

DESIGN AND IMPLEMENTATION OF LABVIEW™ BASED GUI FOR REMOTE OPERATION AND CONTROL OF EXCIMER LASER FOR PLASMA WAKEFIELD ACCELERATION EXPERIMENT

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Abstract

The paper describes the development of a GUI based control software for control/operation, maintenance and data logging of a Coherent CompexPro 102 Excimer Laser (ArF, 193 nm) using LabView™ instrument control software.

INTRODUCTION

The Coherent COMPexPro102 Excimer laser (Fig.1) is an ArF gas based UV laser operating at a wavelength of 193 nm. This laser uses Ar, F₂, Ne, and He gases for its operation. The laser can deliver a maximum energy of ~ 200 mJ at 15 ns pulse width and capable of operating at a pulse repetition rate of 1-20 Hz. The laser is normally controlled using a tethered control panel which has a cable length restriction of around 3 meters. In order that the laser can be controlled and monitored remotely, it is essential that a GUI based interface be developed. The block-diagram of system showing the gas feed system, the I/O system and the energy meters is shown in Fig.2.

Currently, the operation of the laser is carried out manually using the wired keypad. The main motivation of the development of this GUI is for easier user convenience as well as for future use when the laser will be used to generate lithium photo-ionized plasma for the plasma wakefield accelerator experiment system. In the experiment, the laser operation will be carried out remotely and the laser system will be integrated with the accelerator system operations *via* LabView™ instrument



Figure 1: The Excimer laser system.

control software. The GUI of the laser will be integrated with the GUI's of other components of the experiment

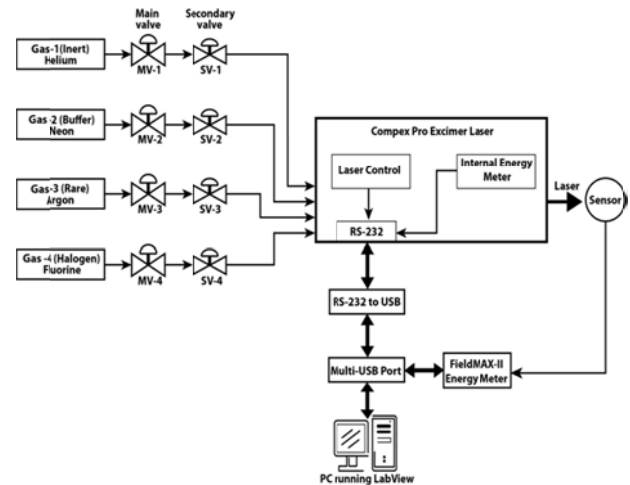


Figure 2: Schematic diagram of the excimer laser system showing the gas lines, I/O interfaces and energy calibration layout.

such as accelerator operation, precision heater controls for the plasma chamber, vacuum /gas fill systems as well as data acquisition equipment, thus providing a single window control of the whole experimental system. Routine laser operation (setting of parameters and running of laser), maintenance operations like gas fill and energy calibration, logging of laser parameters etc., which are currently being carried out manually will be automated using the GUI.

This paper presents the development of the module for the excimer laser, *i.e.*, the required LabVIEW™ virtual instrument modules, GUI interfaces and the required display screens for laser control, parameter display, gas fill operation as well as documentation/logging of the operational parameters of the laser system. The paper also presents the development of a completely automated module for calibration of the internal energy meter of the excimer laser with a calibrated external laser energy meter (Coherent FieldMax-II). This procedure is necessary as the performance and calibration of the internal energy meter which is used by the laser system to stabilize its laser output can vary over a period. This one-switch, automated operation provides a linear-fitted calibration of the internal energy meter with that of a pre-calibrated commercial energy meter. This procedure is

usually carried out after each gas fill to make sure that the health of the laser system is good.

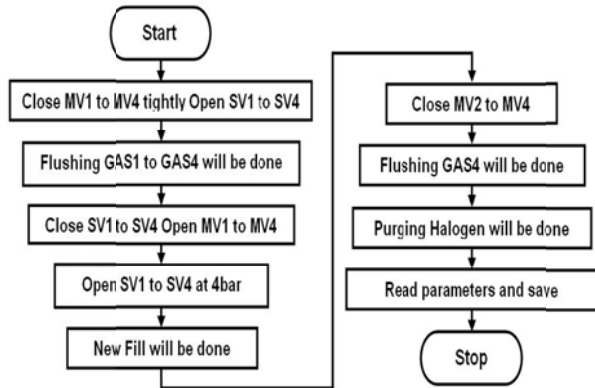


Figure 3: Flow-chart for Gas-Fill Operation.

