UDC 3200 Application Note

Algorithm Set Up Group

Introduction

This data deals with various algorithms in the controller and Timer functions.

The Timer section allows you to configure a time-out period and to select the timer start by either the keyboard (**RUN/HOLD** key) or Alarm 2. An optional digital input can also be configured to the start the timer. The timer display is selectable as either "time remaining" *(see TI REM)* or "elapsed time" *(see E TIME).*

Alarm 1 is activated at the end of the time-out period. When the timer is enabled, it has exclusive control of the alarm 1 relay—any previous alarm 1 configuration is ignored. At time-out, the timer is ready to be activated again by whatever action has been configured.

Function Prompts

ALGORTHM Group Function Prompts

Function Prompt Lower Display	**Selections or Range of Setting** Upper Display	**Parameter Definition**
CONT ALG		The **CONTROL ALGORITHM** lets you select the type of control that is best for your process
	ON-OFF	**ON/OFF** is the simplest control type. The output can be either ON (100 %) or OFF (0 %). The Process Variable (PV) is compared with the setpoint (SP) to determine the sign of the error (ERROR = PV–SP). The ON/OFF algorithm operates on the sign of the error signal. In Direct Acting Control, when the error signal is positive, the output is 100 %; and when the error signal is negative, the output is 0 %. If the control action is reverse, the opposite is true. An adjustable overlap (Hysteresis Band) is provided between the on and off states. **ATTENTION** *Other prompts affected: OUT HYST* **DUPLEX ON/OFF** is an extension of this algorithm when the output is configured for a Duplex control algorithm. It allows the operation of a second ON/OFF output. There is a deadband between the operating ranges of the two inputs and an adjustable overlap (hysteresis) of the on and off states of each output. Both Deadband and Hysteresis are separately adjustable. With no relay action the controller will read 50 %. **ATTENTION** *Other prompts affected: OUT HYST and DEADBAND*

Function Prompt Lower Display	**Selections or Range of Setting** Upper Display	**Parameter Definition**
	PID A **ATTENTION** PID A should not be used for Proportional only action; i.e., no integral (reset) action. Instead, use PD+MR with rate set to 0.	**PID A** is normally used for three-mode control. This means that the output can be adjusted somewhere between 100 % and 0 %. It applies all three control actions—Proportional (P), Integral (I), and Derivative (D)—to the error signal. **Proportional (Gain)**—Regulates the controller's output in proportion to the error signal (the difference between Process Variable and Setpoint). **Integral (Reset)**—Regulates the controller's output to the size of the error and the time the error has existed. (The amount of corrective action depends on the value of proportional Gain.) **Derivative (Rate)**—Regulates the controller's output in proportion to the rate of change of the error. (The amount of corrective action depends on the value of proportional Gain.)
	PID B	**PID B** —Unlike the PID A equation, the controller gives only an integral response to a setpoint change, with no effect on the output due to the gain or rate action, and it gives full response to PV changes. Otherwise controller action is as described for the PID A equation. See note on PID A.
	PD+MR	**PD WITH MANUAL RESET** is used whenever integral action is not wanted for automatic control. The equation is computed with no integral contribution. The MANUAL RESET, which is operator adjustable, is then added to the present output to form the controller output. Switching between manual and automatic mode will be bumpless. If you select PD with Manual Reset you can also configure the following variations: • PD (Two Mode) control, • P (Single Mode) control. Set Rate (D) to 0. **ATTENTION** *Other prompts affected: MAN RSET in the Tuning Set Up group*

