Evaluation System EPC9129 Quick Start Guide

6.78 MHz, 33 W Class 4 Wireless Power System using EPC8010/EPC2038/EPC2019/EPC2016C

May 30, 2018

Version 1.0

|||EPC

EFFICIENT POWER CONVERSION

DESCRIPTION

The EPC9129 wireless power evaluation system is a high efficiency, AirFuel™ Alliance compatible, Zero Voltage Switching (ZVS), voltage mode class-D wireless power transfer demonstration kit capable of delivering up to 33 W into a transmit coil while operating at 6.78 MHz (Lowest ISM band). The purpose of this evaluation system is to simplify the evaluation process of wireless power technology using eGaN® FETs.

The EPC9129 wireless power system is comprised of the four boards (shown in figure 1), namely:

1) A Source Board (Transmitter or Power Amplifier) EPC9512

2) A Class 4 AirFuel compliant Source Coil (Transmit Coil)

3) A Category 3 AirFuel Alliance compliant Receive Device EPC9513

4) A Category 5 AirFuel Alliance compliant Receive Device EPC9514

The amplifier board (EPC9512) features the enhancement-mode, 100 V rated EPC8010 eGaN FET as the main power stage in a dual half bridge configuration; the 100 V rated EPC2038 eGaN FET used as the synchronous bootstrap FET, and the 200 V rated EPC2019 eGaN FET used in the SEPIC pre-regulator. The amplifier can be set to operate in either differential mode or single-ended mode and includes the gate driver(s), oscillator, and feedback controller for the pre-regulator that ensures operation for wireless power control based on the AirFuel standard. This allows for compliance testing to the AirFuel class 4 standard over a load range as high as ±35j Ω.

The EPC9512 can operate in either single-ended or differential mode by changing a jumper setting. This allows for high efficiency operation with load impedance ranges suitable for single ended operation.

The circuits used to adjust the timing for the ZVS class-D amplifiers have been separated to further ensure highest possible efficiency setting. Each half bridge also includes separate ZVS tank circuits.

The amplifier is equipped with a pre-regulator controller that adjusts the voltage supplied to the ZVS class-D amplifier based on the limits of 3 parameters: coil current, DC power delivered to the ZVS class-D amplifier, and maximum operating voltage of the ZVS class-D amplifier. The coil current has the lowest priority followed by the power delivered and amplifier supply voltage having the highest priority. Changes in the device load power demand, physical placement of the device on the source coil and other factors, such as metal objects in proximity to the source coil, contribute to variations in coil current, DC power, and amplifier voltage requirements. Under any of these conditions, the controller will ensure the correct operating conditions for the ZVS class-D amplifier based on the AirFuel standard. The pre-regulator can be bypassed to allow testing with custom control hardware. The board further allows easy access to critical measurement nodes for

accurate power measurement instrumentation hookup. A simplified diagram of the amplifier board is given in figure 2.

The source and device coils are AirFuel compliant and have been pre-tuned to operate at 6.78 MHz with the EPC9512 amplifier. The source coil is AirFuel class 4 compliant and the device coils are AirFuel category 3 and category 5 compliant.

The EPC9513 (Category 3) device board includes a high frequency Schottky diode based full-bridge rectifier, DC smoothing capacitor and 5 V regulator. The regulator is based on a SEPIC converter that features a 200 V EPC2019 eGaN FET. The power circuit is attached to the backside of the coil which is provided with a ferrite shield that prevents the circuit from shunting the coil's magnetic field.

The EPC9514 (Category 5) device board includes a high frequency Schottky diode based full-bridge rectifier, DC smoothing capacitor and 19 V regulator. The regulator is based on a SEPIC converter that features a 100 V EPC2016C eGaN FET. The power circuit is attached to the side of the coil.

For more information on the EPC8010, EPC2038, EPC2019, or EPC2016C please refer to the datasheet available from EPC at **www.epc-co.com**. The datasheet should be read in conjunction with this quick start guide.
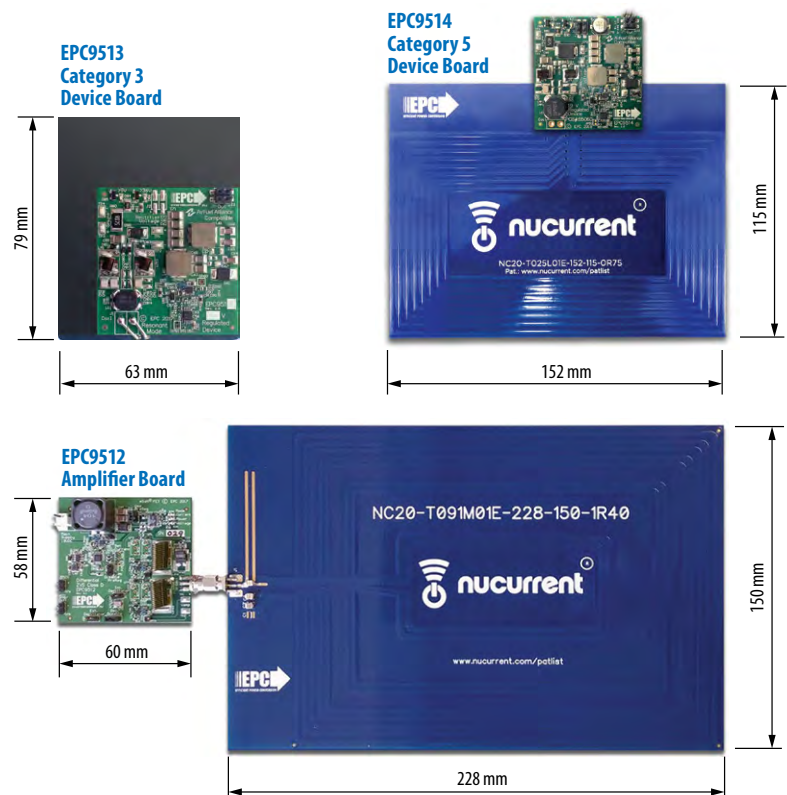

