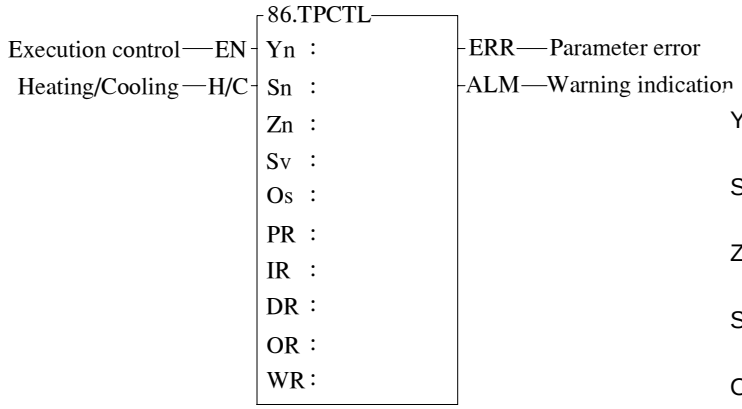
Temperature instruction proper to FB-4AJ(K)xx module

FUN 86 TPCTL	Convenient instruction of PID temperature control proper to FB-4AJ(K)xx module	FUN 86 TPCTL



Range / Ope-rand	Y	HR	ROR	DR	K
	Y0 | Y255	R0 | R3839	R5000 | R8071	D0 | D3071	
Yn	○				
Sn					0～23
Zn					1～24
Sv		○	○*	○	
Os		○	○*	○	
PR		○	○*	○	
IR		○	○*	○	
DR		○	○*	○	
OR		○	○*	○	
WR		○	○*	○	

Yn: Starting address of PID ON/OFF output; it takes Zn points.

Sn: Starting point of PID control of this instruction; Sn = 0～23.

Zn: Number of the PID control of this instruction; 1≤Zn≤24 and 1≤Sn+Zn≤24

Sv: Starting register of the setpoint; it takes Zn registers.

Os: Starting register of the in-zone offset; it takes Zn registers.

PR: Starting register of the gain (Kc); it takes Zn registers.

IR: Starting register of integral tuning constant (Ti);it takes Zn registers..

DR: Starting register of derivative tuning constant (Td); it takes Zn registers.

OR: Starting register of the PID analog output; it takes Zn registers.

WR: Starting of working register for this instruction. It takes 9 registers and can't be repeated in using.

Note: FUN86 must incorporate with FUN85 when using.

Function guide and notifications

- Fun85 instruction employs the multiplexing temperature module FB-4AJ(K)xx (where, xx may be 12,16,24) to get the current value of temperature and let it be as so called Process Variable (PV); after the calculation of software PID expression, it will respond the error with an output signal according to the setting of Set Point (SP),the error's integral and the rate of change of the process variable. Through the closed loop operation, the steady state of the process may be expected.
- Convert the output of PID calculation to be the time proportional on/off (PWM) output, and via transistor output to control the SSR for heating or cooling process; this is a good performance and very low cost solution.
- Through the analog output module (D/A module), the output of PID calculation may control the SCR or proportional valve to get more precise process control.
- Digitized PID expression is as follows:

$$Mn = [Kc \times En] + \sum_{0}^{n} [Kc \times Ti \times Ts \times En] - [Kc \times Td \times (PVn - PVn\text{-}1)/Ts]$$

Where,

Mn: Output at time "n".

Kc: Gain (Range: 1～999；Pb=100(%) / Kc)

Ti: Integral tuning constant (Range:0～999, equivalent to 0.00～9.99 Repeat/Minute)

Td: Derivative tuning constant (Range:0～999, equivalent to 0.00～9.99 Minute)

PVn: Process variable at time "n"

PV n–1: Process variable when loop was last sovled

En: Error at time "n" ; E= SP – PVn

Ts: Solution interval for PID calculation (Valid value are 10, 20, 40, 80 ;the unit is in 0.1Sec)

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Principle of PID parameter adjustment

