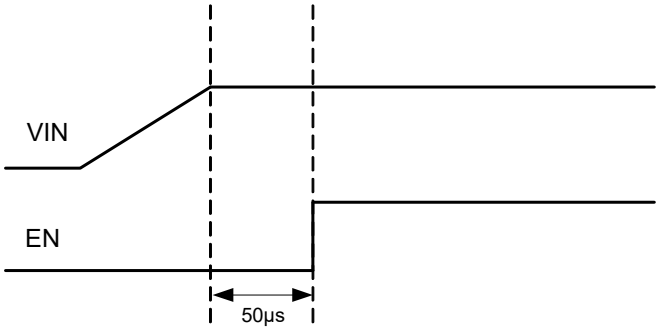
Option Table

Part Number	PFM / Force PWM for Light Load Operation	
	PFM	Force PWM
AOZ2150EQI-30	V	
AOZ2150EQI-31		V

Recommended Start-up Sequence

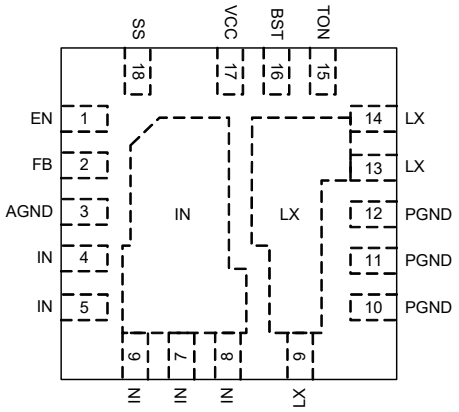


Ordering Information

Part Number	Ambient Temperature Range	Package	Environmental
AOZ2150EQI-30	-40°C to +85°C	18-Pin 3mm x 3mm QFN	Green Product

AOS Green Products use reduced levels of Halogens, and are also RoHS compliant.
Please visit www.aosmd.com/media/AOSGreenPolicy.pdf for additional information.

Pin Configuration



18-Pin 3mm x 3mm QFN
(Top View)

Pin Description

Pin Number	Pin Name	Pin Function
1	EN	Enable Input. The AOZ2150EQI-30 is enabled when EN is pulled high. The device shuts down when EN is pulled low.
2	FB	Feedback Input. Adjust the output voltage with a resistive voltage-divider between the regulator's output and AGND.
3	AGND	Analog Ground.
4, 5, 6, 7, 8	IN	Supply Input. IN is the regulator input. All IN pins must be connected together.
9, 13, 14	LX	Switching Node.
10, 11, 12	PGND	Power Ground.
15	TON	On-Time Setting Input. Connect a resistor between VIN and TON to set the on time.
16	BST	Bootstrap Capacitor Connection. The AOZ2150EQI-30 includes an internal bootstrap diode. Connect an external capacitor between BST and LX as shown in the Typical Application diagram.
17	VCC	Supply Input for analog functions. Bypass VCC to AGND with a 4.7µF~10µF ceramic capacitor. Place the capacitor close to VCC pin.
18	SS	Soft-Start Time Setting Pin. Connect a capacitor between SS and AGND to set the soft-start time.

Absolute Maximum Ratings

Exceeding the Absolute Maximum Ratings may damage the device.

Parameter	Rating
IN, TON to AGND	-0.3V to 30V
LX to AGND(1)	-0.3V to 30V
BST to AGND	-0.3V to 36V
SS, FB, EN, VCC to AGND	-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(2)	2kV

Notes:

1. LX to PGND Transient (t<20ns) ------- -7V to V_{IN}+7V.
2. Devices are inherently ESD sensitive, handling precautions are required. Human body model rating: 1.5kΩ in series with 100pF.

Maximum Operating Ratings

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

Parameter	Rating
Supply Voltage (V_{IN})	6.5V to 28V
Output Voltage Range	0.8V to 0.85*V_{IN}
Ambient Temperature (T_A)	-40°C to +85°C
Package Thermal Resistance (θ_{JA}) (θ_{JC})	 40°C/W 6°C/W

Electrical Characteristics

T_A = 25°C, V_{IN}=12V, EN = 5V, unless otherwise specified. Specifications in **BOLD** indicate a temperature range of -40°C to +85°C.

