

# KTB851

## 600mA Step-Down Converter

## Features

- Vin Range: 2.7V to 5.5V
- Maximum Output Current 600mA
- High Efficiency Up to 98%
- Low Quiescent Current
- High Switching Frequency: 1.6MHz
- Low Dropout in 100% Duty Cycle
- Shutdown Current < 1µA</li>
- No Schottky Diode Required
- Output Auto Discharge when Disabled (Option)
- Integrated Soft-Start : 170µs
- Adjustable Output Voltage Down to 0.6V
- Short Circuit Protection
- Over-Temperature Protection
- Pb-Free Packages:
- ► KTB851 : UTDFN-6, 1.6x1.6x0.55mm
- ► KTB851 : TDFN-6, 1.6x1.6x0.75mm
- ▶ KTB851A/B : TSOT23-5
- RoHS and Green Compliant
- -40°C to +85°C Temperature Range

## Applications

- Mobile Phones
- Portable Instruments
- Digital Still Cameras
- Microprocessor Power
- MP3 Players

## **Typical Application**



## **Brief Description**

The KTB851 is a high efficiency step down converter, using constant frequency PWM current mode control. It uses 1.6MHz high switching frequency which allows the use of small external components. The 2.7V to 5.5V input operating range is ideal for Li-Ion/Polymer powered devices and systems running from regulated 3.3V or 5V voltage rails. 100% duty cycle operation provides the greatest design flexibility for achieving the lowest dropout.

Low output voltage down to 0.6V can be achieved due to the KTB851's low internal voltage reference.

The KTB851 is designed to maintain high efficiency throughout the operating range, which is critical for portable applications. In addition, the KTB851 has an option for output auto discharge feature. This enables the device to quickly discharge the output when the device is disabled.

The KTB851 is available in a small 5-pin TSOT23, 6-pin TDFN 1.6 x 1.6 x 0.75mm and 6-pin UTDFN 1.6 x 1.6 x 0.55mm package.



## **Pin Descriptions**

### TDFN 1.6 x 1.6mm and TSOT23-5

	Pin #			Function	
KTB851A (TSOT23)	KTB851B (TSOT23)	TDFN-6 UTDFN-6	Name		
3	1	1	EN	IC enable pin. Should not be left floating.	
4	5	6	FB	Feedback pin. Provides feedback information to the control loop via external resistor divider connected to the output.	
1	4	5	VIN	Input supply pin. Should be decoupled with a 2.2µF or greater capacitor to GND.	
5	3	4	LX	Inductor connection pin	
2	2	2	AGND	Analog ground pin.	
2	2	3	PGND	Power ground pin.	



(Top View)



**TDFN-6, 1.6mm x 1.6mm UTDFN-6, 1.6mm x 1.6mm** (Top View) KTB851

EN	<u> </u>	·	6	FB
AGND	<u>2</u> ¦	MC	5	VIN
PGND	<u>3</u>		4	LX



## Absolute Maximum Rating<sup>1</sup>

 $(T_A = 25^{\circ}C \text{ unless otherwise noted})$ 

Symbol	Description	Value	Units
VIN, FB, VOUT	Input voltage	-0.3 to 6.0	V
EN, LX	Output and Control pins	-0.3 to VIN + 0.3	V
ILX	Peak LX current	1.2	А
TJ	Operating Junction Temperature Range	-40 to 125	°C
Ts	Storage Temperature Range	-65 to 125	°C
TLEAD	Maximum Soldering Temperature (at leads, 10 sec)	300	°C

## **Thermal Capabilities**

Symbol	Description	Value	Units			
TSOT23-5						
θ <sub>JA</sub>	Thermal Resistance – Junction to Ambient <sup>2</sup>	250	°C/W			
Po	Maximum Power Dissipation at T <sub>A</sub> ≤ 25°C	400	mW			
ΔP <sub>D</sub> /°C	Derating Factor Above $T_A = 25^{\circ}C$	-4.6	mW/°C			
TDFN-6 1.6	TDFN-6 1.6x1.6mm and UTDFN-6 1.6x1.6mm					
θ <sub>JA</sub>	Thermal Resistance – Junction to Ambient <sup>2</sup>	150	°C/W			
PD	Maximum Power Dissipation at T <sub>A</sub> ≤ 25°C	667	W			
ΔP <sub>D</sub> /°C	Derating Factor Above T <sub>A</sub> = 25°C	-6.7	mW/°C			

## **Ordering Information**

Part Number	Auto Discharge	Marking <sup>3</sup>	Operating Temperature	Package
KTB851EVD-ADJ-TR	YES	EKYYZ	-40°C to +85°C	UTDFN-6 1.6x1.6x0.55mm
KTB851EVD-ADJ-1-TR	NO	IMYYZ	-40°C to +85°C	UTDFN-6 1.6x1.6x0.55mm
KTB851EZD-ADJ-TR	YES	YYZ	-40°C to +85°C	TDFN-6 1.6x1.6x0.75mm
KTB851AEHC-ADJ-TR	YES	EKYYZ	-40°C to +85°C	TSOT23-5
KTB851BEHC-ADJ-TR	YES	CAYYZ	-40°C to +85°C	TSOT23-5

<sup>1.</sup> Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum rating should be applied at any one time.

