

Appendix G

ESATAN Thermal Suite - development status

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Thermal & ECLS Software Workshop

ESATAN™ Thermal Suite

Product Development 2007

Author: Chris Kirtley
Date: 30th Oct 2007

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Introduction

ESATAN™ Thermal Suite.

- Outline the current status of the suite.
- Present developments performed over the last year.
 - Resulting in a new release of the suite.
- Strong team available for you over the next 2 days.
 - Workshop is a major event for us.
 - Time for us to listen to what you want.
 - Reassess & update our development plans.

ESATAN Thermal Analyser



Release of ESATAN™ 10 announced at last years workshop.

- Included a completely re-written Training Guide.
 - Models defined by a Space Thermal Engineer.
 - All models provided with the installation.
- On request, ported the software to SUSE Linux.
 - SUSE & CentOS now supported.
- Implemented feature requests.
- Completely new parametric analysis architecture.
 - Easily run multiple solutions, varying parameters.
 - Re-run an analysis using different control parameters.
 - Supported by Parametrics Manager Interface.

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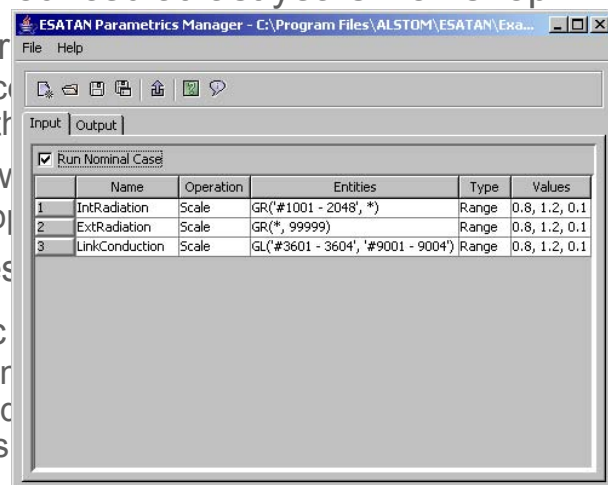
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- Implemented feature reques
- Completely new parametric
 - Easily run multiple solution
 - Re-run an analysis using c
 - Supported by Parametrics



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Thermal Network Pre- & Post-processor

ThermNV 3 Beta demonstrated at the 2006 workshop.

- Very positive feedback received.
 - In response, extended development to implement your requests.
- Released April 2007.
- Provided new reports types.
 - Delta reports.
 - Limits reports.
- Graphical representation of limits report.
- Analysis across results from multiple sets.

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ESATAN™ Thermal Suite

ESATAN 10.2 is now available

- Thermal stability analysis
- PID Controller extended
- Peltier element extended
- Easy access to internal data
- Export thermal data
- Extended control of GFF output
- Improved error messaging
- Address user reported issues

ThermXL 4.6 is now available

- Thermostat function
- PID Controller function
- Extended link to ESARAD
- Port to Microsoft® Office 2007
- Port to Microsoft® Vista®
- Address user reported issues

- These releases in direct response to your requests.
 - User survey 2007; Thank You for your support.

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ESATAN™ 10.2 Release

ESATAN 10.2

- PID Controller extended
- Peltier element extended
- Improved error messaging
- Easy access to internal data
- Thermal stability analysis
- Extended control of GFF output
- Export thermal data

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ESATAN™ 10.2 (PID/Peltier)

- Extension of Peltier Device system element.
 - Original element defined by low-level design parameters.
 - Defined by number of couples & geometric factor.
 - Data not always easily available from manufactures.
 - Extended to higher-level parameters.
 - Defined by.
 - Maximum INTENSITY => geometric factor.
 - +
 - Maximum POWER => number of couples.
 - OR
 - Maximum VOLTAGE => number of couples.
- Extension of PID Controller system element.
 - Allow negative response (optional).

