CASE STUDY
Boost PFC Converter

Performance Analysis: Full Load | Half Load | No Load

www.scspower.in info@scspower.in

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1. Objective of the Case Study

The objective of this case study is to analyse and compare the performance of a Boost PFC (Power Factor Correction) converter under Two distinct load conditions: Full Load, Half Load. The parameters observed and measured include input power factor, total harmonic distortion (THD) and efficiency.

1.1 Aims

- To verify that the converter achieves a power factor > 0.99 at full load.
- To observe how power factor and THD change as load decreases.
- To study the efficiency across all load conditions.

Table 1 Boost PFC Specifications

Parameter	Value	Unit
Input Voltage Range	180 - 272	V_{AC}
Input Frequency	50	Hz
Nominal Input Voltage	230	V_{AC}
Maximum Input Current	20	A
Power Factor (at full load)	> 0.99	-
THD (at full load)	< 5%	-
Inrush Current	5	A
Output Voltage	400 +/- 5%	V_{DC}
Output Current	8	A
Maximum Output Power	3.3	kW

2. Case Study Condition 1: Full Load

2.1 What is Full Load?

Full load refers to the condition where the converter is supplying its maximum rated output power. For example, if the design is rated at 1000 W, full load means the output is loaded with a resistance (or electronic load) set to draw 1000 W at 400 V DC.

This is the most important test condition because:

- PFC performance is designed and optimized for full load.
- Inductor current operates in Continuous Conduction Mode (CCM) — ideal for low THD.
- Thermal stress on components is at its maximum.
- Efficiency is typically at or near its peak value.

2.2 Test Conditions

Load Power: 3.4KW

Load Resistance :50 Ω

Input Voltage: 240 V_{rms}

Mains Frequency (Hz): 50 HZ

2.3 Observations

Table 2: Observation Table of Full Load Condition

Parameter	Expected Value	Measured Value
Input Voltage (V_{in}_rms)	240	240
Input Current (I_{in}_rms)	14.17	14.46
Input Power (P_{in})	3400	3472
Output Voltage (V_{OUT})	400	390
Output Current (I_{OUT})	8.5	8.7
Output Power (P_{OUT})	3400	3417
Power Factor (PF)	> 0.99 expected	0.995
Total Harmonic Distortion (THD)	< 5% expected	4.34%
Efficiency (η)	> 95% expected	97.96%

