

# Development Board EPC9154 Quick Start Guide

*EPC21601*

*40 V, 10 A High Current Pulsed Laser Diode Driver*

Revision 1.0



## DESCRIPTION

The EPC9154 development board is primarily intended to drive laser diodes with short, high current pulses. Capabilities include minimum pulse widths of < 2 ns, peak currents > 10 A, and bus voltage rating of 30 V. The board is shipped with an EPC21601 eGaN® IC. The EPC21601 monolithically integrates an ultrafast eGaN gate driver with and a 10 A, 40 V eGaN IC in one tiny 6-bump BGA IC. The EPC9154 ships with the EPC9989 interposer board. The EPC9989 is a collection of break-away 5 mm x 5 mm square interposer PCBs with footprints for different lasers, RF connectors, and a collection of other footprints designed for experimentation with different loads. The use of the interposers allows many different lasers or other loads to be mounted on the EPC9154. Laser diodes or other loads are not included, and must be supplied by the user.

The EPC9154 combines EPC21601 eGaN IC with a printed circuit board with inputs, outputs, and test points in order to evaluate and demonstrate the capabilities of the IC and connected load. The printed circuit board is designed to minimize the power loop inductance while maintaining mounting flexibility for the laser diode or other load. It includes multiple on-board passive probes for voltages and is equipped with MMCX connections for input and sensing. The EPC21601 IC requires a 5 V<sub>DD</sub> supply, but is designed to interface with 3.3 V and 5 V CMOS logic families. In some cases it can also be driven from 2.5 V and 1.8 V logic families. Finally, the board can also be used for other applications requiring a ground-referenced eGaN IC, e.g. Class E amplifiers, boost converters, or similar. A complete block diagram of the circuit is given in Figure 1, and a detailed schematic in Figure 6.

For more information on the EPC21601 eGaN IC, please refer to the datasheet available from EPC at [www.epc-co.com](http://www.epc-co.com). The datasheet should be read in conjunction with this quick start guide.

## SETUP AND OPERATION

Development board EPC9154 is easy to set up to evaluate the performance of the EPC21601 eGaN IC. Refer to Figure 2 for proper connect and measurement setup and follow the procedure below:

1. Review laser safety considerations. Observe all necessary laser safety requirements including the use of personal protection equipment (PPE) as required. Refer to qualified safety personnel as necessary.
2. With power off, install laser diode U2 or other load. The use of one of the interposers from the included EPC9989 may be used to mount the laser or other load, and this is discussed in the section **LASER DIODE AND LOAD CONSIDERATIONS** for further information.
3. With power off, connect the input power supply bus to +V<sub>BUS</sub> (J1) and ground / return to -V<sub>BUS</sub> (J9) or GND.
4. With power off, connect the logic supply (5.1-1.2 V<sub>DC</sub>) to +V<sub>Logic</sub> (J9) and ground return to -V<sub>Logic</sub> (J9) or GND.
5. With power off, connect the signal pulse generator to the input J3. J3 is terminated with 50 Ω at the input of the EPC21601 IC (U1), and can accommodate 3.3 V and 5 V CMOS logic inputs. This range may be extended in some cases, as discussed in this guide.
6. Connect the remaining measurement MMCX outputs to an oscilloscope, using 50 Ω cables and with the scope inputs set to 50 Ω impedance. See section **MEASUREMENT CONSIDERATIONS** for more information, including the attenuation values for each output. **Note that the current sensing output is not functional for this board revision.**
7. Turn on the logic supply voltage to a value within the specification.
8. Turn on the bus voltage to a value within the specification.

