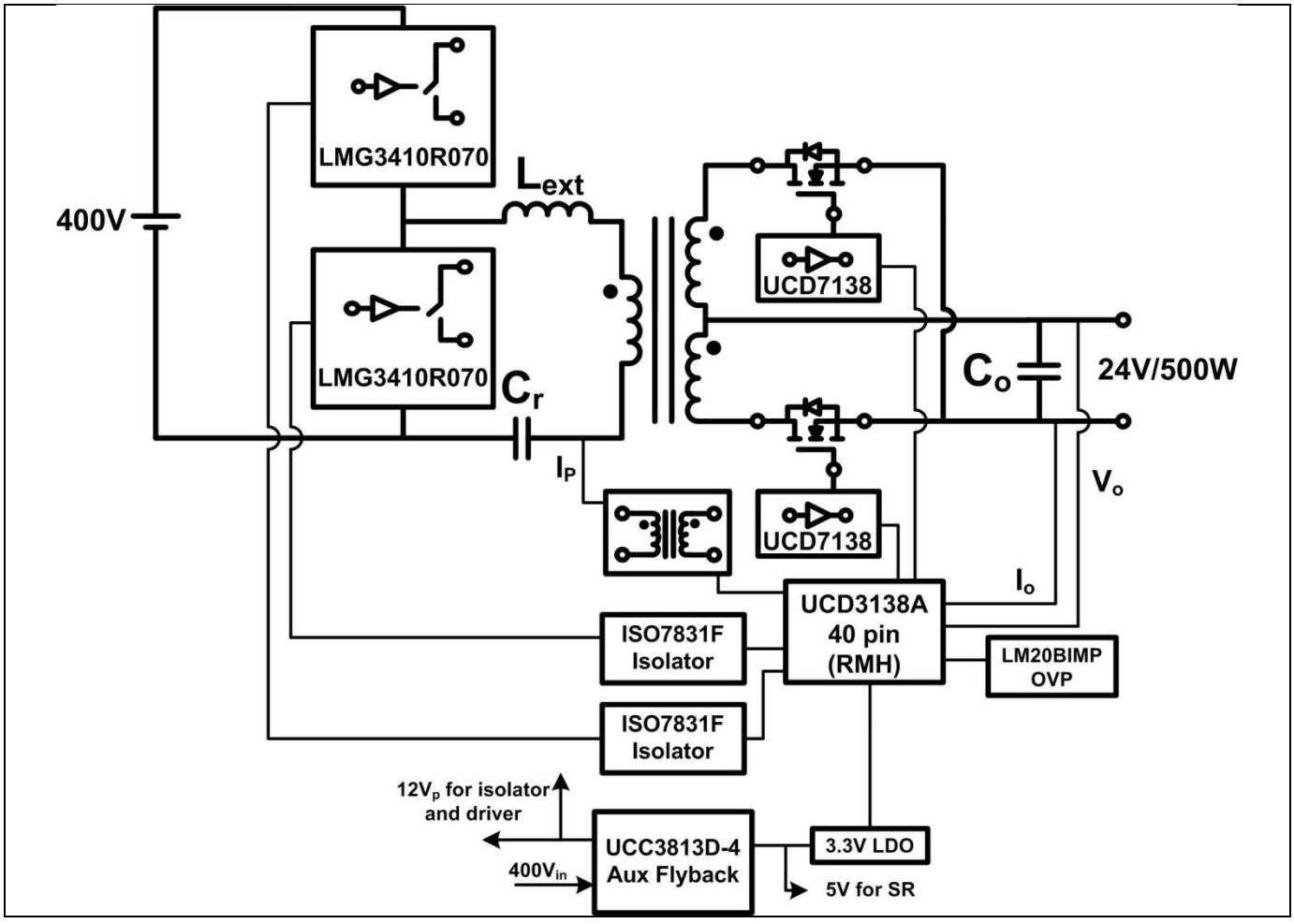
Test Report: PMP21309

24-V/500-W Resonant Converter Reference Design with TI HV GaN FET

Description

The PMP21309 reference design is a high-frequency resonant converter reference design. The output voltage is regulated to 24 V with input voltage ranges from 380 V to 400 V using a resonant tank with 500 kHz resonant frequency. A 97.9% peak efficiency is achieved with this design using TI's high-voltage GaN device, LMG3410R070, along with UCD3138A and UCD7138 to optimize the deadtime and synchronous rectifier (SR) conduction.



1 System Specification

1.1 Board Dimension:

2.5” x 4” x 1.4”

1.2 Input Characteristics

Minimum	Nominal	Maximum	
380	390	400	VDC

1.3 Output Characteristics

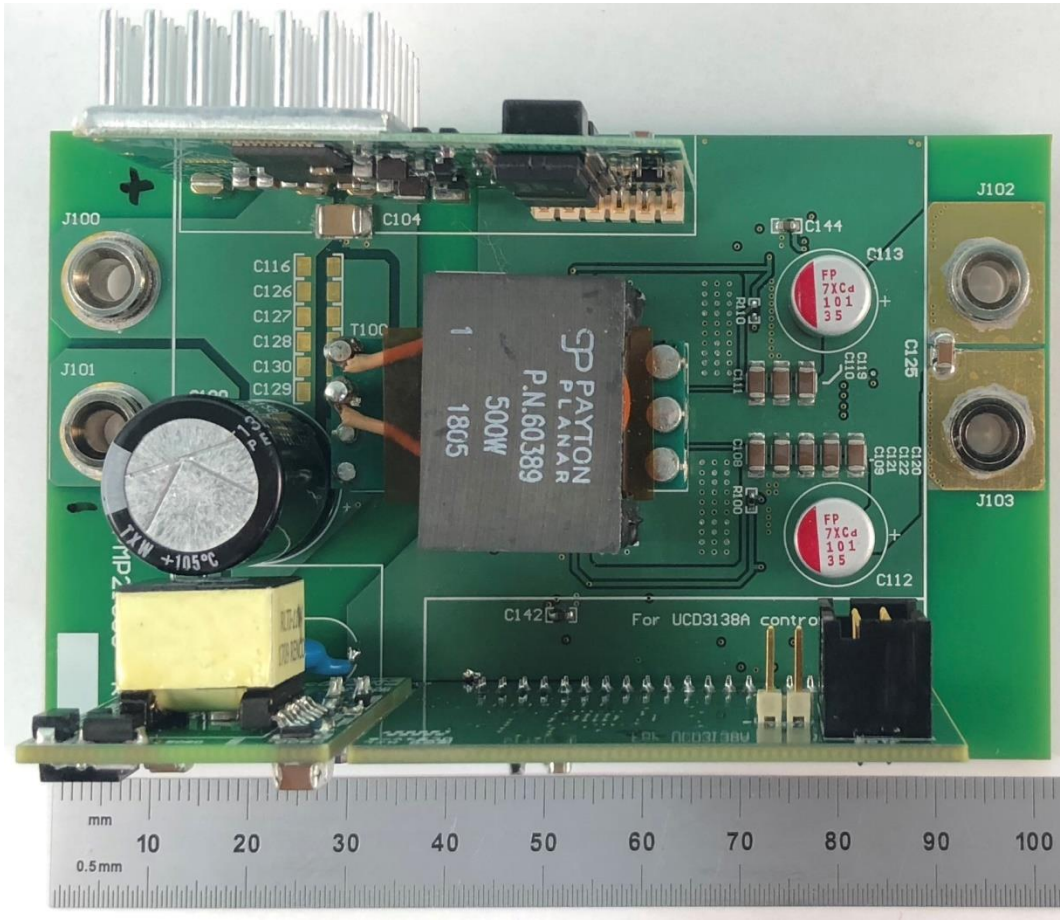
The power supply unit should be able to supply 24V+/-5% with 500W maximum output power.

