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# Technical Description

## LUL, 73 Stock Refurbishment Heating, Ventilating & Air-conditioning Multi-stage Thermostat for Saloon

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## 1. Introduction

The function of the thermostat system Model PTS-SYS is to monitor the Saloon air temperature and provides the heating and ventilation according to a pre-set temperature.

At the heart of the system is the four-stage thermostat, stage 1 switches an external heater contactor off, stages 2, 3 and 4 provide low, medium or high speeds for the five ventilation fans (See drawing number PTS\SYS\SYSTEM for system block diagram).

In addition, the system provides temperature simulation via a key-switch and potentiometer; there are also test facility for the heater earth fault unit and alarm indications.

Briefly, the thermostat system Model: PTS-SYS comprises of:

1. a four-stage thermostat unit, Tactical Model: PTS,
2. two auto-transformers,
3. three Siemens 3TH4031-5C-E4-Z relays with built in varistor suppressors,
4. one row of 21-ways M5 stud terminal,
5. a blocking diode for static converter demand signal,
6. a control panel consisting of:
  - a key-switch, two-push button switches,
  - and a potentiometer.

These components are mounted on a metal plate and basin, for details of which, refer to drawing number PTS\SYS\LAY-COMP.

For simplicity, thereafter, we would refer the thermostat system as: **PTS-SYS** and the four-stage thermostat unit as: **PTS (Piccadilly-Thermostat -Saloon)**

## 2. Interface to external equipments

The PTS-SYS interfaces to two external pieces of equipment:

1. the Heater Earth Fault unit (HEF) and
2. two emergency fans and five non-emergency fans

## 3. The four-stage thermostat unit

The function of the four-stage thermostat unit, model PTS, is to monitor the saloon air temperature and switches external contactors according to a pre-set temperature.

The outputs of the PTS consist of four 16A Schrack relays; each relay has a normally open contact and switches according to the following temperature.

On rising temperature:

- at 17 ° C stage one - heater OFF
- at 21 ° C stage two - ventilation and emergency fans run at low speed
- at 24 ° C stage three - ventilation and emergency fans run at medium speed

at 27 ° C stage four - ventilation and emergency fans run at high speed

On falling temperature:

at 16 ° C stage one - heater ON

at 20 ° C stage two - ventilation and emergency fans OFF

at 23 ° C stage three - ventilation and emergency fans run at low speed

at 26 ° C stage four - ventilation and emergency fans run at medium speed

## **4. Contactors**

### **4.1 Contactor switching**

The PTS has a four-stage relay outputs. These are used for:

1. stage 1 is used to switch a heater contactor with 115Vac 850Hz coil (the heater contactor is not part of the PTS-SYS).
2. stages 2, 3 and 4 are used to drive three Siemens 3TH4 contactors, with a 60Vdc coil; varistor suppressors are built into the contactor's coils.

### **4.2 Ventilation fan-speed switching**

Stages 2, 3 and 4 of the PTS outputs are used to drive three Siemens 3TH4 contactors for the purpose of switching the ventilation fan-speeds. The contactors switch three voltage tapings on the auto-transformers 135, 160 and 240Vac to give low, medium and high speeds respectively (see drawing number 83TS\SYS\CONNECT).

### **4.3 Safe switching**

A feature of the design is the inherent "safe switching" and this could be explained with reference to the System Block Diagram. These contactors switching arrangement and design ensures that should a contactor contact "weld-on" occurs, no damage or over-heating to the system would result, that is, it is not possible to short-circuit the auto-transformer winding.

### **4.4 Contactor coil suppressor**

The Siemens contactors, 3TH4031-5C-E4-Z 60Vdc coil, has a built-in varistor suppressor to the contactor's coil.

Test conducted on the contactor's suppressor shows that it has a clamping voltage of 70Vdc.

## **5. Diagnostic test facility**

Built into the thermostat system, PTS-SYS, is the facility for providing simulated sensor temperature inputs to the PTS. This is achieved by:

- 1) a Craigg Derricott, rotary key-switch, for switching between sensor simulation and normal operations.

2) a potentiometer for sensor simulation.

When the key-switch is switched to the normal mode (key removable), the unit senses the saloon temperature via the external sensor.

