Guide to “The Risø Pulsed OSL attachment” - Stand-alone version

Risø DTU, Denmark
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1 Introduction

The Risø pulsed OSL unit is an attachment to the conventional Risø TL/OSL luminescence reader. This attachment enables measurement of pulsed optically stimulated luminescence (POSL). In POSL the stimulation light is pulsed and the OSL is only measured in between the pulses (see Figure 1). There are several reasons why it may be advantageous to measure the POSL signal.

1. Pulsing provides insight into the luminescence recombination process. The POSL signal after the stimulation pulse decays according to the lifetime of the luminescence centres being stimulated.

2. Pulsing enables reduction of the filtering required to separate the stimulation light from the emitted luminescence. More overlap between the stimulation and detection wavelengths can be tolerated for a given background.

3. Different luminescence centres have different relaxation lifetimes, which means that POSL provides an instrumental way of separating the luminescence emitted from different phosphors.

The Risø pulsed OSL attachment can be used directly with a standard TL/OSL system fitted with a standard OSL stimulation head. The attachment is made in a stand-alone and a built-in version. This guide covers the stand-alone version, which is made as a separate box with settings on the front, whereas the built-in version is installed in the Risø TL/OSL controller with settings from the Sequence Editor software.

2 Hardware

The Risø pulsed OSL attachment is a self-contained unit, based around an 8-bit microcontroller, with 8 kb of flash memory containing the control software. The attachment allows full user control of the power level, and *on*- and *off*- time

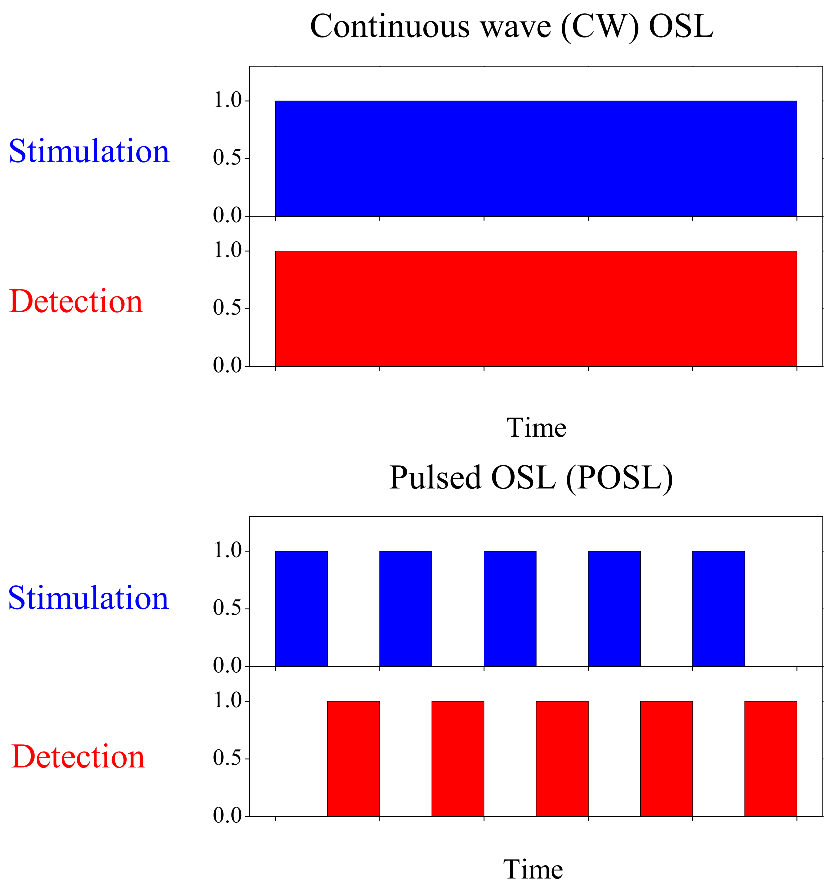

Figure 1: Top graph illustrates continuous wave (CW) mode. In CW stimulation is continuously and so is detection. In pulsed mode (POSL) stimulation is pulsed and detection takes place in between pulses.

