I/A Series® 716C 1/16 DIN Temperature Controller

The Foxboro 716C is a powerful compact, 1/16 DIN, microprocessor-based temperature controller that offers a variety of standard features commonly found only as options with other models.

The 716C offers advanced features, such as Modbus serial communication where data collection capabilities and remote operation are needed. Adaptive Auto-Tune keeps your temperature control process under control. The NEMA 4X faceplates allow these units to be used in applications where washdowns and dust conditions exist.

Designed specifically for manufacturers who need communications to data acquisition equipment, this light and very compact (1/16 DIN size) instrument can perform the most demanding applications with easy configuration and reliable control.

The 716C start-up is as simple as:

- wiring the instrument
- configuring set points and alarm thresholds
- initiating the autotune function

Engineers, technicians, and operators, with or without skills in temperature process or knowledge of PID control parameters, can obtain perfect process control.

FEATURES

- Dual 4-digit LED display
- Universal input (T/C, RTD, mV, V, mA)
- Adaptive Auto-Tune
- NEMA 4X
- UL, CSA rating
- PID control with 0 to 20 mA or 4 to 20 mA control signal
- Time proportional control
- Safety lock-out function prevents unauthorized configuration
- Two independent set points selectable from external input contact
- Up to two independent alarms configurable with automatic or manual reset
- Instrument configurable by keyboard or through serial link

- Output "Turn Off" function, turns off the output and allows the controller to operate as an indicator
- Opto-isolated RS-485 serial communication interface with Modbus (optional)
- 24 V ac/dc supply (optional)
- Conforms to the applicable European Union directives (symbolized by the "CE" Logo marking on the product)

The 716C offers advanced features, usually found in higher priced models, enabling quick start-ups, safe operation, and precise measurement readings.

Quick Start-Ups

The 716C is equipped with a proprietary self-tuning algorithm, SMART (see Figure 1). During start-up and control, the SMART algorithm continuously monitors the process variable and automatically adjusts the PID parameters according to the response of the process variable. The advantage of this continuous self-tuning algorithm is its ability to operate without injecting any artificial change into the system.
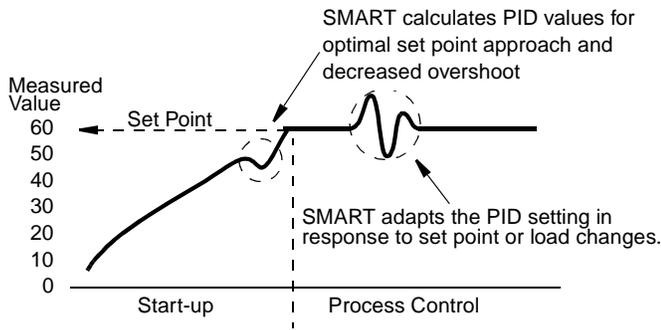
Figure 1. Quick Start-Ups with SMART
Adaptive Self-Tuning

During start-up, the SMART algorithm implements the self-tuning function, calculating the value of the PID parameters in order to optimize the set point approach and decrease overshoot.

During control, the SMART algorithm dynamically adapts the PID parameters for precise control when set point or load changes.

Safe Start-Up and Operation with Soft Start

Implementing Soft Start in heating and cooling control processes can avoid thermal shock and increase the heater life. The Soft Start function enables gradual preheating of the controlled process; simply program the output and time duration to be used during preheating phase. See Figure 2.

The Soft Start function can limit the rate of output change for infinite duration, ensuring that the process will always operate in safe conditions.
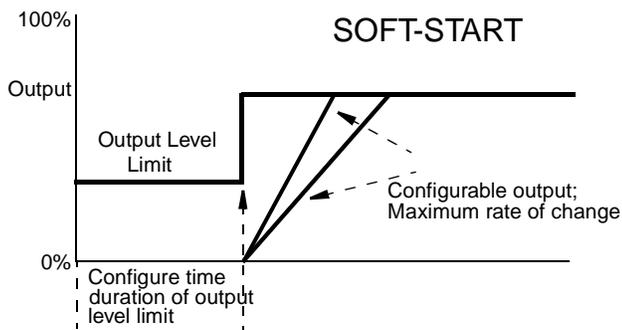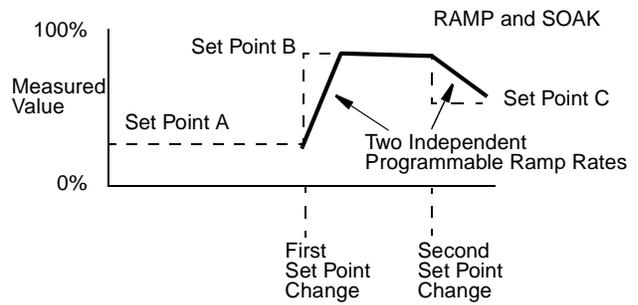

