# Demonstration Board EPC9102 Quick Start Guide

*1/8th Brick Converter featuring EPC2001*

# DESCRIPTION



The EPC9102 demonstration board is a 12 V output, 375 kHz phase shifted full bridge (PSFB) eighth brick converter with 17 A maximum output current and 36 V to 60 V input voltage range. The demonstration board features the EPC2001 enhancement mode (*eGaN*®) field effect transistors (FETs), as well as the first *eGaN* FET specific integrated circuit driver – the National LM5113 from Texas Instruments. The EPC9102 board is intended to showcase the performance that can be achieved using the *eGaN* FETs and *eGaN* driver together.

The EPC9102 demonstration board is oversized to allow connections for bench evaluation.

There are also various probe points to facilitate simple waveform measurement and efficiency calculation. A complete block diagram of the circuit is given in Figure 1. For more information on the EPC2001 *eGaN* FETs or LM5113 driver, please refer to the datasheet available from EPC at www.epc-co.com and www.TI.com. These datasheets, as well that of the LM5030 controller should be read in conjunction with this quick start guide.

**Table 1: Performance Summary (TA = 25 °C)**

| SYMBOL | PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Bus Input Voltage Range | | 36 | 48 | 60 | V |
| $V_{OUT}$ | Switch Node Output Voltage | | | 12 | | V |
| $I_{OUT}$ | Switch Node Output Current | $T_a$ = 25 °C, no forced air cooling†<br>$T_a$ = 25 °C, ~200 LFM<br>$T_a$ = 25 °C, ~400 LFM | | | 8*<br>15*<br>17* | A<br>A<br>A |
| $f_{SW}$ | Switching frequency | | | 375 | | kHz |
| | Output ripple frequency | | | 750 | | kHz |
| | Peak Efficiency | 36 $V_{IN}$, 10 A $I_{OUT}$ | | 94.8 | | % |
| | Full Load Efficiency | 48 $V_{IN}$, 17 A $I_{OUT}$ | | 94 | | % |
| | Full Load Efficiency | 60 $V_{IN}$, 17 A $I_{OUT}$ | | 93.5 | | % |
| | Full Load Efficiency | 36 $V_{IN}$, 17 A $I_{OUT}$ | | 94 | | % |

* Maximum limited by thermal considerations

† Board placed vertical on long edge to aid convection – Do NOT operate horizontally without forced air cooling

## Quick Start Procedure

Demonstration board EPC9102 is easy to set up to evaluate the performance of the EPC2001 *eGaN* FETs and LM5113 driver. Refer to Figure 2 for proper connect and measurement setup and follow the procedure below:

1. With power off, connect the input power supply bus between VIN and INPUT RET banana jacks as shown.
2. Add input and output voltage measurements to the Kelvin connections provided as shown.
3. With power off, connect the active (constant current) load as desired between VOUT and OUT RET banana jacks as shown.
4. Turn on the supply voltage to the required value. (do not exceed the absolute maximum voltage of 60 V on VIN).
5. Measure the output voltage to make sure the board is fully functional and operating no-load.
6. Turn on active load to the desired load current while staying below the maximum current (This will depend on the cooling provided. If no forced air cooling, then keep the load current below 8 A)
7. Once operational, adjust the bus voltage and load current within the allowed operating range and observe the output switching behavior, efficiency and other parameters.
8. For shutdown, please follow steps in reverse.

NOTE. When measuring the high frequency content switch node voltage, care must be taken to avoid long ground leads. Measure these by placing the oscilloscope probe tip through the large vias provided and grounding the probe directly across the return vias provided. See Figure 3 for proper scope probe technique. Scope jacks can be soldered onto the board at these locations as desired. **Please note that primary side switch node scope jacks are referenced to the TOP of the sense resistor and not GND.** When measuring multiple signals ensure that they are always referenced to the same 'ground' potential to avoid potential circuit failure.

