AOZ7203AV Active Bridge Rectifier Controller Application Note

By Duncan Chiu

Introduction

This application note describes the demonstration board of the AOZ7203AV and provides a functional description and how to use the IC function and layout PCB to obtain the best performance.

The AOZ7203AV is a Zero Bridge Loss AlphaZBL™ Controller that controls two external MOSFETs to replace two low-side diodes in the AC to DC diode bridge application. The demonstration board of the AOZ7203AV can help the power supply to reduce power consumption and heat dissipation.

Operation Description

Normal Operation

The demonstration board of the AOZ7203AV with a low-voltage capacitor that can drive the two external N-MOSFETs to replace two low-side diodes in the traditional bridge rectifier application.

In normal operation, after Vcc is charged to UVLO rising level VCC_UP, AOZ7203AV senses the voltages of input pins ACL and ACN to determine when to turn high one of the gates GATEL and GATEN. When the ACL voltage approaches zero and the ACN voltage rises above the switch turn-on threshold VACL/N_ON, the GATEL is turned high, and GATEL drives the N-MOSFET on. When this half AC cycle comes near the end, the ACN voltage falls below the switch turn-off threshold VACL/N_OFF, and the GATEL is turned low. Thus the conduction loss in this half AC cycle is reduced. In the next half AC cycle, the N-MOSFET is driven by GATEN, which is controlled similarly to reduce the conduction loss.

When the AC input voltage is connected, the VCC capacitor is first charged to UVLO rising level VCC_UP (16.5V typical) via the ACL or ACN pin. During normal operation, the VCC capacitor is also charged when the voltage of ACL or ACN rises from zero to the level a little bit above the VCC voltage. The power consumption during charging is minimized to about 1mW to 2mW for AC input with typical line frequency, and the VCC voltage is therefore kept above the UVLO falling level VCC_UVLO (12.5V typical) if the VCC capacitor is large enough. The value of the VCC capacitor is recommended not smaller than 1µF/25V for a typical application. Figure 1 shows the start-up and normal operation waveform.

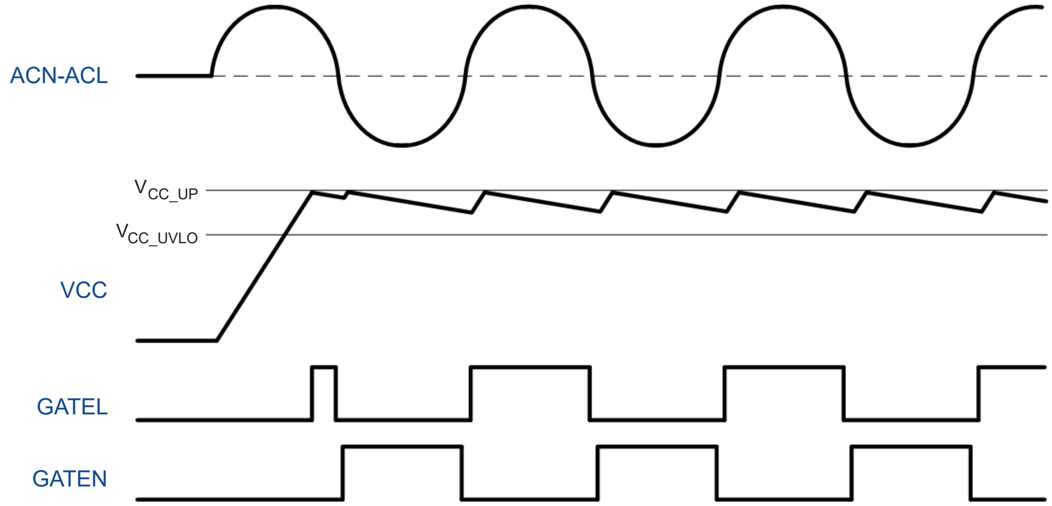


Figure 1. Start-up and Normal Operation

X-Cap Discharge Function Description

When the AC input voltage is removed, after about the X-cap discharge delay time (Tx-delay), the AOZ7203AV enters X-cap discharge mode. The X-cap discharge current Ix-dis (2.8mA typical) is pulled via the ACL or ACN pin to discharge the X capacitors. The GATEL and GATEN are kept low in this mode. If the AC input voltage returns, the AOZ7203AV detects the voltage change on the ACL and ACN pin and leaves the X-cap discharge mode. The VCC voltage is then recharged, and the AOZ7203 operates normally again. Figure 2 shows the X-cap discharge operation waveform.

Note that AOZ7203AV does not support DC input applications. When the input voltage between ACL and ACN is DC level, after about the X-cap discharge delay time (Tx-delay), the AOZ7203AV also enters X-cap discharge mode. Then AOZ7203AV keeps pulling the current Ix-dis via the ACL or ACN pin and driving GATEL and GATEN low. So there is no benefit for increasing efficiency in the DC input application.

