Tune Mode Generator System 2017

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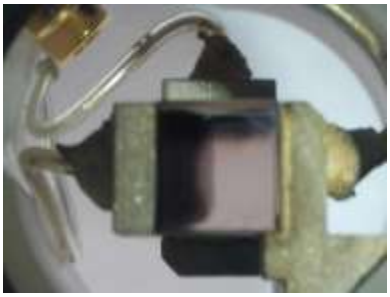
This document describes the design goals and final system construction of the tune mode generator system.

Brief History:

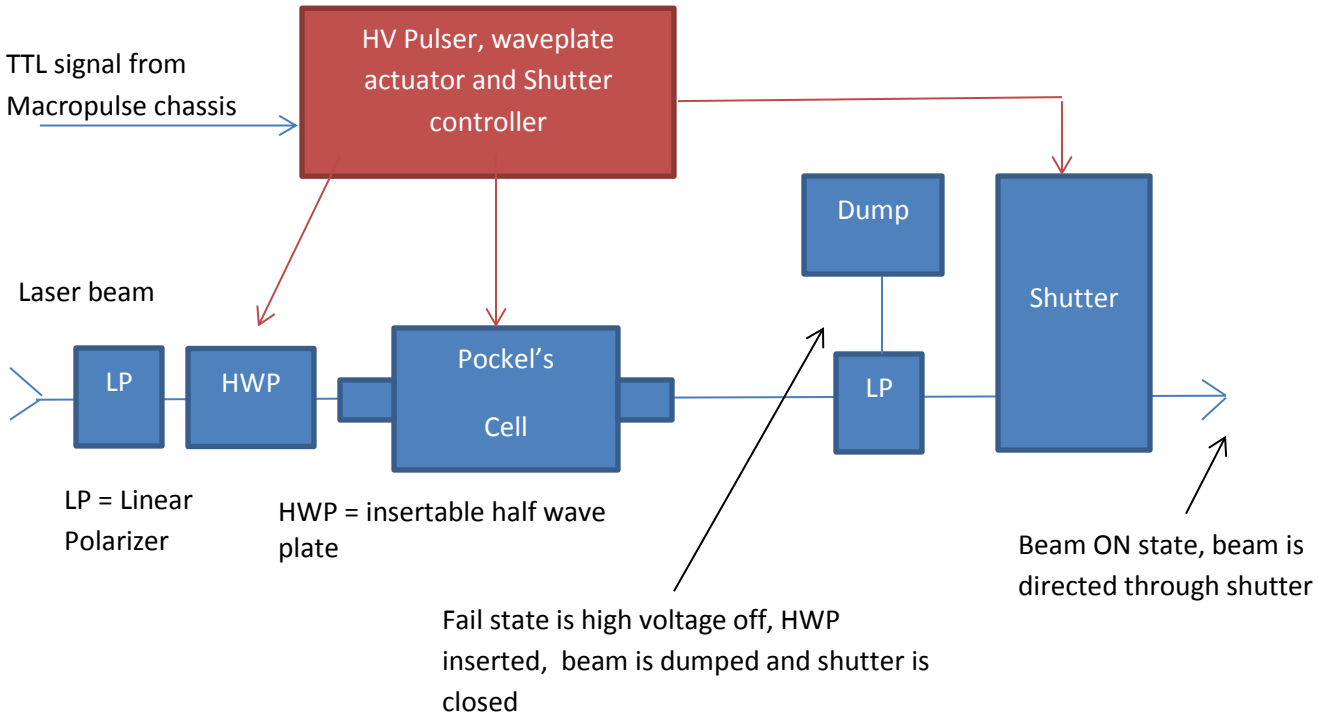


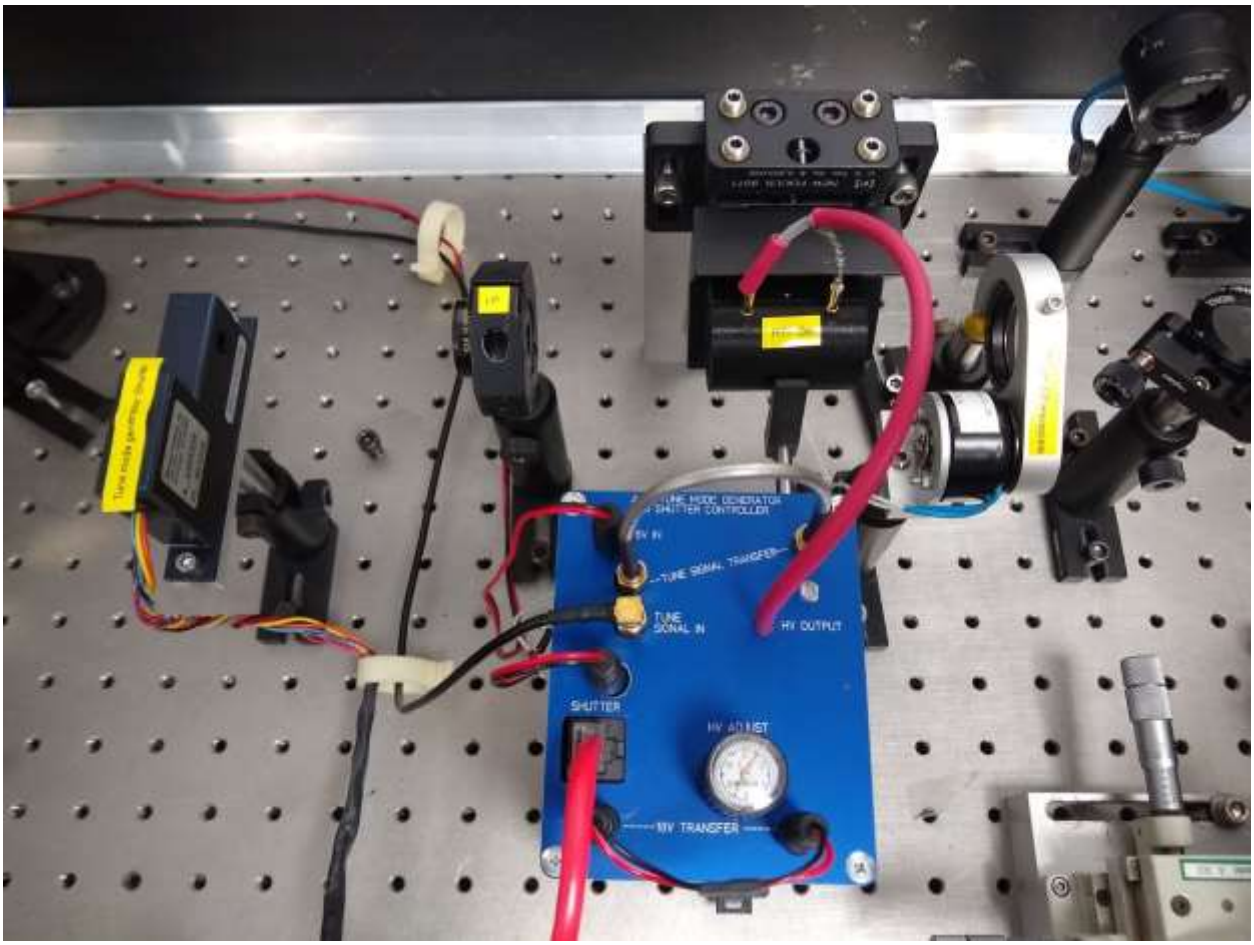
Our tune mode generator system uses RTP pockels cells for high speed chopping of the laser beam. In 2016, we ran with a control scheme that applied high voltage to pass beam for CW mode. Even though the manufacturer stated that RTP did not suffer from ion migration, the crystal failed as is evident from the photo above. The black "growth" is appearing to come from one electrode and is growing over time. This cell is now pulled from service because it was losing transmission and the extinction ratio was dropping below 100:1. Clearly a system needed to be designed that would have no voltage on the cell during CW mode. The new design described here applies high voltage only for tune and viewer-limited modes.

Design Considerations:

1. Make a failsafe circuit that uses "off the shelf" components.
2. There shall be no microcontrollers or programmable logic in the device, so any technician can reproduce the item anytime in the future.
3. Make the circuit board relatively compact.
4. System should operate on 18VDC and removal of 18V will physically stop the laser beam from striking the electron gun with two methods.
   A. The configuration of cell, waveplate, and crossed polarizers shall dump the light upon loss of power.
   B. The laser shutter shall close on loss of power.
5. System must be able to chop the beam on and off using the pockels cell with a rise and fall time of 50ns. The shutter shall close to back up the Pockel's cell within 30ms of any "beam off" request.
6. System shall accurately reproduce the structure of the beam coming from the SCAM module via the macropulse chassis.

