



ACE722E

3MHz 2A Step-Down Converter

Description

The ACE722E is a high-efficiency, DC-to-DC step-down switching regulator, capable of delivering up to 2A of output current. The devices operate from an input voltage range of 2.6V to 5.5V and provide output voltages from 0.6V to VIN, making the ACE722E ideal for low voltage power conversions. Running at a fixed frequency of 3MHz allows the use of small inductance value and low DCR inductors, thereby achieving higher efficiencies. Other external components, such as ceramic input and output caps, can also be small due to higher switching frequency, while maintaining exceptional low noise output voltages. Built-in EMI reduction circuitry makes this converter ideal power supply for RF applications. Internal soft-start control circuitry reduces inrush current. Short-circuit and thermal-overload protection improves design reliability.

ACE722E is housed in a tiny SOT23-5/ DFN2x2-8L package

Features

- η up to 96%
- Up to 2A Max output current
- 3MHz Frequency
- Internal Compensation
- Clock Dithering
- Tiny SOT23-5/ DFN2x2-8L Package

Application

- USB ports/HubS
- Portable Devices
- Cellphones
- Tablet PC
- Set Top Boxes

Absolute Maximum Rating

Parameter		Value
Max Input Voltage		6V
Max Operating Junction Temperature(Tj)		125
Ambient Temperature(Ta)		-20°C~85°C
Package Thermal Resistance (Θ_{jc})	DFN2x2-8L	25°C/W
Power Dissipation	SOT-23-5	250mW
Storage Temperature(Ts)		-40°C-150°C
Lead Temperature & Time		260°C,105
ESD (HBM)		>2000V

Note: Exceed these limits to damage to the device. Exposure to absolute maximum rating conditions may affect device reliability

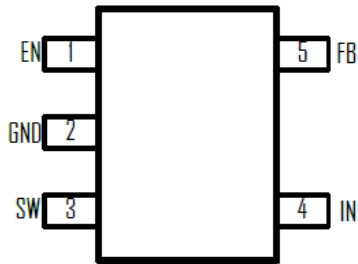


ACE722E

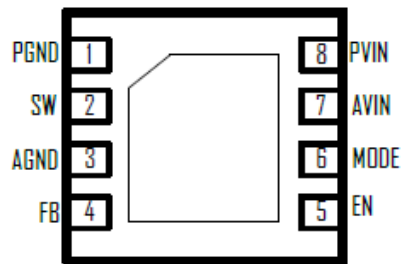
3MHz 2A Step-Down Converter

Packaging Typ

SOT23-5

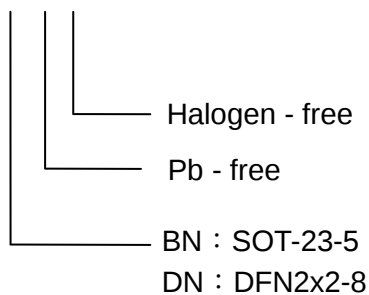


DFN2x2-8



Ordering information

ACE722E XX + H



Pin Description

SOT23-5

PIN #	NAME	DESCRIPTION
1	EN	Enable pin for the IC. Drive this pin to high to enable the part, low to disable.
2	GND	Ground
3	SW	Inductor Connection. Connect an inductor Between SW and the regulator output.
4	IN	Supply Voltage. Short to PIN. Bypass with a 10μF ceramic capacitor to GND
5	FB	Feedback Input. Connect an external resistor divider from the output to FB and GND to set the output to a voltage between 0.6V and VIN

DFN2x2-8L

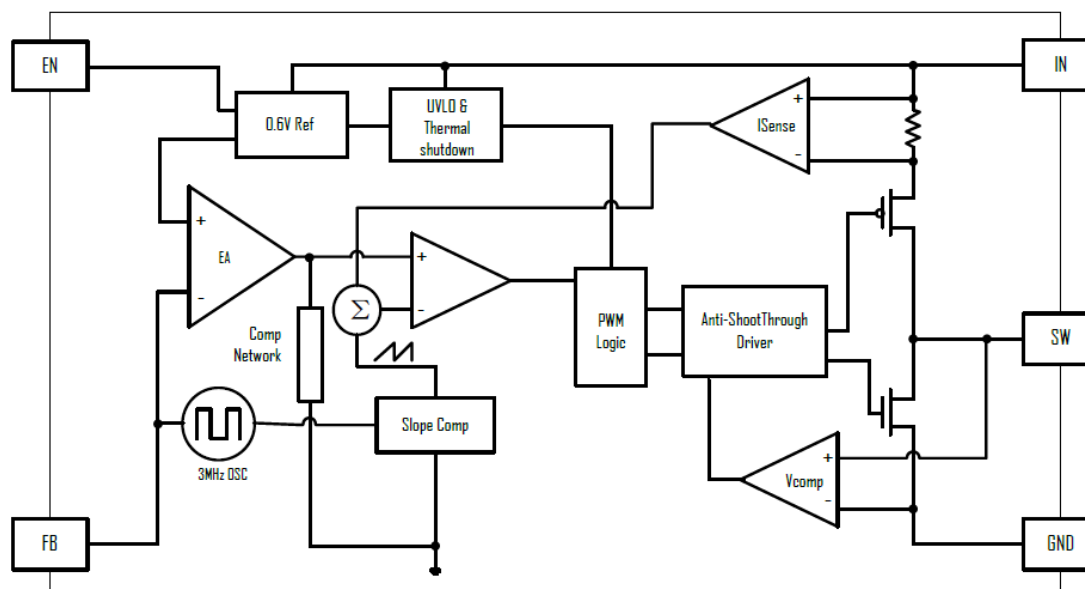
PIN #	NAME	DESCRIPTION
1	PGND	Power Ground. Bypass with a 10μF ceramic capacitor to PVIN
2	SW	Inductor Connection. Connect an inductor Between SW and the regulator output.
3	AGND	Analog Ground, Connect to PGND
4	FB	Feedback Input. Connect an external resistor divider from the output to FB and GND to set the output to a voltage between 0.6V and VIN
5	EN	Enable pin for the IC. Drive this pin to high to enable the part, low to disable.
6	MODE	When forced high, the device operates in fixed frequency PWM mode. When forced low, it enables the Power Save Mode with automatic transition from PFM mode to fixed frequency PWM mode. This pin must be terminated.
7	AVIN	Analog Power. Short externally to PVIN
8	PVIN	Supply Voltage. Bypass with a 10μF ceramic capacitor to PGND



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BLOCK DIAGRAM





ACE722E

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Electrical Characteristics ($V_{IN} = 3.6V$, unless otherwise specified. Typical values are at $T_A = 25^{\circ}C$.)

