Test Report: PMP22089

Half-Bridge Point-of-Load Converter Reference Design With GaN Technology

Texas Instruments

Description

The board is a redesign of the LMG5200POLEVM-10 EVM. It modifies the inboard transformer turns ratio from 5:1 to 3:1 to reduce input the range. The original EVM was designed to evaluate the LMG5200 GaN half-bridge power stage and the TPS53632G half-bridge point-of-load (PoL) controller. This board implements the converter as a single-stage hard-switched half-bridge with a current-doubler rectifier. The board supports input voltages from 24 V to 32 V and output voltages between 0.5 V to 1.0 V with continuous output currents up to 40 A. This topology efficiently supports the high step-down ratio while providing significant output current and controllability.

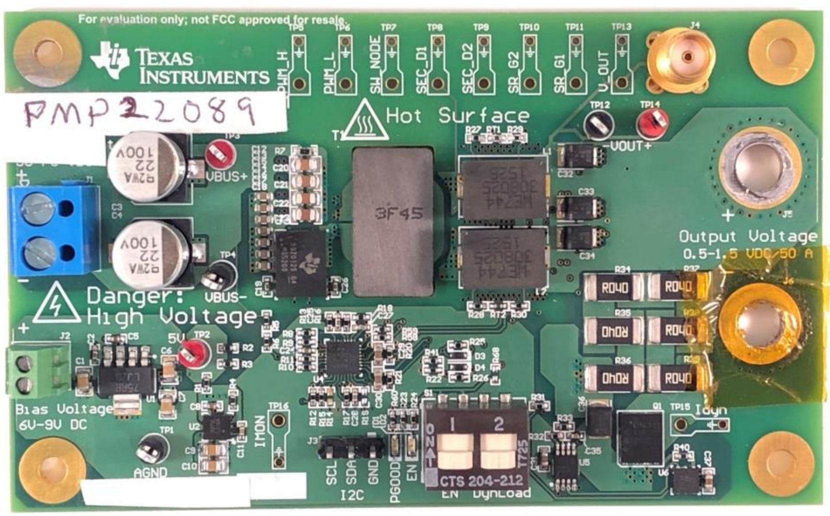

Figure 1 Top of Board

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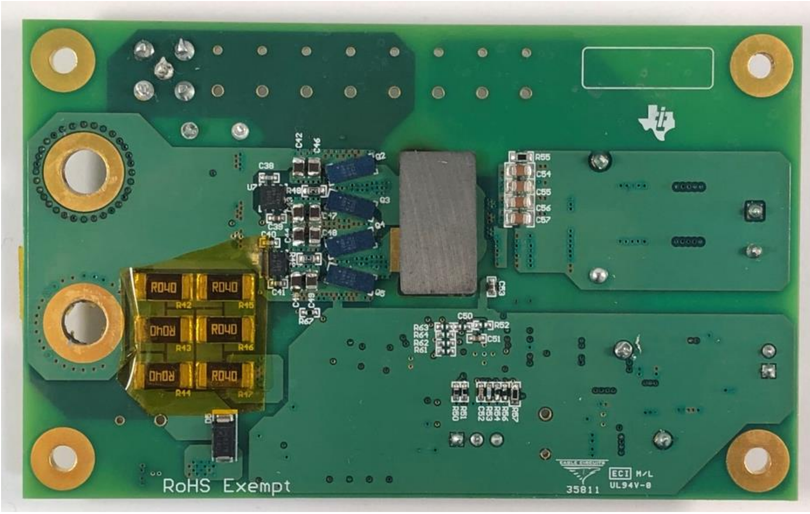

Figure 2 Bottom of Board

1 Test Prerequisites

1.1 Voltage and Current Requirement

PARAMETER	SPECIFICATIONS
Input Voltage Range (J1)	24 Vdc – 32Vdc
Output Voltage	0.5 – 1.0 Vdc
Output Current	40A
TPS53632G Switching Frequency	600kHz

Table 1 System Specifications

1.2 Turning on the Board and Operation

1. Connect the input and output supplies as shown in Figure 4, but do not power them on yet.
2. Connect kelvin voltage sense (from multimeters) to test points TP3, TP4, TP12 and TP14.
3. Ensure the enable (EN) switch is set to off.
4. Connect and power the bias supply between 6 V and 9 V. An on-board LDO provides 5 V and 3.3 V to the power and control circuitry.
5. Power up the input supply and set to the desired input voltage. Set the current limit to 2A.
6. Slide the EN switch to the on position to start the converter. The output voltage will ramp up and the PGOOD LED should light to indicate the output voltage is in regulation.
7. Enable the electronic load and set to the desired load current
8. To use the onboard dynamic load, slide the DynLoad switch to the on position to enable the 120mOhm dynamic Load. This adds 120mOhms in parallel to the load. It can be used isolated or with another load as a base current.

1.3 Turning off the Board

1. Slide the EN switch to the off position.
2. Disable the input voltage supply.
3. Disable the electronic load.
4. Disable the bias supply.

1.4 Notes

- If the converter shuts off due to UVP or over-current protection (OCP), the controller IC must be restarted to re-enable the converter. Shut down the converter by following the steps in Section 1.3, then restart the converter according to the steps in Section 1.2.

- To vary the output voltage, the I2C bus must be used to communicate with the TPS53632G. Consult the user guide for the TPS53632G for the necessary VID protocol. The EVM uses the TPS53632G’s default I2C address. Device Address: 40h. Program Register 00h with 28h for 0.65V, and 3C for 0.85V.

1.5 I2C Programming

1.5.1 Software Download

1. Download the latest version of the Fusion Digital Power Design software from ti.com. It can be found at http://www.ti.com/tool/FUSION_DIGITAL_POWER_DESIGNER.
2. Run the downloaded installation application. Follow the installation instructions. This will install the driver and Texas Instruments Fusion Digital Power Design tool.
3. The I2C GUI that is needed for communicating to the EVM can be accessed from the Windows Programs menu under Texas Instruments.
4. Select the **SMBus & I2C & SAA Debug Tool**. The tool can be launched directly from here or for easier access going forward, it is recommended that the user right-click on the SMBus & I2C & SAA Debug Tool and choose “Pin to Taskbar” or “Pin to Start Menu”.

1.5.2 USB-I2C Adapter Setup

1. Connect the host computer to the USB-TO-GPIO adaptor with the USB-to-Mini-USB cable.
2. Connect the USB-TO-GPIO adaptor at the I2C jumper of the EVM (J3) as indicated by the "SDA", “SCL”, and “GND” labels. It may be necessary to use jumpers to connect the supplied GPIO cable to the pins on the board.

