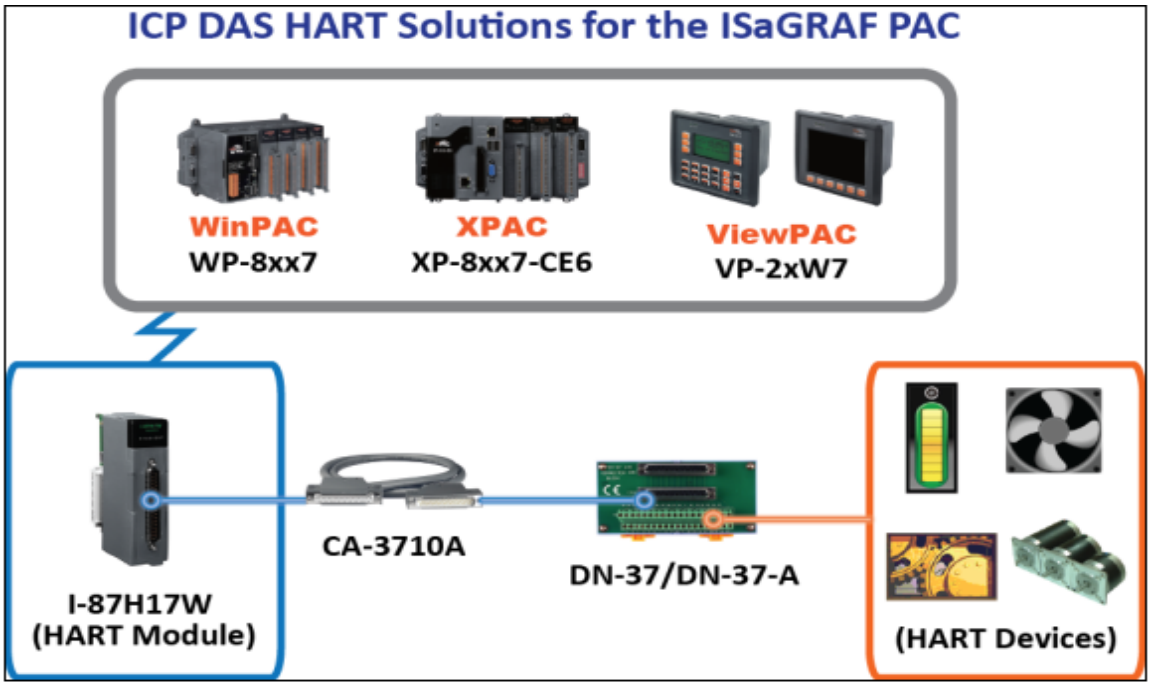
HART Solution : ISaGRAF PAC plus I-87H17W

The ICP DAS XP-8347-CE6 / XP-8747-CE6, WP-8447 / WP-8847 / WP-8437 / WP-8837 and VP-25W7 / VP-23W7 ISaGRAF PAC support the I-87H17W HART Master module since the below driver version.

XP-8xx7-CE6 : driver Ver.1.15 , WP-8xx7 : driver Ver.1.35 , VP-2xW7 : driver Ver.1.27



If the ISaGRAF driver of User's ISaGRAF PAC is older than the above listed version, please visit the following web site to download it and update it to user's PAC.

ISaGRAF driver :
http://www.icpdas.com/en/download/show.php?num=368&nation=US&kind1=&model=&kw=isagraf
ISaGRAF PAC http://www.icpdas.com/en/product/guide+Software+Development__Tools+ISaGRAF#443
Data Sheet :
http://www.icpdas.com/en/download/index.php?nation=US&kind1=6&kind2=15&model=&kw=isagraf
I-87H17W : http://www.icpdas.com/en/product/I-87H17W-G

This paper is the ISaGRAF FAQ-136. User can visit the following web site to download it and demo programs. https://www.icpdas.com/en/faq/index.php?kind=280#751 > 136 .

The XP-8xx7-CE6 PAC supports I-87H17W in its slot No. 1 to 7(Its leftmost slot No. is 1).
The WP-8xx7 PAC supports I-87H17W in its slot No. 0 to 7 (Its leftmost slot No. is 0).
The VP-2xW7 supports I-87H17W in its slot No. 0 to 2 (Its leftmost slot No. is 0).
ICP DAS ISaGRAF PAC don't support the I-87H17W which is plugged in the RS-485 remote expansion base (like the I-87K8, RU-87P8).

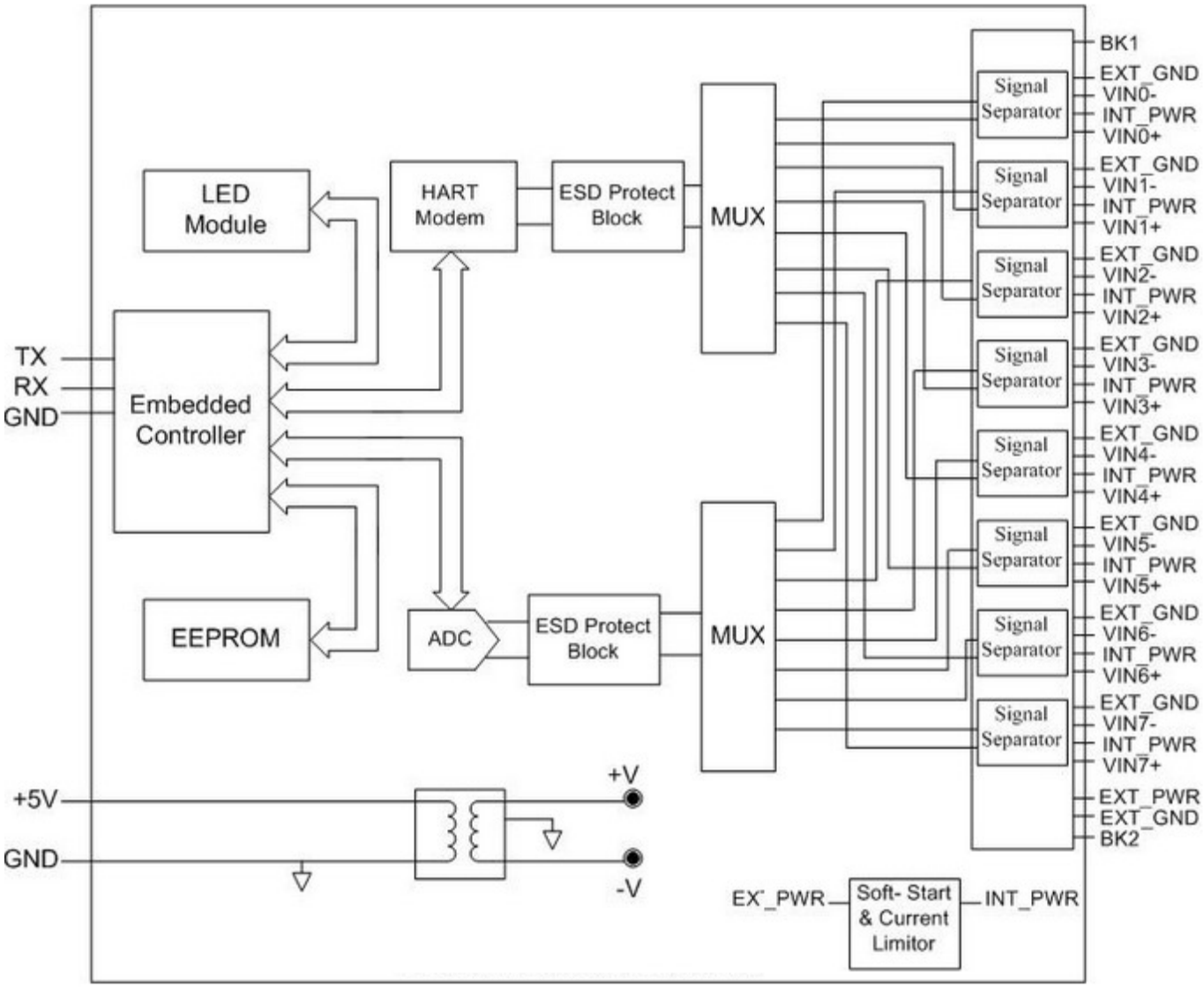
The I-87H17W has 8 Analog input channels. They can measure current inputs (4 to 20 mA) and also they can be used as HART communication channels. Recommend to link only one HART device in each channel.

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1.1 : I-87H17W hardware

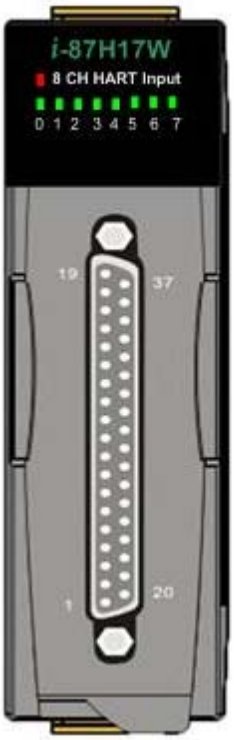
Please visit http://www.icpdas.com/en/product/I-87H17W-G for more information about the I-87H17W hardware. This section lists only “Internal I/O structure” and “Pin assignments” and “Wire connection”.

Internal I/O structure of the I-87H17W :



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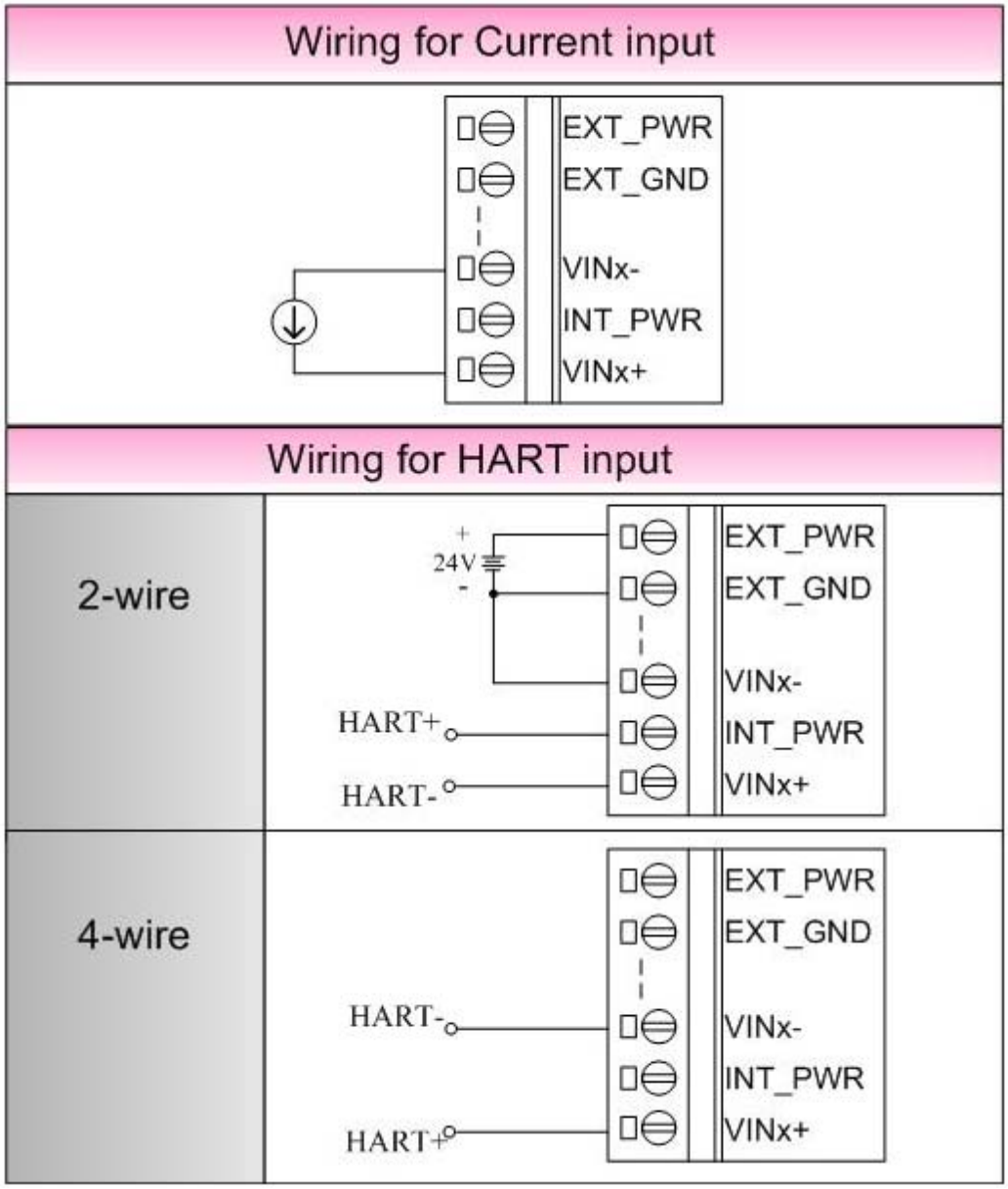
Pin assignments of the I-87H17W :



Pin Assignment Name	Terminal No.		Pin Assignment Name
X	19	37	BK2
EXT_PWR	18	36	EXT_GND
VIN7-	17	35	INT_PWR7
VIN7+	16	34	EXT_GND
VIN6-	15	33	INT_PWR6
VIN6+	14	32	EXT_GND
VIN5-	13	31	INT_PWR5
VIN5+	12	30	EXT_GND
VIN4-	11	29	INT_PWR4
VIN4+	10	28	EXT_GND
VIN3-	09	27	INT_PWR3
VIN3+	08	26	EXT_GND
VIN2-	07	25	INT_PWR2
VIN2+	06	24	EXT_GND
VIN1-	05	23	INT_PWR1
VIN1+	04	22	EXT_GND
VIN0-	03	21	INT_PWR0
VIN0+	02	20	EXT_GND
BK1	01		

37-pin male D-Sub Connector

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Wire connection of the I-87H17W :

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1.2 : Restore the I/O library and ISaGRAF example programs

User may visit https://www.icpdas.com/en/faq/index.php?kind=280#751 > 136 to download the "faq_136.zip" which includes the PDF paper and example projects("faq136_1.pia" to "faq136_4.pia"). Please restore them to your PC / ISaGRAF.

faq136_1	Send HART frame manually from Ch.1 of Slot 2, and then receive the ans frame.
faq136_2	Similar as "faq136_1" but convert the received answer frame to 4 REAL value.
faq136_3	Send HART frame and then receive answer frame automatically from Ch.1 of Slot 2 first. Then switch to handle Ch.2 of Slot 2. And then switch to handle Ch.3 of Slot 2. Then after switch back to hanlde the Ch.1 of Slot 2, ...
faq136_4	Similar as "faq136_3" but using three I-87H17W cards which are plugged in Slot No. 1 , 2 and 3 respectively. Each I-87H17W can process only one channel to communicate with HART device at a time. It must process channels one by one in turn. That is because all the 8 channels in one I-87H17W are sharing the same HART chip . However more than one I-87H17W in different slot No. can process one of their own channels at the same time.

To program the ISaGRAF PAC plus I-87H17W cards, first enable the function of "Variable Array" of your PC / ISaGRAF. Refer to the https://www.icpdas.com/en/faq/index.php?kind=280#751 > 039 to setup it.

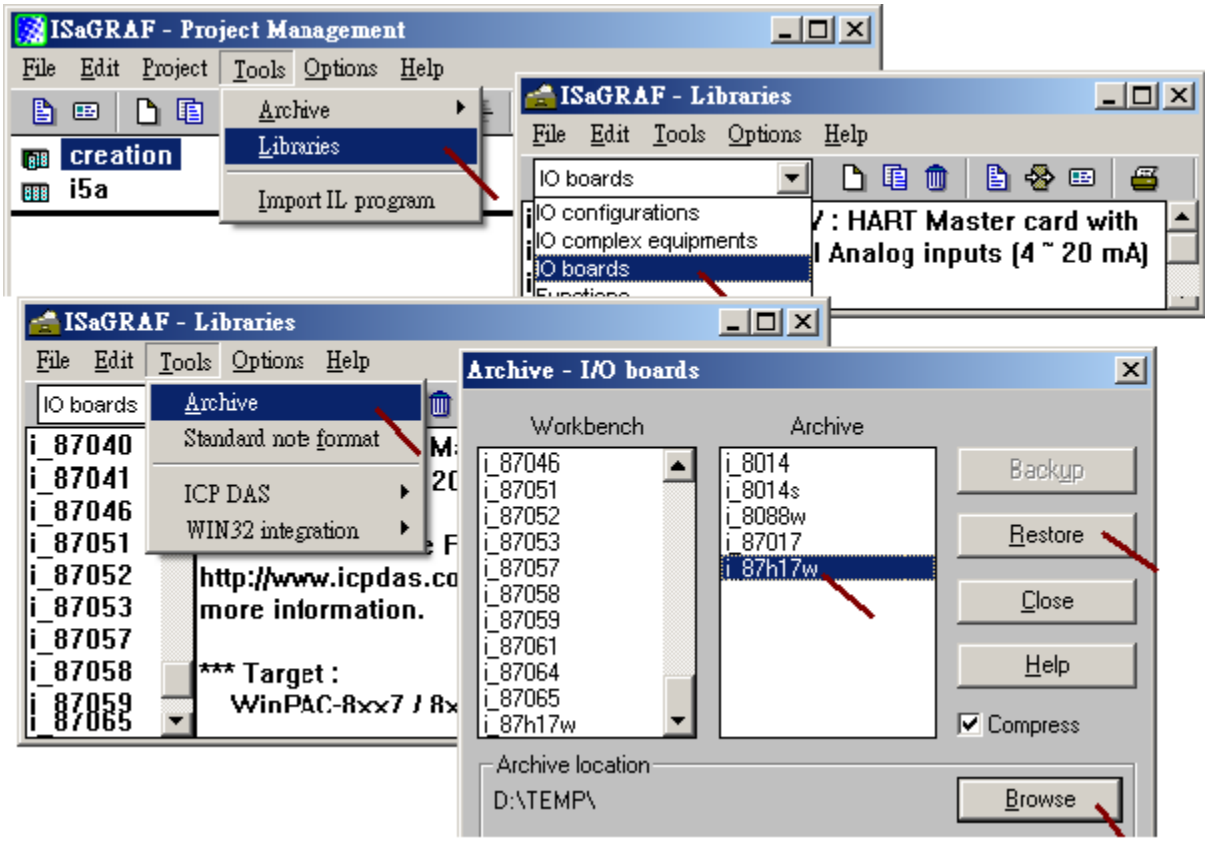
The mothod is to add two rows on the top position of the file "ISA.ini" in the "C:\ISAWIN\EXE\" path where your ISaGRAF software installed. After inserting these two rows, save the "ISA.ini" and then run the PC / ISaGRAF software again.

[DEBUG]
arrays=1

User may refer to the section 1.1 and 1.2 and chapter 2 of the "ISaGRAF User's manual" if he is not familiar with the ISaGRAF programming.

http://www.icpdas.com/en/download/show.php?num=333&nation=US&kind1=&model=&kw=isagraf

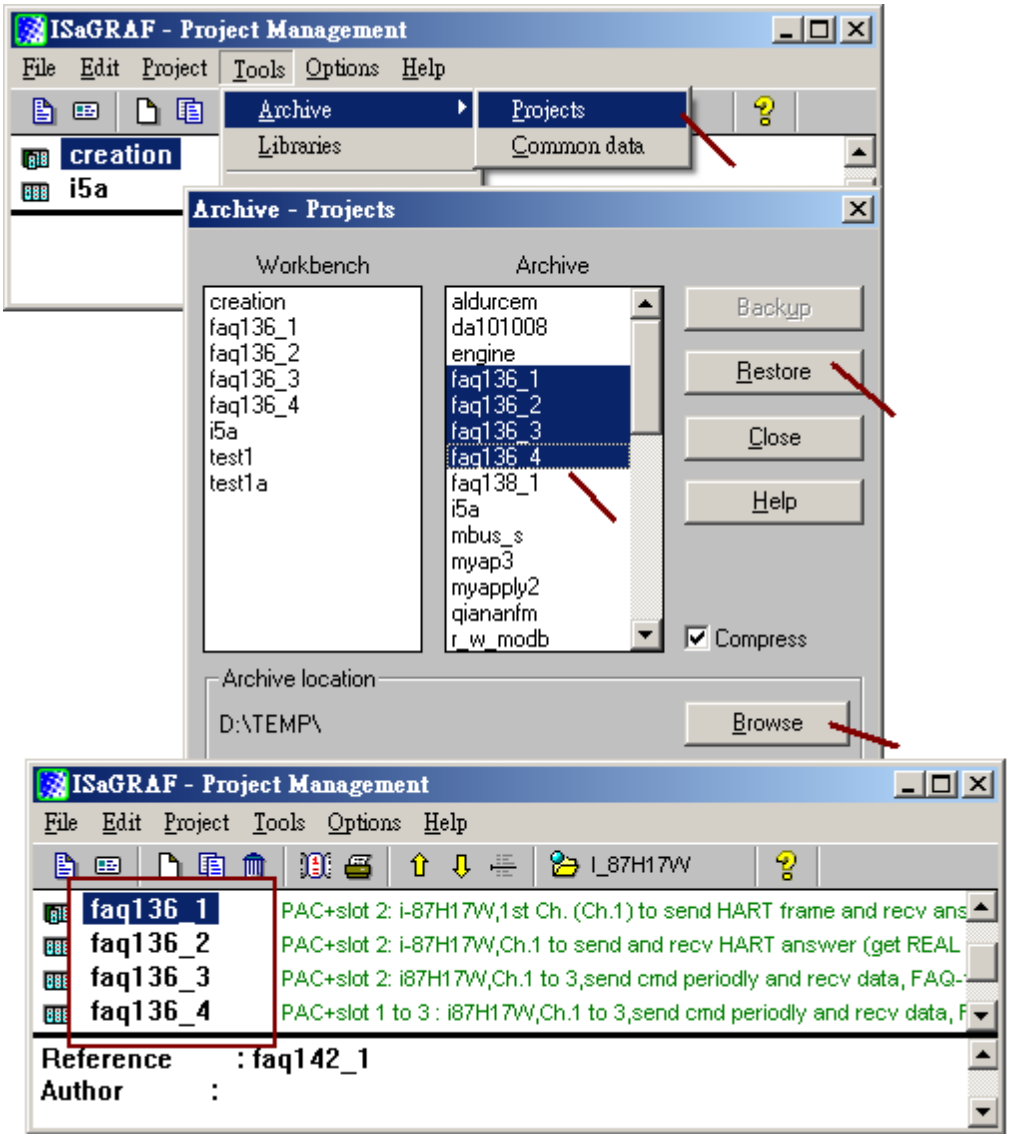
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Restore the “i_87h17w” :

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Restore the ISaGRAF projects - faq136_1.pia, faq136_2.pia, faq136_3.pia and faq136_4.pia :



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1.3 : Format of the HART protocol

Note:

A. This section only introduce the basic format of the HART protocol. It may not fit all the HART devices in the current market all over the world. Please must refer to the document of the respective HART devices and follow their format to work the ISaGRAF PAC with them.

B. DO NOT use the below “Check-byte” in the ISaGRAF program. The I-87H17W card will automatically calculate the “Check-byte” and add it into the HART frame to be sent. When receive a correct HART answer frame from a device, the I-87H17W will remove the “Check-byte” automatically and then pass the answer frame without “Check-byte” to the ISaGRAF program.
C. HART physical layer is using 1200 bps, 1 start-bit, Odd parity, 8 character-size, 1 stop-bit .

I-87H17W send :

Byte-count is the byte amount of the “Data” . Its value is 0 to 255.

Preamble	Delimiter	Address	Command	Byte Count	Data	Check byte
5 ~ 20 byte	1 byte	1 byte (short) 5 byte (long)	1 byte	1 byte	0 ~ 255 byte	1 byte

HART device answer :

Byte-count is the byte amount of the “Data” plus “Response code” . Its value is 0 to 255.

Preamble	Delimiter	Address	Command	Byte Count	Response code	Data	Check byte
5 ~ 20 byte	1 byte	1 byte (short) 5 byte (long)	1 byte	1 byte	2 byte	0 ~ 253 byte	1 byte

Preamble : 5 ~ 20 byte
value of each byte is 255 (16#FF, Hex)

Delimter : 1 byte

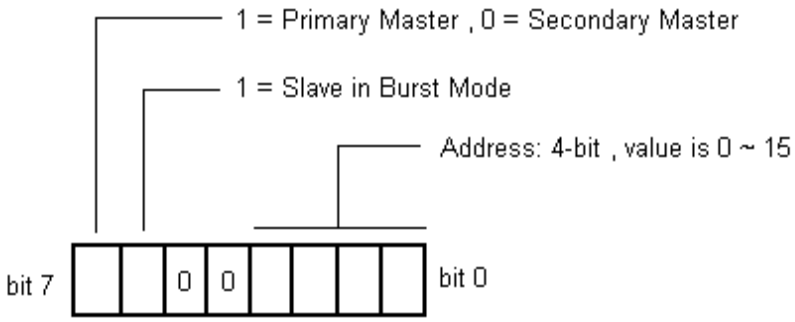
01 :		Short frame, Burst Frame
02 :		Short frame, Master to Slave
06 :		Short frame, Slave to Master
129	(16#81) :	Long frame, Burst Frame
130	(16#82) :	Long frame, Master to Slave
134	(16#86) :	Long frame, Slave to Master

(More in the next page)

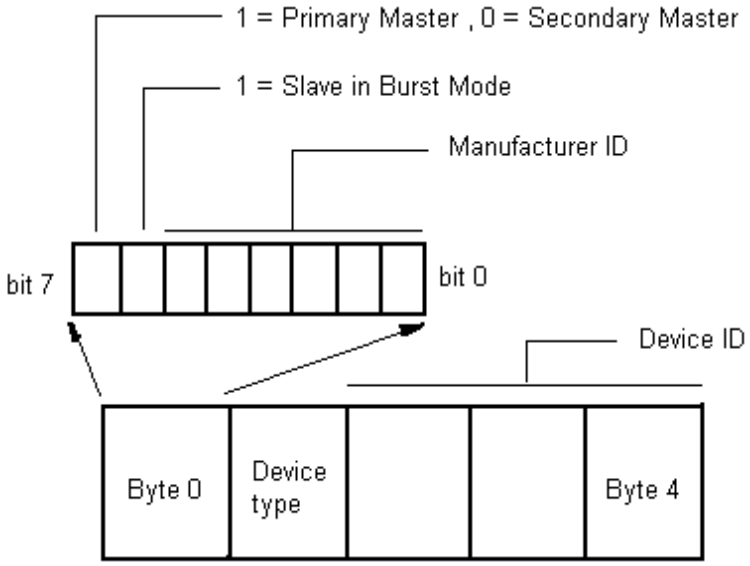
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Address : 1 byte (Short frame) or 5 bytes (Long frame)

Short frame (1 byte) :



Long frame (5 bytes) :



Command : 1 byte , refer to the manual of the HART device for its definition.

Byte-count : 1 byte

I-87H17W send: Byte-count is the byte amount of the “Data” . value is 0 to 255.
Device answer: Byte-count is the byte amount of “Data” + “Response code”. value is 0 to 255.
Response code : 2 byte , refer to the manual of the HART device for its definition.
Data : refer to the manual of the HART device for its definition.

Check-byte : 1 byte

DO NOT use the “Check-byte” in the ISaGRAF program. The I-87H17W card will automatically calculate the “Check-byte” and add it into the HART frame to be sent. When receive a correct HART answer frame from a device, the I-87H17W will remove the “Check-byte” automatically and then pass the answer frame without “Check-byte” to the ISaGRAF program.

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1.4 : Basic concept of the program of the ISaGRAF PAC plus the I-87H17W

For detail ISaGRAF program, please refer to the example project - “faq136_1” to “faq136_4”.
User may also refer to section 1.5 of this paper to test the example projects.

faq136_1	Send HART frame manually from Ch.1 of Slot 2, and then receive the ans frame.
faq136_2	Similar as “faq136_1” but convert the received answer frame to 4 REAL value.
faq136_3	Send HART frame and then receive answer frame automatically from Ch.1 of Slot 2 first. Then switch to handle Ch.2 of Slot 2. And then switch to handle Ch.3 of Slot 2. Then after switch back to hanlde the Ch.1 of Slot 2, ...
faq136_4	Similar as “faq136_3” but using three I-87H17W cards which are plugged in Slot No. 1 , 2 and 3 respectively. Each I-87H17W can process only one channel to communicate with HART device at a time. It must process channels one by one in turn. That is because all the 8 channels in one I-87H17W are sharing the same HART chip . However more than one I-87H17W in different slot No. can process one of their own channels at the same time.

Please make sure your ISaGRAF driver of the XP-8347-CE6 / XP-8747-CE6, WP-8447 / WP-8847 / WP-8437 / WP-8837 and VP-25W7 / VP-23W7 PAC does fit the version requirement listed in the page one of this paper.

To program the ISaGRAF PAC plus I-87H17W cards, first enable the function of “Variable Array” of your PC / ISaGRAF. Refer to the https://www.icpdas.com/en/faq/index.php?kind=280#751 > 039 to setup it.

The mothod is to add two rows on the top position of the file “ISA.ini” in the “C:\ISAWIN\EXE\” path where your ISaGRAF software installed. After inserting these two rows, save the “ISA.ini” and then run the PC / ISaGRAF software again.

[DEBUG]
arrays=1

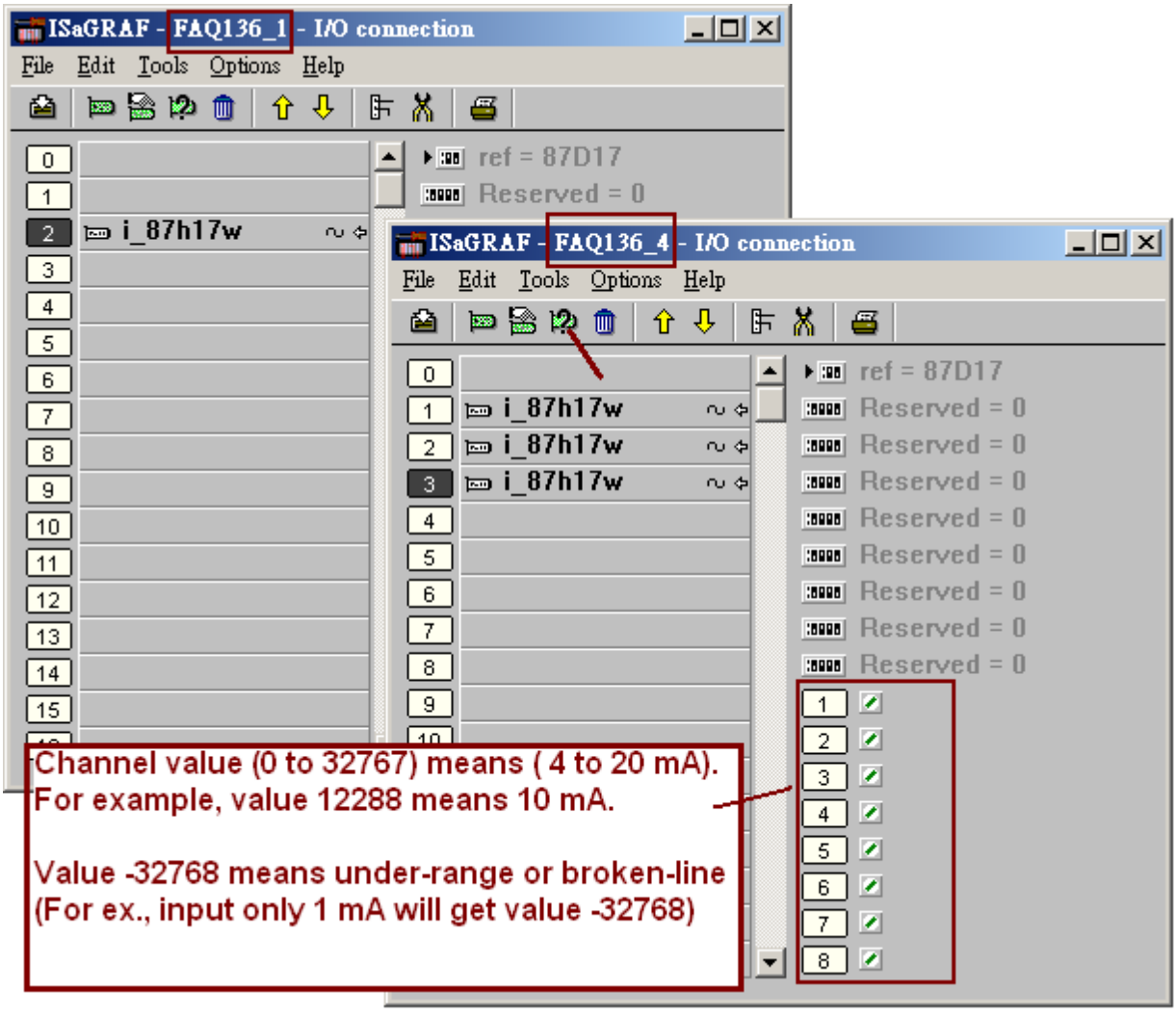
User may refer to the section 1.1 and 1.2 and chapter 2 of the “ISaGRAF User's manual” if he is not familiar with the ISaGRAF programming.

http://www.icpdas.com/en/download/show.php?num=333&nation=US&kind1=&model=&kw=isagraf

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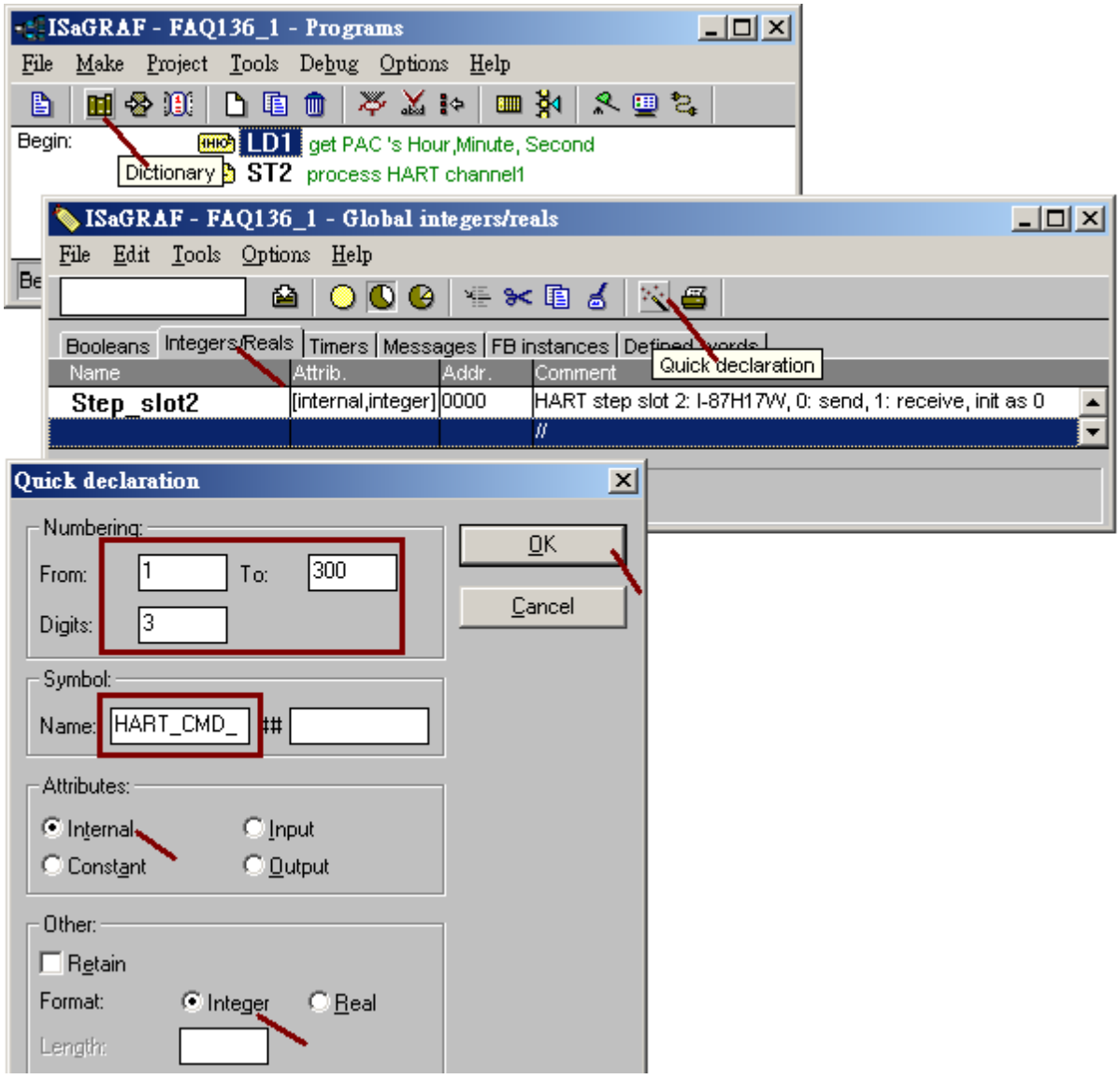
To enable the I-87H17W in the ISaGRAF PAC, connect the “i_87h17w” in the ISaGRAF I/O connection window. The below figure shows the example project - “faq136_1” has enabled one I-87H17W in the slot No. 2, while the “faq136_4” has enabled three I-87H17W in slot No.1 to 3.

Note:
A. The leftmost I/O slot No. of the XP-8xx7-CE6 is 1 .
B. The leftmost I/O slot No. of the WP-8xx7 and VP-2xW7 is 0 .
C. The channel value of the I-87H17W is a value ranging from 0 to 32767 to represent current input of 4 to 20 mA. For example,if value is 12288, it means the current input is 10 mA.If the value is a negative value “-32768” , it means “sensor broken-line” or “current input less than 4 mA” .



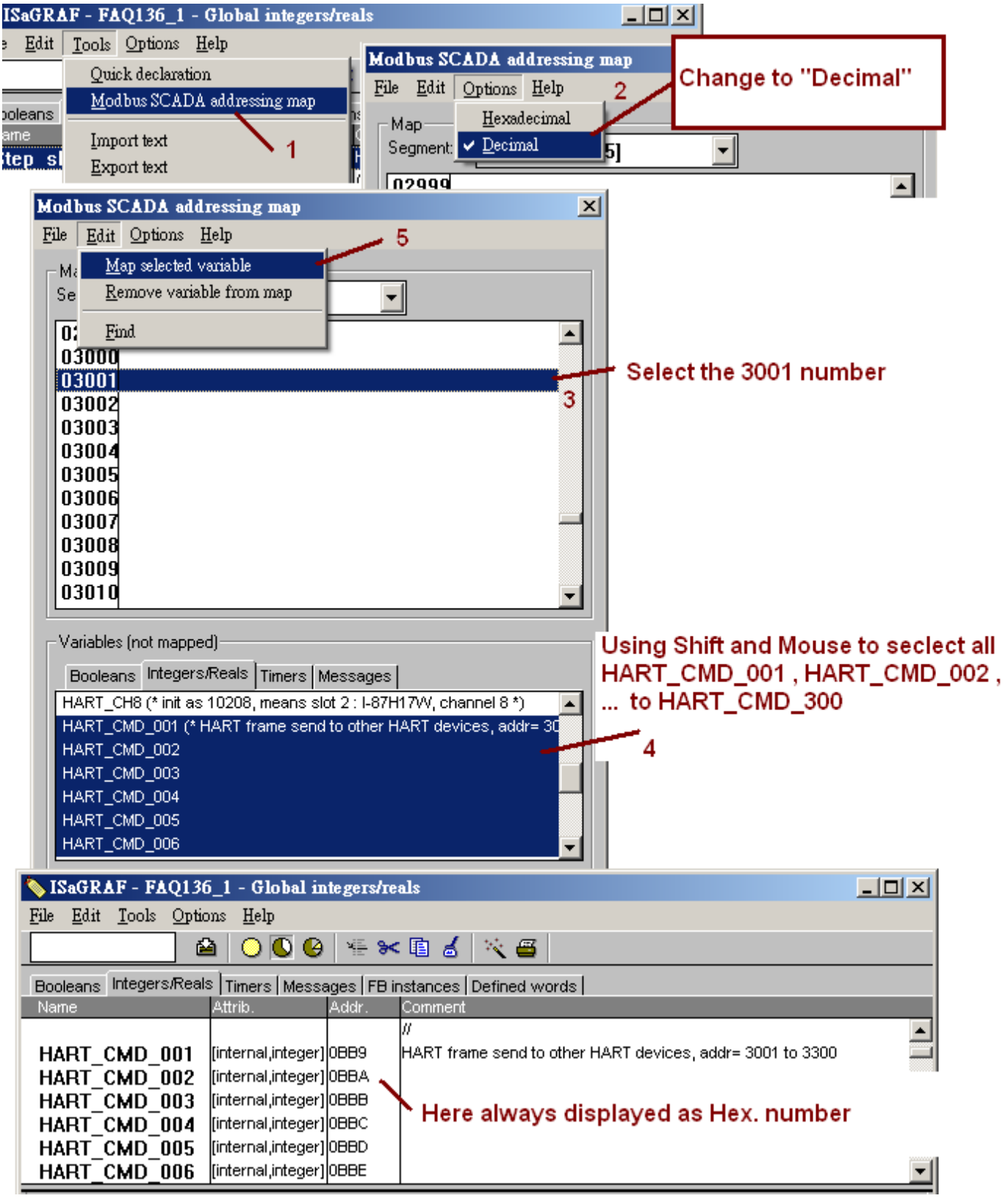
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Please declare 300 integer variables named “HART_CMD_001” to “HART_CMD_300” to store the HART frame to be sent to the HART device. And must assign 300 continuous network-addresss number (3001 to 3300) to them. (More in the next page)



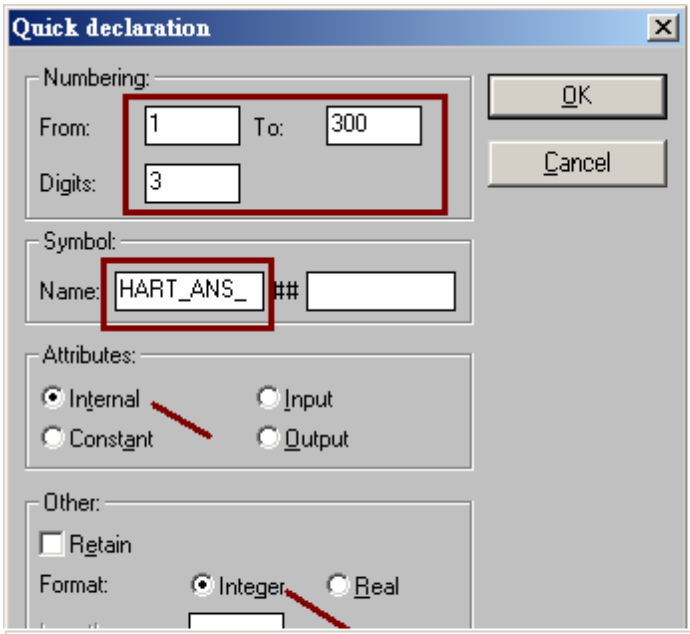
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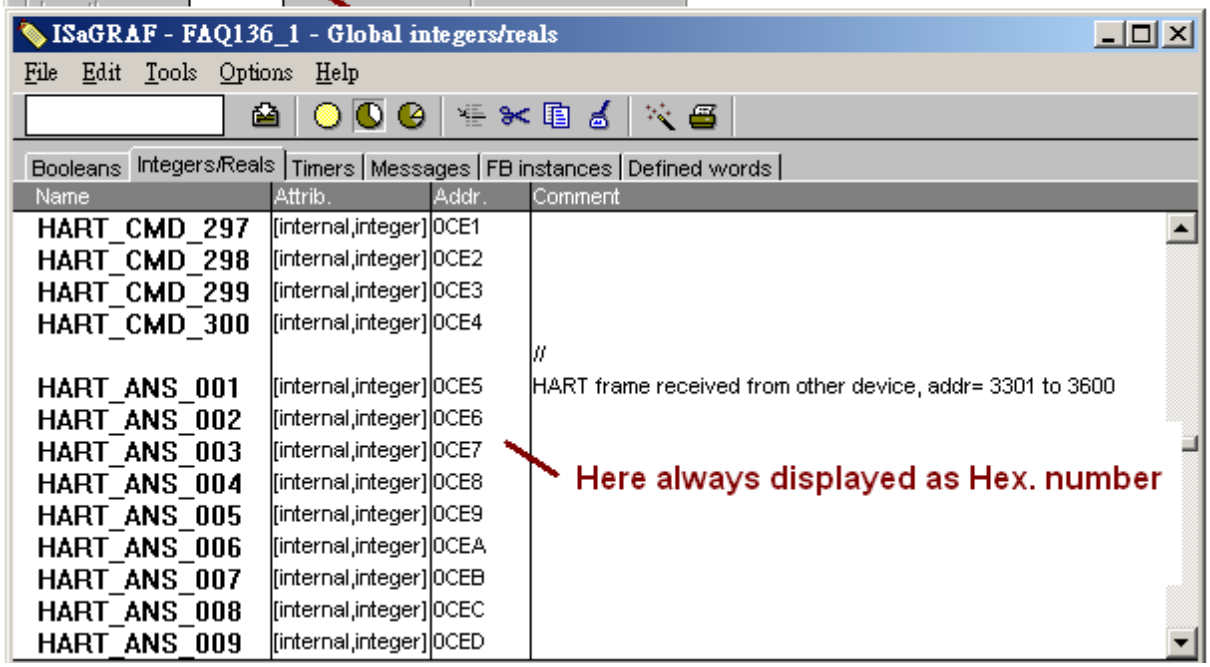
Assign continuous “Network address” as 3001 to 3300 (more in the next page):



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Follow the similar steps to declare 300 integer variables named “HART_ANS_001” to “HART_ANS_300” to store the HART answer frame received from the HART device. And must assign 300 continuous network-addresss number (3301 to 3600) to them.





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The I-87H17W is a 8-channel HART master module. All the 8 channels in the same I-87H17W are sharing the same HART chip. The ISaGRAF program must handle the HART communication one channel by one channel. DO NOT send frame or receive frame for two or more channels in the same I-87H017W at the same time . First handle the sending and receiving of channel 1. When the answer frame is received or the result is established (for example, timeout or error), then switch to handle channel 2, ...

Before sending a HART frame, first use the “COMReady( )” function to check if the I-87H17W is ready for sending frame. If it returns “True”, then use the “COMARY_W( )” function to send a HART frame. Then after, the program should use the “COMReady( )” to check if the answer frame is well received. If it returns “True”, use the “COMARY_R( )” to receive the answer frame.

COMReady

Usage : TMP_Boo := COMReady(Channel_ID) ;

Parameters :

Channel_ID : integer,10S0C , “S” is slot No. of the I-87H17W (0 ~ 7), “C” is channel No (1 ~ 8).
for example, 10203 means Slot 2, Channel 3.

Returns : boolean
True : The I-87H17W is ready for sending HART frame, or
the HART answer frame is well received or the result is established (timeout, error, ..)
False : The I-87H17W is busy or invalid parameters.

COMARY_W

Usage : TMP_Boo := COMARY_W(Channel_ID , Network_addr , Count) ;

Parameters :

Channel_ID : integer,10S0C , “S” is slot No. of the I-87H17W (0 ~ 7), “C” is channel No (1 ~ 8).
for example, 10203 means Slot 2, Channel 3.

Network_addr : integer, 1 ~ 7801 , the network address of the first integer variable which restoring the HART frame to be sent to the HART device.

Count : integer, the byte amount of the HART frame to be sent.
DO NOT include the “Check-byte” (refer to section 1.3).

Returns : boolean
True : calling COMARY_W( ) ok.
False : calling COMARY_W( ) fail. May be invalid parameters, or the I-87H17W is busy, or the network address of integer variables which restoring the HART sending frame are not declared as integer or not assigned with continuous network addr. (refer 1.4).

(More in the next page)

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COMARY_R

Usage : TMP_Int := COMARY_R(Channel_ID , Network_addr) ;

Parameters :

Channel_ID : integer,10S0C , “S” is slot No. of the I-87H17W (0 ~ 7), “C” is channel No (1 ~ 8).
for example, 10203 means Slot 2, Channel 3.

Network_addr : integer, 1 ~ 7801 , the network address of the first integer variable which is used for storing the received HART frame which is coming from HART device.

Note : the “Check_byte” is removed by the I-87H17W after the answer frame is well received. (Please refer to the section 1.3)

Returns : integer

0 : invalid parameter, or network address error, or variables are not declared well (refer 1.4), or the I-87H17W is busy.

> 0 : receive answer frame well. The value is the byte amount (no including the “check-byte”) (please refer to section 1.3)

< 0 : The result is establised but error happens (listed as the following).

-1 : Timeout
-2 : Read_data_too_short error
-3 : Delimiter error
-4 : addr_master error
-5 : addr_burst error
-6 : recv_command error
-7 : checksum error
-8 : response error
-98 : para_mismatch error
-99 : impossible error
-102 : I-87H17W timeout
-104 : invalid frame to send
-105 : invalid frame to send
-117 : can not communicate with the I-87H17W card
-118 : the "i_87h17w" is not connectted in the ISaGRAF IO connection window
-198 : answer frame size larger than 283 bytes
-199 : HART_ANS_xxx are not internal integers or not assigned with correct network address

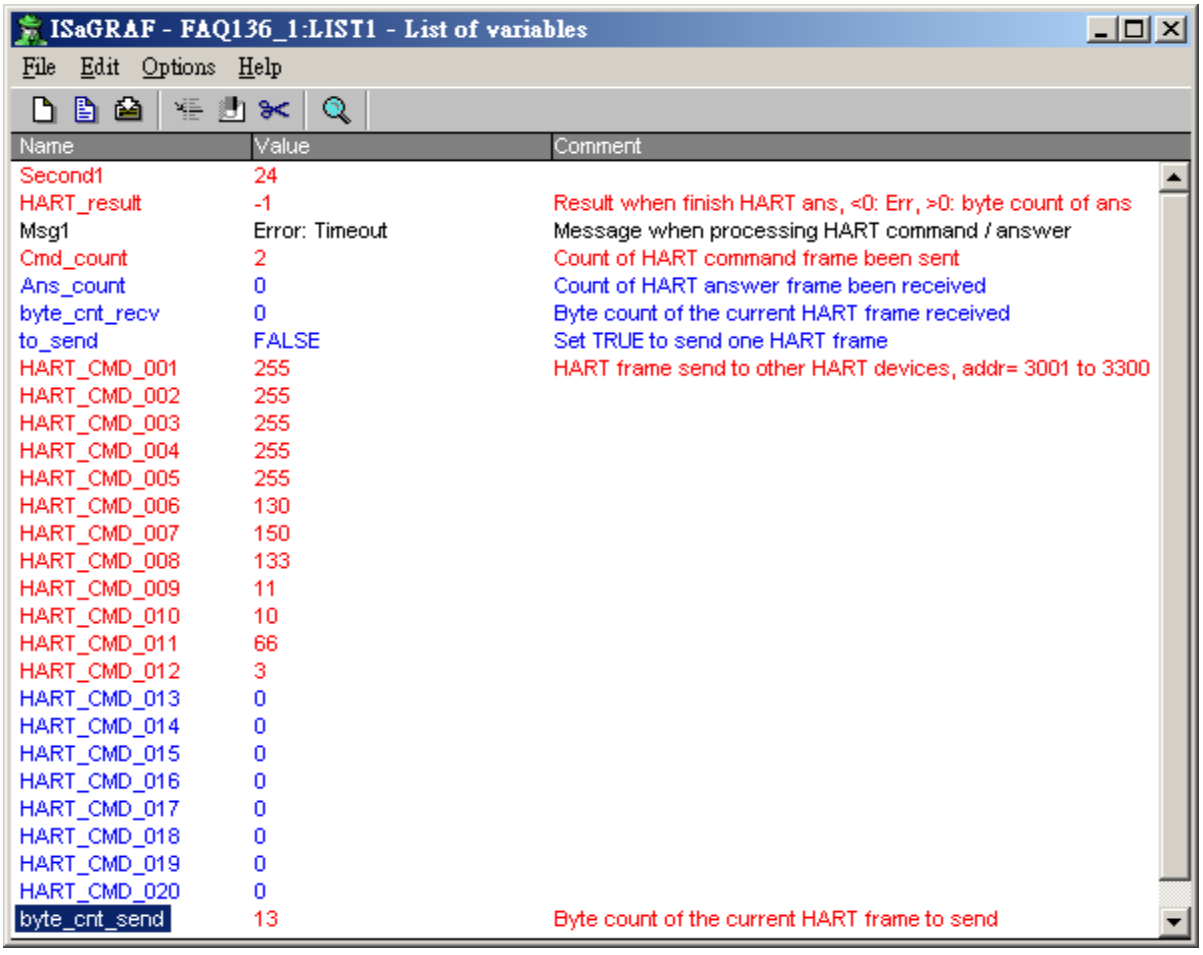
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1.5 : Test the example projects

faq136_1	Send HART frame manually from Ch.1 of Slot 2, and then receive the ans frame.
faq136_2	Similar as “faq136_1” but convert the received answer frame to 4 REAL value.
faq136_3	Send HART frame and then receive answer frame automatically from Ch.1 of Slot 2 first. Then switch to handle Ch.2 of Slot 2. And then switch to handle Ch.3 of Slot 2. Then after switch back to hanlde the Ch.1 of Slot 2, ...
faq136_4	Similar as “faq136_3” but using three I-87H17W cards which are plugged in Slot No. 1 , 2 and 3 respectively. Each I-87H17W can process only one channel to communicate with HART device at a time. It must process channels one by one in turn. That is because all the 8 channels in one I-87H17W are sharing the same HART chip . However more than one I-87H17W in different slot No. can process one of their own channels at the same time.

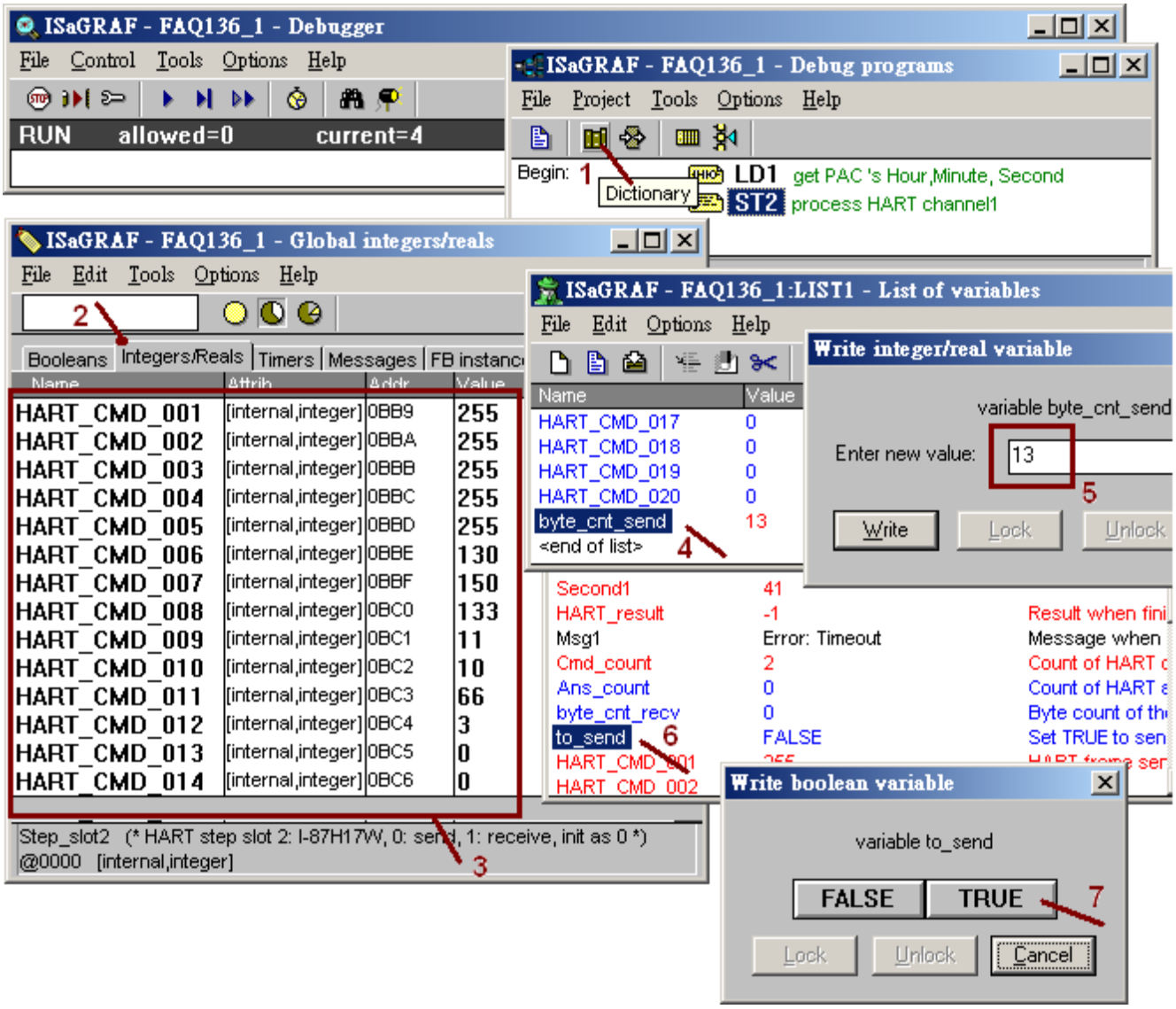
1.5.1 : Test the project “faq136_1” and “faq136_2”

To well test the “faq136_1” project, please must plug one I-87H17W in PAC 's Slot 2 and connect its 1st channel (Ch.1) to the HART device (refer to section 1.1). Then power up the PAC, download the “faq136_1” project to it, then PC / ISaGRAF will show up the below window.



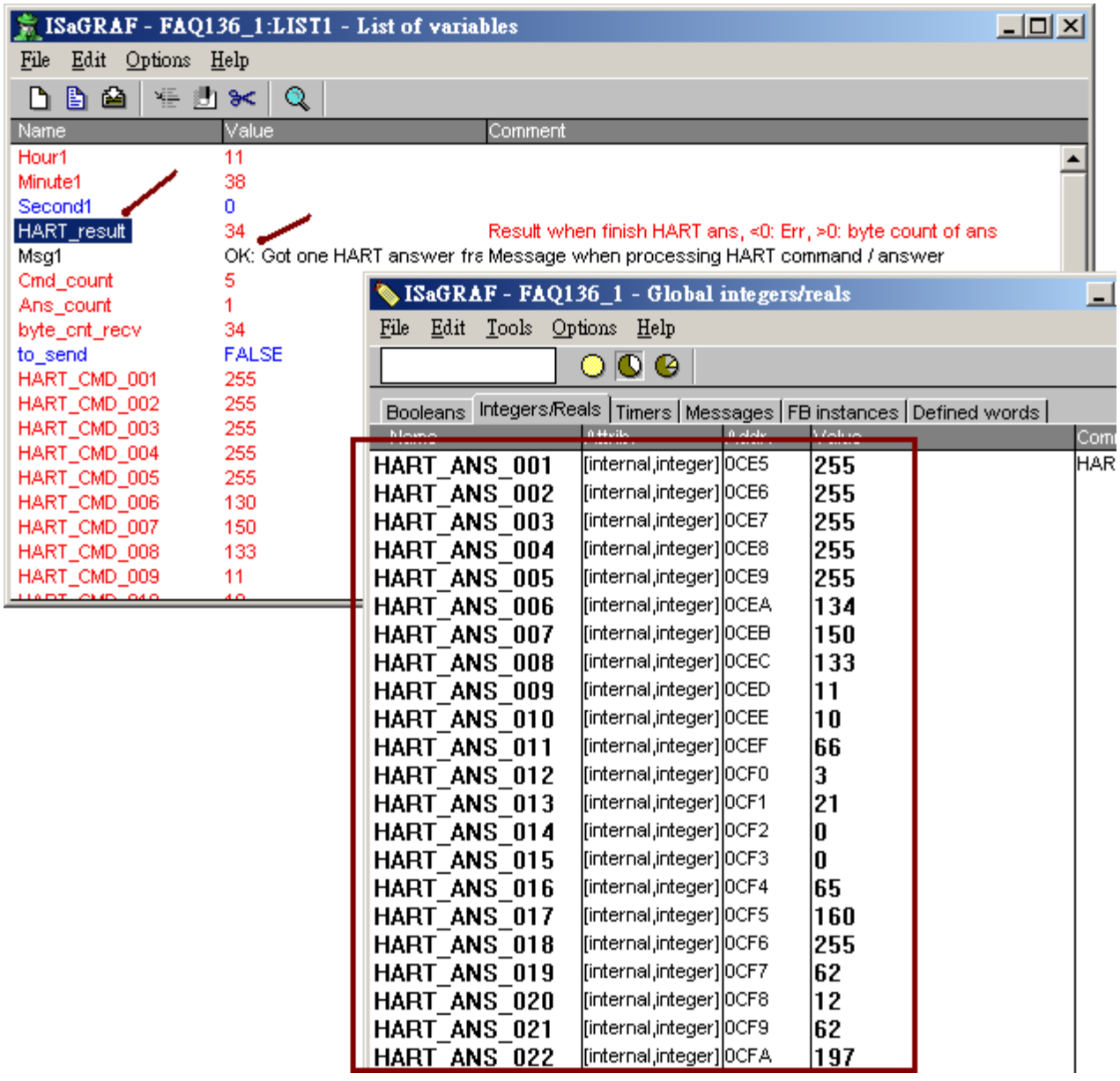
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Before sending a HART frame, first enter the HART frame data to the variables (“HART_CMD_001” to ...). Then remember to enter the correct value to the “byte_cnt_send” . Then set “to_send” as True ro send a HART frame to the HART device. The following figure shows the sending frame has 13 bytes
(“HART_CMD_001” to “HART_CMD_013”)



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Then view the value of the “HART_result” and “Msg1” to see the result of the answer frame. If the value of “HART_result” is larger than 0, for example the below figure shows 34, it means the received answer frame is correct and has 34 bytes (HART_ANS_001 to HART_ANS_034).
However If the value of “HART_result” is less than 0, error happens.



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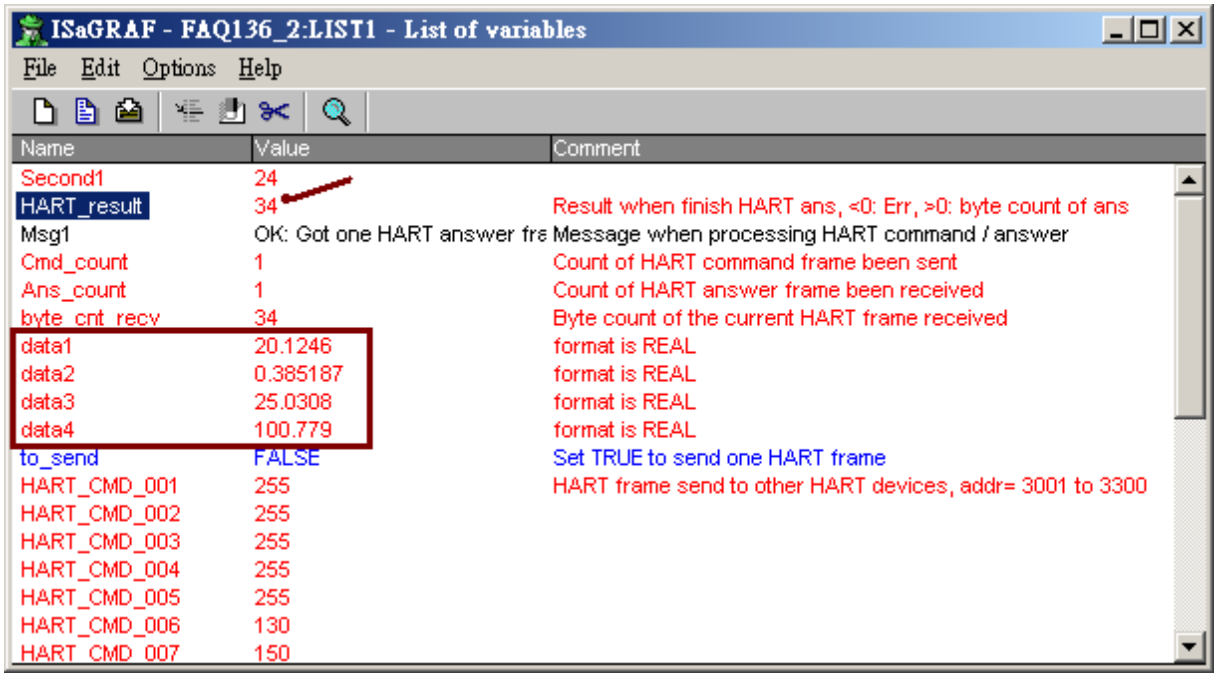
To test the “faq136_2” project is similar as the “faq136_1”. However the “faq136_2” will convert the answer frame 's “Data” (refer to the section 1.3) to become 4 REAL value.

