

DESCRIPTION

The EVHR1211-Y-00B is an evaluation board designed for lithium-ion batteries, which are typically used in e-mobility and uninterruptible power supply (UPS) applications. This device can also be used as a general power supply unit. The EVHR1211-Y-00B regulates the output voltage to 58.8V if there is no battery present. This solution is based on the HR1211, a PFC + LLC combo controller from a single integrated circuit.

Instead of using low-frequency filters, the EVHR1211-Y-00B offers excellent power factor levels with active power factor correction (PFC). The cost-effective design provides high power density. In the place of diodes, synchronous rectification (SR) reduces the voltage drop, while constant current (CC) and constant voltage (CV) control ensure that the battery is charged properly.

Lithium-ion batteries generally require a battery management system (BMS) to ensure that the battery operates within safe parameters. This charger can interact with a BMS through a relay signal, which prevents high-current spikes in the output connection and avoids triggering BMS protections.

Electromagnetic compatibility (EMC) tests, harmonic emission tests, and no-load consumption tests were utilized to ensure that this solution meets industry standards.

PERFORMANCE SUMMARY

Specifications are at T_A = 25°C, unless otherwise noted.

Parameters	Conditions	Value
Input voltage (V _{IN}) range		$85V_{AC}$ to $265V_{AC}$
Output voltage (V _{OUT})		V _{OUT} = 35V to 58.8V
Maximum output current (Iout)		10A
Typical efficiency		92%
Output voltage ripple		$\Delta V_{OUT} = \pm 100 mV$
Output current ripple		∆l _{ou⊤} = ±485mA



EVALUATION BOARD



LxWxH (220mmx100mmx50mm)

Board Number	MPS IC Number
	HR1211
	HF500-15
EVHR1211-Y-00B	MP2009
	MP6925A



QUICK START GUIDE

Follow the procedure below to start up the board. Note that there are exposed, high-voltage AC and DC pads on the board. Do not touch the circuit board while the system is operating, the AC source is disconnected, or while the D6 or D18 LEDs are shining.

- 1. Connect the equipment (see Figure 1). The battery can be replaced with an electronic load.
- 2. Set the electronic load to either constant current (CC) or constant voltage (CV) mode.
- 3. Set the AC voltage source between $85V_{AC}$ and $265V_{AC}.$
- 4. Turn on the AC source.
- 5. Verify that the D6 and D18 LEDs are shining.
- 6. Use the multimeter to verify that the output voltage (before the relay) is within the specified range.
- 7. Close the connection between J1.12 and J1.14 (turn on the relay).
- 8. Turn on the electronic load. Set the load between 58.8V and 30V in CV mode, or set the load between 0A and 9.5A in CC mode.



Figure 1: Measurement Equipment Set-Up

Table 1 shows connectors description:

Table 1: Pin Out						
Connector	Reference	Description				
J2	Live, Neutral and Earth	AC Mains voltage				
J1	+Bat	Positive output port for the battery connection.				
J6	-Bat	Negative output port for the battery connection.				



Figure 2 shows the signal diagram:



Figure 2: Signal Diagram

Table 2 shows the signal description:

Table 2: Signal Description

Signal	Voltage Range	Description		
Vpfc_sw	0Vpc to 410Vpc	PFC stage switch node.		
VBUS	VBUS 0VDC to 410VDC DC link between the PFC and LLC stages.			
GND P	0Vdc	Primary-side ground reference.		
VLLC_SW	0Vpc to 410Vpc	LLC stage switch node.		
VCr	50Vрк to +550Vрк	Resonant capacitor voltage.		
VD_Q4	0Vрк to 150Vрк	Synchronous rectification transistor, drain voltage.		
Vout	0Vpc to 59.8Vpc	Output voltage before the relay.		
GND	0Vdc	Secondary-side ground reference.		



EVALUATION BOARD SCHEMATIC

Figure 3 shows the power factor correction (PFC) stage (AC/DC).