Table 1: Performance Summary (T<sub>A</sub> = 25°C) EPC9154

Symbol	Parameter	Conditions	Min	Nom	Max	Units
V <sub>Logic</sub>	Gate drive and logic supply		5.5		12	V
V <sub>BUS</sub>	Bus input voltage range		0		30*	V
I <sub>LOAD</sub>	Output load current				10**	A
Z <sub>IN</sub>	Input impedance	J3 input		50		Ω
V <sub>INPUT</sub>	Input pulse range		0		5	V
F <sub>INPUT</sub>	Input pulse frequency		0	50	150***	MHz
T <sub>Pin</sub>	Input pulse width		2		1000	ns

\* The voltage rating of the EPC21601 eGaN IC is 40 V. The extremely fast switching transitions may result in ringing. It is the responsibility of the user to ensure that the peak voltage does not exceed the rating.

\*\* This is the EPC21601 rating, and does not account for heat generated by the load. It is the responsibility of the user to ensure that operating temperatures are within component specifications.

\*\*\* The EPC21601 is specified to have a 100 MHz maximum operating frequency, but in many cases can operate at a much higher frequency.

**SAFETY WARNING:** This board is capable of driving laser diodes to generate high power optical pulses. Such pulses are capable of causing **PERMANENT VISION DAMAGE AND BLINDNESS** as well as additional injury or property damage. Laser diodes may emit infrared (IR) light that is invisible to the user, but which can still cause **PERMANENT VISION DAMAGE AND BLINDNESS** as well as additional injury or property damage. User is fully responsible for following proper laser safety procedures to prevent injury or damage.

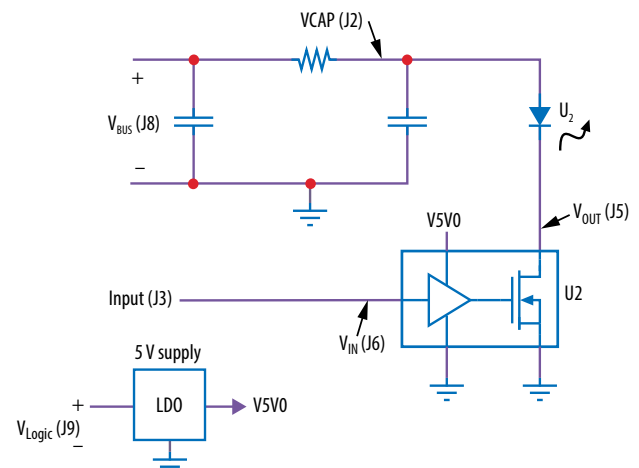


Figure 1: Block diagram of EPC9154 development board

9. Turn on the pulse source and observe switching operation via the outputs and any additional desired probing. Laser diode output may be observed with an appropriate electro-optical receiver.
10. Once operational, adjust the bus voltage, input pulse width, and pulse repetition frequency (PRF) as desired within the operating range and observe the system behavior.
11. For shutdown, please follow steps in reverse.

**NOTE:** This circuit contains nodes with very fast edges and with voltages one or two orders of magnitude higher than standard logic signals. Standard methods and probes for power circuits will normally not provide accurate results and may disrupt circuit operation. Please consider probe choice and use carefully. See [EPC measurement applications note](#).

## OPERATING PRINCIPLE

The EPC9154 is intended as both a demonstration board and a flexible development platform. It is functional out of the box, but is designed to be modified to accommodate a broad range of applications. **It is highly recommended that the user read the entire guide in order to get maximum value from the EPC9154.**

The EPC9154 is shipped as a rectangular pulse laser diode driver. Please refer to the block diagram (Fig. 2) and the schematic (Fig. 6). The EPC9154 basic operating principle is to act as a current gate to allow current from the voltage bus to flow through the laser diode or other load when the IC U2 is commanded on, and stop the load current when the IC is commanded off. The speed of the transitions are affected by the load, but are extremely fast. For example, turn-on and turn-off can be faster than 500 ps and 250 ps, respectively, for a load current of 10 A.

