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 16-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
- SEL function allows to rearrange user menu
- UL/CSA/CE approval
- High performance with low cost

BrainChild

BTC-4100  BTC-7100  BTC-8100  BTC-9100
The Fuzzy Logic plus PID microprocessor-based controller series incorporate two bright, easy to read 4-digit LED displays, indicating process value and 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.

BTC-8100 is a 1/16 DIN size panel mount controller. BTC-7100 is a 1/8 DIN size panel mount controller and BTC-4100 is a 1/4 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, or an alarm. Both outputs can select triac, relay 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 third 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 BTC-9100, BTC-09100, BTC-4100) are available as an additional option. These options allow the units to be integrated with supervisory control system and software.

Programming 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 the 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 12-bit A to D converter for high resolution measurement (true 0.1°F resolution for thermocouples and PT100) and a 15-bit D to A converter for linear current or voltage control output. The ASIC technology provides improved operational performance, low cost, enhanced reliability and higher density.

**Overview**

**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 wire, the 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 anytime 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.

**SEL Function**
The units have the flexibility for user to select those parameters which are most significant to him and put these parameters in the front of display sequence. There are at most 8 parameters can be selected to allow the user to build his own display sequence.
Specifications

**Power**
- 90-250 VAC, 47-63 Hz, 12VA, 5W maximum
- 11-25 VDC / VAC, 12VA, 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: ±1.5 uV/°C for all inputs except mA input
- ±3.0 uV/°C for mA input

**Sensor Lead Resistance Effect**
- T/C: 0.2 uV/°C
- 3-wire RTD: 2.6°C/ohm of resistance difference of two leads
- 2-wire RTD: 2.6°C/ohm of resistance sum of two leads
- Burn-out Current: 200mA
- Common Mode Rejection Ratio (CMRR): 120dB
- Normal Mode Rejection Ratio (NMR): 55dB

**Sensor Break Detection**
- Sensor open for T/C, 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 T/C, RTD and mV inputs
- 0.1 second for 4-20 mA and 1-5 V inputs

**Characteristics**

<table>
<thead>
<tr>
<th>Type</th>
<th>Range</th>
<th>Accuracy @ 25°C</th>
<th>Input Impedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>-120°C-1000°C</td>
<td>±2°C</td>
<td>2.2MΩ</td>
</tr>
<tr>
<td></td>
<td>(-184°F-1832°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>-200°C-1370°C</td>
<td>±2°C</td>
<td>2.2MΩ</td>
</tr>
<tr>
<td></td>
<td>(-328°F-2498°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>-250°C-400°C</td>
<td>±2°C</td>
<td>2.2MΩ</td>
</tr>
<tr>
<td></td>
<td>(-418°F-752°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>-100°C-600°C</td>
<td>±2°C</td>
<td>2.2MΩ</td>
</tr>
<tr>
<td></td>
<td>(-148°F-1050°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0°C-1800°C</td>
<td>±2°C</td>
<td>2.2MΩ</td>
</tr>
<tr>
<td></td>
<td>(32°F-3272°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>0°C-1767°C</td>
<td>±2°C</td>
<td>2.2MΩ</td>
</tr>
<tr>
<td></td>
<td>(32°F-3214°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0°C-1767.8°C</td>
<td>±2°C</td>
<td>2.2MΩ</td>
</tr>
<tr>
<td></td>
<td>(32°F-3214°F)</td>
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<td></td>
</tr>
<tr>
<td>N</td>
<td>-250°C-1300°C</td>
<td>±2°C</td>
<td>2.2MΩ</td>
</tr>
<tr>
<td></td>
<td>(-418°F-2572°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>-200°C-800°C</td>
<td>±2°C</td>
<td>2.2MΩ</td>
</tr>
<tr>
<td></td>
<td>(-328°F-1562°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PT100</td>
<td>-210°C-700°C</td>
<td>±0.4°C</td>
<td>1.3kΩ</td>
</tr>
<tr>
<td></td>
<td>(-346°F-1292°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PT100</td>
<td>-200°C-600°C</td>
<td>±0.4°C</td>
<td>1.3kΩ</td>
</tr>
<tr>
<td></td>
<td>(-328°F-1112°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mV</td>
<td>-8mV-70mV</td>
<td>±0.05%</td>
<td>2.2MΩ</td>
</tr>
<tr>
<td>mA</td>
<td>-3mA-27mA</td>
<td>±0.05%</td>
<td>70Ω</td>
</tr>
<tr>
<td>V</td>
<td>-1.35-11.5V</td>
<td>±0.05%</td>
<td>650Ω</td>
</tr>
</tbody>
</table>

