2A 1.5MHz Synchronous Buck Converter

❖ GENERAL DESCRIPTION

The MA5003 is a monolithic synchronous buck regulator with a built in internal power MOSFET. It achieves 2A continuous output current fix switching frequency with excellent load and line regulation.

Current mode operation provides fast transient response and eases of loop stabilization.

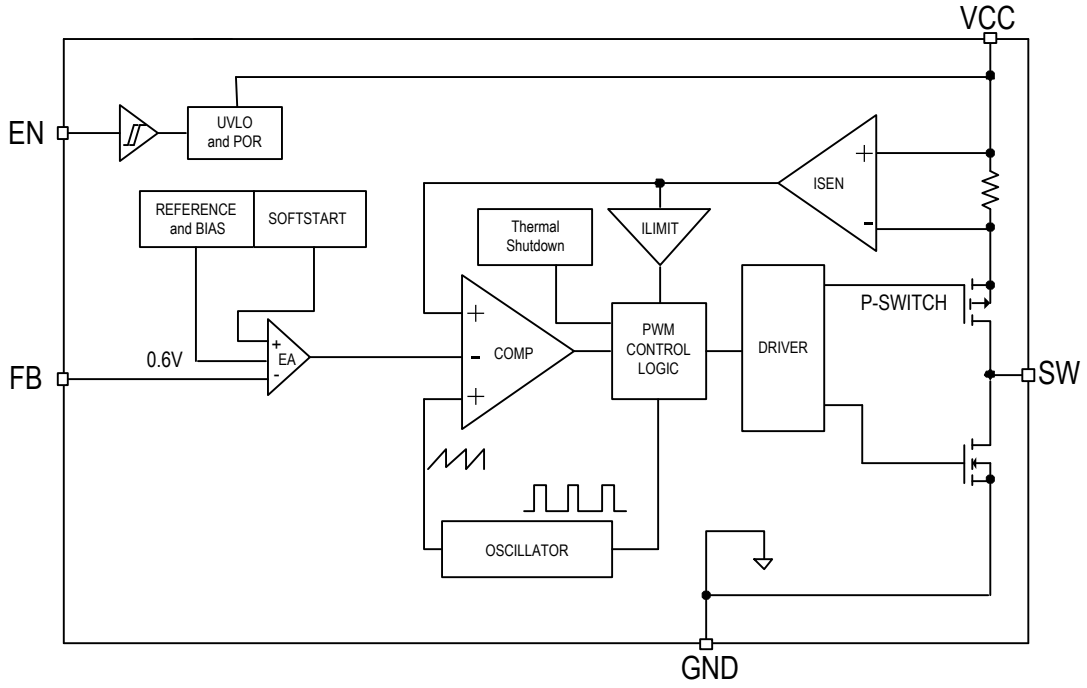
Fault condition protection includes cycle-by-cycle current limiting, output short circuit protection and thermal shutdown. In shutdown mode the regulator draws less than 1μA of supply current. Internal soft-start minimizes the inrush supply current at initial startup.

The MA5003 requires a minimum number of readily available standard external components. It is available in SOT23-5L and SOP8-EP packages.

❖ FEATURES

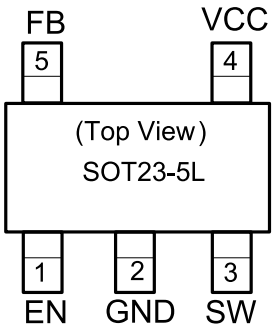
- 2.5V to 5.5V input voltage range
- Up to 2A Output Current
- 150/120mΩ Internal Power MOSFET Switch
- Stable with Low ESR Output Ceramic Capacitors
- Up to 95% Efficiency
- Less than 1μA Shutdown Current
- 1.5Mhz Switching Frequency
- Thermal Shutdown Protection
- Current limit and short circuit protections.
- Output Adjustable from 1V to VIN
- Available in SOT23-5 and SOP8-EP Pb-Free Package
- Build-in soft start function
- Input UVLO and OVLO protections

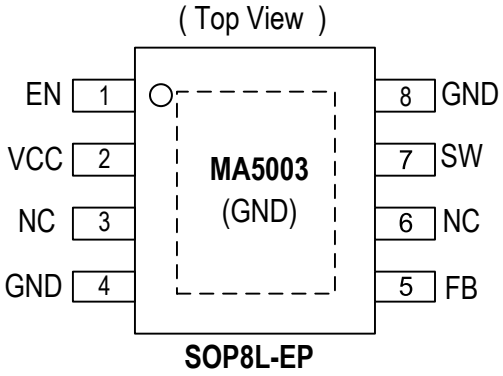
❖ BLOCK DIAGRAM



❖ PIN ASSIGNMENT

The packages of MA5003 are SOT23-5L, and SOP8-EP; the pin assignment is given by:





SOP8L-EP

Name	Description
EN	Chip Enable pin. Active high.
GND	Ground Pin.
SW	Switching Pin
VCC	VCC Input Pin
FB	Feedback Pin.
NC	NO Connect

❖ ORDER/MARKING INFORMATION

Order Information	Top Marking (SOT23-5L)
MA5003XX X Package Type B: SOT23-5L ES: SOP8-EP Packing Blank : Bag A : Taping	B 1 Y W X → ID Code: Internal Week: 01~26(A~Z) 27~52(a~z) Year : 6 = 2016 7 = 2017
	Top Marking (SOP8)
	MA5003 → Part number XXXXX → ID code:internal WW:01~52 Year:16=2016

