OPERATION MANUAL

FAN LOGIC CONTROLLER
(DUAL SENSOR)

DESCRIPTION

The Temperature Monitored Dual-Sensor multi-fan Logic Controller is a compact and rugged instrument designed to monitor and control the temperature within the Outdoor Server Cabinets to ensure smooth and safe operations. Apart from offering intelligent power-saving, effective noise reduction and fan life-enhancing features, it is also an effective safety device that protects the expensive hardware and software in the rack from possible damage due to temperature over-shoots or power related failures and by monitoring essential parameters like Fan Rotor Block, Temperature overshoot, Smoke Detection and unauthorized Door access.

The Temperature Monitored Fan Controller provides a controlled switching which energizes the fans synchronously so as to regulate the temperature inside the panel within acceptable limits, while minimizing noise levels and maintaining a linear air pressure output.

The principle of operation is as follows: Two Temperature Sensors with cable extensions provide a continuous and accurate measurement of the temperature inside the panel and of the ambient air. These temperature signals are transmitted to a micro-controller based electronic control circuit which continuously compares the actual temperature with the preset temperatures for the Fan operations as per the logic algorithms for four-Fan and three-Fan operations are described in a later section. The FLC-R6 thus controls the speed of the Fans based on the differential temperature between the Rack and the ambient area and provides speed variation of the Fans to provide a controlled and linear CFM output of air from the Racks.

Further, the Controller continuously monitors the status of ancillary equipment within the Rack, such as the Smoke Detector and the Door Switch, and provides prescribed behavior of the Fans on receipt of signals from these equipment. The Fans thus operate at optimum duty cycles so as to provide effective power saving and avoiding needless high speed running of the fans, thus enhancing the life cycle of each Fan. Four Relays are provided on the Card for the various alarm conditions. All alarm conditions are indicated by red LEDs on the front panel. The FLC-R6 Card operates on 48 VDC. The Fan Control Card also provides an alternate display of External and Internal temperatures on LED seven segment displays, while also displaying the Alarm Relay status. A communication port is available on the front panel where data is continuously transmitted vide RS485 on Modbus RTU protocol.

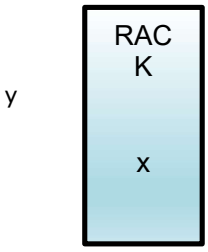
The Fan Logic Controller is, in effect, a linear Exhaust-Air Pressure Controller. Owing to the speed control of the Fans, the temperature is effectively controlled and maintained to the required limits in the Rack. This prevents any over-heating conditions inside the panel and provides optimum conditions for the smooth functioning of the expensive data and communication equipment. This operation ensures that the fans are not unnecessarily kept switched on even when the temperature is within acceptable limits. This greatly enhances the life of the fans and also reduces the load on the power supply or UPS system. Besides, it greatly reduces the droning hum of fans operating together by switching on only the required number of fans.

In conclusion, the Temperature Monitored Fan Controller provides effective control of the following vital parameters in Server Room or Outdoor conditions:

- Significant savings in high electricity (Power) costs.
- Extending the life of the Cooling fans by selective operation.
- Maintaining low noise levels.
- Accurate temperature control within the Outdoor Server Cabinet, thereby protecting expensive equipment.
- Reduction of load on UPS or Battery back-up.

LOGIC

The following is the logic for the fan speed monitoring and temperature control algorithm proposed for the Control Cards for 3 and 4 Fans:



x = Temperature inside Rack
y = Ambient temperature

$\triangle_t = (x - y)^{O}C$

- The Fan operational speed will be computed by the differential between the Internal and External temperatures.
- Two Temperature Sensors with extended cables are provided with the Fan Control Card to sense the inside and outside air temperatures x and y.
- Operating Temperature: 0 to 60 ^{O}C.

