voltage		V_{IN}	4.75		15	V
Feedback Voltage	4.75V ≤ V_{IN} ≤ 15V	V_{FB}	0.873	0.9	0.927	V
High Side Switch On Resistance		R_{ONH}		0.25		Ω
Low Side Switch On Resistance		R_{ONL}		10		Ω
High Side Switch Leakage	$V_{\overline{SHDN}}$=0V, V_{LX}=0V				10	µA
Current Limit	V_{IN}=12V	I_{LIM}		2.95		A
Error Amplifier Transconductance		G_m	400	600	800	µA/V
Oscillator Frequency		f_{OSC}	380	440	500	KHz
Short Circuit Frequency	V_{FB} = 0V			80		KHz
Maximum Duty Cycle	V_{FB} = 0.85V	D_{MAX}	78	85		%
Minimum Duty Cycle	V_{FB} = 0.95V				0	%
Shutdown Threshold Voltage			1.55	1.72	2.00	V
Under Voltage Lockout Threshold	$V_{\overline{SHDN}}$ Rising		2	2.5	3	V
Under Voltage Lockout Threshold Hysteresis				150		mV
Shutdown Supply current	$V_{\overline{SHDN}}$=0V			10		µA
Operating Supply current	$V_{\overline{SHDN}}$=5V; V_{FB} =1V			0.8	1.5	mA
Soft Start Current		I_{SS}		2.5		µA
Thermal Shutdown Temperature		T_{SD}		160		℃

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: It is recommended to use duty ratio above 20% for minimizing resultant duty cycle jitter.

Note 3: It is recommended to connect a soft start capacitor to soft start pin. Leave the soft start pin open may cause large inrush current and output overshooting.

