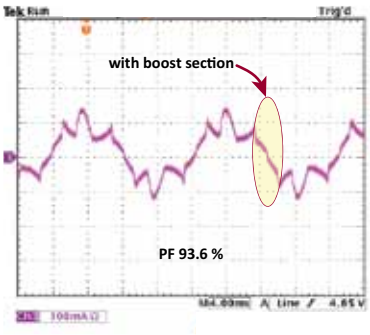
HV9861A LED Driver Demoboard
Boost Assisted, Valley Fill,
120VAC Input, 7W Output, 350mA, 20V, Power Factor ~ 93%

General Description

Certain target markets for LED lighting require a power factor of at least 90%. A power factor over 90% can be attained using valley fill power factor correction with the addition of a small boost converter.

The boost converter lowers line current distortion by adding line current draw in the valley and lowering the peak amplitude of the valley fill capacitor recharging current.



Basic valley fill circuit operation

A valley fill power factor correction circuit operates in two distinctly different modes.

During a first period, here referred to as the valley and coinciding with line voltage being lower than half the peak line voltage, the load is exclusively powered from two energy storage capacitors. Consequently, in the valley the line current is equal to zero. The valley, being characterized by a line voltage less than half the peak line voltage, extends 30° on either side of the line voltage zero crossing.

During a second period, coinciding with the line voltage being higher than half the peak voltage, the load is exclusively powered from the line and not from the valley fill capacitors. Consequently, the line current is not zero. Furthermore, an additional line current is drawn near the peak of the line voltage for recharge of the valley fill capacitors. The two line current components can clearly be identified in the oscillogram of the line current.

Boost converter operation

The boost converter adds current draw in the valley, thereby lowering distortion and raising power factor.

The boost converter switch, a bipolar transistor in common base configuration, is driven indirectly by the current flow in the valley capacitors. In the valley, current is extracted from the valley capacitors during ON time of the main switch, each capacitor contributing half of the load current. The capacitor current in one of the capacitors develops a voltage of about 1.2V across two diodes in series. This voltage provides a forward bias for the base emitter circuit of the boost transistor. Current develops in the boost inductor, which subsequently flows in to the valley capacitors during OFF time.

The boost converter develops a line current with an amplitude which is line voltage dependent. When line voltage is particularly small the boost converter operates in discontinuous mode (DCM) and when the line voltage approaches half the peak voltage the converter operates in continuous conduction mode (CCM). The line current amplitude increases nonlinearly with line voltage in either conduction mode. The boost converter action results in delivery of power to the valley capacitors thereby lowering the amplitude of the capacitor recharging current during the second period.

Specifications

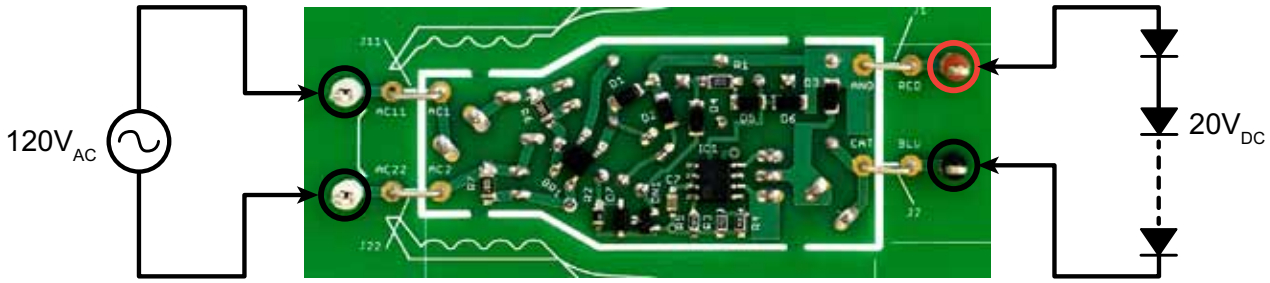
Parameter	Value
Input voltage	100 … 135V_{AC}
Output voltage	20V_{DC}, ±10%
Output current	350 mA_{DC}, ±5%
Output power	7W
Power factor	~93.6%
Total harmonic distortion	~35%
EMI limits	CISPR 15

Parameter	Value
Efficiency	~80%
Output current ripple (at F_{SW})	80%$_{PP}$ (See note)
Output open circuit protection	Yes
Output short circuit protection	Yes
Switching frequency	50kHz … 60kHz
Dimensions	54mm x 24mm x 20mm

Note:

Output current ripple can be reduced in straightforward manner by increasing inductor L3. Alternatively, capacitor C4 can be increased.

