How can I …

Integrate HART into eX80

Architecture?

Tested Validated Documented Architecture

Modular Automation System

Develop
your project

Schneider Electric

Important Information

People responsible for the application, implementation and use of this document must make sure that all necessary design considerations have been taken into account and that all laws, safety and performance requirements, regulations, codes, and applicable standards have been obeyed to their full extent.

Schneider Electric provides the resources specified in this document. These resources can be used to minimize engineering efforts, but the use, integration, configuration, and validation of the system is the user's sole responsibility. Said user must ensure the safety of the system as a whole, including the resources provided by Schneider Electric through procedures that the user deems appropriate.

Notice

This document is not comprehensive for any systems using the given architecture and does not absolve users of their duty to uphold the safety requirements for the equipment used in their systems, or compliance with both national or international safety laws and regulations.

Readers are considered to already know how to use the products described in this document.

This document does not replace any specific product documentation.

The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.

⚠ DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, **will result in** death or serious injury.

Failure to follow these instructions will result in death or serious injury.

⚠ WARNING
WARNING indicates a potentially hazardous situation which, if not avoided, **can result in** death or serious injury. **Failure to follow these instructions can cause death, serious injury or equipment damage.**

⚠ CAUTION
CAUTION indicates a potentially hazardous situation which, if not avoided, **can result in** minor or moderate injury. **Failure to follow these instructions can result in injury or equipment damage.**

CAUTION
CAUTION, used without the safety alert symbol, indicates a potentially hazardous situation which, if not avoided, **can result in** equipment damage. **Failure to follow these instructions can result in injury or equipment damage.**

Note: Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel. No responsibility is assumed by Schneider Electric for any consequences arising out of the use of this material.

A qualified person is one who has skills and knowledge related to the construction, operation and installation of electrical equipment, and has received safety training to recognize and avoid the hazards involved.

Before You Begin

This automation equipment and related software is used to control a variety of industrial processes. The type or model of automation equipment suitable for each application will vary depending on factors such as the control function required, degree of protection required, production methods, unusual conditions and government regulations etc. In some applications more than one processor may be required when backup redundancy is needed.

Only the user can be aware of all the conditions and factors present during setup, operation and maintenance of the solution. Therefore only the user can determine the automation equipment and the related safeties and interlocks which can be properly used. When selecting automation and control equipment and related software for a particular application, the user should refer to

the applicable local and national standards and regulations. The National Safety Council's Accident Prevention Manual also provides much useful information.

Ensure that appropriate safeties and mechanical/electrical interlocks protection have been installed and are operational before placing the equipment into service. All mechanical/electrical interlocks and safeties protection must be coordinated with the related automation equipment and software programming.

Note: Coordination of safeties and mechanical/electrical interlocks protection is outside the scope of this document.

START UP AND TEST

Following installation but before using electrical control and automation equipment for regular operation, the system should be given a start up test by qualified personnel to verify the correct operation of the equipment. It is important that arrangements for such a check be made and that enough time is allowed to perform complete and satisfactory testing.

⚠ WARNING

EQUIPMENT OPERATION HAZARD

- Follow all start up tests as recommended in the equipment documentation.
- Store all equipment documentation for future reference.
- Software testing must be done in both simulated and real environments.

Failure to follow these instructions can cause death, serious injury or equipment damage.

Verify that the completed system is free from all short circuits and grounds, except those grounds installed according to local regulations (according to the National Electrical Code in the USA, for example). If high-potential voltage testing is necessary, follow recommendations in the equipment documentation to prevent accidental equipment damage.

Before energizing equipment:

- Remove tools, meters, and debris from equipment
- Close the equipment enclosure door
- Remove ground from incoming power lines
- Perform all start-up tests recommended by the manufacturer

OPERATION AND ADJUSTMENTS

The following precautions are from NEMA Standards Publication ICS 7.1-1995 (English version prevails):

Regardless of the care exercised in the design and manufacture of equipment or in the selection and rating of components; there are hazards that can be encountered if such equipment is improperly operated.

It is sometimes possible to misadjust the equipment and thus produce unsatisfactory or unsafe operation. Always use the manufacturer's instructions as a guide for functional adjustments. Personnel who have access to these adjustments should be familiar with the equipment manufacturer's instructions and the machinery used with the electrical equipment.

Only those operational adjustments actually required by the operator should be accessible to the operator. Access to other controls should be restricted to prevent unauthorized changes in operating characteristics.

⚠ WARNING
UNEXPECTED EQUIPMENT OPERATION • Only use software tools approved by Schneider Electric for use with this equipment. • Update your application program every time you change the physical hardware configuration. **Failure to follow these instructions can cause death, serious injury or equipment damage.**

INTENTION

This document is intended to provide a quick introduction to the described system. It is not intended to replace any specific product documentation, nor any of your own design documentation. On the contrary, it offers information additional to the product documentation on installation, configuration and implementing the system.

The architecture described in this document is not a specific product in the normal commercial sense. It describes an example of how Schneider Electric and third-party components may be integrated to fulfill an industrial application.

A detailed functional description or the specifications for a specific user application is not part of this document. Nevertheless, the document outlines some typical applications where the system might be implemented.

The architecture described in this document has been fully tested in our laboratories using all the specific references you will find in the component list near the end of this document. Of course, your specific application requirements may be different and will require additional and/or different components. In this case, you will have to adapt the information provided in this document to your particular needs. To do so, you will need to consult the specific product documentation of the components that you are substituting in this architecture. Pay particular attention in conforming to any safety information, different electrical requirements and normative standards that would apply to your adaptation.

It should be noted that there are some major components in the architecture described in this document that cannot be substituted without completely invalidating the architecture, descriptions, instructions, wiring diagrams and compatibility between the various software and hardware components specified herein. You must be aware of the consequences of component substitution in the architecture described in this document as substitutions may impair the compatibility and interoperability of software and hardware.

⚠ CAUTION
EQUIPMENT INCOMPATIBILITY OR INOPERABLE EQUIPMENT Read and thoroughly understand all hardware and software documentation before attempting any component substitutions. **Failure to follow these instructions can result in injury or equipment damage.**

This document is intended to describe how to integrate HART instruments into eX80 M580 PlantStruxure architecture.

⚠ DANGER

HAZARD OF ELECTRIC SHOCK, BURN OR EXPLOSION

- Only qualified personnel familiar with low and medium voltage equipment are to perform work described in this set of instructions. Workers must understand the hazards involved in working with or near low and medium voltage circuits.
- Perform such work only after reading and understanding all of the instructions contained in this bulletin.
- Turn off all power before working on or inside equipment.
- Use a properly rated voltage sensing device to confirm that the power is off.
- Before performing visual inspections, tests, or maintenance on the equipment, disconnect all sources of electric power. Assume that all circuits are live until they have been completely de-energized, tested, grounded, and tagged. Pay particular attention to the design of the power system. Consider all sources of power, including the possibility of back feeding.
- Handle this equipment carefully and install, operate, and maintain it correctly in order for it to function properly. Neglecting fundamental installation and maintenance requirements may lead to personal injury, as well as damage to electrical equipment or other property.
- Beware of potential hazards, wear personal protective equipment and take adequate safety precautions.
- Do not make any modifications to the equipment or operate the system with the interlocks removed. Contact your local field sales representative for additional instruction if the equipment does not function as described in this manual.
- Carefully inspect your work area and remove any tools and objects left inside the equipment.
- Replace all devices, doors and covers before turning on power to this equipment.
- All instructions in this manual are written with the assumption that the customer has taken these measures before performing maintenance or testing.

Failure to follow these instructions will result in death or serious injury.

The TVDA Collection

Tested Validated Documented Architecture (TVDA) guides are meant to help in the implementation of specified solutions. TVDA guides provide a tested and validated example of the proposed architecture to help project engineers and Alliance System Integrators during the design and implementation of a project. The TVDA helps users analyze their architectures, confirm the feasibility of their systems and speed up system implementation.

Each TVDA provides users with:

- A reference architecture based on Schneider Electric's PlantStruxure solution
- Documentation of the system requirements of the architecture – response times, number of devices, features
- Design choices for the application – software and hardware architectures
- Test results to confirm the requirements are met

All explanations and applications have been developed by both Schneider Electric experts and system integrators in our PlantStruxure labs.

TVDAs are not intended to be used as substitutes for the technical documentation related to the individual components, but rather to complement those materials.

Development Environment

Each TVDA has been developed in one of our solution platform labs using a typical PlantStruxure architecture.

PlantStruxure, the process automation system from Schneider Electric, is a collaborative architecture that allows industrial and infrastructure companies to meet their automation needs while at the same time addressing their growing energy efficiency requirements. In a single environment, measured energy and process data can be analyzed to yield a holistically optimized plant.

Table of Contents

1. Introduction

1.1. Purpose

The intent of this document is to

- Set up an M580 reference architecture which integrates eX80 HART modules into a PlantStruxure Hybrid system.
- Design an ‘”eX80 HART Generic” DFB + VJC Genie so you can easily set up the connection between SCADA and instruments.
- Present Asset Management Solution (AMS) offer to manage the HART devices and instruments.
- Select Foxboro, Krohne and E+H instruments as reference to work with M580 eX80 HART architecture.

1.2. Customer Challenges

Collecting field device data via HART technology makes a big difference for enterprises that are using traditional control systems to realize process control.

All in all, the main challenges faced by the end users are:

- How to decrease CAPEX (Capital Expenditure) by using 2-wired HART instruments.
- How to increase operational efficiency and decrease OPEX (Operating Expense).
- How to set up preventive maintenance messages to reduce unplanned downtimes.

For system integrators, the challenge is how to reduce the man-hours during engineering and commissioning stages.

- How to easily integrate HART instruments into the process control system.
- How to realize easy engineering by using FDT (field device tool) /DTM (device type manager) technology.
- How to establish real-time diagnostics and fast problem localization.

1.3. HART Overview

Field devices in traditional control systems usually use a 4 to 20 mA current loop to transmit a measured value into an analog signal; the field status and available operations are limited, and only the highest process level has the decision making authority. As a result, it's hard for the

operators to monitor and control these field instruments with the PAC and SCADA systems, not to mention manage the assets of such a large number of devices.

With the development of the process automation control system, it has become a trend to use digital signals to replace analog signals, implementing a basic process control in the field, adding the information from the field device and facilitating preventive maintenance. Highway Addressable Remote Transducer (HART) protocol, as a transition protocol from analog signal to full digital signal, is especially suitable for enterprises seeking to upgrade and rebuild their device technology from the traditional DCS to intelligent field control.

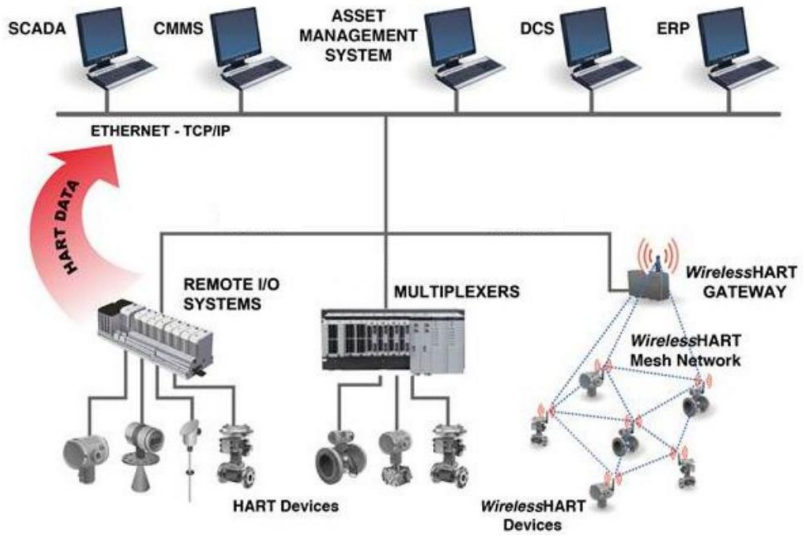


Figure 1: HART delivers the information to the application level

The HART protocol provides digital communication to microprocessors -based analog process control instruments. The Bell 202 frequency shift keying (FSK) standard is used to superimpose a digital signal on top of the 4-20mA current loop analog signal:

- The analog signal transfers the primary measured process variable value.
- The digital signal transfers additional instrument information, including instrument status, additional process variables, configuration data and diagnosis.

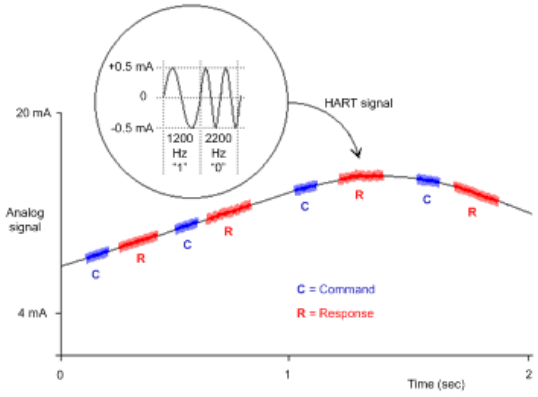


Figure 2: HART delivers information to the application level

Since the HART protocol was first invented by Rosemount in 1986, it has been used and developed. At the beginning, due to the restriction of technology, HART compliant devices are expensive and rare in use.

But in recent decades, more than 130 HART protocol compliant instrument manufacturers have emerged, making this one of the most manufacturer supported and open communication protocols. At the same time, the price of HART devices has fallen sharply, and is nearly on par with that of analog instruments, making HART instruments no longer a "luxury." Furthermore, the hardware and software which support the communication between HART instruments and higher level PCs are abundant and reliable. For all these reasons, HART is attracting user attention again.

To cover the typical needs of HART compliant instrument applications, Schneider Electric provides several industrial offers to integrate HART instruments into its PlantStruxure architecture.

1.4. HART Technology in Water and Wastewater

Every year, large population increases and rapid industrialization put enormous demands on water resources. It is critical that people and industry have an efficient, high-capacity potable water supply as well as eco-friendly water and wastewater treatment.

To achieve this objective, massive instruments are integrated into the treatment processes to realize the quantization of different measurements such as flow, level, temperature, pressure etc. With this comprehensive data, process management becomes easier and more concentrated in the control center of the plant.

Furthermore, the introduction of intelligent instruments like HART technology to the market has made zero downtime and efficient maintenance much easier to achieve. Much time-consuming work like configuration, calibration and diagnostics can be realized remotely and much more efficiently.

To introduce the advantages of using HART, this TVDA will document and demonstrate the HART application within a wastewater treatment plant (WWTP).

1.4.1. HART devices used in WWW

Below is an example of the HART application in one wastewater treatment plant.

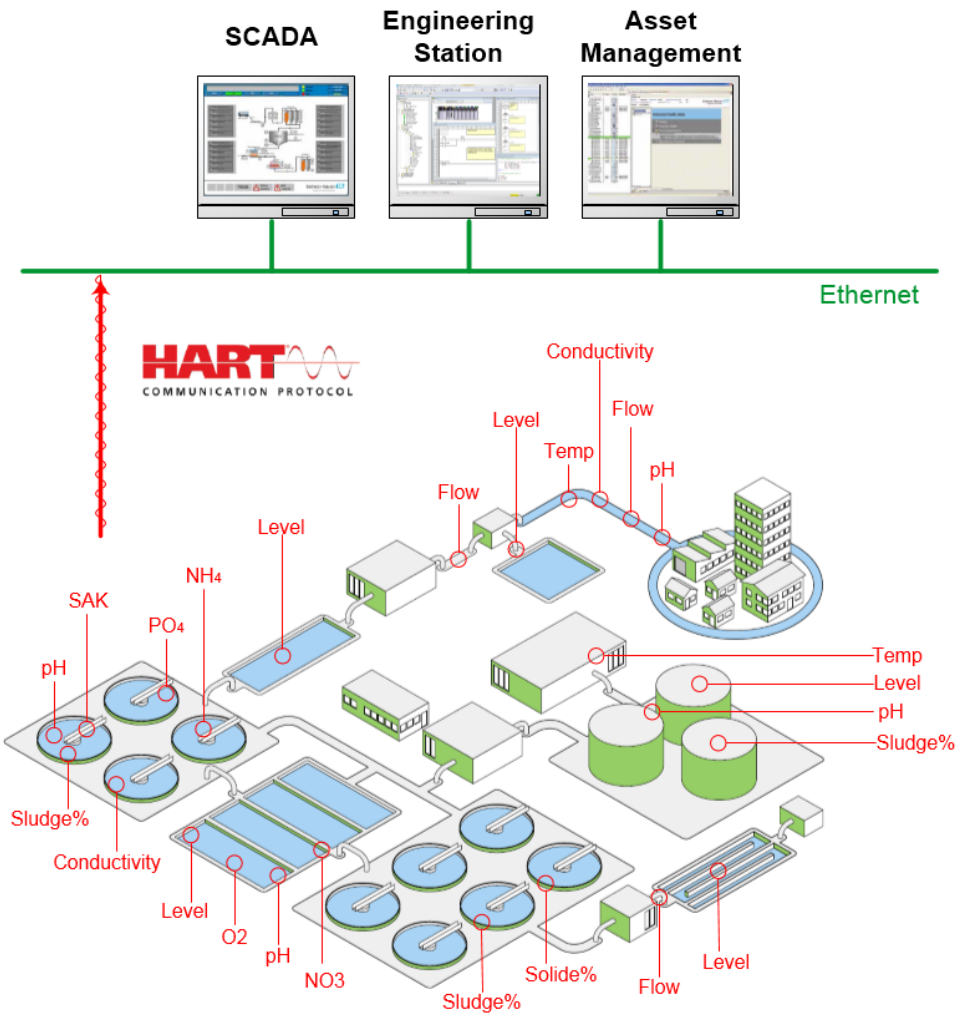


Figure 3: HART application within WWTP

HART Instruments

Large numbers of the instruments and meters function in each station of the WTP / WWTP for fully visibility into the treatment status and process control. In this document, the instruments from Schneider Electric's Foxboro and its CAPP partners, Krohne and E+H, will be used as examples. The HART technology has been integrated into most of their products together with their widely-used asset management software.

In a typical WWTP, there may be hundreds of instruments supporting the entire process control. The instruments can be grouped by their usage.

Usage	Instrument & Meter	Example
Flow Measurement	• Electromagnetic flow meter • Ultrasonic flow meter	
Level Measurement	• Ultrasonic level meter • Radar level meter (TDR or FMCW) • Level switch	
Temperature Measurement	• Temperature transmitter • Cable sensor • HVAC Temperature sensor	
Pressure Measurement	• Pressure transmitter • Differential pressure transmitter	
Analysis Instruments	• COD (chemical oxygen demand) • pH • Conductivity • Solids % • …	
Actuator	• Valve positioner	

Table 1: Common Instrument & Meter Classes

Asset Management Solution (AMS)

With different types of instruments installed all across the plant, the Asset Management Solution (AMS) can help users to easily and efficiently manage all of the devices.

Based on a standardized communication interface like DTM (device type manager) or DD (device description), the AMS can easily set up HART communication with field instruments using the interface provided by manufacturers. Moreover, the preventive maintenance functions can be used to reduce unexpected downtime, and greatly improve availability and operating costs.

As the eX80 HART module supports FDT/DTM interface, we will select an AMS based on FDT/DTM as a reference in this document. And thanks to the FDT/DTM technology, the AMS helps users easily configure and commission wired or wireless instruments, monitor status and alerts, remote troubleshoot from the control room, perform advanced diagnostics, manage calibration, and automatically document all of these activities.

Below are the AMS tools that are commonly used in process automation.

PACTware	Field Care
	

Table 2: Common AMS tool

1.5. Schneider Electric's HART Offer

As one of the leading automation companies in the world, Schneider Electric also offers HART solutions. Our two solutions are the Modicon STB HART interface and the HART master within the eX80 architecture.

1.5.1. Modicon STB HART

STB HART is the HART multiplexer on the distributed STB I/O, and it consists of the HART-enabled Ethernet Modbus TCP NIM (STBNIP2311 V4.x or above), and the HART interface STBAHI8321 which connects the HART instruments with the PAC or STB analog modules.

The STB HART solution allows remote systems to obtain the HART data over Ethernet from instruments on 4-20mA current loops. It targets those applications where cost is a major consideration (e.g., WWW and F&B applications).

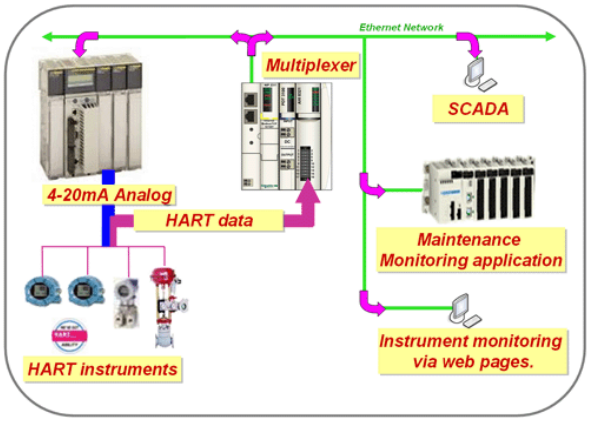


Figure 4: STB HART solution architecture

This solution was introduced in another TVDA entitled, 'How can I integrate HART instrumentation into PlantStruxure Architecture.'

1.5.2. eX80 HART modules

There are two integrated HART analog I/O modules on eX80 architecture connected to the Ethernet backplane of an M580 local rack or eX80 remote drops. The table below indicates the major specifications of these two modules:

Modules	Parameters
BME AHI 0812 **BME AHO 0412**	• High-level isolated analog 8 input channel / 4 output, HART point to point • current range 4 – 20mA, 16 bits • 1000VDC isolation between channels • Standard 2 / 4 wire HART enabled field transmitters • Fast HART V5, V6, V7 standards support, one modem for each channel • HART data mapping on each channel (PV, SV, TV, QV, Current & Percentage value) • Broken wire detection, FDR (fast device replacement) support

Table 3: eX80 HART modules specification

These two modules were developed based on the eX80 Ethernet architecture. In the module, a filter is used to isolate the HART digital and analog signals, and the HART data is transferred to the M580 controller via the Ethernet bus on the backplane. All the HART functions such as data reading, instrument configuration and calibration are established based on the Ethernet protocol.

The 4-20mA analog data is transferred to the controller by the original X Bus on the backplane, so basic analog functions can also be achieved, like overflow / underflow control, digital filtering, sensor alignment and so on.

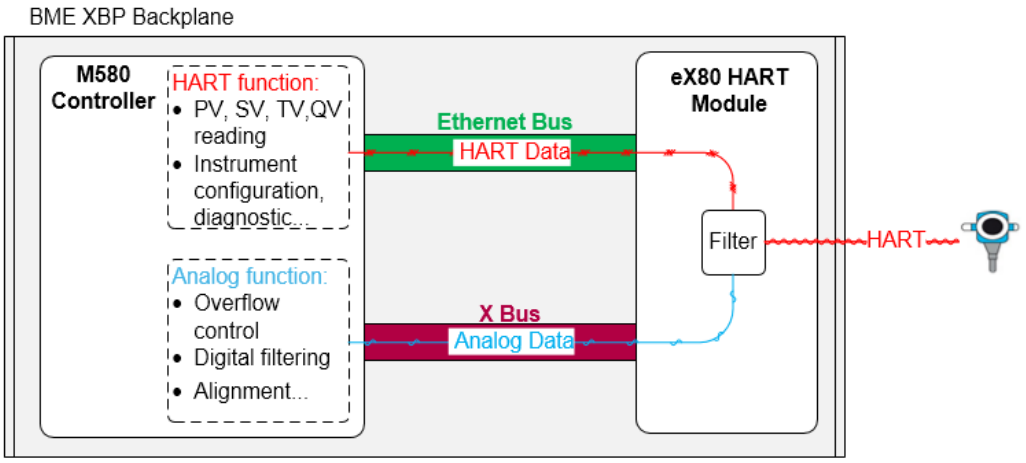


Figure 5: BME XBP Ethernet backplane communication structure

According to the M580 architecture, the eX80 HART module can be installed in two locations:

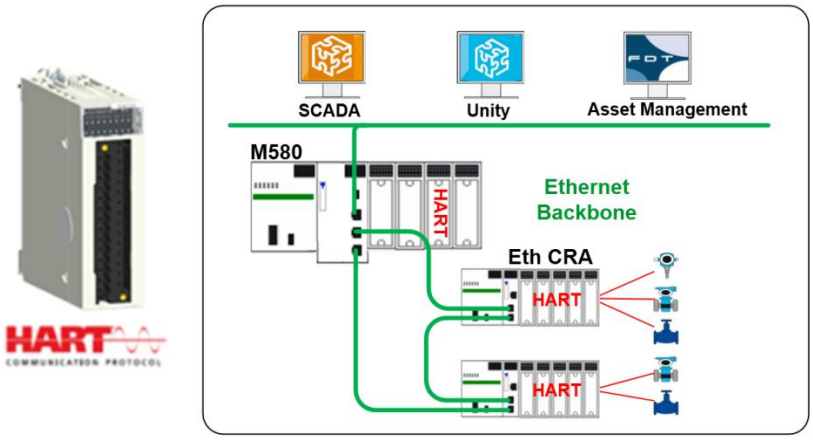


Figure 6: eX80 HART solution architecture

- M580 local I/O Ethernet backplane: Situated on the M580 main local backplane, up to 6 HART modules can be added to the Ethernet backplane. Because the Ethernet BME XBP backplane cannot be used as an extension, the HART modules can't be integrated on the extension backplane.
- M580 remote I/O drop: Situated on the eX80 remote I/O drops with Ethernet backplane and BME CRA EIO adapter module, each drop can add up to 7 HART modules on the Ethernet backplane.

Solution's advantage

This solution is a key enabler and driver for PlantStruxure and the M580 platform to access the targeted process industries in WWW, MMM, F&B and O&G, and provides the following features and benefits:

- Seamless integration of intelligent field devices into the M580 / eX80 platform thanks to PlantStruxure's fully transparent and secured Ethernet architecture.
- M580 HART system helps customers utilize and benefit from their original investment in smart field devices.
- Valuable device and process data is available to M580 and the Asset Management System for plant management, preventive maintenance and operation optimization.

This TVDA will present the HART application integrated with eX80 HART on the M580 ePAC architecture.

1.6. Prerequisites

Before reading further in this document, users should have knowledge about the following technologies and software:

- M580 ePAC architecture
- Unity Pro, DTM tools, Vijeo Citect
- HART Protocol

1.7. About this Document

This TVDA includes the phases of Introduction, Selection, Design, Configuration, Implementation, and Validation.

1. **Introduction**: Introduces HART, customer challenges and prerequisites, as well as the HART offers from Schneider Electric
2. **Selection**: Describes the selected components, reference architecture, and the use case requirements
3. **Design**: Describes how to realize the hardware connection and use cases
4. **Configuration:** Includes M580 remote I/O, eX80 HART module, instrument and AMS settings
5. **Implementation**: Shows the steps to use the eX80 HART Generic DFB + VJC Genie designed by this TVDA
6. **Operation**: Shows how to monitor & control the instruments with SCADA and AMS, including device replacement
7. **Validation**: Presents the performance results of the selected architecture

1.8. Glossary

A glossary is available in the appendix of this document. Please refer to it whenever necessary.

2. Selection

In this chapter, we select a HART reference architecture based on the Schneider Electric's typical WWW architecture, and list HART instruments use cases based on the customer's requirements.

2.1. Typical Schneider Electric WWW Application Architecture

A typical T2 city water and wastewater treatment plant should provide an uninterrupted water supply for about 10,000 ~ 100,000 inhabitants with 5,000 ~ 50,000 m3/day. Depending on the I/O numbers and the distance between treatment stations, there are two typical architectures for a T2 WWTP using Schneider Electric's offer solution.

