

Pockels Cell Concepts

Introduction

ScanImage controls the laser power for two reasons:

1. Controlling the amount of power delivered to the sample
2. Blanking the laser power during mirror turnaround to avoid overexposure

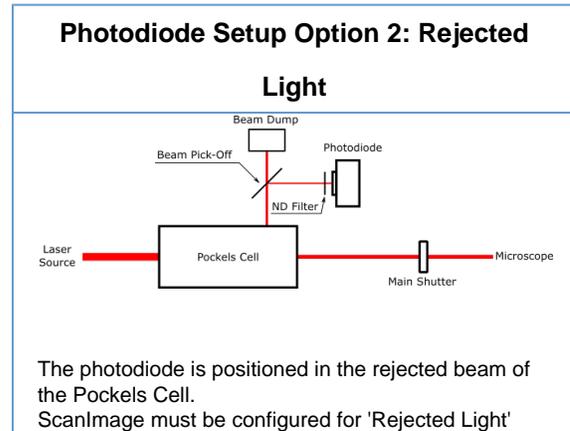
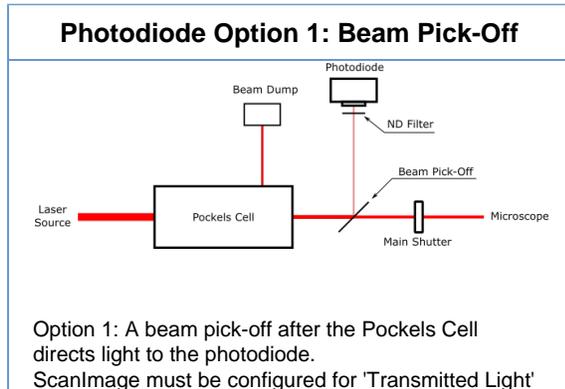
While any beam power modulation device that accepts an analog input signal can be used for power control with ScanImage, the most common modulation device is a Pockels Cell. This article describes the setup and configuration of Pockels Cells for the use with ScanImage. It also describes troubleshooting steps if the modulation does not work as expected.

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Pockels Cell Setup

A Pockels Cell splits the input beam into a 'transmitted beam' and into a 'rejected beam'. The transmitted beam is used for illuminating the sample, while the energy of the rejected beam is dissipated in a beam dump. By changing the control voltage of the Pockels Cell, the power ratio between the transmitted and rejected beam can be adjusted. The Pockels Cell power modulation is non-linear in respect to the control voltage. To compensate for this non-linearity, ScanImage creates a look-up table that translates a desired power into a control voltage. To measure this look up table, a photodiode is placed either in the transmitted beam or the rejected beam. To avoid over-exposure of the photodiode, a small fraction of the beam is picked off, and a ND-filter is used to further reduce the intensity at the photodiode.



- ✔ The Pockels Cell power modulation is temperature dependent. If the microscope's main shutter is placed before the Pockels Cell, the cell heats up while the shutter is open and cools down when the microscope is inactive and the shutter is closed. To ensure the Pockels Cell remains in thermal equilibrium, the shutter should be located after the Pockels Cell.

Wiring

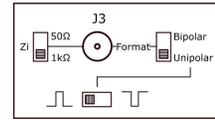
Connect the Pockels Cell to the high voltage driver as described in the user manual. Connect the command input on the driver board to an AO (analog output) of the ScanImage system. Connect the Photodiode to an AI (analog input) on the same DAQ board as the command signal.

For a Conoptics 302(RM) driver, the switches should be set as indicated in the graphic to the right.

- ✔ A high voltage offset can degrade the Pockels Cell over time. With the driver input at 0V and the voltage offset at 0V, rotate the Pockels Cell around its optical axis until the

transmitted power is at its minimum. The power modulation of the Pockels Cell depends on the polarization of the input beam. After the rotational alignment of the Pockels Cell, the polarization of the input beam should not be changed.

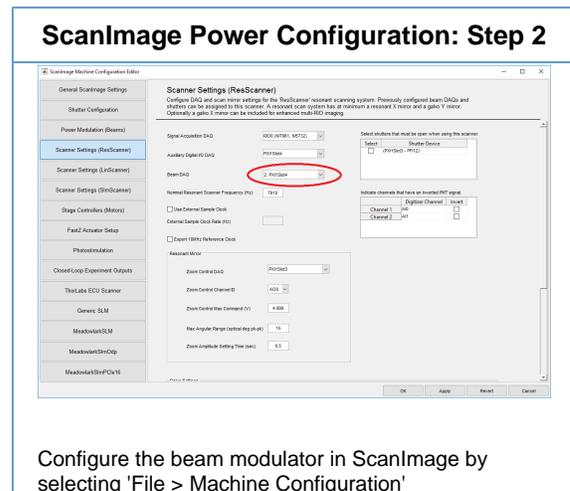
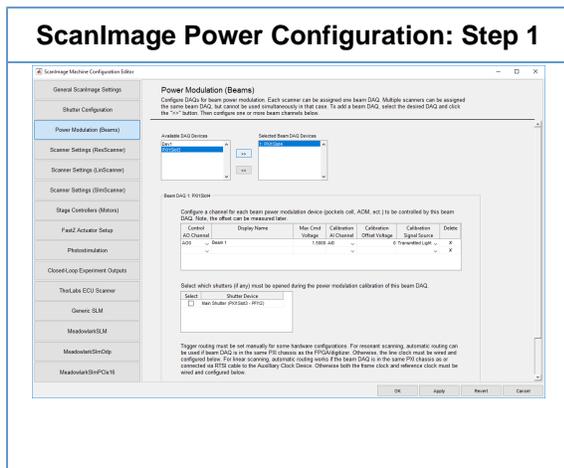
Conoptics 302RM driver settings



ScanImage requires the Conoptics 302RM driver to be set to 1k impedance, non-inverting unipolar input.