EPC9513 Category 3 Device Board — 79 mm × 63 mm

EPC9514 Category 5 Device Board — 115 mm × 152 mm
NC20-TO25L01E-152-115-OR75
Pat. www.nucurrent.com/patlist

EPC9512 Amplifier Board — 58 mm × 60 mm
NC20-T091M01E-228-150-1R40
150 mm × 228 mm
www.nucurrent.com/patlist

Figure 1: EPC9129 evaluation system.

Table 1: Performance Summary (T_A = 25°C) EPC9512

Symbol	Parameter	Conditions	Min	Max	Units
V_{IN}	Bus Input Voltage Range – Pre-Regulator Mode	Also used in bypass mode for logic supply	17.4	24	V
V_{IN}	Amp Input Voltage Range – Bypass Mode		0	80	V
V_{OUT}	Switch-Node Output Voltage			80	V
I_{OUT}	Switch-Node Output Current (each)			1.8*	A
V_{extosc}	External Oscillator Input Threshold	Input 'Low'	-0.3	0.8	V
		Input 'High'	2.4	5	V
$V_{Pre\_Disable}$	Pre-Regulator Disable Voltage Range	Floating	-0.3	5.5	V
$I_{Pre\_Disable}$	Pre-Regulator Disable Current	Floating	-10	10	mA
$V_{Osc\_Disable}$	Oscillator Disable Voltage Range	Open Drain/Collector	-0.3	5	V
$I_{Osc\_Disable}$	Oscillator Disable Current	Open Drain/Collector	-25	25	mA
$V_{sgnDiff}$	Differential or Single-Select Voltage	Open Drain/Collector	-0.3	5.5	V
$I_{sgnDiff}$	Differential or Single-Select Current	Open Drain/Collector	-1	1	mA

Maximum current depends on die temperature – actual maximum current will be subject to switching frequency, bus voltage and thermals.

Table 2a: Performance Summary (T_A = 25°C) EPC9513 - Category 3 Device Board

Symbol	Parameter	Conditions	Min	Max	Units
V_{Unreg}	Un-regulated output voltage			38	V
I_{Unreg}	Un-regulated output current			1.5*	A
V_{Unreg_UVLOR}	UVLO Enable	Un-regulated voltage rising		10.96	V
V_{Unreg_UVLOF}	UVLO Disable	Un-regulated voltage falling	5.96		V
V_{OUT}	Output Voltage Range	V_{Unreg_min} = 8.3 V	4.8	5.1	V
I_{OUT}	Output Current Range	V_{Unreg_min} = 8.3 V	0	1*	A

Actual maximum current subject to operation temperature limits.

Table 2b: Performance Summary (T_A = 25°C) EPC9514

Symbol	Parameter	Conditions	Min	Max	Units
V_{Unreg}	Un-regulated output voltage		12.5	48	V
I_{Unreg}	Un-regulated output current			1.4*	A
V_{Unreg_UVLOR}	UVLO Enable	Un-regulated voltage rising		25	V
V_{Unreg_UVLOF}	UVLO Disable	Un-regulated voltage falling	12.5		V
V_{OUT}	Output Voltage Range	V_{Unreg_min} = 8.3 V	18.75	19.25	V
I_{OUT}	Output Current Range	V_{Unreg_min} = 12.5 V	0	1.4*	A

Actual maximum current subject to operation temperature limits.

MECHANICAL ASSEMBLY

The assembly of the EPC9129 Wireless 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 do not need to be mechanically attached to the source coil.

The coil sets of the EPC9111 and EPC9112 (both the source and device coils) are not compatible with the EPC9129 kit. To prevent inadvertent connection of either, the connectors of the amplifier and coils have been changed from reverse polarity to standard polarity. Please contact EPC for modifications to the original coil set to ensure compatibility with the EPC9512 amplifier.

It is recommended to insert a thin plastic insulator on top of the source coil to prevent accidental contact during operation when locating the device coils that can prevent damage to the amplifier.

DETAILED DESCRIPTION

The Amplifier Board (EPC9512)

Figure 2 shows the system block diagram of the EPC9512 ZVS class-D amplifier with pre-regulator and figure 3 shows the details of the ZVS class-D amplifier section. The pre-regulator is used to control the ZVS class-D wireless power amplifier based on three feedback parameters 1) the magnitude of the coil current indicated by the **green LED**, 2) the DC power drawn by the amplifier indicated by the **yellow LED** and 3) a maximum supply voltage to the amplifier indicated by the **red LED**. 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 80 V and the maximum power drawn by the amplifier is pre-set to 33 W. The coil current magnitude is pre-set to 1.375 A_{RMS} but can be made adjustable using P25. The pre-regulator comprises a SEPIC converter that can operate at full power from 17.4 V through 24 V. If the system is operating in coil current limit mode, then the **green LED** will illuminate. For power limit mode, the **yellow LED** will illuminate. Finally, when the pre-regulator reaches maximum output voltage the **red LED** will illuminate indicating that the system is no longer able to operate to the AirFuel standard as the load impedance is too high for the amplifier to drive. When the load impedance is too high to reach power limit or voltage limit mode, then the current limit LED will illuminate incorrectly indicating current limit mode. This mode also falls outside the AirFuel standard and by measuring the amplifier supply voltage across TP1 and TP2 will show that it has nearly reached its maximum value limit.

