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## **SOFTWARE IMPROVEMENT FOR MERCURY PRESSURE MEASUREMENT SYSTEM**

Working with PLC Communication in LabVIEW-Environment

SOFWARE IMPROVEMENT FOR MERCURY  
PRESSURE MEASUREMENT SYSTEM

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A special measurement system in Philips Lighting Turnhout uses a LabVIEW based software for mercury pressure measurement of ultra high performance burners. This application has become out-of-date, and a new application based on the standard LabVIEW template with a newer software environment was designed.

The aim of this Bachelor's thesis was an implementation of a programmable logic controller and lamp voltage measurement features to the new application. Some additional features were also made during the project with another thesis writer who concentrated on the measurement algorithm. The project was made in a real working environment, and meetings with co-workers were held at regular intervals.

The Goal of the project was achieved and nowadays the new application is operating as part of the online quality control system of the burner production line.

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## **ABBREVIATIONS**

DFM Data Flow Manager

DPL Digital Projection Lighting

FS Functional Specification

GTD Global Technology Development

GUI Graphical User Interface

I/O Input/Output

IOS Input/Output Server

LabVIEW Laboratory Virtual Instrument Engineering Workbench

MAX Measurement & Automation Explorer (National Instruments software)

PC Personal Computer

PCI Peripheral Component Interconnect

PLC Programmable Logic Controller

RS-232 Recommended Standard 232, serial data communications

TFS Transformation Server

UHP Ultra High Pressure

US User Specification

VI Virtual Instrument

V<sub>l</sub> Lamp Voltage (unit is Volt)

# 1 INTRODUCTION

Philips Lighting Turnhout is one of the biggest manufacturers in the world for special lighting. The DPL (Digital Projection Lighting) department produces UHP (Ultra-High Performance) burners. These burners are ideal light sources for projectors and rear projection televisions because they have the highest light output of the micro display projectors. UHP lamps have a long operating time and a low loss of luminous flux during it. The name of the UHP lamp is related to a very high operating pressure that is usually around 200-250 bars. (1.)

Philips has a special way for manufacturing these kinds of burners. This system with high quality materials and an accurate online quality control system ensures that only good products will be delivered to customers. A Special kind of measuring method has been developed for the pressure measurement. This fully automatic PLC-controlled system uses the spectral analysis for pressure calculation.

The application that used to control the measuring unit in the production line has been in use and under development about ten years (2). During this time the source code of the application has become very large and confusing to debug. Because of this, much production time is lost when some program related problems occur. It is very difficult to find experts who are able to fix those problems. This is why it was time for rebuilding the application.

The software that was based on an old software environment sometimes reported a working burner as defect. The Reason for these errors was noticed in the old program, and it had to be fixed. The Old application did some logging of the results but the arrangements of these results were very confusing and difficult to read. Because of that it had to be redone in a better way.

The goal of this project was to develop a continuous, reliable and long-lasting measurement application for the pressure measurement using the LabVIEW template created for Philips. The algorithm design for the measurement and

programming logic controllers was not a part of this project, but some minor features and documentation were.

Due to the relatively big size of the project it was split in two parts for two automation engineering students and it was estimated to take about four months to complete. The other student concentrated on implementing an algorithm for spectral measurement and on developing some other features, e.g. critical files protection by checksums on logging. The interface of the final application was developed together with him during the project.

Another part that is described in this thesis is concentrated on implementing PLC (Programmable Logic Controller) features and serial communication with the digital I/O and lamp voltage measurement with a new type of a multimeter. The most challenging and laborous parts are related to the PLC and serial communication between the PLC, measuring unit and production PC. The main reason for this was that there were so few examples, and the testing time of these features was very limited. The voltage measurement system came up in the end with a possibility to use an old kind of multimeter as well by changing the type from the settings and replacing the device itself.

## **2 PROGRAMMABLE LOGIC CONTROLLERS**

The basic information of the PLCs and digital I/O (Input/output) are explained in this section. There are many different types of these devices on the market but Siemens S7 and National Instruments products were used during this thesis.

### **2.1 Structure of PLC**

Programmable logic controllers are one of the most important devices in the modern industrial automation. PLCs are applied when a production process goes through with logical steps and a certain type of sequenced operations. Today the PLCs are based on microcomputers and they are very reliable devices with thousands of programming possibilities.

The simplified structure of the programmable logic controllers consist of five units which are: the program memory, in which instructions for sequences are stored, the data memory, where status of the working data is stored, the output devices, which are for example motors and switches also called as actuators, the input devices, which are all kinds of sensors and detectors, and finally the central processing unit that handles all of the other units. (3.)

The programmable logic controller used in the measuring machine is a Siemens SIMATIC S7 product family PLC. In this part of the production the PLC handles almost all moving parts of the machine. Programming the actual PLC was not in the scope of this project but programming the communication between the measuring unit and the production PC with LabVIEW was one of the biggest parts of it.

### **2.2 Digital Inputs and Outputs**

Compared to the analog measurement, the digital signal has only one or two states while the analog signal can have numerous actual values. This state

that the digital signal has is usually called either High and Low or '1' and '0'. When this kind of signals exist, the digital I/O devices are used.

Measuring and sometimes generating digital values is faced in many modern applications. A Digital I/O can read from or write to a line (which in this case means a wire or pin) or an entire digital port, which is a collection of lines. On some devices, it is possible to configure the lines individually to either measure or generate digital signals. Each line corresponds to a channel in the task. Generally, measuring and generating digital values is used in laboratory testing, production testing, and industrial process monitoring and control. (5; 6.)

The IO-card used for handshaking between the PLC and the PC in this project was the National Instruments PCI-6527 which is a 48-bit, parallel, isolated digital I/O board for the PCI (Peripheral Component Interconnect). NI PCI-6527 has 24 digital inputs, 24 digital switch outputs, and no jumpers. PCI-6527 can sense digital levels up to 28 VDC and switch the currents up to 120 mA (7).

### 3 HARDWARE OF QUALITY CONTROL UNIT

The hardware on the UHP burner production consists of many different items like lasers, conveyors, multiple PCs etc. The spectral measuring system has three main units that are introduced in this chapter.

#### 3.1 Measuring Unit

The measuring unit used in the pressure measurement phase of the production is a rotating device and it has 32 holders wherein individual burner billets are hold. Each holder has an igniter that is dependent on the product type and power and it must be changed manually before starting the measurement. In addition, separate connectors are mounted for measuring the lamp voltage with a multimeter. The structure of measuring unit is represented in Figure1.

