ALPHA & OMEGA SEMICONDUCTOR

AOZ24585QV

18V/30A Synchronous EZBuck™ Regulator

General Description

The AOZ24585QV is a high-efficiency, easy-to-use DC/DC synchronous buck regulator that operates up to 18V. The device is capable of supplying 30A of continuous output current with an output voltage adjustable down to 0.8V (±0.5%).

The AOZ24585QV integrates an internal linear regulator to generate 5.3V V_{CC} from input. If input voltage is lower than 5.3V, the linear regulator operates at low drop output mode, which allows the V_{CC} voltage is equal to input voltage minus the drop-output voltage of the internal linear regulator.

A proprietary constant on-time PWM control with input feed-forward results in ultra-fast transient response while maintaining relatively constant switching frequency over the entire input voltage range. A low 40ns minimum on-time enables very low output voltages at ultra-high operating frequencies.

Integrated AC ripple injection enables all-ceramic low ESR output filter capacitors and smaller PCB footprint with no external components needed.

Selectable PFM mode optimizes light load efficiency while forced PWM mode maintains constant frequency for lower harmonic noise.

The device features multiple protection functions such as V_{CC} under-voltage lockout, cycle-by-cycle current limit, output over-voltage protection, short-circuit protection, and thermal shutdown.

The AOZ24585QV is available in a 6mm×5mm QFN-36L package and is rated over a -40°C to +125°C ambient temperature range.

Features

- Wide input voltage range:
  - 6.5V to 18V
- 30A continuous output current
- Output voltage adjustable to 0.8V (±0.5%)
- Low $R_{DS(ON)}$ internal NFETs
  - 3.6mΩ high-side
  - 1mΩ low-side
- Integrated LDO or external 5V supply
- Constant On-Time with input feed-forward
- Selectable Switching Frequency Range: 400kHz to 1MHz
- Selectable PFM or forced PWM for light load operation
- Ceramic capacitor stable
- Remote sense
- Power Good output
- Integrated bootstrap diode
- Cycle-by-cycle current limit with selectable setting
- Under-voltage protection and over-voltage protection
- Short-circuit protection
- Selectable protection mode
- Selectable soft start time
- Thermal shutdown
- Thermally enhanced 36-pin 6mm × 5mm QFN

Applications

- Server &storage systems
- Datacom and networking
- Point-of-load DC/DC converters
- Embedded computing
- Compact PCs and gaming systems
- Set-top boxes and LCD TVs

