Inverse Time Delay on LTC/Regulator Controls

Abstract:
The Beckwith M-2001 and M-6200 controls allow for two types of time delay. The time delay is the amount of time the control will wait before taking action after a violation of the voltage occurs.

Basic Settings:

A violation of the voltage is defined by the Bandcenter and Bandwidth settings. The Bandcenter setting establishes the desired operating voltage in secondary quantities. Typical bandcenters range from 118 Vac on the low end to 125 Vac on the high end. The control permits settings between 110 -126 Vac. The bandwidth is applied around the bandcenter to provide an allowed range for the voltage. Half of the bandwidth is added to the bandcenter while the other half is subtracted from the bandcenter. As an example, a control with a bandcenter of 120 Vac and a bandwidth of 2 Vac will take no action as long as the sensed voltage is between 119 Vac and 121 Vac. The two edges, 119 and 121 are referred to as the band edges

If the sensed voltage violates either band edge, the control will take action to bring the sensed voltage back within the band edges. If the sense voltage is above the upper band (121) the controller will attempt to lower the voltage. Likewise, if the sense voltage is below the lower edge (119), the controller will attempt to raise the voltage. When the violation of a band edge occurs, the control waits a programmable amount of time before taking action. This is to allow the system a chance to recover on its own and also to allow for capacitor banks to attempt to change the voltage. The programmable amount of time is referred to as the time delay.

The time delay on traditional analog controllers was a definite time delay. The definite time delay would typically be between 30-120 seconds. A definite time delay of 60 seconds would cause to the controller to wait 60 seconds after a band violation before taking action. The inverse time delay acts differently in that it varies the time delay. The further the voltage is from a band edge, the smaller the delay, allowing the controller to take action faster. The inverse time curve used by the controller is a fixed curve shown below.

Keep in mind that the secondary voltage typically changes approximately 0.75 Vac for every tap taken.

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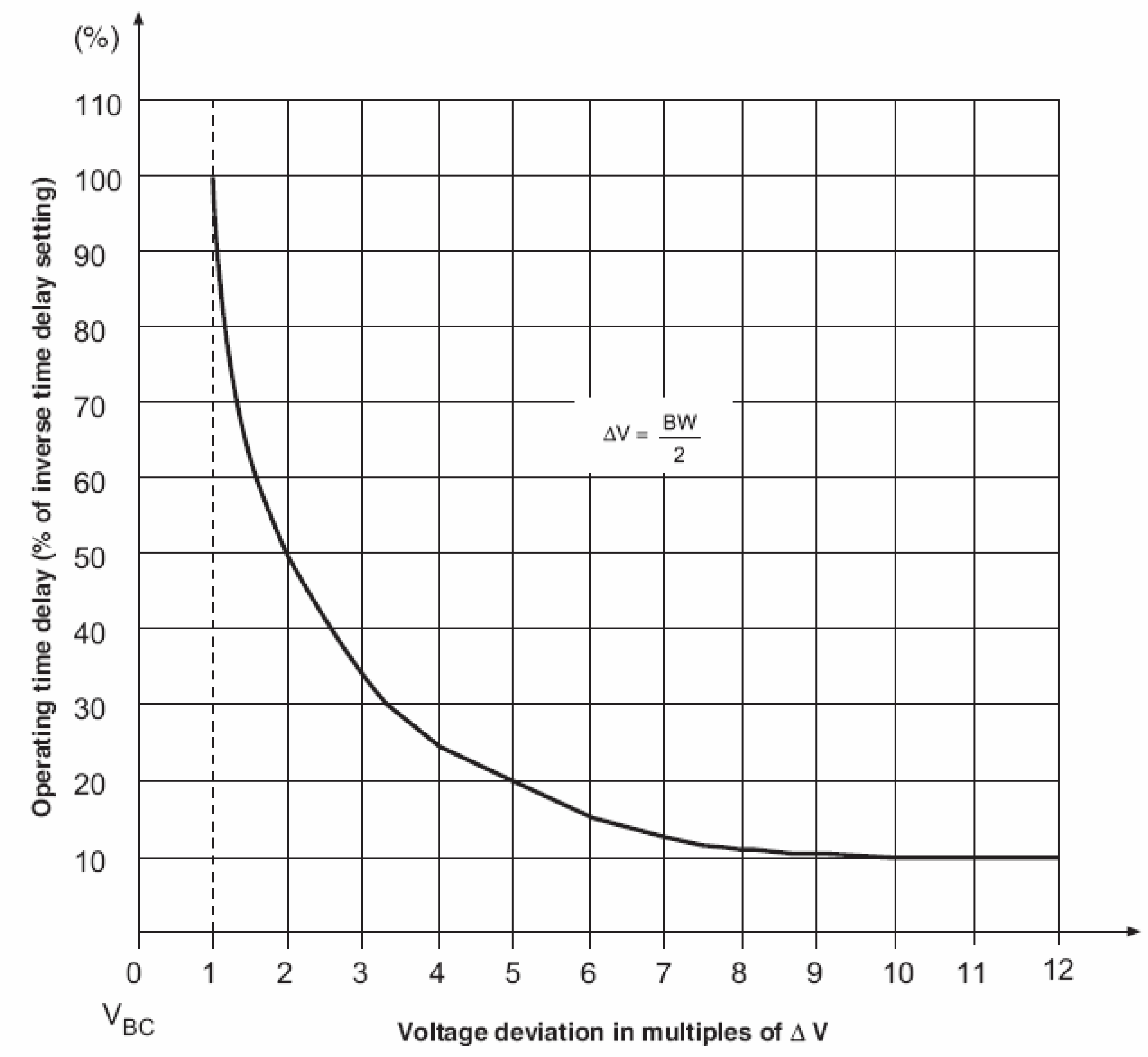