❖ ABSOLUTE MAXIMUM RATINGS (at T_A=25°C)

Characteristics	Symbol	Rating	Unit
VCC pin voltage	V_{IN}	-0.3 to 7	V
SW pin voltage	V_{SW}	-0.7 to V_{IN}+0.3	V
EN, FB pins voltage		-0.3 to V_{IN}+0.3	V
Continuous Power Dissipation	PD	(T_J-T_A) / θ_{JA}	mW
Operating Junction Temperature	Top	-40 to 125	°C
Storage Temperature Range		-65 to 150	°C
Thermal Resistance from Junction to case	SOT23-5L	110	C/W
Thermal Resistance from Junction to ambient	SOT23-5L	250	C/W
Thermal Resistance from Junction to case	SOP8-EP	15	C/W
Thermal Resistance from Junction to ambient	SOP8-EP	65	C/W

Note: θ_{JA} is measured with the PCB copper are (need connect to GND of the MA5003) of approximately 1 in^2 (Multi-layer).

❖ ELECTRICAL CHARACTERISTICS

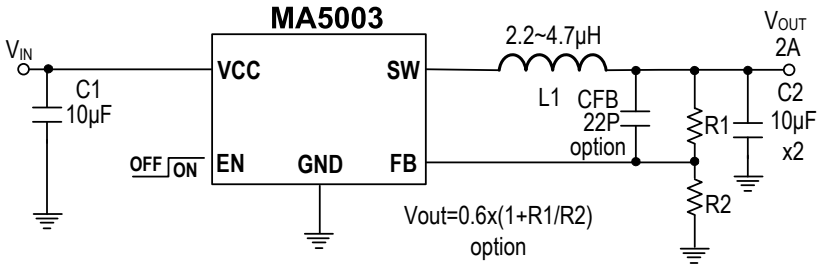
(V_{IN} = 5V, V_{EN} = 5V, V_{OUT} = 3.3V, T_A = 25°C)

Characteristics	Symbol	Conditions	Min	Typ	Max	Units
Input Voltage Range	V_{IN}		2.5	-	5.5	V
Input UVLO	UVLO	I_{OUT}=0A	1.8	2.2	2.5	V
Input OVLO	OVLO	I_{OUT}=0A	-	6.0	-	V
Quiescent Current	I_{CCQ}	V_{FB} = 1V	-	250	350	μA
Shutdown Current	I_{SD}	V_{EN} = 0V	-	0.1	1	μA
FB Pin Voltage	V_{FB}		0.588	0.6	0.612	V
FB Pin Current (Note1)	I_{FB}		-	-	±50	nA
Load Regulation		0A < I_{OUT}<1.5A	-	0.6	-	%
Line Regulation		2.5V<V_{IN}<5.5V	-	0.3	-	%/V
EN Pin Voltage High	V_{ENH}		1.5	-	-	V
EN Pin Voltage Low	V_{ENL}		-	-	0.4	V
EN Pin Leakage Current		V_{EN} = 3V	-	0.1	1	μA
Switching Frequency	F_{OSC}		1.1	1.5	1.9	MHz
Current Limit	C_L	VIN = 3V, VFB = 0.5V or VOUT = 90%, Duty Cycle < 35%	2.2	2.5	-	A
Switching Maximum Duty	Dmax		-	-	100	%
Minimum Duty	Dmin		0	-	-	%
P-Switch $R_{DS(ON)}$	$R_{DS(ON)-P}$		-	150	-	mΩ
N-Switch $R_{DS(ON)}$ (Note1)	$R_{DS(ON)-N}$		-	120	-	mΩ
Low Side Discharger			-	60	-	Ω
Thermal Shutdown	T_{SD}		-	155	-	°C
Thermal Shutdown Protection hysteresis	T_{SH}		-	30	-	°C

Note1: Guaranteed by design.

