**TEST VLPC CRYOSTAT:
PROGRAMMING AND CONFIGURATION OF CRYOGENIC
AND TEMPERATURE INSTRUMENTS**

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Introduction

Currently, Fermi National Accelerator Laboratory is in the midst of a site wide upgrade. Here at D-Zero, one of the components of this upgrade will be the construction of two 48 cassette VLPC cryostats which will be the heart of the new magnetic central fiber tracker. A VLPC or Visible Light Photon Counter is a device that allows physicists to more accurately calculate the origins of particles ejected during a proton - anti-proton collision in the detector. Inside the detector is an optical fiber barrel which surrounds the collision point. When an ejected particle strikes a fiber the result is the release of photons which travel along the fiber until they reach the bottom of a cassette hitting the VLPC chip. These impacts result in voltages which are read by the VLPC chips and sent to the computer for future analysis. From these voltages, physicists can determine the origins of the particles, their charges, their speeds and other information as well.

Within the last few months a test VLPC has been built at D-Zero. This VLPC is comprised of four rectangular cassettes each equipped with heating elements, RTDs and 1024 VLPC chips. This particular configuration is unique here at Fermilab. Other VLPC cryostats that have been built were usually cylindrical in their geometry. The purpose of this test VLPC is to have on hand a reliable model to aid in understanding the complexities involved in running such devices at approximately 10 K, as well as to prepare for the eventual 48 cassette VLPCs to come. In particular, an important aspect of this test phase is to check the engineering involved so that the final cryostats are designed correctly. Also, this test cryostat will enable us to check each of the cassettes to be used in the final cryostat and correct any problems before hand.

Purpose

This engineering note has been written in order to describe the setup of the VLPC as it pertains to the programming, configuration and control of all of the cryogenic and temperature instruments. These instruments include the two pneumatic valves, the pressure transmitter, heating elements of the cassettes, and the various RTDs scattered throughout. (Note: Please refer to the '*Test VLPC: Programming and Control of the Cryogenic and Temperature Instruments*' manual for all the RTD curve-fits, special functions, ladder logic, flow diagrams, etc. which will be discussed throughout this engineering note.)

Computer Configuration

The programming and control of these instruments was done using a SIEMENS 545 Programmable Logic Controller (PLC) along with a Gateway 2000 - Pentium 60

computer (user interface) running TISOFT (used for programming) and FIX DMACS (used for graphical display and control) software. In Figure 1 below, we can see a schematic of PLC including the input/output signal conditioning modules. (Notice the two 8 Channel Analog Output modules require an external 24 VDC power source to be fully operational.)

Figure 1: Schematic of the SIEMENS 545 PLC and modules

The cryogenic and temperature instruments of the test VLPC are individually connected to the appropriate modules of the PLC. A wiring diagram of each module's instruments has been provided in '*Test VLPC: Programming and Control of the Cryogenic and Temperature Instruments*' manual. The PLC is connected via two serial cables to the Gateway 2000 - Pentium 60 computer. One serial cable is used to transmit and receive data between the PLC and the DMACS software. The other serial cable is used by TISOFT for programming of the PLC itself. As mentioned previously, the DMACS software is an easy to use graphical interface for the operator. The on-screen display allows the operator to view the various system components, display instrument data in real time as well as control the instruments via the computer. TISOFT is a commercially available PLC programming software developed by Texas Instruments. The version of TISOFT used for this test setup is a simple ASCII graphical display. A newer version known as SOFTSHOP is currently available but is not used here since I am more familiar and proficient in the use of TISOFT.

Module Configuration

Slot #1

In Figure 1 we see that slot 1 of the PLC crate is occupied by an 8 ch Analog Input Module [SIEMENS Simatic 505-6108A]. The signal conditioning of this module assigns 8 WX (analog input) words. These occupy memory locations WX1 through WX8. At this time only WX1 is being used. It is connected to the test VLPC vacuum transmitter (PT-619-HE) having a range of 0 - 25 psig.

(Note: An table containing the configuration of each module as well as the assignment of the words has been provided in the I/O Map section of this Engineering Note.)

Slots #2 and #3

Slots 2 and 3 are currently left empty but can be filled and configured at anytime. To install a module, simply disconnect the PLC from the power supply, insert the module in the desired slot and configure the I/O of the module using the TISOFT program. TISOFT can be run using the RUN command line in the start menu of the Gateway 2000 computer. Simply type in (C:\TNTI565.BAT P2). Once the program has reached the main TISOFT screen, go ONLINE [F4] and configure the I/O [SPACE , F3] followed by CONFIG [F2].

Slot #4

Slot 4 contains the 16 pt RTD input module [CTI 2557]. This modules reads individual resistances of 4 wire resistors which are then converted to temperature using special function programs within the PLC. The module has assigned to it 16 WX words ranging from WX25 to WX41. Words WX25 through WX28 are assigned to RTDs TE200, TE202, TE204 and TE206, respectively. These four RTDs are currently unavailable and there status is yet to be determined. One possibility is that four of the other RTDs will be moved to these locations while another possibility is that completely new RTDs will be installed. Words WX29 through WX39 are occupied by eleven RTDs: three on the VLPC and eight on the cassettes .

Slot #5

Slot 5 is left empty. (see slots 2 & 3)

Slots #6 & #7

These two slots are each occupied by an 8 ch Analog Output module [SIEMENS Simatic 505-6208A]. Also, each of these modules is connected to an external 24 VDC power supply in order to be fully operational. The modules are assigned 8 WY (analog output) words each, with slot 6 configured for WY49 through WY56 while slot 7 is configured for WY57 through WY64. The output of each cassette's heater is controlled by

words WY49, WY50, WY51 and WY52 for heaters on cassette one through four, respectively. These output values are calculated using loop-mimicking special function programs which employ PI (Proportional and Integral) control of the loops. WY53 and WY54 control the loop output for the two pneumatic valves. This output is simply the percentage of the valve position e.g. 0.0% signifies a closed valve while 100.0% signifies a fully open valve. The valves are controlled both by loops as well as by special function programs; they will be discussed completely in an upcoming section.

Slots #8 - #15

Slots 8 through 15 are left empty. (see slots 2 & 3)

Slot #16

Slot 16 is the Serial Interface Adapter. It serves as the main link between the PLC and the user interface (Gateway 2000 computer). The module is configured with six WY and two WX words, which are used by the module to transmit and receive data.

Programming of RTDs Special Functions

As mentioned previously, the RTDs (Resistance - Temperature Devices) are connected to the 16 ch RTD module of the PLC crate. These RTDs are simple 4 wire resistors shown schematically below.

Figure 2: Wiring Diagram of an RTD

The black and white wires carry the current across the resistor while the red and green wires measure the actual resistance across it. The red and green wires are connected to the actual resistor as closely as possible in order to avoid counting the resistance of the wires leading to the resistor itself. The resistance read by the module (slot 4) ranges from 0 to 1000 ohms. This value is transferred as an integer to the PLC via a WX integer ranging from 0 to 32000. The PLC then converts this integer to the appropriate resistance which in turn is used in an equation to calculate the corresponding temperature in Kelvin. The

Programming of Heaters

Each of the four cassettes of the test VLPC contain two heaters which are used to warm up the cassette based on the temperature readings received from the RTDs on that cassette. Although there are two heaters, they will be controlled as one with their output originating from one analog output word (WY). A PI (Proportional and Integral) control has been selected for the heaters and so a loop will need to be built in order to achieve this. Because the current VLPC setup is only temporary it would be unwise to use a standard SCADA node. Instead a direct driver control will be used. The TID driver (Advanced Texas Instruments Direct I/O Driver) provides the software interface and communications protocol between FIX DMACS and FIX MMI software and the PLC. The heaters require the use of a loop to control them, but since the number of loops in the PLC is limited to 64, and in the future VLPCs the number of heaters may grow to 98 or more, another method of loop control was necessary. The solution was to build a loop-mimicking special function program. This program would perform the necessary PI calculations using V-memory in place of the commonly used LVFs, LMNs, LSPs, etc. The V-memory is used because the TID driver allows only certain memory types to be transferred to DMACS from the PLC and LVF, LMN, etc. are not included. The necessary PID algorithm has been obtained from the Siemens Programming Reference Manual Section 9.3, page 9-6. The special function program for a heater loop would calculate the output of the loop using temperature data as well, and any gains that the user may have specified through the DMACS heater control pages, and send the results to DMACS as a variable float (VF) value.

As an example, let us analyze the special function for the heater in cassette number one. This special function program is named LOOP-A and corresponds to SFPGM16 (see the appendix for a copy of the program). One of the main controls of the heater loop is the ability of the operator to set the loop to Manual or Automatic. The operator simply hits the MANUAL or AUTOMATIC push buttons on his display which in turn control ladder logic contact C2 - see Figure 4 below. (Note: Contact C2 corresponds to LOOP-A, the other heaters use different contacts. A listing of all the relays used for this test VLPC is included in the appendix.)

copies of the loops and special function programs. The ladder logic associated with valve FCV-312-HE is shown in Figure 5 below.

Figure 5. Valve FCV-312-HE Ladder Logic

As in the heaters, the valve must be able to be in automatic or manual modes. A loop V-flag variable (LVF) is used to instruct the loop to achieve the desired mode. By manipulating certain bits with the LVF word, the operator can set mode of the loop accordingly. The binary word (LVF1) associated with loop #1 contains 16 bits, with the leftmost being bit-15 while the rightmost one is bit-0.

[0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0|0]
bit-15 bit-0

BIT	VALUE	ACTION
15	1	Set loop to Manual
14	1	Set loop to Auto
12	1	Loop status: in Auto
12	0	Loop status: in Manual

Figure 6. (LVF) Loop V-Flags

SFPGM22 is used to copy the control V-memory to the appropriate LVFs. For the case of valve FCV-312-HE this means continuously copying V201 to LVF1. This allows the user to change V201 through DMACS and transfer this value to the PLC through the TID driver where it is copied to LVF1 and the loop acts according. The output of the loop is controlled using ladder logic. In ladder rung 77 of Figure 5 we see the box BITP1 which reads the fourth bit from the left (N=4) -- corresponding to bit-12 -- of V201 and turns coil C10 on if the value is 1. This in turn will execute SFPGM23 (Manual Mode) and disable SFPGM20 (Automatic Mode). On the other hand, if the bit-12 is 0 the reverse will occur. A flow diagram of the logic is displayed below.

Figure 7. Loop #1 Ladder Logic Flow Diagram

The operator can set the loop mode by hitting the A/M toggle push-button of the DMACS valve picture (testpod.odf). The action above will result in one of the following situations:

If the loop is already in the automatic mode (i.e. bit-12 is 1) then the hitting the button will set bit 15 in V201 (LVF1) to 1 using the DMACS database block LOOP1MAN (Note: The command in the database block is: D11:V201:15). After a few seconds this bit is cleared back to 0 and the loop will be in manual mode. The status of the loop can be determined by looking at bit 12 of V201. When in manual mode the output and set point

are controlled via SFPGM20, which had been activated in the ladder, by the operator. The operator sets the loop output (LMN1) by modifying V203 while the set point (LSP1) is determined when the operator modifies V205. The set point will not be update in the loop until the loop is set to automatic mode; in the mean time it remains in V-memory V205.

If the loop is in manual mode (i.e. bit-12 is 0) then the DMACS database block (LOOP1AUT) will set bit 14 to 1 (D11:V201:14 in the DMACS database block). Again, after a few seconds this bit will also be reset to 0 while bit-12 of V201 should now be reading 1). In automatic mode SFPGM23 is the active program which is used to obtain the output (LMN1) from the loop and copy it to a V-memory (V203) and send it to DMACS to be displayed. This special function program is nothing more than a status program, modifying V203 externally has no affect on the loop output. On the other hand, modifying the set point (V205) has a direct affect on the loop since the set point value is being continuously updated by the loop.

The loop for valve FCV-308-HE acts in exactly the same manner but it is controlled via a different set of V-memory values. As mentioned previously, a list of all V-memory and Relays has been provided in the appendix of this engineering note, as are all of the special functions and ladder logic that has been used.

DMACS

The graphical interface to be used by the operator is know as FIX DMACS. DMACS is a commercially available program which serves as a graphical user interface for controlling various devices. The user can draw two-dimensional representations of valves, pumps, RTDs, etc. with output readings and control these objects and the data by simply pointing and clicking on them with a mouse. (Note: See the appendix for copies of the pictures.) The first drawing associated with this test VLPC is called *testvlpc.odf* and is located in the C:\WDMACS\PICS\D0 directory. This picture is a more graphical drawing of the flow diagram for the VLPC. Using this picture, the user can view the temperature associated with the various RTDs, the cryostat vacuum pressure, the heater and valve modes as well as control the valves. The four cassettes as well as the two valves are each clickable and bring up separate pictures to control them. The valve picture *testpod.odf* allows the user to change modes as well as modifying valve position (only in manual mode) and changing the set point (both in manual and automatic modes). In the heater pictures (*casX.odf* where X is 1,2,3 or 4 representing the four cassettes), both the resistance as well the temperature of the RTD is displayed. Also, the user can change the heater loop modes and control the output either directly (in manual mode only) or via the proportional and integral gains.

Trouble-Shooting

<u>Problem</u>	<u>Possible Solutions</u>
Can't change valve or heater to manual or automatic modes	<p>** Check that the PLC is in RUN mode [RUN led is on]</p> <p>** Using TISOFT, enter chart mode and using CHANGVAL-[F2] set</p> <p><u>FCV-312-HE</u> V201 = 0 [F8] <u>FCV-308-HE</u> V207 = 0 [F8]</p>
Valves don't seem to be responding to commands (they don't physically move)	<p>** Check that the external 24 VDC power supply is plugged in and the two modules in slots #6 and #7 are on</p> <p>** Check connections between the modules and valves</p> <p>** Manipulate valve output with TISOFT (used when problem cannot be solved without expert help - temporary)</p> <p><u>FCV-312-HE</u></p> <p style="padding-left: 40px;">WY54 = 0 = 0.0% {CLOSED} = 32000 = 100.0% {OPEN}</p> <p><u>FCV-308-HE</u></p> <p style="padding-left: 40px;">WY53 = 0 = 0.0% {CLOSED} = 32000 = 100.0% {OPEN}</p> <p>** Check that the PLC is in RUN mode [RUN led is on]</p>
RTDs are reading incorrectly	<p>** Check connections at modules and at VLPC</p>
Question marks on screen where data should be present EX. ????? ohms	<p>** Click on question mark and place tags on-scan</p> <p>** Check that tag exists in the database</p>

References

1. **Siemens Programming Reference Manual**
2. **Intellution I/O Driver Manual (TID)**
3. **Siemens Analog I/O Modules User Manual**
4. **CTI 2557 Isolated RTD Input Module User Manual**
5. **D0 Upgrade Fiber Tracker Detector 1024 Channel VLPC Cassette**

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D0 TI555 I/O MAP (511)

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Channel	Base	SLOT/PT	I/O Type	Address	DMACS Tagname	Description	Terminal	Sex	Range
1	0	01/01	Analog In	WX0001	PT619	Pressure Transmitter for Helium sample sp			0-25 psig
1	0	01/02	Analog In	WX0002					
1	0	01/03	Analog In	WX0003					
1	0	01/04	Analog In	WX0004					
1	0	01/05	Analog In	WX0005					
1	0	01/06	Analog In	WX0006					
1	0	01/07	Analog In	WX0007					
1	0	01/08	Analog In	WX0008					
1	0	04/01	RTD In	WX0025	TE200-T	Temp. element on Cassette 1			
1	0	04/02	RTD In	WX0026	TE202-T	Temp. element on Cassette 2			
1	0	04/03	RTD In	WX0027	TE204-T	Temp. element on Cassette 3			
1	0	04/04	RTD In	WX0028	TE206-T	Temp. element on Cassette 4			
1	0	04/05	RTD In	WX0029	TE304-T	Temp. element on liquid helium supply			
1	0	04/06	RTD In	WX0030	TE306-T	Temp. element on LHe cold block return			
1	0	04/07	RTD In	WX0031	TE310-T	Temp. element on GHe intercept return			
1	0	04/08	RTD In	WX0032	L2				
1	0	04/09	RTD in	WX0033	L4				
1	0	04/10	RTD in	WX0034	L6				
1	0	04/11	RTD in	WX0035	L8				
1	0	04/12	RTD in	WX0036	M2				
1	0	04/13	RTD in	WX0037	M4				
1	0	04/14	RTD in	WX0038	M6				
1	0	04/15	RTD in	WX0039	M8				
1	0	04/16	RTD in	WX0040					
1	0	06/01	Analog Out	WY0049	HTR200-1	#1 & #2 heater elements on Cassette 1			
1	0	06/02	Analog Out	WY0050	HTR202-3	#1 & #2 heater elements on Cassette 2			
1	0	06/03	Analog Out	WY0051	HTR204-5	#1 & #2 heater elements on Cassette 3			
1	0	06/04	Analog Out	WY0052	HTR206-7	#1 & #2 heater elements on Cassette 4			
1	0	06/05	Analog Out	WY0053	FCV308HE	Flow control valve for cold block He outlet			

Channel	Base	SLOT/PT	I/O Type	Address	DMACS Tagname	Description	Terminal	Sex	Range
1	0	06/06	Analog Out	WY0054	FCV312HE	Flow control valve for GHe intercept He ou			
1	0	06/07	Analog Out	WY0055					
1	0	06/08	Analog Out	WY0056					
1	0	07/01	Analog Out	WY0057					
1	0	07/02	Analog Out	WY0058					
1	0	07/03	Analog Out	WY0059					
1	0	07/04	Analog Out	WY0060					
1	0	07/05	Analog Out	WY0061					
1	0	07/06	Analog Out	WY0062					
1	0	07/07	Analog Out	WY0063					
1	0	07/08	Analog Out	WY0064					

'LADDER LOGIC'

```

1      ! C1      SFPGM1-----+                               C1
      [-] [-*-!      |------(      )
      !          !!      |
      ! C1      !!      |
      [-]/[-+ !      |
      !          +-----+
5      ! C1      SFPGM2-----+                               C1
      [-] [-*-!      |------(      )
      !          !!      |
      ! C1      !!      |
      [-]/[-+ !      |
      !          +-----+
9      ! C1      SFPGM3-----+                               C1
      [-] [-*-!      |------(      )
      !          !!      |
      ! C1      !!      |
      [-]/[-+ !      |
      !          +-----+
13     ! C1      SFPGM4-----+                               C1
      [-] [-*-!      |------(      )
      !          !!      |
      ! C1      !!      |
      [-]/[-+ !      |
      !          +-----+
17     ! C1      SFPGM5-----+                               C1
      [-] [-*-!      |------(      )
      !          !!      |
      ! C1      !!      |
      [-]/[-+ !      |
      !          +-----+
21     ! C1      SFPGM6-----+                               C1
      [-] [-*-!      |------(      )
      !          !!      |
      ! C1      !!      |
      [-]/[-+ !      |
      !          +-----+
25     ! C1      SFPGM7-----+                               C1
      [-] [-*-!      |------(      )
      !          !!      |
      ! C1      !!      |
      [-]/[-+ !      |
      !          +-----+
29     ! C1      SFPGM8-----+                               C1
      [-] [-*-!      |------(      )
      !          !!      |
      ! C1      !!      |
      [-]/[-+ !      |
      !          +-----+
33     ! C1      SFPGM9-----+                               C1
      [-] [-*-!      |------(      )
      !          !!      |
      ! C1      !!      |
      [-]/[-+ !      |

```

```

! C1   SFPGM10-----+
37  [-] [-*-!          !-----C1
    !      !!          !----- ( )
    ! C1  !!          !
    [-]/[-+ !          !
    !      +-----+
! C1   SFPGM11-----+
41  [-] [-*-!          !-----C1
    !      !!          !----- ( )
    ! C1  !!          !
    [-]/[-+ !          !
    !      +-----+
! C1   SFPGM12-----+
45  [-] [-*-!          !-----C1
    !      !!          !----- ( )
    ! C1  !!          !
    [-]/[-+ !          !
    !      +-----+
! C1   SFPGM13-----+
49  [-] [-*-!          !-----C1
    !      !!          !----- ( )
    ! C1  !!          !
    [-]/[-+ !          !
    !      +-----+
! C1   SFPGM14-----+
53  [-] [-*-!          !-----C1
    !      !!          !----- ( )
    ! C1  !!          !
    [-]/[-+ !          !
    !      +-----+
! C1   SFPGM15-----+
57  [-] [-*-!          !-----C1
    !      !!          !----- ( )
    ! C1  !!          !
    [-]/[-+ !          !
    !      +-----+
! C2   SFPGM16-----+
61  [-] [---!          !-----C1
    !      !          !----- ( )
    !      !          !
    !      !          !
    !      +-----+
! C4   SFPGM17-----+
64  [-] [---!          !-----C1
    !      !          !----- ( )
    !      !          !
    !      !          !
    !      +-----+
! C6   SFPGM18-----+
67  [-] [---!          !-----C1
    !      !          !----- ( )
    !      !          !
    !      !          !
    !      +-----+

```

```

! C8      SFPGM19-----+
70 [-] [---!          !------( )
!         !          !
!         !          !
!         !          !
!         +-----+
! C1      SFPGM22-----+          C1
73 [-] [-*-!          !------( )
!         !!         !
! C1 !!         !
! [-]/[-+ !          !
!         +-----+
! C1      BITP1-----+          C10
77 [-] [-*-!          !------( )
!         !! A:V201    !
! C1 !! N=4          !
! [-]/[-+ !          !
!         +-----+
! C10     SFPGM20-----+          C1
83 [-]/[---!          !------( )
!         !          !
!         !          !
!         !          !
!         +-----+
! C10     SFPGM23-----+          C1
86 [-] [---!          !------( )
!         !          !
!         !          !
!         !          !
!         +-----+
! C1      BITP2-----+          C11
89 [-] [-*-!          !------( )
!         !! A:V207    !
! C1 !! N=4          !
! [-]/[-+ !          !
!         +-----+
! C11     SFPGM24-----+          C1
95 [-] [---!          !------( )
!         !          !
!         !          !
!         !          !
!         +-----+
! C11     SFPGM21-----+          C1
98 [-]/[---!          !------( )
!         !          !
!         !          !
!         !          !
!         +-----+
!
101 [------( )
!
END

```

V Address	Description
1	(TE200) - Resistance on Cassette #1
2	(TE200) - Res. #2
3	(TE202) - Resistance on Cassette #2
4	(TE202) - Res. #2
5	(TE204) - Resistance on Cassette #3
6	(TE204) - Res. #2
7	(TE206) - Resistance on Cassette #4
8	(TE206) - Res. #2
9	(TE304) - Resistance on liquid Helium supply
10	(TE304) - Res. #2
11	(TE306) - Resistance on liquid Helium block return
12	(TE306) - Res. #2
13	(TE310) - Resistance on gas Helium intercept return
14	(TE310) - Res. #2
15	(L2) - Resistance
16	(L2) - Res. #2
17	(L4) - Resistance
18	(L4) - Res. #2
19	(L6) - Resistance
20	(L6) - Res. #2
21	(L8) - Resistance
22	(L8) - Res. #2
23	(M2) - Resistance
24	(M2) - Res. #2
25	(M4) - Resistance
26	(M4) - Res. #2
27	(M6) - Resistance
28	(M6) - Res. #2
29	(M8) - Resistance
30	(M8) - Res. #2
31	
32	
33	(TE200) - Temperature on Cassette #1
34	(TE200) - Temp. #2
35	(TE202) - Temperature on Cassette #2
36	(TE202) - Temp. #2
37	(TE204) - Temperature on Cassette #3
38	(TE204) - Temp. #2
39	(TE206) - Temperature on Cassette #4
40	(TE206) - Temp. #2
41	(TE304) - Temperature on liquid Helium supply
42	(TE304) - Temp. #2
43	(TE306) - Temperature on liquid Helium block return
44	(TE306) - Temp. #2
45	(TE310) - Temperature on gas Helium intercept return
46	(TE310) - Temp. #2
47	(L2) - Temperature

V-Address	Description
48	(L2) - Temp. #2
49	(L4) - Temperature
50	(L4) - Temp. #2
51	(L6) - Temperature
52	(L6) - Temp. #2
53	(L8) - Temperature
54	(L8) - Temp. #2
55	(M2) - Temperature
56	(M2) - Temp. #2
57	(M4) - Temperature
58	(M4) - Temp. #2
59	(M6) - Temperature
60	(M6) - Temp. #2
61	(M8) - Temperature
62	(M8) - Temp #2
63	
64	
65	(LOOP-A) Proportional Gain (LKC)
66	(LOOP-A) LKC #2
67	(LOOP-A) Integral Time (LTI)
68	(LOOP-A) LTI #2
69	(LOOP-A) Set-point (LSP)
70	(LOOP-A) LSP #2
71	(LOOP-A) Output
72	(LOOP-A) Output #2
73	(LOOP-B) Proportional Gain (LKC)
74	(LOOP-B) LKC #2
75	(LOOP-B) Integral Time (LTI)
76	(LOOP-B) LTI #2
77	(LOOP-B) Set-point (LSP)
78	(LOOP-B) LSP #2
79	(LOOP-B) Output
80	(LOOP-B) Output #2
81	(LOOP-C) Proportional Gain (LKC)
82	(LOOP-C) LKC #2
83	(LOOP-C) Integral Time (LTI)
84	(LOOP-C) LTI #2
85	(LOOP-C) Set-point (LSP)
86	(LOOP-C) LSP #2
87	(LOOP-C) Output
88	(LOOP-C) Output #2
89	(LOOP-D) Proportional Gain (LKC)
90	(LOOP-D) LKC #2
91	(LOOP-D) Integral Time (LTI)
92	(LOOP-D) LTI #2
93	(LOOP-D) Set-point (LSP)
94	(LOOP-D) LSP #2

Address	Description
95	(LOOP-D) Output
96	(LOOP-D) Output #2
97	
98	
99	
100	
101	(LOOP-A) Sample Rate (LTS)
102	(LOOP-A) LTS #2
103	(LOOP-A) Process Variable (LPV)
104	(LOOP-A) LPV #2
105	(LOOP-A) Error
106	(LOOP-A) Error #2
107	(LOOP-A) Error (n-1)
108	(LOOP-A) Error (n-1) #2
109	(LOOP-A) New Bias
110	(LOOP-A) Bias #2
111	(LOOP-A) Output (n-1)
112	(LOOP-A) Output (n-1) #2
113	(LOOP-B) Sample Rate (LTS)
114	(LOOP-B) LTS #2
115	(LOOP-B) Process Variable (LPV)
116	(LOOP-B) LPV #2
117	(LOOP-B) Error
118	(LOOP-B) Error #2
119	(LOOP-B) Error (n-1)
120	(LOOP-B) Error (n-1) #2
121	(LOOP-B) New Bias
122	(LOOP-B) Bias #2
123	(LOOP-B) Output (n-1)
124	(LOOP-B) Output (n-1) #2
125	(LOOP-C) Sample Rate (LTS)
126	(LOOP-C) LTS #2
127	(LOOP-C) Process Variable (LPV)
128	(LOOP-C) LPV #2
129	(LOOP-C) Error
130	(LOOP-C) Error #2
131	(LOOP-C) Error (n-1)
132	(LOOP-C) Error (n-1) #2
133	(LOOP-C) New Bias
134	(LOOP-C) Bias #2
135	(LOOP-C) Output (n-1)
136	(LOOP-C) Output (n-1) #2
137	(LOOP-D) Sample Rate (LTS)
138	(LOOP-D) LTS #2
139	(LOOP-D) Process Variable (LPV)
140	(LOOP-D) LPV #2
141	(LOOP-D) Error

V-Address	Description
142	(LOOP-D) Error #2
143	(LOOP-D) Error (n-1)
144	(LOOP-D) Error (n-1) #2
145	(LOOP-D) New Bias
146	(LOOP-D) Bias #2
147	(LOOP-D) Output (n-1)
148	(LOOP-D) Output (n-1) #2
200	
201	(FCV312HE) LOOP#1 V-FLAG (LVF1)
202	
203	(FCV312HE) LOOP#1 OUTPUT (LMN1)
204	
205	(FCV312HE) LOOP#1 SET-POINT (LSP1)
206	
207	(FCV308HE) LOOP#2 V-FLAG (LVF2)
208	
209	(FCV308HE) LOOP#2 OUTPUT (LMN2)
210	
211	(FCV308HE) LOOP#2 SET-POINT (LSP2)
212	
213	(TE310) Temperature UNSCALED TO INTEGER [0-300 K]
214	(TE306) Temperature UNSCALED TO INTEGER [0-300 K]

Coil	Description	DB Tagname	Open Tag
1	DEFAULT		
2	(LOOP-A) Manual / Automatic control		
3	-unused-		
4	(LOOP-B) Manual / Automatic control		
5	-unused-		
6	(LOOP-C) Manual / Automatic control		
7	-unused-		
8	(LOOP-D) Manual / Automatic control		
9	-unused-		
10	(FCV312HE) BIT COMPARE - Turn ON/OFF SFPGM		
11	(FCV308HE) BIT COMPARE - Turn ON/OFF SFPGM		
12			

505 I/O CONFIGURATION CHART FOR CHANNEL ... 1 BASE 00
I/O POINTS

	1	2	3	4	5	6	7	8
SLOT 1	WX0001	WX0002	WX0003	WX0004	WX0005	WX0006	WX0007	WX0008

SLOT 2

SLOT 3

	1	2	3	4	5	6	7	8
SLOT 4	WX0025	WX0026	WX0027	WX0028	WX0029	WX0030	WX0031	WX0032

	9	10	11	12	13	14	15	16
SLOT 4	WX0033	WX0034	WX0035	WX0036	WX0037	WX0038	WX0039	WX0040

SLOT 5

	1	2	3	4	5	6	7	8
SLOT 6	WY0049	WY0050	WY0051	WY0052	WY0053	WY0054	WY0055	WY0056

	1	2	3	4	5	6	7	8
SLOT 7	WY0057	WY0058	WY0059	WY0060	WY0061	WY0062	WY0063	WY0064

SLOT 8

SLOT 9

SLOT 10

SLOT 11

SLOT 12

SLOT 13

SLOT 14

SLOT 15

	1	2	3	4	5	6	7	8
SF SLOT 16	WX0161	WX0162	WY0163	WY0164	WY0165	WY0166	WY0167	WY0168

SLOT #1
ANALOG INPUT MODULE

Appendix A
Terminal Block Worksheet

P000018

16 ch RTD MODULE

To assign an input to a specific channel, locate the appropriate channel position on the press in connector block as shown in the following figure (each channel consists of 4 positions).

I1, V+, G, I2

B R G W
(BLACK) (RED) (GREEN) (WHITE)

*=signifies different than standard wiring.

CHANNEL GROUP 1	CHANNEL 1	B, R, G, W	TE200
	CHANNEL 2	B, R, G, W	TE202
CHANNEL GROUP 2	CHANNEL 3	B, R, G, W	TE204
	CHANNEL 4	B, R, G, W	TE206
CHANNEL GROUP 3	CHANNEL 5	R, W, G, B	TE304 - *
	CHANNEL 6	R, B, W, G	TE306 - *
CHANNEL GROUP 4	CHANNEL 7	R, W, G, B	TE310 - *
	CHANNEL 8	B, R, G, W	L2
CHANNEL GROUP 5	CHANNEL 9	B, R, G, W	L4
	CHANNEL 10	B, R, G, W	L6
CHANNEL GROUP 6	CHANNEL 11	B, R, G, W	L8
	CHANNEL 12	B, R, G, W	M2
CHANNEL GROUP 7	CHANNEL 13	B, R, G, W	M4
	CHANNEL 14	B, R, G, W	M6
CHANNEL GROUP 8	CHANNEL 15	B, R, G, W	M8
	CHANNEL 16	[EMPTY]	

Figure 12 Press In Wiring Connector

CAUTION:

RTD wires must be of the same gauge for proper lead length compensation.

Terminal Block Worksheet

P000018

TITLE: TE306

SF PROGRAM 6

CONTINUE ON ERROR (Y,N): YES
ERROR STATUS ADDR (Y,C,WY,V):
PROGRAM TYPE (N,P,C,R): CYCLIC
CYCLE TIME (SEC): 3.0

```
-----
00001 *      THIS PROGRAM IS USED TO CALCULATE THE TEMPERATURE USING
              CURVE-FIT FORMULAS (#1'S) FOR THE X04975 RTD (TE306)
00002 *      WX30      = UNSCALED BINARY INPUT OF RESISTANCE
              V11.     = REAL SCALED INPUT OF RESISTANCE
              V43.     = REAL SCALED TEMPERATURE
00003 *      CONVERT INTEGER RESISTANCE TO REAL RESISTANCE
00004 IF      WX30 < 0
00005 MATH     V11. := WX30 / 60 + 1092.27
00006 ELSE
00007 MATH     V11. := WX30 / 60
00008 ENDIF
00009 *      ***** (3-39K) RANGE *****
00010 IF      V11. >= 151.356
00011 MATH     V43. := -99.027 * ( LOG ( V11. ) ) ** 3.0 + 838.61 * ( LOG ( V11.
              ) ) ** 2.0 - 2381.3 * LOG ( V11. ) + 2270.8
00012 ELSE
00013 *      ***** (39-300K) RANGE *****
00014 MATH     V43. := 579.3 * ( LOG ( V11. ) ) ** 4.0 - 4739.7 * ( LOG ( V11. )
              ) ** 3.0 + 1.4856E4 * ( LOG ( V11. ) ) ** 2.0 - 2.1325E4 * LOG (
              V11. ) + 1.1948E4
00015 ENDIF
00016 *      ***** (300K-->) RANGE *****
00017 IF      V11. <= 34.0 OR V43. > 300.0
00018 MATH     V43. := 300.0
00019 ENDIF
00020 UNSCALE  SCALED INPUT...: V43.          BINARY RESULT.: V214
              LOW LIMIT.....: 0.0          HIGH LIMIT.....: 300.0
              20% OFFSET.....: NO           BIPOLAR.....: NO
****  END  ****
```


TITLE: FCV312HE

SF PROGRAM 20

CONTINUE ON ERROR (Y,N): YES
ERROR STATUS ADDR (Y,C,WY,V):
PROGRAM TYPE (N,P,C,R): CYCLIC
CYCLE TIME (SEC): 1.0

00001 * THIS PROGRAM WILL BE USED TO HELP OPERATE LOOP #1 USING THE
TID DRIVER. THIS REQUIRES ASSSIGNING V-MEMORY TO THE
LMN (LOOP#1 OUTPUT) AND LSP (LOOP#1 SET-POINT)
00002 IMATH LMN1 := V203
00003 MATH LSP1 := V205
**** END ****

TITLE: STATUS1

SF PROGRAM 22

CONTINUE ON ERROR (Y,N): YES
ERROR STATUS ADDR (Y,C,WY,V):
PROGRAM TYPE (N,P,C,R): CYCLIC
CYCLE TIME (SEC): 0.5

00001 * THIS PROGRAM WRITES THE DESIRED STATUS OF THE LOOPS
FROM V-MEMORY SLOT TO LVF1 AND LVF2
00002 IMATH LVF1 := V201
00003 IMATH LVF2 := V207
**** END ****

TITLE: 312-AUTO

SF PROGRAM 23

CONTINUE ON ERROR (Y,N): YES
ERROR STATUS ADDR (Y,C,WY,V):
PROGRAM TYPE (N,P,C,R): CYCLIC
CYCLE TIME (SEC): 0.5

00001 * THIS SPECIAL FUNCTION IS RUN WHEN THE LOOP#1 IS IN AUTOMATIC
MODE. THE LOOP OUTPUT (LMN1) IS WRITTEN TO V-MEMORY V203
00002 IMATH V203 := LMN1
**** END ****

PID LOOP 1 TITLE: FCV312HE
POS/VEL PID ALGORITHM: POS
LOOP VFLAG ADDRESS: V201
SAMPLE RATE (SECS): +0.50000
PROCESS VARIABLE ADDRESS: V213
PV RANGE: LOW = +0.00000
HIGH = +300.000

PV IS BIPOLAR: NO
SQUARE ROOT OF PV: NO
20% OFFSET ON PV: NO

LOOP OUTPUT ADDRESS: WY54
OUTPUT IS BIPOLAR: NO
20% OFFSET ON OUTPUT: YES

RAMP/SOAK PROGRAMMED: NO
RAMP/SOAK FOR SP: NO

ALARM DEADBAND: +0.00000

MONITOR LOW-LOW/HI-HI: NO
MONITOR LOW/HIGH: NO
PV ALARMS: LOW-LOW = +0.00000
LOW = +0.00000
HIGH = +300.000
HIGH-HIGH = +300.000