■ TYPICAL PERFORMANCE CHARACTERISTICS

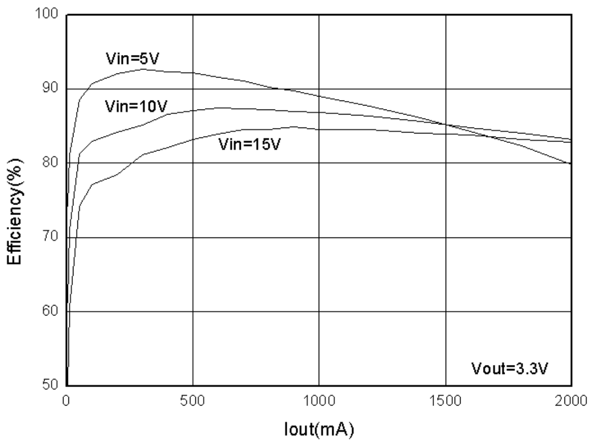


Fig. 1 Efficiency vs. Load Current

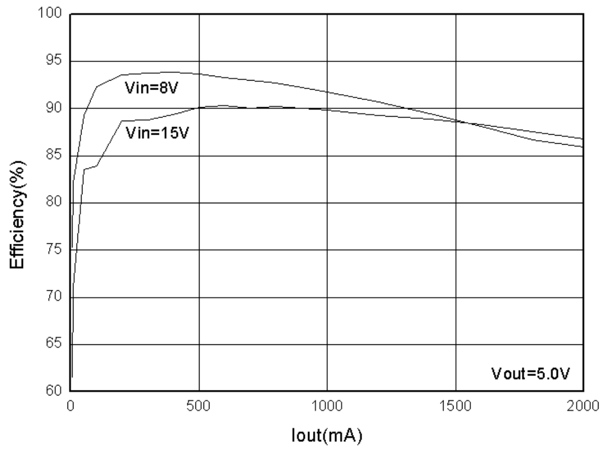


Fig. 2 Efficiency vs. Load Current

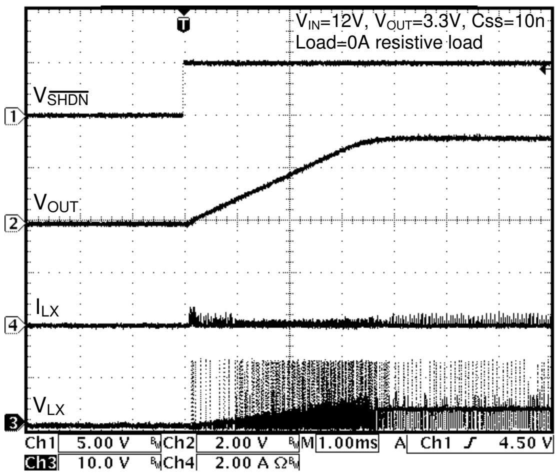


Fig. 3 Start-Up Waveform at V_{OUT}=3.3V, I_{OUT}=0A

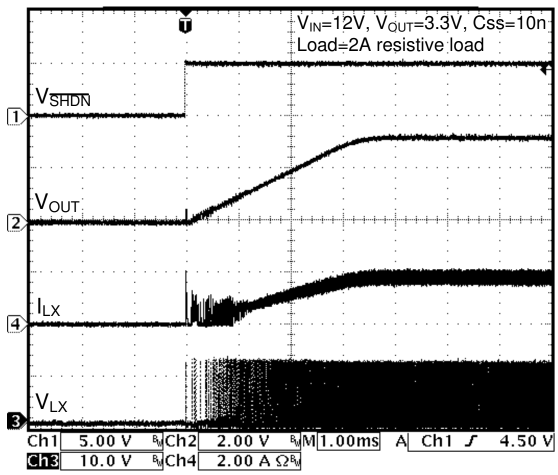


Fig. 4 Start-Up Waveform at V_{OUT}=3.3V, I_{OUT}=2A

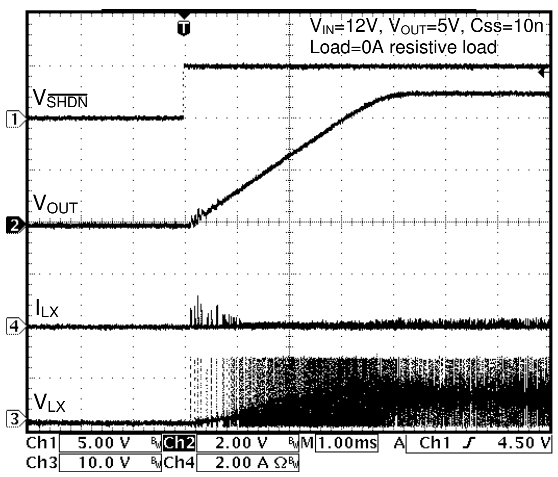


Fig. 5 Start-Up Waveform at V_{OUT}=5V, I_{OUT}=0A

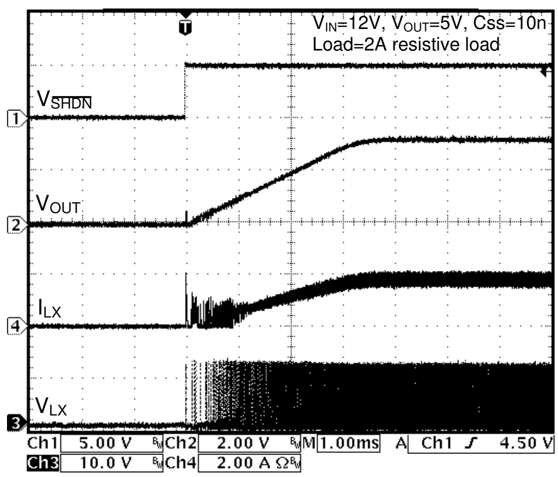


Fig. 6 Start-Up Waveform at V_{OUT}=5V, I_{OUT}=2A

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

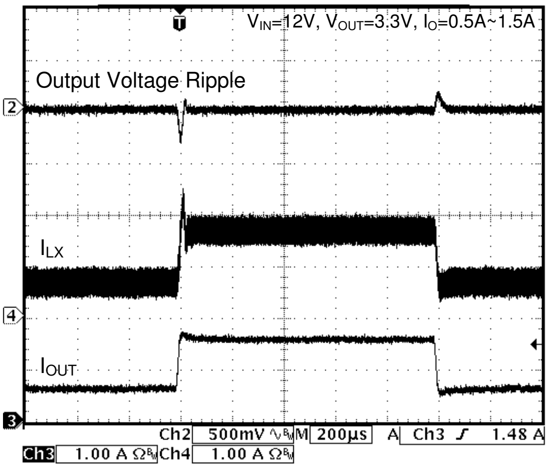


Fig. 7 Load Transient Response at V_{IN}=12V, V_{OUT}=3.3V

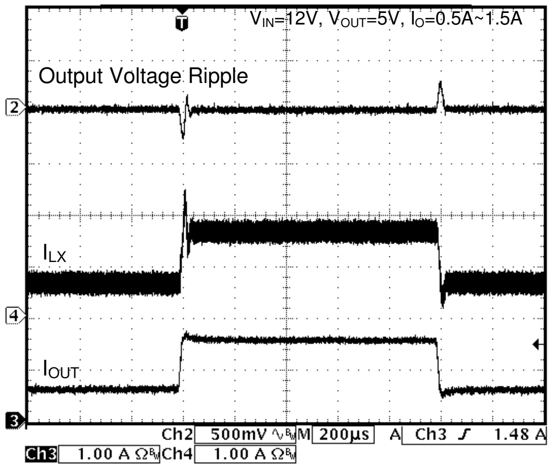


Fig. 8 Load Transient Response at V_{IN}=12V, V_{OUT}=5V

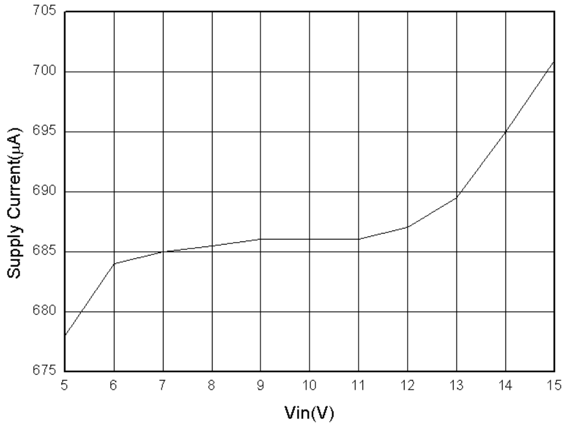


Fig. 9 Supply Current vs. Input Voltage

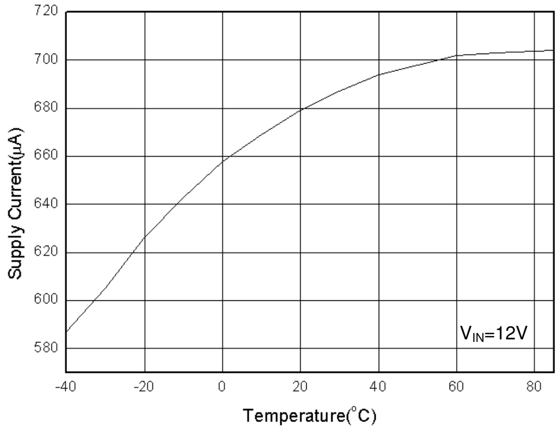


