ELM615DA 2A 18V 500kHz synchronous step down DC/DC converter

■General description

ELM615DA is a high-frequency, synchronous, rectified, step-down, switch-mode converter with internal power MOSFETs. It offers a very compact solution to achieve a 2A continuous output current over a wide input supply range, with excellent load and line regulation. ELM615DA has synchronous-mode operation for higher efficiency over the output current-load range.

Current-mode operation provides fast transient response and eases loop stabilization. Protection features include over-current protection and thermal shutdown.

ELM615DA requires a minimal number of readily available, standard external components and is available in space-saving SOP-8 package.

■Features

- Internal soft start
- Over current protection
- Over temperature protection
- Input voltage : 4.75V to 18V
- Output adjustable voltage : 0.923V to 15V
- Output current : 2A
- Integrated power MOSFET switches : 129mΩ/87mΩ
- Shutdown current : Typ 3μA
- High efficiency : Max 95%
- Constant frequency : Typ 500kHz
- Package : SOP-8

■Application

- Distributed power systems
- Networking systems
- FPGA, DSP, ASIC power supplies
- Notebook computers
- Green electronics or appliance

■Maximum absolute ratings

Parameter	Symbol	Limit	Unit
Supply voltage	Vin	-0.3 to +19.0	V
Switch node	Vsw	-0.3 to Vin+0.3	V
Boost voltage	Vboot	Vsw-0.3 to Vsw+6.0	V
All other pins	Vall	-0.3 to +6.0	V
Power dissipation	Pd	630	mW
Junction temperature	Tj	+150	°C
Operating temperature range	Top	-40 to +85	°C
Storage temperature range	Tstg	-65 to +150	°C

■Selection guide

ELM615DA-N

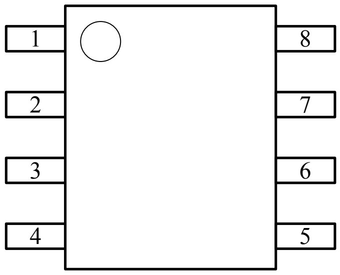
Symbol		
a	Package	D: SOP-8
b	Product version	A
c	Taping direction	N: Refer to PKG file

* Taping direction is one way.

ELM615 D A - N
↑ ↑ ↑
a b c

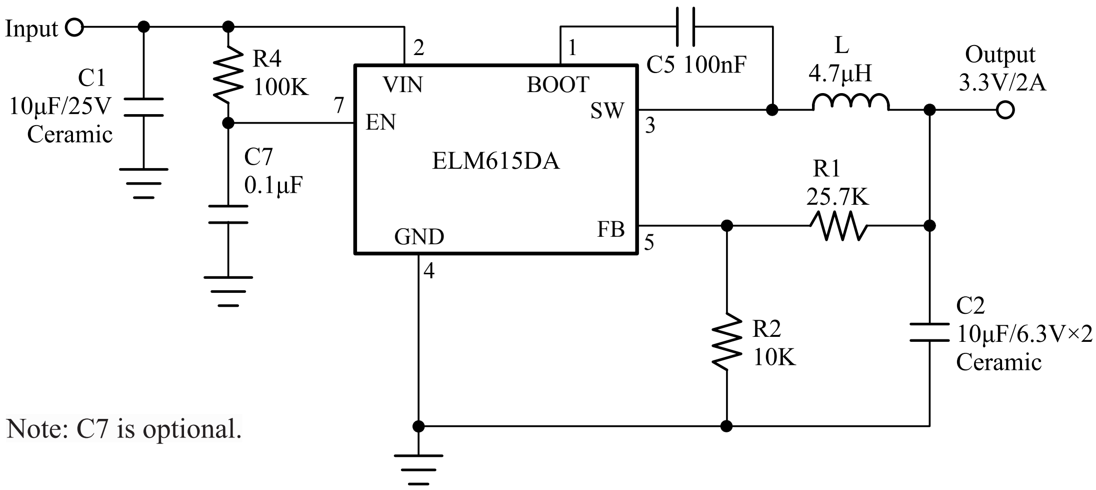
■Pin configuration

SOP-8(TOP VIEW)



