Easy Arc Integration into a Simatic S7-300 Process Control System

Quick Guide

An Introduction on how to Integrate a Hamilton Sensor successfully into a PCS
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1 Introduction

Hamilton Arc™ and VisiFerm™ DO sensors provide both standard analog (4-20 mA) and digital Modbus interfaces. These are built into each sensor and are supported directly from the sensor head.

Hamilton Arc™ and VisiFerm™ DO sensors generate a 4-20 mA signal in a three-wire configuration parallel to the Modbus interface. The sensor’s 4-20 mA interface enables direct connection to control units or PCS with analog I/O.

In this demo case there are two Arc sensors connected to a Simatic S7-315 PCS. This is setup within a small case that can be used for mobile demonstrations and trainings.

To program the process control system the Simatic Step 7 V5.5 development environment is used with an extra software module for Modbus RTU programming. The specific programming code for the demo case can be found on the “Process Analytics Engineering Documentation” DVD P/N:238999-4636.

1.1 Hardware used in this project

The following Components are used in the Demo Case

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCS CPU</td>
<td>Simatic S7-315: CPU 315</td>
</tr>
<tr>
<td>RS 485 Modul</td>
<td>Simatic CP 341 – RS-422/485</td>
</tr>
<tr>
<td>Analog Input Modul</td>
<td>Simatic SM 331 8x 16 bit Type.</td>
</tr>
<tr>
<td></td>
<td>4-20 mA passive 6ES7331-7NF00-0AB0 (galvanically isolated)</td>
</tr>
<tr>
<td>Analog Input Modul</td>
<td>Simatic SM 331 8x 16 bit Type.</td>
</tr>
<tr>
<td></td>
<td>4-20 mA active 6AG1331-7KB02-2AB0 (galvanically isolated)</td>
</tr>
<tr>
<td>Power Supply</td>
<td>Simatic PS 307</td>
</tr>
<tr>
<td>Display</td>
<td>Simatic Basic Touch Panel 15”</td>
</tr>
<tr>
<td>Sensors</td>
<td>Hamilton Arc Sensors, Hamilton Arc Wi 2G Adapter</td>
</tr>
</tbody>
</table>
1.2 Electrical schematic

Panel

Power Supply
PS 307
+ IN 230 VAC
N L1
- OUT 24 VDC

PLC - Simatic S7 300
CPU 315
Ethernet

RS485 Modul
CP 341 - RS-422/485

Analog-Input Modul
AI 8 x 16 bit
6ES7331-7NF00-0AB0
Passive
CH0
mA
galvanically isolated

Analog-Input Modul
AI 8 x 16 bit
6AG1331-7KB02-2AB0
Active
CH0
mA
galvanically isolated

Arc Sensor

Arc Wi 2G Adapter
M12 male connector

Arc Sensor

GND
+24 VDC

4-20 mA Three Wire Connection

4-20 mA Four Wire Connection

Ethernet

Arc Wi 2G Adapter

D-SUB

mA1
8

ModBus A
ModBus B
4 - 20mA –

PE

GND
+24 VDC

D C G H B A

1 4 PE 2 3

Arc Sensor

Passive

Active
2 Electrical connection with Arc sensors

All Hamilton Arc sensors come with a digital RS-485 and one or two analog (4-20 mA) interfaces.

The digital RS485 interface enables communication with Arc sensors in order to: perform measurements, calibrate the sensor and to change the sensor’s configuration parameters.

2.1 VP 8 PIN Designation

To connect a Hamilton Arc Sensor it is required to only use the Hamilton Sensor Cable VP 8.0.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
<th>Cable color code</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>4-20mA interface #1</td>
<td>shield coax black</td>
</tr>
<tr>
<td>C</td>
<td>Power supply +24VDC</td>
<td>cora coax red-transparent</td>
</tr>
<tr>
<td>D</td>
<td>Ground</td>
<td>shield coax red</td>
</tr>
<tr>
<td>G</td>
<td>RS-485 (A)</td>
<td>yellow wire</td>
</tr>
<tr>
<td>H</td>
<td>RS-485 (B)</td>
<td>brown wire</td>
</tr>
</tbody>
</table>

⚠️ ATTENTION! The Arc sensor has no internal galvanic isolator like the Arc Wi 2G Adapter. Accordingly, it is recommended to use a galvanic isolated analog input module. Or else an external galvanic isolation module should be installed between the sensor and the analog input module in order to have a safe electrical environment.
ATTENTION! The analog signal from the sensor is a Pulse-With-Modulation (PWM) of 5 kHZ (VisiFerm DO) / 3.5kHz (Arc Sensors). Without setting a filter, the measurement values will tend to fluctuate.

It is recommended to filter the signal with a rate less than 100Hz measurement. Settings on the analog input module can be adjusted either by the hardware or the software. Consult your analog input module specific instruction.