Fig. 10 Supply Current vs. Temperature

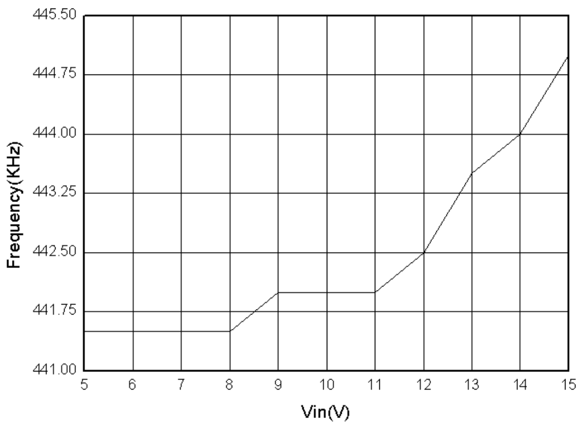


Fig. 11 Oscillator Frequency vs. Input Voltage

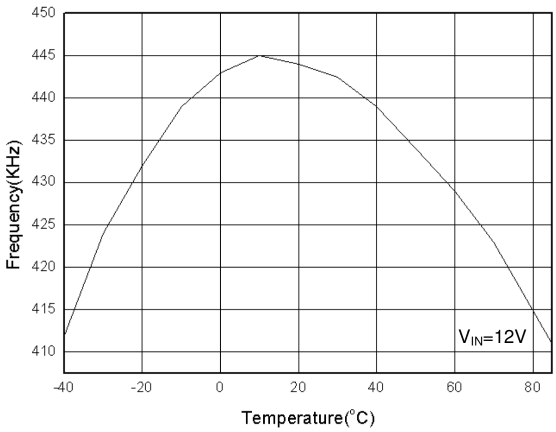


Fig. 12 Oscillator Frequency vs. Temperature

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

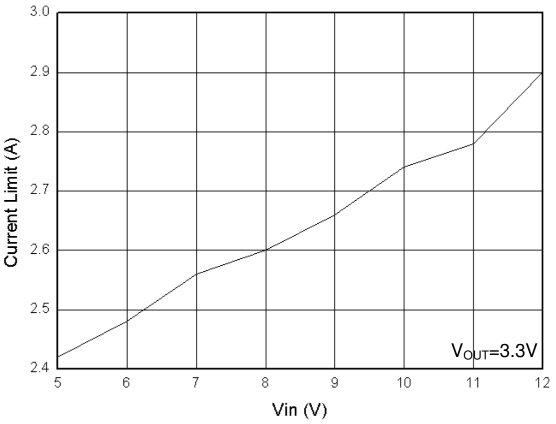


Fig. 13 Current Limit vs. Input Voltage

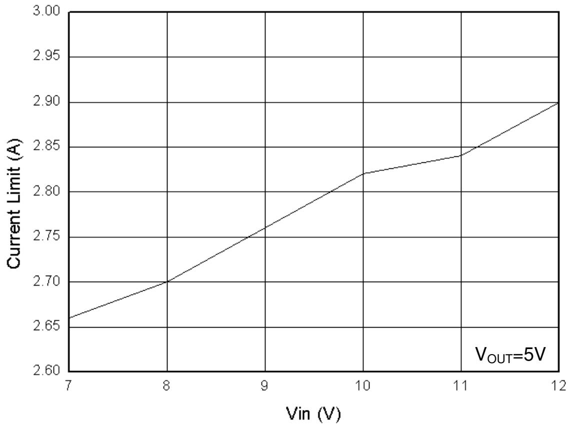


Fig. 14 Current Limit vs. Input Voltage

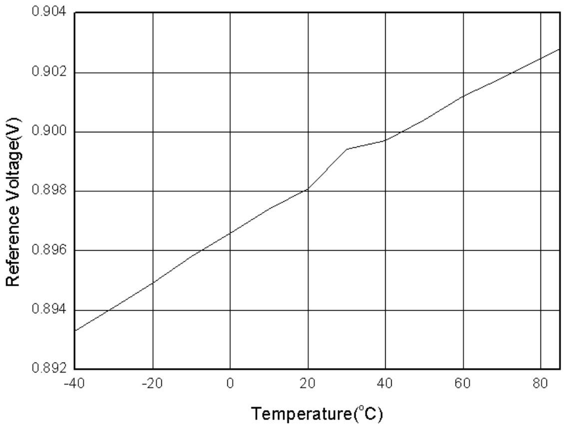
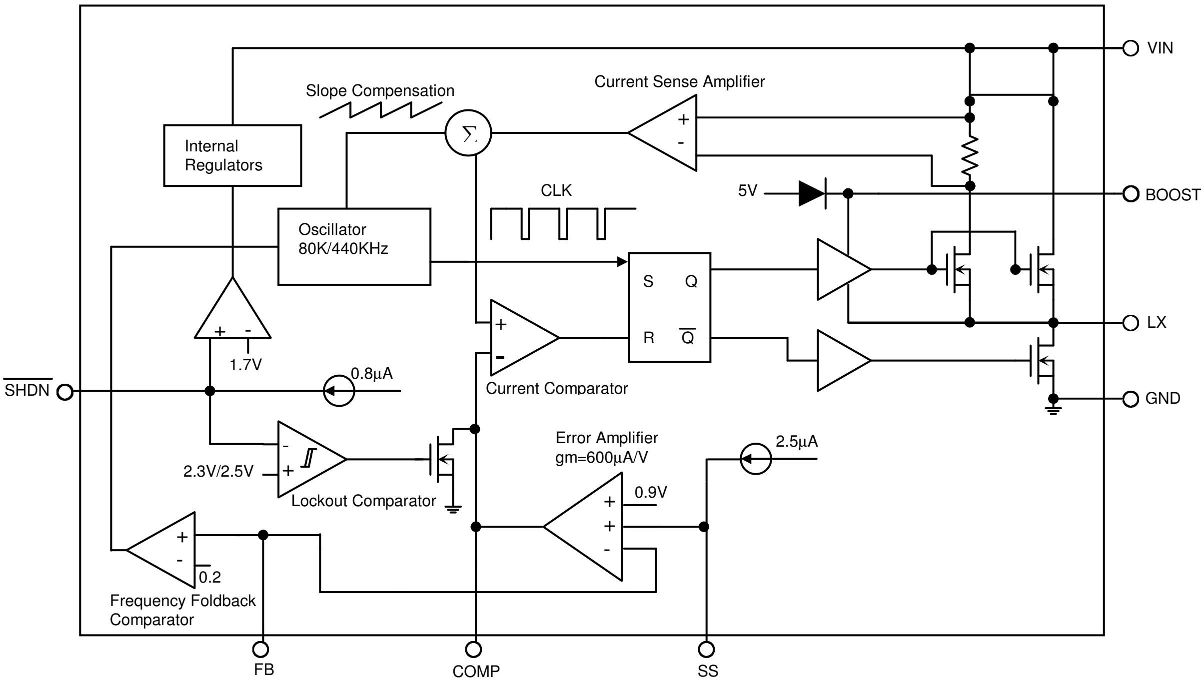


Fig. 15 Reference Voltage vs. Temperature

■ BLOCK DIAGRAM



Functional Block Diagram of AIC1565

PIN DESCRIPTIONS

Pin 1:BOOST: High side gate driver boost input. Supply the drive for the high side N-channel MOSFET switch. Connect a 10nF capacitor from LX to BOOST pin.

Pin 2: VIN: Power supply input pin. Supply the power to the IC and the step down converter. Bypass VIN to GND with a suitably large ceramic capacitor to reduce high-frequency noise on the input.

