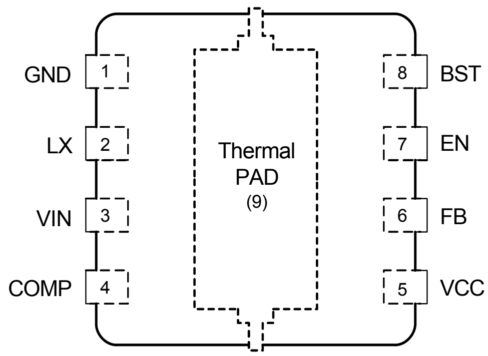
Ordering Information

Part Number	Ambient Temperature Range	Package	Environmental
AOZ6762DI	-40°C to +85°C	8-Pin 3mm x 3mm DFN	RoHS

AOS Green Products use reduced levels of Halogens, and are also RoHS compliant.

Pin Configuration



8-Pin 3mm x 3mm DFN
Top Transparent View

Pin Description

Pin Number	Pin Name	Pin Function
1	GND	System ground.
2	LX	Switching output.
3	VIN	Supply voltage input. When VIN rises above the UVLO threshold and EN is logic high, the device starts up.
4	COMP	External Loop Compensation Pin. Connect a RC network between COMP and GND to compensate the control loop.
5	VCC	The output of LDO. 1µF decoupling capacitor needs added.
6	FB	Feedback input. The FB pin is used to set the output voltage via a resistor voltage divider between the output and GND.
7	EN	Enable input. Pull up EN to logic high will enable the device. Pull EN to logic low will disable the device. EN pin must be connected to VIN if no Enable control is required.
8	BST	Bootstrap input. Connect a capacitor to LX. Typical value is 0.1µF.
9	Thermal PAD	This thermal pad must be connected to GND for normal operation.

Absolute Maximum Ratings[1]

Exceeding the Absolute Maximum Ratings may damage the device.

Parameter	Rating
Supply Voltage (V_{IN}), EN (V_{EN})	20V
LX to GND	-0.3V to V_{IN}+0.3V
LX to GND (20ns)	-5V to 22V
VCC, FB to GND	-0.3V to 6V
VBST TO LX	6V
Junction Temperature (T_J)	+150°C
Storage Temperature (T_S)	-65°C to +150°C
ESD Rating[2]	2kV

Notes:

1. Exceeding the Absolute Maximum ratings may damage the device.
2. Devices are inherently ESD sensitive, handling precautions are required. Human body model rating: 1.5kΩ in series with 100pF.

Maximum Operating Ratings[3]

The device is not guaranteed to operate beyond the Maximum Operating ratings.

Parameter	Rating
Supply Voltage (V_{IN})	4.5V to 18V
Output Voltage Range	0.6V to 0.65*V_{IN}
Ambient Temperature (T_A)	-40°C to +85°C
Package Thermal Resistance DFN 3x3 (θ_{JA})[4]	50°C/W

Notes:

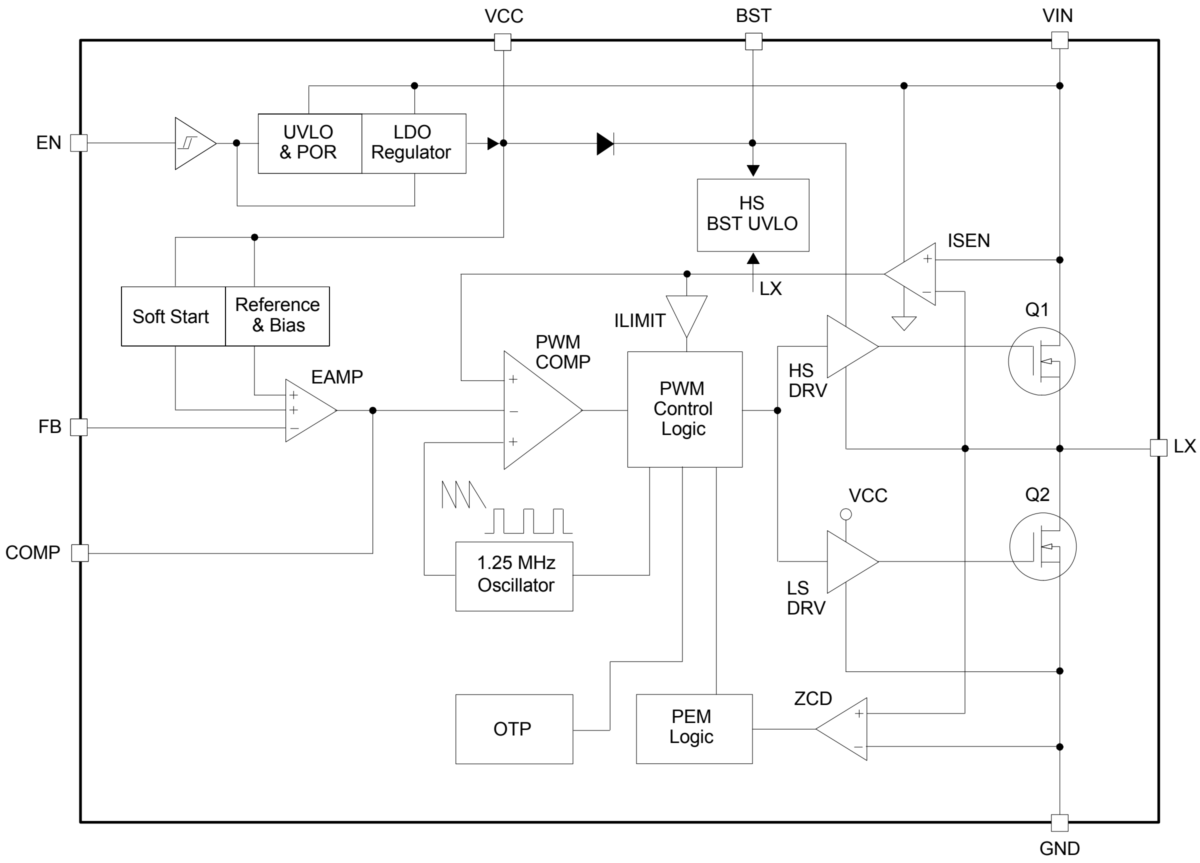
3. The device is not guaranteed to operate beyond the Maximum Operating ratings.
4. The value of θ_{JA} is measured with the device mounted on a 1-in^2 FR-4 four layer board with 2oz copper and Vias, in a still air environment with T_A = 25°C. The value in any given application depends on the user's specification board design.

Electrical Characteristics

T_A = 25°C, V_{IN} = V_{EN} = 12V, V_{OUT} = 3.3V, unless otherwise specified. Specifications in **Bold** indicate an ambient temperature range of -40°C to +85°C. These specifications are guaranteed by design.

Symbol	Parameter	Conditions	Min.	Typ.	Max	Units
V_{IN}	Supply Voltage		**4.5**		**18**	V
V_{UVLO}	Input Under-Voltage Lockout Threshold	V_{IN} rising V_{IN} falling	 **3.2**	4.1 3.7	**4.49**	V V
I_{IN}	Supply Current (Quiescent)	I_{OUT} = 0V, VFB = 1.2V, V_{EN} > 2V		260		µA
I_{OFF}	Shutdown Supply Current	V_{EN} = 0V		0.1	1	µA
V_{FB}	Feedback Voltage	T_A = 25°C	0.591	0.6	0.609	V
R_O	Load Regulation	PWM mode 500mA < ILoad < 2A		0.5		%
S_V	Line Regulation	4.5V < V_{IN} < 18V		1		%
I_{FB}	Feedback Voltage Input Current				200	nA
V_{EN}	EN Input Threshold	Off threshold On threshold	 **2**		**0.6**	V V
V_{HYS}	EN Input Hysteresis			300		mV
I_{EN}	EN Input Current	V_{EN} = 5V		2.5	4	µA
t_{SS}	SS Time			2.6		ms
Modulator						
f_O	Frequency		1100	1250	1400	kHz
D_{MAX}	Maximum Duty Cycle		65	70		%
T_{MIN}	Controllable Minimum Duty Cycle			30		ns
Protection						
I_{LIM}	Current Limit		3.0	4.0		A
T_{OTP}	Over Temperature Shutdown Limit	T_J rising T_J falling		150 100		°C °C
Output Stage						
R_{HS}	High-Side Switch On-Resistance	BST - LX = 5V		145		mΩ
R_{LS}	Low-Side Switch On-Resistance			90		mΩ