In case of a Simatic SM 331 the hardware settings are configured with the Step 7 development environment.

2.2.1 Circuit arrangement with a passive analog input module

The analog input module Simatic SM331 is passive, therefore the sensors analog interface functions as a current sink. An external source is required.
In the case that the analog input module is not galvanic isolated, an external galvanic isolation has to be installed between the sensor and the analog input module.

**Hardware configuration for analog input module SM 331**

(AI 8 x 16 bit; 6ES7331-7NF00-0AB0)

The hardware settings have to be made in the Simatic Step 7 development environment.

The analog input module must be defined as a 4-wire transducer with an input range of 4-20 mA.

Further documentation:

- support.automation.siemens.com  
  S7-315 Module data (PDF)  
  Chapter 4.4 Wiring and connecting current transducers  
  Chapter 6.3 Analog input module SM 331; AI 8 x 16 bit; (6ES7331-7NF00-0AB0)
2.3 Digital RS-485 interface

Arc sensors are always connected to digital controlling devices as Modbus slaves. The Modbus RTU communication protocol corresponds to the Modbus-IDA standard.

⚠️ ATTENTION! As all sensors are delivered with factory-default settings, each sensor’s device address is set to ‘1’. For proper communication in a RS-485 network with several sensors, it is required to use a unique Modbus device address for each sensor.

⚠️ ATTENTION! In the Hamilton programmer’s manual the register counting starts per definition at address 1. Some Modbus master protocols operate with register-count starting at address 0. Usually, the Modbus master software translates the addressing. Thus, the register address of 2088 will be translated by Modbus master software to 2087 which is sent to the sensor (Modbus slave). This must be observed during programming. Please check the specifications of the Modbus master that you are using.

Working with the Simatic Modbus Master driver the register address has to be decrement manually.

Further documentation:

- support.automation.siemens.com s7300_cp341_manual_en_en-US (PDF)
- Modbus-IDA standard: www.modbus.org

2.3.1 Modbus Master (RTU) driver installation

The Simatic Modbus Master module is not part of the standard Step 7 V5.5 package.

Install the Simatic Modbus Master (RTU) driver module:
SIMATIC S7, Modbus Master (RTU) V3.1.6 (6ES7870-1AA01-0YA0)
2.3.2 Hardware configuration

1. Add the CP 341 RS 422/485 module to your hardware definitions.
2. Set the protocol type to Modbus Master:

3. Parameterise the Modbus Master Protocol:
The network needed for Modbus communication is a two wire RS-485 network.

Hamilton sensor Modbus protocol settings

- **Baud Rate**: 19200 Bits/s
- **Data Bits**: 8
- **Stop Bits**: 2
- **Parity**: none
2.3.3 Modbus programming examples

The programming is based on the Siemens manual “s7300_cp341_manual_en_en-US.pdf”.

The programming example of the CP 341, including Modbus function blocks, is supplied on the Modbus Master (RTU) driver installation CD.
2.3.4 Read data from sensor

To send a read request to a Modbus slave device the function block FC23 is used with the “Receive-Flag” (M23.0) as enabled.

Further documentation is found in the Simens manual (s7300_cp341_manual_en_en-US Chapter 6.3.1 S7 Send Data to a Communication Partner).

```
FC23 : Carry out RCV-Receive

<table>
<thead>
<tr>
<th>Comment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>M23.0 RCV_Enable</td>
</tr>
</tbody>
</table>

// -------------------------------
// RCV with Instance-DB
// -------------------------------

CALL "P_RCV_RK", "IDR_P_RCV_RK" FB7 / DB70
KH_R :="M23.0 RCV_Enable" M23.0
R :=
LADDR :=256
DB_NO :="SOURC_DB".DB_Number DB42.DBN6
DBR_NO :="SOURCE_DB".DB_Offset DB42.DBN8
L_TYP :=
L_NO :=
L_OFFSET:=
L_CP_EV:=
L_CP_BIT:=
MNR :="M23.4 New_Data_Received" M23.4
ERROR :="M23.5 Error" M23.5
LEN :="M23.6 RECEIVE-Length" M23.6
STATUS :="M23.6 ReceiveStatus" M23.6
```
2.3.5 Write data to sensor

To send a write request to a Modbus slave device the function block FC21 is used with the “Send-Request-Flag” (M20.0) as enabled.

Further documentation is found in the Siemens manual (s7300_cp341_manual_en_en-US Chapter 6.3.2 S7 receives data from a communication partner).
2.3.6 Data conversion – ASCII

To convert the received data to readable text the high and low BYTE has to be switched in every WORD.

As example the sensor name (ASCII 16) is converted to a 16 characters long string.
2.3.7 Data conversion – Float and Integer

To convert the received data to a float or integer value the high and low WORD has to be switched in every DWORD.

