



## DeltaV HART Capabilities

This document describes the DeltaV capabilities with HART inputs and outputs that are intrinsic to the system. Additional capabilities may be obtained with the addition of AMS.



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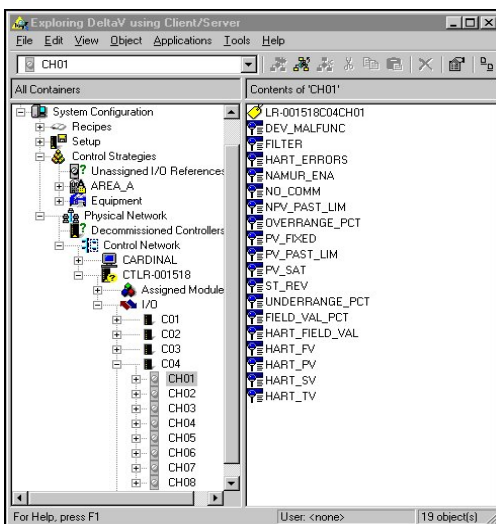
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## Introduction

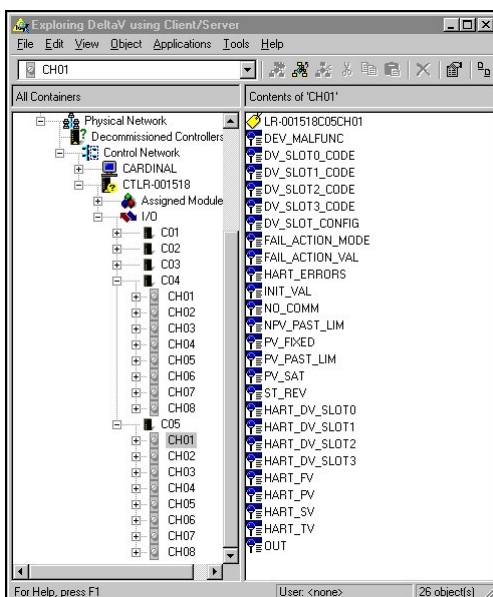
The DeltaV system provides the capability to interface to HART devices. The HART information is communicated digitally and is very helpful for device diagnostics. This information can be used in the DeltaV system to affect control strategy or to alert operators to a transmitter malfunction. Additional capabilities such as managing the device calibration, advanced diagnostics, assigning device tag etc. are performed using AMS software.

The HART analog input channel provides the following values, which can be used for display purposes or for use in a control strategy.



- Analog – raw 4 to 20 mA signal, no HART status is applied
  - Field value, in percent (FIELD\_VAL\_PCT)
- Hybrid – 4 to 20 mA signal, HART status is applied
  - Field value, in engineering units (HART\_FIELD\_VAL)
- HART Dynamic Variables – digital signal, status is applied.
  - Primary Variable, in engineering units (HART\_PV)
  - Secondary Variable, in engineering units (HART\_SV)
  - Tertiary Variable, in engineering units (HART\_TV)
  - Fourth Variable, in engineering units (HART\_FV)

The HART analog output channel provides the following values, which can be used for display purposes or for use in a control strategy.



- HART Dynamic Variables – digital signal, status is applied.
  - Primary Variable, in engineering units (HART\_PV)
  - Secondary Variable, in engineering units (HART\_SV)
  - Tertiary Variable, in engineering units (HART\_TV)
  - Fourth Variable, in engineering units (HART\_FV)
  - Slot Variable 0, in engineering units (HART\_DV\_SLOT0)
  - Slot Variable 1, in engineering units (HART\_DV\_SLOT1)
  - Slot Variable 2, in engineering units (HART\_DV\_SLOT2)
  - Slot Variable 3, in engineering units (HART\_DV\_SLOT3)

Some multi-variable devices have a predefined set of dynamic variables. In others, you can assign process values to the dynamic variables through an external device, such as a Rosemount 275, or software application, such as AMS. The slot variables are an additional set of values that may be obtained from a device by specifying which variable to retrieve, in the DV\_SLOTx\_CODE parameter. Refer to the vendor's documentation for your HART device for specific information on the dynamic variables, how to assign process values to them, and the available slot variables. Refer to the Link Initialization topic, in this whitepaper, for information on setting up the devices to communicate correctly with the DeltaV system.