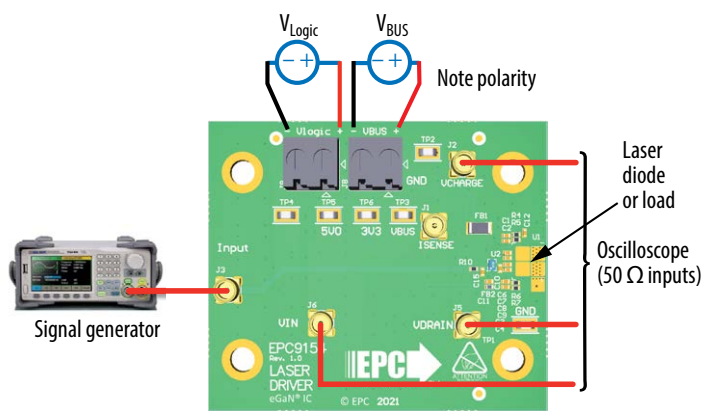


Figure 2: Connection and measurement setup

The IC U2 is controlled via an input pulse that is delivered to MMCX connector J3, which is terminated on the demo board with 50 Ω at the input pin of U2. The EPC21601 is nominally designed for 3.3 V and 5 V CMOS logic levels, but will operate with many 2.5 V CMOS logic devices. When the input goes high, the gate driver stage of U2 turns on the output stage, allowing current flow through the laser diode or load.

The voltage bus for the laser diode or other load is bypassed via the capacitor bank {C22, C23, C24, C25}. This capacitor bank is part of the main power loop inductance, and the layout is designed to minimize the effect of resulting parasitic inductance. The capacitor bank is fed through a relatively small resistance formed by {R10, R11, R12, R13}. The resistance serves to limit the laser or load current continuous value in the case of long pulses, and also serves to damp parasitic resonance of the power loop. The bus is further filtered via capacitors and a ferrite bead to minimize any transients appearing at the V<sub>BUS</sub> (J8) input.

Measurements of key waveforms can be made through the MMCX test points provided. These test points can provide waveform measurements with equivalent bandwidths > 3 GHz. However, they have requirements and properties that differ from most conventional oscilloscope probes. More details on the usage of these test points is provided in section **MEASUREMENT CONSIDERATIONS.**

## OPERATING CONSIDERATIONS

The EPC21601 is specifically designed for high speed, short pulse operation while minimizing the number of external parts required. As a result, there are some additional items and limitations that should be observed. These are discussed below.

### Low V<sub>BUS</sub> operation

The first consideration is that when the IC is operated with V<sub>BUS</sub> < 10 V, the output may miss the one or more of first few pulses of a burst, or the first few pulses may be distorted. In many applications, this may be acceptable, and in such cases, the IC will function with V<sub>BUS</sub> all the way to 0 V.

### Long pulse widths

The second consideration is that the IC is designed for short pulses. It is recommended that the maximum on-time not exceed 1000 ns. Longer pulses are possible, but the output specifications are not guaranteed under such conditions.

### Pulse sources

The EPC21601 supports 3.3 V and 5 V CMOS logic levels, and for many drivers, it will operate with 2.5 V logic levels. However, many logic gates may struggle to drive the 50 Ω input of the EPC9154 demo board. If one wishes to drive the board directly from lower voltage logic, one may need to increase the value of the 50 Ω resistor and use a series termination at the driving gate to prevent ringing on the line. These techniques are covered in many sources. A recommended reference is *High-Speed Digital Design – A Handbook of Black Magic* by Johnson and Graham.

The EPC21601 is intended for high speed operation. While the command input has hysteresis, it is recommended that the signal input waveform has edge transition times < 10 ns.

### Clamping diodes

The EPC9154 is a dual edge control driver. When the IC U2 is turned off, energy stored in the stray power loop inductance can cause a U2 output voltage spike that may exceed the device ratings. In order to reduce the voltage spike, a diode-connected EPC2036 eGaN FET (Q1) can be added to help clamp the drain node. There are also provisions for up to two other clamping diodes D1 and D2. While diodes Q1, D1 and D2 can provide some protection to IC U2 and laser U1, they have parasitic inductance and capacitance that can reduce performance at the very fastest speeds. Hence, they are not populated, and it is left to the user to determine whether they are beneficial for any particular application. D1, D2, and Q2 locations are on the bottom side of the EPC9154 PCB.

