AOZ2140DI

5.5V/3A Synchronous EZBuck™ Regulator and Smart Load Switch

General Description

The AOZ2140DI is a high-efficiency, easy-to-use DC/DC synchronous buck regulator which supports 3V to 5.5V input voltage range. The device is capable of supplying 3A of continuous output current with an output voltage adjustable down to 0.8V (±1.0%).

A proprietary constant on-time PWM control with input feed-forward results in ultra-fast transient response while maintaining relatively 650kHz constant switching frequency over the entire input voltage range.

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 AOZ2140DI also integrates a signal channel load switch with typical 23mΩ on-resistance in a small package. It contains one n-channel MOSFET for up to 5.5V input voltage operation and 5A of continuous output current.

The AOZ2140DI integrates an internal 290Ω load resistor for quick output discharge when load switch is off.

The AOZ2140DI is available in a 3mm×2mm DFN-14L package and is rated over a -40°C to +85°C ambient temperature range.

Features

EZBuck™:

- 3V to 5.5V input voltage range
- 3A continuous current per channel
- Output voltage adjustable down to 0.8V ±1.0%
- Internal $R_{DS(ON)}$ PFET and NFET
  - 140mΩ high-side PFET
  - 45mΩ low-side NFET
- Fixed switching frequency is 650kHz
- Ceramic capacitor stable
- Cycle-by-cycle current limit
- Short-circuit protection
- Over voltage protection
- Thermal shutdown

Smart Load Switch:

- 0.8V to 5.5V input voltage range
- 5A continuous output current
- Low $R_{DS(ON)}$ NFET
  - 23mΩ
- Integrated quick output discharge resistor
- Thermally enhanced 3mm x 2mm DFN-14L package

Applications

- Portable computers
- Compact desktop PCs
- Set top boxes
- LCD TVs
- Cable modems
- Point of load dc/dc converters
- Telecom/Networking/Datacom equipment

Green Product

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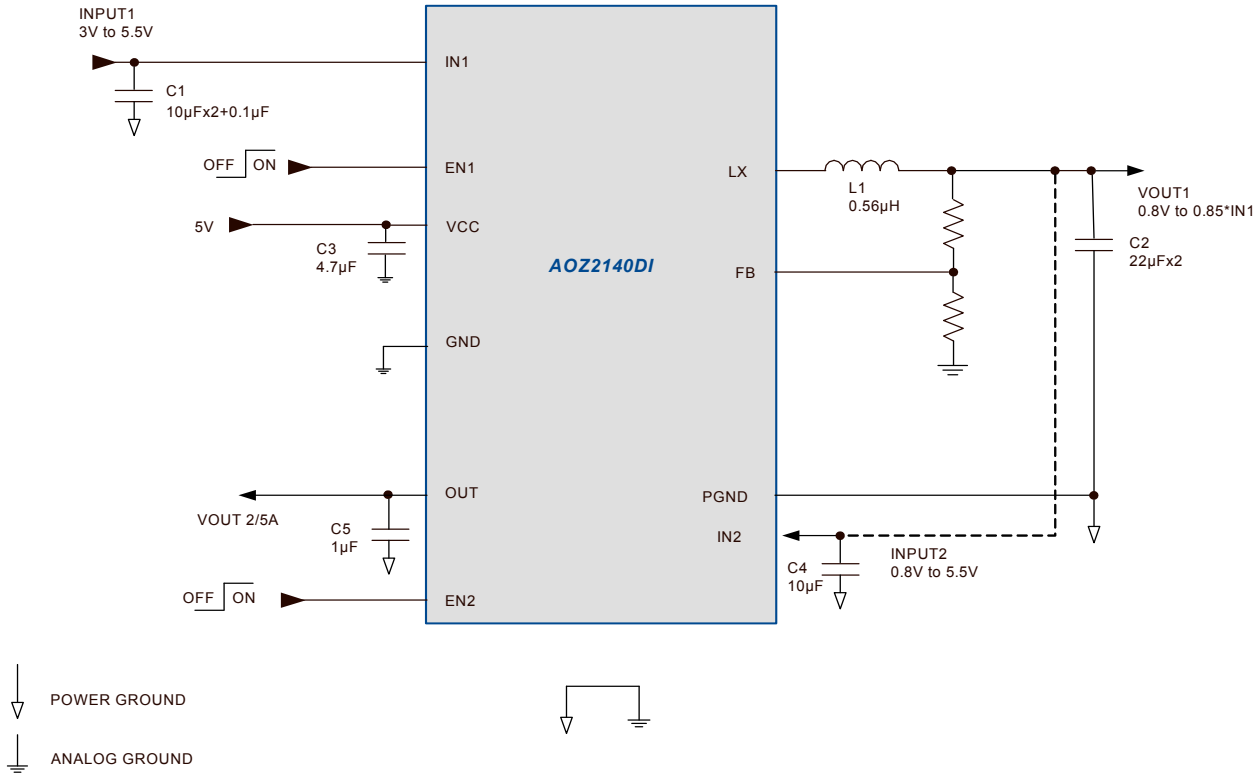
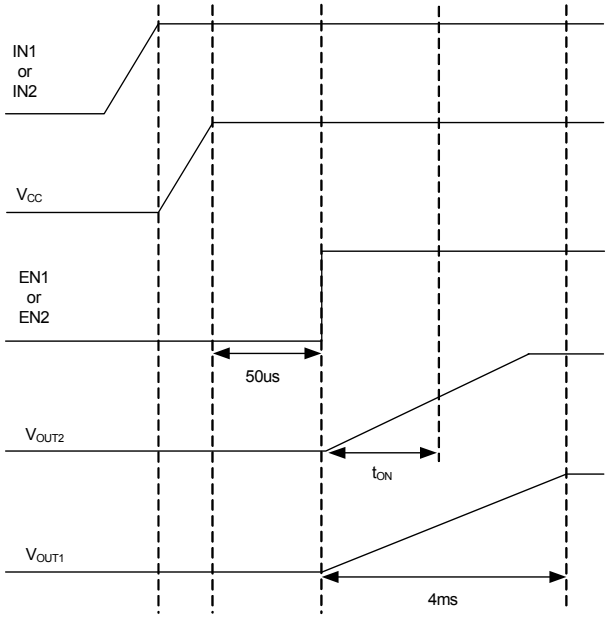
Typical Application



Start-up Sequence



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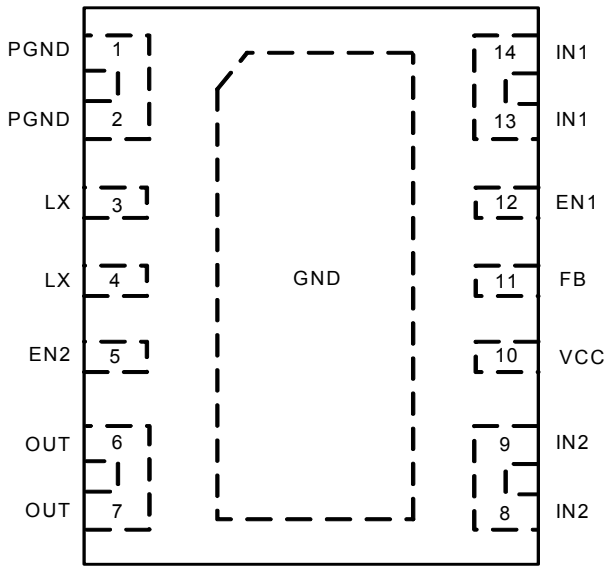
Ordering Information

Part Number	Temperature Range	Package	Environmental
AOZ2140DI	-40°C to +85°C	3mmx2mm DFN-14L	Green

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

Pin Configuration



14-Pin 3mm x 2mm DFN
(Top View)

Pin Description

Pin Number	Pin Name	Pin Function
1, 2	PGND	Power ground.
3, 4	LX	Converter switching node.
5	EN2	Enable input for smart load switch which is ON when EN2 is pulled high and is OFF when EN2 is pulled low. Do not floating this pin.
6, 7	OUT	Smart load switch output.
8, 9	IN2	Supply input for smart load switch. All IN2 pins must be connected together.
10	VCC	Supply input for analog functions. Bypass VCC to GND with a 1µF~10µF ceramic capacitor. Place the capacitor as close to VCC pin as possible.
11	FB	Feedback input for converter. Adjust the output voltage with a resistive voltage-divider between the regulator's output and GND.
12	EN1	Enable input for converter. Converter is enabled when EN1 is pulled high. The converter shuts down when EN1 is pulled low.
13, 14	IN1	Supply input for converter. All IN1 pins must be connected together.
EPAD	Exposed Pad	The exposed bottom pad must be connected to GND. This is also AGND of IC.