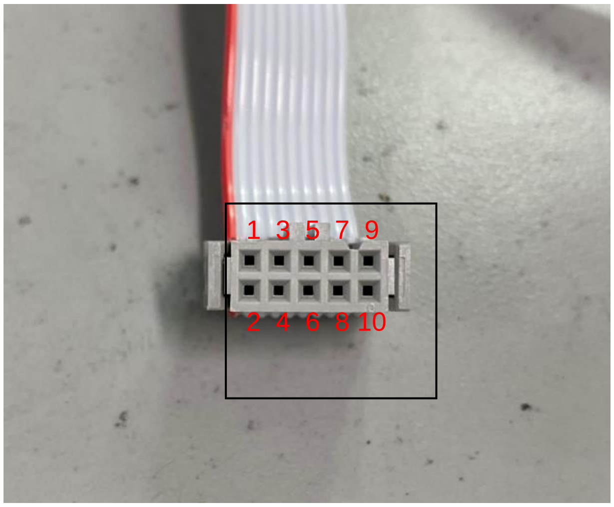

Figure 3 GPIO Cable Pinout (6: GND, 9: SCL, 10: SCA)

3. Provide the bias supply to the EVM. The I2C communication is active when the 6V – 9V bias supply is on, providing 5V to the TPS53632G.

1.5.3 Read and Write Procedure

1. Enter the correct address (Default I2C device address is 40h) of TPS53632G in either box (decimal or hexadecimal).
2. To read data from a specific register address, select the I2C Read panel and enter the address of the register you want to read in the Cmd box.
3. Click “Send”.
4. Ensure you see an ACK (NACK will indicate incorrect I2C communications).
5. Data will be displayed in 2-digit Hexadecimal.
6. To write data to a specific register address, select the I2C Write panel and enter the address in the box.
7. Enter the data to be written in hexadecimal.
8. Click “Send” in that same panel.
9. Ensure you see an ACK (NACK will indicate incorrect I2C communications).