Parameter	Conditions	Min	Typ	Max	Units
Input Voltage Range		2.6		5.5	V
Input UVLO	Rising, Hysteresis=200mV		2.1		V
Input Supply Current	$V_{FB} = 0.65V, MODE = GND$		30		μA
Input Shutdown Current			0.1	1	μA
FB Feedback Voltage	$V_{IN} = 2.5$ to $5.5V$	0.588	0.6	0.612	V
FB Input Current			0.01		μA
Output Voltage Range		0.6		V_{IN}	V
Load Regulation			0.15		%/A
Line Regulation	$V_{IN} = 2.7$ to $5.5V$		0.04		%/V
Switching Frequency		2.4	3	3.6	MHz
NMOS Switch On Resistance	$I_{SW} = 200mA$		100	150	m Ω
PMOS Switch On Resistance	$I_{SW} = 200mA$		80	120	m Ω
PMOS Switch Current Limit			2.5	3	A
SW Leakage Current	$V_{OUT} = 5.5V, V_{SW} = 0$ or $5.5V, EN = GND$			10	μA
EN, MODE Input Current	$EN = MODE = GND$			1	μA
EN, MODE Input Low Voltage		0.4			V
EN, MODE Input High Voltage				1.5	V
Thermal Shutdown	Rising, Hysteresis $\approx 15^{\circ}C$		160		$^{\circ}C$

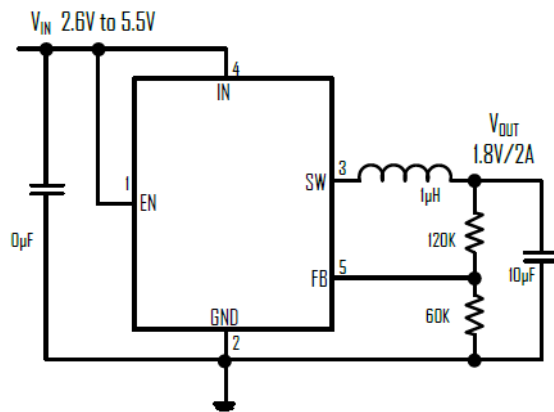


ACE722E

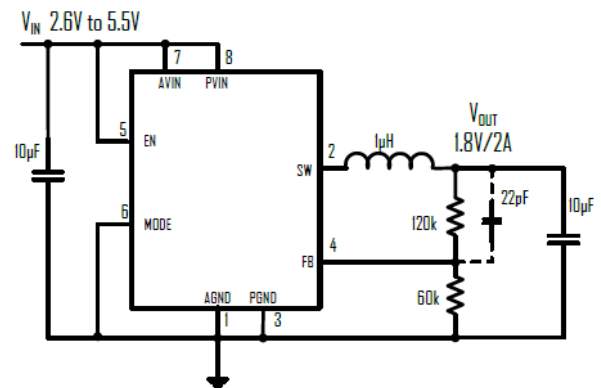
3MHz 2A Step-Down Converter

Typical Application Circuit

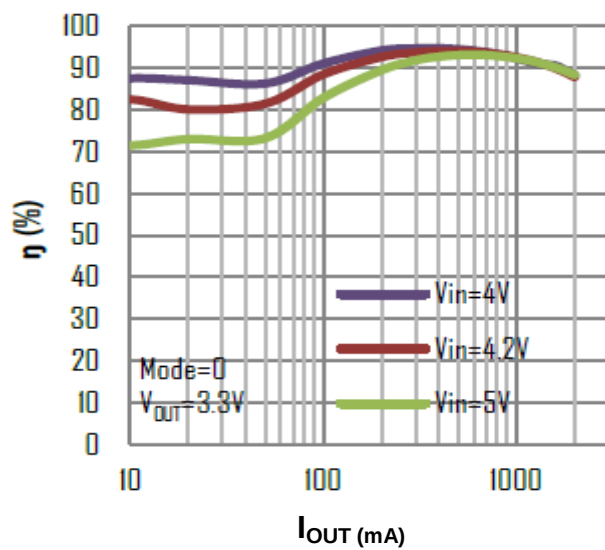
SOT23-5



DFN2x2-8L



Efficiency Vs I_{OUT}



TYPICAL CHARACTERISTICS

(Typical values are at T_A = 25°C unless otherwise specified.)

VER 1.1

5

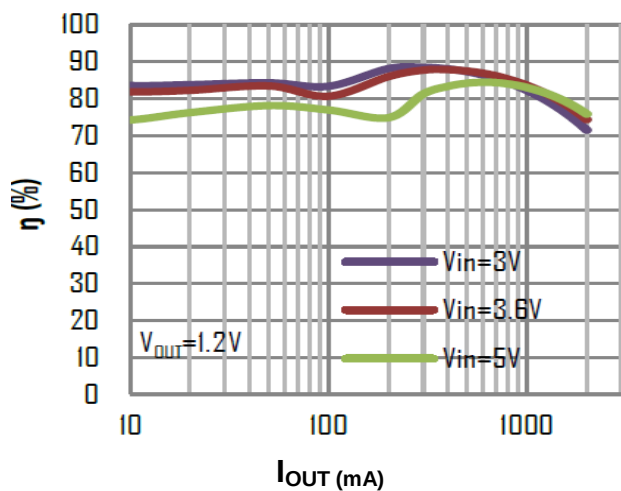


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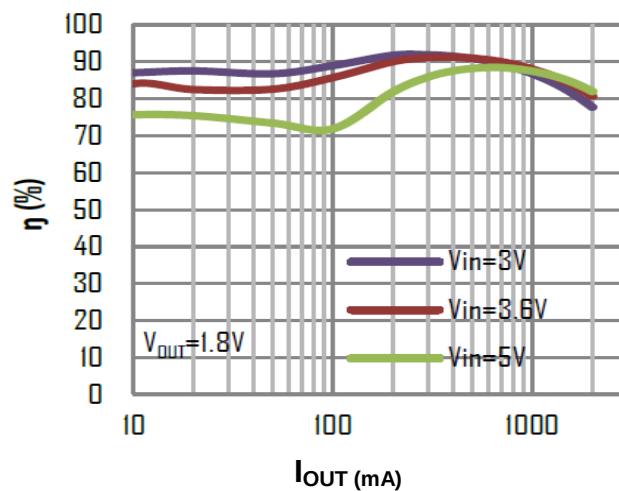
3MHz 2A Step-Down Converter