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Absolute Maximum Ratings

Exceeding the Absolute Maximum ratings may damage the device.

Parameter	Rating
IN1, IN2, LX to PGND(1)	-0.3V to 6V
VCC, FB, EN1, EN2, 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 HBM/CDM(2)	2kV/1kV

Notes:

1. LX to PGND transient (t<20ns) ------- -5V to V_{IN}+5V.
2. Devices are inherently ESD sensitive, handling precautions are required. Human body model rating: 1.5kΩ in series with 100pF

Recommend Operating Ratings

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

Parameter	Rating
Supply Voltage (V_{IN})	3V to 5.5V
Supply Voltage (V_{IN2})	0.8V to 5.5V
Output Voltage Range V_{OUT1}	0.8V to 0.85*V_{IN}
Ambient Temperature (T_A)	-40°C to +85°C
Package Thermal Resistance 3x2 DFN-14 (Θ_{JC}) 3x2 DFN-14 (Θ_{JA})	 10°C/W 65°C/W

Electrical Characteristics

EZBuck™

T_A = 25°C, V_{IN}=5V, V_{CC}=5V, 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_{IN1}	IN1 Supply Voltage		3		5.5	V
V_{UVLO}	Under-Voltage Lockout Threshold of V_{CC}	V_{CC} rising V_{CC} falling	 2.4	2.8 2.55	3	V V
V_{CC_HYS}	V_{CC} UVLO Hysteresis		180			mV
I_q	Quiescent Supply Current	I_{OUT} = 0A, V_{EN1}= 5V, V_{EN2} = 0V		150		µA
I_{OFF}	Shutdown Supply Current	V_{EN1} = V_{EN2}= 0V		100		nA
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 V
	Load Regulation			0.5		%
	Line Regulation			1		%
I_{FB}	FB Input Bias Current				10	nA
Enable						
V_{EN1}	EN1 Input Threshold	Off threshold On threshold	 1.4		0.5	V V
EN1_HYS	EN1 Input Hysteresis		200			mV
Modulator						
T_{ON}	On Time	V_{IN}=5V=V_{CC}, V_{OUT}=1V		310		ns
T_{ON_MIN}	Minimum On Time			200		ns
T_{OFF_MIN}	Minimum Off Time			310		ns
Soft-Start						
T_{SS_OUT}	SS Source Time			4		ms

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Electrical Characteristics *(Continued)*

EZBuck™

T_A = 25°C, V_{IN}=5V, V_{CC}=5V, 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
Under Voltage and Over Voltage Protection						
V_{PL}	Under Voltage Threshold	FB falling		70		%
T_{PL}	Under Voltage Delay Time			20		us
V_{PH}	Over Voltage Threshold	FB rising		120		%
Power Stage Output						
$R_{DSH(ON)}$	High-Side PFET On- Resistance	VIN = 5V VCC = 5V		140		mΩ
	High-Side NFET Leakage	VEN = 0V, VLX = 0V 10			10	uA
$R_{DSL(ON)}$	Low-Side NFET On- Resistance	VLX = 5V VCC = 5V		45		mΩ
	Low-Side NFET Leakage	VEN = 0V			10	uA
Over-Current and Thermal Protection						
	Over Current	VCC = 5V		5		A
	Thermal Shutdown Threshold			150		°C

Smart Load Switch

T_A = 25°C, V_{CC} = 5V, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_{IN2}	IN2 Supply Voltage		0.8		5.5	V
V_{CC}	VCC Supply Voltage		3		5.5	V
V_{UVLO}	Under-Voltage Lockout Threshold of V_{CC}	V_{CC} rising V_{CC} falling	 2.4	2.8 2.55	3	V
I_D	Maximum Continuous Current	V_{IN2} = V_{EN2} = 5V		5		A
I_{PLS}	Maximum Pulsed Switch Current	V_{IN2} = V_{EN2} = 5V Pulse < 300µs, 2% Duty Cycle		7		A
I_q	Quiescent Supply Current of V_{CC}	I_{OUT} = 0A V_{IN2} = 5V, V_{EN1} =0V, V_{EN2}= 5V		150		uA
I_{OFF}	Shutdown Supply Current	V_{EN1} = V_{EN2}= 0V		100		nA
I_{EN2}	EN2 Leakage Current				1	uA
V_{ENH2}	EN2 High Level Voltage		1.4			V
V_{ENL2}	EN2 Low Level Voltage				0.5	V
EN2_HYS	EN2 Input Hysteresis		200			mV
Switching ON Resistance						
R_{ON}	Switch ON-State Resistance	I_{OUT} = -200mA V_{IN2} = 0.8V to 5V		23		mΩ
R_{PD}	Output Pull-Down Resistance	I_{OUT} = 15mA V_{IN2} = 5V, V_{EN2} = 0V		290		Ω

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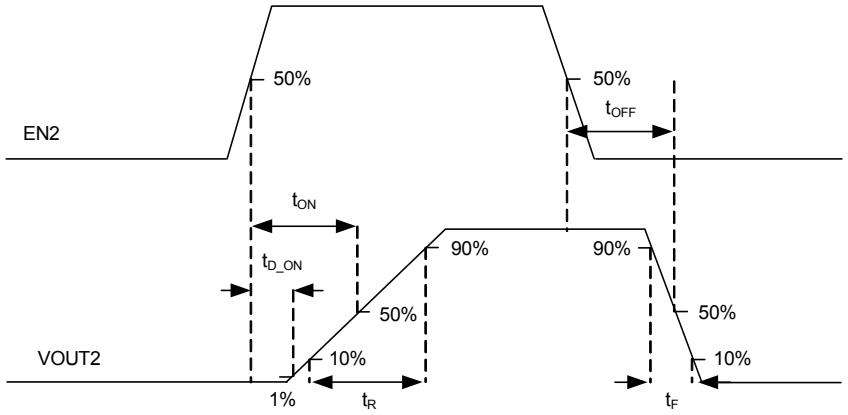
Switching Characteristics



Test conditions: T_A = 25°C, C_4=1uF, C_5=0.1uF, R_{LOUT2}=10Ω, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
VIN2=VCC=5V						
t_{ON}	Turn-ON Time			310		µs
t_{D-ON}	Turn-ON Delay Time			110		µs
t_R	Turn-ON Rise Time			464		µs
t_{OFF}	Turn-OFF Time			1.97		µs
t_F	Turn-OFF Fall Time			2.25		µs
VIN2=2.5V, VCC=3V						
t_{ON}	Turn-ON Time			241		µs
t_{D-ON}	Turn-ON Delay Time			150		µs
t_R	Turn-ON Rise Time			206		µs
t_{OFF}	Turn-OFF Time			5.26		µs
t_F	Turn-OFF Fall Time			3		µs
VIN2=0.8V, VCC=3V						
t_{ON}	Turn-ON Time			172.5		µs
t_{D-ON}	Turn-ON Delay Time			148.8		µs
t_R	Turn-ON Rise Time			45.5		µs
t_{OFF}	Turn-OFF Time			15.5		µs
t_F	Turn-OFF Fall Time			2.85		µs