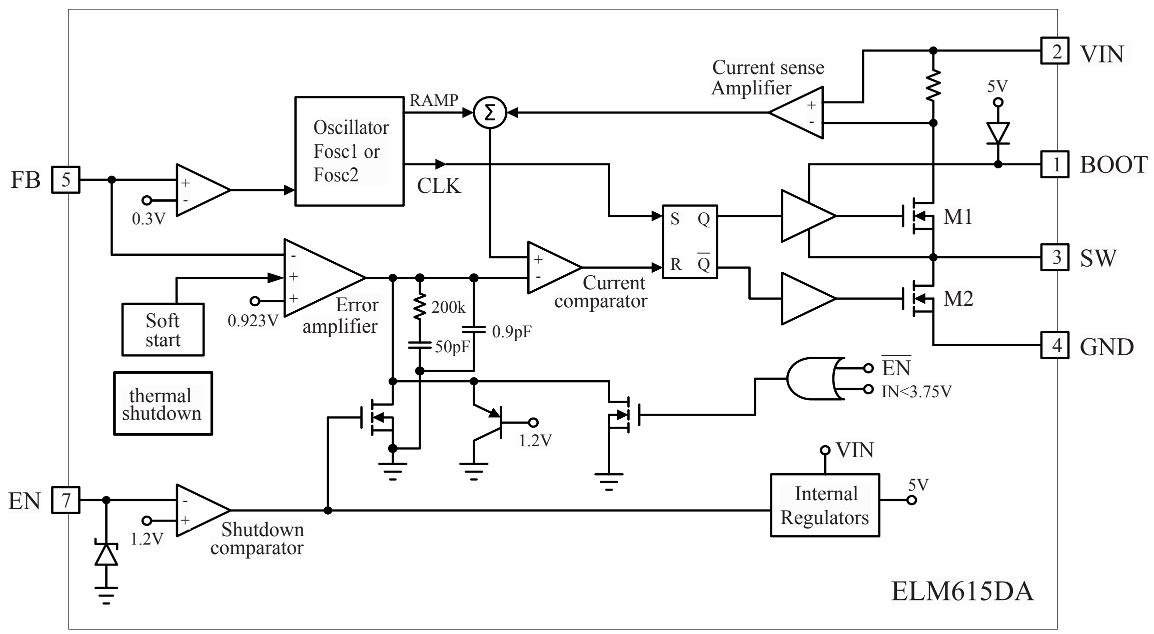
Pin No.	Pin name	Pin description
1	BOOT	High-side gate drive boost input
2	VIN	Power input
3	SW	Power switching output
4	GND	Ground
5	FB	Feedback input
6	NC	Not connected
7	EN	Enable input
8	NC	Not connected

■Standard circuit (Adjustable Output Voltage)



Note: C7 is optional.

■Block diagram



■Electrical characteristics

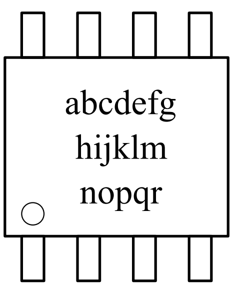
Vin=+12V, Top=25°C, unless otherwise specified

