PMP20978 RevA
Test Report

- **390V – 48V/1kW high frequency resonant converter**
- **950kHz resonant frequency with less than 230g weight**
- **Utilize TI HV GaN FETs as input switches**
- **Optimized LLC SR conduction with UCD7138/UCD3138A**
- **Achieve peak 97.6% efficiency**
- **Power Stage dimension: 2” x 2.1” x 1.7”**

Test Completion Date: November 7, 2017

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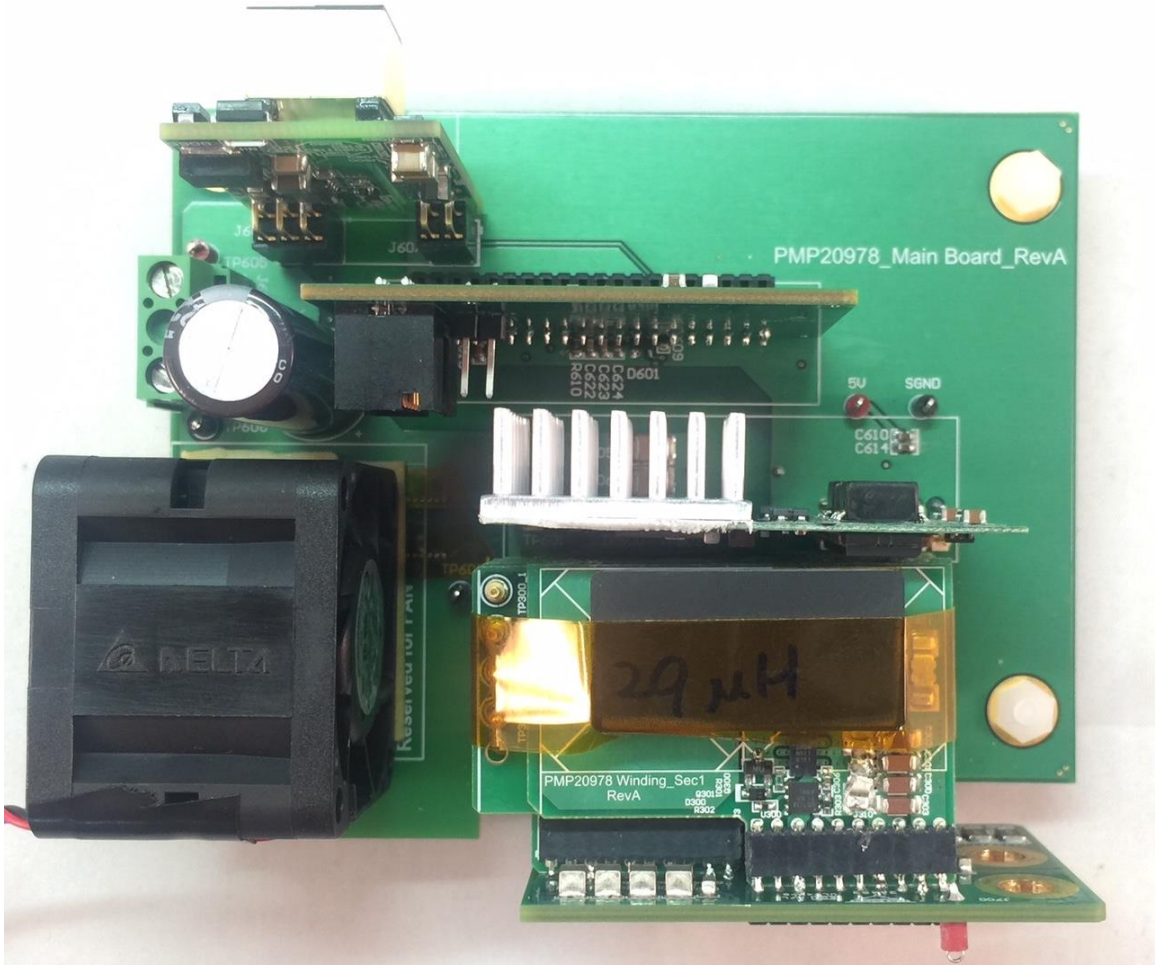
1. Board Photos

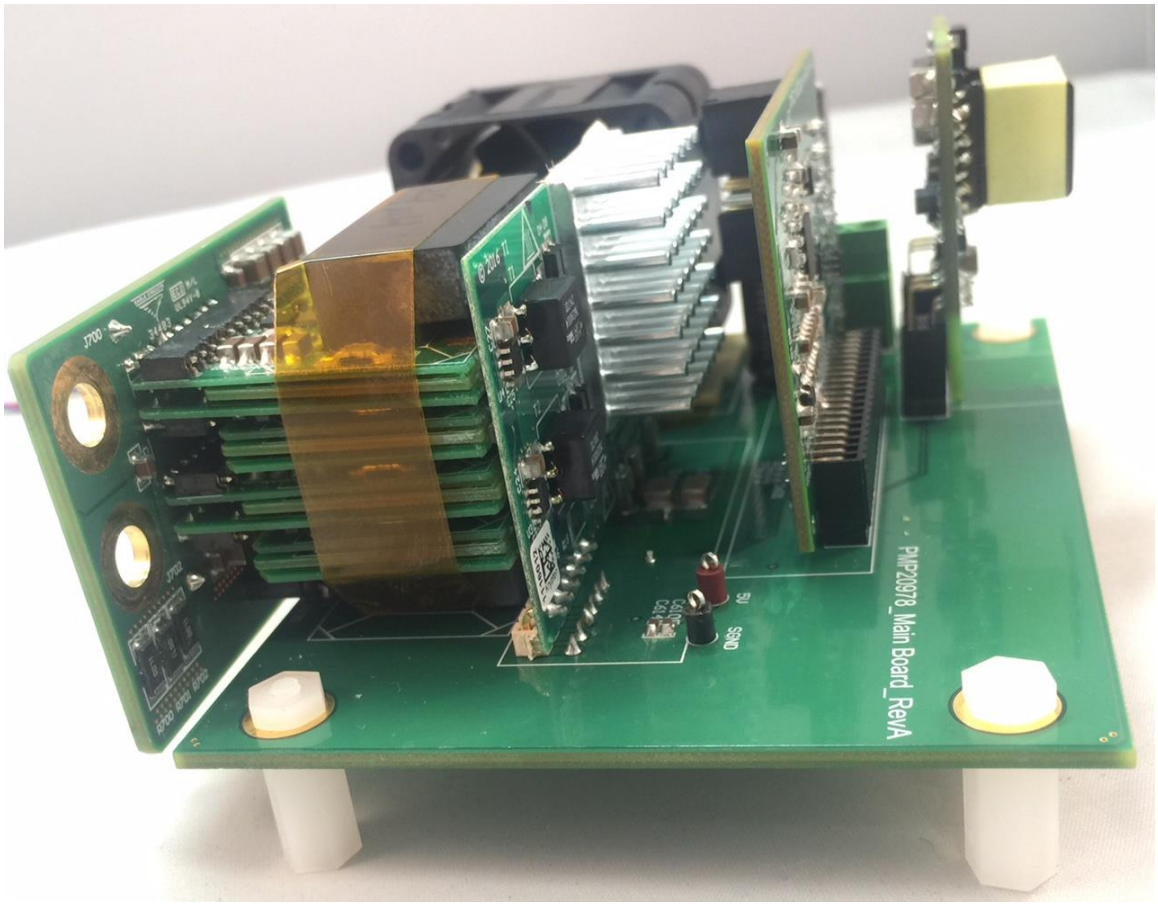
The photographs below show the detailed views of the PMP20978 RevA board. The PMP20978 Rev A board consists of 6 PCB pieces: LMG3410-HB-EVM (SV601254-E), PMP20978_Main Board_RevA, PMP20978 RevA windings, PMP20978 RevA load card, PMP11432ControlCard RevA, PMP20306 RevA bias supply.

1.1 WHOLE BOARD TOP VIEW



1.2 WHOLE BOARD BOTTOM VIEW

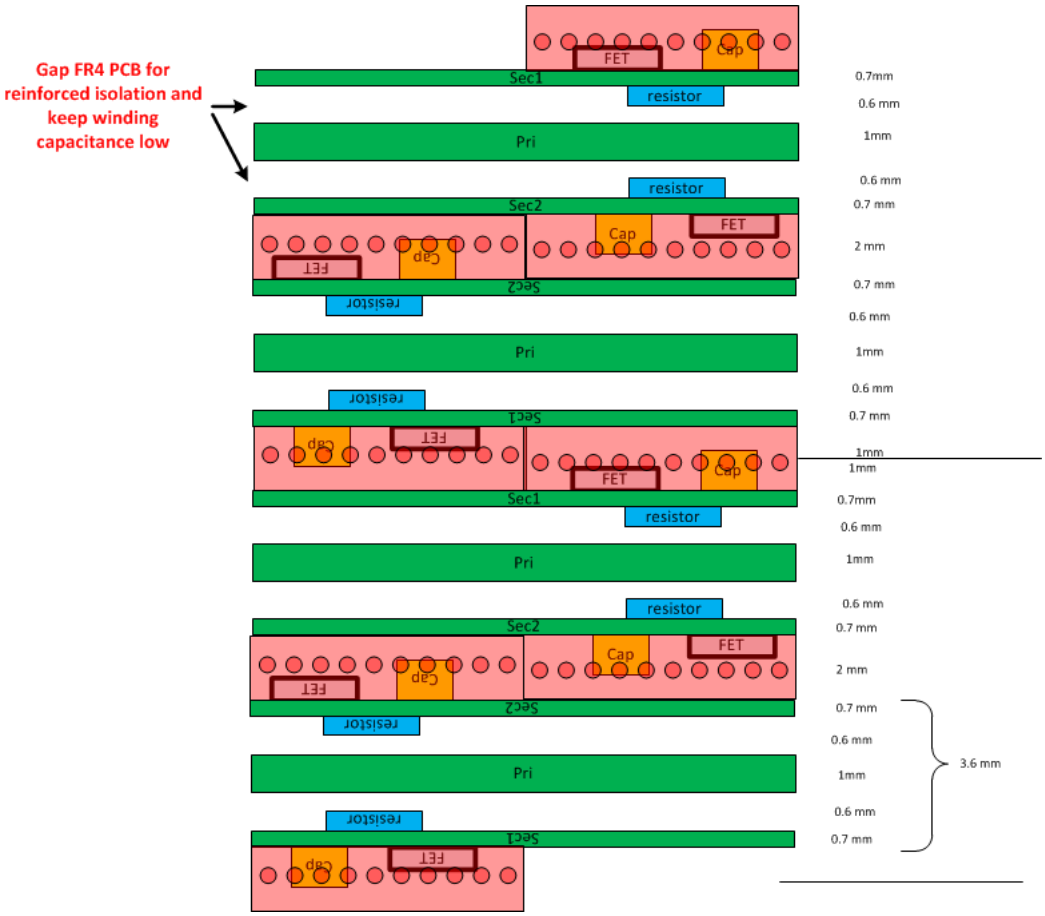
1.3 WHOLE BOARD SIDE VIEW



1.4 WHOLE BOARD - WEIGHT

1.5 TRANSFORMER LAYER STACKUP

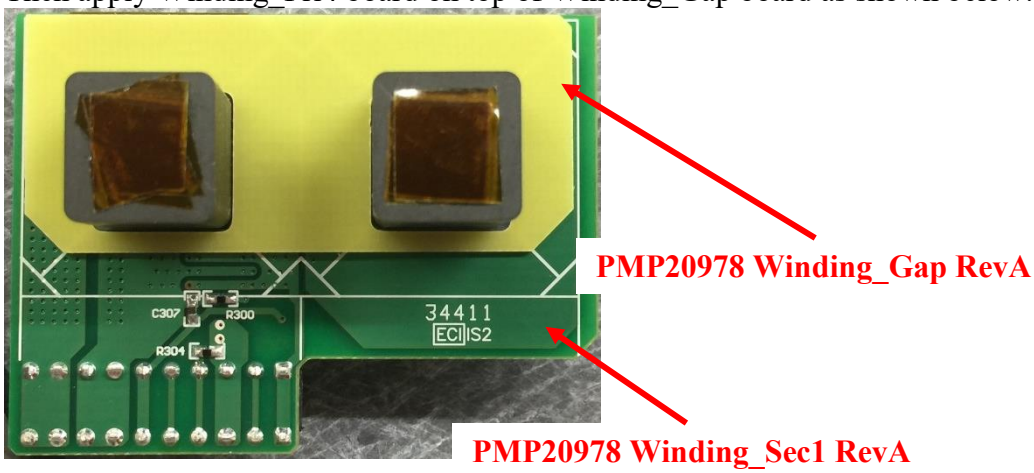
The LLC transformer of PMP20978 RevA consist of a "U" shape core with Hitachi ML91S core material, PMP20978 RevA windings, PMP20978 RevA load card. The transformer is gapped to have 29µH primary inductance (@1MHz measured frequency). Transformer structure is shown in the figure below.

