Development Board EPC9121 Rev. 1.0 Quick Start Guide

EPC2107

10 W Multi-Mode Wireless Power System

EFFICIENT POWER CONVERSION

DESCRIPTION

The EPC9121 is a high efficiency, power demonstration system capable of operating to multiple wireless power standards. It is compatible with the Qi standard of the Wireless Power Consortium (WPC), the Power Matters Alliance (PMA) standard (now merged with AirFuel™ Alliance) and AirFuel (formerly A4WP) wireless power standards. In AirFuel resonant mode, hence referred to as AirFuel mode, the EPC9121 system operates at 6.78 MHz with the amplifier circuit configured for ZVS operation. In this mode, the system can deliver up to 10 W of power into the source coil. In Qi/PMA inductive mode, the system operates at 165 kHz with the amplifier circuit configured for hard-switching operation and can deliver up to 5 W of load power into the device. The purpose of the EPC9121 is to simplify the evaluation process of both resonant and inductive wireless power technologies using eGaN® FETs and eGaN® ICs.

The EPC9121 wireless power system comprises the four boards (shown in figures 1 and 2) namely:

1. A multi-mode capable EPC9511 source board (transmitter or power amplifier)
2. A multi-mode source coil (transmit coil) compatible with the AirFuel Class 2 standard and Qi (A6) /PMA standards
3. An AirFuel compatible Category 3 AirFuel device coil (receive coil) with rectifier and DC output
4. A Wireless Power Consortium (Qi) and Power Matters Alliance (now AirFuel) compatible device coil (receive coil) with rectifier and DC output

The amplifier board features various enhancement-mode GaN devices which are:

- The 100 V rated EPC2107 half-bridge eGaN® IC with integrated synchronous bootstrap FET used in the main wireless power amplifier.
- The 100 V rated EPC2036 eGaN FET used in the ZVS disconnect switch circuit and the main device of the SEPIC converter pre-regulator.
- The 100 V rated EPC2038 eGaN FET used in the controller circuit for changing set points based on operating mode.

The amplifier is configured for single ended operation and includes the gate driver(s), oscillators, and feedback controller for the pre-

Table 2: Performance Summary (T_A = 25 °C) AirFuel and Qi/PMA compatible Device Board					
Symbol	Parameter	Conditions	Min	Max	Units
V_{OUT}	Output Voltage Range		0	38	V
I					

MECHANICAL ASSEMBLY

The assembly of the EPC9121 wireless power transfer demonstration kit is simple and shown in figure 1. The source coil and amplifier have been equipped with 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. It is strongly recommended to place a 5 mm thick sheet of Plexiglas on top of the source coil to provide an insulating barrier for the devices. This will also ensure that the devices are placed at the correct specified distance above the source coil for optimal performance to all the operating standards. This barrier also protects the user touching exposed electrical nodes and static discharge which can destroy the amplifier board.

Only one parameter at any time is used to control the pre-regulator with the highest priority being the maximum voltage supplied to the amplifier followed by the power delivered to the amplifier and lastly the magnitude of the coil current. The maximum amplifier supply voltage is pre-set to 66 V in AirFuel mode and 26 V in Qi/PMA mode and the maximum power drawn by the amplifier is pre-set to 10 W in either mode. The coil current magnitude is pre-set to 580 mA_{RMS} in AirFuel mode and 1500 mA_{RMS} in Qi/PMA mode, but can be made adjustable using P25. The pre-regulator comprises a SEPIC converter that can operate at full power with an input supply voltage from 17 V through 24 V.

The pre-regulator can be bypassed by connecting the positive supply directly to the ZVS class D amplifier supply after removing the jumper at location JP1 and connecting the main positive supply to the bottom pin. JP1 can also be removed and replaced with a DC ammeter to directly measure the current drawn by the amplifier. When doing this, the operator must provide a low impedance connection to ensure continued stable operation of the controller. Together with the Kelvin voltage probes (TP1 and TP2) connected to the amplifier supply, an accurate measurement of the power drawn by the amplifier can be made.

The EPC9511 is also provided with a miniature high efficiency switch-mode 5 V supply to power the logic circuits on board such as the gate drivers and oscillator allowing the EPC9511 board to operate from a single source.

The amplifier comes with two of its own low supply current oscillators. This first oscillator is pre-programmed to 6.78 MHz ± 678 Hz and the second to 165 kHz. The oscillator signal can be disconnected by removing jumper JP71 and can then be sourced from an external oscillator when connected to J70. J70 can also serve as an oscillator reference output when using the internal oscillators.

Determining component values for L_{ZVS} (AirFuel Mode ONLY)

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 capacitor C_{ZVS1} is chosen to have a very small ripple voltage component and is typically around 1 µF. The amplifier supply voltage and switch-node transition time will determine the value of inductance for $L_{ZVS} = L_{ZVS1} + L_{ZVS2}$ 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. The value of the inductance can be calculated using the following equation:

(1)

Where:

Δt_{vt} = Voltage transition time [s]

f_{SW} = Operating frequency [Hz]

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

C_{well} = Gate driver well capacitance [F]. Use 20 pF for the LM5113

NOTE. the amplifier supply voltage V_{AMP} is absent from the equation as it

3. Make sure all instrumentation is connected to the system.
4. Turn on the main supply voltage (19 V). It is not necessary start at 0 V. Instead, preset the voltage to 19 V and then power up.
5. Once operation has been confirmed, observe the output voltage, efficiency and other parameters on both the amplifier and device boards.
6. For shutdown, please follow the above five steps in the reverse order.

b. Operation bypassing the pre-regulator

In this mode, the pre-regulator is bypassed and the main power is connected directly to the amplifier. This allows the amplifier to be operated using an external regulator. NOTE: In this mode there is no protection for ensuring the correct operating conditions for the eGaN devices.

1. Make sure the entire system is fully assembled prior to making electrical connections and make sure jumper JP1 has been removed and installed in JP50 to disable the pre-regulator and place the EPC9511 in bypass mode. Also make sure the source coil is attached to the amplifier and that device board is connected to a load.
2. With power off, connect the main input power supply bus to the bottom pin of JP1 and the ground to the ground connection of J1 as shown in figure 5.
3. With power off, connect the control input power supply bus to $+V_{IN}$ (J1). Note the polarity of the supply connector. This is used to power

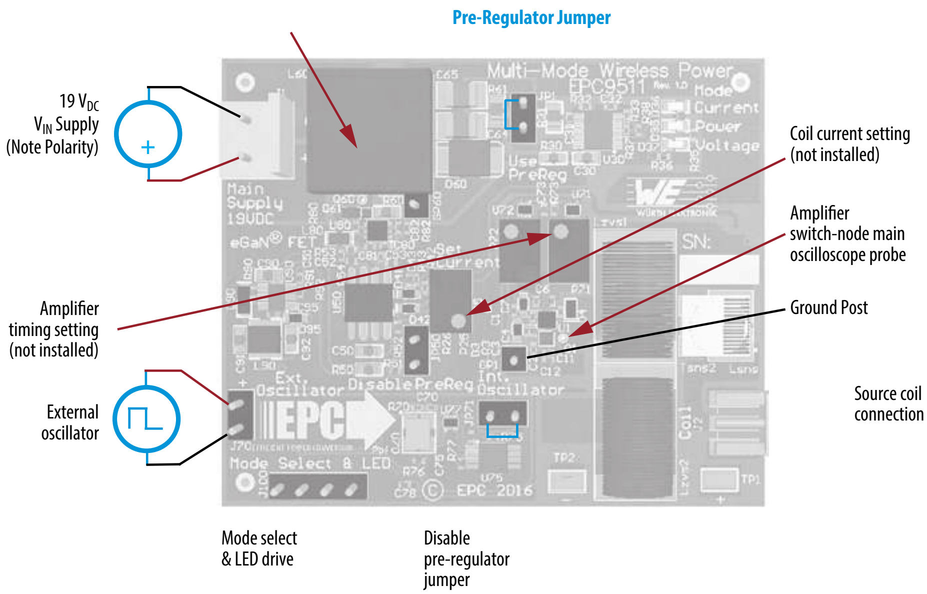

Figure 5: Proper connection and measurement setup for the EPC9511 amplifier board.

Figure 7: Proper connection setup for operating mode selection using jumpers.

Figure 6: Proper connection setup for operating mode selection using a switch and LEDs.

Figure 8: Proper measurement of switch Node waveforms.

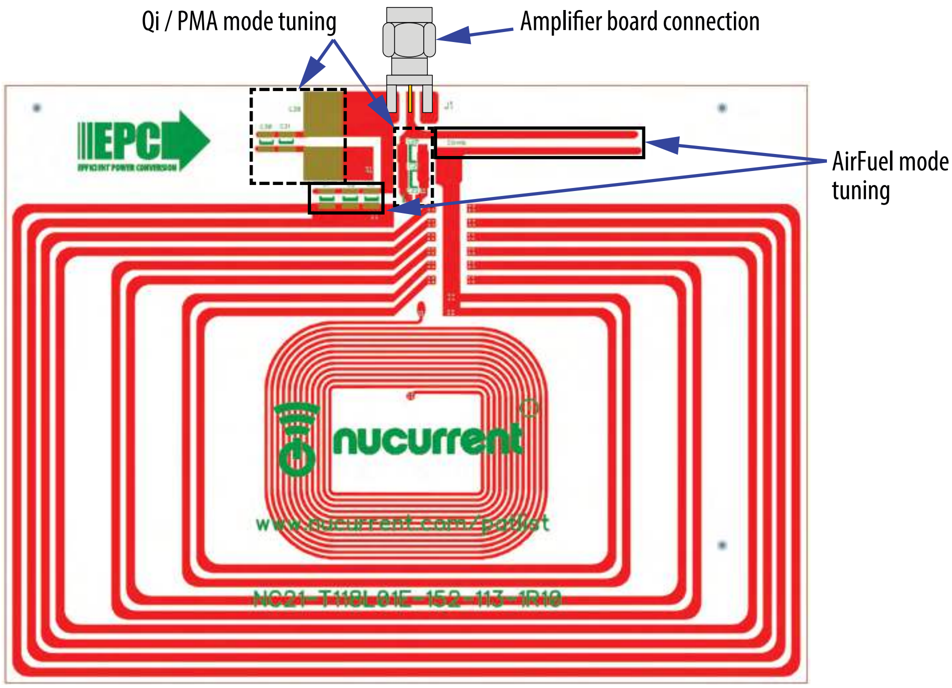

Figure 9: Source coil

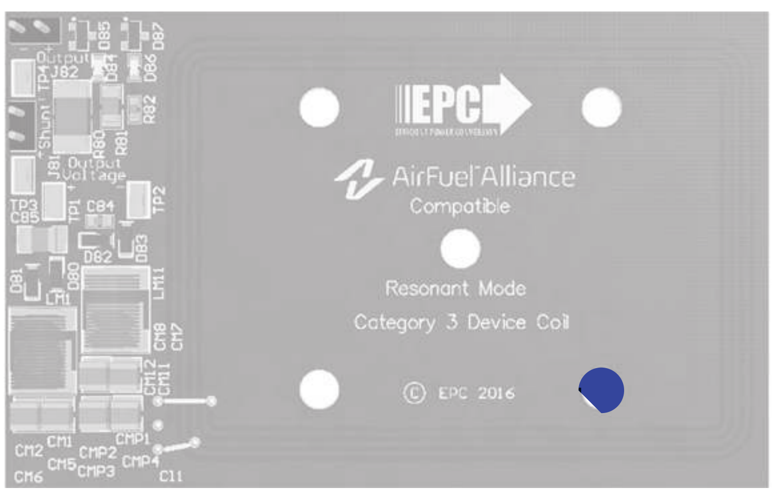

Figure 10: AirFuel compatible device coil with proper connections.
(AirFuel logo used with permission from the AirFuel Alliance)

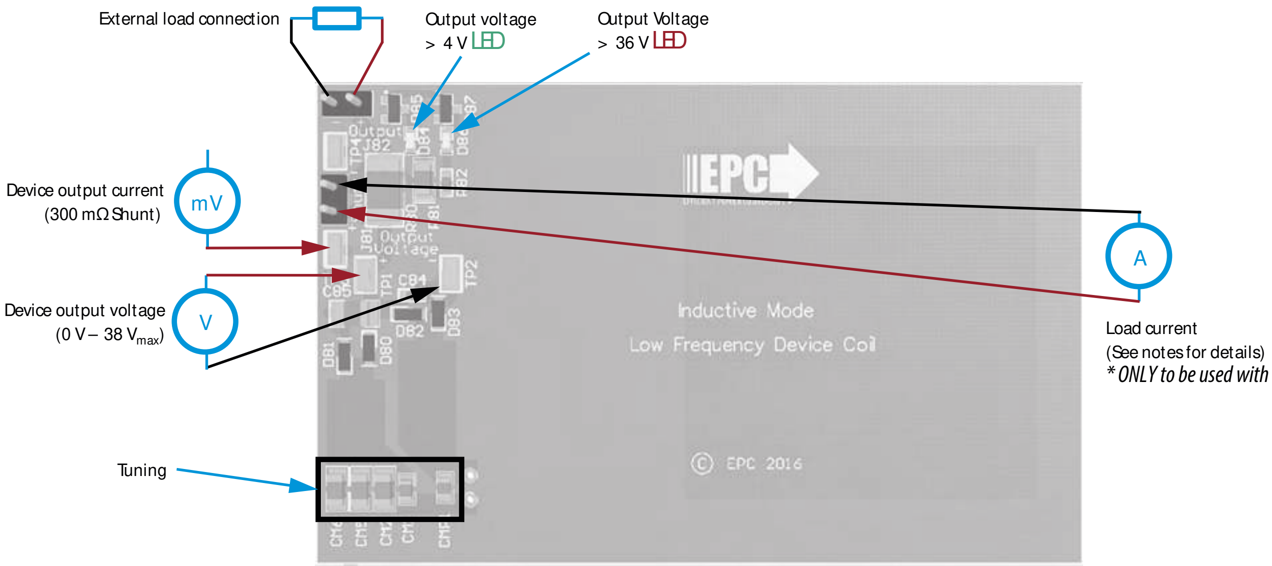

Figure 11: Qi/PMA compatible device coil with proper connections

Figure 12: ZVS timing diagrams

[redacted]

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Table 5: Bill of Materials - Source Coil

Item	Qty	Reference	Part Description	Manufacturer	Part #
1	1	C1	DNP	—	—
2	1	C2	DNP	—	—
3	1	C3	390 pF, 500 V	Johanson	501S42E391JV3E
4	1				

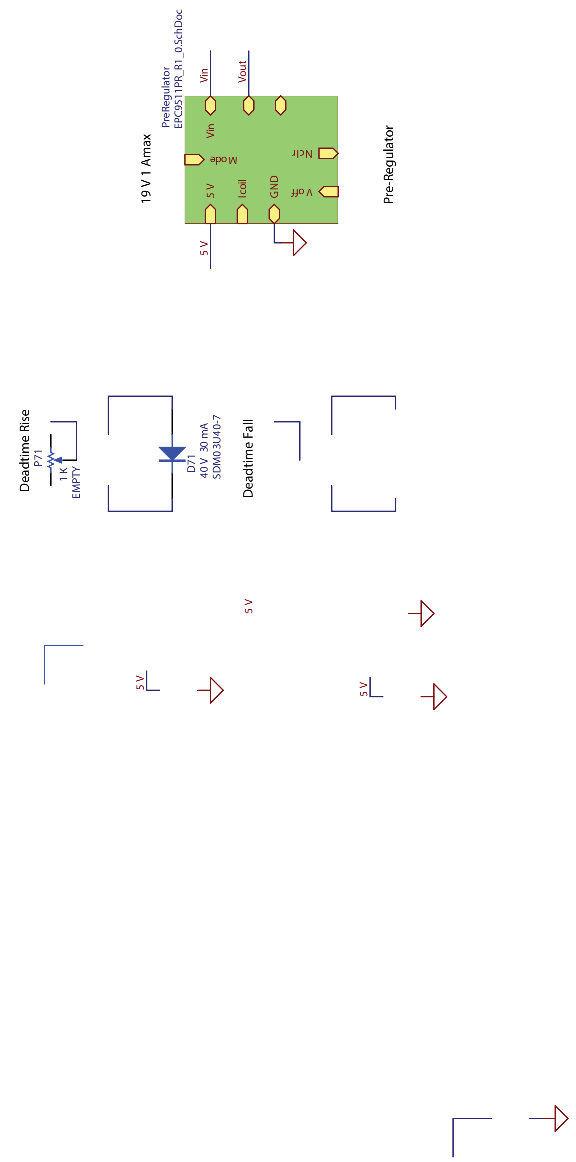


Figure 13: EPC9511 - ZVS class-D amplifier schematic

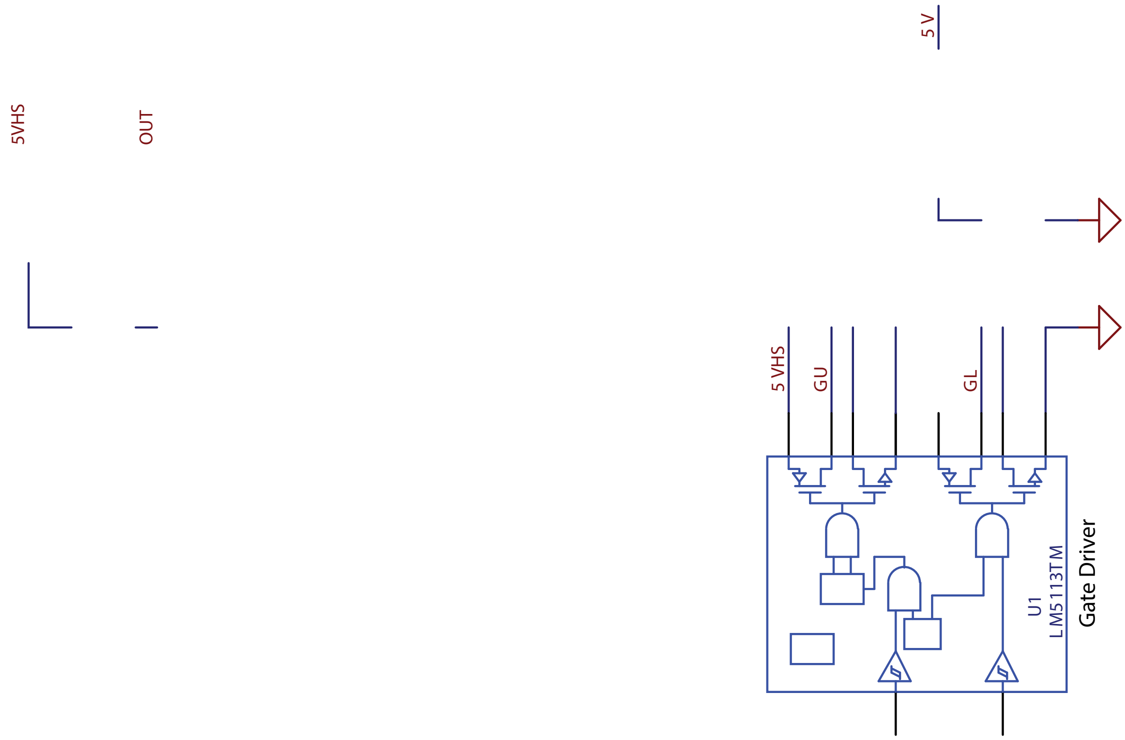


Figure 14: EPC9511 - Gate driver and power devices schematic

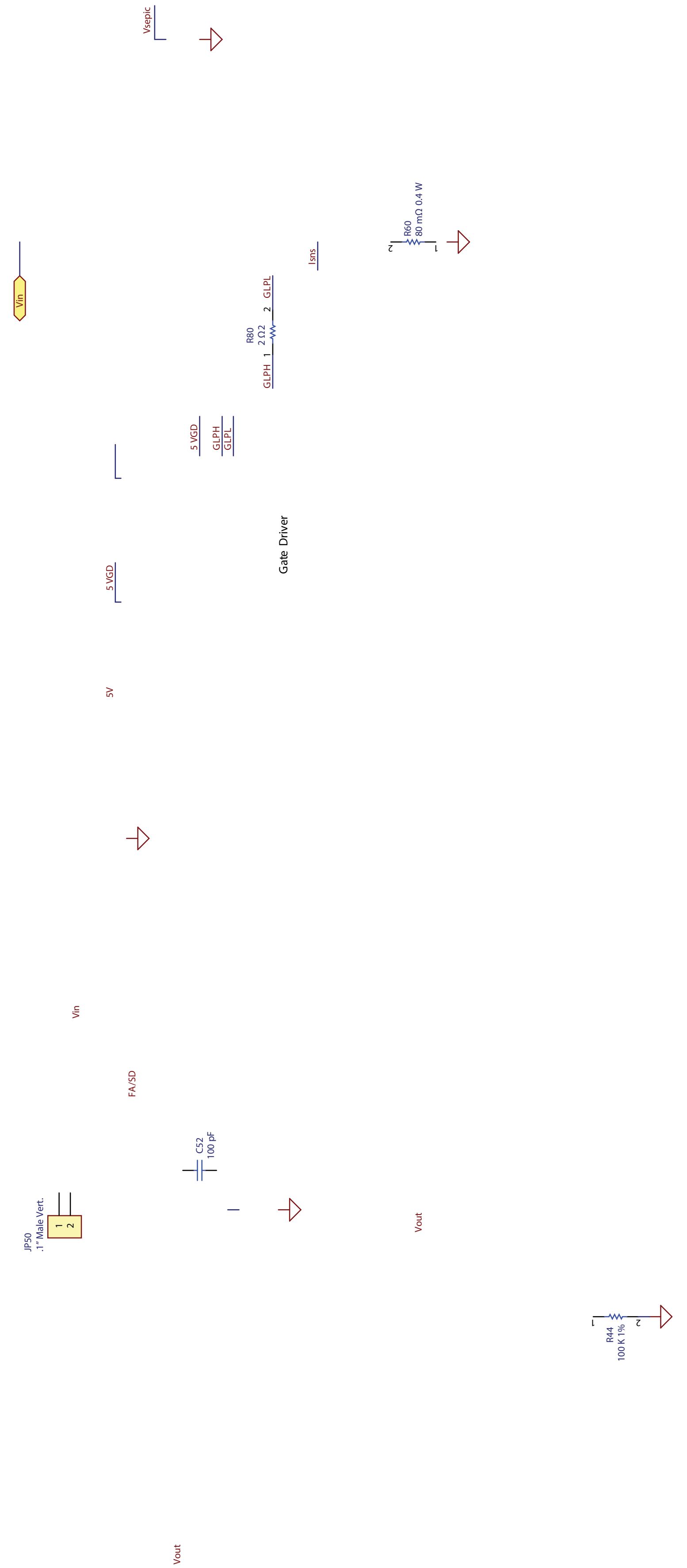


Figure 15: EPC9511 - Pre-regulator schematic

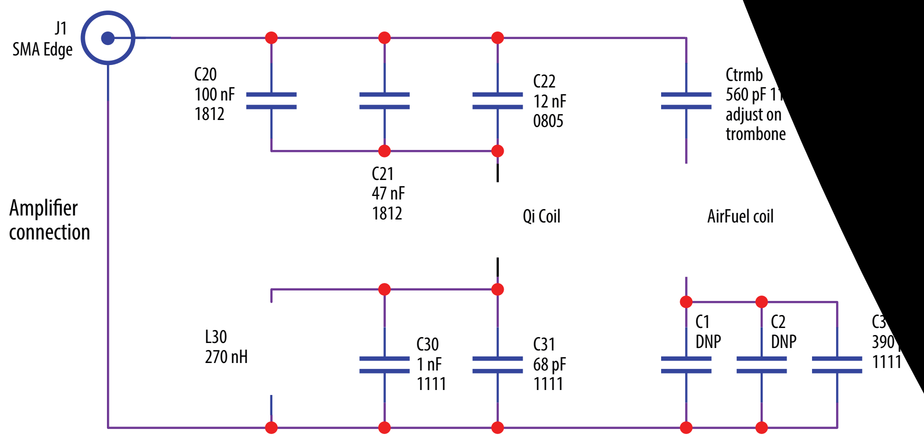
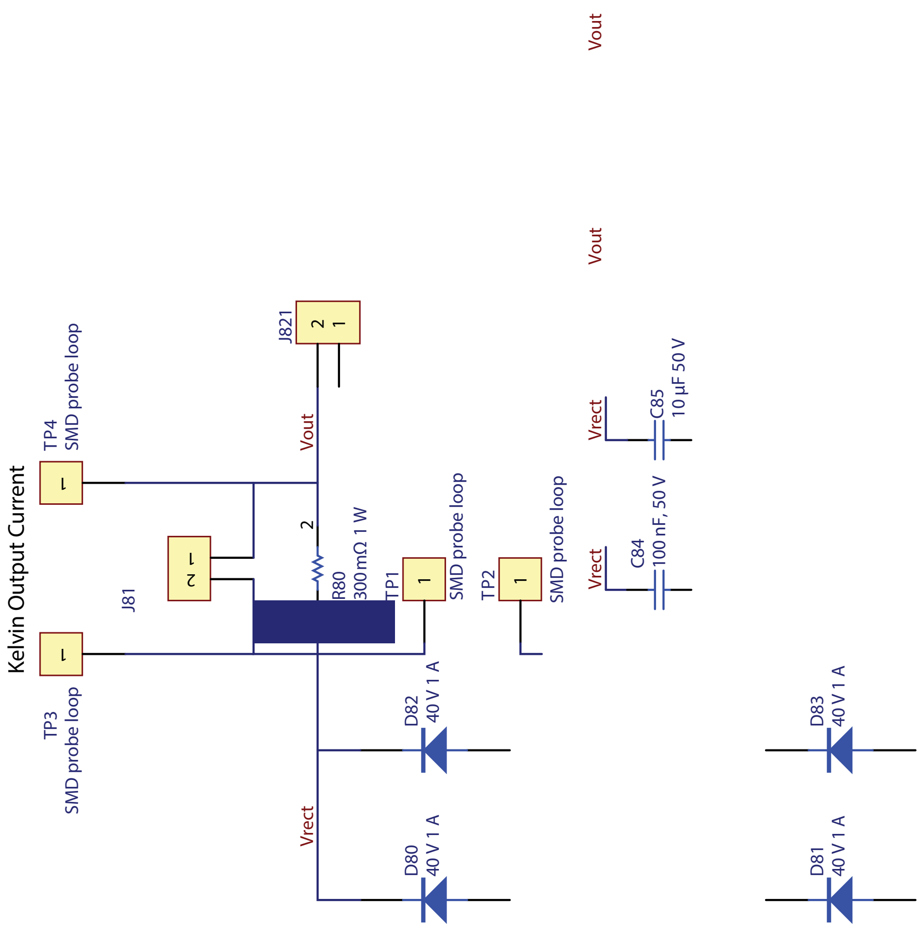


Figure 16: Source coil schematic

Figure 17: Category-3 AirFuel device schematic


Kelvin Output Current
TP4
SMD probe loop
TP3
SMD probe loop
J81
J821
Vout
Vout
Vout
2
R80
300 mΩ 1 W
TP1
SMD probe loop
TP2
SMD probe loop
Vrect
Vrect
Vrect
C84
100 nF, 50 V
C85
10 µF 50 V
D82
40 V 1 A
D80
40 V 1 A
D83
40 V 1 A
D81
40 V 1 A

EPC would like to acknowledge Würth Elektronik (www.we-online.com) for their support of this project.

Würth Elektronik is a premier manufacturer of electronic and electromechanical passive components. EPC has partnered up with WE for a variety of passive component requirements due to the performance, quality and range of products available. EPC9121 development board features various WE product lines including a wireless power charging coil, power inductors, capacitors, LEDs and connectors.

One of the highlights on the board is the 37 x 37 mm sized wireless power charging receiver coil engineered out of Würth Elektronik's design center in Munich, Germany. Based off of EPC's transmitting and receiving controller requirements, the coils and associated capacitors have been carefully selected to optimize efficiency for power transfer as well as meet compliance for the Qi charging standard. Litzwire and high permeability materials are utilized in construction of the coil to yield the highest Q-factor possible. Pot core construction minimize undesirable stray magnetic fields. The coils have been built and endurance tested beyond what the industry calls for due to its commitment to quality standards as a German company.

Also featured on the board are a wide range of Würth Elektronik power inductor technologies including the WE-DD coupled, WE-PMI multilayer chip and WE-AIR air core inductors. The inductors very chosen for their balance between size, efficiency, and power

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Note that this demonstration kit is not compliant with any wireless power standard. It can be used to evaluate wireless power transfer according to the standards and is meant as a tool to evaluate eGaN® FETs and eGaN® ICs in this application.

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www.digikey.com

Demonstration Board Notification

The EPC9121 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 certified 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. Efficient 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.

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