Demonstration System EPC9512 Quick Start Guide

6.78 MHz, 33 W, ZVS Class-D Wireless Power Amplifier using EPC8010/EPC2038/EPC2019

Revision 3.1

EFFICIENT POWER CONVERSION

DESCRIPTION

The EPC9512 wireless power amplifier demonstration board is a high efficiency, AirFuel™ Alliance (formerly A4WP) compatible, Zero Voltage Switching (ZVS), voltage mode class-D wireless power amplifier capable of delivering up to 33 W into a transmit coil while operating at 6.78 MHz (Lowest ISM band). The purpose of this demonstration system is to simplify the evaluation process of wireless power technology using eGaN® FETs.

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

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

For differential mode only 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 7 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 with

2. With power off, connect the main input power supply bus to J1 as shown in figure 5. 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 (Bypass Mode)

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 off, connect the main input power supply bus $+V_{IN}$ to the ININ

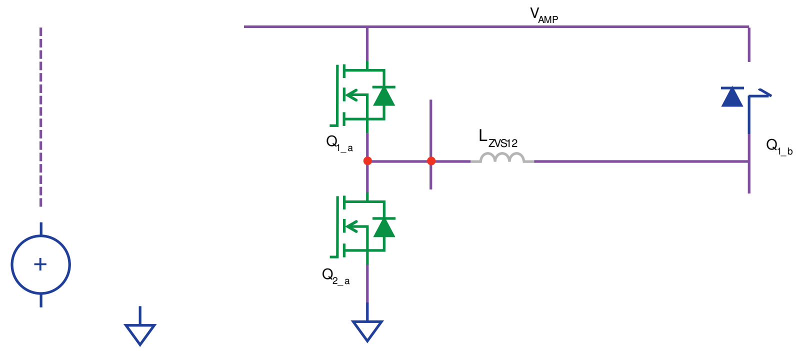

Figure 3: Diagram of EPC9512 ZVS class-D ampli er circuit.

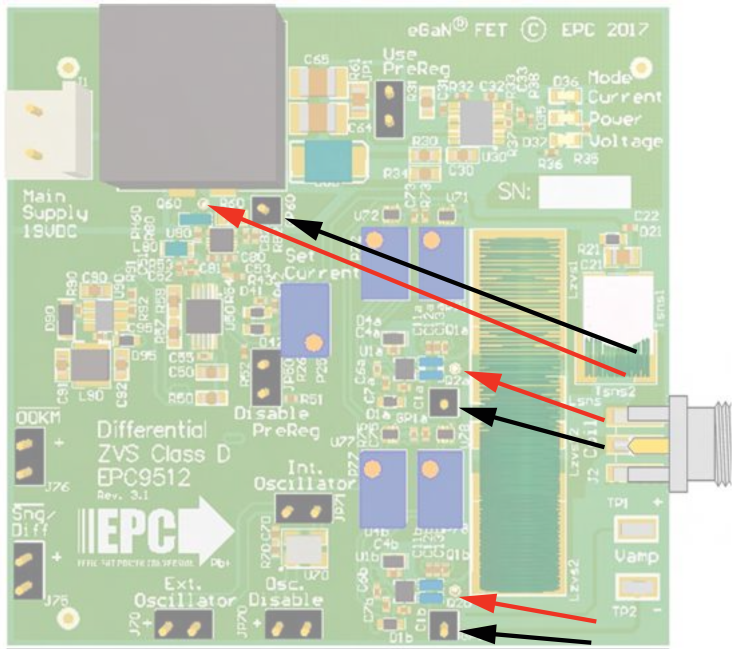

Figure 6: Measurement locations of switch node waveforms.

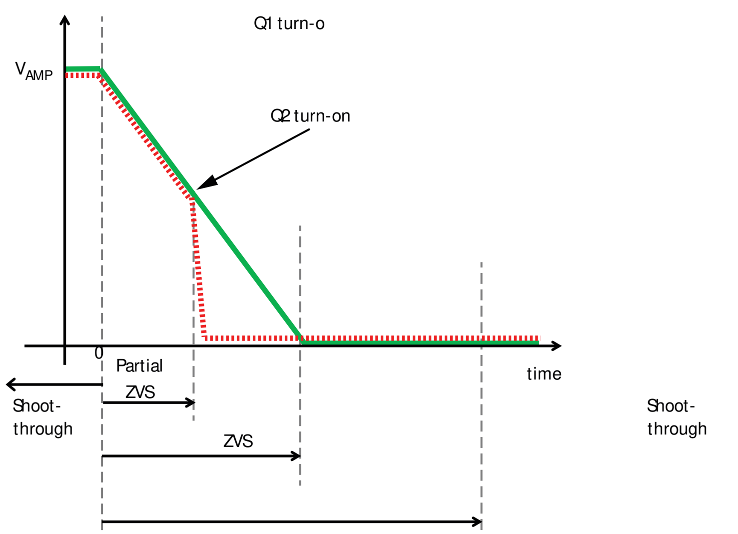

Figure 7: ZVS timing diagrams.

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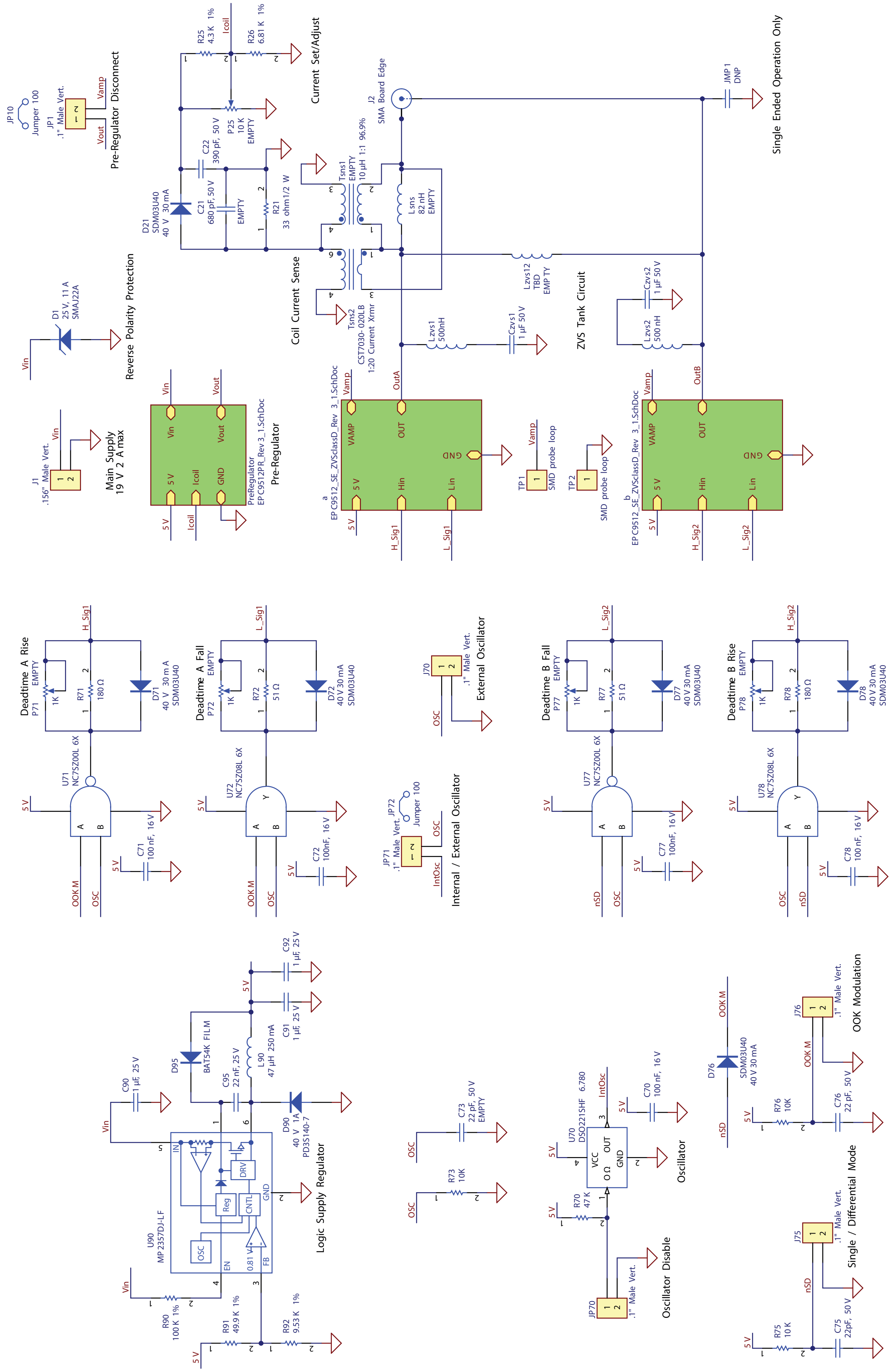

Figure 8: EPC9512 - ZVS class-D amplifier schematic.

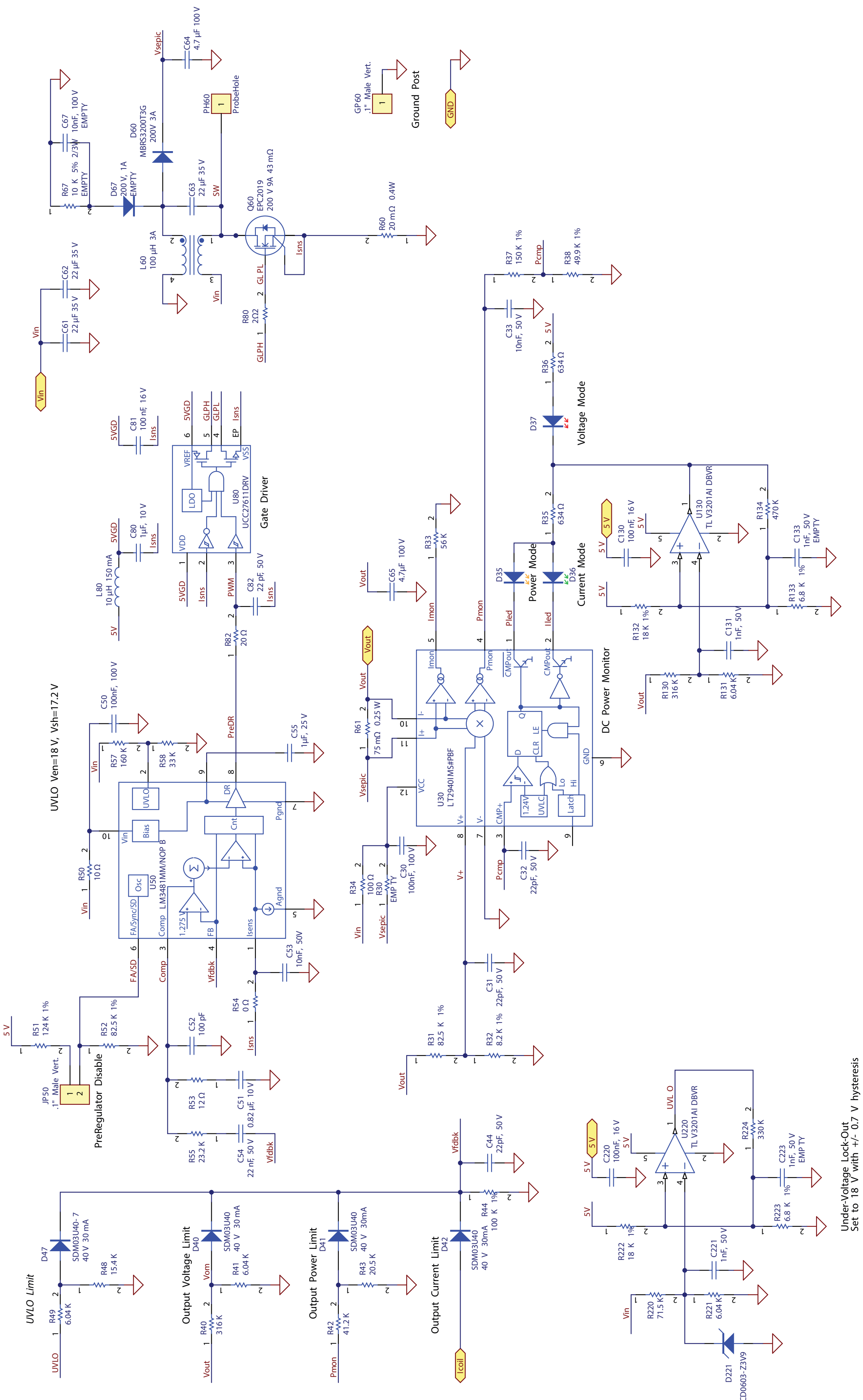

Figure 9: EPC9512 - Pre-regulator schematic for wireless power transfer source.

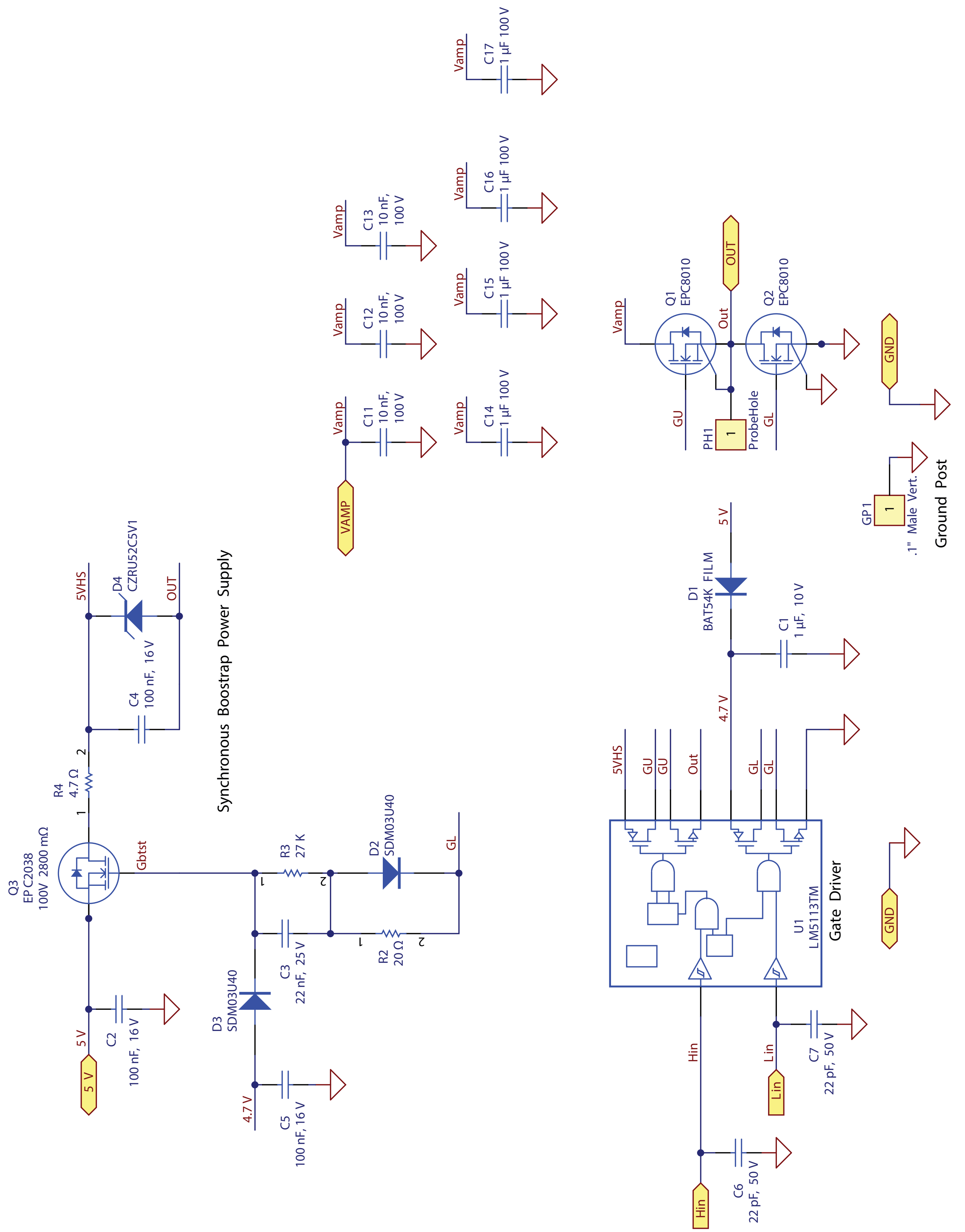

Figure 10: EPC9512 - Gate driver and power devices schematic.
This schematic is repeated for each single-ended ZVS class-D amplifier.

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 handling. Lowest core losses where applicable. High current handling capability. Extremely low DCR losses. Magnetically shielded where applicable. Engineered for reliability.

Learn more at www.we-online.com.

Note that this demonstration board 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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Demonstration Board Warning and Disclaimer

The EPC9512 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.

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