

Test Report: PMP22083

Single Stage AC/DC LCC Resonant Converter Reference Design



Description

This reference design provides up to 265-W constant voltage and constant current output from an 120-V_{AC} input with a single-stage LCC resonant converter stage. The BOM cost of this design is highly optimized with the single-stage structure and the use of UCC256403 driver integrated LLC Resonant Controller. A UCC28910 primary-side regulated Flyback is applied as a bias converter and allows the main power stage to be turned on and off. This design is able to achieve 88% peak efficiency with over 200-kHz switching frequency at 120 V_{AC}.



Top and Bottom of Board

1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1-1. Voltage and Current Requirements

Parameter	Specifications
Input Voltage Range	102 V _{AC} to 132 V _{AC}
Input Frequency	50 Hz to 60 Hz
Output Voltage Range	6 V to 22 V
Maximum Output Current	12 A

1.2 Required Equipment

- An AC source with > 500-W power capability
- A DC electronic load with > 25-V voltage rating and >300-W power level
- Two low-voltage DC sources to provide CCset and CVset voltages.
- One 5-V DC source to provide PSON signal.

1.3 Considerations

When testing the board, apply < 2.5 V on current PWM port (CCset) and < 5 V on voltage PWM port (CVset) before apply AC and PSON high signal.

1.4 Dimensions

Board length×width = 6.2 in × 4.2 in

2 Testing and Results

2.1 Efficiency Graphs

The following graph and table illustrate the efficiency data with directly-supply DC voltage across input capacitors C100 and C108 (that is, V_{BUS} to PGND). 5 V is applied to PSON, voltage PWM, and 5.4 V is applied to current PWM.

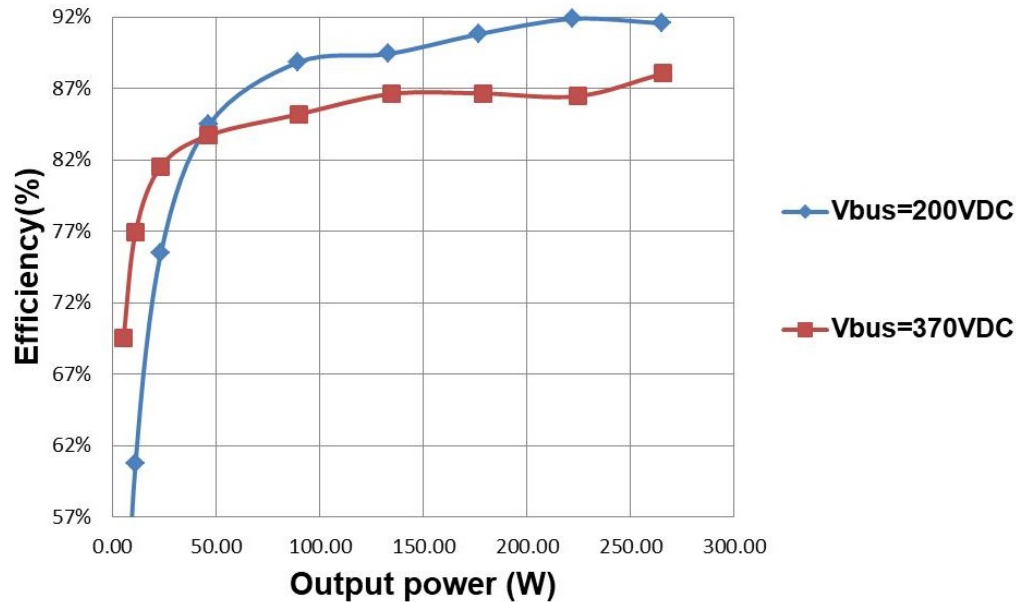


Figure 2-1. DC/DC Efficiency

Table 2-1. DC/DC Efficiency

V_{IN} (V)	I_{IN} (A)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Efficiency (%)
204.75	1.415	289.79	22.079	12.0208	265.40	91.59
204.79	1.181	241.90	22.091	10.0630	222.30	91.90
204.85	0.951	194.87	22.095	8.0108	177.00	90.83
204.97	0.726	148.81	22.106	6.0207	133.09	89.44
205.09	0.493	101.09	22.108	4.0630	89.82	88.86
205.12	0.269	55.12	22.104	2.1065	46.56	84.47
205.13	0.152	31.08	22.107	1.0614	23.46	75.50
205.13	0.090	18.46	22.104	0.5075	11.22	60.77
205.13	0.067	12.57	22.101	0.2466	5.45	43.36
371.72	0.812	301.95	22.129	12.0192	265.97	88.09
371.75	0.700	260.06	22.140	10.1595	224.93	86.49
371.84	0.555	206.25	22.138	8.0751	178.77	86.67
372.02	0.418	155.57	22.148	6.0861	134.79	86.64

Table 2-1. DC/DC Efficiency (continued)

V_{IN} (V)	I_{IN} (A)	P_{IN} (W)	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Efficiency (%)
372.10	0.284	105.56	22.141	4.0626	89.95	85.21
372.13	0.150	55.62	22.111	2.1064	46.57	83.74
372.13	0.078	28.76	22.092	1.0618	23.46	81.56
372.15	0.042	14.58	22.071	0.5083	11.22	76.94
372.15	0.023	7.85	22.065	0.2475	5.46	69.56

The following graph and table illustrate the efficiency data with 5 V applied to PSON, voltage PWM, and 5.4 V applied to current PWM. The input frequency is 60 Hz.

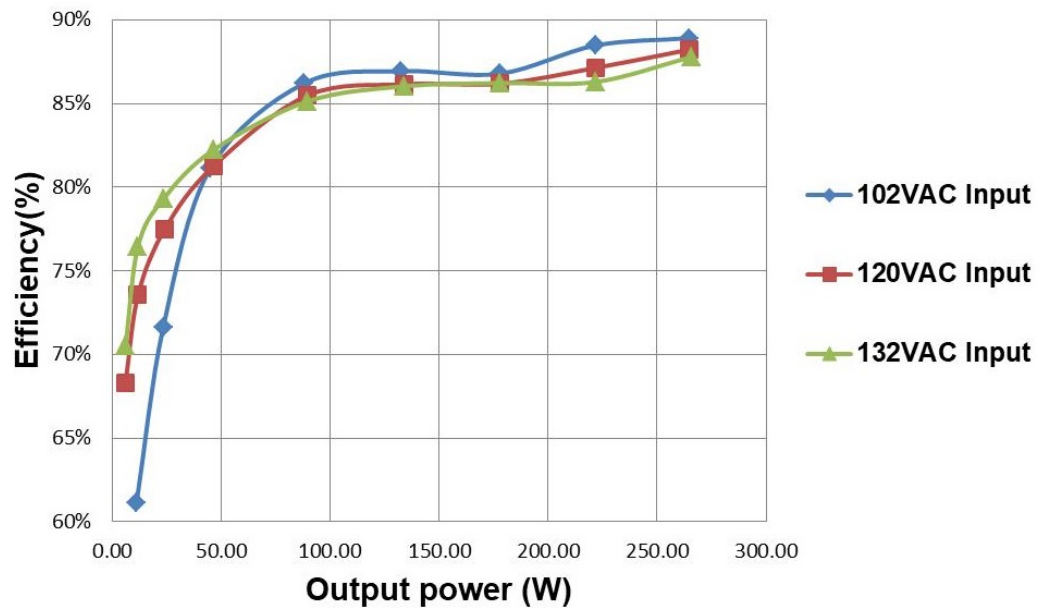
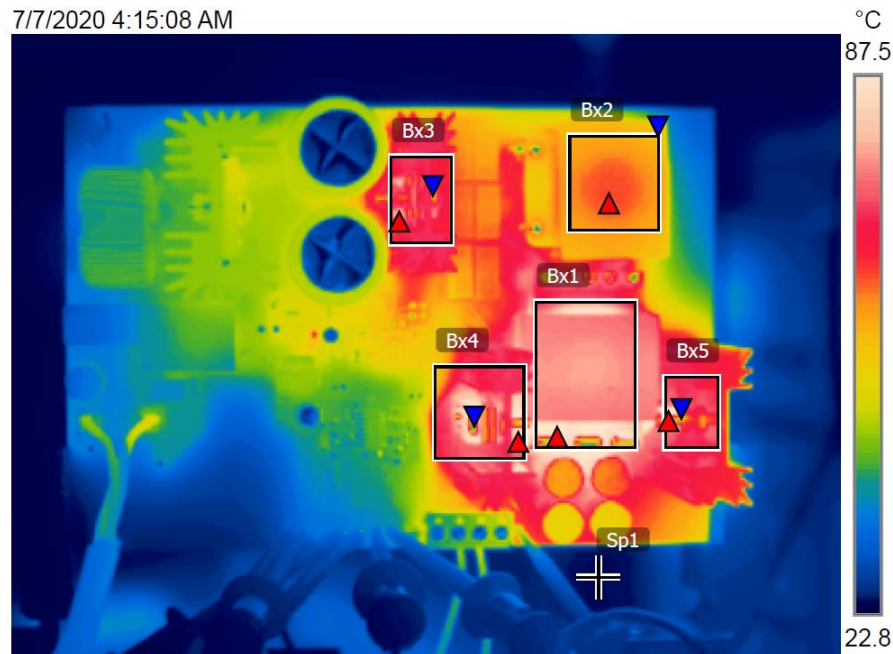