Figure 2. Assurance of Safe Start-Ups

Figure 3. Two Independent Ramp Functions
for Set Point Changes

Ramp Function

There are two independent ramps (ramp up and ramp down) for set point changes (see Figure 3). Some processes require a ramp to reach a new set point value. Often the temperature process may need a fast ramp rate for heating and a slow ramp rate for cooling. Independent ramps can be applied to both set points.

Precise Measurement Readings with Offset

In many applications offset is needed to adjust the measured variable for physical differences which affect the signal received by the controller. In some cases the sensor is not located in the ideal position, which may produce a measurement error. A constant offset can be configured to compensate for the error.

Configuration Tool

Configure the 716C with any personal computer running MS-DOS 5.0 or higher. The configuration tool easily organizes your applications, storing all configuration data for quick start-ups.

Computer Interface
- Provides two types of protocol, RS-485 with MODBUS or JBUS.
- Communicates to Small System using Foxboro I/A Series system for Windows NT
- Provides DDE Interface to Windows-based applications
- Provides an integration tool for applications running under Windows.
  DDE makes data available to your application. The data can then be processed for trending, SPC, data storage, or man/machine Interface. To order, see Model Code.
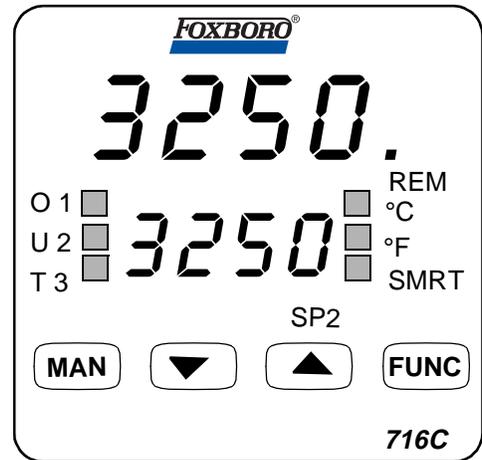
Operator Interface
UPPER DISPLAY
Shows the actual measured value or (during configuration) the value of the selected parameter.
LOWER DISPLAY
Shows the operating set point; the output level; the heater current (in Amperes); and the abbreviated name of the selected parameter. Descriptions of the displays are shown below.

Button	Description
▼	Decreases the selected parameter.
▲	Increases the slected parameter.
FUNC	Displays in sequence all parameters and saves the new settings or displays the output level and heater current.
MAN	Switches from auto to manual mode and vice versa.
▼ + ▲	Starts the default parameters loading procedure.
▼ + FUNC	Enables/disables the output power OFF function.

Indicator	Description
REM	Instrument is under control of the serial link.
SP2	Flashing at a slow rate when SP2 is used.
SMART	ON or flashing when Auto-tune is operating.
MAN	Instrument operating in manual mode.
°C/°F	When input sensor is a TC or RTD, shows the selected engineering units.
OUT1	Main output in ON.
OUT2	ON when: Output 2 is used as cooling output and is ON; or, Output 2 is configured as alarm and instrument detects an alarm or the alarm has not been reset.
Out3	Alarm 2 is in alarm state. Flashes at slow rate when heater current is lower than programmed threshold (HBD). Flashes at higher rate when HBD alarm and alarm 2 are both in alarm state.

STANDARD SPECIFICATIONS

Housing
ABS gray. Self-extinguishing degree V-O per UL-94.

Agency Certification
These controllers have been designed to meet the safety standards of UL, CSA, and CE. For detailed information, or status of testing laboratory approvals/certifications, contact Foxboro.

Environmental Protection
Designed and tested for IP65 and NEMA 4X for indoor locations (when panel gasket is installed)

Installation
Panel mounting by means of brackets

Rear Terminal Block
Up to 15 screw terminals with safety rear cover

Dimensions
See "Dimensions Nominal" section

Mass
250 g maximum (1 lb)

Power Supply (Switch Mode)
100 to 240 V (nominal value) or 24 V ac/V dc ($\pm$10% of the nominal value)

