FeSCADA & ADAM 6017

Introduction

An application was done to show the possibilities of FeSCADA. By the end of this paper the reader will learn how FeSCADA can be used with Advantech ADAM 6017 Ethernet IO module.

- 1. Description
- 2. Hardware
- 3. ADAM 6017 setup
- 4. ADAM 6017 Modbus registers
- 5. FeMODBUS communication setup
- 6. FeSCADA project
- 7. Special application
- 8. Conclusions

1) Description

A heating and cooling application was developed with the aid of Advantech ADAM 6017 Ethernet IO module and a FeSCADA PID controller. Two RTD sensors and one thermocouple sensor are used to read temperatures. A 25W, 10Ω resistor is used as the heating element. Two Solid State Relays (SSR) are used to control the heating power (from a 24 VDC power supply) and a fan (cooling power).

The example is common for other types of Ethernet IOs, because it is an industrial practice for many producers to use Modbus TCP communication.

2)Hardware

The hardware is composed of one Advantech ADAM 6017 Ethernet IO module, with the following characteristics:

- input voltage: 10-30 VDC

- 8 analog inputs, 16-bit resolution, 100 samples/second rages voltage: from ± 0.15 V up to ± 10 V
 - current: ±20 mA, 0~20 mA, 4~20 mA
- 2 digital outputs, sink, 0...30 VDC

- communication protocols: Modbus/TCP, TCP/IP, UDP, HTTP, DHCP, MQTT, SNMP, ASCII command



Two RTD sensors Pt100, together with two temperature transmitters: 0...250°C to 4-20mA and 0...500°C to 4-20mA.





One K type thermocouple wire.



Two Solid State Relays (SSR) 100VDC, 20A.



One NTE 25W, 10Ω resistor, the heating element.



Cooling fan, 24VDC, 0.16A.



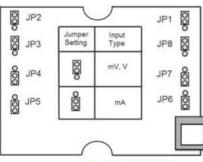
Hardware prices.

Name	Unit price	Qty	Price	Description
ADAM 6017	\$380.00	1	\$380.00	8 channels analog IO module
uxcell Temperature	\$12.00	2	\$24.00	Pt100 signal converter
Transmitter				0250 °C to 4-20 mA
				0500 °C to 4-20 mA
TWTADE PT100	\$13.00	2	\$26.00	Pt100, 3 wire sensors -50200 $^{\circ}$ C
Thermocouple	\$10.00	1	\$10.00	K thermocouple wire
D1D20	\$72.00	2	\$144.00	Solid State Relay 100VDC, 20A

Power spupply 24VDC	\$40.00	1	\$40.00	120W, 24VDC, 5A
Nidec fan, 24DVC	\$13.00	1	\$13.00	0.16A inverter cooling fan
	тот	'AL =	\$637.00	

3) ADAM 6017 setup

ADAM 6017 has to be setup for the type and range of our temperature transmitters and for the thermocouple. By default, the module is setup to read $\pm 10V$. To change a channel to measure current a jumper has to be moved, for that particular channel.



ADAM-6017-BE & AE

Because it has 16 bits resolution, the whole measuring range is converted to:

a) 0...65535, for positive ranges: 0~0.5V, 0~1V, 0~5V, 0~10V, 0~20mA, 4~20mA

b) -32768 ... 32767 for ± ranges: $\pm 0.15V$, $\pm 0.5V$, $\pm 1V$, $\pm 5V$, $\pm 10V$, ± 20 mA

To setup ADAM 6017 for the IP address and the measuring ranges, the software ADAM.NET is used. We set the IP address to 192.168.1.51. See below

