

# 650W Interleaved Boost PFC Z-Rec™ (C3D) Demonstration Board

## 1. Introduction:

The 650W Z-Rec™ demonstration board is a 650-W, two phase interleaved, PFC pre-regulator that uses average current mode control techniques to achieve near unity power factor. The pre-regulator was designed to operate off a universal ac line input of 85 V to 265 V and provides a regulated 390-V dc output. This board demonstrates Cree's 600V Z-Rec™ SiC diode performance at more than 300W per phase. The 650W board is demonstrated with 2A SiC diodes for each phase.

## 2. Features:

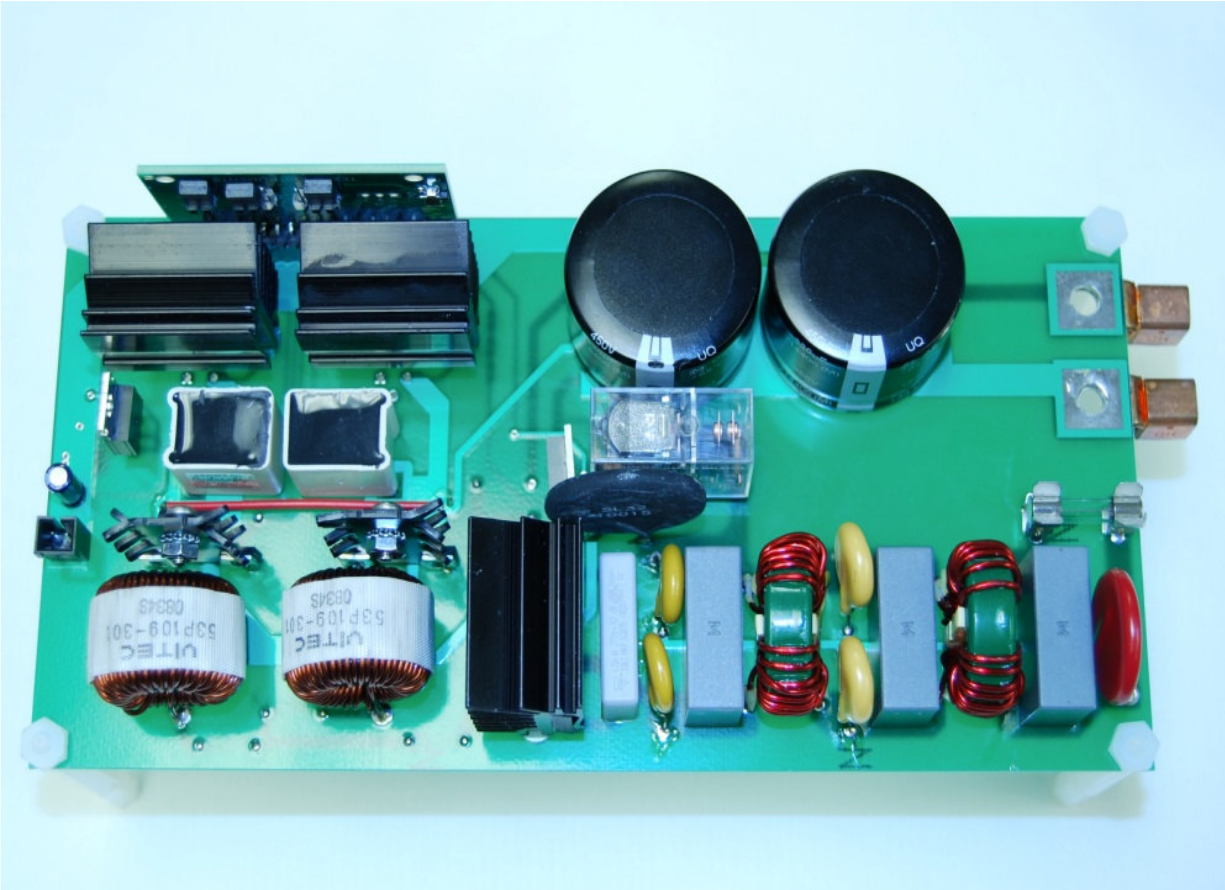
- Designed to meet IEC1000-3-2
- Universal line, 85Vac to 265Vac
- Regulated 390Vdc at 650W output
- Interleaved dual phase design
- Switching frequency 100kHz