Connection Diagram

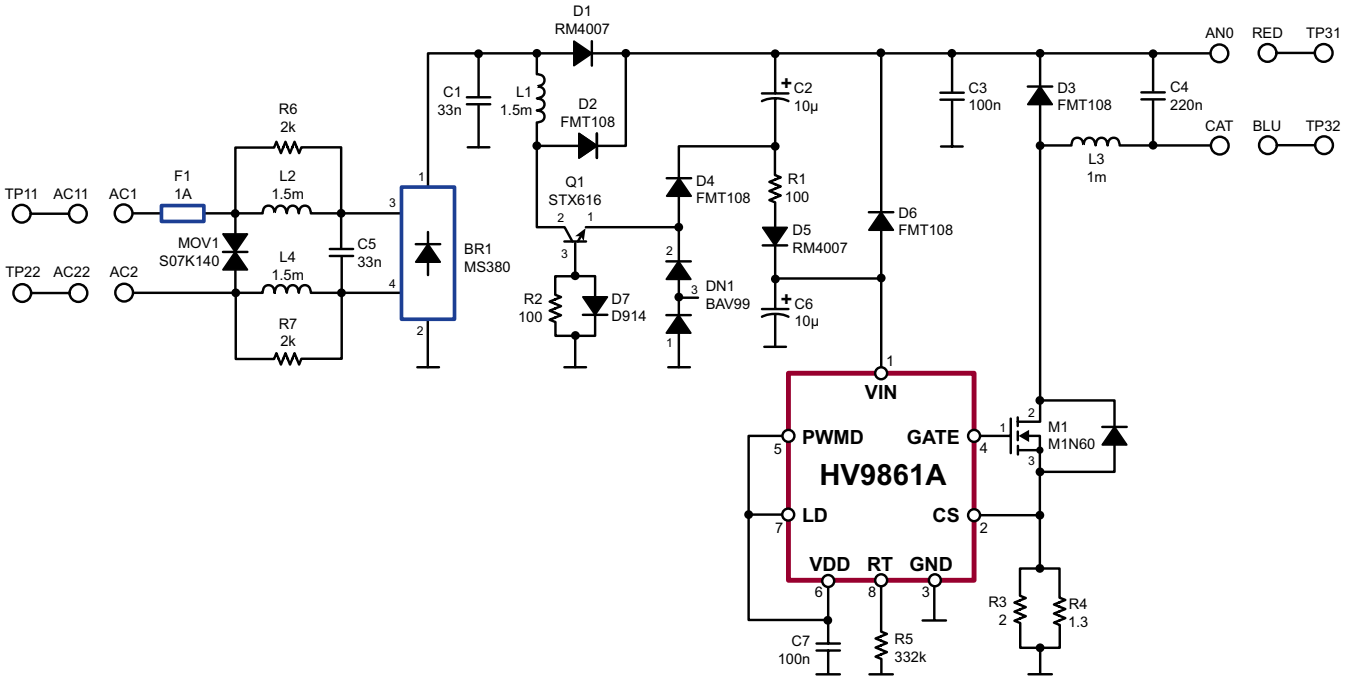


Connections

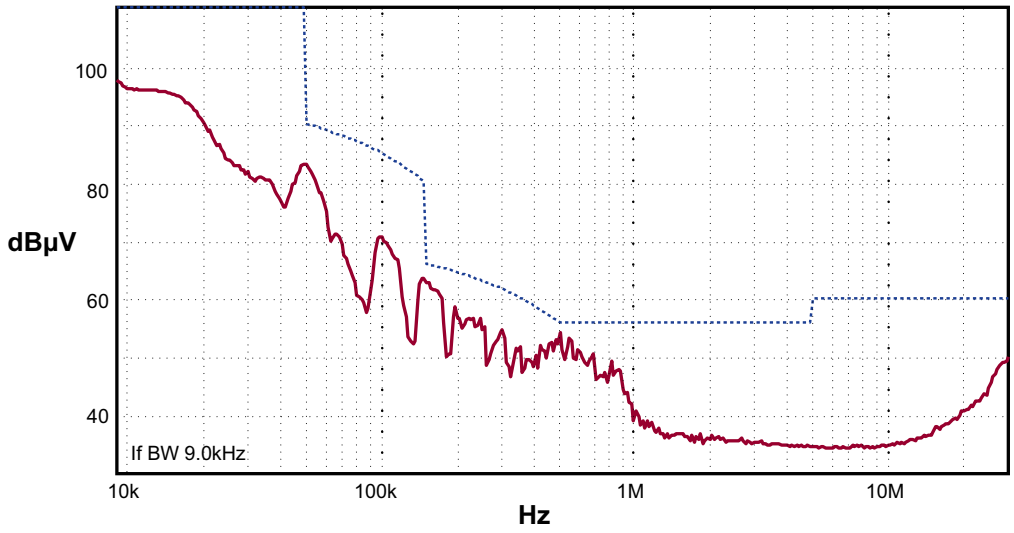
Connect the mains voltage at the input terminals and connect the LED load at the output terminals as shown.

Warning: The mains voltage circuit does not contain galvanic isolation. Do not ground any part of the circuit directly to protective ground by means of test equipment connections.