Pin 3: LX: Switching signal output. Connect output LC filter from LX to output load.

Pin 4: GND: Ground. Connect GND as close as possible to system ground and to the ground of the input bypass capacitor.

Pin 5: FB: Feedback Pin with a typical reference voltage of 0.9V. Connect to the resistive divider between output and ground to set output voltage.

Pin 6: COMP: Compensation pin. COMP is used to compensate the feedback control loop. Connect a RC network from COMP to GND.

Pin 7: $\overline{\text{SHDN}}$: Shutdown Control Pin. The Device will turn off when $\overline{\text{SHDN}}$ is low. For automatic startup, leave this pin unconnected.

Pin 8: SS: Soft-Start Control Pin. Connect a soft-start capacitor to this pin. A 2.5µA constant current charges the soft-start capacitor. Leave open for no soft-start.

COMPONENT SELECTION

V_{IN} (V)	V_{OUT} (V)	L (μH)	C_{OUT} (μF)	R_{COMP} (kΩ)	C_{COMP} (nF)	C_{COMP2} (pF)
12	2.5	6.8 (Taiyo Yuden NR8040T6R8N)	22 ceramic (Taiyo Yuden JMK316BJ226ML-T)	4.3	2.2	None
12	3.3	10 (GOTREND GSDRH124-100M)	22 ceramic (Taiyo Yuden JMK316BJ226ML-T)	5.6	2.2	None
12	5.0	15 (Lee Yu LYS104S-150M)	22 ceramic (Taiyo Yuden JMK316BJ226ML-T)	6.8	1.5	None

APPLICATION INFORMATIONS

Operation

The AIC1565 is a fixed-frequency and high efficiency step-down DC/DC converter with current-mode PWM control architecture. By selecting appropriate circuit components, it can achieve fast transient response. During normal operation, the AIC1565 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 0.9V, the error amplifier varies the voltage at COMP pin. The voltage at COMP pin is compared with the summing signal of current sensing signal and slope compensation signal to determine the duty cycle of internal power switch. In order to prevent overcharging the output capacitor and achieve better efficiency, AIC1565 will enter pulse-skipping mode (PSM) operation while working at light load conditions.