## 3. Electrical Specifications:

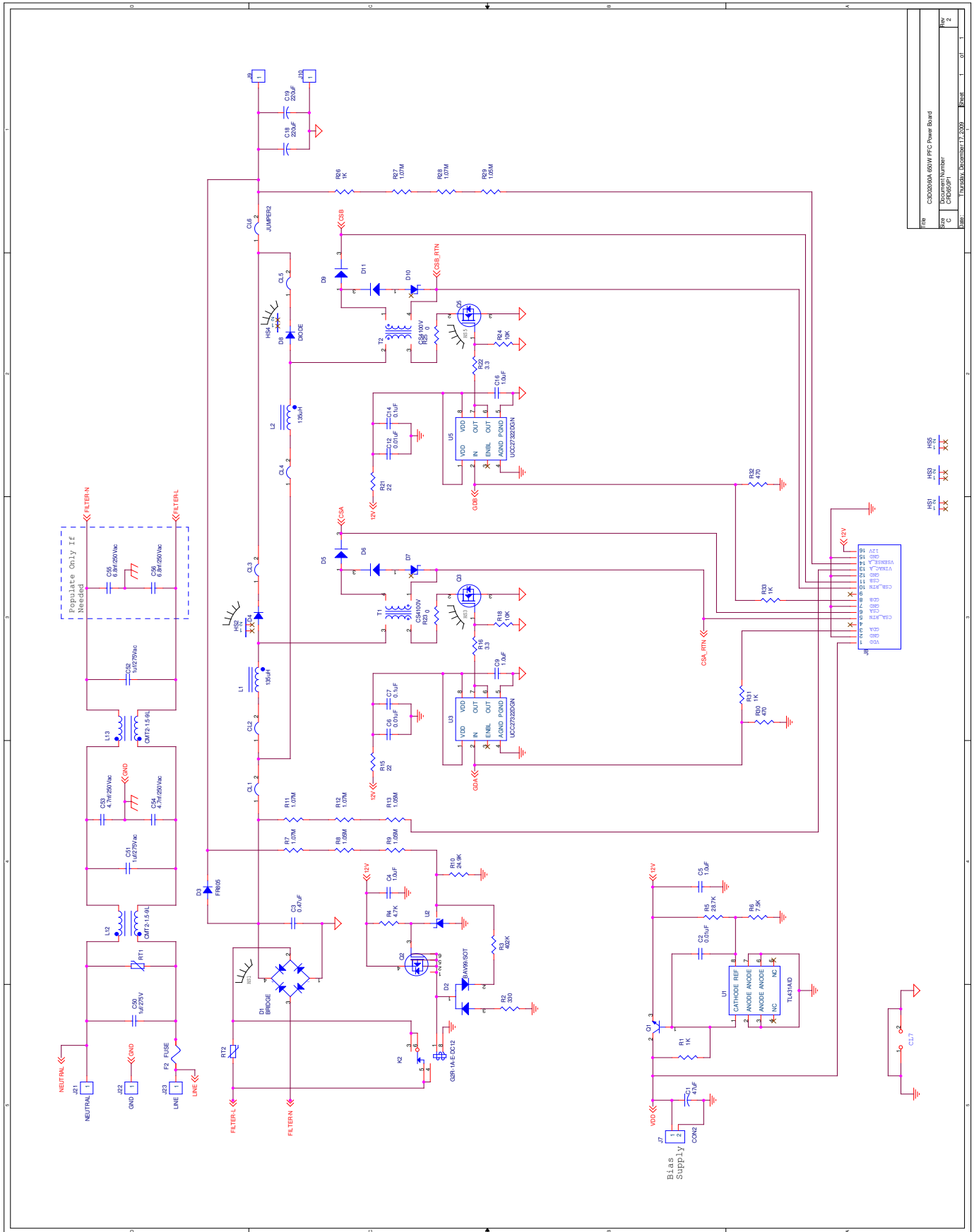
Definition	Minimum	Maximum	Units
<b>RMS Input Voltage (AC line)</b>	<b>85</b>	<b>265</b>	<b>V</b>
<b>Output Voltage</b>		<b>390</b>	<b>V</b>
<b>Line Frequency</b>	<b>47</b>	<b>63</b>	<b>Hz</b>
<b>Power Factor</b>	<b>.9</b>	<b>0.99</b>	
<b>Output Power</b>		<b>650</b>	<b>W</b>
<b>Full Load Efficiency</b>	<b>93</b>	<b>96.6</b>	<b>%</b>

