DC MOTORS
SPEED CONTROLS
SERVO SYSTEMS

SIDMAN

EXPANDED THIRD EDITION

AN ENGINEERING HANDBOOK BY

ELECTRO-CRAFT CORP

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SPEED CONTROLS
SERVO SYSTEMS

AN ENGINEERING HANDBOOK

by

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tem, it is clear that they are sensitive to variations in both load and friction torque.

In cases where it is desirable to have the acceleration and/or deceleration under velocity control, several methods can achieve the desired results.

The simple RC circuit of Fig. 3.3.11 can be employed to control acceleration. First, assume that the switch is initially in the **A** position so that the command voltage V_c is zero. The speed control is, therefore, holding the motor at rest. With the switch set in the **B** position, capacitor **C** is charged through voltage divider R_1, R_2. The voltage V_r will follow an exponential rise (Fig. 3.3.12) until the Zener voltage V_Z is achieved, at which point the reference voltage V_r (as also the command voltage V_c) is stabilized.

As the switch is returned to **A**, the voltage will decline in an inverse exponential fashion.

It should be noted that while the speed control system will follow the acceleration

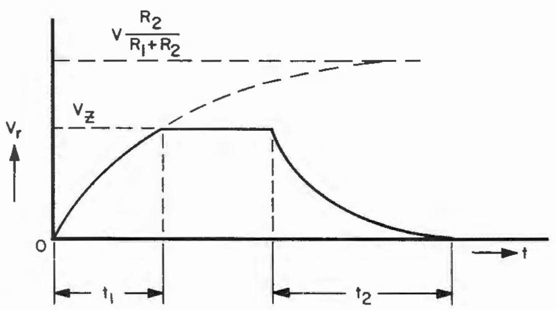


Fig. 3.3.12. Turn-on and turn-off characteristics of the RC circuit in Fig. 3.3.11.

curve (if acceleration rate is within the torque capacity of the system), it may not follow the deceleration curve unless the load conditions and the dynamic braking capacity allow. If this is not the case, then a bidirectional system (servo system) must be used where continuous velocity tracking is necessary.

Another circuit with linear features is shown in Fig. 3.3.13. This is a ramp generator which produces linear, independently adjustable slopes.

The circuits discussed above have been shown as manually operated devices. In many applications, they can be operated by various logic circuits, thereby taking their place in modern process controls.

SWITCHING AMPLIFIERS

While the linear amplifier discussed above performs excellently in high-performance speed controls, it has the problem of heat generation in the output stage, requiring forced-air cooling in amplifiers over 100 to 200 W (depending on ambient temperature and heat sink design). The switching amplifiers overcome this problem by letting its output stage rapidly switch from a nonconductive state to a fully conductive state, thereby minimizing operation of the output stage in the high dissipation region.

Three basic methods are used to control power in switching amplifiers: *pulse-width modulation* (PWM), *pulse-frequency modulation* (PFM), and *silicon controlled rectifier*

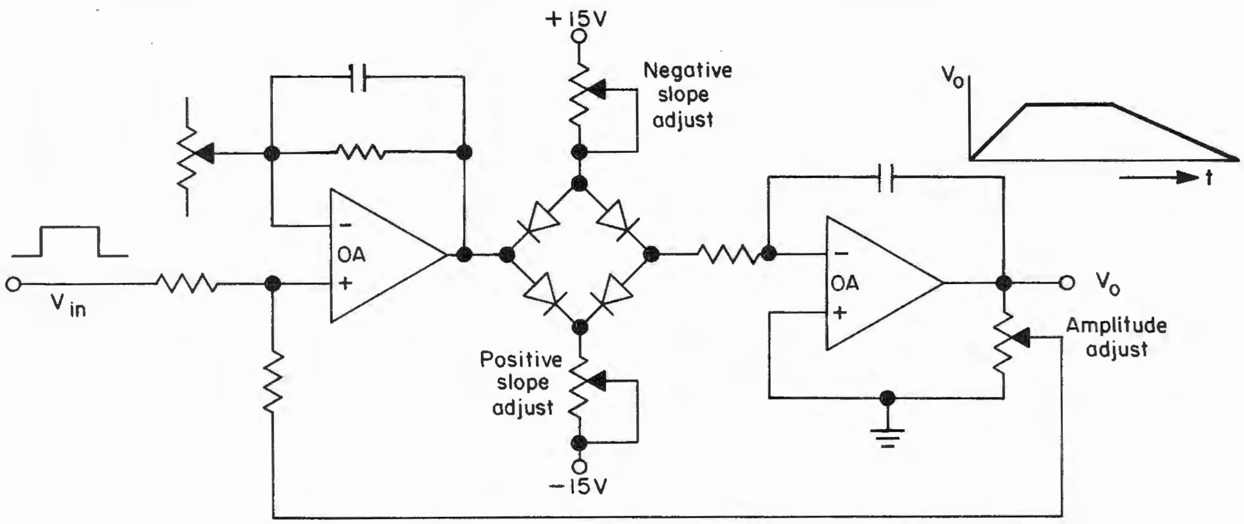
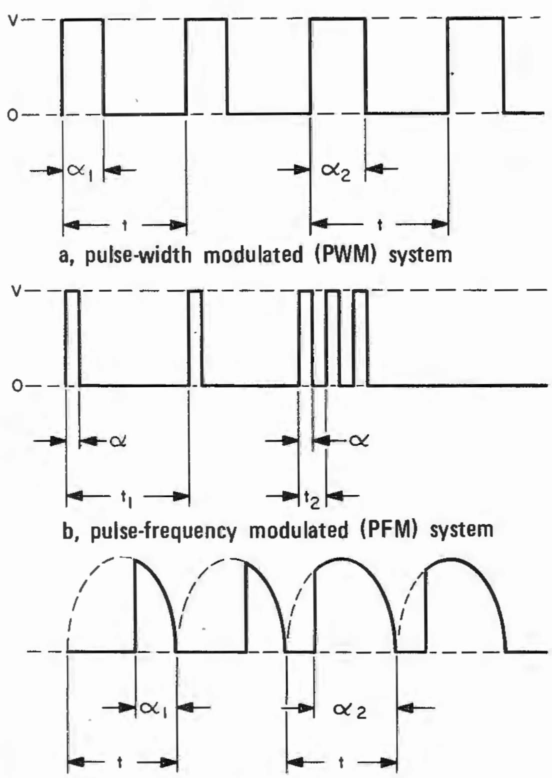


Fig. 3.3.13. Ramp generator with independently adjustable slopes.



a, pulse-width modulated (PWM) system

b, pulse-frequency modulated (PFM) system

c, SCR control system

Fig. 3.3.14. Voltage waveforms in switching amplifiers.

(SCR) *controls.* Their principal differences are shown in Fig. 3.3.14.

The PWM system usually utilizes a DC supply, and the amplifier switches the supply voltage on and off at a fixed frequency and at a variable "firing angle" a (see Fig. 3.3.14a) so that an adjustable average voltage across the load is established. The amount of power transferred to the load (motor) will depend on switching rate and the load inductance. In many of the PWM circuits, the pulse frequency is allowed to shift over a given range – in some cases for a good purpose.

The PFM system has a fixed firing angle and a variable repetition rate (Fig. 3.3.14b), achieving essentially the same results as the PWM, but when used in motor control circuits, the widely variable pulse frequency required causes dissipation problems which makes the PWM more attractive. Incidentally, a PWM circuit with a variable pulse rate is really a hybrid between the two.

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