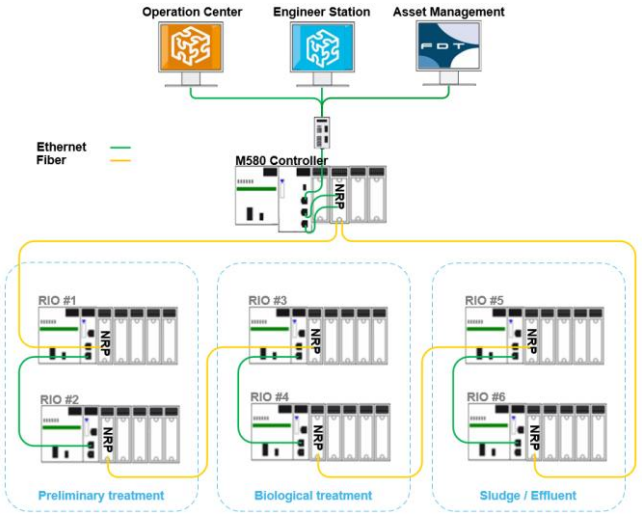
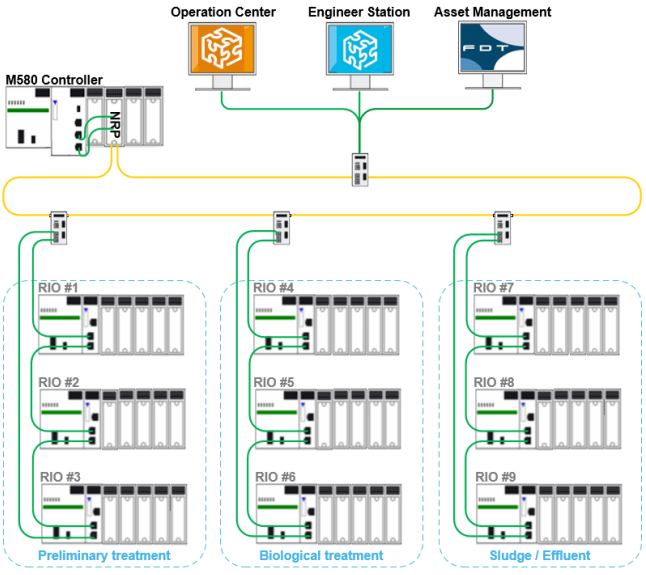
Description	Architecture
Small or Medium size WWTP is a plant with a small or medium number of field I/Os. The PAC and remote I/O drops are all located on the Ethernet RSTP single ring. The NRP module and fiber optics can be used if a long distance is involved.	
Large sized WWTP is a plant with a large number of field I/Os. For this reason, each treatment drop is separated in a sub-ring by switches. And optical fibers are used to connect the main ring. This double ring structure can ensure network communication reliability with large data information exchange.	

Table 4: Typical T2 WWTP Architecture

This TVDA takes the small WWTP as an example, and offers reference eX80 HART architecture to demonstrate the mechanical preliminary treatment process.

Within the preliminary treatment process, there are usually 4 stations: The sewage acceptance station is used to collect and store the wastewater; then the screens station is used to remove large solid contents and interfering matter; later the grease & grit chamber uses ventilated air to separate grit and floating matter such as oil and grease; finally the preliminary sedimentation is used to turn the organic load part into the primary sludge.

The following section will introduce the selected architecture and the instruments installed in the demo application.

2.2. TVDA Selected Architecture

This section introduces the selected architecture, which includes the control room, control network and field instruments.

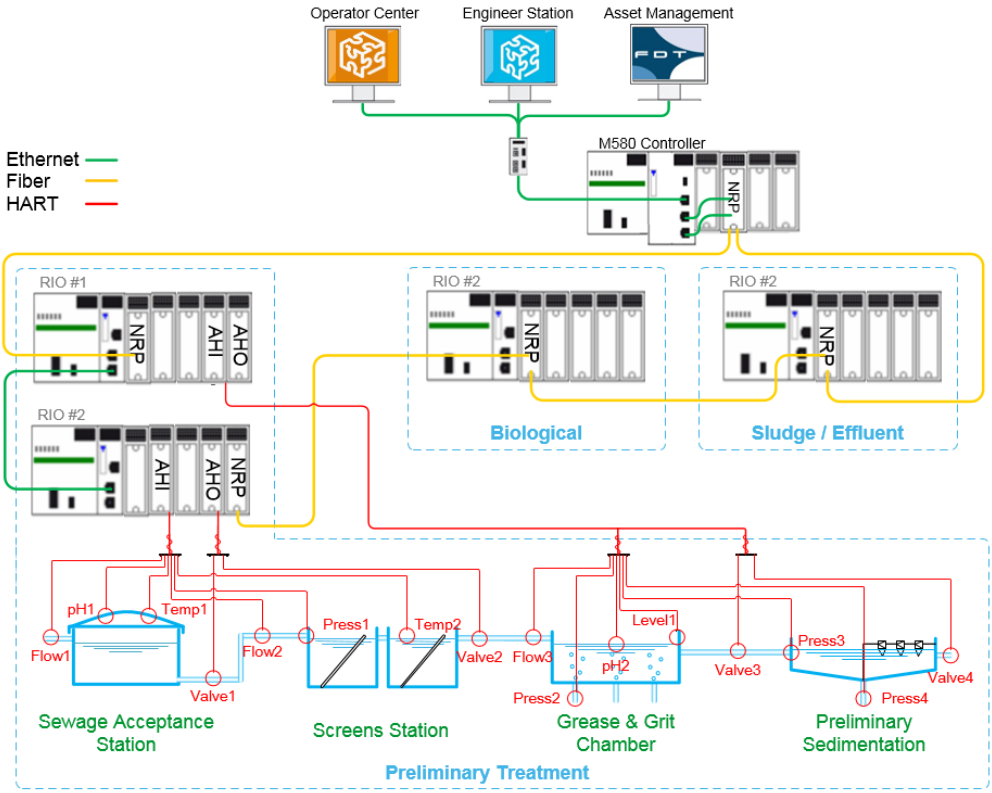


Figure 7: Selected architecture

Control room

Vijeo Citect SCADA is selected to monitor the status and operate all of the instruments in the plant. Unity Pro is used to program the M580, and configure the HART instruments with embedded FDT/DTM browser.

Asset management software is used to manage all intelligent instruments within the entire plant. It provides an efficient way for instrument configuration and preventive maintenance.

Control network

The control network consists of M580 CPU and Ethernet RI/O architecture. The NRP module, optical fiber repeater, is used to extend the distance of RI/O, and the RSTP redundancy ring ensures the high reliability of the network. Meanwhile, the HART modules installed on the RIO #1 & 2 connect to the field instruments.

Field instruments

For the treatment process simulation, HART instruments are used to demonstrate the measurements of the process value in the preliminary treatment stage. The types and models of HART instruments are listed in the table below. Refer to the photo where the instruments are marked with green labels according to their functions in the selected architecture diagram.

Measurements	Instrument Model	Instruments Layout in the Demo
Electromagnetic Flow	Foxboro IMT25 E+H Promag 400 Krohne H250 M40	
Contact Level	Krohne OptiFlex 1100C	
Temperature	Foxboro RTT80 E+H TMT162	
Pressure	Foxboro IDP-10 E+H Deltabar M	
Analyze	Foxboro 876PH Krohne SmartSen 2390	
Valve Positioner	Smar FY301	

Table 5: Instruments selected in the architecture

2.3. Customer Requirements

This part presents the HART instrument application requirements from the customer. There are two typical use cases of using the HART instruments, which are discussed hereafter.

Instrument monitoring & control from SCADA through PAC

The process measurements are important for the treatment plant. The user needs to get the real-time process value and device status through the PAC application. They also need to monitor the HART field instruments and perform some simple operations from the SCADA side.

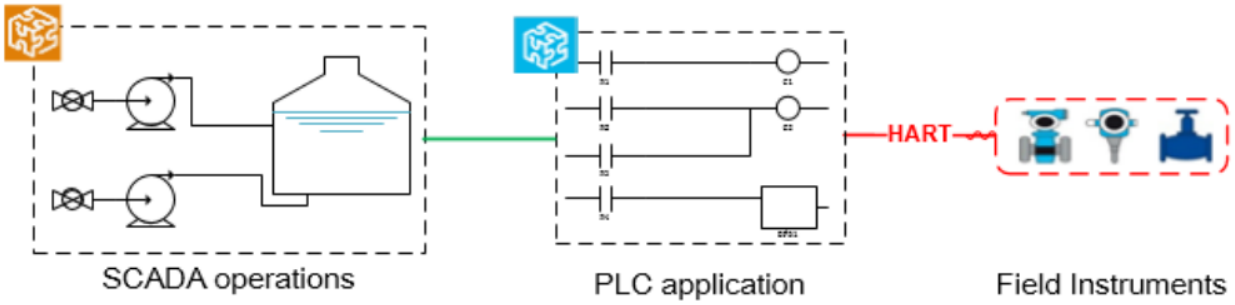


Figure 8: Monitoring & control from SCADA & PAC applications

Instrument management from AMS or Unity Pro

The user needs to manage the entire plant's instruments and perform engineering operations like configuration, diagnosis and calibration by AMS.

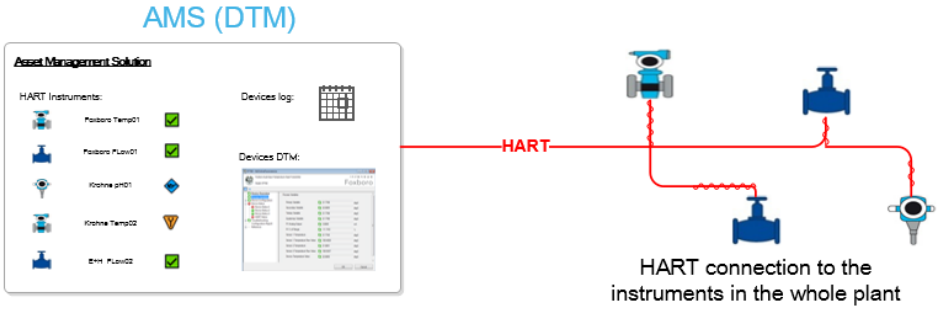


Figure 9: Using DTMs to connect HART Instruments

3. Design

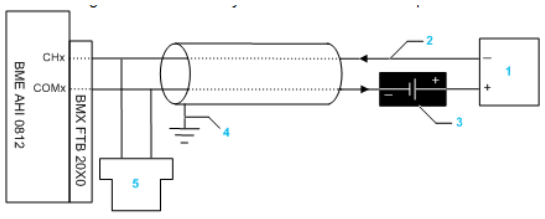
This chapter introduces how to design the hardware connection for installing instruments into the eX80 reference architecture, and how to design the use cases mentioned in the selection chapter.

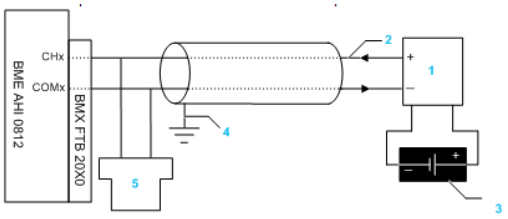
3.1. Instruments Connected to eX80 HART Module

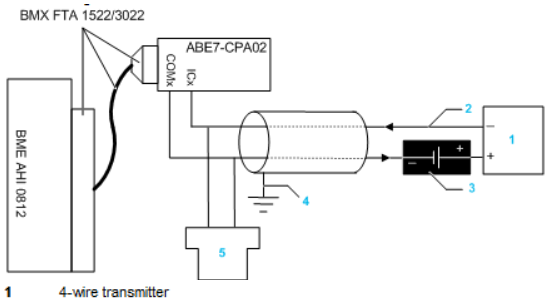
We present the HART hardware wiring at the beginning of the design chapter as it's an important step during the system engineering stage. Users need to be careful to install their HART instruments according to the product's hardware manual. In the HART instruments market, there are two typical wiring modes which include two-wire and four-wire modes. This part details the installation design for the connection between eX80 HART module and HART instruments. The user can select the direct wiring or the TELFAST wiring accessories from Schneider Electric for fast installation.

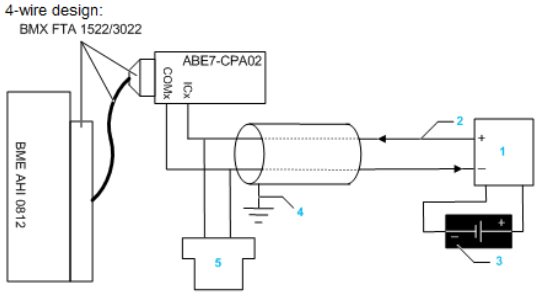
Instruments installation to BME AHI 0812 module (8 Channel Input Module)

Below is the BME AHI wiring diagrams:

<table>
<tr><th>HART module</th><th>Two-wire</th><th>Four-wire</th></tr>
<tr><td rowspan="4">BME AHI 0812</td><td colspan="2">• Without using TELEFAST wiring accessory:</td></tr>
<tr><td> 

1 4-wire transmitter
2 4-20 mA current loop, with arrows indicating direction of current flow
3 Field power supply
4 Protective ground
5 Secondary HART master (hand-held)</td><td> 

1 4-wire transmitter
2 4-20 mA current loop, with arrows indicating direction of current flow
3 Field power supply
4 Protective ground
5 Secondary HART master (hand-held)</td></tr>
<tr><td colspan="2">• Using TELFAST without power supplies</td></tr>
<tr><td> 

1 4-wire transmitter
2 4-20 mA current loop, with arrows indicating direction of current flow
3 Field power supply
4 Protective ground
5 Secondary HART master (hand-held)</td><td>4-wire design:
 

1 4-wire transmitter
2 4-20 mA current loop, with arrows indicating direction of current flow
3 Field power supply
4 Protective ground
5 Secondary HART master (hand-held)</td></tr>
</table>

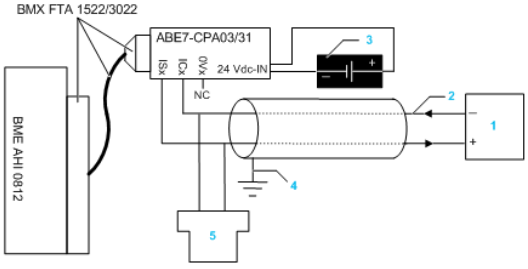
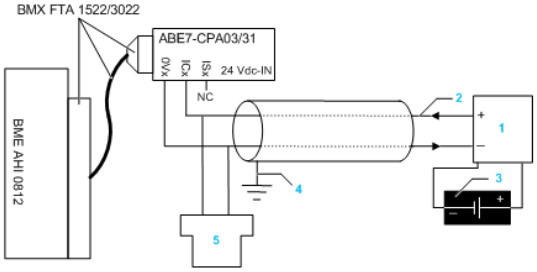
HART module	Two-wire	Four-wire
	• **Using TELFAST with power supplies**	
	2-wire design: BMX FTA 1522/3022  1 4-wire transmitter 2 4-20 mA current loop, with arrows indicating direction of current flow 3 Field power supply 4 Protective ground 5 Secondary HART master (hand-held)	4-wire design: BMX FTA 1522/3022  1 4-wire transmitter 2 4-20 mA current loop, with arrows indicating direction of current flow 3 Field power supply 4 Protective ground 5 Secondary HART master (hand-held)

Table 6: BME AHI 0812 HART module wiring diagram

Instrument installation to BME AHO 0412 module (4 Channel Output Module)

Below are the BME AHO wiring diagrams:

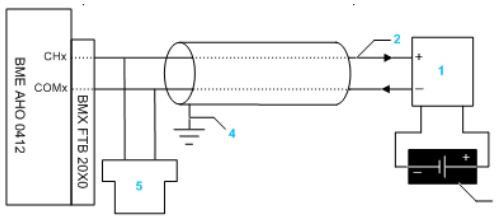
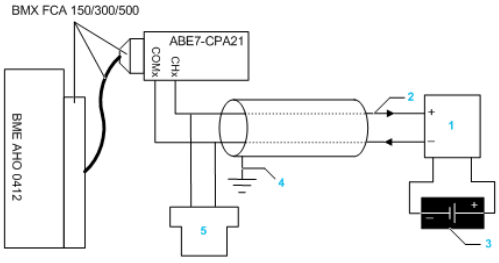
HART module	Two-Wire / Four-Wire
BME AHO 0412	• **Without using TELEFAST wiring accessory:**  1 4-wire transmitter 2 4-20 mA current loop, with arrows indicating direction of current flow 3 Field power supply 4 Protective ground 5 Secondary HART master (hand-held)
	• **Using with TELEFAST wiring accessory:**  1 4-wire transmitter 2 4-20 mA current loop, with arrows indicating direction of current flow 3 Field power supply 4 Protective ground 5 Secondary HART master (hand-held)

Table 7: BME AHO 0412 HART module wiring diagrams

TELEFAST wiring accessory reference

The table lists Schneider Electric's TELEFAST wiring accessories and cables which are compatible with the eX80 HART modules.

HART module	TELEFAST Wiring Accessories	Cable
BME AHI 0812	• ABE7-CPA02: 8-channel TELEFAST • ABE7-CPA03: 8-channel TELEFAST with non-isolated 24Vdc/25mA power supplies • ABE7-CPA31: 8-channel TELEFAST with isolated 24Vdc/25mA power supplies	• BMX FTA 1522: 1.5 m shielded cable • BMX FTA 3022: 3 m shielded cable
BME AHO 0412	• ABE7-CPA21: 4-channel TELEFAST	• BMX FCA 150: 1.5 m shielded cable • BMX FCA 300: 3 m shielded cable • BMX FCA 500: 5 m shielded cable

Table 8: HART module wiring accessories

3.2. Use Case 1: Monitor & Control HART Instruments from SCADA through PAC

The device DDT or Ethernet explicit data exchange is used to set up the communication between SCADA and HART instruments. This TVDA also includes a HART generic DFB + VJC Genie to help you save engineering time. More details on the engineering work are presented below.

3.2.1. Use Device DDT or explicit data exchange

HART module's Device DDT

The eX80 HART module can provide a simple method to get the channel value and status through its device DDT. Below is the Device DDT structure for one channel.

BME_AHI_0812	T_BME_AHI_0812
Freshness	BOOL
Freshness_1	BOOL
Inputs	T_BME_AHI_0812_IN
G_ModuleStatus	DWORD
G_ChannelStatus	DWORD
G_ChannelStatus2	DWORD
P_Channel0_InstrumentStatus	DWORD
P_Channel0_PV	REAL
P_Channel0_SV	REAL
P_Channel0_TV	REAL
P_Channel0_QV	REAL
P_Channel0_CurrentValue	REAL
P_Channel0_PercentValue	REAL
P_Channel0_UpdateCounter	DWORD

Figure 10: HART module's Device DDT

The eX80 HART module works as the HART master in the network with instruments, and periodically sends HART requests to get the instruments' status, current value, and four variable values, PV, SV, TV, QV. Then, the data is sent to the M580 host by Ethernet implicit data exchange. At the end, the SCADA system can access the data stored in the M580 memory. The data flow in this solution is shown in the diagram below:

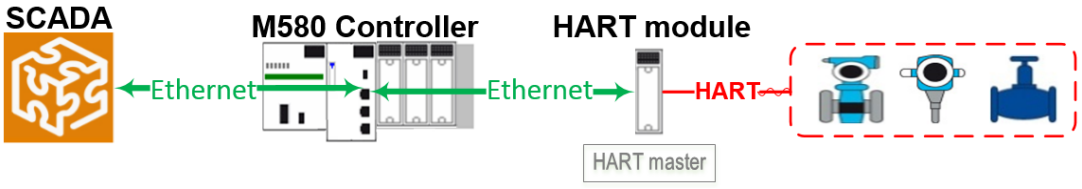


Figure 11: HART module's Device DDT data flow

Additional HART information over Ethernet explicit data exchange

If you need to get more HART information or perform advanced operations to the HART instruments, such as instrument diagnosis, calibration or parameter setting, you can do this through the Ethernet explicit data exchange.

In this case, the M580 works as the HART master and sends the HART command by using 'DATA_EXCH' FB over Ethernet/IP to the HART module, which works in HART port mode to transmit HART frames to the target instruments. The data flow is shown in the diagram below:

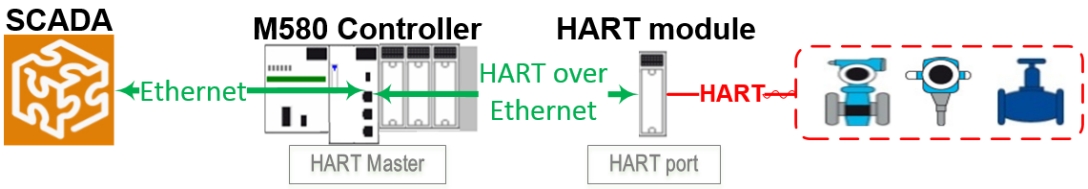


Figure 12: HART over Ethernet explicit data exchange

In the reply, the instruments will send the response frame to the HART module. After processing the commands, the HART module will transfer this response back to the M580 over Ethernet/IP. The table below shows the steps for programming the HART explicit data exchange between M580 and instruments:

Steps	Description
1	Compose a HART command frame over Ethernet/IP.
2	Send the command frame by the DATA_EXCH' FB.
3	Receive the instrument's response, and get the HART information.

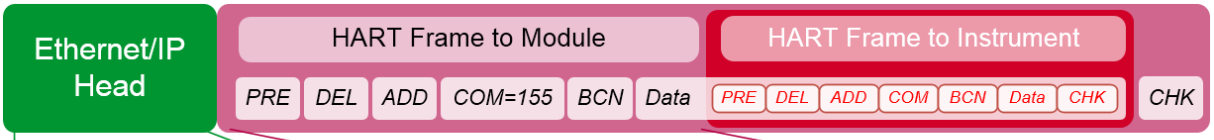
Table 9: Steps of establish HART explicit data exchange

- Compose a HART command frame over Ethernet/IP

The diagram shows a composed HART command frame, which includes the Ethernet/IP head, one HART 155 (Port mode) command sub-frame, and one HART functional command sub-frame.

In the Ethernet/IP head part, you need to add 8 bytes to implement the explicit exchange between M580 and the HART module over Ethernet/IP. The value details can be found in the diagram.

Both in HART 155 and the functional command sub-frame, you need to fill the bytes to follow the format of the HART frame which is shown in the diagram.



Offset	Field	Description	Values
0	Service	Service of the explicit message	**0x4B**
1	Request_Path _Size	The number of words in the Request_Path field	**0x03**
2-7	Request_Path	This byte array describes the path of the request including class ID, instance ID, etc. for this transaction	Class Id: **0x21 0x00 0x10 0x40** Instance Id: **0x24 0x01**

Name	Field	Description
PRE	Preamble	Start of the frame (5 to 20 bytes of hexFF)
DEL	Delimiter	Indicating frame type and physical layer type
ADD	Address	Five byte unique address of destination instrument
COM	Command	Command number. In this case, use 155 (Copy command & Reply)
BCN	Byte Count	Number of bytes in data field
Data	Data	HART command data
CHK	Check Byte	Bitwise exclusive OR of all bytes of the frame

Figure 13: A composed HART command frame

- Send the command frame and receive the response by the DATA_EXCH' FB

In your application, enable the 'DATA_EXCH' FB to send/receive the HART command frame to/from the target instrument through Ethernet, HART module and 4-20mA current loop by your programmed event method. Below is an overview of the data flow between M580 and the instruments.

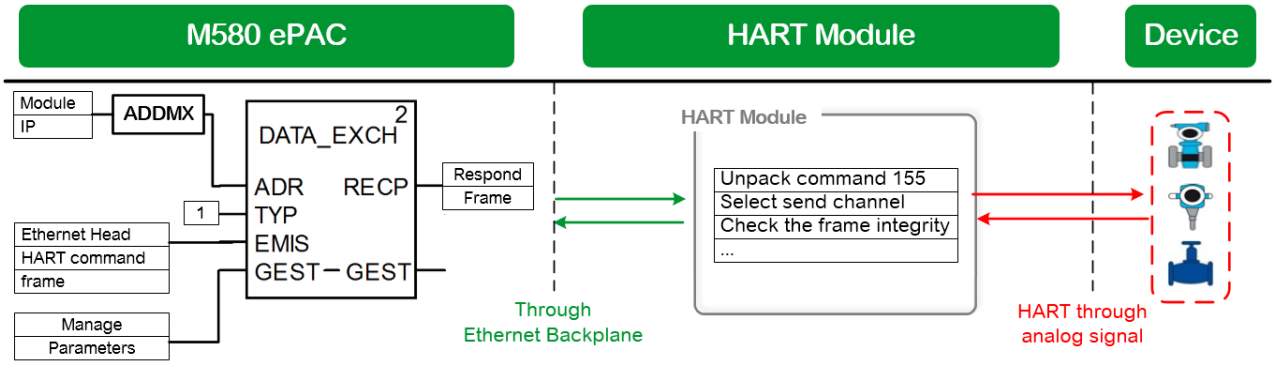


Figure 14: Data flow between M580 and Instruments

- Example of the explicit exchange program

Here is an example of how to read HART device PV range value by explicit exchange program.

Step 1: Compose a HART command over Ethernet/IP, which includes Ethernet/IP head, HART 155 (Hex9B) command sub-frame, and HART 15 (Hex0F) command sub-frame using your program.

Step 2: Set the parameters of the DATA_EXCH FB, which include ADR, Control Type, Command frame DDT and the size of the RECP, then enable the FB to send/receive the HART frame.

Step 3: Get/translate the results of RECP using your program, and display the HART information on the designed DDTs or SCADA. The designed DDTs are several groups of the data structure created by this TVDA, which are used to store different responses to the HART command.

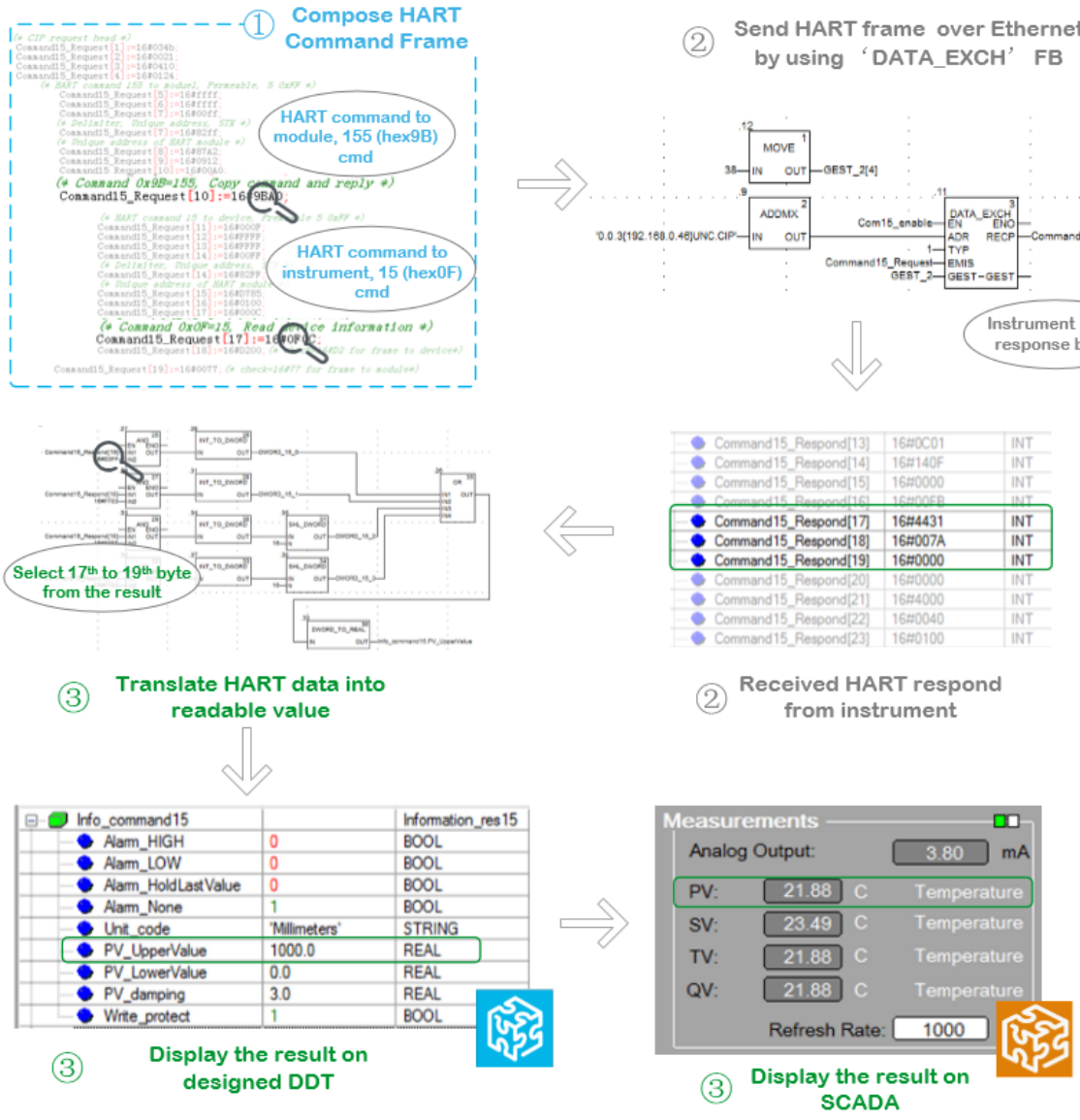


Figure 15: Example of the explicit exchange program for PV (15Command) measurement

3.2.2. Use “eX80 HART Generic” DFB + VJC Genie

We can see from the previous section that the explicit exchange requires significant work on your application design. To minimize this effort, this TVDA includes “eX80 HART Generic” DFB + VJC Genie to decrease the engineering necessary, including HART frame composing, sending, receiving and HART data display/operation on SCADA.

