IMPLEMENTATION OF CONTROL STRATEGIES ON CONTROL LOOPS FIELDBUS FOUNDATION PROTOCOL

By

Saiful Adib B. Abdul Munaff

3656

DISSERTATION REPORT

Submitted to the Electrical & Electronics Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

IMPLEMENTATION OF CONTROL STRATEGIES ON CONTROL LOOPS FIELDBUS FOUNDATION PROTOCOL

by

Saiful Adib B. Abdul Munaff
3656

A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfillment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(ELECTRICAL & ELECTRONICS ENGINEERING)

Approved by,

Dr. Nordin b. Saad,
Project Supervisor.

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

DECEMBER 2006

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Saiful Adib B. Abdul Munaff (3656)

ABSTRACT

The first process control systems used mechanical and pneumatic controllers. Ever since then, the process control sector has seen numerous developments; amongst them is the foundation fieldbus technology. Fieldbus has been around for sometime, but not until recently has it caught the attention of users and manufacturers alike. Fieldbus claims to require less hardware, have easy installation and commissioning, provide good data both in quality and quantity, need easy and simple maintenance and be interoperable with other devices. This project aims to prove those claims. A foundation fieldbus test platform will be designed and built. This test platform will include a simple control loop with fieldbus transmitters, gauges and control valves. A control strategy of cascade control and PID control will be used. Influenced by the safety system of a plant, the test platform is designed to emulate part of the fire water pump system. When there is a leak in the fire water pipes, the drop in pressure inside the pipes will trigger the system to pump in more water. The first part of this project will cover the research and design stages. Thorough research on the fieldbus technology, different control strategies and installation and commissioning is needed for the success of the second part of the project. Once the design has been finalized, and deemed feasible, the test platform will be built. Tests, troubleshooting and maintenance will follow. In the light of further improving this project, state-space mode can be used as an alternative control strategy. It should provide greater performance, increased stability and controllability. Fieldbus has the potential of being the best, with its extra features, such as diagnostics and predictive maintenance. Digital control is the thing of the future.

ACKNOWLEDGEMENT

Firstly, I would like to thank God for thou blessings. The author would like to express endless thanks to all who were involved in making this project a success. Sincere thanks to the author's supervisor, Dr. Nordin b. Saad, Lecturer, Electrical & Electronics Engineering Department, for his encouragement and endless support throughout the two semesters of this project. Many thanks to En. Azhar b. Zainal Abidin and Pn. Siti Hawa Mohd Tahir, EE Lab Technician, who had been very generous in sharing their thoughts and knowledge to ensure that this project was run efficiently. Not forgetting, my colleague, Haffizzull Rahman b. Md. Yusub, who lent a helping hand throughout this project. Special thanks to my family and friends who provided the morale support that got me through tough times. Thank you.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AI	Analogue Input
AO	Analogue Output
DCS	Distributed Control System
DDC	Direct Digital Control
FYP	Final Year Project
HMI	Human Machine Interface
I.S	Intrinsic Safe
I/O	Input/Output
LAN	Local Area Network
OLE	Object Linking and Embedding
OPC	OLE for Process Control
P&I	Piping and Instrumentation
PID	Proportional. Integral and Derivative
PLC	Programmable Logic Controller
RTD	Resistive Temperature Detector
SCADA	Supervisory Control And Data Acquisition

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND OF STUDY

In the 1940's, process instrumentation relied upon pressure signals of 3-15 psi for the monitoring of control devices. In the 1960's, the 4-20 mA analogue signal standard was introduced for instrumentation. Despite this standard, various signal levels were used to suit many instruments which were not designed to the standards specification. The development of digital processors in the 1970's sparked the use of computers to monitor and control a system of instruments from a central point. The specific nature of the tasks to be controlled called for instruments and control methods to be custom designed. In the 1980's smart sensors began to be developed and implemented in a digital control, microprocessor environment. This prompted the need to integrate the various types of digital instrumentation into field networks to optimise system performance. While the "if it works then use it" mentality progressed, it became obvious that a fieldbus standard was required to formalise the control of smart instruments.

The decision to provide an international standard saw the Instrument Society of America (ISA), the International Electrotechnical Commission (IEC), Profibus (German national standard) and FIP (French national standard), form the IEC/ISA SP50 Fieldbus committee. The standard to be developed must integrate the enormous range of control instruments, provide them with interfaces to operate various devices simultaneously, and set a communication protocol to support them all. This daunting task was perceived by many to be moving too slowly, a problem compounded by companies' world wide pushing to have their own product ideas standardised. With the diversity in products and methods of implementation, there was no one direct solution for the standard to be set to.

In 1992, two groups, each consisting of many major companies world wide, emerged to lead the market in a fieldbus solution. The ISP (Interoperable Systems Project) and WorldFIP (Factory Instrumentation Protocol) both share differing views on the implementation of fieldbus, but they claim they will alter their products to conform to the ISA's SP50 standard when it is formalised. In September of 1994, WorldFIP and ISP, joined forces to become Fieldbus Foundation (FF), in an effort to speed up the process of completing the fieldbus standard [1].

1.2 PROBLEM STATEMENT

For several years now companies world wide have been engaged in the testing of the evolving fieldbus standard through implementation in small areas of already operational plants. The aim of these companies is undoubtedly to test the suitability of fieldbus in their operating environments. This real life testing is the best way to examine the reliability of a fieldbus system, and to determine whether fieldbus will live up to the process industry's high expectations. Furthermore, most existing plants are setup with conventional and HART control systems. The jump to a full fieldbus plant will take time and a lot of money. Therefore it will most likely be done in stages, where it will run alongside both HART and conventional systems.

Similarly, this projects main aim is to test the suitability of fieldbus in various operating environments and in different plant setups. Coupled with the advancement in smart sensors and actuator technology, fieldbus is the link to a more versatile control system. The focus is to design, develop and configure and implement a simple single control loop, involving various field instruments, particularly on two control variables: pressure and level, that is to be controlled by a fieldbus system.

1.3 OBJECTIVE & SCOPE OF STUDY

This project aims to find answers on the flexibility and efficiency of the fieldbus system as well as its compatibility to work with older technology such as HART protocol or conventional control systems. Fieldbus is a growing technology in the process and oil &

gas industry. In this project, a typical process control loop with several control variables such as pressure and level will be controlled by a fieldbus network. This would provide a concise familiarization to the fieldbus system that would be used for improving the issues related to a fieldbus system.

In this project, we will take a look at a very basic single loop foundation fieldbus control system. A test skid will be designed and built to implement the control of pressure, and level. We will be using SMAR fieldbus transmitters and valves. We will also be doing a comparison between the fieldbus setup and the conventional setup.

CHAPTER 2
LITERATURE REVIEW

2.1 GOING DIGITAL

Not only are there advantages of going digital, there are also disadvantages of staying with analog. That is, by forgoing digital communication, not only do you miss many benefits, you retain problems and procrastinate the inevitable migration. These analog problems also apply if the hybrid "smart" protocols are used in place of a faster purely digital solution.

Most properties are measured digitally, processed digitally, stored digitally, displayed digitally, controlled digitally, and even actuated digitally - it does not make sense to transmit them analog. The analog domain can in most cases be completely eliminated - it is only a few sensors which are still analog. Though digital instruments were first introduced to enhance fidelity, they have already enabled many new schemes such as control in the field and firmware download. Even if you don't use these, there may be more to come because more useful innovations are sure to follow suit.

Measurements from digital sensors such as in pressure, level, and flow transmitters now have very high accuracy, as good as 0.04% [2]. The quantization error alone due to the digital-to-analog and analog-to-digital conversion required for 4-20 mA may be as large as 0.03% plus drift and differences in calibration in transmitter output and system input make a significant contribution to the total probable error of the measurement. Such an error, for example, translates into a large volume for level measurement in a big storage tank. The analog domain must be eliminated to ensure fidelity.

Many possible signal distortions that could occur on a 4-20 mA signal are not possible to detect and will go undetected until manually tested. If loop current is limited to say 17 mA due to increased loop resistance due to corrosion or becomes some other value due to a ground loop introduced by the signal wires getting in touch with a device, conduit, or junction box ground this cannot be detected. Many conceivable faults on a 4-20 mA signal just turn one signal into another valid value that gets accepted by the system. You cannot detect distortions on an analog signal. A system can't tell the difference between a distorted hardwired signal due to induced noise and a genuine process change.

Devices with microprocessors today provide pretty much the same diagnostics because they use the same sensor and transducer modules with the same auxiliary sensors regardless of protocol used or even when the signal is analog. The sensors and transducer modules are therefore designed for the worst case, that is, to operate from 4 mA. However, devices that has completely eliminated 4-20 mA have more current (10 mA or more) and therefore can run the same diagnostics much faster. The 4 mA limitations must be eliminated to provide faster diagnostics.

As seen with digital audio, telephony, photography etc. in the consumer industry, it is hard to imagine what marvelous innovations and possibility the future will bring, if you have the platform to use it. Since control systems typically remain in operation for ten to twenty years, putting in analog technology now, delays any possibility of adopting such new technologies as they become available. In the future as sales of pure fieldbus devices exceeds that of analog and smart hybrids, they will no longer be forced to use the same sensors and transducer modules. As it will no longer be necessary to operate on 4 mA, these transducers can have more auxiliary sensors used for better diagnostics and subsequent maintenance savings. More powerful processors enable math intensive algorithms such as FFT (Fast Fourier Transform), for example in analysis of noise and vibration of bearings etc. Analog is not possible for anything where the measurement is more than one single simple number, which limits future instrument possibilities such as sensors for hearing (sound bites) and vision (video clip) in remote applications.

Migrating from hardwire to bus is disruptive and therefore it is tempting to put off modernization to the future. However, by investing in analog, breaking the analog legacy later becomes even more difficult and costly. Using analog the plant will not be ready for future advancements.

Hybrid instrument protocols combining the 4-20 mA analog signal with slow digital communication, share the disadvantage of analog. Although hybrid instruments may have almost the same diagnostics as their pure digital counterparts, this may not be so for long as the pure digital devices are permitted to draw more current, which could soon be used in more powerful devices. Although hybrid instruments provide much the same information as their pure digital counterparts, hybrid solutions invariably have low speed digital communication which makes the retrieval much slower. Hybrid solutions must rely on analog for real-time process signal precisely because the digital is too slow. The slow hybrid solutions mean that these devices don't have features such as firmware download recently introduced in pure digital devices. Thus analog hybrids cannot benefit from easy upgrade of improvements in measurement compensation, diagnostics, and other capability.

2.2 WHAT IS FIELDBUS

Fieldbus is a generic-term which describes a new digital communications network which will be used in the industry to replace the existing 4 - 20mA analogue signals [3]. The network is a digital, bi-directional, multidrop, and serial-bus, communications network used to link isolated field devices, such as controllers, transducers, actuators and sensors. Each field device has low cost computing power installed in it, making each device a 'smart' device. Each device will be able to execute simple functions on its own such as diagnostic, control, and maintenance functions as well as providing bi-directional communication capabilities. With these devices, not only will the engineer be able to access the field devices, but they are also able to communicate with other field devices. In essence fieldbus will replace centralised control networks with distributed-control networks. Therefore fieldbus is much more than a replacement for the 4 - 20mA analogue standard. The fieldbus technology promises to improve quality, reduce costs and boost efficiency.

These promises made by the fieldbus technology are derived partly from the fact that information which a field device is required to transmit or receive can be transmitted digitally. This is a great deal more accurate than transmitting using analogue methods. Each field device is also a 'smart' device and can carry out its own control, maintenance and diagnostic functions. As a result it can report if there is a failure of the device or manual calibration is required. This increases the efficiency of the system and reduces the amount of maintenance required.

Each field device will be more flexible as they will have computing power. One fieldbus device could be used to replace a number of devices using the 4 - 20mA analogue standard. Other major cost savings from using fieldbus are due to wiring and installation - the existing 4 - 20mA analogue signal standard requires each device to have is own set of wires and its own connection point. Fieldbus eliminates this need so only a single twisted pair wiring scheme is required.

2.3 ADVANTAGES OF FIELDBUS

The fieldbus has a multitude of advantages that the end users will benefit from. The major advantage of the fieldbus and the one that is most attractive to the end user is its reduction in capital costs. The savings attained by the user stem from three main areas, initial savings, maintenance savings, and savings due to improved systems performance [6].

- Initial Savings

  One of the main features of the fieldbus is its significant reduction in wiring. Each process cell requires only one wire to be run to the main cable, with a varying number of cells available. The cost of installing field equipment in a fieldbus system is thus significantly reduced. Installation costs are further reduced due to the fact that the fieldbus is a multi-drop rather than point-to-point system and the multidrop network can offer a 5:1 reduction in field wiring expense. The price of equipment is reduced significantly in a fieldbus system, with savings of approximately RM 200 per field device possible. The fieldbus system requires less labour to install than conventional bus systems, and saves money due to a reduction in materials needed for the installation. The simpler system design implies that fewer system drawings will be needed in order to develop a fieldbus system. This also has the advantage that the simpler design will result in less complex and faster bus systems.

- Maintenance Savings

The fact that the fieldbus system is less complex than conventional bus systems implies that there will be less overall need for maintenance. The simplification of systems means that the long term reliability of the bus system is increased. With the fieldbus system, it is possible for the operators to easily see all of the devices included in the system and to also easily interpret the interaction between the individual devices. This will make discovering the source of any problems and carrying out maintenance much simpler, and thus will reduce the overall debugging time. The debugging and maintenance of the system will also be enhanced due to the fact that fieldbus enables online diagnostics to be carried out on individual field devices. The online diagnostics include functions such as open wire detection and predictive maintenance and simplify tasks such as device calibration.

- Improved Systems Performance

Fieldbus allows the user increased flexibility in the design of the bus system. Some algorithms and control procedures that with conventional bus systems must be contained in control programs can now reside in the individual field devices, reducing the overall size of the main control system. This reduces the overall systems cost and makes future expansion a simpler prospect. System performance is enhanced with the use of fieldbus technology due to the simplification of the collection of information from field devices. Measurement and device values will be available to all field and control devices in engineering units. This eliminates the need to convert raw data into the required units and will free the control system for other more important tasks. The reduction in information complication will allow the development of better and more effective process control systems. With fieldbus technology, two-way communication between field devices and the control system is made possible. System performance is enhanced due to the ability to communicate directly between two field devices rather than via the control system. This also enables several related field devices to be combined into one device. With fieldbus technology, field instruments can be calibrated, initialised, operated and repaired faster than most conventional analog instrumentation. This leads to an overall reduction in time required to operate the fieldbus system.

- Summary of advantages
    - Reduced need for equipment such as cabinets, cables, etc
    - Reduced maintenance due to fewer equipments
    - Precision process control due to its digital nature
    - Unlimited data for record keeping and troubleshooting
    - Unlimited documentation
    - Early detection of potential equipment failure
    - Eliminates unnecessary replacement of equipment during turnarounds.
    - Knowledge increase on the part of the operators and instrumentation technicians
    - Improved closed loop control performance by configuring control in the field
    - Reduced number of controllers by configuring control in the field
    - Reduced engineering cost of wiring line diagrams
    - Reduced cost of field wiring installation since field instruments identify themselves and do not need point-to-point ring-out
    - Closed loops can be configured with measurements and controllers not in the same wiring segment or even wired to the same controller by using Foundation Fieldbus HSE
    - Costly DCS controllers can be replaced with less expensive industrial PCs when control loops are configured in field devices

2.4 DISADVANTAGES OF FIELDBUS

Every new technology or new product comes with drawbacks. Foundation Fieldbus is no different.

The primary disadvantage of using Foundation Fieldbus is the higher initial cost of the field instruments over HART or analog. There is also the initial steep learning curve to transition from traditional analog with control in a DCS to field control with Foundation Fieldbus. Field control can dramatically reduce the number of controllers required for a DCS, but this is difficult to accept for a first installation. Many users are now on their second to more systems, have experienced the stability of field control, and are now specifying their DCS with many fewer controllers. Field control is capable of replacing 80 to 90 percent of the controls formerly done in the shared controllers of the DCS. The reduction in wiring cost and the reduced cost of the DCS far more than compensates for the higher initial cost of the field instruments.

Network reliability: Yes, someone can cut the cable. If an H1 segment cable is cut, you lose one loop of control and a few other measurements on that segment, if you designed the system for single loop integrity. In most processes, this has been broadly accepted as a "reliable system." You can also cut an analog cable to a field transmitter, and shut down one control loop. This is why a redundancy specification was not included for H1 in the fieldbus standard.

Cutting an HSE cable could shut down many control loops, but HSE has an excellent redundancy specification. Redundant HSE cables should be run on different paths to avoid a single event from severing more than one path. You can also use alternative technologies such as copper cable/fiber optics/wireless to gain path diversity with HSE.

CHAPTER 3
METHODOLOGY

This project aims to build a Foundation Fieldbus test rig which requires extensive research and detailed designing. The project flow is as follows.

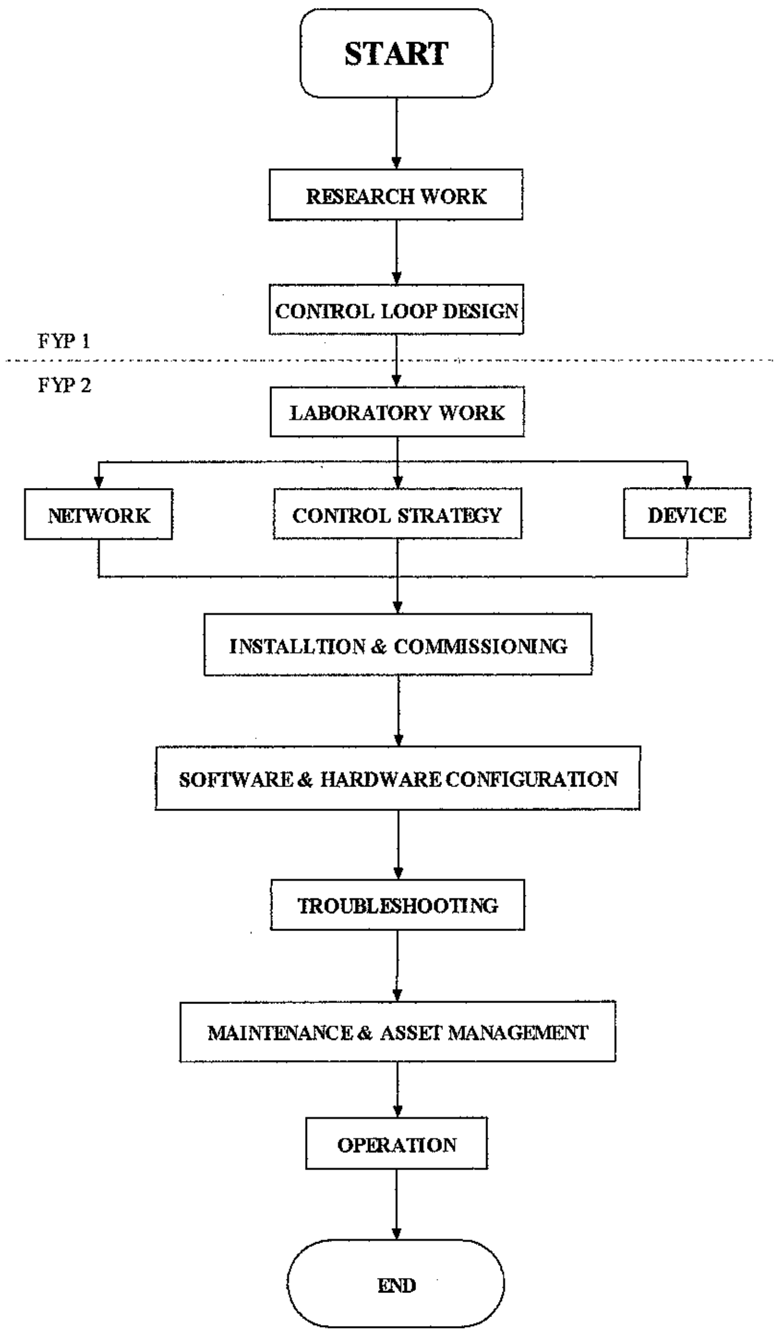


Figure 1 Project work flow

Every successful project begins with good research. The internet, books, journals and papers are the most common research tools. Having done the industrial training with PETRONAS Carigali Sdn. Bhd. The author obtained valuable information on fieldbus from major vendors such as Emerson, Yokogawa and Honeywell. The research covers the fundamentals of fieldbus right down to different control strategies and its implementation. Necessary information on fieldbus instrumentation, its configuration and commissioning has been obtained.

A suitable control loop using cascade control and PID control has been designed using various fieldbus transmitters. This design will be implemented on a skid that will be built in the 2nd part of this project.

Once the Fieldbus test platform has been built, the installation, commissioning and configuration of the fieldbus devices will commence. Prior to installing any device, it is necessary to read the manual and understand all precautionary measures. This will avoid any mishaps during installation. Tests, troubleshooting and maintenance will be carried out if necessary.

3.1 TOOLS & SOFTWARES

All the equipment is available at the Process and Instrumentation Lab, UTP. The Foundation Fieldbus devices are from the SMAR Foundation Series 302. In total there are 5 Foundation Fieldbus devices:

- Pressure transmitter
- Control valve with positioner
- Flow transmitter
- Temperature transmitter
- 4-20 mA converter

For this project, the following tools and software's will be used:

- Host device (PC)
- Fieldbus measurement and control devices
- Power supplies
- Terminators
- Cat5 LAN cable
- Fieldbus bridges and repeaters (optional)
- Configuration and Windows operating software

3.1.1 Host Device

The host device, usually a computer, is the main control centre for the whole system. It is here where the management, monitoring, controlling and maintenance of the control system are carried out. A 2-way connection between the host system and the field devices enables information to be passed from the host to the devices and vice versa.

3.1.2 Wiring Cable

A Foundation Fieldbus system uses a shielded twisted-pair cable to reduce the interference from external noise.

3.1.3 Network Switch

The network switch's function is to connect multiple devices together to form a LAN network. The switch will automatically assign an ip number to the devices connected to it. This ip number serves as the unique address for that device. If any other device wants to contact another device, it has to know the ip address of that device, in order to establish a connection and trade information. The network switch has multiple ports that allow multiple devices to communicate among themselves simultaneously.

3.1.4 Fieldbus Universal Bridge (DFI-302)

The DFI-302 is a single integrated unit with functions of interfacing, linking device, bridge, controller, power supply and distributed I/O system. The DFI-302 includes:

Series	Description	Specification
DF01	Rack with 4 slots	Backplane
DF02	Terminator	End terminator for the last rack
DF50	Power supply for backplane	Input: 90-264 VAC. Output: 5VDC (backplane power supply) 24VDC (external use)
DF51	DFI-302 processor module	1 X 10Mbps Ethernet and 4 X fieldbus H1 channels at 32.25Kbps
DF52	Power supply for fieldbus	Input: 90-264 VAC. Output: 24VDC
DF53	Power supply impedance for fieldbus (4 ports)	To ensure no short circuit occurs between the power supply and the communication signal on the fieldbus.

Table 1 Components of FF Universal Bridge

3.1.5 Fieldbus Field Devices

The devices used in the fieldbus test rig include:

3.1.5.1 Fieldbus Control Valve with Positioner (FY-302)

The FY-302 produces a pressure output required to position a control valve according to an input received over the fieldbus network or from the internal controller.

3.1.5.2 Fieldbus Pressure Transmitter (LD-302)

This pressure transmitter can be used as a differential pressure, absolute pressure or gauge pressure transmitter for flow, level and pressure measurements. It utilizes a capacitive sensor as the sensing element. These capacitive cells provide high reliability under strenuous conditions and work well with liquid, gas or vapor process materials.

3.1.5.3 Terminator (BT-302)

A terminator which has two terminals is polarity insensitive. It is needed at both ends of a fieldbus network segment. Its function is:

- **To prevent signal reflection**: a communication signal bounces back when it reaches the end of the wire, potentially distorting itself. The terminator prevents this phenomenon.
- **Signal current shunt**: a device transmits by rapidly changing the current in the network, either by changing its power consumption or injecting a current. The terminator converts the current change produced by a transmitting device into a voltage change across the entire network. This is picked up by all the devices as means of receiving a signal.

3.1.6 System Configurator (SYSCON)

The SYSCON software was developed for the SMAR Foundation Fieldbus product line. A Personal Computer equipped with this software is able to configure, maintain and operate any SMAR Fieldbus devices through a fieldbus interface. This software also provides a user-friendly Human Machine Interface that is easy, even for beginners. It runs native on the Microsoft Windows NT Operating System Version 4.0 or later, or Windows 2000. Through this software, we are able to gather data from the devices, manipulate it and send back the necessary instructions.

3.1.7 ICONICS GraphWorX32

This software is an Object Linking and Embedding (OLE) for Process Control (OPC) for the HMI and SCADA based clients [7]. OLE is a compound document standard developed by Microsoft Corporation that enables object created with one application and then linking or embedding it into another application. OPC is a standard approach for connecting controllers and I/O devices with HMI clients. Graphical interfaces and trending graphs can be used to view the data in a more meaningful way.

Two ICONICS applications will be used in this project; GraphWorX32 and ControlWorX32. GraphWorX32 is used to create animated graphics for control displays on the host PC. ControlWorX32 is a control application that controls the plant.

CHAPTER 4
SYSTEM DESIGN

Control strategies play a major part in obtaining a good performance form the process. There are many different types of control strategies. Among them, PID control, Cascade control and ratio control. Different strategies will produce different results depending on the desired outcome. Based on the skid setup and the desired output, cascade control is the best control strategy.

4.1 PID CONTROL

PID controllers are process controllers with the following characteristics:

- Continuous process control
- Analog input (also known as "measurement" or "Process Variable" or "PV")
- Analog output (referred to simply as "output")
- Setpoint (SP)
- Proportional (P), Integral (I), and / or Derivative (D) constants

Examples of "continuous process control" are temperature, pressure, flow, and level control. For example, controlling the heating of a tank. For a simple control, there will be two temperature limit sensors (one low and one high). When the low temperature limit sensor is triggered, the heater will be turned on. And when the high temperature limit sensor is triggered, the heater will be turned off. This is very much similar to the operation of a basic home air conditioning system or a thermostat.

In contrast, a PID controller would receive as input, the actual temperature and control a valve that regulates the flow of gas to the heater. The PID controller automatically finds the correct (constant) flow of gas to the heater that keeps the temperature steady at the set point. Instead of the temperature bouncing back and forth between two points, the temperature is held steady. If the set point is lowered, then the PID controller automatically reduces the amount of gas flowing to the heater. If the set point is raised, then the PID controller automatically increases the amount of gas flowing to the heater. Likewise the PID controller would automatically compensate for hot, sunny days (when it is hotter outside the heater) and for cold, cloudy days.

The analog input (measurement) is called the "process variable" or "PV". The PV has to be a highly accurate indication of the process parameter that is being controlled. For example, if the temperature is to be maintained at + or - one degree then it is typical to strive for at least ten times that or one-tenth of a degree. If the analog input is a 12 bit analog input and the temperature range for the sensor is 0 to 400 degrees then the "theoretical" accuracy is calculated to be 400 degrees divided by 4,096 (12 bits) = 0.09765625 degrees. "Theoretical" means that it would assume there was no noise and error in the temperature sensor, wiring, and analog converter (basically an ideal scenario). There are other assumptions such as linearity, where with 1/10 of a degree "theoretical" accuracy, achieving 1 degree of accuracy shouldn't pose a problem even with the usual amount of noise and other problems.

The analog output is often simply referred to as "output". Often this is given as 0 to 100 percent. In the heating example, 0% means that the valve is totally closed and 100% means that the valve is totally open. The set point (SP) is simply the desired process value. In this example, the set point is the process temperature that we want.

The PID controller's job is to maintain the output at a level so that there is no difference (error) between the process variable (PV) and the set point (SP) [4].