Parameter	Symbol	Test condition	Min.	Typ.	Max.	Unit
Supply voltage	Vin		4.75		18.00	V
Output voltage	Vout		0.923		15.000	V
Shutdown supply current	Is	Ven=0V		3	6	µA
Supply current	Iin	Ven=2.0V, Vfb=1.0V		2.0		mA
Feedback voltage	Vfb	4.75V ≤ Vin ≤ 18.00V	0.900	0.923	0.946	V
Error amplifier voltage gain *	Aea			1000		V/V
Error amplifier transconductance	Gea	ΔIc=±10µA		40		µA/V
High-side switch-on resistance *	Rds(on)H			129		mΩ
Low-side switch-on resistance *	Rds(on)L			87		mΩ
High-side switch leakage current	Ileak	Ven=0V, Vsw=0V Top=+125°C			10	µA
Upper switch current limit	Iuswl	Minimum duty cycle	3.0	3.6		A
Lower switch current limit	Ilswl	From drain to source		0		A
Oscillation frequency	Fosc1		400	500	600	kHz
Short circuit oscillation frequency	Fosc2	Vfb=0V	100	125	150	kHz
Maximum duty cycle	Dmax	Vfb=0.5V		90		%
Minimum on time *	to_min			100		ns
EN falling threshold voltage	VenL	Ven falling	0.56	1.12		V
EN rising threshold voltage	VenH	Ven rising		1.22	1.83	V
Input under voltage lockout threshold	Vuvlo	Vin rising		3.5		V
Input under voltage lockout threshold hysteresis	Vuvlo_hys			200		mV
Soft-start period	tss			2		ms
Thermal shutdown threshold	Tsd			150		°C

* Guaranteed by design, not tested.

■Marking

SOP-8



Mark	Content
a ~ r	Assembly lot No. : 0 ~ 9 and A ~ Z

■Application notes

ELM615DA is a synchronous rectified, current-mode, step-down regulator. It regulates input voltages from 4.75V to 18V down to an output voltage as low as 0.923V, and supplies up to 2A of load current.

ELM615DA uses current-mode control to regulate the output voltage. The output voltage is measured at FB through a resistive voltage divider and amplified through the internal trans-conductance error amplifier.

The converter uses internal N-channel MOSFET switches to step-down the input voltage to the regulated output voltage. Since the high side MOSFET requires a gate voltage greater than the input voltage, a boost capacitor connected between SW and BOOT is needed to drive the high side gate. The boost capacitor is charged from the internal 5V rail when SW is low.

1) Pins description

BOOT: High-side gate drive boost input.

BOOT supplies the drive for the high-side N-channel MOSFET switch. Connect a 0.1μF or greater capacitor from SW to BOOT to power the high side switch.

VIN: Power input.

VIN supplies the power to the IC, as well as the step-down converter switches. Drive VIN with a 4.75V to 18V power source. Bypass VIN to GND with a suitably large capacitor to eliminate noise on the input to the IC.

SW: Power switching output.

SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load. Note that a capacitor is required from SW to BOOT to power the high-side switch.

GND: Ground.

FB: Feedback input.

FB senses the output voltage to regulate that voltage. Drive FB with a resistive voltage divider from the output voltage. The feedback threshold is 0.923V.

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. Pull up with 100kΩ resistor for automatic startup.

*)EN terminal voltage is clamped to 5.7V by internal zenar diode when pulled up by 100kΩ resistor.

2) Setting the output voltage

The output voltage is set using a resistive voltage divider from the output voltage to FB pin. The voltage divider divides the output voltage down to the feedback voltage by the ratio:

$$Vfb = Vout \times R2 / (R1 + R2)$$

Where Vfb is the feedback voltage and Vout is the output voltage.

Thus the output voltage is:

$$Vout = 0.923 \times (R1 + R2) / R2$$

R2 can be as high as 100kΩ, but a typical value is 10kΩ. Using the typical value for R2, R1 is determined by:

$$R1 = 10.83 \times (Vout - 0.923V)\ (K\Omega)$$

3) Inductor

The inductor is required to supply constant current to the output load while being driven by the switched input voltage. A larger value inductor will result in less ripple current that will result in lower output ripple voltage. However, the larger value inductor will have a larger physical size, higher series resistance, and/or lower saturation current. A good rule for determining the inductance to use is to allow the peak-to-peak ripple current in the inductor to be approximately 30% of the maximum switch current limit. Also, make sure that the peak inductor current is below the maximum switch current limit. The inductance value can be calculated by:

$$L = [\, Vout / (fs \times \Delta IL)\,] \times (1 - Vout / Vin)$$

Where Vout is the output voltage, Vin is the input voltage, fs is the switching frequency, and ΔIL is the peak-to-peak inductor ripple current.

