

University of Cagliari

Instrumentation & Measurement Group Department of Electrical and Electronic Engineering

DArT Slow Control

Sara Sulis

DArT general meeting at LSC 21 April 2022



Outline

- DArT cRIO Connection Scheme
- NI cRIO 9068 and Modules
- Functionalities scheme
- DArT Slow Control project
 - Front Panel tabs
 - Remote monitoring: Web Page



DArT - cRIO Connection Scheme

University of Cagliari



3



NI cRIO 9068 and Modules

University of Cagliari



Controller with chassis NI CompactRIO-9068

The chassis of the cRIO-9068 is equipped with 3 modules:

- Slot 1: NI 9203 for the 4-20 mA currents acquisition
- Slot 2: NI 9472 for the generation of digital outputs
- Slot 3: NI 9870 for the serial communications





DArT Slow Control scheme

University of Cagliari



5



DArT Slow Control scheme





DArT Slow Control Initial Settings

nitial Settings DArT System	VISA/LXI Power Supply Brooks Controller Arduino Alarms Configuration File Settings	Error Log Operations History Email Acquired Data Usage Control
CRIO-IP Address 10.131.1.33 Scan Interval [ms] 1000 User Enter user name here	Power Supply Initial Values Settings Keithley 2450 (LXI Communication) Minimum Amplitude DC [V] $ \begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$	Email Data Server - Initial Settings Outgoing Mail Server (SMTP) Smtp.gmail.com SMTP Port 587 Email xxxx@gmail.com Password The set of the set of
	Amplitude DC ch1 [V] () 3.4 Current Limit ch1 [A] () 1.6 Current Limit ch2 [A] () 0	Mailing List Alarms and Warnings Setup
	Brooks Controller - Initial Values	
	Start Button START	



DArT Slow Control Initial Settings

University of Cagliari

Settings DArT System	VISA/LXI Power Supply Brooks Controller Arduino Alarms Configuration File Settings	Error Log Operations History Email Acquired Data Usage Control	
IO-IP Address	Power Supply Initial Values Settings	Email Data Server - Initial Settings Save File?	Scan Interval [ms] min/max
	Keithley 2450 (LXI Communication)	Outgoing Mail Server (SMTP)	÷ 0 ÷ 500
	Minimum Amplitude DC [V]	smtp.gmail.com Save Error Log?	max
can Interval [ms]	Maximum Amplitude DC [V]	SAULT ON	÷ 0 ÷ 5000
000	54-32.6	Email	Minimum Amplitude DC [V] min/max
	€0.5 +100.0000 µAT 2 00	xxxx@gmail.com	min 7 0 4 32.6
er Initial Setting nter user name here		Password	max
			÷)○ ÷)○
	Keysight E3649A (Serial Communication)		Maximum Amplitude DC [V] min/max
		Mailing List Alarms and Warnings Setup	min
	Current Limit ch1 [A]	Name: D1(har)	max
	Amplitude DC ch2 IVI		÷)• ÷•
		0.0000 A 📽 A 0.0000 A 📽 A 0.0000 A 📽	Step Amplitude DC [V] min/max
	Current Limit ch2 [A]		
	30	Name: P2[barg]	max
		Lo Hi 0.00000 A 🔮 0.0000 A 🔮 0.0000 A 🥸	
	Brooks Controller - Initial Values		Current Limit [A] min/max
	Channels	Name: P3[barg]	
			max
	Flow Setpoint [ml/min]		÷)0 ÷ 5
	÷ 0 4 0.000	Name: Fin[ml/min]	Amplitude DC ch1 [V] min/max
	() 0.000	Lo Hi HiHi	
			max
		Name: Fout[ml/min]	
	Start Button		Current Limit ch1 [A] min/max
	START		÷ 0 ÷ 0
		Name: T-01[K]	max + 0 / 5
			Amplitude DC ch2 [V] min/max
			max
			Current Limit ch2 [A] min/may
			min
			A max
			Elow Setpoint [m]/min] min/may
			min
			1 0 1 -500 1 -500
			max
			0 Jan 1900

Allowed ranges to set (these controls will be hidden)

•



DArT Slow Control Initial Settings





DArT Slow Control DArT System





DArT Slow Control University of Cagliari DArT System – visual warnings and status indicators

Blinking:

- Red for HiHi (too high value)
- Orange for "Hi" (high value)
- Light blue for "Lo" (low value)
- Blue for "LoLo" (too low value)



"Manual" Valve Status Indicators:

• Blue: the valve is closed





V0 Valve Control:

- Green: the valve is closed
- Light green: the valve is open







DArT Slow Control V0 operation - Relay 24V

- The user needs to hit the "V0" button to open it (the valve control becomes "on" and bright green) and then the button "New Setting?" to confirm: the LED 0 of the NI-9472 turns "on" and the LED of the Finder 95.05, commanding the relay, turns also "on".
- Same procedure to close the valve: the user hits the "V0", the valve button becomes "off" (dark green), then the button "New Setting?" to confirm: the LED 0 of the NI-9472 and the LED of the Finder 95.05 become also "off".







DArT Slow Control University of Cagliari VISA/LXI Power Supply and Brooks Controller

Initial Settings DArT System VISA/LXI Power Supply Brooks Controller Arduino Alarms Confi Shared Variable Generators Write Keithley 2450 (LXI Communication) Maximum Amplitude DC [V] -32.6 Step Amplitude DC [V] 0.5 Current Limit [A] 00.0000 L 0 6 Keysight E3649A (Serial Communication) Amplitude DC ch1 [V] 3.4 Current Limit ch1 [A] 0 0.000 ----Amplitude DC ch2 [V] 1.6 Current Limit ch2 [A] 0

Generators Setting Update Button

New Setting?





DArT Slow Control Arduino – in progress

duino Base Info ASRL4::INSTR	Arduino Base Info ASRL5::INSTR	Arduino Base Info ASRL6::INSTR	Arduino Base Info ASRL7::INSTR	Characteristic France Cost Andrew Room
fo	lofo	Info	Info	shared variable Error Out Arduino Read
				Error Out Arduino ASRL4::INSTR
Firmware version: 383	* Firmware version: 383	* Firmware version: 383	* Firmware version: 383	status code
Board ID: 0xBADC0FEE	* Board ID: 0xBADC0FEE	* Board ID: 0xBADC0FEE	* Board ID: 0xBADC0FEE	status code
Board address: 0x7	* Board address: 0x7	* Board address: 0x7	* Board address: 0x7	
Board type: 0x3	* Board type: 0x3	* Board type: 0x3	* Board type: 0x3	1011/2
Gas type: Argon	* Gas type: Argon	* Gas type: Argon	* Gas type: Argon	source
Calibration switch: On	* Calibration switch: On	* Calibration switch: On	* Calibration switch: On	
Current limit for veto: 4294967295 mA	* Current limit for veto: 4294967295 mA	* Current limit for veto: 4294967295 mA	* Current limit for veto: 4294967295 mA	
Gas threshold temperature: 4294967295 K	* Gas threshold temperature: 4294957295 K	* Gas threshold temperature: 4294967295 K	* Gas threshold temperature: 4294967295 K	
ase lofo Cluster	Race lefo Cluster	Rase Info Cluster	Rase Info Chuster	
and the clarter		lun		
1*Error code	1*Error code	1°Error code	1°Error code	
- 00	-00	.00	00	Error Out Arduino ASRL5::INSTR
				Later and
imware version	Firmware version	Firmware version	Firmware version	status cooe
383	383	383	383	
loard IU	Board ID	Board IU	Board ID	source
BADCOFEE	ABADCOFEE	BADCOFEE	BADCOFEE	
New Ave Allows	Double Library	Design of the second se	Develop Adverse	
loard address	Board address	Board address	Board address	
7	7	7	7	
ioard type	poard type	board type	board type	
3	3	3	3	
and and	Cuba	Carbons	Carbons	Error Ord Andrian ACDI SUINCED
nas type	ONS type	OR type	ous type	Error Out Arduino ASKLOUINSTR
Argon	Argon	Argon	Argon	status code
alibration suitsh	Calibration miltib	Calibration mitch	Calibratian quitch	
division smith	Campauolin smitch	Conviacioni Switten	Campracium Switch	
On	On	On	On	source
"Error code	215 mor code	21Emprode	2'Strot code	
	a cros cour	L LINI COST		
00	00	00	00	
Surrent limit for seto	Current limit for yets	Current limit for yets	Current limit for seto	
4294967295	4294967295	4294967295	4294967295	
as threshold temperature	Gas threshold temperature	Gas threshold temperature	Gas threshold temperature	
and the second				P
4294907293	4294907295	4294907295	4/3/4907/295	Error Out Arduino ASRL7::INSTR
	-	,	,	status code
duino Variable Data ASRL4:INSTR	Arduino Variable Data ASRL5::INSTR	Arduino Variable Data ASRL6::INSTR	Arduino Variable Data ASRL7::INSTR	
da	lato	lefe	lefe	
				101978
Mode: Calibration	Mode: Calibration	Mode: Calibration	Mode: Calibration	JOURG
Errors: -> Short circuit	Errors: -> Short circuit	Errors: -> Short circuit	Errors: -> Short circuit	
ADC Counts: 92 (CRY), 77 (AMB), 82 (LEVL)	ADC Counts: 71 (CRY), 98 (AM8), 86 (LEVL)	ADC Counts: 92 (CRY), 113 (AMB), 103 (LEVL)	ADC Counts: 45 (CRY), 61 (AMB), 62 (LEVL)	
Voltages (mV): 2417 (+24 power supply), 2795 (Mid. point)	Voltages (mV): 2165 (+24 power supply), 3047 (Mid. point)	Voltages (mV): 2795 (+24 power supply), 3324 (Mid. point)	Voltages (mV): 1687 (+24 power supply), 1586 (Mid. point)	
PT-100: 2241 mV II 6 mA	PT-100: 2367 mV II 3 mA	PT-100: 2921 mV II 0 mA	PT-100: 1913 mV II 0 mA	
Temperature (K): 2147483648	Temperature (K): 2147483648	Temperature (K): 2147483648	Temperature (K): 2147483548	
aval Termo (K): 2147483648	Level Temp (K): 2147483548	Level Termo (K): 2147483648	Level Terror (K): 2147483548	
cerei renp (igi ciriniosolo	cerei renip (renzinassario	Level temp (g) E141403040	Cerei Terip (IQI E TETEOSOTO	
ariable Data Cluster	Variable Data Cluster	Variable Data Cluster	Variable Data Cluster	· · · · · · · · · · · · · · · · · · ·
trior_code	error_code	error_code	error_code	
00	00	00	00	
iquid	liquid	liquid	liquid	
0	0	0	0	
tuor_reg	error_reg	error_reg	error_reg	
4	4	24	4	
node	mode	mode	mode	
.0	0	0	0	
and a	a series	L mute	a mode	
mode	5_mode	Simode	5_mode	
Calibration	Calibration	Calibration	Calibration	
P 11		A 11	1 m - 11	
Indoio	s ⁻ udna	2'idao	Studing	
Gas	Gas	Gas	Gas	
heating	ic heating	is heating	is heating	
_neering	in the start of th	in the start of th	in the starting	
0	0	0	0	
intonic mante	historic questr	historic quante	historic events	
-				
0	0	120	E0	
DC Counts	ADC Counts	ADC Counts	ADC Counts	
		43		
n.		76	43	
RY	CRY	CRY	CRY	
7	00	112	41	
	70	10	101	
MB	AMB	AMB	AMB	
11	14	102	10	
N. Contraction of the second s	00	103	04	
	Voltage [mV]	Voltage [mV]	Voltage [mV]	
oltage [mV]	2000	1704	1/07	
oltage [mV]		2/05	1687	
oltage [mV] 1417	2103	+ 24 Bourse Supply	+24 Power Supply	
oltage [mV] 1417 -24 Power Supply	+24 Power Supply	TATE FORTEL AND AND	and a south of the second seco	
oltage [mV] 2417 24 Power Supply	+24 Power Supply	- 24 FONE Joppny	1586	
oltage (mV) 1417 -24 Power Supply 2795	+24 Power Supply 3047	3324		
oltage [mV] 2417 -24 Power Supply 2795 	+24 Power Supply 3047 87.100 (m/s)	3324 PT-100 (mV)	PT-100 ImVI	
oltage (mV) 2417 24Power Supply 2795 T-100 (mV]	+24 Power Supply 3047 PT-100 [mV]	3324 PT-100 [mV]	PT-100 [mV]	
olitage [mV] 2417 2420 exets Supply 2795 7-100 [mV] 2241	247 Power Supply 3047 PT-100 [mV] 2367	97-100 [mV] 2021	PT-100 [mV] 1913	
littage (mV) 2417 -24 Power Supply 2795 -700 (mV) 2241 -700 (mV)	240 Ower Supply 1047 PT-100 [mV] 2367 07.101 (mA)	1324 PT-100 [mV] 2921 PT-100 [mV] 2921 PT-100 [mV]	PT-100 [mV] 1913 PT.100 [m4]	
oltage (mV) 2417 2427 2429 Overs Supply 2795 T-100 (mV) 2241 T-100 (mA)	247 over Supply 3047 PF-100 [mV] 2167 PT-100 [mA]	2824 Pores suppy 3324 PT-100 [mA]	PT-100 [mV] 1913 PT-100 [mA]	
billage (mV) 2417 -28 Power Supply 2795 -7795 -7795 -7790 (mV) 2241 -7-100 (mA) 	- 149 Power Supply 1047 PT-100 (mN) 2367 PT-100 (mA) 3	2424 Forest suppy 3324 PT-100 [mV] 2421 PT-100 [mA] 0	PT-100 [mV] 1913 PT-100 [mA] 0	
018age (mV) 2417 234 Power Supply 2795 2795 2795 2795 2741 2741 2741 2741 2741 2741 2741 2741	2 24 Rovert Supply 247 271-100 (mV) 24.07 91-100 (mA) 3 Tensonautor (0)	3324 PT-100 [mV] 2421 PT-100 [mA] 0 Temperature ID	PT-100 [mV] 1913 PT-100 [mA] 0 Temperature IV3	
018ag (W) 317 34 Poset Supply 775 5-100 (wil) 5-101 (mil) 1-101 (mil) 1-101 (mil)	2.33 Rower Supply (3.77 PT-102 PT-102 PT-102 PT-102 (mA) 3 Temperature (K)	2027 Units July 2 1324 PT-100 (m/l) 2021 PT-100 (m/k) 0 Temperature (k)	PT-100 (mV) 1913 PT-100 (mA) 0 Temperature (K)	
018age1697] 24870 24870ex 50pby 7570 75100 [sw1] 2524 75100 [sw1] 75100 [sw1] 9 9 9 9 9 14241044	242 Power Supply 3017 71-100 (m/t) 21407 72-100 (m/t) 3 1 Temportum (0) 21443464	3326 1326 PT-000 (mN) 1201 7201 1201 0 100 0 100 74:743166 [K]	PT-100 [HV] 1913 PT-100 [HA] 0 Temperature [K] 214/140364	
018age (WV) 24470 24470 2550 2500 (MV) 2510 (MA) 2510 (MA) 4510 (MA)	224 Power Sopply [047] 2347 71:100 (m/l) 3 3 Temperature (N 21:44:1644 21:44:1644	211 Annual Annual 1324 PT-100 (mA) 0 Temperature (A) 1214-034-04 Land Tame 70	PT-100 [eW] [913 PT-100 [eW] [913 PT-100 [emA] 0 Temperature (K) 214340364 Least 7440364	
oltage (INV) 2417 2410-000 (Supply 775 5-100 (M) 241 1-100 (mA) miperature (K) 347-413-04 00 (Teng (K)	- 28 Fever Sopply 047 1217 1217 1217 1210 1210 1210 1210 1210 1211 121 1211 1	1324 #F1:00 (mV) 5221 97:100 (mA) 0 Temperature (R) 214:41006 Lowel Temp (R)	PT-100 [mV] [1913 PT-100 [mA] 0 Temperature [0] [2-4743.048 Level Remp [0]	
Marg (m)	- 24 Forest Supply [047 PF:000 [m/n] 2147 97:000 [m/n] 3 Temperature [4] 114142164 Cenet Temp [4] 214142644	*336 documents PT-00 (mm) 2021 PT-00 (mm) PT-00 (mm) PT-00 (mm) 2142(41)66 Looi (mm) (N) 2142(41)66 Looi (mm) (N)	P: 1:00 (m/n) (113) P: 1:00 (m/n) 0 0 1:14/34/allow [K] 1:14/34/al	
Mag (m/l) 24 Pore Supp. 95 900 (m/l) 900 (m/l) 900 (m/l) 910 (m/l) 910 (m/l) 914 (m/l) 91	224 Found Sopply [047] 1247 12100 (mit) 227 12100 (mit) 3 Temperature [0] 11423648 Local Temp [0] 11443648	13.6 more providence 19.7 mole (mole 19.7 mole (mole 19.7 mole (mole 19.7 mole (mole 19.7 mole (mole 19.7 mole 19.7 mole (mole 19.7 mole 19.7 mo	PT-D00 [m/r] [103 PT-000 [m/r] 0 Temperature (X] [11-0316-0] Level Temp (X] [2-1-036-0] [2	
Intege Intege 247 December Supply 705 S 1000 (mml) Intege 1010 (mml) Intege	2. Set Research apply 2.4	1324 #1-60 (mi) 1321 #1-60 (mi) 1321 #1-10 (mi) 0 0 Temporture (N) 1/1-0.1564 Level Temp (N) 2/14-0.1564 Status Values	PT-D00 [WH] [1913 [1913 [1913 [1913 [1913 [1914] [1	



DArT Slow Control Alarms Configuration

tial Settings DArT System VISA/LXI Power Supply Bro Alarms configurations Mailing List Alarms and Warnings Setup	ooks Controller Arduino Alarms Configurat	File Settings Error Log Operations History Email Acquired Data Usage Co	ontrol
		Error Out Handling Dialog Queue	Show Last Save Save
		Error Queue status code source	



DArT Slow Control File Settings

University of Cagliari

itial Settings	DArT System	VISA/LXI Power Supply Br	ooks Controller Ar	duino Alarms Configuration	File Settings Error Lo	g Operations History	Email Acquired Data	Usage Control
Default File DArT Data	Name Acquisition	File Folder Name DArt Acquisition File	File Name DArT Data Ac	quisition 01-12-21				
Path File								
He T	ader Variable Jay	Time[h:m:s.ms]	P1[bar]	P2[barg]	P3[barg]	Fin[ml/min]	Fout[ml/min]	T-01[K]
He	ader Alarm			1	1			
	larm_P1_HiHi	Alarm_P1_Hi	Alarm_P1_Lo	Alarm_P1_LoLo	Alarm_P2_HiHi	Alarm_P2_Hi	Alarm_P2_Lo	Alarm_P2_LoLo
TDMS	CSV					Error C status	Out Writing File ; code	
	roperty Names Title	Author	File creation date	Description		sourc	d0	
T	itle DArT Acquisition							
C T	escription Data acquisition and	writing test on TDMS file		ĺ				
	ata Group Name Va Measured data	riable Data Group Name Alarm Alarm registered	1					
						Error	Out Close File TDMS Er	ror Out Close File CSV
						statu Source	us code s	tatus code
						sou	3	

Tab TDMS & CSV



DArT Slow Control Error Log

Initial Settings	DArT System	VISA/LXI Power Supply	Brooks Controller	Arduino	Alarms Configuration	File Settings	Error Log	Operations History	Email	Acquired Data	Usage Control		
Default Error L DArT Error Log B Header E T O Status Complet T D Day	DArl System	Crista/LXI Power Supply Error Log Folder Name DArT Error Log h:m:s.ms] Status	Error Log Name DArT Error Log	01-12-21	Alarms Configuration	Frie Settings	e Error Log	Error Out Error I status code	.og		Usage Control		
												_	



DArT Slow Control Operations History – in progress

Settings DArT System VISA/LXI	Power Supply Brooks Controller Arduin	o Alarms Configuration File Settings Error Log	Operations History Email Acquired Data Usage Control
Default Operations History File Name DArT Operations History	Operations History File Folder Name DArT Operations History File	Operations History File Name DArT Operations History 19-04-22	Error Out Operations History status code
Path Operations History File			
Operations History Header	m:s.ms] User Control Name	Old Value New Value	



