

5V, 3A, 1MHz Synchronous Buck Converter

TD6833

General Description

TD6833 is a 3A synchronous buck converter with integrated 75mΩ high side and 65mΩ low side power MOSFETs. The TD6833 design with a current-mode control scheme, can convert wide input voltage of 2.9V to 5.5V to provide excellent output voltage regulation.

The TD6833 is equipped with an automatic Skip/PWM mode operation. At light load, the IC operates in the Skip mode to reduce the switching losses. At heavy load, the IC works in PWM mode.

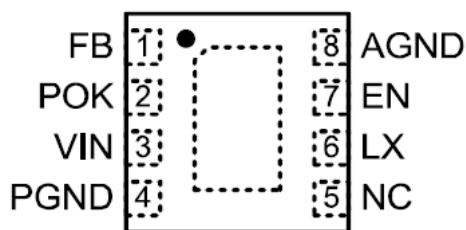
The TD6833 is also equipped with Power-on-reset, soft start and whole protections (under-voltage, overvoltage, over-temperature and current-limit) into a single package.

The TD6833 is available in TDFN2X2-8 package, provide a very compact system solution external components and PCB area.

Features

- High Efficiency up to 95%
- -Automatic Skip/PWM Mode Operation
- Adjustable Output Voltage from 0.6V to VIN
- Integrated 75mΩ High side 65mΩ Low Side MOSFET
- Stable with Low ESR Ceramic Capacitors
- Power-On-Reset Detection on VIN
- Integrate Soft Start and Soft-Stop
- Over-Temperature Protection
- Over Voltage Protection
- Under Voltage Protection
- High Side Current Limit
- Power Good Indication
- Enable/Shutdown Function
- TDFN2X2-8 packages
- Lead Free and Green Devices Available (RoHS compliant)

Pin Configurations



(Top view)

Applications

- Notebook Computer & UMPC
- LCD Monitor/TV
- Set-Top Box
- DSL, Switch HUB
- Portable Instrument

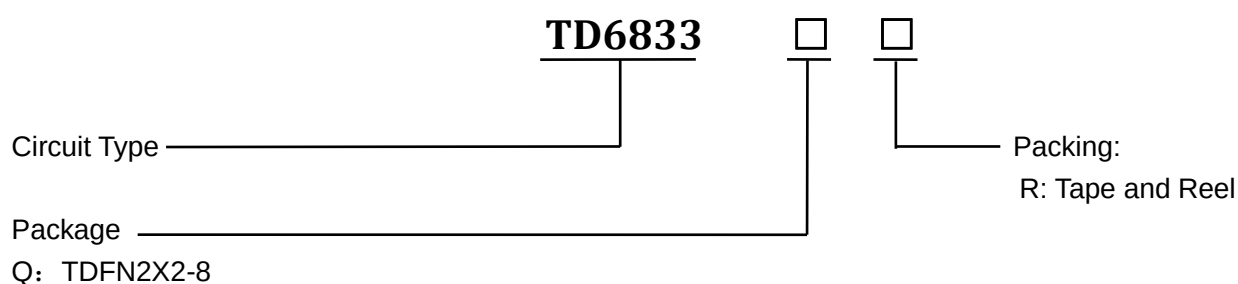
5V, 3A, 1MHz Synchronous Buck Converter

TD6833

Pin Description

Pin Number	Pin Name	Description
1	FB	Output Feedback Input. The TD6833 senses the feedback voltage via FB and regulates the voltage at 0.6V. Connecting FB with a resistor-divider from the converter's output sets the output voltage.
2	POK	Power Good Output. This pin is open-drain logic output that is pulled to ground when the output voltage is not within 10% of regulation point.
3	VIN	The control circuitry and converter supply input. Connecting a ceramic bypass capacitor from VIN to GND to eliminate switching noise and voltage ripple on the input to the IC.
4, Exposed pad	PGND	Power ground. Connect this pin to AGND.
5	NC	No internal connection.
6	LX	Power Switching Output. LX is the Junction of the high-side and low-side Power MOSFETs to supply power to the output LC filter.
7	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator, drive it low to turn it off.
8	AGND	Analog ground. Connect this pin to PGND.

