

REG-D & REG-DA Voltage Regulating Relays: Time Programs

The basic voltage regulation function of an A.Eberle Voltage Regulator Relay (VRR) compares a measured voltage with the value set in the Setpoint setting. If the measured voltage deviates from the Setpoint by more than the value in the Bandwidth setting, then the amount of deviation is sent to the Time Program⁽¹⁾. If the deviation remains in place for long enough, then a Raise or Lower tapping command will be issued as necessary (Figure 1).

The time taken to issue a command will be determined by the deviation amount, the Time Factor and the Time Program selected. Available Time Programs, described later, include those with inverse time, linear and definite time characteristics.

To allow correct functioning in the event of varying voltages, an integrator is used to average the output of the Time Program and smooth the rate of tapping commands.

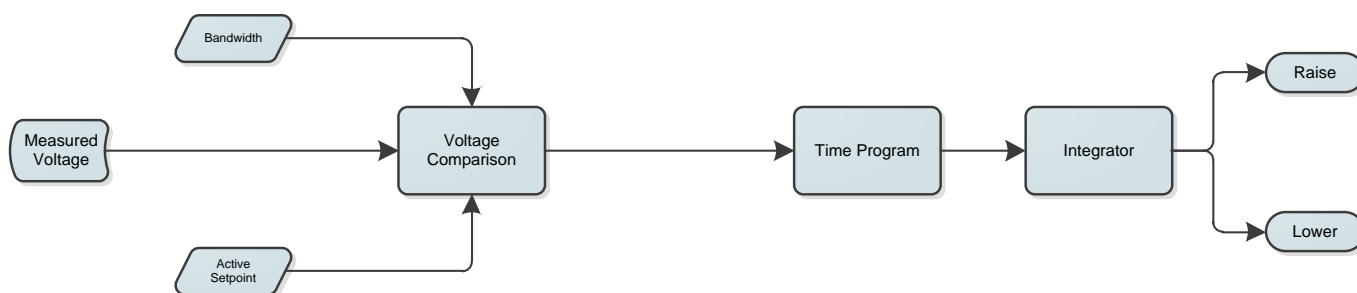


Figure 1. The basic voltage regulation function (without any Current Influence or parallel programs).

This control-mode only remains active within defined boundaries – set via voltage Limit settings. Outside of these Limit boundaries the normal regulation function is temporarily blocked (no tap change commands are issued). This document describes the settings that control the regulation behaviour within the ‘normal’ voltage range.

This document concentrates on ‘basic’ regulation schemes. Those using Current Influence and those operating in a Circulating-Current paralleling scheme will be further detailed in future documents. These use additional algorithms and inputs between the Voltage Comparison and Time Program stages than shown in Figure 1.

(1) Note that in addition to Setpoint and Bandwidth, a ‘100 % Value’ is used in the voltage comparison algorithm. This ‘100 % Value’ must be accounted for when calculating specific regulator time response, such as during commissioning testing. Please refer to our Technical note ‘Setpoint, Bandwidth & 100 % Value’ for further information. For simplicity, the ‘100 % Value’ is not mentioned further in this document

Time Programs

There are four different Time Programs to select from: Integral, Fast Integral, Linear and Constant.

Integral Time Program ($\Delta U \cdot t = \text{const}$)

The Integral Time Program applies an inverse-time curve so that larger deviations cause faster operations. This Time Program is also referred to as $\Delta U \cdot t = \text{const}$.

The reaction time is related to the percentage deviation from the Setpoint by the equation:

$$\text{Reaction time} = 30 \times \frac{bw}{|\text{deviation}|}$$

The resulting curve depends on the value of the Bandwidth (bw) setting. The curve for a Bandwidth of 1 % is shown in Figure 2. The curves for various bandwidths are shown in Figure 3.

