Measurement and testing of DC/DC converter basic parameters

Additional IEEC laboratory exercise

WÜRTH ELEKTRONIK

Measurement setup

Measurement setup contains following devices (Fig. 1):

- two multimeters or device with integrated current and voltage measurement,
- oscilloscope – at least 1 channel with 10 MHz bandwidth,
- load – passive (resistor) or active,
- 12 V constant power supply and adjustable power supply (from 0 to 15 V), with current output at least 2 A.

Block diagram of the measurement setup:

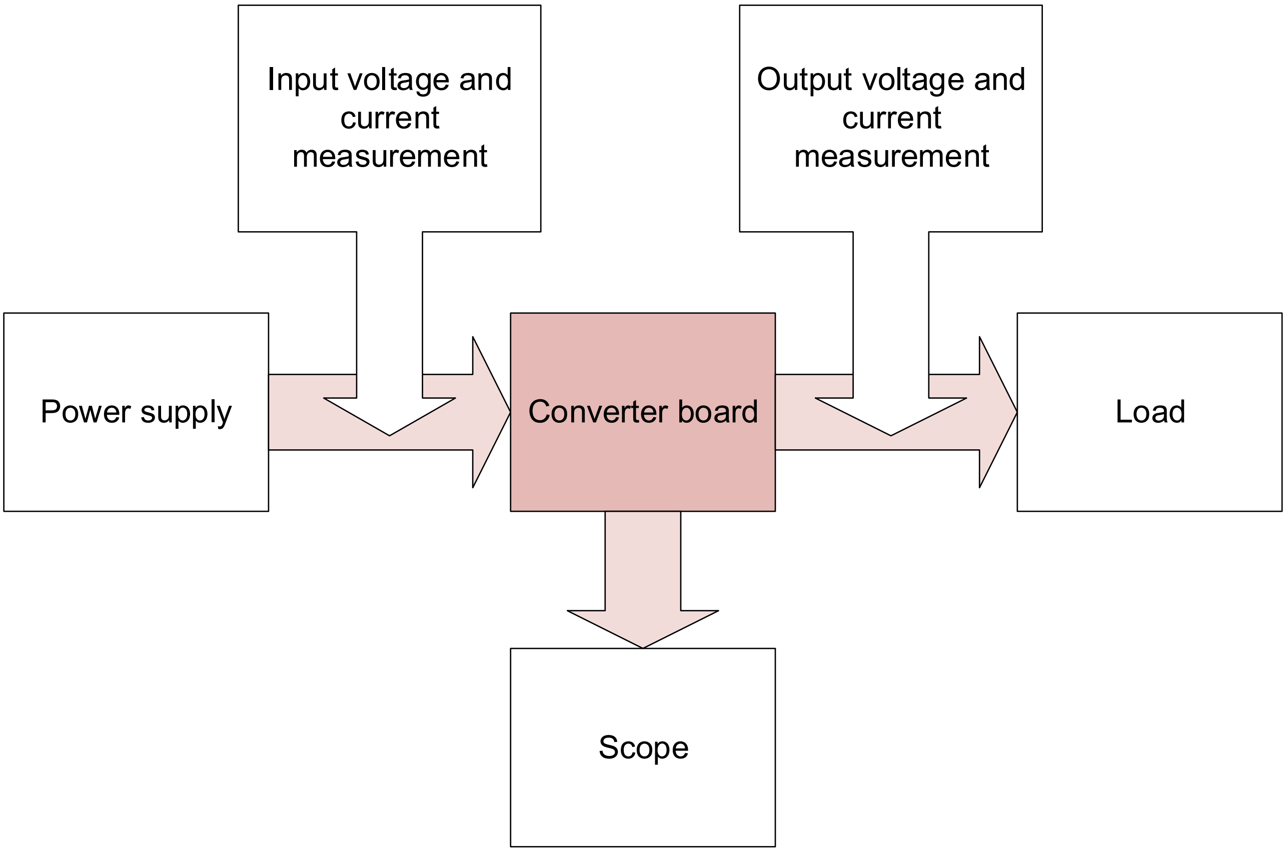

Fig. 1 Block diagram of an exemplary measurement setup

Step-by-step configuration (Fig. 2):

1. Connect small board with the WE-MAPI coil.
2. Make sure switches S1, S2, S3 and S4 are all set to position 1 (1 – ON, others OFF).
3. Make sure jumper "ON/OFF" and fuse J3 are present (short).
4. Connect load to the output (J6) together with voltmeter and ammeter.
5. Connect power supply and measurement cables to voltmeter and ammeter at the input (socket DC J1 for 12V supply or socket J2 for adjustable voltage supply, set at 12V).
6. Turn-on the power.