DArT Slow Control Email Server

Initial Settings	DArT System	VISA/LXI Power Supply	Brooks Controller	Arduino	Alarms Configuration	File Settings	Error Log	Operations History	Email
	Jan Jystem	tion of the one output			rianis configuration			openations matory	
En	nail Data Server								
	Outgoing Mail Serv	ver (SMTP)							
ſ	smtp.gmail.com								
	SMTP Port								
ſ	587								
	Email								
ſ	xxxx@gmail.com								
	Desword								
E	rror Out Email								
S	tatus code								
	source								



DArT Slow Control Trends of the Acquired Data





DArT Slow Control Trends of the Acquired Data

	End												
00:00:00.0 DD/MM/Y1	Reinitialize to Default	0-00.0 /alue	Refres	h									
oh Acqi	Cut Data Copy Data Paste Data												
-46	Description and Tip]	🗆 P1 [bar]
-46.5-													🗌 P2 [barg]
-40.5													🗆 P3 [barg]
-47.5-													🗆 Fin [ml/min]
-48-													Fout [ml/min
-48.5-													T-01 [K]
-49-													T-02 [K]
-49.5-													T-03 [K]
-50-													□ T-04 [K]
-50.5-													[1]
-51-													Error Out Reading
-51.5-													status code
-52-													
-52.5-													source
-53-													
-53.5-													ļ.
-54 -													Error Out Reading
-54.5-													status code
-55-													√ d0
-55.5-													source
-56-													
-56.5- 15:44:44.9	15:49:44.9	15:54:44.9	15:59:44.9	16:04:44.9 06/04/22	16:09:44.9 06/04/22	16:14:44.9 06/04/22	16:19:44.9 06/04/22	16:24:44.9 06/04/22	16:29:44.9 06/04/22	16:34:44.9 06/04/22	16:39:44.9 06/04/22	16:44:44.9 06/04/22	



DArT Slow Control Usage Control

nitial Settings	DArT System	VISA/LXI Power Supply	Brooks Controller	Arduino	Alarms Configuration	File Settings	Error Log	Operations History	Email	Acquired Data	Usage Control	
		– Disk Full										
	cRIO Dis	k 💍										
	Disk Critical %		CPU Load %									
	00 70		0 78									
	Disk Free [B]	Þ	Engine State %									
	IOR INTER	D) D: L 5''H L 9/	0									
	0 B	B) Disk Filled %	HW Scan Utilization %	5								
	Disk Total [B]		0 %									
	0 B	Þ										
												l



DArT Slow Control Main Functionalities

- Data acquisition and processing with slightly adjustable run time (around 1 s)
- Visualization of current measured data and trends at the request of the user
- Security check of the operations
 - Variables acquired outside the defined ranges: high/low (warning) or too high/low (alarm) values are reported
 - Measurements and Event logging associated with date and time
 - Variables limited in ranges in the Slow Control and in the cRIO
 - Tracking of user operations in a file: <u>date, time, user, variable, old and the new values</u> are saved
- Files (data and error log saved on files changed periodically every week):
 - CSV (Comma Separated Values)
 - TDMS (Technical Data Management Streaming)



- Data_TDMS_Visualization.aliases
- Data_TDMS_Visualization
- Data_TDMS_Visualization



DArT Slow Control Web Page

University of Cagliari

System status can be monitored remotely through a web page.

Users can connect using the link: <u>http://10.131.1.34:8001/Web Page - DArT Slow Control.html</u> The web page allows the users <u>to see exactly</u> what the operator is viewing in the application.





DArT Slow Control Latest requests – in progress

- 1. Acquire gas system sensor values
 - 1. Keep the history of the system
- 2. Safety watch.
 - 1. Look for critical sensor values.
 - 2. If any is out of range warn operator and related people.
- 3. Distribute information and system status.
 - 1. To an unrestricted number of viewers
- 4. Allow operators to set parameters.
 - 1. Only operators can modify parameters
 - 2. Two operators for safety.
 - 3. Keep track of operations.
- 5. Automatic procedures to ease the operation.
 - 1. Automatic filling with UAr.
 - 2. Automatic emptying
 - 3. Bottle replacement and cleaning
 - 4. UAr recovering

University of Cagliari

Thank you for your attention

Any questions?