![Xysemi logo]

XP3201

4.75V to 20V Input, 2.5A Synchronous Step-Down Converter with Fast Transient Response

GENERAL DESCRIPTION

The XP3201 is a current mode synchronous buck converter, and has a proprietary curvature circuit that enables fast transient response, enables the device to adopt to both low ESR output capacitors, such as POSCAP or SP-CAP, and ultra-low ESR ceramic capacitors.

The XP3201 operates from 4.75V to 20V Vin input, and the output voltage can be programmed between 0.925V to 14V with 2.5A output current. Due to 95m (High side) and 90m (Low side) integrated FETs, the XP3201 works in high efficiency (up to 94% @12V Input, 3.3V output) .

FEATURES

- 2.5A Output Current
- High Efficient Integrated FETs Optimized for portable application: 95mΩ (High side) and 90mΩ (Low side) High Efficiency
- Up to 95% Efficiency @ 5V Input, 3.3V Output
- Up to 93% efficiency @ 12V Input, 3.3V Output
- Wide Input Voltage Range: 4.75V to 20V @ 2.5A loading
- Wide Output Voltage Range: 0.925V to 14V @ 2.5A loading (32Watt output @max)
- Low Output Ripple and Allows Ceramic Output Capacitor
- Thermal Shutdown Protection
- 340-KHz Switching Frequency(fsw)
- Cycle By Cycle Over Current Limit
- SOP-8 Package

APPLICATIONS

- Wide Range of Applications for Low Voltage System
- Digital TV、DVB、DVR Power Supply
- High Definition Blu-ray Disc Players
- Networking Home Terminal
- Ideal for Portable Applications

Typical Application

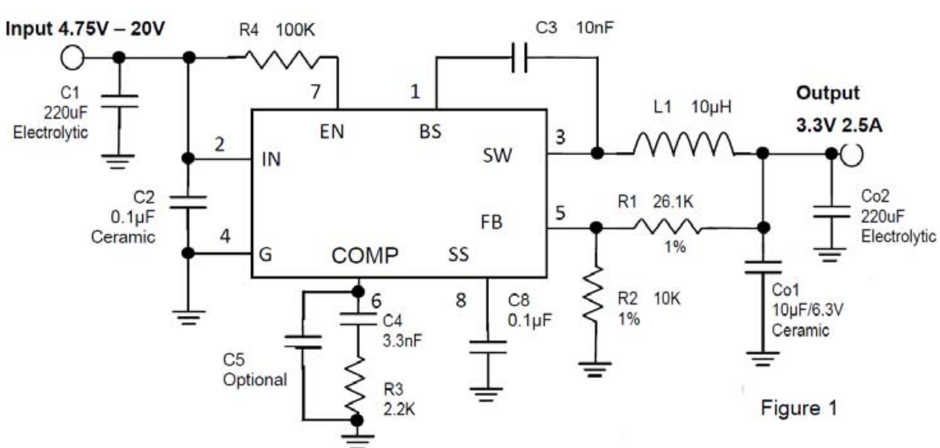
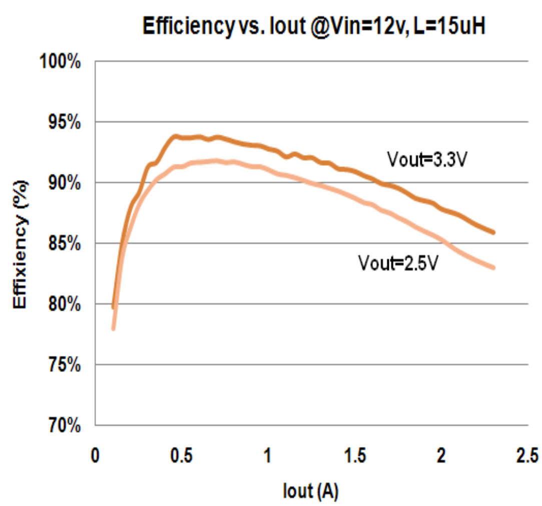