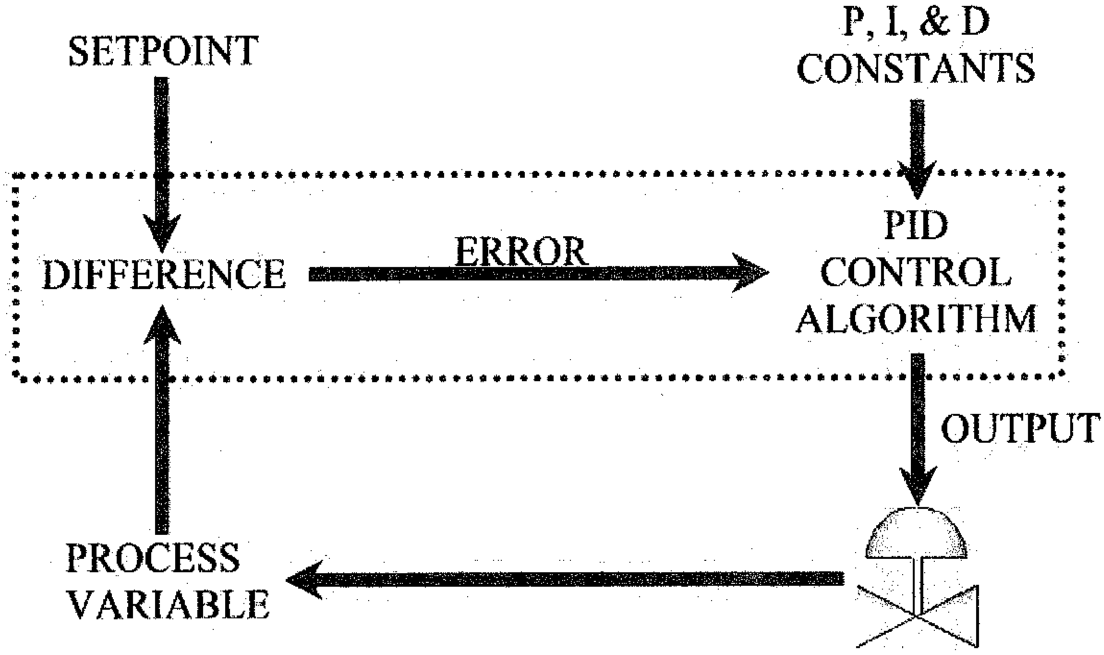


Figure 2 PID control

Referring to figure 2, the valve could be controlling the gas going to a heater, the chilling of a cooler, the pressure in a pipe, the flow through a pipe, the level in a tank, or any other process control system.

PID controllers look at the difference (or "error") between the PV and the SP. It looks at the absolute error and the rate of change of error. Absolute error indicates the total amount of error between the PV and SP. Rate of change of error indicates whether or not the error is getting larger or smaller with time.

When there is a "disturbance", meaning, when the process variable OR the set point quickly changes, the PID controller has to quickly change the output to get the process variable back equal to the set point. For example, a walk-in cooler with a PID controller; when someone opens the door and walks in, the temperature (process variable) could rise very quickly. Therefore the PID controller has to increase the cooling (output) to compensate for this rise in temperature.

Once the PID controller has the process variable equal to the set point, a good PID controller will not vary the output. The output needs to be very steady (not changing). If the valve (motor or other control element) is constantly changing, instead of maintaining a constant value, this would result in wear on the control element.

Therefore there are these two contradictory goals. Fast response (fast change in output) when there is a "disturbance", but slow response (steady output) when the PV is close to the set point.

Note that the output often goes past (over shoots) the steady-state output to get the process back to the set point. For example, a cooler may normally have it's cooling valve open 34% to maintain zero degrees (after the cooler has been closed up and the temperature settled down). If someone opens the cooler, walks in, walks around to find something, then walks back out, and then closes the cooler door, the temperature sensor indicates that the temperature has risen by 20 degrees. So the PID controller will crank the cooling valve open to 50, 75, or even 100 percent, to hurry up and cool the cooler back down, before slowly closing the cooling valve back down to 34 percent.

4.2 CASCADE CONTROL

Cascade Control uses the output of the primary controller to manipulate the set point of the secondary controller as if it were the final control element.

Reasons for cascade control:

- Allow faster secondary controller to handle disturbances in the secondary loop.
- Allow secondary controller to handle non-linear valve and other final control element problems.
- Allow operator to directly control secondary loop during certain modes of operation (such as startup)

Requirements for cascade control:

- Secondary loop process dynamics must be at least four times as fast as primary loop process dynamics.
- Secondary loop must have influence over the primary loop.
- Secondary loop must be measured and controllable

Reasons not to use cascade:

- Cost of measurement of secondary variable (assuming it is not measured for other reasons).
- Additional complexity.

Example of cascade control:

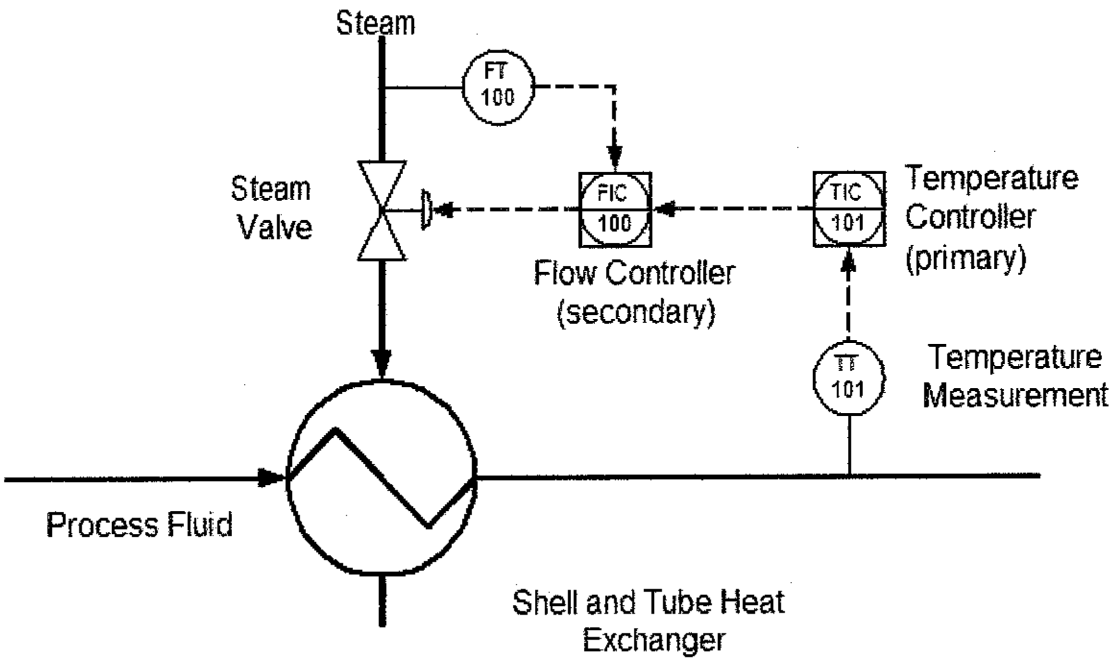


Figure 3 Cascade control

The diagram above shows the control of the heat exchanger outlet temperature using steam flow as the secondary loop.

In most applications, the control loop is not functioning as a cascade loop all the time. The operator (in the case of batch control, the batch control program) has the ability to change modes. Following is the typical selection of modes of operation available for a cascade control loop. Manual and Auto are usually used during startup while cascade is used for normal operation.

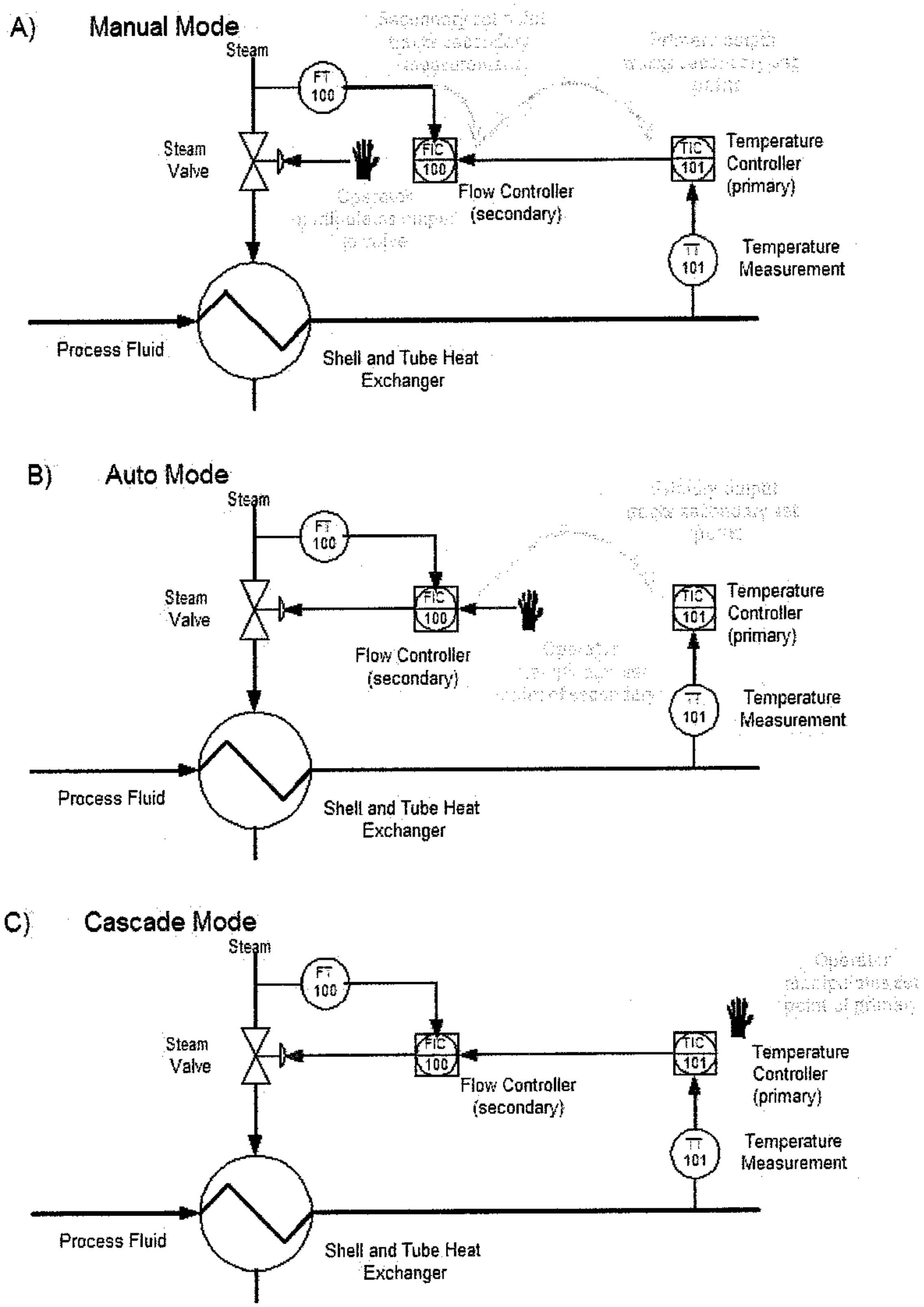


Figure 4 Cascade control modes

Tracking or 'bump less transfer' refers to the smooth transition when switching between modes. This is to ensure that there is no sudden change when switching. In manual mode, the set point of the flow controller tracks the actual flow variable. In auto mode, the output of the temperature controller tracks the setpoint of the flow controller. In cascade mode, the temperature controller manipulates the setpoint of the flow controller.

There is also a scenario called windup. If the secondary controller cannot deliver enough flow, even with its valve is wide open, to bring the primary measured variable to its set point, the primary controller will "windup" and continue to increase the flow set point above the maximum flow. Later, when the flow is sufficient to bring the primary measurement to its set point, the primary controller must take the time to "wind down" the secondary set point to the actual flow before the valve begins to close. To overcome this phenomenon, an external feedback is used to limit the windup by connecting the secondary measurement to the external feedback of the primary, as in the diagram below.

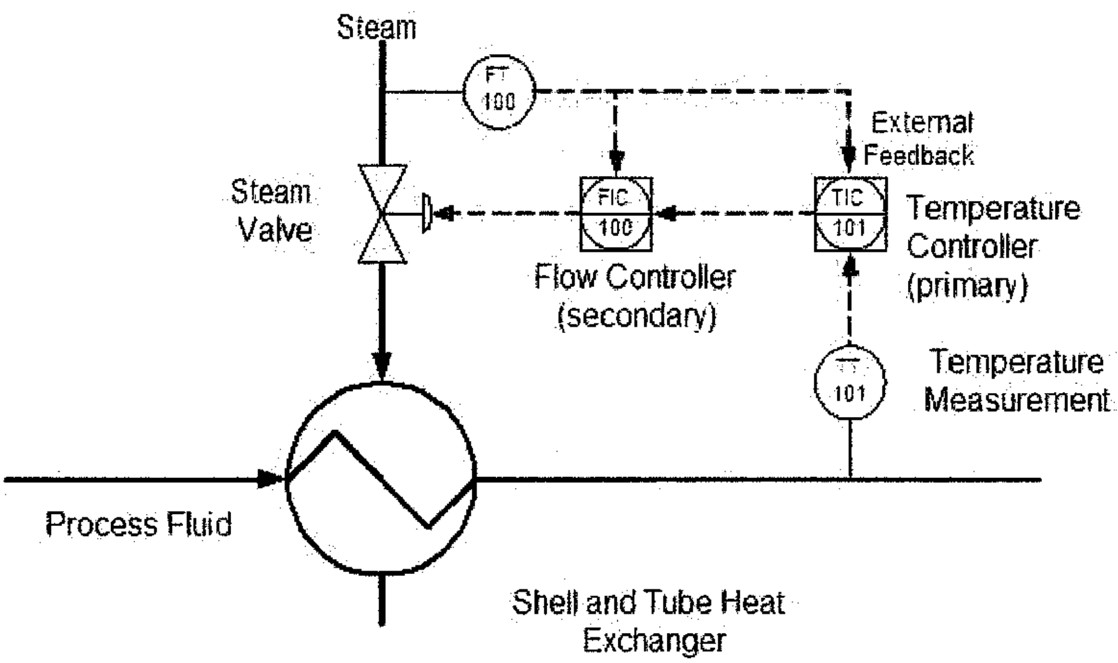


Figure 5 Overcome windup in cascade control

4.3 RATIO CONTROL

Ratio control is used to ensure that two or more flows are kept at the same ratio even if the flows are changing.

Applications of ratio control:

- Blending two or more flows to produce a mixture with specified composition.
- Blending two or more flows to produce a mixture with specified physical properties.
- Maintaining correct air and fuel mixture to combustion.

Example of Ratio control:

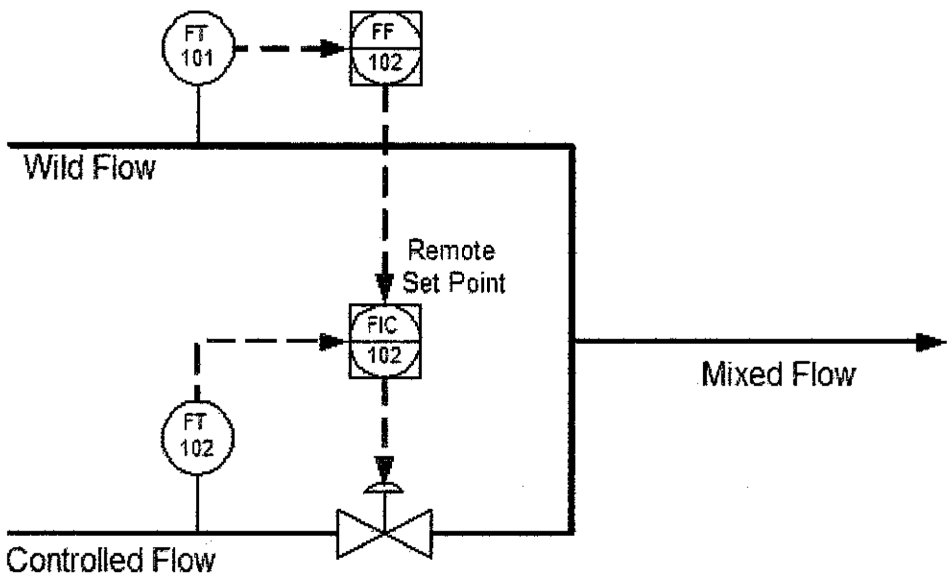


Figure 6 Ratio control

The controlled flow (FIC-102) is increased and decreased to keep it at the correct ratio with the wild flow. The "wild flow" (FT-101) is the flow not controlled by this loop. It may be controlled by some other control loop. The "controlled flow" is controlled by this loop with a set point equal to the measured wild flow multiplied by some value (FF-102).

The measured wild flow is multiplied by a value that may be fixed or may be adjustable by the operator. The result of the multiplication becomes the set point of the controlled flow controller [5].

The options, such as tracking, that apply to cascade control also apply to ratio control. The controlled flow controller is a "secondary loop" in a cascade pair with the wild flow measurement and ratio multiplication.

4.4 SKID DESIGN

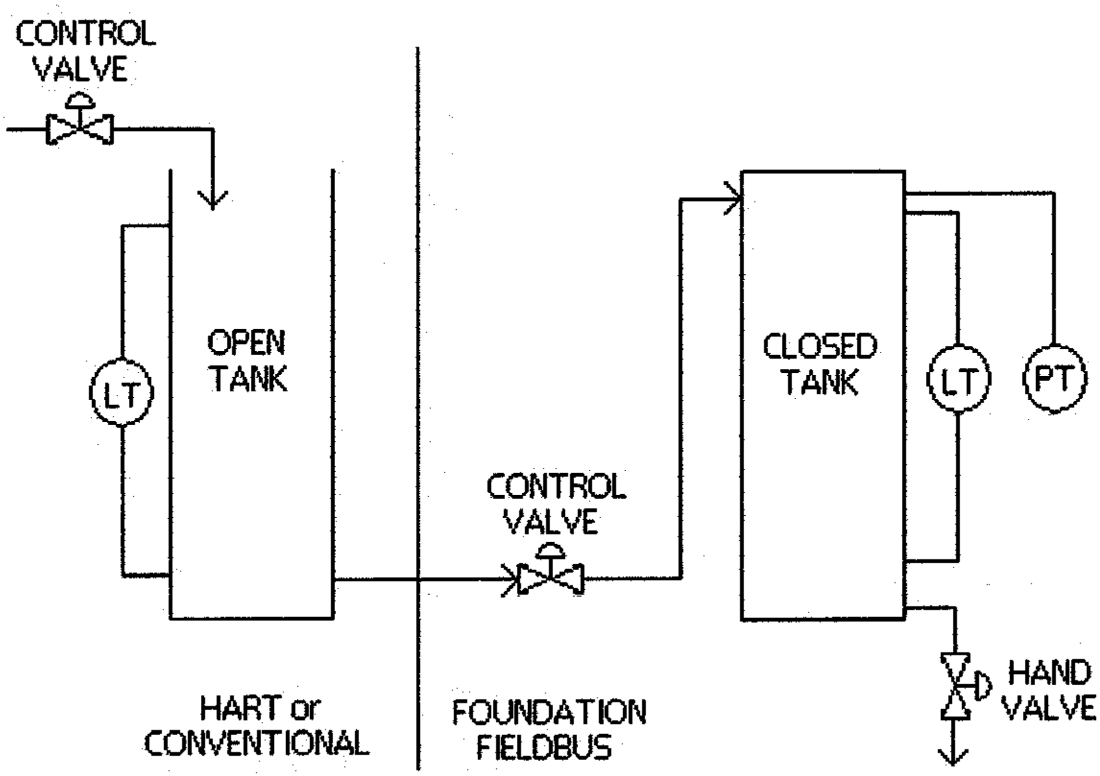


Figure 7 Fieldbus test platform design

4.5 FIREWATER PUMP SYSTEM

The design of this skid was influenced by the safety system of a plant. On every plant, there is a fire water pump system. Fire water is used to put out fires in a plant complex. The fire water safety system consists of pumps, water tanks, valves, transmitters, pipes as well as a control station. The fire water pipes run across the whole complex, covering all areas while forming a closed loop. These pipes are constantly filled with water at a certain pressure. The pressure is maintained by 2 pumps. Therefore the fire water pump system has the task of maintaining the amount of water in the pipes and its pressure.

Two conditions would trigger the fire water pump system; a drop in pressure in the pipes and an increase in the water discharge flow rate. These two conditions point towards a leakage or a burst pipe. This is how the system works:

If there is a leakage in the pipes, the pressure drop will be sensed by the pressure sensors placed around the pipes. If the pressure drops below the minimum allowable value, another pump will be triggered. This pump will try to boost up the pressure to a safe value until the problem is resolved. If for any reason, the problem is not resolved, the leak can turn into a crack and water can discharge. If the water discharge flow rate is greater than the allowable value, another pump is triggered. This pump will try equal the water discharge flow rate by increasing the water input flow rate, so that the difference between the two flows is minimal (or zero).

This project adopts the pressure drop scenario. Referring to figure 7, vessel 2 is a closed vessel. When it is filled with water, to about 80% full, there will be a certain pressure in the vessel. This pressure reading is picked up by the foundation fieldbus pressure transmitter. The hand valve positioned at the bottom of vessel 2 is used to simulate a leakage. When the hand valve is opened a little (leakage occurs), pressure inside the vessel will drop. This will trigger the pump to pump in more water into the vessel to increase the pressure to its desired set point.

To slightly expand the reach of the project a little, the open tank is setup with conventional 4-20 mA devices and the closed tank is setup with Foundation Fieldbus devices. This enables us to make a comparison between Foundation Fieldbus and 4-20 mA devices.

4.6 FOUNDATION FIELDBUS vs. 4-20 mA

	Foundation Fieldbus	**4-20 mA**
Physical Attributes (of devices)	Similar with other devices	Similar with other devices
Internal Components	Low power microprocessor to perform simple calculations, control, and provide diagnostics	Only A/D and D/A converters to convert signal from digital to analogue and vice versa
Installation of Devices	Similar with other devices	Similar with other devices
Connection of Devices	Digital, multidrop, serial bus, 2-way communication link	Analogue, point-to-point, 1-way communication link
Information from Devices	Wealth of information ranging from device manufacturer and firmware version to a 2nd process variable and alarm and trending support.	Only provides process value information.
Expansion of System	Easily expandable with repeaters and Foundation Fieldbus terminators.	Expansion will require a whole new change in wiring, that involves a lot cost

Table 2 Comparison between FF and Analogue

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Foundation fieldbus is an all-digital, serial, two-way communications system that serves as the base-level network in a plant or factory automation environment. It's targeted for applications using basic and advanced regulatory control, and for much of the discrete control associated with those functions. Fieldbus technology is already changing the way systems perform control. It won't be long before it is widely used in advanced process control. Some users have opted to setup pilot fieldbus units, whereas others have gone for a full scale fieldbus plant. It has been stipulated that the fieldbus technology has gained credibility over the DCS system in terms of hardware installation and commissioning, communication speed, data quantity and quality, maintenance and device interoperability.

The study and implementation of a fieldbus network through designing and building a test skid is an intriguing prospect. Only through a project like this are we able to truly see the benefits of fieldbus technology in improving the performances of plant process control.

5.2 FUTURE WORK

After a careful consideration of the options, this project can be expanded in 2 different directions. The 1st would be to implement Foundation Fieldbus in a much larger scale, involving at least 10 FF devices. Only by implementing FF in a large scale, can we really see the advantages and the benefits. The 2nd option would be to conduct an interoperability test. As many vendors have come up with FF devices and their own control system, end users want these various devices to work with each other. An interoperability test would determine whether a vendor A device would work with a vendor B control system as easily and as efficiently as would a vendor B device.

REFERENCES

[1] http://www.fieldbus.org

[2] http://en.wikipedia.org/wiki/Fieldbus_Foundation

[3] Fieldbus Tutorial, A Foundation™ Fieldbus Technology Overview, http://www.smar.com

[4] The PID Control Algorithm: How it works and how to tune it, Process Control Solutions, John Shaw, http://www.jashaw.com/pidbook/

[5] http://learncontrol.com/pid/cascade.html

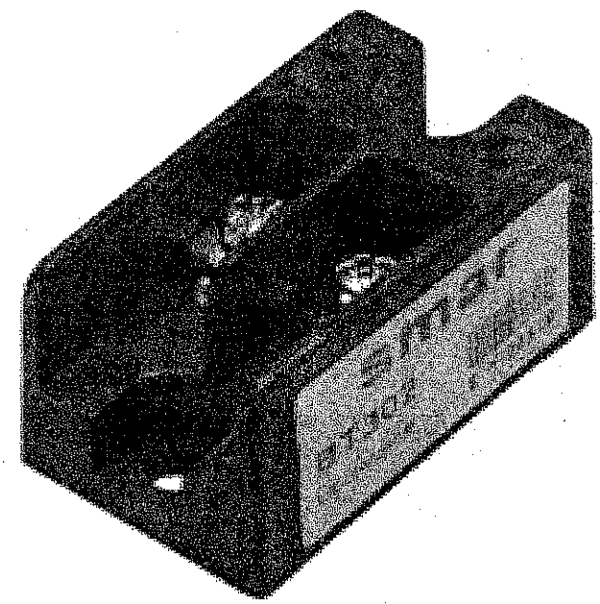
[6] Fieldbus Foundation End User Seminar CD, Holiday Villa, Subang Jaya, August 17, 2005

[7] Design, configuration and implementation of fieldbus system for controlling of a process plant, Dissertation report, Norfadzrina bt. Wahid, UTP, 2005

APPENDIX

INSTRUCTIONS AND INSTALLATION MANUAL

FIELDBUS TERMINATOR



FIRST IN FIELDBUS

I / 02
T302
RSION 1

NDATION

BT302ME

TALLATION

The **BT302** device may be panel mounted or installed in distribution boxes. In order to fix it with screws, the product is supplied with a label (drilling template) showing the markings of the holes. Figure 1 shows the hook-up scheme using the drilling template, and Figure 2 and Figure 5 shows the field installation in a distribution box.

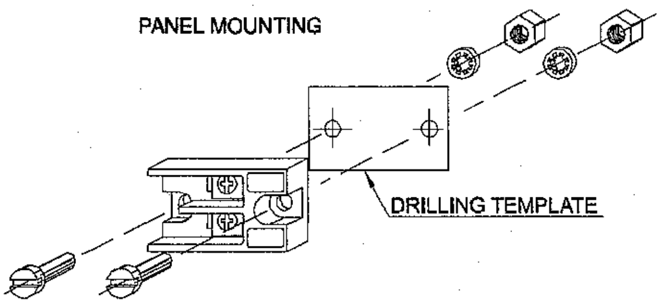


Fig. 1 – FIELDBUS FOUNDATION - BT302 - Mounting

A fieldbus network needs two terminators, one in each end of the main trunk. Therefore, if a terminator is already built in to the Fieldbus power supply or power supply impedance, such as **SMAR PSI302,** only one **BT302** is required as Figure 3 indicates or when the field devices are connected to DP/PA link or coupler devices as you can see in the Figure 4.

