

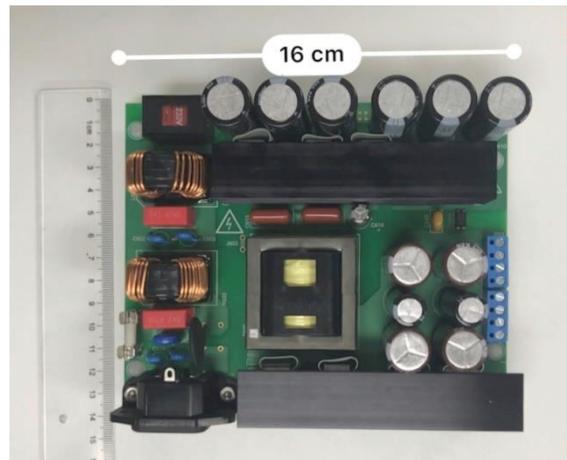
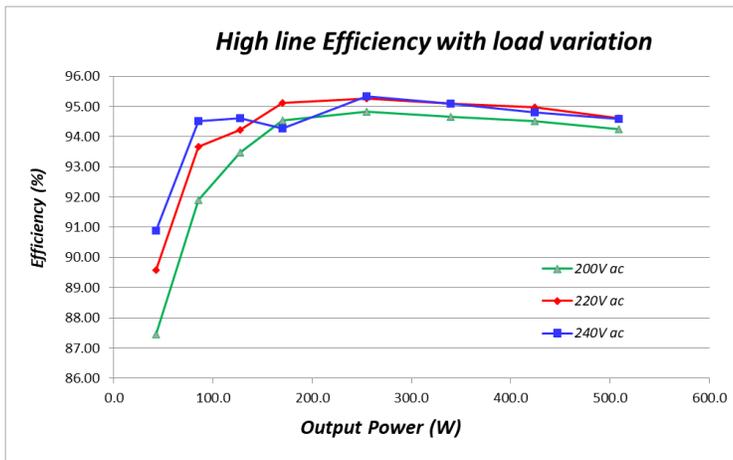
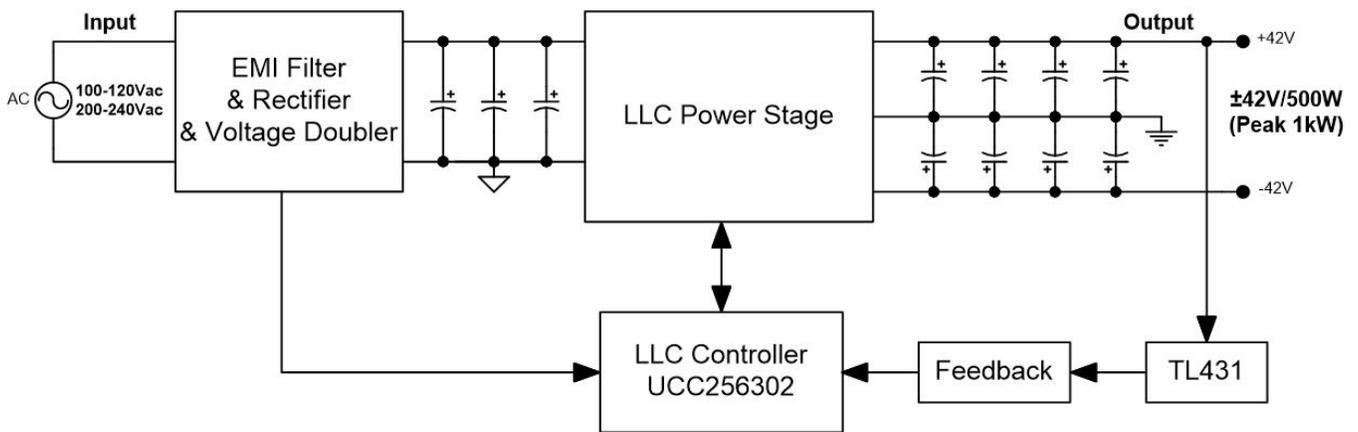
Test Report: PMP40379

500-W, Single Stage LLC Power Supply Reference Design for Audio Amplifier



Description

The PMP40379 is a single stage LLC converter to convert AC input voltage (100-120V_{AC} and 200-240V_{AC}) to isolated $\pm 42V$ DC output with the UCC256302 controller. The PMP40379 has a regulated $\pm 42V$ output that can handle up to 6A of continuous output current and 12A of peak current for 100ms.



An IMPORTANT NOTICE at the end of this TI reference design addresses authorized use, intellectual property matters and other important disclaimers and information.

1 Test Prerequisites

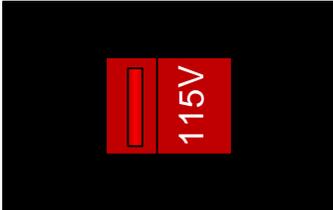
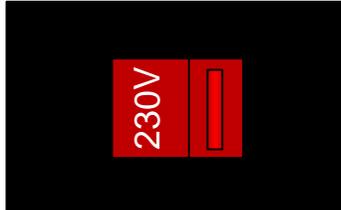
1.1 System Specification

Table 1. System Specification

PARAMETER	SYMBOL	TEST CONDITIONS	MIN	NOM	MAX	UNIT
INPUT CHARACTERISTICS						
High Line Input voltage	V_{AC_HL}	S600 switch to 230V	200	220	240	V
Low Line Input voltage	V_{AC_LL}	S600 switch to 115V	100	110	120	V
Frequency	F_{AC}		47	-	63	Hz
Start-up Input voltage	V_{AC_START}	$I_{OUT} = 0A$, S600 switch to 230V	-	190	-	Vac
Input OVP	V_{IN_UVLO}	$I_{OUT} = 0A$, S600 switch to 230V	-	250	-	Vac
Input UVLO	V_{IN_UVLO}	$I_{OUT} = 0A$, S600 switch to 230V	-	140	-	Vac
OUTPUT CHARACTERISTICS						
Positive Output voltage	V_{OUT1}	$V_{IN} = \text{nom}$, $I_{OUT} = \text{min to max}$	-	42	-	V
Positive Output current	I_{OUT1}	$V_{IN} = \text{min to max}$, $I_{max} < 100\text{ms}$	0	6	12	A
Negative Output voltage	V_{OUT2}	$V_{IN} = \text{nom}$, $I_{OUT} = \text{min to max}$	-	-42	-	V
Negative Output current	I_{OUT2}	$V_{IN} = \text{min to max}$, $I_{max} < 100\text{ms}$	0	6	12	A
Output power	P_{OUT}	$V_{IN} = \text{min to max}$	-	500	1000	W
Output voltage ripple	V_{OUT_RIPPLE}	$V_{IN} = \text{nom}$, $I_{OUT} = \text{max}$	-	-	500	mV
SYSTEM CHARACTERISTICS						
Switching frequency	f_{SW}	$V_{IN} = 220V$, $P_{out} = 500W$	-	60	-	kHz
Peak efficiency	η_{PEAK}	$V_{IN} = 220V$, $I_{OUT} = 3A$	-	-	95.33	%

1.2 Warning

The PMP40379B board can operate with a 115/230Vac input voltage, please verify that the AC mains voltage level matches the setting of the line voltage selector switch S600. If the line selector switch was initially in the incorrect position, set the switch S600 to the correct line voltage as shown in below Figure before plugging in the power cord and turn on the power. Line fuses do not need to be changed when the line voltage is changed.

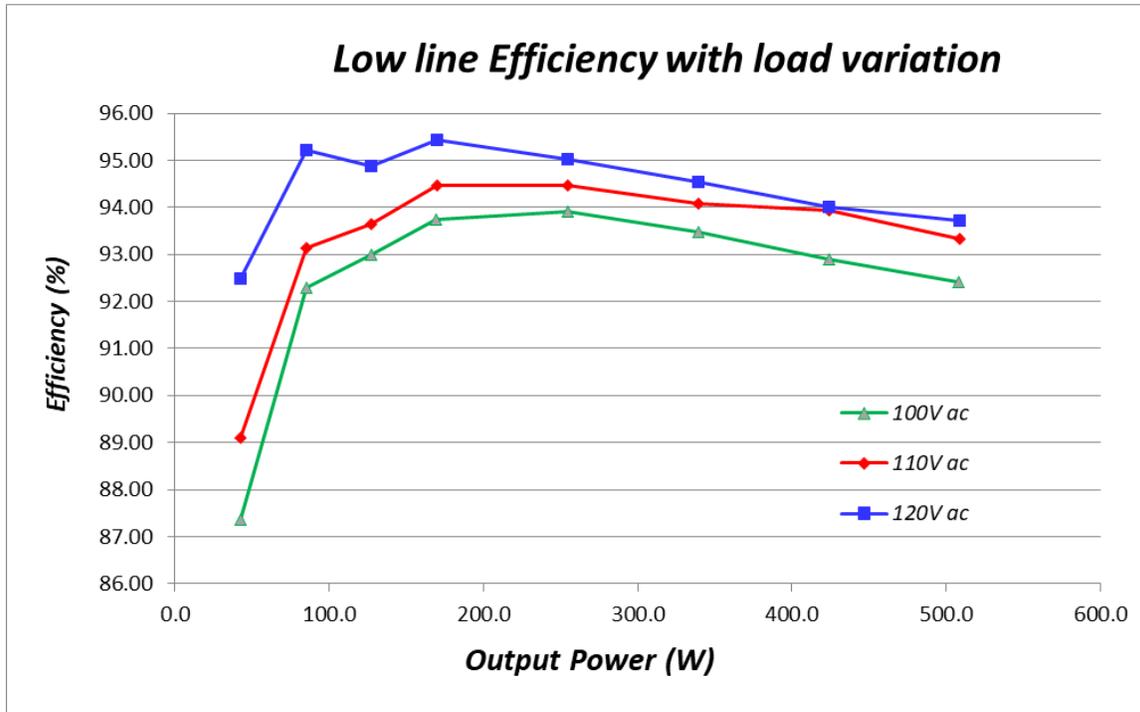
Low Line Input (100-120Vac) Switch Position	High Line Input (200-240Vac) Switch Position
	

High voltage may be present after power down of the PMP40379 board for a long time. Check bulk capacitor and output terminals with a voltage meter, and make sure the bulk capacitors (C605-C610) and output capacitors (C632-C639) has completely discharged before handling the PMP40379B board.