The I/O control of the laser is established via a standard RS-232 interface coupled to the PC through a RS-232-to-USB interface. LabVIEW™ tools like web-publishing Tool, structure palette, string, VISA palette have been used to design this graphical user interface.

The laser is designed to be controlled either from the control panel or from a remote PC but not from both at the same time.

Field-MAX-II-P energy meter with an energy sensor optimized and calibrated for use with 193 nm UV laser is used for external energy measurement. The UV sensor incorporates a DUV quartz diffuser for increased coating damage resistance. The energy meter has USB I/O connectivity and hence could be seamlessly integrated into the laser GUI.

MODULE FOR GAS-FILL OPERATION

Excimer Laser uses a mixture of various gases depending on the wavelength of operation of the laser. The 193 nm operation of the laser uses he, Ne, Ar and F gases in various proportions which are decided by the laser system at the time of gas filling operation. The gas

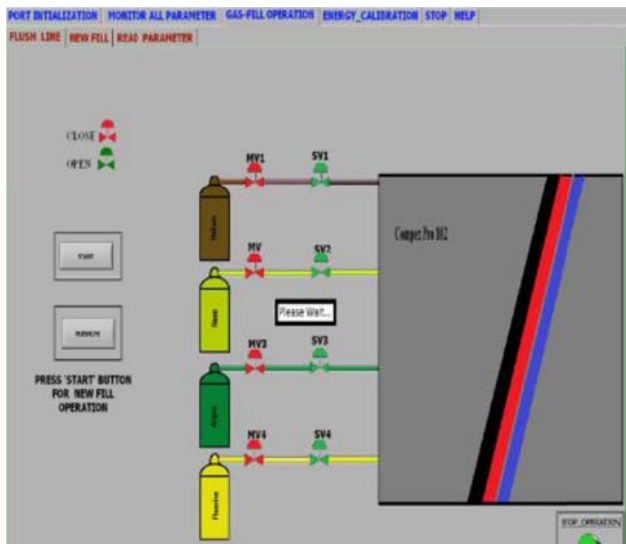


Figure 4: Front-Panel for Flushing gas lines.

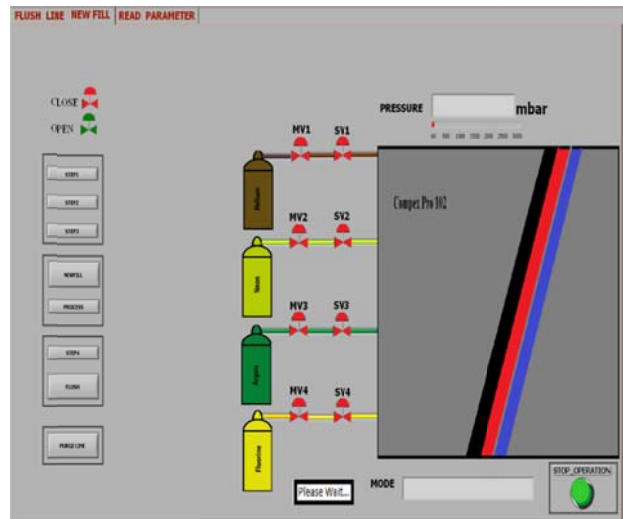


Figure 5: Front-Panel for New fill and Purge line.

fills have to be carried out periodically so as to maintain the laser at its operating energy. The flow-chart of the gas-filling process based on which the GUI has been designed is shown in Fig.3. In this GUI, gas flushing, new-fill, purge-gas line and data logging are automatically carried out.

Front Panel for Flushing gas Lines

Gas flushing is an essential step to clear the gas lines of all impurities before the actual gas fill operation is initiated. When this operation is initiated from the “Flush Line” GUI, all the gas lines will be flushed using helium gas and since Fluorine is a corrosive gas, that line is flushed twice as a precautionary measure. The image of the GUI for Flush Line is shown in Fig.4.