### 4. Demonstration Board

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# 5. Schematics- Power Board



Rev	01	01
File	C:\020004\650W PFC Power Board	
PC	01	
Drawn By	01	
Print	1	01



## 6. Schematics- Daughter Card

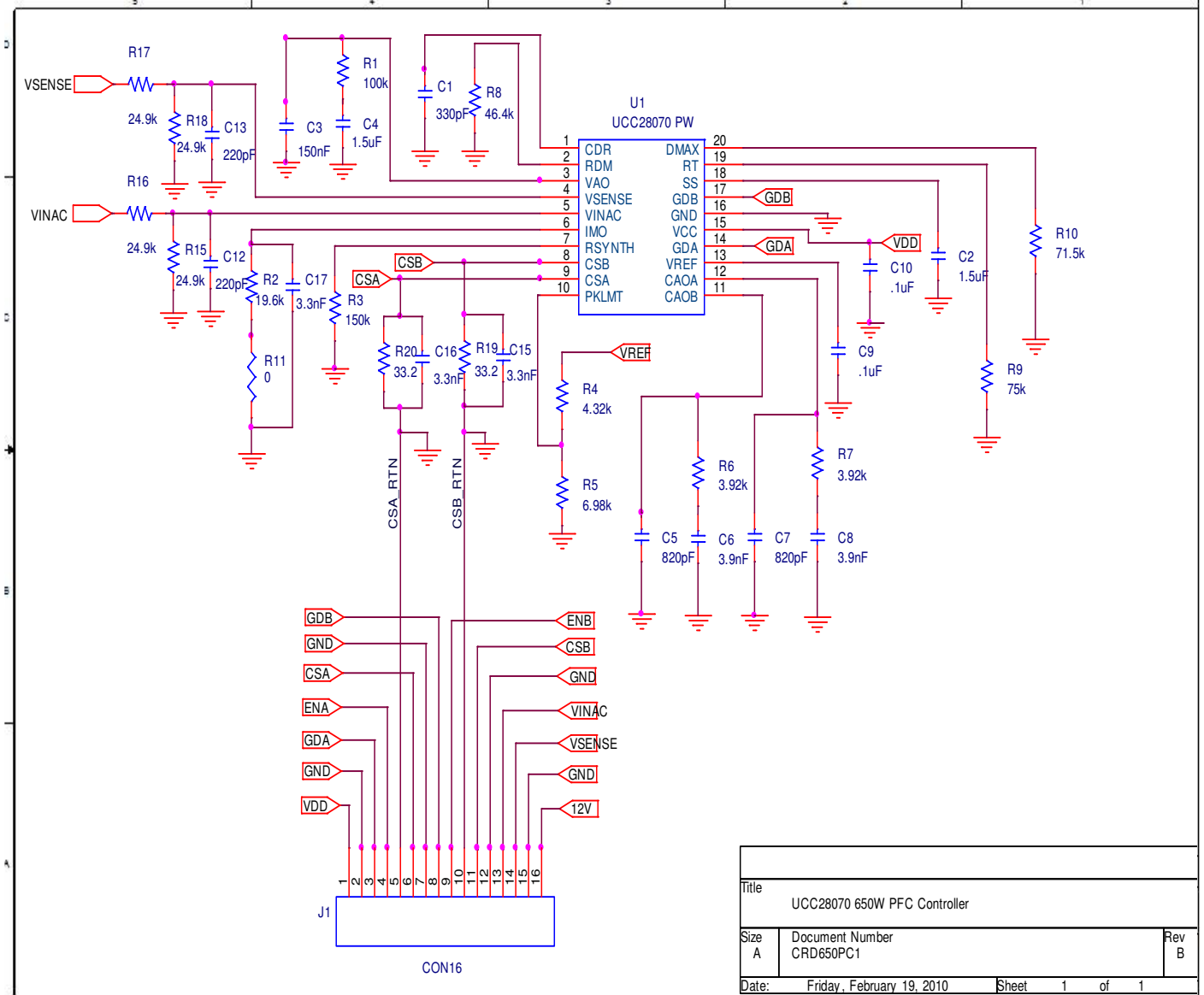
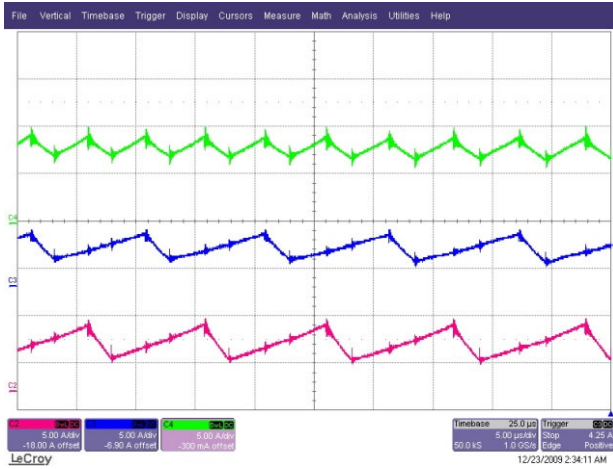
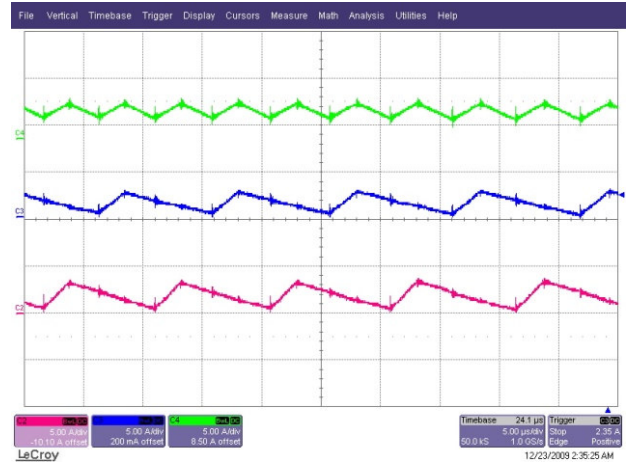