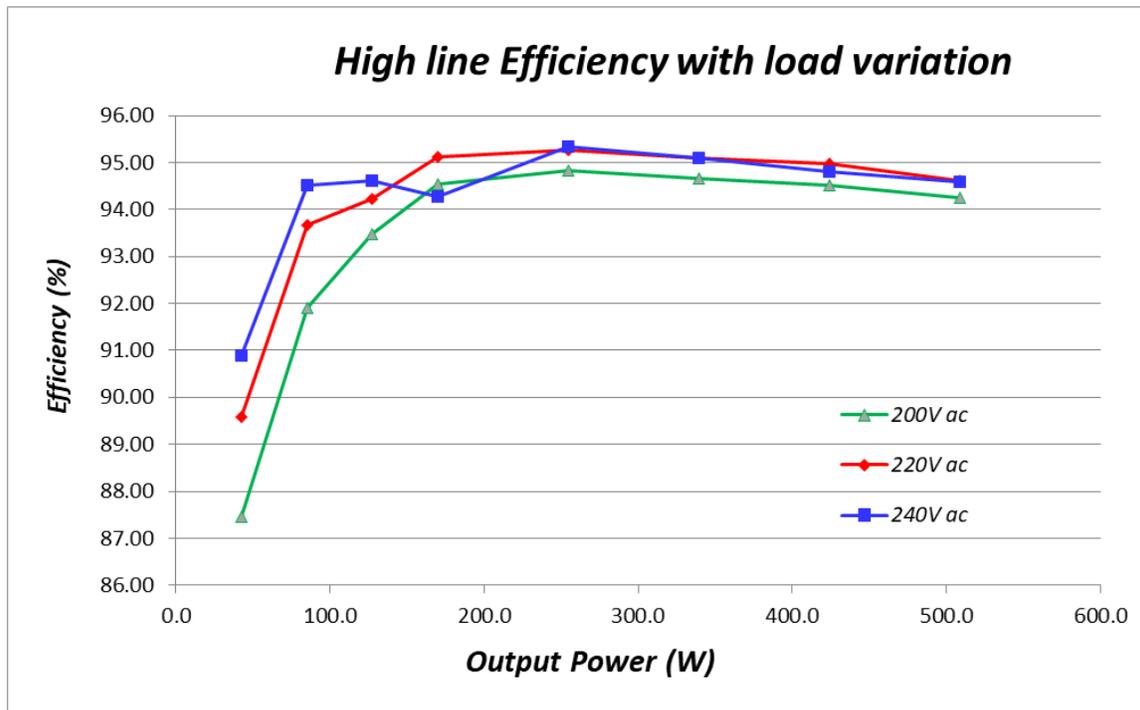
2 Testing and Results

2.1 Efficiency Graphs

The converter efficiency is shown in the figures below for a 100VAC-120VAC input with a $\pm 42V$ output.



The converter efficiency is shown in the figures below for a 200VAC-240VAC input with a $\pm 42V$ output.



2.2 Efficiency Data

Below is the efficiency data for 100VAC-120VAC input with $\pm 42V$ output

V_{INAC} (V)	I_{INAC} (A)	P_{IN} (W)	PF	V_{OUT+} (V)	I_{OUT+} (A)	V_{OUT-} (V)	I_{OUT-} (A)	P_{OUT} (W)	P_{LOSS} (W)	Eff(%)
100	0.90	48.6	0.540	42.46	0.5	42.45	0.5	42.5	6.1	87.36
100	1.65	92.0	0.556	42.46	1.0	42.44	1.0	84.9	7.1	92.28
100	2.41	136.9	0.567	42.45	1.5	42.43	1.5	127.3	9.6	93.00
100	3.14	180.7	0.575	42.45	2.0	42.26	2.0	169.4	11.3	93.75
100	4.61	271.0	0.587	42.44	3.0	42.39	3.0	254.5	16.5	93.91
100	6.07	362.9	0.598	42.44	4.0	42.36	4.0	339.2	23.7	93.46
100	7.53	456.2	0.606	42.42	5.0	42.33	5.0	423.7	32.5	92.88
100	8.96	549.9	0.614	42.41	6.0	42.29	6.0	508.2	41.7	92.41
V_{INAC} (V)	I_{INAC} (A)	P_{IN} (W)	PF	V_{OUT+} (V)	I_{OUT+} (A)	V_{OUT-} (V)	I_{OUT-} (A)	P_{OUT} (W)	P_{LOSS} (W)	Eff(%)
110	0.81	47.7	0.535	42.47	0.5	42.46	0.5	42.5	5.2	89.11
110	1.51	91.2	0.550	42.46	1.0	42.45	1.0	84.9	6.3	93.13
110	2.21	136.0	0.561	42.46	1.5	42.43	1.5	127.3	8.7	93.64
110	2.88	179.7	0.568	42.46	2.0	42.42	2.0	169.8	10.0	94.46
110	4.22	269.5	0.581	42.45	3.0	42.40	3.0	254.6	14.9	94.46
110	5.56	360.7	0.590	42.45	4.0	42.38	4.0	339.3	21.4	94.07
110	6.86	451.4	0.599	42.45	5.0	42.36	5.0	424.0	27.4	93.93
110	8.17	545.0	0.606	42.44	6.0	42.33	6.0	508.6	36.4	93.32
V_{INAC} (V)	I_{INAC} (A)	P_{IN} (W)	PF	V_{OUT+} (V)	I_{OUT+} (A)	V_{OUT-} (V)	I_{OUT-} (A)	P_{OUT} (W)	P_{LOSS} (W)	Eff(%)
120	0.72	45.9	0.530	42.49	0.5	42.48	0.5	42.5	3.4	92.49
120	1.36	89.2	0.545	42.48	1.0	42.47	1.0	85.0	4.3	95.22
120	2.01	134.3	0.555	42.48	1.5	42.46	1.5	127.4	6.9	94.87
120	2.64	178.0	0.563	42.48	2.0	42.45	2.0	169.9	8.1	95.42
120	3.88	268.0	0.575	42.47	3.0	42.42	3.0	254.7	13.3	95.03
120	5.12	359.1	0.584	42.47	4.0	42.40	4.0	339.5	19.6	94.54
120	6.34	451.2	0.593	42.47	5.0	42.37	5.0	424.2	27.0	94.01
120	7.54	543.0	0.600	42.46	6.0	42.35	6.0	508.8	34.2	93.71

Below is the efficiency data for 200VAC-240VAC input with $\pm 42\text{V}$ output