Figure 1



ORDERING INFORMATION

PART NUMBER	TEMP RANGE	SWICHING FREQUENCY	OUTPUT VOLTAGE (V)	OUTPUT CURRENT (A)	PACKAGE	PINS
XP3201	-40°C to 85°C	340KHz	Adjustable	2.5	SOP	8

PIN CONFIGURATION

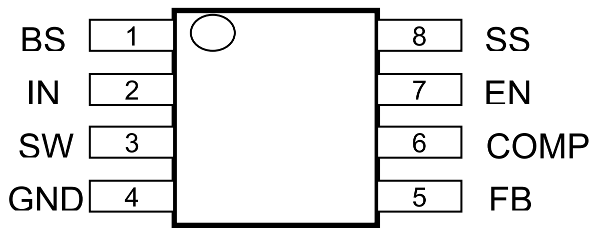


Figure 2. PIN Configuration

PIN DESCRIPTION

Pin NUMBER	Pin Name	Pin Description
1	BS	Supply input for high-side NFET gate driver (boost terminal). Connect capacitor from this pin to SW pin. An internal PN diode is connected between VREG to BS pin.
2	IN	Power input and connected to high side NFET drain
3	SW	Switch node connection between high-side NFET and low-side NFET. Also serve as inputs to current comparators.
4	GND	Signal ground pin, also serve as ground returns for low-side NFET
5	FB	Converter feedback input. Connect with feedback resistor divider
6	COMP	Compensation Node. Used to compensate control loop. Connect a series RC network from COMP to G. In some cases, an additional capacitor is required
7	EN	Enable control input
8	SS	Soft-start control. A external capacitor should be connected to G

ABSOLUTE MAXIMUM RATINGS

(Note: Do not exceed these limits to prevent damage to the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.)

PARAMETER	VALUE	UNIT
IN	-0.3 to 22	V
BS	-0.3 to 27	V
SW	-2 to 22	V
SW (10 ns transient)	-2.5 to 23	V
FB,SS,COMP	-0.3 to 5.5	V
EN	-0.3 to 7.5	V

Operation Junction	-40 to +150	°C
Storage temperature	-55 to +150	°C

DISSIPATION RATINGS

(2oz. trace and copper pad)

PACKAGE	θJA	θJC	UNIT
SOP8	90	45	℃/W

RECOMMENDED OPERATING CONDITIONS

Over operating free-air temperature range(unless otherwise noted)

		MIN	MAX	UNIT
Voltage	Supply input voltage range	4.3	18	V
	VBS	-0.1	25	V
	SS, FB, COMP	-0.1	5	V
	EN	-0.1	7.5	V
	G	-0.1	+0.1	V
TA	Operating free-air temperature	-40	85	℃
TJ	Operating junction temperature	-40	125	℃

ELECTRICAL CHARACTERISTICS

Over operating free-air temperature range(unless otherwise noted)

VIN=12V, TA=25℃

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Supply Current						
Iin	Operating-non-switching supply current	VIN current, TA=25℃, EN=1.8V, VFB=1.0V		1.3	2.0	mA
ISDN	Shut Down Supply Current	VEN=0V		2	4	μA
VFB	Feedback Voltage	4.3V ≤VIN≤18V	0.900	0.913	0.926	V
OVP	Feedback Overvoltage Threshold			1.1		V
Aea	Error Amplifier Voltage Gain			1000		V/V
Gea	Error Amplifier Transconductance	△IC=+/-10μA		900		μA/V
RDS(on)_1	High Side Switch ON Resistance			95		mΩ
RDS(on)_2	Low Side Switch ON Resistance			90		mΩ
Ileakgae	High Side Switch Leakage Current	VEN=0V, VSW=0V		10		μA
ILM_H	High Side Switch Current Limit	Minimum Duty Cycle	2.8	3.5		A
ILM_L	Low Side Switch Current Limit	From Drain to Source		1.0		A
Gcs	COMP Voltage to Current Sense Transconductance			3.5		A/V
Fsw_1	Switching Frequency			340		KHz
Fsw_2	Short Circuit Switching Frequency	VFB=0V		100		KHz
Dmax	Maximum Duty Cycle	VFB=1.0V		90		%
TON_min	Minimum ON Time			220		ns
VEN_1	EN Threshold Voltage	VEN Rising	1.1	1.5	2.0	V
VHys_1	EN Threshold voltage's Hysteresis			100		mV
VEN_2	EN Lockout Threshold Voltage		1.8	2.0	2.2	V