2 Testing and Results

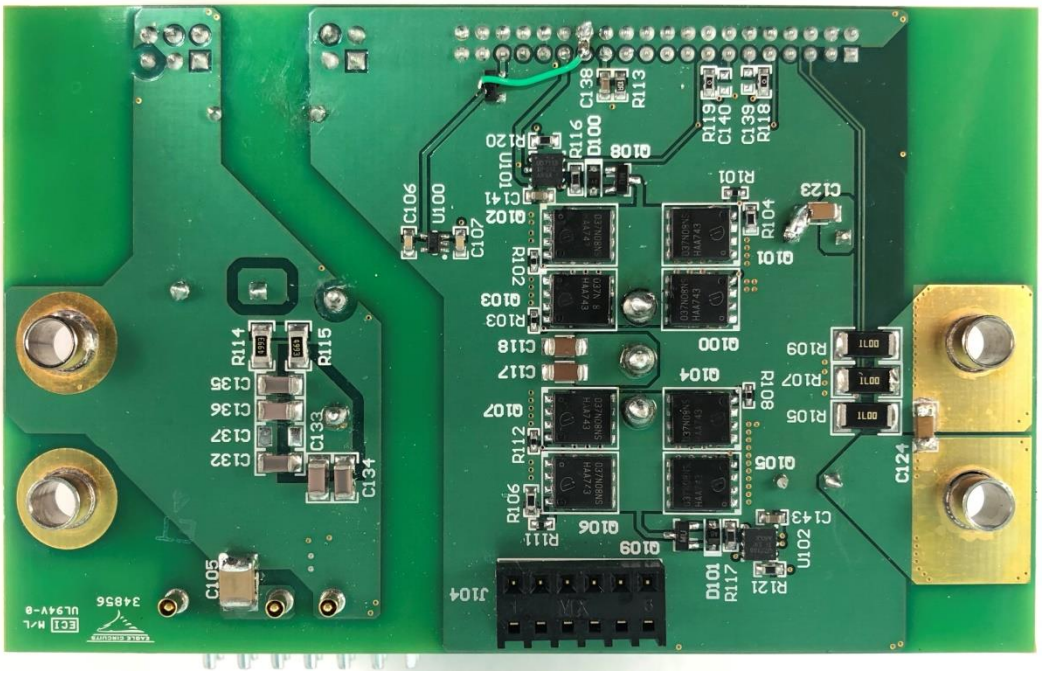
2.1 Board Photos

The photographs below show the top and bottom view of the PMP21309 Rev A board.

2.1.1 Top Side

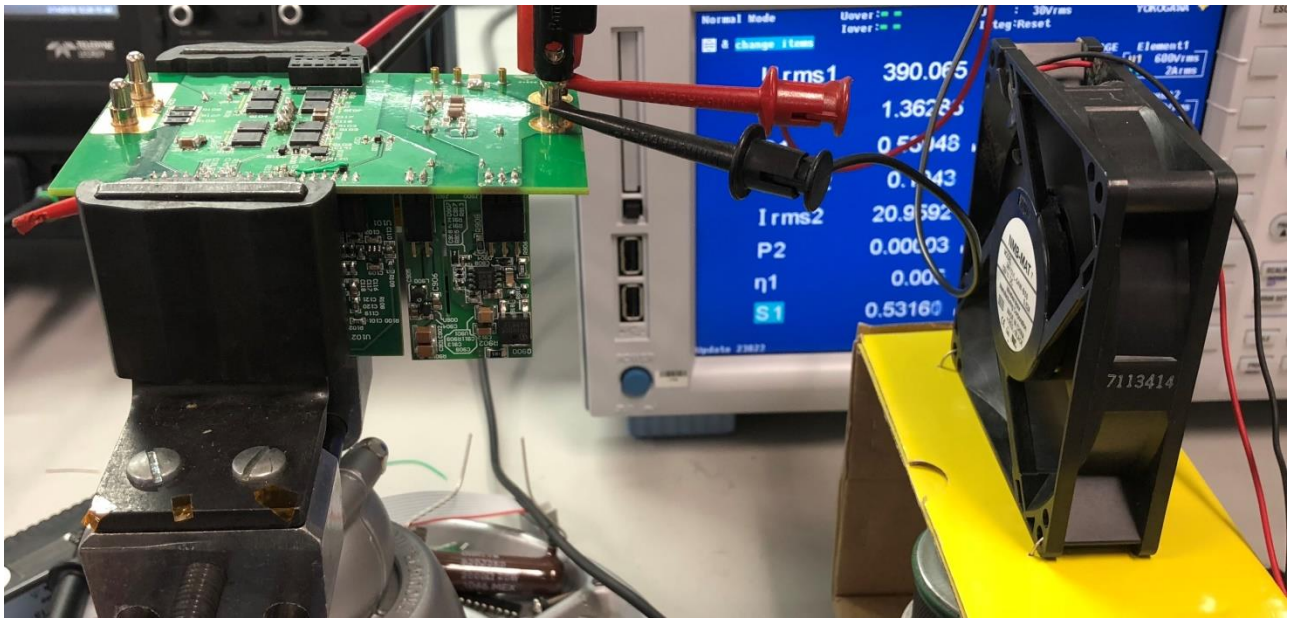


2.1.2 Bottom Side

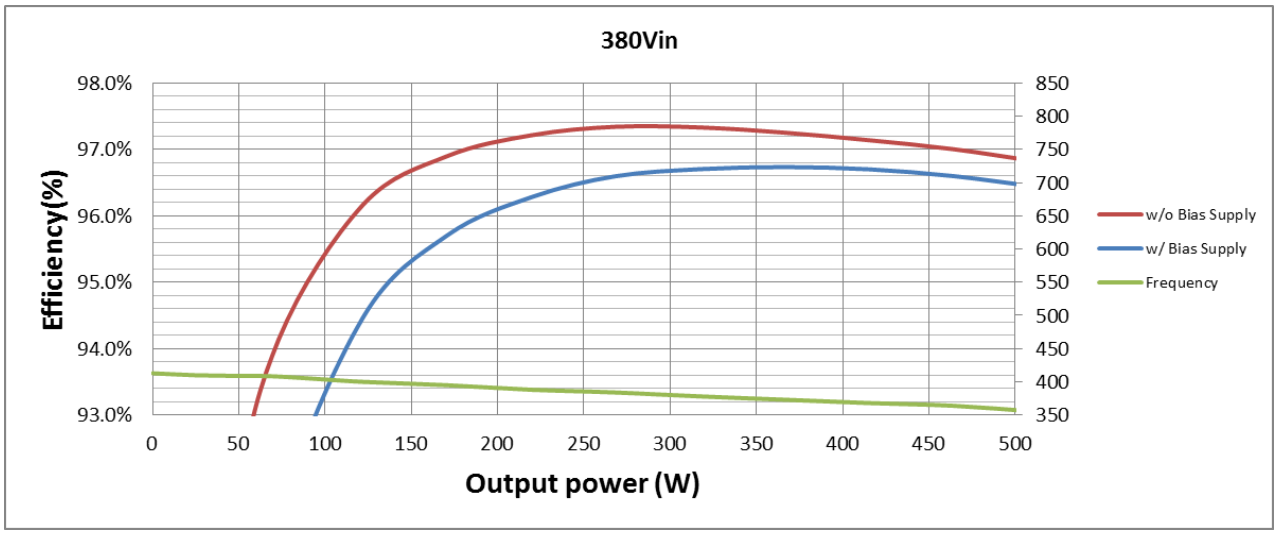


2.2 Efficiency And Switching Frequency

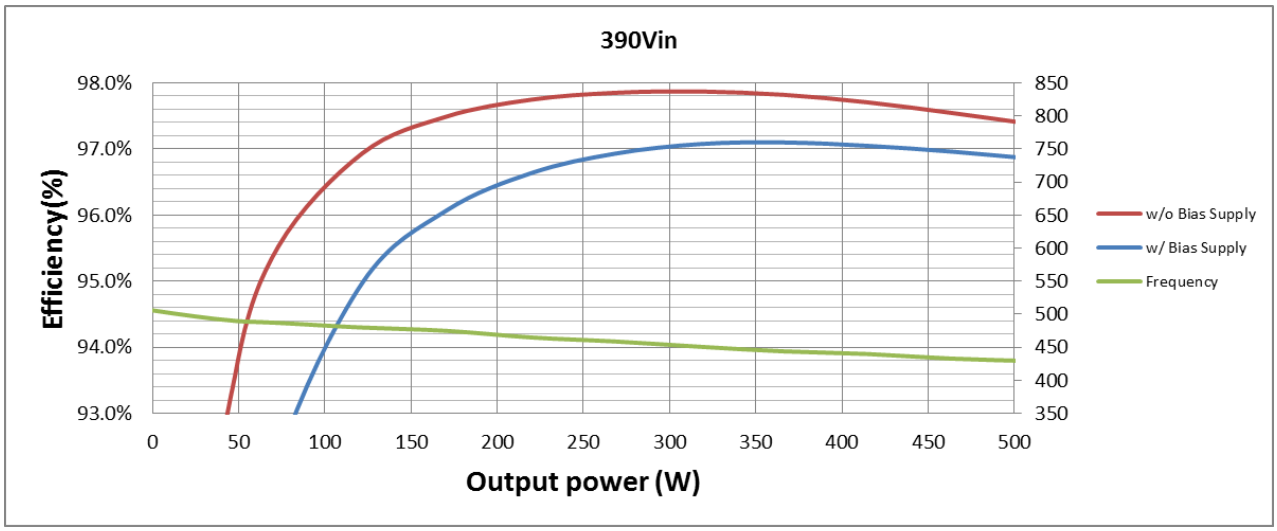
The efficiency curves are shown in the tables and graph below with the set up shown in the figure below. A 12V Fan (NMB Technologies Model # 3610VL-04W-B50) is applied to provide air cooling to the board.