Ordering Information



5V, 3A, 1MHz Synchronous Buck Converter

TD6833

Function Block

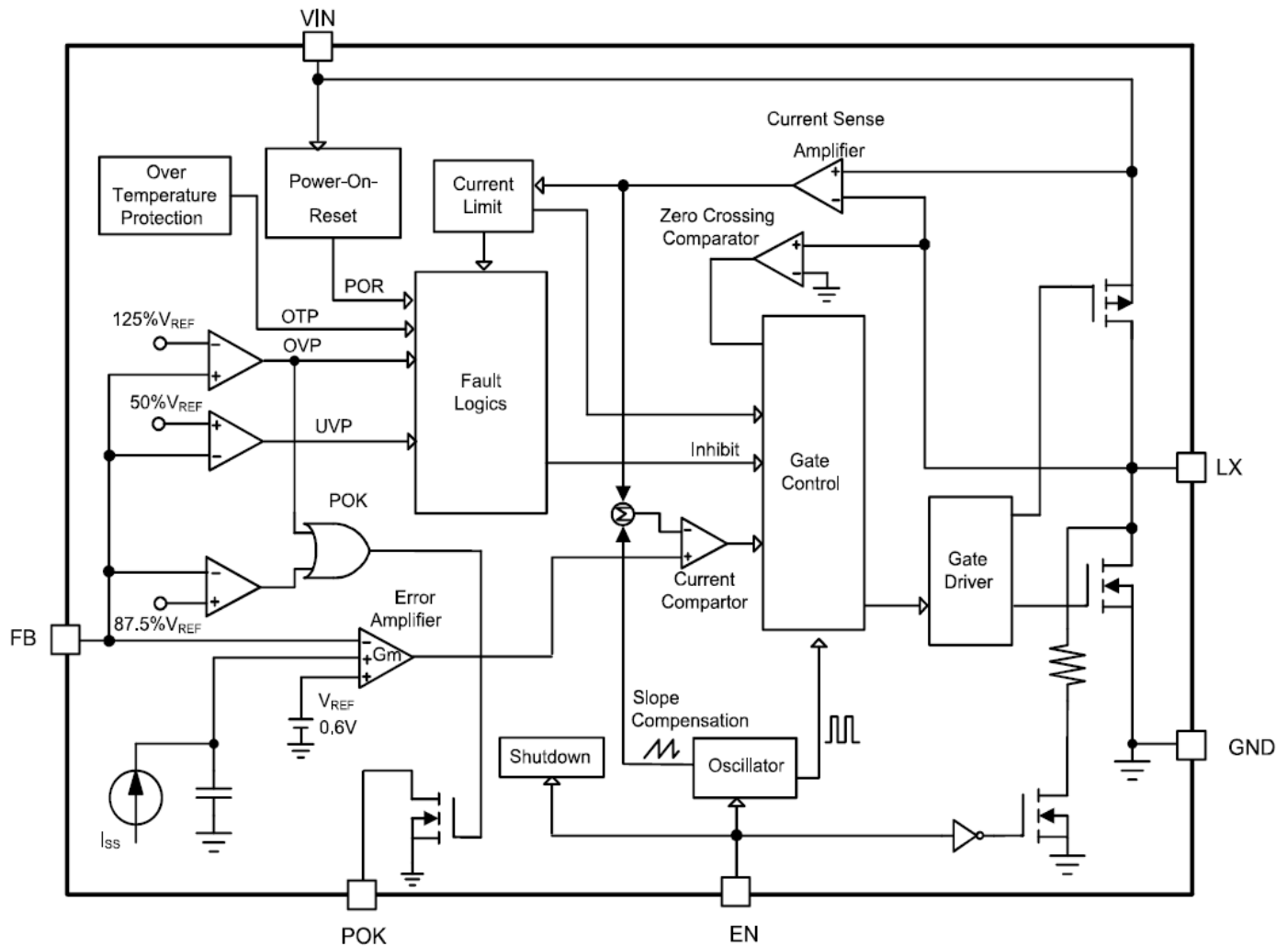


Figure1 Function Block Diagram of TD6833

Absolute Maximum Ratings (Note1)

Symbol	Parameter		Rating	Unit
V_{IN}	Input Supply Voltage to GND		-0.3 ~ 6.5	V
V_{LX}	LX to GND Voltage	< 30ns pulse width	-3 ~ 8	V
		> 30ns pulse width	-1 ~ $V_{IN}+0.3$	V
$V_{IN}-V_{LX}$	VIN to LX Voltage	< 30ns pulse width	-3 ~ 8	V
		> 30ns pulse width	-1 ~ $V_{IN}+0.3$	V
	POK, FB, EN to PGND Voltage		-0.3 ~ 6.5	V
	AGND to PGND Voltage		-0.3 ~ 6.5	V

5V, 3A, 1MHz Synchronous Buck Converter

TD6833

T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 ~ 150	°C
T_{SDR}	Maximum Lead Soldering Temperature (10 Seconds)	260	°C

Note1: 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 under "recommended operating conditions" is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Junction-to-Ambient Resistance in free air (Note 2)	250	°C/W

Note 2: θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air.

Recommended Operation Conditions (Note3)

Symbol	Parameter	Range	Unit
V_{IN}	Control and Driver Supply Voltage	2.9 ~ 5.5	V
I_{OUT}	Converter Output Current	0 ~ 3	A
T_A	Ambient Temperature	-40 ~ 85	°C
T_J	Junction Temp	-40 ~ 125	°C

Note 3: Refer to the typical application circuit

Electrical Characteristics

Unless otherwise specified, these specifications apply over $V_{IN}=3.7V$, $T_A = 25^\circ C$.

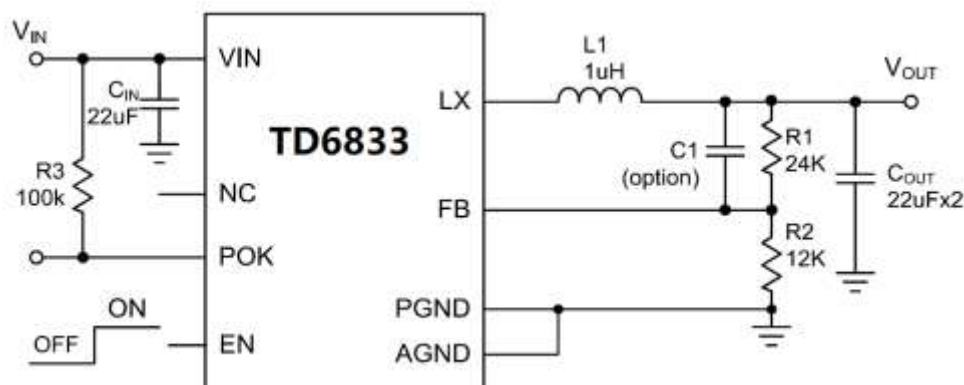
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Supply Current						
I_{DD}	VIN Supply Current	$V_{FB} = 0.66V$	-	65	-	μA
I_{SHDN}	VIN Shutdown Supply Current	EN=GND	-	-	1	μA
Power-On-Reset (POR)						
	VIN POR Voltage Threshold	V_{IN} Rising	2.3	2.4	2.5	V
	VIN POR Hysteresis		0.1	0.2	0.3	V
Reference Voltage						
V_{REF}	Reference Voltage		-	0.6	-	V
		$T_A = 25^\circ C$	-1	-	+1	%