A physical schematic diagram of the laser table components is shown below:





The image above is the actual tune mode generator with placement of optical components as represented in the previous schematic layout, but in this case the beam starts on the right and is delivered through the shutter on the left. This layout consumes about 12” by 8” of table space for each laser, and can be made more compact if desired.

The insertable halfwave plate is controlled by a rotary solenoid. When 18V is applied, it lifts the plate up by rotating 45 degrees. When power is removed, the plate falls by gravity and spring return pressure.

From a standpoint of the Personnel Safety System (PSS) interface, it should be obvious that removing the incoming power feed (18VDC) will secure the beam with two methods.

1. The pockel's cell high voltage will be off and the cell will not be able to rotate polarization. The insertable wave plate will drop into the beam path by both gravity and spring load. The alignment of the waveplate and the linear polarizers will divert the beam to the dump.
2. The shutter drive circuit will not have power to open the shutter. The shutter is spring loaded to close and will stop beam.

The control scheme is as shown below:

Beam Mode	**Pockels cell High Voltage**	**half wave plate**	**Shutter**
Beam OFF	OFF	Inserted	Closed
Viewer-Limited	Pulsing	Inserted	Open
Tune	Pulsing	Inserted	Open
CW	OFF	Retracted	Open

In addition, the circuit will actively pulse the Pockels cell to high voltage and hold it for 100ms whenever we are in CW mode and a transition to beam Off mode occurs. As a result, an incoming Fast Shut Down (FSD) from CW mode will still rapidly cut away the beam to the extinction ratio of the cell until the shutter closes to back up the "beam Off" command.

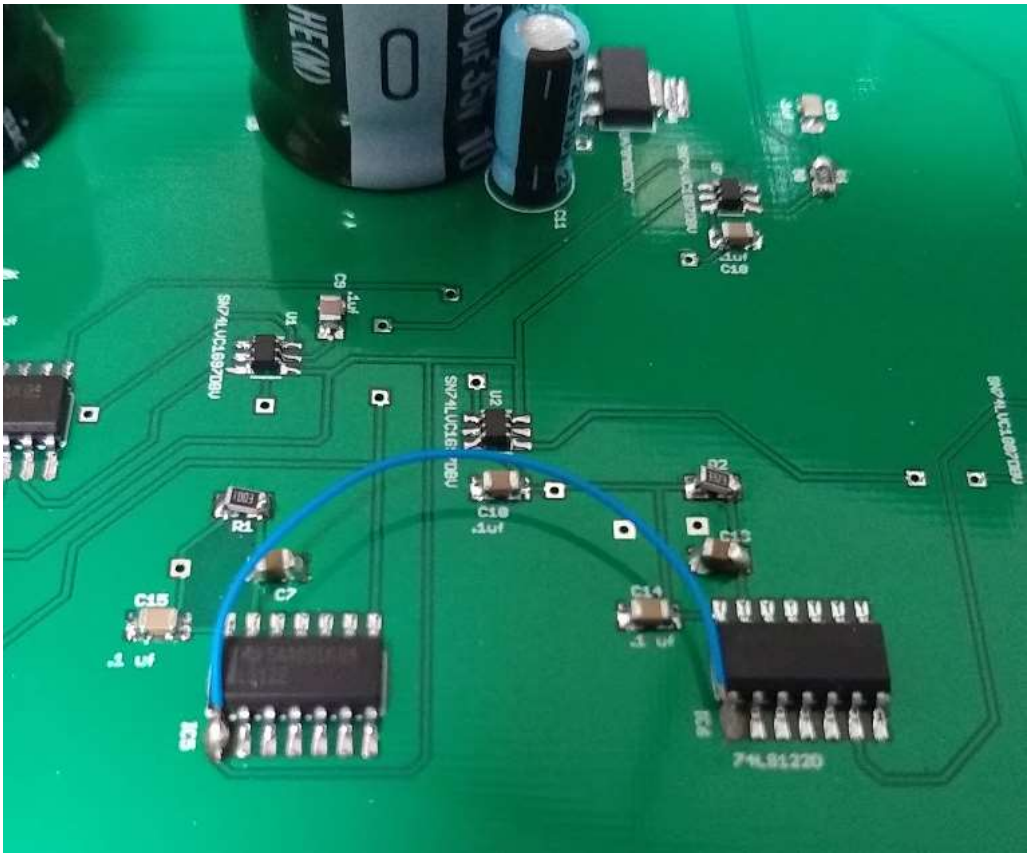
Shutter drive Circuit

The shutter drive circuit board watches the incoming TTL signals and makes a determination to open or close the shutter based on that signal. When TTL is high, the shutter opens. When TTL is pulsing greater than 37hz, the shutter opens. When TTL is low for longer than 27ms, the shutter closes.

