

# Auto-tune PID Temperature Controller



## FEATURES

- Easy-to-use
  - Fuzzy modified PID heat & cool control
  - Fast A-D sampling rate (5 times/s)
  - Universal input (PT100, thermocouple) with high accuracy 18-bit A-D
  - Analog output (linear current or voltage) uses high accuracy 15-bit D-A
  - RS-485 RS-232 interface
  - Programming port provided on board
  - Support manual control & auto-tune function
  - Wide variety of alarm mode selection
  - Lockout protection control
  - Bumpless transfer during failure mode
  - Soft-start ramp and dwell timer
  - Bright display stabilized with digital filter
  - Front panel sealed to NEMA 4X & IP65
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- UL/CSA/CE approval
  - High performance with low cost





## Overview

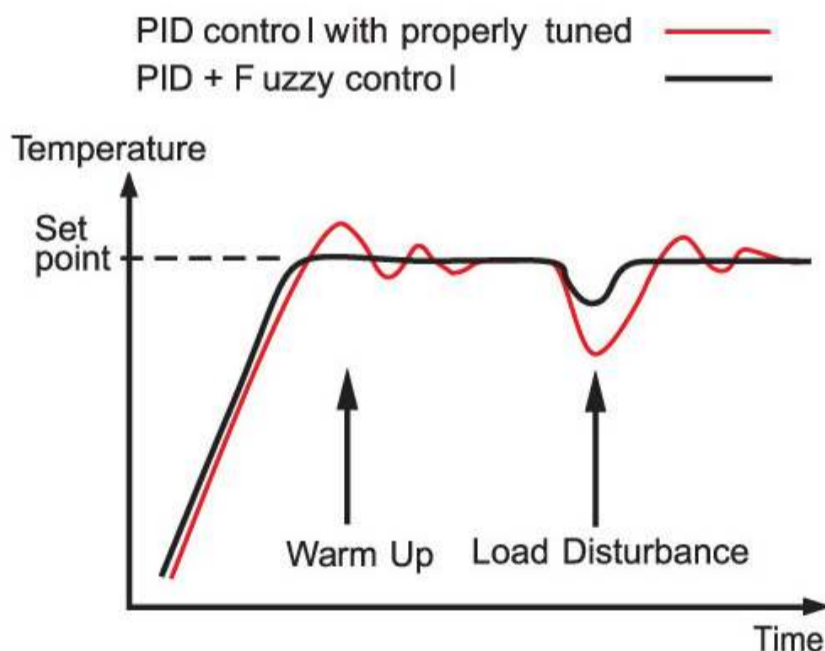
The Fuzzy Logic plus PID microprocessor-based controller series, incorporate a bright, easy to read 4-digit LED display, indicating process value or set point value. The Fuzzy Logic technology enables a process to reach a predetermined set point in the shortest time, with the minimum of overshoot during power-up or external load disturbance.

F32 is a 1/32 DIN size panel mount controller. F48 is a 1/16 DIN size panel mount controller. These units are powered by 11-26 or 90-250 VDC/VAC supply, incorporating a 2 amp. control relay output as standard. The second output can be used as cooling control, an alarm or dwell timer. Both outputs can select triac, 5V logic output, linear current or linear voltage to drive external device. There are six types of alarm plus a dwell timer can be configured for the second output. The units are fully programmable for PT100 and thermocouple types J, K, T, E, B, R, S, N, L with no need to modify the unit. The input signal is digitized by using a 18-bit A to D converter. Its fast sampling rate allows the unit to control fast processes.

Digital communications RS-485 or RS-232 ( for F 32 ) are available as an additional option. These options allow the units to be integrated with supervisory control system and software.

A programmable port is available for automatic configuration, calibration and testing without the need to access the keys on front panel.

By using proprietary Fuzzy modified PID technology, the control loop will minimize the overshoot and undershoot in a shortest time. The following diagram is a comparison of results with and without Fuzzy technology.



### High Accuracy

The series are manufactured with custom designed ASIC (Application Specific Integrated Circuit ) technology which contains a 18-bit A to D converter for high resolution measurement ( true 0.1°F resolution for thermocouple and PT100 ) and a 15-bit D to A converter for linear current or voltage control output. The ASIC technology provides improved operating performance, low cost, enhanced reliability and higher density.