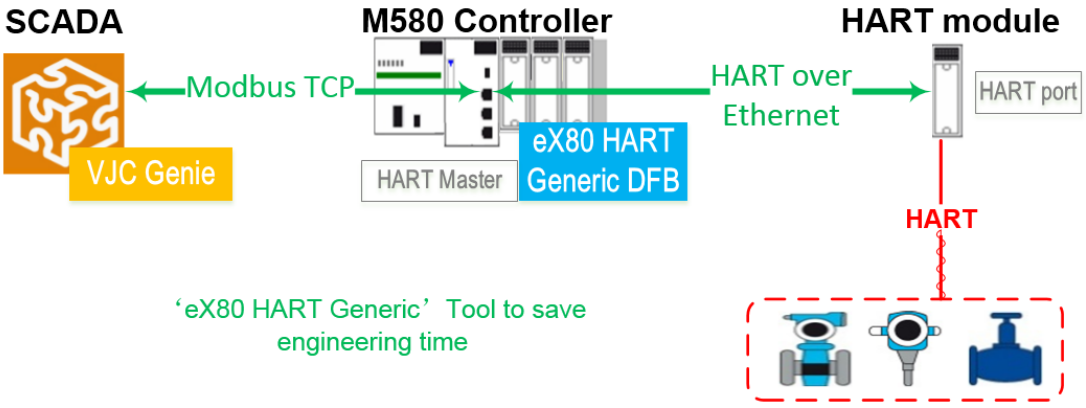


Figure 16: “eX80 HART Generic” DFB data flow

Meanwhile, this TVDA also creates a user DDT named ‘eX80_HART_Setting’ which can simply associate the variables to the Unity DFB, and quickly set data links with the VJC genie.

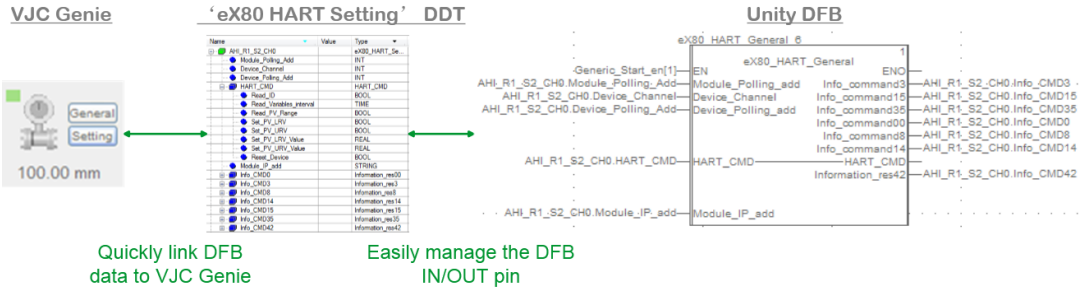


Figure 17: “eX80 HART Setting” Unity DDT

DFB design

Here are the details for the introduction of the “eX80 HART Generic” Unity DFB.

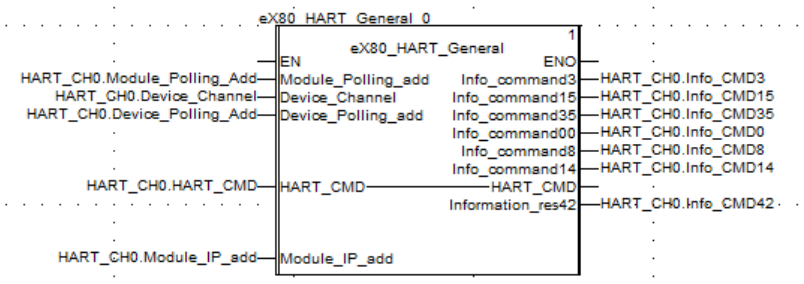


Figure 18: “eX80 HART Generic” Unity DFB

Pin Type	Field Name	Description

Pin Type	Field Name		Description
Inputs	Module_Polling_Add		Polling address of HART module
	Device_Channel		HART module's channel number connects to the instrument
	Device_Polling_Add		Polling address of the instrument
	Module_IP_add		HART module's IP address
Input / Output	HART_CMD	Read_ID	Read module and instrument device ID
		Read_Variables_Interval	Interval to refresh the measurements (ms)
		Read_PV_Range	Read PV range values
		Set_PV_URV	Set PV upper range value
		Set_PV_LRV	Set PV lower range value
		Reset_Device	Set to reset the instrument
Output	Info_command0		Command 0 (Read unique identifier) result.
	Info_command3		Command 3 (Read dynamic variable and loop current) result
	Info_command8		Command 8 (Read dynamic variable classifications) result
	Info_command14		Command 14 (Read Primary variable transducer information) result
	Info_command15		Command 15 (Read device information) result
	Info_command35		Command 35 (Write Primary variable range values) result
	Info_command42		Command 42 (Perform device reset) result

Table 10: HART commands used within the eX80 HART Generic DFB

Note: The designed DFB is a generic tool which can be used with different HART instruments, and it can get most of the general information and measurements for plant process control or asset management. If, however, you need to operate more advanced or manufacturer defined functions, we highly recommend using the manufacturer's DTMs with AMS or Unity.

VJC Genie Design

The “eX80 HART Generic” VJC genie is designed for working with the “eX80 HART Generic” DFB as the user interface on a SCADA page. Below is the layout of the general HART VJC genie.

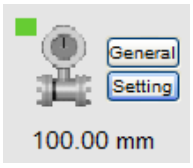


Figure 19: Vijeo Citect eX80 HART Genie

You can read the PV value and unit status at the overview of the genie. Click the buttons on the right side of the genie to access two pop-up windows for detailed information and settings. The general window indicates the communication information, measurement values and device status. The settings window is used to read the transducer limits and set the output of the lower/upper range value.

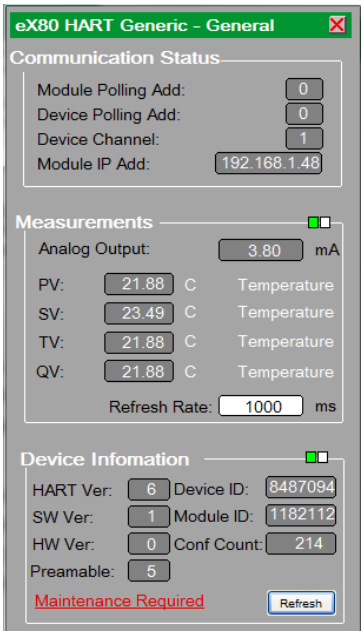
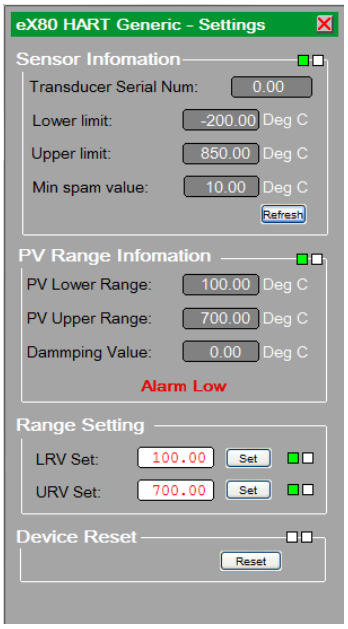
General Window	Setting Window
	

Table 11: General and Setting windows within the VJC genie

With this genie, you just need to select the channel name to complete the instrument variable connection. The channel name is imported from Unity’s DDT named ‘eX80_HART_Setting’ which is mentioned above.

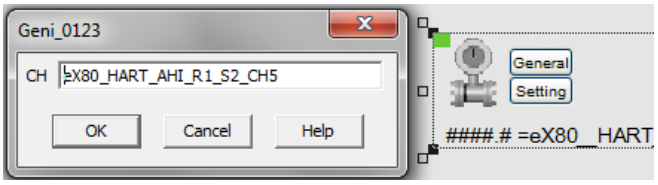


Figure 20: Use Vijeo Citect eX80 HART Genie with the Unity DDT

3.3. Use Case 2: Instrument Management with DTM from AMS or Unity Pro

Besides supervising and controlling the instruments from the SCADA system, the AMS or Unity with DTM can easily manage the instruments in configuration, diagnosis and calibration.

Thanks to the M580 Ethernet-through structure, a PC installed with AMS or Unity with DTM could connect to the HART instruments directly through the transparent PlantStruxure Ethernet architecture without any other HART adapters or new wirings. The M580, BME backplane and BME CRA module work as switches for setting up HART communication between the DTMs and HART modules based on Ethernet/IP. The data flow of this use case is shown in the below diagram.

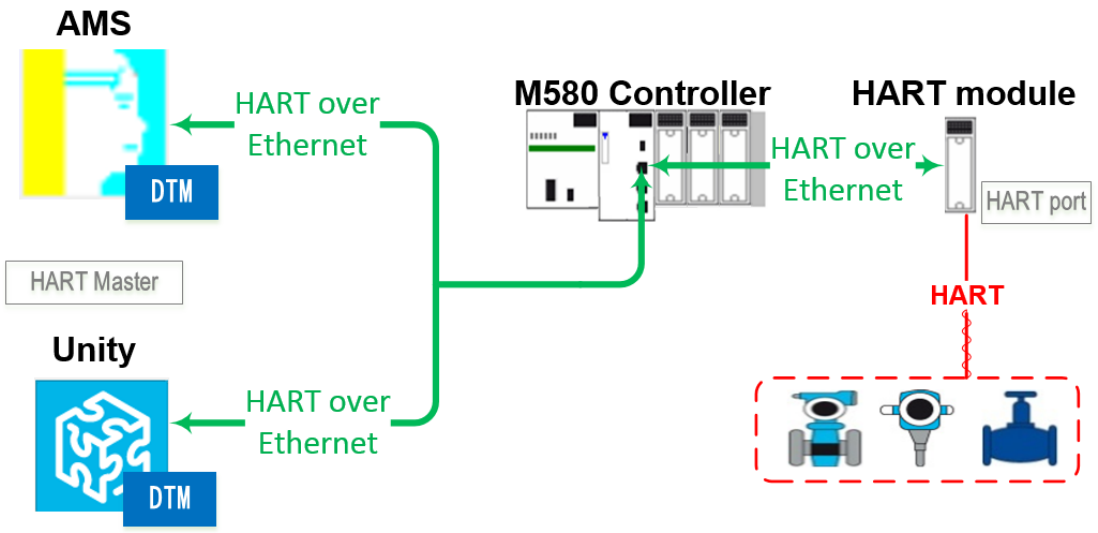


Figure 21: Using DTMs to connect HART Instrument

3.3.1. AMS design and diagnostic function

The AMS provides highly useful functions such as remote configuration, calibration and real-time diagnosis with the intelligent instruments. This solution offers a systematic method to access and manage the HART instruments using the manufacturer's DTM within a standardized interface.

First, it is necessary to set up the plant devices' topologic network, and then you can easily distinguish the installed instrument's process and function.

To establish communication with the HART module, the **Ethernet/IP adapter DTM** needs to be installed as an Ethernet getaway in PACTware™ or FieldCare™. This adapter can discover the eX80 HART modules by scanning their IP addresses. After the HART module has been connected, the topology scan function is used to locate field instruments and find best-matching DTMs.

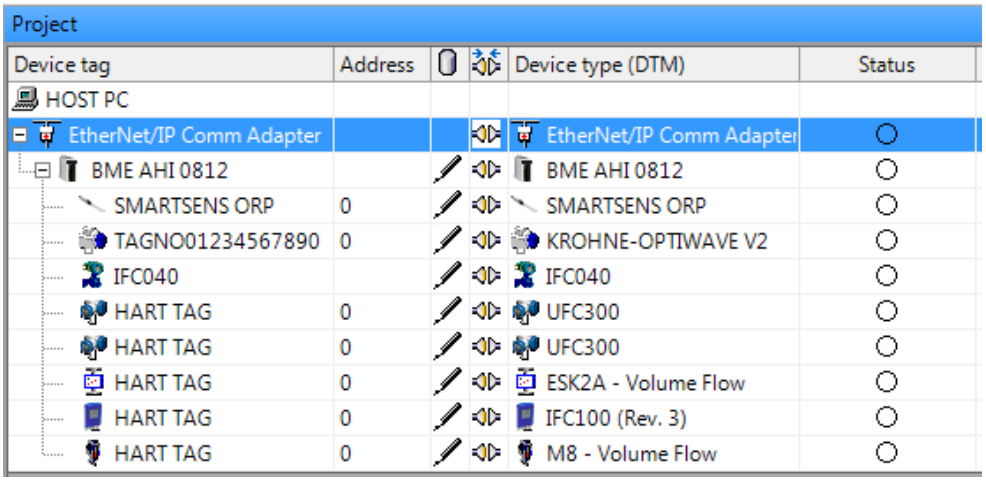


Figure 22: HART devices in the field (PACT ware)

The AMS can help users find the maintenance information and instrument errors before the device failure or process breakdown occurs. The easiest way to manage device status is to use the diagnostic scan function. It periodically scans device status, and saves all of the statuses with timestamps and logging in the database, making it easy for users to get the status of all the instruments, and make appropriate maintenance plans.

A diagnostic scan result is shown as the below diagram.

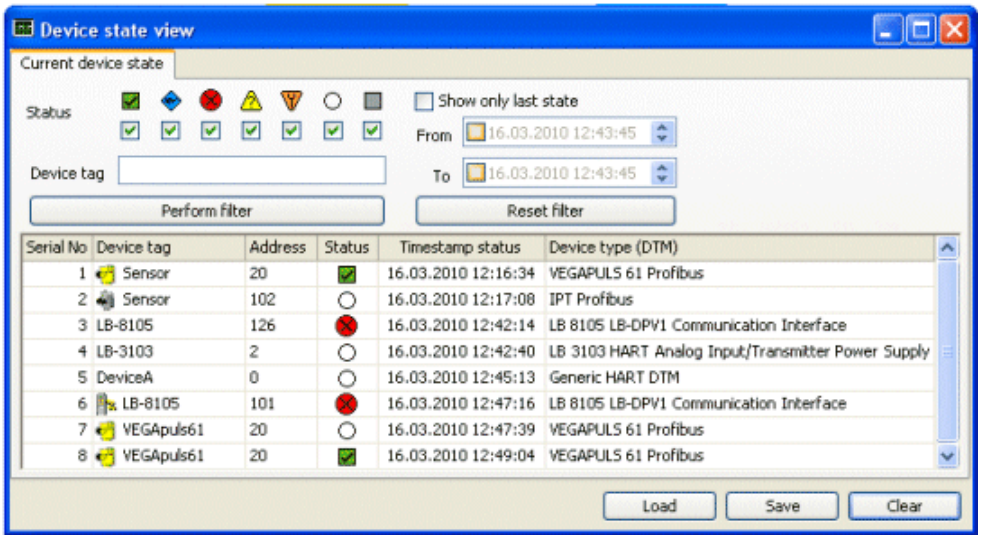


Figure 23: HART instruments diagnostic scan (PACT ware)

The AMS provides HART device diagnostic status as ‘active,’ ‘maintenance required,’ ‘outside of specification,’ ‘check function,’ ‘failure,’ etc. With this useful information, unexpected downtime can be drastically reduced and operating costs can be significantly saved.

4. Configuration

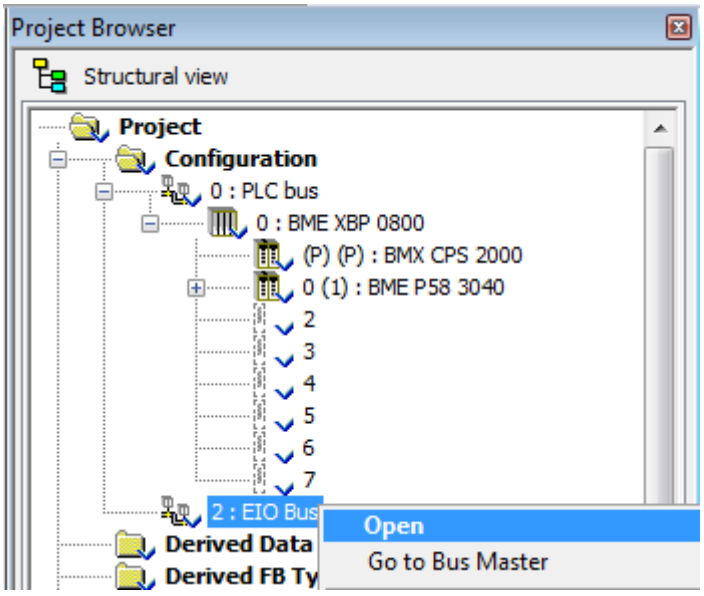
This chapter demonstrates the basic steps and the necessary configurations for establishing communication between the control systems and installed instruments.

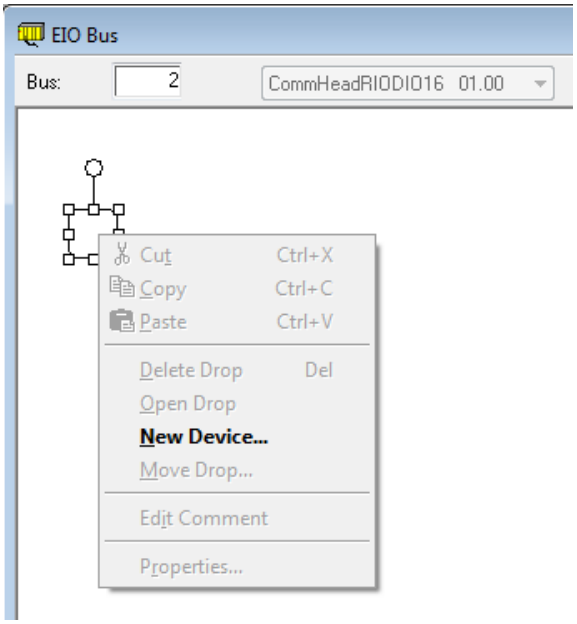
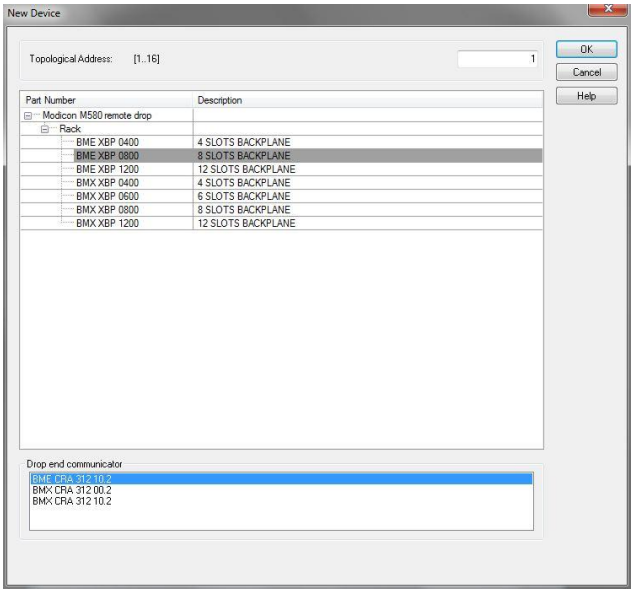
It includes how to add Ethernet remote I/O drops on M580 structure, how to configure an eX80 HART module using its DTM, how to establish the Ethernet connection with the field devices, and how to configure AMS software to connect the modules.

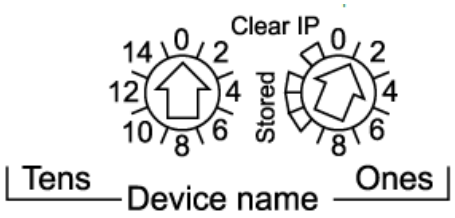
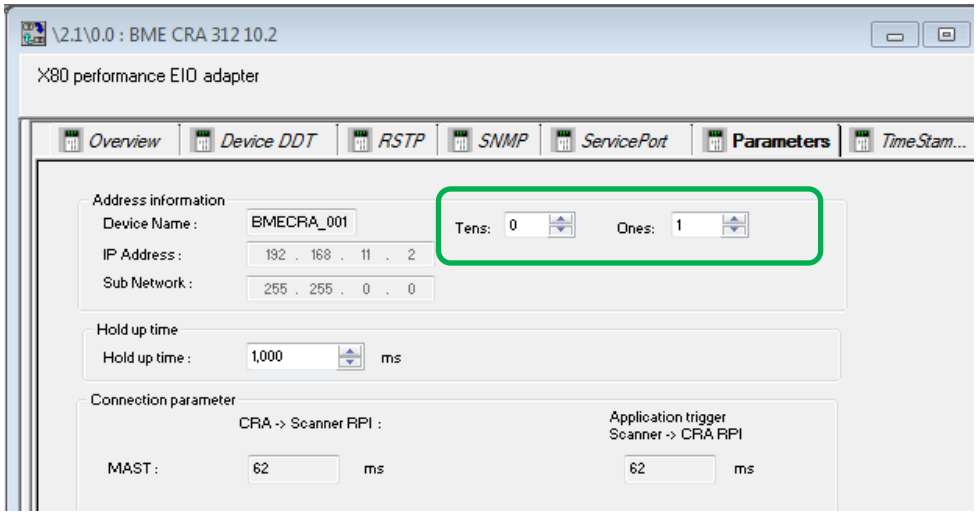
4.1. Configure Ethernet I/O Drop on M580 Structure

Create a Unity project with an M580 CPU (only the CPUs ending with 40 can support RIO and EIO). Users can add up to 16 EIO drops into the EIO bus.

Each drop contains a main remote rack, a power supply module, a BME CRA adapter and an eX80 I/O module:

Step	Action
1	Create a project with M580 X040 CPU, and add Ethernet I/O drops in **Project Browser.** Double click the **EIO Bus** to open. 

Step	Action
2	Add a new drop in the select EIO, and right click the empty bus to choose **New Device…** 
3	Within the **New Device** window, Ethernet backplane and BME CRA must be selected in order to support the eX80 HART module. 

Step	Action
4	Open the CRA configure window to define the parameters. In order to identify the drop number and acquire the **IP address** by the CRA **Device Name**, the **Tens** and **Ones** on the **Rotary Switch** of CRA parameters should be the same on the front of the adapter module.  
5	To add other EIO drops, repeat steps 2 to 4. Within the M580 structure, a maximum of 16 RIO drops are supported for the 3040 & 4040 CPUs, and a maximum of 8 RIO drops for the 2040 CPU.

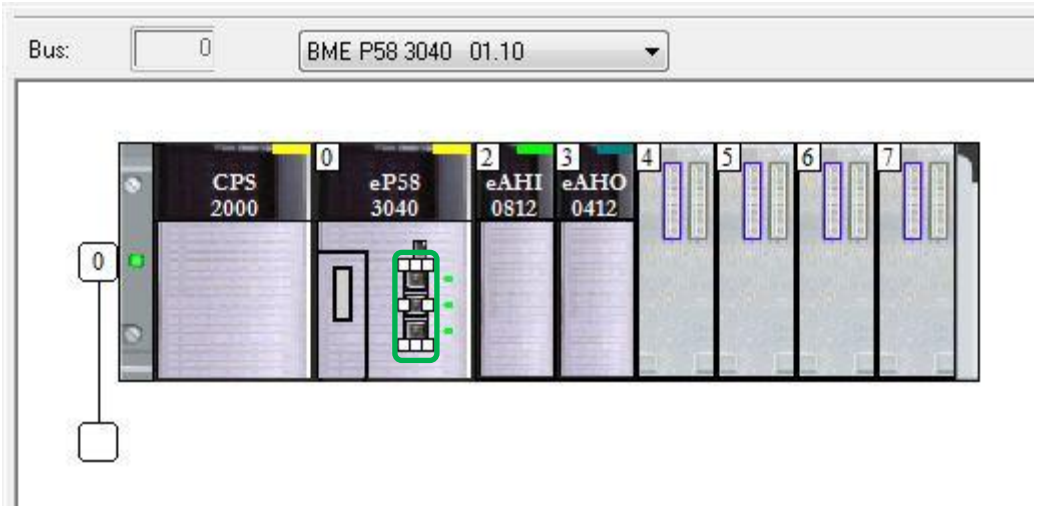
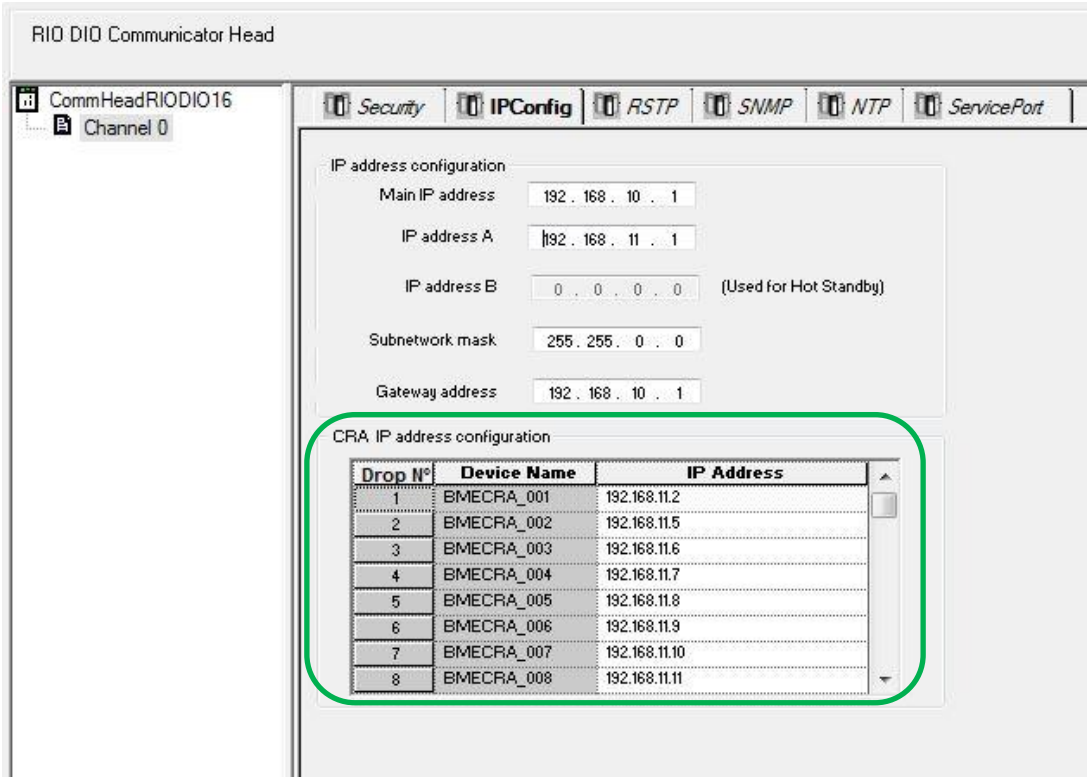
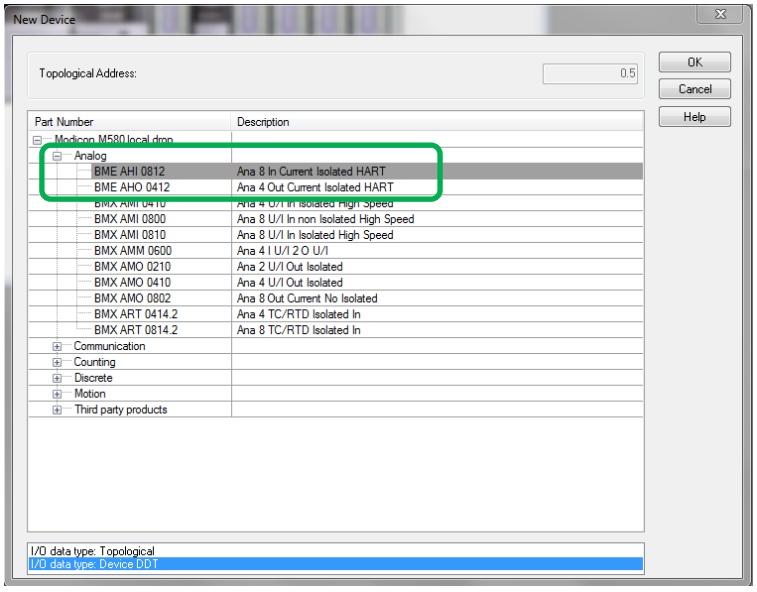
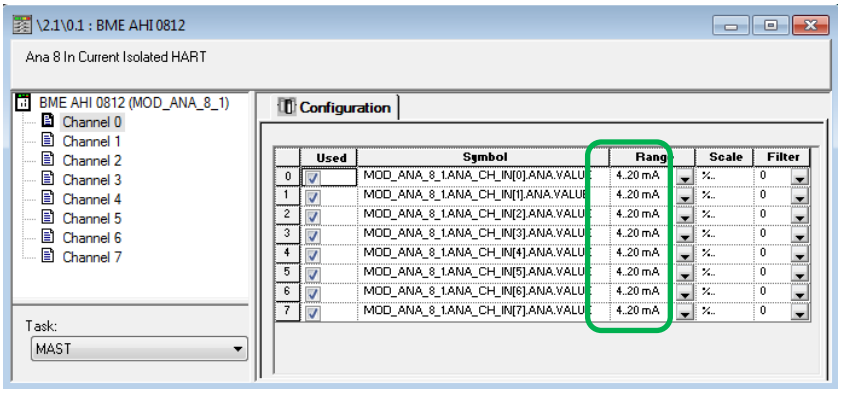
Step	Action
6	Double click the Ethernet port of M580 to open the Ethernet service window. 
7	Within the **IPConfig** window, check that the RIO drops have been added, or modify the CRA's IP address. 

