International Rectifier

USER GUIDE

User Guide #0601

IRDC2086-330W Reference Design
Rev. 2-28-06

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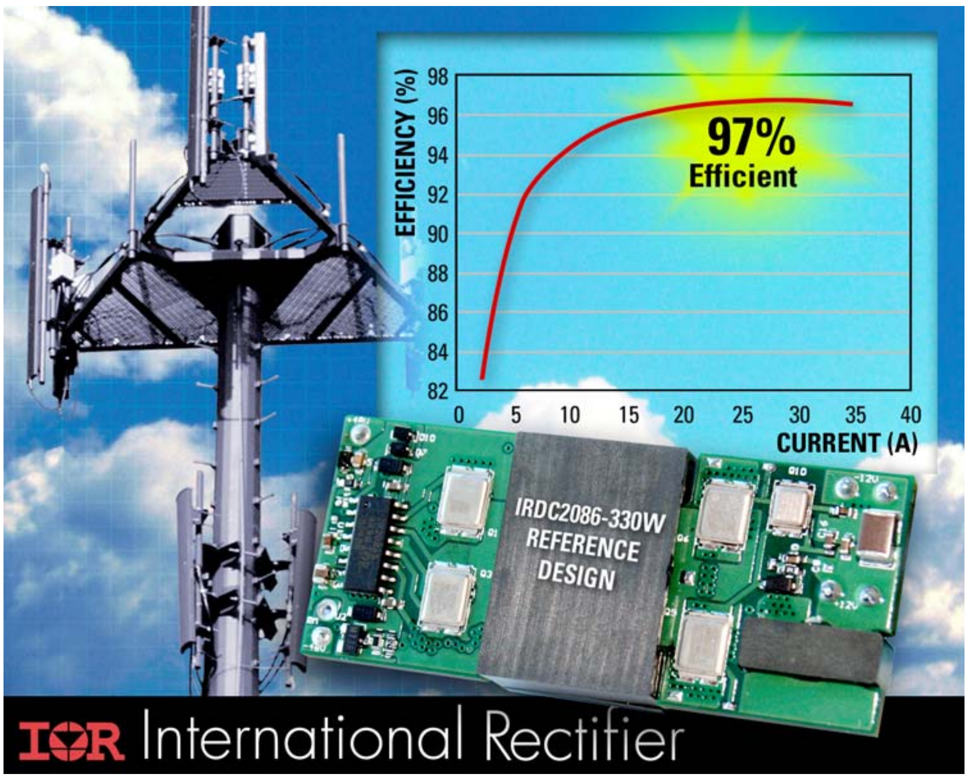

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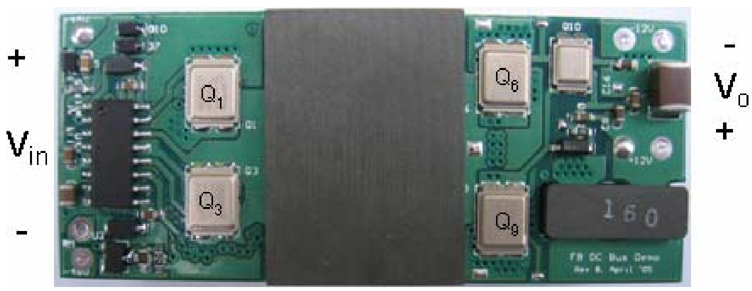
Overview

The IRDC2086-330W Reference Design is a 330W, 97% efficient, 48V-to-9.6V (35A), unregulated full bridge DC bus converter. The featured chipset solution consists of the IR2086S control IC, 80V primary side DirectFETs (IRF6646), 30V secondary side DirectFETs (IRF6635), primary side biasing FET (IRF7380) and the secondary side gate clamp FET (IRF6621).

