Double Pulse Testing (remote) practical

For course “Advanced Power Electronics” EE4515 at Delft University of Technology

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1. Introduction

For course EE4515 a Double Pulse Tester (DPT) has been developed. The students will be introduced to a simplified half-bridge DPT configuration. In general DPT has many benefits, however the most valuable one is that future Power Electronic engineers (the students of this course) are able to test their developed power electronics under worst-case conditions. Mainly to reduce the risk of later unforeseen problems. More details on DPT can be found in [1]. Fig. 1a shows the proposed topology, where Q1 and Q2 are the Devices Under Test (DUTs) and Fig. 1b the typical waveforms. Due to Covid-19, the developed set-up should be capable to be used as onsite as well as online variant. The operating principle is as follows:

With the variable pulse length of *t1* the turn-off current *is1* can be set at different levels. After turn-off of Q2 the inductive current (*iL1*) freewheels through the anti-parallel diode of Q1. When Q2 turns on again (pulse t2) the recovery of Q1 can be investigated.

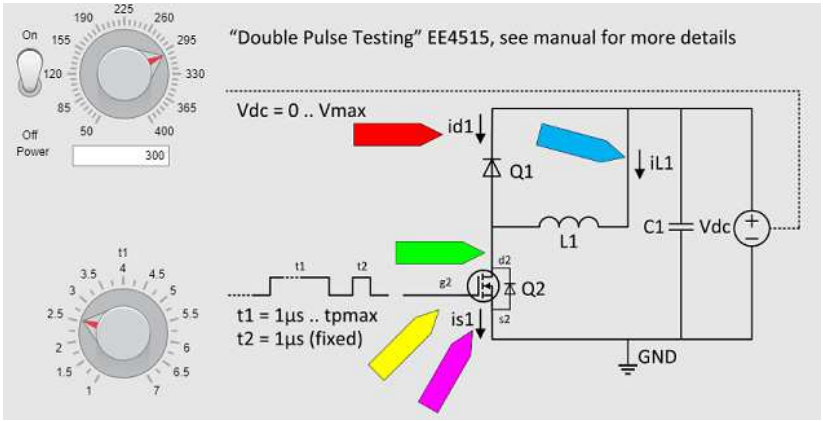

Fig.1a: DPT topology and remote control

Fig.1b: Typical DPT waveforms and zoom-in

During the onsite variant of the practical the student has the ability to put different types of mosfets or diodes (Si, SiC, GaN) in the sockets of Q1 and Q2 and investigate the commutation phenomena. The voltage VDC and the pulse duration t1 can be set manually. For the online variant these settings can be done remotely and there are more parallel set-ups with different semiconductor configurations.

Typical waveforms depicted in Fig. 1b are gate voltage of Q2 (yellow); drain voltage of Q2 (green); source current Q2 (purple) and inductor current of L1 (blue). In the zoom-in window (bottom of Fig. 1b) the switching behavior can be investigated in detail.

2. Specification

The practical is build-up with the following equipment:

- Desktop PC with webcam and Matlab/Simulink
- SM400 AR from Delta Electronics (LAN option for remote control via Simulink)
- DLM3000 series oscilloscope from Yokogawa (including LAN remote interface)

- Current monitor 411 from Pearson (or on-board shunt resistor)
- TU-Delft interface boards with TMS320 Launchpad's from TI (for remote control & for DPT pulse generation)

More detailed electrical specifications are:

- Double pulses: t1 adjustable 1 … tpmax = 20µs, t2 = 1µs (single or with repetition rate of 1Hz)
- Power supply (VDC): adjustable 50..400V
- DUTs (Q1, Q2): N-type mosfets, which are compatible with TO220 and TO247 housing types (Fig. 2)
    - Or several types of diodes (for Q1) in different "anode"/"cathode" configurations, such as C3D04060, BYV29, C3D20060D, DSEI60, IDW30, will also fit in this design.
- Mosfet driver (Q2): UCC37322 (8p PDIP for easy replacement in case of failure during onsite practicals)
- Load inductor (L1): ETD54 core and bobbin 110µH (or 200µH) (< 20A)
- Gate resistor (Rg): On studs easy adjustable by the students

