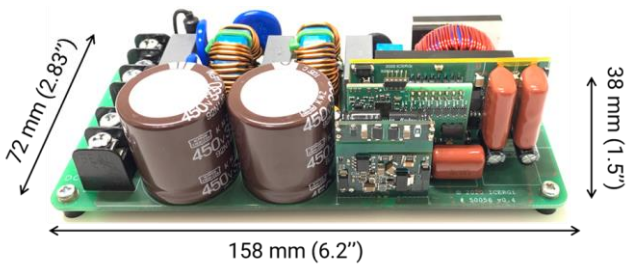
2kW 9A TOTEM-POLE PFC USING VISHAY MOSFETs

Preliminary – January 2021



- Cost leadership for highest efficiency PFC
- Highest efficiency up to 98.8%* @ 230Vac and 97.6% @ 115Vac with diode rectification
- Low power loss minimizing air-cooling
- Leading power density > 75 W/in^3
- Compact magnetics – 4 x smaller than conventional PFC
- Usage of AEQ101 qualified 150V Vishay MOSFETs SQJ872EP
- Digital Multimode control extending high efficiency to light load
- Designed to meet industrial/medical approvals criteria

* 99% @ 230V$_{AC}$ with a synchronous rectification

ELECTRICAL SPECIFICATIONS

INPUT

Input range	85Vac - 265Vac, 47Hz to 63Hz
Input voltage -Fault condition	265Vac – 300Vac, 5 sec max (programmable)
Maximal input current	9A$_{rms}$
Power Factor	>0.9 @ 230V$_{AC}$ and 100% load
Inrush Current	40A pk, cold start
Earth Leakage Current	< 300µA
No-load Power (standby only active)	< 500mW when inhibit is active
Input protection	12.5A / 250V dual fuse

OUTPUT

Maximum Power	2000W @ 230Vac, forced-air cooling 1000W @ 115Vac, forced-air cooling
Minimal load	No minimal load required
Start-up delay	Typical 3s from input AC turn-on
Nominal output voltage	400V (programmable)
Maximal output current	5A @ 230Vac 2.5A @ 115Vac 1.75A @ 85Vac

CONTROL AND PROTECTION

Control method	Fixed frequency PWM
Switching frequency (Multimode operation)	66kHz for input current > 2.5A$_{rms}$ 33kHz for input current < 2.5A$_{rms}$
Digital control firmware	Version 1.91
Overvoltage protection	440V (programmable). PFC will temporarily stop and resume operation when the bulk capacitor voltage drops below 430V
Over current protection	14A – PFC will temporarily stop and resume operation after a cool off period of 200us 15 over current events in less than 60s will result in a latch-up condition
Overload	2200W @ 230Vac. Default condition – restart 1100W @ 115Vac. Default condition – restart When the input current > 9Arms. Default condition – restart
Overtemperature protection	Yes – temporarily disabled (activated for enclosed implementation only)
Remote Inhibit	Yes – temporarily disabled
Light load management	Reduce conduction angle for output power less than 65W Burst mode for no and very light loads
AC OK	Yes - temporarily disabled
I2C Communication	Yes - temporarily disabled

START-UP

Minimal load	No minimal load required
Maximal load	1000W @ 230Vac (programmable) 500W @ 115Vac (programmable)
Start-up time	Less than 100ms (typically)
Start-up voltage	85Vac-265Vac
Maximal start-up time	16 line-cycles (programmable) – PFC will disable drive signals and attempt to restart again once the time-out event is detected
Maximal number of continuous restarting attempts	10 – PFC will latch up afterwards (programmable)