CONTROL CARD OPERATIONAL LOGIC (for both Three and Four fans)

- The primary objective is to reduce the high frequency whine emitted by the Fans during high speed operation and to optimize the speeds of the Fans so as to provide minimal usage of Fans during lower loads and optimal usage as internal and external temperatures oscillate during the day and night. Since the single-Sensor based algorithm can only provide speed control based on feedback of the internal temperature of the cabinet, it is recommended to create an algorithm based on the differential of the external and internal air temperatures by using a dual-sensor Card.

- By this logic, the Fans will not be energized in the condition when the load within the panel is nominal, or when the temperature within the cabinet is within acceptable limits, or even when the differential between the external and internal temperatures is minimal. The speeds will be optimized automatically based on the differential temperature (Delta $\triangle$t).

- A Base Temperature level of 27^{o}C can be set as the limit below which all Fans will be switched off. (Internal temp. limit is settable, below that set point all fans will be OFF)

- Above 27^{o}C, the Fans will rotate synchronously with optimized speeds in the various temperature bands over the given operational span.

- When the temperature within the Cabinet rises and $\triangle_t \geq 2.5^{o}$C, all the Fans will get energized and run synchronously at optimal speeds as per the table below.

- As temperature inside the Cabinet rises and the $\triangle_t$ increases, the speeds of all Fans will rise synchronously and steadily increase from 10% to a maximum of 85% as per table given below.

- The dual temperature feedback system will thus ensure that the Fans do not run merely based on internal or external temperatures but are optimized to run only at desired speeds to cool the system without loss of power, unnecessarily high noise levels, preventing dust chokes in the filters and enhancing fan life.

- As a Fan-Test feature, on pressing the middle key for five seconds, all Fans will turn on and will run for a period of 10 seconds at full 100% Duty Cycle.

RPM TO TEMPERATURE CONTROL ALGORITHM CHART (WITH DUAL SENSOR)

RPM to Temperature control algorithm with dual sensor				
Internal Temp. °C	**Delta □t (Outlet - Inlet)**	**Duty cycle (Rising)**	**Duty cycle (Falling)**	**dB reading**
<25			Off	
25	< 2.5	OFF	10.00%	
27.5 fan ON	> 2.5	10.00%	10.00%	
30 to 35	2.5	10.00%	20.00%	
	5.0	20.00%	40.00%	
	7.5	40.00%	60.00%	
	10	60.00%	70.00%	< 55 dB
	> 10	70.00%	80.00%	
35 to 40	< 2.5	20.00%	30.00%	
	2.5	30.00%	40.00%	
	5.0	40.00%	50.00%	
	7.5	50.00%	60.00%	
	10	60.00%	80.00%	
	> 10	80.00%	80.00%	< 60 dB
40 to 45	< 2.5	30.00%	40.00%	
	2.5	40.00%	50.00%	
	5.0	50.00%	60.00%	
	7.5	60.00%	80.00%	
	10	80.00%	85.00%	
	> 10	85.00%	85.00%	
45 to 50	< 2.5	50.00%	70.00%	
	2.5	70.00%	80.00%	
	5.0	80.00%	85.00%	< 65 dB
	7.5	85.00%	85.00%	
	10	85.00%	85.00%	
	> 10	85.00%	85.00%	

- If the $\triangle_t$ remains below 2.5°C, then the Fans will remain Off irrespective of the temperature within the Cabinet or the ambient temperature.
- Similarly, as the $\triangle_t$ drops, the speed of the Fans will reduce proportionately and will come to a complete stop when the $\triangle_t$ drops below 2.5°C, or the internal temperature drops below 25°C.
- The Card will provide a numeric seven-segment red LED Digital display to indicate the internal and external temperatures and other set-up parameters at any time.
- Also, the card will provide a data communication port to transmit data of all relevant operational status and fault information parameters such as fans, temperature, and other cabinet accessories being monitored by the card to a remote DCS system on RS485 on Modbus RTU protocol.

With the above logic and dual sensor operation, we can achieve the following advantages:-

1. The Fans will be operated only when the temperature differential is higher than a preset level and cooling is required. The Fans will stay switched off when the temperature differential is low.