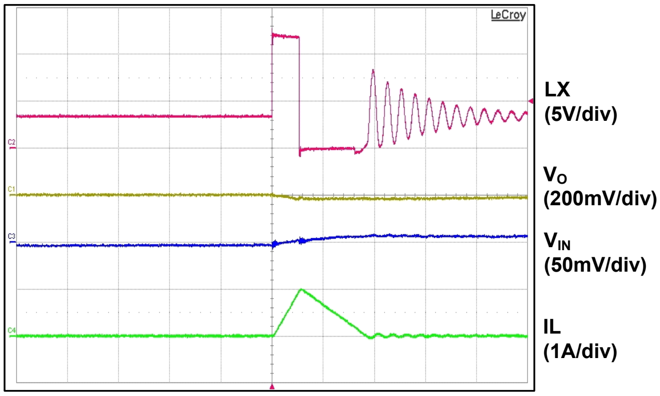
Functional Block Diagram



Typical Characteristics

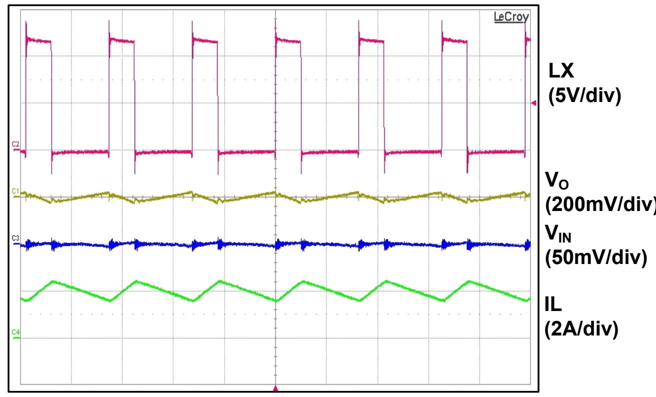
T_A = 25°C, V_{IN} = V_{EN} = 12V, V_{OUT} = 3.3V, unless otherwise specified.