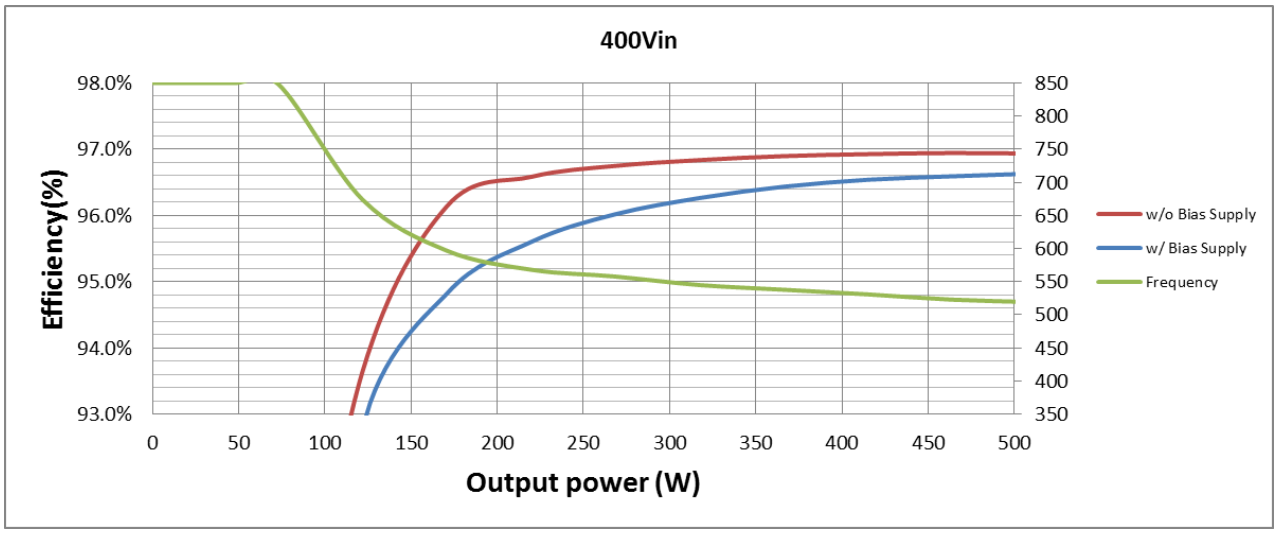
2.2.1 380V_{DC} Input



2.2.2 390V_{DC} Input



2.2.3 400V_{DC} Input



2.2.4 Efficiency Data (bias supply – PMP20306 excluded)

Vin(V)	Iin(A)	Pin(W)	Vout(V)	Iout(A)	Pout(W)	Eff(%)	Fsw(kHz)
380.085	1.3993	529.9	24.4792	20.9581	513.0375	96.82%	355
380.095	1.26221	477.84	24.4792	18.9363	463.54	97.01%	364
380.109	1.12864	427.06	24.4798	16.9468	414.85	97.14%	368
380.115	0.9957	376.54	24.4818	14.9581	366.2	97.25%	373
380.128	0.86328	326.19	24.4819	12.9686	317.49	97.33%	378
380.133	0.72941	275.35	24.4834	10.9475	268.032	97.34%	384
380.062	0.60098	226.37	24.4847	8.9881	220.0709	97.22%	388
380.076	0.46889	176.06	24.486	6.9675	170.6	96.90%	395
380.09	0.3399	126.7	24.4867	4.9762	121.84	96.16%	400
380.099	0.21353	77.67	24.4898	2.9862	73.12	94.14%	408
380.104	0.15155	52.81	24.4898	1.9741	48.33	91.52%	409
380.112	0.09638	28.78	24.491	0.9948	24.34	84.57%	410
380.112	0.05925	4.36	24.4922	0	0	0.00%	413
390.1	1.35325	526.81	24.476	20.9572	512.94	97.37%	429
390.111	1.22047	475.13	24.478	18.9343	463.47	97.55%	433
390.125	1.0906	424.53	24.4801	16.944	414.7908	97.71%	440
390.135	0.96169	374.28	24.4817	14.9549	366.12	97.82%	444
390.148	0.83366	324.31	24.4832	12.9641	317.4	97.87%	451
390.155	0.70423	273.83	24.4841	10.9434	267.94	97.85%	459
390.166	0.57927	225.05	24.486	8.984	219.98	97.75%	465
390.181	0.45099	174.9	24.4872	6.9633	170.51	97.49%	475
390.199	0.32498	125.6	24.4876	4.9718	121.75	96.93%	480
390.21	0.20011	76.46	24.4903	2.9825	73.04	95.53%	487
390.218	0.13781	51.55	24.4915	1.9708	48.26	93.62%	490
390.228	0.08004	27.46	24.4918	0.9911	24.27	88.38%	497
390.232	0.03852	3.02	24.4927	0	0	0.00%	506
401.086	1.32252	529.37	24.4821	20.9599	513.14	96.93%	519
401.099	1.19522	478.28	24.4833	18.9381	463.66	96.94%	523
401.106	1.07021	428.12	24.4844	16.9479	414.9592	96.93%	531
401.119	0.94531	378.01	24.4861	14.9586	366.2778	96.90%	538
401.132	0.82059	327.94	24.4874	12.9686	317.5673	96.84%	545
401.148	0.6938	277.09	24.4879	10.9474	268.08	96.75%	558
401.157	0.57109	227.89	24.4896	8.988	220.11	96.59%	568
401.164	0.44486	177.47	24.4893	6.9669	170.61	96.13%	597
401.171	0.32545	130.11	24.4896	4.9752	121.84	93.64%	674
401.189	0.21018	83.36	24.49	2.9852	73.11	87.70%	848
401.195	0.13961	55.27	24.4913	1.9731	48.32	87.43%	851
401.198	0.07255	28.44	24.4909	0.993	24.31946	85.51%	851
401.194	0.01338	1.79	24.4907	0	0	0.00%	851

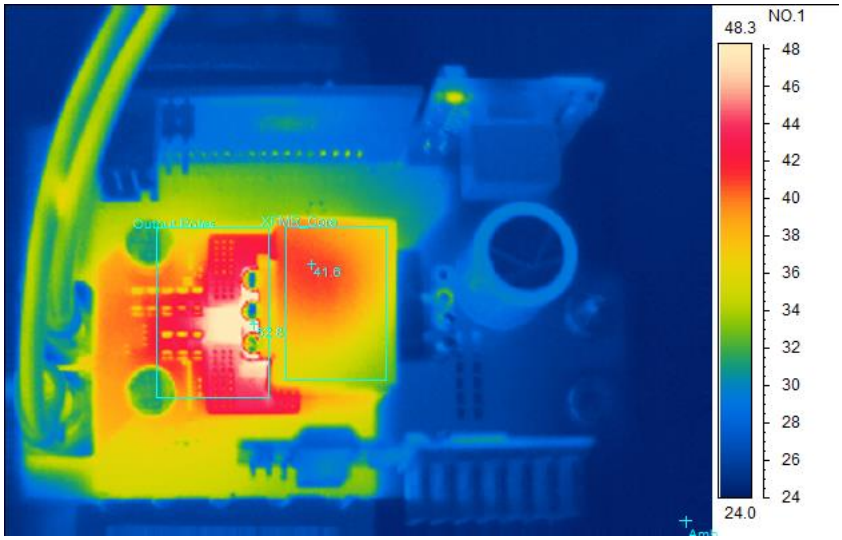
2.2.5 Efficiency Data (bias supply – PMP20306 included)