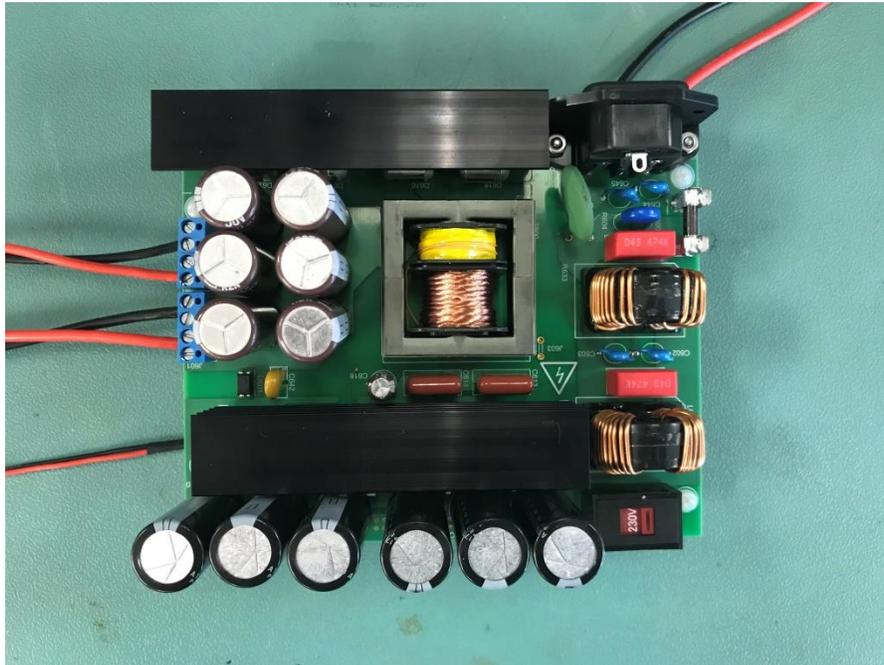
V_{INAC} (V)	I_{INAC} (A)	P_{IN} (W)	PF	$V_{\text{OUT+}}$ (V)	$I_{\text{OUT+}}$ (A)	$V_{\text{OUT-}}$ (V)	$I_{\text{OUT-}}$ (A)	P_{OUT} (W)	P_{LOSS} (W)	Eff(%)
200	0.514	48.6	0.471	42.47	0.5	42.46	0.5	42.5	6.1	87.45
200	0.951	92.4	0.485	42.47	1.0	42.46	1.0	84.9	7.5	91.91
200	1.379	136.2	0.493	42.47	1.5	42.44	1.5	127.4	8.9	93.48
200	1.796	179.6	0.499	42.46	2.0	42.43	2.0	169.8	9.8	94.54
200	2.640	268.5	0.508	42.46	3.0	42.41	3.0	254.6	13.9	94.82
200	3.481	358.4	0.514	42.45	4.0	42.38	4.0	339.3	19.1	94.67
200	4.313	448.5	0.519	42.44	5.0	42.35	5.0	423.9	24.6	94.52
200	5.144	539.5	0.524	42.43	6.0	42.32	6.0	508.5	31.0	94.25
V_{INAC} (V)	I_{INAC} (A)	P_{IN} (W)	PF	$V_{\text{OUT+}}$ (V)	$I_{\text{OUT+}}$ (A)	$V_{\text{OUT-}}$ (V)	$I_{\text{OUT-}}$ (A)	P_{OUT} (W)	P_{LOSS} (W)	Eff(%)
220	0.462	47.4	0.467	42.48	0.5	42.48	0.5	42.5	4.9	89.59
220	0.857	90.7	0.480	42.48	1.0	42.46	1.0	84.9	5.7	93.68
220	1.256	135.2	0.489	42.47	1.5	42.45	1.5	127.4	7.8	94.23
220	1.640	178.5	0.494	42.47	2.0	42.44	2.0	169.8	8.7	95.11
220	2.414	267.3	0.503	42.47	3.0	42.41	3.0	254.6	12.7	95.25
220	3.182	356.9	0.509	42.46	4.0	42.39	4.0	339.4	17.5	95.09
220	4.255	446.6	0.515	42.46	5.0	42.37	5.0	424.1	22.5	94.97
220	4.701	537.7	0.520	42.45	6.0	42.34	6.0	508.7	29.0	94.61
V_{INAC} (V)	I_{INAC} (A)	P_{IN} (W)	PF	$V_{\text{OUT+}}$ (V)	$I_{\text{OUT+}}$ (A)	$V_{\text{OUT-}}$ (V)	$I_{\text{OUT-}}$ (A)	P_{OUT} (W)	P_{LOSS} (W)	Eff(%)
240	0.422	46.8	0.462	42.49	0.5	42.49	0.5	42.5	4.3	90.88
240	0.786	89.9	0.476	42.49	1.0	42.48	1.0	85.0	4.9	94.52
240	1.157	134.7	0.485	42.49	1.5	42.46	1.5	127.4	7.3	94.61
240	1.529	180.2	0.490	42.49	2.0	42.45	2.0	169.9	10.3	94.27
240	2.229	267.2	0.499	42.48	3.0	42.43	3.0	254.7	12.5	95.33
240	2.940	357.0	0.505	42.48	4.0	42.40	4.0	339.5	17.5	95.10
240	3.648	447.5	0.511	42.47	5.0	42.38	5.0	424.3	23.2	94.81
240	4.347	538.0	0.515	42.46	6.0	42.35	6.0	508.9	29.1	94.59

2.3 Standby Efficiency Data

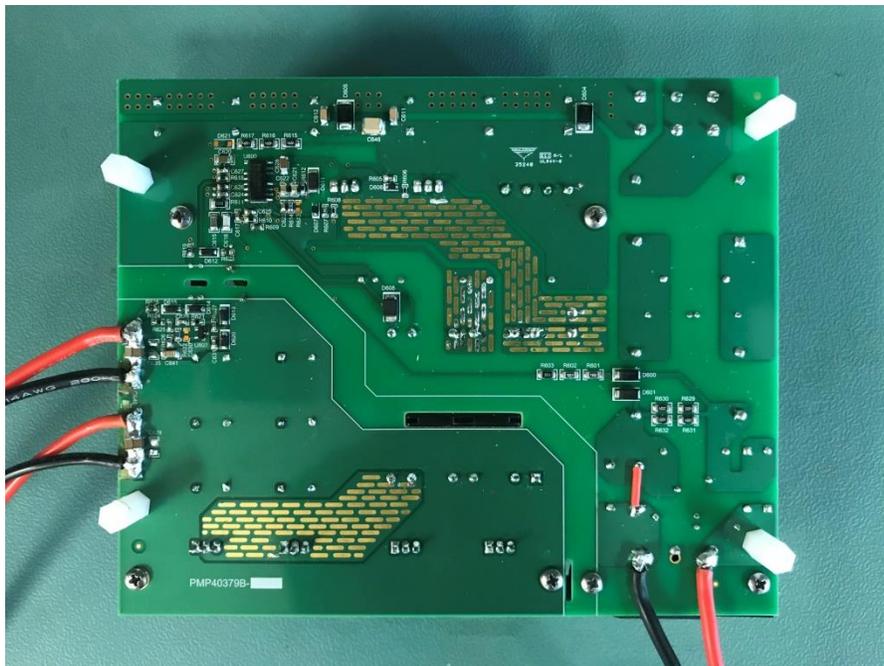
V_{INAC} (V)	I_{INAC} (mA)	P_{IN} (mW)	V_{OUT1} (V)	V_{OUT2} (V)	P_{OUT} (W)	No Load Power(mW)
100	37.95	477.0	42.44	42.42	0.0	477.00
110	41.08	411.4	42.44	42.43	0.0	411.40
120	44.54	380.5	42.44	42.43	0.0	380.50
200	73.76	529.1	42.44	42.42	0.0	529.10
220	81.05	458.6	42.44	42.43	0.0	458.60
240	88.36	436.9	42.44	42.43	0.0	436.90

2.4 Dimensions

The photos below show the top and bottom view of the PMP40379B board. Board dimension is 160mm x 130mm.