Light Load Operation



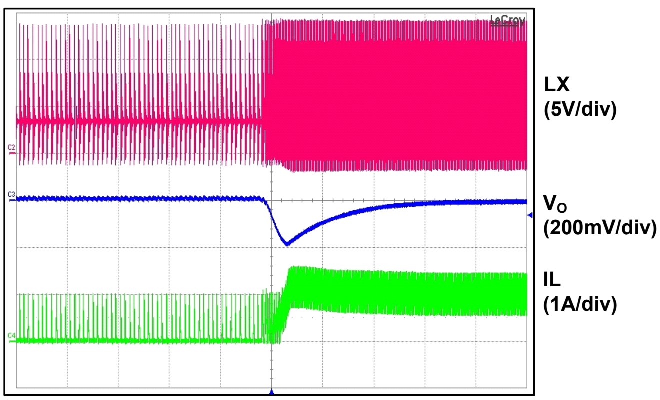
1μs/div

Full Load Operation



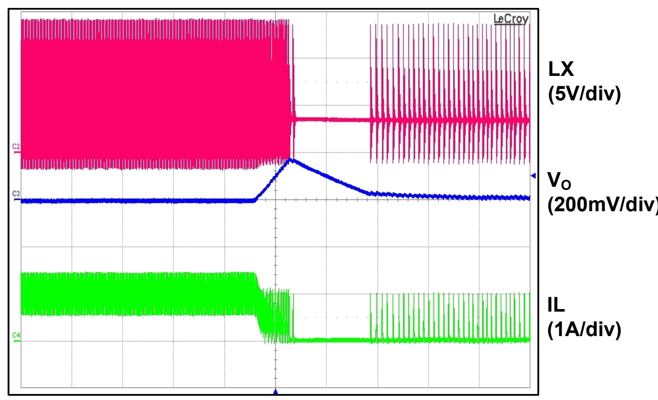
1μs/div

PEM to PWM Transition



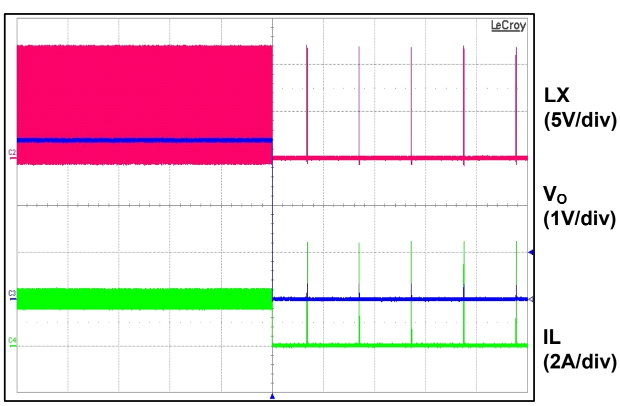
0.5ms/div

PWM to PEM Transition



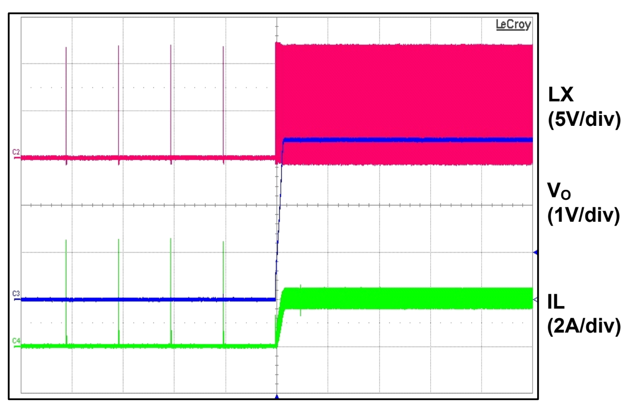
0.5ms/div

Short Protection



10ms/div

Short Circuit Recovery

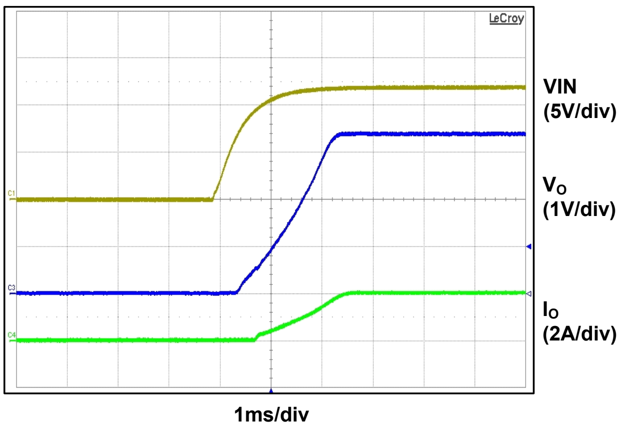


10ms/div

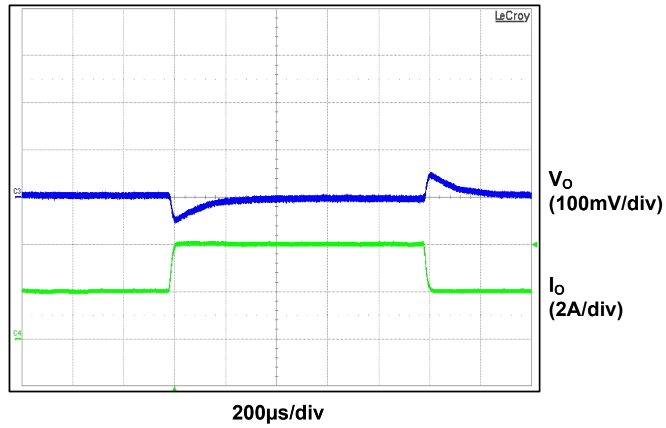
Typical Characteristics *(continued)*

T_A = 25°C, V_{IN} = V_{EN} = 12V, V_{OUT} = 3.3V, unless otherwise specified.

Start-up to Full Load

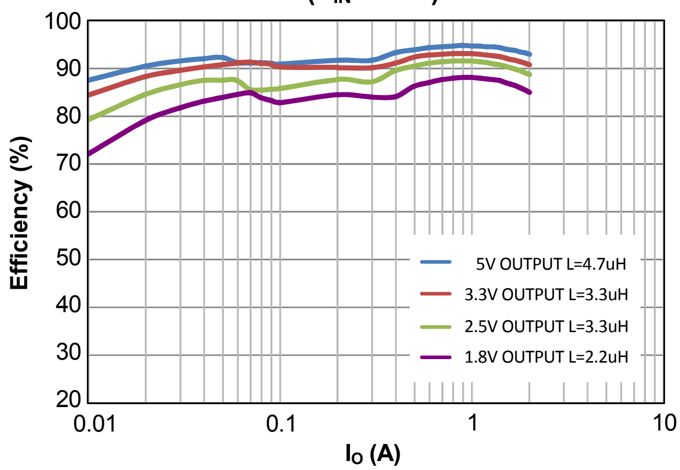


50% to 100% Load Transient



Efficiency

AOZ6762DI Efficiency (V_{IN} = 12V)



Detailed Description

The AOZ6762DI is a current-mode step down regulator with integrated high-side NMOS switch and low-side NMOS switch. It operates from a 4.5V to 18V input voltage range and supplies up to 2A of load current. Features include, enable control, Power-On Reset, input under voltage lockout, output over voltage protection, internal soft-start and thermal shut down.

The AOZ6762DI is available in DFN3X3 package.

Enable and Soft Start

The AOZ6762DI has internal soft start feature to limit in-rush current and ensure the output voltage ramps up smoothly to regulation voltage. A soft start process begins when the input voltage rises to 4.1V and voltage on EN pin is HIGH. The soft start time is programmed by internal soft start capacitor and is set to 3.5ms (Typ).

The EN pin of the AOZ6762DI is active high. Connect the EN pin to VIN if enable function is not used. Pull it to ground will disable the AOZ6762DI. Do not leave it open. The voltage on EN pin must be above 2V to enable the AOZ6762DI. When voltage on EN pin falls below 0.6V, the AOZ6762DI is disabled.

Light Load and PWM Operation

Under low output current settings, the AOZ6762DI will operate with pulse energy mode to obtain high efficiency. In pulse energy mode, the PWM will not turn off until the on time get a fixed time which is defined by Vin, Vo and switching frequency.

Steady-State Operation

Under heavy load steady-state conditions, the converter operates in fixed frequency and Continuous-Conduction Mode (CCM).

he AOZ6762DI integrates an internal N-MOSFET as the high-side switch. Inductor current is sensed by amplifying the voltage drop across the drain to source of the high side power MOSFET. Output voltage is divided down by the external voltage divider at the FB pin. The difference of the FB pin voltage and reference is amplified by the internal transconductance error amplifier. The error voltage is compared against the current signal, which is sum of inductor current signal and input and output modulated voltage ramp compensation signal, at PWM comparator input. If the current signal is less than the error voltage, the internal high-side switch is on. The inductor current flows from the input through the inductor to the output. When the current signal exceeds the error voltage, the high-side switch is off. The inductor current is freewheeling through the internal low-side N-MOSFET switch to output. The internal adaptive FET driver guarantees no turn on overlap of both high-side and low-side switch.

Comparing with regulators using freewheeling Schottky diodes, the AOZ6762DI uses freewheeling NMOSFET to realize synchronous rectification. It greatly improves the converter efficiency and reduces power loss in the low-side switch.

The AOZ6762DI uses a N-Channel MOSFET as the high-side switch. Since the NMOSFET requires a gate voltage higher than the input voltage, a boost capacitor is needed between LX pin and BST pin to drive the gate. The boost capacitor is charged while LX is low

Output Voltage Programming

Output voltage can be set by feeding back the output to the FB pin by using a resistor divider network. In the application circuit shown in Figure 1. Usually, a design is started by picking a fixed R_2 value and calculating the required R1 with equation below.

$$V_O = 0.6 \times \left(1 + \frac{R_1}{R_2}\right)$$

Combination of R1 and R2 should be large enough to avoid drawing excessive current from the output, which will cause power loss.

Some standard value of R_1, R_2 and most used output voltage values are listed in Table 1.

VO (V)	R1 (kΩ)	R2 (kΩ)
1.0	10	15
1.2	10	10
1.5	15	10
1.8	20	10
2.5	31.6	10
3.3	68.1	15
5.0	110	15

Table 1.

Protection Features

The AOZ6762DI has multiple protection features to prevent system circuit damage under abnormal conditions.

Over Current Protection (OCP)

The sensed low side MOSFET valley current signal is also used for over current protection. Since the AOZ6762DI employs valley current mode control, during over current conditions, it will skip a pulse if the valley current over the OC point setting until the output drop to some level after current limit. The AOZ6762DI will shut down and auto restart with hiccup mode. To prevent the current running away in the extreme case, the minimum inductor value needed is 2.2µH for the application.

Power-On Reset (POR)

A power-on reset circuit monitors the VIN voltage. When the VIN voltage exceeds 4.1V, the converter starts operation. When VIN voltage falls below 3.7V, the converter will be shut down.

Thermal Protection

An internal temperature sensor monitors the junction temperature. It shuts down the internal control circuit and high side NMOS if the junction temperature exceeds 150ºC. The regulator will restart automatically under the control of soft-start circuit when the junction temperature decreases to 100ºC.

Application Information

The basic AOZ6762DI application circuit is show in Figure 1. Component selection is explained below.

Input Capacitor

The input capacitor must be connected to the V_{IN} pin and GND pin of AOZ6762DI to maintain steady input voltage and filter out the pulsing input current. The voltage rating of input capacitor must be greater than maximum input voltage plus ripple voltage.

The input ripple voltage can be approximated by equation below:

$$\Delta V_{IN} = \frac{I_O}{f \times C_{IN}} \times \left(1 - \frac{V_O}{V_{IN}}\right) \times \frac{V_O}{V_{IN}}$$

Since the input current is discontinuous in a buck converter, the current stress on the input capacitor is another concern when selecting the capacitor. For a buck circuit, the RMS value of input capacitor current can be calculated by:

$$I_{CIN\_RMS} = I_O \times \sqrt{\frac{V_O}{V_{IN}}\left(1 - \frac{V_O}{V_{IN}}\right)}$$

if let *m* equal the conversion ratio:

$$\frac{V_O}{V_{IN}} = m$$

The relation between the input capacitor RMS current and voltage conversion ratio is calculated and shown in Figure 2 below. It can be seen that when V_O is half of V_{IN}, C_{IN} it is under the worst current stress. The worst current stress on C_{IN} is 0.5 x I_O.

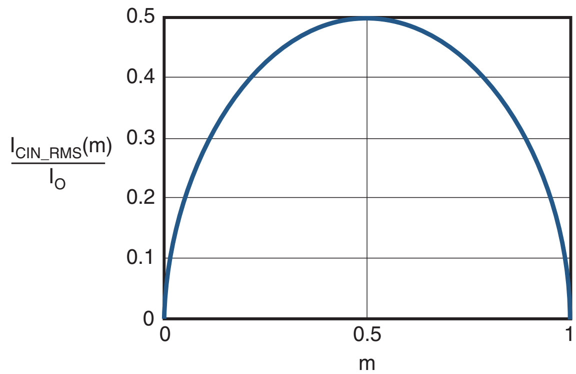


Figure 2. I_{CIN} vs. Voltage Conversion Ratio

For reliable operation and best performance, the input capacitors must have current rating higher than $I_{CIN-RMS}$ at worst operating conditions. Ceramic capacitors are preferred for input capacitors because of their low ESR and high current rating. Depending on the application circuits, other low ESR tantalum capacitor may also be used. When selecting ceramic capacitors, X5R or X7R type dielectric ceramic capacitors should be used for their better temperature and voltage characteristics. Note that the ripple current rating from capacitor manufactures are based on certain amount of life time. Further de-rating may be necessary in practical design.