### LASER DIODE OR LOAD CONSIDERATIONS

The EPC9154 can be used as is to mount a laser diode or other load. Figure 3 highlights the output pad locations. However, many laser suppliers have different mounting footprints, making it difficult to optimize the performance of the driver and still maintain the desired flexibility. The use of an interposer PCB provides a solution to this problem with a small added performance penalty in the form of an additional 50 pH to 100 pH power loop inductance. The EPC9154 ships with the EPC9989 interposer PCB, shown in Figure 4. The EPC9989 has an assortment of 5 mm square interposer PCBs that can be snapped off the board. These interposers have various footprints on the top side that can accommodate several surface mount laser diodes, an MMCX connector, and several patterns designed to accommodate a wide variety of possible loads. These interposers mount between the EPC9154 and the laser diode or other load. The EPC9989 is updated as new lasers or loads become available, so Figure 4 may not show the latest board. Figure 5 shows an example of an Excelitas SMD laser diode mounted with one of the interposers.

Finally, a ground pad is made available for those who wish to use the board for alternative applications.

The recommended use of the interposer is the following:

1. Apply solder paste to the U1 pads on the EPC9154 PCB.
2. Apply solder paste to the appropriate pads on the top side of the interposer.
3. Place the desired interposer with the bottom side facing the top side of the EPC9154 on the U2 footprint, making sure the pads on the bottom of the interposer align with the footprint on top of the EPC9154 PCB.
4. Place the laser diode or desired load on the interposer, making sure the pads on the bottom of the laser or load align with the footprint on top of the interposer PCB.
5. Reflow the entire assembly with the recommended temperature profile for the solder used. The use of a reflow oven that can meet the recommended soldering specifications is highly recommended. Other reflow methods may also be used based on the experience of the user.

The power loop inductance, including that of the laser diode, is a primary factor that determines the shape of the laser pulse. Considerable effort has been made to minimize power loop inductance while maximizing the choice of laser diode and its orientation. The discharge caps, laser diode or other load, and the eGaN FET must all be mounted in close proximity to each other in order to minimize inductance. As a result, the user must take care not to damage any components when mounting the laser or changing other components in the power loop.

The EPC9154 is capable of driving laser diodes with current pulses can result in peak powers of several tens of watts of optical power. Laser diodes for lidar applications are designed with this in mind, but thermal limitations of the laser package mean that pulse widths, duty cycles, and pulse repetition frequency limitations must be observed. Read laser diode data sheets carefully and follow any manufacturers' recommendations.