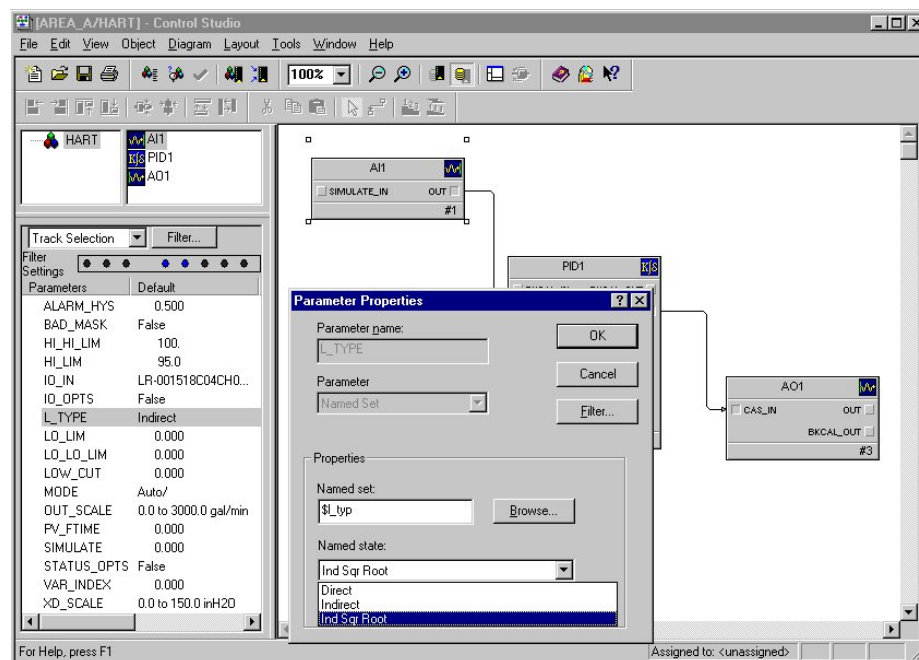
## Scaling HART Values

When the IO\_IN parameter of an Analog Input function block references the HART\_FIELD\_VAL parameter, the AI function block downloads scaling values and units to the HART transmitter to provide the correct translation between transmitter units and process units. You select the type of scaling by configuring the linearization type parameter (L\_TYPE):

**Direct signal conditioning** – The values for 0% and 100% of OUT\_SCALE are downloaded to the transmitter and the Analog Input function block OUT parameter is scaled using these values.

**Indirect signal conditioning** – The values for 0% and 100% and the units of XD\_SCALE are downloaded to the transmitter. The channel input value is scaled using a linear interpolation between the range values of XD\_SCALE and the range values of OUT\_SCALE.

**Indirect square root signal conditioning** – The values for 0% and 100% and the units of XD\_SCALE are downloaded to the transmitter. The normalized channel input value has a square root applied before it is scaled using a linear interpolation between the range values of XD\_SCALE and the range values of OUT\_SCALE.





For example, if you have a transmitter with a range of  $x^{\circ}\text{C}$  to  $y^{\circ}\text{C}$  and you wish to use the range  $100^{\circ}\text{C}$  to  $300^{\circ}\text{C}$  for control, configure `L_TYPE = Direct` and `OUT_SCALE = 100°C - 300°C`. The range  $100^{\circ}\text{C}$  to  $300^{\circ}\text{C}$  will be downloaded to the transmitter and the channel input value of  $100^{\circ}\text{C}$  to  $300^{\circ}\text{C}$  will be displayed in the `HART_FIELD_VAL` parameter.

If you have a transmitter with a range of  $x$  inches to  $y$  inches and you wish to use the range 0 inches to 150 inches for the transmitter and the range of 0 gallons to 3000 gallons per minute for control, configure `L_TYPE = Indirect square root`, `XD_SCALE = 0 - 150 in.`, and `OUT_SCALE = 0 - 3000 gallons per minute`. The range 0 to 150 inches will be downloaded to the transmitter and the channel input value of 0 to 150 inches will be displayed in the `HART_FIELD_VAL` parameter.

Because these values are downloaded to the transmitter during link initialization, make sure you configure the correct values in `XD_SCALE` and `OUT_SCALE`. Many HART devices have different rules on initialization values. Refer to the Link Initialization topic for information on setting up the devices to communicate correctly with the DeltaV system.

Here are other scenarios that affect scaling.

- You might connect a hand-held device to an instrument in the field to change its scale values. The controller detects this change in the instrument and sends Command 15 to read the new values. These new values are then updated in the AI block.
- During loop tuning, you can change the range values in an AI function block. These changes are sent to the HART instrument.
- An SFC could write new range values to the AI block in preparation for running a new product through a batch process. These changes are sent to the HART instrument.