Note:
1. The value of the below frame is displayed as Hex. format.
2. The below frame is only for illustration. It may not fit the “Data” definition of your HART device. Please follow the “Data” definition of your HART device to modify the program of “faq136_2”,

I-87H17W send : FF FF FF FF FF 82 96 85 0B 0A 42 03 00 (13 bytes)

Device answer : FF FF FF FF FF 86 96 85 0B 0A 42 03 15 00 00 41 A0 FF 3E 0C 3E C5 37 48 20 41 C8 3F 22 39 42 C9 8E D1 (34 bytes)

Then the result is as the following.
data1 = 20.1246 (41 A0 FF 3E)
data2 = 0.385187 (3E C5 37 48)
data3 = 25.0308 (41 C8 3F 22)
data4 = 100.779 (42 C9 8E D1)



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1.5.2 : Test the project “faq136_3”

If you havn't test the “faq136_1” yet, recommend to play it once (refer to section 1.5.1)

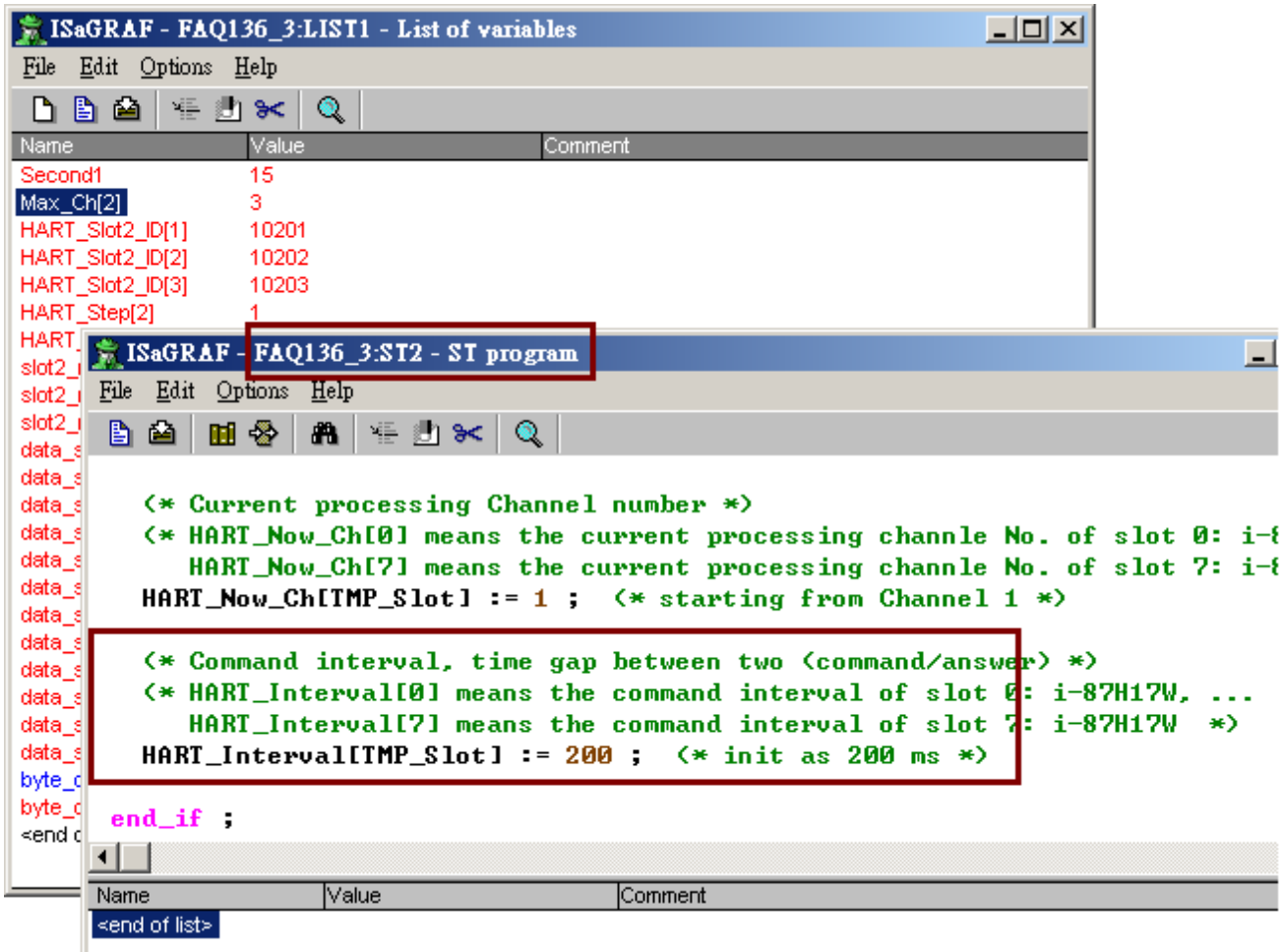
To well test the “faq136_3” project, please must plug one I-87H17W in PAC 's Slot 2 and connect its Ch.1, Ch.2 and Ch.3 to HART devices (refer to section 1.1). Then power up the PAC, download the “faq136_3” to the PAC, then the PC / ISaGRAF will show up the following window.

If you just want to test the first channel (Ch.1) only, set the value of the “Max_Ch[2]” to 1 (it means only process slot 2 's channel 1) .

This “faq136_3” will automatically send frame and then receive answer from Ch.1 to Ch.3 one by one.

There is a setting called “silence period” which means the time to wait before sending the next HART frame after a channel 's answer frame is received. The variable “HART_Interval[0]” to “HART_Interval[7]” in the “faq136_3” project defines the “silence period” of the Slot No. 0 to 7. Its unit is ms. Recommend to set it as 100 to 2000 ms. The “faq136_3” set it as 200 ms .

(More about the “Variable Array” , please visit https://www.icpdas.com/en/faq/index.php?kind=280#751 > 039)



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1.5.3 : Test the project “faq136_4”

If you havn't test the “faq136_1” yet, recommend to play it once (refer to section 1.5.1)

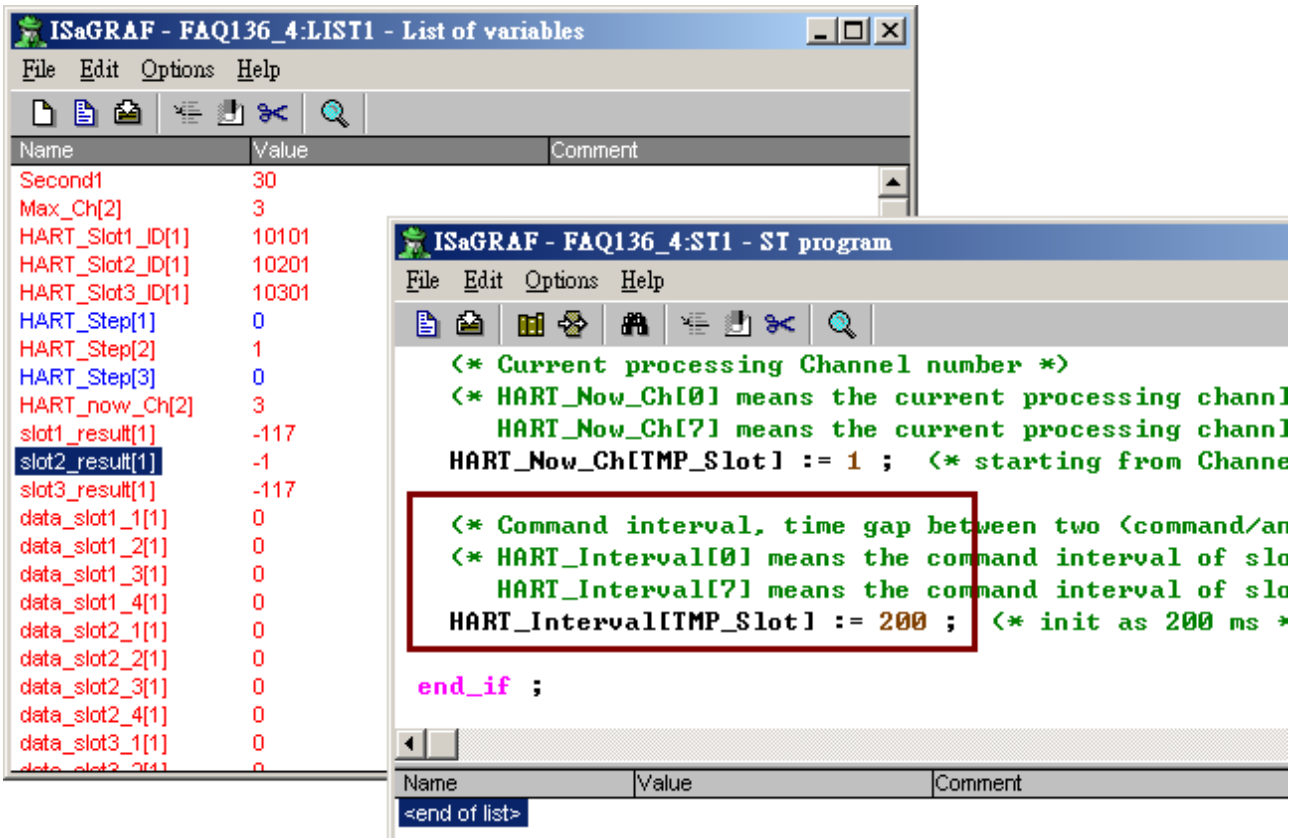
To well test the “faq136_4” project, please must plug three I-87H17W in PAC 's Slot 1 , 2 and 3. Then connect their Ch.1, Ch.2 and Ch.3 to HART devices (refer to section 1.1). Then power up the PAC, download the “faq136_4” to the PAC, then the PC / ISaGRAF will show up the following window.

If you just want to test the first channle (Ch.1) only, set the value of “Max_Ch[1]” , “Max_Ch[2]” and “Max_Ch[3]” to 1 (it means only process their channel 1 in slot 1 , 2 and 3) .

This “faq136_4” will automatically send frame and then receive answer from Ch.1 to Ch.3 one by one.

There is a setting called “silence period” which means the time to wait before sending the next HART frame after a channel 's answer frame is received. The variable “HART_Interval[0]” to “HART_Interval[7]” in the “faq136_4” project defines the “silence period” of the Slot No. 0 to 7. Its unit is ms. Recommend to set it as 100 to 2000 ms. The “faq136_4” set it as 200 ms .

(More about the “Variable Array” , please visit https://www.icpdas.com/en/faq/index.php?kind=280#751 > 039)



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