IMPLEMENTING PID COMPENSATION

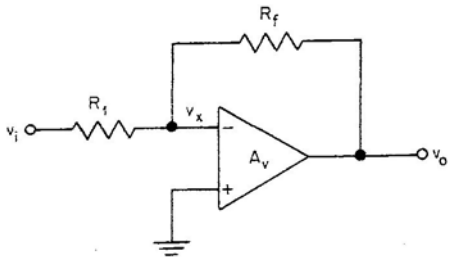
George Younkin, P.E., MSEE

Modern commercial servo drives use digital algorithms to implement PID type compensation. This is not recommended practice for individual designers unless they have the digital background necessary. For the individual designer, analog compensation techniques can be used to implement the required compensation, as has been the case for many years previously.

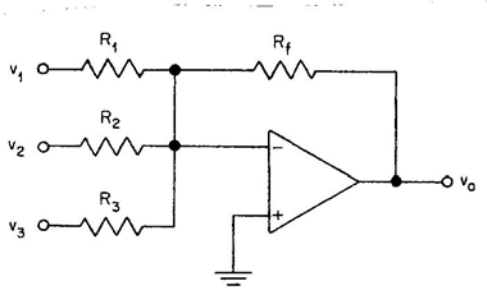
The servo compensation is accomplished with the use of operational amplifiers. These amplifiers can usually be found in electronics stores. The operational amplifier is represented by a triangle pointing to the right, with some capacitors and resistors connected to it.

$$A = \frac{v_o}{v_{in}} = -\frac{R_f}{R_1}$$

The circuit voltage gain as a function of frequency is called A. Since R_f and R_1 represent resistances, the amplifier gain is some what independent of frequency, as shown.

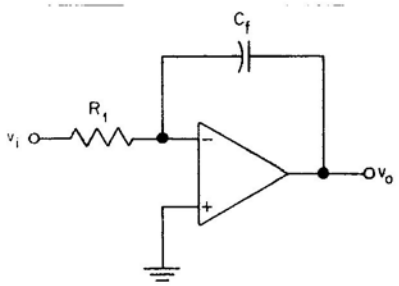


This operational amplifier is the same as a proportional (P) gain compensation. This operational amplifier is in the preamp stage of the servo amplifier. This same operational amplifier can be used to create both Integral (I) and differential (D) servo compensation or any combination thereof. It should be remembered that integral compensation is the same as a lag filter and the differential compensation is the same as a lead filter. Some examples are shown as follows for an integrator (I) and differentiator (D). The basic operational amplifier is shown having 3 inputs. One input is used for the servo command. A second input is used for the servo feedback signal. The 3rd input could be used for feedforward or a similar special function. The integrator (I) is an integral command at all frequencies. The differentiator (D) will differentiate and will also have a lead characteristic for all frequencies.

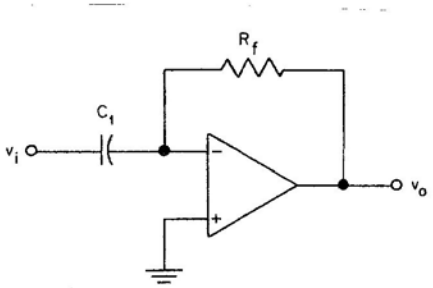


Summing circuit.

