1MHz, 3A Synchronous Step-Down Regulator

Features

- High Efficiency: Up to 95%
- 50µA Operating Quiescent Current
- <1µA Shutdown Current
- Internal Soft Start Function
  Output Current
  G2823DRE1U: 3A Continuous
- 2.7V to 6.5V Input Voltage Range
- 1MHz Switching Frequency
- No Schottky Diode Required
- 100% Duty Cycle in Dropout Operation
- 0.6V Reference Allows Low Output Voltages
- Thermal Shutdown Protection
- Output Short-Circuit Latch-off Protection
- Output Overvoltage Latch-off Protection
- Power Good
- RoHS Compliant

Applications

- Cellular Telephones
- Personal Information Appliances
- Microprocessors and DSP Core Supplies
- Wireless and DSL Modems
- Digital Still and Video Cameras
- MP3 Players
- Portable Instruments

General Description

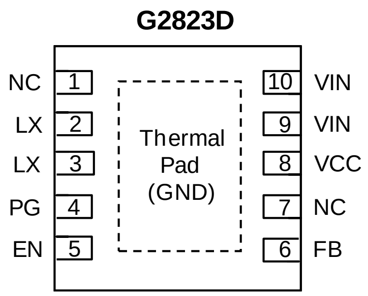
The G2823D is a high efficiency monolithic synchronous buck regulator using a constant frequency, current mode architecture. Supply current during operation is only 50µA and drops to <1µA in shutdown. The 2.7V to 6.5V input voltage range makes the G2823D ideally suited for single Li-Ion battery-powered applications. 100% duty cycle provides low dropout operation, extending battery run time in portable systems. Switching frequency is internally set at 1MHz, allowing the use of small surface mount inductors and capacitors. The internal synchronous switch increase efficiency and eliminates the need for an external Schottky diode. Built-in soft start function eliminates in-rush current that could damage the system. Output latch-off operation protects the step-down regulator from damage under short circuit and overvoltage conditions.

Ordering Information

ORDER NUMBER	MARKING	OUTPUT VOLTAGE	TEMP. RANGE	PACKAGE (Green)
G2823DRE1U	2823D	Adjustable	-40°C to +85°C	TDFN3X3-10

Note: RE: TDFN3X3-10
1: Bonding Code
U: Tape & Reel
Green : Lead Free / Halogen Free

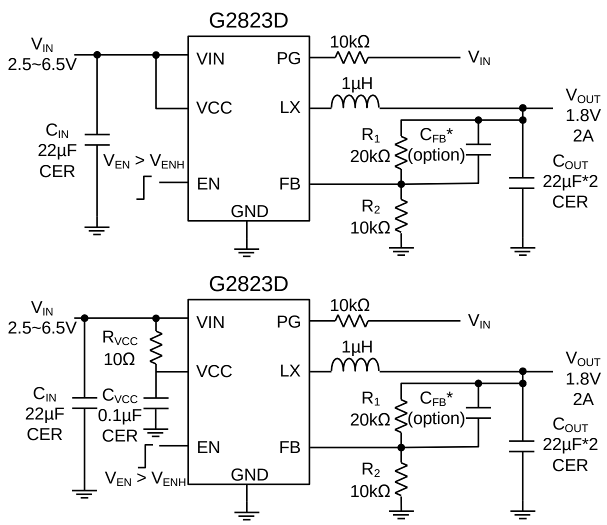
Pin Configuration



TDFN3X3-10

Note: Recommend connecting the Thermal Pad to the Ground for excellent power dissipation.

Typical Application Circuit



Absolute Maximum Ratings

VIN, VCC, PG to GND . . . . -0.3V to +7V
EN, FB to GND. . . . . -0.3V to (VIN + 0.3V)
LX to GND . . . . -0.3V to (VIN + 0.3V)
LX to GND . . . . -3V to (VIN + 3V) for <20ns
Thermal Resistance Junction to Ambient, (θ_{JA})*
TDFN3X3-10 . . . . 96°C/W
Continuous Power Dissipation (T_A = +25°C)
TDFN3X3-10. . . . . .1.3W
Thermal Resistance Junction to Case, (θ_{JC})
TDFN3X3-10. . . . . .30°C/W
Operating Temperature Range . . . . -40°C to 85°C
Maximum Junction Temperature . . . . 150°C
Storage Temperature Range . . . . -65°C to 165°C
Reflow Temperature (soldeing,10 sec) . . . . .260°C
ESD(HBM) 2KV
ESD(CDM) 500V

*Please refer to 1in^2 of 1oz PCB Layout Section

Electrical Characteristics

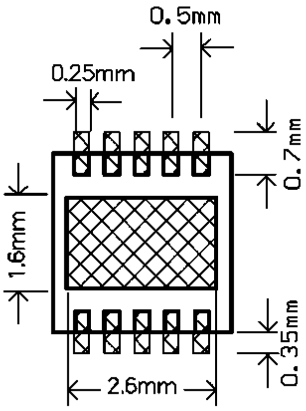
(V_{IN}=5V, V_{OUT} =1.8V, L=1μH, C_{OUT} =22μFx2, T_A =25°C)

The device is not guaranteed to function outside its operating conditions. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified.