Front Panel for New-Fill and Purge Line

This GUI assists in the gas-fill procedure. Once the “NEWFILL” operation is initiated, the GUI will prompt the user to open or close appropriate gas valves (MV1/SV1 to MV4/SV4) and go through the process of first evacuating the gas lines and the laser cavity and then filling all the

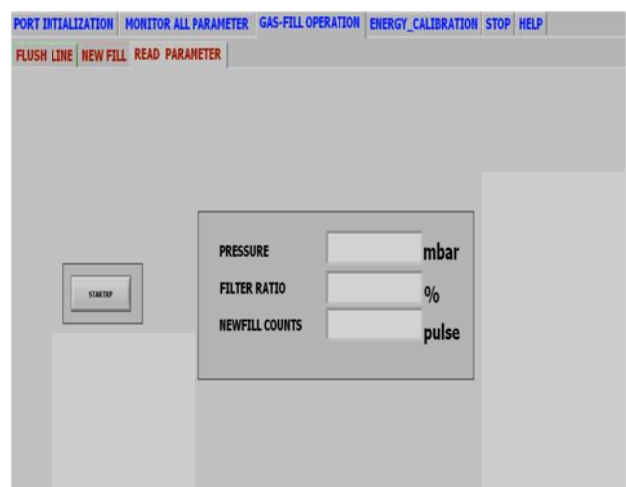


Figure 6: Front-Panel for post gas fill parameters.

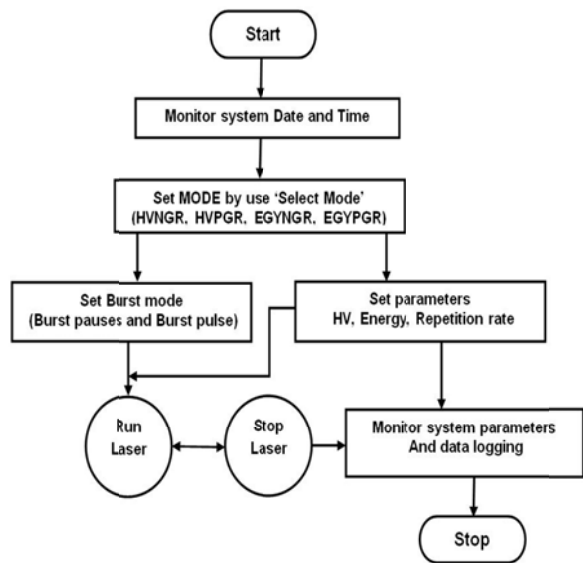


Figure 7: Flow chart for monitor and set laser parameter.

required gases at appropriate pressures into the laser system. Currently, these gas valves are manually operated. In future, the whole operation could be fully automated if the manual valves are replaced by electrically controlled valves. Once the gas fill is over, the GUI will automatically flush the gas lines and purge the lines with inert gas for safety. The GUI for the gas fill is shown in Fig.5. Post gas-fill parameters of the system are shown via GUI shown in Fig. 6. This also logs the data to the log file.

Front Panel for Display of Laser Maintenance Parameters

Other system maintenance parameters such as gas pressures, filter ratio (lifetime of the halogen filter), total laser pulses, pulses after refill, tube temperature etc can be displayed.

By using the “STARTRP” command, these parameters can be logged into an Excel file for laser maintenance purposes. The flow chart for this GUI is shown in Fig.6.

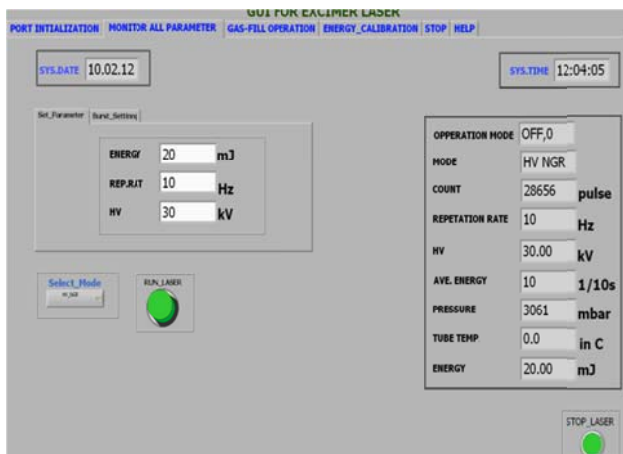


Figure 8 : Front-panel of Monitor and laser Set parameter.