Figure 2: UCC28070 Daughter Card Schematics

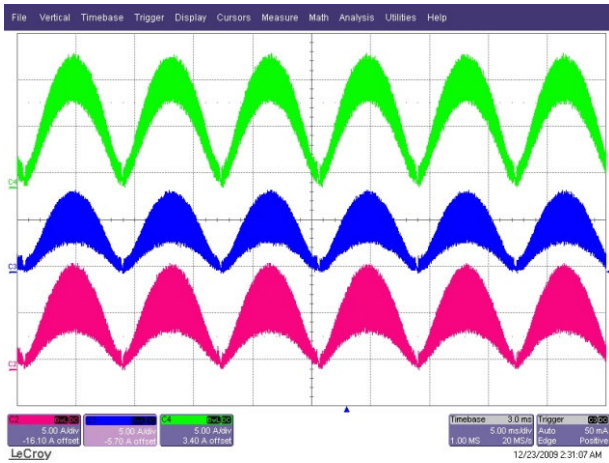
## 7. Input Ripple Cancellation Waveforms



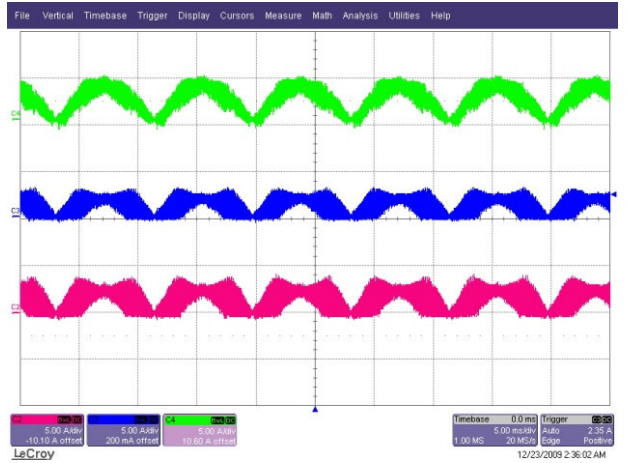
**Figure 3: Input and Inductor Current Ripple at  $V_{in}=85V$  RMS and  $P_{out}=650W$**