Power Consumption
10 VA

Insulation Resistance
>100 M Ω per IEC 348

Isolation Voltage
1500 Vrms per IEC 348

Sampling Time
For linear inputs - 250 ms
For TC or RTD inputs - 500 ms

D/A Conversion
Dual slope integration

Accuracy
$\pm$0.2% full scale value @ 25 °C and nominal power supply voltage

Noise Immunity
EMISSION
Generic emission standard EN 50081-2
Basic emission standard EN 55011

IMMUNITY
Generic immunity standard EN 50082-2:
a. Electrical discharge requirements:
Severity Level 3 (per IEC 801-2)
b. Electrical fast transient/burst requirements:
Severity Level 3 (per IEC 801-4)
c. Radiated electromagnetic field immunity between 27 MHz - 1000 MHz, 10 V/m (per IEC 801-3)

Common Mode Rejection
120 dB @ 50/60 Hz

Normal Mode Rejection
60 dB @ 50/60 Hz

Normal Operating Temperature Limits
0 and +50 °C (32 and 122 °F)

Storage Temperature Limits
-20 and +70 °C (-4 and +158 °F)

Relative Humidity Limits
20% and 85% RH, noncondensing

Protection
a. Watchdog for automatic reset
b. DIP Switches for configuration and calibration parameters

Universal Analog Input
ANALOG INPUT
All inputs are factory calibrated and selectable by front keyboard.
THERMOCOUPLES TYPE
J, K, L, R, S, T and N are keyboard configurable.
ENGINEERING UNITS
°C and °F keyboard configurable
CALIBRATION
Per IEC 584-1
SENSOR BREAK
Downscale or upscale programmable. On RTD input, a special test is provided to signal over-range when input resistance is less than 15 Ω. (Short circuit sensor detection.)
INPUT IMPEDANCE
>1M Ω
REFERENCE JUNCTION
Automatic compensation for an ambient temperature between 0 and 50 °C

STANDARD SPECIFICATIONS (Continued)

Standard Ranges Table

TC Type	Range
L	0/400.0 °C
L	0/900 °C
J	0/400 °C
J	0/1000 °C
K	0/400 °C
K	0/1200 °C
N	0/1400 °C
R	0/1760 °C
S	0/1760 °C
T	0/4000 °C
L	0/1650 °F
J	0/1830 °F
K	0/2190 °F
N	0/2550 °F
R	0/3200 °F
S	0/3200 °F
T	0/750 °F

NOTE
For TC inputs, it is possible to set the minimum span to 300°C or 600°F. In this way, it is possible to increase the sensitivity of the control parameters.

RTD INPUT

Standard Ranges Table

°C	°F
-199.9/400	-199.9/750
-200/800	-330/1470

NOTE
For RTD inputs, it is possible to set the minimum span to 100 °C or 200 °F. In this way, it is possible to increase the sensitivity of the control parameters.

REFERENCE JUNCTION DRIFT
  0.1 °C/°C

mA dc AND V dc LINEAR INPUTS
  mA dc Input (Standard)
    0-20 mA dc and 4-20 mA dc, keyboard configurable

  Input Impedance
    <5 Ω

  V dc Input
    0-5 V dc and 1-5 V dc configurable;
    input impedance: > 200 k Ω

    0-10 V dc and 2-10 V dc configurable;
    input impedance: > 400 k Ω

    0-60 mV dc and 12-60 mV configurable;
    input impedance: > 1 M Ω

  Read-out
    Keyboard configurable from -1999 to 4000

  Decimal Point
    Configurable in any position

Logic Input
  The 716C is equipped with a logic contact input to be used to select between the main set point and the auxiliary set point (SP or SP2).

Set Points
  Two set points are available:
  - Main Set Point (SP)
  - Auxiliary Set Point (SP2)
  SET POINT TRANSFER
    Transfer from SP to SP2 and vice versa may be driven by logic input (contact closure).
NOTE
    The transfer may be done by a step transfer or by a ramp with two different configurable rates of rise (ramp up and ramp down).

  SET POINT LIMITERS
    Set Point low limit and set point high limit are configurable.

Control Action
  ALGORITHM
    PID + Smart AutoTune/Adaptive, and Time Proportional Control
  PROPORTIONAL BAND
    Configurable from 1.0% to 200.0% of the input span. Setting a PB equal to 0 sets the control action to On/Off.