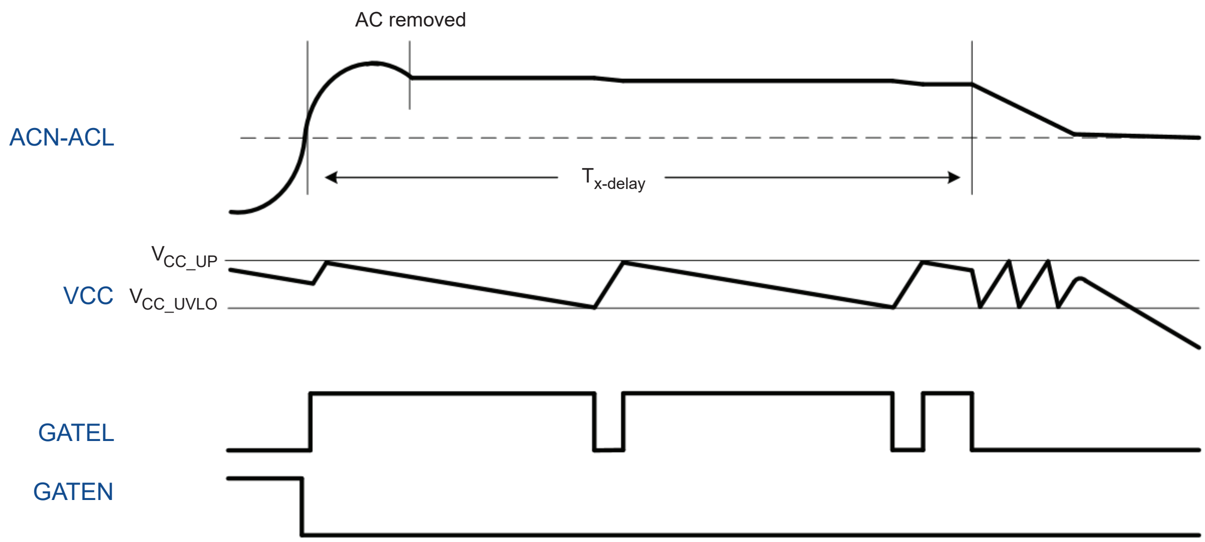
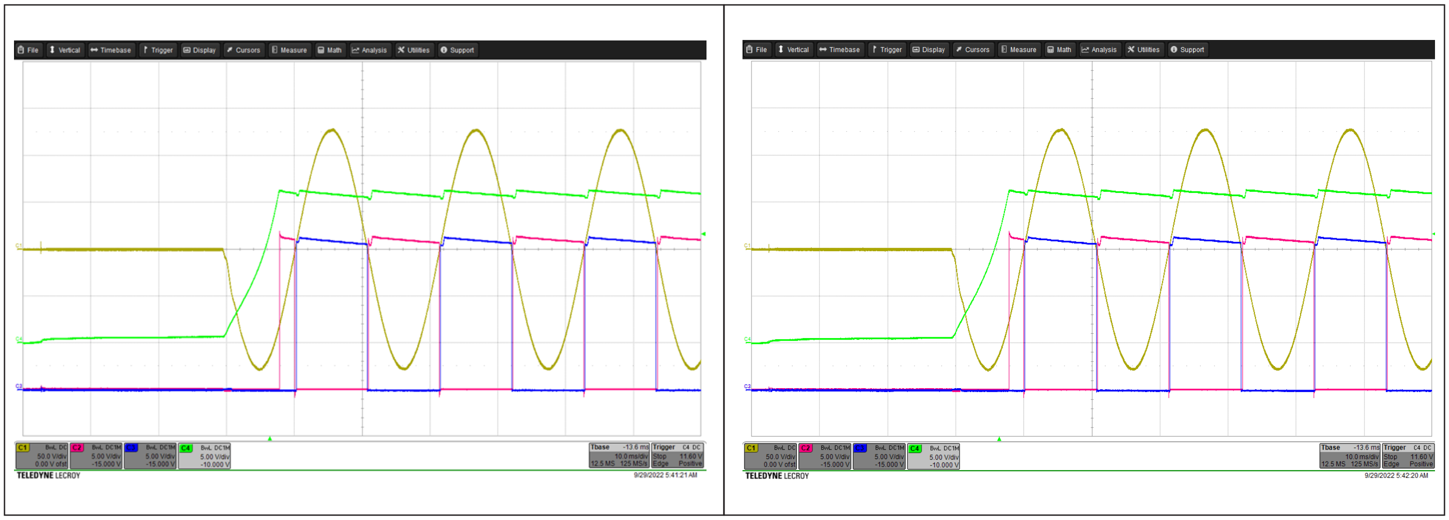


Figure 2. X-Cap Discharge Operation

Demonstration Board Performance

Start-up Sequence

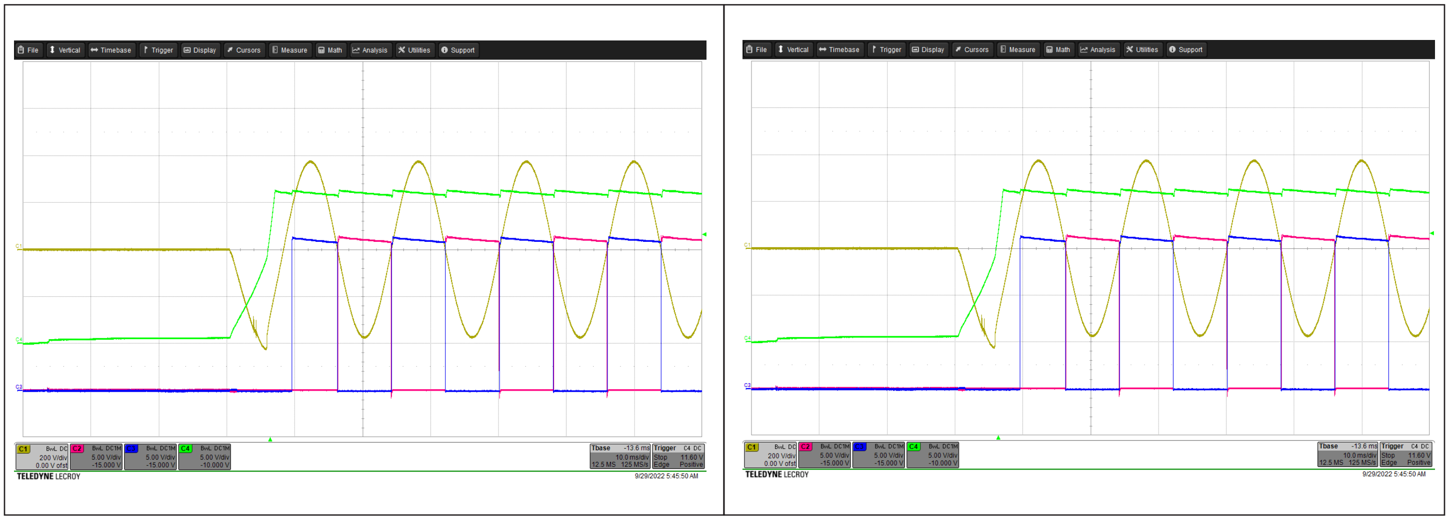
After AC input voltage is applied, the Vcc is charged to UVLO rising level VCC_UP, AOZ7203AV senses the voltages of input pins ACL and ACN to determine when to turn high or low one of the gates GATEL and GATEN. Figures 3 and 4 show the start-up sequence waveform at no load and 280W full load and high/low line conditions.



