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DEVELOPING AN INTERFACE FOR **WEIGHING SENSOR**

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Abstrac

The main objective of this project is to develop an interface for a weighing sensor SIEMENS SIWAREX R (load Cell), attached with SIWAREX U weighing module rack for Siemens S7-300 PLC. At first, to learn more how the software works, learning modules were controlled, like 7-segment display, site traffic light, step control and PID controller. Finally for the weighing interface, the PLC was programmed with the software SIMATIC MANAGER 7 and the touch panel interface was created using the software SIMATIC WinCC flexible 2008.

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1. OBJECTIVES

The objective of this project is develop one interface for one Touch Panel for weighing module PLC. For this reason is necessary to use specific programs for make it, this programs are SIMATIC S7, SIWATOOL U and WinCC flexible 2008.

2. KEYBORDS

PLC, SIMATIC S7, Weight sensors, Weight interfaces, SIWAREX U, WinCC flexible 2008.

3. INTRODUCCION

Weighing is one of the most important process in the industry.

SIWAREX U is ideal solution for all applications where measured with strain gauge sensors such as load cells, load sensors or torque axis.

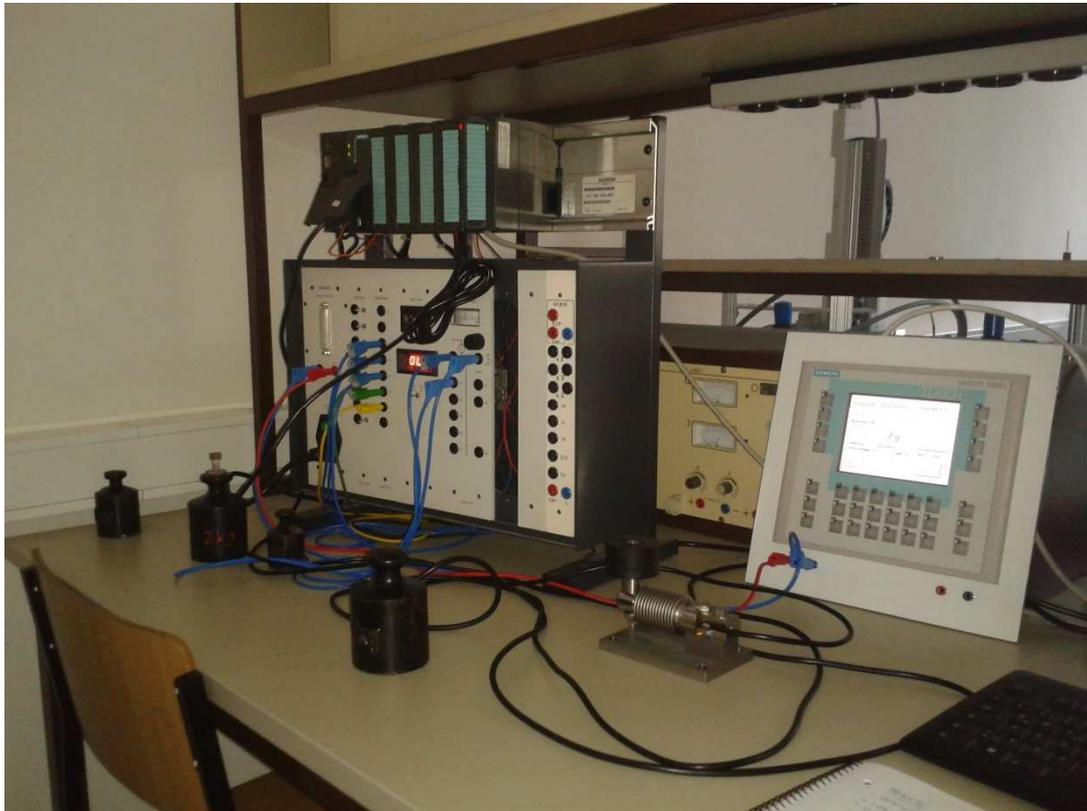
Typical applications for weighing are:

- Monitor levels of silos and hoppers
- Monitoring of crane and cable loads
- Measure loads conveyors
- Protect mills or industrial surge lifts
- Scales in hazardous areas (Ex realizable using an interface)
- Monitoring of belt tension

4. DIFERENTS ELEMENTS

4.1 ELEMENTS FOR WEIGHING PROCESS

The elements that are needed to measure the weight are (Picture 1):



Picture 1: *The elements of PLC*

- PLC
- SIWAREX U, PLC rack.
- The Touch Panel
- The weighing sensor SIWAREX R.
- Personal computer
- Junction Box

4.2 PLC

Power Line Communication (PLC), transmits a data cable that is also used to transport AC electrical power transmission to consumers. Also used for these actions: power-line carrier, power-line digital subscriber line (PDSL), mains communication, power-line telecommunications, or power-line networking (PLN).

The first PLC was developed in 1969. They are now widely used and extend from small self-contained units for use with perhaps 20 digital inputs/outputs to modular systems which can be used for large numbers of inputs/outputs, handle digital or analogue inputs/outputs, and also carry out proportional-integral-derivative control modes.



Picture 2: *PLC Siemens SIMATIC S7*

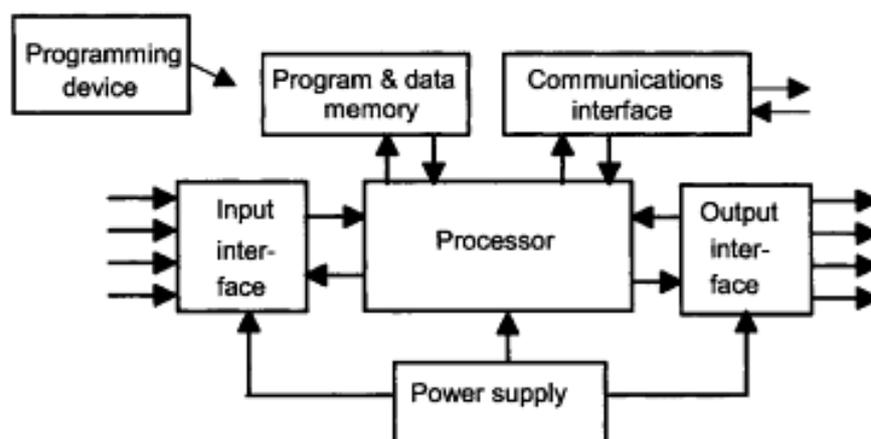
4.2.1 WHAT IS THE FUNCTION OF PLC

A basic PLC system consist of a transmitter unit capable of adding the communication signal to the AC power line signal and receiver unit capable of separating the communication signal from AC power component signal.

In an ideal PLC system, the output signal of the receiver is a perfect copy of the signal which was introduced to the transmitter. Is any signals which may impinge upon the system from a source other than the transmitter are ignored by the receptor. The ideal PLC system should furthermore not become a source of noise either through direct transmission or by radiation.

In previous circuits, PLC systems has been used for relatively low carrier frequencies of 160 Kilohertz (KHz) to 455 Kilohertz (KHz). Some PLC can use a frequency as high as 1.5 Megahertz (MHz).

The AC power line may broadcast the communication signal. This creates noise which may interfere with other communication signals. If the communication signal strength is too low, the signal will be overpowered by the level of noise on the line. If the communication signal is strong and is a very high frequency, the power line may begin to radiate and thus violate government regulations regarding interface and harmful radiation levels.



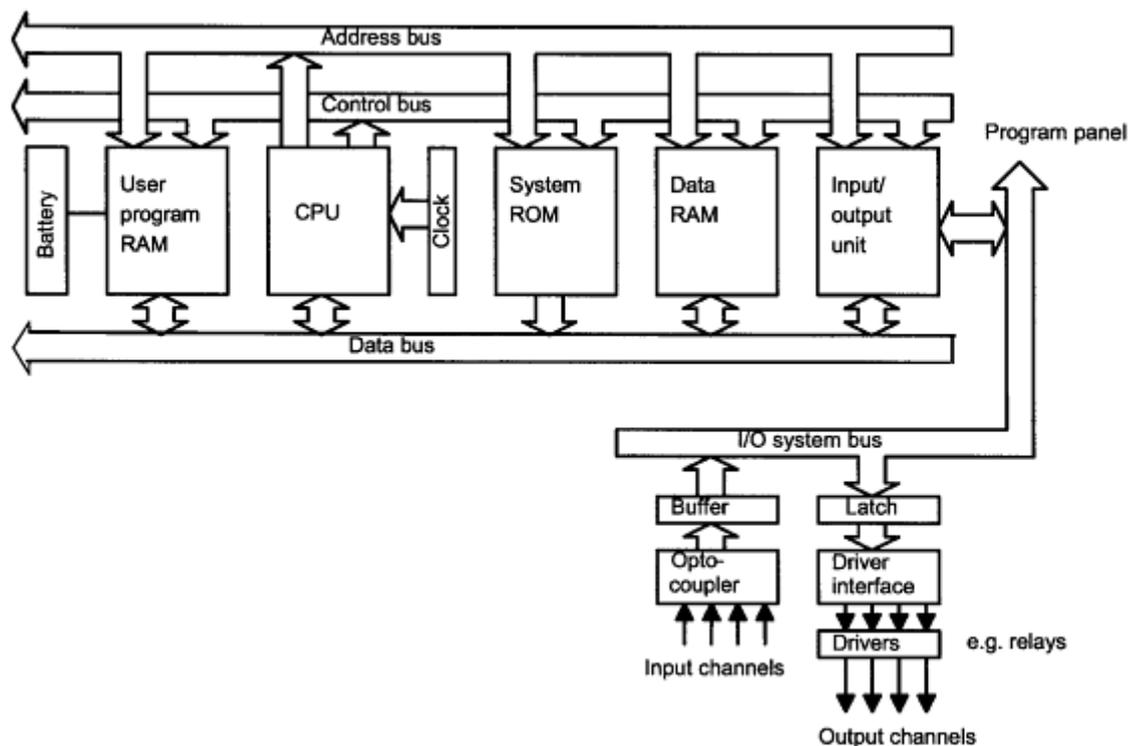
Picture 3: *The PLC system*

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1. The processor unit or central processing unit (CPU) is the unit containing the microprocessor and this interprets the input signals and carries out the control actions, according to the program stored in its memory, communicating the decisions as action signals to the outputs.
2. The power supply unit is needed to convert the mains AC voltage to the low DC voltage (5V) necessary for the processor and the circuits in the input and output interface modules.
3. The programming device is used to enter the required program into memory of the processor. The program is developed in the device and then transferred to the memory unit of the PLC.
4. The memory unit is where the program is stored that is to be used for the control actions to be exercised by the microprocessor and data store from the input for processing and for the output for outputting.
5. The input and output sections are where the processor receives information from external devices and communicates information to external devices. The inputs might be from switches, with the automatic drill, or other sensors such as photo-electric cells, as in the counter mechanism, temperature sensors, or flow sensors, etc. The outputs might be to motor starter coils, solenoid valves, etc.
6. The communications interface is used to receive and transmit data on communication networks from or to other remote PLCs. It is concerned with such actions as device verification, data acquisition, synchronisation between user applications and connection management.

4.2.1.1 Internal architecture

It consist of a central processing unit (CPU) containing the system microprocessor, memory, and input/output circuitry. The CPU controls and processes all the operations within the PLC. It is supplied with a clock with a frequency of typically between 1 and 8 MHz. This frequency determines the operating speed of the PLC and provides the timing and synchronisation for all elements in the system. The information within the PLC is carried by means of digital signals. The internal paths along which digital signals flow are called buses. In the physical sense, a bus is just a number of conductors along which electrical signals can flow. It might be tracks on a printed circuit board or wires in a ribbon cable. The CPU uses the data bus for sending data between the constituent elements, and the address bus to send the addresses relating to internal control actions. The system bus is used for communications between the input/output ports and the input/output unit.



Picture 4: *Architecture of a PLC*

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4.2.1.1.1 The CPU

The internal structure of the CPU depends on the microprocessor concerned. In general they have:

1. An arithmetic and logic unit (ALU) which is responsible for data manipulation and carrying out arithmetic operations of addition and subtraction and logic operations of AND, OR, NOT and EXCLUSIVE-OR.
2. The memory, termed registers, located within the microprocessor and used to store information involved in program execution.
3. A control unit which is used to control the timing of operations.

