ANALOG INTERFACING AND INDUSTRIAL CONTROL (PART II)

Book: Microprocessors and Interfacing-Douglas V. Hall (Chapter 10)

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Microcomputer based smart scale

- Load cell converts applied weight into a proportional electrical signal
- It is then amplified and converted into a digital value
- Can be read by the microprocessor and sent to the attached display
- User can enter price per pound by using keyboard
  - Shown on the display
- When the user presses compute key on the keyboard
  - Microprocessor multiplies the weight times the price per pound and displays the computed price
- After holding the price display long enough for the user to read it, the scale goes back to reading the weight and displaying it

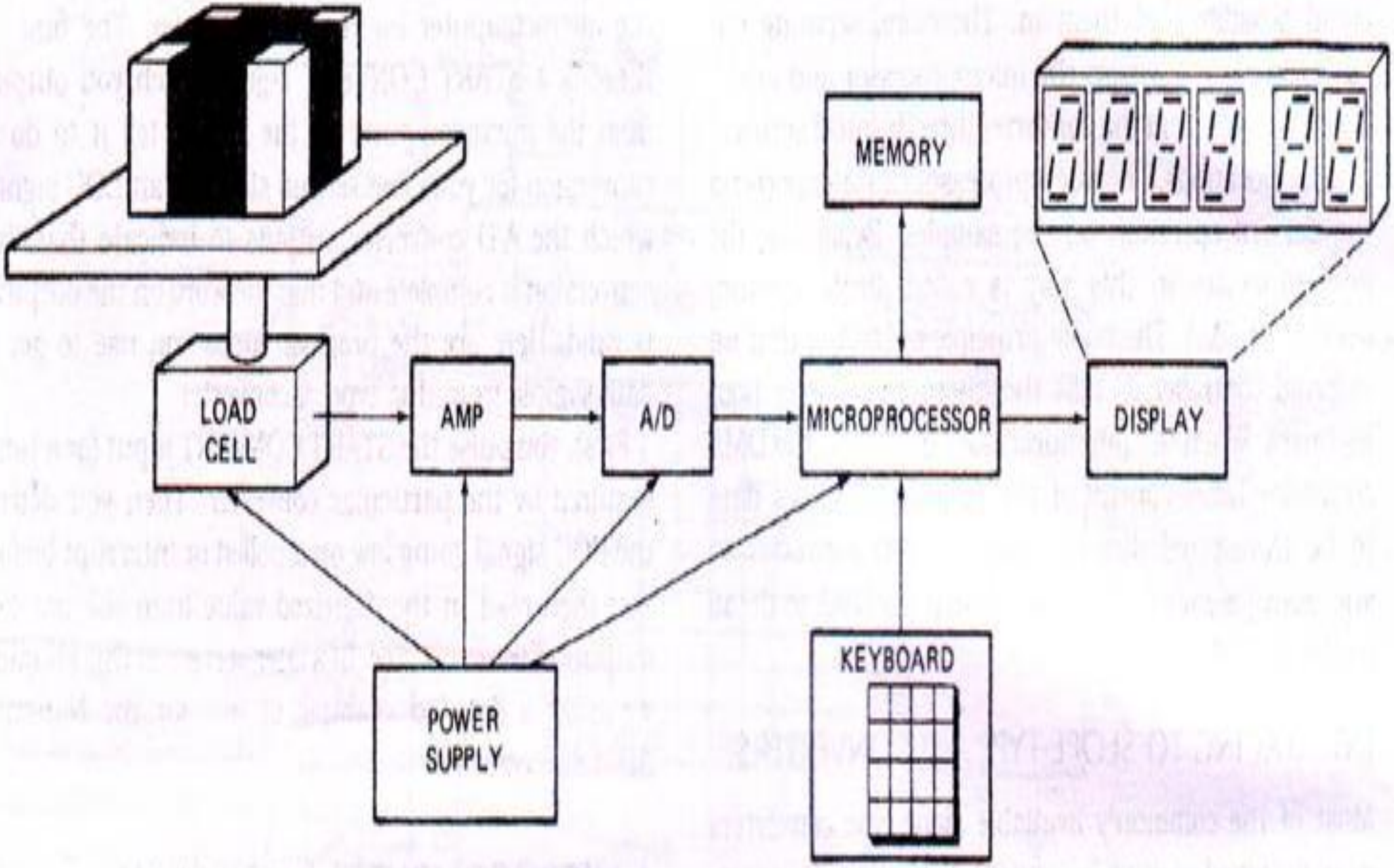
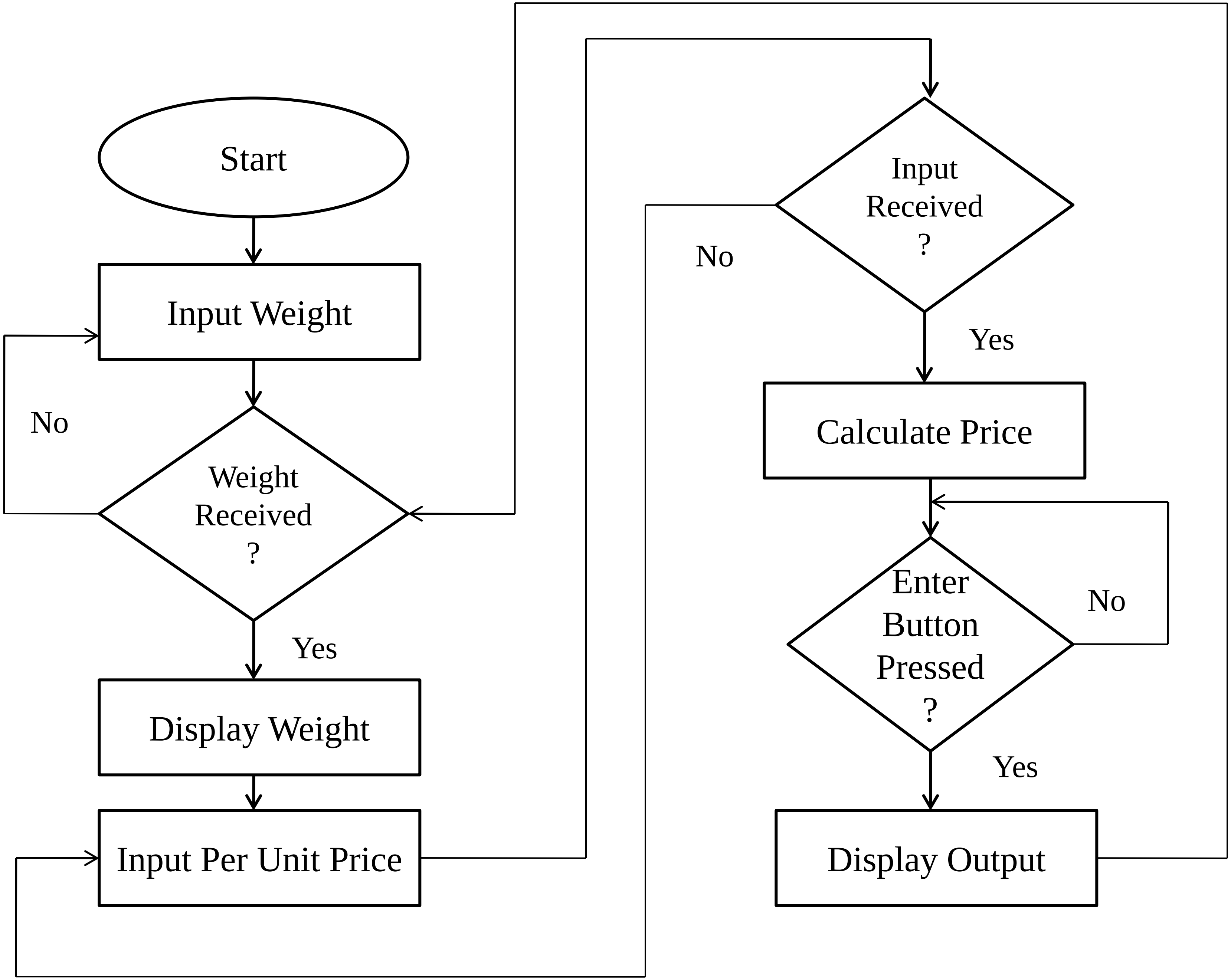


FIGURE 10-22 Block diagram of microcomputer-based smart scale.


