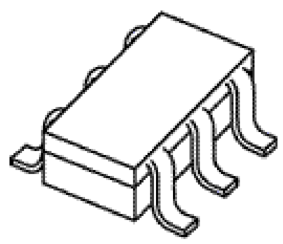
Regulated Charge Pump



Features

- 5V fixed output voltage
- Max. output current: 80mA@ V_{IN}>3.2V
- Power conversion efficiency: 81.8%@V_{IN}=3V, I_{OUT}=60mA
- Input voltage range : 2.8V to 5V
- Over-current protection
- Short-circuit protection
- Thermal shutdown
- RoHS compliant and lead (Pb)-free

Product Description

The MBI6501 is a high performance charge pump DC/DC converter that produces a regulated 5V output voltage. The operating voltage of MBI6501 is ranging from 2.8V to 5V. It is easy to use and no external inductor is required in application.

The MBI6501 features very low quiescent current, over-current protection, thermal shutdown and short-circuit protection. The MBI6501 is available in SOT-23-6 and TSOT-23-6 packages.

Applications

- LED backlight for mobile phone, smart phone
- Camera flash white LED
- Power supply for LCD modules

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Typical Application Circuit

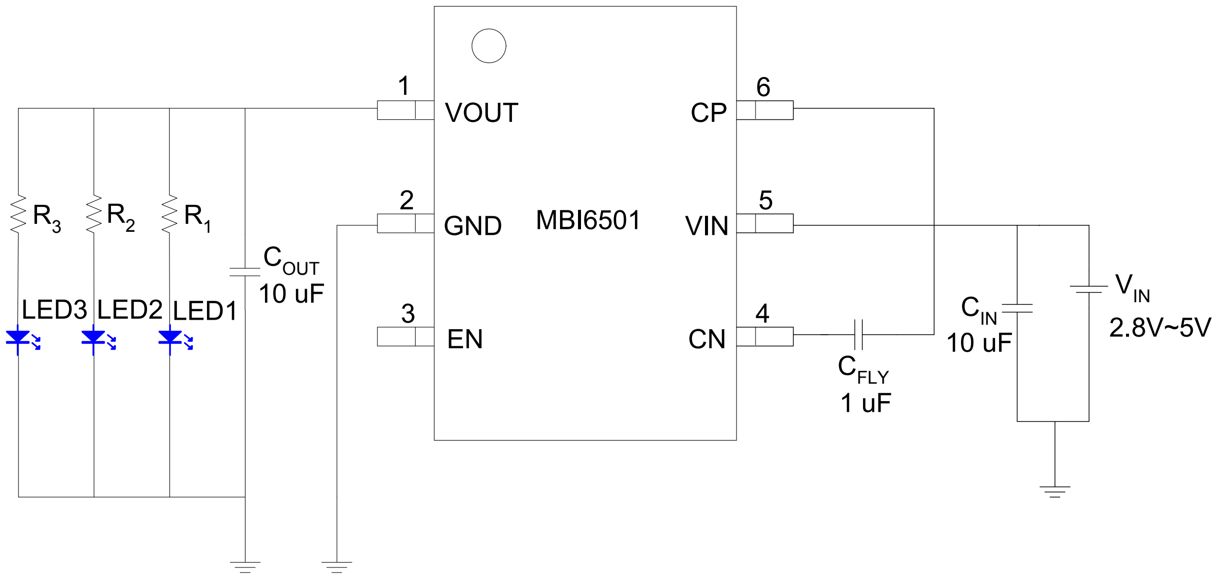


Fig. 1

Functional Diagram

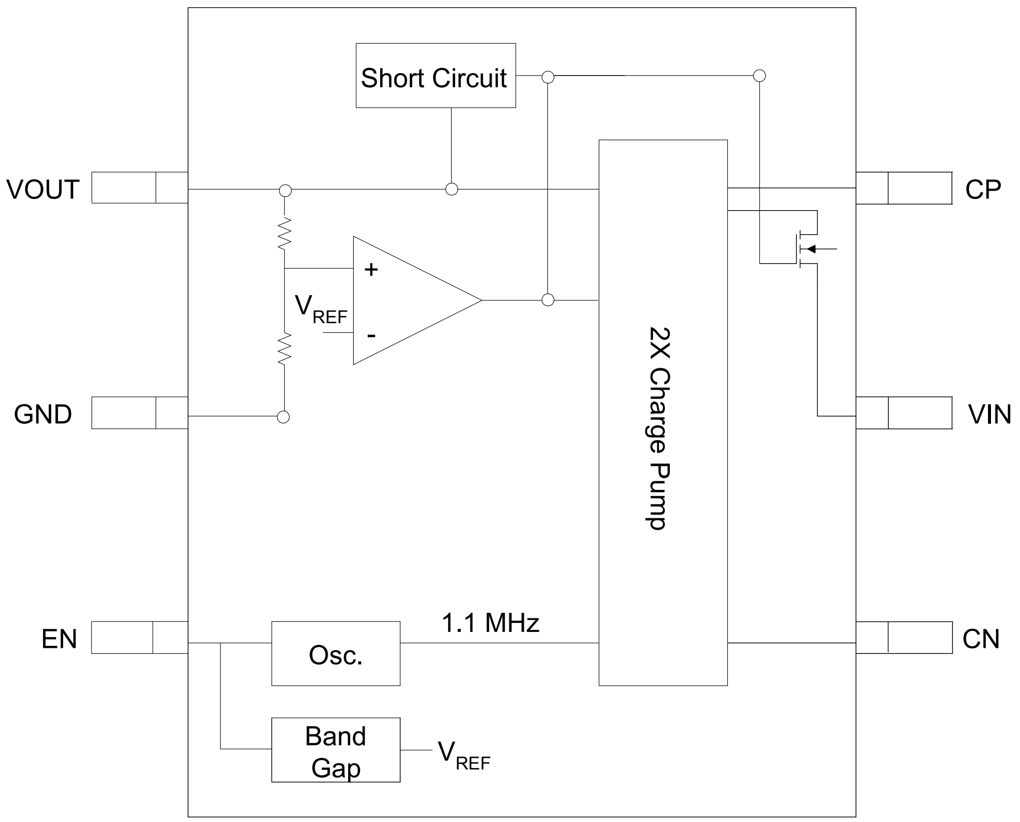
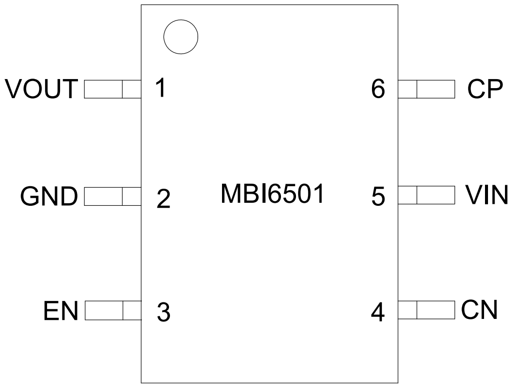