Specifications:												
ΔT Value (°C)	ΔT Value (°C)	ΔT Value (°C)	ΔT Value (°C)	ΔT Value (°C)	ΔT Value (°C)	ΔT Value (°C)	ΔT Value (°C)	ΔT Value (°C)	ΔT Value (°C)	ΔT Value (°C)	ΔT Value (°C)	ΔT Value (°C)
N/A	N/A	87	76	0.47	0.7	1.9	0.26	0.26	0.156	0.156	0.169	0.169

Marlow Peltier Device

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ESATAN™ 10.2 (Error Handling)

- Enhancement of Error Messaging.
 - Format & content of error message improved.

```

@----- | MESSAGE 1 |-
@
@@@ FATAL ERROR
@
@ Problem.....: Insufficient dynamic storage
@ Current action....: Reading node pairs for inter-model links
@ Info.....: Need at least 1682 storage locations.
@               Set DYSTOR on the $EXECUTION line of the
@               main model:
@               $EXECUTION, DYSTOR = 10000
@ Context.....: Initialising model before solution
@
@ Reference.....: (LOADI , 1)
@-----
@
@

```

- Close-out user-reported issues.

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ESATAN™ 10.2 (Data Access)

- Requirement to access ESATAN data structures.
 - Full set of node GET & SET routines.
 - e.g. GETC (1) [get capacitance of node 1].
 - e.g. SETT (1, 20.0D0) [set capacitance of node 1 = 20.0D0].
 - Full set of conductor GET & SET routines.
 - e.g. GETGL (CURRENT, 1, 2) [get value of GL(1, 2)].
 - e.g. SETGL (CURRENT, 1, 2, 120.0D0) [set GL(1, 2) = 120.0].
 - Facilitates accessing internal data from external routines.
 - Simplifies constructing loops within operation blocks.

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ESATAN™ 10.2 (Thermal Stability)

- Thermal Stability Analysis.
 - Stringent requirements coming from projects, Lisa Pathfinder.
 - Critical to isolate components against thermal disturbances.
 - Interested over a specified frequency range.
 - Can use a traditional approach to analysis stability.
 - Transient runs, time consuming.
 - Associated issues related to sampling & analysing response.
 - ESATAN 10.2 launches its new Thermal Stability Analysis capability.
 - Provided as a new solver, SLFRTF.
 - Dump Gain & Phase to CSV for a given frequency range, DMPFR.
 - During a solution, get Gain & Phase at given frequency, EVALFR.

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ESATAN™ 10.2 (Thermal Stability)

- Stability analysis performed around steady state condition.
 - Analysis of complete model.
- ```

$EXECUTION
 CALL SOLVIT # Calculate steady state
#
 CALL SLFRTF # Stability analysis

```
- ... and then, output gain and phase for specified input / output pairs over a given range of frequencies.

```

Output gain/phase between radiator and unit1
 CALL DMPFR('input', RADIATOR, 'output', UNIT1,
 f_start, f_end, n_freq, ' ')

```

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## ESATAN™ 10.2 (Thermal Stability)

- Gain and Phase dump (CSV) files generated.
  - Data easy to post-process, for example with MS® Excel.
  - Files generated, *model.fr\_gain.csv* and *model.fr\_phase.csv*.

|    | A                            | B                    | C                    | D                    |
|----|------------------------------|----------------------|----------------------|----------------------|
| 1  | # Frequency Response - Gains |                      |                      |                      |
| 2  | # LISA_PF                    | 24 OCTOBER 2007      | 15:45:00             |                      |
| 3  | # ESATAN 10.2                |                      |                      |                      |
| 4  | #                            |                      |                      |                      |
| 5  | # Frequency                  | gain(Q27010, T21501) | gain(Q27020, T21501) | gain(Q27030, T21501) |
| 6  | 1.00E-08                     | 0.174623             | 0.147859             | 0.171879             |
| 7  | 1.17E-08                     | 0.174622             | 0.147859             | 0.171878             |
| 8  | 1.38E-08                     | 0.174621             | 0.147858             | 0.171877             |
| 9  | 1.62E-08                     | 0.174619             | 0.147857             | 0.171875             |
| 10 | 1.91E-08                     | 0.174617             | 0.147855             | 0.171873             |
| 11 | 2.24E-08                     | 0.174614             | 0.147852             | 0.17187              |
| 12 | 2.63E-08                     | 0.17461              | 0.147849             | 0.171866             |
| 13 | 3.09E-08                     | 0.174604             | 0.147844             | 0.171861             |
| 14 | 3.63E-08                     | 0.174596             | 0.147838             | 0.171853             |
| 15 | 4.27E-08                     | 0.174586             | 0.147828             | 0.171843             |
| 16 | 5.01E-08                     | 0.174571             | 0.147816             | 0.171828             |
| 17 | 5.89E-08                     | 0.17455              | 0.147799             | 0.171809             |
| 18 | 6.92E-08                     | 0.174522             | 0.147775             | 0.171781             |
| 19 | 8.13E-08                     | 0.174482             | 0.147742             | 0.171743             |
| 20 | 9.55E-08                     | 0.174428             | 0.147697             | 0.171691             |
| 21 | 1.12E-07                     | 0.174354             | 0.147635             | 0.171619             |
| 22 | 1.32E-07                     | 0.174251             | 0.147549             | 0.17152              |
| 23 | 1.55E-07                     | 0.174109             | 0.14743              | 0.171384             |
| 24 | 1.82E-07                     | 0.173915             | 0.147268             | 0.171196             |
| 25 | 2.14E-07                     | 0.173647             | 0.147044             | 0.170938             |

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## ESATAN™ 10.2 (Thermal Stability)

- Gain and Phase dump (CSV) files generated.
  - Data easy to post-process, for example with MS® Excel.
  - Files generated, *model.fr\_gain.csv* and *model.fr\_phase.csv*.

|    | A                            | B                    | C                    | D                    |
|----|------------------------------|----------------------|----------------------|----------------------|
| 1  | # Frequency Response - Gains |                      |                      |                      |
| 2  | #                            | OCTOBER 2007         | 15:45:00             |                      |
| 3  | # Frequency                  | gain(Q27010, T21501) | gain(Q27020, T21501) | gain(Q27030, T21501) |
| 4  | 1.00E-08                     | 0.174623             | 0.147859             | 0.171879             |
| 5  |                              | 0.174622             | 0.147859             | 0.171878             |
| 6  |                              | 0.174621             | 0.147858             | 0.171877             |
| 7  |                              | 0.174619             | 0.147857             | 0.171875             |
| 8  | 1.38E-08                     | 0.174617             | 0.147855             | 0.171873             |
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| 12 | 2.63E-08                     | 0.174596             | 0.147838             | 0.171853             |
| 13 | 3.09E-08                     | 0.174586             | 0.147828             | 0.171843             |
| 14 | 3.63E-08                     | 0.174571             | 0.147816             | 0.171828             |
| 15 | 4.27E-08                     | 0.17455              | 0.147799             | 0.171809             |
| 16 | 5.01E-08                     | 0.174522             | 0.147775             | 0.171781             |
| 17 | 5.89E-08                     | 0.174482             | 0.147742             | 0.171743             |
| 18 | 6.92E-08                     | 0.174428             | 0.147697             | 0.171691             |
| 19 | 8.13E-08                     | 0.174354             | 0.147635             | 0.171619             |
| 20 | 9.55E-08                     | 0.174251             | 0.147549             | 0.17152              |
| 21 | 1.12E-07                     | 0.174109             | 0.14743              | 0.171384             |
| 22 | 1.32E-07                     | 0.173915             | 0.147268             | 0.171196             |
| 23 | 1.55E-07                     | 0.173647             | 0.147044             | 0.170938             |
| 24 | 1.82E-07                     |                      |                      |                      |
| 25 | 2.14E-07                     |                      |                      |                      |

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## ESATAN™ 10.2 (Thermal Stability)

- Gain and Phase dump (CSV) files generated.
  - Data easy to post-process, for example with MS® Excel.
  - Files generated, *model.fr\_gain.csv* and *model.fr\_phase.csv*.

|    | A                            | B        | C                    | D        |
|----|------------------------------|----------|----------------------|----------|
| 1  | # Frequency Response - Gains |          |                      |          |
| 2  | gain(Q27010, T21501)         |          | gain(Q27030, T21501) |          |
| 3  |                              | 0.174679 |                      | 0.171879 |
| 4  |                              |          |                      | 0.171878 |
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| 15 | 4.27E-08                     | 0.174586 | 0.147828             | 0.171843 |
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| 23 | 1.55E-07                     | 0.174109 | 0.14743              | 0.171384 |
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| 25 | 2.14E-07                     | 0.173647 | 0.147044             | 0.170938 |

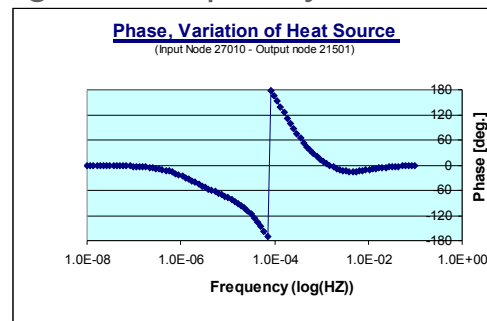
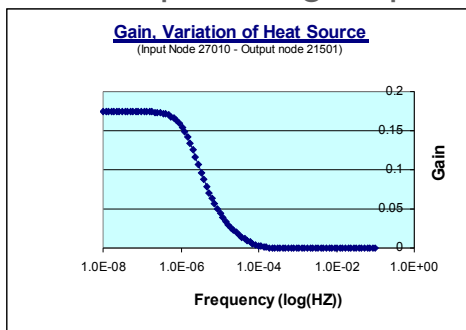
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## ESATAN™ 10.2 (Thermal Stability)

- Gain and Phase dump (CSV) files generated.
  - Data easy to post-process, for example with MS® Excel.
  - Files generated, *model.fr\_gain.csv* and *model.fr\_phase.csv*.
- Provides plots of gain/phase against frequency.



- ... or easily plot output PSD versus frequency.

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## ESATAN™ 10.2 (Thermal Data Output)

Thermal data output.

- Provide finer control of data stored within the GFF file.
  - Select individual nodes, groups, alias.
  - Select specific nodal entities, T, QI, QE, ...
  - Select conductor types, GL, GR, GF, ...

```
CALL DMPGFF('#10-110', 'NODES(T) CONDUCTORS(GL)', CURRENT, '')
```

- Easier pre- and post-processing within ThermNV.
- ESARAD 6.2 supports extended routine.

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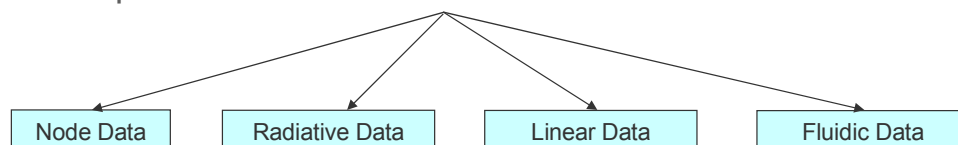
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## ESATAN™ 10.2 (Thermal Data Output)

Thermal Data Output.

- Export basic thermal model data to CSV format, `DMPTHM`.
  - Direct request from users.
  - Dumps data at given point in time.
  - Output in vector / matrix format.



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## ESATAN™ 10.2 (Thermal Data Output)

### Thermal Data Output.

- Export basic thermal model data to CSV format, DMP THM.

|    | A                                    | B       | C      | D | E |
|----|--------------------------------------|---------|--------|---|---|
| 1  | # Basic Thermal Model Data - Nodes   |         |        |   |   |
| 2  | # H_SECTION 27 OCTOBER 2007 14:27:13 |         |        |   |   |
| 3  | # ESATAN 10.2                        |         |        |   |   |
| 4  | #                                    |         |        |   |   |
| 5  | #T                                   | C       | Q      |   |   |
| 6  | 138.101                              | 170.834 | 0      |   |   |
| 7  | 144.792                              | 41.7591 | 52.753 |   |   |
| 8  | 142.218                              | 82.5482 | 0      |   |   |
| 9  | 139.887                              | 81.6699 | 0      |   |   |
| 10 | 139.287                              | 81.4437 | 0      |   |   |
| 11 | 138.964                              | 40.661  | 0      |   |   |
| 12 | -273.15                              | 0       | 0      |   |   |
| 13 | 135.295                              | 55.318  | 0      |   |   |
| 14 | 135.66                               | 110.826 | 0      |   |   |
| 15 | 136.298                              | 111.159 | 0      |   |   |
| 16 | 135.705                              | 110.85  | 0      |   |   |
| 17 | 135.386                              | 55.3417 | 0      |   |   |
| 18 | -273.15                              | 0       | 0      |   |   |

... in time.

format.

Linear Data

Fluidic Data

... in third-party tools, e.g. MATLAB

## ESATAN™ 10.2 (Thermal Data Output)

### Thermal Data Output.

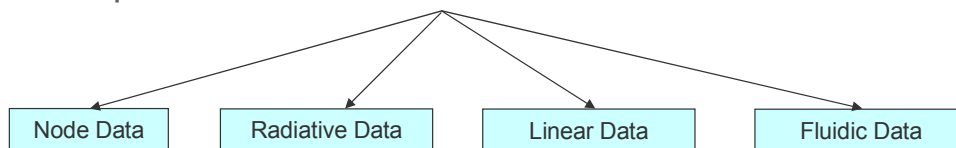
- Export basic thermal model data to CSV format, DMP THM.
  - Direct request from users.

|    | A                                                | B       | C       | D       | E       | F       | G | H       | I       | J       | K       | L       | M |
|----|--------------------------------------------------|---------|---------|---------|---------|---------|---|---------|---------|---------|---------|---------|---|
| 1  | # Basic Thermal Model Data - Linear Conductances |         |         |         |         |         |   |         |         |         |         |         |   |
| 2  | # H_SECTION 27 OCTOBER 2007 14:27:13             |         |         |         |         |         |   |         |         |         |         |         |   |
| 3  | # ESATAN 10.2                                    |         |         |         |         |         |   |         |         |         |         |         |   |
| 4  | #                                                |         |         |         |         |         |   |         |         |         |         |         |   |
| 5  | # GL                                             |         |         |         |         |         |   |         |         |         |         |         |   |
| 6  | 0                                                | 0       | 0       | 14.5954 | 0       | 0       | 0 | 0       | 0       | 14.4568 | 0       | 0       | 0 |
| 7  | 0                                                | 0       | 18.1443 | 0       | 0       | 0       | 0 | 0       | 0       | 0       | 0       | 0       | 0 |
| 8  | 0                                                | 18.1443 | 0       | 17.8684 | 0       | 0       | 0 | 0       | 0       | 0       | 0       | 0       | 0 |
| 9  | 14.5954                                          | 0       | 17.8684 | 0       | 17.7035 | 0       | 0 | 0       | 0       | 0       | 0       | 0       | 0 |
| 10 | 0                                                | 0       | 0       | 17.7035 | 0       | 17.6516 | 0 | 0       | 0       | 0       | 0       | 0       | 0 |
| 11 | 0                                                | 0       | 0       | 0       | 17.6516 | 0       | 0 | 0       | 0       | 0       | 0       | 0       | 0 |
| 12 | 0                                                | 0       | 0       | 0       | 0       | 0       | 0 | 0       | 0       | 0       | 0       | 0       | 0 |
| 13 | 0                                                | 0       | 0       | 0       | 0       | 0       | 0 | 0       | 17.2412 | 0       | 0       | 0       | 0 |
| 14 | 0                                                | 0       | 0       | 0       | 0       | 0       | 0 | 17.2412 | 0       | 17.2976 | 0       | 0       | 0 |
| 15 | 14.4568                                          | 0       | 0       | 0       | 0       | 0       | 0 | 0       | 17.2976 | 0       | 17.3001 | 0       | 0 |
| 16 | 0                                                | 0       | 0       | 0       | 0       | 0       | 0 | 0       | 0       | 17.3001 | 0       | 17.2489 | 0 |
| 17 | 0                                                | 0       | 0       | 0       | 0       | 0       | 0 | 0       | 0       | 0       | 17.2489 | 0       | 0 |
| 18 | 0                                                | 0       | 0       | 0       | 0       | 0       | 0 | 0       | 0       | 0       | 0       | 0       | 0 |

## ESATAN™ 10.2 (Thermal Data Output)

### Thermal Data Output.

- Export basic thermal model data to CSV format, `DMP.THM`.
  - Direct request from users.
  - Dumps data at given point in time.
  - Output in vector / matrix format.