### Fast Sampling Rate

The sampling rate of the input A to D converter reaches 5 times/second. The fast sampling rate allows this series to control fast processes.

### Fuzzy Control

The function of Fuzzy control is to adjust PID parameters from time to time in order to make manipulation output value more flexible and adaptive to various processes. The results is to enable a process to reach a predetermined set point in the shortest time, with the minimum of overshoot and undershoot during power-up or external load disturbance.

### Digital Communication

The units are equipped with RS-485 or RS-232 interface card to provide digital communication. By using the twisted pair wires there are at most 247 units can be connected together via RS-485 interface to a host computer.

### Programming Port

A programming port is used to connect the unit to a pc for quick configuration, also can be connected to an ATE system for automatic testing & calibration.

### Auto-tune

The auto-tune function allows the user to simplify initial setup for a new system. A clever algorithm is provided to obtain an optimal set of control parameters for the process, and it can be applied either as the process is warming up ( cold start ) or as the process has been in steady state ( warm start ).

### Lockout Protection

According to actual security requirement, one of four lockout levels can be selected to prevent the unit from being changed abnormally.

### Bumpless Transfer

Bumpless transfer allows the controller to continue to control by using its previous value as the sensor breaks. Hence, the process can be well controlled temporarily as if the sensor is normal.

### Soft-start Ramp

The ramping function is performed during power up as well as any time the set point is changed. It can be ramping up or ramping down. The process value will reach the set point with a predetermined constant rate.

### Digital Filter

A first order low pass filter with a programmable time constant is used to improve the stability of process value. This is particularly useful in certain application where the process value is too unstable to be read.

## Specifications

### Power

90-250 VAC, 47-63 Hz, 10VA, 5W maximum  
11-26 VAC / VDC, 10VA, 5W maximum

### Signal Input

**Resolution** : 18 bits

**Sampling Rate** : 5 times / second

**Maximum Rating** : -2 VDC minimum, 12 VDC maximum  
( 1 minute for mA input )

**Temperature Effect** :  $\pm 1.5 \mu\text{V}/^\circ\text{C}$  for all inputs except  
mA input  
 $\pm 3.0 \mu\text{V}/^\circ\text{C}$  for mA input

#### Sensor Lead Resistance Effect :

T/C:  $0.2 \mu\text{V}/\text{ohm}$

3-wire RTD:  $2.6^\circ\text{C}/\text{ohm}$  of resistance difference of two leads

2-wire RTD:  $2.6^\circ\text{C}/\text{ohm}$  of resistance sum of two leads

**Burn-out Current** : 200nA

**Common Mode Rejection Ratio ( CMRR )** : 120dB

**Normal Mode Rejection Ratio ( NMRR )** : 55dB

#### Sensor Break Detection :

Sensor open for TC, RTD and mV inputs,

Sensor short for RTD input,

below 1 mA for 4-20 mA input,

below 0.25V for 1 - 5 V input,

unavailable for other inputs.

#### Sensor Break Responding Time :

Within 4 seconds for TC, RTD and mV inputs,

0.1 second for 4-20 mA and 1 - 5 V inputs.