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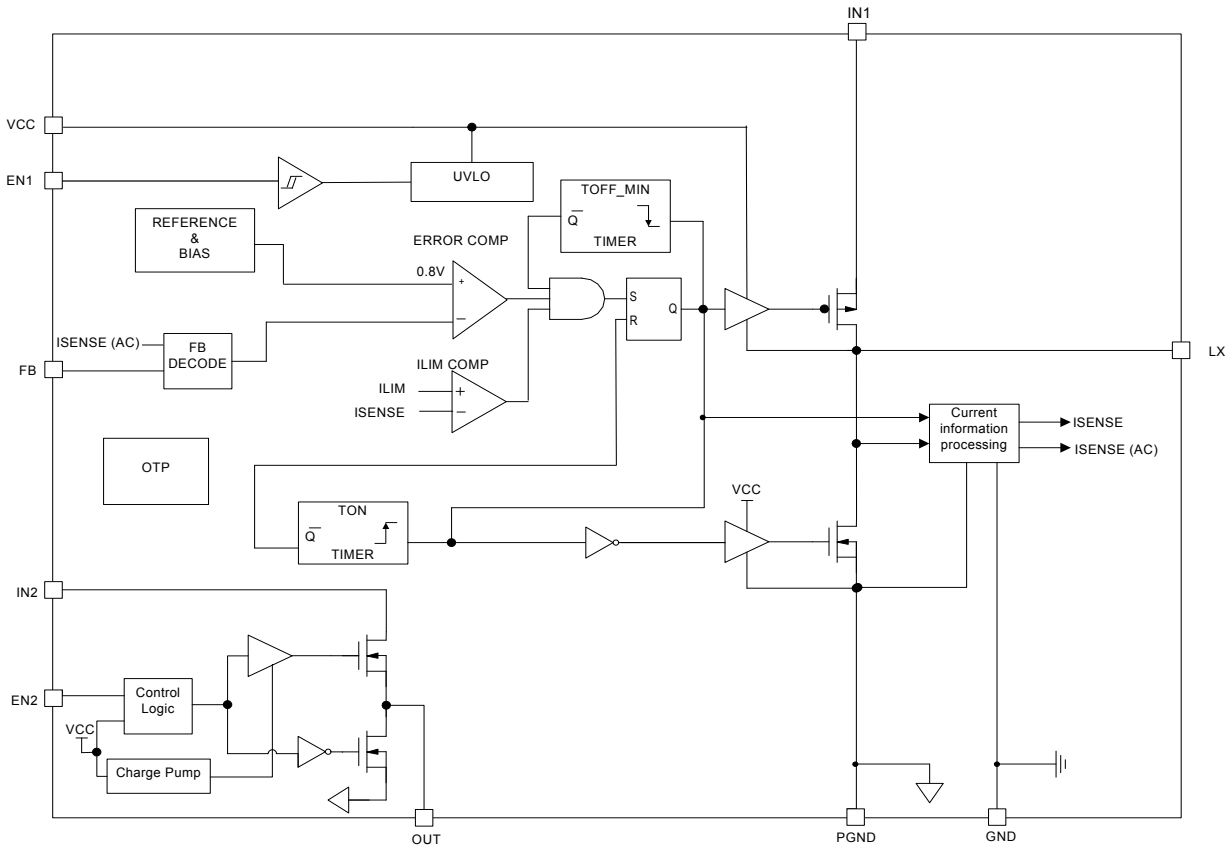
Functional Block Diagram



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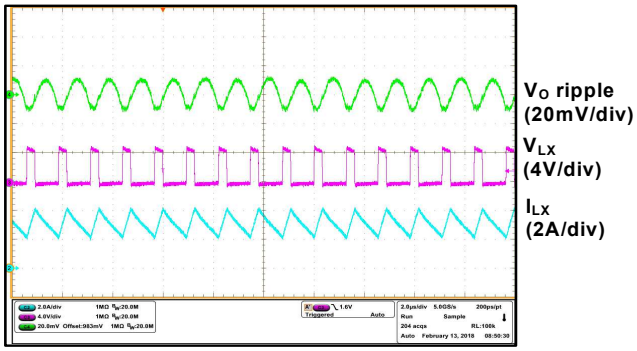
Typical Performance Characteristics

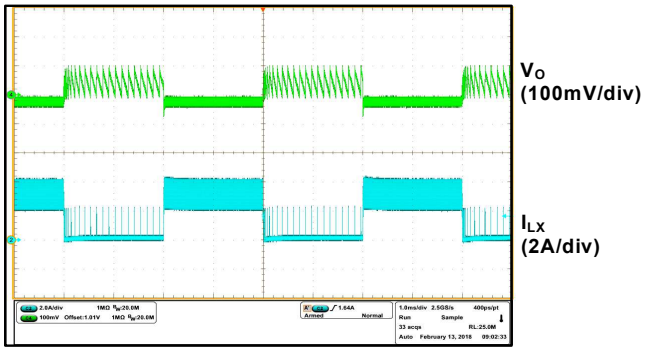
EZBuck™

T_A=25°C, V_{IN}=5V, V_{OUT}=1V, unless otherwise specified.

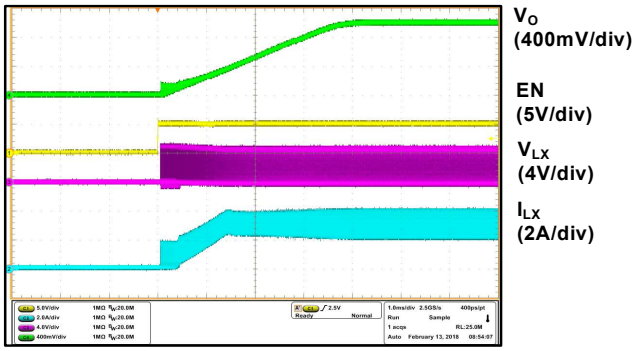
Normal Operation



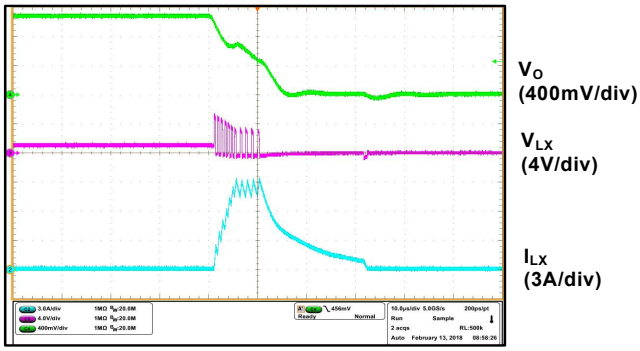
Load Transient 0A to 3A



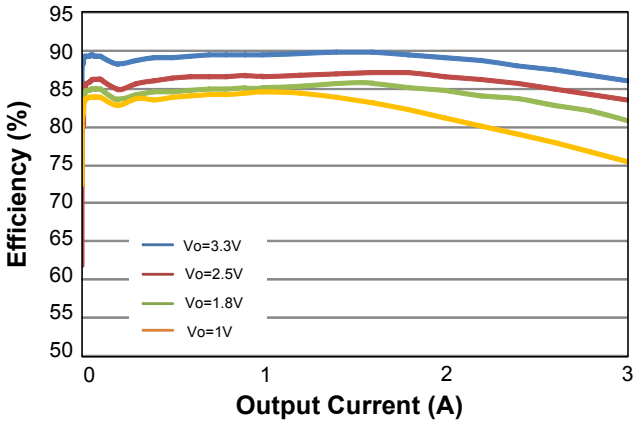
Full Load Start-up



Short Circuit Protection



Efficiency vs. Load Current



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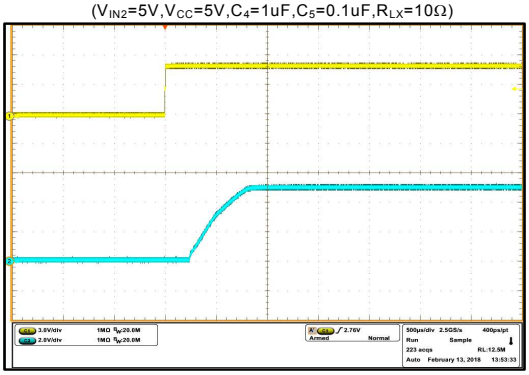
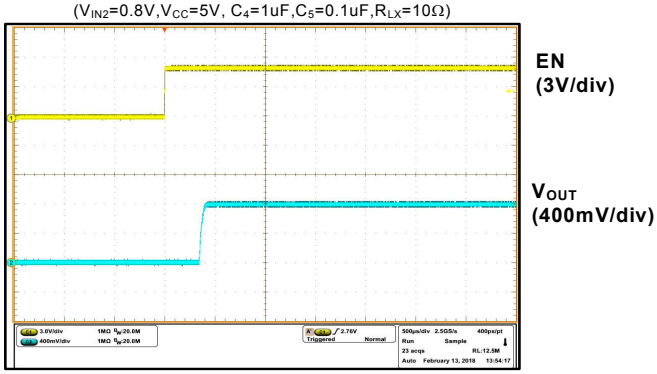
Typical Performance Characteristics