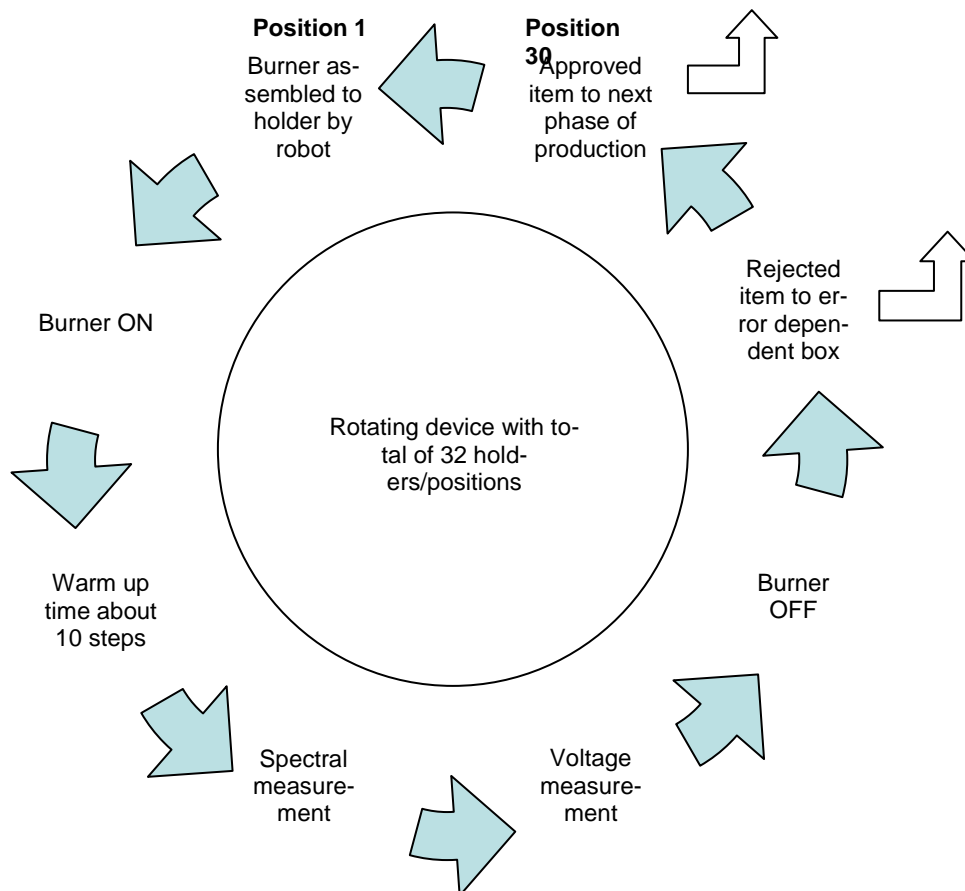


FIGURE 1. Structure of measuring unit

The measuring unit rotates one step at a time to give the burner a warm up time for the measurements. A spectrum is first acquired with a spectrometer, and in the following step the  $V_{Ia}$  (Lamp Voltage) is measured. These results are stored in the buffer, and later the mercury pressure is calculated with a special algorithm. The steps and measurements are represented in Figure 2.

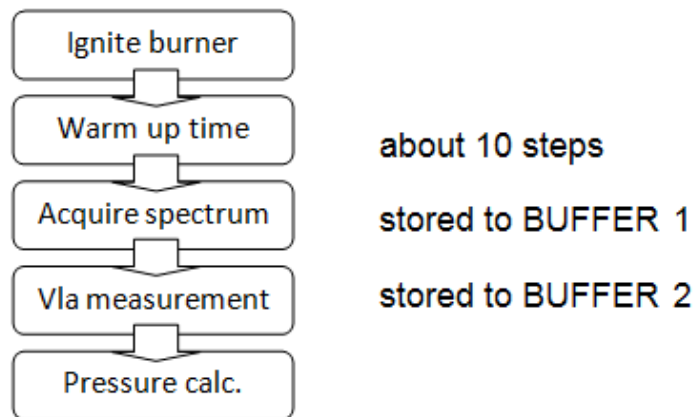


FIGURE 2. Measuring unit operations

### 3.2 Spectrometer

A spectrometer is used when the properties of light at a specific wavelength have to be measured. Most often, the variable that is measured is the intensity of light. The Acton Standard Series spectrometer from Princeton Instruments was used during this project.

Acton SpectraPro-300i was used in the testing phase and Acton SpectraPro-2300i was used in the production line. Both of these have a very good accuracy and a small error rate. Possible wavelengths for these are in range of 0...1400 nm and about 0.1 nm resolution (8; 9).

### 3.3 Multimeter

The measurement of the lamp voltage is measured by a Fluke 8808A digital multimeter (the front panel of the device is represented in Figure 3). It has a

5.5 digit resolution and a very good accuracy and the reliable 2x4 ohms 4-wire measurement technique with various measurement options. It is connected to the measuring unit with RS-232.

The operation of this device is almost fully automatic and it is done by the *pHg Measurement* application. The only function that must be configured in the device is setting up the communication parameters of the device, although this is also done automatically in the final version of the application. (10.)



FIGURE 3. Front panel of Fluke 8808A Multimeter

## 4 LabVIEW AND APPLICATION TEMPLATE

The most important design tool in Philips for the machine vision applications is LabVIEW (Laboratory Virtual Instrument Engineering Workbench). LabVIEW is system design software that provides engineers and scientists with the tools needed to create and deploy measurement and control systems through unprecedented hardware integration (13). The basic flow of the LabVIEW-programming and structure of the application template, what was used in this project, are described in this chapter.

### 4.1 LabVIEW-Programming

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to the text-based programming languages, where instructions determine the order of the program execution, LabVIEW uses dataflow programming, where the flow of data through the nodes on the block diagram determines the execution order of the Virtual Instruments (VIs) and functions. VIs are LabVIEW programs that correspond physical instruments.

In LabVIEW, the user interface is built by using a set of tools and objects. The user interface is known as the front panel (Figure 4). After the front panel has been built, the code is added by using graphical representations of functions to control the front panel objects. This graphical code, also known as G-code or block diagram code (Figure 5), is added to the block diagram. In some ways, the block diagram resembles a flowchart. (11.)

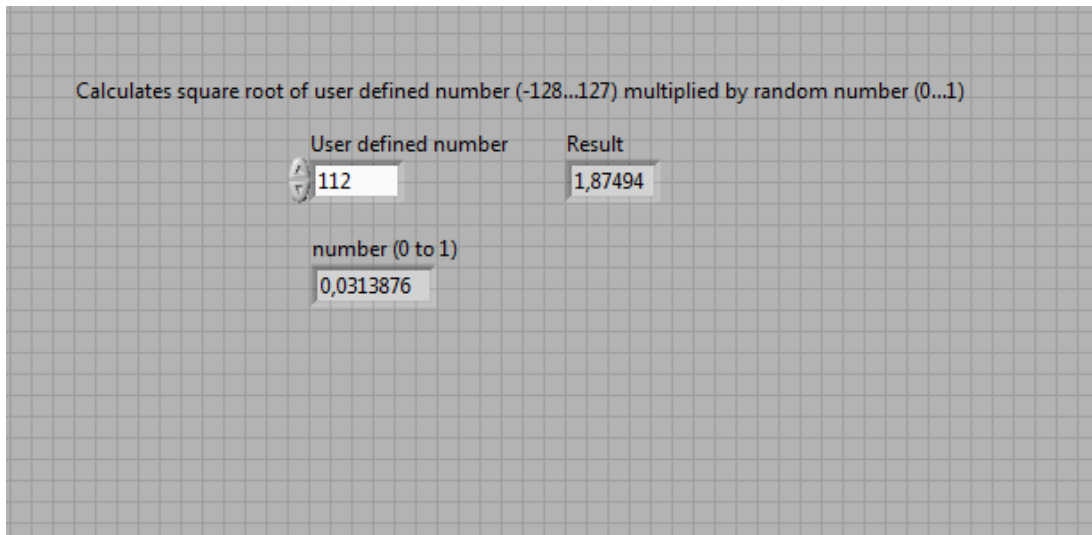


FIGURE 4. The front panel of simple LabVIEW program

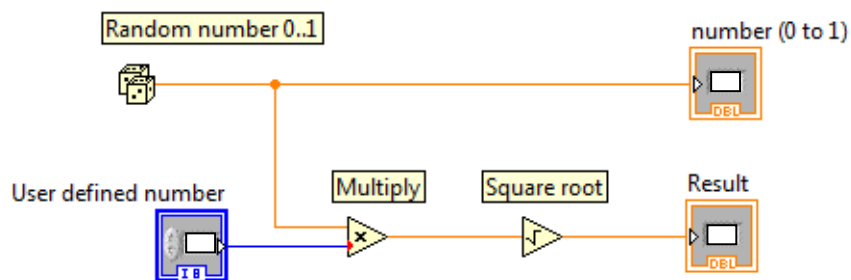


FIGURE 5. The block diagram of simple LabVIEW program

Philips Lighting's GTD (Global Technology Development) Mechanization department made the decision of using LabVIEW because it has a good support for rapid prototyping and development with a wide range of use in almost every possible measuring application. In addition, it has an easily maintainable software and a clear GUI (Graphical User Interface), and the software will most likely be completed more quickly than if it is made from the blank design.

## 4.2 Application Template

At Philips Lighting a standard template for software development is used instead of building every application individually. With this kind of procedure the economical benefits are possible. There are numerous re-usable elements in this application template. This makes it easy to create a new software by combining parts of the old software. It also helps to troubleshoot the software which is made by someone else than the troubleshooter himself.

