AT7241

40V/600mA, 2MHz Synchronous Step-Down Converter

Immense Advance Tech.

FEATURES

- 4.7V to 40V operating input range
  600mA output current
- Up to 93% efficiency
- High efficiency (>78%) at light load
- Internal Soft-Start
- 2MHz switching frequency
- Input under voltage lockout
- Current run-away protection
- Short circuit protection
- Thermal protection
- Available in SOT26 package

APPLICATION

- Distributed Power Systems
- Automotive Systems
- High Voltage Power Conversion
- Industrial Power Systems
- Battery Powered Systems

DESCRIPTION

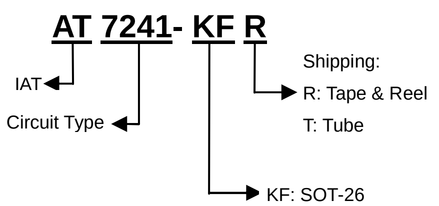
The AT7241 is a current mode monolithic buck switching regulator. Operating with an input range of 4.7V~40V, the AT7241 delivers 600mA of continuous output current with two integrated N-Channel MOSFETs. The internal synchronous power switches provide high efficiency without the use of an external Schottky diode. At light loads, the regulator operates in low frequency to maintain high efficiency and low output ripple.

Current mode control provides tight load transient response and cycle-by-cycle current limit.

The AT7241 guarantees robustness with short-circuit protection, thermal protection, current run-away protection, and input under voltage lockout.

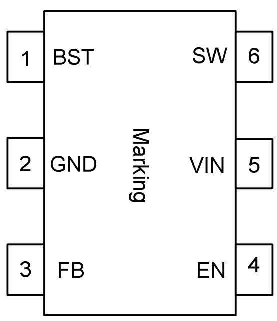
The AT7241 is available in 6-pin SOT26 package, which provides a compact solution with minimal external components.

ORDER INFORMATION



PIN CONFIGURATIONS (TOP VIEW)

SOT-26



PIN DESCRIPTIONS

Pin Name	Pin Description
BST	Bootstrap pin for top switch. A 0.1uF or larger capacitor should be connected between this pin and the SW pin to supply current to the top switch and top switch driver.
GND	Ground.
FB	Output feedback pin. FB senses the output voltage and is regulated by the control loop to 800mV. Connect a resistive divider at FB.
EN	Drive EN pin high to turn on the regulator and low to turn off the regulator.
V_{IN}	Input voltage pin. V_{IN} supplies power to the IC. Connect a 4.7V to 40V supply to V_{IN} and bypass V_{IN} to GND with a suitably large capacitor to eliminate noise on the input to the IC.
SW	SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.

TYPICAL APPLICATION CIRCUITS

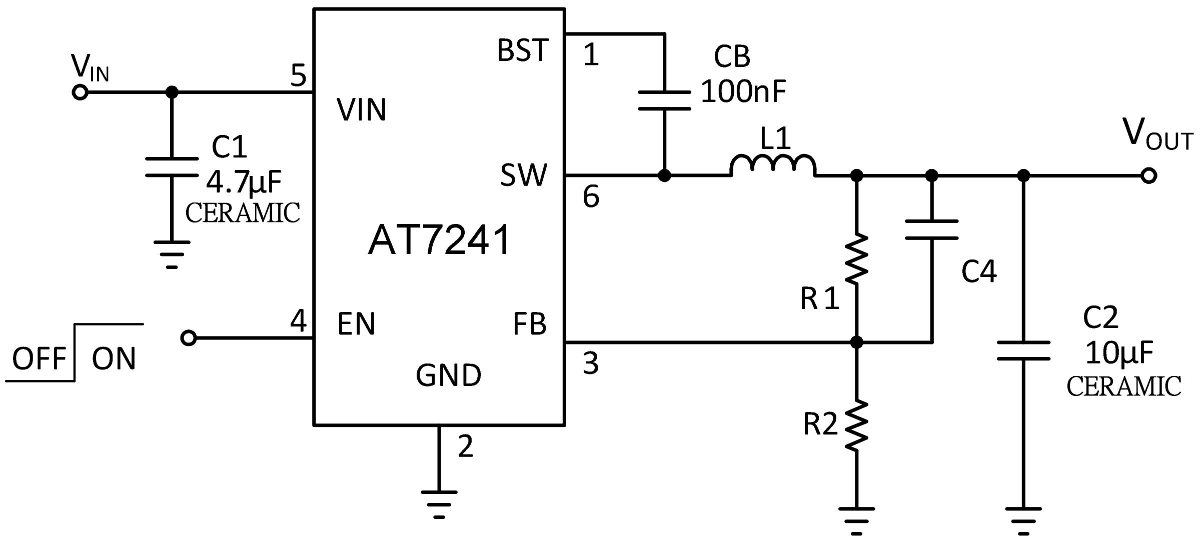
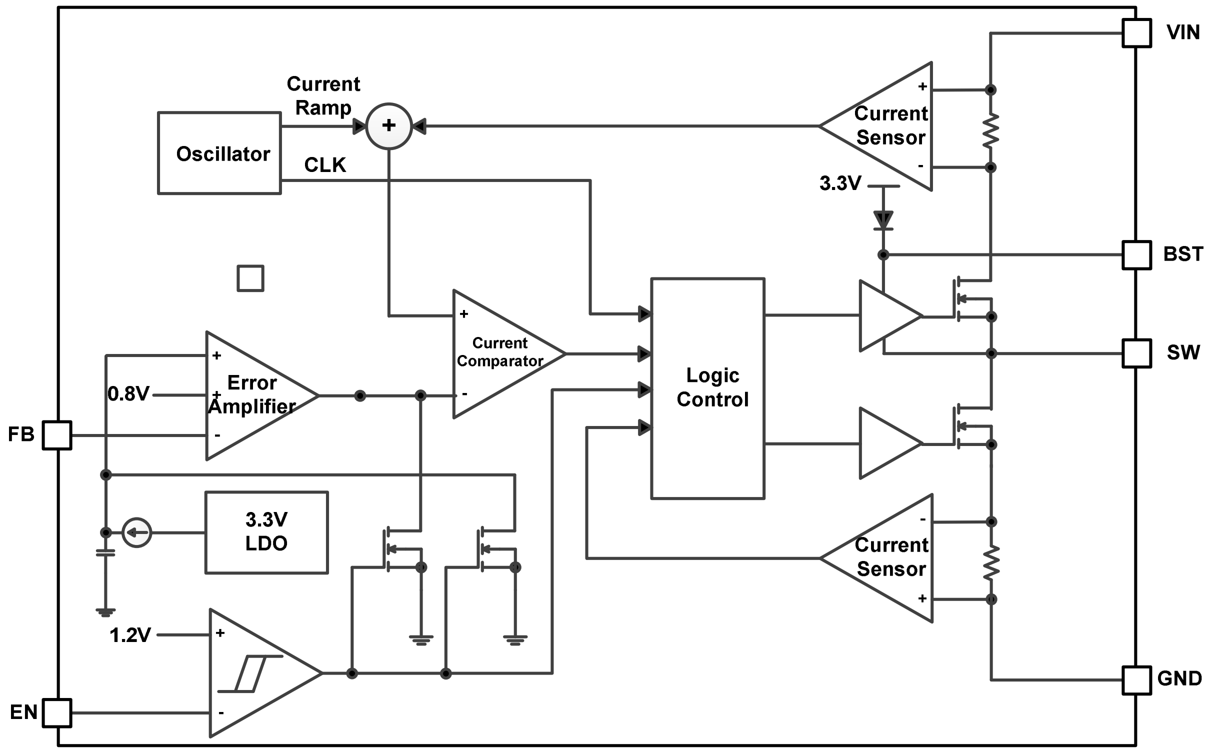


Figure 1.

Vout	R1	R2	C4	L1	C2
5.0V	11.2K	2.1K	Optional	4.7uH	10μF
3.3V	11.2K	4.22K	Optional	4.7uH	10μF
2.5V	11.2K	4.99K	Optional	4.7uH	10μF

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS(Note 1)

Parameter	Symbol	Max Value	Unit
V_{IN}, EN, SW Pin		-0.3 to +44	V
BST Pin	V_{BST}	SW -0.3 to SW+5	V
All other Pins		-0.3 to +6	V
Maximum Junction Temperature	T_J	150	℃
Storage Temperature Range	T_{STG}	-60 to +150	℃
Lead Temperature(Soldering) 5 Sec.	T_{LEAD}	260	℃
Power Dissipation P_D @ T_A=25℃	P_D	300	mW
Thermal Resistance Junction to Ambient (Note 2)	θ_{JA}	333	℃ / W
Thermal Resistance Junction to Case	θ_{JC}	106.6	℃ / W

RECOMMENDED OPERATING CONDITIONS (Note 3)

Parameter	Symbol	Operation Conditions	Unit
Input Voltage	V_{IN}	4.7 to 40	V
Output Voltage	V_{OUT}	0.8 to V_{IN}-3V	V
Operating Junction Temperature Range	T_J	-40 to +125	℃
Operating Ambient Temperature Range	T_{OPA}	-40 to +85	℃

Note 1: Stresses listed as the above “Absolute Maximum Ratings” may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2: Thermal Resistance is specified with the component mounted on a low effective thermal conductivity test board in free air at T_A=25℃.

Note 3: The device is not guaranteed to function outside its operating conditions.

ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, T_A = 25ºC, unless otherwise stated.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
V_{IN} Undervoltage Lockout Thershold	V_{IN_MIN}	V_{IN} rising	—	4.3	—	V
V_{IN} Undervoltage Lockout Hysteresis	$V_{IN\_MIN\_HYST}$		—	250	—	mV
Shutdown Supply Current	I_{SD}	V_{EN}=0V	—	0.1	1	μA
Supply Current	I_Q	V_{EN}=5V, V_{FB}=1.2V	—	40	60	μA
Feedback Voltage	V_{FB}	4.7V<V_{IN}<40V	776	800	824	mV
Top Switch Resistance(Note 4)	$R_{DS(ON)T}$		—	500		mΩ
Bottom Switch Resistance(Note 4)	$R_{DS(ON)B}$		—	220	—	mΩ
Top Switch Leakage Current	I_{LEAK_TOP}	V_{IN}=40V, V_{EN}=0V, V_{SW}=0V	—	—	1	uA
Bottom Switch Leakage Current	I_{LEAK_BOT}	V_{IN}= V_{SW} = 40V, V_{EN}=0V	—	—	1	uA
Top Switch Current Limit	I_{LIM_TOP}	Minimum Duty Cycle	—	1	—	A
Switch Frequency	f_{SW}		—	2	—	MHz
Minimum On Time	T_{ON_MIN}		—	80	—	ns
Minimum Off Time	T_{OFF_MIN}	V_{FB}=0V	—	100	—	ns
EN shut down threshold voltage	V_{EN_TH}	V_{EN} rising,FB=0V	1.18	1.3	1.42	V
EN shut down hysteresis	V_{EN_HYST}		—	40	—	mV
Thermal Shutdown(Note 4)	T_{TSD}		—	135	—	℃
Thermal Shutdown hysteresis(Note 4)	T_{TSD_HYST}		—	15	—	℃

Note 4: Guarantee by design.

APPLICATION INFORMATION

The output voltage is determined by the resistor divider connected at the FB pin, and the voltage ratio is:

$$V_{FB} = V_{OUT} \times \frac{R_1}{R_2 + R_1}$$

where VFB is the feedback voltage and V_{OUT} is the output voltage.

Choose R1 around 2.1kΩ, and then R2 can be calculated by:

$$R_2 = R_1 \times \left(\frac{V_{OUT}}{0.8V} - 1 \right)$$

The following table lists the recommended values.

V_{OUT}(V)	R2(kΩ)	R1(kΩ)
2.5	4.99	11
3.3	4.22	13.3
5	2.1	11.2

Input Capacitor

The input capacitor is used to supply the AC input current to the step-down converter and maintaining the DC input voltage. The ripple current through the input capacitor can be calculated by:

$$I_{C1} = I_{LOAD} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}$$

where ILOAD is the load current, V_{OUT} is the output voltage, V_{IN} is the input voltage.

