ISO-DA16/DA8

Hardware Manual

Warranty

All products manufactured by ICP DAS are warranted against defective materials for a period of one year from the date of delivery to the original purchaser.

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1. Introduction

1.1 General Description

The ISO-DA16/DA8 is bus-type isolated 14-bit D/A card for PC/AT compatible computers. The optical isolation of the ISO-DA16/DA8 can withstand up to 2500Vrms of common-mode voltage.

The ISO-DA16/DA8 offers 16/8 channel analog output. The voltage output range can be configured as ±10V, ±5V, 0-10V, 0-5V and the current output can be configured as 0 to 20mA or 4 to 20 mA.

The board's innovative design improves on several drawbacks of the conventional D/A card. These features are as follows:

- Trimless, no jumpers, high channel number and high isolation(2500V) design.
- All calibrations can be done by software. The calibration data is stored in the on-board EEPROM.
- The power-on value of the analog output can be pre-defined by the user and is stored in the on-board EEPROM.
- Six different configurations: ±10V, ±5V, 0-10V, 0-5V, 0-20mA or 4-20 mA.
- Every channel can be programmed as voltage output or current output
- All channel configurations can be selected and changed by software. The user doesn't have to change any hardware.
- All 16 channels can be configured and used in different configurations at the same time.(for example, channel_0 = ±10V, channel_1 = 4-20mA, channel_2 = 0 to 5V, ….., at the same time)
- The onboard machine independent timer can be programmed from 0.1 ms to 100 ms. When the time is up, a hardware signal can be used to interrupt PC.
- 16 channels D/I can be directly connected to isolated daughter board, DB-16P
- 16 channels D/O can be directly connected to relay board, DB-16R, DB-24R
- All these features are implemented in a small, compact, reliable and half-size PCB.

1.2 The Block Diagrams

The block diagram of ISO-DA16/DA8 is shown as follows:

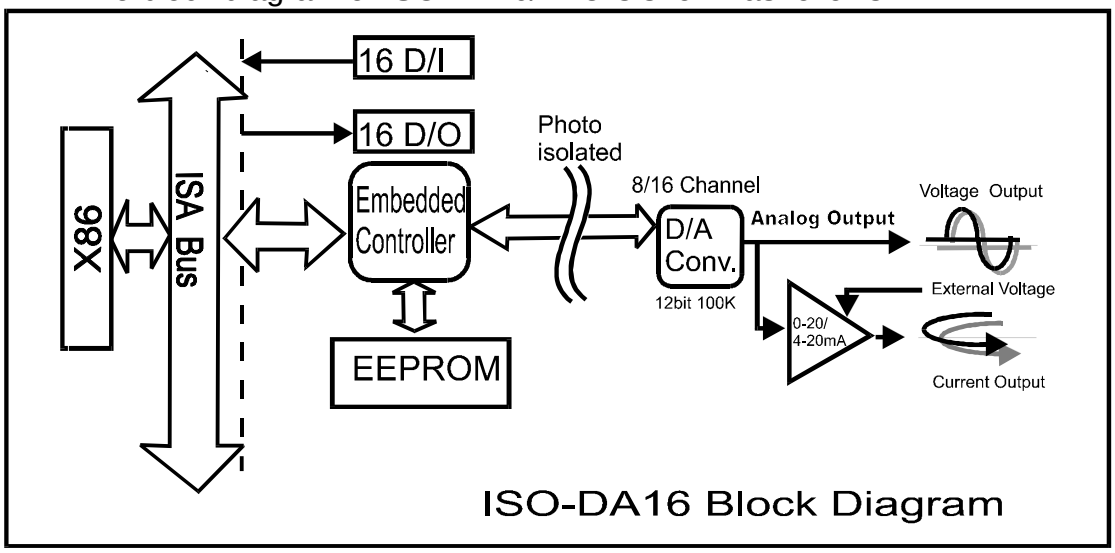


Figure 1: The block diagram of ISO_DA16.

The X86 sends one command to the embedded controller through ISA bus. The embedded controller will auto read and execute this command. The results of this command will be stored in the internal data memory of the embedded controller, therefore the X86 can read back and analyze these results through ISA bus.

The X86 site and the analog output site are fully isolated. Therefore noises from external devices will be isolated from the X86, this will improve the X86's reliability.

The calibration can be done by software without any hardware trimming. The X86 will send out the calibration command, the embedded controller will store this calibration data into EEPROM. After first power-on, the software driver on the X86 site can download this calibration data from EEPROM.

The power-on start-up value of the analog output can be set by software. These power-on values are also stored in EEPROM. After first power-on, the embedded controller will load this data automatically and controller the D/A output to their start-up values. These start-up values programmed to be voltage output or current output.

The X86 only needs to send out commands, and the embedded controller will handle the control details.

1.3 Features

The general features of ISO-DA16/DA8 are given as follows:

- AT bus
- 2500VDC photo-isolation protection
- 8/16 channel, 14-bit analog output
- Unipolar or bipolar outputs available for each channel
- Voltage/ current output for each channel
- Command set programming
- Software Calibration

1.4 Specifications

Analog Outputs

D/A converter : 14-bit DAC
Channels : 8/16 independent
Type : double-buffered, multiplying
Integral linearity : 0.006% FSR ; typical
Differential linearity : 0.006 % FSR ; typical

Voltage Output Range :

Unipolar : 0~5V or 0~10V
Bipolar : +/-10Vor,+/- 5V
Current drive : +/-5mA
Absolute accuracy : 0.01% FSR typical
Power on state : 0V bipolar ; 5V unipolar

Current Output Range :

0-20mA or 4-20mA
Absolute Accuracy : 0.1% FSR typical
Excitation voltage range : + 7 V to +40V
Power On state : 4mA bipolar , 12mA Unipolar

Stability

Offset temperature coefficient : +/- 50μV/°C
Gain temperature coefficient : +/- 10ppm/°C

Power Requirements:

ISO-DA8 : +5VDC @800mA max.
ISO-DA16. : +5VDC @1400mA max.

General Environmental

Operating temp 0-50°C
Storage temp -20°C to 70°C
Humility 0 to 90% non-condensing
Dimensions 182 mm x 122 mm

1.5 Product Check List

In addition to this manual, the package includes the following items:

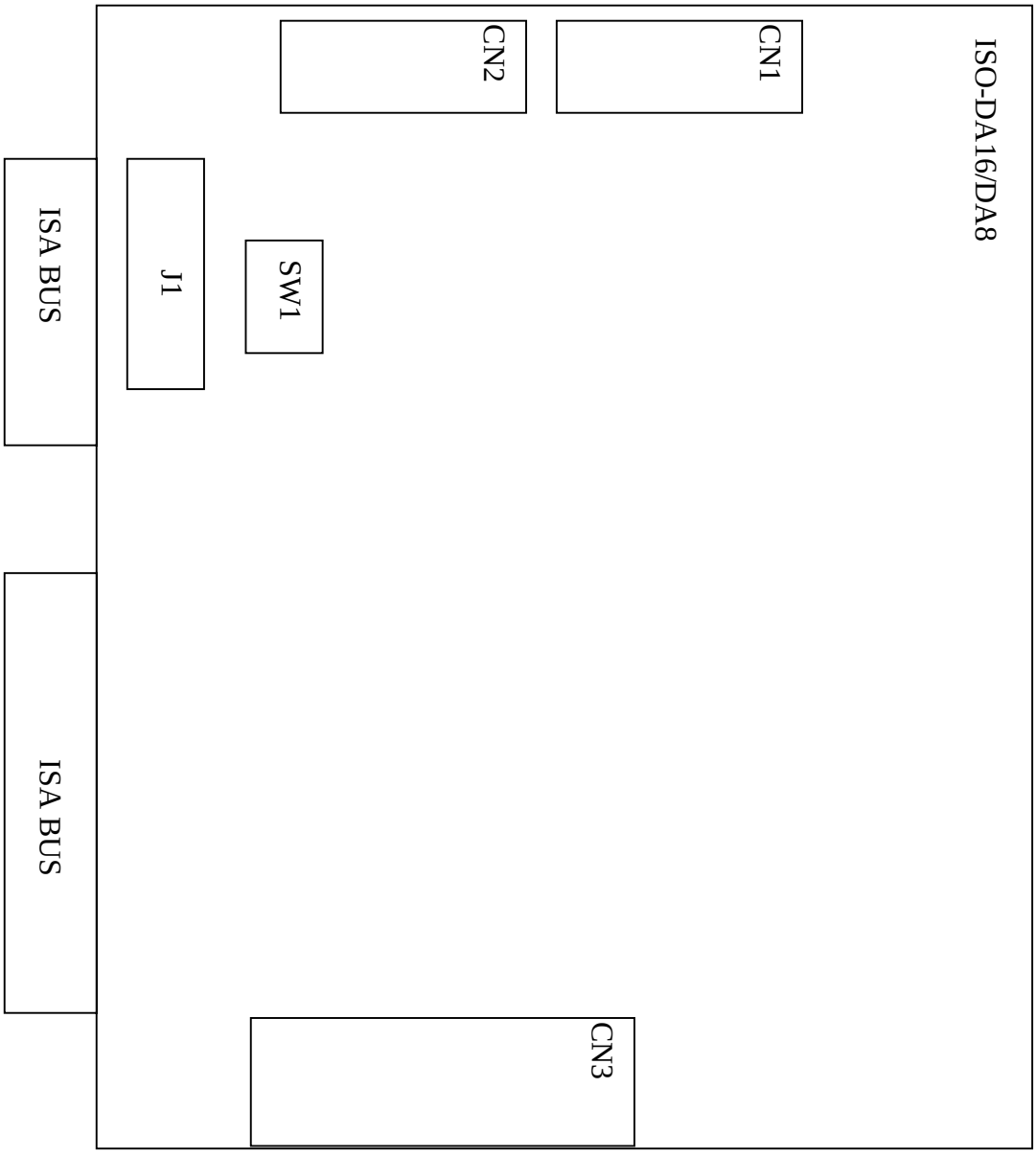
- ISO_DA16/DA8 multifunction card.
- One piece of company floppy diskette or CD.

Attention !

If any of these items is missing or damaged, please contact your local field agent. Save the shipping materials and carton in case you want to ship or store the product in the future.

2. Hardware Configuration

2.1 Board Layout



CN1 : 16 channel D/I

CN2 : 16 channel D/O

CN3 : 16/8 channel voltage/current output

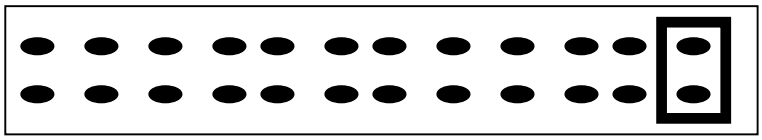
J1 : IRQ selection

SW1 : I/O BASE address selection

2.2 J1 : IRQ Channel Selection

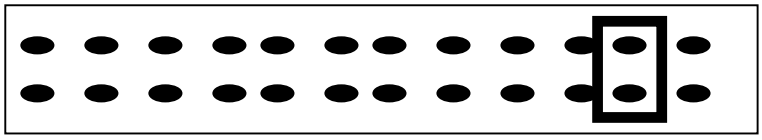
There is one machine independent timer in ISO-DA16/DA8. This timer is programmable from 0.1mS to 100ms. When the timer is up, the embedded controller will generate an hardware interrupt signal. This signal can be used to interrupt PC or can be read back by polling in PC site.

NO Interrupt (default)



IRQ	3	4	5	6	7	9	10	11	12	14	15	NC

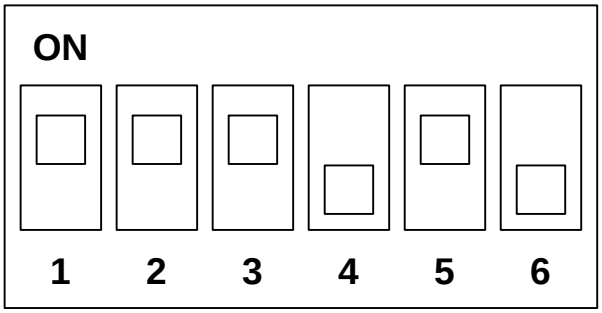
Interrupt 15



IRQ	3	4	5	6	7	9	10	11	12	14	15	NC

2.3 I/O Base Address Setting

The ISO-DA16 occupies 8 consecutive locations in I/O address space from BASE to BASE+7. The default setting is 0x220 as following :



A8 A7 A6 A5 A4 A3

BASE ADDR	A8	A7	A6	A5	A4	A3
200-208	ON	ON	ON	ON	ON	ON
208-20F	ON	ON	ON	ON	ON	OFF
220-228(☑)	ON	ON	ON	OFF	ON	ON
228-22F	ON	ON	ON	OFF	ON	OFF
300-308	OFF	ON	ON	ON	ON	ON
308-30F	OFF	ON	ON	ON	ON	OFF
3F0-3F8	OFF	OFF	OFF	OFF	OFF	ON
3F8-3FF	OFF	OFF	OFF	OFF	OFF	OFF

(☑) : default base address is 0x220

The PC I/O port mapping is given below.

ADDRESS	Device	ADDRESS	DEVICE
000-1FF	PC reserved	320-32F	XT Hard Disk
200-20F	Game/control	378-37F	Parallel Printer
210-21F	XT Expansion Unit	380-38F	SDLC
238-23F	Bus Mouse/Alt. Bus Mouse	3A0-3AF	SDLC
278-27F	Parallel Printer	3B0-3BF	MDA/Parallel Printer
2B0-2DF	EGA	3C0-3CF	EGA
2E0-2E7	AT GPIB	3D0-3DF	CGA
2E8-2EF	Serial Port	3E8-3EF	Serial Port
2F8-2FF	Serial Port	3F0-3F7	Floppy Disk
300-31F	Prototype Card	3F8-3FF	Serial Port

The I/O control registers are defined as follows:

I/O Address	Input Operation	Output Operation
BASE	D/I low byte read	D/O low byte read
BASE+1	D/I high byte read	D/O high byte read
BASE+2	Read Status	D/O output enable
BASE+3	Read Command	Write Command
BASE+4	Clear Interrupt Signal	Reserved

2.3.1 D/I Input Buffer Register

(READ) Base: D/I Input Buffer Low Byte Data Format

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

(READ) Base+1: D/I Input Buffer High Byte Data Format

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

D/I 16bit input data: D15….D0 , D15=MSB,D0=LSB

The ISO-DA16/DA8 provides 16 TTL compatible digital inputs. The low 8 bits are stored in address BASE. The high 8 bits are stored in address BASE+1.

2.3.2 D/O Output Latch Register

(WRITE) Base: D/O Output Latch Low Byte Data Format

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

(WRITE) Base+1: D/O Output Latch High Byte Data Format

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
D7	D6	D5	D4	D3	D2	D1	D0

D/O 16bit output data: D15….D0 , D15=MSB,D0=LSB

The ISO-DA16/DA8 provides 16 TTL compatible digital outputs. The low 8 bits are stored in address **BASE.** The high 8 bits are stored in address **BASE+1.** When first powered-on, all the D/O output latch ports are disabled, therefore all D/O are in floating state. All D/O will active if any value output to BASE+2, D/O output enables control register. If these D/O are active, they will active and can't be disable again. So only one enabled output is enough.

2.3.3 Status Register

(READ) Base+2: Status Format

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
X	X	X	X	D3	D2	D1	D0

D0=1 ➔ ready to read

D1=1 ➔ ready to write

D2=2 ➔ embedded controller error

D3=3 ➔ embedded controller sends a hardware interrupt signal

X=don't care

2.3.4 D/O Output Enable Register

(WRITE) Base+2: D/O Output Enable Register Format

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
X	X	X	X	X	X	X	X

X=don't care

When first powered-on, all the D/O output latch ports are disabled,therefore all D/O are in floating state. All D/O will active if any value output to BASE+2,D/O output enables control register. If these D/O are active, they will activate and can't be disabled again. So only one enabled output is enough.

2.3.5 Read/Write Command Register

(Write) Base+3: Write Command Register

(Read) Base+3: Read Command Register

Refer to chapter 4 for command sets format.

2.3.6 Clear Interrupt Signal Register

(READ) Base+4: Clear Interrupt Signal Register Format

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
X	X	X	X	X	X	X	X

X=don't care

The onboard machine independent timer can be programmed from 0.1ms to 100ms. When the time is up, a hardware signal can be used to interrupt PC. This signal will be active until access to BASE+3, clear interrupt signal register. The J1 will be in NC position in the factory setting, but the hardware interrupt signal is also active. Therefore the software will access or read the clear interrupt signal register after the timer is up.

2.4 CN1 Connector

CN1 : Digital Input Connector Pin Assignment.

Pin Number	Description	Pin Number	Description
1	Digital Input 0/TTL	2	Digital Input 1/TTL
3	Digital Input 2/TTL	4	Digital Input 3/TTL
5	Digital Input 4/TTL	6	Digital Input 5/TTL
7	Digital Input 6/TTL	8	Digital Input 7/TTL
9	Digital Input 8/TTL	10	Digital Input 9/TTL
11	Digital Input 10/TTL	12	Digital Input 11/TTL
13	Digital Input 12/TTL	14	Digital Input 13/TTL
15	Digital Input 14/TTL	16	Digital Input 15/TTL
17	PCB‘s GND output	18	PCB‘s GND output
19	PCB‘s +5V output	20	PCB ‘s +12V output

The ISO-DA16/DA8 has 16-channel TTL compatible D/I. The **DB-16P**(16 channel isolation input board) is designed for directly connecting to these D/I.

2.5 CN2 Connector

CN2 : Digital Output Connector Pin Assignment.

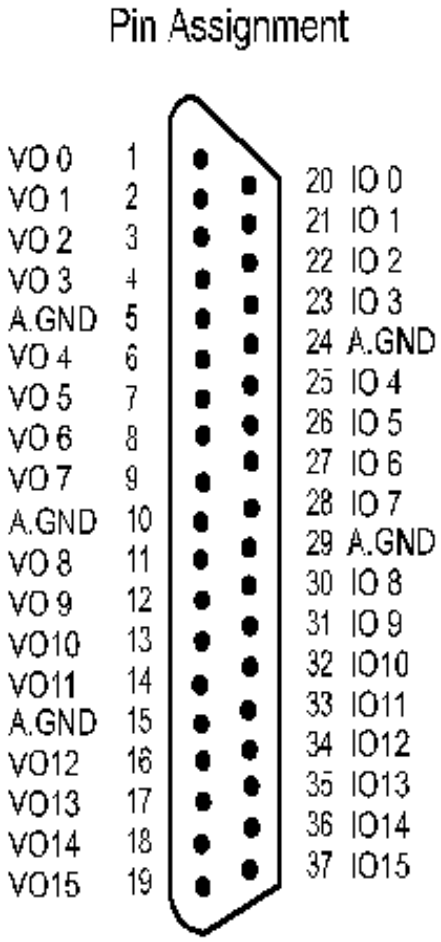
Pin Number	Description	Pin Number	Description
1	Digital Output 0/TTL	2	Digital Output 1/TTL
3	Digital Output 2/TTL	4	Digital Output 3/TTL
5	Digital Output 4/TTL	6	Digital Output 5/TTL
7	Digital Output 6/TTL	8	Digital Output 7/TTL
9	Digital Output 8/TTL	10	Digital Output 9/TTL
11	Digital Output 10/TTL	12	Digital Output 11/TTL
13	Digital Output 12/TTL	14	Digital Output 13TL
15	Digital Output 14/TTL	16	Digital Output 15/TTL
17	PCB‘s GND output	18	PCB‘s GND output
19	PCB‘s +5V output	20	PCB‘s +12V output

The ISO-DA16/DA8 has 16-channel TTL compatible D/O. The **DB-16R**(16 channel relay board) and **DB-24PR**(24 channel power relay board) are designed for connecting to these D/O

2.6 CN3 Connector

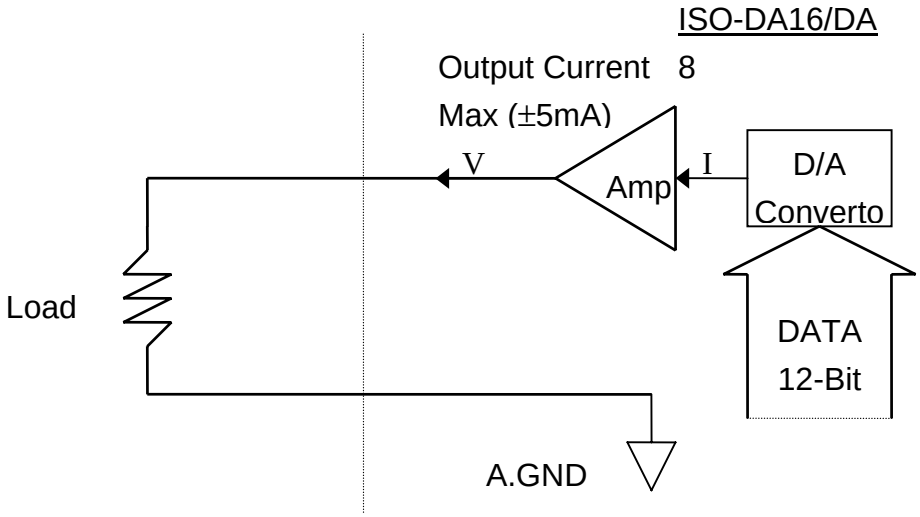
Pin assignment for single-ended analog input

Pin	Name	Pin	Name
1	Voltage Output 0	20	Current Output 0
2	Voltage Output 1	21	Current Output 1
3	Voltage Output 2	22	Current Output 2
4	Voltage Output 3	23	Current Output 3
5	Analog Ground	24	Analog Ground
6	Voltage Output 4	25	Current Output 4
7	Voltage Output 5	26	Current Output 5
8	Voltage Output 6	27	Current Output 6
9	Voltage Output 7	28	Current Output 7
10	Analog Ground	29	Analog Ground
11	Voltage Output 8	20	Current Output 8
12	Voltage Output 9	31	Current Output 9
13	Voltage Output 10	32	Current Output 10
14	Voltage Output 11	33	Current Output 11
15	Analog Ground	34	Current Output 12
16	Voltage Output 12	35	Current Output 13
17	Voltage Output 13	36	Current Output 14
18	Voltage Output 14	37	Current Output 15
19	Voltage Output 15		



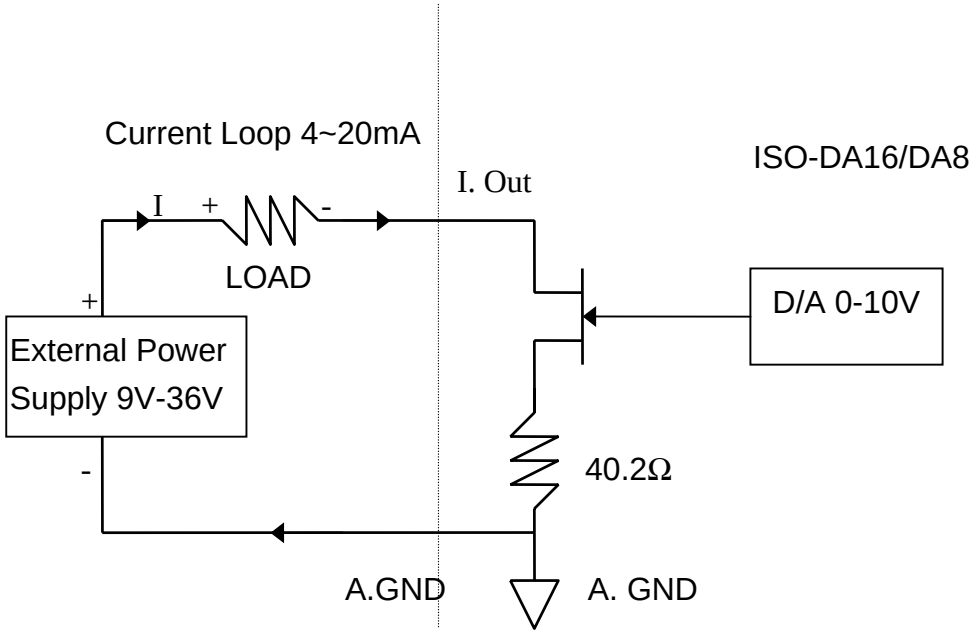
2.7 Signal Connection

2.7.1 Voltage Output Connection



The ISO-DA16/DA8 voltage output maximum current: ± 5 mA

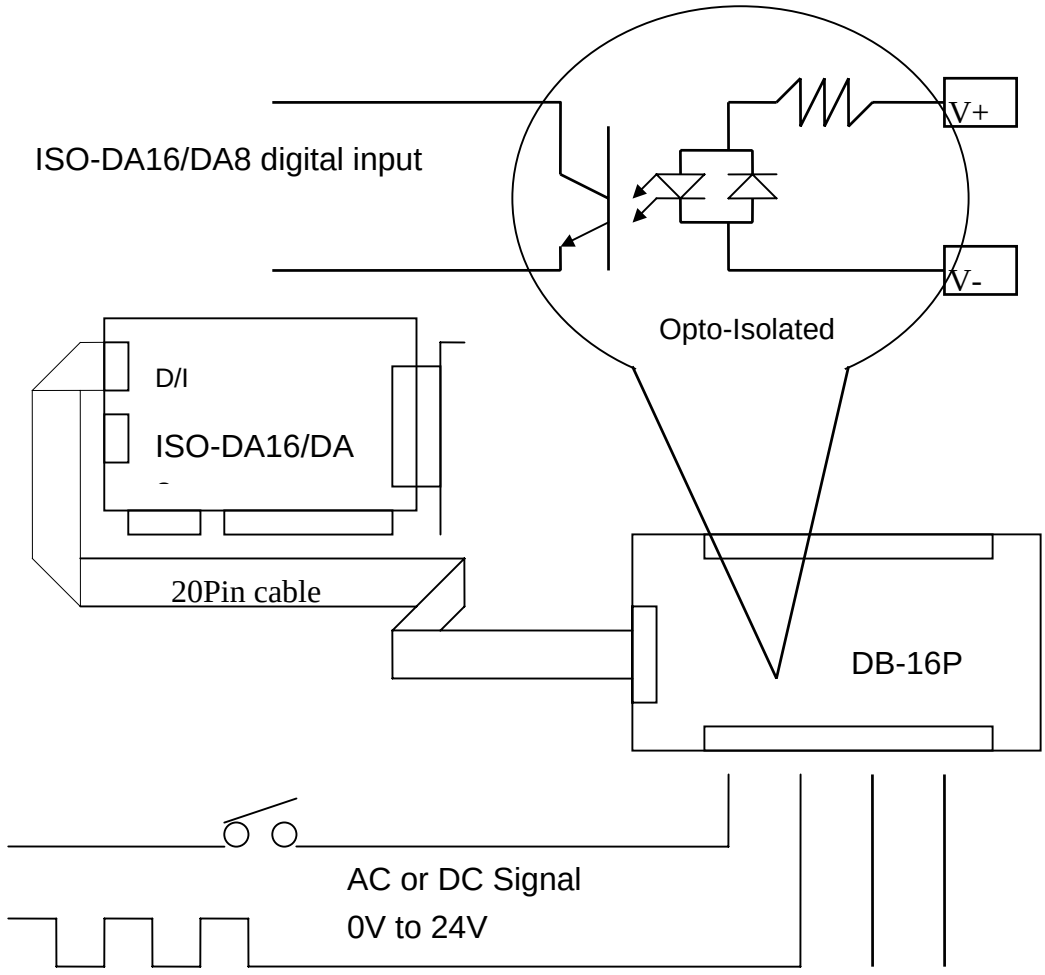
2.7.2 Current Output Connection



2.8 Daughter Boards

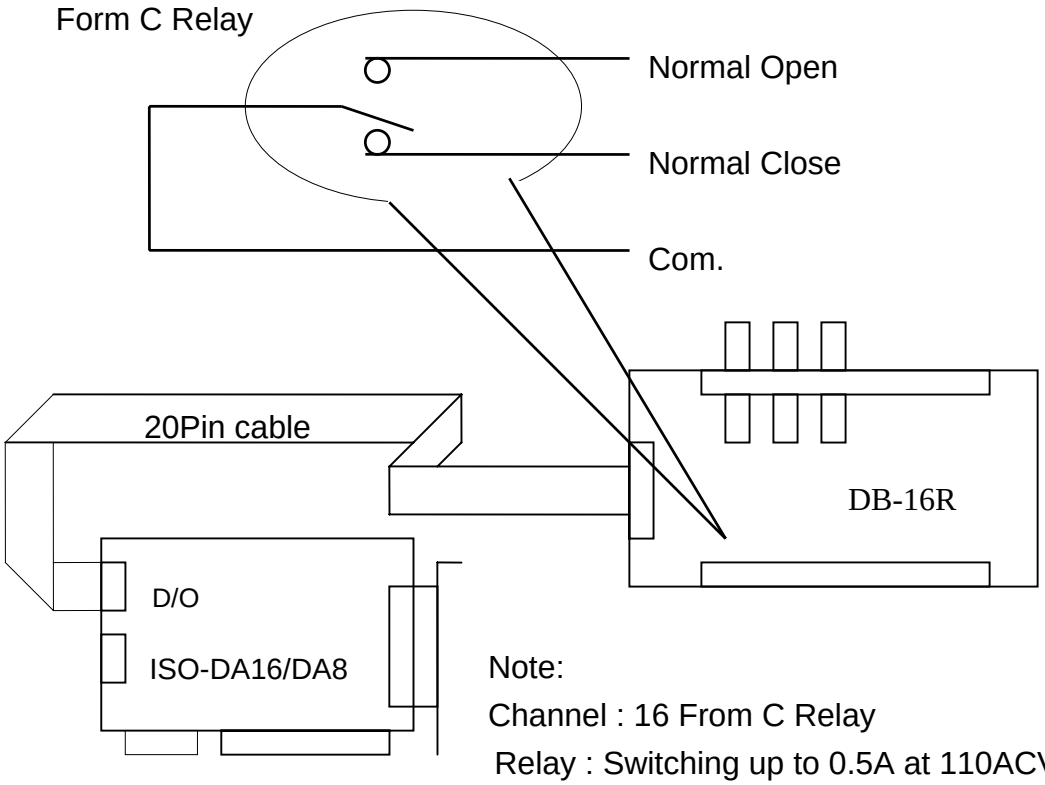
2.8.1 DB-16P Isolated Input Board

The DB-16P is a 16 channel isolated digital input daughter board. The optically isolated inputs of the DB-16P consist of a bi-directional optocoupler with a resistor for current sensing. You can use the DB-16P to sense DC signal from TTL levels up to 24V or use the DB-16P to sense a wide range of AC signals. You can use this board to isolate the computer from large common-mode voltage, ground loops and transient voltage spikes that often occur in industrial environments.



2.8.2 DB-16R Relay Board

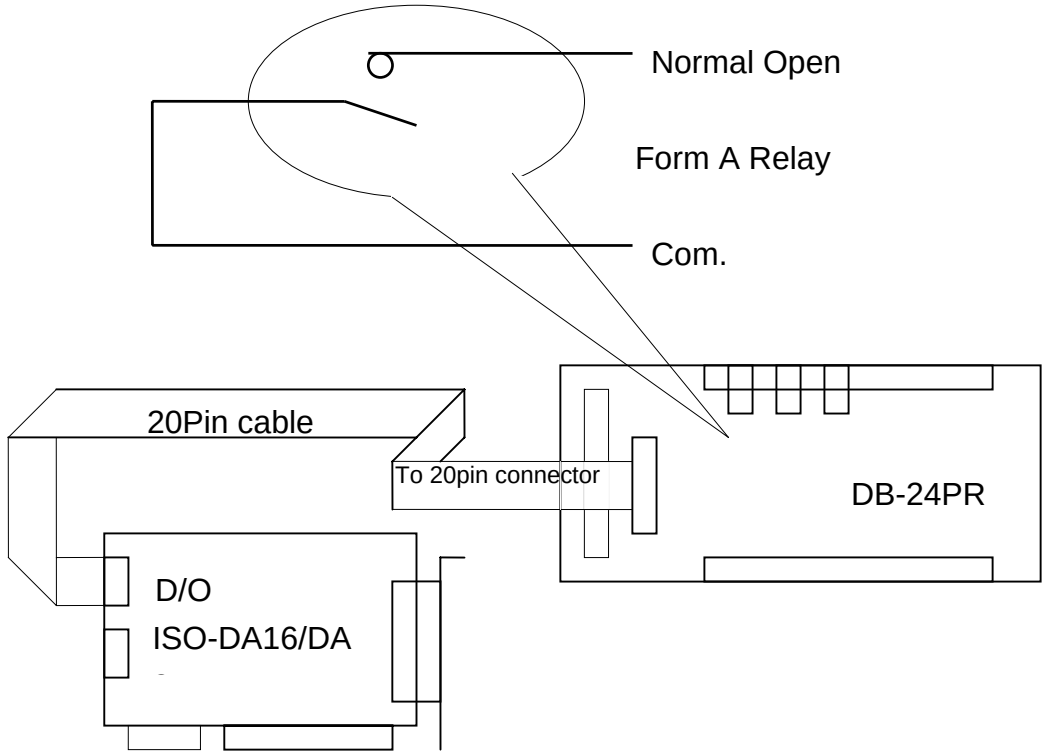
The DB-16R 16 channel relay output board consists of 16 form C relays for efficient switching of loads by programmed control. It is connector and functionally compatible with 785 series board but with industrial type terminal blocks. The relay are energized by applying a 5 volt signal to the appropriate relay channel on the 20-pin flat connector. There are 16 enunciator LEDs for each relay, light when their associated relay is activated. To avoid overloading your PC's power supply, this board provides a screw terminal for external power supply.



Note:
Channel : 16 From C Relay
Relay : Switching up to 0.5A at 110ACV
or 1A at 24DCV

2.8.3 DB-24PR Power Relay Board

The DB-24PR, 24-channel power relay output board consists of 8 form C and 16 form A electromechanical relays for efficient switching of loads by programmed control. The contact of each relay can control a 5A load at 250ACV/30VDCV. The relay is energized by applying a 5 volt signal to the appropriate relay channel on the 20-pin flat cable connector(just using 16 relays) or an 50-pin flat cable connector.(OPTO-22 compatible, for DIO-24 series). Twenty-four enunciator LEDs, one for each relay, light when their associated relay is activated. To avoid overloading your PC's power supply, this board needs a +12VDC or +24VDC external power supply.



Note:

50-Pin connector(OPTO-22 compatible), for DIO-24, DIO-48, DIO-144

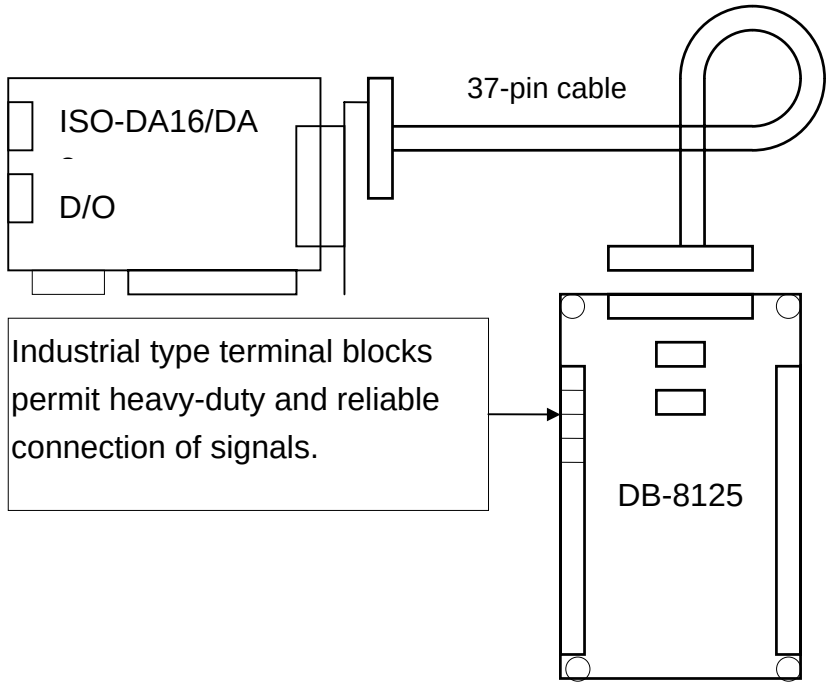
20-Pin connector for 16 channel digital output, A-82X, A-62X, DIO-64, ISO-DA16/DA8

Channel : 16 Form A Relay , 8 Form C Relay

Relay : switching up to 5A at 110ACV / 5A at 30DCV

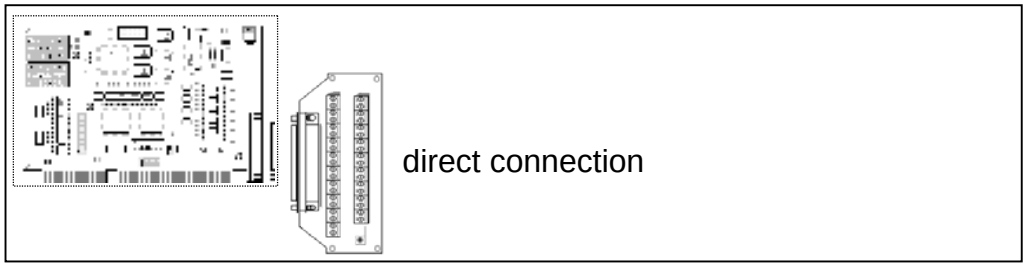
2.8.4 DB-8125 Screw Terminal Board

The DB-8125 is low cost universal screw terminal board. For 37-pin D-type connectors or two 20-pin connectors.



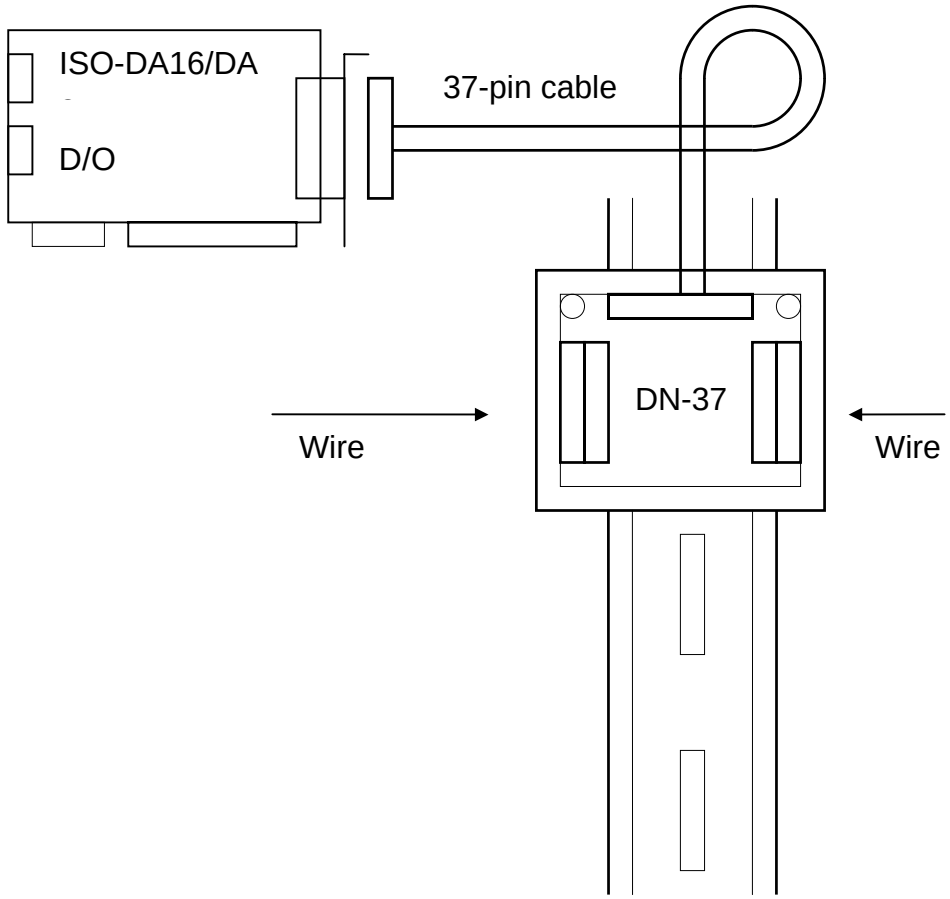
2.8.5 DB37

The DB-37 is a daughter board that directly connects to a D-sub 37 pins connector. It is designed for easy wire connections.



2.8.6 DN-37 (D-Sub Connector with DIN Rail Mounting)

Termination accessory with 37 screw terminals for easy connection of field I/O signals to 37-pin boards. Includes one 37-pin D-sub connector for direct connection to 37-pin cables with hardware for mounting on a standard DIN rail.



3. Function Operation

3.1 The ±10V Voltage Output

The D/A converter of the ISO-DA16/DA8 is 14-bit, from 0x0000 to 0x3FFF. The hardware is designed to output voltage about ±10.1V as follows:

0x0000 → about -10.1 volt

0x3FFF → about +10.1 volt

Therefore the software can calibrate the voltage output to ±10.000 volt without any hardware VRs adjustment. For example,

Channel Number	Min[n]=-10.000 volt	Max[n]=10.000 volt
0	134	16294
1	132	16296
2	134	16294
3	134	16295
4	137	16297
5	136	16297
6	138	16296
7	135	16295
8	135	16297
9	131	16298
10	136	16299
11	135	16296
12	133	16297
13	127	16302
14	134	16296
15	132	16296

If the user needs to send out **VV** volt to **channel n** voltage output, the hex value, **HH**, sent to D/A converter is given as follows:

Delta[n]=20.0/(MAX[n]-Min[n]); → Delta = volt per count

HH = (VV+10.0)/Delta[n]+Min[n]; → HH = Hex value sent to D/A converter

3.2 The ±5V Voltage Output

The voltage output hardware of ISO-DA16/DA8 is always in ±10V range. If the user need to output ±5V range, the software is the same as described in Sec. 3.1. Because the user wants to output ±5V range, therefore VV will be in the ±5V range, so the HH will be about from 0x1000 to 0x2FFF. **This means the resolution is about 13 bits.**

3.3 The 0-10V Voltage Output

The voltage output hardware of ISO-DA16/DA8 is always in ±10V range. If the user needs to output 0-10V range, the software is the same as described in Sec. 3.1. Because the user want to output 0-10V range, therefore VV will be in the 0-10V range, so the HH will be about from 0x2000 to 0x3FFF. **This means the resolution is about 13 bits.**

3.4 The 0-5V Voltage Output

The voltage output hardware of ISO-DA16/DA8 is always in ±10V range. If the user need to output 0-5V range, the software is the same as described in Sec. 3.1. Because the user wants to output 0-5V range, therefore VV will be in the 0-5V range, so the HH will be about from 0x2000 to 0x2FFF. **This means the resolution is about 12 bits.**

3.5 The 0-20mA Current Output

The voltage output hardware of ISO-DA16/DA8 is always in ±10V range. The 0-10V voltage output will convert to 0-22mA current output. Therefore the software can calibrate the current output to 0-20mA without any hardware VRs adjustment. For example,

Channel Number	Min[n]=0 mA	Max[n]=20.000 mA
0	134	16294
1	132	16296
2	134	16294
3	134	16295
4	137	16297
5	136	16297
6	138	16296
7	135	16295
8	135	16297
9	131	16298
10	136	16299
11	135	16296
12	133	16297
13	127	16302
14	134	16296
15	132	16296

If the user need to send out **II** mA to **channel n** voltage output, the hex value, **HH**, sent to D/A converter is given as follows:

Delta[n]=20.0/(MAX[n]-Min[n]); → Delta = mA per count
HH = II/Delta[n]+Min[n]; → HH = Hex value sent to D/A converter

The resolution is about 13 bit.

3.6 The 4-20mA Current Output

The voltage output hardware of ISO-DA16/DA8 is always in ±10V range. The 0-10V voltage output will convert to 0-22mA current output. If the user needs to output 4-20mA, the software is the same as described in Sec. 3.5. Because the user want to output 4-20mA, therefore II will be in the 4-20 range, so the HH will be about from 0x2600 to 0x3FFF. **This means the resolution is about 13 bits.**

3.7 No VR & No Jumper Design

In the conventional 12-bit D/A board, for example A-626/A-628, there are many jumpers for the following functions:

(1) Select the reference voltage (internal -10/-5/or external)
(2) Select unipolar/bipolar (0-10V or ±10V)
(3) Select different output range (0-10V or 0-5V)

And there are many VRs for the following functions:

(1) Voltage output offset adjustment
(2) Voltage output full-scale adjustment
(3) Current output offset adjustment
(4) Current output full-scale adjustment

There are so many VRs and jumpers, this makes QC and re-calibration very difficult. Every step must be handled by human hands. It is not a happy job for people to calibrate these D/A boards.

When we design the ISO-DA16/DA8, we try to remove all these terrible VRs and jumpers but still maintain the same precision and performance. In the long run, we selected a 14-bit D/A converter and adapted the software calibration to provide at least the same performance & precision as A-626/A-628 as follows:

Configuration	Equivalent Bit	Resolution
-10V to +10V	14 bit	
0V to 10V	13 bit	
-5V to +5V	13 bit	
0V to 5V	12 bit	
0mA to 20mA	13 bit	
4mA to 20mA	13 bit	

- All the VRs and jumpers are removed.
- All calibrations can be done by software.
- All channel configurations can be selected by software, no need to change any hardware.
- The precision is at least the same as A-626/A-628.
- All 16 channels can be configured and used in different configurations at the same time.(for example, channel_0 = ±10V, channel_1 = 4-20mA, channel_2 = 0 to 5V, …..)
- All these features can be implemented in a small, compact, reliable and half-size PCB.

3.8 Software Calibration

It is recommended to use a 16-bit A/D card to calibrate the ISO-DA16/DA8. The ICP Con I-7000 series is a set of precision remote controlled modules. The I-7017 is 8-channel 16-bit precision A/D module(24-bit sigma-delta A/D converter), we use two I-7017 for voltage output calibration and another two I-7017 for current output calibration.

The steps for channel_n voltage output calibration are given as follows:

step 1 : HH=0
step 2 : send HH to ISO-DA16/DA8 channel_n
step 3 : measure the I-7017 channel_n,
if this value is just >= -10V, then goto step5
step 4 : increment HH and goto step2
step 5 : Min[n]=HH-1
step 6 : HH=0x3FFF
step 7 : send HH to ISO-DA16/DA8 channel_n
step 8 : measure the I-7017 channel_n,
if this value is just >= +10V, then goto step10
step 9 : increment HH and goto step7
step 10: Max[n]=HH
NOTE : Min[n] & Max[n] are described in Sec. 3.1

The steps for channel_n current output calibration are given as follows:

step 1 : HH=0x2000
step 2 : send HH to ISO-DA16/DA8 channel_n
step 3 : measure the I-7017 channel_n,
if this value is just >= 0mA, then goto step5
step 4 : increment HH and goto step2
step 5 : Min[n]=HH-1
step 6 : HH=0x3FFF
step 7 : send HH to ISO-DA16/DA8 channel_n
step 8 : measure the I-7017 channel_n,
if this value is just >= 20mA, then goto step10
step 9 : increment HH and goto step7
step 10: Max[n]=HH
NOTE : Min[n] & Max[n] are described in Sec. 3.5