Circuit Schematic

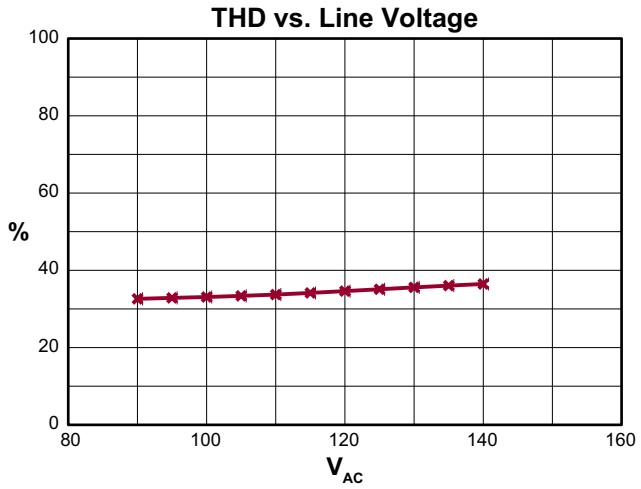


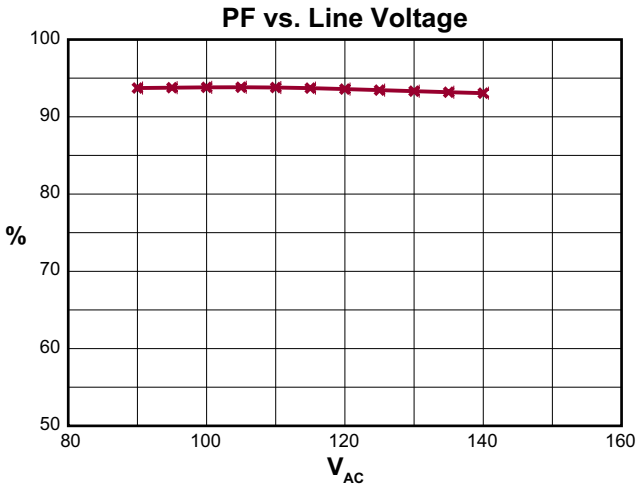
EMI Signature

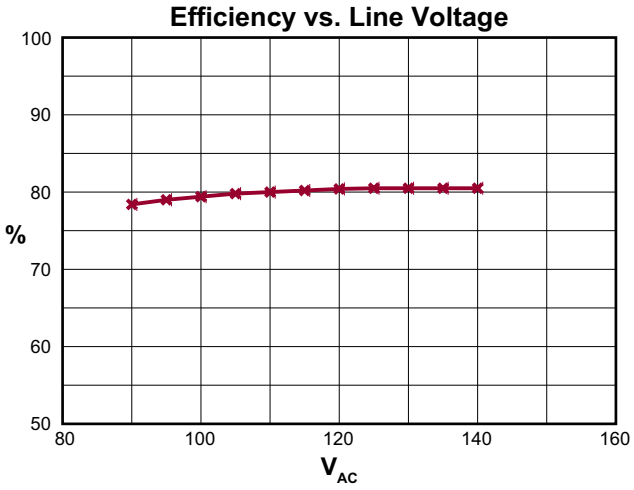


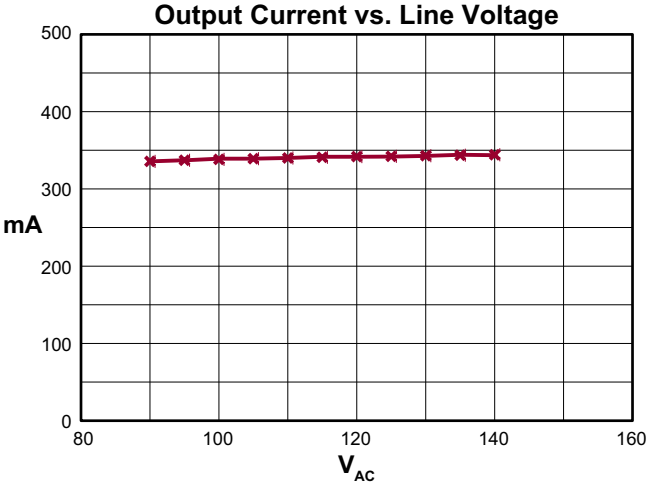
Notes:

PCB suspended approximately 3 inches above reference plane.
Peak detector in peak hold mode for 10 min.

