UDC 3300 APPLICATION NOTE

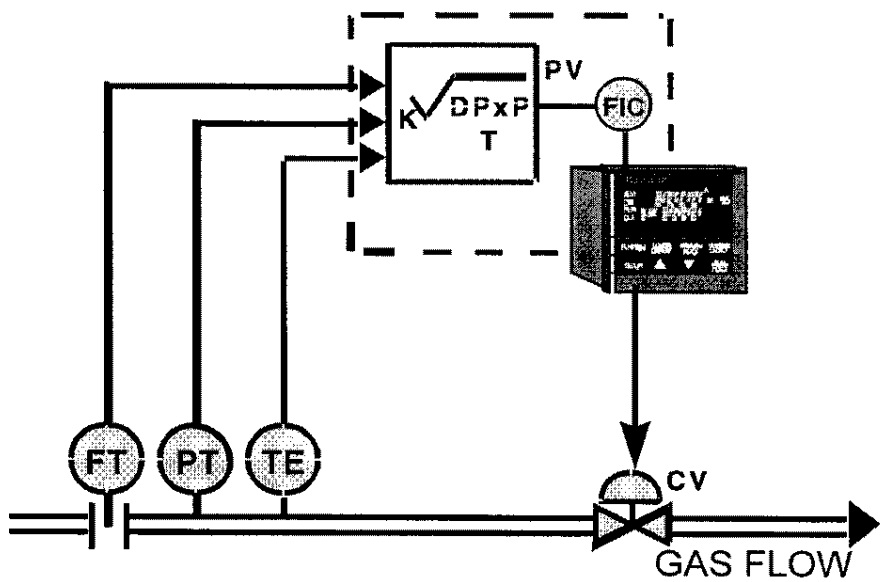
MASS FLOW COMPENSATION and CONTROL

PROBLEM

Provide a controller which continuously measures flow (DP), temperature, and pressure plus performs flow compensation of the process variable to minimize errors in measurement and control of the flowing medium.

SOLUTION

Specify a UDC 3300 with the optional math algorithm configured as multiplier/divider to automatically compensate the measured flow signal for variations in flowing temperature and/or pressure. The result of the math algorithm's calculation is used as the process variable of the control loop. The UDC 3300 has the capability of measuring a thermocouple or RTD directly which eliminates a source of error and saves the cost of supplying a separate temperature transmitter. The application is illustrated below. The recommended Model Number is: ***DC330E - xx - xCx - 14- xxxxx0 - 00.***.



CONFIGURATION

The basic configuration specific to this application is given below.

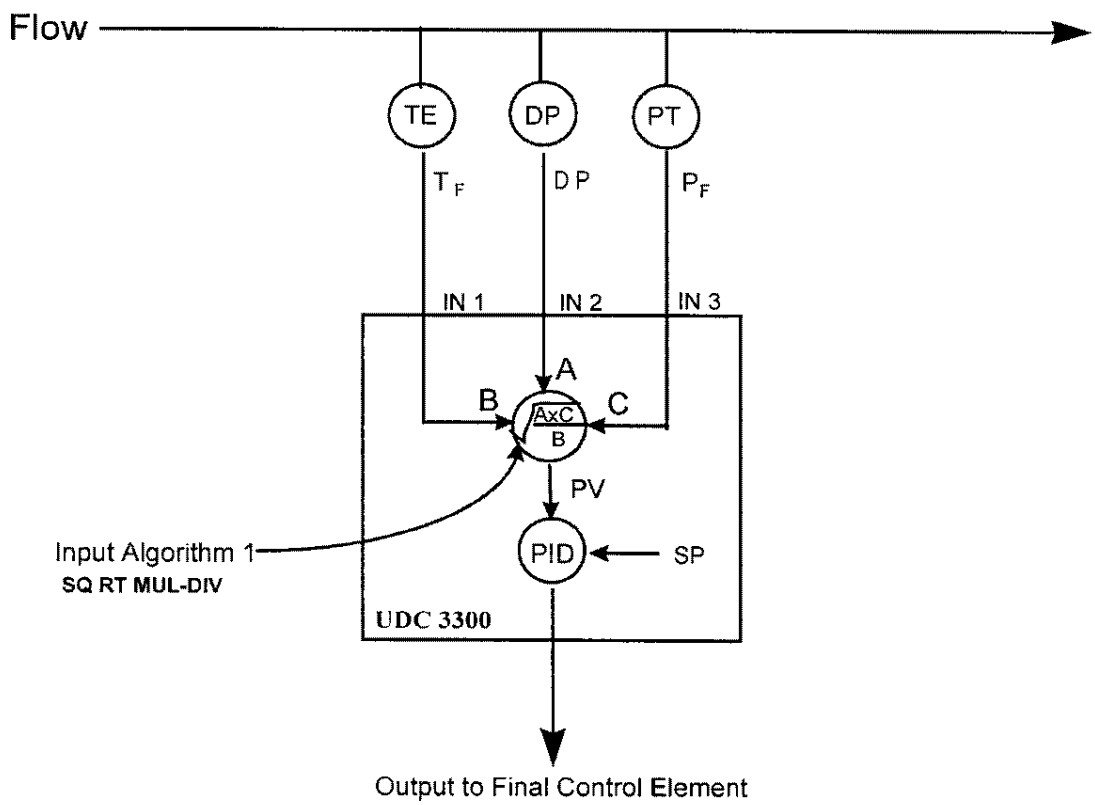
CONT ALG = PIDA
INP ALG1 = K• Sq Rt [(A • C)÷B] • [Calc Hi – Calc Lo]
INP ALG2 = None