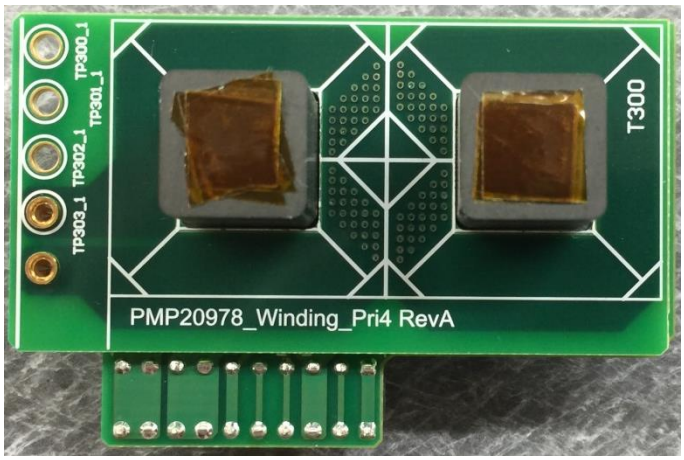


1.6 TRANSFORMER ASSEMBLY PROCESS

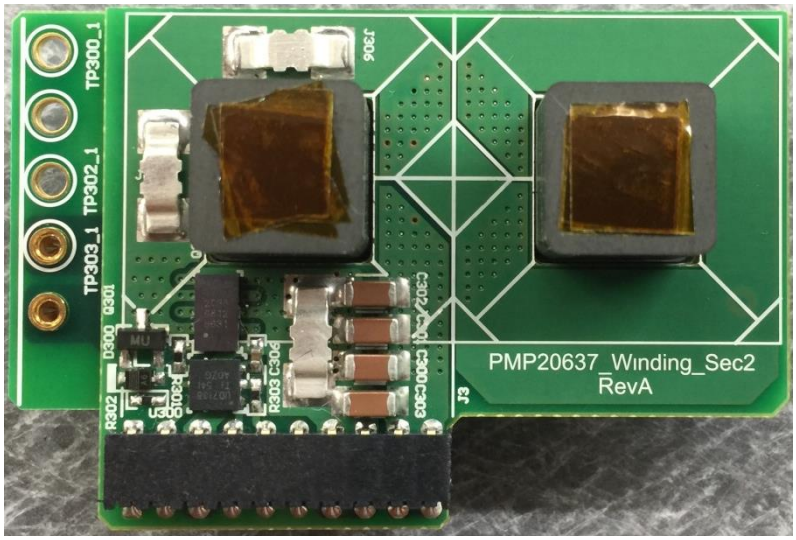
Below figures show the assembly process of the PMP20978 transformer with Hitachi ML91S core:

Step 1: Apply Winding_Sec1 and Winding_Gap boards to the U core as shown below. Then apply Winding_Pri4 board on top of Winding_Gap board as shown below.

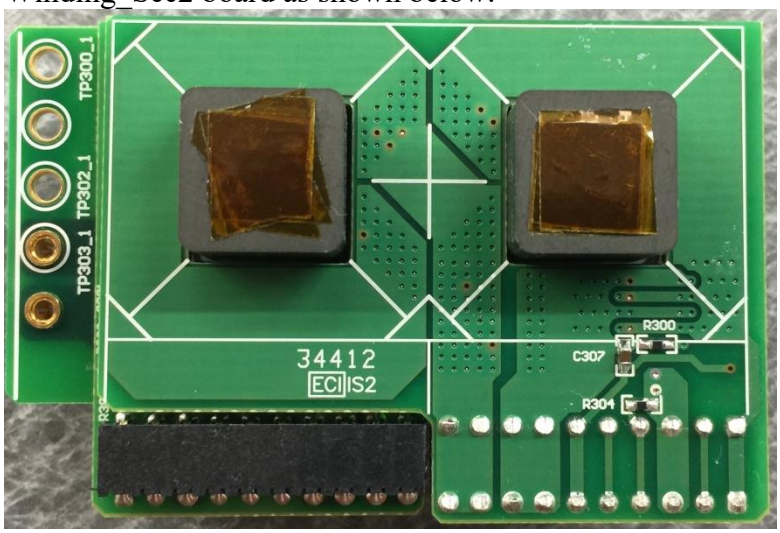


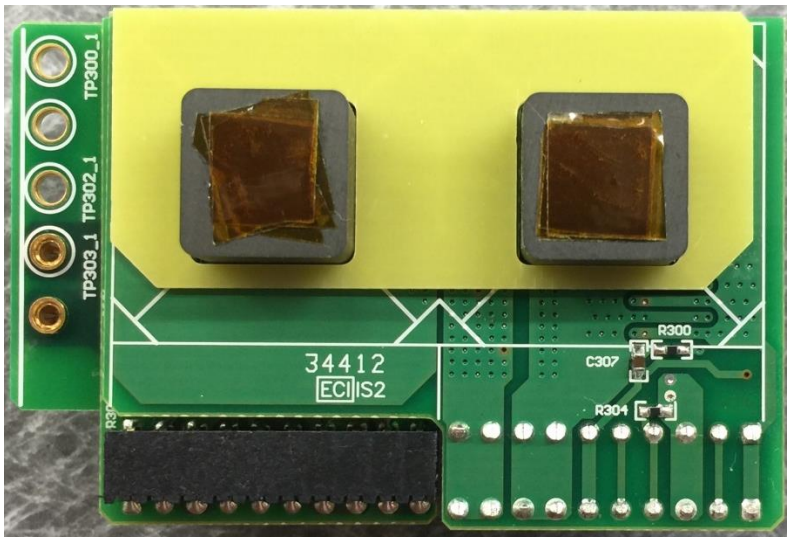


Step 2: Apply Winding_Gap board on top of Winding_Pri4 board as shown below. Then apply Winding_Sec2 board on top of Winding_Gap board as shown below.

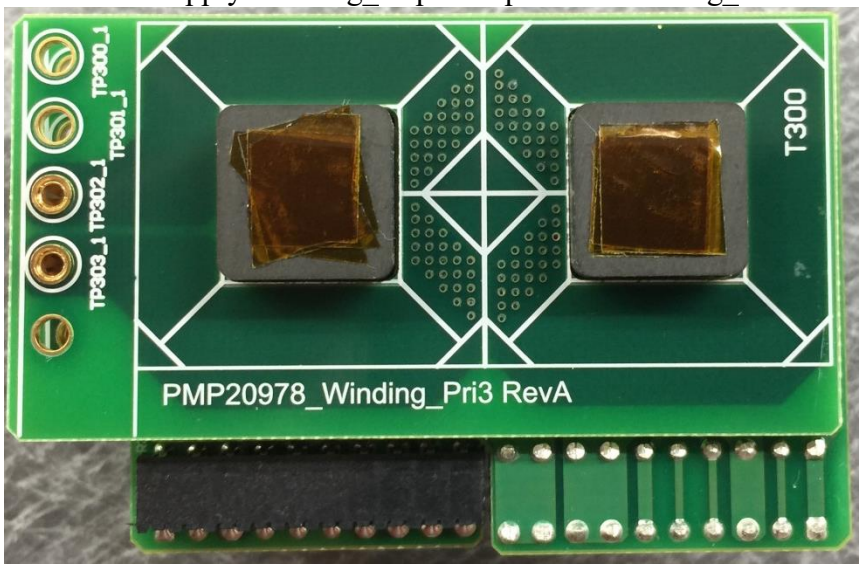


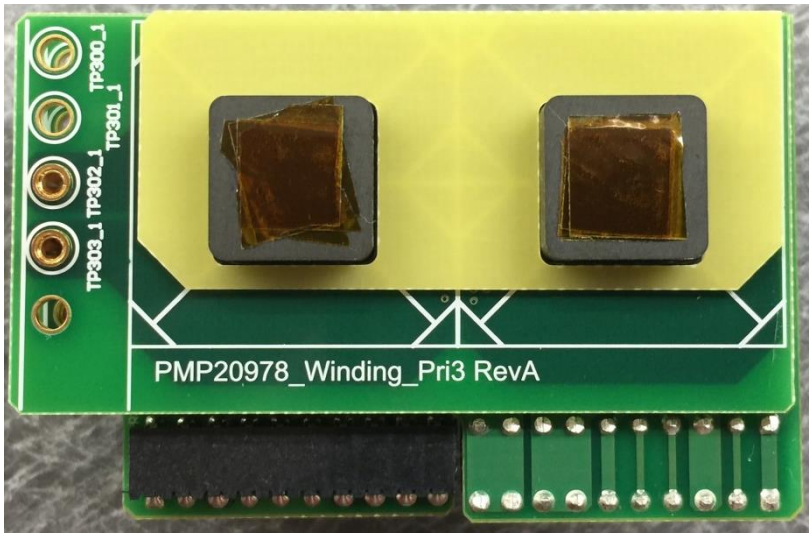
Step 3: Apply another Winding_Sec2 board on top of the Winding_Sec2 board placed in step 2 back to back as shown below. Then apply Winding_Gap board on top of the Winding_Sec2 board as shown below.



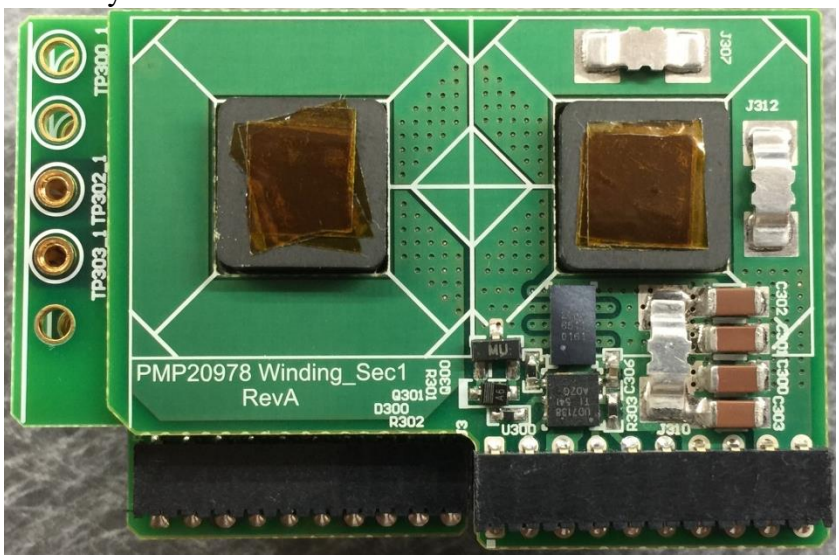


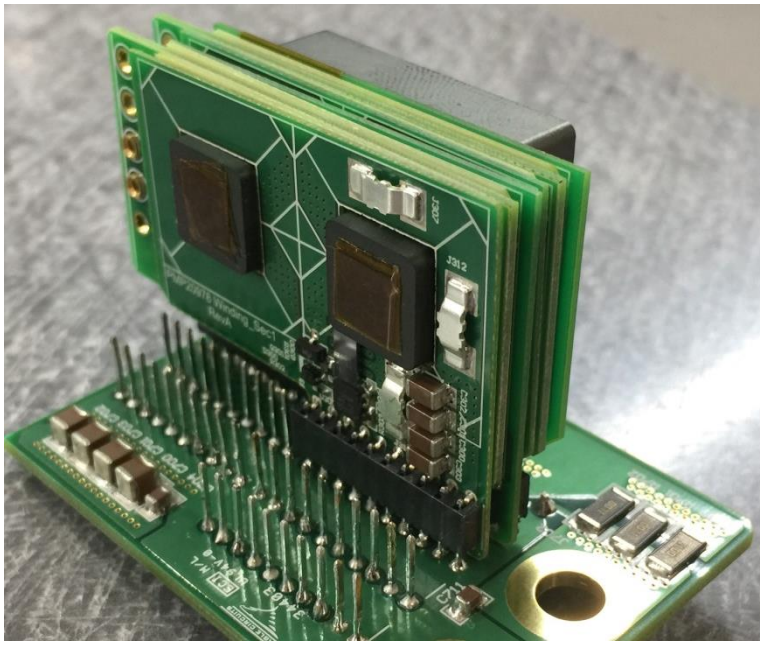
Step 4: Apply Winding_Pri3 board on top of Winding_Gap board placed as shown below. Then apply Winding_Gap on top of the Winding_Pri3 board as shown below.