The structure of the template consists of DFMs (Data Flow Managers) which deliver and receive information to and from the IOSs (Input/Output Servers) and TFSs (Transformation Servers). The IOSs handle all external devices, such as multi- and spectrometers, displays and communication. The TFSs process all of the collected information. (12.) The architectural design of the software based on the Philips LabVIEW template is seen on Figure 6.

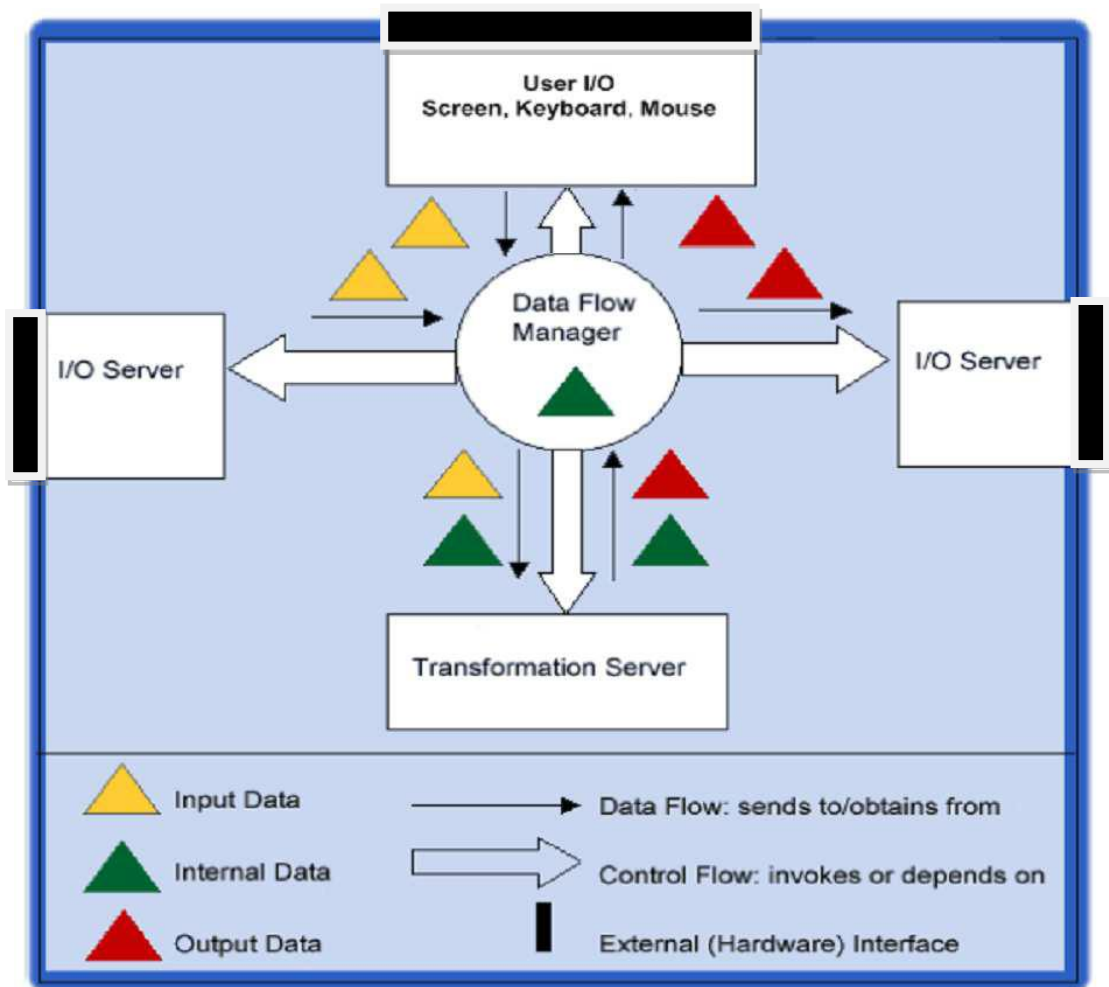


FIGURE 6. Software design pattern (12)

## **5 DESIGN PROCESS OF APPLICATION**

The project started by receiving a user specification from the customer, and on that basis the functional specification could be written. After the agreement between the customer and the designer the design process of the application was ready to begin. The implementation of the PLC and multimeter to the application is also described in this chapter.

### **5.1 User Specification and Functional Specification**

User Specification (US) is used to describe what is included in the project and what is not. In the US the client can propose his/her wishes to the project supplier. It is also a very important document for planning the project.

In this project the US was made by Chris Dries, Measuring Specialist, and he was the client. On the start of this project the US was reviewed with the client and the discussion of the topics was made. According to this and later meetings with client the project was ready to start. The User Specification can be seen in Appendix 1.

The Functional Specification (FS) is the supplier's response to the US. It describes the supplier's point of view about the project and says how the required items are done. This is also a document that should be well detailed and easy to refer to if any disagreements between the client and the supplier come up during the project. If any parts of the US is not feasible, it must be informed in the FS.

Based on the User Specification, the Functional Specification was made after studying the main parts of the old measurement application and the presently used Philips' application template. Writing an FS turned out to be quite challenging and it took a while to complete it, and some changes were made during the weekly meetings with the client. The latest Functional Specification is presented in Appendix 2.

## 5.2 Implementing the Actions of PLC

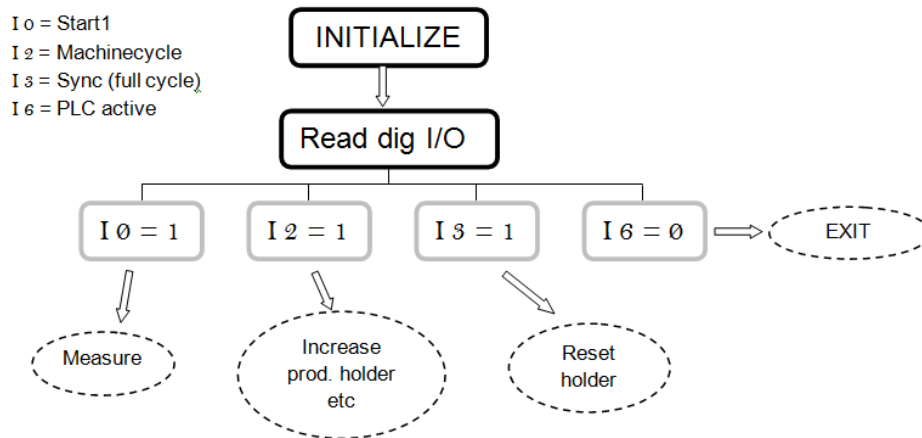


FIGURE 7. Simplified flowchart of digital I/O changes and reactions

The National Instruments PCI-6257 digital I/O-card is used to read the bits between the PLC and the production PC (a simplified flowchart in Figure 7). As the application starts, the initialization begins and a specific VI is used to flush the existing values from the I/O. This has to be done to make sure that the old values in the digital I/O do not change any variables in the PLC before they are meant to do so. After flushing the I/O, the functional globals are initialized in the way that those are ready to receive new values from the I/O.

The next step is creating and opening tasks for the input and output channels. First, the channel is selected as task using *DAQmx Create Task.vi*. This was created earlier in MAX (Measurement&Automation Explorer) which is a tool for configuring the hardware and software. Then, the channel/task is started using *DAQmx Start Task.vi*. After this, the digital IO is ready for reading and writing the values.

### 5.2.1 Handshaking Signals for PLC Operations

Every action that the PLC makes is dependent on some other action. The PLC state is either HIGH or LOW. The communication via the digital I/O is based on these values. The indicators for the digital I/O changes were designed to the GUI (represented in Figure 8). In addition to this, the structure

of the designing had to be quite straightforward in order to make the flow of the application easy to understand.