### Characteristics

Type	Range	Accuracy @25°C	Input Impedance
J	-120°C-1000°C (-184°F-1832°F)	$\pm 2^\circ\text{C}$	2.2M $\Omega$
K	-200°C-1370°C (-328°F-2498°F)	$\pm 2^\circ\text{C}$	2.2M $\Omega$
T	-250°C-400°C (-418°F-752°F)	$\pm 2^\circ\text{C}$	2.2M $\Omega$
E	-100°C-900°C (-148°F-1652°F)	$\pm 2^\circ\text{C}$	2.2M $\Omega$
B	0°C-1800°C (32°F-3272°F)	$\pm 2^\circ\text{C}$ (200°C-1800°C)	2.2M $\Omega$
R	0°C-1767.8°C (32°F-3214°F)	$\pm 2^\circ\text{C}$	2.2M $\Omega$
S	0°C-1767.8°C (32°F-3214°F)	$\pm 2^\circ\text{C}$	2.2M $\Omega$
N	-250°C-1300°C (-418°F-2372°F)	$\pm 2^\circ\text{C}$	2.2M $\Omega$
L	-200°C-900°C (-328°F-1652°F)	$\pm 2^\circ\text{C}$	2.2M $\Omega$
PT100 (DIN)	-210°C-700°C (-346°F-1292°F)	$\pm 0.4^\circ\text{C}$	1.3K $\Omega$
PT100 (JIS)	-200°C-600°C (-328°F-1112°F)	$\pm 0.4^\circ\text{C}$	1.3K $\Omega$
mV	-8mV - 70mV	$\pm 0.05\%$	2.2M $\Omega$
mA	-3mA - 27mA	$\pm 0.05\%$	70.5 $\Omega$
V	-1.3V - 11.5V	$\pm 0.05\%$	650K $\Omega$

### Output 1 / Output 2

**Relay Rating** : 2A/240 VAC, life cycles 200,000 for  
resistive load

**Pulsed Voltage** : Source Voltage 5V,  
current limiting resistance 66 $\Omega$ .

#### Linear Output Characteristics

Type	Zero Tolerance	Span Tolerance	Load Capacity
4-20 mA	3.6-4 mA	20-21 mA	500 $\Omega$ max.
0-20 mA	0 mA	20-21 mA	500 $\Omega$ max.
0-5 V	0 V	5-5.25 V	10 K $\Omega$ min.
1-5 V	0.9-1 V	5-5.25 V	10 K $\Omega$ min.
0-10 V	0 V	10-10.5 V	10 K $\Omega$ min.

### Linear Output

**Resolution** : 15 bits

**Output Regulation** : 0.02 % for full load change

**Output Settling Time** : 0.1 sec. ( stable to 99.9 % )

**Isolation Breakdown Voltage** : 1000 VAC

**Temperature Effect** :  $\pm 0.01\%$  of SPAN /  $^\circ\text{C}$

### Triac ( SSR ) Output

**Rating** : 1A / 240 VAC

**Inrush Current** : 20A for 1 cycle

**Min. Load Current** : 50 mA rms

**Max. Off-state Leakage** : 3 mA rms

**Max. On-state Voltage** : 1.5 V rms

**Insulation Resistance** : 1000 Mohms min. at 500 VDC

**Dielectric Strength** : 2500 VAC for 1 minute

### Alarm ( Output 2 )

**Alarm Relay** : Form A, Max. rating 2A/240VAC,  
life cycles 200,000 for resistive load.

**Alarm Functions** : Dwell timer,  
Deviation High / Low Alarm,  
Deviation Band High / Low Alarm,  
Process High / Low Alarm,

**Alarm Mode** : Normal, Latching, Hold, Latching / Hold.

**Dwell Timer** : 0.1-4553.6 minutes

### Data Communication

**Interface** : RS-232 ( 1 unit ), RS-485 ( up to 247 units )

**Protocol** : Modbus Protocol RTU mode

**Address** : 1 - 247

**Baud Rate** : 2.4 ~ 38.4 Kbits/sec

**Data Bits** : 7 or 8 bits

**Parity Bit** : None, Even or Odd

**Stop Bit** : 1 or 2 bits

**Communication Buffer** : 160 bytes

### Analog Retransmission

**Output Signal** : 4-20mA, 0-20mA, 0-5V, 1-5V, 0-10V

**Resolution** : 15 bits

**Accuracy** :  $\pm 0.05\%$  of span  $\pm 0.0025\%/^\circ\text{C}$

**Load Resistance** : 0-500 ohm (for current output)

10K ohm minimum (for voltage output)

**Output Regulation** : 0.01% for full load change

### User Interface

**Single 4-digit LED Displays** : 10 mm

## Connection Diagrams

**Keypad :** 3 keys **F 32** , 4 keys **F 48**

**Programming Port :** For automatic setup, calibration and testing

**Communication Port :** Connection to PC for supervisory control

### Control Mode

**Output 1 :** Reverse ( heating ) or direct ( cooling ) action  
**Output 2 :** PID cooling control, cooling P band 50 ~ 300% of PB, dead band -36.0 ~ 36.0% of PB