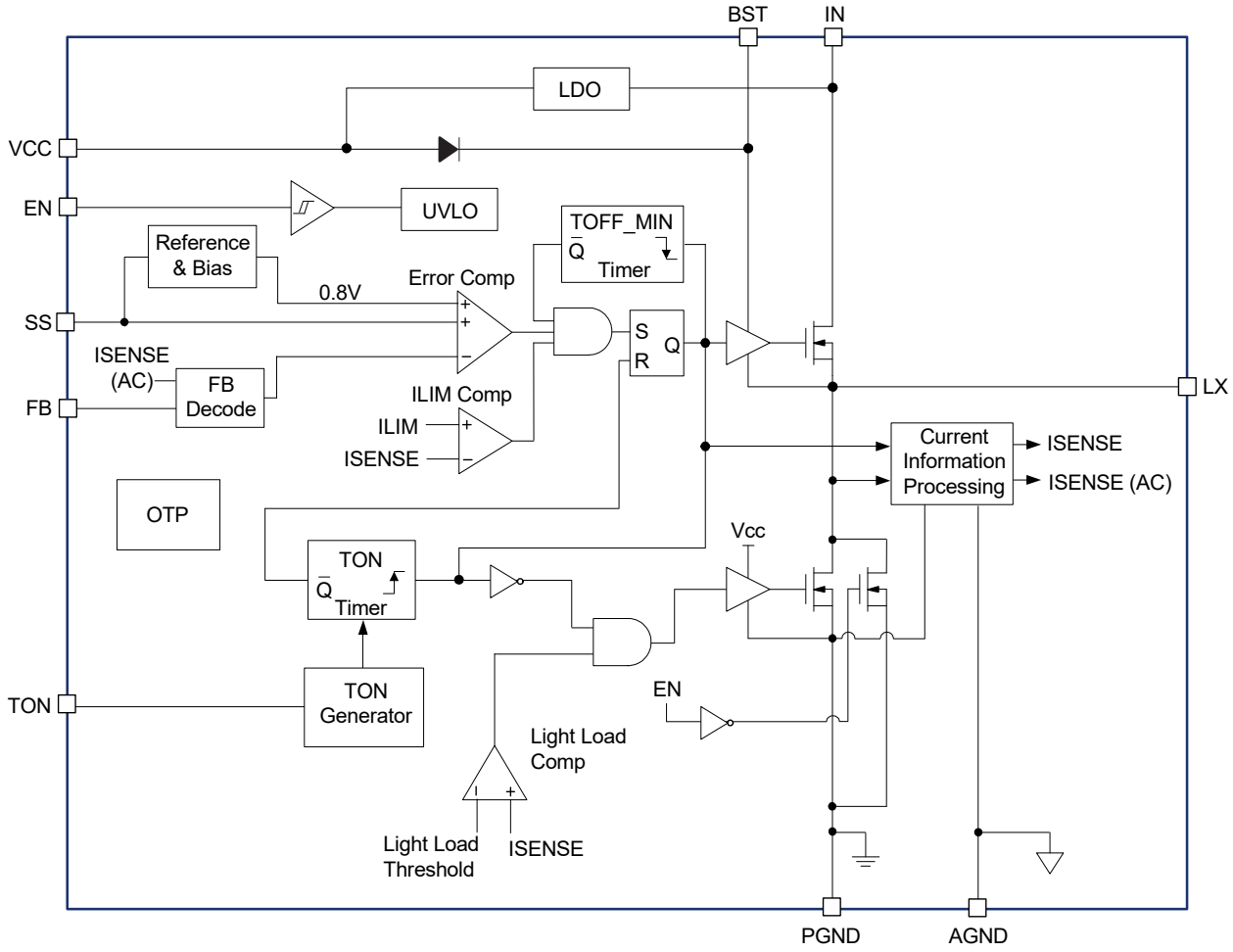
Symbol	Parameter	Conditions	Min.	Typ.	Max	Units
V_{IN}	IN Supply Voltage		**6.5**		**28**	V
V_{UVLO}	Under-Voltage Lockout Threshold	V_{CC} rising V_{CC} falling	 **3.2**	**4.0** **3.7**	**4.4**	V
I_q	Quiescent Supply Current of V_{CC}	I_{OUT} = 0, V_{EN} > 2V, PFM		**0.16**		mA
I_{OFF}	Shutdown Supply Current	V_{EN} = 0V		**15**		µA
V_{FB}	Feedback Voltage	T_A = 25°C T_A = 0°C to 85°C	0.792 0.788	0.800 0.800	0.808 0.812	V
	Load Regulation			0.5		%
	Line Regulation			1		%
I_{FB}	FB Input Bias Current				200	nA
Enable						
V_{EN}	EN Input Threshold	Off threshold On threshold	 1.6		0.5	V
V_{EN_HYS}	EN Input Hysteresis			300		mV
Modulator						
T_{ON_MIN}	Minimum On Time			60		ns
T_{ON_MAX}	Maximum On Time			2.6		µs
T_{OFF_MIN}	Minimum Off Time			300		ns
Soft-Start						
I_{SS_OUT}	SS Source Current	V_{SS} = 0 C_{SS} = 0.001µF to 0.1µF	7	11	15	µA
Under Voltage and Over Voltage Protection						
V_{PL}	Under Voltage Threshold	FB falling		70		%
T_{PL}	Under Voltage Delay Time			32		µs
V_{PH}	Over Voltage Threshold	FB rising		120		%

Electrical Characteristics

T_A = 25°C, V_{IN}=12V, EN = 5V, unless otherwise specified. Specifications in **BOLD** indicate a temperature range of -40°C to +85°C.