VHys_2	EN Lockout Hysteresis		210	mV
VUVLO	Input Under Voltage Lockout Threshold	VIN Rising	3.0 3.6 4.2	V
VHys_3	Input Under Voltage Lockout Threshold Hysteresis		600	mV
Iss	Soft-Start Current	Vss=0V	4.25 4.40 4.55	μA
VFB-SS	Setting Feedback Voltage by Using Soft-Start Voltage	Only when VSS < 0.85V by adding resistor on SS pin VSS= Iss*RSS=4.40μA*RSS	VSS+30mV	
Tss	Soft-Start Period	Css=0.1μF	15	ms
TSD	Thermal Shutdown		160	℃

FUNCTIONAL BLOCK DIAGRAM

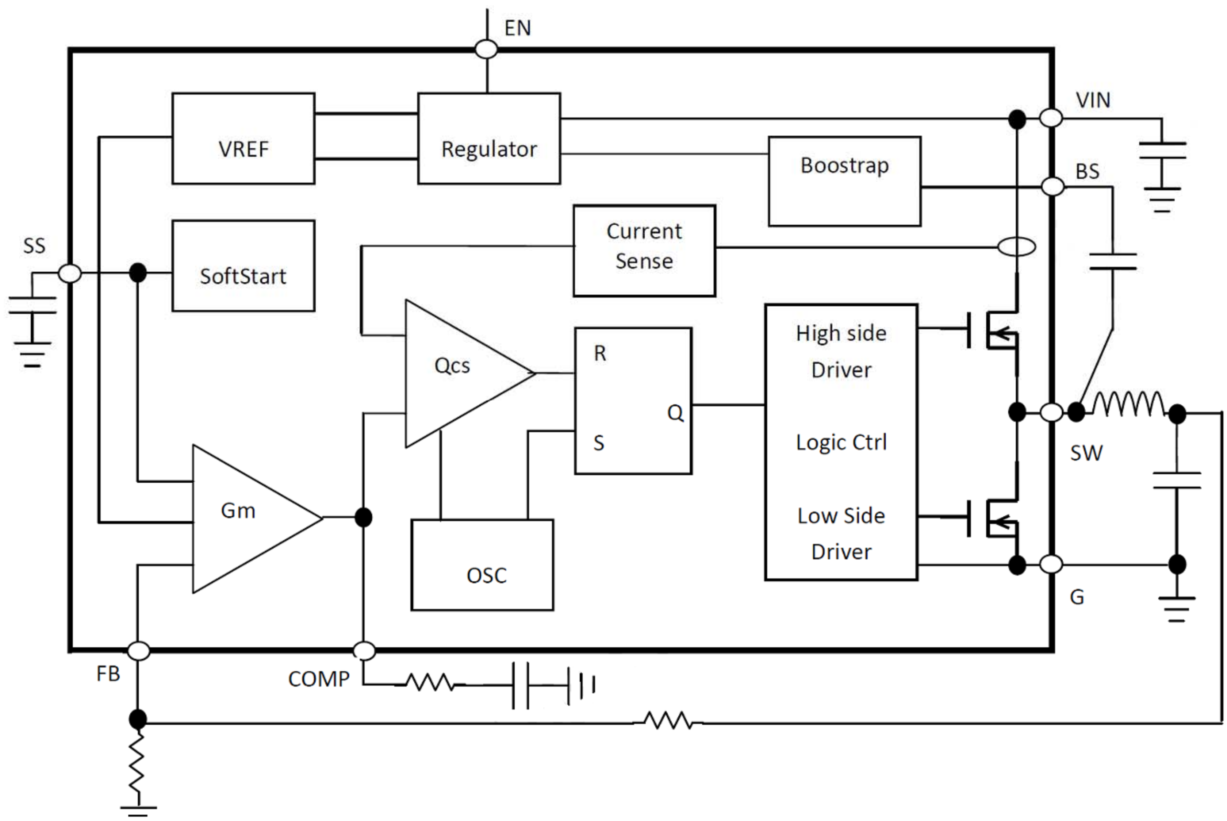


Figure 3. Functional Block Diagram

APPLICATION INFORMATION

OPERATION

XP3201 is a synchronous rectifying step-down switching converter that achieves faster transient response by employing current control mode system with typically 340KHz fixed frequency pulse width modulation.