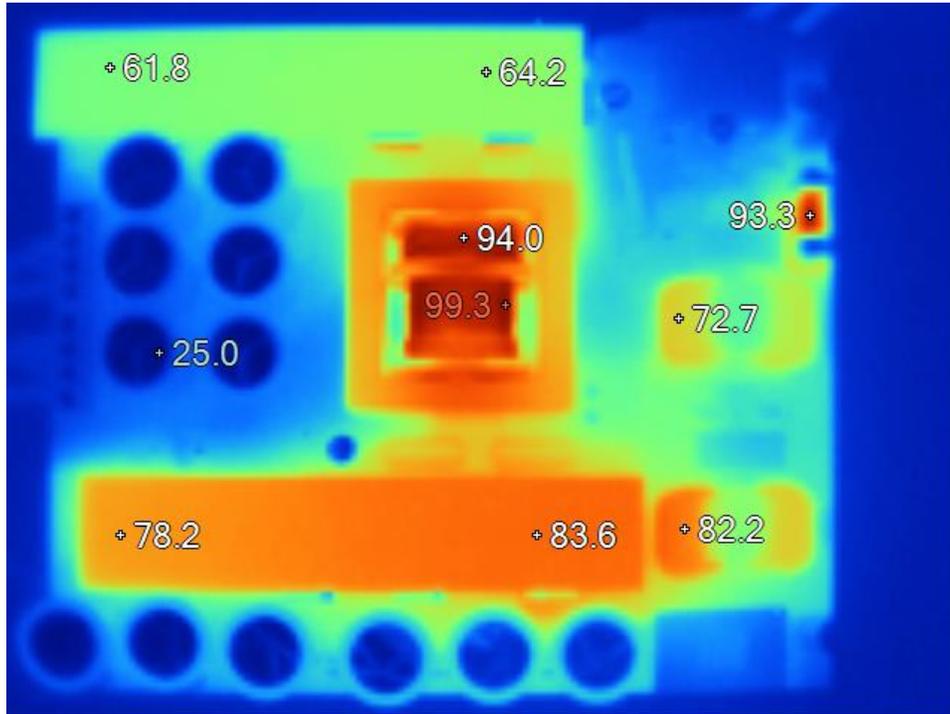
Top side



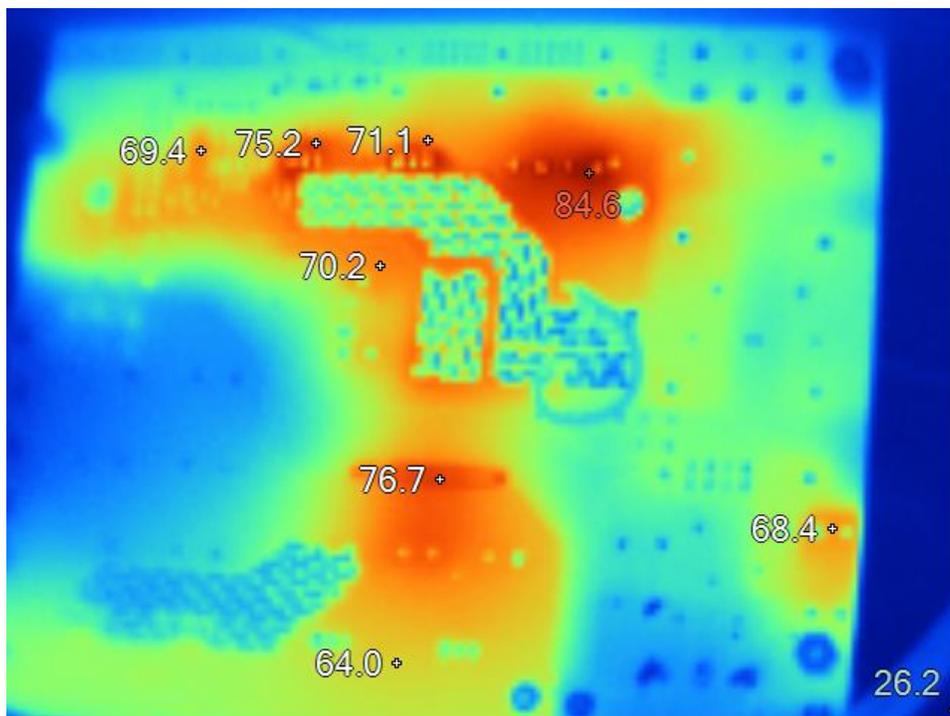
Bottom side

2.5 Thermal Images

The thermal images below show a top view and bottom view of the board. The board is placed vertically during the test, where the input and output connectors are at the bottom side. The ambient temperature was 25°C with no air flow. The input voltage was 110Vac/60Hz and the output was loaded with $\pm 42V/6A$.



Top side

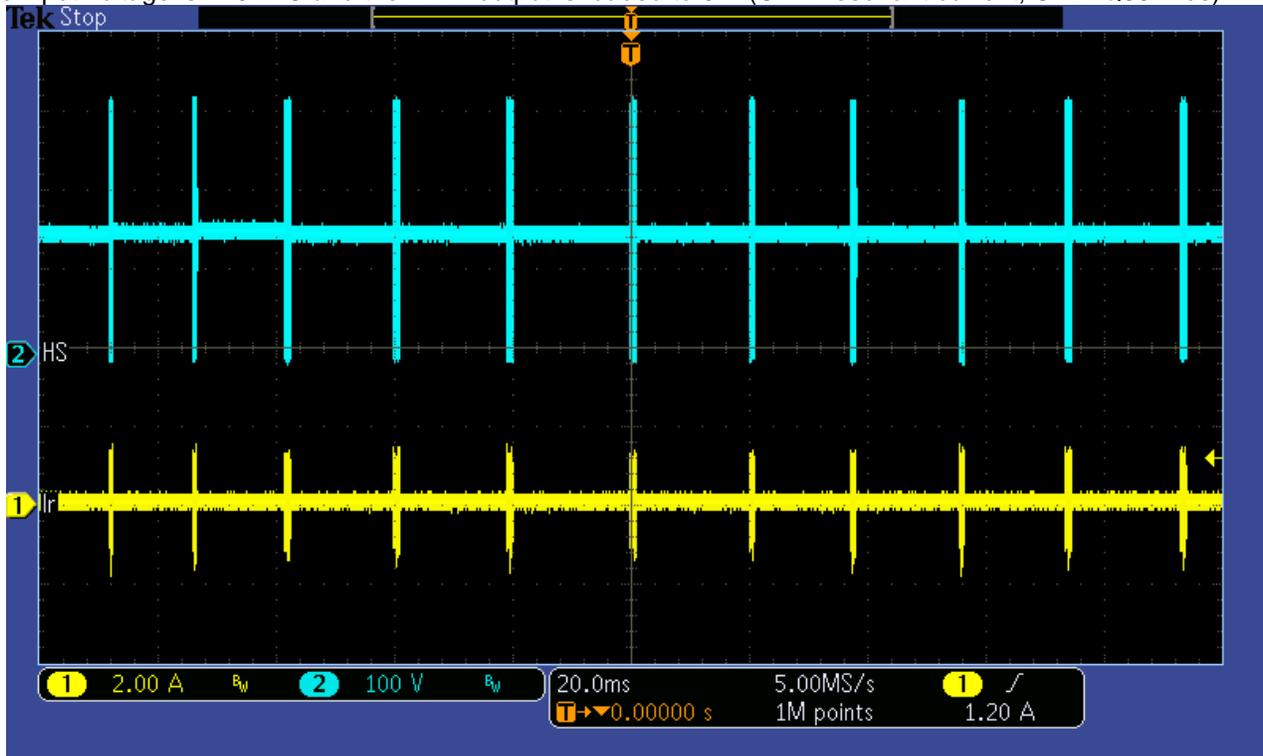


Bottom side

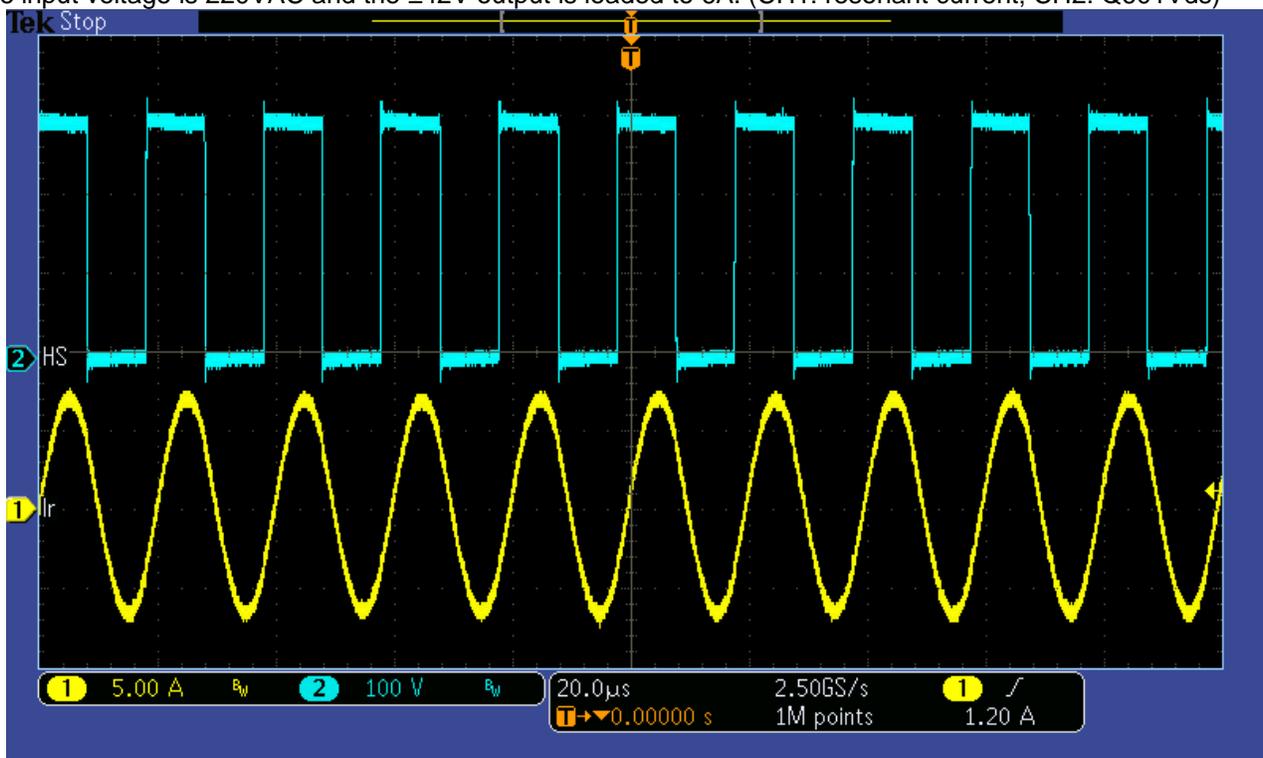
3 Waveforms

3.1 Switch Node

The photo below shows the switch node voltage (Q601 Vds) and resonant current waveforms at no load. The input voltage is 220VAC and the $\pm 42\text{V}$ output is loaded to 0A. (CH1: resonant current; CH2: Q601Vds)