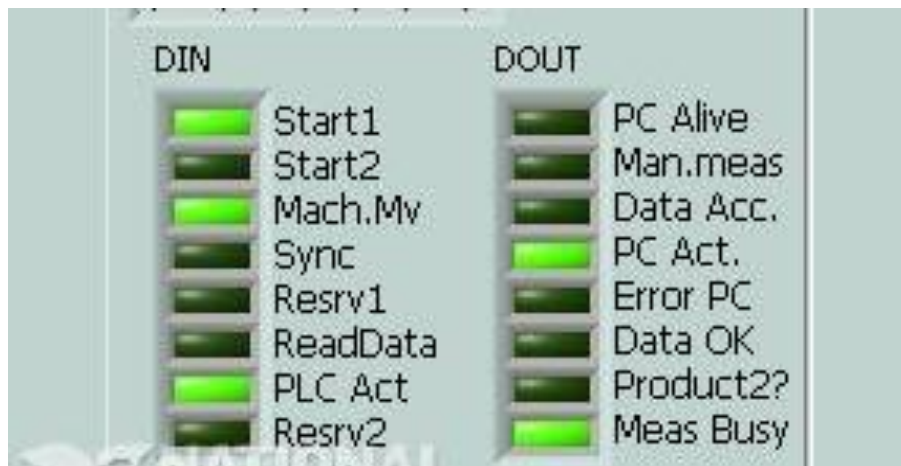


FIGURE 8. Digital IO indicators in user interface (changes in PCI)

The PLC first feeds the rotating measuring unit one position forwards (the total of 32 positions). The PC must check if the PLC is active (bit *PLC Act* is HIGH) and respond it by setting a *PC Act* bit to the state HIGH. When this happens, the PLC knows that the PC is ready for communicating.

The serial port is initialized, and if no errors are detected, the communication notifier *ISOpen* is set HIGH. The PLC gives a start command. When the start command is available and the *Auto* button is pressed in the application, the PC starts reading data from the PLC via the serial port. If there are some problems in the communication and no actions happen in 10 minutes, the application goes to the STOP state.

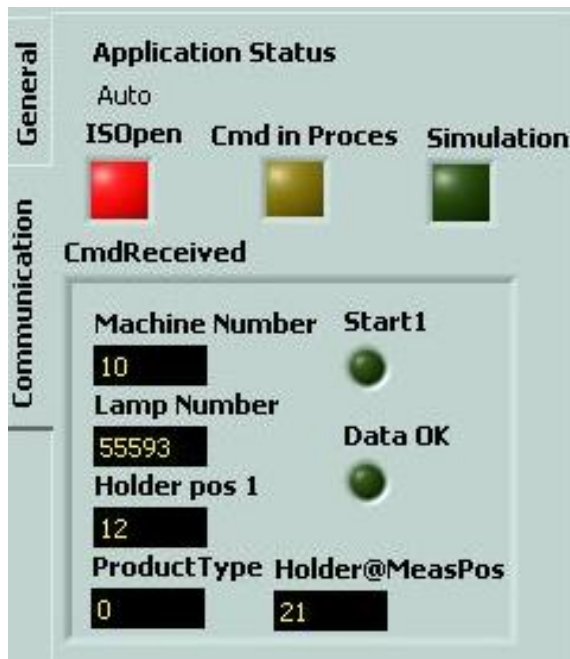


FIGURE 9. Commands received from PLC shown in user interface

After this, the PC starts reading data from the PLC. The maximum time for reading this data is three 200ms cycles. If the received data is valid, the *Data OK* value is updated to the digital output. When the data is received from the PLC and if the length of the message is correct, the data is sent to the sequencer. The data received from the PLC can be seen on the GUI in the Communication tab (Figure 9).

### 5.2.2 Handling Measurement Data

In the measurement position, the spectrum is acquired and the calculated line width result is stored to BUFFER 1. In the other position, the lamp voltage is measured for that previously measured spectrum. Based on these results, the pressure inside the burner is calculated and this result is stored to BUFFER 2. For keeping each value (peak width, pressure, voltage and spectral position) accurate enough, those are multiplied by 1000. In other words, the values are changed to pikometers, millibars and millivolts. In the other step, the measurement data is converted to the format that the PLC understands (8-bit integer).

After all values have been received and sent, the data of the next burner from BUFFER 1 is moved to BUFFER 2. The final step is to check the holder in position 1 at the measuring unit in the way that holder in the measurement position can be calculated. Every rising edge of the input bit *Mach.Mv* (Machine Movement), the holder position, the lamp number (which works as clockcounter) and the holder at the measurement position values are incremented by 1. Because of the constant amount of holders present, the bit *Sync* is set HIGH when holder one is at position one and the holder position value is reset.

Due to the complicated old software and the lack of examples based on the new framework, the designing and implementing of these features took a great deal of time. One big problem was also the limited time to test the PLC communication because the production had to be kept running as much as possible. During some maintenance standstills it was possible to test the communication but only about one hour in two weeks.

Finally, some of the Philips communication specialists and maintenance engineers managed to build a testing environment that was acting in the same way as the measuring unit in production, what comes to the PLC operations. This gave a possibility to test that the program was working after every change that was made.

### **5.3 Implementing Lamp Voltage Measurement Function**

Measuring the lamp voltage must be done for the calculation of the pressure inside the burner. In the old application it was done by a Fluke 45 multimeter and it had to be replaced with a new and more accurate multimeter (Fluke 8808A).

When the measurement application is set to the automatic mode, the first step is to initialize the multimeter, where all the settings are loaded. The settings which must be set are measurement function, measurement rate, measurement ranges and communication settings. In the measurement function,

the user can choose what type of a measurement is done based on the source, for example AC or DC voltage, frequency etc. The measurement rate defines how many measurements can be done in one second. In the measurement ranges, the user can define the ranges for the selected units, for example millivolt and kilohertz.

After loading the settings, the actual lamp voltage measurement can be done and the results are saved in a buffer from where those are collected later. All of these steps are possible to be done in the individual measurement IOS (Figure 10) by pressing buttons INIT, CONFIG and MEASURE. The individual measurement was implemented for cases where only one burner had to be measured.

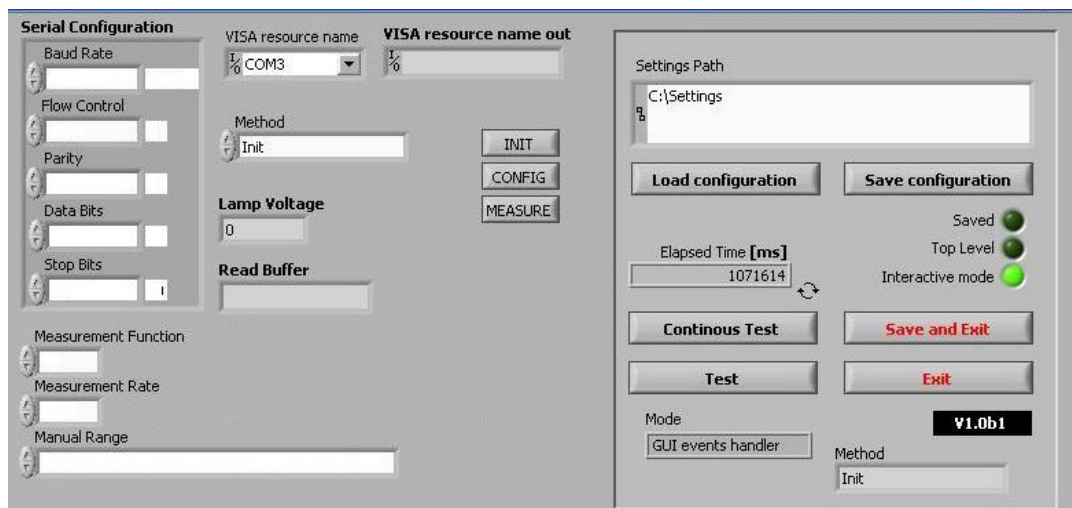


FIGURE 10. Graphical user interface for V1a measurement (Fluke 8808A)

The implementation of the lamp voltage measurement was rather easy because there were quite good examples in the old application even though it was somewhat unclearly done. The challenge of this phase was the implementation of two different kinds of multimeters in a way that it was easy to change the type of the multimeter. In addition testing this feature was easy because it was possible to connect the multimeter directly to the PC and check that the values were reasonable.

## 6 RESULTS AND SUMMARY

The project goal was to replace the old complicated measurement software with a new one based on an easily maintainable standard template. The goal was achieved, and nowadays the application is running in the production.