Start
Input Weight
No
Weight Received ?
Yes
Display Weight
Input Per Unit Price
Input Received ?
No
Yes
Calculate Price
Enter Button Pressed ?
No
Yes
Display Output

Microprocessor Based Industrial Control System

- One area in which microprocessors and microcomputers have had a major impact is industrial process control.
- Process control involves first measuring system variables such as motor speed, temperature, the flow of reactants, the level of liquid in a tank, the thickness of a material etc.
- The output of the controller then adjusts the value of each variable until it is equal to a predetermined value called a ***set point***.
- System controller must maintain each variable as close as possible to its set point value.
- It must compensate as quickly and accurately as possible for any change in the variable caused by, for example , increased load on the motor.

Controlling the Speed of a dc motor

- A dc generator or tachometer is attached to the shaft of the motor .
- It puts out a voltage proportional to the speed of the motor.
- A fraction of the tachometer output voltage is fed back to the inverting input of the power amplifier driving the motor.
- In the non-inverting input of the amplifier, a positive voltage is applied as set point.
- When the power is turned on, the motor accelerates
  - Until voltage fed back from the tachometer is nearly equal to the set point voltage.

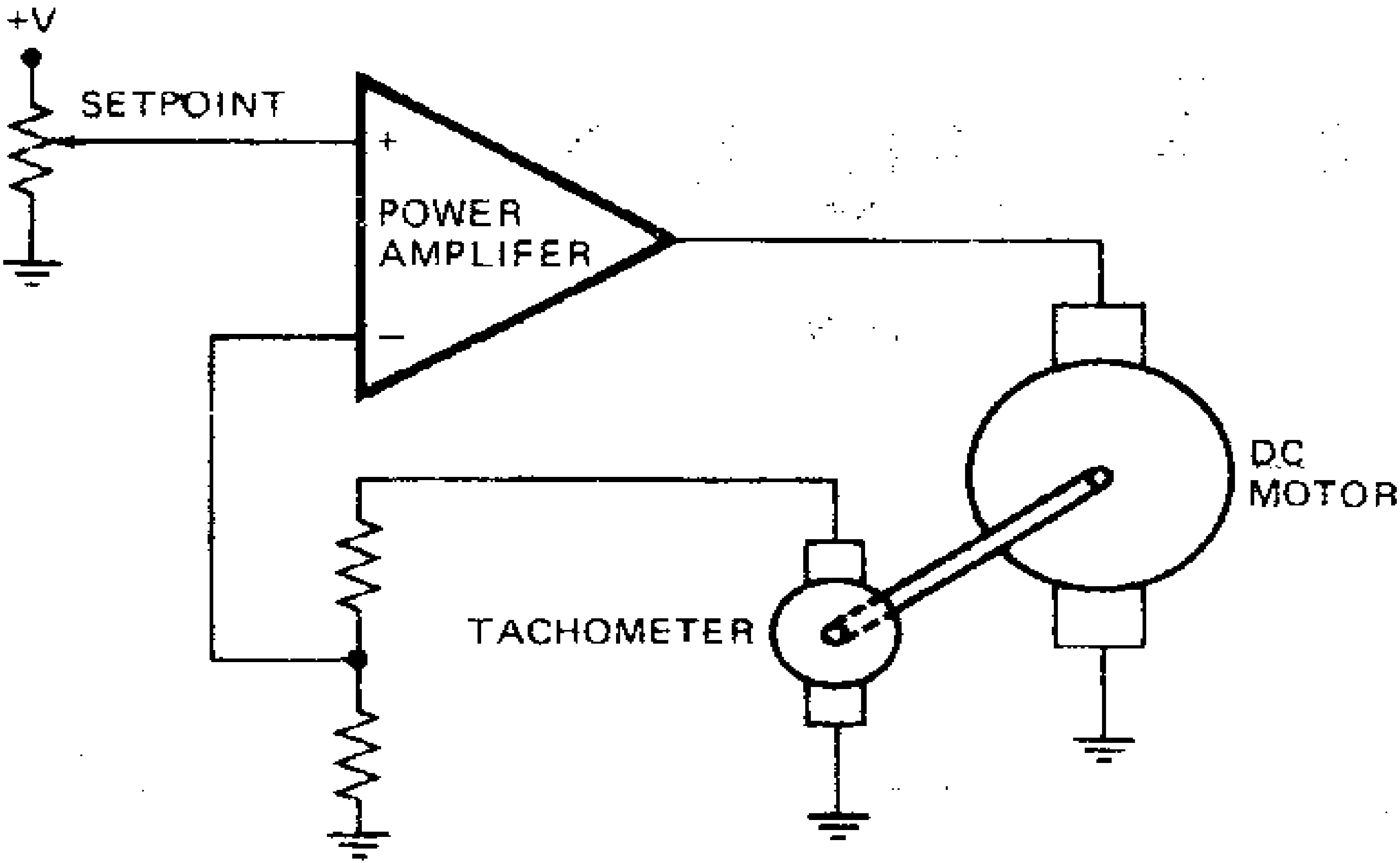


FIGURE 10-27 Circuit for controlling speed of dc motor using feedback from tachometer.