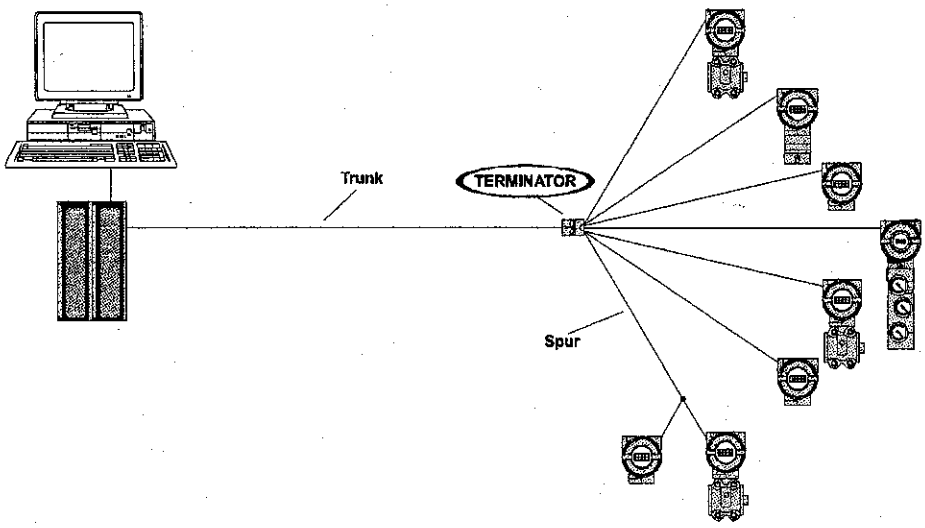


Fig. 2 – FIELDBUS FOUNDATION - Tree Topology

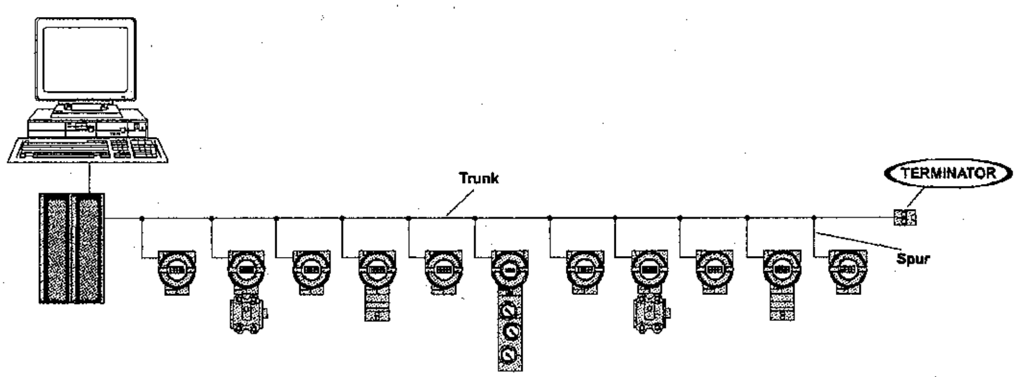


Fig. 3 – FIELDBUS FOUNDATION - Bus Topology

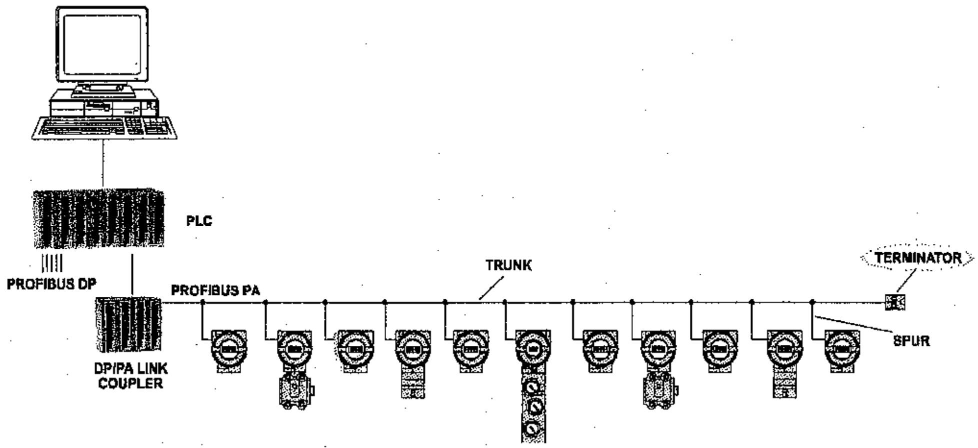


Fig. 4 – PROFIBUS PA – Bus Topology

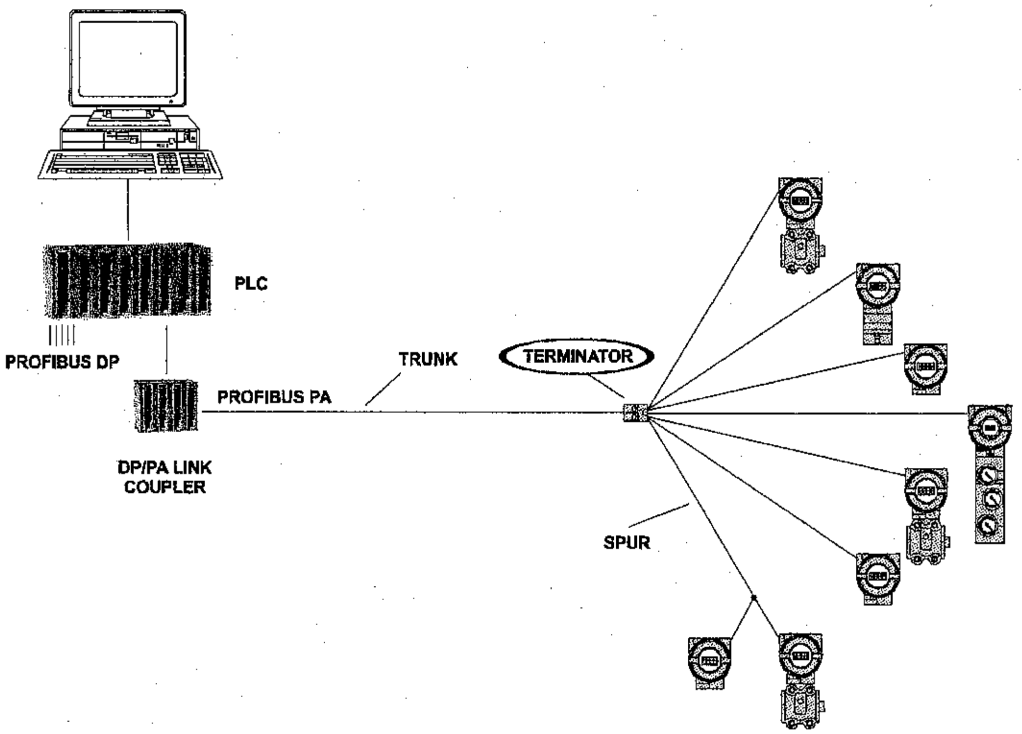


Fig. 5 – PROFIBUS PA – Tree Topology

CHNICAL DATA

Electrical Characteristics:
Maximum Operational Voltage: 35 Vdc
Input Impedance: 100 Ω ∀ 2% @ 7.8 KHz – 39kHz

Mechanical Characteristics:
Size (W H D H H): 19 H 23 H 40 mm
Weight: 20g

Environmental Characteristics:
Operation: $T_{AMB.}$ -40E C to 75E C @ RH 10% to 95%, without condensation
Storage: TAMB. -55E C to 85E C @ RH 5% to 95%, without condensation

Safety Characteristics:
Intrinsic Safety: FM, CSA, NEMKO and CEPEL

ORDERING CODE	DESCRIPTION
BT302	Terminator

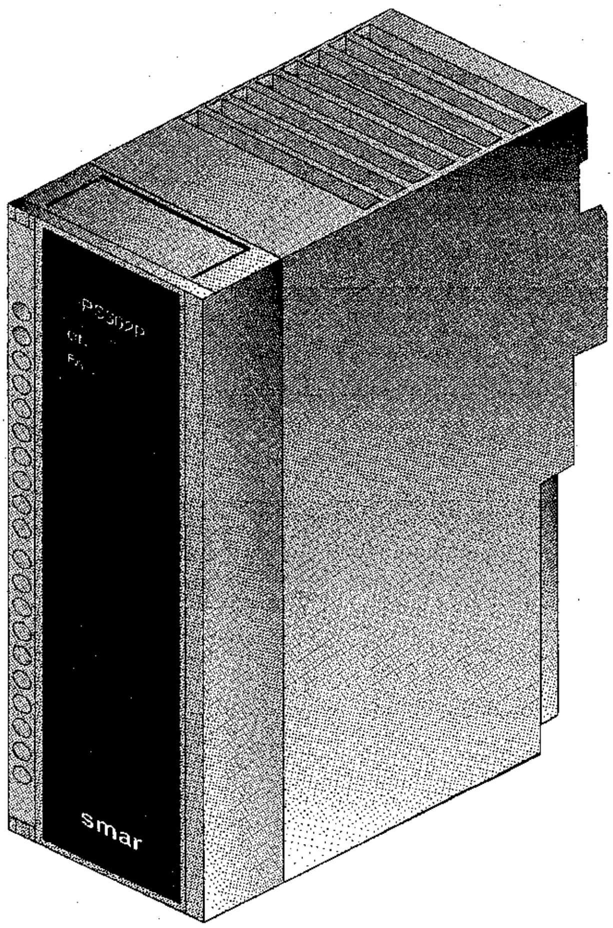
INSTALLATION MANUAL

PS302P

smar

FIRST IN FIELDBUS

FIELDBUS POWER SUPPLY



JUL / 02

S302P

'ERSION 1

FOUNDATION

PS302PME

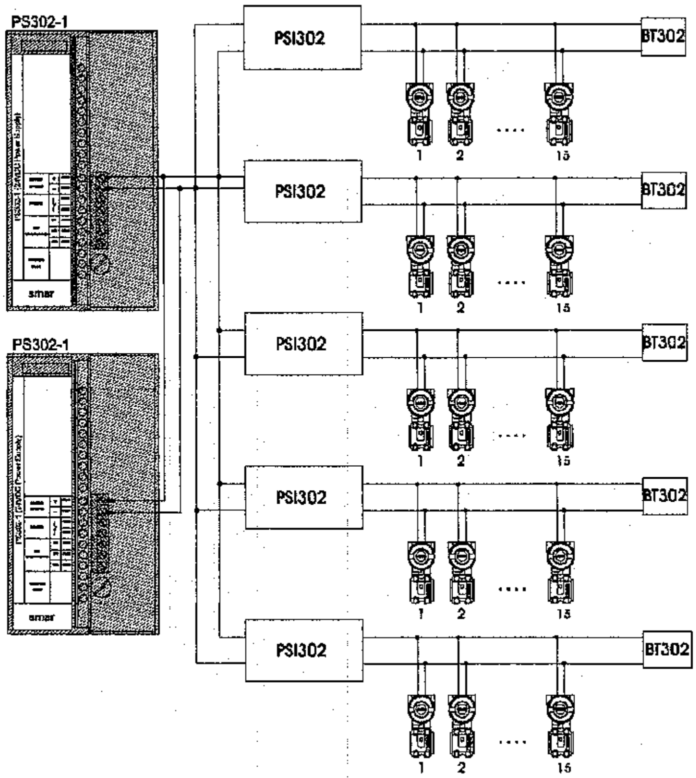


Fig. 1 – Connection Diagram of Fieldbus Elements to PS302-1

CTRICAL CONNECTIONS

There are 3 terminals of input (7B, 6B and 5B) in the **PS302-1,** may be connected NEUTRAL/PHASE or PHASE/PHASE and the enclosure ground, 2 terminals (3B and 4B) are connected to a contact to activate an alarm in case of power failure and output short-circuit or overcurrent and 2 terminals of output 24 Vdc (1B e 2B).

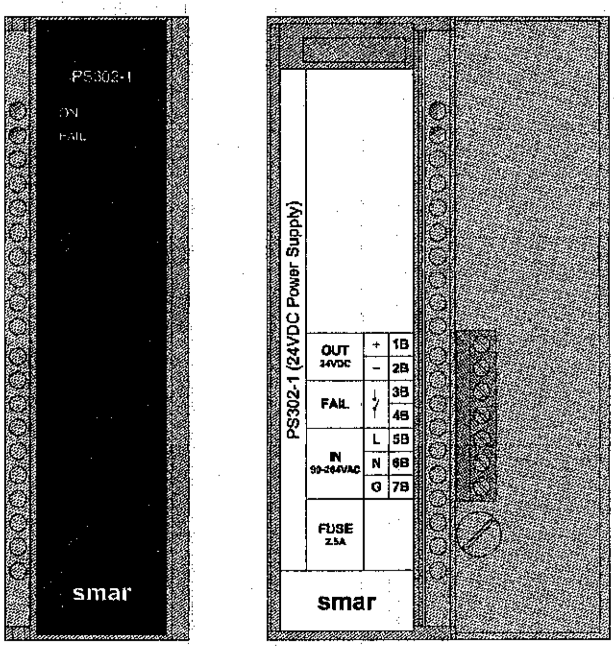


Fig. 2 – Terminal Blocks

'ALLATION

It can be fixed, the **PS302-1** through the rack or for the auxiliary support (optional) (Fig. 3) with the device:

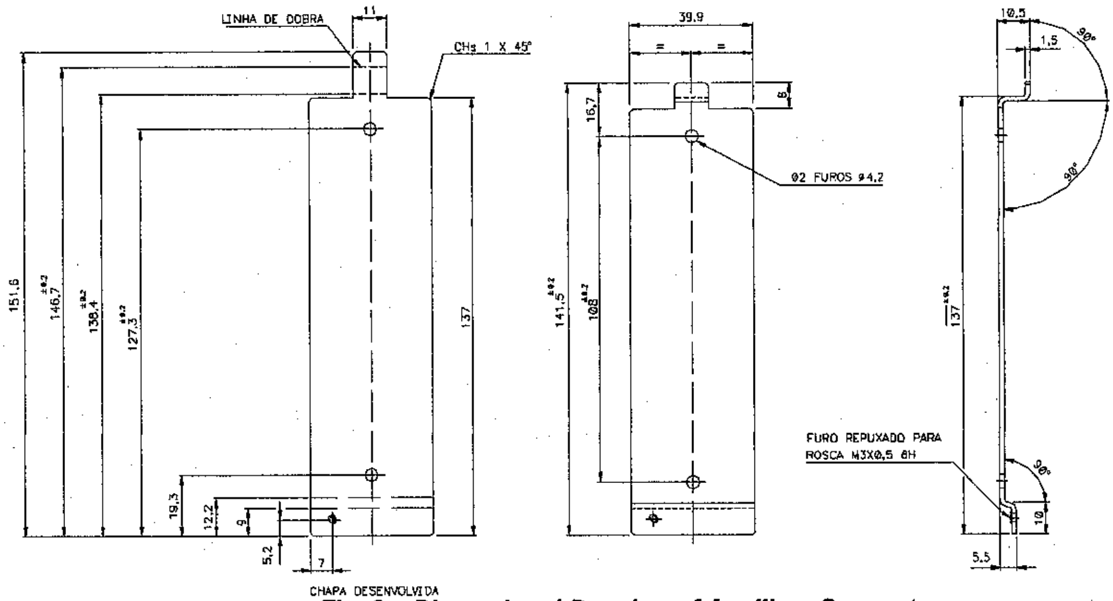


Fig. 3 – Dimensional Drawing of Auxiliary Support

To fixing the **PS302-1** through the rack:
1- To fix the rack in DIN rail or directly by means of screws;
2- It fits for **PS302-1** in the rack.

To fixing the **PS302-1** through the auxiliary support:
3- To fix the supplied suports directly by means of screws;
4- It fits for **PS302-1** in the auxiliary support.

'VTENANCE

Table 1, indicates some problems wich might occur:

	PROBABLE CAUSE	SOLUTION
Power supply unit on and FAIL red led on	• Short circuited output • Output overcurrent • Input voltage <90 or <127 Vdc	• Check output connections • Check if the current is below 1.5A • Input voltage must be in accordance with the specifications
Power supply unit on and ON green led out	• Fuse FU1 burnt, probably due to input overvoltage (voltage > 260 Vac or > 367 Vdc)*	• Replace the FU1 fuse for a spare one

Note: *Overcurrents or short-circuits in the **PS302-1**, output will not burn the internal fuse FU1.

Tab. 1 – Possible cause and solution of PS302-1 problems

HNICAL DATA

INPUT	
AC	90 to 260 Vac at 47 to 440 Hz
Maximum consumption	45 Watts
DC	127 to 367 Vdc.

OUTPUT	
Voltage	24 Vdc ± 1% for: load varying form 0 to full load. voltage between 90 and 260 Vac.
Current	0 a 1.5 A
Ripple	20 mv peak to peak

ALARME OUTPUT
1 A, 30 Vdc SPST, Fail clossed

AMBIENT OPERATION TEMPERATURE
0 °C to 50 °C

STORAGE TEMPERATURE
30 °C to 70 °C

ISOLATION	
Between output and enclosure ground	500 V_{RMS}
Between input and output	3000 V_{RMS}

PHYSICAL CHARACTERISTICS	
Size	40 mm x 142 mm x 126 mm
Weight	700 g

LD302

FIRST IN FIELDBUS

'R/02

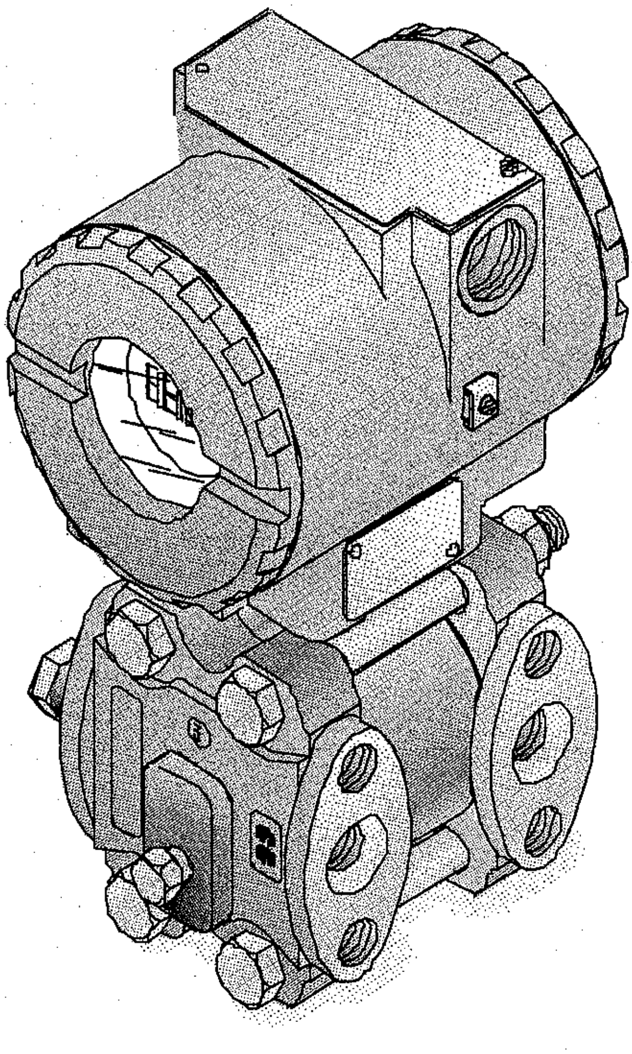
)302

SION 3

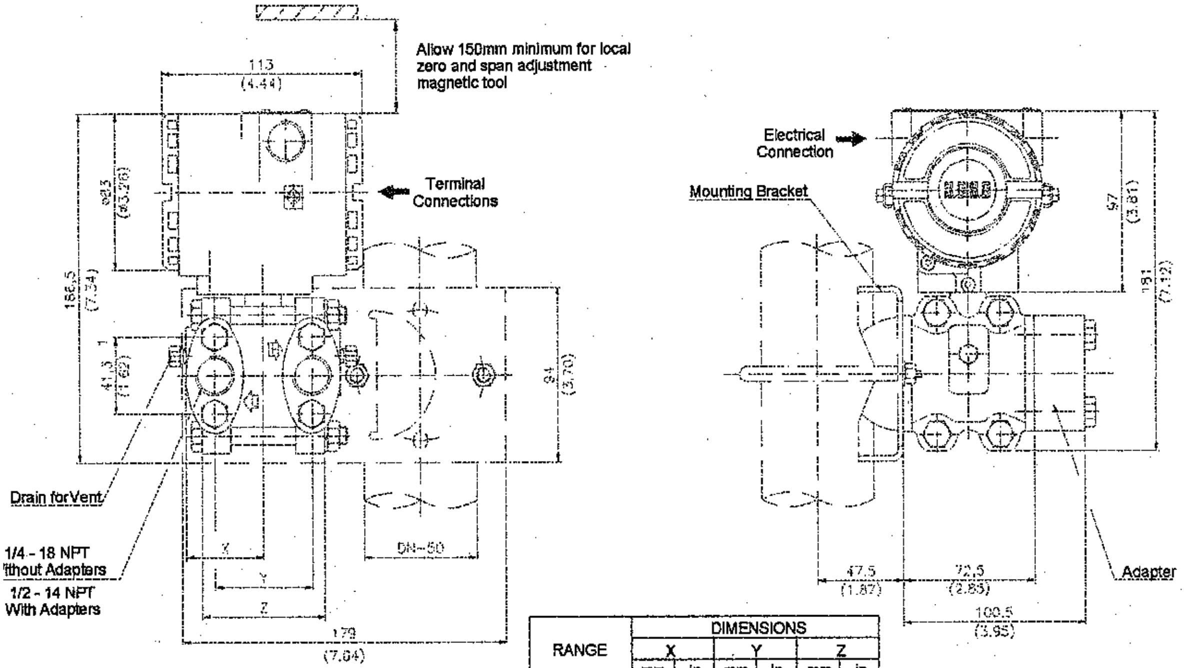
DATION

OPERATION & MAINTENANCE
INSTRUCTIONS MANUAL

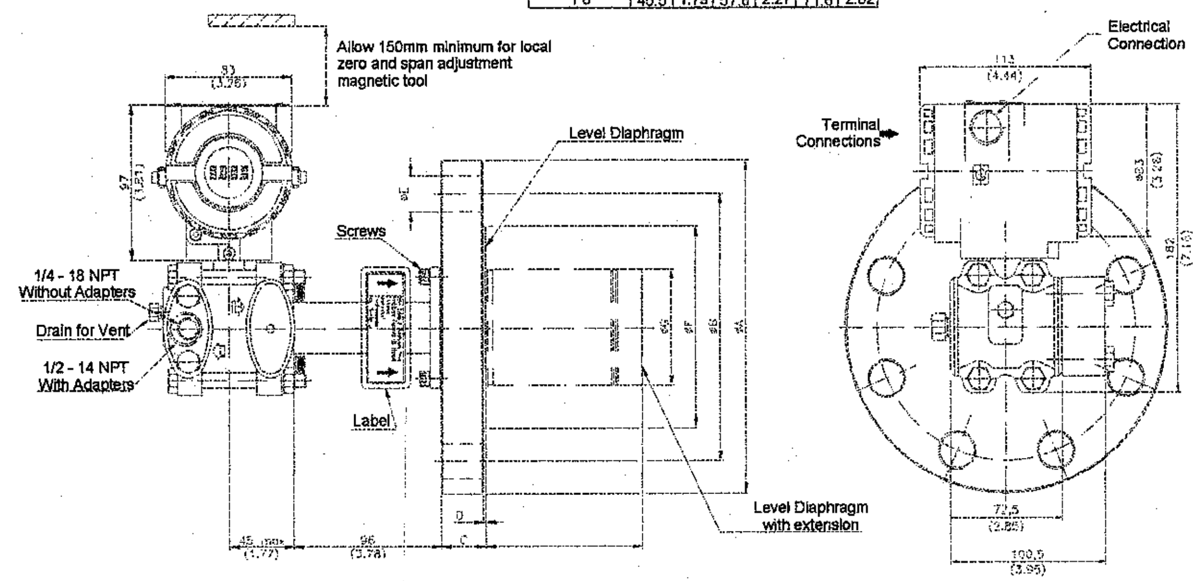
FIELDBUS PRESSURE TRANSMITTER



LD32FME



RANGE	DIMENSIONS					
	X		Y		Z	
	mm	in	mm	in	mm	in
F1 - F2 - F3	43.5	1.71	54.0	2.16	68.0	2.68
F4	44.5	1.75	56.0	2.20	70.0	2.76
F5	45.0	1.77	57.2	2.25	70.6	2.78
F6	45.5	1.79	57.6	2.27	71.6	2.82



ANSI B 16.5 - DIMENSIONS									
DN	class	A	B	C	D	E	F	G	X
2"	150	152.4	120.7	22	1.6	19.1	91.9	48	4
	300	165.1	127	22.8	1.6	19.1	91.9	48	8
	600	165.1	127	32.3	6.4	19.1	91.9	48	8
3"	150	190.5	152.4	24.4	1.6	19.1	127	73	4
	300	209.5	168.1	29	1.6	22.2	127	73	8
	600	209.5	168.1	38.7	6.4	22.2	127	73	8
4"	150	228.6	190.5	24.4	1.6	19.1	158	96	8
	300	254	200	32.2	1.6	22.3	158	96	8
	600	273	215.9	45	6.4	25.4	158	96	8

DIN 2501 / 2526 form D - DIMENSIONS									
DN	PN	A	B	C	D	E	F	G	X
50	10/40	165	125	20	3	18	102	48	4
80	10/40	200	160	24	3	18	138	73	8
100	10/16	220	180	20	3	18	158	96	8
	25/40	235	190	24	3	22	162	96	8

Figure 1.1 - Dimensional Drawing and Mounting Position for LD302

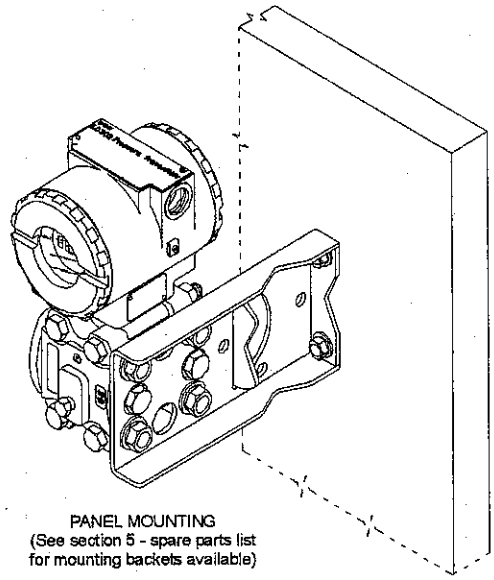


Figure 1.2 - Dimensional Drawing and Mounting Position for LD302

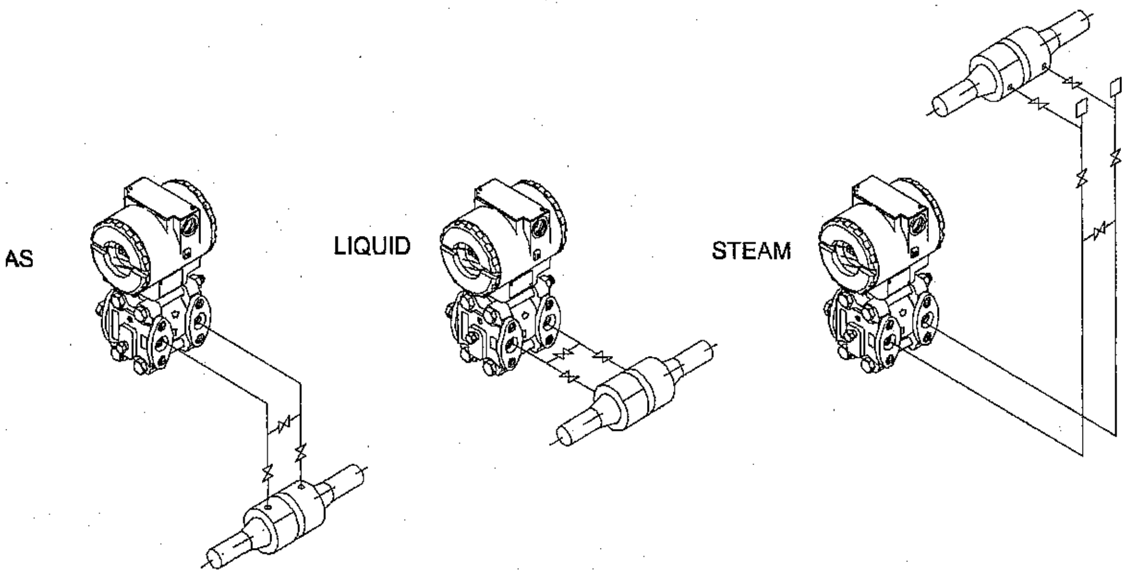


Figure 1.3 - Position of the Transmitter and Taps

NOTE

Except for dry gases, all impulse lines should slope at the ratio 1:10, in order to avoid trapping bubbles in the case of liquids, or condensation from steam or wet gases.

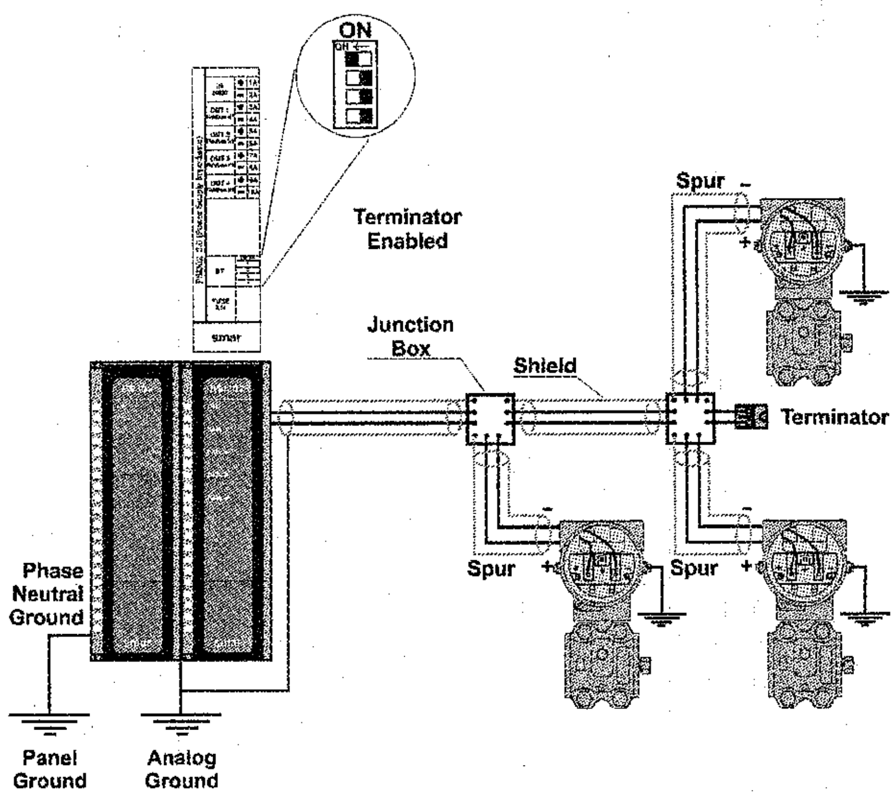


Figure 1.6 - Bus Topology

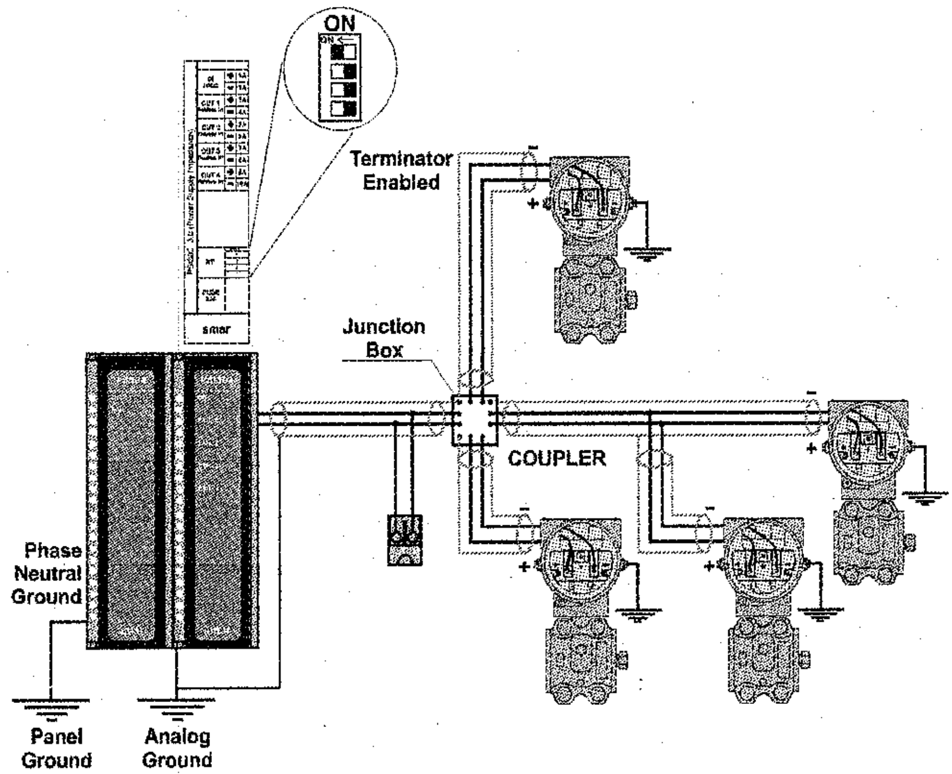


Figure 1.7 - Tree Topology

Operation

The **LD302** Series Pressure Transmitters use capacitive sensors (capacitive cells) as pressure sensing elements, as shown in Figure 2.1 - Capacitive Cell. This is exactly the same sensor as the LD301 series uses, the sensor modules are therefore interchangeable.