It reduces the power dissipated by using internal lower Rds-on MOSFET as a rectifier instead of a diode rectifier externally connected to a conventional DC/DC converter IC.

For PWM operation, at the beginning of each clock cycle initiated by the clock signal, the High Side MOSFET switch is turned on. The current flows now from the input capacitor via the High Side MOSFET switch through the inductor to the output capacitor and load. During this phase, the current ramps up until the PWM comparator trips and the control logic will turn off the switch. The current limit comparator will also turn off the switch in case the current limit of the High Side MOSFET switch is exceeded. After a dead time preventing shoot through current, the Low Side MOSFET rectifier is turned on and the inductor current will ramp down. The current flows now from the inductor to the output capacitor and to the load. It returns back to the inductor through the Low Side MOSFET rectifier. The next cycle will be initiated by the clock signal again turning off the Low Side MOSFET rectifier and turning on the on the High Side MOSFET switch.

UNDERVOLTAGE LOCKOUT

The undervoltage lockout circuit prevents the device from malfunctioning at low input voltages and from excessive discharge of the battery and disables the output stage of the converter. The undervoltage lockout threshold is typically 3.1V with falling VIN.

ENABLE

The device is enabled setting EN pin to high. The EN input can be used to control power sequencing in a system with various DC/DC converters. The EN pin can be connected to the output of another converter, to drive the EN pin high and getting a sequencing of supply rails. With EN = GND, the device enters shutdown mode in which all internal circuits are disabled.

SOFTSTART

The INN9182T has an soft start circuit that controls the ramp up of the output voltage. The output voltage ramps up from 5% to 95% of its nominal value within typical 15ms by using 0.1uF at SS pin. This limits the inrush current in the converter during ramp up.

SHORT CIRCUIT PROTECTION

The High Side and Low Side MOSFET switches are short-circuit protected with maximum switch current = ILIMF. The current in the switches is monitored by current limit comparators. Once the current in the High Side MOSFET switch exceeds the threshold of it's current limit comparator, it turns off and the Low Side MOSFET switch is activated to ramp down the current in the inductor and High Side MOSFET switch. The High Side MOSFET switch can only turn on again, once the current in the Low Side MOSFET switch has decreased below the threshold of its current limit comparator.

THERMAL SHUTDOWN

As soon as the junction temperature, TJ, exceeds 160°C (typical) the device goes into thermal shutdown. In this mode, the High Side and Low Side MOSFETs are turned-off. The device continues its operation when the junction temperature falls below the thermal shutdown hysteresis.

STABILITY LOOP COMPENSATION

AS the current mode control is designed to sense a inductor current, a pole (phase lag) appears in the low frequency area due to a CR filter consisting of a output capacitor and a load resistance, while a zero appears in the high frequency area due to the output capacitor and its ESR. So the phase is easily compensated by adding a zero to the error amplifier output with C and R as described below to cancel a pole at the error amplifier.

Fp= 1/(2π x Ro x Co)

Fz(ESR)= 1/(2π x RESR x Co)

Pole at error amplifier:

When the output current decrease, the load resistance Ro increases and the pole frequency lowers,

Fp(min) =1/(2π x Romax x Co)

Fp(max) =1/(2π x Romin x Co)

Zero at error amplifier:

Increasing capacitance of the output capacitor lowers the pole frequency while the zero frequency does not change.

Fz(amp.) =1/(2π x Rcomp x Ccomp)

Stable feedback loop will be achieved by cancelling the pole fp(min.) produced by the output capacitor and the load resistance with CR zero correction by the error amplifier.

Fz(amp.) =Fp(min)

RECOMMENDED COMPONENT SELECTION

Compatible with several main competitors without any external component change!