As example the measurement value of PMC1 (Register address 2090) is converted to a float value.

```
FC100 : Title:
  //Value
  //
  L  "DB100 Reg2090 Receive">Value Low" DB100.DBW0
  T  DB100.DBW 33
  L  "DB100 Reg2090 Receive">Value High" DB100.DBW2
  T  DB100.DBW 20

  //Float
  //
  L  "DB100 Reg2090 Receive">Float Low" DB100.DBW4
  T  DB100.DBW 26
  L  "DB100 Reg2090 Receive">Float High" DB100.DBW6
  T  DB100.DBW 24

  //Status
  //
  L  "DB100 Reg2090 Receive">Status Low" DB100.DBW8
  T  DB100.DBW 30
  L  "DB100 Reg2090 Receive">Status High" DB100.DBW10
  T  DB100.DBW 28

  //Min Limit
  //
  L  "DB100 Reg2090 Receive">Min Limit Low" DB100.DBW12
  T  DB100.DBW 34
  L  "DB100 Reg2090 Receive">Min Limit High" DB100.DBW14
  T  DB100.DBW 32

  //Max Limit
  //
  L  "DB100 Reg2090 Receive">Max Limit Low" DB100.DBW16
  T  DB100.DBW 38
  L  "DB100 Reg2090 Receive">Max Limit High" DB100.DBW18
  T  DB100.DBW 36
```

2.3.8 4-20 mA Scale

The 4-20 mA current interface regulates the input current according to the sensor measurements. The 4-20 mA current interface is configured at the factory with the range value and unit for the measurements as indicated on the certificate. Follow the instructions in the section entitled 'Configuration and monitoring of the sensor' to adjust the sensor according to the requirements of your application.
3 Electrical connection to Arc Wi 2G Adapter

The Arc Wi 2G adapter includes an additional internal galvanic isolator for enhanced signal quality. The analog interface functions as a current sink, therefore has to be externally powered.

Further product information:


3.1 M12 (A coded) Pin Designation with respect to Hamilton M12 Sensor Cable

To connect a Hamilton Arc Wi 2G Adapter it is recommended to use the Hamilton M12 cable.

<table>
<thead>
<tr>
<th>M12 PIN</th>
<th>Function</th>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>+4-20 mA</td>
<td>Blue</td>
<td>4-20 mA two-wire interface, functions as a current sink and needs to be powered. It regulates the input current according to the sensor measurements. Galvanically isolated from the power supply (Insulation test voltage max UT 500 V(AC).</td>
</tr>
<tr>
<td>2</td>
<td>-4-20 mA</td>
<td>White</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>+24 VDC</td>
<td>Black</td>
<td>Power supply: +24 VDC (7-30 VDC) (Power supply can be external; not from PCS)</td>
</tr>
<tr>
<td>1</td>
<td>GND</td>
<td>Brown</td>
<td>Ground</td>
</tr>
<tr>
<td>Housing</td>
<td>Shield</td>
<td>Green/Yellow</td>
<td>Connected to the housing including the VP 8 female connector.</td>
</tr>
</tbody>
</table>

⚠️ ATTENTION! Always use Hamilton M12 cables, available in a range of different lengths, for the easiest and safest connection of Arc pH, ORP, DO or conductivity sensors.
3.2 Circuit arrangement with a passive analog input module

The sensor’s analog interface functions as a current sink and has to be powered.

In case of the analog input module functioning as a current sink, then an external power supply is required.

Hardware configuration for analog input module SM 331
(AI 8 x 16 bit; 6ES7331-7NF00-0AB0)

The hardware settings have to be made in the Simatic Step 7 development environment. The analog input module must be defined as a **4-wire transducer** with an input range of **4-20mA**.

Further documentation:

- support.automation.siemens.com  S7-315 Module data (PDF)
- Chapter 4.4 Wiring and connecting current transducers
- Chapter 6.3 Analog input module SM 331; AI 8 x 16 bit; (6ES7331-7NF00-0AB0)
3.3 Circuit arrangement with an active analog input module

The Arc Wi 2G adapter includes an additional internal galvanic isolator for enhanced signal quality. Connection to the process control system is simplified to four wires, consisting of the two-wire power supply and the two-wire 4-20 mA interface. 4-20 mA two-wire interface functions as a current sink and it regulates the input current according to the sensor measurements. This interface requires an external power supply.

**Typical Connection to PCS**

![Electrical Connection with Arc Wi 2G Adapter Diagram](diagram.png)

*The easiest form of wiring using the Arc Wi 2G Adapter.*

**Note:** Arc Wi 2G Adapter supports only one 4-20 mA interface and no digital outputs. Sensor has only to be configured with 4-20 mA.