STANDARD SPECIFICATIONS (Continued)

INTEGRAL TIME
Configurable from 1 second to 20 minutes (or off). Setting the PB equal to 0 changes the control action to ON/OFF.
HYSTERESIS (FOR ON/OFF CONTROL ACTION)
Configurable from 0.1% to 10.0% of the input span
DERIVATIVE TIME
Configurable from 1 second to 10 minutes, or excluded (off)
INTEGRAL PRELOAD
Configurable for 1 control output, from 0 to 100% of the output range
AUTO/MANUAL MODE
Selectable by front pushbutton or logic input
AUTO/MANUAL TRANSFER
Bumpless
OVERLAP/DEADBAND
Keyboard configurable from -20% (deadband) to +50% (overlap) of the proportional band
DIRECT/REVERSE ACTION
Keyboard configurable

Outputs
Three output types provide one analog signal and two relay outputs.
OUTPUT 1 TYPE
Opto-isolated 0-20 mA or 4-20 mA configurable
Function
Programmable as:
-control output (heating or cooling)
-retransmission of the measured value
-retransmission of the operating set point

Scaling
Configurable from -1999 to 9999

Maximum Load
500 Ω

Resolution
- 0.1% when used as control output
- 0.05% when used as analog retransmission

Digital Filter
A digital filter for the retransmission output is available (with the same time constant as the readout).

Output Level Indication (as control output only)
From 00.0 to 100.0%

Output Status Indication
The OUT 1 indicator flashes with a duty cycle proportional to the output level.

OUTPUT 2 TYPE
SPST relay contact (NO or NC selectable by jumper) with rated current 2 A at 250 V ac on resistive load
Function
Configurable as:
- Control output (heating or cooling)
- Alarm 1 output

OUTPUT 3 TYPE
Relay with SPST contact with rated current 2 A at 250 V ac on resistive load
Function
Configurable as:
- Control output (heating or cooling)
- Alarm 2 output
The two relays can be used together for heating and cooling.

Relative Cooling Gain
Keyboard programmable from .20 to 1.0

Cooling Cycle Time
From 1 second to 200 seconds

RELAY OUTPUTS
The relay outputs are protected with a varistor. The contact rating for the main output is 3 A/250 V ac on resistive load. The contact rating for OUT 2 and OUT 3 is 1 A/250 V ac on resistive load.
OUTPUT ACTION
Direct or reverse function configurable

Output "Turn Off" Function
This function disables the control output allowing the instrument to operate as an indicator. When control is resumed, "turn off" is disabled and the instrument will operate as follows:
• The integral component of the output signal will be set to zero;
• The soft start function will be enabled;
• The alarm masking function will be enabled.

Alarms
Two alarms for Activation of two relays
ALARM FUNCTIONS
Each alarm can be configured as process alarm, band alarm, or deviation alarm.
ALARM RESET
Automatic or manual reset programmable on each alarm
ALARM MASKING
Each alarm can be configured as masked alarm or standard alarm. Alarm masking allows suppression of alarm indicators at start-up and after a set point change.

STANDARD SPECIFICATIONS (Continued)

ALARM INDICATIONS
  Two indicators show when respective alarm is on.
ALARM OUTPUTS
  Two SPST relays; contact rated at 2 A
  250 V ac resistive load
PROCESS ALARM
  Operational Mode
    Configurable high or low

  Alarm Set Point
    Configurable in engineering units within the
    entire range

  Hysteresis
    Configurable from 0.1% to 10.0% of the input
    span

BAND ALARM
  Operating Mode
    Inside or outside band configurable

  Alarm Set Point
    Configurable from 0 to 500 units

  Hysteresis
    Configurable from 0.1% to 10.0% of the input
    span

DEVIATION ALARM
  Operating Mode
    High or low configurable

  Alarm Set Point
    Configurable from -500 to +500 units

  Hysteresis
    Configurable from 0.1% to 10.0% of the input
    span

Serial Interface (Optional)
  TYPE
    RS-485
  PROTOCOL TYPE
    Modbus, Jbus
  BAUD RATE
    Keyboard configurable from 600 to 19200 baud
  ADDRESS
    From 1 to 255