Figure 2-2. AC/DC Efficiency

Table 2-2. AC/DC Efficiency

V_{IN} (V)	I_{IN} (A)	P_{IN} (W)	P.F.	V_{OUT} (V)	I_{OUT} (A)	P_{OUT} (W)	Efficiency (%)
102.10	3.941	297.70	0.740	22.018	12.0224	264.71	88.92
102.06	3.371	250.50	0.728	22.024	10.0634	221.64	88.48
102.02	2.804	205.00	0.716	22.030	8.0766	177.93	86.79
102.06	2.156	152.63	0.694	22.037	6.0214	132.70	86.94
101.96	1.502	102.20	0.667	22.037	3.9981	88.11	86.21
102.06	0.872	55.47	0.623	22.043	2.0415	45.00	81.13
102.07	0.544	32.68	0.588	22.042	1.0615	23.40	71.60
102.03	0.327	18.30	0.548	22.040	0.5076	11.19	61.13
120.06	3.472	300.20	0.720	22.037	12.0204	264.89	88.24
120.05	2.991	254.50	0.709	22.039	10.0623	221.76	87.14
120.04	2.484	206.60	0.693	22.050	8.0759	178.08	86.19
120.01	1.932	155.71	0.672	22.044	6.0863	134.16	86.16
120.06	1.356	104.79	0.644	22.053	4.0622	89.58	85.49
120.04	0.793	57.15	0.600	22.052	2.1059	46.44	81.26
120.01	0.464	31.13	0.559	22.048	1.0942	24.12	77.50
120.02	0.261	16.17	0.516	22.044	0.5394	11.89	73.55
119.98	0.157	8.98	0.478	22.041	0.2783	6.13	68.31
13.97	3.240	302.50	0.707	22.031	12.0537	265.56	87.79
131.96	2.800	257.00	0.695	22.041	10.0628	221.79	86.30
132.07	2.305	206.50	0.679	22.047	8.0765	178.06	86.23
132.06	1.795	155.94	0.658	22.044	6.0867	134.18	86.04
132.04	1.263	105.21	0.631	22.048	4.0626	89.57	85.14
132.05	0.727	56.47	0.588	22.046	2.1062	46.43	82.23
132.04	0.410	29.51	0.544	22.045	1.0613	23.40	79.28
132.09	0.234	15.55	0.502	22.042	0.5394	11.89	76.47
132.01	0.142	8.70	0.465	22.039	0.2785	6.14	70.53

2.2 Thermal Images

The following thermal images show a top view and bottom view of the board. The ambient temperature is 20°C with no forced air flow. The input is at 120 V_{AC} and the output is at 22-V, 12-A loads.



Measurements

Bx1	Max	90.3 °C
Bx2	Max	67.1 °C
	Min	59.5 °C
	Average	64.0 °C
Bx3	Max	81.5 °C
	Min	60.5 °C
	Average	72.2 °C
Bx4	Max	93.5 °C
	Min	44.6 °C
	Average	74.7 °C
Bx5	Max	97.4 °C
	Min	58.9 °C
	Average	73.3 °C
Sp1		24.7 °C

Figure 2-3. Top-Side Thermal Image



Measurements

Bx1	Max	100.0 °C
Bx2	Max	82.5 °C
	Min	44.5 °C
	Average	67.1 °C
Bx3	Max	75.9 °C
	Min	28.7 °C
	Average	65.1 °C
Sp1		23.8 °C

Figure 2-4. Bottom-Side Thermal Image

2.3 Frequency Response

Frequency responses are taken with directly-supplied DC voltage across input capacitors C100 and C108 (that is, V_{BUS} to PGND). 5 V is applied to PSON, *Current PWM* and *Voltage PWM* voltage applied differently for different current and voltage regulation settings.