It should be noted and understood here that if you were to create an odd beam mode with the SCAM user mode that has a repetition rate slower than 37 Hz, you may end up in a bad state where the shutter is repeatedly cycling. For this reason, we say beam mode should be OFF, or pulsing greater than 50 Hz. We don't want to even approach 37 Hz that is set by logic timers that may drift slightly.

The physical layout of the board allows it to mount within the internal slide rails of a Hammond 1455 Series electronics box. The schematic for this circuit is in the design package as an eagle file and a pdf.

There was one mistake on the original gerber for board manufacture. As you can see in the photo, pin 1 of IC4 needed a jumper to pin 1 of IC5. This is repaired in the board file now.



Pockel's Cell driver circuit:

The Pockel's cell driver circuit board also slides into a Hammond 1455 series electronics enclosure. The circuit board has a small 2kV regulated DC-DC power supply and a pair of fast Insulated Gate Bipolar Transistors (IGBT's) in a half-bridge configuration that allows the Pockel's Cell output line to be rapidly driven between positive high voltage and ground. The half-bridge allows the output to rest indefinitely in either output condition. The half-bridge driver has cross-over protection so both IGBT's cannot be energized simultaneously. The schematic for this circuit is in the design package as an eagle file and a pdf.

Assembly:

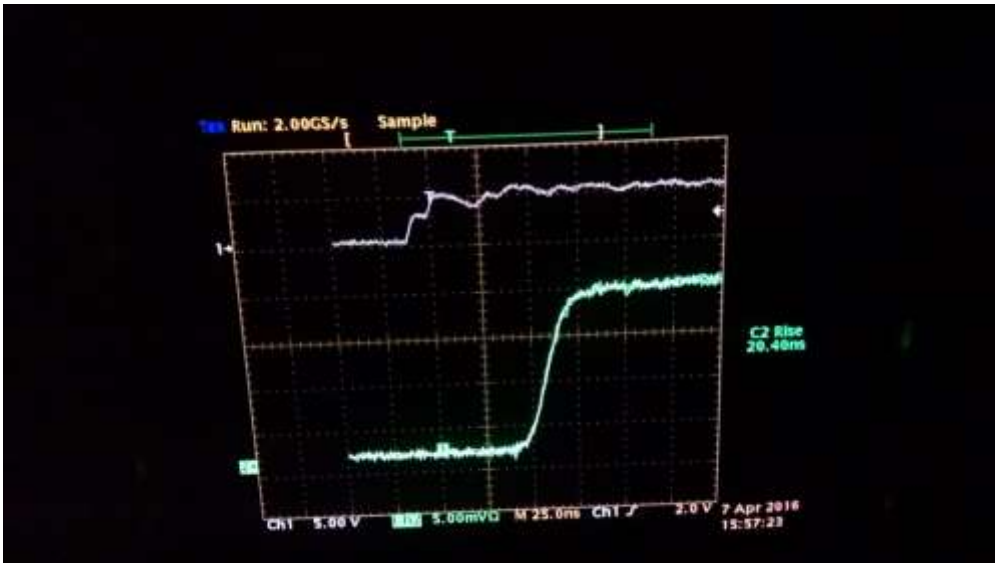
The Pockel's cell switch is placed in the larger Hammond 1455N1201 box (120mmX103mmX53mm). The shutter drive is placed in a smaller 1455L1201 box that is bolted to the side of the larger box. This are separated so the EMI produced by the high voltage switch will not affect the shutter control.

A DIN rail clip is attached to the rear of the assembly. This lets it quickly snap down to a DIN rail mounted on the laser table.