2.4 Waveform

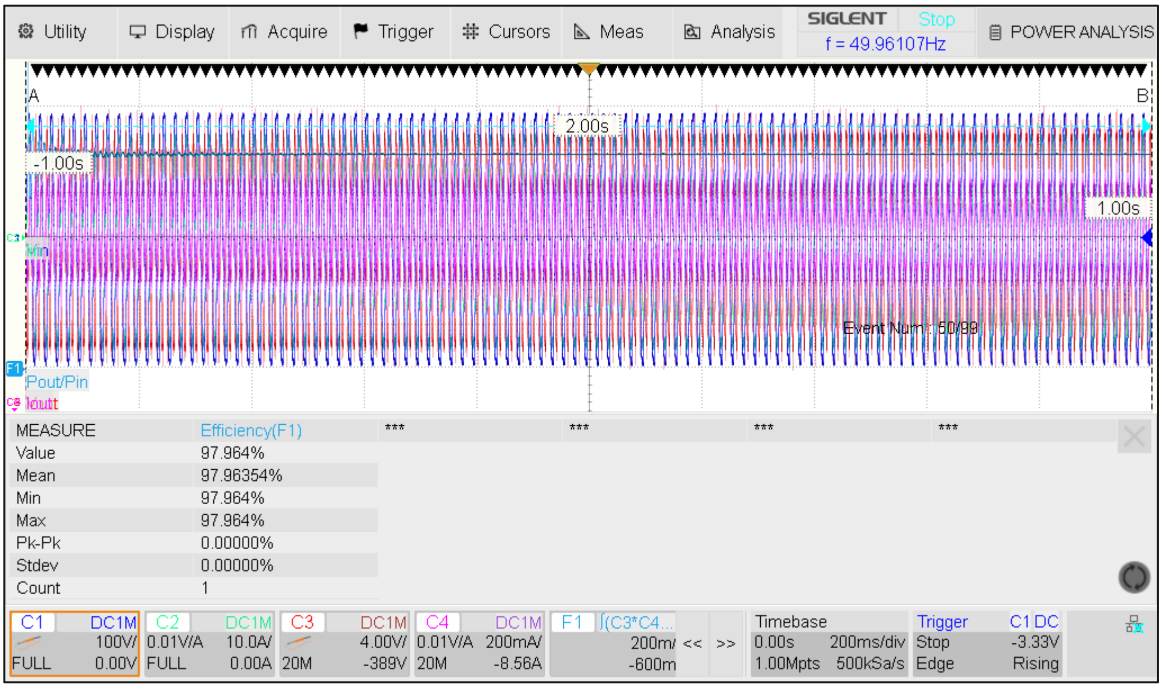


Figure 1: 100% Load Boost PFC Efficiency

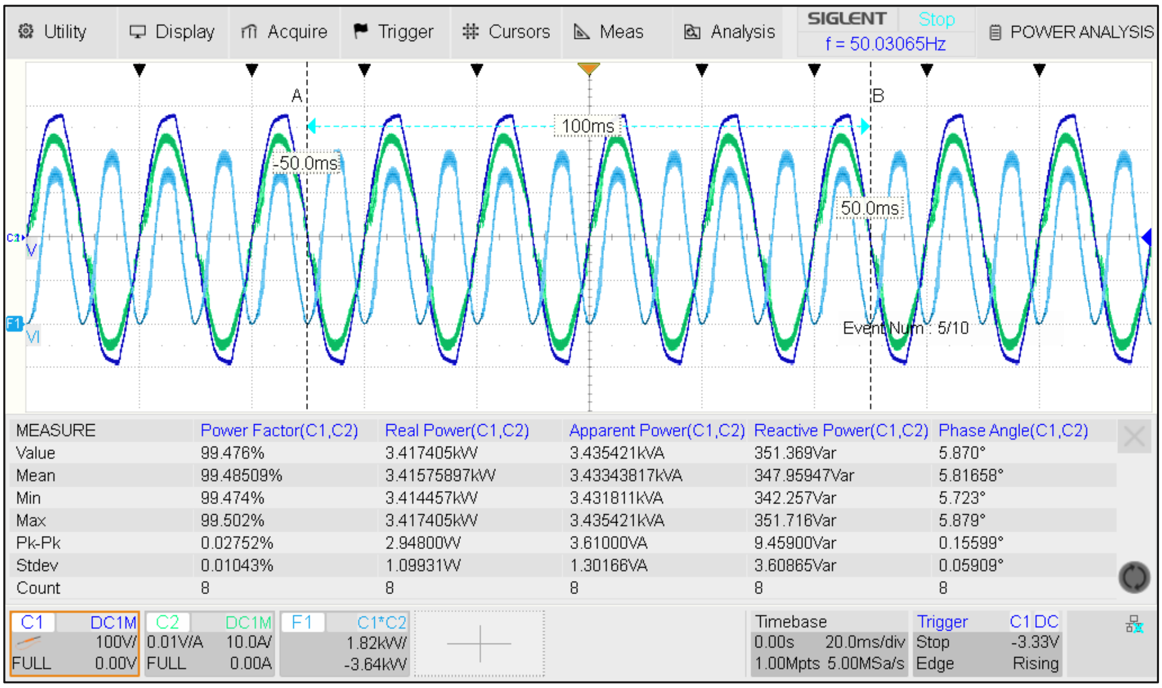
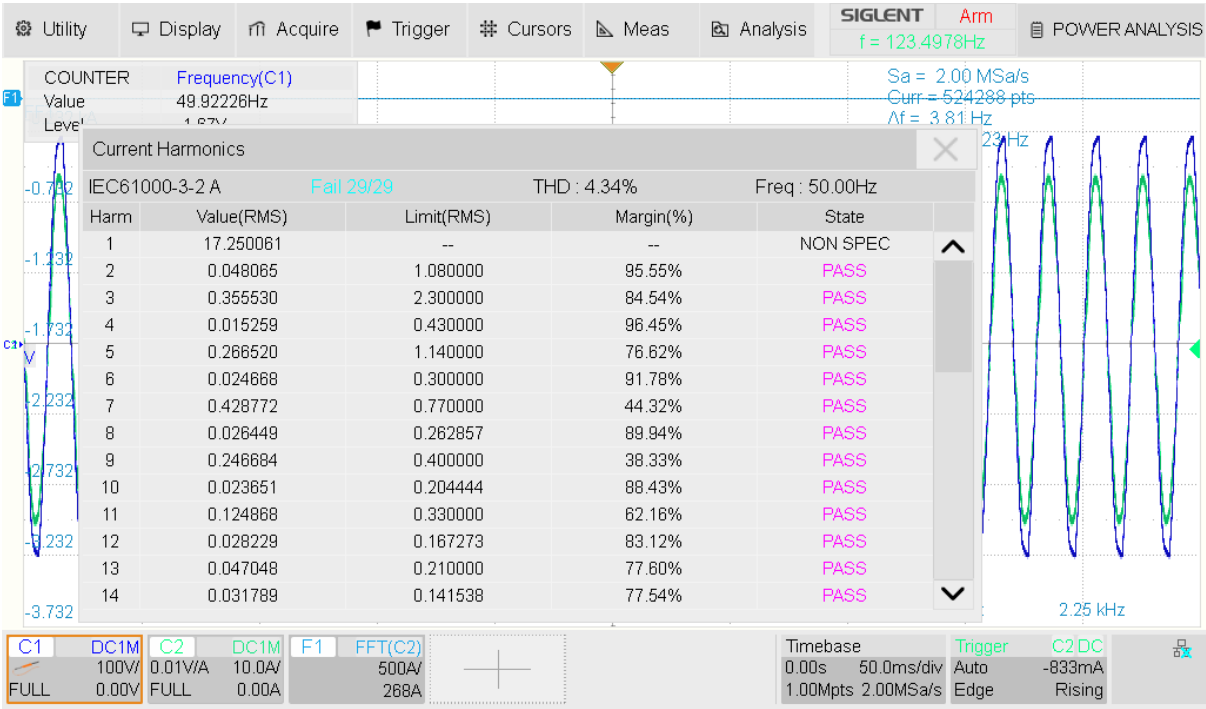