5V, 3A, 1MHz Synchronous Buck Converter

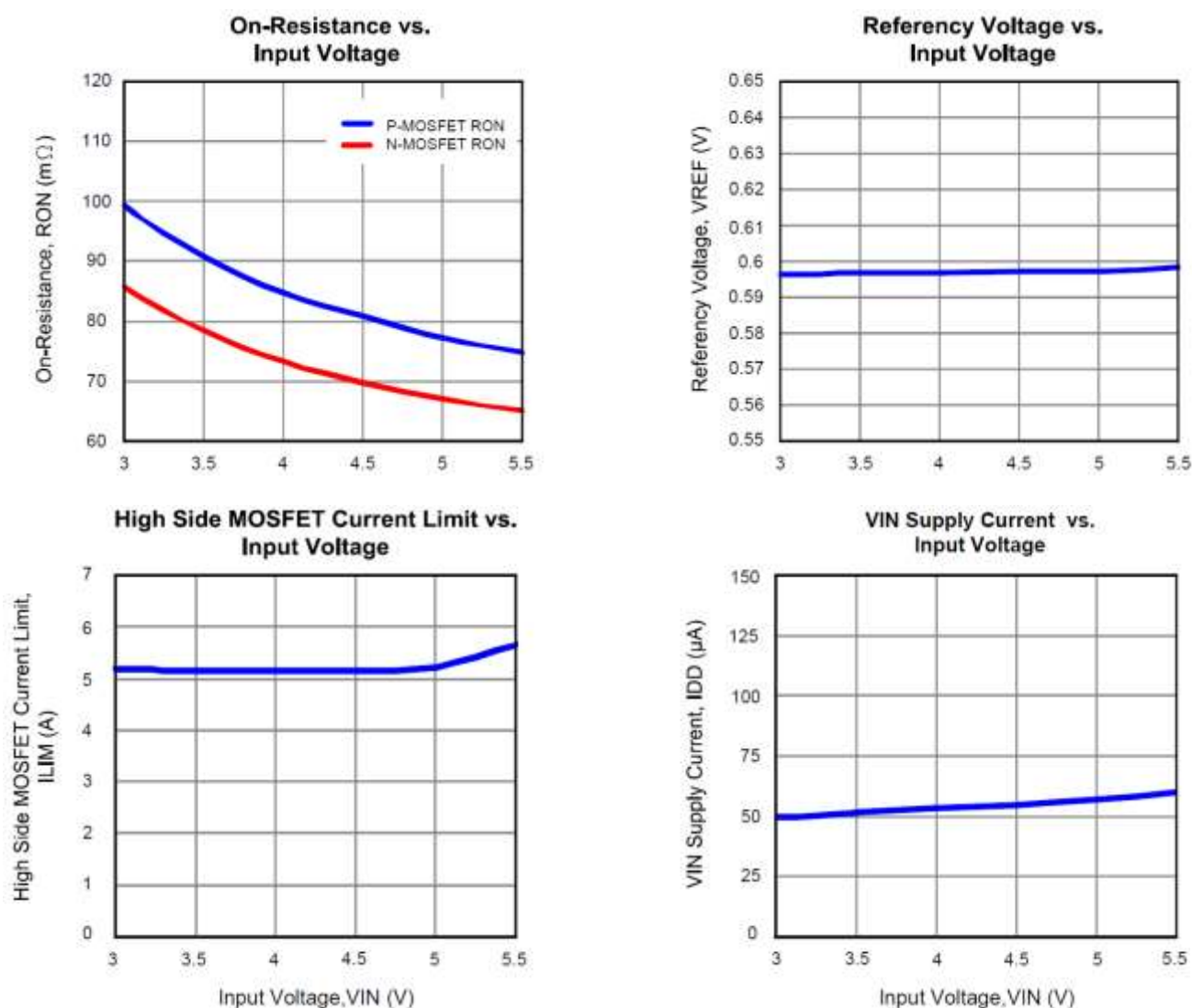
TD6833

	Output Accuracy	$I_{OUT}=10mA\sim 3A$, $V_{IN}=2.9\sim 5.5V$	-1.5	-	+1.5	%
Oscillator						
F_{OSC}	Oscillator Frequency		0.85	1	1.15	MHz
	Minimum on Time		-	70	-	ns
Power MOSFET						
	High Side P-MOSFET Resistance	$V_{IN}=5V$, $I_{LX}=0.5A$, $T_A=25^{\circ}C$	-	75	-	mΩ
	Low Side P-MOSFET Resistance	$V_{IN}=5V$, $I_{LX}=0.5A$, $T_A=25^{\circ}C$	-	65	-	mΩ
	High/Low Side MOSFET Leakage Current		-	-	10	μA
	Internal Discharge Resistance		-	1.1	-	kΩ
Protections						
I_{LIM}	High Side MOSFET current-limit	Peak Current, $V_{IN}=2.9\sim 5.5V$ $T_A=-40\sim 125^{\circ}C$	4	5	6	A
T_{OTP}	Over-temperature Trip Point (Resoft start after OTP)		-	160	-	°C
	Over-temperature Hysteresis		-	50	-	°C
	Over- Voltage Protection threshold	V_{OUT} Rising	120	125	130	% V_{REF}
	Under-Voltage Protection threshold		-	50	-	% V_{REF}