Symbol	Parameter	Conditions	Min.	Typ.	Max	Units
Power Stage Output						
$R_{DS(ON)}$	High-Side NFET On-Resistance	V_{IN} = 12V		50		mΩ
	High-Side NFET Leakage	V_{EN} = 0V, V_{LX} = 0V			10	µA
$R_{DS(ON)}$	Low-Side NFET On-Resistance	V_{LX} = 12V		50		mΩ
	Low-Side NFET Leakage	V_{EN} = 0V			10	µA
Over-current and Thermal Protection						
I_{LIM}	Current Limit		4.5			A
	Thermal Shutdown Threshold	T_J rising T_J falling		150 100		°C

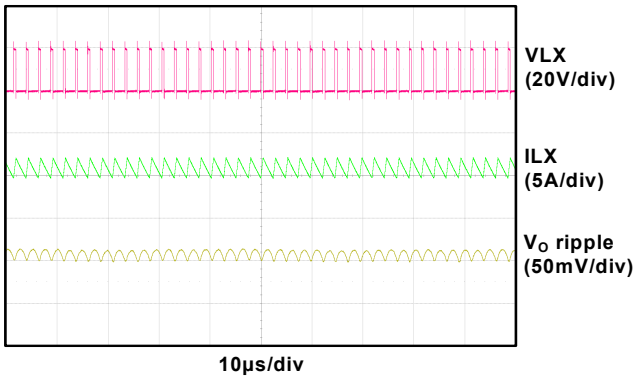
Functional Block Diagram



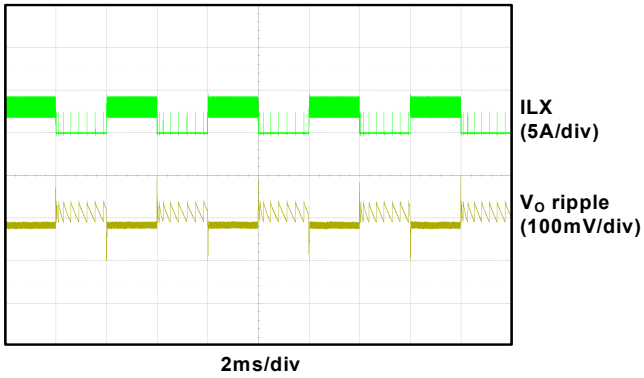
Typical Performance Characteristics

Circuit of Typical Application. T_A = 25°C, V_{IN} = 19V, V_{OUT} = 3.3V, unless otherwise specified.