Fig. 2: Detail of the sockets for Q1 and Q2, here equipped with a TO220 diode and a CREE TO247 mosfet

3. First proto

In the beginning of 2021 the first remote lab prototype was launched, which is based on the described specification above. This online set-up and the student interface screen is shown in Fig. 3 and was tested up to 400V and 20A. The student has the ability to store his/her measurements as a screen dump as well as to download detailed CSV data for further analyses.

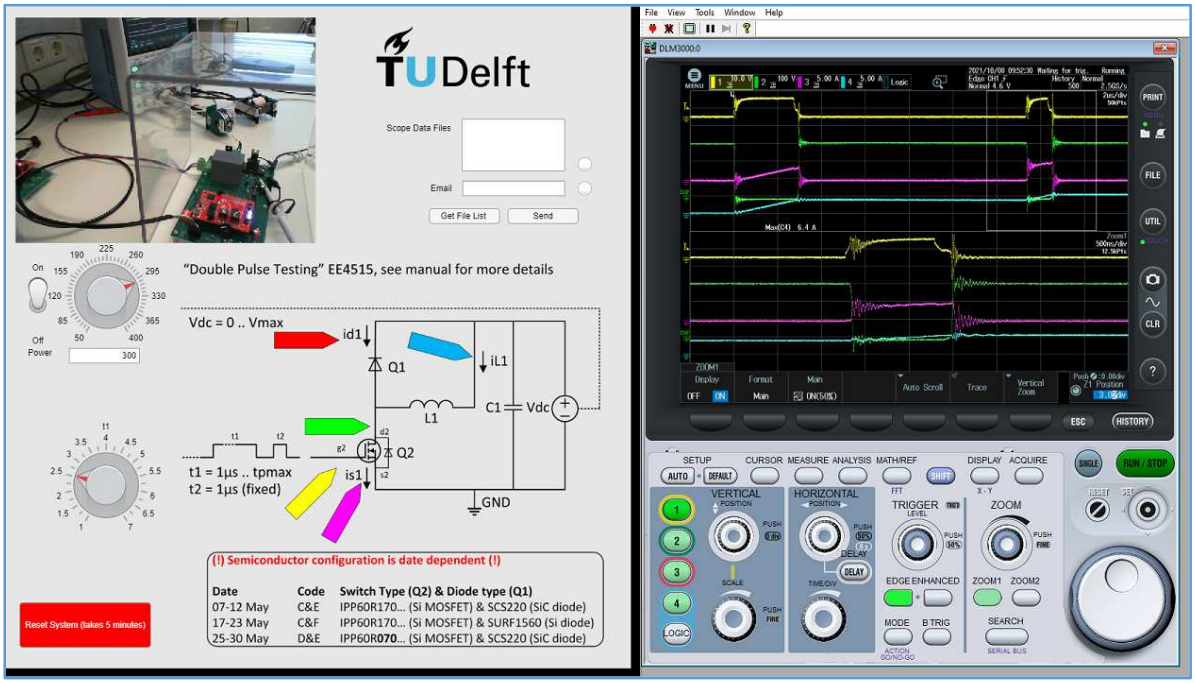

Fig. 4: Student screen remote DPT practical set-up

The schematic and the concept PCB of this prototype is described in Appendix A.