	Over-Voltage Protection debounce time		20	25	30	μS
Soft-Start, Enable and POK						
T_{SS}	Soft Start time		0.5	0.8	1.1	ms
	EN Enable threshold		1.4	-	-	V
	EN shutdown threshold		-	-	0.5	V
	EN Pull Low Current		-	0.5	1	μA
	POK threshold	POK in from Lower (POK Goes High)	82.5	87.5	92.5	% V_{OUT}
		POK Low Hysteresis (POK Goes Low)	-	5	-	% V_{OUT}
		POK in from Higher (POK Goes High)	120	125	130	% V_{OUT}
	Power Good pull low resistance		-	-	30	Ω
	Power Good Debounce	High to low	-	20	-	μS
T_{D_EN}	EN Delay Time		400	600	800	μS
T_{D_PG}	Power Good Debounce	Low to High	1	3	6	μS

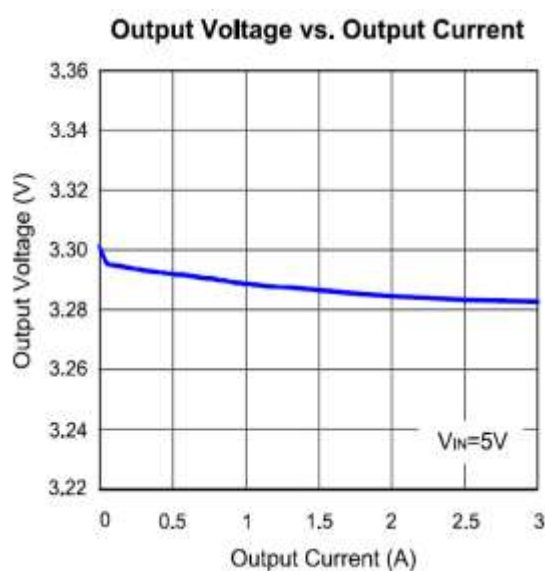
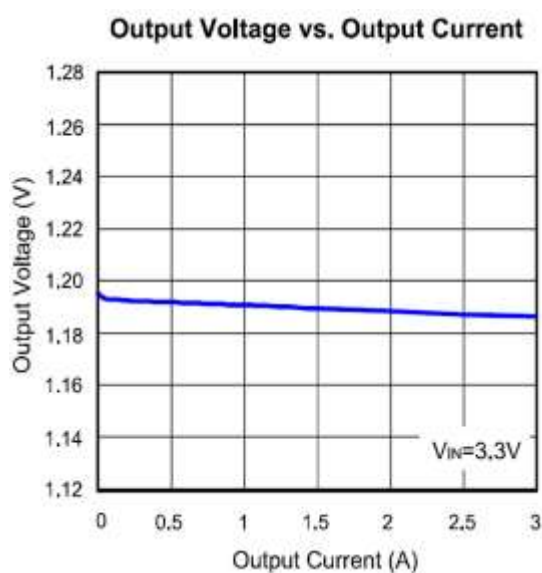
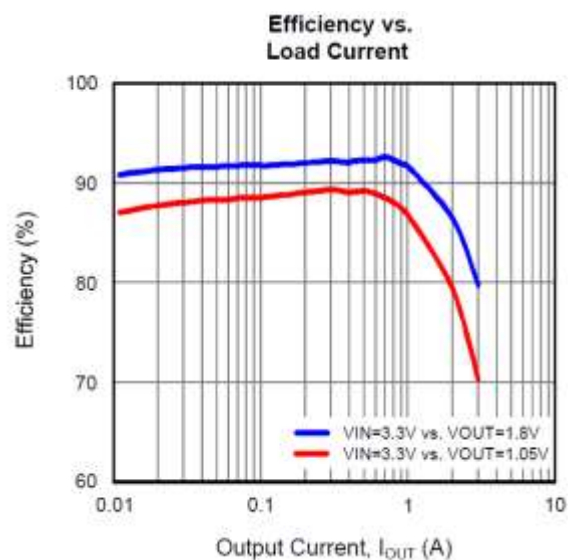
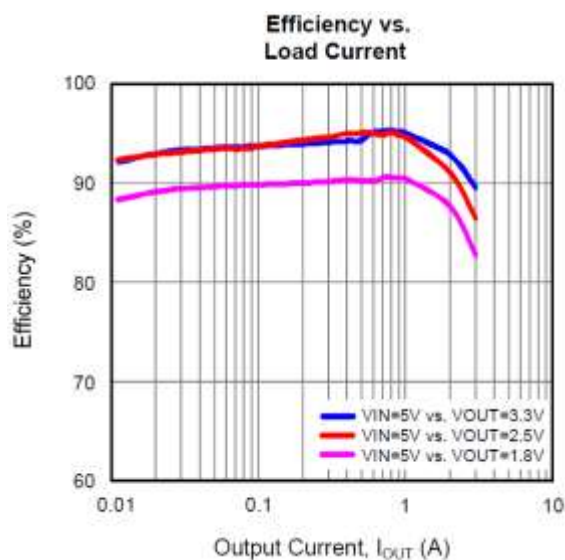
Typical Application Circuit



Typical Operating Characteristics



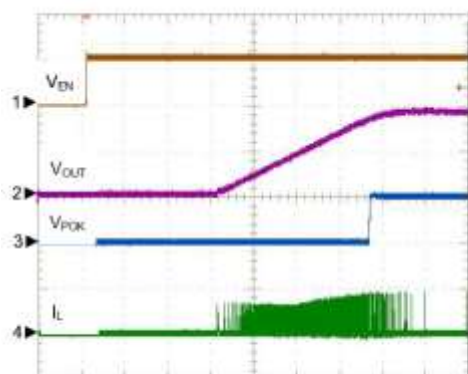
Typical Operating Characteristics (Cont.)



