

1. Description

The μP6323K2M-6 is a high performance offline AC-DC switcher for mobile phone charger and adapter applications. The device uses Pulse Frequency Modulation (PFM) and Pulse Width Modulation (PWM) multi-mode to build Discontinuous Conduction Mode (DCM) fly back power supplies.

The μP6323K2M-6 provides accurate Constant Voltage (CV) and Constant Current (CC) without requiring TL431 and opto-coupler. It also eliminates the need of loop compensation circuitry while maintaining stability.

The μP6323K2M-6 features adjustable cable drop compensation function to meet various cables with different lengths and gauges and built-in line voltage compensation.

The μP6323K2M-6 uses the μPsemi's proprietary VCC forward power supply technology to achieve lower standby power, faster startup time with small VCC capacitor, and excellent dynamic performance without secondary IC.

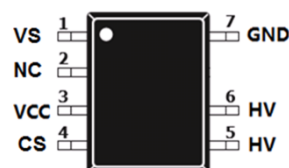
2. Applications

- Mobile Phone Charger
- E-tool Adapter
- LED Isolated Power Supply
- Standby Power Supply
- Digital Camera

3. Features

- Built-in 700V BJT for 85Vac~265Vac Range
- Excellent Dynamic Performance
- Less than 75mW Standby Power
- High Precision Constant Voltage and Current Without TL431 and Opto-coupler
- Multi-mode PWM/PFM Operation for Efficiency and Audio Noise Improving
- Adjustable Cable Compensation (1%~8%)
- Excellent System ESD Performance
- No Need for Control Loop Compensation
- Valley Turn-on to Reduce Switching Loss and Improve EMI
- Operating Frequency Jitter Function for Conductive EMI Suppression
- DoE(VI)/CoC tier2 Compliant Efficiency
- Multiple Protections
 - ◆ Over Temperature Protection(OTP)
 - ◆ Output Over-Voltage Protection(OVP)
 - ◆ Output Short Circuit Protection(SCP)
 - ◆ Line Voltage OVP and VCC OVP
 - ◆ VS Resistor Open/Short Protection
 - ◆ CS Resistor Open/Short Protection
 - ◆ IC Single Pin Floating Protection

4. Pin Assignments



SOP7 package

5. Pin descriptions

Pin number	Pin Name	Pin Functions
1	VS	Voltage feedback. The CV and CC regulation are realized based on the voltage sampling of this pin
2	NC	Not connect
3	VCC	The power supply for the IC. In order to get the correct operation of the IC, a capacitor with low ESR should be placed as close as possible to the VCC pin
4	CS	Sense primary side current for turning off the integrated power BJT.
5,6	HV	The collector pin of the integrated power BJT
7	GND	The ground of the IC

6. Absolute Maximum Ratings (Note 1)

Parameter	Name	Range	Unit
Collector voltage of Power BJT	HV	-0.5 to 700	V
Voltage at VCC to Ground	VCC	-0.5 to 38	V
VS input voltage	VS	-30 to 30	V
Voltage at CS to Ground	CS	-0.5 to 6	V
Maximum junction temperature	T _{JMAX}	150	°C
Lead temperature	T _{LEAD}	260	°C
Storage temperature	T _{STG}	-55 to 150	°C
Thermal resistance (Note2)	θ _{JA}	100	°C/W
Human Body Mode ESD per ANSI/STM5.1-2001		+/-4000	V
Charged Device Model per JEDEC JESD22-C101F		+/-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 beyond those under “Recommended operating conditions” is not implied.