4. References

[1]: David Levett, Ziqing Zheng and Tim Frank, Infineon Technologies, Double Pulse Testing: The How, What and Why, Bodo´s Power Systems® April 2020 www.bodospower.com

Appendix A: Schematic and PCB Single- & Double Pulse Tester (SPT, DPT)

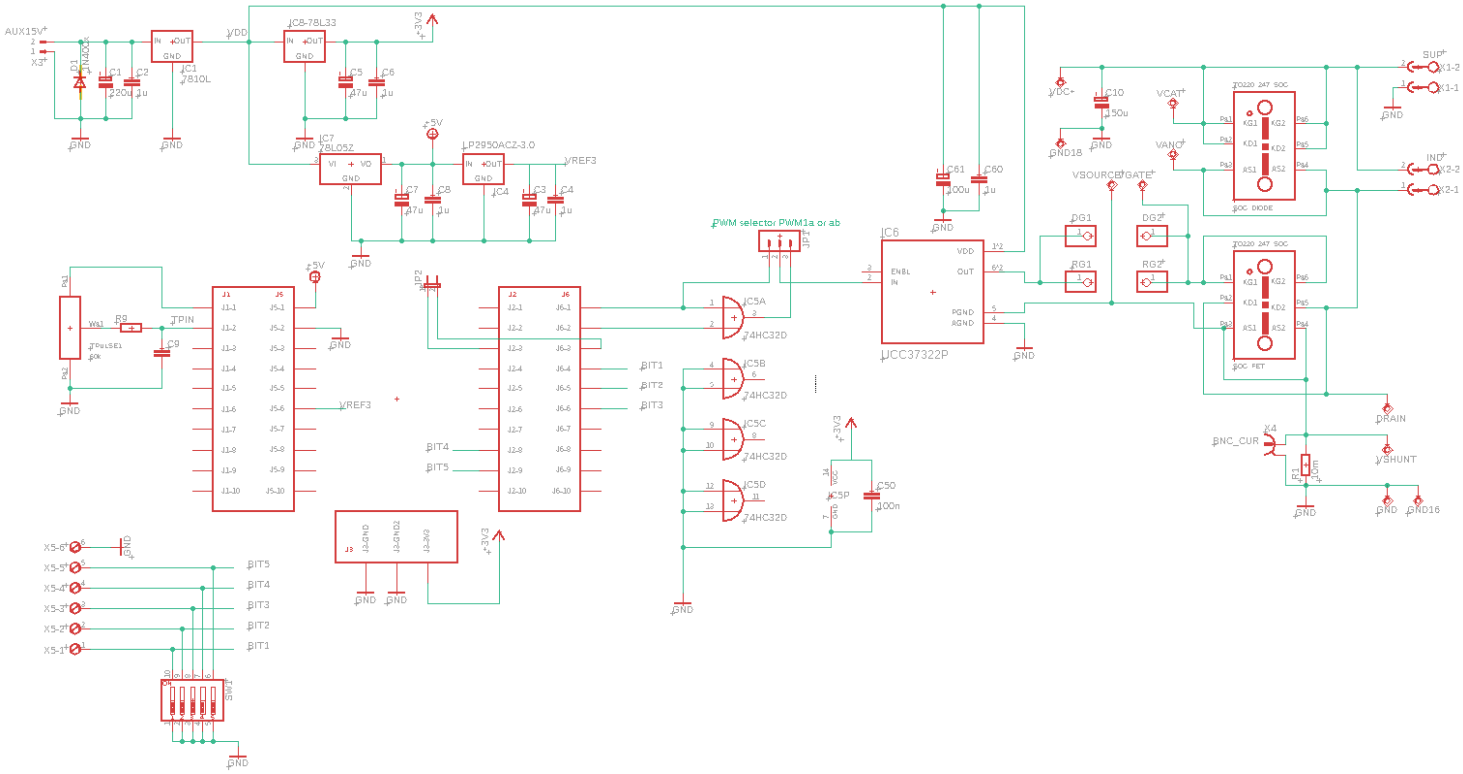

Figure A1: Schematic of the Double Pulse Tester for onsite and online practical variant

Parameters at a glance:

- The double pulse t1+t2, where t1 is adjustable from 1…20us and t2 fixed at 1us, is generated via the TMS320 PWM1a and PWM1b channels and combined with selector jumper JP1.
  - Single Pulse Tester (SPT 1-2) or Double Pulse Tester (DPT 2-3) mode.
- Pulse t1 is adjustable via:
  - On board potentiometer for on-site practical or
  - Five bits digital input for on-line practical control (data lines have pull-up resistor via TMS320, SW1 can be used for commissioning or test purposes of the on-line variant)

- VDC max. is 400V (now limited by supply 400V; capacitor C10, 450V max.; plugs X1 and X2, 630V max.)
- The pulse(s) can triggered by onboard TMS320 switch GPIO12 (onsite variant) or every 1 sec. automatically (jumper JP2)
- Studs DG and RG are for student adjustable gate resistor/diode combinations to adjust the switching speed.
- Special (quick change) Sullins sockets for most TO220 and TO247 transistor/diode types
- Onboard probe connection points/hooks for gate, drain, source, cathode, anode and vshunt measurement
- Easy through hole PCB design for easy maintenance in case of failure during practical's (e.g. gate driver change)
- Single auxiliary 15V supply that creates the needed 10V (gate drive), 5V (logic), 3V3 (µC) and 3V (AD-ref).

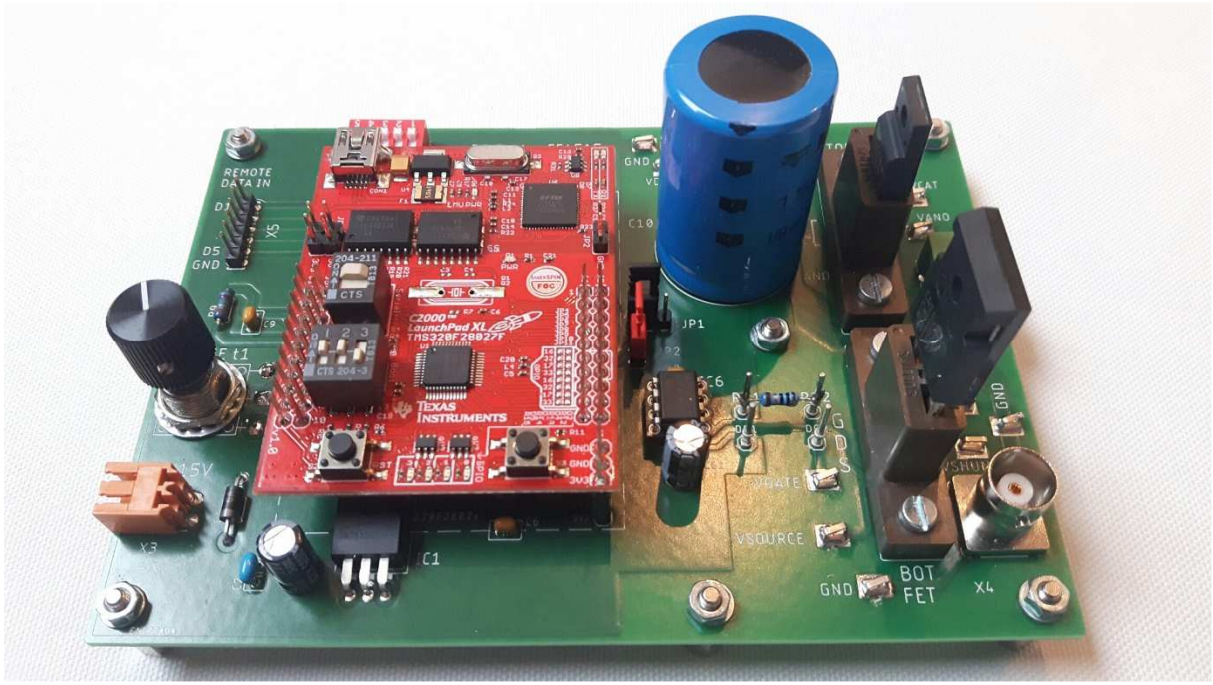

Figure A2: First assembled proto