SOT23-5

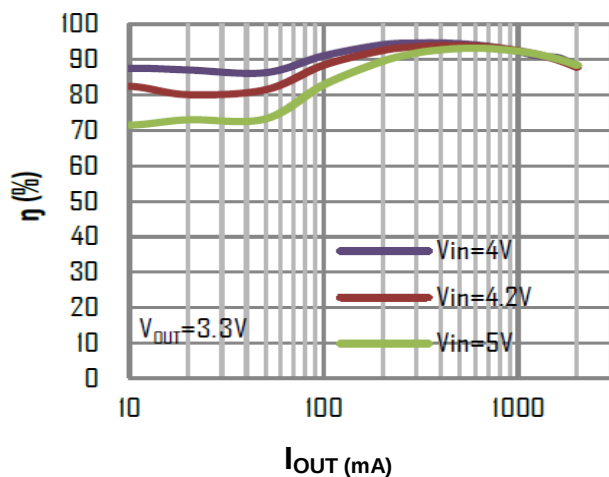
Efficiency Vs I_{OUT}



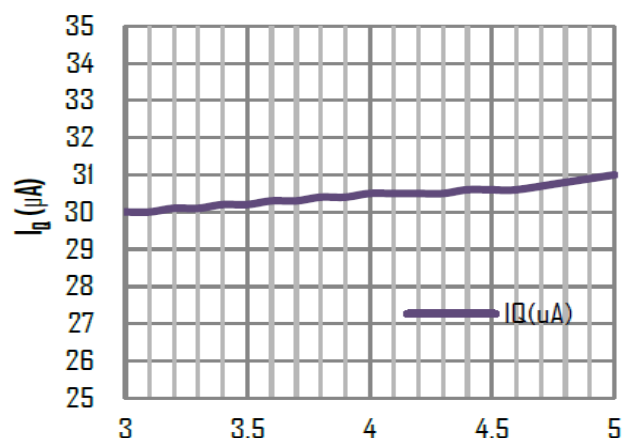
Efficiency Vs I_{OUT}



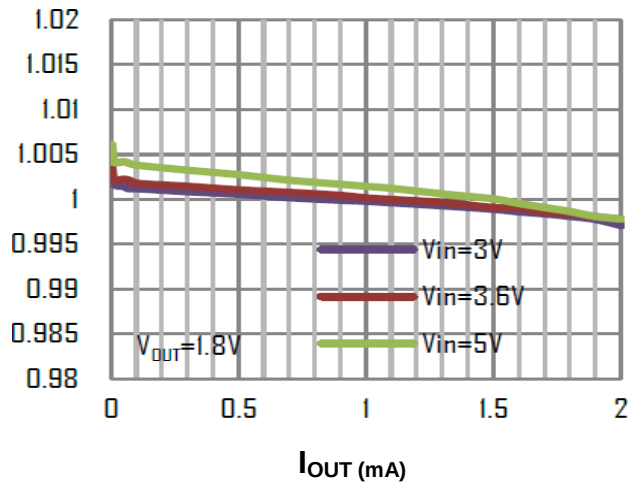
Efficiency Vs I_{OUT}



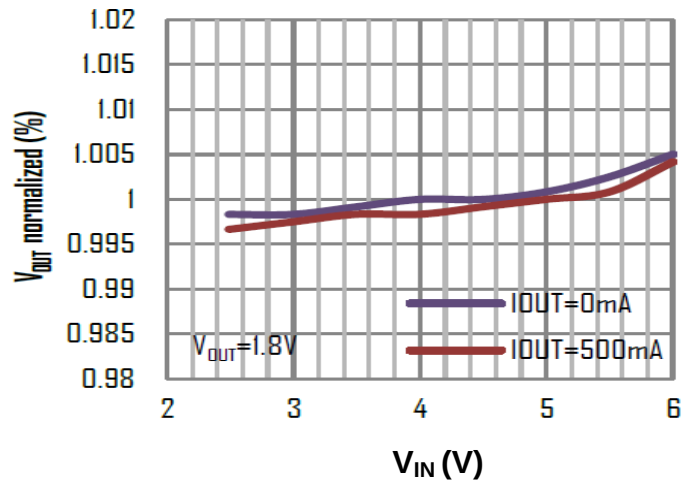
I_Q Vs V_{IN}



V_{OUT} Accuracy Vs



V_{OUT} Accuracy Vs V_{IN}





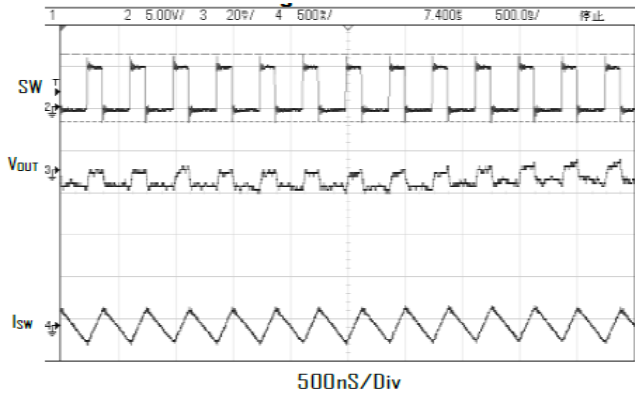
TYPICAL CHARACTERISTICS

(Typical values are at $T_A = 25^\circ\text{C}$ unless otherwise specified.)

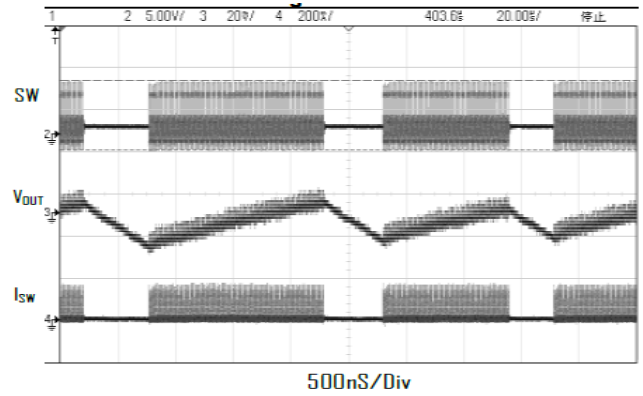
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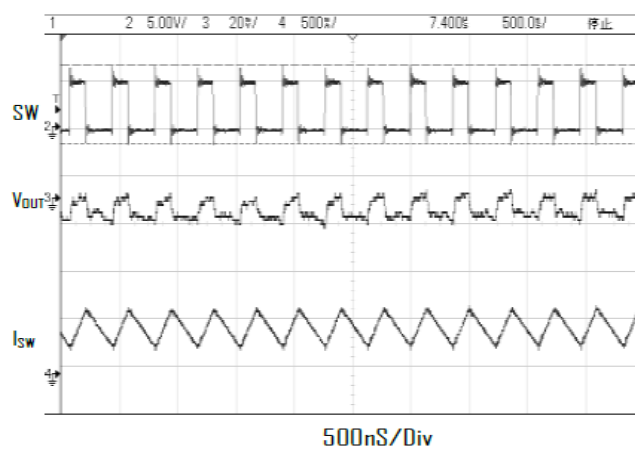
SWITCHING WAVEFORMS
Light Load 20mA