**Output 1 / Output 2**
- Relay Rating: 2A/240VAC, life cycles 200,000 for resistive load
- Pulsed Voltage: Source Voltage 5V
  (current limiting resistance 66Ω)

**Linear Output Characteristics**

<table>
<thead>
<tr>
<th>Type</th>
<th>Zero Tolerance</th>
<th>Span Tolerance</th>
<th>Load Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-20 mA</td>
<td>3.6-4 mA</td>
<td>20-21 mA</td>
<td>5000Ωmax.</td>
</tr>
<tr>
<td>0-20 mA</td>
<td>0 mA</td>
<td>20-21 mA</td>
<td>5000Ωmax.</td>
</tr>
<tr>
<td>0-5 V</td>
<td>0 V</td>
<td>5-5.25 V</td>
<td>10 kΩmin.</td>
</tr>
<tr>
<td>1-5 V</td>
<td>0.9-1.1 V</td>
<td>5-5.25 V</td>
<td>10 kΩmin.</td>
</tr>
<tr>
<td>0-10 V</td>
<td>0 V</td>
<td>10-10.5 V</td>
<td>10 kΩmin.</td>
</tr>
</tbody>
</table>

**Linear Output**
- Resolution: 15 bits
- Output Regulation: ±0.05% for full load change
- Output Setting Time: 0.1 sec. (stable to 0.99 %)
- Isolation Breakdown Voltage: 1000 VAC
- Temperature Effect: ±0.1% of SPAN / °C

**Triac (SSR) Output**
- Rating: 1A/240VAC
- Inrush Current: 20A for 1 cycle
- Min. Load Current: 60 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**
- Alarm Relay: Form C, 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: ±0.05% of span ±0.0025%/°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**
- Dual 4-digit LED Displays:
  - BTC-4100
  - Upper 0.65" (14mm)
  - Lower 0.4" (10 mm)
BTC-8100, BTC-7100, BTC-9100

Upper 0.4" (10 mm)
Lower 0.31" (8 mm)

Keypad: 4 keys
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-U 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/s² for 2 hours
Shock Resistance: 200 m/s² (20 g)
Moldings: Flame retardant polycarbonate
Dimensions:
BTC-4100: 96 mm(W) X 96 mm(H) X 85 mm(D), 65 mm depth behind panel
BTC-7100: 72 mm(W) X 72 mm(H) X 78.2 mm(D), 55 mm depth behind panel
BTC-8100: 48 mm(W) X 96 mm(H) X 80 mm(D), 55 mm depth behind panel
BTC-9100: 48 mm(W) X 48 mm(H) X 116 mm(D), 105 mm depth behind panel
Mounting:
BTC-4100: panel mount, cutout 92 X 92 (mm)
BTC-7100: panel mount, cutout 68 X 68 (mm)
BTC-8100: panel mount, cutout 45 X 92 (mm)
BTC-9100: panel mount, cutout 45 X 45 (mm)
Weight:
BTC-4100: 260 grams
BTC-7100: 200 grams
BTC-8100: 210 grams
BTC-9100: 150 grams

Approval Standards
Safety: UL61010-1
CSA C22.2 No. 24-93
EN61010-1 (IEC61010-1)
Protective Class:
IP65 front panel with additional option,
IP50 front panel without additional option,
all indoor use,
IP 20 housing and terminals with protective cover.
EMC:
EN61326