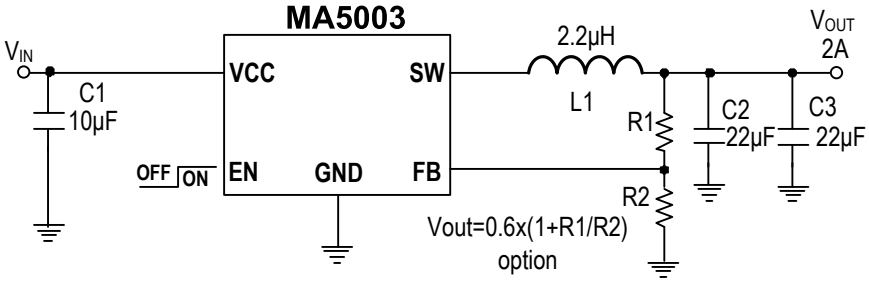
❖ APPLICATION CIRCUIT

【1.8V≦V_{OUT}≦4.4V】

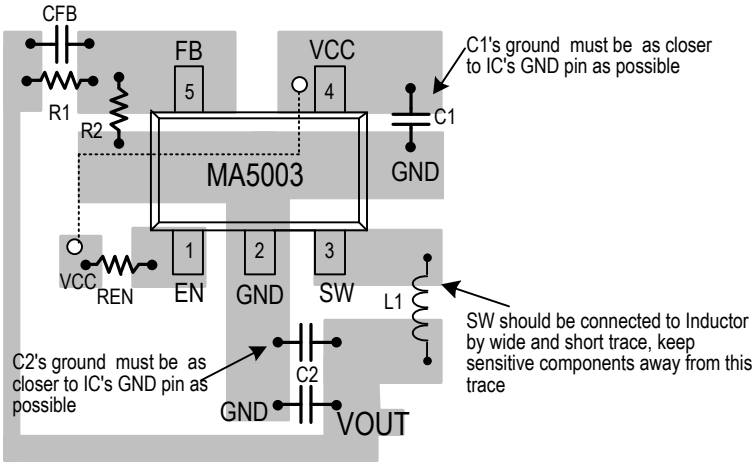


$V_{OUT}=V_{FB}$ × (1+R1/R2), V_{FB} = 0.6V, R2 suggest 60k~300kΩ

【1.0V≦V_{OUT}≦1.6V】



Layout Guide



❖ FUNCTION DESCRIPTION

Normal Operation

The MA5003 uses a user adjustable frequency, current mode, synchronous step-down architecture with internal paver switch. During normal operation, the internal power switch is turned on each cycle when the oscillator sets the SR latch, and turned off when the comparator resets the SR latch. The peak inductor current at which comparator resets the SR latch is controlled by the output of error amplifier EA. While the high-side switch is off, the external schottky diode turns on until either the inductor current starts to reverse or the beginning of the next switching cycle.

Dropout Operation

As the input supply voltage decreases to a value approaching the output voltage, the duty cycle increases toward the maximum on-time. Further reduction of the supply voltage forces the high-side switch to remain on for more than one cycle until it reaches 100% duty cycle.

The output voltage is dropped from the input supply for the voltage which across the high-side switch.

Setting the Output Voltage

Application circuit item shows the basic application circuit with adjustable output version. The external resistor sets the output voltage according to the following equation:

$V_{OUT}=V_{FB} \times (1+R1/R2)$, V_{FB} = 0.6V, R2 suggest 60k~300kΩ

Table 1 Resistor select for output voltage setting

V_{OUT}	R2	R1
1.0V	150K	100K
1.2V	100K	100K
1.5V	100K	150K
1.8V	100K	200K
2.5V	150K	470K
3.3V	100K	450K

Over Temperature Protection

In most applications the MA5003 does not dissipate much heat due to high efficiency. But, in applications where the MA5003 is running at high ambient temperature with low supply voltage and high duty cycles, such as in dropout, the heat dissipated may exceed the maximum junction temperature of the part. If the junction temperature reaches approximately 155°C, the internal high-side power switch will be turned off and the LX node will become high impedance.

Over Current Protection

The MA5003 cycle-by-cycle limits the peak inductor current to protect embedded switch from damage. Hence the maximum output current (the average of inductor current) is also limited. In case the load increases, the inductor current is also increase. Whenever the current limit level is reached, the output voltage cannot be regulated and starting to drop.

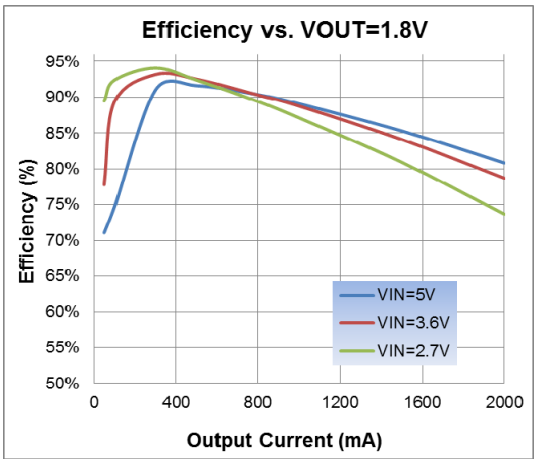
Soft-Start

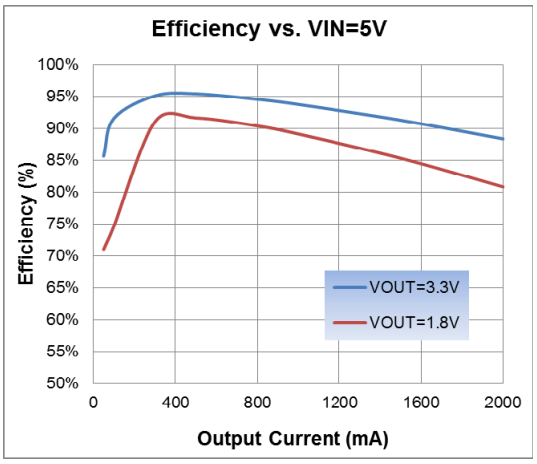
The MA5003 employs internal soft-start circuitry to reduce supply inrush current during startup conditions. When the device exits under-voltage lockout or shut-down mode, the soft-start circuitry will slowly ramp up the output voltage.