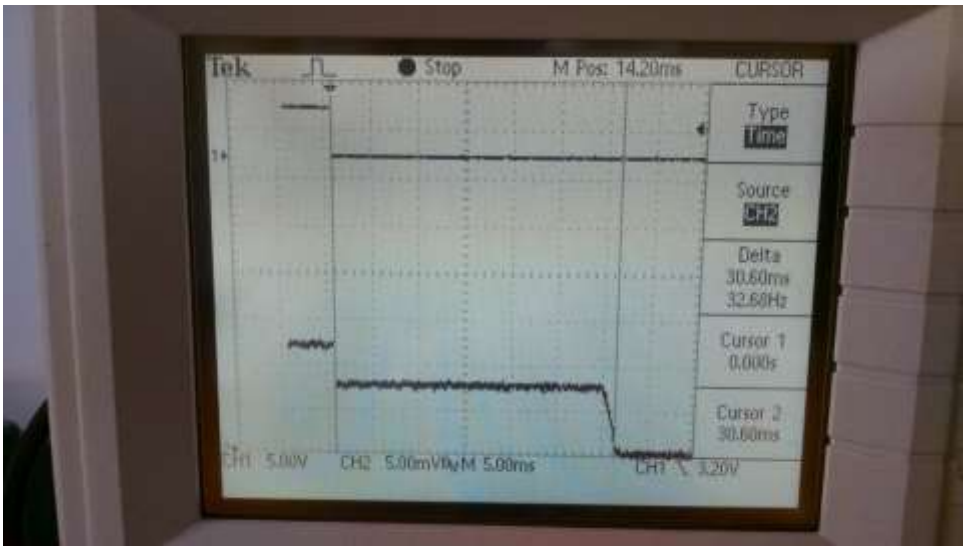
The boards are slipped into their respective boxes.

A custom cover plate from Front Panel Express ties it all together from the top. We had to drill one additional hole for the waveplate connector which was a late revision.

Operation:



Trace that shows the high speed response of the circuit to an "ON" command. Rise time is 20.4ns from 0 to 1800V. The fall time is identical. The white trace is the TTL input, and the green trace is a fast photodiode response of the laser light passing through the Pockel's cell.



Trace showing the shutter closure time. In this image the top trace is the command for "beam off". The bottom trace is the laser beam passing through a purposely misaligned Pockel's cell and the shutter

before striking a photodiode to create this trace. Notice the Pockel's cell immediately drops the power within 20ns to an intermediate level. This level would normally be so low that we cannot discern the shutter closure. 30ms later, we see the shutter close to completely block the beam.

The laser shutter we are presently using is the LST400.

Datasheet of the LST400 from nmlaser.com

Model LST400 Series Specifications

This model is designed for use as a safety interlock and for some processing applications. For high activity processing, consider the LS055W8 model. The LST400 provides TTL output position sensors for the open and closed states as standard equipment. The thin body style and 8 mm aperture accommodate many popular laser sources. The –IR suffix replaces the over-coated aluminum mirror with gold, for use in the IR, including CO2. This option must be used for CO2 lasers.

Compatible system controllers include user built capacitor discharge, PWM current drivers, and our controller models CX3000B, CX1100, and CX2450B.

Options are available using a suffix code system. Many options cannot be installed after manufacture, so choose carefully. Choose the –IR suffix for CO2 and IR use, starting at about 700 nm. The standard over-coated aluminum mirror is good from deep UV to about 4 microns. Special mirrors are not currently available, except for OEM applications. Cable options are available, call for details.

See the "Mechanical Drawing" tab for dimensions. Also see the "Application Notes" tab on the home page menu for important operational issues including: thermal mounting, user-built circuits, polarization, lifetime, jitter, vacuum operation, and contamination. See the "Accessories" tab for useful system components.

Special Considerations for this model include damage threshold assessment. The shutter is not designed for high energy, low repetition rate Q-switched lasers. See LS055W8 and LSTXY-W8 for these applications. Thermal mounting must be given strong attention if optical power dissipation is near the upper limit of the rating.

Restricted use for this model is only limited to damage threshold and wavelength considerations. It can be used in any orientation w/r to gravity.