Vout	Cout	R1	R2	R3 (comp)	C4 (comp)	C5 (optional)	L(inductor)
1.0V	22µF Ceramic X2	1.0K	10K	1K Ω	6.8nF	OPEN	2.0µH
1.2V	22µF Ceramic X2	4.7K	15K	1K Ω	6.8nF	OPEN	2.2µH
1.8V	22µF Ceramic X2	9.7K	10K	1K Ω	6.8nF	OPEN	3.3µH
2.5V	22µF Ceramic X2	12.0K	6.8K	1K Ω	6.8nF	OPEN	6.8µH
3.3V	22µF Ceramic X2	26.1K	10K	2.2K Ω	3.3nF	OPEN	10µH
5.0V	22µF Ceramic X2	30.0K	6.8K	2.7K Ω	3.3nF	OPEN	22µH
1.0V	470µF/6.3V/Electrolytic	1.0K	10K	1K Ω	6.8nF	150pF	2.0µH
1.2V	470µF/6.3V/Electrolytic	4.7K	15K	1K Ω	6.8nF	150pF	2.2µH
1.8V	470µF/6.3V/Electrolytic	9.7K	10K	1K Ω	6.8nF	150pF	3.3µH
2.5V	470µF/6.3V/Electrolytic	12.0K	6.8K	1K Ω	6.8nF	150pF	6.8µH
3.3V	470µF/6.3V/Electrolytic	26.1K	10K	2.2K Ω	3.3nF	150pF	10µH
5.0V	470µF/10V/Electrolytic	30.0K	6.8K	2.7K Ω	3.3nF	150pF	22µH
12V	470µF/25V/Electrolytic	62.0K	5.1K	3.3K Ω	3.3nF	150pF	47µH

OUTPUT VOLTAGE SETTING

The output voltage can be calculated to:

$$V_{OUT}=V_{REF} \times (1+ R1/R2)$$

To minimize the current through the feedback divider network, the sum of R1 and R2 should not exceed ~100KΩ, to keep the network robust against noise.

INDUCTOR SELECTION

The inductor value has a direct effect on the ripple current. The selected inductor has to be rated for its dc resistance and saturation current. The inductor ripple current (IL) decreases with higher inductance and increases with higher VIN or VOUT.

$$\Delta_{LI} = V_{OUT} \times (1-V_{OUT}/V_{IN})/(L \times f) \qquad (1)$$

$$I_{Lmax} = I_{outmax} + \Delta_{LI} \qquad (2)$$

With:

f = Switching Frequency (340KHz typical)

L = Inductor Value

Δ_{LI} = Peak to Peak inductor ripple current

I_{Lmax} = Maximum Inductor current

Equation 1 calculates the maximum inductor current in PWM mode under static load conditions. The saturation current of the inductor should be rated higher than the maximum inductor current as calculated with Equation 2.This is recommended because during heavy load transient the inductor current will rise above the calculated value.

OUTPUT CAPACITOR SELECTION

The current mode control scheme of the INN9182T allows the use of tiny ceramic capacitors. Ceramic capacitors with low ESR values have the lowest output voltage ripple and are recommended. The output capacitor requires either an X7R or X5R dielectric. Y5V and Z5U dielectric capacitors, aside from their wide variation in capacitance over temperature, become resistive at high frequencies.

At nominal load current, the device operates in PWM mode and the RMS ripple current is calculated as:

$$I_{RMSCout}=V_{OUT}\ x\ (1-V_{OUT}\ /V_{IN})/(L\ x\ f)\ *\ 0.289$$

INPUT CAPACITOR SELECTION

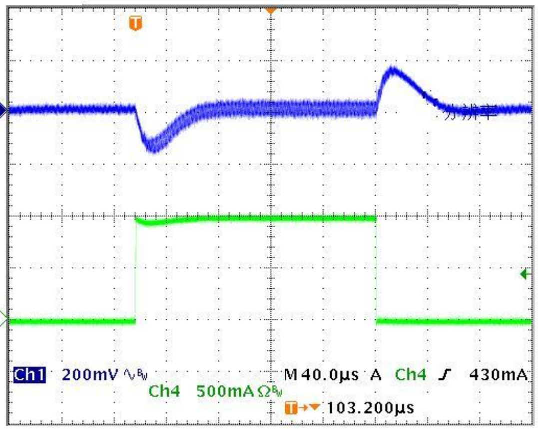
An input capacitor is required for best input voltage filtering, and minimizing the interference with other circuits caused by high input voltage spikes. For most applications, a 10μF to 22μF ceramic capacitor is recommended. The input capacitor can be increased without any limit for better input voltage filtering.