■ < * 4 / \$ > □							
Serial Strengt	ADAM-6017 (MC	DBUS)					
Ethemet	CI	_				Calibration	
E-8 192.168.1.51-[ADAM-6017]	Channel index	4			Apply	Zero	Span
E-6017	Input range:	1~	20 mA		-		
		14 4	LU III/N				
Ch-1 Ch-2							
	Integration time	a: [60⊦	4.2	•	Annie		
🔼 Ch-4		loor	12		Apply		
🖸 Ch-5	A						
		100			100 million (1997)		
🖸 Ch-6	Channel setting	Averag	e setting Modb	ous (Current) M	odbus (Max) Mo	odbus (Min)	
🔼 Ch-7				-	odbus (Max) Mo		
Ch-7	Location	Туре	Value[Dec]	Value[Hex]	Value[Eng]	Description	
⊠ Ch-7 ⊠ Average 	Location 40001	Type Word	Value[Dec] 32953	Value[Hex] 80B9	Value[Eng]	Description Ch-0 : +/- 10 V	
	Location 40001 40002	Type Word Word	Value[Dec] 32953 32773	Value[Hex] 80B9 8005	Value[Eng] 0.057 V 0.002 V	Description Ch-0 : +/- 10 V Ch-1 : +/- 10 V	
⊠ Ch-7 ⊠ Average 	Location 40001 40002 40003	Type Word Word Word	Value[Dec] 32953 32773 32776	Value[Hex] 8089 8005 8008	Value[Eng] 0.057 V 0.002 V 0.003 V	Description Ch-0 : +/- 10 V Ch-1 : +/- 10 V Ch-2 : +/- 10 V	
Ch-7 Average 6017 GCL 192.168.1.3 Others	Location 40001 40002 40003 40004	Type Word Word Word Word	Value[Dec] 32953 32773 32776 32776 32773	Value[Hex] 80B9 8005 8008 8008 8005	Value[Eng] 0.057 V 0.002 V 0.003 V 0.003 V 0.002 V	Description Ch-0 : +/- 10 V Ch-1 : +/- 10 V Ch-2 : +/- 10 V Ch-3 : +/- 10 V	
GO17 GCL GO17 GCL 192.168.1.3 GO17 GCL Favorite Group	Location 40001 40002 40003 40004 40005	Type Word Word Word	Value[Dec] 32953 32773 32776 32776 32773 3104	Value[Hex] 80B9 8005 8008 8008 8005 0C20	Value[Eng] 0.057 V 0.002 V 0.003 V 0.002 V 4.758 mA	Description Ch-0 : +/- 10 V Ch-1 : +/- 10 V Ch-2 : +/- 10 V Ch-3 : +/- 10 V Ch-3 : +/- 10 V Ch-4 : 4~20 mA	
Ch-7 Average 	Location 40001 40002 40003 40004	Type Word Word Word Word	Value[Dec] 32953 32773 32776 32776 32773	Value[Hex] 80B9 8005 8008 8008 8005	Value[Eng] 0.057 V 0.002 V 0.003 V 0.003 V 0.002 V	Description Ch-0 : +/- 10 V Ch-1 : +/- 10 V Ch-2 : +/- 10 V Ch-3 : +/- 10 V	
GO17 GCL GO17 GCL 192.168.1.3 GO17 GCL Favorite Group	Location 40001 40002 40003 40004 40005	Type Word Word Word Word Word	Value[Dec] 32953 32773 32776 32776 32773 3104	Value[Hex] 80B9 8005 8008 8008 8005 0C20	Value[Eng] 0.057 V 0.002 V 0.003 V 0.002 V 4.758 mA	Description Ch-0 : +/- 10 V Ch-1 : +/- 10 V Ch-2 : +/- 10 V Ch-3 : +/- 10 V Ch-3 : +/- 10 V Ch-4 : 4~20 mA	
Ch-7 Average 	Location 40001 40002 40003 40004 40005 40006	Type Word Word Word Word Word Word	Value[Dec] 32953 32773 32776 32773 3104 6205	Value[Hex] 80B9 8005 8008 8005 0C20 183D	Value[Eng] 0.057 V 0.002 V 0.003 V 0.002 V 4.758 mA 5.515 mA	Description Ch-0 : +/- 10 V Ch-1 : +/- 10 V Ch-2 : +/- 10 V Ch-3 : +/- 10 V Ch-4 : 4-20 mA Ch-5 : 4~20 mA	
Ch-7 Average 	Location 40001 40002 40003 40004 40005 40006 40007	Type Word Word Word Word Word Word Word	Value[Dec] 32953 32773 32776 32773 3104 6205 0	Value[Hex] 80B9 8005 8008 8005 0C20 183D 0000	Value[Eng] 0.057 V 0.002 V 0.003 V 0.002 V 4.758 mA 5.515 mA 4.000 mA	Description Ch-0:+/-10 V Ch-1:+/-10 V Ch-3:+/-10 V Ch-3:+/-10 V Ch-3:+/-10 V Ch-4:4^20 mA Ch-5:4^20 mA Ch-7:+/-150 mV	
Ch-7 Average 	Location 40001 40002 40003 40004 40005 40006 40007 40008	Type Word Word Word Word Word Word Word Word	Value[Dec] 32953 32773 32776 32773 3104 6205 0 32771	Value[Hex] 80B9 8005 8008 8005 0C20 183D 0000 8003	Value[Eng] 0.057 V 0.002 V 0.003 V 0.002 V 4.758 mA 5.515 mA 4.000 mA	Description Ch-0: +/- 10 V Ch-1: +/- 10 V Ch-3: +/- 10 V Ch-3: +/- 10 V Ch-3: +/- 10 V Ch-5: 4^20 mA Ch-6: 4^20 mA	