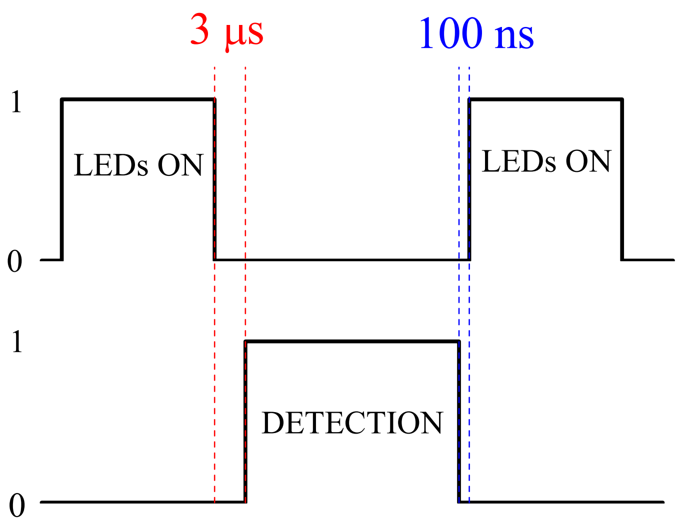

Figure 2: Schematic diagram of the pulse timing. Detection begins 3 μs after the switch-off signal has been sent to the LEDs. This delay allows the LEDs to have switched off completely before detection begins. Detection ends approximately 100 ns prior to the next LEDs switch-on pulse.

settings via front panel thumb wheels. These settings are used to initialise the programmable timer and preset the voltage to be applied to each cluster of blue or IR diodes. The system is connected between the Risø Minisys/Controller OSL output and the LED stimulation head of a standard Risø automated reader. The microcontroller detects the switch-on and switch-off signals from the Minisys for each of the blue and IR diode groups. When a switch-on signal is received, the programmable timer begins to pulse the preset voltage connected to the selected LEDs, through a solid state switch. A delay of 800 ns is inserted between the programmable timer and this switch to allow for external/internal synchronisation. Once pulsing of the LEDs has begun the stimulation intensity is monitored using a photo-diode built into the stimulation head. This feedback signal is digitised using a 12-bit analogue to digital converter so it can be read by the microcontroller. This then compensates for any drift in stimulation intensity by adjusting the voltage applied to the LEDs accordingly. For *on* pulses of $< 100\,\mu$s this signal is monitored on a pulse by pulse basis; for longer periods, however, the pulses are monitored at regular intervals within the *on*-period itself. So that the LED pulsing unit may be used directly with the standard Minysis/Controller system, a photon-count gating circuit has been included. This provides a counting window within the *off*-period of each pulse

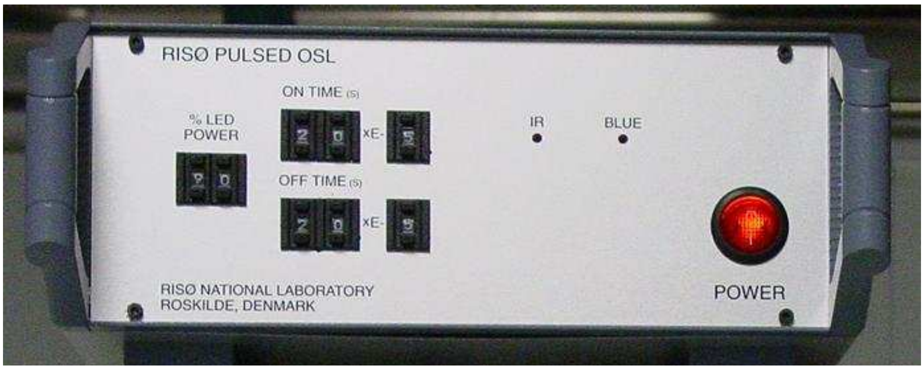

Figure 3: Picture of the Risø Pulsed OSL attachment

cycle. Incoming TTL photo multiplier (PM) pulses are gated off while the LEDs are switched on, but allowed to pass (to be counted) during the LED off-period. The exact starting time of this window relative to the diode pulse is preset using the internal synchronisation mentioned above; the start time can be (internally) adjusted from ~ 500 ns prior to the LEDs being switched off, to $\sim 25\,\mu$s after. The default start time is $2.5\,\mu$s after switch-off. This setting is chosen to allow the LEDs to have switched off completely before counting begins. The counting window ends approx. 700 ns prior to the next LED switch-on pulse (see Figure 2).