LDS

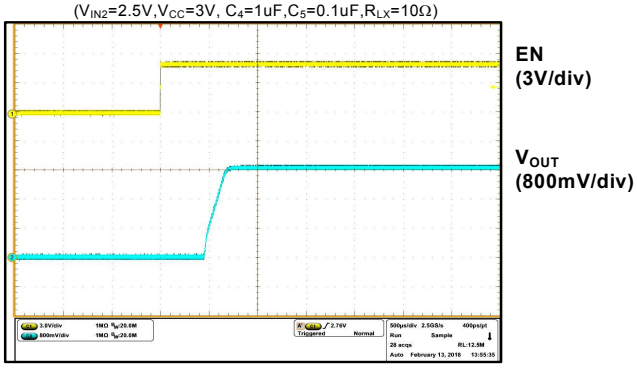
Turn-ON & Turn-ON Rise Times
(V_{IN2}=5V,V_{CC}=5V,C_4=1uF,C_5=0.1uF,R_{LX}=10Ω)



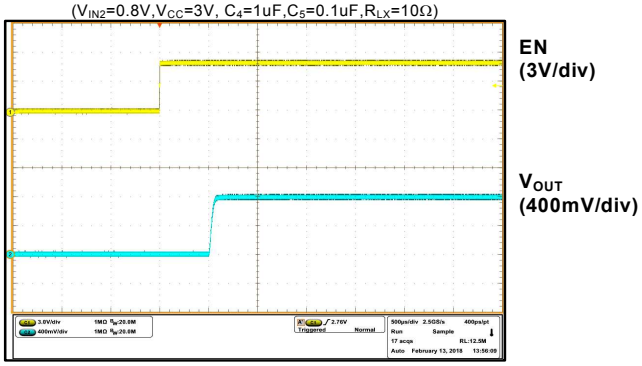
Turn-ON & Turn-ON Rise Times
(V_{IN2}=0.8V,V_{CC}=5V, C_4=1uF,C_5=0.1uF,R_{LX}=10Ω)



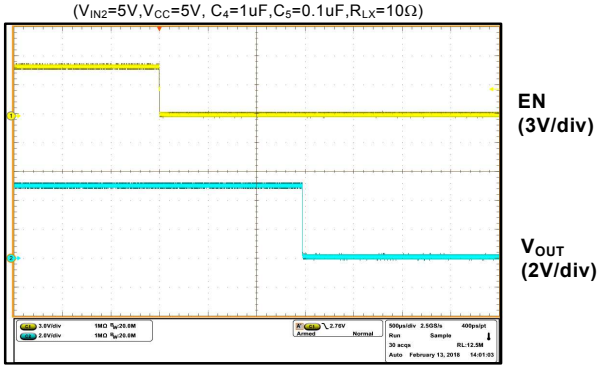
Turn-ON & Turn-ON Rise Times
(V_{IN2}=2.5V,V_{CC}=3V, C_4=1uF,C_5=0.1uF,R_{LX}=10Ω)



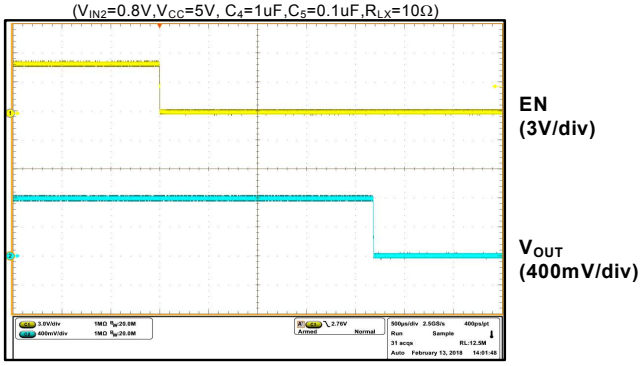
Turn-ON & Turn-ON Rise Times
(V_{IN2}=0.8V,V_{CC}=3V, C_4=1uF,C_5=0.1uF,R_{LX}=10Ω)



Turn-OFF & Turn-OFF Fall Times
(V_{IN2}=5V,V_{CC}=5V, C_4=1uF,C_5=0.1uF,R_{LX}=10Ω)



Turn-OFF & Turn-OFF Fall Times
(V_{IN2}=0.8V,V_{CC}=5V, C_4=1uF,C_5=0.1uF,R_{LX}=10Ω)



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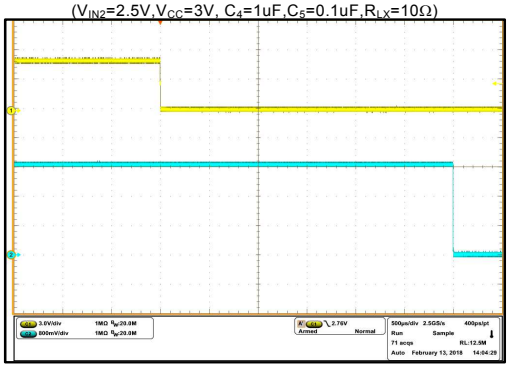
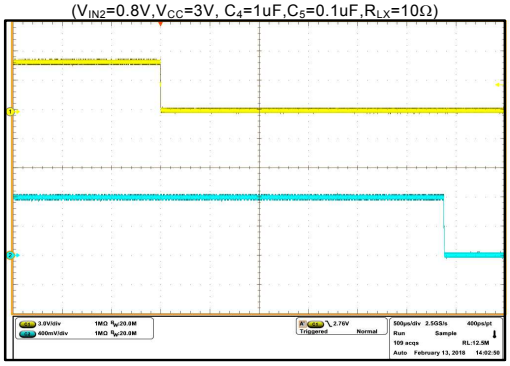
Typical Performance Characteristics

LDS

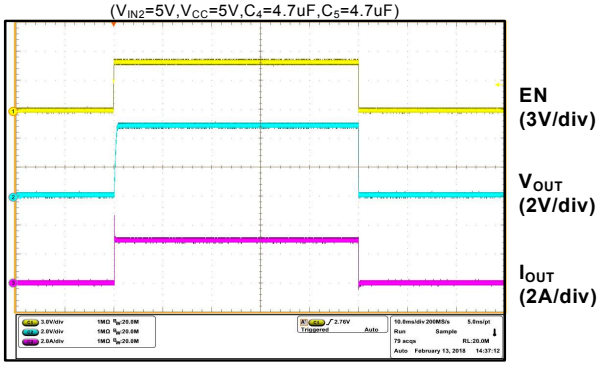
Turn-OFF & Turn-OFF Fall Times
(V_{IN2}=2.5V,V_{CC}=3V, C_4=1uF,C_5=0.1uF,R_{LX}=10Ω)



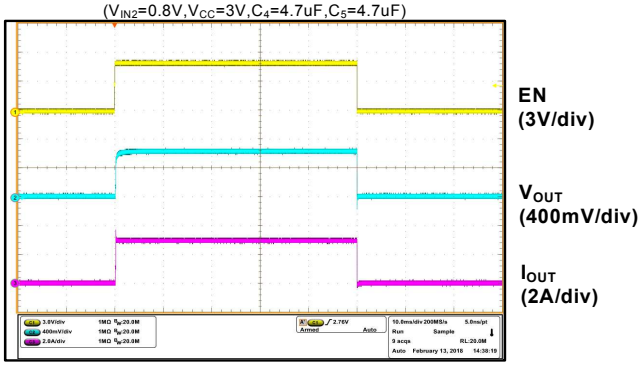
Turn-OFF & Turn-OFF Fall Times
(V_{IN2}=0.8V,V_{CC}=3V, C_4=1uF,C_5=0.1uF,R_{LX}=10Ω)



Turn-ON & Turn-OFF @ IOUT=3A
(V_{IN2}=5V,V_{CC}=5V,C_4=4.7uF,C_5=4.7uF)



Turn-ON & Turn-OFF @ IOUT=3A
(V_{IN2}=0.8V,V_{CC}=3V,C_4=4.7uF,C_5=4.7uF)



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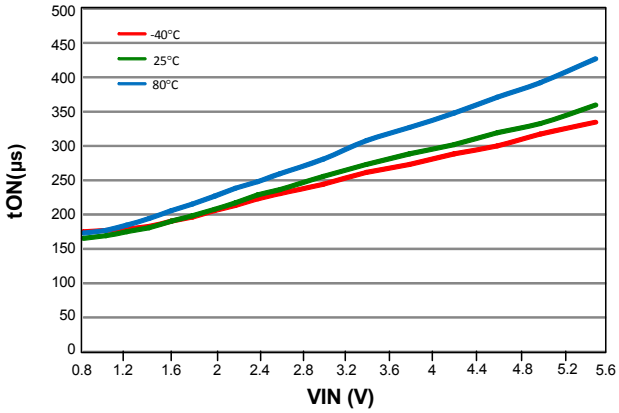
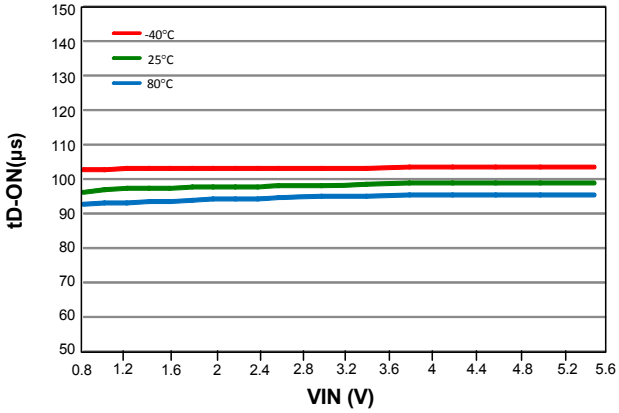
Typical Characteristics