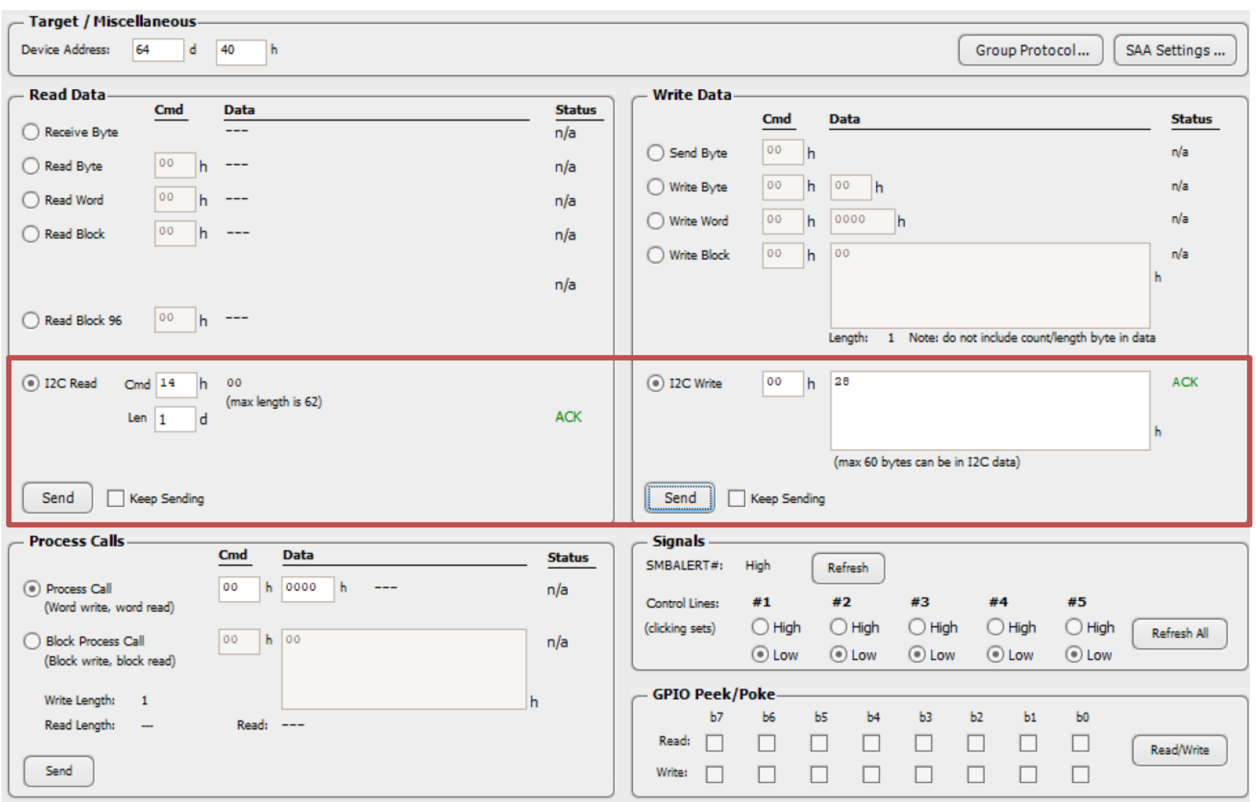

Figure 4 I2C GUI

2 Testing and Results

2.1 Efficiency Graphs

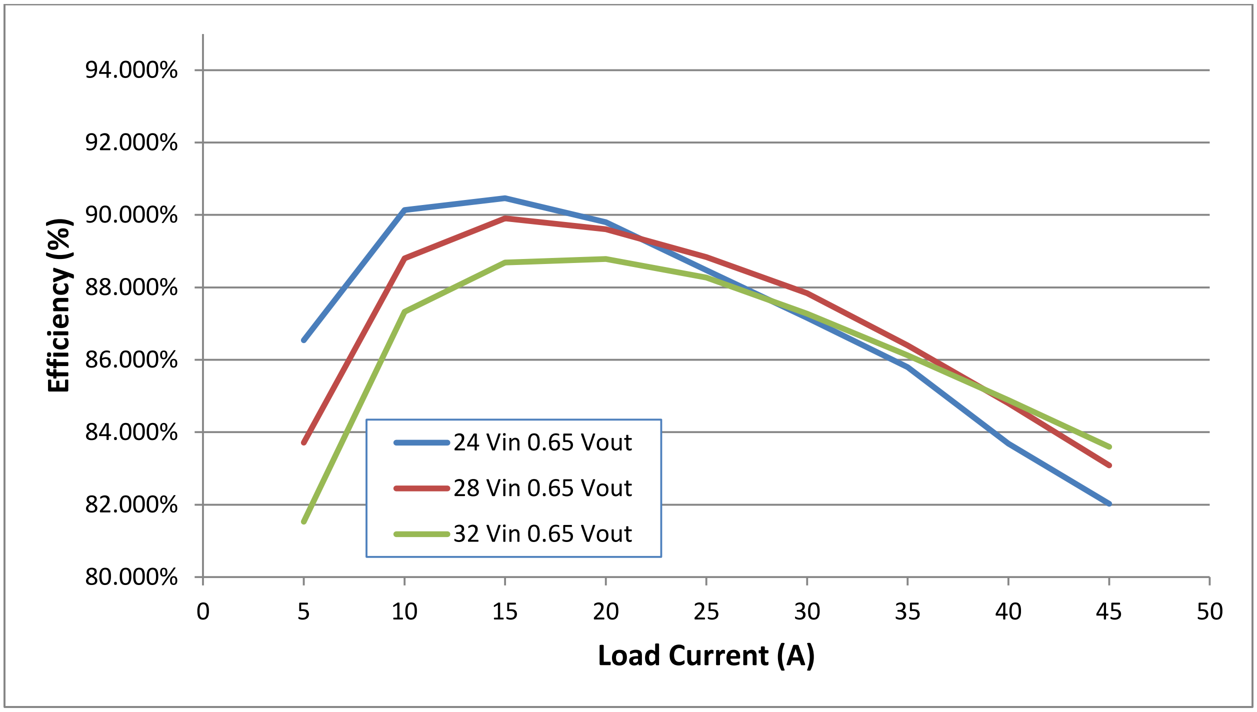

Figure 4 Efficiency graph for 0.65 Vout

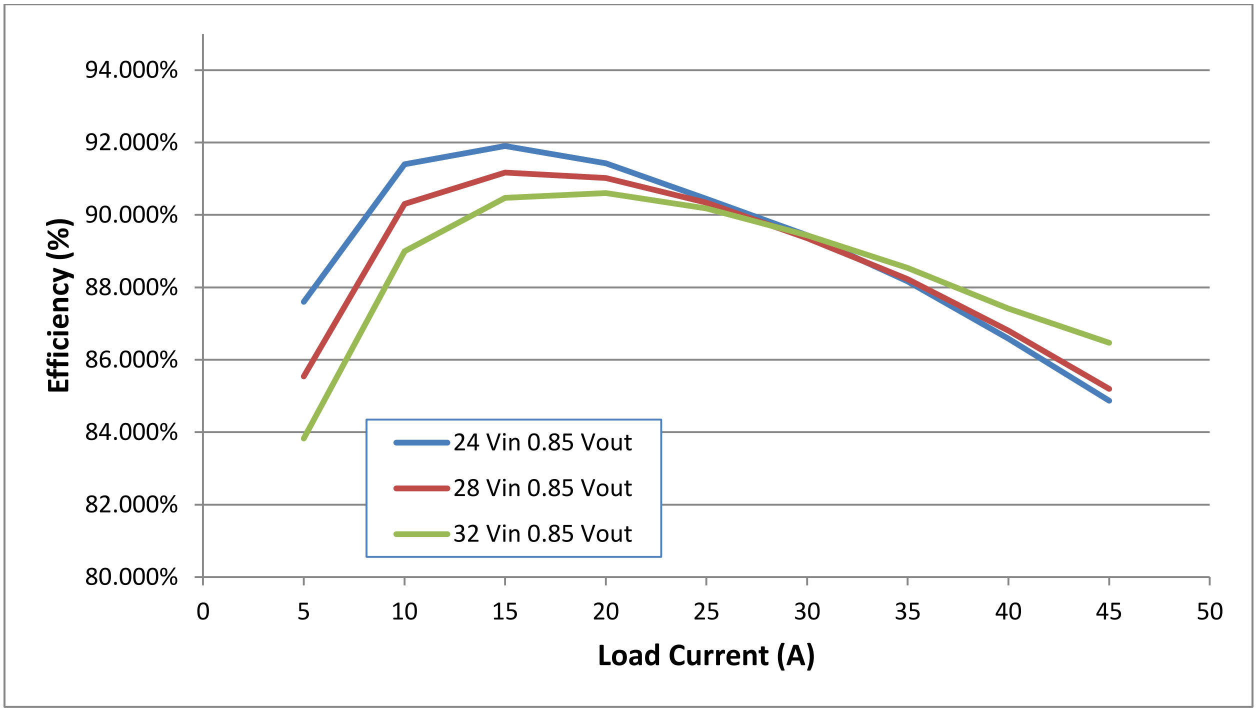

Figure 5 Efficiency graph for 0.85 Vout

2.2 Efficiency Data

Target Vin	Target Vout	Input Voltage (V)	Input Current (A)	Input Power (W)	Output Voltage (V)	Output Current (A)	Output Power (W)	Efficiency (%)	Power Loss (W)
24V	0.65V	24.000	0.156	3.732	0.646	5.000	3.230	86.535%	0.503
		24.000	0.297	7.128	0.643	10.000	6.425	90.137%	0.703
		24.000	0.442	10.596	0.639	15.000	9.585	90.459%	1.011
		24.000	0.590	14.160	0.636	20.000	12.716	89.802%	1.444
		24.000	0.744	17.859	0.632	25.000	15.800	88.471%	2.059
		24.000	0.902	21.658	0.629	30.000	18.876	87.156%	2.782
		24.000	1.068	25.620	0.628	35.000	21.980	85.792%	3.640
		24.000	1.240	29.755	0.623	40.000	24.900	83.683%	4.855
		24.000	1.415	33.960	0.619	45.000	27.855	82.023%	6.105
	0.85V	24.000	0.201	4.829	0.846	5.000	4.230	87.599%	0.599
		24.000	0.384	9.223	0.843	10.000	8.430	91.400%	0.793
		24.000	0.571	13.704	0.840	15.000	12.594	91.900%	1.110
		24.000	0.762	18.288	0.836	20.000	16.720	91.426%	1.568
		24.000	0.958	22.997	0.832	25.000	20.800	90.447%	2.197
		24.000	1.159	27.816	0.829	30.000	24.879	89.441%	2.937
		24.000	1.366	32.784	0.826	35.000	28.903	88.162%	3.881
		24.000	1.583	37.992	0.822	40.000	32.894	86.580%	5.098
		24.000	1.809	43.416	0.819	45.000	36.846	84.867%	6.570
28V	0.65V	28.000	0.138	3.858	0.646	5.000	3.230	83.713%	0.628
		28.000	0.259	7.241	0.643	10.000	6.430	88.802%	0.811
		28.000	0.381	10.676	0.640	15.000	9.599	89.904%	1.078
		28.000	0.507	14.196	0.636	20.000	12.720	89.603%	1.476
		28.000	0.636	17.814	0.633	25.000	15.825	88.837%	1.989
		28.000	0.768	21.504	0.630	30.000	18.888	87.835%	2.616
		28.000	0.906	25.368	0.626	35.000	21.917	86.396%	3.451
		28.000	1.049	29.372	0.623	40.000	24.908	84.802%	4.464
		28.000	1.198	33.544	0.619	45.000	27.869	83.080%	5.676
	0.85V	28.000	0.177	4.945	0.846	5.000	4.230	85.544%	0.715
		28.000	0.333	9.324	0.842	10.000	8.420	90.305%	0.904
		28.000	0.493	13.804	0.839	15.000	12.585	91.169%	1.219
		28.000	0.656	18.368	0.836	20.000	16.718	91.017%	1.650
		28.000	0.823	23.038	0.833	25.000	20.813	90.338%	2.226
		28.000	0.994	27.835	0.829	30.000	24.873	89.359%	2.962
		28.000	1.170	32.754	0.826	35.000	28.900	88.231%	3.855
		28.000	1.353	37.881	0.822	40.000	32.884	86.808%	4.997
		28.000	1.544	43.243	0.819	45.000	36.842	85.196%	6.402
32V	0.65V	32.000	0.124	3.962	0.646	5.000	3.230	81.533%	0.732
		32.000	0.230	7.360	0.643	10.000	6.427	87.323%	0.933
		32.000	0.338	10.813	0.639	15.000	9.590	88.687%	1.223
		32.000	0.448	14.326	0.636	20.000	12.720	88.787%	1.606
		32.000	0.560	17.920	0.633	25.000	15.818	88.267%	2.103
		32.000	0.676	21.632	0.629	30.000	18.879	87.273%	2.753
		32.000	0.795	25.440	0.626	35.000	21.910	86.124%	3.530
		32.000	0.917	29.344	0.623	40.000	24.908	84.883%	4.436
		32.000	1.042	33.344	0.619	45.000	27.873	83.592%	5.471
	0.85V	32.000	0.158	5.046	0.846	5.000	4.230	83.822%	0.816
		32.000	0.296	9.469	0.843	10.000	8.427	88.998%	1.042
		32.000	0.435	13.917	0.839	15.000	12.591	90.473%	1.326
		32.000	0.577	18.454	0.836	20.000	16.720	90.602%	1.734
		32.000	0.721	23.085	0.833	25.000	20.818	90.178%	2.267
		32.000	0.869	27.808	0.829	30.000	24.870	89.435%	2.938
		32.000	1.020	32.646	0.826	35.000	28.903	88.533%	3.743
		32.000	1.176	37.632	0.822	40.000	32.896	87.415%	4.736
		32.000	1.332	42.624	0.819	45.000	36.855	86.465%	5.769