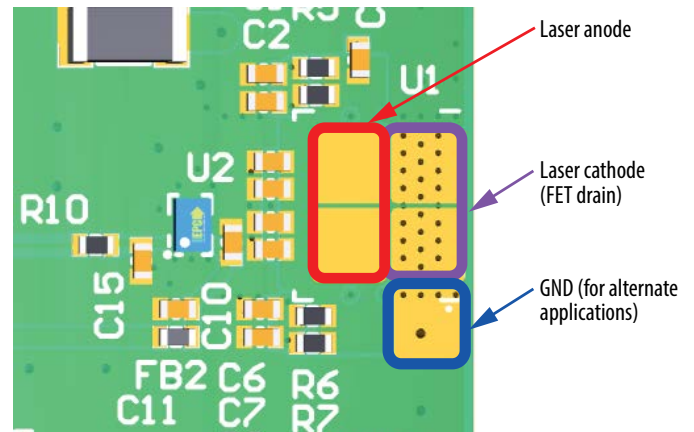


Figure 3: Output terminals of the EPC9154

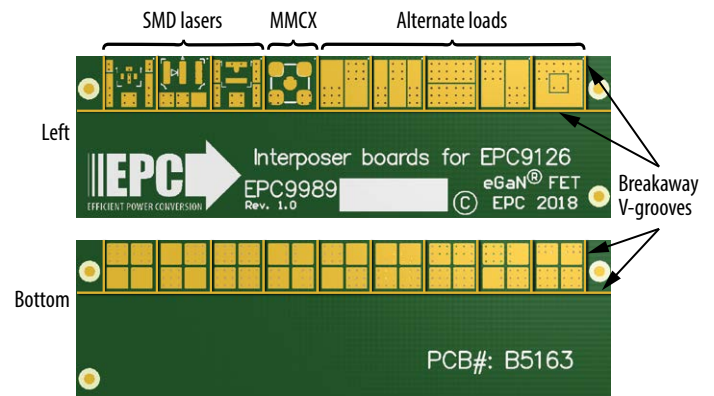


Figure 4: EPC9989 interposer. Note that this board is revised as needed to accommodate new lasers and other loads as needed, so the picture may not show the latest revision.

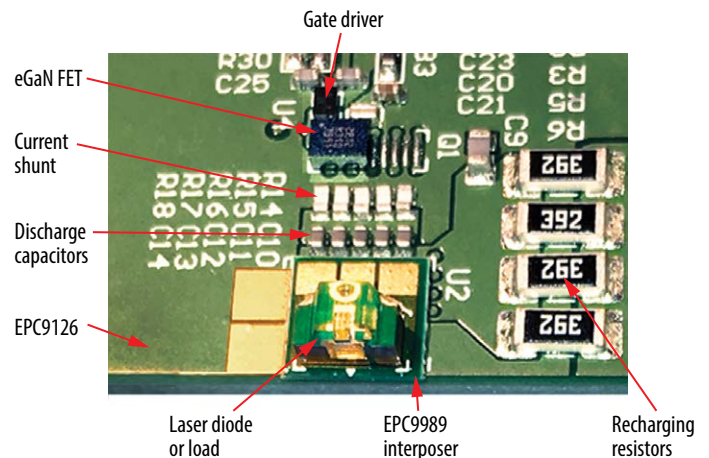


Figure 5: Laser diode mounting on output terminals with interposer. Please note that the photograph is of the EPC9126 demo board, but the same interposers and footprints apply to the EPC9154.

## MEASUREMENT CONSIDERATIONS

MMCX jacks are provided to measure several voltages in the circuit, including EPC21601 IC input (J6) and output (J5) voltages, and the charge voltage of the energy storage cap (J2). All measurement points are designed to be terminated in 50  $\Omega$ , hence when viewing waveforms, the oscilloscope inputs should be set to a 50  $\Omega$  input. Ideally, unused inputs should be also terminated with a 50  $\Omega$  load to prevent the probes from creating additional resonances. The output voltage and the discharge cap sense voltage have on-board terminations to greatly reduce this effect, and in practice, the remaining resonances are small enough to ignore in most applications. It is recommended that the user verify this for their own requirements.

All sense measurement MMCXs, except for the shunt measurement (J1), use the transmission line probe principle to obtain waveform fidelity at sub-ns time scales. They have been verified to produce near-identical results to a Tektronix P9158 3 GHz transmission line probe. As a result of their design, they have a built-in attenuation factor. The impedance of the probes at the measurement node is relatively small ( $\sim 1$  k $\Omega$ ). In order to minimize the effects of the low probe impedance on the operation of the demo board, the output voltage (J5) and capacitor voltage (J2) probes have DC blocking capacitors. As a result, measured pulse waveforms will exhibit droop as pulse widths are increased. The user should keep these factors in mind if accustomed to more conventional oscilloscope probes.