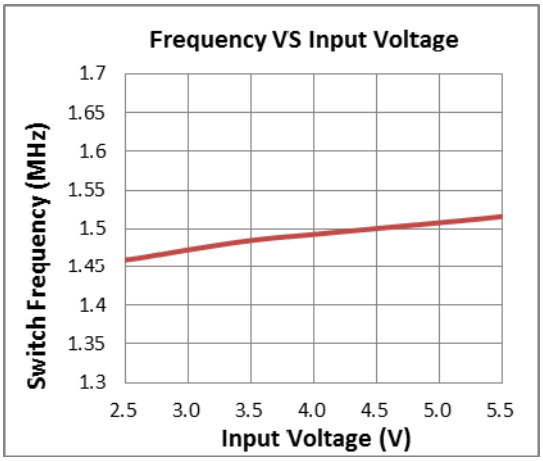
Short-circuit Protection

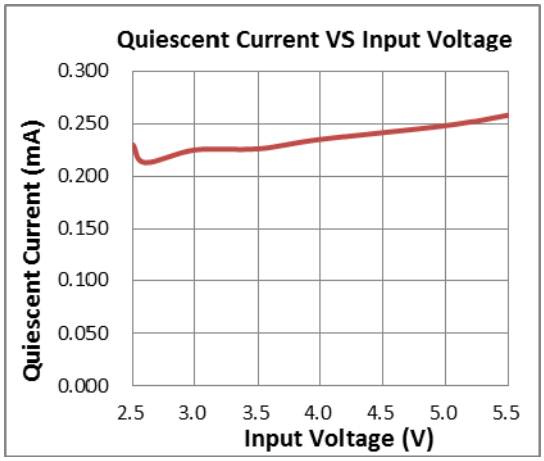
Short-circuit protection will activate once the feedback voltage falls below, and the operating frequency will be reducing normal switching frequency to reduce power delivered from input to output.

❖ TYPICAL CHARACTERISTICS



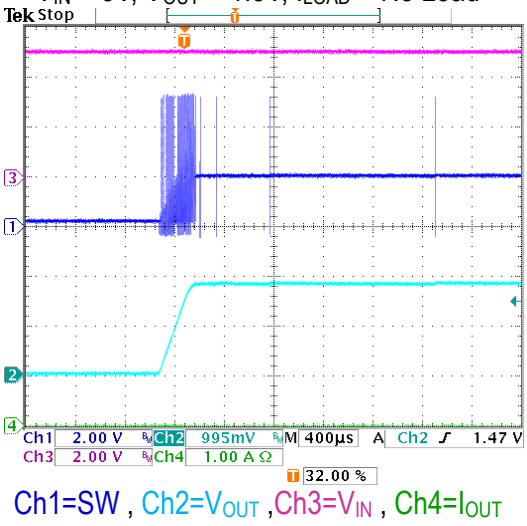






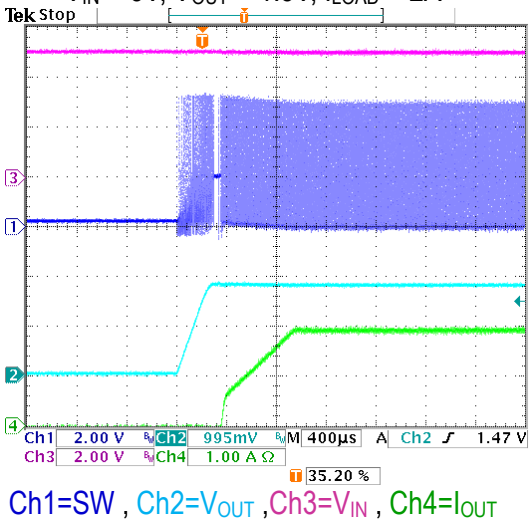
Turn-on from EN

V_{IN} = 5V, V_{OUT} = 1.8V, I_{LOAD} = No Load



Ch1=SW , Ch2=V_{OUT} ,Ch3=V_{IN} , Ch4=I_{OUT}

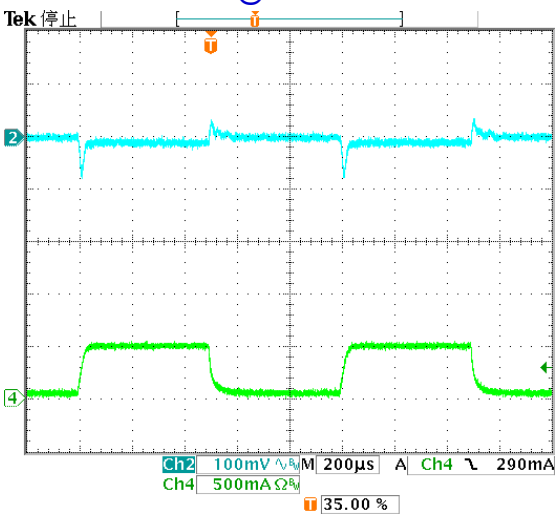
V_{IN} = 5V, V_{OUT} = 1.8V, I_{LOAD} = 2A



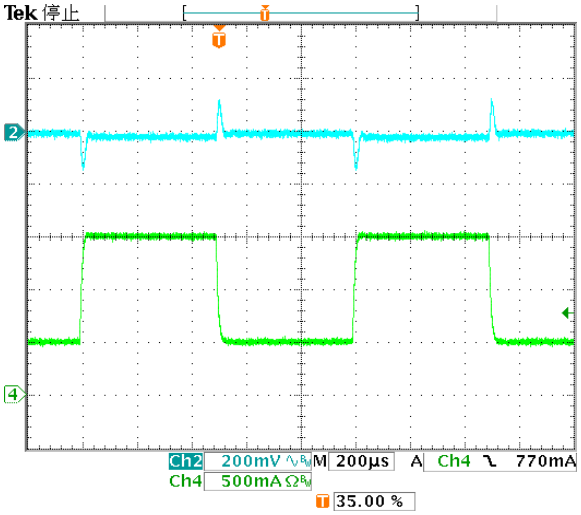
Ch1=SW , Ch2=V_{OUT} ,Ch3=V_{IN} , Ch4=I_{OUT}