<sup>2.</sup> Junction to Ambient thermal resistance is highly dependent on PCB layout. Values are based on thermal properties of the device when soldered to an EV board.

<sup>3. &</sup>quot;YYZ" is the date code and assembly code.



## **Electrical Characteristics**<sup>4</sup>

The *Min* and *Max* specs are applied over the full operation temperature range of  $-40^{\circ}$ C to  $+85^{\circ}$ C, VIN = EN = 3.6V, while Typ values are specified at room temperature (25°C) unless otherwise noted.

Symbol	Description	Conditions	Min	Тур	Max	Units
V <sub>IN</sub>	Input Voltage Range		2.7		5.5	V
		V <sub>IN</sub> Rising			2.7	V
Vuvlo	UVLO Threshold	Hysteresis		200		mV
		V <sub>IN</sub> Falling		2.3		V
lq	IC supply current	$V_{\text{IN}} = V_{\text{EN}} = V_{\text{FB}} = 3.6 V$		44	70	μA
I <sub>SHDN</sub>	Vin pin shutdown current	EN = GND		0.1	1.0	μA
Vfb	Feedback Voltage KTB851-ADJ	$T_A = 25^{\circ}C$	0.588	0.600	0.612	V
ΔVουτ	Output Voltage Accuracy	$V_{IN} = V_{OUT} + 0.2V$ to 5.5V, $V_{IN} \ge 3.5V$ , $T_A = 25^{\circ}C$ , $0A < I_{OUT} < 600mA$	-3		3	%
Іоит	Output Current		600			mA
ΔVfb	VFB Line Regulation	$V_{IN} = 2.7V$ to $5.5V$		0.1		%/V
$\Delta V_{OUT\_LINE}$	Output Voltage Line Regulation	$V_{\text{IN}}$ = 2.7V to 5.5V, $I_{\text{OUT}}$ = 300mA		0.5		%/V
$\Delta V_{\text{OUT}\_\text{LOAD}}$	Output Voltage Load Regulation	$I_{OUT} = 1$ mA to 600mA		0.4		%
fosc	Oscillator Frequency			1.6		MHz
DMAX	Maximum Duty Cycle		100			%
ILIM	Output Current Limit			1.0		Α
RDS(ON)P	High-side P-Channel on-resistance	I <sub>LX</sub> = 100mA		0.35		Ω
Rds(on)n	Low-side N-Channel on-resistance	I <sub>LX</sub> = -100mA		0.3		Ω
Ilx_lkg	LX Leakage Current	$EN = GND$ , $V_{LX} = GND$ , $V_{IN} = 5.5V$		±0.01		μA
TPULLDOWN	Output pull-down discharge time <sup>5</sup>	$EN = GND$ , $C_{OUT} = 10\mu F$ , $V_{OUT} = 3.3V$		2.5		ms
Ts	Soft-start time			170		μS
V <sub>Th-L</sub>	EN pin logic low voltage				0.4	V
$V_{\text{Th-H}}$	EN pin logic high voltage		1.4V		VIN	V
I <sub>EN</sub>	Enable Leakage Current			±0.1	±1	μA
<b>–</b>	Junction thermal shutdown temperature			140		°C
I J_TH	Junction thermal shutdown hysteresis			15		°C

<sup>4.</sup> The KTB851 is guaranteed to meet performance specifications over the -40°C to +85°C operating temperature range by design, characterization and correlation with statistical process controls.

<sup>5.</sup> The KTB851-1 option does not have output auto discharge feature.



## **Typical Characteristics**

 $V_{IN}$  = 3.6V, L = 2.2µH (Murata LQH3NPN2R2NJ0),  $C_{IN}$  = 4.7µF,  $C_{OUT}$  = 10µF with VOUT = 1.8V,  $T_{AMB}$  = 25°C unless otherwise specified.



Efficiency vs. Output Current (VOUT = 1.2V)



Quiescent Current (non-switching)



Efficiency vs. Output Current (VOUT = 1.8V)





## **Typical Characteristics**















## **Typical Characteristics (Continued)**





Load Regulation (VOUT = 3.3V)



Line Regulation



Line Regulation (VOUT = 3.3V)





## **Typical Characteristics (Continued)**

 $V_{IN}$  = 3.6V, L = 2.2µH (Coilcraft LPS3015-222), C<sub>IN</sub> = 4.7µF, C<sub>OUT</sub> = 10µF, C1 = 22pF with VOUT = 1.8V, T<sub>AMB</sub> = 25°C unless otherwise specified.