4.2.1.1.2 The buses

The buses are the paths used for communication within the PLC. The information is transmitted in binary form, which is as a group of bits with a bit being a binary digit of 1 or 0 that is ON/OFF states. The term word is used for the group of bits constituting some information. So an 8-bit word might be the binary number 00100110. Each of the bits is communicated simultaneously along its own parallel wire. The system has four buses:

1. The data bus carries the data used in the processing carried out by the CPU. A microprocessor termed as being 8-bit has an internal data bus which can handle 8-bit numbers. In this way, you can perform operations between 8-bit numbers and deliver results as 8-bits values.
2. The address bus is used to carry the addresses of memory locations. So that each word can be located in the memory, every memory location is given a unique address. Just like houses in a town are each given a distinct address so that they can be located, so each word location is given an address so that data stored at a particular location can be accessed by the CPU either to read data located there or put, that is, write, data there. It is the address bus which carries the information indicating which address is to be accessed. If the address bus consist of 8 lines, the number of 8-bit words, and hence number of distinct addresses, is $2^8=256$. With 16 address lines, 65536 addresses are possible.

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3. The control bus carries the signals used by the CPU for control, for instance to inform memory devices whether they are to receive data from an input or output data and to carry timing signals used to synchronise actions.
4. The system bus is used for communications between the input/output ports and the input/output unit.

4.2.1.1.3 Memory

There are several memory elements in a PLC system:

1. System read-only-memory (ROM) to give permanent storage for the operating system and fixed data used by the CPU.
2. Random-access memory (RAM) for the user's program.
3. Random-access memory (RAM) for data. This is where information is stored on the status of inputs and outputs devices and the values of timers and counters and other internal devices. The data RAM is sometimes referred to as a data table or register table. Part of this memory, that is a block of addresses, will be reserved for input and output addresses and the states of those inputs and outputs. Part will be set aside for present data and part for storing counter values, timer values, etc.
4. Possibly, as a bolt-on extra module, erasable and programmable read-only-memory (EPROM) for RAMs that can be programmed and then the program made permanent.

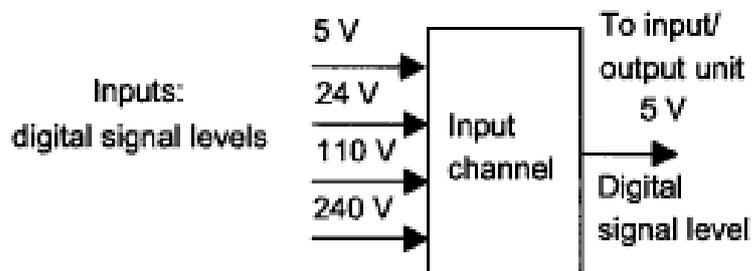
The programs and data in RAM can be changed by the user. All PLCs will have some amount of RAM to store programs that have been developed by the user and program data. However, to prevent the loss of programs when the power supply is switched off, a battery is used in the PLC to maintain the RAM contents for a period of time. After a program has been developed in RAM it may be loaded an EPROM memory chip, often a bolt-on module to the PLC, and so made permanent. In addition there are temporary buffer stores for the input/output channels.

4.2.1.1.4 Input/output unit

The input/output unit provides the interface between the system and the outside world, allowing for connections to be made through input/output channels to input devices such as sensors and output devices such as motors and solenoids. It is also through the inputs/outputs unit that programs are entered from a program panel. Every input/output point has a unique address which can be used by the CPU. It is like a row of houses along a road, number 10 might be the 'house' to be used for output to a particular motor.

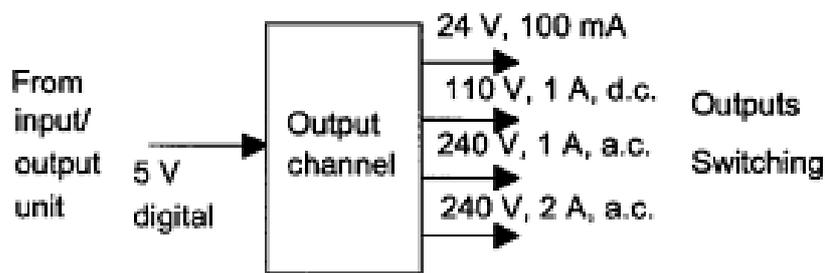
The input/output channels provide isolation and signal conditioning functions so that sensors and actuators can often be directly connected to them without the need for other circuitry. Electrical isolation from the external world is usually by means of optoisolators (the term optocoupler is also often used). When a digital pulse passes through the light-emitting diode, a pulse of infrared radiation is produced. This pulse is detected by the phototransistor and gives rise to a voltage in that circuit. The gap between the light-emitting diode and the phototransistor gives electrical isolation but the arrangement still allows for a digital pulse in one circuit to give rise to a digital pulse in another circuit.

The digital signal that is generally compatible with the microprocessor in PLC is 5V DC. However, signal conditioning in the input channel, with isolation, enables a wide range of input signals to be supplied to it. A range of inputs might be available with a large PLC, for example, 5V, 24V, 110V and 240V digital/discrete, that is ON-OFF, signals (Picture 5). A small PLC is likely to have just one form of input, for example 24V.



Picture 5: *Input levels*

The output from the input/output unit will be digital with a level of 5V. However, after signal conditioning with relays, transistors or triacs, the output from the output channel might be a 24V, 100mA switching signal, a DC voltage of 110V, 1A or perhaps 240V, 1A AC, or 240V, 2A AC, from a triac output channel. With a small PLC, all the outputs might be of one type, for example 240V AC, 1A. With modular PLCs however, a range of outputs can be accommodated by selection of the modules to be used.



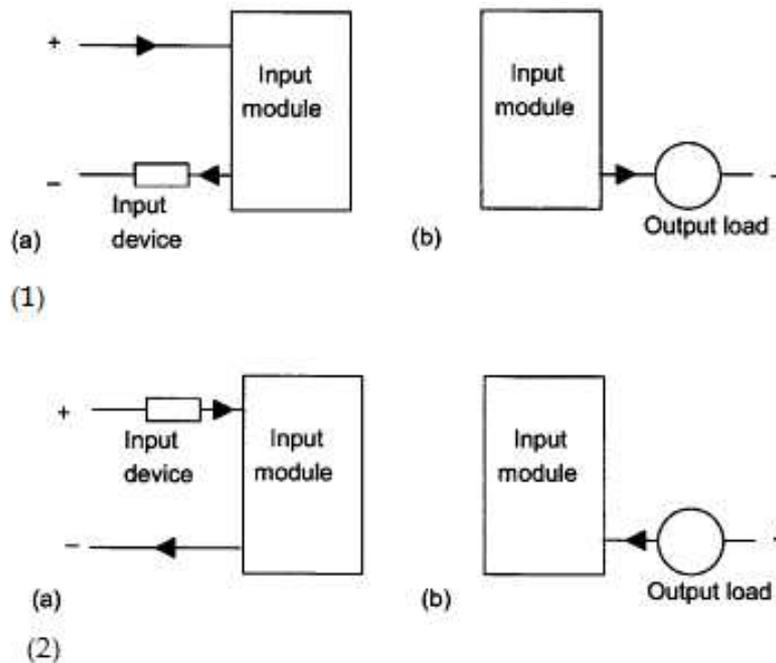
Picture 6: *Output levels*

Outputs are specified as being of relay type, transistor type or triac type:

1. With the relay type, the signal from the PLC output is used to operate a relay and is able to switch currents of the order of a few amperes in external circuit. The relay not only allows small currents to switch much larger currents but also isolates the PLC from the external circuit. Relays are, however, relatively slow to operate. Relay outputs are suitable for AC and DC switching. They can withstand high surge currents and voltage transients.
2. The transistor type of output uses a transistor to switch current through the external circuit. This gives a considerably faster switching action. It is, however, strictly for DC switching and is destroyed by overcurrent and high reverse voltage. As a protection, either a fuse or built-in electronic protection are used. Optoisolators are used to provide isolation.
3. Triac outputs, with optoisolators for isolation, can be used to control external loads which are connected to the AC power supply. It is strictly for AC operation and is very easily destroyed by overcurrent. Fuses are virtually always included to protect such outputs.

4.2.1.1.5 Sourcing sinking

The terms sourcing and sinking are used to describe the way in which DC devices are connected to a PLC. With sourcing, using the conventional current flow direction as from positive to negative, an input device receives current from the input module, that is the input module is the source of the current (Picture 7.1 (a)). If the current flows from the output module to an output load then the output module is referred to as sourcing (Picture 7.1 (b)). With sinking, using the conventional current flow direction as from positive to negative, an input device supplies current to the input module, that is the input module is the sink for the current (Picture 7.2(a)). If the current flows to the output module from an output load then the output module is referred to as sinking (Picture 7.2(b)).



Picture 7: Sourcing (1) and sinking (2).

4.2.2 APPLICATIONS OF PLC TECHNOLOGY

4.2.2.1 Indoor or short range

It is typical of home automation, electrical installation of the house was used as a transmission medium, such as lighting control and other electrical devices without the need to install additional wiring or distribution of video, television, music or the Internet to access it anywhere in the house.

Usually these device operate by injecting a high frequency carrier signal on the wiring of the house. This carrier signal is modulated with digital signals. Each receiver system has an address that identifies you and allows you to be individually managed, so that only the decoded data sent to this address. This device can be connected to standard plugs or be permanently connected to the electrical installation. Because these signal can propagate to neighboring homes belonging to the same distribution system, there is a network ID to refer to the owner and prevents the data received may be transported out of the house.

4.2.2.2 Outdoor or long range

Use medium and low voltage lines to provide service to broadband Internet access, video distribution and television or in mobile what is called the local loop or last mile that is the connection from the central different telephone subscribers. This enables a telecommunications infrastructure much cheaper than others such as fibre optic or coaxial cable, which allows sending data speeds of up to 200 Mbit/s and also has coverage potential wider.

There exists an intermediate between this group and the previous data that is to provide service (broadband Internet and/or distribution TV) to multiple users (homes) for large buildings such as skyscrapers.

Within this group, the standard emphasizes open access through PLC promoted by the European Union, known as OPERA (Open PLC European Research Alliance).

Utility companies use special coupling capacitors to connect radio transmitters to the power-frequency AC conductors. Frequencies used are in the range of 24 to 500 kHz, with transmitter power levels up to hundreds of watts. These signals may be impressed on one conductor, on two conductors or on all three conductors of a high-voltage AC

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transmission line. Several PLC channels may be coupled onto one HV line. Filtering devices are applied at substations to prevent the carrier frequency current from being bypassed through the station apparatus and to ensure that distant faults do not affect the isolated segments of the PLC system. These circuits are used for control of switchgear, and for protection of transmission lines. For example, a protective relay can use a PLC channel to trip a line if a fault is detected between its two terminals, but to leave the line in operation if the fault is elsewhere on the system.

While utility companies use microwave and now, increasingly, fibre optic cables for their primary system communication needs, the power-line carrier apparatus may still be useful as a backup channel or for very simple low-cost installations that do not warrant installing fibre optic lines.

Power-line carrier communication (PLCC) is mainly used for telecommunication, tele-protection and tele-monitoring between electrical substations through power lines at high voltages, such as 110 kV, 220 kV, 400 kV. The major benefit is the union of two applications in a single system, which is particularly useful for monitoring electric equipment and advanced management techniques (such as OpenADR and OpenHAN).

The modulation generally used in these system is amplitude modulation. The carrier frequency range is used for audio signals, protection and a pilot frequency. The pilot frequency is a signal in the audio range that is transmitted continuously for failure detection.

The voice signal is compressed and filtered into the 300 Hz to 4000 Hz range, and this audio frequency is mixed with the carrier frequency. The carrier frequency is again filtered, amplified and transmitted. The transmission power of these HF carrier frequencies will be in the range of 0 to +32 dBW. This range is set according to the distance between substations. PLCC can be used for interconnecting private branch exchanges (PBXs).

To sectionalize the transmission network and protect against failures, a wave trap is connected in series with the power (transmission) line. They consist of one or more sections of resonant circuits, which block the high frequency carrier waves (24 kHz to 500 kHz) and let power frequency current (50 Hz – 60 Hz) pass through. Wave traps are

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used in switchyard of most power stations to prevent carrier from entering the station equipment. Each wave trap has a lightning arrester to protect it from surge voltages.

A coupling capacitor is used to connect the transmitters and receivers to the high voltage line. This provides low impedance path for carrier energy to HV line but blocks the power frequency circuit by being a high impedance path. The coupling capacitor may be part of a capacitor voltage transformer used for voltage measurement.

Power-line carriers may change its transmission system from analogue to digital to enable Internet Protocol devices. Digital power-line carrier (DPLC) was developed for digital transmission via power lines. DPLC has the required quality of bit error rate characteristics and transmission ability such as transmitting information from monitored electric-supply stations and images.