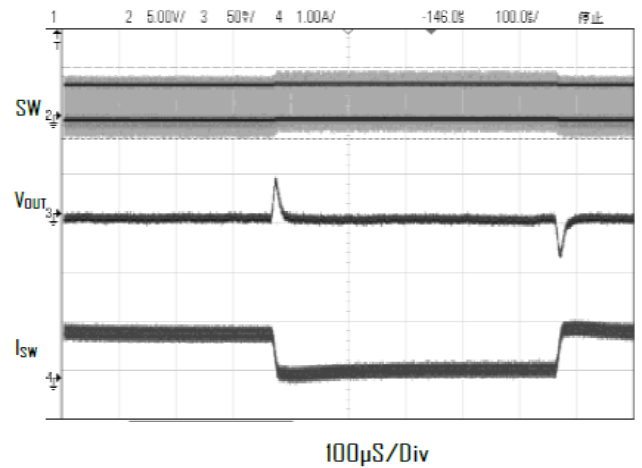
SWITCHING WAVEFORMS
Light Load 20mA



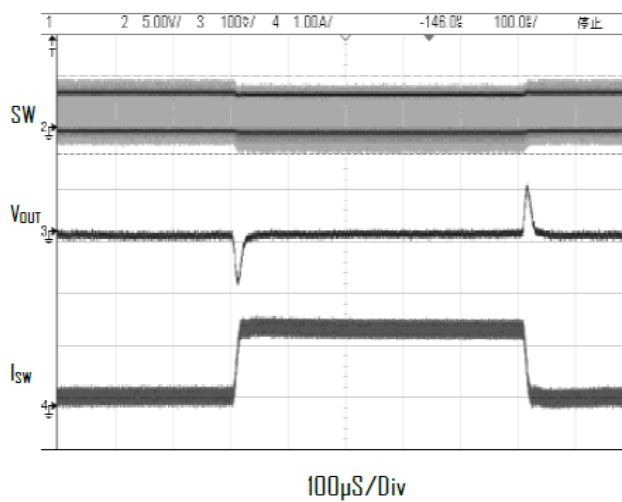
SWITCHING WAVEFORMS
Medium Load 0.5A



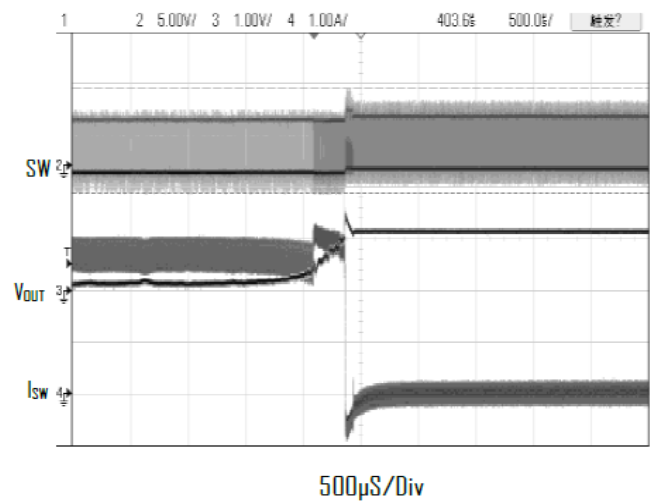
Load Transient
 $V_{OUT}=1.2\text{V } 0.2\text{ A to } 1.0\text{ A}$