Function Prompt Lower Display	**Selections or Range of Setting** Upper Display	**Parameter Definition**
CONT ALG (continued)	3PSTEP	**THREE POSITION STEP** —The Three Position Step Control algorithm allows the control of a valve (or other actuator) with an electric motor driven by two controller relay outputs; one to move the motor upscale, the other downscale without a feedback slidewire linked to the motor shaft. The deadband is adjustable in the same manner as the duplex output algorithm. The Three Position Step Control algorithm provides an output display (OUT) which is an estimated motor position, since the motor is not using any slidewire feedback. Although this output indication is only an approximation, it is "corrected" each time the controller drives the motor to one of its stops (0 % or 100 %). It avoids all the control problems associated with the feedback slidewire (wear, dirt, noise). When operating in this algorithm, the estimated OUT display is shown to the nearest percent (i.e., no decimal). This selection forces the Output Algorithm selection to "POSITON". Refer to the *Operation* section for motor position displays. As a customer configurable option, when a second input board is installed, the motor slidewire can be connected to the controller. The actual slidewire position is then shown on the lower display as POS. **This value is used for display only. It is NOT used in the Three Position Step algorithm.** To configure this option, set Input 2 actuation to SLIDEW and then calibrate Input 2 **ATTENTION** *Other prompts affected: DEADBAND*
TIMER	DISABLE ENABLE	**TIMER** allows you to enable or disable the timer option. The timer option allows you to configure a timeout period and to select timer start by either the keyboard (RUN/HOLD key) or Alarm 2. A digital input can also be configured to start the timer. When the timer is enabled, it has exclusive control of the alarm 1 relay; any previous alarm configuration is ignored. At timeout, the timer is ready to be re-activated by whatever action has been configured. Alarm 1 is activated at the end of the timeout period.
PERIOD	0:00 to 99:59	**PERIOD** allows you to configure the length of timeout period (from 0 to 99 hours: 59 minutes).

Function Prompt Lower Display	**Selections or Range of Setting** Upper Display	**Parameter Definition**
START	KEY ALARM 2	**START** allows you to select whether the timer starts with the keyboard (Run/Hold key) or Alarm 2.
L DISP	TI REM E TIME	**L DISP** allows you to select whether time remaining (TI REM) or elapsed time (E TIME) is displayed for the timer option. The time is shown on the lower display in HH:MM format along with a rotating "clock" character. • If the "clock" rotation is *clockwise,* elapsed time is indicated. • If the "clock" rotation is *counterclockwise,* time remaining is indicated.
INPUT MATH ALGORITHMS—Controllers with two inputs are provided with one input algorithm. Unless otherwise noted, these selections are provided only as part of the Math Options package. Each algorithm can be configured to provide a derived (calculated) PV or a derived Remote Setpoint. Up to three inputs may be applied to the calculation. See Inputs A, B, and C for definitions per equation All algorithms operate in engineering units except Feedforward (F FWRD) which operates in percent of output units. **ATTENTION** When the Input C configuration is set to NONE, the value of Input C used in the functions is automatically set to 1.0, except for the Summer algorithm, where it is set to 0.0.		
INP ALG1	NONE	**INPUT ALGORITHM 1** has the following selections from which to choose: **NONE**—No algorithm configured
	W AVG (See Note 2) (Standard feature on controllers with two analog inputs)	**WEIGHTED AVERAGE**—When you configure for Weighted Average, the controller will compute a PV or SP for the control algorithm from the following equation:
	Alg1 = [(Input A x Ratio A + Bias A) + (K x Input B x Ratio B + Bias B)] / (1 + K)] + Alg1Bias	
	F FWRD (Standard feature on controllers with two analog inputs)	**FEEDFORWARD SUMMER**—Feedforward uses Input A, following a Ratio and Bias calculation as a value summed directly with the PID computed output value and sent, as an output value, to the final control element. This algorithm will only function in automatic mode and is not used for Three Position Step Control applications. The following formula applies:
	Controller Output = PID Output + (Input A x Ratio A + Bias A) x (100 / Input A Range)	