When the key-switch is switched to the test mode, the potentiometer is switched to the thermostat unit sensor input and could be used to simulate a change in the saloon temperature. The potentiometer could simulate the temperature variation from 16 °C to 27 °C thereby enable the checking of the contactor switchings of the four-stage outputs; visual indications of outputs are given by four LED indicators on the thermostat unit.

It must be borne in mind that for the sensor simulation to become operational, the Platinum Resistance Thermometer (PT100) must be properly connected - that is TC1 and TC2 are the shorted terminals at the sensor probe end. However, if the sensor is not connected, the test still could be simulated by simply shorting the TC1 and TC2 on the M5 stud terminal rail.

During test mode, the key is not removable and that the key prevents the door of the compartment which houses the PTS-SYS, from closing. This prevents the key from accidentally left in the test position.

## **6. Heater earth fault**

### **6.1 Heater Earth Fault Test (HEF Test)**

Simulation of Heater Earth Fault is made by depressing the normally open, green "HEF Test" button, located at the front panel of the system. When this button is depressed, it simulates an earth fault current by introducing a current imbalance in the Heater Earth Fault unit.

An external resistor ( $R_e$ ) is connected between the thermostat system terminal number '92N' and the supply ground;  $R_e$  is not part of the thermostat system (see PTS system connections, drawing number 83TS\SYS\CONNECT).

The value of the resistor  $R_e$  depends on the sensitivity of the HEF.

When the "HEF Test" button is depressed, the 'Heater Earth Fault' alarm (red) illuminates.

### **6.2 Heater Earth Fault Reset (HEF Reset)**

A normally closed "HEF Reset" push-button (red) is connected in series with the -52Vdc supply to the Heater Earth Fault unit (HEF) and externally connected to the M5 stud terminal number 92B (see PTS system connections, drawing number 83TS\SYS\CONNECT).

When the "HEF Test" push-button (green) is depressed, it simulates an earth fault and the "HEF Fault" alarm indicator illuminates and could be reset by the "HEF Reset" button (red). When pressed, the red button disconnects the -52Vdc supply to the HEF, in doing so, it resets the HEF Fault alarm indicator- provided that the HEF Fault no longer present.

Note that the HEF unit is not part of the thermostat system, but it does require to interface with the PTS-SYS via the M5 stud terminal number 92B.

### **6.3 Heater Earth Fault alarm (HEF Alarm)**

The Heater Earth Fault alarm is a red LED indicator resides inside the thermostat unit. When an alarm occurs, a -52Vdc appears at the M5 stud terminal number 91D and the HEF Alarm indicator illuminates.

When the thermostat system is fully connected to the locomotive; the HEF Alarm indicator could be tested by pushing the "HEF Test" button, as described under the section 6.1.

## **7. Sensor**

A platinum resistance thermometer sensor PT100 to BS1904 class A, with error not greater than  $\pm 0.15$  ° C, 3-wire connection, is connected to the PTS-SYS M5 stud terminal numbers TC1, TC2, TC3 and EE (see drawing number PTS\SYS\SENSOR for detail); EE is the screened cable of the sensor.

The sensor is colour coded, TC1 and TC2 are red, TC3 is white and EE is green.

A three core, 1mm square, screened cable to RSE\STD\024 type 8 is used. The sensor is supplied with 600mm of this cable.

See Platinum Resistance Probe, drawing number PTS\SYS\SENSOR for further details.

## **8. Logic signals**

### **8.1 Static converter demand signal**

Whenever the thermostat system output switches to fan cooling, this occurs when the temperature exceeds 21 ° C, low-speed fan cooling is called for; contactor RL3 is energised and generates a -52Vdc voltage via RL3 and diode D1, as shown in drawing number PTS\SYS\CONNECT.

Note that the above condition could be simulated by using the diagnostic test facility as described in section 5. To test the diode, you may connect an external Siemens 3TH4 60V coil (A1 as marked on the contactor) to the terminal number 87 on the M5 stud terminal and the other end of the coil (A2) to the E terminal. The 3TH4 contactor should be energised together with the RL3 contactor of the PTS-SYS system, when the temperature exceeds 21°C.