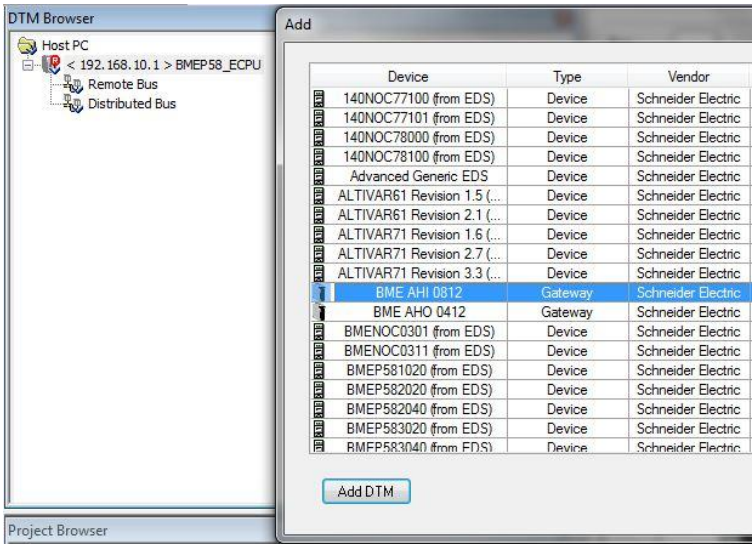
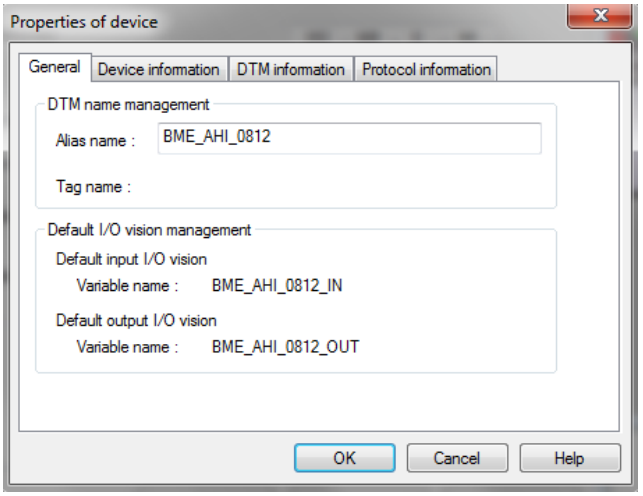
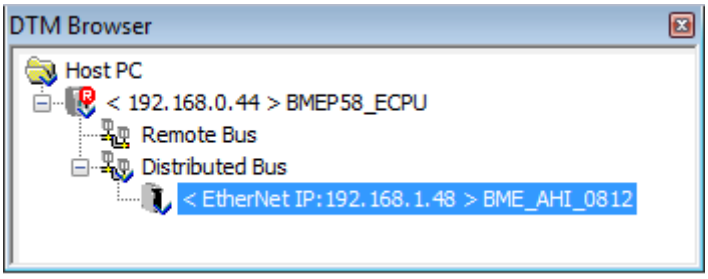
Table 12: Configuring Ethernet I/Os on the M580 structure

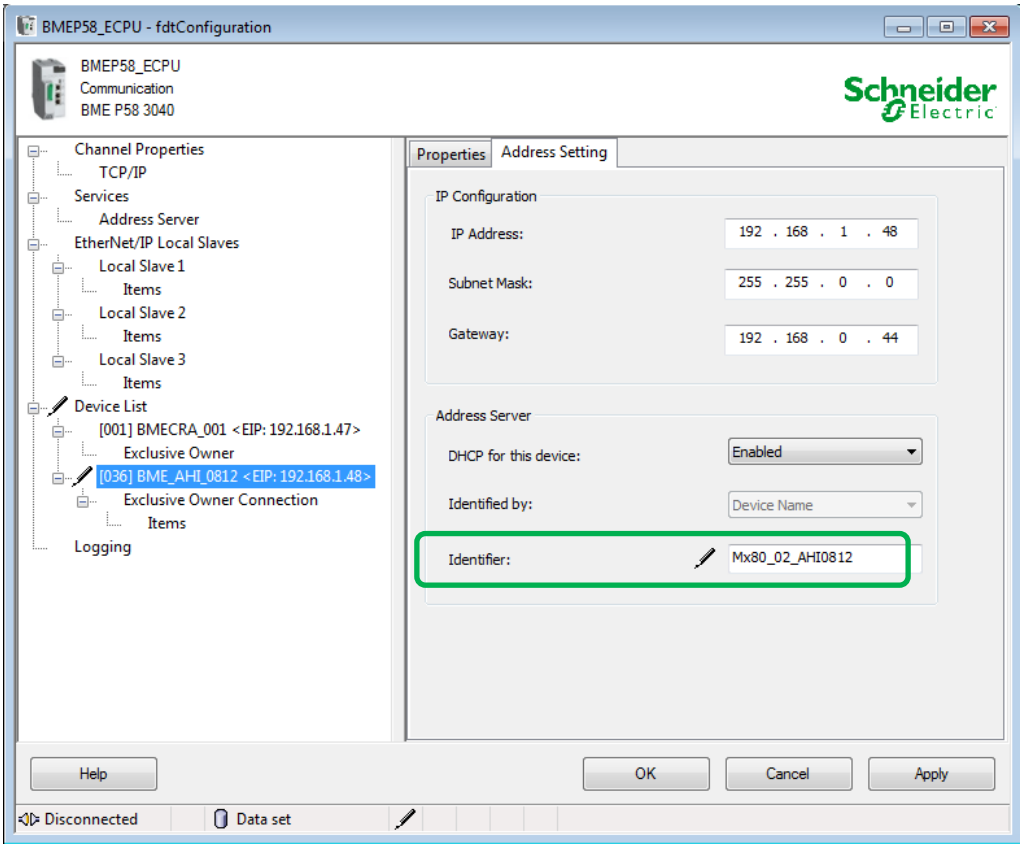
4.2. Configure eX80 HART Modules

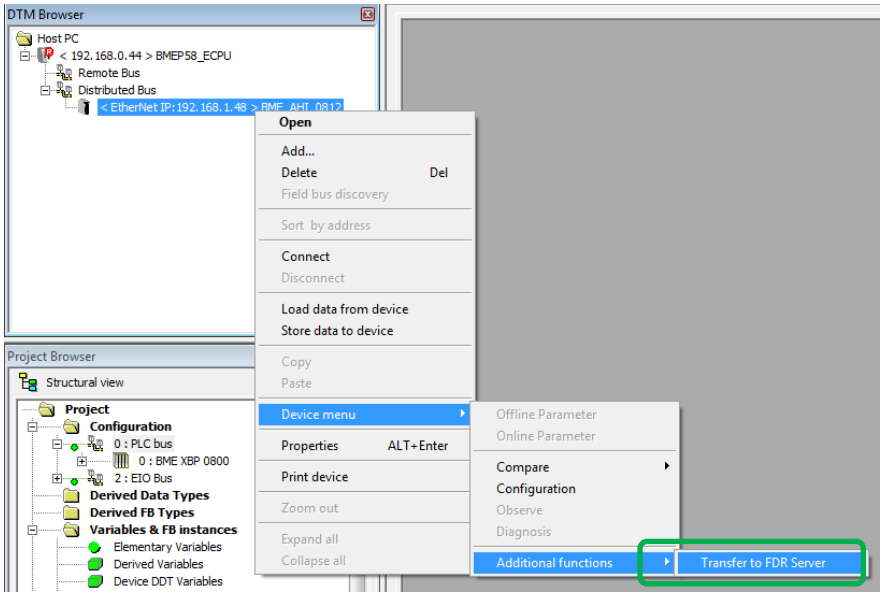
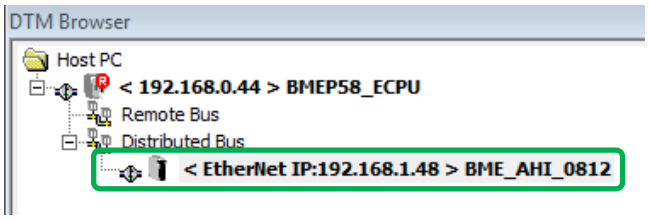
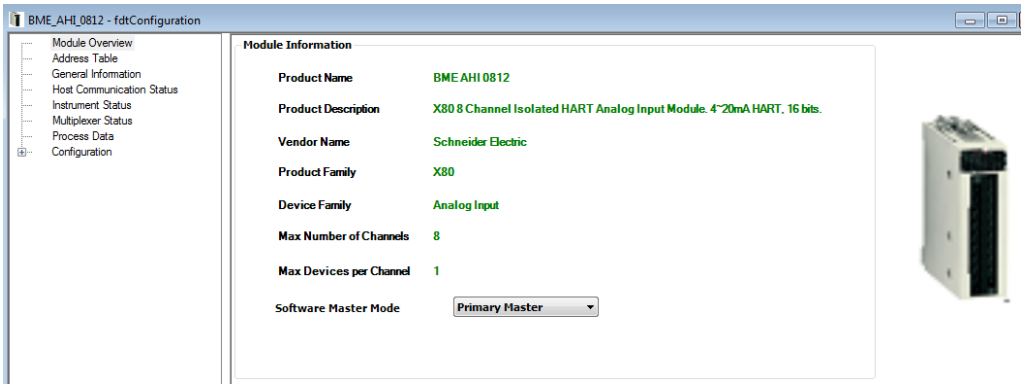
You need to add the eX80 HART modules' DTM into the Unity Device Type Manager, as well as add them in to the M580's remote I/O.

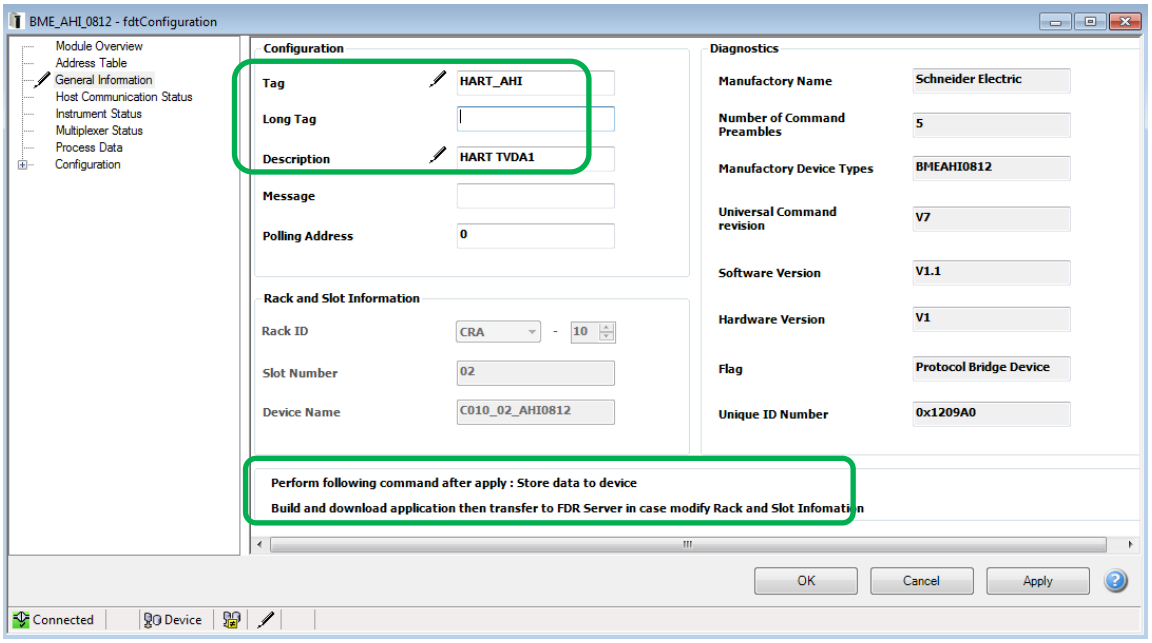
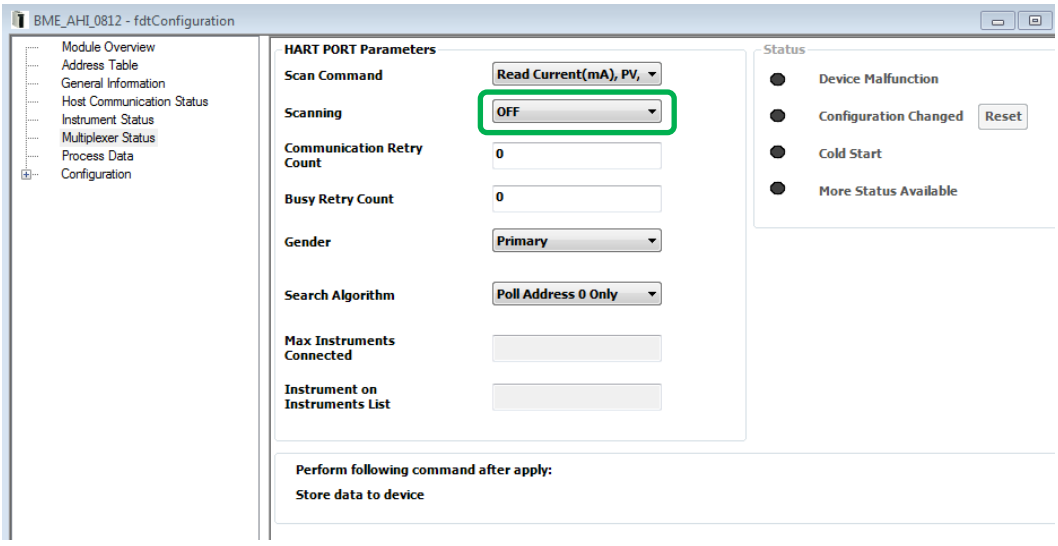
In order to establish an Ethernet connection to transfer HART data between the M580 and HART modules, the M580 will distribute the IP address according to the HART modules' device name by DHCP server. Therefore, this section details how to configure a correct device name for the module.

Step	Action
1	Within both the M580 local rack and remote I/O Ethernet backplane, double click the empty slot. Then, select the x80 HART modules within the Analog group.  When installing in a local rack, you can choose the IODDT or Device DDT for the HART modules' diagnostics. When being installed in a remote rack, however, you can only use the Device DDT.
2	Double click the newly-added BME AHI module. The configuration interface is the same style as the analog module, but the channel is only for 4...20mA. 

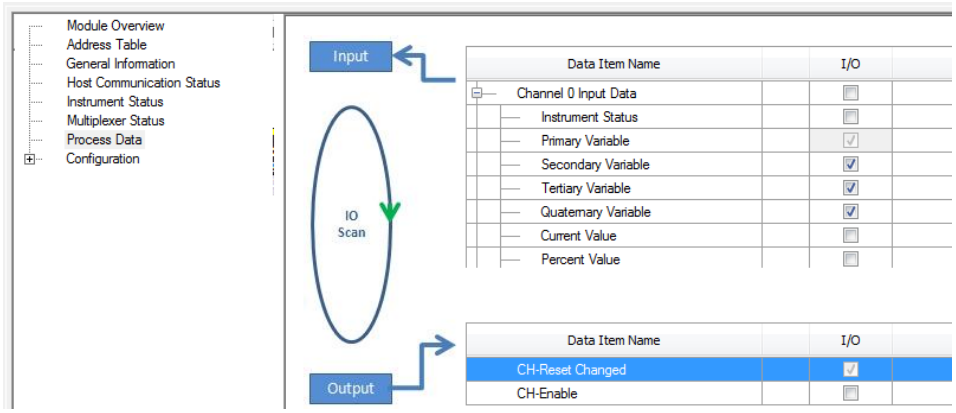
Step	Action
3	Open the **DTM Browser**, and right click the **BMEP58_ECPU** to select BME AHI or AHO module's DTM. 
4	The **Alias name** of the module can be modified. 
5	An AHI HART module has now been successfully added. You can open the module's DTM to configure the HART parameters and check instruments status. But to get this DTM online, it first need to set the HART module's IP address in the M580 DTM or BME NOC DTM. 

Step	Action
6	Within the **DTM Browser** window, double click the **BMEP58_ECPU** to enter the M580 DTM page. Choose the HART modules in the **Device List**, and select the **Address Setting** tag to modify the **IP Configuration** and **Identifier name**.  The HART module uses the device identifier name to request an IP address from the FDR server. You need to create the Device Name identifier by concatenating the Rack ID and Slot Number values, as follows: For the HART module within the local main rack, the **Identifier** should be: **Mx80_XX_AHI0812 / Mx80_XX_AHO0412** XX refers to the slot number of the module. For example, 'Mx80_02_AHI0812' is the Identifier of the BME AHI 0812 in slot n.2 of the main rack. For the HART module within the Ethernet I/O rack, the **Identifier** should be: **CYYY_XX_AHI0812 / CYYY_XX_AHO0412** XX also refers to the slot number of the module, and YYY refers to the remote drop CRA's device number (Tens + Ones on rotary switch) on the EIO bus. For example, 'C005_02_AHI0812' is the Identifier of the BME AHI 0812 in slot n.2 of the EIO connected by the BMECRA_005 adapter on the rack.

Step	Action
7	Build the project and download to the CPU. Then open the DTM Browser, right click the HART module and perform 'Transfer to FDR server'. After that, the HART module can receive its IP address which we have configured in M580's DTM. 
8	Right click the HART module in DTM Browser, and select 'Connect' to link the HART DTM online. 
9	In Module Overview page, it shows the module information and you can choose the HART master as the primary or the secondary. 

Step	Action
10	In the General Information page, it shows the module HART configuration, the rack and slot information and also the diagnostics. At the end of the each HART DTM page, it indicates the necessary steps to enable the modification applied on the page.  In this case, we modify the HART module's tag and description in this page. As indicated at the end of the page, it is required to perform a 'store data to device' to enable the new configuration.
11	In the Multiplexer status page, you will find the HART PORT parameters which allow you to configure the HART communication mode and status. If the 'eX80 HART Generic' DFB is used in the Unity application, while the HART DTM is connected, it's highly recommended to switch 'Scanning' to OFF to optimize HART communication performance. 

Step	Action
12	In the 'Process Data' page, you can select the I/O data which you want to map to the HART multiplexer scan and associate with the Device DDT. By default, each channel's four measurements - PV, SV, TV, and QV - are selected.



You can also include other items, like 'Instrument Status', 'Current Value', etc. The more items you select, the larger the M580's DIO scanner size. The HART module's 'Process Data' size should not exceed the CPU's limits.

Based on the CPU & NOC's DIO scan size, we can calculate how many HART modules can be installed with different HART host. The results are listed in the table below.

HART host(1)	DIO scan INPUT size	DIO scan OUTPUT size	AHI size	AHO size	HART modules install number with IN(min)	HART modules install number with IN(max)
BME P58 2040\3040\4040	2048 Bytes	2048 Bytes	IN(min)(3)=44 IN(max)=268	IN(min)=24 IN(max)=136	AHI:2048/44=46 or AHO: 61(4)	AHI:2048/268=7 or AHO:2048/136=15
BME NOC 03*1	3637 Bytes(2)	3645 Bytes			AHI:3637/44=82 or AHO: 112(4)	AHI:3637/268=13 or AHO:3637/136=26

(1) The BME P58 1020 \ 2020 \ 3020 \ 4020 CPUs don't support remote IOs, so the HART modules can only install in the local rack. 6 HART modules can be installed.

(2) The BME NOC includes 4096 input bytes and 4096 output bytes for DIO scan, some memory is reserved for the NOC internal use.

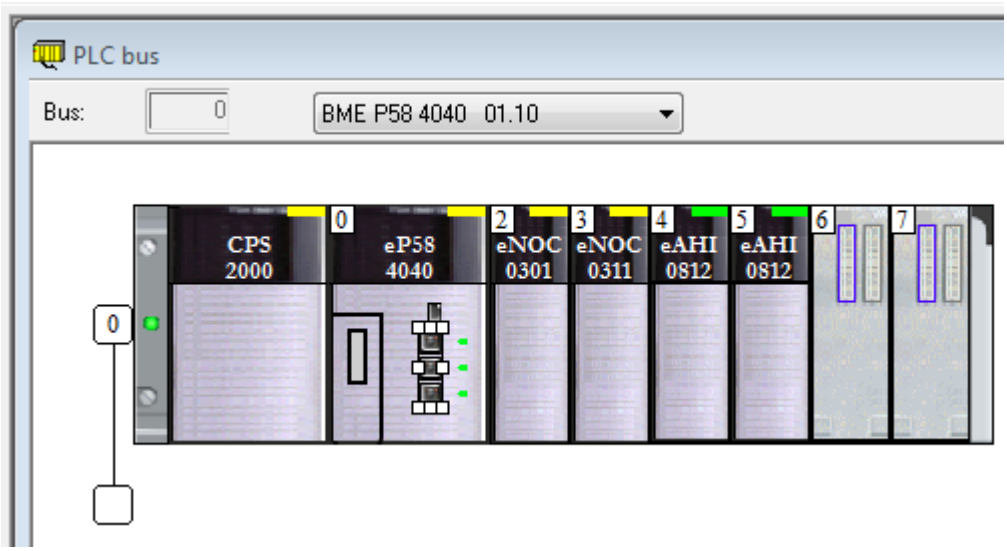
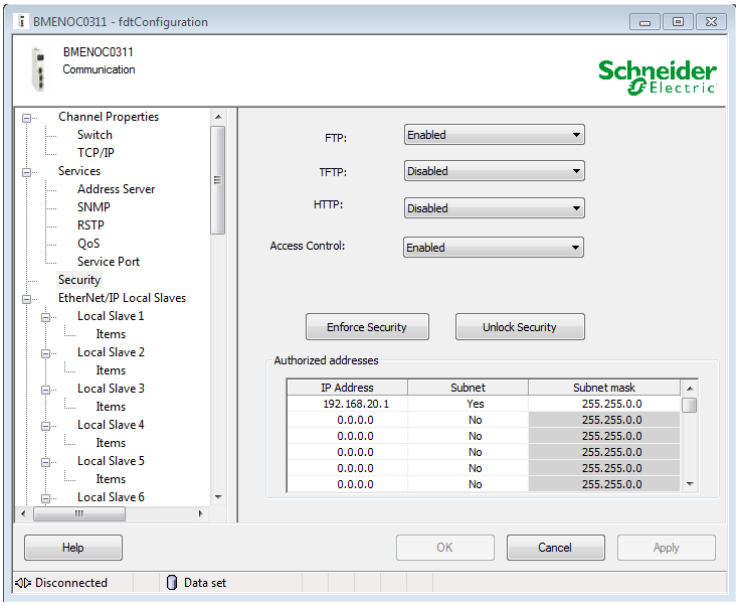
(3) (Min) for minimum item selected, (max) for all the items selected in the DTM 'Process Data' page.

(4) The maximum number of DIO device is 61 for BME P58 2040\3040\4040 CPU, and 112 for BME NOC.

Table 13: Configuring eX80 HART module

4.2.1. Configure HART Modules with BME NOC

As mentioned in the above section, you can also use the BME NOC 0301 and BME NOC 0311 module as the host to increase the HART modules installed number. Below is the process to configure the HART modules linked with BME NOC 03*1.

Step	Action
1	Add BME NOC 0301 or NOC 0311 into the Ethernet slot of the main rack. 
2	Enable the FTP service of NOC on its security page so that the NOC Ethernet/IP server can access the HART modules through the Ethernet bus of the BME rack. 