Load Transient Response

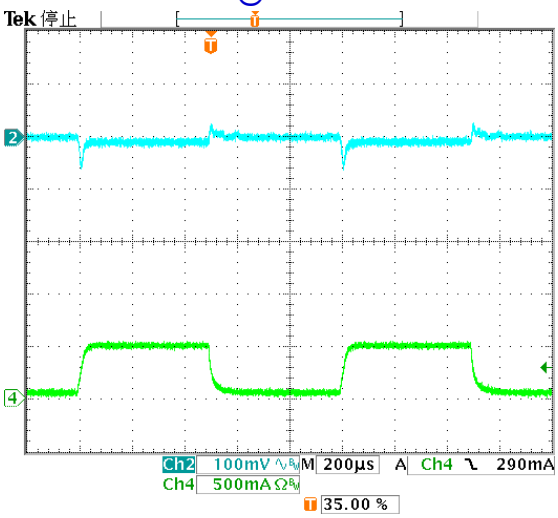
5V→3.3V @50mA→500mA



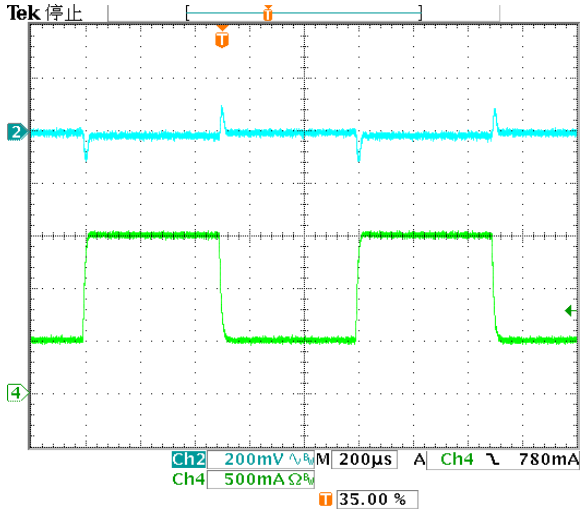
5V→3.3V @500mA→1.5A



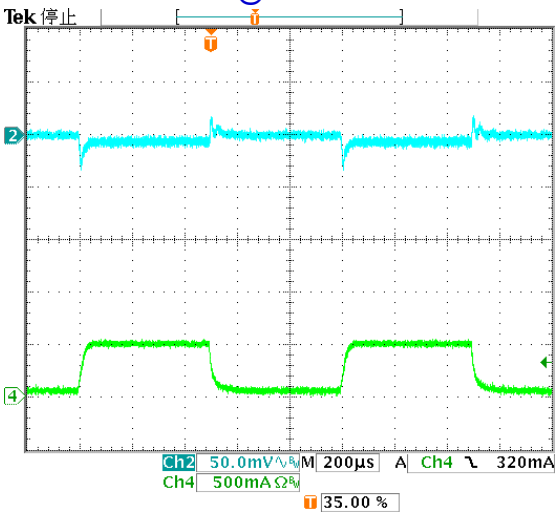
5V→2.5V @50mA→500mA



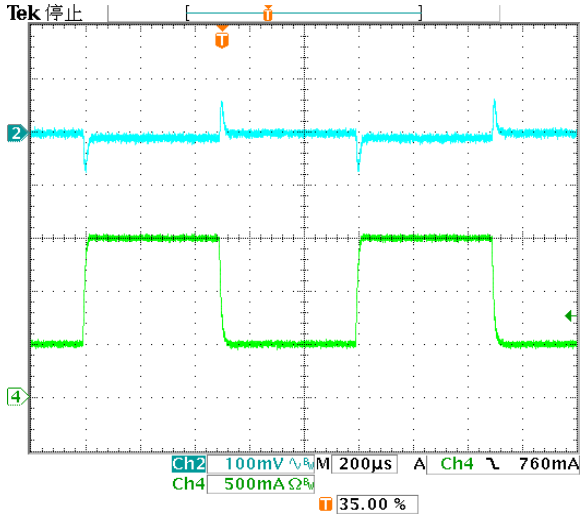
5V→2.5V @500mA→1.5A



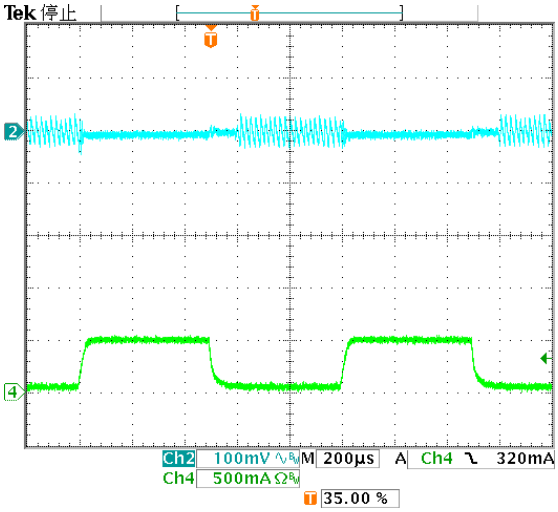
5V→1.8V @50mA→500mA



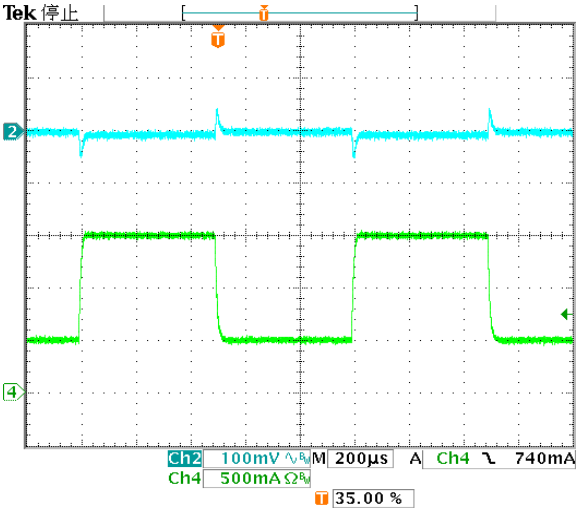
5V→1.8V @500mA→1.5A



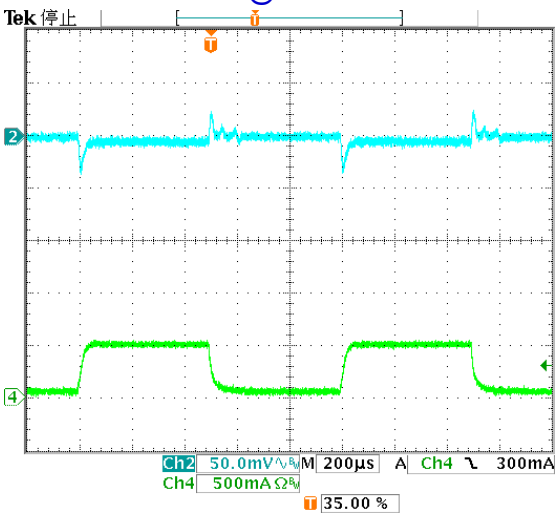
5V→1V @50mA→500mA



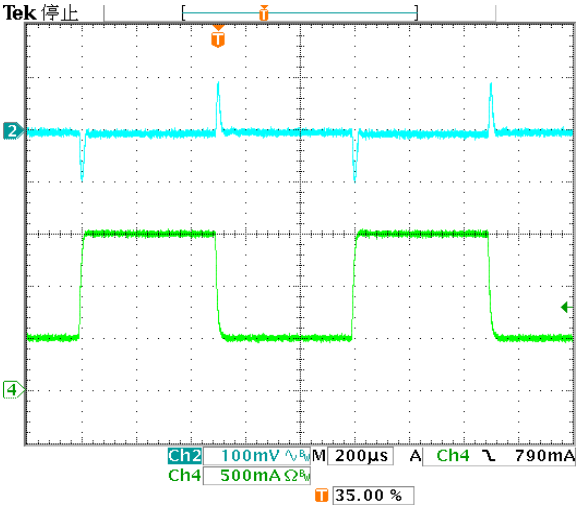
5V→1V @500mA→1.5A



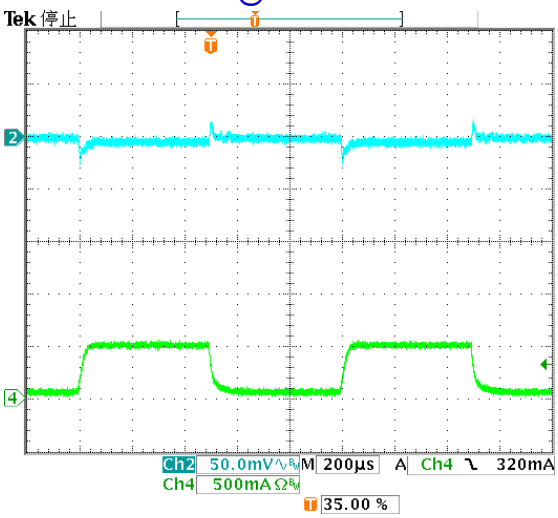
