HART® 7.x Field Device Specification for AMI-II CACE Transmitters

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1. INTRODUCTION

1.1 Scope

The SWAN Analytical Instruments model AMI-II CACE transmitter complies with HART Protocol Revision 7.5. This document specifies all the device specific features and documents HART Protocol implementation details (i.e. the Engineering Unit Codes supported). The functionality of this Field Device is described sufficiently to allow its proper application in a process and its complete support in HART capable Host Applications.

1.2 Purpose

This specification is designed to complement the AMI-II CACE manual by providing a complete description of this Field Device from a HART Communication perspective.

1.3 Who should use this document?

The specification is designed to be a technical reference for HART capable Host Application Developers, System Integrators and knowledgeable End Users. It also provides functional specifications (e.g., commands and performance requirements) used during development, maintenance and testing. This document assumes the reader is familiar with HART Protocol requirements and terminology.

1.4 References

HART Smart Communications Protocol Specification. HCF_SPEC-12. Available from the HCF.

MenAMI2_CACE_xx.pdf. Available from the SWAN Analytical Instruments web page.

2. DEVICE IDENTIFICATION

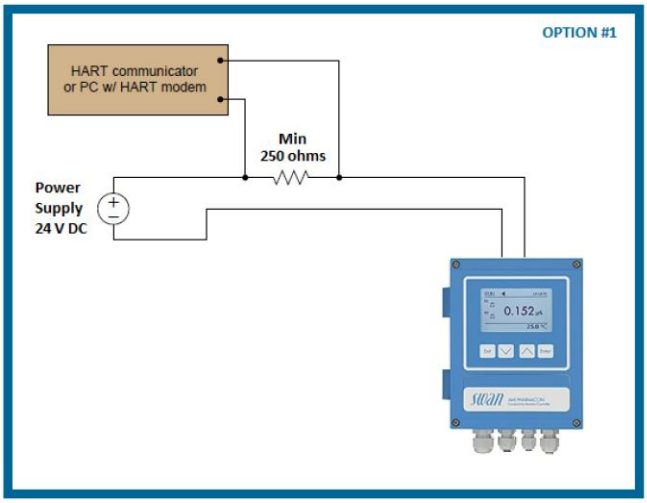
Manufacturer Name:	SWAN Analytical Instruments	**Model Name(s):**	AMI-II CACE
Manufacture ID Code:	24757 (60B5 Hex)	**Device Type Code:**	58923 (E62B Hex)
HART Protocol Revision	7.5	**Device Revision:**	1
Number of Device Variables	11		
Physical Layers Supported	FSK		
Physical Device Category	Transmitter, Non-DC-isolated Bus Device		

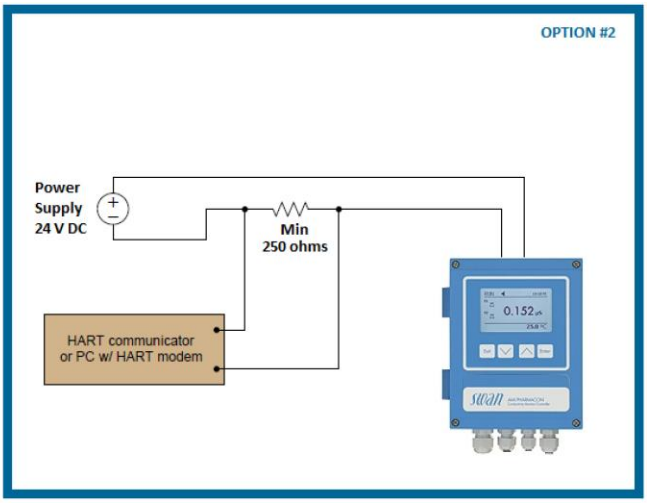
3. PRODUCT OVERVIEW

The AMI-II CACE HART communication option board provides a 4 to 20mA output signal and can be monitored and configured using a HART master device or a hand-held communicator.