PARAMETER	SYMBOL	TEST CONDITIONS	Min	TYP	MAX	UNIT
Input Voltage Range	V_{IN}		2.7	---	6.5	V
Quiescent Current	I_Q	I_{OUT}=0, V_{FB}=V_{REF}×105%	---	50	---	μA
Shutdown Current	I_{SHDN}	EN=0	---	0.1	1	μA
Feedback Reference Voltage	V_{REF}		0.594	0.6	0.606	V
PFET RON	$R_{DS(ON),P}$		---	60	---	mΩ
NFET RON	$R_{DS(ON),N}$		---	50	---	mΩ
PFET Current Limit	I_{LIM}		4.0	5.0	6.0	A
EN rising threshold	V_{ENH}	Logic High	1.5	---	---	V
	V_{ENL}	Logic Low	---	---	0.4	
Input UVLO threshold	V_{UVLO}		---	---	2.65	V
UVLO hysteresis	V_{HYS}		---	0.2	---	V
Oscillator Frequency	F_{OSC}	I_{OUT}=500mA	---	1	---	MHz
Output Latch-off Threshold	V_{OVP}	FB (Overvoltage)	---	0.72	---	V
	V_{SCP}	FB (Short Circuit)	---	0.2	---	
Min ON Time			---	75	---	ns
Max Duty Cycle			100	---	---	%
Soft Start Time	T_{SS}		---	1	---	ms
Output Discharge Switch On Resistance	R_{DISCH}		---	50	---	Ω
PG Pin Threshold (related to V_{OUT})		Rising	---	90	---	%
		Falling	---	85	---	
PG Open-Drain Impedance (PG=low)			---	---	10	Ω
Thermal Shutdown Temperature	T_{SD}		---	150	---	°C
Line regulation		I_{OUT} = 1A, V_{IN} = 2.7V to 6.5V	---	0.05	---	%/V
Load regulation		I_{OUT} = 0.5A to 3A	---	0.2	---	%/A
Output Capacitor	C_{OUT}		22	---	---	μF