- As the gain (Kc) adjustment getting larger, the larger the proportional contribution to the output. This can obtain a sensitive and rapid control reaction. However, when the gain is too large, it may cause oscillation. Do the best to adjust “Kc” larger (but not to the extent of making oscillation), which could increase the process reaction and reduce the steady state error.
- Integral item may be used to eliminate the steady state error. The larger the number (Ti, integral tuning constant), the larger the integral contribution to the output. When there is steady state error, adjust the “Ti” larger to decrease the error.
  When the “Ti” = 0, the integral item makes no contribution to the output.
  For exa. , if the reset time is 6 minutes, Ti=100/6=17；if the integral time is 5 minutes, Ti=100/5=20.
- Derivative item may be used to make the process smoother and not too over shoot. The larger the number (Td, derivative tuning constant), the larger the derivative contribution to the output. When there is too over shoot, adjust the “Td” larger to decrease the amount of over shoot.
  When the “Td” = 0, the derivative item makes no contribution to the output.
  For exa, if the rate time is 1 minute, then the Td = 100; if the differential time is 2 minute, then the Td = 200.
- Properly adjust the PID parameters can obtain an excellent result for temperature control.
- The default of gain value (Kc) is as follows:
  When the setting of span and polarity of the module is 0～10V, the default of gain (Kc) is 60.
  When the setting of span and polarity of the module is 0～5V, the default of gain (Kc) is 30.
  When the setting of span and polarity of the module is -10～10V, the default of gain (Kc) is 120.
  When the setting of span and polarity of the module is -5～5V, the default of gain (Kc) is 60.
- The default of integral tuning constant is 17, it means the reset time is 6 minutes (Ti=100/6=17).
- The default of derivative tuning constant is 100, it means the rate time is 1 minutes (Td=100).

Instruction guide

- FUN86 instruction must be incorporated with FUN85 ; the FUN85 instruction is for temperature measurement and it must be enabled, then, can the FUN86 start working.
- When execution control “EN” = 1, it depends on the input status of H/C for PID operation to make heating (H/C=1) or cooling (H/C=0) control. The current values of measured temperature are through the multiplexing temperature module FB-4AJ(K)xx to get ; the set points of desired temperature are stored in the registers starting from Sv. With the calculation of software PID expression, it will respond the error with an output signal according to the setting of set point, the error's integral and the rate of change of the process variable. Convert the output of PID calculation to be the time proportional on/off (PWM) output, and via transistor output to control the SSR for heating or cooling process; where there is a good performance and very low cost solution. It may also apply the output of PID calculation (stored in registers starting from OR), by way of D/A analog output module, to control SCR or proportional valve, so as to get more precise process control.
- When the setting of Sn, Zn ($0 \leqslant Sn \leqslant 23$ and $1 \leqslant Zn \leqslant 24$, as well as $1 \leqslant Sn + Zn \leqslant 24$) comes error, this instruction will not be executed and the instruction output “ERR” will be ON.
- This instruction compares the current value with the set point to check whether the current temperature falls within deviation range (stored in register starting from Os). If it falls in the deviation range, it will set the in-zone bit of that point to be ON; if not, clear the in-zone bit of that point to be OFF, and make instruction output “ALM” to be ON.

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- In the mean time, this instruction will also check whether highest temperature warning (the register for the set point of highest temperature warning is R4008). When successively scanning for ten times the current values of measured temperature are all higher than or equal to the highest warning set point, the warning bit will set to be ON and instruction output “ALM” will be on. This can avoid the safety problem aroused from temperature out of control, in case the SSR or heating circuit becomes short.
- This instruction can also detect the unable to heat problem resulting from the SSR or heating circuit runs open, or the obsolete heating band. When output of temperature control turns to be large power (set in R4006 register) successively in a certain time (set in R4007 register), and can not make current temperature fall in desired range, the warning bit will set to be ON and instruction output “ALM” will be ON.
- WR: Starting of working register for this instruction. It takes 9 registers and can’t be repeated in using.

  The content of the two registers WR+0 and WR+1 indicating that whether the current temperature falls within the deviation range (stored in registers starting from Os). If it falls in the deviation range,the in-zone bit of that point will be set ON; if not, the in-zone bit of that point will be cleared OFF.