For using electrolytic capacitor as input capacitor, a 0.1uF to 1.0uF ceramic capacitor has to be added in and be close to VIN pin and G pin. This ceramic capacitor can be increased without any limit for better input voltage filtering.

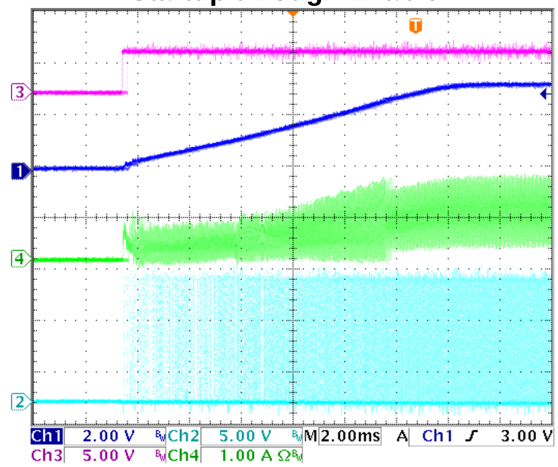
TYPICAL PERFORMANCE CHARACTERISTICS

（Vin=12V,Vout=3.3V, L=10μH, Cin=10μF, Cout=22μF, TA=+25℃）

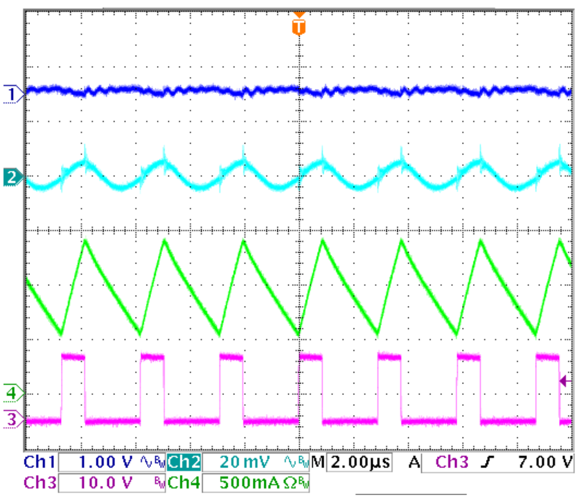
Fast Transient Response (20A/μs)



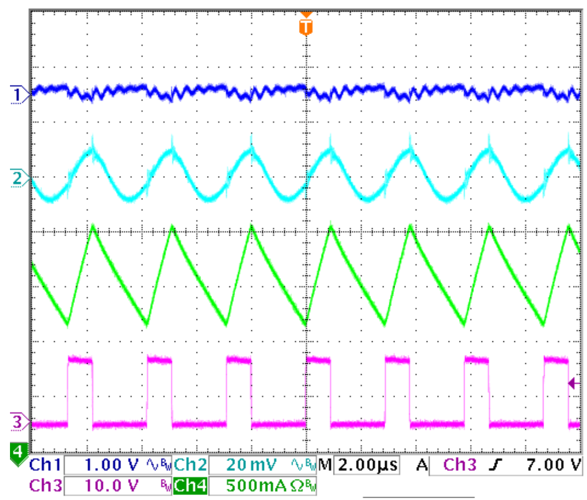
Startup through Enable



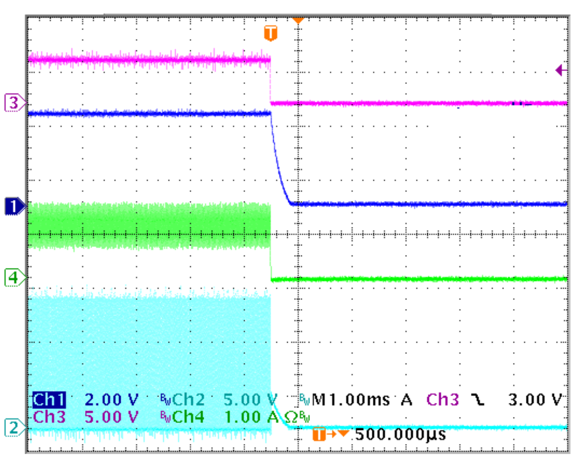
1A Load Operation (20MHZ)