Function Prompt Lower Display	Selections or Range of Setting Upper Display	Parameter Definition
	FFWDMu (Standard feature on controllers with two analog inputs)	**FEEDFORWARD MULTIPLIER** —Feedforward uses Input A, following a Ratio and Bias calculation as a value multiplied directly with the PID computed output value and sent, as an output value, to the final control element. This algorithm will only function in automatic mode and cannot be used for Three Position Step Control applications. The following formula applies: Controller Output = PID Output x (Input A x Ratio A + Bias A) / Input A Range
	SUMMER (See Note 2)	**SUMMER WITH RATIO AND BIAS**—The following formula applies: Alg1 = (Input A x Ratio A + Bias A) + (Input B x Ratio B + Bias B) + (Input C x Ratio C + Bias C) + Alg1Bias
	HI SEL (See Note 2)	**INPUT HIGH SELECT WITH RATIO AND BIAS**—This selection specifies the PV or SP as the higher of Input 1 or Input 2. The following formula applies: Alg1 = higher of (Input A x Ratio A + Bias A) or (Input B x Ratio B + Bias B)
	LO SEL (See Note 2)	**INPUT LOW SELECT WITH RATIO AND BIAS—** This selection specifies the PV or SP as the lower of Input 1 or Input 2. The following formula applies: Alg1 = lower of (Input A x Ratio A + Bias A) or (Input B x Ratio B + Bias B)
	√MuDIV (See Note 1)	**MULTIPLIER DIVIDER WITH SQUARE ROOT** — The following formula applies: Alg1 = K * Sq.Rt. {(Input A x Ratio A + Bias A) x (Input C x Ratio C + Bias C) / (Input B * Ratio B + Bias B)} x (Calc Hi – Calc Lo) + Alg1Bias ***See** Error! Reference source not found. **at the end of this section for an example of Mass Flow Compensation using the Multiplier/Divider Algorithm.***
	√MULT (See Note 1)	**MULTIPLIER WITH SQUARE ROOT**The following formula applies: Alg1 =K x Sq.Rt.{(Input A x Ratio A + Bias A) x (Input B x Ratio B + Bias B) x (Input C x Ratio C + Bias C)} x (Calc Hi – Calc Lo) + Alg1Bias
	MuDIV (See Note 1)	**MULTIPLIER DIVIDER—**The following formula applies:

Function Prompt Lower Display	**Selections or Range of Setting** Upper Display	**Parameter Definition**
Alg1 = K x [{(Input A x Ratio A + Bias A) x (Input C x Ratio C + Bias C)} / (Input B x Ratio B + Bias B)] x (Calc Hi – Calc Lo) + Alg1Bias		
	MULT (See Note 1)	**MULTIPLIER** —The following formula applies:
Alg1 = K x [(Input A x Ratio A + Bias A) x (Input C x Ratio C + Bias C) x (Input B x Ratio B + Bias B)] x (Calc Hi – Calc Lo) + Alg1Bias		
	CARB A	**CARBON POTENTIAL A**—Make this selection if you have a Cambridge or Marathon monitor type Zirconium Oxide sensor. See Note 3
	CARB B	**CARBON POTENTIAL B**—Make this selection if you have a Corning type Zirconium Oxide sensor. This algorithm requires a temperature range within the region of 1380 to 2000°F. See Note 3.
	CARB C	**CARBON POTENTIAL C**—Make this selection if you have an A.A.C.C. type Zirconium Oxide sensor. This algorithm requires a temperature range within the region of 1380 °F to 2000 °F. See Note 3.
	CARB D	**CARBON POTENTIAL D**—Make this selection if you have a Barber Coleman, MacDhui, or Bricesco type Zirconium Oxide sensor. This algorithm requires a temperature range within the region of 1380 to 2000°F. See Note 3.
	FCC	**CARBON POTENTIAL FCC**—Make this selection if you have a Furnace Controls Corp Accucarb type Zirconium Oxide sensor. This algorithm requires a temperature range within the region of 1380 °F to 2000 °F. See Note 3.
	DEW PT	**DEWPOINT OF CARBONIZING ATMOSPHERE**—Use this selection if you are using any Zirconium Oxide Carbon Probe and you want to measure the atmosphere in terms of Dewpoint. The range is –50 °F to 100 °F or –48 °C to 38 °C. This algorithm requires a temperature range within the region of 1000 °F to 2200 °F and a minimum carbon probe value of 800 millivolts.
	OXYGEN	**PERCENT OXYGEN RANGE**—Make this selection if you are using a Zirconium Oxide Oxygen Probe to measure Percent of Oxygen in a range of 0 to 40 % O_2. This algorithm requires a temperature range within the region of 800 °F to 3000 °F.