Figure 3: PFC Stage



Figure 4 shows the resonant converter stage (DC/DC), constant current constant voltage (CC-CV) control, and synchronous rectification.



Figure 4: LLC Stage (CC-CV and SR)

Figure 5 shows the auxiliary supply system.



Figure 5: Auxiliary Supply



Figure 6 shows an alternative current sensing, fans and alternative connector (H15).



Figure 6: Fans (Current Sensing and Connector Options)



EVHR1211-Y-00B BILL OF MATERIALS

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN	
6	C1, C2, C3, C14, C16, C17	6.8nF	Film capacitor, 2kV	r15mm (18mmx6 mm)	TDK	B32672L8682J000	
3	C12, C23, C27	22µF	Electrolytic capacitor, 35V	r2.54mm, d6.3mm	United Chemi- Con	EFL-350ELL220MF07D	
5	C15, C26, C28, C61, C76	1nF	MLCC capacitor, 50V	0603	Kemet	C0603X102K5RAC3316	
2	C19, C29	10nF	MLCC capacitor, 50V	0603	AVX	06035C103JAT2A	
2	C25, C45	47nF	MLCC capacitor, 50V	0603	Kemet	C0603C473K5RACTU	
3	C20, C24, C46	10pF	MLCC capacitor, 50V	0603	AVX	06035A100JAT2A	
1	C21	22nF	MLCC capacitor	0603	Kemet	C0603C223K5RACAUTO	
1	C22	2.2µF	Electrolytic capacitor, 450V	r3.5mm, d8mm	United Chemi- Con	ESMQ451ELL2R2MHB5D	
2	C31, C44	1µF	Film capacitor, 350V _{AC}	r27.5mm	Kemet	F861BZ105M310A	
3	C32, C49, C52	100nF, 50V	MLCC capacitor, 50V	0603	Kemet	C0603X104K5RAC3316	
1	C34	100pF	MLCC capacitor	0603	AVX	06035A101JAT2A	
2	C35, C59	220µF	Electrolytic capacitor, $35V_{DC}$	r3.5mm, d8mm	Rubycon	35ZL220MEFC8X16	
1	C36	10µF	MLCC capacitor, 25V	0603	TDK	C1608X5R1E106M080AC	
2	C37, C51	1µF	MLCC capacitor, 50V	0603	Tayo Yuden	UMK107BJ105KA-T	
3	C6, C6A, C38	4.7µF	MLCC capacitor, 50V	1206	Murata	GRM319R61H475KA12D	
2	C40, C42	22nF	MLCC capacitor, 500V	1206	Kemet	C1206V223KCRACTU	
1	C41	330µF	Electrolytic capacitor, 450V	r10mm, d30mm	United Chemi- Con	EKMZ451VSN331MR30S	
1	C47	4.7nF	MLCC capacitor, 50V	0603	AVX	06035C472KAT2A	
1	C48	680pF	MLCC capacitor, 50V	0603	Kemet	C0603C681J5GACTU	
5	C5, C7, C10, C11, C30	330µF	Electrolytic capacitor, 63V	r5mm, d13mm	Wurth	860080778021	
2	C60, C74	1µF	MLCC capacitor, 50V	1206	Kemet	C1206C105K5RECTU	
2	C62, C63	22pF	MLCC capacitor, 200V	0603	Kemet	C0603C220J2GACTU	
1	C69	2.2nF	MLCC capacitor, 50V	1206	Kemet	C1206C222K5RACTU	
2	C8, C13	220pF	MLCC capacitor, 1000V	1206	Multicomp	MC1206B221K102CT	
1	C9	33nF	Film capacitor, 630V _{DC}	r22.5mm, (26.5mmx 16mm)	Kemet	R73QN23304030J	
4	CY1, CY3, CY8, CY11	4.7nF	CY capacitor	r7.5mm	Kemet	C947U472MZVDBA7317	
5	CY2, CY4, CY5, CY6, CY10	10nF	CY capacitor	r7.5mm	Kemet	C981U103MZVDBA7317	