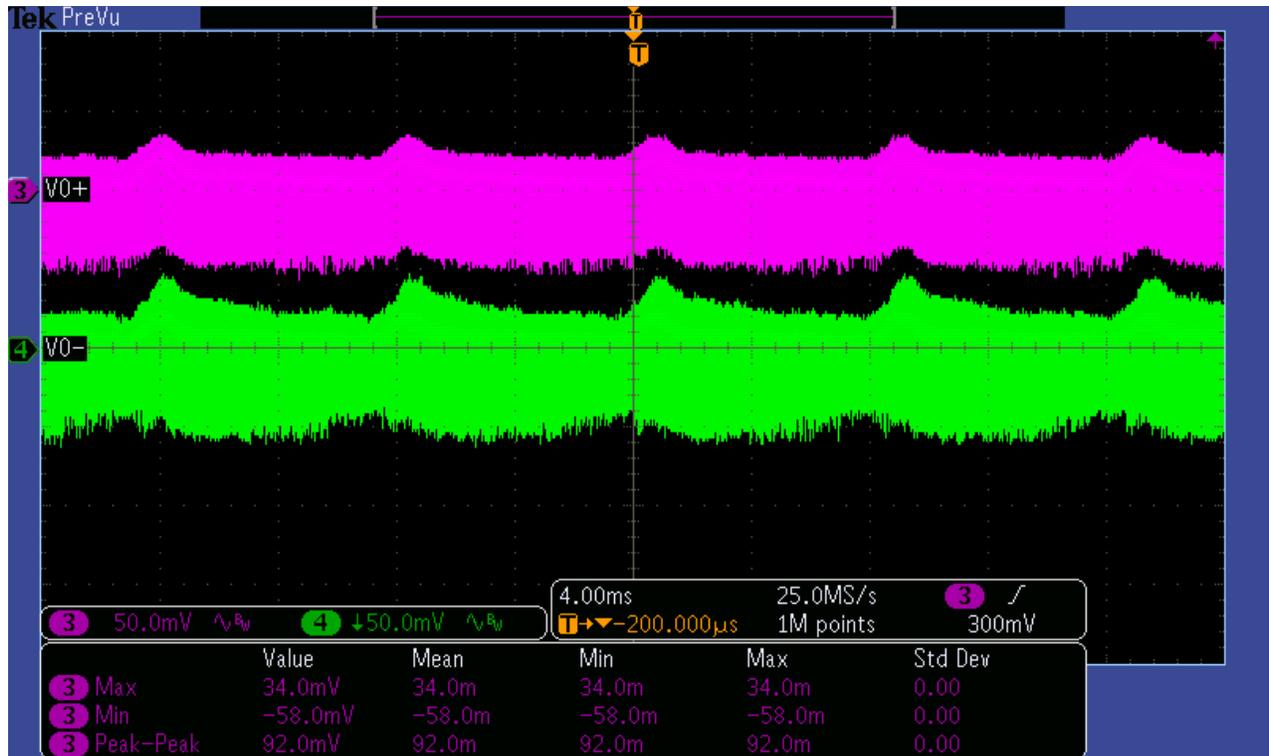


The photo below shows the switch node voltage (Q601 Vds) and resonant current waveforms at full load. The input voltage is 220VAC and the $\pm 42\text{V}$ output is loaded to 6A. (CH1: resonant current; CH2: Q601Vds)



3.2 Output Voltage Ripple

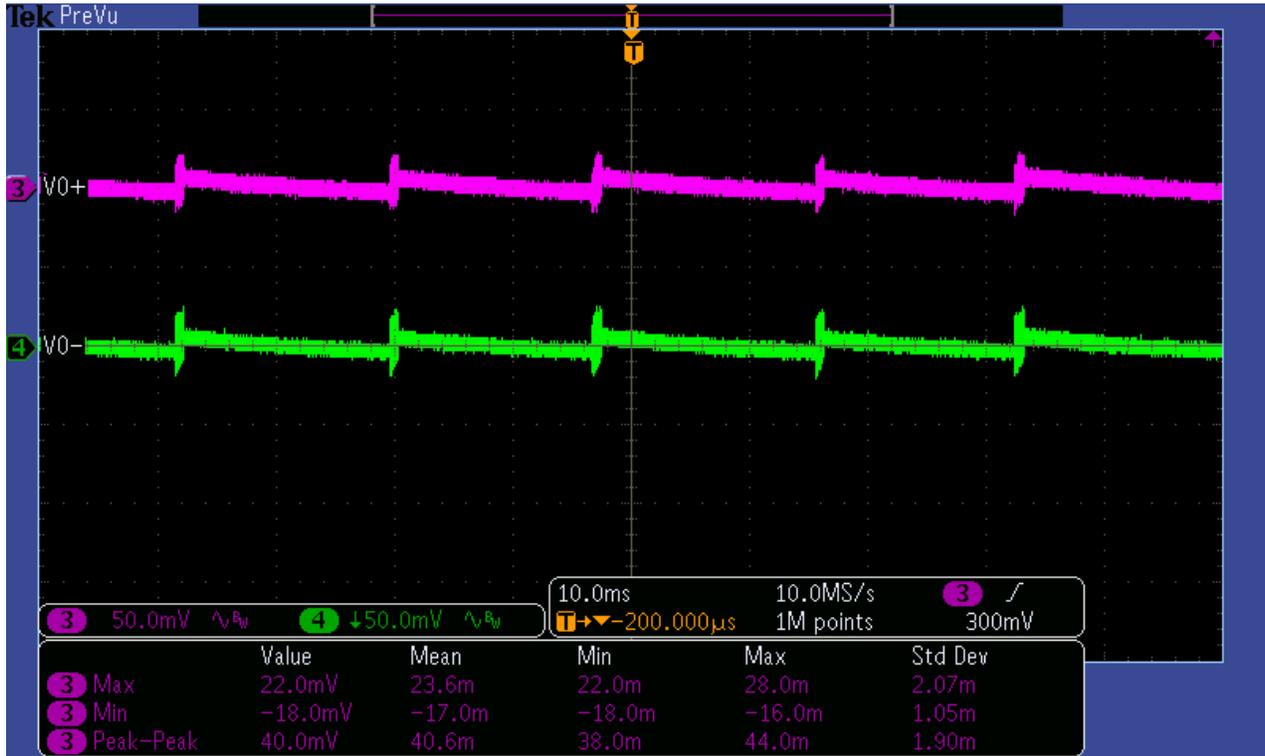
The output ripple voltage is shown in the figure below. The image was taken with the $\pm 42\text{V}$ output loaded to 6A and the input voltage set to 110VAC. (CH3: +42V output in AC coupling, CH4: -42V output in AC coupling)



The output ripple voltage is shown in the figure below. The image was taken with the $\pm 42\text{V}$ output loaded to 6A and the input voltage set to 220VAC. (CH3: +42V output in AC coupling, CH4: -42V output in AC coupling)



The output ripple voltage is shown in the figure below. The image was taken with the $\pm 42\text{V}$ output loaded to 0A and the input voltage set to 110VAC . (CH3: $+42\text{V}$ output in AC coupling, CH4: -42V output in AC coupling)

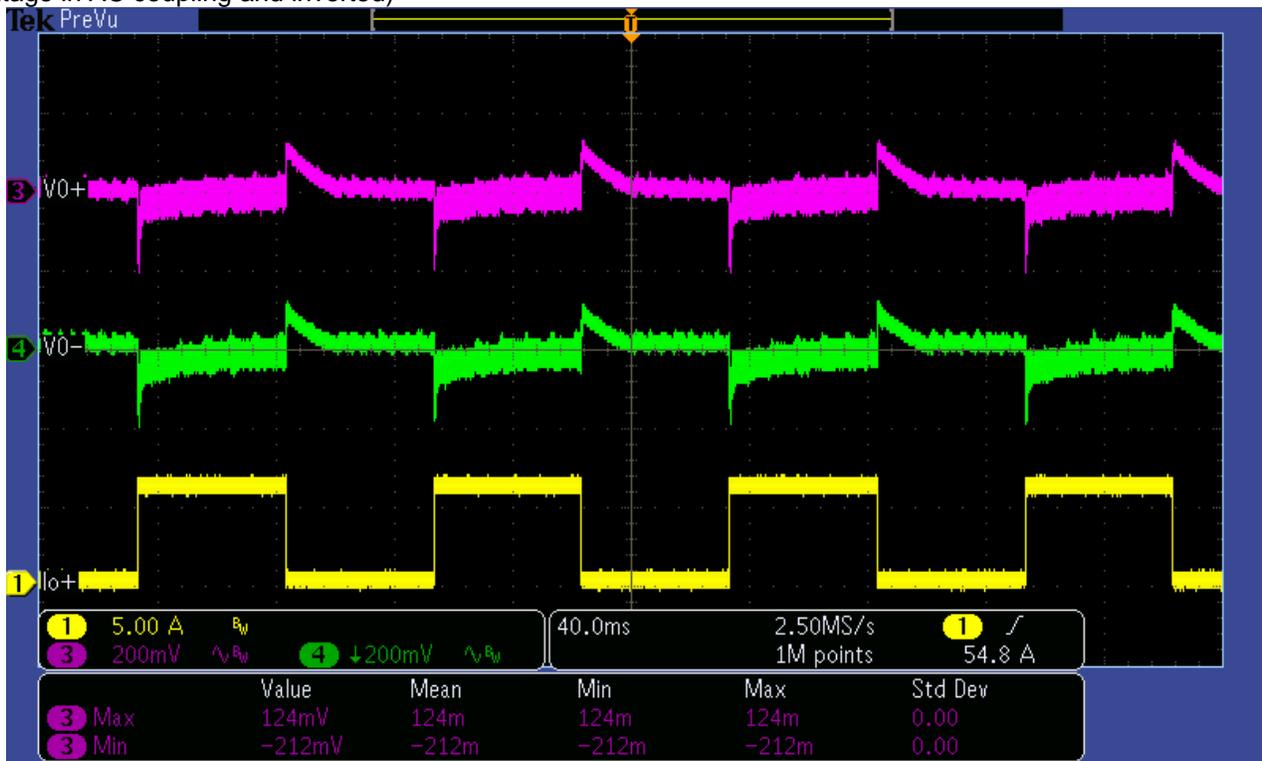


The output ripple voltage is shown in the figure below. The image was taken with the $\pm 42\text{V}$ output loaded to 0A and the input voltage set to 220VAC . (CH3: $+42\text{V}$ output in AC coupling, CH4: -42V output in AC coupling)