Thus the input capacitor can be calculated by the following equation when the input ripple voltage is determined.

$$C_1 = \frac{I_{LOAD}}{f_S \times \Delta V_{IN}} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

where C1 is the input capacitance value, fs is the switching frequency, $\triangle V_{IN}$ is the input ripple current.

The input capacitor can be electrolytic, tantalum or ceramic. To minimizing the potential noise, a small X5R or X7R ceramic capacitor, i.e. 0.1uF, should be placed as close to the IC as possible when using electrolytic capacitors.

A 4.7uF ceramic capacitor is recommended in typical application, and an extra 47uF electrolytic capacitor is needed if hot-plug is required.

Output Capacitor

The output capacitor is required to maintain the DC output voltage, and the capacitance value determines the output ripple voltage. The output voltage ripple can be calculated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_S \times C_2}\right)$$

where C2 is the output capacitance value and RESR is the equivalent series resistance value of the output capacitor.

The output capacitor can be low ESR electrolytic, tantalum or ceramic, which lower ESR capacitors get lower output ripple voltage.

The output capacitors also affect the system stability and transient response, and a 10uF ceramic capacitor is recommended in typical application.

Inductor

The inductor is used to supply constant current to the output load, and the value determines the ripple current which affect the efficiency and the output voltage ripple. The ripple current is typically allowed to be 30% of the maximum switch current limit, thus the inductance value can be calculated by:

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

where V_{IN} is the input voltage, V_{OUT} is the output voltage, fs is the switching frequency, and $\triangle I_L$ is the peak-to-peak inductor ripple current.

External Boostrap Capacitor

A boostrap capacitor is required to supply voltage to the top switch driver. A 0.1uF low ESR ceramic capacitor is recommended to connected to the BST pin and SW pin.

PCB Layout Note

For minimum noise problem and best operating performance, the PCB is preferred to following the guidelines as reference.

1.Place the input decoupling capacitor as close to AT7241 (V_{IN} pin and PGND) as possible to eliminate noise at the input pin.

The loop area formed by input capacitor and GND must be minimized.

2. Put the feedback trace as far away from the inductor and noisy power traces as possible.

3. The ground plane on the PCB should be as large as possible for better heat dissipation.

FUNCTIONAL DESCRIPTION

The AT7241 is a synchronous, current-mode, step-down regulator. It regulates input voltages from 4.7V to 40V down to an output voltage as low as 0.8V, and is capable of supplying up to 600mA of load current.

Current-Mode Control

The AT7241 utilizes current-mode control to regulate the output voltage. The output voltage is measured at the FB pin through a resistive voltage divider and the error is amplified by the internal transconductance error amplifier.

Output of the internal error amplifier is compared with the switch current measured internally to control the output current.

PFM Mode

The AT7241 operates in PFM mode at light load.

In PFM mode, switch frequency decreases when load current drops to boost power efficiency at light load by reducing switch-loss, while switch frequency increases when load current rises, minimizing output voltage ripples.

Shut-Down Mode

The AT7241 shuts down when voltage at EN pin is below 0.3V. The entire regulator is off and the supply current consumed by the AT7241 drops below 0.1uA.

Power Switch

N-Channel MOSFET switches are integrated on the AT7241 to down convert the input voltage to the regulated output voltage. Since the top MOSFET needs a gate voltage great than the input voltage, a boost capacitor connected between BST and SW pins is required to drive the gate of the top switch.

The boost capacitor is charged by the internal 3.3V rail when SW is low.

V_{IN} Under-Voltage Protection

A resistive divider can be connected between V_{IN} and ground, with the central tap connected to EN, so that when V_{IN} drops to the pre-set value, EN drops below 1.2V to trigger input under voltage lockout protection.

Output Current Run-Away Protection

At start-up, due to the high voltage at input and low voltage at output, current inertia of the output inductance can be easily built up, resulting in a large start-up output current. A valley current limit is designed in the AT7241 so that only when output current drops below the valley current limit can the top power switch be turned on. By such control mechanism, the output current at start-up is well controlled.

Output Short Protection

When output is shorted to ground, output current rapidly reaches its peak current limit and the top power switch is turned off. Right after the top power switch is turned off, the bottom power switch is turned on and stay on until the output current falls below the valley current limit. When output current is below the valley current limit, the top power switch will be turned on again and if the output short is still present, the top power switch is turned off when the peak current limit is reached and the bottom power switch is turned on. This cycle goes on until the output short is removed and the regulator comes into normal operation again.

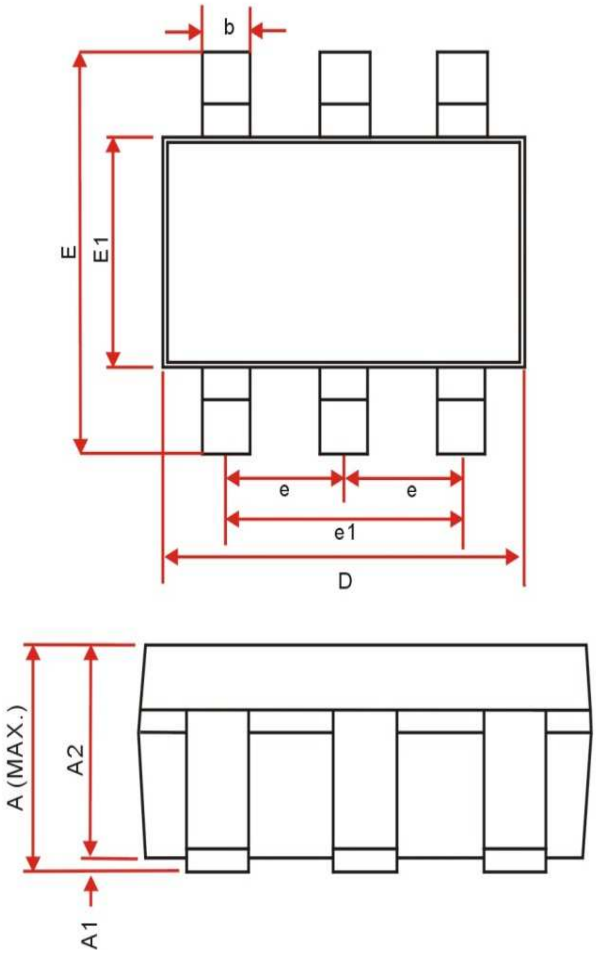
FUNCTIONAL DESCRIPTION(CONTINUED)

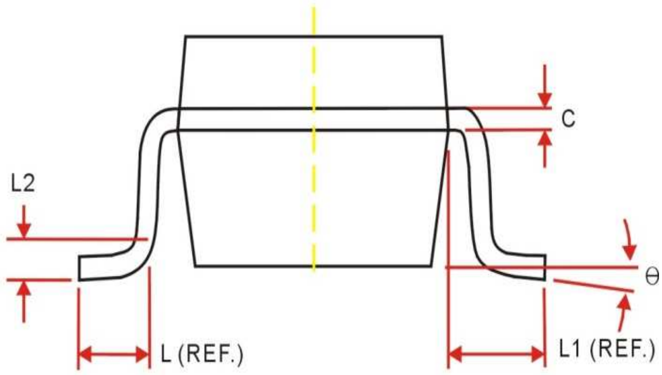
Thermal Protection

When the temperature of the AT7241 rises above 135℃, it is forced into thermal shut-down.
Only when core temperature drops below 120℃ can the regulator becomes active again.

PACKAGE OUTLINE DIMENSIONS

SOT-26 PACKAGE OUTLINE DIMENSIONS





Symbol	Dimensions In Millimeters	
	Min	Max
A	1.45 MAX.	
A1	0	0.15
A2	0.90	1.30
C	0.08	0.22
D	2.90 REF.	
E	2.80 REF.	
E1	1.60 REF.	
L	0.30	0.60
L1	0.60 REF.	
L2	0.25 REF.	
θ	0°	10°
b	0.30	0.50
e	0.95REF.	
e1	1.90REF.	