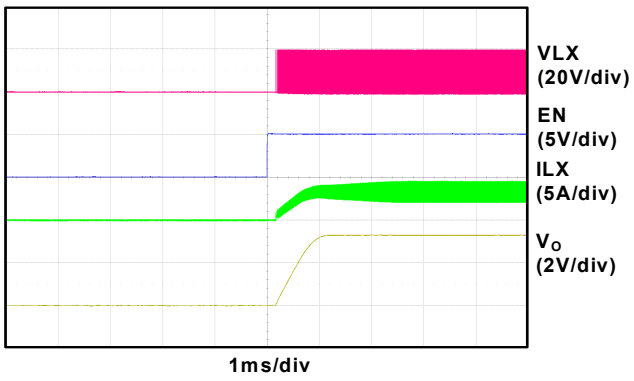
Normal Operation



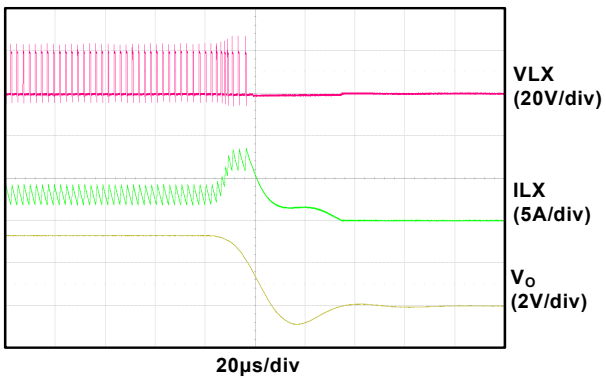
Load Transient 0A to 3A



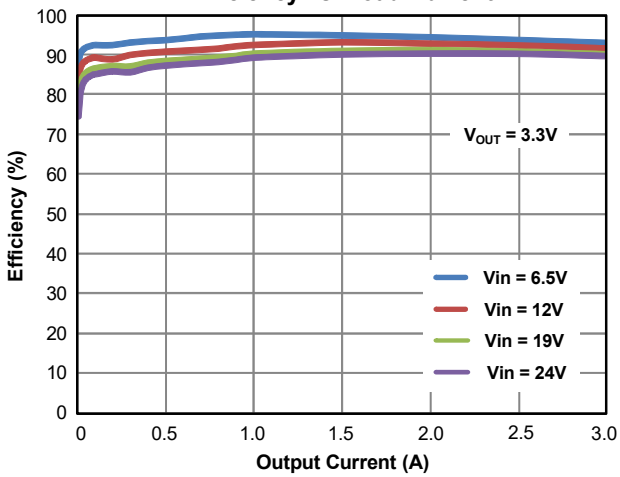
Full Load Start-up



Short Circuit Protection



Efficiency vs. Load Current



Detailed Description

The AOZ2150EQI-30 is a high-efficiency, easy-to-use, synchronous buck regulator optimized for notebook computers. The regulator is capable of supplying 3A of continuous output current with an output voltage adjustable down to 0.8V.

The input voltage of AOZ2150EQI-30 can be as low as 6.5V. The highest input voltage of AOZ2150EQI-30 can be 28V. 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, cycle-by-cycle current limit, output over voltage and under voltage protection, short-circuit protection, and thermal shutdown.

The AOZ2150EQI-30 is available in 18-pin 3mm×3mm QFN package.

Input Power Architecture

The AOZ2150EQI-30 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 AOZ2150EQI-30 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 4.5V and voltage on EN pin is HIGH. An internal current source charges the external soft-start capacitor; the FB voltage follows the voltage of soft-start pin (V_{SS}) when it is lower than 0.8V. When V_{SS} is higher than 0.8V, the FB voltage is regulated by internal precise band-gap voltage (0.8V). The soft-start time for FB voltage can be calculated by the following formula:

$T_{SS}(\mu s) = 80 \times C_{SS}(nF)$

If C_{SS} is 1nF, the soft-start time will be 80µ seconds; if C_{SS} is 10nF, the soft-start time will be 800µ seconds.

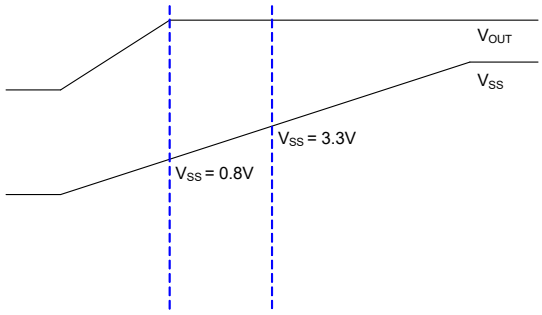


Figure 1. Soft Start Sequence of AOZ2150EQI-30

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

The control algorithm of AOZ2150EQI-30 is constant-on-time PWM control with input feed-forward. The simplified control schematic is shown in Figure 2. The high-side switch on-time is determined solely by a one-shot whose pulse width is inversely proportional to input voltage (IN). The one-shot is triggered when the internal 0.8V is higher than the combined information of FB voltage and the AC current information of inductor, which is processed and obtained through the sensed low-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.

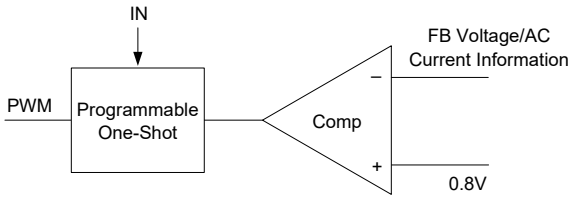


Figure 2. Simplified Control Schematic of AOZ2150EQI-30

The constant-on-time PWM control architecture is a pseudo-fixed frequency with input voltage feed-forward. The internal circuit of AOZ2150EQI-30 sets the on-time of high-side switch inversely proportional to the IN.

$$T_{on} \propto \frac{R_{ton}(\Omega)}{V_{in}(V)} \quad (1)$$

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

$$F_{sw} = \frac{V_{out}}{V_{in} * T_{on}} \quad (2)$$

Once the product of V_{in}*T_{on} is constant, the switching frequency keeps constant and is independent of input voltage.