## CIRCUIT PERFORMANCE

The EPC9102 demonstration circuit was designed to showcase the size and performance that can readily be achieved at 375 kHz operation using *eGaN* FETs rather than to optimize the design for maximum output power. The operating frequency is roughly 50% - 100% higher than similar commercial units.

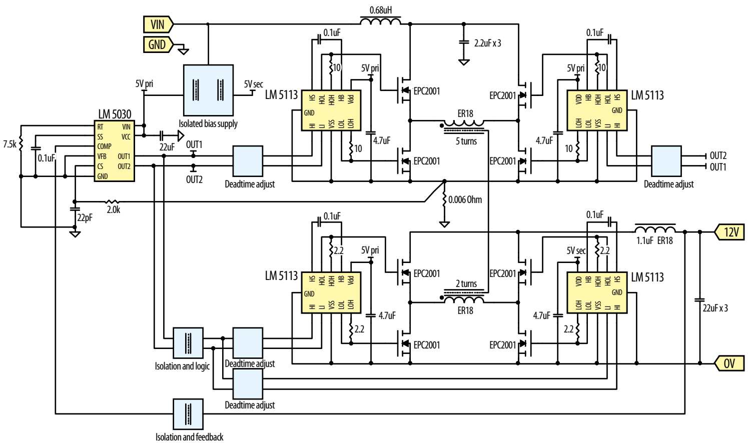


Figure 1: Block Diagram of EPC9102 Demonstration Board

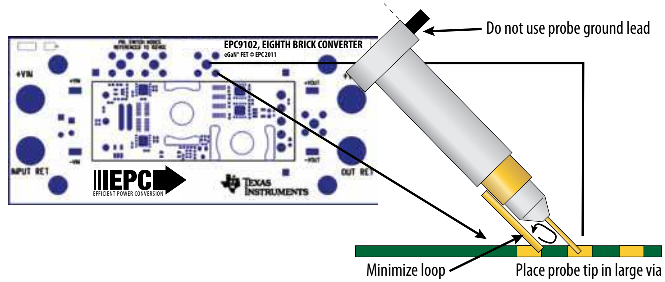




Figure 3: Proper Measurement of Switch Nodes or Output Voltage

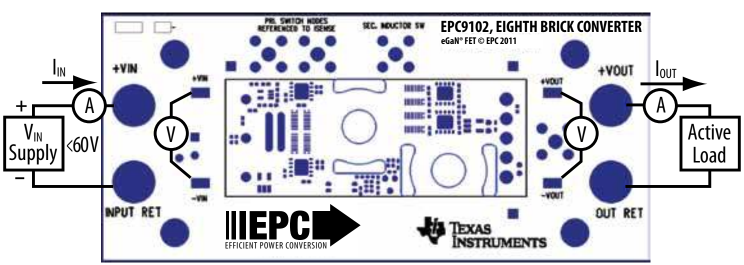




Figure 2: Proper Connection and Measurement Setup

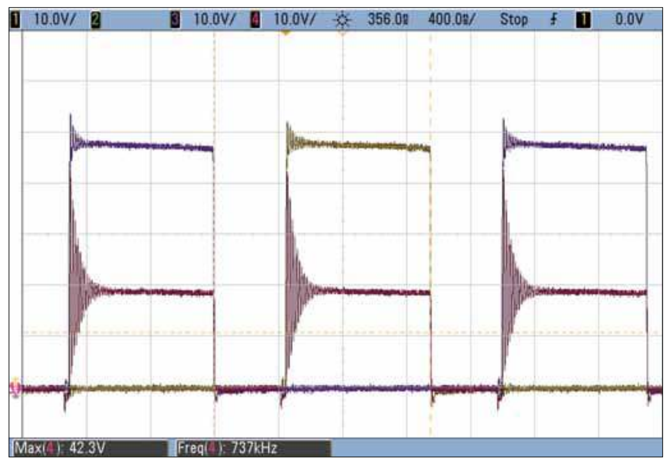


Figure 4: Typical waveforms taken at 48 $V_{IN}$ to 12 $V_{OUT}$/15 $A_{OUT}$
CH1: Primary side switch node A voltage – CH3: Primary side switch node B voltage –
CH4: Secondary side bridge voltage