**KTB851** 

### **Functional Block Diagram**



### **Functional Description**

The KTB851 is a step-down converter, using constant frequency current-mode control. The 2.7V to 5.5V input operating range is ideal for both Li-Ion/Polymer powered devices and systems running from regulated 3.3V or 5V voltage rails. It can deliver up to 600mA with its integrated power MOSFETs. It uses high frequency 1.6MHz switching to allow the use of small external components, which makes it ideally suited for small form factor portable systems. Integrating very low  $R_{DS(ON)}$  power MOSFETs enables power conversion efficiency up to 97%. Fixed and adjustable output options are available, providing the flexibility to deliver output voltages from 0.6V to  $V_{IN}$ . The KTB851 will operate with input voltages as low as 2.7V, however due to increased resistance of the power devices as the input voltage decreases, the maximum load current decreases. A feature provided in the KTB851 is 100% duty cycle operation, which allows the input voltage to decrease until the high side P-channel MOSFET no longer turns off at each oscillator cycle. Further decrease in the input voltage forces the high side MOSFET to remain turned on 100% of the time. At this point, the output inductor. The KTB851 is protected against short circuit conditions as well as IC over-temperature conditions. When the IC is disabled, the shutdown current decreases to less than 1µA.





Figure 1. Typical Application Circuit – Adjustable Output Voltage

#### **Control Loop Operation**

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The output voltage of KTB851 is regulated by modulating the pulse width of the high-side switch at a fixed frequency determined by the internal oscillator. The high-side switch is controlled by a flip-flop driven by the internal oscillator and a comparator that takes inputs from the error signal from an error amplifier with the sum of the sensed current signal and compensation ramp. The driver turns ON and OFF the high-side PMOS while the low-side NMOS transistor is turned OFF then ON; the switches are never turned ON at the same time in order to prevent a direct path from input to ground. Each new cycle starts with the high-side PMOS switch turning ON with the rising edge of the internal oscillator clock. The inductor current ramps up until the sum of the current sense signal and compensation ramp becomes higher than the error amplifier's voltage. Once this has occurred, the PWM comparator resets the flip-flop, the high-side switch is turned OFF while the low-side switch is turned ON. Due to the internal low-side switch, there is no need for an external Schottky diode. To avoid shoot-through current passing directly from input to ground in case the PMOS is not fully turned off before the NMOS is turned ON, a short amount of break-before-make time is factored into the gate drive circuitry.

#### **Dropout Operation with 100% Duty Cycle**

In order to operate with an input voltage close to the output voltage, the KTB851 allows the high-side PMOS switch to remain on for more than one cycle which will increase the converter duty cycle as the input voltage approaches the output voltage. When the duty cycle reaches 100%, the PMOS switch is turned on continuously to deliver current to the output. At this point, the output voltage is determined by the input voltage minus the cumulative voltage drop across the high-side PMOS switch and inductor.

#### **Current Limit Protection**

To protect the IC and the system, KTB851 limits the peak current through the main P-channel MOSFET switch. To minimize power dissipation and stresses under current limit and short-circuit conditions, the inductor switching current cannot exceed a fixed current limit. Once the current in the P-channel MOSFET reaches its current limit and the feedback FB pin voltage is below about 0.3V, the P-channel MOSFET is turned off and the N-channel MOSFET is turned on to discharge the current in the inductor. After some delay, the switching operation restarts automatically and P-channel current monitoring continues.



## **Application Information**

#### Output Voltage Programming

The external resistor divider connected between the converter's output and FB pin of KTB851 sets the output voltage as shown in Figure 1. In order to limit the bias current required in the resistor divider while maintaining good noise immunity, the minimum suggested value for R2 is  $40k\Omega$ . A larger value resistor has the benefit of lower quiescent current; however, it increases the impedance of the IC's FB node, increasing the sensitivity to external noise. Selecting R2 of approximately  $60k\Omega$  will provide better transient response. R1 can be calculated by the following equation:

$$R1 = R2 \times \left(\frac{V_{OUT}}{0.6V} - 1\right)$$

R1	R2	Output Voltage
60.4kΩ (1%)	60.4kΩ (1%)	1.2V
121kΩ (1%)	60.4kΩ (1%)	1.8V
191kΩ (1%)	60.4kΩ (1%)	2.5V
243kΩ (1%)	60.4kΩ (1%)	3.0V
274kΩ (1%)	60.4kΩ (1%)	3.3V

#### Capacitor Selection

Small size X5R or X7R ceramic capacitors are required. A 4.7µF or higher input capacitor is recommended to improve transient behavior of the regulator and EMI behavior of the total power supply circuit. The input capacitor should be placed as close as possible to the input VIN pin and the PGND pin of the KTB851.