4) ADAM 6017 Modbus registers

The following table is showing the Modbus register numbers for the IO module: channels data and digital outputs.

Parameter	Modbus register number	Description
Data channels 07 (read only)	07	Holding registers , 16 bits, with the values from the 8 channels
Digital outputs 0,1 (read/write)	16, 17	Coils addresses for the two digital outputs

5) FeMODBUS communication setup

FeMODBUS software is used to connect to ADAM 6017, which is a Modbus server on port 502. We send 2 requests: one is to read the first 10 holding registers every 751 ms, the second is to write 2 coils, every 10 ms. We put two times the coils writing, to make sure the ADAM will get the command. The fast coil writing is essential for a good PID control.

Serve	ers List				RSN = R	emote Serv	ver Numb	er					
Serv	erName	Serv	/erIP	Server	LocalIP	LocalPo	ort RSN	Active	Connec	. Error	TCP/IP Connection My IP Address	Modbus Request Pa Function Code	rameters
Rem	ote_Ard	192.16	58.1.17	502	192.168.2	. 1025	i 1	Yes	Yes	0000	127.0.0.1	02 - Read discrete	inp <mark>u</mark> ts 👻
Adva	antech	192.16	58.1.51	502	127.0.0.1	1025	2	Yes	Yes	0000	1 12/10/01		
											My Port 1025	Unit Address	255
											Server IP Address	Remote Register Address	0
					TCP/IP connec	tion error b	oits: Close	ed - Open Fail	ed - No Ansv	ver - Socket Err	or 192.168.1.51		
Requ	uests List	Sel	lect a serv	ver to see t	ne assigned red	quests list						How Many Registers?	10
RN	Func	Uni	RegAdo	dr RegN	o Offset	Active	Cyclical	CycleTime	Error	StatusBits	Server Port 502		0
1	3	255	0	10	0	Yes	Yes	751	0000	111	Server Name	Address	
2	15	255	16	2	2	Yes	Yes	10	0000	100	Advantech	Cyclical? Yes/No	Yes 💌
3	15	255	16	2	2	Yes	Yes	10	0000	111			
											Add Modify Del	Cycle Time [ms]	300
						Error bit: [Data - Ex	ception - MBA	P - Time out	Refrest		Active	V
	ing Registe			out Register		Message S	tatus: Se	ent - Answere	d - Processe	d	1	Add Modify	
Inde	ex Valu	Je	In	idex Va	lue							Add Modify	Del
0	32	953	0	0			s Digital Ir	nputs (Read C		_			
1	32	773	1	0		D							
2	32	776	2	0		16	5 Digital C	oils (Set/Rese	et)				Save in file
3	32	770	3	0		D							Load from f

After setting up all the requests we defined tags which we linked with different registers on the local computer. The tags are used for DDE communication between

FeMODBUS and FeSCADA. All the tags are assigned to the Remote Server Number 2 (RSN 2).

Index	TagName	DataType	UpdateType	RSN	RegType	RegAddr	Value	1
23	Reg8	Word 16	Read	1	Holding Register	8	0	
24	Adam_Out0_Write	Byte8	Write	2	Digital Coil	2	0	
25	Adam_Out1_Write	Byte8	Write	2	Digital Coil	3	0	
26	Adam_Reg0	Word16	Read	2	Holding Register	0	32953	
27	Adam_Reg1	Word16	Read	2	Holding Register	1	32776	
28	Adam_Reg2	Word16	Read	2	Holding Register	2	32776	
29	Adam_Reg3	Word16	Read	2	Holding Register	3	32773	
30	Adam_Reg4	Word 16	Read	2	Holding Register	4	3071	
31	Adam_Reg5	Word16	Read	2	Holding Register	5	6184	
32	Adam_Reg6	Word16	Read	2	Holding Register	6	0	
33	Adam_Reg7	Word16	Read	2	Holding Register	7	32769	
Tag N	lame	Data Type	Updat	e Type			Data view	
Adan	n_Out0_Write	Byte8	▼ Write		- Ac	bb	Sig.Dec	
	RSN (Server number)				Upd	late		
	2	Register Ty	/pe		Del	-+-		
	Register Address	Digital Coil	•		Dei	ete	Cano	el
	2					ve		

6)FeSCADA project

The first step in a FeSCADA project is to define the DDE communication channels and the tags. In the picture below one can see that we defined one DDE channel as channel number 1: DDE_Application = "MB" and DDE_Topic = "TAGS".

Every tag has an internal name used in FeSCADA and a DDE Name for communication with the MB DDE server. All the tags defined in FeMODBUS will have a correspondent tag in FeSCADA. We kept the name the same with 3 exceptions:

FeMODBUS	FeSCADA	Scaled			
Adam_Reg4	Adam_Reg4_RTD2	Scaled	Max Eng Value 500	Offset Value 0	Max Raw Value 65535
Adam_Reg5	Adam_Reg5_RTD1	Scaled	Max Eng Value 250	Offset Value 0	Max Raw Value 65535

	aw Value
▼ Scaled 3658 -32507 3845	3

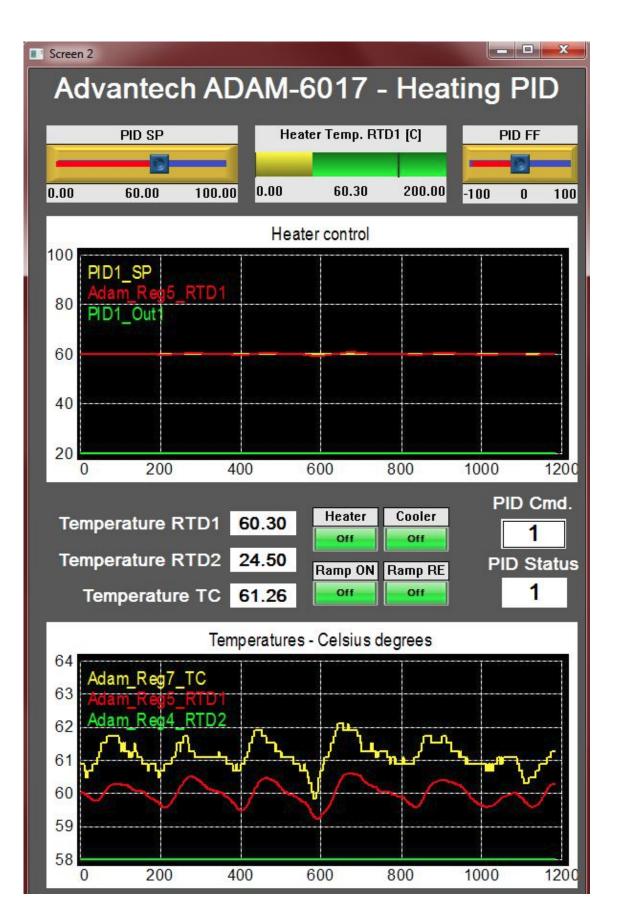
The scaling for type K thermocouple is based on its sensitivity of approximately 41μ V/°C and 150mV maximum range, for 32767.

The thermocouple has to be calibrated at 0 °C (water with ice) and it will be acceptable in the range 0 ... 100 °C. For calibration we changed the *Offset Value* and *Max Raw Value*.

Observation: The thermocouple value is not as precise as the RTD's.

	Tag Name	DDE Name	DDE	Data Type	Update T	Value		No	DDE Ap	DDE Topic	Con
44	Adam_Out0_Write	Adam_Out0_Write	1	Integer	Write	0		1	MB	TAGS	Yes
45	Adam Out1 Write	Adam Out1 Write	1	Integer	Write	0		2	FESDDE	TAGS	No
46	Adam Reg0	Adam_Reg0	1	Integer	Read	0.057680		3			
47	Adam Reg1	Adam Reg1	1	Integer	Read	0.001526		- 4-			
48	Adam_Reg2	Adam_Reg2	1	Integer	Read	0.002441		5			
49	Adam_Reg3	Adam_Reg3	1	Integer	Read	0.001526		6			
50	Adam_Reg4_RTD2	Adam_Reg4	1	Integer	Read	26.024261		7			
51	Adam_Reg5_RTD1	Adam_Reg5	1	Integer	Read	52.483406	=	8			
52	Adam_Reg6	Adam_Reg6	1	Integer	Read	-10.000305	-	9			
53	Adam_Reg7_TC	Adam_Reg7	1	Integer	Read	55.928650		10			
54	Counter	Reg0	1	Integer	Read/Write	485		11			
55	Input0	Inp0	1	Integer	Read	0		12			
56	Input1	Inp1	1	Integer	Read	0	+	13			
Ada) Name am_Reg7_TC E Name am_Reg7 E Channel	Int	a Type eger al Value	Upd	late Type ad 🔻	Add Update Delete Search			DDE Applicat		te
DDB		lax Eng Value		Offset Value	Max Raw	/alue					

Now we can build a screen (window) to show the data, and to put some indicators and buttons. In the picture below one can see a snapshot of this screen.



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No	Туре	Control	Кр	Кі	Кd	In Min	In Max	Out Min	Out Max	Bias	PWM	PWM	SP Tag
0	PID	E=SP-PV	5	0.04	20	-100	100	-100	100	0.00	Yes	2.00	PID1 S
1	PID	E=SP-PV	18	5.14	15.75	-100	100	-100	100	0.00	No	3.00	PID2_9
•				m									
Typ	-	Update Input S				Tag <> 0	UT2 Tag) the		= [0Max] = [0Min] e	for PID		100%]	
	10.000	1.00	-	Scali	5. Texas			PID1_SP	/ << De	I No	Tag Na	me	
	ntrol	010	sec	Inpu	it Max	-11 -11	Innu	t PV TagNam		1	Bit1		
E=5	SP-PV	_			100			Reg5_RTD1		2	Bit3		
Use	PWM	PWM C	yde [sec]	Inpu	it Min	4	Addin	Keys_Kibs	L << De	3	c1		
Yes		▼ 2.0	00		-100		Input	Bias TagNan	ne	4	c2		
(PID1_Out1	< De	5	c2_avg c2_cnt		
Paran	neters			Out	out Max		+ Output O	UT1 TagNam	e	7	c2_cnc	•t	
_	- Gain				100		Adam	Out0_Write	< < De		Log_R		
	5			Out	out Min		- Output O	UT2 TagNan	ne	9	Person	_Counting_:	1
Ki		Ti [sec]		_	-100	1		Out1 Write		10		_Counting_2	2
0	.04	125.00						T		11 12	Person PID1 C		- 62
Kd		Td [sec]		Bias [9	41	- <u></u>	Comm	hand TagNar	ne	12	PID1_C		
12048	20	4.00		0.0	-			PID1_CME) << De		PID1_C		
	20	1.00		0.0	10	0 <mark>= d</mark> i	sabled, 1 =	auto, 2 = m	anual	15	PID1_S	Р	
	larm 1 if	PV < Input M	lin for mo	re than 1	sec	_	Sta	atus TagNam	ne	16	PID1_S		
		PV > Input M					P	ID1_STATUS	5 << De	17	PID2_C PID2_F		
		i v > inpuci-			1 Sec					10	FIDZ I	010	

In FeSCADA we defined some more memory tags and a PID: *PID1_SP*, *PID1_CMD*, *PID1_STATUS*, etc. (see below).

When *PID1_CMD* has the value 1(one) the PID is active and it will compute the outputs to maintain the process value as close as possible to the set point value, *PID1_SP*. The set point value can be changed by the user. We read the process temperature from *Adam_Reg5_RTD1*.

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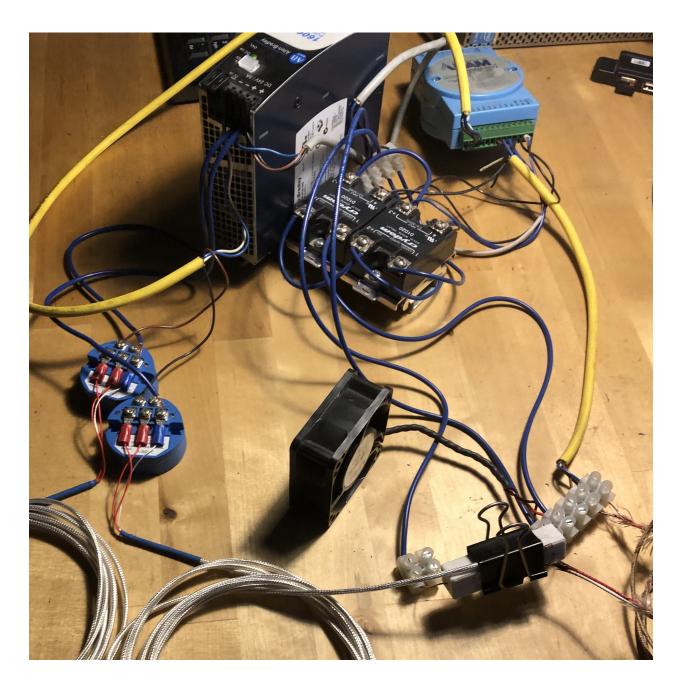
The PID outputs are using pulse width modulation (PWM). The cycle time is 2 seconds.

If the PID output is positive then the heating output (OUT1) is used in the proportion: $0...100\% \rightarrow 0...2$ seconds.

If the PID output is negative then the cooling output (OUT2) is used in the proportion: 0... -100% \rightarrow 0...2 seconds.

 $OUT1 \rightarrow Adam_OutO_Write$, which is used for SSR1, current (heating),

 $OUT2 \rightarrow Adam_Out1_Write$, which is used for SSR2, fan (cooling).

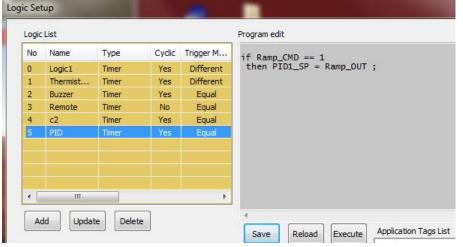


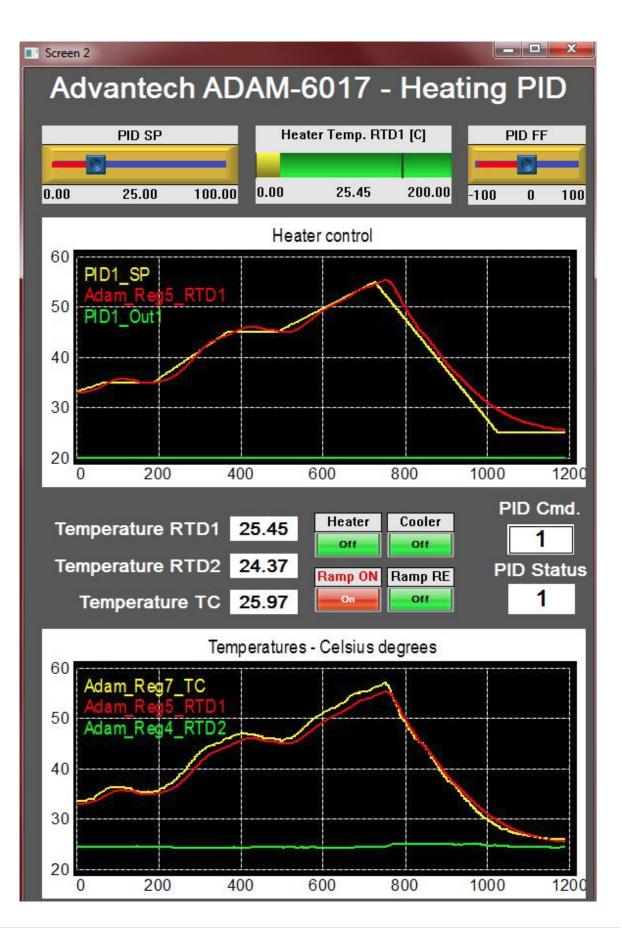
7) Special application

We defined a ramp with the memory tags: *Ramp_CMD*, *Ramp_STATUS*, *Ramp_OUT*.