3 Settings

A picture of the attachment is shown in Figure 3.

The thumb wheels to the left control the power of the LEDs, which can be set at any integer value between 1 and 99%.

The thumb wheels to the right control the on- and off-time of the LEDs. The on-time may be set from $0.2\,\mu$s to 10 s, and the off-time from $0.6\,\mu$s to 10 s. However there are certain restrictions on the setting of the thumb wheels as explained below. If the settings of the thumb wheels are invalid, the IR and Blue indicator LEDs on the front panel will flash until the settings are valid.

Restrictions to thumb wheel settings:

- Exponents factors of 10^{-8} and 10^{-9} are invalid
- Setting of on-time $< 0.2\,\mu$s is invalid
- Setting of off-time $< 0.6\,\mu$s is invalid

- Depending on the exponent factor of the lower of on-time and off time there are limitations to the other time setting:

Exponent factor of the lower of on-time and off time	The maximum setting of the larger of on-/off-time
10^{-7}	$13 \cdot 10^{-3}$ s = 13 ms
10^{-6}	$65 \cdot 10^{-3}$ s = 65 ms
10^{-5}	$65 \cdot 10^{-2}$ s = 650 ms
10^{-4}	$65 \cdot 10^{-1}$ s = 6.5 s
10^{-3}, 10^{-2}, 10^{-1}, 10^{0}	$65 \cdot 10^{0}$ s = 65 s

If off-time is lower than on-time and exponent factor is 10^{-3}, 10^{-4},...10^{-6} the digit setting of 01 and 02 of off-time are invalid. When the on-time is below approximately 5 μs the LED pulse shape may not be as rectangular as for on-times higher than 5 μs, especially at high power settings. If rectangular pulse shape is important you should restrict on-time to above 5 μs.

Setting is only possible in steps larger than or equal to 0.2 μs; For instance a setting of 1.7 μs will effectively be 1.6 μs.

4 Adjusting the power level

The power level of the pulsed OSL unit must be adjusted prior to use. This can be achieved by either sending the OSL stimulation head to Risø or following the instructions given below.
To adjust the power level of the unit the following items are required:

- A voltmeter with high impedance input (standard digital voltmeter, DVM)
- The pulsed OSL calibration unit (see Figure 4)

As the driver circuitry of the pulsed OSL unit is different from the driver circuitry of the CW LED unit, using the same percentage of power on the two units does not ensure that the power density on the sample is the same.

The adjustment of the power level is a 3 stage process:

A. Gain for blue and IR stimulation LEDs are adjusted and thumb wheels settings are set to ensure that the stimulation LEDs are not damaged in the process (Step 1-6)

B. Maximum current to blue and IR LEDs are adjusted (Step 7-17). This stage is an iterative process

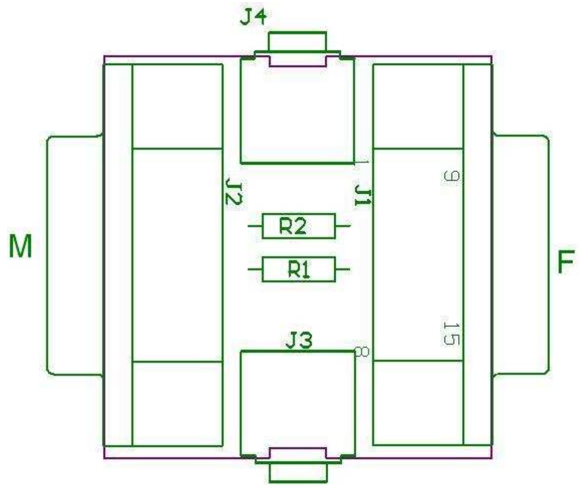

Figure 4: Layout diagram of the pulsed OSL calibration unit. "J3" IR diodes current monitor Jack socket. "J4" Blue diode current monitor Jack socket. "M" Male connector to pulsing unit. "F" Female connector to OSL head.

