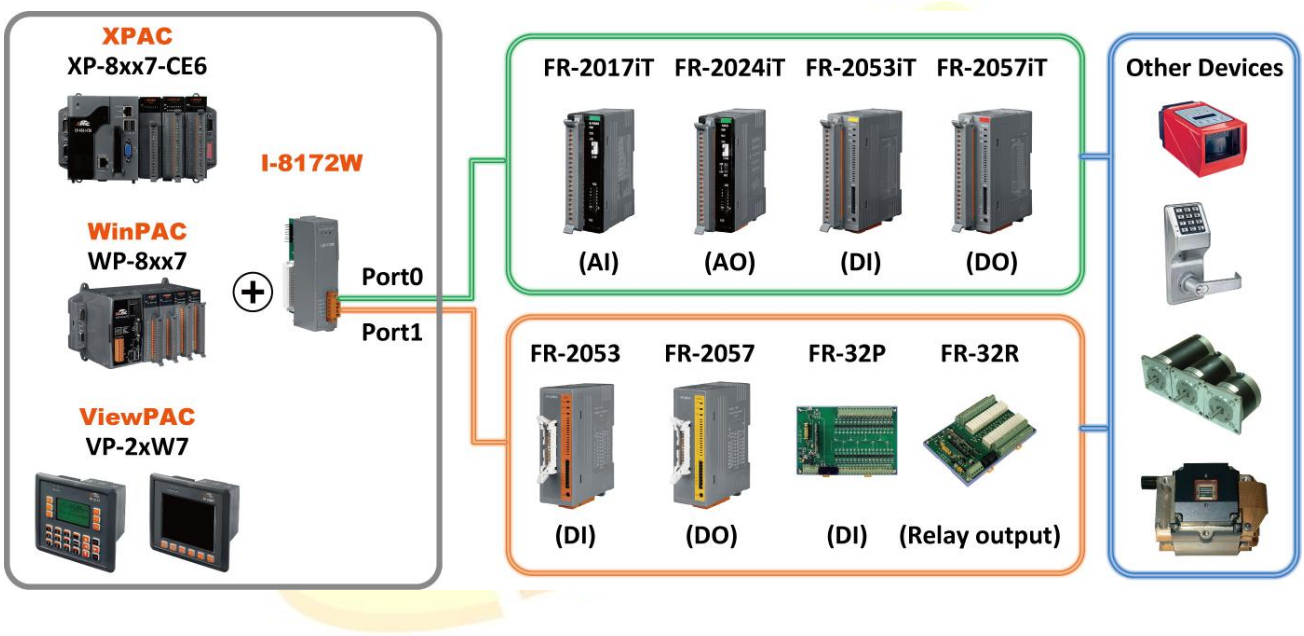
How to use the FRnet AI/AO module with the ISaGRAF PAC

Introduction :

It is a document about how to read/write the status of FRnet AI(FR-2024iT)/AO(FR-2017iT) module with the ISaGRAF PAC.

The following ISaGRAF driver supports to operate the FRnet AI/AO module

ISaGRAF PAC	Version
WP-8xx7/8xx6	1.48
VP-25W7/23W7/25W6/23W6	1.40
XP-8xx7-CE6/XP-8xx6-CE6	1.28



The link to download this document and demo programs :
http://www.icpdas.com/faq/isagraf_c.htm > FAQ-154 .

The link to download ISaGRAF drivers :
http://www.icpdas.com/products/PAC/i-8000/isagraf-link.htm

The product data sheet:
http://www.icpdas.com/products/PAC/i-8000/data%20sheet/data%20sheet_c.htm

More information about I-8172W and FRnet I/O module:
http://www.icpdas.com/products/Remote_IO/frnet/frnet_list.htm

The FAQ about how to operate the FRnet DI/DO module with the ISaGRAF PAC

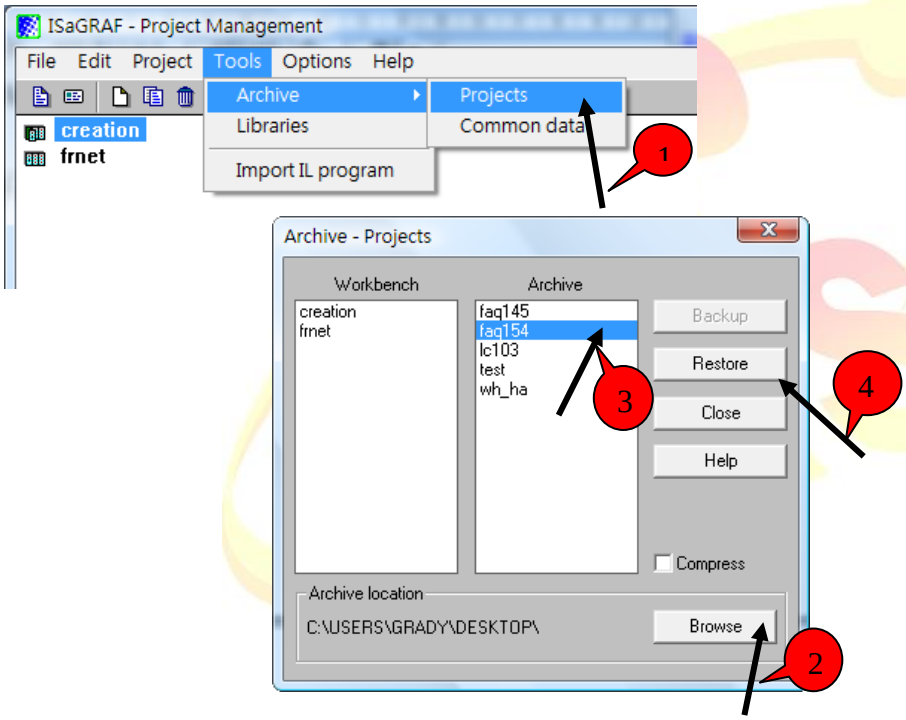
http://www.icpdas.com/faq/isagraf/082_c.htm

1.1 : Restore the ISaGRAF library, fr_16ai.fia, fr_8ao.fia, and the ISaGRAF demo project to PC / ISaGRAF

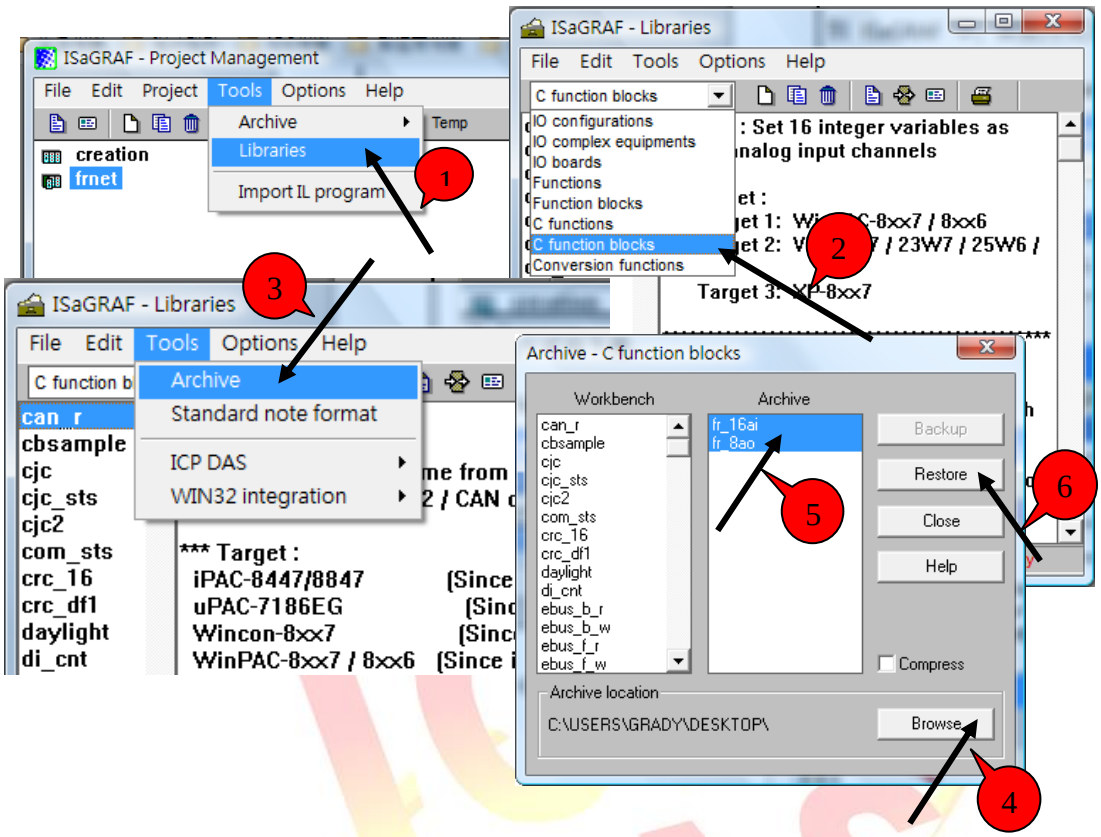
User can download the file "faq_154.zip" that includes the Demo project and this PDF document from the ISaGRAF FAQ website http://www.icpdas.com/faq/isagraf.htm > 154 and restore it to your PC/ISaGRAF.

For ISaGRAF software operation, please refer to the Chap. 1.1, 1.2 & Chap. 2 of "ISaGRAF User's Manual". The manual, file name "user_manual_i_8xx7.pdf" and "user_manual_i_8xx7_appendix.pdf", can be get from the ISaGRAF PAC CDROM or the following website.
http://www.icpdas.com/products/PAC/i-8000/getting_started_manual.htm

- **Restore the demo project "faq154.pia" :**



- **Restore the ISaGRAF library "fr_16ai.fia" and "fr_8ao.pia" :**



1.2. Introduction of FR-2017iT:

- **Hardware description:**

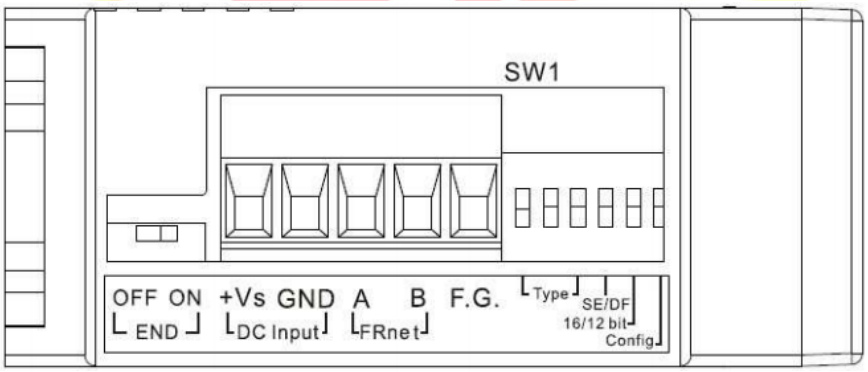
  The FR-2017iT is a 16-bit (1 channel) and 12-bit (8-channel differential or 16-channel single-ended) analog inputs module that provides two ways to select input range (+/-150mV, +/-500mV, +/-1V, +/-5V, +/-10V, +/-20mA, 0~20mA and 4~20mA).

  The refresh rate by each channel status is different, due to the channel mode of the FRnet module. The refresh rate of one channel mode is 100ms/time. The refresh rate of 8 channel mode is 250ms/time. The refresh rate of 16 channel mode is 500ms/time. But the refresh rate is not changed when add more and more modules to the FRnet bus.

  More detail description about FR-2017iT, please refer to the following website:
  http://www.icpdas.com/products/Remote_IO/frnet/fr-2017it.htm

- **Hardware setting:**

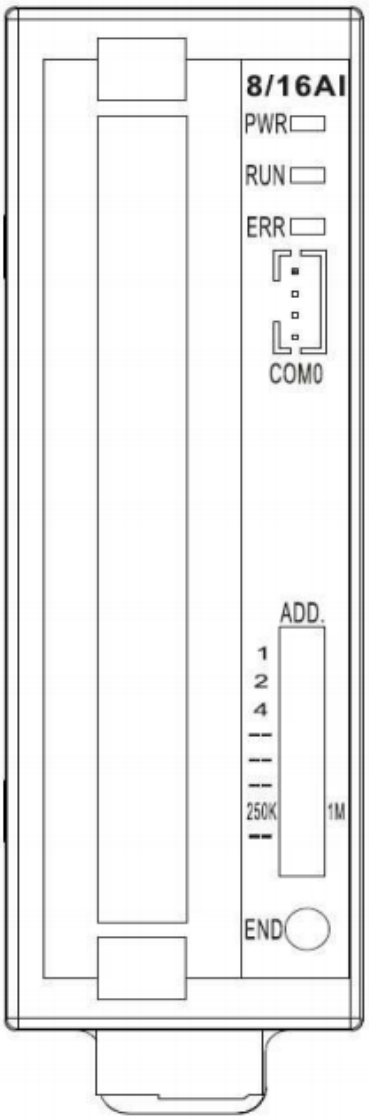
  - **SW1 :** The SW1 can be used to configure the module to 8-ch differential/16-ch single-ended, 12/16-bit resolution and individual/all Channel mode.



Pin1 Pin2 Pin3	Type code: 000~111, for +/-500mV, +/-1V, +/-5V, +/-10V+/-20mA (requires optional external 125ohm resistor)
Pin4 SE/DF	ON→16 Single-ended OFF→8 Differential
Pin5 Resolution	ON→16-bit OFF→12-bit
Pin6 Configuration	ON→Software Selectable OFF→Switch Selectable

Type	SW1			Min	Max
	1	2	3		
0 ~ 20mA	ON	ON	ON	000 (0mA)	FFF (20mA)
4 ~ 20mA	OFF	ON	ON	000 (4mA)	FFF (20mA)
+/-10V	ON	OFF	ON	800 (-10V)	7FF (+10V)
+/-5V	OFF	OFF	ON	800 (-5V)	7FF (+5V)
+/-1V	ON	ON	OFF	800 (-1V)	7FF (+1V)
+/-500mV	OFF	ON	OFF	800 (-500mV)	7FF (+500mV)
+/-150mV	ON	OFF	OFF	800 (-150mV)	7FF (+150mV)
+/-20mA	OFF	OFF	OFF	800 (-20mA)	7FF (+20mA)

- **Dip switch:** The dip switch can be used to configure the module address and the speed of FRnet bus.



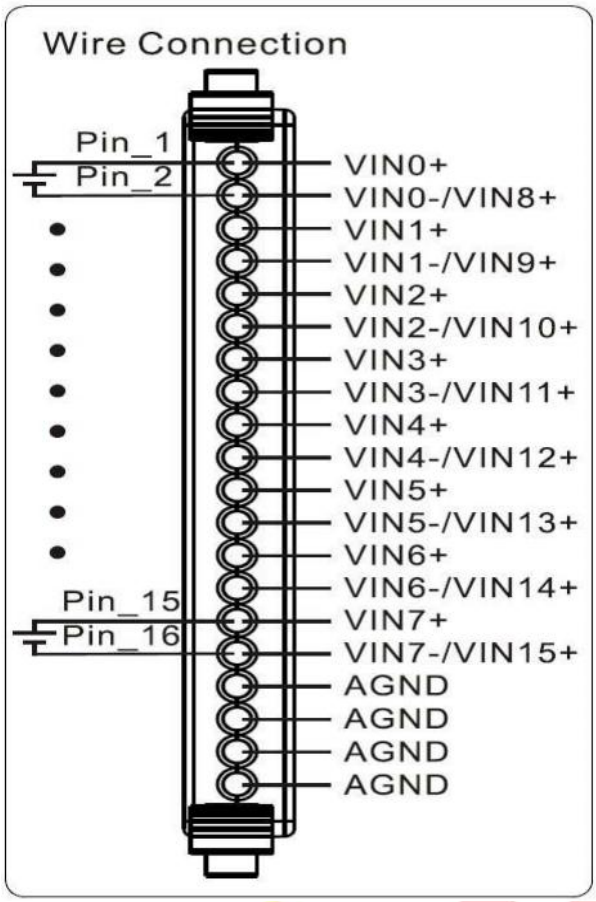
LED Mapping	
PWR	Power LED
RUN	Communication Run LED
ERR	Communication Error LED
END	Terminal resistor On

DIP Switch	
Pin1	Module Address: 0~7
Pin2	
Pin3	
Pin4	Reserved
Pin5	Reserved
Pin6	Reserved
Pin7	Speed: ON ➔ 250k bps OFF➔ 1M bps
Pin8	Reserved

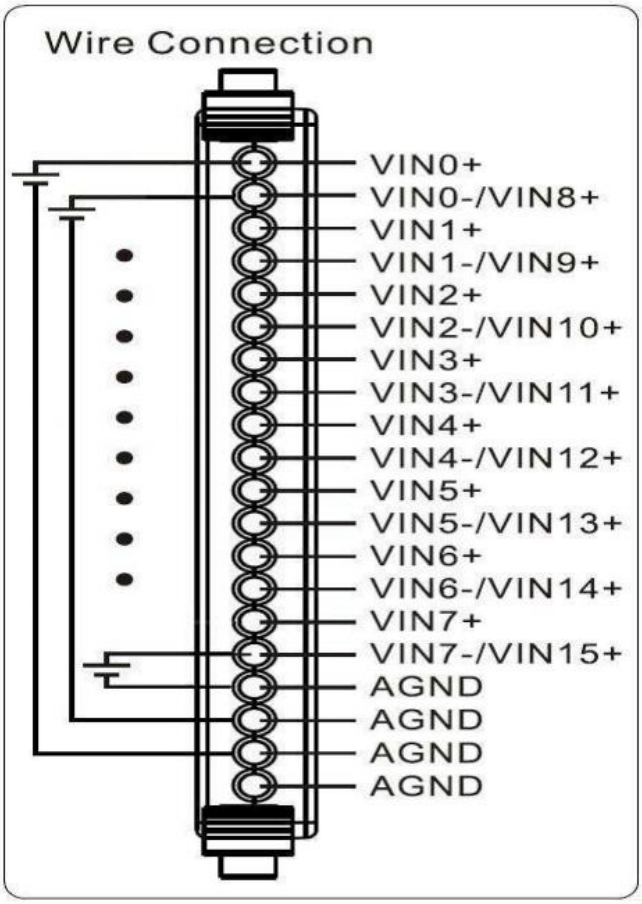
COM0
Each analog channel is allowed to configure an individual range by CA-0904 cable.

- **Wire connection:**

The wiring of 8-ch differential analog inputs



The wiring of 16-ch single-ended analog inputs

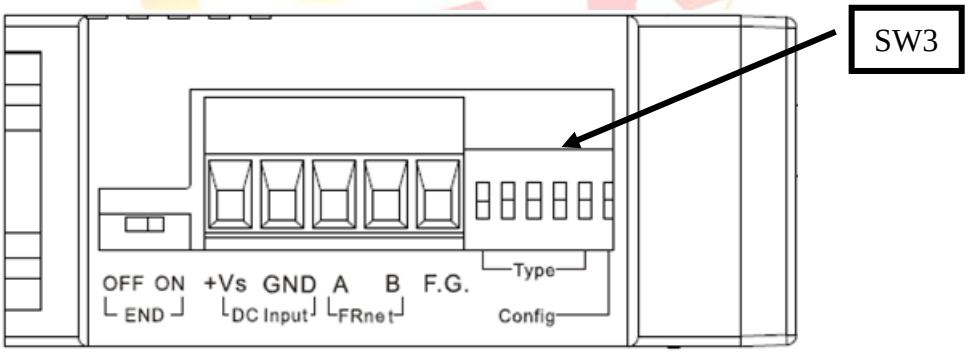


1.3. Introduction of FR-2024iT:

- **Hardware description:**
  The FR-2024iT is a 12-bit, 4-ch analog outputs module that provides programmable output range (0 ~ + 10 VDC, -10 VDC ~ +10 VDC, 0 ~ +5 VDC, -5 VDC ~ +5 VDC, 0 ~ +20mA, +4mA ~ +20mA). The refresh rate of each output channel is about 10ms/time. For example, if the ISaGRAF scan time is 10ms, it will update one of the AO output channel per 10ms. But the refresh rate is not changed when add more and more modules to the FRnet bus.

  More detail description about FR-2024iT, please refer to the following website:
  http://www.icpdas.com/products/Remote_IO/frnet/fr-2024it.htm

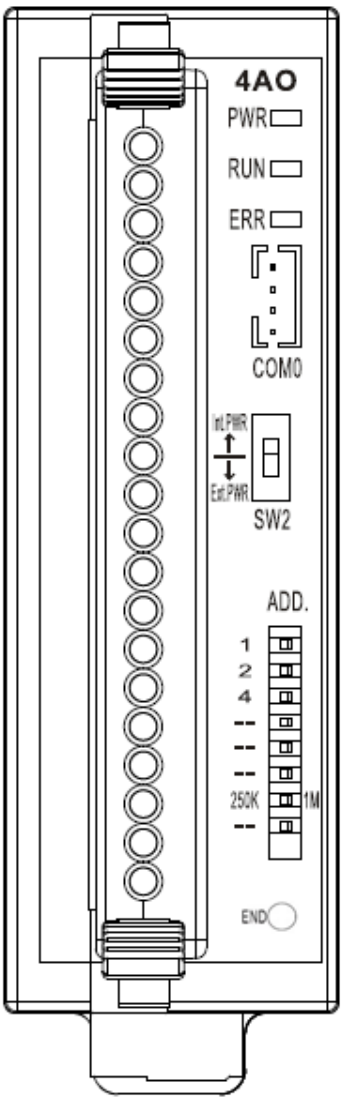
- **Hardware setting:**
  - **SW3 :** The SW3 can be used to configure the output type or enable/disable the safe value mode.



Pin1	Type code: 000~111, for 0~20mA, 4~20mA, 0~5V, +/-5V, 0~10V, +/-10V	
Pin2		
Pin3		
Pin4	Reserved	
Pin5	Safe value	ON→Output safe values when FRnet communication failed
		OFF→ Output not changed when FRnet communication failed
Pin6	Software configuration	OFF→ Software configuration
		ON→DIP switch configuration

Type	SW3			Min	Max
	1	2	3		
0 ~ 20mA	ON	ON	ON	000 (0mA)	FFF (20mA)
4 ~ 20mA	OFF	ON	ON	000 (4mA)	FFF (20mA)
0V ~ +10V	ON	OFF	ON	000 (0V)	FFF (+10V)
-10V~+10V	OFF	OFF	ON	800 (-10V)	7FF (+10V)
0V ~ +5V	ON	ON	OFF	000 (0V)	FFF (+5V)
-5V ~ +5V	OFF	ON	OFF	800 (-5V)	7FF (+5V)

- **Dip Switch :** The dip switch can be used to configure the module address and the speed of FRnet bus.

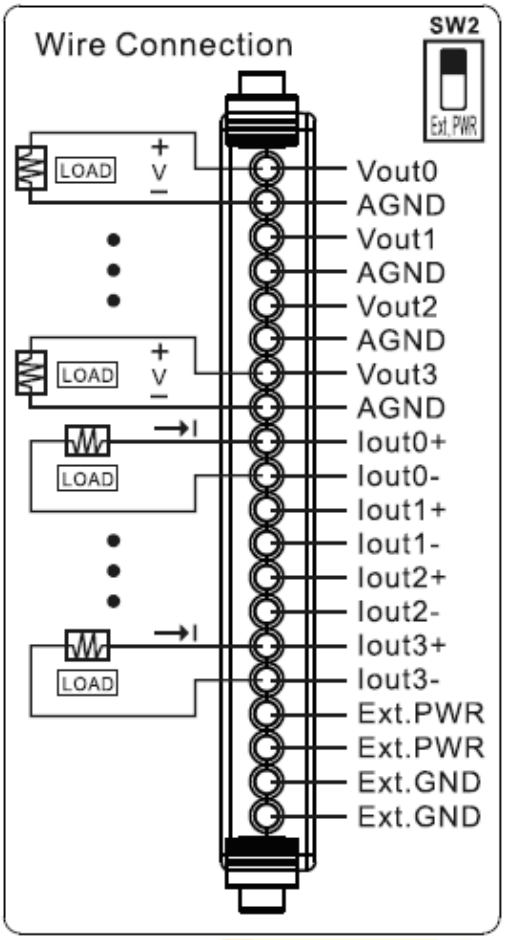


LED Mapping	
PWR	Power LED
RUN	Communication Run LED
ERR	Communication Error LED
END	Terminal resistor On
SW2 Switch	
Int.pwr	Internal Power
Ext.pwr	External Power
DIP Switch	
Pin1	Module Address: 0~7
Pin2	
Pin3	
Pin4	Reserved
Pin5	Reserved
Pin6	Reserved
Pin7	Speed: ON → 250k bps OFF→ 1M bps
Pin8	Reserved
COM0	
Each analog channel is allowed to configure an individual range by CA-0904 cable.	

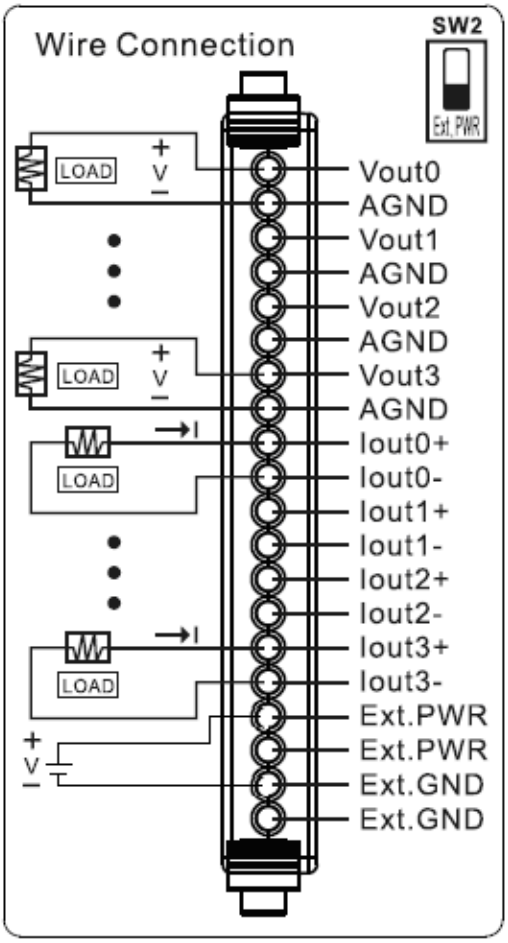
- **Wire connection:**

  SW2: it can be use to set the module using internal or external power.

The connection of internal power:



The connection of external power:



1.4. The description of C-function block "fr_16ai":

- **Parameter**：

Name	Type	description
Slot_	integer	The slot which plugged the I-8172W related to the FRnet AI. WP-8xx7: max. 8 pcs. of I-8172W; can be slot 0~7 VP-25W7/23W7: max. 3 pcs.; can be slot 0~2 XPAC-8xx7: max. 7 pcs.; can be slot 1~7
Port_	integer	The I-8172W port that link to the FRnet AI (0 or 1)
Addr_	integer	Module address. AI module: 8 ~ 15
Type_	integer	Set up the output type: 16#00 : -15mV→+15mV (Val is -32768 to 32767) 16#01 : -50mV→+50mV (Val is -32768 to 32767) 16#02 : -100mV→+100mV (Val is -32768 to 32767) 16#03 : -500mV→+500mV (Val is -32768 to 32767) 16#04 : -1V → +1V (Val is -32768 to 32767) 16#05 : -2.5V → +2.5V (Val is -32768 to 32767) 16#06 : -20mA → 20mA (Val is -32768 to 32767), with 125 ohm 16#07 : 4mA → 20mA (Val is 0 to 32767), with 125 ohm 16#08 : -10V → 10V (Val is -32768 to 32767) 16#09 : -5V → 5V (Val is -32768 to 32767) 16#0A : -1V → 1V (Val is -32768 to 32767) 16#0B : -500mV → 500mV (Val is -32768 to 32767) 16#0C : -150mV → 150mV (Val is -32768 to 32767) 16#0D : -20mA → 20mA (Val is -32768 to 32767) 16#1A : 0mA → 20mA (Val is 0 to 32767), with 125 ohm
IN1_~IN16_	integer	The related variable names of the 16 AI channels. Please declare a "Dump_ai" integer internal variable name and assigned it to those none-using channels. ＊ Please do not assign the constant to the none-using channels.

- **Return**

Name	Type	Description
Q_	Boolean	Always return True.

1.5. The description of C-function block "fr_8ao":

- **Parameter**：

Name	Type	Description
Slot_	integer	The slot which plugged the I-8172W related to the FRnet AO. WP-8xx7: max. 8 pcs. of I-8172W; can be slot 0~7 VP-25W7/23W7 : max. 3 pcs.; can be slot 0~2 XPAC-8xx7: max. 7 pcs.; can be slot 1~7
Port_	integer	The I-8172W port that link to the FRnet AO (0 or 1)
Addr_	integer	Module address. AO module: 0~7
Type_	integer	Set up the output type: 16#30 : 0mA ---> 20mA (Val is 0 to 32767) 16#31 : 4mA ---> 20mA (Val is 0 to 32767) 16#32 : 0V ---> 10V (Val is 0 to 32767) 16#34 : 0V ---> 5V (Val is 0 to 32767) 16#33 : -10V ---> 10V (Val is -32768 to 32767) 16#35 : -5V ---> 5V (Val is -32768 to 32767)
Out1_~Out8_	integer	The related variable names of the 8 AO channels. Please declare a "Dump_ao" integer internal variable name and assigned it to those none-using channels. ＊ Please do not assign the constant to the none-using channels.

- Return

Name	Type	Description
Q_	Boolean	Always return true

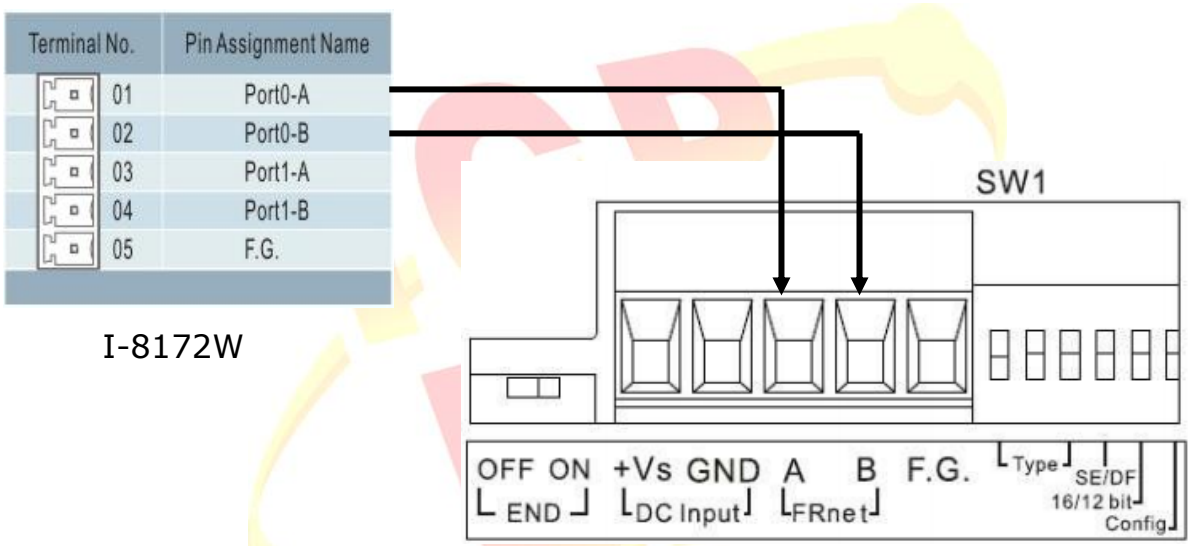
- **Notice about using FRnet AI/AO module:**

  Fast I/O scan, it is about 3 ms per FRnet I/O scan. But it can be only got one channel status per scan. (This depends on your program's PLC scan time, for ex, if the ISaGRAF PLC program scan time is about 15 ms, then the scan time for one AI/AO channel will be 15 ms, not 3 ms.)

1.6. Test the demo project "faq154":

- **Hardware requirement** :
  1. ISaGRAF PAC(CE based) X 1(EX. : XP-8347-CE6)
  2. I-8172W FRnet master X 1
  3. FR-2017iT X 1
  4. FR-2024iT X 1

- **Hardware initialization** :
  1. Plug I-8172W in the slot 1 of ISaGRAF PAC
  2. Connect FR-2017iT, FR-2024iT and the Port0 of I-8172W with the FRnet bus
  3. the FRnet wire connection is as the following figure

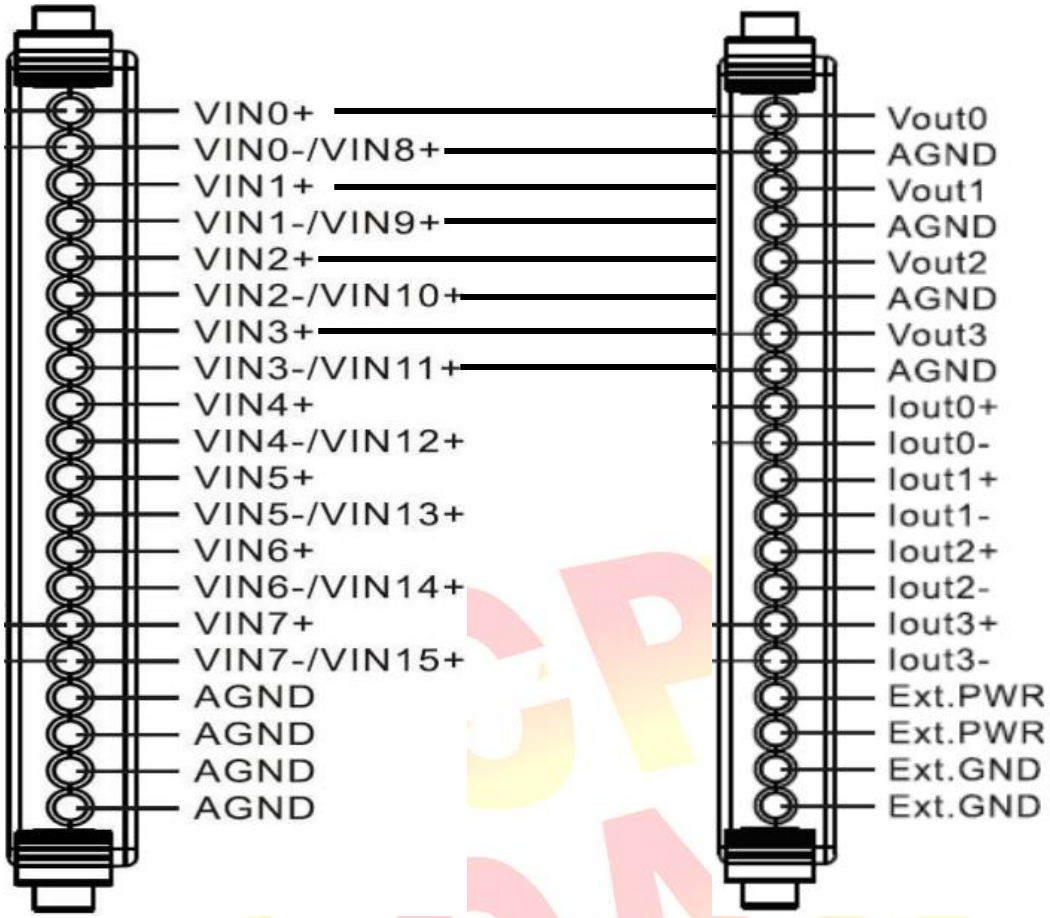


I-8172W

FR-2017iT/FR-2024iT

4. Set the bus speed of FR-2017iT,FR-2024iT as 1M
   (Notice : In the same bus, the speed of the FRnet modules must be the same. Or the communication between module and module will not work.)
5. Set the input type of FR-2017iT as +-10V(SW1 : PIN1~3 ON OFF ON)
6. Set the channel mode of FR-2017iT as Differential (SW1 : Pin4 OFF)
7. Set the ID of FR-2017iT as 1(ADD dip switch : PIN1~3 ON OFF OFF)
8. Set the output type of FR-2024iT as +-10V and use internal power (SW3 : PIN1~3 OFF OFF ON, SW2 : Int PWR)
9. Set the ID of FR-2024iT as 2(ADD dip switch : PIN1~3 OFF ON OFF)
10. Connect the Vout0 of FR-2024iT to the Vin0 of FR-2017iT, and so on (Vout0~3), just like the figure in the next page.

- **The wire connection between FR-2017iT and FR-2024iT**

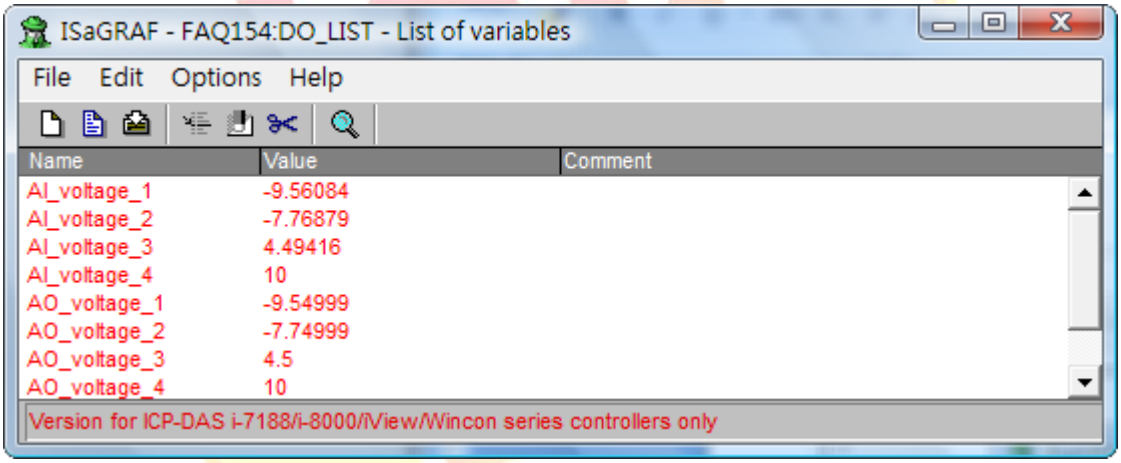


FR-2017iT FR-2024iT

- **How to operate the demo project FAQ154**

1. Recompile the ISaGRAF project and download it into the ISaGRAF PAC. If you are not familiar to the ISaGRAF software, please refer to "ISaGRAFUser's manual" Chap.1.1~1.2 and Chap.2. The manual files, chinese_user_manual_i_8xx7.pdf andchinese_user_manual_i_8xx7_appendix.pdf, can be got from the CDROM of ISaGRAF PAC package or the following website. http://www.icpdas.com/products/PAC/i-8000/getting_started_manual.htm

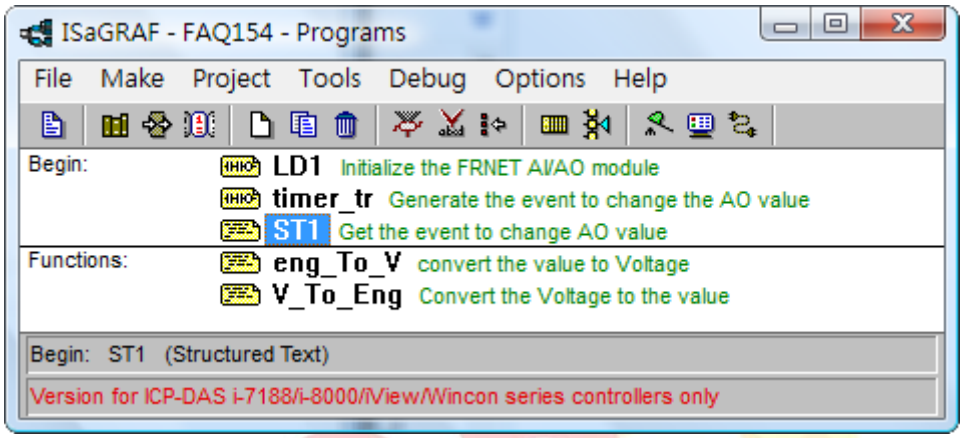
2. User can observe the change of AO_voltage_1~4 and AI_voltage_1~4 from +10V to +10V in the spy list, just like the figure below.



1.7. Description of Demo Program "faq154"

- **ISaGRAF Project Architecture**：

  This project contains two LD programs(LD1、timer_tr), an ST program(ST1), and two User define C-function(eng_To_V、V_To_eng)



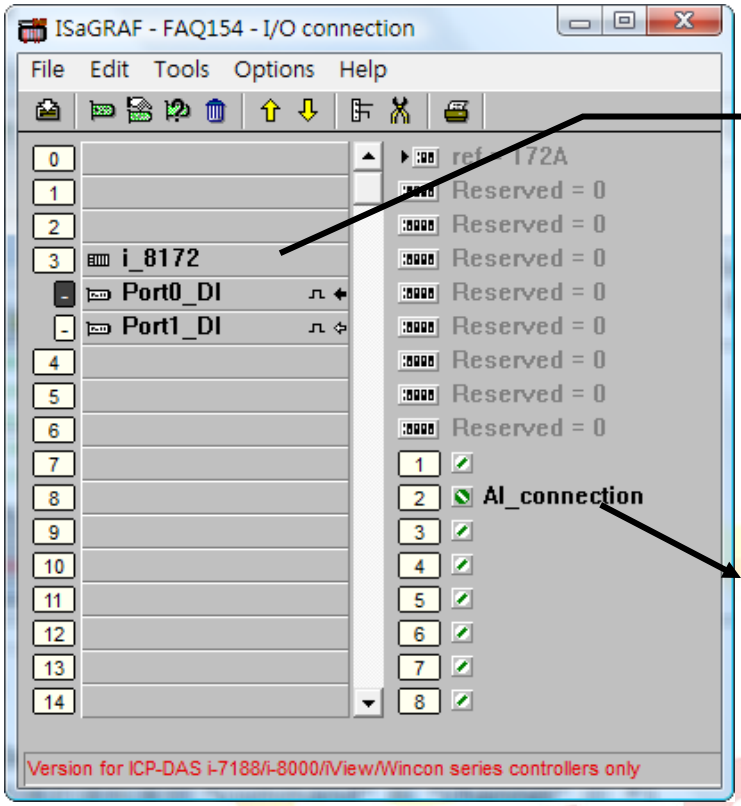
- **The setting of FRnet module in this demo project**

	FR-2017iT	FR-2024iT
Address	1	2
Type	+-10V(ON OFF ON)	+-10V(OFF OFF ON)
Speed	1M bps	1M bps

- **ISaGRAF variables**

Name	Type	Property	Description
Init	Boolean	Internel	Set to true at Init, for initializing the FRnet module
AI_connection	Boolean	Internel	The connection status of FRnet AI module
AO_1_event	Boolean	Internel	The event to change the status of AO1
AO_2_event	Boolean	Internel	The event to change the status of AO2
AO_3_event	Boolean	Internel	The event to change the status of AO3
AO_4_event	Boolean	Internel	The event to change the status of AO4
AI_01~AI_04	Integer	Internel	The AI status of FR-2014iT
Dump_AI	Integer	Internel	To connect the none-using channels of FRnet AI module
AO_01~AO_04	Integer	Internel	The AO status of FR-2017iT
Dump_AO	Integer	Internel	To connect the none-using channels of FRnet AO module
AI_voltage_1~4	Real	Internel	The status of AI channel. The unit is volt.
AO_voltage_1~4	Real	Internel	The status of AO channel. The unit is volt
T1	Timer	Internel	Set to 500ms at init, for generating the pulse

- **I/O connection**

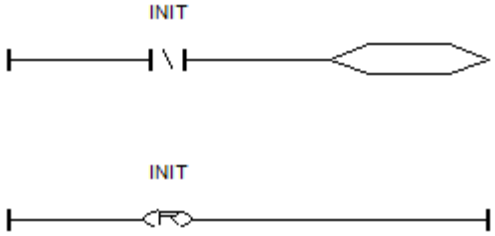


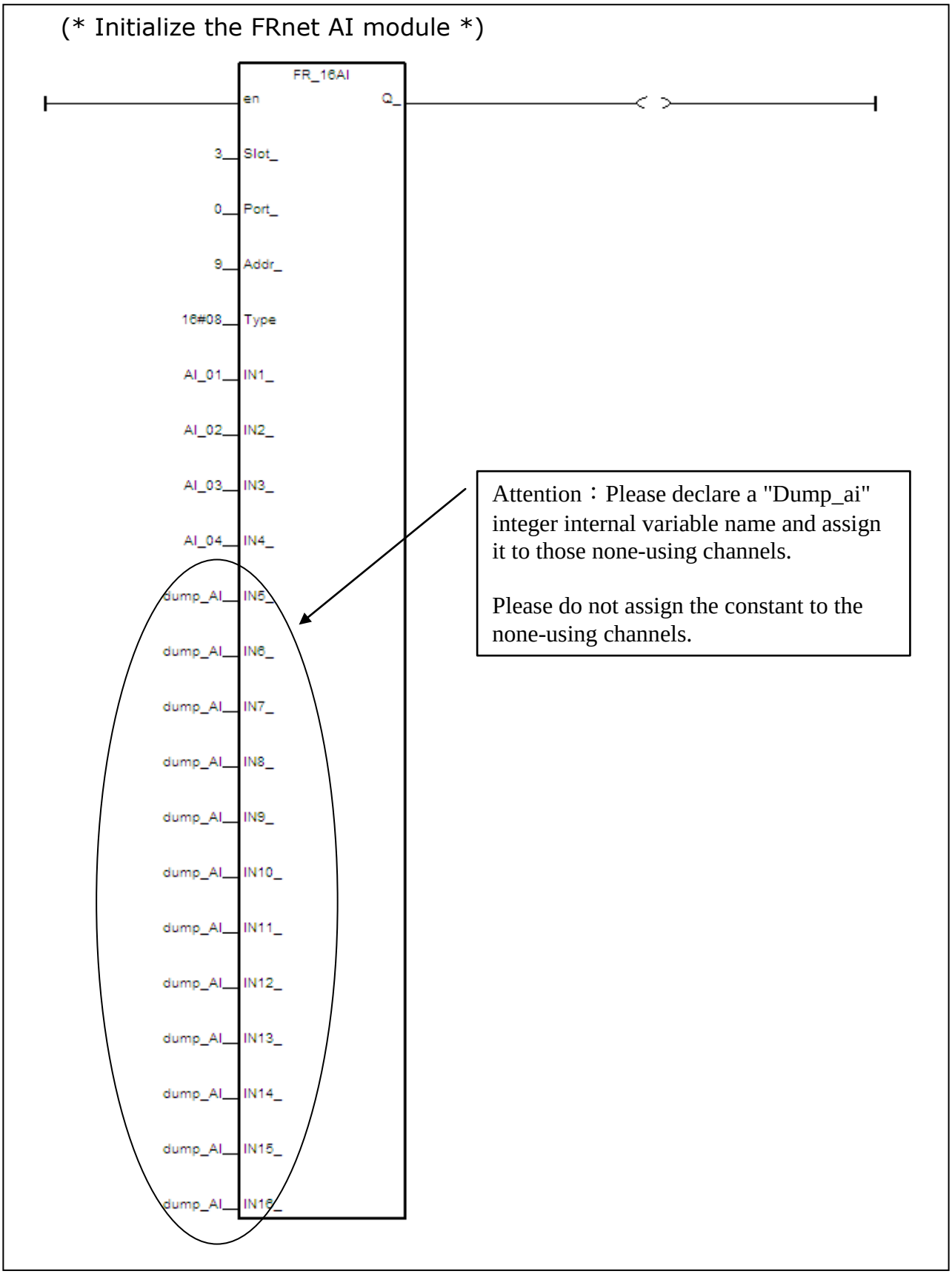
Insert the i_8172 module in the slot3

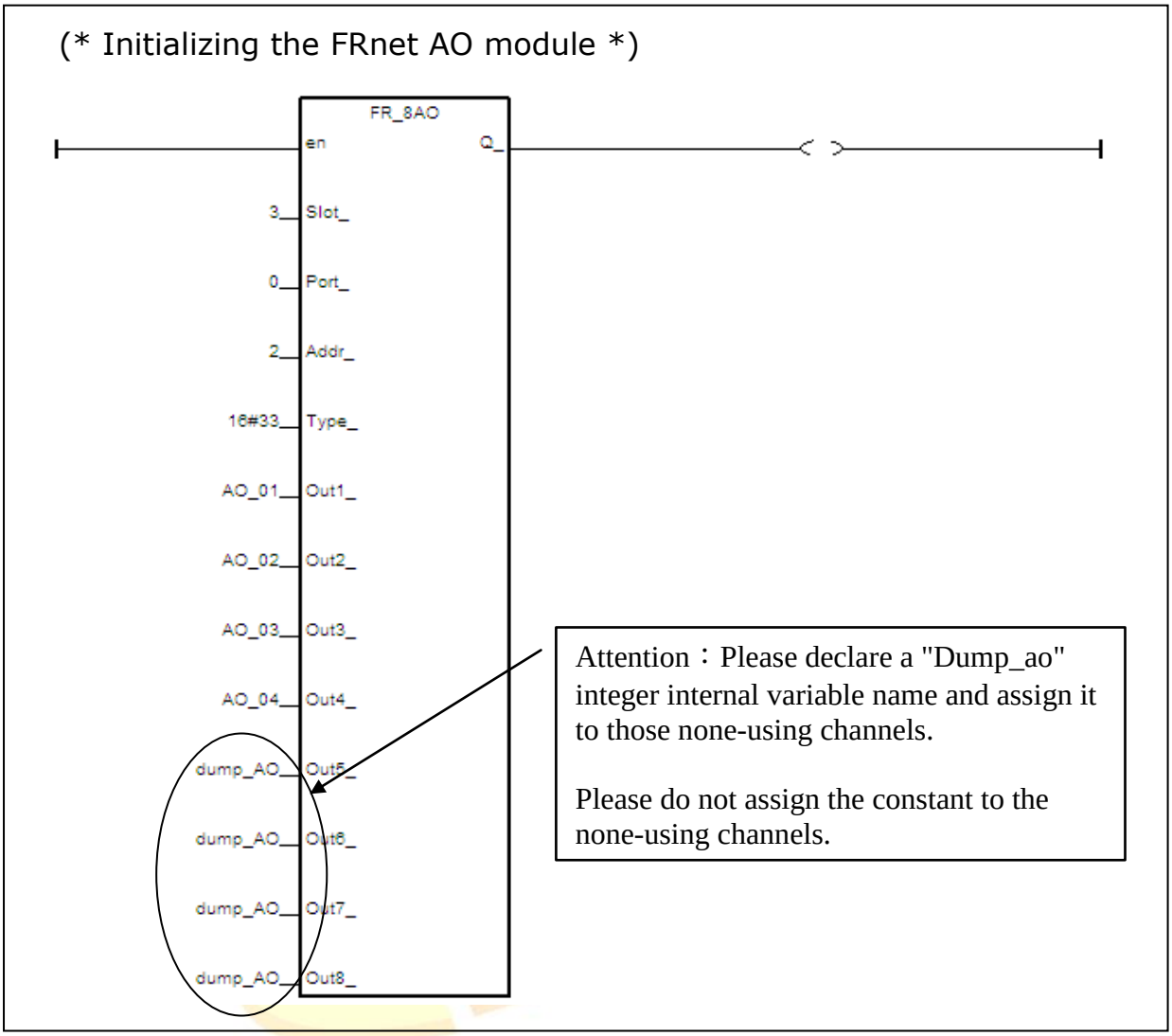
Assign the variable "AI_connection" to the second channel, for getting the status of the connection.

- **The description of "LD1" program** :

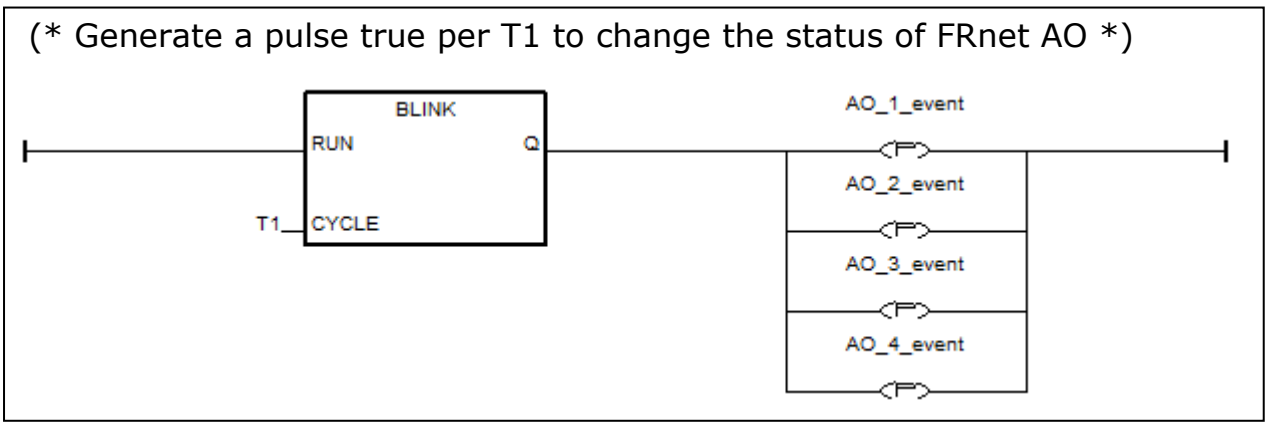
```
(* Set the variable "INIT" as false in the first scan, *)
(* for initializing the FRnet modules. *)
(* Please do not use the C function block "Fr_16ai" and "Fr_8ao"  *)
(* in the other program. *)
(* Do not use the array variable in the C-function block "FR_8ao" *)
(* and "FR_16ai". *)
```




(* Initialize the FRnet AI module *)
FR_16AI
en
Q_
3__ Slot_
0__ Port_
9__ Addr_
16#08__ Type
AI_01__ IN1_
AI_02__ IN2_
AI_03__ IN3_
AI_04__ IN4_
dump_AI__ IN5_
dump_AI__ IN6_
dump_AI__ IN7_
dump_AI__ IN8_
dump_AI__ IN9_
dump_AI__ IN10_
dump_AI__ IN11_
dump_AI__ IN12_
dump_AI__ IN13_
dump_AI__ IN14_
dump_AI__ IN15_
dump_AI__ IN16_
Attention：Please declare a "Dump_ai" integer internal variable name and assign it to those none-using channels.
Please do not assign the constant to the none-using channels.



- **The description of "timer_tr" program**：



- **The description of "ST1" program:**

```
(* Convert the raw data into the data in volt *)
AI_voltage_1 := eng_To_V(AI_01);
AI_voltage_2 := eng_To_V(AI_02);
AI_voltage_3 := eng_To_V(AI_03);
AI_voltage_4 := eng_To_V(AI_04);


(* while getting the trigger event of AO channel1, add 0.01V to it *)
(* If its value is over +10V, set it as -10V *)
if AO_1_event then

  AO_voltage_1 := AO_voltage_1 + 0.01;

  if AO_voltage_1 > 10.0 then

    AO_voltage_1 := -10.0;

  end_if;

  AO_01 := V_To_eng(AO_voltage_1);

end_if;


(* while getting the trigger event of AO channel2, add 0.05V to it *)
(* If its value is over +10V, set it as -10V *)
if AO_2_event then

  AO_voltage_2 := AO_voltage_2 + 0.05;

  if AO_voltage_2 > 10.0 then

    AO_voltage_2 := -10.0;

  end_if;

  AO_02 := V_To_eng(AO_voltage_2);

end_if;
```

```
(* while getting the trigger event of AO channel3, add 0.1V to it *)
(* If its value is over +10V, set it as -10V *)
if AO_3_event then

   AO_voltage_3 := AO_voltage_3 + 0.1;

   if AO_voltage_3 > 10.0 then

      AO_voltage_3 := -10.0;

   end_if;

   AO_03 := V_To_eng(AO_voltage_3);

end_if;


(* while getting the trigger event of AO channel4, add 0.5V to it *)
(* If its value is over +10V, set it as -10V *)
if AO_4_event then

   AO_voltage_4 := AO_voltage_4 + 0.5;

   if AO_voltage_4 > 10.0 then

      AO_voltage_4 := -10.0;

   end_if;

   AO_04 := V_To_eng(AO_voltage_4);

end_if;
```

- **The description of user defined C-function "eng_To_V"** ：

```
(* Convert the data in volt into the 2's complement value *)
V_To_Eng := ANA(V / 10.0 * 32767.0);
```

- **V_To_eng** 程式說明：

```
(* Convert the 2's complement value into the data in volt *)
eng_To_V := REAL(value) / 32767.0 * 10.0;
```