## Error Conditions

HART field devices report internal self-test status information and indications of signal integrity. This information is sent in a status byte that is sent with each HART message. The error conditions affect the status associated with channel data, the channel integrity parameter (OINTEG), and the status text visible in the diagnostics application (STATUS).

### Effect of Error Conditions on Channel Data Status

When an Analog Input function block references a HART channel, error conditions affect the statuses of the OUT parameter in the Analog Input function block. The following table describes the effect of HART and system-derived errors on the status of the OUT parameter. (If multiple errors are present, the worst case status is reported.)

Table 1 Effect of HART Error Conditions on Parameter Status

Parameter	Effect of HART Error Conditions on Parameter Status			
	Field Device Malfunction	Analog Output Saturated	NPV Out of Limits	PV Out of Limits
HART_FIELD_VAL	Bad	Uncertain	No effect	Uncertain
FIELD_VAL_PCT	No effect	No effect	No effect	No effect
HART_PV	Bad	No effect	No effect	Uncertain
HART_SV	Bad	No effect	Uncertain	No effect
HART_TV	Bad	No effect	Uncertain	No effect
HART_FV	Bad	No effect	Uncertain	No effect
DEV_MALFUNC	True (1)			
NO_COMM				
NPV_PAST_LIM			True (1)	
OINTEG	True (1)	True (1)	True (1)	True (1)
PV_FIXED				
PV_PAST_LIM				True (1)
PV_SAT		True (1)		



Table 2 Effect of Derived Status Error Conditions on Parameter Status

Parameter	Effect of Derived Status Error Conditions on Parameter Status	
	Loss of Digital Comms	5% Comm Error Rate
HART_FIELD_VAL	Uncertain	No effect
FIELD_VAL_PCT	No effect	No effect
HART_PV	Bad	Uncertain
HART_SV	Bad	Uncertain
HART_TV	Bad	Uncertain
HART_FV	Bad	Uncertain
DEV_MALFUNC		
NO_COMM	True (1)	
NPV_PAST_LIM		
OINTEG	True (1)	
PV_FIXED		
PV_PAST_LIM		
PV_SAT		

### Effect of Error Conditions on Diagnostics Status Text

Error conditions trigger text information in DeltaV Diagnostics to help you troubleshoot problems. The following status text strings might appear:

**Good** – No problems detected, data is valid.

**Not Enabled** – The HART channel is currently disabled.

**A/D Converter Error** – The HART channel detected an error in its A/D converter.

**Sensor Bad** – The HART channel detected an open or short or a NAMUR high or low limit alarm.

**5% Comm Error Rate with Card** – The controller detected communication errors with at least 5% of the transmissions from the AI-HART card.

**Stale Data** - The controller detected that the AI-HART card is not updating data.

**5% Comm Error Rate with Device** – The HART channel is detecting errors with at least 5% of the digital communications from the attached HART instrument.

**Not Communicating with Device** – The HART channel is unable to digitally communicate with the attached HART instrument.

**Device is in Burst Mode** – The DeltaV system does not support burst mode. If the attached HART instrument is configured for burst mode, digital communications are slowed. Analog information is unaffected.



**Device Malfunction** – The HART instrument detected a problem with itself or with one of its associated sensors.

**Analog Output Current Fixed** – The HART instrument is reporting that its analog output value is configured to a fixed value.

**Primary Variable Out of Limits** – The HART instrument is reporting that the primary measurement is outside the sensor limits.

**Analog Output is Saturated** - The HART instrument is reporting that the analog output value is saturated.

**Non-primary Variable Out of Limits** – The HART instrument is reporting that one of the non-primary measurements is outside the associated sensor limits.

**Device is Write Protected** – The HART channel attempted to configure the analog output scale information of the attached HART instrument and the instrument reported that it is in write-protect mode.

**Device Configuration Access is Restricted** – The HART channel attempted to configure the analog output scale information of the attached HART instrument and the instrument reported that it has restricted access to the configuration changes.

**Device Configuration Units Invalid** – The HART channel attempted to configure the analog output scale information of the attached HART instrument and the instrument reported that the units specified are not valid for this instrument.

**Device Configuration Both Ranges Out of Limits** – The HART channel attempted to configure the analog output scale information of the attached HART instrument and the instrument reported that both the upper and lower range values were outside valid limits.

**Device Configuration Upper Range Too High** – The HART channel attempted to configure the analog output scale information of the attached HART instrument and the instrument reported that upper range value was too high.