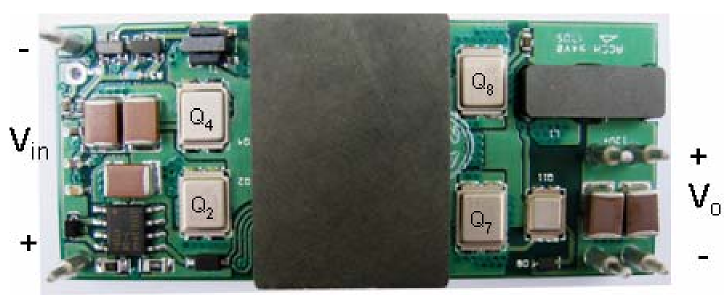
The DC bus converter, with 50% duty ratio offers the following features:

1. Zero voltage switching (ZVS) of the primary switches. This feature also guarantees the flux balance of the transformer.
2. The reverse recovery of the secondary synchronous FETs is eliminated due to the soft turn off of the secondary switch. The voltage stress of the secondary switch is also minimized.
3. The effective duty ratio is increased due to the ZVS operation. Loss associated with the dead-time is reduced. The ripple of the output current and the core loss of the output inductor are also reduced.

Board Description and Circuit Capability



(a)



(b)

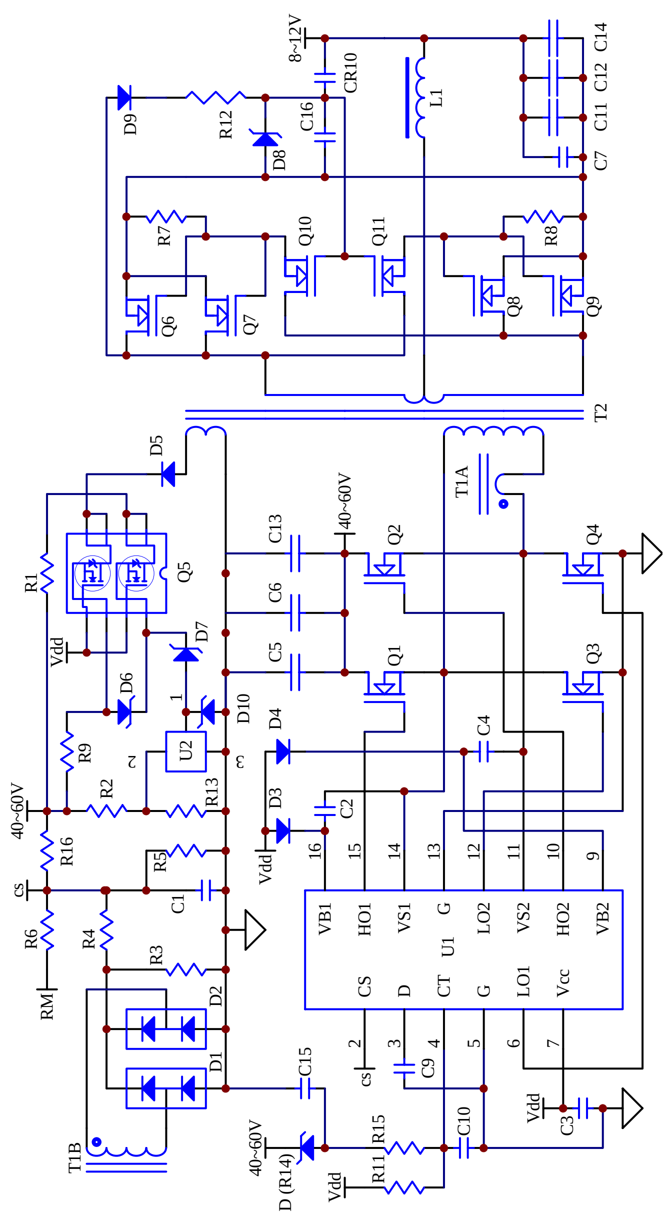
Fig. 1. The pictures of DC bus converter demo board with IR2086S Chipset: (a) front side and (b) back side of the converter.