LDS

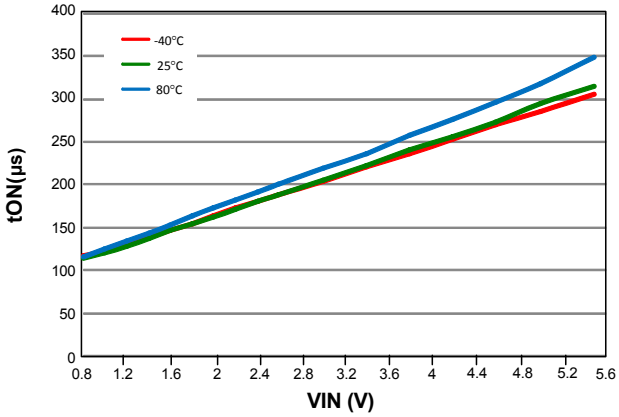
t_{ON} vs. V_{IN} (V_{CC}=3V)



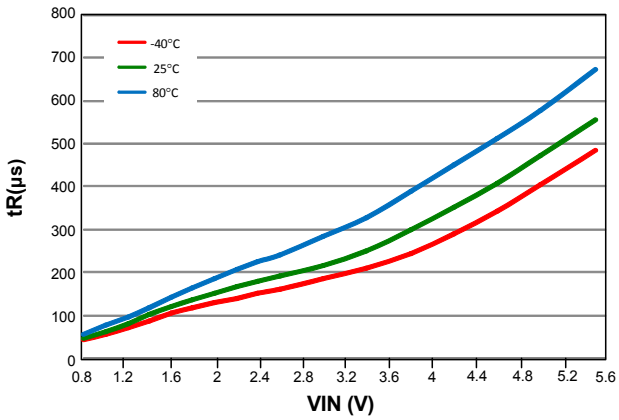
t_{D-ON} vs. V_{IN} (V_{CC}=5.5V)



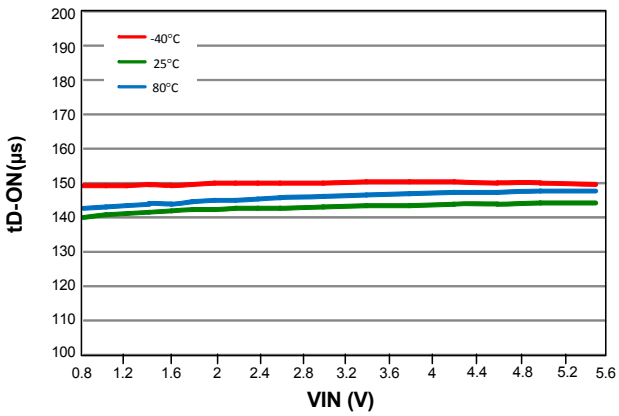
t_{ON} vs. V_{IN} (V_{CC}=5.5V)



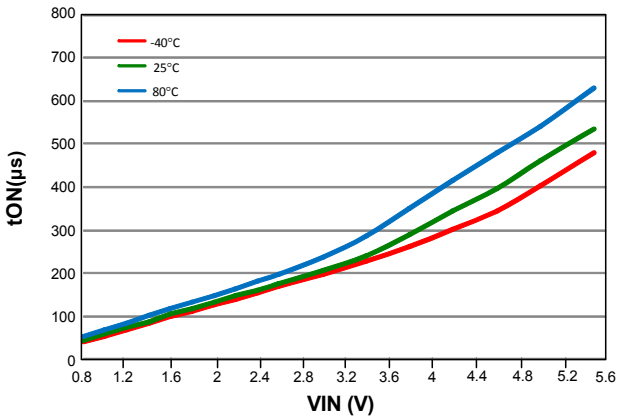
t_R vs. V_{IN} (V_{CC}=3V)



t_{D-ON} vs. V_{IN} (V_{CC}=3V)



t_R vs. V_{IN} (V_{CC}=5V)



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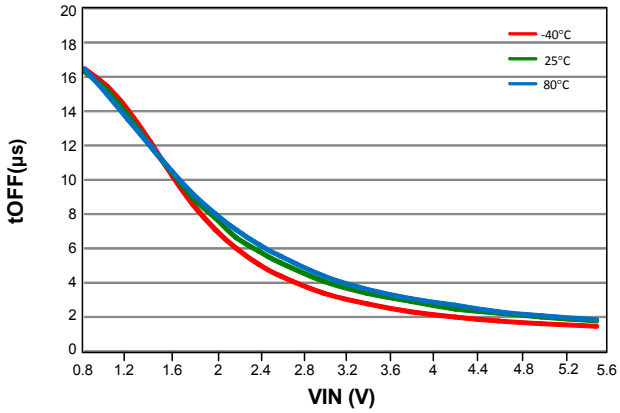
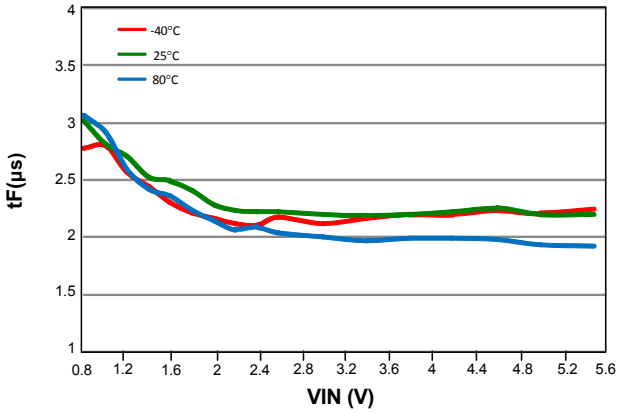
Typical Characteristics

LDS

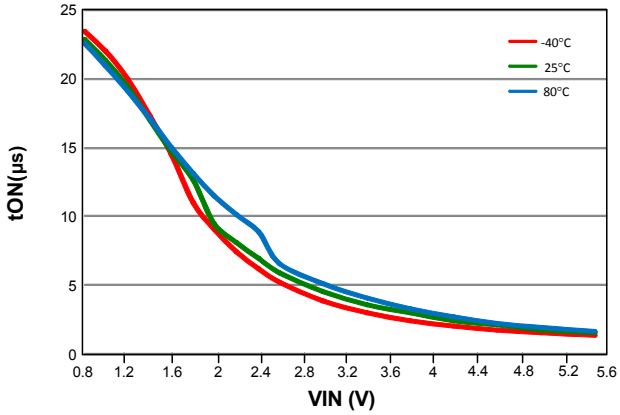
t_{OFF} vs. V_{IN} (V_{CC}=3V)



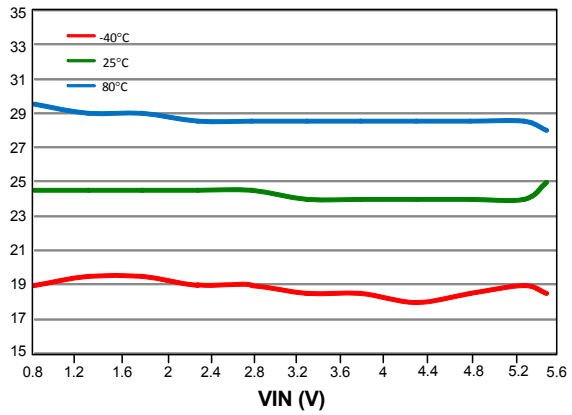
t_F vs. V_{IN} (V_{CC}=5.5V)