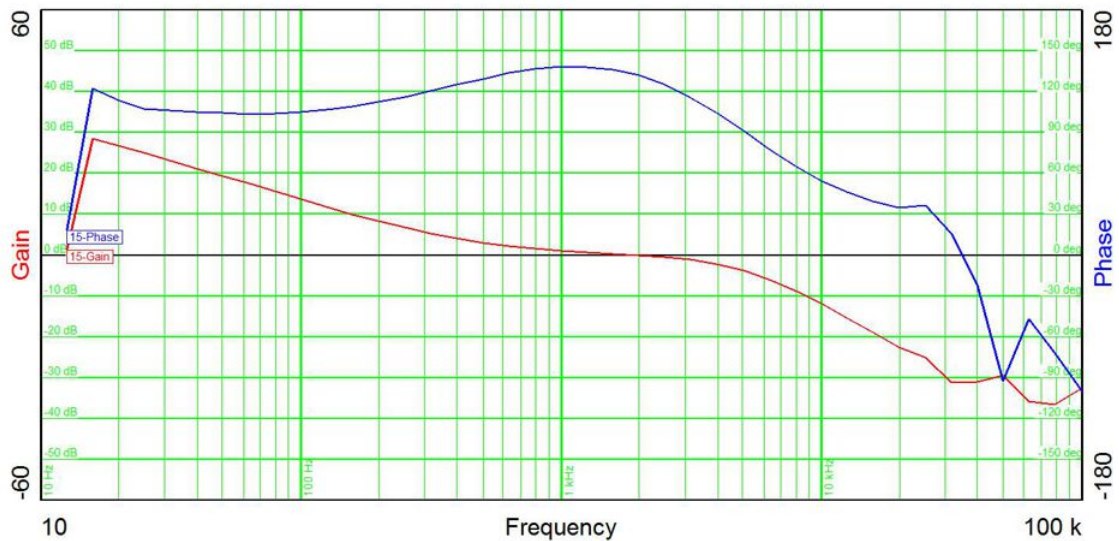


Figure 2-5. Constant Voltage Loop at 200- V_{DC} Input and 24-V, 12-A Output

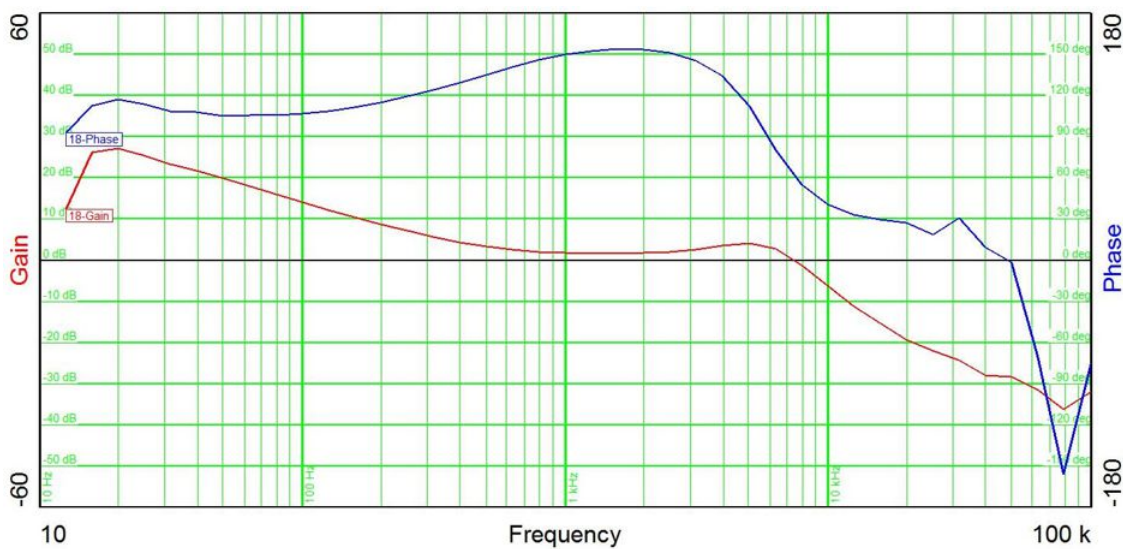


Figure 2-6. Constant Voltage Loop at 370- V_{DC} Input and 24-V, 12-A Output

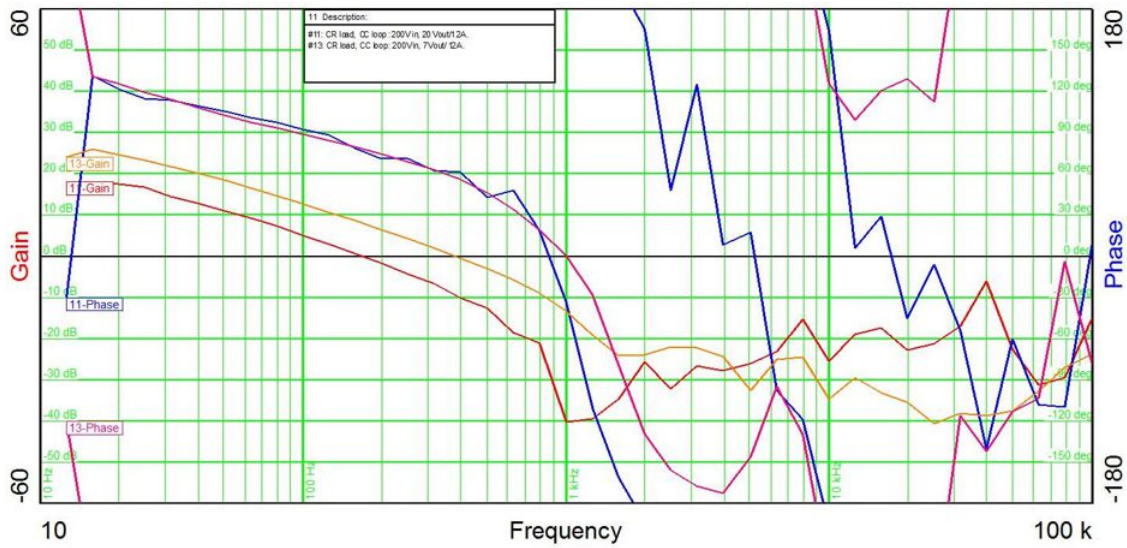


Figure 2-7. Constant Current Loop at 200-V_{DC} Input With Constant Resistor Load

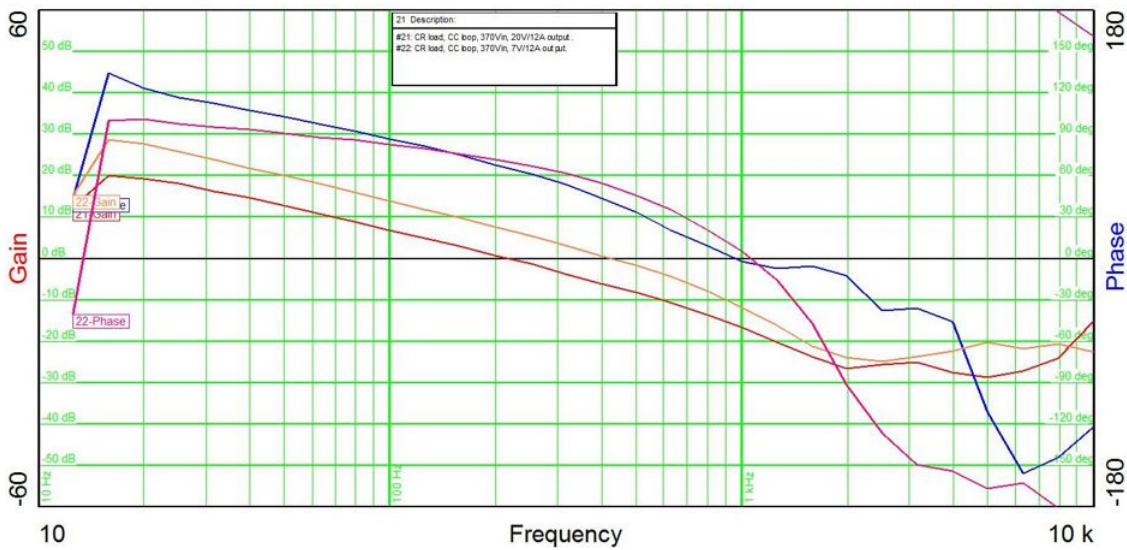


Figure 2-8. Constant Current Loop at 370-V_{DC} Input With Constant Resistor Load