Note2: The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a

7. Recommended Operating Conditions

Symbol	Parameter	Range	Unit
HV	Power device voltage	0~600	V
VCC	Supply voltage	4~35	V

8. Electrical Parameter

(Ta=25°C, unless otherwise specified)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Power supply(VCC pin)						
Quiescent current	I _{CC}	VCC= V _{st} -1V	280	380	480	μA
Startup voltage	V _{ST}		5.5	7.5	9.5	V
Minimum operating voltage	V _{UVLO}		2.9	3.2	4.5	V

Offline AC-DC Primary Side Regulation Switcher

Startup current	I _{ST}	VCC=V _{st} -1V		0.85	1.5	μA
Constant voltage control (VS pin)						
VS regulation voltage	V _{VS}		-2.91	-2.86	-2.81	V
Cable compensation current at Max load	I _{CAB}	Note 3		50		μA
Min. operating frequency	f _{MIN}		3000	3500	4000	Hz
Constant Current Control (CS pin)						
Threshold voltage @40%~100% Load	V _{CSMAX}	Note 4	560	590	620	mV
Threshold voltage @0%~5% Load	V _{CSMIN}	Note 3		150		mV
Pre-shutdown voltage	V _{CSPRE} /V _{CS}	Note 3		83		%
Leading edge blanking	T _{LEB}	At V _{CSMAX}		500		ns
Maximum duty of secondary winding conduction	D _{MAX}	Note 3		0.57		
Frequency jitter						
VCS modulation	ΔV _{CS} /V _{CS}	Note 3	4	5	6	%
VCS modulation frequency	f _{MOD}	Note 3	0.8	1	1.2	kHz
Drive control (Note 3)						
Drive current	I _{DRV}			56		mA
Overdrive time	t _{OVD}			300		ns
Driving current rising time	t _{DR}	VCC=12V		65		ns
Pull down resistance for sink capacity	R _{DS_{ON}}			3		Ω
Sinking current rising time	t _{SR}	VCC=12V		35		ns
Protection function						
Shutdown temperature	T _{OTP}	Note 3		160		°C
Temperature hysteresis	T _{HYS}	Note 3		25		°C
VCC over voltage protection threshold	V _{VCC_OVP}		35	36.5	38	V
VS over voltage protection threshold	V _{VS_OVP}			3.2		V
Short circuit protection threshold	V _{VS_HICCUP}			1.74		V
Duration time under V _{VS} (SCP)	t _{SCP}	Note 3		64		ms

Note 3: These parameters are guaranteed by design and characterization

Note 4: V_{CSMAX} is an equivalent parameter tested in closed loop to ensure the precise constant current.

Ref.	Description	Qty.	Ref.	Description	Qty.
F1	2Ω,0.5W	1	USB1	USB Connector	1
EC1、EC2	4.7uF/500V, electrolytic	2	R11	200Ω,0805, 5%	1
EC3	500uF/7.5V, Solid	1	Rst1, Rst2	15MΩ, 0805, 5%	2
C1	1nF/1000V, 0805, ceramic	1	R2	200Ω,0805, 5%	1
Cvcc	680nF/50V, 0805, ceramic	1	R1	200kΩ, 0805, 5%	1
L1	680uH 0410	1	R3	2Ω, 0805, 5%	1
BD1	MB10S, 1000V 1A	1	Rcs1	2Ω, 0805, 1%	1
D1	1N4007, SOD-123	1	Rvs1	7.5kΩ, 0603,1%	1
D2	IN4148, SOD-123	1	Rvs2	10kΩ, 0603, 1%	1
D3	3A40, SMA	1	Rvs3	510kΩ, 0603, 1%	1
DZ1	4.7V, Zener	1	U1	μP6323K2M-6, SOP-7	1
T1	EE13	1			
Total Components:25					

Table1, μP6323K2M-6 5V1A BOM

11. Principle of Operation

The typical application circuit of μP6323K2M-6 is a conventional flyback converter with a 3-winding transformer---primary winding (N_P), secondary winding (N_S) and auxiliary winding (N_A), as shown in typical application. The forward auxiliary winding is used for providing VCC supply voltage for IC and sensing the output voltage feedback signal to VS pin.

