GLAST Large Area Telescope

Instrument Flight Software Development Team

Functional Demonstration
February 16, 2005

Stanford Linear Accelerator Center

LTC Demo Objectives

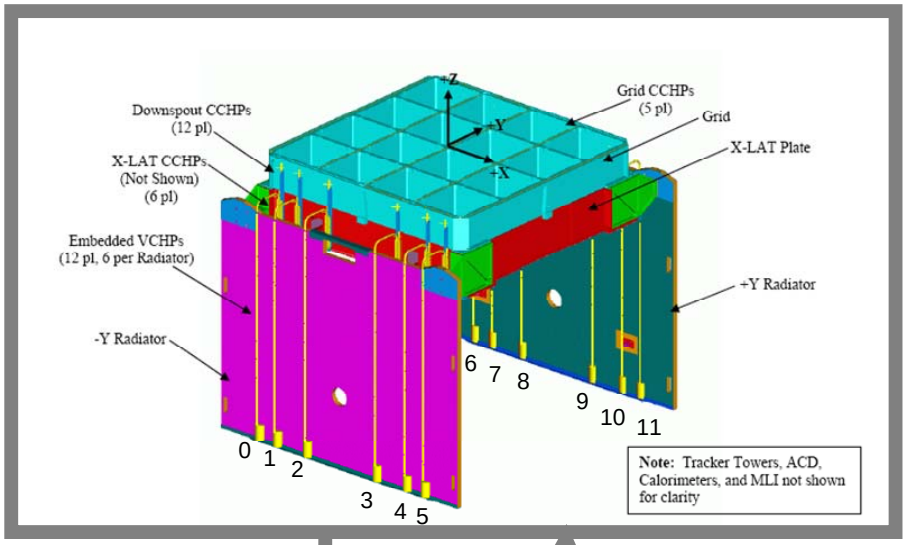
- **Establish LTC status versus requirements**
- **Expose LTC operation & configuration capabilities to users**
- **Obtain feedback to change requirements or software**

Demonstration Overview: Status vs. Requirements

- **Today's demo covers the Thermal Control System:**
  - **The demo uses simulated ADC counts that would normally be read from the PDU via the LAT Communications Board**
  - **Otherwise, all functionality closely resembles that for the Flight Unit: (1) reading thermal control parameters from the SIU file system, (2) converting ADC counts and executing the control algorithm, (3) manipulating the heater control switches on the SIB**
  - **Addresses the following requirements:**
    - **5.3.19.1.1 Sensor to ADC Mapping**
    - **5.3.19.1.2 Set of Sensors to be Read**
    - **5.3.19.1.3 Set of Sensors for Algorithm**
    - **5.3.19.1.4 Raw ADC Data**
    - **5.3.19.1.5 Control Parameters**
    - **5.3.19.2 Thermal Control Initialization**
    - **5.3.19.3 Convert ADC to Temperature**
    - **5.3.19.5 Determine Heater Setting**
    - **5.3.19.6 Shut-Down**
    - **5.3.19.12 Heater Control Signals**
    - **5.3.19.13 TCS Telemetry**

Overview of the System

HP[0] -Y Rad. VCHP 0
:
HP[5] -Y Rad. VCHP 5
HP[6] +Y Rad. VCHP 0
:
HP[11] +Y Rad. VCHP 5



RIT Monitor – thermistors
RES Temp. Monitor - RTD

Primary/Redundant

PDU

\ 12

SIB

PCI

VCHP Heater Status (On/Off)

X12/PDU

X12/PDU

VCHP Reservoir Temps

Radiator IFTemps

Thermal Control Software

"On/OFF" VCHP Heater

"Open" VHCP Watch-dog Sw

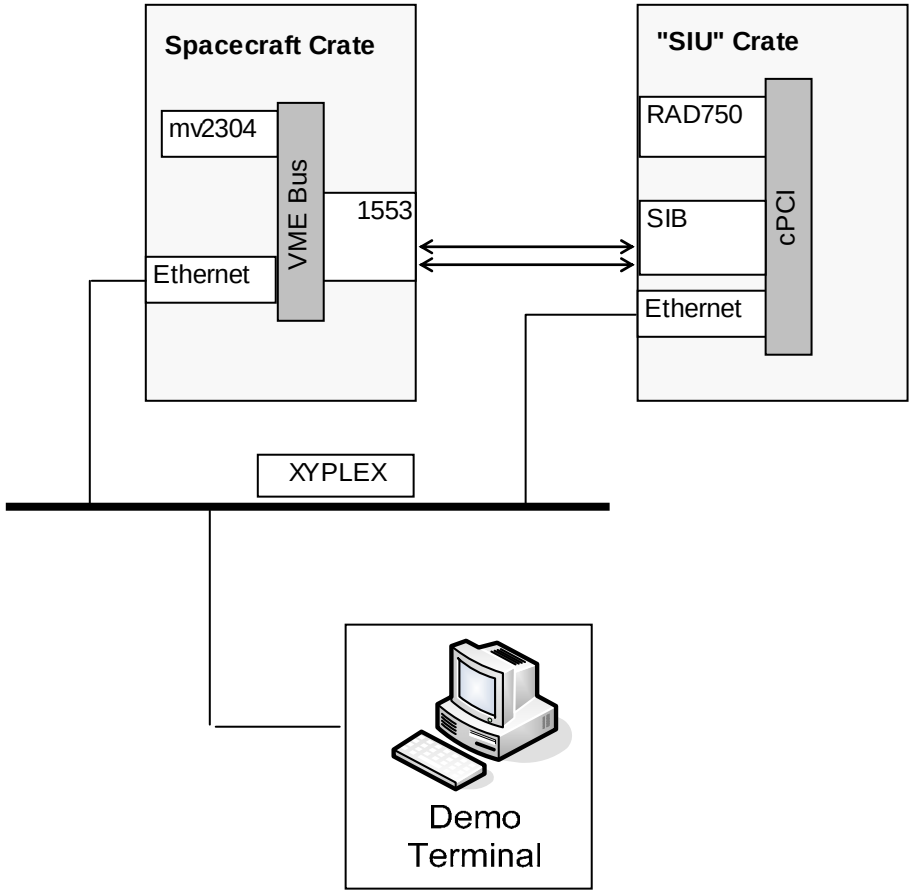
Configuration Files
- Sensor To ADC Mapping.
- ADC To Temp Param.
- Algorithm Param.
- Control/Monitoring Param