Load Transient
 $V_{OUT}=1.8\text{V } 0.2\text{ A to } 1.5\text{ A}$



Short-Circuit Recovery

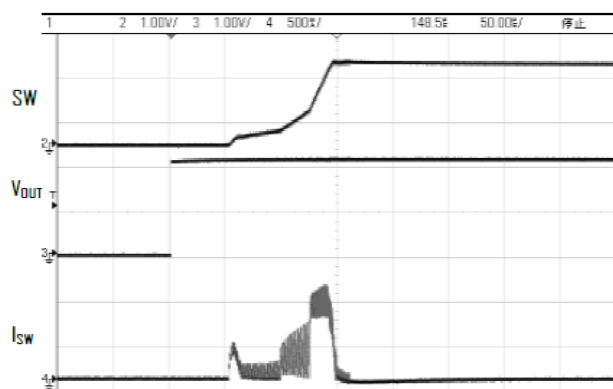




ACE722E

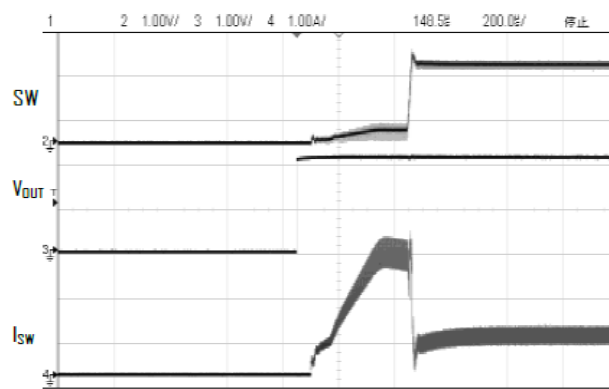
3MHz 2A Step-Down Converter

Short-UP Waveform
No Load



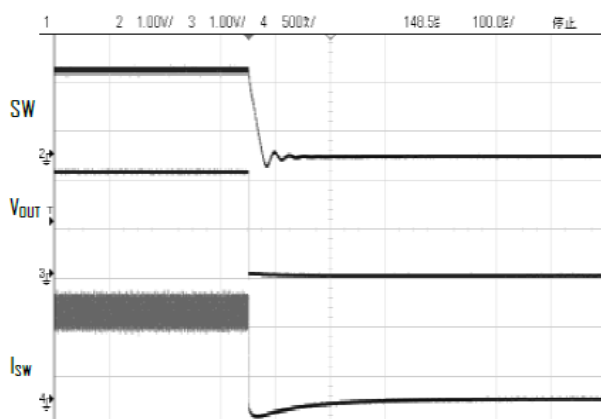
50μs/Div

Short-UP Waveform
I_{OUT}=1A



200μs/Div

Short down Waveform
I_{OUT}=1A



100μs/Div



ACE722E

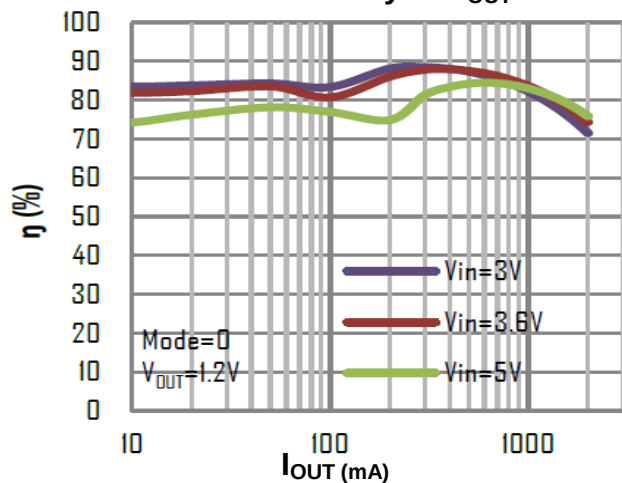
3MHz 2A Step-Down Converter

TYPICAL CHARACTERISTICS

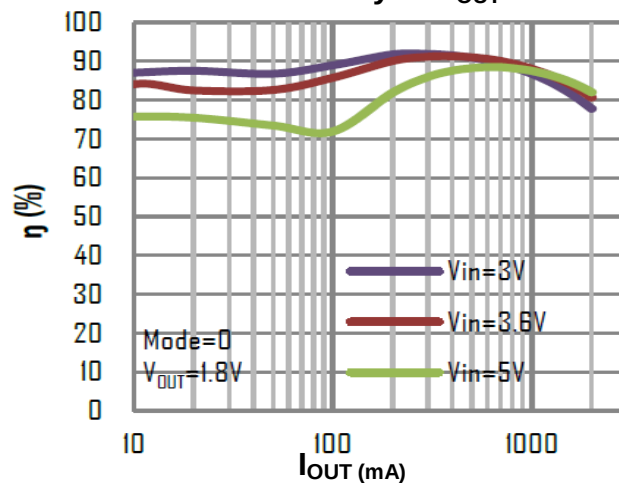
(Typical values are at $T_A = 25^\circ\text{C}$ unless otherwise specified.)