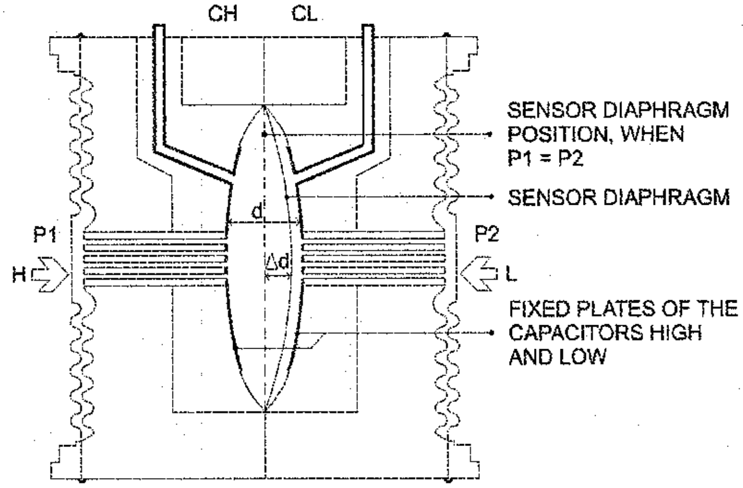


Figure 2.1 - Capacitive Cell

ctional Description - Sensor

Where,
P_1 and P_2 are the pressures and $P_1 \geq P_2$
CH = Capacitance between the fixed plate on P_1 side and the sensing diaphragm.
CL = Capacitance between the fixed plate on the P_2 side and the sensing diaphragm.
d = Distance between CH and CL fixed plates.
Δd = Sensing diaphragm's deflection due to the differential pressure $\Delta P = P_1 - P_2$.

Knowing that the capacitance of a capacitor with flat, parallel plates may be expressed as a function of plate area (A) and distance (d) between the plates:

$$C \approx \frac{\varepsilon \times A}{d}$$

Where,
ε = Dielectric constant of the medium between the capacitor's plates.

$$CH \approx \frac{\varepsilon \times A}{(d/2) + \Delta d} \text{ and } \frac{\varepsilon \times A}{(d/2) - \Delta d} \approx CL$$

However, should *CH* and *CL* be considered as capacitances of flat and parallel plates with identical areas, then:
However, should the differential pressure (ΔP) applied to the capacitive cell not deflect the sensing diaphragm beyond d/4, it is possible to assume ΔP as proportional to Δd, that is:

$$\Delta P \propto \Delta d$$

By developing the expression (CL - CH)/(CL + CH), it follows that:

$$\frac{CL - CH}{CL + CH} = \frac{2\Delta d}{d}$$

As the distance (d) between the fixed plates CH and CL is constant. It is possible to conclude that the expression (CL - CH)/(CL + CH) is proportional to Δd and, therefore, to the differential pressure to be measured.
Thus it is possible to conclude that the capacitive cell is a pressure sensor formed by two capacitors whose capacitance vary according to the applied differential pressure.

ctional Description – Electronics

Refer to the block diagram Figure 2.2 - LD302 Block Diagram Hardware.
The function of each block is described below.

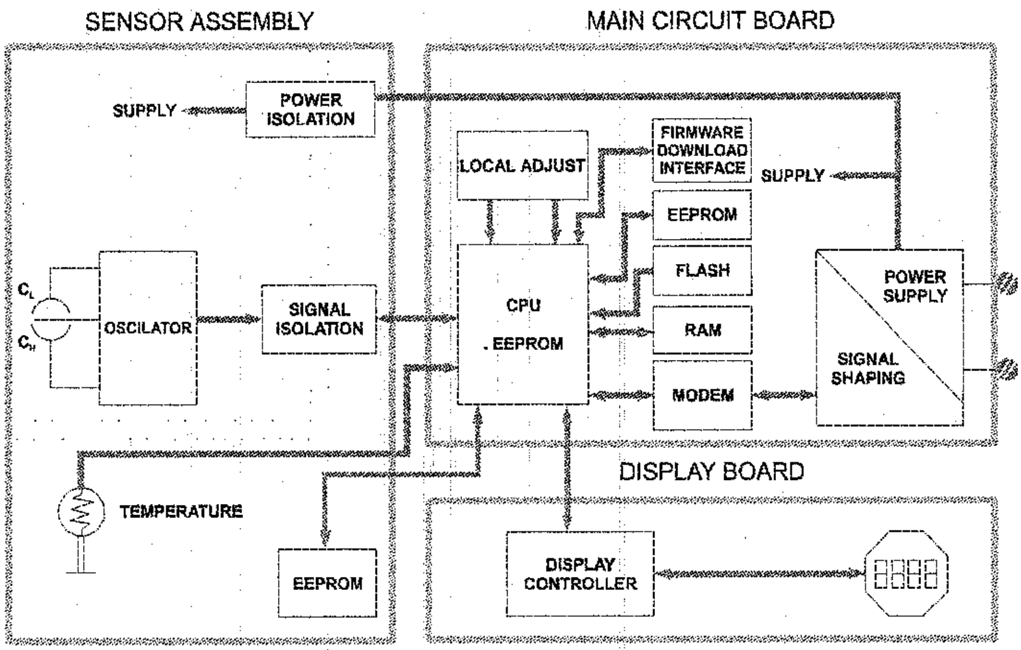


Figure 2.2 - LD302 Block Diagram Hardware

Oscillator
This oscillator generates a frequency as a function of sensor capacitance.

Signal Isolator
The control signals from the CPU and the signal from the oscillator are isolated to avoid ground loops.

Central Processing Unit (CPU), RAM, FLASH and EEPROM
The CPU is the intelligent portion of the transmitter, being responsible for the management and operation of measurement, block execution, self-diagnostics and communication. The program is stored in a FLASH memory for easy upgrade and saving data on power-down event occurrence. For temporary storage of data there is a RAM. The data in the RAM is lost if the power is switched off, however the main board has a nonvolatile EEPROM memory where the static data configured that must be retained is stored. Examples of such data are the following: calibration, links and identification data.

Sensor EEPROM
Another EEPROM is located within the sensor assembly. It contains data pertaining to the sensor's characteristics at different pressures and temperatures. This characterization is done for each sensor at the factory. It also contains the factory settings; they are useful in case of main board replacement, when its does an automatic upload of data from the sensor board to main board.

ection 3

Configuration

One of the many advantages of Fieldbus is that device configuration is independent of the configurator. The **LD302** may be configured by a third party terminal or operator console. Any particular configurator is therefore not addressed here.

This section describes the characteristics of the blocks in the **LD302**. They follow the Fieldbus specifications, but in terms of transducer blocks, the input transducer block and display, they have some special features on top of this.

ansducer Block

Transducer block insulates function block from the specific I/O hardware, such as sensors, actuators. Transducer block controls access to I/O through manufacturer specific implementation. This permits the transducer block to execute as frequently as necessary to obtain good data from sensors without burdening the function blocks that use the data. It also insulates the function block from the manufacturer specific characteristics of certain hardware.

By accessing the hardware, the transducer block can get data from I/O or passing control data to it. The connection between Transducer block and Function block is called channel. These blocks can exchange data from its interface.

Normally, transducer blocks perform functions, such as linearization, characterization, temperature compensation, control and exchange data to hardware.

›w to Configure a Transducer Block

Each time when you select a field device on **SYSCON** by instantiating on the Operation menu, automatically you instantiate one transducer block and it appears on screen.

The icon indicates that one transducer block has been created and by clicking twice on the icon, you can access it.

The transducer block has an algorithm, a set of contained parameters and a channel connecting it to a function block.

The algorithm describes the behavior of the transducer as a data transfer function between the I/O hardware and other function block. The set of contained parameters, it means, you are not able to link them to other blocks and publish the link via communication, defines the user interface to the transducer block. They can be divided into Standard and Manufacturer Specific.

The standard parameters will be present for such class of device, as pressure, temperature, actuator, etc., whatever is the manufacturer. Oppositely, the manufacturers specific ones are defined only for its manufacturer. As common manufacturer specific parameters, we have calibration settings, material information, linearization curve, etc.

When you perform a standard routine as a calibration, you are conducted step by step by a method. The method is generally defined as guide line to help the user to make common tasks. The **SYSCON** identifies each method associated to the parameters and enables the interface to it.

The SYSCON configuration software can configure many parameters of the Input Transducer block.

ıe device was
ıtantiated as
)302

ɜre, you can see all
ɔcks instantiated.

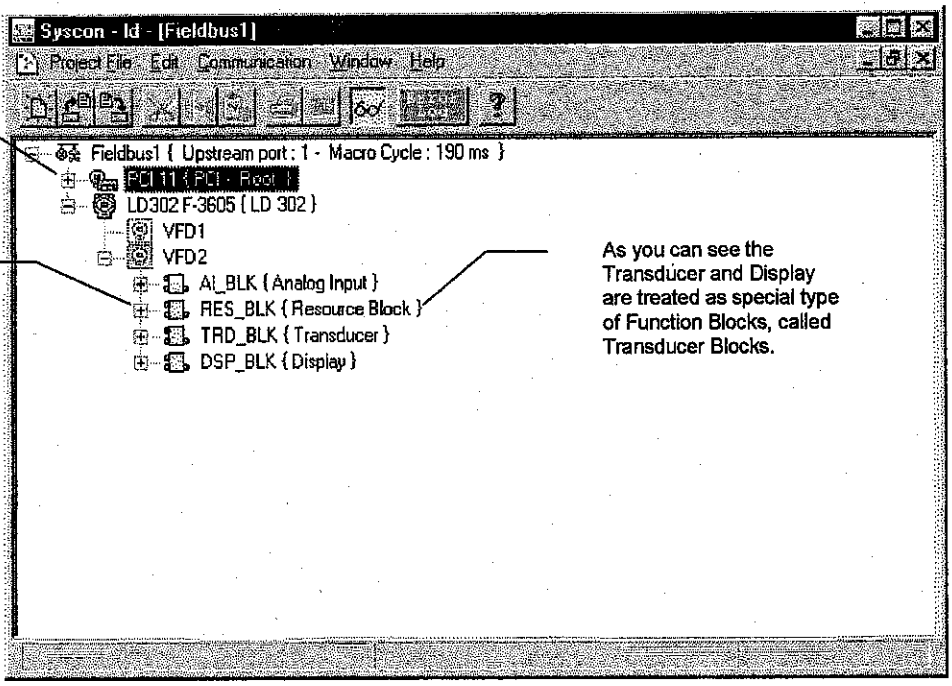


Figure 3.1 - Function and Transducers Blocks

ıwer and Upper Trim

Each sensor has a characteristic curve that establishes a relation between the applied pressure and the sensor signal. This curve is determined for each sensor and it is stored in a memory together with the sensor. When the sensor is connected to the transmitter circuit, the content of its memory is made available to the microprocessor.

Sometimes the value on the transmitter display and transducer block reading may not match the applied pressure.
The reasons may be:

- The transmitter mounting position.
- The user's pressure standard differs from the factory standard.
- The transmitter had its original characterization shifted by over pressurization, over heating or by long term drift

The **TRIM** is used to match the reading with the applied pressure.
There are three types of trim available:

Lower Trim: It is used to trim the reading at the lower range. The operator informs the **LD302** the correct reading for the applied pressure. The most common discrepancy is the lower reading.

Upper Trim: It is used to trim the reading at the upper range. The operator informs the correct reading to **LD302** for the applied pressure.

For best accuracy, trim should be done at the operating range. The Figure 3.2 - LD302 SYSCON - Transducer Configuration Screen, Figure 3.3 - LD302 SYSCON - Transducer Configuration Screen and Figure 3.4 – LD302 SYSCON - Transducer Configuration Scren below show the trim adjustment operation into SYSCON.

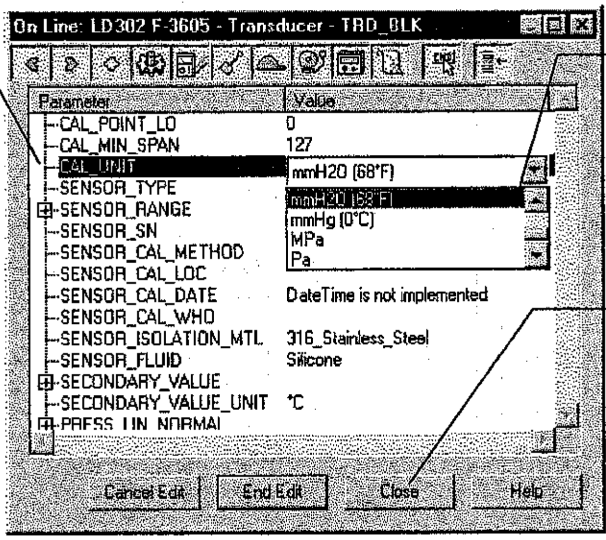
essure Trim - LD302

Via SYSCON

It is possible to calibrate the transmitter by means of parameters CAL_POINT_LO and CAL_POINT_HI.

First of all, a convenient engineering unit should be chosen before starting the calibration. This engineering unit is configured by CAL_UNIT parameter. After its configuration the parameters related to calibration will be converted to this unit.

he parameter :AL_UNIT hould be onfigured ccording to the :ngineering Unit vished for alibrating the levice.



The Engineering Units can be choosen from the Pressure Units list box

After the selection this key should be pressed to complete the

Figure 3.2 - LD302 SYSCON – Transducer Configuration Screen

The following engineering unit's codes are defined for pressure according to Foundation Fieldbus® standard:

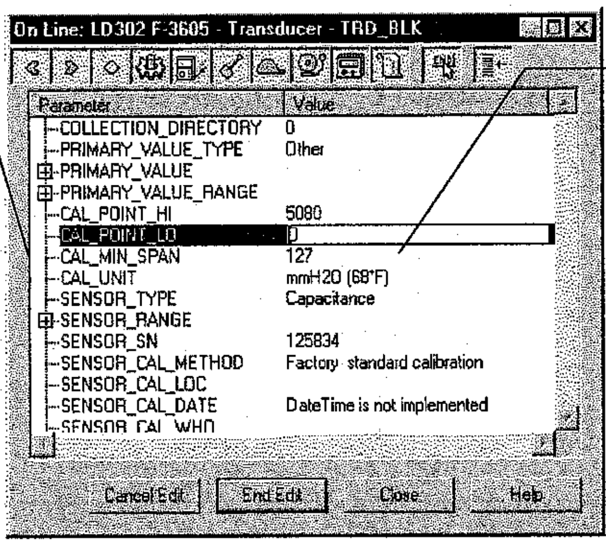
UNIT	CODES
InH2O a 68°F	1148
InHg a 0°C	1156
ftH2O a 68°F	1154
mmH2O a 68°F	1151
MmHg a 0°C	1158
Psi	1141
Bar	1137
Mbar	1138
g/cm2	1144
k/cm2	1145
Pa	1130
Kpa	1133
Torr	1139
Atm	1140
Mpa	1132
inH2O a 4°C	1147
mmH2O a 4°C	1150

CAL_UNIT allows the user to select different units for calibration purposes than the units defined by SENSOR_RANGE. The SENSOR_RANGE parameter defines the maximum and minimum values the sensor is capable of indicating, the engineering units used, and the decimal point.

Let's take the lower value as an example:
Apply to the input zero or the pressure lower value in an engineering unit, this being the same used in parameter CAL_UNIT, and wait until the readout of parameter PRIMARY_VALUE stabilizes.

Write zero or the lower value in parameter CAL_POINT_LO. For each value written a calibration is performed at the desired point.

he Lower ange Value hould be ntered. This alue must be nside of the ensor range mits allowed for ach type of ensor.

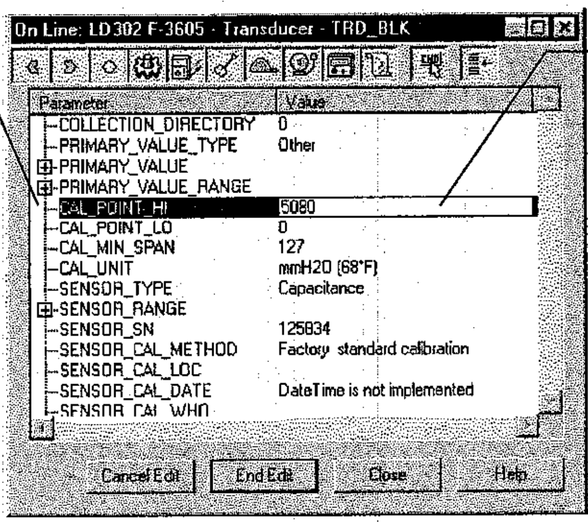


For its case, a sensor range 2 is used: The URL is 5080 mmH2O or 200 inH2O.

Figure 3.3 - LD302 SYSCON - Transducer Configuration Screen

Let's take the upper value as an example:
Apply to the input as the upper value a pressure of 5,000mmH_2O and wait until the readout of parameter PRIMARY_VALUE stabilizes. Then, write the upper value as, for example, 5,000mmH_2O in parameter CAL_POINT_HI. For each value written a calibration is performed at the desired point.

he Upper ange Value hould be ntered. This alue must be nside of the ensor range imits allowed or each type of ensor.



For its case, a sensor range 2 is used: The URL is 5080 mmH2O or 200 inH2O.

Figure 3.4 - LD302 SYSCON - Transducer Configuration Screen

WARNING

It is recommendable that a convenient engineering unit be chosen by means of parameter XD_SCALE of the Analog Input Block, considering that the range limits of the sensor must be respected, these being 100% and 0%.

It is also recommendable, for every new calibration, to save existing trim data in parameters CAL_POINT_LO_BACKUP and CAL_POINT_HI_BACKUP, by means of parameter BACKUP_RESTORE, using option LAST_TRIM_BACKUP.

a Local Adjustment

In order to enter the local adjustment mode, place the magnetic tool in office "Z" until flag "MD" lights up in the display. Remove the magnetic tool from "Z" and place it in orifice "S". Remove and reinsert the magnetic tool in "S" until the message "LOC ADJ" is displayed. The message will be displayed during approximately 5 seconds after the user removes the magnetic tool from "S". Let's take the upper value as an example:

Apply to the input a pressure of 5,000mmH_2O.
Wait until the pressure of readout of parameter P_VAL (PRIMARY_VALUE) stabilizes and then actuates parameter UPPER until it reads 5,000.

NOTE

Trim mode exit via local adjustment occurs automatically should the magnetic tool not be used during approximately 16 seconds.

Keep in that even when parameters LOWER or UPPER already present the desired value, they must be actuated so that calibration is performed.

Limit Conditions for Calibration:
For every writing operation in the transducer blocks there is an indication for the operation associate with the waiting method. These codes appear in parameter XD_ERROR. Every time a calibration is performed. Code 0, for example, indicates a successfully performed operation.

Upper:
SENSOR_RANGE_EUO < NEW_UPPER < SENSOR_RANGE_EU100 * 1.25
Otherwise, XD_ERROR = 26.
(NEW_UPPER - PRIMARY_VALUE) < SENSOR_RANGE_EU100 * 0.1
Otherwise, XD_ERROR = 27.
(NEW_UPPER - CAL_POINT_LO) >CAL_MIN_SPAN * 0,75
Otherwise, XD_ERROR = 26.

NOTE

Codes for XD_ERROR:
16: Default Value Set
22: Out of Range.
26: Invalid Calibration Request.
27: Excessive Correction.

haracterization Trim

It is used to correct the sensor reading in several points.

Use an accurate and stable pressure source, preferably a dead-weight tester, to guarantee the accuracy must be at least three times better than the transmitter accuracy. Wait for the pressure to stabilize before performing trim.

The sensor characteristic curve at a certain temperature and for certain ranges may be slightly nonlinear. This eventual non-linearity may be corrected through the Characterization Trim.

The user may characterize the transmitter throughout the operating range, obtaining even better accuracy.

The characterization is determined from two up to five points. Just apply the pressure and tell the transmitter the pressure that is being applied.

> **WARNING**
>
> The characterization trim changes the transmitter characteristics.
>
> Read the instructions carefully and certify that a pressure standard with accuracy 0.03% or better is being used, otherwise the transmitter accuracy will be seriously affected.

Characterize a minimum of two points. These points will define the characterization curve. The maximum number of points is five. It is recommended to select the points equally distributed over the desired range or over a part of the range where more accuracy is required.

The Figure 3.5 - The Characterization Curve Configuration shows the window of SYSCON to characterize a new curve. Note that CURVE_X indicates the applied pressure according to standard pressure source and CURVEX_Y indicates measured pressure value to **LD302.**

The number of points is configured in parameter CURVE_LENGTH, being in the maximum 5 points. The entry points will be configured in the CURVE_X and of output in the CURVE_Y.

The Parameter CURVE_BYPASS_LD controls the enabling/disabling of the curve and has the following options:

- "Enable and Restore Cal ",
- "Enable and Backup Cal " ,
- "Disable and Restore Cal " ,
- "Disable or Allows to enter the points"

To configure the points of the curve, the option **"Disable or Allows to enter the points "** must be choosen. Apply the desired pressure and wait that the same one stabilizes. When stabilizing to read the pressure normalized through parameter PRESS_NORMAL and then to write in CURVE_X and CURVE_Y, the normalized pressure and the applied pressure, respectively. Finally is necessary to write in the CURVE_LENGTH parameter, the number of configured points, from 2 to 5 points. In case you do not desire to qualify the curve, please, choose the option " Disable and Restore Cal". For enabling and save the calibration settings, please, choose "Enable and Backup Cal".

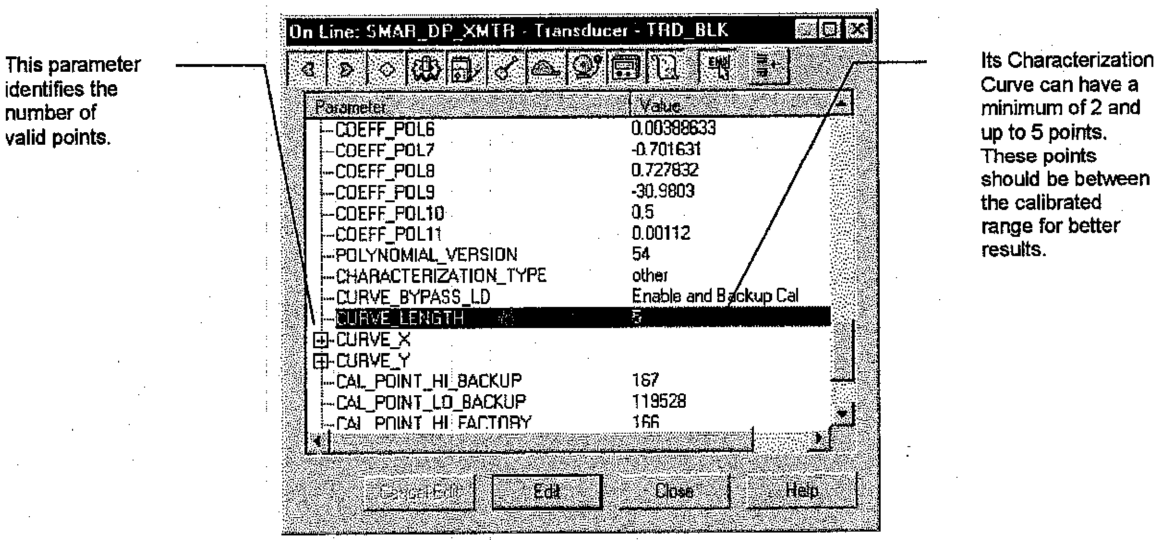
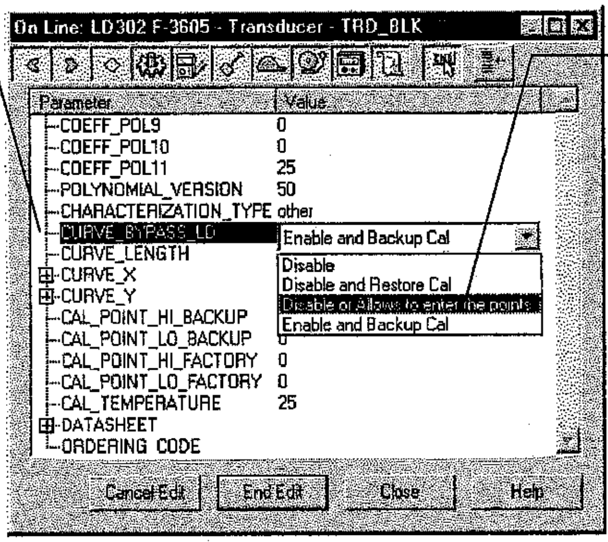


Figure 3.5 - The Characterization Curve Configuration

ᒥhis parameter ıctivates or ꞁeactivates the ᑕharacterizatio ı Curve after he points have ɔeen ɔonfigured.



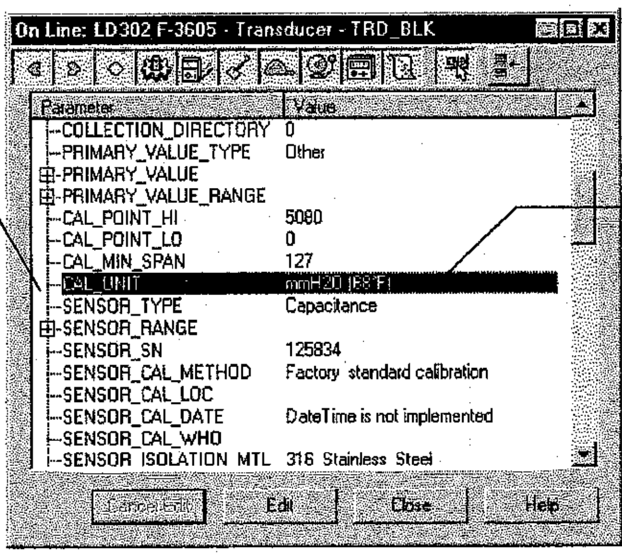
By the list box the user can enable or disable the Characterization Curve, enter the points, restore or backup the curve entered. This parameter should be used preferable by a method of calibration.