3.3V→1.8V @50mA→500mA



3.3V→1.8V @500mA→1.5A

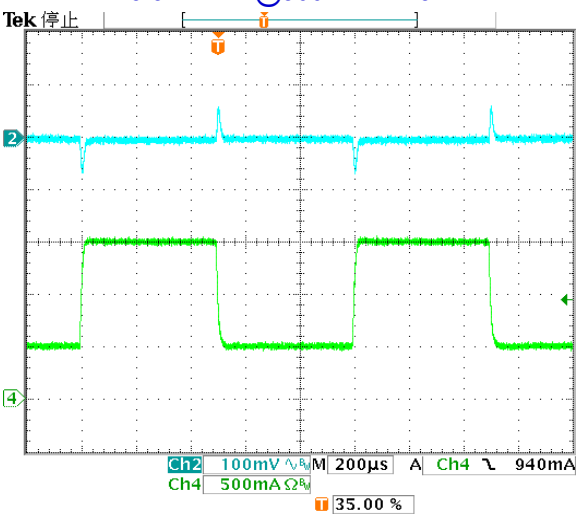


3.3V→1V @50mA→500mA



Ch2=V_{OUT}, Ch4=I_{OUT}

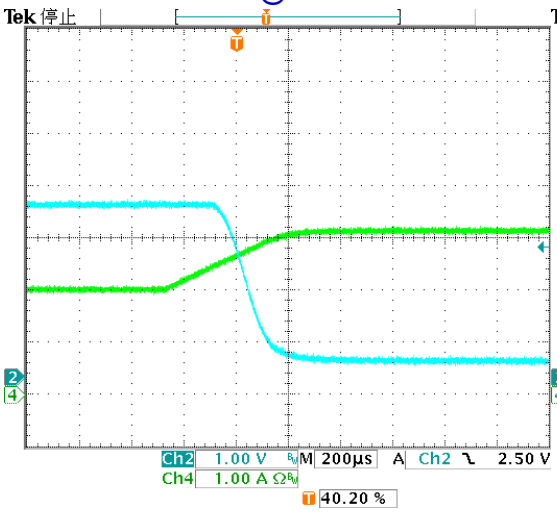
3.3V→1V @500mA→1.5A



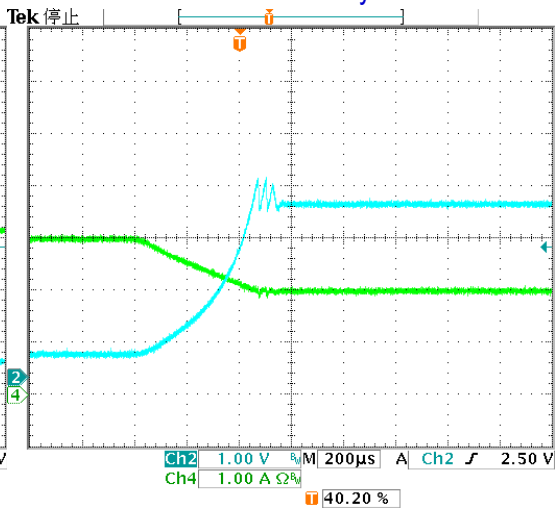
Ch2=V_{OUT}, Ch4=I_{OUT}

Current Limit

5V→3.3V @2A→OCP

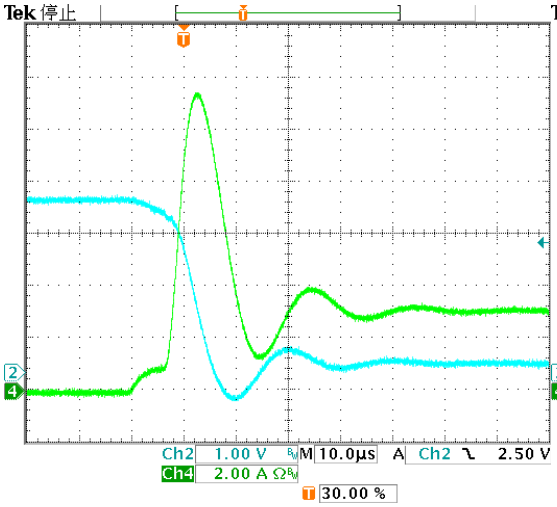


Auto Recovery

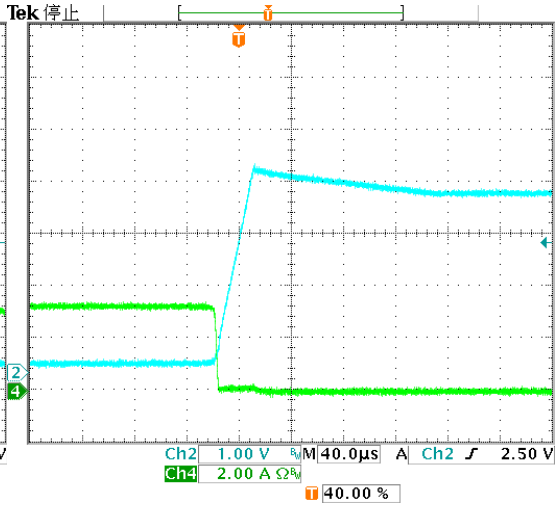


Short-circuit Protection

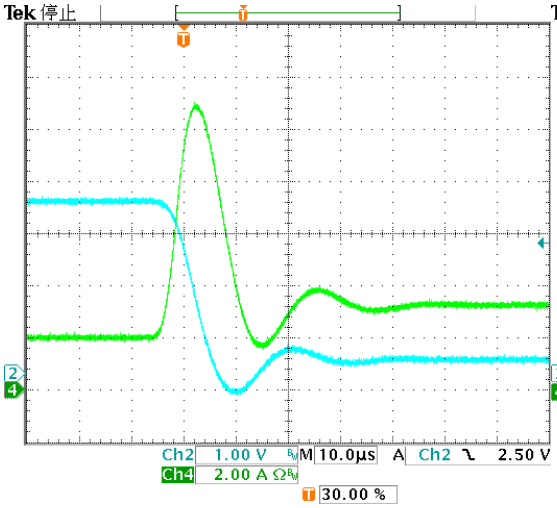
5V→3.3V @0A→SCP



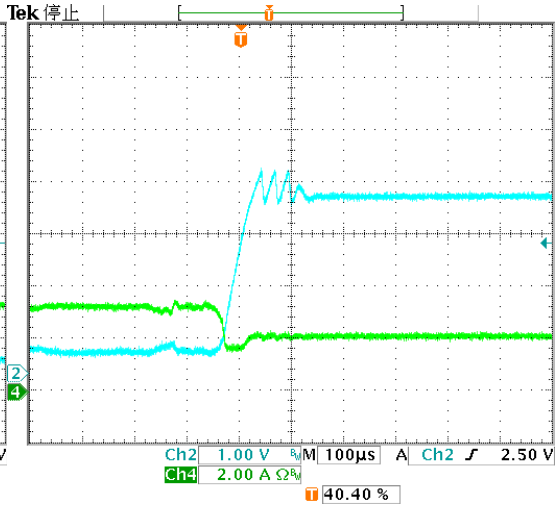
Auto Recovery



5V→3.3V @2A→SCP