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 inserting the jumper into location JP50 to disable the pre-regulator followed by connecting the main positive supply to the bottom pin of JP1.

JP1 can also be removed and replaced with a DC ammeter to directly measure the current drawn by the amplifier. When doing this observe 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 EPC9512 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.

The amplifier comes with its own low supply current oscillator that is pre-programmed to 6.78 MHz ± 678 Hz. It can be disabled by placing a jumper into JP70 or can be externally shutdown using an externally controlled open collector / drain transistor on the terminals of JP70 (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 J70 (note which pin is the ground connection) and the jumper (JP71) is removed.

The pre-regulator can also be disabled in a similar manner as the oscillator using JP50. However, note that this connection is floating with respect to the ground so removing the jumper for external connection requires a floating switch to correctly control this function. Refer to the datasheet of the controller IC and the schematic in this quick start guide for specific details.

The ZVS timing adjust circuits for the ZVS class-D amplifiers are each independently settable to ensure highest possible efficiency setting and includes separate ZVS tank circuits.

Additional protection features

An undervoltage-lockout circuit has been implemented for the input voltage (V_{IN}). The amplifier board will not start unless V_{IN} reaches its minimum required value specified in table 1.

A clamp diode also protects the board from V_{IN} over-voltage for a brief period and accidental reverse polarity connection with up to 11 A current protection.

On-Off-Key (OOK) modulation

On-Off-Key (OOK) modulation (as illustrated in figure 6) can be implemented by applying the modulation signal at J76. It is compatible with 5 V logic only. When the signal is high, the power stage functions normally; when the signal is low, the gate drive signal of one half-bridge is shut off. Therefore, for optimal performance, the signal should be synchronized with the oscillator signal. The modulation signal should also change state between the oscillator states and must complete an even number of clock cycles. Failure to follow this will lead to DC voltage shift on the ZVS capacitor (C_{zvs}) and other harmonic generation issues in the amplifier output. The OOK modulation frequency will also become present and thus could lead to radiated emission violations if the frequency exceeds what is allowed in the ISM band.

When not using OOK modulation, J76 should be left open – an on-board pull-up resistor keeps the level high.

Single ended or Differential Mode operation

The EPC9512 amplifier can be operated in one of two modes; single-ended or differential mode. Single ended operation offers higher amplifier efficiency but reduced imaginary impedance drive capability. If the reflected impedance of the tuned coil load exceeds the capability of the amplifier to deliver the desired power, then the amplifier can be switched over to differential mode. In differential mode, the amplifier is capable of driving an impedance range of 1 Ω through 56 Ω and ±35j Ω and maintains either the 1.375 A_{RMS} coil current or deliver up to 33 W of power. The EPC9512 is set by default to differential mode and can be switched to single ended mode by inserting a jumper into 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.

For differential mode <u>only</u> operation, the two ZVS inductors L_{ZVS1} and L_{ZVS2} can be replaced by a single inductor L_{ZVS12} and by removing C_{ZVS1} and C_{ZVS2}.

ZVS Timing Adjustment

Setting the correct time to establish ZVS transitions is critical to achieving high efficiency with the EPC9512 amplifier. This can be done by selecting the values for R71, R72, R77, and R78 or P71, P72, P77, and P78 respectively. This procedure is best performed using a potentiometer installed at the appropriate locations that is used to determine the fixed resistor values. The procedure is the same for both single-ended and differential mode of operation. The timing MUST initially be set WITHOUT the source coil connected to the amplifier. The timing diagrams are given in figure 12 and should be referenced when following this procedure. Only perform these steps if changes have been made to the board as it is shipped preset. The steps are:

1. With power off, remove the jumper in JP1 and install it into JP50 to place the EPC9512 amplifier into Bypass mode. Connect the main input power supply (+) to JP1 (bottom pin for bypass mode) with ground connected to J1 ground (-) connection.

2. With power off, connect the control input power supply bus (19 V) to (+) connector (J1). Note the polarity of the supply connector.

3. Connect a LOW capacitance oscilloscope probe to the probe-hole of the half-bridge and the ground post.

4. Turn on the control supply – make sure the supply is approximately 19 V.

5. Turn on the main supply voltage starting at 0 V and increasing to the required predominant operating value (such as 24 V but NEVER exceed the absolute maximum voltage of 80 V).

6. While observing the oscilloscope adjust the applicable potentiometers to achieve the green waveform of figure 12.

7. Repeat for the other half-bridge.

8. Replace the potentiometers with fixed value resistors if required. Remove the jumper from JP50 and install it back into JP1 to revert the EPC9512 back to pre-regulator mode.