Fig. 2

Pin Configuration



Pin Description

Pin Name	Function
VOUT	Output voltage terminal
GND	Ground terminal for control logic and current sink
EN	Chip enable terminal (high active)
CN	Flying capacitor negative terminal
VIN	Supply voltage terminal
CP	Flying capacitor positive terminal

Maximum Ratings

Characteristics		Symbol	Rating	Unit
Supply Voltage		V_{IN}	-0.3~6V	V
Other I/O Pin Voltage		-	0~6	V
Power Dissipation (By simulation)	GST	P_D	0.51	W
	GTT		0.51	
Thermal Resistance (By simulation)	GST	$R_{th(j-a)}$	244	°C/W
	GTT		244	
Operating Junction Temperature		$T_{j,max}$	150	°C
Operating Temperature		T_{opr}	-40~+85	°C
Storage Temperature		T_{stg}	-55~+150	°C

Electrical Characteristics

(V_{IN}=3.7V, Ta=25°C, unless otherwise specified)

Characteristics		Symbol	Condition	Min.	Typ.	Max.	Unit
Supply Voltage		V_{IN}	V_{OUT}=5V	2.8	-	V_{OUT}	V
Output Voltage		V_{OUT}	V_{IN}>3.2V, I_{OUT}<80mA	4.8	5	5.2	V
Quiescent Current		I_Q	I_{OUT}=0mA, no load	-	2.2	4	mA
Shutdown Current		I_{SHD}	V_{IN}=4.5V, V_{EN}<0.4V	-	0.5	1	uA
Maximum Output Current		I_{OUT}	V_{IN}>3.2V	80	-	-	mA
Over-Current Threshold		I_1	As Fig. 3	-	150	-	mA
Short-Circuit Current Threshold		I_2	As Fig. 4	-	60	-	mA
Output Ripple		-	I_{OUT}=60mA, C_{OUT}=10uF	-	30	-	mV
Operation Frequency		F_{OSC}	-	0.8	1.1	1.3	MHz
Input Voltage of EN pin (Digital)	High Level	V_{IH}	-	1.5	-	-	V
	Low Level	V_{IL}	-	-	-	0.4	V
Thermal Shutdown Junction Temperature Threshold		T_{SHD}	When T_j approaches T_{SHD}.*	-	160	-	°C

*T_j means junction temperature.

Test Circuit for Electrical Characteristics

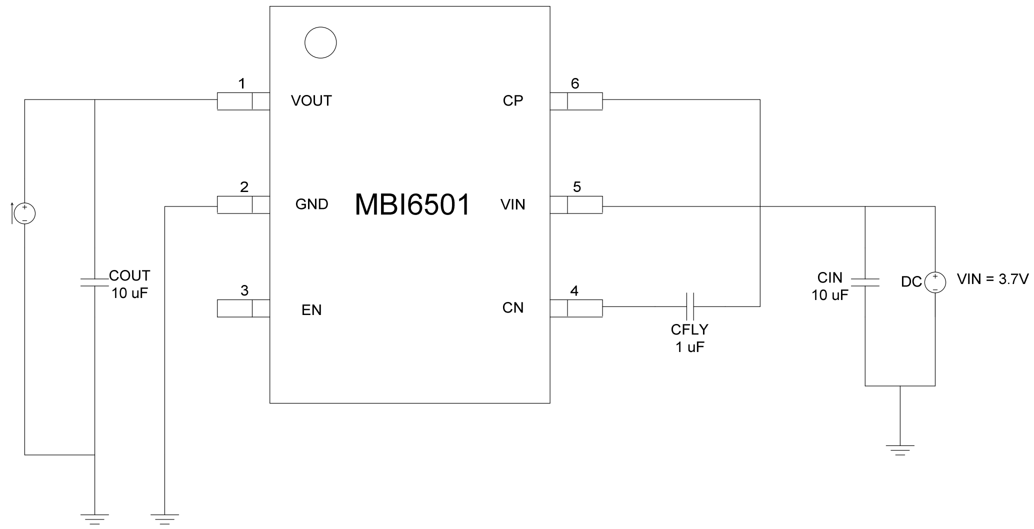


Fig. 3

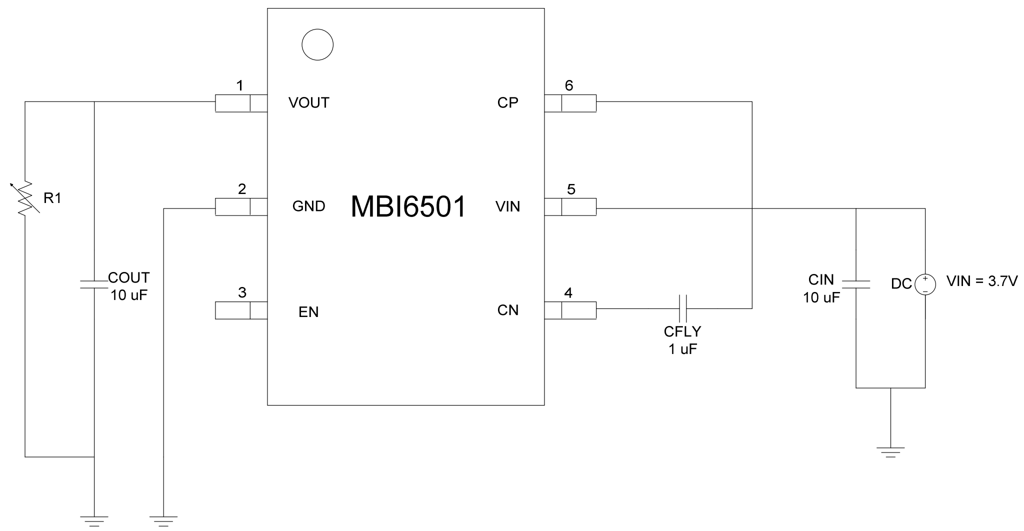


Fig. 4

Typical Operating Characteristics

($C_{IN}=C_{OUT}=10uF$, $C_{FLY}=1uF$, Ta=25°C, unless otherwise specified)