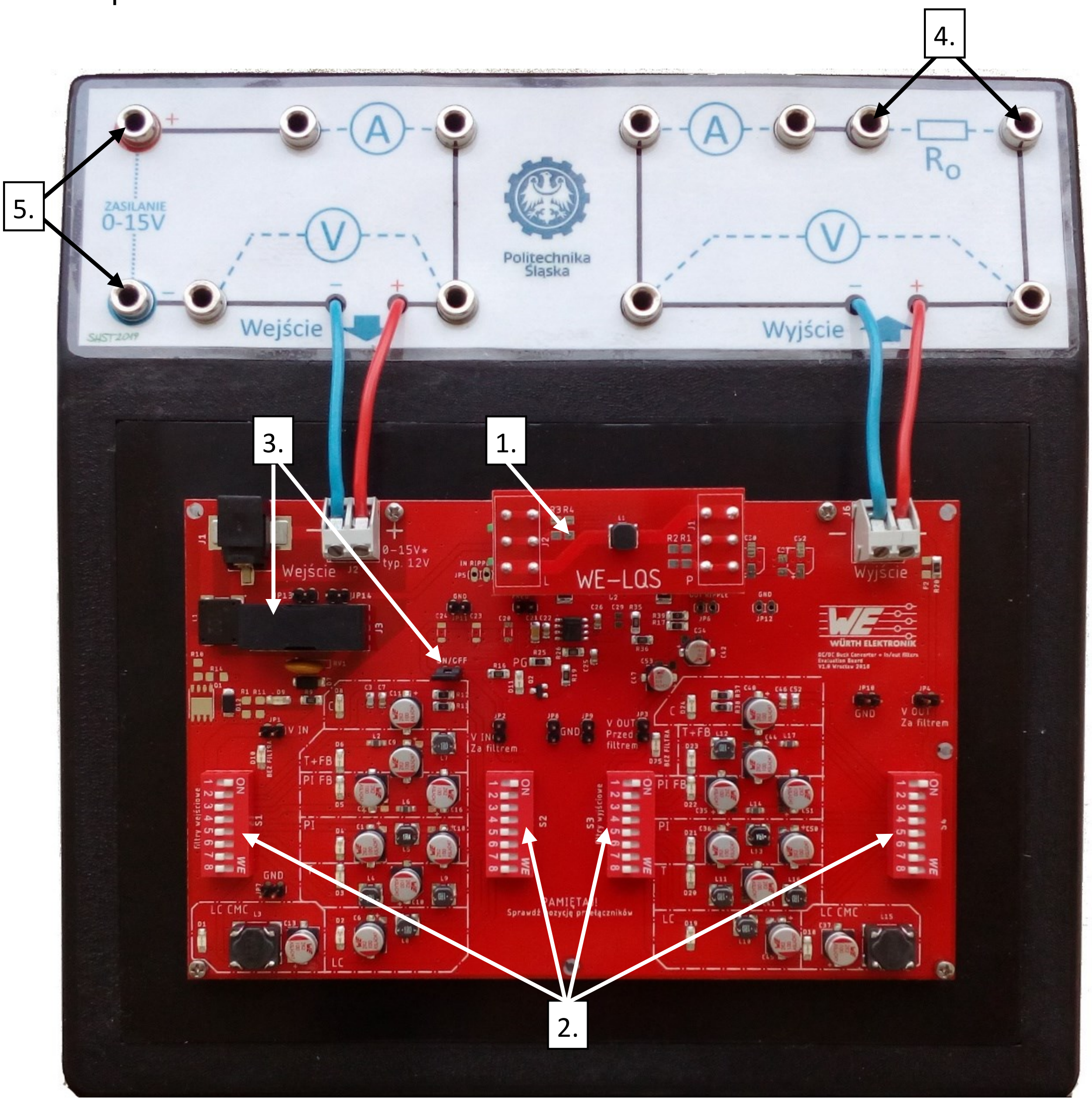

Fig. 2 Laboratory board with sockets for connecting DC ammeters and voltmeters

Measurement report and conclusions

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Name, surname, group, section

Task 1. Calculation of line regulation.

The exercise should be carried out using a power source with adjustable voltage, e.g. a laboratory power supply.

Initial setup:

- U_{in_12V} = 12 V (nominal input voltage)
- load (with given load current).

Measure value of output voltage U_{out_12V} for nominal input voltage $U_{in} = U_{in\_12V}$ = 12 V and given load. Then measure output voltage U_{out} for variable input voltage U_{in} in range 5 ÷ 15 V with 0.5 V step. Calculate *voltage line regulation*:

$$S = \frac{\Delta U_{OUT}}{\Delta U_{IN}} \cdot 100\ [\%] = \frac{U_{OUT\_12V} - U_{OUTmeasured}}{U_{IN\_12V} - U_{IN_{measured}}} \cdot 100\ [\%]$$

S' = (Uout - 5V) * 100 / 5V [%]

Put measurement results in the table below.