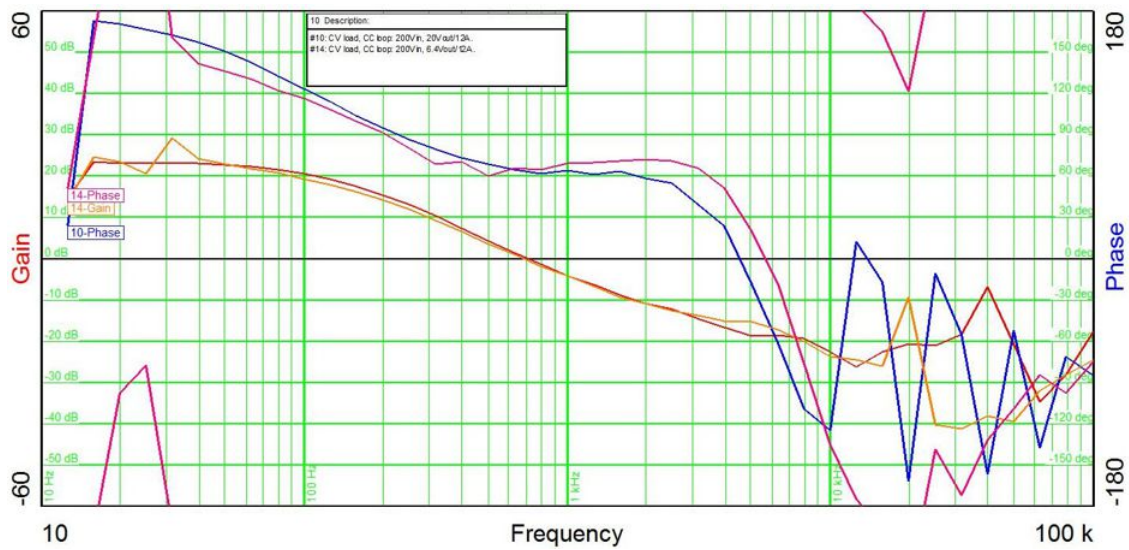


Figure 2-9. Constant Current Loop at 200-V_{DC} Input With Constant Voltage Load

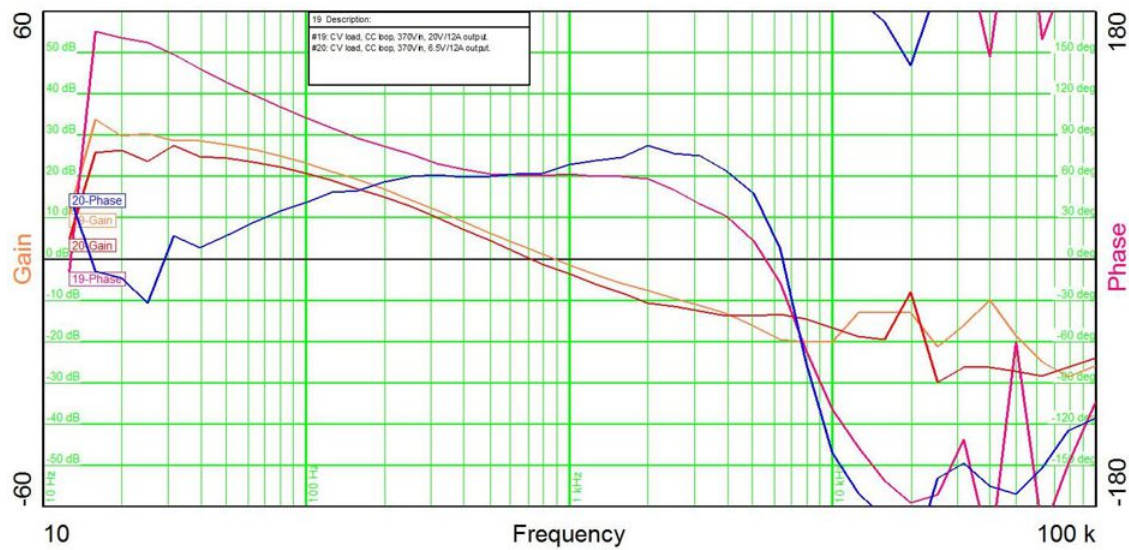


Figure 2-10. Constant Current Loop at 370-V_{DC} Input With Constant Voltage Load

3 Waveforms

3.1 Start-up

The following images illustrate the output voltages at start-up. 5 V is given to PSON. *Current PWM* and *Voltage PWM* voltage are applied differently for different current and voltage regulation settings.