DFN2x2-8L

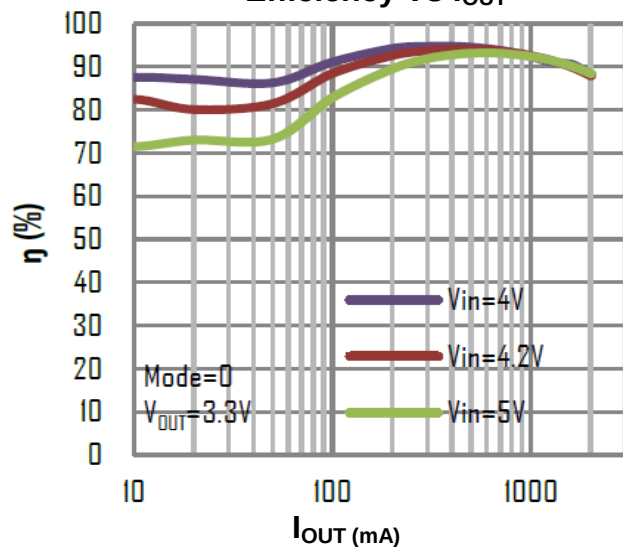
Efficiency Vs I_{OUT}



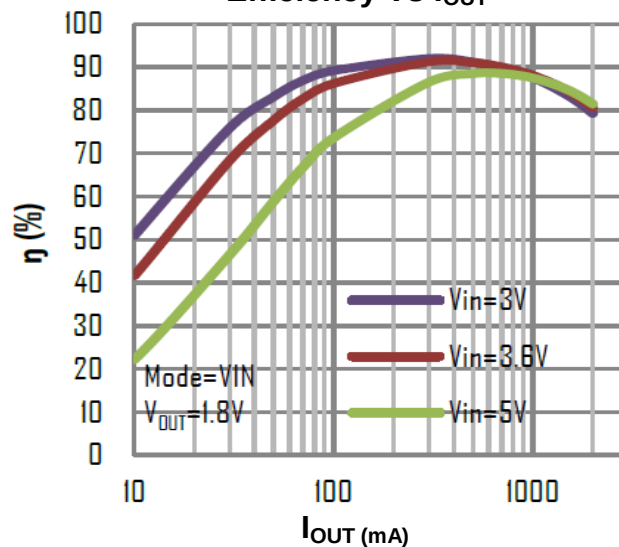
Efficiency Vs I_{OUT}



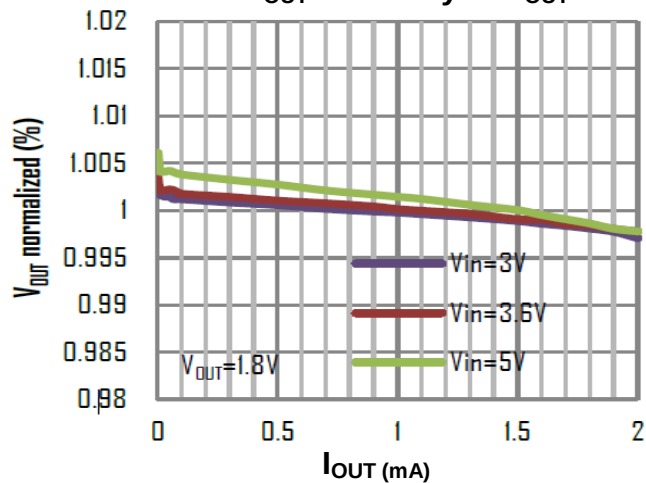
Efficiency Vs I_{OUT}



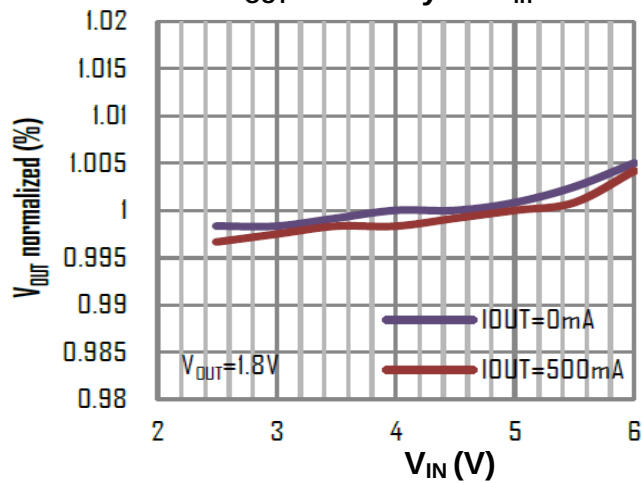
Efficiency Vs I_{OUT}



V_{OUT} Accuracy Vs I_{OUT}



V_{OUT} Accuracy Vs V_{IN}





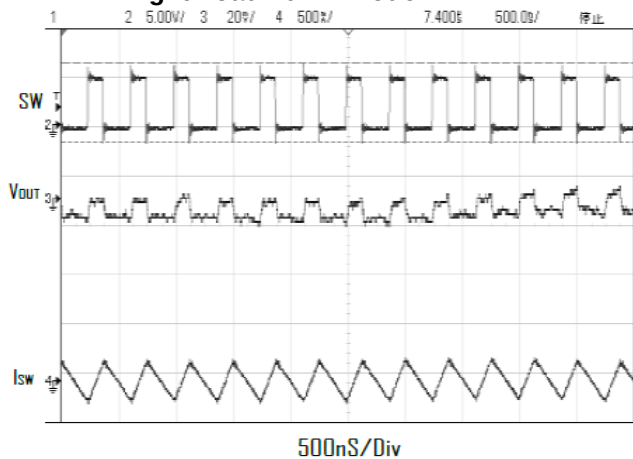
ACE722E

3MHz 2A Step-Down Converter

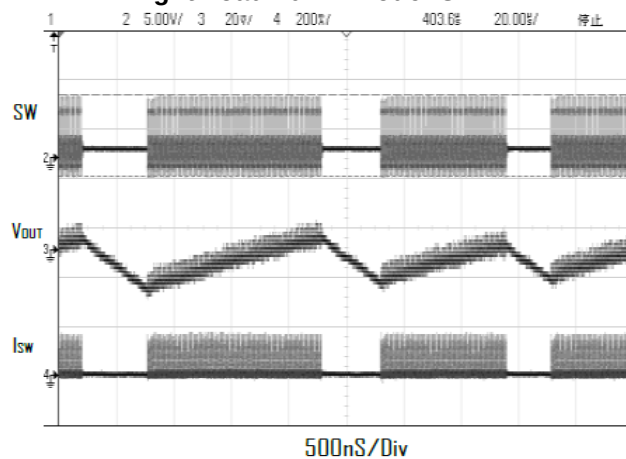
TYPICAL CHARACTERISTICS

(Typical values are at $T_A = 25^\circ\text{C}$ unless otherwise specified.)

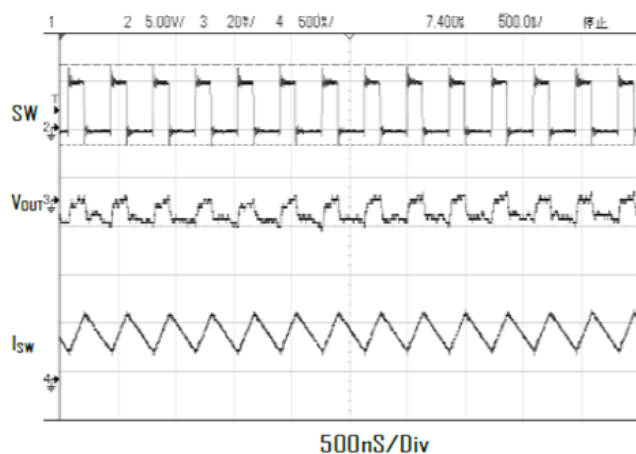
SWITCHING WAVEFORMS
Light Load 20mA Mode=VIN



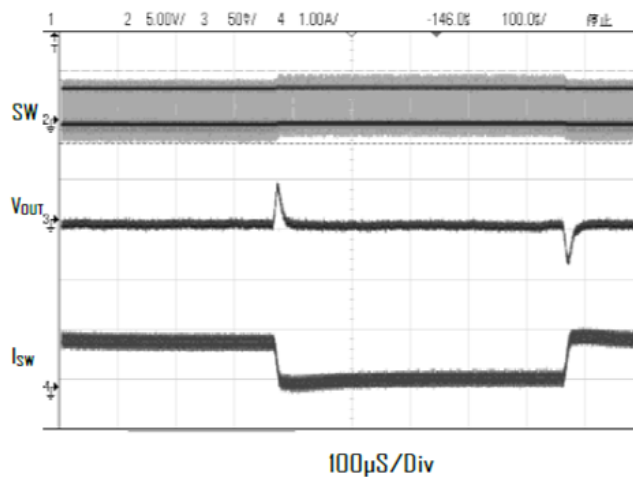
SWITCHING WAVEFORMS
Light Load 20mA Mode=GND



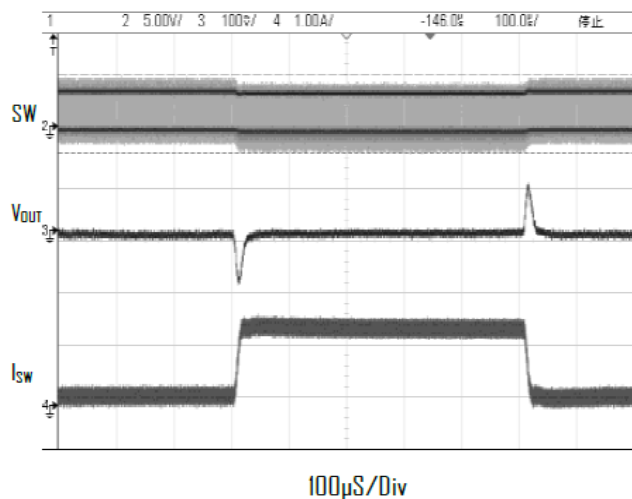
SWITCHING WAVEFORMS
Medium Load 0.5A



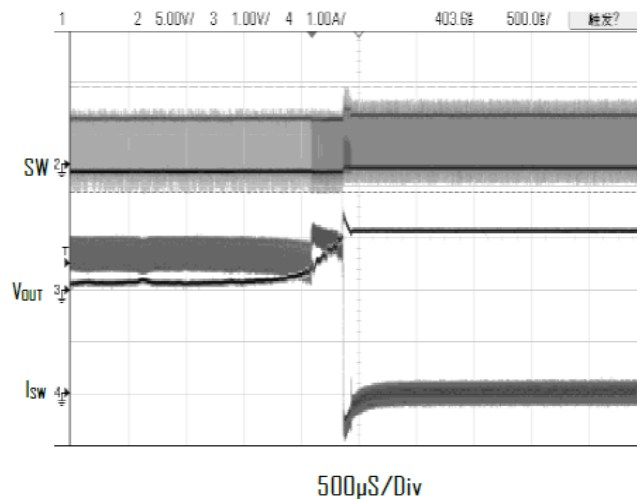
Load Transient
 $V_{OUT}=1.2\text{V } 0.2\text{ A to } 1.0\text{ A}$