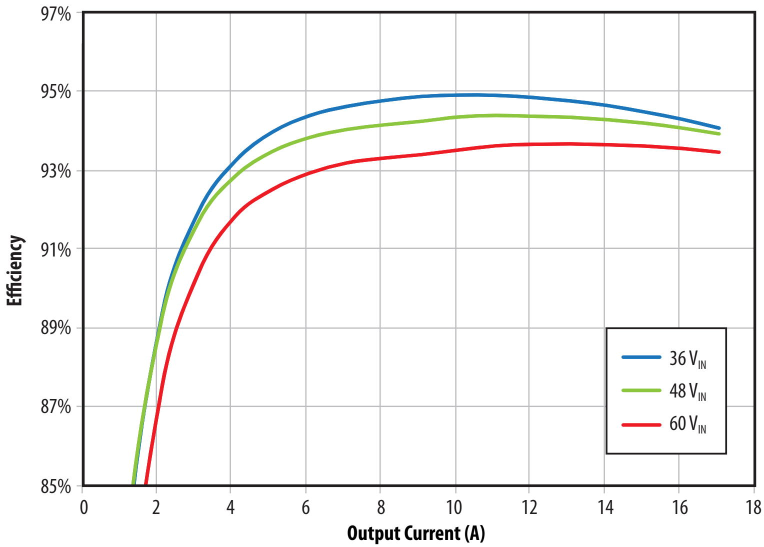



Figure 5: Typical efficiency curves

## THERMAL CONSIDERATIONS

The EPC9102 demonstration board thermal images for steady state full load operation are shown in Figure 6. The EPC9102 is intended for bench evaluation with low ambient temperature and forced air cooling. Operation without forced air cooling is possible for limited power operation and will quickly become thermally limited. Care must be taken to not exceed the absolute maximum junction temperature of 125 °C and stay within the constraints of the other components within the circuit.

NOTE. The EPC9102 demonstration board does not have any input overvoltage protection on board. Over-current is set to ~20 A, while primary side over temperature protection is set to ~90 °C. Care must be taken to avoid failure due to over temperature.