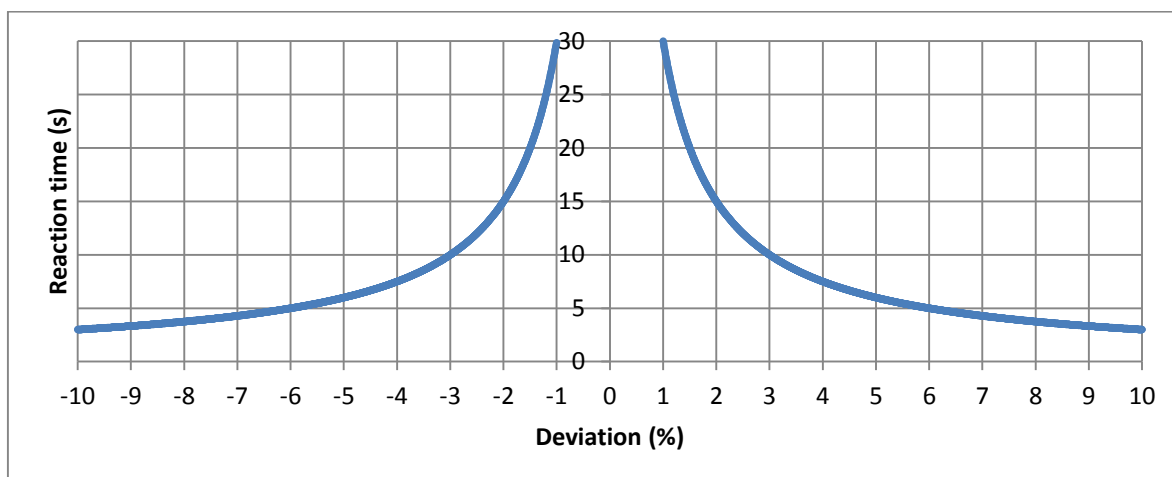


Figure 2. The Integral Time Program with a setting bandwidth = 1 %.

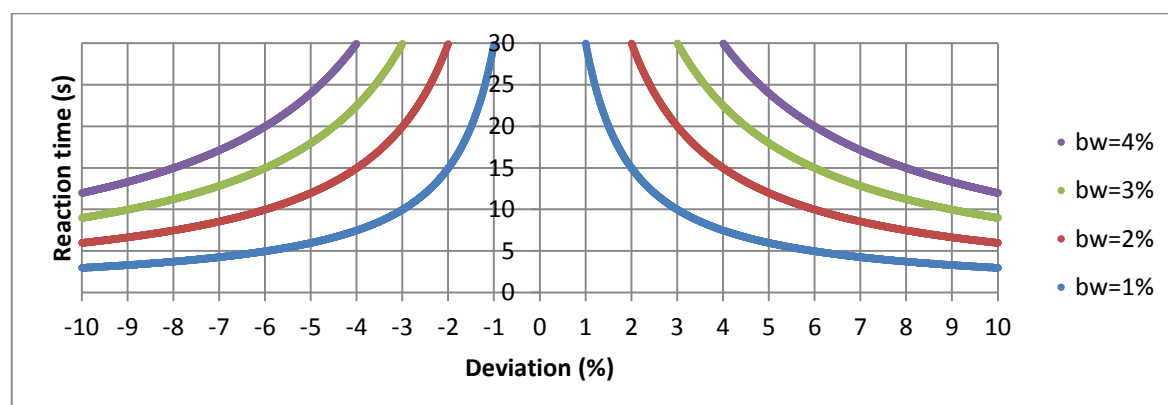


Figure 3. The effect of the Bandwidth setting on the Integral Time Program.

Fast Integral Time Program

The Fast Integral Time Program provides a similar response to the integral curve but with a steeper slope. The reaction time is given by:

$$\text{Reaction time} = 30 \times \left(\frac{bw}{|\text{deviation}|} \right)^{1.6}$$

The characteristic curves are shown in Figures 4 and 5.