The diode D1 acts as a blocking diode; there could be several similar diodes connected to a common Static Converter Demand signal line and any one of these diodes (cathode end) could be switched to the -52Vdc supply rail - in simple logic terms, these diodes form the logic inputs to an 'OR' CIRCUIT.

## **9. Static converter**

## 9.1 Static converter fault alarm (Conv. Fault)

This is provided by a filament bulb GEC Alsthom red indicator, 22mm round. An aluminium clad, 470R, 25 watt resistor is connected in series with the 24V bulb. When an alarm occurs, a -52Vdc is connected to the bulb and resistor; the voltage across the bulb is 15Vdc, to give the bulb a longer operating life. The connection of this alarm signal is made via the M5 stud terminal number 92YL, as shown in drawing number 83TS\SYS\CONNECT.

The Static converter fault alarm is fitted to the trailer vehicle only.

Use a DVM to measure the voltage across 92YL terminal, this should measure -52Vdc when the static converter alarm occurs and the GEC red lamp should illuminate.

## 9.2 Static Converter ON indicator (Conv. ON)

The static converter ON is a green LED indicator resides in the PTS unit; the LED derives its power from an isolated winding (5Vac) of the auto-transformer.

The green LED illuminates when 240Vac is present.

## 10. Test and calibration

The multi-stage thermostat unit, model PTS, could be tested and calibrated in situ. All that is required is the Test and Calibration unit, model TC1000 .

Briefly, the TC1000 unit is housed in a carrying-case. The unit consists of a LCD display, a 10-turns potentiometer and a Derricott switch. Connection of the unit to the system is made via two mating pairs of 5-way Litton bayonet plug-socket connectors.

The TC1000 unit's LCD display could display three different temperatures:

1. The saloon sensor temperature (Derricott switch in sensor-position).
2. The test temperature (Derricott switch in test-position)
3. The reference temperature (Derricott switch in sensor-position and reference resistor connected)

Note that the reference resistor is connected to an independent bayonet free-plug and mates with the sensor-socket of the TC1000. The reference resistor value is 108.18 ohm (21°C) and uses a high precision, high stability resistor (15 ppm/°C).

## 11. Wiring

All external wiring to the unit, PTS-SYS, is made via the 21-way M5 stud terminals and follow the cable markers from inside the unit.

Refer to drawing number 83TS\SYS\CONNECT for the terminal connections.

All internal wiring is given under Appendix B of this document.

## 12 Technical specification

This technical specification relates to the Electronic Four-Stage Thermostat temperature sensing unit, model PTS. It is the heart of the PTS-SYS, which is the subject of this Manual, hence its detailed specification is given here.

### POWER SUPPLY

<b>Voltage</b>	-32 to -63 Vdc; -52 Vdc nominal.
<b>Ripple</b>	Unaffected by 2 volt peak to peak.
<b>Input protection</b>	Reverse polarity protection. Surges and transients to BRB/RIA 12.
<b>Low battery cut-out</b>	The unit outputs are inhibited when the supply voltage reaches $32.5 \pm 0.5$ Vdc during a falling voltage and become enabled at $36 \pm 1$ Vdc during a rising voltage.
<b>Current consumption</b>	170mAdc maximum at -33Vdc (when outputs 2,3 and 4 are on). 70mAdc minimum at -33Vdc (when all outputs are off) 110mAdc maximum at -52Vdc (when outputs 2,3 and 4 are on) 45mAdc minimum at -52Vdc (when all outputs are off). 105mAdc maximum at -63Vdc (when outputs 2,3 and 4 are on). 40mAdc minimum at -63Vdc (when all outputs are off).

### SENSOR

	One PT100 sensor, to BS1904 class A; sensor error not greater than $\pm 0.15^\circ\text{C}$ ; third wire compensation against error due to lead resistance.
<b>Lead resistance error</b>	Less than $0.05^\circ\text{C}$ error for every 10 meter of sensor cabling; (for copper cable cores 1mm square).
<b>Screened cable</b>	Sensor cable wires must be screened and connected to system earth.
<b>Interchangeability</b>	The temperature probes are easily detachable and interchangeable with sensor error altered by not more than $\pm 0.15^\circ\text{C}$ .
<b>Time constant</b>	20 to 40 seconds when the sensor is subject to an air stream of 2m/s.