Table 2 Efficiency Table

2.3 Thermal Image

All thermal images are taken after a 10 minute soak with no airflow.

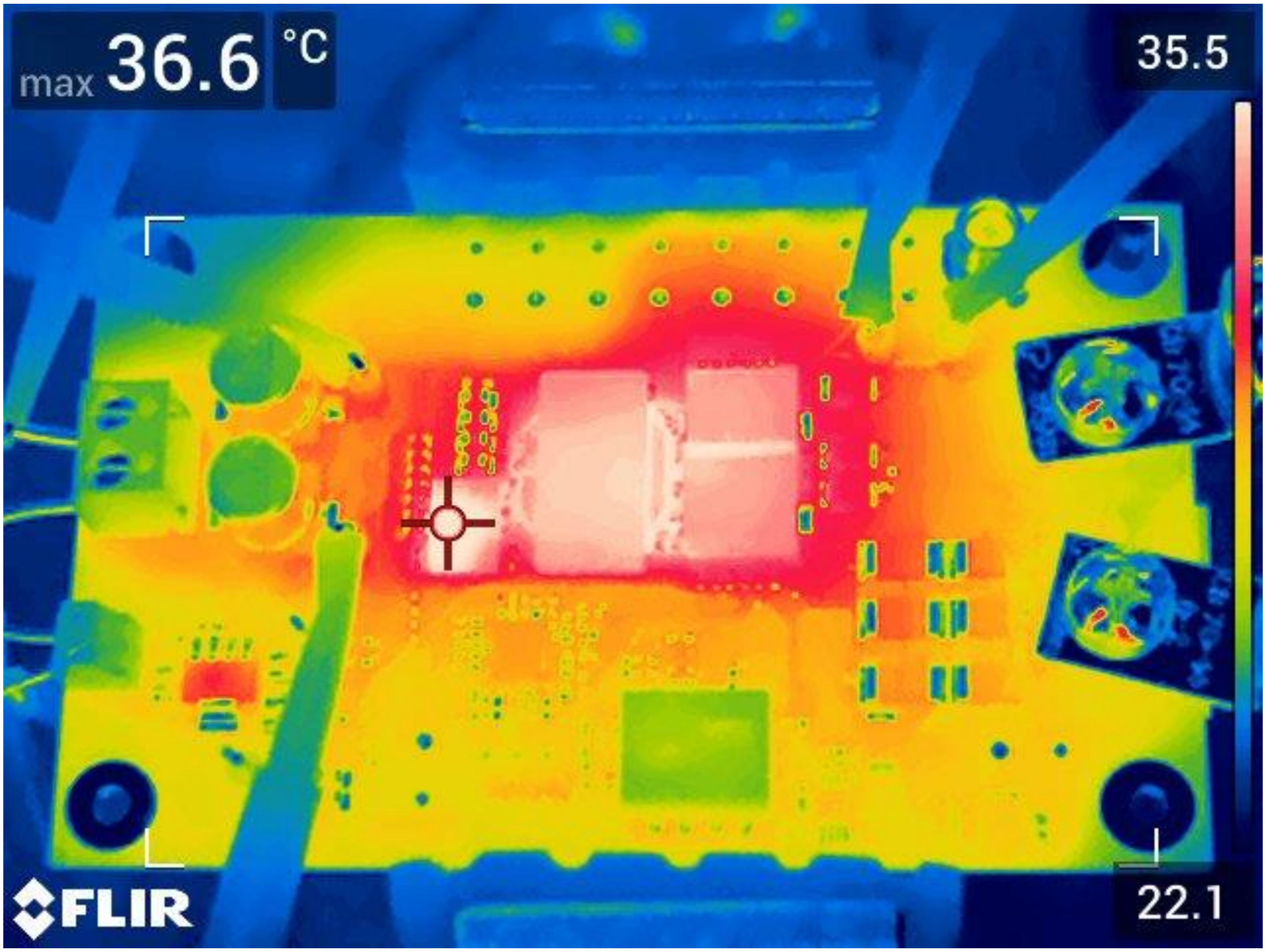

Figure 3 Top of board. Conditions were as follows: Vin = 28 V, Vout = 0.85 V, Load = 14 A