Operating Waveforms

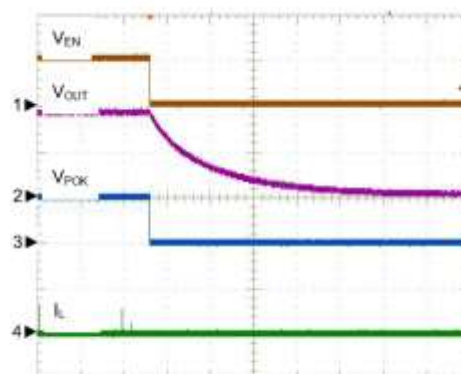
Refer to the typical application circuit. The test condition is $V_{IN}=5V$, $V_{OUT}=1.8V$, $T_A=25^{\circ}C$ unless otherwise specified.

Enable without Loading



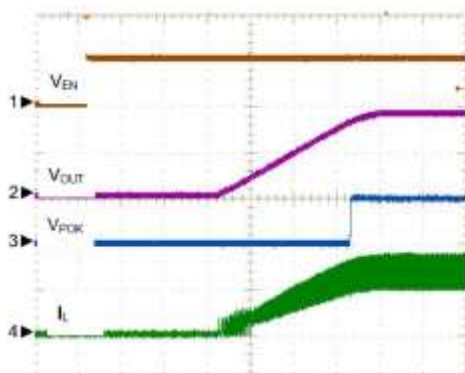
CH1: V_{EN} , 5V/Div, DC
CH2: V_{OUT} , 1V/Div, DC
CH3: V_{POK} , 5V/Div, DC
CH4: I_L , 1A/Div, DC
TIME: 200us/Div

Shutdown without Loading



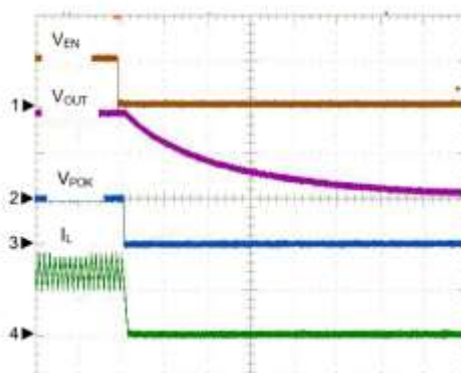
CH1: V_{EN} , 5V/Div, DC
CH2: V_{OUT} , 1V/Div, DC
CH3: V_{POK} , 5V/Div, DC
CH4: I_L , 1A/Div, DC
TIME: 40ms/Div

Enable with 3A Loading



CH1: V_{EN} , 5V/Div, DC
CH2: V_{OUT} , 1V/Div, DC
CH3: V_{POK} , 5V/Div, DC
CH4: I_L , 2A/Div, DC
TIME: 200us/Div

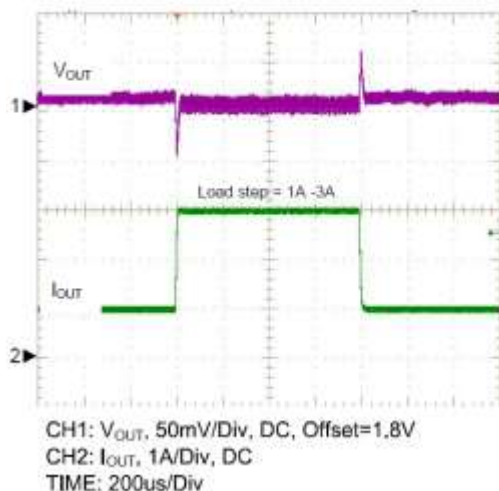
Shutdown with 3A Loading



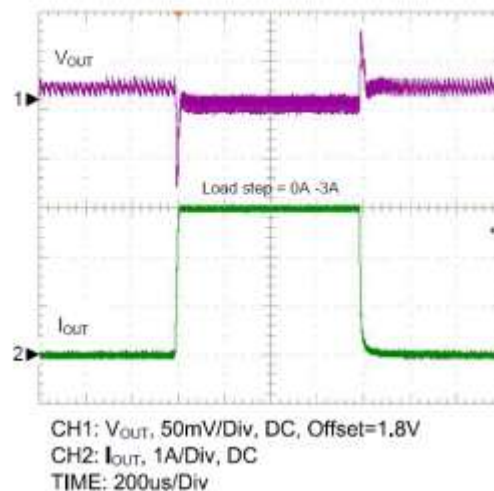
CH1: V_{EN} , 5V/Div, DC
CH2: V_{OUT} , 1V/Div, DC
CH3: V_{POK} , 5V/Div, DC
CH4: I_L , 2A/Div, DC
TIME: 10us/Div

Operating Waveforms (Cont.)