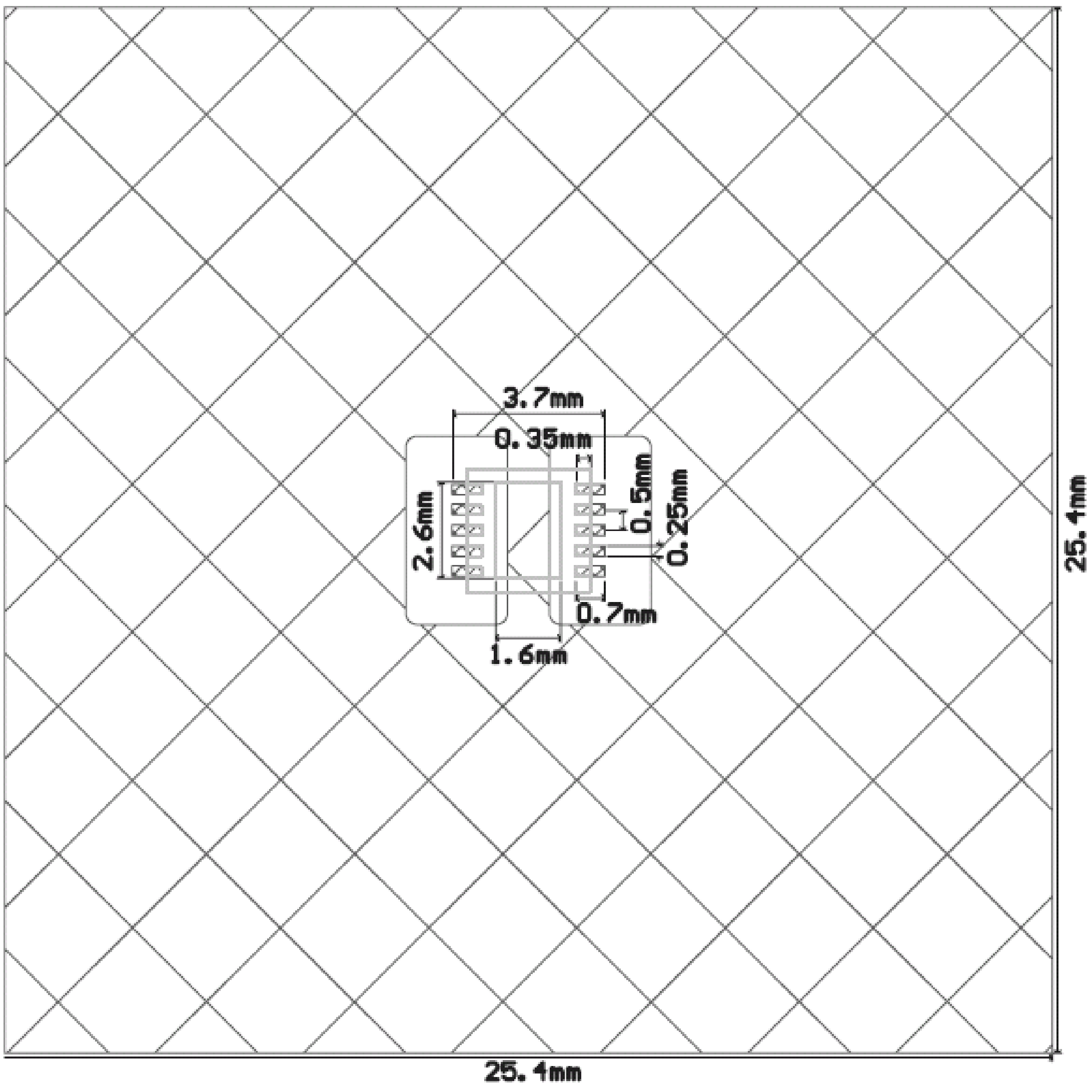
Minimum Footprint PCB Layout Section

TDFN3X3-10



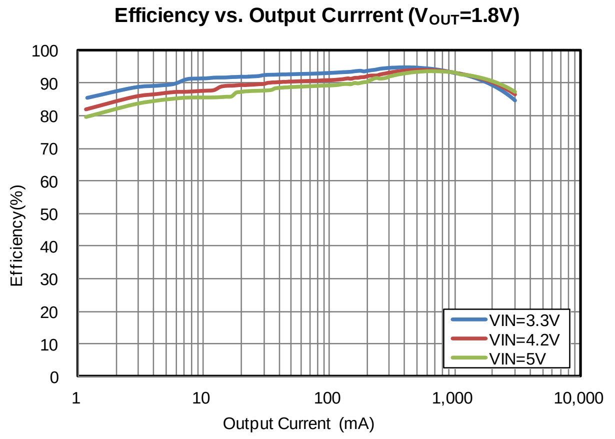
1in^2 of 1oz PCB Layout Section

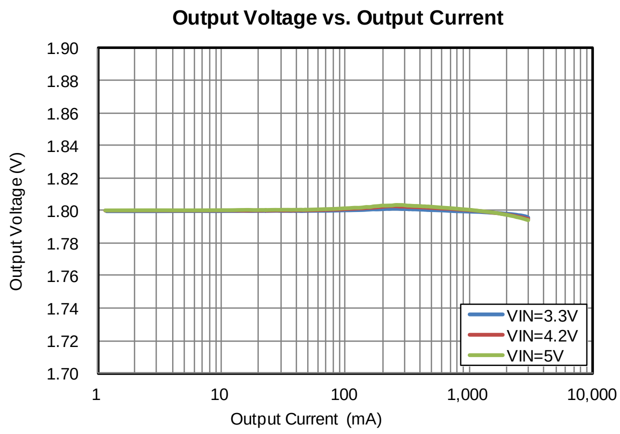
TDFN3X3-10

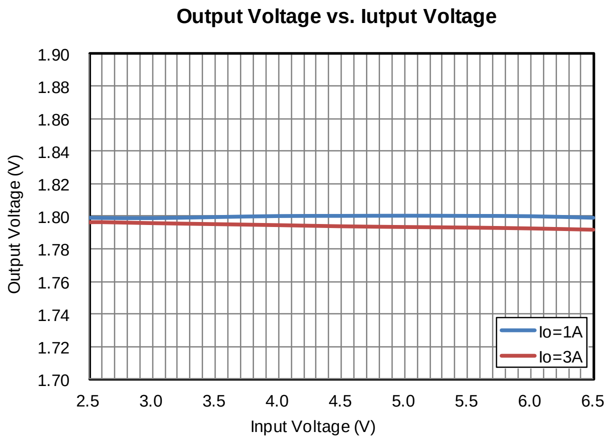


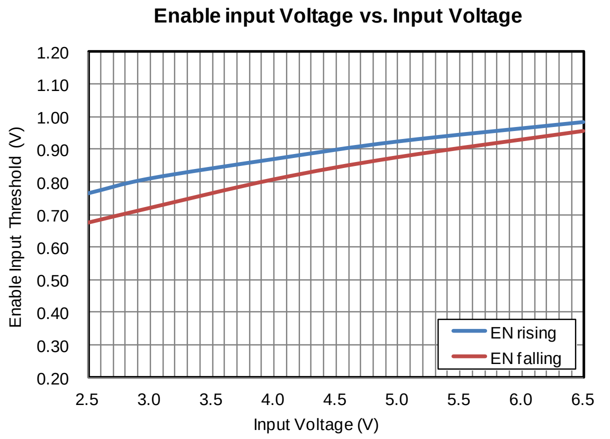
Typical Performance Characteristics

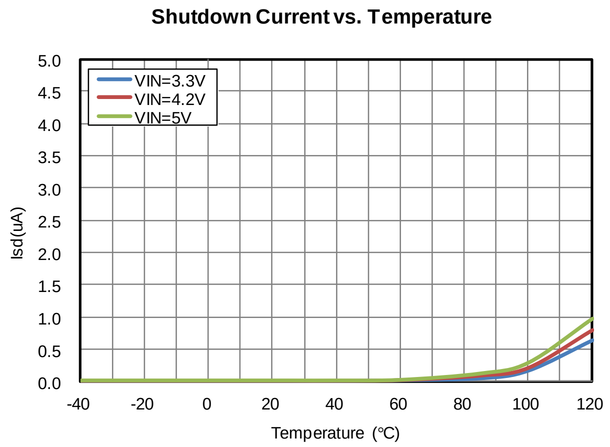
(V_{OUT} =1.8V, L=1µH, C_{OUT} =22µFx2, T_A =25°C)