C. An automatic calibration procedure over the entire power range is performed (Step 18-19).

A picture of the circuit board is shown in Figure 5.

1. Connect the pulsed OSL unit to the MiniSys/Controller (but NOT to the OSL head) and switch on the mains AC power to both units.
2. measure the voltage between "ground" and "TP1" (see Figure 5). Adjust "P9" to give -8.0 V ($\pm$0.05 V)
3. measure the voltage between "ground" and "TP2". Adjust "P10" to give -4.0 V ($\pm$0.05 V).
4. Switch off the mains AC power (230 V or 110 V, as appropriate to your supply) to the pulsed OSL unit.
5. Ensure that both "P1" and "P2" are fully rotated (> 20 turns) anticlockwise. This ensures that the photodiode gain is set to a maximum.
6. Turn off the pulsed OSL unit. Now adjust the maximum diode current to final values. Adjust the thumb wheel settings to: % LED POWER: 99
   ON TIME = 50 x 10-6
   OFF TIME = 50 x 10-6
   Check these settings carefully! Incorrect setting may damage the OSL unit.

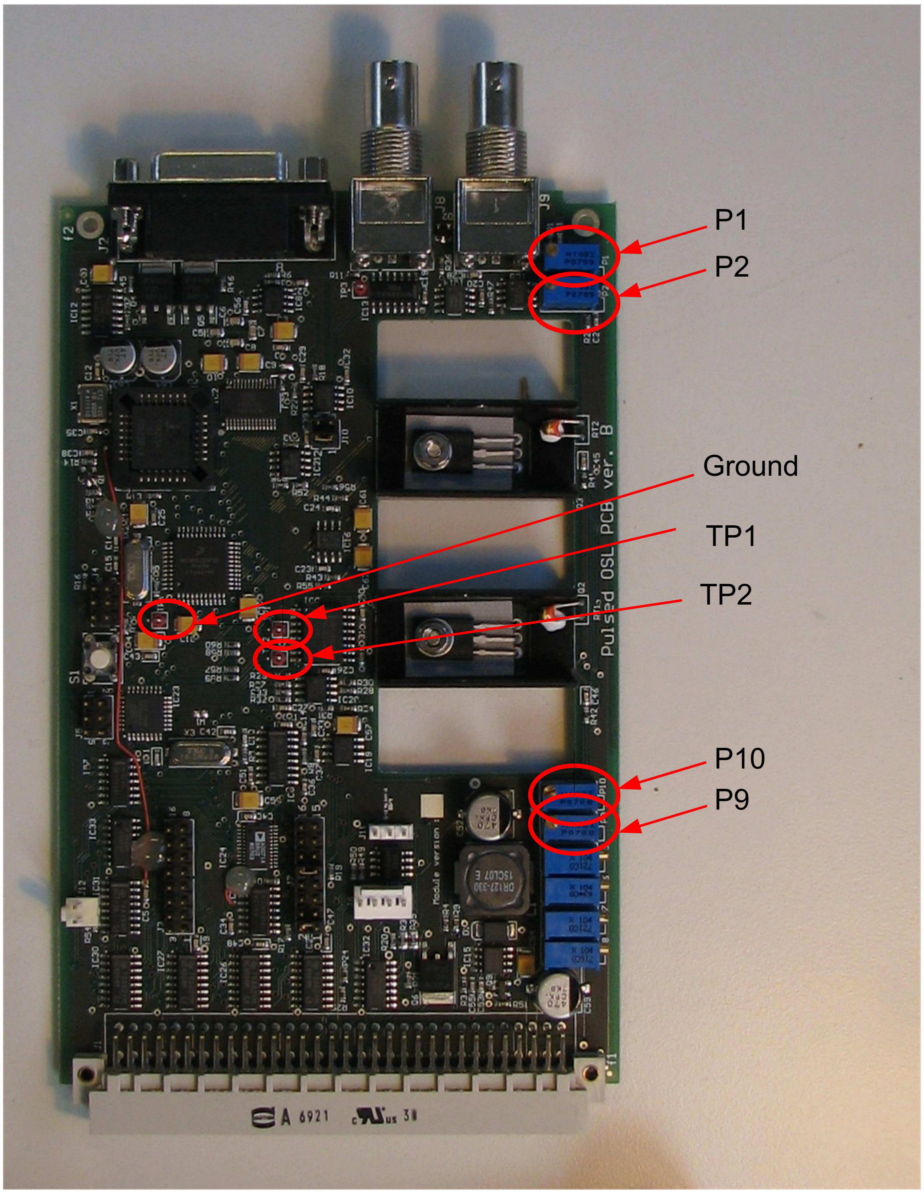

Figure 5: Picture of the circuit board. Please note the positions of "ground", "TP1", "TP2", "P1", "P2", "P9" and "P10"

7. Connect one end of the pulsed OSL calibration unit (Figure 4) to pulsed OSL unit (Figure 3; the socket on the pulsed unit which normally connects to the OSL head plug) and connect the other end to the OSL head itself.

8. Connect the voltmeter to “J4” using the Jack plug to banana plug lead provided (i.e. across “R2”) on the calibration unit. This will show the current through the blue diodes.

9. Switch on mains AC power supply to the pulsed OSL unit (use the “POWER” switch on the front panel of the pulsed OSL unit)

10. Switch on the blue diodes in the Risø Control program

11. Adjust “P1” (photo detector gain) clockwise. The DVM voltage will slowly increase. Continue to adjust “P1” until the DVM just stops increasing (the voltage must not exceed 0.22 V). If the voltage cannot exceed 0.165 V then adjust “P9” approximately 0.5 turn clockwise. If it is still not possible to exceed 0.165 V then adjust “P9” further approximately 0.5 turn clockwise (this may be repeated a number of times if necessary).