**Rev. 1 of the EPC9154 does not include a current shunt, therefore the current shunt output J1 is not used at this time. A future revision may include this functionality.**

Table 2 summarizes the properties of the MMCX test points for ease of reference.

NOTE. The EPC9154 demonstration board does not have any thermal protection on board.

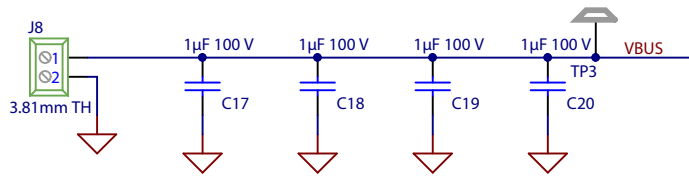
**Table 2: Key properties of the MMCX test points for ease of reference**

Designator	PCB label	Description	Attenuation factor	Internal 50 $\Omega$ termination	Attenuation factor
J2	CAP	Bus capacitor voltage (VCHARGE on schematic)	41 V/V	YES	YES
J1	SHUNT	Not used	Not used	Not used	Not used
J5	V <sub>OUT</sub>	U2 output voltage	41 V/V	YES	YES
J6	V <sub>IN1</sub>	U2 input voltage	20 V/V	NO	NO

**Table 3: Bill of Materials - EPC9154**

Item	Quantity	Reference	Part Description	Manufacturer	Manufacturer Part #
1	12	C1, C2, C3, C4, C6, C7, C8, C9, C10, C11, C12, C16	CAP CER 0.1 $\mu$ F 50 V X7R 0402	TDK	C1005X7R1H104K050BB
2	2	C5, C15	CAP CER 5PF 50 V COG 0402	TDK	C1005COG1H050C050BA
3	4	C17, C18, C19, C20	CAP CER 1 $\mu$ F 100 V X7S 0805	TDK	CGA4J3X7S2A105K125AB
4	2	C21, C26	CAP CER 4.7 $\mu$ F 25 V X5R 0603	TDK	C1608X5R1E475K080AC
5	5	C22, C23, C24, C25, C27	CAP CER 1 $\mu$ F 50 V X7R 0603	Taiyo Yuden	UMK107AB7105KA-T
6	2	D1, D2	DIODE SCHOTTKY 100 V 200 mA SOD523	ST Microelectronics	BAT41KFILM
7	1	FB1	FERRITE BEAD 50 $\Omega$ 1206 12 A 1LN	Murata	BLM31SN500SN1L
8	1	FB2	FERRITE BEAD 330 $\Omega$ 0402 0.7 A 280 m $\Omega$	TDK	MPZ1005S331ET000
9	5	J1, J2, J3, J5, J6		Molex	734152063
10	2	J8, J9	3.81 mm 2 pos. Euro Block	Tyco	1776113-2
11	8	MB1, MB2, MB3, MB4, MB5, MB6, MB7, MB8	5 hole Mouse Bites	N/A	N/A
12	1	Q1	100 V 73 m $\Omega$ 1.7 A	EPC	EPC2036
13	1	R2	RES SMD 49.9 $\Omega$ 1% 1/10 W 0402	Panasonic	
14	1	R3	RES SMD 0 $\Omega$ JUMPER 1/20 W 0201	Panasonic	ERJ-1GE0R00C
15	4	R4, R5, R6, R7	RES SMD 1 $\Omega$ 1% 1/5 W 0402	Vishay Dale	CRCW04021R00FKEDHP
16	2	R8, R15	RES SMD 1K $\Omega$ 1% 1/10 W 0402	Panasonic	ERJ-2RKF1001X
17	1	R10	RES SMD 0 $\Omega$ JUMPER 1/16 W 0402	Yageo	RC0402JR-070RL
18	2	R11, R16	RES SMD 49.9 $\Omega$ 1% 1/20 W 0201	Yageo	RC0201FR-0749R9L
19	1	R18	RES SMD 953 $\Omega$ 1% 1/10 W 0402	Panasonic	ERJ-2RKF9530X
20	2	R23, R24	RES SMD 0 $\Omega$ JUMPER 1/10 W 0402	Panasonic	ERJ-2GE0R00X
21	6	TP1, TP2, TP3, TP4, TP5, TP6		Keystone	5015
22	1	U2	40 V 10 A 60 m $\Omega$ FET with integrated driver, 5 V <sub>DD</sub> 3.3 V logic in	EPC	EPC21601
23	1	U3	5.0 V 250 mA DFN	MicroChip	MCP1703T-5002E/MC
24	1	U4	Linear Regulator 3v3 500 mA 6-WSON (2x2)	Texas Instruments	TLV755XXPDRVR
25	1	R28	Resistor, 10 k $\Omega$ , $\pm$ 5%, 0.063 W, 1/16 W, 0402	Yageo	RC0402JR-0710KL