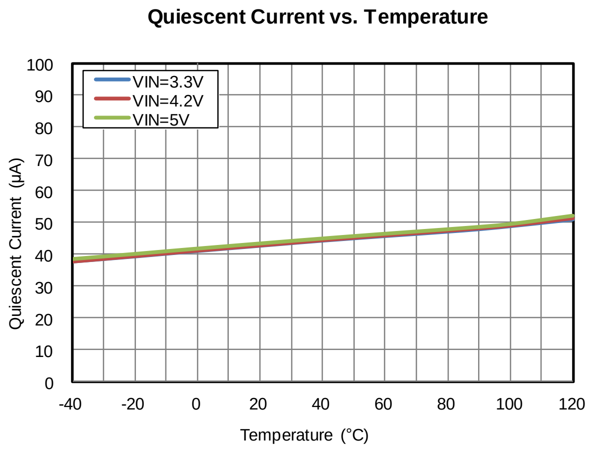






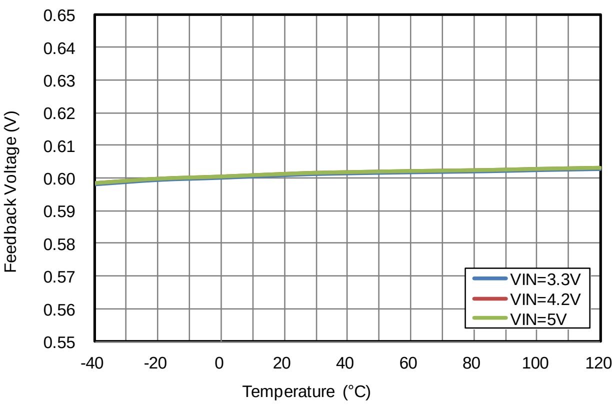




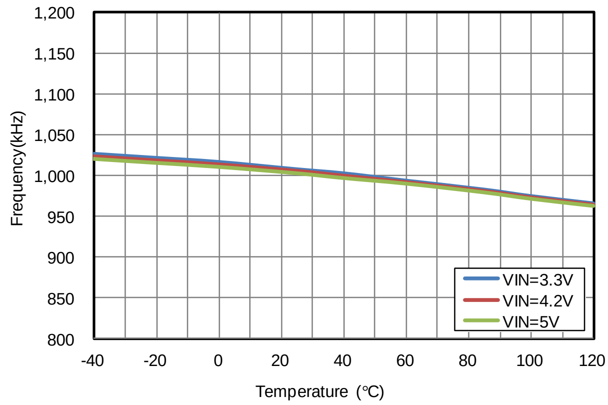


Typical Performance Characteristics (continued)

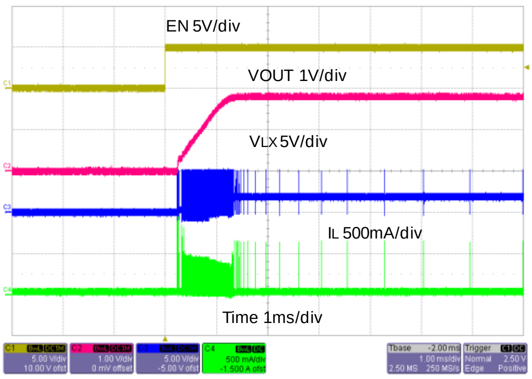
Feedback Voltage vs. Temperature



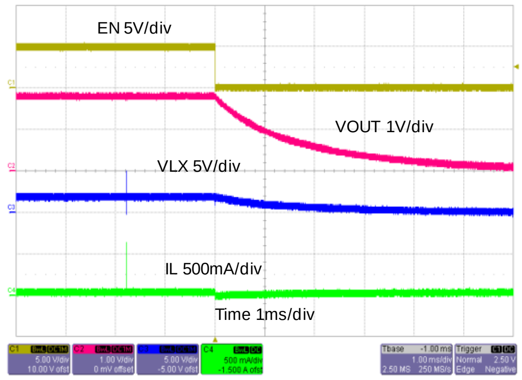
Switching frequency vs. Temperature



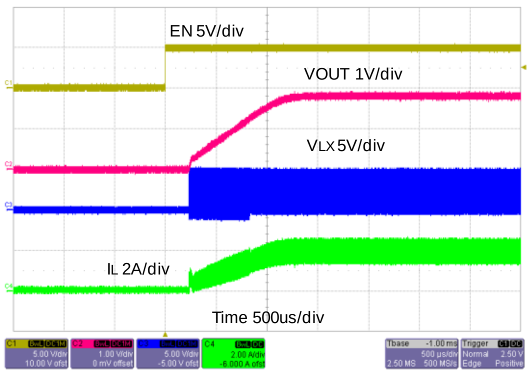
Power On from EN (I_O=0A)