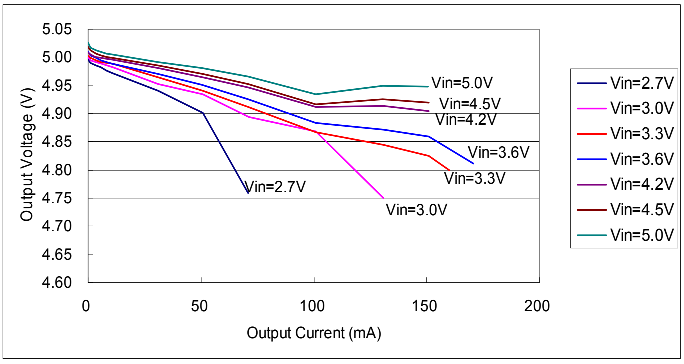


Fig. 5 Output Voltage vs. Output Current ($C_{IN}=C_{OUT}=10uF$, $C_{FLY}=1uF$)

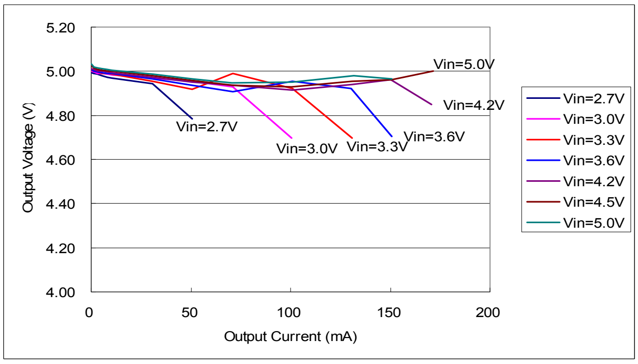


Fig. 6 Output Voltage vs. Output Current ($C_{IN}=C_{OUT}=1uF$, $C_{FLY}=0.1uF$)

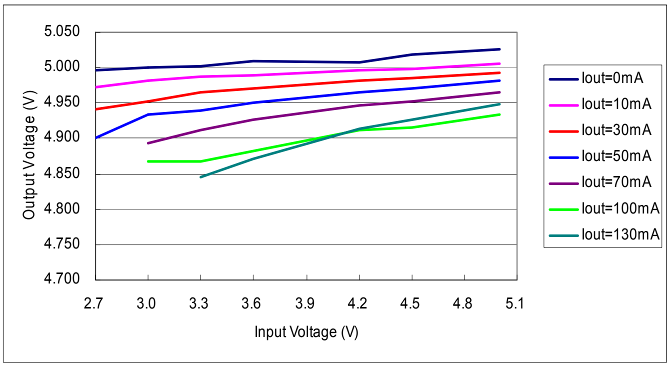


Fig. 7 Output Voltage vs. Input Voltage ($C_{IN}=C_{OUT}=10uF$, $C_{FLY}=1uF$)

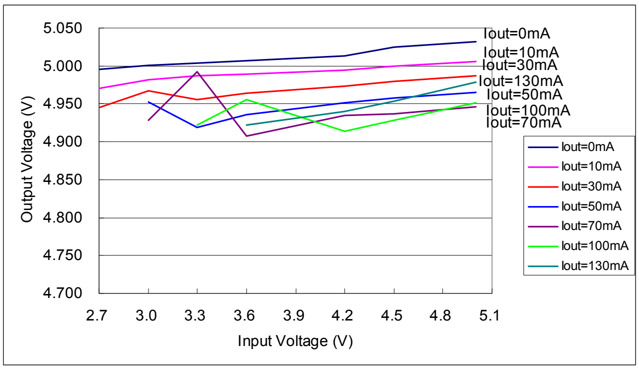


Fig. 8 Output Voltage vs. Input Voltage ($C_{IN}=C_{OUT}=1uF$, $C_{FLY}=0.1uF$)

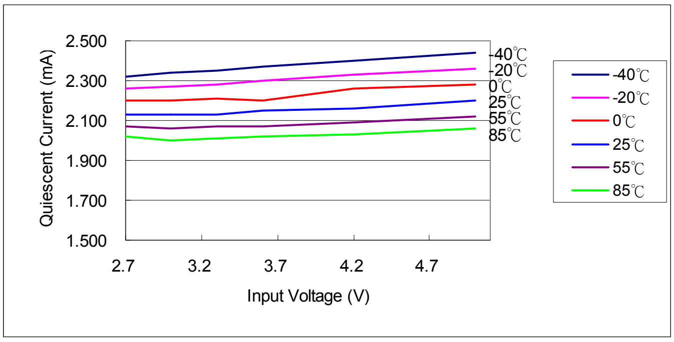


Fig. 9 Quiescent Current vs. Input Voltage

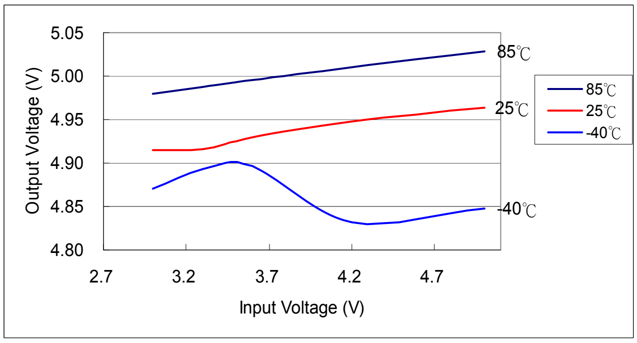


Fig. 10 Output Voltage vs. Input Voltage ($I_{OUT}=60mA$)