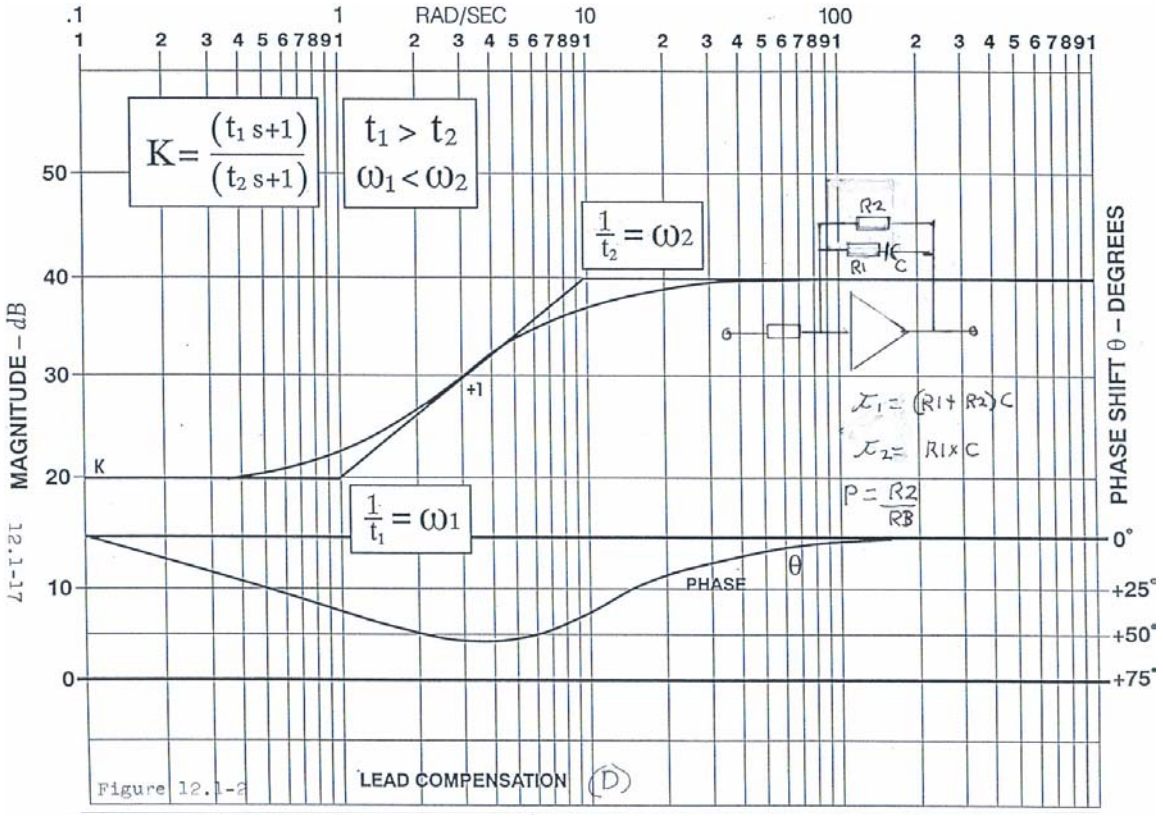
However, in normal practice it will be required to have the I compensation start at a desired frequency. Likewise it will be required to have the D compensation start at a desired frequency. A typical differentiator or lead/lag compensation is shown followed by a typical integral or lag/lead compensation.

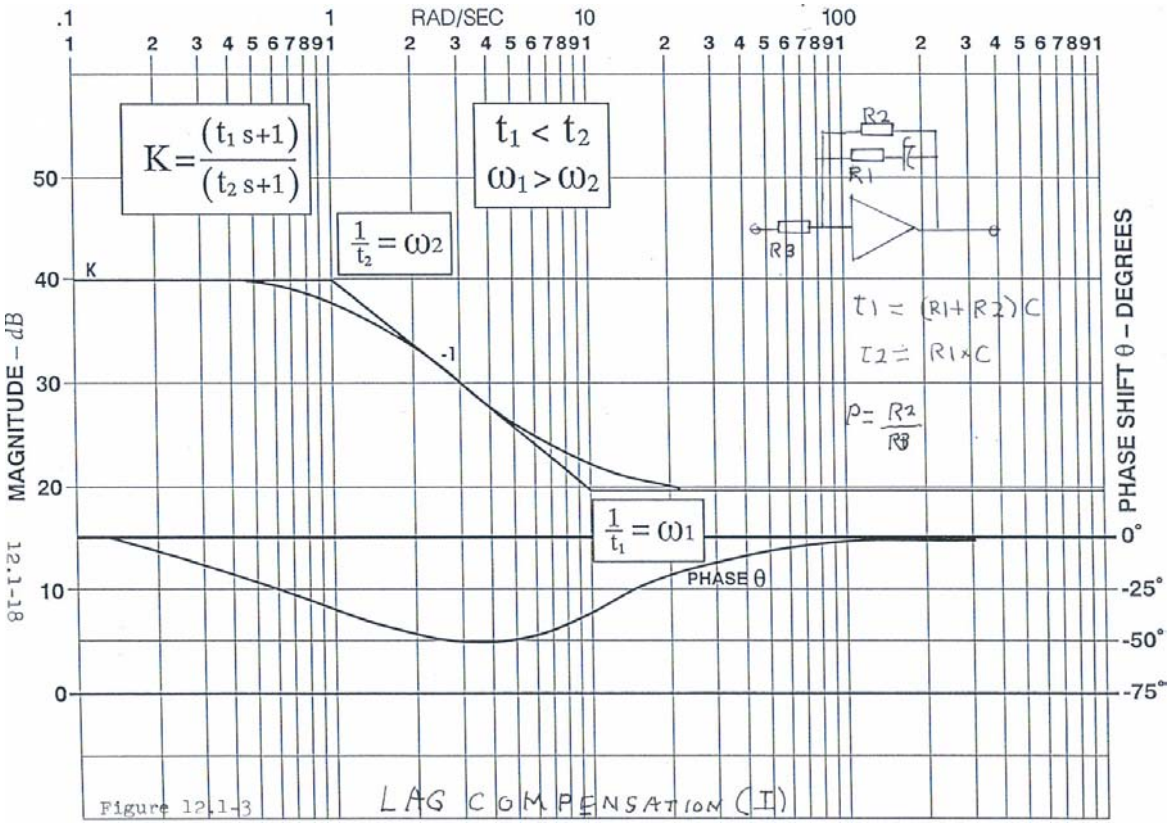


Integrator.