EVHR1211 BILL OF MATERIALS (continued)

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN
7	D1, D2, D3, D5, D10, D11, D23	75V	Signal diode, 100mA	SOD-323F	On Semiconductor	1N4148WS
1	D13	150V	Signal diode, 3A	DO-214AC	Diodes Inc.	STPS3150U
1	D21	650V	Signal diode, 8A	TO-263	Royal Ohm	SCS308AJTLL
1	D22	600V	Diode bridge, 15A	GSIB15	Vishay Semiconductors	GSIB1560-E3/45
1	D26	80V	Signal diode, 1A	DO-214AC	Diodes Inc.	B180-13-F
3	U7, U10, U11	2.495V	Voltage reference, 1%, 36V	SOT-23-5	TI	TL431IDBVT
2	D6, D18	2.2V	Signal diode, 20mA	0603	Rohm	SML-D12P8WT86C
7	D8, D12, D14, D16, D20, D24, D25	600V	Signal diode, 1A	DO-214AC	On Semiconductor	RS1J
1	F1	15A	Input fuse, 450V		Littelfuse	0487015.MXEP
1	F2	20A	Output fuse, 80V	FKS ATO	Littelfuse	16.670.005.202
1	HS1	-	Heatsink	-	Sandoval Martinez	MPS600W
1	L1	90µH	Resonant inductor	RM12	Custom	RM12-L1
1	L2	300µH	PFC inductor	35mmx25 mm	Custom	3525-L2
1	L3	2 x 11.4mH	Input CM filter, 10A	R6166	VAC	T60405-R6166-X210
1	L4	100µH	Input DM filter, 6A		Wurth	7447070
1	L6	2 x 11.7mH	Output CM filter, 12A	R6166	VAC	T60405-R6166-X035
4	Q1, Q2, Q3, Q3A	650V	LLC MOSFET, 31.2A, 99mΩ	TO-263	Infineon	IPB65R110CFDAATMA1
4	Q1, Q2, Q3, Q3A	650V	PFC MOSFET, 31.2A, 99mΩ	TO-263	Infineon	IPB65R110CFDAATMA1
4	Q4, Q5, Q6, Q7	120V	SR MOSFET, 10A, 31mΩ	PQFN-8	Infineon	IRFH5015TRPBF
1	Q8	20V	Sig P-channel MOSFET, 0.9A	SOT-23-3	Diodes Inc.	ZXM61P02F
1	R1	30Ω	NTC	MS15	Ametherm	MS1530004
6	R3, R9, R10, R16, R18, R24	0Ω	Thin film resistor	0603	Vishay	CRCW06030000Z0EA
8	R2, R11, R12, R17, R20, R21, R42, R85	100kΩ	Thin film resistor	0603	TE Connectivity	CRGCQ0603F100K
1	R13	2kΩ	Thin film resistor	1206	TT Electronics	WCR1206-2KFI
2	R14, R14A	20Ω	Thin film resistor	1206	Yageo	RC1206JR-0720RL



EVHR1211 BILL OF MATERIALS (continued)