Choose an inductor that will not saturate under the maximum inductor peak current. The peak inductor current can be calculated by:

$$Ilp = Iload + [\, Vout / (2 \times fs \times L)\,] \times (1 - Vout / Vin)$$

Where Iload is the load current.

The choice of which style inductor to use mainly depends on the price vs. size requirements and any EMI requirements.

4) Optional schottky diode

During the transition between high-side switch and low-side switch, the body diode of the low-side power MOSFET conducts the inductor current. The forward voltage of this body diode is high. An optional Schottky diode may be paralleled between the SW pin and GND pin to improve overall efficiency. Table 1 lists example Schottky diodes and their Manufacturers.

Part number	Voltage and Current Rating	Vendor
B130	30V, 1A	Diodes Inc.
SK13	30V, 1A	Diodes Inc.
MBRS130	30V, 1A	International Rectifier

Table 1 : Diode selection guide.

5) Input capacitor

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current to the step-down converter while maintaining the DC input voltage. Use low ESR capacitors for the best performance. Ceramic capacitors are preferred, but tantalum or low-ESR electrolytic capacitors may also suffice. Choose X5R or X7R dielectrics when using ceramic capacitors.

Since the input capacitor (C1) absorbs the input switching current it requires an adequate ripple current rating. The RMS current in the input capacitor can be estimated by:

$$Ic1 = Iload \times [\, (Vout / Vin) \times (1 - Vout / Vin)\,]^{1/2}$$

The worst-case condition occurs at Vin = 2Vout, where Ic1 = Iload/2. For simplification, choose the input capacitor whose RMS current rating greater than half of the maximum load current.

The input capacitor can be electrolytic, tantalum or ceramic. When using electrolytic or tantalum capacitors, a small, high quality ceramic capacitor, i.e. 0.1μF, should be placed as close to the IC as possible. When using ceramic capacitors, make sure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at input. The input voltage ripple for low ESR capacitors can be estimated by:

$$\Delta Vin = [\, Iload / (C1 \times fs)\,] \times (Vout / Vin) \times (1 - Vout / Vin)$$

Where C1 is the input capacitance value.

6) Output capacitor

The output capacitor is required to maintain the DC output voltage. Ceramic, tantalum, or low ESR electrolytic capacitors are recommended. Low ESR capacitors are preferred to keep the output voltage ripple low. The output voltage ripple can be estimated by:

$$\Delta Vout = [\ Vout / (fs \times L)\ ] \times (1 - Vout / Vin) \times [\ Resr + 1 / (8 \times fs \times C2)\ ]$$

Where C2 is the output capacitance value and Resr is the equivalent series resistance (ESR) value of the output capacitor.

In the case of ceramic capacitors, the impedance at the switching frequency is dominated by the capacitance. The output voltage ripple is mainly caused by the capacitance. For simplification, the output voltage ripple can be estimated by:

$$\Delta Vout = [\ Vout / (8 \times fs^2 \times L \times C2)\ ] \times (1 - Vout / Vin)$$

In the case of tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated to:

$$\Delta Vout = [\ Vout / (fs \times L)\ ] \times (1 - Vout / Vin) \times Resr$$

The characteristics of the output capacitor also affect the stability of the regulation system. ELM615DA can be optimized for a wide range of capacitance and ESR values.

7) External bootstrap diode

An external bootstrap diode may enhance the efficiency of the regulator, the applicable conditions of external BOOT diode are:

• Vout = 5V or 3.3V; and • Duty cycle is high : D = Vout / Vin > 65%

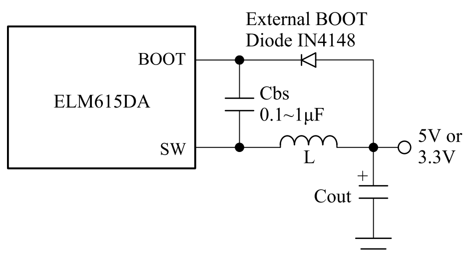


Figure 1: Add optional external bootstrap diode to enhance efficiency.

In these cases, an external BOOT diode is recommended from the output of the voltage regulator to BOOT pin, as shown in Figure 1.