Function Prompt Lower Display	**Selections or Range of Setting** Upper Display	**Parameter Definition**
ATTENTION The Carbon and Dewpoint selections will automatically set the first input actuation to Carbon. The Oxygen selection will automatically set the first input actuation to Oxygen. Input 2 can be any input actuation, but it is normally a type K, R or S thermocouple input, depending upon the probe type selected. All calculations are performed by the Controller with Percent Carbon shown as the PV display. The actual value of each analog input may be viewed on the lower display. For all Carbon Types, if the value of Percent Carbon falls below 0.1% - such as can happen when the Carbon Probe voltage output falls below 900 mVdc – then the Controller will continue to update the PV display, but the accuracy is unspecified. Likewise, if the measured temperature falls outside of the specified ranges as noted above for the Carbon, Oxygen and Dewpoint input types, then the Controller will continue to update the PV display, but the accuracy is unspecified. For the Dewpoint algorithm, if the Carbon Sensor voltage falls below 800 mVdc, then the Dew Point is calculated as if the sensor voltage was at 800 mVdc.		
MATH K	0.001 to 1000 floating	**WEIGHTED AVERAGE RATIO OR MASS FLOW ORIFICE CONSTANT (K) FOR MATH SELECTIONS**—Only applicable for algorithms W AVG or General Math selections √MuDIV, √MULT, MuDIV, or MULT.
CALC HI	–999. To 9999. Floating (in engineering units)	**CALCULATED VARIABLE HIGH SCALING FACTOR FOR INPUT ALGORITHM 1**—Used only when either Summer, Input Hi/Lo, or one of the General Math functions was selected as the Input Algorithm. See Note 2.
CALC LO	–999. To 9999. Floating (in engineering units)	**CALCULATED VARIABLE LOW SCALING FACTOR FOR INPUT ALGORITHM 1**—Used only when either Summer, Input Hi/Lo, or one of the General Math functions was selected as the Input Algorithm. See Note 2.
ALG1 INA	 INPUT 1 INPUT 2 OUTPUT	**ALGORITHM 1, INPUT A SELECTION** will represent one of the available selections. **Input 1** **Input 2** **Output** – Should not be used for Three Position Step Control applications)
ALG1 INB	 INPUT 1 INPUT 2 OUTPUT	**ALGORITHM 1, INPUT B SELECTION** will represent one of the available selections. **Input 1** **Input 2** **Output** – Should not be used for Three Position Step Control applications)

Function Prompt Lower Display	**Selections or Range of Setting** Upper Display	**Parameter Definition**
ALG1 INC	NONE INPUT 1 INPUT 2 OUTPUT	**ALGORITHM 1, INPUT C SELECTION** will represent one of the available selections. **None** **Input 1** **Input 2** **Output** – Should not be used for Three Position Step Control applications)
PCT CO	0.020 to 0.350 (fractional percent of CO)	**PERCENT CARBON** is only applicable when Carbon Potentialis selected. Enter the value in percent carbon monoxide that is applicable for the enriching gas used in fractional form. FOR EXAMPLE: Natural Gas = 20.0 % CO, then setting is 0.200 Propane Gas = 23.0 % CO, setting is 0.230
ALG1 BIAS	-999 to 9999 floating (in engineering units)	**INPUT ALGORITHM 1 BIAS—**Does not apply to selections: FFWRD, FFWDMU, HISEL or LOSEL.
PCT H2	1.0 to 99.0 (% H_2)	**HYDROGEN CONTENT FOR DEWPOINT** is only applicable when Dewpoint is selected. Enter a value for the percentage of Hydrogen content that is applicable.

Math Algorithm Notes:

1. Calculation ranges for the Math Algorithms are set via CALC HI and CALC LO parameters and are between –999. and 9999. The SP High and Low values (SP Range) are independent of these settings and can be any value between –999. and 9999.
2. The CALC HI and CALC LO values determine the range limits for the SP High and Low values for the Weighted Average, Summer, Hi Select and Low Select algorithms.
3. If the Ratio for Input 2 is set to 0.0, then a constant value may be used for the Input 2 value via the Input 2 Bias setting. For this configuration, the Input 2 low range and the Sooting diagnostic messages are disabled.