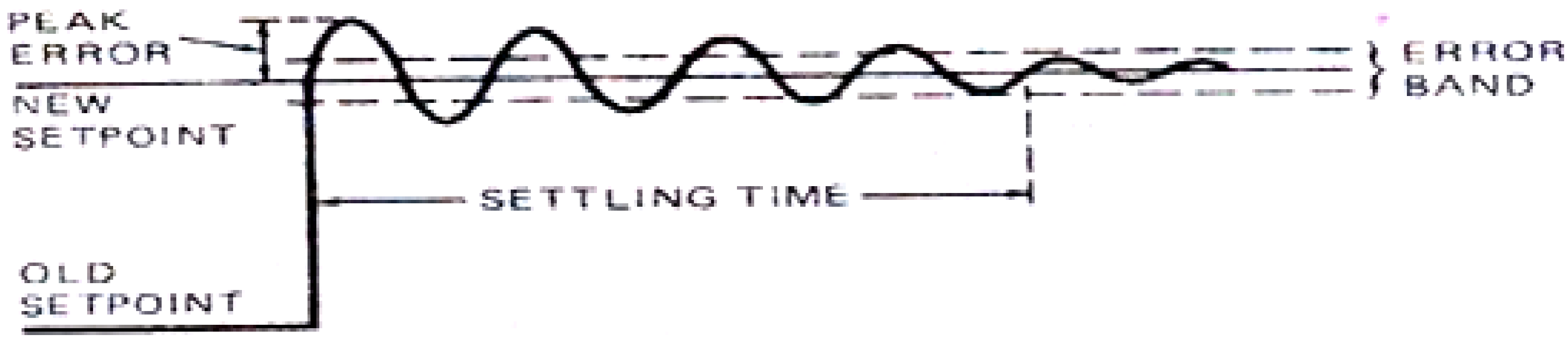
Controlling the Speed of a dc motor

- If the load on the motor is increased, the motor will initially slow down
  - Voltage output from the tachometer will decrease
    - Increase the difference in voltage between the inputs of the amplifiers
      - Cause it to drive more current in the motor.
- Now, the increased current will increase the speed of the motor to nearly the speed it had before the increased load has added
- The similar reaction takes place if the load on the motor is decreased

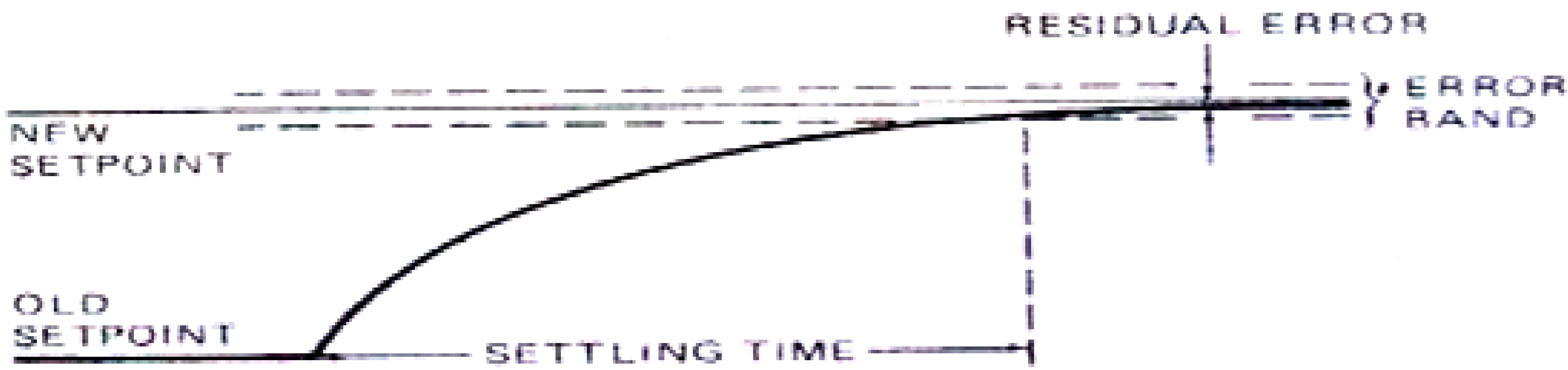
Problems

- For the applications in which the load and/or the set point changes drastically, there are several potential problems