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN	
10	R5, R19, R26, R33, R40, R44, R48, R48A, R102, R103	10kΩ	Thin film resistor	0603	TE Connectivity	CRGCQ0603J10K	
1	R28	120kΩ	Thin film resistor	0603	Yageo	RC0603FR-07120KL	
1	R22	39kΩ	Thin film resistor	0603	TE Connectivity	CRGCQ0603F39K	
2	R23, R41	51kΩ	Thin film resistor	0603	Vishay	CRCW060351K0FKEA	
1	R27	2Ω	Thin film resistor, 600mW	MRS25	Vishay	MRS25000C2008FCT00	
1	R30	220kΩ	Thin film resistor	0603	TE Connectivity	CRGCQ0603F220K	
7	R34, R46, R46A, R57, R60, R64, R64A	10Ω	Thin film resistor	0603	Vishay	CRCW060310R0FKEA	
6	R31, R32, R35, R36, R81, R83	2kΩ	Thin film resistor	0603	Vishay	CRCW06032K00FKEA	
1	R4	510Ω	Thin film resistor	0603	Vishay	CRCW0603510RFKEA	
1	R96	0Ω	Thin film resistor	0603	Yageo	RC0603FR-070RL	
1	R43	1kΩ	Thin film resistor	0603	Vishay	CRCW06031K00FKEA	
4	R45, R49, R54, R56	3.9MΩ	Thin film resistor	1206	Yageo	RC1206FR-073M9L	
2	R52, R59	2.43MΩ	Thin film resistor	1206	Yageo	RC1206FR-072M43L	
4	R50, R51, R72, R73	33mΩ	Thin film resistor	2818	Vishay	WSHM2818R0330FEB	
1	R53	5.1kΩ	Thin film resistor	1206	TT Electronics	WCR1206-5K1FI	
1	R55	100Ω	Thin film resistor	0603	Vishay	CRCW0603100RFKEA	
2	R58, R63	33kΩ	Thin film resistor	0603	Yageo	AC0603FR-0733KL	
2	R6, R6A	20mΩ	Thin film resistor	2512	Ohmite	PCS2512DR0200ET	
1	R65	62kΩ	Thin film resistor	0603	Vishay	CRCW060362K0FKEA	
1	R7	36Ω	Thin film resistor	1206	Multicomp	MCWR12X36R0FTL	
1	R92	150kΩ	Thin film resistor	1206	TE Connectivity	CRGCQ1206F150K	
1	R93	20Ω	Thin film resistor	1206	Vishay	CRCW120620R0FKEA	
2	R67, R94	1kΩ	Thin film resistor	0603	Yageo	RC0603JR-071KL	
1	RL1	12V _{DC}	Thin film resistor, 30A	TA9	TE Connectivity	T9AS1D12-12	
5	SK1, SK2, SK3, SK4, SK5	M3x0.5	Screw, 6mm	М3	Keystone	9191-4	
6	SP1, SP1A, SP2, SP2A, SP3, SP3A	1.6W/mK	Insulator	-	Bergquist	HF300P-0.001-00-0404	
2	U2, U4	50mA	Optocoupler, 5000V	SMD-4	On Semiconductor	FOD817A3SD	
1	VAR1	195J 8KA	Varistor	Disc, 20mm	EPCOS	B72220S0461K101	



EVHR1211 BILL OF MATERIALS (continued)

Qty	Ref	Value	Description	Package	Manufacturer	Manufacturer PN	
1	R38	20KΩ	Resistor 0603	0603	Yageo	RC0603FR-0720KL	
1	R61	9.53kΩ	Resistor 0603	0603	Yageo	RC0603FR-079K53L	
2	R62, R66	0Ω	Resistor 1206	1206	Yageo	RC1206JR-070RL	
1	R68	3.9Ω	Resistor 1206	1206	Vishay Dale	CRCW12063R90FKEAHP	
1	R74	100kΩ	NTC	1206	VISHAY	NTHS1206N17N1003JE	
1	RL2	12V 10A	Relay	-	TE Connectivity	OJ-SH-112HM,000	
1	SW1	-	Switch	WS-SLTV	Wurth Electronics	450301014042	
1	C50	1nF	Capacitor, 100nF, 50V	0603	KEMET	C0603X102K5RACTU	
2	FAN1, FAN2	-	Fan, 35x35x10	-	Sunon	MF35101V1-1000U-A99	
2	J1, J6	50A	Connector	M3	Wurth Electronics	74650073R	
1	J2	10A	Connector, 250V, 10A, IEC 14	-	Bulgin	PX0580/PC	
2	J3, J4	-	Connector, 2 poles	-	JST	B2B-XH-A(LF)(SN)	
1	TR1	150µH	LLC transformer, 3:1:1	RM14	MPS	RM14 - TR1	
1	TR2	8.6mH	FB transformer, 4.5:1	EF20	MPS	EF20 - TR2	
1	U1	700V	FB controller, 4.5Ω	SOIC-8	MPS	HF500-15	
1	U3	HR1211	Combo controller	SOIC-20	MPS	HR1211GY	
1	U8	MP6924	SR controller	SOIC-8	MPS	MP6924GS	
1	U6	MPQ8112	High-side current- sense amplifier	TSOT23- 6L	MPS	MPQ8112GJ-AEC1-Z	