Vin(V)	Iin(A)	Pin(W)	Vout(V)	Iout(A)	Pout(W)	Eff(%)
380.166	1.42829	532.75	24.5213	20.9524	513.76	96.44%
380.173	1.2884	480.54	24.5222	18.9303	464.2	96.60%
380.174	1.153	429.59	24.5231	16.9402	415.42	96.70%
380.178	1.01936	379.03	24.5243	14.9512	366.66	96.74%
380.186	0.88689	328.71	24.526	12.9614	317.88	96.71%
380.188	0.75342	277.77	24.5258	10.9406	268.32	96.60%
380.193	0.62704	228.78	24.5256	8.9822	220.29	96.29%
380.193	0.49791	178.4	24.5268	6.9617	170.74	95.71%
380.208	0.37657	129.05	24.5285	4.9702	121.91	94.47%
380.21	0.26202	79.99	24.5297	2.9809	73.12	91.41%
380.215	0.21346	55.15	24.5304	1.9703	48.33	87.63%
380.22	0.1744	31.1	24.5316	0.9904	24.29	78.10%
380.259	0.18764	6.67	24.5322	0	0	0.00%
390.127	1.3907	530.56	24.5145	20.9603	513.82	96.84%
390.126	1.25571	478.85	24.5185	18.9368	464.29	96.96%
390.135	1.12513	428.14	24.5194	16.9463	415.5	97.05%
390.136	0.99573	377.71	24.5217	14.9565	366.75	97.10%
390.145	0.86746	327.54	24.5226	12.9662	317.96	97.08%
390.154	0.73896	276.92	24.5251	10.945	268.42	96.93%
390.154	0.61601	228.02	24.5256	8.9853	220.36	96.64%
390.158	0.49186	177.8	24.5272	6.9646	170.82	96.07%
390.169	0.37559	128.42	24.5281	4.9729	121.98	94.99%
390.18	0.26752	79.29	24.5294	2.9834	73.18	92.29%
390.181	0.22189	54.35	24.5312	1.9714	48.36	88.98%
390.193	0.19054	30.23	24.532	0.9916	24.32	80.45%
390.206	0.18962	5.74	24.5326	0	0	0.00%
400.03	1.35421	531.7	24.5207	20.9546	513.81	96.64%
400.034	1.2256	480.65	24.5226	18.9325	464.27	96.59%
400.039	1.09961	430.39	24.5245	16.9424	415.5	96.54%
400.042	0.97433	380.27	24.525	14.9532	366.72	96.44%
400.049	0.85018	330.25	24.5253	12.9633	317.92	96.27%
400.056	0.72448	279.51	24.5267	10.9425	268.38	96.02%
400.069	0.60398	230.47	24.529	8.9833	220.35	95.61%
400.072	0.48211	180.12	24.53	6.9629	170.79	94.82%
400.082	0.36949	131.47	24.5301	4.9713	121.94	92.75%
400.089	0.27697	89.04	24.5299	2.981	73.12	82.12%
400.092	0.22186	60.41	24.5316	1.9699	48.32	79.99%
400.103	0.18277	33.11	24.5306	0.9905	24.3	73.39%
400.124	0.18556	5.7	24.5314	0	0	0.00%

2.3 Thermal Images

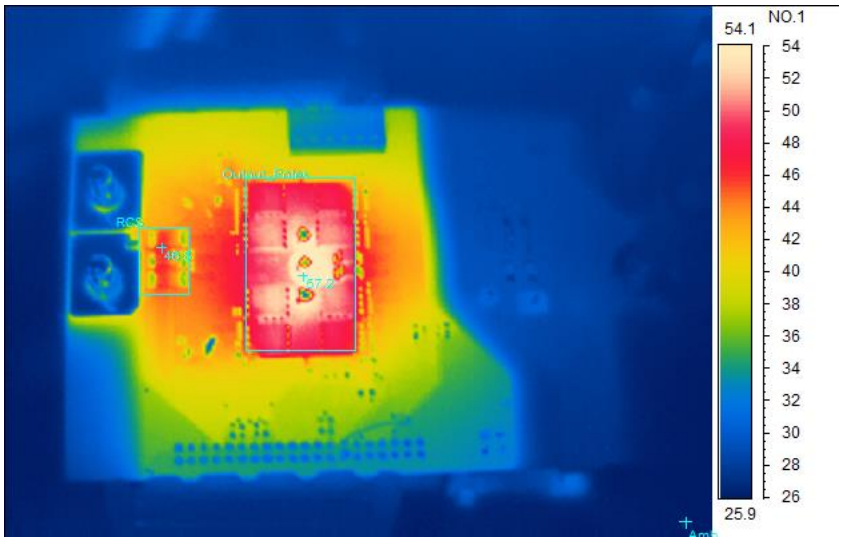
The thermal images below show a top view and bottom view of the board. The board is placed vertically during the test, where the input and output connecters are at the bottom side. The ambient temperature was 25ºC with forced air flow (The same set up as efficiency measurement). The output was loaded with 24.5V/21A.

2.3.1 390V_{DC} Input, Top View



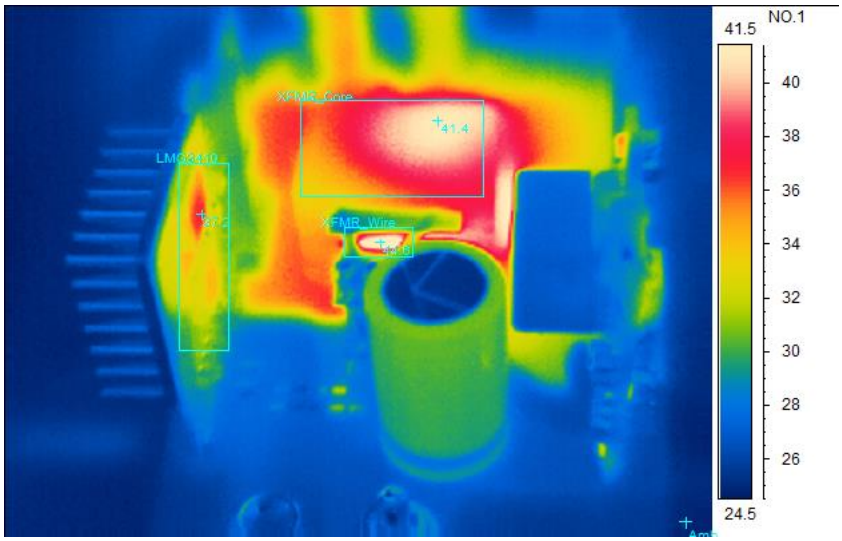
Spot analysis	Value
Amb	24.3°C
Area analysis	**Value**
XFMR_CoreMax	41.6°C
Output PolesMax	52.8°C

2.3.2 390V_{DC} Input, Bottom View



Spot analysis	Value
Amb	25.9°C
Area analysis	**Value**
Output_PolesMax	57.2°C
RCS Max	46.8°C