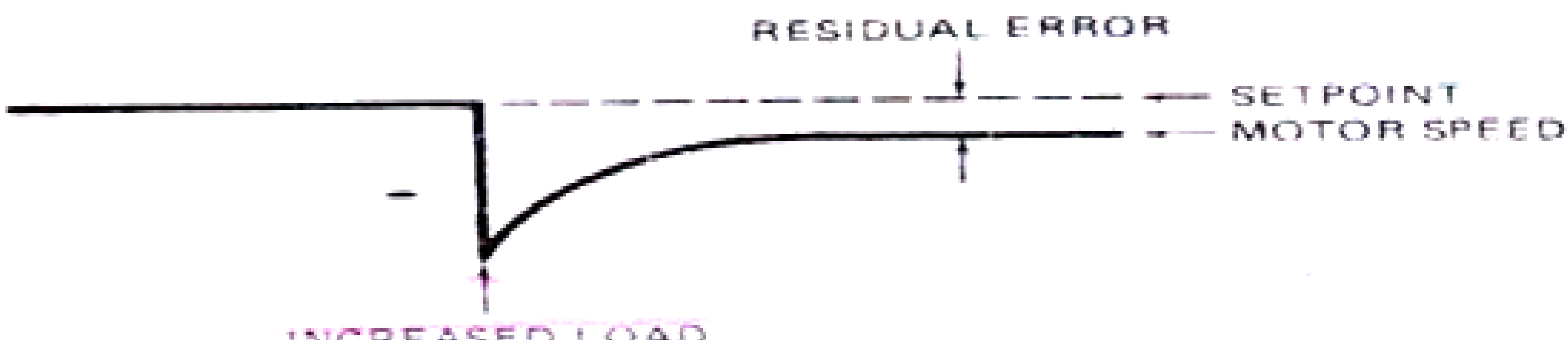
- **Overshoot**
  - When the set point is changed
    - In this case, the variable- motor speed (for example) overshoots the new set point and bounces ups and downs for a while.
    - The time it takes the bouncing to settle within a specified error range or error band is called the *settling time*.
    - This type of response is referred to as *underdamped*.
    - Damping can be added.


PEAK
ERROR
ERROR
BAND
NEW
SETPOINT
SETTLING TIME
OLD
SETPOINT

(a)


RESIDUAL ERROR
ERROR
BAND
NEW
SETPOINT
OLD
SETPOINT
SETTLING TIME

(b)


RESIDUAL ERROR
SETPOINT
MOTOR SPEED
INCREASED LOAD

Problems

- **Undershoot**
  - If too much damping is added.
  - This type of response is referred to as an over-damped response.
  - The difficulty is that it takes a long time for the variable to reach the new set point.
- **Residual Error**
  - There is some noticeable difference between the set point and the voltage fed back from the tachometer.
  - This difference is amplified by the gain of the amplifier to produce the additional derive for the motor.
  - For stability reason, gain of many control systems cannot be too high.
  - Therefore some residual error always exists between the set point and actual output.

Solution-PID Controller

- Circuits with more complex feedback are used
- Here the power amplifier is an adder with 4 inputs
- The current supplied to the summing point of the adder by the set point input produces the basic drive output current
- If there is no difference between the set point an the feedback voltage from the tachometer
  - Other 3 inputs do not supply any current
- Amplifier 1 compares the set point value with the feedback voltage from the tachometer
- If speed of the motor is at set point value
  - Amplifier 1 output will be zero
  - Amplifier 2,3,4 will contribute no current to the summing junction of the power amp

