Demonstration System EPC9111 Quick Start Guide

6.78 MHz, ZVS Class-D Wireless Power System using EPC2014C/EPC2038

Revision 3.2

EFFICIENT POWER CONVERSION

DESCRIPTION

The EPC9111 Wireless power demonstration system is a high efficiency, A4WP compatible, Zero Voltage Switching (ZVS), Class-D Wireless Power transfer demonstration kit capable of delivering up to 35 W into a DC load while operating at 6.78 MHz (Lowest ISM band). It includes an amplifier board (EPC9506) with a pre-regulator that limits the output current and voltage and ensures proper operation of the amplifier regardless of coupling and load variations between the source and device. The purpose of this demonstration system is to simplify the evaluation process of the wireless power technology using eGaN® FETs.

The EPC9111 wireless power system comprises three boards (shown in figure 1) namely:

1) A Source Board (Transmitter or Power Amplifier) EPC9506
2) A Class 3 A4WP compatible Source Coil (Transmit Coil)
3) A Category 3 A4WP compatible Device Coil with rectifier and DC smoothing capacitor.

The amplifier board features the EPC2014C and EPC2038 enhancement mode field effect transistor (FET) in an optional half-bridge topology (single ended configuration) or default full-bridge topology (differential configuration), and includes the gate driver/s and oscillator that ensures operation of the system at 6.78 MHz The amplifier board can also be operated using an external oscillator or by using the included ultra low power oscillator.

This revision can operate in either Single ended or Differential mode by changing a jumper setting. This allows for high efficiency operation with load impedance ranges that allow for single ended operation.

Finally, the timing adjust circuits for the ZVS Class-D amplifiers have been separated to further ensure highest possible efficiency setting and includes separate ZVS tank circuits.

MECHANICAL ASSEMBLY

The assembly of the EPC9111 Wireless Demonstration kit is simple and shown in figure 1. The source coil and amplifier have been equipped with reverse polarity SMA connectors. The source coil is simply connected to the amplifier.

The device board does not need to be mechanically attached to the source coil.

The Amplifier Board (EPC9506)

Figure 2 shows a diagram of the EPC9506 ZVS Class-D amplifier with pre-regulator. The pre-regulator is set to a specified DC output current limit (up to 1.5 A) by adjusting P49 and operates from 8 V through 36 V input. The output voltage of the pre-regulator is limited to approximately 2 V below the input voltage. The pre-regulator can be bypassed by moving the jumper (JP60) over from the right 2 pins to the left 2 pins. To measure the current the amplifier is drawing, an ammeter can be inserted in place of the jumper (JP60) in the location based on the operating mode (pre-regulator or bypass).

The amplifier comes with its own oscillator that is pre-programmed to 6.78 MHz ± 678 Hz. It can be disabled by placing a jumper into J70 or can be externally shutdown using an externally controlled open collector / drain transistor on the terminals of J70 (note which is the ground connection). The switch needs to be capable of sinking at least 25 mA. An external oscillator can be used instead of the internal oscillator when connected to J71 (note which is the ground connection) and the jumper (JP70) is moved from the right 2 pins to the left 2 pins.

The pre-regulator can also be disabled in the same manner as the oscillator using J51. The pre-regulator can be bypassed, to increase the operating voltage (with no current or thermal protection) to the amplifier or to use an external regulator, by moving the jumper JP60 from the right 2 pins to the left 2 pins. Jumper JP60 can also be used to connect an

Determining Component Values for L_{ZVS}

The ZVS tank circuit is not operated at resonance, and only provides the necessary negative device current for self-commutation of the output voltage at turn off. The capacitance C_{ZVS} is chosen to have a very small ripple voltage component and is typically around 1 µF. The amplifier supply voltage, switch-node transition time will determine the value of inductance for L_{ZVSx} which needs to be sufficient to maintain ZVS operation over the DC device load resistance range and coupling between the device and source coil range and can be calculated using the following equation:

(1)

Where:

Δt_{vt} = Voltage transition time [s]

fsw = Operating frequency [Hz]

C_{OSSQ} = Charge equivalent device output capacitance [F].

Note that the amplifier supply voltage V_{AMP} is absent from the equation as it is accounted for by the voltage transition time. The charge equivalent capacitance can be determined using the following equation:

(2)

To add additional immunity margin for shifts in coil impedance, the value of L_{ZVS} can be decreased to increase the current at turn off

SWITCHING BETWEEN SINGLE-ENDED AND DIFFERENTIAL MODE OPERATION

The ZVS Class-D amplifier can be operated in either single-ended or differential mode operation by changing the jumper setting of J75. When inserted the amplifier operates in the single-ended mode. Using an external pull down with floating collector/ drain connection will have the same effect. The external transistor must be capable of sinking 25 mA and withstand at least 6 V.

THERMAL CONSIDERATIONS

The EPC9111 demonstration system showcases the EP2014C and EPC2038 eGaN FETs in a wireless energy transfer application. Although the electrical performance surpasses that of traditional silicon devices, their relatively smaller size does magnify the thermal management requirements. The EPC9111 is intended for bench evaluation with room ambient temperature with load power up to 35 W without the need for a heat-sink. However, the operator must observe the temperature of the gate driver and eGaN FETs to ensure that both are operating within the thermal limits as per the datasheets.

NOTE. The EPC9111 demonstration system has limited current and thermal protection only when operating off the Pre-Regulator. When bypassing the pre-regulator there is no current or thermal protection on board and care must be exercised not to over-current or over-temperature the devices. Wide coil coupling and load range variations can lead to increased losses in the devices.

Pre-Cautions

The EPC9111 demonstration system has no controller or enhanced protections systems and therefore should be operated with caution. Some specific pre-cautions are:

1.

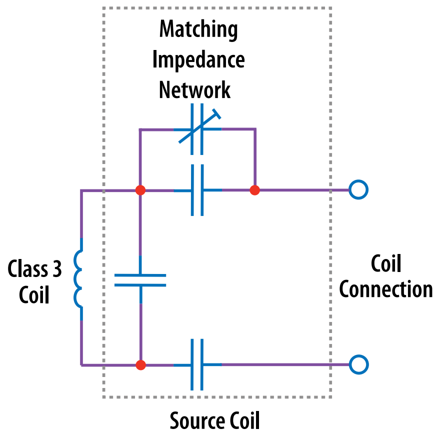

Figure 3: Diagram of the A4WP Class 3 Source Coil

Figure 4: Basic Schematic of the A4WP Category 3 Device Board

Figure 5: Proper Connection and Measurement Setup for the EPC9506 Ampli er Board

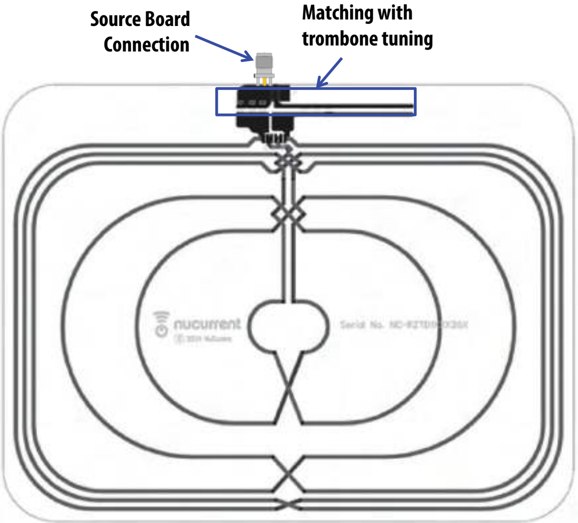

Figure 6: Proper Connection for the Source Coil

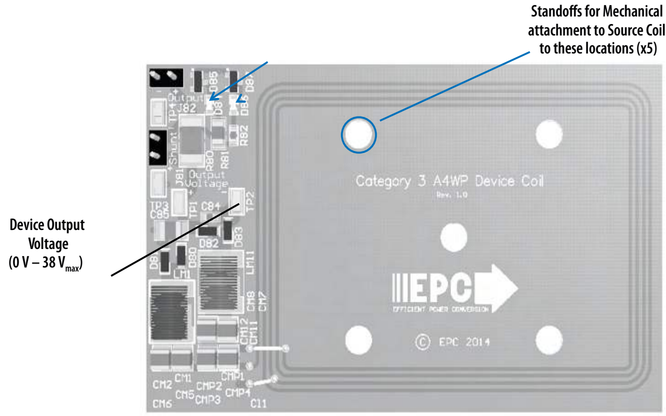

Figure 7: Proper Connection and Measurement Setup for the Device Board

Figure 8: Proper Measurement of the Switch Nodes Using the Hole and Ground Post

Figure 9: ZVS Timing Diagrams

[redacted]

(continued on next page)

Table 5: Bill of Materials - Source Coil

Item	Qty	Reference	Part Description	Manufacturer	Part #
1	1	Ctrombone	680 pF, 300 V	Vishay	VJ1111D681KXDAR
2	1	C1	DNP	–	–
3	1	C2	15 pF, 1500 V	Vishay	VJ1111D150JXRAJ
4	1	C3	560 pF, 300 V	Vishay	VJ1111D561KXDAR
5	1	PCB1	Class 3 coil former	NuCurrent	R26_RZTX_D1
6	2	C4, C6	0 Ω, 0612	Vishay	RCL06120000Z0EA
7	17				