3.3 Load Transients

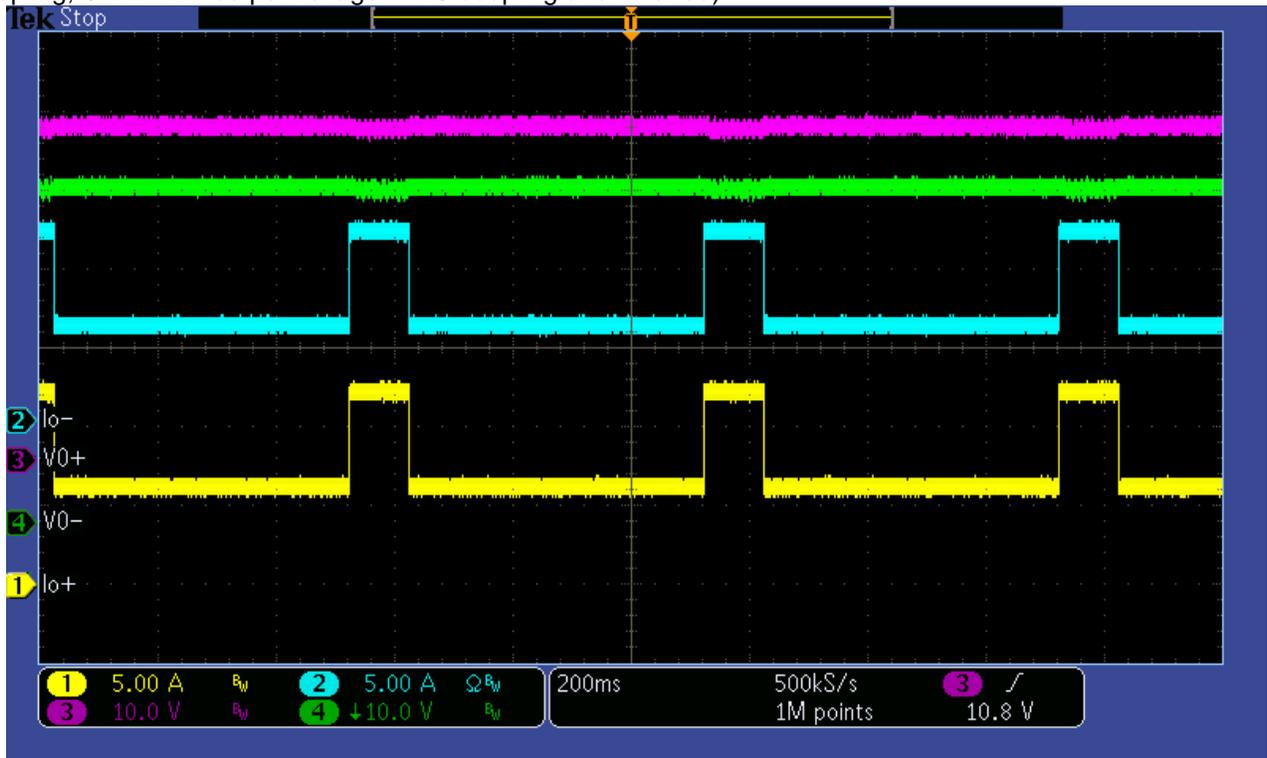
The photo below shows the $\pm 42\text{V}$ output voltage when the load current is stepped between 0A and 6A with an input voltage of 110VAC. (CH1: +42V output current, CH3: +42V output voltage in AC coupling, CH4: -42V output voltage in AC coupling and inverted)



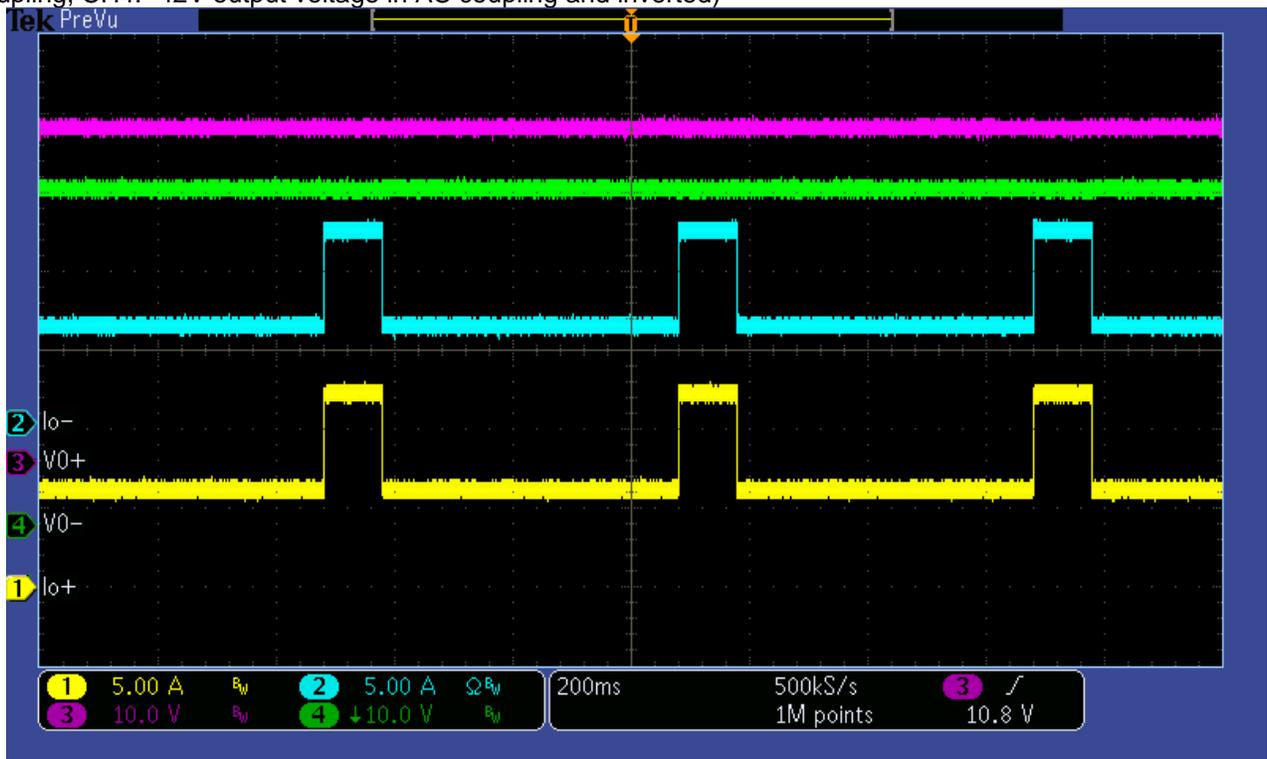
The photo below shows the $\pm 42\text{V}$ output voltage when the load current is stepped between 0A and 6A with an input voltage of 220VAC. (CH1: +42V output current, CH3: +42V output voltage in AC coupling, CH4: -42V output voltage in AC coupling and inverted)



The photo below shows the $\pm 42\text{V}$ output voltage when the load current is stepped between 6A and 12A with an input voltage of 110VAC. (CH1: +42V output current, CH2: -42V output current, CH3: +42V output voltage in AC coupling, CH4: -42V output voltage in AC coupling and inverted)