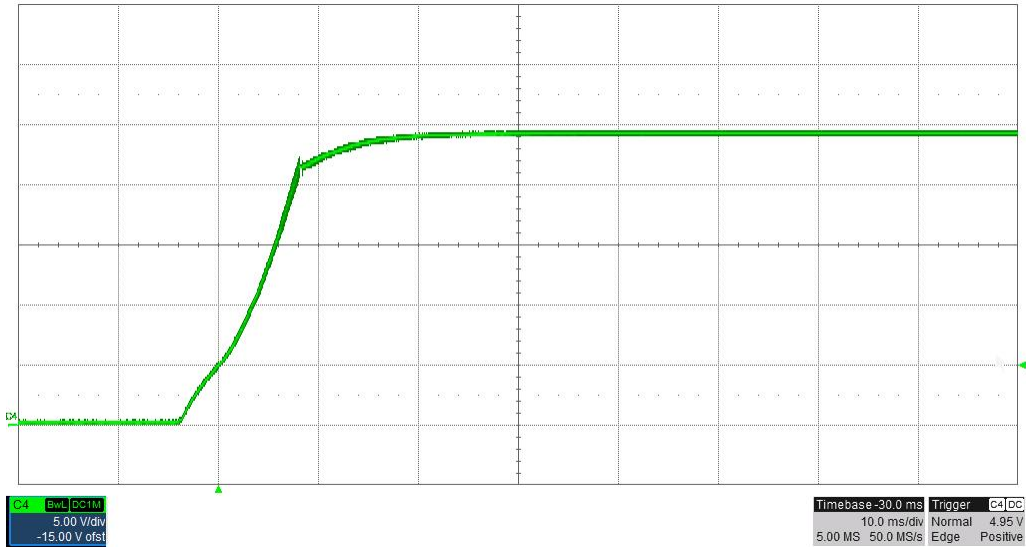


Figure 3-1. Start-up at 102-V_{AC}, 60-Hz Input, 24-V Output With no Load

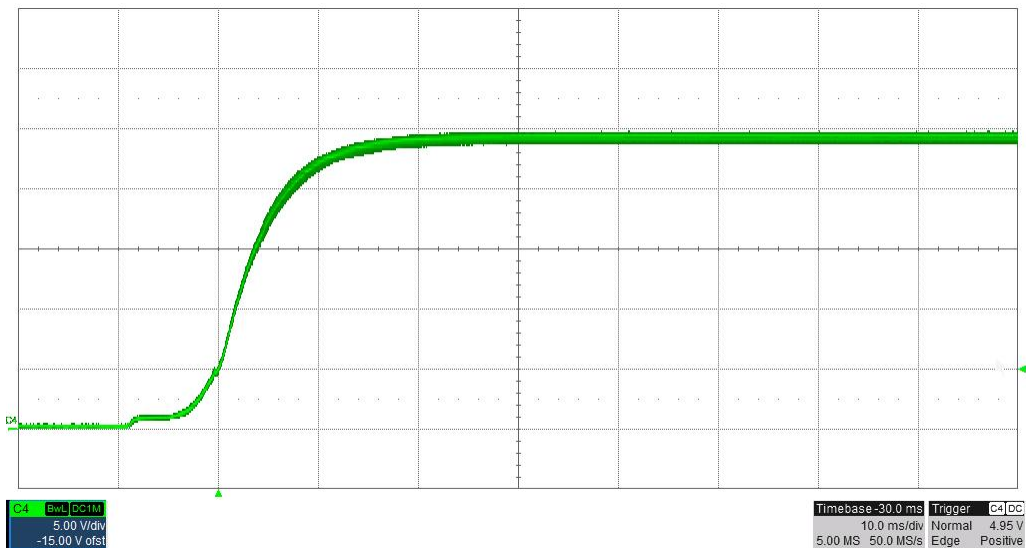


Figure 3-2. Start-up at 102-V_{AC}, 60-Hz Input, 24-V, 4-A Output

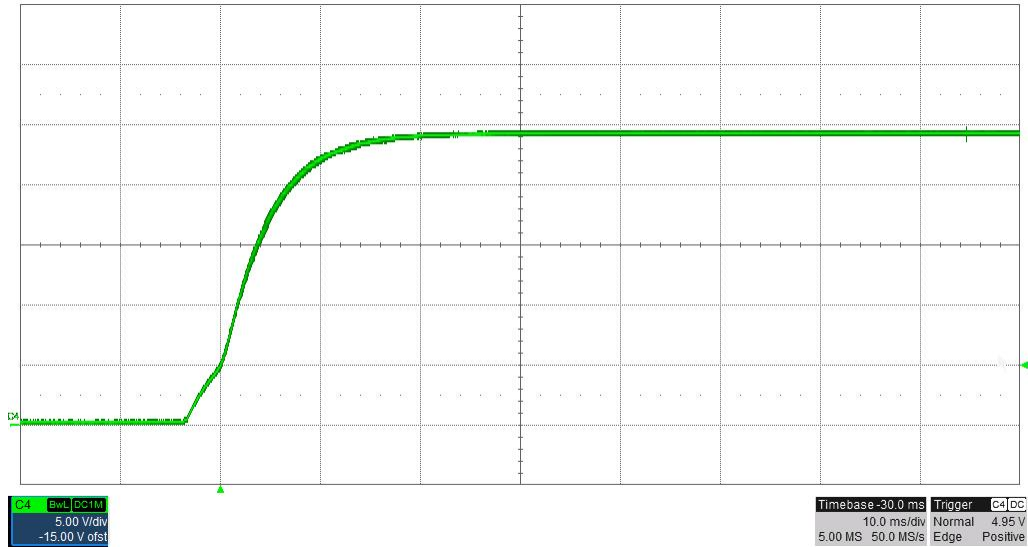


Figure 3-3. Start-up at 120-V_{AC}, 60-Hz Input, 24-V Output With no Load

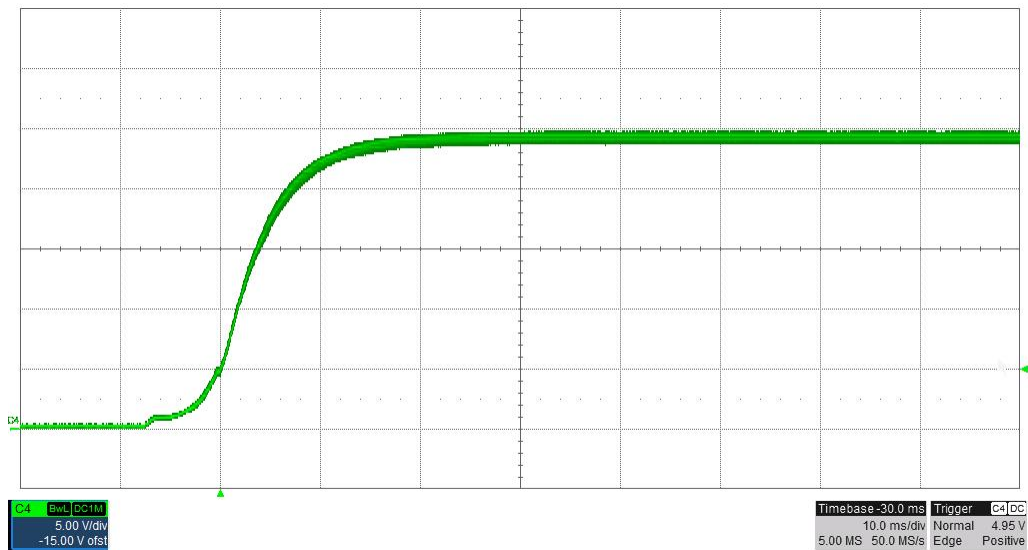


Figure 3-4. Start-up at 120-V_{AC}, 60-Hz Input, 24-V, 4-A Output

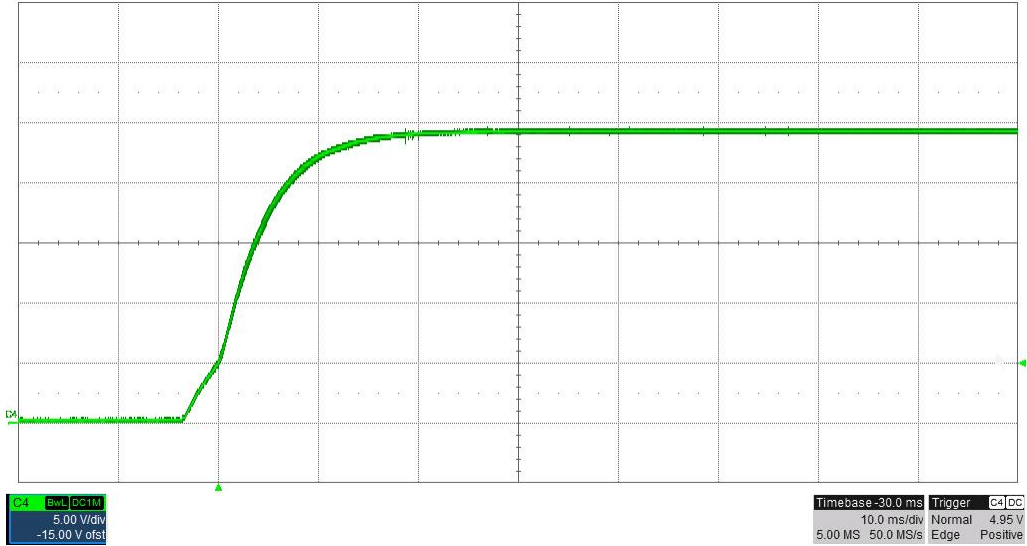