3.1 Connections

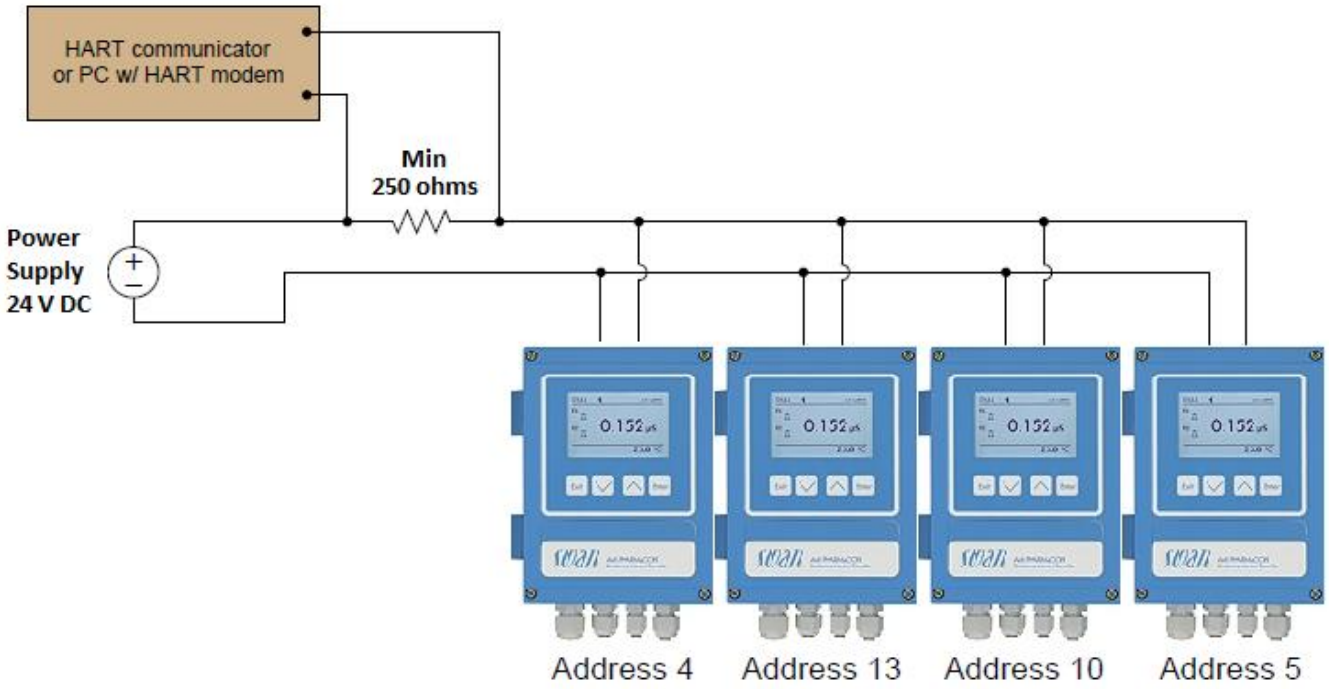
3.1.1 Point to point Mode





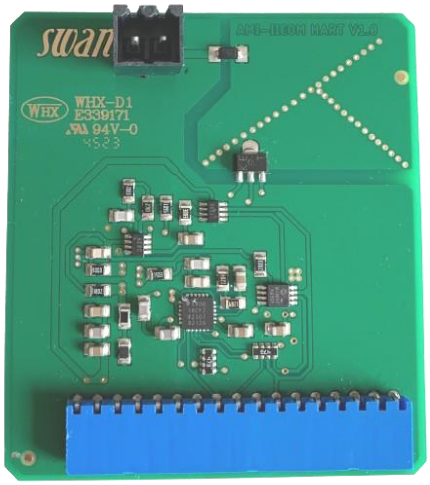
An external minimum 250 Ω (maximum 800 Ω) resistor is needed in order to communicate with HART protocol.