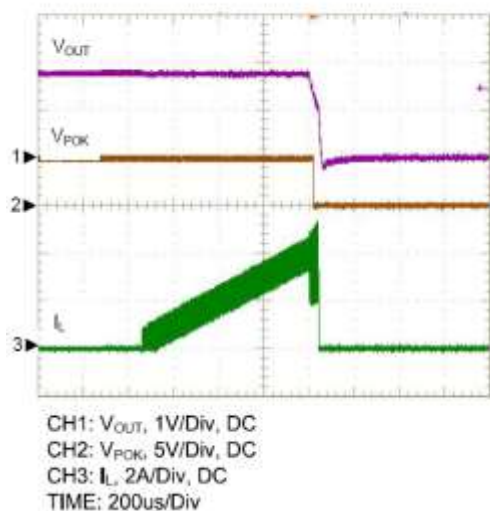
Load Transient



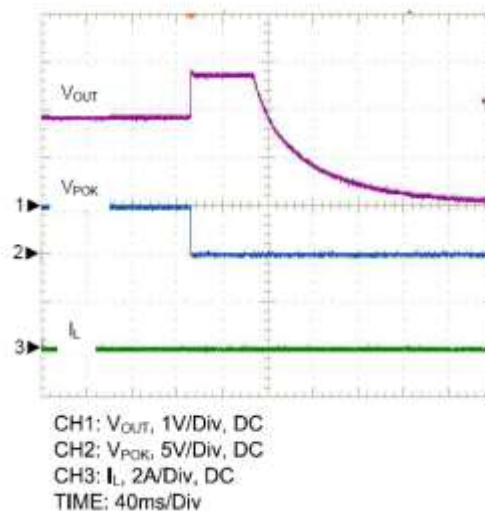
Load Transient



Current Limit

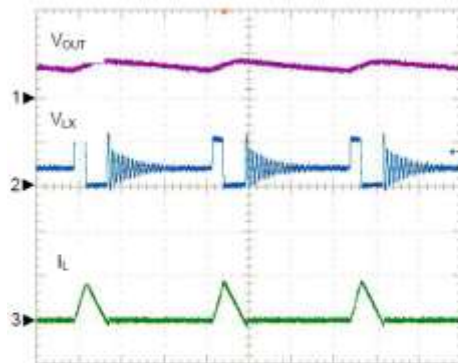


Over Voltage Protection



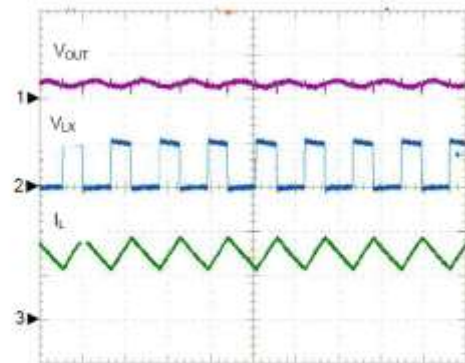
Operating Waveforms (Cont.)

Normal Operation in Light Load



$I_{OUT} = 100mA$
CH1: V_{OUT} , 50mV/Div, DC, Offset=1.8V
CH2: V_{Lx} , 5V/Div, DC
CH3: I_L , 1A/Div, DC
TIME: 1 μ s/Div

Normal Operation in Heavy Load



$I_{OUT} = 3A$
CH1: V_{OUT} , 50mV/Div, DC, Offset=1.8V
CH2: V_{Lx} , 5V/Div, DC
CH3: I_L , 2A/Div, DC
TIME: 1 μ s/Div

Function Descriptions

VIN Power-On-Reset (POR)

The TD6833 keeps monitoring the voltage on VIN pin to prevent wrong logic operations which may occur when VIN voltage is not high enough for internal control circuitry to operate. The VIN POR rising threshold is 2.4V with 0.2V hysteresis.

During startup, the VIN voltage must exceed the POR threshold. Then the IC starts a start-up process and ramps up the output voltage to the voltage target.

Output Under-Voltage Protection (UVP)

In the operational process, if a short-circuit occurs, the output voltage will drop quickly. Before the current-limit circuit responds, the output voltage will fall out of the required regulation range. The under-voltage continually monitors the FB voltage after soft-start is completed. If a load step is strong enough to pull the output voltage lower than the under-voltage threshold, the IC shuts down converter's output.

The under-voltage threshold is 50% of the nominal output voltage. The TD6833 will be latched after undervoltage protection.

Over-Voltage Protection (OVP)

The over-voltage function monitors the output voltage by FB pin. When the FB voltage increases over 125% of the reference voltage due to the high-side MOSFET failure or for other reasons, the over-voltage protection comparator will trigger the voltage of Discharge Resistance and shutdown the converter output.

Over-Temperature Protection (OTP)

The over-temperature circuit limits the junction temperature of the TD6833. When the junction temperature exceeds $T_J = 160^{\circ}\text{C}$, a thermal sensor turns off the both power MOSFETs, allowing the devices to cool. The thermal sensor allows the converters to start a start-up process and to regulate the output voltage again after the junction temperature cools by 50°C . The OTP is designed with a 50°C hysteresis to lower the average T_J during continuous thermal overload conditions, increasing lifetime of the TD6833.

Current-Limit Protection

The TD6833 monitors the output current, flows through the high-side and low-side power MOSFETs, and limits the current peak at current-limit level to prevent the IC from damaging during overload, short-circuit and overvoltage conditions. Typical high side power MOSFET current limit is 5A.

Soft-Start

The TD6833 has a built-in soft-start to control the rise rate of the output voltage and limit the input current surge during start-up. During soft-start, an internal voltage ramp connected to one of the positive inputs of the error amplifier, rises up to replace the reference voltage until the voltage ramp reaches the reference voltage. During soft-start without output over-voltage, the TD6833 converter's sinking capability is disabled until the output voltage reaches the voltage target.