On-board File System

SIU PROCESSOR

Context for the Demonstration

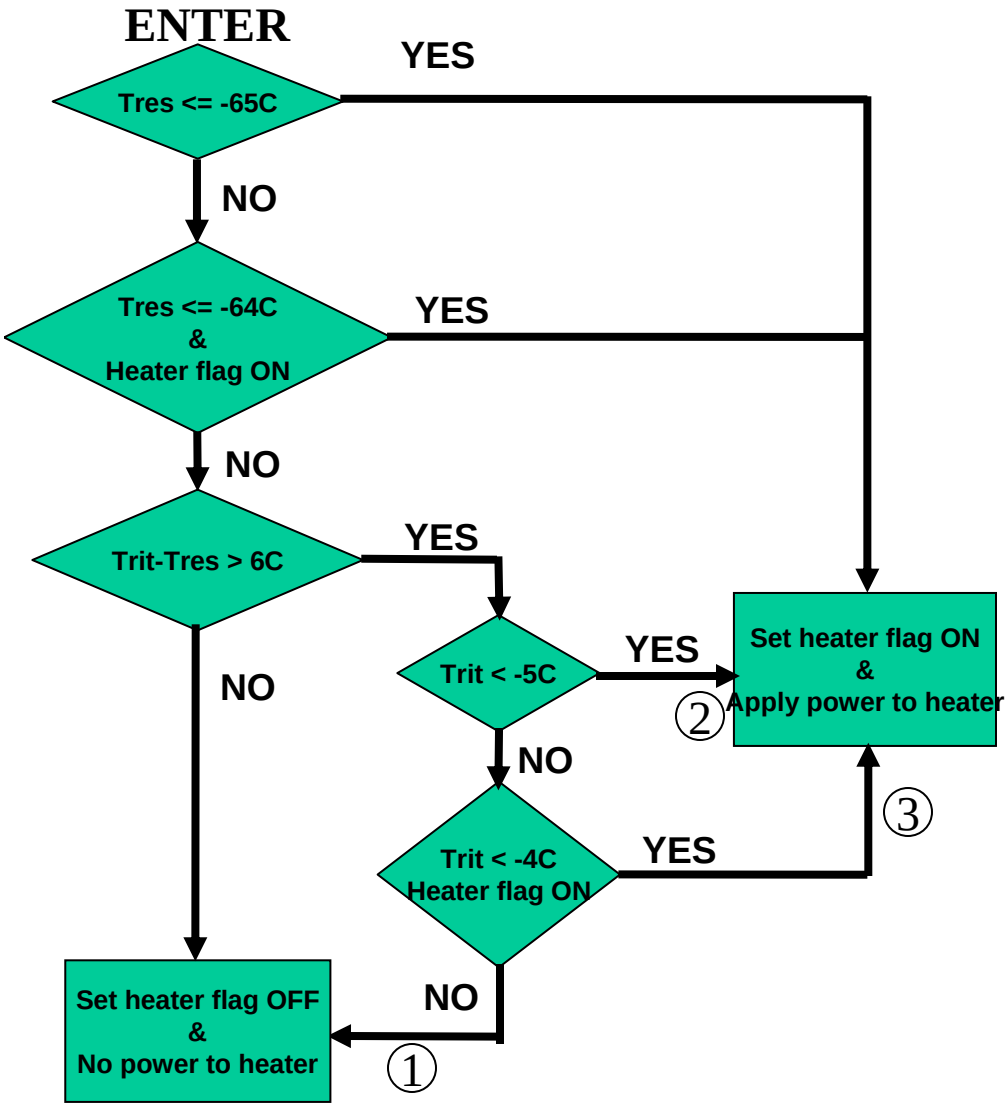
- The demonstration is run using:
  - An mv2304 CPU crate to act as the Spacecraft
  - A RAD750 crate to act as the SIU
- Thermal Control telecommands and telemetry are sent over the 1553 interface
- FSW will be loaded on the Spacecraft and SIU crates



Simulated Sensor Data

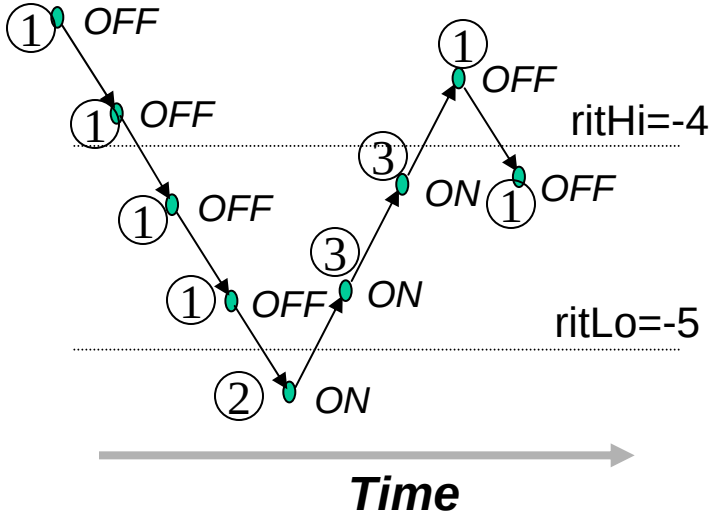
- In actual operations, the ADC data is read from the PDU via the LAT Communications Board, but the demo is simulated:
  - However, only minimal changes are required to read from the hardware
- Today's simulated data follows a basic linear function of "heating" and "cooling":
  - If the HP reservoir heater is currently on:
    - New RIT temperature = current RIT temperature + 0.2C
  - If the HP reservoir heater is currently off:
    - New RIT temperature = current RIT temperature – 0.2C
  - Some random noise is added to this progression