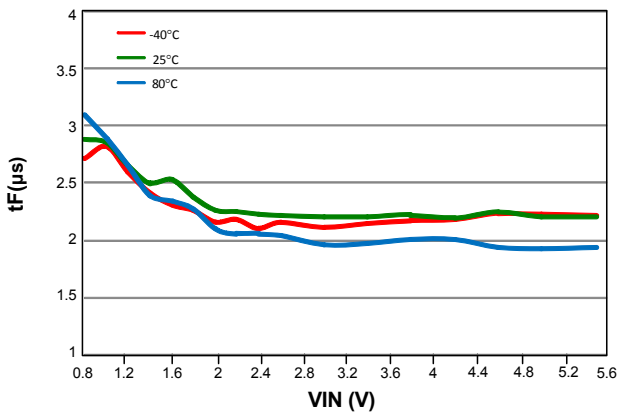
t_{OFF} vs. V_{IN} (V_{CC}=5.5V)



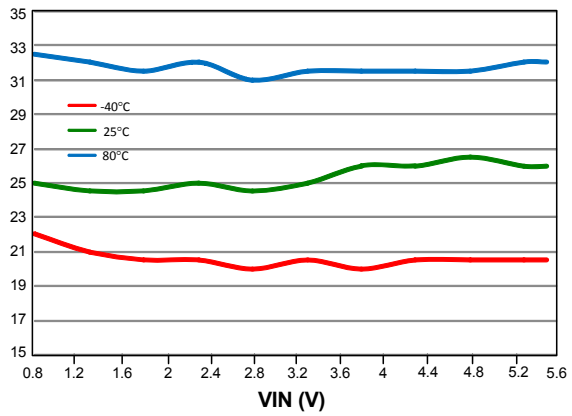
R_{DSON} vs. V_{IN} (V_{CC}=5.5V, I_{OUT}=200mA)



t_F vs. V_{IN} (V_{CC}=3V)



R_{DSON} vs. V_{IN} (V_{CC}=3V, I_{OUT}=200mA)



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Detailed Description

The AOZ2140DI is a multi-function product which includes one EZBuck converter and one smart load switch.

The converter of AOZ2140DI is a high-efficiency, easy-to-use DC/DC 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 AOZ2140DI can be as low as 3V. The highest input voltage of AOZ2140DI can be 5.5V. 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 regulators 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 smart load switch of AOZ2140DI is enabled when EN2 pin is on active high with 1.4V or above voltage. The smart load switch is disabled when the EN2 pin is lower than 0.5V.

The AOZ2140DI is available in a 14-pin 3mm×2mm DFN package.

Enable and Soft-Start

The converter of AOZ2140DI 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 V_{CC} rises to 2.8V and voltage on EN1 pin is high. An internal current source charges the internal soft-start capacitor; the FB voltage follows the voltage of soft-start (V_{SS}) when V_{SS} 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). SS_OK will be high when V_{SS} ramps up to 1.2V, as Fig 1. The soft-start time typical is 4ms from EN1 to V_{OUT1} settling. UVP and OCP enable after SS_OK is high.

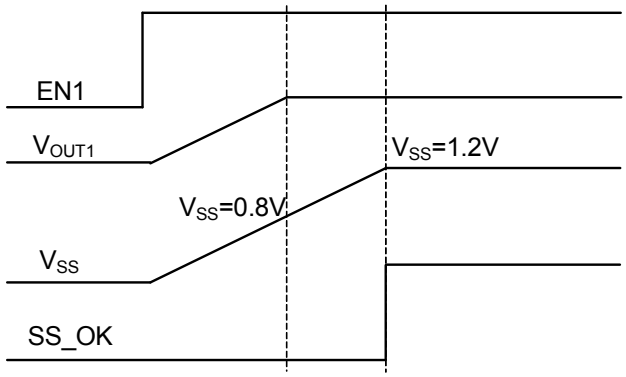

Figure 1. Soft Start Timing of AOZ2140DI

Constant On-Time PWM Control with Input Feed-Forward

The control algorithm of AOZ2140DI is constant on-time PWM Control with input feed-forward.

The simplified control schematic is shown in Fig 2. The high-side switch on-time is determined solely by a one-shot whose pulse width is determined by one internal resistor and is inversely proportional to input voltage (IN1). 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 extra AC current information can help the stability of constant on-time control even with pure MLCC application, which has very low ESR. Besides, the AC current information doesn't have DC component so there is no offset when output load is changed. It is fundamentally different from other V^2 constant on-time control schemes.

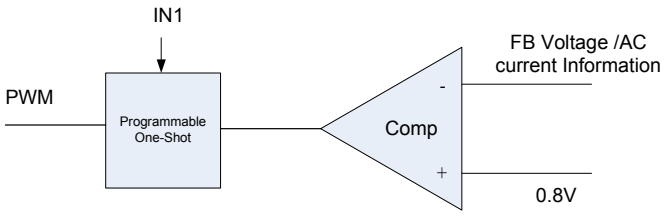

Figure 2. Simplified Control Schematic of AOZ2140DI

True Current Mode Control

Pure MLCC solution is popular for DC/DC applications due to small size, good performance at high frequency, low ESR and ESL, and so on. However, the constant on-time control is easy to happen double pulses or multiple pulses in using pure MLCC solution. Because there is a phase lag between output voltage ripple and inductor current ripple and it get worst with low ESR application.

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The converter of AOZ2140DI senses the low-side MOSFET current and processes it into DC and AC items by using AOS proprietary technique. The AC current information is injected on the FB pin in phase. And hence, the stability of constant on-time control can work stable with low ESR of output capacitor and has better noise immunity.

Current-Limit Protection

The AOZ2140DI has the current limit protection by using $R_{DS(ON)}$ of the low-side MOSFET to be as a current sensing. In order to get real current signal, a minimum constant off-time is implemented after the on-time. The threshold of current limit is about 5A of inductor valley current. If the current exceeds the current limit threshold, the PWM controller is not allowed to pulse one-shot. The current limit will keep the low-side MOSFET turn-on until the current in the low-side MOSFET is smaller than the current limit threshold.

Output Current Over-current Protection

The AOZ2140DI considers this is a true failed condition when OCP (inductor valley current=5A) is triggered continuously 20us. After that, AOZ2140DI will be turned-off high-side and turned-on low-side MOSFETs until inductor current goes to zero.

Output Voltage Under-voltage Protection

There are two UVP thresholds. One is 70% of output voltage and the other is 50% of output voltage. The former is with a 20us delay to prevent false trigger. High-side will be turned-off and low-side will be turned-on until inductor current reaches zero current. Please note, there is no UVP function during soft-start.

Output Voltage Over-voltage Protection

The threshold of OVP is 1.2 times of output voltage. When the output voltage exceeds the OVP threshold, high-side MOSFET is turned-off and low-side MOSFETs is turned-on until inductor current downs to zero.

Over Temperature Protection

AOZ2140DI provides an over temperature protection function when the junction temperature is higher than 150°C. Both two outputs will be latched when OTP is triggered.

Applications Information

The basic AOZ2140DI application circuit is shown in the first page. The related components selection and suitable input/output voltage range are explained as below sections.

Input Capacitor Selection

For the converter of AOZ2140DI, the input capacitors must be connected between IN1 pins and PGND pins. The input ripple voltage can be derived as:

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

Therefore, C_{IN} can be obtained by request input voltage ripple and related parameters. Since the input current is pulsating in the buck converter, the current stress of the input capacitor should be considered when selecting the capacitor. For the buck converter, the RMS value of the input capacitor current can be calculated by:

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

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 Fig. 3. It can be obtained that when V_O is a half of V_{IN}, C_{IN} is under the worst current stress. The worst current stress on C_{IN} is $0.5 \cdot I_O$.

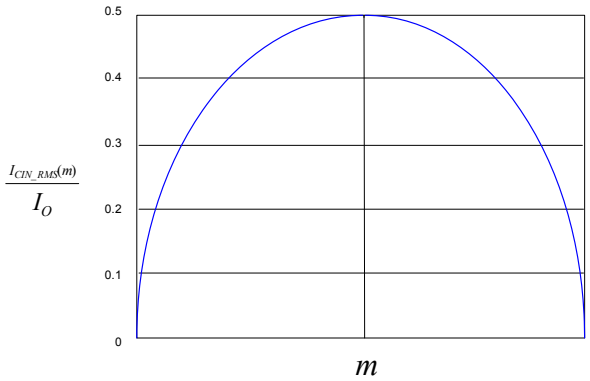

Figure 3. I_{CIN} vs. Voltage Conversion Ratio

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 applica-

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tion 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 better temperature and voltage characteristics. Note that the ripple current rating from capacitor manufactures is based on certain amount of life time and more capacitors are needed when input voltage is low application. Further de-rating may be necessary for practical design requirement.