90 VAC/No Load 90 VAC/Full Load

CH1:VAC 50V/div, CH2:GATEL 5V/div, CH3:GATEN 5V/div, CH4:Vcc 5V/div

Figure 3. Start-up Waveform at 90 VAC



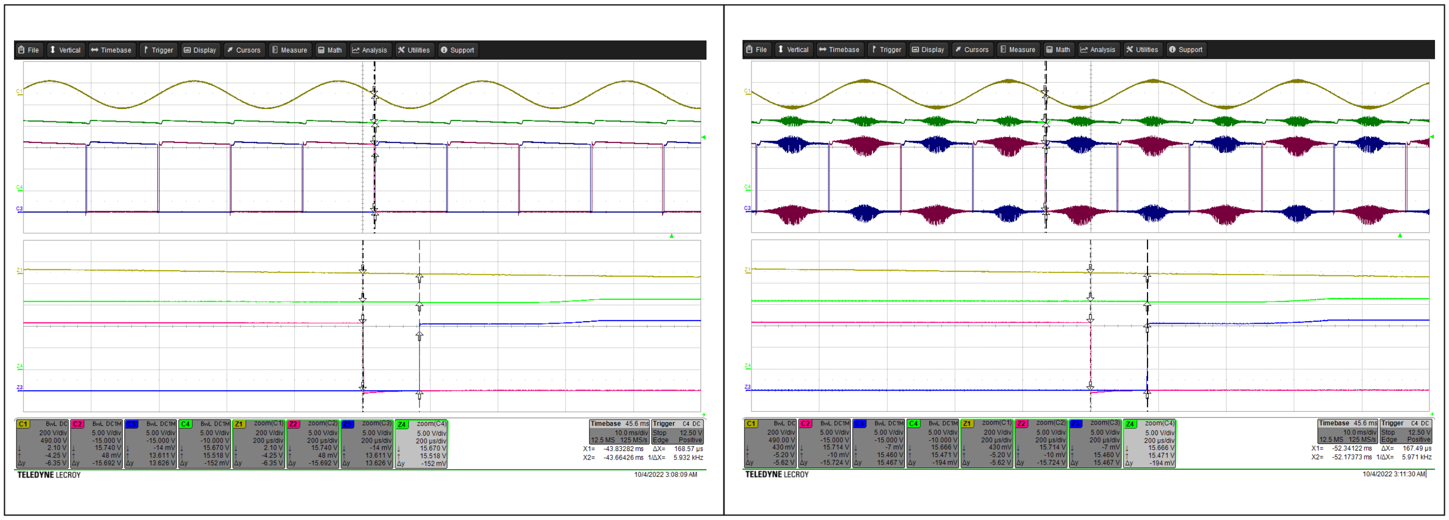
264 VAC/ No Load 264 VAC/ Full Load

CH1:VAC 200V/div, CH2:GATEL 5V/div, CH3:GATEN 5V/div, CH4:Vcc 5V/div

Figure 4. Start-up Waveform at 264 VAC

Normal Operation

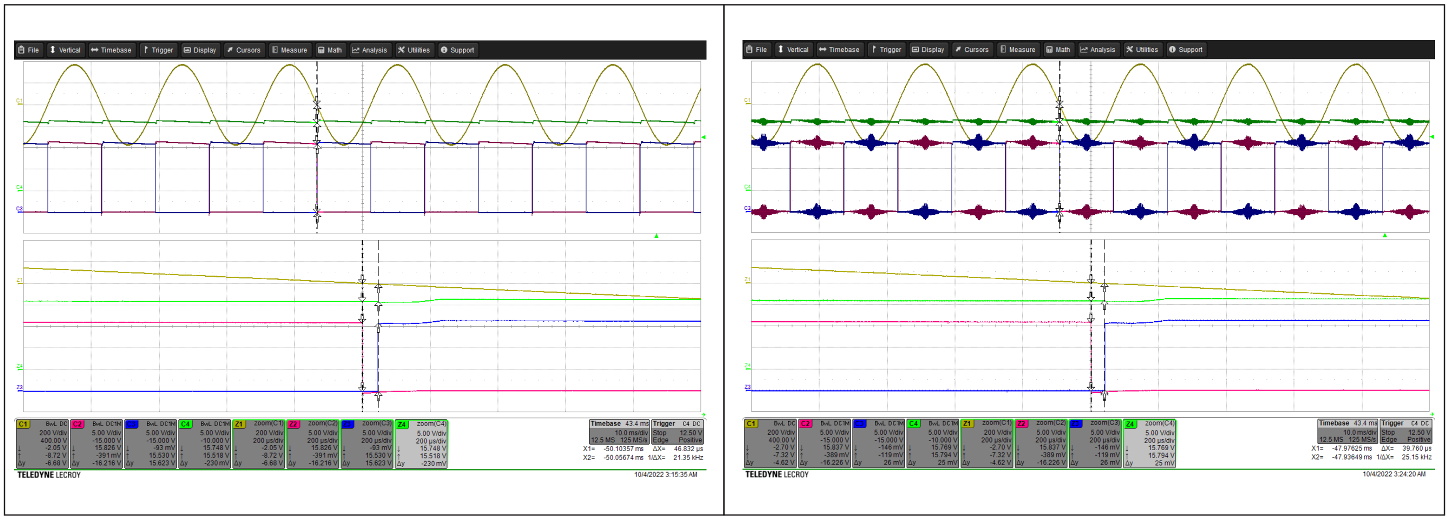
In the normal operation, when the ACL voltage approaches zero, and the ACN voltage rises above the switch turn-on threshold VACL/N_ON, the GATEL is turned high, and GATEL drives the N-MOSFET on. When this half AC cycle comes near the end, the ACN voltage falls below the switch turn-off threshold VACL/N_OFF, and the GATEL is turned low. Figures 5 and 6 show the normal operation waveform at no load and 280W full load and high/low line conditions. The waveform of GATEL and GATEN will not be overlapped in these conditions.



90 VAC/No Load **90 VAC/Full Load**

CH1:VAC 200V/div, CH2:GATEL 5V/div, CH3:GATEN 5V/div, CH4:Vcc 5V/div

Figure 5. Normal Operation Waveform at 90 VAC



264 VAC/ No Load **264 VAC/ Full Load**

CH1:VAC 200V/div, CH2:GATEL 5V/div, CH3:GATEN 5V/div, CH4:Vcc 5V/div

Figure 6. Normal Operation Waveform at 264 VAC

Efficiency

Below are the efficiency results of the 280W power supply, including using a bridge diode for the AC rectifier and using AOZ7203AV EVB for the AC rectifier. Figures 9 and 10 compare the test results of using the bridge diode and the AOZ7203AV EVB at 115 VAC/230 VAC input and full load/75% load/50% load/25% load condition.