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 capacitors C_{ZVS1} and C_{ZVS2} are chosen to have a very small ripple voltage component and are 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:

$$L_{ZVS} = \frac{\Delta t_{vt}}{8 \cdot f_{sw} \cdot (C_{OSSQ} + C_{well})} \tag{1}$$

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 is accounted for by the voltage transition time. The C_{OSS} of the EPC8010 eGaN FETs is on the same order of magnitude as the gate driver well capacitance C_{well} which as a result must now be included in the ZVS timing calculation. The charge equivalent capacitance of the eGaN FETs can be determined using the following equation:

$$C_{OSSQ} = \frac{1}{V_{AMP}} \cdot \int_0^{V_{AMP}} C_{OSS}(v) \cdot dv \qquad (2)$$

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 of the devices (which will increase device losses). Typical voltage transition times range from 2 ns through 8 ns. For the differential case the voltage and charge (C_{OSSQ}) are doubled when calculating the ZVS inductance.

The Source Coil

Figure 4 shows the schematic for the source coil which is Class 4 AirFuel compliant. The matching network includes only series tuning. The matching network series tuning is differential to allow balanced connection and voltage reduction for the capacitors.

The Device Boards

Figure 5 shows the basic schematic diagram of the EPC9513 and EPC9514 device boards which comprises a tuning circuit for the device coil with a common-mode choke for EMI suppression, a high frequency rectifier and SEPIC converter based output regulator. The EPC9513 is powered using a Category 3 AirFuel Alliance compliant device coil and the EPC9514 is powered using a Category 5 AirFuel Alliance compliant device coil Both are by default tuned to 6.78 MHz for the specific coil provided with it. The tuning circuit comprises both parallel and series tuning which is also differential to allow balanced connection and voltage reduction for the capacitors.

The device boards have have limited over-voltage protection using a TVS diode that clamps the un-regulated voltage to 38 V (EPC9513) or 46 V (EPC9514) . This can occur when the receive coil is placed above a high power transmitter with insufficient distance to the transmit coil and there is little or no load connected. During an over-voltage event, the TVS diode will dissipate a large amount of power and the red LED will illuminate indicating an over-voltage. The receiver should be removed from the transmitter as soon as possible to prevent the TVS diode from over-heating.

The EPC9513 and EPC9514 can be operated with or without the regulator. The regulator can be disabled by inserting a jumper into position JP50 and connecting the load to the unregulated output terminals. In regulated mode, the design of the EPC9513 and EPC9514 controller will ensure stable operation in a wireless power system. The regulator operates at 280 kHz (EPC9513) or 300 kHz (EPC9514) and the controller features over current protection that limits the load current to 1 A for the EPC9513 and 2 A for the EPC9514.

The EPC9513 and EPC9514 device boards come equipped with Kelvin connections for easy and accurate measurement of the un-regulated and regulated output voltages. The rectified voltage current can also be measured using the included shunt resistor. In addition, the EPC9513 and EPC9514 have been provided with a switch-node measurement connection for low inductance connection to an oscilloscope probe to yield reliable waveforms.

The EPC9513 is designed to operate in conjunction with EPC9127 (10 W EPC9510), EPC9128 (16 W EPC9509), EPC9129 (33 W EPC9512) and EPC9121 (10 W EPC9511) transmitter units. The EPC9514 is designed to operate in conjunction with EPC9129 (33 W EPC9512) transmitter units.

QUICK START PROCEDURE

The EPC9129 evaluation system is easy to set up and evaluate the performance of the eGaN FET in a wireless power transfer application. Refer to figure 1 to assemble the system and figures 8, 9, and 10 for proper connection and measurement setup before following the testing procedures.

The EPC9512 can be operated using any one of two alternative methods:

a. Using the pre-regulator

b. Bypassing the pre-regulator

a. Operation using the pre-regulator

The pre-regulator is used to supply power to the amplifier in this mode and will limit the coil current, power delivered or maximum supply voltage to the amplifier based on the pre-determined settings.

The main 19 V supply must be capable of delivering 2.3 ADC. **DO NOT turn up the voltage of this supply when instructed to power up the board, instead simply turn on the supply**. The EPC9512 board includes a pre-regulator to ensure proper operation of the board including start up.

1. Make sure the entire system is fully assembled prior to making electrical connections and make sure jumper JP1 is installed. Also make sure the source coil and device coil with load are connected.

2. With power off, connect the main input power supply bus to J1 as shown in figure 8. Note the polarity of the supply connector.

3. Make sure all instrumentation is connected to the system.

4. Turn on the main supply voltage to the required value (19 V).

5. Once operation has been confirmed, observe the output voltage and other parameters on both the amplifier and device boards.

6. For shutdown, please follow 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 FETs.

When in bypass mode it is crucial to slowly turn up the supply voltage starting at 0 V. Note that in bypass mode you will be using two supplies; one for logic and the other for the amplifier power.

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 to place the EPC9512 amplifier in bypass mode. Also make sure the source coil and device coil with load are connected.

2. With power <u>off</u>, connect the <u>main</u> input power supply bus +V_{IN} to the bottom pin of JP1 and the ground to the ground connection J1 as shown in figure 8.

3. With power <u>off</u>, connect the <u>control</u> input power supply bus to J1. Note the polarity of the supply connector. This is used to power the gate drivers and logic circuits.

4. Make sure all instrumentation is connected to the system.

5. Turn on the control supply – make sure the supply is 19 V range.

6. Turn on the main supply voltage to the required value (it is recommended to start at 0 V and do not exceed the absolute maximum voltage of 80 V).

7. Once operation has been confirmed, adjust the main supply voltage within the operating range and observe the output voltage, efficiency and other parameters on both the amplifier and device boards.

8. For shutdown, please follow steps in the reverse order. Start by reducing the main supply voltage to 0 V followed by steps 6 through 2.