GREEN Product

Typical Applications

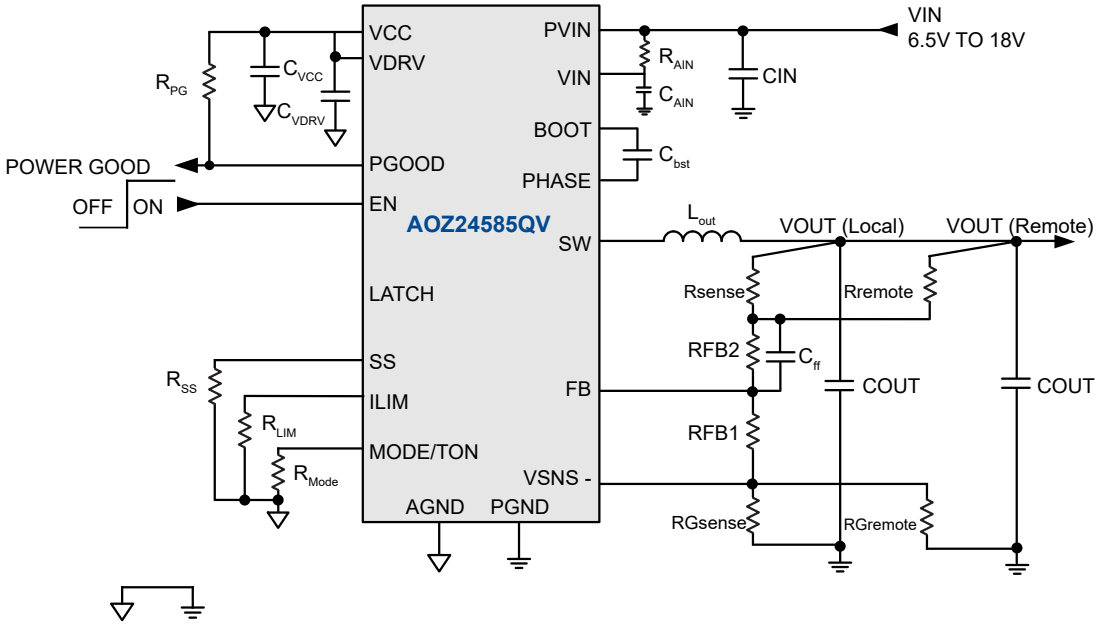


Figure 1. Typical Application Circuit

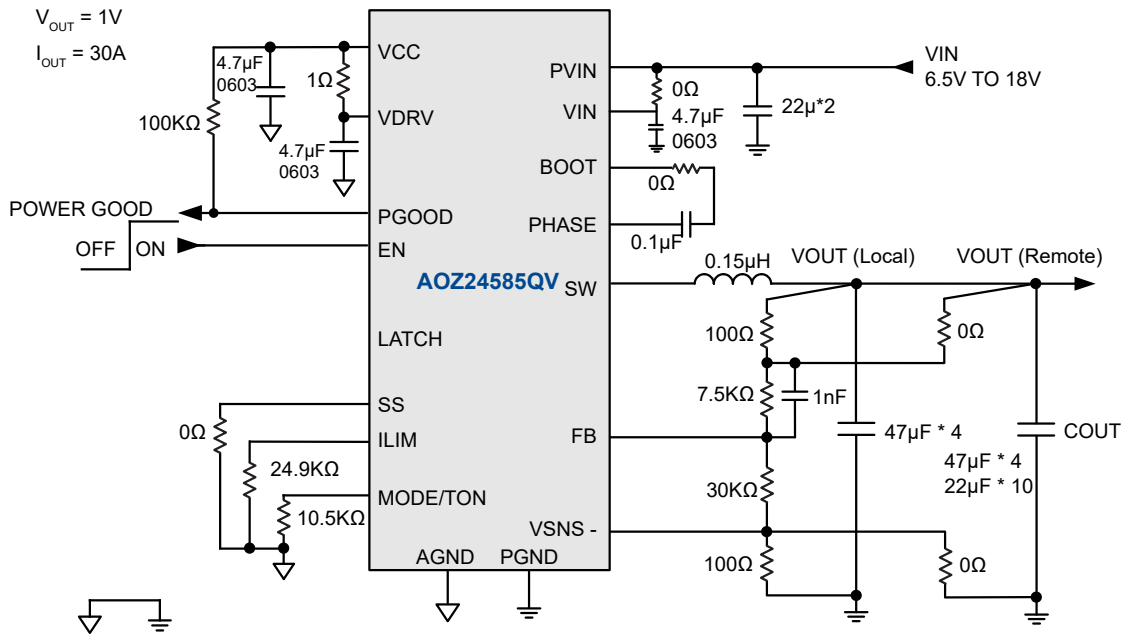


Figure 2. Typical Application Parameter for 1.1V Output

Typical Applications *(Continued)*

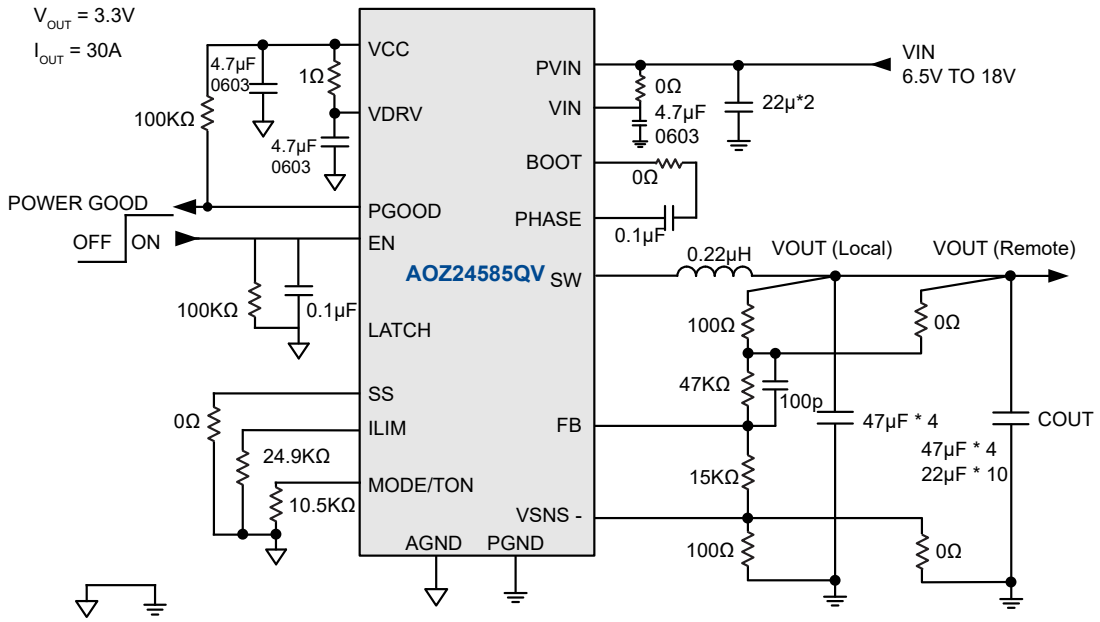


Figure 3. Typical Application Parameter for 3.3V Output

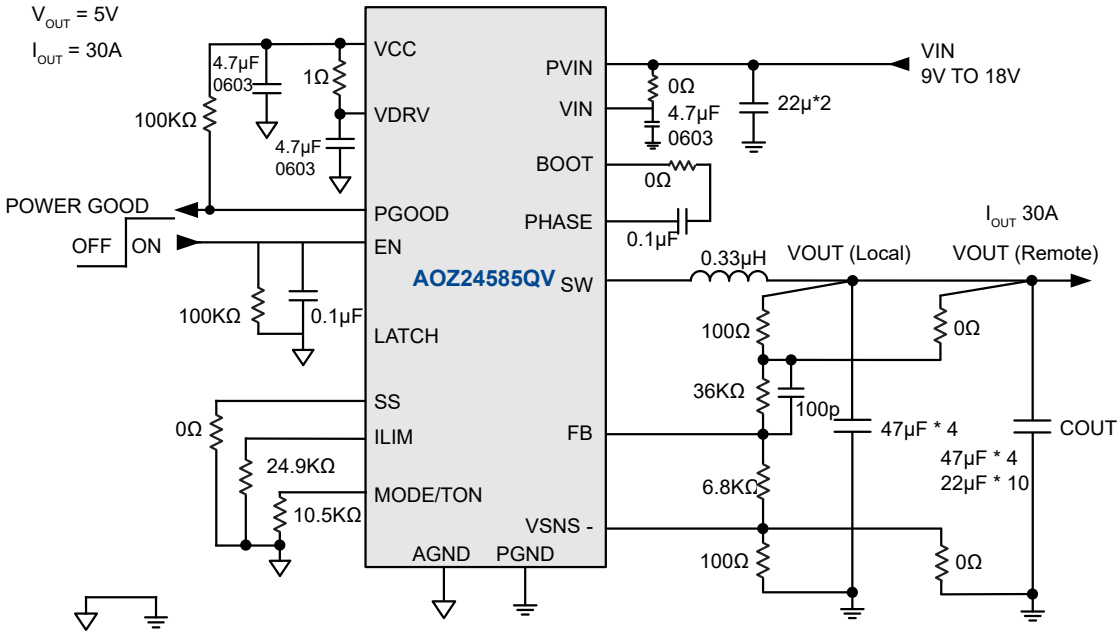


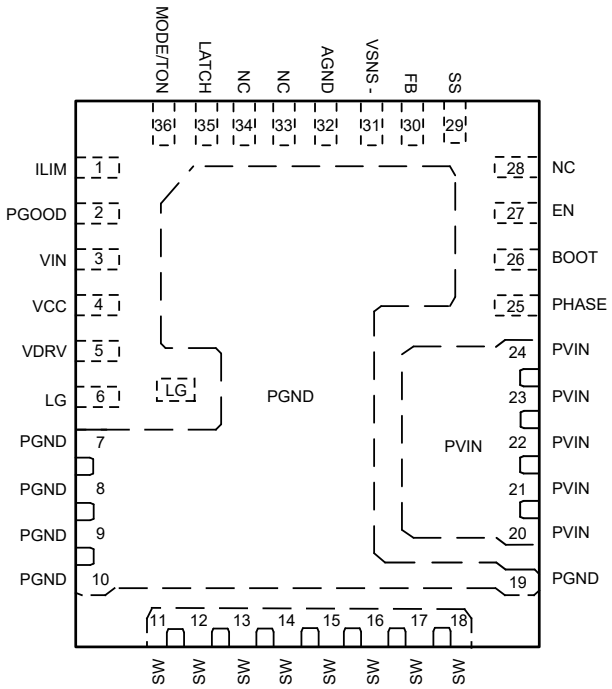
Figure 4. Typical Application Parameter for 5V Output

Ordering Information

Part Number	Ambient Temperature Range	Package	Environmental
AOZ24585QV	-40°C to +125°C	QFN6x5-36L	Green Product

AOS products are offered in packages with Pb-free plating and compliant to RoHS standards.
Please visit https://aosmd.com/sites/default/files/media/AOSGreenPolicy.pdf for additional information.

Pin Configuration



AOZ24585QV
6mmx5mm QFN-36L

Pin Description

Pin Number	Pin Name	Pin Function
1	ILIM	Current limitation level setting pin. Connect a resister between ILIM and GND to set over current protection level.
2	PGOOD	Power Good Signal Output. PGOOD is an open-drain output used to indicate the status of the output voltage. It is internally pulled low when the output voltage is 15% lower than the nominal regulation voltage or 20% higher than the nominal regulation voltage. PGOOD is pulled low during soft start and shut down.
3	VIN	Internal 5V LDO input. Connect VIN pin to IN pins. A RC filter from PVIN to VIN is suggested for better noise immunity as shown on Typical Application.
4	VCC	Supply for analog functions. Bypass VCC to GND with a 4.7μF~10μF ceramic capacitor. Place the capacitor close to VCC pin.
5	VDRV	Internal 5V LDO output and supply for the internal driver. Bypass VDRV to PGND with a 4.7μF~10μF ceramic capacitor. Place the capacitor close to VCC pin.
6	LG	Gate of Low-side MOSFET. Do not have external component connect to it.
7-10,19	PGND	Power Ground. Should be connected to system ground.
11-18	SW	Switch Node. Connect to an output inductor.
20-24	PVIN	Supply Input. PVIN is the regulator input. All PVIN pins must be connected together.
25	PHASE	Source pin of High-side MOSFET. Connect a bootstrap capacitor between this pin and BOOT pin.
26	BOOT	Bootstrap Capacitor Connection. Provide bootstrap voltage for the High-side driver. AOZ24585QV includes an internal bootstrap diode. Connect a bootstrap capacitor between BOOT and PHASE.
27	EN	AOZ24585QV is enabled when EN is pulled high. The device shuts down when EN is pulled low. Assert EN to high for power-up after IN is well supplied. Power-off the device by EN off is suggested.
28	NC	No Connect. Recommend floating.
29	SS	Soft Start Time Setting Pin. Connect a resistor between SS and AGND to choose soft start time.
30	FB	Feedback (Differential remote sense positive Input). Adjust the output voltage with a resistive voltage-divider connected to the regulator's output.
31	VSNS-	Remote sense negative input. Connect this pin to remote negative sense point.
32	AGND	Analog Ground. Ground of controller. Connect to system ground with a few ground vias.
33, 34	NC	No Connect.
35	LATCH	Protection mode selection. Floating for Latch mode. Connect to ground for hiccup mode.
36	MODE/TON	Multi-function pin. Connect a resistor between this pin and AGND to program switching frequency and operation mode.

Absolute Maximum Ratings

Exceeding the Absolute Maximum ratings may damage the device.