4.2.2.3 Wiring home networks (broadband)

PLC technology can also be used in the networking of home computers and peripheral devices, including those that require network connections, although at present there are no standards for this type of application. Existing standards or standards have been developed by different companies within the framework defined by the U.S. organizations Home Plug Power line Alliance and Universal Power line Association.

4.2.2.4 Power management

Currently, power companies are working on improving this technology in mind control and monitoring of energy. The model of creating electricity is increasingly dispersed, that is power generation does not occur only in large central but distributed way. An example of this monitoring are electric meters that are starting to install some blocks and allow the utility company to obtain the power consumption of the subscriber in real time.

4.2.2.5 Other applications

PLC technology is also being studied and applied in cars because that way it saves weight by using the same cable to send communications and energy.

4.2.3 ADVANTAGES

- Cost savings in infrastructure because it uses the existing electrical infrastructure. Not needed works.
- Flexible technology, topology and network features can be modified easily to mind.
- Easy to install.
- The electrical plug is taken only for power, voice and data. No interference with the electricity supply.
- The services offered are competitive in price and quality, is a valid alternative to ADSL (Asymmetric Digital Subscriber Line) and CATV (cable television).
- Can integrate different services on the same network (telephony, internet access, television distribution...) and may even have different networks on the same electrical installation, thanks to the temporal multiplexing or frequency.

4.2.4 DISADVANTAGES

- Depending on the frequencies used and technology, can produce radiation in bands HF, interfering frequencies used by emergency and security forces and the amateur side. That is why some governments such as the Americans and Japanese had opposed PLC deployments in the past. Today, however, there are devices that allow the PLC to select the frequency at which it is transmitted, it is the case, for example, chip technology company DS2.
- The profitability of these services is not always assured.

4.3 SIWAREX U

SIWAREX U (Picture 8) is a versatile weighing module for all simple tasks of weighing and force measurement. The module compact can be used seamlessly with PLC's SIMATIC programmable. In this case, the total data access it is possible via the SIMATIC.



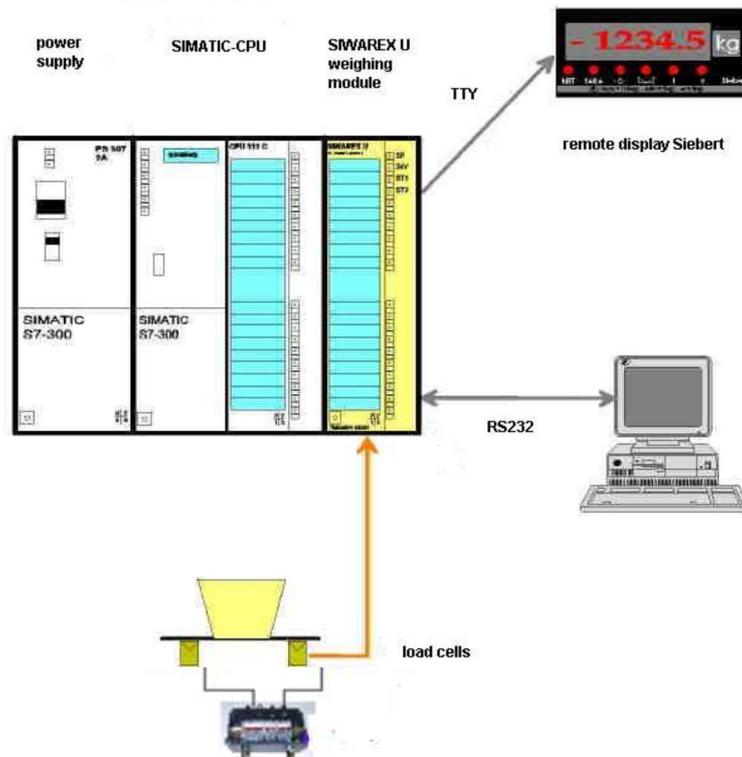
Picture 8: *SIWAREX U*

4.3.1 DESIGN

SIWAREX U is a function module (FM) of the SIMATIC S7-300 can be snapped directly to the backplane bus SIMATIC S7-300 or ET 200M. The assembling and wiring are considerably simplified thanks to the mounting rails (Snap-on mounting) (Picture 8).

The connection of the load cells, power supply and serial ports is performed by the standard 20-pin front connector.

The operation of SIWAREX U in SIMATIC guarantees complete integration of technology weighing PLC.



Picture 9: System overview with SIWAREX U

4.3.2 FUNCTION

SIWAREX U is available with either one or two measurement channels. Measurement channel is required for each scale.

The main function of SIWAREX U is to measure the voltage sensors and convert it into a weight value. If is necessary, the signal can be digitally filtered.

As well as determining weighing SIWAREX monitors two channel limit as it can freely set values (ex. Min. / Max.).

The SIWAREX U are factory-calibrated. This will be theoretical adjustment of the balance without weights, and you can change the module without renewed adjustment of scale. And if "active bus" used the modules can even be changed on the fly.

Consistent and uniform communication between all system components enables the integration and the fast, reliable and diagnosis in industrial processes.

SIWAREX U has two serial ports. One the TTY port lets you connect up to four digital remote displays. In these, besides the two weights weighing channels 1 and 2 can be

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displayed two values on the remote displays more defined via SIMATIC. The other RS232 port, can connect a PC to adjust the balance.

SIWAREX U not only integrates into the application software with classic programming languages for PLC, that is, STL (Statement List), LD (Ladder Diagram) SFC (Sequential Function Chart) or SCL (Structured Control Language). There is also the possibility of a graphical configuration CFCs (Continuous Function Chart) using images simulated or "faceplates" provided by PCS 7 for displaying scales.

Faced with the electronic modules connected in series, with SIWAREX U the high cost of additional modules are deleted typically required for connection to SIMATIC S7.

Integration in SIMATIC allows you to configure systems weighing of modular structure and free programmable, which can adapt to the internal requirements of each company.

The SIWATOOL U software adjusts the SIWAREX with the usual comfort of Windows, with independency of the PLC. All specifications for weighing modules can be defined in entry screens and saved and printed out on a printer reports to document the processes of the production plant.

The online mode also ensures early detection of errors through various diagnostic options offered SIWATOOL U.

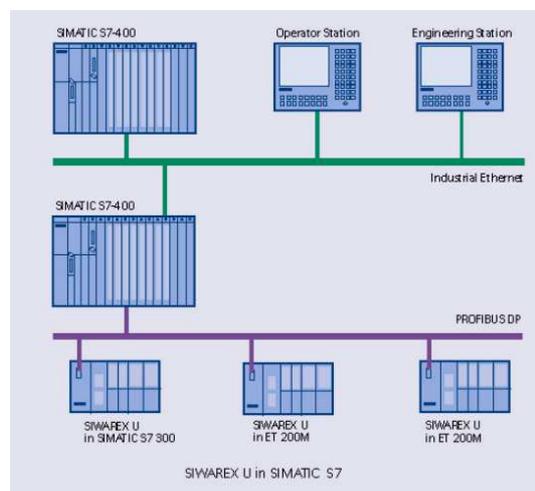
The module SIWAREX U is also suitable for classified areas. There is the possibility to realize feeding the load cells with intrinsically safe by means of optional Ex interface.

4.3.3 ADVANTAGES

- Uniform design system and consistent communication in SIMATIC.
- Application in the distributed system connected thanks to PROFIBUS DP /PROFINET via ET200M.
- Measurement of weight or force with a high resolution of 65000 parts and an accuracy of 0.05%.
- Space saving by applying the two-channel version for two scales.
- Direct connection of a remote display to the TTY interface.
- Simple Parameterizing with SIWATOOL.
- Supports replacement of module without renewed adjustment of scale.
- Supports theoretical adjustment without adjustment weights.
- Intrinsically-safe load cell supply for the hazardous area zones 1,2 (optional).
- Can be used for Ex-applications.

4.3.4 SYSTEM INTEGRATION IN SIMATIC S7

SIWAREX U is a module of SIMATIC S7 300. The user is fully free in the configuration of the automation solution, including the weighing application. By means of a relevant combination of the SIMATIC modules, optimal solutions can be found for small, medium-sized, and large systems. With the aid of the configuration package and sample applications for SIMATIC, customer-specific/sector-specific solutions can be developed very quickly. The following picture shows a typical combination for a medium-sized system.



Picture 10: Configuration SIMATIC S7 with SIWAREX U

4.4 SIMATIC S7

4.4.1 DESCRIPTION

SIMATIC S7-300 controller saves on installation space and features a modular design. A wide range of modules can be used to expand the system centrally or to create decentralized structures according to the task at hand, and facilitates a cost-effective stock of spare parts.

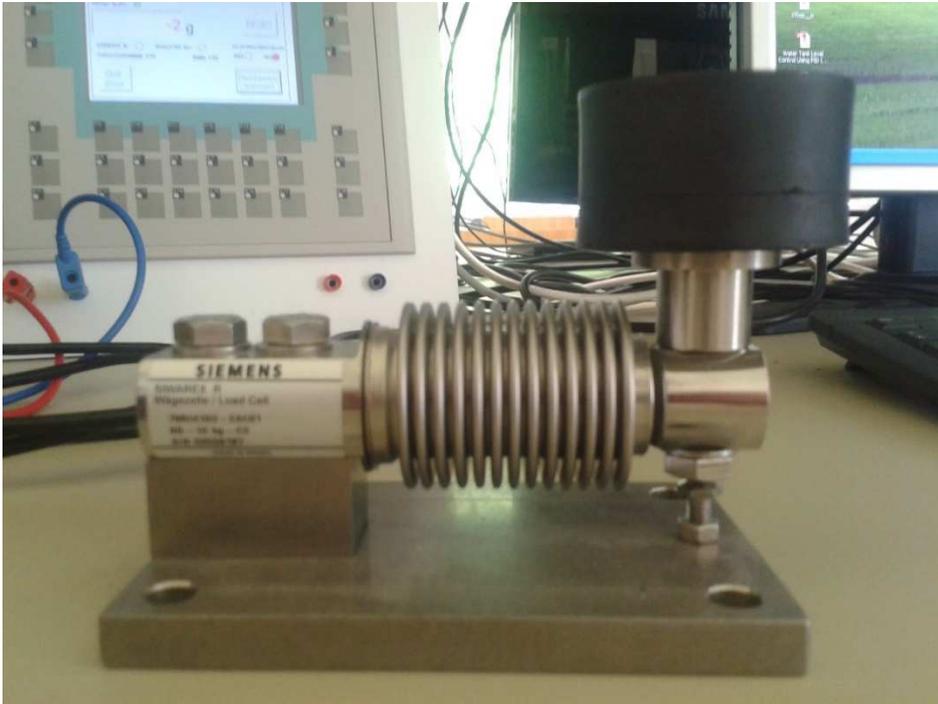
The multi-facetted module range allows modular customization to suit the most varied tasks.

Function modules are intelligent modules that independently execute the technological tasks like counting, measuring, cam control, PID control and motion control. Therefore they reduce the load on the CPU. They are used when a high level of accuracy and dynamic response is required.

4.4.2 ADVANTATGES

- High degree of accuracy and dynamic response.
- Specialized and universal modules with a wide range of functions.
- CPU is not involved since the functionality is stored in the firmware of each module.
- Quick reaction times (deterministic dynamic response).
- Engineering with configuring tool, integrated into STEP 7.
- The S7-300's range of CPUs provides the right solution for every application, and customers only pay for the performance actually required for a specific task.
- Integral PROFINET interfaces enable simple networking of the controllers, and simple data exchange with the operations management level.
- The narrow module width results in a compact controller design or a small control cabinet.
- The ability to integrate powerful CPUs with Industrial Ethernet/PROFIBUS interface, integrated technological functions, or fail-safe designs make additional investments unnecessary.

4.5 SIWAREX R



Picture 11: *SIWAREX R*

SIWAREX R load cells are used for static and dynamic measurements of forces and weights. They can be used for almost all applications in industrial weighing technology. These may be for example:

- Container, hopper or platform scales.
- Rollway, belt or crane scales.
- Filling/packing plants, proportioning and mixing.
- Filling level and completeness inspection.
- Equipment for monitoring pressing and clamping procedures.
- Dynamic scales.

All applications can be located in areas with mandatory calibration or in hazardous areas.

The measuring element is a double bending beam made of stainless steel to which 4 strain gauges are applied. The strain gauges are arranged so that two are stretched and two are compressed.

Under the influence of the load acting in the measuring direction, the spring bodies and therefore the friction-locked strain gauges are elastically deformed. This generates a measuring signal voltage that is proportional to the load.