MODULE FOR LASER MONITOR AND SET PARAMETERS

This GUI is basically to display the various operating and set parameters of the laser. Parameters such as laser energy, laser repetition rate and mode of operation (Constant energy or constant voltage) can be set. Also, there is an option to activate the burst-mode operation of the laser if desired so by the user. Flowchart for this GUI is shown in Fig.7. Front-panel for this is shown in Fig.8.

There are four basic operating modes under “Select Mode” viz, HV-PGR, HV-NGR (constant voltage mode with and without gas purge), EGY-PGR, EGY-NGR, (constant energy mode with and without gas purge) for setting the running mode for the excimer laser. At a time, only one of the four options can be activated and can be changed only after laser is in off mode.

MODULE FOR LASER ENERGY CALIBRATION

The internal energy meter of the excimer laser taps a small percentage of the laser beam to monitor the beam energy. This is used for stabilizing the laser output. Over time, the calibration of this internal energy meter deteriorates and needs to be corrected over time. The calibration of the internal energy meter can be done against a pre-calibrated external energy meter. By plotting the outputs of both the internal and external energy meters at various operating voltages, one can determine if the internal energy meter is correct. If the calibration is found to off by more than an acceptable percentage, then the internal energy meter needs to be physically recalibrated. The flow-chart for energy calibration is shown in Fig.9. The “START CALIBERATION” process requires the outputs of both the laser and the external energy meter to be read, the data averaged and standard deviation determined for

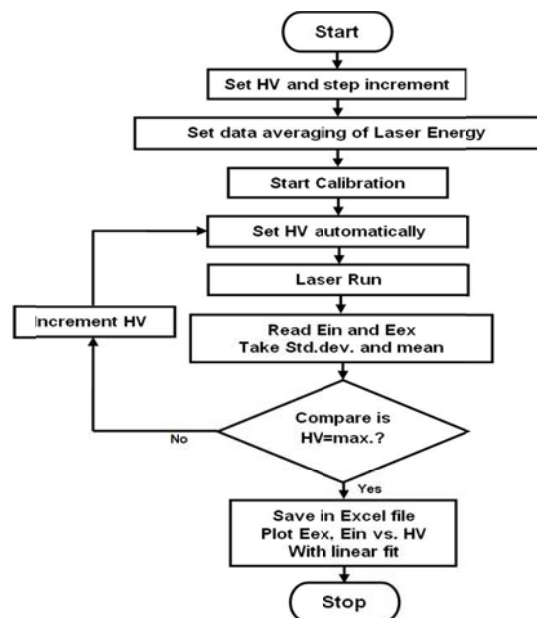


Figure 9: Flow-chart for Energy Calibration.

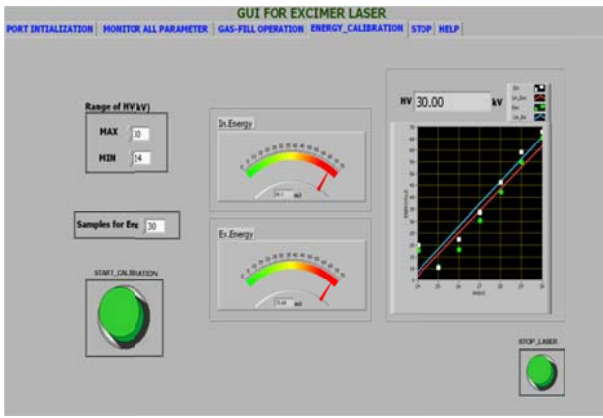


Figure 10: Front-Panel of Energy-Calibration GUI.

various voltage levels. The averaged data is plotted in the graph *in-situ*. After the process ends, the data is saved in Excel form, and finally plotted against laser high voltage, as shown in Fig 10. The data points are then linearly fitted to obtain slopes, which are then compared to determine if the calibration of the internal energy meter is within acceptable limits. The internal statistical math modules of LabVIEW™ are used for this. The logged data in Excel format is shown in Fig.11.