3.1.2 Multidrop Mode



A single minimum 250 Ω resistor (maximum 800 Ω) is needed to communicate with all the instruments connected to the bus, and each of them must provide 4mA.

3.1.3 HARTREC Board



The HARTREC Board must be installed in the AMI-II transmitter in order to communicate with HART.

4. PRODUCT INTERFACES

4.1 Process Interface

4.1.1 Sensor Input Channels

Refer to AMI-II CACE manual to details on mounting Conductivity and Flow sensors.

4.2 Host Interface

4.2.1 Process Specific Conductivity

The 4 to 20mA output of the AMI-II CACE HART option board represents a process value measurement, scaled according to the configured range of the instrument. This output corresponds to the Primary Variable. HART Communication is supported on this loop.

Since Dynamic Variables are mappable, PV can correspond to one of the following variables:

- Specific Conductivity (sc)
- Cation Conductivity (cc)
- Degassed Conductivity (dc)
- First Temperature
- Second Temperature
- Third Temperature
- Conductivity difference
- Main Flow
- First Calculated Value (pH)
- Second Calculated Value (Ammonium)

It is also possible to set the PV from the instrument local display, in the “Signal Output 3 / Parameter” settings.

4.3 Local Interfaces

4.3.1 Local Controls and Displays

This device has a local display that allows the complete configurability of the instrument.

Refer to AMI-II CACE manual to details on it.

4.3.2 Write Protection

The Field Device has no “Write protection mode”.

5. DEVICE VARIABLES

This Field Device exposes 11 Device Variables.

Device Variables	Variables Meaning	Units
0	Specific Conductivity (sc)	uS/cm
1	Cation Conductivity (cc)	uS/cm
2	Degassed Conductivity (dc)	uS/cm
3	First Temperature	°C
4	Second Temperature	°C
5	Third Temperature	°C
6	Conductivity Difference	uS/cm
7	Main Flow	l/h
8	First Calculated Value (pH)	pH
9	Second Calculated Value (Ammonium)	ppm
10	Case Temperature	°C

5.1 Device Variable 0 Specific Conductivity (sc)

Specific Conductivity is read by Specific Conductivity - 1st Temperature sensors (Refer to AMI-II CACE manual to details on it).

5.2 Device Variable 1 Cation Conductivity (cc)

Cation Conductivity is read by Cation Conductivity - 2nd Temperature sensors (Refer to AMI-II CACE manual to details on it).

5.3 Device Variable 2 Degassed Conductivity (dc)

Degassed Conductivity is read by Degassed Conductivity - 3rd Temperature sensors (Refer to AMI-II CACE manual to details on it).

5.4 Device Variable 3 First Temperature

First Temperature is read by Specific Conductivity - 1st Temperature sensors (Refer to AMI-II CACE manual to details on it).

5.5 Device Variable 4 Second Temperature

Second Temperature is read by Cation Conductivity - 2nd Temperature sensors (Refer to AMI-II CACE manual to details on it).

5.6 Device Variable 5 Third Temperature

Third Temperature is read by Degassed Conductivity - 3rd Temperature sensors (Refer to AMI-II CACE manual to details on it).

5.7 Device Variable 6 Conductivity Difference

Conductivity Difference is calculated starting from Specific and Cation Conductivity sensor (Refer to AMI-II CACE manual to details on it).

5.8 Device Variable 7 Main Flow

Main Flow is read by the flow rate sensor (Refer to AMI-II CACE manual to details on it).

5.9 Device Variable 8 First Calculated Value (pH)

pH is calculated starting from Specific Conductivity-1st Temperature and Cation Conductivity - 2nd Temperature sensors (Refer to AMI-II CACE manual to details on it).

5.10 Device Variable 9 Second Calculated Value (Ammonium)

Ammonium is calculated starting from Specific Conductivity - 1st Temperature and Cation Conductivity - 2nd Temperature sensors (Refer to AMI-II CACE manual to details on it).

5.11 Device Variable 10 Case Temperature

Case Temperature shows the Temperature read inside the Electronic Box.