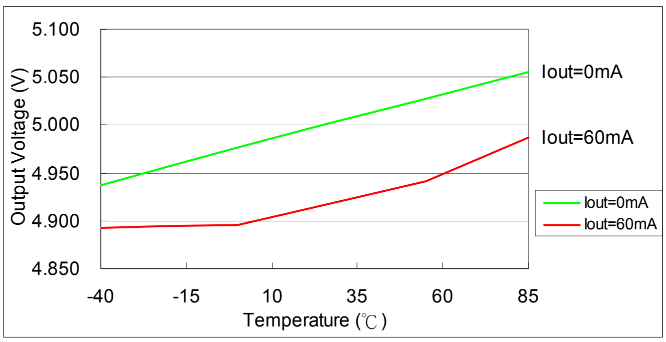


Fig. 11 Output Voltage vs. Temperature ($V_{IN}=3.3V$)

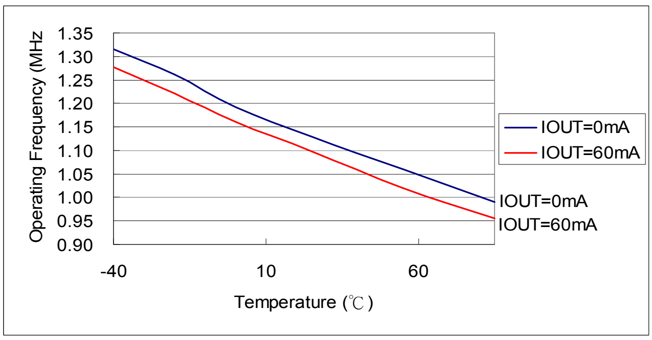


Fig. 12 Operating Frequency vs. Temperature ($V_{IN}=3.7V$)

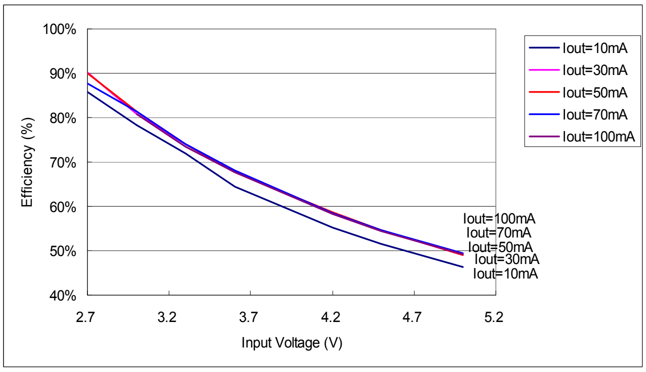


Fig. 13 Efficiency vs. Input Voltage

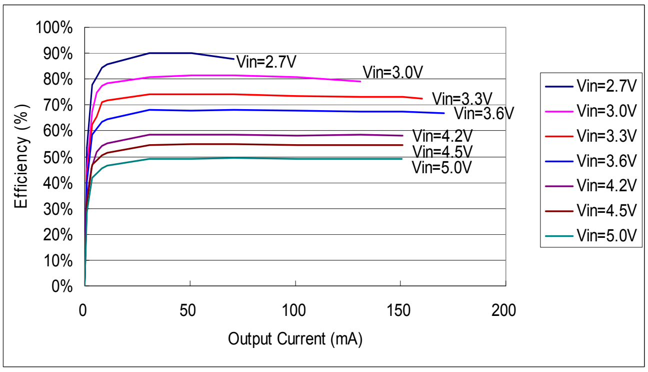


Fig. 14 Efficiency vs. Output Current

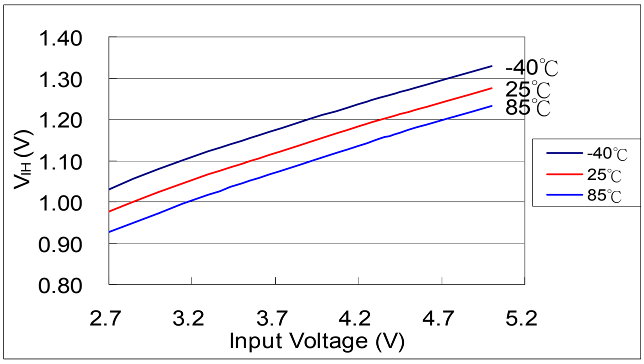


Fig. 15 V_{IH} vs. Input Voltage

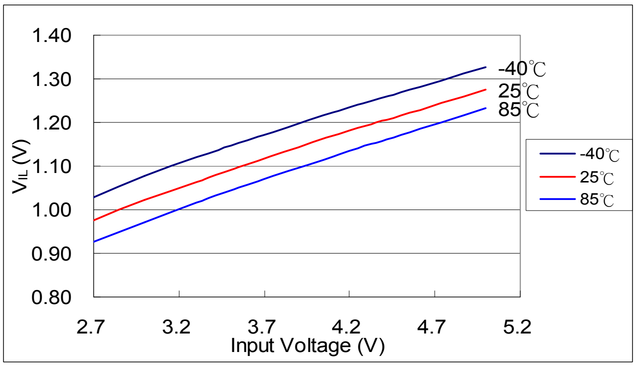


Fig. 16 V_{IL} vs. Input Voltage

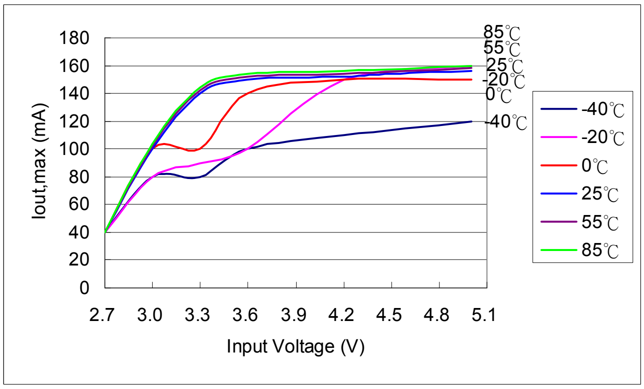


Fig. 17 Maximum Output Current vs. Input Voltage

Switching Characteristics

(C_{IN}=C_{OUT}=10uF, C_{FLY}=1uF, Ta=25°C, unless otherwise specified)