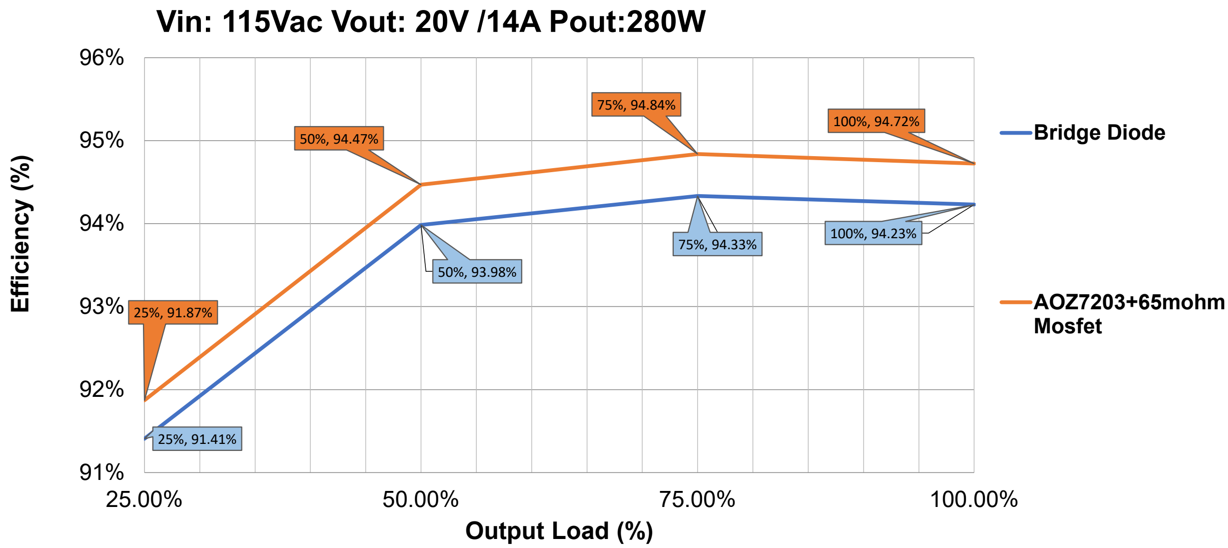


Figure 7. Efficiency Test Results at 115 VAC Input

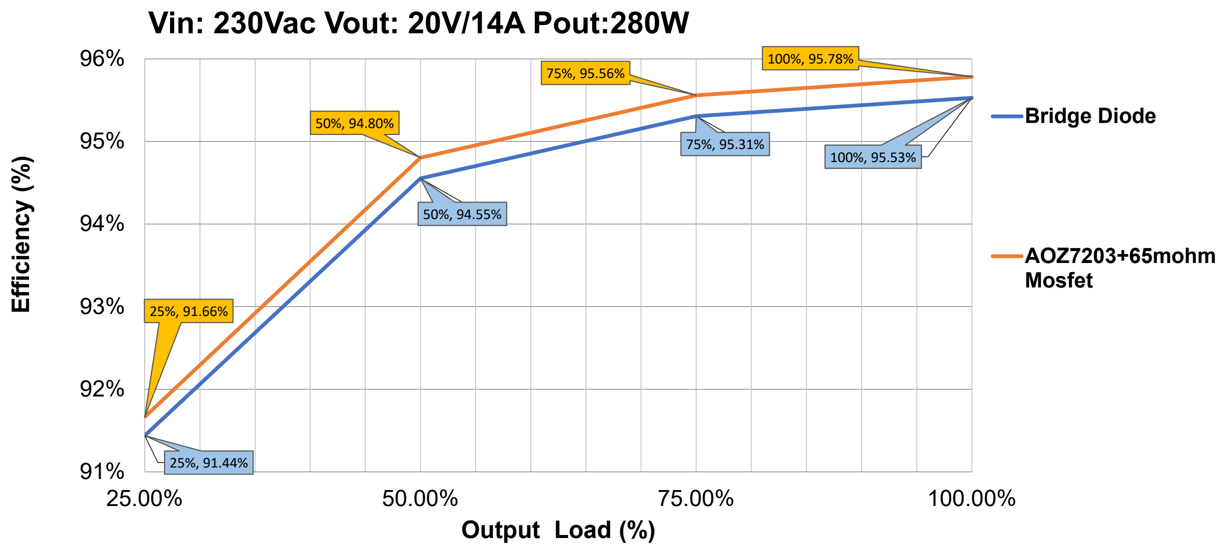


Figure 8. Efficiency Test Results at 230 VAC Input

Power Consumption at No Load

Below are the power consumption results of the 280W power supply at no load. These test results include using a bridge diode for the AC rectifier and using AOZ7203AV EVB for the AC rectifier. Tables 1 and 2 compare the power consumption results of using the bridge diode and the AOZ7203AV EVB at 115 VAC/230 VAC input conditions; the power consumption results of the AOZ7203AV EVB are almost the same as the bridge diode.

Table 1. Power Consumption at No Load and 115 VAC Input

Input Voltage	115VAC	
AC Rectifier	Bridge Diode with 280W Power Supply	AOZ7203 EVB with 280W Power Supply
Power Consumption at No Load	**157.26mW**	**158.16mW**

Table 2. Power Consumption at No Load and 230 VAC Input

Input Voltage	230VAC	
AC Rectifier	Bridge Diode with 280W Power Supply	AOZ7203 EVB with 280W Power Supply