Figure 3-5. Start-up at 132-V_{AC}, 60-Hz Input, 24-V Output With no Load

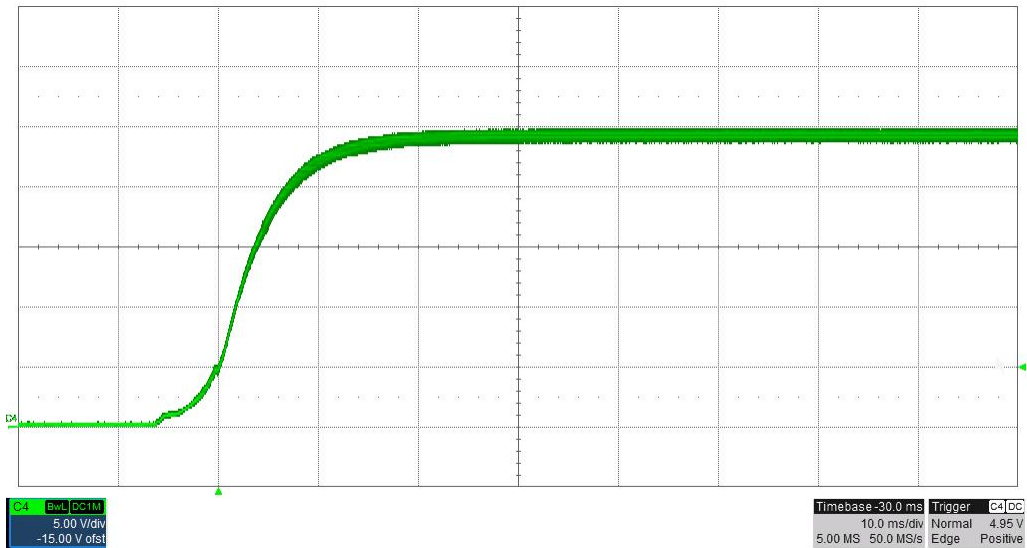


Figure 3-6. Start-up at 132-V_{AC}, 60-Hz Input, 24-V, 4-A Output

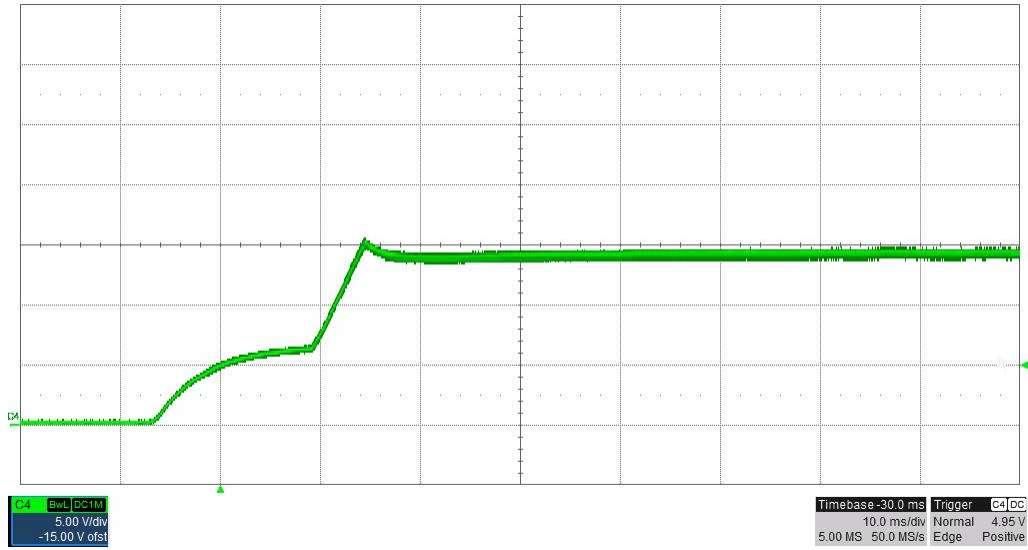


Figure 3-7. Start-up at 102-V_{AC}, 60-Hz Input, Constant Resistor Load, 14-V, 5-A Output

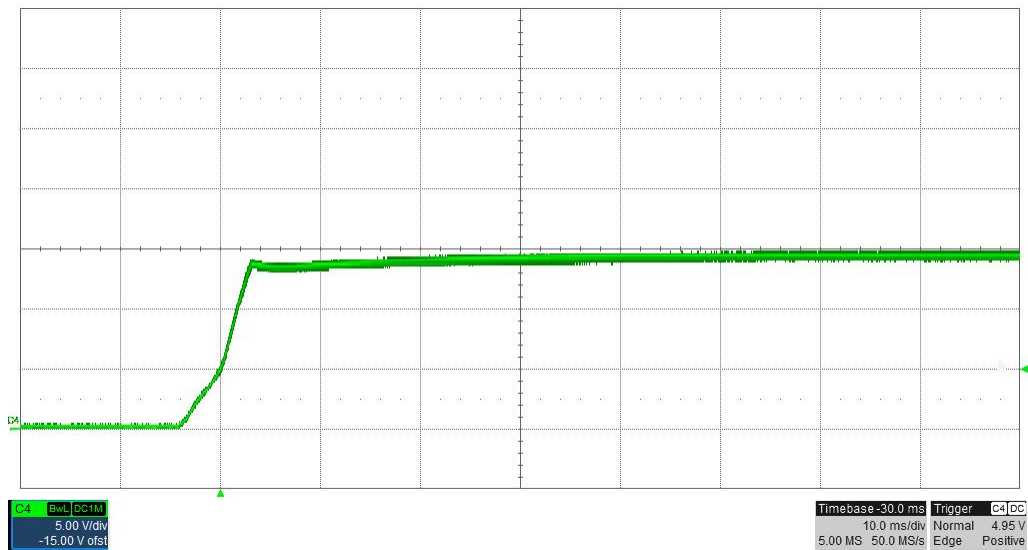


Figure 3-8. Start-up at 120-V_{AC}, 60-Hz Input, Constant Resistor Load, 14-V, 5-A Output

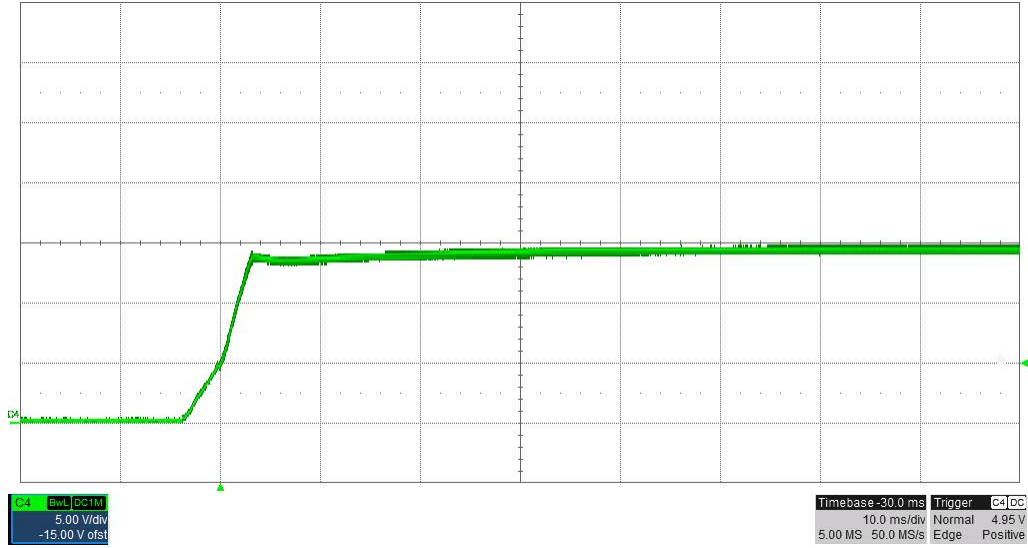
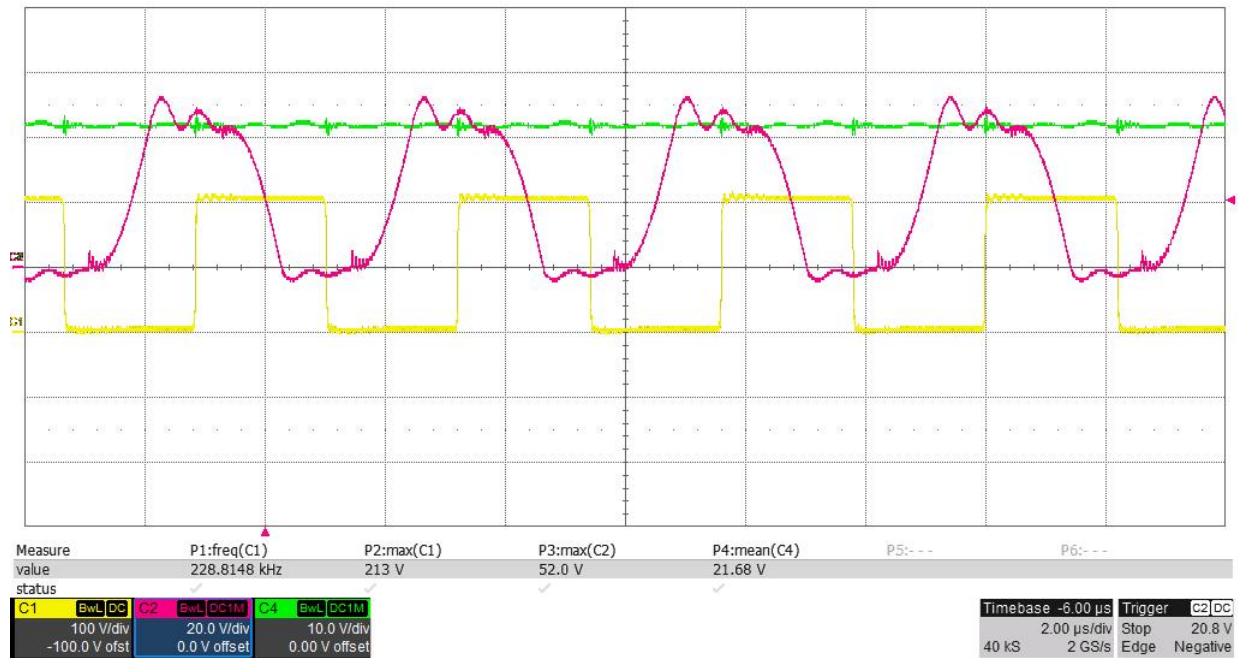


