1. Features

- Lossless load current detection in secondary side
- Programmable load current for LED indicator color change

2. Applications

- Li+ and Ni-MH battery chargers
- Adapters
- E-bike chargers

3. Typical applications

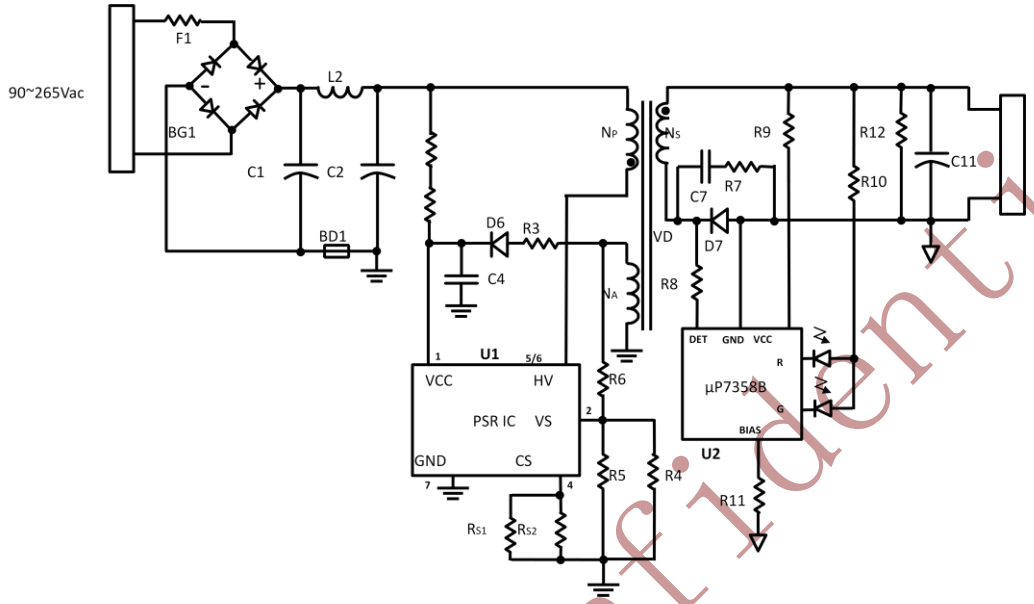
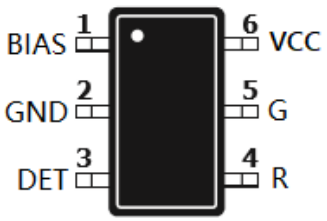


Fig.1 5V1A Charger

4. Pin definitions



µP7358B

Pin number	Pin Name	Pin Type	Pin Functions
1	BIAS	I/O	Set the load current for LED switching
2	GND	Ground	Ground of the controller
3	DET	Input	Detection of load current
4	R	Output	Current sink for red LED indictor
5	G	Output	Current sink for green LED indictor
6	VCC	Power supply	Power supply of the controller

5. Absolute maximum ratings (Note 1)

Parameter	Name	Range	Unit

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Voltage at VCC to Ground	VCC	-0.3 to 36	V
Voltage at R/Gto Ground	R/G	-0.3 to 36	V
Voltage at DET to Ground	DET	-0.3 to 45	V
Voltage at BIAS to Ground	BIAS	-0.3 to 5.0	V
Continuous R/G pin sink current	$I_{R/G}$	20	mA
Power dissipation @ T_A=25℃	P_D	0.3	W
Maximum junction temperature	T_{JMAX}	150	℃
Lead temperature	T_{LEAD}	300	℃
Storage temperature	T_{STG}	-55 to 150	℃
ESD 电压(ANSI/STM5.1-2001)	HBM	±4000	V
ESD 电压（ JEDEC JESD22-C101C）	CDM	±1000	V
Latchup test per JEDEC 78D		+/-200	mA

Note1: Stresses over those listed under “Absolute maximum ratings” may cause permanent damages to the device. These are stress ratings only, functional operation of the device at these or any other conditions beyond those indicated under “Recommended Operating Conditions” is not implied. Exposure to “Absolute Maximum Ratings” for extended periods of time may affect device reliability.

6. Thermal parameter

Junction to ambient thermal resistance	θ_{JA}(SOT23-6)	200	℃/W

7. Recommended operating conditions

Parameter	Symbol	Min	Max	Unit
Supply voltage	VCC	4.0	32	V
DET voltage	V_{DET}	-0.2	40.0	V
R/G voltage	V_R /V_G	-0.2	32	V
Ambient Temperature	T_A	-40	85	℃

8. Electrical parameters

(TA =25 ℃, unless otherwise specified)

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Parameter	Symbol	Condition	Min	Typ	Max	Unit
Power supply						
Operating current	I_{CC}		200	300	400	µA
Startup voltage	V_{ST}		3.2	3.5	3.9	V
Minimum operating voltage	V_{UVLO}		3.0	3.3	3.7	V
Startup current	I_{ST}	VCC= V_{ST} -0.1V	50	130	200	µA
Internal timer period	T_P		6	8	10	mS
LED switching						
Capacitor forΣ T_{ONS}R2G	C_{R2G}		14.7	15.5	16.3	nF
Capacitor forΣ T_{ONS}G2R	C_{G2R}		19.1	20.2	21.2	nF
Minimum Vs voltage	V_{S_MIN}				4.5	V
Ampere Second Product	ASP		110	143	173	µA*µS

9. Functional block diagram

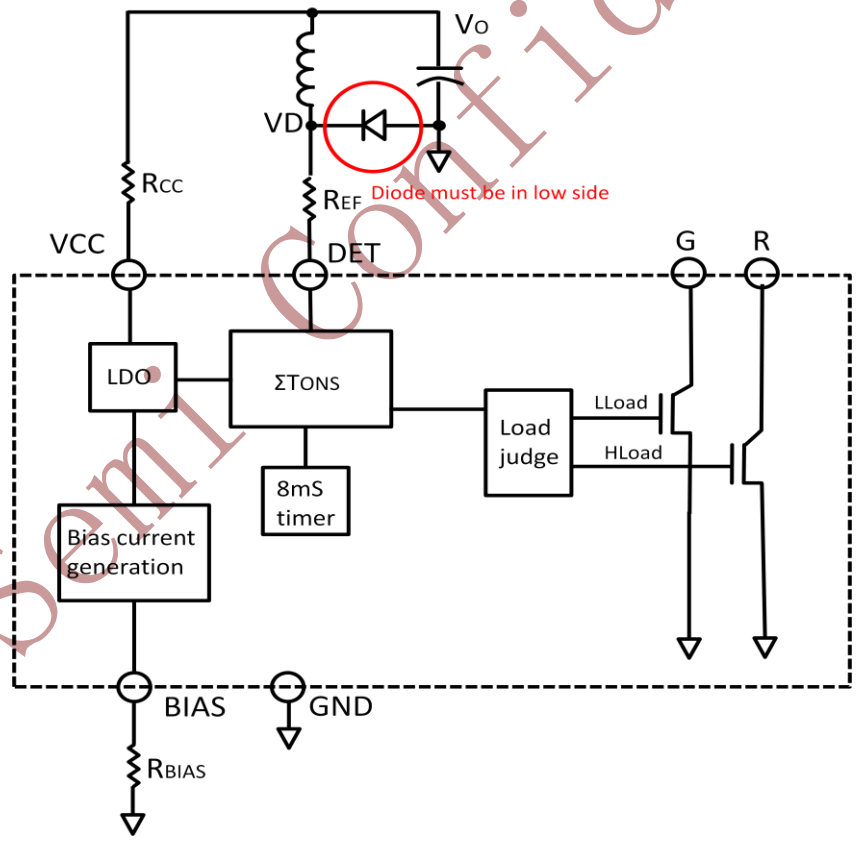

Fig.2 µP7358B block diagram

10. Principle of operation

The µP7358B detects the load currents of a switching mode power supply and switching the color of a common anode LED indicator when the load current is crossing a specified load (e.g. 10% of full load) during battery charging process. The µP7358B supports switching mode power supply

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working in Discontinuous Conduction Mode (DCM), Quasi Resonant Mode (QR) or Continuous Conduction Mode (CCM). The load current that LED is changing its color is set by a resistor from the BIAS pin to GND.

10.1 Power up and power down sequences

Refer to Fig.1, after AC power supply is applied to the converter, the primary switcher (U1) starts to deliver energy to the output capacitor C11, the output voltage begins rising from 0V. When the VCC voltage of μP7358B is larger than the startup voltage V_{ST}, the controller μP7358B starts to work, pin R exhibits low impedance to GND, pin G exhibits high impedance to GND, LED is in red state. When the AC power supply is removed from the converter, the VCC voltage of μP7358B will fall below $V_{UVLO,}$ the controller stops working, LED is in off state. For typical Vout 20V~32V application， R9=10K. When Vout lower than 20V， Reduce R9 appropriately.

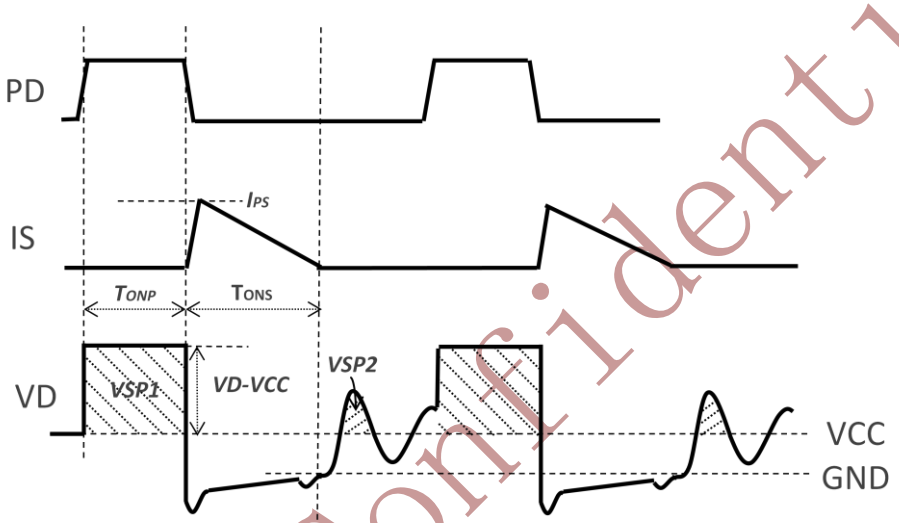

Fig.3 Load current detection in μP7358B

10.2 Load current detection

Refer to Fig.2 and Fig.3, μP7358B detects load current by analyzing the voltage waveforms of the secondary winding via DET pin. The mean secondary winding conduction time is an index of the load current. μP7358B summarizes the secondary winding conduction timeΣT_{ONS} in a pre-defined time internal (8mS), then compares with the red to green changing time (ΣT_{R2G}) and the green to red changing time (ΣT_{G2R}) setting with R_{BIAS} by

$$\Sigma T_{R2G}=R_{BIAS}*C_{R2G}$$

and

$$\Sigma T_{G2R}=R_{BIAS}*C_{G2R}$$

If$\Sigma T_{ONS}<\Sigma T_{R2G}$, pin R switches from low impedance to high impedance, pin G switches from high impedance to low impedance, LED color changes from red to green. On the other hand, if$\Sigma T_{ONS}>\Sigma T_{G2R}$, pin R switches from high impedance to low impedance, pin G switches from low impedance to high impedance, LED color changes from green to red.

μP7358B analyzes the Volt-Second Product (VSP) of the secondary winding waveform via DET pin to identify the secondary winding conduction. The volt-second product during primary switch turn on (VSP1) is much (usually 2.5X+) higher than the volt-second product of the resonant ringing (VSP2), as illustrated in Fig.3. In μP7358B, a reference VSP_{REF} is defined to distinguish the primary side switch turn on and the resonant ringing:

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$$VSP_{REF}=R_{EF}*ASP$$

where ASP is an µP7358B parameter called Ampere-Second Product. The measured VSP generated by primary side turn on, which equals (VD-VCC)*T_{ONP}, must be larger than VSP_{REF} in all load conditions to guarantee the proper function of µP7358. Usually, R_{EF} is selected as

$$R_{EF}=0.6*VSP_{MIN}/ASP$$

where VSP_{MIN} is the minimum VSP of the secondary winding, generated by the primary side power switch turn on.

VSP_{MIN} corresponds to the minimum primary peak current, usually in no load condition. In the 5V/1A application of Fig1, R_{EF}(R8)=75KΩ .

µP7358B needs a minimum secondary winding voltage at primary side power switch turn on (T_{ONP}) for load current detection. For µP7358B, the value of VD–VCC during primary side power switch turn on time (T_{ONP}) must be higher than V_{S_MIN}. The corresponding minimum rectified input line voltage (V_{IN_MIN}) is $V_{IN\_MIN}= V_{S\_MIN}*(N_P/N_S)$.

10.3 Setting the load current for color switching of LED

The load current to switching LED color is set by R_{BIAS}. For a given switching mode power supply, the total T_{ONS} in a specified time interval (8mS for µP7358B) is an index of the load current. If we want to set 10% load current for color switching, we can simply measure the total T_{ONS} (Σ T_{ONS}) at 10% load current in a specified time interval (8mS for µP7358B), and select

$$R_{BIAS}=\Sigma T_{R2G}/C_{R2G}$$

Thus the LED indicator will change from red to green at 10% load current, and from green to red at 13% load current.

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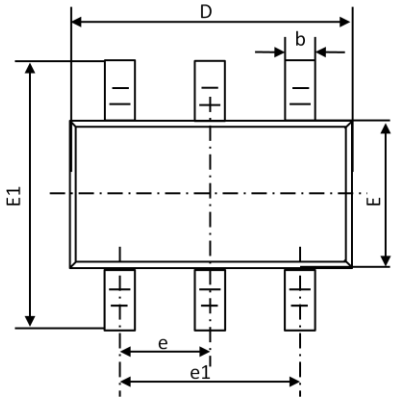
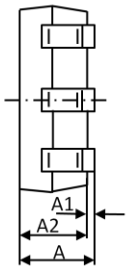
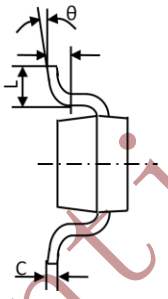
11. Ordering information

Part number	Mark ID	Package	Packing
μP7358BK	78B	SOT23-6	3,000 / Reel

12. Mechanical dimensions







UNIT	A	A1	A2	b	c	D	E	E1	e	e1	L	θ
mm	1.45MAX	0 0.15	0.9 1.3	0.3 0.5	0.1 0.2	2.82 3.02	1.5 1.7	2.65 2.95	0.95	1.8 2	0.3 0.6	0° 8°

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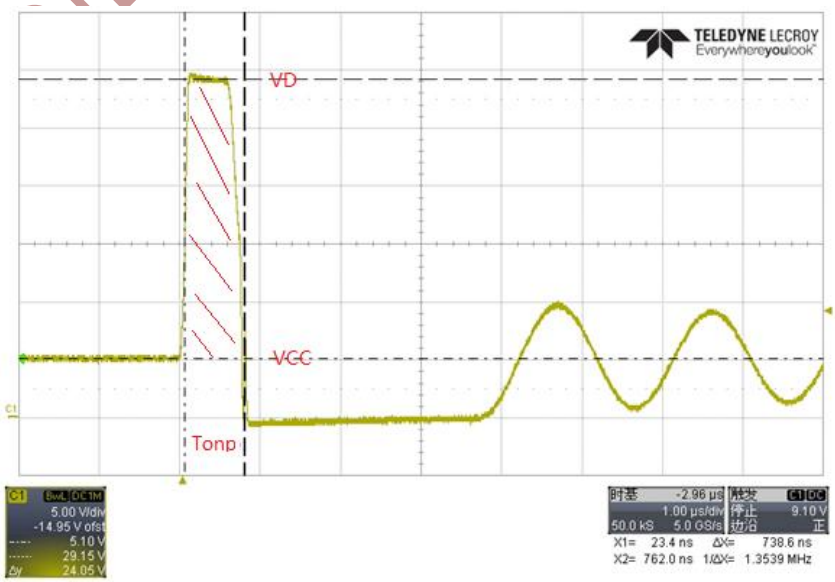
Appendix: Procedure of selecting REF, RBIAS