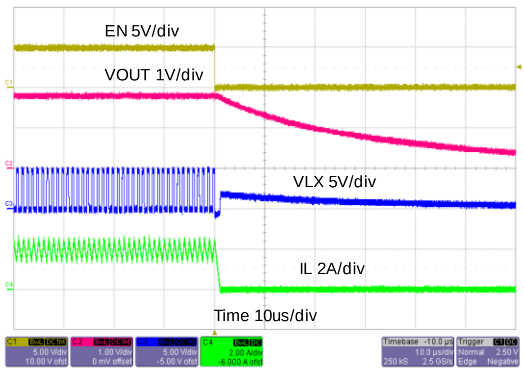
Power Off from EN (I_O=0A)



Power On from EN (I_O=2A)

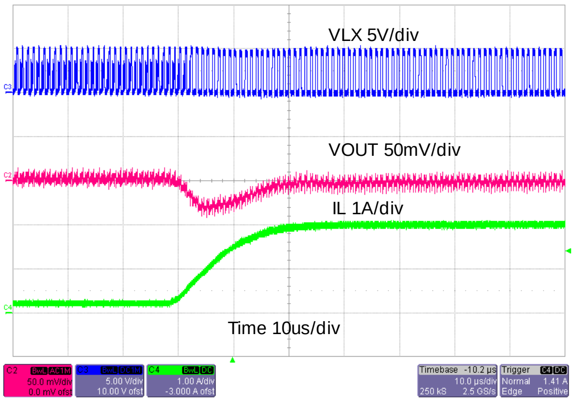


Power Off from EN (I_O=2A)

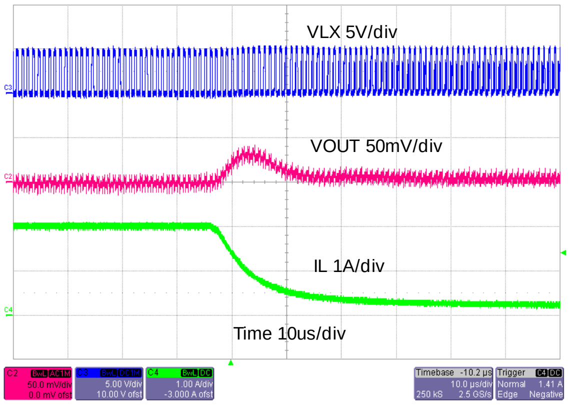


Typical Performance Characteristics (continued)

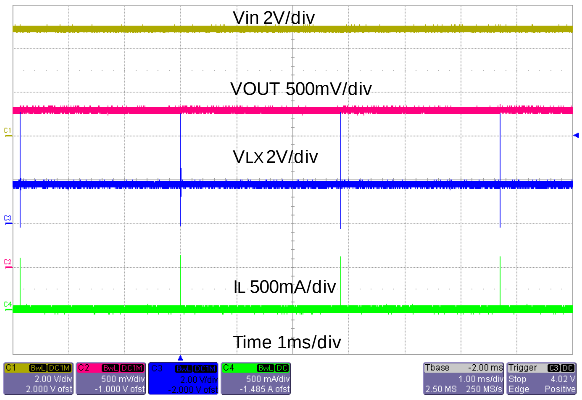
Load Transient Response (0.2A to 2A)



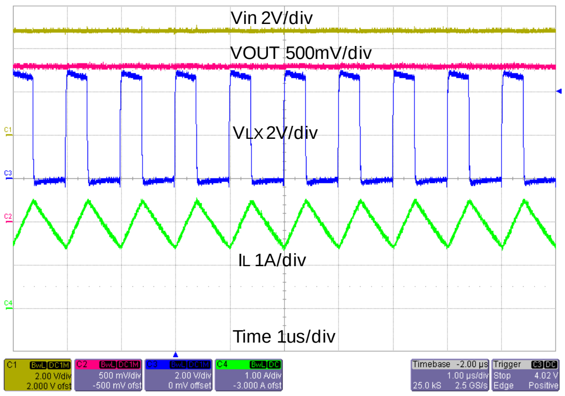
Load Transient Response (2A to 0.2A)