Figure 3.6 - The Characterization Curve Configuration

ɜnsor Information

The main information about the transmitter can be accessed selecting the Transducer block icon option as shown on the <u>*Figure 3.10 - Creating Transducers and Function Blocks*</u>. The sensor information will be displayed as shown below.

his parameter ssigns the E.U. for ꞁ parameters ꞁlated to calibration ıethods. Normally, ıey start their ames with CAL_



The appropriate calibration unit can be choosen by selecting the Engineering Units available for each type of Transducer Block

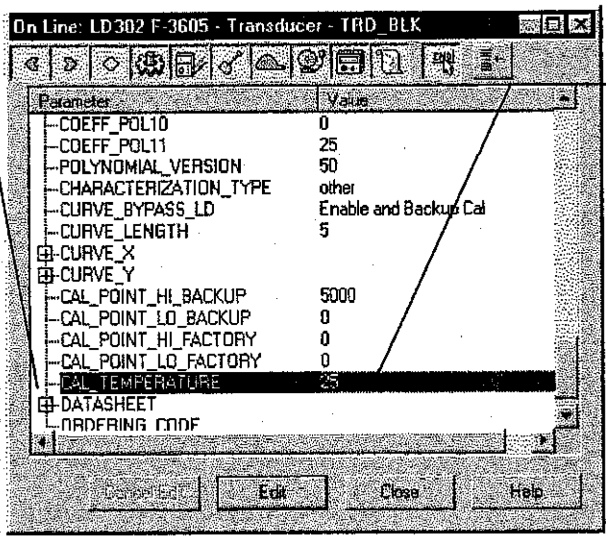
Figure 3.7 - Transducer Block - Sensor Information

Only application dependent options defined by combo boxes can be changed. (E.g. Flange Type, O' Ring Material, etc.) And the others are only factory configured (e.g. Sensor Isolating Diaphragm, Sensor Fluid, etc.).

ɜmperature Trim

Write in parameter TEMPERATURE_TRIM any value in the range -40°C to +85°C. After that, check the calibration performance using parameter SECONDARY_ VALUE.

ly adjusting this arameter to the urrent emperature, the evice's emperature ndication is djusted.



Normally, its operation is done by a method in the factory.

Figure 3.8 - The Temperature Trim Configuration

nsor Data Reading

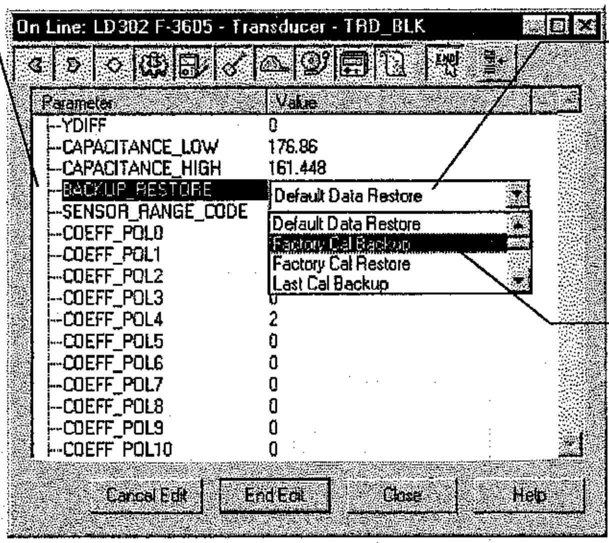
All time that transmitter **LD302** is on, is verified if the serial number of the sensor in the sensor board is the same that the recorded serial number in E2PROM in the main board. When these numbers are different (a swap of sensor set or main board was carried through) the data stored in the E2PROM of sensor board is copied to the E2PROM of the main board.

Through the parameter BACKUP_RESTORE, also this reading can be made, choosing the option "SENSOR_DATA_RESTORE". The operation, in this case, is made independent of the sensor serial number. Through the option "SENSOR_DATA_BACKUP", the sensor data stored in the main board Eeprom memory can be saved in the E2PROM of the sensor board. (This operation is done at factory).

Through this parameter, we can recover default data from factory about sensor and last saved calibration settings, as well as making the rescue of calibrations. We have the following options:

- **Factory Cal Restore:** Recover last calibration settings made at factory;
- **Last Cal Restore:** Recover last calibration settings made by user and saved as backup;
- **Default Data Restore:** Restore all data as default;
- **Sensor Data Restore:** Restore sensor data saved in the sensor board and copy them to main board Eeprom memory.
- **Factory Cal Backup:** Copy the actual calibration settings to the factory ones;
- **Last Cal Backup:** Copy the actual calibration settings to the backup ones;
- **Sensor Data Backup:** Copy the sensor data at main board Eeprom memory to the Eeprom memory located at the sensor board;
- **None:** Default value, no action is done.

'his parameter s used to save r restore the lefault, factory r user configuration tored at the sensor module.



By selecting the options contained in the list box, operations of backup and restore data in the sensor module can be

Using its option, the user can save his last calibration settings.

Figure 3.9 - Transducer Block - Backup/Restore

ansducer Display – Configuration

Using the SYSCON is possible to configure the Display Transducer block. As the name described it is a transducer due the interfacing of its block with the LCD hardware.

The Transducer Display is treated as a normal block by **SYSCON**. It means, this block has some parameters and those ones can be configured according to customer's needs. (See the Figure 3.10 – Creating Transducers and Function Blocks.

The customer can choose the parameters to be shown at LCD display, they can be parameters just for monitoring purpose or for acting locally in the field devices by using a magnetic tool.

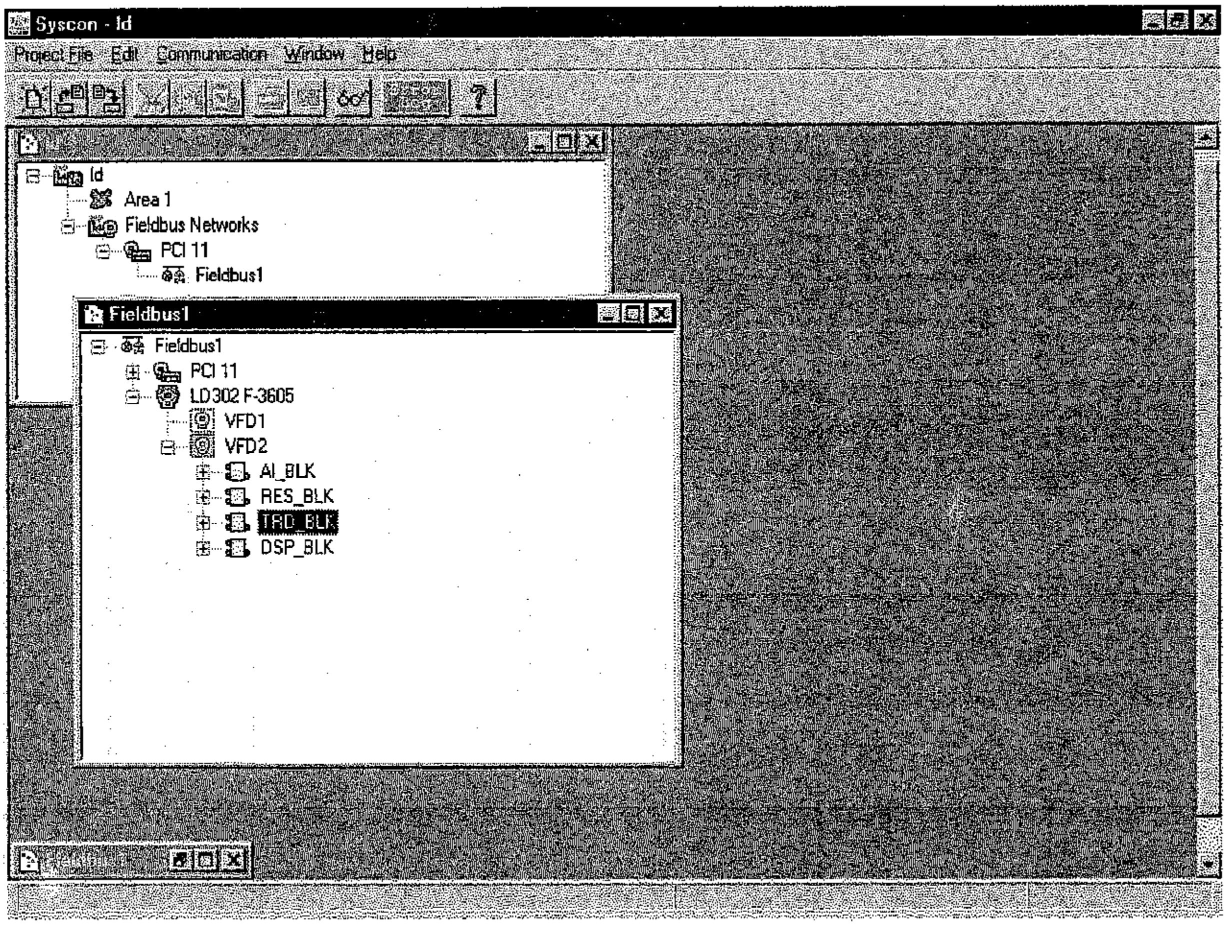


Figure 3.10 – Creating Transducers and Function Blocks

splay Transducer Block

The local adjustment is completely configured by **SYSCON**. It means, the user can select the best options to fit his application. From factory, it is configured with the options to set the Upper and Lower trim, for monitoring the input transducer output and check the Tag. Normally, the transmitter is much better configured by **SYSCON**, but the local functionality of the LCD permits an easy and fast action on certain parameters, since it does not rely on communication and network wiring connections. Among the possibilities by Local Adjustment, the following options can be emphasized: Mode block, Outputs monitoring, Tag visualization and Tuning Parameters setting.

The interface between the user is described very detailed on the "*General Installation, Operation and Maintenance Procedures Manual*". *Please take a detailed look at this manual in the chapter related to "Programming Using Local Adjustment". It is significantly the resources on this transducer*

display, also all the **Series 302** field devices from SMAR has the same methodology to handle with it. So, since the user has learned once, he is capable to handle all kind of field devices from SMAR.

All function block and transducers defined according Foundation Fieldbus™ have a description of their features written on binary files, by the Device Description Language.

This feature permits that third parties configurator enabled by Device Description Service technology can interpret these features and make them accessible to configure. The Function Blocks and Transducers of Series 302 have been defined rigorously according the Foundation Fieldbus specifications in order to be interoperable to other parties.

In order to able the local adjustment using the magnetic tool, it is necessary to previously prepare the parameters related with this operation via SYSCON (System Configuration). The Figure 3.8 - The Temperature Trim Configuration and the Figure 3.9 - Transducer Block - Backup/Restore show all parameters and their respective values, which shall be configured in accordance with the necessity of being locally adjusted by means of the magnetic tool. All values shown on the display are default values.

There are seven groups of parameters, which may be pre-configured by the user in order to able, a possible configuration by means of the local adjustment. As an example, let's suppose that you don't want to show some parameters; in this case, simply write an invalid Tag in the parameter, Block_Tag_Param_X. Doing this, the device will not take the parameters related (indexed) to its Tag as a valid parameters.

finition of Parameters and Values

Block_Tag_Param
This is the tag of the block to which the parameter belongs to use up to a maximum of 32 characters.

Index_Relative
This is the index related to the parameter to be actuated or viewed (0, 1, 2...). Refer to the Function Blocks Manual to know the desired indexes, or visualize them on the SYSCON by opening the desired block.

Sub_Index
In case you wish to visualize a certain tag, opt for the index relative equal to zero, and for the sub-index equal to one (refer to paragraph Structure Block in the Function Blocks Manual).

Mnemonic
This is the mnemonic for the parameter identification (it accepts a maximum of 16 characters in the alphanumeric field of the display). Choose the mnemonic, preferably with no more than 5 characters because, this way, it will not be necessary to rotate it on the display.

Inc_Dec
It is the increment and decrement in decimal units when the parameter is Float or Float Status time, or integer, when the parameter is in whole units.

Decimal_Point_Numb.
This is the number of digits after the decimal point (0 to 3 decimal digits).

Access
The access allows the user to read, in the case of the "Monitoring" option, and to write when "action" option is selected, then the display will show the increment and decrement arrows.

Alpha_Num
These parameters include two options: value and mnemonic. In option value, it is possible to display data both in the alphanumeric and in the numeric fields; this way, in the case of a data higher than 10000, it will be shown in the alphanumeric field.

In option mnemonic, the display may show the data in the numeric field and the mnemonic in the alphanumeric field.

In case you wish to visualize a certain tag, opt for the index relative equal to zero, and for the sub-index equal to one (refer to paragraph Structure Block in the Function Blocks Manual).

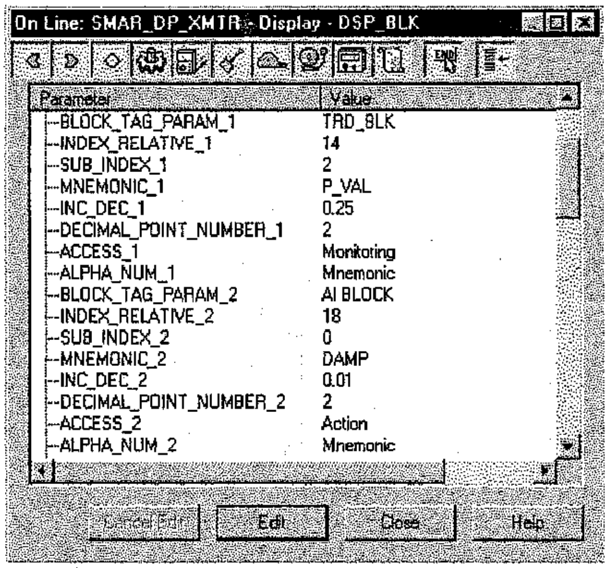


Figure 3.11 - Parameters for Local Adjustment Configuration

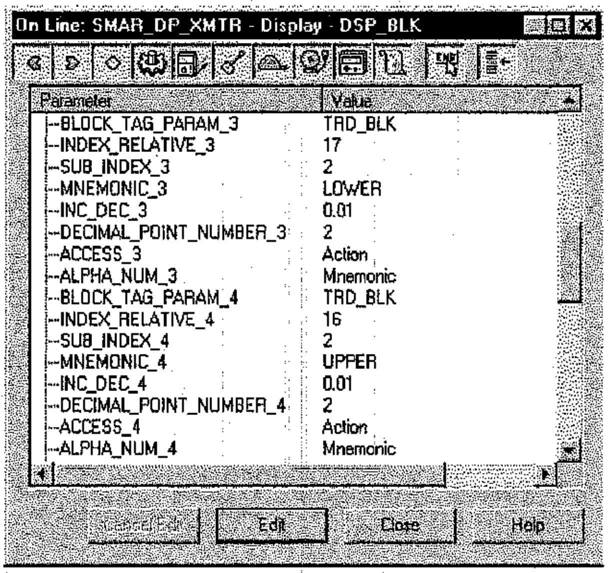


Figure 3.12 - Parameters for Local Adjustment Configuration

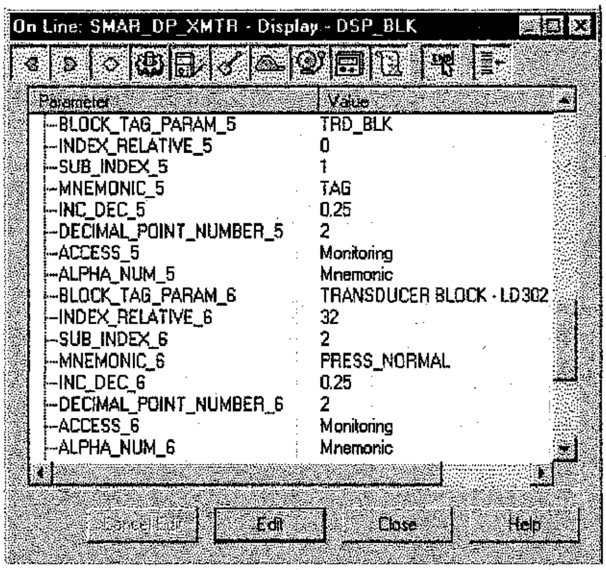


Figure 3.13 - Parameters for Local Adjustment Configuration

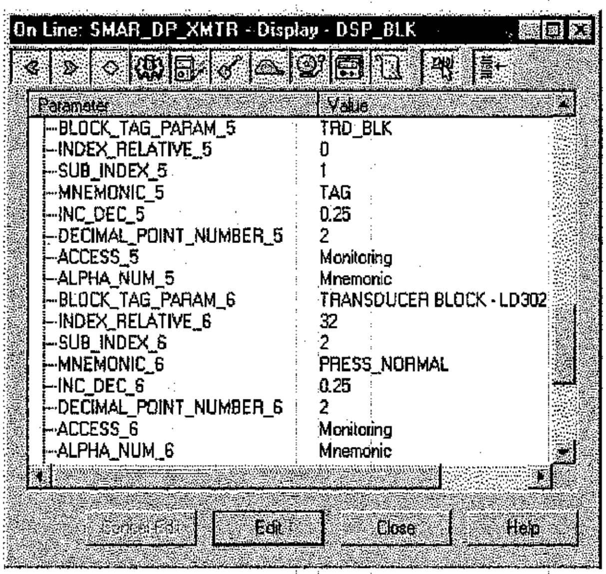
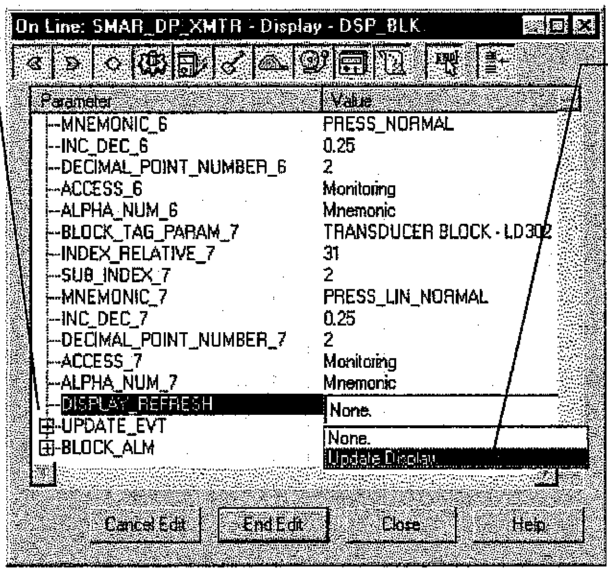


Figure 3.14 - Parameters for Local Adjustment Configuration

his parameter
pdates the local
djustment
rogramming tree
onfigured on
ach device.



The option "update" should be selected in order to execute the upgrade of local adjustment programming tree. After its step all the parameters selected will be shown on the LCD display.

Figure 3.15 - Parameters for Local Adjustment Configuration

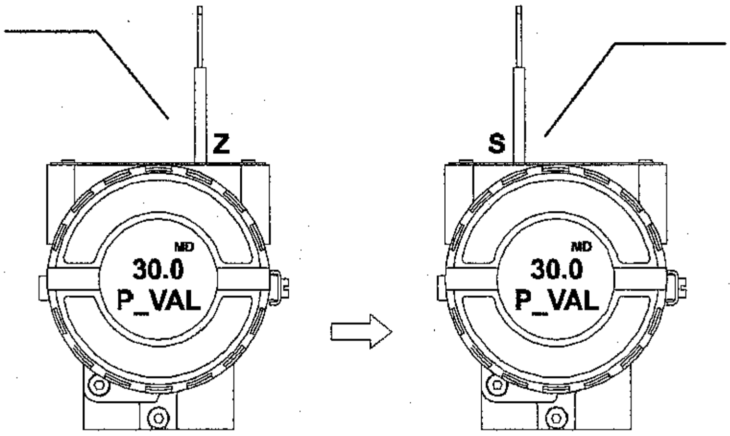
ogramming Using Local Adjustment

The local adjustment is completely configured by **SYSCON**. It means, the user can select the best options to fit his application. From factory, it is configured with the options to set the Upper and Lower trim, for monitoring the input transducer output and check the Tag. Normally, the transmitter is much better configured by **SYSCON**, but the local functionality of the LCD permits an easy and fast action on certain parameters, since it does not rely on communication and network wiring connections. Among the possibilities by Local Adjustment, the following options can be emphasized: Mode block, Outputs monitoring, Tag visualization and Tuning Parameters setting.

The interface between the user is also described very detailed on the "*General Installation, Operation and Maintenance Procedures Manual*" Please take a detailed look at this manual in the chapter related to "Programming Using Local Adjustment". It is significantly the resources on this transducer display, also all the Series 302 field devices from **SMAR** has the same methodology to handle with it. So, since the user has learned once, he is capable to handle all kind of field devices from **SMAR**.

All function block and transducers defined according *Foundation Fieldbus™* have a description of their features written on binary files, by the *Device Description Language*. This feature permits that third parties configurator enabled by *Device Description Service* technology can interpret these features and make them accessible to configure. The Function Blocks and Transducers of Series 302 have been defined rigorously according the Foundation Fieldbus specifications in order to be interoperable to other parties.

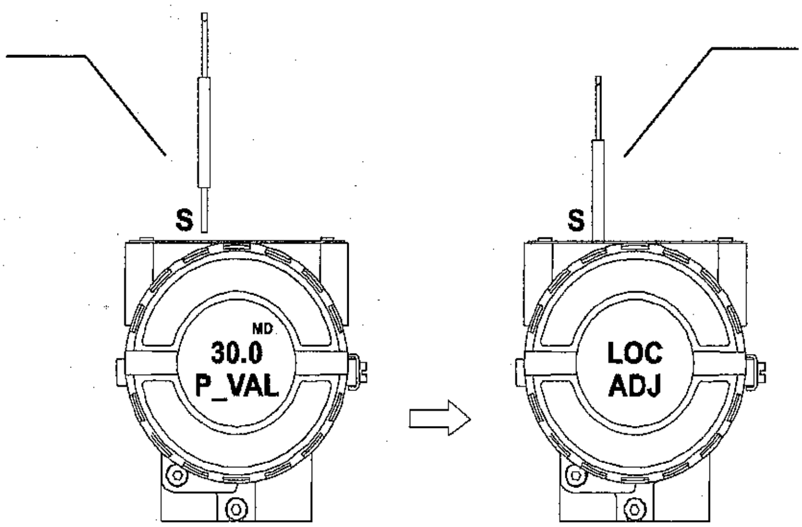
In order to start the local adjustment, place the magnetic tool in orifice Z and wait until letters MD are displayed.



Place the magnetic tool in orifice **S** and wait during 5 seconds.

Figure 3.16 - Step 1 - LD302

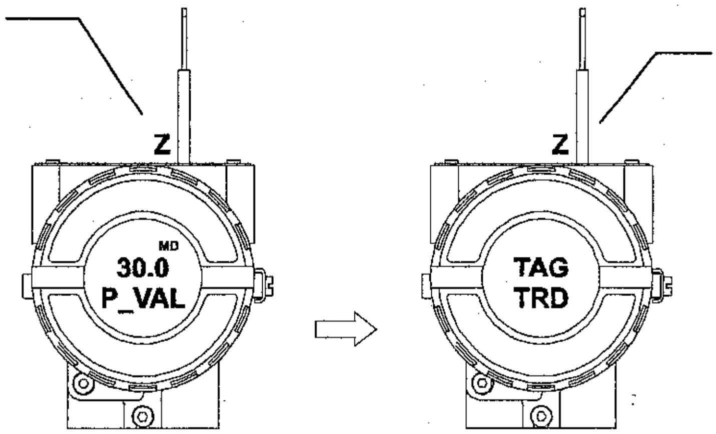
Remove the magnetic tool from orifice **S**.



Insert the magnetic tool in orifice **S** once more and **LOC ADJ** should be displayed.

Figure 3.17 - Step 2 - LD302

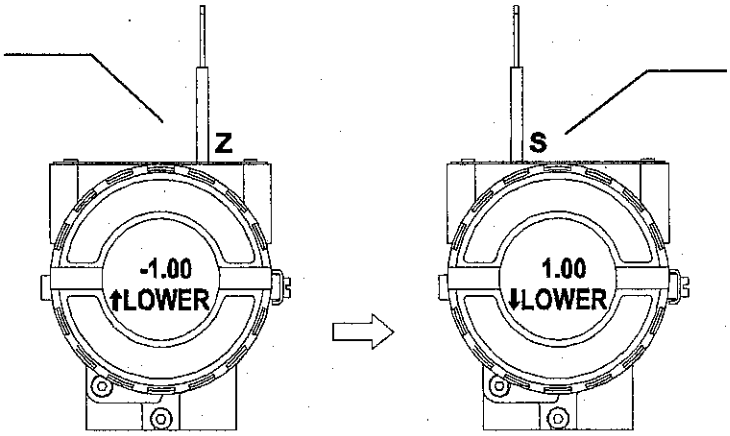
Place the magnetic tool in orifice **Z**. In case this is the first configuration, the option shown on the display is the **TAG** with its corresponding mnemonic configured by the SYSCOM. Otherwise, the option shown on the display will be the one configured in the prior operation. By keeping the tool inserted in this orifice, the local adjustment menu will rotate.



In this option the first variable (P_VAL) is showed with its respective value (if you to want that it keeps static, put the tool in **S** orifice and stay there.

Figure 3.18 - Step 3 - LD302

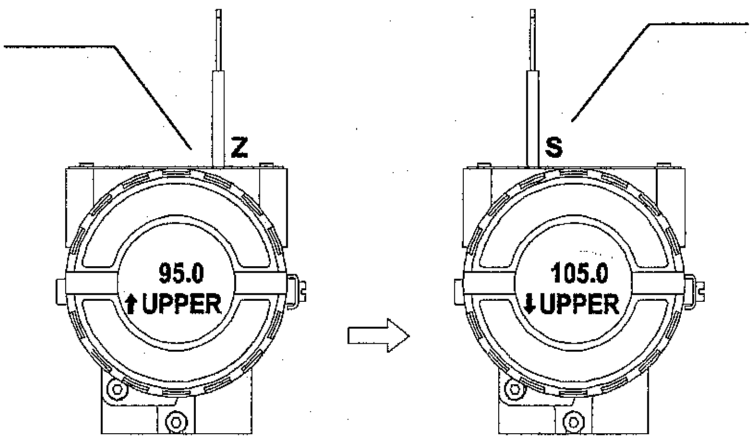
In order to range the lower value(lower), simply insert the magnetic tool in orifice S as soon as LOWER is shown on the display. An arrow pointing upward (↑) increments the valve and an arrow pointing downward (↓) decrements the value. In order to increment the value, keep the tool inserted in S up to set the value desired.



In order to decrement the lower value, place the magnetic tool in orifice Z to shift the arrow to the downward position and then, by inserting and keeping the tool in orifice S, it is possible to decrement the lower value.

Figure 3.19 - Step 4 - LD302

In order to range the upper value(upper), simply insert the magnetic tool in orifice S as soon as upper is shown on the display. An arrow pointing upward (↑) increments the valve and an arrow pointing downward (↓) decrements the value. In order to increment the value, keep the tool inserted in S up to set the value desired.



In order to decrement the upper value, place the magnetic tool in orifice Z to shift the arrow to the downward position an then, by insetting and keeping the tool in orifice S, it is possible to decrement the upper value.

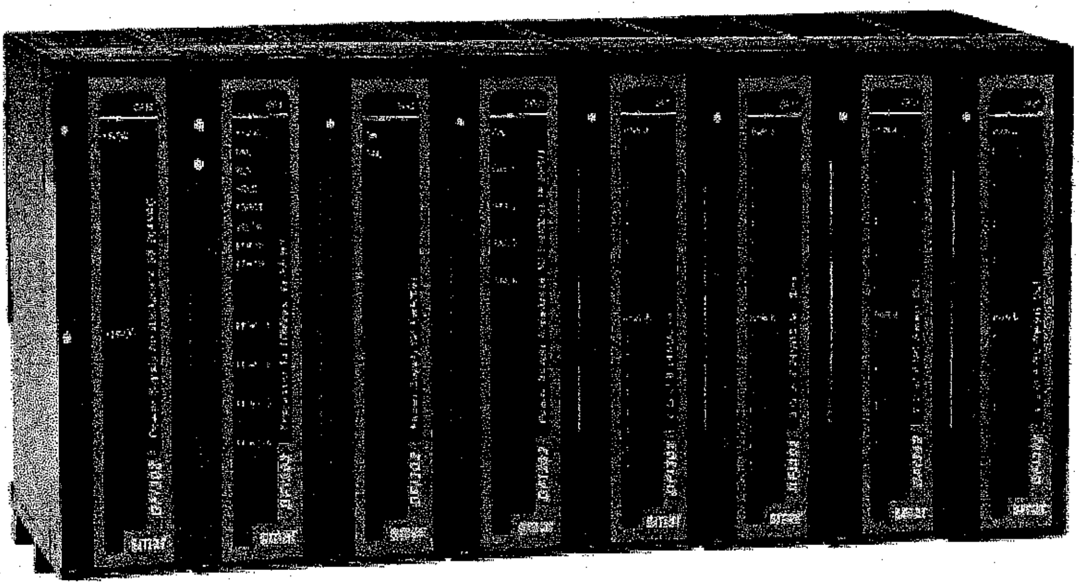
Figure 3.20 - Step 5 - LD302

NOTE

This Local adjustment configuration is a suggestion only. The user may choose his preferred configuration via SYSCON, simply configuring the display block (See Programming Using Local Adjustment.)