Power Consumption at No Load	**229.27mW**	**232.07mW**

X-CAP Discharge Operation

In the X-CAP discharge mode, the X-CAP discharge current of AOZ7203 discharges the X capacitors via the ACL or ACN pins. Figure 9 shows the X-CAP discharge operation waveform at no load, and the capacitance value of X-cap is 6µf and 264 VAC input condition. The detected delay time of X-CAP discharge mode is nearly 110ms, and the discharge time is nearly 621ms. The test results can meet the safety requests of IEC-60950 and IEC-623268-1.

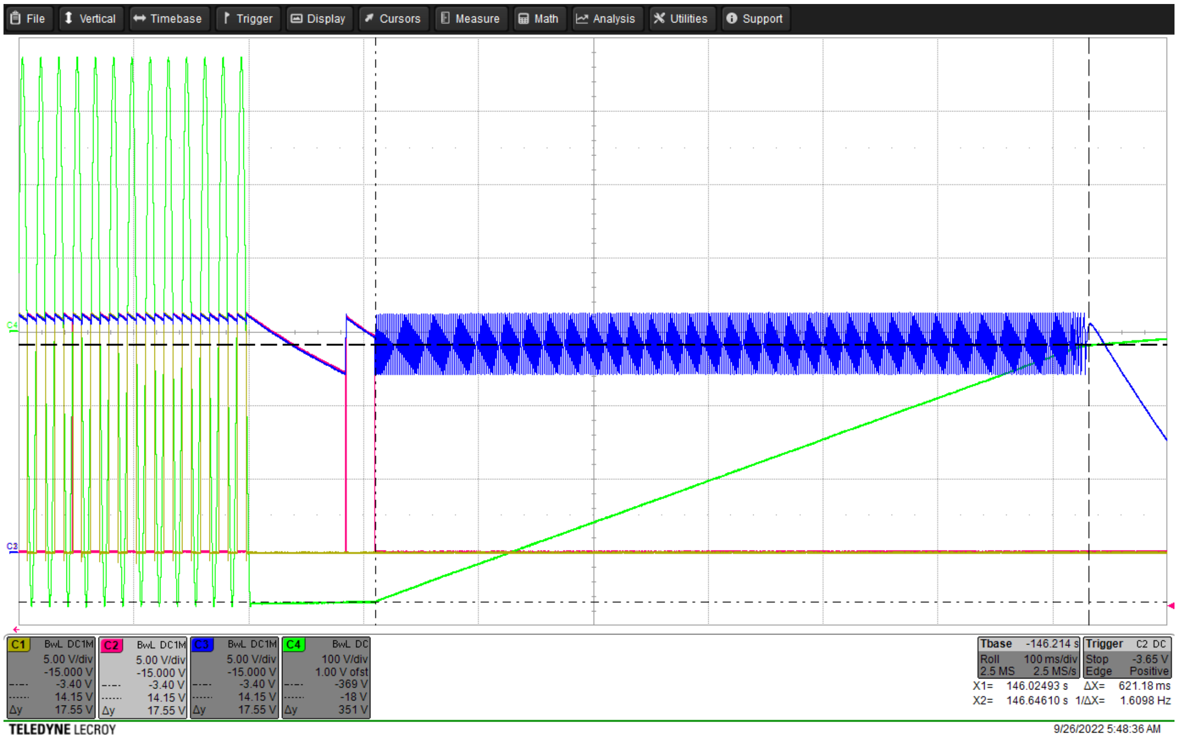


Figure 9. X-CAP Discharge Waveform

AC Line Transient

When AC voltage is changed from low line to high line or high line to low line, the AOZ7203 EVB no shoot-through occurs in the transient time of AC voltage change, and the active bridge circuit operates normally. Figures 10 and 11 show the AC line transient waveform at low line changes to the high line and high line changes to the low line. The waveform of GATEL and GATEN will not be overlapped in these conditions.