One challenge in this project was that the new application was made on LabVIEW which is a rather new software environment. The other challenge was the size of the project. Because of the size of the project, it was divided into two separate parts. This meant that communication with other student was very important to avoid making duplicate items for the application.

The support from the hosting company was great and the meetings with the customer Chris Dries, Toon Raes (LabVIEW coordinator), Geert van Baelen and Yves Casteels (DPL supervisors) and some other employees gave a great deal of information for the project.

By this knowledge, I would recommend to start using the testing environment for the PLC in a much earlier phase of the project. The lack of the test system caused big problems for debugging the errors in the application. Understanding the standard LabVIEW template took also quite much time.

Altogether, the project was very educational and gave a good opportunity to learn about working structure practices in a big company.

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## **APPENDICES**

Appendix 1. User Specification (written in Dutch by Chris Dries)

Appendix 2. Functional Specification

IT : QDL-DPL	<p style="text-align: center;">Gebruikersspecificatie (GS) UHP_PHg V1.0</p>	<p>Kode :</p> <p>Datum : 02/02/11</p>
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<p>N.V. Philips Lighting Fabrieken Turnhout</p>	<p>Auteur : C. Dries</p>	<p>1/7</p>

IT : QDL-DPL	Gebruikersspecificatie (GS) UHP_PHg V1.0	Kode :  Datum : 02/02/11
<p><b>1. Projectomschrijving</b></p> <p><b>1.1. Algemene doelstelling en argumentatie</b> De doelstelling van dit project is de ontwikkeling van gebruiks- en onderhoudsvriendelijke software voor de Kwikdrukmeting.</p> <p><b>1.2. Projectresultaat</b> Het resultaat bestaat uit een aantal functies:</p> <ul style="list-style-type: none"> <li>• Installatie</li> <li>• Kalibratie</li> <li>• Meten</li> <li>• Logging</li> <li>• Error trapping</li> <li>• Bijkomende metingen</li> </ul> <p><b>1.3. Afbakening van het project</b> De software, installatie procedures, testplan, handleidingen en eventueel nodige hardware behoren tot dit project.</p> <p><b>1.4. Niet tot het project behoren</b> Onderzoeken naar de meetmethode. Aanpassingen aan de meetmolen.</p> <p><b>1.5. Randvoorwaarden</b> De software wordt ontwikkeld en bedrijfsklaar gemaakt op 1 operationele opstelling. Er wordt in samenspraak met productie een maximum van 2 dagen (48 uur) op de productie machines voorzien voor test en ontwikkeling van de software. Er moet steeds een back-up procedure voorzien zijn zodat productie binnen 2 uur terug kan draaien. Vervolgens worden de overige opstellingen aangepast. De software en procedures worden gedocumenteerd en gearhiveerd volgens de BM voorschriften.</p> <p><b>1.6. Dwingende eisen</b> De installatie, diagnose van problemen en het opzetten van bijkomende meetpunten moet kunnen zonder ingrijpen van een programmeur door een "gewone" gebruiker.</p>		
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<p>Settings mogen enkel op 1 plaats staan, er zijn zo weinig mogelijk settings bestanden. De settings worden centraal beheerd van uit 1 plaats in het programma.</p> <p>De software moet overzichtelijk en volgens de Turnhout standaarden opgebouwd en gearchieveerd worden, inclusief een Image van C:\.</p> <p>Enkel na overleg met de projectleider en de projecteigenaar mag er een verandering in de personeelbezetting en of in de planning doorgevoerd worden.</p> <p>De implementatie van algoritmes word in team gereviewd door de programmeur, de projecttrekker en de nodige specialisten.</p> <p>Opgegeven prijzen gelden voor het gehele project (alle mijlpalen) inclusief documentatie, image, archivering,.... Een gedeeltelijke prijs tot mijlpaal 3 kan indicatief mee opgegeven worden.</p> <p><b>1.7. Wensen</b> Administrator rechten zijn niet nodig om de software te gebruiken.</p> <p><b>2. Productgegevens</b></p> <p><b>2.1. Te verwerken producttypes</b> Losse burners van 50 w tot 400 W conform huidige werkwijze (PLC communicatie)</p> <p><b>3. Proces</b></p> <p><b>3.1. Proceskeuze</b> De keuze van het meetprincipe berust deels op de bestaande software (versie na de aanpassingen voor de Fluke Vla meter) deels op nog uit te voeren testen. De software moet de kwikdruk betrouwbaar berekenen zonder invloed van de sporadisch optredende extra piek. Voor de ontwikkeling wordt gestart van af het frame work van de vernieuwde broomsoftware.</p> <p><b>3.2. Processpecificaties</b> Elke meting wordt minstens gedefinieerd door middel van een centrale golflengte, belichtingstijd en zoek gebieden, indien nodig kan dit uitgebreid worden.</p> <p><b>3.3. Procescontroles</b> Dagelijkse controle moet optioneel (vinkje) mogelijk zijn voor de lichttechnische kalibratie</p>		
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<p><b>4. Machineconcept</b></p> <p><b>4.1. Algemene beschrijving</b></p> <p>De software bestuurt een Roper Scientific spectrometer (OMA). Doormiddel van deze spectrometer wordt het spectrum gemeten. Aan de hand van de analyse van dit spectrum wordt de kwikdruk in de burner bepaald. Alle metingen worden gestandaardiseerd naar een belichtingstijd van 1 sec. De lampspanning word gemeten door een Fluke 8808A.</p> <p><b>4.2. gedetailleerde beschrijvingen:</b></p> <p><b>4.2.1. Burner types</b></p> <p>Voor elke burner type kan zo nodig de meet parameters aangepast worden. De de aanpassingen en toevoegingen van types moet mogelijk zijn zijn zonder tussenkomst van een programmeur.</p> <p>De parameters zijn tenminste:</p> <ul style="list-style-type: none"> <li>• Centrale golflengte</li> <li>• Verwachte piek breedte</li> <li>• Base line type</li> <li>• Grenzen van de meetwaarde</li> </ul> <p><b>4.2.2. logging</b></p> <p>Zowel fout meldingen als meet resultaten worden gelogd op D:\.</p> <p>De software moet op dezelfde manier communiceren met Cirkel als nu.