USER'S MANUAL

Fieldbus Universal Bridge



DFI302

FIRST IN FIELDBUS

Y / 02

I302

NDATION

DFI302ME

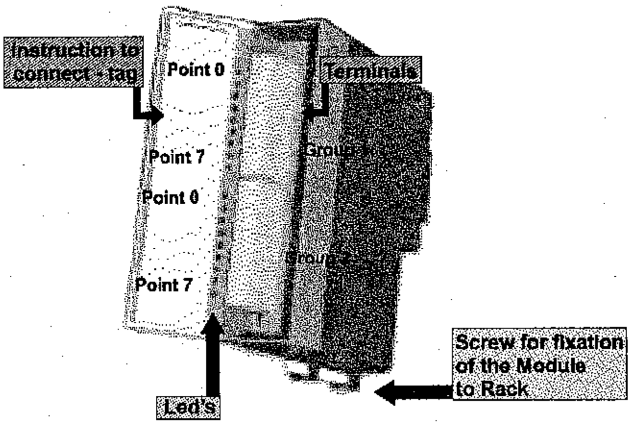
hapter 2 – Installing

RNING: Make sure to follow all the steps included in this chapter to avoid malfunction of the system.

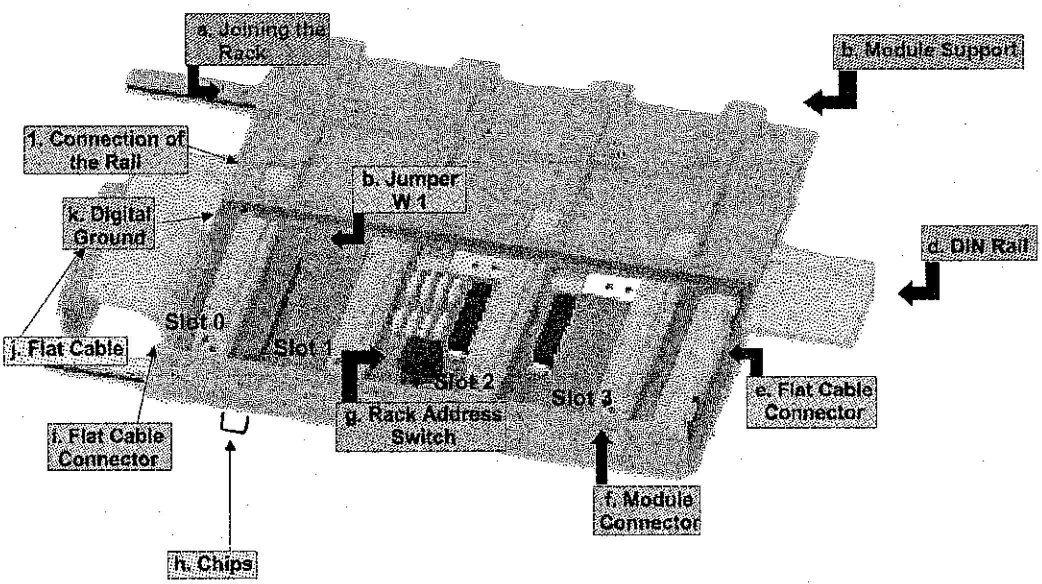
ing the Rack's and the Modules

See below the figures and descriptions of the Module and the Rack:

Module



RACK



a. **Joining the Rack** - when assembling more than one rack in a same DIN rail, uses the special metallic piece to link one rack to the other. This connection generates stability to the assembly and makes possible the digital ground connection (k);
b. ***Jumper W1*** – when connected, it allows that rack to be powered by the previous rack;
c. **Module support**;
d. **DIN Rail**;

e. **Flat Cable Connector** – When existing more than one rack in the same DIN rail, they must be hooked up by a flat cable (j) connected to the Flat Cable connectors (i) and (e);
f. **Module Connector**;
g. **Rack Address Switch**;
h. **Clips** - Used to fix rack in the DIN rail.;
i. **Flat Cable Connector (Inferior)**– When existing more than one rack in the same DIN rail, they must be hooked up by a flat cable (j) connected to the Flat Cable connectors (i) and (e);
j. **Flat Cable**;
k. **Digital Ground** – When there are more than one rack in the same DIN rail, the connection between digital grounds (k) must be reinforced through appropriate metallic piece;
l. **Connection of the Rail**;

nstall a Rack in the DIN rail

Locate the "Clips"on the bottom of the Rack;
Use a screw-driver (or your fingers) to pull them down;
Place the back of the Rack on the top of the DIN rail edge;
Accommodate the Rack on the DIN rail and push the clips up. You will hear a click sound when they lock properly;
Set the correct address for the Rack using the rotating switch at the Rack.
Notes: Addresses can NOT be repeated.

ling Racks (Local I/O Expansion)

Local I/O Expansion is the process of adding more Racks connecting them throught the Rack. A flat-cable is used for this purpose. Different sizes are available to reach different situations.
Connect the new Rack with the previous one by using a selected flat-cable;
Don't forget to place a terminator in the last Rack;
Set the address for the new Rack using the rotating switch;

v to install a Module

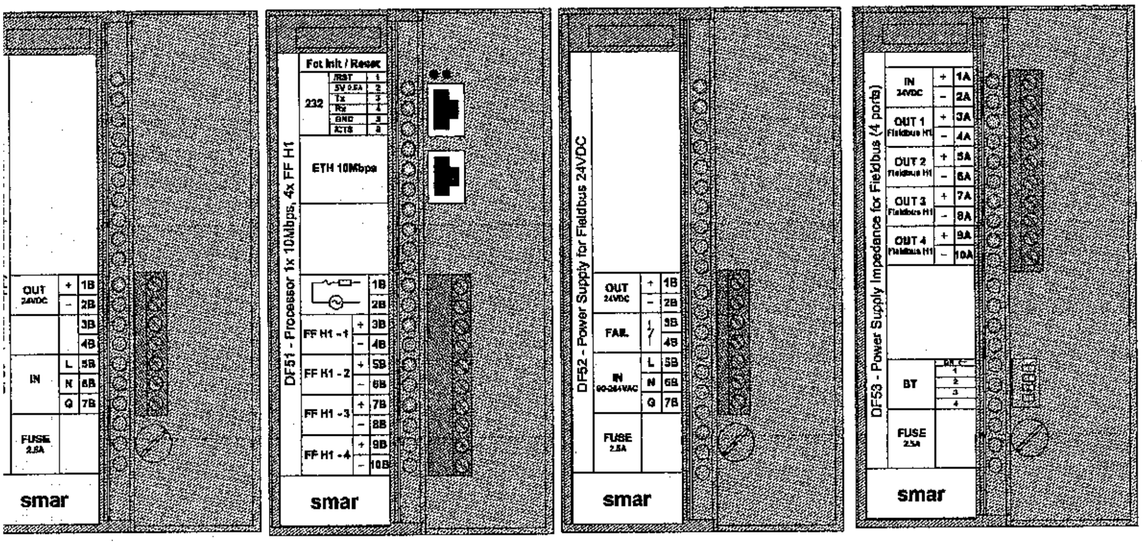
Locate the tab on the top of a free Slot in the Rack;
Mount the Module by inserting the tab in the "square hole" on the back top of the Module box.
Use is as a rotating latch!
Latch the Module on to the connector (slot) on the Rack by pressing it.
Use a screw driver to tie the Module in the rack with the locking screw located at bottom os the Module box.

S for the Assembly

In case you have more than a rack in the same module:
Leave to do the fixation in the DIN rail at the end of the assembly;
Keep free the slot 3 of rack to be able to establish connection to the following module for the connector of flat cable;
Verify intently the addresses configuration (addressing key), as well as the Jumper W1 and the cable of the BUS;
Remember that to give continuity to DC power supply of previous rack it is necessary that jumper W1 would be connected;
Make the amendment of racks and strengthens the digital ground of the hardware;

talling the Hardware

See the details of the view frontal of the modules:



Basic system DFI302 (frontal view - opened)

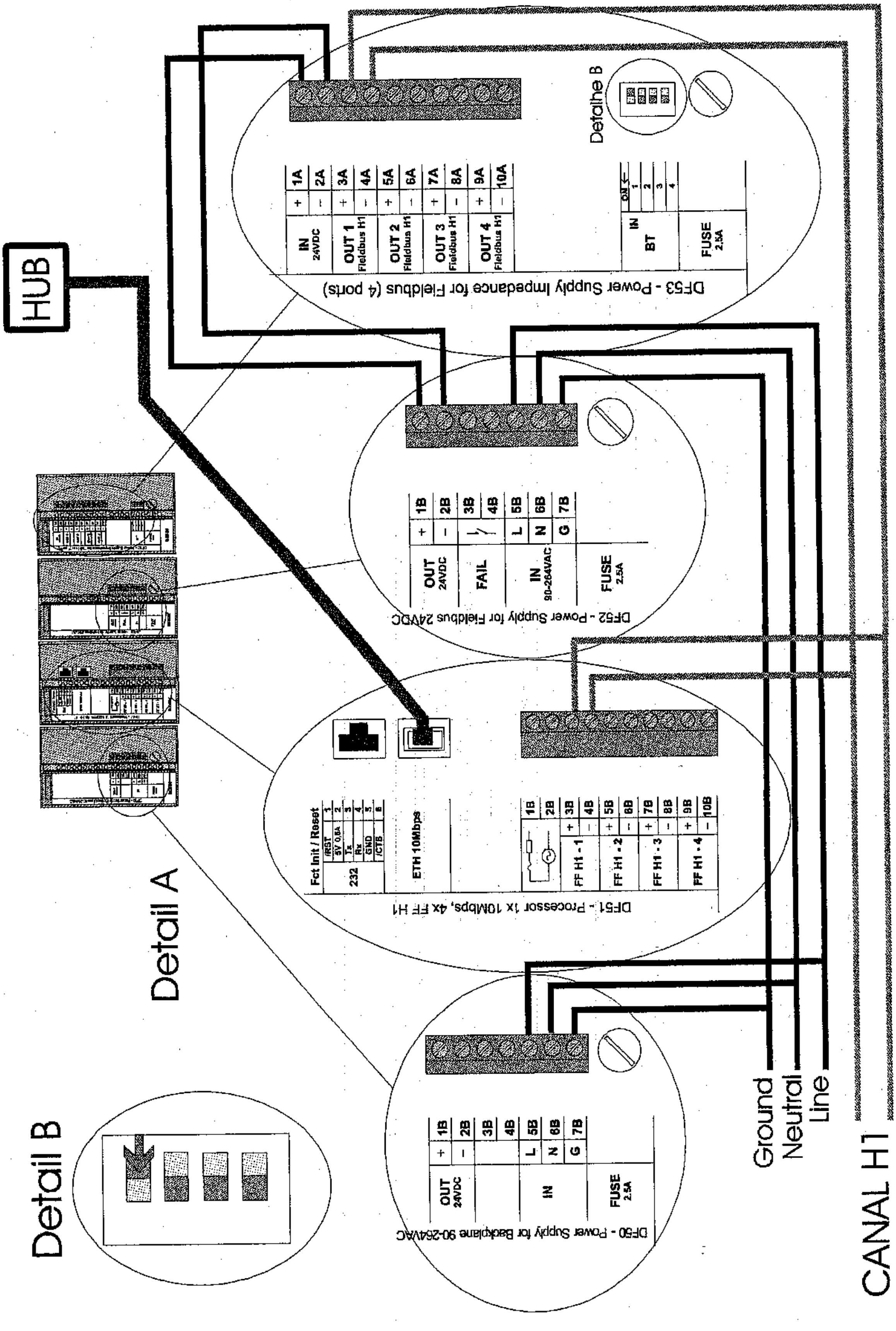
Shielded twisted-pair cable is used for wiring the DFI302's and hubs together. The DFI302's have simple RJ-45 connectors. No special tools or skills are therefore required. Installation is simple and very fast. LED's indicate active communication or failure.
You connect and disconnect without having to power down. The hub/switched based star topology means that you can disconnect devices without disrupting control or communication of other nodes.
The two types of existing cables enable connection DF51/hub (DF54 cable) or direct connection DF51/pc (DF55 cable). See the Chapter 5 for more details.

Basic Installation Tips:

1) Connect the four modules (DF50, DF51, DF52, DF53) plus the terminator (DF2) in the Rack (DF1).
2) Connect the AC in the DF50 and DF52 input.
3) Connect the DF52 output to the DF53 input.
4) Plug the 10BaseT - twisted pair cable, connecting DF51 to the HUB.
5) Connect the Fieldbus H1 bus in the DF51 and DF53 FF H1 ports.
6) DFI302 gets its IP automatically from DHCP Server but if one is not available, a fixed IP will be generated (192.168.164.100). This initial fixed address IP can be changed through FBTools (see the Topic " Connecting DFI302 in your Sub-Net");

Observe in the following figure:

In the **detail A** are shown the above mentioned electric connections, without the rack view (Rack DF1) and the terminator (DF2).
In **detail B** are shown the switches that enable the internal terminator for each Fieldbus H1channel In this example, we have only a Fieldbus H1 channel powered on, so the corresponding switch 1 is ON.



HUB
Detail A
Detail B
Detalhe B
DF53 - Power Supply Impedance for Fieldbus (4 ports)
IN 24VDC
OUT 1 Fieldbus H1
OUT 2 Fieldbus H1
OUT 3 Fieldbus H1
OUT 4 Fieldbus H1
1A 2A 3A 4A 5A 6A 7A 8A 9A 10A
IN BT
FUSE 2.5A
DF52 - Power Supply for Fieldbus 24VDC
OUT 24VDC
FAIL
IN 90-264VAC
1B 2B 3B 4B 5B 6B 7B
L N G
DF51 - Processor 1x 10Mbps, 4x FF H1
Fct Init / Reset
232
ETH 10Mbps
FF H1 - 1
FF H1 - 2
FF H1 - 3
FF H1 - 4
1B 2B 3B 4B 5B 6B 7B 8B 9B 10B
DF50 - Power Supply for Backplane 90-264VAC
OUT 24VDC
IN
FUSE 2.5A
Ground
Neutral
Line
CANAL H1

ıg the Fault Indication

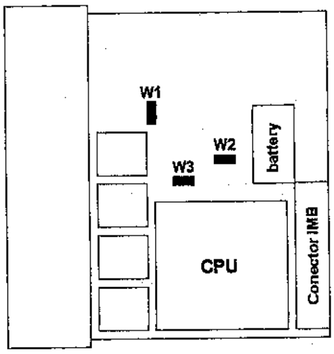
The 1B and 2B Terminals available in the DF51, may be used in a Fault Indication application. Actually, these terminals are only a NC Relay.

The NC Relay supports:

0.5A @ 125VAC
0.25A @ 250VAC
2A @ 30VDC

Normally, DF51 forces this relay to keep opened but if any bad condition crashes the Processor, the hardware will close the relay. This status may be used in redundancy situation where the backup Processor reads this contact and knows about the fault. Other possibility is using this contact to turn on an alarm.

ıpers on Board



The W1 Simulate jumper must be ON to enable simulation in the Simulate (SIMULATE_D or SIMULATE_P) parameter of output and input function blocks.

Do not use W2 and W3 jumpers because they are used to download programs in the factory.

ing the Fault Indication

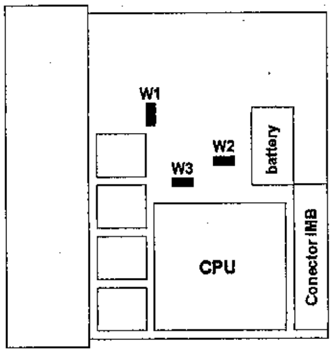
The 1B and 2B Terminals available in the DF51, may be used in a Fault Indication application. Actually, these terminals are only a NC Relay.

The NC Relay supports:

0.5A @ 125VAC
0.25A @ 250VAC
2A @ 30VDC

Normally, DF51 forces this relay to keep opened but if any bad condition crashes the Processor, the hardware will close the relay. This status may be used in redundancy situation where the backup Processor reads this contact and knows about the fault. Other possibility is using this contact to turn on an alarm.

mpers on Board

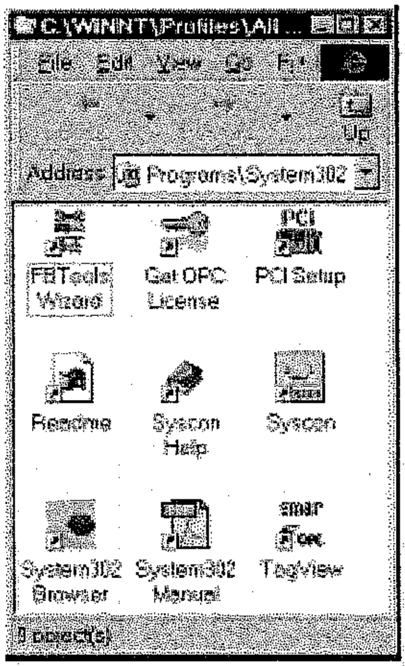


The W1 Simulate jumper must be ON to enable simulation in the Simulate (SIMULATE_D or SIMULATE_P) parameter of output and input function blocks.

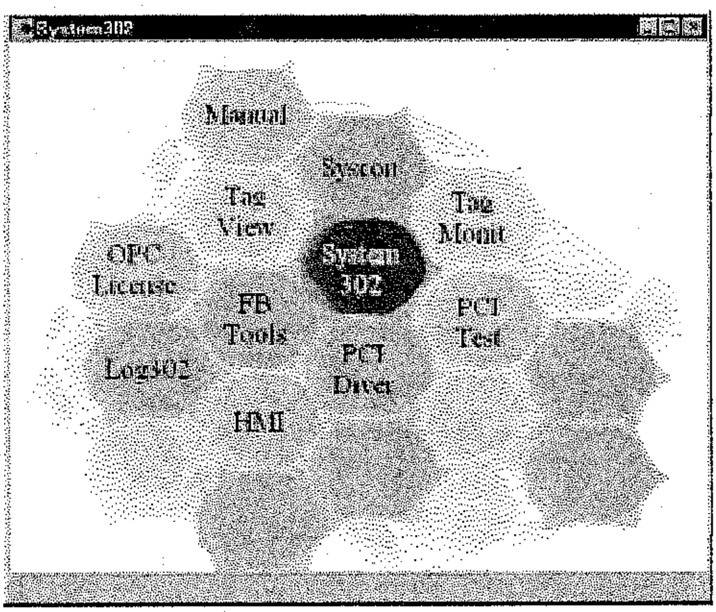
Do not use W2 and W3 jumpers because they are used to download programs in the factory.

Installing the System302

Install the software from the CD of System302. Verify if at the end of the installation the following folder is created:



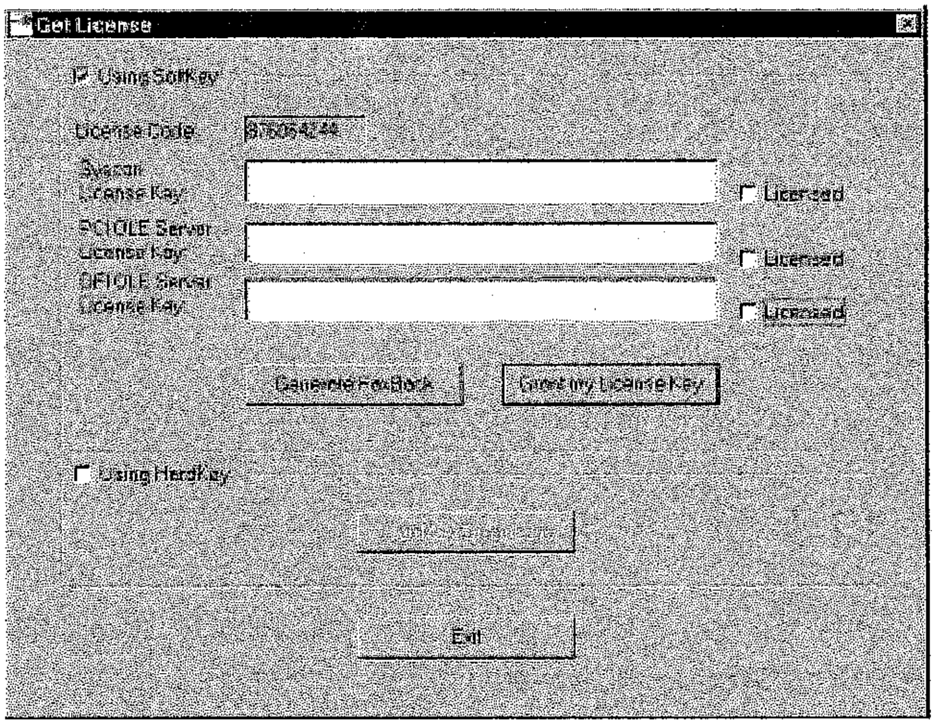
The softwares can be accessed by the shortcut "System302 Browser".



This shortcut gives access to the main applications of the System302.

tting the license for DFI OLE Server

Open "Get OPC License" in the System302 folder and generate the FaxBack to send to Smar.



Obtaining the return of FaxBack from Smar, with the Licenses Key's, type the codes in the blank fields (observe the last figure) and click the button " Grant my License Key ".
If the codes were accepted, messages will be generated confirming the operation success.
At this time, DFI OLEServer and/or PCI OLE Server and/or Syscon will be ready to be used.

nnecting the DFI302 in the Sub-Net

The environment to work with the DFI302 involves a network (Sub-Net) where IP addresses will be necessary for each connected equipment.
The automatic solution for attribution of these addresses, is called DHCP Server ***(Dinamic Host Configuration Protocol SERVER).***
Using DHCP Server these IP addresses are generated automatically preventing any problem as the attribution of equal addresses for two distinct equipment.

ATTENTION: To connect more than one DFI302, the following steps must be fully executed for each DFI302.

1- Connect the Ethernet cable DF54 of the module DF51 to its respective Sub-Net Switch (or HUB);

Note: For point-to-point connection (the module DFI302 linked directly to the computer) use crossed cable DF55.

2- Turn on the module DF51. Be sure that LED ETH10 and LED RUN are lit;

3- Keep firmly pressed the left Push-Button (Factory Init / Reset) and press the right Push-Button for three times, assuring that the Led FORCE is blinking 3 times for second.

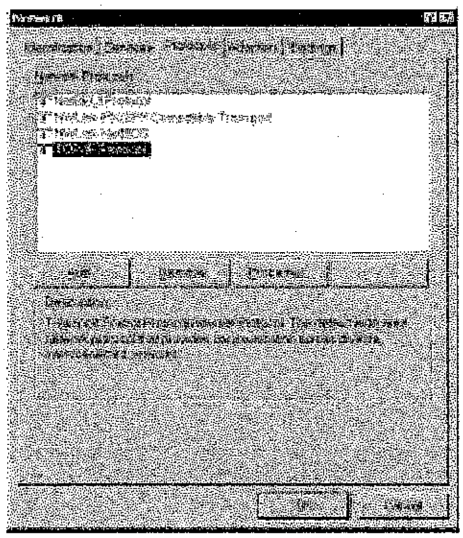
Note: If you lost the number of times that the right Push-Button was pressed, verify the number of times for second that the Led FORCE is blinking. It will turn to blink once a second after the fourth touch (the function is rotative);

4- Release the left Push-Button and the system will execute the RESET and subsequently will execute the firmware with the standards values for IP address and the Sub-Net Mask.

5- If your network has a DHCP server (consult the administrator of your network) the DF51 is already connected to your Sub-Net. Otherwise it will be with IP address 192.168.164.100 and you will have to execute the next steps;

The Network does not have a DHCP Server:
You need to change for a while the IP address of your computer (for this is necessary knowledge of network management). Enter in the Windows Control Panel - and choose the option Network;
Note: If the in the Network options is missing TCP/IP protocol, proceed the installation using the Windows setup.

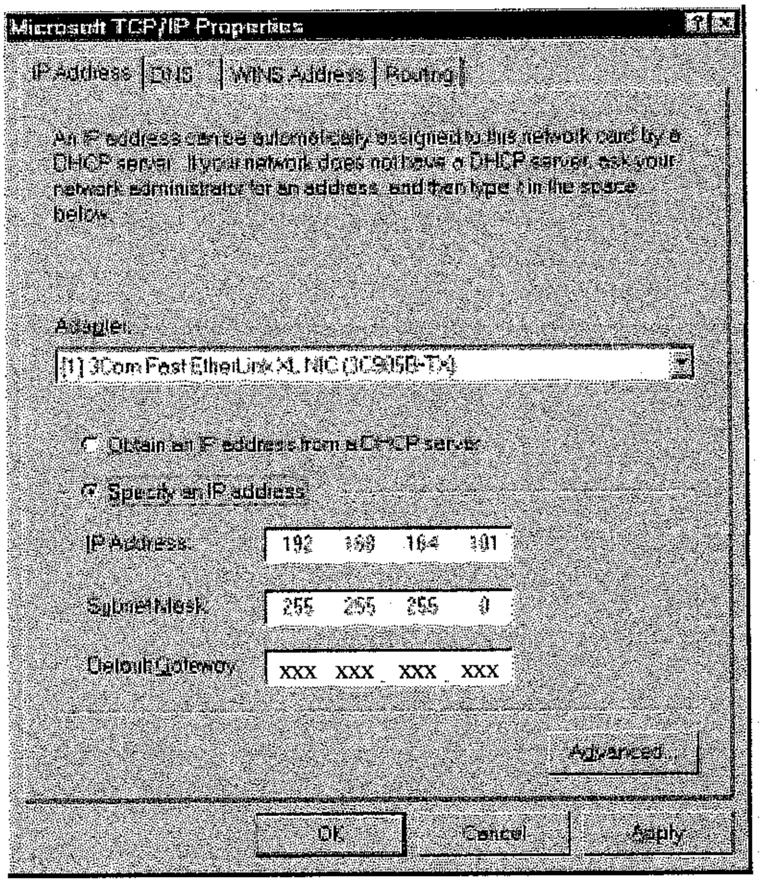
6- Now choose the Protocols folder (see the figure below) and TCP/IP Protocols and click in the Properties button;



7- Take a note of the original values of IP address and Sub-Net Mask of the computer to restore them at end of the operation.

8- Change IP address and the Sub-Net Mask of the computer, for it to be in the same Sub-Net of DFI302. The network administrator must supply the IP address.

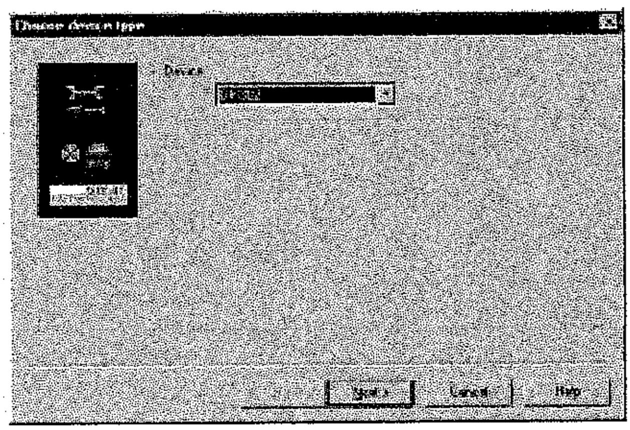
Note: The values will be something like: IP Address 192.168.164.XXX and network mask (Subnet Mask) 255.255.255.0. Keep the default gateway value.



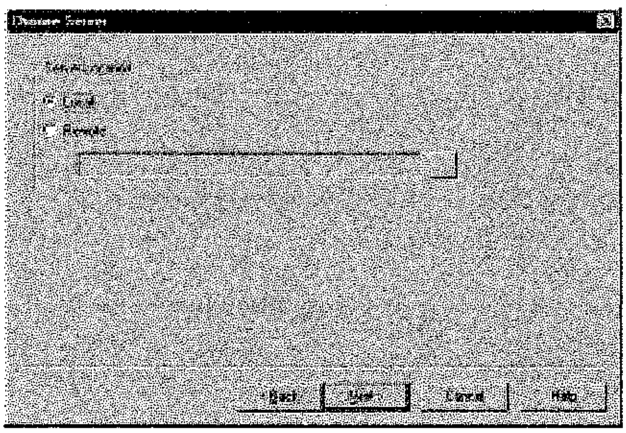
ATTENTION: Do not use the address 192.168.164.100. This is already used as DFI302 ***default*** address.