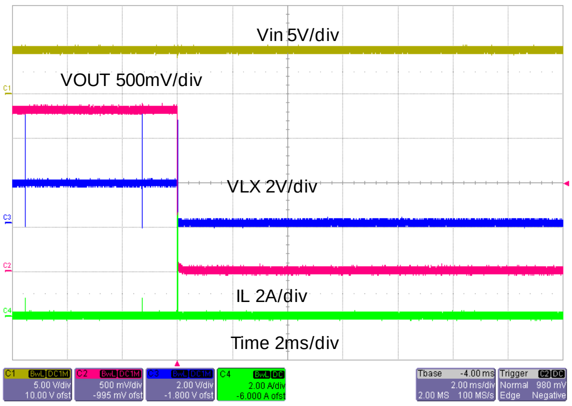
Steady State Operation (I_O=0A)



Steady State Operation (I_O=2A)



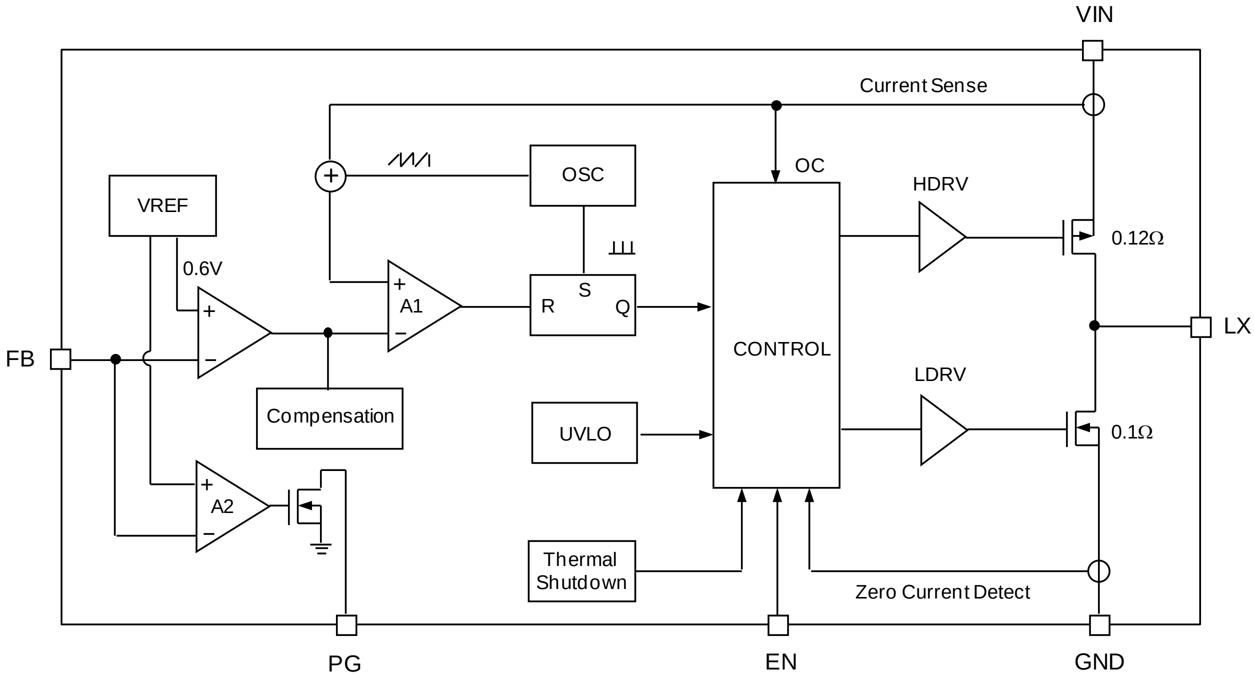
Short Circuit Waveform (Output short)



Pin Descriptions

PIN	NAME	FUNCTION
1,7	NC	No Connection
2,3	LX	Switch Pin
4	PG	Power Good. When V_{OUT} is within 10% of regulation point, the output is open drain
5	EN	Enable Control Pin (Active high, do not leave EN pin floating)
6	FB	Feedback Pin
8	VCC	Signal Input Power Supply Pin
9,10	VIN	Power Input Power Supply Pin
Thermal Pad	GND	Ground Pin

Block Diagram



Function Description

Normal Operation

The G2823D uses a constant frequency, current mode step-down architecture. Both high/low-side switches are internal. During normal operation, the internal high-side (PMOS) switch is turned on each cycle when the oscillator sets the SR latch, and turned off when the comparator (A1) resets the SR latch. The peak inductor current at which comparator (A1) resets the SR latch, is controlled by the output of error amplifier EA. While the high-side switch is off, the low-side switch is turned on until either the inductor current starts to reverse or the beginning of the next switching cycle.

Dropout Operation

As the input supply voltage decreases to a value approaching the output voltage, the duty cycle increases toward the maximum on-time. Further reduction of the supply voltage forces the high-side switch to remain on for more than one cycle until it reaches 100% duty cycle. The output voltage is dropped from the input supply for the voltage which across the high-side switch.

