REG-D & REG-DA Voltage Regulating Relays: An overview of the regulation schemes

Depending on the settings applied, an A.Eberle Voltage Regulator Relay (VRR) can perform a variety of functions, from simple voltage control of a single transformer, to control of a disparate multi-transformer bank with line drop compensation. This technical note provides a basic overview of the main control programs and their interaction.

Voltage regulation of a single transformer

Basic regulation

With the most basic settings applied, the REG-D/DA acts as a simple voltage regulating relay. If the measured voltage deviates from the voltage Setpoint by more than the Bandwidth setting, then a tap command is issued in an attempt to return the voltage to within the Bandwidth. The time taken to issue a command will be determined by the Time Program selected: Inverse Time, Linear and Definite Time programs are amongst those available. 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.

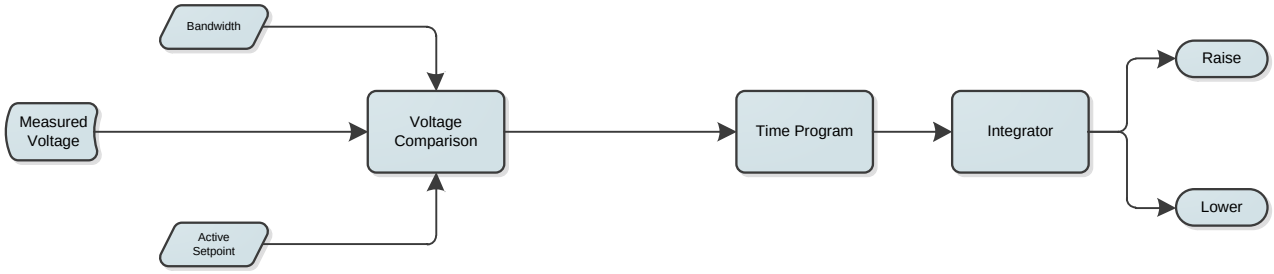

Figure 1. The basic voltage regulation function of a VRR (without any Current Influence or parallel programs).

Regulation with Current Influence

When 'Current Influence' is applied, the target voltage is dynamically adjusted by the relay, depending on the level of current flowing in the system (Figure 2). The type of current considered (apparent, active or reactive) as well as the level of influence that is applied can all be adjusted via settings. Current Influence via the Line-Drop Compensation method is also available.

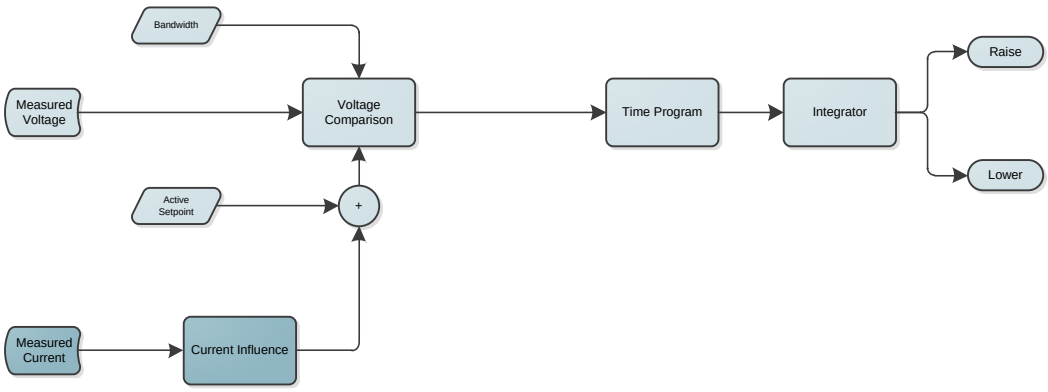

Figure 2. Basic behaviour with Current Influence applied.

HV Power Measurements & Protection Ltd
Unit 4, 1 Porters Ave, Eden Terrace, Auckland
P O Box 26-074, Epsom, Auckland 1030, New Zealand
Tel: +64-9- 377 2001
Fax: +64-9- 302 2142
Email: info@hvpower.co.nz

Regulation with different paralleling schemes

When transformers are operated in parallel then regulation behaviour is changed depending on the paralleling program chosen.

Master-Follower schemes

If a simple Master-Follower scheme is used, then one relay becomes the Master and performs the voltage regulation calculations. The 'Followers[1]' simply follow the command of the Master as to which tap they should change to. As the transformers should be matched, and always on the same tap, there should be negligible circulating current. Circulating current is however monitored as a backup check[i].