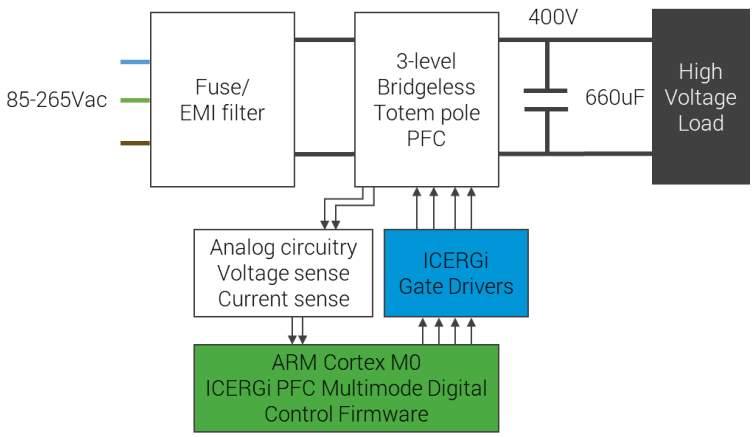
EMC EMISSIONS

	Standard	Pre-compliance Pass Level
Line Harmonics	IEC 61000-3-2	Class A
Conducted EMI	EN55022/32	Class B
Radiated EMI	EN55022/32	To be confirmed
Voltage Fluctuations & Flicker	IEC 61000-3-3	To be confirmed

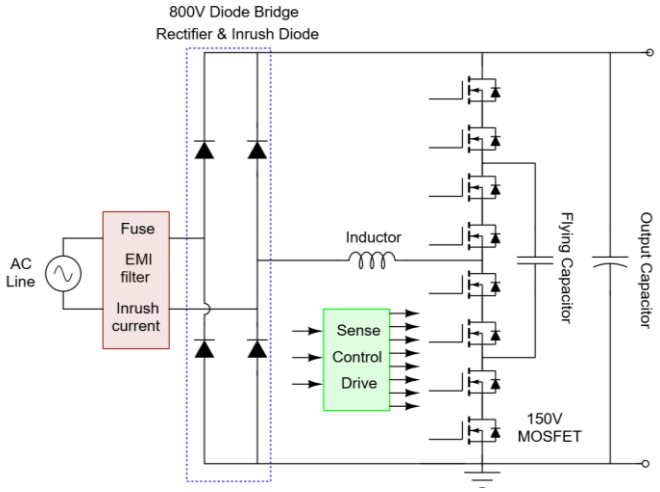
EMC IMMUNITY

	Standard		Pre-compliance Pass Level
Electrical Fast Transient	IEC 61000-4-4 ±2kV differential		Class A
Input Voltage Surge	IEC 61000-4-5 Class 4 ±2kV differential mode / ±4kV common mode		Class A
Voltage Dips and Short Interruptions	IEC 61000-4-11 230Vac 50Hz	Dip 30% (161Vac) for 500ms, 0º, 90º, 180º, 270º, 1.3kW	Class A
		Dip 60% (92 Vac) for 500ms, 0º, 90º, 180º, 270º, 680W	Class A
		Dip 100% (0 Vac) for 10ms, 0º, 90º, 180º, 270º, 2kW	Class A
		Dip 100% (0 Vac) for 20ms, 0º, 90º, 180º, 270º, 2kW	Class B
		PFC output voltage drops below 300V because of low hold-up capacitance values	
		Dip 100% (0Vac) for 500ms, 2kW	Class B
		For AC/DC power supply, PFC will see no load until its output reach around 400V_{DC}	
	IEC 61000-4-11 115Vac 50Hz	Dip 30% (81 Vac) for 500ms, 0º, 90º, 180º, 270º, 680W	Class A
		Dip 60% (46 Vac) for 500ms, 0º, 90º, 180º, 270º, 680W	Class B
		The PFC is programmed to restart if the AC input voltage is below 70V_{AC} (programmable)	
		Dip 100% (0 Vac) for 10ms, 0º, 90º, 180º, 270º, 1kW	Class A
		Dip 100% (0Vac) for 20ms, 0º, 90º, 180º, 270º, 1kW	Class B
		PFC output voltage drops below 300V because of a low hold-up capacitance value	
		Dip 100% (0Vac) for 500ms, 1kW	Class B
		For AC/DC power supply, PFC will see no load until its output reach around 400V_{DC}	
ESD	IEC 61000-4-2		To be confirmed
Radiated	IEC 61000-4-3		To be confirmed
Conducted	IEC 61000-4-3		Class B
Magnetic Field	IEC 61000-4-8		To be confirmed