12. Turn “P1” anticlockwise to set the voltage to 0.165 V (within 0.160 and 0.170 V).

13. 13. Now adjust the IR diodes. Move the jack plug to “J3” on the OSL calibration unit. In the Risø Control Program switch off the blue diodes and switch on the IR diodes instead

14. 14. Adjust “P2”(photo detector gain) clockwise. The DVM voltage will slowly increase. Continue to adjust “P2” until the DVM just stops increasing (The voltage must not exceed 0.58 V). If the voltage cannot exceed 0.48 V then adjust “P10” approximately 0.5 turn clockwise. If it is still not is possible to exceed 0.48 V the adjust “P10” further approximately 0.5 turn (this may be repeated a number of times if necessary).

15. Turn “P2” anticlockwise to set the voltage to 0.48 V (within 0.465 and 0.495 V)

16. Switch off the IR diodes in the Risø Control program

17. Switch off the power to the OSL pulsing unit

18. Run a calibration routine. This is done by adjusting the thumb wheel setting (Figure 3) to:
    % LED POWER: 00
    ON TIME = 50 x 10-6
    OFF TIME = 50 x 10-6
    (Setting the % LED POWER to 00 results in the initiation of the LED calibration routine when the power is reconnected.)

19. Turn on the power to the OSL pulsing unit. The unit will now start an automatic calibration routine. The 'BLUE' indicator on the front of the pulsing unit will light for approx. 30 s. Then the 'IR' indicator on the front will light for approx. 30 s. Finally both indicators will be turned off as an indication of a successful calibration. If the calibration is unsuccessful try to repeat the process carefully. If the calibration procedure is still unsuccessful contact Risø Support (+45 4677 4935 or osl@risoe.dk)

5 Connection

Connecting the Pulsed OSL unit is described in the following sections. Instructions are given both for a Minisys based system (section 5.1) and for a Controller based system (section 5.2). Remember to switch off the power before changing the system configuration.