Inductor

The inductor is used to supply constant current to output when it is driven by a switching voltage. For given input and output voltage, inductance and switching frequency together decide the inductor ripple current, which is:

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

The peak inductor current is:

$$I_{Lpeak} = I_O + \frac{\Delta I_L}{2}$$

High inductance gives low inductor ripple current but requires larger size inductor to avoid saturation. Low ripple current reduces inductor core losses. It also reduces RMS current through inductor and switches, which results in less conduction loss. Usually, peak to peak ripple current on inductor is designed to be 20% to 40% of output current.

When selecting the inductor, make sure it is able to handle the peak current without saturation even at the highest operating temperature.

The inductor takes the highest current in a buck circuit. The conduction loss on inductor need to be checked for thermal and efficiency requirements.

Surface mount inductors in different shape and styles are available from Coilcraft, Elytone and Murata. Shielded inductors are small and radiate less EMI noise. But they cost more than unshielded inductors. The choice depends on EMI requirement, price and size.

Output Capacitor

The output capacitor is selected based on the DC output voltage rating, output ripple voltage specification and ripple current rating.

The selected output capacitor must have a higher rated voltage specification than the maximum desired output voltage including ripple. De-rating needs to be considered for long term reliability.

Output ripple voltage specification is another important factor for selecting the output capacitor. In a buck converter circuit, output ripple voltage is determined by inductor value, switching frequency, output capacitor value and ESR. It can be calculated by the equation below:

$$\Delta V_O = \Delta I_L \times \left(ESR_{CO} + \frac{1}{8 \times f \times C_O}\right)$$

where,

C_O is output capacitor value and ESR_{CO} is the Equivalent Series Resistor of output capacitor.

When a low ESR ceramic capacitor is used as output capacitor, When low ESR ceramic capacitor is used as output capacitor, the impedance of the capacitor at the switching frequency dominates. Output ripple is mainly caused by capacitor value and inductor ripple current. The output ripple voltage calculation can be simplified to:

$$\Delta V_O = \Delta I_L \times \frac{1}{8 \times f \times C_O}$$

If the impedance of ESR at switching frequency dominates, the output ripple voltage is mainly decided by capacitor ESR and inductor ripple current. The output ripple voltage calculation can be further simplified to:

$$\Delta V_O = \Delta I_L \times ESR_{CO}$$

For lower output ripple voltage across the entire operating temperature range, X5R or X7R dielectric type of ceramic, or other low ESR tantalum are recommended to be used as output capacitors.

In a buck converter, output capacitor current is continuous. The RMS current of output capacitor is decided by the peak to peak inductor ripple current. It can be calculated by:

$$I_{CO\_RMS} = \frac{\Delta I_L}{\sqrt{12}}$$

Usually, the ripple current rating of the output capacitor is a smaller issue because of the low current stress. When the buck inductor is selected to be very small and inductor ripple current is high, output capacitor could be overstressed.

Loop Compensation

The AOZ6762DI employs peak current mode control for easy use and fast transient response. Peak current mode control eliminates the double pole effect of the output L&C filter. It greatly simplifies the compensation loop design.

With peak current mode control, the buck power stage can be simplified to be a one-pole and one-zero system in frequency domain. The pole is dominant pole can be calculated by:

$$f_{p1} = \frac{1}{2\pi \times C_O \times R_L}$$

The zero is a ESR zero due to output capacitor and its ESR. It is can be calculated by:

$$f_{Z1} = \frac{1}{2\pi \times C_O \times ESR_{CO}}$$