Load Transient
 $V_{OUT}=1.8\text{V } 0.2\text{ A to } 1.5\text{ A}$



Short-Circuit Recovery

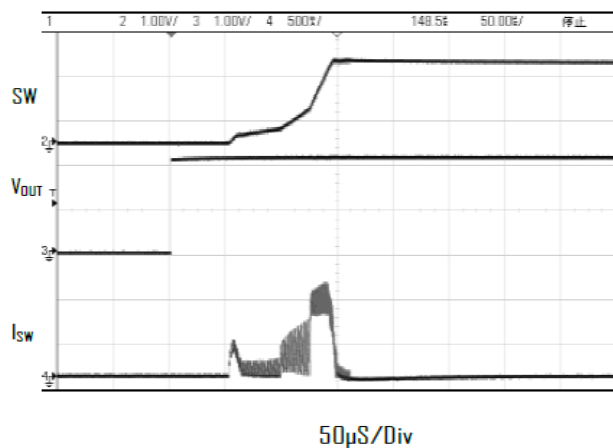




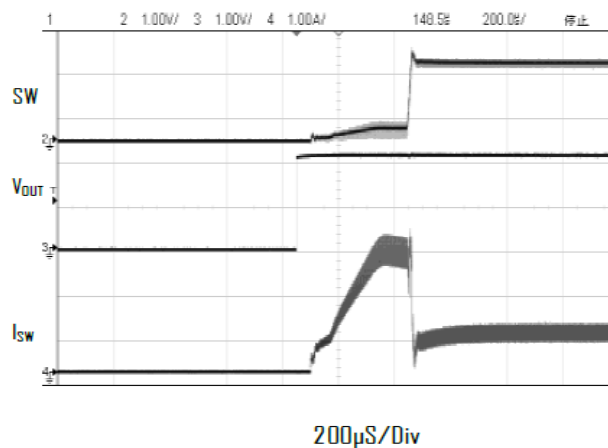
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3MHz 2A Step-Down Converter

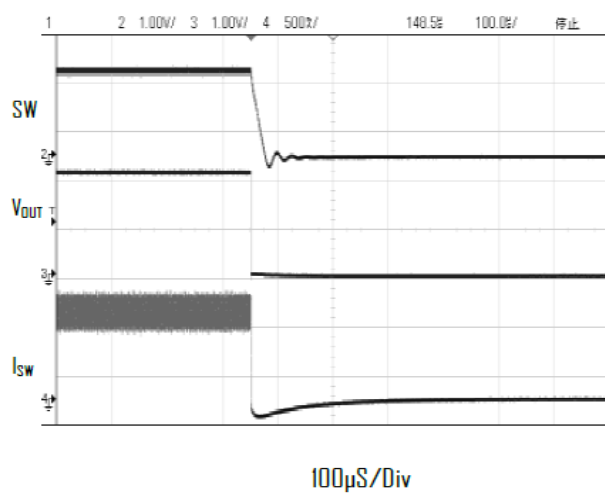
Short-UP Waveform
No Load



Short-UP Waveform
I_{OUT}=1A



Short down Waveform
I_{OUT}=1A





FUNCTIONAL DESCRIPTIONS

The ACE722E high efficiency switching regulator is a small, simple, DC-to-DC step-down converter capable of delivering up to 2A of output current. The device operates in pulse-width modulation (PWM) at 3MHz from a 2.6V to 5.5V input voltage and provides an output voltage from 0.6V to VIN, making the ACE722E ideal for on-board post-regulation applications. An internal synchronous rectifier improves efficiency and eliminates the typical Schottky free-wheeling diode. Using the on resistance of the internal high-side MOSFET to sense switching currents eliminates current-sense resistors, further improving efficiency and cost.

Load Operation

ACE722E uses a PWM current-mode control scheme. An open-loop comparator compares the integrated voltage-feedback signal against the sum of the amplified current-sense signal and the slope compensation ramp. At each rising edge of the internal clock, the internal high-side MOSFET turns on until the PWM comparator terminates the on cycle. During this on-time, current ramps up through the inductor, sourcing current to the output and storing energy in the inductor. The current mode feedback system regulates the peak inductor current as a function of the output voltage error signal. During the off cycle, the internal high-side P-channel MOSFET turns off, and the internal low-side N-channel MOSFET turns on. The inductor releases the stored energy as its current ramps down while still providing current to the output.

Current Sense

An internal current-sense amplifier senses the current through the high-side MOSFET during on time and produces a proportional current signal, which is used to sum with the slope compensation signal. The summed signal then is compared with the error amplifier output by the PWM comparator to terminate the on cycle.

Current Limit

There is a cycle-by-cycle current limit on the high-side MOSFET. When the current flowing out of SW exceeds this limit, the high-side MOSFET turns off and the synchronous rectifier turns on. ACE722E utilizes a frequency fold-back mode to prevent overheating during short-circuit output conditions. The device enters frequency fold-back mode when the FB voltage drops below 200mV, limiting the current to I_{PEAK} and reducing power dissipation. Normal operation resumes upon removal of the short-circuit condition.

Soft-start

ACE722E has a internal soft-start circuitry to reduce supply inrush current during startup conditions. When the device exits under-voltage lockout (UVLO), shutdown mode, or restarts following a thermal-overload event, the I soft-start circuitry slowly ramps up current available at SW.

**UVLO and Thermal Shutdown**

If IN drops below 1.9V, the UVLO circuit inhibits switching. Once IN rises above 2.1V, the UVLO clears, and the soft-start sequence activates. Thermal-overload protection limits total power dissipation in the device. When the junction temperature exceeds $T_J = +160^{\circ}\text{C}$, a thermal sensor forces the device into shutdown, allowing the die to cool. The thermal sensor turns the device on again after the junction temperature cools by 15°C , resulting in a pulsed output during continuous overload conditions. Following a thermal- shutdown condition, the soft-start sequence begins.

DESIGN PROCEDURE**Setting Output Voltages**

Output voltages are set by external resistors. The FB threshold is 0.6V.

$$R_{\text{TOP}} = R_{\text{BOTTOM}} \times [(V_{\text{OUT}} / 0.6) - 1]$$

Inductor Selection

The peak-to-peak ripple is limited to 30% of the maximum output current. This places the peak current far enough from the minimum overcurrent trip level to ensure reliable operation while providing enough current ripples for the current mode converter to operate stably. In this case, for 2A maximum output current, the maximum inductor ripple current is 667 mA. The inductor size is estimated as following equation:

$$L_{\text{IDEAL}} = (V_{\text{IN(MAX)}} - V_{\text{OUT}}) / I_{\text{RIPPLE}} \times D_{\text{MIN}} \times (1 / F_{\text{OSC}})$$

Therefore, for $V_{\text{OUT}} = 1.8\text{V}$,

The inductor values is calculated to be $L = 0.60\mu\text{H}$.

Chose 1Mh.

For $V_{\text{OUT}} = 1.2\text{V}$,

The inductor values is calculated to be $L = 0.469\mu\text{H}$.