NOTE.
1. When measuring the high frequency content switch-node (Source Coil Voltage), care must be taken to avoid long ground leads. An oscilloscope probe connection (preferred method) has been built into the board to simplify the measurement of the Source Coil Voltage (shown in figure 11).

2. AVOID using a Lab Benchtop programmable DC as the load for the category 3 and category 5 device boards. These loads have low control bandwidth and will cause the EPC9129 system to oscillate at a low frequency and may lead to failure. It is recommended to use a fixed low inductance resistor as an initial load. Once a design matures, a post regulator, such as a Buck converter, can be used.

Go to www.epc-co.com periodically for updates on new wireless power device evaluation boards capable of delivering a regulated output.

THERMAL CONSIDERATIONS

The EPC9129 evaluation system showcases the EPC8010, EPC2019, EPC2038, and EPC2016C 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 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 EPC9129 evaluation 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. Excessively wide coil coupling and load range variations can lead to increased losses in the devices.

Pre-Cautions

The EPC9129 evaluation system has no enhanced protection systems and therefore should be operated with caution. Some specific precautions are:

1. Never operate the EPC9129 system with a device board that is AirFuel compliant as this system does not communicate with the device to correctly setup the required operating conditions and doing so can lead to failure of the device board. Please contact EPC should operating the system with an AirFuel compliant device be required to obtain instructions on how to do this. Please contact EPC at info@epc-co.com should the tuning of the coil be required to suit specific conditions so that it can be correctly adjusted for use with the ZVS class-D amplifier.

2. There is no heat-sink on the devices and during experimental evaluation it is possible present conditions to the amplifier that may cause the devices to overheat. Always check operating conditions and monitor the temperature of the EPC devices using an IR camera.

3. Never connect the EPC9512 amplifier board into your VNA in an attempt to measure the output impedance of the amplifier. Doing so will severely damage the VNA.
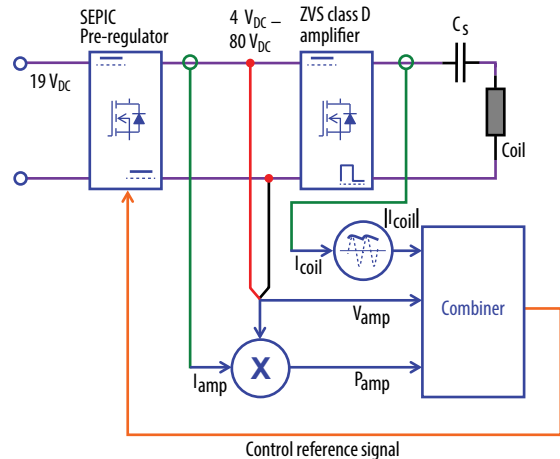

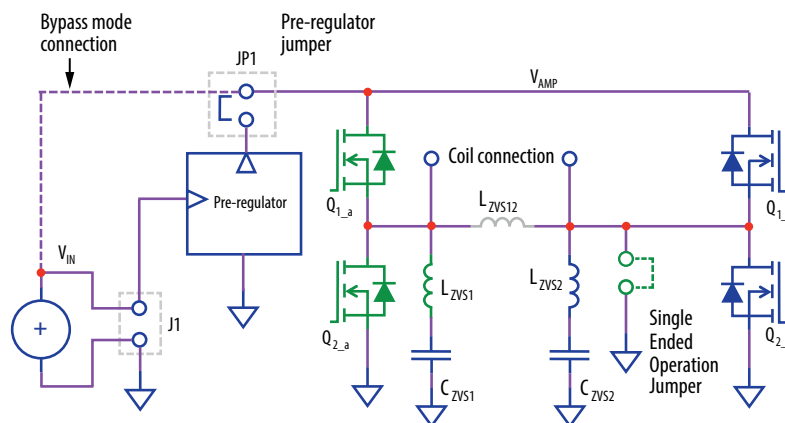Figure 2: Block diagram of the EPC9512 wireless power amplifier.

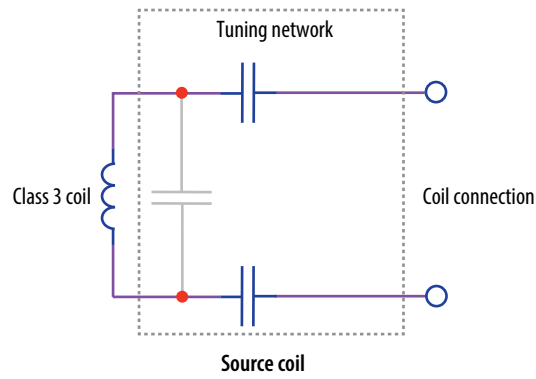Figure 3: Diagram of EPC9512 ZVS class-D amplifier circuit.