</p> <p>De gelogde meetresultaten zijn minstens:</p> <ul style="list-style-type: none"> <li>• Het numeriek resultaat van elke meetwaarde <ul style="list-style-type: none"> <li>○ Voor elke producttype een aparte folder</li> <li>○ Per week een nieuw bestand, oude bestanden worden na 4 weken verwijderd.</li> <li>○ De eerste regel bevat telkens de kolom koppen</li> <li>○ Tab of komma gescheiden</li> </ul> </li> <li>• Eventueel gebruikte kalibratie factoren</li> <li>• De lamp spanning</li> <li>• Het complete gemeten spectrum in ASCII en of Excel formaat.</li> </ul> <p><b>4.2.3. error trapping</b></p> <p>De fout afhandeling en fout detectie is zo opgebouwd dat er maximale ondersteuning is bij het diagnosticeren van problemen.</p> <p><b>4.2.4. daglamp</b></p> <p>Dagelijks word de daglamp in de opstelling geplaatst. Het spectrum van de dag lamp wordt vergeleken met de certificaatwaarde. Als de daglamp meer dan de gestelde grenzen afwijkt, krijgt de operator een foutmelding.</p>		
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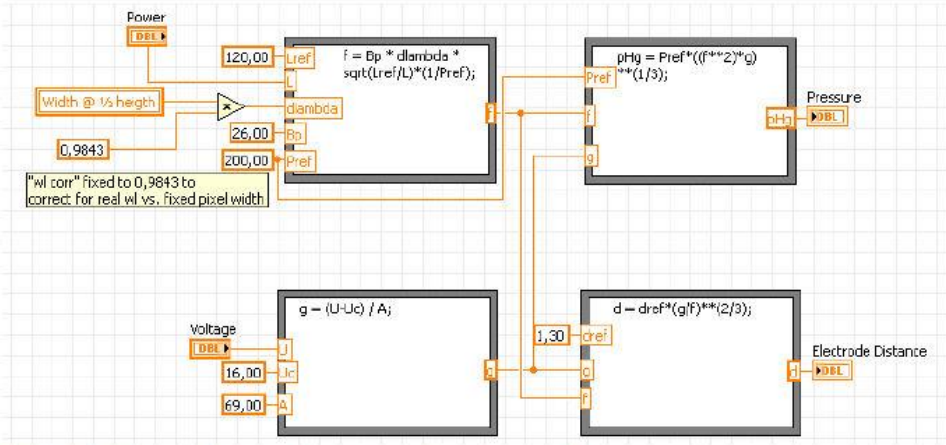
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<p><b>4.2.5. settings</b> Alle settings worden op een overzichtelijke wijze op 1 plaats gegroepeerd en geëditeerd. Het editeren van de settings gebeurt in de GUI niet in de "ini" bestanden. Ongeoorloofd editeren van de settings (ook offline in de ini bestanden) wordt onmogelijk gemaakt en of bewaakt (bv. door checksums). Alle settings in de ini bestanden moeten gedocumenteerd zijn.</p> <p>Er zijn een aantal gemeenschappelijke settings voor het programma:</p> <ul style="list-style-type: none"> <li>• Pat settings voor log bestanden , FF,...</li> <li>• Daglamp grenzen</li> <li>• Roi</li> <li>• Shutteroffset</li> <li>• Slit breedte</li> <li>• grating</li> <li>• A/D converter keuze</li> <li>• Mogelijk productielijnen</li> <li>• Product types <ul style="list-style-type: none"> <li>○ Belichtingstijd</li> <li>○ Hardware of software binning</li> <li>○ Product specifieke kalibratie waarden</li> </ul> </li> </ul> <p><b>4.2.6. installatie</b> De installatie procedure van af een clean geïnstalleerde Windows PC tot het werkend meetsysteem moet uitgevoerd kunnen worden door een gebruiker zonder tussenkomst van de programmeur. De installatie procedure mag volgende stappen omvatten:</p> <ul style="list-style-type: none"> <li>• Installatie run time Labiew</li> <li>• Installatie of copieren van het programma naar een voorgeschreven map.</li> <li>• Installatie van de OMA</li> <li>• Installatie van Winspec en Spectra Pro</li> <li>• Copieren of aanmaken "ini" bestanden</li> <li>• Manueel aanmaken van een snelkoppeling op het bureel blad</li> <li>• De installatie gebeurt op een type 2 pc met firewall</li> </ul> <p><b>4.2.7. GUI (Graphical User Interface)</b> De GUI wordt opgebouwd op basis van de CIT/BM template. De toepassing heeft minstens dezelfde vensters als de broom software.</p> <p><b>4.2.8. Diagnostiek</b> De bedoeling van de diagnostiek module is de gebruiker de mogelijkheid geven om halfautomatisch diagnostische metingen te doen. V&amp;O technici krijgen zo de mogelijkheid om eventueel telefonisch bijgestaan door TTM, BM of Imspec bij problemen de juiste acties te ondernemen.</p> <p><b>4.2.9. meten</b></p> <ul style="list-style-type: none"> <li>• De meting moet dezelfde parameters naar Cickel sturen als nu.</li> </ul>		
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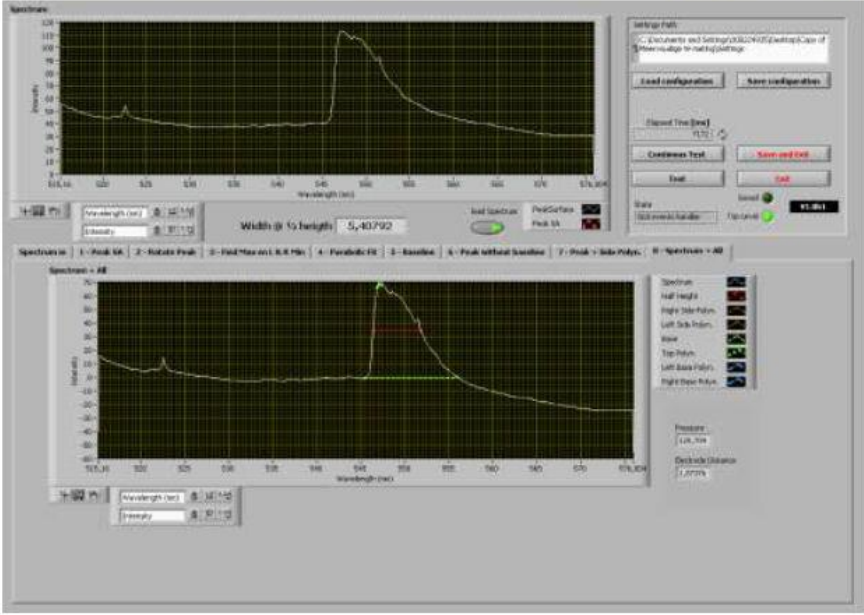
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<p><b>4.3. Snelheid</b> De snelheid wordt bepaald door de meetmolen, de toepassing moet de meting binnen 75% van de takt tijd kunnen afronden.</p> <p><b>4.4. Bediening</b></p> <p><b>4.4.1. Operator taken</b> Zoals in de bestaande situatie</p> <p><b>4.4.2. Specifieke start-stop procedures</b> Zoals in de bestaande situatie</p> <p><b>4.4.3. Veiligheid en ergonomie</b> De opstelling moet aan alle geldende voorschriften voldoen.</p> <p><b>4.4.4. Handleiding / bedieningsvoorschrift</b> Een gedetailleerde handleiding is onderdeel van het project. De handleiding bevat minstens:</p> <ul style="list-style-type: none"> <li>• Gebruikers handleiding voor het meten</li> <li>• Installatie handleiding</li> <li>• Gebruikers handleiding voor het instellen van de opstelling</li> <li>• Kalibratie voorschriften</li> <li>• Een fouten lijst met mogelijke fout oorzaken</li> </ul> <p><b>4.5. Opleiding (operators en V&amp;O technici)</b> Er wordt minstens een opleiding voorzien voor een (TOP) operator, V&amp;O en de leden van de TTM groep. Deze mensen verzorgen opleiding voor iedere verder gebruiker en of technicus.</p>		
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<p><b>5. Normen</b></p> <p><b>5.1. Veiligheid</b></p> <ul style="list-style-type: none"><li>- De software moet eventueel onveilige toestanden voor de gebruiker of de instrumenten bewaken en afvangen. De huidige situatie levert geen problemen en moet bijgevolg gehandhaafd blijven.</li></ul> <p><b>5.2. Bijkomende eisen</b></p> <p><b>5.3. Ergonomie</b></p> <ul style="list-style-type: none"><li>- De software moet met zo weinig mogelijk handelingen bediend kunnen worden, minder handelingen als de huidige software is beter meer handelingen mag niet.</li></ul> <p><b>5.4. Milieu</b></p> <ul style="list-style-type: none"><li>- Kwik afzuiging is voorzien op de opstelling</li></ul>		
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<p><b>1. Introduction</b></p> <p>The software of the mercury pressure measurement on the measuring production mills of DPL burner is not (anymore) up to all expectations. To ensure the continuity of the production process a software upgrade is more and more needed. The goal of this project is to determine the technical and economic feasibility of an upgrade and if the upgrade is necessary execute it in a secured way. (C. Dries)</p> <p>The task of this project was to develop a user-friendly software and thus provide maintenance for the mercury pressure measurement. This application will be written with LabVIEW 2009 (9.0 SP1) -software. Following applications will be used as a basis for the new application:</p> <ul style="list-style-type: none"> <li>• GTD Meervoudige W-meting</li> <li>• GTD Broommeting</li> <li>• Inline Kwikdruk meting</li> </ul> <p>From these applications only parts needed are used.</p>		