lamps List			-	Teitial	alue is for T	imo ramos		Values List	t	
No Name	e Based or	Size	Inpu		in seconds.			Step	Time	ValueOut
0 Ram	p1 Time	7				Initial Deriva	tive	1	120	30
1 Ram	p2 Time	6		Initial \	Value	0.00		2	180	35
						0.00		3	120	35
				25	5.000	Final Derivati	ive	4	180	45
						0.00		5	120	45
			_				_	6	240	55
<				Initial a	nd final deri	ivatives are for		7	300	25
Add	Update Delete		8							
Add	Update					Save Values	s			
Ramp Nam	e	Sta	atus:				- 1			
Ramp1		'R	amp 1' - 5	Stopped						
Ramp	Type Number of	Steps					-0.1			
(base	ed on) (Point				the state of the second	1 Cab				
-		s)		Appi	ication Tags	s List	_			
Time	▼ 7	5)		No	ication Tags Tag Nam		•			
Constant Constant	• 7	5)		No 1	Tag Nam Bit1		<			
Time Value	<u> </u>	5)	- ()(No 1 2	Tag Nam Bit1 Bit3					
Constant Constant	• 7	5)	<	No 1 2 Del 3	Tag Nam Bit1 Bit3 c1					
Contract.	• 7	5)	<<	No 1 2 Del 3 4	Tag Nam Bit1 Bit3 c1 c2					
Value	TagName	s)		No 1 2 Del 3 4 5	Tag Nam Bit1 Bit3 c1 c2 c2_avg					
Value Value 25.0000	Tinput TagName Output TagName Ramp_OUT	\$)		No 1 2 Del 3 4	Tag Nam Bit1 Bit3 c1 c2 c2_avg c2_avg c2_cnt	e				
Value Value 25.0000 Command	Toput TagName Output TagName Ramp_OUT Command TagName	\$)	<	No 1 2 0el 3 4 5 6 7 8	Tag Nam Bit1 Bit3 c1 c2 c2_avg	e				
Value Value 25.0000 Command	Tinput TagName Output TagName Ramp_OUT Command TagName Ramp_CMD			No 1 2 0el 3 4 5 6 7 8	Tag Nam Bit1 Bit3 c1 c2 c2_avg c2_ont c2_reset Log_R	e				
Value Value 25.0000 Command	Toput TagName Output TagName Ramp_OUT Command TagName		<	No 1 2 Del 3 4 5 6 7 8	Tag Nam Bit1 Bit3 c1 c2 c2_avg c2_cnt c2_reset Log_R Person_C	e				
Value Value 25.0000 Command	Tinput TagName Output TagName Ramp_OUT Command TagName Ramp_CMD		<	No 1 2 3 4 5 6 7 7 8 9 10 11	Tag Nam Bit1 Bit3 c1 c2 c2_avg c2_cnt c2_reset Log_R Person_C Person_C Person_F	e Counting_1 Counting_2 Reset				
Value Value 25.0000 Command 0 0 = Stop/h	Thout TagName Output TagName Ramp_OUT Command TagName Ramp_CMD Hold, 1 = Start, 2 = Rese		<	No 1 2 Del 3 4 5 6 7 8 9 10 11 12	Tag Nam Bit1 Bit3 c1 c2 c2_avg c2_cnt c2_reset Log_R Person_C Person_C	e Counting_1 Counting_2 Reset ID				

In the same time we defined a logic program that will copy the value of the tag *Ramp_Out* in the PID set point tag, *PID1_SP*, if the ramp is running (if *Ramp_CMD* is 1).





8) Conclusions

The application has shown an example of using FeSCADA and FeMODBUS to monitor 3 temperature sensors and to control a heating and cooling system with the aid of ADAM 6017 Ethernet IO module from Advantech. The communication protocol is Modbus TCP.