9- Click in the apply button;

10- Execute the FBTools Wizard. Choose the DFI302 device and click " Next ";

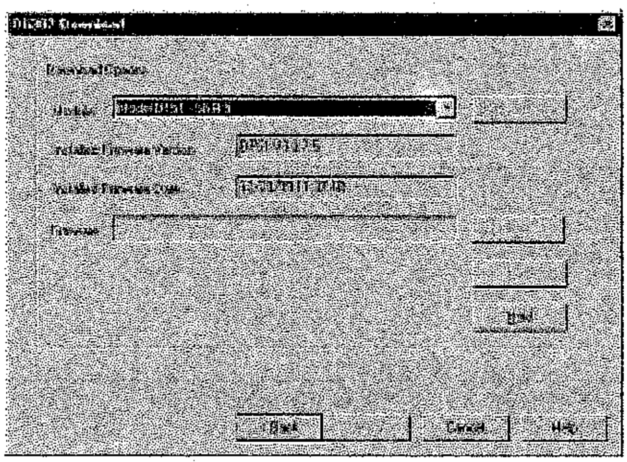


11- Choose the DFI OLEServer path to be used (default: Local) and click " ***Next*** ";



12- Select the desired DF51 module in the option "Module" using its serial number as reference which you could locate in the external identification label;

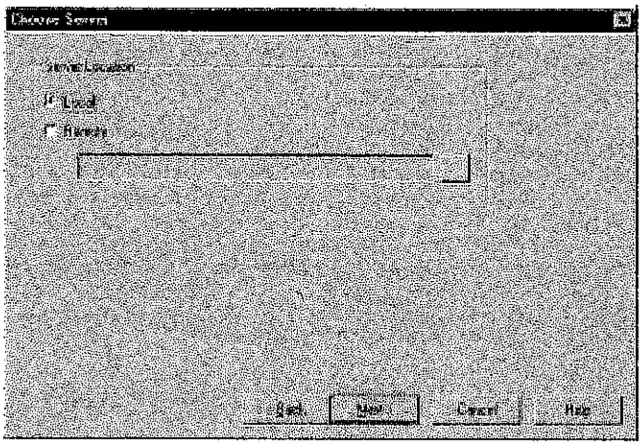
ATTENTION! The non-observance of this step may imply in serious consequence



13- Press the button " Hold " to interrupt the Firmware that is being executed in DF51 module;

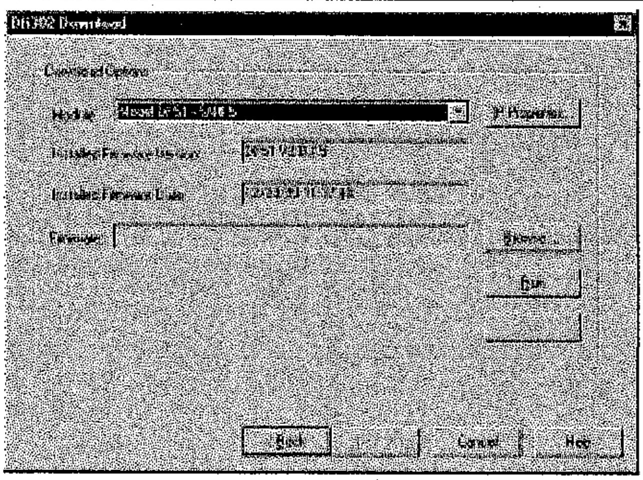
14- After you choose Hold of DF51, the module won't be more executing Firmware and therefore it will stop all its activity in the Fieldbus line. Confirm the operation on the screen;

15- Check if HOLD Led is lit. After interrupting the execution of Firmware press " Next " to continue with the procedure;



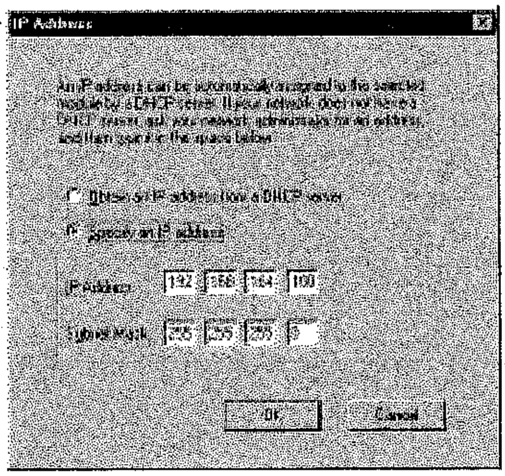
16- Select the desired DF51 module.

ATTENTION! The non-observance of this step may imply in serious consequence.



17- The default option is the attribution through a DHCP Server. Click in the option " Specify an IP address ";

18- Enter IP Address and the Sub-Net Mask;



ATTENTION: Avoid to use the address 192.168.164.100 (DFI302 default address).

TIP: Write down the IP addresses that will be specified and the serial Numbers of each DF51 module. It will help in the identification and diagnostics of possible faults.

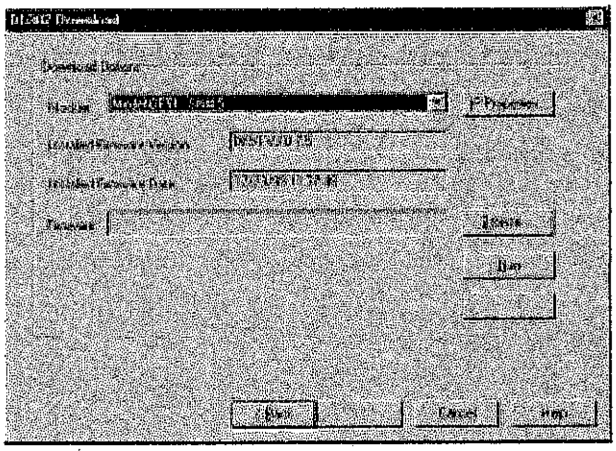
19- Click " **OK** " to finish the operation;

20- Return to the screen of TCP/IP properties of your computer and restore the original values of IP address and Sub-Net Mask;

21- After returning the original IP address, the process will return in the following screen. Type " **Next** " to go the next screen and to put the Firmware in execution in DFI302 again;

22- Select DF51 module;

ATTENTION! The non-observance of this step may imply in serious consequence.



23- Click " **Run** " to execute DFI302 Firmware again;

24- Click " **Cancel** " in the screen " Choose Server " to finish the operation of IP Attribution;

25- In DOS prompt, type C:\>arp - d 192.168.164.100 <enter> (see the observation below)

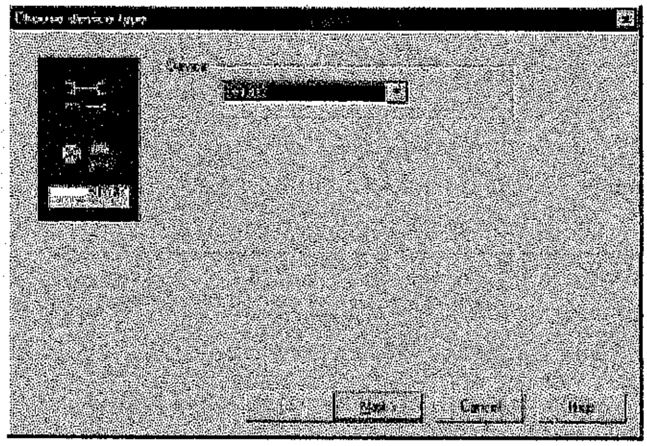
26- End of the procedure of Connection of DFI302 in your Sub-Net, for others modules repeat this procedure.

Observation: In case that you have to configure more than one DFI302, execute the following command to clean ARP table, before passing to the next DFI302 configuration. C:\>arp - d 192.168.164.100 < enter >

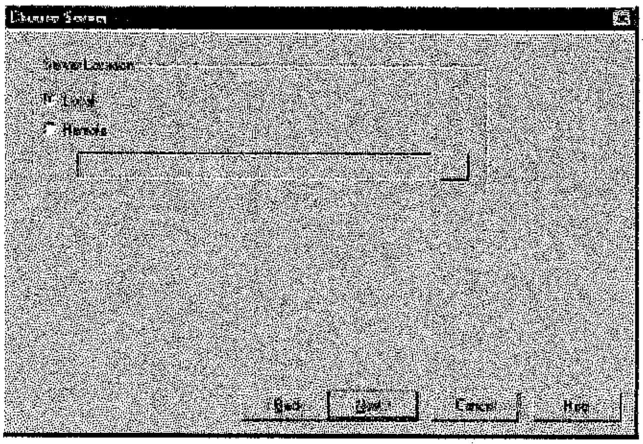
hapter 3 - Configuring

dating the Firmware

1. Assure that the DFI302 is on and it has been connected in the Sub-network using the procedure "Connecting the DFI302 in the Sub-network";
2. Execute the FBTools Wizard.exe, (located in the directory of Smar work, generally "drive:\Program Files\Smar\FBTools\FBTools Wizard.exe", through the shortcut "FBTools Wizard" in the folder of Smar work);
3. Choose the device DFI302 in the drop down menu and click "Next";

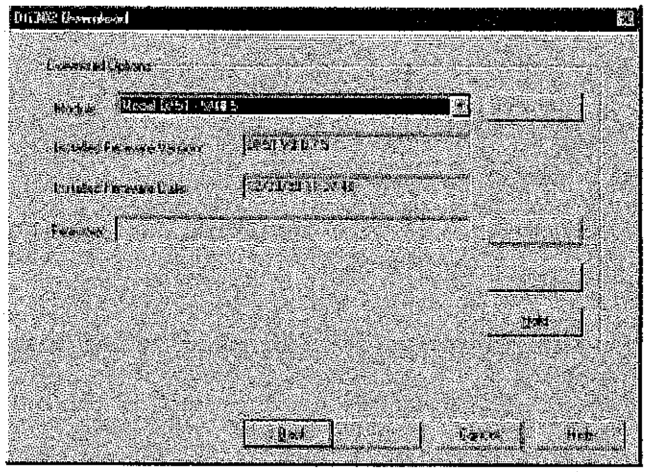


4. Choose the DFI OLE Server path to be used (default: Local) and click the button "Next ".



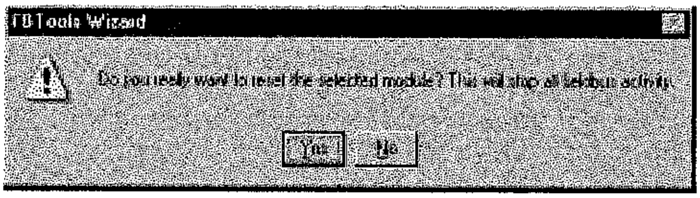
5. Using the drop down menu, choose the DF51 module desired in the" Module " option using the serial number as the reference (verify the proper DF51 module has been chosen by checking the lateral labels below the drop down menu).

ATTENTION! The non-observance of this step can imply in serious consequences.

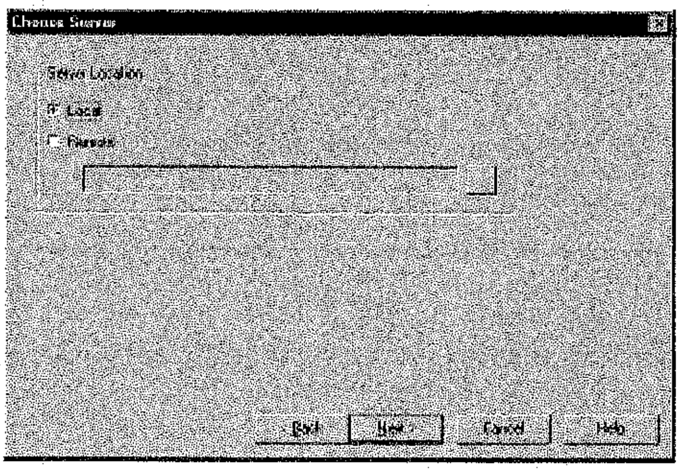


6. To continue, it will be necessary to interrupt the Firmware that is being executed in the DF51 module by clicking the button "Hold";

7. After the DF51 Hold, the module will not be executing the Firmware and therefore all activity in the Fieldbus network will be stopped. Confirm this operation by clicking "Yes" in the window shown below.

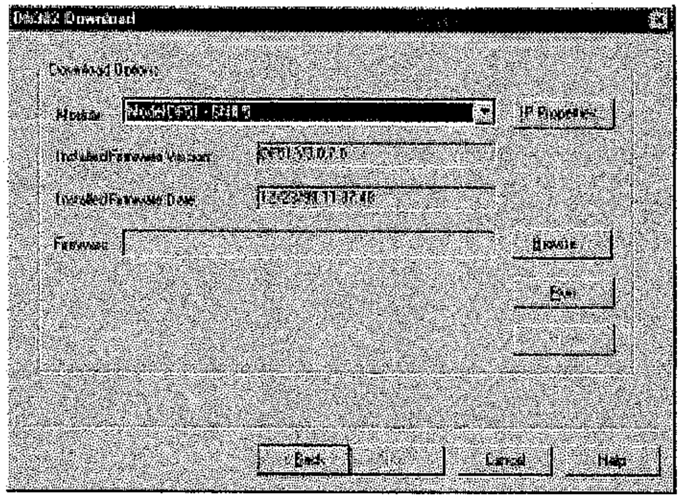


8. Check to be sure that the "Hold" LED is lit. After stopping the Firmware execution in the Module (Hold) , the following window will be displayed. Click "Next."



9. Using the drop down menu, choose the desired DF51 module in the option " Module " using the serial number as reference (verify the proper DF51 module has been chosen by checking the lateral labels below the drop down menu).

ATTENTION! Not completing this step may result in serious consequences.

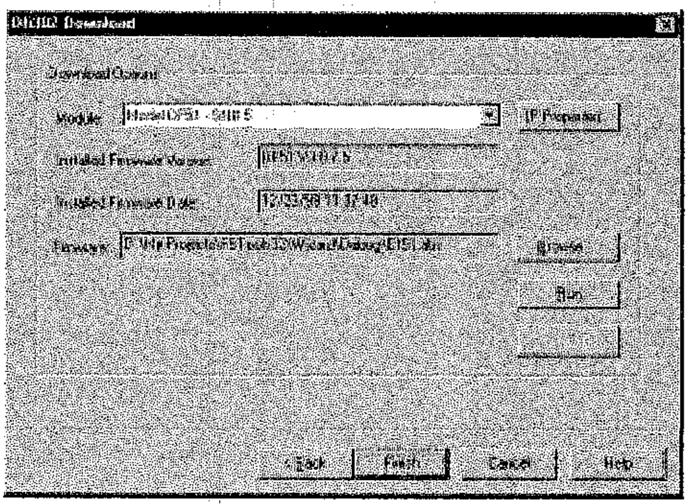


Observe that this window displays the version information (Firmware Version Installed) and the Firmware date (Firmware Date Installed) currently loaded in DF51 module;

10. Click the button " Browse... " to choose what firmware file will be loaded (DF51*.abs file);

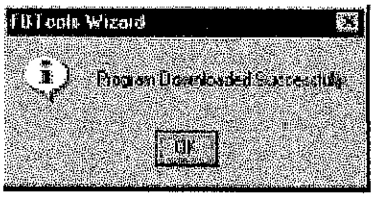
Firmware Version	Description
DF51Vxyzw.abs	LAS Active in the startup
DF51VxyzwR.abs	Used for redundance LAS Passive in the startup (Use DFI-TRD-xx Transducer block to set it Active or Backup)

11. After using the drop down menu to choose the archive to be loaded, click the button "Finish" to initiate the firmware download;

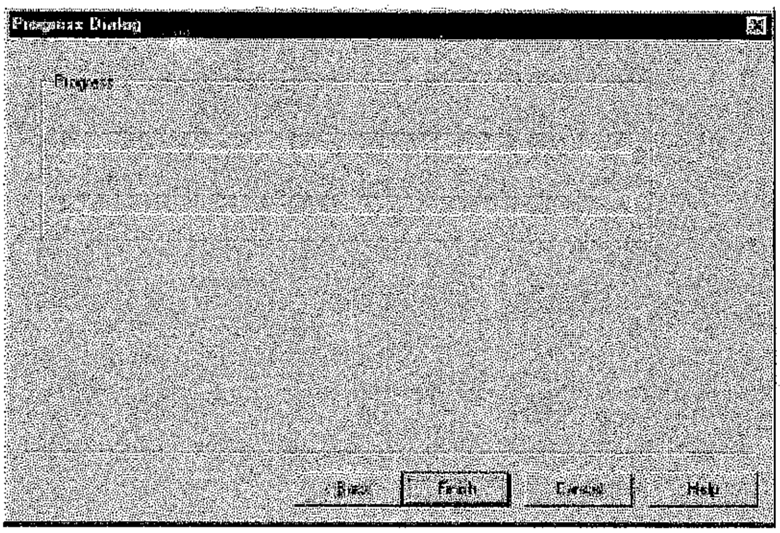


12. The window displaying the progress of the download will appear during the download process as shown below.

13. When the download is completed, a status window will appear with the message "Program Downloaded Successfully." Click "OK" in the window shown below to continue. At this time, the DFI302 will be in the " Run Mode " already. (Make sure that the RUN LED is lit);



14. To Finish click "finish " in the following window.

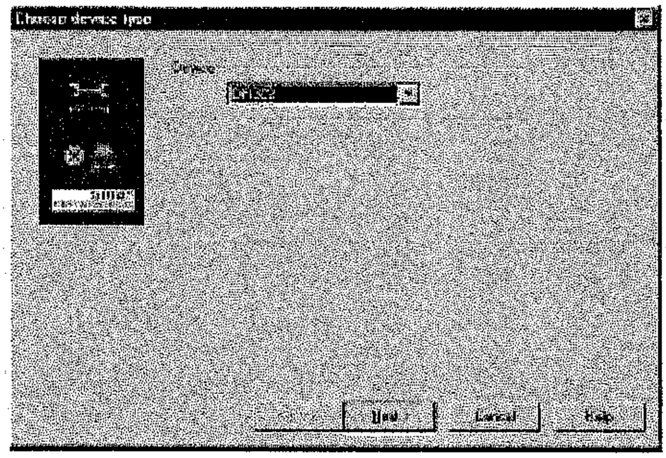


COMMENT: Consult the Product Manual for more information about FBTools

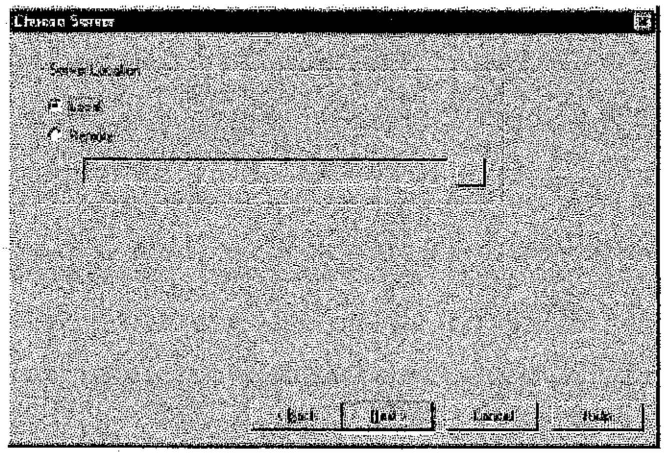
odifying IP address

To change the DFI302 in the Sub-network, the procedure " Connecting the DFI302 in the Sub-Network " (described in chapter 2) must be executed. To change only the IP address, execute the following steps:

1. Assure the DFI302 is on and that it has been connected to the Sub-Network. If it hasn't, run the procedure " Connecting the DFI302 to the sub-network" before continuing.
2. Execute the FBTools Wizard, (located in the directory of Smar work, generally "drive:\Program Files\Smar\FBTools\FBTools Wizard.exe ", through the shortcut " FBTools Wizard " in the folder of Smar work);
3. Choose the DFI302 device in the drop down menu and click " Next ";

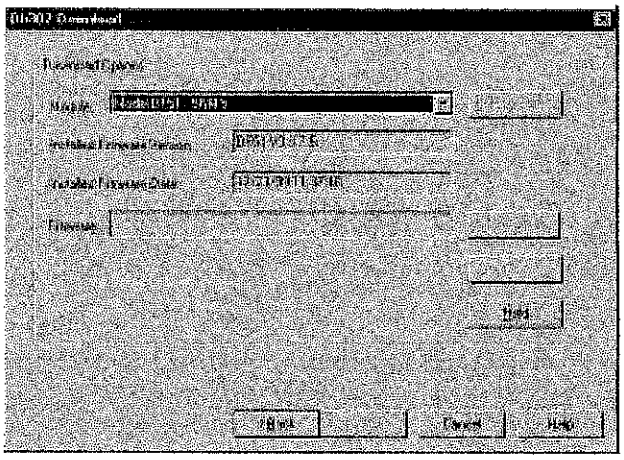


4. Choose the DFI OLE Server path to be used (default: Local) and click the button " Next ";



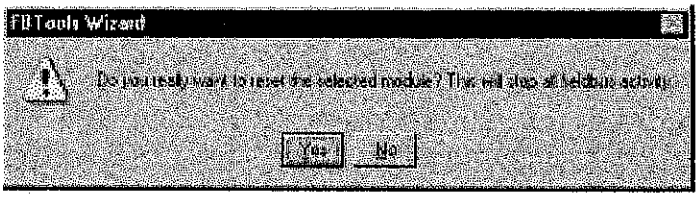
5. Using the drop down menu, choose the desired DF51 in the option " Module " using the serial number as reference (verify that the proper DF51 module has been chosen by checking the lateral labels below the drop down menu).

ATTENTION! Not completing this step may result in serious consequences.

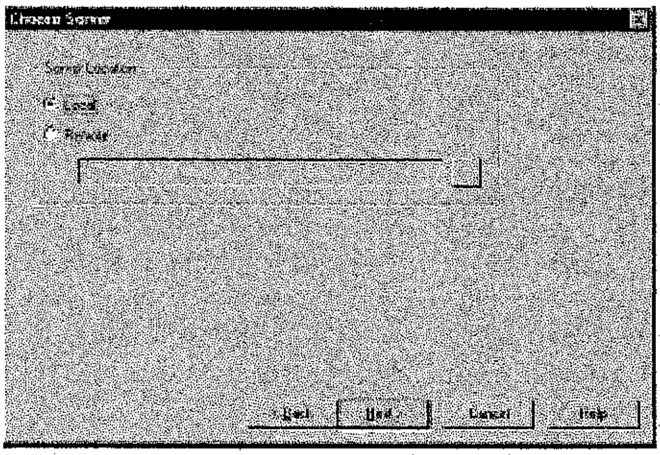


6. To continue it will be necessary to stop the Firmware that is being executed in the DF51 module by clicking the button " Hold ";

7. After the DF51 Hold, the module will not be executing the Firmware and therefore all activity in the Fieldbus network will be stopped. Confirm this operation by clicking "Yes" in the window shown below.

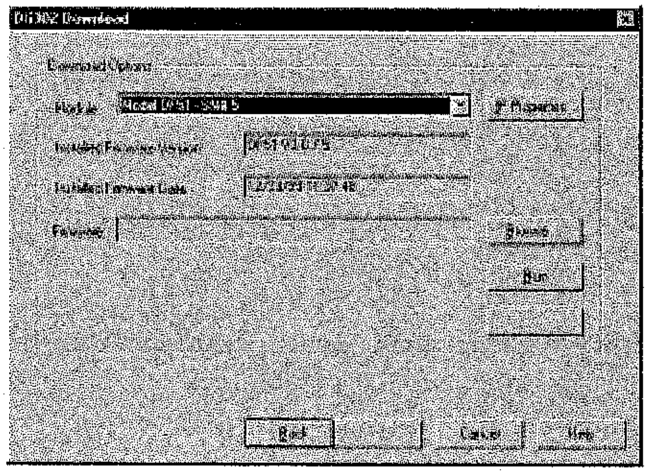


8. Verify that the HOLD LED is lit. After finishing the Firmware execution in the Module (Hold) the following window will appear again. Click " Next " to continue the procedure;

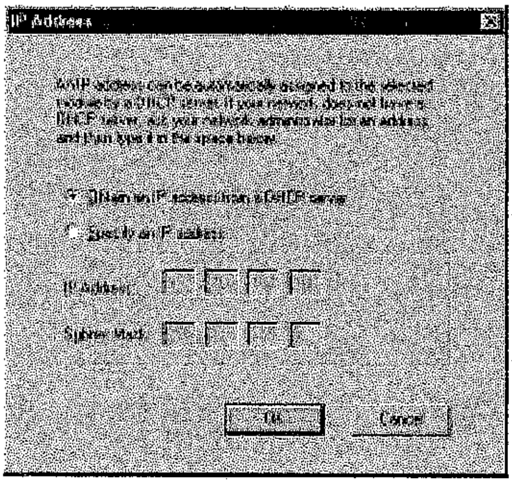


6. Using the drop down menu, choose the desired DF51 in the option " Module " using the serial number as reference (verify that the proper DF51 module has been chosen by checking the lateral labels below the drop down menu).

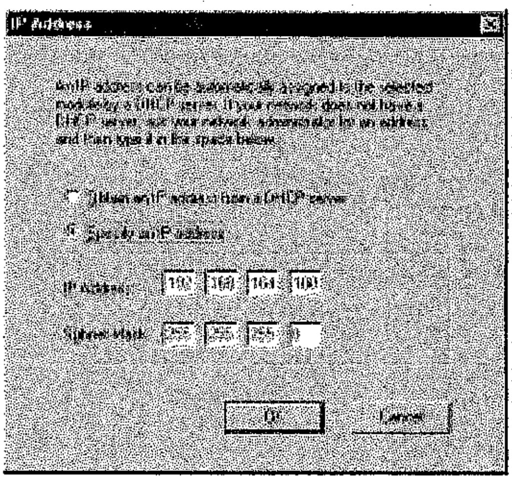
ATTENTION! Not completing this step may result in serious consequences.



10. Now we have the opportunity to set the IP address attribute by clicking the button " IP Properties... ";



11. The default attribute is through a DHCP Server. Click the option " Specify an IP address " to choose a different IP address



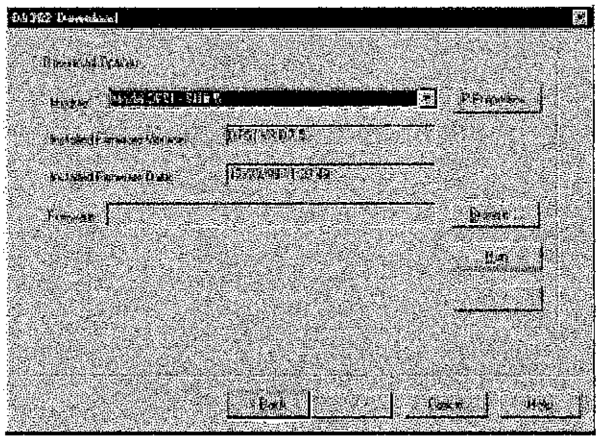
12. Type the IP Address and the Sub-Network Mask (provider by the network administrator) that will be associated with the DFI302.

ATTENTION: Do not use the address 192.168.164.100 because this is the standard address used for the DFI302. In addition, be sure that the chosen address is not in use.

TIP: Take note of the IP address attributes and relate them to the serial numbers of each module DF51, this will help in the identification and diagnosis of possible faults later.

13. Click " OK " to finish the operation.

14. After setting the new IP address attribute, the process will return the window, "Choose Server ," shown below. Click " Next " to return to executing the Firmware in the DFI302 again.



15. Using the drop down menu, choose the desired DF51 in the option " Module " using the serial number as reference (verify that the proper DF51 module has been chosen by checking the lateral labels below the drop down menu).

ATTENTION! Not completing this step may result in serious consequences.

16. Click " Run " to return the Firmware to executing in the DFI302 again;

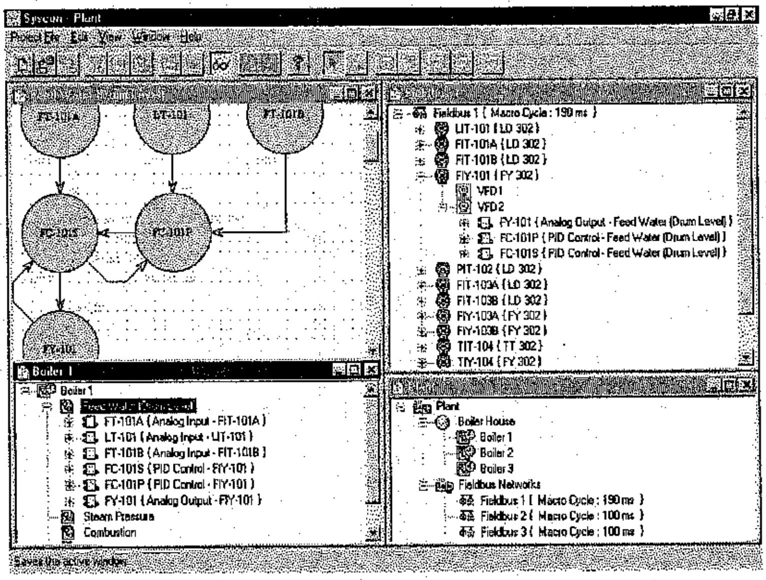
17. Click "Cancel" in the window " Choose Server " to complete assigning the IP attributes.

18. This ends the setting of the IP address attributes.

nfiguring the DFI302 by Software

ATTENTION: The DFI302 can be configured by Syscon, to assure that the procedure "Connecting the DFI302 in the Sub-Network" has been completed successfully.

The **DFI302** is fully configured through the Function Blocks available in the Fieldbus Foundation standard. This allows for all systems (DFI302 and field equipment) to be fully configured by only one application. Process Control, inter-tracking Logic, Prescriptions, Alarms, Calculations and Equations can all be configured in one environment.