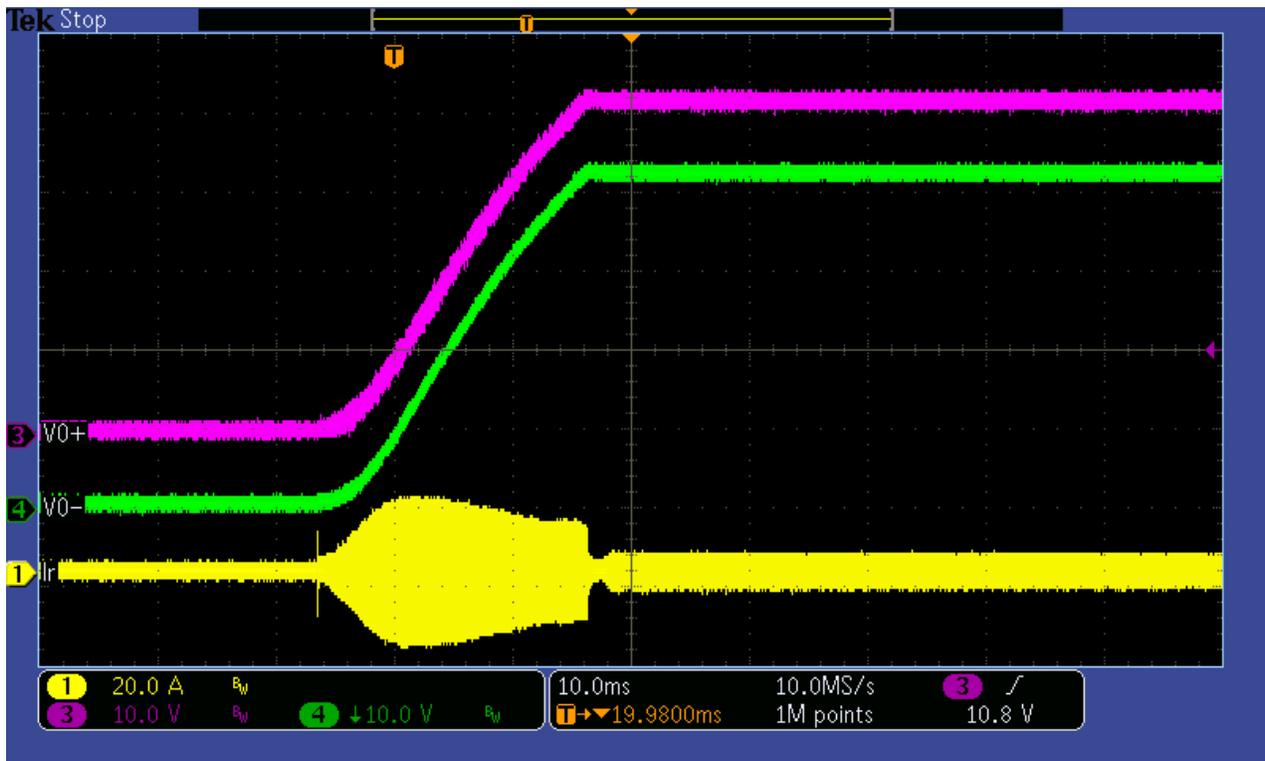


The photo below shows the $\pm 42\text{V}$ output voltage when the load current is stepped between 6A and 12A with an input voltage of 220VAC. (CH1: +42V output current, CH2: -42V output current, CH3: +42V output voltage in AC coupling, CH4: -42V output voltage in AC coupling and inverted)

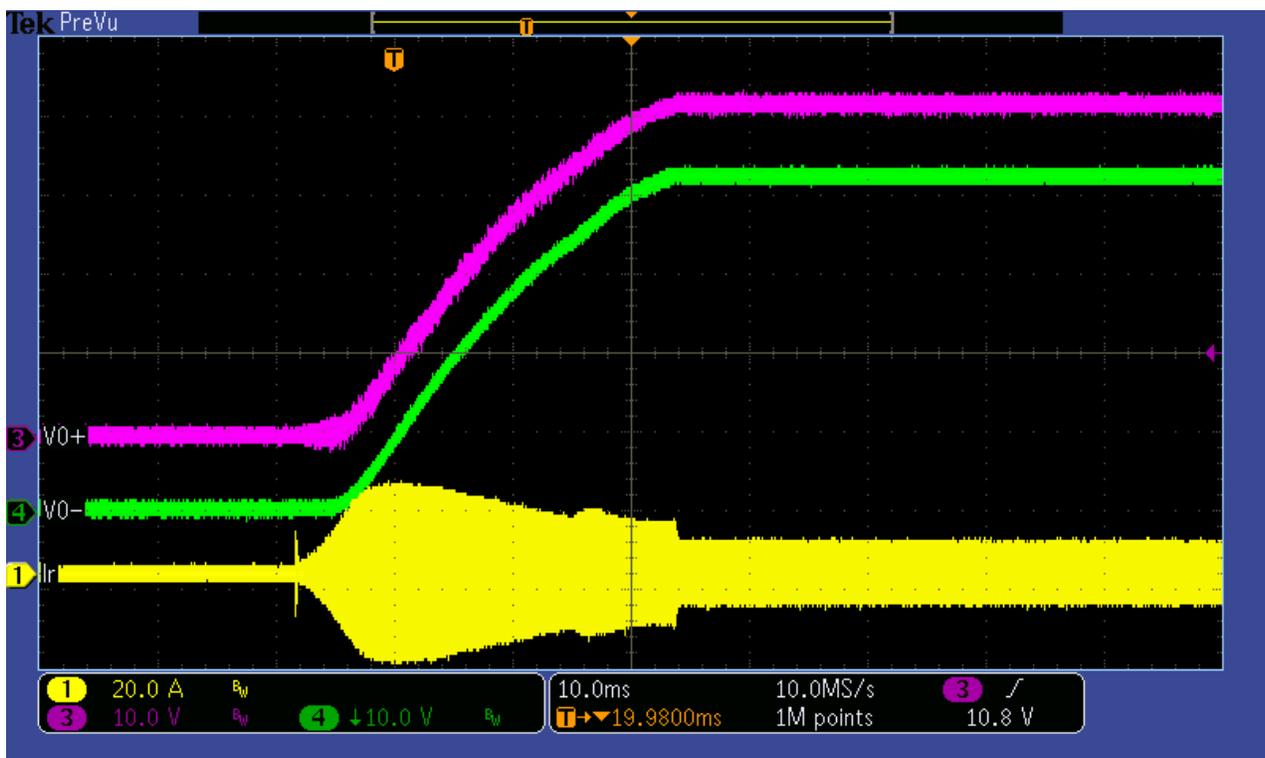


3.4 Start-up Sequence

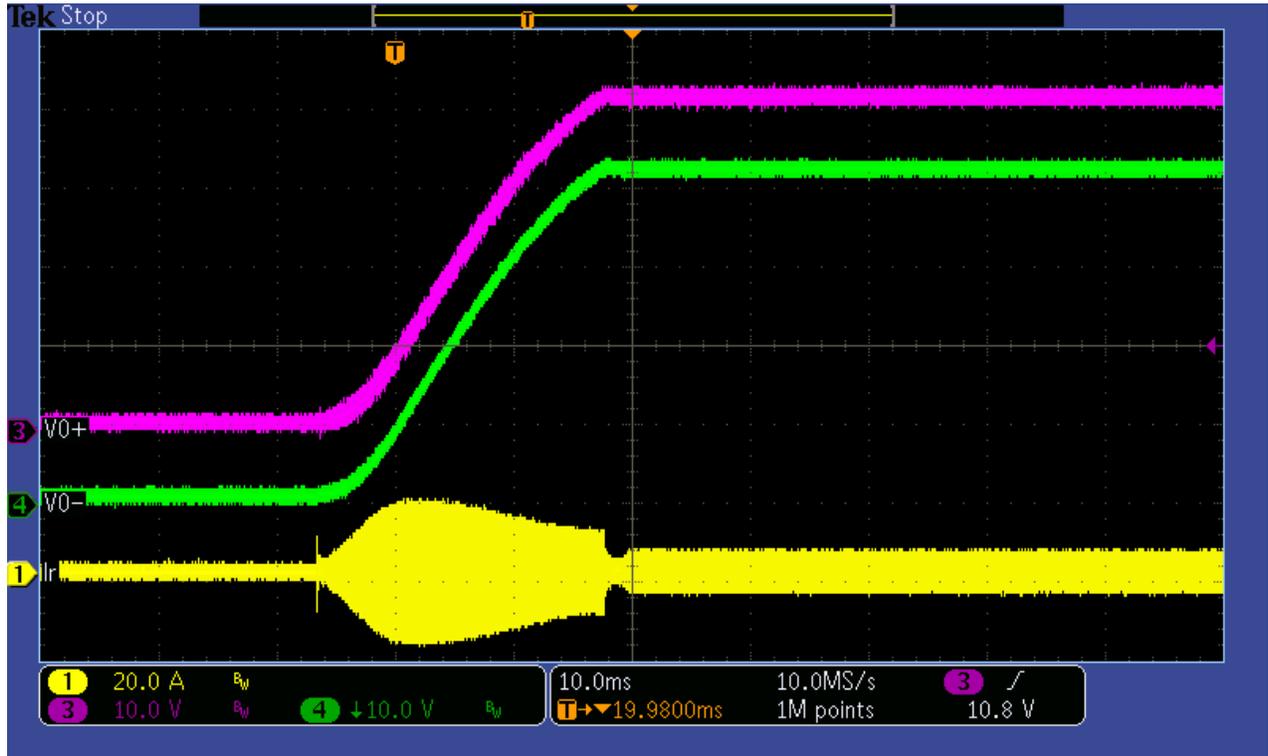
The photo below shows the output voltage startup waveform after the application of 110VAC and loaded to 0A. (CH1: resonant current, CH3: +42V output voltage, CH4: -42V output voltage)



