Test Plan Heating Board

Made on March 31st, 2025

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Date: 7th of april 2025
PCB nr.: 1

Used devices

Write down below the serial number of the required devices for testing

Benodigdheden	***Typenummer***
Multimeter	EDU34450A
Power supply	EDU36311A
Load	2x 200 Ω THT resistors in parallel
Oscilloscope	DSOX1204G

Hardware testing

Assembly

Test	***Channel 1***	***Channel 2***	***Channel 3***	***Channel 4***
Quality of the soldering	Quality of the soldering was good, connection between ground and J3 missing because of a broken pin.			
Orientation IC's	Correct.			
Resistor R11 (mΩ)	101 ± 0.1	101.2 ± 0.1	100.5 ± 0.1	100.6 ± 0.05
No short between 3V3 and GND	Correct.			
No short between input and GND	Correct.			
No short between output and ground GND	Correct	Correct	Correct	Correct
Resistor between 3V3 and SDA (kΩ)	2.199			
Resistor between 3V3 and	2.197			

SCL (kΩ)	

Power supply

Place 3.3V on J2 and continue the measurements

Test	***Channel 1***	***Channel 2***	***Channel 3***	***Channel 4***
Measure voltage on IC's	3.3V	3.3V	3.3V	3.3V
Measure voltage on TP2 (A1)	3.3V	3.3V	0V	0V
Measure voltage on Tp3 TP3 (A0)	3.3V	0V	3.3V	0V

MOSFETs

Test	***Channel 1***	***Channel 2***	***Channel 3***	***Channel 4***
Resistor between TP6 and VOUT, PWM = 0V	Open	Open	Open	Open
Resistor between TP6 and VOUT, PWM = 3V3, 0.1 A load	93 mΩ	93.5 mΩ	93.8 mΩ	92 mΩ

Function testing

INA219

Connect the board through the J3 or J4 to the Arduino to test the communication with the INA219 chips.

Test	***Channel 1***	***Channel 2***	***Channel 3***	***Channel 4***
Test if I2C communication is present	Correct.	Correct.	Correct.	Correct.
Measured current @ 0.1 A (assuming 0.1 Ω resistor)	0.102 ± 0.001 A	0.102 ± 0.001 A	0.099 ± 0.001 A	0.100 ± 0.001 A

MOSFETs

Now also connect the J2 to the Arduino to test the MOSFETs. Pull 100 mA with the load. PWM frequency is 5 kHz, duty cycle is at 25%

Test	***Channel 1***	***Channel 2***	***Channel 3***	***Channel 4***

Measure Vout with an oscilloscope, is there a neat squarewave at the output?	Correct.	Correct.	Correct.	Correct.

General remarks

Some issues were encountered during testing. Both the issue and the solution will be discussed in this section.

Current sensor measurements in combination with PWM

Due to the use of PWM, the current sensor will sometimes measure no current, and at other moments all the current. This results in an inconsistent measurement. To solve this, the frequency of the PWM is increased and the amount of samples per measurement is increased. This resulted in a better average measurement, which resulted in a current that was of similar accuracy as the power supply.

Used settings:
- 12 bit bus resolution
- 128 samples per measurement
- 5 kHz PWM frequency

Turn-off time PMOS

With the initial testing, at a frequency of around 5 kHz, the turnoff speed of the mosfet was slower than expected. This resulted in the actual duty cycle not properly aligning with the input duty cycle. Because it was slower than expected, the output duty cycle ended up being higher than the input duty cycle which should not be the case. This effect is shown in figures 1 and 2. To prevent this effect from happening, firstly R13 was set to 0Ω and R12 was changed to a 2.2kΩ resistor. Changing these resistors should lead to the Mosfet discharging faster, thus reducing the turn-off time. This seemed to resolve the issue, however, when measuring the 4th channel the current sensor values were producing confusing results. We believe this was caused by some EMI problems by very high turn-off or turn-on times. Because of this, the 0Ω resistor was changed to a 2.2kΩ resistor which solved the problem. This resulted in figures 3 to 6.