Over Temperature Protection

The G2823D has an integrated over-temperature protection circuit that monitors the device junction temperature, and stop switching if the junction temperature over 150°C. When the junction temperature cools down to 130°C, the device will restart.

Soft-Start

During normal power-up, as the input voltage exceeds UVLO threshold, the soft-start circuitry will slowly ramp up the output voltage. This feature prevents supply inrush current and output voltage overshoots during startup conditions.

Over Current Protection

Cycle-by-cycle peak inductor current limit is used to protect embedded switch from damage. The typical peak current limit is 4.0A. If the current through high-side FET over the current limit threshold, high-side FET is turned off immediately. Hence the maximum output current (the average of inductor current) is also restricted.

Short-circuit and Overvoltage Latch-Off Protection

Short-circuit latch-off protection will activate once the feedback voltage falls below 0.2V. Besides, Overvoltage latch-off protection will also activate once the feedback voltage rises beyond 0.72V. The function latches off the output to provide fault protection until those conditions are removed and the step-down regulator is reset by enable control.

Application Information

Inductor Selection

For most applications, the value of the inductor will fall in the range of 1μH to 4.7μH. Its value is chosen based on the desired ripple current. Large value inductors lower ripple current and small value inductors result in higher ripple currents. Higher V_{IN} or V_{OUT} also increase the ripple current ΔI_L:

$$\Delta I_L = \frac{1}{f \bullet L} V_{OUT}\left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Where f=switching frequency, L=inductance. A reasonable inductor current ripple is usually set as 1/2 to 1/5 of maximum out current.

The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation. For better efficiency, choose a low DCR inductor.

Capacitor Selection

In continuous mode, the source current of the top MOSFET is a square wave of duty cycle V_{OUT}/V_{IN}. To prevent large voltage transients, a low ESR input capacitor sized for maximum RMS current must be used. The maximum RMS capacitor current is given by:

$$I_{RMS} \cong I_{OMAX} \bullet \frac{\sqrt{V_{OUT}(V_{IN} - V_{OUT})}}{V_{IN}}$$

This formula has a maximum at $V_{IN}=2V_{OUT}$, where $I_{RMS}=I_{OUT}/2$. This simple worst case condition is commonly used for design because even significant deviations do not offer much relief.

The selection of C_{OUT} is driven by the required effective series resistance (ESR). Typically, once the ESR requirement for C_{OUT} has been met, the RMS current rating generally far exceeds the $I_{RIPPLE(P-P)}$ requirement. The output ripple ΔV_{OUT} is determined by:

$$\Delta V_{OUT} \cong \Delta I_L (ESR + \left(\frac{1}{8 \bullet f \bullet C_{OUT}}\right)$$

For a fixed output voltage, the output ripple is highest at maximum input voltage since ΔI_L increases with input voltage.

Output Voltage Programming

In the adjustable version of G2823D, the output voltage is set by a resistive divider according to the following formula:

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

Parameters Suggestion Table

V_{OUT}(V)	R1(KΩ)	R2(KΩ)	L(μH)	C_{OUT}(μF)
3.3	45	10	1	22x2
2.5	31.6	10	1	22x2
1.8	20	10	1	22x2
1.2	10	10	1	22x2
1.05	7.5	10	1	22x2

* If R2 is larger than 100k, a 10~22pF ceramic cap in parallel with R1 is recommended.

Efficiency Considerations

Although all dissipative elements in the circuit produce losses, one major source usually account for most of the losses in G2823D circuits: I^2R losses. The I^2R loss dominates the efficiency loss at medium to high load currents. To minimize the power consumption from feedback resistors, a value of between 10k and 1M for both R1 and R2 is recommended.

The I^2R losses are calculated from the resistances of the internal switches, R_{SW}, and external inductor R_L. In continuous mode, the average output current flowing through inductor L is "chopped" between the main switch and the synchronous switch. Thus the series resistance looking into the LX pin is a function of both top and bottom MOSFET $R_{DS(ON)}$ and the duty cycle (D) as follows:

$$R_{SW}=(R_{DS(ON)TOP})(D)+(R_{DS(ON)BOTTOM})(1-D)$$

The $R_{DS(ON)}$ for both the top and bottom MOSFETs can be obtained from Electrical Characteristics table. Thus, to obtained I^2R losses, simply add R_{SW} to R_L and multiply the result by the square of the average output current.

Other losses including C_{IN} and C_{OUT} ESR dissipative losses and inductor core losses generally account for less than 2% total additional loss.

Checking Transient Response

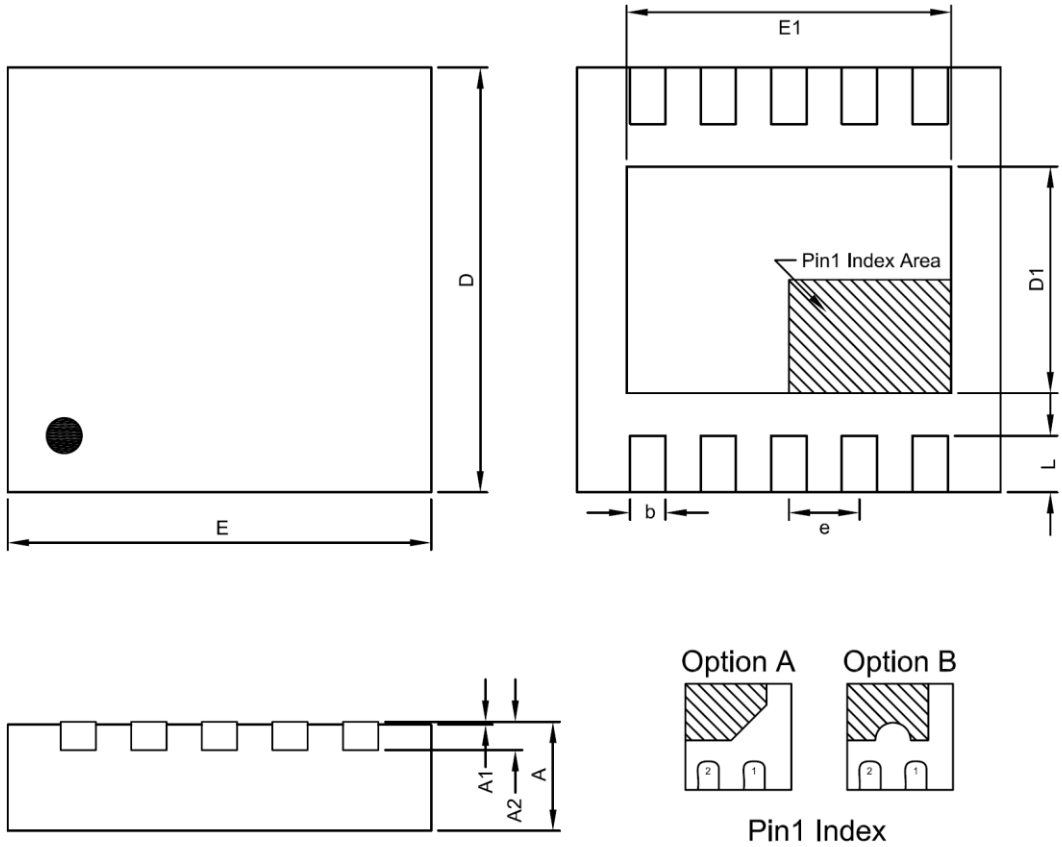
The regulator loop response can be checked by looking at the load transient response. Switching regulators take several cycles to respond to a step in load current. When a load step occurs, V_{OUT} immediately shifts by an amount equal to ($\Delta I_{LOAD} \cdot$ ESR), where ESR is the effective series resistance of C_{OUT}. ΔI_{LOAD} also begins to charge or discharge C_{OUT}, which generates a feedback error signal. The regulator loop then acts to return V_{OUT} to its steady-state value. During this recovery time V_{OUT} can be monitored for overshoot or ringing that would indicate a stability problem. For large load transient step applications, a 10~22pF ceramic cap in parallel with R1 is recommended.

Thermal considerations

In most application the G2823D does not dissipate much heat due to its high efficiency. But, in applications where the G2823D is running at high ambient temperature with low supply voltage and high duty cycles, such as in dropout, the heat dissipated may exceed the maximum junction temperature of the part. If the junction temperature reaches approximately 150°C, both power switches will be turned off and the LX node will become high impedance.

Assume power dissipation on G2823D P_D=0.1W, ambient temperature T_A=70°C, thermal resistance of junction to ambient θ_{JA}=250°C/W, then temperature junction $T_J = T_A + \theta_{JA} * P_D$ = 95°C.

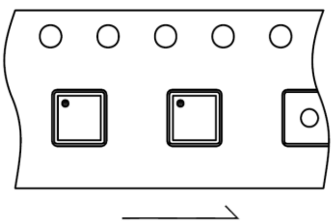
Package Information



TDFN3X3-10 Package

Symbol	DIMENSION IN MM			DIMENSION IN INCH		
	MIN.	**NOM.**	**MAX.**	**MIN.**	**NOM.**	**MAX.**
A	0.70	0.75	0.80	0.0276	0.0295	0.0315
A1	0.00	- - -	0.05	0.0000	- - -	0.0020
A2	0.20 REF			0.0079 REF		
D	2.95	3.00	3.05	0.1161	0.1181	0.1201
E	2.95	3.00	3.05	0.1161	0.1181	0.1201
D1	1.50	1.60	1.75	0.0591	0.0630	0.0689
E1	2.20	2.60	2.70	0.0866	0.1024	0.1063
b	0.18	0.25	0.30	0.0071	0.0098	0.0118
e	0.50 BSC			0.0197 BSC		
L	0.30	0.40	0.50	0.0118	0.0157	0.0197

Taping Specification



PACKAGE	Q'TY/REEL
TDFN3X3-10	3,000 ea