Figure 3-1 Inverse Time Delay Curve

As an example, if the following settings were applied to the controller
Bandcenter 122
Bandwidth 3
Definite Time Delay 60 seconds
And the sensed voltage was 116 Vac, With the 122 bandcenter and 3 volt bandwith the control will attempt to keep the sense voltage between 120.5 and 123.5. With the measured voltage at 116 it is 4.5 volts below the lower band edge. We would expect the control to issue 6 raise taps to get the voltage back into band as 4.5 volts /.75 volts per tap = 6 taps. The controller would wait 60 seconds before asserting the raise output. Using the same settings with a 60 second time delay using inverse time, the control would wait:
ΔV=Bandwidth/2
ΔV = 3/2 = 1.5
Voltage Deviation in multiples of ΔV = [Vin/Bandcenter] (ΔV = [122-116]/1.5 = 4)
As can be from the curve a V of 4 causes the control to use 25% of the time delay
60 * 0.25 = 15 seconds.

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As can be seen, the control will only wait 15 seconds before asserting the raise output even though the time delay is set at 60 seconds.

If the sense voltage was 120 instead of 116, the control would need to raise 1 tap (120.5 -120 = 0.5) and the control would wait (122 – 120)/1.5 = 1.33

From the curve 1.33 equates to approximately 80% of the 60 seconds or 48 seconds.

From the above curve one can see that the time delay will always be between 100% and 10% of the setting (6-60 seconds in the example). One can also see that the control takes action quicker as the voltage gets further away from the bandcenter.

Assume for the same control we used a 120 second inverse time delay instead of a 60 second definite time delay. For the first example of the measured voltage at 116 we would be using 25% of the 120 seconds which would be 30 seconds. So we are responding to the large voltage swing twice as fast as the definite time at 60 seconds. But when the sense voltage is 120 volts we are using 80% of the 120 seconds or 96 seconds.

Application:
By using a longer time delay, 120 instead of 60, but selecting inverse time instead of definite, the following advantages are received. For small voltage swings, the controller will be slowed down. This provides two major benefits. First it allows the system more time to stabilize on its own, thus reducing the number of operations on the regulator/LTC. Second, it allows voltage controlled capacitor banks down line to have more time to respond to the voltage change. By allowing the capacitor bank to operate, we again reduce the number of operations on the LTC or regulator. As the voltage swings greatly due to loss of load or picking up of load, the LTC actually operated faster than the definite time, producing better power quality to the end customers. This can be very beneficial on bus regulators or LTCs. This is because they are attempting to regulate the voltage on multiple feeders. A loss of one or more feeders can impact the bus voltage, thus affecting the remaining feeders. The inverse time curve will respond to this situation faster.

Therefore it is recommended that the inverse time be used on LTCs and bus regulators. Another application is for down line regulators that are either behind a recloser or that feed an industrial facility with heavy loads that vary often. Each of these conditions can again cause large voltage variations.

One possible concern in using the inverse time delay is attempting to coordinate it with down line regulators using the definite time. It is good practice to have the upstream regulators with shorter time delays to allow them to operate first due to the fact that the affect the voltage on the entire circuit. If the substation LTC is using inverse time delay and the down line regulators are using definite time, small variations in the voltage may allow for the down line regulator to operate first. A typical practice would be to allow for 10-15 seconds between each set of regulators.

Inverse Time Delay on LTC/Regulator Controls

As an example, using the settings from above for the LTC, a 60 second definite time delay would cause the first set of down line regulators to be set at 70-75 seconds. Now, if we change the LTC to 120 seconds using inverse time, a small variation (120 volts was .5 volts below the lower band edge) the LTC would be using a time delay of 96 seconds. This would allow the line regulators to operate first. If the voltage was still too low between the LTC and the line regulators, the LYC would still issue a raise after 96 seconds, causing a higher voltage on the entire circuit. This may cause the voltage below the line regulators to possibly be too high. This would then cause the line regulators to issue a lower. Though no damage is done, the line regulators have had to perform 2 operations that were not required. By changing the definite time delay on the line regulators to 100 seconds, this problem would be avoided.

As a general rule using the inverse time delay on source regulation devices can minimize operations on the source regulation devices, provide easier coordination with down line capacitor banks (especially voltage controlled capacitor banks) and provide for faster response to major voltage swings.

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