Parameter	Rating
PVIN, VIN to AGND	-0.3V to 20V
PVIN to SW and Phase	-0.3(dc)~25V(dc); below -5V for 5ns above 32V for 2ns
SW to AGND	-0.3(dc)~25V(dc); below -5V for 5ns above 32V for 2ns
BST to AGND	-0.3V to 31V
BST to SW	-0.3V to 6V
The other pins	-0.3V to +6V
PGND to AGND	-0.3V to +0.3V
Junction Temperature (T_J)	+150 °C
Storage Temperature (T_S)	-65 °C to +150 °C
ESD Rating (1)	2kV

Note:

1. Devices are inherently ESD sensitive, handling precautions are required. Human body model rating: 1.5kΩ in series with 100pF.

Recommended Operating Conditions

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

Parameter	Rating
Supply Voltage (V_{IN})	6.5V to 18V
Output Voltage Range	0.8V to 6V
Ambient Temperature (T_A)	-40 °C to +125 °C
Package Thermal Resistance (Θ_{JA})	13.05°C/W

Electrical Characteristics

T_A = 25 °C, V_{IN} = 12V, EN = 5V, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
General						
V_{IN}	IN Supply Voltage		6.5		18	V
V_{UVLO}	Under-Voltage Lockout Threshold of V_{CC}	V_{CC} rising V_{CC} falling	3.6	4.4 4.1	4.8	V
I_q	Quiescent Supply Current of V_{IN}	I_{OUT} = 0A, V_{EN} > 2V, no switching		1.6		mA
I_{OFF}	Shutdown Supply Current of V_{in}	V_{EN} = 0V		15		µA
V_{REF}	Reference Voltage	T_A = 25°C T_A = -40°C to 125°C	796 792	800 800	804 808	mV
I_{FB}	FB Input Bias Current	V_{FB} = 0.8V			200	nA
V_{ZCD}	Zero Cross Detect Threshold (ZCD)	V_{in} = 12V, V_{OUT} = 1V, L = 0.15µH, Fsw = 600KHz	-2.1	-0.7	0.6	
$T_{ZCD\_blanking}$	Zero Cross Detect Blanking Time(4)			50		ns
VCC LDO Output						
V_{CC}	Output Voltage	6.5V ≤ V_{IN} ≤ 18V, I_{CC}= 50mA		5.3		V
Enable						
V_{EN}	EN Input Threshold	Off threshold On threshold	1.2		0.5	V
V_{EN_HYS}	EN Input Hysteresis			250		mV

Electrical Characteristics *(Continued)*

T_A = 25°C, V_{IN} = 12V, EN = 5V, unless otherwise specified.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
Vin							
V_{IN}	Vin Input Threshold	Off threshold On threshold		3		2.5	V
V_{IN_HYS}	Vin Input Hysteresis				500		mV
Modulator							
T_{ON}	On Time	V_{OUT} = 1V, V_{IN} = 12V, R_{TON} = floating or 12.1k			104		ns
T_{ON_MIN}	Minimum On Time				40		ns
T_{OFF_MIN}	Minimum Off Time				300	400	ns
Switching Frequency							
F_{SW}	Switching Frequency in FCCM	1% Resister from MODE/TON pin to AGND, VOUT = 1V	7.5k		500		kHz
			0-		600		
			Floating		800		
			2.49k		1000		
	Switching Frequency in PFM		4.99k		500		
			10.5k		600		
			12.1k		800		
			14k		1000		
Soft Start							
T_{SS}	Soft Start Time	1% Resister from SS pin to AGND	0k or 4.53k		1		ms
			1.5k or 5.76k		2		
			12.1k or Floating		4		
			3.48k or 8.87k		8		
Power Good Signal							
V_{PG_LOW}	PGOOD Low Voltage	I_{OL} = 1mA				0.5	V
	PGOOD Leakage Current					±1	µA
V_{PGH}	PGOOD Threshold (Low level to High level)	FB rising			90		%
V_{PGL}	PGOOD Threshold (High Level to Low level)	FB rising FB falling			120 85		%
	PGOOD Threshold Hysteresis				5		%

Electrical Characteristics *(Continued)*

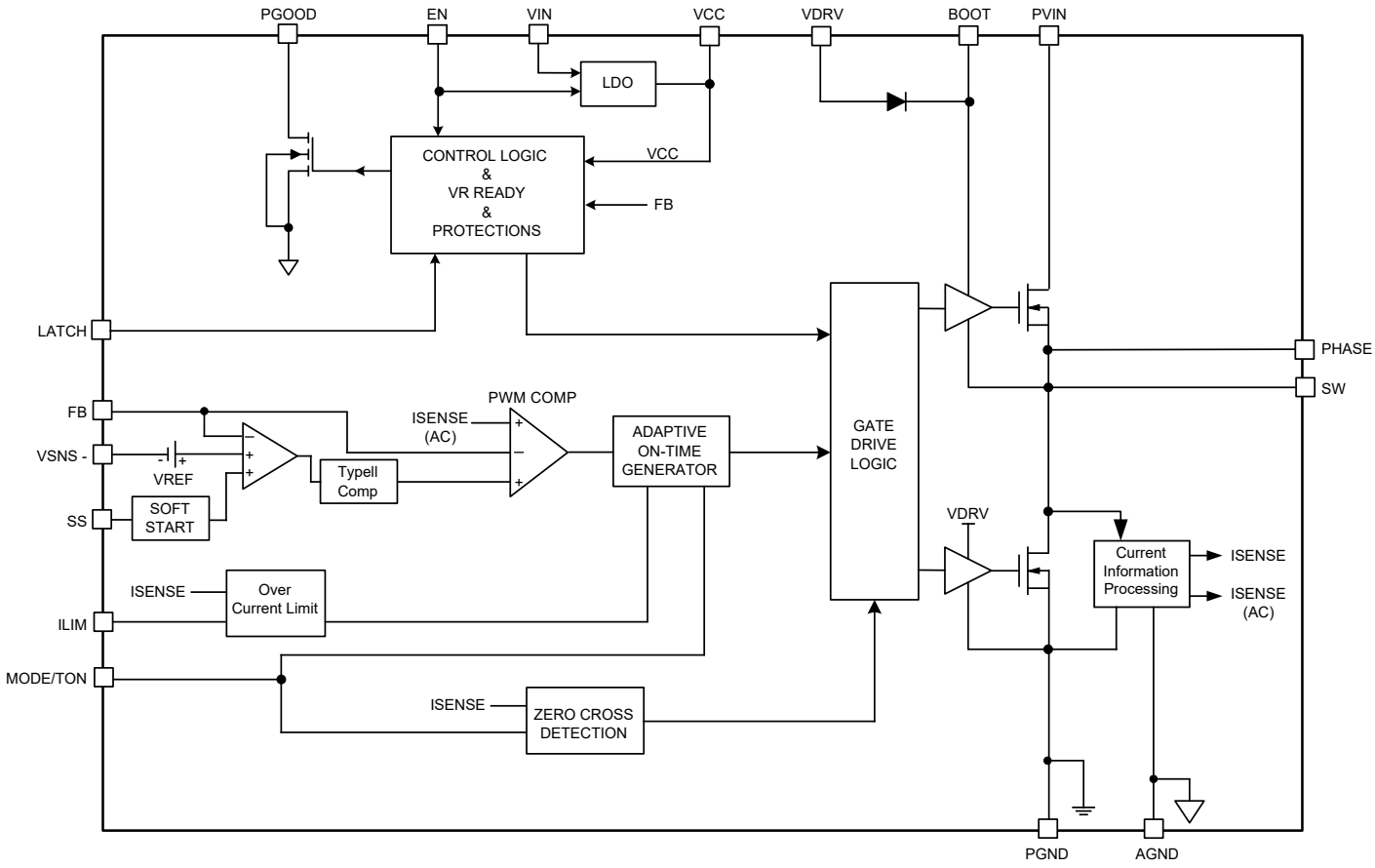
T_A = 25°C, V_{IN} = 12V, EN = 5V, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Under Voltage and Over Voltage Protection						
V_{PL}	Under Voltage Threshold	FB falling		50		%
V_{PH}	Over Voltage Threshold	FB rising		120		%
Over Current Limit						
I_{OC}	Over Current Threshold	T_J = 25°C, R_{LIM} = 12.1kΩ	15.3	19.1	23.0	A
		T_J = 25°C, R_{LIM} = 16.2kΩ	20.5	25.6	30.8	
		T_J = 25°C, R_{LIM} = 21.5kΩ	27.2	34	40.8	
		T_J = 25°C, R_{LIM} = 24.9kΩ	31.2	39.3	47.2	
Power Stage Output						
$R_{DS(ON)}$	High-Side NFET On-Resistance	V_{gs} = 5V		3.6		mΩ
	High-Side NFET Leakage	V_{EN} = 0V, V_{sw} = 0V			10	µA
$R_{DS(ON)}$	Low-Side NFET On-Resistance	V_{gs} = 5V		1		mΩ
	Low-Side NFET Leakage	V_{EN} = 0V			10	µA
Thermal Protection						
	Thermal Shutdown Threshold	T_J rising T_J falling		150 125		°C

Notes:

3. The Ton is trimmed so that the target switching frequency is achieved at around 10A load current using AOZ24585QV demo board.
4. Guaranteed by design, not tested in production.
5. Zero Cross Detect will be triggered when the threshold is higher than the value obtained by multiplying the inductor current and the low-side Rds_on.