2.3.3 390V_{DC} Input, Side View

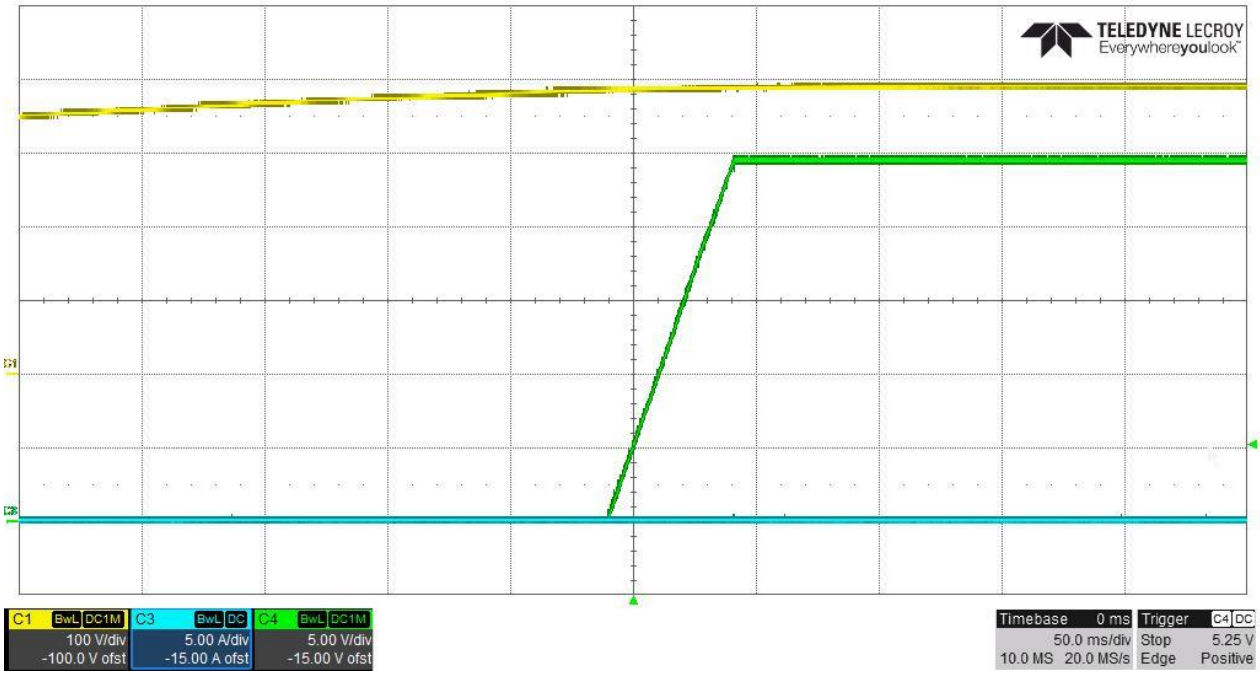


Spot analysis	Value
Amb	25.0°C
Area analysis	**Value**
XFMR_CoreMax	41.4°C
LMG3410Max	37.2°C
XFMR_Wire Max	44.6°C

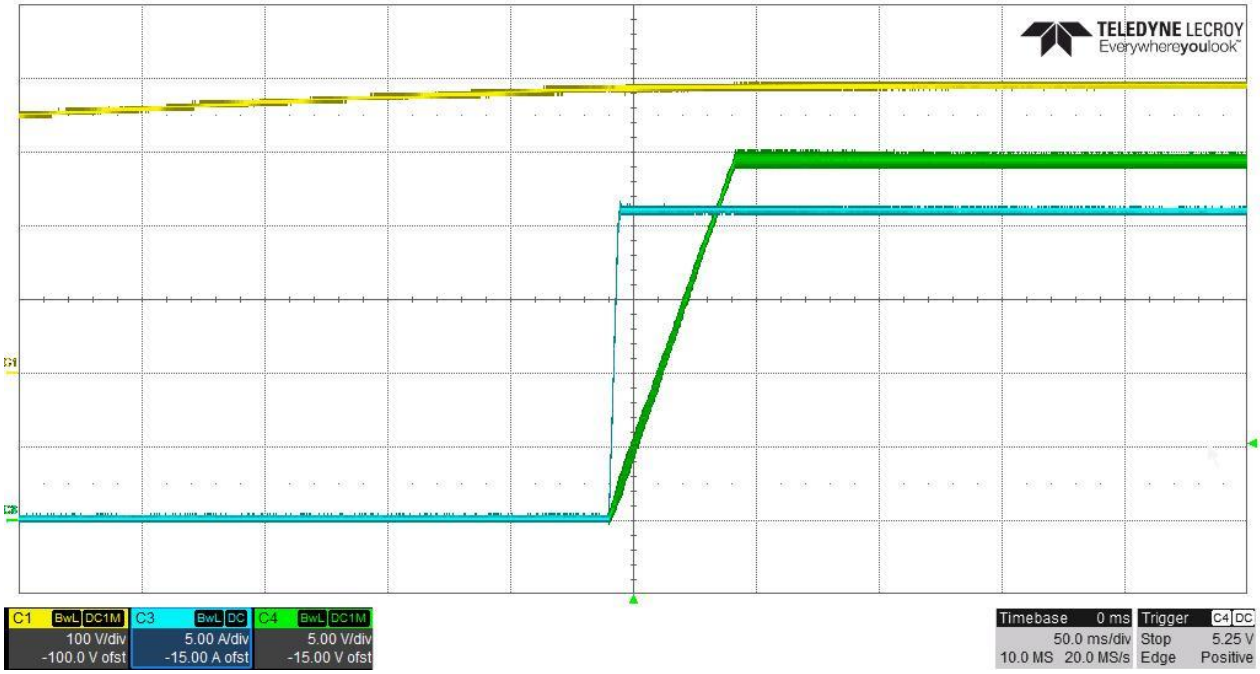
2.4 Startup

The voltages at startup are shown in the images below with 390VDC input where C1 is input voltage, C3 is output current, and C4 is output voltage.