Differentiator.





The next question is where do these P, I and D compensation operational amplifiers go? The servo drive consists of a motor and a servo amplifier. The amplifier has a power output stage to supply voltage to the motor, and an input stage (preamplifier) where the servo compensation goes. Thus the input to the amplifier goes to an operational amplifier with multiple inputs. One input is where the servo command voltage goes. The second input is where the feedback (position signal or velocity signal) goes. A typical DC SCR servo amplifier is shown as:

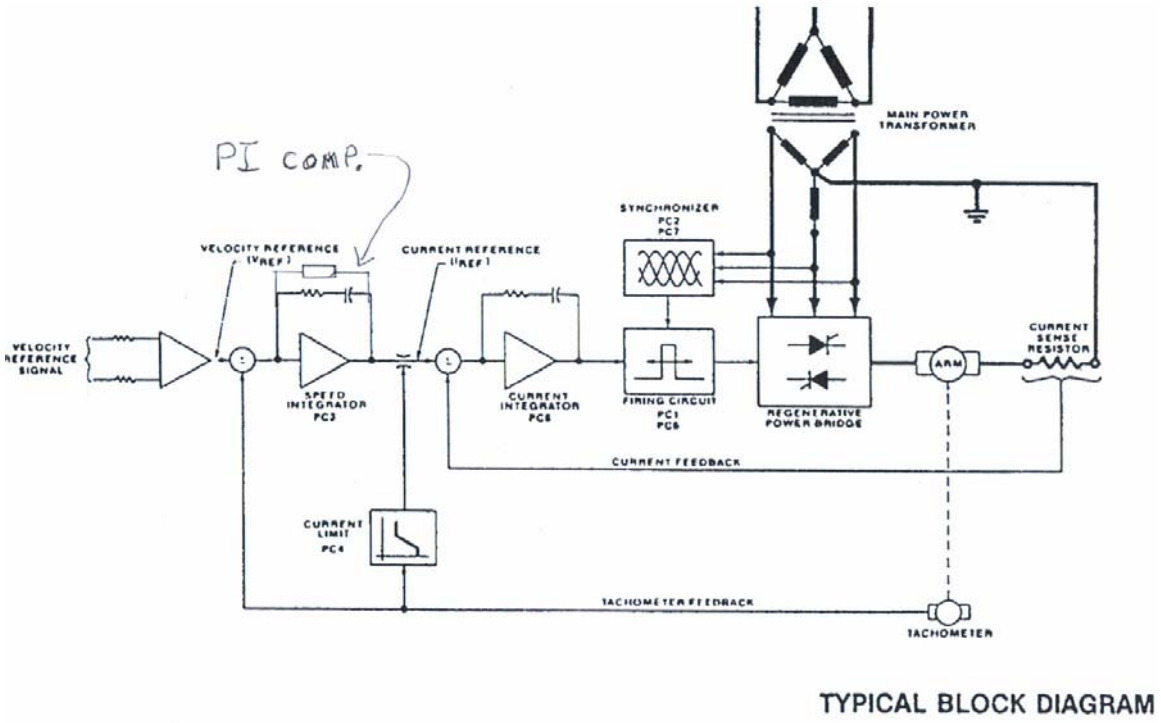


Fig. 7 Gettys DC SCR electric drive diagram. (Courtesy of Gettys Corp.)

This amplifier is just one example of many kinds of servo amplifiers that can be used. To make the servo drive stable, it requires some control background to determine just what P, I, or D is required. Most commercial servo drives can operate without D compensation. In fact, if D compensation is used, it should be cut off about one decade above the servo bandwidth. Otherwise the differential effect will continue to increase until every resonance in the machine will start to rattle.

A suggested reference to implement digital PID is as follows:

George A. Perdikaris, Ph.D., Professor, Engineering & Computer Science

Office: MOLN-235 Phone: (262) 595-2489 Fax: (262) 595-2114

E-mail: perdikar@uwp.edu

Education: B.S.E.E, University of Illinois-Champaign/Urbana, 1965.

M.S.E.E. & Ph.D., University of Missouri-Columbia, 1970.

Teaching: Computer Engineering/Computer Science

Research: Industrial control systems, real-time/embedded systems and applications.

Societies: IEEE (computers, industry applications, controls, robotics & automation), ACM.

Textbook: COMPUTER CONTROLLED SYSTEMS: Theory and Applications

Kluwer Academic Publishers, 1991, 1996.

Awards: Wisconsin Distinguished Professor. IEEE-Milwaukee Memorial Award, 1996.