Time	HV	E _{in}	Linfit E _{in}	E _{ex}	Linfit E _{ex}	Slope E _{in}	Slope E _{ex}	STD E _{ex}
H:M:S	kV	mJ	mJ	mJ	mJ			
11:13:52	24	103.13	104.18	109.43	108.85	14.65	14.53	7.35
11:15:50	25	123.2	118.83	113.64	123.39	14.65	14.53	8.15
11:17:32	26	137.42	133.48	129.25	137.92	14.65	14.53	7.20
11:19:46	27	155.79	148.12	151.34	152.45	14.65	14.53	7.45
11:21:52	28	168.85	162.77	163.17	166.99	14.65	14.53	6.43
11:23:43	29	181.06	177.42	178.28	181.52	14.65	14.53	7.97
11:25:52	30	193.73	192.07	191.75	196.06	14.65	14.53	7.35

Figure 11: Data for energy calibration saved in excel file.

LABVIEW™ DRIVERS FOR EXCIMER LASER

In this Virtual Instrument driver (VI) file, all the Sub-VI drivers for different commands related to the excimer laser operation have been developed and incorporated. The VI-Tree showing the various VI's generated for compiling this GUI depicted schematically in Fig.13.

Flush Command

There are four “Flush” commands are used to flush gas lines of the various gases used for operation of the excimer laser (Halogen, Buffer, Rare, and Inert gases).

Write Command

The four sub-routines under this VI are set/control functions related to running of the laser *ie.*, “Run Laser”, “Stop Laser”, “Change value of HV”, “Repetition Rate” .

Read Command

All parameters (like operation-mode, mode, repetition-rate, HV, Energy, Pressure, System time and date, tube temperature, etc.) of excimer laser are read by running this VI.

LOGICAL SUB-ROUTINES

There are five sub-routines under this VI. Password sub VI is used for the security purpose. Call VI is used for to call VI from folder where it has been saved. Regression is used to find relation between two parameters by linear fit.

Mathematics

These sub-VIs are used for to estimate mean, min, max, standard deviation and slope for data in the energy calibration operation.

Save file

All data logging operations are carried out by this VI.

Multi Y-axes Graph

All multi X-Y graphical representations are carried out by this VI.

Steps for Gas-fill

All user messages related to step-wise explanation/confirmation of the manual part of the gas-fill operation are displayed to the user when this VI is run.

MODULES FOR EXCIMER LASER

There are four sub VI modules (like Port Initialization, Gas-Fill operation, Monitor and set parameter and Energy calibration) for excimer laser which have been designed under this module.

CONCLUSIONS

GUI for port initialization, setting and monitor all parameters of excimer laser, gas fill operation and energy calibration for excimer laser are designed by serial interface using RS-232, DB-9 connector. But, all parameters of excimer laser are monitor and set with one second or two second delay. Virtual instrument of Excimer laser and external energy meter is designed using LabVIEW™ software. Real-Time Data acquisition will be done in various file like .doc.,pdf,.xls,.txt etc. All laser operation will be done on internet in LabVIEW™ environment if all computers are connected



Figure 12: View of the plasma accelerator laboratory showing the ArF laser and the plasma accelerator chamber.

in LAN. Automatic programming will be design for Laser operations and it will be change. Laser operation will be become faster and safe than it operate manually. Laser

[6] User Manual for Coherent FieldMaxII-P Laser Energy Meter.

[7] Béla G. Lipták, “Process Software and Digital Networking” Instrument Engineer’s Handbook, 3rd edition, CRC press, (2002).

[8] User Manual, Coherent Energy Max Sensors.

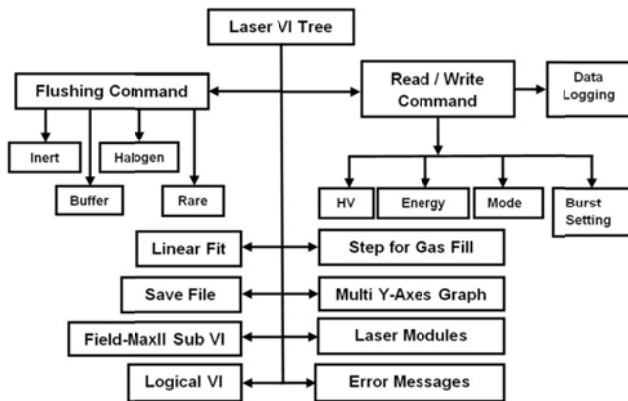


Figure 13: The V-I tree for the Excimer laser.

operations are easy to operate and understand by user. Laser Data will be transferred for long distance using RS-232 to RS-485 converter.

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