LTC Control Logic

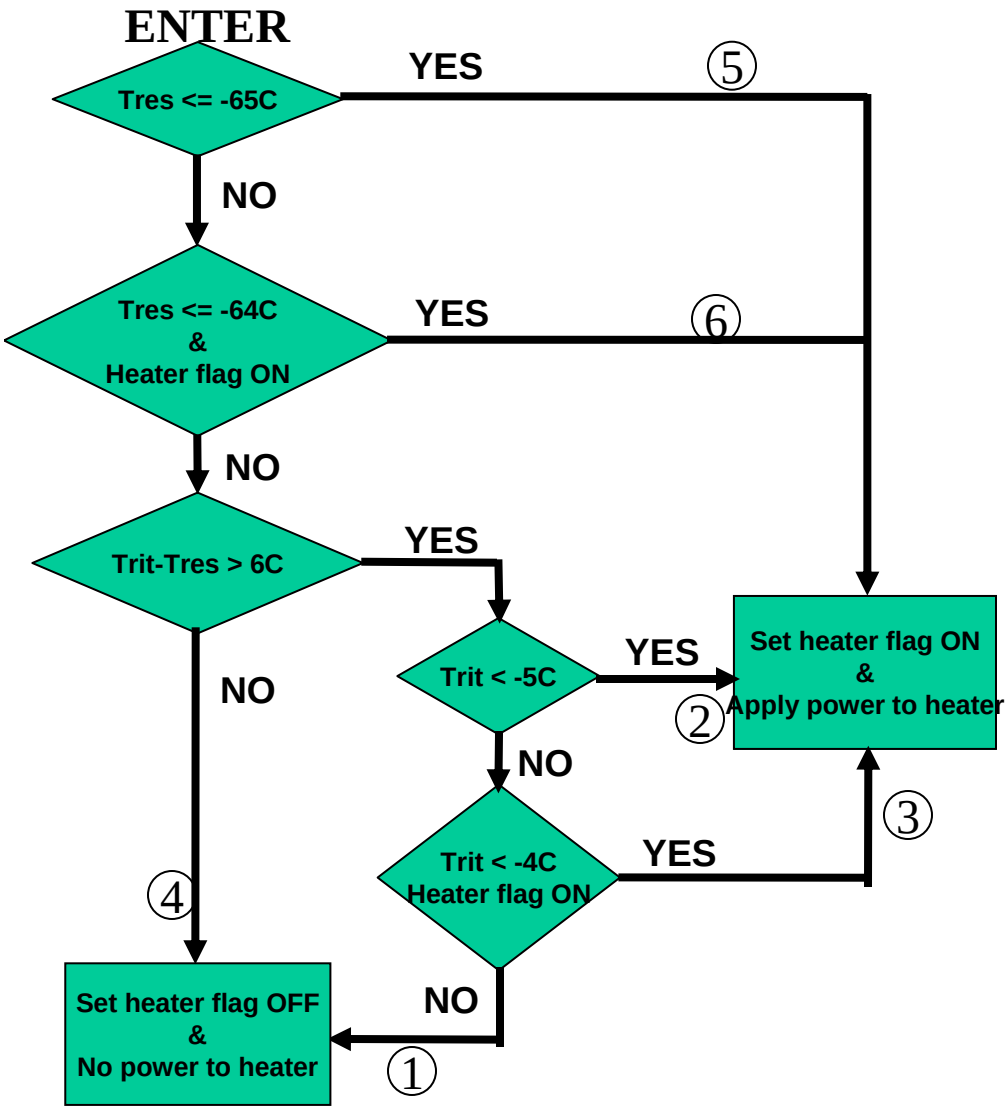


Assumptions:

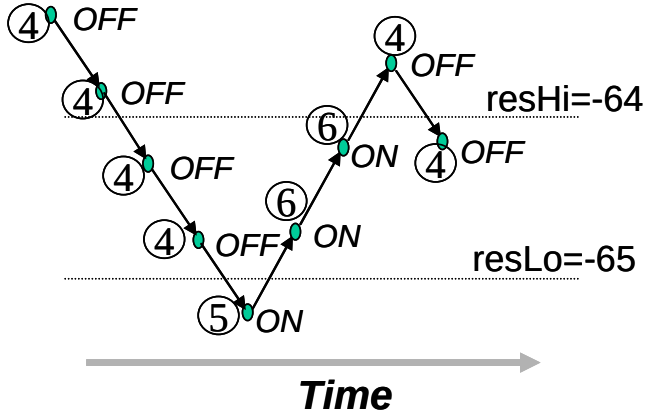
- *Start htr flag OFF*
- *Trit-Tres > 6C*



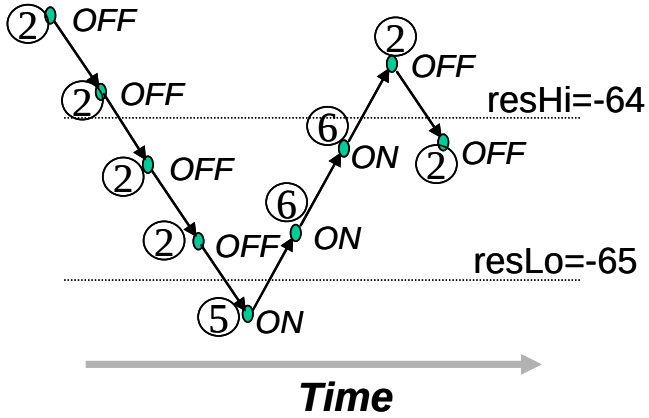
LTC Control Logic (II)