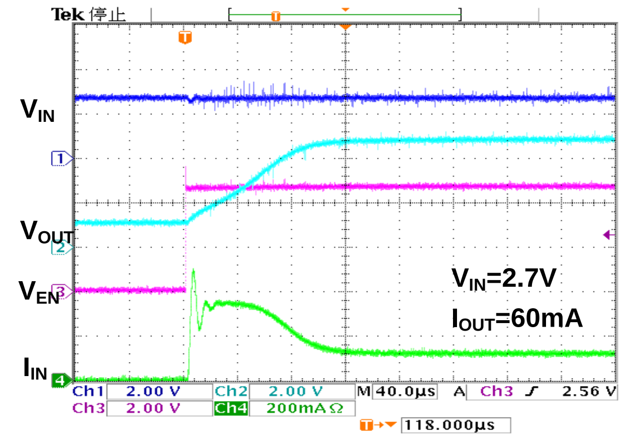


Fig. 18 Inrush Current (V_{IN}=2.7V, I_{OUT}=60mA)

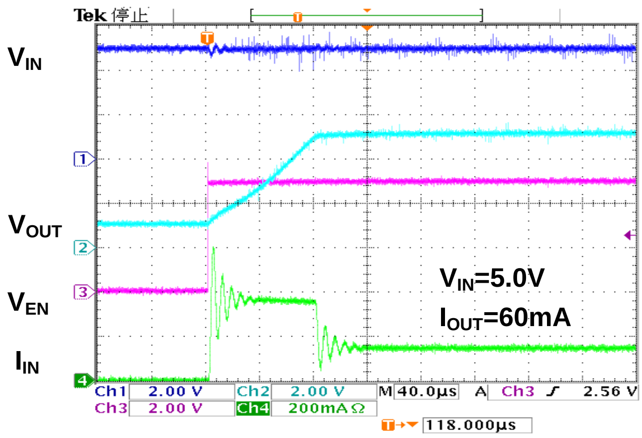


Fig. 19 Inrush Current (V_{IN}=5.0V, I_{OUT}=60mA)

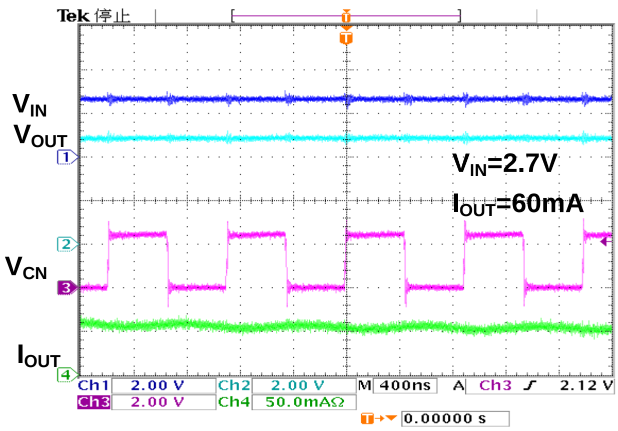


Fig. 20 Normal Operation

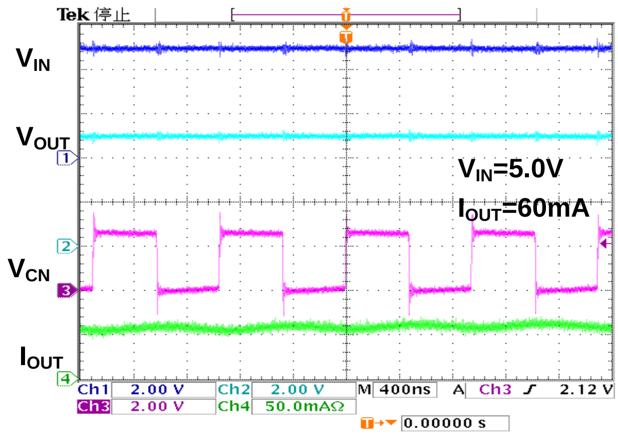


Fig. 21 Normal Operation

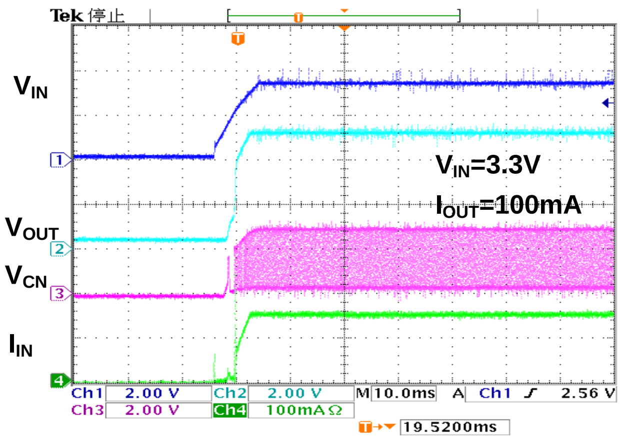


Fig. 22 Start-Up Waveform (V_{IN}=3.3V, Iout=100mA)

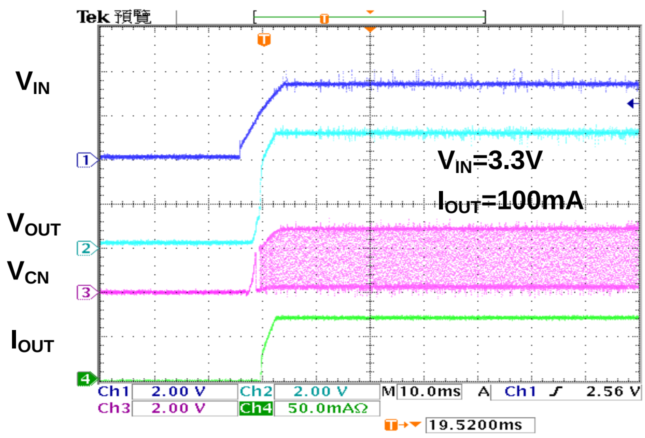


Fig. 23 Start-Up Waveform (V_{IN}=3.3V, Iout=100mA)