6. DYNAMIC VARIABLES

6.1 Mappable Variables

Four mappable Dynamic Variables are implemented.

Dynamic Variables	Variables Meaning	Units
PV	Spec. Cond. – Cat. Cond. – Deg. Cond. – 1st Temp – 2nd Temp – 3rd Temp – Cond. Diff. – Main Flow – pH – Ammonium	uS/cm - uS/cm - uS/cm -°C –°C –°C – uS/cm - l/h – pH – ppm
SV	Spec. Cond. – Cat. Cond. – Deg. Cond. – 1st Temp – 2nd Temp – 3rd Temp – Cond. Diff. – Main Flow – pH – Ammonium	uS/cm - uS/cm - uS/cm -°C –°C –°C – uS/cm - l/h – pH – ppm
TV	Spec. Cond. – Cat. Cond. – Deg. Cond. – 1st Temp – 2nd Temp – 3rd Temp – Cond. Diff. – Main Flow – pH – Ammonium	uS/cm - uS/cm - uS/cm -°C –°C –°C – uS/cm - l/h – pH – ppm
QV	Spec. Cond. – Cat. Cond. – Deg. Cond. – 1st Temp – 2nd Temp – 3rd Temp – Cond. Diff. – Main Flow – pH – Ammonium	uS/cm - uS/cm - uS/cm -°C –°C –°C – uS/cm - l/h – pH – ppm

It is possible to associate any of these dynamic variables to PV, SV, TV or QV with a HART Master (or Handheld Communicator).

The PV is also settable from the instrument local display's settings.

6.2 PV Transfer Functions

The Primary Variable Transfer Function can be read with command 15. Its meaning is referred to the following table.

Transfer Function Type	**Code**
Linear	240
Bilinear	241
Logarithmic	242
Control Upwards	243
Control Downwards	244

7. STATUS INFORMATION

7.1 Field Device Status

The functions of the Field Device Status bits are specified in HCF_SPEC-99. Further details of their implementation are described in the following table.

Bit	Name	Notes
7	Device Malfunction	Set on any detected Hardware Error
6	Configuration Changed	Set if any changes are made to Field Device Configuration
5	Cold Start	Set when powered-up or after a device reset
4	More Status Available	Set if any Alarm or Maintenance has changed its status. More information is available via cmd 48
3	Loop Current Fixed	The Loop Current is being held at a fixed value and is not responding to process variations
2	Loop Current Saturated	The Loop Current has reached its upper (or lower) endpoint limit and cannot increase (or decrease) any further
1	Non-PV Out of Limits	A Device Variable not mapped to the PV is beyond its operating limits
0	PV Out of Limits	The PV is beyond its operating limit

7.2 Extended Device Status

Contains additional information regarding the status of the Field Device.

Bit	Name	Notes
2	Critical Power Failure	Set when battery is becoming critically low (less than 15 min) and Field Device not connected to Power Supply
1	Device Variable Alert	Set when one or more Device Variables are in one of the following conditions: • Hi/low limited (Limit Status) • Bad (Process Data Status) • Poor Accuracy (Process Data Status)
0	Maintenance Required	Not Used

7.3 Additional Device Status (Command #48)

Command #48 returns 10 additional bytes of data (Int32 or Int16 Little Endian), with the following status information:

(ALARMS-MAINTENANCE CODES)