Figure 2: 100% Load Boost PFC Power Factor



Current Harmonics

IEC61000-3-2 A Fail 29/29 THD : 4.34% Freq : 50.00Hz

Harm	Value(RMS)	Limit(RMS)	Margin(%)	State
1	17.250061	--	--	NON SPEC
2	0.048065	1.080000	95.55%	PASS
3	0.355530	2.300000	84.54%	PASS
4	0.015259	0.430000	96.45%	PASS
5	0.266520	1.140000	76.62%	PASS
6	0.024668	0.300000	91.78%	PASS
7	0.428772	0.770000	44.32%	PASS
8	0.026449	0.262857	89.94%	PASS
9	0.246684	0.400000	38.33%	PASS
10	0.023651	0.204444	88.43%	PASS
11	0.124868	0.330000	62.16%	PASS
12	0.028229	0.167273	83.12%	PASS
13	0.047048	0.210000	77.60%	PASS
14	0.031789	0.141538	77.54%	PASS

Figure 3: 100% Load Boost PFC THD

3. Case Study Condition 2: Half Load Condition

3.1 What is Half Load?

Half load refers to operating the converter at 50% of its rated output power. For a 3.3kW design, this means the output supplies only 1.65kW. This condition represents a typical real-world scenario because most power supplies operate at partial load for a significant portion of their lifetime.

Key behaviours expected at half load:

- Power factor drops slightly compared to full load but should still be > 0.95.
- Efficiency may drop slightly due to fixed switching losses becoming proportionally larger.
- Output voltage should remain regulated at 400 V (good voltage regulation).

3.2 Test Conditions

Load Power: 1.7 KW

Load Resistance :100 Ω

Input Voltage: 240 V_{rms}

Mains Frequency (Hz): 50 HZ

2.3 Observations

Table 3: Observation Table of Half Load Condition

Parameter / Observation	Expected / Typical Range	Measured Value
Input Voltage (V_{in}_rms)	240	240
Input Current (I_{in}_rms)	7	7.26
Input Power (P_{in})	1700	1743
Output Voltage (V_{OUT})	400	390
Output Current (I_{OUT})	4.25	4.4
Output Power (P_{OUT})	1700	1713
Power Factor (PF)	> 0.99 expected	0.9724
Total Harmonic Distortion (THD)	< 5% expected	4.99%
Efficiency (η)	> 95% expected	97.52%

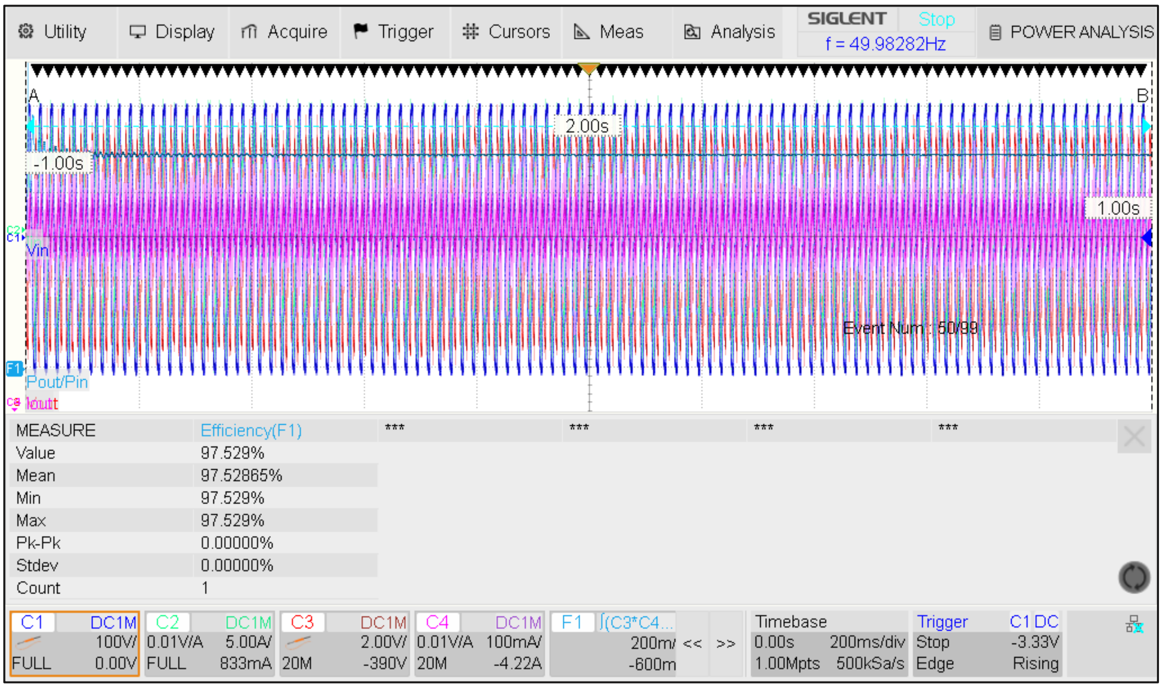


Figure 4: 50% Load Boost PFC Efficiency

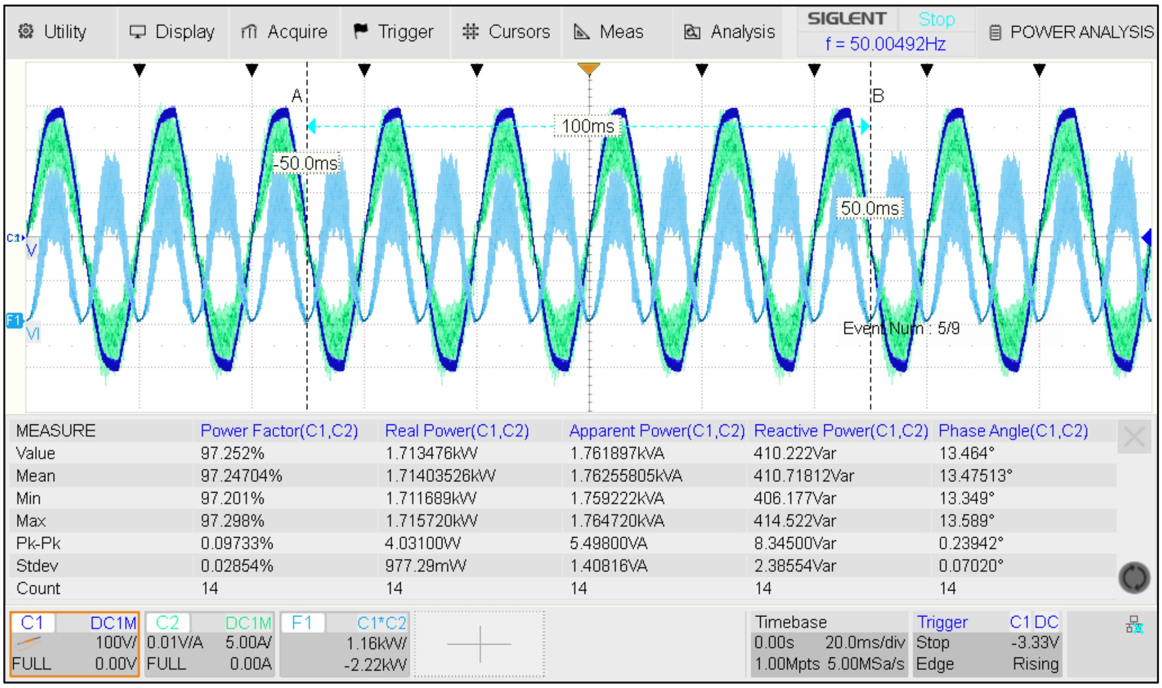
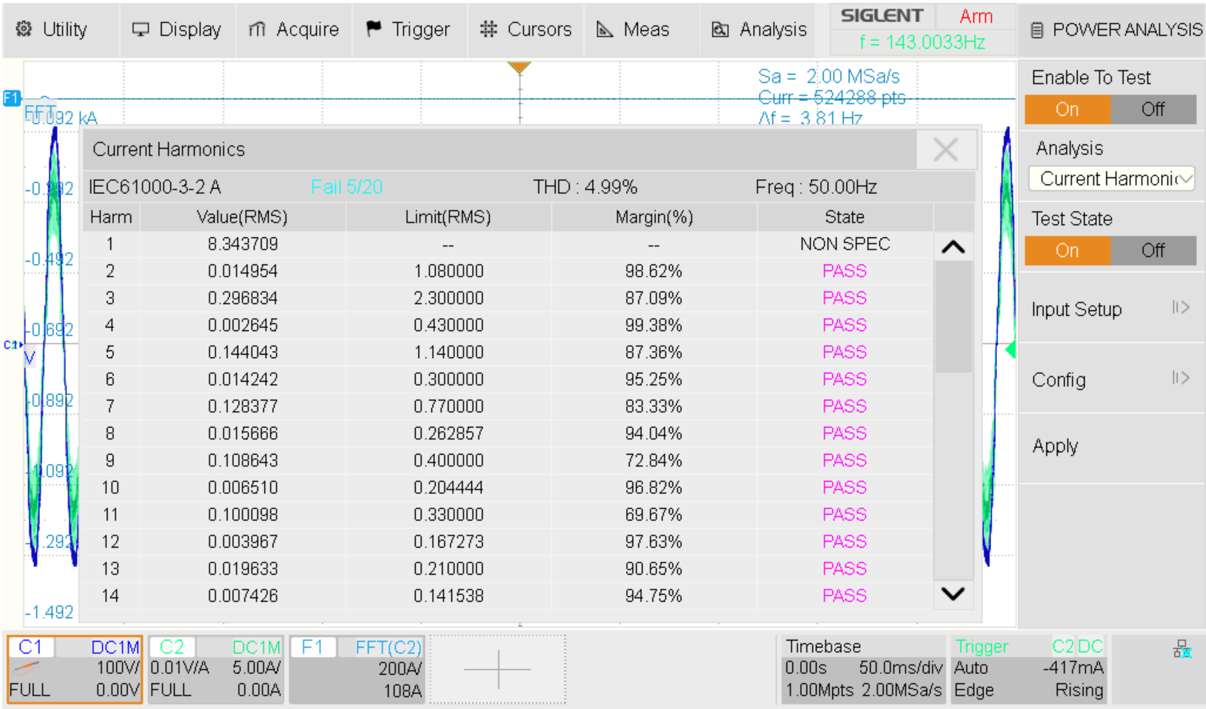


Figure 5: 50% Load Boost PFC Power Factor



Harm	Value(RMS)	Limit(RMS)	Margin(%)	State
1	8.343709	--	--	NON SPEC
2	0.014954	1.080000	98.62%	PASS
3	0.296834	2.300000	87.09%	PASS
4	0.002645	0.430000	99.38%	PASS
5	0.144043	1.140000	87.36%	PASS
6	0.014242	0.300000	95.25%	PASS
7	0.128377	0.770000	83.33%	PASS
8	0.015666	0.262857	94.04%	PASS
9	0.108643	0.400000	72.84%	PASS
10	0.006510	0.204444	96.82%	PASS
11	0.100098	0.330000	69.67%	PASS
12	0.003967	0.167273	97.63%	PASS
13	0.019633	0.210000	90.65%	PASS
14	0.007426	0.141538	94.75%	PASS

Figure 6: 50% Load Boost PFC THD

4 Conclusion

The performance analysis of the Boost PFC converter under full load and half load conditions demonstrates that the converter operates efficiently while maintaining a high-power factor and low harmonic distortion. At full-load operation, the converter achieved a power factor of 0.995, THD of 4.34%, and efficiency of 97.96%, which satisfies the expected design targets. The converter also maintained stable output voltage regulation close to the desired 400 V DC output.

Under half load condition, the converter continued to perform effectively with a power factor of 0.9724, THD of 4.99%, and efficiency of 97.52%. Although a slight reduction in power factor and efficiency was observed compared to full load operation, the overall performance remained within acceptable limits.

The results confirm that the Boost PFC converter provides excellent input current shaping, reduced harmonic distortion, and high conversion efficiency across different loading conditions. Therefore, the designed converter is suitable for high-power applications requiring improved power quality, efficient energy conversion, and compliance with power factor correction standards.