An external resistor between the IN and TON pins sets the switching on-time according to the following curves:

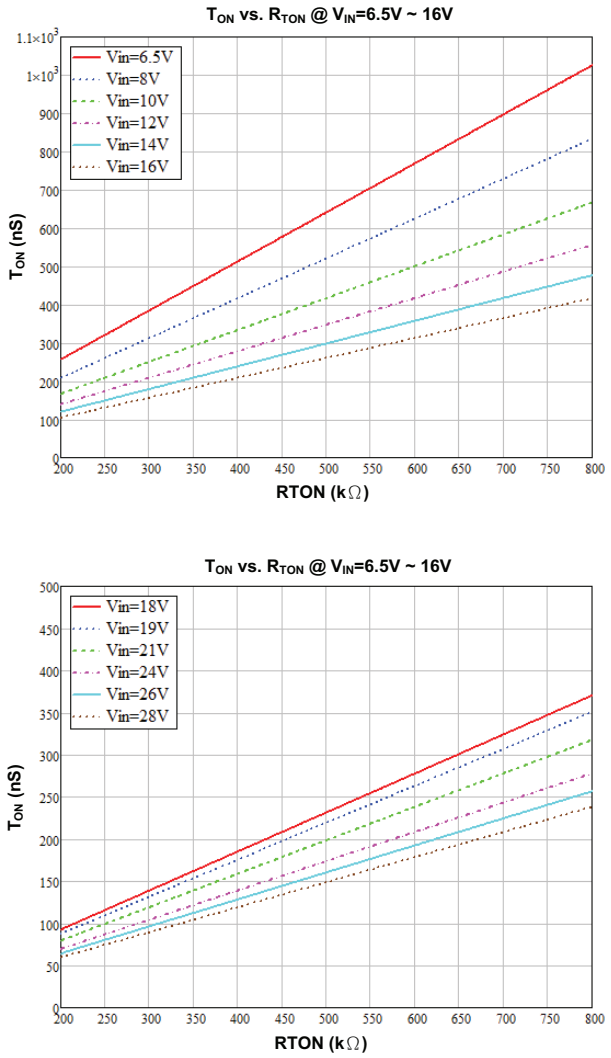


Figure 3. Ton vs. Rton Curves for AOZ2150EQI-30

A further simplified equation will be**:**

$$F_{sw}(KHz) = \frac{V_{out}(V)}{V_{in}(V) \cdot T_{on}(nS)} \cdot 10^6 \qquad (3)$$

If V_o is 1V, V_{in} is 19V, and set Fs=400kHz. According to eq.(3), T_{on}=131.6nS is needed. Finally, use the T_{on} to R_{ton} curve, we can find out R_{ton} is 300kΩ. This algorithm results in a nearly constant switching frequency despite the lack of a fixed-frequency clock generator.

True Current Mode Control

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 can not be used as output capacitor.

The AOZ2150EQI-30 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 AOZ2150EQI-30 has the current-limit protection by using R_{dson} of the low-side MOSFET to be as current sensing. To detect real current information, a minimum constant off time (300ns typical) is implemented after a constant-on time. If the current exceeds the current-limit threshold, the PWM controller is not allowed to initiate a new cycle. The actual peak current is greater than the current-limit threshold by an amount equal to the inductor ripple current. Therefore, the exact current-limit characteristic and maximum load capability are a function of the inductor value and input and output voltages. The current limit will keep the low-side MOSFET on and will not allow another high-side on-time, until the current in the low-side MOSFET reduces below the current limit.

After 8 switching cycles, the AOZ2150EQI-30 considers this is a true failed condition and thus turns-off both high-side and low-side MOSFET and shuts down. The AOZ2150EQI-30 enters hiccup mode to periodically restart the part. When the current limit protection is removed, the AOZ2150EQI-30 exits hiccup mode.

Output Voltage Under-Voltage Protection

If the output voltage is lower than 70% by over-current or short circuit, AOZ2150EQI-30 will wait for 32µs (typical) and turns-off both high-side and low-side MOSFET and shuts down. When the output voltage under-voltage protection is removed, the AOZ2150EQI-30 restarts again.

Output Voltage Over-voltage Protection

The threshold of OVP is set 20% higher than 0.8V. When the V_{FB} voltage exceeds the OVP threshold, high-side MOSFET is turned-off and low-side MOSFET is turned-on 1µs, then shuts down. When the output voltage over-voltage protection is removed, the AOZ2150EQI-30 restarts again.