**Figure 4: Input and Inductor Current Ripple at  $V_{in}=265V$  RMS and  $P_{out}=650W$**



**Figure 5: Input and Inductor Current Ripple at  $V_{in}=85V$  RMS and  $P_{out}=650W$**



**Figure 6: Input and Inductor Current Ripple at  $V_{in}=265V$  RMS and  $P_{out}=650W$**

## 8. Performance Data with C3D02060 (with Cooling)

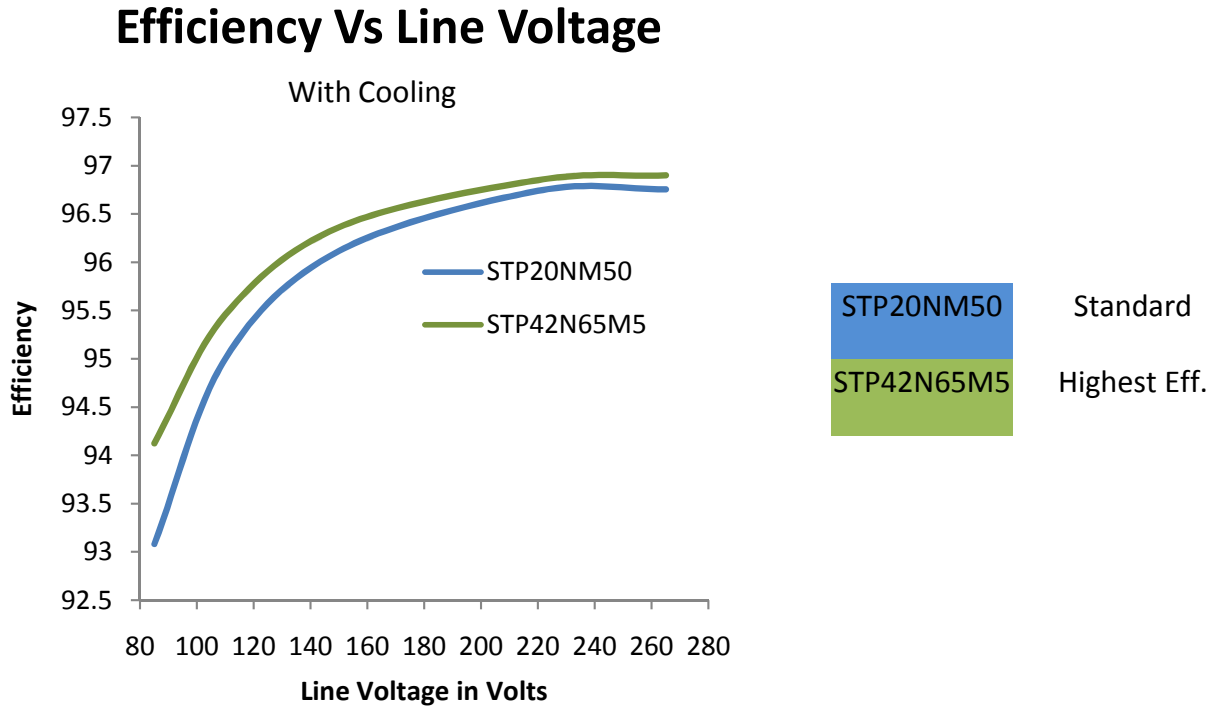


Figure 7: Efficiency Data at Pout=650W for various line voltages

## 9. Performance Data with C3D02060 –STP42N65M5(without Cooling)

Vin (V)	Iin(V)	PF	Eff (%)	Q1 (deg C)	Q2 (deg C)	D1 (deg C)	D2 (deg C)
265	2.5	0.988	96.64	58.4	58.1	56.8	62.2
220	3.1	0.994	96.62	60.6	59.4	61.5	66.6
150	4.5	0.999	96.20	70.3	68.6	69.8	74.2
110	6.2	0.999	95.37	82.1	79.6	78.6	83.7
85	8.2	0.999	93.73	97.4	93.2	90.5	94.7