Current Limitation

The AIC1565 provides current limit function by using an internal sensing resistor. When the internal 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 switchs.

Short Circuit Protection

While the output is shorted to ground, the switching frequency of AIC1565 will be reduced to fifth 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.

Soft-Start

The AIC1565 provides the soft-start function. Initially, the voltage at SS pin is 0V. Then an internal current source of 2.5μA (typ.) charges an external soft-start capacitor. During the soft-start period, the voltage at SS pin will limit the feedback threshold voltage at FB pin. When the voltage at SS pin is higher than 0.9V, the feedback threshold voltage at FB pin reaches the desired value. The soft-start time can be calculated in accordance with the following equation.

$$t_{SS} = C_{SS} \times \frac{0.9V}{2.5\mu A}$$

The soft-start capacitor is discharged to GND when the $\overline{SHDN}$ pin is connected to GND.

Shutdown

By connecting the $\overline{SHDN}$ pin to GND, the AIC1565 can be shut down to reduce the supply current to 10μA (typ.). At this operation mode, the output voltage of step-down converter is equal to 0V. For automatic startup, leave $\overline{SHDN}$ pin unconnected.

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.

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

Diode

A Schottky diode with low forward drop voltage and fast reverse recovery is the ideal choice for better efficiency. The forward drop voltage of a Schottky diode will result in the conduction losses in the diode, and the diode capacitance (C_T or C_D) will cause the switching losses. Therefore, it is necessary to consider both forward voltage drop and diode capacitance for diode selection. In addition, the rating of selected Schottky diode should be able to handle the input voltage and the maximum peak diode current.

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.

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

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.

When using the ceramic capacitor as the input capacitor, the high input voltage transient may be generated at some start-up conditions, such as connecting the input to a live power source. By adding a small resistor in series with the input ceramic capacitor, the high input voltage transient can be improved.

Soft-Start Capacitor

The soft-start of AIC1565 begins from V_{SS}=0V and ends while V_{SS} reaches 0.9V. During the soft-start period, an internal current source of 2.5µA (typ.) charges the soft-start capacitor. Hence, the soft-start capacitor should be large enough to ensure that the output voltage has reached the regulation value before the soft-start function has finished.

Output Voltage Programming

By connecting a resistive divider R_1 and R_2, the output voltage of AIC1565 step-down converter can be set. V_{OUT} can be calculated as:

$$V_{OUT} = 0.9 \times \left(1 + \frac{R_1}{R_2}\right)$$

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

Loop Compensation

In order to avoid the poor output voltage ripple and low efficiency caused by instability, AIC1565 requires a proper external compensation network to compensate its feedback loop. In this external compensation network, the compensation resistor ,R_{COMP}, and the compensation capacitor, C_{COMP}, are used to set the high-frequency integrator gain and the integrator zero. C_{COMP2} is used to cancel the zero caused by the output capacitor and its ESR. While using the ceramic capacitor as the output capacitor, C_{COMP2} can be omitted due to the small ESR.

The values of the compensation components given in this data sheet yield a stable control loop for the given output voltage and capacitor. If different conversions and output capacitors are requires, some values of the compensation components may need to be adjusted to ensure stability.

Layout Consideration

In order to ensure a proper operation of AIC1565, 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, the Schottky diode 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 and should be away from the ground of the Schottky diode.
6. The FB pin should be connected to the feedback resistors directly and the route should be away from the noise sources.

Fig. 16 to 19 show the layout diagrams of AIC1565.