4.6 SIMANTIC PANEL TOUCH

For this project used SIMANTIC PANEL TOUCH for operator control and monitoring. In this case it use OP1778B HMI device. This panel is versatile that could use with key or touching depends the things you need to make.

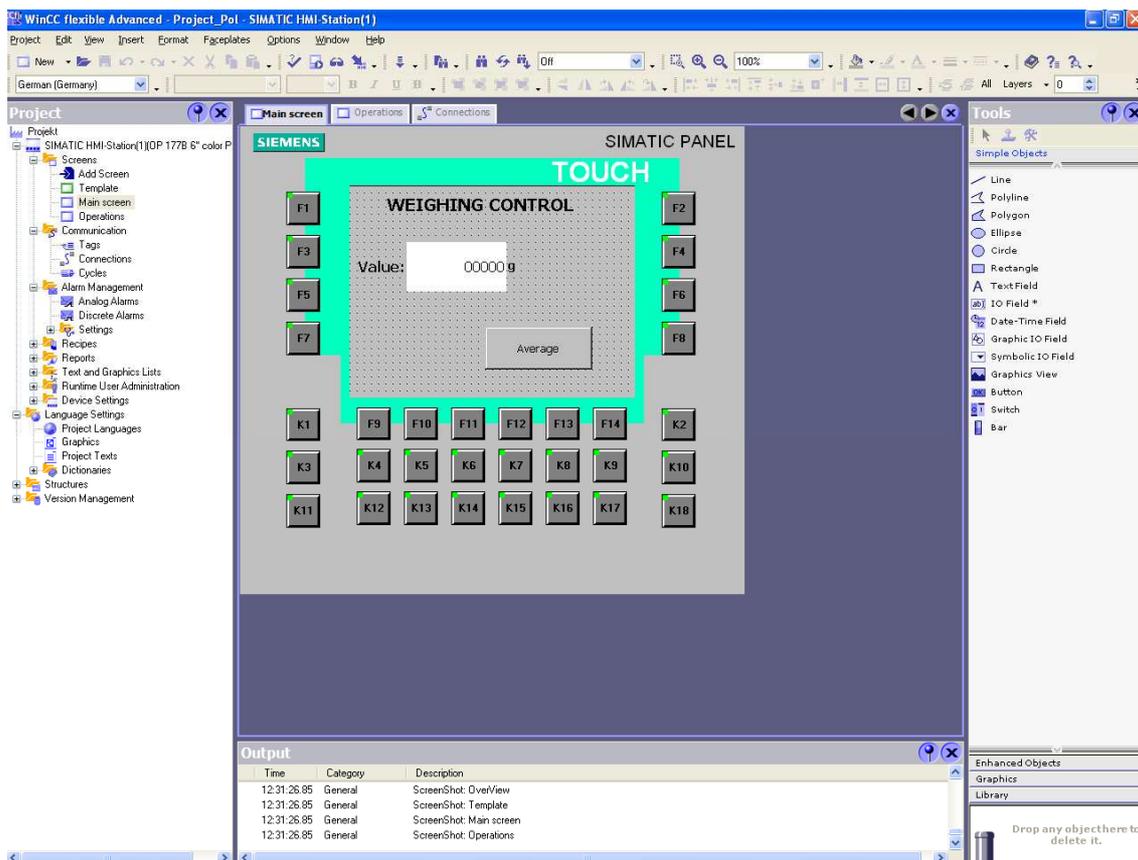
Is necessary make one configuration with WinCC flexible 2008 for use the panel. This combination had specials highlights.

- Freely definable message classes (acknowledgement behaviour and representation can be configured).
- Graphics and texts can be switched language-dependent and are freely scalable.
- Permanent window and template concept for creating screen templates.
- Message history is retained even with devices switched off – and without battery.
- Online language switchover with 5 selectable languages, incl. Asian and Cyrillic fonts.
- Analog signals (limit signals) as well as bit signals to display plant statuses.
- Recipe data sets can already be flexibly prepared off-line when configuring.
- User administration (security) – authentication by means of user ID and password can also be edited off-line.
- Privileges specific to user groups are an integral component of the user administration.

4.7 WINCC FLEXIBLE 2008

WinCC flexible 2008 software package provides the development environment Siemens under the scadas for visualization and industrial process control. Its most important features can be summarized as:

- Open Architecture development (programming in C).
- Support Active X technologies.
- Communication with other applications via OPC.
- Easy communication with drivers (code that implements the communications protocol with a specific intelligent computer) implemented.
- Online Programming: is not necessary to stop the development runtime to update the changes in the same.



Picture 12: Main screen of WinCC flexible 2008

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Main screen for use WinCC flexible 2008.

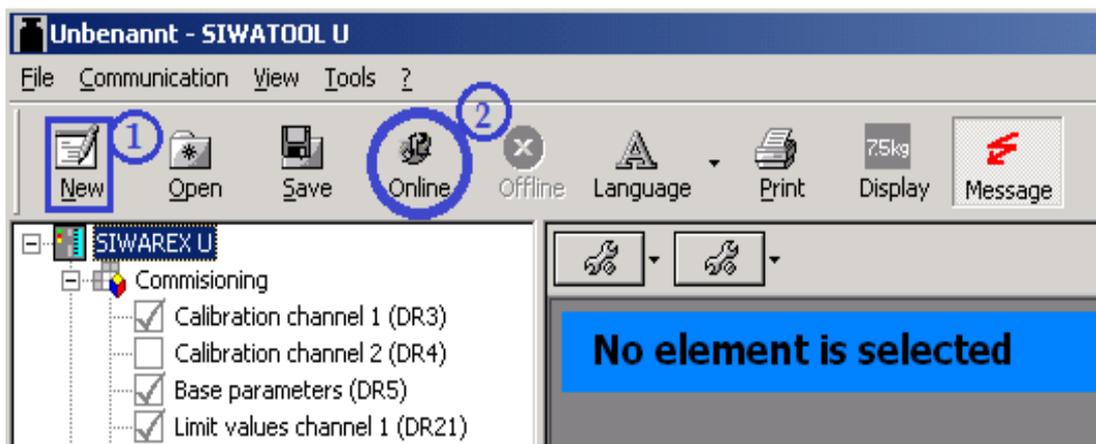
- Project Explorer: It is located to the left of the window. Here you can explore all the settings related to the project. In this part we access the variables created and connections located in the communications section. Besides this you can perform other tasks such as creating recipes, scripts structures ...
- Workspace: Located in the central part of the project window. Here using the graphical editor we can create the shapes we want giving different animations as: visibility, appearance flickering movements....
- Tools: In this part we have various tools such as: Simple geometric shapes (line, circle, square, polyline ...), Date field, text field, button, switch ... Here we can also access libraries already created or imported by us.

5. METHODS

5.1 ESTABLISH AND ADJUSTMENT THE COMMUNICATION TO THE SIWAREX U MODULE

First of all is necessary communicated the SIWATOOL U and SIWAREX U if it the next process want to be available. Following is an explanation of how to make the connection.

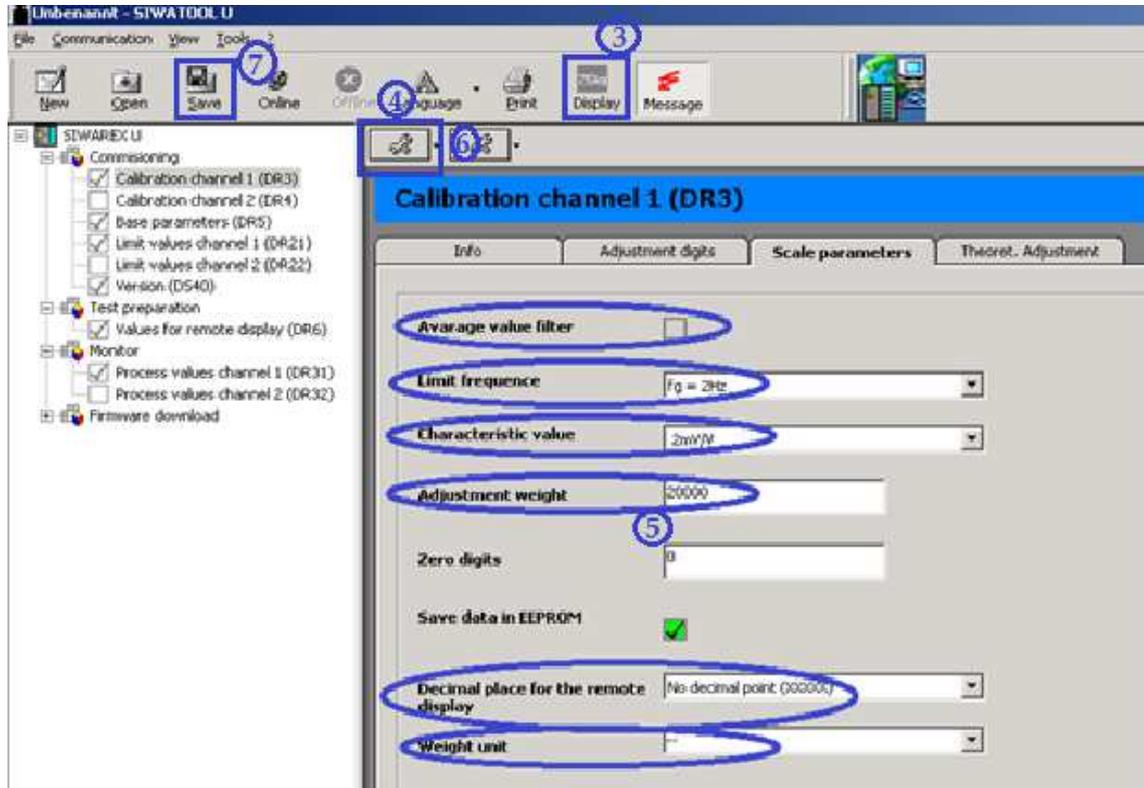
Open the program SIWATOOL U and first of all its necessary establish one connection between SIWAREX U module and SIWATOOL software, click the bottom online.



Picture 13: *Communication SIWATOOL U module to SIWAREX U.*

First of all is necessary created a new project and after is necessary connecting online with SIWAREX U.

When the communication is established check the following parameter-settings:



Picture 14: Calibration of SIWATOOL U

1. Press the button “New”.
2. Press the button “Online”.
3. Press the button “Display”.
4. Without any weight on the weighing scale press the button “Adjust zero valid (1)”.
5. Put 2Kg load, provided with the weighing kit in the sensor and adjust the properties in SIWAREX > Commissioning > Calibration Channel 1(DR3) and in Adjustment Weight for the value of 2000 (g), and after press Send.
6. Press the button “Adjustment weight valid (2).”
7. Finally you need to save the new scale, for that press the button “save”.

Once completed these steps, the next time you open the project with WinCC or Touch panel the scale be saved.

5.2 HARDWARE CONFIGURATION IN SIMATIC S7

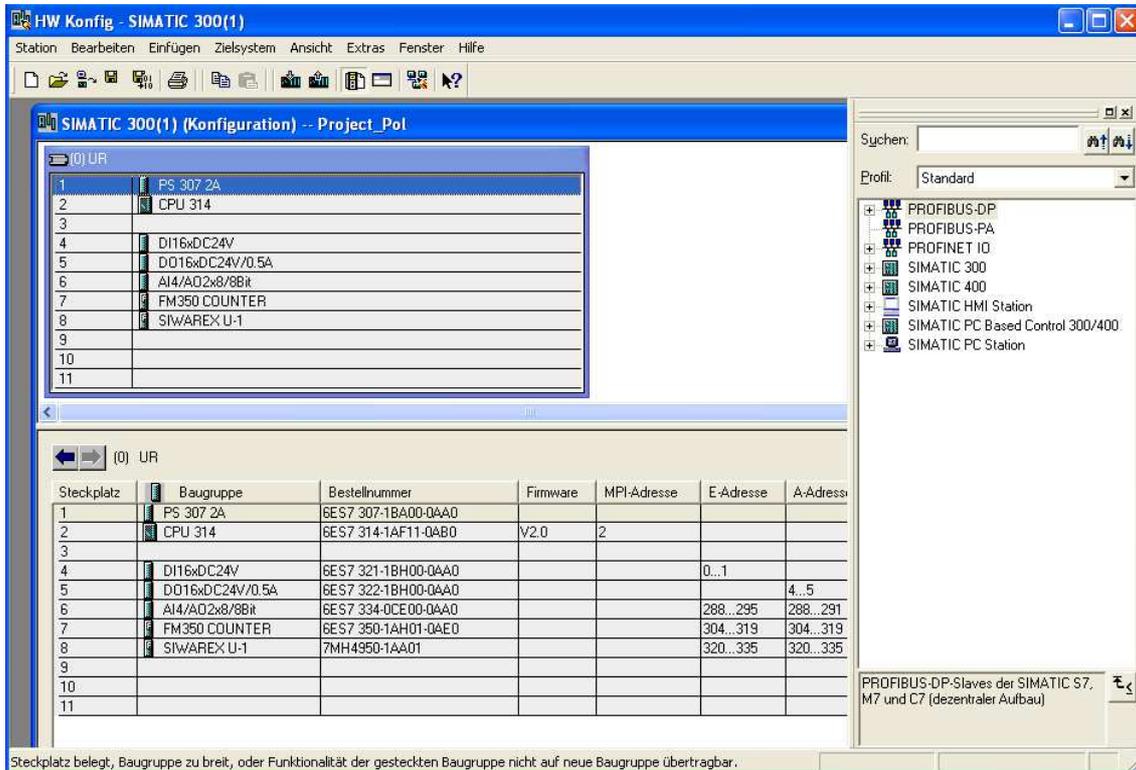
After the connection of SIWATOOL U it is the moment for start the configuration of SIMATIC S7. This is the program where it creates the program for PLC. Is essential make correctly the configuration of hardware, as every project needed a personal configuration.