Functional Block Diagram



Typical Characteristics

T_A = 25°C, F_{SW} = 600kHz unless otherwise specified.

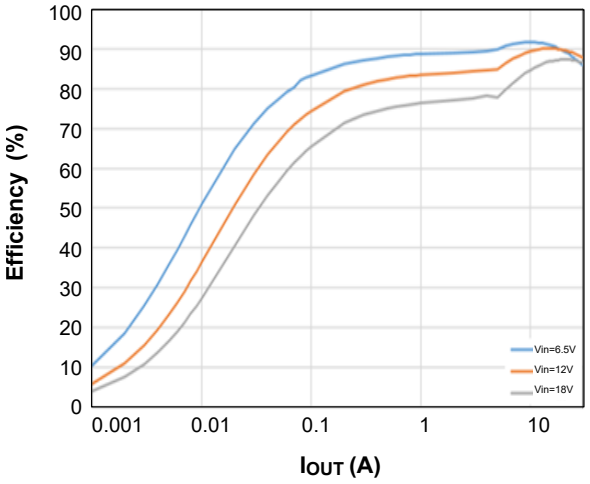


Figure 5. Efficiency when V_{OUT} = 1V

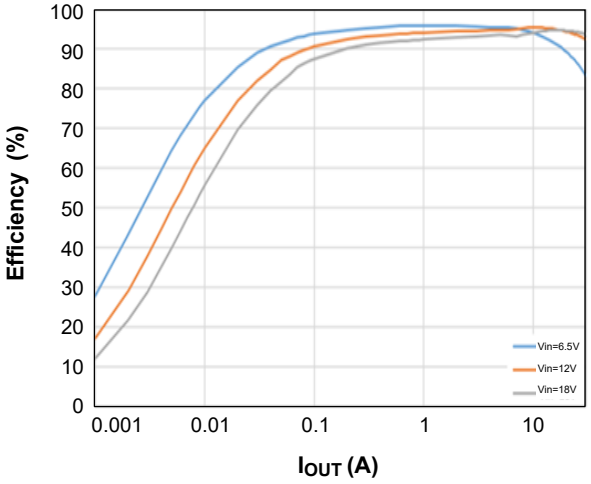


Figure 6. Efficiency when V_{OUT} = 3.3V

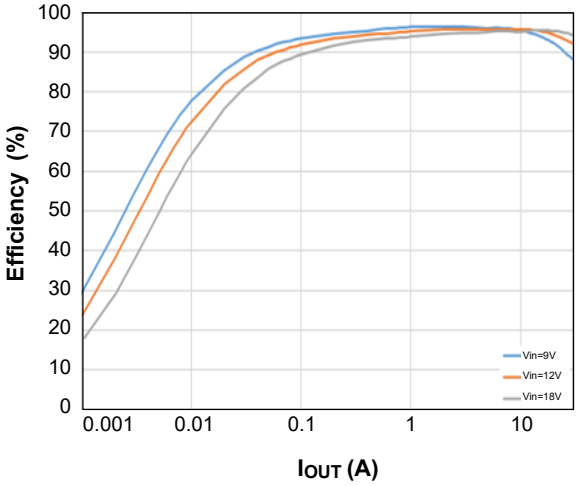
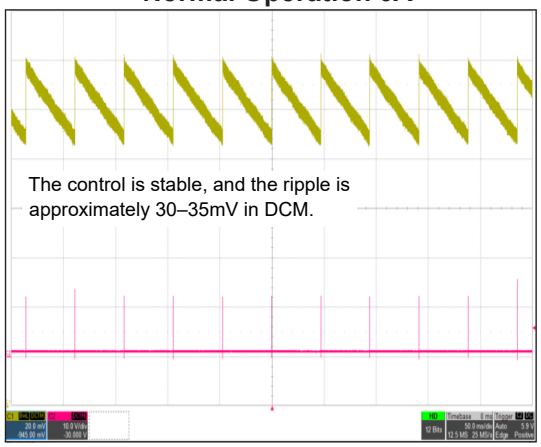


Figure 7. Efficiency when V_{OUT} = 5V

Typical Characteristics

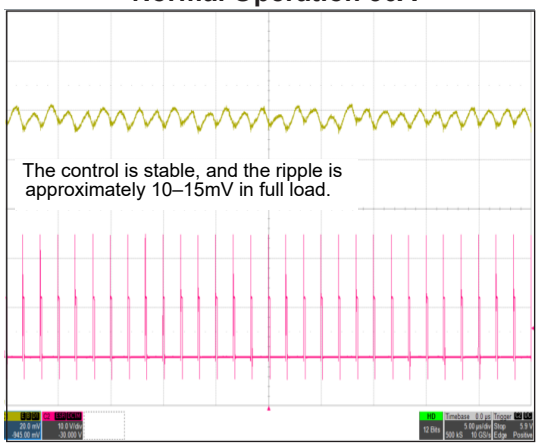
T_A = 25°C, V_{IN} = 12V, V_{OUT} = 1V, F_{SW} = 600kHz unless otherwise specified.