2.4.1 No Load

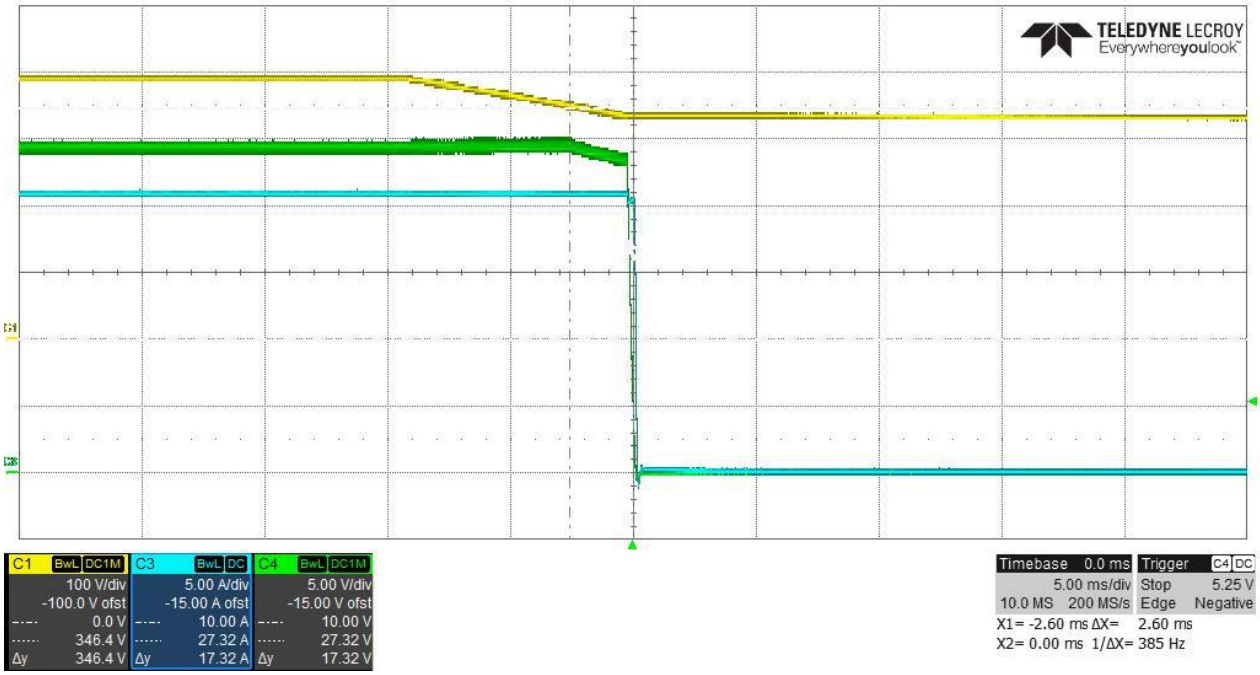


2.4.2 24V/21A



2.5 Turn Off

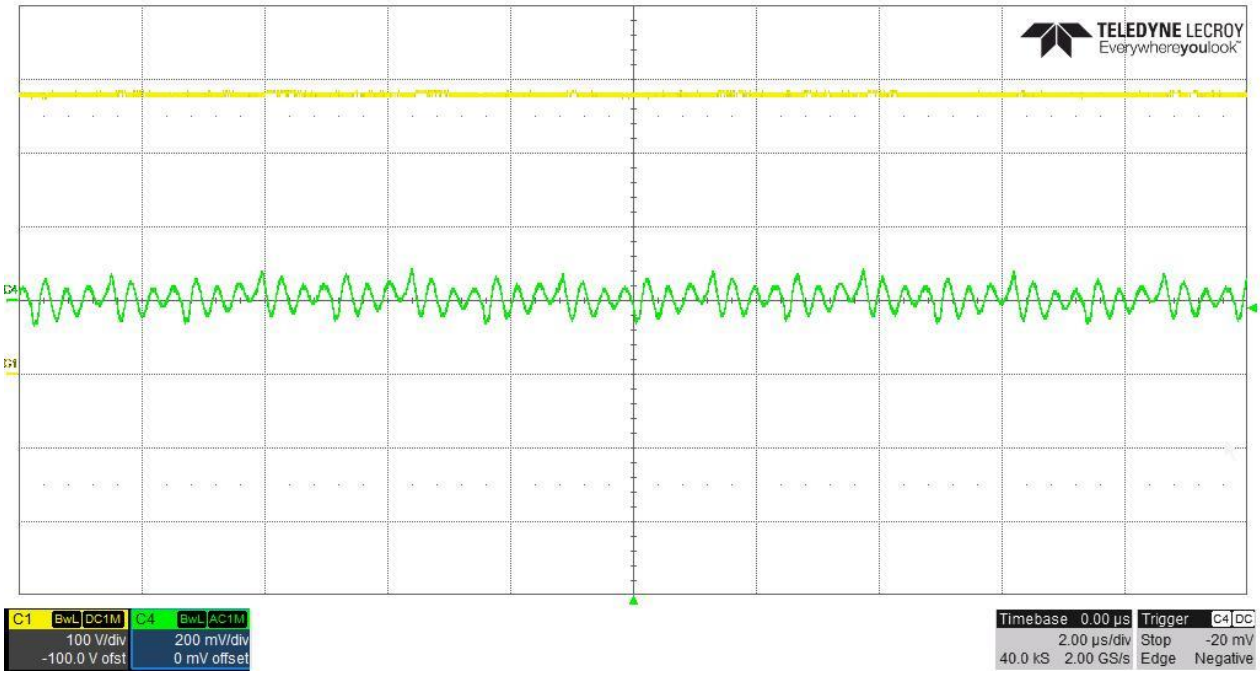
The voltage at turn off transient at 21A load is shown in the images below with 390VDC input where C1 is input voltage, C3 is output current, and C4 is output voltage.



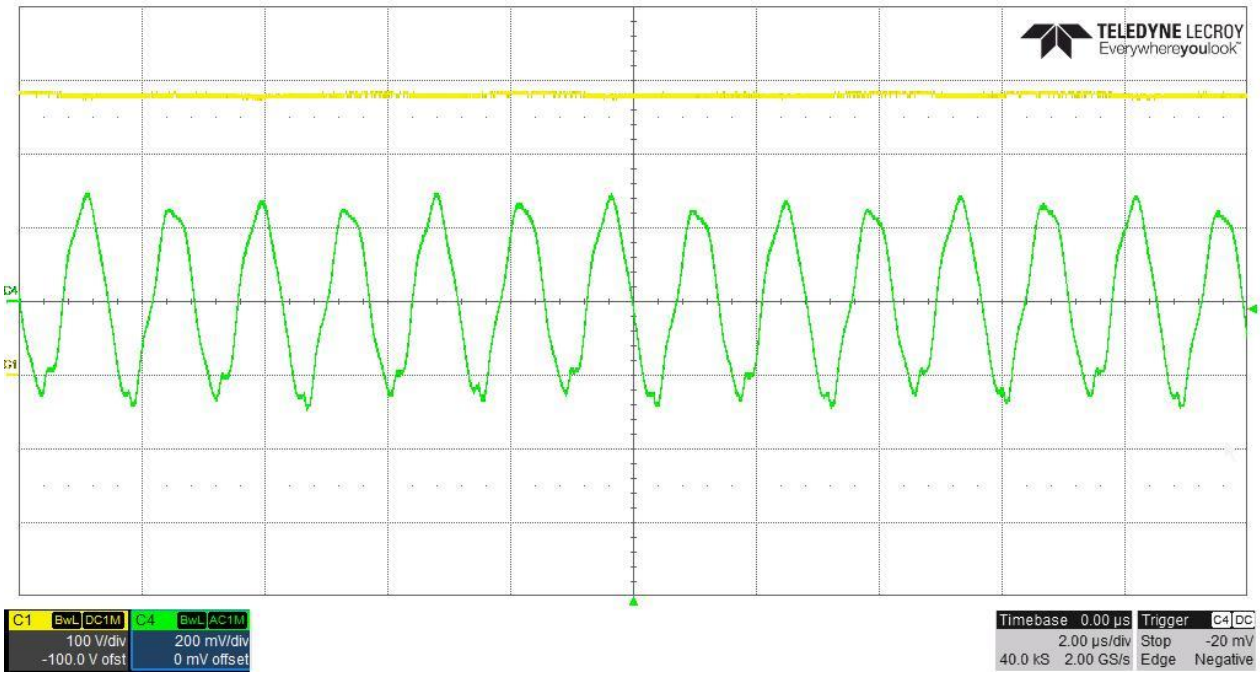
2.6 Output Ripple Voltages

Ripple voltages are shown in the images below, where C1 is the input voltage and C4 is output voltage in AC level.