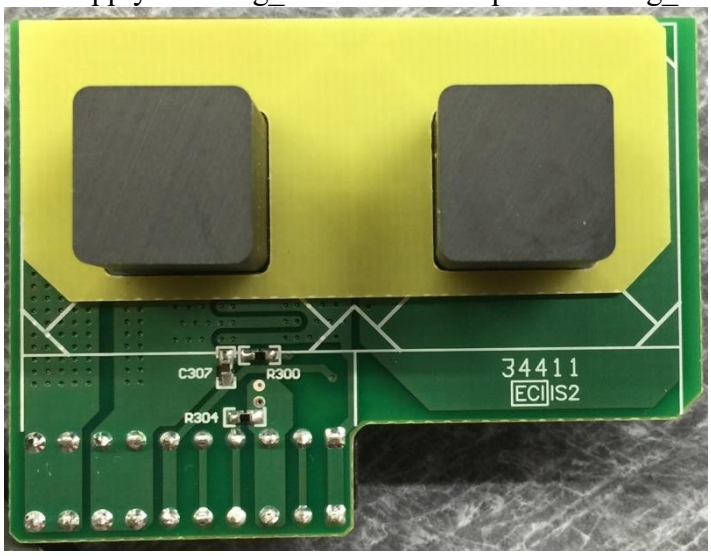


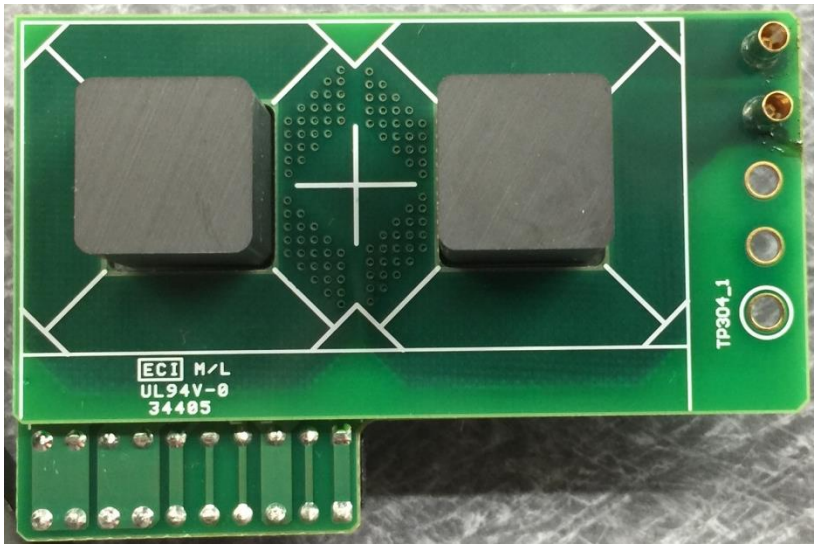
Step 5: Apply Winding_Sec1 board on top of Winding_Gap board placed as shown below. Then apply the assembled PCB windings and the U core to PMP20978 load card Rev A board as shown below. Steps 1 through 5 complete half of the transformer assembly.



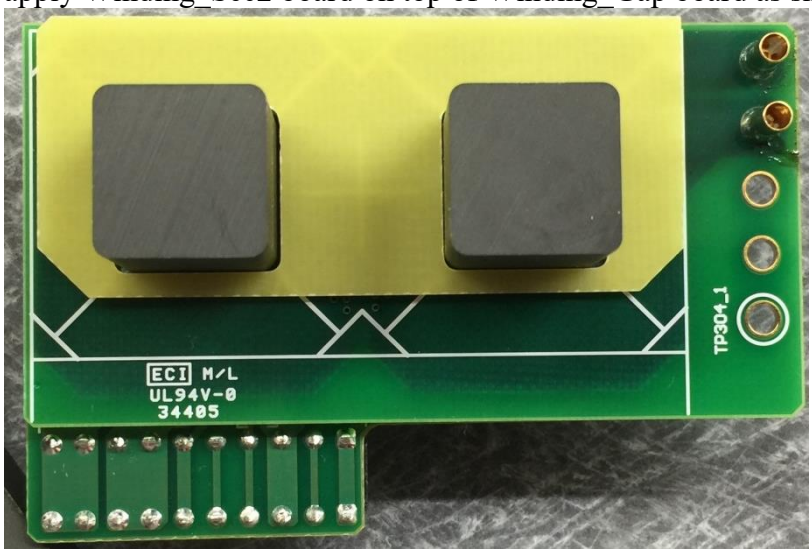


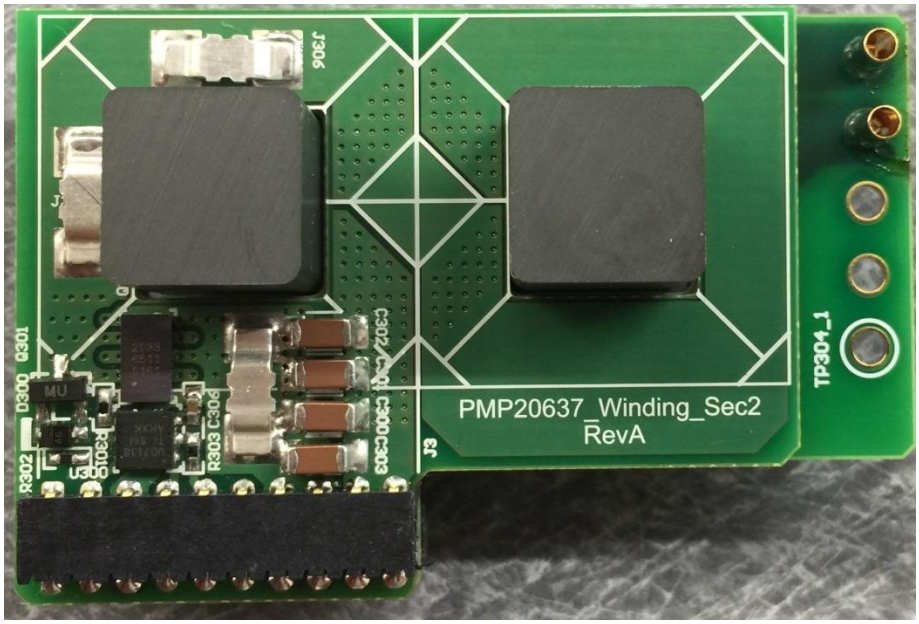
Step 6: Apply Winding_Sec1 and Winding_Gap boards to the U core as shown below. Then apply Winding_Pri1 board on top of Winding_Gap board as shown below.



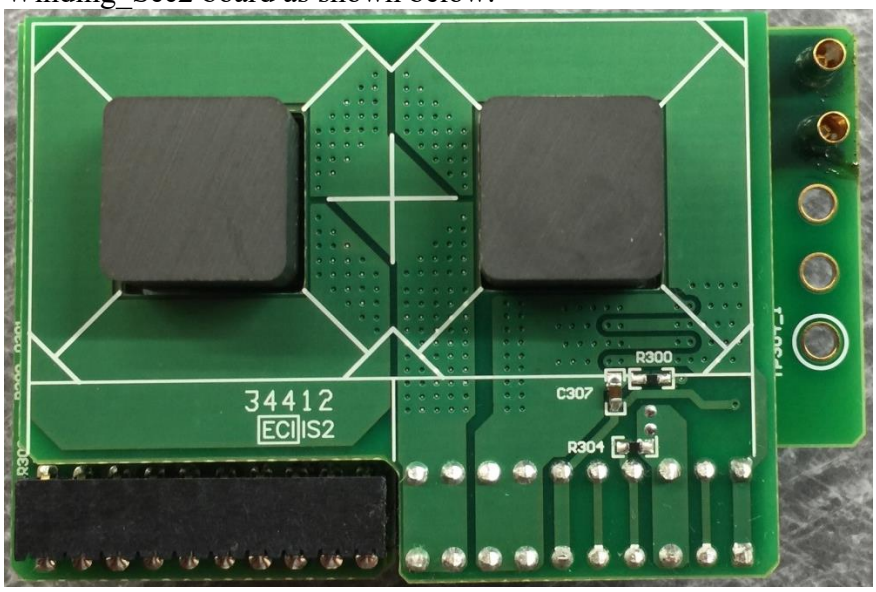


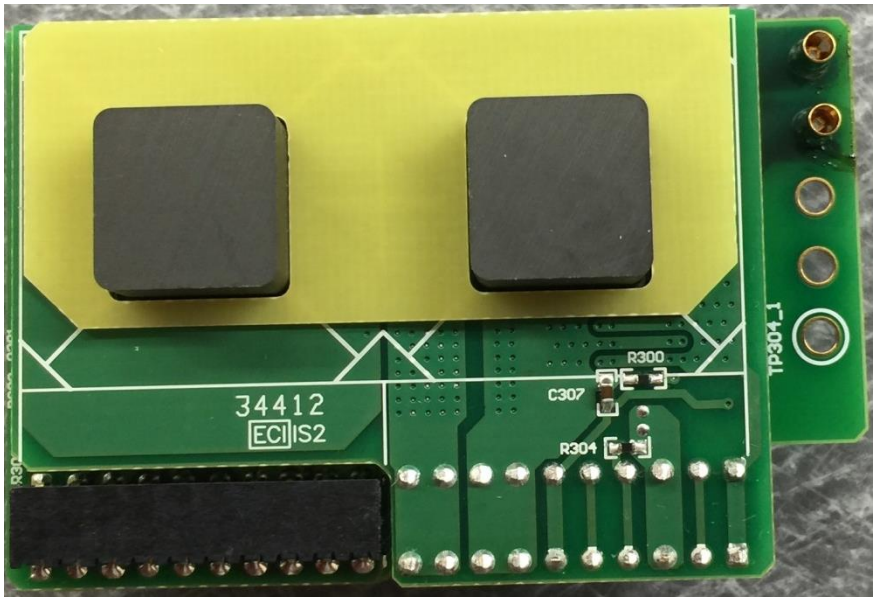
Step 7: Apply Winding_Gap board on top of Winding_Pri1 board as shown below. Then apply Winding_Sec2 board on top of Winding_Gap board as shown below.



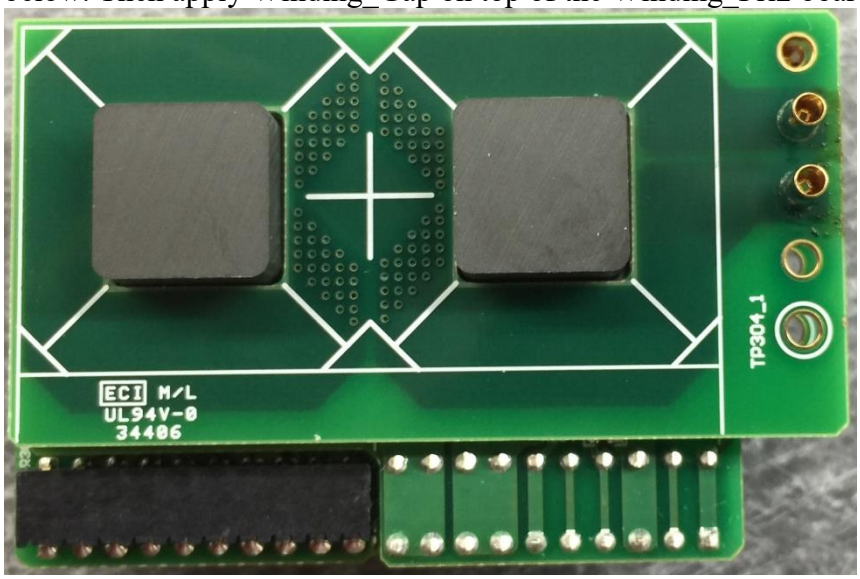


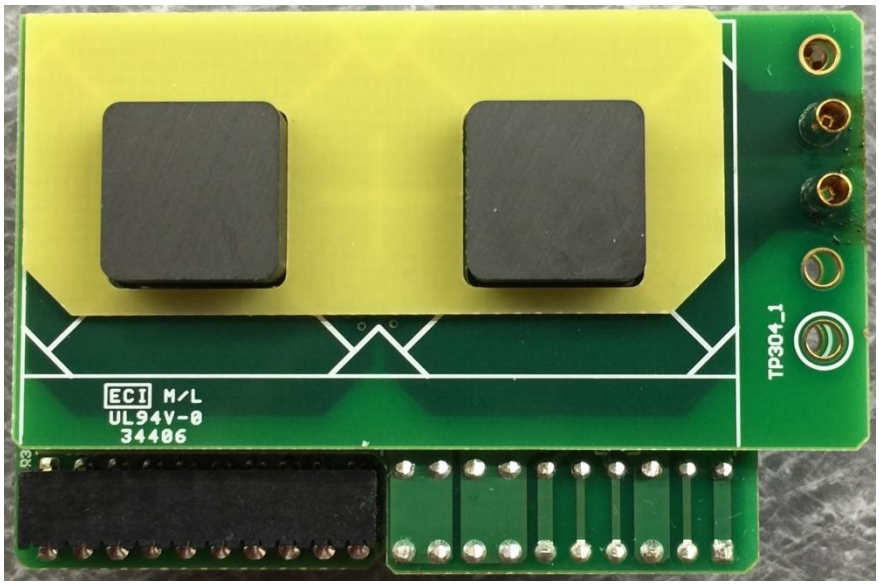
Step 8: Apply another Winding_Sec2 board on top of the Winding_Sec2 board placed in step 7 back to back as shown below. Then apply Winding_Gap board on top of the Winding_Sec2 board as shown below.