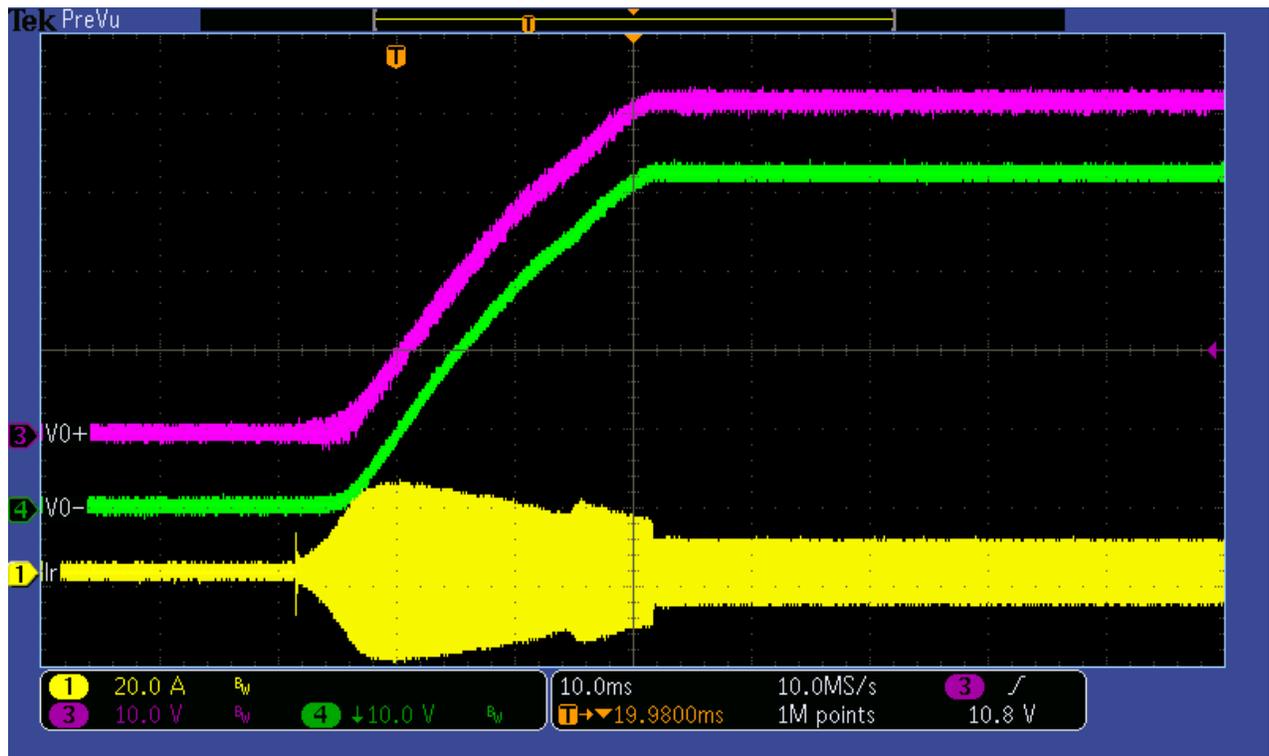
The photo below shows the output voltage startup waveform after the application of 110VAC and loaded to 6A. (CH1: resonant current, CH3: +42V output voltage, CH4: -42V output voltage)



The photo below shows the output voltage startup waveform after the application of 220VAC and loaded to 0A. (CH1: resonant current, CH3: +42V output voltage, CH4: -42V output voltage)

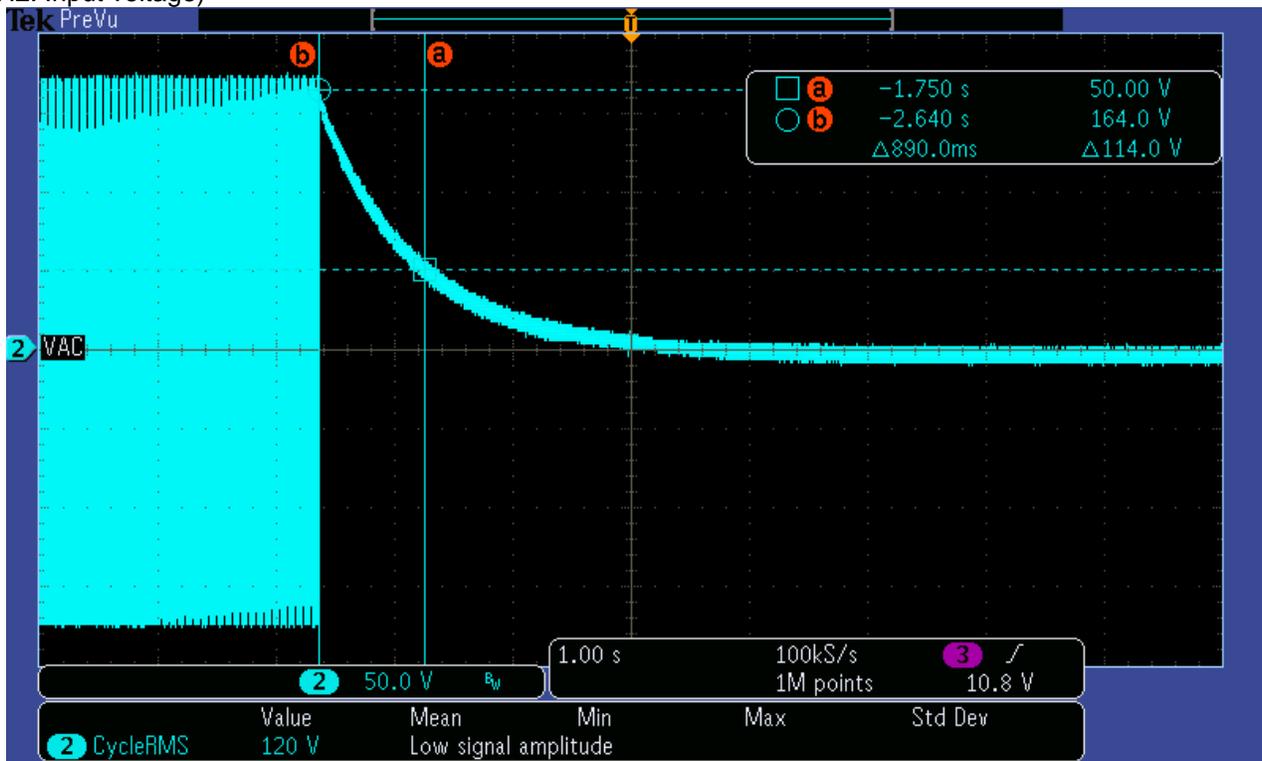


The photo below shows the output voltage startup waveform after the application of 220VAC and loaded to 6A. (CH1: resonant current, CH3: +42V output voltage, CH4: -42V output voltage)

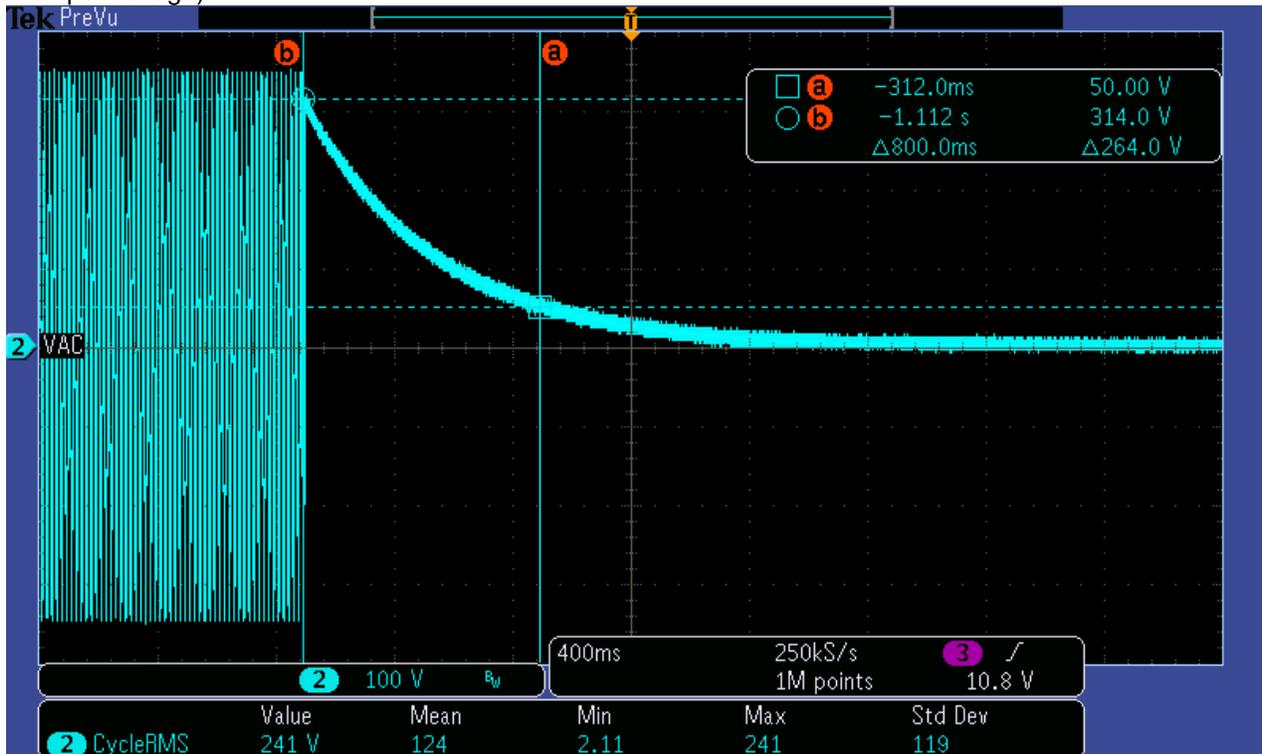


3.5 X-Cap Discharge

The photo below shows the input voltage waveform after the 120VAC disconnects at no load conditions. (CH2: Input voltage)



The photo below shows the input voltage waveform after the 240VAC disconnects at no load conditions. (CH2: Input voltage)



IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you will fully indemnify TI and its representatives against, any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to TI's Terms of Sale (<https://www.ti.com/legal/termsofsale.html>) or other applicable terms available either on [ti.com](https://www.ti.com) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2021, Texas Instruments Incorporated