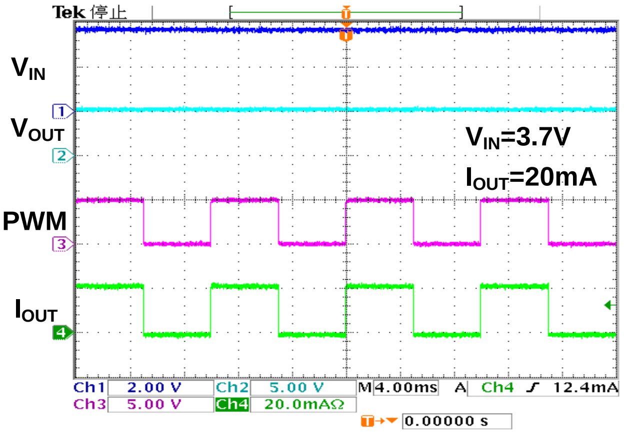


Fig. 24 Dimming Operation (Refer to Fig. 26)

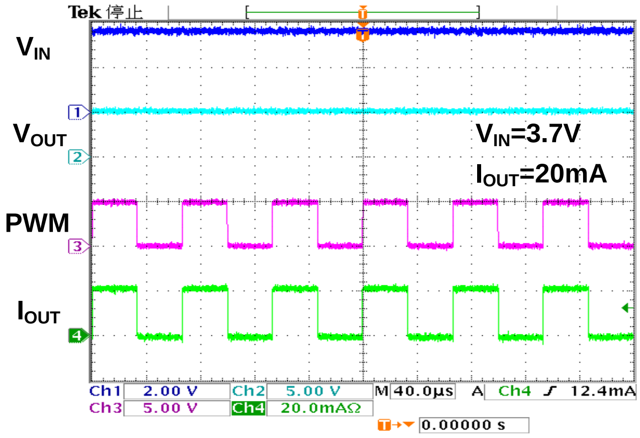


Fig. 25 Dimming Operation (Refer to Fig. 26)

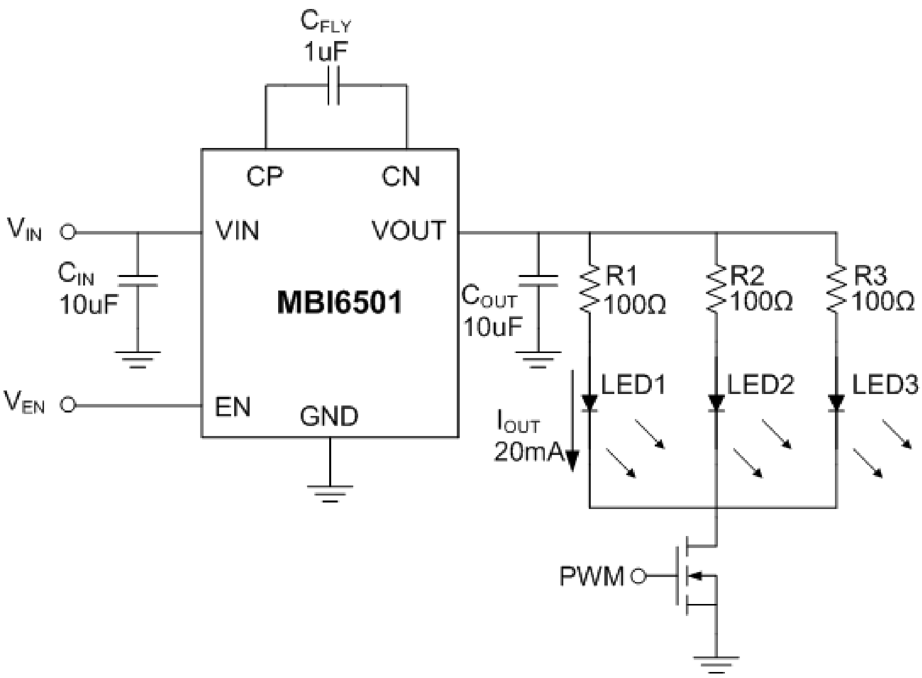


Fig. 26 Application circuit for backlight dimming

Application Information

The MBI6501 uses a switched capacitor charge pump to boost V_{IN} to a regulated output voltage. Regulation is achieved by sensing the output voltage through a voltage divider and modulating the charge pump output current according to the error signal. A 2-phase non-overlapping clock activates the charge pump switches. The flying capacitor is charged from V_{IN} on the first phase of the clock. On the second phase of the clock, the flying capacitor is stacked in series with V_{IN} and connected to V_{OUT}. This sequence of charging and discharging the flying capacitor continues at a free running frequency of 1.1MHz (typ.).

Shutdown Mode

The MBI6501 is in the shutdown mode when a logic “0” is applied to the EN pin. In the shutdown mode, all circuitry is turned off and the MBI6501 draws only leakage current from the V_{IN} supply. Furthermore, V_{OUT} is disconnected from V_{IN}. The EN pin is a CMOS input with a threshold voltage of approximately 0.4V. Since the EN pin is a very high impedance CMOS input, it should never be allowed to float. To ensure that its state is defined, it must always be driven with a valid voltage level.

Over-Current Protection (I_1)

In normal operation, the charging of the pump and output capacitors usually leads to relatively high peak input currents which can be much higher than that of the average load current. The MBI6501 has built in over-current circuit to limit the output peak current can not exceed 150mA, lowering the total EMI production of the device and lowering output voltage ripple and input current ripple.

Short-Circuit Protection (I_2)

The MBI6501 has built in short-circuit current protection to prevent output voltage can’t reach 5V at short-circuit condition. During a short-circuit condition, the MBI6501 will automatically limit its output current I_2 to 60mA.

Thermal Shutdown (T_{SHD})

At higher temperatures, or if the input voltage is high enough to cause excessive self-heating of the part, the thermal shutdown circuitry will shut down the charge pump once the junction temperature exceeds 160°C (typ.). The charge pump resumes working once the junction temperature is below 140°C (typ.). The MBI6501 will cycle in and out of thermal shutdown indefinitely without latch-up or damage.