For this project it necessary the next configuration:

- First is necessary create a new project in SIMATIC S7.
- One time made this is necessary this steps:
 - Name of the project > SIMATIC_S7 > CPU314 > Hardware

In this moment click two times Hardware and appear a new page, this page is the place where it make the configuration.

- Before start the configuration is the moment for choose the PLC that is being used. In this case is used SIMATIC-300. To choose the program is provided on the right side of the screen. Is very important select the correct Hardware, in this case CPU314.
 - SIMATIC 300 > Rack-300 > CPU314
- Now is the time to start configuring. Is very important put the racks or modules in the correct position, in the picture 15 below you can see how you have to put the racks in this project. The names and numbers of every module and racks can be found in their specifications.
- When the configuration is done is the moment for save and upload in PLC.



Picture 15: Configuration of Hardware

- To use the weighing module has to copy a program example in SIMATIC S7. This program can be found on the CD supplied.
- The next step is:
 - SIMATIC300(1) > CPU314 > S7-Program(1) > Blocks
 - Now copy the folder DB9. DB9 has different variables that can be used with the sensor SIWAREX R.
- To verify that everything is working have to enter in “OB1”. Once there its necessary click the button Monitor ON/OFF this button is the button with the glasses symbol. This opens one new windows with all variables and check if all is working well.
- The value read in the sensor and in the SIWATOOL U, will appear in the address DB9.DBW12.

Ones make that and all is working good, saves the project and all is done.

6. DEVELOPMENT OF WEIGHING SYSTEM

6.1 LEARNING MODULES

Before starting building the weighing interface first one step is required: to learn how the programs works. For this was suggested that the student follow the E-learning training with SIMATIC S7, in the website of the Institut für Automatisierungstechnik (www.global.hs-mittweida.de/~ifa/).

The learning modules consists of 4 experiments, describe step to step helping the student to work with this software. They are: 7 segments display, site traffic light, two-step level controller and PID level controller.

In every experiment there are specific external boards so we can simulate the problem and fix it. In the website are described how the problem is and give a solution of an implementation on SIMATIC S7.

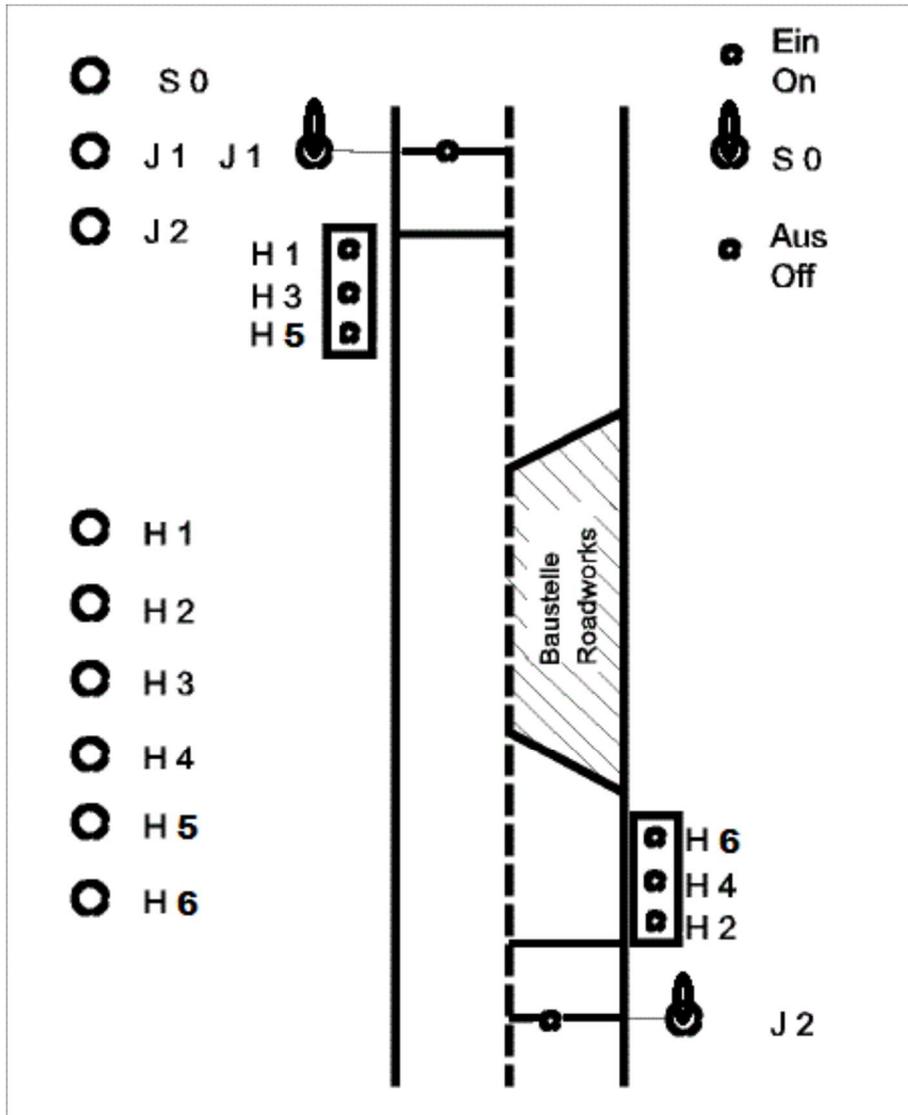
It was done exactly as the website describes, and a little of extra work in the system Site Traffic light, showed below.

6.2 SITE TRAFFIC LIGHT SYSTEM

The traffic has to be narrowed because of construction work. There is only one track, and a traffic light should control the traffic.

Switching on the system (switch S0) - both traffic lights has to signalize RED. If one initiator (J1 or J2) sends the signal "1" (that's the case when a car is at J1 or J2, which in real life represented a sensor of proximity), the appropriate traffic light has to become GREEN after 10 seconds. The green phase must persist at least 20 seconds before both traffic lights switch to RED if the other initiator is operated possibly. After 10 seconds the other track is served with green. If no initiator is operated, the traffic light remains in the last state. Switching off the traffic lights should be allowed only after a green phase.

The following schematic of the problem, the university module, is shown below in Picture 16.



Picture 16: Schematic of the problem traffic light system, also learning module.

6.2.1 EXPERIMENTAL PROCEDIMENTS

First we connect the module and build the experiment in the way shown on Picture 17.



Picture 17: *Workbench with all elements used in the learning module traffic lights system.*

The follow Table 1 show all the connections between the modules and the PLC and the address used in the WinCC Software.

INPUT/OUTPUT	VARIABLE	DEVICE	LOGICAL	ALLOCATION
Input Switch 0 (S0)	I1.0	Switch "ON"	I1.0=1	digital input 0
Input Initiator 1(J1)	I1.1	Initiator "ON"	I1.1=1	digital input 1
Input Initiator 2 (J2)	I1.2	Initiator "ON"	I1.2=1	digital input 2
Output Green Lamp 1 of J1 (H1)	Q4.1	Lamp "ON"	Q4.1 = 1	Digital output 1
Output Green Lamp 2 of J2 (H2)	Q4.2	Lamp "ON"	Q4.2 = 1	Digital output 2
Output Yellow Lamp 1 of J1 (H3)	Q4.3	Lamp "ON"	Q4.3 = 1	Digital output 3
Output Yellow Lamp 2 of J2 (H4)	Q4.4	Lamp "ON"	Q4.4 = 1	Digital output 4
Output Red Lamp 1 of J1 (H5)	Q4.5	Lamp "ON"	Q4.5 = 1	Digital output 5
Output Red Lamp 2 of J2 (H6)	Q4.6	Lamp "ON"	Q4.6 = 1	Digital output 6

Table 1: Connections between the modules and the PLC and their address.

6.2.2 SOLUTION

It becomes evident that the program works as a status machine.

The traffic light can be implemented either in automatic mode or by means of a priority circuit.

In this case are used the priority circuit. It's important that the input conditions are interlocked against each other. In the available case, 4 start conditions are possible:

- a) There is a car at J1 and J2.
- b) There is only a car at J1.
- c) There is only a car at J2.
- d) There is a car neither at J1 nor at J2.

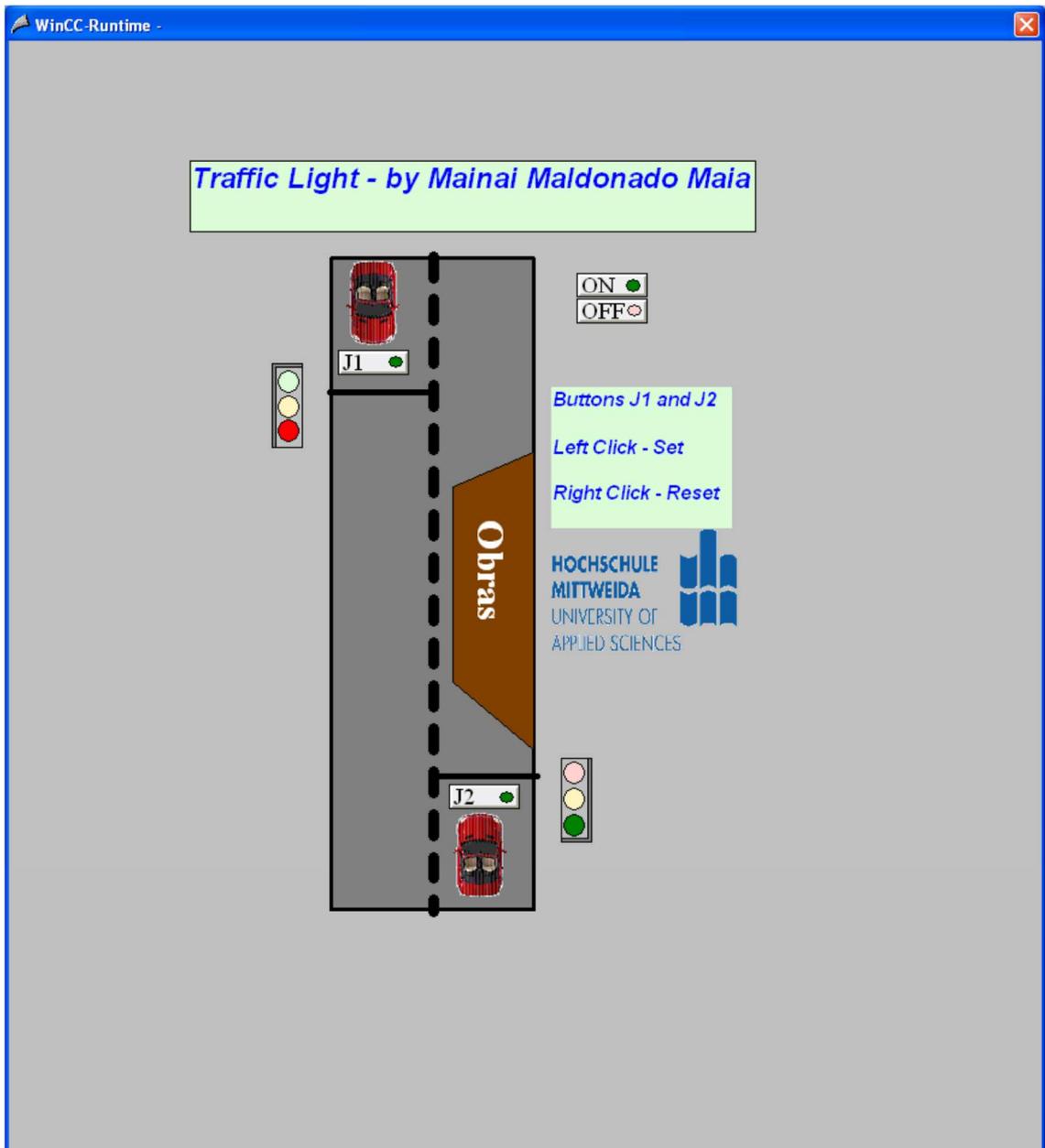
If the step enabling conditions J1 and J2 (a) are fulfilled at the same time one state has to be given priority.