Normal Operation 0A



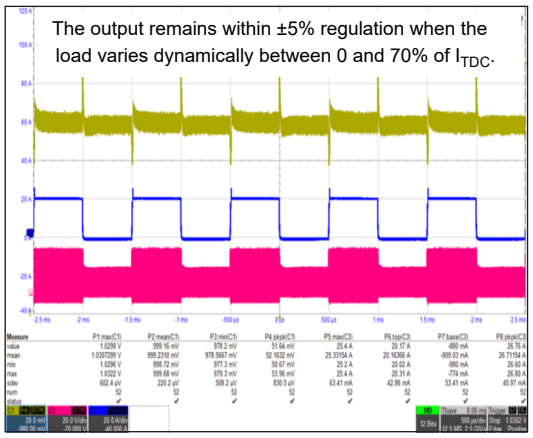
50ms/div

Normal Operation 30A



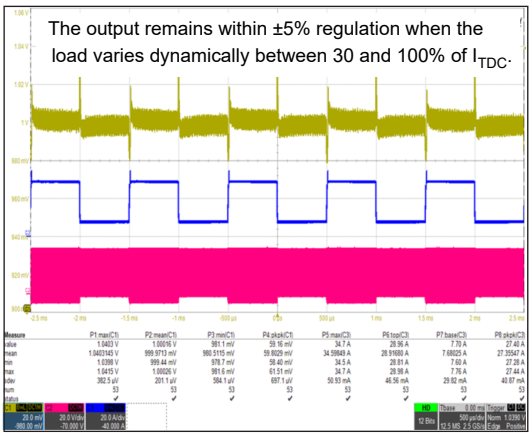
5µs/div

Load Transient 0A to 21A



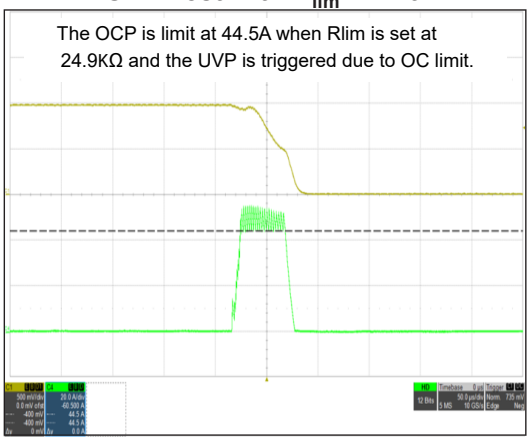
500µs/div

Load Transient 9A to 30A



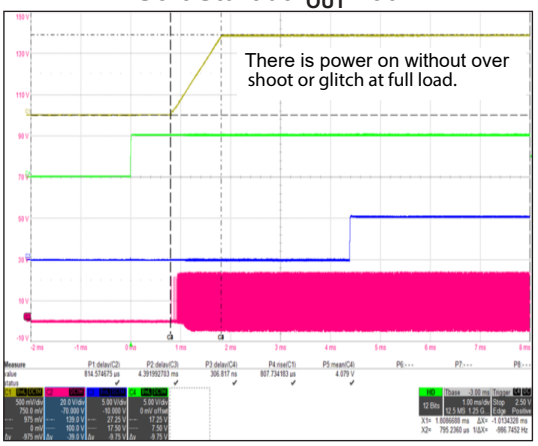
500µs/div

OCP Test with R_{lim} = 24.9K



50µs/div

Soft Start at I_{OUT}= 30A



1ms/div

Detailed Description

The AOZ24585QV is a high-efficiency, easy-to-use, synchronous buck regulator. The regulator is capable of supplying 30A of continuous output current with an output voltage adjustable down to 0.8V. The programmable switch frequency can be set by external resistor with 4 step from 500K to 1MHz, enabling optimization for PCB area and efficiency.

The input voltage of AOZ24585QV can be as low as 6.5V. The highest input voltage of AOZ24585QV can be 18V. Constant on-time PWM with input feed-forward control scheme results in ultra-fast transient response while maintaining relatively constant switching frequency over the entire input range. True AC current mode control scheme guarantees the regulator can be stable with ceramics output capacitor. Protection features include V_{CC} under-voltage lockout, current limit, output over-voltage and under-voltage protection, short-circuit protection, and thermal shutdown.

The AOZ24585QV is available in 36-pin 6mm×5mm QFN package.

Input Power Architecture

The AOZ24585QV integrates an internal linear regulator to generate 5.3V (±5%) V_{CC} from input. If input voltage is lower than 5.3V, the linear regulator operates at low drop-output mode; the V_{CC} voltage is equal to input voltage minus the drop-output voltage of internal linear regulator.

Enable and Soft Start

The AOZ24585QV has external soft start feature to limit in-rush current and ensure the output voltage ramps up smoothly to regulate voltage. A soft start process begins when V_{CC} rises to 4.4V and voltage on EN pin is HIGH. The slew rate of soft start can be decided by an external resistor between GND and SS pin, soft start timing according to the following table:

Table 1. Soft Start Time

Item	Describe	Set	Value		Unit
T_{SS}	Soft Start Time	1% Resister from SS pin to AGND	0k or 4.53k	1	ms
			1.5k or 5.76k	2	
			12.1k or Floating	4	
			3.48k or 8.87k	8	

The FB voltage follows the internal signal when it is lower than V_{ref}. If internal signal is higher than V_{ref}, the FB voltage is regulated by internal precise bandgap voltage (0.8V). The PGOOD signal is delay 2.5ms high after V_{FB} is Vref (0.8V). The soft start time for PGOOD can be calculated by the following formula:

$$T_{ss\_PG} = T_{ss} + T_{PG\_delay} \quad (1)$$

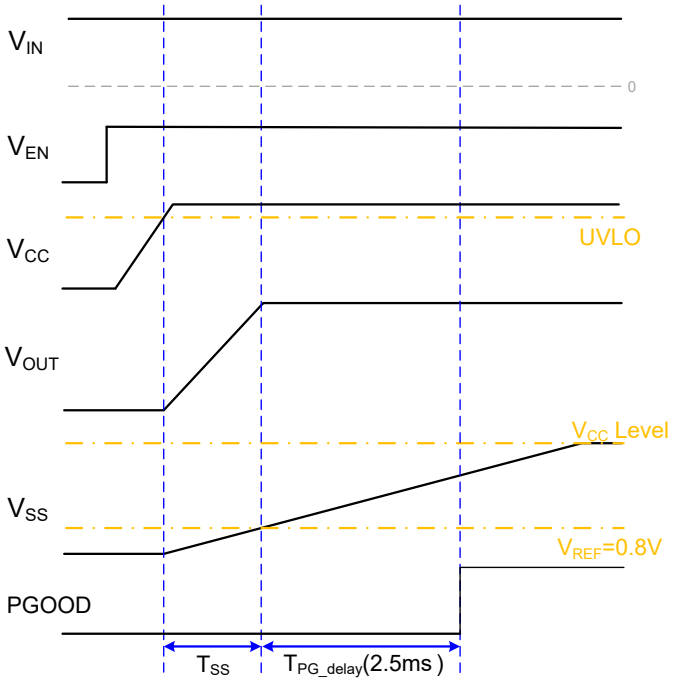


Figure 8. Soft Start Sequence of AOZ24585QV

Constant-On-Time PWM Control with Input Feed-Forward

The control algorithm of AOZ24585QV is constant on-time PWM control with input feed-forward. The simplified control schematic is shown in Figure 9. The high-side switch on-time is determined by Fsw pin strap and it's inversely proportional to input voltage (IN). The one-shot is triggered when the Vref is higher than the combined information of FB voltage, internal error amplifier and the AC current ramp, which is processed and obtained through the sensed lower-side MOSFET current once it turns-on. The added AC current information can help the stability of constant-on time control even with pure ceramic output capacitors, which have very low ESR. The AC current information has no DC offset, which does not cause offset with output load change, which is fundamentally different from other V^2 constant-on time control schemes.

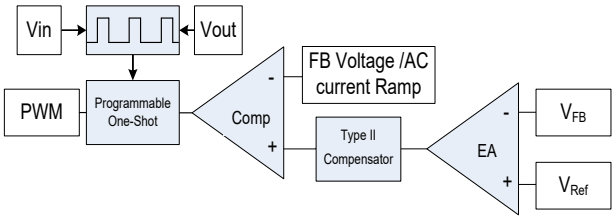


Figure 9. Simplified Control Schematic of AOZ24585QV

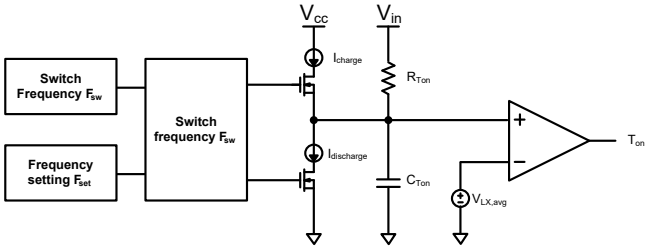


Figure 10. Constant-Frequency Control Schematic

The constant-on-time PWM control architecture is a pseudo-fixed frequency with input voltage feed forward and output voltage. An external resistor between GND and Mode/Ton pin sets the switching F_{sw} according to the following table:

Table 2. Switching Frequency

Describe	Set	Value	Typical	Unit
Switching Frequency in FCCM	1% Resister from MODE/TON pin to AGND, VOUT = 1V	7.5k	500	kHz
		0-	600	
		Floating	800	
		2.49k	1000	
Switching Frequency in PFM		4.99k	500	
		10.5k	600	
		12.1k	800	
		14k	1000	

The internal circuit of AOZ24585QV sets the on time of high-side switch inversely proportional to the IN.

$$T_{ON} \propto \frac{1}{V_{in}(V)} \quad (2)$$

To achieve the flux balance of inductor, the buck converter has the equation:

$$T_{ON} = \frac{V_{out}}{V_{in} * F_{SW}} \quad (3)$$

This algorithm results in a nearly constant switching frequency despite the lack of a fixed-frequency clock generator.