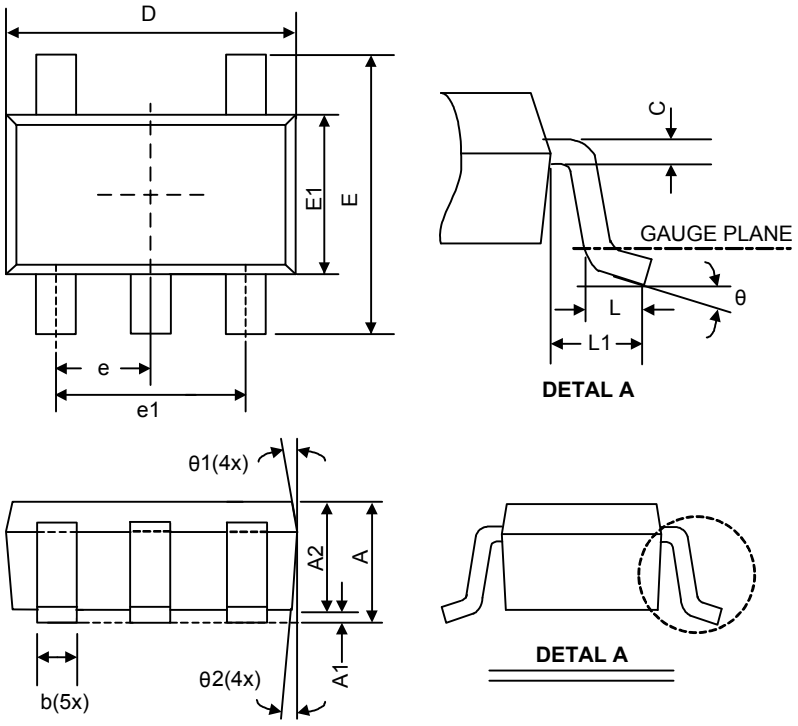


Auto Recovery



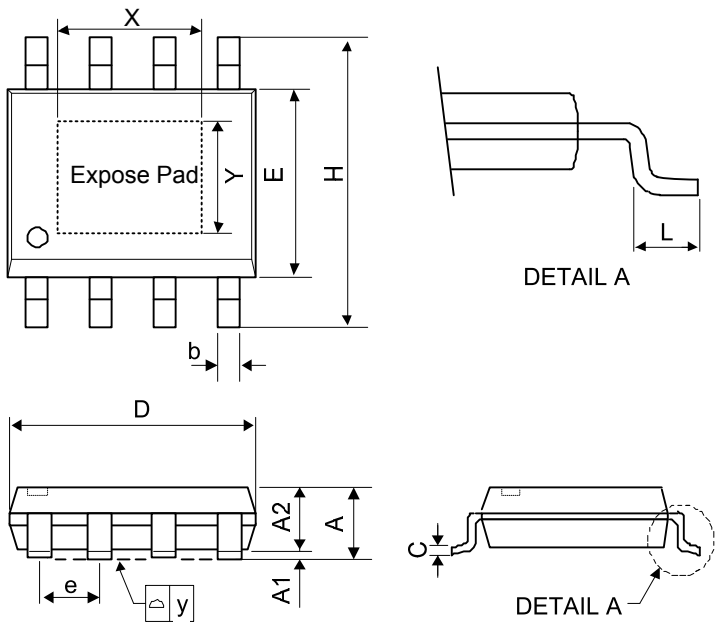
❖ Package Outlines

(1) SOT23-5L



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.05	-	1.35	0.041	-	0.053
A1	0.05	-	0.15	0.002	-	0.006
A2	1.00	1.10	1.20	0.039	0.043	0.047
b	0.30	-	0.50	0.012	-	0.020
C	0.08	-	0.22	0.003	-	0.009
D	2.80	2.90	3.00	0.110	0.114	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
E	2.60	2.80	3.00	0.102	0.110	0.118
L	0.30	-	0.60	0.012	-	0.024
L1	0.50	0.60	0.70	0.020	0.024	0.028
e1	1.80	1.90	2.00	0.071	0.075	0.079
e	0.85	0.95	1.05	0.033	0.037	0.041
θ	0°	4°	8°	0°	4°	8°
θ1	5°	10°	15°	5°	10°	15°
θ2	5°	10°	15°	5°	10°	15°

(2) SOP8-EP



Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.75	-	-	0.069
A1	0	-	0.15	0	-	0.06
A2	1.25	-	-	0.049	-	-
C	0.1	0.2	0.25	0.0075	0.008	0.01
D	4.7	4.9	5.1	0.185	0.193	0.2
E	3.7	3.9	4.1	0.146	0.154	0.161
H	5.8	6	6.2	0.228	0.236	0.244
L	0.4	-	1.27	0.015	-	0.05
b	0.31	0.41	0.51	0.012	0.016	0.02
e	1.27 BSC			0.050 BSC		
y	-	-	0.1	-	-	0.004
X	-	2.34	3.43	-	0.092	0.135
Y	-	2.34	2.54	-	0.092	0.10

Mold flash shall not exceed 0.25mm per side
JEDEC outline: MS-012 BA