2. The Fans will run only at the optimized speed for cooling the cabinet and will slow down the speed as temperature differential drops. The Fans will stop when the temperature differential is within set limits or when a pre-specified minimum internal temperature is reached.

3. If load temperature increases, the Fans will operate at higher speed, thereby bringing the cabinet temperature to within normal limits in the shortest possible time.

4. This will optimize Fan usage, thereby eliminating needless operation and enhancing the life of the Fans. It will also reduce the operational noise to a minimum. The life of the Fans will thus be significantly increased. Also, frequent cleaning of the filters will not be required because of dust chokes.

5. The Card can also provide LED indications for Fan Failure (Blocked Rotor) alarms, Temperature High Alarm/ Temperature Sensor Open Alarm, Door-Open Alarm and Smoke Detector Alarm.

6. An optional two-digit digital display visible from the front panel will be provided to indicate the internal temperature, external temperature with LED indication and set-value temperature for Fan initialization. A local push button will allow the operator to easily select the parameter that needs to be set.

7. An RS-485 communication port on Modbus RTU protocol will be provided for required communication to a PLC or DCS system to monitor and log the temperature and Fan data. This feature will be very useful in case of alarms related to Smoke Detector, Door opening, Temperature sensor faults and Fan failure in the cabinet. This will also enable the operator to take alternative and remedial action from remote locations.

RS-485 (ON MODBUS RTU PROTOCOL) REGISTER MAP

USER SETTINGS

KEY PRESSED	INITIAL DISPLAY	ALTERNATING DISPLAY	FUNCTION
(POWER ON)	35	-	Temperature value of Internal Temp. Sensor (With LED Indication)
-	25	-	Temperature value of External Temp. Sensor (With LED Indication)
PROG **P**	St	25	Initialization Set-point for Fans (Internal Temperature). It can be set from 25 to 55 by using Increment and Decrement keys. e.g If set as 25, then no fan will run below 25°C.
PROG **P**	Id	01	This is the Slave ID for RS-485 Communication
PROG **P**	35	-	Temperature value of Internal Temp. Sensor (With LED Indication)
	25	-	Temperature value of External Temp. Sensor (With LED Indication)

RS-485 Register Map:

Setting	
Baud Rate	9600
Parity	None
Data Bits	8
Stop Bit	1

Modbus Register No.	Applicable Modbus Function	Description	Values
40001	03,06	oF-1	Not Applicable to user
40002	03,06	oF-2	
40003	03,06	Set limit for Internal Temp.	25 to 55 Deg. C
40004	03	Relay Status	0 Bit : 1-Relay ON, 0-Relay OFF (Smoke Relay) 1 Bit : 1-Relay ON, 0-Relay OFF (Door Open Relay) 2 Bit : 1-Relay ON, 0-Relay OFF (Rotor Block Relay) 3 Bit : 1-Relay ON, 0-Relay OFF (HRT/Sensor Open Relay)
40005	03	Process Value of Internal Temp.	0 to 99 Deg. C
40006	03	Process Value of External Temp.	0 to 99 Deg. C
40007	03	Sensor Open Indication	0 Bit : 1-Internal Sensor Open, 0-Internal Sensor OK 1 Bit : 1-External Sensor Open, 0-External Sensor OK
40008	03	PWM 1 Status	Duty Cycle of Fan 1
40009	03	PWM 2 Status	Duty Cycle of Fan 2
40010	03	PWM 3 Status	Duty Cycle of Fan 3
40011	03	PWM 4 Status	Duty Cycle of Fan 4

Note: 40011 Register is not applicable for 3 Fan.