U_{in} [V]	U_{out} [V]	S [%]	U_{in} [V]	U_{out} [V]	S [%]	U_{in} [V]	U_{out} [V]	S [%]
5.0	4.57	91,4	8.5	-II-	58,23	**12.0**	4.95	41,25
5.5	4.95	90	9.0		55	12.5		39,6
6.0	4.95	82,5	9.5		52,11	13.0	-II-	38,08
6.6	4.95	76,15	10.0		49,5	13.5	4.95	36,66
7.0	-II-	70,71	10.5		47,14	14.0	4.95	35,36
7.5	-II-	66	11.0		45	14.5	--	--
8.0		61,88	11.5	-II-	43,04	15.0		

Task 2. Calculation of power efficiency.

In order to calculate power efficiency of the converter, measure:

a) input voltage and current,
b) output voltage and current.

Then, calculate input power P_{in} ,output power P_{out} and calculate converter efficiency:

$$\mu = \frac{P_{out}}{P_{in}} \cdot 100 \, [\%]$$

Repeat measurements and calculations for three different load currents (in range 0 ÷ 2 A) and three selected values of input voltage (total 9 combinations). Use table below.

U_{in} [V]	U_{out} [V]	I_{in} [A]	I_{out} [A]	Efficiency [%]
9	*4.973*	*0.172*	*0.263*	*84.49*
9	4,906	0,58	0,92	86,47
9	4,956	0,31	0,47	83,49
9	4,990	0,14	0,19	75,25
12	4,907	0,44	0,91	84,57
12	4,956	0,24	0,46	79,16
12	4,990	0,11	0,19	71,82
14 15	4,907	0,39	0,91	81,78
15	4,955	0,22	0,48	77,22
15	4,991	0,11	0,19	61,58

Task 3. Measurement of operating frequency of turn-on time T_{on}

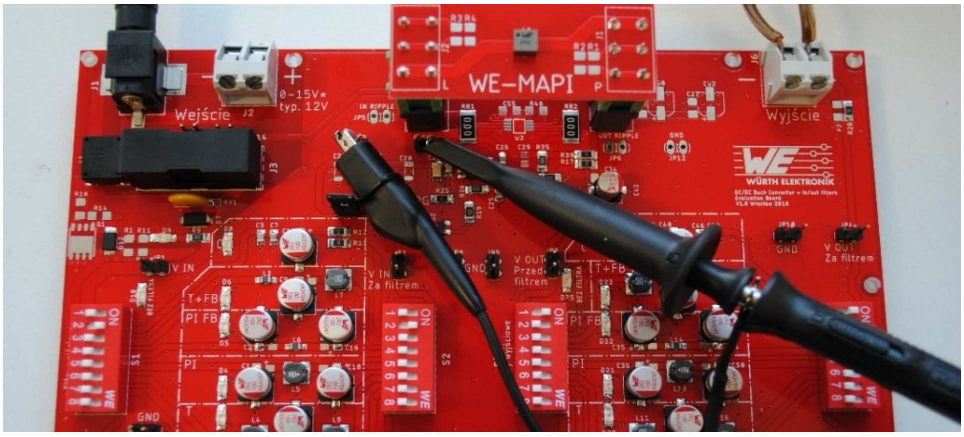

Fig. 3 Test points (connectors) for measurement of frequency and turn-on time of switch signal

Connect oscilloscope to FREQ and GND pins (Fig. 3). Measure:

a) period of switching signal T_{period},
b) time T_{on} when switching signal is *high*,
c) input voltage U_{IN}.

Repeat measurements for three given loads R_o.

Calculate coefficient γ:

$$\gamma = \frac{T_{on}}{T_{period}}$$

If γ < 1, the converter is *step-down (buck) converter*. Value of coefficient γ determines output voltage:

$$U_{OUT} = U_{IN} \cdot \gamma$$

Compare theoretical calculations with measurements. Calculate absolute ΔU_{out} and relative errors δ_{Uout}.

Load current [A]	Switching period [ns]	Switching frequency [MHz]	Turn-on time T_{on} [ns]	γ	Calculated U_{out} [V]	Measured U_{out} [V]	ΔU_{out} [V]	δU_{out} [%]
0.5	*720*	*1.389*	*304*	*0.422*	*5.067*	*4.951*	*0.116*	*2.28*
0,90	710	1,408	314	0,442	5,304	4,908	-0,396	-7,46
0,46	710	1,408	308	0,434	5,208	4,957	-0,251	-4,82
0,19	710	1,408	310	0,437	5,244	4,957	-0,287	-5,47

Conclusions

Write final conclusions and short summary below.

Voltage line regulation efficiency should remain constant for input voltages over 5.5V, however we have used a wrong formula of calculating that parameter. It should represent the drop of output voltage compared to ideal 5V in reflection of changing Uin.
We observe that power efficiency changes depending on both input voltage and consumed power (current). When the source voltage increases, the losses to output power ratio increases, because the converter has to do more work to step-down that voltage. When changing the load resistance, we can notice that the efficiency drops as well. That's due to the design of the converter. It's made for handling high power consumption, so it's efficiency is the highest for low resistance.