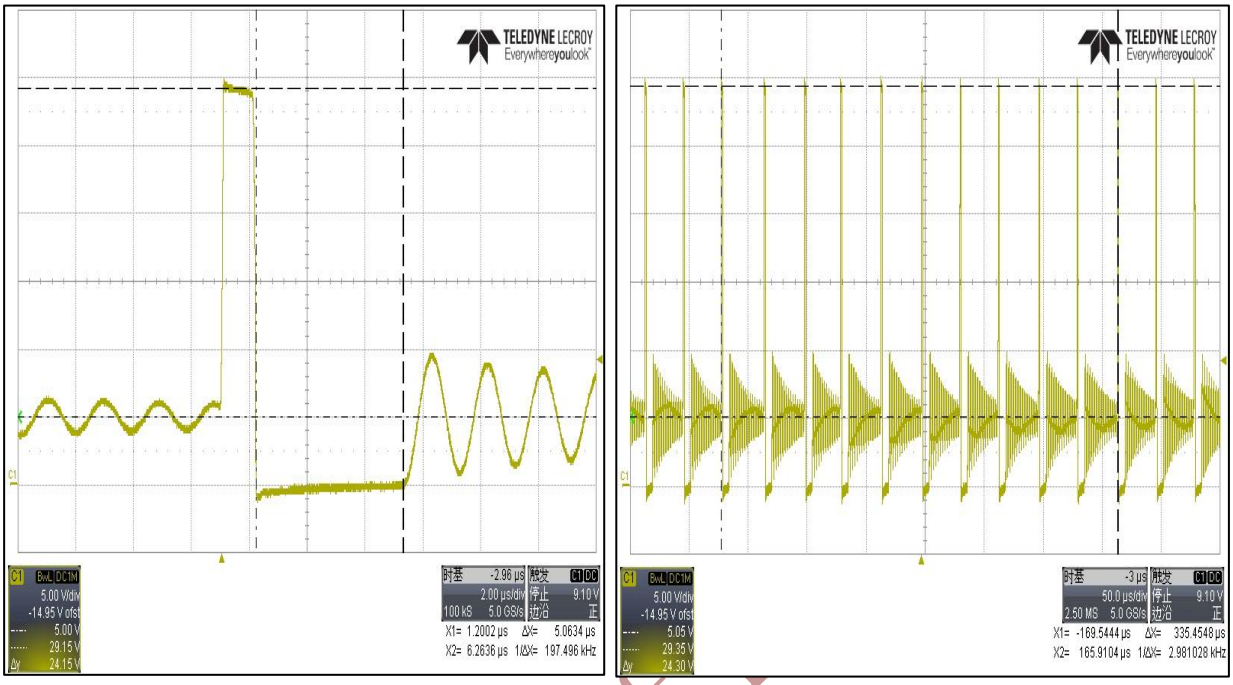
1. Measure the minimum Volt-Second Product (VSPMIN) @ power device turn on, in no load condition



VSP_{MIN}=24.05V*0.7386uS

R_{EF}=0.6*VSP_{MIN}/ASP=74.5KΩ

2. Measure the Tons and average operating frequency at intended load to switch LED color red to green:



Tons=5.0634uS

f=29.81KHz

Σ $T_{ONS@8mS}$=Σ T_{R2G}=8mS*Tons*f=1208uS

R_{BIAS}=Σ T_{R2G}/C_{R2G}=1208uS/15.5nF=78KΩ

3. Fine tune the R_{BIAS} resistor to get the exact load current of switching LED from red to green: if the measured load current of LED color switching is larger than target value, decrease the R_{BIAS} slightly; if the measured load current of LED color switching is smaller than target value, increase the R_{BIAS} slightly.

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