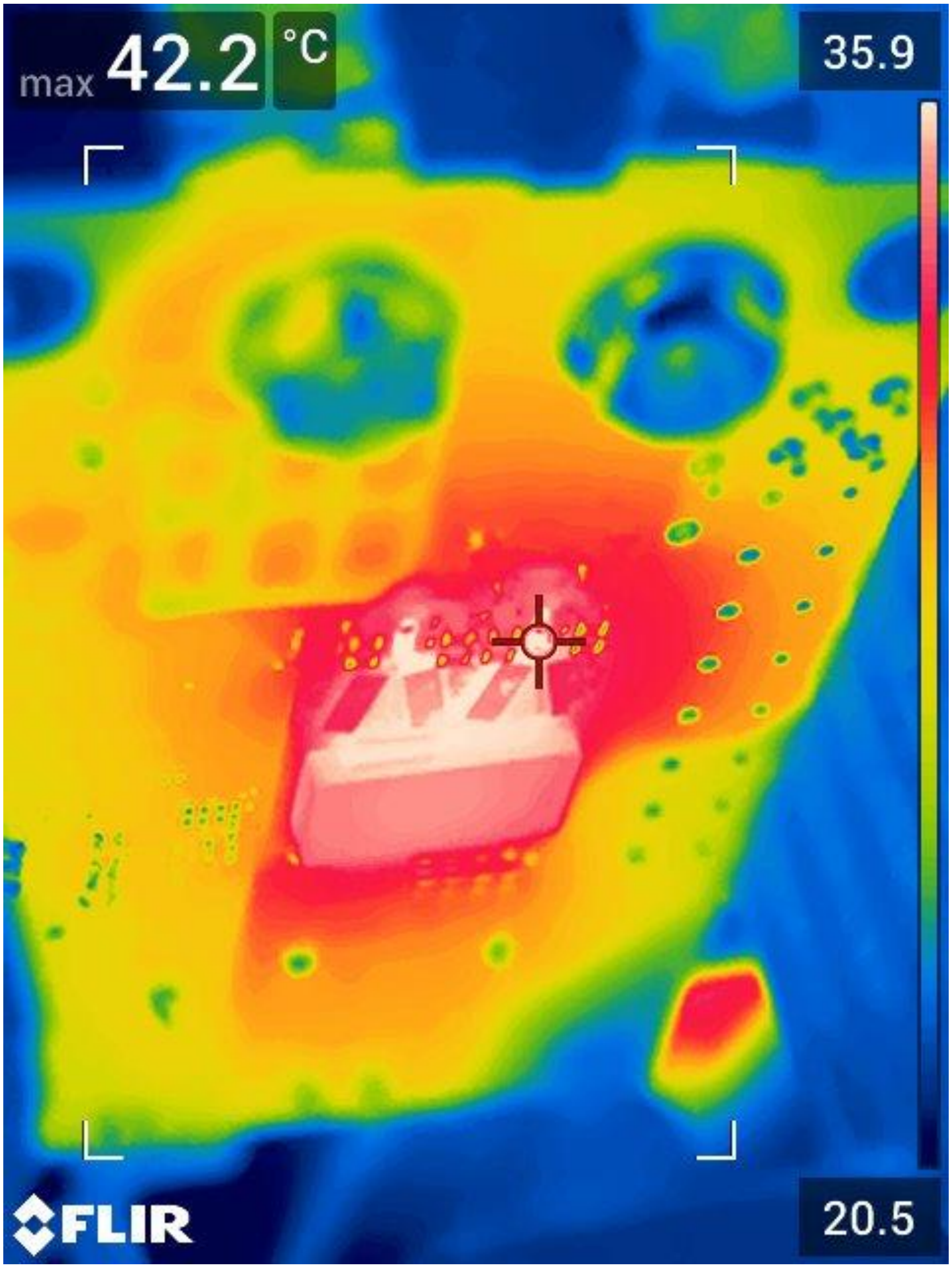

Figure 4 Bottom of Board**.** Conditions were as follows: Vin = 28 V, Vout = 0.85 V, Load = 14 A