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<h2 data-bbox="336 551 528 584">2. Features</h2> <h3 data-bbox="379 633 1114 667">2.1 Algorithm for measuring the mercury vapor pressure</h3> <p data-bbox="419 712 1383 824">“TFS Width at half height.vi” will calculate the width of the Hg-peak at half height of the peak. Using the width of the peak it is possible to calculate the resulting mercury pressure and electrode distance. The algorithm will use a variety of user-defined settings to accomplish this in the needed accuracy:</p> <ul data-bbox="459 842 1383 1070" style="list-style-type: none"> <li>• # of samples for fitting the polynomials at             <ul style="list-style-type: none"> <li>○ base of the peak</li> <li>○ sides of the peak to find the width</li> </ul> </li> <li>• boundary wavelengths for the Hg-peak</li> <li>• a wavelength to the right (longer wavelengths) of the 546 nm side-peak, from where the application will start looking for the actual maximum of the peak</li> </ul> <p data-bbox="419 1126 1383 1272">Algorithm used will be based in the old LabVIEW 7.1 -application, mostly done by H.J. v. Aalderen. The actual calculations, which will result in the value of pressure and electrode distance, are from “PFL - Aachen report 1594/2002: Spectroscopic determination of operating pressure, arc length and radiation properties of UHP lamps. E. Fischer”.</p>  <p data-bbox="419 1778 1054 1812">FIGURE 1. Calculation of the pHg and electrode distance</p>		
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<p>Algorithm for finding the width at half height:</p> <ol style="list-style-type: none"> <li>1. Find the boundaries of the Hg peak</li> <li>2. Rotate the peak so that both boundaries are at the same level</li> <li>3. Fit polynomials at the boundaries</li> <li>4. Calculate a tangential line for the two polynomials to form a base line</li> <li>5. Remove the portion of the spectrum below the base line</li> <li>6. Locate the intensity of the spectrum at the user-defined wavelength, which has to be set to be in between of the 546 nm side-peak and the actual maximum of the peak</li> <li>7. <i>Using that intensity as a central point start calculating averages (for the user-defined amount of samples), move to right one sample at a time and continue calculating averages until coming to a point where the first average is equal to or larger than the last calculated value</i></li> <li>8. <i>Use that point as a right-side limit for the searching of the maximum</i></li> <li>9. Fit a polynomial between those two points</li> <li>10. Search for a maximum at the polynomial resulting on the intensity (and so the height) of the peak max</li> <li>11. Divide the height by two, and fit polynomials on the sides of the peak at the half height</li> <li>12. Search for the half height on the side polynomials and calculate the difference of the found wavelengths, resulting in the width of the peak at half height</li> </ol>  <p>The screenshot shows a software interface for spectrum analysis. The main window displays a plot of Intensity versus Wavelength (nm) from 400 to 700 nm. A prominent peak is visible at approximately 546 nm. The interface includes a 'Settings Panel' on the right with options for 'Load configuration', 'Save configuration', 'Clipboard Time (s)', 'Continue Test', 'Exit', 'Start', and 'Stop'. Below the plot, there are several tabs for different analysis methods: '1 - Peak SA', '2 - Rotate Peak', '3 - Find Max on L.R.R. Plot', '4 - Parabolic Fit', '5 - Baseline', '6 - Peak without Baseline', '7 - Peak - Side Polys', and '8 - Spectrum - All'. The 'Width @ 1/2 height' is displayed as 5.40792. A 'Spectrum' panel on the right shows various analysis options like 'Half Height', 'High Side Polys', 'Left Side Polys', 'None', 'Top Polys', 'Left Base Polys', and 'Right Base Polys'. The 'Precision' is set to 144.704 and the 'Spectrum Distance' is 1.07776.</p>		
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<p><b>2.2 Logging</b></p> <p>After measuring the properties of a burner the collected data is stored on the computer used, in the D: -drive, following the standards of the framework. Logging is done in TDMS- and delimiter-separated values -formats. Following data will, at least, be logged in a human-readable form:</p> <ul style="list-style-type: none"> <li>• Peak width at half height</li> <li>• Numerical result (mercury pressure)</li> <li>• Gain and offset used to manipulate the end result (pHg)</li> <li>• Lamp voltage</li> </ul> <p>Original spectra will be logged as TDMS, a binary-based file format.</p> <p>Also each product type will be logged in their own folder and in there arranged into subfolders (which are named after the current week number). Log files older than 28 days are removed automatically when the application is idling.</p> <p>National Instruments provides Add-In Tools to use TDMS with Microsoft Excel and OpenOffice.org Calc.</p>		
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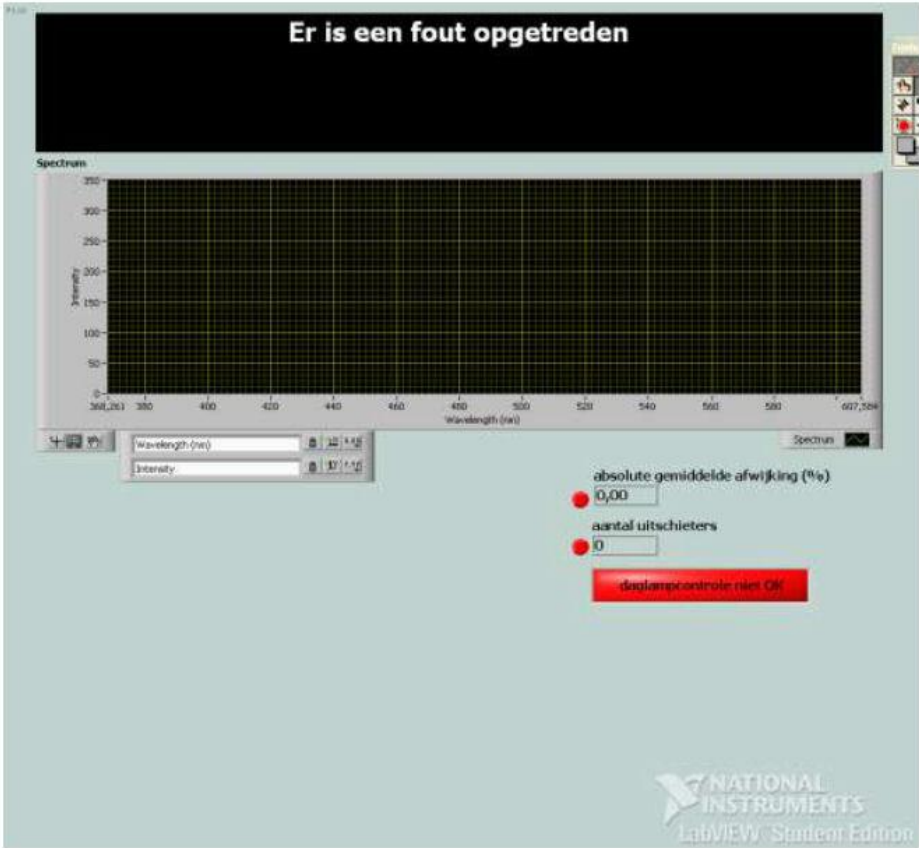
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<p><b>2.3 Daily check</b></p> <p>Spectrum of a halogen lamp is compared with the previously given certificate values. If the measured spectrum is not within the given limits, operator will be given an error message. Interface is based on the bromine measuring application.</p> 		
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FIGURE 3. Illustrative screenshot of the daily lamp check interface