### INDICATORS

<b>Indicators</b>	7 LEDs are provided for indicating the status of the supplies, alarms and outputs.
<b>DC supply</b>	LED1, green; illuminates when the dc voltage -52Vdc is present.
<b>240Vac</b>	LED2, green; illuminates when the static converter supply 240Vac voltage is present.
<b>Heat output</b>	LED3, orange; illuminates when heat is ON.
<b>Low-speed</b>	LED4, yellow; illuminates when low-speed in ON.
<b>Medium-speed</b>	LED5, yellow; illuminates when medium-speed is ON.
<b>High-speed</b>	LED6, yellow; illuminates when high-speed in ON.
<b>Heater fault</b>	LED7, red; illuminates if and when earth fault occurs.

### RELAY OUTPUT

<b>Relays</b>	The unit has four relay outputs, type: Schrack RP330024, single pole.
<b>Contact rating</b>	The relays are rated at 250Vac, 16A.

<b>Mechanical life</b>	Greater than 30 million operations.
<b>Electrical life</b>	Greater than 1 million operations at 52Vdc, 0.5Adc.

## OUTPUT SWITCHING

### On rising temperature

at 17°C	heater OFF.
at 21°C	ventilation and emergency fans at low speed.
at 24°C	ventilation fans and emergency fans at medium speed.
at 27°C	ventilation fans and emergency fans at high speed.

### On falling temperature

at 16°C	heater ON.
at 20°C	ventilation and emergency fans are OFF.
at 23°C	ventilation and emergency fans at low speed.
at 26°C	ventilation and emergency fans at medium speed.

**Accuracy** the switching repeatability is within  $\pm 0.3^{\circ}\text{C}$  of each setpoint on rising temperature.

**Hysteresis** The switching hysteresis on the rising or falling temperature of each stage is in the range 0.7 to 1°C.

**Maximum drift** Maximum of 0.3°C drift in switching temperature, over the temperature range of 17 to 27°C and 1.5°C drift over -15 to 55°C.

## ENVIRONMENT

**operating temperature** -15°C to +55°C.

**storage temperature** -30° to +85°C.

**relative humidity** 0 to 90%.

**IP rating** IP65

## MECHANICAL

**Connector 1** Litton CIR030-18-19P-F80-T12, 10-ways rear panel mounted connector with pin contacts.

The free-end of the connector being a socket type, CIR060F-18-19S-F80-T12 plug.

**Connector 2 (sensor)** Litton CIR030-16S-8S-F80-T12, 5-ways, rear panel mounted connector with socket contacts.

The free-end of the connector being a pin contact type, CIR06F-6S-8P-F80-T12 plug.

**Sensor probe** PRT100 to BS1904 class A

### Dimensions and fixing holes

refer to drawing number: PTS\SYS\LAYOUT

**Housing** material: sheet steel 16SWG.

finish: grey hammer powder coat.

### **13. Standards**

RSE/STD/031-PART 1: ISSUE B, GENERAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT

BRB/LU/RIA NO.13:1990, GENERAL SPECIFICATION FOR ELECTRONIC EQUIPMENT USED ON TRACTION AND ROLLING STOCK.

BRB/LU/RIA NO.12:1984, GENERAL SPECIFICATION FOR PROTECTION OF TRACTION AND ROLLING STOCK ELECTRONIC EQUIPMENT FROM TRANSIENT AND SURGES IN DC CONTROL SYSTEM.

BRB/LU/RIA NO.18:1990, GENERAL SPECIFICATION FOR INTERFERENCE TESTING FOR ELECTRONIC EQUIPMENT USED ON TRACTION AND ROLLING STOCK.

BRB/LU/RIA NO.20:1988, EQUIPMENT FOR VIBRATION AND SHOCK TESTING OF EQUIPMENT FOR RAILWAY VEHICLES.

### **14. Ordering information**

Ordering code: 83TS/PTS-SYS

You are welcome to order the unit by code or by description - 83/PTS-SYS; LUL, Piccadilly Line 83 Stock Refurbishment Heating, Ventilating, Air-conditioning and Fan Switching Multi-stage Thermostat System for Saloon.

### **15. Supplier information**

#### **Tactical Controls Limited**

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