PID SERVO COMPENSATION _ WHAT UNITS?

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Classical servo drive compensation used analog lead/lag filters. These lead/lag filter circuits have been implemented with analog operational amplifier circuits to compensate servo drives. During the process of servo synthesis (compensation), it was required to calculate the required resistor/capacitor values and then install or change these components in the operational amplifier filter circuits.

With the introduction of digital servo drives the use of proportional, integral and differential (PID) algorithms became common place. A PID servo block diagram with the associated approximate (Bode) frequency response is shown in figure 1. The differential part of the compensation should be used with caution since the amplitude response increases with frequency, which may amplify some undesirable system resonances. In general, many industrial servo drives use proportional, integral (PI) type of servo compensation[1]. The servo block diagram and approximate (Bode) frequency response is shown in figure 2.

In commercial servo drives that use digital type PID servo compensation, the proportional gain constant K_p will vary widely from one manufacturer to another. K_i (integral compensation) and K_d ($_{differential}$ compensation) usually have the same base dimension as K_p but with an additional dimension of (1/sec) for K_i and (sec) for K_d. Entering the desired values into a control menu enters them into the control. These numbers differ from one manufacturer to another depending on the digital compensation software. The user can enter recommended numbers for these compensations via the operation manual from the drive manufacturer. However, for the servo engineer to make a system analysis, the actual units of each compensation is required.

Familiar engineering units are preferred for proportional gain K_p with units of (amp/rpm). Then to maintain a compatible set of units for subsequent analysis, it is necessary that gain K_i be in units of (amp/sec/rpm) and differential gain K_d in units of (amp-sec/rpm). Since the numerical values assigned to K_p, K_i, and K_d are different from one manufacturer to another, it is useful to the servo engineer to be able to relate the compensation values of one manufacturer to another in their actual units. Computing the real units of each type of compensation must be done in cooperation with the servo drive manufacturer. Three typical manufacturers examples are as follow:

ALLEN-BRADLEY

$$K_P = K_{P\ per\ unit} \times \frac{I\ rated\ [a]}{1000\ [rpm]} = [a/rpm]$$

$$K_I = K_{I\ per\ unit} \times \frac{I\ rated\ [a/sec]}{1000\ [rpm]} = [a/sec/rpm]$$

INDRAMAT

$$K_P = \frac{P\ gain \times Proportional[nm\text{-}min] \times 8.85 \times 2pi\ [ra]}{K_T\ [lb\text{-}in/a]\qquad\qquad [rev]} = [a/rpm]$$

$$K_I = \frac{I\ gain \times Integral[nm/sec] \times 8.85 \times 2pi\ [ra]}{K_T\ [lb\text{-}in/a]} = [a/sec/rpm]$$

FANUC

$$K_P = \frac{P \times J_m\ [Kg\text{-}Cm\text{-}sec^2]}{K_T\ [Kg\text{-}Cm/a]} = [a/rpm]$$

$$K_I = \frac{I \times J_m\ [Kg\text{-}Cm\text{-}sec^2]}{K_T\ [Kg\text{-}Cm/a]} = [a/sec/rpm]$$

Note: P & I values are from the manufacturer. K_T =Torque constant, J_m = Inertia.

[1] B.C. Kuo, Automatic Control Systems, Prentice Hall, 7th edition, 1995.