**ON-OFF :** 0.1 - 90.0 ( °F ) hysteresis control ( P band = 0 )

**P or PD :** 0 - 100.0 % offset adjustment

**PID :** Fuzzy logic modified  
 Proportional band 0.1 ~ 900.0°F.  
 Integral time 0 - 1000 seconds  
 Derivative time 0 - 360.0 seconds

**Cycle Time :** 0.1 - 90.0 seconds

**Manual Control :** Heat (MV1) and Cool (MV2)

**Auto-tuning :** Cold start and warm start

**Failure Mode :** Auto-transfer to manual mode while sensor break or A-D converter damage

**Ramping Control :** 0 - 900.0°F/minute or 0 - 900.0°F/hour ramp rate

### Digital Filter

**Function :** First order

**Time Constant :** 0, 0.2, 0.5, 1, 2, 5, 10, 20, 30, 60 seconds programmable

### Environmental & Physical

**Operating Temperature :** -10°C to 50°C

**Storage Temperature :** -40°C to 60°C

**Humidity :** 0 to 90 % RH ( non-condensing )

**Altitude :** 2000m maximum

**Pollution :** Degree 2

**Insulation Resistance :** 20 Mohms min. ( at 500 VDC )

**Dielectric Strength :** 2000 VAC, 50/60 Hz for 1 minute

**Vibration Resistance :** 10 - 55 Hz, 10 m/s<sup>2</sup> for 2 hours

**Shock Resistance :** 200 m/s<sup>2</sup> ( 20 g )

**Moldings :** Flame retardant polycarbonate

**Dimensions :**

F 32 --- 50mm(W) X 26.5mm(H) X 110.5mm(D),  
 98.0 mm depth behind panel

F 48 --- 48mm(W) X 48mm(H) X 94mm(D),  
 86 mm depth behind panel

**Mounting:** F 32--- panel mount, cutout 22 X 45 ( mm )  
 F 48 --- panel mount, cutout 45 X 45 ( mm )

**Weight :** F 32--- 120 grams  
 F 48--- 140 grams

### Approval Standards

**Safety :** UL61010C-1

CSA C22.2 No. 24-93

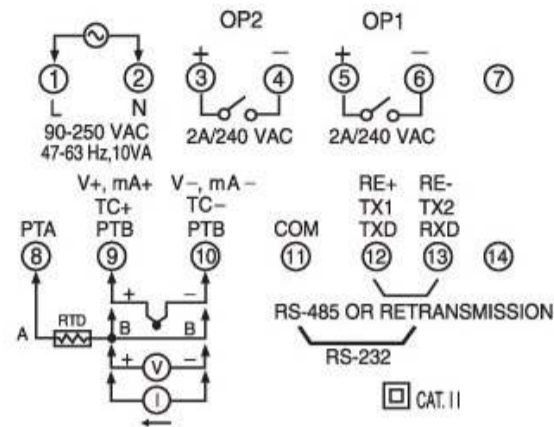
EN61010-1 ( IEC1010-1 )

**Protective Class :**

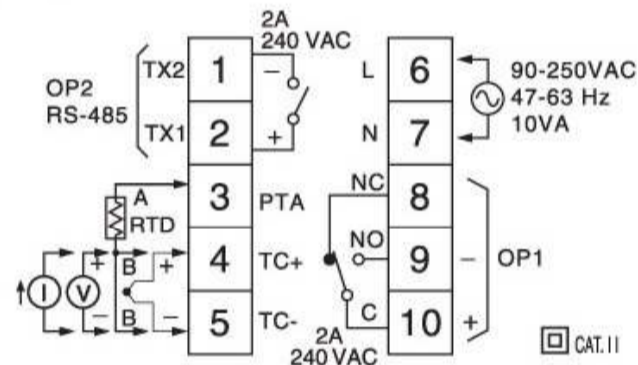
NEMA 4X ( IP65 ) front panel for C21,  
 IP30 front panel for C91, all indoor use,  
 IP 20 housing and terminals