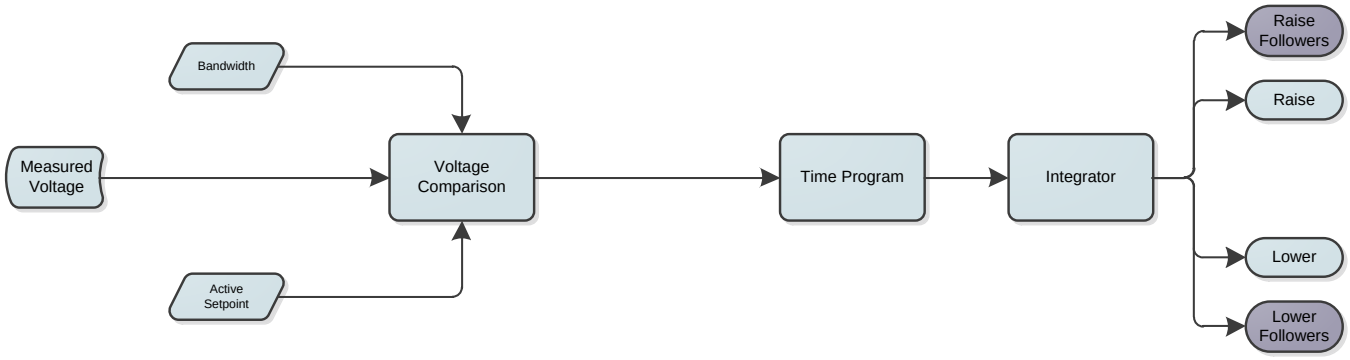

Figure 3. Master-Follower scheme (Master relay logic shown). The Master makes tapping decisions which are mimicked by 'Following' relays.

The Master-Follower scheme can also be used in combination with one of the current influence programs such as Line-Drop Compensation. The Setpoint is dynamically adjusted by the Master relay depending on the level of current flowing in the system. The current is automatically calculated to be the total load on the parallel group of transformers.

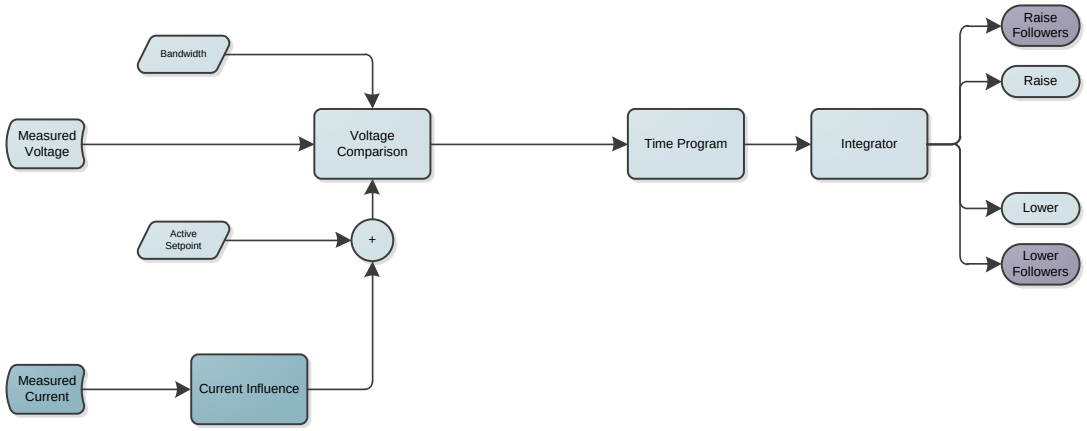

Figure 4. Master-Follower scheme modified with the addition of a Current Influence program.

[1] Master-Follower and Master-Slave schemes are very similar. In a Master-Follower scheme, no tap offset is permitted. If a 'Follower' is brought into a parallel group on a different tap, it will be tapped to be the same as the Master. Master-Slave schemes are no longer supported in current firmware. In these older schemes, Master and Slave(s) could have a tap difference (offset). If a Slave was brought into a parallel group on a different tap, that tap offset was maintained. For example if the Master was tapped up one tap, the Slave(s) were also be tapped up one tap with the offset remaining. Be aware that in Master-Follower schemes, the 'follower' is often referred to as a 'Slave'.

HV Power Measurements & Protection Ltd
Unit 4, 1 Porters Ave, Eden Terrace, Auckland
P O Box 26-074, Epsom, Auckland 1030, New Zealand
Tel: +64-9- 377 2001
Fax: +64-9- 302 2142
Email: info@hvpower.co.nz

Circulating-Current schemes

With regulators operating in Circulating-Current mode, all the regulators are measuring local transformer current, and sharing communications to determine circulating current. The main noticeable feature of Circulating-Current paralleling schemes is that transformers may not all be on the same tap. In a Circulating-Current paralleling scheme, each VRR continuously calculates the circulating current and uses this as an additional input to the Time Program. The voltage deviation and circulating current are added in a way such that tap change commands for each relay are in a direction that tend to reduce both parameters simultaneously.