The recommended external BOOT diode is IN4148, and the BOOT capacitor is 0.1 ~ 1μF.

When Vin≤ 6V, for the purpose of promote the efficiency, it can add an external Schottky diode between VIN and BOOT pins, as shown in Figure 2.

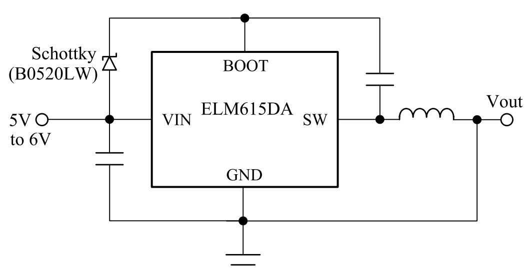


Figure 2: Add a Schottky diode to promote efficiency when Vin ≤ 6V.

8) PCB layout guide

PCB layout is very important to achieve stable operation. Please follow the guidelines below.

1) Keep the path of switching current short and minimize the loop area formed by Input capacitor, high-side MOSFET and low-side MOSFET.
2) Bypass ceramic capacitors are suggested to be put close to the VIN Pin.
3) Ensure all feedback connections are short and direct. Place the feedback resistors and compensation components as close to the chip as possible.
4) Rout SW away from sensitive analog areas such as FB.
5) Connect VIN, SW, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.

9) BOM of ELM614xA

Please refer to the Standard circuit.

Item	Reference	Part
1	C1	10μF
2	C5	100nF
3	C7	0.1μF
4	R4	100K

Table 2: BOM selection table I.

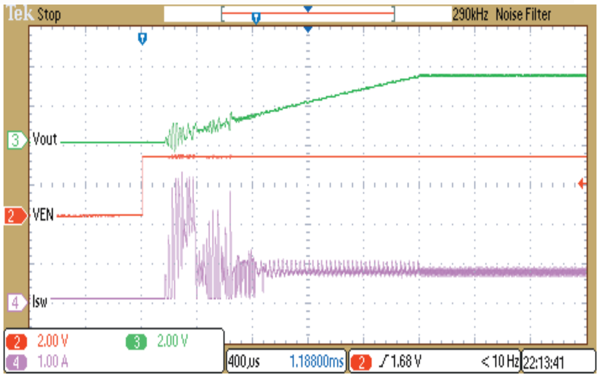
	L	R1	R2	C2
Vout = 5.0V	6.8μH	44.2K	10K	10μF×2
Vout = 3.3V	4.7μH	25.7K	10K	10μF×2
Vout = 2.5V	4.7μH	17.1K	10K	10μF×2
Vout = 1.8V	3.3μH	9.50K	10K	10μF×2
Vout = 1.2V	2.2μH	3.00K	10K	10μF×2
Vout = 1.0V	2.2μH	0.834K	10K	10μF×2

Table 3: BOM selection table II.

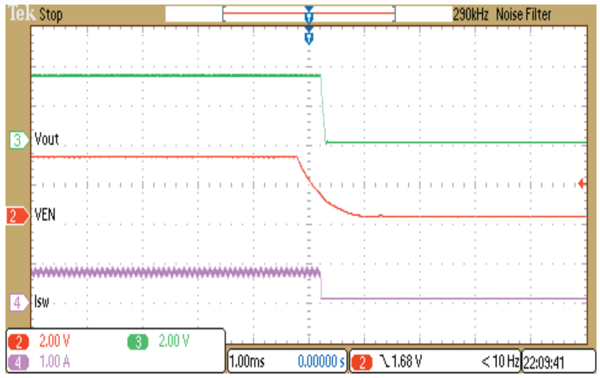
■Typical characteristics

Vin=12V, Vout=3.3V, L=4.7μH, C1=10μF, C2=10μF×2, Top=+25°C, unless otherwise noted.