The output capacitance depends on the maximum output current required. A  $4.7\mu$ F or  $10\mu$ F ceramic capacitor works well in most situations.

#### **Inductor Selection**

The KTB851 is designed to use a  $2.2\mu$ H to  $10\mu$ H inductor. To prevent core saturation, ensure that the inductorsaturation current rating exceeds the peak inductor current for the application. The worst-case peak inductor current can be calculated with the following formula:

$$I_{Peak(L)} = \frac{V_{OUT} \times I_{OUT(MAX)}}{\eta \times V_{IN(MIN)}} + \left[\frac{V_{OUT}}{2 \times L \times f_{SW}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)\right]$$

where  $\eta$  is the estimated efficiency.

The recommended inductor value depends on the output voltage VOUT setting. For most applications, a  $2.2\mu$ H inductor is preferred. For higher output voltage setting above 2.8V, it is recommended to use a larger inductor value of  $4.7\mu$ H.

VOUT Setting (V)	Inductor L (µH)
< 2.8V	2.2
2.8V or higher	4.7



If the inductor value is smaller, the inductor peak current will increase. To maintain stable operations for the buck converter, the inductor peak current must be less than both the KTB851 current limit threshold and the inductor saturation current rating. Manufacturer's specifications of inductors list both the inductor DC current rating, which is a thermal limitation, and peak inductor current rating, which is determined by the saturation characteristics. Measurements at full load and high ambient temperature should be performed to ensure that the inductor does not saturate or overheat due to its parasitic resistance. Bench measurements are recommended to confirm actual inductor peak current IPEAK and to ensure that the inductor does not saturate at maximum output current.

Inductor Part Number	Value (µH)	DCR (Ω)	Saturation Current (A)	Dimensions (mm)	Manufacturer
LPS3015-222ML	2.2	0.11 max	2.0	3 × 3 × 1.5	Coilcraft
LPS3015-472ML	4.7	0.20 max	1.3	3 × 3 × 1.5	Coilcraft
MIPS2520D2R2	2.0	0.11 typ	1.1	2.5 x 2 x 1	FDK

#### **Recommended Inductor Part Numbers**

#### Layout Guidelines

Proper layout techniques are critical when implementing a high frequency DC-DC converter to minimize noise coupling between the converter and the system. Use short and wide traces in the main current path. Keep the same ground reference for input and output capacitors. A pulsating high-frequency current path includes the input capacitor Cin and the buck high-side and low-side internal FETs. Therefore the input capacitor should be located close to the VIN pin and PGND pin. Take care to isolate the feedback pin (FB) from the switching pin (LX) and the current path to guard against external noise coupling into the sensitive node. The resistor divider R2 ground terminal should be connected directly to the AGND pin. Add a feed-forward capacitor between the converter's output and KTB851's FB pin to improve stability and transient response. A four layer PCB with a ground plane and a power plane will help the converter's noise immunity and overall performance.



Figure 2. Recommended Layout for TDFN-6 Package



KTB851

## **Packaging Information**

### UTDFN1.6x1.6-6 (1.60mm x 1.60mm x 0.55mm)





Dimension	mm				
Dimension	Min.	Тур.	Max.		
A	0.50	0.55	0.60		
A1	0.00	0.02	0.05		
A3	0.152 REF.				
b	0.15	0.20	0.25		
D	1.50	1.60	1.70		
D2	1.25	1.30	1.35		
E	1.50	1.60	1.70		
E2	0.65	0.70	0.75		
е	0.50 BSC				
L	0.20	0.25	0.30		

**Side View** 

### **Recommended Footprint**



\* Dimensions are in millimeters.



### TDFN-6 1.6x1.6x0.75mm Package





Dimension	mm				
Dimension	Min.	Тур.	Max.		
А	0.70	0.75	0.80		
A1	0.00	0.02	0.05		
A3	0.203 REF.				
b	0.20	0.25	0.30		
D	1.55	1.60	1.65		
D2	0.90	1.00	1.10		
E	1.55	1.60	1.65		
E2	0.50	0.60	0.70		
е	0.50 BSC				
L	0.20	0.25	0.30		

Side View

### **TDFN-6 Recommended Footprint**



\* Dimensions are in millimeters.



### **TSOT23-5**



Dimension	mm				
Dimension	Min.	Тур.	Max.		
А	0.70	0.80	0.90		
A1	0.00	0.05	0.10		
b	0.30	0.40	0.50		
С	0.10	0.15	0.20		
D	2.80	2.90	3.00		
E	2.65	2.80	2.95		
E1	1.50	1.60	1.70		
е	0.95 BSC				
e1	1.9 BSC				
L	0.30		0.60		
Θ	4°		8°		

#### **TSOT23-5 Recommended Footprint**



\* Dimensions are in millimeters.

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