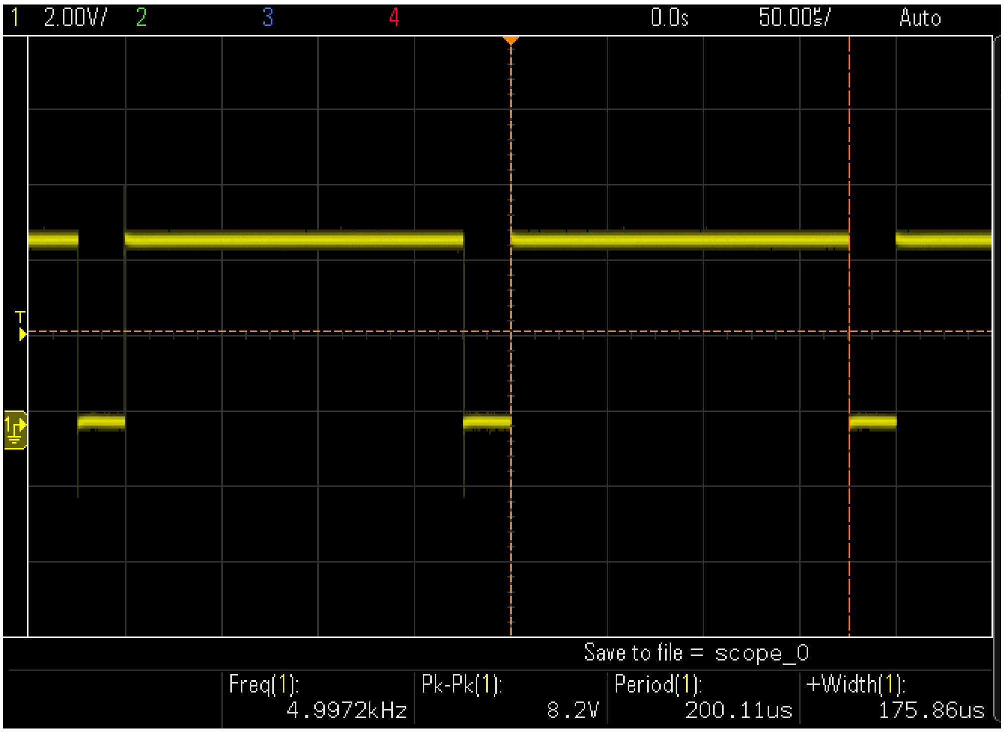

Figure 1: Oscilloscope output of the PWM signal at the PWM input of the board. Duty cycle ~ 88%, frequency is 5 kHz.