## 10. EMI Performance:

### 2 Common modes 1.5 mH with one Y2 caps 6.8n and X2 Caps= 1uF



Figure 8: Frequency sweep from 150kHz to 1MHz  
Vin=208V RMS and Pout=650W

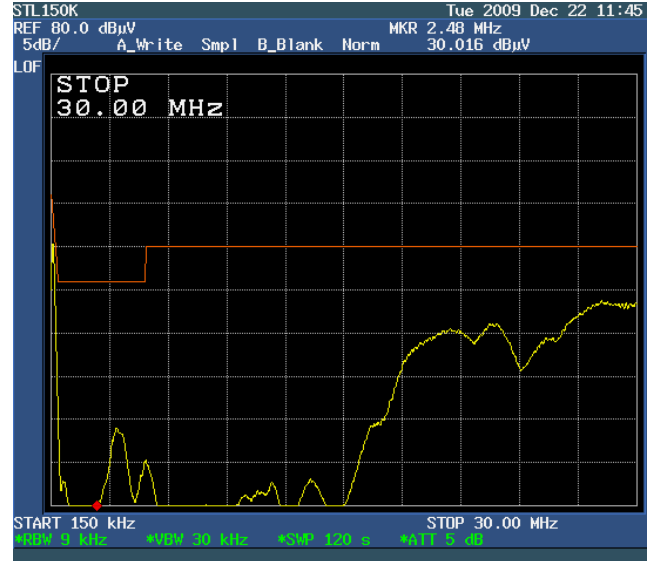


Figure 9: Frequency sweep from 150kHz to 30MHz  
Vin=208V RMS and Pout=650W

### 2 Common modes 1.5 mH with both with Y2 caps (4.7n and 6.8n) X2 Caps= 1uF



Figure 10: Frequency sweep from 150kHz to 1MHz  
Vin=208V RMS and Pout=650W



Figure 11: Frequency sweep from 150kHz to 30MHz  
Vin=208V RMS and Pout=650W

## 11.1 Bill of Materials - Power Board

Quantity	Reference	Value	Description	Size	Part Number	Mfr
5	CL1,CL2,CL4,CL5,CL6	N/A	Jumper, 0.400 inch length, PVC Insulation, AWG 22,	0.060 x 0.400 inch	923345-04-C	3M
2	CL7,CL2	N/A	Jumper, 2.000 inch length, PVC Insulation, AWG 18	0.035 inch Dia.	923345-20-C	3M
1	C1	47uF	Capacitor, Aluminum Electrolytic, 35V	0.197 inch	ECA-1VM470	Panasonic
3	C2,C6,C12	0.01uF	Capacitor, Ceramic, 25V, X7R, ±10%	0603	Std	Std
1	C3	0.47uF	Capacitor, 0.47UF, 305VAC, EMI SUPPRESSN	0.336 x 1.043 inch	BFC233820474	Vishay
4	C4,C5,C9,C16	1.0uF	Capacitor, Ceramic, 25V, X5R, ±10%	0603	Std	Std
2	C14,C7	0.1uF	Capacitor, Ceramic, 25V, X7R, ±10%	0603	Std	Std
2	C19,C18	220uF	Capacitor, Aluminum, 450V, 20%, -40C° to 105C°	35mm Dia	EETUQ2W221LJ	Panasonic
1	D1	BRIDGE	RECT BRIDGE GPP 25A 600V GBJ	1.190 x 0.190 inch	GBJ1506-BP	Diodes
1	D2	BAV99/SOT	DIODE SW DUAL 75V 350MW SOT23	SOT23	BAV99-7-F	Diodes
1	D3	FR805	RECT FAST REC 600V 8A TO-220A	TO220AC	FR805	Diodes
2	D4,D8	C3D02060A	Diode Zero Recovery SiC 600V-2A	TO220AC	C3D02060A	CREE
4	D5,D6,D9,D11	BAS16/SOT	Diode, Switching, 150-mA, 75-V, 350mW	SOT23	BAS16-V-GS08	Vishay-Liteon
2	D10,D7	33V	Diode, Zener, 33-V @ 3.8-mA, 225-mW, 5%	SOT23	MMBZ5257BLT1	Motorola
1	F2	15A	Fuse, Fast-Acting, 5x20mm 217 Series	5x20mm	0217015.HXP	Littelfuse
2	FB2	10A	Fuseholder, 5x20mm fuses, board mount (Qty: 2)	6x12mm	0751.0062	Shurter
2	HS1, HS3, HS5	780653B1180	Heatsink, Vertical-mount	1.180 x 0.764 inch	780653B1180	Aavid
2	HS2,HS4	592502	Heatsink, TO-220, Vertical-mount, 30°C/W	0.88 x 0.25 inch	592502B03400G	Thermalloy
1	J8	PPTC161LF BN-RC	Header, 16-pin, 100mil spacing, Female	0.100 inch x 16	PPTC361LFBN-RC	Sullins
1	K2	G2R-1A-E-DC12	Relay, Reed, DPST, 16A, 250VAC	0.210 x 0.810 inch	G2R-1A-E-DC12	Omron