Where: Alg 1 INA = IN 2 - Differential Pressure
Alg 1 INB = IN 1 - Temperature
Alg 1 INC = IN 3 - Pressure

Calc Hi = Maximum Flow value expected
Calc Lo = Mimimum Flow value expected
K = Math K = See Example provided below

PV SOURCE = INP ALG1
SP Hi Lim = Calc Hi
SP Lo Lim = Calc Lo
ACTION = Reverse (typically)

All other configuration items are treated as a normal single input PV control loop.



Specific configuration and calculation details are shown in the following Example :

Example - Mass Flow Compensation

A gas flow rate of 650 SCFM develops a differential pressure of 90" H_2O across an orifice plate at reference conditions of 30 psig and 140 °F. Compensate this gas flow for temperature and pressure variations.

$$\text{Flow} = K\sqrt{\frac{DP_f \times P_f}{T_f} \times \frac{T_{ref}}{P_{ref}}}$$

Where:
f = flowing conditions
ref = reference conditions (in absolute units)

Apply Multiplier/Divider Algorithm:

$$PV = K\sqrt{\frac{(\text{Input A} \times \text{Ratio}_A + \text{Bias}_A) \times (\text{Input C} \times \text{Ratio}_C + \text{Bias}_C)}{(\text{Input B} \times \text{Ratio}_B + \text{Bias}_B)}} \times (\text{Calc}_{HI} - \text{Calc}_{LO})$$

Assign inputs using Engineering units:

Let:

Input A = DP_f = IN1 (in H_2O)
Input B = T_f = IN2 + Bias2 = IN2 °F + 460 (°R)
Input C = P_f = IN3 + Bias3 = IN3psig + 14.7(psia)
T_{ref} = 140°F + 460 = 600 °R
P_{ref} = 30 psig + 14.7 = 44.7 psia
$Calc_{Hi}$ = 650.0
$Calc_{Lo}$ = 0.0 > Flow in SFCM at Reference Conditions
K = to be determined next

Note: If temperature and pressure signals are already ranged in absolute units, no Bias is required for inputs B and C.

$$PV = Q_{SCFM} = \sqrt{\frac{DP_f \times (IN3 + 14.7)}{(IN2 + 460)}} \times K^2 \times (650.0 - 0.0)$$

Note: When IN2 and IN3 are at the reference conditions of 600 °R (140 °F) and 44.7psia (30 psig) respectively and DP_f = 90" H_2O, the equation must calculate 650 SCFM. To accomplish this, divide the DP value by "90" to normalize the equation.

$$Q_{SCFM} = \sqrt{\frac{DP_f}{90} \times \frac{(IN3 + 14.7)}{(IN2 + 460)} \times \frac{T_{ref}}{P_{ref}}} \times 650$$

Rearranging terms:

$$Q_{SCFM} = \sqrt{\underbrace{DP_f \times \frac{(IN3 + 14.7)}{(IN2 + 460)}}_{\text{Variable}} \times \underbrace{\frac{1}{90} \times \frac{T_{ref}}{P_{ref}}}_{\text{Constant} = K^2}} \times 650$$

Example continued on next page

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Example - Mass Flow Compensation

Determined value of K:

$$K^2 = \frac{1}{90} \times \frac{T_{ref}}{P_{ref}} = \frac{600}{(90)(44.7)} = 0.14914$$

Therefore K = 0.386

$$Q_{SCFM} = (0.386)(650)\sqrt{\frac{DP_f \text{ (in } H_2O) (IN3 + 14.7)}{(IN2 + 460)}}$$

K

$(Calc_{HI} - Calc_{LO})$

Summary of Flow Values At Values Conditions

	Temp (T_f) (°R)	Pressure (T_f) (psia)	Flow (SFCM)	
			DP_f = 45" H_2O (50%)	DP_f = 90" H_2O (100%)
Reference Conditions	140°F + 460	30 psi + 14.7	459	650
	170° F + 460	50 psi + 14.7	539	763
	170°F + 460	20 psi + 14.7	395	559
	110°F + 460	50 psi + 14.7	567	802
	110°F + 460	20 psi + 14.7	415	587

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