CONVERTER ARCHITECTURE

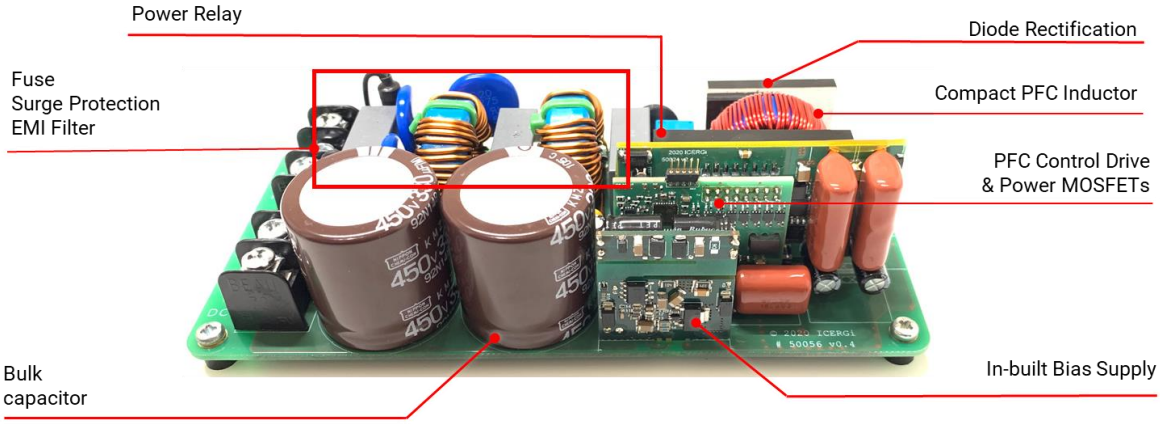


Block diagram of ICERGi PFC stage including EMI filter stage



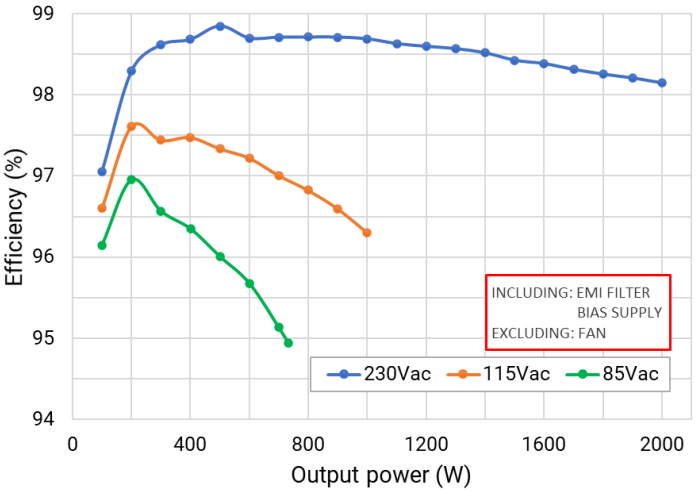
Simplified circuit diagram of a 3-level full-bridge totem-pole PFC featuring 8 x 150V 35mΩ Vishay MOSFETs (SQJ872EP)