2	L1,L2	78uH	Power Inductor (78uH @ 10.7ADC Bias & 309uH @0ADC)	0.913 X 1.165 inch	53P109-301	Vitec
2	L1,L2	95uH	Power Inductor (67 Turns, 95uH@8.5ADC & 390uH@0ADC)	1.794 X .691 inch	77076-A7,16AWG	Magnetics
1	Q1	TIP29	Transistor, NPN 1A, 40V	TO-220V	TIP29-BP	Micro Commercial
1	Q2	ZXMP6A17 E6TA	MOSFET P-CH 60V 3A SOT-23-6	SOT23-6	ZXMP6A17E6TA	Zetex
2	Q3,Q5	STP20NM5 0	MOSFET, N-ch, 500V-V, 20-A, 200- milliOhms	TO-220V	STP20NM50	ST
2	Q3,Q5	STP42N65 M5	MOSFET, N-ch, 650V-V, 33-A, 79- milliOhms	TO-220V	STP42N65M5	ST
1	RT1	V275LA40A P	Varistor, Disk, 275V	0.220 x 1.043 inch	V275LA40AP	Littelfuse
1	RT2	7 Ohm	Varistor, Disk, 265V max., 15A @ 65C°	0.200 x 1.180 inch	SL32 10015	Amethern
3	R1,R31,R33	1K	Resistor, Chip, 1/16W, ±1%	0603	Std	STD
1	R26	1k	Resistor, Chip, 1/16W, ±1%	0805	Std	STD
1	R2	330	Resistor, Chip, 1/16W, ±1%	0603	Std	STD
1	R3	402K	Resistor, Chip, 1/16W, ±1%	0603	Std	STD
1	R4	4.7K	Resistor, Chip, 1/16W, ±1%	0603	Std	STD
1	R5	28.7K	Resistor, Chip, 1/16W, ±1%	0603	Std	STD
1	R6	7.5K	Resistor, Chip, 1/16W, ±1%	0603	Std	STD
5	R7,R11,R12,R27,R28	1.07M	Resistor, Chip, 1/16W, ±1%	0805	Std	STD
4	R8,R9,R13,R29	1.05M	Resistor, Chip, 1/16W, ±1%	0805	Std	STD
1	R10	24.9K	Resistor, Chip, 1/16W, ±1%	0805	Std	STD
2	R21,R15	22	Resistor, Chip, 1/16W, ±1%	0603	Std	STD
2	R16,R22	3.3	Resistor, Chip, 1/16W, ±1%	0805	Std	STD
2	R18,R24	10K	Resistor, Chip, 1/16W, ±1%	0603	Std	STD
2	R25,R23	0	Resistor, Chip, 1/16W, ±1%	0805	Std	STD
2	R30,R32	470	Resistor, Chip, 1/16W, ±1%	0603	Std	STD
2	T1,T2	CS4100V	Transformer, Current Sense, 100:1	0.570 x 0.770 inch	CS4100V-01L	Coilcraft
1	U1	TL431AID	IC, Adj Shunt Regulator, 100-mA, 36-V	SO8	TL431AID	TI