  Bit definition of WR+0 explained as follows:
  Bit0=1, it represents that the temperature of the Sn+0 point is in-zone…
  Bit15=1, it represents that the temperature of the Sn+15 point is in-zone.

  Bit definition of WR+1 explained as follows:
  Bit0=1, it represents that the temperature of the Sn+16 point is in-zone…
  Bit7=1, it represents that the temperature of 24th point is in-zone.

  The content of the two registers WR+2 and WR+3 are the warning bit registers, they indiacte that whether there exists the highest temperature warning or heating circuit opened.

  Bit definition of WR+2 explained as follows:
  Bit0=1, it means that there exists the highest warning or heating circuit opened at the Sn+0 point...
  Bit15=1, it means that there exists the highest warning or heating circuit opened at the Sn+15 point.

  Bit definition of WR+11 explained as follows:

  Bit0=1, it means that there exists the highest warning or heating circuit opened at the Sn+16 point...
  Bit7=1 , it means that there exists the highest warning or heating circuit opened at the 24th point.
  Registers of WR+4 ～ WR+8 are used by this instruction.
- This instruction can only be used to perform heating or cooling control of positive temperature.
- Whether the FUN86 is placed in main or sub program and no matter the execution control “EN”=0 or 1, this instruction must be executed every scan.

Specific registers related to FUN86

- R4005 : The content of Low Byte to define the solution interval between PID calculation
  =0, perform the PID calculation evey 2 seconds (System default).
  =1, perform the PID calculation evey 4 seconds.
  =2, perform the PID calculation evey 8 seconds.
  ≥3, perform the PID calculation evey 1 second.（R4004 must be 166 to make sense）
  : The content of High Byte to define the cycle time of PID ON/OFF（PWM）output.
  =0，PWM cycle time is 2 seconds (system default)
  =1，PWM cycle time is 4 seconds.
  =2，PWM cycle time is 8 seconds.
  ≥3，PWM cycle time is 1 second.

Note 1: When changing the value of R4005, the execution control “EN” of FUN86 must be set at 0. The next time when execution control “EN” =1, it will base on the latest set point to perform the PID calculation.

Note 2: The smaller the cycle time of PWM, the more even can it perform the heating. However, the error caused by the PLC scan time will also become greater. For the best control, it can base on the scan time of PLC to adjust the solution interval of PID calculation and the PWM cycle time.

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- R4006: The setting point of large power output detection for SSR or heating circuit opened, or heating band obsolete. The unit is in % and the setting range falls in 80～100(%); system default is 90(%).
- R4007: The setting time to detect the continuing duration of large power output while SSR or heating circuit opened, or heating band obsolete. The unit is in second and the setting range falls in 300～65535 (seconds); system default is 600 (seconds).
- R4008: The setting point of highest temperature warning for SSR, or heating circuit short detection. The unit is in degree and the setting range falls in 50～65535; system default is 350 (degrees).
- R4012: Each bit of R4012 to tell the need of PID temperature control.
  Bit0=1 means that 1st point needs PID temperature control.
  Bit1=1 means that 2nd point needs PID temperature control.
  ・
  ・
  Bit15=1 means that 16th point needs PID temperature control.
  (The default of R4012 is FFFFH)
- R4013: Each bit of R4013 to tell the need of PID temperature control.
  Bit0=1 means that 17th point needs PID temperature control.
  Bit1=1 means that 18th point needs PID temperature control.
  ・
  ・
  Bit7=1 means that 24th point needs PID temperature control.
  (The default of R4013 is FFFFH)
- While execution control “EN”=1 and the corresponding bit of PID control of that point is ON (corresponding bit of R4012 or R4013 must be 1), the FUN73 instruction will perform the PID operation and respond to the calculation with the output signal.
- While execution control “EN”=1 and the corresponding bit of PID control of that point is OFF (corresponding bit of R4012 or R4013 must be 0), the FUN73 will not perform the PID operation and the output of that point will be OFF.
- The ladder program may control the corresponding bit of R4012 and R4013 to tell the FUN73 to perform or not to perform the PID control, and it needs only one FUN86 instruction.