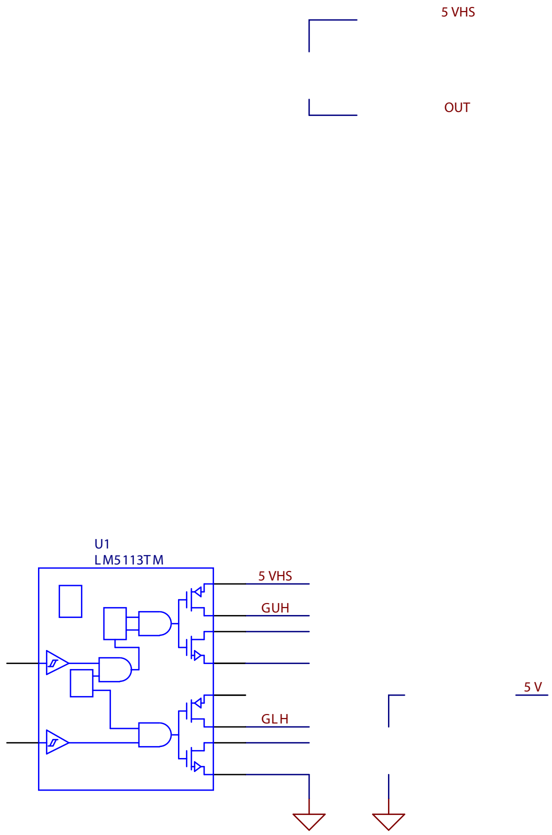

Figure 10: EPC9506 Source Board Ampli er Schematic

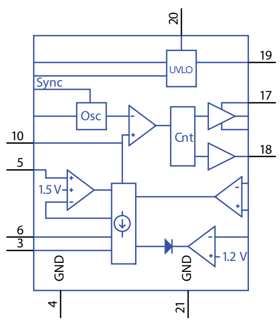

Figure 11: EPC9506 - Source Board Pre-Regulator Schematic

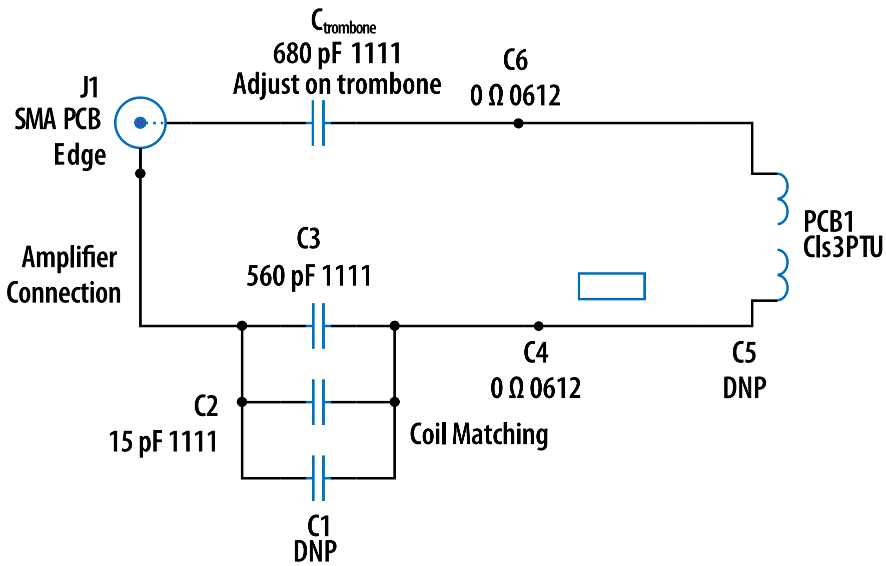

Figure 12: Class 3 Source Board Schematic

Figure 13: Category 3 Device Board Schematic

EPC Products are distributed through Digi-Key.

www.digikey.com

Demonstration Board Warning and Disclaimer

The EPC9111 board is intended for product evaluation purposes only and is not intended for commercial use. Replace components on the Evaluation Board only with those parts shown on the parts list (or Bill of Materials) in the Quick Start Guide. Contact an authorized EPC representative with any questions.

This board is intended to be used by certi ed professionals, in a lab environment, following proper safety procedures. Use at your own risk.

As an evaluation tool, this board is not designed for compliance with the European Union directive on electromagnetic compatibility or any other such directives or regulations. As board builds are at times subject to product availability, it is possible that boards may contain components or assembly materials that are not RoHS compliant. E cient Power Conversion Corporation (EPC) makes no guarantee that the purchased board is 100% RoHS compliant.

The Evaluation board (or kit) is for demonstration purposes only and neither the Board nor this Quick Start Guide constitute a sales contract or create any kind of warranty, whether express or implied, as to the applications or products involved.

Disclaimer: EPC reserves the right at any time, without notice, to make changes to any products described herein to improve reliability, function, or design. EPC does not assume any liability arising out of the application or use of any product or circuit described herein; neither does it convey any license under its patent rights, or other intellectual property whatsoever, nor the rights of others.