Discharge Resistance

At the moment of shutdown controlled by EN signal, under-voltage event or over-voltage event, the TD6833 use the resistance to discharge the output voltage in the output capacitors. Certainly, the load current also discharges the output voltage.

Enable and Shutdown

Driving EN to ground places the TD6833 in shutdown. In shutdown mode, the internal power MOSFETs turns off, all internal circuitry shuts down and the quiescent supply current reduces to less than $1\mu\text{A}$.

Power Good Indicator

The IC has an open-drain POK pin that indicates the output regulation state.

During soft start, POK goes high when the output reach 87.5% of their target value. During normal operation, when the output is not within the range of 87.5% to 125% of the target voltage, the POK signal will be pulled low immediately.

When the output returns between 82.5% and 120% of the

5V, 3A, 1MHz Synchronous Buck Converter**TD6833**

target value, the POK will remain high again.

Since POK is an open-drain pull-down device, it usually requires an external pull-up resistor; however, if the pin is not used, no resistor is necessary.

Application Information

Input Capacitor Selection

Because buck converters have a pulsating input current, a low ESR input capacitor is required. This results in the best input voltage filtering, minimizing the interference with other circuits caused by high input voltage spikes.

Also, the input capacitor must be sufficiently large to stabilize the input voltage during heavy load transients. For good input voltage filtering, usually a 22μF input capacitor is sufficient. It can be increased without any limit for better input-voltage filtering. Ceramic capacitors show better performance because of the low ESR value, and they are less sensitive against voltage transients and spikes compared to tantalum capacitors. Place the input capacitor as close as possible to the input and GND pin of the device for better performance.

Inductor Selection

For high efficiencies, the inductor should have a low DC resistance to minimize conduction losses. Especially at high-switching frequencies, the core material has a higher impact on efficiency. When using small chip inductors, the efficiency is reduced mainly due to higher inductor core losses. This needs to be considered when selecting the appropriate inductor. The inductor value determines the inductor ripple current. The larger the inductor value, the smaller the inductor ripple current and the lower the conduction losses of the converter. Conversely, larger inductor values cause a slower load transient response. A reasonable starting point for setting ripple current, ΔI_L , is 40% of maximum output current. The recommended inductor value can be calculated as below:

$$L \geq \frac{V_{OUT} \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}{F_{SW} \cdot \Delta I_L}$$

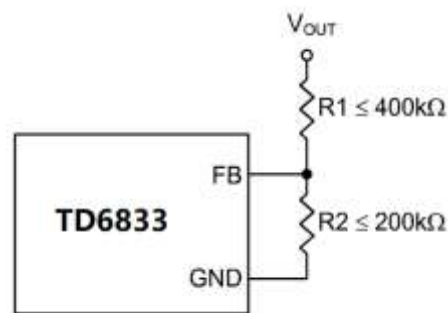
$$I_{L(MAX)} = I_{OUT(MAX)} + 1/2 \times \Delta I_L$$

To avoid the saturation of the inductor, the inductor should be rated at least for the maximum output current of the converter plus the inductor ripple current.

Output Voltage Setting

In the adjustable version, the output voltage is set by a resistive divider. The external resistive divider is connected to the output, allowing remote voltage sensing as shown in "Typical Application Circuits". A suggestion of maximum value of R2 is 200kΩ to keep the minimum current that provides enough noise rejection ability through the resistor divider. The output voltage can be calculated as below:

$$V_{OUT} = V_{REF} \cdot \left(1 + \frac{R1}{R2}\right) = 0.6 \cdot \left(1 + \frac{R1}{R2}\right)$$



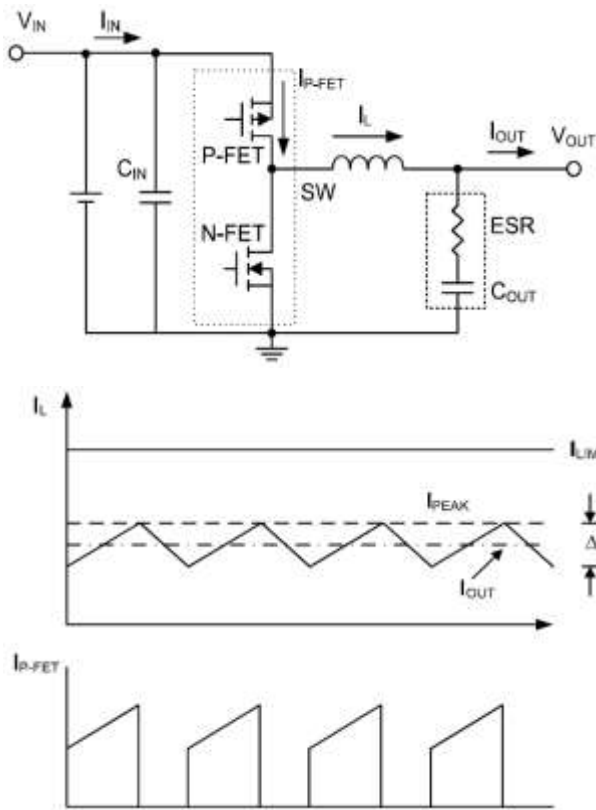
Output Capacitor Selection

The current-mode control scheme of the TD6833 allows the use of tiny ceramic capacitors. The higher capacitor value provides the good load transients response.