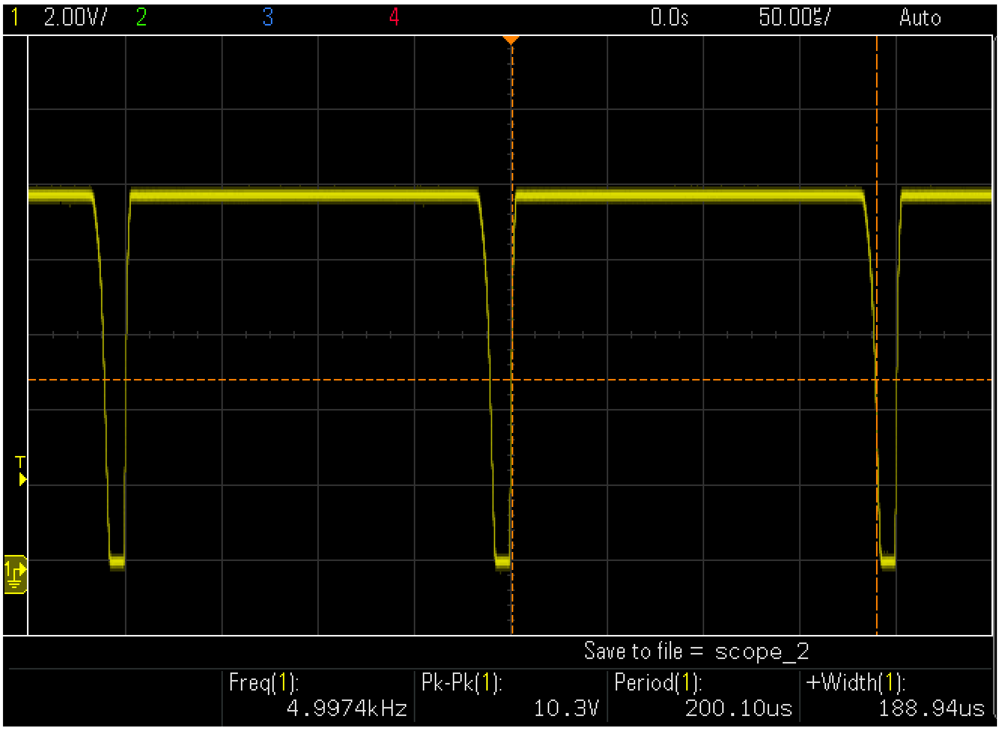

Figure 2: Oscilloscope output of the output voltage of the board. Input PWM duty cycle ~ 88% and the frequency is 5 kHz. The duty cycle of the output voltage is ~ 94%.

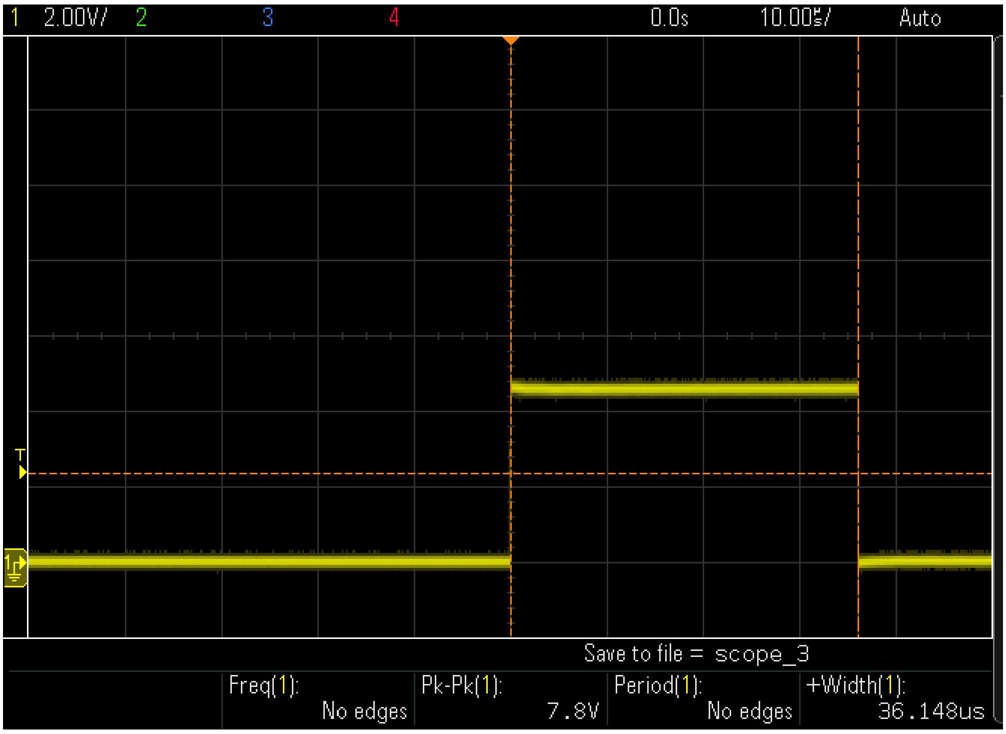

Figure 3: Oscilloscope output of the PWM signal at the PWM input of the board. Duty cycle ~ 18%, frequency is 5 kHz.