EVB TEST RESULTS

Performance curves and waveforms are tested on the evaluation board. Input = $230V_{AC}$, output = $50.4V_{DC}/10A$ (14S Li-Ion STD), unless otherwise noted.



HARMONIC ORDER



Performance curves and waveforms are tested on the evaluation board. Input = $230V_{AC}$, output = $50.4V_{DC}/10A$ (14S Li-Ion STD), unless otherwise noted.



System Inrush Current

V_{IN} = 265V_{AC}, no load





Input Characteristics (Low Line)

V_{IN} = 120V_{AC}, V_{OUT} = 58.8V, I_{OUT} = 9.5A



PFC (High Line) VIN = 230VAC, VOUT = 58.8V, IOUT = 9.5A, full load







Performance curves and waveforms are tested on the evaluation board. Input = $230V_{AC}$, output = $50.4V_{DC}/10A$ (14S Li-lon STD), unless otherwise noted.





LLC Constant Current (57V) VIN = 230VAC, VOUT = 57V, IOUT = 10A



SR Constant Current (57V)

 $V_{IN} = 230V_{AC}, V_{OUT} = 57V, I_{OUT} = 10A$





 EVHR1211-Y-00B Rev. 1.1
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Performance curves and waveforms are tested on the evaluation board. Input = $230V_{AC}$, output = $50.4V_{DC}/10A$ (14S Li-Ion STD), unless otherwise noted.



Load Transient (CV) VIN = 230VAC, VOUT = 58.8V, IOUT = 5 to 9.5A



V_{IN} = 230V_{AC}, V_{OUT} = 58.8V, I_{OUT} = 3A

Start-Up



Load Transient (CC)

VIN = 230VAC, VOUT = 35 to 55V, IOUT = 10A



Shutdown

V_{IN} = 230V_{AC}, V_{OUT} = 58.8V, I_{OUT} = 9.5A







Performance curves and waveforms are tested on the evaluation board. Input = $230V_{AC}$, output = $50.4V_{DC}/10A$ (14S Li-lon STD), unless otherwise noted.



Neutral (Based on EN55032 Class B) VIN = 230VAC, VOUT = 58.8V, IOUT = 9.5A,







PCB LAYOUT



Figure 7: Top Layer



Figure 8: Mid-Layer 1



PCB LAYOUT (continued)



Figure 9: Mid-Layer 2



Figure 10: Bottom Layer



REVISION HISTORY

Revision #	Revision Date	Description	Pages Updated
1.0	9/27/2021	Initial Release	-
		Updated the EVB images, LxWxH dimensions, and Efficiency vs. Input Voltage curve	2
		Updated Figure 1 and Table 1	3
		Updated Figures 2–6	4–7
1.1	2/22/2023	 Updated the EVHR1211-Y-00B Bill of Materials section: <u>Updated</u>: C49, C52, C59, C51, C46, CY8, CY4, D11, D12, Q3, Q3A, R1, R28, R14, R14A, R5, R31, R32, R35, R45, R54, R49, R56, R52, R59, R50, R51, R72, R73, R58, R63, R94, R67, R96, R38, R61, R62, R66, R68, R74, RL2, SW1, U6, C50, FAN1, FAN2, J1, J6, J2, J3, J4 <u>Removed</u>: C72, C75, C19A, C73, C33, C39, C4, CY4A, D9, D4, D7, D15, R25, R95, U9, U5 	8–11
		Updated all of the curves in the EVB Test Results section	12
		Updated Figures 7–10	17–18
		Grammar and formatting updates; updated header and footer formatting	All

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