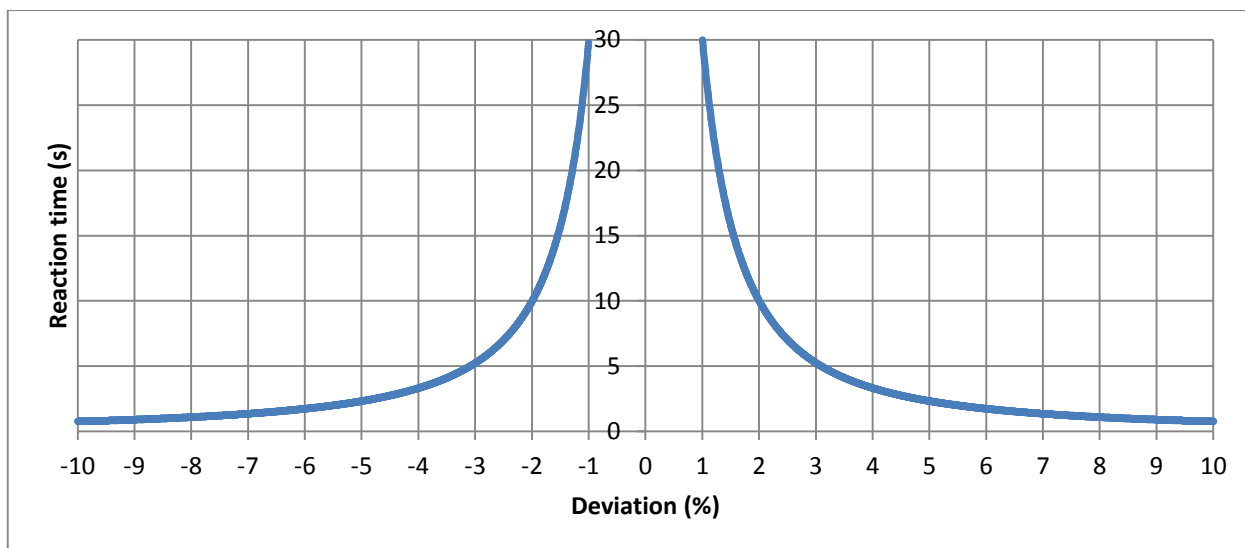


Figure 4. The Fast Integral Time Program with a setting bandwidth = 1 %.

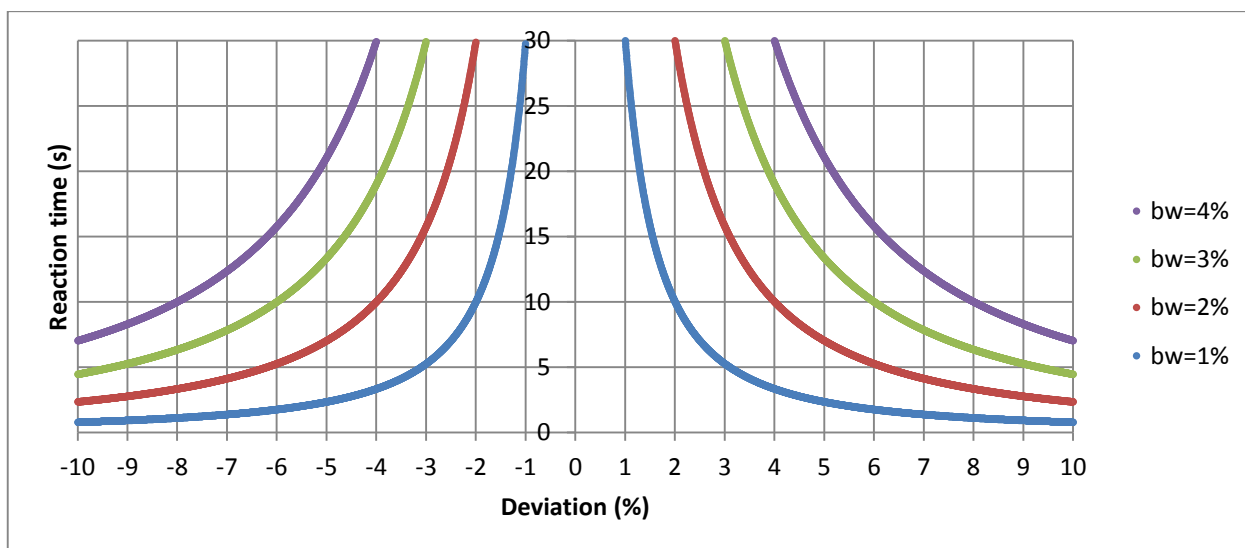


Figure 5. The effect of the Bandwidth setting on the Fast Integral Time Program.