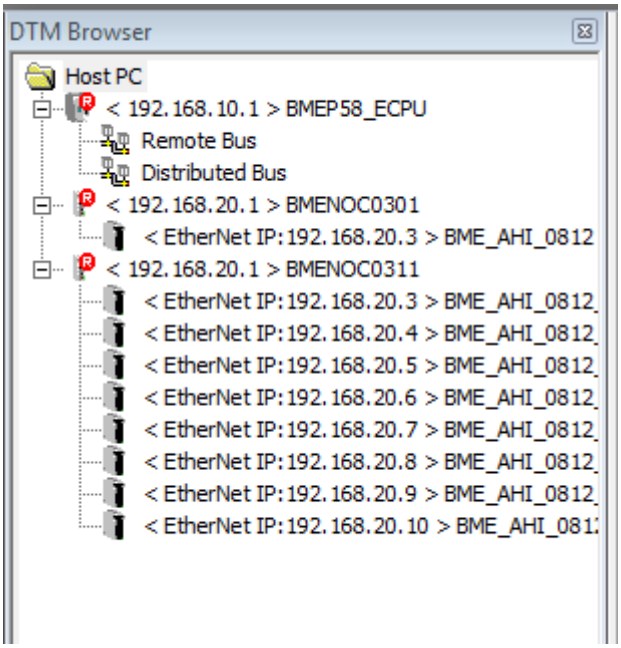
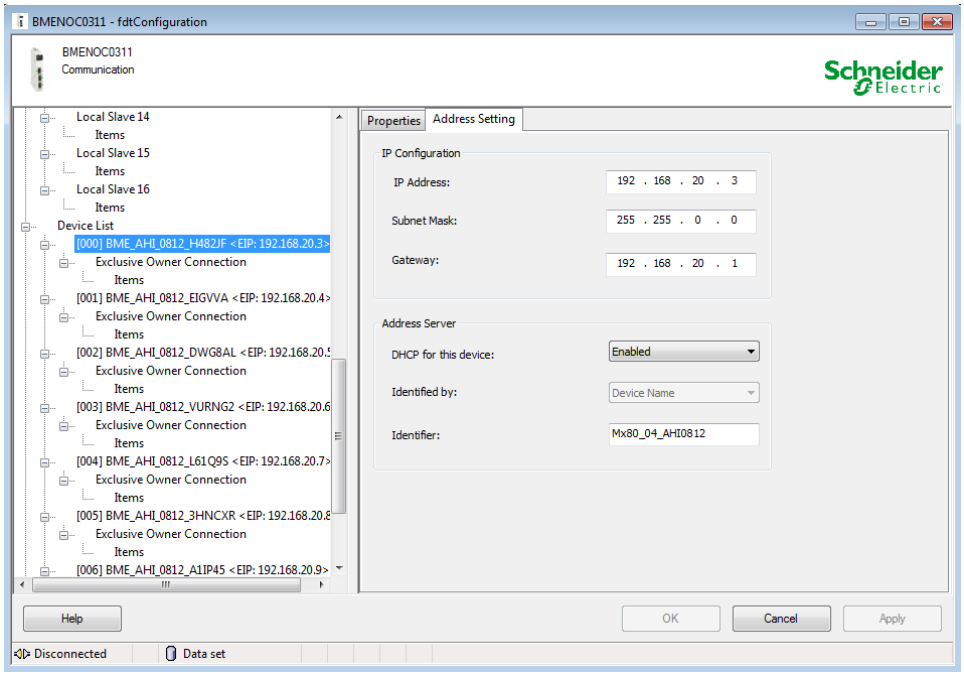
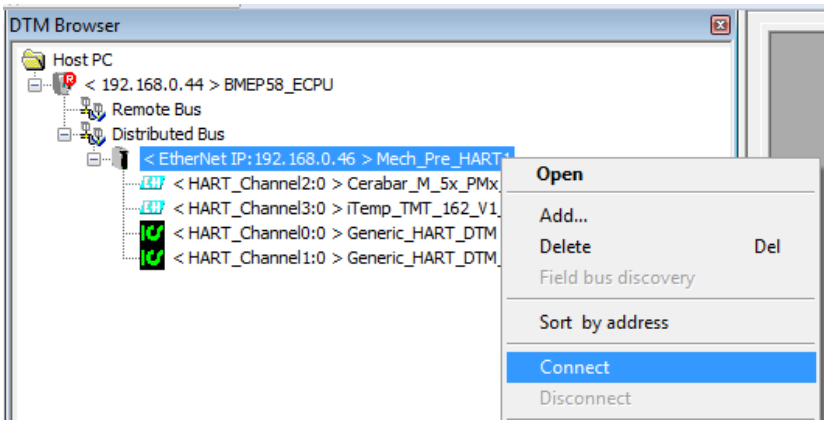
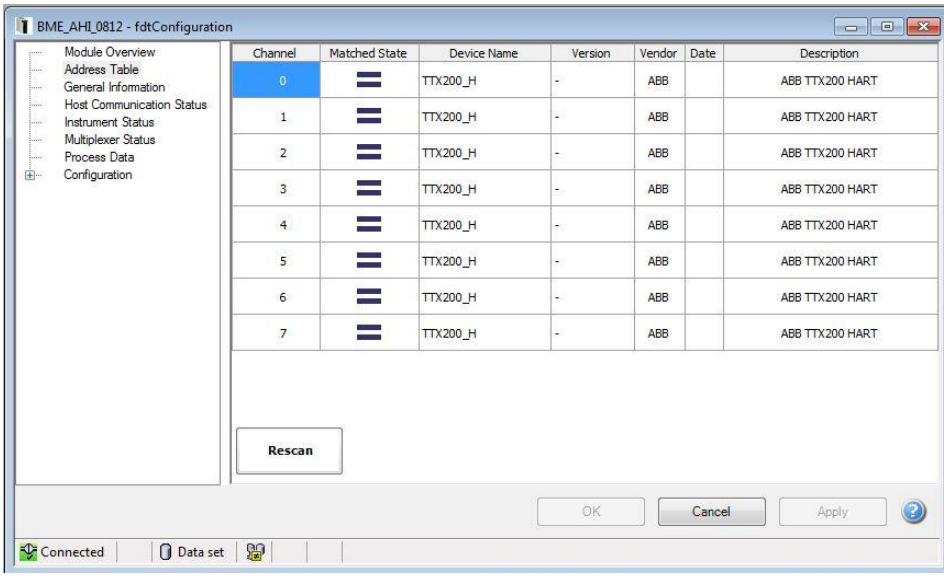
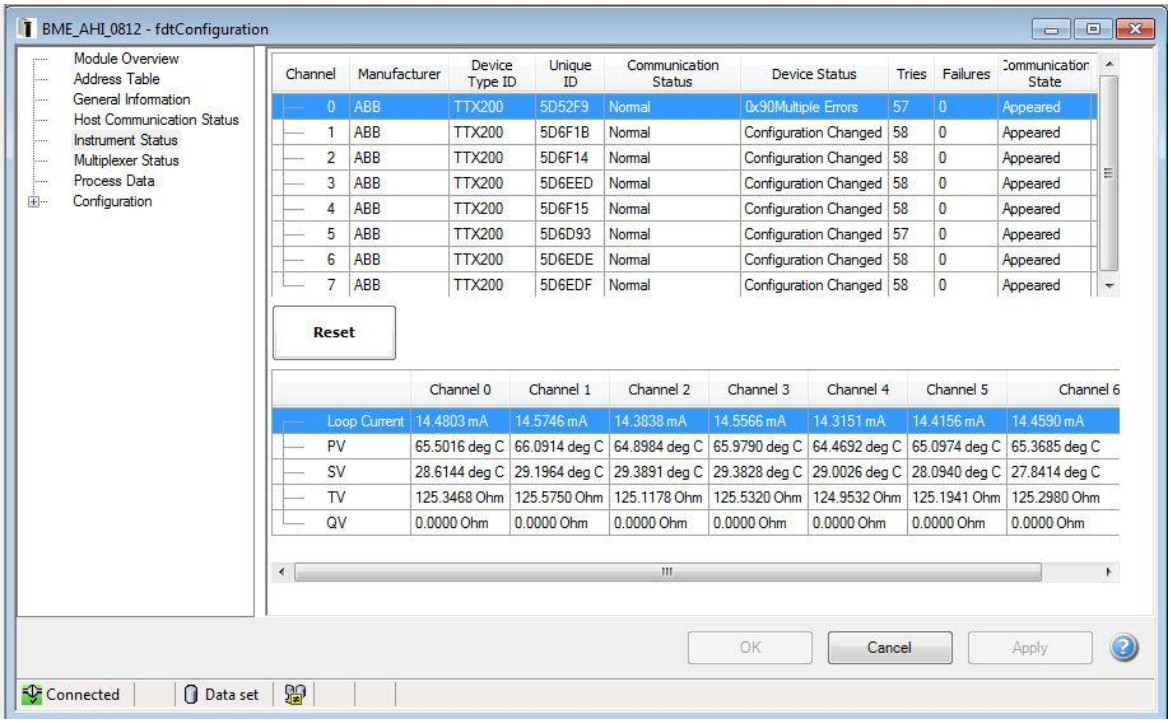
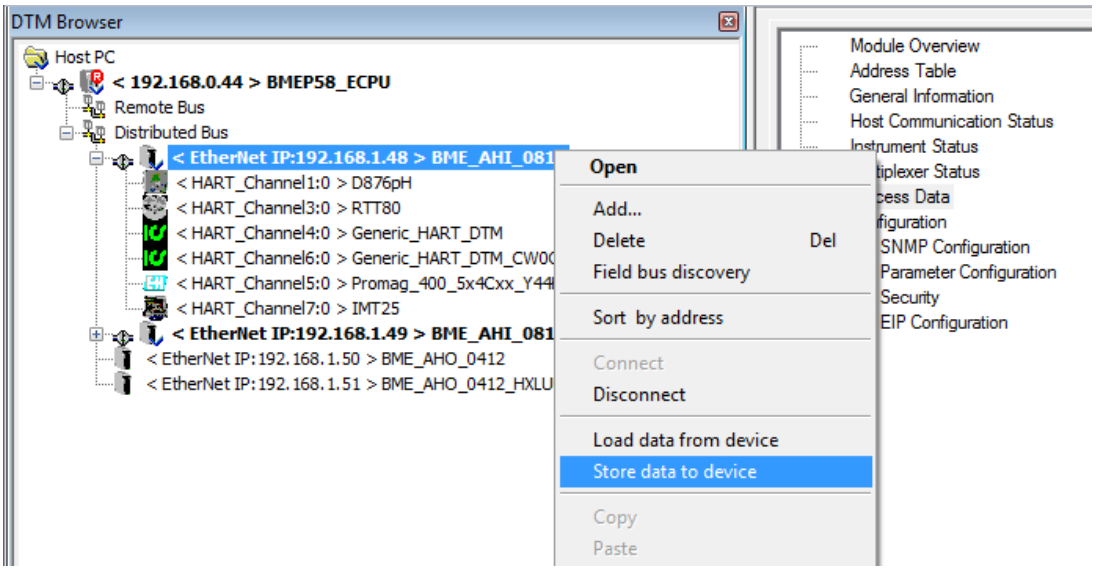
Step	Action
3	Add HART modules to the local or remote rack, but the HART modules' DTM should be added under the NOC master. 
4	Configure the DHCP server of the NOC to assign IP addresses to the HART modules. 

Table 14: Configure HART module with BME NOC

4.3. Establish Ethernet Connection with HART Module and Instruments

When the connection between the HART module and instruments is established, the real-time HART data can be shown on the DTMs.

Step	Action
1	Within the **DTM Browser**, right click the HART modules or HART instruments. Choose **Connect** to establish the **Ethernet Connection**. 
2	After the connection is established, the installed HART instruments' **status**, **Description**, and **Matched State** show in the **Address Table** tab. 

Step	Action
3	In the **Instrument Status** tab, all of the connection status and real-time data are accessible. 
4	If you change the parameters online in the ‘module overview,’ ‘general information’ or ‘multiplexer status’ windows within the module’s DTM, you will need to manually ‘store data to device’ in order to enable these new parameters to be stored to the module. 

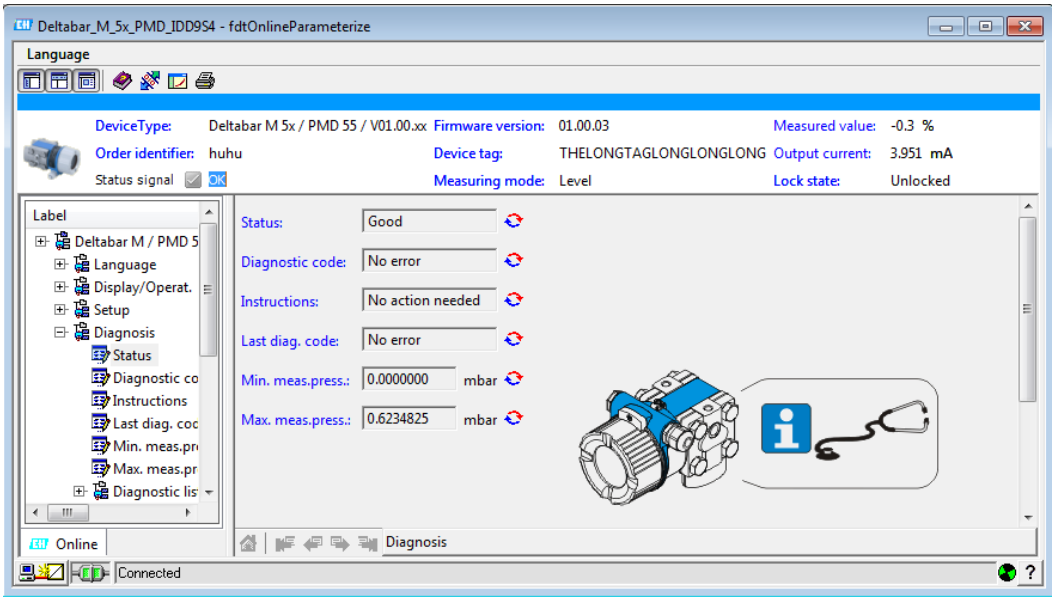
Step	Action
5	As with the HART modules, HART instruments can also be connected to set up the HART functions. After the connection is established, the HART functions can work within instruments' DTMs, like **parameterize, operate, calibration, simulation and diagnosis**. 

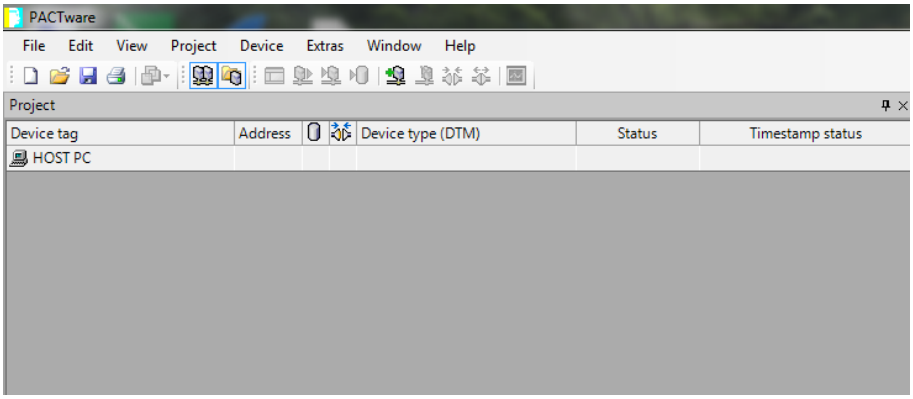
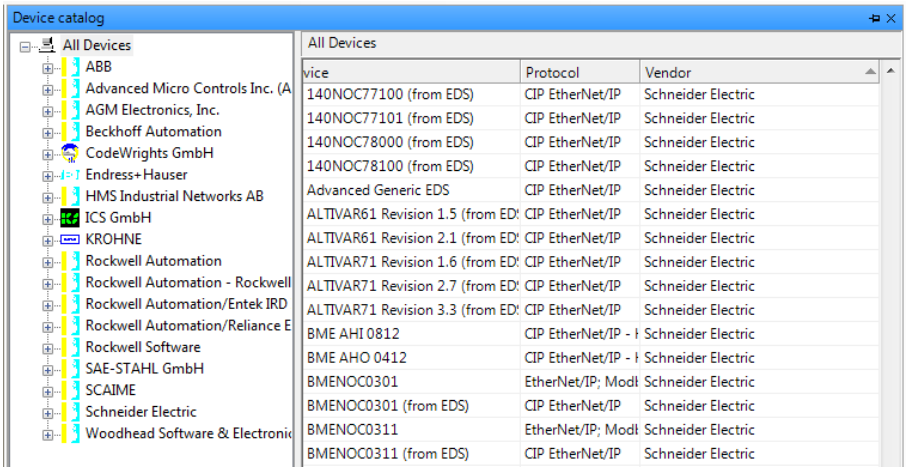
Table 15: Establish Ethernet communication with HART module and device

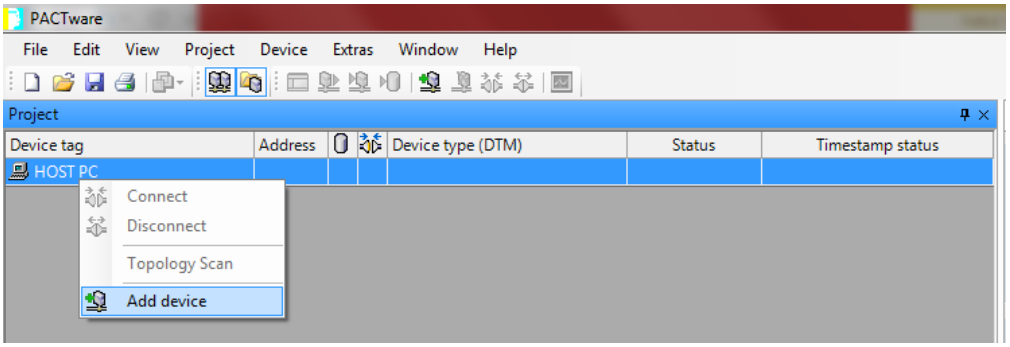
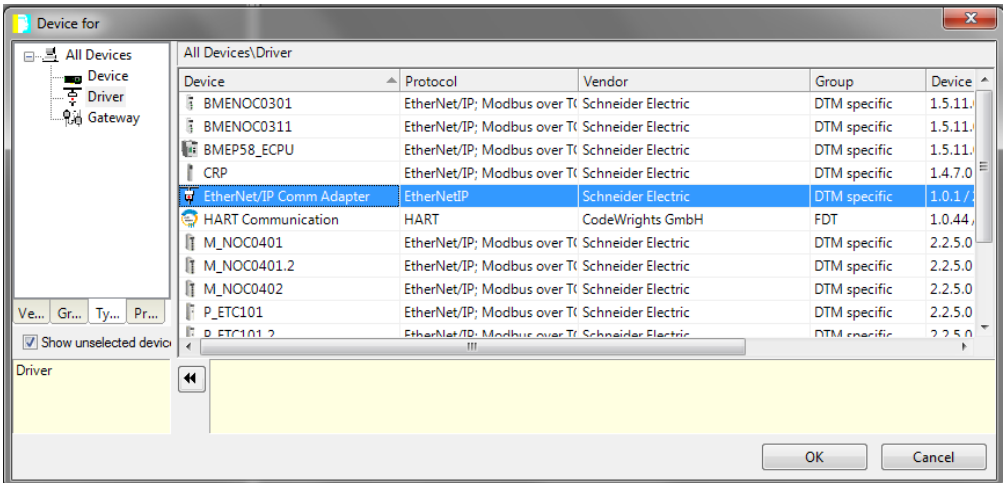
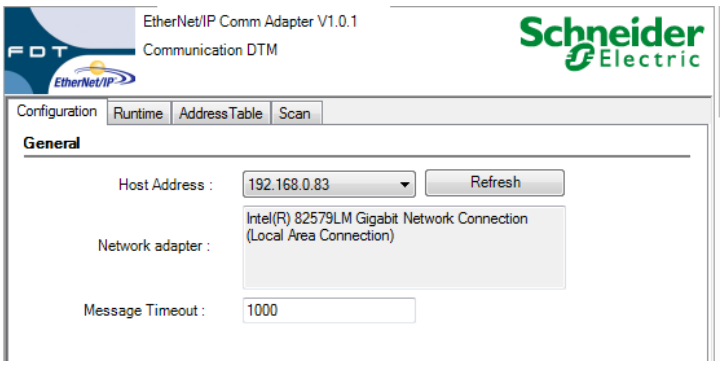
4.4. Configure AMS

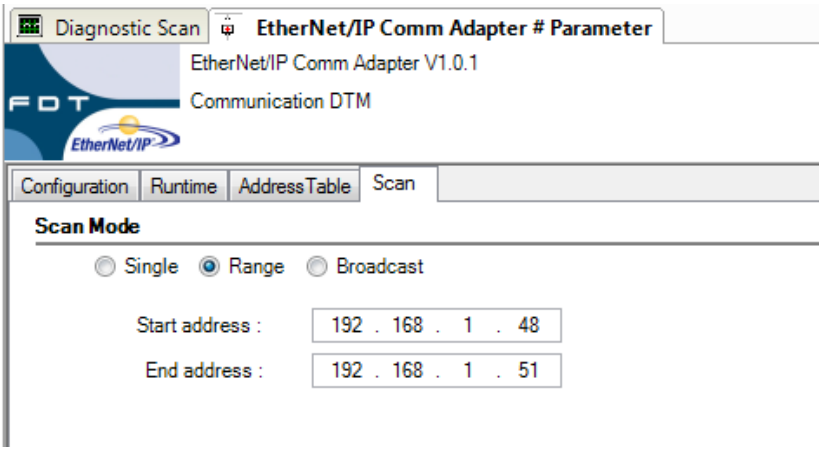
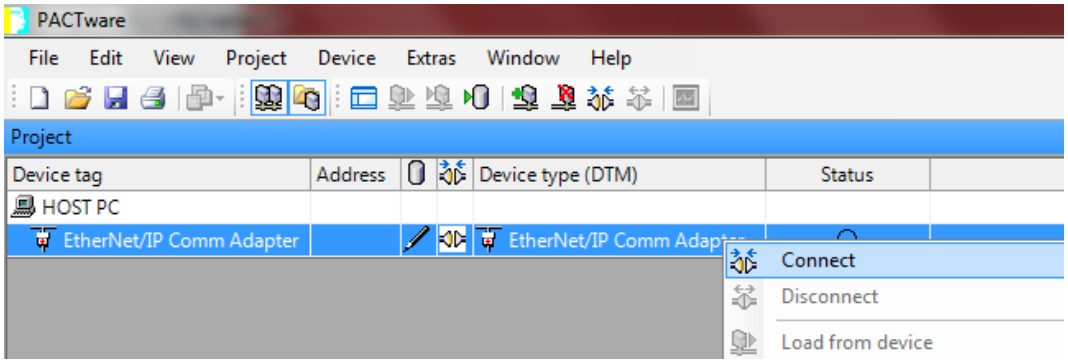
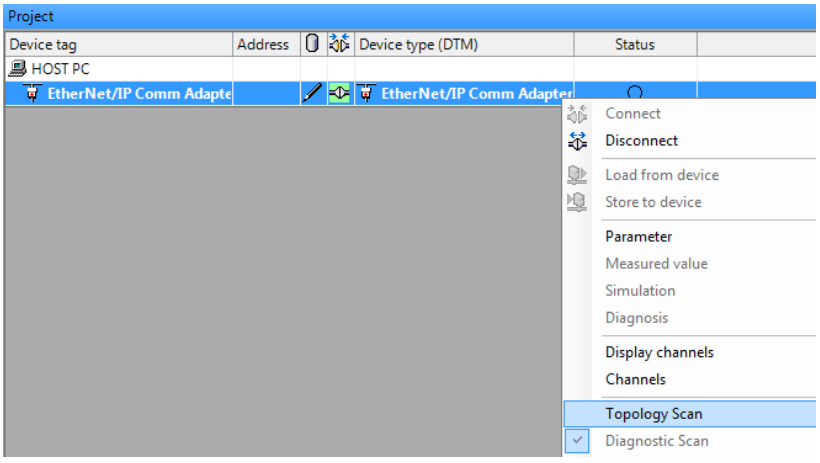
In this section, we will present how to configure the asset management software to manage our HART devices.

To establish the communication, an **EtherNetIP Communication DTM library** should be installed first. This can be downloaded from Schneider Electric's Global website. We will take the Pact ware and field care as demonstration.

4.4.1. PACTware configuration

Step	Action
1	Create a new project in the AMS. It will show a **HOST PC** tag in the window. 
2	It will also show all the devices which the DTMs have installed and are fully support in the **Device catalog**. 

Step	Action
3	Add a new device to set up communication between the AMS and HART modules. 
4	In the device catalog, choose the **EtherNet/IP Comm Adapter,** which is also developed by Schneider Electric, to scan the AMS accessible device as eX80 HART modules in the network. 
5	Within this **EtherNet/IP Comm Adapter** DTM, you can select the **Host Address** to start the scan. 

Step	Action
6	Then go to the **Scan** page. You can select the **Scan Mode** as **Single, Range or Broadcast**. In this case, we set all the HART modules' IP within the range. 
7	Complete the **EtherNet/IP Comm Adapter** DTM setting, and you will enable the connection to this device. 
8	After connecting successfully, the connection status will be green. Then right click on this device and choose **Topology Scan**. 

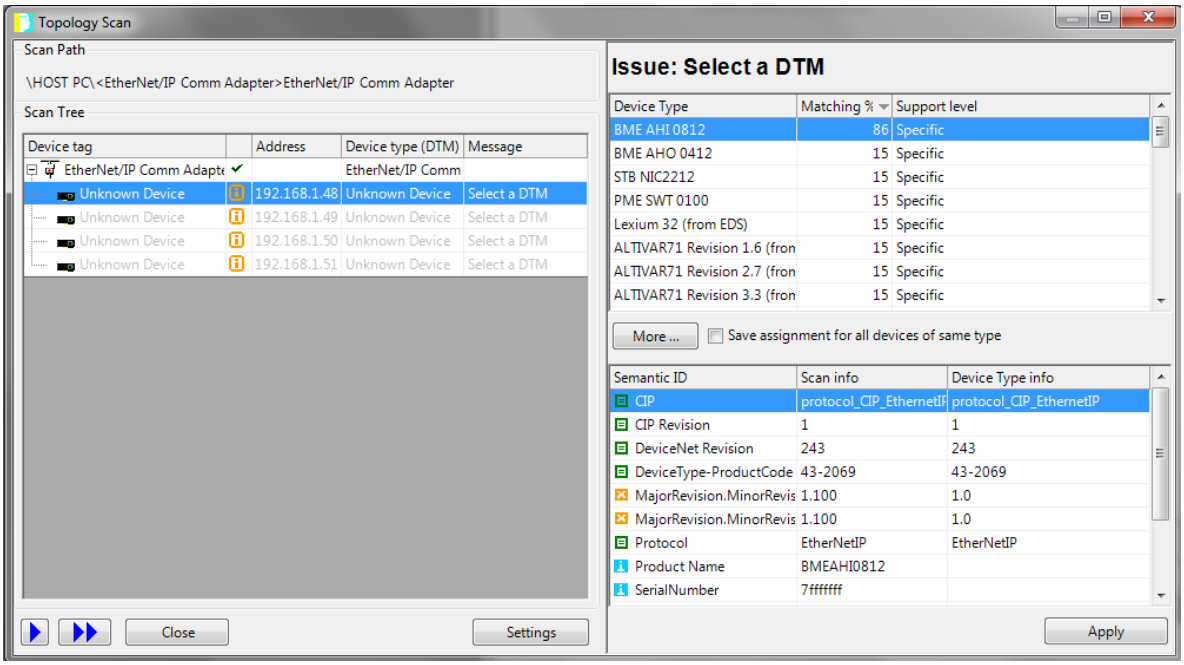
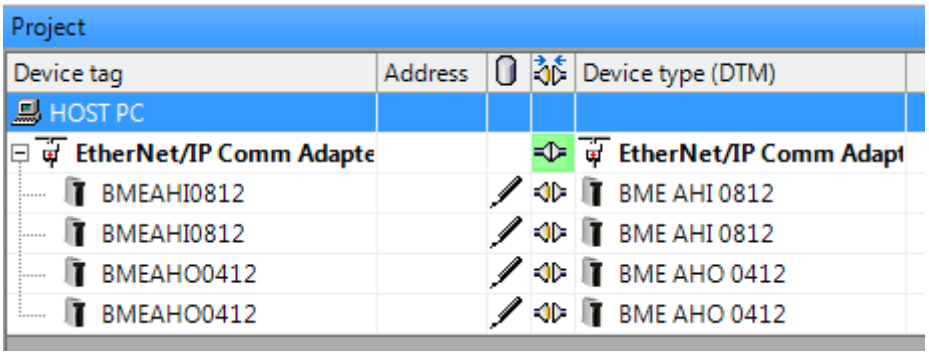
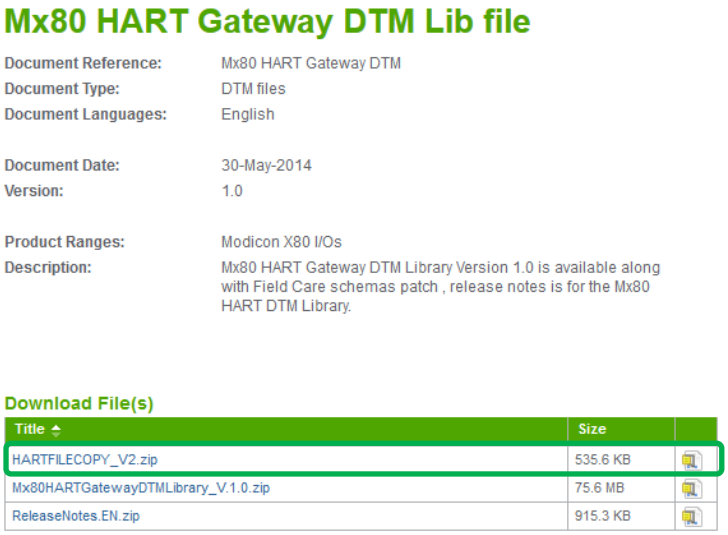
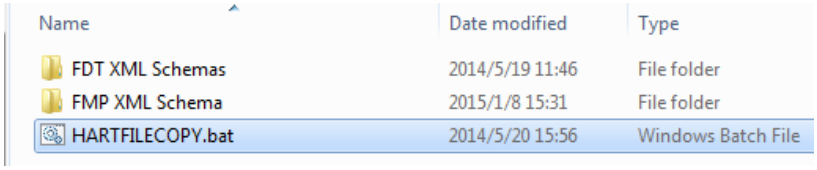
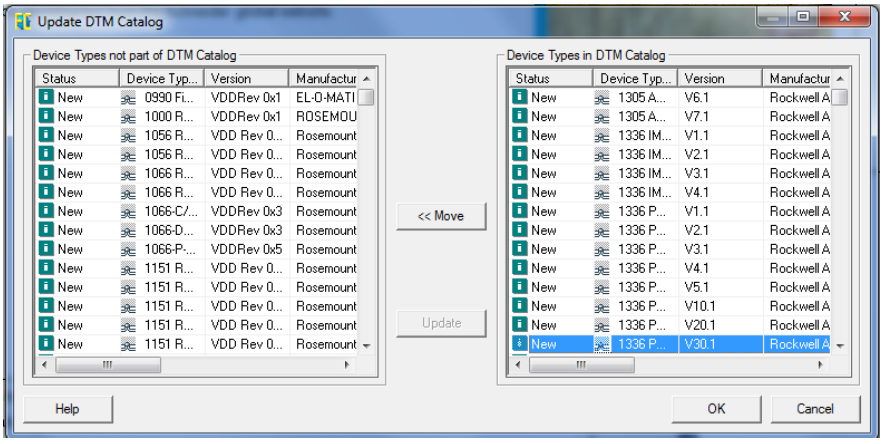
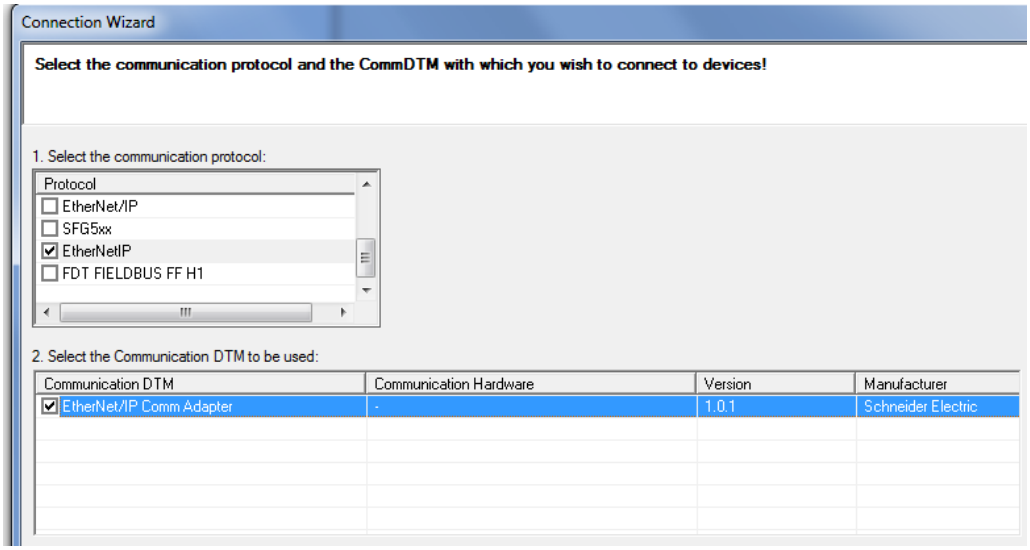
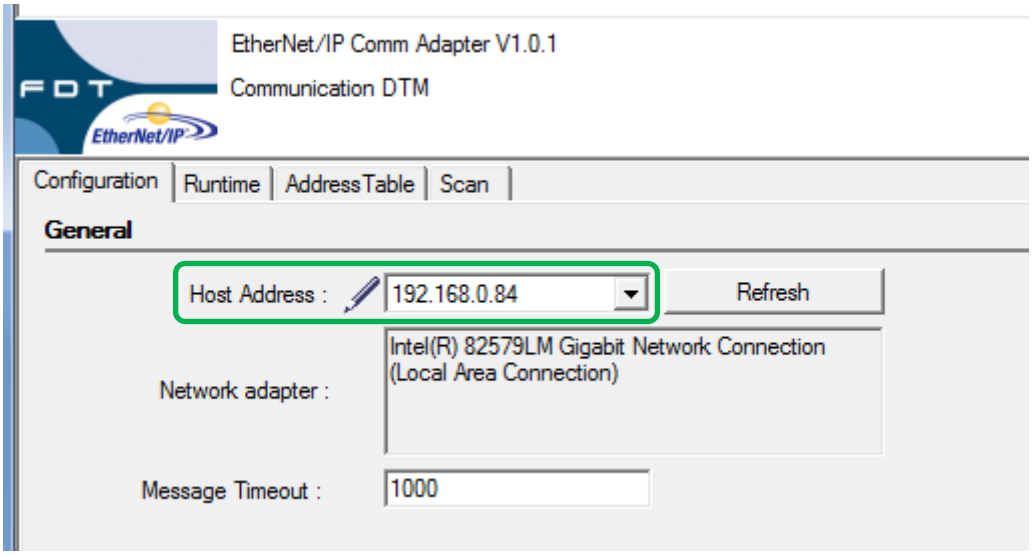
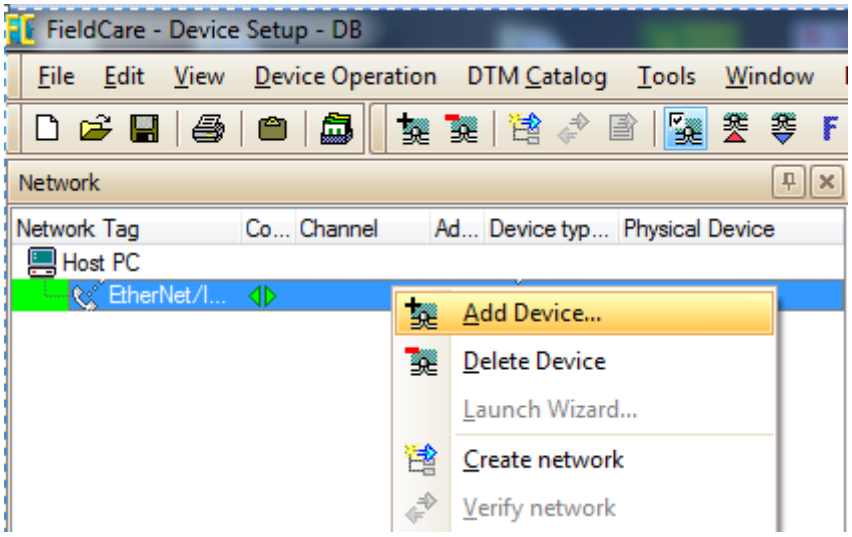
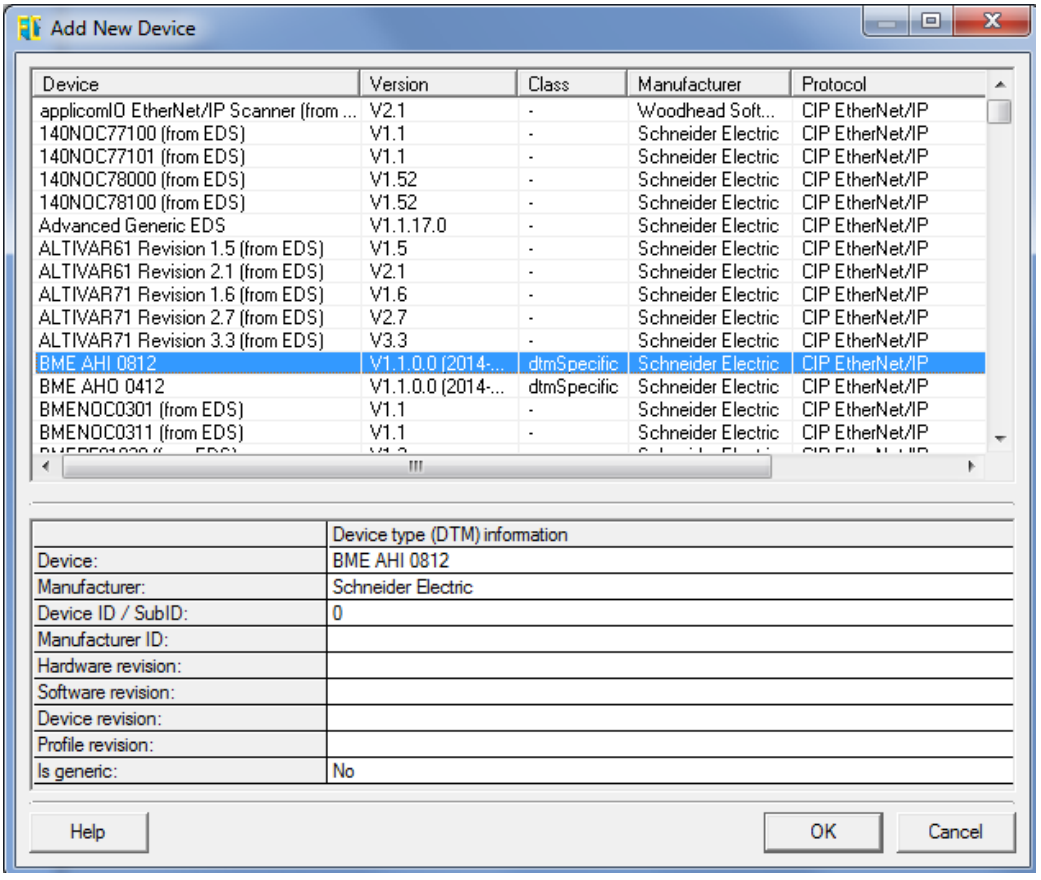
Step	Action
9	Click the blue **Start** sign to start the topology scan. It will scan the IP address as defined above. After the scanning, it will show the devices and you can choose the matching DTM according to the device information. In this case, the **BME AHI 0812** would be selected. 
10	All the accessible HART modules can establish an Ethernet connection with this Comm Adapter within the AMS. Below is the HART modules' topologic structure within the selected architecture. 

Table 16: PACTware Configuration

4.4.2. Field care configuration

Step	Action
1	To solve the compatibility problem of the eX80 HART DTM and field care, you must install a small patch before configuring the eX80 HART on the field care. This 'HARTFILECOPY_V2.zip' patch can be downloaded from Schneider Electric's global website. 
2	Download and unzip this patch. Then run the batch file within the fold. It will automatically copy the file into the field care installation folder. 
3	After the automatic scan is finished, the DTM list will be shown on the field care, and you can select which DTMs need move into the field care catalog. And after this operation, the field care connection wizard will appear. 

Step	Action
4	As with the PACTware setting, you must add the 'EtherNet/IP Comm Adapter' to connect the HART modules. This DTM is in the EtherNetIP protocol. 
5	Select the PC's host address which is used to connect the PAC and the modules. In this case, it is '192.168.0.84' 

Step	Action
6	After this EtherNet/IP Comm Adapter has been properly configured, you can add DTM modules to this adapter. Right click the adapter's DTM and choose 'Add Device.' 
7	Here is a BME AHI module as an example. 

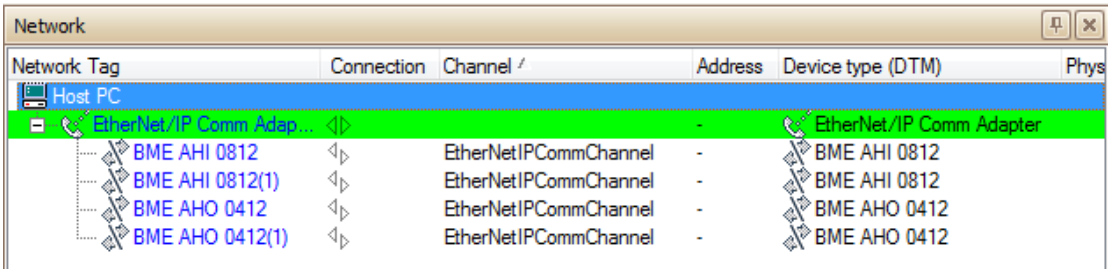
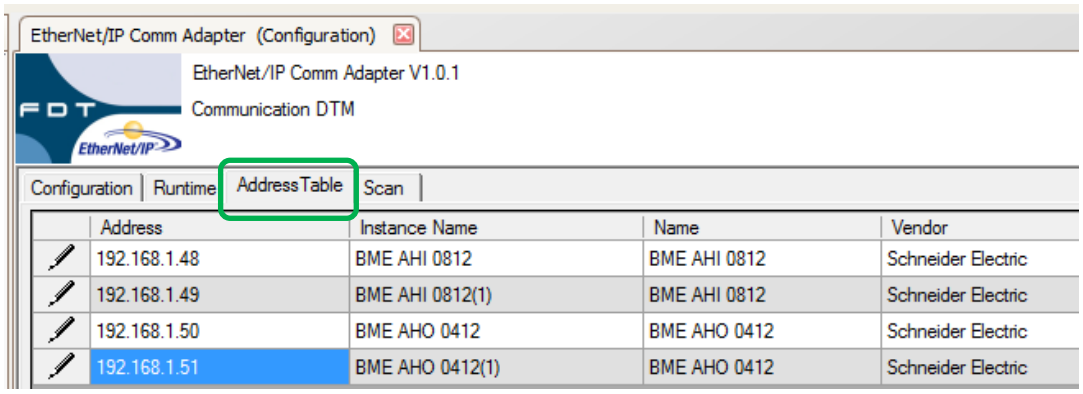
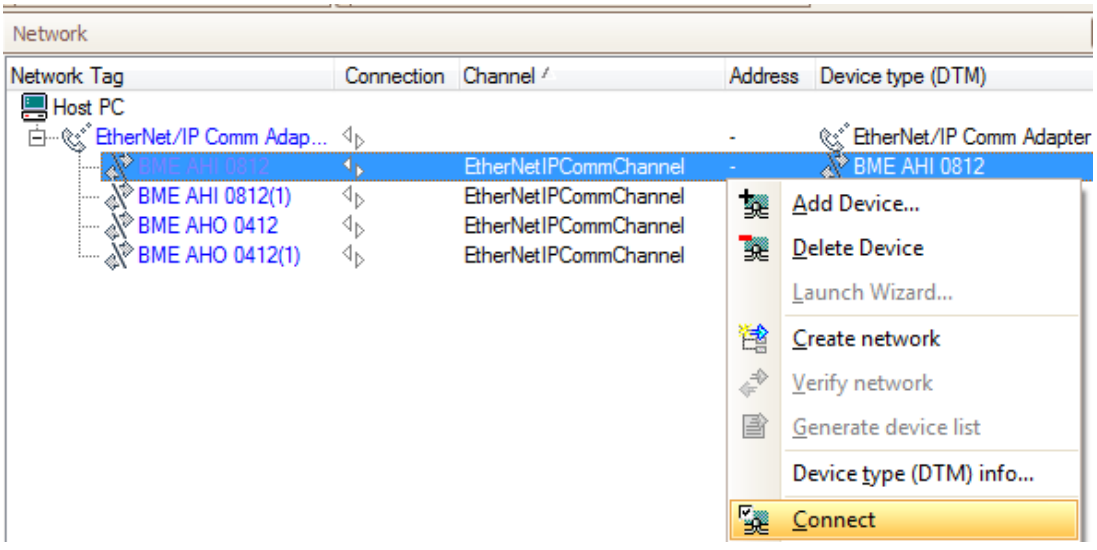
Step	Action
8	After the above installation is completed, the HART structure in this TVDA is shown as below. 
9	Open the adapter's DTM and configures the right IP address for these HART modules. Go to the Address Table and modify the IP address. 
10	After the IP address is set, the HART modules can be connected online within the field care, and you can add devices to the channels in the same way as the Unity DTM browser or PACTware. 

Table 17: Field Care Configuration

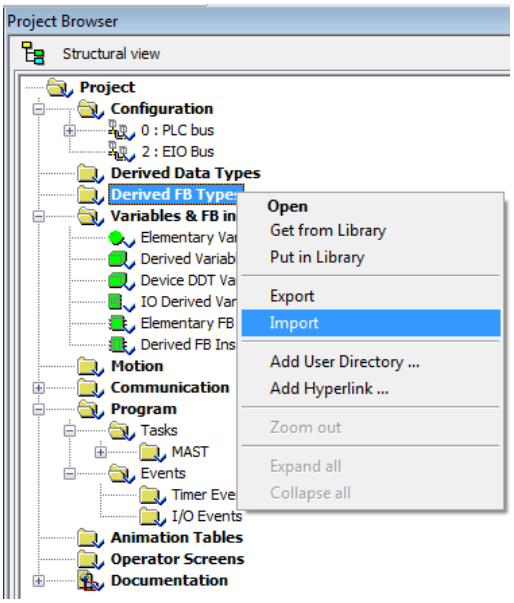
5. Implementation

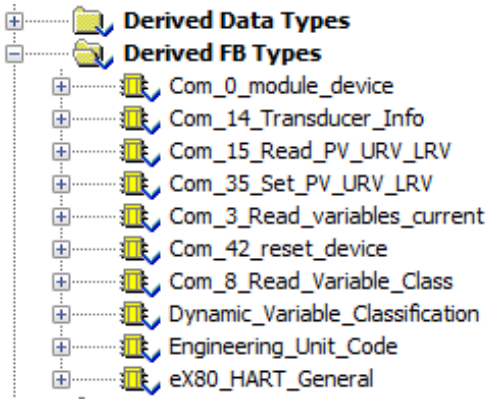
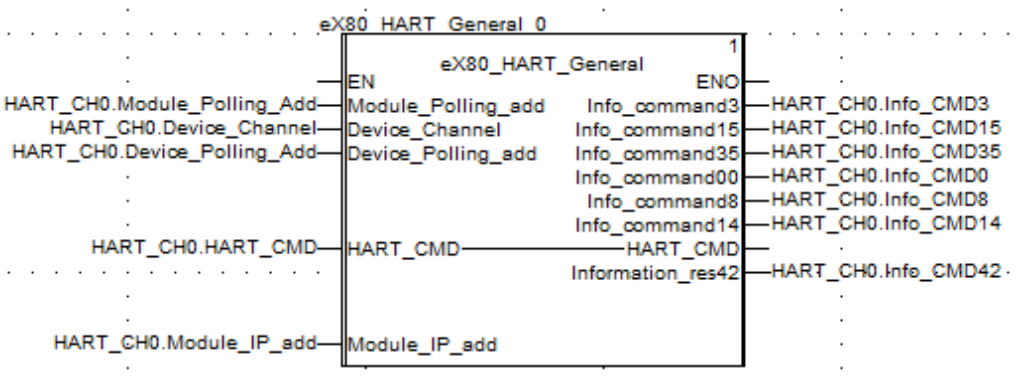
This chapter will present the steps to implement the ‘eX80 HART Generic’ DFB + VJC Genie to monitor & control the instrument from the SCADA through the PAC.

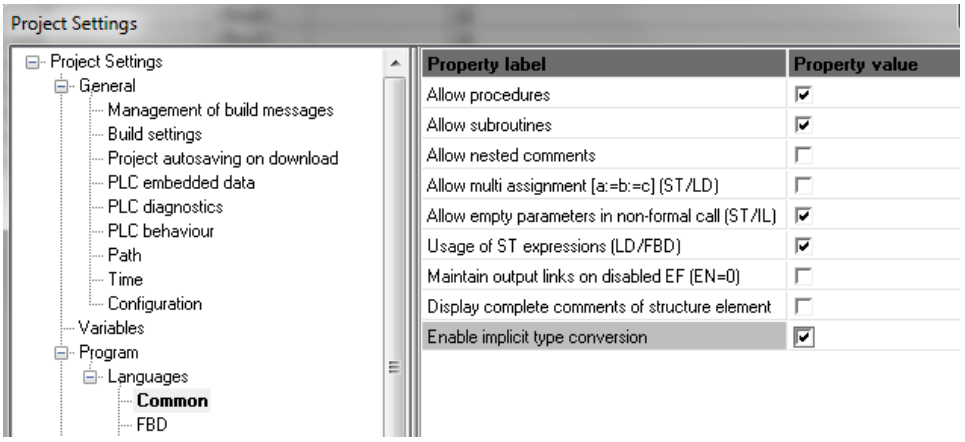
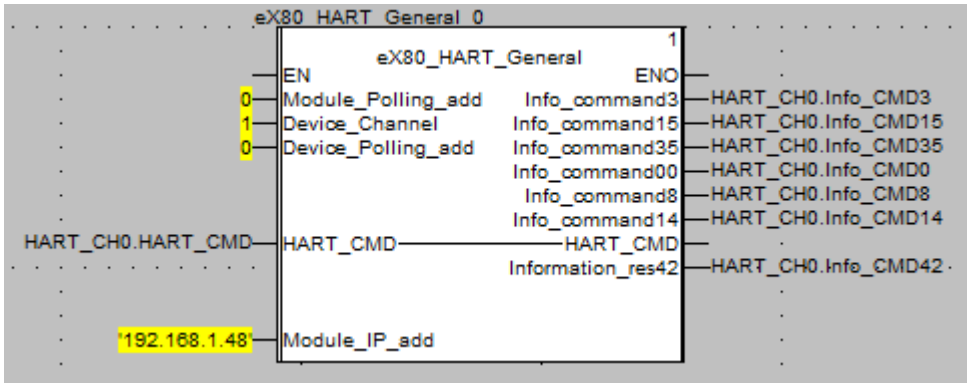
To manage instrumentation from AMS or Unity Pro with DTM, the configuration steps to use the DTMs were presented in Chapter 4.

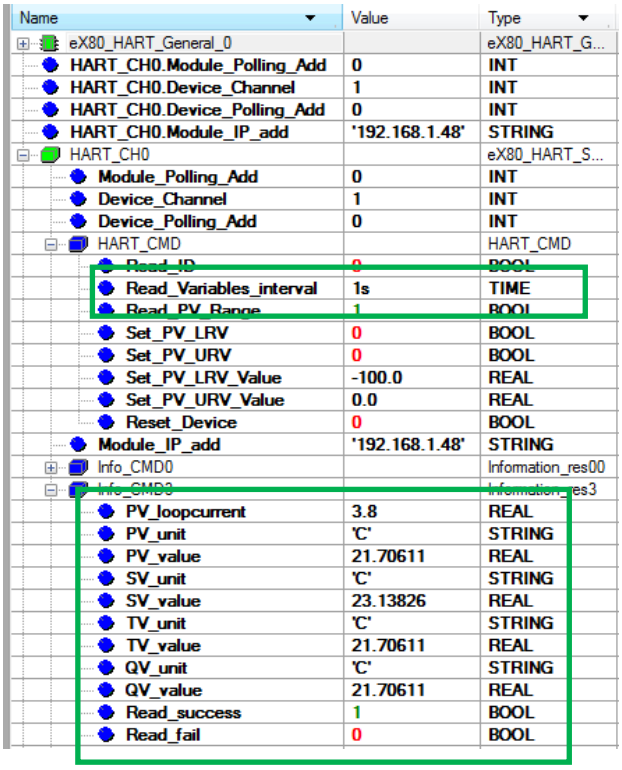
5.1. Implement “eX80 HART Generic” DFB

Below are the steps to implement the “eX80 HART Generic” Unity DFB.

Step	Action
1	In the Unity Project Browser, right click the ‘Derived FB Types,’ and choose ‘Import.’ 

Step	Action
2	After successfully importing the DFB, all the embedded DDT & DFBs will also be imported into the project. For clarity, each HART command has its own DFB and stores the information to specific DDT. 
3	Create a new section, and add the new ‘eX80_HART_Generic’ DFB. Then attach the ‘eX80_HART_Setting’ DDT instance to the DFB as below. All of the pins of the DFB are associated with this DDT. 

Step	Action
4	As an implicit type of conversion is used in this DFB, you must 'Enable implicit type conversion' in the Project Settings before building the application. 
5	To establish a simple connection to the device, first define the connection parameter. For example, we set the 'Module/Device polling add'= 0 (as defined in module's DTM), set 'Device Channel'= 1 (as the device is on the first channel of the module), and set the 'Module IP add'='192.168.1.48' in string format. 

Step	Action
6	If we enable command 3 to read the measurements, we first have to set 'Read_ID' to 1 and 'HART_CMD.Read_variables_interval' to 1000ms. The DFB will then send command 3 within each 1s.  If the connection has been successfully established, and the device has responded to the measurements, then we can check the PV, SV, TV and QV values, and the units within the DDT's 'Info_CMD3.'

Name	Value	Type
eX80_HART_General_0		eX80_HART_G...
HART_CH0.Module_Polling_Add	0	INT
HART_CH0.Device_Channel	1	INT
HART_CH0.Device_Polling_Add	0	INT
HART_CH0.Module_IP_add	'192.168.1.48'	STRING
HART_CH0		eX80_HART_S...
Module_Polling_Add	0	INT
Device_Channel	1	INT
Device_Polling_Add	0	INT
HART_CMD		HART_CMD
Read_ID	0	BOOL
Read_Variables_interval	1s	TIME
Read_PV_Range	1	BOOL
Set_PV_LRV	0	BOOL
Set_PV_URV	0	BOOL
Set_PV_LRV_Value	-100.0	REAL
Set_PV_URV_Value	0.0	REAL
Reset_Device	0	BOOL
Module_IP_add	'192.168.1.48'	STRING
Info_CMD0		Information_res00
Info_CMD3		Information_res3
PV_loopcurrent	3.8	REAL
PV_unit	'C'	STRING
PV_value	21.70611	REAL
SV_unit	'C'	STRING
SV_value	23.13826	REAL
TV_unit	'C'	STRING
TV_value	21.70611	REAL
QV_unit	'C'	STRING
QV_value	21.70611	REAL
Read_success	1	BOOL
Read_fail	0	BOOL

Table 18: Implement 'eX80 HART Generic' DFB

5.2. Implement “eX80 HART Generic” VJC Genie

This section presents the steps to establish the connection between the M580 and Vijeo Citect (VJC) via OFS, and implement the VJC genie on the SCADA page.

Configure OFS connection

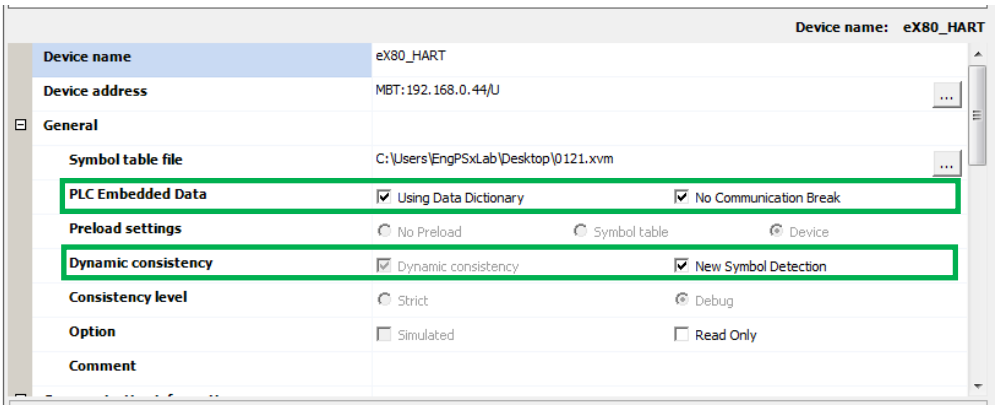
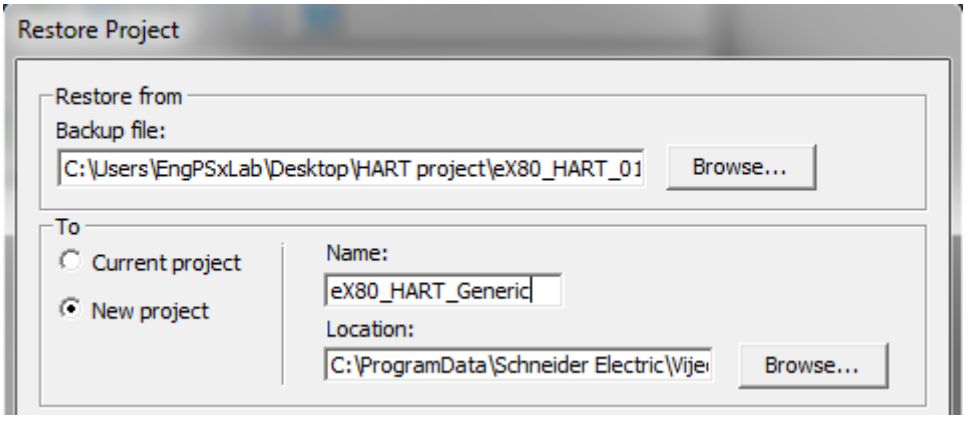
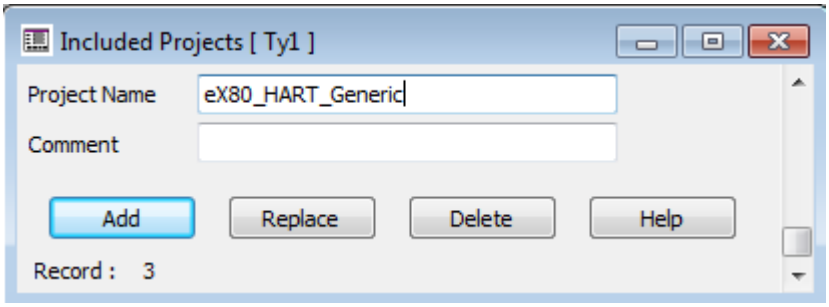
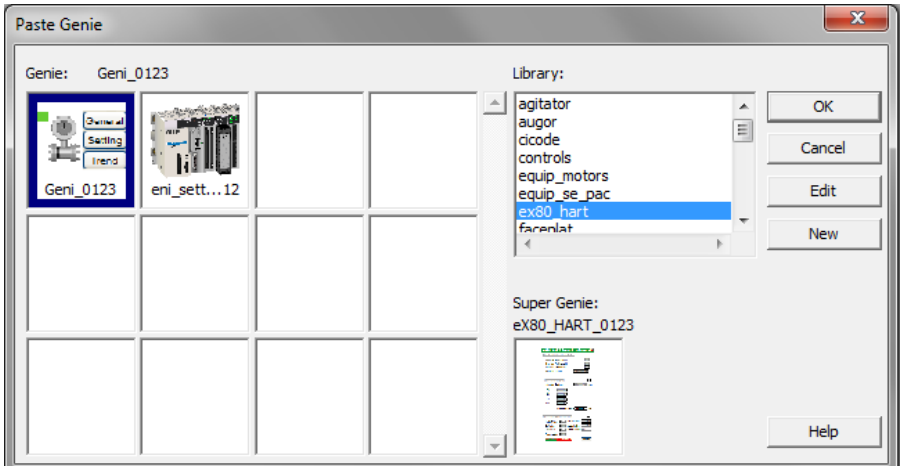
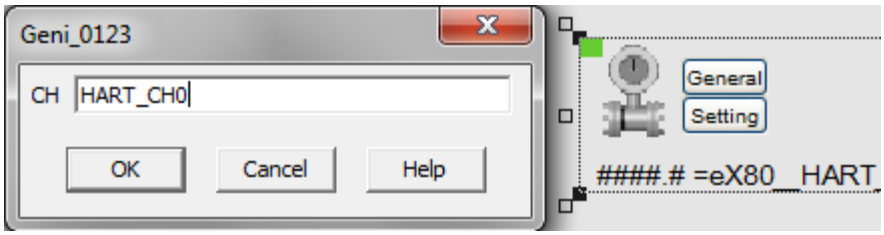
Step	Action
1	Export the XVM file from the Unity project, and set the OFS connection parameters as in the table below. 

Table 19: Configure ‘eX80 HART Generic’ VJC Genie

Implement VJC Genie on the SCADA system

The VJC genie is named of “eX80_HART_Generic.” The user must include this project to theirs in order to use the genie.

Step	Action
1	Within the Citect explorer, restore the ‘eX80_HART_Generic’ as a new project. 

Step	Action
2	Within your own project, select the 'System' tag, and the 'included project' to add the "eX80_HART_Generic" project to your SCADA project. 
3	After the project has been successfully included, the genie can be found within the project's library. You can add a new page and then add one 'eX80_HART_Generic.' 
4	Select 'CH,' which is the name of the DDT imported from Unity. In this case, the name is 'HART_CH0.' 

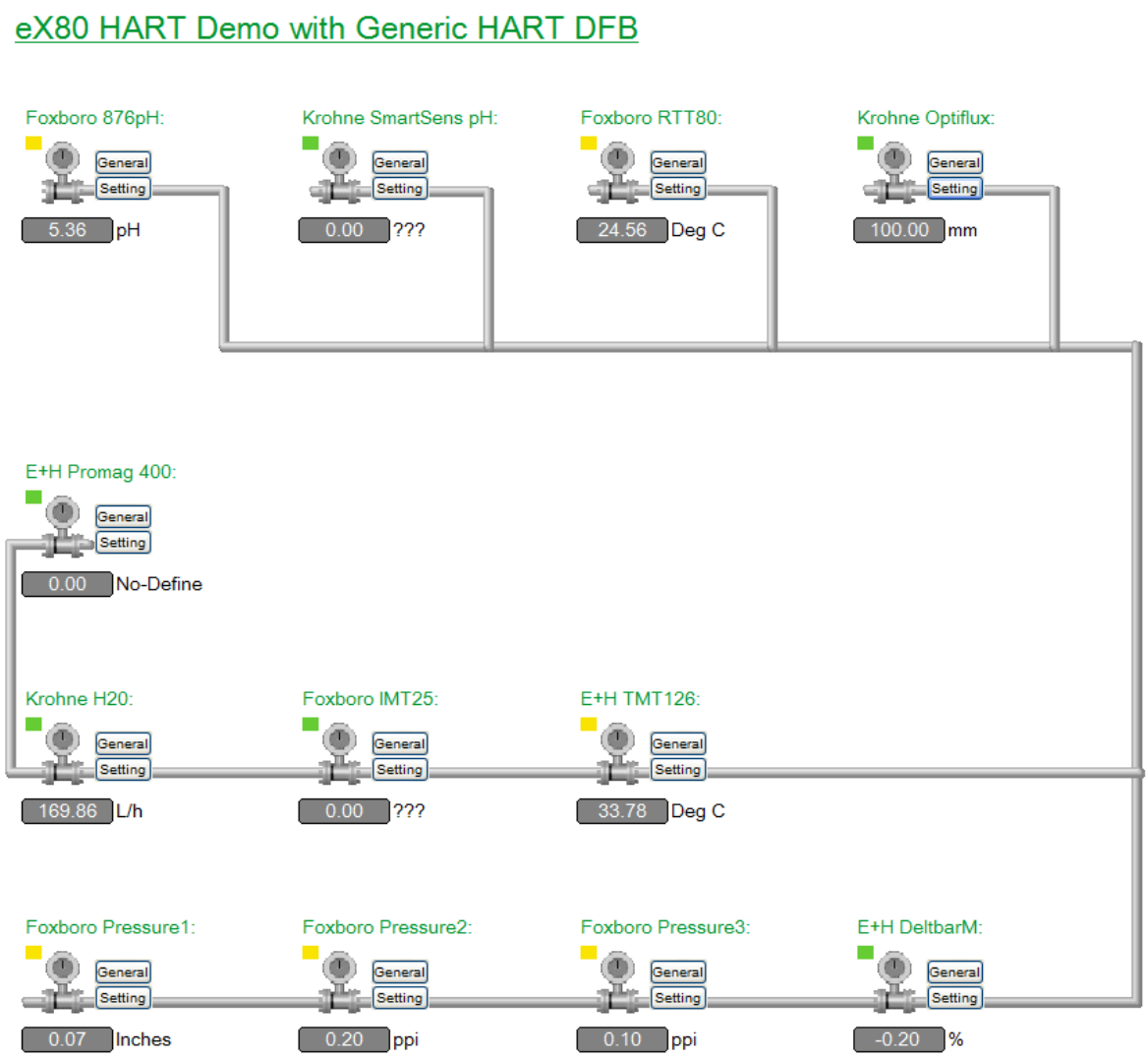
Step	Action
5	After the above implementation, we can get the data from the HART instruments when VJC is in online mode. 

Table 20: Configure VJC Genie on the SCADA

6. Operation & Maintenance

This chapter presents how to operate the “eX80 HART Generic” VJC Genie on a SCADA page, how to operate the AMS software and instruments’ DTMs, and discusses device & instrument replacement.

6.1. How to Operate the “eX80 HART Generic” VJC Genie on SCADA

The implemented genies on the SCADA pages can provide instrument information and send supported commands.

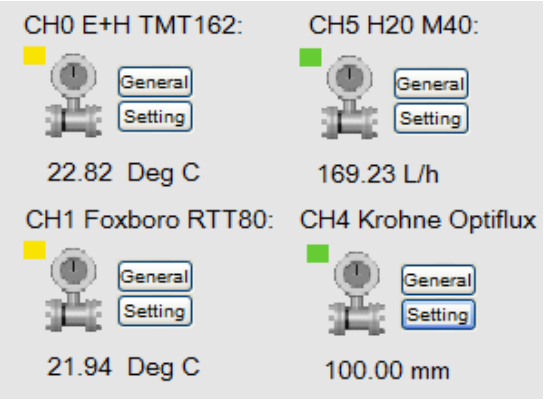


Figure 24: SCADA Genie used

Firstly, the basic device status is shown on the upper left of the genie. It supports three statuses distinguished by color.

Parameter in ADDMX	Description
Green	Status is good; no maintenance needed.
Yellow	Maintenance needed: The devices haven’t malfunctioned, but they require maintenance services. Device Variable Alert: There’s a device variable in an alarm or warning.
Red	Critical Power Failure: Power is becoming critically low. The devices can still operate on stored power, but they will begin to disconnect from the network if the power level drops too far.

Table 21: VJC Genie’s status according to color

To the right of the genie, there are two buttons that open different popup windows:

General window

In the Communication Status section, you can get the module's IP address, device channel and polling address. In the Measurements part, you can check the device's analog output value, four variable values and their units. Meanwhile, you can also modify the refresh rate of these measurements. 'Device Information' contains the device's identification number, HART version and configuration counter. It can also display the alarm status at the bottom of the popup window.

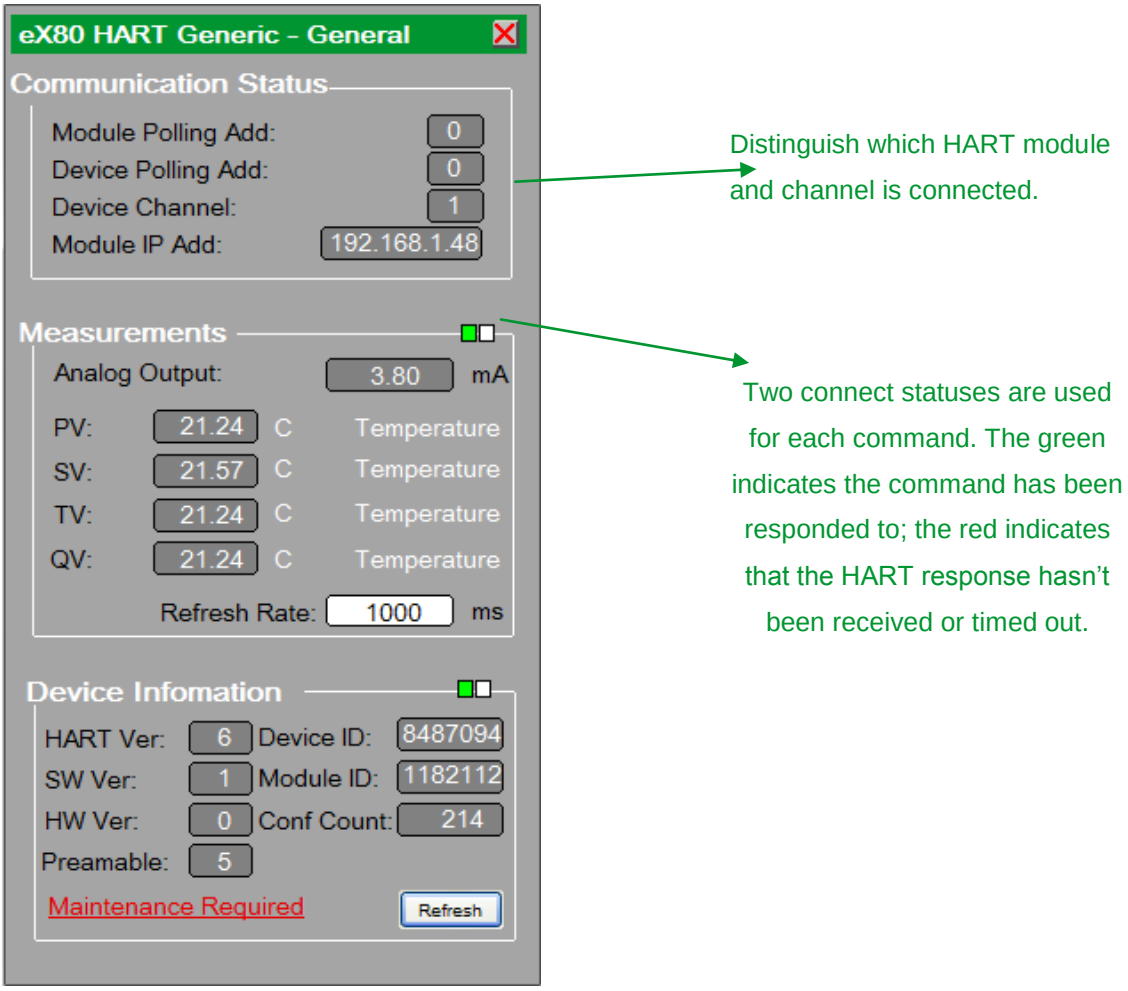


Figure 25: VJC Genie 'General' Window

Setting window

The instrument's transducer information like the measure limits, spam value and serial number can be checked in the 'Sensor Information' section. In the 'PV Range Information' area, the lower range indicates the PV measurement when the device's output is 4mA, and the upper range indicates the measurement when it's 20mA.

These two PV range values can be modified in the ‘Range Setting’ section. Be mindful that neither the lower nor the upper range should exceed the transducer limits, otherwise the modifications will not succeed. There is also a ‘Reset’ function to reset the device’s microprocessor. The execution of this command, however, may take some time to complete, and the device may not respond to subsequent commands until the reset has finished.

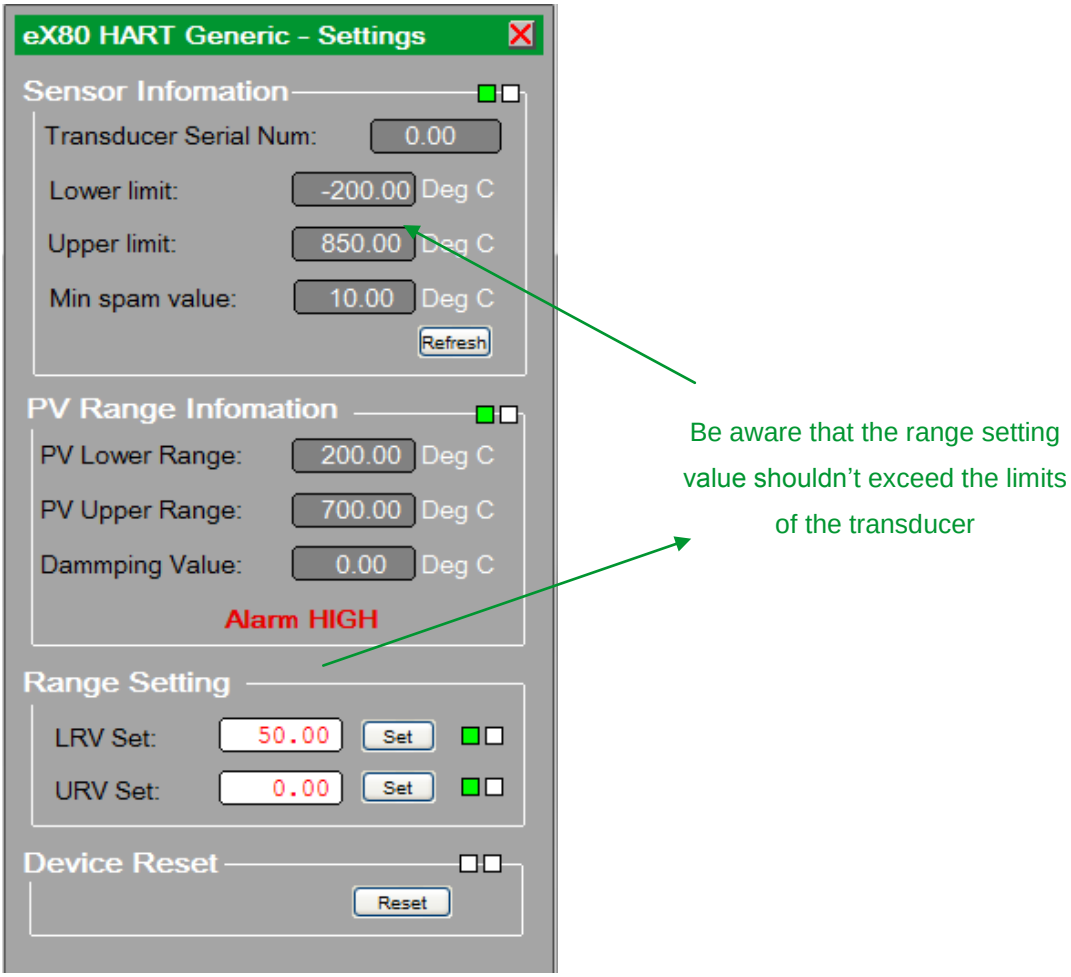


Figure 26: VJC Genie ‘Setting’ Window

6.2. How to Operate with AMS

This section introduces how to operate the AMS to manage the HART instruments. The PACTware is used as an example.

Topology Scan

When using the AMS for the first time to connect HART instruments, the instrument DTMs need to be added to the AMS device network. You must ensure all the DTMs are properly installed.

In the section below, the topology scan function is used to scan the entire HART network to find the best matched DTM for each instrument.

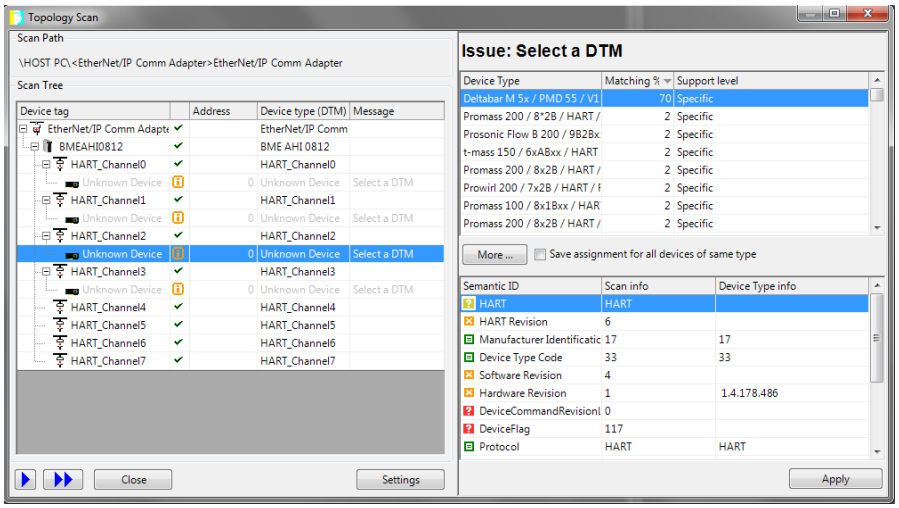
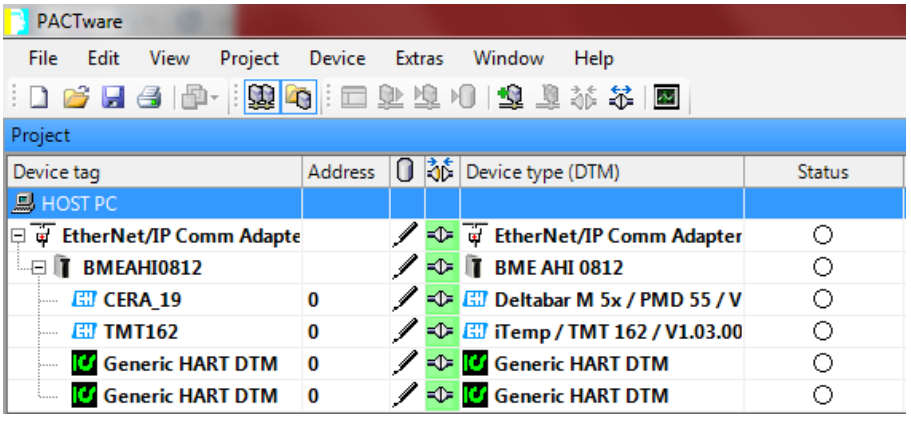
Step	Action
1	Right click on the HART module. It can perform a topology scan for each channel of this module, and you can select the corresponding DTM. If there is no suitable DTM, the generic HART DTM can also be chosen. 
2	Connect all the linked field devices in the AMS. The status of a successfully connected instrument will become green. 

Table 22: Topology Scan within PACTware

After the topology scans are completed, the entire HART instruments structure will be shown as below.

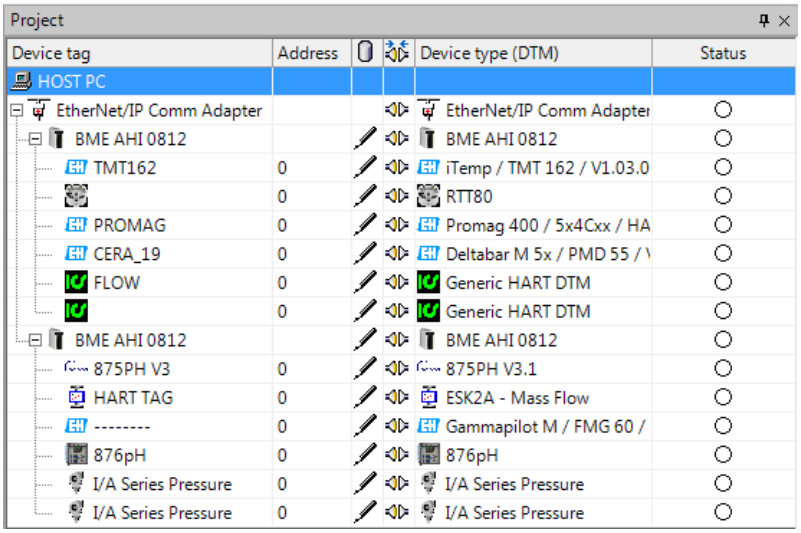
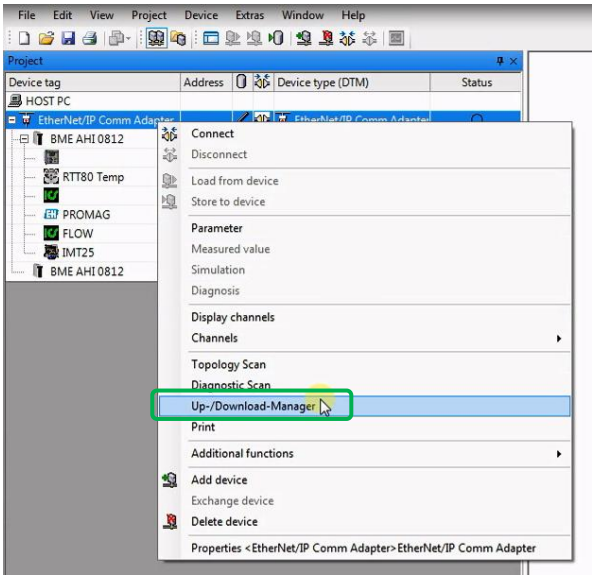


Figure 27: HART network topology tree configured within the PACTware

Up / Download Manager

Before we use these DTMs, we need to upload their configuration. PACTware provides this batching function called Up / Download Manager.

Step	Action
1	Right click the Ethernet/IP Comm Adapter; select the 'Up / Download Manager.' Then, you can select the devices to be synchronized, and whether to upload or download from the devices. 

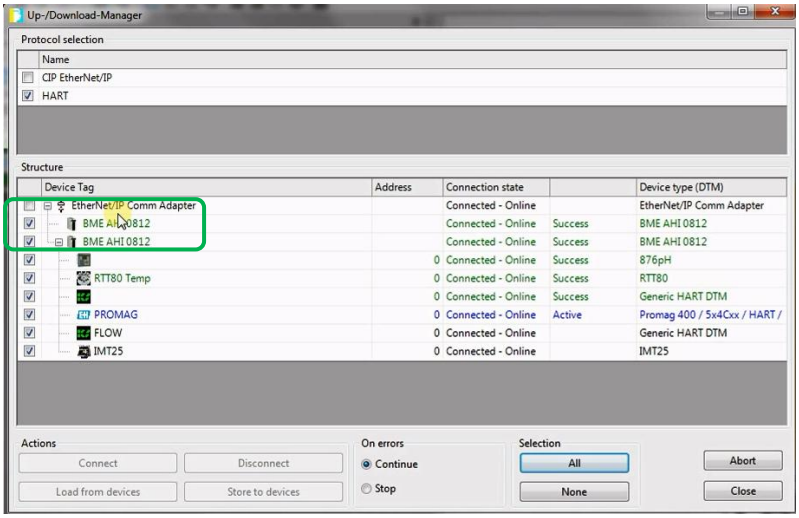
Step	Action
2	In this case, we choose ‘Load from devices’ to upload the instruments’ status and configurations into the PACTware. This window shows the connection status of each device. 

Table 23: Operate the Up / Download Manager within PACTware

Diagnostic Scan

Diagnostic scans help you read all the instruments’ statuses. It supports the cyclic reading of device status and gives useful data for preventive maintenance.

Within the PACTware, this diagnostic scan can be accessed in the ‘View’ option. Select instruments which need to be scanned. ‘Read device state(s) from device’ is used to read all the instruments’ status once, then the AMS will connect to the device one at a time to get the diagnostic data.

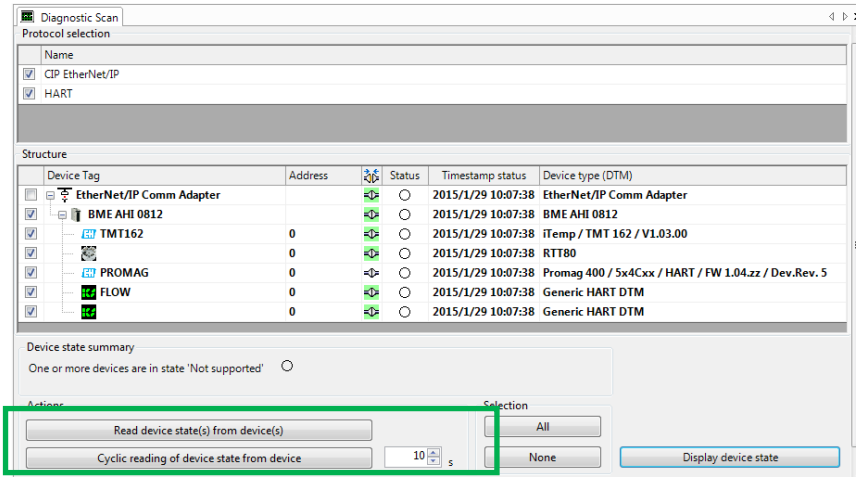


Figure 28: PACTware diagnostic scan window

You can also select the cyclic reading function. You will need to define the cycle period for performing the diagnosis. Then click ‘Display device state’ to show the status of all the instruments.

In the PACTware, the status is defined according to the NAMUR recommendation NE107:

Parameter in ADDMX	Description
	Diagnosis active
	Diagnosis passive
	Failure
	Check function
	Outside of specification
	Maintenance required
	Device status not supported

Table 24: PACTware status definition

6.3. How to Operate with Unity Pro using DTM

This section presents how to operate the HART modules with a Unity Pro DTM browser.

6.3.1. DTM operation within Unity Pro

The ‘Field bus discovery’ function is used to scan the devices linked to the module and help you find the best-matching DTM for the instrument. For this function, the HART module needs to be in online mode, and the instruments should be powered on with a strong connection.

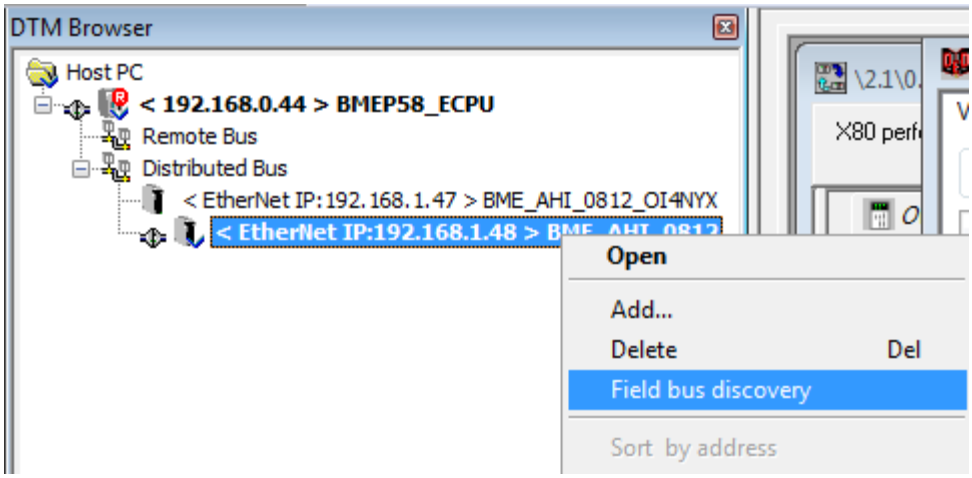


Figure 29: Unity DTM browser field bus discovery

For HART instruments which don’t have a specific DTM, or when the manufacturer’s DTM hasn’t been installed on the PC, the HART generic DTM could be used instead of establishing HART communication. The diagram below shows the module linked with online instruments.