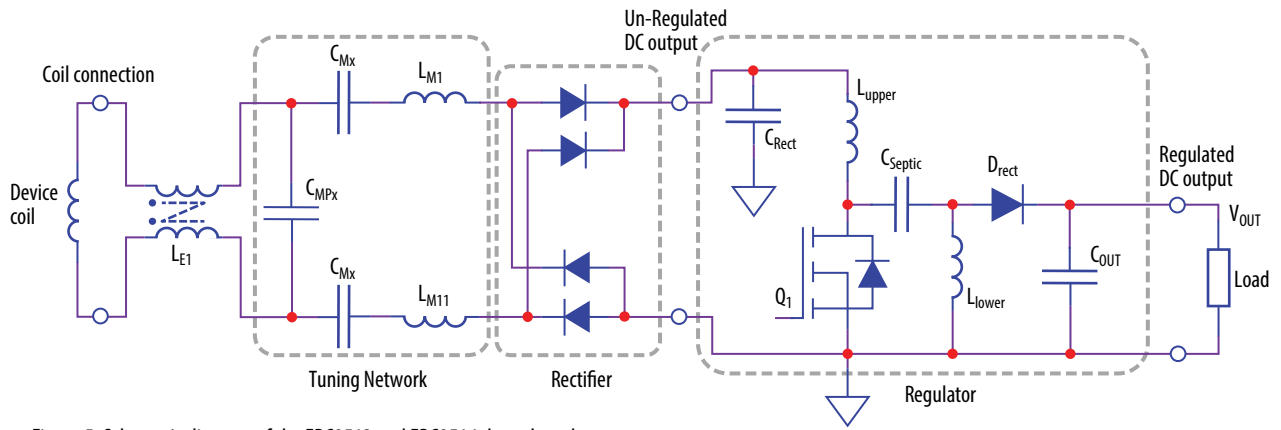Figure 4: Schematic of AirFuel Class 4 source coil.

Figure 5: Schematic diagram of the EPC9513 and EPC9514 demo board.
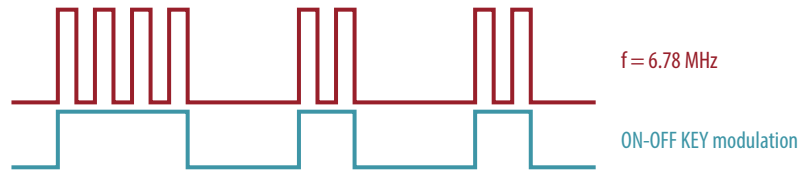

f = 6.78 MHz

ON-OFF KEY modulation

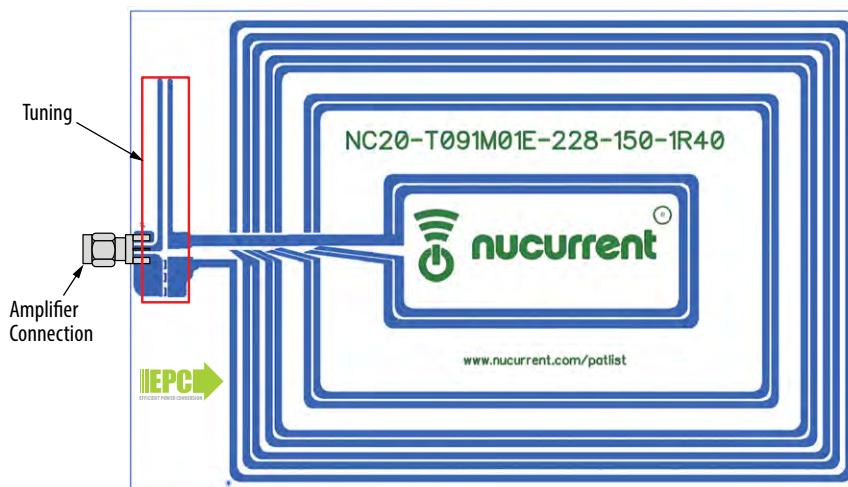Figure 6: ON-OFF-KEY modulation.

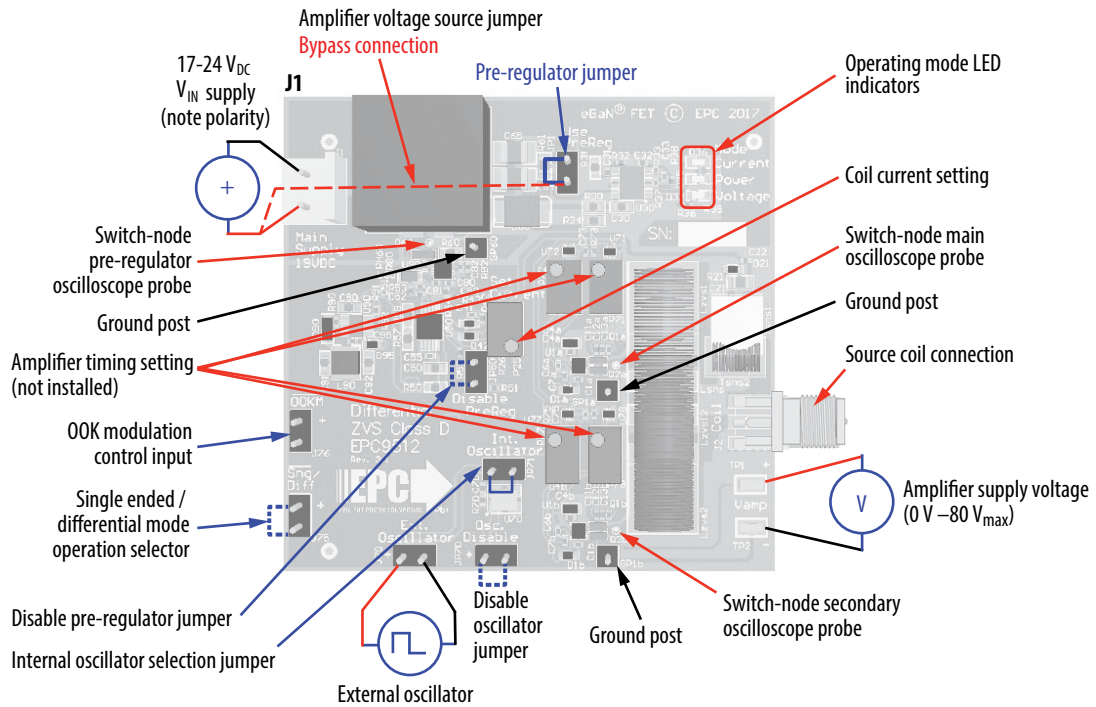

Figure 7: Proper connection for the source coil.