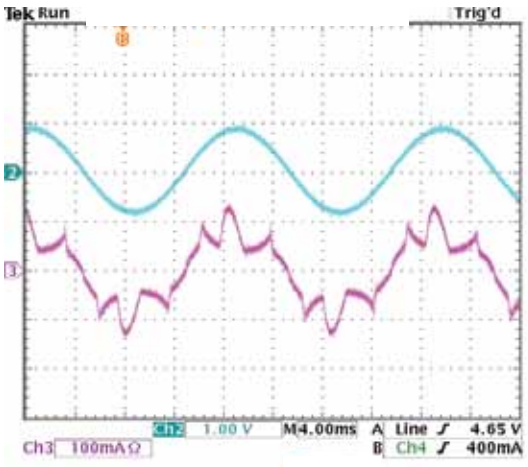


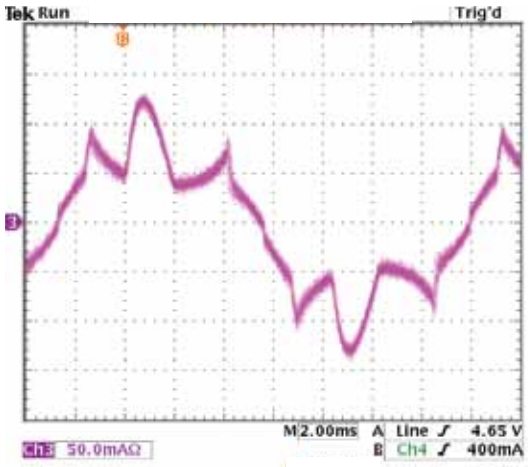




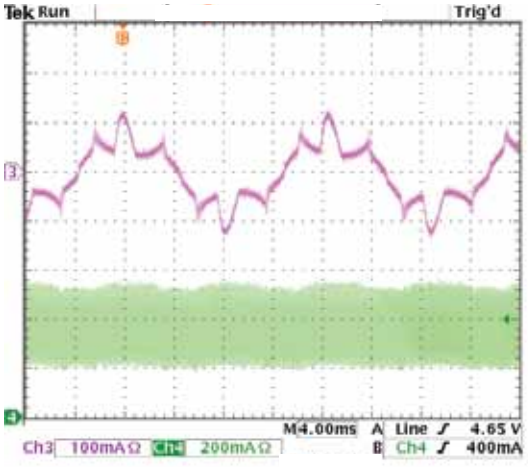


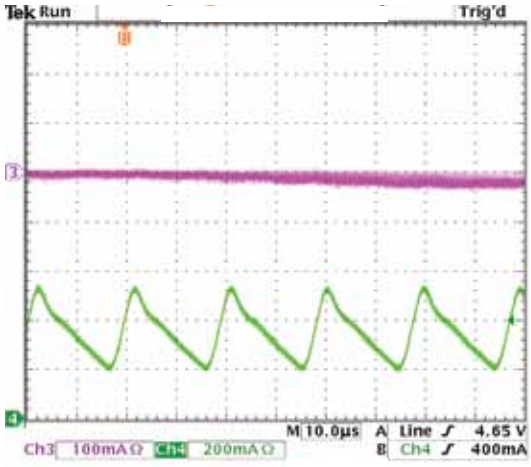
Line Voltage and Line Current at Nominal Line and Load