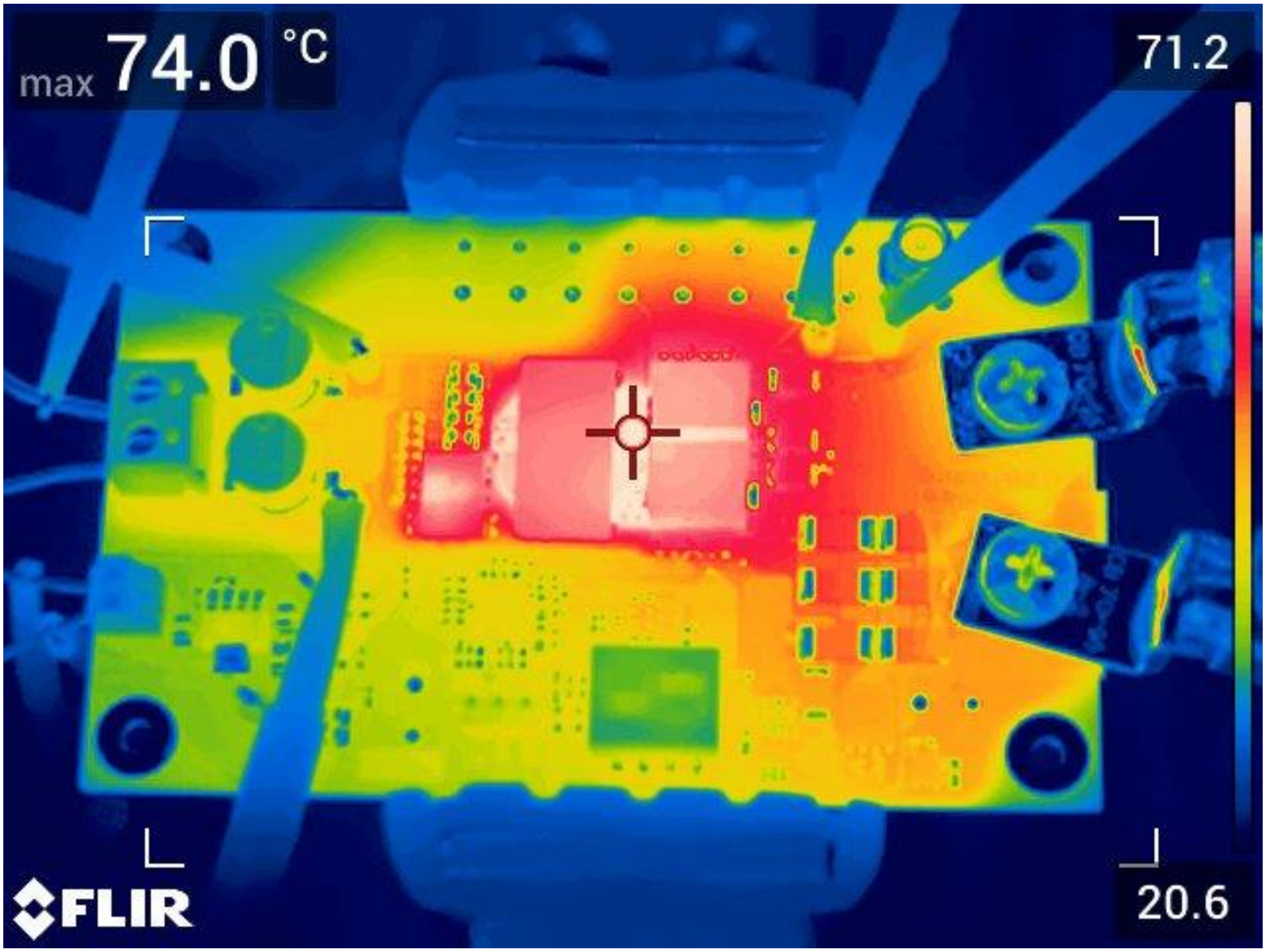

Figure 5 Conditions were as follows: Vin = 32 V, Vout = 0.65 V, Load = 40 A

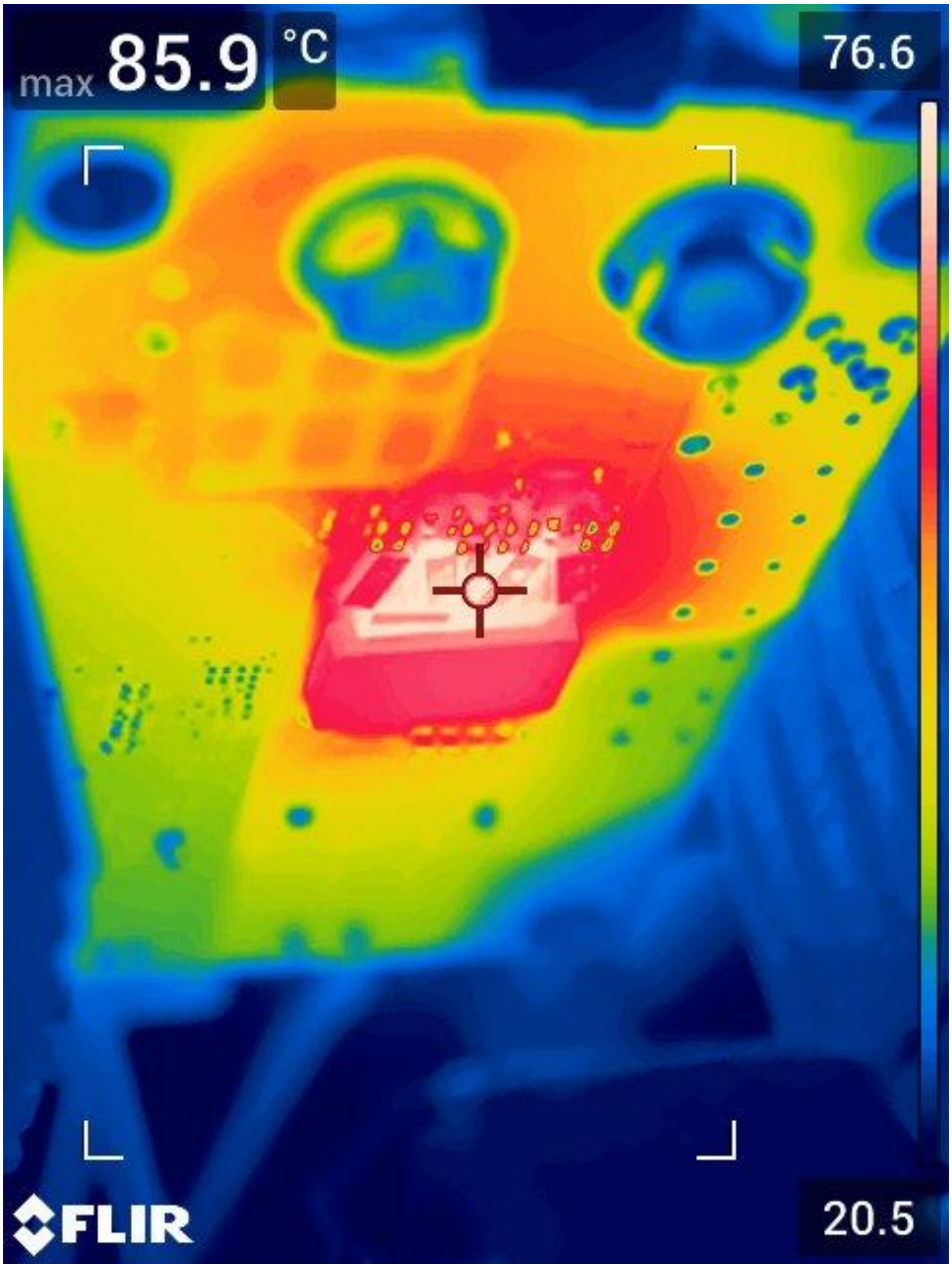

Figure 6 Conditions were as follows: Vin = 32 V, Vout = 0.65 V, Load = 40 A

3 Waveforms

3.1 Output Voltage Ripple

Measurements were taken using the SMA connector with a 50Ohm termination.

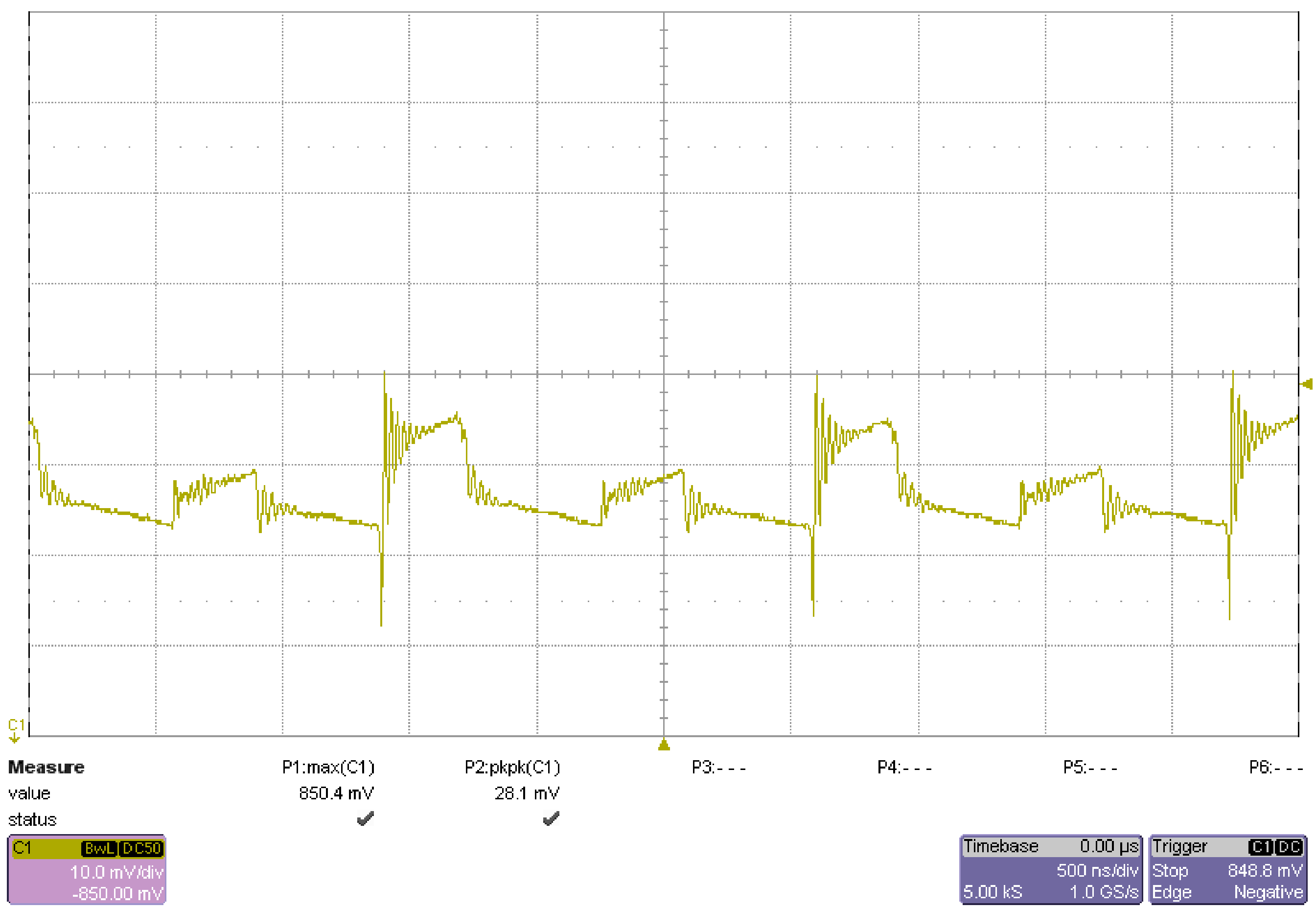

Figure 7 Vin = 28 V, Vout = 0.85 V, ILoad = 14 A.