TERMINAL DETAILS

TERMINAL BLOCK

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
C	NO	C	NO	NO	C	NC	NO	C	NC	NO	C	NC	NO	C	NC
				RELAY-1			RELAY-2			RELAY-3			RELAY-4		
	SMOKE SENSE		**DOOR SENSE**	Smoke Alarm			Door Alarm			Temp. Sens Alarm			Fan Rotor Alarm		

TERMINAL NO.	NOTATION	DESCRIPTION
1	+	Smoke Detector
2	X	No Connection
3	+	Door Switch
4	X	No Connection
5	NO	Smoke Alarm Relay (NO)
6	C	Smoke Alarm Relay (Comm)
7	NC	Smoke Alarm Relay (NC)
8	NO	Door Switch Alarm (NO)
9	C	Door Switch Alarm (Comm)
10	NC	Door Switch Alarm (NC)
11	NO	High Temp/ Sensor Open Alarm (NO)
12	C	High Temp/ Sensor Open Alarm (Comm)
13	NC	High Temp/ Sensor Open Alarm (NC)
14	NO	Blocked Rotor Alarm (NO)
15	C	Blocked Rotor Alarm (Comm)
16	NC	Blocked Rotor Alarm (NC)

TESTING PROCEDURE

The Temperature Sensor with long Cable is insulated with Black tape. This Cable is for External temperature sensing.

The Temperature Sensor with short Cable is insulated with Red tape. This Cable is for Internal temperature sensing.

The following checks need to be performed:-

1. Connect the Cables from all Fans to the Card.
2. Connect Power Supply of 48 VDC to the two green terminals on the side of the Card.
3. Insert the Temperature Sensors in the respective slots.
4. Switch on the instrument.
5. See the Internal and External temperatures displayed alternately at 4 second intervals with Green LEDs indicating the corresponding parameter.
6. As a Fan-Test feature, on pressing the middle key for five seconds, all Fans will turn on and will run for a period of 10 seconds at full 100% Duty Cycle.
7. Check for all Alarm conditions as below :-

ALARM CONDITIONS (common for 3 and 4 Fan Control Cards)

- **Smoke detector Alarm**
  For Smoke Detector Alarm, connect +48 VDC to terminal #1
  Absence of 48 VDC indicates No-Smoke condition.
  Presence of 48 VDC indicates Smoke Alarm condition and will give Relay Alarm and all Fans will go off.
  If an alarm signal is received from the Smoke Detector, all Fans will be turned OFF; and the corresponding Alarm Relay (Relay-1) will get energized and it's Red alarm LED will light up.

- **Door Open Alarm**
  For Door-Switch Alarm, connect +48 VDC to terminal # 3.
  Presence of 48 VDC indicates Door Closed condition.
  Absence of 48 VDC indicates Door Open condition, which will give Relay Alarm and all Fans will go Off.
  If this feature is not being used, Terminal #3 should be permanently connected to +48 VDC.

  If an alarm signal is received from the Door Switch, all Fans will be turned OFF; and the corresponding Alarm Relay (Relay-2) will get energized and it's Red alarm LED will light up.

- **Temperature Sensor Open / High Temp. Alarm**
  If the Internal Temperature sensor will open or if the internal temperature crosses 59 deg C, then all Fans will rotate at 100% speed; and the corresponding Alarm Relay (Relay-3) will get energized and it's red alarm LED will light up.

  If the External Temperature sensor will open then all Fans will be OFF; and the corresponding Alarm Relay (Relay-3) will get energized and it's red alarm LED will light up.

  If both sensors will open then all Fans will rotate at 100% speed; and the corresponding Alarm Relay (Relay-3) will get energized and it's red alarm LED will light up.

  Above 59°C all fans will run at 100% speed and the corresponding Alarm Relay (Relay-3) will get energized and it's Red alarm LED will light up.

- **Fan Rotor Block**
  If any of the Fans gets faulty or some obstruction blocks the smooth rotation of any Fan, the balance Fans will rotate as per normal temperature cycle; and the corresponding Alarm Relay (Relay-4) will get energized and it's red alarm LED will light up.

8. Check RS485 communication for all required parameters. The Register Map for RS485 communication is given in Page 5.