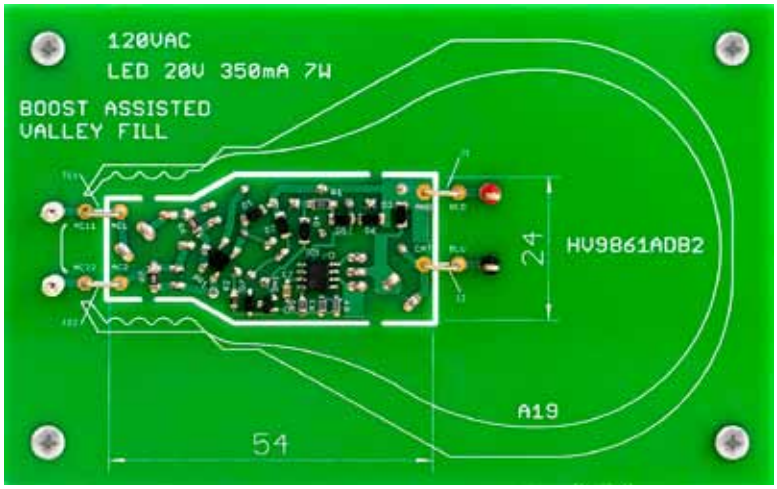


Line Current and Output Current at Nominal Line and Load

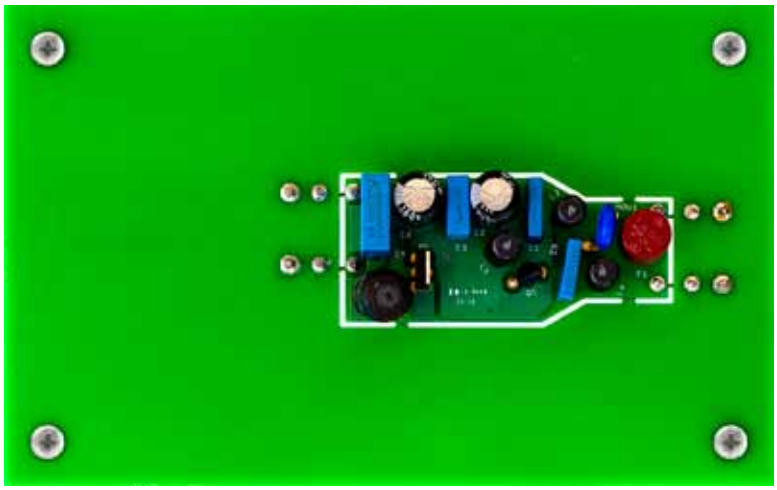




HV9861ADB2 *(top view)*

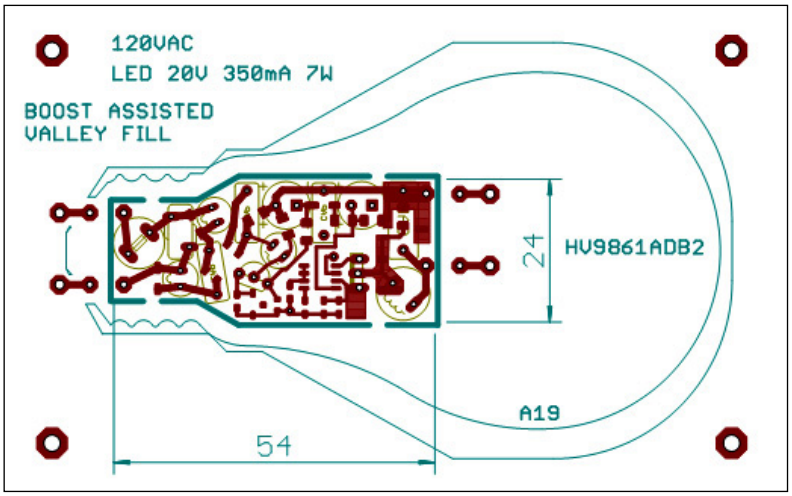


HV9861ADB2 *(bottom view)*



Actual Dimensions: 130mm x 81mm

Silk Screen



Bill of Materials

Qty	Ref	Description	Mfr	Part Number
1	BR1	Bridge rectifier 500mA 380V_{AC} 800VRRM SMD	Diotec	MS380
1	R1	Resistor thick film 1/8W 1% SMD 1206 100Ω	Yageo	RC1206FR-07100RL
1	R2	Resistor thick film 1/8W 1% SMD 0805 100Ω	Yageo	RC0805FR-07100RL
1	R3	Resistor thick film 1/8W 1% SMD 0805 2Ω	Yageo	RC0805FR-072RL
1	R4	Resistor thick film 1/8W 1% SMD 0805 1.3Ω	Yageo	RC0805FR-071R3L
1	R5	Resistor thick film 1/8W 1% SMD 0805 332kΩ	Yageo	RC0805FR-07332KL
2	R6, R7	Resistor thick film 1/8W 1% SMD 1206 2kΩ	Yageo	RC1206FR-072KL
1	C7	Cap ceramic X7R 10% 50V_{DC} SMD 0805 100nF	Yageo	CC0805KRX7R9BB104
1	C4	Cap poly metalized 10% 125C 160VAC 250VDC 10mm 220nF	Epcos	B32521C3224K
2	C1, C5	Cap poly metalized 5% 125C 160VAC 250VDC 7.5mm 33nF	Epcos	B32520C3333J
1	C3	Cap poly metalized 10% 125C 160VAC 250VDC 7.5mm 100nF	Epcos	B32520C3104K