- Useful for post-processing in third-party tools, e.g. MATLAB

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## ThermXL 4.6 Release

### **ThermXL 4.6 is now available**

- Port to Microsoft® Office 2007
- Port to Microsoft® Vista®
- Extended link to ESARAD
- Thermostat function
- PID Controller function

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## ThermXL 4.6

- ThermXL 4.6 aimed at responding to user requests.
  - Now compatible with MS® Office 2007.
  - Now compatible with MS® Vista®.
    - Validated with Office XP & 2007 and Vista & 2007 configurations.
  - Extension of import model from ESARAD v6.2.
    - Imports complete network, including non-geometric nodes/conductors.
    - Imports boundary conditions (temperature / heat load).

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## ThermXL 4.6, continued

- User survey requests.
  - Modelling a thermostat => `STMThermostat`.
    - Implemented as a user-callable function.
    - Corresponds to ESATAN THRMST routine.
  - Modelling a PID Controller => `STMPIDController`.
    - User-callable function.
    - Corresponds to ESATAN PID Controller system element.

*example*



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# ThermXL 4.6 (Example)

Excel spreadsheet showing a formula: `=STMPIDController(NodesID16,NodesID17,NodesID15,NodesID18,NodesID19,NodesID20,NodesID21,NodesID22,NodesID23,NodesID24)`

| Group | Number | Label    | Type | mC       | $\alpha$ | $\epsilon$ | Area     | OS | OA | OE | OI       | T0 [C] | T [C]  | RCTime   | Imbalance |
|-------|--------|----------|------|----------|----------|------------|----------|----|----|----|----------|--------|--------|----------|-----------|
| 10    | 12     | Wall 1   | D    | 1.00E-01 | 0.00     | 0.00       | 1.00E+00 |    |    |    |          | 20.00  | 4.79   | 2.78E-03 | 2.10E-01  |
| 14    | 14     | Interm 2 | D    | 1.00E-01 | 0.00     | 0.00       | 1.00E+00 |    |    |    |          | 20.00  | 1.99   | 3.45E-03 | 1.72E-01  |
| 16    | 16     | Interm 3 | D    | 0.00E+00 | 0.00     | 0.00       | 1.00E+00 |    |    |    |          | 20.00  | -1.44  | 4.35E-03 | 1.12E-01  |
| 18    | 18     | Interm 4 | D    | 0.00E+00 | 0.00     | 0.00       | 1.00E+00 |    |    |    |          | 20.00  | -5.89  | 0.00E+00 | -1.90E-03 |
| 20    | 20     | Wall 2   | D    | 0.00E+00 | 0.00     | 0.00       | 1.00E+00 |    |    |    |          | 20.00  | -11.62 | 0.00E+00 | -1.04E-03 |
| 100   | 100    | Hot End  | D    | 0.00E+00 | 0.00     | 0.00       | 1.00E+00 |    |    |    | 4.50E+01 | 20.00  | 7.04   | 0.00E+00 | -5.47E-13 |
| 200   | 200    | Cold End | B    | 0.00E+00 | 0.00     | 0.00       | 0.00E+00 |    |    |    |          | -20.00 | -20.00 | 0.00E+00 | 7.45E+01  |

| PID Controller          | PID1 |
|-------------------------|------|
| Temperature of Node 7   | 5.89 |
| Set Point Temperature   | -7   |
| Proportional Term (P)   | 6    |
| Integral Term (I)       | 3.5  |
| Differential Term (D)   | 0.1  |
| PID Maximum Output      | 60   |
| PID Minimum Output      | 0    |
| Minimum Error           | 0    |
| Allow Negative Response | OFF  |

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## Conclusion

- ESATAN 10.2 is now available for download.
  - Implements features requested by users.
  - New Thermal Stability Analysis solver.
- ThermXL 4.6 is now available for download.
  - As for ESATAN, implements features requested by users.
  - Now available on MS Vista & Office 2007.
- ESATAN is a powerful tool integrated within the ESARAD graphical user interface.
- Strong team available for you over the next 2 days.
  - Workshop is a major event for us.
  - Time for us to listen to what you want.

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