Byte	Bit	Meaning	Code
0-3 (INT32)	0	Cond. 1 Alarm high	**E001**
	1	Cond. 1 Alarm low	**E002**
	2	Cond. 2 Alarm high	**E003**
	3	Cond. 2 Alarm low	**E004**
	4	Cond. 3 Alarm high	**E005**
	5	Cond. 3 Alarm low	**E006**
	6	Temp. 1 high	**E007**
	7	Temp. 1 low	**E008**
	8	Sample Flow high	**E009**
	9	Sample Flow low	**E010**
	10	Temp.1 shorted	**E011**
	11	Temp.1 disconnected	**E012**
	12	Case Temp. high	**E013**
	13	Case Temp. low	**E014**
	14	pH Calculation undef	**E015**
	15	Degasser status	**E016**
	16	Control Timeout	**E017**
	17	Degasser disconnected	**E018**
	18	Temp.2 shorted	**E019**
	19	Temp.2 disconnected	**E020**
	20	Temp.3 shorted	**E021**
	21	Temp.3 disconnected	**E022**
	22	Degasser Ctl Timeout	**E023**
	23	Input active	**E024**
	24	IC MK41T56	**E025**
	25	IC LM75	**E026**
	26	undefined	**E027**
	27	undefined	**E028**
	28	Calibration Degasser	**E029**
	29	I2C Frontend	**E030**
	30	Calibration Recout	**E031**
	31	Wrong Frontend	**E032**

4-5 (INT16)	0	EDI module exhausted	**E065**
	1	Reserved	
	2	Reserved	
	3	Reserved	
	4	Reserved	
	5	Reserved	
	6	Reserved	
	7	Reserved	
	8	Reserved	
	9	Reserved	
	10	Reserved	
	11	Reserved	
	12	Reserved	
	13	Reserved	
	14	Reserved	
	15	Reserved	
14-17 (INT32)	0	pH Alarm high	**E033**
	1	pH Alarm low	**E034**
	2	Alk. Alarm high	**E035**
	3	Alk. Alarm low	**E036**
	4	Temp. 2 high	**E037**
	5	Temp. 2 low	**E038**
	6	Temp. 3 high	**E039**
	7	Temp. 3 low	**E040**
	8	undefined	**E041**
	9	Degasser blocked	**E042**
	10	EDI out of range	**E043**
	11	No Sample Flow	**E044**
	12	EDI DAC disconnected	**E045**
	13	EDI ADC disconnected	**E046**
	14	EDI Module Worn-Out	**E047**
	15	undefined	**E048**
	16-31	Reserved	

"Reserved" bits are always set to 0.

All bits used in these bytes indicate device/sensor failure or maintenances, and always set bit 4 of the Device Status byte.

8. UNIVERSAL COMMANDS

Number	Name	Notes
0	Read Unique Identifier	Returns identity information of the Field Device
1	Read Primary Variable	Returns PV value and its unit
2	Read Loop Current and Percent of Range	Returns AO value and % range
3	Read Dynamic Variables and Loop Current	Returns PV, SV, TV and QV values and corresponding unit values along with AO value
6	Write Polling Address	Changes Field Device's polling address and loop current mode
7	Read Loop Configuration	Returns polling address and loop current mode status
8	Read Dynamic Variable Classifications	Returns dynamic variables classification
9	Read Device Variables with Status	Returns device variables with status
11	Read Unique Identifier Associated With Tag	Same response as command 0 when Tag matches
12	Read Message	Returns 24 bytes of packed ASCII data
13	Read Tag, Descriptor, Date	Returns tag, descriptor (packed ASCII format) and date from the device
14	Read Primary Variable Transducer Information	Returns PV transducer limits and span
15	Read Device Information	Returns PV unit value, LRV, URV, damping value and write protect code
16	Read Final Assembly Number	Returns final assembly number
17	Write Message	Write 24 bytes of packed ASCII data.
18	Write Tag, Descriptor, Date	Writes tag, descriptor (packed ASCII format) and date to the device

19	Write Final Assembly Number	Writes final assembly number to the device
20	Read Long Tag	Returns 32-byte Long Tag
21	Read Unique Identifier Associated with Long Tag	Same response as command 0 when Long Tag matches
22	Write Long Tag	Writes Long Tag to the Field Device
38	Reset Configuration Changed Flag	Resets the configuration change flag
48	Read Additional Device Status	See 7.3 for details

9. COMMON-PRACTICE COMMANDS

9.1 Supported Common Practice Commands

Number	Name	Notes
33	Read Device Variables	Returns all the Supported Device Variables
50	Read Dynamic Variable Assignment	Returns the Variable Numbers associated with PV, SV,TV and QV
51	Write Dynamic Variable Assignment	Writes the Variable Numbers associated with PV, SV,TV and QV

9.2 Burst Mode

This Field Device does not support Burst Mode.