Power Conversion Efficiency

The power conversion efficiency of the MBI6501 is similar to that of a linear regulator with an effective input voltage of twice the actual input voltage. This occurs because the input current for a voltage doubling charge pump is approximately twice the output current. In an ideal regulating voltage doubling the power efficiency would be given by:

Efficiency (%)=$P_{OUT}/P_{IN}=V_{OUT}*I_{OUT}/V_{IN}*I_{OUT}*2=V_{OUT}/(2*V_{IN})$

At moderate to high output power, the switching losses and the quiescent current of the MBI6501 are negligible and the expression above is valid. For example, with V_{IN}=3V, I_{OUT}=60mA and V_{OUT} regulating to 5V, the measured efficiency is 81.8% which is in close agreement with the theoretical 83.3% calculation.

Dimming for Backlight

With additional MOSFET, MBI6501 can easily perform dimming function for backlight application. Please refer Fig. 26, the application circuit. Fig. 24 and 25 shown the results when apply different frequency of PWM signals to control the MOSFET

External Capacitor Selection

Three external capacitors, C_{IN}, C_{OUT} and C_{FLY}, determine the MBI6501 performances. Optimum performance can be obtained by using a low-ESR ceramic capacitors. Due to high ESR, tantalum and aluminum capacitors are not recommended for charge pump application. To reduce noise and ripple, a low-ESR ceramic capacitor is recommended for C_{IN} and C_{OUT}. The value of C_{OUT} determines the amount of output ripple voltage. An output capacitor with larger value results in smaller ripple. C_{FLY} is critical for the charge pump. The larger C_{FLY} is, the larger output current and smaller ripple voltage obtain. However, large C_{IN} and C_{OUT} are required when large C_{FLY} is applied. C_{IN} : C_{FLY} and C_{OUT} : C_{FLY} should be approximately 10:1.

Layout Considerations

Due to the switching frequency and high transient current of the MBI6501, careful consideration of PCB layout is necessary. To achieve the best performance of the MBI6501, minimize the distance between every two components and also minimize every connection length with a maximum trace width.

Package Heat Dissipation (PD)

The maximum package heat dissipation, $P_D(max)=(Tj–Ta)/R_{th(j-a)}$, decreases as the ambient temperature increases. In addition, the GST and GTT share the same curve of power dissipation versus ambient temperature.

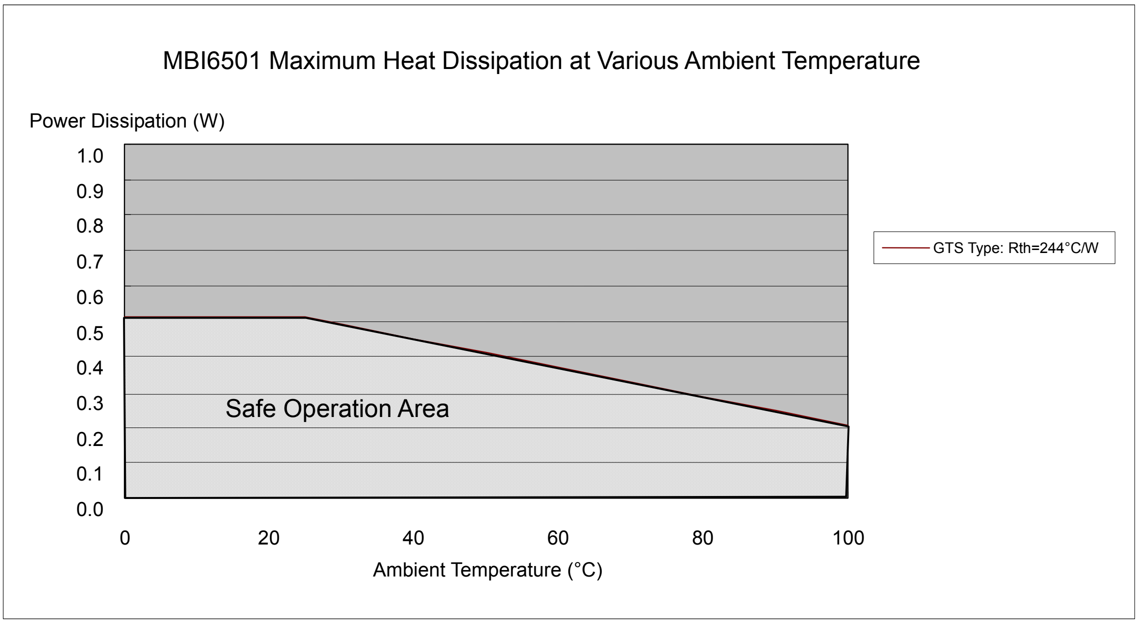
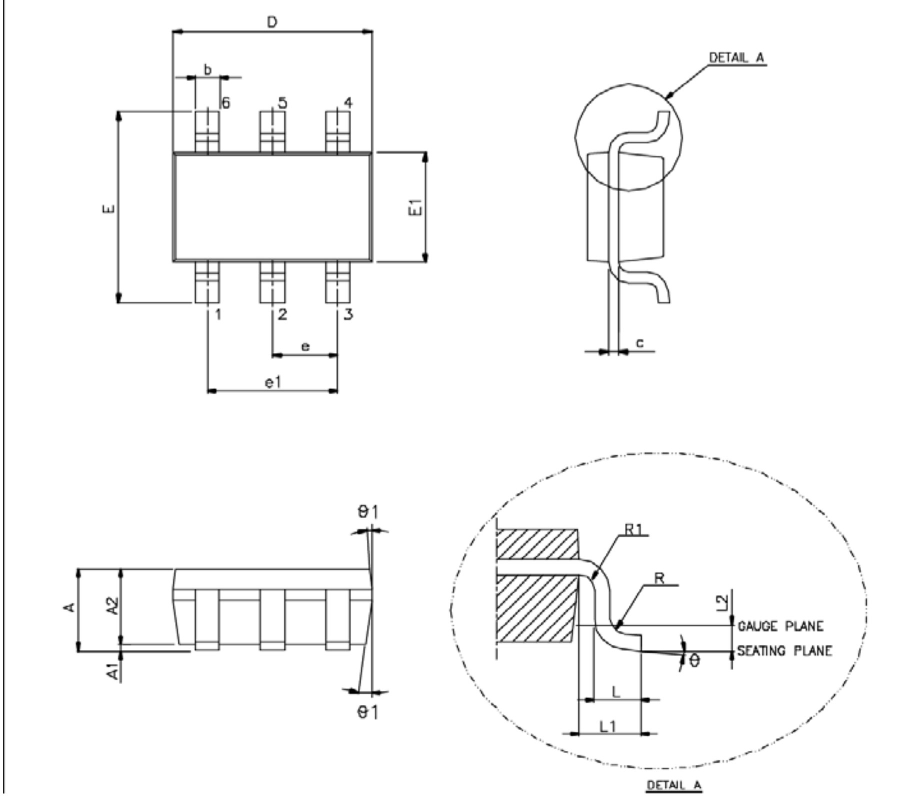