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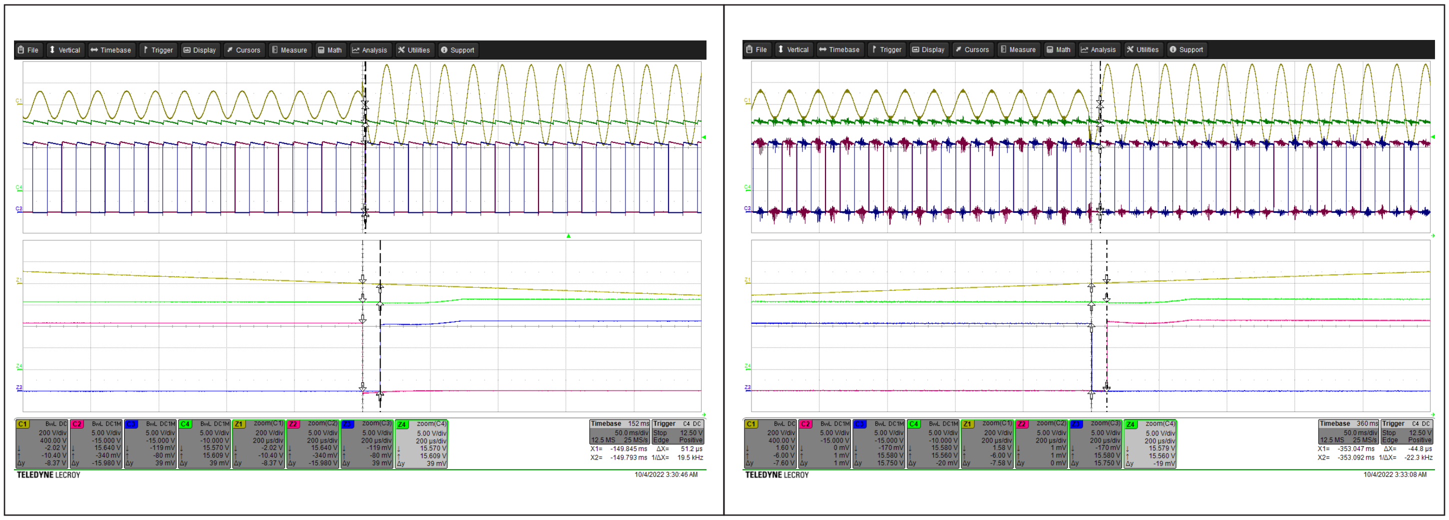
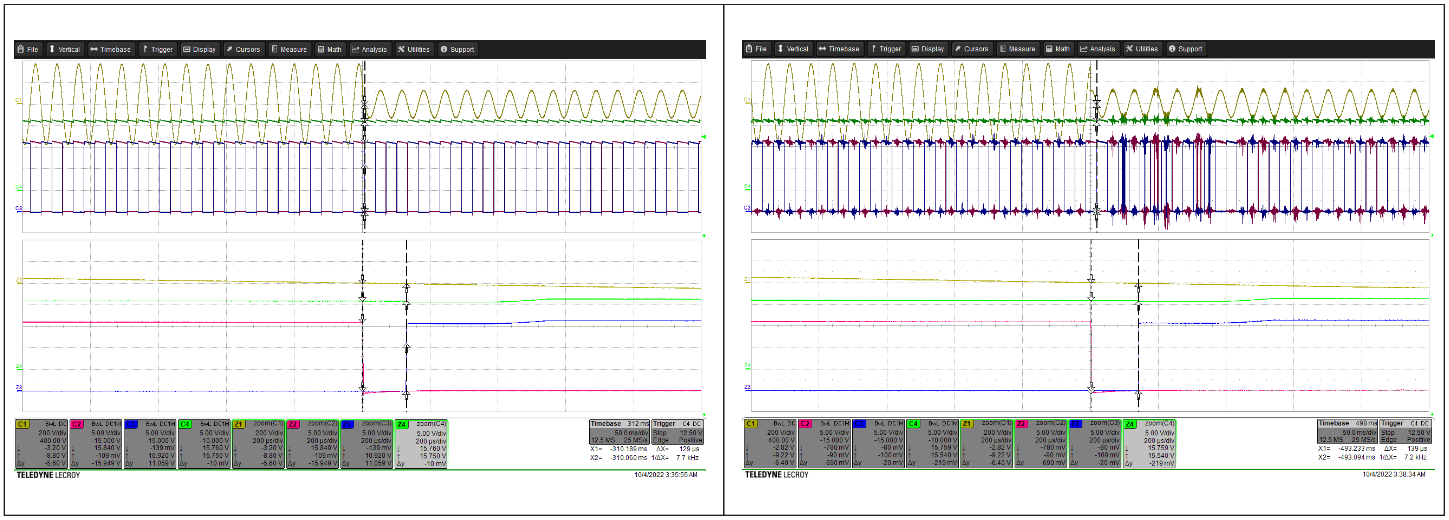