2	C2, C6	Cap electrolytic 105C 12khr 20% 160VDC THD 8x9 10µF	Rubycon	160LLE10MEFC8X9
4	D2, D3, D4, D6	Diode ultrafast 1A 600V 35ns SMD SOD-123H	Comchip	CSFMT108-HF
1	D7	Diode 75V 4ns SMD SOD-123 200mA 400mW	Fairchild	MMSD914
2	D1, D5	Diode standard 1A 1kV SMD SOD-123F	Comchip	CGRM4007-G
1	DN1	Diode network BAV99 300mA 75V 4ns SMD SOT-23-3	Diodes Inc	BAV99-7-F
1	IC1	IC power management LED driver HV9861A SMD SOIC-8	Supertex	HV9861ALG-G
1	Q1	Transistor NPN 2.8W 500V 1.5A THD TO-92AP STX616	ST Micro	STX616-AP
1	M1	MOSFET N-channel 600V 1A 8.5R THD IPak STD1NK60	ST Micro	STD1NK60-1
1	L3	Inductor THD 5mmLS 8x12mm 1mH 510mA	Abracon	AIUR-02H-102K
3	L1, L2, L4	Inductor THD 6mm dia 1.5mH 8.0Ω	Wuerth	7447462152
1	MOV1	Varistor MOV THD disc 7mm 180VDC 140VAC .2kA 9.5J	Epcos	S07K140
1	F1	Fuse 300VAC slow TR5 Series 383 1A	LittelFuse	38311000000
4	J1, J2, J11, J22	Buswire AWG22	Any	…
2	TP11, TP22	Testpoint PCB compact orange	Keystone	5013
1	TP31	Testpoint PCB compact red	Keystone	5010
1	TP32	Testpoint PCB compact blue	Keystone	5127

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