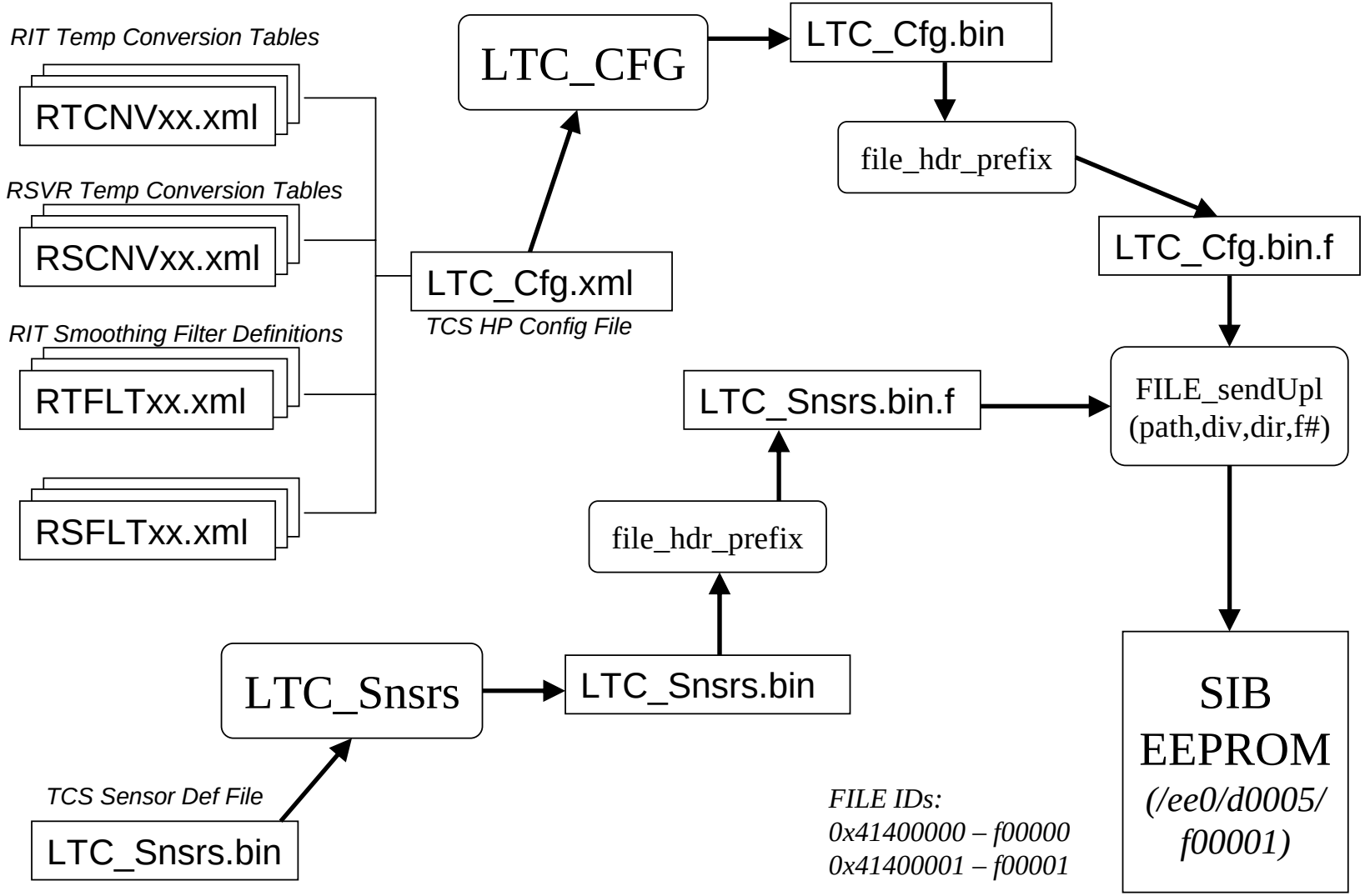
Assumptions:
- *Start htr flag OFF*
- *Trit-Tres <= 6C*



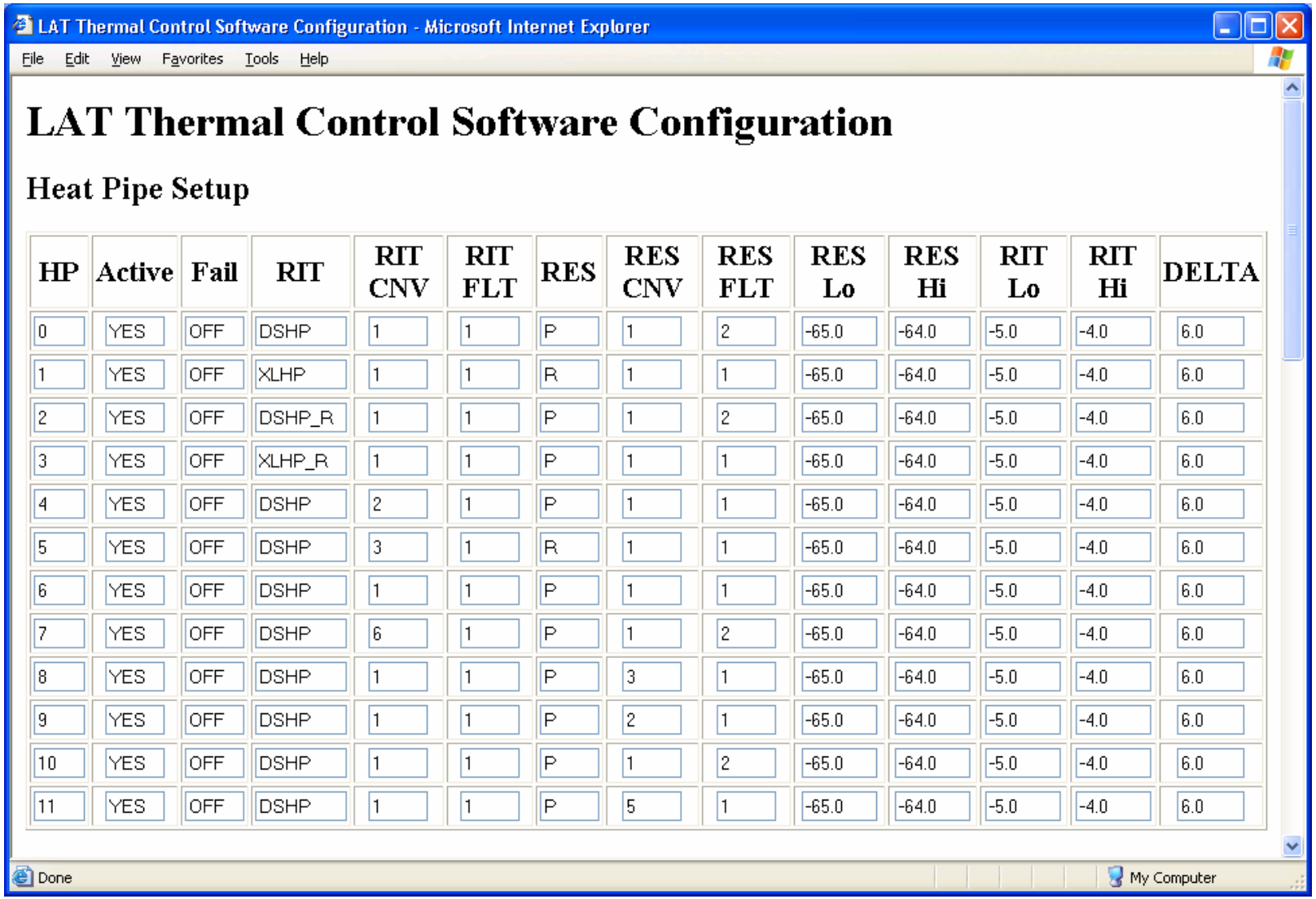
Assumptions:
- *Start htr flag OFF*
- *Trit-Tres > 6C*