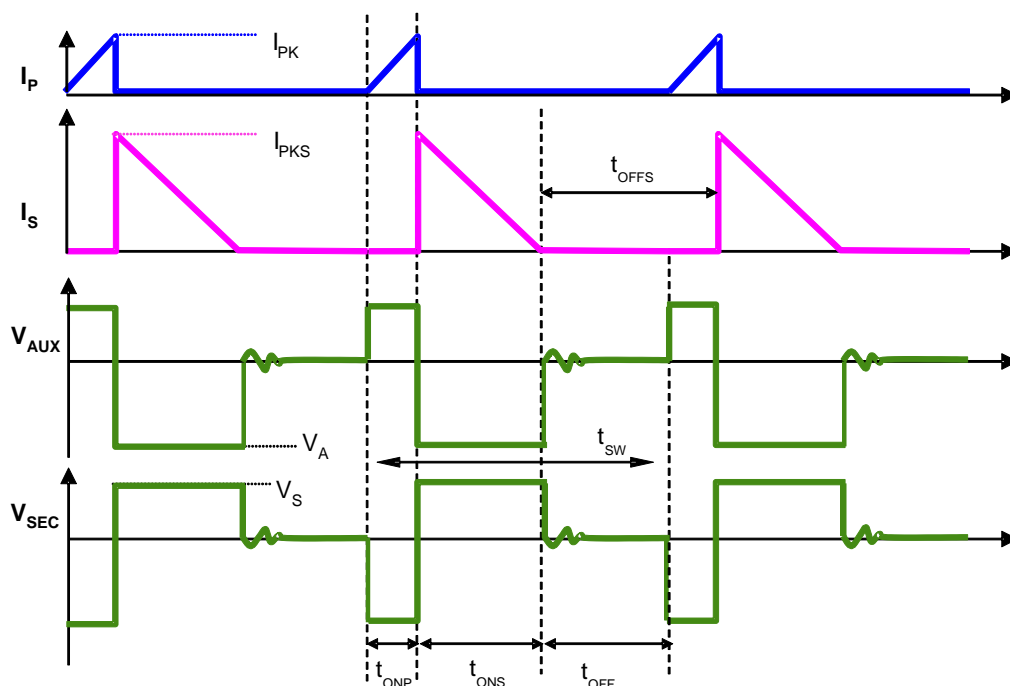


Fig.3 Typical Waveforms

Fig.3 shows the typical waveforms which demonstrate the basic operating principle of μP6323K2M-6 application. And the parameters are defined as following.

- I_P ---The primary side current
- I_S ---The secondary side current
- I_{PK} ---Peak value of primary side current
- I_{PKS} ---Peak value of secondary side current
- V_{SEC} ---The transient voltage at secondary winding
- V_S ---The stable voltage at secondary winding when rectification diode is in conducting status, which equals the sum of output voltage V_O and the forward voltage drop of diode
- V_{AUX} ---The transient voltage at auxiliary winding
- V_A --- The stable voltage at auxiliary winding when rectification diode is in conducting status, which equals the sum of voltage V_{CC} and the forward voltage drop of auxiliary diode
- t_{SW} ---The period of switching frequency
- t_{ONP} ---The conduction time when primary side switch is “ON”
- t_{ONS} ---The conduction time when secondary side diode is “ON”
- t_{OFF} ---The dead time when neither primary side switch nor secondary side diode is “ON”
- t_{OFFS} --- The time when secondary side diode is “OFF”

11.1 Proprietary VCC Forward Power Supply

The μP6323K2M-6 adopts the μPsemi's proprietary VCC forward power supply technology, which the polarity terminal of auxiliary winding is opposite to the commonly used flyback power supply.

In the traditional VCC flyback power supply, the forward voltage of auxiliary winding is $V_O * N_{AS}$. The output voltage is very low when starting, $V_O * N_{AS}$ is less than VCC voltage and can't supply VCC power. At this stage the power consumption on VCC is depending on previous storage, so it is necessary to use the large VCC capacitance in order to maintain normal starting.

In the μPsemi's proprietary VCC forward power supply, as long as the primary side is switched on, the forward voltage of auxiliary winding is $1.414 * V_{AC} / N_{PA}$ and can supply VCC power, which is independent of the output voltage. Therefore, the VCC forward power supply can use smaller VCC capacitor (470nf~1uf generally used), and the starting resistance can be about 20M to achieve lower standby power and faster startup time.