**EMC:** EN61326

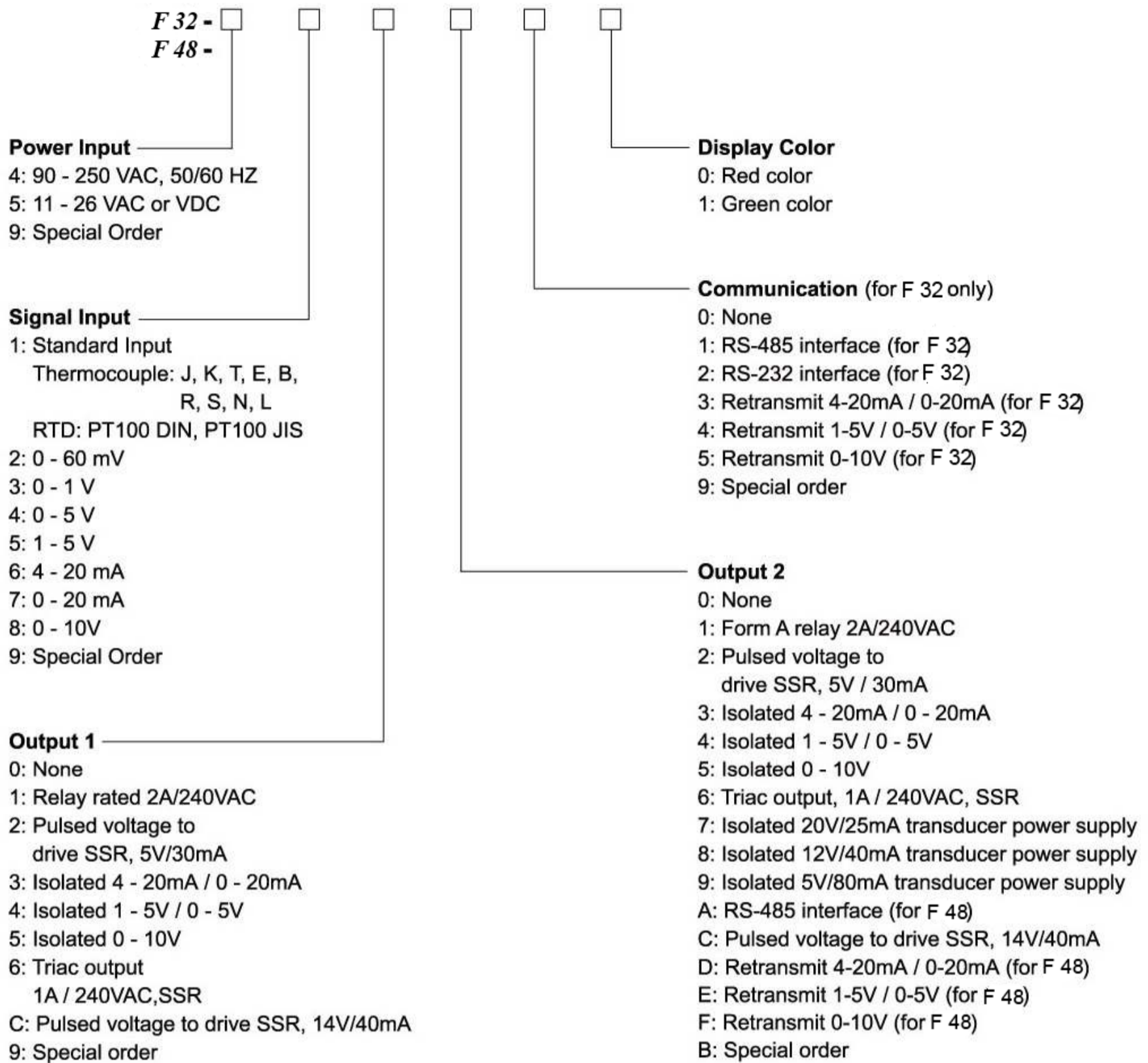
F 32



F 48



## Ordering Code



Standard model without option

Fx1 - 411000: power 90-250VAC, standard input thermocouple + PT100,  
output 1 - relay, output 2 - none, communication - none, red display