The IR2086-330W is an open-loop, isolated full-bridge DC-DC converter with 5:1 voltage conversion ratio. The front side and back side of the demo board are shown in Fig. 1.

To evaluate operation and performance, connect a power supply to the input terminals and a power load to the output terminals. Input and output terminals are marked in Fig. 1. To duplicate the performance data reported on page two, approximately 400 LFM of airflow is needed across the module.

The circuit is designed to deliver continuous 30A output current in the 40V-60V input voltage range, with 400 LFM of airflow. Output voltage for this input voltage range will vary from 7.7V to 12.0V, and the total available output power from the module will range from around 300W at 40V to about 350W at 60V input. The complete schematic of the demo board is shown in Fig. 2.

Fig. 2. Board Schematic



To optimize the performance with wide input voltage range, the converter is operated with variable frequency. The variable switching frequency is realized by connecting the timing resistor R15 to V_{in} via a zener diode D (the footprint is labeled as R14 on the PCB board). When the V_{in} is low, the charge current for the timing capacitor C10 is low. Therefore, a low switching frequency is generated. The range of the switching frequency is 133kHz to 226kHz when the input voltage varies from 40 to 60V. Curve 1 in Fig. 3 shows the switching frequency variation vs. the input voltage. The benefit of the variable frequency is the reduction of the losses due to the reduced magnetizing current when the input voltage increases, as observed from curve 2.

Fixed operation frequency can be achieved easily by removing D(R14) and connect the timing resistor R11 to V_{cc}. Fixed operation frequency is a good option when the input voltage is narrow. Curve 3 in Fig. 3 shows the magnetizing current variation when the converter is operated with a constant 180kHz switching frequency.

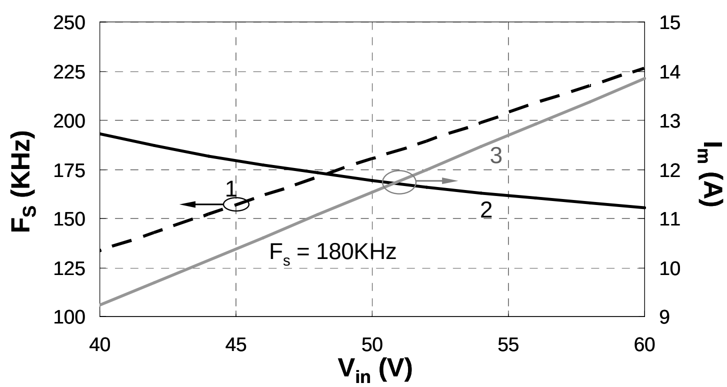


Fig. 3. Magnetizing current with constant and variable frequency.

The circuit starts to operate when the primary voltage reaches about 32V, sending pin 1 of the voltage detector (U2) high. The gate of the Q5 is about 14V. V_{cc} is generated and the circuit begins to operate. After that, the high frequency voltage filtered by D5 sustains V_{cc}.

The circuit design is size-optimized in order to demonstrate true performance of the IR2086S control IC, IRF6646 primary FETs and IRF6635 secondary FETs. To probe the circuit waveforms use an oscilloscope probe with minimal length for the ground pin and connect directly to the pins of the IC/MOSFET device.

To measure circuit efficiency, the voltage and current at the input and output of the demo board need to be accurately measured. Use of calibrated shunts for input and output current measurements is strongly recommended, as is use of a thermal camera for thermal performance evaluation. Efficiency measurements at V_{in}=48V and different output power are shown in Fig. 4. The black curve shows the efficiency with two IRF6635 in each secondary socket (total four IRF6635) with an output power to P_o=325W (V_o=9.3V, I_o=35A). The gray curve shows the efficiency measurements with one IRF6635 in each secondary socket with output power to P_o=325W.

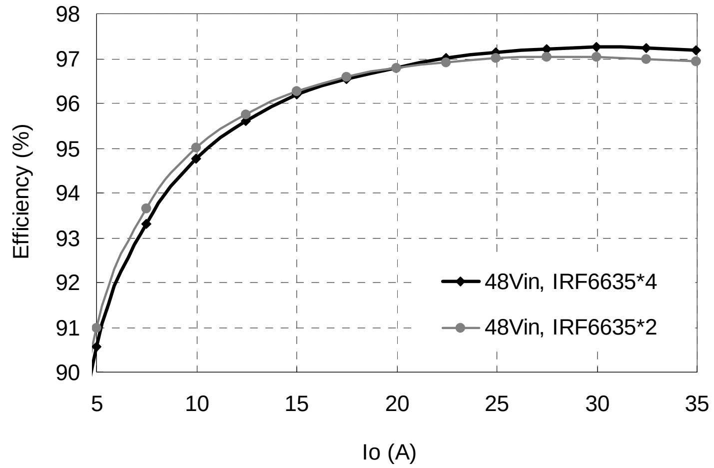
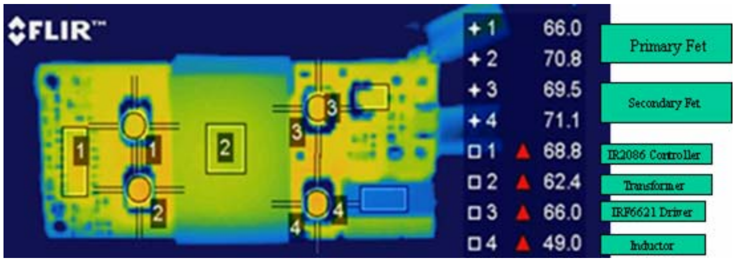
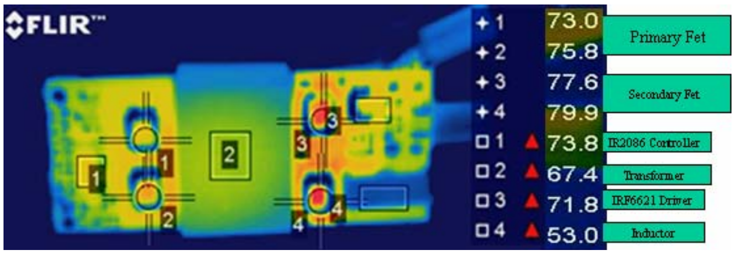


Fig. 4. Efficiency at 48-60Vin, 350W max with 400LFM air flow.

Thermal images with 325W output power at 48Vin with four IRF6635 and two IRF6635 are shown in Fig. 5(a) and (b) respectively. Temperature measurements at different conditions are listed in table 1. Inputs and outputs of two or more modules can be connected in parallel to provide required higher output power. Due to natural output voltage droop associated with open-loop operation, no additional circuitry is required for accurate current sharing (+/-10%).



(b)Two IRF6635 used on secondary



(a) Four IRF6635 used on secondary.

Fig. 5. Thermal image at 48Vin, 325W output power with 400LFM air flow:

Table 1. Temperature measurement (°C) at V_{in}=48V and I_o=35A.

	IRF6646		IRF6635		IR2086S	Transformer	Driver	Inductor
IRF6635 x4	66	71	70	71	69	62	66	49
IRF6635 x2	73	76	78	80	74	67	72	53

As shown in Fig. 2, the primary side current is sensed with a current transformer. The current transformer turns ratio is 150:1. The sensed AC current information is rectified and fed into the current sense pin of the IR2086S after some RC filtering. Fig. **6** shows the output voltage during current hiccup mode. Current limit was set at 42A and the load was increased over the current trip point. It can be seen that the controller attempts to turn on the converter once in a period of 400ms. The 400ms period is determined by the external capacitance of C9.

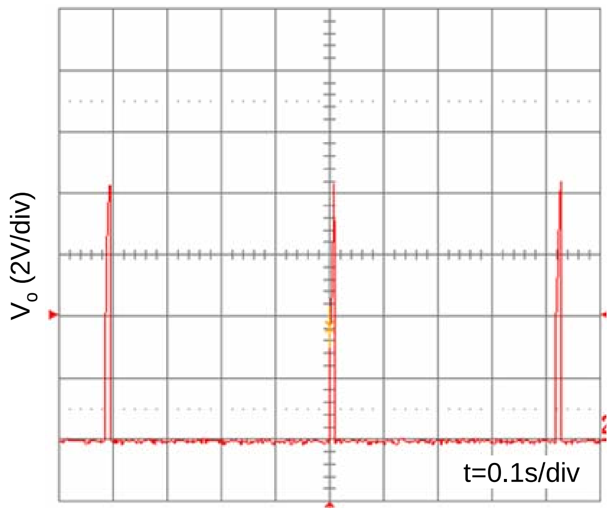
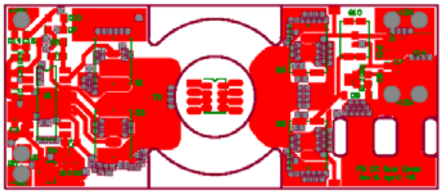


Fig. 6. Output voltage waveform during hiccup mode at current limit setting of 42A.

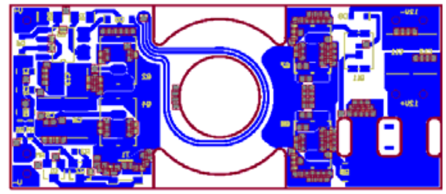
During remote shut down, CR10 provides a path to discharge the bias stored in C16 quickly.

Layout

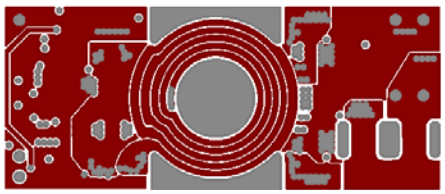
Fig. 7. Board PCB Layout (Total of 12 layers). Gerber files available on request.



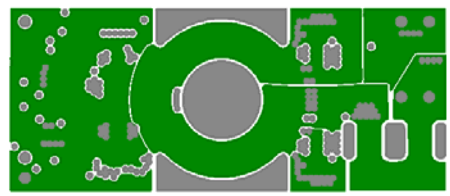
(a) top Layer



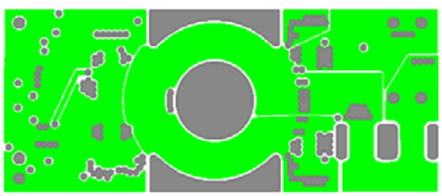
(b) bottom layer



(c) layer 1



(d) layer 2

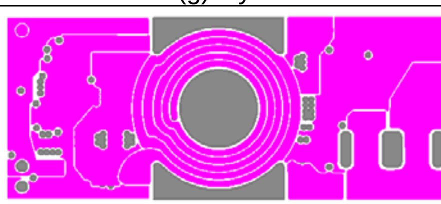


(e) layer 3

(f) layer 4

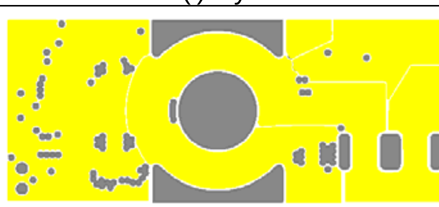
(g) layer 5

(h) layer 6

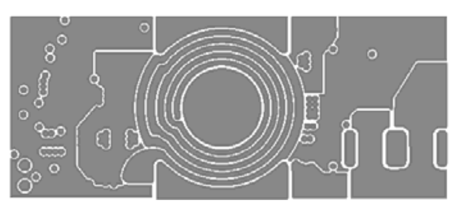


(i) layer 7

(j) layer 8



(k) layer 9



(l) layer 10

Bill Of Material (BOM)

	Designator	Category	Part Type	Footprint	Part Number	Vendor
1	C16, C9	Capacitors	0.1u 50V	0603 SMD	PCC2153CT	Digi-Key
2	C10	Capacitors	220p, 50V	0603 SMD	PCC221BVCT	Digi-Key
3	C1, C15	Capacitors	10000pF, 50V	0603 SMD	490-1512-1-ND	Digi-Key
4	C11, C12, C14	Capacitors	33u, 16V	1812 SMD	445-1443-1-ND	Digi-Key
5	C2, C4, C7, CR10	Capacitors	1u, 16V	0603 SMD	PCC2224CT	Digi-Key
6	C5, C6, C13	Capacitors	2.2u, 100V	1812 SMD	445-1439-1-ND	Digi-Key
7	C3	Capacitors	4.7u, 16V	0805 SMD	PCC2323CT	Digi-Key
8	D6, D10	Diode Zener	5V	SOD323	BZT52C5V1SDICT	Digi-Key
9	D7 D8	Diode Zener	9.1V	SOD324	BZT52C9V1SDICT	Digi-Key
10	D3, D4, D5, D9	Diode Switch	75V	SOD-123	1NN4148WDICT	Digi-Key
11	D1, D2	Diode Schottky	BAT54S	SOT-23	BAT54S	Digi-Key
12	R3	Resistor	3.48	0603 SMD	RK73H1J3R48F	Garrett
13	R5, R6, R7, R8, R13	Resistor	10K 1%	0603 SMD	RK73H1JLTD1002F	Garrett
14	D(R14)	Zener Diode	12V	SOD323	BZT52C12SDICT	Digi-Key
15	R12	Resistor	20K 1%	0603 SMD	RK73H1JLTD2002F	Garrett
16	R9	Resistor	39K 1%	0805 SMD	9C06031A3922FKRFT	Garrett
17	R4	Resistor	1.8K 1%	0603 SMD	9C06031A1821FKHFT	Garrett
18	R15	Resistor	82K 1%	0603 SMD	CRCW0603-8252FRT1	Garrett
19	R1	Resistor	100 1%	0805 SMD	RK73H2ALTD1000F T	Garrett
20	R2	Resistor	120K 1%	0603 SMD	CRCW0603-1213FRT1	Garrett
21	R16	Resistor	910K 1%	0402 SMD	RK73H1JLTD9093F	Garrett
22	T1	Transformer	CURRENT_SENSE	SMD	PCD1548CT-ND	Digi-Key
23	U1	IC	IR2086	SOIC-16	IR2086	IR
24	Q1, Q2, Q3, Q4	D/FET	IRF6646	MN	IRF6646	IR
25	Q6, Q7, Q8, Q9	D/FET	IRF6635	MX	IRF6635	IR
26	Q10, Q11	D/FET	IRF6621	SQ	IRF6621	IR
27	Q5	SO8	IRF7380	SO-8	IRF7380	IR
28	L1	Inductor	Inductor	PLANAR_IND _BRIDGE	E14/3.5/5-3F3-A160	Elna
29	U2	IC Volt detector	TC54	SOT23	TC54VN2702ECB71CT	Digi-Key
30	T2	Planar Transformer	Planar Transformer	GAP=16Mil	TP4AEQP25/23 Plate	MH&W
					TP4AEQP25/23 Plate TP4AHEQ25/8-Z	MH&W
					8mil Cirlex kapton	CIRLEX
31	Vin -/ I Out -	Mil Max Pin	Pins for Input and output Connection	PIN	3125-2-00-01-00-00-08-0	MIL MAX
32	Vin +/ I Out +	Jack	Banana Jack Black	Nylon Banana Jack	J152-ND	Digi-Key
33	Vin +/ I Out +	Jack	Banana Jack Red	Nylon Banana Jack	J151-ND	Digi-Key