Constant-Frequency Control

The constant-frequency control compares the switching frequency (F_{sw}) with the set frequency (F_{set}). The internal current source charges or discharges C_{ton} if F_{sw} is higher or lower than the threshold of F_{set}. The switching frequency changes due to the variation in Ton.

True Current Mode Control

AOS' COT control scheme uses a patented current injection technique to provide stable performance using all-ceramic output capacitors. The constant-on-time control scheme is intrinsically unstable if output capacitor's ESR is not large enough as an effective current-sense resistor. Ceramic capacitors usually cannot be used as output capacitor.

The AOZ24585QV senses the low-side MOSFET current and processes it into DC current and AC current information using AOS proprietary technique. The AC current information is decoded and added on the FB pin on phase. With AC current information, the stability of constant-on-time control is significantly improved even without the help of output capacitor's ESR; and thus the pure ceramic capacitor solution can be applicant. The pure ceramic capacitor solution can significantly reduce the output ripple (no ESR caused overshoot and undershoot) and less board area design.

Current-Limit Protection

The AOZ24585QV features current-limit protection by using the Rds_on of the low-side MOSFET as a current-sensing element. To accurately detect current, a minimum constant off-time (typically 300ns) is implemented following each constant on-time. If the current exceeds the current-limit threshold, the PWM controller is prevented from initiating a new cycle. The actual peak current surpasses the current-limit threshold by an amount equal to the inductor ripple current. Consequently, the exact current-limit characteristics and maximum load capability depend on the inductor value as well as the input and output voltages. The current limit keeps the low-side MOSFET on and prevents another high-side on-time until the current in the low side MOSFET falls below the current-limit threshold.

The AOZ24585QV enters hiccup mode, periodically restarting the part. When the current limit protection is removed, the AOZ24585QV exits hiccup mode.

Current-Limit Setting

The current limit threshold mentioned in the last paragraph can be set by connecting an external resistor between GND and the ILIM pin. This sets the current limit according to the following table:

Table 3. Current Limit

Describe	Set	Value	Min	Typ	Max	Unit
Current Limit Threshold	1% Resister from I_{Lim} pin to AGND	12.1k	15.3	19.1	23.0	A
		16.2k	20.5	25.6	30.8	
		21.5k	27.2	34	40.8	
		24.9k	31.2	39.3	47.2	

As shown in Figure 11, when the magnitude of the switch node voltage V_{LX} exceeds V_{ILIM}, the OCL signal is triggered. The behavior in an over current condition is described in the section Current-Limit Protection.

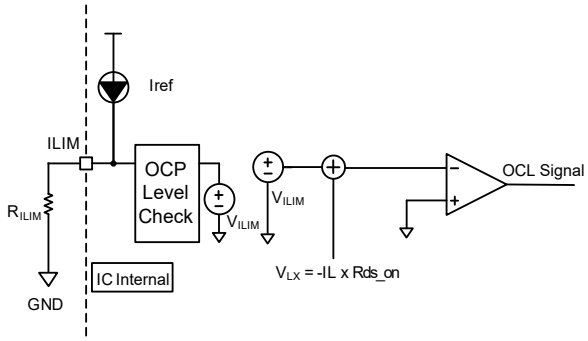


Figure 11. Illustration of Current-Limit Setting

Output Voltage Under-voltage Protection

The under-voltage protection (UVP) is activated after the soft start process. If the voltage at the feedback pin is lower than V_{REF} due to over current or a short circuit, the AOZ24585QV will turn off both the high-side and low-side MOSFETs and shut down. It can be restarted by cycling the EN signal.

Output Voltage Over-voltage Protection

The over-voltage protection (OVP) threshold is set 20% higher than V_{REF}. When the voltage at feedback pin is exceeds the OVP threshold, the high-side MOSFET is turned off, and the low-side MOSFET is turned on for 1 µs before the device shuts down. It can also be restarted by cycling the EN signal.

Power Good Output

The power good (PGOOD) output is an open-drain output and requires a pull-up resistor. If V_{SS} is higher than V_{REF}, the PG signal will go high after 2ms. When the voltage at the feedback pin is 15% below V_{REF}, PGOOD is pulled low. Similarly, when the feedback voltage is 20% above V_{REF}, PGOOD is also pulled low.

When combined with the under-voltage protection circuit, this current-limit method is effective in nearly all circumstances.

Application Information

The basic AOZ24585QV application circuit is shown on page 2. Component selection is explained below.

Input Capacitor

The input capacitor must be connected to the IN pins and PGND pin of the AOZ24585QV to maintain steady input voltage and filter out the pulsing input current. A small decoupling capacitor, usually 4.7µF, should be connected to the V_{CC} pin and AGND pin for stable operation of the AOZ24585QV. 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:

$$\Delta V_{IN} = \frac{I_{OUT}}{f \times C_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \frac{V_{OUT}}{V_{IN}} \quad (4)$$

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:

$$I_{CIN\_RMS} = I_{OUT} \times \sqrt{\frac{V_{OUT}}{V_{IN}}\left(1 - \frac{V_{OUT}}{V_{IN}}\right)} \quad (5)$$

if let m equal the conversion ratio:

$$\frac{V_{OUT}}{V_{IN}} = m \quad (6)$$

The relation between the input capacitor RMS current and voltage conversion ratio is calculated and shown in Figure 12. It can be seen that when V_{OUT} is half of V_{IN}, C_{IN} is under the worst current stress. The worst current stress on C_{IN} is $0.5 \cdot I_{OUT}$.

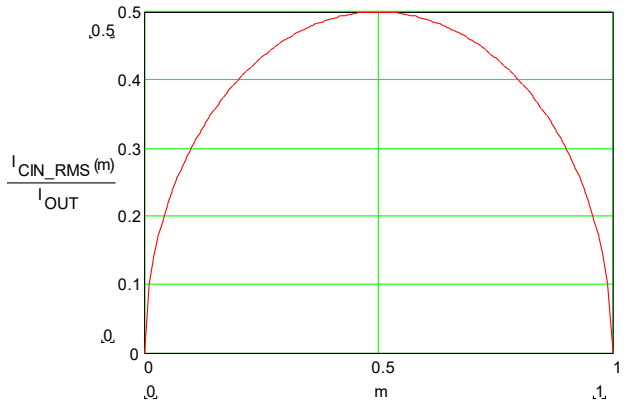


Figure 12. I_{CIN} vs. Voltage Conversion Ratio

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 ripple current rating. Depending on the application circuits, other low ESR tantalum capacitor or aluminum electrolytic capacitor may also be used. When selecting ceramic capacitors, X5R or X7R type dielectric ceramic capacitors are preferred for their better temperature and voltage characteristics. Note that the ripple current rating from capacitor manufactures is based on certain amount of life time. Further de-rating may be necessary for practical design requirement.

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,

$$\Delta I_L = \frac{V_{OUT}}{f \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \quad (7)$$

The peak inductor current is:

$$I_{Lpeak} = I_{OUT} + \frac{\Delta I_L}{2} \quad (8)$$

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 30% to 50% 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 needs 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:

$$\Delta V_{OUT} = \Delta I_L \times \left(ESR_{C_o} + \frac{1}{8 \times f \times C_o}\right) \quad (9)$$

where C_O is output capacitor value and ESR_{CO} is the Equivalent Series Resistor of 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 further simplified to:

$$\Delta V_{OUT} = \Delta I_L \times \frac{1}{8 \times f \times C_o} \quad (10)$$

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:

$$\Delta V_{OUT} = \Delta I_L \times ESR_{C_o} \quad (11)$$

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:

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

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.

Thermal Management and Layout Consideration

In the AOZ24585QV buck regulator circuit, high pulsing current flows through two circuit loops. The first loop starts from the input capacitors, to the VIN pin, to the LX pins, to the filter inductor, to the output capacitor and load, and then return to the input capacitor through ground. Current flows in the first loop when the high side switch is on. The second loop starts from inductor, to the output capacitors and load, to the low side switch. Current flows in the second loop when the low side switch is on.

In PCB layout, minimizing the two loops area reduces the noise of this circuit and improves efficiency. A ground plane is strongly recommended to connect input capacitor, output capacitor, and PGND pin of the AOZ24585QV.