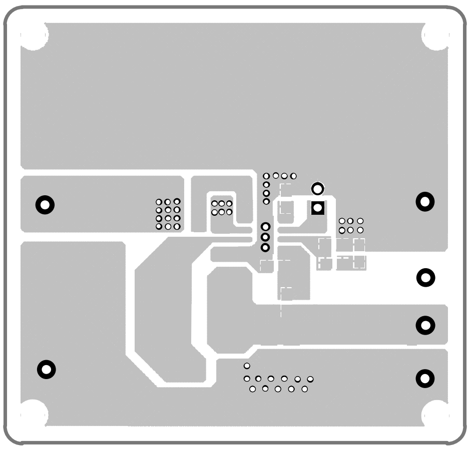


Fig. 16 Top Layer

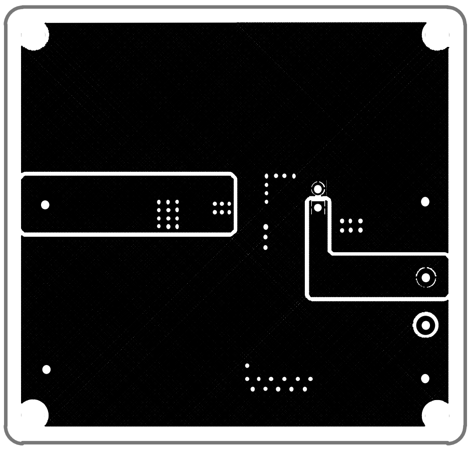


Fig. 17 Bottom Layer

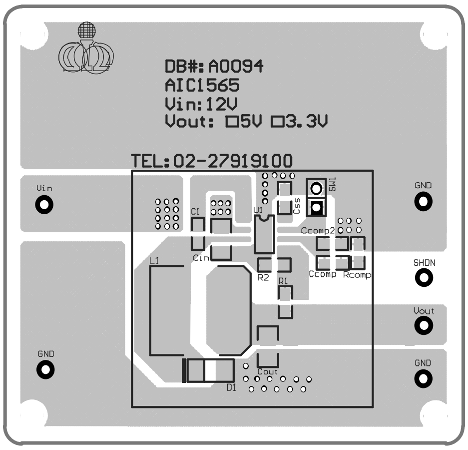


Fig. 18 Top Over Layer

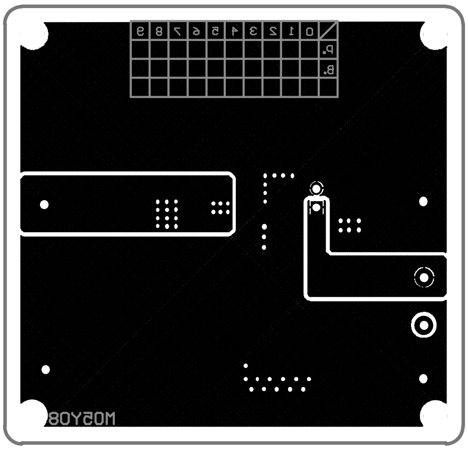


Fig. 19 Bottom Over Layer

APPLICATION EXAMPLES

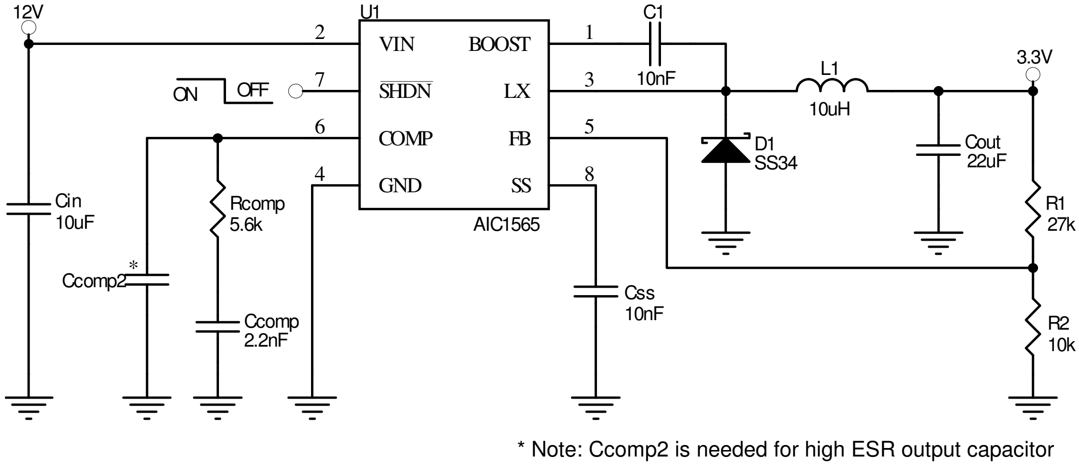
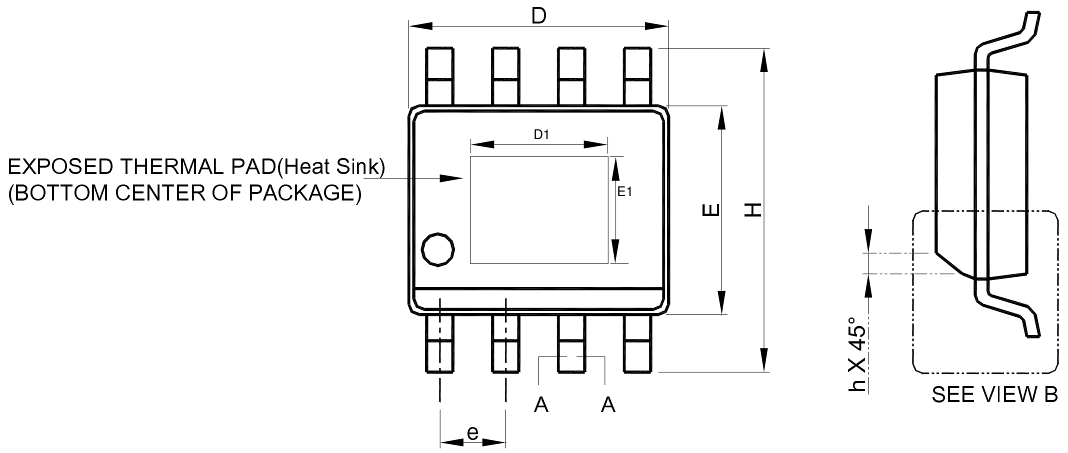
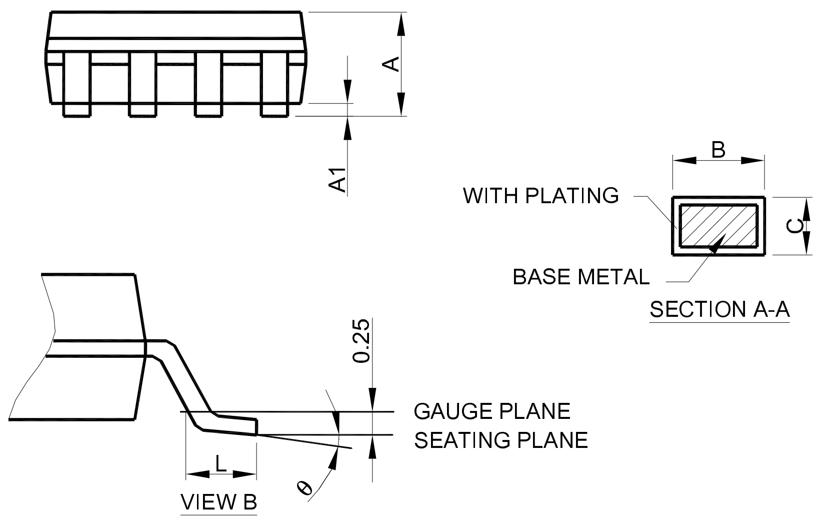


Fig. 20 AIC1565 Application Circuit at V_{OUT}=3.3V

PHYSICAL DIMENSIONS

● SOP-8 Exposed Pad (Heat Sink) PACKAGE OUTLINE DRAWING





SYMBOL	SOP-8 Exposed Pad(Heat Sink)	
	MILLIMETERS	
	MIN.	MAX.
A	1.35	1.75
A1	0.00	0.15
B	0.31	0.51
C	0.17	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
q	0°	8°
D1	1.5	3.5
E1	1.0	2.55

Note : 1. Refer to JEDEC MS-012E.
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.

Note: