

Features

- 95% Efficient possible DC/DC Converter
- Built-in LED Driver and Open LED Overvoltage Protection
- Transformerless Inverting Controller for CCD Bias
- 2 Channel Built-in MOSFET Current- Mode PWM and 4 Channel Extra PWM Controllers (CH-3 Synchronous Output)
- Up to 1MHz Operating Frequency
- Shutdown Current <1uA
- Built-in Soft-Start Function
- Built-in Short-Circuit Protection Function
- QFN48 Package

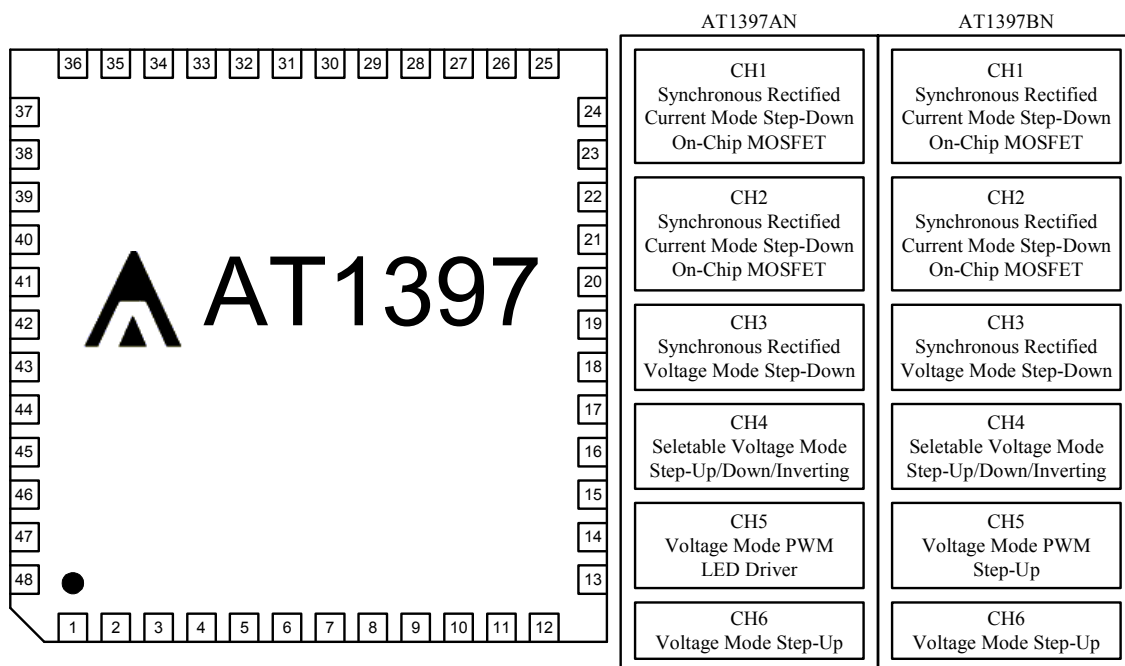
General Description

The AT1397A/B provide a complete power supply solution for digital cameras. They improve performance, component count, and size compared to other multi-channel controllers in 1-cell Li-Ion designs. On-chip MOSFETs provide up to 92~95% efficiency for critical power supplies, while additional channels operate with external FETs for optimum design flexibility. All channels DC/DC operate at one fixed frequency settable from 100KHz to 1MHz to optimize size, cost, and efficiency.

Applications

- DSC Power Supply

Pin Assignment



Ordering Information

Part Number	Package	Marking
AT1397□N	QFN48,Green	□□□□□□

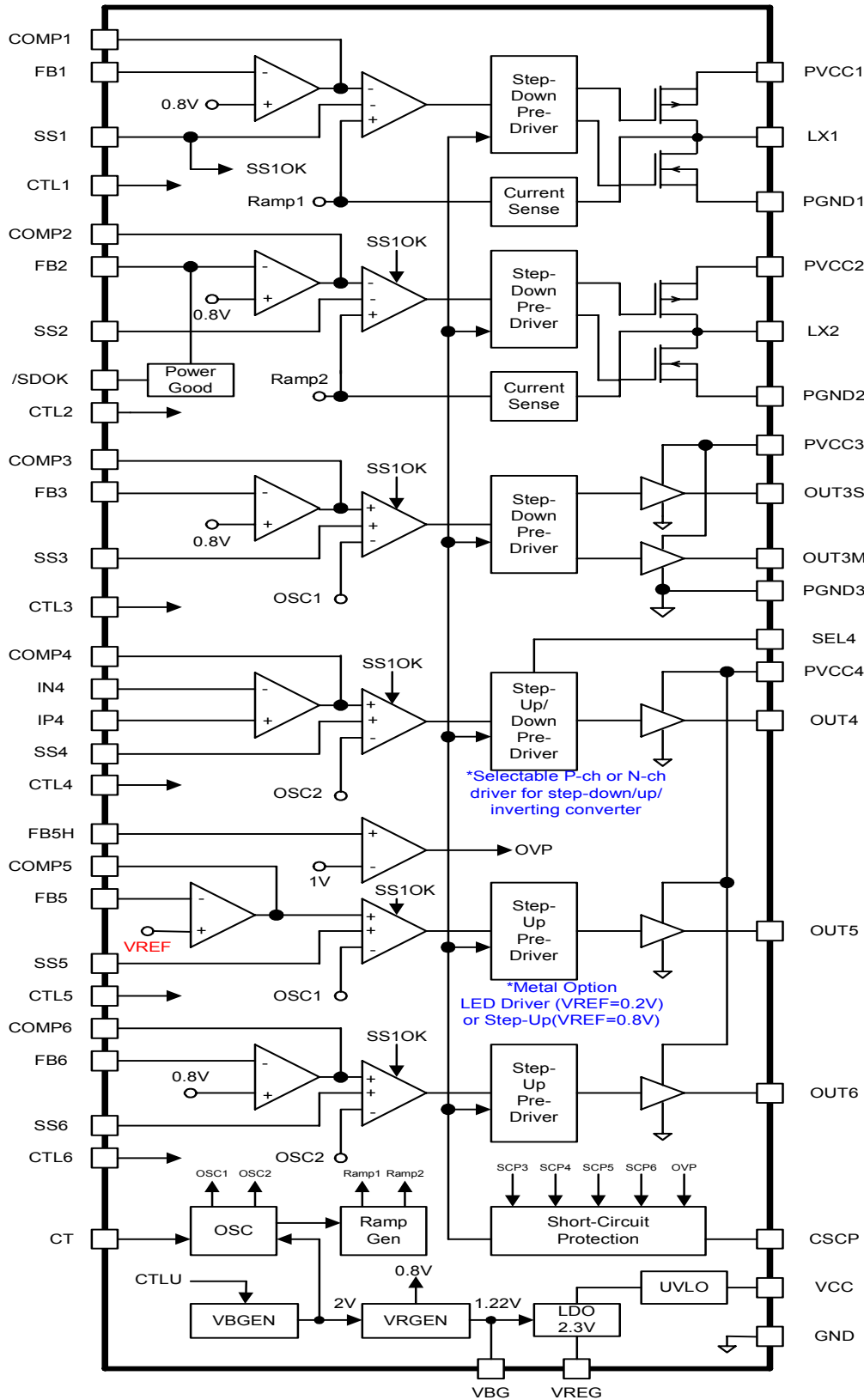
□ : A:1397AN B:1397BN

□□□□□□ : Date Code

*For more marking information, contact our sales representative directly.

Aimtron reserves the right without notice to change this circuitry and specifications.

Block Diagram



Pin Description

Symbol	Pin No.	Descript
SS1	1	CH1 Soft-Start Input
CTL5	2	CH5 Enable Input
CTL6	3	CH6 Enable Input
LX1	4	CH1 Converter Switching Node
CTL1	5	CH1 Enable and Chip Enable Input
PGND1	6	Power Ground
PGND2	7	Power Ground
CTL2	8	CH2 Enable Input
LX2	9	CH2 Converter Switching Node
CTL3	10	CH3 Enable Input
CTL4	11	CH4 Enable Input
SS2	12	CH2 Soft-Start Input
/SDOK	13	Open-Drain, Active Low, Power Good for CH2
CSCP	14	Short Circuit Protection Input
PVCC2	15	CH2 Converter Input
COMP2	16	CH2 Controller Compensation Node
FB2	17	CH2 Converter Feedback Input
SS3	18	CH3 Soft-Start Input
COMP3	19	CH3 Compensation Node
FB3	20	CH3 Feedback Input
SS4	21	CH4 Soft-Start Input
COMP4	22	CH4 Compensation Node
IN4	23	CH4 Negative Feedback Input
IP4	24	CH4 Positive Feedback Input
PVCC3	25	CH3 Power Input
OUT3M	26	CH3 Master Output Driver
OUT3S	27	CH3 Slave Output Driver
PGND3	28	Power Ground
OUT4	29	CH4 Output Driver
OUT5	30	CH5 Output Driver
OUT6	31	CH6 Output Driver
PVCC4	32	CH4, CH5 and CH6 Power Input
GND	33	Power Ground
FB5H	34	CH5 Controller Over Voltage Protection Input
FB5	35	CH5 Controller Voltage Feedback/Current Feedback
COMP5	36	CH5 Compensation Node
VBG	37	Reference Bypass
SS5	38	CH5 Soft-Start Input
FB6	39	CH6 Feedback Input
COMP6	40	CH6 Compensation Node
CT	41	Oscillator Control
VREG	42	Reference Output
FB1	43	CH1 Converter Feedback Input
COMP1	44	CH1 Controller Compensation Node
VCC	45	IC Power Input
PVCC1	46	CH1 Converter Input
SS6	47	CH6 Soft-Start Input
SEL4	48	Configures the CH4 as a Step-Up or Step-Down

Absolute Maximum Ratings*1

Parameter	Symbol	Rated Value		Units
		Min.	Max.	
Storage Temperature	T _{STG}	-55	150	°C
Operating Temperature T _A	T _{OPR}	-35	85	°C
PVCC1,PVCC2,PVCC3,PVCC4 Input Voltage	-	-0.3	6.0	V
LX1,LX2, OUT3M,OUT3S Input Voltage	V _{LX/OUT}	-0.3	6.0	V
Other Input Pin	-	-0.3	6.0	V
LX1, LX2 Current	-	-	2.25	A
OUT3M,OUT3S Current	-	-	200	mA
ESD Susceptibility*2	HBM	-	2	KV
	MM	-	200	V
Power Consumption	Pd	-	1000	mW

1. Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
2. Device are ESD sensitive. Handling precaution recommended. The Human Body model is a 100pF capacitor discharged through a 1.5KΩ resistor into each pin.

Recommended Operating Conditions

(T_a=+25°C)

Parameter	Symbol	Value			Unit
		Min	Typ	Max	
Startup power supply voltage	V _{CC}	2.5	--	5.5	V
Power supply voltage	PVCC	2.5	--	5.5	V
Feedback input voltage	V _{IN}	0	--	V _{CC} -2	V
Control input voltage	V _{CTL}	0	--	V _{CC}	V
Soft start capacitor	C _{SS}	--	0.1	1.0	μF
Short Circuit Protection Capacitor	C _{SCP}	--	0.1	1.0	μF
VREG pin capacitor	C _{VREG}	0.082	0.1	--	μF
Operating ambient temperature*	T _A	-20	25	85	°C

*Using X5R or X7R input capacitors.

Electrical Characteristics

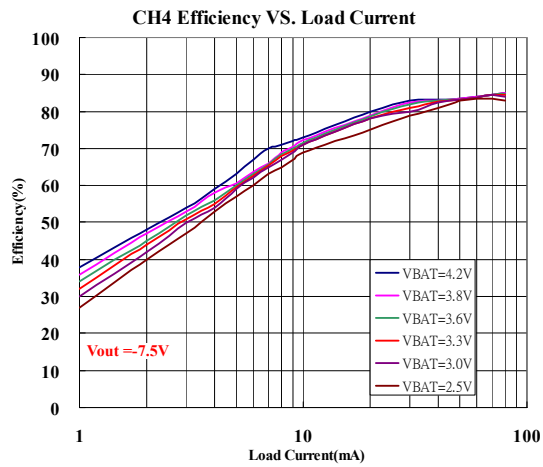
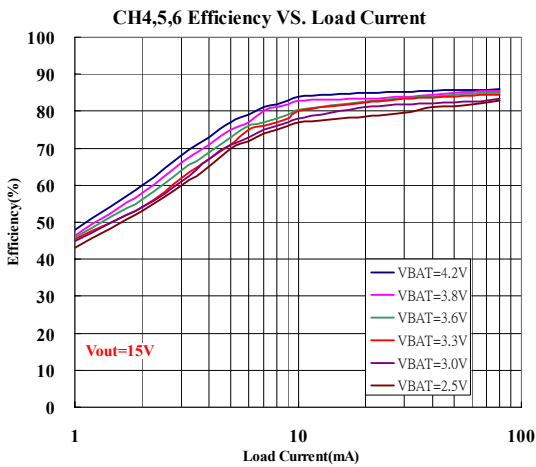
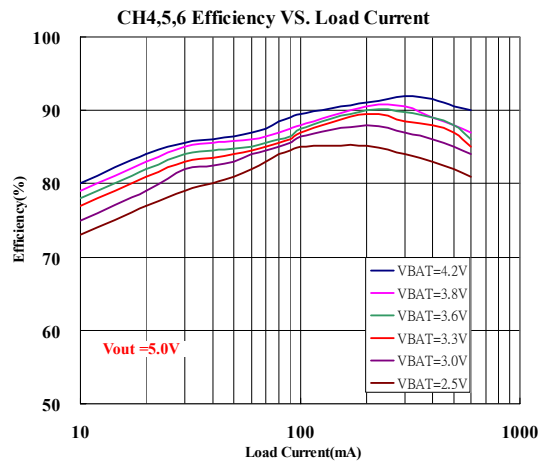
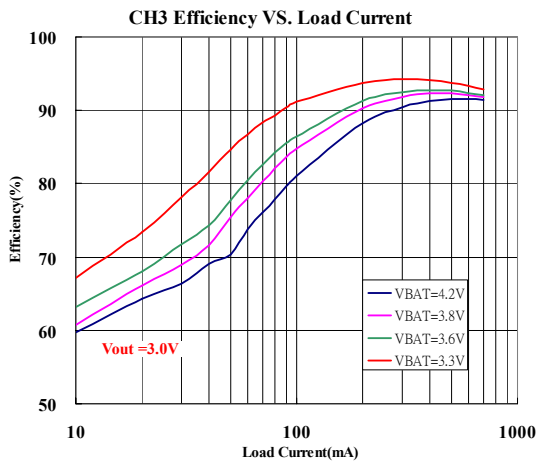
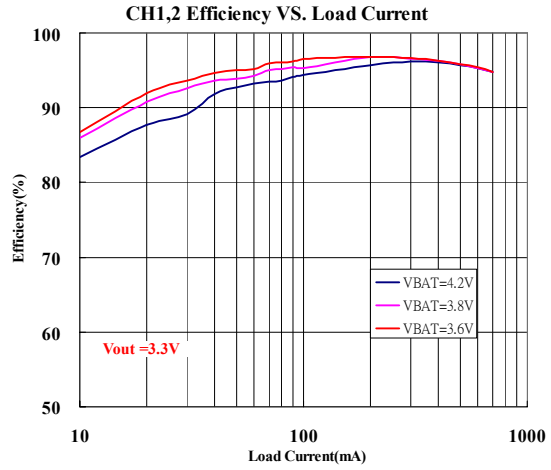
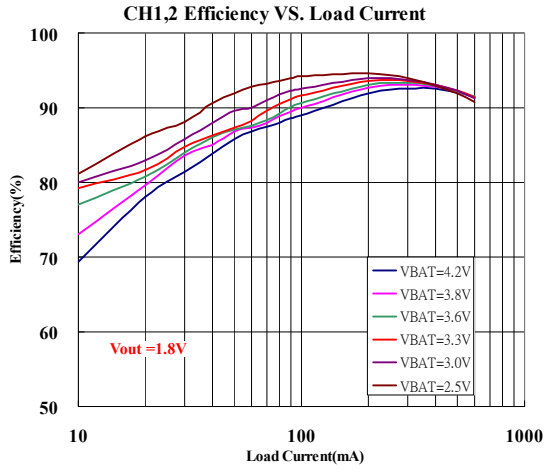
(PVCC1=PVCC2=PVCC3=PVCC4=VCC=3.6V, Ta=+25°C)

Parameter	Symbol	Condition	Values			Unit
			Min.	Typ.	Max.	
GENERAL						
Input Voltage Range	VCC	IC Power Input	2.5	-	5.5	V
VCC Under Voltage Lockout	V _{UV}	-	2.35	2.4	2.45	V
UVLO Hysteresis	V _{HY}	-	-	100	-	mV
CH1,CH2 Switch- Off Input Current	I _{IN1}	No Switching, FB1=FB2=0.9V CTL1=CTL2=3.6V, other disable	-	1.1	1.2	mA
CH1,CH2, CH3(or 4,5,6) Switch- Off Input Current	I _{IN2}	No Switching, FB1=FB2=FB3=0.9V CTL1=CTL2=CTL3=3.6V, other disable	-	1.3	1.4	mA
Shutdown Current	I _{CC}	All CTL disable, VCC=3.6V	-	1	10	μA
REFERENCE						
Reference Output Voltage	V _{REG}	I _{REG} =1mA	2.25	2.30	2.35	V
Reference Load Regulation	ΔV _{REG1}	1mA < I _{REG} < 5mA	-	5	10	mV
Reference Line Regulation	ΔV _{REG2}	2.5 < VCC < 5.5V	-	-	5	mV
OSC						
Frequency	f _{OSC}	CT=82pF	-	500	-	KHz
Frequency variation with Temperature	Δf _{OSC1}	T _a =-20°C ~+85°C	-	1	10	%
Frequency variation with Input Voltage	Δf _{OSC2}	V _{CC} =2.5V~5.5V	-	1	5	%
CHANNEL 1, 2						
Input Voltage Range	PVCC1/2	-	2.5	-	5.5	V
Normal Operating Soft-Start Charge Current	I _{SS1/2}	V _{CC} =2.5V~5.5V	0.7	1	1.3	μA
FB Regulation Voltage	V _{FB1/2}	T _a =-20°C ~+85°C	0.784	0.8	0.816	V
FB input Current	I _{FB1/2}	FB1/2=0.8V	-	-	100	nA
Current-Sense Amplifier Transresistance	R _{CS}	-	-	0.6	-	V/A
Transconductance	G _{MEA}	-	-	120	-	μs
Maximum Duty Cycle	D _{MAX}	FB1/2=0.7V	-	100	-	%

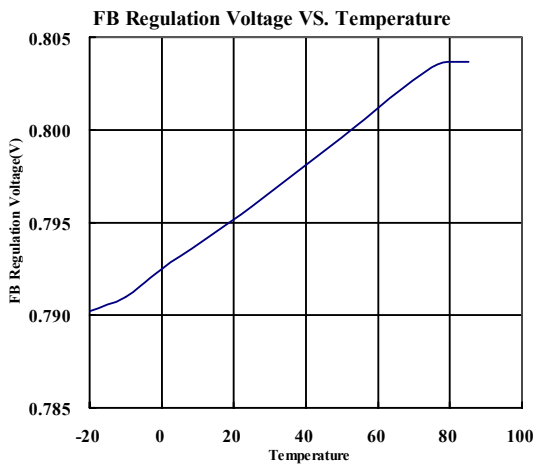
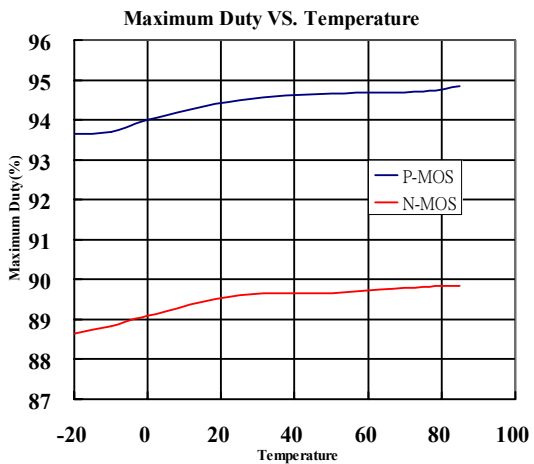
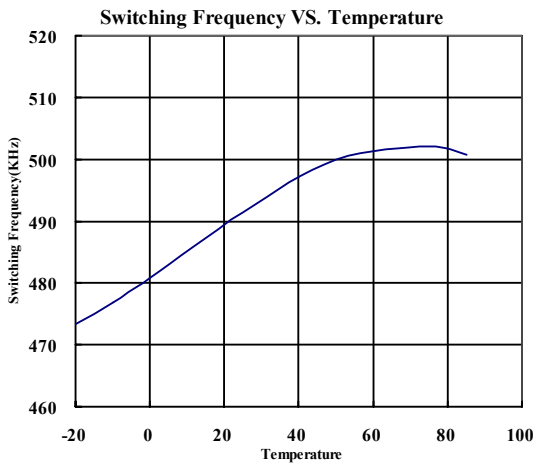
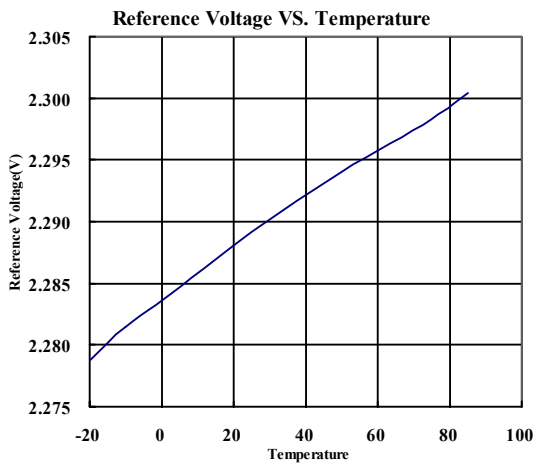
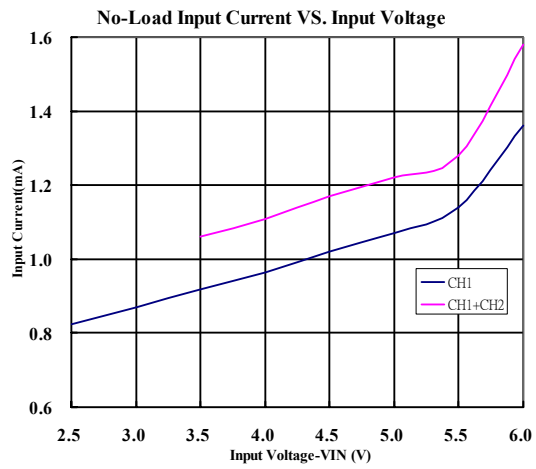
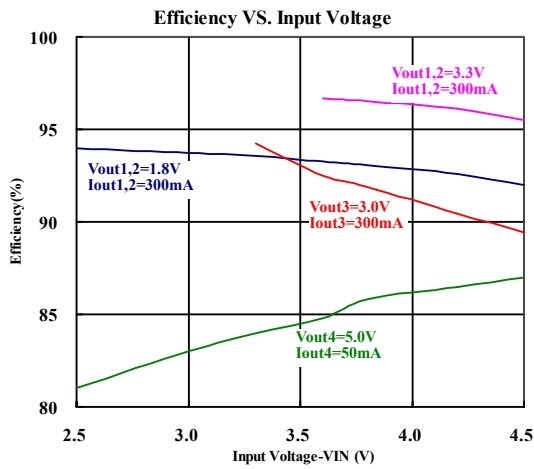
LX Leakage Current	$I_{LX1/2}$	$V_{LX1/2}=0\sim 3.6V$	-	1	5	μA
Switch On-Resistance	R_N	N-Channel	-	200	250	$m\Omega$
	R_P	P-Channel	-	250	300	$m\Omega$
P-Channel Current Limit	I_{Limit2}	-	1.0	1.2	1.4	A
N-Channel Turn-off Current	I_{REV2}	-	-	20	-	mA
/SDOK Output Low Voltage	V_{SDOK}	0.1mA into /SDOK	-	0.01	0.1	V
/SDOK Leakage current	I_{L_SDOK}	CTL2=0V, /SDOK=5.5V	-	0.1	1	μA
CHANNEL 3						
Input Voltage Range	PVCC3	-	2.5	-	5.5	V
Normal Operating Soft-Start Charge Current	I_{SS3}	$V_{CC}=2.5V\sim 5.5V$	0.7	1	1.3	μA
FB3 input Current	I_{FB3}	FB3=0.8V	-	-	100	nA
FB3 Regulation Voltage	V_{FB3}	$T_a=-20^{\circ}C\sim +85^{\circ}C$, FB3=COMP3	0.784	0.8	0.816	V
Error Amplifier Voltage Gain	AV	DC	80	-	-	dB
Error Amplifier Frequency Bandwidth	BW	AV=0dB	-	5	-	MHz
Error Amplifier Output Voltage	V_{OH}	-	-	1.0	-	V
	V_{OL}	-	-	10	-	mV
Error Amplifier Output Source/Sink Current	I_{source}	COMP=0.8V	-	1	-	mA
	I_{sink}	COMP=0.8V	-	60	-	μA
Maximum Duty Cycle	D_{MAX}	FB3=0.7V	-	100	-	%
Output Source/Sink Current	I_{source}	DUTY=90%,OUT=1/2VCC C	-	-130	-80	mA
	I_{sink}	DUTY=0%,OUT=1/2VCC	65	100	-	mA
Output On-Resistor	R_{OH}	OUT=-15mA	-	18	30	Ω
	R_{OL}	OUT=15mA	-	16	25	Ω
CHANNEL 4, 5, 6						
Input Voltage Range	PVCC4	CH4, 5, 6	2.5	-	5.5	V
Normal Operating Soft-Start Charge Current	$I_{SS4/5/6}$	$V_{CC}=2.5V\sim 5.5V$	0.7	1	1.3	μA
FB4/5/6 Regulation Voltage	$V_{FB4/5/6}$	$T_a=-20^{\circ}C\sim +85^{\circ}C$, FB =COMP	0.784	0.8	0.816	V
FB5 Regulation Voltage for LED Driver	V_{FB5}	$T_a=-20^{\circ}C\sim +85^{\circ}C$, FB5=COMP5	0.19	0.20	0.21	V

FB5H OVP Trip Level	V_{FB5H}	$T_a = -20^{\circ}\text{C} \sim +85^{\circ}\text{C}$,	0.98	1.00	1.02	V
Error Amplifier Voltage Gain	AV	DC	80	-	-	dB
Error Amplifier Frequency Bandwidth	BW	AV=0dB	-	5	-	MHz
Error Amplifier Output Voltage	V_{OH}	-	-	1.0	-	V
	V_{OL}	-	-	10	-	mV
Error Amplifier Output Source/Sink Current	I_{source}	COMP=0.8V	-	1	-	mA
	I_{sink}	COMP=0.8V	-	60	-	μA
Maximum Duty Cycle	D_{MAX}	FB_ ₋ =0.7V	85	90	95	%
	D_{MAX}	FB5=0.1V	85	90	95	%
Output Source/Sink Current	I_{source}	DUTY=90%,OUT=1/2VCC	-	-130	-80	mA
	I_{sink}	DUTY=0%,OUT=1/2VCC	65	100	-	mA
Output On-Resistor	R_{OH}	OUT=-15mA	-	18	30	Ω
	R_{OL}	OUT=15mA	-	16	25	Ω
SHORT CIRCUIT PROTECTION						
Threshold Voltage	V_{TH}	CH3,CH4,CH5,CH6	-	0.9	-	V
V_{CSCP} Detect Voltage	V_{TH}	CH3,CH4,CH5,CH6	-	0.7	-	V
CSCP Charge Current	I_{CSCP}	CH3,CH4,CH5,CH6	0.7	1	1.3	μA
CONTROL BLOCK						
CTL Input Voltage	V_{IH}	Active Mode	1.5	-	VCC	V
	V_{IL}	Standby Mode	0	-	0.5	V
CTL Hysteresis	ΔV_H	-	-	100	-	mV
SEL4 Input Voltage	V_{IH}	Step-Up Type	1.5	-	VCC	V
	V_{IL}	Step-Down Type	0	-	0.5	V
SEL4 Hysteresis	ΔV_H	-	-	100	-	mV

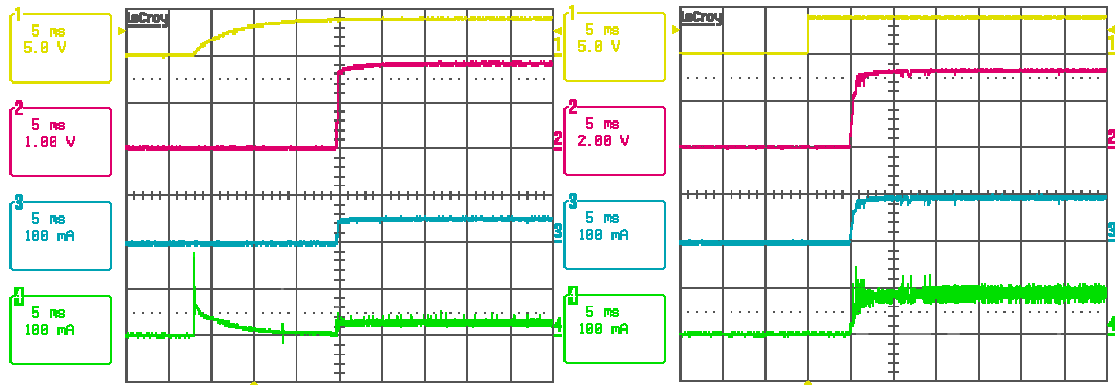
Typical Characteristics



Typical Characteristics (Continued)

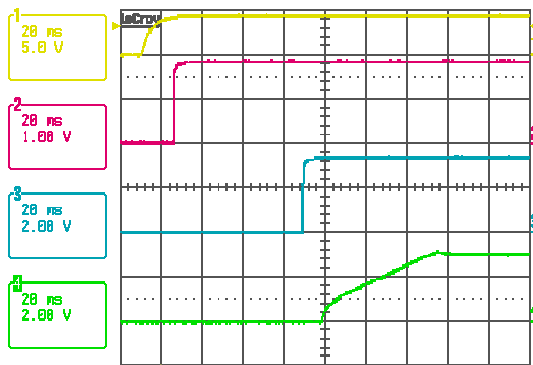


Typical Characteristics (Continued)

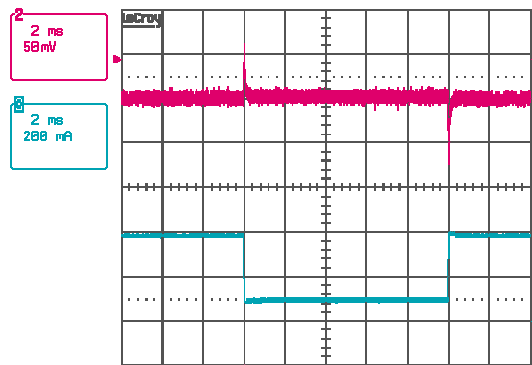


VBAT=3.8V
 CH1 : CTL1 , CH2 : VOUT1
 CH3 : IOUT1 , CH4 : Iin

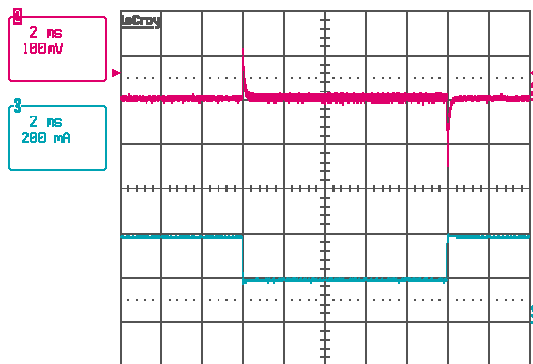
VBAT=3.8V
 CH1 : CTL2 , CH2 : VOUT2
 CH3 : IOUT2 , CH4 : Iin



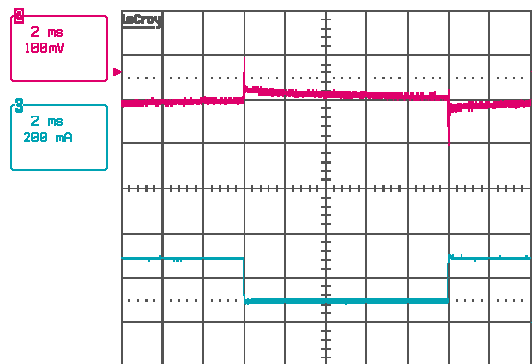
VBAT=4.2V
 CH1 : CTL , CH2 : VOUT1
 CH3 : VOUT2 , CH4 : VOUT3



VBAT=3.8V
 CH2 : VOUT1 , CH3 : IOUT1
 CH4 : VOUT3

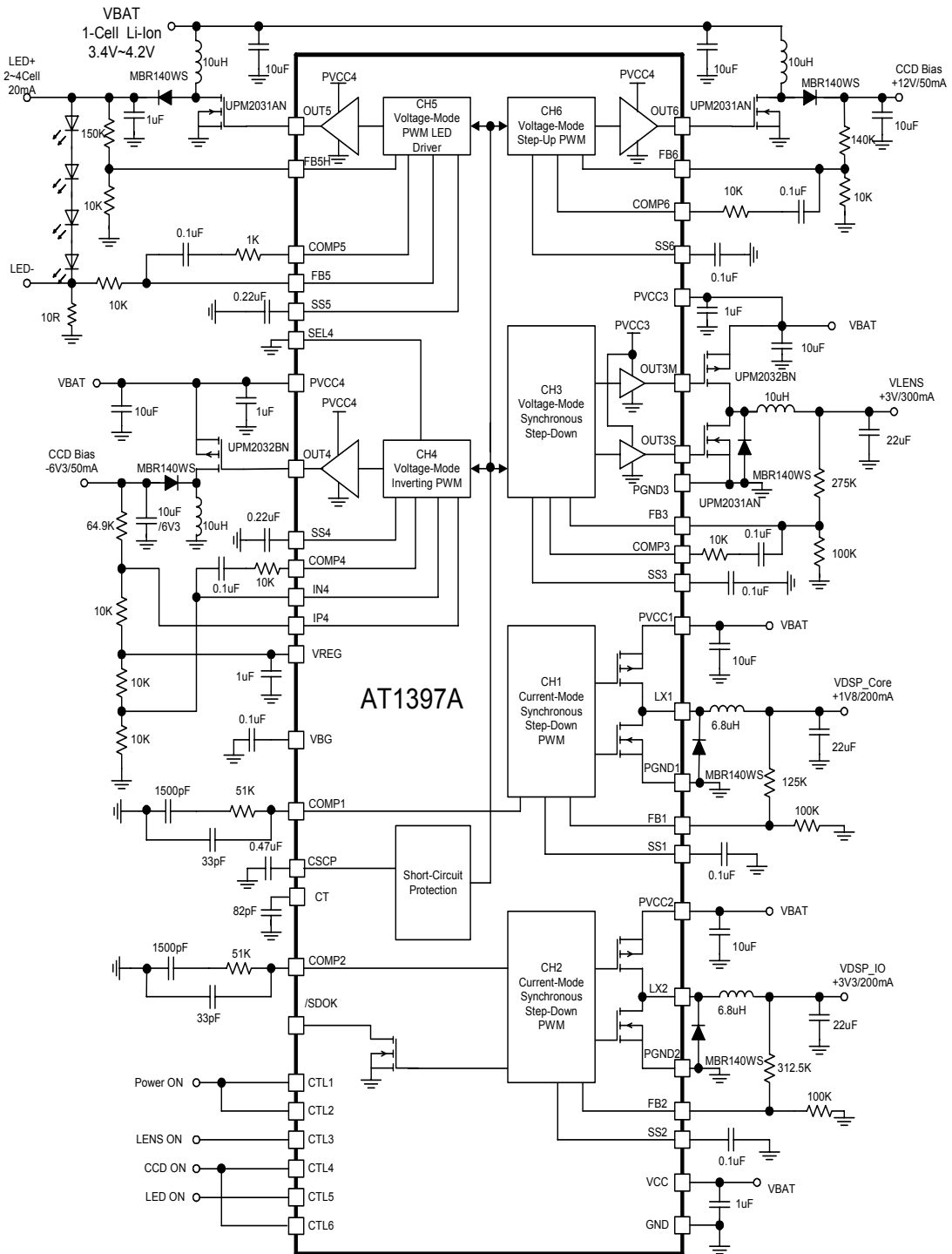


VBAT=3.8V
 CH2 : VOUT2 , CH3 : IOUT2



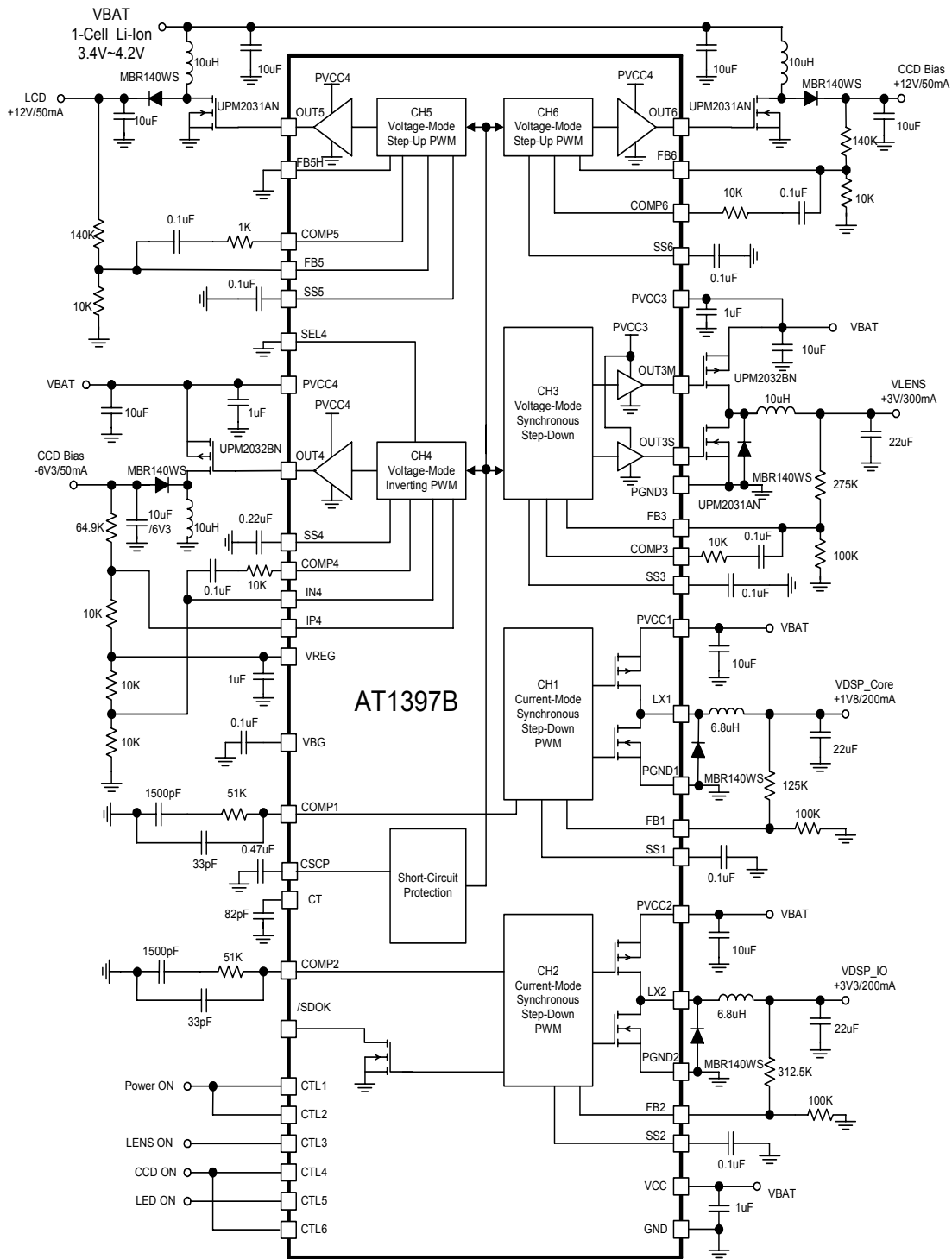
VBAT=3.8V
 CH2 : VOUT3 , CH3 : IOUT3

Typical Application Circuits



1-Li Battery Application 1

Typical Application Circuits (Continued)



1- Li Battery Application 2

Application Information

The AT1397A/B include 6 channels DC/DC to generate a multiple-output digital camera power-supply system. It include :

- Step-Down DC/DC converter with on-chip synchronous MOSFETs.(CH1, CH2)
- Main synchronous DC/DC controller for Step-Down converter.(CH3)
- Selectable DC/DC controller for boost/flyback/buck/inverting converters.(CH4)
- White LED driver with open LED protection or boost controller.(CH5)
- Boost/flyback controller.(CH6)

Step-Down DC/DC Converter (CH1, CH2)

The step-down DC/DC is optimized for generating DSP voltage (down to 0.8V) at high efficiency. It runs from the voltage at PVCC1/PVCC2. This pin can be connected directly to the battery if sufficient headroom exists to avoid dropout.

The CH2 also features an open-drain /SDOK output that goes low when the CH2 is in regulation. /SDOK may be used to drive an external P-MOSFET that gates 3V power to the LENS after the DSP_IO voltage is in regulation (Figure 1). The R1,R2 and C1 is for MOSFET soft-start function to avoid the more inrush current .

Step-Down DC/DC Converter (CH3)

The CH3 is step-down voltage mode PWM converter. An external MOSFET and synchronous rectifier allow conversion efficiencies as high as 93%. Step-down operation can be direct from Li-Ion cell if the minimum input voltage exceeds the desired output by approximately 200mV.

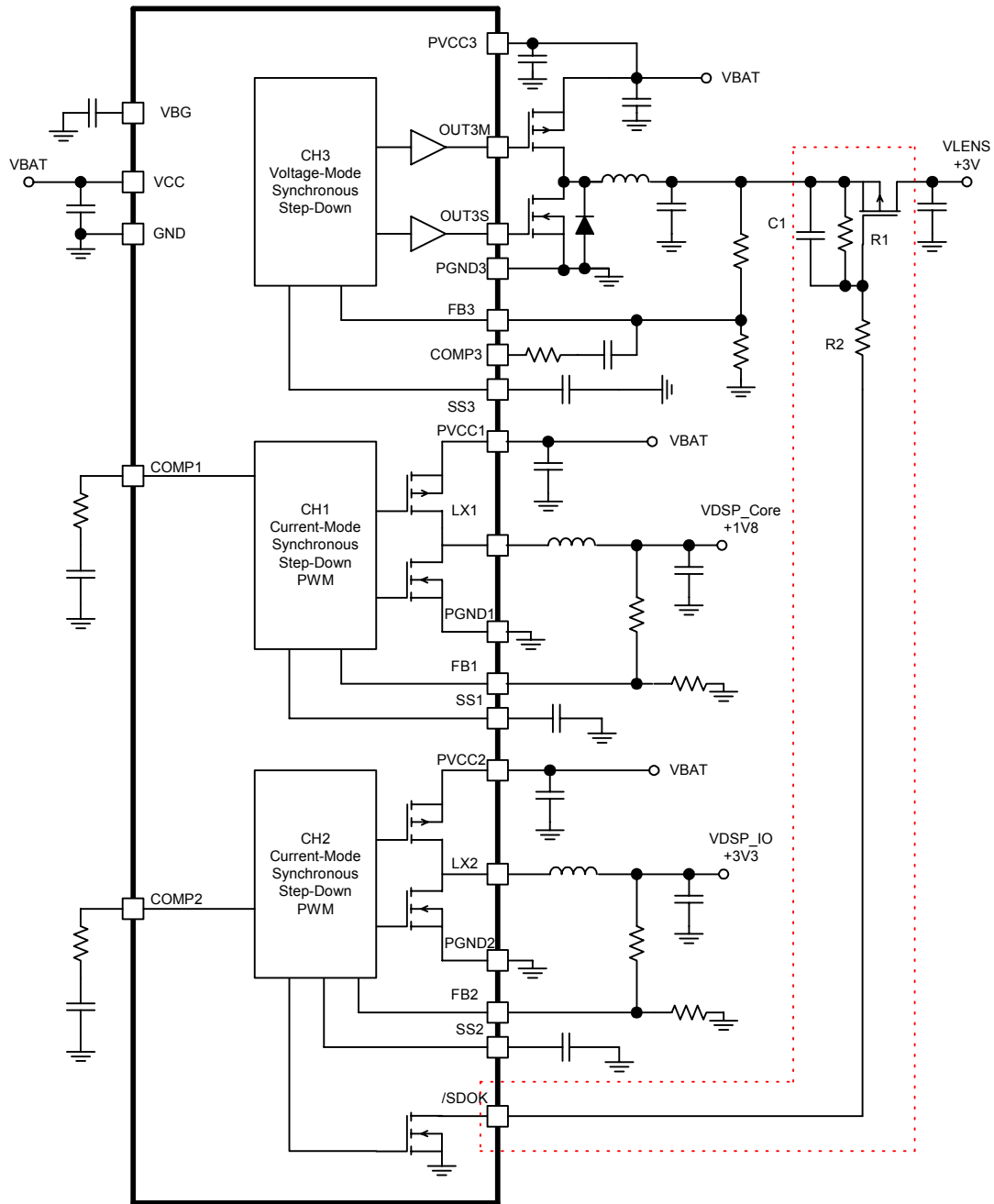


Figure 1. Using /SDOK to drive external P-MOSFET that gates 3V power to LENS after 3.3V I/O voltage is in regulation

Auxiliary Controller (CH4, CH5, CH6)

The three auxiliary controllers operate as fixed-frequency voltage-mode PWM controllers. They use the external MOSFETs, so output power is determined by external components. All of auxiliary controllers have a guaranteed duty cycle of maximum duty cycle of 85% (boost-type) or 100%(buck/inverting type). In boost designs that employ continuous current (CCM), the maximum duty cycle limits the boost ratio so:

$$1 - \frac{V_{IN}}{V_{OUT}} \leq 85\%$$

With discontinuous inductor current (DCM), no such limit exists for the input/output ratio since the inductor has time to fully discharge before the next cycle begins. The discontinuous conduction mode boost voltage conversion relationship is given by:

$$V_o = V_i \times \frac{1 + \sqrt{1 + \frac{4 \times D^2}{K}}}{2} \quad D = \sqrt{K \times M \times (M - 1)}$$

Where K is defined as:

$$K = \frac{2 \times L}{R \times T_s} \quad M = \frac{V_o}{V_i}$$

The CH4 is selectable DC/DC controller for drive N-channel MOSFETs (SEL=high) or P-channel MOSFETs (SEL=low). It can be configure as the inverting circuit (Figure 2), typically for CCD and LCD bias. This is useful in height-limited designs where transformers may not be desired. The efficiency is more than the charge-pump inversion for some load conditions.

The CH5 can be configure as a switching-mode boost current source for white LEDs, FB5 (0.2V) provides current-sensing feedback, while FB5H (1.0V) provides (optional) open-LED over-voltage protection (Figure 3). If used as a boost converter, FB5H is grounded and FB5 (0.8V) is used as the feedback input. In this case, CH5 behaves exactly like CH4 and CH6.

The CH6 can be used for conventional DC/DC boost and flyback designs.(Figure 4 ,Figure 5 and Figure 6)

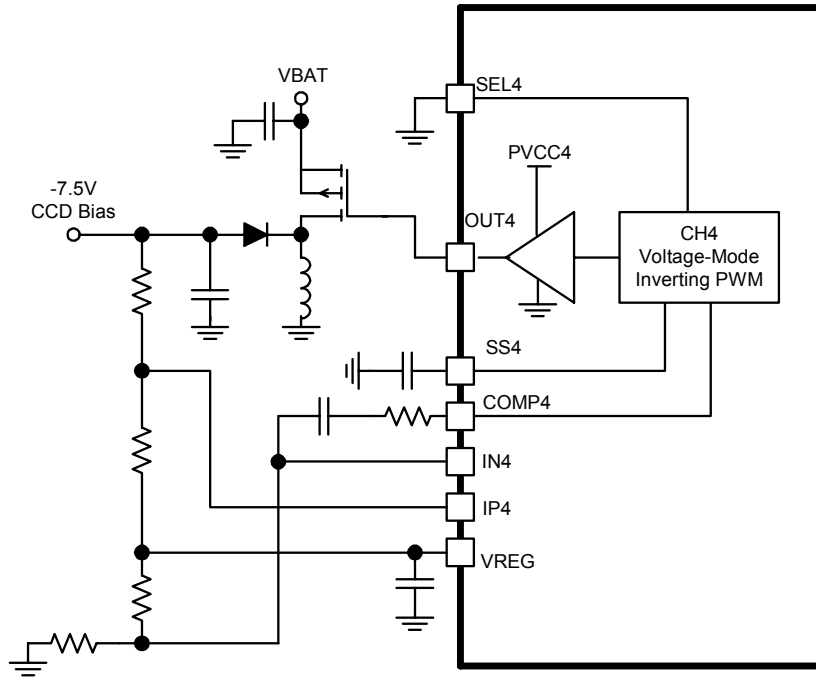


Figure 2. Regulated -7.5V negative CCD Bias.

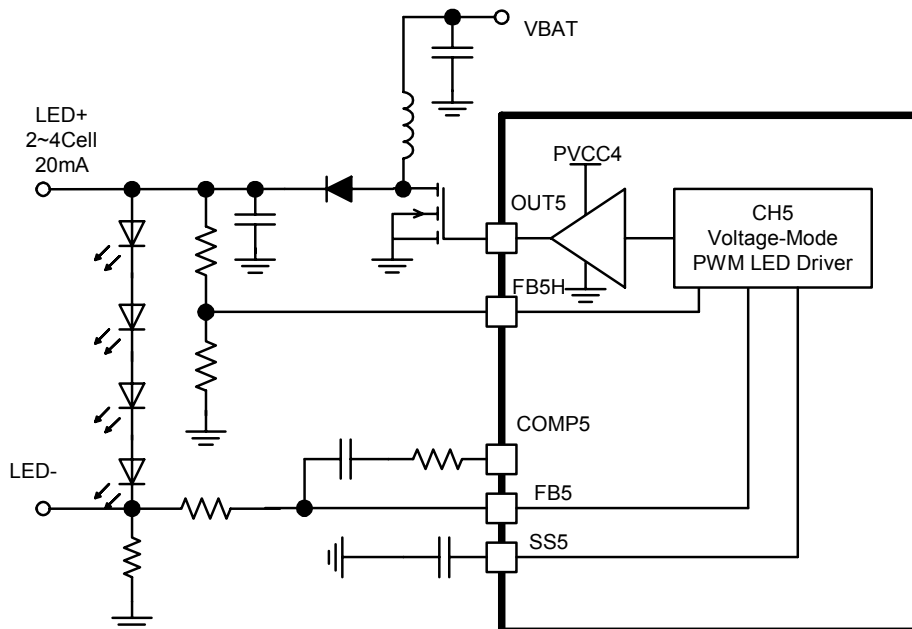


Figure 3. LED Drive with open LED over-voltage protection

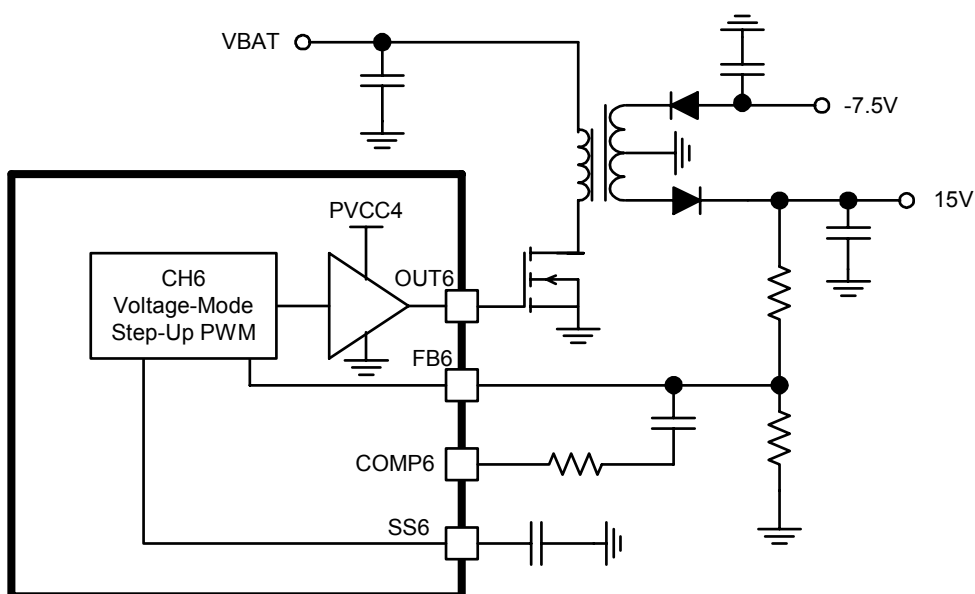


Figure 4. +15V and -7.5V CCD Bias with transformer

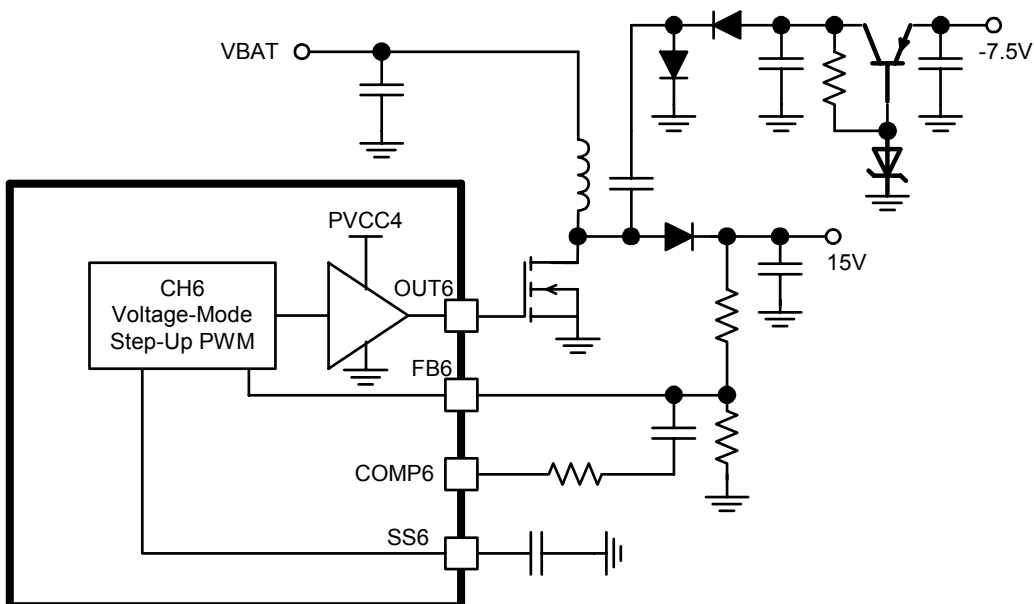


Figure 5. +15V and -7.5V CCD Bias with Charge-Pump Inversion

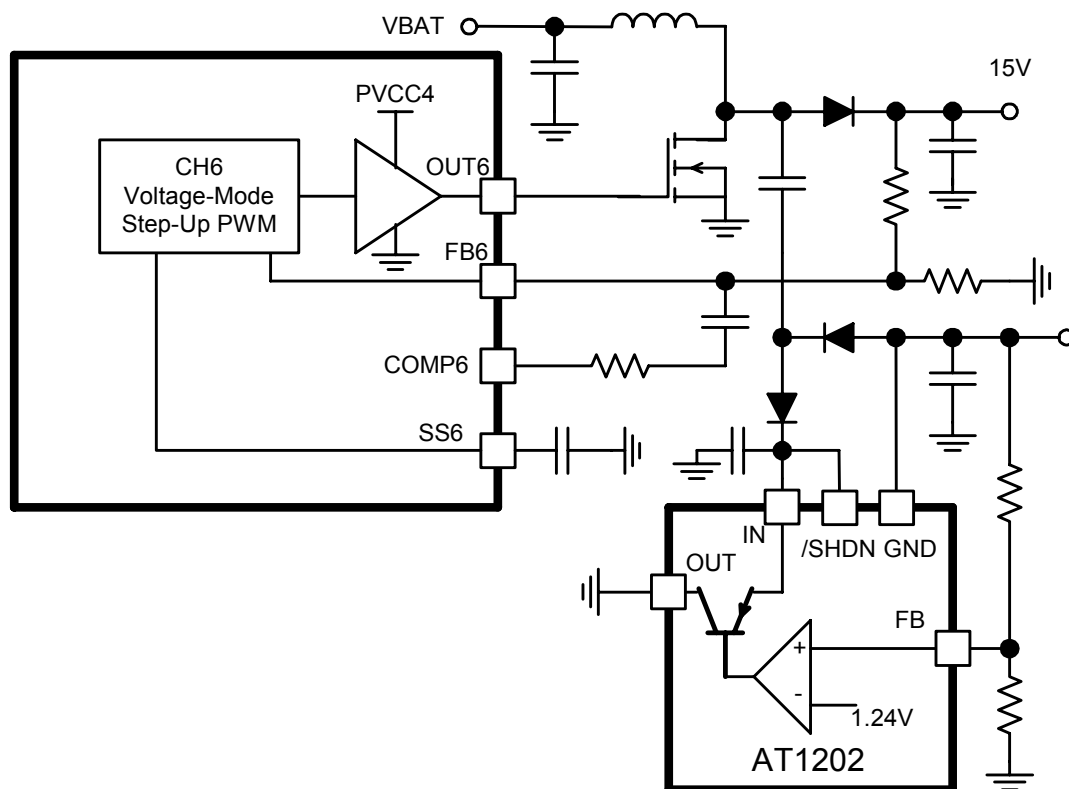


Figure 6. +15V and -7.5V CCD Bias with Charge-Pump (using AT1202 to regulated the negative output)

Soft-Start Setting (CH1~CH6)

The AT1397A/B all channels feature a soft-start function that limits inrush current and prevents excessive battery loading at start-up by ramping the output voltage of each channel up to the regulation voltage. However that CH2 to CH6 start until the CH1 reaches regulation. Consider the input voltage and load current to design the capacitor connected to the SS pin. It can calculate the CH1~6 soft start time $T_s(s)$ (valid threshold 0.3~0.8V interval).

$$C \times \frac{\Delta V}{\Delta t} = I$$

$$T_s(s) = 0.5 \times C(\mu F)$$

Note : It could be disabled soft start function by floating SS pin.

SCP Protection Setting (CH3~CH6)

The CSCP comparator detects CH3, CH4, CH5 and CH6 output voltage while the power converter work at normal condition. At the same time, the voltage level of CSCP pin is held at low level. If the output load of these converters rapidly malfunction or short, causing the output voltage to drop, the CSCP comparator detects that to enable short circuit protection. The time period when short circuit protection show as follow equation.

Short detection time ($T_{PE}(s)$)

$$T_{PE}(s) = 0.9 * C_{CSCP} (\mu F)$$

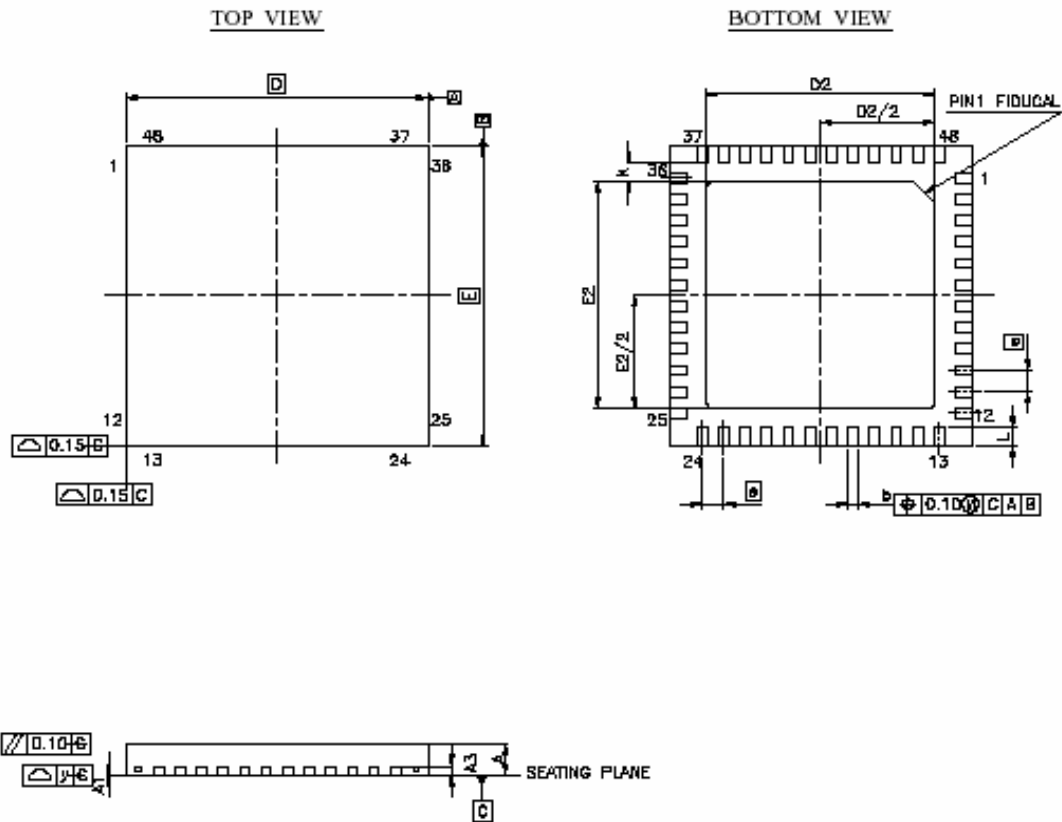
Note : It could be disabled short circuit protection function by connecting CSCP pin into the ground.

Determine the triangular Oscillator Frequency

The triangular oscillator frequency is determined by the timing capacitor (C_T). It is difficult to incorporate these non-linear characteristics into the equation. This difference is caused by characteristics, such as changes in the maximum voltage amplitude of the sawtooth waveform with the C_T value and the circuit delay causing the maximum amplitude to become large in the case of a high oscillating frequency even for the same capacitor. In practical use, therefore, the user should read the C_T values from the characteristic curve or should determine an approximate target value by using the equation.

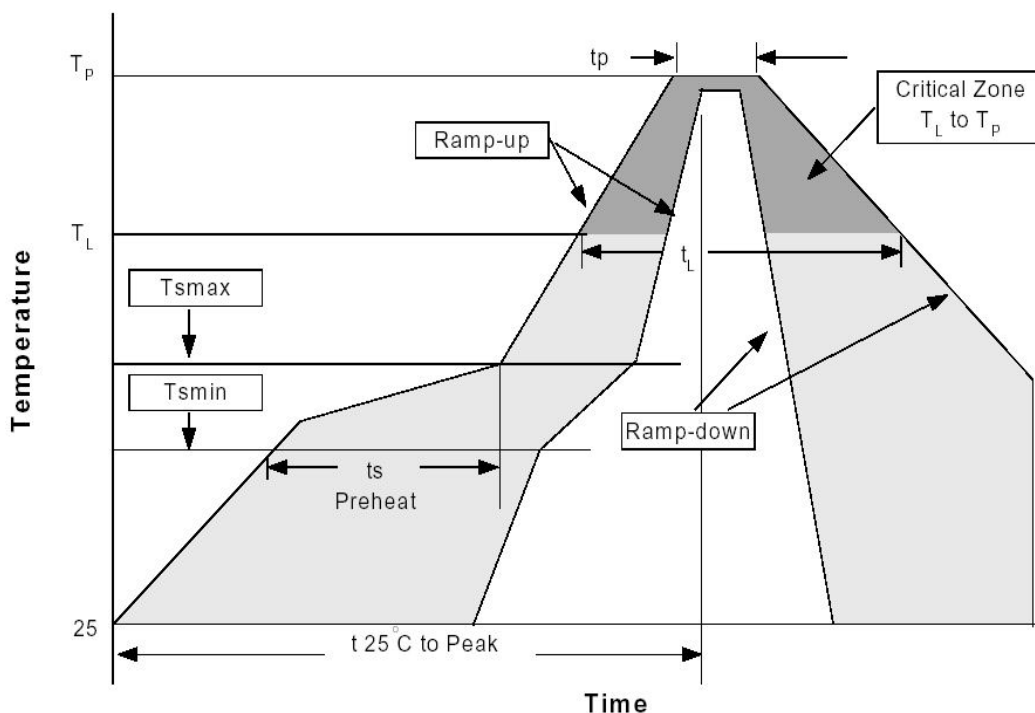
$$f_{osc}(KHz) = \frac{41000}{C_T(pF)}$$

Package Outline: QFN48



SYMBOL	DIMENSION (MM)			DIMENSION (MIL)		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	27.6	29.5	30.5
A1	0	0.02	0.05	0	0.79	1.97
A3	0.203 REF			8 REF		
b	0.18	0.23	0.30	7.1	9.1	11.8
D	700 BSC			276 BSC		
D2	5.10	5.30	5.50	201	209	217
E	700 BSC			276 BSC		
E2	5.10	5.30	5.50	201	209	217
ϕ	0.50 BSC			19.7 BSC		
k	0.20			7.9		
L	0.30	0.40	0.50	11.8	15.7	19.7
y	0.08			3.15		

Reflow Profiles



Profile Feature	Sn-Pb Eutectic Assembly		Pb-Free Assembly	
	Large Body Pkg. thickness ≥2.5mm or Pkg. volume ≥350mm ³	Small Body Pkg. thickness <2.5mm or Pkg. volume <350mm ³	Large Body Pkg. thickness ≥2.5mm or Pkg. volume ≥350mm ³	Small Body Pkg. thickness ≥2.5mm or Pkg. volume ≥350mm ³
Average ramp-up rate (T _L to T _P)	3°C/second max.		3°C/second max.	
Preheat -Temperature Min(T _{min}) -Temperature Max (T _{max}) -Time (min to max)(t _s)	100°C 150°C 60-120 seconds		150°C 200°C 60-180 seconds	
T _{max} to T _L -Ramp-up Rate	-		3°C/second max.	
Time maintained above: -Temperature (T _L) -Time (t _L)	183°C 60-150 seconds		217°C 60-150 seconds	
Peak Temperature(T _p)	225+0/-5°C	240+0/-5°C	245+0/-5°C	250+0/-5°C
Time within 5°C of actual Peak Temperature (t _p)	10-30 seconds	10-30 seconds	10-30 seconds	20-40 seconds
Ramp-down Rate	6°C/second max.		3°C/second max.	
Time 25°C to Peak Temperature	6 minutes max.		8 minutes max.	

*All temperatures refer to topside of the package, measured on the package body surface.