In the AOZ24585QV buck regulator circuit, the major power dissipating components are the AOZ24585QV and the output inductor. The total power dissipation of converter circuit can be measured by input power minus output power.

$$P_{total\_loss} = V_{IN} \times I_{IN} - V_{OUT} \times I_{OUT} \quad (13)$$

The power dissipation of inductor can be approximately calculated by DCR of inductor and output current.

$$P_{inductor\_loss} = I_{OUT}^2 \times R_{inductor} \times 1.1 \quad (14)$$

The actual junction temperature can be calculated with power dissipation in the AOZ24585QV and thermal impedance from junction to ambient.

$$T_{junction} = (P_{total\_loss} - P_{total\_loss}) \times \theta_{JA} + T_A \quad (15)$$

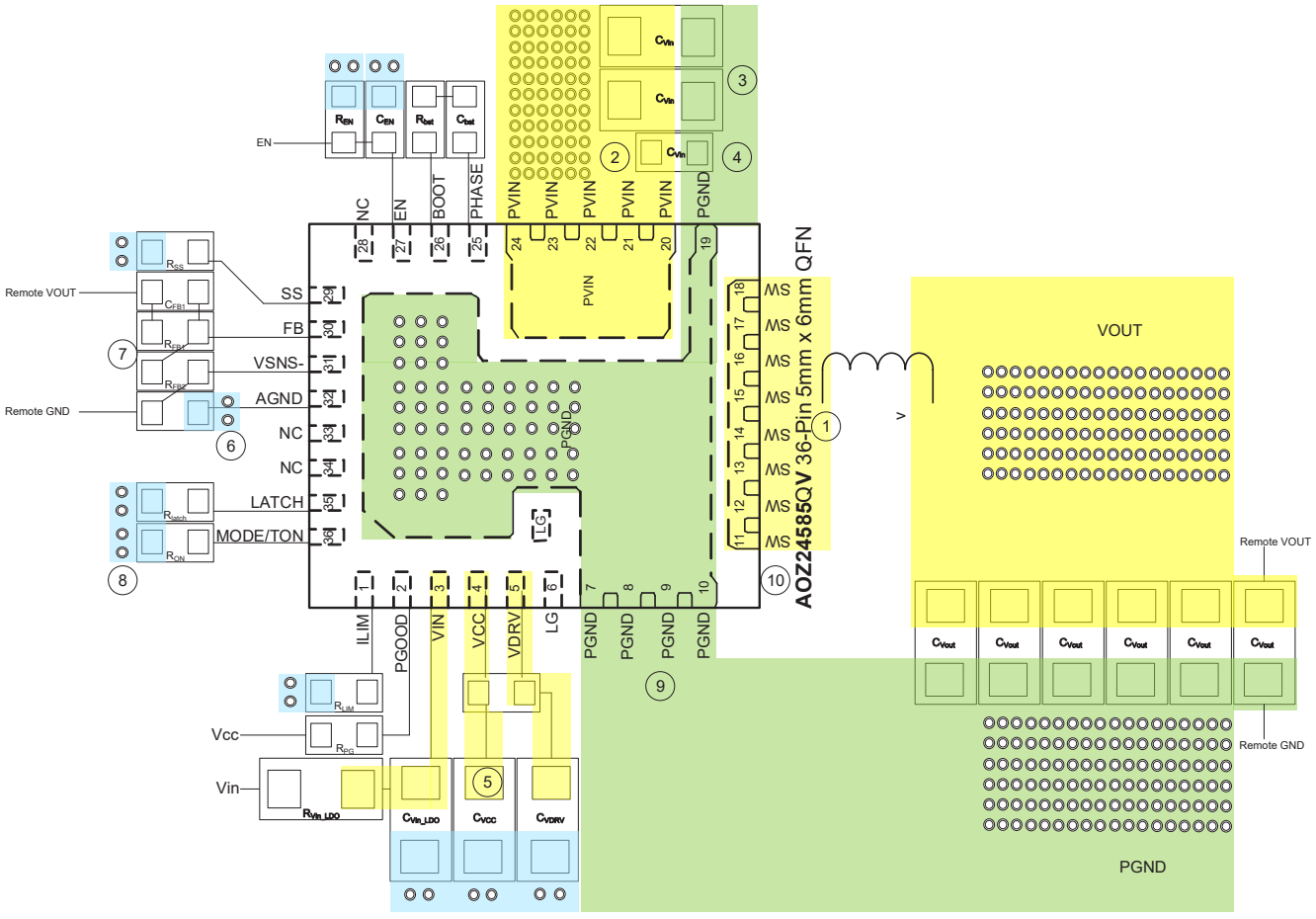
The maximum junction temperature of AOZ24585QV is 150ºC, which limits the maximum load current capability.

The thermal performance of the AOZ24585QV is strongly affected by the PCB layout. Extra care should be taken by users during design process to ensure that the IC will operate under the recommended environmental conditions.

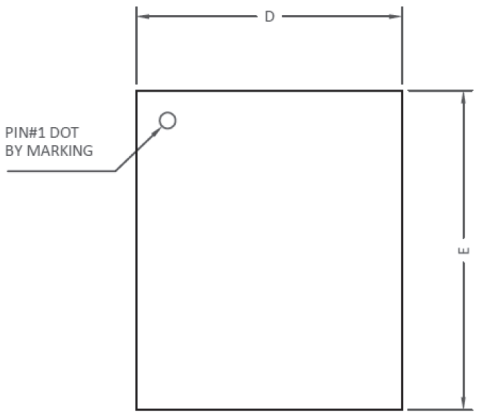
Layout Considerations

Several layout tips are listed below for the best electric and thermal performance.

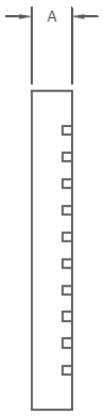
1. The LX pins and pad are connected to internal low side switch drain. They are low resistance thermal conduction path and most noisy switching node. Connect a copper plane to the LX pin to help thermal dissipation. The inductor needs to be placed as close to LX pin as possible.
2. The IN pins and pad are connected to internal high side switch drain. They are also low resistance thermal conduction path. Connected a large copper plane to IN pins to help thermal dissipation.
3. Connect a large PGND copper plane to PGND pin. Thick and short PGND trace could keep power path impedance low.
4. Input decoupling capacitors should be connected to the IN pin and the PGND pin as close as possible to reduce the switching spikes.
5. Decoupling capacitor C_{VCC} should be connected to V_{CC} and GND as close as possible. Connect this GND to GND layer with vias as shown in below figure. Place C_{VCC} on the same layer with IC.
6. Connect AGND to GND layer with vias right close to AGND pin as shown in below figure.
7. Voltage divider R1 and R2 should be placed as close as possible to FB and RGND. Place R1 and R2 on the same layer with IC.
8. RTON should be connected as close as possible to Pin 36 (TON pin). Place RTON on the same layer with IC.
9. A ground plane is preferred; Pin 7-10 (PGND) must be connected to the ground plane through via as shown in the figure below.
10. Sensitive signal traces such as feedback trace must be shielded from all noise sources, especially the LX node.
11. The feedback trace should be taken directly from output capacitor pad and use thin trace. FB trace goes through other layer and shielded by GND layer is acceptable.
12. No signal should run on nearby layer under the LX trace or under the inductor.
13. Pour copper plane on all unused board area and connect it to stable DC nodes, like VIN, GND or VOUT.
14. Insert at least two inner layers (or planes) connected to the power ground, in order to shield and isolate the small signal traces from noisy power lines.