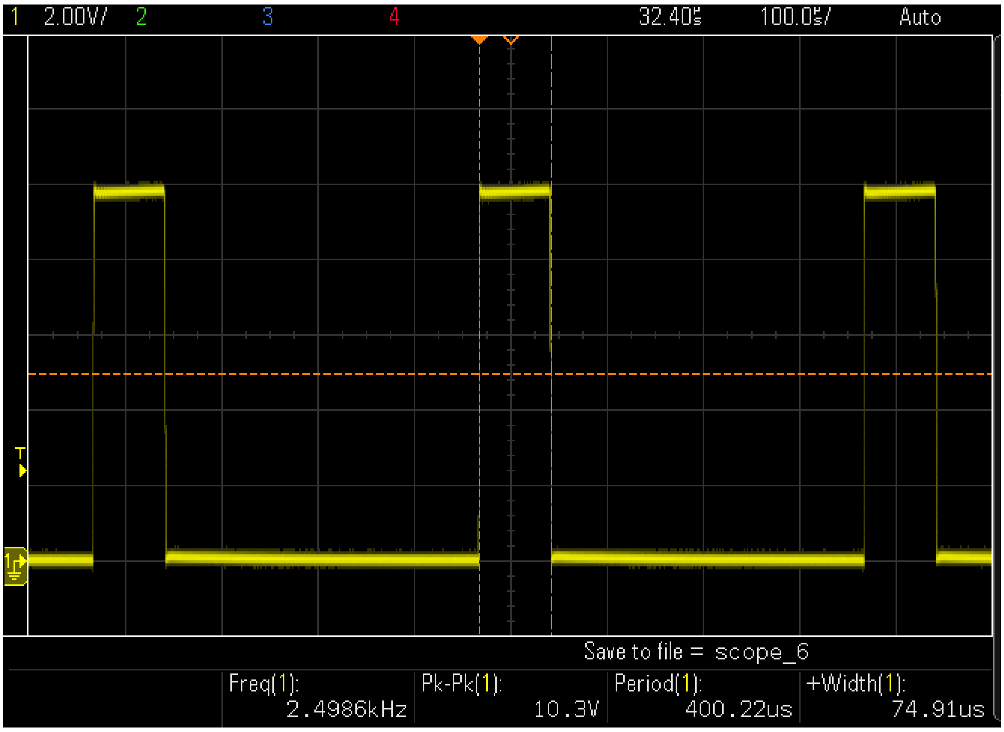

Figure 4: Oscilloscope output of the output voltage of the board. Input PWM duty cycle ~ 18% and the frequency is 2.5 kHz. The duty cycle of the output voltage is ~ 18%.