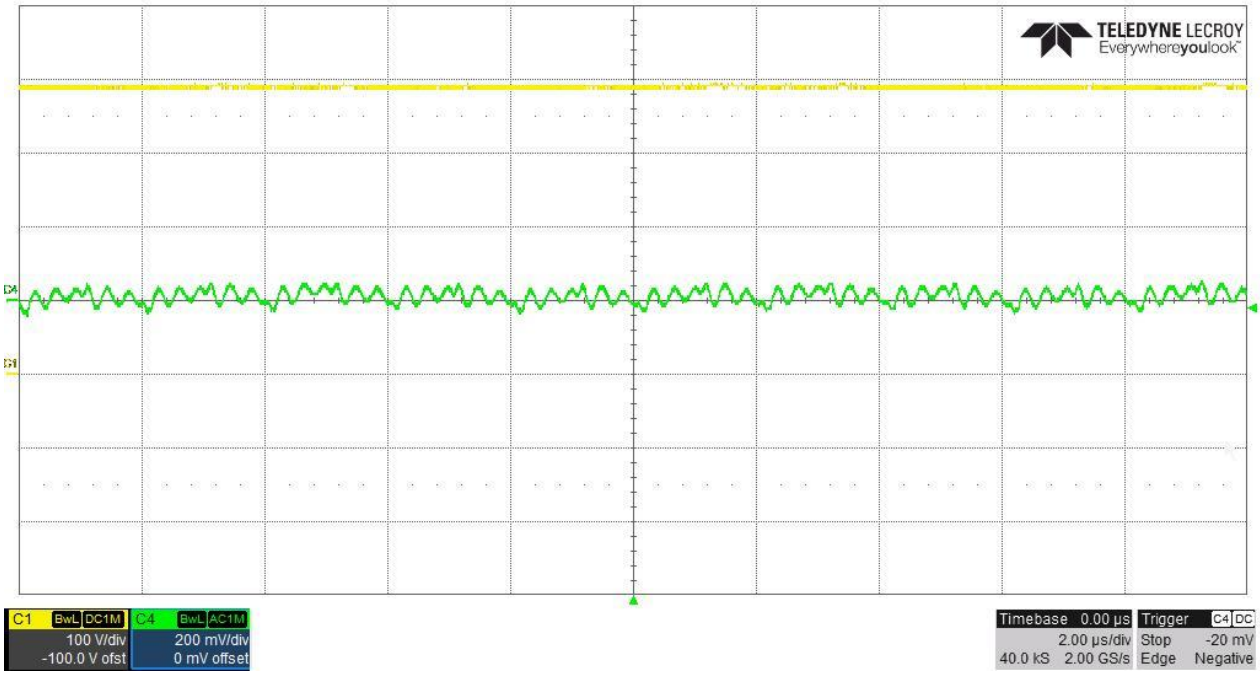
2.6.1 380VDC input, no load



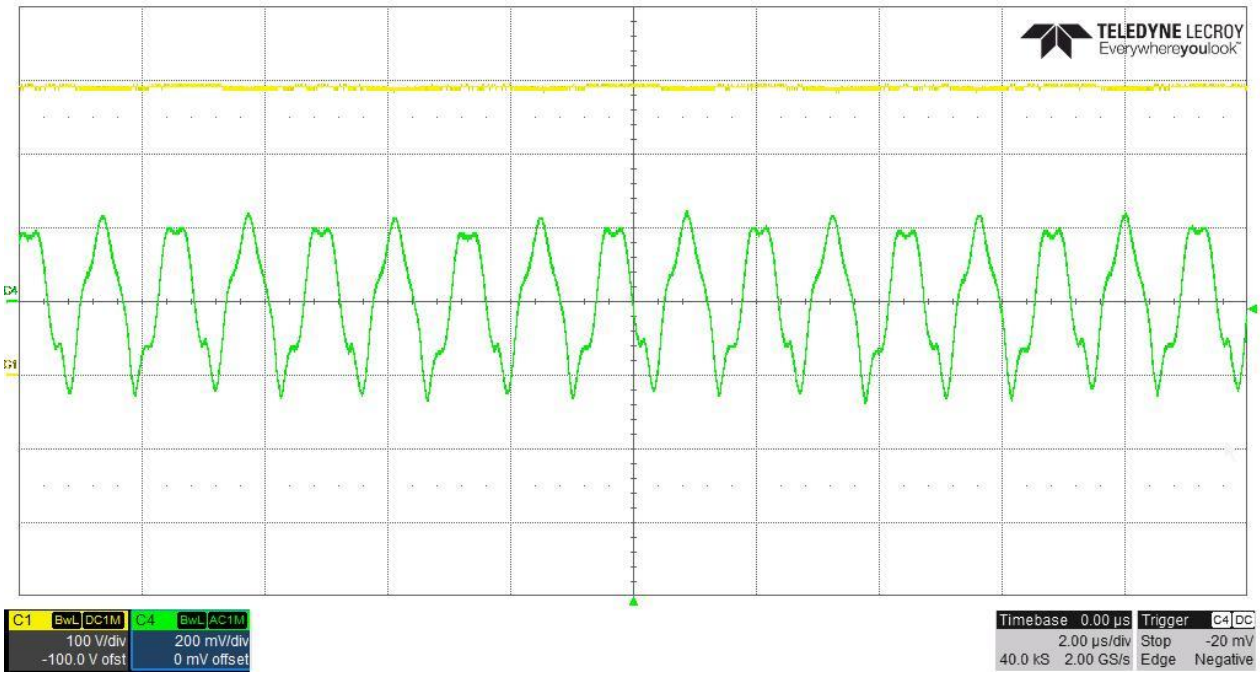
2.6.2 380VDC input, 21A load



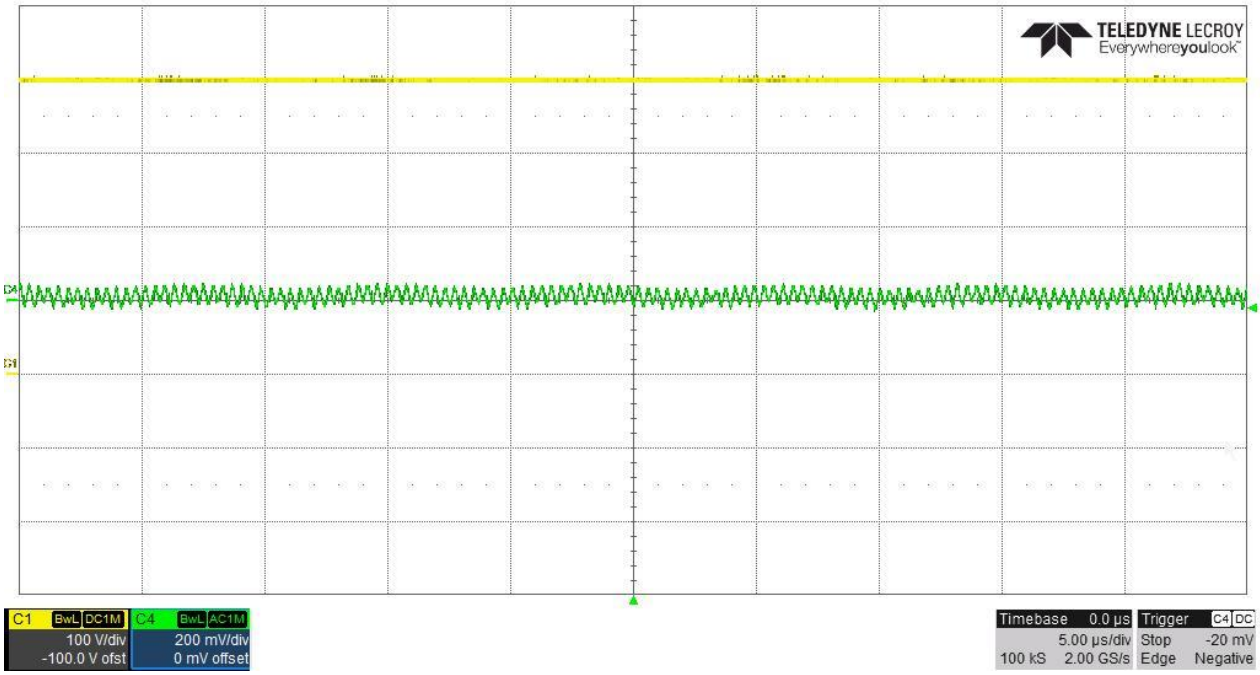
2.6.3 390VDC input, no load



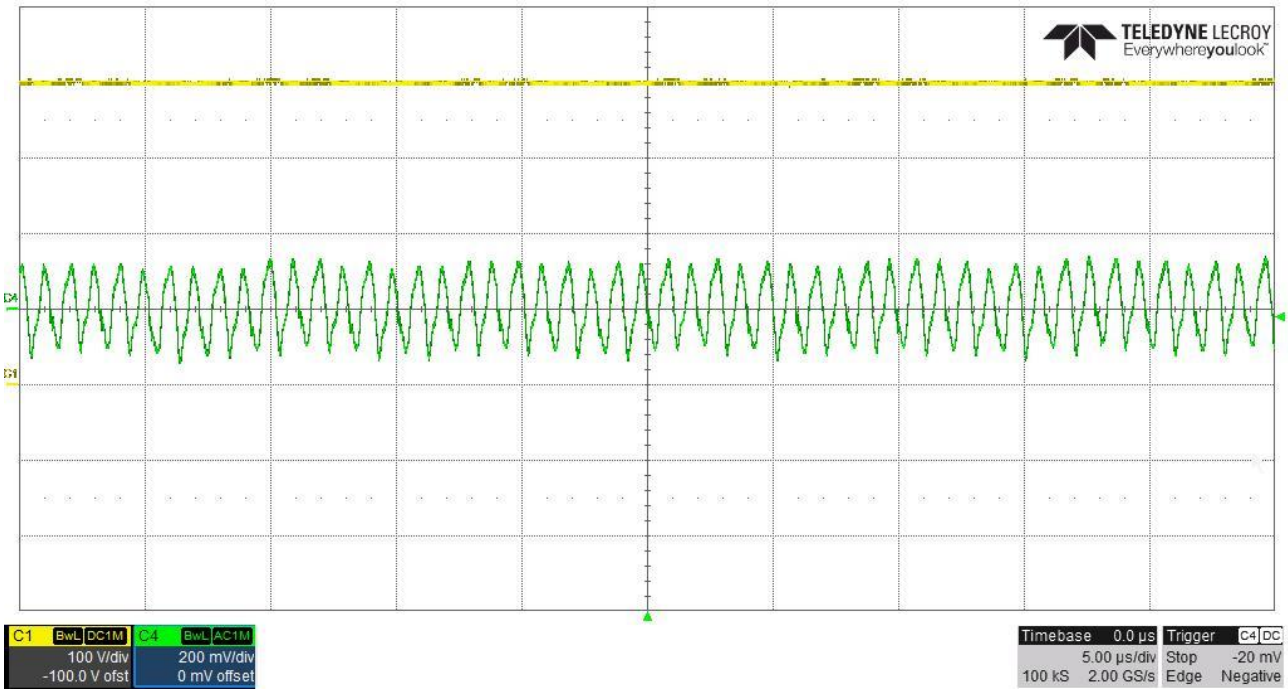
2.6.4 390VDC input, 21A load



2.6.5 400VDC input, no load

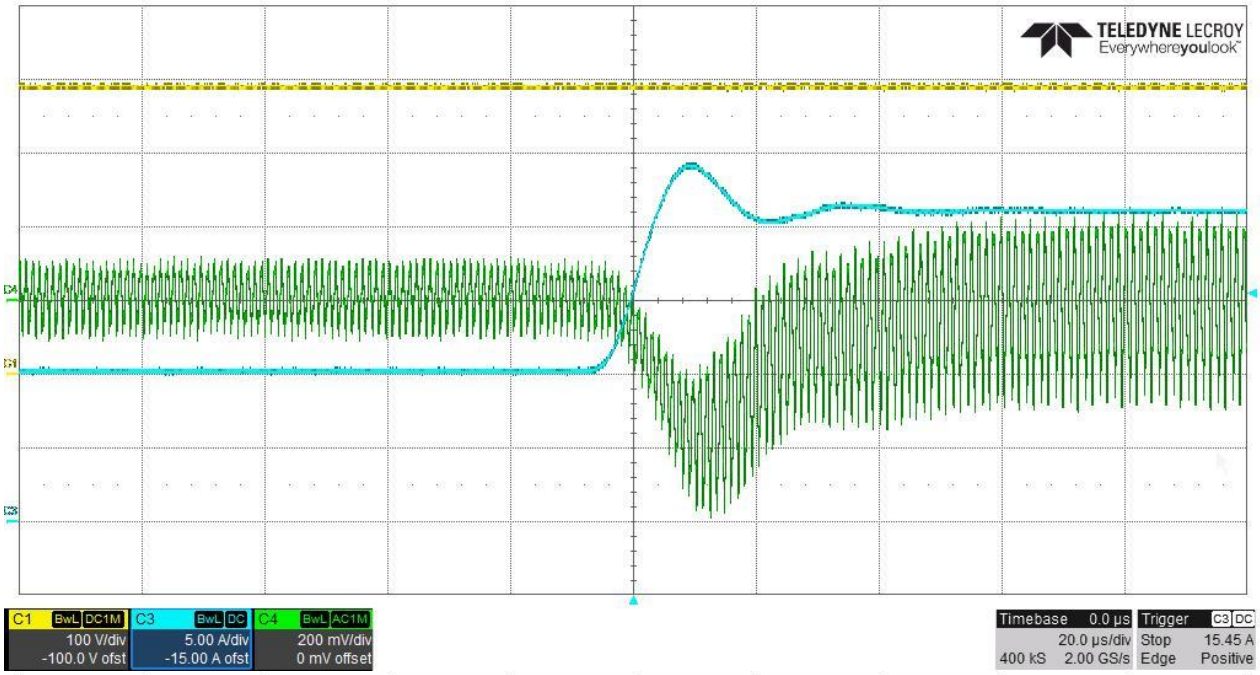


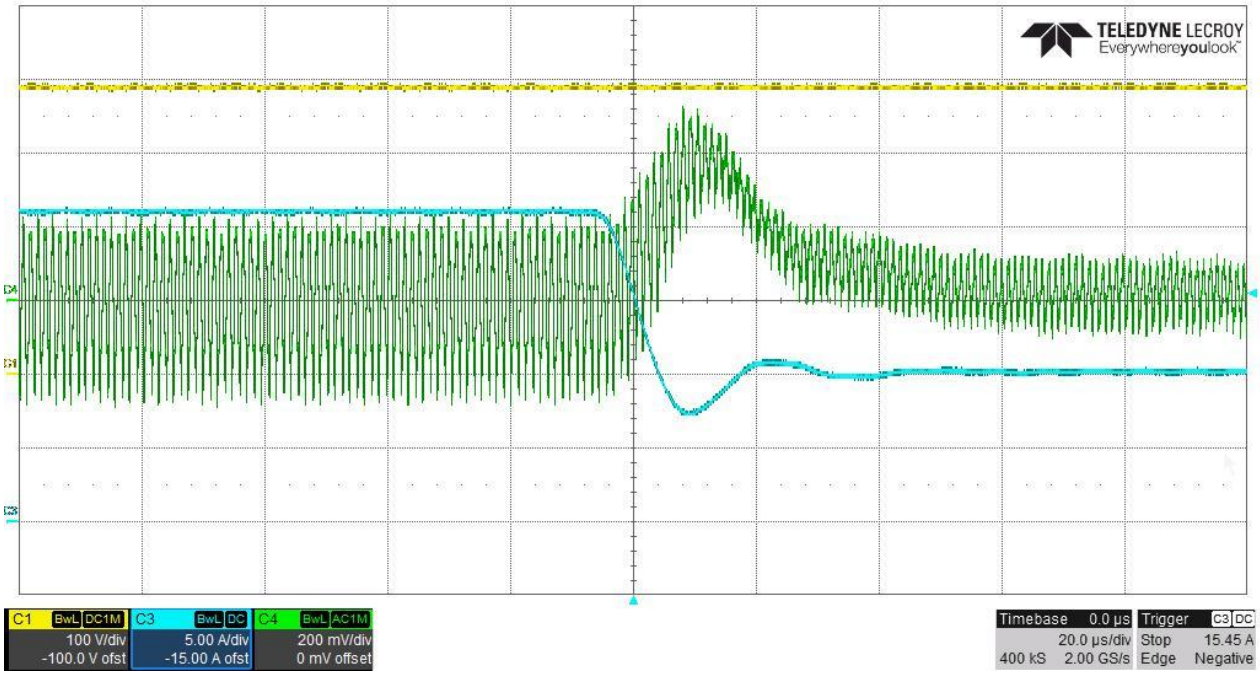
2.6.6 400VDC input, 21A load