Creating LTC Configuration File Binaries



Example LTC Heat Pipe Configuration Table

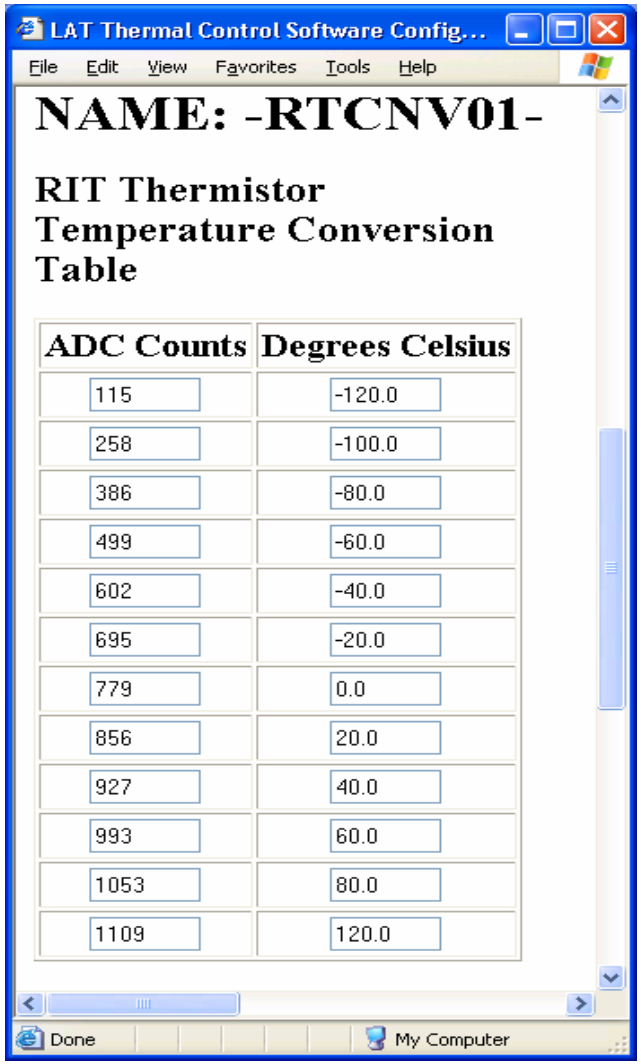


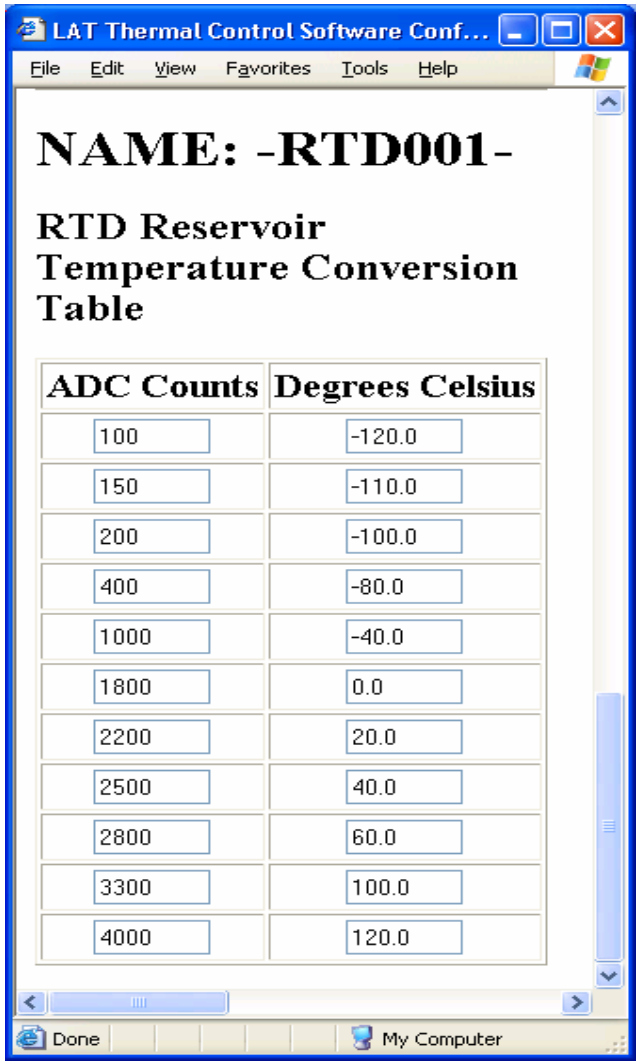
LAT Thermal Control Software Configuration