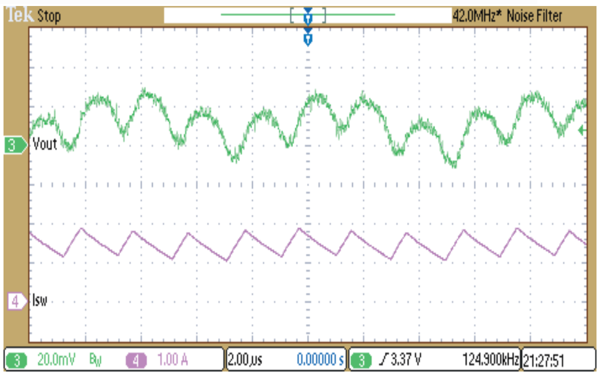
Start Up & Inrush Current (12V→3.3V, Load=1A)



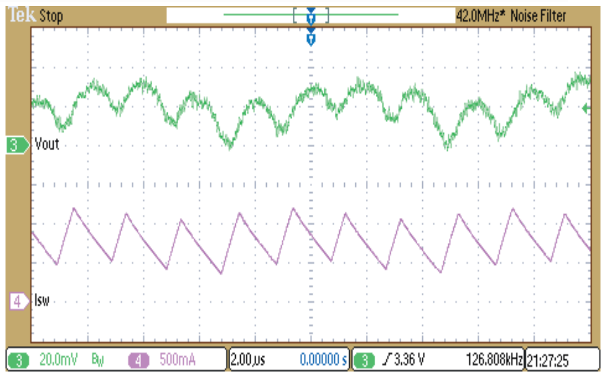
Shut Down (Iout 1A→Shut down)



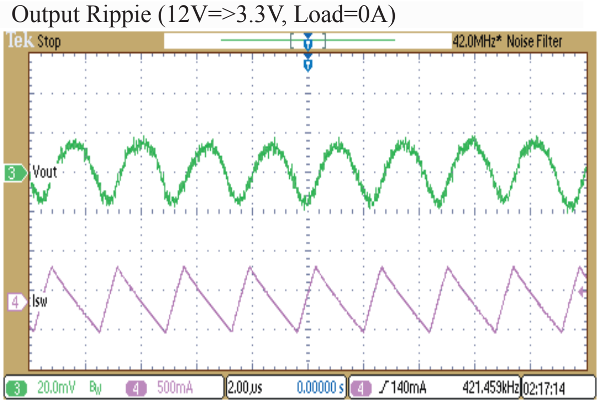
Output Rippie (12V=>3.3V, Load=2A)



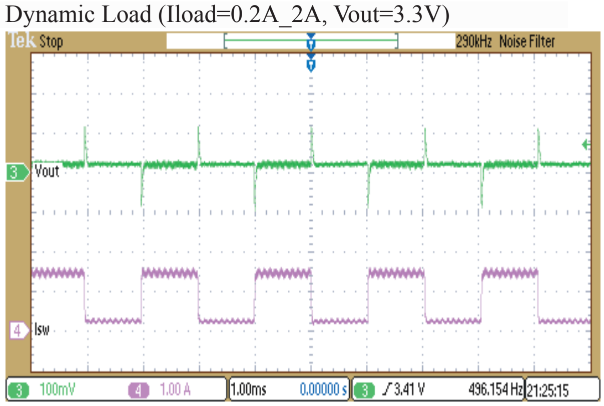
Output Rippie (12V=>3.3V, Load=1A)



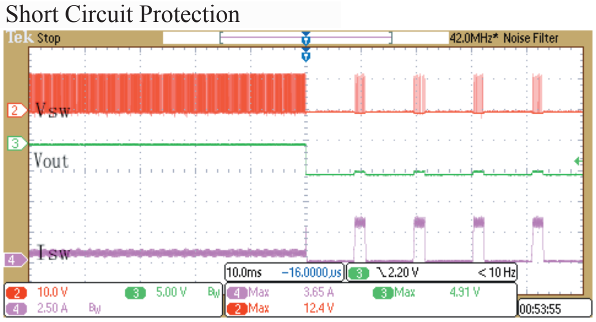
Output Rippie (12V=>3.3V, Load=0A)



Dynamic Load (Iload=0.2A_2A, Vout=3.3V)



Short Circuit Protection



Efficiency