Figure 3-9. Start-up at 132-V_{AC}, 60-Hz Input, Constant Resistor Load, 14-V, 5-A Output

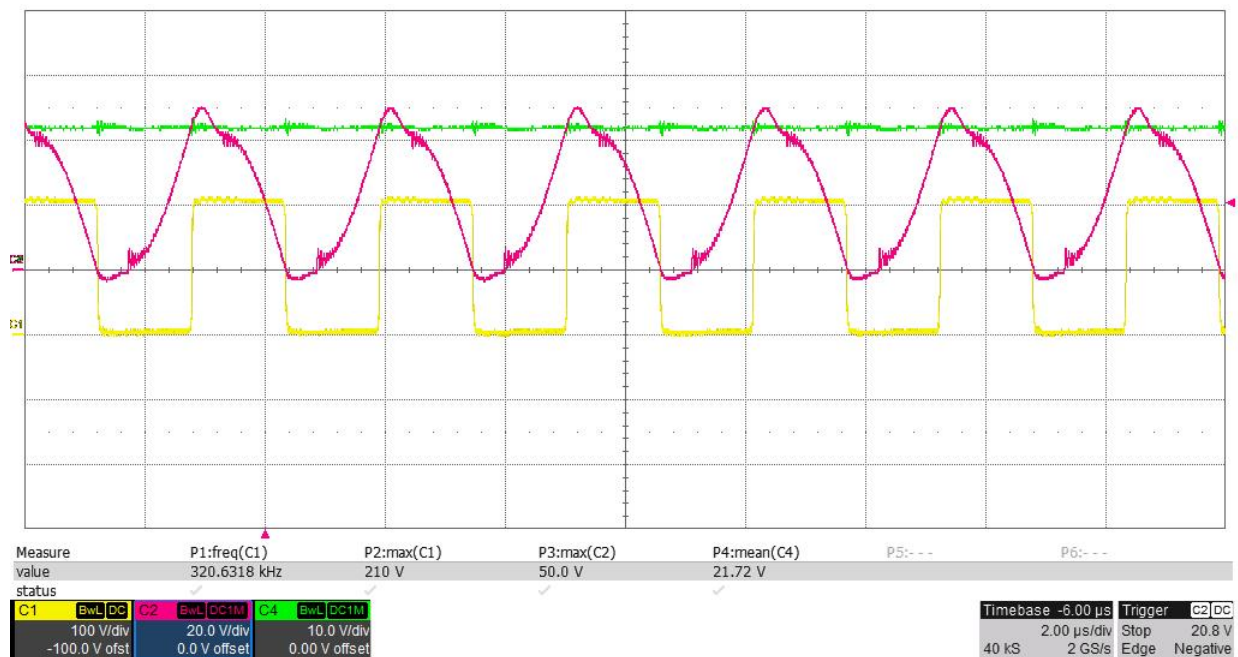
3.2 Switching Waveforms

The following figures show the switching behavior of the PMP22083.