Ceramic capacitors with low ESR values have the lowest output voltage ripple and are recommended. If required, tantalum capacitors may be used as well. The output ripple is the sum of the voltages across the ESR and the ideal output capacitor.

$$\Delta V_{OUT} \cong \frac{V_{OUT} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}{F_{SW} \cdot L} \cdot \left(ESR + \frac{1}{8 \cdot F_{SW} \cdot C_{OUT}}\right)$$

When choosing the input and output ceramic capacitors, choose the X5R or X7R dielectric formulations. These dielectrics have the best temperature and voltage characteristics of all the ceramics for a given value and size.



Power Sequencing

At start-up, it is necessary to ensure that the V_{IN} (the voltage supplied to MOSFET drain) and V_{EN} are sequenced correctly to avoid erroneous latch-off. To avoid UVP latch-off happened at start-up due to sequencing issues, the key method is the V_{IN} should be larger than the output under-voltage threshold plus the drop through the pass MOSFET when that output is enabled.

Figure2 shows the V_{IN} comes up before the V_{EN} . Recommended power on sequence is shown in Figure2.

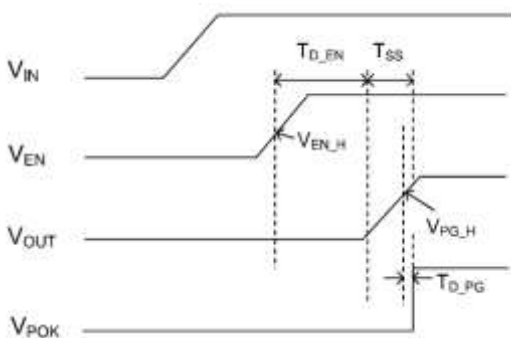
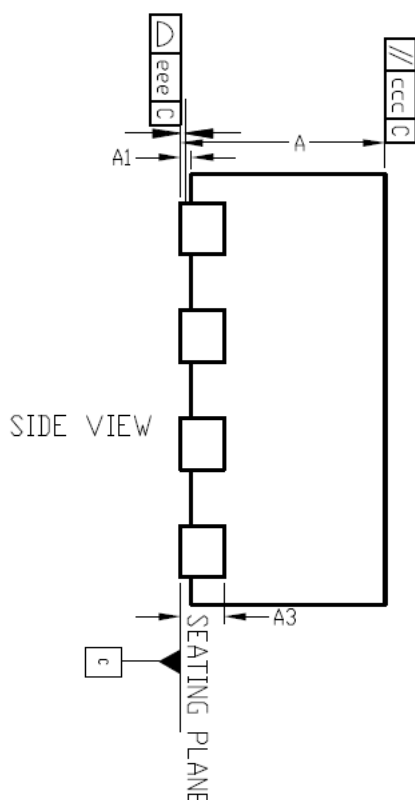
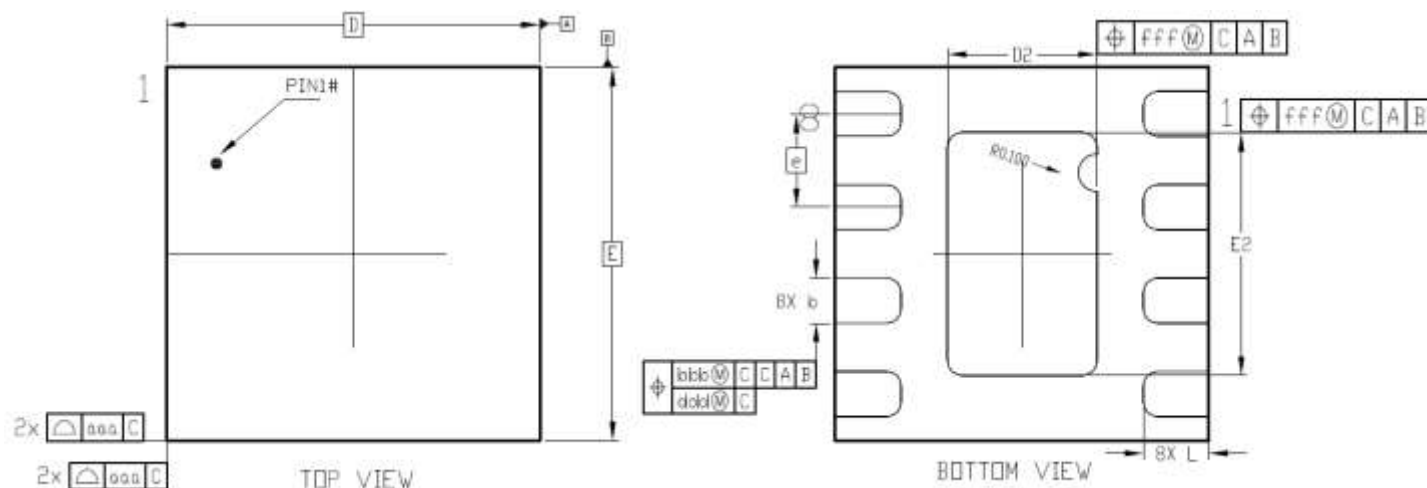


Figure 2. TD6833B power on sequence.

Package Information

TDFN2X2-8 Package Outline Dimensions



DIM SYMBOL	MIN.	NOM.	MAX.
A	0.70	0.75	0.80
A1	0	0.02	0.05
A3	-	0.2REF	-
b	0.19	0.24	0.29
D	2.00BSC		
E	2.00BSC		
E2	1.25	1.30	1.35
D2	0.75	0.80	0.85
e	0.50BSC		
L	0.30	0.35	0.40
K	0.20		
aaaa	0.15		
bbbb	0.10		
CCC	0.10		
ddd	0.05		
eee	0.08		
fff	0.10		

Design Notes