Figure 8: Proper connection and measurement setup for the amplifier board.
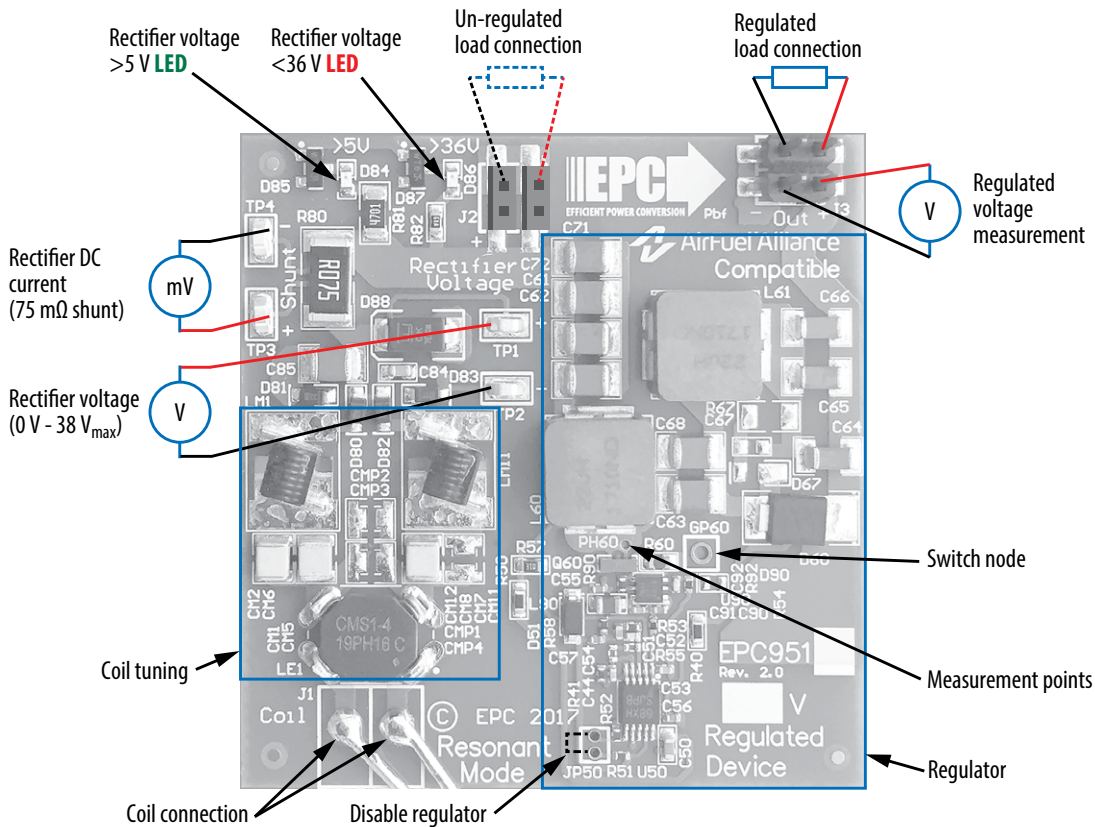

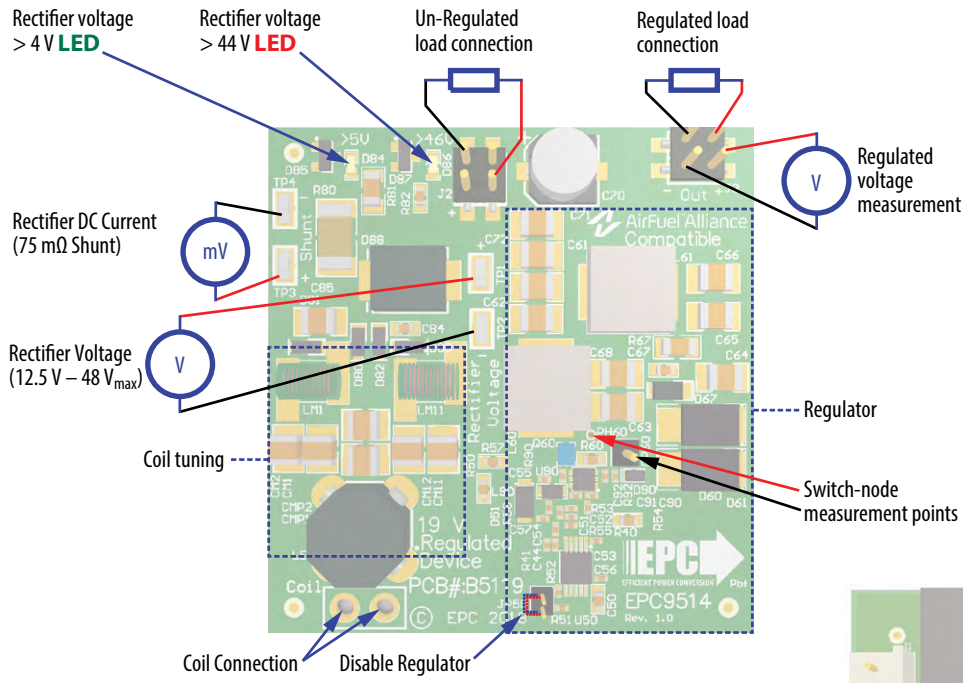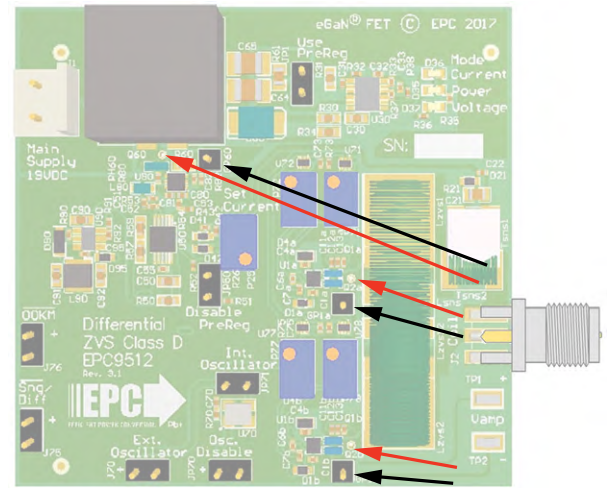Figure 9: Proper connection and measurement for the EPC9513 receiver board.

Rectifier voltage
> 4 V **LED**

Rectifier voltage
> 44 V **LED**

Un-Regulated
load connection

Regulated load
connection

Regulated
voltage
measurement

Rectifier DC Current
(75 mΩ Shunt)

mV

Rectifier Voltage
(12.5 V – 48 V$_{max}$)

V

Coil tuning

Regulator

Switch-node
measurement points

Coil Connection   Disable Regulator

Figure 10: AirFuel Category 5 device board.

Figure 11: Measurement locations of switch node waveforms on EPC9512 amplifier board.

V_{AMP}

Q1 turn-off

Q2 turn-on

time

0

Partial
ZVS

Shoot-
through

ZVS

ZVS + diode
conduction

V_{AMP}

Q2 turn-off

Q1 turn-on

time

0

Partial
ZVS

Shoot-
through

ZVS

ZVS + diode
conduction
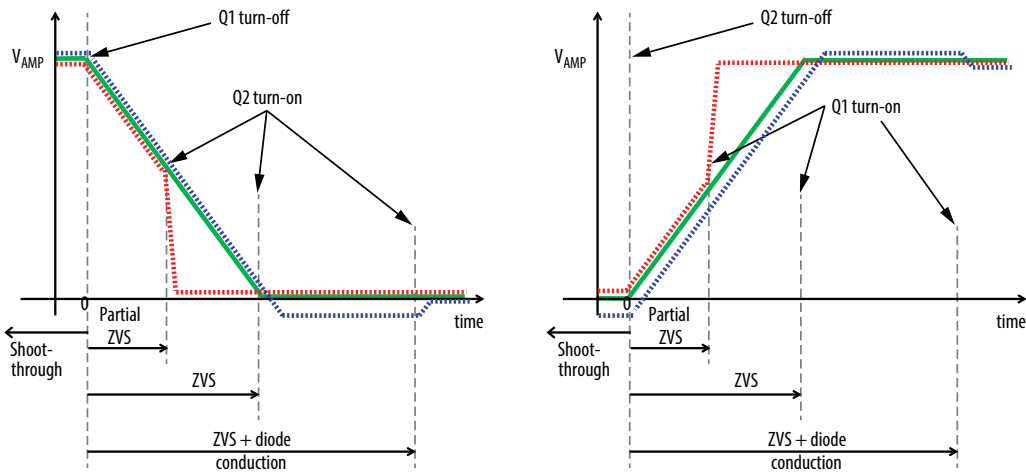
Figure 12: ZVS timing diagrams.

For support files including schematic, Bill of Materials (BOM), and gerber files please visit the
EPC9129 landing page at: https://epc-co.com/epc/products/demo-boards/epc9129

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. EPC9129 system features various Würth Elektronik product lines including capacitors, LEDs and connectors.

Learn more at www.we-online.com.

EPC would like to acknowledge Johanson Technology (www.johansontechnology.com) for their support of this project. Information on the capacitors used in this kit can be found at http://www.johansontechnology.com/S42E.

EPC would like to acknowledge NuCurrent (www.NuCurrent.com) for their support of this project.

NuCurrent is a leading developer of high-efficiency antennas for wireless power applications. Compliant across AirFuel Alliance and Wireless Power Consortium (Qi) standards, NuCurrent works closely with electronic device OEMs and integrators to custom-design, rapid-prototype and integrate the optimal antenna for a broad range of applications. NuCurrent's patented designs, structures and manufacturing techniques mitigate typical high frequency effects, offering higher efficiency, smaller sizes, higher durability and lower cost with wireless power application development.

For more information, visit http://nucurrent.com

Logos and trademarks belong to the respective owner. AirFuel™ logo used with permission.

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.

For More Information:

Please contact **info@epc-co.com**
or your local sales representative

Visit our website:
www.epc-co.com

Sign-up to receive
EPC updates at
bit.ly/EPCupdates

⫴EPC ➤
EFFICIENT POWER CONVERSION

DigiKey EPC Products are distributed through Digi-Key.
www.digikey.com