### 2.4 Adding new products and their settings

User has the option to add new products and the settings for those products for operators to use. The interface and operation are based on the bromine measuring application. When the measuring is started, the burner type has to be selected and depending on this selection according burner settings are loaded automatically. Burner type specific parameters include:

- A wavelength right of the 546 nm side-peak
- Expected peak position (Boundaries for the baseline)
- Number of samples for polynomials at base and sides and for the peak's top area average calculations
- Gain and offset to manipulate the resulting mercury pressure value

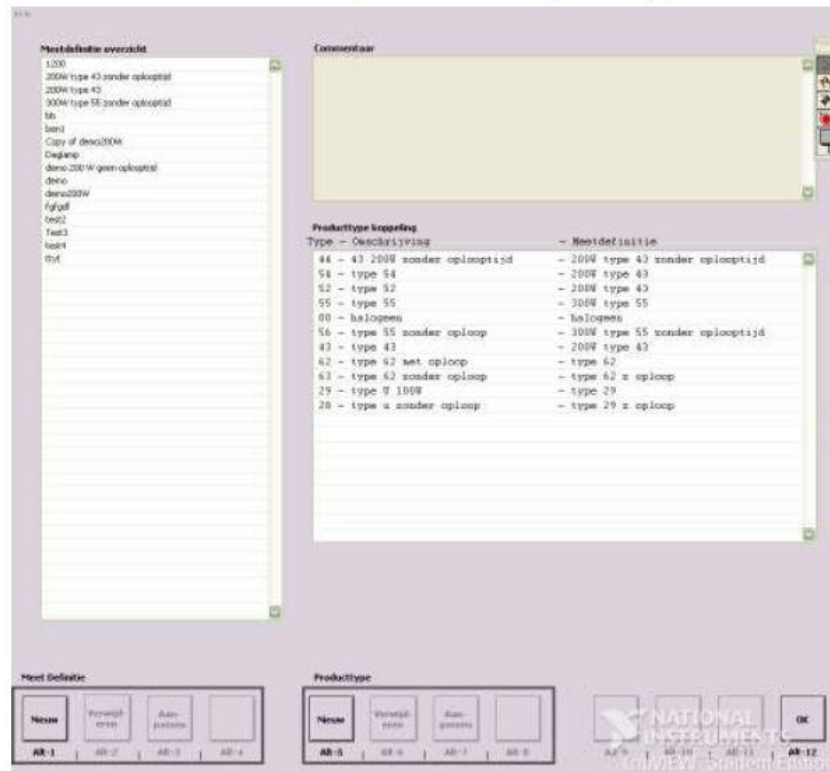
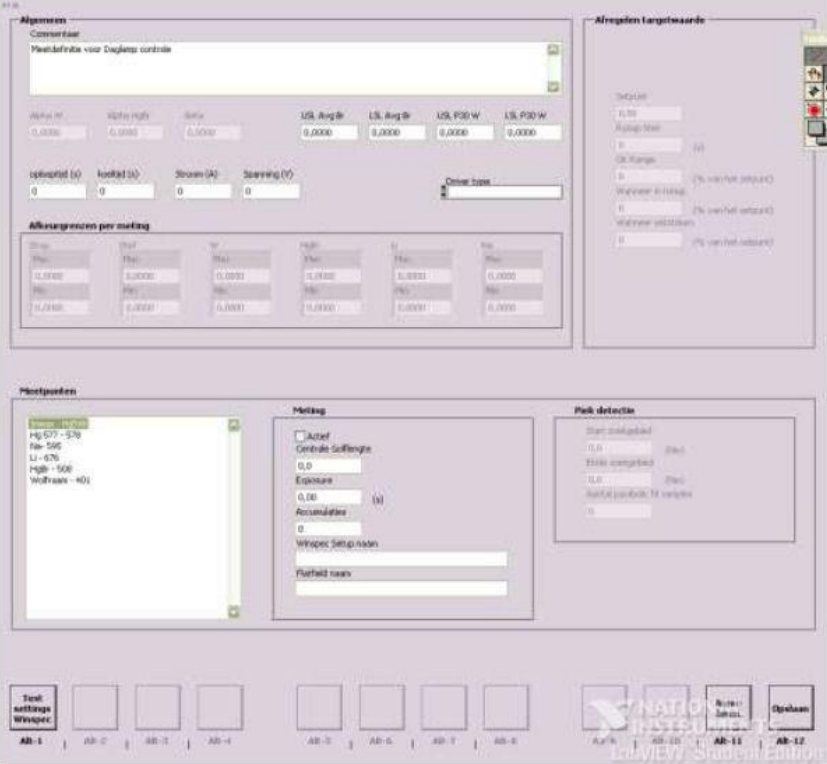


FIGURE 4. Illustrative screenshot of the product adding/modifying interface

This feature will be password protected, and in use for the Quality Engineers and Administrators.

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<b>2.5 Changing the parameters of the burners</b>		
User has the option to change the parameters mentioned at 2.4.		
		
<p><i>FIGURE 5. Illustrative screenshot of the parameter changing interface</i></p>		
<p>This feature will be password protected, and in use for the Quality Engineers and Administrators. Guide for adding/changing these parameters is in user manual.</p>		
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<p><b>2.6 Setting the shutter offset from within the application</b></p> <p>User has the option to set the shutter offset (at the system settings), application will then take it into account when doing measurements.</p> <p>This feature will be password protected, and in use for the Quality Engineers and Administrators.</p>		
<p><b>2.7 Settings-files</b></p> <p>All necessary settings are edited on the application interface. Depending on the user level different settings can be modified. Operator will not have the possibility to edit any settings.</p> <p>Winspec-settings are partly human-readable and partly binary. Tampering with those is not in the scope of the project, except for protecting them with checksums (2.8).</p> <p>System settings are in ini-file format, measuring definitions (product type specific) in xml.</p>		
<p><b>2.8 Checksums</b></p> <p><i>User is presented a panel in where the user can choose the files on the computer to protect with the checksum. For the settings files used in the framework the checksum will be calculated automatically and updated when updating the settings within the application.</i></p> <p>The checksum is calculated using the MD5-algorithm. The hash (=checksum) is saved in a file called "checksums.ini". The directory of the file for which the hash was calculated for will serve as an ini-file "section", and the filename itself as the key for the hash. Hash is the value for that key, and it is expressed as a 32-digit hexadecimal number.</p> <p>The "checksum.ini" will be processed thoroughly at the startup of the application. All the checksums for section+"\\"+key (which corresponds to file path + filename) are calculated and compared to the stored checksum. If any difference is found, the user is presented with an error dialog (with a list of the files which failed the check) and the startup of the program is prevented. User has the option to exit or to let the application calculate new checksums after inputting a Quality Engineer or an Administrator –level password. If all files pass the test no output is given to user.</p>		
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<p><b>3. Installation</b></p> <p>When the application is ready to use it will be installed on the measuring machine (MM2) in the production line. The new application is installed on a new Type 2 PC and the old applications will remain on their current computers. In the case the new application crashes (or otherwise is not working properly) for some reason during the testing phase, the older application remaining on the older PC can be set up quickly and the production is able to run again in two (2) hours. Image of the C:\ -drive on a freshly installed new PC will be created after confirmed it will work as is.</p> <p>Installation to measurement system contains following items:</p> <ul style="list-style-type: none"> <li>○ Installing Run Time LabVIEW</li> <li>○ Copying application to a specified folder</li> <li>○ Copying (default) settings files to a specified folder</li> <li>○ Installing OMA</li> <li>○ Installing Winspec and Spectra Pro</li> <li>○ Shortcut creation</li> </ul> <p>Guide for installing these items is included in the user manual or in a separated installation guide.</p>		
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<h3>4. User Interface</h3>		
<p>The user interface is based on the <i>Broommeting and W-meting</i> applications. Screen appearance/features will depend on user level and the following user levels will be in use:</p>		
<ul style="list-style-type: none"> <li>○ Operator</li> <li>○ Quality Engineer (password protected)</li> <li>○ Administrator (password protected)</li> </ul>		
<p>An option for manual measurement will be added in GUI (only available to Quality Engineer and Administration users).</p>		
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FIGURE 5. Illustrative screenshot of the start window of GUI

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<p><b>5. Error handling</b></p> <p>The error detection and error handling is constructed so that there is support in diagnosing problems. When an error occurs, the error message will be shown in the GUI. Depending on the type of error, user must react to this by pressing the OK-button or contact e.g. maintenance for solving the problem. Non-critical errors should not stop the process. Error codes will be listed and explained as necessary in the documentation/user manual.</p>		
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<h2 data-bbox="336 461 644 499">6. Documentation</h2> <ul data-bbox="419 548 1010 875" style="list-style-type: none"><li data-bbox="419 548 608 577">• User manual<ul data-bbox="459 591 1010 790" style="list-style-type: none"><li data-bbox="459 591 887 620">○ User manual for the measurement<ul data-bbox="539 633 1010 663" style="list-style-type: none"><li data-bbox="539 633 1010 663">• Guide for setting up the measurement</li></ul></li><li data-bbox="459 676 692 705">○ Installation guide</li><li data-bbox="459 719 778 748">○ Calibration requirements</li><li data-bbox="459 761 895 790">○ A list of possible errors and causes</li></ul></li><li data-bbox="419 846 572 875">• Test plan.</li></ul>		
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