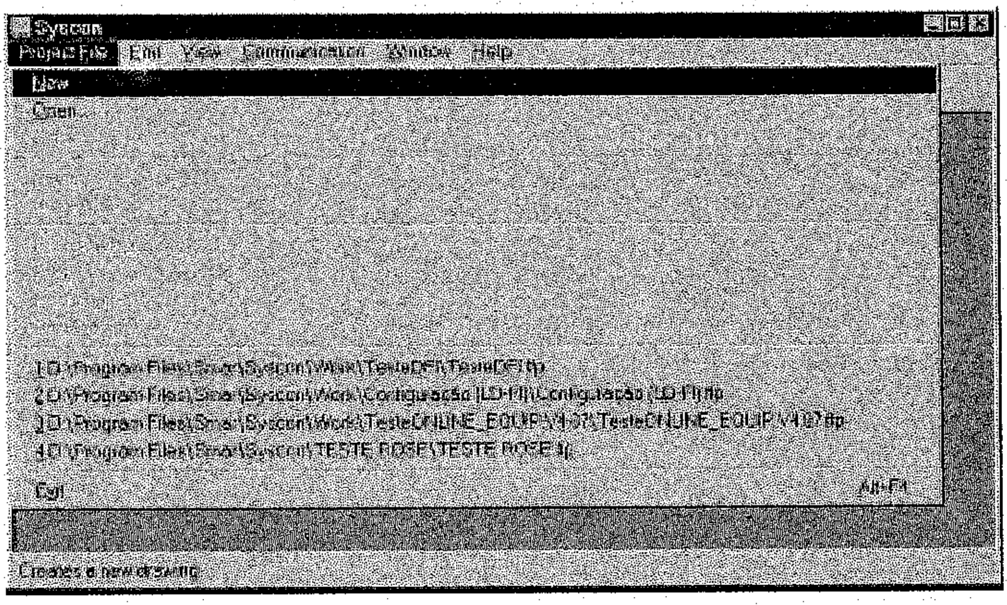
To see the plant, go surfing at the network of the equipment and control strategies in SYSCON software.

The **DFI302** works with the SYSCON configuration and maintenance software using the plug-'n'-play feature to detect, to identify and to set the address attributes for the connected, removed or malfunctioning devices. Once connected to the Ethernet through a firewall or a workstation, the **DFI302** is detected and then given either a fixed or variable IP address attribute depending on the FBTools adjustment procedure. This eliminates any problems with micro-switches (Dip-switches) or address duplications.

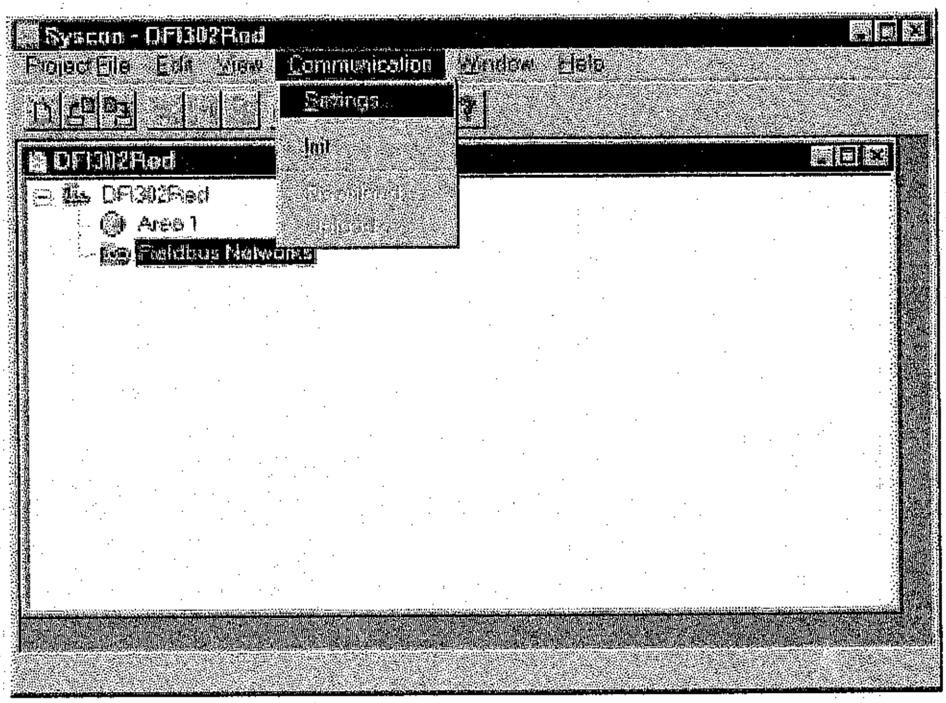
reating a New Plant

Verify that the System302 package (contained within Syscon) was installed.

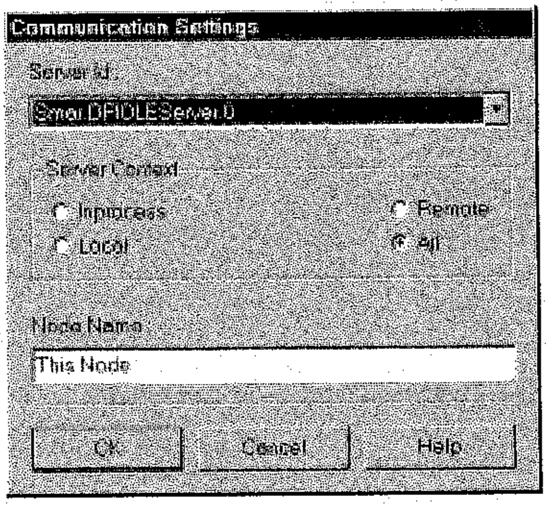
1. Once Syscon has been installed, execute application number one:
2. In the main window choose Project File - > New



3. Choose Projects and assign a name to the new plant;
4. Configure the application number so that it uses the DFI OLE Server;
5. In the Main Window choose Communication - > Settings;



6. Choose the Smar.DFIOLEServer.0 for the parameter Server Id in the drop down menu and click OK;



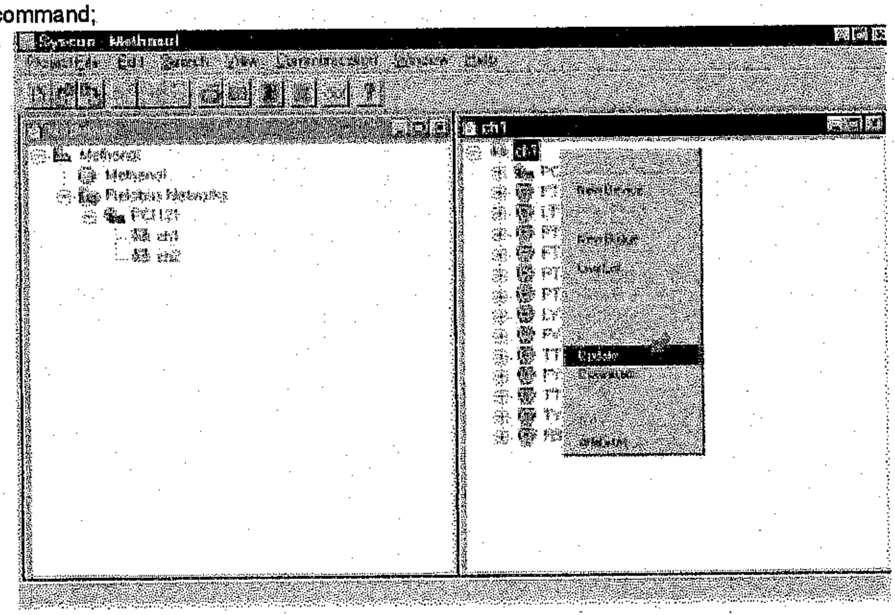
7. Add all the Fieldbus channels to be used;
8. In DFI302 device, add the Transducer and Resource blocks;
9. Set the configuration of the Device to "Off line";
10. The basic part of the DFI302 configuration is now ready;

The others procedures are in the Syscon manual in greater detail.

ownloading Configuration

ownload to the Fieldbus Network

1. Assure that the live list is showing all the Field Devices with Tags and Addresses smaller than 0x30, otherwise execute ASSIGN TAG to them;
2. Press right button of the mouse over the desired Fieldbus Network and execute UPDATE command;

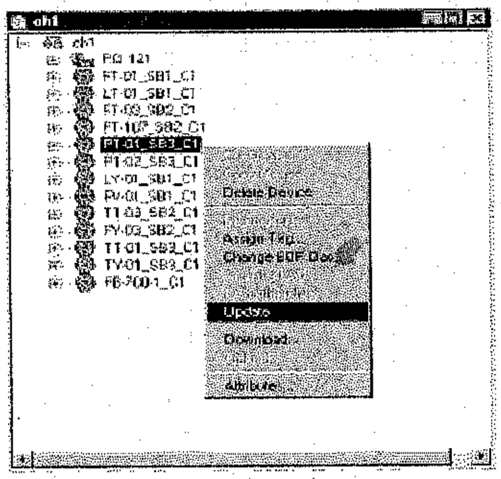


3. Wait for the live list to be completed;
4. Press right button of the mouse over the desired Fieldbus Network and execute DOWNLOAD command;

5. Make sure to save the Syscon Configuration to permit future Partial Download. In general it is necessary to change something in the configuration to enable the "save" icon. This procedure will not be necessary in the coming Syscon versions but the Syscon 4.0x versions need it yet.

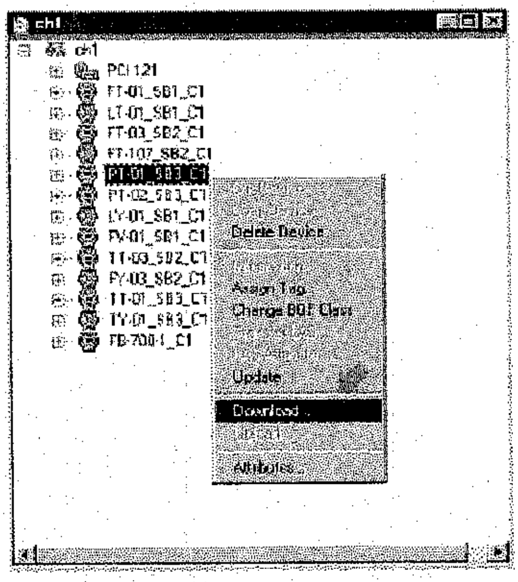
rtial Download to the Field Device

6. Make sure you "saved" the configuration after a complete download, otherwise the Partial Download will not work. See details on the "Download to the Fieldbus Network" steps.
7. Assure that the live list shows the desired Field Device with TAG and ADDRESS smaller than 0x30 otherwise, execute ASSIGN TAG to them;
8. Press right button of the mouse over the desired Field Device and execute UPDATE command;



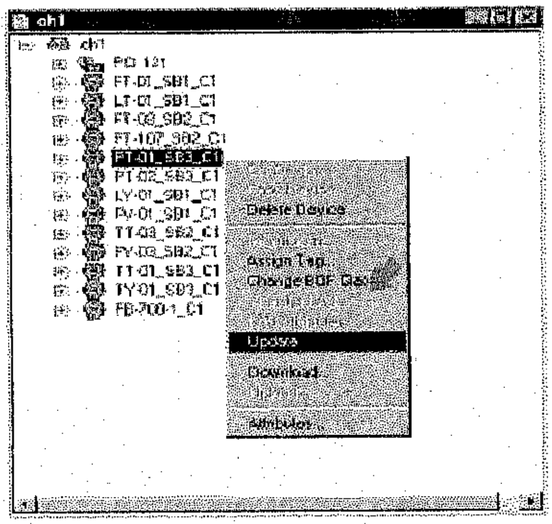
9. Wait for the live list to be completed;

10. Press right button of the mouse over the desired Field Device and execute DOWNLOAD command.

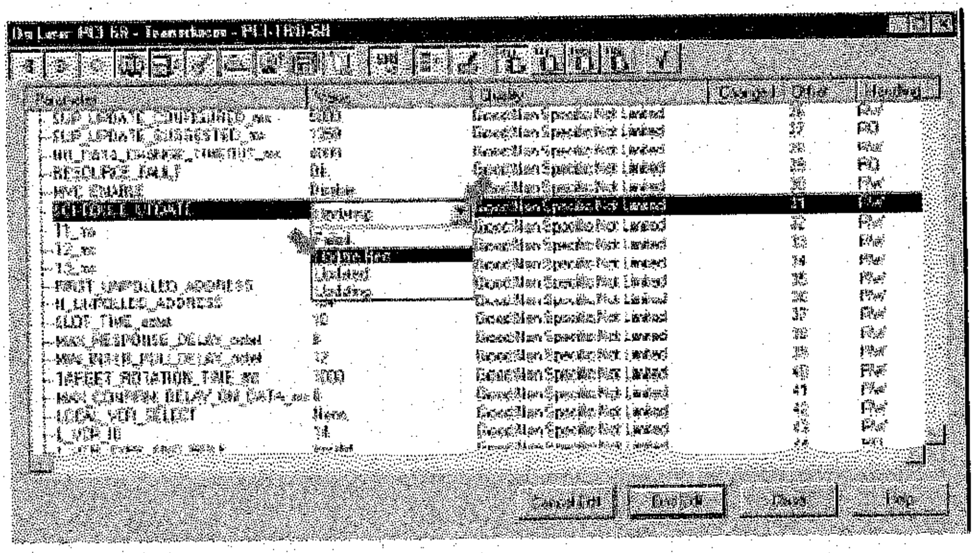


rtial Download to the Bridge

11. Make sure you "saved" the configuration after a complete download, otherwise the Partial Download will not work. See details on the "Download to the Fieldbus Network" steps.
12. Press right button of the mouse over the desired Bridge and execute UPDATE command;

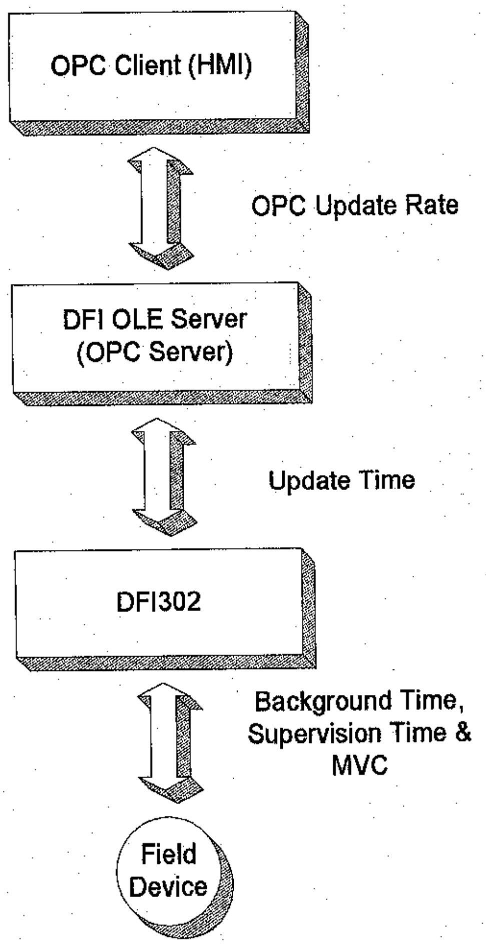


13. Wait for the live list to be completed;
14. Press right button of the mouse over the desired Bridge and execute DOWNLOAD command;
15. Choose On Line Characterization for the Bridge transducer block and change the parameter SCHEDULE_UPDATE to Update Req. Click End Edit... The SCHEDULE_UPDATE parameter will not stay in Update Req permanently, it will go to Updating and then to Updated.



ptimizing Supervision

There are some important steps included in the DFI302 configuration that could improve the supervision time. Just before to go to the procedures, a brief description for the System302 architecture is presented to make easier to understand where each parameter configured takes effect.



Taking a look on the previous architecture, we are able to follow the data since the source (Field Device) until the destination (HMI). Starting from the Field Device, the data source is collected by DFI302 during the **Background** time included in the Fieldbus Macrocycle. When using **MVC** (Multiple Variable Container), these data are grouped in an optimized way. The **Supervision Time** controls the rate that a MVC is read from the Field Device. Each **Update Time**, DFI302 sends the data to DFI OLE Server which updates its database. All the OPC Groups will be updated according the **OPC Update Rate**.

Following are the steps to be configured in order to get a better and optimized time for each system.

ckground time

Tune the background time (or background traffic) is one of the first steps to do. The Syscon configurator calculates the Macrocycle according the number of links in the configuration and permits the user to add the Background time. Although Syscon adds a minimum value automatically, is necessary to calculate the ideal background to each Fieldbus Network. There is a role to calculate the Background time based on the formula used to calculate the Fieldbus Macrocycle. Operational and Background Traffic compose the Macrocycle.

The ideal Macrocycle for non-Redundant Systems is:

*Ideal Macrocycle non Red = ((30*NDEV)+(30*NEL))*1.2*

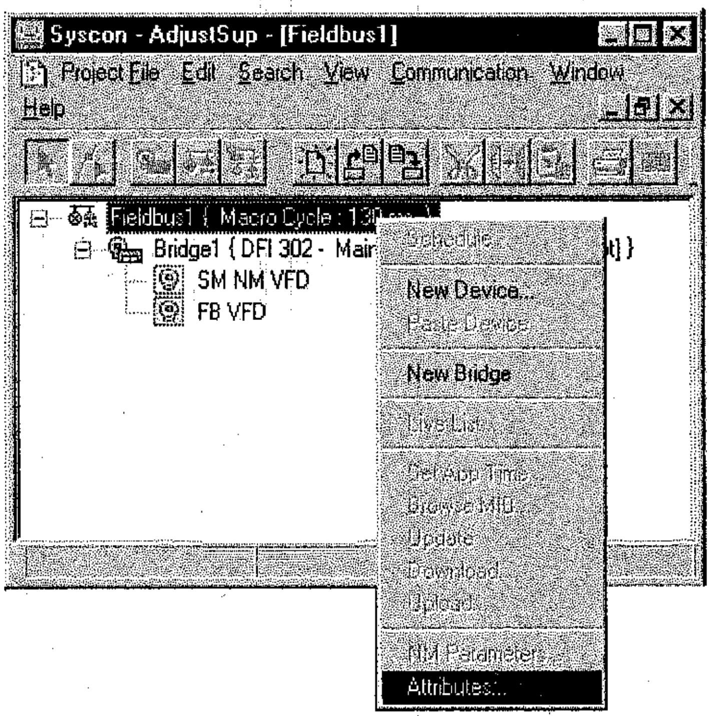
The ideal Macrocycle for Redundant Systems is:

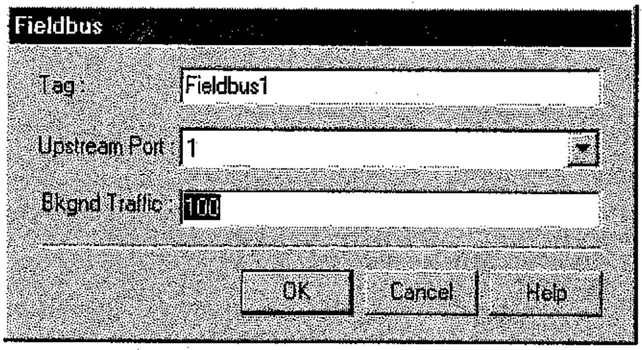
*Ideal Macrocycle Red = ((60*NDEV)+(30*NEL))*1.2*

Where, NDEV is the Number of Field Devices in the Fieldbus Network
NEL is the Number of External Links (between Field Devices)

Knowing the Ideal Macrocycle, go to Fieldbus Attributes under Syscon and adjust the background time until Syscon shows the desired Macrocycle on the screen.

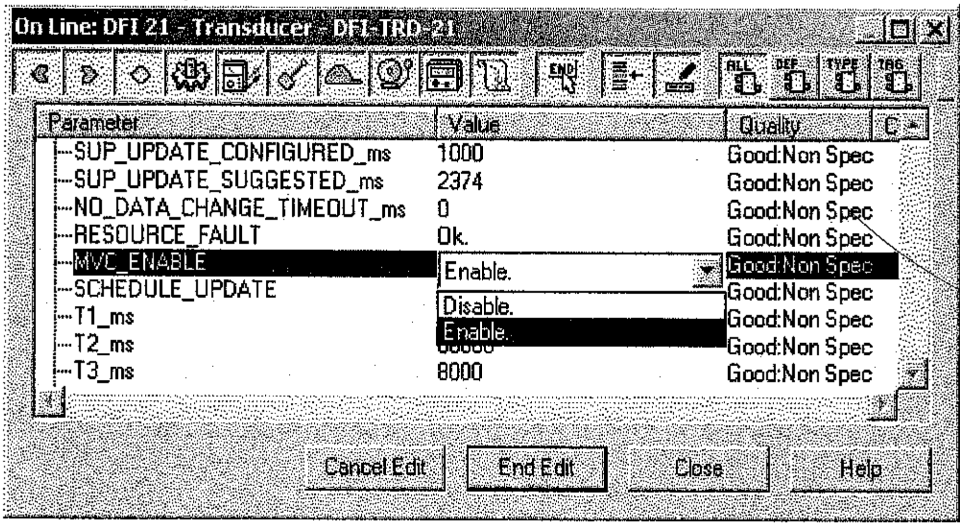
IMPORTANT: After completed the adjust in every Fieldbus Channel, run a complete configuration download.





/C

Multiple variable containers, is a data container that will have all the Data of a Device. If it is disabled, the Data are sent through block views. Each block has 4 views, which gives a lot of overhead to the communication.
The MVCs come to optimize this communication sending only one big packet per device instead of 4 small ones per block. Just set the MVC_ENABLE parameter inside the DF51 Transducer Block to "Enable" this feature. All the changes done on this parameter takes effect after new Supervision startup.



pervision Time

The Supervision Time is the time required for the DFI302 to acquire the entire field device's Data destined for the supervision workstation. Remember that this data is sent through the Background time part of the macrocycle part. During the Supervision time the interface device completely refreshes its internal database. So, it only makes sense to be performed in a system that is already up and running, together with all HMI (Human Machine Interface) software involved.

The DFI302 transducer block has three (3) other parameters that are also used to optimize the supervision in System302.

- Parameter 1: SUP_UPDATE_CONFIGURED_ms
- Parameter 2: SUP_UPDATE_SUGGESTED_ms

These two parameters define the time that the bridge has to poll the supervision data from the Devices. Start configuring the SUP_UPDATE_CONFIGURED_ms as 2 times the Ideal Macrocycle. After 10 minutes approximately, the parameter SUP_UPDATE_SUGGESTED_ms will indicate an optimal time and a change may be done again.

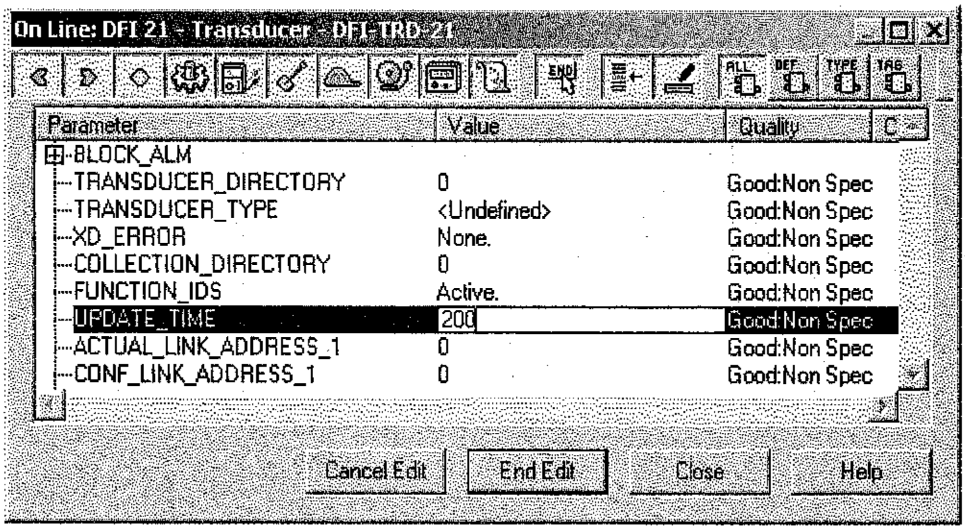
- Parameter 3: NO_DATA_CHANGE_TIMEOUT_ms

On data change is a mechanism to optimize the data transference between the bridge and the HMI software. With this mechanism the bridge will only send data that has changed.
The HMI has a time-out for the data, which means that if it does not receive a communication point after a certain period it will indicate lack of communication. That is where the NO_DATA_CHANGE_TIMEOUT_ms comes in. It will define a time-out to the bridge, if a certain value does not change over that period it will be sent to the HMI any way, avoiding the HMI timeout to expire.

Notes:
1) Good values for the parameter NO_DATA_CHANGE_TIMEOUT_ms are between the range 2500 to 6000, depending on the configuration load.
2) All the changes done on this parameter takes effect after new Supervision startup.

date Time

The UPDATE_TIME is used by DFI302 to refresh the DFI OLE Server database. Normally only the dynamic data are refreshed at this rate. Static data are refreshed each NO_DATA_CHANGE_TIMEOUT.
Using Syscon, open the online characterization for DF51 Transducer Block and adjust the parameters UPDATE_TIME and NO_DATA_CHANGE_TIMEOUT to the desired values. Take in mind that adjusting UPDATE_TIME to 200 ms, the DF51 will refresh the data more frequently than the default value (1000 ms) and it will load a little bit more the Ethernet traffic.



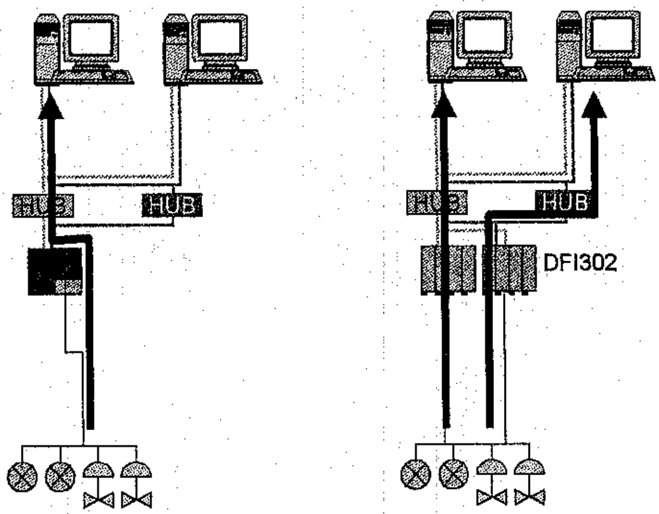
C Update Rate

The client (HMI) can specify an "update rate" for each group. This determines the time between when the exception limit is checked. In other words, if the group is set to 1 second, but the data is changing each 500 ms, the client will be advised each 1 second. The update rate is a request from the client and the server will respond with an update rate that is as close as possible to that requested.

Each client has specific ways to configure this rate. Consult the manual for the HMI and do it as necessary.

ɔundancy of the Control Network

For critical applications the Ethernet network can be made redundant. For a redundant Fieldbus Ethernet Network, the electric installation is simply duplicated. All Ethernet devices, including workstations, are connected to the Ethernet buses. Also, the Hubs/Switches of the network are duplicated. The DFI302 and workstations continuously monitor both the Fieldbus and Ethernet networks. In the case any one of the two fails, the user will be informed and the network will use the good one. The switching is totally safe and transparent to the other system parts. Failure due to a single fault is thus prevented, and the control will continue. The LEDs indicate which of the Ethernet networks are operational or have failed. The Smar trades commercial or industrial Hubs for pair-twisted cable or optic fibers. Industrial level hubs can be assembled in the DIN track and can have redundant sources.



Typical versus Smar Solution: The DFI302 interface permits 2 redundant paths.

pical application using redundancy

A typical application using redundancy is described now. Have in mind that DFI302 system permits redundancy to be configured in many levels and some of them will be available in future versions. E.g. Function Blocks and Modbus Gateway features configured internally inside DF51 are not able to be redundant at this current time.

The DFI302 permits two redundant paths from HMI (Human Machine Interface) to Field Device. To do that:

- Install two different DF51 in the same 1 to 4 Fieldbus Networks (e.g. First DF51, IP=192.168.**164**.51 / Subnet Mask 255.255.255.0 and Second DF51, IP=192.168.**163**.51 / Subnet Mask 255.255.255.0)
- Install two HUBs or Switches
- Install two workstations running HMI
- Each workstation must have two different NIC (Network Adapter Card)
- Each NIC must be configured in a different subnet range (e.g. NIC1, IP=192.168.**164**.50 / Subnet Mask 255.255.255.0 and NIC2, IP=192.168.**163**.50 / Subnet Mask 255.255.255.0)
- Configure in the file SmarOleServer.ini, the NIC Adapter that will be used on each workstation Ports (e.g. First workstation, NIC=192.168.**164**.50 and Second workstation, Nic=192.168.**163**.50)
- Doing so, each DFI OLE Server will choose a NIC Adapter that is connected with a specific DF51.
- When configuring the HMI, configure each TAG to be monitored using two possible ways: First one, using Local DFI OLE Server, second option, using Remote DFI OLE Server (some HMI does not permit this kind of configuration and you need to use an external software).

- To validate Remote connection between Client and Server, make sure to configure DCOM and NT Security. The steps are described in the System302 documentation (SmarOleServer docs).

The following figure illustrates the two paths: