Description of

CODESYS Integration

for

IS1+ field stations
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1 System overview

As an off-the-shelf explosion protected unit, the IS1+ field station can be installed directly in the potentially explosive atmosphere (Zone 1 or Zone 2). It can also be installed in the safe area. The picture above shows a Zone 2 solution with CODESYS.

The IS1+ 9442 CPU can optionally be extended by an integrated CODESYS Runtime System. CODESYS is an IEC 61131-3 automation software for project engineering of control systems. This allows automation tasks to be processed locally in IS1+ CPUs.

In this case, the RIO typical connection of IS1+ to higher-level PLCs via AS-Bus protocols (PROFIBUS, PROFINET, EtherNet/IP, MODBUS TCP) is deactivated. Higher-level systems can, for example, be connected to the CODESYS Runtime System in the IS1+ CPU via OPC-UA.

This document describes the project engineering of IS1+ field stations in the CODESYS Development System as well as their functions in the CODESYS Runtime System within an IS1+ CPU.

Knowledge of the general handling of CODESYS is recommended.

Literature references
Support Address
List of abbreviations
2 System requirements

Hardware requirements:

- IS1+ Field station with CPU 9442/35-10-00, Socket 9496/.. and Power Module PM 9445/.. 9442/xxxx with CODESYS Licency.

Software requirements:

- 9442 CPU Firmware V2.xx.yyyy
  
  The above mentioned CPU firmware contains a CODESYS Runtime System V3.5.15.0 A CODESYS Development System Version 3.5.15 or higher must be used.

  This IS1+ CPU variant is equipped with a CODESYS license sticker with a unique CODESYS license number.

<table>
<thead>
<tr>
<th>IS1+ CPU Firmware Revision</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1.xx.yyy-zzzz</td>
<td>IS1+ Remote I/O</td>
</tr>
<tr>
<td>V2.xx.yyy-zzzz</td>
<td>IS1+ CODESYS PLC</td>
</tr>
</tbody>
</table>

Operation with CODESYS License only with IS1+ CPU Type 9442 /xxxx …..

- Driver Package for integration of IS1+ into the CODESYS Development System

  File: R_ STAHL IS1+ CODESYS V2.xx.yy.zzzz.package

  For compatibility reasons, the version numbers of IS1+ CPU Firmware and IS1+ CODESYS Package must match except for the rear part (.zzzz)

  The currently installed IS1+ Package version can be displayed or uninstalled in Tools -> Package Manager.

2.1 Demo Modus

The above mentioned IS1+ 9442 CPU firmware variant V2.xx.yy-zzzz is optionally available and can be loaded into all IS1+ 9442 CPUs for demo and evaluation purposes even without previous CODESYS extension.

In this case the CODESYS Runtime System works in demo mode with a limited runtime of 2 hours with full functionality. Then the runtime system is switched off and a powercycle is required for restarting.

WebVisu works in demo mode for about 30 minutes.
3 IS1+ Configuration

The protocol selection switch 'S1: Prot' in the socket of the corresponding IS1+ field station is to be set to Position 6 = MODBUS TCP.

Depending on the I/O modules to be used, a suitable configuration and parameterization of the IS1+ field station must be created using the tools IS1 DTM or I.S.Wizard and loaded into the 9442 CPU. A 9442 CPU with MODBUS TCP must be selected in the tool during configuration.

Description of the configuration of I/O module operating modes, parameters, scaling, etc. see document: Operating instructions MODBUS TCP for IS1+ field stations.

Note: The AS-Bus interface with MODBUS TCP is deactivated in combination with CODESYS. The CPU selection with MODBUS TCP is for internal configuration only. Operation of the AS-Bus protocols in parallel with CODESYS, is not possible. Access via the AS-Bus protocols is disabled. In this case, output data can only be written via the user program in the CODESYS Runtime System.

From the list of I/O modules configured in the 9442 CPU, the data structure of all I/O signals in the CODESYS project of the Development System can be generated automatically.

See Automatic I/O-Module configuration

3.1 IP Address of IS1+ CPU

Two separate IP addresses for the Ethernet communication are available for the 9442 IS1 CPU:

- **IP-AS:** Realtime bus to automation system (MODBUS TCP, PROFINET, EtherNet/IP.)
  When using the CODESYS system, this interface is **not used** and settings have no function.

- **IP-SB:** Service Bus Functions: Web-Server, IS1 DTM, HART, Standard TCP Traffic, SW-Update.
  This IP address must be used to connect the CODESYS Development System.

The IP-SB address can be set using the tool IS1+ Detect or via the IS1+ Web Diagnostics.

3.2 LED display IS1+ CPU

CODESYS operation without AS protocol:

<table>
<thead>
<tr>
<th>LED Display</th>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS EXCH LED</td>
<td>On</td>
<td>PLC RUN</td>
</tr>
<tr>
<td></td>
<td>Off</td>
<td>PLC Stop</td>
</tr>
<tr>
<td>STATUS LED</td>
<td>Function</td>
<td>tbd</td>
</tr>
</tbody>
</table>

(Spare LED_Res -> first CPUs covered by foil).

Note: IS1+ CPU Firmware Download via IS1+ Web Page is blocked at PLC RUN (AS EXCH = On)

In addition, the description of LED displays of the 9442 CPU according to the operating manual applies.
3.3 WEB Server

Two separate WEB servers are integrated in an IS1+ CPU with CODESYS:

<table>
<thead>
<tr>
<th>WEB Server</th>
<th>Access</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS1+ Web Diagnostic</td>
<td>IP-SB in Webbrowser</td>
<td>Diagnosis of IS1+ I/O modules and CPU hardware</td>
</tr>
<tr>
<td></td>
<td>Change the IP address of the IS1+ CPU.</td>
<td>Firmware Download IS1+ CPU.</td>
</tr>
</tbody>
</table>

CODESYS WebVisu allows the user to create his own websites in the development system which can be downloaded into the IS1+ Runtime System. Symbolic variables can be linked directly to finished graphic objects from a library with little effort.

WebVisu can be optionally configured in the CODESYS project

-> Application -> Add Objekt -> Visualisation

Both web servers can be operated in parallel.


WebVisu runs in demo mode without CODESYS license and is switched off 30 minutes after powercycle.
4 CODESYS System

A CODESYS Runtime System V 3.5 can optionally be integrated in IS1+ 9442 CPUs.

For PLC project engineering according to IEC 61131, a CODESYS Development System V3.5 or higher must be used. Various automation languages are supported:

- IL (Instruction List),
- ST (Structured Text),
- LD (Ladder Diagram),
- FBD (Function Block Diagram),
- SFC (Sequential Function Chart),
- CFC (Continuous Function Chart)

The Development System can be downloaded free of charge from the CODESYS Store: https://store.codesys.com/codesys.html

Project engineering created with the CODESYS Development System can be loaded into Runtime Systems in IS1+ CPUs and executed there.

Supported CODESYS options:

- CODESYS WebVisu
- CODESYS OPC UA Server
- Modbus TCP Server
- Modbus TCP Client

4.1 Installation

- Download CODESYS Development System and install it on your PC.

- Install R. STAHL CODESYS Package on your PC.
  Start package installation by double-clicking on File: R. STAHL IS1+ CODESYS Bx.y.z.package
  - Select ‘Typical Installation’.

- After completion of both installations start CODESYS Development System on PC
4.2 Project engineering

- Create a project in CODESYS.
- Select IS1+ RIO as device and desired programming language.

An IS1+ field station is created in the project tree. The BusRail with 16 empty slots for I/O modules is located parallel to the Device.

4.2.1 Connect IS1+ Field station

Setting of the IS1+ IP-SB address in the CODESYS project:

- Function ‘Edit object’ (Right Mouse on Device) opens the Communication window see below.
- Select ‘Scan Network’

  ➔ Select IS1+ CPU from list of found devices.
  - Serial number = MAC Address of the IS1+ CPU
  - ‘Wink’ activates LED displays on the IS1+ CPU for 5 seconds.
• Alternatively: Enter IP-SB address and connect to IS1+ field station.

![Communication Settings](image)

**Green = IS1+ Field station is connected.**

**Optional:** IP-SB Address of the IS1+ CPU

### 4.2.2 Manual I/O-Module configuration

**Plug device** (right mouse click on Busrail in device tree)

Manually insert I/O modules into the project tree according to the IS1+ configuration.

All different I/O module types of the IS1+ system are mapped to two universal data structures:

- **AUM** Analog Universal Module
- **DUM** Digital Universal Module

![Plug Device](image)

**Attention:** Windows remain open and further IOMs can be inserted by selecting another IOM slot in the tree. Close the window manually after completing the IOM configuration.

Depending on the real I/O module type used and the configured operating mode, parts of the generated data structure may remain unused.

Example: If a DI module without counter/frequency function has been configured, the corresponding signals of the data structure remain unused.
An error is reported in online mode if the I/O module configuration and data structure (AUM, DUM) are incorrectly assigned.

Optionally plug **HART Devices** into channels of an IS1+ HART module:

The device name (default = HART_Device) can be configured.

A data structure is created with the four possible HART variables (PV, SV, TV, QV) of a HART field device including Value, Unit and DV status as well as EXTDEVSTATUS of the device.

The update of these HART variables is independent of the number of HART variables (+4HV, +8HV) configured via the operating mode in the IS1+ HART module.
4.2.3  Automatic I/O-Module configuration

Scan for devices (right mouse click on BusRail in the device tree).  
All I/O modules configured in the IS1+ field station are automatically transferred to the device tree in the CODESYS project regardless of the IOM type plugged in.  
HART devices which are connected to IS1+ IOMH and found via the HART Livelist are also automatically integrated in the project tree.

When the I/O modules are created in the device tree, an I/O image with the associated signals and data structures of the module is automatically generated.  
Variable names are empty by default.

Attention! Existing module names in the device tree are overwritten with default values and must be changed manually afterwards if necessary!

4.2.4  Symbolic Variable Names

Symbolic variable Names for use in the PLC program as well as unit and description are empty by default and can be configured project-specifically for each signal.

This data can also be processed externally using the functions:
- Export mappings to CSV
- Import mappings from CSV

Attention on DO signals.  
Here, only either the integer variable or the individual bits can be assigned to a symbolic name so that the write access is unique. In the event of an error, the symbols of the bits are discarded during import.
4.2.5 Counter-/Frequency channel allocation to CODESYS DUM Data structure

32 bit up/down counter:
If a channel pair is configured as 32 bit up/down counter, the counter value is mapped into the first of the two counter variables (CFx). The second of the two counter variables (CFx+1) is not updated and is always = 0.

Allocation counter (CNTR) Reset / STOP:

<table>
<thead>
<tr>
<th>Bit</th>
<th>CNTR channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>configured operation mode</th>
<th>Channels supporting CF function</th>
<th>Channels without CF function</th>
<th>CNTR Reset / STOP Bit allocation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIM + 2 CF</td>
<td>14 + 15</td>
<td>0 – 13</td>
<td>6 - 7</td>
</tr>
<tr>
<td>DIM + 6 CF</td>
<td>10 - 15</td>
<td>0 – 9</td>
<td>2 - 7</td>
</tr>
<tr>
<td>DIM + 8 CF</td>
<td>8 - 15</td>
<td>0 – 7</td>
<td>0 - 7</td>
</tr>
</tbody>
</table>

Further details of the counter / frequency function see document:
Operation Manual MODBUS TCP for IS1+ Field stations.
4.2.6 Login
This loads the I/O configuration and the PLC program into the runtime environment of the IS1+ field station.

4.2.7 Online Config Mode
Manual Loopcheck. No PLC program is executed. All input values are updated cyclically. Output values can be written manually.

4.2.8 HART Variables (HV)

DV Status:
DV Status = good (0xc0 = 192) if HART Variable is readable.
DV Status = bad (0x00) if HART Variable is not readable.

EXTDEVSTATUS:
Contains NAMUR NE107 compatible condensed status information. Fully readable only by devices with HART 7 or higher. From HART 6 only bits 0 and 1 are included. Updated status info is delivered if the HART Field Device (HFD) is available and EXTDEVSTATUS is supported. If the HFD is not reachable or EXTDEVSTATUS is not supported by the HFD, the IOMH will set:
- EXTDEVSTATUS = Good / Normal (0x00) if HV variable readable.
- EXTDEVSTATUS = Failure (0x08) if HV variable not readable.

Extract from HCF / FCG Spec-183 Tab. 5.2:

<table>
<thead>
<tr>
<th>Unit Code [dez]</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>bar</td>
</tr>
<tr>
<td>8</td>
<td>mbar</td>
</tr>
<tr>
<td>32</td>
<td>°C</td>
</tr>
<tr>
<td>36</td>
<td>mV</td>
</tr>
<tr>
<td>37</td>
<td>Ohm</td>
</tr>
<tr>
<td>39</td>
<td>mA</td>
</tr>
<tr>
<td>41</td>
<td>Litter</td>
</tr>
<tr>
<td>45</td>
<td>Meter</td>
</tr>
<tr>
<td>49</td>
<td>mMeter</td>
</tr>
<tr>
<td>58</td>
<td>V</td>
</tr>
<tr>
<td>59</td>
<td>pH</td>
</tr>
<tr>
<td>127</td>
<td>kW</td>
</tr>
<tr>
<td>128</td>
<td>kWh</td>
</tr>
<tr>
<td>163</td>
<td>kOhm</td>
</tr>
</tbody>
</table>
4.2.9 Start
The cyclic PLC operation is started. Outputs are controlled via the PLC program.

4.2.10 Status and Diagnostic
In online mode, module errors are displayed in the device tree and textually in the device parameters.

Signal errors are indicated by the signal status and can be evaluated by the PLC program, displayed in the WebVisu and reactions can be programmed.
4.2.11 MODBUS TCP Master / Slave Device

A MODBUS TCP Master (Client) and a MODBUS TCP Slave Device (Server) are integrated in the IS1+ CODESYS CPU. The complete MODBUS configuration is done directly in the CODESYS Development System.

The MODBUS Configurator consists of editors for the following device categories, which are hierarchically suspended in the device tree:

1. **Ethernet**:
   The settings of the Ethernet adapter such as IP address, subnet mask etc. are configured here.

2. **Modbus TCP Master (Client)**:
   A TCP Master mode can be inserted under the Ethernet node. Modbus-specific communication settings can be defined here, e.g. the "Response Timeout" for determining how long the response of a Modbus TCP slave is waited for.

3. **Modbus TCP Slave**:
   Several Modbus TCP Slave devices can be inserted under the Modbus TCP Master. Here the slave address and a series of Modbus commands (incl. associated I/O mapping) are defined, which are then processed by the driver and exchanged with this Modbus TCP Slave.

4. **Modbus TCP Slave Device**:
   IS1+ CPU works as MODBUS Slave Device. Data can be read and written from external MODBUS TCP Master devices.

The Modbus driver supports all Modbus function codes for the exchange of I/O data:
- FC 01 - Read Coils
- FC 02 - Read Discrete Inputs
- FC 03 - Read Holding Registers
- FC 04 - Read Input Registers
- FC 05 - Write Single Coil
- FC 06 - Write Single Register
- FC 15 - Write Multiple Coils
- FC 16 - Write Multiple Registers
- FC 23 - Read/Write Multiple Registers

Maximum 32 Modbus TCP slaves are supported.

For details on the MODBUS TCP configuration see ‘Help’ in the CODESYS Development System.
4.2.11.1 add Ethernet port to IS1+ CPU

Device -> Add Device -> Ethernet

Select Interface = eth0 with existing connection to IS1+ CPU.

With this MODBUS TCP uses the set IP-SB address of the IS1+ CPU.

4.2.11.2 add Modbus TCP Master or Slave Device

Ethernet -> Insert Device -> Modbus TCP Master / Slave Device
4.2.11.3 Modbus TCP Master (Client):

Select **Auto-reconnect** for automatic restart of cyclic connections after faults.
CODESYS Integration

4.2.11.4 add MODBUS TCP slaves to Master

Modbus TCP Master -> Add Device -> Modbus TCP Slave

Add Channel:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mapping</th>
<th>Channel</th>
<th>Address</th>
<th>Type</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%MW0 ...</td>
<td></td>
<td>Channel 0</td>
<td>%MW0</td>
<td>WORD</td>
<td>0x0000</td>
<td>Read Input Registers</td>
</tr>
<tr>
<td>%MW1 ...</td>
<td></td>
<td>Channel 1</td>
<td>%MW1</td>
<td>WORD</td>
<td>0x0001</td>
<td>Write Multiple Registers</td>
</tr>
</tbody>
</table>

Technical alterations reserved.
## Modbus_TCP_Slave

### General

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Value</th>
<th>Default Value</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NewChannelConfig</td>
<td>BOOL</td>
<td>true</td>
<td>true</td>
<td></td>
<td>Use the new Channel Config format</td>
</tr>
<tr>
<td>Unit-ID</td>
<td>LSINT</td>
<td>255</td>
<td>16#FF</td>
<td></td>
<td>Unit-ID of the Device</td>
</tr>
<tr>
<td>ResponseTimeout</td>
<td>DWORD</td>
<td>1000</td>
<td>1000</td>
<td></td>
<td>Maximum time for a Slave to respond in ms</td>
</tr>
<tr>
<td>IP-Address</td>
<td>ARRAY[3] OF BYTE</td>
<td>[192, 168, 6, 1]</td>
<td>[192, 168, 6, 0]</td>
<td>Configure IP Address of TCP Slave.</td>
<td></td>
</tr>
<tr>
<td>Port</td>
<td>LSINT</td>
<td>502</td>
<td>502</td>
<td></td>
<td>Port where the slave is listening</td>
</tr>
</tbody>
</table>

### Channel 0

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Value</th>
<th>Default Value</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function Code</td>
<td>LSINT</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read Offset</td>
<td>LSINT</td>
<td>16#000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read Length</td>
<td>LSINT</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write Offset</td>
<td>LSINT</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write Length</td>
<td>LSINT</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigger</td>
<td>Enumeration of LSINT</td>
<td>CYCLIC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycle Time</td>
<td>DWORD</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error Handling</td>
<td>Enumeration of BOOL</td>
<td>Keep last value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EnableRegister</td>
<td>BOOL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Channel 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Value</th>
<th>Default Value</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function Code</td>
<td>LSINT</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read Offset</td>
<td>LSINT</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read Length</td>
<td>LSINT</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write Offset</td>
<td>LSINT</td>
<td>16#00A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write Length</td>
<td>LSINT</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trigger</td>
<td>Enumeration of LSINT</td>
<td>CYCLIC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycle Time</td>
<td>DWORD</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Error Handling</td>
<td>Enumeration of BOOL</td>
<td>Keep last value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EnableRegister</td>
<td>BOOL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Configuration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type</th>
<th>Value</th>
<th>Default Value</th>
<th>Unit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MasterAddress</td>
<td>LSINT</td>
<td>16#F0300000</td>
<td>16#F0300000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2.11.5 Modbus TCP Slave Device (Server):

- **ModbusTCP_Slave_Device**

  - **Configured Parameters**
    - Watchdog: [on/off]
    - Slave port: [300]
    - Unit ID: [0-63]
    - Holding registers: [10, 20]
    - Input registers: [10, 20]
    - Writeable: [on/off]

  - **Data Model**
    - Start Addresses:
      - Coils: [0]
      - Discrete inputs: [0]
      - Holding registers: [0]
      - Input registers: [0]

  - **ModbusTCP_Slave_Device**

    - **Find/Filter/Show all**
      - Variables:
        - Application: [ASLI3]
          - Inputs:
            - Inputs[0]: %W[0]
            - Inputs[1]: %W[1]
            - Inputs[2]: %W[2]
            - Inputs[3]: %W[3]
            - Inputs[4]: %W[4]
            - Inputs[5]: %W[5]
            - Inputs[6]: %W[6]
            - Inputs[7]: %W[7]
            - Inputs[8]: %W[8]
            - Inputs[9]: %W[9]

        - Outputs:
          - Outputs[0]: %QW[0]
          - Outputs[1]: %QW[1]
          - Outputs[2]: %QW[2]
          - Outputs[3]: %QW[3]
          - Outputs[4]: %QW[4]
          - Outputs[5]: %QW[5]
          - Outputs[6]: %QW[6]
          - Outputs[7]: %QW[7]
          - Outputs[8]: %QW[8]
          - Outputs[9]: %QW[9]
CODESYS Integration

4.2.12 OPC-UA Server

An OPC UA server is integrated in the IS1+ 9442 Codesys CPU.

Project engineering: Application -> Add Object -> Add Symbol Configuration

Support OPC UA features is activated by default.

A list of all symbols and data structures used in the project is generated automatically.

Symbols and data structures that are to be transferred via OPC-UA must be selected here.

Optional functions are available under 'Settings'.
After compiling and downloading the project into an IS1+ Codesys station, the selected data are available in the OPC-UA server in the IS1+ CPU.

This data can be accessed using OPC-UA clients.

Example of data access using UaExpert (OPC-UA Client from Unified Automation GmbH)
4.3 ‘Hello World’ in IEC 61131-3

Here is a simple Mini-PLC program in Structured Text (ST) as an example:
A DI input signal (DI_S4_8) is mapped to a DO output (DO_S5_0).

```
PLC_PRG
1  PROGRAM PLC_PRG
2  VAR
3  END_VAR

1  DO_S5_0 := DI_S4_8;
2  DO_S15 := DO_S15[2880] := 5;
3  test := 'Abcd1234';
4  RETURN
```

Variable values for debugging are displayed online.

Example: Creating and applying a data structure (data unit type DUT):

```
DUT
Create a new data unit type

Name
TestStruct1
Type
Structure

VAR

TEST STRUCT
1  test1: INT;
2  test2: INT;
3  END_STRUCT
4  END_TYPE

PLC_PRG
1  PROGRAM PLC_PRG
2  VAR
3  test: STRING;
4  myStruct : TestStruct1;
5  END_VAR

1  DO_S5_0 := DI_S4_8;
2  DO_S15 := DO_S15;
3  test := 'Abcd1234';
4  myStruct.test1 := 1;
5  myStruct.test2 := 2;
```
4.4 System Analysis

4.4.1 Cycle time

Application -> Task configuration -> Maintask
The time behaviour of the program execution is set here.

Application -> Task configuration
Shows current and statistical data about the real time behavior of the configured tasks.

Right mouse click on line -> Reset drag pointers for min and max values.
4.4.2 Memory Utilization

FLASH:

A total of 27 MB FLASH memory is available for program code and visualizations. Display at 'Internal Parameters' of the IS1+ RIO:

In addition, after compilation and download of program code and visualizations, the storage space occupied by CODESYS is displayed in 'Messages':

1. Size of generated code: 1691726 bytes
2. Size of global data: 652511 bytes
3. Total allocated memory size for code and data: 2371856 bytes

RAM:

Display at 'Messages':

1. Memory area 0 contains: Data, Input, Output, Memory and Non-safe data size: 1048576 bytes, highest used address: 685128, largest contiguous memory gap: 368448 bytes (33 %)
2. Memory area 3 contains: Code: 2199248 bytes, highest used address: 1691728, largest contiguous memory gap: 507520 bytes (22 %)
4.5  Update

**IS1+ 9442 CPU Firmware Update:**
Firmware updates of the IS1+ 9442 CPU can be loaded via the IS1+ web server if required.
For this purpose, the PLC must first be set to the Stop state via the Codesys Development Tool.
An IS1+ CPU firmware download via the IS1+ web page is blocked when the PLC is in RUN mode.
(LED 'AS EXCH' = On)

**IS1+ Codesys package:**
A suitable IS1+ Codesys Package is delivered together with a IS1+ 9442 Codesys Firmware File (.SWU).
The IS1+ Package version currently installed in the Codesys Development Tool can be displayed in Tools -> Package Manager.
Older parallel installed Package Versions can be displayed in the Package Manager via 'Display Versions'.
If the new IS1+ package version is not yet installed in the Codesys Development Tool, the new package supplied must be installed.

A newly installed IS1+ package version is not always automatically transferred to existing Codesys configurations. Check the package version used in the project under 'Information -> Description' at Device, BusRail and I/O module level.

If required, after the package installation in the project, the function 'Update Device' has to be called up at device level and for each configured I/O module.

Instead of manually calling the function 'Update Device' for all configured I/O modules, the attached script 'updateTree.py' can be started, which automates the update of the I/O modules.
call: Tools -> Scripting -> Execute Script File

After the update has been completed, the project must be recompiled and loaded into the IS1+ CPUs.
5 Security

R. STAHL Security Whitepaper. …. TBD

CODESYS Security Hints:
https://www.codesys.com/security/codesys-security.html

CODESYS Security Whitepaper:

6 Liability

Exclusion of liability of R. STAHL for consequences of faulty PLC project planning …. TBD …..

7 List of abbreviations

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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AS</td>
<td>Automation System</td>
</tr>
<tr>
<td>AIM</td>
<td>Analogue Input Module</td>
</tr>
<tr>
<td>AIMH</td>
<td>Analogue Input Module + HART</td>
</tr>
<tr>
<td>AUMH</td>
<td>Analog Universal Module AI/AO with HART</td>
</tr>
<tr>
<td>SAIMH</td>
<td>Safety Analogue Input Module + HART (PROFIsafe)</td>
</tr>
<tr>
<td>AOM</td>
<td>Analogue Output Module</td>
</tr>
<tr>
<td>DiM</td>
<td>Digital Input Module</td>
</tr>
<tr>
<td>DIOM</td>
<td>Digital Input Output Module</td>
</tr>
<tr>
<td>DOM</td>
<td>Digital Output Module</td>
</tr>
<tr>
<td>DOMR</td>
<td>Digital Output Module Relays</td>
</tr>
<tr>
<td>DOMV</td>
<td>Digital Output Module Valves</td>
</tr>
<tr>
<td>HW</td>
<td>Hardware</td>
</tr>
<tr>
<td>IOM</td>
<td>General description of I/O Module</td>
</tr>
<tr>
<td>MQTT</td>
<td>Message Queuing Telemetry Transport</td>
</tr>
<tr>
<td>OPC-UA</td>
<td>Open Platform Communications - Unified Architecture</td>
</tr>
<tr>
<td>PM</td>
<td>Power Module</td>
</tr>
<tr>
<td>SW</td>
<td>Software</td>
</tr>
<tr>
<td>TIM</td>
<td>Temperature Input Module</td>
</tr>
<tr>
<td>FCG</td>
<td>FieldComm Group (former HART Communication Foundation HCF)</td>
</tr>
<tr>
<td>HART</td>
<td>Highway Addressable Remote Transducer</td>
</tr>
<tr>
<td>PV</td>
<td>Primary Variable</td>
</tr>
<tr>
<td>SV</td>
<td>Secondary Variable</td>
</tr>
<tr>
<td>TV</td>
<td>Tertiary Variable</td>
</tr>
<tr>
<td>QV</td>
<td>Quaternary Variable</td>
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8 Version changes

<table>
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<th>Version Operating Instructions</th>
<th>9442 CPU Firmware</th>
<th>Extensions / Changes</th>
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<tbody>
<tr>
<td>B0.11</td>
<td>V1-0-xx-yyyy</td>
<td>Work</td>
</tr>
<tr>
<td></td>
<td></td>
<td>First released version</td>
</tr>
</tbody>
</table>

9 Literature references

https://www.codesys.com/
https://en.wikipedia.org/wiki/CODESYS

10 Support Address

IS1+ Support: R. STAHL Schaltgeräte GmbH
Business Unit Automation Interface and Solutions
eMail: support.automation@r-stahl.com
Support information: http://www.r-stahl.com
Service Hotline IS1+: +49 (7942) 943-4123
Telefax: +49 (7942) 943-40 4123

CODESYS Support: https://www.codesys.com/support-training.html

CODESYS Forum: https://forum.codesys.com/