Heat Pipe Setup

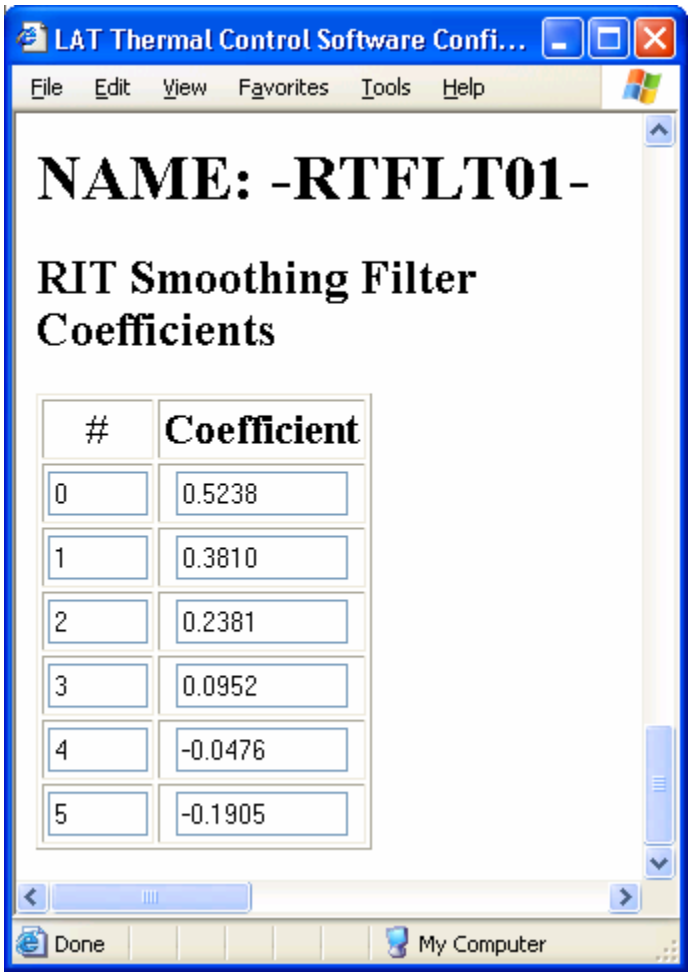
HP	Active	Fail	RIT	RIT CNV	RIT FLT	RES	RES CNV	RES FLT	RES Lo	RES Hi	RIT Lo	RIT Hi	DELTA
0	YES	OFF	DSHP	1	1	P	1	2	-65.0	-64.0	-5.0	-4.0	6.0
1	YES	OFF	XLHP	1	1	R	1	1	-65.0	-64.0	-5.0	-4.0	6.0
2	YES	OFF	DSHP_R	1	1	P	1	2	-65.0	-64.0	-5.0	-4.0	6.0
3	YES	OFF	XLHP_R	1	1	P	1	1	-65.0	-64.0	-5.0	-4.0	6.0
4	YES	OFF	DSHP	2	1	P	1	1	-65.0	-64.0	-5.0	-4.0	6.0
5	YES	OFF	DSHP	3	1	R	1	1	-65.0	-64.0	-5.0	-4.0	6.0
6	YES	OFF	DSHP	1	1	P	1	1	-65.0	-64.0	-5.0	-4.0	6.0
7	YES	OFF	DSHP	6	1	P	1	2	-65.0	-64.0	-5.0	-4.0	6.0
8	YES	OFF	DSHP	1	1	P	3	1	-65.0	-64.0	-5.0	-4.0	6.0
9	YES	OFF	DSHP	1	1	P	2	1	-65.0	-64.0	-5.0	-4.0	6.0
10	YES	OFF	DSHP	1	1	P	1	2	-65.0	-64.0	-5.0	-4.0	6.0
11	YES	OFF	DSHP	1	1	P	5	1	-65.0	-64.0	-5.0	-4.0	6.0