Connection Diagrams

BTC-9100

BTC-7100

BTC-8100, BTC-4100
Ordering Code

BTC-9100 - BTC-8100 - BTC-7100 - BTC-4100

Power Input
4: 90 - 250 VAC, 50/60 Hz
5: 11 - 26 VAC or VDC
9: Special Order

Signal Input
1: Standard Input
   Thermocouple: J, K, T, E, B, R, S, N, L
   RTD: PT100 DIN, PT100 JIS
2: 0 - 60 mV
3: 0 - 1 V
4: 0 - 5 V
5: 1 - 5 V
6: 4 - 20 mA
7: 0 - 20 mA
8: 0 - 10 V
9: Special Order

Options
0: Panel mount IP50 standard
1: Panel mount IP65 water resistant rubber installed
2: DIN Rail mount with IP50 (for BTC-9100 only)
3: DIN Rail mount with IP65 (for BTC-9100 only)

Communications
0: None
1: RS-485 interface
2: RS-232 interface (not available for BTC-7100)
3: Retransmit 4-20mA / 0-20mA
4: Retransmit 1-5V / 0-5V
5: Retransmit 0-10V
9: Special order

Alarm
0: None
1: Form C relay 2A/240VAC
9: Special order

Output 1
0: None
1: Relay rated 2A/240VAC
2: Pulsed voltage to drive SSR, 5V/30mA
3: Isolated 4 - 20mA / 0 - 20mA
4: Isolated 1 - 5V / 0 - 5V
5: Isolated 0 - 10V
6: Triac output, 1A / 240VAC, SSR
C: Pulsed voltage to drive SSR, 14V/40mA
9: Special order

Output 2
0: None
1: From A relay 2A/240VAC
2: Pulsed voltage to drive SSR, 5V/30mA
3: Isolated 4 - 20mA / 0 - 20mA
4: Isolated 1 - 5V / 0 - 5V
5: Isolated 0 - 10V
6: Triac output, 1A / 240VAC, SSR
7: Isolated 20V/25mA Transducer
   Power Supply
8: Isolated 12V/40mA Transducer
   Power Supply
9: Isolated 5V/80mA Transducer
   Power Supply
C: Pulsed voltage to drive SSR, 14V/40mA
A: Special order

Standard model without option
BTC-x100-4110000: power 90-250VAC, standard input thermocouple + PT100,
output 1 - relay, output 2 - none, alarm - none, communication - none, panel mount IP50 standard
**Accessories**

OM94-6 = Isolated 1A / 240VAC Triac Output Module (SSR)
OM94-7 = 14V / 40mA SSR Drive Module
OM96-3 = Isolated 4 - 20 mA / 0 - 20 mA Analog Output Module
OM96-4 = Isolated 1 - 5V / 0 - 5V Analog Output Module
OM96-5 = Isolated 0 - 10V Analog Output Module
CM94-1 = Isolated RS-485 Interface Module for BTC-7100 / 8100 / 4100
CM94-2 = Isolated RS-232 Interface Module for BTC-8100 / 4100
CM94-3 = Isolated 4-20mA / 0-20mA Retrans Module for BTC-8100 / 4100 / 7100
CM94-4 = Isolated 1-5V / 0-5V Retrans Module for BTC-8100 / 4100 / 7100
CM94-5 = Isolated 0-10V Retrans Module for BTC-8100 / 4100 / 7100
CM97-1 = Isolated RS-485 Interface Module for BTC-9100
CM97-2 = Isolated RS-232 Interface Module for BTC-9100
CM97-3 = Isolated 4-20mA / 0-20mA Retrans Module for BTC-9100
CM97-4 = Isolated 1-5V / 0-5V Retrans Module for BTC-9100
CM97-5 = Isolated 0-10V Retrans Module for BTC-9100
DC94-1 = Isolated 20V / 25mA DC Output Power Supply
DC94-2 = Isolated 12V / 40mA DC Output Power Supply
DC94-3 = Isolated 5V / 80mA DC Output Power Supply
CC94-1 = RS-232 Interface Cable (2M)
CC91-1 = Programming Port Cable
RK91-1 = Rail Mount kit for BTC-9100

**Related Products**

SNA10A = Smart Network Adaptor for third party software, which converts 255 channels of RS-485 or RS-422 to RS-232 Network.
SNA12A = Smart Network Adaptor for programming port to RS-232 interface.
BC-Set = Configuration Software

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