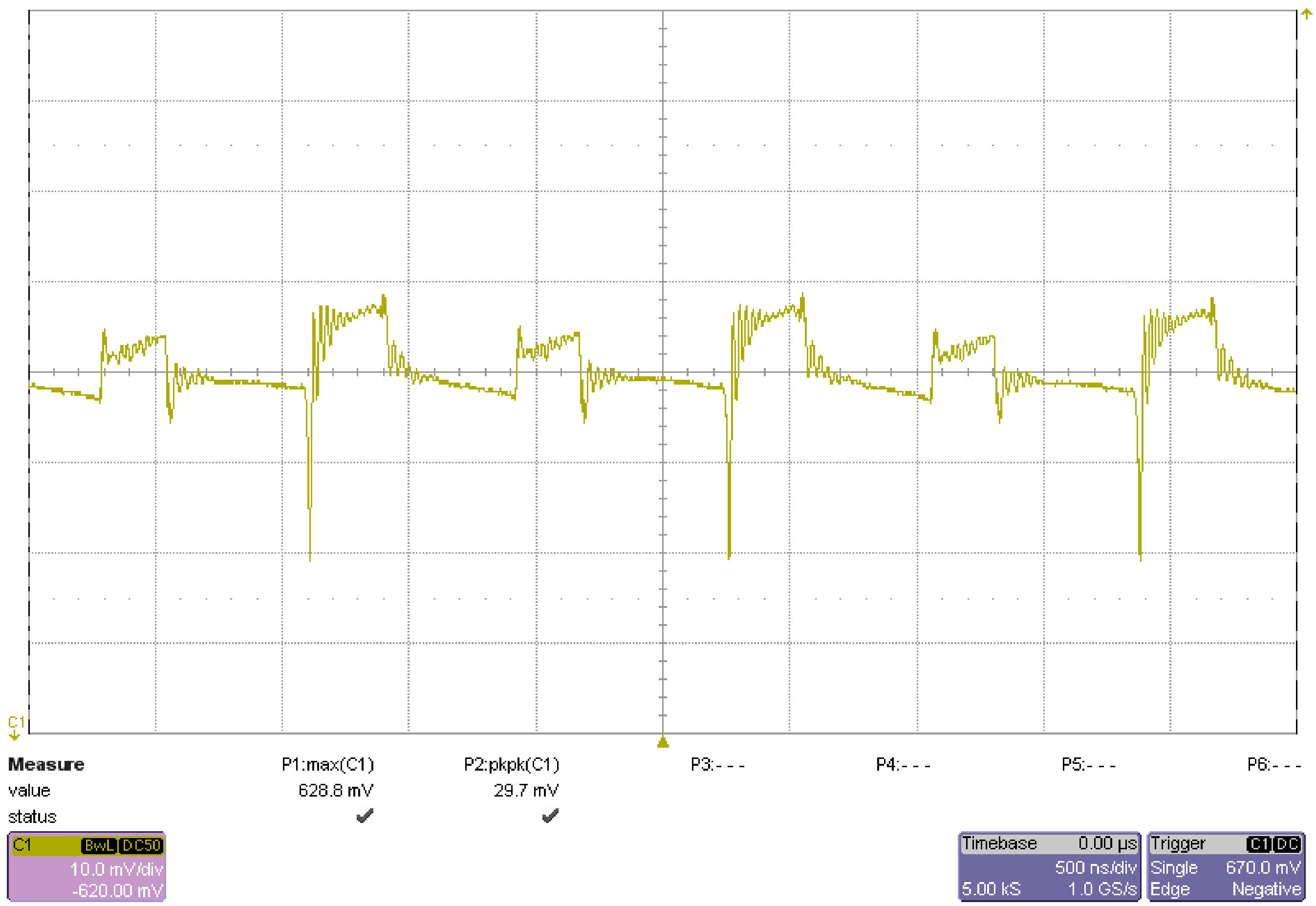

Figure 8 Vin = 28 V, Vout = 0.65 V, ILoad = 40 A

3.2 Load Transients

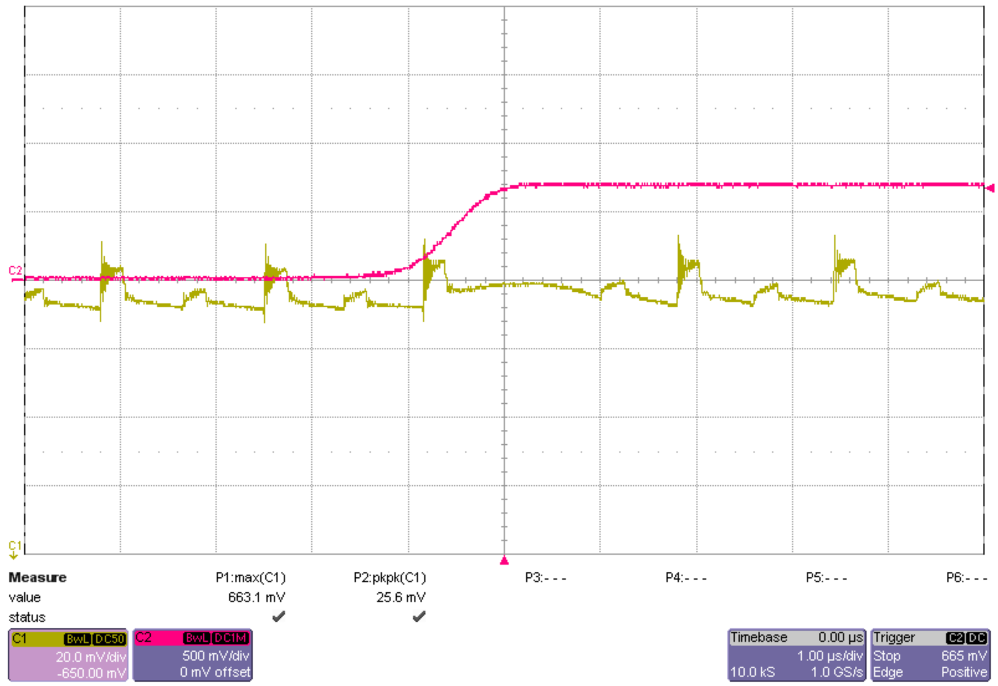

Figure 9 Load transient used was the on-board dynamic load. Capture shows the Ramp up load transient response. Load goes between 0 A and 5.41 A. Vin = 28 V and Vout = 0.65 V.