RAMP/SOAK FLAG ADDRESS: NONE
STATUS SETPOINT
STEP R/S BIT (UNITS)

REMOTE SETPOINT: NONE
CLAMP SP LIMITS: LOW = +0.00000
HIGH = +300.000

LOOP GAIN: +2.99929
RESET (INTEGRAL TIME): +2.00000
RATE (DERIVATIVE TIME): +0.00000
FREEZE BIAS: YES

DERIVATIVE GAIN LIMITING: NO
LIMITING COEFFICIENT: +10.0000

SPECIAL CALCULATION ON: PV
SPECIAL FUNCTION: SFPGM20

LOCK SETPOINT: NO
LOCK AUTO/MANUAL: NO
LOCK CASCADE: NO

ERROR OPERATION: NONE
REVERSE ACTING: YES

MONITOR DEVIATION: NO
DEVIATION ALARM: YELLOW = +0.00000
ORANGE = +0.00000

MONITOR RATE OF CHANGE: NO
RATE OF CHANGE ALARM: +0.00000

MONITOR BROKEN XMITTER: NO

RAMP RATE	SOAK TIME	DEADBAND
(UNITS/MIN)	(MIN)	(UNITS)

D-ZERO TEST CRYOSTAT

EXIT

CASSETTE #1

	TEMP. [K]	RESIST. [ohms]
	205.149	105.83
L4	188.819	107.30
L6	300.000	0.42
L8	300.000	0.22
M2	300.000	0.38
M4	300.000	0.25
M6	300.000	0.42
M8	300.000	0.25
HEATER		
0.99 %		

PROCESS VARIABLE 205.148621
SET-POINT 201.602997
PROPORTIONAL GAIN 0.010
INTEGRAL GAIN 60.000

MANUAL

AUTO

MANUAL

OUTPUT 0.9927188%

SELECT OUTPUT

LO = 100.0%

ADDENDUM TO:

D0 ENGINEERING NOTE: 3823.113-EN-470

Zaczek, Mariusz

8-27-97

D-Zero Mechanical Group

Purpose

The purpose of this addendum is to list the new additions to the 3823.113-EN-470 engineering note for the test cryostat.

Additions

The new addition presented in this addendum deals solely with the loop programming of the valves FCV-312-HE and FCV-308-HE. A need has risen for the ability of the controller to change the loop gains -- proportional (P), integral (I) and derivative (D) gains. This has been achieved through the addition of special function program 25 (see the end of this addendum). Special function 25 compares two variable memory values and updates particular gains as necessary. As an example, let us analyze the programming of the proportional gain control for valve FCV-312-HE. In the DMACS environment variable memory V215. serves as both the input of the proportional gain and the output. The user input a desired gain (V215.) which is then sent to the PLC where the value is compared with V227. (temporary 2nd proportional gain). If V215. is less than or greater than V227. then this value is copied into LKC1. If the values are equal no update of LKC1 is performed. The next two lines constantly copy the value of LKC1 to V215. and V217.

The above special function thus allows the user to both input the desired gains while also viewing the current gain. If this function had not been employed, one might change a gain value in TISOFT, for example, and this would not be updated in DMACS, thereby possibly confusing the operator.

An additional ladder logic rung has been added to activate SFPGM25 (see below).

VLV_GAIN (SFPGM25)

TITLE: VLV_GAIN

SF PROGRAM 25

CONTINUE ON ERROR (Y,N): YES
ERROR STATUS ADDR (Y,C,WY,V):
PROGRAM TYPE (N,P,C,R): CYCLIC
CYCLE TIME (SEC): 2.0

```
-----
00001 *      THIS SPECIAL FUNCTION IS USED TO HELP CONTROL THE FCV312HE AND
              FCV308HE VALVES THROUGH THE MANIPULATION OF GAINS (PROPORTIONAL,
              INTEGRAL, DERIVATIVE
00002 *      VALVE FCV312HE
00003 *      --PROPORTIONAL GAIN--
00004 IF      V227. <> V215.
00005 MATH     LKC1. := V215.
00006 ENDIF
00007 MATH     V215. := LKC1.
00008 MATH     V227. := LKC1.
00009 *      --INTEGRAL GAIN--
00010 IF      V229. <> V217.
00011 MATH     LTI1. := V217.
00012 ENDIF
00013 MATH     V217. := LTI1.
00014 MATH     V229. := LTI1.
00015 *      --DERIVATIVE GAIN--
00016 IF      V231. <> V219.
00017 MATH     LTD1. := V219.
00018 ENDIF
00019 MATH     V219. := LTD1.
00020 MATH     V231. := LTD1.
00021 *
00022 *      VALVE FCV308HE
00023 *      --PROPORTIONAL GAIN--
00024 IF      V233. <> V221.
00025 MATH     LKC2. := V221.
00026 ENDIF
00027 MATH     V221. := LKC2.
00028 MATH     V233. := LKC2.
00029 *      --INTEGRAL GAIN--
00030 IF      V235. <> V223.
00031 MATH     LTI2. := V223.
00032 ENDIF
00033 MATH     V223. := LTI2.
00034 MATH     V235. := LTI2.
00035 *      --DERIVATIVE GAIN--
00036 IF      V237. <> V225.
00037 MATH     LTD2. := V225.
00038 ENDIF
00039 MATH     V225. := LTD2.
00040 MATH     V237. := LTD2.
**** END ****
```