KEY COMPONENT PLACEMENT

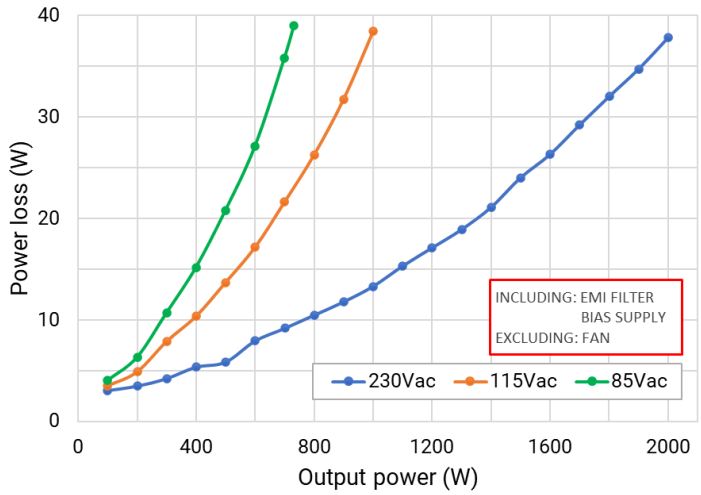


PERFORMANCE SUMMARY

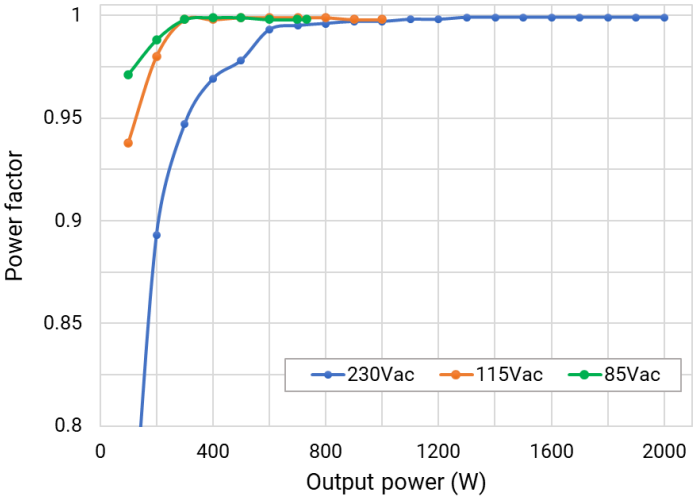
PFC Stage Efficiency



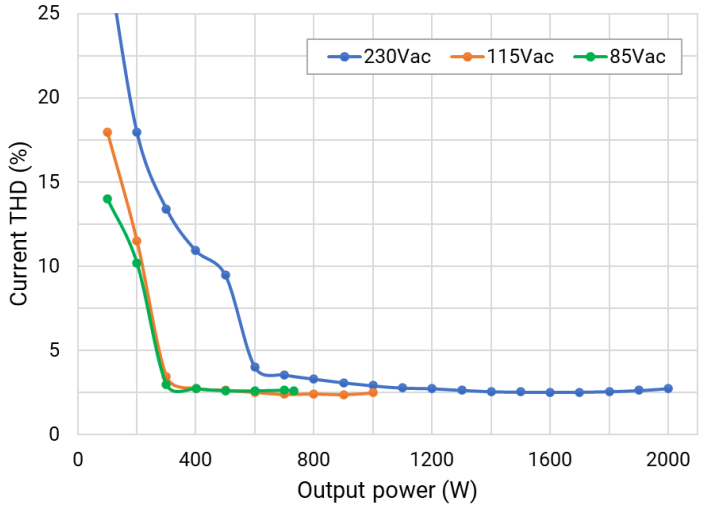
PFC Stage Loss



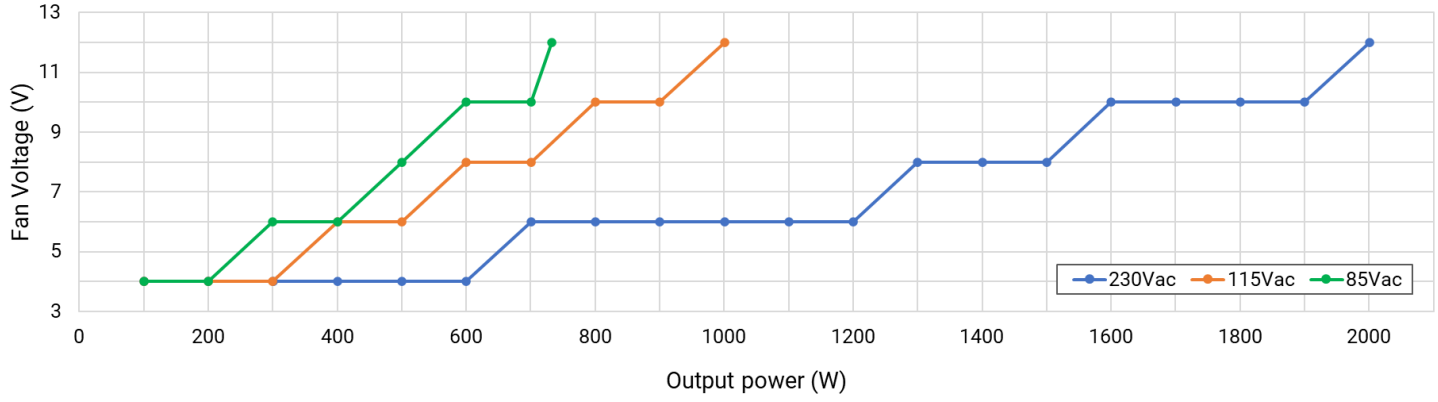
Power Factor



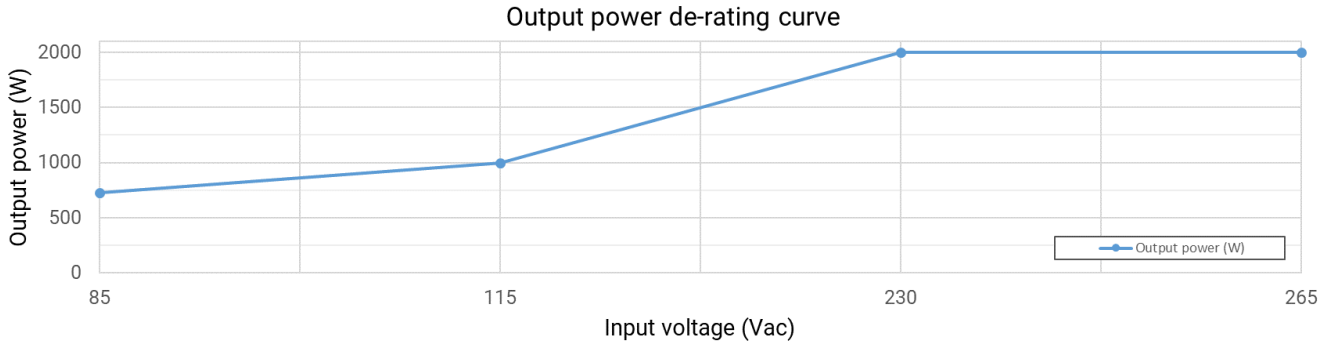
Input Current Distortion



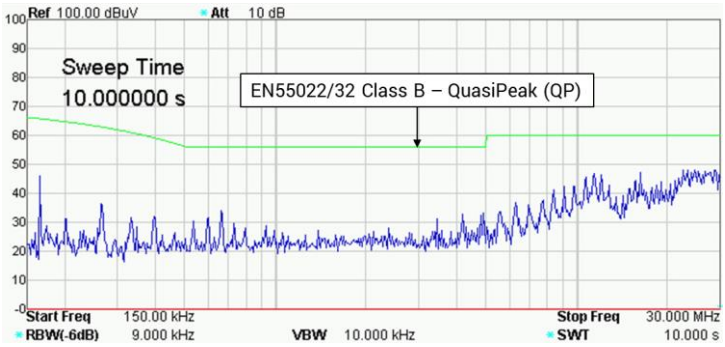
Fan Voltage For Forced-Air Cooling

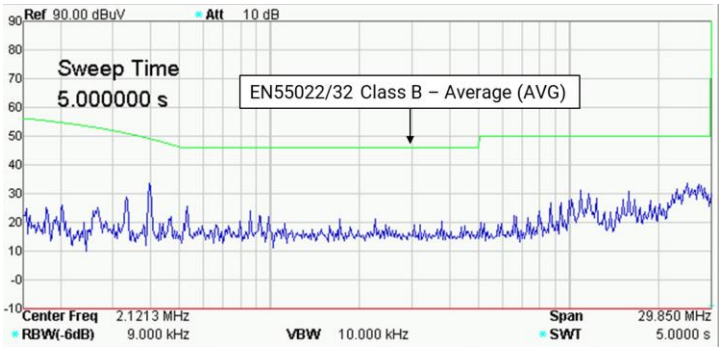


OUTPUT POWER DERATING



CONDUCTED EMI





Test condition: Input voltage V_{IN} = 230V_{AC}, output power P_{OUT} = 2000W,
ambient temperature T_a = 25ºC, measured phase = Live

Harmonic current emissions

Test Summary		General Results			
Test type	IEC 61000-3-2	Test value	Average	Minimum	Maximum
Test date / time	1/18/2021 1:31 PM	Watts (kW)	1.9859	1.9818	1.9893
Overall test status	PASS	Power Factor (m)	998.86	998.74	998.92
Pre-comp category	Class A	Amps fundamental (A)	8.6723	8.6564	8.6959
Specified voltage	230V_{AC}	V_{RMS} (V)	229.16	228.53	229.74
Specified frequency	50 Hz	Frequency (Hz)	49.856	49.839	49.869
Test duration	00:02:30	A_{RMS} (A)	8.6759	8.6507	8.7066
Ambient temperature	23°C ± 3°C	Vcf	1.3873	1.3845	1.3921
Humidity	< 75%				

Revision History

Date	Version	Changes
08-07-2020	1.0	First release
20-09-2020	1.1	Updated EMI emissions and immunity information
18-02-2021	1.2	Revised measurement conditions and data, updated graphs