Universitat Autònoma de Barcelona

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MELISSA Pilot Plant Higher Plants Chamber: Control Hardware Design

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SECTION 1

MELISSA Pilot Plant Higher Plants Chamber: Control Hardware Design

TN 95.3

MELISSA PILOT PLANT HPC CONTROL HARDWARE DESIGN DOCUMENT

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CONTENTS

LIST OF ACRONYMS

CIVb	Compartment IVb
HPC	Higher Plants Compartment
I/O	Input / Output
PLC	Programmable Logic Controller
MELiSSA	Micro-Ecological Life Support System Alternative
MPP	MELiSSA Pilot Plant
UAB	Universitat Autònoma de Barcelona
UoG	University of Guelph

1. SCOPE

This document describes the design of the Control System for the Higher Plants Compartment (HPC) that is to be installed at the MELiSSA Pilot Plant, located at the UAB's premises.

This document is the output of activity 1.2, as described in the annex to AD1, and describes the design of the HPC Control System cabinet, which is the object of activity 2 in the same annex to AD1.

This document is also the same one identified as output to W.P. Ref. 95.3, described in RD1.

It contains the electrical design, mechanical design and implementation, identification of components and connectivity information for connection to the HPC.

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1 Applicable documents

AD1 SHERPA ENGINEERING, Purchase Order P1804_NTE, MELiSSA HPC Control System, dated 03/04/07

AD2 UoG (Dr. G. Waters) e-mail, dated 05/09/07 with attachment UoG HPC1 Prototype IO Tables Edited by GW Sept 5 2007.xls

2.2 Reference documents

RD1 Work Order MELiSSA Pilot Plant: HPC Control Design and Implementation, MELiSSA Pilot Plant Frame Contract 19445/05/NL/CP, ref. OFR-ESA-02/07-UAB, dated 23/03/07

3. MELISSA CIVB HPC OVERVIEW

The Higher Plants Compartment, HPC, also referred as Compartment IVb or CIVb, is one element within the MELiSSA loop, whose concept is depicted in Figure 3-1 The purpose of the HPC is the production of O_2 and edible biomass by growing higher plants in a controlled environment which, in turn, will consume CO_2 and $NO3^-$ generated within the loop.

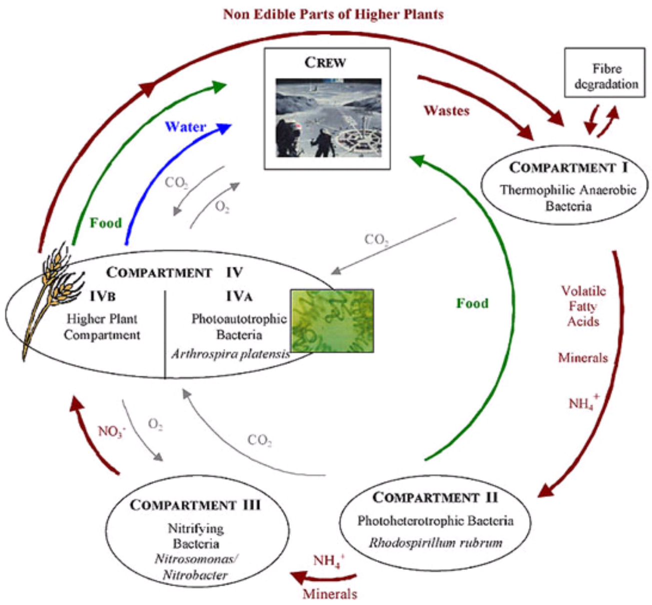


Figure 3-1 MELiSSA LOOP CONCEPT

Two elements can be distinguished in the MELiSSA HPC, as shown in Figure 3-2:

- The HPC chamber,
- Control Cabinet,

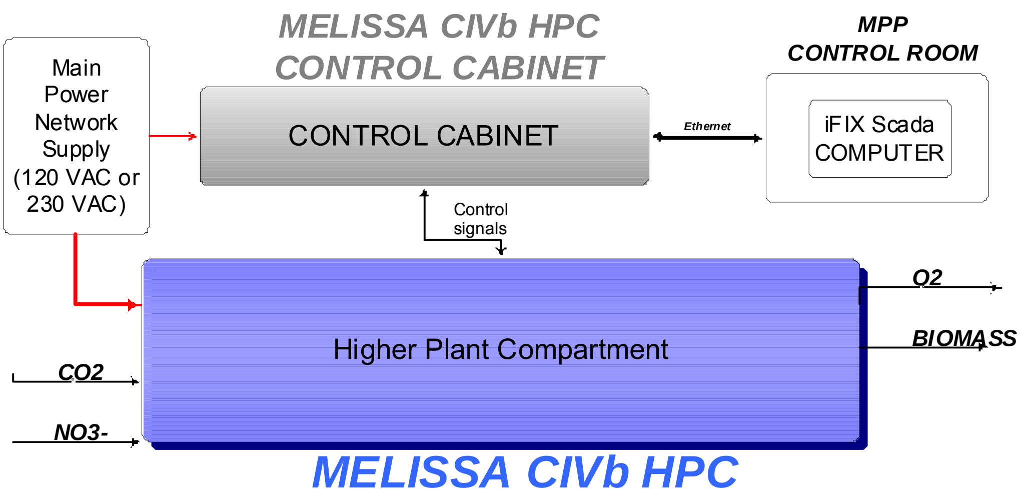


Figure 3-2 MELiSSA CIVb HPC overview

Higher Plant Compartment, HPC

The HPC, shown in Figure 3-3, provides the habitat, conditions and infrastructure for the controlled growth of higher plants. For what concerns the control system it features all the actuators (fans, pumps, blowers, etc.), sensors and power control devices needed for the an automatic control and status monitoring. The HPC concept is similar to an automatic greenhouse with a liquid and gas closed loop.

The MELiSSA has been developed by the University of Guelph (Canada), and is to be installed at the MELiSSA Pilot Plant (MPP) at the UAB premises.

Figure 3-3 MELISSA CIVb Higher Plant Compartment

Control cabinet

The Control Cabinet (Figure 3-4) houses the HPC Control System equipment. It contains the PLC (Programmable Logic Controller) with the required processor, I/O and power supply modules, interface connectors, network elements and power safety devices. It also features a touch screen framed in its door for local monitoring and control. This equipment allows the control and monitoring of all the HPC parameters required for its automatic operation. The Control Cabinet is to be installed next to the HPC also at MPP in UAB.

Figure 3-4 Control cabinet

4. MELISSA CIVB HPC CONTROL CABINET OVERVIEW

The MELISSA CIVb HPC Control Cabinet acquires from the HPC and supplies to the HPC all the signals needed to control and monitoring the HPC. Figure 4-1 reproduces the control concept and details the main elements within the cabinet.

The Control System is housed in a industrial metallic cabinet model TS8806.500 by Rittal. The cabinet's size 800x600x2000 mm (w x d x h). An HMI panel (Magellis touch screen) is embedded in the cabinet's front door (Figure 3-4).

The Control System consists of two main blocks:

PLC Control:

- PLC SIGNALS
  - Analog input voltage
  - Analog input current
  - Digital input
- LOW POWER RELAYS
  - Digital output

Information Distribution:

- HMI PANEL VIEW
- ETHERNET SWITCH (Ethernet network)

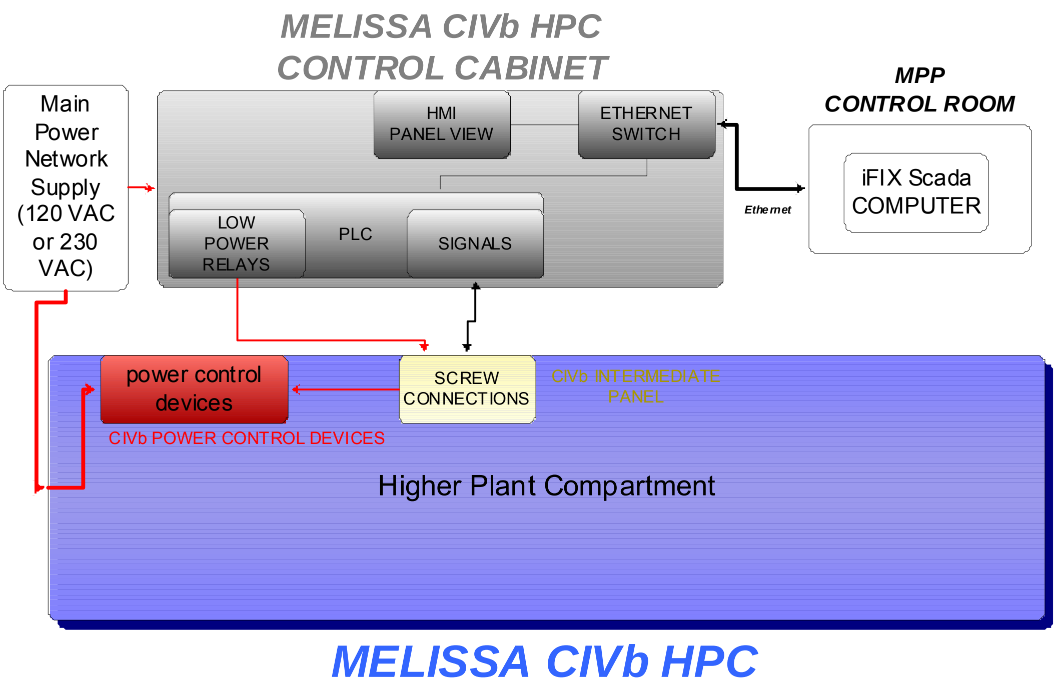


Figure 4-1 MELiSSA CIVb HPC detailed overview

The Control Cabinet features three interfaces:

- Interface to the MPP power supply (mains) with European characteristics (220 -230 VAC, 50 Hz)
- Interface with the HPC by means of an intermediate connector panel which receives the wiring originated at the HPC and mates it with the corresponding wiring originated in the Control Cabinet
- Interface with the MPP Control Room using an Ethernet connection for allowing the implementation of the monitoring and surveillance functions on the MPP’s central computer

5. MELISSA CIVB HPC CONTROL CABINET DESCRIPTION

Figure 5-1 shows a block diagram with the control cabinet's elements. Three subsystems can be identified:

- ***ENERGY DISTRIBUTION***
  - ELECTRICAL PROTECTIONS
  - POWER SUPPLIES
    - 24 VAC
    - 24 VDC
    - UPS (Uninterrupted Power Supply)
    - PLC POWER SUPPLY
- ***ELECTRONICS***
  - PLC
    - I/Os
  - ETHERNET SWITCH
  - HMI PANEL VIEW
- ***TERMINAL BLOCKS***
  - I/Os CONNECTORS
  - RELAYS

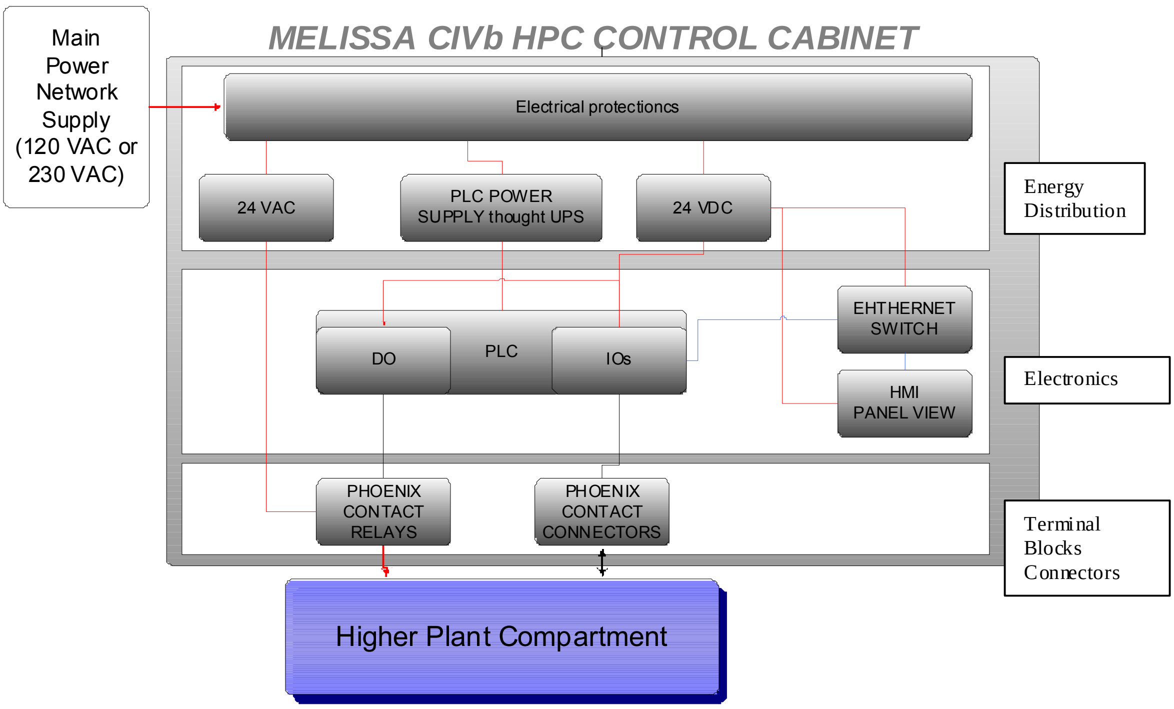


Figure 5-1 MELiSSA CIVb Control Cabinet detailed view

5.1 CIVB HPC Energy Distribution

This subsystem distributes power to all the components within the control cabinet that must be powered (either using AC directly from the mains at 220-230 VAC and 50 Hz, or DC through converters).

To be underlined that devices located within the HPC like pumps, fan and other actuators will be powered independently from the Control Cabinet.

The components of the Energy Distribution S/S are:

- ELECTRICAL PROTECTIONS
    - Magnetothermic
    - Differential
- POWER SUPPLIES & LOADS
    - 24 VAC
    - 24 VDC
    - UPS (Uninterrupted Power Supply)
    - PLC POWER SUPPLY

5.1.1 Power consumption

Table 5-1 shows all the electrical loads of MELISSA CIVb HPC control cabinet.

DEVICE	*POWER CONSUPTION [W]*	*Operational range voltage*
24VDC POWER SUPPLY	150 W	100-240 VAC
24 VAC POWER SUPPLY	300 W	115 OR 230 VAC (CONFIGURABLE)
CABINET FANS	50 W	230 V
PLC POWER SUPPLY x 2	300 W	115 OR 230 VAC (CONFIGURABLE)
Total	**800 W**	

Table 5-1 ELECTRICAL LOADS OF MELISSA CIVB HPC CONTROL CABINET

The exact power consumption is difficult to be estimated, and it must take into account potential expansions. It is usually oversized with a 20% security factor to consider future system expansions. Thus the system is dimensioned to withstand a power consumption up to 960 W.

*Ps(electronics) = P(nominal)*Security factor*	*P(nominal)*	*Security factor*
960 W	800 W	1,2

5.1.2 Current consumption

The cos(Φ) parameter is the angle difference between voltage and current. This parameter depends on the type of electronic device and situation. Modern electronics power supply have a good cos(Φ) factor, but high electric noise (harmonics). The 24 VAC transformer and low power fans are devices that have worse cos(phi) factor, but this is not much relevant. Transformer's cos(Φ) depends on the load, so the current value can be determined easily.

The value cos(Φ)=0,98 can be select for current determination, as shown in Table 5-2 (where current is also computed for AC power systems at 115 VAC, for comparison purposes).

Is (electronics) = Ps (electronics)/ (Voltage*cos(phi))	Ps (electronics)	Voltage	cos (phi)
4,3 A	960 W	230 VAC	0,98
8,5 A	960 W	115 VAC	0,98

Table 5-2 Current consumption depends of supply voltage

5.1.3 Wire cross section calculation

To determine the wire cross section needed in the Control Cabinet installation guideless given in Table 5-3 are used. This information, together with the corrections given later in Table 5-4 and Table 5-5, are extracted from the *Reglamento Baja Tensión* (Low Voltage Regulation) applicable to electrical installations in Spain.

service temperature 70ºC - ambient temperature 30ºC			
size	admisible current (A)		
nominal mm^2	Group 1	Group 2	Group 3
0,75	-	12	15
1,0	11	15	19
1,5	15	19	23
2,5	20	25	32
4,0	25	34	42
6,0	33	44	54
10,0	45	61	73

Table 5-3 Current capability in function of nominal cross section in mm^2 and installation type.

Where:

- Group 1: single conductor plastic pipe
- Group 2: multi-wire in plate
- Group 3: single conductor and multi-conductor cable in free air

The group that is applicable fort the HPC Control Cabinet is group 2. Conductors will be grouped within a plastic cover in groups of 2 to 8 wires. Therefore, a derating factor equal to 0,7 must be applied in accordance to Table 5-4.

Number of conductors	Factor
4 a 6	0,8
7 a 24	0,7
25 a 42	0,6
more than 42	0,5

Table 5-4 Derating factor for multi-conductor cables

In worse case conditions the highest estimated ambient temperature inside of control cabinet is around 45º C. The target equipment service temperature is 60ºC, in order to ensure a good safety range. So, according Table 5-5 a temperature correction factor equal to 0.58 must be applied.

Ambient temperature °C	Factor	
	Service temperature	
	60ºC	75 - 90ºC
30 to 40	0,82	0,88
40 to 45	0,71	0,82
45 to 50	0,58	0,75
50 to 55	0,41	0,67
55 to 60		0,58
60 to 70		0,35

Table 5-5 Temperature factor correction

Therefore, taking into consideration the multi-conductor and temperature correction factors current levels can be determined, as shown in Table 5-6:

		Multi-conductor correction factor	Ambient temperature correction factor	Both correction factor
Nominal mm2	**Group 2**	**0,7**	**0,58**	**0,406**
0,75	12 A	8,4 A	7,0 A	***4,9 A***
1,00	15 A	10,5 A	8,7 A	***6,1 A***
1,50	19 A	13,3 A	11,0 A	***7,7 A***
2,50	25 A	17,5 A	14,5 A	***10,2 A***
4,00	34 A	23,8 A	19,7 A	***13,8 A***
6,00	44 A	30,8 A	25,5 A	***17,9 A***
10,00	61 A	42,7 A	35,4 A	***24,8 A***

Table 5-6 Current carrying capacities of copper conductors with correction factors

Table 5-7 shows the wire requirements depending on the expected current consumption. In the case of 220VAC cables of 2,5mm^2 and 1mm^2 can be used. The exact section is indicated in the cabinet's electrical schematics.

NET	REQUIREMENTS	WIRE
I/O Signals	Max. 1A at 24VAC	24 AWG
24VDC	Max. Current 5A	1mm^2
220VAC / 125VAC	Distribution max. 8,5A	2,5mm^2
	device supply	1mm^2

Table 5-7 Type of wire depending of the net

5.2 Electrical protection devices

The HPC Control Cabinet features two main electric protections:

- Magnetothermic
- Differential

Magnetothermic devices are used to protect overcurrent and shortcircuit. Differential device is used as a safety protection to operators, using Earth Leakage Protection system.

5.2.1 Magnetothermic selection

There are three main types of magnetothermic protection: B,C,D defined by the international regulation IEC 60898 (Circuit-breakers for overcurrent protection for household and similar installations), whose performance is shown in Figure 5-2:

- Type B: 3 a 5 In
- Type C: 5 a 10 In
- Type D: 10 a 20 In

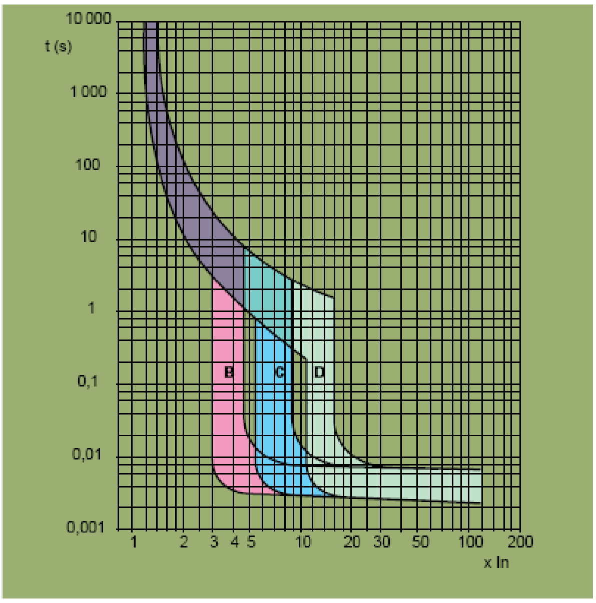


Figure 5-2: Circuit breakers performance

In this case the selection is type C as it is the most common used in standard applications (type B is used for long wire distance installations and type D is usually used for motor applications). For the Control Cabinet a 230VAC 6A rated magnethotermic is selected because the maximum consumption is 4.3A, see Table 5-2

5.2.2 Differential selection

The selected differential device will support an overall consumption of 16 A with a 10 mA protection.

5.2.3 Electrical energy distribution s/s schematic

Figure 5-3 shows the electrical distribution network implemented in HPC Control Cabinet

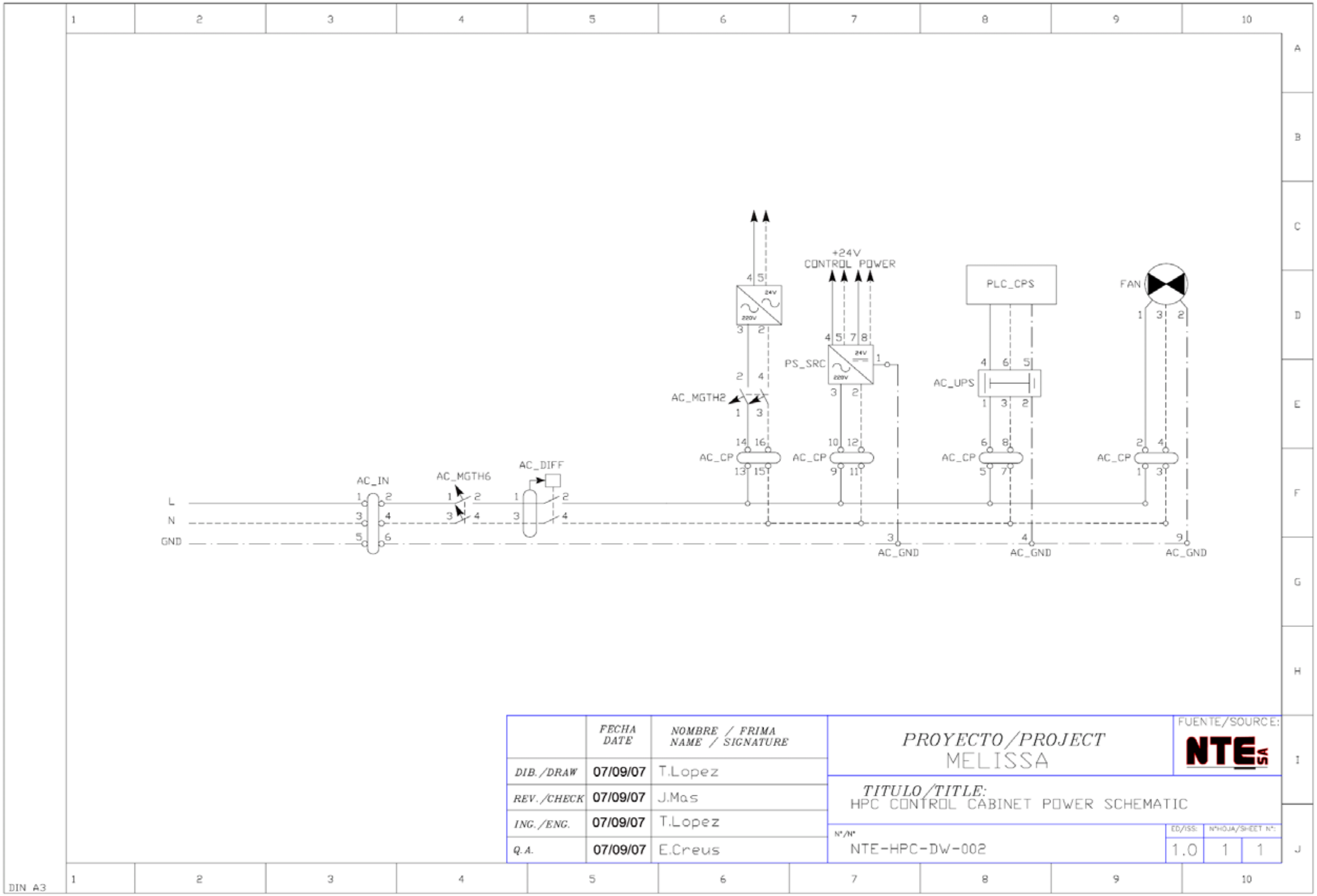


Figure 5-3 HCP Control Cabinet power schematic

5.2.4 115/230VAC Configuration

The HPC Control cabinet can operate either at 230 VAC or 115 VAC. The default configuration is 230 VAC. The wiring and electrical protections implemented in the cabinet also support 115 VAC.

To change the AC voltage configurations some changes must be done in the:

- PLC power supplies
- 24VAC Transformer

5.2.4.1 PLC power supply configuration

Modification is shown in Figure 5-4.

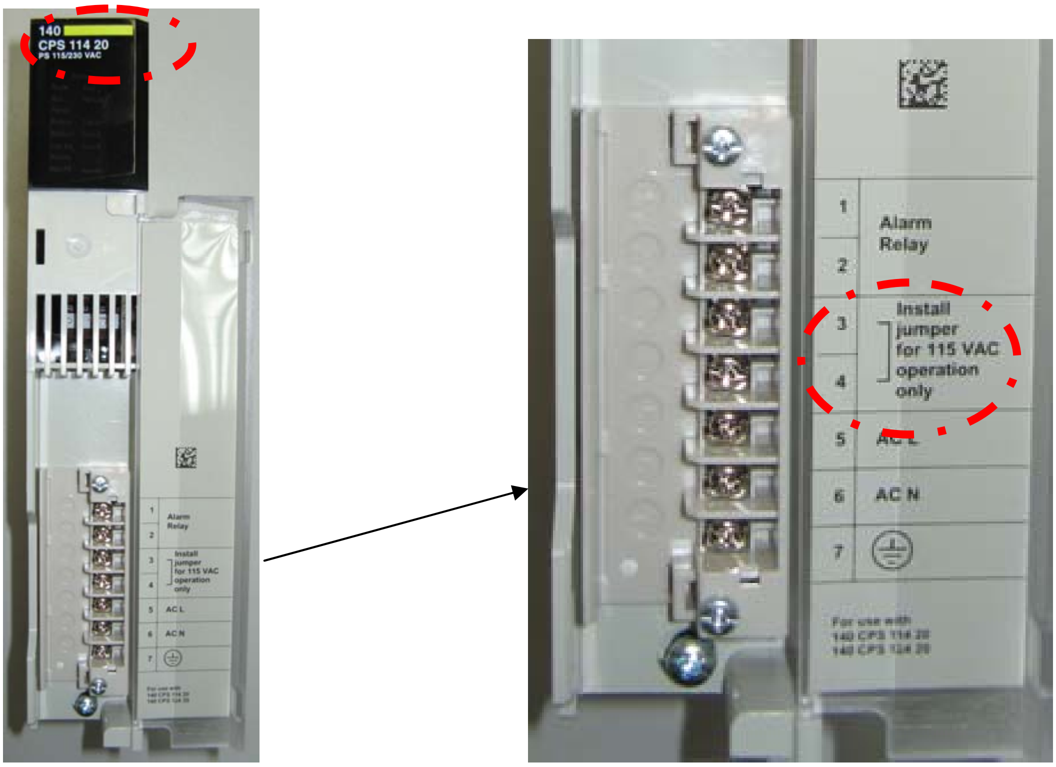


Figure 5-4 PLC power supply change for 115 VAC operation

5.2.4.2 24 VAC transformer configuration

To operate at 115VAC, connection of transformer will be between 0V and 115VAC (terminals 5 and 8 in Figure 5-5).

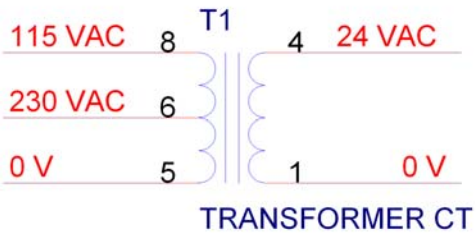


Figure 5-5 24 VAC transformer change for 115 VAC operation

WARNING: WRONG AC CONFIGURATION CAN DAMAGE THE EQUIPMENT.

DEFAULT SETTING MUST NOT BE ALTERED IF THE POWER SUPPLY IS AT 230 VAC

5.3 CIVB HPC ELECTRONICS

The HPC Control Cabinet core element is the Quantum PLC by Scheneider, which is configured by:

- The processor card
- Set of I/O cards
- Power supply cards

5.3.1 I/O analysis

The Scheneider PLC system features specific I/O cards depending on the nature of the signals to be processed:

Digital Input, DI cards, model ***140DDI84100***, with 16 ports

Digital Output, DO cards, model ***140DDO35300***, with 32 ports

Analog Current Input, ACI cards, model ***140ACI03000***, with 8 ports

- Voltage: (1 – 5 VDC) or Current (4 – 20 mA)
- Resolution 12 bits

Analog Voltage Input, AVI cards, model ***140AVI03000***, with 8 ports

- Voltage: (0 – 10 VDC) or (0 – 5 VDC) or Current (4 – 20 mA)
- Resolution 16/15/14 bits, and bipolar option in available.

Analog Output, AO cards, model ***140ACO13000***, with 8 ports

Table 5-8 shows the I/O requirements to meet the HPC needs, according to the interface documentation, i.e. type and number of signals, provided by UoG in the AD2 document. The NEEDED row accounts for 8 extra (spare) inputs in each class, except for the AO type.

I/Os	*DI*	*DO*	*AI*			*AO*
			ACI	*AVI (0-10VDC)*	*TOTAL*	
USED	17	20	21	20	41	5
NEEDED	25	28			49	5

Table 5-8 I/O used in the HCP1

The number of cards needed to meet these requirements is reported in Table 5-9:

Reference	Number of cards	IO type	IO per card	total IO
140DDI84100	2	DIGITAL IN	16	32
140DDO35300	1	DIGITAL OUT	32	32
140ACI03000	3	CURRENT IN	8	24
140AVI03000	4	VOLTAGE IN	8	32
140ACO13000	1	CURRENT OUT	8	8

Table 5-9 I/O cards required for the PLC system

Eleven IO cards are needed to fulfil specifications indicated in Table 5-8. However, the Schneider's Quantum PLC configuration requires and especial expansion IO card if more than ten IO cards must be controlled. If only 10 IO cards would be implemented the margin for free input and output access points would be as presented in Table 5-10. It is observed that the margin of eight (8) free access points is well met for the DI and DO class of signals. The margin is seven (7) for the AI type and it is three (3) for the AO type.

Therefore, a PLC configuration with 10 IO cards instead of 11 is taken, as it is considered to provide enough free access margin, which renders unnecessary the additional (non-negligible) expenses associated to the inclusion of the 11th card. The I/O margin (free signals) is shown in Table 5-10:

I/Os	DI	DO	AI			AO
			ACI	AVI (0-10VDC)	TOTAL	
USED	17	20	21	20	41	5
NEEDED	25	28			49	5
AVALIABLE	32	32	24	24	48	8
TOTAL FREE (ACTUALLY NOT USED)	15	12	3	4	7	3

Table 5-10 Number of I/O need, available and free signals

5.3.2 PLC configuration

The various Quantum PLC cards are mechanically mounted on two backplanes (named PLC and PLC expansion) with 10 available slots each. The distribution of these cards is displayed in Table 5-11 and Table 5-12, showing the manufacturer reference identification (140XXXXXXXX), the description of the module and the mnemonic identification used in the CIVb_RACK. The physical PLC assembly on the backpanels is shown in Figure 5-6.

PLC									
1	2	3	4	5	6	7	8	9	10
140CPS11420	140CPU43412A	140NOE77101	140DDI84100	140DDI84100	140ACO13000	140DDO35300			140XBE10000
Backplane Power Supply module	CPU module	Ethernet module	16 Digital inputs 10-60 VCC	16 Digital inputs 10-60 VCC	8 Analog output 0-20/4-20 mA	32 Digital output 60VCC			Rack expansion
CIVb_PLC_CPS	CIVb_PLC_CPU	CIVb_PLC_NOE	CIVb_PLC_IO_DDI	CIVb_PLC_IO_DDI	CIVb_PLC_IO_ACO	CIVb_PLC_IO_DDO			CIVb_PLC_XBE

Table 5-11 PLC backplane card distribution

PLC EXPANSION									
1	2	3	4	5	6	7	8	9	10
140CPS11420	140AVI03000	140AVI03000	140AVI03000	140AVI03000		140ACI03000	140ACI03000	140ACI03000	140XBE10000
Backplane Power Supply module	8 Analog input 0-10 VDC	8 Analog input 0-10 VDC	8 Analog input 0-10 VDC	8 Analog input 0-10 VDC		8 Analog input 4-20 mA	8 Analog input 4-20 mA	8 Analog input 4-20 mA	Rack expansion
CIII_PLC_CPS	CIVb_PLC_IO_AVI	CIVb_PLC_IO_AVI	CIVb_PLC_IO_AVI	CIVb_PLC_IO_AVI		CIVb_PLC_IO_ACI	CIVb_PLC_IO_ACI	CIVb_PLC_IO_ACI	CIVb_PLC_XBE

Table 5-12 PLC backplane expansion card distribution

Figure 5-6 PLC assembly on backpanels

5.4 CIVb HPC TERMINALS BLOCKS

5.4.1 VARIOFACE PHOENIX PLUGGABLE SYSTEM

Internal wiring in the HPC Control cabinet is implemented using the PHOENIX *VARIOFACE PLUGGABLE* system. Figure 5-7 compares this wiring approach to the traditional wiring system. This graphic comparison shows that this latter wiring system is more cumbersome and prone to errors.

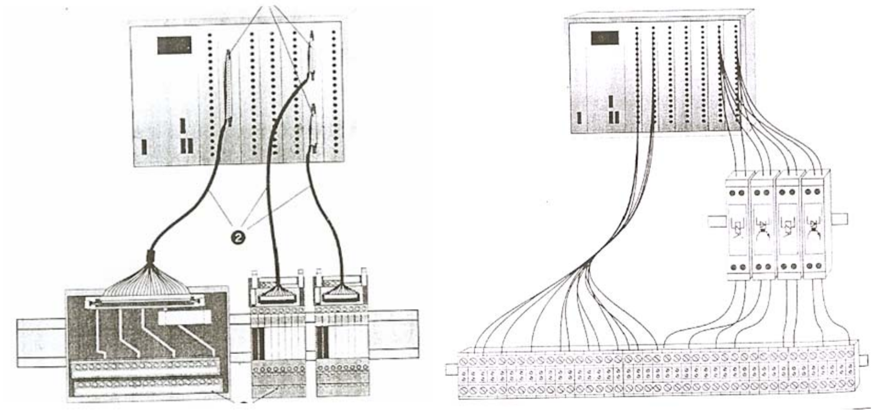
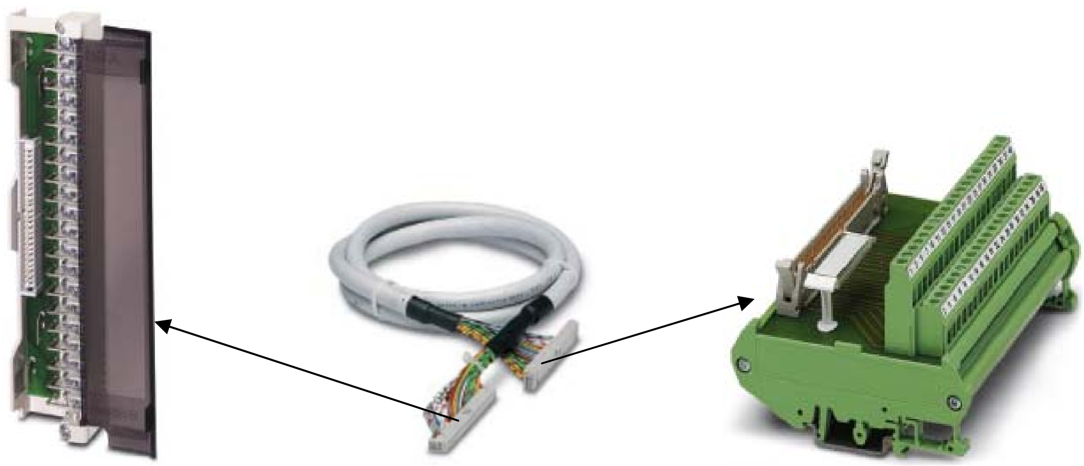


Figure 5-7 PHOENIX VARIOFACE pluggable system vs traditional wiring system

This PHOENIX VARIOFACE wiring system consist of (see Figure 5-8)

- PLC frontal module FLKM 50-PA-MODI-TSX/Q
- Pre-built cable with IDC connectors
- Connection modules FLKM 50/MODI-TSX/Q



FLKM 50-PA-MODI-TSX/Q
PLC FRONT MODULE

FLKM 50/MODI-TSX/Q
CONNECTOR INTERFACE
MODULE

Figure 5-8 different components of PHOENIX VARIOFACE PLUGGABLE system

Interface module is compatible pin to pin with plc cards. It means that pin one of plc card is physically connected to pin one of interface module (see Figure 5-9).

Figure 5-9 electrical diagram of front module and interface module by phoenix

5.4.2 VARIOFACE PHOENIX RELAY Modules

VARIOFACE PHOENIX RELAY module is split in to modules RELAY_1 and RELAY_2. Each module has 16 relays, therefore 32 relays are available, from #1 to #32. Each relay has 3 connection: ports (Figure 5-10). Relay characteristics are shown in Figure 5-15. Relays have enough power to connect all low power loads(all of them, down 30 W at 24VAC).

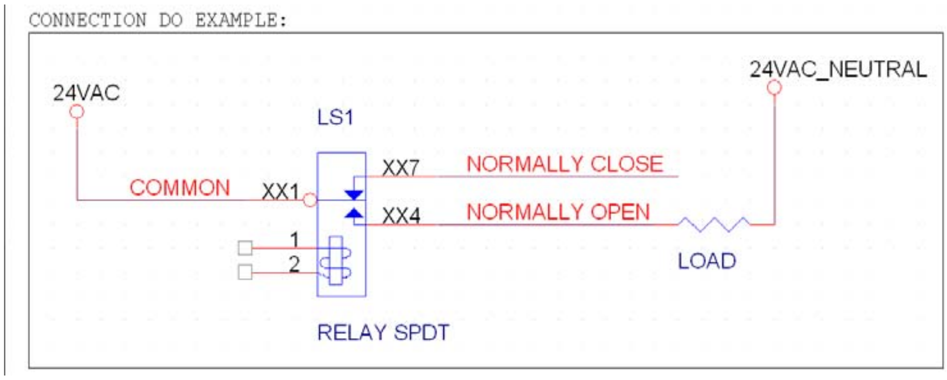


Figure 5-10 Relay connection logic

XX1: common contact.

XX4: NO contact (Normally Open)

XX7: NC contact (Normally Close).

Where:

- XX= number of physical relay [1….32]
- XX1=[11,21,31,...101,111,…321]
- XX4=[14,24,34…104,114…324]
- XX7=[17,27,37,…107,117,….327]

UMK-16RM/KSR-G 24/21/PLC

Input data	
Nominal input voltage U_N	24 V AC/DC ±10 %
Name of protection	Free-wheeling diode
Protective circuit/component	Damping diode
Operating voltage display	LED green
Status display/channel	Yellow LED
Output data	
Contact type	1 PDT
Maximum switching voltage	250 V AC/DC
Limiting continuous current	5 A

Figure 5-11 Phoenix relay performance

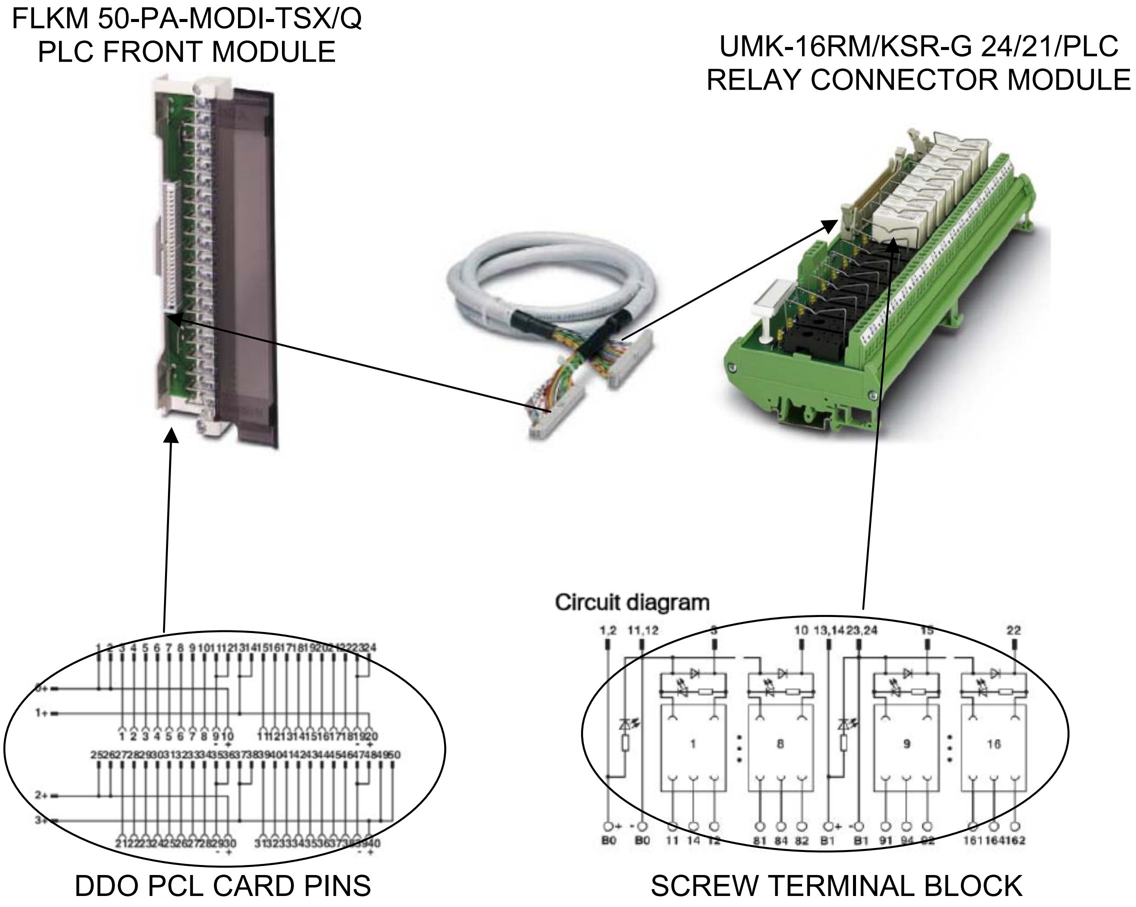


Figure 5-12 VARIOFACE PHOENIX and relay connector module

5.4.3 DIGITAL INPUT

There are 17 digital input signals needed and 8 additional ones must be left as spare. The selected card is 140DDI84100, with 32 digital input arranged in sixteen double groups. Each group can be connected to different voltage references. Voltage input can be between 10 to 60 V.

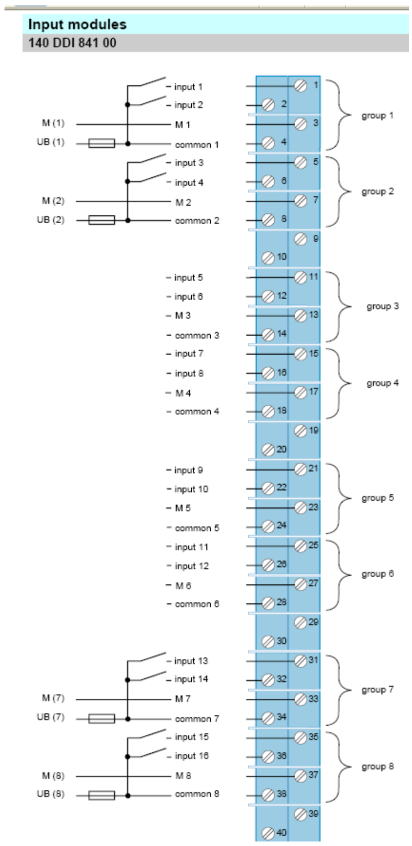


Figure 5-13 DIGITAL INPUT CONNECTION

Figure 5-13 shows the electric diagram corresponding to the digital input card 140DDI84100, where:

- M(x)= -24 VDC
- UB(x)= COMMON(x)= +24 VDC
- INPUT(x)= DIGITAL INPUT NUMBER

Fort most of the applications is sufficient to connect all M(x) terminal to -24 VDC and all UB(x) to +24 VDC. In this way if a sensor provides +24 VDC the PLC detects a logical true, and if the voltage is -24 VDC then detects a logical false. This type of connection is shown in Figure 5-14 for the digital input signals arriving to the Control Cabinet. Table 5-13 identifies the 17 DI signals with the associated variable names and pin correspondence.

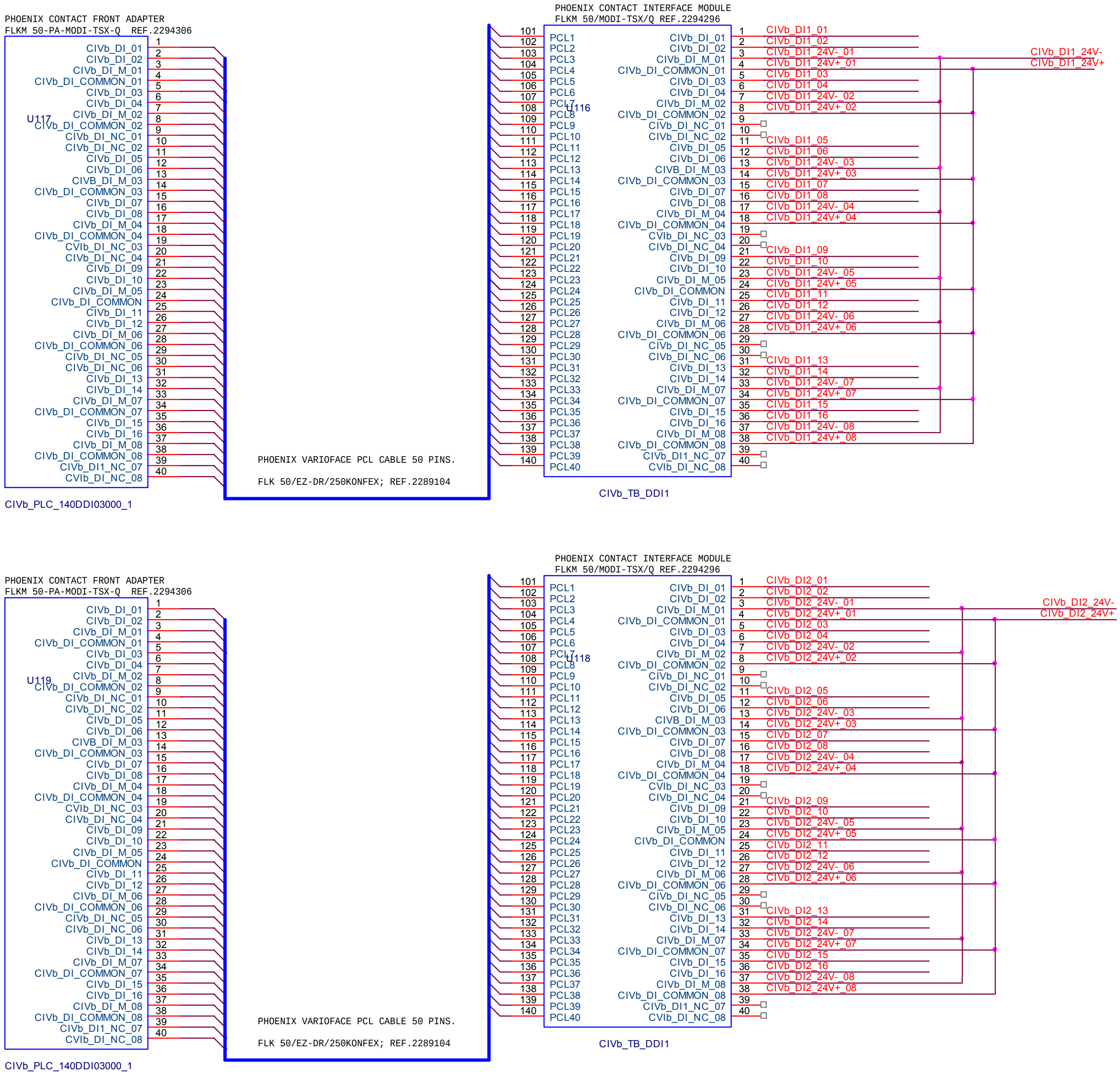
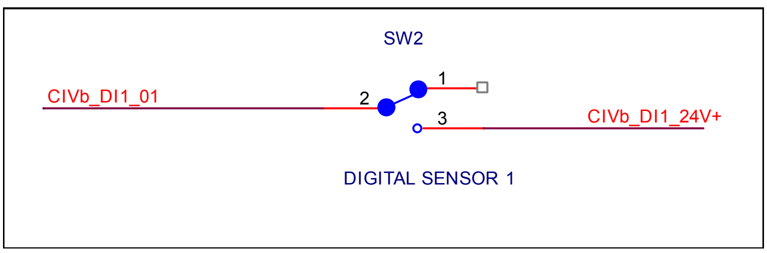


Figure 5-14 DI schematic

CONNECTION EXAMPLE:



This table was send by SHERPA at 27/09/07 17:41									This information is based in GUELPH 5 september IO table						
#	Control Loop	Control_Loop_Name	Instrument Tag Name	Tag Variable	Inputs	Outputs	Description	Signal	PLC MEMORY	ELECTRICAL SIGNAL	PHOENIX BLOCK TERMINAL	INPUT VARIABLE	OUTPUT VARIABLE	PHISICAL PIN CONNECTION (PHOENNIX TERMINAL)
1	450_1	Exterior Air Lock Door Control - Side A	ZS_450_1_01	ZS_450_1_01	Y		Upper Exterior Air Lock Door Contact - Side A	DI	100.001	24 VDC	DDI_1	1		1
2	450_1	Exterior Air Lock Door Control - Side A	ZS_450_1_02	ZS_450_1_02	Y		Lower Exterior Air Lock Door Contact - Side A	DI	100.002	24 VDC	DDI_1	2		2
4	451_1	Exterior Air Lock Door Control - Side C	ZS_451_1_01	ZS_451_1_01	Y		Upper Exterior Air Lock Door Contact - Side C	DI	100.003	24 VDC	DDI_1	3		5
5	451_1	Exterior Air Lock Door Control - Side C	ZS_451_1_02	ZS_451_1_02	Y		Lower Exterior Air Lock Door Contact - Side C	DI	100.004	24 VDC	DDI_1	4		6
10	452_1	Air Lock Purge Control - Side A	PSH_452_1_01	PSH_452_1_01	Y		Airlock A pressure switch	DI	100.005	24 VDC	DDI_1	5		11
14	453_1	Air Lock Purge Control - Side C	PSH_453_1_01	PSH_453_1_01	Y		Airlock A pressure switch	DI	100.006	24 VDC	DDI_1	6		12
21	455_1	Lighting Loft Temperature Control	IS_455_1_01	IS_455_1_01	Y		Flow/Noflow of Light Loft Fan A	DI	100.007	24 VDC	DDI_1	7		15
22	455_1	Lighting Loft Temperature Control	IS_455_1_02	IS_455_1_02	Y		Flow/Noflow of Light Loft Fan B	DI	100.008	24 VDC	DDI_1	8		16
23	455_1	Lighting Loft Temperature Control	IS_455_1_03	IS_455_1_03	Y		Flow/Noflow of Light Loft Fan C	DI	100.009	24 VDC	DDI_1	9		21
35	457_1	pH Control	LT_457_1_01	LT_457_1_01	Y		Acid Tank Level	DI	100.010	24 VDC	DDI_1	10		22
36	457_1	pH Control	LT_457_1_02	LT_457_1_02	Y		Base Tank Valve	DI	100.011	24 VDC	DDI_1	11		25
40	458_1	EC Control	LT_458_1_01	LT_458_1_01	Y		Level sensor Stock A	DI	100.012	24 VDC	DDI_1	12		26
41	458_1	EC Control	LT_458_1_02	LT_458_1_02	Y		Level sensor Stock B	DI	100.013	24 VDC	DDI_1	13		31
44	460_1	Nutrient and Condensate Levels Control	LT_460_1_01	LT_460_1_01	Y		High Level sensor for reservoir tank	DI	100.014	24 VDC	DDI_1	14		32
45	460_1	Nutrient and Condensate Levels Control	LT_460_1_02	LT_460_1_02	Y		Low Level sensor for reservoir tank	DI	100.015	24 VDC	DDI_1	15		35
46	460_1	Nutrient and Condensate Levels Control	LT_460_1_03	LT_460_1_03	Y		High Level sensor for condensate tank	DI	100.016	24 VDC	DDI_1	16		36
47	460_1	Nutrient and Condensate Levels Control	LT_460_1_04	LT_460_1_04	Y		Low Level sensor for condensate tank	DI	100.017	24 VDC	DDI_2	1		1
					17	**0**		**17**						

Table 5-13 DI variables and pin correspondence

5.4.4 DIGITAL OUTPUT

The selected Digital Output card is 140DOO35301, providing 32 outputs in groups of eight. PLC supply is +24VDC. Each output pin (bit) can supply 500 mA with 24 VDC. Figure 5-15 shows the corresponding electrical diagram.

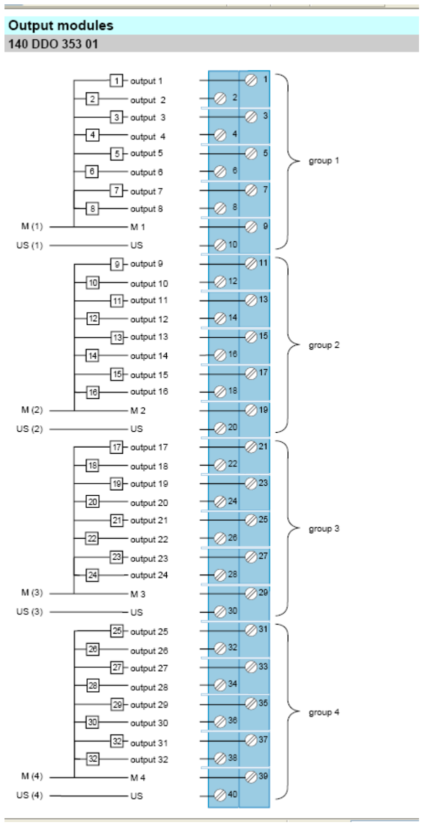


Figure 5-15 Digital output connections of DDO PLC CARD

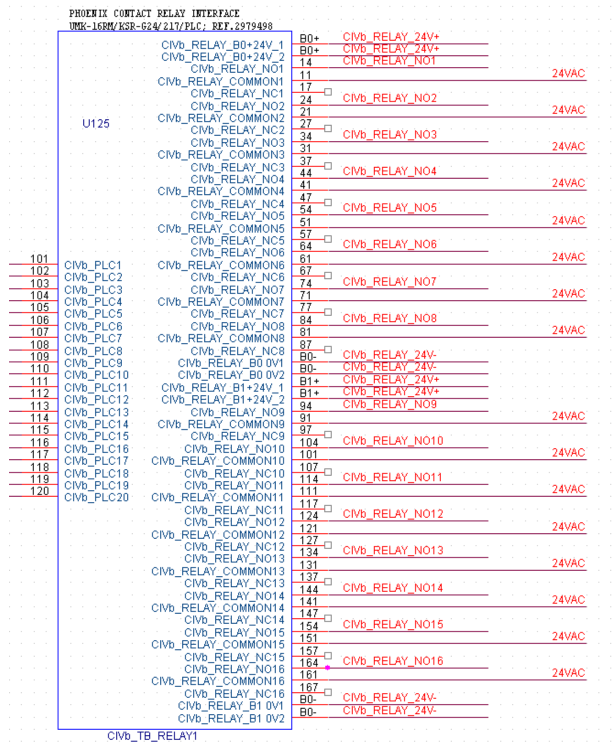
Where:

- M(x)= 24 VDC-
- UB(x)= COMMON(x)= 24 VDC+
- OUTPUT(x)= DIGITAL OUTPUT NUMBER

For most of the applications is sufficient to connect all M(x) signals to -24 VDC and all of UB(x) to +24 VDC.

FROM		TO			
PIN NUMBER	SIGNAL NAME	PIN NUMBER	SIGNAL NAME		
SCHENEIDER ELECTRIC MODICON TSX QUANTUM	SCHENEIDER ELECTRIC MODICON TSX QUANTUM	PHOENIX CONTACT VARIOFACE PLUGGABLE CONNECTOR	PHOENIX CONTACT VARIOFACE PLUGGABLE CONNECTOR	PHOENIX CONTACT VARIOFACE PLUGGABLE CONNECTOR CORRESPONDENCE WITH INTERNAL RELAY	NEEDED SUPPLY VOLTAGE
1	OUTPUT 1	A0	CIV_DO1_01	RELAY 1	
2	OUTPUT 2	A1	CIV_DO1_02	RELAY 2	
3	OUTPUT 3	A2	CIV_DO1_03	RELAY 3	
4	OUTPUT 4	A3	CIV_DO1_04	RELAY 4	
5	OUTPUT 5	A4	CIV_DO1_05	RELAY 5	
6	OUTPUT 6	A5	CIV_DO1_06	RELAY 6	
7	OUTPUT 7	A6	CIV_DO1_07	RELAY 7	
8	OUTPUT 8	A7	CIV_DO1_08	RELAY 8	
9	M1	9	CIV_DO1_M1		24 VDC-
10	US1	10	CIV_DO1_US1		24 VDC+
11	OUTPUT 9	A8	CIV_DO1_09	RELAY 9	
12	OUTPUT 10	A9	CIV_DO1_10	RELAY 10	
13	OUTPUT 11	A10	CIV_DO1_11	RELAY 11	
14	OUTPUT 12	A11	CIV_DO1_12	RELAY 12	
15	OUTPUT 13	A12	CIV_DO1_13	RELAY 13	
16	OUTPUT 14	A13	CIV_DO1_14	RELAY 14	
17	OUTPUT 15	A14	CIV_DO1_15	RELAY 15	
18	OUTPUT 16	A15	CIV_DO1_16	RELAY 16	
19	M2	19	CIV_DO1_M2		24 VDC-
20	US2	20	CIV_DO1_US2		24 VDC+
21	OUTPUT 17	A16	CIV_DO1_17	RELAY 17	
22	OUTPUT 18	A17	CIV_DO1_18	RELAY 18	
23	OUTPUT 19	A18	CIV_DO1_19	RELAY 19	
24	OUTPUT 20	A19	CIV_DO1_20	RELAY 20	
25	OUTPUT 21	A20	CIV_DO1_21	RELAY 21	
26	OUTPUT 22	A21	CIV_DO1_22	RELAY 22	
27	OUTPUT 23	A22	CIV_DO1_23	RELAY 23	
28	OUTPUT 24	A23	CIV_DO1_24	RELAY 24	
29	M3	29	CIV_DO1_M3		24 VDC-
30	US3	30	CIV_DO1_US3		24 VDC+
31	OUTPUT 25	A24	CIV_DO1_25	RELAY 25	
32	OUTPUT 26	A25	CIV_DO1_26	RELAY 26	
33	OUTPUT 27	A26	CIV_DO1_27	RELAY 27	
34	OUTPUT 28	A27	CIV_DO1_28	RELAY 28	
35	OUTPUT 29	A28	CIV_DO1_29	RELAY 29	
36	OUTPUT 30	A29	CIV_DO1_30	RELAY 30	
37	OUTPUT 31	A30	CIV_DO1_31	RELAY 31	
38	OUTPUT 32	A31	CIV_DO1_32		
39	M4	39	CIV_DO1_M4		24 VDC-
40	US4	40	CIV_DO1_US4		24 VDC+

Table 5-14 PLC to phoenix module interface connection



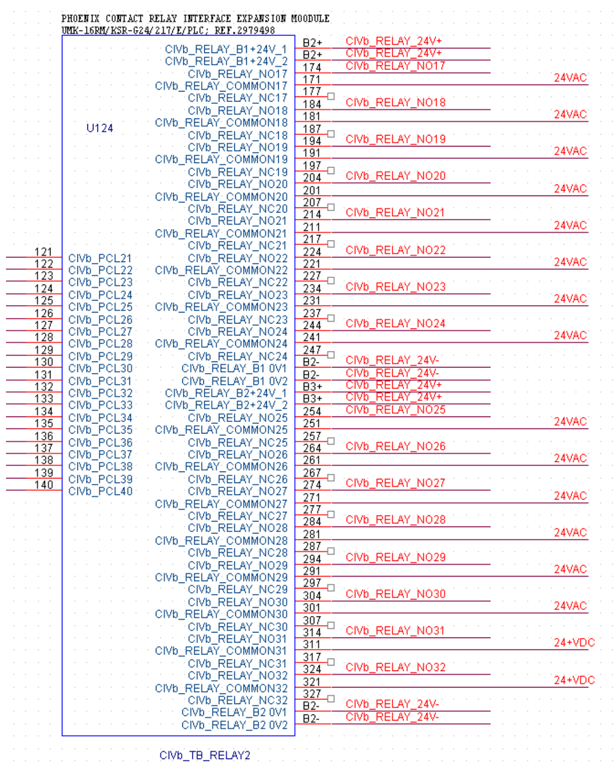


Figure 5-16 PHOENIX module interface connections

This table was send by SHERPA at 27/09/07 17:41									This information is based in GUELPH 5 september IO table					
#	Control Loop	Control_Loop_Name	Instrument Tag Name	Tag Variable	Inputs	Outputs	Description	Signal	PLC MEMORY	ELECTRICAL SIGNAL	PHOENIX BLOCK TERMINAL	INPUT VARIABLE	OUTPUT VARIABLE	PHISICAL PIN CONNECTION (PHOENNIX TERMINAL)
3	450_1	Exterior Air Lock Door Control - Side A	ZI_450_1_01	No Measurement		Y	Led Indicator when door is open - Side A	DO	000001	24VDC	RELAY_1		31	314
6	451_1	Exterior Air Lock Door Control - Side C	ZI_451_1_01	No Measurement		Y	Led Indicator when door is open - Side C	DO	000002	24VDC	RELAY_1		32	324
7	452_1	Air Lock Purge Control - Side A	SV_452_1_01	SV_452_1_01_MV		Y	Solenoid Valve for injection of pressurized air into airlock A	DO	000003	24VAC	RELAY_1		1	14
8	452_1	Air Lock Purge Control - Side A	SV_452_1_02	SV_452_1_02_MV		Y	Airlock A ventilation Solenoid Valve	DO	000004	24VAC	RELAY_1		2	24
11	453_1	Air Lock Purge Control - Side C	SV_453_1_01	SV_453_1_01_MV		Y	Solenoid Valve for injection of pressurized air into airlock C	DO	000005	24VAC	RELAY_1		3	34
12	453_1	Air Lock Purge Control - Side C	SV_453_1_02	SV_453_1_02_MV		Y	Airlock C ventilation Solenoid Valve	DO	000006	24VAC	RELAY_1		4	44
15	454_1	Light Intensity Control	IRC_454_1_01	IRC_454_1_01_MV		Y	Turn On/Off lamps - A	DO	000007	24VAC	RELAY_1		5	54
16	454_1	Light Intensity Control	IRC_454_1_02	IRC_454_1_02_MV		Y	Turn On/Off lamps - B	DO	000008	24VAC	RELAY_1		6	64
17	454_1	Light Intensity Control	IRC_454_1_03	IRC_454_1_03_MV		Y	Turn On/Off lamps - C	DO	000009	24VAC	RELAY_1		7	74
24	455_1	Lighting Loft Temperature Control	GP_455_1_01	GP_455_1_01_MV		Y	Operation of Light Loft Fan A	DO	000010	24VAC	RELAY_1		8	84
25	455_1	Lighting Loft Temperature Control	GP_455_1_02	GP_455_1_02_MV		Y	Operation of Light Loft Fan B	DO	000011	24VAC	RELAY_1		9	94
26	455_1	Lighting Loft Temperature Control	GP_455_1_03	GP_455_1_03_MV		Y	Operation of Light Loft Fan C	DO	000012	24VAC	RELAY_1		10	104
30	456_1	Irrigation System	GP_456_1_01	GP_456_1_01_MV		Y	Main irrigation Pump P2001	DO	000013	24VAC	RELAY_1		11	114
33	457_1	pH Control	SV_457_1_01	SV_457_1_01_MV		Y	Acid Tank Valve	DO	000014	24VAC	RELAY_1		12	124
34	457_1	pH Control	SV_457_1_02	SV_457_1_02_MV		Y	Base Tank Valve	DO	000015	24VAC	RELAY_1		13	134
38	458_1	EC Control	SV_458_1_01	SV_458_1_01_MV		Y	Stock A inject Valve	DO	000016	24VAC	RELAY_1		14	144
39	458_1	EC Control	SV_458_1_02	SV_458_1_02_MV		Y	Stock B inject Valve	DO	000017	24VAC	RELAY_1		15	154
43	459_1	Nutrient Tank Temperature Control	SV_459_1_01	SV_459_1_01_MV		Y	Nutrient cooling line valve	DO	000018	24VAC	RELAY_2		16	164
48	460_1	Nutrient and Condensate Levels Control	GP_460_1_01	GP_460_1_01_MV		Y	Condensate pump relay	DO	000019	24VAC	RELAY_2		17	174
78	463_1	CO2 Control	SV_463_1_01	SV_463_1_01_MV		Y	CO2 injection line. Solenoid	DO	000020	24VAC	RELAY_2		18	184
					0	**20**		**20**						

Table 5-14 Digital output signals

5.4.5 ANALOG CURRENT OUTPUT

Five analog output actuators are connected. For this type of signals additional spare pins are not requested. The selected card is a 140ACO13000. Figure 5-17 shows the electrical diagram.

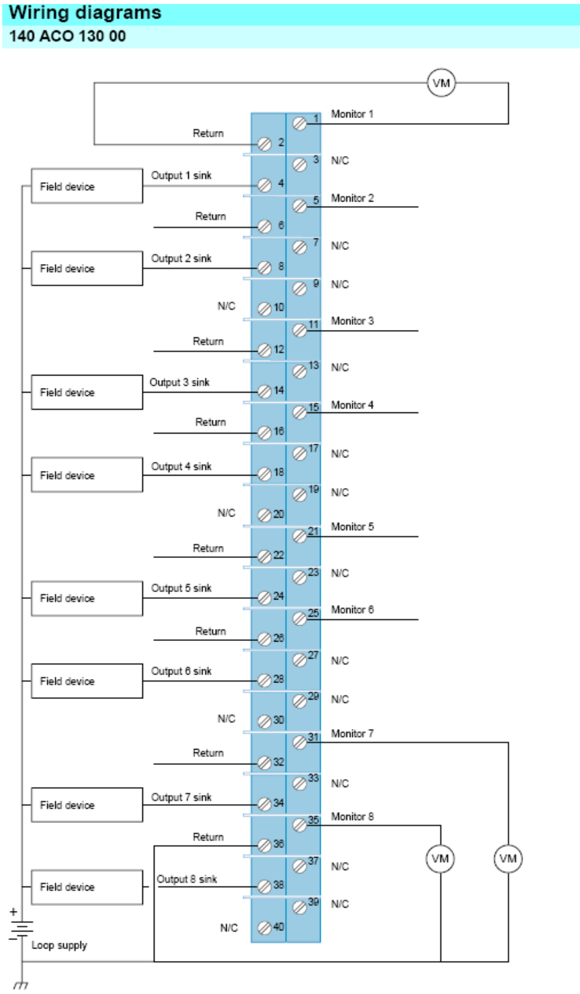


Figure 5-17 ANALOG CURRENT OUTPUT

Where:

- Return= 24 VDC- point, all pins with the same name are internally interconnect.
- Output x sink= output current

Monitor pins are not used.

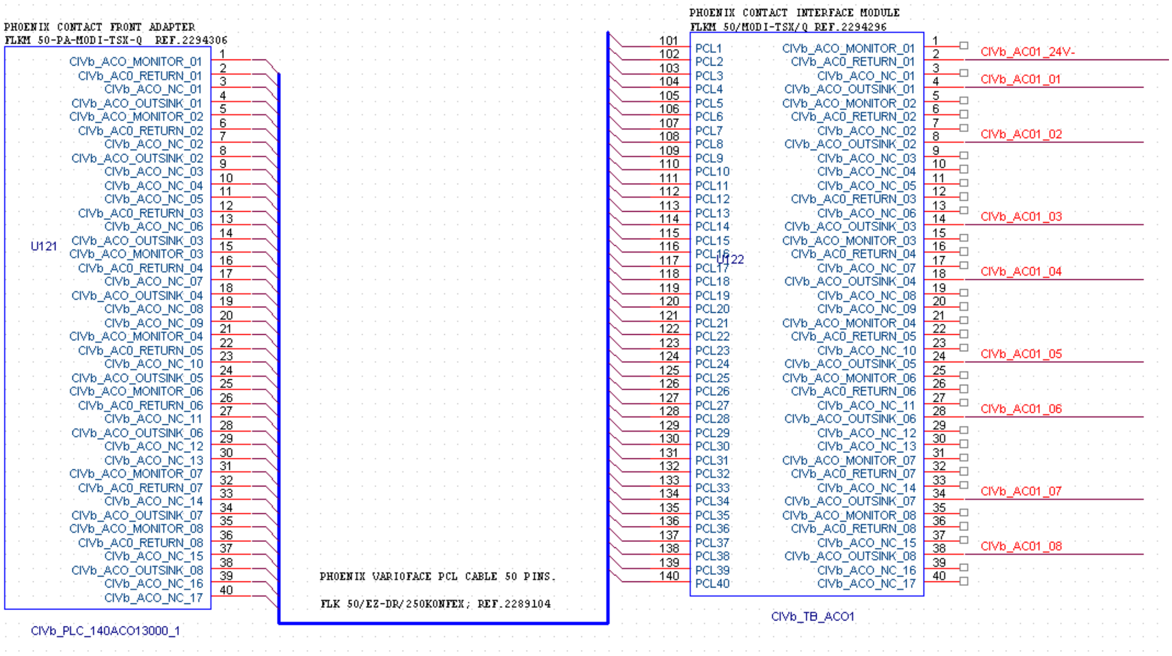


Figure 5-18 Connections between ACO plc card, phoenix module and sensor connections

5.4.6 ANALOG INPUTS

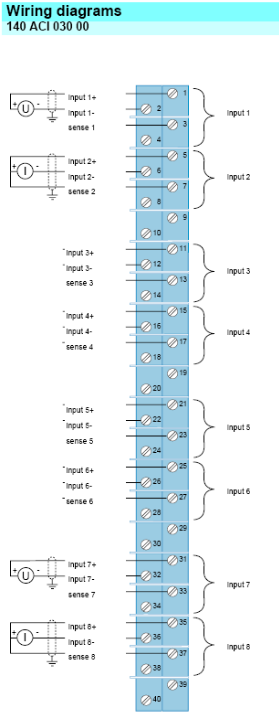
The Quantum PLC system provides two types of analog input cards with the following characteristics:

140ACI0300:

- Voltage: (1 – 5 VDC) or Current (4 – 20 mA)
- Resolution 12 bits

140AVI0300:

- Voltage: (0 – 10 VDC) or (0 – 5 VDC) or Current (4 – 20 mA)
- Resolution 16/15/14 bits, and bipolar option in available.



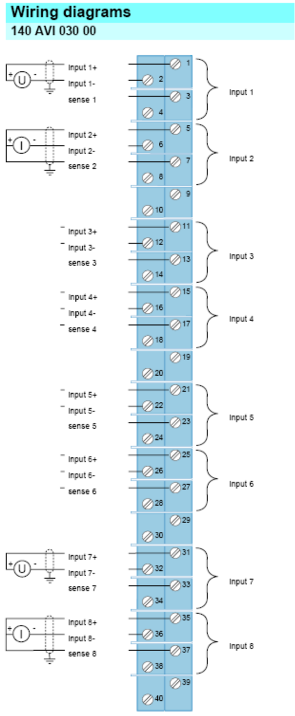


Figure 5-19 Analog current input & Analog voltage input PLC card diagram

Note: sense x pins have to be connect to input x+ in ACI PLC card, for current configuration.

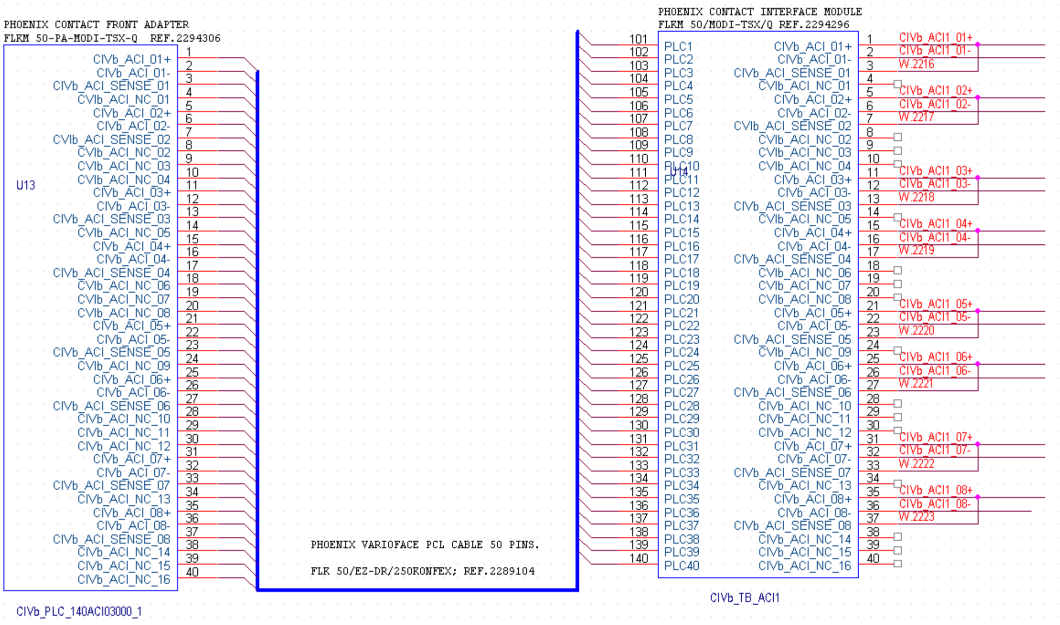
Where:

- X= Number of sensor from 1 to 8.

Figure 5-20 shows this configuration.

5.4.6.1 ACI (Analog Current Input)

There are three ACI cards, from ACI_1 to ACI_3.



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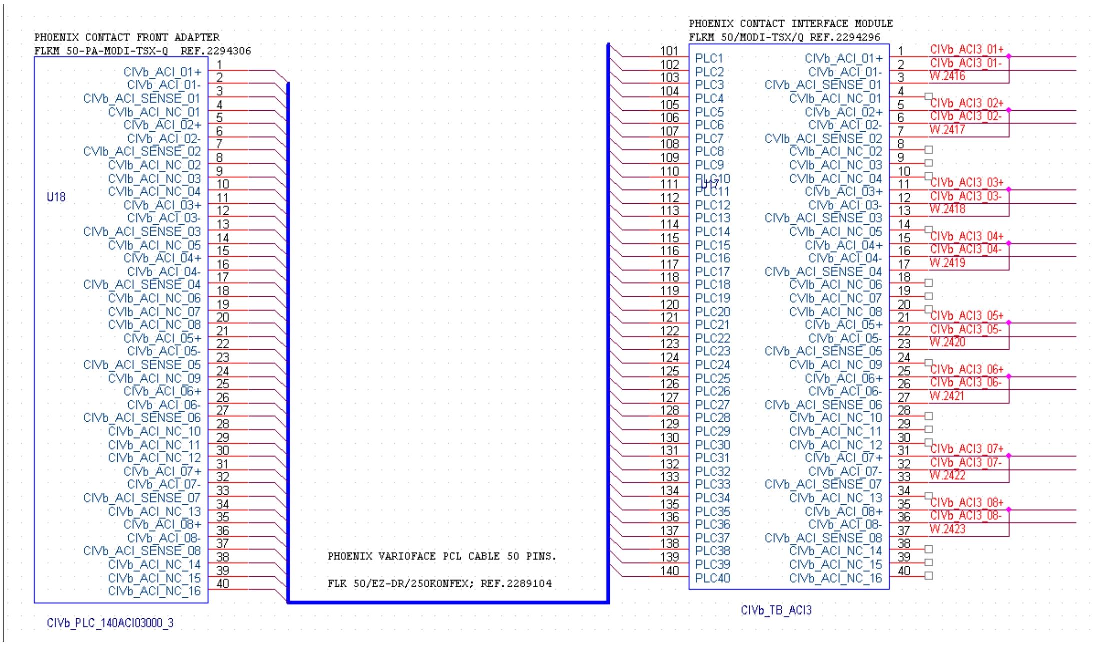
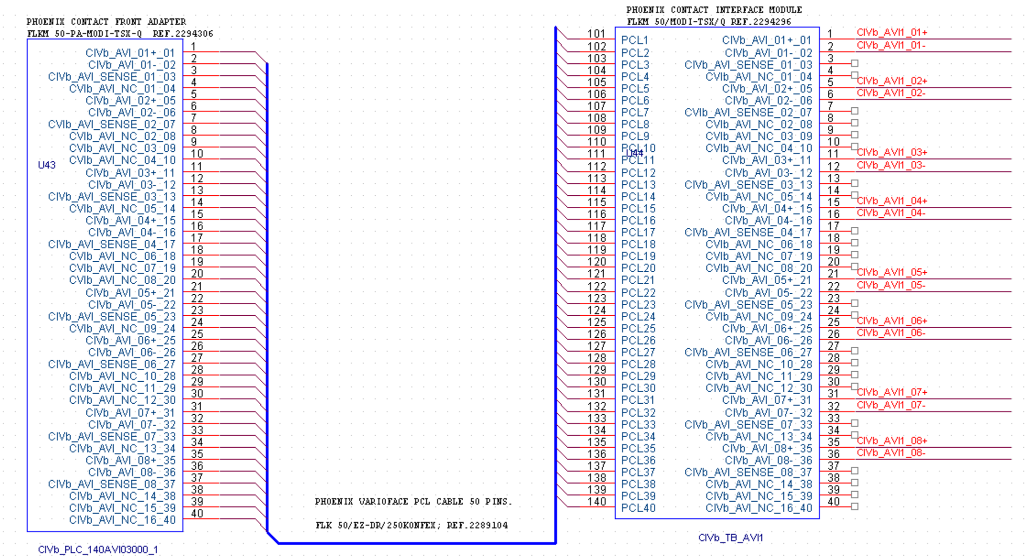


Figure 5-20 PLC ACI cards schematics

5.4.6.2 AVI (Analog Voltage Input)

There are four PLC AVI CARDS



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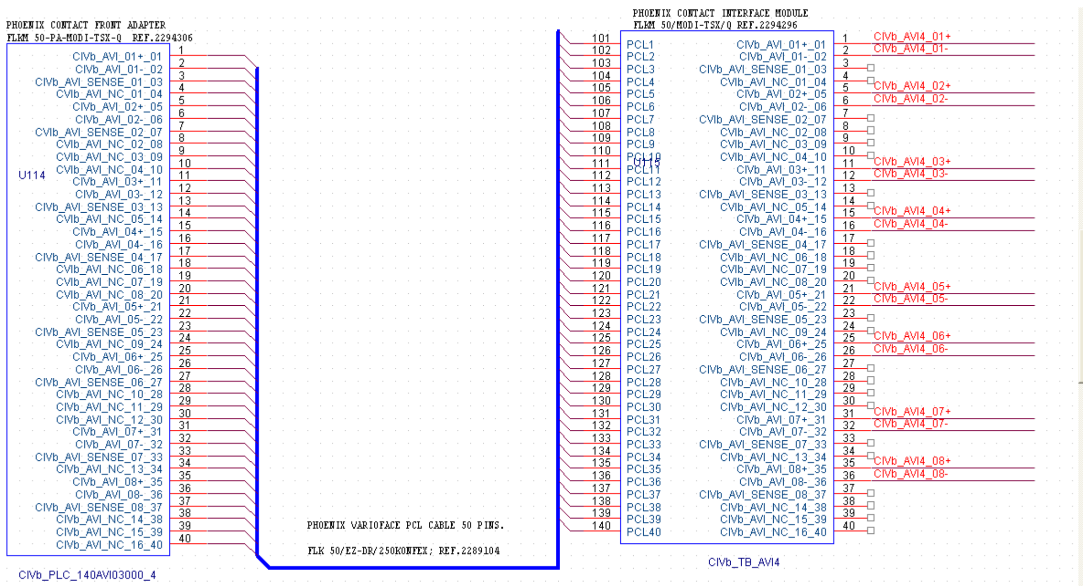

Figure 5-21 PLC AVI CARDS ELECTRICAL SCHEMATIC

#	Control Loop	Control_Loop_Name	Instrument Tag Name	Tag Variable	Inputs	Outputs	Description	Signal	PLC MEMORY	ELECTRICAL SIGNAL	PHOENIX BLOCK TERMINAL	INPUT VARIABLE	OUTPUT VARIABLE	PHISICAL PIN CONNECTION (PHOENNIX TERMINAL)
49	461_1	Control of Air circulation fans	GP_461_1_01	GP_461_1_01_MV		Y	Air circulation fan with VFD	AO	400001	4-20mA	ACO_1		1	4
72	462_1	Chamber Temperature and Humidity Control	CV_462_1_01	CV_462_1_01_MV		Y	Chilled Water Control Valve	AO	400002	4-20mA	ACO_1		2	8
73	462_1	Chamber Temperature and Humidity Control	CV_462_1_02	CV_462_1_02_MV		Y	Hot Water Control Valve	AO	400003	4-20mA	ACO_1		3	14
75	463_1	CO2 Control		FC_463_1_01_SP		Y	CO2 Mass Flow set point	AO	400004	4-20mA	ACO_1		4	18
80	463_1	CO2 Control		FC_463_1_02_SP		Y	Injection Line - CO2 Mass Flow set point	AO	400005	4-20mA	ACO_1		5	24
					0	5		5						

TABLE 5-15 ACO signals used

#	Control Loop	Control_Loop_Name	Instrument Tag Name	Tag Variable	Inputs	Outputs	Description	Signal	PLC MEMORY	ELECTRICAL SIGNAL	PHOENIX BLOCK TERMINAL	INPUT VARIABLE	OUTPUT VARIABLE	PHISICAL PIN CONNECTION (PHOENNIX TERMINAL)
9	452_1	Air Lock Purge Control - Side A	PT_452_1_01	PT_452_1_01	Y		Pressure sensor for airlock A	ACI	300.037	4-20mA	ACI_1	1		1 +; 2 -
13	453_1	Air Lock Purge Control - Side C	PT_453_1_01	PT_453_1_01	Y		Pressure sensor for airlock C	ACI	300.038	4-20mA	ACI_1	2		5 +; 6 -
31	456_1	Irrigation System	FT_456_1_01	FT_456_1_01	Y		Outlet nutrient flow sensor	ACI	300.039	4-20mA	ACI_1	3		11 +; 12 -
32	457_1	pH Control	TT_457_1_01	TT_457_1_01	Y		pH sensor	ACI	300.040	4-20mA	ACI_1	4		15 + ; 16 -
37	458_1	EC Control	CT_458_1_01	CT_458_1_01	Y		Electrical Conductivity of nutrient	ACI	300.041	4-20mA	ACI_1	5		21 +; 22 -
51	462_1	Chamber Temperature and Humidity Control	TT_462_1_01	TT_462_1_01	Y		Temperature A1 associated with humidity	ACI	300.042	4-20mA	ACI_1	6		25 +; 26 -
55	462_1	Chamber Temperature and Humidity Control	TT_462_1_05	TT_462_1_05	Y		Temperature B1 associated with humidity	ACI	300.043	4-20mA	ACI_1	7		31 +; 32 -
59	462_1	Chamber Temperature and Humidity Control	TT_462_1_09	TT_462_1_09	Y		Temperature C1 associated with humidity	ACI	300.044	4-20mA	ACI_1	8		35 +; 36 -
63	462_1	Chamber Temperature and Humidity Control	TT_462_1_13	TT_462_1_13	Y		Temperature for facility chilled water	ACI	300.046	4-20mA	ACI_2	1		1 +; 2 -
64	462_1	Chamber Temperature and Humidity Control	TT_462_1_14	TT_462_1_14	Y		Temperature for facility hot water line	ACI	300.047	4-20mA	ACI_2	2		5 +; 6 -
65	462_1	Chamber Temperature and Humidity Control	TT_462_1_15	TT_462_1_15	Y		Chilled coil surface temperature	ACI	300.048	4-20mA	ACI_2	3		11 +; 12 -
66	462_1	Chamber Temperature and Humidity Control	TT_462_1_16	TT_462_1_16	Y		Heating coil surface temperature	ACI	300.049	4-20mA	ACI_2	4		15 + ; 16 -
67	462_1	Chamber Temperature and Humidity Control	TT_462_1_17	TT_462_1_17	Y		Chilled Exit temperature	ACI	300.050	4-20mA	ACI_2	5		21 +; 22 -
68	462_1	Chamber Temperature and Humidity Control	TT_462_1_18	TT_462_1_18	Y		Hot Exit temperature	ACI	300.051	4-20mA	ACI_2	6		25 +; 26 -
69	462_1	Chamber Temperature and Humidity Control	AT_462_1_01	AT_462_1_01	Y		Humidity A1 associated with temp A1	ACI	300.052	4-20mA	ACI_2	7		31 +; 32 -
70	462_1	Chamber Temperature and Humidity Control	AT_462_1_02	AT_462_1_02	Y		Humidity B1 associated with temp B1	ACI	300.053	4-20mA	ACI_2	8		35 +; 36 -
71	462_1	Chamber Temperature and Humidity Control	AT_462_1_03	AT_462_1_03	Y		Humidity C1 associated with temp C1	ACI	300.055	4-20mA	ACI_3	1		1 +; 2 -
74	463_1	CO2 Control	FC_463_1_01	FC_463_1_01	Y		CO2 Mass Flow	ACI	300.056	4-20mA	ACI_3	2		5 +; 6 -
76	463_1	CO2 Control	AT_463_1_01	AT_463_1_01	Y		CO2 Analyser	ACI	300.057	4-20mA	ACI_3	3		11 +; 12 -
77	463_1	CO2 Control	AT_463_1_02	AT_463_1_02	Y		O2 Analyser	ACI	300.058	4-20mA	ACI_3	4		15 + ; 16 -
79	463_1	CO2 Control	FC_463_1_02	FC_463_1_02	Y		Injection Line - CO2 Mass Flow	ACI	300.059	4-20mA	ACI_3	5		21 +; 22 -
					21	0		21						

TABLE 5-16 PLC ACI cards signals connections

#	Control Loop	Control_Loop_Name	Instrument Tag Name	Tag Variable	Inputs	Outputs	Description	Signal	PLC MEMORY	ELECTRICAL SIGNAL	PHOENIX BLOCK TERMINAL	INPUT VARIABLE	OUTPUT VARIABLE	PHISICAL PIN CONNECTION (PHOENNIX TERMINAL)
18	454_1	Light Intensity Control	OT_454_1_01	OT_454_1_01	Y		PAR Sensor - A	AVI	300.001	0-10V	AVI_1	1		1 +; 2 -
19	454_1	Light Intensity Control	OT_454_1_02	OT_454_1_02	Y		PAR Sensor - B	AVI	300.002	0-10V	AVI_1	2		5 +; 6 -
20	454_1	Light Intensity Control	OT_454_1_03	OT_454_1_03	Y		PAR Sensor - C	AVI	300.003	0-10V	AVI_1	3		11 +; 12 -
27	455_1	Lighting Loft Temperature Control	TT_455_1_01	TT_455_1_01	Y		Light Loft Temperature sensor A	AVI	300.004	0-5V	AVI_1	4		15 +; 16 -
28	455_1	Lighting Loft Temperature Control	TT_455_1_02	TT_455_1_02	Y		Light Loft Temperature sensor B	AVI	300.005	0-5V	AVI_1	5		21 +; 22 -
29	455_1	Lighting Loft Temperature Control	TT_455_1_03	TT_455_1_03	Y		Light Loft Temperature sensor C	AVI	300.006	0-5V	AVI_1	6		25 +; 26 -
42	459_1	Nutrient Tank Temperature Control	TT_459_1_01	TT_459_1_01	Y		Temperature sensor for solution reservoir	AVI	300.007	0-5V	AVI_1	7		31 +; 32 -
50	461_1	Control of Air circulation fans	FT_461_1_01	FT_461_1_01	Y		Air velocity sensor	AVI	300.008	0-5V	AVI_1	8		35 +; 36 -
52	462_1	Chamber Temperature and Humidity Control	TT_462_1_02	TT_462_1_02	Y		Temperature A2	AVI	300.010	0-5V	AVI_2	1		1 +; 2 -
53	462_1	Chamber Temperature and Humidity Control	TT_462_1_03	TT_462_1_03	Y		Temperature A3	AVI	300.011	0-5V	AVI_2	2		5 +; 6 -
54	462_1	Chamber Temperature and Humidity Control	TT_462_1_04	TT_462_1_04	Y		Temperature A4	AVI	300.012	0-5V	AVI_2	3		11 +; 12 -
56	462_1	Chamber Temperature and Humidity Control	TT_462_1_06	TT_462_1_06	Y		Temperature B2	AVI	300.013	0-5V	AVI_2	4		21 +; 22 -
57	462_1	Chamber Temperature and Humidity Control	TT_462_1_07	TT_462_1_07	Y		Temperature B3	AVI	300.014	0-5V	AVI_2	5		25 +; 26 -
58	462_1	Chamber Temperature and Humidity Control	TT_462_1_08	TT_462_1_08	Y		Temperature B4	AVI	300.015	0-5V	AVI_2	6		31 +; 32 -
60	462_1	Chamber Temperature and Humidity Control	TT_462_1_10	TT_462_1_10	Y		Temperature C2	AVI	300.016	0-5V	AVI_2	7		35 +; 36 -
61	462_1	Chamber Temperature and Humidity Control	TT_462_1_11	TT_462_1_11	Y		Temperature C3	AVI	300.017	0-5V	AVI_2	8		1 +; 2 -
62	462_1	Chamber Temperature and Humidity Control	TT_462_1_12	TT_462_1_12	Y		Temperature C4	AVI	300.019	0-5V	AVI_3	1		5 +; 6 -
81	464_1	Chamber Pressure	PT_464_1_01	PT_464_1_01	Y		Growing Area Pressure	AVI	300.020	?	AVI_3	2		35 + ; 36-
82	465_1	Ambient Parameters	TT_465_1_01	TT_465_1_01	Y		Ambient temperature	AVI	300.021	?	AVI_3	3		11 +; 12 -
83	465_1	Ambient Parameters	PT_465_1_01	PT_465_1_01	Y		Ambient pressure	AVI	300.022	?	AVI_3	4		21 +; 22 -
					20	**0**		**20**						

TABLE 5-17 PLC AVI CARDS signals connections

5.5 CONTROL CABINET MECHANICAL DESIGN

The Control Cabinet mechanical design and components layout is shown in Figure 5-22. Figure 5-23 shows the Control Cabinet appearance once assembled.

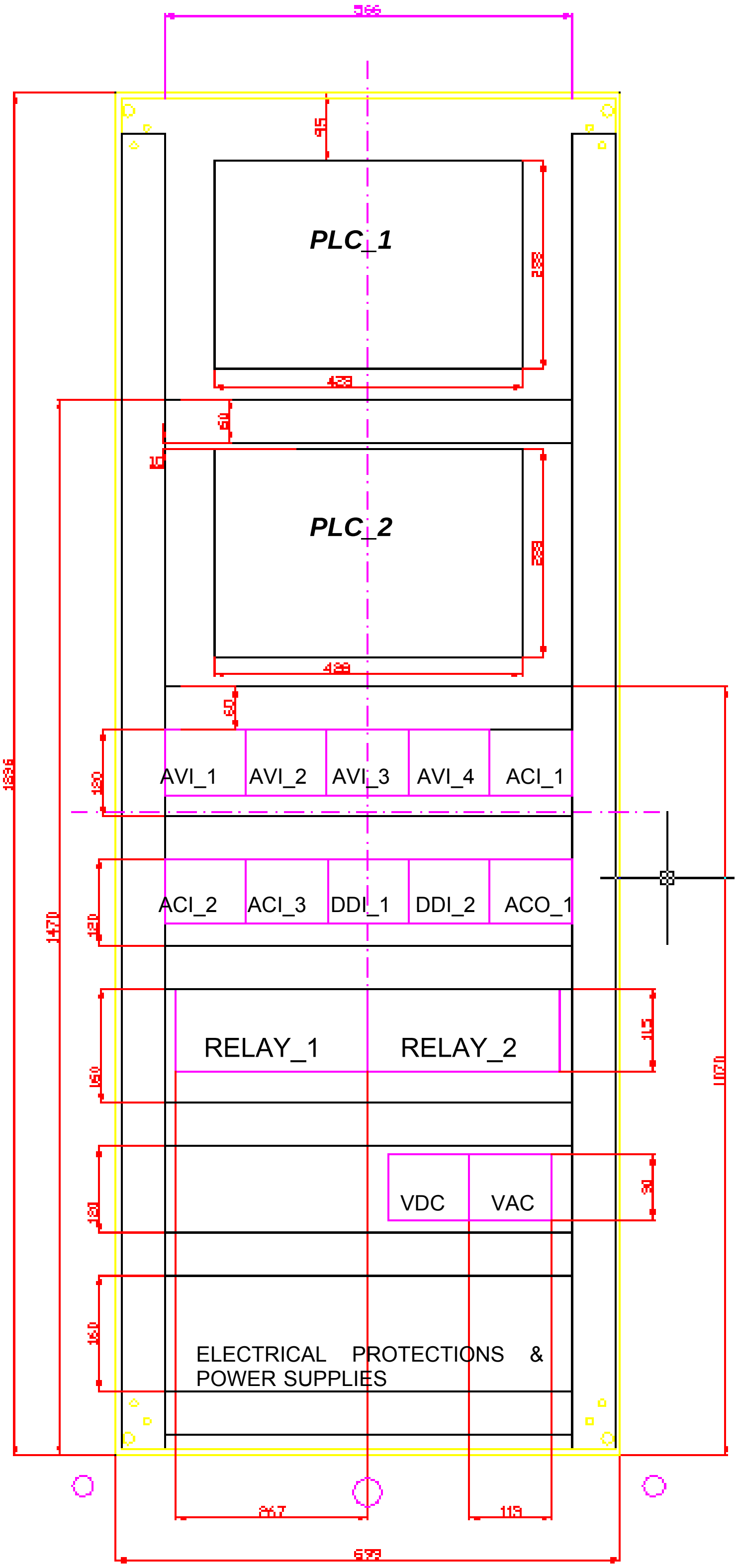

Figure 5-22 HPC Control Cabinet layout

Figure 5-23 HPC Control Cabinet assembled

6. ELECTRICAL SCHEMATIC

The HPC Control Cabinet electrical schematic is provided in drawing NTE-HPC-DW-001, issue 1.0

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7. ANNEX 1: I/O TABLES (AS PER AD2)

Last Updated SEPT 5 2007

Control Loop	Description	Control Instrument	IO	DI	DO	AI	AO	Elect. Int.	Instrument Type	# DEVICES	DEVICE	POWER (WATTS)	PHASE (SINGLE OR 3)	VOLTAGE	Remarks
				Signal							Load caracteristics				
XLC 04021A	Extrior air lock door contact sensors	Relay	O402A	4				Dry contact	Sensor	4					
	LED Indicators (indicating exterior doors are open)	Indicator	TBD		2			5 VDC	LED Indicator	4	LED indicator lamp			5VDC	
	Air Lock Purge Control														
XLC 04011	Injection of pressurized calibrated air into airlock A via solenoid	Relay	V4011		1			24 VAC DO	Normally closed solenoid	1	*Low power relay for solenoid at 10 W, 22/24V, 60Hz*	*10 W*	1	24 VAC	Normally closed solenoid connected to pressurized bottle air
XLC 04021	Injection of pressurized calibrated air into airlock C via solenoid	Relay	V4021		1			24 VAC DO	Normally closed solenoid	1	*Low power relay for solenoid at 10 W, 22/24V, 60Hz*	*10 W*	1	24 VAC	Normally closed solenoid connected to pressurized bottle air
XLC 04031	Airlock A ventilation solenoid valve	Relay	V4031		1			24 VAC DO	Normally closed solenoid	1	*Low power relay for solenoid at 10 W, 22/24V, 60Hz*	*10 W*	1	24 VAC	
XLC 04041	Airlock C ventilation solenoid valve	Relay	V4041		1			24 VAC DO	Normally closed solenoid	1	*Low power relay for solenoid at 10 W, 22/24V, 60Hz*	*10 W*	1	24 VAC	
	Airlock pressure sensor - Airlock A	Pressure sensor				1		4-20 mA	Sensor	1	Sensor excitation voltage	< 1 W		24 VDC	1 pressure sensor for airlock, 1 pressure sensor immediately upstream of gas tank,
	Airlock pressure sensor - Airlock C	Pressure sensor				1		4-20 mA	Sensor	1	Sensor excitation voltage	< 1 W		24 VDC	
	Airlock pressure switch - Airlock A	Switch		1				Dry contact	Switch						
	Airlock pressure switch - Airlock C	Switch		1				Dry contact	Switch						
	Growing Area Presure Sensor	Pressure sensor				1		4-20 mA	Sensor	1	Sensor excitation voltage	< 1 W		24 VDC	
	Air Lock Subsystem Total			6	6	3	0								
	Light Intensity Control														
ALC L1011	Turn on/off lamps positioned above ch	Relay	XY L1011A		1			24 VAC to contactor	Relay to contactors (contactors supplied by NTE)	1	*Low Power Relay to Higher Power Contactor to be supplied by NTE*	*Up to NTE*	*1*	*230 VAC phase to neutral*	6 x 600 W HPS, 3 x 400 W MH total, 2 HPS and 1 x MH for each of the three strings
ALC L1011	Turn on/off lamps positioned above chamber	Relay			1			24 VAC to contactor	Relay to contactors (contactors supplied by NTE)	1	*Low Power Relay to Higher Power Contactor to be supplied by NTE*	*Up to NTE*	*1*	*230 VAC phase to neutral*	contactors at 1600W per string x 3 strings
ALC L1011	Turn on/off lamps positioned above chamber	Relay			1			24 VAC to contactor	Relay to contactors (contactors supplied by NTE)	1	*Low Power Relay to Higher Power Contactor to be supplied by NTE*	*Up to NTE*	*1*	*230 VAC phase to neutral*	
ALC L1011	Acquire light intensity and Signal conditioner	PAR Sensor				1		0 - 10 V DC	Sensor	1				0 - 10 V DC	Need signal conditioners for each light sensor
ALC L1011	Acquire light intensity and Signal Conditioner	PAR Sensor				1		0 - 10 V DC	Sensor	1				0 - 10 V DC	Need signal conditioners for each light sensor
ALC L1011	Acquire light intensity and Signal Conditioner	PAR Sensor				1		0 - 10 V DC	Sensor	1				0 - 10 V DC	Need signal conditioners for each light sensor
	Lighting Loft Temperature Control														
TLC A1001	Operation of light loft fans	Relay		1				5 VDC		1			*3*	*480 VAC phase to phase*	Through contactor at 1500W each x 3 fans
TLC A1001	Operation of light loft fans	Relay		1				5 VDC		1			*3*	*480 VAC phase to phase*	
	Operation of light loft fans	Relay	XY A1002	1				5 VDC		1			*3*	*480 VAC phase to phase*	
	Flow/no flow for loft fans - A	Switch		1				0 or 5 VDC	Flow/no flow						
	Flow/no flow for loft fans - B	Switch		1				0 or 5 VDC	Flow/no flow						
	Flow/no flow for loft fans - C	Switch		1				0 or 5 VDC	Flow/no flow						
TLC A1001	Light loft temperature sensor	Thermisters	TT A1001A			1		0-5 V DC	Thermister	1	Sensor excitation voltage			0-5 V DC	See note below
TLC A1001	Light loft temperature sensor	Thermisters	TT A1001B			1		0-5 V DC	Thermister	1	Sensor excitation voltage			0-5 V DC	See note below
TLC A1001	Light loft temperature sensor	Thermisters	TT A1001C			1		0-5 V DC	Thermister	1	Sensor excitation voltage			0-5 V DC	See note below
	Lighting Subsystem Total			6	3	6	0								
	Irrigation System														
XLC P2011	Main Irrigation Pump	Relay	XY P2001		1			24 VAC to relay	1/2 hp from motor through contactor	1	*Controller will have a low voltage on/off*	*754 W +*	*1*	*24 VAC*	With contactor sized at 1500 W (1.5 hp)
	Irrigation flow sensor (T201)	Sensor				1		4-20 mA	Flow sensor	1		1			
	Control of pH in the Solution														
ALC T2011	pH sensor	pH sensor	AT T2011			1		4-20 mA	Sensor	1		< 1 W		24 VDC	Loop powered device
ALC T2011	Acid tank valve	Solenoid valve	AV T2011A		1			24 VAC	Normally closed solenoid	1	*Low power relay for solenoid at 10 W, 22/24V, 60Hz*	*10 W*	*1*	*22 VAC*	
ALC T2011	Basic tank valve	Solenoid valve	AV T2011B		1			24 VAC	Normally closed solenoid	1	*Low power relay for solenoid at 10 W, 22/24V, 60Hz*	*10 W*	*1*	*22 VAC*	
	Acid tank level			1				Dry contact	Sensor	1					
	Base tank level			1				Dry contact	Sensor	1					
	Control of Electrical Conductivity in the solution														
CLC T2012	Electrical conductivity of nutrient sensor	EC sensor	CT T2012			1		4-20mA	Sensor			< 1 W		24 VDC	Loop powered device
CLC T2012	Stock solution A inject line	Solenoid valve	CV T2012A		1			24 VAC	Normally closed solenoid	1	*Low power relay for solenoid at 10 W, 22/24V, 60Hz*	*10 W*	*1*	*22 VAC*	
	Level Sensor for stock A			1				Dry contact	Float Sensors/Contact Sensor	1					
CLC T2012	Stock solution B inject line	Solenoid valve	CV T2012B		1			24 VAC	Normally closed solenoid	1	*Low power relay for solenoid at 10 W, 22/24V, 60Hz*	*10 W*	*1*	*22 VAC*	
	Level Sensor for Stock B			1				Dry contact	Float Sensors/Contact Sensor	1					
	Temperature Sensor for solution reservoir	Thermistors				1		0-5 V DC	Thermistor	1					
	Nutrient solution tank cooling line	Solenoid valve			1			24 VAC	Normally closed solenoid	1	*Low power relay for solenoid at 10 W, 22/24V, 60Hz*	*10 W*	*1*	*22 VAC*	
	Control of Nutrient Solution and Condensate Water Levels														
LLC T2013	Level sensor for reservoir tank (high and low)	Le	T T2013	2				Dry contact	Float Sensors/Contact Sensor	1					Dry contact, with low and high alarm
LLC T2013	Level sensor for condensation tank (high and low)	Le	T T2021	2				Dry contact	Float Sensors/Contact Sensor	1					Dry contract
LLC T2013	Condensate pump relay	R	Y P6011		1			24 VAC to relay	Normally closed solenoid	1	*Low power relay for solenoid at 10 W, 22/24V, 60Hz*	*< 20 w?*	*1*	*22 VAC*	
	Hydroponics Subsystem Total			8	7	4	0								
	Control of Air circulation fan														
XLC P3011	Air circulation fan with variable frequency drive controller	Motor	XY P3011				1	24 VAC	VFD (see comment)		*AC MOTOR SPEED CONTROL*	*fan controller 3kW?*	*3*	*480 VAC phase to phase*	Through contactor (3000 W each), variable speed
	1 air velocity sensor	flow sensor				1		0-5 V DC	Sensor						
	Temperature Control														
TLC A3001	Temperature sensor	Thermistors	TT A3001A			3		0-5 V DC	Thermistor						Vaisala
TLC A3001	Temperature sensor	Thermistors	TT A3001B			3		0-5 V DC	Thermistor						Vaisala
TLC A3001	Temperature sensor	Thermistors	TT A3001C			3		0-5 V DC	Thermistor						Vaisala
TLC A3001	Regulatory valve chilled water - proportional valve	Flow valve	V301				1	4-20 mA	Control Valve						
TLC A3001	Regulatory valve hot water - proportional valve	Flow valve	V302				1	4-20 mA	Control Valve						
	Temp sensor for facility chilled water line	Thermistors				1		4-20 mA	Thermistor						
	Temp sensor for facility hot water line	Thermistors				1		4-20 mA	Thermistor						
	Chilled coil surface temperature	Thermistors				1		4-20 mA	Thermistor						
	Heating coil surface temperature	Thermistors				1		4-20 mA	Thermistor						
	Hot exit temperature	Thermistors				1		4-20 mA	Thermistor						
	Chilled Exit Temperature	Thermistors				1		4-20 mA	Thermistor						
	Humidity Control														
ALC A3002	Humidity sensor (built in with temp sensor)	Humidity sensor	AT A3002A			1		4-20 mA	Sensor	1		<1 W		24 VDC	Aspirated humidity sensors, Vaisala - comes with temp sensor
ALC A3002	Humidity sensor (built in with temp sensor)	Humidity sensor	AT A3002B			1		4-20 mA	Sensor	1		<1 W		24 VDC	Aspirated humidity sensors, Vaisala
	Humidity sensor (built in with temp sensor)	Humidity sensor	AT A3002B			1		4-20 mA	Sensor	1		<1 W		24 VDC	Aspirated humidity sensors, Vaisala
	RH associated temperature	Temperature				1		4-20 mA	Sensor	1		<1 W		24 VDC	Aspirated temperature sensors, Vaisala
	RH associated temperature	Temperature				1		4-20 mA	Sensor	1		< 1 W		24 VDC	Aspirated temperature sensors, Vaisala
	RH associated temperature	Temperature				1		4-20 mA	Sensor	1		< 1 W		24 VDC	Aspirated temperature sensors, Vaisala
	Atmospheric Subsystem Total			0	0	22	3								
	CO2 Control														
ALC A3003	CO2 mass flow/sensor controller for feed to analyzer	Fl	TC A3003A			1	1	24V DC In, 4-20 mA OR 0-10V out	MFC	1					
ALC A3003	Infrared Gas Analyzer (IRGA) calib. for CO2	An	TCO A3003			1		4-20 mA	Analyzer	1					
ALC A3003	Paramagnetic Analyzer calib. for O2	An	TO2 A3003			1		4-20 mA	Analyzer	1					
ALC A3003	CO2 injection line - solenoid	Re			1			24 VAC	Normally closed solenoid	1	*Low power relay for solenoid at 10 W, 22V, 60Hz*	*10 W*	*1*	*22 VAC*	
	CO2 injection line - mass flow/sensor controller					1	1	24V DC In, 4-20 mA OR 0-10V out	MFC	1					
	CO2 Control Subsystem Total			0	1	4	2								
Total				20	17	39	5								

Pl... Up to 8 extra for each (except AO)

Dr. Geoffrey Waters: All control loop labels, sensor IDs etc will change to conform to MPP nomenclature standards. For now, the convention used…

Dr. Geoffrey Waters: Interior doors no longer have contact sensors - operated…

Dr. Geoffrey Waters: Strictly, this belongs in the Air Handling subsystem rows, but is left here, close to the other pressure sensors.

Dr. Geoffrey Waters: Tipping bucket sensor was duplicated with…

Dr. Geoffrey Waters: AC TECH VFD c/w: Nema 1 enclosure : 1 or 3 phase input, three phase

Dr. Geoffrey Waters: Its need is dependent upon which type of analyzer we use (if an onboard sample pump is not on the analyzer we will…

******* Camera — For each of the three cameras, likely 12 V at 3W per camera
Cameras must be purchased in Europe for PAL system
Output is to a video device not to PLC, PLC may provide power

Questions

Others:
Ambient room temperature
Pressure sensor – 24 Vpower and 4-20mA out
Thermisters – NTC 3000 ohm @ 25 C Fenwall Unicurve (UUA series)

Control Loop	Description	Control Instrument	IO	DI	DO	AI	AO	Elect. Int.	Instrument Type	# DEVICES	DEVICE	POWER (WATTS)	PHASE (SINGLE OR 3)	VOLTAGE	Remarks
XLC 04021A	Extrior air lock door contact sensors	Relay	O402A	4				Dry contact	Sensor	4					
	Air Lock Purge Control														
	Airlock pressure switch - Airlock A			1				Dry contact	Switch						
	Airlock pressure switch - Airlock C			1				Dry contact	Switch						
	Air Lock Subsystem Total			6											
	Lighting Loft Temperature Control														
TLC A1001	Operation of light loft fans		XY A1001	1				5 VDC		1			3	*480 VAC phase to phase*	Through contactor at 1500W each x 3 fans
TLC A1001	Operation of light loft fans	lay	XY A1002	1				5 VDC		1			3	*480 VAC phase to phase*	
	Operation of light loft fans	lay	XY A1002	1				5 VDC		1			3	*480 VAC phase to phase*	
	Flow/no flow for loft fans - A	tch		1				0 or 5 VDC	Flow/no flow						
	Flow/no flow for loft fans - B	tch		1				0 or 5 VDC	Flow/no flow						
	Flow/no flow for loft fans - C	tch		1				0 or 5 VDC	Flow/no flow						
	Lighting Subsystem Total			6	0	0	0								
	Control of pH in the Solution														
	Acid tank level			1				Dry contact	Sensor	1					
	Base tank level			1				Dry contact	Sensor	1					
	Control of Electrical Conductivity in the solution														
	Level Sensor for stock A			1				Dry contact	Float Sensors/Contact Sensor	1					
	Level Sensor for Stock B			1				Dry contact	Float Sensors/Contact Sensor	1					
	Control of Nutrient Solution and Condensate Water Levels														
LLC T2013	Level sensor for reservoir tank (high and low)	Level sensor	LT T2013	2				Dry contact	Float Sensors/Contact Sensor	1					Dry contact, with low and high alarm
LLC T2013	Level sensor for condensation tank (high and low)	Level sensor	LT T2021	2				Dry contact	Float Sensors/Contact Sensor	1					Dry contract
	Hydroponics Subsystem Total			8	0	0	0								

Dr. Geoffrey Waters: All control loop labels, sensor IDs etc will change to conform to MPP nomenclature standards. For now, the convention used in TN 85.5 is retained.

Dr. Geoffrey Waters: Interior doors no longer have contact sensors - operated manually

Dr. Geoffrey Waters: Tipping bucket sensor was duplicated wuth level sensors - no longer required

TOTAL	DI	20

Control Loop	Description	Control Instrument	IO	DI	DO	AI	AO	Elect. Int.	Instrument Type	# DEVICES	DEVICE	POWER (WATTS)	PHASE (SINGLE OR 3)	VOLTAGE	Remarks
	Air Lock Purge Control														
	Airlock pressure sensor - Airlock A	Pressure sensor				1		4-20 mA	Sensor	1	or excitation vo	< 1 W		24 VDC	1 pressure sensor for
	Airlock pressure sensor - Airlock C	Pr				1		4-20 mA	Sensor	1	or excitation vo	< 1 W		24 VDC	
	Growing Area Presure Sensor	Pr				1		4-20 mA	Sensor	1	or excitation vo	< 1 W		24 VDC	
	Air Lock Subsystem Total					**3**									
	Irrigation System														
	Irrigation flow sensor (T201)	Se				1		4-20 mA	Flow sensor	1		1			
	Control of pH in the Solution														
ALC T2011	pH sensor	pH sensor	AT T2011			1		4-20 mA	Sensor	1		< 1 W		24 VDC	Loop powered device
	Control of Electrical Conductivity in the solution														
CLC T2012	Electrical conductivity of nutrient sensor	EC sensor	CT T2012			1		4-20mA	Sensor			< 1 W		24 VDC	Loop powered device
	Hydroponics Subsystem Total					3									
	Temperature Control														
	Temp sensor for facility chilled water line	Thermistors				1		4-20 mA	Thermistor	1					
	Temp sensor for facility hot water line	Thermistors				1		4-20 mA	Thermistor	1					
	Chilled coil surface temperature	Thermistors				1		4-20 mA	Thermistor	1					
	Heating coil surface temperature	Thermistors				1		4-20 mA	Thermistor	1					
	Hot exit temperature	Thermistors				1		4-20 mA	Thermistor	1					
	Chilled Exit Temperature	Thermistors				1		4-20 mA	Thermistor	1					
	Humidity Control														
ALC A3002	Humidity sensor (built in with temp sensor)	Humidity sensor	AT A3002A			1		4-20 mA	Sensor	1		<1 W		24 VDC	Aspirated humidity sensors, Vaisala - comes with temp sensor
ALC A3002	Humidity sensor (built in with temp sensor)	Humidity sensor	AT A3002B			1		4-20 mA	Sensor	1		<1 W		24 VDC	Aspirated humidity sensors, Vaisala
	Humidity sensor (built in with temp sensor)	Humidity sensor	AT A3002B			1		4-20 mA	Sensor	1		<1 W		24 VDC	Aspirated humidity sensors, Vaisala
	RH associated temperature	Temperature				1		4-20 mA	Sensor	1		<1 W		24 VDC	Aspirated temperature sensors, Vaisala
	RH associated temperature	Temperature				1		4-20 mA	Sensor	1		< 1 W		24 VDC	Aspirated temperature sensors, Vaisala
	RH associated temperature	Temperature				1		4-20 mA	Sensor	1		< 1 W		24 VDC	Aspirated temperature sensors, Vaisala
	Atmospheric Subsystem Total					12									
	CO2 Control														
ALC A3003	Infrared Gas Analyzer (IRGA) calib. for CO2	Analyzer	ATCO A3003			1		4-20 mA	Analyzer	1					
ALC A3003	Paramagnetic Analyzer calib. for O2	Analyzer	ATO2 A3003			1		4-20 mA	Analyzer	1					
	CO2 Control Subsystem Total					2									

Dr. Geoffrey Waters: Strictly, this belongs in the Air Handling subsystem rows, but is left here, close to the other pressure sensors

TOTAL ACI 20

Control Loop	Description	Control Instrument	IO	DI	DO	AI	AO	Elect. Int.	Instrument Type	# DEVICES	DEVICE	POWER (WATTS)	PHASE (SINGLE OR 3)	VOLTAGE	Remarks
	Light Intensity Control														
ALC L1011	Acquire light intensity and Signal conditioner	PAR Sensor	AT L1011A			1		0 - 10 V DC	Sensor	1				0 - 10 V DC	Need signal conditioners for each light sensor
ALC L1011	Acquire light intensity and Signal Conditioner	PAR Sensor	AT L1011B			1		0 - 10 V DC	Sensor	1				0 - 10 V DC	Need signal conditioners for each light sensor
ALC L1011	Acquire light intensity and Signal Conditioner	PAR Sensor	AT L1011C			1		0 - 10 V DC	Sensor	1				0 - 10 V DC	Need signal conditioners for each light sensor
	Lighting Loft Temperature Control														
TLC A1001	Light loft temperature sensor	Thermisters	TT A1001A			1		0-5 V DC	Thermister	1	or excitation voltage			0-5 V DC	See note below
TLC A1001	Light loft temperature sensor	Thermisters	TT A1001B			1		0-5 V DC	Thermister	1	or excitation voltage			0-5 V DC	See note below
TLC A1001	Light loft temperature sensor	Thermisters	TT A1001C			1		0-5 V DC	Thermister	1	or excitation voltage			0-5 V DC	See note below
	Lighting Subsystem Total					6									
	Control of Electrical Conductivity in the solution														
	Temperature Sensor for solution reservoir	Thermistors				1		0-5 V DC	Thermistor	1					
	Hydroponics Subsystem Total					1									
	Control of Air circulation fan														
	1 air velocity sensor	flow sensor				1		0-5 V DC	Sensor	1					
	Temperature Control														
TLC A3001	Temperature sensor	Thermistors	TT A3001A			3		0-5 V DC	Thermistor	1					Vaisala
TLC A3001	Temperature sensor	Thermistors	TT A3001B			3		0-5 V DC	Thermistor	1					Vaisala
TLC A3001	Temperature sensor	Thermistors	TT A3001C			3		0-5 V DC	Thermistor	1					Vaisala
	Atmospheric Subsystem Total					10									
	CO2 Control														
ALC A3003	CO2 mass flow/sensor controller for feed to analyzer	Fl	FTC A3003A			1		24V DC In, 4-	MFC	1					
	CO2 injection line - mass flow/sensor controller					1	1	24V DC In, 4-	MFC	1					
	CO2 Control Subsystem Total					2									

Dr. Geoffrey Waters: Its need is dependent upon which type of analyzer we use (if an onboard sample pump is not on the anlayzer we will need to regulate flow)

TOTAL	AVI	19

Control Loop	Description	Control Instrument	IO	DI	DO	AI	AO	Elect. Int.	Instrument Type	# DEVICES	DEVICE	POWER (WATTS)	PHASE (SINGLE OR 3)	VOLTAGE	Remarks
	Control of Air circulation fan														
XLC P3011	Air circulation fan with variable frequency drive controller	Motor	XY P3011				1	24 VAC	VFD (see comment)	1	*OR SPEED C*	*controller 3k*	*3*	*480 VAC phase to phase*	Through contactor (3000 W each), variable speed
	Temperature Control														
TLC A3001	Regulatory valve chilled water - proportional valve	Flow valve	V301				1	4-20 mA	Control Valve	1					
TLC A3001	Regulatory valve hot water - proportional valve	Flow valve	V302				1	4-20 mA	Control Valve	1					
	Atmospheric Subsystem Total						3								
	CO2 Control														
ALC A3003	CO2 mass flow/sensor controller for feed to analyzer	Flow sen/cont	FTC A3003A				1	24V DC In, 4-	MFC	1					
	CO2 injection line - mass flow/sensor controller						1	24V DC In, 4-	MFC	1					
	CO2 Control Subsystem Total						2								

TOTAL ACO 5

Dr. Geoffrey Waters: Its need is dependent upon which type of analyzer we use (if an onboard sample pump is not on the anlayzer we will need to regulate flow)

Dr. Geoffrey Waters: AC TECH VFD c/w: Nema 1 enclosure : 1 or 3 phase input, three phase output. : 220v/50/60 GE 1.5 hp

8. ANNEX 2: PLC I/O CARDS DATA SHEET INFORMATION

Characteristics (continued)

V d.c. input module characteristics

Model			140 DDI 841 00		140 DDI 853 00		140 DDI 673 00
Number of inputs			16		32		24
Number of groups			8		4		3
Points/group			2		8		
Input voltage		⎓ V	10...60				88...150
LEDs			Active 1...16 (green)		Active 1....32 (green)		Active 1....24 (green)
Addressing requirements			1 input word		2 input words		
On state current	⎓ 12 V	mA	5...10				2.5 min. @ c 125 V
	⎓ 24 V	mA	6...30				
	⎓ 48 V	mA	2...15				
	⎓ 60 V	mA	1...5				
Group supply/tolerance			on state	off state	on state	off state	
	⎓ 12 V / + / - 5 %	V	9...12	0...1.8	9...12	0...1.8	–
	⎓ 24 V / - 15...+ 20 %	V	11...24	0...5	11...24	0...5	–
	⎓ 48 V / - 15...+ 20 %	V	34...48	0...10	34...48	0...10	–
	⎓ 60 V / - 15...+ 20 %	V	45...60	0...9	45...60	0...12.5	–
Absolute maximum input		V	⎓ 75				∼ 156.25 including ripple
Response time	Off - on	ms	4				0.7 (defaults filter) 1.5 (optional filter)
	On - off	ms	4				0.7 (defaults filter) 1.5 (optional filter)
Switching frequency		Hz	100 max.				–
Isolation	Group-to-group	V (rms)	⎓ 700 for 1 minute				∼ 1780 for 1 minute
	Group-to-bus	V	2500 for 1 minute				
Bus current requirement		mA	200		300		200
Power dissipation		W	1 + (0.62 x # of points on)				
External power (U_A)		⎓ V	10...60 (group supply), not required for this module				
Fusing	Internal		–				
	External		User discretion				
Logic			Sink				
Agency approvals			UL 508, CSA 22.2-142, CE, FM Class1 Div. 2, c UL				

Characteristics (continued)

V d.c. output module characteristics

Model			140 DDO 353 00	140 DDO 353 10/ 140 DDO 353 01	140 DDO 843 00
Number of outputs			32 (4 groups of 8)		16 (2 groups of 8)
LEDs			Active F 1...32 (green) - indicates point status		Active 1...16 (green) - indicates point status
Addressing requirements			2 output words		1 output word
Voltage	Operating (max)	⎓ V	19.2...30		10.2...72
	Absolute (max)	⎓ V	56 for 1.3 ms decaying voltage pulse	–	72 (continuous)
	1.0 ms	⎓ V	–	50 decaying pulse	–
	on state drop/point	⎓ V	0.4 @ 0.5 A		1 max. @ 2 A
Maximum load current	Each point	A	0.5		2
	Each group	A	4		6
	Per module	A	16		12
	Off state leakage/point	mA	0.4 @ 30 V	DDO 353 10: 0.4...30 VDC DDO 353 01: < 1...24 VDC	1 @ 60 V max
Surge current maximum	Each point	A	5 @ 500 µs duration (no more than 6 per minute)	DDO 353 10: 5 @ 1 ms duration (no more than 6 per minute). DDO 353 01: 2 (limited internally).	7.5 @ 50 ms duration (no more than 20 per minute)
Response time (resistive loads)	Off - on	ms	1 (max.)		1
	On - off	ms	1 (max.)	DDO 353 10: < 1 DDO 353 01: < 0.1	1
Output protection (internal)			Transient voltage suppression	DDO 353 10: transient voltage suppression DDO 353 01: Overload and short-circuit-proof through temperature supervision	Over voltage (suppression diode)
Load inductance maximum		Henry	0.5 @ 4 switch frequency or $L = \frac{0.5}{I^2F}$ where: L = Load Inductance (Henry) I = Load Current (A) F = Switching Frequency (Hz)		–
Load capacitance maximum		µF	50	–	
Tungsten load maximum		W	–	DDO 353 10: 12 @ 24 V	–
Isolation	Group-to-group	⎓	500 V rms for 1 minute		700 V for 1 minute
	Output-to-bus	⎓	1780 V rms for 1 minute		–
	Group-to-bus	⎓	–		2500 V for 1 minute
Fault detection			Blown fuse detect, loss of field power		–
Bus current requirement		mA	330	330 (max)	160
Power dissipation		W	1.75 + (0.4 V x total module load current)	DDO 353 10: 2.0 + (0.4 V x total load current) DDO 353 01: 5 (all points)	1 + (1 V x total module load current)
External power		⎓	19.2...30 V		10...60 V
Fusing	Internal	A	5 per group		8 per group time-lag
	External	A	5 per group The group fuse is not guaranteed to protect each output switch for all possible overload conditions. 3 A per point recommended		8 per group The group fuse is not guaranteed to protect each output switch for all possible overload conditions. 2 A per point recommended
Logic			Source	DDO 353 10: sink DDO 353 01: source	Source
Agency approvals			UL 508, CSA 22.2-142, CE, FM Class1 Div. 2, c UL	DDO 353 10: UL 508, CSA 22.2-142, CE, FM Class1 Div. 2, c UL. DDO 353 01: UL 508, CSA 22.2-142, CE, FM Class1 Div. 2 (pending), c UL	UL 508, CSA 22.2-142, CE, FM Class1 Div. 2, c UL

Output module characteristics

Model			140 ACO 020 00	140 AVO 020 00	140 ACO 130 00
Number of channels			See page 48205/7		8
Addressing requirements		Words	See page 48205/7		8 output
Module ranges and resolution			See page 48205/7		0…25 mA, 0…25,000 counts 0…20 mA, 0…20,000 counts 4…20 mA, 0…16,000 counts (default range) 4…20 mA, 0…4,095 counts
Loop voltage		⎓ V	See page 48205/7		6 … 30 max
Internal voltage drop		⎓ V	See page 48205/7		6 min, 30 max. @ 25 mA
Accuracy error @ 25 °C			See page 48205/7		± 0.2% of full scale
Linearity			See page 48205/7		± 4 µA 0…25 mA, 0 … 25,000 counts ± 4 µA 4…20 mA, 0…16,000 counts ± 12 µA 4…20 mA, 0…4,095 counts ± 4 µA 0…20 mA, 0…20,000 counts
Absolute drift w/temperature			See page 48205/7		Typical: 0.004% of full scale Maximum: 0.007% of full scale
Isolation	Channel-to-channel		See page 48205/7		None
	Field-to-bus		See page 48205/7		∼ 1780 V for 1 minute
Update time		ms	See page 48205/7		5 for all 8 channels
Settling time full scale step change		ms	See page 48205/7		1.6 to 5% of the final value 3.2 to 0.1%of the final value
Fault detection			See page 48205/7		Open circuit in 4…20 mA mode. Specific channel is identified by the red channel LED. Also reported back to the controller in the I/O MAP status byte.
Bus current required		mA	480	700	550
Power dissipation		W	5.3 max.	4.5 max.	5.0
External power			See loop voltage on previous page	Not required for this module	See loop voltage above
Fusing	Internal		–		
	External		–	0.063 A, 250 V *(1)* Fuse type : 3 AG fast acting	–
Voltage Monitor	Range		1...5 V (main current loop must be active)	–	
	Scaling		V_{out} (Volts) = I_{loop} (mA) x 0.25	–	
	Output impedance	Ω	300 typical	–	
	Wire length	m	1 max	–	
Agency approvals			UL 508, CSA 22.2-142, FM Class1 Div.2, C€, cUL		UL 508, CSA 22.2-142, FM Class1 Div.2, C€, cUL (pending)

Input module characteristics

Model			140 ACI 030 00	140 AVI 030 00
Number of channels			8 differential	
Addressing requirements			9 input words	
Input ranges (selectable on a per channel basis)	Bipolar		–	⎓ ± 10 V; ⎓ ± 5 V; ± 20 mA
	Unipolar		–	⎓ 0…10 V; ⎓ 0…5 V; 0…20 mA
	Unipolar w/offset		–	⎓ 1… 5 V; 4…20 mA
Voltage input	Linear measuring range		⎓ 1…5 V	(input range) x 1.024
	Absolute maximum	⎓ V	50	
	Impedance	MΩ	> 20	
Current input	Linear measuring range	mA	4…20	(input range) x 1.024
	Absolute maximum	mA	25	
	Impedance	Ω	250 ± 0.03%	
Absolute accuracy error @ 25° C (voltage mode)	Typical		± 0.05% of full scale	± 0.03%
	Maximum		± 0.1% of full scale	± 0.05% of full scale
Linearity			± 0.04%	± 0.008%
Accuracy drift w/temperature	Typical		± 0.0025% of full scale / °C	± 0.0015% of full scale / °C
	Maximum		± 0.005% of full scale / °C	± 0.004% of full scale / °C
Common mode rejection		dB	> - 72 @ 60 Hz	> - 80 @ 60 Hz
Input filter			Single pole low pass, - 3 dB cutoff @ 15 Hz, ± 20%	Single pole low pass, - 3 dB cutoff @ 847 Hz, ± 20%
Isolation	Channel-to-bus	z	⎓ 1000 V, 3000 Vpp, for 1 minute	⎓ 750 V, ∼ 500 V rms, for 1 minute
	Channel-to-channel	z	⎓ 30 V max.	⎓ 200 V, ∼ 135 V rms max.
Update time		ms	5 for a all channels	10 for a all channels
Fault detection			Broken wire (4…20 mA mode) or under voltage range (1…5 V)	Broken wire in 4…20 mA mode Out of range @ 1…5 V
Bus current requirement		mA	240	280
Power dissipation		W	2	2.2
External power			–	
Resolution		bits	12	16 for ± ⎓ 10 V, ⎓ 0…10 V. 15 for ± ⎓ 5 V, ⎓ 0…5 V, ± 20 mA, 0…20 mA. 14 for ⎓ 1…5 V, 4…20 mA
Agency approvals			UL 508, CSA 22.2-142, FM Class1 Div.2, CE, cUL (pending)	UL 508, CSA 22.2-142, FM Class1 Div.2, CE, cUL

Card Reference	PHOENIX NAME	REMARK	PHOENIX REF	QUANTITY
140DDI84100	FLKM 50-PA-MODI-TSX-Q	FRONT ADAPTER	2294306	2
	FLKM 50/MODI-TSX/Q	INTERFACE MODULE	2294296	2
		CABLE		2

Card Reference	PHOENIX NAME	REMARK	PHOENIX REF	QUANTITY
140ACI03000	FLKM 50-PA-MODI-TSX-Q	FRONT ADAPTER	2294306	5
	FLKM 50/MODI-TSX/Q	INTERFACE MODULE	2294296	5
		CABLE		5

Card Reference	PHOENIX NAME	REMARK	PHOENIX REF	QUANTITY
140AVI03000	FLKM 50-PA-MODI-TSX-Q	FRONT ADAPTER	2294306	2
	FLKM 50/MODI-TSX/Q	INTERFACE MODULE	2294296	2
		CABLE		2

Card Reference	PHOENIX NAME	REMARK	PHOENIX REF	QUANTITY
140ACO13000	FLKM 50-PA-MODI-TSX-Q	FRONT ADAPTER	2294306	1
	FLKM 50/MODI-TSX/Q	INTERFACE MODULE	2294296	1
		CABLE		1

Card Reference	PHOENIX NAME	REMARK	PHOENIX REF	QUANTITY
140DDO35300	FLKM 50-PA-MODI-TSX-Q	FRONTAL	2294306	1
	UMK-16RM/KSR-G24/21/PLC	RELE	2979498	1
	UMK-16RM/KSR-G24/21/E/PLC	RELE EXPANSION	2979508	1