**Main Supply Input**



**Logic Supply**

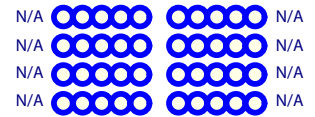
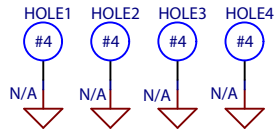
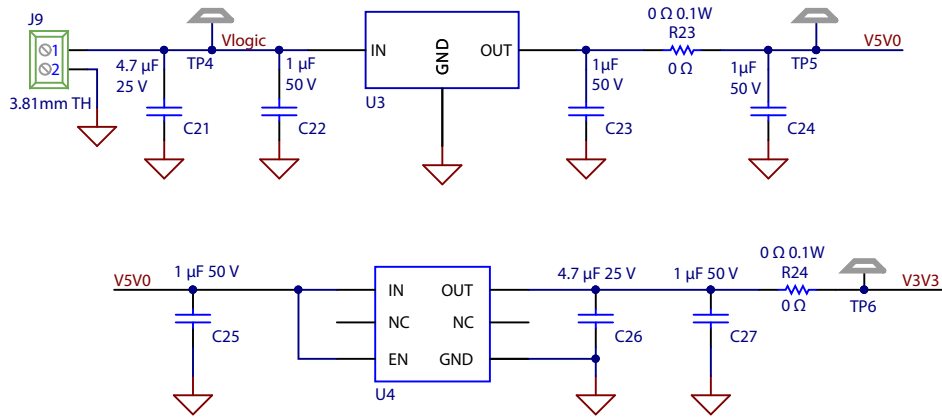


Figure 6: Schematic EPC9154 (part1)