The result is a sequence control system, with which the stepping from one step to the next one takes place dependently on the step-conditions.

Out of this conditions a ladder program were made and loaded to PLC. This ladder program can be view in the Attached Documents 1.

6.2.3 SUPERVISORY INTERFACE

A Supervisory Interface was created in the Siemens supervisory software SIMATIC WinCC EXPLORER. With the supervisory interface we can have a representation of what is happening far from the traffic light. We can also control it. For this we need a communication between the supervisory software and the CLP. For this tags are used. The supervisory created and running is in the following Picture 18.



Picture 18: Supervisory created and running for the traffic light system.

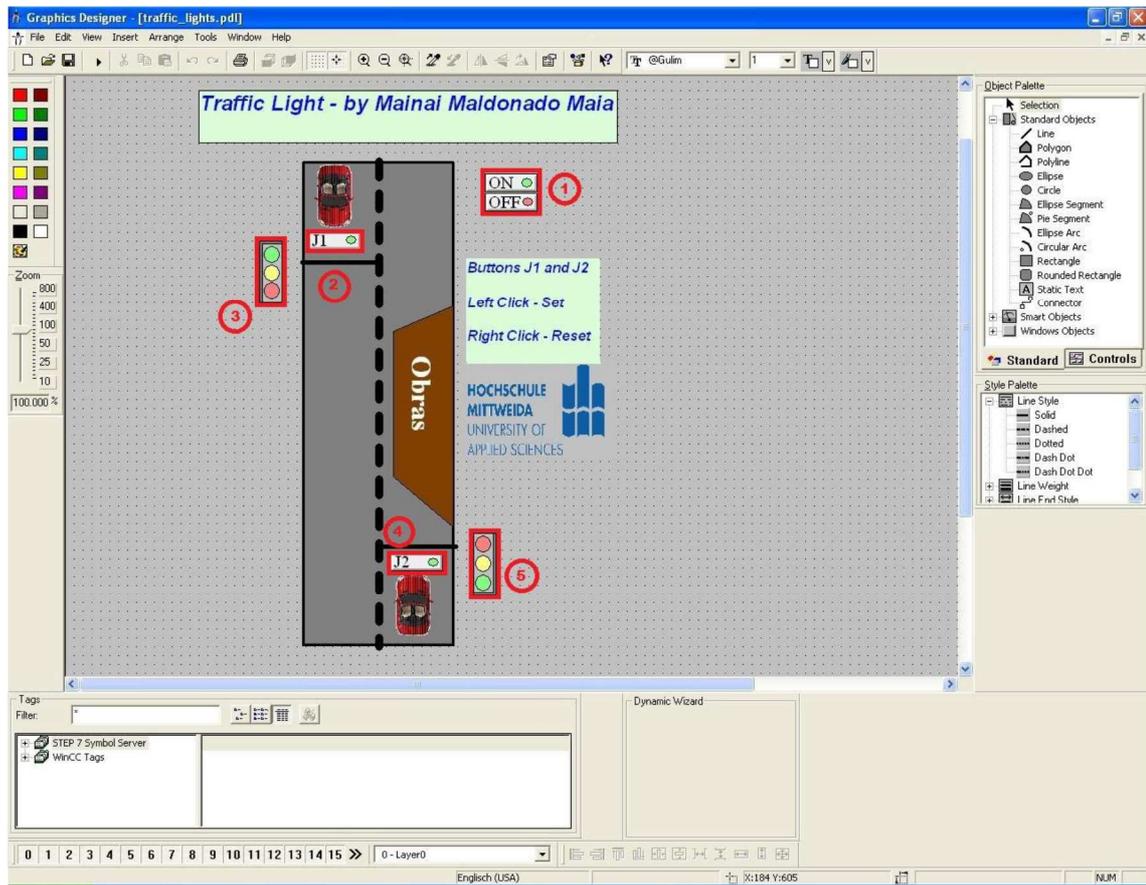
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In this program a tag can be of two different types: Boolean, assuming only values HIGH or LOW, or Unsigned 8-bits value, assuming integer values. In the Picture 19 the tags created are showed and their type and their address on the PLC.

Name	Type	Parameters
S1	Binary Tag	E0.0
J1	Binary Tag	E0.1
J2	Binary Tag	E0.2
H1	Binary Tag	A4.1
H2	Binary Tag	A4.2
H3	Binary Tag	A4.3
H4	Binary Tag	A4.4
H5	Binary Tag	A4.5
H6	Binary Tag	A4.6
work	Unsigned 8-bit value	MB10
M00_S0	Unsigned 8-bit value	MB0
M01_S1	Unsigned 8-bit value	MB1
M02_J2	Unsigned 8-bit value	MB2

Picture 19: *Tags used in the traffic lights system supervisory.*

In the Picture 20, showed the process of creating the supervisory program. The picture is explained in the Table 2.



Picture 20: Process of creating the supervisory program for the traffic light system.

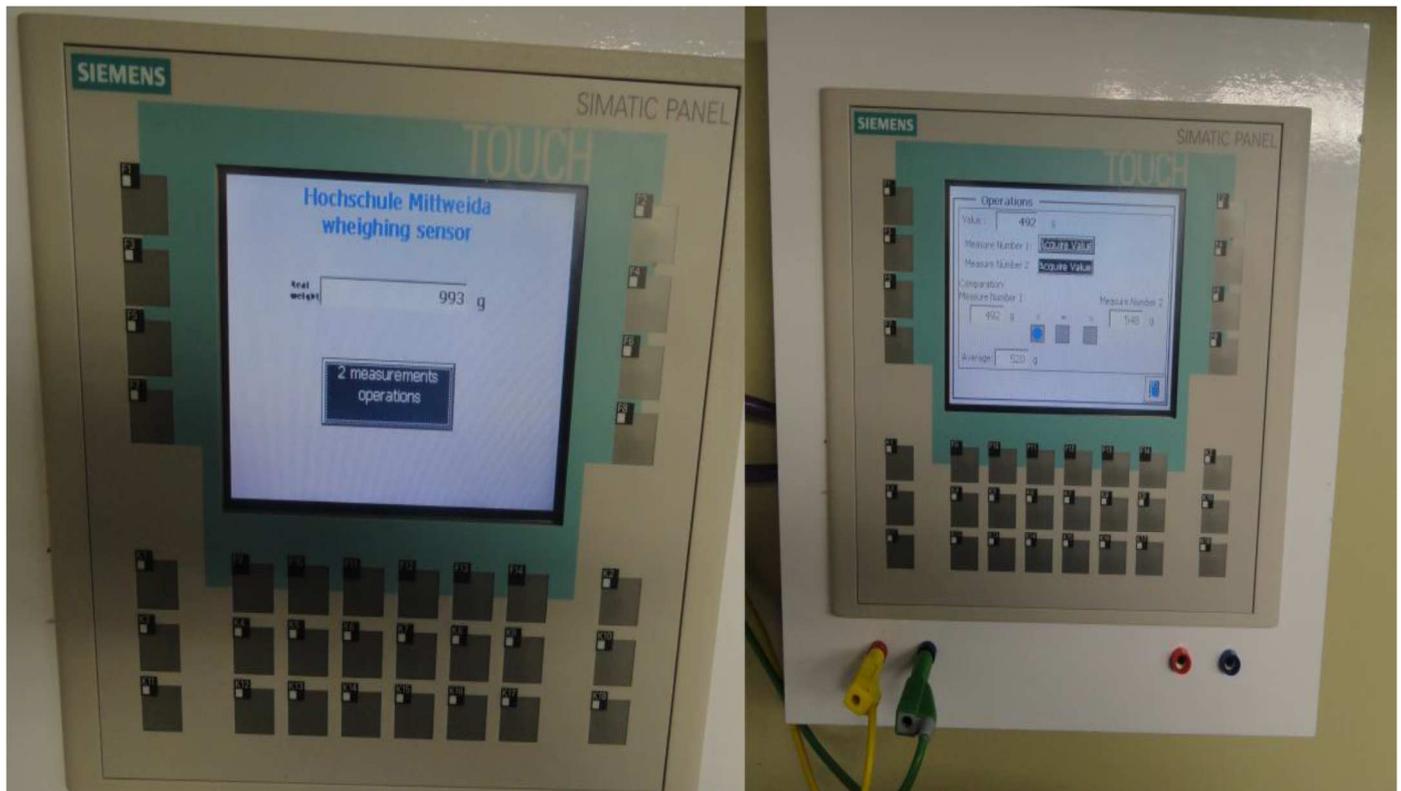
NUMBER	OBJECT	ACTIONS
1	Buttons On/Off	On – On Click Set tag M00_S0, Off reset the same tag. The light near the words On and Off show if the program is on ON or OFF
2	Button Sensor J1	Left Click – Set tag M01_S1. The light near the button goes on. Right click – Reset the same tag and turn the light off.
3	Traffic Light 1	Red light – Turn on only if the tag H5 is HIGH, Yellow light – Turn on only if the tag H3 is HIGH, Green light – Turn on only if the tag H1 is HIGH
4	Button Sensor J2	Left Click – Set tag M02_J2. The light near the button goes on. Right click – Reset the same tag and turn the light off.
5	Traffic Light 2	Red light – Turn on only if the tag H6 is HIGH, Yellow light – Turn on only if the tag H4 is HIGH, Green light – Turn on only if the tag H2 is HIGH

Table 2: Explanation of the process of creating the supervisory program.

6.3 WEIGHING SYSTEM

The weighing system, including its Hardware, was described in the Material and Methods section and an Interface for the touch panel was created.

In the Picture 21 is shown the program running in a touch panel.



Picture 21: Weighing system program running in a touch panel.

In the main screen it is possible to see the exactly weight read in the sensor SIWAREX R. It is possible just because of the library present in the example program. In the main screen there is also a button “2 measurements operations” that changes the program for the second screen.

In the second screen “Operations”, the measurement read in the sensor is also shown. There is two buttons, ‘Acquire Measurement 1’, and ‘Acquire Measurement 2’, to acquire measurements and work with them. After you click the two buttons for acquire the measurements, the measurements saved can be seen in the middle of the screen. Also can be seen a comparison between the two measures, if they are equal or the first measurement

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is greater or lower than the second measurement. In the bottom of the screen can be the average between the two measurements and a button to return to the first screen.

The program was tested several times, with a weighing set, available in the lab, with predetermined weights of 500g, 1kg and 2kg, shown in the Picture 12.



Picture 22: *Weighing set available on laboratory*

6.3.1 DEVELOP OF HARDWARE

To create the system the first thing you do is create the Hardware in SIMTIC S7 and the interface for the panel touch with WinCC flexible 2008. This was explain inside chapters methods.

The next step is to create the hardware to control the entire process, this has to be simple and easy to understand, because it will be the one you have to use to create the interface.

The program is develop with SIMATIC S7, and is necessary use one OB1, FB1 and for the tag I_Gross_weight_CH1 is necessary the DB9 and UDT9, this is explain inside chapter hardware configuration in SIMATIC S7. The program create is develop in the attached documents.

To make the program faster and easier to use a different variable so that its introduction into different blocks is more accessible and easy to understand will be created. Then we see the variables created.

NAME OF TAGS	ADRESS	TYPE
Active_comparation	M149.0	Boolean
Comp_adq1	M155.0	Boolean
Comp_adq1	M157.0	Boolean
Comp_less	M170.0	Boolean
Comp_equal	M171.0	Boolean
Comp_greater	M172.0	Boolean
Comp_value1	MW165	Int
Comp_value2	MW168	Int
SUM	MW192	Int
Average	MW194	Int
I_Gross_weight_CH1	DB9.DBW12	Int
S_actual_value_CH1.I_Gross_CH1	DB9.DBW100	Int

Table 3: Variables used for develop the Hardware

This variables is using for made the interface with the program WinCC.