ScanImage Configuration

In ScanImage, open the Machine Configuration Editor by selecting 'File > Machine Configuration'. In the Power Modulation section, select one or more NI-DAQ devices, and configure the Analog Outputs and Analog Inputs for the connected Pockels Cell. Next, each configured Beam DAQ board should be assigned to a Scanner. The Scanner then uses the Beam DAQ board during imaging for power modulation.



Configure the beam modulator in ScanImage by selecting 'File > Machine Configuration'



After changing settings in the Machine Configuration Editor, ScanImage needs to be restarted to apply the changes.

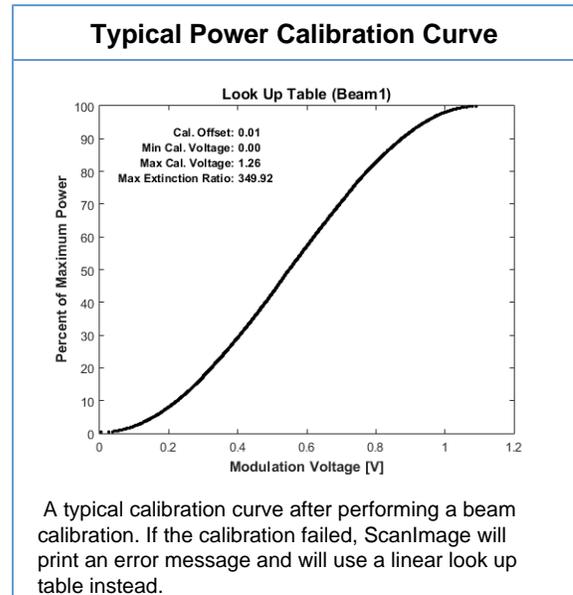
Calibration

The Pockels Cell power modulation is non-linear in respect to the control voltage. To compensate for this non-linearity, ScanImage creates a look-up table that translates a desired power into a control voltage. After the Pockels Cell is configured, follow the steps below to create a look up table.

Power Calibration Procedure

		Pwr
Beam DAQ 1 CH 1	<input checked="" type="checkbox"/>	1
Beam DAQ 2 CH 1	<input type="checkbox"/>	1

1. Select which beam to calibrate
2. Shutter the laser and select 'Calibrate' to measure the dark voltage of the photodiode
3. Open the laser shutter and select 'Calibrate'
4. Select 'Show Curve' to plot the Pockels Cell response



✔ The look-up table depends on the operating temperature of the Pockels Cell and the wavelength of the laser. It is recommended to recalibrate the look-up table before the start of every experiment to ensure the power modulation is reliable.

Alignment

When ScanImage is idle, the scanners are parked, the shutters are closed and the Pockels Cell does not transmit light. For alignment, select 'Point' in the ScanImage Main Controls window. This will open the shutter and center the mirrors. To allow light through the Pockels Cell, change the slider in the Power Controls window to the desired power, and check the box 'Direct Mode'. To abort the alignment, select the 'Abort' in the Main Controls. This will park the scanners, close the shutters and Pockels Cells.

Imaging

During imaging, change the slider in the Power Control GUI to change the laser power.

✔ ScanImage **blanks the beam during scanner turnaround** to avoid overexposing the sample. Since the Pockels Cell does not respond to a changed control voltage instantaneously, the image can show blanking artifacts on the left and right edges. ScanImage can compensate for this effect by shifting the command voltage in time. This time shift can be set in the field 'Beam Lead Time' in the Power Controls Window. Typically, a value of 2us is sufficient.

Troubleshooting

If the power calibration fails, try the following steps. Remember to take appropriate precautions when operating high power lasers.

Ensure hardware is functioning

Ensure ScanImage is not active. Connect the photodiode to an oscilloscope. Change the offset dial on the Pockels Cell driver board and observe if the voltage of the photodiode is changing. Ensure the photodiode is not saturating, and the output voltage does not exceed 10V. If necessary, adjust the output gain of the photodiode or change the optical density of the ND filter.

Ensure the DAQ AO is functioning

Open a [NI MAX Test Panel](#) for the DAQ board connected to the Pockels Cell driver. Open the tab 'Analog Output' and select the correct output channel. Change the output value and select 'Update' to send a constant signal to the driver. Observe on the oscilloscope if the photodiode output is changing. Ensure not to exceed the maximum voltage of the driver board input.

Ensure the DAQ AI is functioning

Reset the analog output voltage to zero. Connect the photodiode to a DAQ AI channel on the same board as the command output. In the NI Test Panel, select the tab 'Analog Input' and select the correct AI channel. Click 'Start' to update the graph. Change the offset dial on the driver and observe if the AI voltage level changes.

Close the NI Test Panel.

Check the ScanImage configuration

In ScanImage, select File > Machine Configuration and verify the settings for the Power Modulation (see above). Verify the settings for AO channel, AI channel, transmitted/rejected light, and shutters.

Calibrate the Pockel Cell in ScanImage

Follow the instruction above to obtain a calibration curve

Verify the power under the objective

In the main window, select 'Point' to center the scanner mirrors. Change the slider in the Power Control Window to 5%. Check the box 'Direct Mode' and verify that the laser reaches the objective. Uncheck the box 'Direct Mode'.

Verify the power throughput while scanning

Start a Focus in ScanImage. Verify with a powermeter that the beam power changes as you change the power in the ScanImage power controls. Abort the focus.