90 VAC to 264 VAC/ No Load **90 VAC to 264 VAC/ Full Load**

CH1:VAC 200V/div, CH2:GATEL 5V/div, CH3:GATEN 5V/div, CH4:Vcc 5V/div

Figure 10. AC Line Transient Waveform at 90 VAC



264 VAC to 90 VAC/ No Load **264 VAC to 90 VAC/ Full Load**

CH1:VAC 200V/div, CH2:GATEL 5V/div, CH3:GATEN 5V/div, CH4:Vcc 5V/div

Figure 11. AC Line Transient Waveform at 264 VAC

Surge Test Result

The AOZ7203 EVB with 280W power supply is tested surge test which is 3kV differential mode, between two AC line is added Varistor which is 14D511 in the test, the application circuit please refers to figure12. Table 3 shows surge test results, which can pass in the 3kV differential mode.

Table 3. Surge 3KV Differential Mode Test Results

Vin	Surge level	Polarity	Phase	Strikes	Criteria
230V	3kV	Positive	0	5	A
230V	3kV	Positive	90	5	A
230V	3kV	Positive	180	5	A
230V	3kV	Positive	270	5	A
230V	3kV	Negative	0	5	A
230V	3kV	Negative	90	5	A
230V	3kV	Negative	180	5	A
230V	3kV	Negative	270	5	A

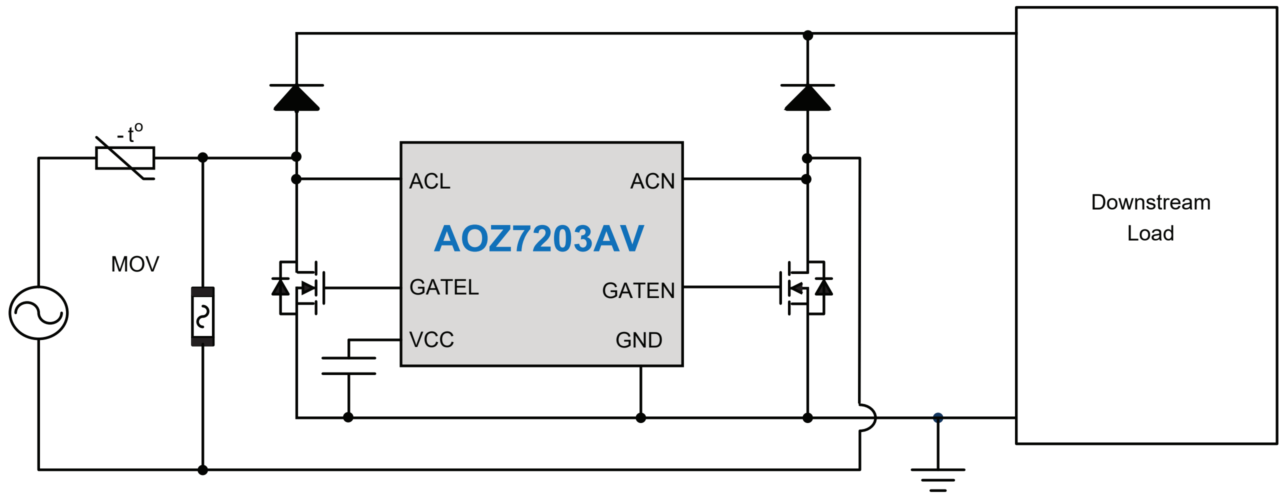


Figure 12. Application Circuit

Demonstration Board Circuit Configuration

The demonstration board circuit of AOZ7203AV, as shown in figure 13, consisted of four high voltage diodes, two high voltage MOSFETs, one 0805 size capacitor, two 0603 size resistors, and one AOZ7203 controller. R3, R4, D5, D6, B3, and B4 are recommended for high frequency noise suppression.

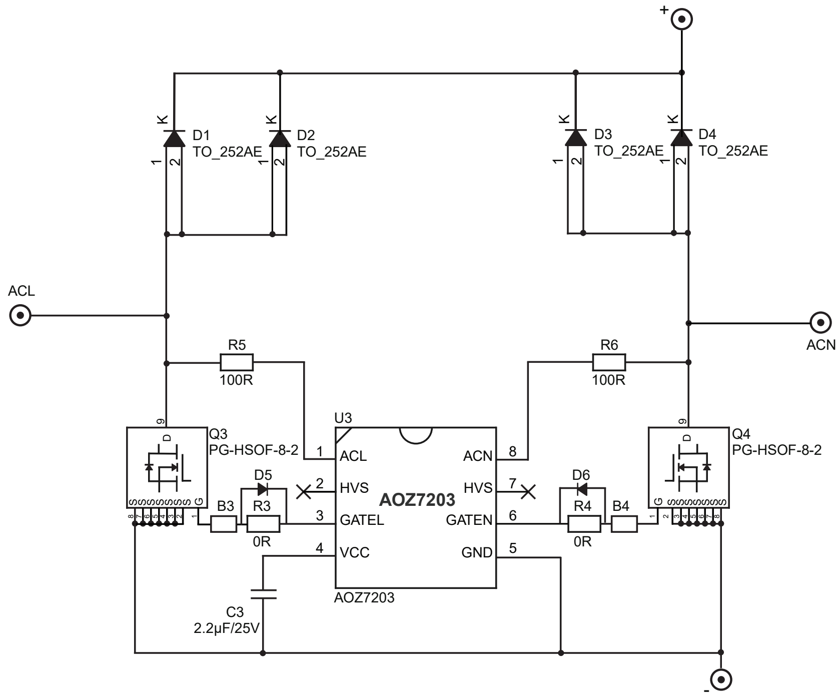
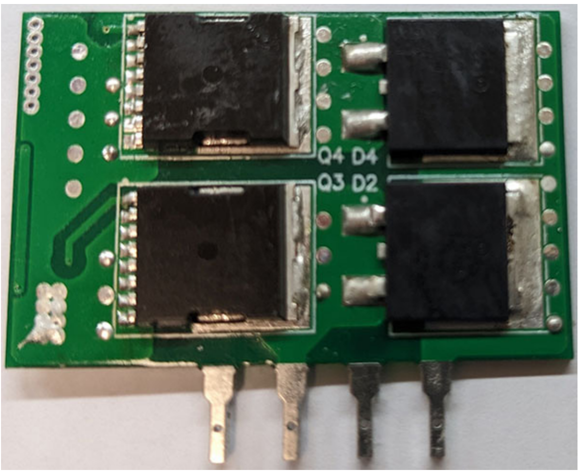