9.3 Catch Device Variable

This Field Device does not support Catch Device Variable.

10. DEVICE-SPECIFIC COMMANDS

This Field Device does not support Device Specific Commands.

11. TABLES

11.1 Engineering Type Unit Codes

Units of Measurement	Unit Code
Temperature Degrees Celsius	32
Electric Potential millivolts	36
Electric Resistance Ω	37
Miscellaneous Hertz	38
Electric Current milliamperes	39
Time Minutes	50
Time Seconds	51
Time Hours	52
Time Days	53
Miscellaneous Percent	57
Electric Potential Volts	58
Miscellaneous pH	59
Miscellaneous Micro Siemens per centimeter	67
Flow Liters per hour	138
Concentration Parts per million	139
Electric Resistance kΩ	163
Concentration Parts per billion	169
Not used	250
Special	253

11.2 Classification Type Unit Codes

Measurement	Meas. Code
Temperature	64
Volumetric flow	66
Time	70
Frequency	80
Analytical	81
Electric Potential	83
Current	84
Resistance	85
Conductance	87
Concentration	90
Turbidity	97
Not used	250
Special	253

12. PERFORMANCE

12.1 Sampling Rates

Typical sampling rates are shown in the following table.

Conductivity (Specific, Cation and Degassed) sensor value sample	1 per second
Temperature (1st, 2nd and 3rd) sensors value sample	1 per second
Flow rate sensor value sample	1 per second
Case Temperature sensor sample	1 per second

Note: all the Device Variables use an Infinite Impulse Response Filter, with coefficients depending on the measured variable. The Damping Value is different for each of the Device Variables, and can be read through Command 15.

12.2 Power-Up

On power up, the transmitter takes approximately 10 seconds to be ready. During this period, the device will not respond to HART commands.

12.3 Command Response Times

Minimum	2ms
Typical	5ms
Maximum	150ms

12.4 Long Messages

The largest data field used is in the response to Command 9: up to 71 bytes including the two status bytes.

12.5 Non-Volatile Memory

EEPROM is used to hold the device's configuration parameters. New data is written to this memory immediately on execution of a write command, before the consequent response.

12.6 Modes

Loop current mode can be disabled or enabled using command 6.

12.7 Write Protection

Write-protection is not selectable, and is always set as "not write protected".

12.8 Damping

Damping time is calculated for each dynamic variable.

ANNEX A. CAPABILITY CHECKLIST

Manufacturer, model and revision	SWAN Analytic Instruments, AMI-II CACE rev. 1
Device type	Transmitter
HART revision	7.x
Device Description available	Yes
Number and type of sensors	8 (seven external, one internal)
Number and type of actuators	0
Number and type of host side signals	1: 4 - 20mA analog
Number of Device Variables	11
Number of Dynamic Variables	4
Mappable Dynamic Variables?	Yes
Number of common-practice commands	3
Number of device-specific commands	0
Bits of additional device status	80
Alternative operating modes?	No
Burst mode?	No
Write-protection?	No

ANNEX B. DEFAULT CONFIGURATION

Parameter	Default value
PV Sensor Type	Specific Conductivity
Lower Range Value	0 uS/cm
Upper Range Value	3000 uS/cm
PV Units	uS/cm
Damping time constant	3.184 seconds
Fault-indication jumper	Not used
Write-protect jumper	Not used
Number of response preambles	5

ANNEX C. REVISION HISTORY

Document Title	HART Interface Description AMI-II CACE			
Document ID	A-96.310.871			
Document Revision	Date	Device Revision	DD Revision	Description
1.0	23/04/2024	1	1	First release, for HART 7.x Device