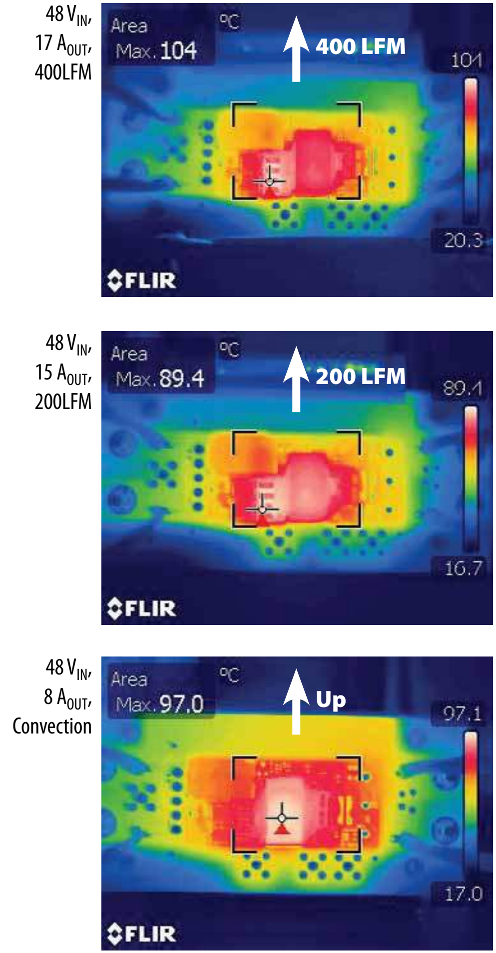
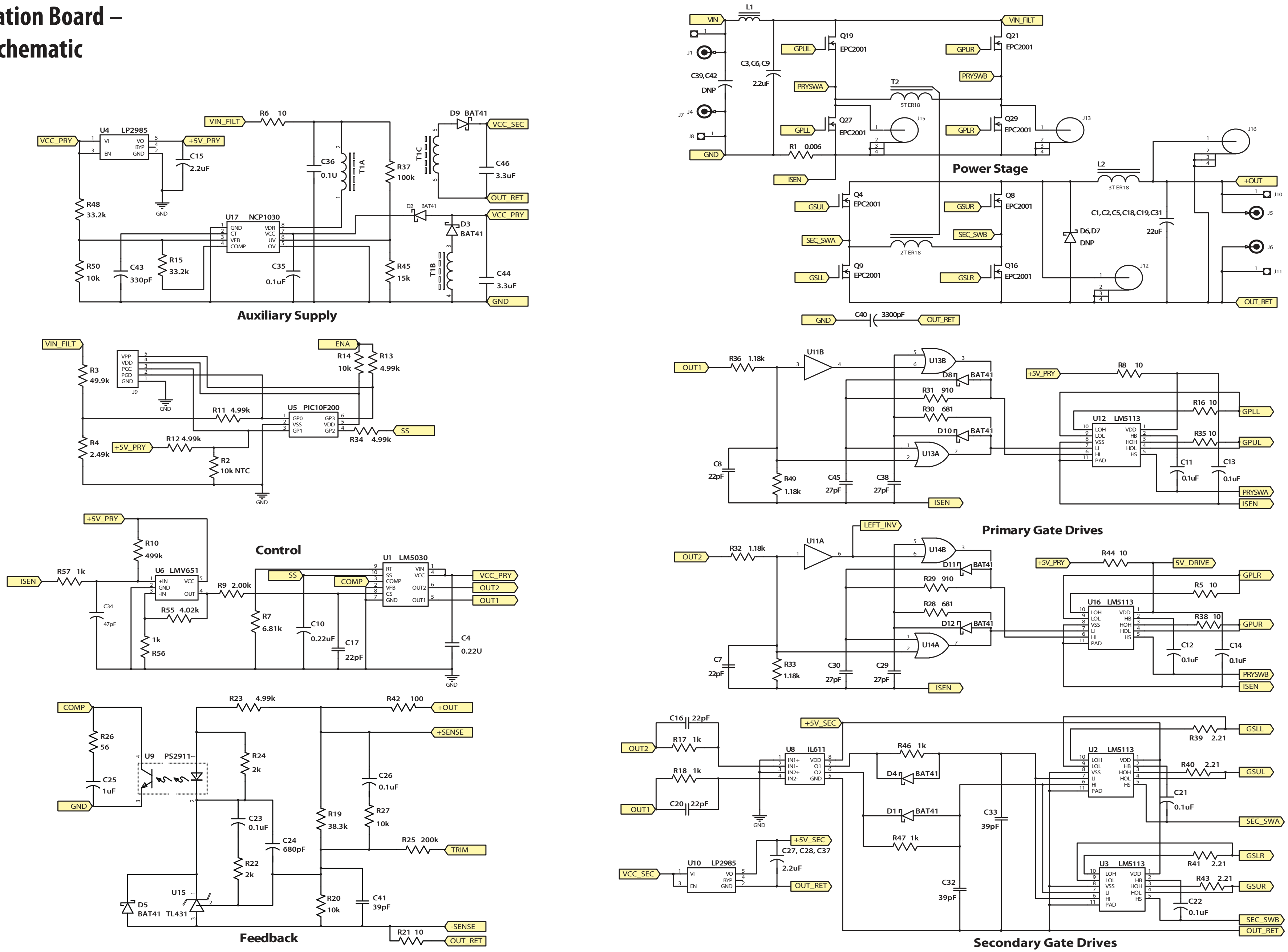