Example Temperature Conversion Tables

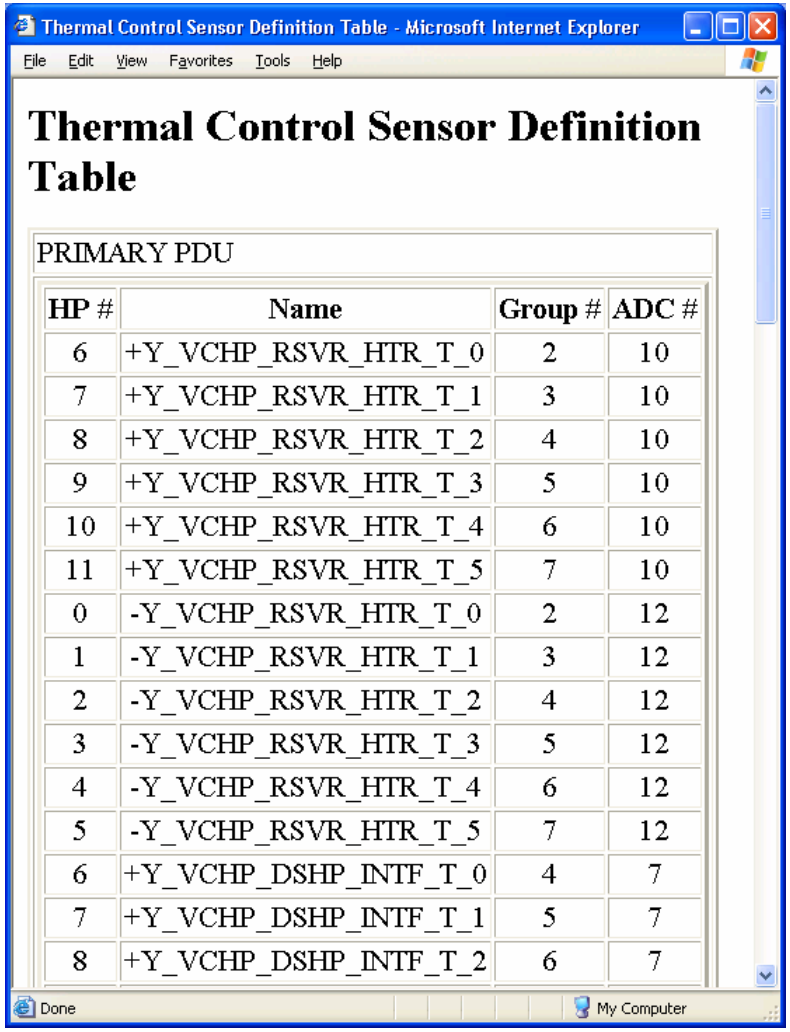




Example Smoothing Filter Configuration Table



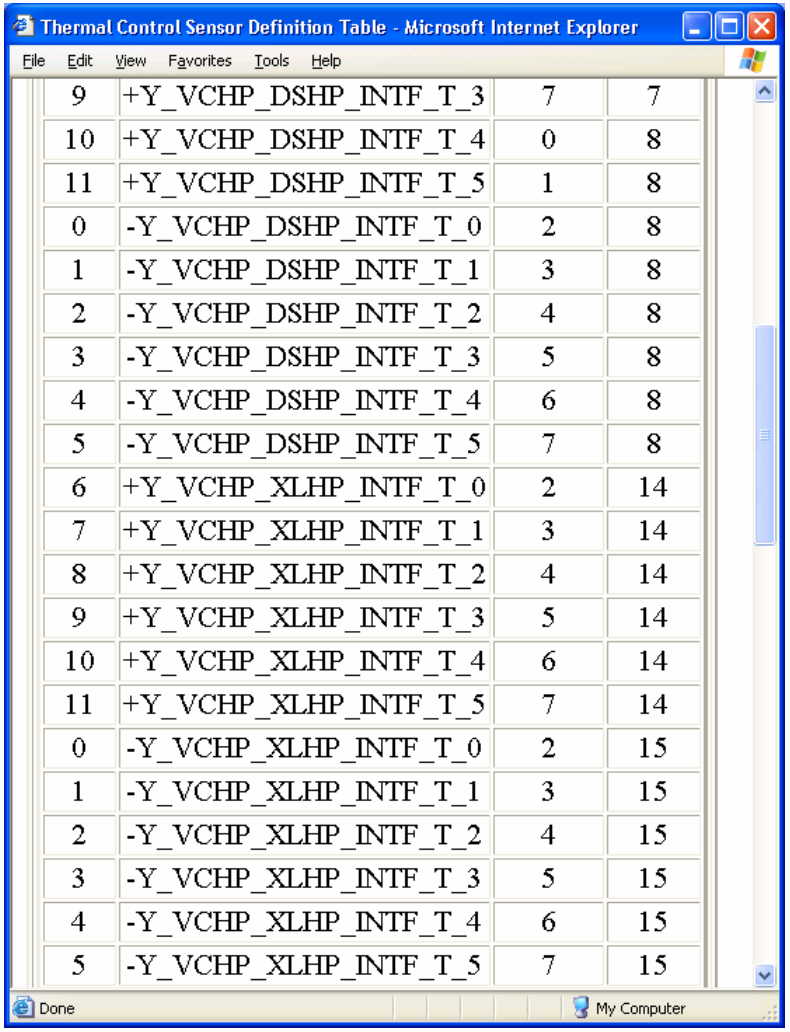
Example LTC Sensor Definition Table



Thermal Control Sensor Definition Table

PRIMARY PDU

HP #	Name	Group #	ADC #
6	+Y_VCHP_RSVR_HTR_T_0	2	10
7	+Y_VCHP_RSVR_HTR_T_1	3	10
8	+Y_VCHP_RSVR_HTR_T_2	4	10
9	+Y_VCHP_RSVR_HTR_T_3	5	10
10	+Y_VCHP_RSVR_HTR_T_4	6	10
11	+Y_VCHP_RSVR_HTR_T_5	7	10
0	-Y_VCHP_RSVR_HTR_T_0	2	12
1	-Y_VCHP_RSVR_HTR_T_1	3	12
2	-Y_VCHP_RSVR_HTR_T_2	4	12
3	-Y_VCHP_RSVR_HTR_T_3	5	12
4	-Y_VCHP_RSVR_HTR_T_4	6	12
5	-Y_VCHP_RSVR_HTR_T_5	7	12
6	+Y_VCHP_DSHP_INTF_T_0	4	7
7	+Y_VCHP_DSHP_INTF_T_1	5	7
8	+Y_VCHP_DSHP_INTF_T_2	6	7



9	+Y_VCHP_DSHP_INTF_T_3	7	7
10	+Y_VCHP_DSHP_INTF_T_4	0	8
11	+Y_VCHP_DSHP_INTF_T_5	1	8
0	-Y_VCHP_DSHP_INTF_T_0	2	8
1	-Y_VCHP_DSHP_INTF_T_1	3	8
2	-Y_VCHP_DSHP_INTF_T_2	4	8
3	-Y_VCHP_DSHP_INTF_T_3	5	8
4	-Y_VCHP_DSHP_INTF_T_4	6	8
5	-Y_VCHP_DSHP_INTF_T_5	7	8
6	+Y_VCHP_XLHP_INTF_T_0	2	14
7	+Y_VCHP_XLHP_INTF_T_1	3	14
8	+Y_VCHP_XLHP_INTF_T_2	4	14
9	+Y_VCHP_XLHP_INTF_T_3	5	14
10	+Y_VCHP_XLHP_INTF_T_4	6	14
11	+Y_VCHP_XLHP_INTF_T_5	7	14
0	-Y_VCHP_XLHP_INTF_T_0	2	15
1	-Y_VCHP_XLHP_INTF_T_1	3	15
2	-Y_VCHP_XLHP_INTF_T_2	4	15
3	-Y_VCHP_XLHP_INTF_T_3	5	15
4	-Y_VCHP_XLHP_INTF_T_4	6	15
5	-Y_VCHP_XLHP_INTF_T_5	7	15

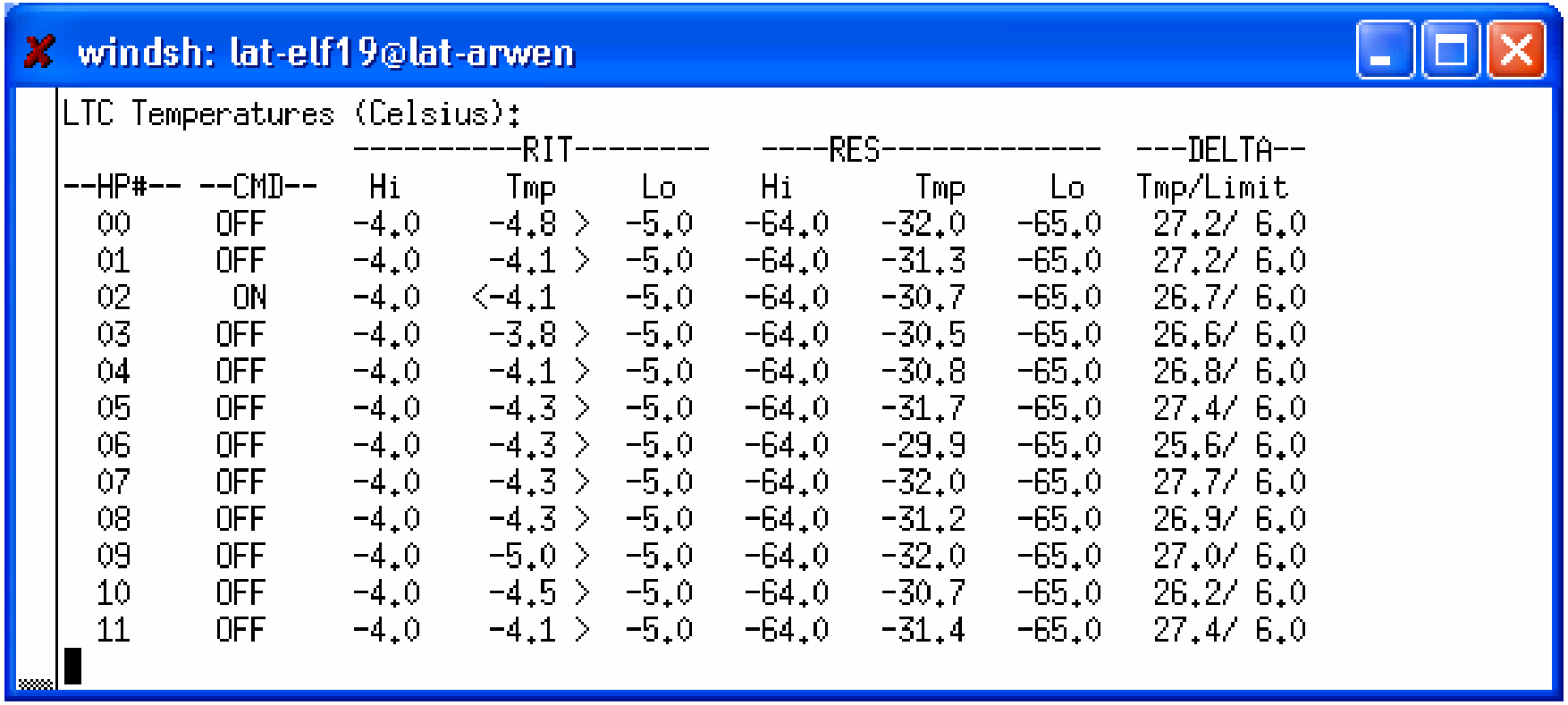
Demo Procedure (Spacecraft Side)