5.1 Connecting to a MiniSys

The pulsed OSL unit is attached to a Minisys based system by connecting "COUNTS OUT" on the Control box with "PM SIGNAL IN" on the pulsing unit. The "PM SIGNAL OUT" on the Pulsed OSL unit is connected to "MINISYS PM" on the Minisys. See black lines in Figure 6. The OSL head connects to the "OSL HEAD" on the pulsing unit (marked with a red oval in Figure 6). Connect "OSL IN" on the pulsing unit with the Minisys as shown by the red line in Figure 6.
In true CW mode the OSL head must be connected directly to the Minisys (see the red oval in Figure 7. The "COUNTS OUT" on the Control box must be connected with the Minisys as indicated by the black line.
In *pseudo*-CW mode the stimulation light is pulsed but the photon-count gating circuit is overridden (e.g. all photons are being counted). This is achieved by connecting the Minisys and the Control box as shown by the black line in Figure 7 and connecting the OSL head to the pulsing unit (see red oval in Figure 6).

5.2 Connecting to a Controller

The pulsed OSL unit is attached to the Controller by connecting "Preamp out" on the Controller with "PM SIGNAL IN" on the pulsing unit. The "PM SIGNAL OUT" on the Pulsed OSL unit is connected to "Counter in" on the Controller. See black lines in Figure 8. The OSL head connects to the "OSL HEAD" on the pulsing unit (marked with a red oval in Figure 8). Connect "OSL IN" on the pulsing unit with the Controller as in Figure 8.
In true CW mode the OSL head must be connected directly to the Controller (see the red oval in Figure 9. The "Preamp out" and the "Counter in"on the Controller must be connected with the looped as indicated by the black line.

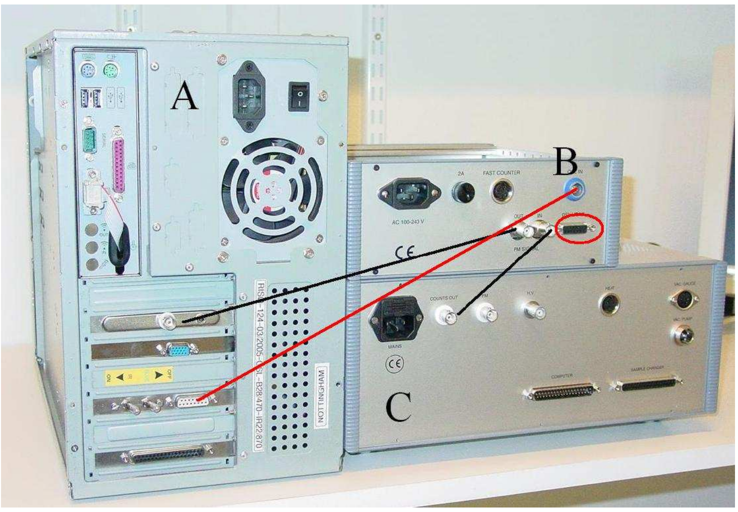

Figure 6: Connecting the attachment to a minisys system. A) Minisys B) Pulsed OSL unit C) Control box

Figure 7: Running the system in true CW mode (Minisys based system).

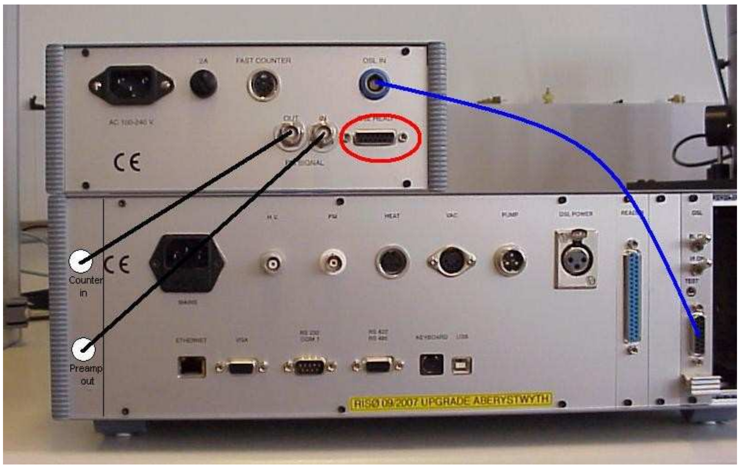

Figure 8: Connecting the attachment to a Controller system.

Figure 9: Running the system in true CW mode (Controller based system).