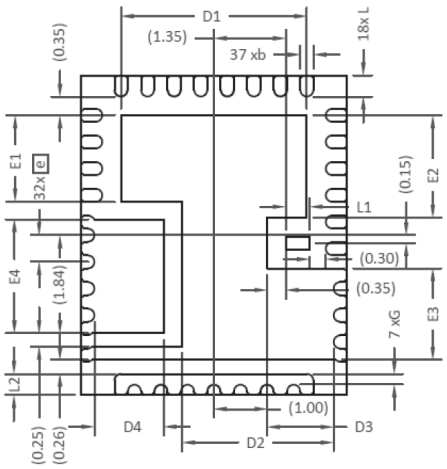
Package Dimensions, QFN6x5-36L



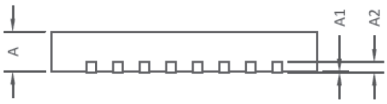
TOP VIEW



SIDE VIEW

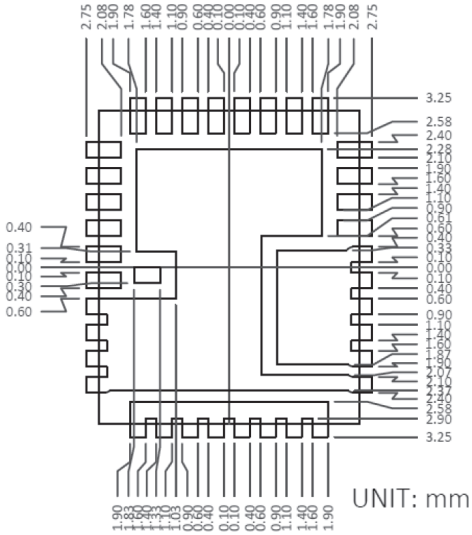


BOTTOM VIEW



SIDE VIEW

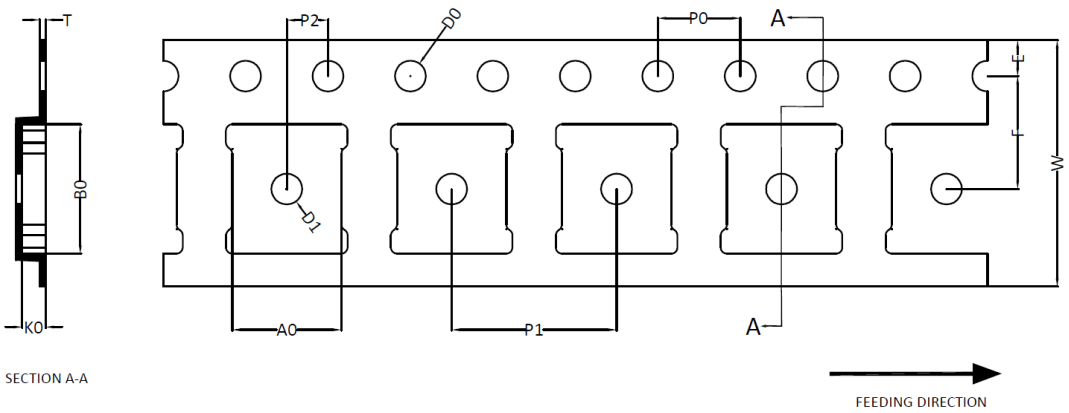
RECOMMENDED LAND PATTERN



SYMBOLS	DIMENSION IN MM			DIMENSION IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.70	0.75	0.80	0.028	0.030	0.031
A1	0.00	-	0.05	0.000	-	0.002
A2		0.20REF			0.008REF	
b	0.20	0.25	0.30	0.008	0.010	0.012
D	4.90	5.00	5.10	0.193	0.197	0.201
D1	3.40	3.50	3.60	0.134	0.138	0.142
D2	2.75	2.85	2.95	0.108	0.112	0.116
D3	1.15	1.25	1.35	0.045	0.049	0.053
D4	1.20	1.30	1.40	0.047	0.051	0.055
E	5.90	6.00	6.10	0.232	0.236	0.240
E1	1.52	1.62	1.72	0.060	0.064	0.068
E2	1.82	1.92	2.02	0.072	0.076	0.080
E3	1.62	1.72	1.82	0.064	0.068	0.072
E4	2.04	2.14	2.24	0.080	0.084	0.088
e		0.50BSC			0.02BSC	
G	0.15	0.20	0.25	0.006	0.008	0.010
L	0.30	0.40	0.50	0.012	0.016	0.020
L1	0.35	0.45	0.55	0.014	0.018	0.022
L2	0.30	0.40	0.50	0.012	0.016	0.020

NOTE:
CONTROLLING DIMENSION IS MILLIMETER.
CONVERTED INCH DIMENSIONS ARE NOT NECESSARILY EXACT.

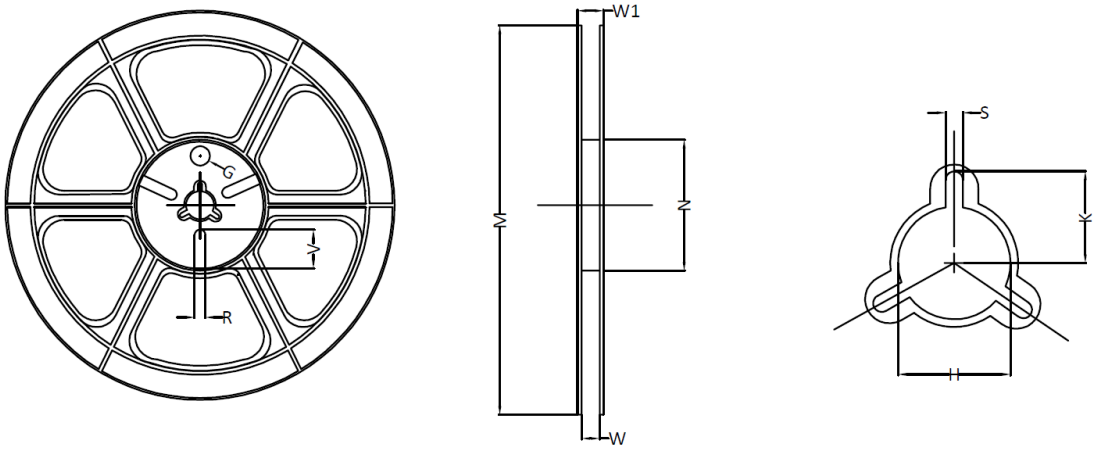
Tape and Reel Dimensions, QFN6x5-36L



UNIT: MM

PACKAGE	A0	B0	K0	D0	D1	W	E	F	P0	P1	P2	T
QFN6x5	5.30 ±0.10	6.30 ±0.10	1.15 ±0.10	Ø1.50 +0.10 -0.00	Ø1.50 +0.20 -0.00	12.00 +0.30 -0.10	1.75 ±0.10	5.50 ±0.05	4.00 ±0.10	8.00 ±0.10	2.00 ±0.05	0.30 ±0.03

QFN6x5_36L_EP2_S Reel



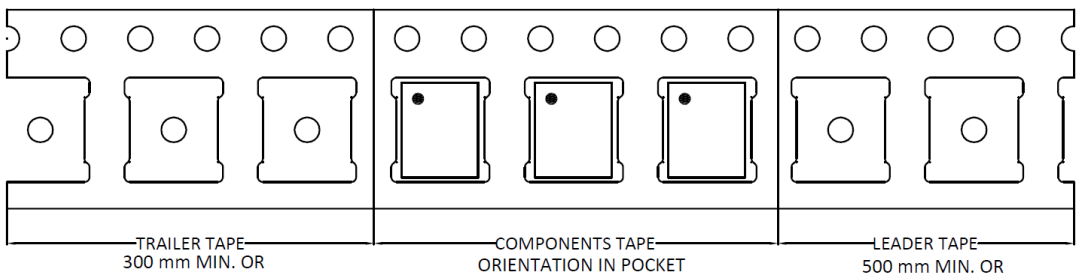
UNIT: MM

TAPE SIZE	REEL SIZE	M	N	W	W1	H	K	S	G	R	V
12 mm	Ø330	Ø330 ±0.50	Ø97.00 ±0.10	13.0 ±0.30	17.40 ±1.00	Ø13.0 +0.5 -0.2	10.6	2.00 ±0.50	---	---	---

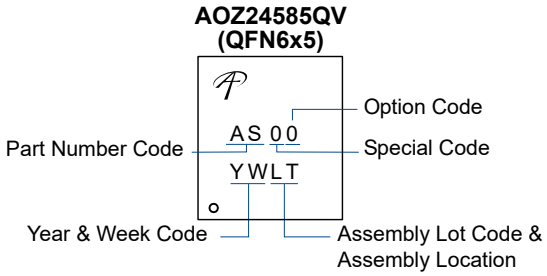
QFN6x5_36L_EP2_S Tape

Leader / Trailer & Orientation

Unit Per Reel: 3000pcs



Part Marking



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