**Device Configuration Upper Range Too Low** – The HART channel attempted to configure the analog output scale information of the attached HART instrument and the instrument reported that the upper range value was too low.

**Device Configuration Lower Range Too High** – The HART channel attempted to configure the analog output scale information of the attached HART instrument and the instrument reported that the lower range value was too high.

**Device Configuration Lower Range Too Low** – The HART channel attempted to configure the analog output scale information of the attached HART instrument and the instrument reported that the lower range value was too low.

**Device Configuration Range Span Too Small** – The HART channel attempted to configure the analog output scale information of the attached HART instrument and the instrument reported that the difference between the high and low range values was too small.

**Device Configuration Range Invalid** – The HART channel attempted to configure the analog output scale information of the attached HART instrument and the instrument reported that one or both range values are invalid.

**Device Configuration Error** – The HART channel attempted to configure the analog output scale information of the attached HART instrument and a configuration error was detected.



## Using Error Conditions for Control Strategy

In addition to the status associated with the Analog Input function block OUT parameter, you can reference the possible error conditions directly in a control module by linking an Internal Read Parameter via an External Reference to one of the HART channel Boolean parameters. The following are the HART channel Boolean parameters:

**Field Device Malfunction (DEV\_MALFUNC)** – True when the HART instrument detects a problem with itself or associated sensors.

**PV Fixed (PV\_FIXED)** – True when the HART instrument has been in test loop mode or is in multi-drop mode. In test loop mode, the HART instrument's analog output value is held at the configured value and does not reflect the process.

**PV Saturated (PV\_SAT)** – True when the analog output of the HART instrument is saturated.

**PV Past Limits (PV\_PAST\_LIM)** – True when the primary measurement is outside the sensor operating limits. In this case, the analog parameters (FIELD\_VAL\_PCT and HART\_FIELD\_VAL) and the digital parameter (HART\_PV) are not reliable; this is reflected in their associated status values.

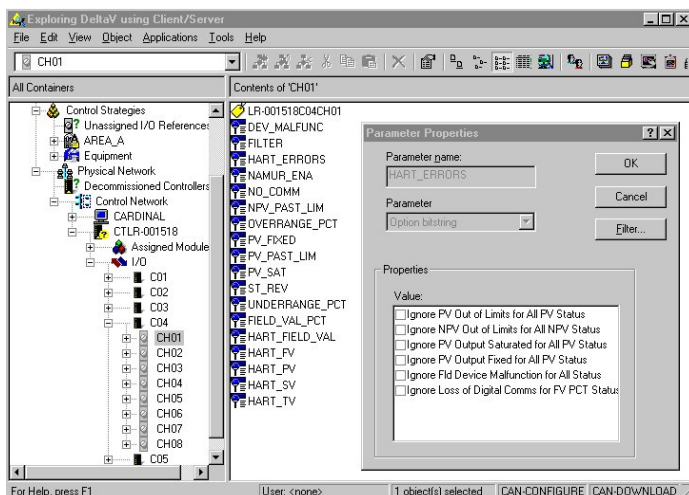
**NPV Past Limits (NPV\_PAST\_LIM)** – True when one of the non-primary measurements is outside the sensor operating limits. There is no indication of which non-primary measurement is bad.

**No Communications (NO\_COMM)** – True when the HART channel cannot communicate digitally with the attached HART instrument.

**Output Integrity (OINTEG)** – True when one or more of the following conditions are True:

- AI-HART card detects a problem with itself
- An open or short is detected on a HART channel input
- An analog NAMUR high or low level is detected
- DEV\_MALFUNC is True
- PV\_FIXED is True
- There has been a problem configuring the HART instrument during initialization.

## Customizing Control on Error Conditions



In some cases, you may want to use HART data even though the instrument is reporting certain error conditions. The HART\_ERRORS parameter allows you to select which HART status error values are ignored in your control strategy.

The HART\_ERRORS parameter masks HART error conditions that you determine are not required for your application. For example, you may have a measured variable that is outside limits occasionally but is not a problem for the process. You can select the Ignore PV Out of Limits for All PV Status option in the HART\_ERRORS parameter to disregard this error condition.



You modify the HART\_ERRORS parameter by selecting the channel properties and checking one or more of the following actions:

**Ignore PV Out of Limits for All PV Status** – Primary variable (PV) values that are higher or lower than the configured limits are ignored when determining PV statuses.