11.2 Constant Voltage (CV) Operation

Constant voltage operation occurs when the load is between no-load and full-load. Output voltage is sensed at the VS pin, which is connected to the auxiliary winding via resistors R_{VS1} and R_{VS2} . The VS waveform is sampled at t_{SAMPLE} , around 2/3 duration of the secondary winding conduction time(T_{ONS}). The sampled voltage is regulated at V_{VS} by the voltage control loop. The CV output is determined by the resistors R_{VS1} , R_{VS2} and the turn ratio of secondary winding to auxiliary winding (N_S/N_A). The output voltage at cable end is:

$$V_O = |V_{VS}| \times \left(1 + \frac{R_{VS1}}{R_{VS2}}\right) \times \frac{N_S}{N_A}$$

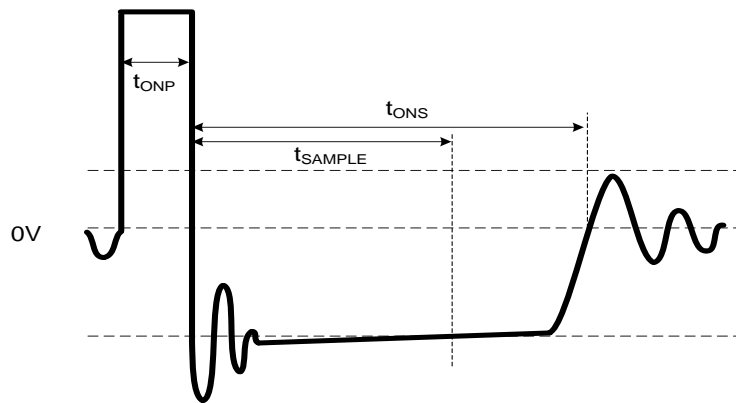


Fig.4 Auxiliary Voltage Waveform

11.3 Constant Current (CC) Operation

The μP6323K2M-6 can work in constant-current (CC) mode. Figure 3 shows the secondary current waveforms. In CC operation mode, the CC control loop of μP6323K2M-6 will keep a fixed proportion between D1 on-time t_{ONS} and D1 off-time t_{OFFS} . The fixed proportion is

$$\frac{t_{ONS}}{t_{OFFS}} = \frac{4}{3}$$

The relationship between the output current and secondary peak current I_{PKS} is given by:

$$I_{OUT} = \frac{1}{2} \times I_{PKS} \times \frac{t_{ONS}}{t_{ONS} + t_{OFFS}}$$

As to tight coupled primary and secondary winding, the secondary peak current is

$$I_{PKS} = \frac{N_P}{N_S} \times I_{PK}$$

Thus the output constant-current is given by:

$$I_{OUT} = \frac{1}{2} \times \frac{N_P}{N_S} \times I_{PK} \times \frac{t_{ONS}}{t_{ONS} + t_{OFFS}} = \frac{2}{7} \times \frac{N_P}{N_S} \times I_{PK}$$