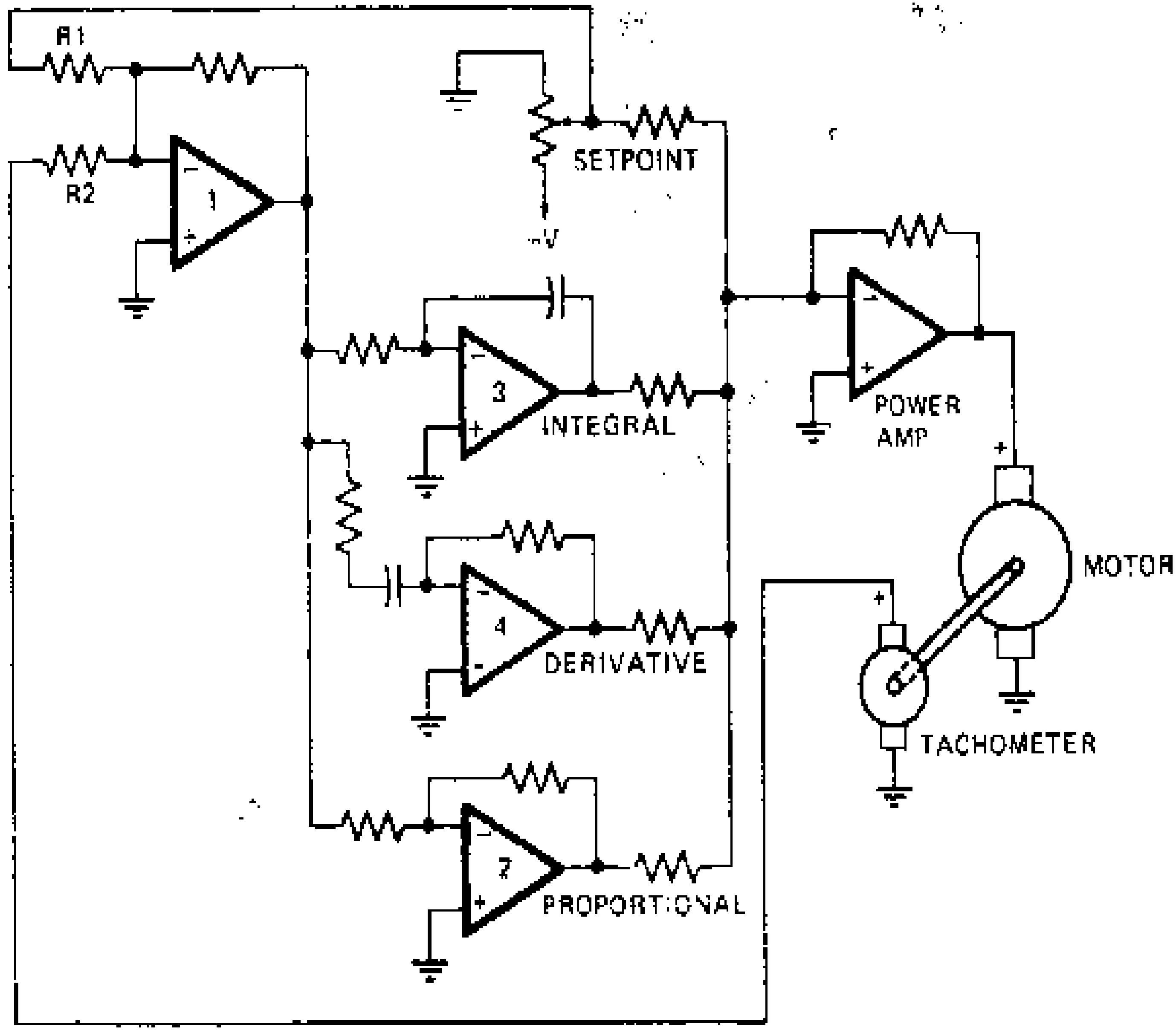


FIGURE 10-29 Circuit showing proportional, integral, and derivative feedback control.

Solution-PID Controller

- If speed of the motor is not at set point value
  - Amplifier 1 now has some output
  - Amplifier 2,3,4 produces three types of feedback of this error signal to the summing junction of the power amp
- Amplifier 3 provides integral feedback
  - The cure for residual error
- Amplifier 4 improves the response time of the system
  - Provides derivative feedback
  - Produces signal, proportional to the rate of the change of the error signal
  - If the load on the system is suddenly changed, this circuit will give a quick feedback to try to correct the error

Solution-PID Controller

- By using combination of these types of feedback , a system can be adjusted for optimum response to changes in load or set point
- Amplifier 2 provides proportional feedback
- Process control loops that uses all these three types of feedback are called *proportional Integral derivative* or PID control loops