Linear Time Program

The Linear Time Program provides a straight line characteristic curve according to the equation:

$$\text{Reaction time} = 30 - \left(3 \times \frac{|\text{deviation}|}{bw} \right)$$

The characteristic curves are shown in Figures 6 and 7.

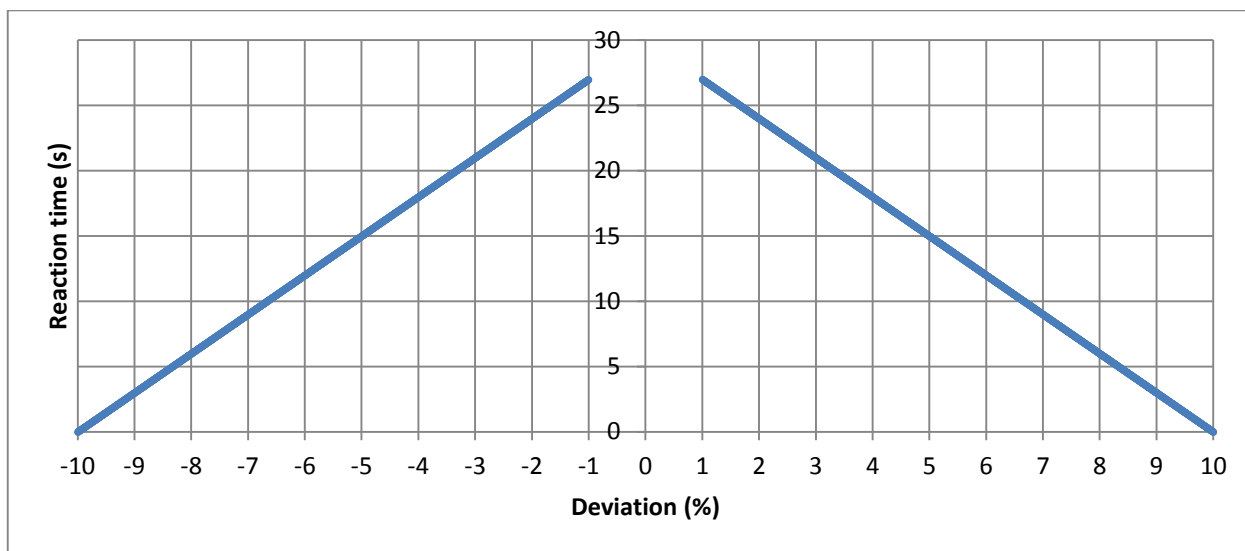


Figure 6. The Liner Time Program with a setting Bandwidth = 1 %.