6.3.2 DEVELOP THE INTERFACE

Once you create the hardware that will run the PLC is the time to start creating the interface program. The creation of the interface is free to be the way you want, but it has to resemble the hardware created. This interface is to be seen on the touch screen, for that reason we have to do in the simplest way, as they are for workers and has to try to work as comfortable and fast as possible. For this is very important made clearly the Hardware, because after is more easy to combine with the interface the most easy way.

With the software WinCC flexible 2008 are created the interface. This interface consists of 2 screens (Picture 22), the first is main screen and the second is the operations.

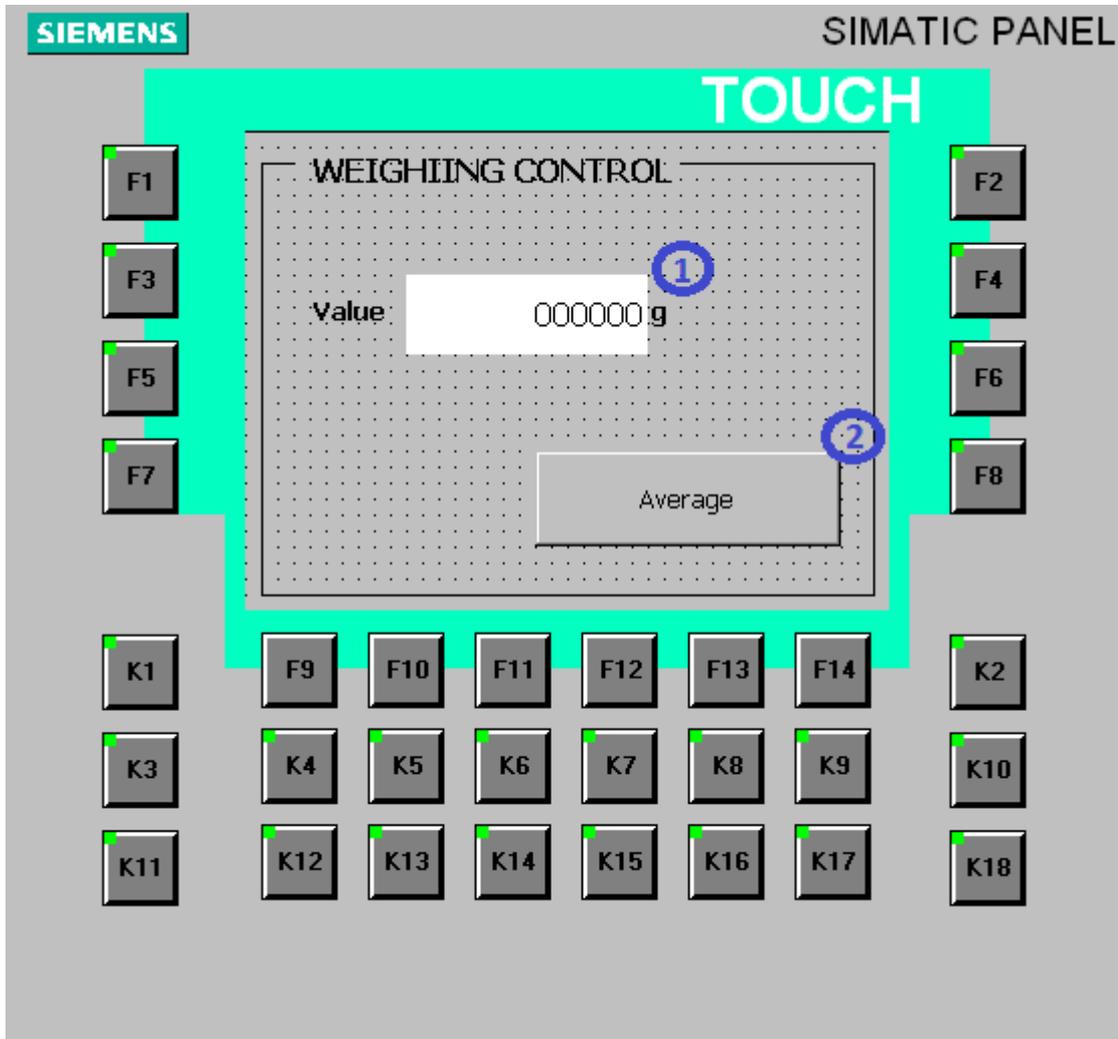
The main screen is the screen that you can see the actual weight sensor that reads SIWAREX R. That is possible only because the variables created inside the Hardware are introduced in the program. After seeing the weight, there is a button "average" that once clicked takes you to the operation screen.

Here, first of all, have two buttons "Measurement 1" and "Measurement 2". This buttons acquire de measurement, this buttons takes you and other time inside the main screen.

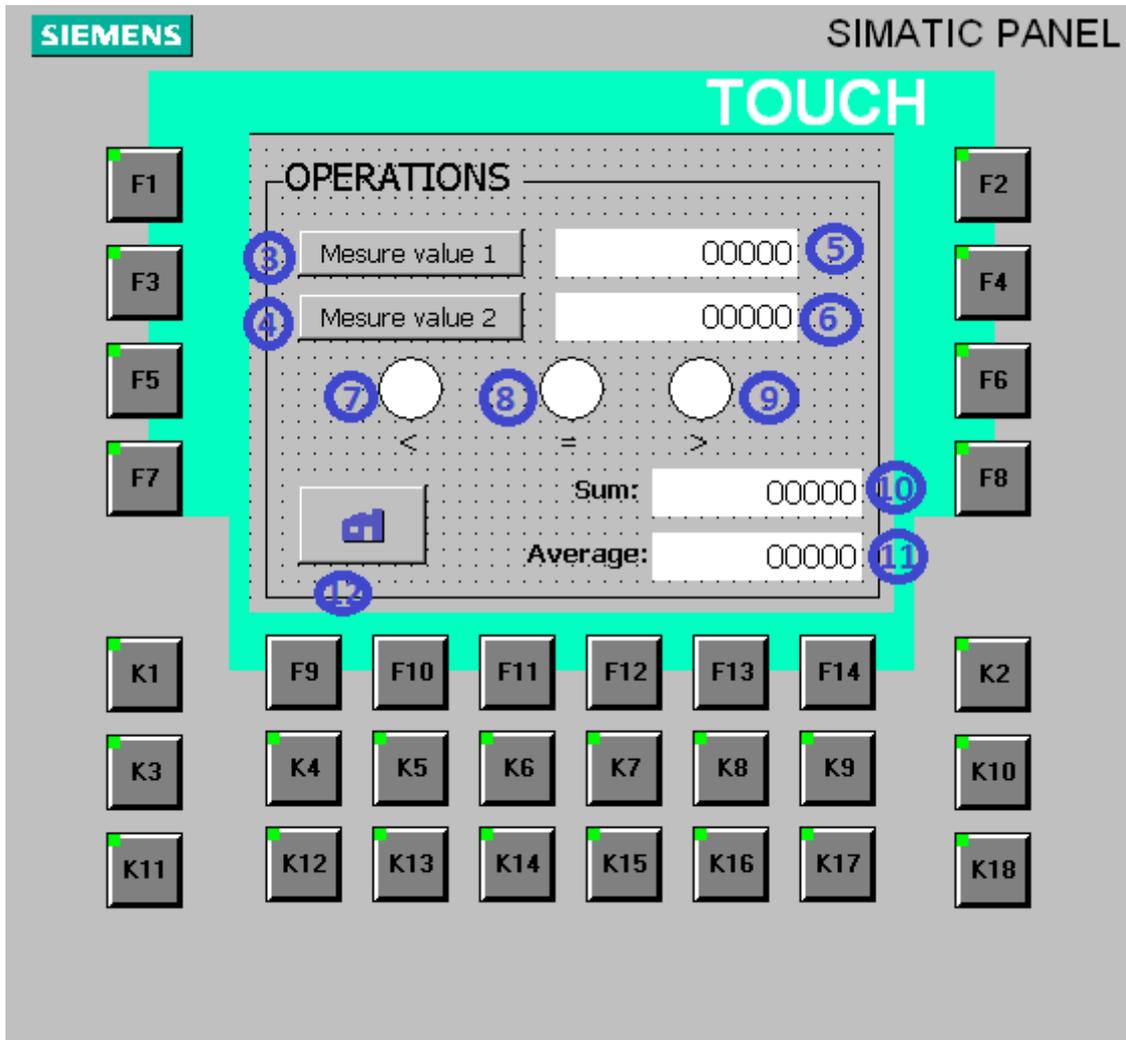
After this have the values of measurement 1 and 2. This is important to know the weight that each. Also you can see the comparison among them, if the measurement 1 is less, greatest or equal than the 2 measurement.

Finally it is possible see the average.

Now can be seen the process of creation (Picture 22).



Picture 22: Main screen of interface



Picture 23: Operation screen of the interface

The next table explains the development of the program.

NUMBER	INTERFACE	HOW IT WORKS
1	Number – box	Output of the tag I_Gross_weight_CH1
2	Button	Active screen “operation”, and set tag Active_comparation
3	Number – box	Output of the tag I_Gross_eight_CH1
4	Button	On press set tag Comp_adq1. On release reset the same tag.
5	Button	On press set tag Comp_adq2. On release reset the same tag.
6	Number - box	Output of the tag comp_value1
7	Number – box	Output of the tag Comp_value2
8	Marker (output)	Visible it the tag Comp_less is high
9	Marker (output)	Visible if the tag Comp_equal is high
10	Marker (output)	Visible if the tag Comp_greater is high
11	Number - box	Output of the tag Average
12	Button	Active screen “main screen”

Table 4: *Explanation of the development interface*

7. CONCLUSIONS

This project has seen the value that have the plc in real life, especially work. In this case, creating the weighing interface has been found necessary to do the simplest things for a worker. With all the problems has had in time to use the SIMATIC S7, has been seen as a program of great power and capacity to implement programs for the PLC.

If we look at the entire set for this project, it can be seen that the combination of all programs and driver do you have a great power. First of all, with the Siemens S7-300 combined with SIWAREX U module, the realization of the hardware is much simply. Second, thanks to the WinCC flexible 2008 software can perform a neat interface and simple way so that you can see on the touch panel. If we combine SIMATIC S7 with SIWATOOL U to make the correct tare and the interface have created a fairly simple process with few steps and very useful.

In this project with the interface can be read the real weight, and all the results obtained in practice were correct and the objective have been achieved successfully.

8. BIBLIOGRAPHY

http://books.google.de/books?id=zsyTTGxCIdMC&pg=PA7&redir_esc=y#v=onepage&q&f=false

<http://www.automation.siemens.com/mcms/sensor-systems/en/weighing-systems/load-cell/bending-beam-load-cells/Pages/siwarex-r-bb.aspx>

<http://support.automation.siemens.com/WW/llisapi.dll?func=cslib.csinfo&lang=en&objid=28392477&caller=view>

<http://usedplcs.co.uk/manuals/siemens/HMI/TP177B.pdf>

<http://w3.siemens.com/mcms/programmable-logic-controller/en/simatic-s7-controller/s7-300/cpu/Pages/Default.aspx>

9. ACKNOWLEDGMENTS

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10. SIGNATURES

Pol Barnaus Fernàndez

INTERN

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MENTOR / EPSEM / SPAIN

11. APPENDIX

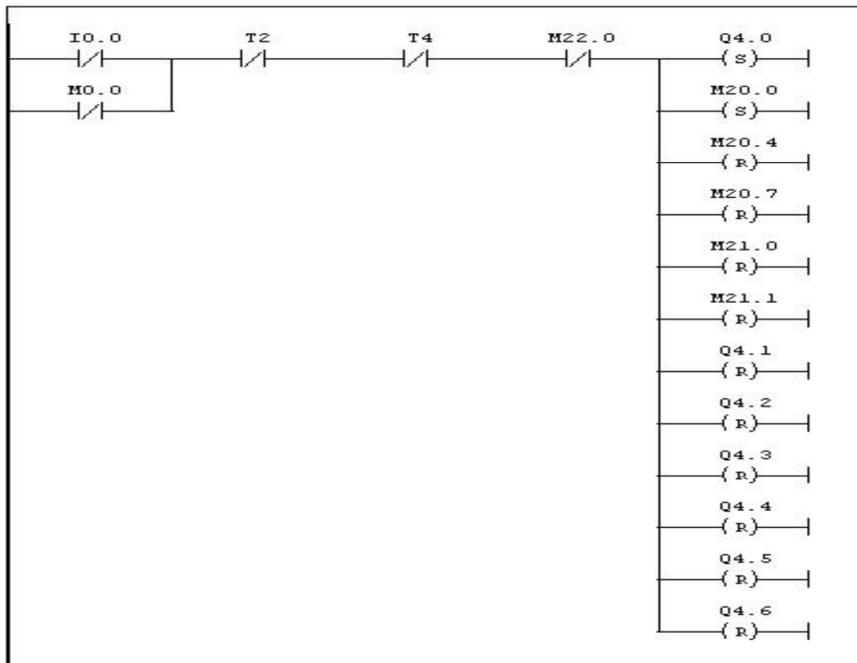
11.1 LADDER FOR TRAFFIC LIGHTS SYSTEM LEARNING MODULE