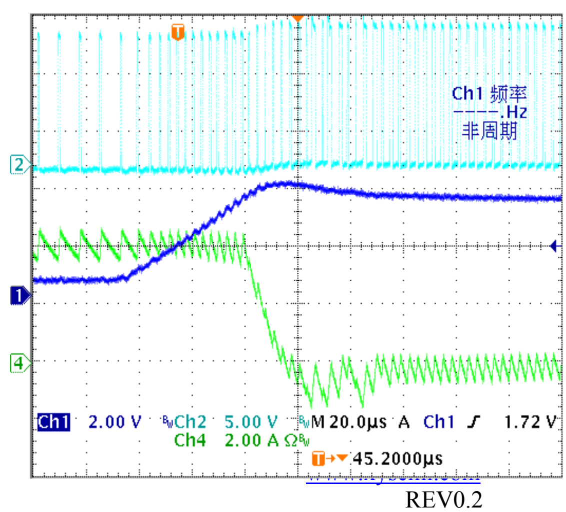
2A Load Operation （20MHZ）



Shutdown through Enable

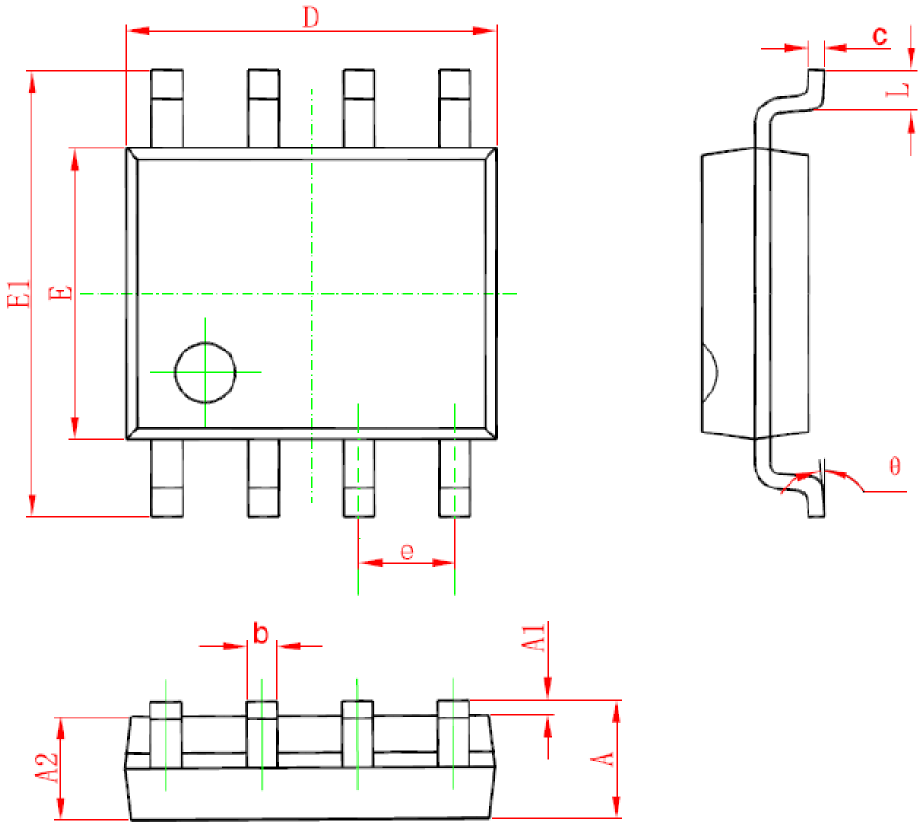


Short Circuit Recovery



PACKAGE OUTLINE

SOP8 PACKAGE OUTLINE AND DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°