MODEL CODE

716C= Dual 4-Digit Display Temperature Controller

        <u>Control Action</u>
0 = PID or SMART Adaptive Control

        <u>Output Analog Type</u>
 7 = mA linear Control Output

        <u>Output Relay Type</u>
 1 = Two Relay Outputs

        <u>Alarms And Communication</u>
 1 = Alarm 2
 3 = Alarm 2 + Opto-isolated RS-485

        <u>Power Supply</u>
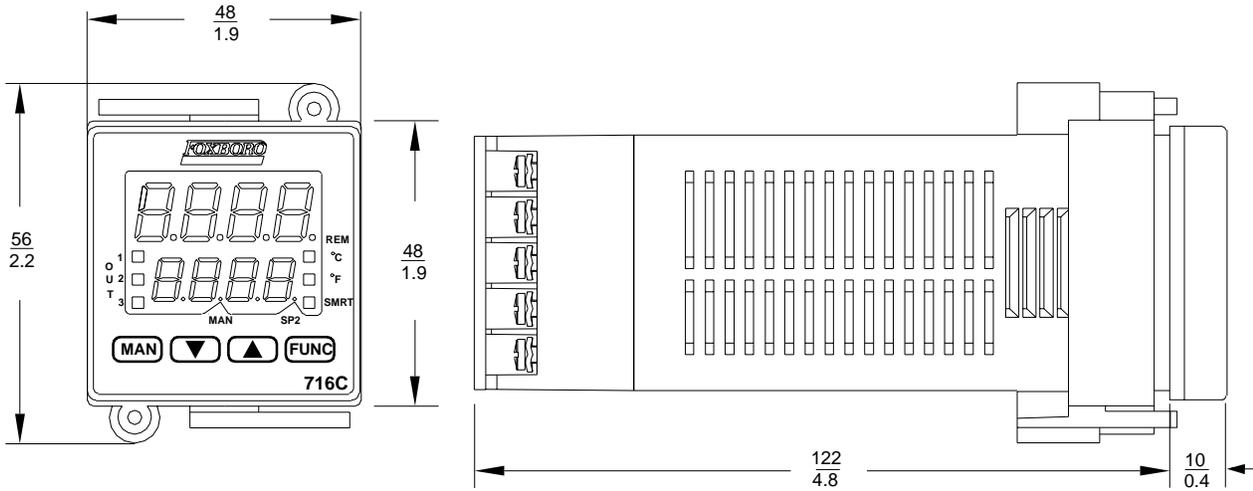 3 = 100 - 240 V ac
 5 = 24 V ac or dc

Example: 716C-07113

DDE Interface to Windows Applications: use with Windows 3.10 or higher.
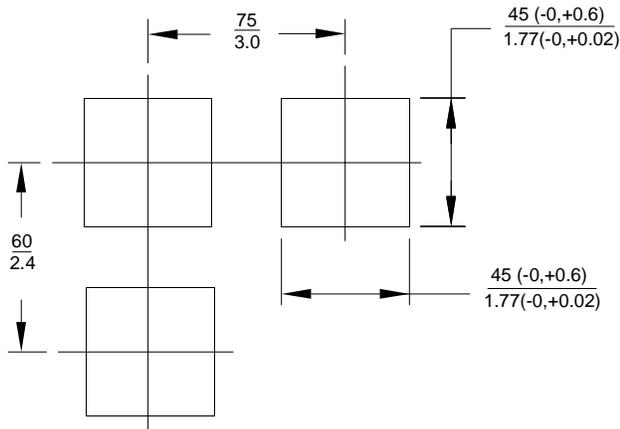Order Part No. 20AATZA.

Configuration Software: use with MS-DOS 5.0 or higher. Order Part No. 20AATZG.
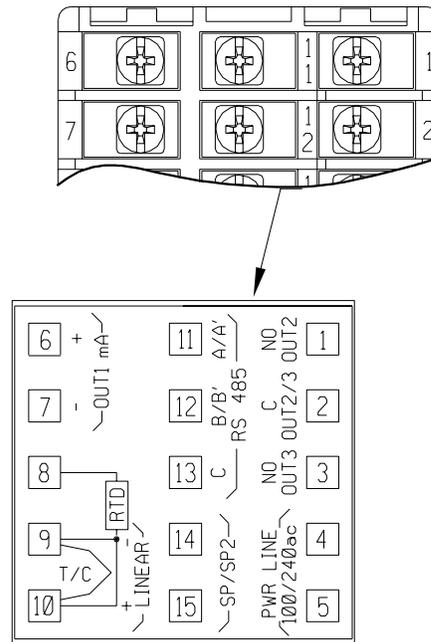
DIMENSIONS - NOMINAL

$\dfrac{mm}{in}$

48
1.9

56
2.2

716C

48
1.9

122
4.8

10
0.4

PANEL CUTOUT DIMENSIONS

75
3.0

60
2.4

45 (-0,+0.6)
1.77(-0,+0.02)

45 (-0,+0.6)
1.77(-0,+0.02)

TERMINAL CONNECTIONS

6 + OUT1 mA
7 -

8
9   RTD
10   T/C   LINEAR +

11 A/A'
12 B/B'   RS 485
13 C

14   SP/SP2
15

1 NO   OUT2
2 C   OUT2/3

3 NO   OUT3
4

5   PWR LINE
100/240ac