OB1 : "traffic light lad(Cycle)"

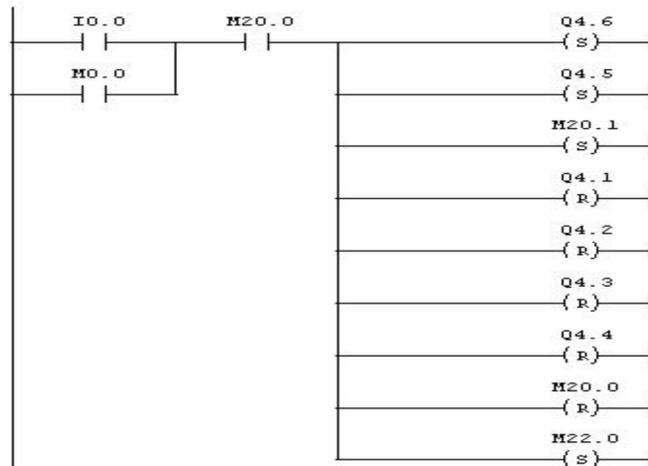
Comment:

Network 1: Inicialization

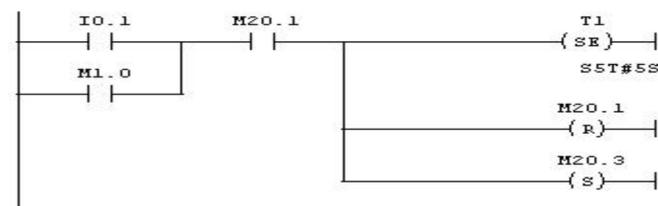
i0.0 - digital input 1 and m0.0 - equivalent of digital input 1 in supervisory



Network 2: Switching on the traffic lights

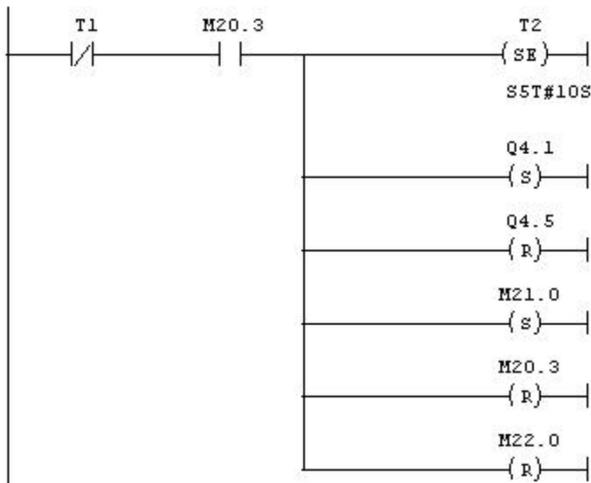


Network 3: car at J1



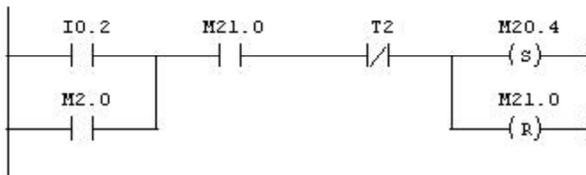
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Network 4 : green phase an J1



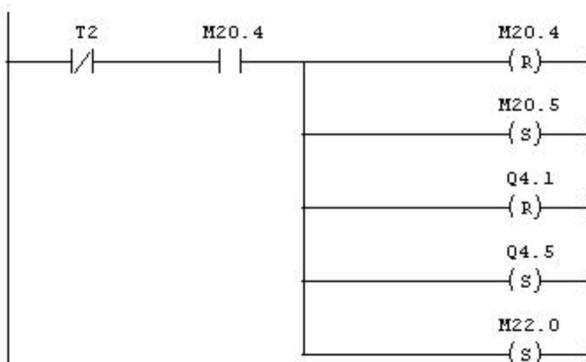
Network 5 : green at j1

if no car is at J2, J1 remains green



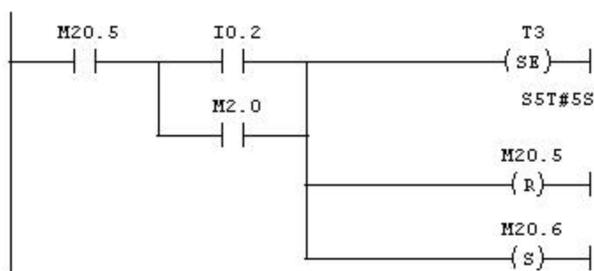
Network 6 : Title:

switch the traffic lights -> red



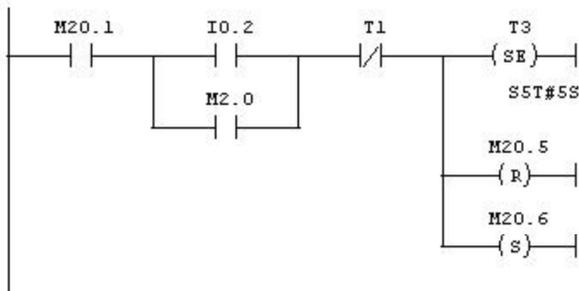
Network 7 : Car at J2

traffic light at J1 remains red

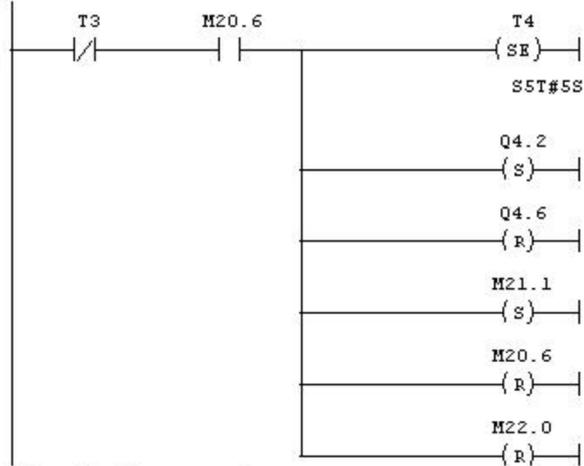


Network 8 : Title:

Car is coming to J2 -> j2 sends 1

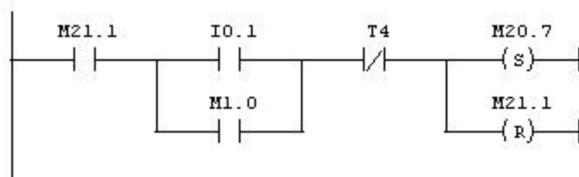


Network 9 : switch the traffic light -> green at J2



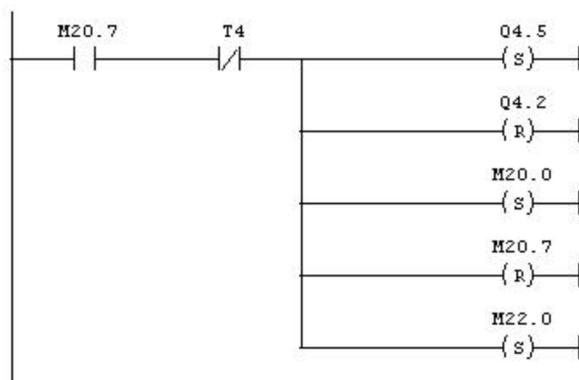
Network 10 : green phase

no car in J1



Network 11 : end

red light in both J1 and J2



11.2 WEIGHING BLOCKS IN SIMATIC S7

OB1 : "Main Program Sweep (Cycle)"

Kommentar:

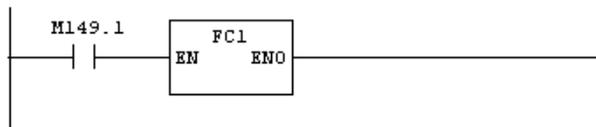
Netzwerk 1: Titel:

Kommentar:



Netzwerk 2: Titel:

Kommentar:



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FCL : OPER&TIONS

Kommentar:

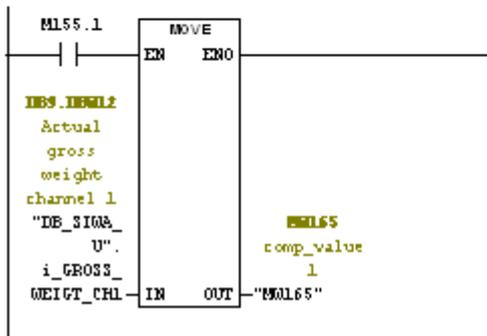
Netzwerk 1: Titel:

Read value for the sensor 1



Netzwerk 2 : Titel:

Read value for the sensor 1



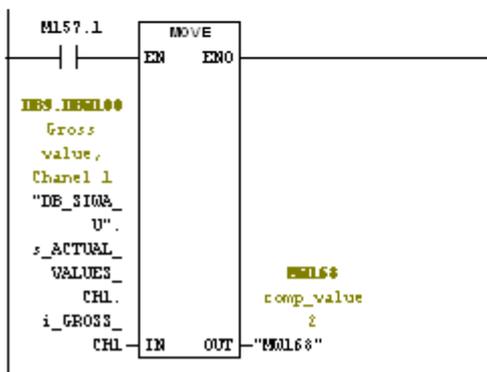
Netzwerk 3 : Titel:

Read the value for the sensor 2



Netzwerk 4 : Titel:

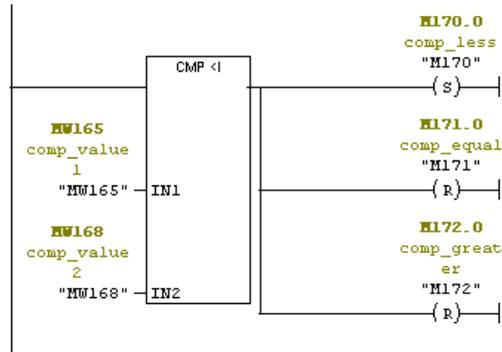
Read value for the sensor 2



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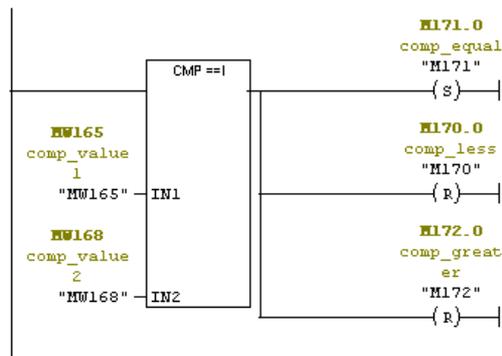
Netzwerk 5 : comp_less

MD1 less than MD2



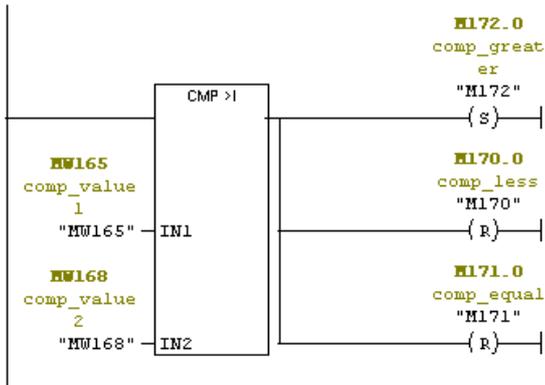
Netzwerk 6 : comp_equal

MD1 equal than MD2



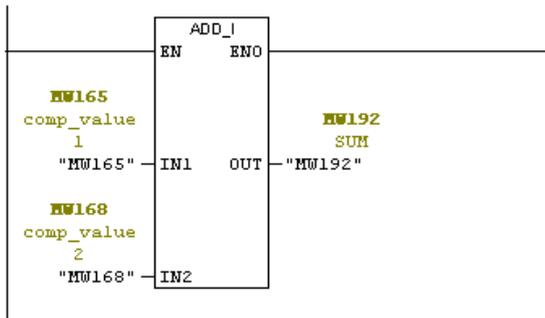
Netzwerk 7 : comp_greater

MD1 greates than MD2



Netzwerk 8 : Titel:

Sum mesure 1 + mesure 2



Netzwerk 9 : Titel:

Average