11.4 Switching Frequency Control

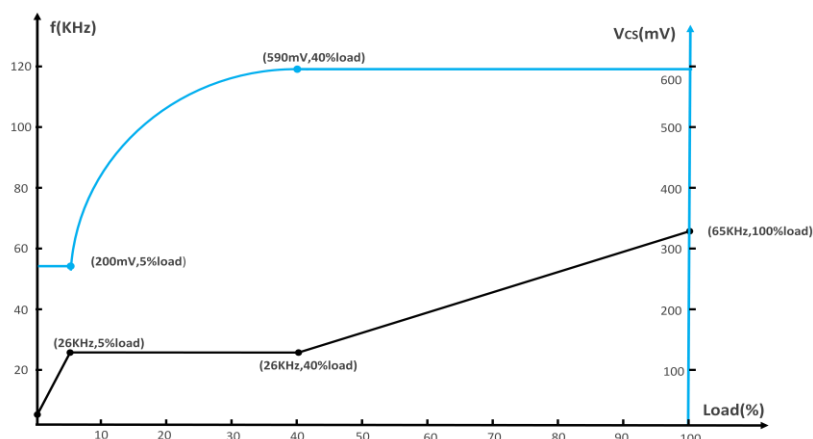


Fig.6, Switching frequency and CS voltage v.s. load current

The μP6323K2M-6 works in Pulse Frequency Modulation (PFM) mode to control output voltage and current. As shown in Fig.6, the CS voltage at the power device turnoff instant varies from V_{CSMIN} to V_{CSMAX} when the load increases from no load to full load. Operating frequencies varies from 3.9 kHz at no load to up to 65 kHz at full load. The power device is turned on when the ring voltage is down to its valley (quasi-resonant switching). This can reduce turn on losses of the power device. It can also generate switching period jittering to reduce EMI.

11.5 Adjustable Cable Compensation

To meet the voltage drop of different output cables, the μP6323K2M-6 can realize the adjustable cable compensation. The VS pin source a current proportional to the load to generate cable compensation voltage. The cable compensation current at max load is I_{CAB} . The cable compensation voltage V_{CAB} can be adjusted by setting the R_{VS1} , R_{VS2} values. Neglecting the forward conduction voltage of second D2, the cable compensation voltage at max load is

$$V_{CAB} = I_{CAB} \times R_{VS1} \times \frac{N_S}{N_A}$$

The output voltage at PCB end is

$$V_{O_PCB} = V_O + V_{CAB}$$

The cable compensation percentage is approximately

$$\frac{V_{CAB}}{V_O} = I_{CAB} \times R_{VS1} // R_{VS2} / |V_{VS}| - 0.05$$

For 5V1A typical application: $R_{VS1} = 7.5K\Omega$, $R_{VS2} = 10K\Omega$, $\frac{V_{CAB}}{V_O}$ is about 4%

The -0.05 item in the formula is to compensate load regulation.

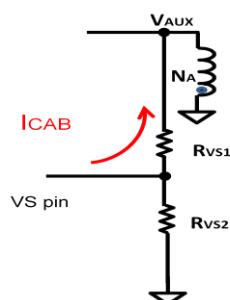


Fig.5. Adjustable Cable Compensation Circuit

11.6 Protection

The μP6323K2M-6 has multiple built-in fault protection functions:

- ◆ Line Voltage OVP and VCC OVP
- ◆ Output Short Circuit Protection(SCP)
- ◆ Output Over-Voltage Protection(OVP)
- ◆ Over Temperature Protection(OTP)
- ◆ VS Resistor Open/Short Protection
- ◆ CS Resistor Open/Short Protection
- ◆ IC Single Pin Floating Protection

11.6.1 AC Line Voltage OVP and VCC OVP

When the system works normally, the forward voltage of V_{AUX} charges the VCC capacitor at the primary turn-on (t_{ONP}) stage. The VCC voltage reflects the AC line voltage. That is to say, VCC over voltage protection can realize AC line voltage over voltage protection.

When the VCC voltage is over the threshold voltage V_{VCC_OVP}, the device will be turned off and enter auto-recovery mode that the IC immediately shuts down and then restarts until the line voltage drops below V_{LINE_OVP} when the VCC voltage restarts to V_{ST}.

$$V_{LINE_OVP} = 0.707 \times V_{VCC_OVP} \times \frac{N_P}{N_A}$$

11.6.2 Short Circuit Protection (SCP)

Short Circuit Protection (SCP) detection principle is similar to the normal output voltage feedback detection by sensing VS pin voltage. When the detected VS pin voltage is below |V_{VS_HICCUP}| for a duration of about t_{SCP}, the SCP is triggered. Then the μP6323K2M-6 enters auto-recovery mode, so that the VCC voltage changes between V_{ST} and UVLO threshold until V_{VS_HICCUP} condition is removed.