RECOMMENDED CONTROLLER =	USER CIRCUIT — OUR CONTROLLER
Aperture Diameter =	8.0 mm
Typical Beam Diameter used for Specs =	6.0 mm
Maximum Shutter Repetition Rate =	3 Hz
CW and Quasi-CW Optical Power Handling =	25 W (OEM to 50 W
Typical Damage Threshold, Aligned Polarization =	300 mJ/cm
Delay to Begin Opening after Command Open =	10 ms
Opening Time Switching Speed =	20 ms
Delay to Begin Closing after Command Close =	10 ms
Closing Time Switching Speed =	20 ms using CX3000B
Minimum FWHM Exposure Capability =	30 ms using CX3000B
Thermal Power Dissipation Holding Open =	4 W
Thermal Power Dissipation, Repetitive Cycling =	8 W @ 3 Hz
Nominal Magnetic Winding Impedance =	15 Ohms
Cable/Wire Type and Length =	18 inch, 6 leads 22 g.
Mounting Surface for Thermal Sinking =	Base Plate
Position Sensors =	Logic TTL, Require 5 VDC @ 20 mA
Weight =	4 Oz.
Size (see mechanical drawing) =	3.80 x 2.06 x .64 Inches

Parts list of shutter board: (refer to system schematic)

Part	description	Source and part number
IC2, 3	Solenoid driver chip	TI DRV102F (digikey 296-15964-1)
U1-3, 5-8	Configurable multifunction gate	SN74LVC1G97DBV (digikey 296-15581-1)
X1,X3	Power connector 2.5X5mm	CUI corp PJ-102BH (digikey CP-102BH)
IC1,5,6	74LS122D in SO14 package	74LS122D
X2,X4	SMA board edge connectors	Digikey 931-1175
S1	DIL switch	Digikey GH7135-ND
Diodes D1-4	SMC package Schottky diode	ON semiconductor MBRS3100T3G (or equiv)
IC7	5V regulator type 7805TV	On Semi MC7805CTG or equiv
C2,C5	1000uf 35V capacitor	Nichicon UHE1V102MHD6 or equiv
J1	8P8C RJ-45 connector	Amp 54602-908LF or equiv
All chip resistors and capacitors as shown on schematic and silkscreen		
Enclosure	Hammond Manufacturing 1455 series	1455L1201 (digikey)

Parts list of Pockel's Cell driver board: (refer to system schematic)

Part	description	Source and part number
X3	Power connector 2.5X5mm	CUI corp PJ-102BH (digikey CP-102BH)
IC2	15V switcher type voltage regulator	Digikey 945-1048
U$5	3kV HV iso 15V DC-DC converter	DCH010515SN7 (Digikey 296-20642)
U2,4	2500V IGBT IXGT2N250	Digikey IXGT2N250
U2,3	SI82394BD gate driver IC	Digikey 336-3383-5
U$6	0-2KV 2.5mA regulated supply	PICO Electronics HVP2P
LED	High effic Amber LED	Digikey 516-1779-1
R7	100 ohm resistor	Any 805 type

R4	100K resistor	Any 805 type
R3	82.5K resistor	Any 805 type
R3	Not stuffed- can be used if 50ohm matching desired in future.	
R1,2	7K resistor (+/- 5%)	Any 805 size
X2	SMA board edge connector	Digikey 931-1175
C2,C4,C7,C8	.1uf capacitor	Any 805 size rated >24V
C1,C3,C6,C9	1uf capacitor	Any 805 size rated >24V
C5,C12	100pf capacitor	Any 805 size rated >24V
C11,13,14	10uf 35V capacitor	package C050-.025 by .075
C10,15,16,17	220pf 3KV capacitor	DEA1X3F221JA3B (jlab stockpile)
IC1	5V regulator type 7805TV	On Semi MC7805CTG or equiv
Enclosure	Hammond Manufacturing 1455 series	1455N1201 (digikey)
DIN rail clip	Optional mounting method for box	Hammond HM1361-ND (digikey)
Barrel plug for power and jumper between boards		(3 per system) Digikey 839-1166
6” SMA cables	1 per system	Vcablemart.com

Custom front panel from Front Panel Express

The full design package for this device is located on the M: drive at:

M:\inj_group\Official Electronic Design Packages

The folder contains the following files:

GERBER files zipped and ready for manufacture

Eagle board and schematic files (Pockels cell driver is called rtp01)

Board schematics in DXF format.

Front Panel Express – front panel layout (.fpd file) and bitmap images of panel and purchase.

Front Panel Express file exported as DXF

Schematics of printed circuit boards in PDF format.