Fig. 27

Outline Drawing



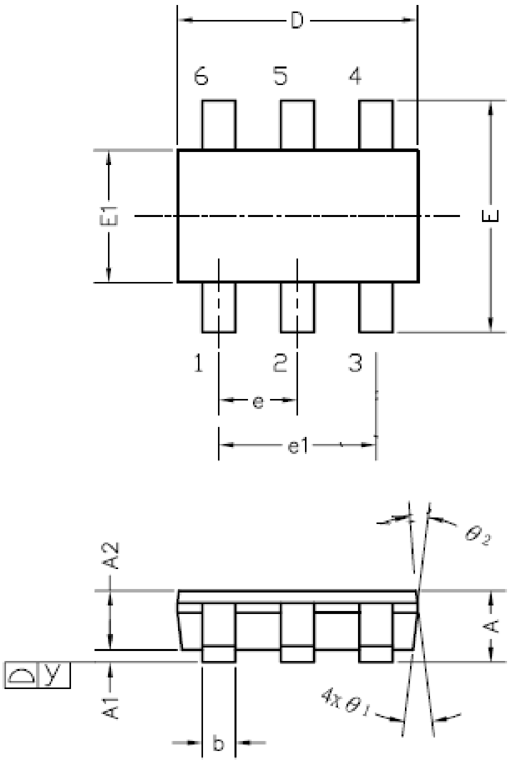
VARIATION (ALL DIMENSIONS SHOWN IN MM)

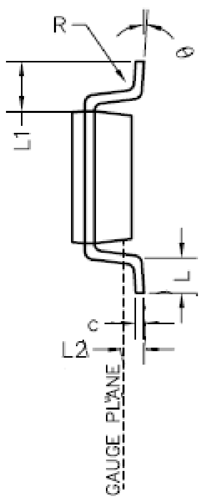
SYMBOL	MIN.	NOM.	MAX.
A	–	–	1.45
A1	–	–	0.15
A2	0.90	1.15	1.30
b	0.30	–	0.50
c	0.08	–	0.22
D	2.90 BSC.		
E	2.80 BSC.		
E1	1.60 BSC.		
e	0.95 BSC		
e1	1.90 BSC.		
L	0.30	0.45	0.60
L1	0.60 REF.		
L2	0.25 BSC.		
R	0.10	–	–
R1	0.10	–	0.25
θ	0°	4°	8°
θ1	5°	10°	15°

NOTE : 1.JEDEC OUTLINE : MO–178 AB

MBI6501GST Outline Drawing

Note: The unit for the outline drawing is mm.



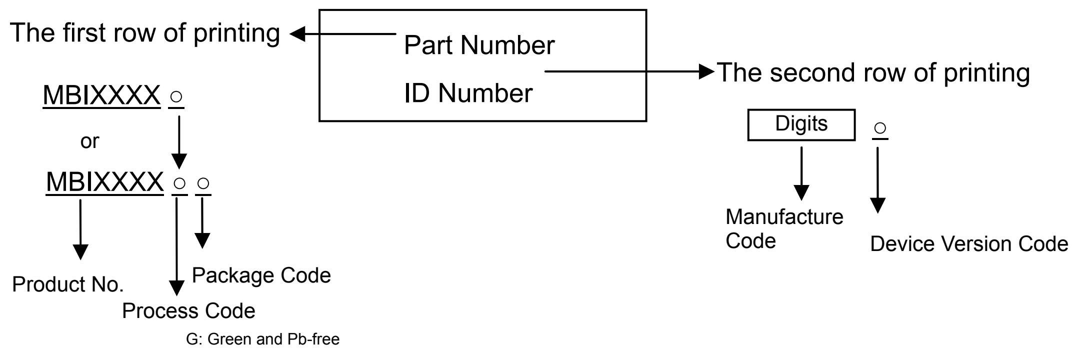


Symbol	inch			mm		
	Min	Nom	Max	Min	Nom	Max
A	0.030	-	0.035	0.75	-	0.90
A1	0.000	-	0.004	0.00	-	0.10
A2	0.028	0.030	0.031	0.70	0.75	0.80
b	0.014	-	0.020	0.35	-	0.51
c	0.004	-	0.010	0.10	-	0.25
D	0.110	0.114	0.118	2.80	2.90	3.00
E	0.102	0.110	0.118	2.60	2.80	3.00
E1	0.059	0.063	0.067	1.50	1.60	1.70
e	0.0374 BSC			0.95 BSC		
e1	0.0748 BSC			1.90 BSC		
L	0.015	-	-	0.37	-	-
L1	0.0236 REF			0.60 REF		
L2	0.0098 BSC			0.25 BSC		
y	-	-	0.004	-	-	0.10
R	0.004	-		0.10	-	-
θ	0°	-	8°	0°	-	8°
θ1	7° NOM			7° NOM		
θ2	5° NOM			5° NOM		

Note:
1. Dimension D does not include mold flash, protrusions or tate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.10 mm PER end. Dimension E1 does not include interlead flash or protrusion. Interlead flash or protrusion shall not exceed 0.15 mm PER side.
2. The package top may be smaller than the package bottom. Dimensions D and E1 are determined at the outermost extremes of the plastic body exclusive of mold flash, tie bar burrs, gate burrs and interlead flash, but including any mismatch between the top and bottom of the plastic body.

MBI6501GTT Outline Drawing

Product Top Mark Information



Product Revision History

Datasheet Version	Device Version Code
V1.00	A
V1.01	A
V1.02	A
V1.03	A

Product Ordering Information

Product Number	Green Package Type	Weight (g)
MBI6501GST	SOT-23-6L	0.016
MBI6501GTT	TSOT-23-6L	0.0128

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