For the load switch of AOZ2140DI, a capacitor of 1uF or higher value is recommended to place close to the IN2 pins. This capacitor can reduce the voltage drop caused by the in-rush current during the turn-on transient of the load switch. A higher capacitance can be used to further reduce the voltage drop during high-current application.

Inductor

The inductor is used to supply a constant current to the 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:

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

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, a peak to peak ripple current on the inductor is designed to be 30% to 50% of the output current. When selecting the inductor, make sure it is able to handle the peak current without saturation even at the highest operating temperature.

There is a highest current RMS in the inductor in the buck converter. The conduction loss on the inductor needs to be checked for thermal and efficiency consideration.

Surface mount inductors in different shape and styles are available from capacitor vendors. Shielded inductors are small and radiate less EMI noise. But they cost more than unshielded inductors. The choice depends on the 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, the output ripple voltage is determined by the inductor value, switching frequency, output capacitor value and ESR. It can be calculated by the equation below:

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

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

When the low ESR ceramic capacitor is used as the output capacitor, the impedance of the capacitor at the switching frequency dominates. The output ripple is mainly caused by the 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:

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

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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, the output capacitor could be overstressed.

For the smart load switch, a capacitor of 0.1uF or higher value is recommended to place between the OUT2 pins and GND. The switching times are affected by the capacitance. A larger capacitor makes the initial turn-on transient smoother. In order to prevent the output voltage droop, this capacitor must be large enough to supply a fast transient load.

Output Voltage Regulation Performance

As well known, off-time is used to compensate power loss in constant on-time topology. In order to avoid switching frequency is too high and stability issue, off-time usually has a minimum value. Therefore, regulation performance of output voltage is limited through minimum off-time, as shown in Fig.4. For an example to explain clearly, the regulation of 4.5V to 3.3V is good when Io≤1A. If it operates with Io>1A, the output voltage is decreased with Io is increased due to minimum off-time limitation. Please note that the results of Fig.4 operate in force CCM condition and the results are changed with different power loss.

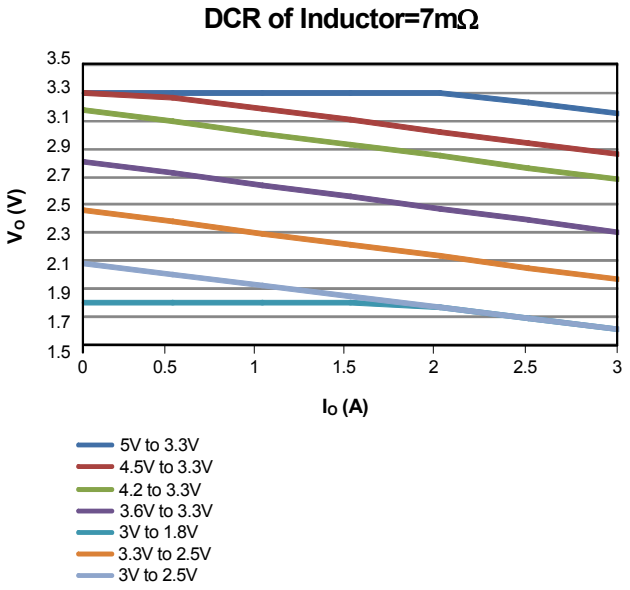

Figure 4. Output Voltage Regulation Performance

Thermal Considerations and Layout Considerations

In the AOZ2140DI 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 turned-on. The second loop starts from the inductor, to the output capacitors and load, to the low side switch. Current flows in the second loop when the low side low side switch is turned-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, GND, and PGND pin of the AOZ2140DI.

In the AOZ2140DI buck regulator circuit, the major power dissipating components are the AOZ2140DI and the output inductor. The total power dissipation of the converter circuit can be measured by input power minus output power.

$$P_{total\_loss} = (V_{IN1} \cdot I_{IN1} + V_{IN2} \cdot I_{IN2}) - (V_{O1} \cdot I_{O1} + V_{O2} \cdot I_{O2})$$

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

$$P_{indcutor\_loss} = I_O^{\,2} \cdot R_{inductor} \cdot 1.1$$

The actual junction temperature can be calculated with the power dissipation in the AOZ2140DI and thermal impedance from junction to ambient.

$$T_{junction} = (P_{total\_loss} - P_{inductor\_loss}) \cdot \Theta_{JA}$$

The maximum junction temperature of the AOZ2140DI is 150ºC, which limits the maximum load current capability.

The thermal performance of the AOZ2140DI is strongly affected by the PCB layout. Extra care should be taken by users during the design process to ensure that the IC will operate under the recommended environmental conditions.

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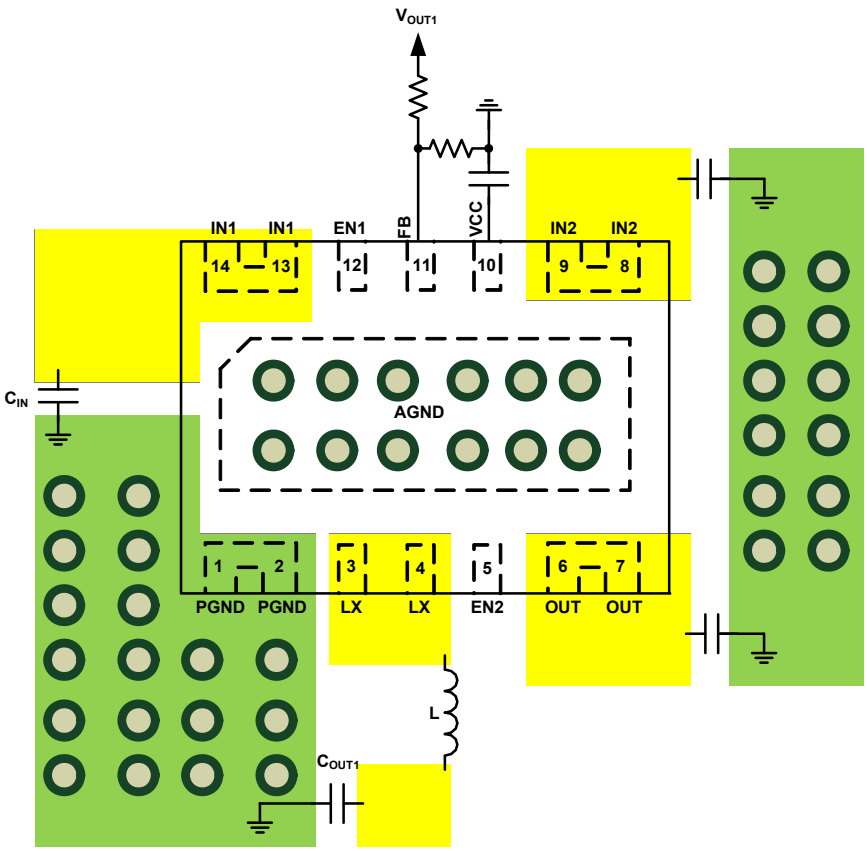
Layout Considerations

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. Connected a large copper plane to LX pin to help thermal dissipation.
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. Input capacitors should be connected to the IN pin and the PGND pin as close as possible to reduce the switching spikes.
4. Decoupling capacitor C_{VCC} should be connected to V_{CC} and AGND as close as possible.
5. Voltage divider R1 and R2 should be placed as close as possible to FB and AGND.
6. A ground plane is preferred; PGND and AGND must be connected to the ground plane through vias.
7. Keep sensitive signal traces such as feedback trace far away from the LX pins.
8. Pour copper plane on all unused board area and connect it to stable DC nodes, like VIN, GND or VOUT.