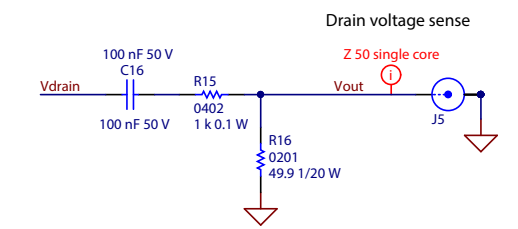
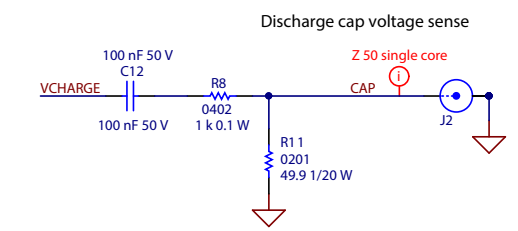
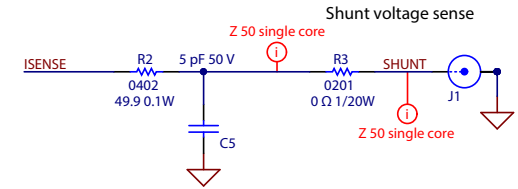
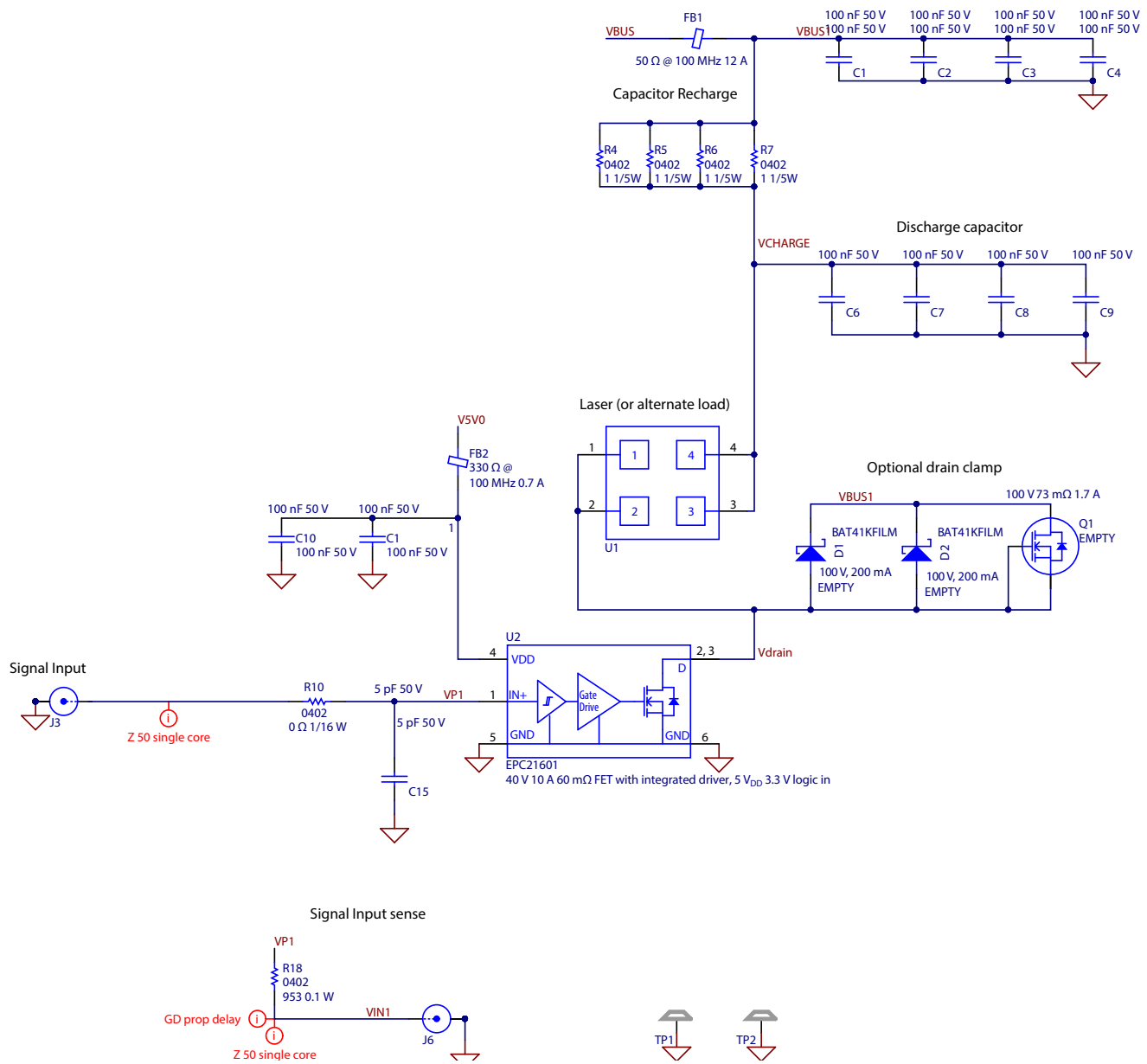


Figure 7: Schematic EPC9154 (part 2)



## For More Information:

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