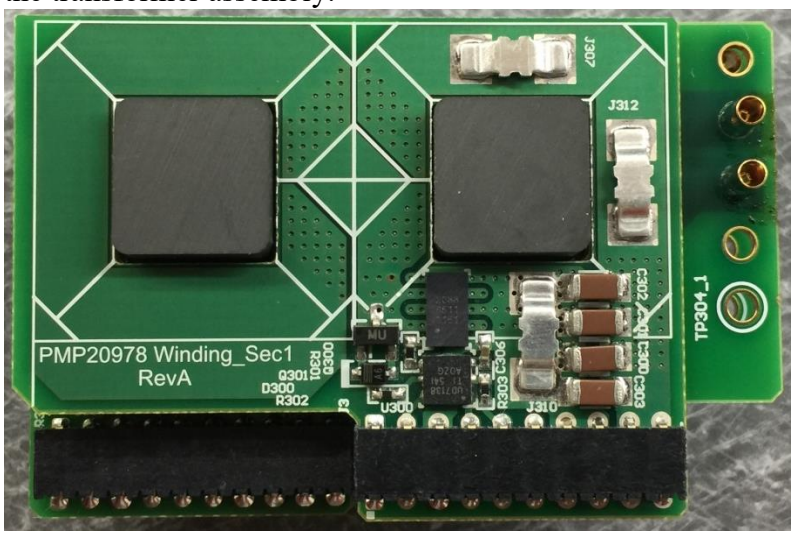


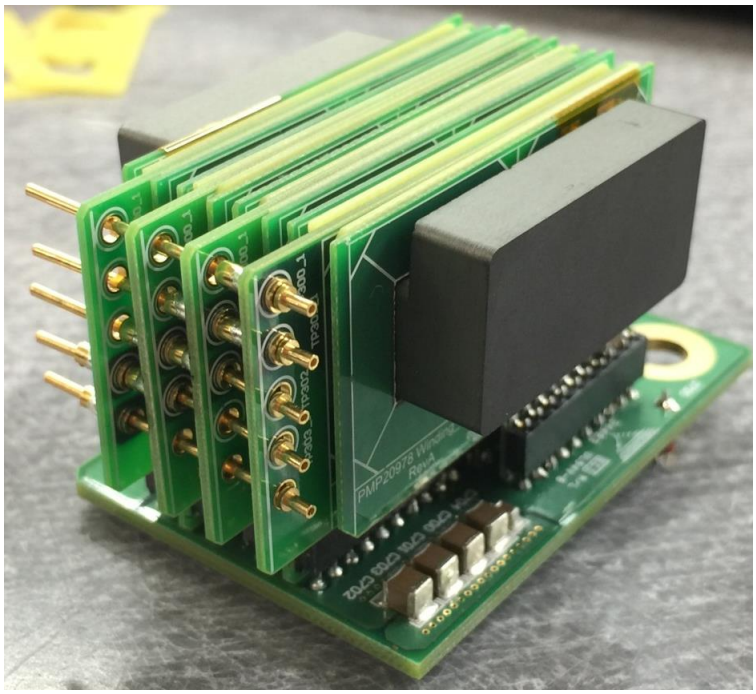
Step 9: Apply Winding_Pri2 board on top of Winding_Gap board placed as shown below. Then apply Winding_Gap on top of the Winding_Pri2 board as shown below.



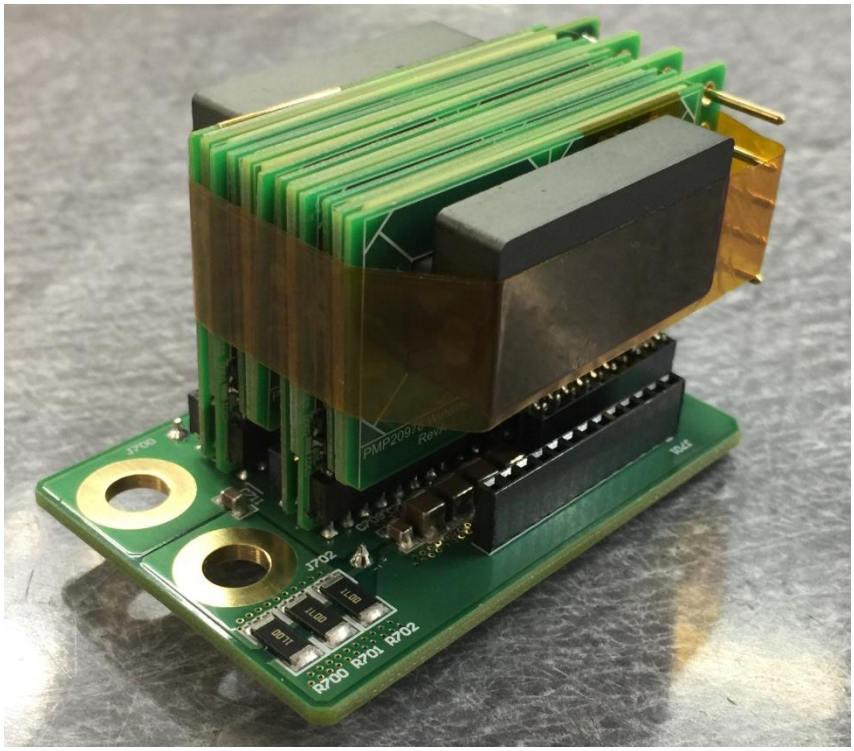


Step 10: Apply Winding_Sec1 board on top of Winding_Gap board placed as shown below. Then apply the assembled PCB windings and the U core to PMP20978 load card Rev A board as shown below. Then apply Mill-Max pins (P/N: 3106-2-00-15-00-00-08-0) to pin receptacles on Winding_Pri1 through Winding_Pri4Steps 1 through 10 complete the transformer assembly.



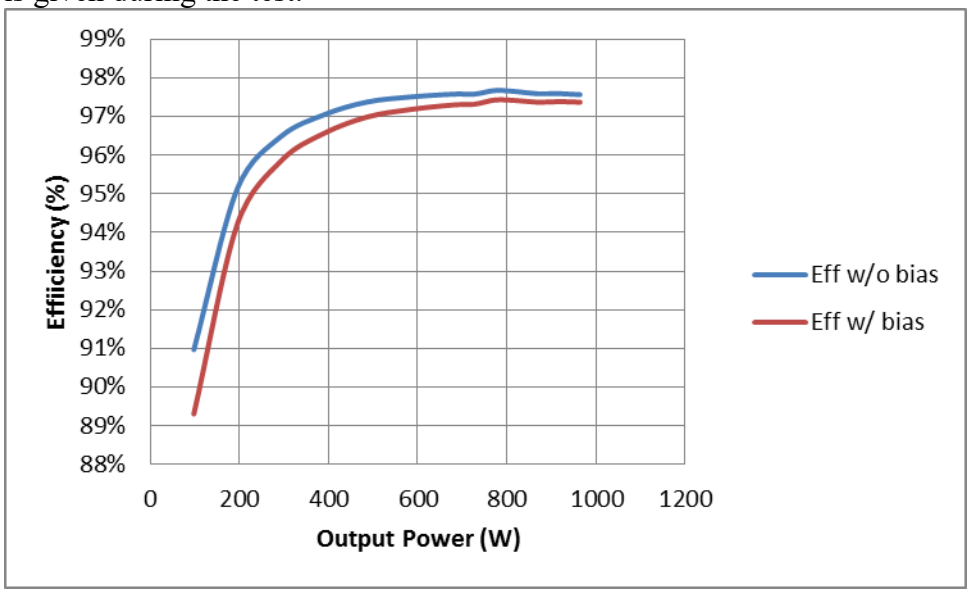


1.7 TRANSFORMER SIDE VIEW



2. Efficiency

The efficiency curves are shown in the tables and graph below. A 12V Fan (Delta FFB03612EHN at full speed) is applied to provide air cooling to the board. 390V_{DC} input is given during the test.

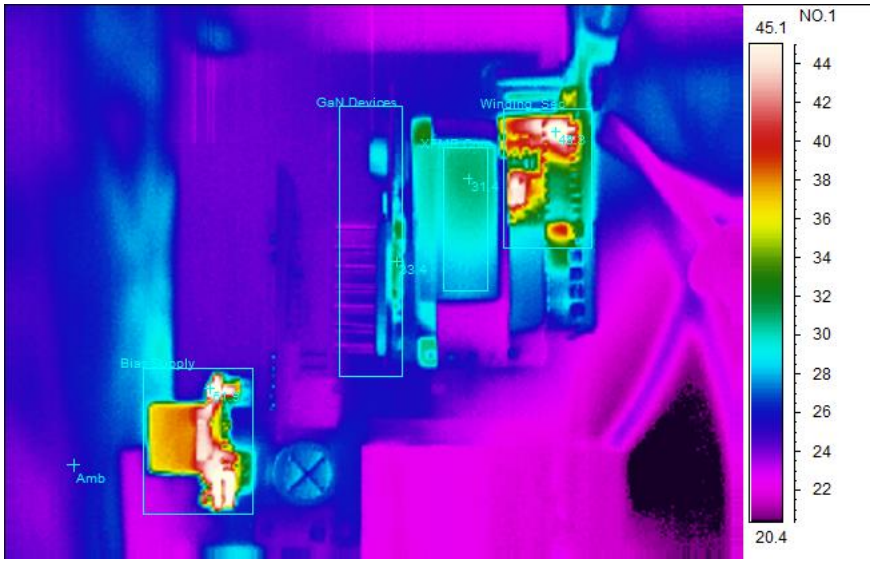


Vin (V)	Iin (A)	Vout (V)	Iout (A)	Vbias (V)	Ibias (A)	Po (W)	Eff w/ bias	Eff w/o bias
390	0.2759	48.94	2.00096	5	0.4	97.88	89.31%	90.97%
390	0.5269	48.87	4.001921	5	0.4	195.48	94.21%	95.13%
389.9	0.7784	48.8	6.002881	5	0.4	292.8	95.84%	96.48%
389.9	1.0301	48.72	8.003842	5	0.4	389.76	96.56%	97.04%
389.9	1.2814	48.65	10.0048	5	0.4	486.5	96.99%	97.37%
389.9	1.5331	48.57	12.00576	5	0.4	582.84	97.18%	97.50%
389.8	1.7848	48.49	14.00672	5	0.4	678.86	97.30%	97.58%
389.8	1.9107	48.45	15.0072	5	0.4	726.75	97.32%	97.58%
389.8	2.034	48.4	16.00768	5	0.4	774.4	97.43%	97.67%
389.8	2.16	48.36	17.00816	5	0.4	822.12	97.41%	97.64%
389.8	2.286	48.31	18.00864	5	0.4	869.58	97.37%	97.59%
389.7	2.411	48.26	19.00912	5	0.4	916.94	97.38%	97.59%
389.7	2.536	48.21	20.0096	5	0.4	964.2	97.37%	97.56%

3. Thermal Performance

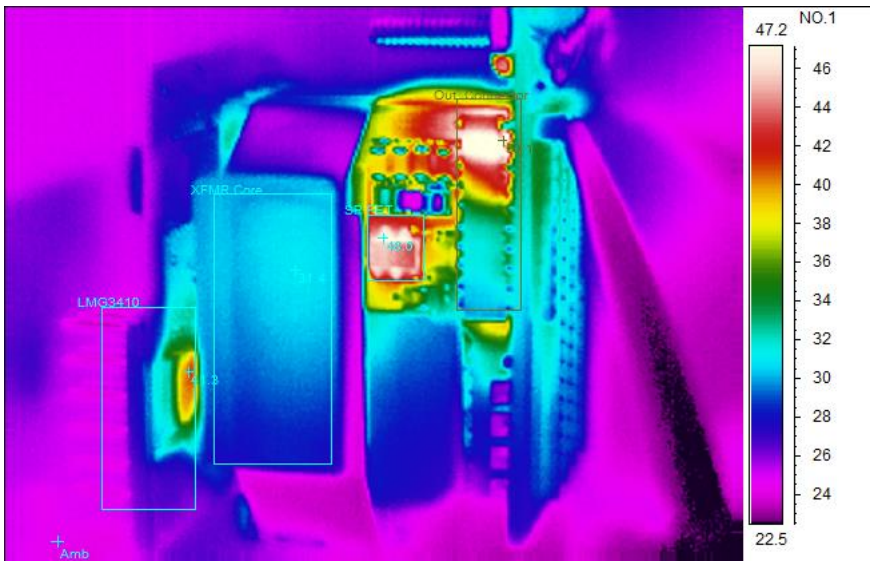
During the thermal test, a 12V Fan (Delta FFB03612EHN at full speed) is applied to provide air cooling to the board.