**Ignore NPV Out of Limits for All NPV Status** – Non-primary variable (NPV) values that are higher or lower than the configured limits are ignored when determining NPV statuses.

**Ignore PV Output Saturated for All PV Status** – PV values that are output saturated are ignored when determining PV statuses.

**Ignore PV Output Fixed for All PV Status** – PV values that have a fixed output are ignored when determining PV statuses.

**Ignore FLD Device Malfunction for All Status** – Values determined during a field device malfunction are ignored when determining statuses.

**Ignore Loss of Digital Comms for FV\_PCT Status** – Values determined during the loss of digital communications are ignored when determining the field value in percent (HART\_FIELD\_VAL) status.

Note: The default value for these actions is disabled (False). That is, these status conditions are not ignored. When you enable these actions, the block ignores the specified statuses.



## Link Initialization

In order for the HART field device to be compatible with the DeltaV system, it must be able to communicate using the HART commands listed in this section.

In the DeltaV system, HART link initialization is performed by the DeltaV AI-HART card and the controller function block.

## I/O Card Initialization

When an AI-HART card is plugged in, it assumes that all channels are only analog. When you configure the card, you can set the channel to HART\_ANALOG\_INPUT, or HART\_ANALOG\_OUTPUT.

The card then tests for an open circuit. If no open circuit is detected, the card sends out HART Command 0 (Read Manufacturer and Device Type) followed by Command 59 (Write Number of Response Preambles).

## Controller Function Block Channel Initialization

The DeltaV controller also performs HART channel initialization. As soon as the controller is notified that an AI-HART card configuration is complete, it sends Command 0 to each HART channel.

If an AI function block is linked to the HART\_FIELD\_VAL parameter of the HART channel, the first time the function block executes, it sends scaling information (high and low range and units) to the HART instrument for its analog output signal. The high and low range information are sent via HART Command 35 (Write Primary Variable Range Values). The units code is sent via HART Command 44 (Write Primary Variable Units). At this time, the HART instrument sets a bit saying that it has changed its configuration to the new values. The controller sends HART Command 15 (Read Primary Variable Output Information) to read the range and units information. This is followed by Command 38 (Reset Configuration Change Flag) to clear the change flag in the instrument.

Here are other scenarios that affect link initialization.

- You might connect a hand-held device to an instrument in the field to change its scale values. The controller detects this change in the instrument and sends Command 15 to read the new values.
- During loop tuning, you can change the range values in an AI function block. These changes are sent to the HART instrument.
- A SFC could write new range values to the AI block in preparation for running a new product through a batch process. These changes are sent to the HART instrument.
- You might specify range values to a high level of precision and some HART instruments may not be able to support that precision. The controller sends Command 15 to detect the actual range precision the instrument is using in the process.

If a HART instrument does not support the HART Commands 44 and 35 (used to set the scale values), the values read by HART Command 15 are compared to those specified by the AI function block. If the values are the same, they are accepted and the channel operates normally. If the values are not the same (or if the HART instrument is write-protected or blocking access to that configuration information) Command 15 is sent again and the initialization repeats. If the values still are not the same, the channel is marked Bad.



## HART Units Handling

The HART protocol allows units which may be unique to a particular HART instrument and unknown to the DeltaV system. To deal with this for a specific function block, select one of the following values for the Engineering unit descriptor: hyphen (-), blank space ( ), or no units. The DeltaV system then uses the units that are currently configured in the HART instrument. If the type of units are known to the DeltaV system, the units are displayed in the XD\_SCALE parameter of the AI function block. However if they are unknown to the DeltaV system, the units field in XD\_SCALE is blank.

## HART Value Update Rate

After this initialization phase, the card sends out Command 3 (Read Dynamic Variables and Primary Variable) repeatedly to each HART channel. Each channel configured for HART analog input is scanned in turn. If all channels are set to HART\_ANALOG\_INPUT, Command 3 will be sent to each channel approximately every six seconds. The analog values for each channel are scanned in much faster: at the same rate as an analog input channel. If the output is configured to use the slot variables then Command 33 is issued every alternate scan.

## HART devices for use with the DeltaV system

The DeltaV system provides support for many HART devices out of the box with the standard DeltaV software installation. However, over time, it may be necessary to add support for HART devices not included with a particular DeltaV release. When new devices are released, the device description files for these new HART devices can be downloaded from <http://www.emersonprocess.com/ams/prodevdown.htm>. Once downloaded, the device description files can be added to the DeltaV system from the DeltaV ProPLUS station (or AMS Device Manager Server Plus station if installed) to provide full device support within the system.