1	U2	TL431AIDBZR	IC PREC SHUNT REG ADJ SOT23-3	SOT23-3	TL431AIDBZR	TI
2	U5,U3	UCC27322DGN	IC, Single 9-A High Speed Low-Side MOSFET Driver	MSOP-8	UCC27322DGN	TI
3	C50,C51,C52	1uF	Capacitor, 1uF, 275VAC, 560VDC X2 Cap	10x18.5x26.5 mm	R46KN410000N2	Arcotronics
2	C55,C56	6.8nF	Capacitor, 6.8nF, 300V, Ceramic, Y2-VY2 series	14.5mm Dia.	VY2682M59Y5US63	Vishay
2	C53,C54	4.7nF	Capacitor, 4.7nF, 300V, Ceramic, Y2-VY2 series	12.5mm Dia.	VY2472M49Y5US6*	Vishay
2	L12,L13	1.5mH	Common Mode Choke, 1.5mH, 9A, 17uH Leakage	1.23x1.25x.825 inch	CMT2-1.5-9L	Coilcraft
6	2x @ HS1, HS3,HS5	Spacers	Board Spacers, Standoffs, 0.125" (3.2mm) 1/8", Nylon #4	0.125 x 0.250	875	Keystone Electronics
4	2x @ HS1, HS3, HS5	Screw	Pan Head Screw M3 (steel) 0.236" (6.00mm)	0.236" (6.00mm)	Std	STD
4	1x @ HS3, HS5 1x @ HS2, HS4	Insulator	Thermal Pad Silicon TO220		3223-07FR-51	Berquist
2	1x @HS2, HS4	Nut	Std #4/40 Steel Nut		Std	STD
2	1x @ HS2, HS4	Screw	Pan Head Screw #4/40 Steel 0.5"		Std	STD
2	1x @HS2, HS4	Shoulder Washer	Washer/Bushing #4 0.031"L Nylon		3049	Keystone Electronics
			Highest Efficiency			
			Standard			



## 11.2 Bill of Materials - Control Card

Quantity	Reference	Value	Description	Size	Part Number	Mfr
1	C1	330pF	Capacitor, Ceramic, 50V, C0G, ±5%	0603	STD	STD
2	C2,C4	1.5uF	Capacitor, Ceramic, 16V, X5R, ±10%	0603	STD	STD
1	C3	150nF	Capacitor, Ceramic, 25V, X7R, ±10%	0603	STD	STD
2	C5,C7	820pF	Capacitor, Ceramic, 50V, C0G, ±5%	0603	STD	STD
2	C6,C8	3.9nF	Capacitor, Ceramic, 50V, X7R, ±10%	0603	STD	STD
2	C9,C10	.1uF	Capacitor, Ceramic, 25V, X7R, ±10%	0603	STD	STD
2	C12,C13	220pF	Capacitor, Ceramic, 50V, C0G, ±5%	0603	STD	STD
3	C15,C16,C17	3.3nF	Capacitor, Ceramic, 50V, X7R, ±10%	0603	STD	STD
1	J1	PBC16SBAN	CONN, HEADER, .100, SINGL, R/A, 16POS	0.100 inch x 16	PBC36SBAN	Sullins
1	R1	100k	Resistor, Chip, 1/16W, ±1%	0603	STD	STD
1	R2	19.6k	Resistor, Chip, 1/16W, ±1%	0603	STD	STD
1	R3	63.4k	Resistor, Chip, 1/16W, ±1%	0603	STD	STD
1	R4	4.32k	Resistor, Chip, 1/16W, ±1%	0603	STD	STD
1	R5	6.98k	Resistor, Chip, 1/16W, ±1%	0603	STD	STD
2	R6,R7	3.92k	Resistor, Chip, 1/16W, ±1%	0603	STD	STD
1	R8	46.4k	Resistor, Chip, 1/16W, ±1%	0603	STD	STD
1	R9	75k	Resistor, Chip, 1/16W, ±1%	0603	STD	STD
1	R10	71.5k	Resistor, Chip, 1/16W, ±1%	0603	STD	STD
1	R11	0	Resistor, Chip, 1/16W, ±1%	0603	STD	STD
4	R15,R16,R17,R18	24.9k	Resistor, Chip, 1/16W, ±1%	0603	STD	STD
2	R19,R20	33.2	Resistor, Chip, 1/10W, ±1%	0805	STD	STD
1	U1	UCC28070 PW	IC, Two- Phases Interleaved CCM PFC Controller	TSSOP-20	UCC28070PW	TI