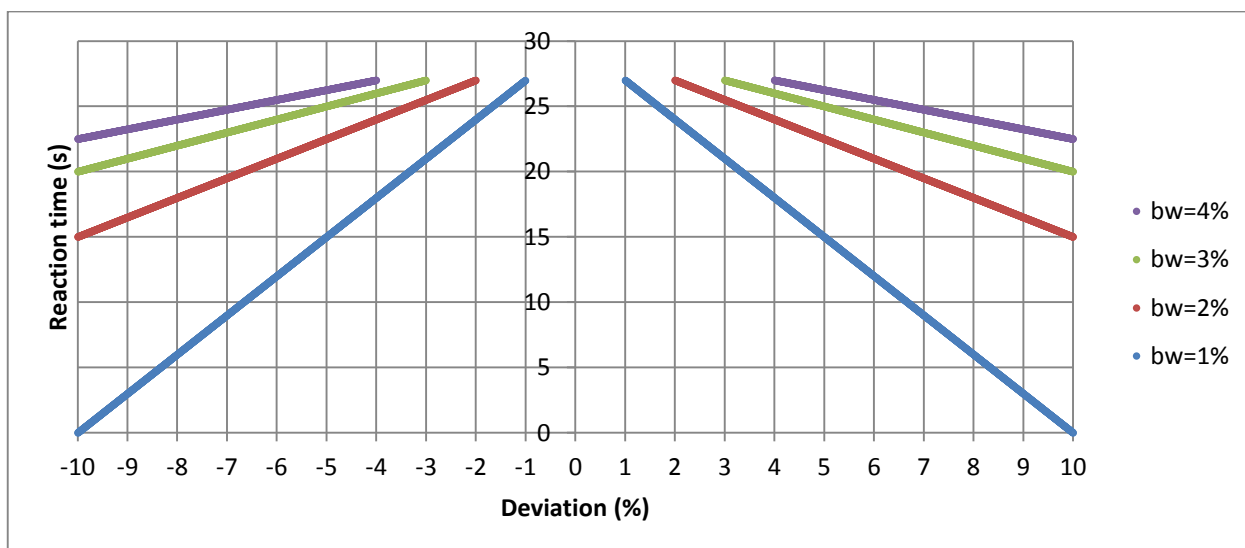


Figure 7. The effect of the Bandwidth setting on the Linear Time Program.

Constant Time Program

The Constant Time Program is a two-stage definite-time regulation scheme. If the deviation exceeds the Bandwidth for more than the set time delay then a raise or lower command is issued.

Time delay T1 is used if the measured voltage exceeds the Bandwidth but is less than 2 times the Bandwidth. When the deviation is more than 2 times the Bandwidth then the time T2 will apply. This is shown in the reaction time equation:

$$\text{Reaction time} = \begin{cases} \text{time 1} & \text{if } bw < |deviation| < 2 \times bw \\ \text{time 2} & \text{if } |deviation| > 2 \times bw \end{cases}$$

As a general rule the time T2 should be set to a shorter time than T1 so that larger deviations are corrected faster than small deviations.

Time Factor

The Time Factor setting is a multiplier that is applied to the reaction time calculated by the Integral, Fast Integral and Linear Time Programs. To determine the actual reaction time for a given deviation, the times shown in the reaction-time curves must be multiplied by the Time Factor setting.

The Time Factor does not apply when the Constant Time Program is selected.

Integrator and Trend Memory

Integrator

The integrator is an averaging function that defines how the relay responds under conditions that vary the deviation during the reaction time of the Time Program. The integrator is graphically shown in the regulator display mode as the Progress Bar.

Every second that the deviation is outside of the Bandwidth, the integrator is partly filled. The amount that it is filled is inversely proportional to the time that the regulator would take to react if the voltage remained constant at this level.

Example:

If the Time Program indicates that at the present level of deviation the time taken to tap = 20 s then every second 1/20 (5 %) would be added to the integrator.

When the integrator reaches 100 % then a tap command will be issued and the integrator will be emptied.

Where the deviation varies while the integrator is filling, the total time taken to issue a tapping command is the weighted-average of the deviations that were present during the time the integrator takes to fill.

Trend Memory

The Trend Memory feature controls the time it takes the integrator to reset if the deviation falls back within the Bandwidth 'dead-band' before the integrator has had time to completely fill. Applying a non-zero Trend Memory setting is similar to activating an 'electromechanical reset' feature on a digital protection relay overcurrent element.

If Trend Memory is set to zero then when the deviation falls below threshold, then the integrator will reset instantly.

If a non-zero value is set then the memory will reset at a linear rate depending on the time set and how full the buffer was at the time the reset process started. For example if the Trend Memory = 30 s and the voltage falls back to within the Bandwidth just before the regulator was about to issue a tap command, then the time taken to fully reset will be 30 s. If the integrator was only half-full then reset would take 15 s.

If the deviation again exceeds the Bandwidth before the integrator fully resets then it will begin refilling from the present value.

If the Progress Bar is empty, this indicates that the integrator has completely reset and the trend memory has expired.

More information

For further information on transformer control with A.Eberle Voltage Regulating Relays refer to <http://www.hvpower.co.nz/TechnicalLibrary/VoltageRegulators.html> or contact HV Power.