As to the normal system startup, the time duration of VS pin voltage below V_{VS_HICCUP} should be less than t_{SCP} to avoid entering SCP mode. But for the output short condition or the output voltage below a certain level, the SCP mode will be triggered. For typical 5V application, V_{SCP} is about 1V.

$$V_{SCP} = |V_{VS_HICcup}| \times (1 + \frac{R_{VS1}}{R_{VS2}}) \times \frac{N_S}{N_A} + I_{CAB} \times R_{VS1} \times \frac{N_S}{N_A} - V_{D3}$$

11.6.3 Output Over Voltage Protection

The μP6323K2M-6 includes output over-voltage protection (OVP). If the voltage at VS pin exceeds V_{VS_OVP} for 3 successive switching cycles, the device immediately shuts down and enters auto-recovery mode.

$$V_{OVP} = |V_{VS_OVP}| \times (1 + \frac{R_{VS1}}{R_{VS2}}) \times \frac{N_S}{N_A} + I_{CAB} \times R_{VS1} \times \frac{N_S}{N_A}$$

11.6.4 Over Temperature Protection

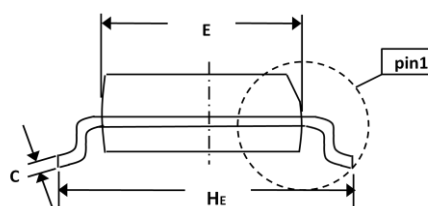
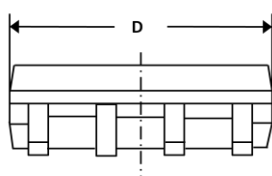
The μP6323K2M-6 provides internal over-temperature protection (OTP). If the junction temperature reaches the threshold T_{OTP} , the device enters auto-recovery mode. If the junction temperature decreases by T_{HYS} when the VCC voltage restarts to V_{ST} , the device can recover to normal operation. If not, the power system enters hiccup mode until the junction temperature decreases below $T_{OTP} - T_{HYS}$.

12. Ordering Information

Part number	Mark ID	Package	Packing	Output power
μP6323K2M-6	6323K2M-6	SOP7	4000/Reel	5W

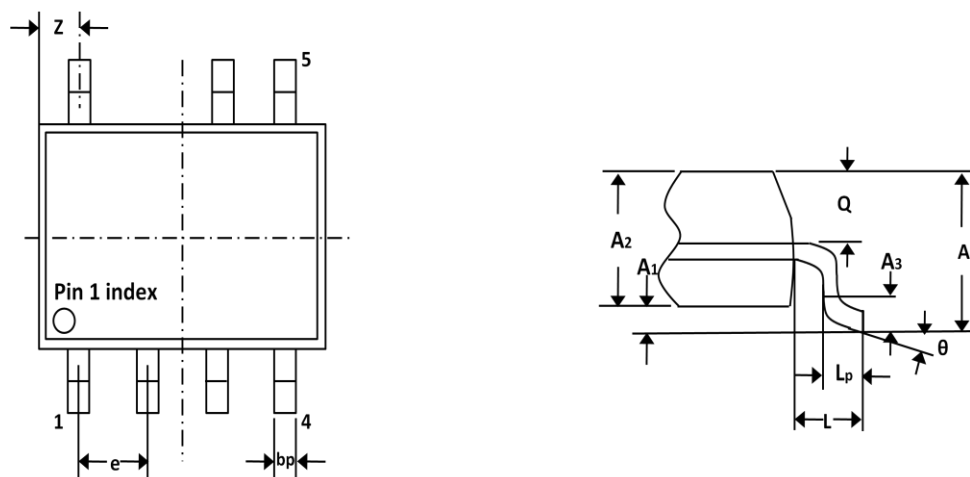
13. Mechanical dimensions

SOP7



μP6323K2M-6

Offline AC-DC Primary Side Regulation Switcher



UNIT	A	A1	A2	A3	bp	c	D	E	e	HE	L	Lp	Q	Z	θ
mm	1.75MAX	0.10 0.25	1.25 1.65	0.25	0.31 0.51	0.17 0.25	4.8 5.0	3.8 4.0	1.27	5.8 6.2	1.05	0.4 1.2	0.6 0.7	0.3 0.7	0° 8°