- **Embedded Spacecraft Simulator (lat-elf 9)**
  - **< lat2304.vxw (load spacecraft software object files)**
  - **SCP_init 3 (start 1553 telecommand & telemetry with LAT)**
  - **SCP_setDiagnostic n (dump n LTC telemetry records)**
  - **LTC_SndSetParam (send telecommand to change HP limits)**

Demo Procedure (LAT Side)

- **RAD750 LAT-LTC (lat-elf19)**
  - **< latR750.vxw (load LAT side software object files)**
  - **LCP_init (start 1553 telecommand & telemetry with spacecraft)**
  - **LTC_Init 2,1,0x41400000,0x41400001 (LTC init with config files from EEPROM)**
  - **LTC_StartTask (start LTC periodic and telecommand processing)**

LAT Side LTC Demo Output



LTC Spacecraft Side Telemetry Dump

windsh: lat-elf9@flora01

```
 10- 13 0x000ddd04                  timestamp (usec) .908548

---------------------------------- LTC Telemetry Payload ---------------------------------

HP Selected Sensors RIT/RSVR: 0000 0x10 0x6250
 11-D/P 10-D/P 9-D/P 8-D/P 7-D/P 6-D/P 5-D/R 4-D/P 3-XR/P 2-DR/P 1-X/R 0-D/P

HP Sensors Status (RIT/RSVR): 0000/0000
#00-OK/OK #01-OK/OK #02-OK/OK #03-OK/OK #04-OK/OK #05-OK/OK #06-OK/OK #07-OK/OK #08-OK/OK #09-OK/OK #10-OK/OK #11-OK/OK

HPs Active: 0xfff

Raw ADC Counts:
HP# 00 DSHP_RIT-762 DSHP_RIT_R-762 XLHP_RIT-762 XLHP_RIT_R-762 RSVR_HTR-1171 RSVR_HTR_R-1172
HP# 01 DSHP_RIT-759 DSHP_RIT_R-759 XLHP_RIT-759 XLHP_RIT_R-759 RSVR_HTR-1161 RSVR_HTR_R-1162
HP# 02 DSHP_RIT-757 DSHP_RIT_R-757 XLHP_RIT-757 XLHP_RIT_R-757 RSVR_HTR-1164 RSVR_HTR_R-1161
HP# 03 DSHP_RIT-758 DSHP_RIT_R-758 XLHP_RIT-758 XLHP_RIT_R-758 RSVR_HTR-1174 RSVR_HTR_R-1171
HP# 04 DSHP_RIT-759 DSHP_RIT_R-759 XLHP_RIT-759 XLHP_RIT_R-759 RSVR_HTR-1169 RSVR_HTR_R-1170
HP# 05 DSHP_RIT-760 DSHP_RIT_R-760 XLHP_RIT-760 XLHP_RIT_R-760 RSVR_HTR-1157 RSVR_HTR_R-1157
HP# 06 DSHP_RIT-760 DSHP_RIT_R-759 XLHP_RIT-760 XLHP_RIT_R-760 RSVR_HTR-1198 RSVR_HTR_R-1198
HP# 07 DSHP_RIT-759 DSHP_RIT_R-759 XLHP_RIT-759 XLHP_RIT_R-759 RSVR_HTR-1160 RSVR_HTR_R-1159
HP# 08 DSHP_RIT-759 DSHP_RIT_R-760 XLHP_RIT-760 XLHP_RIT_R-760 RSVR_HTR-1169 RSVR_HTR_R-1172
HP# 09 DSHP_RIT-762 DSHP_RIT_R-762 XLHP_RIT-762 XLHP_RIT_R-761 RSVR_HTR-1174 RSVR_HTR_R-1175
HP# 10 DSHP_RIT-761 DSHP_RIT_R-761 XLHP_RIT-760 XLHP_RIT_R-761 RSVR_HTR-1191 RSVR_HTR_R-1188
HP# 11 DSHP_RIT-758 DSHP_RIT_R-758 XLHP_RIT-758 XLHP_RIT_R-758 RSVR_HTR-1160 RSVR_HTR_R-1161

HP Sensor Temperatures (celsius):#00- -4.1/-31.5 #01- -4.8/-31.9 #02- -5.2/-31.8 #03- -5.0/-31.3 #04- -4.8/-31.6 #05- -4.5/-32.2
 #06- -4.5/-30.1 #07- -4.8/-32.0 #08- -4.8/-31.6 #09- -4.1/-31.3 #10- -4.3/-30.5 #11- -5.0/-32.0

HP Reservoir Heater Commanding: 0xfff
#00-ON #01-ON #02-ON #03-ON #04-ON #05-ON #06-ON #07-ON #08-ON #09-ON #10-ON #11-ON

------------------------------ End LTC Telemetry Payload ---------------------------------
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