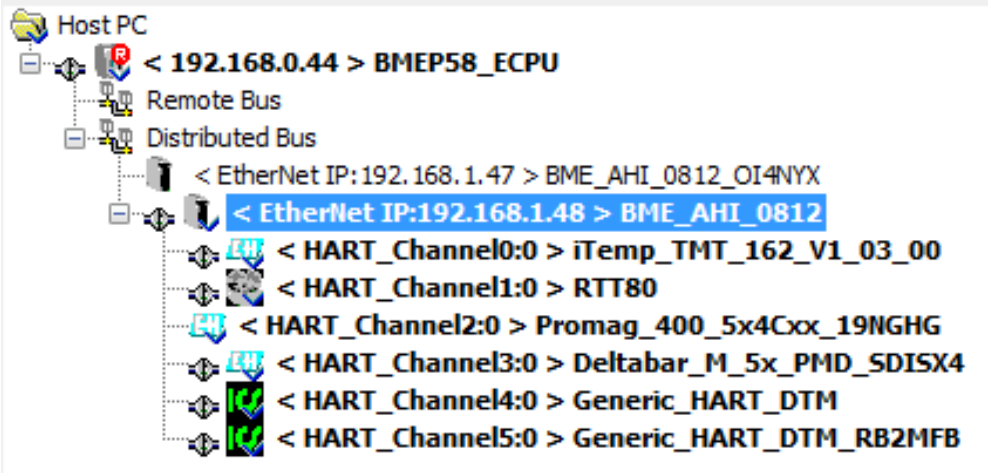


Figure 30: Unity DTM browser with devices

You can open these instruments' DTMs to check the status and perform some settings. Here, we use the Foxboro RTT80 temperature transmitter as an example. The DTM can provide detailed information, such as sensor status, diagnostics, settings, etc.

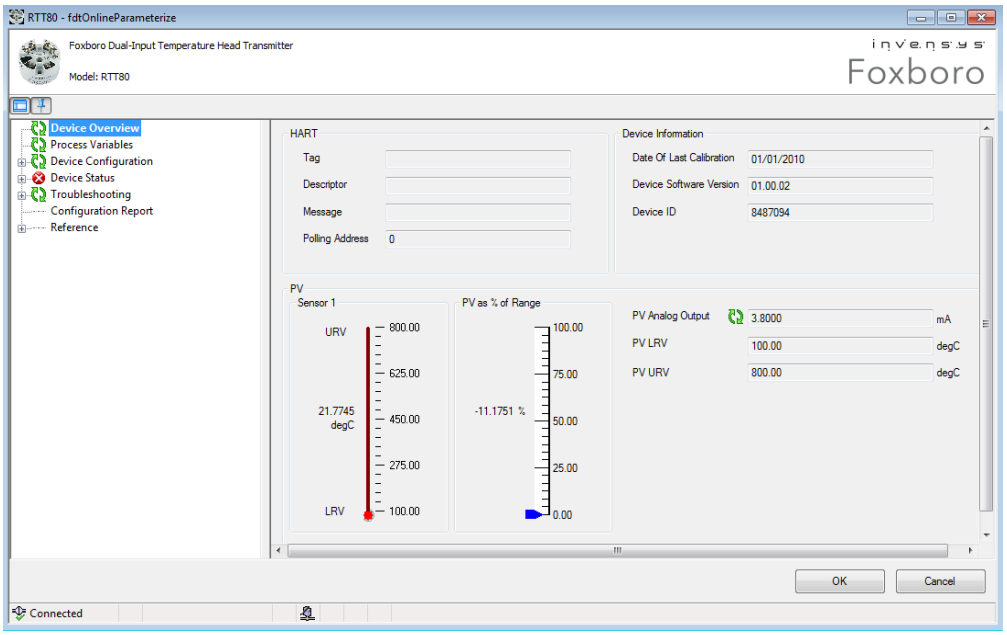


Figure 31: Foxboro RTT80 DTM's overview page

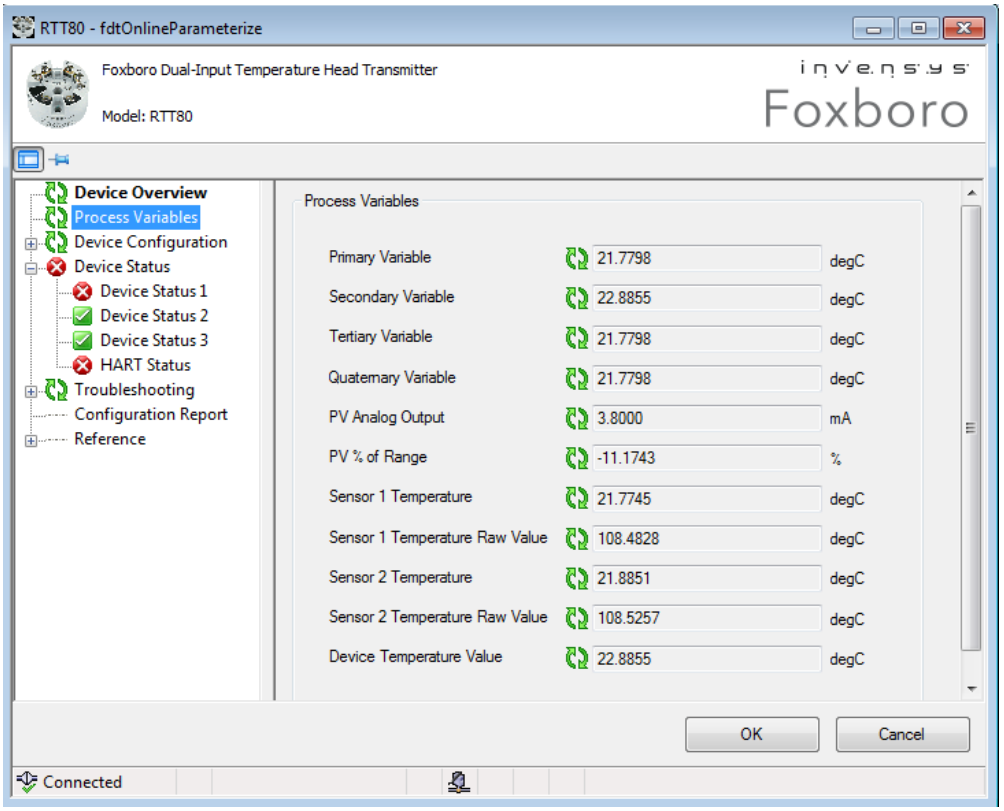


Figure 32: Foxboro RTT80 DTM's variables page

6.4. System Maintenance

By selecting HART intelligent instruments, you can not only access the devices status and measurements easily, but also benefit from efficient asset management and maintenance in the process plant. This section will present the process for instrument replacement.

6.4.1. Instruments replacement

When the ‘maintenance required’ status is detected in the system, it means the device’s diagnostic system has found an error among the instruments and they need to be repaired or replaced.

If you remove the faulty instrument and replace it with a new one, the module will directly enable the HART communication, but it will mark this channel as changed with unmatched devices, because its device ID is different.

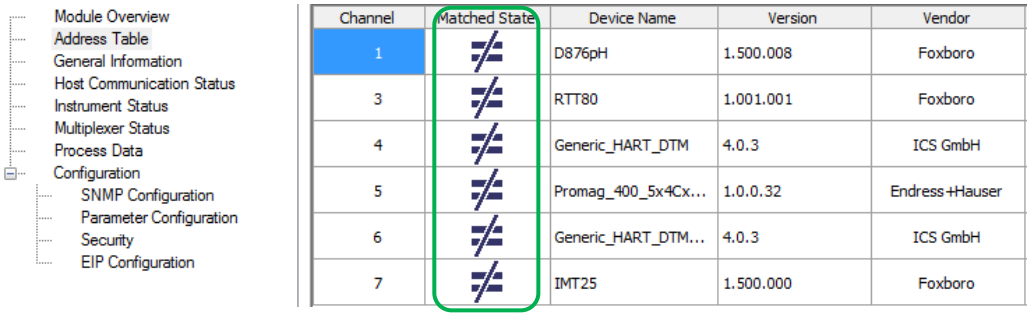


Figure 33: Address table of matched state

This unmatched state appears on the module’s LED state or within the module’s DTM. You can accept all channels’ changes by entering ‘255’ into the ‘G_ResetChanged_ID’ within the module’s Device DDT.

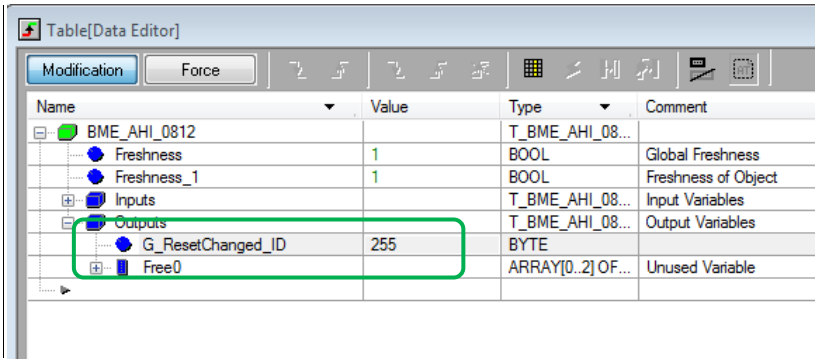


Figure 34: Address table of matched state

On the ‘eX80 HART Generic’ SCADA page, the linked instruments are rescanned every two minutes so the information for the newly-replaced device can be received. And you can also press the ‘Refresh’ button to perform an immediate rescan.

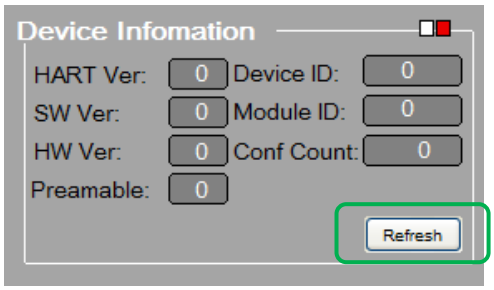


Figure 35: eX80 Generic HART refresh

6.4.2. eX80 HART Module replacement

If the HART module is abnormal, you can simply replace it without losing the module's configurations. Thanks to the fast device replacement (FDR) service, the module's IP address parameter and configuration can be restored to the replacement module.

In this case, the M580 CPU or the BME NOC module acts as FDR server. They can store the IP address and configuration parameters for the modules on the network. Each network module is identified by its device name, and after the FDR service is enabled, the server can reconfigure the modules.

But some data, like HART port parameters, is not stored in the FDR server, so you need to 'store data to device' to download these parameters to the HART module.

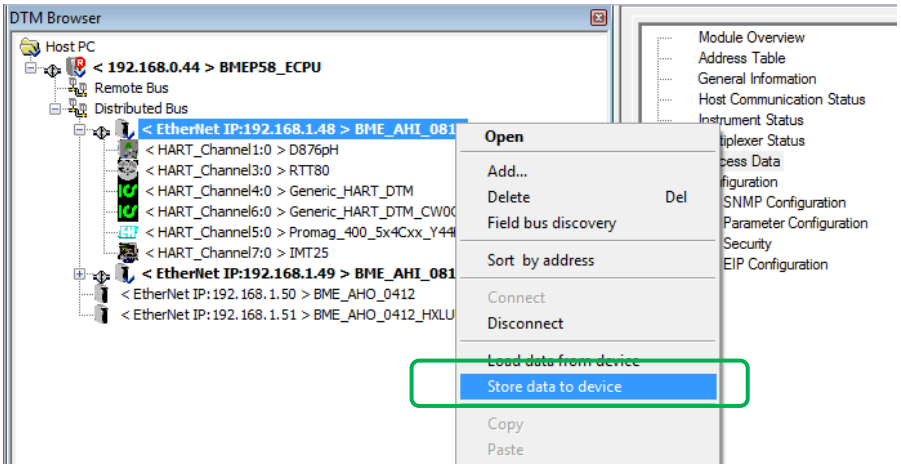


Figure 36: Module replacement

As with the instrument replacement, you can recognize the new module simply by refreshing the device status.

6.4.3. M580 CPU & NOC module replacement

If the M580 CPU or NOC needs to be replaced, the PAC application needs to be downloaded into the M580 CPU. As the network parameters and module's configuration are stored by the application, perform a 'transfer to FDR server' to upload the configuration from the application to the FDR server in the M580.

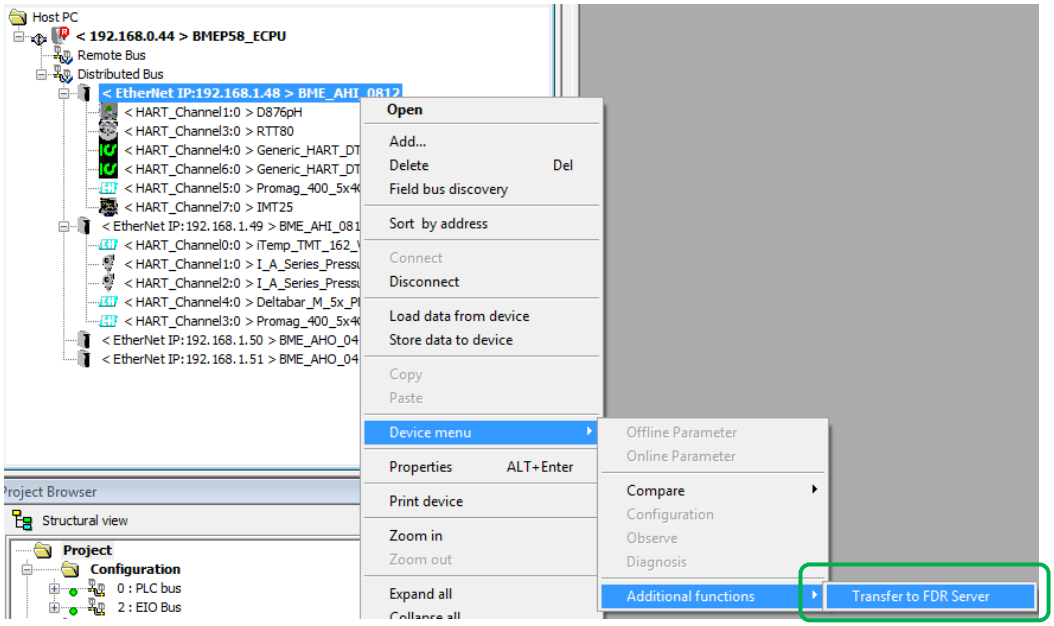


Figure 37: Transfer to FDR Server

Meanwhile, each HART module needs to perform 'store data to device' to enable the HART parameters. As with the instrument replacement process, you can recognize the new module by refreshing the device status.

7. Validation

Although HART is not a speed-critical protocol, the following chapter addresses performance testing on our selected architectures.

HART Data Flow

In this TVDA, the HART data started from the PAC or DTMs, passed through the M580 and Ethernet backplane, reaching the HART modules located on local I/O or remote drops, before finally arriving in the instruments on the current loop.

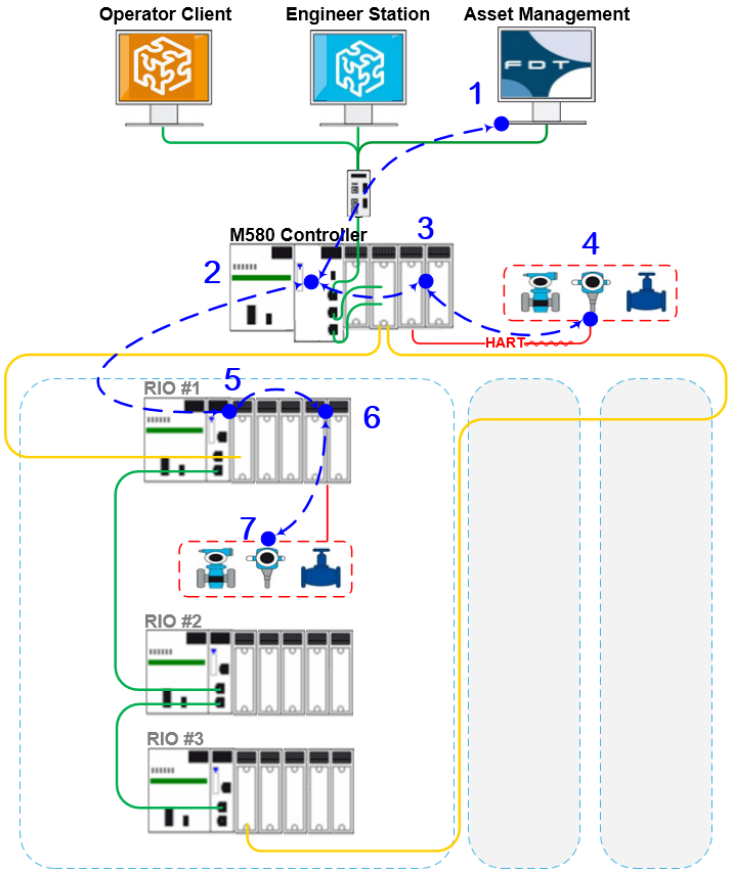


Figure 38: HART data flow

There are two different data flows:

1. Using the DATA_EXCH FB to send/receive the HART data by PAC application. The data flow as 2 -> 3 -> 4 or 2 -> 5 -> 6 -> 7.
2. Using the AMS's instrument DTM to send/receive the HART data. The data flow as 1-> 2 -> 3 -> 4 or 1 -> 2 -> 5 -> 6 -> 7.

7.1. Test with DATA_EXCH in M580

A fast task with 1ms period is used as a timer to calculate the application's response time between sending the HART request and receiving the HART response by the 'DATA_EXCH'FB.

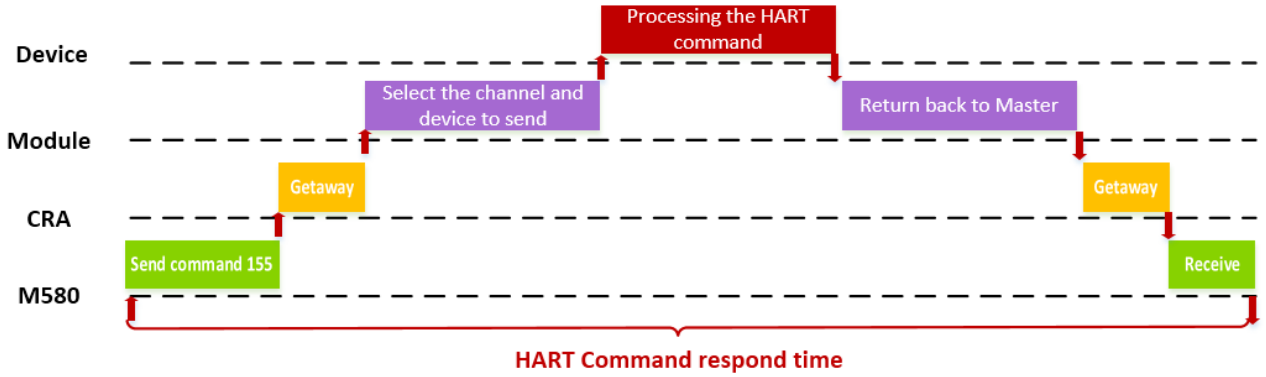


Figure 39: M580 response time test diagram

Below is the test result with the M580 as HART master:

Response Time (ms)	Mast task scan time	Foxboro RTT80	E+H TMT162	Krohne H250 M40
HART on local I/O	Cycle (max period=2ms)	Min:26 Average:40 Max:66	Min:26 Average:39 Max:49	Min:31 Average:40 Max:57
	20ms	Min:41 Average:50 Max:60	Min:41 Average:51 Max:61	Min:41 Average:51 Max:96
	50ms	Min:52 Average:77 Max:100	Min:52 Average:76 Max:126	Min:52 Average:76 Max:122
	100ms	Min:101 Average:150 Max:200	Min:101 Average:150 Max:200	Min:102 Average:151 Max:200
HART on Remote I/O	Cycle (max period=2ms)	Min:33 Average:40 Max:62	Min:25 Average:39 Max:65	Min:33 Average:40 Max:61
	20ms	Min:42 Average:51 Max:78	Min:42 Average:51 Max:60	Min:41 Average:51 Max:87
	50ms	Min:52 Average:76 Max:100	Min:52 Average:77 Max:130	Min:52 Average:76 Max:149

Response Time (ms)	Mast task scan time	Foxboro RTT80	E+H TMT162	Krohne H250 M40
	100ms	Min:102 Average:151 Max:200	Min:102 Average:151 Max:200	Min:102 Average:153 Max:254

Table 25: Test results by using communication blocks in M580

As these three referenced instruments all have close results for each case, we are using the results for Foxboro's RTT80 to summarize the test conclusions.

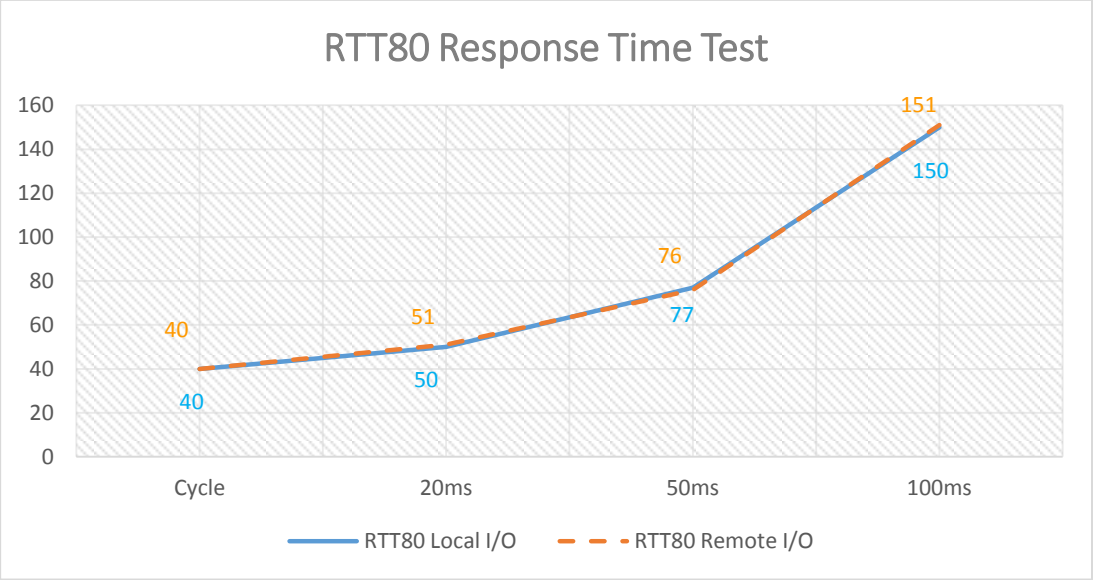


Figure 40: Foxboro RTT80 HART response time according to the CPU scan

According to the test results with same task scan time, HART modules installed on either the local I/O or remote I/O have the same performance.

As the 'DATA_EXCH' FB is used in the PAC's application, the task scan time is one of the most significant factors that impact on the application's response time. It indicates that the application's response time increases along with the task's scan time.

7.2. Test with DTM through AMS

As there is no timer in the AMS, we use Wire Shark to calculate the interval between the HART request and response. PACTware is used as the HART master in this test.

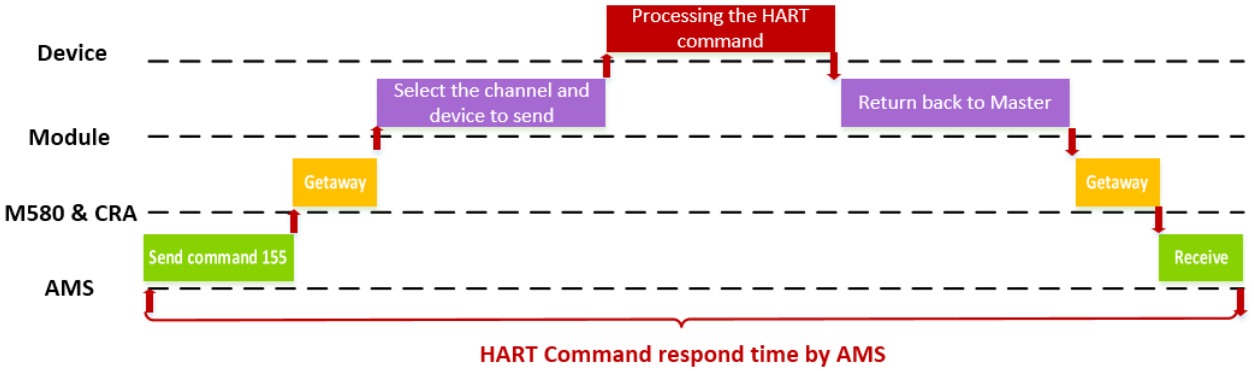


Figure 41: AMS Response time test diagram

Below is the test result with the AMS as the HART master:

Response Time (ms)	Foxboro RTT80	E+H TMT162	Krohne H250 M40
HART on local I/O	Min:21.279 Average:25.4432 Max:31.366	Min:20.684 Average:24.2789 Max:28.69	Min:21.235 Average:24.6732 Max:28.923
HART on remote I/O	Min:22.984 Average:26.2881 Max:29.576	Min:22.245 Average:26.1687 Max:30.672	Min:21.091 Average:26.1027 Max:30.7632

Table 26: Test results by using DTMs in AMS

Based on the test results, the response time from the instruments installed on the local I/O is faster than on the remote I/O, as the HART data doesn't need to go through RIO.

7.3. Test conclusion

After the above tests, we can draw the following conclusions:

- Using the DTM can set up a stable and fast HART communication with field instruments.
- Using explicit data exchange can achieve good performance, but it is impacted by the PAC's scan time.

8. Conclusion

This TVDA guide began with the introduction of the HART technology, and followed with a WWW application. It took the mechanical preliminary treatment process as an example to present the eX80 HART reference architecture. Based on customer requests, two use cases have been outlined: The instruments monitor & control from SCADA through PAC, and the instruments management from AMS or Unity's DTM.

The Design chapter was dedicated to realizing the use cases listed in the Selection chapter. The "eX80 HART Generic" DFB + VJC Genie are designed to save on engineering time and the Implementation chapter showed how to use it. The Operation & Maintenance chapter addressed how to operate the "eX80 HART Generic" DFB + VJC Genie and AMS software. We also introduced the maintenance procedures in the event that devices need replacement. At the end of this document, an ART test was performed on a selected architecture with 'Data_EXCH' and AMS.

All in all, these two eX80 HART modules can provide a simple and efficient solution to integrating HART communication into the eX80 architecture. With the M580's open structure, HART data can easily be accessed anywhere on the Ethernet.

9. Appendix

9.1. Glossary

The following table describes the acronyms and defines the specific terms used in this document.

Term	Description
HART	Highway Addressable Remote Transducer Protocol
AMS	Asset Management Software: A software application that can configure, monitor and manage devices employed as part of an industrial automation system
DCS	Distributed Control System
SCADA	Supervisory Control and Data Acquisition
PAC	Process Automation Controller
PAC	Programmable Logic Controller
DFB	Derived Function Block (designed by Unity Pro for PAC, PAC logic program)
FDR	Faulty Device Replacement
DHCP	Dynamic Host Configuration Protocol. A TCP/IP protocol that allows a server to assign an IP address based on a device name (host name) to a network node
DTM	Device Type Manager. A DTM is a software component that acts as a device driver. It contains information for configuring, diagnosing and maintaining particular field devices. Many manufacturers provide device-specific DTMs, but a generic DTM can also be used to drive a wide variety of devices.
Dynamic Variables	The HART protocol uses Command 3 for obtaining up to four dynamic variables: PV, SV, TV and QV (primary, secondary, tertiary and quaternary variables). One or all of the above may be used to provide data from the HART instrument to the control system.

Table 27: Glossary

9.2. Bill of materials and software

The following table summarizes all of the selected hardware and software used in this document.

Description	Reference	Firmware or software version	Function
M580	BME M580 3040	V1.0	CPU
	BMX CPS 2000	N/A	Power
	BME AHI 0802	PV01	Analog input with HART
	BME AHO 0412	PV01	Analog output with HART
	BMX NRP 0201	PV01	Fiber converter
	BME CRA 312	PV01	X80 EIO adapter
	BME XBP	PV01	Ethernet supported backplane
SCADA	Vijeo Citect	V7.40 SP1	Supervisory control and data acquisition
Unity Pro	Unity Pro XL	V8.1 141023H	PAC programming software
AMS	PACT Ware	V4.1	AMS software
	Field Care	V2.09	
DTM	eX80 HART Gateway	V1.0	eX80 HART modules DTM

Table 28: Bill of materials

Company	Reference	Function
Foxboro	RTT80	Temperature
	IDP10	Pressure
	IMT25	Electromagnetic Flow
	876PH	pH Analysis
E+H	TMT162	Temperature
	Deltabar M	Pressure
	Promage 400	Electromagnetic Flow
Krohne	Optiflex 1100C	Time Domain Reflectometry Level
	H250 M40	Variable Area Flow Meter
	SMARTSens 2390	pH Analysis

Table 29: Bill of HART instruments

Schneider Electric Industries SAS
Head Office
35, rue Joseph Monier
92506 Rueil-Malmaison Cedex
FRANCE

www.schneider-electric.com

Print:

Version 1.00 – 05 2015