Figure 6: Thermal images of EPC9102 under different cooling conditions

## Table 2 : Bill of Material

| Item | Qty | Reference | Part Description | Manufacturer / Part # |
|---|---|---|---|---|
| 1 | 6 | C1, C2, C5, C18, C19, C31 | Capacitor, 22uF, 16V, X5R, 10% | C2012X5R1C226K |
| 2 | 1 | C10 | Capacitor, 0.22uF, 16V, X7R, 10% | GRM155R71C224KA12D |
| 3 | 9 | C11, C12, C13, C14, C21, C22, C23, C26, C35 | Capacitor, 0.1uF, 16V, X7R, 10% | GRM155R71C104KA88D |
| 4 | 4 | C15, C27, C28, C37 | Capacitor, 2.2uF, 6.3V, X5R | C1005X5R0J225M |
| 5 | 1 | C24 | Capacitor, 680pF, 25V, NPO, 5% | C1005C0G1E681J |
| 6 | 1 | C25 | Capacitor, 1uF, 6.3V, X5R, 10% | GRM155R60J105KE19D |
| 7 | 4 | C29, C30, C38, C45 | Capacitor, 27pF, 50V, NPO, 5% | GRM1555C1H270JZ01D |
| 8 | 3 | C3, C6, C9 | Capacitor, 2.2uF, 100V, X7R, 10% | HMK325BJ225KN-T |
| 9 | 3 | C32, C33, C41 | Capacitor, 39pF, 50V, NPO, 5% | GRM1555C1H390JZ01D |
| 10 | 1 | C34 | Capacitor, 47pF, 50V, NPO, 5% | GRM1555C1H470JZ01D |
| 11 | 1 | C36 | Capacitor, 0.1uF, 100V, X7R, 10% | GRM188R72A104KA35D |
| 12 | 1 | C4 | Capacitor, 0.22uF, 25V, X5R, 10% | TMK107BJ224KA-T |
| 13 | 1 | C40 | Capacitor, 3300pF, 2000V, X7R, 10% | 202S43W332KV4E |
| 14 | 1 | C43 | Capacitor, 330pF, 25V, NPO, 10% | ECJ-0EB1E331K |
| 15 | 2 | C44, C46 | Capacitor, 3.3uF, 16V, X5R, 10% | C1608X5R1C335K |
| 16 | 5 | C7, C8, C16, C17, C20 | Capacitor, 22pF, 50V, NPO, 5% | GRM1555C1H220JZ01D |
| 17 | 5 | D1, D2, D3, D4, D9 | Diode, 100V, 0.2A SCHOTTKY | BAT41KFILM |
| 18 | 4 | D8, D10, D11, D12 | Diode, 40V, 0.03A, SCHOTTKY | CDBQR00340 |
| 19 | 4 | J1, J4, J5, J6 | Connector, banana jack | KEYSTONE, 575-4 |
| 20 | 4 | J7, J8, J10, J11 | Test point | KEYSTONE, 5015 |
| 21 | 1 | L1 | Inductor, 0.68uH, 5.5A | Vishay, IHLP1212BZERR68M11 |
| 22 | 1 | L2 | Inductor, 1.2uH | Ferrox cube, ER18/3/10-3F35-A120 |
| 23 | 8 | Q4, Q8, Q9, Q16, Q19, Q21, Q27, Q29 | eGaN FET | EPC, EPC2001 |
| 24 | 1 | R1 | Resistor, 0.006, 2W, 1% | RL7520WT-R006-J |
| 25 | 1 | R10 | Resistor, 499k, 1/16W, 1% | MCR01MZPF4993 |
| 26 | 5 | R11, R12, R13, R23, R34 | Resistor, 4.99k, 1/16W, 1% | CRCW04024K99FKED |
| 27 | 4 | R14, R20, R27, R50 | Resistor, 10.0k, 1/16W, 1% | MCR01MZPF1002 |
| 28 | 2 | R15, R48 | Resistor, 33.2k, 1/16W, 1% | CRCW040233K2FKED |
| 29 | 6 | R17, R18, R46, R47, R56, R57 | Resistor, 1.00k, 1/16W, 1% | RC0402FR-071KL |
| 30 | 1 | R19 | Resistor, 38.3k, 1/16W, 1% | ERJ-2RKF3832X |
| 31 | 1 | R2 | NTC, 10k, 1% | ERT-J0EG103FA |
| 32 | 1 | R21 | Resistor, 10.0, 1/10W, 1% | ERJ-3EKF10R0V |
| 33 | 1 | R25 | Resistor, 200k, 1/16W, 1% | CRCW0402200KFKED |
| 34 | 1 | R26 | Resistor, 56, 1/16W, 1% | RC0402FR-0756RL |
| 35 | 2 | R28, R30 | Resistor, 681, 1/16W, 1% | ERJ-2RKF6810X |
| 36 | 2 | R29, R31 | Resistor, 910, 1/16W, 1% | RC0402FR-07910RL |
| 37 | 1 | R3 | Resistor, 49.9k, 1/10W, 1% | ERJ-3EKF4992V |
| 38 | 4 | R32, R33, R36, R49 | Resistor, 1.18k, 1/16W, 1% | CRCW04021K18FKED |
| 39 | 1 | R37 | Resistor, 100, 1/10W, 1% | ERJ-3EKF1003V |
| 40 | 4 | R39, R40, R41, R43 | Resistor, 2.21, 1/16W, 1% | CRCW04022R21FKED |
| 41 | 1 | R4 | Resistor, 2.49k, 1/16W, 1% | CRCW04022K49FKED |
| 42 | 1 | R42 | Resistor, 100, 1/16W, 1% | MCR01MZPF1000 |
| 43 | 1 | R45 | Resistor, 15.0k, 1/16W, 1% | MCR01MZPF1502 |
| 44 | 7 | R5, R6, R8, R16, R35, R38, R44 | Resistor, 10, 1/16W, 1% | RMCF0402FT10R0TR-ND |
| 45 | 1 | R55 | Resistor, 4.02k, 1/16W, 1% | ERJ-2RKF4021X |
| 46 | 1 | R7 | Resistor, 6.81k, 1/16W, 1% | ERJ-2RKF6811X |
| 47 | 3 | R9, R22, R24 | Resistor, 2.00k, 1/16W, 1% | CRCW04022K00FKED |
| 48 | 1 | T1 | Transformer, bias | Custom Coils, CCI 7082 |
| 49 | 1 | T2 | Transformer, 5:2 | Ferrox cube, ER18/3/10-3F35-A630 |
| 50 | 1 | U1 | I.C., PWM controller | Texas Instruments, LM5030MM |
| 51 | 1 | U11 | I.C., dual inverter | 74LVC2G14GW,125 |
| 52 | 2 | U13, U14 | I.C., dual nor gate | SN74LVC2G02DCUR |
| 53 | 1 | U15 | I.C., voltage reference | TL431AQDBZR,215 |
| 54 | 1 | U17 | I.C., bias controller | NCP1030DMR2G |
| 55 | 4 | U2, U3, U12, U16 | I.C., half bridge driver | Texas Instruments, LM5113SD |
| 56 | 2 | U4, U10 | I.C., regulator | LP2985IM5-5.0/NOPB |
| 57 | 1 | U5 | I.C., uController | PIC10F222T-I/OT |
| 58 | 1 | U6 | I.C., opamp | LMV651MG/NOPB |
| 59 | 1 | U8 | Isolator, passive | IL611-1E |
| 60 | 1 | U9 | Isolator, opto | PS2911-1-F3-A |
| 61 | 4 | X1, X2, X3, X4 | Stand-offs | KEYSTONE, 5062-2 |
| 62 | 0 | C39, C42 | Capacitor, DNP | |
| 63 | 0 | D6, D7 | Diode, DNP | |
| 64 | 0 | J9 | Header, DNP | |

# Demonstration Board – EPC9102 Schematic
Rev. 1.0



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