3.1 380VDC INPUT, 46.9V/21A OUTPUT: TOP SIDE, WHOLE BOARD



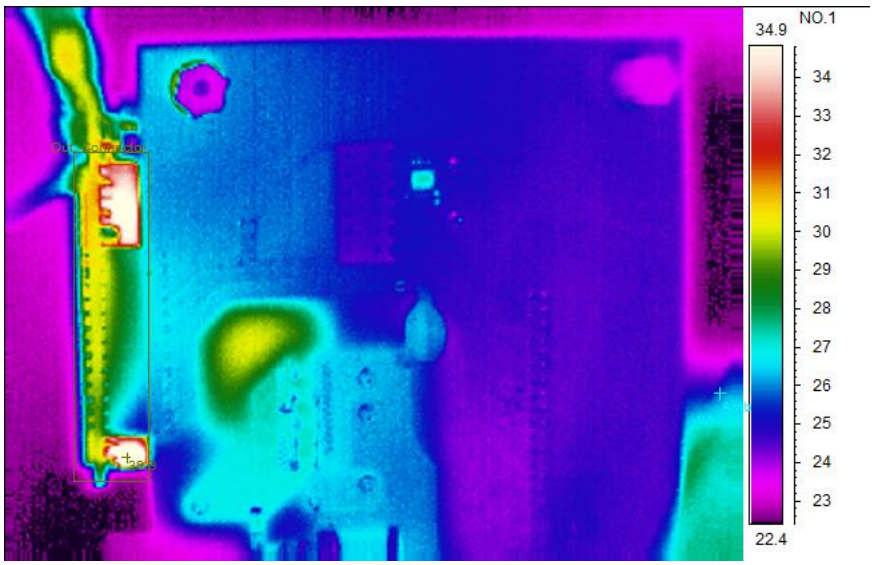
Spot analysis	Value
Amb Temperature	25.4°C
Area analysis	**Value**
Bias SupplyMax	51.9°C
XFMR CoreMax	31.4°C
GaN DevicesMax	33.4°C
Winding_SecMax	48.3°C

3.2 380VDC INPUT, 46.9V/21A OUTPUT: TOP SIDE, MAIN POWER STAGE



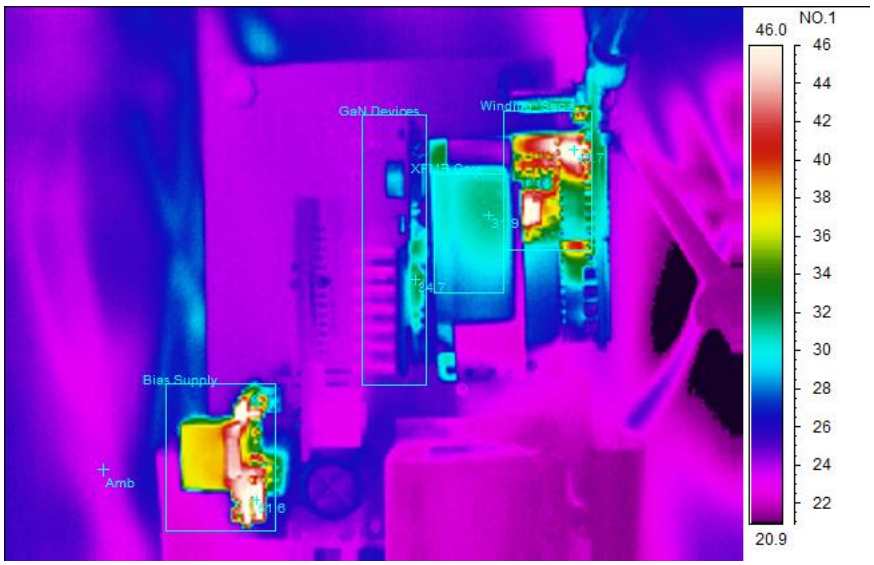
Spot analysis	Value
Amb Temperature	24.5°C
Area analysis	**Value**
LMG3410Max	41.3°C
SR FETMax	48.0°C
XFMR CoreMax	31.4°C
Out. Connector Max	50.1°C

3.3 380VDC INPUT, 46.9V/21A OUTPUT: BOTTOM SIDE



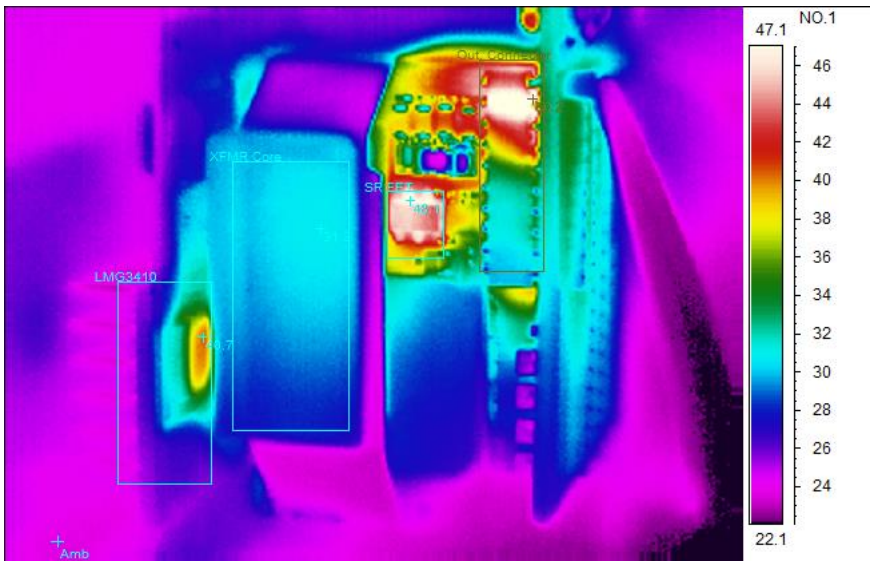
Spot analysis	Value
Amb Temperature	25.8°C
Area analysis	**Value**
Out. ConnectorMax	39.9°C

3.4 390VDC INPUT, 48.1V/21A OUTPUT, TOP SIDE, WHOLE BOARD



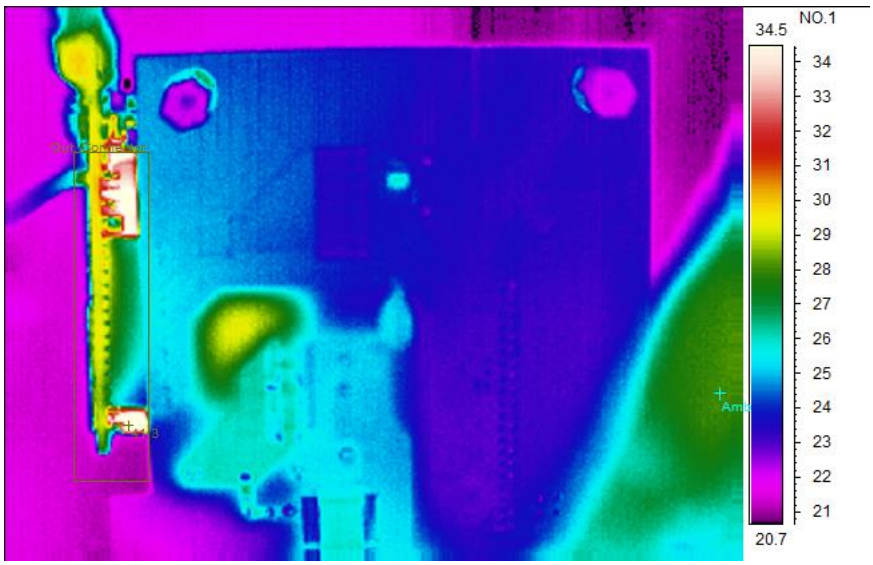
Spot analysis	Value
Amb Temperature	24.0°C
Area analysis	**Value**
Bias SupplyMax	51.6°C
XFMR CoreMax	31.9°C
GaN DevicesMax	34.7°C
Winding_SecMax	49.7°C

3.5 390VDC INPUT, 48.1V/21A OUTPUT, TOP SIDE, MAIN POWER STAGE



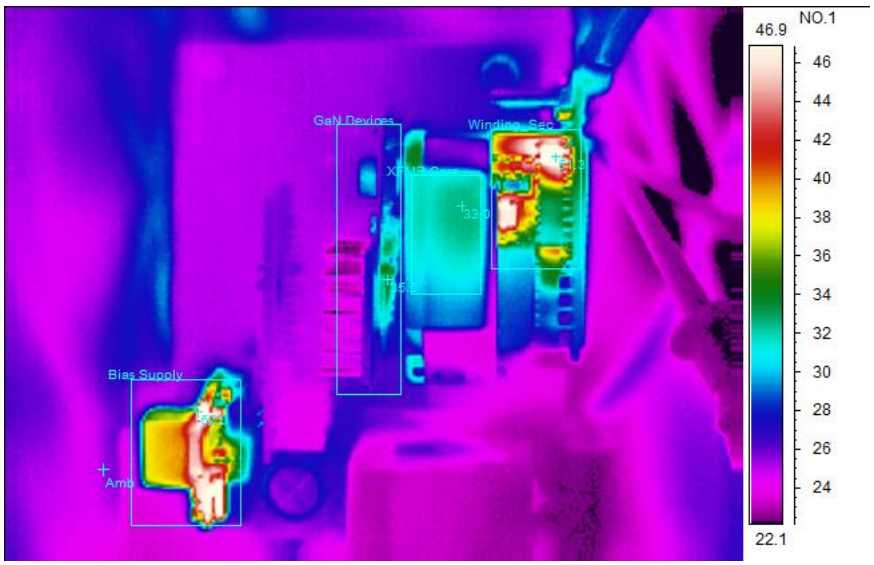
Spot analysis	Value
Amb Temperature	23.9°C
Area analysis	**Value**
LMG3410Max	40.7°C
SR FETMax	48.1°C
XFMR CoreMax	31.3°C
Out. Connector Max	50.2°C

3.6 390VDC INPUT, 48.1V/21A OUTPUT, BOTTOM SIDE



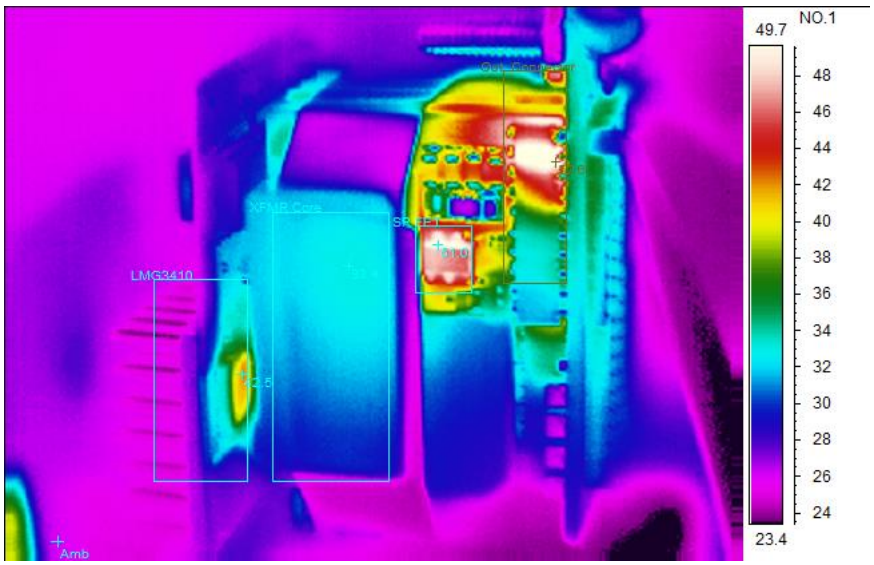
Spot analysis	Value
Amb Temperature	28.1°C
Area analysis	**Value**
Out. ConnectorMax	41.3°C

3.7 400VDC INPUT, 49.4V/21A OUTPUT, TOP SIDE, WHOLE BOARD



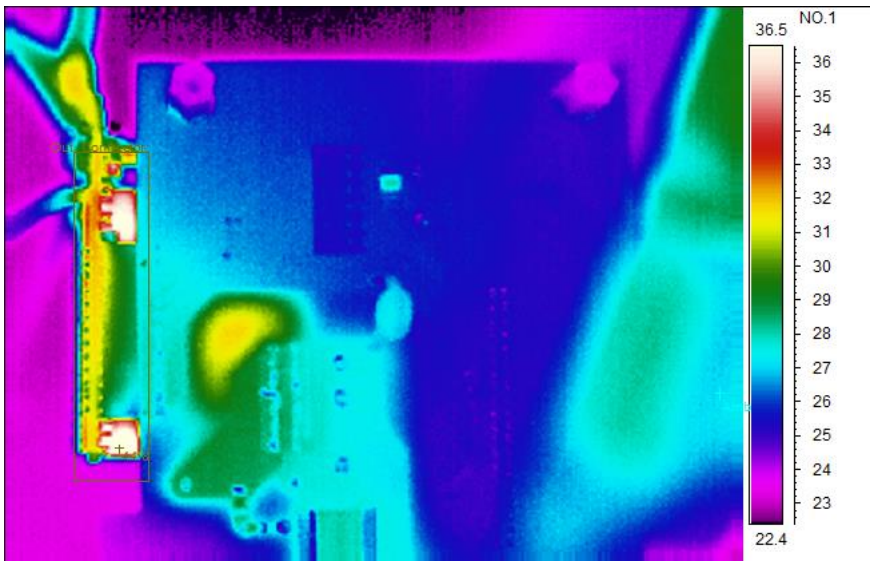
Spot analysis	Value
Amb Temperature	25.4°C
Area analysis	**Value**
Bias SupplyMax	52.0°C
XFMR CoreMax	33.0°C
GaN DevicesMax	35.5°C
Winding_SecMax	51.3°C

3.8 400VDC INPUT, 49.4V/21A OUTPUT, TOP SIDE, MAIN POWER STAGE



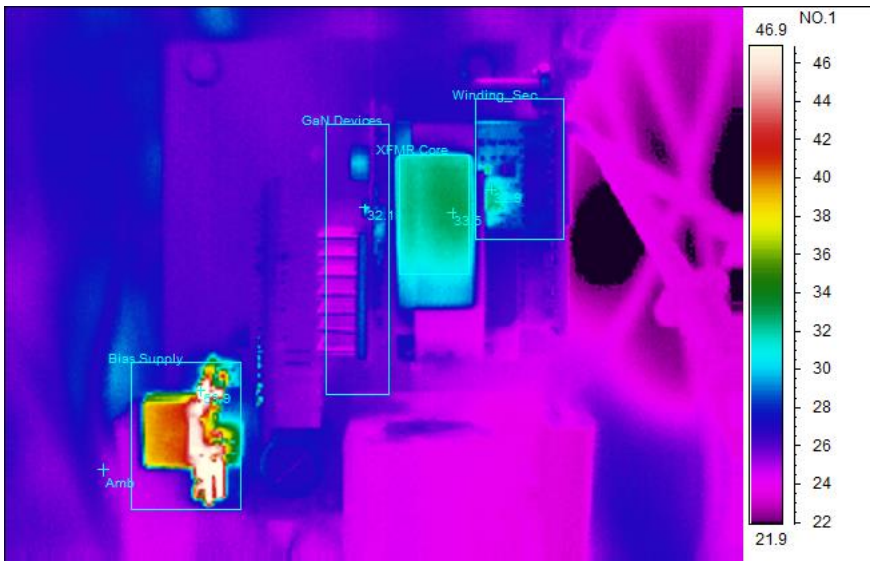
Spot analysis	Value
Amb Temperature	26.2°C
Area analysis	**Value**
LMG3410Max	42.5°C
SR FETMax	51.0°C
XFMR CoreMax	33.4°C
Out. Connector Max	52.6°C

3.9 400VDC INPUT, 49.4V/21A OUTPUT, BOTTOM SIDE



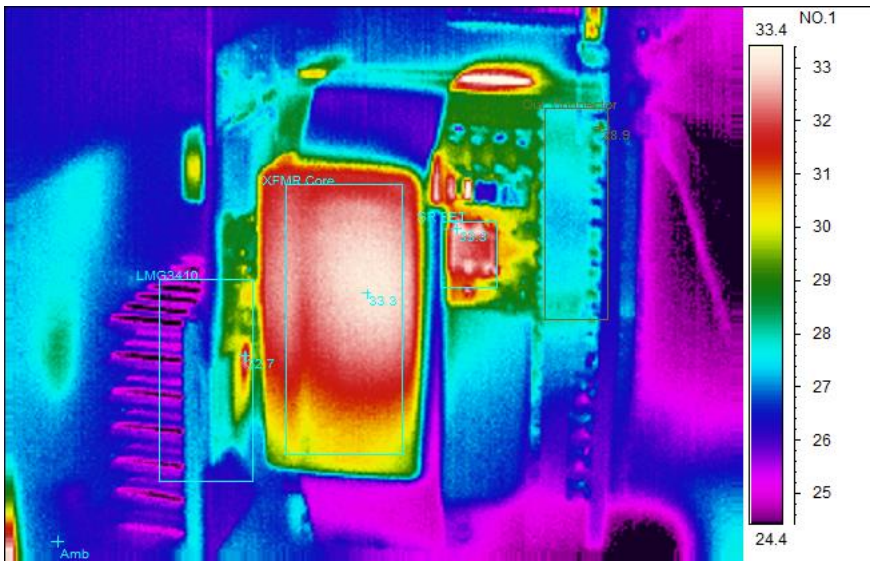
Spot analysis	Value
Amb Temperature	27.0°C
Area analysis	**Value**
Out. ConnectorMax	44.8°C

3.10 400VDC INPUT, 50.3V/0A OUTPUT, TOP SIDE, WHOLE BOARD



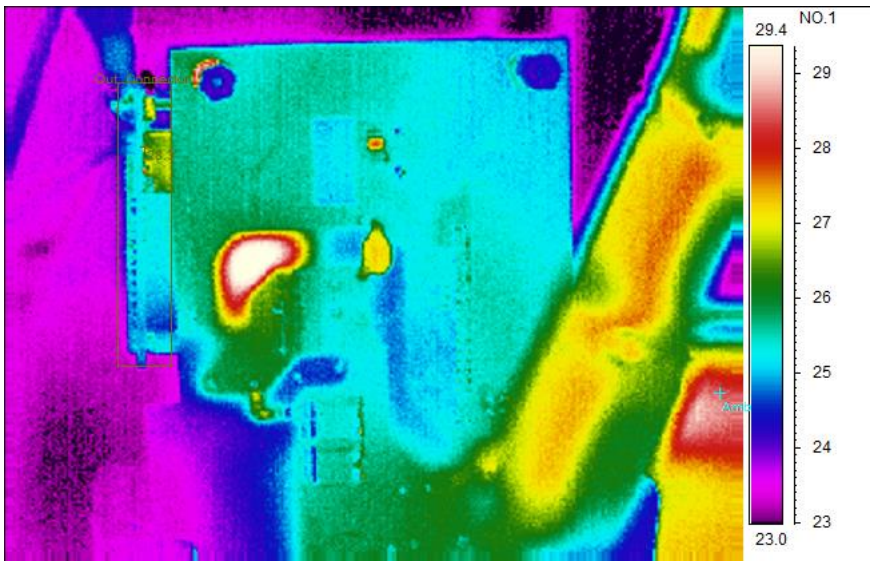
Spot analysis	Value
Amb Temperature	25.8°C
Area analysis	**Value**
Bias SupplyMax	53.9°C
XFMR CoreMax	33.5°C
GaN DevicesMax	32.1°C
Winding_SecMax	32.9°C

3.11 400VDC INPUT, 50.3V/0A OUTPUT, TOP SIDE, MAIN POWER STAGE



Spot analysis	Value
Amb Temperature	26.8°C
Area analysis	**Value**
LMG3410Max	32.7°C
SR FETMax	33.3°C
XFMR CoreMax	33.3°C
Out. Connector Max	28.9°C

3.12 400VDC INPUT, 50.3V/0A OUTPUT, BOTTOM SIDE

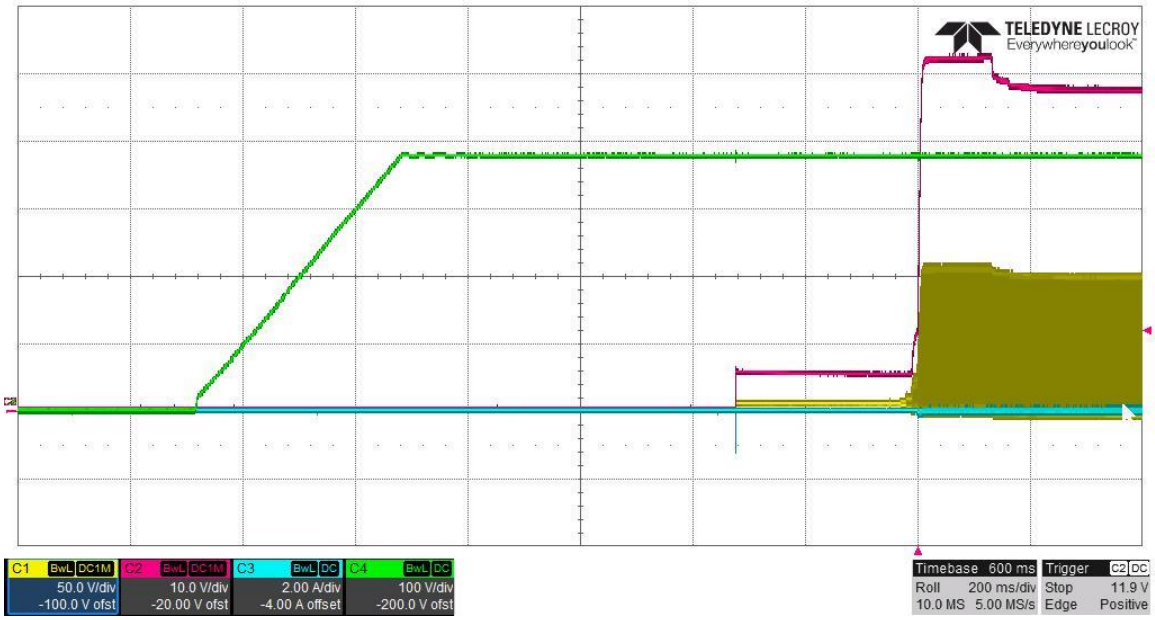


Spot analysis	Value
Amb Temperature	28.6°C
Area analysis	**Value**
Out. ConnectorMax	28.3°C

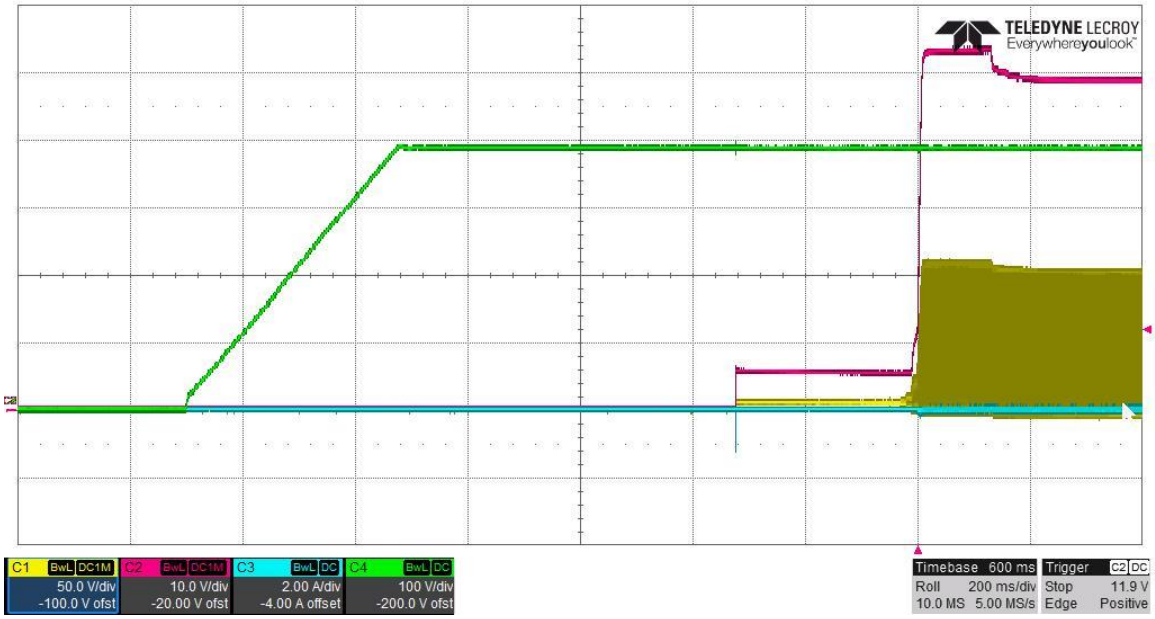
4. StartUp Transient

Oscilloscope channel assignments during the startup transient tests are C1: SR V_{DS}, C2: V_{out}, C3: I_{out}, C4: V_{in}.

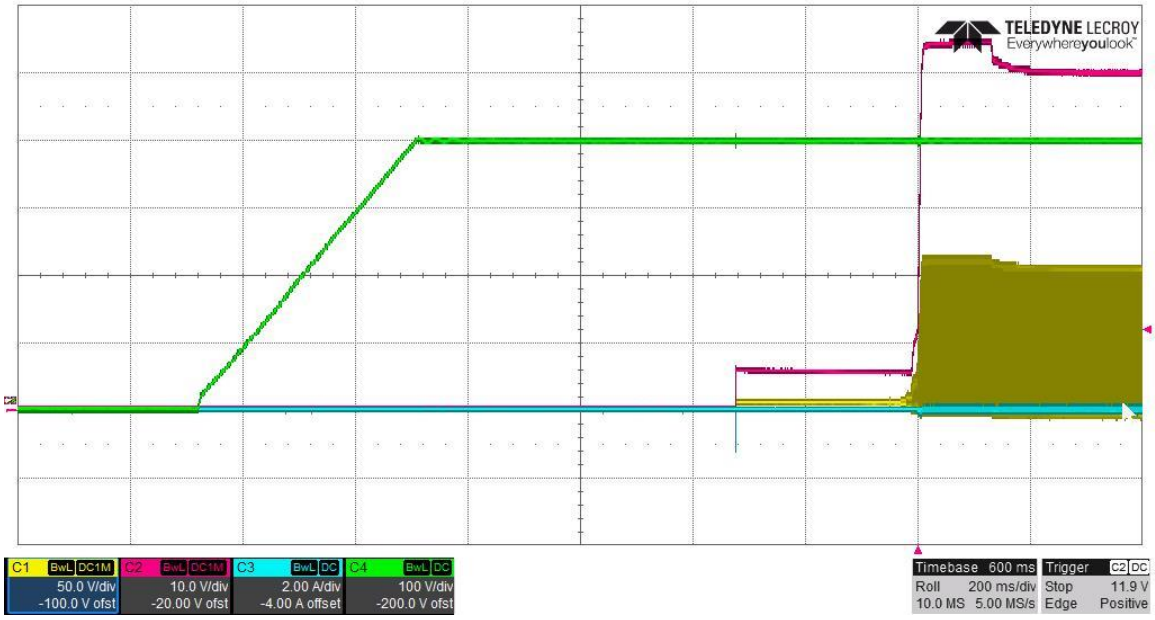
4.1 380VDC INPUT, 48V NO LOAD



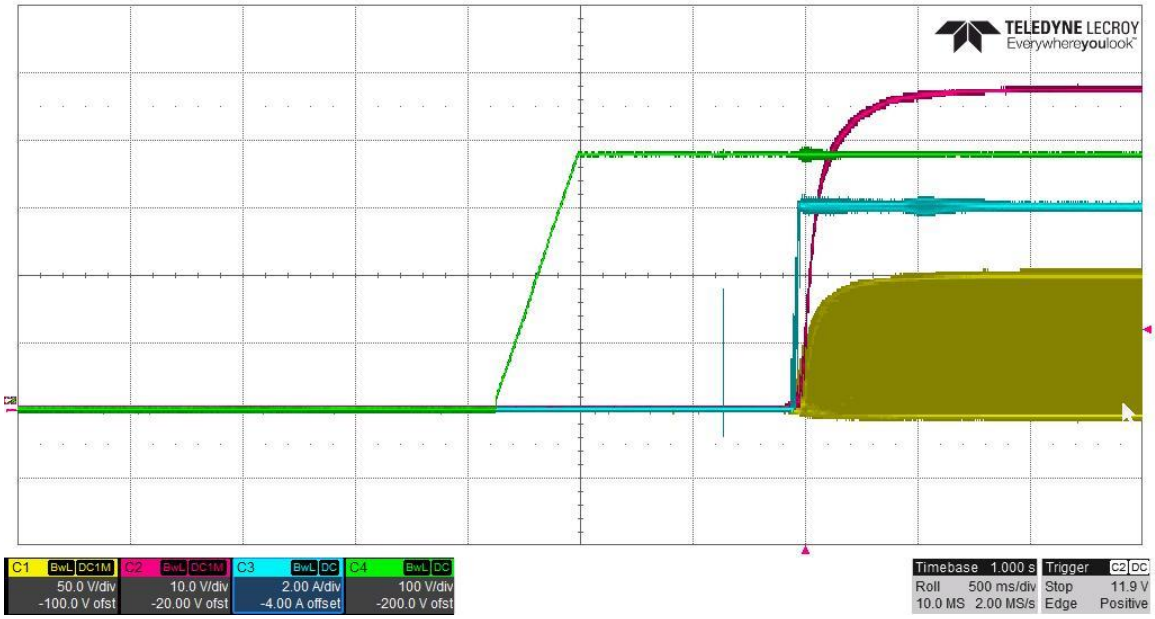
4.2 390VDC INPUT, 48V NO LOAD



4.3 400VDC INPUT, 48V NO LOAD



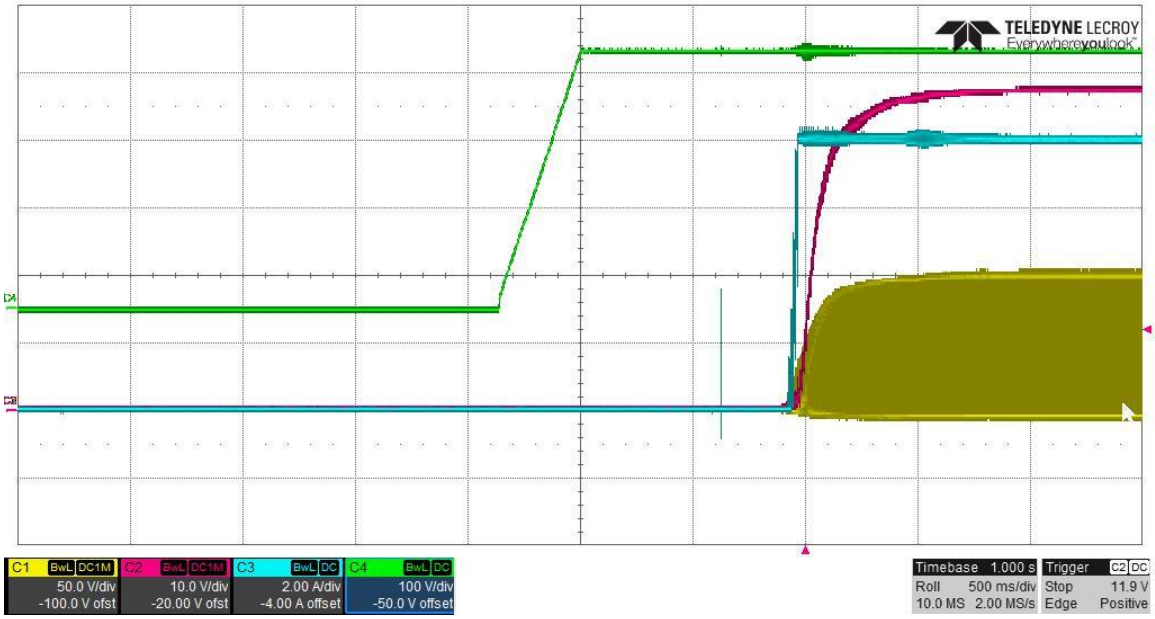
4.7 380VDC INPUT, 48V/6A



4.8 390VDC INPUT, 48V/6A

4.9 400VDC INPUT, 48V/6A

4.10 380VDC INPUT, 48V/8A



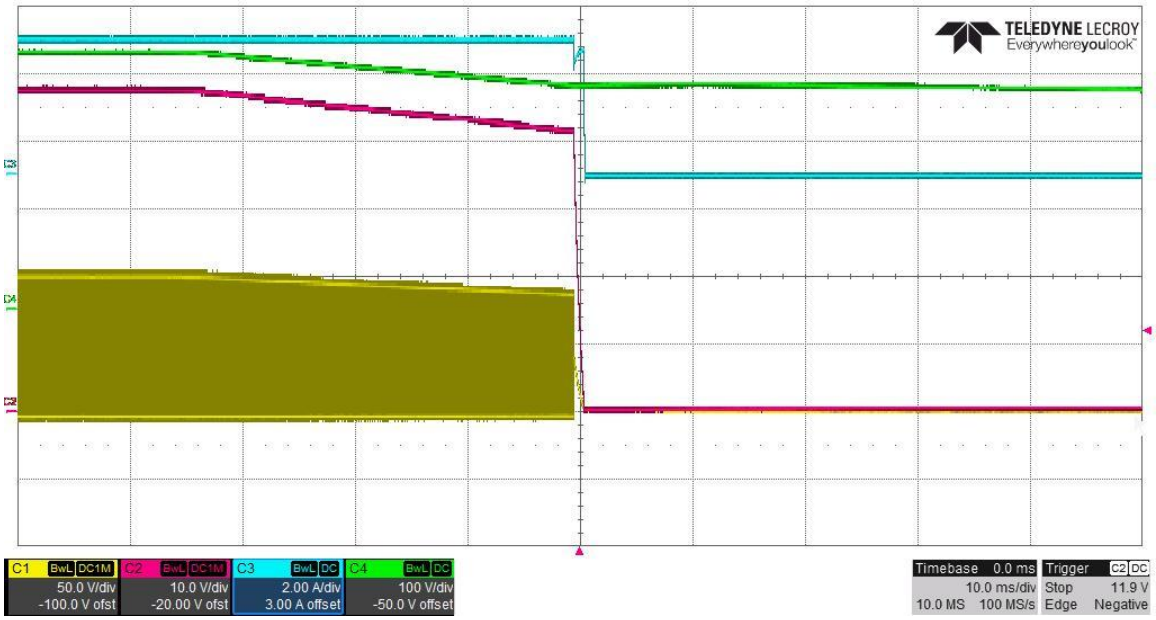
4.11 390VDC INPUT, 48V/8A

4.12 400VDC INPUT, 48V/8A

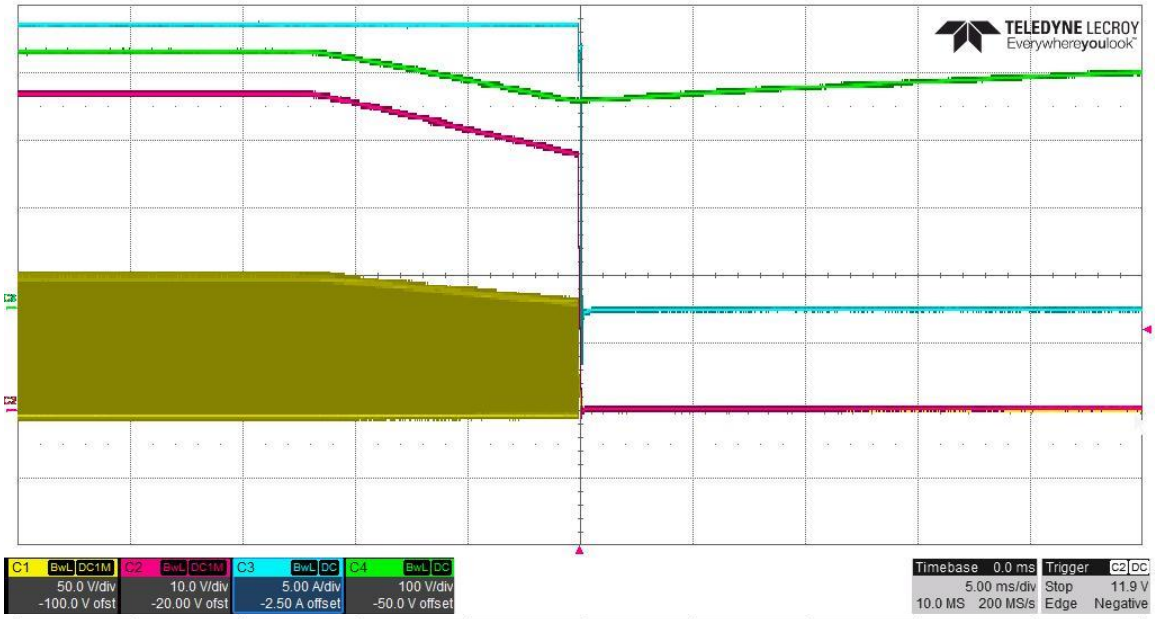
5. Turn Off Transient

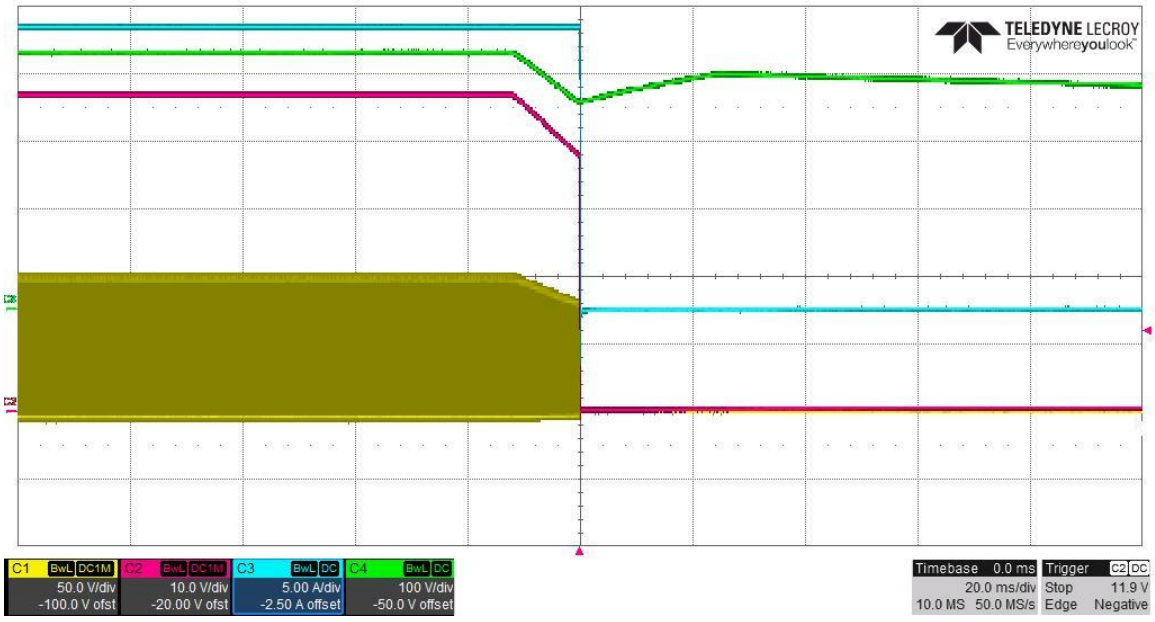
Oscilloscope channel assignments during the turn off transient tests are C1: SR V_{DS}, C2: V_{out}, C4: V_{in}.

5.1 380VDC INPUT, 48V/4A



5.2 380VDC INPUT, 48V/21A

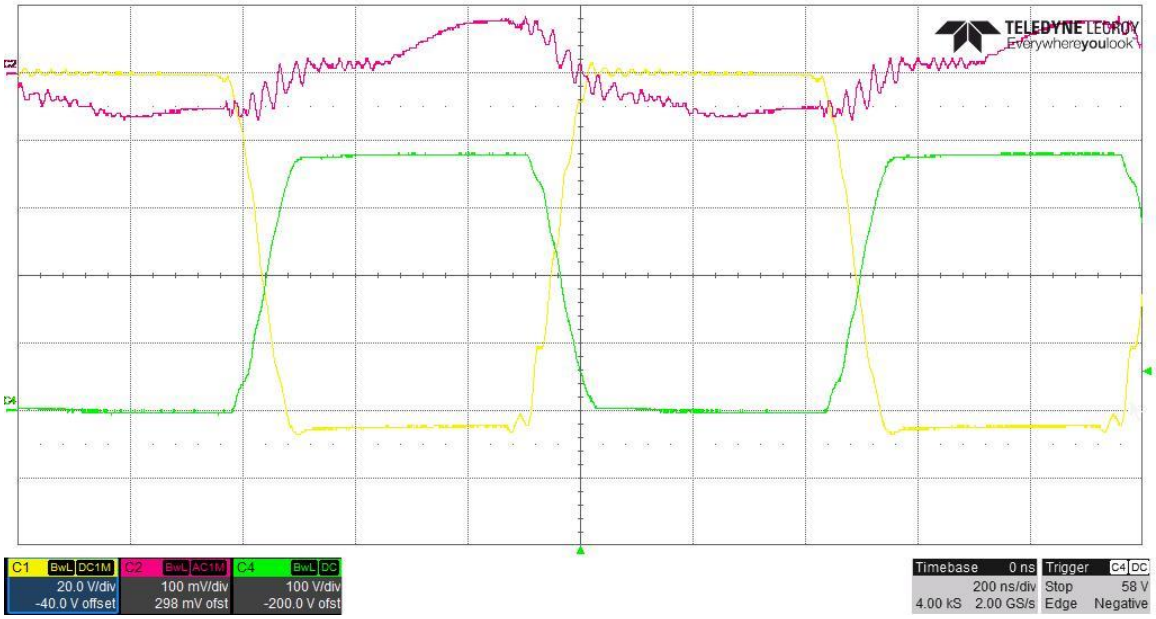




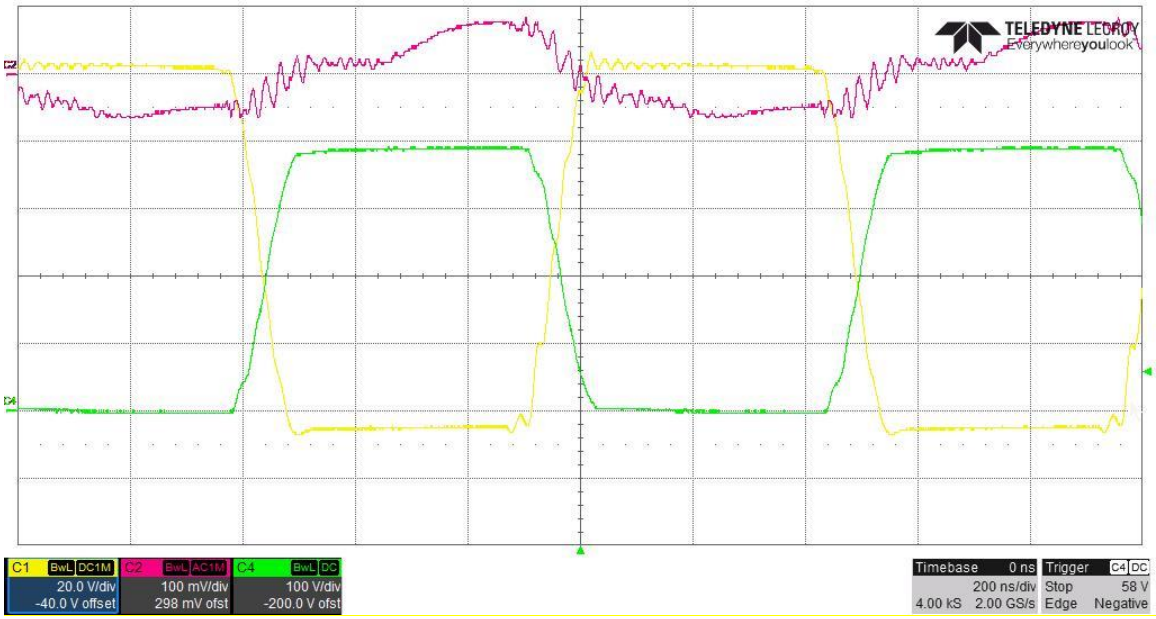
6. Key Waveforms

Oscilloscope channel assignments in these tests are C1: SR FET V_{DS} voltage, C2: Output voltage ripple, C4: Primary switching node.

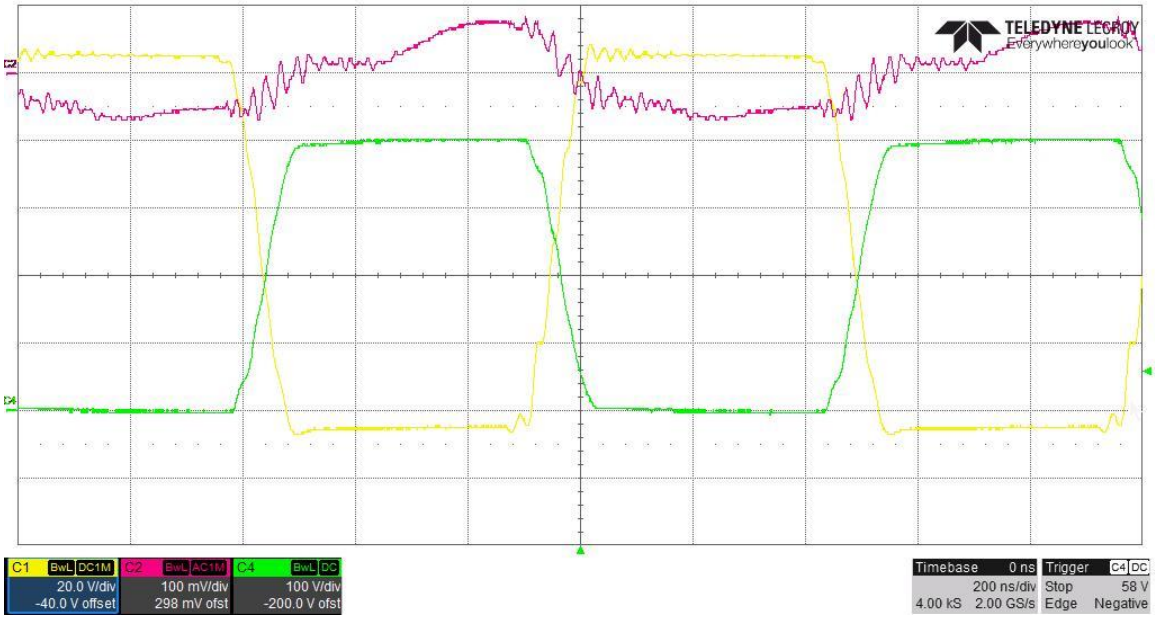
6.1 380VIN, 48V NO LOAD



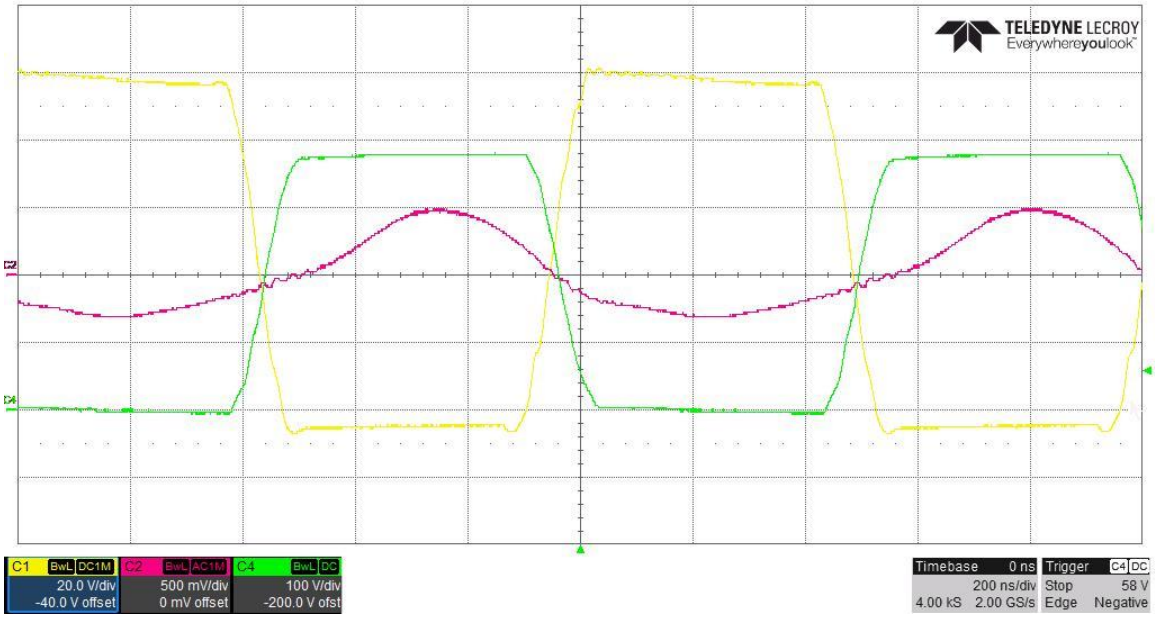
6.2 390VIN, 48V NO LOAD



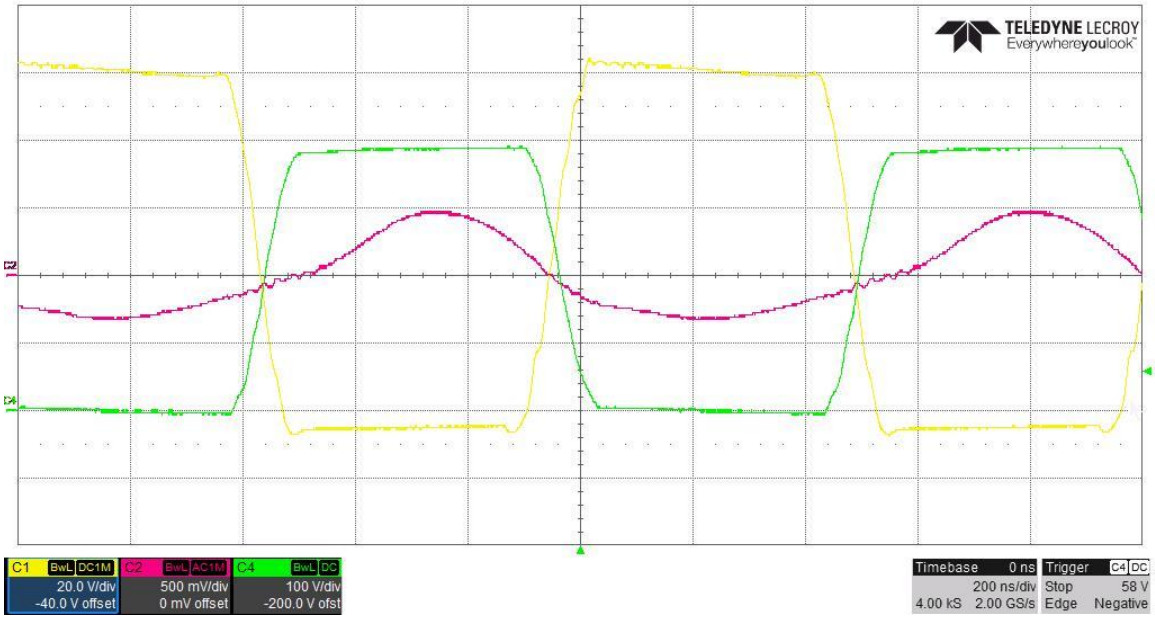
6.3 400VIN, 48V NO LOAD



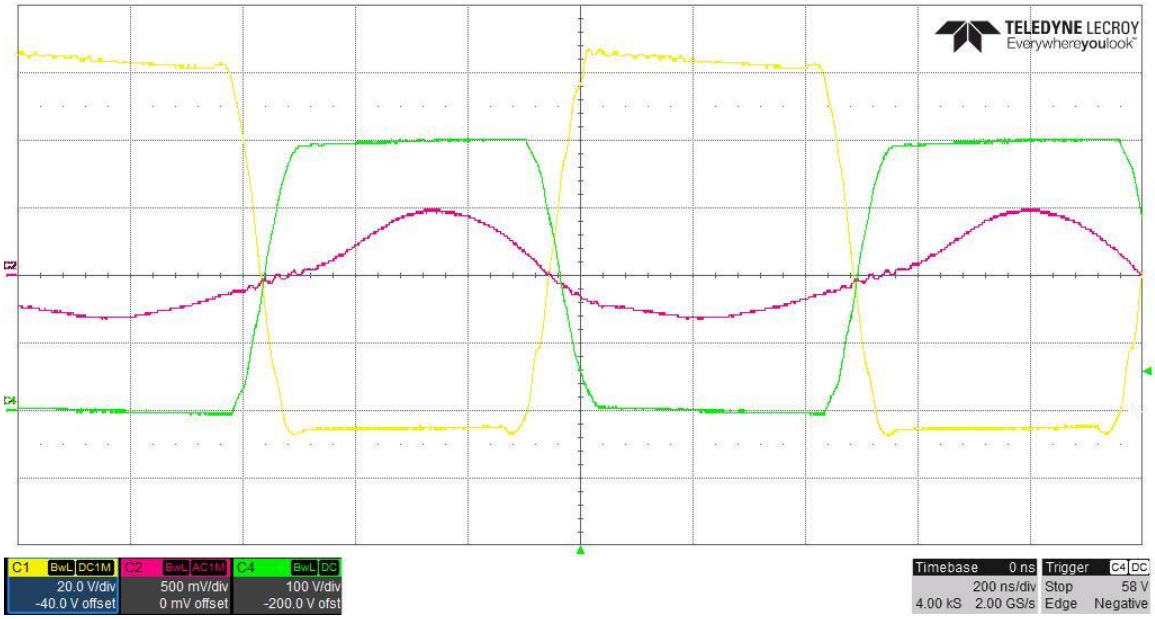
6.4 380VIN, 48V/21A



6.5 390VIN, 48V/21A



6.6 400VIN, 48V/21A



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