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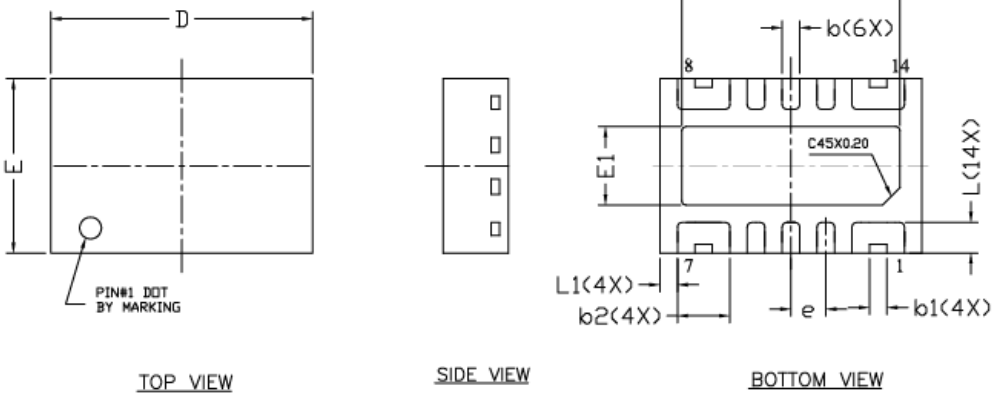
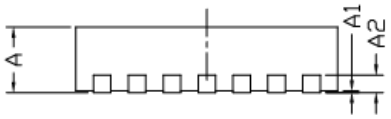
Package Dimensions, DFN3x2A-14L, EP1_S



TOP VIEW

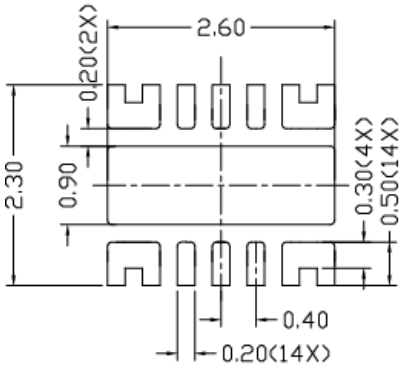
SIDE VIEW

BOTTOM VIEW



SIDE VIEW

RECOMMENDED LAND PATTERN



SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS 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	0.2 REF			0.008 REF		
E	1.90	2.00	2.10	0.075	0.079	0.083
E1	0.80	0.90	1.00	0.031	0.035	0.039
D	2.90	3.00	3.10	0.114	0.118	0.122
D1	2.40	2.50	2.60	0.094	0.098	0.102
L	0.30	0.35	0.40	0.012	0.014	0.016
L1	0.15	0.20	0.25	0.006	0.008	0.010
b	0.15	0.20	0.25	0.006	0.008	0.010
b1	0.15	0.20	0.25	0.006	0.008	0.010
b2	0.55	0.60	0.65	0.022	0.024	0.026
e	0.40 BSC			0.016 BSC		

UNIT: mm

NOTE
1. CONTROLLING DIMENSION IS MILLIMETER.
   CONVERTED INCH DIMENSIONS ARE NOT NECESSARILY EXACT.
2. TOLERANCE :±0.05 UNLESS OTHERWISE SPECIFIED.
3. RADIUS ON ALL CORNER ARE 0.152 MAX., UNLESS OTHERWISE SPECIFIED.
4. PACKAGE WARPAGE: 0.012 MAX.
5. NO ANY PLASTIC FLASH ALLOWED ON THE TOP AND BOTTOM LEAD SURFACE.
6. PAD PLANARITY: ±0.102
7. CRACK BETWEEN PLASTIC BODY AND LEAD IS NOT ALLOWED.

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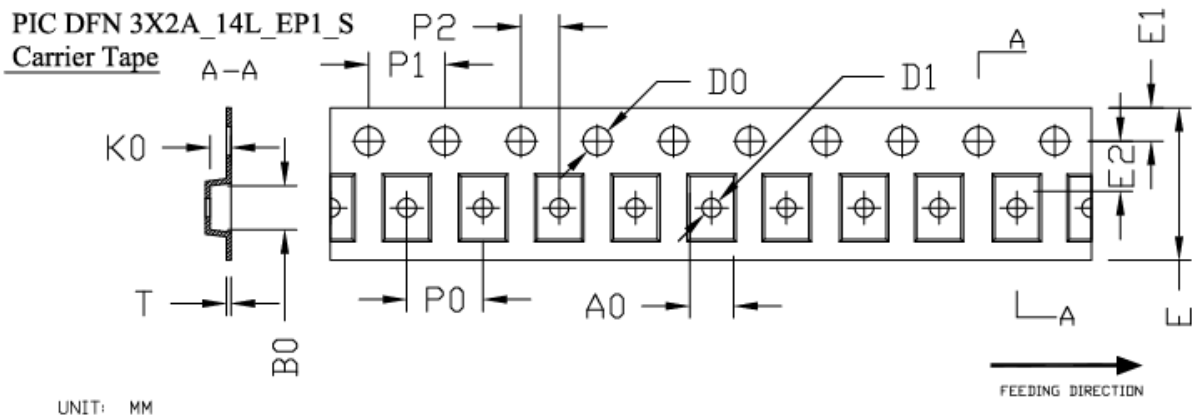
Tape and Reel Dimensions, DFN3x2A-14L, EP1_S

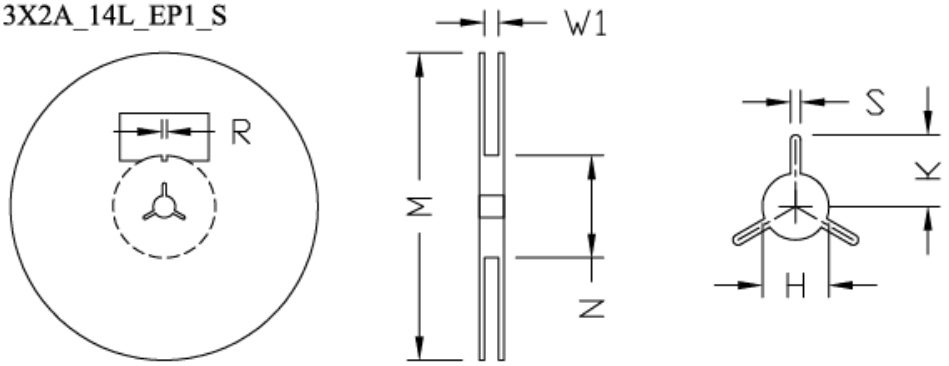
PIC DFN 3X2A_14L_EP1_S
Carrier Tape



UNIT: MM

PACKAGE	A0	B0	K0	D0	D1	E	E1	E2	P0	P1	P2	T
PIC DFN3X2	2.20 ±0.10	3.20 ±0.10	1.03 ±0.10	1.50 +0.1 -0	1.00 +0.25 -0	8.00 +0.30 -0.1	1.75 ±0.10	3.50 ±0.05	4.00 ±0.10	4.00 ±0.10	2.00 ±0.05	0.23 ±0.02

PIC DFN 3X2A_14L_EP1_S
REEL



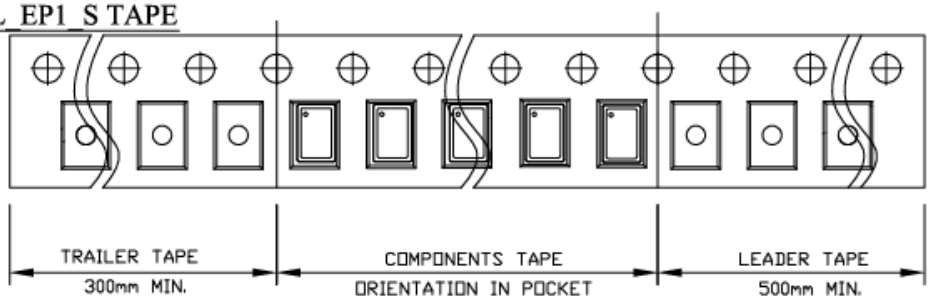
UNIT: MM

TAPE SIZE	REEL SIZE	M	N	W1	H	S	K	R
8	ø180	ø180.0 ±0.50	60.0 ±0.50	8.4 +1.5 -0.0	13.0 ±0.20	1.5 MIN.	13.5 MIN.	3.0 ±0.50

PIC DFN 3X2A_14L_EP1_S TAPE

Leader / Trailer
& Orientation

Unit Per Reel:
3000pcs



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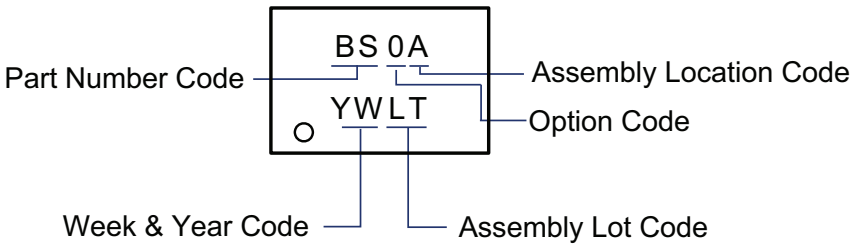
Package Marking

AOZ2140DI
(DFN3x2-14)



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2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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