Chose $0.47\mu\text{H}$

The resulting ripple is

$$I_{\text{RIPPLE}} = (V_{\text{IN(MAX)}} - V_{\text{OUT}}) / L_{\text{ACTUAL}} \times D_{\text{MIN}} \times (1 / F_{\text{OSC}})$$

When,

$$V_{\text{OUT}} = 1.8\text{V}, I_{\text{RIPPLE}} = 403\text{mA}$$

$$V_{\text{OUT}} = 1.2\text{V}, I_{\text{RIPPLE}} = 665\text{mA}$$

Output Capacitor Selection

For most applications a nominal $10\mu\text{F}$ or $22\mu\text{F}$ capacitor is suitable. The ACE722E internal compensation is designed for a fixed corner frequency that is equal to

$$f_c = \frac{1}{1.2 \times \pi \times C_{\text{OUT}} \times L} = 50\text{Khz}$$

For example, for $V_{\text{OUT}} = 1.8\text{V}$, $L = 1\mu\text{H}$, $C_{\text{OUT}} = 10\mu\text{F}$, for $V_{\text{OUT}} = 1.2\text{V}$, $L = 0.47\mu\text{H}$, $C_{\text{OUT}} = 22\mu\text{F}$

The output capacitor keeps output ripple small and ensures control-loop stability. The output capacitor must also have low impedance at the switching frequency. Ceramic, polymer, and tantalum capacitors are suitable, with ceramic exhibiting the lowest ESR and high-frequency impedance. Output ripple with a ceramic output capacitor is approximately as follows: $V_{\text{RIPPLE}} = I_{L(\text{PEAK})} [1 / (2\pi \times f_{\text{OSC}} \times C_{\text{OUT}})]$

If the capacitor has significant ESR, the output ripple component due to capacitor ESR is as follows:

$$V_{\text{RIPPLE(ESR)}} = I_{L(\text{PEAK})} \times \text{ESR}$$



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Input Capacitor Selection

The input capacitor in a DC-to-DC converter reduces current peaks drawn from the battery or other input power source and reduces switching noise in the controller. The impedance of the input capacitor at the switching frequency should be less than that of the input source so high-frequency switching currents do not pass through the input source. The output capacitor keeps output ripple small and ensures control-loop stability.

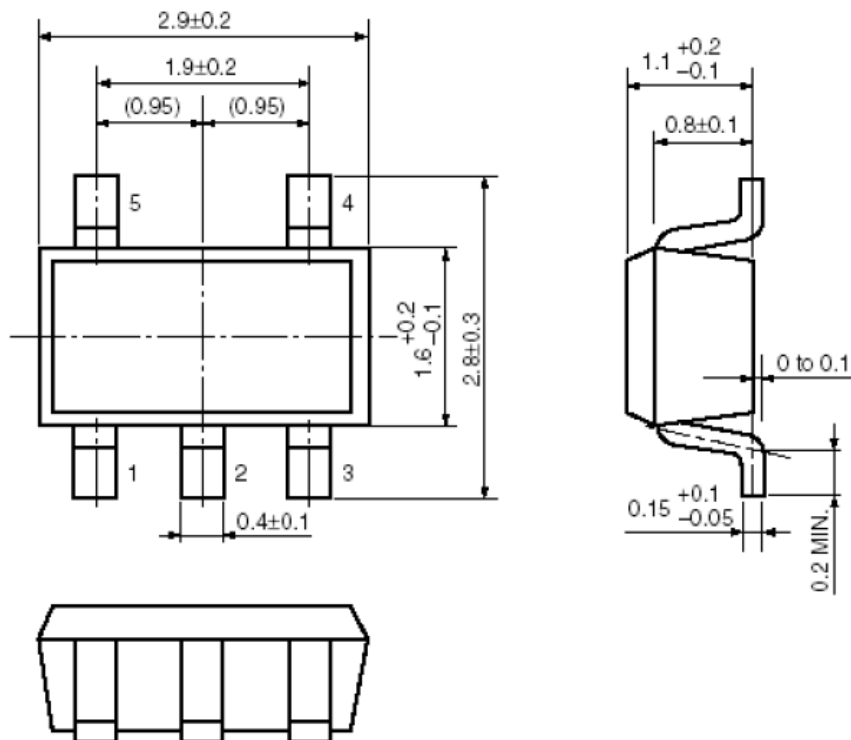


ACE722E

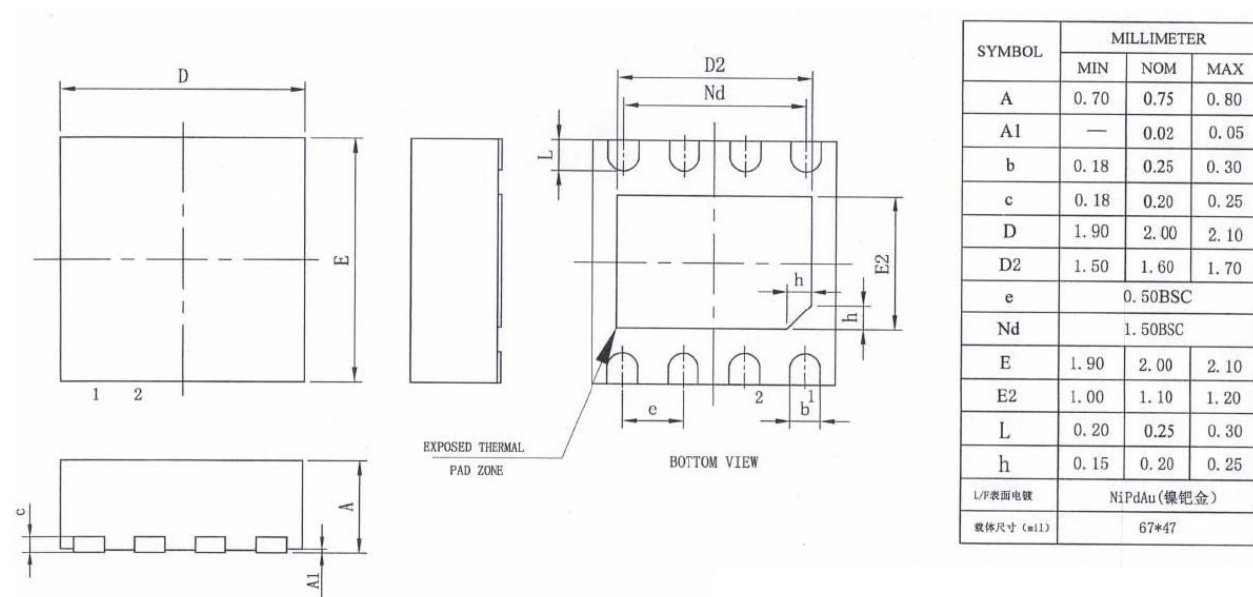
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Packing Information

SOT-23-5



DFN2X2-8L



VER 1.1



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Notes

ACE does not assume any responsibility for use as critical components in life support devices or systems without the express written approval of the president and general counsel of ACE Electronics Co., LTD. As sued herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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<http://www.ace-ele.com/>