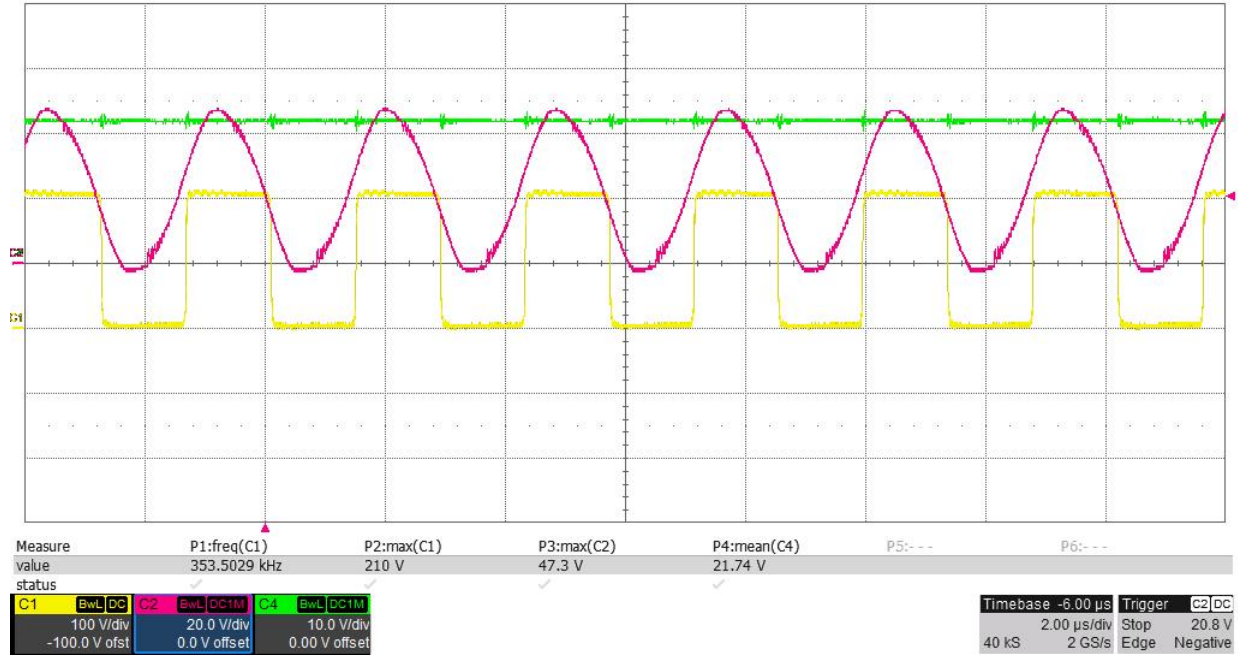
C1: Q103_VGS, C2: D102, C4: VOUT

Figure 3-10. 200-V_{DC} Input, 22-V, 12-A Output



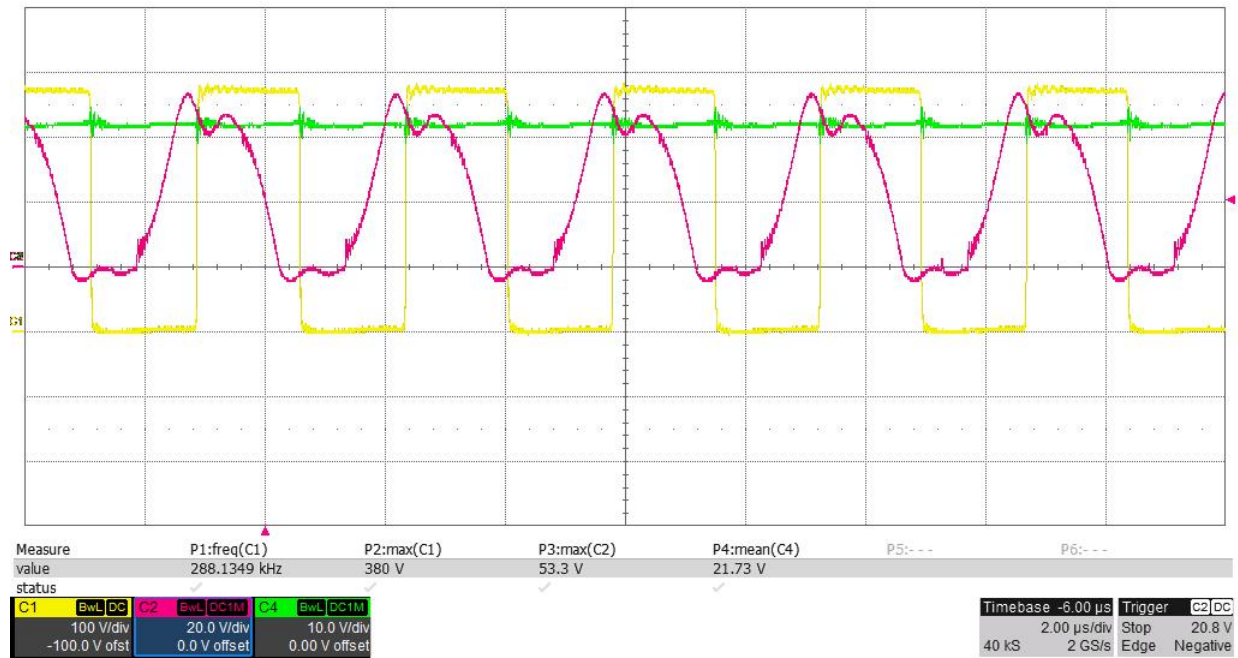
C1: Q103_VGS, C2: D102, C4: VOUT

Figure 3-11. 200-V_{DC} Input, 22-V, 4-A Output



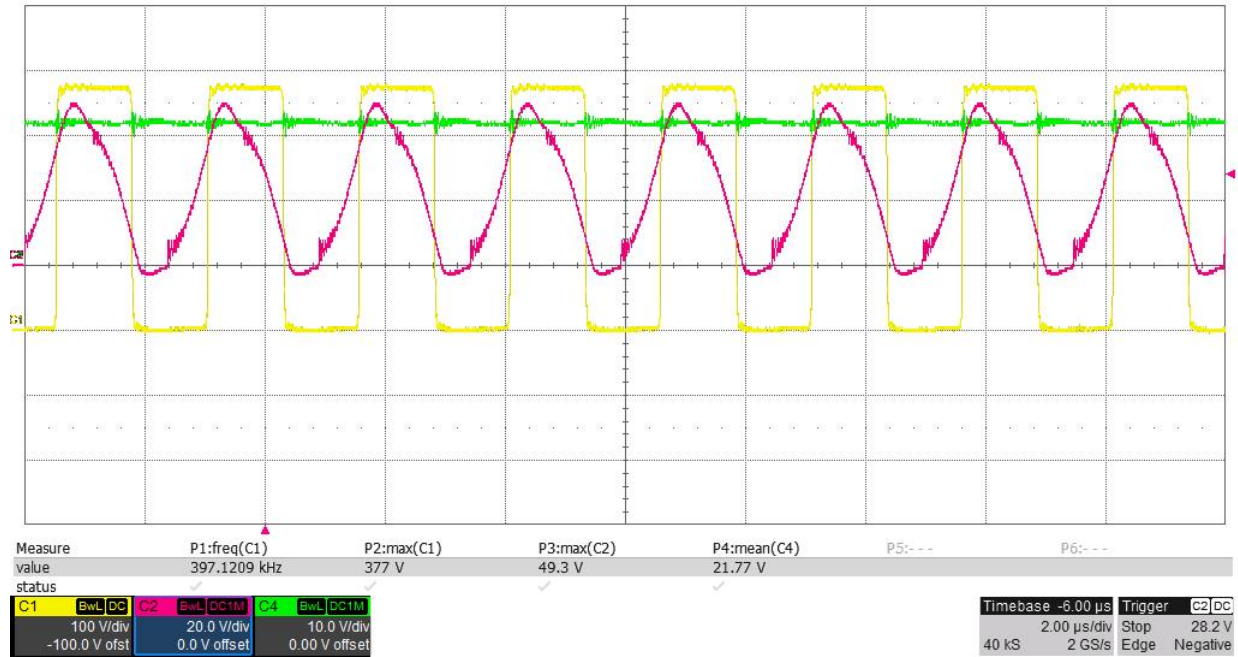
C1: Q103_VGS, C2: D102, C4: VOUT

Figure 3-12. 200-V_{DC} Input, 22-V, 1-A Output



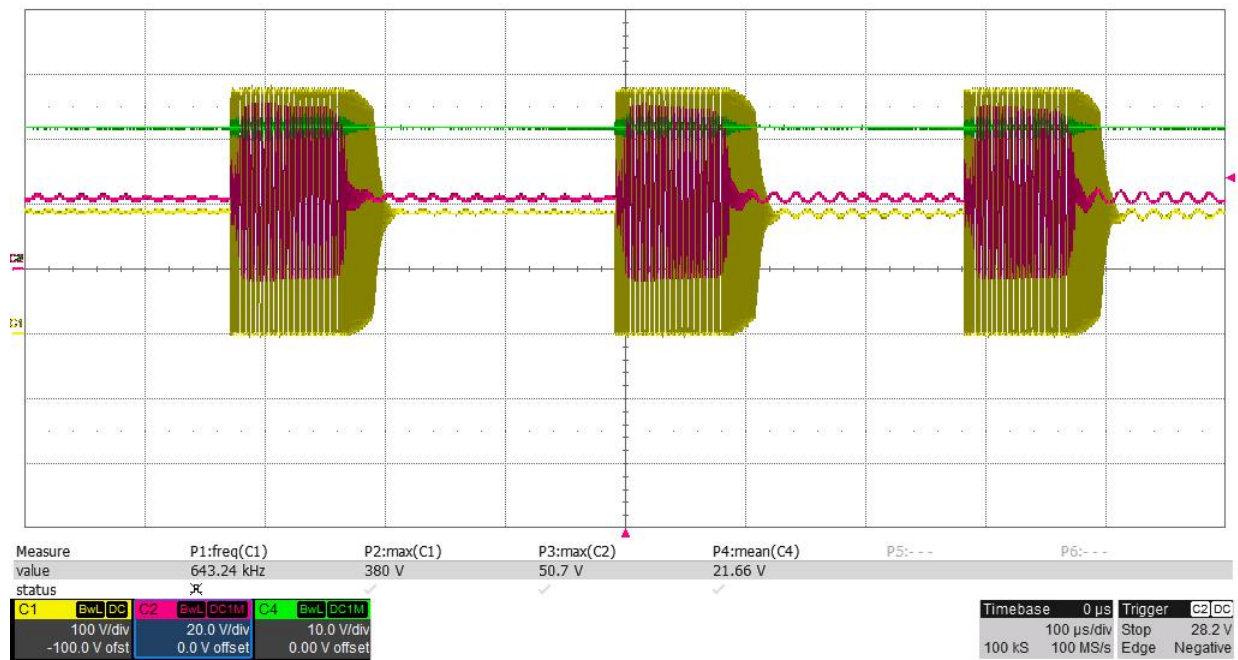
C1: Q103_VGS, C2: D102, C4: VOUT

Figure 3-13. 370 V_{DC} Input, 22-V, 12-A Output



C1: Q103_VGS, C2: D102, C4: VOUT

Figure 3-14. 370-V_{DC} Input, 22-V, 4-A Output



C1: Q103_VGS, C2: D102, C4: VOUT

Figure 3-15. 370-V_{DC} Input, 22-V, 1-A Output

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