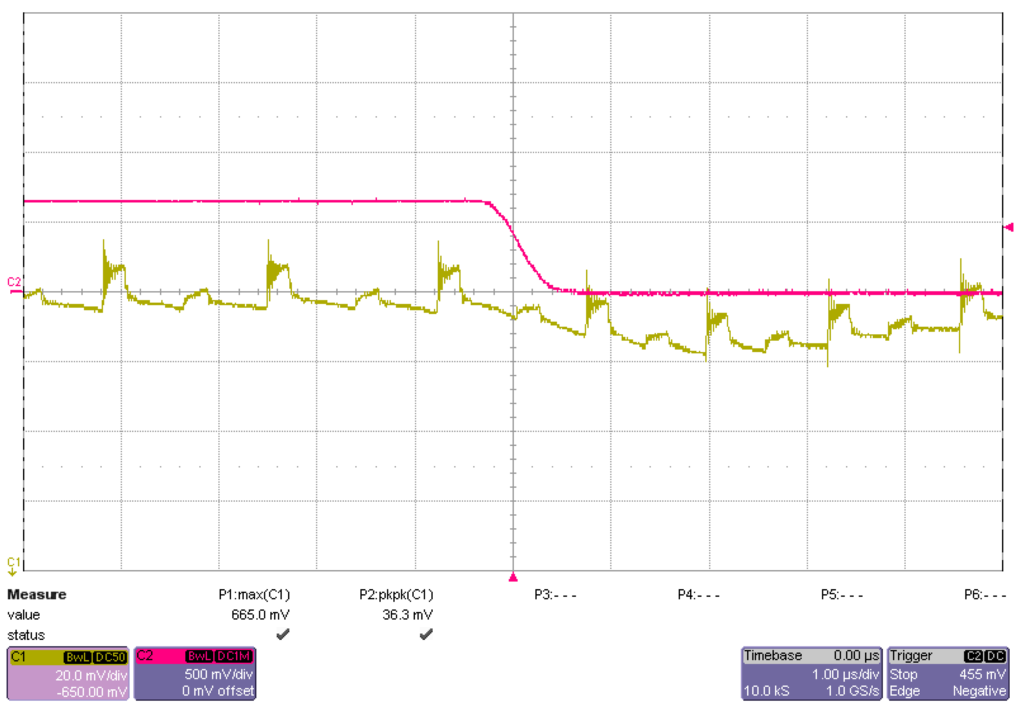

Figure 10 Load transient used was the on-board dynamic load. Capture shows the Ramp up load transient response. Load goes between 0 A and 5.41 A. Vin = 28 V and Vout = 0.65 V.

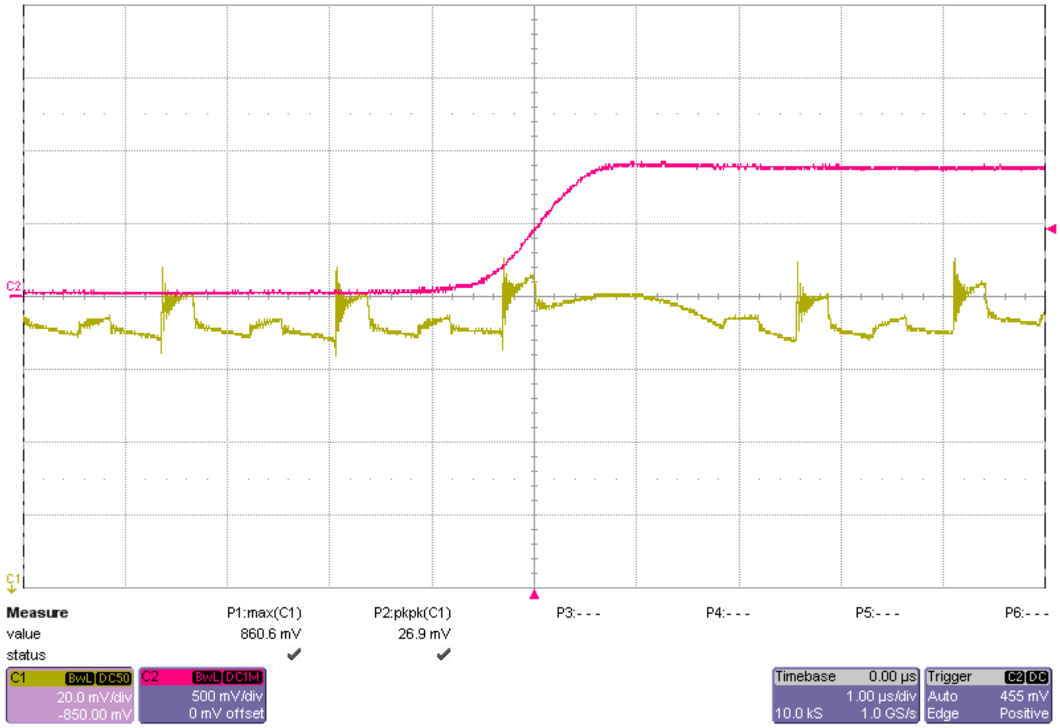

Figure 11 Load transient used was the on-board dynamic load. Capture shows the Ramp up load transient response. Load goes between 0 A and 7.08 A. Vin = 28 V and Vout = 0.85 V.

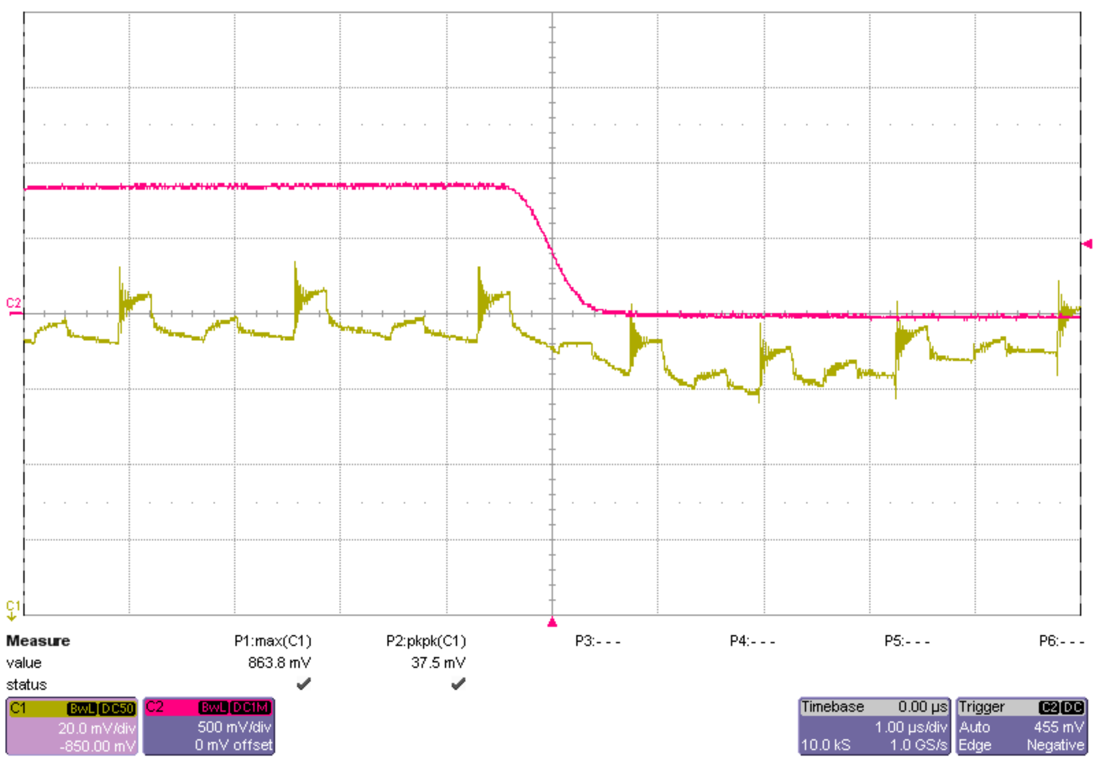

Figure 12 Load transient used was the on-board dynamic load. Capture shows the Ramp up load transient response. Load goes between 0 A and 7.08 A. Vin = 28 V and Vout = 0.85 V.