Figure 13. Demonstration Circuit

Demonstration Board Photograph

The demonstration board consists of two 600V/45mΩ MOSFETs, two 600V/20A diodes, and an AOZ7203 active bridge controller. The demonstration board has four leads that can directly replace traditional bridge diode. The photograph of the demonstration board is shown in figure 14.



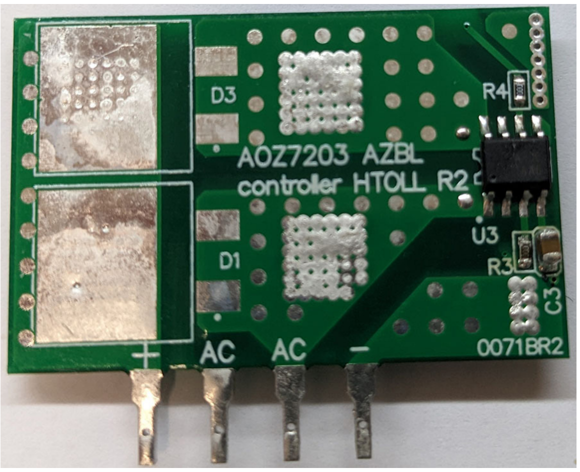


Figure 14. The Demonstration Board Photograph of AOZ7203AV

Bill of Materials

Table 4. The BOM List of the Demonstration Board

Component Location	Component Description	Part Number	Manufacturer
D2 - D4	20A/600V	SE20DJ	Vishay
D1 - D3	N/A		
Q1 - Q2	8A/600V/Rds(on) = 65mΩ	AOTL065A60	AOS
U1	Active Bridge Controller	AOZ7203AV	AOS
R3 - R4	0Ω 0603		
C3	2.2µf/25V 0805		
R5 - R6	100 ~ 510Ω 0603		
D5 - D6	N/A		
B3 - B4	N/A		

Layout Guidelines

The layout rules of AOZ7203AV suggest referring to the items below:

- The peripheral components are placed as close as possible to the IC.
- Large copper-clad and multi-layer PCB are recommended for cooling.
- Adding vias on the exposed pad can let heat quickly pass through to other layers.
- G-S pull down resistor value normally is over 10kΩ, recommend fine-tune Rgs value that maintain Vcc_min above 14.5V while gate on period.
- Recommend to separate signal and power GND pattern.

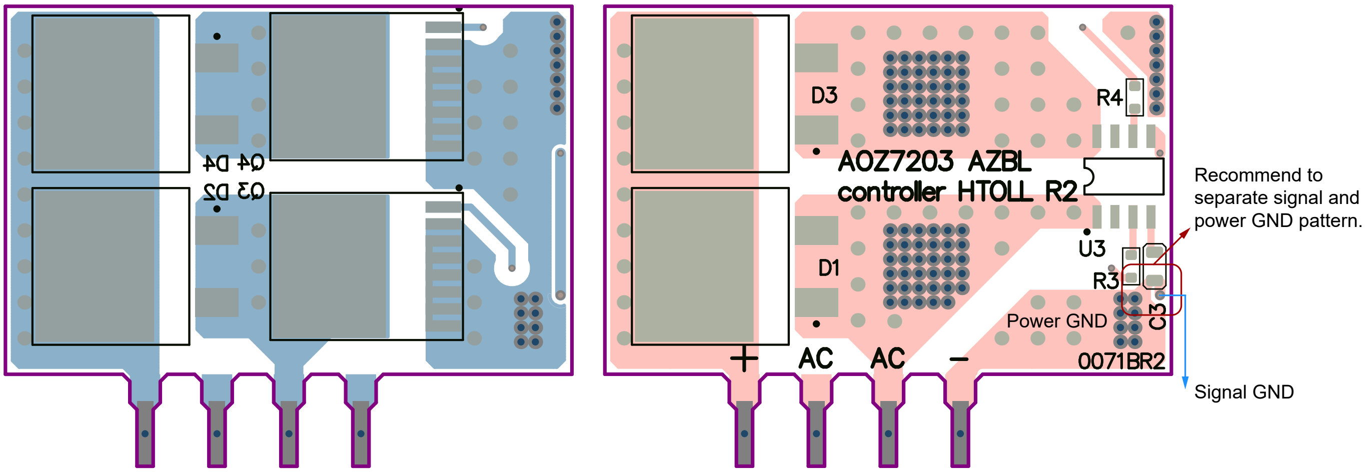


Figure 15. The Demonstration Board Layout Example of AOZ7203AV

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