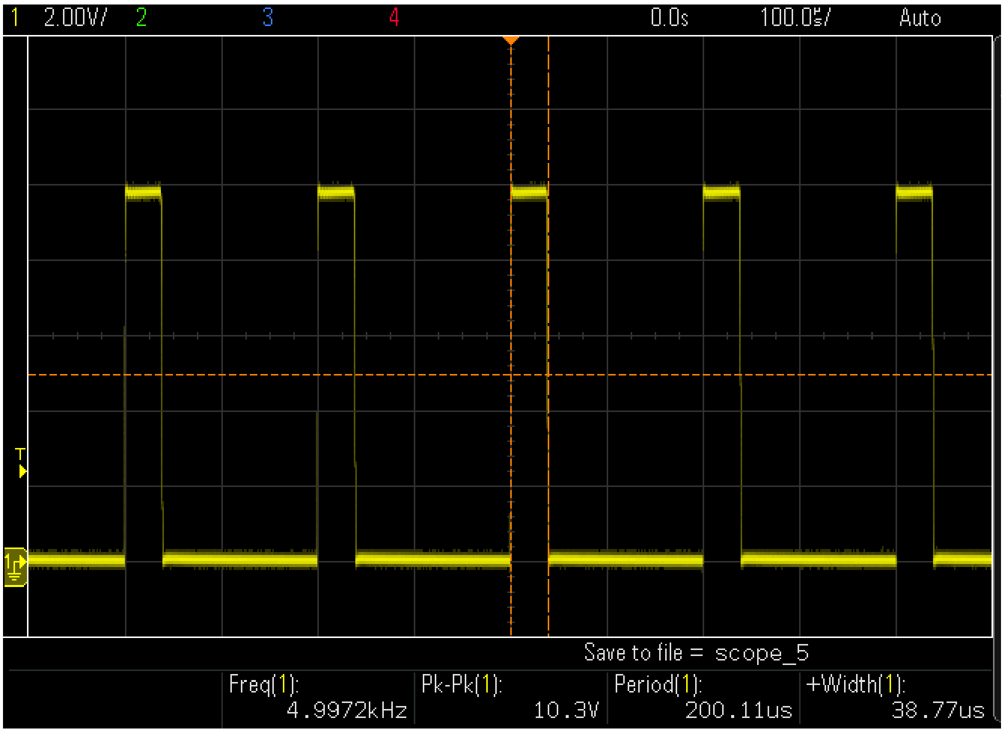

Figure 5: Oscilloscope output of the output voltage of the board. Input PWM duty cycle ~ 18% and the frequency is 5 kHz. The duty cycle of the output voltage is ~ 19%.

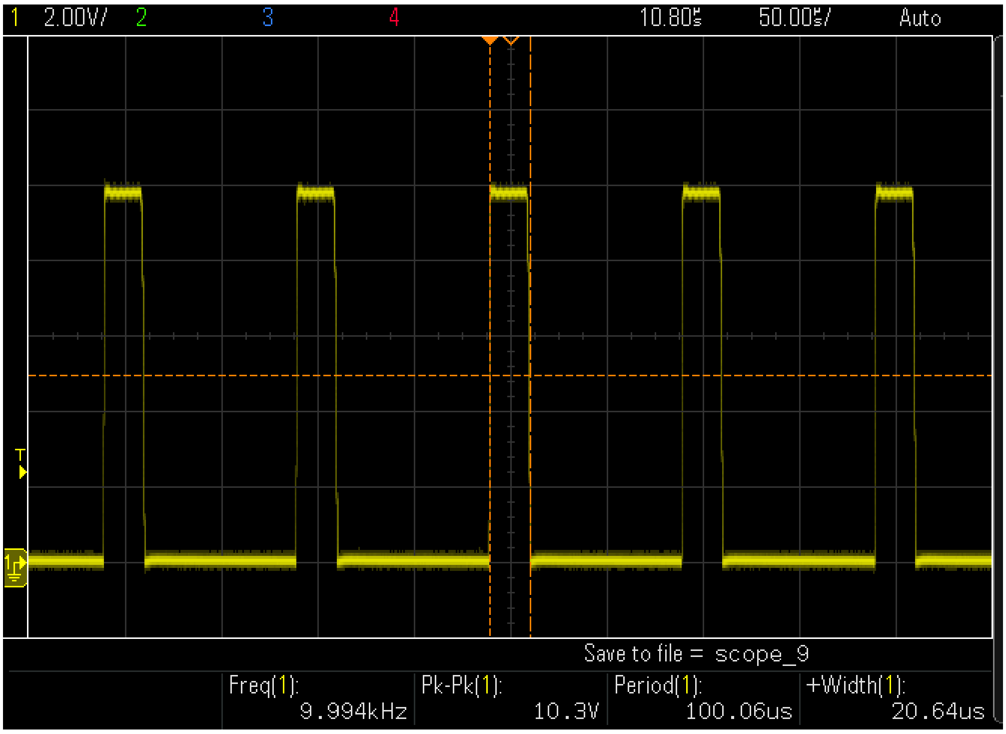

Figure 6: Oscilloscope output of the output voltage of the board. Input PWM duty cycle ~ 18% and the frequency is 10 kHz. The duty cycle of the output voltage is ~ 20%.