2.7 Load Response

Load response is tested at 390V input with 10A to 21A load transient, where C1 is the input voltage, C3 is output current and C4 is output voltage in AC level.



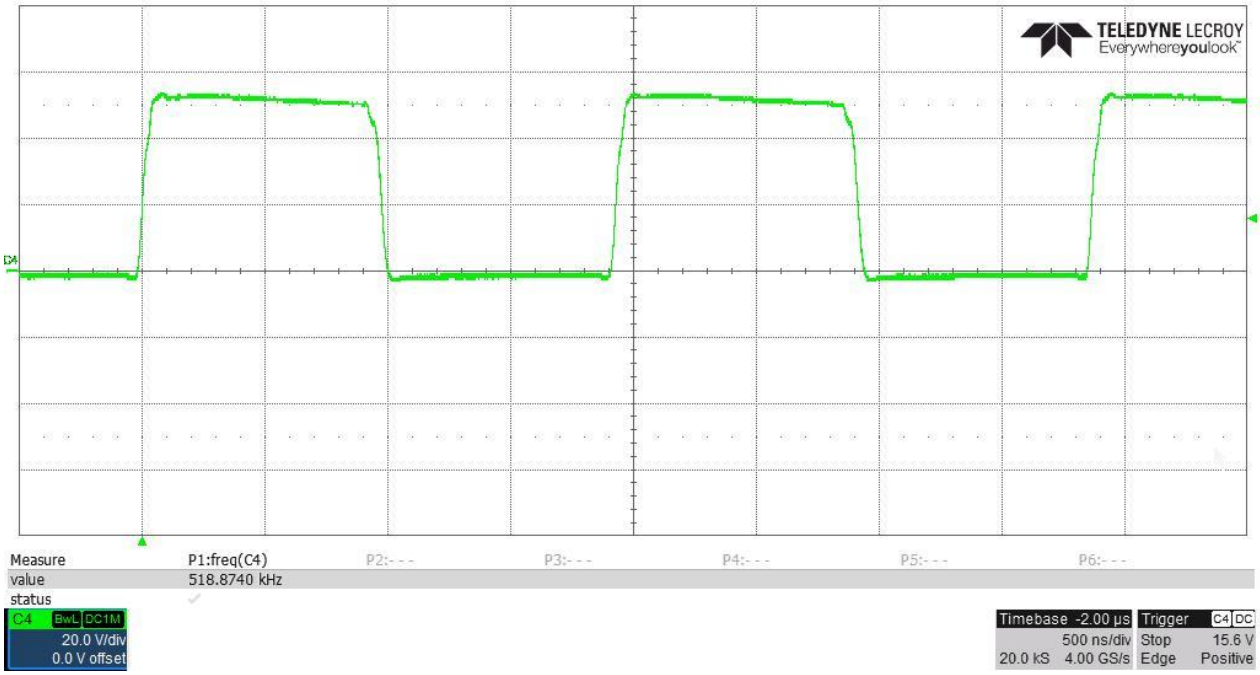


2.8 Synchronous Rectifier Conduction

2.8.1 Q103 V_{DS} @ 380V_{IN} and 24V/21A

2.8.2 Q103 V_{DS} @ 390V_{IN} and 24V/21A

2.8.3 Q103 V_{DS} @ 400V_{IN} and 24V/21A



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