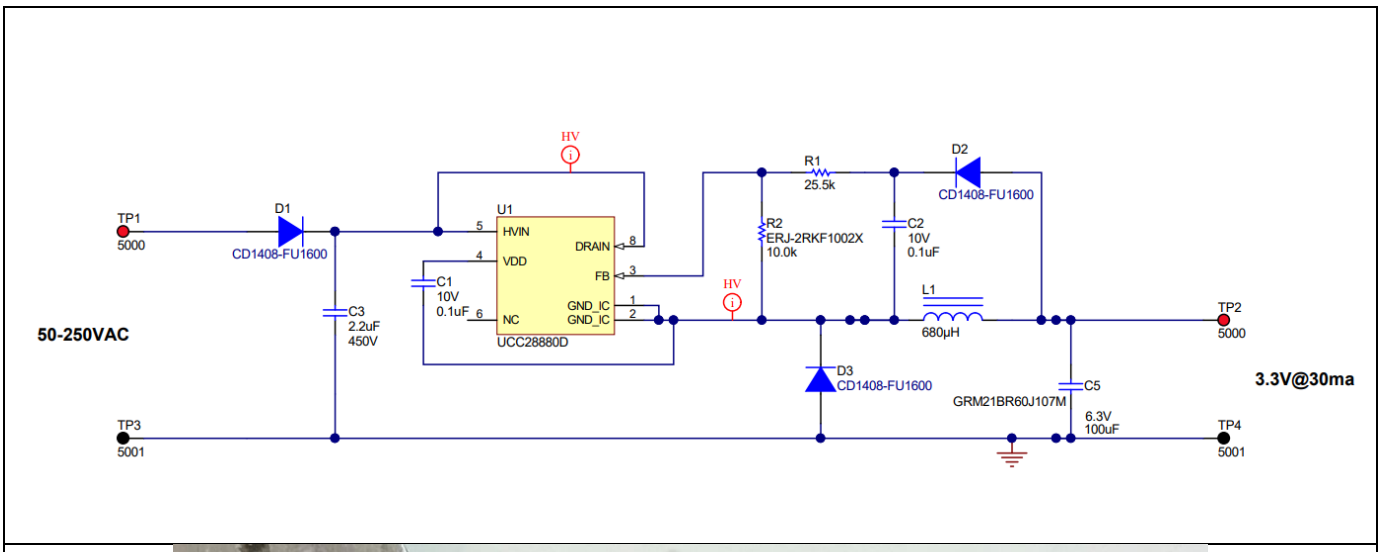
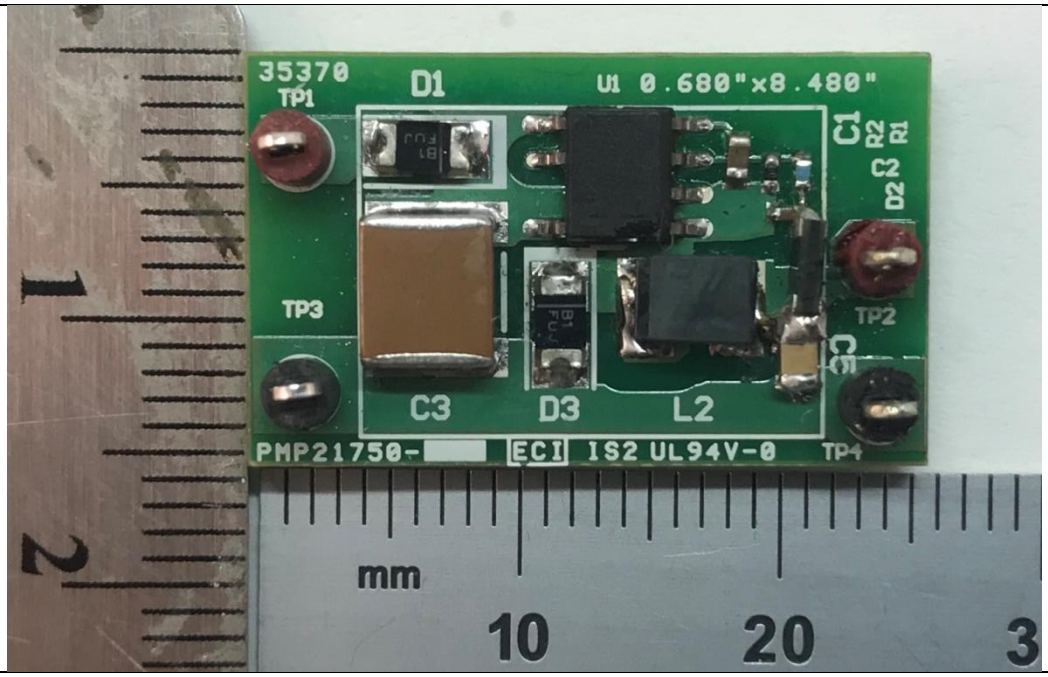
Test Report: PMP21750

Tiny, Universal Line to 3.3V/30mA Reference Design for Circuit Breakers

Description

Using the UCC28880 FET integrated buck controller, this design provides a universal line to non-isolated 3.3V/30mA for Arc Fault and Ground Fault Circuit Interrupter circuit breaker systems. This tiny design is built on a single layer PCB in a space optimized 0.680" by 0.480" footprint by implementing a half-bridge rectifier and not requiring a large transformer.





1 Test Prerequisites

1.1 Voltage and Current Requirements

Table 1. Voltage and Current Requirements

PARAMETER	SPECIFICATIONS
V_{IN}	50-250VAC, 60Hz
V_{OUT}	3.3V @ 30mA

*1.2 Required Equipment**

- Fluke 97 III True RMS Multimeter x2
- Kikusui PLZ334W Electronic Load
- California Instruments Model 1251P AC Power Source
- Tektronix PA1000 Power Analyzer
- Teledyne Lecroy Wavesurfer 3074 Oscilloscope

1.3 Considerations

- Tiny, 0.326in^2 footprint.
- Less than 300mW power loss
- 3% load regulation at 30mA load
    - Load regulation can be improved by adding linear regulator at output

D2 was modified after initial design to a larger diode with higher voltage rating.

PCB marking misprints:

- L2 = L1
- Footprint size is 0.680” x 0.480”

2 Testing and Results

2.1 Efficiency Graphs

The board efficiency and power dissipation is shown in Figure 1 for inputs of 50VAC, 120VAC, and 250VAC at 60Hz with 3.3V output.

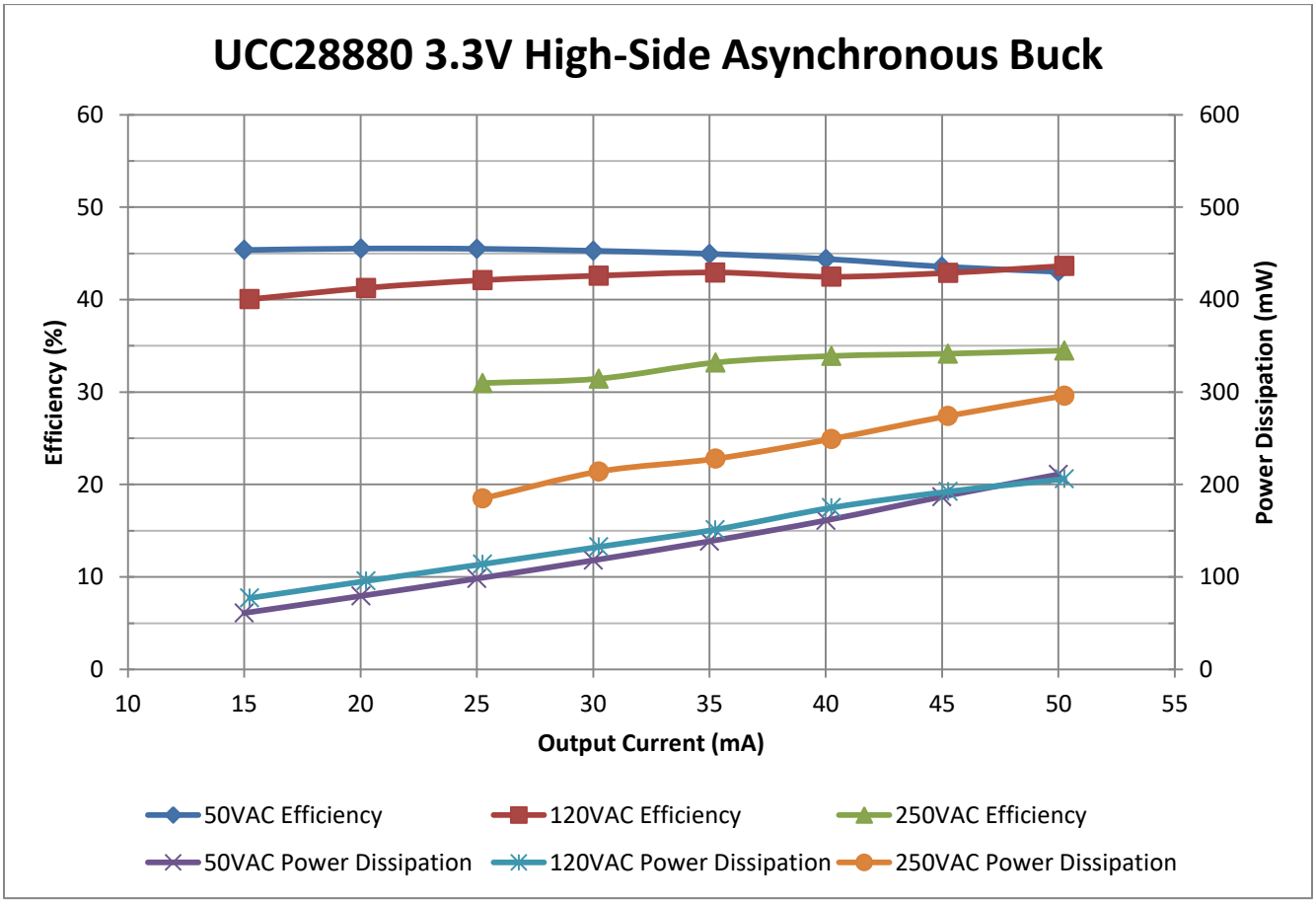


Figure 1. Efficiency and power dissipation curves for 50VAC, 120VAC, and 250VAC at 60Hz with 3.3V output

2.2 Efficiency Data

The board efficiency and power dissipation data is shown in Table 2 for inputs of 50VAC, 120VAC, and 250VAC at 60Hz with 3.3V output.

Table 2. Efficiency data for 50VAC, 120VAC, and 250VAC at 60Hz with 3.3V output

Input				Output			Calculations	
Vin, rms (V)	Iin, rms (mA)	Pin (mW)	P.F.	Vout (V)	Iout (mA)	Pout (mW)	Loss (mW)	Efficiency (%)
50.0	6.059	111.7	0.369	3.377	15.00	50.7	61.0	45.37
50.0	7.669	145.9	0.380	3.317	20.02	66.4	79.5	45.52
50.0	9.375	180.2	0.385	3.279	25.01	82.0	98.2	45.50
50.0	11.168	215.6	0.386	3.253	30.01	97.6	118.0	45.28
50.0	13.186	251.8	0.382	3.233	35.01	113.2	138.6	44.95
50.0	15.607	289.9	0.372	3.217	40.01	128.7	161.2	44.40
50.0	19.172	331.1	0.345	3.206	45.00	144.3	186.8	43.57
50.0	24.71	370.1	0.300	3.184	50.00	159.2	210.9	43.02
120.1	3.533	128.8	0.304	3.384	15.24	51.6	77.2	40.04
120.1	4.263	162.8	0.318	3.319	20.24	67.2	95.6	41.26
120.1	4.981	196.7	0.329	3.28	25.25	82.8	113.9	42.10
120.1	5.668	230.9	0.339	3.251	30.25	98.3	132.6	42.59
120.1	6.357	265.0	0.347	3.228	35.25	113.8	151.2	42.94
120.1	7.197	304.1	0.352	3.209	40.25	129.2	174.9	42.47
120.1	7.898	336.8	0.355	3.192	45.26	144.5	192.3	42.89
120.1	8.308	365.6	0.367	3.175	50.26	159.6	206.0	43.65
250.4	-	-	-	3.412	15.24	52.0	-	-
250.4	-	-	-	3.336	20.25	67.6	-	-
250.4	3.378	267.8	0.317	3.285	25.25	82.9	184.9	30.97
250.4	3.802	312.2	0.328	3.246	30.25	98.2	214.0	31.45
250.4	4.179	341.1	0.326	3.211	35.26	113.2	227.9	33.19
250.4	4.581	377.2	0.329	3.177	40.25	127.9	249.3	33.90
250.4	4.974	416.3	0.334	3.142	45.25	142.2	274.1	34.15
250.4	5.335	452.0	0.338	3.102	50.26	155.9	296.1	34.49

*Input power could not be accurately measured for less than 3mA

2.3 Load Regulation

The board load regulation is shown in Table 2 for inputs of 50VAC, 120VAC, and 250VAC at 60Hz with 3.3V output.

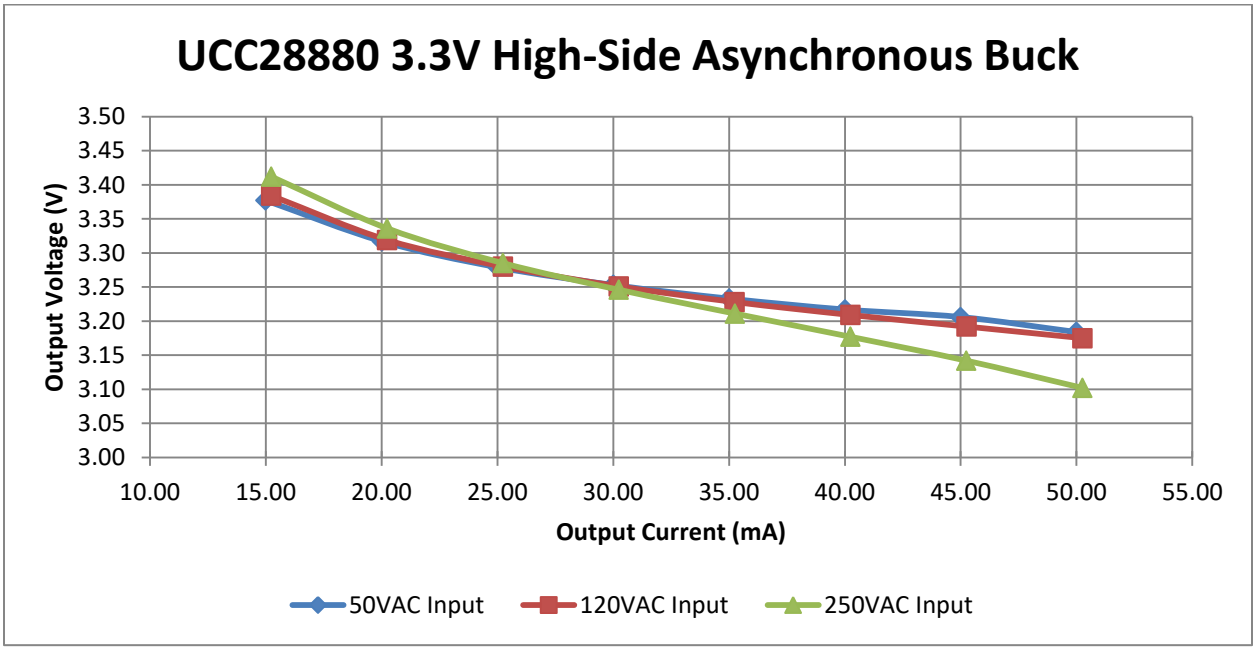


Figure 2. Load regulation curves for 50VAC, 120VAC, and 250VAC at 60Hz with 3.3V output

2.4 Thermal Images

Figure 3 shows the board thermals at ambient temperature of 22°C with input of 120VAC at 60Hz with 3.3V output at 20mA load. Figure 4 shows the board thermals at ambient temperature of 22°C with input of 120VAC at 60Hz with 3.3V output at 30mA load. Figure 5 shows the board thermals at ambient temperature of 22°C with input of 120VAC at 60Hz with 3.3V output at 50mA load.

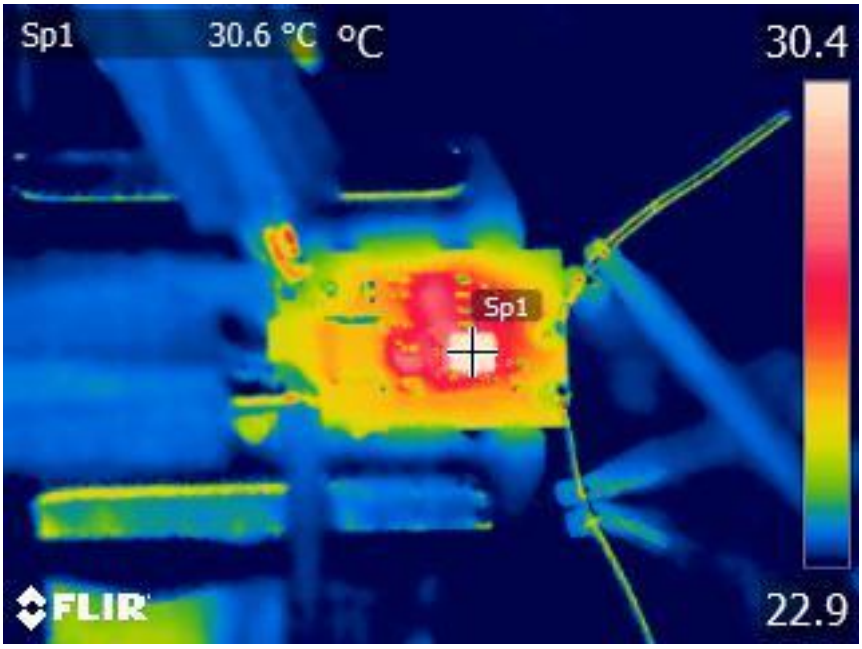


Figure 3. Thermals for 120VAC at 60Hz with 3.3V output at 20mA load

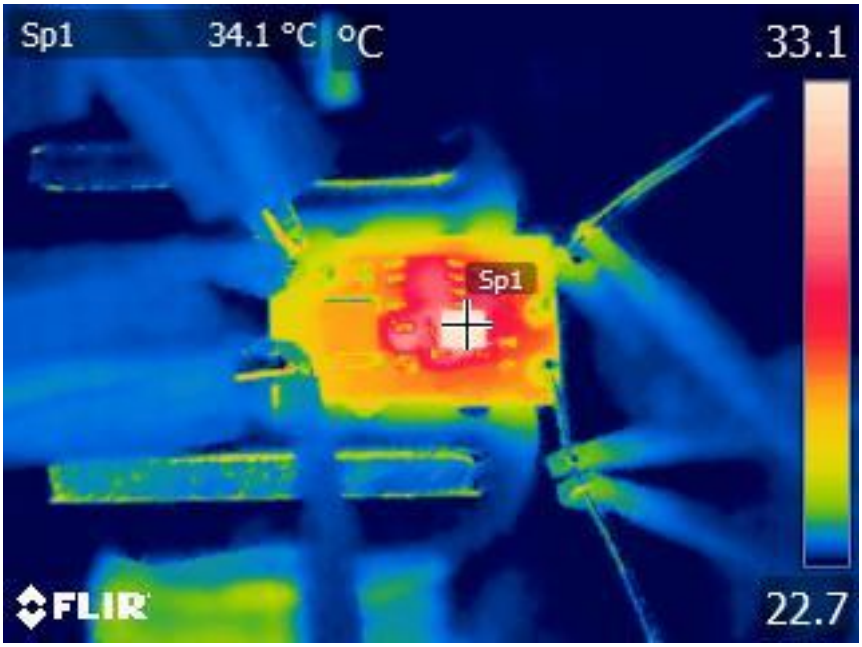


Figure 4. Thermals for 120VAC at 60Hz with 3.3V output at 30mA load

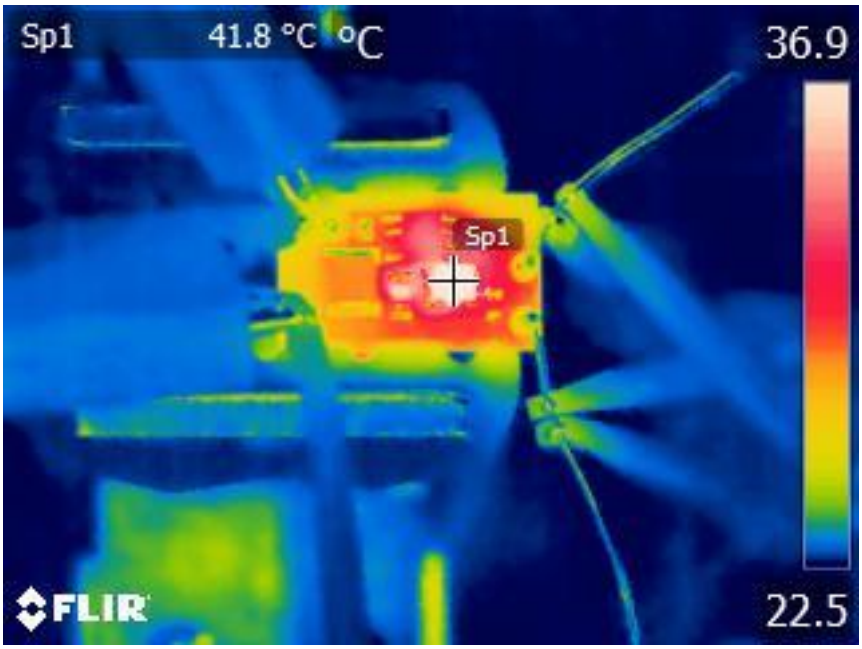


Figure 5. Thermals for 120VAC at 60Hz with 3.3V output at 50mA load

3 Waveforms

3.1 Switching

The switch node voltage waveform is shown in Figure 6 for input of 120VAC at 60Hz with 3.3V output at 30mA load. (50.0V/div, 50.0µs/div)

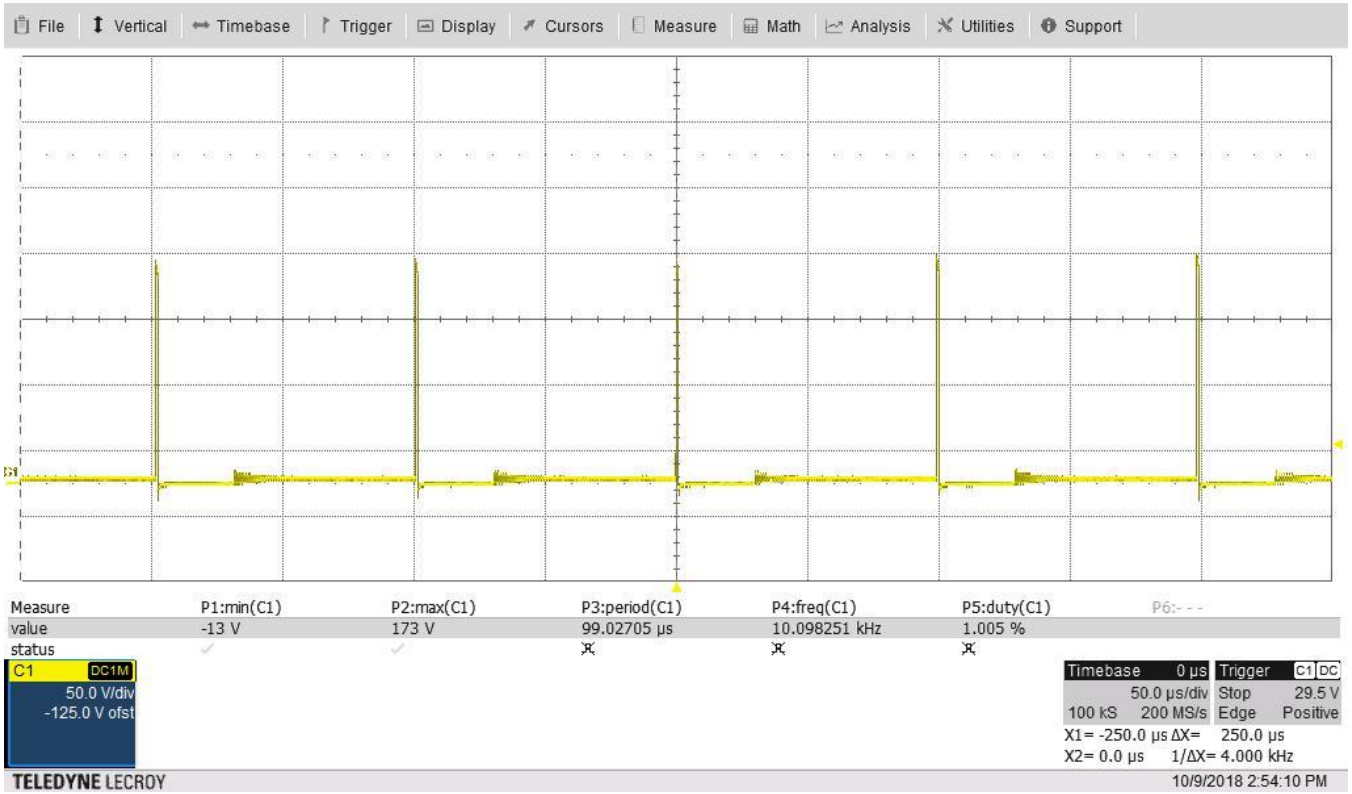


Figure 6. Switch node voltage for 120VAC at 60Hz with 3.3V output at 30mA load

3.2 Output Voltage Ripple

The output voltage ripple waveform is shown in Figure 7 for input of 120VAC at 60Hz with 3.3V output at 15mA load. (50.0mV/div, 100µs/div)

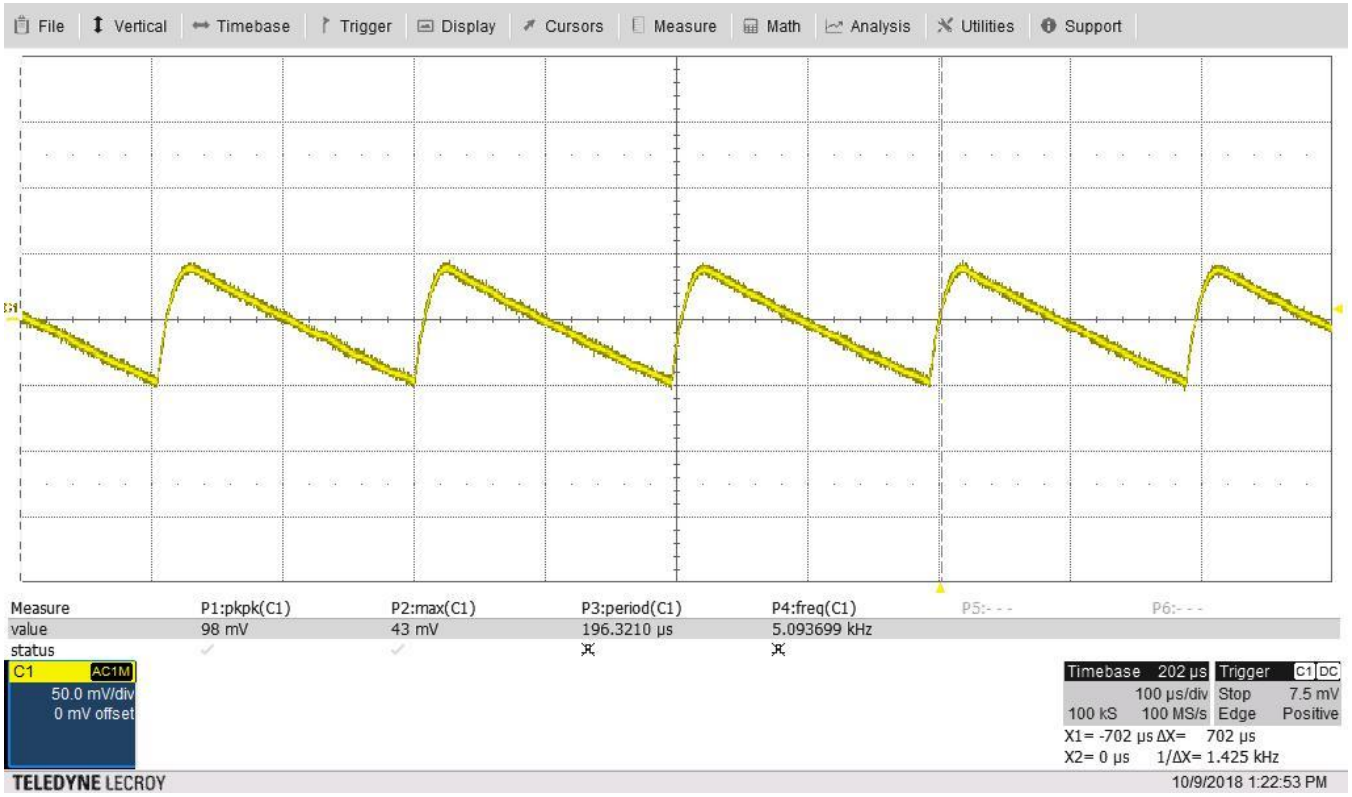


Figure 7. Output voltage ripple for 120VAC at 60Hz with 3.3V output at 15mA load

3.3 Load Transients

The 3.3V output (AC coupled) during 15mA to 50mA load step is shown in Figure 8 for input of 120VAC at 60Hz. (200mV/div, 50ms/div)

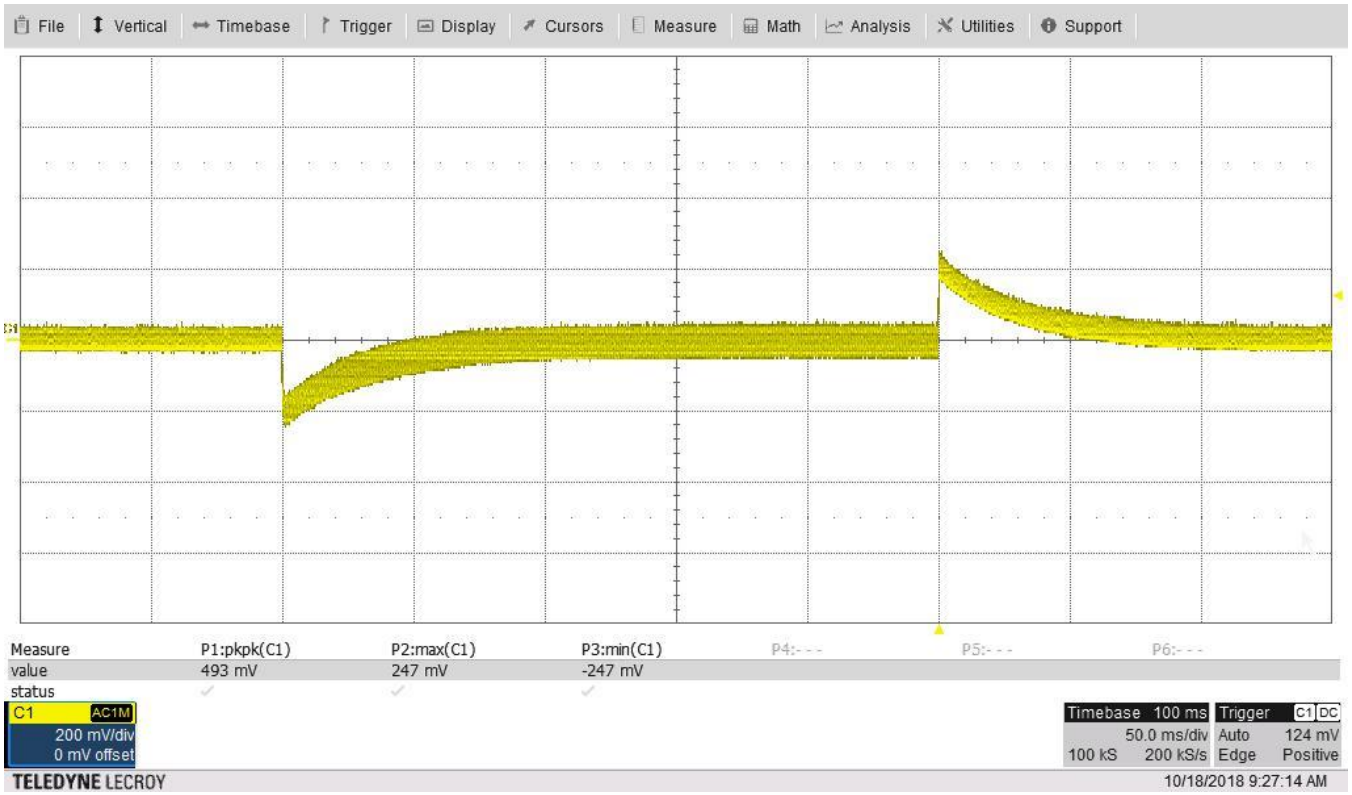


Figure 8. 3.3V output during 15mA to 50mA load step for 120VAC at 60Hz

3.4 Start-up Sequence

The output voltage start-up waveform is shown in Figure 9 for input of 120VAC at 60Hz with 3.3V output at 30mA load. (100V/div, 1.000V/div, 5ms/div)

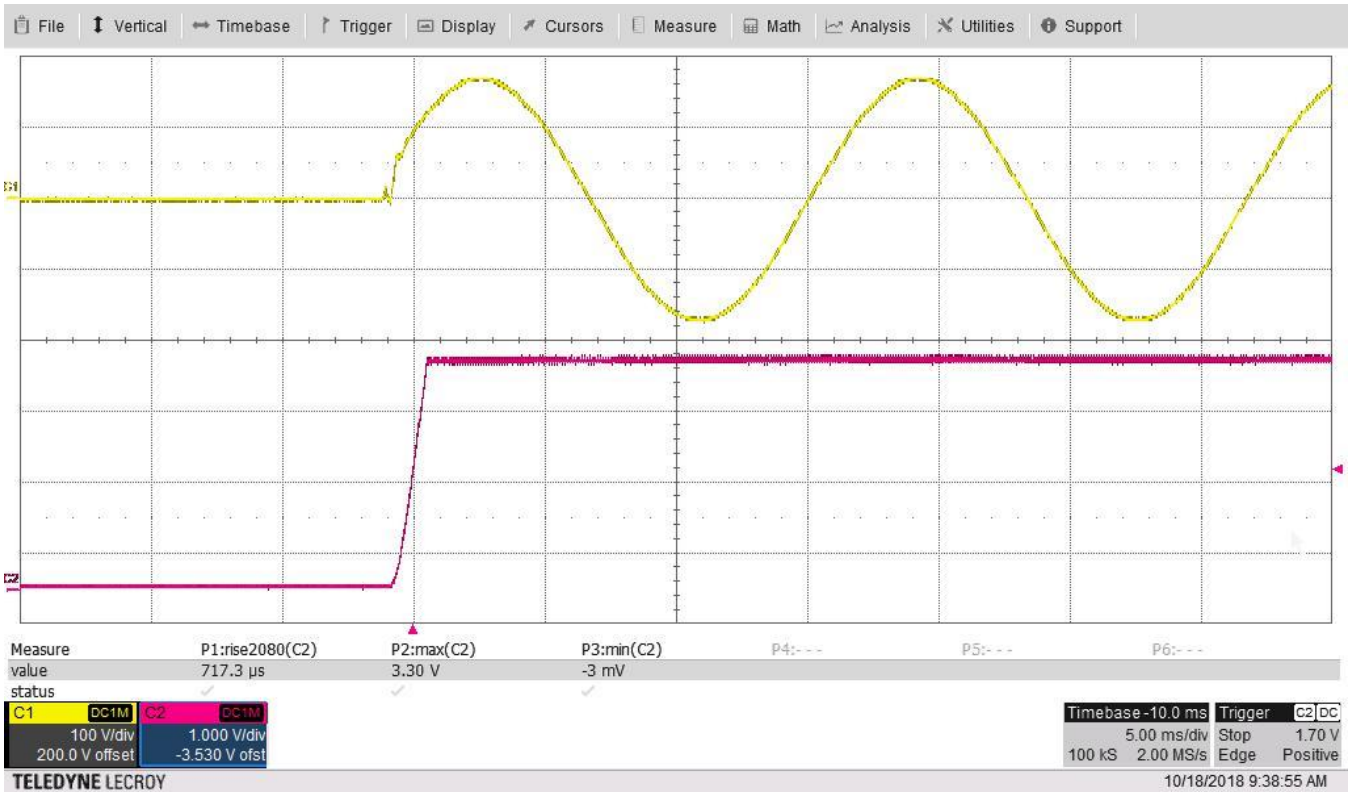


Figure 9. Output voltage start-up waveform for 120VAC at 60Hz with 3.3V output at 30mA load

3.5 Shut-down Sequence

The output voltage shut-down waveform is shown in Figure 10 for input of 120VAC at 60Hz with 3.3V output at 30mA load. (100V/div, 1.000V/div, 20ms/div)

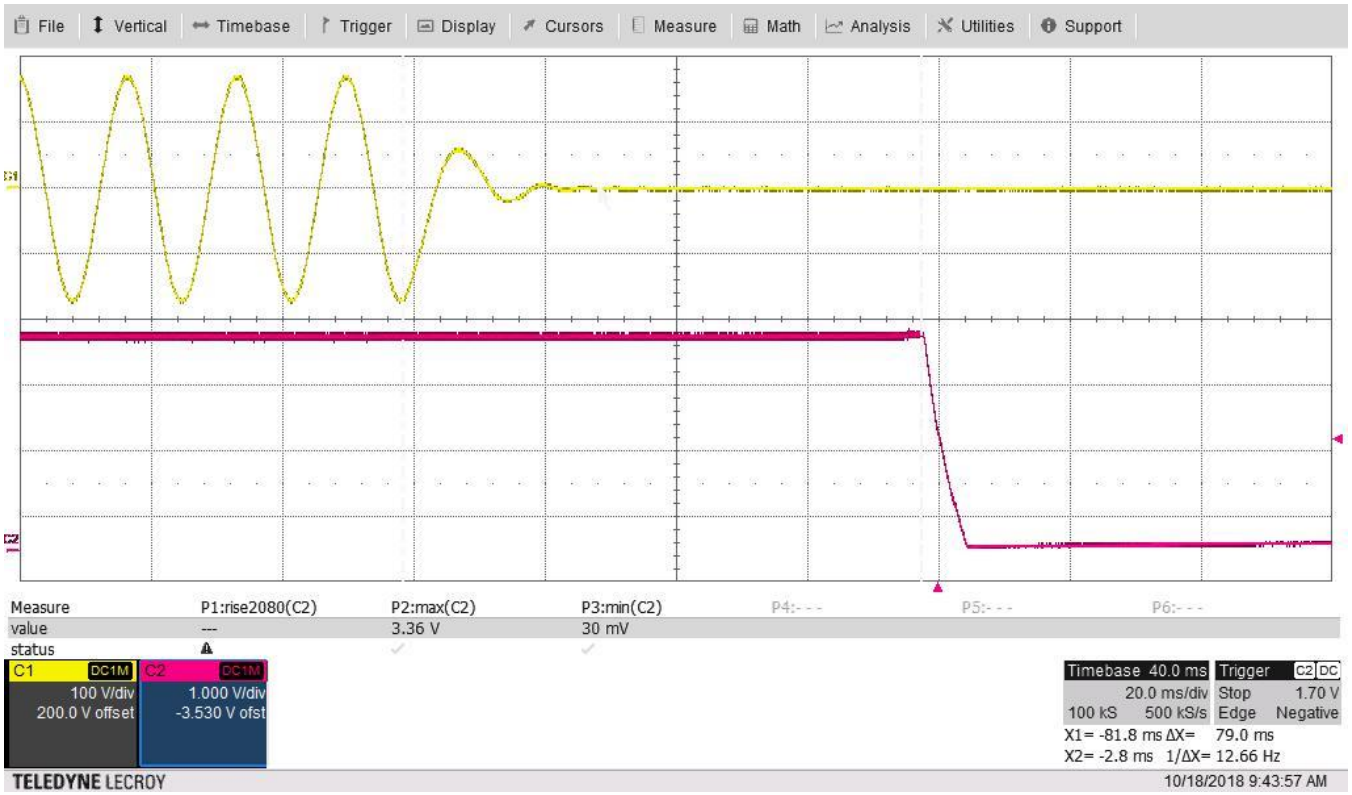


Figure 10. Output voltage shut-down waveform for 120VAC at 60Hz with 3.3V output at 30mA load

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