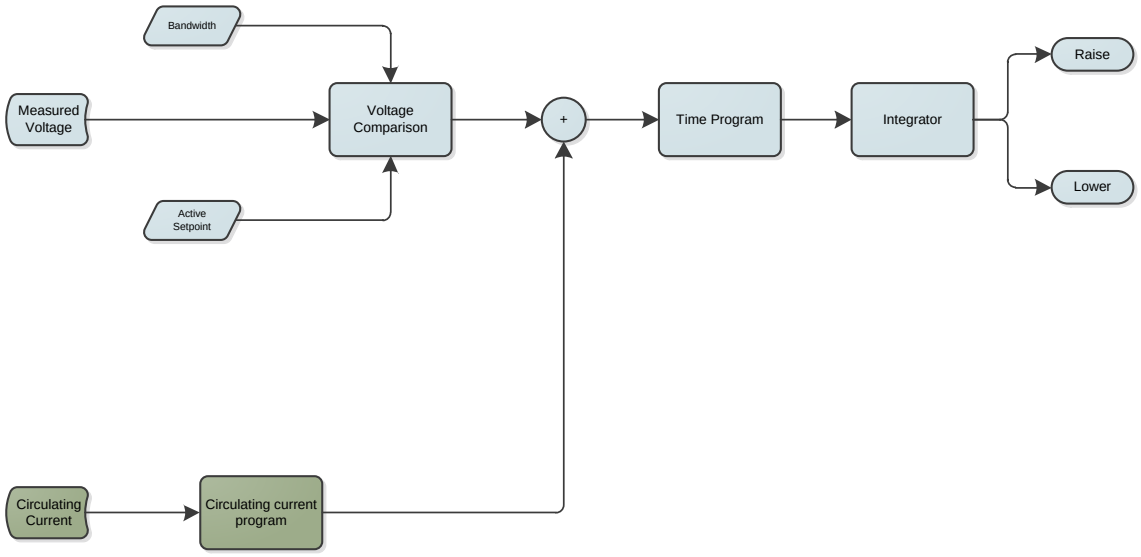

Figure 5. The voltage regulation logic with the additional influence of circulating current.

Current Influence can also be applied to work together with Circulating-Current paralleling schemes.

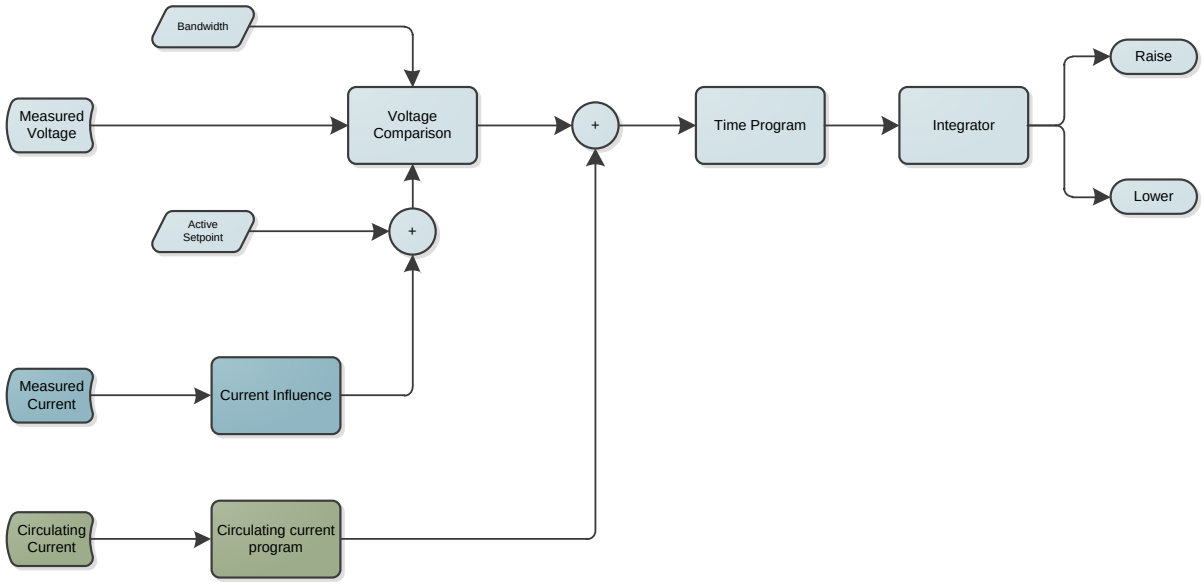

Figure 6. Circulating-Current parallel scheme with Current Influence applied.

HV Power Measurements & Protection Ltd
Unit 4, 1 Porters Ave, Eden Terrace, Auckland
P O Box 26-074, Epsom, Auckland 1030, New Zealand
Tel: +64-9- 377 2001
Fax: +64-9- 302 2142
Email: info@hvpower.co.nz

Regulation via P or Q

Instead of using Voltage as the basic controlled variable it is also possible to regulate based on the Real or Reactive power. This function is most commonly applied to phase-shifting transformers.

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.

[i] Refer to HV Power's technical note 'Voltage Regulator backup supervision functions & error reporting' for further details.

HV Power Measurements & Protection Ltd
Unit 4, 1 Porters Ave, Eden Terrace, Auckland
P O Box 26-074, Epsom, Auckland 1030, New Zealand
Tel: +64-9- 377 2001
Fax: +64-9- 302 2142
Email: info@hvpower.co.nz